

MEMOIR 2

Studies of the Actinoceratida

I. The Ordovician Development of the Actinoceratida,
With Notes on Actinoceroid Morphology and
Ordovician Stratigraphy

II. *Macroloxoceras*, a Devonian Homeomorph
of the Actinoceratida

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PART I

THE ORDOVICIAN DEVELOPMENT OF THE
ACTINOCERATIDA, WITH NOTES ON
ACTINOCEROID MORPHOLOGY AND
ORDOVICIAN STRATIGRAPHY

Abstract

Descriptions of new Ordovician species of Actinoceratida are combined with a review of the evolution and faunal development of the order in the Ordovician. New morphological information includes spatial relationships of cameral and siphonal deposits in complete shells of several species, and a revised concept of the canal system. Occurrences of actinoceroids in the Ordovician of North America, eastern Asia, and northern Europe are summarized. A revised concept of evolution of the group is presented. Reason is given for regarding *Bathmoceras* as the ancestor of the order; it gave rise to *Polydesmia* having thick primitive rings and dendritic radial canals. Reticulate canals characterize Whiterock actinoceroids, of which the genera *Wutinoceras*, *Cyrtonybyoceras*, and *Adamsoceras* are characteristic. *Ormoceras*, developed from *Adamsoceras*, continues beyond the close of the Ordovician, giving rise to *Deiroceras*, of which *Troedssonoceras* is a synonym. *Actinoceras* yields itself to division into species groups of faunal and stratigraphic value. *Leurortho*

ceras is a synonym of this genus, and *Saffordoceras* and *Troostoceras* are doubtfully distinct. *Kochoceras* is derived from *Actinoceras*. Internal differences indicate that *Ganioceras* and *Lambeoceras* are homeorphic but not closely related.

Stratigraphic notes include a general discussion of the Ordovician, with special reference to the recent revisions, recognition of a pre-Chazyan interval, the Chazy-Black River hiatus, and the correlation of the Red River beds with the Cobourg and Eden. A revision of the Montoya group is presented. The importance of austral-boreal oscillations is emphasized, the actinoceroids being predominantly boreal in faunal affinities, although in Cobourg time *Deiroceras* and *Orthonybyoceras* invaded the austral realm.

The systematic portion includes discussion of 5 genera, one of which, *Adamsoceras*, is new. Thirty-one species are described and illustrated, all but two of which are new; these are listed in the table of contents.

Introduction

This work combined the descriptions of new species of actinoceroids with a review of the order as developed in the Ordovician of North America. A primary concern has been the tracing of stocks with special reference to their faunal and stratigraphic significance. This has involved some contributions to the morphology and phylogeny of the group.

One of the most serious problems encountered in the study of actinoceroids is the actual recognition and definition of species. Many actinoceroids were large shells when complete. Some species of *Actinoceras* attained a length of 3 feet. Species of *Ormoceras*, *Armenoceras*, and *Gonioceras* attained lengths of between 1 and 2 feet. What one commonly finds, however, is a series of specimens which, while imposing in themselves, are mere scraps when compared to the complete shells. Species, of necessity, often have been based upon such material.

The definition of species has depended heavily upon the outline of the siphuncle segments, the relative size and position of the siphuncle in the shell, and the nature of the cross-section, obliquity, lobation, and spacing of the septa. Yet it is true, as shown by the species here described from relatively complete material, that all these features may change widely from the apical to the anterior end of the phragmocone. Indeed, without connecting parts, and basing conclusions on published descriptions, one would be justified in regarding apical and anterior fragments of some of these species as distinct species. *Actinoceras winstoni* shows in the young the relatively large siphuncles characteristic of the adults of Black River species. Later segments are smaller and typical of the group of Trenton species to which this belongs. The very latest siphuncle segments are so simplified in outline that they are typical of *Leurorthoceras*, formerly considered a distinct genus but shown here to embrace a group of species of

Actinoceras of which only the latest stages of phragmocone have been known.

From these facts one well may question the validity of many of the species which have been named. The question of validity can be settled only when more complete material is collected and studied. At present many species are known very incompletely, and their identification requires material commensurate with the portions from which the species have been described. Regrettably, most of the known material of actinoceroids is extremely fragmentary. Description, including redescription of previously named forms, is to be most strongly urged, but it is not a task of easy attainment. Complete shells, even when found, are very difficult to extract; something approaching quarrying operations may be involved in the process. Again, many formations have yielded only fragmentary shells; sometimes only isolated portions of siphuncles. It is of some comfort to reflect that without the present descriptions based upon fragmentary material, our knowledge of the range and structural variation within the actinoceroids would be almost nonexistent.

Our present concept of actinoceroid classification and evolution rests primarily upon the work of Foerste and Teichert (1930) and Teichert (1933, 1935). As at present understood, the actinoceroids appear early after the close of Canadian time and become widely diversified relatively early in the Ordovician, after which genera are long ranging and wide ranging. *Actinoceras* is known first from species of Black River age, but it continues to the close of the Ordovician; one species (Foerste, 1928) was described as from the Silurian, although this is believed to be an error. *Ormoceras* appears as early as the Chazyan and continues through the Ordovician into the Silurian; the youngest species known is in the early Middle Devonian Onondaga limestone of New York.

Armenoceras ranges from beds of approximately Black River age through the Ordovician, is abundant in the Silurian, and is modified into *Metarinenoceras* in the Lower Devonian. Other genera are less wide ranging but, except for a few bizarre and restricted types, extend widely enough in the Ordovician that one hesitates to consider them of any precise stratigraphic value. Species, on the other hand, are regarded as confined to relatively small geographic regions, and usually to a very small stratigraphic interval.

Polydesmia, known from the earliest post-Canadian of eastern Asia, is probably the oldest known actinoceroid. Morphologically it shows several features regarded as primitive and suggesting an origin of the actinoceroids in *Bathmoceras*, as discussed more fully below. It is in essentially superadjacent beds that the actinoceroids first became widespread. Such beds, formerly identified rather tentatively as Chazyan, with the realization that the limits of the Chazyan were perhaps extended downward thereby, have been set aside recently as the Whiterock stage by Cooper (1956). Here are actinoceroids with the siphuncle outlines of *Nybyoceras* and *Ormoceras*, but differing from younger and typical members of these genera in possessing a complex reticular type of canal system. These forms are deemed worthy of recognition as distinct genera, which can be recognized now as characterizing the Whiterock stage of North America, the Wuting limestone of Manchuria, and the probably equivalent beds (undifferentiated and unnamed as yet) in the Ordovician of Tasmania, and as penetrating the *Platyurus* horizon of the *Orthoceras* limestone sequence of the Baltic.

Differentiation in the genus *Actinoceras* was resolved not in terms of generic or subgeneric divisions but in terms of species groups. Three such groups characterize Black River beds; one is characteristic of the Trenton, and the two others are confined to Red River and Richmond faunas. It has long been questioned whether in the arctic region, where supposedly Red River faunas contain elements suggestive of the Black River which are absent in more southerly and better known sections, necessarily hurried work may not have left some earlier strata grouped with those of Red River age. A survey of the actinoceroids shows that the Arctic alone contains in apparent Red River associations *Actinoceras* of Black River species groups and *Gonioceras*, both elsewhere unknown in Red River or post-Black River beds. Similar analysis of other of the larger and long-ranging genera, requiring examination of Asiatic as well as American material, has not been published at this time. In the case of American Ar

menoceras, no results of value have come from a review of the species. Perhaps this will be corrected when species are known from more complete materials. The same is true of *Ormoceras*, many species of which from eastern American faunas have escaped description. A serious possibility exists that Ordovician *Ormoceras* and homeomorphs belonging to the Stereoplasmoderata of the Michelinoceratida have been confused.

Analysis of the occurrence of actinoceroids in North America shows a sparse early assemblage of Whiterock age, which well may be increased with further study of the faunas. The next glimpse of actinoceroids is afforded by the Chazyan. The boreal invasion of Black River faunas brought the first of the typical boreal associations, with *Actinoceras*, *Gonioceras*, *Ormoceras*, and the earliest *Deiroceras*. By Rockland time the boreal elements are definitely more specialized. The actinoceroids decline in the Hull, only *Actinoceras* of the *winstoni* group being found there. The Cobourg invasion is largely marked by *Deiroceras* (= *Troedssonoceras*) and the advent of the small ubiquitous *Orthonybyoceras*. Both became adapted to austral faunas; the former persists into the Maysville, whereas the latter becomes the dominant cephalopod of the eastern Cincinnati.

Meanwhile, in the north and west, the Red River faunas produced a very different assemblage, which now can be regarded as of Cobourg-Eden age. Here large *Armenoceras*, previously unknown in the American section, appear with *Actinoceras* of the simplicem and *anticostiense* types, *Kochoceras*, *Lambeoceras*, *Ormoceras*, and *Nybyoceras*. The boreal invasion of the east which marks Richmond time brought various representatives of these genera, except *Kochoceras*, into various of the eastern regions of the Richmond; *Actinoceras* into Anticosti, *Lambeoceras* and *Armenoceras* into Indiana and Ohio, *Armenoceras* into the Maquoketa of Iowa, *Armenoceras* alone into the Aleman of New Mexico and the Stony Mountain of Manitoba, and *Actinoceras* and *Armenoceras* into the Shamattawa limestone of Hudson Bay. Curiously, the northern and western Richmond beds which overlie the Red River faunas have yielded very few actinoceroids so far. The reported occurrence of actinoceroids in the American Ordovician presents only isolated glimpses of actinoceroid evolution. It is the intention of the present work to fill in gaps in the record as far as the material permits, and to point out some new conclusions which this material makes possible.

Acknowledgments

The present work is based upon a long accumulation of specimens. Guidance, stratigraphic information, and help in collecting in Quebec were supplied by Dr. G. W. Sinclair and Dr. T. H. Clark, both of whom have contributed material of their own collecting. One specimen described here is from collections of the New York State Museum. For aid in collecting in the Montoya group of New Mexico, I am particularly indebted to Mr. A. K. Armstrong, now of the University of Cincinnati.

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It is planned that the considerable material here described from the collection of the writer will be deposited with the New Mexico Bureau of Mines and Mineral Resources, which gave support to the present investigation.

Morphological Notes

The present investigation is systematic and faunal in its primary objectives, and no special effort is made to discuss morphological questions. However, several new facts not previously known or adequately emphasized have become apparent, and attention is directed to other matters on which further investigation is to be urged.

Teichert (1933) has shown the hydrostatic significance of cameral and siphonal deposits. It has long been known that such deposits commonly appear some time after the formation of septa and siphuncle, that their growth is gradual and uniform, and that there is an adoral interval of the phragmocone in which deposits are wanting. There has been no information, however, on the relative extent of either siphonal or cameral deposits in relation to complete shells, mature or immature. *Actinoceras margaretae* and *A. aequale* now supply information on these matters for two species of the *A. ruedemanni* group. *A. ruedemanni* itself is a much larger species than either of these and has a much longer phragmocone. The portion of phragmocone figured by Foerste and Teichert (1930, pl. 52, fig. 2.) is separated from a mature living chamber by a length, missing from this specimen, which is probably as long as the portion figured. This conclusion, based upon my own collecting, is consistent with the relatively great development of both cameral and siphonal deposits in the specimen noted, in relation to both *A. margaretae* and *A. aequale*. *A. winstoni* shows the relationship of siphonal deposits to a large complete shell of the *A. winstoni* group. *A. mutabile* shows clearly the delay of growth of both cameral and siphonal deposits in a member of the *A. paquettense* group. More information is needed, for the relative growth of both cameral and siphonal deposits is clearly a matter which varies from one species to another. *Armenoceras callaghami* shows deposits of the siphuncle extending fairly close to the base of the mature living chamber, but cameral deposits are developed only in the apical end of the holotype, where they are very thin. In *Lambeoceras* there is now indication that cameral deposits are developed in the lateral extremities of the camerae and are present only in camerae well removed from the base of the living chamber. In *Gonioceras*, cameral deposits are thickest in the region of the lateral flanges of the shell. Relationship of the camerae showing deposits to the living chamber is not evident; obviously there is again an appreciable delay between formation of septa and development of cameral deposits.

Although it has been evident that cameral deposits in actinoceroids are concentrated on the ventral side of the shell, there has been no mention of their bilaterally symmetrical pattern. Similarly, the siphonal deposits are thickest ventrally and show a bilateral symmetry previously unnoted. In Plate 2, figures 4 and 5, two cross-sections of *A. gradatum* are shown. Figure 4 shows the bilateral symmetry of the radial canals. This feature is difficult to demonstrate by sections, for a cross-section will intersect the canals only incompletely, because of their longitudinal curvature. The siphonal deposit here shows a midventral protuberance. The same protuberance is shown in figure 5, in a section across the narrower part of a siphuncle segment, where no radial canals are evident. This section shows lateral alate projections of the out

line of the siphuncle, a feature not previously noted in actinoceroids. Both sections show thin episeptal deposits, which are thick ventrally and thin dorsally; evidently the surface of the deposit had only slight relief. Plate 3, figure 4 shows siphonal deposits in *A. aequale*. The section cuts the siphuncle at a point at which the siphonal deposits remain comparatively small and leave a relatively large empty central cavity. Again the deposits show a prominent midventral protuberance, extending from the ventral side toward the center.

Teichert (1933) designated various types of radial canals in terms of genera and species. This terminology proves somewhat cumbersome and a bit ambiguous, particularly since there appears to be no species of *Nybyoceras* which shows clearly what was called the "*Nybyoceras* type" of structure. Indeed, the concept of the *Nybyoceras* type seems to have been developed primarily from the study of *Elrodoceras*, supplemented perhaps by *Nybyoceras foerstei* and *Cyrtonybyoceras*. Both of the last-mentioned forms possess additional complications of structure and, indeed, are not really typical of the simple double arcs of the "*Nybyoceras* type" at all. In the present work it has been necessary to divide *Nybyoceras*, removing species with the more complex reticular canal system to *Wutinoceras*.

Variations in the canal system of the actinoceroids are of evolutionary significance. Once the perispantium developed, supplying a place where interchange of metabolic products, and probably of the blood itself, could take place between cameral and siphonal tissues, it was no longer necessary for the blood tubes to be numerous and to divide finely as they approach the edge of the siphuncle. Specialization began with a series of numerous, fine, branching tubes and developed toward simpler systems of fewer, more regularly arranged, and larger tubes. The various types can be summarized as follows:

1. Dendroid. Numerous fine branching tubes, complexly branching as they approach the siphuncle wall. Known only in *Polydesmia*.
2. Reticular. A system of double arcs, complicated by complex and seemingly rather irregular branching, and by a tubular network which is largely, though not completely, concentrated in the central part of the siphuncle, close to the central canal. This type is found in genera of the Whiterock stage, *Wutinoceras*, *Cyrtonybyoceras*, and *Adamsoceras*.
3. Double-arc. From a point of juncture with the central canal, usually located in the septal foramen rather than in the expanded part of the segment, one series of arcs curves back to the middle of the expanded part of the apical segment, another extends forward to the perispantium in the anterior segment (Teichert, 1933, pl. 14, fig. 49.) This type is found in many, but not all, *Armenoceras* and in some derivatives of this genus.
4. Rectilinear. The double-arc type is modified only in form. Proximal parts of the tubes are pressed against the central

canal and then bent abruptly in the middle of the segments, so that they extend almost straight to the perispantium. This type has been fully observed only in *Elrodoceras*.

5. Single-arc. The radial canals leave the central canal near or at the level of the septal foramen, curve back and then outward, and join the perispantium, sometimes with minor branching, in the expanded part of the segment. The pattern is similar to the apical half of the double-arc type, with the forward projecting canals completely suppressed. It is developed in some *Armenoceras* and *Nybyoceras*, and throughout *Gonioceras*, *Lambeoceras*, *Selkirkoceras*, **and** *Actinoceras* and its derivatives.
6. Horizontal. Simple straight radial canals extend at right angles from the central canal to the perispantium in the middle of the expanded part of each siphuncle segment. This development is possibly polyphyletic. It derives in typical *Ormoceras* from the reticular type of the ancestral *Adamsoceras*. It may possibly be developed again by

modification of the single-arc, the double-arc, or the retilinear types.

There is need of further study of a number of structural features in actinoceroids. Details of the surface patterns of cameral deposits are as yet inadequately known. Information is needed on the relationship of the growth of cameral and siphonal deposits to the shell as a whole in more species and genera. Further examination is needed of possible variation in fine structure of the connecting ring; related is an investigation of the Kontaktschnitt (Teichert, 1933), to determine whether it is a part of the original connecting ring or a supplemental structure. It would be helpful to have more information on the bilaterally symmetrical pattern of the radial canals, particularly in the reticular type, which requires clarification. The mural part of the septum typically is well developed in actinoceroids. Curiously, the septal furrow has been observed in only a very few actinoceroids, largely in species of *Orthonybyoceras*. Conchial furrows have not yet been observed in the actinoceroids; it is believed that they are not developed in the group. Further examination of specimens for both furrows is a desideratum.

Stratigraphic Summary of the Actinoceroids in the Ordovician

NORTH AMERICA

WHITEROCK

It is only recently that the Whiterock stage has been proposed (Cooper, 1956) for an interval in the Ordovician younger than the latest Canadian and older than the true Chazyan. Although its cephalopods are as yet very incompletely known, its few actinoceroids are very characteristic and notable for the reticular type of canal system. From the Whiterock of Nevada, *Adamsoceras isabelae* is described here. The Table Head beds of Newfoundland have yielded *Cyrtonybyoceras clouei* (Barrande), *C. haesitans* (Billings), and *C. barrandei* Teichert. *Cyrtonybyoceras* is not known from any other horizon or locality. Also from the Table Head is the form here named *Adamsoceras billingsi*.

As pointed out in the discussion of the genus, *Adamsoceras* is known in the *Platyurus* limestone of northern Europe, where its species were described originally in terms of the genus *Ormoceras*. *Adamsoceras* continues into the Wuting limestone of Manchuria, where it is joined by *Wutinoceras*. These same two genera appear in the Ordovician of Tasmania (Teichert and Glenister, 1953), though described as species of *Ormoceras* and *Nybyoceras*.

CHAZY

The lower Chazyan Day Point limestone has yielded only a small cephalopod association (Flower, 1956), which is anomalous and not closely related to the cephalopods of the middle and upper Chazyan. Cooper (1956) has found the brachiopod assemblage also anomalous and regards the Day Point limestone of the Champlain Valley as without equivalents elsewhere in North America. The Day Point beds have yielded no actinoceroids.

The Crown Point and Valcour limestones have much in common faunally. Their few actinoceroids show a material advance beyond the forms known in the Whiterock stage. Strangely, the specialized genus *Gonioceras* appears, being represented by *G. chaziense* Ruedemann, common to the Crown Point and Valcour limestones, and by *G. brainerdi*, known as yet only from the holotype from the Crown Point beds. *Armenoceras* is probably the ancestor of *Gonioceras*, but in America this genus does not appear until Red River and Cobourg time. It is however, well developed in the early Mohawkian Toufangian of Asia, and a species in the Wuting limestone of probable Whiterock age establishes its presence in earlier beds. Typical *Ormoceras*, with simple horizontal canals, in contrast to the older *Adamsoceras*, with reticulate canals, appears. *Ormoceras champlainense* Flower possibly is not actually Chazyan, but may have come from the Black River or Isle La Motte beds of the Champlain valley instead. However, *O. neumani*, described below from the Newmarket limestone of Maryland, supplies a definite record of a typical *Ormoceras* in the Chazyan.

Nybyoceras is represented by the small anomalous species

N. cryptum known from the middle-Chazyan Crown Point limestone of the Champlain Valley. *Nybyoceras ulrichi* occurs in the McLish limestone of Oklahoma.

As yet no definite records of actinoceroids are known in the Ashby or Porterfield stages of Cooper (1956) in the Appalachian region, although this lack perhaps may be corrected with further work. Outside this region, there is question as to the proper equivalents of these beds.

BLACK RIVER

The Pamela limestone has yielded few cephalopods, still fewer which are determinable, and only one known actinoceroid. The latter, long identified as a *Gonioceras*, is described here as *G. pameliense*. It is in the Lowville limestone that the first great incursion of *Actinoceras* appears. From the Lowville beds of Ottawa, *A. margaretae*, *A. aequale*, and *A. gradatum* are described. *Actinoceras* is present in the Lowville of northwestern New York, but is rarer and more fragmentary. Probably the same species are present there. The writer has obtained a large specimen from near Watertown, N. Y., close to and probably identical with *A. aequale*. No *Ormoceras* nor *Gonioceras* are known. The Lowville at Meath station, Ontario, has yielded a portion of a phragmocone of an *Actinoceras* of the *A. centrale* type, and a small portion of a phragmocone showing the siphuncle outline of a *Leurorthoceras*.

The Chaumont limestone of northwestern New York yields abundant *Actinoceras*. Three species have been described from portions of phragmocones, *A. tenuifilum*, *A. centrale*, and *A. ruedemanni*. *Orthoceras fusiforme* Hall is the anterior end of an *Actinoceras* but has not yet been identified in terms of the three species described from phragmocones. It may be that more than these three species are present. *Gonioceras* is abundant and is represented by *G. anceps* and *G. quadratum*. *Ormoceras* is represented by *O. cf. josephianum*. At Ottawa *Actinoceras* is abundant, and *Ormoceras* is present. There are indications (Clark, 1952, and in conversation) that similar associations are present in the Leray of the St. Lawrence valley at Montreal and to the northeast. *Gonioceras* is reported from the Montreal region (Clark, 1952). At Ottawa the generic position of *Orthoceras menelaus* Billings as *Ormoceras* (Foerste, 1932-33) requires further confirmation.

Above the Chaumont, Kay (1937) cites abundant *Gonioceras* in the Rockland of Ontario. At the Paquette Rapids of the Ottawa River, *Actinoceras paquetense*, *A. billingsi*, *A. abortivum*, *Gonioceras paquetense*, *G. obtusum*, *Ormoceras allumettense*, *Deiroceras paquetense*, and *D. pertinax* occur.

St. Joseph Island has yielded *Actinoceras cf. libanum*, *A. sp.*, *Ormoceras josephianum*, *O. casei*, and *Deiroceras kindlei*; *Gonioceras*, if present, appears to have escaped notice.

The Platteville limestone has yielded *Actinoceras be-loitense*, *A. turinense*, *A. janessvillense*, *A. cf. bigsbyi* (under which name certainly two forms have been included),

Gonioceras occidentale, *G. kayi*, and *Deiroceras schofieldi*. *Ormoceras* is unreported.

The Platin limestone of Missouri has yielded *Actinoceras glencoense*, *A. cinctum*, *A. circulare* and *Deiroceras richteri*.

Platteville equivalents of the cryptovolcanic structure at Kentland, Indiana, have yielded *Actinoceras kentlandense* (with which *A. cf. beloitense*, as identified by Foerste, possibly may be conspecific) and *Gonioceras kayi*.

Armenoceras ehlersi of St. Joseph Island is not a typical *Armenoceras*; it is anomalous for the genus in many respects and is believed to be a *Murrayoceras*, with the siphuncle segments slightly expanded. (Compare with *Murrayoceras noveboracense* Flower, 1952.) *Sactoceras* species are not listed; they have not yielded evidence of actinoceroid structure and are believed to be allied to the Stereoplasmoceratidae of the Michelinoceratida rather than to the Actinoceratida.

In Quebec the Rockland equivalents have yielded *Actinoceras imperator* Clark (1928, 1952) from the Montreal region. It is strange that other beds of Rockland age in Quebec have not yielded any actinoceroids, although brevicones with Platteville affinities are known in the Pont Rouge beds. This is the more singular because the superadjacent beds correlated with the Hull contain *Actinoceras*, frequently as an abundant and conspicuous constituent of the fauna.

TRENTON

The Rockland beds, formerly considered lowermost Trenton, still present something of a problem. In New York they are thin-bedded black limestone of Trenton aspect and with a dominant association of Trenton aspect, but when traced into Canada, at the northern end of Lake Ontario, they change facies and bear a molluscan association more similar to that of the Black River. The writer agrees with Cooper (1956) in grouping the Rockland faunas with those of Black River age. The Hull and its equivalents have yielded no actinoceroids in Ontario or New York, but *Actinoceras winstoni* is characteristic of these beds in the St. Lawrence valley, between Montreal and Quebec. The higher Sherman Fall equivalents have yielded no actinoceroids in New York, Ontario, or Quebec. The Cobourg of northwestern New York has yielded *Deiroceras remotiseptum*; at Ottawa it has yielded *Deiroceras python*. The Terrebonne and Tetreauville of the upper St. Lawrence Valley have yielded no such forms, to the writer's knowledge; however, the latest Trenton of Lake St. John has yielded the same genus, although fragments do not permit accurate specific evaluation.

Foerste described "*Leurorthoceras*" *husseyi* from the "Cornell member," never accurately defined, of northern Michigan. Other faunal elements suggest the Cobourg equivalence of these beds. Actinoceroids as yet are unreported from the Trenton of the upper Mississippi valley. *Westonoceras*(?) *rallsense* Foerste and Teichert of the Kimmswick limestone of Missouri is an actinoceroid; certainly not a *Westonoceras*. It is anomalous in several respects and more like the otherwise Silurian genus *Elrodoceras*, in the form of the siphuncle segments, than any known Ordovician genus.

EAST-CENTRAL REGION

Some uncertainty is involved in the precise correlation between the eastern sections discussed above and the Ordo

vician limestones of central Kentucky and Tennessee. Confusion is best avoided by discussing these regions separately.

The Murfreesboro limestone of Tennessee has yielded a *Gonioceras*, not as yet adequately known but certainly not conspecific with the Chazyan species or with *G. pameliense*. The Murfreesboro limestone was regarded formerly as Chazyan. Indeed, it is the only formation outside the Chazyan of the Champlain Valley which contains *Gonioceras* and *Ruedemannoceras* in association. Cooper (1956) has placed the formation higher, but still in a position below the Pamelia of New York.

The overlying Pierce and Ridley limestones have yielded no actinoceroids. The Lebanon limestone has yielded a *Gonioceras* and *Actinoceras* ("*Leurorthoceras*") *lebanonense*. The overlying Carters limestone has supplied *Actinoceras tennesseeense*, *A. pohli*, and *A. saffordi*. *Ormoceras* is present, but no species have been described. *Gonioceras* is unknown. The Tyrone limestone is developed in Kentucky and no longer is recognized as such in Tennessee. From the "Tyrone" of Tennessee (beds above the Carters [Busier, 1932] and now generally united with that formation), the following actinoceroids are reported: *Actinoceras caneyense* (as from either Tyrone or Cannon limestones), *A. glenni*(?), *Ormoceras normanense*, and *O. troosti*. Foerste and Teichert (1930) note some anomalies in the structures of the *Ormoceras* and indicate the need of further study of these and other species of the genus in the Black River-Trenton interval. Some of these species may not be true actinoceroids.

The Bigby limestone is the source of *Actinoceras capitolum*, as well as of *Troostoceras paulocurvatum* and this variety *abbreviatum*. As noted in the discussion of *Actinoceras*, the separation of *Troostoceras* as a distinct genus now appears a procedure of doubtful merit. These forms are all very similar to *Actinoceras winstoni*. The writer has collected a group of these actinoceroids in an unusual state of preservation, near Franklin, Tennessee. They are in limestone, but all original shell parts are replaced by gypsum.

In Kentucky, beds in the Camp Nelson limestone correlated with the Lebanon limestone of Tennessee have yielded *Actinoceras libanum* and "*Leurorthoceras*" *altopontense*. In reducing *Leurorthoceras* to a synonym of *Actinoceras*, this specific name becomes a homonym of *Actinoceras altopontense* Foerste and Teichert. The name *Actinoceras foerstei* is proposed, therefore, for *Leurorthoceras altopontense*.

The Tyrone limestone of Kentucky has yielded an association of *Actinoceras altopontense*, *A. arcanum*, *A. fusiforme*, *A. cf. bigsbyi*, *A. jessaminense*, *A. kentuckiense*, and *Ormoceras ferecentricum*.

The Curdsville limestone, long correlated with the Kirkfield beds of Ontario and through them, less certainly, with the Hull of the Ottawa valley, has yielded *Actinoceras curdsvillense*, a species known from only a few camerae, and *Deiroceras curdsvillense*.

The late Trenton Catheys limestone of Tennessee and the Cynthiana limestone of Kentucky are regarded as equivalents and show marked similarities in their faunas. They are probably to be correlated with the Cobourg. The boreal invasion which marks the typical Cobourg is here not obvious, although it is suggested by the appearance of a *Probillingsites*, a genus particularly characteristic of the Cobourg beds and the Terrebonne of Quebec. Possibly the appearance of *Armenoceras* is to be connected with a boreal invasion. The

closely related *A. brevicameratum* of the Catheys and *A. vaupeli* of the Cynthiana mark the first appearance of true *Armenoceras* in the Ordovician of eastern North America, but they are not closely similar to any of the species known from obviously boreal associations. *Orthonybyoceras* makes its first known appearance here. *Deiroceras* reappears, represented by *Deiroceras capitolense*, *D. nashvillense*, and *D. baileyi*. The last species was described in terms of the genus *Troedssonoceras*. *Deiroceras obscurolineatum* is present in the Cynthiana limestone of Kentucky, where *Orthonybyoceras* also is common.

Deiroceras continues into the Leipers of Tennessee, where it is represented by *D. rowenae*. In the Cincinnati section, *D. turbidum* occurs in the Fairmount beds, and *D. mutilatum* in the Mount Hope and Fairmount; a specimen from the Bellevue beds has been assigned tentatively to the latter species.

Orthonybyoceras becomes the dominant orthoconic genus of the Cincinnati beds of the Cincinnati region, ranging from Eden to Richmond. It is present in the Leipers of Tennessee; *Deiroceras dismukesense* of the Richmond of Tennessee probably belongs in the genus. It is the dominant orthocone of the Cincinnati of southern Ontario and northwestern New York and has been recognized by the writer in the Richmond of Quebec. It is probably represented in the Maquoketa shale by species assigned to *Sactoceras*. It is unknown in the Anticosti section. Although its presence in northern Red River faunas is uncertain, it may be there. *Ormoceras?* sp. of Baffin Island (Miller, Youngquist, and Collinson, 1954; pl. 2,2, fig. 5) suggests the genus, but sections have not been made. It is definitely present in the Burnam limestone of central Texas and in the Second Value formation of the Montoya group of New Mexico. It is present, though rare, in the Richmondian Aleman beds of New Mexico.

The dominance of *Orthonybyoceras* and *Deiroceras* in later Ordovician austral faunas is a clear example of specialized stocks within the dominantly boreal actinoceroids which have become adapted to an austral environment.

APPALACHIAN REGION

No thorough attempt is made here to record the actinoceroids in the Appalachian region. Most reported occurrences rest upon faunal lists, and only the more obvious genera can be regarded as properly identified. Butts, in various U. S. G. S. folios, reported *Gonioceras* rather widely through the Appalachians. It would appear that *Gonioceras* actually did penetrate farther into this region than did the other actinoceroids. Adequate restudy of the species is yet to be accomplished. Flower described *Gonioceras hubbardi*, from beds formerly known as the Chickamauga limestone of Virginia. The use of Chickamauga has been so overextended as to be meaningless, in the light of more recent work (Cooper, 1956). Possibly the occurrence is in beds now regarded as equivalent to the Lebanon of central Tennessee. The Ottossee shale of the Appalachians has yielded *Gonioceras*; the specific relations remain for future study.

Actinoceras lindense of the "Lowville" of Pennsylvania is a good *Actinoceras*. It has not been possible to determine its exact stratigraphic position, and the term Lowville has been

employed so widely in the Appalachians as to be meaningless today.

RED RIVER FAUNAS

Red River faunas extend from the Burnam limestone of the Llano uplift, and the Montoya of New Mexico and western Texas, northward through the lower Fremont and Bighorn groups to the type Red River of Manitoba. From there, equivalents can be recognized northward in the Nelson limestone of Hudson Bay and various localities in the Arctic archipelago, notably Mt. Silliman in Baffin Land, to the Cape Calhoun formation of northern Greenland. Though long mistakenly identified as Richmond, the Red River faunas actually are superimposed by Richmond beds. In New Mexico the succession above the Red River faunas begins with two horizons, which, if not early Richmond, may be of Maysville age (Flower, 1956). The Montoya is removed from northern New Mexico by erosion. In the southern half of the State there is a general tendency for dolomitization to increase from south to north. Where dolomitization is advanced, it obscures original lithic differences, destroys many of the fossils, and produces massive beds from which collecting in situ is extremely difficult.

The next glimpse of the Red River and Richmond succession is afforded by the Fremont limestone of Colorado. This "limestone" is actually a dolomite, with a Red River fauna below and Richmond faunas above. The Bighorn group supplies a similar section, also largely in dolomite. Comparison with the Montoya shows a striking similarity, and it is evident that the dolomitization has played a major role in obscuring the Red River-Richmond boundary. At the southern end of Lake Winnipeg, however, the limestones are largely unaltered, and here the Richmondian Stony Mountain succession has long been recognized above the Red River beds. On the west side of Hudson Bay the Nelson limestone is recognizable as the equivalent of the Red River, with the Shamattawa limestone of Richmond age above it. Foerste and Cox (1936) have noted that the meager collections from the Ordovician of Akpatok Island show a striking consistency with the Nelson-Shamattawa zonation, and suggest that there also Richmond beds may occur above those of Red River age. In the Arctic archipelago much less is known of the stratigraphy in general; indeed, many collections are small and necessarily casual. It may be noted, however, that the Mt. Silliman beds of Baffin Island show evidence of Red River faunas but no clear evidence of the presence of overlying Richmond beds. Teichert (1934, 1937, 1937-a) has described other arctic faunas having strong Red River affinities. At Cape Calhoun, in northern Greenland, the Cape Calhoun beds contain a Red River association, again without demonstrable Richmond above but with the *Gonioceras* Bay limestone below. The *Gonioceras* Bay limestone shows pronounced Black River affinities. The Cape Calhoun succession is anomalous among the Red River faunas in containing *Gonioceras* and *Actinoceras* of the *A. ruedemanni* type. This suggests that too much may be included in the Cape Calhoun beds, and that with the typical Red River association there have been grouped lower beds, with a fauna of probably late Black River age.

It is further evident, from the sections in New Mexico, *that* warping, elevation, and erosion intervened between *the*

deposition of the Red River beds and those of Richmond age above. It is clear that the Red River beds are pre-Richmond; it remains to determine their position still more precisely. Kay (1936) considered the Stewartville limestone, which contains a fauna of Red River aspect, as equivalent to the Cobourg. Subsequently Flower (1952) found many of the Red River cephalopod genera in the Terrebonne limestone of Quebec. The faunas of the Red River (Second Value) of the lower Montoya in New Mexico contain in addition some elements unreported in more northerly Red River faunas. These suggest affinities with the Kimmswick limestone of Missouri, the Catheys-Cynthiana limestones of Tennessee and Kentucky, and the Rogers Gap fauna (regarded as a southern molluscan facies of the Eden). The evidence, which will be published elsewhere in detail, suggests overwhelmingly the equivalence of the Red River with the late Trenton and Eden, but not with the Maysville. Other considerations, also to be published elsewhere, suggest that the Eden and late Trenton, as currently generally delimited, are largely, if not completely, overlapping in time.

The actinoceroids of the Red River faunas will be summarized geographically from south to north. The Burnam limestone of Central Texas has yielded a large cephalopod assemblage, largely unstudied in detail. *Armenoceras* may be represented by more than the one species, *A. burnamense*, described here. *Selkirkoceras burnamense* is present. The faunas of the Second Value formation of New Mexico, far from exhausted by the collecting done thus far, have yielded *Actinoceras incantatum*, *Armenoceras callaghani*, *A. australe*, *A. vesperale*, *Lambeoceras rotundum*, *L. armstrongi*, and *Nybyoceras montoyense*.

Collecting has been less extensive in the Fremont dolomite of Colorado. The only actinoceroid thus far recorded is *Actinoceras* sp. (Sweet, 1955).

The Bighorn group of Wyoming has provided a rich cephalopod fauna from the Lander sandstone (Miller, 1932; Foerste, 1935), but the overlying dolomites have yielded fewer specimens. The massive nature of the dolomite is a serious limiting factor in our knowledge, making extraction of specimens in situ almost impossible. Known specimens appear to have come largely from loose boulders. It is evident that the dolomites contain forms with Red River affinities, but it is not certain whether Richmond beds precede the inception of the Leigh member. The Lander sandstone appears to be a local basal sandstone, in this respect being analogous to the Cable Canyon sandstone of New Mexico. It has yielded a rich cephalopod assemblage containing the following actinoceroids: *Actinoceras enterprisense*, *Paractinoceras canadense*, *Kochoceras magnicameratum*, *K. subcirculare*, *K. subellipticum*, *K. sublentiforme*, *K. grande*, *Lambeoceras cultratum*, *L. peculiare*, *L. (?) sp.*, *L. confertum*, *L. cf. confertum*, *L. landerense*, and *L. acutilaterale*. Dolomites above have yielded *Armenoceras* spp., *Actinoceras* spp., *Lambeoceras* sp., and *Selkirkoceras bighornense*, formerly identified with *S. tyndallense*.

In the Red River series of Manitoba (Foerste, 1929), the silty limestones of the Dog Head member have yielded few actinoceroids but are the source of *Actinoceras simplicem*, formerly identified as *A. cf. bigsbyi* by Foerste, and *Lambeoceras* cf. pincers. The thin-bedded calcilites of the Cat Head member have yielded no actinoceroids and, indeed, few cephalopods. Those known are oncoceroids unlike species

found in the other members. The Selkirk limestone has *Armenoceras* as its commonest fossil; probably more than the one described species, *A. richardsoni*, is present. *Ormoceras* is present, represented by *O. lambei* and *O. cf. allumettense* (which is certainly not that species but deserves a new name). *Paractinoceras canadense*, *Selkirkoceras curzeatum*, *S. tyndallense*, *Kochoceras tyrrelli*, *K. cf. tyrrelli*, and *Huronina occidentalis* are the remaining forms.

The next glimpse of the Red River fauna is afforded by the Nelson limestone of Hudson Bay (Foerste and Savage, 1927). No actinoceroids are reported. The Mt. Silliman beds of Baffin Island yielded *Actinoceras* spp., *Kochoceras*, *cuneiforme* and *Lambeoceras baffirzense*.

The Cape Calhoun fauna (Troedsson, 1926) contains a possible admixture of a Red River with an older fauna. Incorporation of an older fauna is suggested strongly by the presence of *Actinoceras* of the *A. ruedemanni* species group and several species of *Gonioceras*. Red River elements include *Lambeoceras princeps*, *L. nuflum*, *L. magnum*, *L. boreum*, *Armenoceras arcticum*, *A. arcticum* var. *angustum*, *A. sp.*, *A. cancinnum*, *Huronina arctica*, *Kochoceras cuneiforme* and its variety *robustum*, *K. ellipticum* and its variety *minutum*, *K. undulatum*, and *K. productum*. The last species is slender and suggests a transition to the ancestral *Actinoceras* of the *A. ruedemanni* group. Here also is *Calhounoceras candelabrum*, a doubtful actinoceroid.

Beneath the Cape Calhoun beds the Gonioceras Bay limestone is recognized as a distinct unit. It yields *Actinoceras vetustum*, originally described in terms of the genus *Kochoceras*, *A. hanseni* and *A. ruedemanni*, described as species of *Leurorthoceras*, and *Gonioceras holtedahli*.

RICHMOND FAUNAS

In the type Richmond of the Cincinnati region (Flower, 1946), *Orthonybyoceras* is the dominant actinoceroid and continues from the underlying Maysville and Eden. In the lower Whitewater beds *Lambeoceras richmondense* occurs, and the Saluda has yielded *Armenoceras madisonense* and *A. richmondense*. In southern Ontario *Orthonybyoceras* is the only actinoceroid so far recognized; the same is true of the Richmond of the St. Lawrence valley of Quebec. Anticosti Island (Foerste 1928, 1928-a) has yielded *Actinoceras gamachiense* from the Ellis Bay formation, and *A. carletonense* and *A. anticostiense* from the English Head beds. *Armenoceras sedgewicki* is from the Vaureal beds; *A. sp.* from the English Head beds.

The Maquoketa shale of Iowa has yielded (Foerste, 1936) *Armenoceras clermontense* and *A. iowense*, both of which have the large siphuncles of boreal types, whereas both *Deiroceras shideleri* and *Sactoceras maquoketense* probably should be assigned to *Orthonybyoceras*.

The Richmond Fernvale of Tennessee has yielded "*Deiroceras*" *dismukesense*, an inadequately known species which probably is an *Orthonybyoceras*.

The Aleman limestone of New Mexico has yielded *Orthonybyoceras* and *Armenoceras lenticontractum*. No species are definitely known as yet from the Richmond portion of the Fremont or Bighorn groups. The Stony Mountain formation of Manitoba has yielded a large *Armenoceras*, *A. saxosum* Foerste. *Tripleuroceras robsoni* Whiteaves is certainly an actinoceroid, and probably an *Armenoceras*. The

beds from which it comes are here regarded as latest Ordovician rather than early Silurian.

The Shamattawa limestone of Hudson Bay has yielded a series of actinoceroids. *Kochoceras shainattawaense* is clearly an *Actinoceras*, strikingly similar to *A. carletonense* of the *Anticosti* section. *Actinoceras parksi* is of the *A. anticostiense* group. *Armenoceras* is represented by two species, *A. magnum* and one tentatively assigned to *A. richardsoni*. *Huronia septata* completes the list. No Ordovician as young as the Richmond is known from points farther north.

NORTHERN EUROPE

Actinoceroids in the Ordovician of Europe are confined to the Scandinavian and Baltic regions. The genus *Adamsoceras* is represented by *A. holmi* and *A. oelandicum*, both originally described as species of *Ormoceras*, from the *Platyurus* horizon of the *Orthoceras* limestone sections. Affinities of *Ormoceras laeva* (Schmidt), as well as its stratigraphic position, are both uncertain. *Ormoceras* sp. of Troedsson (1926), from the upper *Chasmops* beds, appears to be a true *Ormoceras*.

Actinoceroids are not encountered again in the section until the Lyckholm beds are attained. These have yielded *Nybyoceras bekkeri*, *N. balticum*, *N. intermedium*, and *Ormoceras heckeri* (Troedsson, 1926; Teichert, 1930).

EASTERN ASIA

North China, Manchuria, and Korea have yielded a large number of actinoceroids, made known largely through the work of Grabau (1922), Kobayashi (1927, 1930, 1934), and Endo (1932, 1935).

From the Maruyama bed Kobayashi described *Polydesmia watanabei*, *P. shimamurai*, *P. sp.*, and *P. (Maruyamaceras) peshanense*. It is significant that the Maruyama bed first was considered as allied with the underlying Wolungian (Upper Canadian), rather than with the Toufangian. The overlying Chikunsan shale has yielded no actinoceroids, but many are found in the superadjacent Makkol limestone. Endo (1932) and Kobayashi (1934) agree in correlating the Makkol limestone with the Ssuyen limestone of Endo. Endo has not recognized the Maruyama bed in the regions which he has studied, but recognizes the Santayo limestone (Canadian) as a correlate of the Wolungian of Kobayashi. Above the Santayo, in ascending order, are the Kangyao, Wuting, and Ssuyen formations. Reportedly, the Ssuyen, rather than underlying formations, has yielded some *Maruyamaceras*. All specimens come from sections in which the Wuting and Kangyao have not been recognized. The writer is inclined to agree with Kobayashi (1940, p. 36-37) that possibly some older beds have been identified with the Ssuyen limestone there. It will remain for future work to determine whether the Maruyama bed is materially older than the Kangyao and Wuting limestones, as now appears probable, or whether it may be a facies of one or the other.

The Kangyao limestone has provided only a very few,

inadequately known actinoceroids, *Armenoceras nakaoui* and *A. nanum takayamai*. Both could possibly be members of the Stereoplasmoceratidae rather than actinoceroids. The Wuting limestone has yielded *Wutinoceras foerstei*, *Adamsoceras manchuriense*, and an apparently typical *Armenoceras*, *A. numatai*. Forms with reticulate canal systems, *Wutinoceras* and *Adamsoceras*, suggest correlation with the White-rock stage of North America.

The Ssuyen limestone and its equivalent, the Makkol limestone, contain a large association of actinoceroids. It is not necessary to list all the species, which have largely been summarized by Kobayashi (1934), with suggestions as to possible synonymy of some of them. It is sufficient to mention that there is one undoubtedly *Actinoceras* and abundant *Armenoceras* and *Ormoceras*. *Yabeites* Endo appears to be an *Armenoceras*. Reports of *Gonioceras* are dubious. A single tiny species assigned to *Lambeoceras* is anomalous in its small size; its morphology is not known in enough detail to permit accurate evaluation of its generic position.

Granting equivalence of the Ssuyen and Makkol limestones, their correlation with the American section presents some problems. That the underlying Chikunsan formation contains a cephalopod fauna of strong Chazyan affinities suggests its correlation with the Chazyan. It should be noted, however, that we know almost nothing of cephalopod faunas in the Chazy-Black River hiatus; the Makkol and Ssuyen formations might belong there. They may or may not extend up into the Black River. Black River age is suggested by a true *Actinoceras*, but the evidence is entirely negative, for nothing is known of the pre-Black River history of that genus. It is evident, however, that *Actinoceras* was well diversified by the time of its appearance in America in the Lowville.

The Ssuyen-Makkol faunas are of significance in that they supply a glimpse of early Middle Ordovician actinoceroid faunas which are more generalized than those of North America. From North American evidence it is clear that such faunas existed somewhere. *Gonioceras* in the Chazyan must have developed from the simpler *Armenoceras*, the appearance of which in America is delayed until the Red River faunas. One would expect to find in such an association *Nybyoceras* and perhaps the beginning of *Actinoceras*; the Ssuyen and Makkol fulfill these requirements perfectly. Regrettably, many of the species are known only from fragments of phragmocones and fail to show such variations with growth as one might expect. Further investigation into the siphuncle structures is needed, particularly among the smaller forms assigned to *Ormoceras* and *Sactoceras*. While actinoceroids tend to develop simplification of the siphuncle outline, they are approached by another contemporaneous stock, the Stereoplasmoceratidae, belonging to the Michelinoceratida. Investigations of the writer relating to this stock (on which publication is delayed, owing to the desirability of incorporating new material) indicate that where the siphuncles are expanded and the deposits thick, structures may be developed very similar to those of both the Pseudorthoceratidae and the Actinoceratida.

Evolution of the Actinoceratida

PREVIOUS VIEWS

Various opinions have been offered as to the origin of the actinoceroids and the directions of evolution within the group. Teichert (1933) attempted to unite the actinoceroids and the endoceroids on the basis of their large siphuncles and long septal necks. Although septal necks are well developed in the Actinoceratida from the inception of the stock, the same is not true of the Endoceratida. Instead, the primitive endoceroids have short aneuchoanitic necks, like those of the ancestral Ellesmeroceratidae. Within the order the lengthening of the neck occurred in at least two independent lines, once in the Piloceratidae, from which the Endoceratidae are descended, and again in specialized derivatives of the Proterocameroceratidae (Flower, 1955-a). In the same publication (1933), Teichert suggested a possible origin of the actinoceroids in some early Canadian genera, *Sinoeremoceras* and *Multicameroceras*, which had then only recently been described. These genera are united now in the family Pletronoceratidae and are probably the most primitive cephalopods known (Flower, 1954). Septal necks are aneuchoanitic; the thick rings alone outline the expanded part of the segment, termed the siphuncular bulb. No subsequent information, however, has come to light which would support Teichert's suggestion. On the other hand, the appearance of similar bulbs in the early stages of *Ruedemannoceras* indicates that the Discosorida developed directly from the Pletronoceratidae, independent of all other cephalopods.

Kobayashi (1935) and Schindewolf (1935) attempted to derive the actinoceroids from what is now the Michelinoceratida. According to their views, actinoceroids with small siphuncles (such species as are generally placed in *Ormoceras* or *Sactoceras*) were primitive. Through these forms, it is possible to suggest a connection with the Michelinoceratida; in particular, through Ordovician forms with expanded siphuncles, referred to the Stereoplasmoceratidae. Although the Stereoplasmoceratidae sometimes resemble actinoceroids so closely that strong homeomorphy is evident, there appears to be no real connection. Further, it may be noted that the actinoceroids appeared earlier than any of the Stereoplasmoceratidae. Homeomorphy between the stocks is more evident in beds of approximately Black River age, and in Black River to early Trenton beds of eastern North America than in earlier strata. Homeomorphy rather than a real relationship is therefore indicated.

Flower (1941) suggested an origin of the actinoceroids, through *Polydesmia* as the oldest and most primitive genus, in *Bathmoceras* of the Ellesmeroceratida. This would involve modification of the thick connecting ring of *Bathmoceras* into the similarly shaped annulosiphonate deposit of *Polydesmia*.

Concepts of evolution within the order have varied, necessarily, according to the hypothesis of origin. Teichert (1935) presented a scheme of evolution, taking account of *Polydesmia* (then called *Maruyamaceras*, but misspelled *Murayamaceras*) as the archaic radicle of one line, typified by *Actinoceras*; another line had as its nucleus *Armenoceras*. Flower (1940) suggested that the apparent recapitulation of

the early stages of *Actinoceras* might indicate a phyletic succession of *Polydesmia*, *Nybyoceras*, *Armenoceras*, and *Actinoceras*.

PRIMITIVE FEATURES

Before passing to a more thorough analysis of the actinoceroid origin, it is necessary to consider what features must be regarded as primitive within the group as a whole. Here stratigraphic evidence, morphological evidence, and theoretical considerations are combined.

There can be little question that *Polydesmia* is the oldest of the actinoceroids. It is, accordingly, reasonable to expect this genus to show some peculiar features which may be primitive. It differs from other actinoceroids in having the annulosiphonate deposits extended forward in the cavity of the siphuncle, a pattern which is duplicated elsewhere only in the still older genus *Bathmoceras*. Its septal necks are typically actinoceroid in length and in curvature, but a peculiar feature is that the connecting ring is so anomalously thick that it was mistaken at first for a holochaoanitic septal neck (Kobayashi, 1940). As noted under the discussion of the genus in the systematic part of the present work, there have been several misconceptions concerning its morphology, not the least of which involves failure to recognize the radial canal system as composed of numerous small complexly branching tubes, forming the dendritic type of radial canal system. It is in overlying beds that the reticular type of canal system is found, where structure is still complex centrally but simplified peripherally. It is in younger and more specialized forms that the double-arc, single-arc, and horizontal types of canal systems are found. Stratigraphy suggests strongly that in the actinoceroids the direction of evolution was from irregular, complexly branching, numerous small tubes to fewer and more regular larger ones.

Theoretical considerations support this same interpretation. The siphonal strand functions in all nautiloids to maintain a metabolic connection between the main part of the animal and the camerae. There is good reason to believe that cameral tissues were primitive and were supplied with blood through the connecting ring. Such a connection could have been made in one of two ways, either by penetration of the ring by capillaries, or by passage of the blood through the ring, as in a haemocoel. Without attendant specializations, the ring was a barrier to the passage of any large tubes; probably to any tubes large enough to be visible macroscopically. It is thus logical that the dendritic type of canal system found in the ancient genus *Polydesmia* is primitive. In the actinoceroids, however, the perispantium developed, a space avoided by growing calcareous deposits; this was either a haemocoel or a space in which tubes divided rapidly. Once this space was developed, specialization of the siphonal vascular system became possible.

The first step is found in the reticulate type, still complex but consisting of fewer larger and more regular tubes than those of the dendritic type. Radial canals still branch as they approach the perispantium, but such branching is far less extensive than before. Something of a transition from the

dendritic type to the horizontal type of *Ormoceras* is suggested by some of the species of *Adamsoceras*. It is now evident that *Ormoceras* developed early, and at least one typical species, *O. neumani*, is known in the Chazyan. Apparently the simple horizontal type of canal is retained throughout *Ormoceras* and its descendants. In *Wutinoceras*, on the other hand, there is a clear suggestion of the beginning of the double-arc type of canal system, such as appears to be developed in the older species of *Nybyoceras* (*N. cryptum* and *N. ulrichi*). Advanced species in the later Ordovician, however, are simpler in structure, and apparently the double arcs have been reduced to single arcs, to judge from Teichert's illustrations (1930). The double arcs are found in some species of *Armenoceras*, but there are other species which have only single arcs. Single arcs are found in the Huroniidae, presumably descendants of *Armenoceras*, and in *Gonioceras* and *Selkirkoceras*, the origin of which in *Armenoceras* is evident by many similarities of structure. *Actinoceras*, which is clearly derived from *Armenoceras*, possesses only single arcs. *Elrodoceras* has the double arcs modified into a rectilinear pattern, the proximal part of the radial canals lying against the central canal, then bending abruptly, so that the distal part is almost straight, perpendicular to the central canal, and extends directly to the perispantium. Incomplete evidence suggests also that the single arcs may be modified into the horizontal type in end lines of development apart from the Ormoceratidae, in which such development was first noted.

There is clearly a general trend toward simplification of the radial canal system, and similar trends were developed in distinct lines of descent. The usual end products, the single arcs and the horizontal type, are developed in several stocks independently. Specialization, but not precise relationship, is indicated by the end products of this trend in evolution. These considerations support the stratigraphic evidence of the primitive nature of the dendritic and the reticular types of radial canals.

ANCESTRY OF THE ACTINOCERATIDA

One may return to *Polydesmia* with some confidence that its canal system is primitive, and examine it for other primitive features with more assurance than before. The primitive nature of the very thick connecting ring requires little comment. Thick rings are a primitive feature which abound in the Ellesmeroceratida and such more specialized types as the Endoceratida, Tarphyceratida, and Discosorida. Their presence in *Polydesmia*, the oldest of the actinoceroids, also may be considered primitive. The most remarkable feature of *Polydesmia* is the forward prolongation of the deposits in the siphuncle. If not primitive, it is strange that this feature is unknown in younger actinoceroids. Similarity of form suggests origin of these structures from the very thick connecting rings of *Bathmoceras* (Holm, 1899). Such an interpretation encounters several objections, which are perhaps more apparent than real. The inner part of the thick rings of *Bathmoceras* apparently is not differentiated structurally from the marginal part. Apparently the whole of the ring developed to completion essentially at the time when the anterior septum was secreted and a new camera was formed. The deposits of *Polydesmia* are differentiated structurally from a primary relatively thick connecting ring. Growth relations suggest that such deposits appeared long after the formation of the

primary part of the ring, and that thereafter their growth was slow and extended over a considerable period of time.

Differentiation of one part of the ring from another, so that it may appear to be a different structural entity, is known elsewhere in the nautiloids. In the Ellesmeroceratida there is generally a layering apparent in sections of the ring. Such layering appears to extend back to the primitive Plectronoceratidae. The eyelet, developed independently in the Endoceratida and the Tarphyceratida, is a concentration of dense amorphous material, originally forming the inner or siphonal side of the ring at its very tip.

In the Discosorida there occurs the most remarkable development yet observed. Here the apical part of the ring is differentiated into two layers differing in texture and composition. In the Cyrtogomphoceratidae and the derived families Westonoceratidae and Lowoceratidae, the two layers comprising the bullette typically are strongly inflated. They simulate annulosiphonate deposits as known in the Actinoceratida and Michelinoceratida, but sections show that they are an inherent part of the connecting ring.

Similarly there is some indication of delay in the development of structures derived from the connecting ring. Actinosiphonate deposits as developed in the Oncoceratida are at first nothing more than extensions of the inner surface of the connecting ring. Plainly the pattern is developed in accordance with a previously developed pattern in the siphonal strand. Such deposits may be delayed in development in *Valcouroceras* (Hower, 1943). In *Augustoceras* their development is essentially contemporaneous with the formation of the ring and the septum, to which its anterior end is attached. In *Manitoulinoceras*, however, deposits are seen so rarely that the only suitable explanation is that they are developed only in the gerontic stage of the organism. In Silurian and Devonian Oncoceratida, the development of actinosiphonate deposits is similarly delayed in many genera. Further, it may be noted that structural differentiation occurs as a specialization in actinosiphonate deposits, the rays being supported in some genera by dense dark, and probably relatively strong, median bands.

It now appears that the Mandaloceratidae developed from the Ruedemannoceratidae of the Discosorida. In specialized members of the family there are structures, developing late in the life of the individual connecting ring, which appear at first as irregular bullettes, and which later may send out irregular rays, so that they resemble the actinosiphonate deposits of the Oncoceratida.

It can thus be seen that neither structural differentiation of the materials involved, nor delay of growth of the annular deposits of the actinoceroids, offers a serious objection to the theory that such deposits are developed from the connecting ring. The same origin well may be applied to the smaller deposits found in many Michelinoceratida. Curiously, annular deposits showing lamellae normal to the lines of growth are found neither in the Actinoceratida nor in the Michelinoceratida. Such lamellae are present in the cameral deposits, parietal deposits, and endocones of the Discosorida, and are a safe indication of structures composed of prismatic aragonite. Such aragonite is particularly characteristic of many molluscan shells and is developed only in structures laid down by a functional secreting surface (i.e., a functional mantle). Whatever their origins (and the origins in Actinoceratida and Michelinoceratida well may be different), the

annulosiphonate deposits in these two groups appear to be structures secreted within tissue, rather than formed by a functional mantle surface.

No forerunners of the canal system or perispatium of the actinoceroids are known in *Bathmoceras*. This apparent objection has no significance. These features are peculiar to the actinoceroids, and their coenogenetic appearance at the beginning of the group is a fact that must be faced, whatever origin of the group is postulated.

What is known of the morphology of *Bathmoceras* depends almost completely upon Holm's (1899) work. Although exceptionally fine and detailed for its day, this study now leaves much to be desired. Thinsection studies are needed, to examine differentiation within the rings, and general restudy of the genus is highly desirable. Unfortunately, material for such a study is not available to the writer and is, indeed, extremely hard to obtain. *Bathmoceras* is found usually in a poor state of preservation, unsuitable for such study. Holm devotes several pages to an account of his examination of several specimens before finding the one upon which his classic study is based. It may be pointed out that the absence of any trace of canals, or other structures resembling those of actinoceroids, possibly may be corrected when a more detailed study of *Bathmoceras* can be completed.

Holm's study of *Bathmoceras* does show one significant feature. Necks are sinuate and long, and the siphuncle outline is sinuate externally. In this pattern one may see a possible beginning of the expansion of siphuncle segments in the camerae, which is developed to a much greater extent in the actinoceroids.

While there is still something of a morphological gap between *Bathmoceras* and *Polydesmia*, other suggested origins of the actinoceroids involve even greater anomalies, morphological or stratigraphic, or both. That the first actinoceroids are separated from the Plectronoceratidae by an appreciable stratigraphic gap is not, perhaps important; a similar gap separated the first of the Discosorida from the plectronoceroids. However, the oldest of the discosorida have early stages showing the siphuncular bulbs of the Plectronoceratidae. No similar evidence has been found in the actinoceroids indicative of ancestry directly from the Plectronoceratidae. Origin in the endoceroids now seems completely untenable. Endo-cones are an inherent feature of that group, and origin in them of the annular deposits of the actinoceroid siphuncle seems impossible. It is now known that the long necks of the endoceroids are developed only in specialized members of that group. Forms having such necks are either too young to be actinoceroid ancestors or, as in the Piloceratidae, show specializations so foreign to the actinoceroids as to make them most unconvincing ancestors of the stock. Origin in the Michelinoceratidae would be relatively simple, for that group has annular deposits. However, as far as is known the first actinoceroids have large and not small siphuncles, and further, they apparently precede the Michelinoceratidae stratigraphically. Indeed, Michelinoceratidae with good annuli in slightly expanded siphuncle segments are as yet unknown in beds older than the middle Chazyan. On the other hand, *Bathmoceras* is late Canadian, apparently not much older than *Polydesmia*. One can see in *Bathmoceras* sinuate siphuncle segments which may well develop into the markedly expanded ones of *Polydesmia*, and it has been shown above that while derivation of the deposits of *Polydesmia* from

the rings of *Bathmoceras* involves some radical changes, similar changes have been observed elsewhere in cephalopod evolution.

EVOLUTION WITHIN THE ACTINOCERATIDA

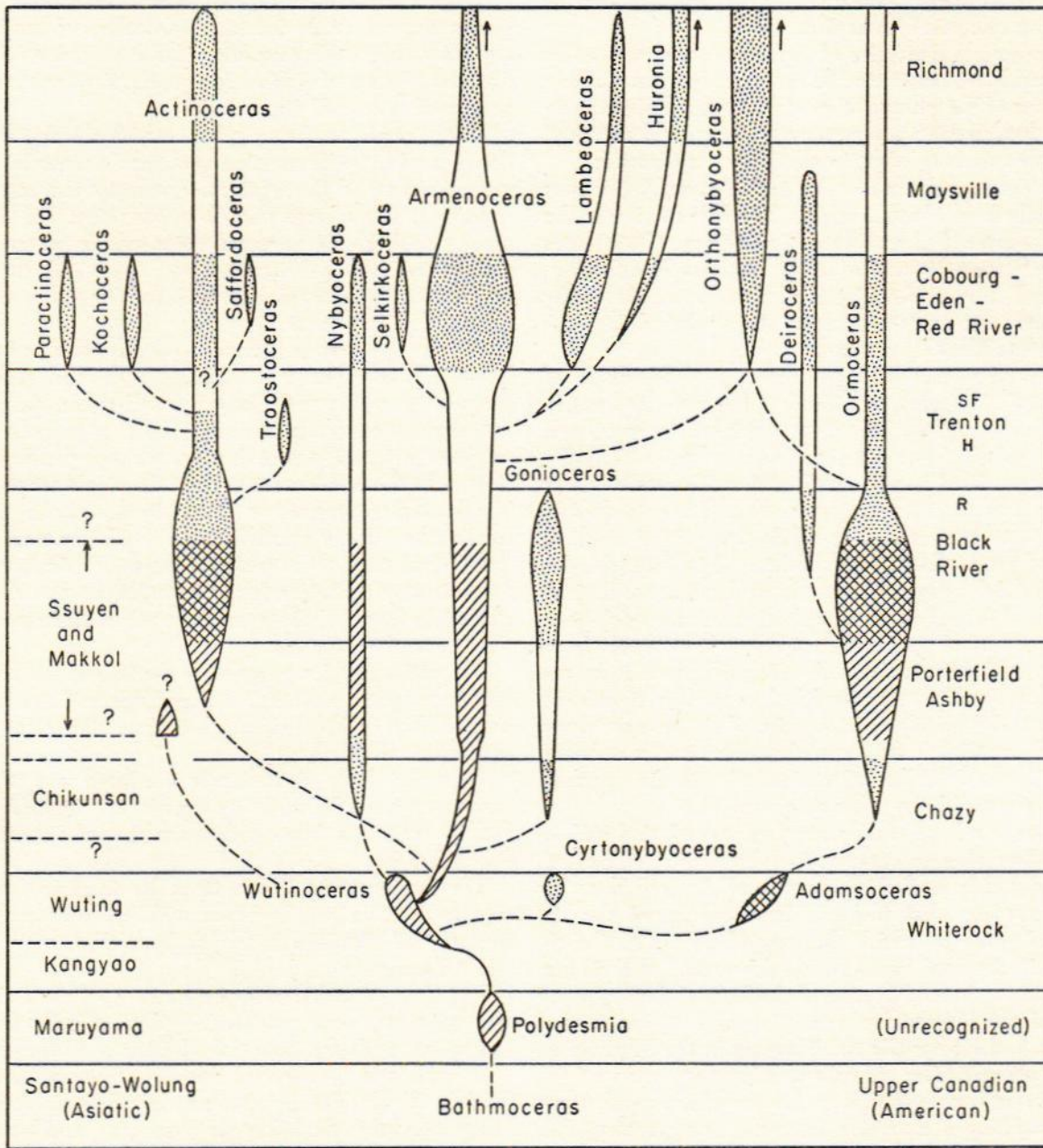
The accompanying figure (fig. I) portrays the evolutionary relationships within the Actinoceratida, with precise records of the stratigraphic range of the genera. Although it is evident that there are many matters yet to be resolved, several new facts of significance are now evident. Family categories are not indicated, as homeomorphy, rather than relationship, is believed to be involved in the families as previously defined.

From the foregoing discussion it is evident that *Polydesmia* is the oldest and most primitive of the actinoceroids. It has a broadly expanded siphuncle with thick rings. Deposits are produced into forward projecting lobes. Numerous dendritic radial canals extend from the central canal to the perispatium. They are very fine and best seen in cross-sections. In longitudinal section they are not prominent, and the lines of juncture of the separate annular deposits have been mistaken for the canals.

Three Whiterock genera indicate the next general evolutionary step, involving simplification of the canals from the dendritic to the reticulate type. Short, broadly expanded segments are found in *Wutinoceras* and in *Cyrtonybyoceras*, whereas smaller, less expanded segments similar to those of *Ormoceras* characterize *Adamsoceras*. *Jeholoceras*, as noted in the systematic descriptions, is doubtfully distinct from *Wutinoceras*.

Nybyoceras is very similar to *Wutinoceras* in the form of the siphuncle segments; therefore, it is here regarded as derived from that genus. Two species of the North American Chazyan, *N. cryptum* Flower and *N. ulrichi* Foerste and Teichert, appear to have double arcs, and, at least in the latter, radial canals branch slightly as they approach the perispatium. A number of early Middle Ordovician forms are known from the Asiatic section. The last occurrence, in the Lyckholm of Esthonia and the Second Value of New Mexico, is found at two geographic extremes of the Red River faunas. These forms appear to have attained the simple single arcs in their radial canals.

Armenoceras is here regarded as stemming directly from *Wutinoceras*. Little is known of the structural details of the older species of *Armenoceras*, which are exclusively Asiatic. *A. numatai*, from the Wuting limestone of Manchuria, is the oldest species so far known. It becomes prolific in the Ssuyen and Makkol faunas and appears only later in North America in the contemporaneous Red River faunas of the north and west, and in the Cynthiana and Catheys of Kentucky and Tennessee. It is unknown in the black shaly limestones of the Cobourg or its equivalents in New York or Quebec. Environment may have supplied a natural barrier. We know of no species from beds of Maysville age, but the genus is widely, if not abundantly, represented in Richmondian strata. It continues on into the Middle Silurian. As yet no species groups have been differentiated; it would be futile to undertake such a work without access at first hand to the important Asiatic representatives. Curiously, the species similar to those of the Red River beds with large massive siphuncles extend into the Richmond. Even in the *Discosorus* faunas (early Clinton) of north-central North America and



EVOLUTION OF THE GENERA OF THE ACTINOCERATIDA IN THE ORDOVICIAN

Figure 1

Known occurrences of the genera are indicated in terms of the Asiatic section, on the left, and the American section, on the right. Occurrences in Asia are indicated by oblique lines, those in America by dots, those common to both regions by crosshatching. Boundaries of the Asiatic units in comparison to the American are necessarily inferential. The American column has been modified to recognize the pre-Chazyan Whiterock stage, a Chazy-Black River hiatus occupied by the Ashby and Porterfield stages of Cooper (1936), and inclusion of the Rockland (R) in the Black River. Hull (H) and Sherman Fall (SF) are retained in the Tienton. A division is needed for the Cobourg-Red River equivalents, of which the Eden is regarded as a facies.

the Arctic, there are forms which are not obviously different from their Ordovician forerunners.

Gonioceras is derived from *Armenoceras* as shown by the similarity of their siphuncle outlines. No transitional types are known, and the oldest known *Gonioceras* is only slightly generalized in suture or cross-section. True representatives of the genus are exclusively American.

Selkirkoceras is a derivative of *Armenoceras* in which the initial siphuncle segments have become greatly inflated. Only short portions of the phragmocone are known. Plainly, however, the phragmocone was never very long, and the shell was probably extremely short in relation to its diameter.

Except for one species in the Ssuyen limestone, *Actinoceras* is known only from North America. The first species, in the Lowville, are diversified, and the earliest glimpse of the genus gives no indication of its true origin in time. Significantly, the groups of *A. ruedemanni* and *A. centrale* are essentially of Black River age, and the group of *A. paquettense* appears confined to late Black River strata.

The Trenton species belong exclusively to the group of *A. winstoni*. *Saffordoceras* and *Troostoceras*, indicated as distinct in Figure 1, are both very close to this species group and of doubtful validity. The recurved septa on which *Saffordoceras* is differentiated require confirmation. *Troostoceras* was differentiated as a faintly exogastric shell. If such a generic distinction is to be regarded as valid, *A. winstoni* must be separated as yet another genus, because of its faintly endogastric form. Such a distinction would tend to obscure obvious relationships. *Leurorthoceras* is a generic name to which have been assigned various species of *Actinoceras* known only from anterior parts of phragmocones showing siphuncle segments of reduced size and greatly simplified form. It is significant that many, and probably most, species of *Actinoceras* show shells which are slightly fusiform when the anterior ends are completely known. Similar faint contraction of the aperture is as yet unknown in any other actinoceroids.

Kochoceras is a large shell, strongly flattened, and with a relatively short phragmocone. It is a breviconic edition of *Actinoceras*, much as *Selkirkoceras* is of *Armenoceras*. Its siphuncle suggests that it came from species of the *A. ruedemanni* group in which the expanded part of the siphuncle is in flattened contact with the ventral wall of the camera, resulting in modification of the form of the segment.

Origin of the Huroniidae, consisting of *Huronina* in the Ordovician, and *Huroniella* and *Huronina* in the Silurian, is admittedly obscure. The recumbent brims suggest an origin in *Armenoceras*, but no species are known which supply anything approaching a transition from the one genus to the other.

Lambeoceras has been placed formerly with *Gonioceras* in the Gonioceratidae. Although the two genera are similar in their extremely flattened shells, they are so different in the form of the siphuncle segments that they are clearly homeomorphs, stemming from different parts of the actinoceroids. *Lambeoceras* is here indicated as probably derived from *Armenoceras*, close to the point from which *Huronina* also was developed. The origin of *Lambeoceras* in *Kochoceras* is also possible; something of a transition is suggested by siphuncle outline and also, in *L. rotundum*, by the cross-section of the shell. Indeed, *Kochoceras*, by its short recumbent brims, is the possible ancestor of both *Lambeoceras* and *Huronina*.

Paractinoceras could, from its siphuncle, be derived either from *Actinoceras* or from *Ormoceras*. That it is markedly fusiform and develops ventral lobes suggests strongly that it is a slender miniature of *Actinoceras*. It is known only from Red River faunas.

Ormoceras clearly is derived from *Adamsoceras*. The two genera are essentially identical in outline of the siphuncle segments, their difference lying in the reduction of the reticular canal system of *Adamsoceras* to the simpler, more regular horizontal system of *Ormoceras*.

Deiroceras is an *Ormoceras* in which the septal foramen becomes wider, without corresponding increase in the maximum diameter of the segment. The result is a more slender siphuncle, but a large one. It appears that the distinction among such shells between those which were extremely smooth and called *Deiroceras*, and those with fluted shells referred to *Troedssonoceras*, is false; *Troedssonoceras* is a synonym of *Deiroceras*.

Orthonybyoceras in general aspect appears to be derived logically from *Ormoceras*, agreeing with it in general shell proportions and in the relatively small siphuncle. However, its early stages clearly have the broad recumbent brims of *Armenoceras*, and, where deposits are well developed in the siphuncle, the canals seem to be of the single-arc type, which is unknown on *Ormoceras*. An origin in *Armenoceras*, therefore, seems a better possibility. It should be noted, however, that *Ormoceras* itself may not be monophyletic; in its present scope it may contain what is regarded as true *Ormoceras*, stemming from *Wutinoceras*, as well as homeomorphs derived from *Armenoceras*.

Ordovician species assigned to *Sactoceras* are not considered in the present discussion of phylogeny. Some are *Ormoceras* with very small siphuncles; some almost certainly are not actinoceroids.

From the above discussion it is evident that some slight rearrangement of family groups is required. *Polydesmia* and its subgenus *Maruyamacerina* properly constitute the Polydesmiidae.

The family name Wutinoceratidae is revived to accommodate the Whiterock genera with reticular canals. Here are included *Wutinoceras* (= *Jeholoceras*?), *Cyrtonybyoceras*, and *Adamsoceras*.

The Ormoceratidae comprise forms with small siphuncles and horizontal canal systems, including only *Ormoceras* and *Deiroceras*, with the doubtful addition of *Orthonybyoceras*.

Armenoceras, *Nybyoceras*, and *Selkirkoceras* are united in the Armenoceratidae, being characterized by siphuncles often so expanded that the brims are recumbent, and having canal systems ranging from the double-arc to the single-arc types.

The family Gonioceratidae contains only the genus *Gonioceras*.

The family name Lambeoceratidae is proposed for *Lambeoceras*.

The family Huroniidae is not emended, including *Huronina* and *Huroniella*.

The Actinoceratidae include *Actinoceras*, *Paractinoceras*, and *Kochoceras*, with *Saffordoceras* and *Troostoceras* regarded as doubtfully distinct from *Actinoceras* itself. *Leurorthoceras* is demonstrated now to be a synonym of *Actinoceras*.

Notes on Ordovician Correlations

In the present attempt to trace the actinoceroids throughout the Ordovician, it has been necessary to include the results of some recent work (notably Cooper, 1956), as well as some unpublished emendations of the American Ordovician, which also are required. The latter involve many uncertainties, and the present result is a compromise which probably will please no one completely.

The recent correlation chart of the Ordovician (Twenhofel et al, 1954) requires some emendation, particularly in the correlation of the Red River beds. Subsequently Cooper (1956) has proposed a revision of the Chazy-Black River part of the column. Although suppression of Chazy and Black River as major entities seems unfortunate, the scheme has brought out several new facts of importance. Of particular significance in relation to the present study is the recognition of a post-Canadian and pre-Chazyan interval, the Whiterock stage, and recognition of an appreciable gap between the type Chazy and the type Black River.

It has long been the feeling of the writer that the recognition of the Canadian as a distinct system would simplify immensely the problem of early Paleozoic stratigraphy. Such a move would leave the Canadian as a four-part system, leaving the remainder of the Ordovician to be resolved in terms of Chazyan, Mohawkian, and Cincinnati. However, Cooper's clarification of the lower part of the Ordovician leaves uncertain the best place to draw a Chazy-Black River boundary, and the conclusions of the writer have shown that the Mohawkian-Cincinnati boundary must be redrawn.

So different is the Canadian from the Ordovician that it is desirable either to consider it a distinct system, or to regard it as a subsystem, a new name being given to the remainder of the Ordovician as a complementary subsystem. Not only is the separation of the Canadian as a distinct system a less radical step as far as terminology is concerned, but it appears to offer a better expression of some very real differences.

Canadian limestone faunas exhibit a wide uniformity over North America. In contrast, Chazyan to Richmond beds are occupied by groups of essentially local faunas, migrating and intermingling to a perplexing degree. It is, indeed, this local aspect of the faunas which has caused much uncertainty and many differences of opinion concerning post-Canadian correlations. The local nature of the faunas of the type Chazyan long has been a handicap in recognizing Chazyan equivalents in the Appalachians and, indeed, over much of North America. Similar local aspects of faunas have been the source of many other perplexities, such as the correlation of the Pamela, the hypothesis of the Blount group, and the correlation of the Red River faunas, to mention only a few of the problems which have at one time or another attained prominence in the geological literature.

Canadian limestones, on the other hand, exhibit a remarkable uniformity over eastern and central North America. Some difficulty attends accurate correlation of these beds with those of the Cordilleran province, but the difficulty well may be due to incomplete knowledge of the faunas. If so, one may expect that in time this difficulty will be resolved. Eastern Canadian faunas are known largely from the cephalopods, gastropods, and brachiopods. The faunas of the Cordilleran region are known as yet largely from the trilobites,

the brachiopods being less completely known, and the remaining elements being largely undescribed. Nevertheless, even with our present incomplete knowledge of Canadian faunas, the general problem of correlation is simple in relation to that of the Ordovician as restricted.

Canadian limestone faunas appear to be set off sharply from those of the black graptolite shale facies. It is only in the restricted Ordovician that one finds clear intergradation of both the facies and the faunas.

Faunally, the Canadian is relatively isolated from the Ordovician above and is characterized by stocks of its own. In the cephalopods (Flower, 1952), the Canadian-Ordovician boundary involves changes never lower than of generic rank, and generally of the rank of families and orders. The Ellesmeroceratida and Tarphyoceratida are almost completely Canadian. The Canadian Endoceratida comprise the great expansion of the Proterocameroceratidae, and all the Piloceratidae. The Ordovician is marked by the appearance of the orders Michelinoceratida, Oncoceratida, Discosorida, and Actinoceratida; probably also by the Barrandeoceratida, with the doubtful exception of some possible Canadian Plectoceratidae. The Ordovician Endoceratida comprise the specialized family Endoceratidae, developed from the Canadian Piloceratidae, and a number of stocks, specialized in themselves but representing highly modified descendants of the Proterocameroceratidae of the Canadian. At present other groups seem less distinct in their Canadian and Ordovician developments; perhaps because their evolution is less clearly understood. One may note, however, the development of the hystricurids among the trilobites and the Syntrophiidae among the brachiopods. The graptolites show a Canadian development which is dominated by the Dichograptidae. The Chazyan part of the Deepkill (beds 6 and 7 of Ruedemann) shows a mixture of specialized Dichograptidae with the first of the Diplograptidae. The early Mohawkian Normanskill contains the last survivors of the Dichograptidae and a few species of *Didymograptus*, with expansion of the Diplograptidae and appearance of the Dicellograptidae as common elements in the faunas. Dicellograptidae and Diplograptidae alone dominate later (post-Chazyan) faunas.

The uniformity of Canadian faunas, as compared to the local aspect of Ordovician faunas, indicates general uniformity of environment in the Canadian, in contrast to varying environments in the Ordovician. Possibly the Canadian was uniform climatically, whereas the Ordovician was marked by climatic fluctuations. The tectonic histories were different; the Canadian relatively stable, the Ordovician marked by bentonites, general filling of the major troughs by coarse elastics, and orogeny culminating in the Taconic orogeny of eastern North America. The distinctness of Canadian and Ordovician in their faunas indicates the development of specific Canadian stocks, which either disappeared, allowing their places to be taken by others, or were so modified by evolution that the Ordovician descendants generally are placed in major taxonomic categories distinct from their Canadian ancestors. Relatively long periods of time for the Canadian and Ordovician are indicated, with intervening general land emergence. Indeed, there are few places where perplexity concerning the Canadian-Ordovician

boundary exists at the present time. These considerations favor recognition of the Canadian and Ordovician as distinct systems.

Divisions within the Canadian favor a natural division of the system into four major units. At the moment, it is easier to recognize these units than to find suitable names for them. The following scheme is tentative, as far as nomenclature is concerned:

I. Gasconadian. Here are included the equivalents of the Van Buren and Gasconade of the Ozark region, and their equivalents. Recognizable in general are: (a) An initial phase, often restricted geographically, with rather local faunas; (b) widespread beds of Gasconade in the restricted sense; (c) late beds comprising the *Kainella* zone, known as yet only from the Cordilleran region. This division is the late Ozarkian of Ulrich, with the reservation that the Gasconade and the Tribes Hill are equivalents and not successive intervals of deposition.

II. Demingian. Middle Canadian beds in the east are restricted and confined largely to the *Lecanospira* faunas. In the west a definite succession is known, comprising the first endoceroid zone, first piloceroid zone, the oolite and succeeding gastropod beds of the El Paso section in New Mexico, and F and lower G of the Garden City sections. The name is taken from Deming, New Mexico, because of the exceptional development of this interval in the Cooks Range, Florida Mountains, and several other nearby sections.

III. Jeffersonian. Early Upper Canadian beds generally are restricted geographically. There is evidence of oscillatory advances of the sea over most of the continent, of brief duration; what is left today consists often only of erosional remnants, as evinced by the local nature of the *Eccyliomphalus planidorsalis* faunas around the Adirondacks. Here are included the Jefferson City (Rich Fountain and Theodosia), Cotter, and Powell.

IV. Cassinian. The last great advance of the Canadian seas is marked by a rather different geographic pattern of preserved sediments. Here belong the Fort Cassin and Providence Island beds of the Champlain Valley, and the Smithville and Black Rock of northern Arkansas. Perplexity exists as to Smithville-Powell relationships; little wonder, as the Powell section still is inadequately described, and its faunas are known only very incompletely.

The Ordovician as thus restricted begins with the White-rock stage of Cooper (1956). This is particularly significant in the understanding of the actinoceroids, for this stage is dominated by the Wutinoceratidae almost, if not entirely, to the exclusion of other families. The one known exception is found not in America but in the Wuting limestone of Manchuria, where an apparently typical *Armenoceras* is found with *Wutinoceras* and *Adamsoceras*.

In the present chart the name Chazy is retained for the next interval. It is felt by the writer (Flower, 1955) that the Chazy faunas are known as yet very imperfectly. It seems unwise to discard the name Chazy for this reason. Most of the known Chazy actinoceroids, it may be noted, are from the type Chazy; none are known from the middle or southern Appalachians, and one has been described from the McLish of Oklahoma, the Chazy correlation of which has long been evident. Thus retention of the term Chazy seems particularly appropriate for purposes of the present study. The use of either Chazy or Marmour involves one

anomalous feature; it is peculiar that the Champlain valley should contain the only deposits known of lower Chazy age. The brachiopod fauna is clearly anomalous. The meager cephalopod fauna appears to be allied to forms as yet undescribed from the Whiterock stage, rather than from the middle or upper Chazy.

The contrast between Chazy and Black River faunas is so great that it hardly can be explained in terms of faunas from different realms. Rather, the Black River faunas show a marked evolutionary advance beyond those of the Chazy. For such evolution a considerable time span is required. Cooper, for the first time, has defined and named this interval, including therein two new stages, the Porterfield and Ashby. The latter are of little direct importance to the present problem, for in their type regions they have yielded no actinoceroids; only one formation correlated with this interval, the Murfreesboro limestone, has yielded actinoceroids in the east-central area.

The term Black River is retained for the next interval. Like the type Chazy, the type Black River section has never been thoroughly explored paleontologically. The one major revision, the placing of the Rockland with the Black River rather than with the Trenton, resolves many faunal anomalies encountered previously in speaking of Black River in contrast to Trenton faunas, and is to be welcomed.

It is probably true that close scrutiny of any part of the column, in the light of new faunal evidence, will reveal previous stratigraphic classifications as generalizations in need of revision. Cooper's new divisions of the earlier part of the Ordovician exemplify this trend. He has, nevertheless, retained the Trenton unmodified, except for removal of the Rockland. The investigations of the writer, however, have shown a serious need for emendation of the upper part of the section (Flower, 1956). Overwhelming evidence long has indicated the pre-Richmond age of the Red River faunas and now supports correlation of these beds, not with the Maysville, as the writer had at first believed, but with the late Trenton and Eden. This interval seems rather wide for the relatively short succession of strata and the homogeneous nature of the Red River faunal successions. The anomaly is reduced, however, if the Eden and late Trenton are considered as largely contemporaneous beds, owing their differences to environmental conditions.

Current correlations have tended perhaps to stretch this part of the Ordovician too far apart. The Upper Ordovician position of the Cincinnati section, and its correlation above the Trenton, rested originally upon recognition of the equivalence of the *Triarthrus eatoni* horizon in the Utica of New York with the same zone in the Fulton, at the base of the Cincinnati. Subsequent trends led to separation of these zones. The Fulton came to be considered as the basal unit of the Cincinnati, and it even has been proposed that the Point Pleasant beds below, which the writer regards as probable equivalents of the Denmark member of the Sherman Fall, should be included also in the Cincinnati. Work in New York established the Utica as a facies of the Trenton, and the *T. eatoni* horizon was established as equivalent to the early Cobourg limestones, well down in the Trenton, with upper Cobourg, Collingwood, and Gloucester recognized above. Equivalence is best restored by recognizing again the equivalence of the *T. eatoni* zones of the Utica and Fulton. It will follow that unless there is an unrecognized break

in the Cincinnati section, the Eden and later Trenton are largely contemporaneous. Probably the best solution is readjustment of the Middle-Upper Ordovician boundary at the base of the Cobourg.

Maysville and Richmond remain unemended, except, of course, for recognition of the pre-Richmond age of the Red River faunas.

An essential feature of post-Canadian Ordovician strata is the admixture of local faunules, due to obvious migration of various faunal elements. This presents serious problems in correlation. Ulrich and Foerste, in many papers, attributed these conditions to alternate advances of faunas of boreal and austral origin. This generalization is still the best and, as far as the writer knows, the only hypothesis which offers any explanation for the observed phenomena. Boreal invasions are recognized as marking the Chazy, Black River, Cobourg, and Richmond of eastern North America. In the cephalopods, certain stocks are largely boreal, but within these stocks are types which mingle with austral faunas, become adapted to them, and finally become an integral part thereof. Through Chazy and Black River time, the known actinoceroids and discosorids are confined essentially to faunas showing other evidence of invasion of boreal elements. Chazyan actinoceroids are known largely from the Champlain valley, where the only known Chazy discosorids also occur. It is believed that this invasion of boreal elements was relatively restricted geographically. Elsewhere austral elements held sway. The resultant anomalies of faunas were such that for years there has been uncertainty as to precise Chazy equivalents in many regions of North America. The problem was most severe in the Appalachians, where typical Chazy elements could not be recognized readily.

The succeeding Ashby and Porterfield intervals appear to represent faunas, best developed in the Appalachians, in which there was a marked retreat of the boreal elements and a nearly complete dominance of austral elements. A general absence of the boreal actinoceroids and discosorids is to be expected. Yet the Murfreesboro limestone of central Tennessee has yielded the discosorid *Ruedemannoceras* and the actinoceroid *Gonioceras*. It is probably in beds in the Appalachian region correlated with the Murfreesboro limestone that *Gonioceras* occurs. The writer has, on this basis, questioned assignment of the Murfreesboro to a post-Chazyan interval.

The Black River brought a second boreal invasion, imperfect in the Pamelia and Lowville, reaching its acme in the Chaumont, and retreating in the Rockland. The Rockland recession is marked by an interesting contrast between beds in Ontario similar to the Black River in faunas and lithology, and equivalent beds in adjacent New York more similar to the Trenton both in lithology and in the general aspect of the faunas. It is in the Black River invasion that *Gonioceras*, which seems to extend farther into austral realms than its associates, penetrated far into the Appalachian region. *Actinoceras* penetrates central Tennessee and becomes particularly prolific there. The discosorids, on the other hand, show a less marked advance, being confined to the northern Simard limestone in the east, and in the central region not penetrating south of the Platteville limestone of the upper Mississippi valley.

The third boreal invasion brings unlike associations into the black shaly limestones of the Cobourg and Terrebonne

beds of Quebec and into the largely mudfree limestones of the Catheys and Cynthiana of Kentucky. The Cobourg association is marked only by *Deiroceras* of the actinoceroids, *Westonoceras*, *Lavaloceras* and *Winnipegoceras* of the discosorids, and such other boreal elements as the Apsidoceratidae and *Probillingsites* of the Ascoceratida. In the central basin of Tennessee, one finds rare *Deiroceras* and abundant *Orthonybyoceras* among the actinoceroids. The discosorids are represented by the first species of *Faberocheras*. The Catheys marks the beginning of a faunal group of cephalopods which persist in this same general area throughout Maysville time, apparently becoming a part of the austral faunal assemblage. These stocks persist into the Richmond, a second boreal invasion bringing other genera into association with them, and continue with slight modification into the Brassfield. *Deiroceras* alone of these types is short lived, persisting into the Maysville but unknown in younger beds. *Faberocheras* continues in the Maysville, becomes modified in cross-section, and reappears as *Clarksivillia* in the Richmond and as *Glyptodendron* in the Brassfield. *Orthonybyoceras* is dominant throughout the Cincinnati; *Euorthoceras* of the Brassfield probably is a continuation of the stock.

Acceptance of the reality of the austral-boreal oscillations necessarily introduces many uncertainties into the problem of Ordovician correlations. It is fallacious to assume that a genus penetrating eastern North America only in the Richmond invasion did not have a much longer existence in its source area. *Armenoceras* invades eastern North America primarily in the Richmond, but it is known in earlier Red River faunas in the west, and its occurrence in eastern Asia is necessarily in the early half of the Middle Ordovician.

Many characteristic Red River genera, supposedly Richmond, appear in the Cobourg invasion. Some of these (*Westonoceras* and *Winnipegoceras*) actually are unknown in true Richmond strata. Likewise, if advance and recession of boreal faunas is a gradual process, faunal correlations will tend to assume equivalence of austral-boreal transitions in various stratigraphic columns, which must certainly be untrue. If one is to take as a type section one in the Appalachians, where boreal faunas penetrated only imperfectly, and then only at the peak of their advances, what general picture will result? One will expect to find formational units in this region rather broadly extended vertically in a correlation chart. In contrast, such regions as New York, Ontario, or Quebec, where boreal invasions lasted longer, will be treated as having widely separated groups of formations, each group regarded as representing only a short time span. This is exactly the picture presented by Cooper's correlation chart. Although this work clearly marks a great advance, and although at present proper corrections cannot be made, failure to recognize boreal-austral fluctuations may have produced some minor distortions, notably too great restriction of the type Chazy and Black River and indication of the gap between them as probably somewhat too great.

In summary it may be pointed out that the present scheme of the Ordovician is necessarily tentative and of the nature of a compromise. The presence of a Whiterock stage clearly must be recognized, as well as a hiatus between Black River and Chazy beds. Little has been said of the proper disposal of the Ordovician into Lower Middle and Upper divisions. It is felt that such divisions are not natural and have come to assume of late more importance than they deserve.

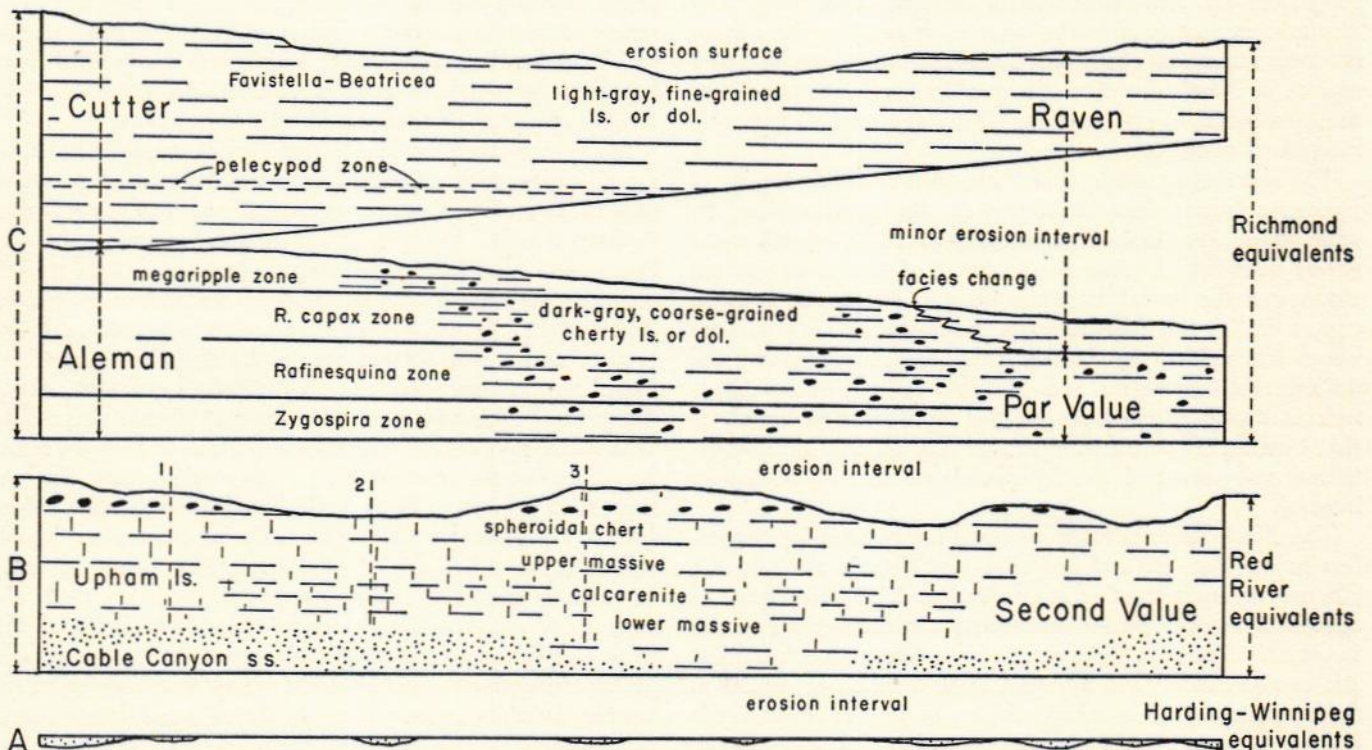
The Montoya Group

A more thorough study of the Montoya group will be presented at another time. The occurrence of the several species described here involves the presentation of a somewhat modified interpretation of the geological history, and a different stratigraphic nomenclature from that previously used. Both require a brief explanation.

The Montoya, first differentiated as the Montoya limestone (Richardson, 1908) in the Franklin Mountains, later was recognized generally over southern New Mexico. Entwistle (1944) proposed a division into three members: (1) The Second Value member, of lower massive noncherty limestone or dolomite, with sand in the basal beds; (2) the Par Value member, of thin-bedded limestone or dolomite, with abundant chert; and (3) the Raven member, of thin beds of light-gray dolomite, relatively chertfree. Kelley and Silver (1952) raised the Montoya to the status of a group, recognizing within it four formations: (1) the Cable Canyon sandstone, brown-weathering coarse sandstones; (2) the Upham dolomite, massive noncherty dolomite, sometimes limestone; (3) the Aleman dolomite, dark-gray medium-grained limestones and

dolomites, with abundant chert; (4) the Cutter dolomite, light-gray fine-grained dolomite and limestone, with little or no chert. It can be seen that in general definition the Cable Canyon and Upham correspond to the Second Value member of Entwistle; the Aleman and Cutter to Entwistle's Par Value and Raven members. The proposal of new names supposedly was justified because "the type localities designated by Entwistle were not in continuous stratigraphic exposure, and in addition were faulted and variously altered by mineralization." The reasons seem hardly valid. Strangely, the Cable Canyon section is complicated by some minor faulting and extensive slumping, and is in itself not beyond reproach as far as alteration is concerned.

Pray (1953) retained the lower dark dolomites in the Montoya but proposed as a separate formation the Valmont, with essentially the scope and definition of the Cutter dolomite and the Raven member. Status of the Valmont as a formation rests upon the fact that it had been included generally with the overlying Fusselman rather than with the Montoya, and that it was more distinct from the Montoya than were the



GENERALIZED SECTION OF THE MONTOYA IN SOUTHERN NEW MEXICO

Figure 2

Deposition is regarded as comprising three widely separated periods: A. Harding-Winnipeg erosion remnants; B. Red River beds; and C. Richmond beds. Each of these periods was separated by major uplift, accompanied by gentle warping and followed by erosion. Sections 1, 2, and 3 show the relationship of the Ash Canyon, Hembrillo, and Rhodes Canyon sections of the San Andres. Zones discussed in the text are shown, as well as the stratigraphic names which have been applied to the Montoya in New Mexico. Those of Kelley and Silver are shown at the left; those of Entwistle at the right, where the general section is in close accord with that of the Silver City region in which type sections occur. It may be noted that the apparent stratigraphic break between the Aleman and Cutter accords essentially with the boundary in the Caballos and in regions to the south and east. To the west, however, the break becomes greater, Raven lithology appears in the *Rhynchotrema capax* zone, and the Raven member appears to have a significant depositional break within it.

divisions within the Montoya from one another. The Upham and Aleman have yielded strongly contrasting faunas, the lower beds having a fauna then identified in terms of that of the Galena dolomite of the upper Mississippi Valley, and the Aleman having a Richmond fauna (Richardson, 1909). From the Valmont, however, no types have been reported which would indicate that it is materially younger than the underlying Aleman. The general relationships of these units are shown in Figure 2.

The studies of the writer have led to the conclusion that the Montoya group embraces three widely separated intervals of deposition: First, a basal remnant of sandstones, probably to be correlated with the Winnipeg and Harding sandstones; second, a series of limestones and local basal sands of Red River age; and third, a sequence of Richmond strata (fig. 2).

Remnants of an early basal sand are extremely local and rarely more than 2 feet in thickness. Generally the sandstone is light gray, saccharoidal, and nonresistant. It has yielded no megafossils as yet. No name is proposed for this interval at the present time.

The Red River deposits are embraced in the original definition of Entwistle's Second Value member, and the Second Value is treated here as of formational rank. The Cable Canyon sandstone is a basal sandy facies, intergrading with the calcareous Upham facies both vertically and horizontally. Dolomitization of the Second Value formation tends to obscure original bedding, to alter original lithology, and to destroy many of the fossils, but it is a secondary phenomenon developed to a varying extent from one section to another. Detailed sections will be presented at another time. It will suffice here to point out that there is a definite zonation of considerable significance, entirely apart from the Cable Canyon-Upham differentiation. In the San Andres Mountains, dolomitization increases from south to north. Throughout the area it is possible to recognize: (1) A lower massive limestone, with varying amounts of sand in the basal part; (2) a calcarenite, in which crinoid fragments usually are evident, even where dolomitization is advanced; and (3) an upper dense massive member, commonly with spheroidal cherts and some silicified fossils in its upper part. The presence of a characteristic but undescribed *Rhynchotrema* and a *Sowerbyella* show the fauna of this bed to be allied to that of the Upham, and to be completely foreign to the overlying Aleman, where faunas of Richmond aspect occur.

The Cooks Range section, which has supplied a number of the cephalopods here described, is unique in its lithological succession. A basal 5-foot bed of calcarenite riddled with worm borings forms the base of the Montoya; above is 35 feet of nearly pure coarse brown-weathering sandstone, of which the top 5 feet is more calcareous and grades into the Upham facies above. The 40 feet of Upham limestone is dark, fine grained, and massive at the base and at the top, but the middle is a coarse calcarenite replete with brachiopods. A 10-foot layer of white saccharoidal calcarenite completes the second value (Red River) part of the section.

The fauna of the Second Value is a large one, as yet imperfectly known. It is evident, however, that it contains many types closely related to the Red River faunas of Manitoba, and even of the Cape Calhoun series of northern Greenland. Gastropods include *Maclurina* cf. *manitobensis*, *Hormotoma winnipegensis*, *Fusispira* sp., and others not yet represented by specimens adequate for identification. *Receptaculites* is

common. Corals include *Halysites*, *Streptelasma*, *Calapoecia*, *Plasmopora*, *Columnaria*, and *Paleophyllum*. Hydro-corals are represented by a *Beatricea*-like form, possibly a new genus, and encrusting forms. Cephalopods include *Cyclendoceras*, *Endoceras*, *Cyrtogomphoceras*, *Westonoceras*, *Lambeoceras*, *Armenoceras*, *Actinoceras*, *Nybyoceras*, *Orthonybyoceras*, *Michelinoceras*, *Gorbyoceras*, *Apsidoceras*, *Charactoceras*, *Wilsonoceras*, and oncoceroids not as yet closely studied.

A large brachiopod assemblage contains many typical Red River types, but also many as yet unreported in Red River faunas. The *Rhynchotrema*, *Sowerbyella*, and *Clitambonites* appear to be without counterparts in more northern Red River faunas. These and other species show affinities in part with the Kimmswick, in part with the Rogers Gap fauna of Kentucky, and in part with the Cynthiana and Catheys faunas. Trilobites, as yet studied only casually, appear to have remarkably strong affinities with those of the Kimmswick limestone.

It should be noted that some sections, particularly where both the Second Value and the Aleman are dolomitized, show the contact between the two so obscured as to be recognized only with the greatest difficulty. Other sections, notably those of the Florida Mountains, Pierce Canyon in the Black Range, the Cooks Range, and Lone Mountain, show an amazing contrast between the two.

The next unit, consisting of dark-gray medium-grained dolomites, usually with abundant chert, is found in some sections primarily as a limestone rather than as a dolomite. It can be resolved into a number of zones, characterized chiefly by their faunas, but also having lithic differences which are somewhat variable, owing largely to variations in the extent of dolomitization. The lowest zone is characterized by a fauna dominated by *Zygospira*, *Dalmanella*, and *Cornulites*, with some other rarer forms. Succeeding it, in beds which are generally more cherty, is a fauna dominated to such an extent by a large *Rafinesquina* that other forms usually are not observed.

A third zone is characterized by a mixed brachiopod fauna, with *Hebertella*, *Platystrophia*, *Rhynchotrema capax*, *R. argenturicum*, *Rhynchotrema cuneata*, a host of orthoids not yet studied, and *Streptelasma*. This zone, particularly thick in the Florida Mountains, Cooks Range, and the southern Franklin Mountains, also has yielded massive trepostomaceous bryozoa. A fourth zone is characterized by surfaces showing large megarripples, often outlined in chert, with a meager fauna of silicified trepostomaceous bryozoans, small branching forms, and rare *Orthonybyoceras* and *Endoceras*. These beds are, lithically, the Second Value member of Entwistle and the Aleman formation of Kelley and Silver.

The overlying gray fine-grained dolomites, the Raven of Entwistle, the Cutter of Kelley and Silver, and the Valmont of Pray, as defined lithically, follow. Faunas are more local in aspect, but in general the lower part contains a brachiopod association, followed by a thin persistent silty layer with abundant pelecypods; the upper beds have yielded favositid corals and *Beatricea*.

Some facts suggest a gradual transition from the Aleman into the Cutter. The contact is often seemingly gradational lithologically, and often marked by alternation of dark-gray cherty dolomite and lighter finer grained noncherty limes. The western sections, including those near Silver City, Hermosa, and the Black Range, show the light-gray dolomite

appearing low in the section, and the mixed brachiopod fauna, the third zone of the Aleman, appears as the basal part of the Cutter.

Other considerations suggest a directly opposite conclusion. The thin silty pelecypod-bearing zone appears to be a reliable horizon marker. Yet in the San Andres Mountains it appears at progressively lower levels in Ash Canyon, Hembrillo Canyon, and Rhodes Canyon, suggesting that the Cutter represents progressive onlap from south to north. Furthermore, the western sections, especially those noted above, which exhibit light-gray Cutter or Raven lithology in the *R. capax* zone, show no evidence whatsoever of the megaripple zone. It appears that the lighter gray finer textured limestone of the *R. capax* zone is a facies phenomenon, but that above this horizon there is a break in deposition, the megaripple zone being completely wanting here. Further, if the northward progressive onlap relations of the San Andres section hold here, the silty pelecypod zone is wanting, because the lower beds above this break represent a horizon above the pelecypod-bearing silts. It appears, therefore, that there is a break in deposition, which lies essentially at the Aleman-Cutter contact, but which is, by original definition, not at the Par Value-Raven contact, but rather within the Raven member of Entwistle. For this reason, it appears that the Aleman and Cutter are more natural divisions to recognize within the upper Montoya than the Par Value and Raven divisions, although for practical purposes mapping well may take account of the latter divisions in the Silver City and Black Range regions of New Mexico.

The highest faunas found in the Cutter are characterized by favositid corals, including *Favistella* and *Foersteophyllum* (the sort of thing that 20 years ago was known as *Columnaria*), and *Beatricea*. It is coming now to be realized that the latest Ordovician faunas of the western United States are dominated by favositid corals (Berdan and Duncan, 1955). Elements of the lower Cutter suggest equivalence with the Whitewater beds of Ohio and Indiana, although a position of the basal beds in the Liberty is not impossible. Pending clarification which will come with closer study, it is never

theless evident that the Cutter contains associations of late Richmond age. The megaripple zone has yielded as yet nothing of great diagnostic stratigraphic value. The underlying zone, with a varied association characterized particularly by *Rhynchotrema capax*, is clearly to be correlated with the Waynesville; more closely, with the middle Waynesville (Clarksville) member, though it is possible that the lower member is represented also. One is tempted to look for some basis for correlating the two lower zones with Arnheim. Amazingly, however, nothing has been found as yet in their rather restricted faunas which would suggest Arnheim age. The genera present are long-ranging types; if they offer nothing which is diagnostically Arnheim, neither is there anything which would favor a correlation with the Richmond, in contrast to the upper Maysville.

The underlying Second Value formation contains a Red River fauna, and there can be no question as to its correlation with the Red River beds of Manitoba. The writer had long expected that the Red River faunas would prove to be of Covington (Eden and Maysville) age. However, faunal affinities suggest instead correlation with the Cobourg, the Cynthia and Catheys, and the Eden. No faunal evidence has yet been found to suggest that Red River deposition may be as young as the Maysville. Instead, the Montoya sections supply evidence that between the deposition of the Red River and the Richmond intervals there was uplift, gentle warping, and erosion. Such erosion may have occupied most or all of Maysville time. If the break is to be restricted to any part of the Maysville, it must be regarded as occupying the early rather than the late part, for there is a serious possibility that the lower Aleman may be late Maysville in age rather than early Richmond.

The age of the basal sandstones, regarded as erosion remnants of Harding-Winnipeg deposition, is yet to be determined precisely. It is certain, however, that they are either of Black River age or slightly older, and that an appreciable gap in time separated this depositional cycle from that of the Red River faunas.

Systematic Descriptions

Genus **POLYDESMIA** Lorenz

Polydesmia Lorenz (1906) preoccupies *Maruyamaceras* Kobayashi, the identity of the two having been shown by Teichert (1937). A review of the genus, including the subgenus *Maruyamacerina* Kobayashi (1936), has been presented by Kobayashi.

Morphologically this actinoceroid is characterized by a large broad siphuncle. The septal necks are definitely recurved and free, the length of neck equaling or exceeding the length of the brim. At the apical end of the segment, the rings are broadly adnate to the adapical septa, but may join them and then curve away from them, leaving an interseptal cavity before joining them finally at the septal foramen. Deposits within the siphuncle appear as simple annuli, rounded in section; when mature, they are prolonged into lobes which project obliquely inward and forward. Annuli at their inception are formed not at the extreme tip of the connecting ring, where it passes within the recurved septal neck, but some distance forward, the point of origin lying often opposite the interseptal cavity. Kobayashi has differentiated this as a *pro-Actinoceras* stage. It was followed by an *Actinoceras* stage, with the annular deposit simply larger, so that its apical part does project within the septal foramen, and finally by the elongated *Polydesmia* stage.

Lines of juncture between the individual annulosiphonate deposits curve forward as they approach the center of the siphuncle, and thus resemble superficially the radial canal system of *Actinoceras*.

Indeed, Kobayashi interpreted these lines as radial canals, but presented cross-sections showing very different structures, which are clearly the true radial canals (Kobayashi, 1940, pl. 3, fig. 6; pl. 4, fig. 21, 22, 25, 27, 29; pl. 25, fig. 19). That radial canals necessarily follow the lines of juncture between annulosiphonate deposits in the Actinoceratida is a false assumption. Indeed, radial canals are established in tissues of the siphuncle prior to development of deposits, and the deposits gradually engulf them with growth, as was clearly shown by Teichert (1933). Kobayashi also interpreted *Polydesmia* as having a siphuncle formed only of septal necks. This conclusion must be rejected also, although it must be noted that the connecting rings, here quite thick, present the aspect of continuations of the septal necks, as they do in the Tarphyceratidae and Proterocameroceratidae. Cameral deposits are known in *Polydesmia canaliculata*, the only species for which the phragmocone outside the siphuncle is at all known. The phragmocone is straight and moderately expanding. There is some question as to its original cross-section and the proximity of the siphuncle to the ventral wall. The living chamber is unknown; it is, therefore, uncertain whether the shell was simple in form, or whether the anterior end became fusiform, as in *Actinoceras*.

All the known species are from eastern Asia. *P. watanabei* Kobayashi, *P. shimamurai* Kobayashi, *P. sp.* Kobayashi, and *P. (Maruyamacerina) peshanense* (Kobayashi) are from the Maruyama bed of Shantung, and also Korea. This bed underlies the Toufangian and was grouped originally with the underlying Shorin limestone of Canadian age. Endo

(1932), on the other hand, reports species now known as *Polydesmia canaliculata* Lorenz and *P. elegans* (Endo) from the Ssuyen limestone near Niu-hsin-tai, Manchuria. Identity of the beds from which these species came with the true Ssuyen appears dubious and has been questioned by Kobayashi. Endo (1932, p. 25-27), however, recognized in this general region Ssuyen limestone containing these forms, with the Wuting limestone, the Kangyao limestone, and the Canadian Santayo below. The Wuting of this region has yielded *Wutinoceras foerstei*, *Adamsoceras manchuriense*, and *Armenoceras nimatai* (which, to judge from the description and illustration, is a good *Armenoceras*).

Genus **WUTINOCERAS** Shimizu and Obata (1936)

Orthoconic actinoceroids, with siphuncle segments broadly expanded. The siphuncle is ventral and the septa deeply curved. As a consequence the apical end of each segment shows a broad area of adnation ventrally; this area is slight or even wanting dorsally. Septal necks generally are narrowly free, but with brims greater than the length of the neck; the necks may also be recumbent, with the anterior end of the siphuncle segment adnate to the septum. When this is true, the adnation is pronounced dorsally and is slight or wanting ventrally. The main feature by which *Wutinoceras* is recognized, however, is the presence of a reticulate type of canal structure.

Discussion. As redefined, *Wutinoceras* is a genus which precedes *Nybyoceras* stratigraphically. The following species are placed here:

Wutinoceras foerstei (Endo). This is the genotype by original designation; from the Wuting formation of Manchuria.

Wutinoceras paucicubiculatum (Teichert and Glenister). Ordovician; Railton, Tasmania.

Wutinoceras multicubiculatum (Teichert and Glenister). Ordovician; Railton, Tasmania.

Only one younger species suggests *Wutinoceras*; but better evidence is needed for this form. It is *Nybyoceras aigawaense* Endo (1935), of the Ssuyen limestone of Manchuria. Its canals may possibly be of the double arc type, though branching irregularly. Clear evidence of reticular structure is wanting.

Genus **NYBYOCERAS** Troedsson (1926)

Considerable confusion surrounds the proper limits of this genus in spite of much discussion. When Troedsson (1926) first proposed the name as a subgenus of *Actinoceras*, he believed the shell to be breviconic, a conclusion which does not appear to be valid. True, known specimens are short fragments of phragmocones, but there is no good reason to believe that the shell was short; typical material gives all evidence of being gently expanding.

The genus generally has been accepted on the basis of the vertical outline of the siphuncle. On the venter, septal necks are either short and free, as suggested by Troedsson's (1926) Plate 63, Figure 4, or recumbent for a short distance (cf. pl.

63, fig. 2). On the dorsum, the brim unquestionably is recumbent, and the anterior end of the connecting ring follows the septum for an appreciable distance. At the apical end of the segment, the ring is broadly adnate to the septum on the venter, but adnate for only a short distance on the dorsum.

The siphuncle outline alone has been taken as the criterion of the genus. One may, however, wonder whether such an outline might not be found in any *Armenoceras* in which the siphuncle is relatively small in diameter in proportion to the shell as a whole, and lies close to the venter, and in which the septa are rather strongly arched. There are such species of *Armenoceras*, and most of them have been described from specimens showing unoriented or horizontal longitudinal sections of the siphuncle. Endo (1932) described as *Nybyoceras foerstei* a specimen from the Wuting limestone of Manchuria. This fulfills the requirements of *Nybyoceras* in that the apical end of the ring is broadly adnate to the septum ventrally but only narrowly so dorsally. The septal necks are short in length, and the brims are longer than the necks, but on neither dorsum nor venter are the brims recumbent, that is, so recurved as to lie in contact with the free part of the septum.

Shimizu and Obata (1936) erected the genus *Wutinoceras* for this species and made a wholesale reassignment of the species which Endo (1932, 1935) had assigned to *Nybyoceras*. Teichert and Glenister (1953) regarded *Wutinoceras* as a synonym of *Nybyoceras*. The writer is in agreement with Teichert and Glenister in rejecting the validity of *Nybyoceras* as a breviconic shell, one of the differences invoked by Shimizu and Obata in erecting *Wutinoceras*. Shimizu and Obata are not in error, however, in believing the necks to be "ormoceratoid" (that is, with brim and neck subequal, the neck free and not recumbent), for this condition is clearly shown by Endo's published photograph of *N. foerstei*. The anomalous forward bending of the septa as they depart from the siphuncle and approach the ventral wall of the shell is accepted by Teichert and Glenister as a valid difference, though an unimportant one. It is, however, clearly a feature which is not original but the result of slight crushing of the ventral side of the shell. Almost identical conditions are shown in the present section of *Adamsoceras isabelae* (pl. 5, fig. 4).

The actinoceroid genera as defined by Shimizu and Obata have little value. They are defined in terms of details of the outline of the siphuncle segments. It is dubious whether, even if these conditions were uniform, the genera could be considered as natural. The changes which occur as ontogeny progresses have not been considered. Acceptance of the genera as defined is completely impossible.

The fact remains that *Nybyoceras*, as currently understood, is an extremely long-ranging genus, not altogether uniform in structure. There is reason to question whether, as it now stands, it represents a natural group.

A clue to the situation is to be found in the radial canal system. Teichert (1933) defined as the *Nybyoceras* type of canal system one here renamed the double-arc type. Curiously, no such structures are found in *N. bekkeri*, the genotype, nor in *N. balticum* or *N. intermedium*. These three species, from the Lyckholm beds of Esthonia, constitute the nucleus of the genus. The figures of Troedsson (1926) and Teichert (1930) show only the single-arc type. What Teichert

illustrated (1933, pl. 14, fig. 47) as the *Nybyoceras* type of radial canal system does not seem to be perfectly developed in any species of *Nybyoceras* then described. Species of *Nybyoceras* in Lyckholm and the equivalent Red River faunas have single, not double, arcs. Double arcs are present in *Nybyoceras foerstei*, but there are numerous interconnecting tubes, and the structure is obviously much more complex than shown by Teichert's drawing. It clearly is of the reticular as defined above.

The same criticism must be extended to apply to the radial canals of *Cyrtonybyoceras*. The double-arc system may exist in *Nybyoceras ulrichi*, but the extant figure is enough to suggest, but hardly to prove, the presence of the structures. *N. cryptum* of the Chazyan does show the presence of the double arcs, without the adjunct of accessory interconnecting tubes.

At the present time it is evident that the reticular type of radial canal system is common to actinoceroids of a definite stratigraphic position, below that of those species showing double arcs, single arcs, or horizontal canals. It is desirable, therefore, to recognize these species as constituting different genera. *Wutinoceras* is revived and redefined accordingly.

As restricted, *Nybyoceras* contains the following species:

N. ulrichi Foerste and Teichert, Simpson group of Oklahoma.

N. cryptum Flower, middle Chazyan of the Champlain Valley.

N. montoyense, n. sp., Upham limestone of Texas and New Mexico.

N. bekkeri Troedsson, Lyckholm beds of Esthonia.

N. balticum (Troedsson), Lyckholm beds of Esthonia.

N. intermedium Teichert, Lyckholm beds of Esthonia.

Proper assignment of species from the Ssuyen beds of Manchuria is not possible from the extant descriptions and figures, as radial canal structure and even the outline of the siphuncle are not always adequately shown. Certainly none of the species except *N. aigawaense* suggest the *Wutinoceras* type of structure of the canal system; even in this species, better evidence could be desired. *N. marginale*, *N. exortivum*, *N. Troedssoni*, and *N. penhsiense* are typical of *Nybyoceras* in proportions of the siphuncle. *N. (?) annectans* is atypical in having an extremely broad siphuncle, and both shell and siphuncle appear to be faintly curved endogastrically. Two of the Ssuyen species, *N. tenuitubulatum* Endo and *N. compressum* Endo, have very small siphuncles, and their generic resting place is something of a problem. They are resembled rather closely by early stages of *Orthonybyoceras*, but it is not certain whether they should be placed there, or whether another generic group should be erected for these species.

Nybyoceras montoyense Flower, n. sp.

Pl. 1 o, fig. 9.

This species is known from a fragment of a phragmocone 130 mm long, containing portions of 15 camerae. The cross-section is only faintly greater in breadth than in height, the dorsum is well arched, the venter is slightly flattened, and the shell expands from 40 and 45 mm to 62 and 65 mm in a length of 100 mm. The dorsal profile is straight; the ventral profile, wanting basally, shows adorally a slight but definite

convexity over the anterior half of the type. The septa are extremely deeply curved, and slope slightly forward on the venter. At a shell height of 60 mm the septum has a depth of 14-16 mm, the depth being equal to the length of one and a half camerae. Camerae increase in depth from 8 mm, at the base of the type, to 10 mm, at the anterior end. The siphuncle is broad but not broadly expanded, and enlarges slightly more gradually than does the shell. Basally the ventral part of both siphuncle and shell have been destroyed. At midlength, where the shell is 52 mm high, the siphuncle segment expands from 18 to 25 mm in height. The septal foramen lies 10 mm from the venter and 25 mm from the dorsum. At the anterior end, the shell has an estimated height of 55 mm; here the siphuncle increases from 20 to 25 mm in the plane of the section. Perhaps an additional 1 mm should be allowed, as the section is not quite central here. At the base, the shell is 45 mm wide, and the height estimated at 40 mm. The siphuncle is here 18 mm across, circular in section, 15 mm from the dorsum, and 7 mm from the venter.

The outline of the siphuncle shows a short free septal neck on the dorsum, but on the venter the neck is short and recumbent. The apical end of the connecting ring is broadly adnate to the free part of the septum on both the dorsum and the venter. Replacement has obscured the main features of the canal system.

Discussion. The holotype retains with the siphuncle most of the surrounding parts of the phragmocone. In the apical half, the ventral part of both shell and siphuncle have been destroyed, and secondary calcite has been deposited there, having a fibrous structure. The species is anomalous among other *Nybyoceras* for the broad area of adnation on the ventral side of the siphuncle. The shell is a moderately rapidly expanding one, the ventral profile being slightly convex adorally, suggesting that the whole shell may have been faintly fusiform, as in many species of *Actinoceras*. Essential internal structures are present, but slight color differentiation and some dolomitization have made them difficult to determine. Although the entire cross-section of the shell is present, as usual in species from the Upham dolomite, the shell cannot be separated from its matrix. As a consequence, illustrations are confined to the longitudinal section and a restoration of the cross-section.

Holotype. New Mexico Bureau of Mines.

Occurrence. From the Upham dolomite, Second Value formation; from near the scenic drive at El Paso.

Genus **ADAMSOCERAS** Flower, n. gen.

Genotype: ***Adamsoceras isabelae*** Flower, n. sp.

This genus is erected for actinoceroids which resemble *Ormoceras* in the general features of the outline of the siphuncle segments, but which differ from it in possessing a reticular type of radial canal system. Shells are typically slightly depressed in section. The siphuncle lies fairly close to the venter, and sutures develop low ventral lobes. The known forms are slender and gently expanding. No mature living chambers are known.

Discussion. Phyletically the group of species for which this genus is erected is particularly significant. *Adamsoceras* supplies a connection between *Wutinoceras*, as here revised, and *Ormoceras*. With *Wutinoceras* and *Cyrtonybyoceras*,

Adamsoceras appears to be confined to a very early post-Canadian horizon. Cooper (1956) has proposed recently to call this the Whiterock stage in North America. The genotype is from the upper part of the Pogonip group of Ikes Canyon, of the Toquima range of Nevada, probably from the sponge beds, and from the *Rysostrophia* zone of Cooper. The only congeneric species previously recorded from North America is from the Table Head formation of Point Rich, Newfoundland. This form Teichert (1933, pl. 9, fig. 6) erroneously identified with the Black River species *Ormoceras allumettense* (Billings). The name *Adamsoceras billingsi* is here proposed for this species, which differs from *A. isabelae* in the much deeper camerae, and the somewhat larger siphuncle, which is located considerably farther from the ventral wall of the shell and in possessing reticulate radial canals.

In eastern Asia *Adamsoceras manchuriense* Endo (1932) is typical of the genus, occurring in the Wuting formation which underlies the Ssuyen limestone. It is in the Ssuyen limestone that typical *Ormoceras*, *Armenoceras*, and *Actinoceras* occur in association. Significantly, *Adamsoceras* predates this association, which is typically early Mohawkian in aspect; equivalence with the Whiterock stage is a logical inference.

In Tasmania *Adamsoceras johnstoni* (Teichert and Glenister) occurs. It is known only from King Extended Hill, Zeehan, western Tasmania. Detailed knowledge of the stratigraphy or of the associated fauna is lacking, but again there is a strong suggestion of Whiterock equivalence.

Troedsson (1926) described two species of *Ormoceras* from the *Orthoceras* limestone which appear to belong to *Adamsoceras*. His *Ormoceras holmi*, from the Vaginatenkalk (B3 or Kunda formation of Raymond) of Kandel, Esthonia, with a paratype from the same horizon at Reval, Esthonia, and another from the Upper Red *Orthoceras* limestone, probably the *Platyurus*-kalk, of Oeland, shows rather complex radial canals and a wide central canal, along which other smaller tubes appear to be alined, but lacks definite evidence of the typical reticulate radial canal system. His *Ormoceras oelandicum*, known from two specimens from the Upper Red *Orthoceras* limestone of Oeland, again from the *Platyurus* horizon, shows more definite evidence of double arcs which are complexly branching. This species fails again to show a definite reticular structure, although it suggests one in a somewhat simplified condition.

It has been somewhat difficult previously to explain how it could be that *Ormoceras* appeared as early as the Chazyan, if it is a relatively specialized genus, as suggested by Teichert (1935). *Adamsoceras* supplies the explanation, for *Ormoceras*, the first species of which are slightly younger, is quite clearly derived from *Adamsoceras* by reduction of the reticulate type of radial canals to simple horizontal canals. It shows further that the *Ormoceratidae* were derived very early, *Adamsoceras* dating the beginning of the trend, by developing the *Ormoceras* type of siphuncle outline. It serves also to clarify the phyletic position of *Ormoceras* in the Actinoceratida.

Adamsoceras isabelae Flower, n. sp.

P1.5, fig. 1-4; text fig. 3A.

This form is known from a single specimen, representing

a portion of a phragmocone 130 mm long. Vertical crushing, slight apically, is progressively greater toward the anterior end of the shell, where some fragments of calcarenite suggest that a portion of the extreme base of the living chamber may be represented. The shell is broadly depressed in cross-section, the dorsum more arched than the venter. In its present condition the type increases from a width of 38 mm and a height of 31 mm at the base, where crushing is negligible, to 46 mm and 32 mm respectively in the basal 45 mm. At the adoral end of this portion, crushing has flattened the ventral side of the shell materially, and has increased the width and reduced the height slightly. In the next 35 mm the width increases to 56 mm, and the height decreases to 30 mm; at the adoral end, 40 mm farther, crushing reduces the height to 15 mm, and the width decreases to 52 mm, suggesting that the shell was assuming a slightly fusiform outline here.

The type contains 16 camerae, which vary between 6 and 7 mm in length. They show neither any perceptible adoral increase in depth nor the extreme adoral shortening of the last camera to be expected in a mature shell. Sutures are essentially transverse over the dorsum; adorally, however, crushing presents the aspect of broad dorsal saddles, a condition which probably is not original. Sutures slope strongly apicad from dorsum to venter on the strongly rounded lateral portion and describe broad shallow lobes as they cross the more flattened ventral surface. The depth of the septum, in relation to a vertical median line, is 15 mm at a shell height of 35 mm and is slightly greater than the length of two camerae. In the plane of the suture, which is inclined about 30 degrees from the normal, the depth is 10 mm.

The siphuncle is composed of segments like those of *Ormoceras* in outline. A segment is spheroidal; the septal necks have short, free, recurved brims; the apical end of the connecting ring is adnate ventrally but not dorsally. A segment expands from 5 mm to 9 mm within a camera and is 6 mm long. The eight segments shown in the section taken from the basal part of the type show no progressive variation in outline from one to another. Within the siphuncle can be seen portions of the central canal and a complex ramifying pattern of radial canals, forming the reticulate type of radial canal system. Traces of the perispatium, and of the canals joining it, can be seen in some segments.

In the section it should be noted that septa are normal and apparently unmodified by distortion from the siphuncle to the dorsal wall. On the small region between the siphuncle and the venter, however, crushing has caused an irregular steepening of obliquity of the septa, which are sometimes broken. At the middle of the section the septal foramen lies 28 mm from the dorsal shell wall, has a height of 5 mm, and is 6 mm from the venter. Prior to crushing, this last measurement was evidently between 8 and 9 mm. Even the apical camerae lack any trace of definite organic deposits, though concentric layers of calcite line the camerae. One anterior camera was broken and penetrated by matrix. That this matrix lies not against the septa, but is separated from them by thin layers of calcite, suggests early replacement of cameral tissue, prior to invasion of sediments.

Discussion. In spite of the crushing to which the type has been subjected, it is possible to reconstruct the proportions of this species quite adequately. Probably the shell expanded

gradually, the width increasing slightly more rapidly than the height. At the anterior end, which is close to, if not at the base of, the living chamber, the shell underwent a marked reduction in rate of lateral expansion, which would produce the slightly fusiform shell shape common to many, though not all, Actinoceratida. The species is named for Mrs. J. Lee Adams.

Holotype. Collection of the writer.

Occurrence. Pogonip limestone; Ikes Canyon, Toquima Range, Nevada. Precise horizon data are lacking, but the specimen is from the Whiterock stage of Cooper (1956), either from the sponge beds (division N of Hintze, 1952; *Anomalorthis* zone of Cooper, 1956), or possibly, though less probably, from the overlying *Rhysostrophia* zone. Collected by Dr. J. Lee Adams.

Genus **ORMOCERAS** Stokes

As at present delimited, *Ormoceras* includes straight actinoceroids, gently expanding, section little modified from the circular; siphuncle composed of segments which are relatively small at the septal foramen, rounded, spheroidal in outline; the septal necks short, sharply recurved or narrowly rounded, but not recumbent. Radial canals are straight and normal to the central canal.

The outline of the siphuncle alone has been employed usually to distinguish *Ormoceras*. In this respect, it appears to grade into other genera which actually are not intimately related to it. It may be considered as an *Actinoceras*, in which the segments are small, the necks short and inconspicuous. It may be considered as grading into *Armenoceras*, in which the segments are more broadly expanded and the necks recumbent. *Sactoceras*, as generally employed (though rather too broadly) is an *Ormoceras* in which the siphuncle becomes relatively tiny.

In the present work it is recognized that *Ormoceras* represents a stock not related to *Actinoceras* or *Armenoceras*, but stemming through *Adamsoceras* from *Wutinoceras*. The *Ormoceras* stock is long lived. The earliest known species is of Chazyan age, *O. neumani*. *O. champlainense*, originally described as from the Chazyan, according to its original label actually may be from Black River strata instead. The genus is well represented in the Black River (see Foerste, 1932-33), unknown in the typical Trenton, present (though not widely) in the Red River faunas, and not definitely known in the Richmond. The Middle Silurian affords another glimpse of the genus, here little changed. It is believed that Silurian species of *Armenoceras* are modifications of *Ormoceras*, rather than true descendants of Ordovician *Armenoceras*, for they have the simple radial canals of *Ormoceras*, and not the series of double arcs which characterize many, if not all, Ordovician *Armenoceras*. *Ormoceras* is found again in the Helderbergian faunas of New York and in F2 of Bohemia, as well as in the Schoharie and Onondaga formations of the lower Middle Devonian. No younger species have yet been found, but the last of its descendants are certainly to be found in the various species of *Rayonnoceras*, which ranges from late Middle Mississippian into early Pennsylvanian.

Species which agree with *Ormoceras* in the outline of the siphuncle, but which possess complex radial canals similar to those of *Wutinoceras*, are set aside as the genus *Adamsoceras*.

Distinctions between *Ormoceras* and *Sactoceras*, as the latter genus generally has been used, are those of degree. In general, species assigned to *Sactoceras* are smaller shells, the siphuncles being even smaller than those of *Ormoceras*, in proportion to other shell features. Species assigned to *Sactoceras* generally fail to show good deposits in the siphuncle. It is not even certain that such species as Foerste (1932-33) assigned to *Sactoceras* from the Black River beds actually are actinoceroids. Some at least are certainly to be assigned instead to the family Stereoplasmoceratidae. Foerste and Teichert (1930) called attention to the rather unsatisfactory nature of some of the species which they provisionally described as species of *Ormoceras* from the Ordovician of Tennessee.

Even disregarding these doubtful forms, *Ormoceras* is recognizable in the main as a valid and very long-lived genus, developed from the older *Adamsoceras* by simplification of the radial canals, and existing from Chazy through the early Middle Devonian. Logically, *Deiroceras* and *Troedssonoceras* are derivatives of *Ormoceras*, appearing in late middle or early upper Trenton time. No species transitional between the genera have been found. More must be known of the interior of *Paractinoceras* before it will be certain whether it is a derivative of *Actinoceras* or of *Ormoceras*. The great width of the siphuncle in earlier stages suggests an origin in *Actinoceras* rather than in *Ormoceras*. *Orthonybyoceras* is a possible derivative of *Ormoceras*, appearing in the late Trenton of the Nashville region and persisting as the dominant cephalopod of the type Cincinnati.

Ormoceras neumani Flower, n. sp.

Pl. 1, fig. 5; pl. 5, fig. 9; pl. 6, fig. 6.

The shell is straight, essentially circular in cross-section, and very slender. The holotype is a shell 80 mm long. It is broken near the middle, the two parts being slightly displaced. It expands from 13 to 16 mm in the basal 25 mm and to 19 mm in the next 25 mm; the rate of expansion appears to be uniform to the adoral end. There are 25 camerae and a basal 14 mm of an incomplete living chamber. Sutures appear to be oblique, although, as such, they are not exposed. Camerae show little variation in depth, averaging 3 mm deep until the last four, which become gradually shallower, the last being 2 mm deep. The septa are rather deeply curved, the depth equaling one and a half camerae. The siphuncle is sub-central throughout, the segments small, but slightly broader apically than adorally. A segment 2.6 mm long, near the apex, increases from 2 mm at the septal foramen to 4 mm. The brim is slightly longer than the neck, free, the segment well rounded. The segment is subspherical in section; the area of adnation is slight and much shorter than the brim.

Adorally a segment 3 mm long increases from 1.8 mm to 3.2 mm. Necks are of the same length as before, but the brim is here reduced to considerable less than the length of the neck. The segment shows a narrower form and no area of adnation.

Cameral deposits are represented probably by thin lines of calcareous material in the apical camerae on the supposed ventral side of the shell. The deposits of the siphuncle are small annuli on the ventral side only of adoral segments. Apically, adjacent deposits join on the venter, but none are present on the dorsal side. In the camerae just apicad of the

break in the specimen, the section is somewhat off center of the siphuncle; here the deposits appear to extend to the dorsal side, which is clearly the effect of the off-center condition of the section here.

Discussion. This species is extremely generalized in the small siphuncle, central in position. The shell is small and slender, and the siphuncle is unusually small in proportion to the shell. The structure shows that this is a typical *Ormoceras* and- a true actinoceroid. If *Ormoceras champlainense* is regarded as a form from the Black River or Rockland beds rather than from the Chazy, this is one of the oldest, if not the oldest, true *Ormoceras*.

Holotype. U. S. National Museum.

Occurrence. Newmarket limestone; from the Pinesburg Station quarry, Maryland.

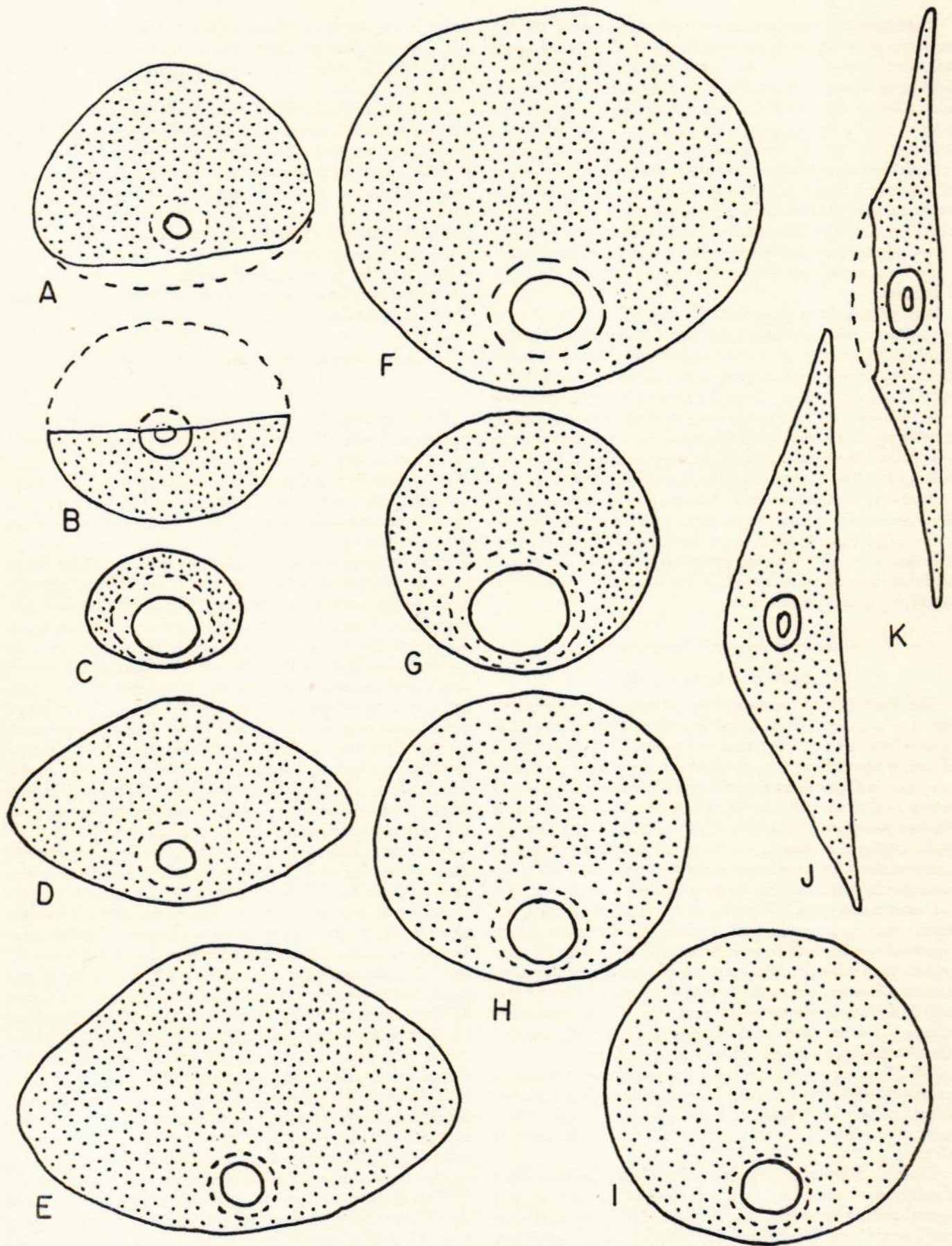
Ormoceras dartoni Flower, n. sp.

Pl. 9, fig. 3; text fig. 3B.

The type consists of a portion of a phragmocone, with a maximum length of 100 mm. The shell apparently is circular in section or has only the faintest flattening of the ventral side. It expands 7 mm in a length of 50 mm, and 14 mm in 100 mm, increasing from 40 to 47 mm in 50 mm. Ten camerae occur in the length of 80 mm, increasing in depth gradually from 7 to 8 mm. Septa are rather deeply curved, a septum being 10 mm deep where the shell is 41 mm across, and equal to one and a third camerae in depth. The siphuncle is perfectly central in position. The segments are well rounded and the septal necks short but free, a segment 8 mm long expanding from 6 to 14 mm within the camera. Deposits are well developed in the type, showing part of the central canal, and showing radial canals straight and perfectly normal to the central canal. In the figured section, thin episepal deposits are seen on the left side of the siphuncle. Camerae on the right offer indication of similar deposits, but their margins are obscure; the cavity remaining is here filled with white calcite, and recrystallization has obscured original differences between organic cameral deposits and inorganic calcite secreted within the cavities of the camerae.

Discussion. This species is comparable to *Ormoceras lambei* Foerste, from the Dog Head member of the Red River formation of Manitoba. The species are somewhat similar in spacing of septa, rate of expansion, and in the strong curvature of the septa, but *O. dartoni* has much larger and much more broadly expanded siphuncle segments. In this respect, *O. dartoni* is more similar to a species which Foerste (1929) figured as *Armenoceras* cf. *allumettense* (Billings), from the Selkirk member of the Red River beds. This form differs from *O. dartoni* in the definitely eccentric position of the siphuncle, as well as in the less strongly curved and more closely spaced septa. The reference of the species to *Armenoceras* or to *Orthoceras allumettense* Billings is questionable. Although the siphuncle segments are rather broader than in most *Ormoceras*, it is not clearly evident that the septal necks are actually recumbent. The radial canal system is the simple one typical of *Ormoceras* and atypical of *Armenoceras*. *O. allumettense* Billings is a species from the beds of the Paquette Rapids of the Ottawa River. Foerste (1933, p. 9) later assigned typical material of *O. allumettense* to *Ormoceras*, a conclusion with which the writer concurs.

Holotype. Collection of the writer.



CROSS-SECTIONS OF ACTINOCEROIDS

Figure 3

Occurrence. Top of the lower massive limestone member of the Second Value formation, Montoya group; from near the crest of the Scenic Drive, El Paso, at the southern end of the Franklin Mountains.

Genus **DEIROCERAS** Hyatt

The shell is straight and slender, the camerae relatively deep; section subcircular, sutures simple. The siphuncle is broad at the septal foramen; segments gently rounded, enlarged within the siphuncle, generally longer than broad. Septal necks only gently recurved; no area of adnation. Deposits annular in siphuncle; radial canals straight and normal to central canal.

The typical group of species which forms the nucleus of the genus is found in beds of Cobourg age and is known largely from rather poor internal molds containing siphuncles. *Deiroceras python*, the genotype, is from the Cobourg of Ottawa. *D. remotiseptum* (Hall) is from the Cobourg of northwestern New York. *D. richteri* Foerste and Teichert occurs in the Prosser of Minnesota. *D. curdsvillense* is from the Curdsville limestone of Tennessee, and *D. nashvillense* from the Catheys or Bigby, probably the former, of Tennessee.

There is a group of older species. *D. schofieldi*, of the Platteville of Minnesota, is a large typical form. An internal mold is known which is smooth, but the surface is not well preserved. *D. paquettense* has a smooth shell but is not typical of the genus, the shell apparently being small (no specimens of very large diameter are known), the siphuncle relatively small, and the segments markedly swollen anteriorly. The *D. kindlei* from St. Joseph Island is very similar. *D. pertinax* (Billings) is a small faintly fluted shell. The siphuncle is not adequately known.

The fluting of *D. pertinax*, the general similarity of sections of *D. nashvillense* and of *Troedssonoceras baileyi*, both of the Catheys, make one wonder whether *Deiroceras* and *Troedssonoceras* may not be one and the same genus. In the past, specimens showing shell surfaces with fluting have been placed in *Troedssonoceras*, and specimens failing to show the fluting have been placed in *Deiroceras*. It is evident, however, that the shell surface is not adequately known for the small group of Cobourg species, including the genotype, and the internal molds are reasonably well known only in species of earlier, Black River age. Of these forms *D. pertinax*, although its interior could be better known, shows faint fluting. *D. schofieldi*, shows none, but typical *Troedssonoceras* with similar rough surfaces may have the longitudinal markings almost lost. *D. curdsvillense* shows very faint traces of longitudinal markings on its surface. *D. kindlei* appears to be smooth. *D. paquettense* is certainly smooth but may not be a typical member of the genus. Surfaces are not known for *D. richteri*, *D. nashvillense*, or *D. capitolense*. *D. dismukesense*, of the Richmond of Tennessee, is atypical; it is more probably an *Orthonybyoceras*.

Further support for assuming the identity of *Troedssonoceras* and *Deiroceras* is supplied by an obvious *Troedssonoceras* from the latest Trenton of the Lake St. John region, and by a few segments of a large siphuncle, obviously *Deiroceras*, from the same beds. The inference that the two fragments represent a single species is strong, although not capable of proof from the material at present available.

Certainly *Troedssonoceras* and *Deiroceras* are very closely related; it is questionable whether their separation is proper, even if some typical species are found to be perfectly smooth, and others definitely fluted. Other species with only very faint longitudinal markings will supply a transition. Further, it is not evident whether *Deiroceras python* is actually a smooth shell. For these reasons, it seems best to regard *Troedssonoceras* as a synonym of *Deiroceras*. Present information fails to supply differences distinguishing the genera other than those of preservation phenomena.

Deiroceras, sp.

Pl. I I, fig. 7.

The latest Trenton limestones of the Lake St. John region have yielded, in an association of Cobourg aspect, two fragments of a *Deiroceras*. One, not figured here, consists of three isolated siphuncle segments. There is not enough to show more than that it is a *Deiroceras*, and that it must have come from a relatively large shell. A second specimen is figured here, retaining four camerae and parts of a fifth. It is notable in that it has the slender form and very deep camerae of a *Deiroceras*, combined with fluting of the shell typical of *Troedssonoceras*. The shell is 72 mm long, expanding from 31 mm wide and 34 mm high, at the base, to 33 and 38 mm respectively, near the anterior end. Compression of the shell may be due to slight crushing rather than an original condition. Sutures are faintly oblique, sloping forward from venter to dorsum. The basal septum has a depth of 6 mm normal to the suture. The siphuncle is poorly preserved, but the septal foramen is here 6 mm wide and 7 mm high, located 5 mm from the venter and 22 mm from the dorsum. The four camerae are irregular in length, varying from 13 to 15 mm. The shell surface is lost, but the internal mold shows faint, low, rounded longitudinal ridges, with concave inter-spaces slightly wider than the ridges.

Discussion. The present material is regrettably fragmentary and inadequate for close specific comparisons. It is, however, of particular interest to find in the latest Trenton of Lake St. John, Quebec, two specimens, one of which shows the siphuncle of *Deiroceras*, the other showing the external fluted shell of *Troedssonoceras*. The occurrence of *Probillingsites* in the same association suggests Cobourg-Terrebonne age of the beds.

Holotype. Collection of Dr. G. W. Sinclair.

Occurrence. From the late Trenton of the Lake St. John region. Precise locality data not supplied.

A. *Adamsoceras isabelae*. Cross-section near base of holotype, with restoration of ventral outline prior to crushing. B. *Ormoceras dartoni*. Cross-section from near base of holotype. C-E. *Actinoceras margaretae*. Cross-sections: C, from base of holotype; D, from middle of phragmocone, septum at anterior end of pl. 2, fig. 8, and at base of pl. r, fig. 4; E, from anterior end of phragmocone, anterior end of pl. r, fig. 4. F. *Actinoceras aequale*. Cross-section, slightly distorted, from anterior end of phragmocone of holotype. G-I. *Actinoceras winstoni*. Successive sections: G, from base of preserved part of phragmocone of holotype, at middle of pl. 6, fig. 5; H, from anterior end of pl. 6, fig. 5, showing marked reduction in diameter of siphuncle; I, from anterior end of phragmocone, anterior end of pl. 7, fig. 4, showing extreme reduction in size and degree of expansion of the siphuncle segment. J. *Gonioceras quadratum*. Restored cross-section. K. *Gonioceras anceps*. Cross-section, middorsal area restored, based upon pl. 8, fig. 2-3. All sections approximately x 1.

Genus **ACTINOCERAS** Bronn

It is unnecessary to repeat a description of this genus, a task already adequately accomplished (Foerste and Teichert, 1930; Teichert, 1933; Foerste, 1933). The present discussion is limited to a stratigraphic survey of the species in the Ordovician, in an attempt to trace evolution within the genus and to determine the faunal and stratigraphic significance of the groups within it.

Shells of *Actinoceras* are generally large. Except for one breviconic group of species, shells commonly range between 2 and 3 feet in length. In this considerable length of the phragmocone, proportions change as growth progresses; there is sufficient difference between early and late growth stages that their specific identity is not at once obvious. Such changes involve all features: the spacing of the septa, the development of the lobes of the sutures, the curvature of the septum, the cross-section of the shell, the size of the siphuncle relative to that of the shell, and the nature of the outline of the segments. Generally, late siphuncle segments become smaller and simpler in outline. The suspicion of Foerste and Teichert (1930) that *Leurorthoceras* represents only a late growth stage of shells which in early stages are typical *Actinoceras*, has been confirmed by new material.

About 45 species of *Actinoceras* have been described from North America, including Greenland and the Arctic archipelago. Eastern Asia has yielded a single typical species, but none are known from Australia, Africa, Europe, or South America. The specimens on which most species are based represent relatively small parts of phragmocones and are almost invariably early parts, in which the siphuncle is large and broadly expanded. Indeed, specimens showing only late stages of the siphuncle, where the segments are small and scarcely expanded, formed the basis of another genus, *Leurorthoceras*. Except for one little known species believed to be an *Orthonybyoceras*, *Leurorthoceras* represents only late growth stages of *Actinoceras*; further, it represents mainly, though probably not completely, members of but one species group in the genus as outlined below. Several species have been based upon such short fragments of phragmocones that only commensurate specimens could be identified with them with absolute certainty. The situation is regrettable but natural. Material is commonly preserved in a fragmentary condition. Large, relatively complete shells are obtained only when a special effort is made toward that end. They rarely are found and usually are hard to obtain.

In spite of the obvious fact that knowledge of most of the described species is extremely fragmentary, it is possible to trace something of the evolution of the genus and to point out species groups and evolutionary trends within *Actinoceras* of considerable faunal and stratigraphic value.

The oldest species of *Actinoceras* thus far known are of Lowville age. The species *A. margaretae*, *A. aequale*, and *A. gradatum*, described in the following pages, show a diversity of proportions indicating appreciable diversity of form and suggesting considerable departure from unknown older and less diversified forms. *A. margaretae* is unique in the strongly fusiform shell, the strongly flattened cross-section, the relatively small siphuncle, and slight exogastric curvature of the early portion. *A. aequale* and *A. gradatum* are straight and less flattened, have larger siphuncles, and are more similar to

the Chaumont members of the *A. ruedemanni* group. An undescribed fragment from the Lowville of Meth Station, Ontario, shows short, broad siphuncle segments, indicating that there was differentiation of the *A. centrale* group as early as Lowville time.

GROUP OF *Actinoceras margaretae*

A. margaretae is so different from other species that it is perhaps deserving of a species group of its own. In a more general sense, it is related clearly to the *A. ruedemanni* group and not to any other. Its peculiar features have been noted above.

GROUP OF *Actinoceras ruedemanni*

Typical members of the *A. ruedemanni* group are essentially straight shells, fusiform over the anterior portion. The cross-sections lack the prominent flattening of *A. margaretae*, but are wider than high, and the venter may be slightly more flattened than the dorsum. Sutures have broad ventral lobes. Siphuncles are relatively large in the earlier two-thirds of the phragmocone; their outlines are sinuate, the recurved septal neck being as smoothly rounded as is the expanded portion of the segment outlined by the connecting ring in the camerae. In late growth stages the siphuncle becomes relatively small at the septal foramen, and the degree of expansion of the segment in the camera is reduced. Species for which late growth stages are definitely known do not attain such simplicity of outline that one would be tempted to assign them to *Leurorthoceras*. Latest growth stages of the siphuncles have been observed, however, only in relatively few of the species, and this generalization may not apply to all members of the group. Two species, *A. lebanonense* and *A. altopontense*, formerly assigned to *Leurorthoceras* are from the Lebanon horizon, presumably of Black River age. Other species of *Leurorthoceras* from eastern North America are younger and appear to pertain to late stages of the *A. capitolum* group, but the earlier age of these species raises at least the question whether *Leurorthoceras* could not have developed also in the *A. ruedemanni* group.

More typical of this group, however, are such shells with fusiform anterior ends and not attaining the simplicity of *Leurorthoceras*. Although the species has not generally been recognized, *Orthoceras fusiforme* Hall (1847) is certainly the anterior part of a large mature *Actinoceras*. Three species of *Actinoceras* in the same association are recognized from portions of phragmocones, *A. tenuifilum* (Hall), *A. ruedemanni* Foerste and Teichert, and *A. centrale* Foerste. Shells of the general aspect of *A. fusiforme* may be attained in late growth stages of all three species. Such specimens show considerable variation in size and in degree of contraction at the mature aperture. It is evident that there is wide variation here which may be explicable in terms of several different species of *Actinoceras* in the Chaumont limestone, possibly more than the three already described. A similar fusiform shell is developed in *A. beloitense* (Foerste and Teichert, 1930, pl. 28, fig. 2). The probable Platteville beds in the cryptovolcanic structure at Kentland, Indiana, yielded the anterior part of a large fusiform *Actinoceras*, which Rowley (1906) described as *Poterioceras kentlandense*. Shrock and Raasch (1937,

p. 575; Pl. 9, fig. 8-9) have reproduced Rowley's description and figure. Foerste (1921, p. 278) overlooked Rowley's species but identified *A. beloitense* from Kentland, Indiana. Without Rowley's type at hand, it is impossible to determine whether his species and *A. beloitense* are the same; there appear, however, to be sufficient differences to merit recognition of both species.

The following species are referred to the group of *A. ruedemanni*:

- A. aequale* Flower, Lowville beds of Ottawa.
- A. gradatum* Flower, Lowville beds of Ottawa.
- A. ruedemanni* Foerste and Teichert, Chaumont limestone of New York.
- A. tenuifilum* (Hall), Chaumont limestone of New York.
- A. beloitense* (Whitfield), Platteville limestone of Minnesota.
- A. kentlandense* (Rowley), Platteville beds, Kentland, Indiana.
- A. arcuonotum* Flower, Tyrone limestone, Kentucky.
- A. sinclairi* Flower, Simard limestone of Quebec.
- A. imperator* Clark, Rockland beds of Quebec.
- A. gravicentrum* Fenton, Prosser limestone of Missouri.

These are species which are fairly well known. With them it is reasonably safe to group the following species, typical in every respect insofar as they are known, but known only from relatively small portions of phragmocones:

- A. saffordi* Foerste and Teichert, Carters limestone of Tennessee.
- A. glenni* Foerste and Teichert, Tyrone limestone of Tennessee.
- A. kentuckiense* Foerste and Teichert, Tyrone limestone of Kentucky.
- A. altopontense* Foerste and Teichert, Tyrone limestone of Kentucky.
- A. libanum* Foerste and Teichert, Lebanon member, Camp Nelson limestone, Kentucky.
- A. poh/i* Foerste and Teichert, Tyrone limestone of Kentucky.
- A. jessaminense* Foerste and Teichert, Tyrone limestone of Kentucky.
- A. arcanum* Foerste and Teichert, Tyrone limestone of Kentucky.
- A. turinense* Foerste, Platteville limestone of Michigan.
- A. janesvillense* Foerste, Platteville limestone of Wisconsin.
- A. circulare* Foerste and Teichert, Plattin limestone of Missouri.
- A. cinctum* Foerste and Teichert, Plattin limestone of Missouri.
- A. adnatum* Foerste and Teichert, Plattin limestone of Missouri.
- A. billingsi* Foerste, Paquette Rapids bed of the Ottawa River.

The last two species are known to have the siphuncle in contact with the venter over a considerable series of camerae, and it is flattened accordingly. However, it has not been evident to what extent such flattening, which is nearly always present to some extent in early growth stages, is developed in many of the other species.

Regrettably, more than one form seems to have been figured as *Actinoceras bigsbyi*. Foerste's (1932, pl. 19, fig. 4) specimen belongs to the above group, but the original of Foerste and Teichert (1930, pl. 27, fig. 1A-C) is a different form, pertaining to the group of *A. paquettense*.

GROUP OF *Actinoceras centrale*

Occurring also in beds of Black River age is a group of species of *Actinoceras* characterized by closely spaced septa. The siphuncles are broad; as a consequence their segments appear extremely short in proportion. The outline of the segments is smoothly rounded; broadly rounded in the expanded portion and somewhat more narrowly rounded in the contracted portion. A listed undescribed specimen records the presence of this stock in the Lowville. The stock proceeds through the Chaumont and its equivalents into beds of probable Rockland age. The species are as follows:

- A. sp.*, Lowville limestone, Meth Station, Ontario.
- A. caneyense* Foerste and Teichert, Cannon or Tyrone beds of Tennessee.
- A. lentiexpansum* Foerste and Teichert, Cannon limestone, Tennessee.
- A. centrale* Foerste, Chaumont limestone of New York.
- A. pohli* Foerste and Teichert, Carters(?) limestone of Tennessee.

The only younger form which appears to belong to this group is *A. curdsvillense* Foerste and Teichert, from the Curdsville limestone of Tennessee. The species is known, however, from such a short portion of a phragmocone that until it is better known, its position anywhere is necessarily inferential.

GROUP OF *Actinoceras paquettense*

Here are included breviconic actinoceroids. The phragmocone never attained any appreciable length, but in the few extant camerae, rarely more than 20, are crowded such changes in form and size of the siphuncle as one finds by comparing the entire length of perhaps 30-40 camerae of members of the *A. ruedemanni* group. The specimen figured by Foerste and Teichert (1930, pl. 27, fig. 1A-C) is perhaps larger than most forms and supplies something of a transition into the *A. ruedemanni* group, which is regarded as ancestral to this one.

All members of this species group which come from beds of accurately known position, are of late Black River age, either equivalents of the Rockland, or lying in a possible pre-Rockland post-Chaumont hiatus. It is tempting to conclude that this species group may have some stratigraphic value. It may have, but there is one possible exception. *A. bellefontense* is from beds formerly identified as Lowville of Pennsylvania. It is now known that many beds formerly identified with the Lowville in the Appalachians and the east-central region, represent a Lowville type of environment, but are not equivalent to it in age. Unfortunately, it has not been possible to establish the origin of this species in more modern stratigraphic terms. Too many different things have been called Lowville. The species is not, however, good evidence of an earlier stratigraphic appearance of this species group than that suggested above.

The following species belong in the group of *A. paquettense*:

- A. paquettense* Foerste and Teichert, Paquette Rapids beds of the Ottawa River.
- A. abortivum* Flower, same occurrence.
- A. mutabile* Flower, Simard limestone, Quebec.

- A. bellefontense* Foerste and Teichert, "Lowville" beds of Pennsylvania.
A. glencoense Foerste and Teichert, Plattin limestone of Missouri.
A. cf. bigsbyi, the form noted previously from the Platteville of Wisconsin.

GROUP OF *Actinoceras winstoni*

Actinoceras winstoni is known from a relatively complete series of siphuncle segments. Although in early stages the segments are large, sinuate, and well expanded, they later become smaller, shorter, and only gently expanded, a condition maintained over the greater part of the length of the phragmocone. The extreme anterior end of the phragmocone shows, however, simplification of the siphuncle to the plano-convex segments formerly considered characteristic of the genus *Leurorthoceras*. Shells are well rounded in cross-section, not flattened; ventrally the sutures still have well-developed ventral lobes. Shells may be slightly curved but are not known to attain the gibbosity or the fusiform shape of the whole found in the *A. ruedemanni* group.

This species group is unknown in typical Black River faunas but appears instead to characterize beds of Trenton age. Any more precise statement involves differences of opinion as to precise correlations. In general such *Actinoceras* species appear to be found in Hull equivalents, although they may extend higher in Tennessee. The uncertainty stems from the difficulty of recognizing Sherman Fall beds and faunas in the Kentucky-Tennessee central basins.

- A. winstoni* Flower. Hull beds of Quebec.
A. capitolum (Safford), Bigby limestone, Tennessee.

So closely related as to be considered members of the same genus are *Troostoceras paulocurvatum* Foerste and Teichert and *T. paulocurvatum abbreviatum*, both also from the Bigby member of Tennessee. If one accepts as a generic criterion the slight exogastric curvature shown in the ventral profile of these two species, certainly still another genus is needed for the faintly endogastric *A. winstoni*. *Saffordoceras*, known only from a single specimen of *S. nelsoni* Foerste and Teichert, of the Catheys limestone of Tennessee, is allied also in the characteristics of the siphuncle. The genus *Saffordoceras* is based upon the presence of septa recurved laterally, somewhat as in *Gonioceras*. This feature is shown so irregularly in the type that one wonders whether it may not be a result of distortion. If so, the genus is not valid.

Since it is demonstrable that the essential features of *Leurorthoceras* are attained in the anterior ends of shells of this group, those species also must be considered. As previously noted, it is not certain that such simplicity cannot be attained in other species groups. However, from all evidence, whereas *L. lebanonense* and *L. altopontense* are older and especially in need of study from more complete specimens, *L. husseyi*, of Cornell, Michigan, may be included safely in the *A. winstoni* group. From the associated fauna it is the one actinoceroid in faunas of Cobourg-Stewartville age and affinities. Other species are from the Arctic and are either: (a) Constituents of Red River faunas; (b) possibly from pre-Red River beds which have not been differentiated from the overlying Red River, but which should be; or (c) from erratics or from occurrences in situ in the Arctic, from regions where the

stratigraphy and faunas are so poorly known that definite stratigraphic assignment is not possible.

GROUP OF *Actinoceras simplicem*

This species group is characterized by siphuncles in which the early segments are broad and evenly rounded. In late growth stages, however, the siphuncle remains large and ventral, but the expansion of the segments in the camerae is greatly reduced.

Actinoceras simplicem Flower, n. sp., is a new name proposed for the species and the specimen which Foerste (1929, pl. 26, fig. 1) described and figured as *A. cf. bigsbyi*, from the Dog Head member of the Red River of southern Manitoba. The holotype (Geological Survey of Canada, no. 5598) is from the Dog Head limestone of Clark's Point, Lake Winnipeg. Necks are long, at least half the length of a camera, and are scarcely recurved; the whole of the segment is only faintly convex.

Actinoceras incantatum Flower is a member of this same species group, although the trend toward reduction of the siphuncle segments is less advanced. *Actinoceras* sp., figured by Miller and Carrier (1942, pl. 79, fig. 2-3), exhibits this same general trend. From the nature of early siphuncle segments, this species group is logically a modification of the *A. centrale* group of Black River time.

In the Richmond of Anticosti are found species not very adequately known, it is true, but nevertheless showing features of this species group. *A. gamachiense* Foerste (1928, p. 290, pl. 42, fig. 1, 2) is anomalous in the very large cross-section of the siphuncle and the ventral flattening of both siphuncle and shell. However, the dorsal wall of the siphuncle shows a simplification of outline typical of the present group.

Actinoceras carletonense Foerste (1928) is still less adequately known. Foerste (1928, pl. 42, fig. 3) illustrates some broadly rounded siphuncle segments which appear to decrease markedly in size as traced orad over a short series of camerae. The adoral reduction in size of the segments is explicable by the nature of the section, which penetrates close to the middle of the segment apically, but which departs progressively from the median line as is traced orad. With allowance for this, the segments are fairly typical of the *A. simplicem* group. Another figure (Foerste, 1928, pl. 43, fig. 2) shows a portion of a siphuncle from a later growth stage. Necks are long, gently recurved, the tips pointing obliquely outward and backward; the remainder of the segment is more rounded than is typical of the *simplicem* group, but closer nevertheless to members of the group than to those of any other.

GROUP OF *Actinoceras anticostiense*

In this species group early siphuncle segments may be well rounded and sinuate in outline, as in the *A. ruedemanni* group. Over most of the phragmocone, however, the adult segments show a long tubular anterior region, and an apical region, often less than half the length of the segment, in which the expansion is abruptly concentrated. The septa bend to form long tubular septal necks, which terminate in very short brims, abruptly recurved, which mark the anterior end of the strongly rounded expanded part of the segment.

Apically the connecting ring is broadly adnate to the apical septum.

A. anticostiense is the only member of the group represented by a reasonably complete shell (see Foerste 1928-a, p. 227; pl. 4, fig. 1; pl. 5, fig. 1-3). As in the *A. ruedemanni* group, the shell expands moderately rapidly and is depressed in section. Sutures develop broad lobes as they cross the venter but are essentially transverse on the dorsum. An anterior reduction in rate of expansion of the living chamber gives the shell a fusiform appearance, but the condition is not so extreme as in members of the *A. ruedemanni* group.

Two Richmond species belong here, *A. anticostiense* (Billings), of the English Head and Vaureal formations of Anticosti, and *A. parksi* (Foerste 1921), of the Shamattawa limestone of Hudson Bay.

In the Bighorn group of Wyoming, dolomitization has obscured original differences between an early Red River series of deposits and a later Richmond series. It has also left the rock so hard and massive that collecting in place is almost impossible. Most specimens are known from fallen boulders. It is, therefore, uncertain from what part of the Bighorn group a similar form was derived. A species figured as *Actinoceras* sp. by Miller and Carrier (1942, pl. 79, fig. 1) clearly belongs to the *A. anticostiense* group.

A. huronioides, of the Simard limestone of Anticosti, is plainly a forerunner of this species group. It is the only species of Black River age even tending toward the siphuncle outline of the *A. anticostiense* group. Presumably this is the form which Barrande (1870, pl. 434, fig. 9-10) figured as *A. anticostiense*, from the Lake St. Jean area.

INADEQUATELY KNOWN SPECIES

A number of specimens of *Actinoceras* have been figured and described, but happily not named, based upon inadequate material from Red River and Richmond faunas. Sweet (1955) figured and described as *Actinoceras* sp. a fragment of a few camerae, evidently of a rather early growth stage, from the Fremont limestone of Colorado. The camerae are unusually long, the septa strongly oblique. Not enough of the siphuncle is exposed to permit placing it in any of the above groups even tentatively. All that can be said is that the rather long septal necks are consistent with this being a member of the *A. simplicem* or of the *A. anticostiense* group.

Miller and Carrier (1942, pl. 75, fig. I) figure as *Actinoceras* sp. a shell in which the dorsum, as well as the venter, bears broad lobes. Dorsal lobes are elsewhere unknown in the genus. As the siphuncle is not exposed, reference of the specimen to *Actinoceras* is necessarily tentative.

Miller (1932) described a large orthoconic shell from the Lander sandstone of the Bighorn group as *Actinoceras enterprisense*. The siphuncle is large and subcentral, but details of its outline are not reported. It cannot be assigned, therefore, to any of the above species groups.

ARCTIC SPECIES

From the foregoing discussion, it is evident that Black River *Actinoceras* species fall into three species groups unrecognized in Red River faunas. Red River and Richmond species fall into two other groups. Only one species, *A. huronioides*,

of the Black River, presages the later development of the *A. anticostiense* group. With this single exception, the two species groups last mentioned are unknown in faunas as old as the Black River. The discussion of Arctic forms has been delayed until the completion of the treatment of more southerly species of better established stratigraphic position, in order that they could be evaluated in terms of the conclusions thus reached.

It is in the Arctic that *Actinoceras* occurs in: (1) True Red River associations; (2) associations which may underlie Red River faunas, but which thus far have not been distinguished from them; and (3) isolated localities where there is so little evidence, from observed stratigraphy or associated faunas, that there is no basis for an attempt to evaluate the beds in terms of any part of the Black River-Richmond interval. It remains to see how these species fit into the species groups established above, and what stratigraphic conclusions they may suggest as to age.

Beneath the Cape Calhoun series of Greenland is the Gonioceras Bay limestone. It has yielded no species described by Troedsson (1926) in terms of *Actinoceras*, but it is necessary to assign to *Actinoceras* two species described in terms of *Leurorthoceras*, and one which has been assigned to *Kochoceras*. *Actinoceras vetustum* (Troedsson) is removed to *Actinoceras* from *Kochoceras* because, as discussed under that genus, the ventral profile of the siphuncle is more in accord with this generic assignment. The species is of the *A. ruedemanni* group and is one of several forms in which the expanded part of the siphuncle is appressed against the ventral wall of the camerae. Of the two species formerly assigned to *Leurorthoceras*, there is not enough known to attempt any analysis in terms of species groups. Assignment to the group of *A. ruedemanni* is possible, but our present incomplete knowledge of the species does not eliminate assignment to other groups, notably that of *A. winstoni*. Such a possibility seems unlikely, for what is known of the fauna suggests a Black River age and an interval not particularly late within these limits.

From the Cape Calhoun beds of northern Greenland Troedsson (1926) described *A. tenuifilum* var. *clarkei*, which Teichert (1933) later reassigned as *A. ruedemanni* var. *clarkei*. It clearly belongs to the group of *A. ruedemanni*, with large siphuncles of smoothly rounded profile; its affinities with *A. ruedemanni* are certainly close. *A. centrale calhounense* clearly is related to the Chaumont *A. centrale*, but the siphuncle is slightly larger in proportion to the diameter of the shell, and the camerae are not as short. One would ally both forms with Black River rather than with Richmond or Red River species.

Baffin Island has yielded two fragments tentatively assigned by Miller, Youngquist, and Collinson (1954) to *A. ruedemanni* var. *clarkei*. The fragments are short; only one shows any part of the siphuncle, and only one shows any indication of the siphuncle. Reference to *Actinoceras* is likely, but any specific reference is extremely hazardous with such material.

Actinoceras sp. Foerste (1921, pl. 27, fig. 7) appears to be typical of Black River species in the short necks, expansion of the segment over most of the length between the septa, and contraction of anterior siphuncle segments. It is from Boothia Felix or King William Land.

Actinoceras tenuifilum ursinum Foerste (1921), from Bear

Island, is a form clearly deserving of specific rank, with extremely broad, short siphuncle segments. It belongs to the *A. centrale* group.

A. amundseni Foerste (1921), from Boothia Felix or King William Land, is known only from a fragment, but is peculiar in several respects. Ventral lobes of the sutures are subangular instead of rounded. Necks are very short, and the siphuncle is unique in that the greatest width of each segment is concentrated in its anterior half. Apically the rings are very broadly adnate to the septa, which are steeply inclined.

Actinoceras sp. Foerste (1921, pl. 29, fig. 3) is known from a natural, nearly vertical longitudinal section. The doubtful occurrence (Boothia Felix or King William Land) is the same as for *A. amundseni*. Siphuncle segments appear typical of the *A. ruedemanni* group.

Teichert (1937) has added other species from Washington Land. His *A. boggildi* is known from a short portion of a shell, evidently from the apical rather than the adoral part of the phragmocone. Siphuncle segments are unusually short and broad. Slight contraction of the 8th and 9th segments suggests that the species may belong to the *A. paquettense* species group. His *A. websterense* is unquestionably part of a larger, more elongate shell. Again necks are short, and the segment is broadly rounded and expanded in the camera over most of its length. It appears to be allied to the *A. ruedemanni* group.

From the above discussion, it is evident that Arctic species are of Black River aspect. Singularly, none of them, even those reputedly from the Cape Calhoun beds and therefore presumably part of a faunal association of Red River aspect, can be placed in either of the two species groups known to characterize the later Ordovician Red River faunas or the younger faunas of Richmond age.

It should be noted that in eastern North America, *Actinoceras* reaches its peak in the boreal faunas of Black River time. The stock declines in early Trenton time, the last species in Quebec being of Hull age. If there are any species of Sherman Fall age, they are not found in typical Sherman Fall faunas, although some *Actinoceras* from the younger Trenton of Tennessee may prove to be that young. Only "*Leurorthoceras*" *husseyi* represents the genus in faunas of Cobourg age and aspect, though it is true that the anomalous *Saffordoceras* of the Catheys of Tennessee is probably contemporaneous. The genus is unknown in the Cincinnati of the east-central region, Ontario, and Quebec. The sole invasion of the genus in the east in Richmond time is known on the Island of Anticosti.

ASIATIC SPECIES

Actinoceras is rare in eastern Asia. Kobayashi (1934) recognizes only one valid species of the genus, *A. concavum* Endo (1932). This form has a siphuncle of rather short, broad segments; the necks are short, and the greater part of the length of the segments are convex in outline. It appears to be allied to the group of *A. centrale* and is certainly typical of the species of Black River age in eastern North America. Endo (1935) has since assigned three other species to *Actinoceras*, all of which are atypical in the small size of the shell and the small size of the siphuncle, or both, and it would appear that they would fit better in the Ormoceratidae. Of these forms, *A. kakui* is known from a portion of phragmocone far

smaller in diameter than the usual apical ends of *Actinoceras*. Its internal structure is not well displayed. *A. konoii* is only slightly larger, is again closely septate, and has a small siphuncle which is central. *A. fuchouense* is somewhat larger but, again, closely septate; the siphuncle is anomalously small. Early stages of Cincinnati *Orthonybyoceras* are reminiscent of what is known of *A. konoii* and *A. fuchouense*. Certainly none of these species is a typical *Actinoceras*.

Actinoceras margaretae Flower, n. sp.

Pl. 1, fig. 1-4; pl. 2, fig. 8; text fig. 3C-E.

This is a large, striking fusiform species, notable for the slight exogastric curvature of the early portion, the strongly depressed cross-section, with venter more flattened than dorsum and sides strongly rounded, and the relatively small siphuncle. The holotype is a nearly complete mature shell 19.5 in. long, expanding in a length of 300 mm from 15 to 21 mm, at the base, to 67 and 88 mm, near the base of the living chamber, and contracting to 85 and 35 mm at the aperture, where crushing has caused some distortion, in an additional length of 170 mm. Sutures are straight and transverse dorsally and laterally, and describe broad rounded lobes on the venter. Camerae vary in depth. The first few are between 7 and 8 mm long, shortening to 6 mm, then increasing gradually to 9 mm, after which they shorten irregularly to 7 and 8 mm. The spacing of the camerae is somewhat erratic; the last five occupy a length of 15 mm. At the apex, the siphuncle is so close to the venter that no camerae can be seen between its ventral wall and the ventral wall of the shell. In vertical section, the sutures slope forward from the siphuncle to the dorsum and are scarcely curved. The slope is about equal to the length of a siphuncle segment. In the anterior part, the septa become more normally curved, the greatest septal depth being near the center of the shell and dorsal of the siphuncle. Here at a shell height of 56 mm, the septum is 10 mm deep, equal to the length of one and one-third camerae.

The siphuncle segments, comparatively large in the first few camerae, rapidly become relatively slender. In the anterior third of the phragmocone, the height across the septal foramen increases more rapidly than does the maximum height of the segment, with a consequent reduction in the convexity of the individual segments.

A vertical section through the apical 160 mm of the phragmocone (pl. 2, fig. 8) shows the venter slightly and uniformly convex. Concavity of the dorsum is marked, and probably increased from its original condition by slight crushing, as indicated by some irregularity of the septa. In this length the cross-section is only slightly depressed initially. Adorally it has become 36 mm high and 60 mm wide; venter flattened, slightly convex, sides strongly rounded; dorsum more arched than the venter, with very slight dorsolateral flattening (text fig. 3D). The first segment of the siphuncle estimated at 0 mm is incomplete but anomalously long. It expands vertically from 11 to 17 mm. The next five segments show a general decrease in the septal foramen and maximum expansion of the segment. At midlength of the section, a segment expands from 6 to 11 mm and is 7 mm long. From this point the camerae increase gradually in length, and the segments of the siphuncle enlarge, so that at the anterior end of the section a segment is 8 mm long, increasing vertically from 8 to 16 mm.

A second section shows the anterior part of the phragmocone (pl. 1, fig. 4). Here inorganic calcite has obscured the basal portion to some extent. It can be seen, however, that the siphuncle segments are enlarging, the camerae are increasing gradually, and the siphuncle segments are coming to be more distant from the venter. The basal 78 mm contains nine camerae, where the calcite somewhat obscures the outline of the siphuncle. It is evident, however, that near the base a segment 9 mm long expands from 7 to 14 mm. The septal foramen is 11 mm from the venter and 29 mm from the dorsum. The next eight segments, in a length of 60 mm, show a gradual decrease of length to 8 and 7 mm. The curvature of the septum is marked here, the siphuncle remains about the same distance from the venter, and the septal foramen increases more gradually than does the height of the shell. The foramen thus becomes increasingly oblique. Expansion of segments in the camerae is reduced, a segment near the base of this interval, the 11th in this section, increasing from 6 to 11 mm, whereas the 17th shows an increase from 7 to probably 10 mm, the dorsal siphuncle wall being lost here. Comparison in the troth segment shows that the ventral wall of the siphuncle is expanded by 3.5 mm, the dorsum by 2.5 mm. In the 17th, the venter is increased by only 1.8 mm; expansion on the dorsum is always slightly less. The anterior six segments occupy a length of 20 mm. One septum is missing dorsally, and the segments shorten without any reduction in the general increase across the septal foramen. Expansion in the camerae is reduced still more. In this species the anterior segments more closely resemble those of an *Ormoceras* exceptionally broad across the septal foramen than those of a *Leurorthoceras*.

Deposits in the siphuncle show a large apical cavity. Either the true shell apex is represented here, or if there were early segments atypical of *Actinoceras* in the outline of the segments, as in *A. ruedemanni* (Flower, 1940), they may have been lost in life, for the enlarged cavity here seems a normal one, rather than a result of solution upon the deposits. The anterior part of the section shows traces of the central and radial canals in several places. It is notable that the central canal lies very close to the dorsum in the apical part and later gradually assumes a central position. The anterior end of the basal section (pl. 2, fig. 8) shows the anterior end of the canal widening, for deposits have not grown to completion here. There is no trace of deposits at all in the anterior 15 segments. The development of episeptal deposits is unusually slight in this species. Such deposits are confined to the apical 16 camerae, although they may extend farther forward on the venter, where recrystallization has obscured them.

The living chamber, 170 mm long, retains part of the aperture dorsally. Crushing has decreased the original height, and probably has increased the original width slightly, thus tending to reduce the fusiform condition of the shell as viewed dorsally or ventrally, but exaggerating it in lateral view.

Discussion. This *Actinoceras* is distinctive in the unusually broadly depressed cross-section attained in the anterior part of the phragmocone. The siphuncle is exceptionally slender, although the form of the segments places the species in the group of large Black River species, rather than in the group of *A. capitulinum*.

Among associated species, *A. aequale* is a larger form, and less strongly fusiform anteriorly; the siphuncle is larger, the cross-section less depressed. *A. graclatum* has camerae so simi-

lar in depth to those of *A. margaretae*, that at first the two species were thought to be one; its siphuncle, however, is again much larger in diameter in proportion to the shell as a whole. The species is unique in the broadly depressed cross-section with strong dorsolateral flattening.

Holotype. Collection of the writer.

Occurrence. From the Lowville beds, Ottawa, Ontario.

Actinoceras aequale Flower, n. sp.

Pl. 3, fig. 1-5; text fig. 3F.

The holotype is a large shell, rather rapidly expanding initially, 490 mm long, and slightly fusiform over the living chamber. It increases gradually from 24 and 35 mm to a width of 95 mm and a height estimated at 70 mm, in the 300 mm of the phragmocone, at the anterior end of which the dorsal profile becomes slightly convex. Vertical crushing has altered the proportions of the living chamber, but it extends for a maximum length of 165 mm, in which the lateral profiles become slightly convex, attaining a width of 164 mm, at the last possible measurement, and an estimated width of 190 mm at the extreme anterior end, with an incomplete height of 60 mm. Allowance for crushing suggests an original adoral width of 85 mm and a height of 75 mm.

The cross-section is wider than it is high, but shows both dorsum and venter evenly and equally rounded. Sutures are transverse over most of the phragmocone and show only broad shallow lobes on the venter, a condition maintained to the anterior end of the phragmocone. The camerae increase from 10 mm, where they first can be made out, to 15 mm; the last few are contracted, indicating that the holotype represents a mature shell.

The basal 90 mm expands from 24 and 35 mm to 42 and 50 mm. In this length coarse calcite has obscured septa and siphuncle. A cross-section at its anterior end (pl. 3, fig. 4) shows the siphuncle narrowly arched middorsally, slightly flattened dorsolaterally, strongly rounded ventrolaterally, and slightly flattened ventrally. It is 23 mm high and 24 mm wide. There is a faint production of the outline laterally. The deposits in the siphuncle bear a midventral protuberance, are thin ventrolaterally to dorsolaterally, and are thicker middorsally.

The next 155-mm interval of the phragmocone (pl. 3, fig. 5), incomplete dorsally, is sectioned in the vertical plane, exposing the siphuncle and showing part of 14 segments. Camerae here increase in length from 10 to 12 mm. At the base a siphuncle segment expands from 21 to 30 mm vertically, the expanded part being in contact with the mural part of the septum ventrally, but removed from the dorsum by 14 mm. At the adoral end, where the shell is 80 mm wide and 68 mm high, the septal foramen has decreased from 21 to 12 mm and is 15 mm from the venter, where the distance before was 5 mm. The connecting ring is lost dorsally here, but a few segments earlier the siphuncle expands from 12 to 21 mm in the camerae. Necks have become longer and brims shorter by proportion; the whole segment is small in proportion to the shell, and its expansion in the camera is reduced markedly.

The anterior, unsectioned part of the specimen contains 6 normal camerae, ranging up to 15 mm in depth, in a length of 70 mm, followed by 3 gerontic camerae occupying the last 20 mm. The proportions of the living chamber have been

given already. It should be noted that the aperture is not attained; the living chamber, however, could not, by analogy with other species, be much longer than the extant portion.

Siphonal deposits are typical. The anterior portion shows annuli fused on the venter, and essentially continuous from the 16th camera from the living chamber to the apex. The most adoral ventral annulus is in the 12th camera from the living chamber. On the dorsum the last annulus is in the 17th camera, and deposits are fused from the 19th or 20th camera to the apex. In the sectioned portion the fusion of deposits leaves a simulacrum of an endosiphon, which must terminate in the central tube at about the middle of the apical 90 mm of the specimen. Recrystallization apparently has destroyed radial canals in the portion sectioned. This portion also is notable in that it shows no cameral deposits between the siphuncle and the dorsal wall, although thin episeptal deposits extend to the 20th camera from the living chamber, between the siphuncle and the venter.

Portions of the shell are preserved but show no surface markings.

Discussion. This species is a rather short fusiform *Actinoceras*, in contrast to the two associated species or to typical members of the group of *A. ruedemanni*. It fails to approach, however, the group of breviconic species, of which *A. mutabile* is one of the largest and longest known. Of associated forms, *A. margaretae* is distinguished by a shell more slender initially, more definitely fusiform adorally; its siphuncle is uniformly smaller in proportion to the shell, the cross-section broadly flattened, and the septa more closely spaced. *A. gradatum* is more slender in the early phragmocone; septa are more closely spaced, the adoral reduction in size of the siphuncle segments occurs earlier, and the species was apparently a considerably smaller shell when mature. *A. ruedemanni*, closest in siphuncle proportions of the early phragmocone, was a much longer and more slender shell, one in which the early phragmocone enlarges much more gradually. The same differences will separate other Chaumont and Platteville species.

Holotype. Collection of the writer.

Occurrence. From the Lowville beds, on the outskirts of Ottawa, Ontario.

Actinoceras gradatum Flower, n. sp.

Pl. 2, fig. 1-5.

This species is known from a relatively complete portion of a phragmocone, 275 mm in length. The shell is moderately and uniformly expanded, increasing from 22 and 25 mm, at the base, to 43 and 56 mm, in the basal 100 mm. It attains a maximum width of 71 mm, near the adoral end, with an estimated height of 45-50 mm, the dorsum being weathered there. The cross-section is slightly depressed, but the dorsum and venter are equally rounded basally; adorally the dorsum appears to have been slightly more flattened than the venter. The sides are broadly rounded, contrasting with the much more narrowly rounded sides in *A. margaretae*.

The basal 100 mm, sectioned essentially vertically, has 4 camerae basally in a length equal to a shell height of 30 mm, and adorally 3 camerae in a similar length equal to an adoral shell height of 30 mm. Sutures are transverse dorsally and laterally, and are not displayed ventrally; any ventral lobation evidently is relatively slight. The siphuncle expands here

proportionately with the increase in the diameter of the shell. At the base a siphuncle segment increases in height from 15 to 19 mm and is 7 mm in length. Adorally the segment increases from 20 to 26 mm and is 9 mm long. On the venter the expanded part of the segments is in contact with the ventral wall of the shell, a feature lost in later growth stages. Calcite replacing the annulosiphonate deposits is coarse, and most original structure has been lost. Adorally a rather large central canal is evident, and traces of curved radial canals typical of the genus are evident at several places. At the base the cavity of the central tube is considerably expanded, a feature which suggests that the present specimen approaches very close to the true apex of the shell. No ontogenetic progression, such as was observed in *A. ruedemanni*, is evident. On the ventral side of the siphuncle, calcite largely fills the cameral space, here very small, and some cameral deposits are probably involved. On the dorsum there is only a very faint thickening of the free part of the septa. The mural part of the septa and the shell wall are missing dorsally.

The next anterior part of the specimen shows two cross-sections of shell and siphuncle. The basal section (pl. 2, fig. 5) shows a shell 44 mm wide and 36 mm high. The siphuncle is 22 mm high. In the plane of the section, it is in broad contact with the venter but is curious in shape, widening gradually from the dorsal side to two lateral nodelike expansions well below midheight, and then narrowing, the sides becoming convex again after a short concave interval, as the venter is approached. The central canal is broad, faintly and rather irregularly lobed, 6 mm wide, 4 mm high, 6 mm from the dorsal wall of the siphuncle, and 14 mm from the ventral wall. The curious shape of the siphuncle in cross-section has not been fully explained, nor has it been noted in other species. It is partly due to a section cutting the siphuncle segments at right angles to the shell axis, and thus slightly obliquely in reference to the segments of the siphuncle. The faint lateral nodose expansions are, however, not susceptible to such an explanation. Cameral deposits form a band of light calcite against the mural part of the septum and the ventral shell wall, and are not differentiated clearly from the septa because of replacement. They are present only in the ventral half of the shell.

A second section, 14 mm farther forward (pl. 2, fig. 4), presents a very different aspect, largely because it cuts the segment at a different level, one showing something less than maximum expansion on the venter, but the maximum expansion on the dorsal side. The shell is 45 mm wide, with an estimated height of 37 mm, the dorsum being not quite complete. The siphuncle here is 26 mm wide, and 25 mm high, showing none of the irregularity of the preceding section. The siphuncle is not quite in contact with the venter. It is surrounded by a band of calcite, marking intersection of the plane of the section with a septum very close to the siphuncle. The central canal is large here, and portions of a number of radial canals can be seen. There is evidence of a bilaterally symmetrical pattern in two prominent dorsolateral radial canals lying in the plane of the section, a ventral concavity, and ventrolateral extensions of the central tube.

In the anterior 160 mm, 18 segments of the siphuncle are shown. Here the siphuncle undergoes two important changes, a general reduction in the size of the segments and a gradual removal of the siphuncle from the ventral wall of the shell. Basally a segment expands in height from 17 to 26 mm, is

10 mm long, and is 5 mm from the venter at the septal foramen. Adorally a segment increases in height from 7 to 14 mm and is 9 mm from the venter.

Camerae in this part increase gradually from 7 to 10 mm in length; no adoral contraction of the camerae is evident. The marked anterior reduction in the siphuncle is an indication that the type comes close to the anterior end of the phraemocone. Siphonal deposits thin adorally in this part of the shell. The last trace of the deposit on the dorsal side is

○ camerae from the anterior end; on the venter the deposits extend to the third camera.

Throughout the shell the septal necks are moderately recurved and remain appreciably shorter in length than half the length of the camera.

Discussion. Externally this species is similar enough in rate of expansion and spacing of septa to be confused with *A. margaretae*. It is evident not only that there is a marked difference in the cross-section, this species being much more broadly rounded laterally and lacking the marked ventral flattening of *margaretae*, but that the proportions of the siphuncle are completely different, the segments being much larger, showing a later and much less marked reduction in size, and lacking the apical arcuation which that species possesses.

Holotype. Collection of the writer.

Occurrence. From the Lowville of Ottawa, Ontario.

Actinoceras sinclairi Flower, n. sp.

Pl. 7, fig. 3; text fig. 4A-B.

The holotype is a specimen 270 mm long, preserving somewhat more than the ventral half of a siphuncle of 32 segments, with traces of the ventral shell wall and septa over the anterior 19 segments. The siphuncle segments enlarge gently over the basal two-thirds of the type and contract gently over the anterior third. The segments and the camerae show a gradual reduction in length, being 10 mm long basally and decreasing to 9.5 mm, so that there are 11 camerae in the basal 110 mm of the specimen. Reduction is continued to 7 mm in length near the anterior end, beyond which the three anterior camerae are anomalously long, 9 to 10 mm in length. The basal segment increases laterally from 15 to 18 mm; the expansion is gentle and well rounded. The 10 segment, 9.5 mm long, expands from 18 to 23 mm, showing the constricted portion somewhat elongated, but still gently concave and not sharply set off from the convex apical portion. By the 16th camera the anterior part of the segment outlined by the neck is nearly two-thirds the length of the segment. Its outline is faintly concave, but the curvature of the apical expanded portion is much greater. By the 28th segment the anterior contraction of the siphuncle is marked. Here the segment is 9 mm long, expanding from 12 to 15 mm; the neck is more evenly curved again and clearly less than half the segment in length. Further contraction in the last 5 segments is apparent, but the siphuncle here is weathered below its center. The maximum width is not shown, and the contraction is therefore exaggerated.

Parts of the anterior 19 camerae are preserved. The septa are gently curved on either side of the siphuncle and slope strongly forward from it as they approach the shell wall. The camerae are 18 mm deep, where the shell measures 45 mm across, although this measurement clearly does not represent the maximum shell width, which would be obtained farther

toward the dorsum than is shown by any preserved part of this specimen. The natural section as viewed shows the mid-ventral line slightly to the left of the center. There the siphuncle is very close to the shell wall, and the expanded part of the segment is separated narrowly from being in contact with the shell. It is estimated that the shell is a gently expanded one, probably increasing from 65 to 70 mm in the anterior 150 mm, where traces of the camerae are preserved. The specimen clearly did not quite attain maturity, for the anterior camerae are longer than those preceding, and elsewhere in the genus anterior camerae are shortened. Without this evidence, one would be tempted to conclude that the gradual decrease in depth of camerae and decrease of the size of the anterior segments of the siphuncle indicate an approach to maturity.

Basal siphuncle segments are close to those of *A. bigsbyi* (of Foerste, 1932-33) in form but are broader in proportion to their length. Anterior segments are shortened and anomalous, first in developing quite long necks with very short brims, and later in reducing the length of the neck and returning to a more generalized and more smoothly rounded outline of the segment.

The trend shown in the middle anterior camerae of this species toward the group of *A. anticostiense* is developed over a much shorter series of camerae in *A. huronioides*. That species clearly had siphuncle segments which were even broader in proportion to their length, and had in general a series of segments which increase rather than decrease in length as growth progresses.

Holotype. Collection of the writer.

Occurrence. From the lower beds of the Simard limestone; from a quarry on the outskirts of Ste. Anne de Chicoutimi, Quebec.

Actinoceras huronioides Flower, n. sp.

P1.8, fig. 8.

Although only the siphuncle of this form is known, it is so remarkable as to distinguish this species from all other known *Actinoceras*. The type siphuncle is 30 mm long and contains 19 segments. It is slender, 22 mm across at mid-length, and so uniform that there is no apparent reduction or expansion of diameter with growth. There is, however, a remarkable ontogenetic variation in the outline of the siphuncle segments. A basal segment, 5 mm long, shows a strongly rounded neck, with a brim pointing obliquely out at the tip; expansion of the segment on one side 3.5 mm; brim and neck subequal and 1.5 mm; area of adnation 3 mm. Here the siphuncle segment must have been at least 12 mm, and probably 14 mm, across at the septal foramen. Anterior segments show a gradual lengthening of the neck, reduction of the brim, and reduction of expansion of the segment in the camerae. By the 12th segment, its length is 7 mm, the wall shows an expansion of 3.5 mm, and the area of adnation is 3 mm. The neck has increased to 3 mm, and the brim has decreased to 1 mm. The anterior end of each segment is gently concave, the apical end gently convex.

By the last three camerae, the 6th to the 18th, the segment has become much more slender, and the neck lengthens, so that there is a long anterior region, slender, very gently concave, the expansion rather strongly limited to less than the apical half. The whole aspect of the segments resembles su-

perforated that of a *Huronina*, although in that genus the expansion is, of course, in the anterior, not the apical, half of the segment. The segment here is 8 mm long and expanded only by 2 mm. The area of adnation is between 0.8 and 1.9 mm, the neck is increased to 4.5 mm, the brim reduced to 0.8 mm.

Discussion. Although the siphuncle is incomplete, the segments were obviously very broad in proportion to their length. The ontogenetic progression in a series of 19 camerae is much more marked than that found in the 31 camerae of *Actinoceras sinclairi*. It is notable that early segments of the siphuncle are typical of the group of *A. ruedemanni* in general outline; the necks are well recurved, brims pointing obliquely apicad and distad, and well developed. As growth progresses, the condition of the group of *A. anticostiense* is approached. The present species fails to show the extreme straightness of outline of the anterior end of the siphuncle segment which properly characterizes that species group, but does approach it more closely than any other *Actinoceras* yet known from the Black River association.

Holotype. Collection of the writer.

Occurrence. From the Simard limestone; from a quarry on the outskirts of Ste. Anne de Chicoutimi, Quebec.

Actinoceras mutabile Flower, n. sp.

Pl. 2, fig. 7; pl. 4, fig. 4-5; pl. 5, fig. 8; text fig. 4C-D.

This is a relatively small *Actinoceras*, with a faintly fusiform living chamber. The holotype, 131 mm in length, contains a phragmocone 85 mm in length, with 13 camerae, expanding from 27 and 30 mm to 34 and 47 mm. It has a living chamber incomplete adorally, with a maximum length of 81 mm. The living chamber increases uniformly with the phragmocone in the basal part, increasing from 34 and 47 mm to 37 and 54 mm in the basal 35 mm; later the lateral profiles become convex, so that adorally the rate of expansion is reduced markedly. Restoration of the anterior end gives a width of 60 mm and a height of 34 mm. There is no trace of the aperture. The living chamber may have been half again as long when complete. The ventral profile also is very slightly convex over the anterior end of the living chamber. The dorsum there is so crushed that the original condition of its profile is not evident.

The shell surface is nowhere preserved. The surface of the internal mold is preserved particularly well on the venter and shows faint numerous longitudinal impressions, all very faint but with a median one stronger than the others, possibly representing the conchial furrow (Flower, 1939), which has not been observed elsewhere in actinoceroids.

In cross-section the shell is always wider than high, the width progressing proportionately in relation to the height, as growth progresses. The convexity of the cross-section is slightly greater dorsally than ventrally.

Sutures are straight and transverse dorsally and laterally, but describe very broad shallow lobes on the venter. The penultimate septum is exposed, showing a width of 44 mm and a height of 35 mm. The depth of the septum from the dorsal suture is 10 mm, but from the ventral suture only 5 mm. The septal foramen here is circular, 4 mm across and 4 mm from the venter.

The basal part of the specimen was sectioned vertically and exhibits a gradual adoral decrease in depth of camerae and

an amazingly rapid adoral decrease in both maximum and minimum diameters of the siphuncle. At the base, where the shell is 27 mm high, the camera is 9 mm deep. The siphuncle here expands from 13 to 30 mm in height. Succeeding segments become gradually shorter and rapidly much smaller (pl. 5, fig. 8). At the anterior end of the sectioned portion, the third camera from the base of the living chamber, the shell is 34 mm high; the siphuncle segment expands from 8 to 11 mm and at the septal foramen is 4 mm from the venter. It will be noted that the expansion of the segments is much greater basally than anteriorly. At the base the expanded part of the segment is separated more narrowly from the shell wall than at the adoral end. Should reduction of the siphuncle progress much farther, the resulting segments would be essentially those of the mature portion of *Leurorthoceras*. Only in the two adoral camerae is the siphuncle unobserved. It is noteworthy that the segments of the siphuncle are fairly uniform in outline throughout in the first five camerae. The length of the camerae contracts slightly, however, and the septa become less oblique, and more transverse on the dorsal side of the siphuncle. It is in the next four camerae that the siphuncle contracts markedly, a condition continued into the next two camerae, though the rate of contraction is reduced. Septal necks shorten only slightly as growth progresses; basally they are about one-third the length of the camera; adorally they are one-fourth to one-fifth the length of the camera. Basally the apical end of the connecting ring is broadly adnate to the septum dorsally; adorally the area of adnation diminishes and disappears completely.

The annulosiphonate deposits within the siphuncle are developed nowhere well enough to fill the siphuncle except for the canal system. On the venter the first trace of annular deposits is seen in the fourth camera from the living chamber; apically the annuli increase in size, as is normal for such deposits. On the dorsum, however, the first trace of such a deposit is seen in the ninth camera from the living chamber. Cameral deposits are seen on the venter in the 12th camera from the living chamber but may extend farther orad, for the ventral part of the phragmocone is missing in the next five anterior segments. Calcite largely occupies the dorsal camerae but is mainly inorganic. Possibly in the 13th camera there is a this episeptal deposit on the dorsal side.

Apical variation in the slope of the septa and outline of the siphuncle suggests that the apex of the holotype is not far removed from the true apex of the shell; certainly not more than 2 or 3 camerae are missing. It is significant that in this rather abortive species there is no region of the shell in which siphonal deposits have grown to completion, and cameral deposits are only faintly developed apically. One may expect this condition in a shell with an extremely short phragmocone.

Discussion. This species belongs to the species group of *Actinoceras paquettense*, in which the phragmocone is short, and in which the siphuncle undergoes marked modification of outline of the segments and contraction in size as growth progresses. It is notable as the only form in this group for which knowledge of the shell is reasonably complete. The siphuncle shows a less advanced development of the annular deposits than do allied species, causing one to wonder whether these other species, known from more fragmentary material, actually had longer phragmocones than the present known specimens indicate. If they did, the anterior segments of the siphuncle must have become so small and slender that

it would be almost impossible to distinguish them from *Leurorthoceras*. Such species have been noted under the discussion of the genus.

Holotype. Collection of G. Winston Sinclair, Canada Geological Survey.

Occurrence. From the Simard limestone, Ste. Anne de Chicoutimi, Quebec. It should be noted that precise location in the Simard limestone is not known. One is tempted to assume that it is from the higher beds containing a Paquette Rapids fauna. The large *Actinoceras sinclairi* in the lower portion is not to be confused with this species.

Actinoceras abortivum Flower, n. sp.

P1.3, fig. 6; pl. 11, fig. 5-6.

This species is based upon a siphuncle from the Paquette Rapids beds of the Ottawa River. The specimen was long regarded by the writer as *A. paquettense*, but comparison with the description of that species shows that the camerae are shorter, the adoral contraction of the siphuncle is even more extreme, and the whole was a considerably smaller shell. The holotype contains parts of nine camerae in a length of 62 mm. In an equal length of *A. paquettense* there are eight segments. In *A. abortivum* the first segment is 7 mm long and has a width of 18 mm; the second is 9 mm long and 22 mm wide; the third 8 mm long and 24 mm wide; the fourth 8 mm long and 26 mm wide. Later segments decrease gradually in both length and width, the fifth being 7.5 mm long and 24 mm wide, the eighth 7 mm long and 15 mm wide, the last, possibly somewhat abraded, 6 mm long and only 10 mm wide. Basal segments are in such broad, flattened contact with the ventral wall that the septal foramen is marked only as a thin incised line, and the neck must have been essentially recumbent ventrally, as in *Armenoceras*. As the septum is traced laterally, where the siphuncle is free from the ventral wall, the siphuncle assumes the gentle sinuate curvature of an *Actinoceras*. This condition is confined to the dorsum of the earliest segments. In later ones, as the zone of flattening of the siphuncle narrows progressively, the *Actinoceras* type of outline spreads from the sides increasingly toward the mid-ventral region. Even at the sixth suture, however, there is a small midventral region, where the neck is recumbent.

The height of the segments is not well displayed, as weathering from the dorsolateral surface has removed part of the siphuncle. It is evident that the siphuncle must have had a height of 20 mm or more at the third segment, where the expansion is the greatest. The eighth segment shows a height of 14 mm, where it comes very close to the septal foramen. Here the segment is estimated as expanding from 14 to 16 mm in height. The weathered dorsolateral surface shows short, broad segments, like *A. ruedemanni* in outline, where they are free from ventral flattening. It also shows part of the central canal, which is here central in the third segment, curving toward the dorsum, and coming to lie in the dorsal side of later segments. In the seventh and eighth segments the tube is expanding, an indication that here the deposits have not filled the siphuncle to capacity. It also indicates clearly that the specimen was quite short, and that the missing anterior camerae and siphuncle segments were few in number.

Discussion. This species represents the extremity of the trend toward development of short phragmocones in which the siphuncle segments — short, broad, broadly expanded

basally — undergo a rapid change toward others which are smaller and less expanded.

Holotype. Collection of the writer.

Occurrence. From the Black River beds of the Paquette Rapids of the Ottawa River.

Actinoceras winstoni Flower, n. sp.

Pl. 6, fig. 1-5; pl. 7, fig. 4; pl. 9, fig. 8; text fig. 3G-I.

This is a long, very slender actinoceroid from the Hull beds of Quebec. The cross-section shows dorsum and venter well and evenly rounded, and is subcircular, being scarcely wider than high. The complete shell shows very gentle adoral expansion and very slight endogastric curvature. Although a mature shell is known showing the usual last shortened camerae and what must have been over half of the living chamber beyond, there is no indication of the usual fusiform condition of the shell in the vertical profile. Sutures, straight and transverse dorsally, develop broad lobes over the venter, which appear at an early stage and broaden, becoming less angular and more broadly rounded in the late growth stages. The septa are evenly rounded and deeply curved, the depth of the septum being uniformly only slightly less than the length of two camerae. The siphuncle undergoes a remarkable plasticity. Early segments are relatively large and broadly expanded, but in a comparatively short length of the phragmocone become smaller at the septal foramen and relatively slightly expanded in the camerae. This feature, characteristic of the group of *A. winstoni*, as noted in the generic discussion, is retained throughout most of the phragmocone. As further shell growth progresses, the segments tend to become gradually less expanded, and in the latest observed stage show a simplicity of outline which approaches that considered characteristic of the genus *Leurorthoceras*. Probably the condition of *Leurorthoceras* is actually attained, for we have no specimens in which the siphuncle segments are preserved in the last 90 mm of the phragmocone.

The holotype is a portion of a shell 50 cm in length. Its apex is continued for another 80 mm by a portion of a siphuncle, somewhat abraded (pl. 7, fig. 1-3, 5). The anterior 150 mm of the specimen represents a living chamber.

Camerae are deep initially, the early siphuncle segments showing an average length of 9 mm, a condition maintained in the succeeding three camerae. In the next few septa the camerae shorten to 7 mm and then increase very gradually in depth as traced orad, becoming 9 mm long 300 mm farther. Not far beyond are two shortened camerae, indicating maturity of the shell, each 5 mm deep.

Sutures develop a shallow ventral lobe, which becomes deeper and more angular in the early ephebic stage, after which the depth remains constant; the lobe, however, becomes broader and more shallowly rounded.

The eight basal siphuncle segments are abraded (pl. 6, fig. 5) and incompletely preserved. It is evident, however, that they are relatively large and strongly oblique, owing to the unusual depth of the septa. On the average a segment is 9 mm long and expands from 14 to 20 mm. Shortly beyond, at the base of the phragmocone, a segment 9 mm long expands from 17 to 22 mm. Not far beyond, the segments shorten, and the siphuncle becomes smaller and less strongly expanded. Ten camerae later the siphuncle segment increases from 17 to 20 mm and is 7 mm long. Eight camerae later the

segment, 7 mm long, increases from 11 to 15 mm in height. In the 29th camera the height increases from 11 to 14 mm, but the segment is now 8 mm long. In the last complete camera preserved, the height increases from 13 to 15 mm.

Throughout, the necks are one-third the length of the segment; the brims slightly less than the neck. In horizontal section the apical end of the segment shows the rings broadly adnate to the apical septum. In vertical section the area of adnation is still broader on the ventral side, but there is none whatsoever on the dorsal side of the siphuncle.

In the holotype the basal 12 segments of the siphuncle are large and broad. The next 3 contract markedly, the succeeding 23 segments remaining of the general type of *A. capitulinum*. The remaining anterior segments are incompletely preserved, but the dorsal outline is here becoming more simplified than is the ventral one. In the last complete segment observed, the segment expands from 10 to 15 mm, the expansion on the ventral side of the siphuncle being 4 mm, that on the dorsal side 1 mm. In the most anterior segment observed, the venter, which alone is preserved, shows an expansion of only 3 mm; here the dorsum must have been nearly straight. As there remain 14 camerae in a length of 95 mm to the base of the living chamber, in which the siphuncle is not preserved, there can be little doubt but that here simplification is continued farther, the siphuncle attaining the condition of one of the more advanced and simplified species of *Leurorthoceras*. The shell height, 50 mm at the first preserved camera, increases to 54 mm in the basal 100 mm to 65 mm in the next 100 mm, and to 70 mm in the next such interval. It remains at 72 mm for the last two 100-mm intervals.

Two paratypes are figured. The first (pl. 6, fig. 4) is a portion of a phragmocone which preserves the ventral surface. The dorsum is lost by weathering, and apically the dorsal side has been ground to the level of the siphuncle. The specimen, 265 mm long, gives evidence of 26 camerae. In the basal part the shell expands apparently from 21 to 41 mm in 100 mm. This expansion, however, is purely in the plane of the siphuncle, and neither original expansion nor the maximum shell width are attained. The first siphuncle segment is without surrounding shell or camerae. The first complete camera, 9 mm long, shows a segment expanding from 12 to 16 mm. By the 7th complete camera the segment is reduced to 7 mm in length and expands from 14 to 20 mm. This part of the shell is plainly equivalent to the very basal septate part of the holotype. By the 14th camera a segment has increased to 8 mm and expands laterally from 16 to 20 mm.

A second paratype (pl. 9, fig. 8) shows a horizontal section through a later stage of the phragmocone. Here the shell expands in width from 50 to 57 mm in 80 mm. The camerae are subequal in depth and 8 mm long. Basally a siphuncle segment increases from 15 to 18 mm in the camera; adorally the increase in width is from 16 to 18 mm.

Discussion. This species, characteristic of the Hull equivalent from St. Casimir, Grondines sheet, Quebec, brings out several interesting features. Because of its slight curvature, it was at first assigned to *Troostoceras*. But *Troostoceras* is exogastric, and this shell is slightly endogastric. As it was already questionable whether such slight convexity as is shown on the ventral side of *Troostoceras* is a valid basis for separating it from *Actinoceras*, separation of this new species would be even more questionable. The early segments of the siphuncle

are large. This feature, already suggested by other species of the *A. capitulinum* group, but suggested rather than demonstrated by the previous described and figured material, is here corroborated. The small slightly expanded segments of the *A. capitulinum* type persist throughout most of the phragmocone but gradually become simplified, approaching in preserved segments, and possibly attaining in those not preserved, the condition of *Leurorthoceras*.

Both Teichert and the writer had suspected that *Leurorthoceras* might be based upon an assemblage of species known from late portions of phragmocones in which simplification of the siphuncle has developed, but that early portions of some of the species, including certainly the genotype and others which are closely similar to it, would be placed in *Actinoceras*. Of course, such simplification is not confined to *Actinoceras*. In *Orthonybyoceras*, in a group of smaller shells belonging to the Ormoceratidae, one finds early segments close to the borderline between *Armenoceras* and *Ormoceras*, but later segments which approach and, indeed, attain the outline of *Leurorthoceras*. The evidence which *A. winstoni* supplies confirms the supposition that typical *Leurorthoceras* represents very late growth stages of species which, from earlier portions, are typical of *Actinoceras*.

Holotype and paratypes. Collection of the writer.

Occurrence. From the lower *Receptaculites* beds of the Trenton (regarded as of Hull age) at Ste. Anne de Casimir; from several localities on the Ste. Anne River near St. Casimir, Grondines sheet, Quebec. *Actinoceras* has been noted at this horizon in other localities, notably by the powerhouse on the Jacques Cartier River, south of Pont Rouge, and in the *Plectoceras* beds at Loretteville, near the city of Quebec. They well may represent this same species, but thus far no specimens have been found where they could be collected.

Actinoceras incantatum Flower, n. sp.

Pl. 9, fig. 1-24 pl. 11, fig. 1-2.

This species is known only from portions of phragmocones, moderately expanding, the shell slightly depressed in section. The siphuncle, subcentral in earlier stages, more ventrally located in later ones, is composed of short, well-rounded segments in early growth stages, differing from the group of *A. centrale* mainly in the greater length of the septal necks. In later stages the necks become still longer, and the outline of the siphuncle is simplified, expansion of the segments in the camerae being reduced.

The holotype (pl. 11, fig. 1-2) is a portion of a phragmocone, about 160 mm long, preserved in dolomite. Weathering has exposed the siphuncle adorally, but apically a section was made, to show its essential features. As viewed in pl. 11, fig. 2, the specimen is seen from the dorsal side, the midventral region showing at the anterior end, to the left of the center of the specimen, where siphuncle and shell wall are very close. A cut at midlength shows that the siphuncle there is 25 mm wide and 20 mm high. It is 5 mm from the venter and must have been 5-10 mm from the dorsum. The shell here is estimated to be 36 mm wide and 30 mm high. An apical longitudinal section (pl. 11, fig. t) shows 70 mm of phragmocone, of which the basal half is poorly preserved. The apparent rapid expansion shown here is not natural, for the section is progressively eccentric from its anterior to its apical end. The great rate of apical expansion suggests possible original curva-

ture of the shell there. In the anterior 60 mm of the section, the shell expands from 22 to 43 mm in the plane of the section, which is slightly less than the maximum width of the shell. In the anterior 60 mm, shown in pl. 11, fig. 2, expansion is from 43 to 56 mm. Camera average 5 mm in length in the apical half of the specimen (pl. 11, fig. 1) but increase in the adoral half to 7 mm. Septa are strongly curved, their curvature equal to one and three-fourths siphuncle segments, and 14 mm in depth at a shell width of 48 mm. At the extreme base, siphuncle segments are obscure, but at a shell width of 35 mm a siphuncle segment 5 mm long clearly expands from 15 to 19 mm. Here necks are about one-third the length of a segment. In the adoral weathered part of the siphuncle, the necks have become markedly longer and outline a part of the siphuncle segment, which is gently and almost uniformly concave, occupying about two-thirds the length between the septa. The apical part of the segment is convex but is only gently curved. Clearly the siphuncle is approaching very close to the pattern shown in *A. simplicem*.

Dolomitization has obscured details of internal structure. Part of the canal system of the siphuncle is shown, however, and the apical section strongly suggests episeptal deposits in the camerae.

The paratype (pl. 9, fig. x-2) is a portion of a phragmocone 128 mm long, most of which is figured here in a nearly horizontal longitudinal section. A cross-section at the base (pl. 9, fig. 2) shows a siphuncle 5 mm from the venter, 20 mm wide, and 16 mm high. In the illustrated section the dorsal wall of the shell is incomplete; it is better preserved on the mirror image of this section, which was cut longitudinally. The siphuncle is shown here to be very nearly central in position in a shell definitely depressed in cross-section. The 19 segments of the siphuncle increase in length gradually and rather irregularly from 5 to 7 mm. Basally siphuncle segments are almost identical in proportion to those shown in the base of the holotype; adorally there is indication of a similar elongation of the necks and a trend toward a similar simplification of the outline, but dolomitization here is advanced, making differentiation of neck and connecting ring largely impossible. The shell expands in width from 41 to 59 mm in a length of 80 mm. Corresponding expansion in height cannot be measured. The maximum width of the siphuncle segments increases from 19 to 21 mm in the same length. Septal curvature is equal to the length of one and three-fourths camerae. The paratype shows portions of the canal system quite clearly; indeed, the central canal is clearer than is the wall of the siphuncle. Episeptal deposits can be recognized in the camerae in spite of dolomitization.

Neither the holotype nor the paratype shows the suture pattern clearly. The anterior end of the holotype shows part of the shell wall; here with coarse, irregular, transverse, rather rugose markings.

Discussion. This species belongs clearly to the group of *A. simplicem*. It is remarkable for the strongly depressed cross-section of both shell and siphuncle, and for the subcentral position of the siphuncle.

Holotype and paratype. New Mexico Bureau of Mines and Mineral Resources.

Occurrence. Both specimens on which the species is based are from dolomites in the upper part of the 30-35 feet of the Upham dolomite, occurring just below the zone with large spheroidal concretions, in Mud Springs Mountain, New

Mexico. A fragment of the siphuncle of the same species was found loose in a block of Upham dolomite in Ash Canyon, in the San Andres Mountains, New Mexico.

Genus **LEURORTHOCERAS** Foerste
Genotype: **Leurorthoceras hansenii** Foerste

Leurorthoceras Foerste, 1921, Denison Univ. Bull., Sci. Lab. Jour., v. 19, p. 278.

---- Troedsson, 1926, Meddelelser om Grønland, bd. 71, p. 58.

---- Foerste, 1928, Michigan Univ., Mus. of Geol. Contr., v. 3, p. 44.

---- Foerste and Teichert, 1930, Denison Univ. Bull., Sci. Lab. Jour., v. 25, p. 256.

---- Foerste, 1933, *ibid.*, v. 28, p. 29.

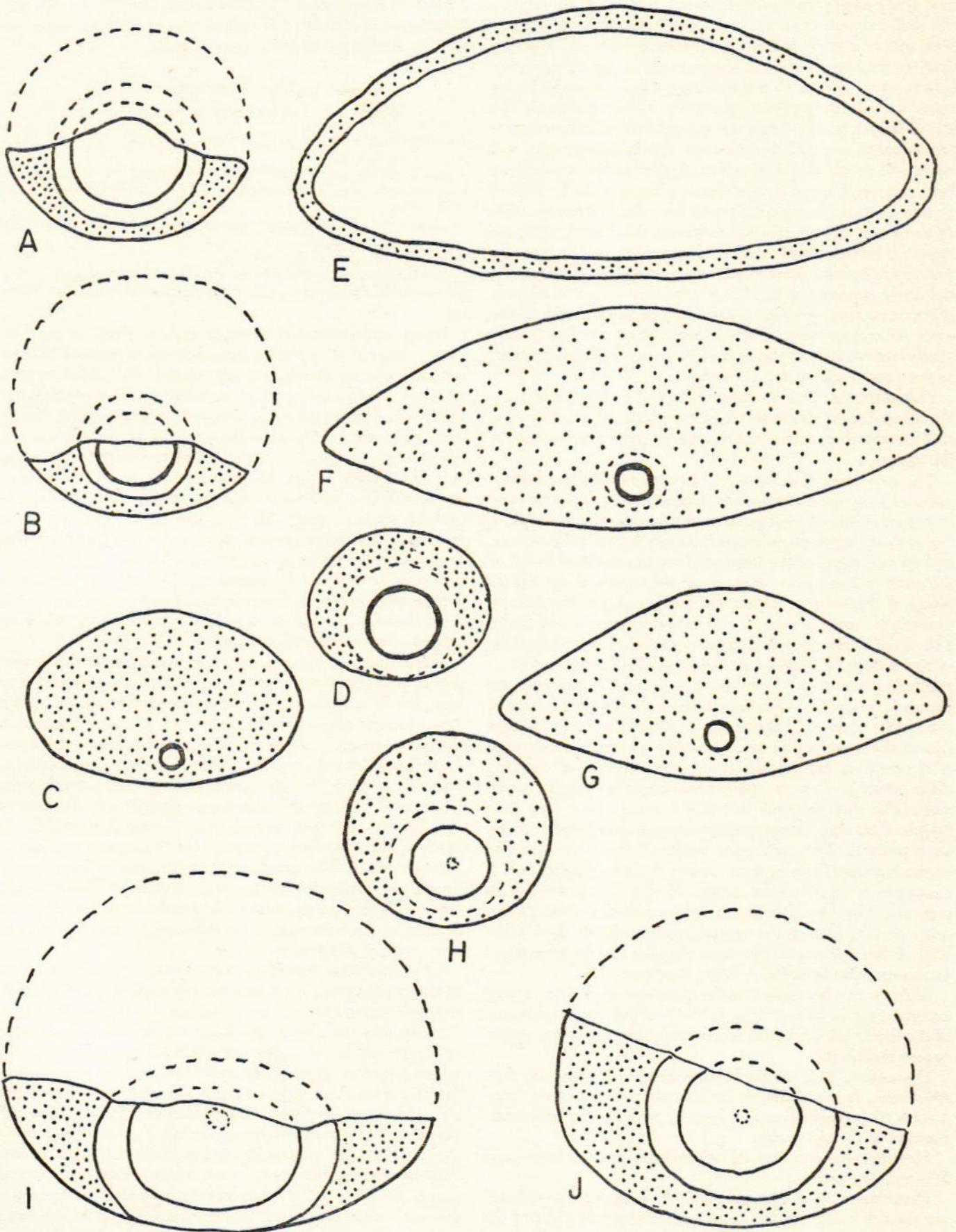
---- Teichert, 1934, Meddelelser om Grønland, bd. 92, p. 21.

---- Miller, Youngquist, and Collinson, 1954, Geol. Soc. Am. Mem. 62, p. 66.

It has been remarked (Foerste and Teichert, 1930; Teichert, 1934) that typical *Leurorthoceras* resembles *Actinoceras* strongly in cross-section and ventral lobes of the sutures, and that though the anterior segments of the siphuncle are extremely slender, the early ones are more expanded. Specimens previously assigned to the genus have been fragments representing the anterior camerae and consequently showing only late growth stages. In the earliest stages available their siphuncles are broader and more rapidly expanding, approaching the condition of *Actinoceras*. The specimens suggest that still earlier growth stages might be identical with typical epebic stages of that genus. This supposition is now confirmed by *Actinoceras winstoni*. It is clear that this species belongs not only to *Actinoceras*, but to a specific group within it. It, therefore, would appear that *Leurorthoceras* is best regarded as a synonym of *Actinoceras*.

It is a matter of opinion, of course, whether the two genera should be merged, or whether redefinition should allow one group of species to be recognized as the genus *Leurorthoceras*. Some considerations favor each course. If *Leurorthoceras* is to be recognized, it must include not only those species currently assigned to it, but *A. winstoni* as well. One could not place *A. winstoni* in this genus without also including the whole species group of *Actinoceras capitulinum*. To include these species, however, would be to include many which are not definitely known to attain the siphuncle outline of *Leurorthoceras*, because the species in question are known from fragments, in which the anterior parts of the siphuncle have not been made known adequately. It is therefore the opinion of the writer that *Leurorthoceras* is best regarded as a synonym of *Actinoceras*.

While the condition of *Leurorthoceras* is certainly attained - in the species group of *A. winstoni*, it may be developed also in some, though not all, species of the *A. ruedemanni* group. *A. margaretae* attains a simplicity of the anterior segments and approaches, but does not quite attain, the type of siphuncle outline regarded as characteristic of *Leurorthoceras*. Neither is such full simplicity attained in the associated Lowville species *A. aequale* or *A. gradatum*. Observations indicate that *A. beloitense* approaches but does not quite attain the simplicity of *Leurorthoceras*; nor does *A. ruedemanni*. However, some other members of the *A. ruedemanni* species group may do so. That they may is suggested by the occurrence of some species of *Leurorthoceras* in beds correlated with the Black River, where members of the *A. capitulinum* group are unknown. *Leurorthoceras lebanonense* and L.



CROSS-SECTIONS OF ACTINOCEROIDS

Figure 4

altopontense are two such species. Additional fragments, one from the Lowville beds near Meath Station, Ontario, indicate that anterior simple segments of the *Leurorthoceras* type are attained as early as Lowville time.

The arctic species of *Leurorthoceras*, including the genotype, are of uncertain stratigraphic position. This is true of *L. chidleyense* and *L. hanseni*, both based upon specimens from erratics from Port Burwell, Labrador. *L. hanseni* was identified doubtfully by Troedsson from the Gonioceras Bay limestone at Cape Calhoun, Greenland, and *L. (?) ruedemanni* was described from the same association. *L. groenlandicum* Teichert is from Washington Land, Greenland. In the Mt. Silliman beds of Baffin Island, in an association of Red River aspect, *L. baffinense* occurs. The only possibly contemporaneous species so far recorded is *L. husseyi* Foerste, from the Cornell member of the Trenton of northern Michigan. Associated cephalopods suggest that this member is an equivalent of the Cobourg and the Stewartville. *Leurorthoceras* is unrecognized as yet in the Red River faunas from southern Manitoba to New Mexico.

Orthonybyoceras Shimizu and Obata (= *Treptoceras* Flower) is a genus of smaller shells, suggestive of the Ormoceratidae. Early siphuncle segments are so broad as to suggest a possible origin not in *Ormoceras*, but in *Armenoceras*. The question must be left for further investigation. Mention of the genus is relevant to *Leurorthoceras*, because anterior siphuncle segments in various species attain the planoconvex profile and relatively slight expansion of the segments of *Leurorthoceras*. Such patterns, however, are developed in shells half, or less, the size of typical *Leurorthoceras*. The stock is dominant in the Cincinnati of east-central North America; in the Cincinnati arch, in southern Ontario, and in the St. Lawrence valley of Quebec. It has its beginning certainly as early as the Catheys of Tennessee and the Cynthiana of Kentucky, of late Trenton (Cobourg) age. It has not been recognized in earlier Ordovician strata, but the smaller orthocones of the Black River through middle Trenton are known as yet very inadequately. It is unknown in the northern Red River faunas but enters the Upham limestone faunas of southern New Mexico. However, no species complete enough for description have been found.

Genus KOCHOCERAS Troedsson

Kochoceras contains large shells, with a large blunt apex, beyond which the shell is considerably more rapidly expanding than in *Actinoceras*. The ventral side is so strongly flattened, and lobes are so prominently developed there, that a casual inspection of the ventral surface might lead one to mistake this genus for *Lambeoceras*. Septa, however, are more widely spaced, and an internal mold of the venter usually will show evidence of contact of the very large siphuncle with the ventral wall of the shell. Apically the siphuncle is extremely large, occupying three-fourths or more

of the width and height of the shell. In vertical section the siphuncle segments resemble those of *Actinoceras* in outline in their dorsal profile. On the venter, however, the siphuncle segment is closely appressed against the ventral wall of the shell for most of its length. The septal neck is short and so recurved that its tip may touch the free part of the septum, but as yet no sections have shown recumbent necks, as in *Armenoceras*.

It generally has been accepted that *Kochoceras* is related closely to *Actinoceras*. Indeed, there is a strong similarity between *Kochoceras* and species of *Actinoceras* of the groups of *ruedemanni* and *paquettense*, particularly in those species of both groups in which the siphuncle is closely appressed against the ventral wall of the shell. *Actinoceras abortivum*, in the *A. paquettense* group (pl. 3, fig. 6; pl. II, fig. 5-6), shows an extreme development of this sort.

Nowhere in *Kochoceras*, however, is there such rapid adoral reduction and simplification of the siphuncle segments as in the *A. paquettense* group. Rather, there is a gradual progression more similar to that found in those members of the *A. ruedemanni* group, in which the siphuncle segments are in flattened contact with the ventral wall of the shell.

Two species assigned to *Kochoceras* are, indeed, so close to *Actinoceras* that one may wonder whether they would not be better assigned to that genus. *K. (?) vetustum* Troedsson, of the Gonioceras Bay limestone, shows a ventral profile of the siphuncle more in accord with that of *A. ruedemanni* than with that of any species of *Kochoceras*. Based upon a fragment preserving parts of eight siphuncle segments, it evidently represents the anterior part of a siphuncle, for at its anterior end the annular deposits are thinning, the central tube widening into a conical cavity. *K. productum* Troedsson, of the Cape Calhoun series, is likewise a relatively slender shell, but its siphuncle shows the expanded part of the segments in contact with the shell wall on the venter, and the strongly recurved septal necks on the venter are typical of *Kochoceras*. However, this species is atypical of *Kochoceras* in the very slender form of the shell and the relatively small diameter attained by the initial part of the holotype, which, to judge from its conformation, was probably quite close to the actual apex of the shell.

K. sp. II, aff. *K. ellipticum* of Troedsson (1926, p. 73; pl. 43, fig. 1-3) presents a sharp contrast to the preceding forms. It is a portion of a siphuncle, with a rather long initial chamber, actually a little longer than suggested in pl. 43, fig. 1, and with later segments subequal in length. The greatest width and height is attained in the third siphuncle segment; beyond that point the segments become very gradually smaller over the next eight segments, for the remainder of the length of the specimen. If one should enlarge the initial siphuncle segment greatly, so that it becomes equal in length to about three segments, and should exaggerate the contraction of the succeeding segments, a siphuncle very like that of

A-B. *Actinoceras sinclairi*. Cross-sections: A, from near base of preserved part of phragmocone of holotype, from near middle of pl. 7, fig. 3; B, from anterior end of same specimen, showing marked reduction in size of siphuncle. C-D. *Actinoceras mutabile*. Cross-sections: C, at antepenultimate septum, from break near midlength of holotype, shown on pl. 4, fig. 4-5; D, somewhat restored, from base of holotype, showing much more rounded cross-section and much larger siphuncle. E-G. *Lambeoceras rotundum*. Cross-sections: E, from anterior end of holotype, a natural section showing thick irregular shell wall; F, from anterior end of pl. r r, fig. 9; G, from base of pl. r 1, fig. 9, showing changes in shell section, and position and size of siphuncle. H. *Armenoceras vesperale*. Restored cross-section from near base of holotype. I. *Armenoceras callaghani*. Cross-section restored from near anterior end of phragmocone of holotype. J. *Armenoceras australe*. Cross-section restored, from break at anterior end of basal piece of pl. 7, fig. 5. All sections approximately x 1.

Selkirkoceras would result. That *Selkirkoceras* possesses recumbent septal necks makes its origin in *Armenoceras* much more likely than an origin in *Kochoceras*. *Kochoceras* and *Selkirkoceras* probably represent analogous developments in the *Actinoceras* and *Armenoceras* stocks respectively. It is curious, however, that in both *Selkirkoceras* and *Kochoceras* there is a tendency for the tip of the septum, where it is recurved to form the neck, to be bent apicad where it is enfolded by the connecting rings.

Floweroceras Miller and Youngquist (1947) is clearly an actinoceroid, very close to *K. (?) vetustum* and *K. productum*. Unfortunately, when the genus was described, its authors failed to recognize its actinoceroid affinities. It is questionable whether the recognition of a genus here is desirable. Consistency probably would require recognition also of some species of *Actinoceras* as congeners, and would involve serious consideration of giving generic names to the species groups of *Actinoceras*.

With the exception of *K. (?) vetustum*, which is placed better in *Actinoceras*, all the known species of *Kochoceras* are from faunas of Red River aspect and, almost certainly, of essentially the same age. *Kochoceras* is recognized in the Cape Calhoun beds of Greenland, various localities in the Arctic archipelago, and Baffin Island. No species are known from the Nelson limestone. The genus is represented in the Red River beds of southern Manitoba and in the Bighorn group of Wyoming, but is unknown, at least as yet, in the Fremont group of Colorado or the Montoya group of New Mexico. *Kochoceras shamattawaense* Foerste and Savage is the only species which has been assigned to the genus from beds of Richmond age. The fragment on which this is based is strangely reminiscent of *Actinoceras* in the ventral outline of the siphuncle and is certainly not a typical *Kochoceras*. Indeed, its section is very reminiscent of *Actinoceras carletonense* Foerste (1928, pl. 43, fig. 2).

Genus ARMENOCERAS Foerste

Probably the oldest species of *Armenoceras* known are from Manchuria and north China. The Wuting formation, which by the presence of *Adamsoceras* and *Wutinoceras*, actinoceroids with the primitive reticulate type of canal system, is probably Whiterock in age, has yielded one *Armenoceras*, *A. numatai* Endo, typical of the genus from all that can be learned from the figure and description. The overlying Ssuyen limestone (Endo 1932) is apparently equivalent to the *Actinoceras* limestone of Grabau and the Makkol limestone of Kobayashi. It has yielded numerous representatives of *Armenoceras*, which have been reviewed by Kobayashi (1934); some others have since been described, mainly by Endo (1935). Although there is some question as to possible synonyms among the species, evidently there are many species present in this general horizon. A post-Chikunsan age of the Makkol is evident by superposition. The Chikunsan itself is allied faunally to the Chazyan, particularly in its cephalopods; approximate Chazyan age is therefore indicated. The Makkol is post-Chazyan, and early rather than late Mohawkian, but its boundaries in relation to Ashby, Porterfield, and Black River are as yet uncertain.

In North America no *Armenoceras* is known from beds of Chazyan age. Probably the Black River *A. ehlersi*, from St. Joseph Island, is not an *Armenoceras* but a *Murrayoceras*,

with the siphuncle outline expanded. *A. milleri* Foerste, from the Perryville limestone of Kentucky, again seems a somewhat dubious representative of the genus. In the late-Trenton Catheys limestone of Tennessee, one finds *A. brevicameratum* Foerste and Teichert, and the equivalent Cynthiana limestone of Kentucky has yielded the closely related *A. vaupeli* Flower. The genus is unknown in the Eden or Maysville or their recognized equivalents. In the late Richmond, namely the Whitewater and Saluda of Ohio and Indiana, *A. richmondense* and *A. madisonense* occur. In the Maquoketa shale of Iowa, *A. iowense* and *A. clermontense* are found. In Anticosti, A., sp. is figured from the English Head, and *A. sedgwicki* is described from the Vaureal beds.

In contrast, Red River and Richmond faunas of the north and west yield large species, sometimes in abundance. The Montoya of New Mexico has yielded *A. callaghani*, a large characteristic species, rapidly expanding, with the anterior septa very close and often incomplete, as well as *A. australe* and *A. vesperale*. The boulders of the Burnam limestone of the Llano uplift of Texas have yielded large and abundant *Armenoceras* specimens of the general aspect of *A. barnesi*. Some boulders are so full of siphuncles of such forms that it is impossible to section one specimen without cutting others. No *Armenoceras* has been reported from the Fremont of Colorado, but collecting there has not been exhaustive. The Lander sandstone of the Bighorn group has yielded no specimens of the genus, but Miller and Carrier (1952) have figured a large form from the lower dolomites above the sandstone. In southern Manitoba *A. richardsoni* is the most abundant and characteristic single cephalopod of the Selkirk limestone, but it is unknown in the Dog Head or Cat Head members. No *Armenoceras* is known from the Nelson limestone of Hudson Bay nor from the Mt. Silliman beds of Baffin Island. Northern Greenland has yielded large typical forms from the Cape Calhoun beds, from which Troedsson described *A. arcticum*, *A. arcticum* var. *angustum*, and *A. concinnum*.

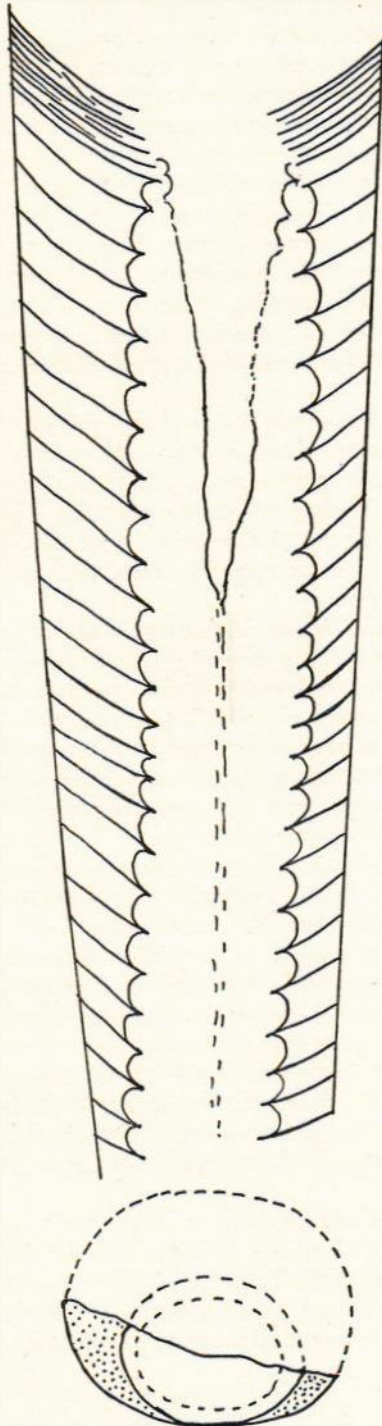
In overlying Richmond beds of the same general region, *A. lenticcontractum* is described from the R. *capax* beds of the Aleman of New Mexico. *A. saxosum* and *A. (?) robsoni* are from the Stony Mountain beds of southern Manitoba. Although the Nelson limestone of Hudson Bay has yielded no species, the overlying Shamattawa limestone has yielded two large forms, *A. magnum* and *A. cf. richardsoni*.

It is difficult to distinguish Red River and Richmond species, but it is also difficult to point out any features by which the earlier Silurian species of *Armenoceras* can be separated readily from their Ordovician forerunners. Although it is not intended to review Silurian actinoceroids here, it is necessary to point out that *Armenoceras* is common in the *Discosorus* faunas of northern North America, at Timiskaming, in northern Michigan, on the west shore of Hudson Bay, and on Southampton Island. A number of arctic species are known, of which it cannot as yet be definitely determined whether they are Ordovician or Silurian.

Armenoceras callaghani Flower, n. sp.

Pl. 10, fig. 2, 8; text fig. 41, 5.

This is a fine large *Armenoceras*, moderately expanding throughout the phragmocone, the proportions of the living chamber unknown. It has a large broad siphuncle, located



Armenoceras callaghani

Figure 5

A. Restored longitudinal section, nearly horizontal, but with the right side slightly closer to venter than the left. B. Cross-section at base of holotype. Note later cross-section with proportionately smaller siphuncle shown in fig. 31. Both figures X 1/2.

ventrally, so that the expanded parts of the segments are in contact with the shell wall on the venter. The cross-section of the siphuncle is elliptical but not markedly flattened where in contact with the venter. The venter is slightly flattened, and the cross-section of the shell is elliptical. Septa are moderately distant, but the last ones are extremely closely spaced, and some of them appear to be incomplete.

The shell is estimated as expanding from 55 to 110 mm in width, over a length of 230 mm, at the level of the siphuncle; maximum widths probably increase from 60 to 120 mm. In 120 mm the siphuncle expands from 42 to 50 mm in width; corresponding heights are estimated at 30 and 40 mm. The 25 normal camerae occupying most of the length of the type increase in length from 8 to 13 mm. In the anterior 50 mm there are at least 18 septa, some of which are incomplete. Septa curve forward markedly from the siphuncle to the shell wall, the depth of curvature being about equal to the length of a camera. The 7th siphuncle segment from the apical end of the type expands from 36 to 42 mm in width and is 10 mm in length. In the 18th camera the segment expands from 40 to 50 mm and is 11 mm long.

The apical camerae show very thin episeptal deposits, which are wanting in the anterior camerae. The siphuncle is largely occupied by annular deposits, which have fused and fail to preserve details of structure apically. In the anterior 130 mm of the siphuncle the adorally thinning deposits leave a large tapering central cavity.

There is indication of broad shallow ventral lobes of the sutures. The dorsal part of the shell has not been observed fully.

Discussion. This is a large imposing *Armenoceras*, characterized by evidently elliptical cross-section, the large broad ventral siphuncle, rather deep camerae, rather strongly curved septa, and extreme crowding of the anterior septa. The species is not uncommon in the Second Value formation. Almost invariably, however, specimens cannot be removed by any means short of quarrying or explosives. The type, though fragmentary and unprepossessing, nevertheless shows the essential features of the species.

The species belongs to the group of *Armenoceras richardsoni* but is distinguished from all other forms by the ventral siphuncle, its broad section, the broad cross-section of the shell, the rather deep camerae of the ephebic part, and the extreme crowding of the anterior septa. Such septa have been observed in several specimens, most of which could not be collected. Either the septa were imperfect in life, or they were so thin that they always are found in a broken condition. No such anterior septa have yet been observed in any other of the Red River or Richmond species of *Armenoceras*.

Holotype. New Mexico Bureau of Mines and Mineral Resources.

Occurrence. From the lower part of the Upham limestone member, Second Value formation, 3 feet above the top of the Cable Canyon sandstone member; from the Cooks Range, New Mexico. Collected by A. K. Armstrong and the writer.

Armenoceras lenticontractum Flower, n. sp.

Pl. 10, fig. x, 3.

This species is known from a siphuncle with traces of attached camerae. The siphuncle is large, with short, broad segments, and is peculiar mainly in the gentle contraction of

the siphuncle adorally, which gives it a fusiform aspect quite unknown in other species of the genus. The type has a maximum length of 280 mm and preserves 31 camerae, the basal two being incomplete. At the first clear segment at the base, the width expands from 23 to 31 mm, and the segment is 7 mm long. In the next 100 mm the siphuncle expands normally, increasing to segments 8 mm long, which expand laterally from 35 to 40 mm. In the next 50 mm the contraction of the siphuncle has begun, for a segment increases from 28 to 36 mm, but its length has increased uniformly to 9 mm. In the next 50 mm the segment, 10 mm long, increases from 21 to 26 mm. In the last 50 mm the siphuncle segment, now 1 mm long, has decreased, so that it expands only from 20 to 28 mm.

Septal necks are recumbent and actually constrict the septal foramen internally far more than indicated by the above figures, which are taken from the conformation of the exterior of the siphuncle. The central canal is well developed and exposed at several points on the sections. Radial canals are nearly transverse, though irregular as seen in the section, and plainly conform to the pattern of double arcs common in the genus.

The specimen suggests that the siphuncle was depressed only slightly in section and lay close to, and probably in contact with, the ventral wall of the shell. Little remains of the shell, but the extant portion suggests a cross-section which was depressed only slightly.

Discussion. This species is based upon a large specimen which is unusual in its preservation. Clearly the specimen lay with its ventral side uppermost. The dorsum, below, was incomplete and apparently was abraded prior to burial. Abrasion has removed not only most of the phragmocone but has worn down the dorsal side of the massive siphuncle. Weathering of the ventral surface had removed part of it also. Because of the size of the specimen, it was removed in several parts, which were cut and ground independently. The anterior part of the figured section passes slightly ventrad of the center of the siphuncle. The annular deposits are incipient at the extreme anterior end of the specimen, but from the sixth camera apicad to the end of the specimen are mature, filling the siphuncle except for a rather unusually large central canal with radial canals extending to the perispantium.

The gentle anterior contraction of the siphuncle is highly distinctive and has not been observed in any other *Armenoceras*. The holotype probably had a shell 45 to 50 mm in diameter basally, expanding gently and uniformly adorally. The camerae increase gradually in depth as growth progresses, and the usual shortened, crowded camerae marking maturity have not been observed.

Holotype. New Mexico Bureau of Mines and Mineral Resources.

Occurrence. From the lower part of the *Hebertella-Rhynchotrema-Platystrophia* zone of the Aleman limestone; from the Cooks Range, New Mexico. The age of the beds is regarded as equivalent to the Waynesville of the type Richmond.

Armenoceras australe Flower, n. sp.

Pl. 7, fig. 5; pl. 8, fig. ; text fig. 4J.

This is a large, gently expanding *Armenoceras*, closely septate, with septa moderate in curvature. The siphuncle is

eccentric, slightly depressed, and composed of broad short segments, which expand very gradually with growth. The shell is extremely large and rather slender. The holotype, 215 mm long, consists mainly of a siphuncle with only part of the phragmocone. The segments increase in length from 6 mm to 14 mm. Near the base, a segment expands from 16 to 23 mm; near the adoral end, expansion is from 28 to 33 mm. The segments increase in length, and in distance across the septal foramen, without proportionate increase in expansion in the camerae. Near the base, where the shell is 52 mm across in the plane of the siphuncle, the septa are 14 mm in curvature at the siphuncle. Here the siphuncle is 30 mm across at maximum width, 8 mm from the venter, and an estimated 22 mm from the dorsum. The section of shell and siphuncle are both circular, or nearly so. The shell expands from 52 to 56 mm in 33 mm, a rate of x mm in 11. At the anterior end of the shell, the septa and shell wall are not preserved.

A specimen tentatively assigned to the same species (pl. 8, fig. 1) is here represented by a natural longitudinal section, showing the maximum diameter of the siphuncle apically, but cutting it slightly off center adorally. The shell here expands from 65 to 76 mm in 70 mm, the siphuncle increasing from 32 to 35 mm. The camerae increase in depth from 7 to 8.5 mm.

Deposits in the siphuncle, clearest in the holotype, show a central tube widening adorally where deposits have not grown to fill the siphuncle. Radial canals are curved, the concave side directed adorally. Both ends of the siphuncle are about equally adnate; in contrast to *A. vesperale*, however, the area of adnation is relatively small. The second specimen shows that episeptal and hyPOSEPTAL deposits are developed. No cameral deposits are evident in the holotype.

Discussion. This is a large *Armenoceras* of the general aspect of *A. richardsoni*. The siphuncles alone would be difficult to distinguish from late growth stages, but in *richardsoni* the segments are longer in proportion to their diameter, a difference more marked when earlier growth stages are compared. *A. richardsoni* has a more marginal siphuncle, and the septa are much more strongly curved. *A. arcticum* Troedsson is more similar in the shallowly curved septa, but the siphuncle is somewhat smaller in proportion to the shell, and its segments are longer in proportion to their diameter.

Types. Holotype and paratype; from the collection of the writer.

Occurrence. From the Upham limestone facies of the Second Value formation. The holotype is from the Upham of the southern end of the Franklin Mountains, near the Scenic Drive, El Paso, Texas. The specimen tentatively referred to the species is from the Upham of the Florida Mountains, New Mexico.

Armenoceras vesperale Flower, n. sp.

Pl. 11, fig. 10; text fig. 4H.

This is a relatively small, extremely slender *Armenoceras*. The shell is circular in section, or nearly so, and expands at a rate of 10 mm in a length of 90 mm. The holotype preserves the ventrolateral half of a shell, with a maximum length of 130 mm. A section near the base shows the siphuncle to be circular, 20 mm across the expanded part of a segment, and 6 mm from the venter. The shell here is 32 mm across. Su-

tures are straight and transverse basally, but appear to slope very slightly orad from venter to dorsum in the adoral part of the shell. Camerae are short. In the basal part, 3 camerae occupy a length of 15 mm; adorally, 3 occupy a length of 20 mm. The curvature of the septa is gentle, though only observed on the ventral side, where the curvature is equal to between one-half and two-thirds the length of a camera.

The siphuncle is typical of *Armenoceras*, broad across the septal foramen. Apically the ring is broadly adnate. The recurved brim is apparently in contact with the free part of the septum, as is the anterior end of the connecting ring. Adnation is about equal at both ends of the segment. Near the base, a segment 6 mm long expands from 10.5 mm to 21 mm. The area of adnation exists up to a segmental width of 17 mm. The free part of the ring is gently, evenly rounded. Siphonal deposits fill the siphuncle of the type, except for the siphonal vascular system. The central tube is large, and its peripheral structure complex, apparently bearing a faint vestige of the double arcs of the radial canals of the double-arc type. However, over most of their length the radial canals are simple, pointing obliquely apicad and distad as they leave the central tube, curving to a horizontal position distally, and, in general, joining the perispantium at the middle of the segment. On the ventrolateral region, shown on the left of the figure (pl. II, fig. 10), the septa are faint, being enclosed in episeptal and hyposeptal deposits. In apical segments a narrow dark band of matrix in the middle of the camera curves from the middle of the siphuncle segment, where it conforms to the radial canal in curvature and position, outward and slightly forward, conforming to the shape of the camera.

The shell surface is not preserved. The surface of the internal mold is smooth.

Discussion. This is a small and extremely slender *Armenoceras*, both features distinguishing it from all previously known forms from the later Ordovician of North America. The 130 mm of the phragmocone clearly represents only the apical part of the phragmocone of a specimen. Camerae must have extended farther forward, increasing the phragmocone to 250 or 300 mm. To judge from the general proportions and the blunt ends found in other actinoceroids, probably not more than 50 mm is missing apically. The relatively shallow curvature of the septa is also distinctive of the species.

The holotype represents only the upper side of a specimen. The lower half of the specimen was lost. It was removed evidently by solution of the sediments, as its under margin is stylolitic and irregular.

Holotype. New Mexico Bureau of Mines and Mineral Resources.

Occurrence. From the middle of the Upham limestone member, Second Value formation, Montoya group; from near the top of the northern end of the Cooks Range, New Mexico. Collected by A. K. Armstrong and the writer.

Armenoceras barnesi Flower, n. sp.

Pl. 9, fig. 7.

This is a moderately slender *Armenoceras*, with deeply curved septa, thus resembling *A. richardsoni*. It is distinctive in elliptical section of both siphuncle and shell, and in the fact that the siphuncle is well removed from the ventral wall of the shell.

The type, a portion of phragmocone 150 mm in maximum length, shows a shell 44 mm wide and 32 mm high at the base, increasing adorally to a width of 66 mm and a height estimated at 50 mm, in a length of 120 mm. At the base the expanded siphuncle is 20 mm wide, 14 mm high, 7 mm from the venter, and 10 mm from the dorsum. Adorally the siphuncle is 23 mm wide, 20 mm high, and 9 mm from the venter.

Camerae and siphuncle segments increase in length from 7 to only 8 mm in the length of the specimen. Septa are very strongly curved and are 14 mm deep at a shell width of 55 mm in the plane of the section, or equal in length to one and three-fourths siphuncle segments. Deposits in the siphuncle are typical of the genus. Apically the recurved necks are obscured by recrystallization. Adorally, at a shell width of 55 mm, the segment increases from 14 mm, at the septal foramen, to 24 mm in maximum expansion, most of the increase being formed by the area of adnation of siphuncle with the free part of the septum. The section shows well-developed episeptal deposits over most of its length. Hyposeptal deposits, more retarded in development, are thin in the apical camerae and are not apparent in the anterior ones.

Discussion. The shell resembles *A. richardsoni* in general proportions of the siphuncle and in possessing deeply curved septa, but differs from it in the more central position of the siphuncle. In *A. richardsoni* the siphuncle is in contact with the venter to a much later growth stage than that represented by the holotype of *A. barnesi*.

Holotype. Collection of the writer.

Occurrence. From the boulders of the Burnam limestone, Burnam Ranch, Burnet County, Texas. (See Cloud, Barnes, and Duncan, 1953.)

Armenoceras -(?)- *robsoni* (Whiteaves)

Tripleuroceras robsoni Whiteaves, 1898, Ottawa Naturalist, v. 12, n. 6, p. 123.
---Whiteaves, 1906, Geol. Surv. Canada, Pal. Foss., v. 3, pt. 4, p. 281; pl. 31-32.

The material on which this species is based consists of late growth stages of rather large, straight, gently expanding shells. They lack the anterior fusiform condition of most *Actinoceras*, though parts of a mature living chamber are known, which should show this condition if it had existed. The shell is depressed in section and bears prominent lobes on the ventral surface. The siphuncle is near the ventral wall and is expanded within the camerae, but details of its outline are not clearly shown. The large size of the shell, the large expanded ventral siphuncle, and the ventral lobes suggest that the material on which this species is based represents anterior parts of shells of actinoceroids. Reference of the species to *Tripleuroceras*, a Devonian genus, clearly seems totally unconvincing today. Indeed, in the light of advances made in the understanding of nautiloids since Whiteaves' time, the only genera which are thus wide ranging are generalized types (*Michelinoceras*, *Kionoceras*, etc.). Even these genera may be divided and restricted stratigraphically when our understanding of them is more complete.

Although it is obvious that Whiteaves' material represents the anterior end of an actinoceroid, it is not evident, in the light of the poor preservation of the siphuncle, in which genus it should be placed. *Actinoceras* is a possibility, but one opposed by the failure of the anterior end of the shell to as-

sume a fusiform profile. It is curious also that no *Actinoceras* has been recognized in the Stony Mountain formation of Manitoba. *Armenoceras* is a more likely generic repository. Like *Actinoceras*, it often has well-developed ventral lobes. Indeed, such lobes are shown clearly by material of the writer's own collecting from the Selkirk member of the Red River formation of southern Manitoba. Only one species, *A. richardsoni*, has been generally recognized in the Red River beds. *Armenoceras* is known also in the Stony Mountain formation, and *A. saxosum* Foerste was based upon a portion of a siphuncle without septa or shell wall. The writer's collecting has yielded a smaller siphuncle of considerably different proportions, which may be an earlier growth stage of *A. saxosum* or may be a different species. More must be known of proportions which take place in *Armenoceras* as growth progresses, before a decision on this matter can be made. If there is any ontogenetic change even faintly approaching that demonstrated in *Actinoceras*, the two specimens could belong to the same species. It is further possible that they both could belong to the same species as *Tripleuroceras robsoni*; if so, that species name would clearly have priority over *A. saxosum*. Definite identification must await careful study of more complete material.

This is only one of several species based on the anterior ends of actinoceroids. Others are *Orthoceras fusiforme* Hall and *Potrioceras kentlandense* Rowley. Because these species were not obviously similar to actinoceroids as known from portions of phragmocones, preserving the large broadly expanded siphuncles, and because they often did not show the siphuncles well, the deposits within them, which give them such prominence in earlier parts of the phragmocone, often being destroyed in the anterior camerae, the affinities of these species with the actinoceroids generally have been overlooked. It should be noted that Whiteaves displayed particular perspicacity in this respect, for in describing *Tripleuroceras robsoni* he compared his species with *Actinoceras beloitense* Whitfield, of the Platteville limestone of the northern Mississippi Valley.

The types of *A. robsoni* in the collection of the Geological Survey of Canada are from Stonewall, Manitoba. Baillie (1951) cites the species as from the *Tyrrelloceras insigne* zone of the Silurian Stonewall formation. Abundance of favositid corals gives this horizon a Silurian aspect, which is probably deceptive, for favositid corals are recognized now as dominant constituents of the latest Ordovician faunas in western North America (Berdan and Duncan, 1953). The presence of *Beatricea*, *Antiptectoceras*, and *Beloitoceras* indicates an Ordovician rather than a Silurian age for these beds.

Genus SELKIRKOCERAS Foerste

The conformation of the siphuncle segments of this genus agrees in general with that found in *Armenoceras*, segments having the free part of the septum broadly incorporated into the siphuncle in broad areas of adnation, and the septal necks being recumbent. The remarkable features whereby the genus differs from *Armenoceras* are the extremely large blunt shell and the very large initial segment of the siphuncle, beyond which later segments become smaller and shorter. The known specimens show, at the most, seven initial segments of the siphuncle. One might suspect that *Selkirkoceras* may represent the initial portion of species, the later growth stages

of which could be typical of *Armenoceras*. However, in the Red River beds, *Armenoceras* is represented abundantly. The writer's collecting there showed that *A. richardsoni*, the dominant species, has a shell of circular section down to such an early growth stage as to overlap the large depressed apical end from which *Selkirkoceras* is known. Further, the siphuncle segments become shorter and smaller around than the anterior segments of *Selkirkoceras*, without showing the definite vertical flattening of that genus. It is then necessary to conclude that *Selkirkoceras* is a modification of *Armenoceras*. Probably it was a breviconic shell as well as a flattened one. *S. burnamense* shows an adoral expansion of the central canal, suggesting an approach to the anterior part of the phragmocone, where the annular deposits become smaller and finally disappear. There is no evidence as yet as to how many camerae exist between the known apical 6 or 7 camerae and the living chamber. However, *Selkirkoceras* is probably a breviconic and strongly flattened edition of *Armenoceras*, and the two genera are comparable to each other just as are the breviconic *Kochoceras* and the longiconic *Actinoceras*.

Selkirkoceras is a genus so characteristic that all specimens of it seem somewhat similar. Foerste (1929), however, recognized two species in the Selkirk limestone. *S. cuneatum*, the genotype, is known from a large broadly depressed shell, blunt apically. The anterior four siphuncle segments are depressed, close to the venter, and subequal in outline and in size. The large initial chamber is not exposed. The section of the anterior end of the type shows the septa gently inclined as they approach the siphuncle, and nearly transverse as they are incorporated therein, although the very tips, including the recumbent brims, are pointed slightly apicad.

S. tyndallense Foerste, from the Selkirk limestone, is known from isolated siphuncles only. The initial segment is large, blunt, and broadly expanded at its anterior end. The following five segments show a slight decrease in length and marked decreases in both height and width. Throughout, the siphuncle is in contact with the ventral wall of the shell. A transverse longitudinal section shows the septa involved in the area of adnation to be relatively transverse. In lateral view the septal markings are transverse.

Miller and Carrier (1942, p. 546; pl. 75, fig. 2-4) have figured and described as *S. tyndallense* a specimen from the Bighorn group which the writer believed to be specifically distinct. Its initial chamber is considerably longer, the expanded anterior end more rounded. The succeeding six siphuncle segments show a general decrease in height and width but vary erratically in length, the fourth being longer than the others. The siphuncle is in flattened contact with the ventral wall of the shell but differs from *S. tyndallense* in that it shows septal markings which slope apicad from venter to dorsum to a very marked degree. For this form the name *S. bighornense* is here proposed.

S. burnamense shows a still larger initial siphuncle segment. The succeeding segments, subequal in length, show an erratic decrease in width; the third is broader than the second, the others progressively narrower. The last is longer than the four preceding segments. This form is mainly distinctive, however, in the very steep slope of the free part of the septa; even the parts of the septa incorporated in the siphuncle show a marked obliquity, in relation to which comparable parts of *S. tyndallense*, *S. bighornense*, and *S. cuneatum* are essentially transverse. Whether septal markings on the siphuncle

are transverse in a vertical direction, as in *tyndallense* and *cuneatum*, or oblique, as in *bighornense*, is not evident from the present material.

Selkirkoceras burnamense Flower, n.

sp. Pl. 9, fig. 6.

This form is known from a horizontal longitudinal section showing a siphuncle 85 mm long and retaining 6 segments. The apical segment, 34 mm long, expands bluntly to 50 mm across. Expansion is more marked on the left than on the right, indicating that the plane of the section is oblique to the horizontal and is closer to the dorsum on the left, and to the venter on the right. The next 4 segments are subequal in length, 10 mm each, *Armenoceras*-like in form, and show a gradual decrease in maximum diameter, the 4 measuring 44, 45, 38, and 36 mm respectively. A last, incomplete segment expands to only 32 mm but is longer (at least 12 mm) than those preceding; its outline is indistinct.

On the right side, part of the shell wall is preserved. Septa are very steeply inclined from the venter to the siphuncle, and their course, where incorporated in the expanded siphuncle, is sinuate. Even so, the incorporated free parts of the septa retained in the siphuncle slope apicad strongly as they extend toward the septal foramina. The section shows the central canal, though it is displaced; evidently slight pressure has affected the original proportions of the specimen. Radial canals are nearly transverse where they depart from the central canal, and curve forward as they approach the perispatium.

No cameral deposits are evident. Siphonal deposits leave as cavities in the siphuncle only the central and radial canals. Widening of the central canal in the anterior segment suggests that the shell was a short one, and that there were not many camerae between the extant part and the living chamber. Fracture of the central canal indicates that the specimen has been flattened somewhat. The radial canals are nearly normal to the central canal where they join it, but tend to curve forward as they approach the perispatium. There appears to be a single series of canals, as in the *Actinoceras ruedemanni* type, and not a double series, as in *Nybyoceras* and many species of *Armenoceras*.

Discussion. The obliquity of the septa and the proportions of the siphuncle segments serve to distinguish this species, as noted under the generic discussion.

Holotype. Collection of the writer.

Occurrence. From the Burnam limestone at its type locality (see Cloud, Barnes, and Duncan, 1953), Burnet County, Texas.

Genus GONIOCERAS Hall

The shells of this genus have one side almost perfectly flat, the other slightly convex, the sides acute. The sutures have median lobes rising to rounded or, rarely, subangular saddles; then with lateral lobes in the extreme margins. Such saddles and lobes constitute the lateral flanges. The siphuncle is depressed, consisting of broadly expanded segments. Teichert (1934) has shown that the segments are broadly adnate, with short, nearly recumbent, septal necks.

This is one of the most easily recognized genera of nautiloids. Recognition of the species is another matter, because

proportions change as growth progresses. There is sometimes a slight difference in the suture pattern of the two sides. Most specimens are thin-shelled and flat and are known from natural sections on weathered surfaces. Also, specimens are often incomplete laterally, where the shell is extremely thin as well as narrow; consequently the nature of the lateral flanges of the sutures frequently is not well shown, and the rate of expansion of the shell is difficult to determine. Natural sections exposing the siphuncle often do not show the true lateral extremities, because commonly the one side is perfectly flat, and the siphuncle lies somewhat removed from it. This fact brings up the interesting question as to which side of the shell should be regarded as dorsal, and which as ventral. It has been assumed commonly that the extremely flat side is ventral. Such an interpretation is suggested by the fact that in flattened nautiloids it is generally the venter that is flattened, and the dorsum more rounded. Curiously, in *G. chaziense* the siphuncle is very close to the more flattened of the two sides, but in *G. obtusum* and *G. paquettense* the siphuncle appears to be well removed from that side of the shell and to be in flattened contact with the more convex side. The clearest surfaces have supplied no indication of septal or conchial furrows by which orientation can be checked, and there is no evidence supplied as yet from the aperture or the cameral or siphonal deposits which will solve the dilemma. That the flattened side may be ventral is suggested, albeit not conclusively, by the fact that though well-preserved surfaces are known, there is no indication of the septal furrow. This is not conclusive, because the septal furrow, though very characteristic of *Orthonybyoceras*, has not been observed in most other actinoceroids as yet; indeed, its preservation seems to require conditions of sedimentation foreign to the massive limestones which yield most specimens of *Gonioceras* and, also, most of the larger actinoceroids.

The early stages of *Gonioceras* are here described from two species from the Paquette Rapids beds of the Ottawa River. They are, amazingly, quite different, one showing a series of small, narrow, depressed initial siphuncle segments. Later segments enlarge rapidly over several camerae and then become nearly uniform in size. The other shows the apparently initial part of the siphuncle expanding rapidly from a small segment, subcircular in cross-section, later segments enlarging rapidly and becoming flattened. Both specimens are etched and too fragile for sectioning. It appears, however, that the early segments have the essential form of the adult, but details of structure cannot be ascertained from this material. It is interesting to note that there are here two distinct types of apical ends, one blunt, with oblique segments, the other contracting apically to a series of small, slender segments, with no marked obliquity of septa or segments. Two types of apical ends have been noted already in other actinoceroids by Kobayashi (1937), who suggested sexual dimorphism as an explanation. Although this explanation is hardly convincing, no better one has been offered.

The oldest species of *Gonioceras* are *G. chaziense* and *G. brainerdi* of the middle Chazyan of the Champlain Valley. *G. chaziense* continues into the Valcour limestone, which has many species in common with the Crown Point limestone. That *G. brainerdi* is not known from there is not significant; it is known so far only from the holotype. Although the cross-section is rather high, and the siphuncle is close to the flattened side of the shell, *G. chaziense* already is well specialized

in its sutures, the lateral flanges being sharply set off from the median lobe, and the sutures at this point extending so sharply forward that they are in actual contact on the flattened side of the shell. Surprisingly, *G. pameliense* is more generalized in suture pattern but shows an apical rapidly expanding portion and an anterior more slender region, features continued on into more specialized types. The Chaumont has yielded *G. anceps* and *G. quadratum*. *Gonioceras* extends as far as Montreal in the Chaumont equivalents, usually referred to as Leray. The writer prefers the term Chaumont, being convinced of the correctness of the premise on which the term was proposed; namely, that there is no real division between the Leray and the Watertown limestones. A single *Gonioceras*, *G. multiseptatum*, occurs in the Mohawk valley. Its horizon is in some doubt, but it is more probably from a Lowville remnant than from the lower Trenton. The Chaumont is unknown there.

Above the Chaumont, Kay (1937) cited *Gonioceras* as abundant in the Rockland beds of Ontario, at the northern end of Lake Ontario. It is present in the beds of the Paquette Rapids. Material from there proves to be quite unlike *G. kayi* and represents two new species, *G. paquettense* and *G. obtusum*.

In the northern Mississippi Valley, *G. occidentale*, *G. occidentale homerense*, and *G. kayi* characterize the Platteville limestone. The writer has collected *G. kayi* from the Platteville equivalent of the cryptovolcanic structure at Kentland, Indiana.

In Tennessee, *Gonioceras* occurs in the Murfreesboro limestone, again in the Lebanon limestone, and in a post-Carters formation near Shelbyville, Tennessee. These specimens have not been determined properly; such material as the writer has found has not been considered suitable for description or close specific comparison. Butts, in numerous U. S. G. S. folios, has cited *Gonioceras* from various localities in Pennsylvania and Virginia. These forms require more study before their specific relationships can be established. Flower (1943-b) described *G. hubbardi* from the Chepultapec of Giles County, Virginia.

Thus far, *Gonioceras* is confined certainly to beds ranging from the middle Chazyan Crown Point limestone through the Rockland, which formerly was considered lower Trenton, but which is grouped by the writer and by Cooper (1956) with the Black River. The remaining species are from Greenland, and their age presents something of a problem. Troedsson described *G. holtedahli* from the *Gonioceras* Bay limestone, and the following species from the overlying Cape Calhoun beds: *G. groenlandicum*, *G. cf. groenlandicum*, *G. angulatum*, and *G.*, sp. The dominant faunal elements of the Cape Calhoun beds indicate their correlation with the Red River beds of Manitoba and their equivalents. It is only in the extreme Arctic that such associations apparently contain *Gonioceras*. It is here also that *Actinoceras* appears, of Black River rather than Red River type. Either we have here a deposit so close to the reservoir area of boreal faunas that Black River types persisted long here, or else — and this seems more probable — there are lower beds of materially older age, which have been grouped mistakenly with the Red River faunas of the Cape Calhoun beds.

The descriptions of the following species will serve to bring out some new points relating to the distribution and morphology of *Gonioceras*. Much other material indicates that there

are probably many other species awaiting description from better material.

Gonioceras chaziense Ruedemann

Pl. 2, fig. 6; pl. 5, fig. 5-7; pl. 7, fig. 1, 2;
pl. 8, fig. 4-7; pl. 9, fig. 4.

Gonioceras chaziense Ruedemann, 1906, New York State Mus. Bull. 90, p. 494; pl. 36, fig. 3-4.

This is a relatively small *Gonioceras*, the maximum observed width of the shell being 64 mm. The siphuncle is close to the flattened side of the shell; so close that slight etching will expose the expanded part of the segments. The opposite side is much more strongly arched than in any other *Gonioceras* species so far known. The median lobes of the sutures are moderately and evenly curved, but as they rise laterally to the lateral flanges they rise so steeply that the sutures may be in contact in their ascent. When the suture again curves transversely, it lies level with the median lobe of the sixth succeeding adoral suture. The suture is broadly convex orad laterally, and between the line formed by juncture of sutures and the extreme lateral margin is almost perfectly symmetrical.

One of the most complete specimens is a fragment (pl. 8, fig. 5, 6) 84 mm long. In 59 mm, 29 camerae are preserved. The median lobe expands from 29 to 40 mm in a length of 80 mm. Loss of the fragile lateral margin makes impossible more than an estimate of the total width of the shell, but the shell expansion here is estimated as between 50 and 65 mm. It is possible, however, that in the incomplete basal part the rate of expansion is greater.

At the base, where the shell width is incomplete, the shell is 14 mm high. The siphonal side is scarcely convex; the opposite side is highly arched and rather narrowly rounded in the middle. Here the shell is 14 mm high. The septal foramen, 6.5 mm wide, 5.5 mm high, lies 0.5 mm from the flat side of the shell; an annular marking around it indicates that the expanded part of the segment must come into contact with the shell wall. The shell width here is estimated at about 50 mm. In a length of 37 mm, at a second break across the shell, the height has increased to 15 mm, and the width is estimated at 55 mm. Here the septal foramen is 2 mm high, 5 mm wide, 3 mm from the flattened side of the shell. The siphuncle expands to 7 mm high and 9 mm wide, and is again in contact with the flat side of the shell. There are 4 camerae in a length of 10 mm at the base of the specimen; 4 in 8 mm at the adoral end. The median lobe is evenly curved; at its sides the sutures slope so strongly forward that they are usually in contact and can be distinguished only with difficulty.

A second specimen (pl. 5, fig. 5-7) retains the greater part of the width of the shell and is 60 mm long. It is slightly crushed, and the extremely thin lateral portion is not entirely present, leaving the sides ragged in appearance. At the base the shell is 11 mm high and 46 mm wide. Slight crushing has probably reduced the shell height here. The siphuncle has a septal foramen 2 mm high and 4 mm wide, and expands to 7 and 9 mm, being in contact with the flat side of the shell. Here the flattened side is slightly convex in the middle and faintly concave halfway to either side. The convex side appears evenly arched, the curvature not increasing toward the middle, as in the preceding specimen. In 44 mm the shell has expanded to 17 mm high and 58 mm wide. The siphuncle

as seen in cross-section is 6 mm wide and 5 mm high. It evidently does not show maximum expansion of the segment and is slightly removed from the flat side of the shell. Here the flattened side is slightly and evenly convex, without ventrolateral concavity. The dorsum is more broadly arched and again lacks the median increase in curvature of the preceding specimen. Camerae are shallow. Basally 5 camerae occupy a length of 10 mm; adorally 6 occur in a similar length.

On the flattened side, as before, the sutures come to lie almost, sometimes perfectly, in contact as they rise to form the lateral flanges. On the convex side they are narrowly separated. The flanges are high, gently and evenly recurved, and their recurvature is equal to the depth of two camerae.

A third specimen (pl. 7, fig. 1) shows part of the adoral end of the flattened side of a phragmocone which, when complete, had a width of 62 mm adorally. The shell wall is present and shows faint longitudinal fibrous structure, brought out by slight etching. The shell wall is thin and so translucent that the septa can be seen through it. Eight camerae can be seen in the median portion; parts of more on the lateral flange. In the illustration of this form (pl. 7, fig. 1), the shell form is reconstructed by supplementing an ordinary photograph with another taken with the sides reversed. The flattened side of the shell is faintly convex, the opposite side strongly arched, resembling the first hypotype more than the second.

A fourth specimen (pl. 2, fig. 6) is figured only in basal view, to show the cross-section. Only part of the median portion is present here, the lateral flanges being lost. The figured portion has a basal height of 17 mm. The median lobe is 56 mm across, and the total width must have been at least 80 mm. Adorally the shell extends 40 mm farther at the middle and includes part of the base of a living chamber, which is 20 mm high at the middle and must have been 85 mm wide.

Three natural sections from the type locality show little more than natural sections of the siphuncle and parts of the septa, but are remarkable in showing appreciable differences in proportions. One specimen (pl. 8, fig. 4) shows 23 camerae in 43 mm. The septa are closer here than in the forms previously discussed, $5\frac{3}{4}$ septa in the basal 10 mm and 6 in an adoral 10 mm. Only the median lobe of the septa is preserved. The siphuncle segments are extremely short and broad; one, 1.6 mm long, expands from 2.5 mm to 7.5 mm. The median lobe is 28 mm across adorally, and this specimen represents an earlier growth stage than that of any of the specimens previously discussed.

A second specimen from the type locality (pl. 9, fig. 4) shows 16 siphuncle segments in a length of 32 mm; again the septa show only part of the median lobe.

Discussion. Although this species is represented only by fragmentary specimens, it is now possible to attain a better concept of its features than was possible from the two incomplete natural sections on which the species originally was based. Reexamination of types indicates that the extreme lateral part of the suture, as figured by Ruedemann (1906, pl. 36, fig. 4), is adventitious, and the sutures do not straighten, as he indicated, upon approaching the extremely lateral angles of the shell. The form is closely septate; one side is slightly convex, the other more strongly arched than in any other *Gonioceras* so far known. The lateral flanges of the sutures rise to an unusual extent in so old a species.

Types. Holotype and paratype, New York State Museum.

The original of Ruedemann (1906, pl. 36, fig. 4) is here designated as the lectotype. Hypotypes are in the collection of the writer.

Occurrence. The holotype and paratype are from the *Maclurites* ledges of the middle Chazyan, from the type section of the Chazyan, southwest of Chazy, New York. Two hypotypes are from this locality. Additional specimens, showing more clearly the shell features and, in particular, the cross-section, are from the Valcour limestone near Little Monty Bay, southeast of Chazy, New York. The species has been observed also in other outcrops of the middle and upper Chazyan, notably from Isle La Motte and Valcour Island, and from outcrops west of Vergennes, Vermont.

Gonioceras brainerdi Flower, n. sp.

Pl. 11, fig. 4.

This species is represented by a natural section of a phragmocone, showing 45 mm of the siphuncle and containing 17 segments. Near the base a segment attains a width of 10 mm and is 3 mm long. The median lobe of the suture is 24 mm wide, the sutures being strongly oblique and little curved as they pass from the beginning of the lateral flange to the siphuncle. The depth of the lobe here is 7 mm and its width 24 mm, equal to the length of $2\frac{1}{2}$ siphuncle segments. The sutures slope forward at the edge of the flanges but do not fuse, and are level with the median basal part of the third anterior septum. Septa curve gently, are convex orad, toward the margin, and are more transverse than in *G. chaziense*. Their extreme lateral portion has not been observed.

Discussion. Although we have only a fragmentary specimen, it is evident that a species is represented here which differs markedly from *G. chaziense* in proportions. The broad siphuncle and deep camerae suggest that it represents a later growth stage than material of *G. chaziense*. The median lobe of the suture is so narrow, however, that the shell width at the middle of the specimen could not have been over 45 mm, even when a most liberal allowance is made for the width of the lateral flanges.

Holotype. Collection of the writer.

Occurrence. From the *Maclurites* ledges of the middle Chazyan, from the type section of the Chazyan, southwest of Chazy, New York.

Gonioceras pameliense Flower, n. sp.

Pl. 9, fig. 5.

This is a small *Gonioceras*; at least, the known specimens fail to indicate any appreciable size. It is moderately expanding and is known completely from specimens showing natural sections of the shell. The holotype, 82 mm long, preserves 19 camerae and 2 apical segments of a siphuncle without camerae. The apical angle of 45 degrees at the base is reduced markedly at a shell width of 58 mm, and continues over the anterior 45 mm of the shell at between 25 and 30 degrees. The first septum, 40 mm across, arises only 7 mm from the median lobe to the saddles and descends only 3 mm to the sides. As growth progresses, the curvature of the sutures is accentuated, the median lobe remaining broad and shallow and well rounded, but the sutures tend to extend farther apicad in their lateral extremities. The last septum where measurement is possible shows a depth of the lateral

lobe of 12 mm, slightly greater than the depth of the median lobe at this point. At an earlier stage, where the shell is 60 mm across, median and lateral lobes are of equal depth. The beginning of the lateral flanges is marked by a less pronounced steepening of the sutures than in *G. chaziense*, *G. anceps*, or *G. quadratum*. Curvature is gentle, the suture never coming to form an angle of more than 45 degrees with the horizontal; in the other species it may reach 65 to 80 degrees.

The natural section of the holotype shows some differences between the sutures on the left and right sides. On the left, the extreme lateral extremity of the shell is shown; on the right, the section extends slightly above the point of greatest shell width. In attempting a restoration of the specimen it was necessary to allow for a slight displacement of about half a camera from the x 1th to 14th septa. Farther orad the discrepancy is lost as it passes into the central anterior part of the shell, which is missing. The cross-section cannot be ascertained. Rate of expansion and suture pattern serve, however, to distinguish this species.

Holotype. New York State Museum.

Occurrence. From the Pamela limestone, 2 miles east of Perch Lake, New York.

Gonioceras anceps Hall

Pl. 8, fig. 2-3; text fig. 3K.

Gonioceras anceps Hall, 1847, Paleontology of New York, v. I, p. 54 (pars); pl. 14, fig. ia-b (not fig. ii, ic or id)

This species has remained unrevised since Hall's description. Bassler (1915) presents other references, but they add nothing to our knowledge of the species. It has been assumed that *G. anceps* is the only species of *Gonioceras* in the Chaumont limestone of northwestern New York. Actually there are two distinct forms here, deserving of specific rank. One is a large shell, expanding fairly rapidly to a width of about

100 mm, with an apical angle in the initial part of about 40 degrees, and then showing a reduction in the rate of lateral expansion, the apical angle decreasing to between 25 and 30 degrees in the next 80 mm. Beyond this point the shell may become much more slender, and the whole must attain a length of well over 2 feet. Hall's type, the original of his pl. 54, fig. 1a, is designated as the lectotype of *G. anceps*. This is a specimen 150 mm long. The basal 15 mm is irregular and appears to represent only matrix. In the next 90 mm the shell expands from 62 to 100 mm, and in the anterior 50 mm the shell becomes more slender, the two parts having angular measurements essentially as given above.

A hypotype is here figured, a specimen presenting an exceptionally fine flat surface of the shell. The base is slightly oblique to the shell axis, but the lateral outline, as restored, increases 70 to 115 mm in the basal 55 mm, and to 145 mm in the next 50 mm. The natural section at the base, slightly oblique, sloping forward on the left, is 76 mm wide and 12 mm high. The siphuncle, 8 mm high and 12 mm wide, is expanded and narrowly separated from the flat side of the shell. From its center it is 44 mm to one side, 32 mm to the other, giving a restored width, normal to the axis, of 76 mm. The convex side of the shell is slightly irregular in the median portion, suggesting that the shell height has been reduced by abrasion of this side of the shell prior to burial. A suture at midlength shows a depth of the median lobe, 55 mm wide,

of 14 mm, equal to 5 1/2 camerae. The maximum curvature of the septa is 25 mm from the highest saddle to the median lobe, equal to 1 to or 1 x camerae. The lateral lobe descends 12 mm, about the length of 4 camerae. The figured specimen preserves the sutures with exceptional clarity to the extreme lateral margin of the shell.

Discussion. This is a large species, strongly flattened, and expanding rapidly up to a relatively large shell width. Camerae average 8 in a length of 20 mm throughout.

Types. Holotype, American Museum of Natural History; hypotype, collection of the writer.

Occurrence. Common in the Chaumont limestone of the Black River valley, near Watertown, New York. The hypotype here figured came from the natural bridge of the Perch River, near Limerick, New York.

Gonioceras quadratum Flower, n. sp.

Pl. 4, fig. 1-2; text fig. 3J.

This species is distinguished from the associated *G. anceps* by the fact that the shell becomes slender at a relatively early growth stage, the species never attaining the width of *anceps*. The holotype expands laterally from 85 to 100 mm in the basal 80 mm, as restored, and to 115 mm in the next 80 mm, the rate of expansion being gentle and uniform. Presumably the early part of the shell is more rapidly expanding. The lateral flanges of the shell are broad, 30 mm wide where the median lobe is 40 mm, and 35 mm where it is 50 mm. Sutures curve forward from the median lobe to the lateral saddles for a length of 20 mm (where the shell width is 110 mm), equal to the length of 7 camerae, and are recurved laterally 12 mm, equal to the length of 5 camerae. Lateral saddles are broadly and gently rounded, the lateral tip not strongly increased in curvature as the lateral margin of the shell is approached.

The siphuncle is typical of the genus in the form of the segments. The center of the siphuncle is apically 7 mm from the flat side of the shell, and the expanded part of the segment clearly is not in contact with the shell on that side. At a shell width of 95 mm the shell is 9 mm high at the lateral flanges, which are here 28 mm from the lateral extremity. The median shell height is estimated to be 16 mm.

Discussion. This species, long identified with *G. anceps*, shows a number of important differences: the more slender form, which is attained at a shell width barely half that at which *anceps* loses its early rapid lateral expansion; the wide lateral flanges; and the cross-section, which is materially higher in proportion to the width of the shell. The lateral flanges are less transverse at the top of the saddles and are more evenly rounded, showing a smaller increase in curvature as they approach the lateral sides.

Holotype. Collection of the writer.

Occurrence. From the Chaumont limestone, from the edge of the Black River, 1.5 miles west of Watertown, New York.

Gonioceras multiseptatum Flower, n. sp.

Pl. 4, fig. 3.

This is a small, extremely slender, closely septate *Gonioceras*. The type preserves 19 siphuncle segments in a length of 39 mm. Except for the first two, which are shorter and smaller, the camerae average 2 mm in depth and show no

marked adoral increase in depth. The first 3 siphuncle segments increase in maximum width from 5 to 9 mm, beyond which expansion is very gradual. The 9th segment expands from 3 to 10 mm horizontally within the camera; the 5th expands from 5 to 12 mm. Only the median lobe of the septa is preserved. Where it is 39 mm across, the lobe is 12 mm deep, equal to nearly 4 camerae in length. The siphuncle is well displayed in natural section; the form of the segments is typical of the genus. The apical camerae are partially silicified, stand out in relief, and show evidence of episeptal deposits. The preserved side of the shell is perfectly flat. The siphuncle is well removed from it, the siphuncle center being 6 mm from the flat side of the shell. Probably the expanded part of the segment is separated narrowly from the ventral wall of the shell.

Discussion. Although the species is incompletely known, the obviously slender form of the shell, small size, and very close septa distinguish it from any described species except *G. chaziense*. That species has the flat side of the shell more convex and the siphuncle closer to this wall of the shell; the camerae are somewhat deeper, and the median lobe of the suture is more strongly curved centrally. This specimen is of particular interest in that it supplies the only evidence of *Gonioceras* in the Mohawk valley of New York.

Holotype. Collection of the writer.

Occurrence. From beds of Black River age, probably from remnants of the Lowville, from North Litchfield, Herkimer County, New York.

Gonioceras obtusum Flower, n. sp.

Pl. 10, fig. 4-7, 10.

A silicified *Gonioceras*, 20 mm long, preserving 6 segments of the siphuncle, the median part of the phragmocone, and the flat (but not the convex) wall, appears to represent the apical portion of shell. The basal segment of the siphuncle is slightly oblique, sloping forward on the side of the shell, which is slightly convex, 5 mm wide and 5 mm high. It is only 1.5 mm long. Although its outline is smoothed, it possibly could represent an abraded specimen, broken at the juncture of the annuli and later smoothed by abrasion. The second segment is elliptical, 9 mm wide, the height expanding from 6 to 7.5 mm. It also slopes forward on the convex side of the shell. Succeeding segments show a gradual increase in size and a decrease of obliquity. The last segment, 14 mm wide and 9.5 mm high, is 2 mm from the flattened wall of the shell and must have been separated much more narrowly from the convex side. The septal foramen at its anterior end is 4 mm high and 6.5 mm wide. The basal 3 camerae occupy a length of 9 mm; the anterior 3, 10.2 mm. The median lobe of the suture on the flattened side is 30 mm wide and 9 mm deep, equal to the length of 2 1/2 camerae.

Discussion. This specimen appears to represent the true apical end of a shell and is amazingly unlike other *Gonioceras* from the same association. That it represents a different species is indicated by the broader and shallower ventral lobe on the flattened side of the shell and the slightly deeper camerae. Also, the tendency which this specimen shows for the siphuncle segments to slope forward as they approach the convex side of the shell is definitely opposed to the features shown in *Gonioceras paquettense*. Later parts of the shell will show camerae slightly deeper than those of *paquettense*, and

probably lateral lobes which are less inclined. Certainly the median lobe is shallower, more transverse at the middle, and less strongly rounded.

G. occidentale has somewhat shallower camerae, and its lateral lobes are strong, more continuously curved as they approach the margins.

Holotype. Collection of the writer.

Occurrence. From the Paquette Rapids beds of Black River age, from the Paquette Rapids of the Ottawa River.

Gonioceras paquettense Flower, n. sp.

Pl. I I, fig. 3, 8; pl. 12, fig. 8, 9.

This species is known from a series of fragments, all representing a relatively early growth stage. They would suggest that the species was small, never attaining a phragmocone of much more than 100 mm. This appearance may be false, for all specimens are fragments of silicified phragmocones, and it appears that silicification is advanced in these specimens where the primary shell structures are thickened by cameral or siphonal deposits, usually both being present. It may be that there is a considerable anterior portion missing, which either was largely broken prior to burial, or is not commonly preserved, because it is not silicified. The camerae are relatively shallow. The median lobe of the septum is rather deep and particularly strongly curved centrally in the early stages. The lateral saddles are high but broadly rounded, as in *G. occidentale*, and not sharply curved, as in *G. kavi*. The lateral lobes of the sutures are gently inclined and never slope back as far as in either of those species.

The holotype (pl. 11, fig. 3) retains parts of 11 camerae, quite uniform in length, averaging 3 1/2 camerae in a length of 10 mm. Siphuncle segments, typical of the genus, are subequal in proportions and 10-11 mm wide. They are depressed in section; the septal foramen is small. The rate of expansion varies with growth, decreasing from the apical to the adoral portion. The median lobe is deep and narrowly rounded basally; 12 mm deep where the crests of the saddles are 45 mm across, the depth equal to 3 1/2 camerae, or slightly more. Lateral lobes are inclined gently, the curvature lessening as they approach the lateral margin of the shell. A paratype (pl. 12, fig. 8) shows a specimen, the basal part of which is commensurate with the holotype, the anterior end representing camerae not shown on the holotype. This specimen preserves parts of the lateral flanges on both sides. Ten siphuncle segments occur in a length of 30 mm. Median lobes of the sutures are somewhat broader adorally. Lateral saddles are rounded. The lateral lobes, as in the holotype, are gently inclined, straightening as the lateral margin is approached. That the rate of expansion appears greater on this specimen is the result of imperfect preservation of the sides.

A third specimen (pl. 11, fig. 8) is remarkable in that it shows an early portion of the siphuncle. This specimen, 44 mm long through the siphuncle, preserves parts of 17 siphuncle segments and the median part of the shell. The flattened side is well preserved; the convex side is missing, thereby exposing the siphuncle. The first 5 segments are extremely short, the width increasing from 5.5 to 6 mm, the height from 4.5 to 5 mm, the length from 1.5 to 2 mm. Insofar as can be determined without sectioning, they appear to be typical of *Gonioceras* in form. They are, however, anomalously small. In lateral view they are transverse, failing to show any tend-

ency to slope forward on the convex side of the shell. The 6th to 11th segments enlarge rapidly, increasing in width from 6.5 to 12 mm, in height from 5.5 mm to an estimated 8 mm, and in length from 2 to 3 mm. In lateral profile the expanded parts of the segments, straight apically, are here concave. From the 12th to the 18th camerae, increase in size of the segments is greatly reduced, the height increasing to 9 mm, the width to 13 mm, the length to 5 mm. Throughout, the exposed surface of the siphuncle shows a slight flattening, suggesting that the expanded parts of the segments may have been flattened by coming into contact with the convex shell wall. They are not in contact with the flattened side, being separated from it by 2.5 mm apically, and 1.5 mm adorally. On the flattened side of the shell the median lobes are strongly rounded, as in the holotype, with which its anterior end agrees closely in proportions.

A third paratype (pl. 12, fig. 9), containing 12 siphuncle segments in a length of 33 mm, shows reduction in size of the basal segments of the siphuncle and marked shortening of the basal camerae. It serves to show the identity of the holotype with the second paratype. An anterior segment of the siphuncle shows the septal foramen 5 mm across. The segment expands to 10.5 mm in width and is 3 mm long. The median lobes of the sutures are largely preserved, but the lateral flanges are wanting.

Discussion. This species, the common one at the Paquette Rapids of the Ottawa river, is clearly neither *G. kayi* nor *G. occidentale*, as pointed out in the preliminary diagnosis of the species.

Holotype and paratypes. Collection of the writer.

Occurrence. From the Paquette Rapids beds of the Ottawa River, correlated by Kay with the Rockland, lower Trenton (Kay, 1937). Cooper (1956) and the writer regard the beds as of Black River, rather than Trenton, age.

Genus LAMBEOCERAS Foerste

This genus includes actinoceroids strongly flattened in cross-section and with sides acutely angled, like *Gonioceras*. The sutures show ventral and dorsal lobes, the ventral lobe being the deeper of the two, though differences may be slight. The sutures produce high angular saddles on the sides, and are never recurved laterally as in *Gonioceras*. The siphuncles exhibit extremely long septal necks with short brims, recumbent or nearly so; these mark the adoral beginning of the expanded part of the segment, which is broadly rounded. The apical end of the connecting ring may be broadly adnate to the adapical septum.

Lambeoceras characterizes Red River faunas from Cape Calhoun, Greenland, to El Paso, Texas. Eastward it is known from the Stewartville dolomite. It is not known as yet in the Cobourg of Ontario nor in its equivalent in northern Michigan, but a single species, *L. montrealense*, occurs in Quebec. In the Richmond it is known from the Whitewater and Saluda of Ohio and Indiana, but has not been reported from the Maquoketa of Iowa, nor from the Stony Mountain of Manitoba or the Richmond of Ontario or Quebec, and is unknown from Anticosti or from the Whitehead beds of Gaspé.

The relationships of the genus are perplexing. It can be derived from *Gonioceras* only by suppression of the lateral

recurved flanges of the sutures and by marked modifications of the structure of the siphuncle. These discrepancies are so great as to suggest that the genera are homeomorphic in being strongly flattened shells, with the sides strongly angular, but are homeomorphs and not closely related. *Gonioceras*, with its broadly rounded segments, nearly recumbent brims, and broad areas of adnation, agrees with typical *Armenoceras* in internal structure and clearly was derived from that genus. Curiously, *Gonioceras* occurs in America far earlier than does *Armenoceras*, but the early development of *Armenoceras* elsewhere is attested by its presence in the Wuting limestone in association with *Adamsoceras* and *Wutinoceras* (Endo, 1932).

Lambeoceras shows a very different type of siphuncle (Troedsson, 1926; Teichert, 1934), with a very short recumbent brim. No closely similar siphuncles are known. It could have developed, however, from a type of *Armenoceras* close to the point at which *Huron* developed. It could be derived also from *Actinoceras* of the group of *A. anticostiense*, by increasing the acuteness of the very short brim, and by exaggerating both the long straight neck and the abruptness of expansion of the apical half of the siphuncle segment.

Deposits in the siphuncle are typical of the actinoceroids. Within the siphuncle, radial canals form simple curved arcs but may bifurcate as they approach the perispantium.

The reported early stages of *Lambeoceras* (Leith, 1942) unfortunately are based on a specimen belonging to *Rasmus-senoceras*.

Lambeoceras rotundum Flower, n. sp.

Pl. 11, fig. 9; pl. 12, fig. 7, I o; text fig. 4E-G.

The holotype, and only known specimen, preserves a portion of a shell 280 mm in length. The entire width is not preserved in the basal portion, but the lateral expansion has an apical angle of about 20 degrees. The basal 95 mm expands vertically from 20 to 35 mm and contains 15 camerae, 7 mm long and subequal in length. Adoral camerae vary between 7 and 8 mm in depth, but the variation is erratic, and the adoral increase in depth of camerae is slight. The siphuncle in the apical portion shows segments typical of *Lambeoceras* in outline. A segment near the apical end has a foramen 6 mm across, 7 mm from the venter. The segment expands to a height of 11.5 mm and is 2 mm from the venter. The neck is 2 mm long and the brim short and very sharply re-curved; the connecting ring springs from it, being nearly horizontal at its inception, then curving apicad, outlining the broadly rounded segment. As the ring approaches the adapical septal foramen, it joins the free part of the septum, forming a broad area of adnation on both dorsum and venter.

Annular deposits in the siphuncle are poorly shown and evidently altered by replacement. Calcite between the siphuncle and the venter is believed to represent an original cameral deposit. It extends to the lateral margins of the shell but is wanting on the dorsum. At the adoral end of the section, the siphuncle has become 7 mm across the septal foramen and is 8 mm from the venter. The ventral part of the siphuncle expands, so that its wall is 2 mm from the venter. The connecting ring is destroyed on the dorsal side. At the anterior end of this interval, the cross-section shows the sides bluntly pointed, the venter gently arched, and the dorsum much more strongly arched (strongly curved near the center),

but with a definite middorsal flattening. In the next 15 mm the cross-section has increased to 115 mm wide and 42 mm high. Here the arching of the dorsum and the venter are sub-equal, the sides more convex as they approach the lateral margins, and the lateral angles more rounded. A natural section at the extreme anterior end of the specimen is slightly oblique to the horizontal; it shows a width of 120 mm and a height of 42 mm. Here the tendency toward rounding of the lateral angles is carried further; so much so that the anterior end does not suggest a *Lambeoceras*, but rather a *Kochoceras*.

A horizontal section was cut through the anterior end, showing the siphuncle (pl. 12, fig. 10). The long septal necks are shown, with their short, sharply recurved brims, but nowhere in this section is there any trace of the connecting ring.

Discussion. The holotype is a fine large specimen, which it was found impossible, however, to remove from its matrix. It is, therefore, illustrated necessarily by a number of sections. The apical part of the shell shows a little of the dorsal surface of the internal mold, which exhibits the usual lobes of the sutures. Since a vertical section through this part of the shell shows the septa sloping slightly forward from venter to dorsum, it is evident that ventral lobes are slightly deeper than the dorsal lobes, as is usual in the genus. The early septa are only slightly curved in vertical section, but are faintly convex apicad; not orad, as in *L. armstrongi*. In relation to *L. armstrongi* this is a larger species and more gently expanding. The curious changes in cross-section as ontogeny progresses have not been noted in any other species, and the extent to which the lateral angles are rounded in their late growth stages is unique in *Lambeoceras*.

Holotype. New Mexico Bureau of Mines and Mineral Resources.

Occurrences. From unit 3 of the Upham limestone member, Second Value formation, Montoya group; from the southern end of the Franklin Mountains, near the Scenic Drive, El Paso, Texas. Collected by Margaret F. Flower and the writer.

Lambeoceras armstrongi Flower, n. sp.

Pl. 12, fig. 1-6.

This is a moderately expanding, rather small species of *Lambeoceras*. The holotype, and only known specimen, is rather fragmentary but can be clearly restored. In the 130 mm of the length of the specimen, it expanded laterally from 50 to 97 mm, an increase of 35 mm in a length of 100 mm; in 100 mm the height increases from 20 to 35 mm, an increase of 15 mm. The cross-section at the base shows a moderate and even convexity of the dorsum, but the venter is concave ventrolaterally and arched into a small but prominent median convexity. The extreme lateral areas are lost here, but a similar section is shown at mid-length of the specimen, where the width is 67 mm, the height 30 mm. At this growth stage the convexity of the dorsum decreases laterally, becoming nearly flat dorsolaterally; curvature again increases as the lateral angles are approached, which have a measurement of 60 degrees. The midventral region is convex, the ventrolateral regions adjacent to it markedly concave. The cross-section here becomes practically straight in the extreme ventrolateral regions close to the lateral angles.

The specimen is septate throughout. The basal 5 camerae

show an increase in depth from 7 to 8 mm. The middle camerae are obscure but certainly do not increase to over 9 mm in length. The penultimate camera is 7 mm, the last one 6 mm, the shortening here suggesting that the specimen was a mature individual, retaining on its anterior end the basal part of a mature living chamber. The ventral lobe is deeper than the dorsal one by about the length of a camera. Dorsal and ventral lobes are in close accord laterally, so that there is no vertical curvature of the septa there, but the discordance is confined to the middle half of the shell and is greatest at the plane of symmetry. In lateral profile the septum is nearly transverse for the short distance from the ventral wall to the septal foramen, and then slopes forward, being faintly convex adorally instead of adapically, as is usual in the nautiloids. Ventral lobes not only are deeper than those of the dorsum, but are more strongly rounded centrally.

In the apical fragment of 5 camerae, the septal foramen is compressed; it is 6 mm high, 5 mm wide, 4 mm from the venter, and 10 mm from the dorsum. At the adoral end the septal foramen appears to be circular, 6 mm in diameter, and 5 mm from the venter. Shell height increases in this interval from 20 to 30 mm. This portion of the shell was sectioned horizontally to expose the siphuncle. The 5 segments increase gradually in length from 7 to 8 mm. The septa are nearly horizontal as they join the siphuncle. They bend abruptly apicad at right angles, extend for a distance of one-third the length of the segment, and then are sharply recurved into short brims which point almost straight forward, and which may extend a third of the distance back toward the free part of the septum. Connecting rings outline strongly expanded and broadly rounded parts of the siphuncle segment. Apically they join the next adapical septum, with an area of adnation considerably greater than the outward extent of the brims, and can be traced within the septal necks to their very tips. In the section the ring has an appreciable thickness, and the opaque section alone might well be interpreted mistakenly as representing a holochonitic condition. The perispatial cavity is filled with dark material, making the outline of the segments particularly clear. Calcite fills the cavity of the siphuncle, which fails to show central or radial canals. In the plane of the section an apical segment 7 mm long expands from 4.5 mm across the septal foramen to 13 mm. Adorally, where possibly the maximum diameter of the foramen may not be attained, the segment, 8 mm long, increases in width from 4 mm to 14 mm.

Discussion. In spite of the unprepossessing exterior of the holotype, it presents the essential proportions of the shell and shows this species to be a very distinctive one in its fairly rapid lateral expansion, the median convexity and lateral concavity of the venter in cross-section, and the curvature of the septum forward from the siphuncle to the dorsum, so that its convexity is directed forward instead of apically. This feature is well marked in early growth stages but appears to be reduced with later growth. It has been observed in *L. sinclairi*, although it is much less strongly developed in that species. It is not indicated by *L. rotundum* nor by descriptions or material relating to the larger species described from the Bighorn group, the Red River series of Manitoba, or any of the numerous arctic forms. These larger forms show a much smaller discordance in the depth of the dorsal and ventral lobes of the shell.

Holotype. New Mexico Bureau of Mines and Mineral Resources.

Occurrence. From a 1- to 2-ft zone of friable sandy limestone marking the transition from the Cable Canyon sandstone into the Upham "dolomite" (here a good limestone), near the point at which the Montoya crosses the north-south ridge of the Cooks Range. The Second Value formation here consists of 3 ft of coarse dolomitic limestone replete with large, more dolomitic worm borings; 35 ft of brown-weathering Cable Canyon sandstone; the 1 to 2 ft of sandy limestone; then 40 ft of pure limestone, the base and top fine grained, the middle coarse and granular, capped by a 10-ft interval of conspicuous white saccharoidal crystalline limestone. Above is 80 ft of Par Value formation, with the Raven dolomite above.

Genus **JEHOLOCERAS** Kobayashi and Matumoto

Jeholoceras Kobayashi and Matumoto, 1942, Japanese Jour. Geology and Geography, v. 18, p. 315.

Jeholoceras was erected for the reception of a single species, *Jeholoceras robustum* Kobayashi and Matumoto, the description and illustration of which accompany the description of the genus. The shell is a large, straight, slender actinoceroid. The single specimen is known from a portion of about 15 camerae, obviously from a fairly late growth stage, yet well enough removed from the base of the living chamber to show a good development of deposits in the camerae and siphuncle.

The shell probably was slightly depressed in cross-section, a condition accentuated by crushing of the ventral side of the type, as indicated by irregularity in the cross-sections (Kobayashi and Matumoto, pl. 30, fig. 1, a) and by distortion of septa between the siphuncle and the ventral wall (ibid., pl. 30, fig. 3) very similar to that observed in *Adamsoceras isabelae*. The siphuncle is close to the venter, but even the expanded parts of the segments are not in contact with the ventral wall in the growth stage from which the species is known. Segments are broad and broadly expanded in the camerae. On the venter the septal necks are either narrowly free or very narrowly adnate to the free part of the septum; some segments suggest one condition, some suggest the other. The apical end of the ring joins the free part of the septum in a long area of adnation ventrally. Dorsally the septal neck is recumbent, and possibly the anterior part of the connecting ring is also in broad contact with the free part of the septum. Apically the area of adnation of the connecting ring appears to be somewhat less extensive than on the venter. The siphuncle outline is thus more similar to that of *Wutinoceras* and *Nybyoceras* than to true *Armenoceras*, in which such dorsoventral differentiation does not occur.

Within the siphuncle the radial canals divide rather complexly as they approach the perispantium. The longitudinal section already referred to shows some irregular, linear, dark markings clearly indicative of the reticular type of canal system. The section suggests that there are also double arcs, as in *Wutinoceras*. As the canals approach the perispantium, they can be seen to be irregular in tangential longitudinal section. Small branches are seen extending forward and backward, as is natural if division of the canals is not to be confined to a plane normal to the central canal.

Camerae contain episeptal and hyposeptal deposits.

Discussion. *Jeholoceras*, as determined by the characters shown by the genotype, is clearly distinct from *Armenoceras*, but is more similar in siphuncle outline to *Nybyoceras*, as that genus formerly was used. It has the reticular canals of *Wutinoceras*, as redefined in the present paper and set apart from *Nybyoceras*. Indeed, *Jeholoceras* may not be distinct from *Wutinoceras*, as that genus is at present defined; of course, under its original definition, *Wutinoceras* did not merit serious consideration as a valid genus of actinoceroids. There are obvious differences in the appearance of the canal systems between *Wutinoceras foerstei* (Endo) and *Jeholoceras robustum* Kobayashi and Matumoto. It seems possible that some of the obvious differences, at least, are due to the fact that the published figure of *W. foerstei* cuts the center of the siphuncle and exposes the central tube. In *Jeholoceras robustum*, on the other hand, the figured section clearly does not show the central tube throughout its length; rather, it shows peripheral linear tubes close to the central canal.

The only known species of *J. robustum* is from the Toufangian of Jehol province. This is several hundred miles west of the region investigated by Endo, and reference to the Toufangian is apparently a generalization, though a wise one. From the presence of reticular canals, one may wonder whether *Jeholoceras* comes from strata as young as the Makkol limestone of Kobayashi or the Ssuyen of Endo, or whether, perhaps, it may not be from earlier strata equivalent to the Wuting limestone of Endo and, therefore, homotaxial with, and probably equivalent to, the Whiterock of North

Genus **ORTHONYBYOCERAS** Shimizu and Obata

Teichert and Glenister (1952) have pointed out correctly that *Treptoceras* Flower is preoccupied by *Orthonybyoceras* Shimizu and Obata. The genus is anomalous in many ways. We know it as well developed and even dominant in the Cincinnati of Ohio and Indiana, including the species of "*Orthoceras*" from the Cincinnati of southern Ontario, northwestern New York, and Quebec. Species from the Catheys and Cynthia limestone of Tennessee and Kentucky have been recognized, but as yet the genus has not been recognized in earlier Ordovician beds.

Shells are generalized orthocones, smooth, subcircular, and with straight sutures. Internal molds commonly show the septal furrow on the dorsum. The siphuncle varies in position but is rarely very close to the ventral wall. Its segments are expanded within the siphuncle and may show remarkable changes as ontogeny progresses. Early segments are broadly expanded like those of *Armenoceras*, with recumbent brims. Later segments may resemble *Nybyoceras*; then they may become more slender, as in *Ormoceras*. Later the expansion in the camerae is reduced, as in *Deiroceras*; sometimes with the dorsal wall nearly straight, as in *Leurorthoceras*. A feature unusual in actinoceroids is the fact that cameral deposits are commonly developed so that they extend farther forward in the shell than do the deposits of the siphuncle. Deposits in the siphuncle are found only in very early stages but appear to be typical of actinoceroids when they are fully developed.

A feature of *Orthonybyoceras* which apparently sets it apart from other actinoceroids is the septal furrow. The furrow is commonly preserved in typical species of the genus

in the Cincinnatian, and it is a conspicuous feature in *O. duseri*. For this reason the genus has been reexamined closely for possible indications that it might be a homeomorph of the actinoceroids, possibly derived from the Stereoplasmoceratidae. No such indication has been found. It appears instead that the Cincinnatian sedimentation produced conditions particularly favorable to the preservation of the septal furrow.

The genus is known in the Cincinnatian around the southern margin of the Nashville dome, although most of the species have not been studied closely enough to make specific relationships clear. Certainly *Deiroceras dismukesense* Foerste and Teichert, of the Fernvale beds of southern Tennessee, is a typical member of the genus. The Maquoketa shale of Iowa contains typical *Orthonybyoceras* in *Sactoceras maquoketense* Foerste, and *Deiroceras shideleri* Foerste.

What little is known of the orthocones of the lower Silurian Brassfield limestone of Ohio suggests that they may be related closely to *Orthonybyoceras* and possibly might even be congeneric with it. If so, the name *Orthonybyoceras* will have to be suppressed in favor of *Euorthoceras* Foerste. At the present time evidence on the matter is inconclusive; the siphuncle outlines of *Euorthoceras* are similar to those of *Orthonybyoceras*, but nothing is known of the deposits of the camerae or siphuncle.

Ancestors of the Cincinnatian species of *Orthonybyoceras* are certainly to be found in the late Trenton Cynthiana and Catheys limestones of Kentucky and Tennessee. As yet the genus cannot be traced farther into other late Trenton faunas nor into earlier Mohawkian associations. There are Mohawkian orthocones with small siphuncles somewhat expanded in the camerae, but as yet we know very little of the morphology of such species. They could be actinoceroids and forerunners of *Orthonybyoceras*, or they could be members of the Michelinoceratida, possibly of the family Stereoplasmoceratidae. Lack of suitably preserved material makes proper study of these forms impossible at the present time. It may be noted, however, that Foerste (1932, 1933) has described, in terms of the genus *Sactoceras*, a number of species of this aspect from beds of Black River age.

Orthonybyoceras extends into the faunas of the Second Value formation of the lower part of the Montoya group. Material collected too late for study at this time suggests that it penetrated the Fish Haven dolomite of northern Utah. In both occurrences it is associated with faunas of Red River aspect and, doubtless, of Red River age. In other Red River associations the genus appears to be absent. It is unknown in the Fremont limestone of Colorado, the Bighorn group of Wyoming, the Red River or Stony Mountain of southern Manitoba, the Ordovician of Hudson Bay, or the Cape Calhoun series of Greenland. Some small orthocones of the Mt. Silliman beds of Baffin Land may possibly represent *Orthonybyoceras*. Miller, Youngquist, and Collinson (1954) assigned these species to *Ormoceras*. They are largely relatively short portions of phragmocones of rather small shells. They have not been sectioned for the most part. All that can be noted is that their general proportions suggest *Orthonybyoceras* closely and are at distinct variance with the large species of

Ormoceras found elsewhere in associations of Red River aspect.

Genus **SACTOCERAS** Hyatt

Sactoceras, based upon *Orthoceras richteri* Barrande of the Middle Silurian of Bohemia, has been employed widely, though mistakenly, for orthoconic nautiloids with slightly expanded, rather small siphuncles. The genotype has a subcentral siphuncle. The segments are somewhat smaller than in typical *Ormoceras* in proportion to the size of the shell, and are expanded less markedly in proportion to their length and the distance across the septal foramen. Deposits in the siphuncle are plainly annular and typical of the actinoceroids. Some figures of the species show a marked reduction in the size of the siphuncle in the anterior part of the phragmocone, a feature found in many other actinoceroid genera. It well may be that *Sactoceras* is to *Ormoceras* very much as *Paractinoceras* is to *Actinoceras*. The question as to whether *Sactoceras* should be recognized as distinct from *Ormoceras* is clearly one with respect to which individual opinions must play an important role. The writer regards the generic name as one best dropped from general use, since distinction of the genotype from *Ormoceras* is doubtful from the present evidence, and since *Sactoceras* has been employed so widely and mistakenly in the past, that one is inclined to regard any species assigned to it with suspicion.

The Ordovician species which have been assigned to *Sactoceras* are, almost without exception, inadequately known orthocones with small septal foramina, and with siphuncle segments rounded and expanded, though never strongly expanded, within the camerae. Deposits within the siphuncles are unknown for many of the species, and their position is uncertain. Some species referred to *Sactoceras* are actinoceroids. *Sactoceras maquoketense* is such a form and is clearly a species best referred to *Orthonybyoceras*. For other species the evidence is less clear. It is evident that all Ordovician cephalopods with expanded siphuncles are not actinoceroids. The Discosorida, readily recognized in the main by the bullettes, inflations of the apical end of the connecting ring simulating annulosiphonate deposits, are in general cyrtococones rather than orthocones. They are never orthocones with subcentral siphuncles, which one would be tempted to name *Sactoceras*. In the Ordovician, however, there is another stock of orthocones, the family Stereoplasmoceratidae, with small, often subcentral, siphuncles composed of slightly expanded segments. Without evidence of the deposits in the siphuncle, they are confused easily with the actinoceroids. It is evident that such forms are prevalent in the American Ordovician, and some species previously referred to *Sactoceras* may well belong there. *Proteoceras* Flower (1955) is one such genus; indeed, *Orthoceras diffidens* Billings belongs to it, though Foerste (in Twenhofel, 1938) had referred the species to *Deiroceras*. It will suffice at the present to emphasize that Ordovician species referred to *Sactoceras* are inadequately known, but almost certainly more than one stock is involved.

References

- Baillie, A. H. (1951) *Silurian geology of the interlake area, Manitoba*, Manitoba Dept. Mines Pub. 50-1, 82 p., 5 fig., 5 tables.
- (1952) *Ordovician geology of Lake Winnipeg and adjacent areas, Manitoba*, Manitoba Dept. Mines Pub. 51-6, 64 p., 4 fig.
- Barnes, V. E., Cloud, P. E., and Duncan, H. (1953) *Upper Ordovician of central Texas*, Am. Assoc. Petrol. Geol. Bull., v. 37, p. 1030-1043, 3 fig.
- Barrande, J. (1865-77) *Système Silurien du centre de la Bohême*, v. 2, Céphalopodes: texte, pt. 1 (1867), pt. 2 (1870), pt. 3 (1874), pt. 4 (1877), suppl. texte (1877); planches, pl. 1-107 (1865), pl. 108-244 (1866), pl. 245-350 (1868), pl. 351-460 (1870), suppl. pl. 461-530 (1877).
- Bassler, R. S. (1932) *The stratigraphy of the central basin of Tennessee*, Tennessee Div. Geol. Bull. 38, 268 p., 49 pl., 4 maps, chart.
- Berdan, J. M., and Duncan H. (1955) *Ordovician age of the rocks mapped as Silurian in western Wyoming*, Wyoming Geol. Assoc. Guide Book, 10th Annual Field Conference, p. 48-49.
- Brainerd, E., and Seeley, H. M. (1888) *The original Chazy rocks*, Am. Geologist, v. 2, p. 232-330.
- (1891) *The Chazy formation of the Champlain Valley*, Geol. Soc. Am. Bull., v. 2, p. 293-300.
- Butts, C. (1940) *Geology of the Appalachian valley in Virginia*, Virginia Geol. Survey Bull. 52, pt. 1, 567 p.; pt. 2, 271 p., 135 pl.
- Clark, T. H. (1928) *A new cephalopod from the Trenton limestone of Montreal*, Canadian Field Naturalist, v. 24, n. 8, p. 187-189, 1 fig.
- (1952) *Montreal area, Laval and Lachine map areas*, Quebec Dept. Mines Geol. Rpt. 46, 157 p., 3 maps, 16 pl.
- (1955) *St. Jean-Beloeil area*, Quebec Dept. of Mines Geol. Rpt. 66, 53 p., maps.
- Cooper, G. A. (1956) *Chazy and related brachiopods*, Smithsonian Inst. Misc. Coll., v. 127, pt. 1, 1024 p., 3 fig., 1 chart; pt. 2, 269 pl.
- Darton, N. H. (1917) *A comparison of Paleozoic sections in southern New Mexico*, U. S. Geol. Survey Prof. Paper 108-C, p. 31-55, pl. 13-21, fig. 2-15.
- Endo, R. (1930) *The presence of Nybyoceras in southern Manchuria*, Denison Univ. Bull., Sci. Lab. Jour., v. 25, p. 297-300, pl. 60.
- (1932) *The Canadian and Ordovician formations of southern Manchuria*, U. S. Natl. Mus. Bull., v. 164, 152 p., 40 pl., 1 map.
- (1935) *Additional fossils from the Canadian and Ordovician rocks of the southern part of Manchuoko*, Tohoku Imp. Univ. Sci. Rpts., ser. 2, v. 16, n. 4, p. 191-223, pl. 10-15.
- Entwistle, L. P. (1944) *Manganiferous iron ore deposits near Silver City, New Mexico*, N. Mex. School of Mines, State Bur. Mines and Mineral Resources Bull. 19, 70 p., 11 fig., maps.
- Flower, R. H. (1939) *Study of the Pseudorthoceratidae*, Palaeontographica Americana, v. 2, n. 10, 214 p., 9 pl., 22 fig.
- (1939-a) *Structure and taxonomic position of Troedssonoceras Foerste*, Jour. Paleontology, v. 13, p. 481-484, pl. 50.
- (1940) *The apical end of Actinoceras*, Jour. Paleontology, v. 14, p. 436-442, pl. 61 (pars), 1 fig.
- (1940-a) *Some Devonian Actinoceroidea*, Jour. Paleontology, v. 14, p. 442-446, pl. 61 (pars).
- (1941) *Notes on structure and phylogeny of euryisiphonate cephalopods*, Palaeontographica Americana, v. 3, n. 13, 56 p., 3 fig., 3 pl.
- (1943) *Investigations of actinosiphonate cephalopods*, Bull. Am. Paleontology, v. 28, p. 30-67, pl. 2-6 (pars), text fig. 2.
- (1943-a) *New Ordovician cephalopods from eastern North America*, Bull. Am. Paleontology, v. 28, p. 62-68, pl. 2, 4-5 (pars), text fig. 3.
- (1943-b) *A Goniceras from Virginia*, Bull. Am. Paleontology, v. 28, p. 21-29, pl. 2 (pars).
- (1946) *Ordovician cephalopods of the Cincinnati region*, Bull. Am. Paleontology, v. 29, n. 116, 656 p., 50 pl., 22 fig.
- (1952) *New Ordovician cephalopods from eastern North America*, Jour. Paleontology, v. 26, p. 24-59, pl. 5-10, 1 fig.
- (1952-a) *Cephalopods from the Harding and Manitou formations of Colorado*, Jour. Paleontology, v. 26, p. 508-518, pl. 60-61.
- (1954) *Cambrian cephalopods*, N. Mex. Inst. Min. and Technology, State Bur. Mines and Mineral Res. Bull. 40, 51 p., 3 pl., 7 fig.
- (1955) *New Chazyan orthocones*, Jour. Paleontology, v. 29, p. 806-830, pl. 77-81, 1 fig.
- (1955-a) *Status of endocerooid classification*, Jour. Paleontology, v. 29, p. 329-317, pl. 32-35, 6 fig.
- (1956) *Age of the Red River faunas (Ordovician), Manitoba to New Mexico*, Geol. Soc. Am. Bull., v. 67, p. 1696.
- , and Kummel, B. (1950) *A classification of the nautiloidea*, Jour. Paleontology, v. 24, p. 604-616, 1 fig.
- Foerste, A. F. (1921) *Notes on arctic Ordovician and Silurian cephalopods, chiefly from Boothia Felix—King William Land, Bache Peninsula and Bear Harbour*, Denison Univ. Bull., Sci. Lab. Jour., v. 19, p. 247-306, pl. 27-35.
- (1928) *Cephalopoda in Twenhofel*, Geology of Anticosti Island, Canada Geol. Survey Mem. 154, 480 p., 60 pl.
- (1928-a) *Some hitherto unfigured cephalopods from Anticosti Island*, Royal Soc. Canada Trans., 3d ser., v. 22, p. 223-234, pl. 1-11.
- (1928-b) *Contributions to the geology of Foxe Land, Baffin Island, pt. 2, The cephalopods of Putnam Highland*, Michigan Univ., Mus. Paleont., Contr., v. 2, n. 3, p. 25-69, pl. 1-11.
- (1928-c) *American arctic and related cephalopods*, Denison Univ. Bull., Sci. Lab. Jour., v. 23, p. 1-110, pl. 1-29.
- (1929) *The cephalopods of the Red River formation of Manitoba*, Denison Univ. Bull., Sci. Lab. Jour., v. 24, p. 129-235, pl. 11-39.
- (1930) *Three studies of cephalopods*, Denison Univ. Bull., Sci. Lab. Jour., v. 24, p. 265-382, pl. 41-63.
- (1932-33) *Black River and other cephalopods from Minnesota, Wisconsin, Michigan and Ontario*, Denison Univ. Bull., Sci. Lab. Jour., pt. 1: v. 27, p. 47-136, pl. 7-37 (1932); pt. 2: v. 28, p. 1-146 (1933).
- (1935) *Big Horn and related cephalopods*, Denison Univ. Bull., Sci. Lab. Jour., v. 30, p. 1-96, pl. 1-22.
- (1936) *Cephalopods from the Maquoketa shale of Iowa*, Denison Univ. Bull., Sci. Lab. Jour., v. 30, p. 231-258, pl. 27-36.
- , and Cox, I. H. (1936) *Cephalopods and a Beatrixia from Akpatok Island*, Geol. Mag., v. 73, p. 289-307, pl. 4, text fig. 1-8.
- , and Savage, T. E. (1927) *Ordovician and Silurian cephalopods of the Hudson Bay area*, Denison Univ. Bull., Sci. Lab. Jour., v. 22, p. 1-108, pl. 1-24.
- , and Teichert, C. (1930) *The actinocerooids of east-central North America*, Denison Univ. Bull., Sci. Lab. Jour., v. 25, p. 201-296, pl. 27-59.
- Grabau, A. W. (1922) *Ordovician fossils from North China*, Paleontologia Sinica, ser. B, v. 1, fasc. 1, 127 p., 9 pl., 20 fig.
- Hall, J. (1947) *Paleontology of New York*, v. 1, Albany, 338 p., 33 pl.
- Holm, G. (1889) *Om Bathmoceras*, Geol. fören. Stockholm Förh., bind 21, p. 271-304, pl. 5-11, 3 fig.
- Hyatt, A. (1900) *Cephalopoda in Zittel-Eastmann*, Textb. Paleont., v. 1, 1st ed., p. 502-592 (reprinted in later editions with varying pagination).
- Kay, G. M. (1935) *Ordovician Stewartville-Dubuque problems*, Jour. Geology, v. 43, p. 561-590, 10 fig.
- (1937) *Stratigraphy of the Trenton group*, Geol. Soc. Am. Bull., v. 48, p. 233-302, 10 pl., 13 fig.
- (1942) *Ottawa-Bonnechere graben and Lake Ontario homocline*, Geol. Soc. Am. Bull., v. 53, p. 565-646, 7 pl., 7 fig.
- Kelley, V. C., and Silver, C. (1952) *Geology of the Caballo Mountains*, N. Mex. Univ. Pub., Geol. Ser., n. 4, 286 p., 19 pl., 26 fig.
- Kobayashi, T. (1934) *The Cambro-Ordovician formations and faunas of south Chosen: Paleontology, pt. 1, Middle Ordovician faunas*, Tokyo Imp. Univ., Fac. Sci. Jour., sec. 2, v. 3, p. 329-520, pl. 1-44.
- (1935) *Restudy on Manchuroceras with a brief note on the classification of endocerooids*, Geol. Soc. Japan Jour., v. 42, n. 506, p. 736-752, pl. 20, 21.
- (1937) *Contributions to the study of the apical end of the Ordovician nautiloid*, Japanese Jour. Geology and Geography, v. 14, p. 1-21, pl. 1-2, 3 fig.
- (1940) *Polydesmia, an Ordovician actinocerooid from eastern Asia*, Japanese Jour. Geology and Geography, v. 17, p. 27-44, pl. 3-5, 3 fig.

- , and Matumoto, T. (1942) *Three new Tofangian nautiloids from eastern Asia*, Japanese Jour. Geology and Geography, v. 18, p. 313-317, pl. 30-31.
- Leith, E. (1942) *Notes on the cephalopod Lambeoceras lambei from Manitoba*, Jour. Paleontology, v. 16, p. 130-132, pl. 22, 1 fig.
- Miller, A. K. (1932) *The cephalopods of the Big Horn formation of the Wind River Mountains of Wyoming*, Connecticut Acad. Arts and Sci. Trans., v. 31, p. 197-297, pl. 1-31.
- , and Carrier, J. B. (1942) *Ordovician cephalopods from the Bighorn Mountains of Wyoming*, Jour. Paleontology, v. 16, p. 531-548, pl. 75-79, 5 fig.
- , Youngquist, W., and Collinson, C. (1954) *Ordovician cephalopod fauna of Baffin Island*, Geol. Soc. Am. Mem. 62, 234 p., 63 pl., 18 fig.
- Pray, L. C. (1953) *Upper Ordovician and Silurian stratigraphy of Sacramento Mountains, Otero County, New Mexico*, Am. Assoc. Petrol. Geol. Bull., v. 37, 1894-1918, 10 fig.
- Richardson, G. B. (1908) *Paleozoic formations in trans-Pecos Texas*, Amer. Jour. Sci., 4th ser., v. 25, p. 475-479.
- Rowley, R. R. (1906) in Greene, G. K., *Contributions to Indiana paleontology*, v. 2, pt. 1 and 2.
- Roy, S. K. (1941) *The upper Ordovician of Frobisher Bay, Baffin Land*, Field Mus. Nat. History Geol. Mem., v. 2, 212 p., 146 fig.
- Ruedemann, R. (1906) *Cephalopods of the Champlain basin*, New York State Mus. Bull. 90, 611 p., 38 pl., 57 fig.
- (1926) *The Utica and Lorraine formations of New York*, pt. 2, *Systematic paleontology: n. 2, Molluscs, crustaceans and eurypterids*, New York State Mus. Bull. 272, 227 p., 28 pl., 26 fig.
- Schindewolf, O. H. (1935) *Bemerkungen zur Ontogenie der Actinoceroideen und Endoceren (Cephal., Nautil.)*, Neues Jahrb. für Mineral., usw., Beil.-Bd. 74, Abt. B, p. 89-113, 8 fig.
- (1941) *Ueber das Apikalende der Actinoceren (Cephal., Nautil.)*, Reichsamt für Bodenforschung, Jahrb. für 1941, Bd. 62, p. 207-247, pl. 8-10, 14 fig.
- Shimizu, S., and Obata, T. (1935) *New genera of Gotlandian and Ordovician nautiloids*, Shanghai Sci. Inst. Jour., sec. 2, v. 2, p. 1-10.
- (1936) *Three new genera of Ordovician nautiloids belonging to the Wutinoceratidae (nov.)*, from east Asia, Shanghai Sci. Inst. Jour., sec. 2, v. 2, p. 27-35.
- (1936-a) *On some new genera of Ordovician nautiloids from east Asia*, Shanghai Sci. Inst. Jour., sec. 2, v. 2, p. 11-25.
- Shrock, R. R., and Raasch, G. O. (1937) *Paleontology of the undisturbed Ordovician rocks near Kentland, Indiana*, Am. Midland Naturalist, v. 18, 532-607, pl. 1-11.
- Sinclair, G. W. (1953) *Middle Ordovician beds in the Saguenay valley, Quebec*, Amer. Jour. Sci., v. 25, p. 841-854, 2 fig.
- Sweet, W. C. (1935) *Cephalopods from the Fremont limestone of Colorado*, Jour. Paleontology, v. 29, p. 71-82, pl. 16-18, 1 text fig.
- Teichert, C. (1930) *Die Cephalopoden Fauna der Lyckholm-Stufe der Ostbaltikums*, Palaeont. Zeitschr., Bd. 12, p. 264-312, pl. 5-9, 4 fig.
- (1933) *Der Bau der Actinoceroideen Cephalopoden*, Palaeontographica, Bd. 78, Abt. A, p. 111-230, pl. 8-15.
- (1934) *Untersuchungen an Actinoceroideen Cephalopoden aus Nordgrönland*, Meddelelser om Grönland, bind 92, nr. 10, p. 1-48, 22 fig.
- (1935) *Structures and phylogeny of actinoceroideen cephalopods*, Amer. Jour. Sci., ser. 5, vol. 29, p. 1-23, 5 fig.
- (1937) *A new Ordovician fauna from Washington Land, North Greenland*, Meddelelser om Grönland, bind 119, nr. 1, p. 1-65, pl. 1-7.
- (1937-a) *Ordovician and Silurian faunas from arctic Canada*, Rpt. 5th Thule Exped., 1021-24, v. 1, n. 5, 170 p., 24 pl., map.
- (1937-b) *Polydesmia canaliculata Lorenz, an Ordovician actinoceroideen cephalopod*, Geol. Soc. Japan Jour., v. 44, p. 110-113, text fig. 1-2.
- , and Glenister, B. F. (1953) *Ordovician and Silurian cephalopods from Tasmania*, Bull. Am. Paleontology, v. 34, n. 144, 66 p., 6 pl., 3 fig.
- Troedsson, G. T. (1926) *On the Middle and Upper Ordovician faunas of northern Greenland. I. Cephalopods*, Meddelelser om Grönland, bind 71, p. 1-157, pl. 1-65.
- Twenhofel, W. H. (1928) *Geology of Anticosti Island, Canada*, Geol. Survey Mem. 154, 480 p., 60 pl., map.
- (1938) *Geology and paleontology of the Mingan Islands, Quebec*, Geol. Soc. Am. Special Papers, n. 11, 132 p., 24 pl.
- , et al. (1954) *Correlation of the Ordovician formations of North America*, Geol. Soc. Am. Bull., v. 56, p. 247-298, 2 fig., 1 pl.
- Ulrich, E. O., and Foerste, A. F. (1933) *The earliest known cephalopods*, Science, n. ser., v. 78, p. 288-289.

PART II

MACROLOXOCERAS,

A DEVONIAN HOMEOMORPH
OF THE ACTINOCERATIDA

Abstract

The new genus *Macroloxoceras* is described from two species: The genotype *M. magnum*, from the Dyer dolomite of Colorado, and *M. minor*, from the Percha shale of New Mexico, both of very late Devonian age. Together with *Bergoceras*, *Paraloxoceras*, and *Pseudactinoceras*, this genus comprises the new subfamily Macroloxoceratinae of the Pseudorthoceratidae. Although in the entire subfamily there is a

strong resemblance to *Rayonnoceras*, reexamination of the evidence suggests this relationship is homeomorphic, though a remarkable example of contemporaneous convergence. *Pseudocyrtoceras*, sp. Schindewolf is assigned to the Pseudorthoceratinae. In spite of its resemblances to the Macroloxoceratinae, *Rayonnoceras* retains actinoceroid features favoring its derivation from *Ormoceras*.

Introduction

The remarkable new genus *Macroloxoceras*, on which the present study is based, first came to the attention of the writer through two specimens collected near Glenwood Springs, Colorado, by Dr. William H. MacQuown. Both specimens came from loose boulders at the foot of an escarpment in which both the Devonian Dyer dolomite member of the Chaffee limestone and the Mississippian Leadville formation were exposed. The specimens not having been found in situ, there was, of course, some uncertainty as to their Devonian or Mississippian age.

The specimens themselves, here described as *Macroloxoceras magnum*, provided no clear evidence of age. Although they seemed to be closely related to forms previously known only from the Mississippian of Belgium, they were obviously not close enough to them to be considered congeneric. Consequently this resemblance was far from being conclusive evidence of a Mississippian age. An origin in the Devonian was suggested by the lithology of the specimens. Also, one of them was found at the foot of the escarpment at a point at which the Mississippian had been eroded some 300 yards back from the edge. It was not until some 10 years later that a second species of the genus was found by the writer in the Percha shale of New Mexico. This occurrence greatly strengthens the inferred Devonian origin of the Colorado form.

Some aspects of *Macroloxoceras magnum*, on which understanding of the genus primarily rests, suggested a combination of actinoceroid and pseudorthoceroid features. The general shell proportions are paralleled by those of many actinoceroids. The shell is large, strongly depressed in section, with broad lobes on the ventral side. Such features are common in actinoceroids, but are not typical of the Michelinoceratida. Similar lobes occur in a number of large Ordovician actinoceroids, and the cross-section is rather similar to that of *Actinoceras margaretae*. The gross features of the siphuncle also resemble those of actinoceroids. The septal foramen is relatively large. The siphuncle segments are spheroidal, but truncated at the septal foramina, with strongly recurved septal necks and broad areas of adnation at the apical ends of the rings. Annulosiphonate deposits in the siphuncle are massive and were penetrated by radial canals. Although all these

features suggest the Actinoceratida, details of structure proved inconsistent with assigning the genus to that order.

Large size, though a general actinoceroid feature, is by no means confined to this group of orthocones. Barrande (x865-1877) had described forms of somewhat comparable size from the late Middle Devonian (his horizon G₃) of Bohemia. Although their structures are not adequately known, these shells are certainly to be assigned to the Michelinoceratida. An undescribed *Bradfordoceras* from the Conewango beds of the Upper Devonian of New York attains a larger size than that indicated by the material of *M. magnum*. True, none of these forms are comparable to *Macroloxoceras* in the nature of the cross-section, and the ventral lobes of the sutures are neither as broad nor as strongly developed, but these features are essentially superficial.

Both the relative size and general proportions of the siphuncle segments are consistent with assigning to *Macroloxoceras* a position in the family Ormoceratidae of the Actinoceratida. This family is the only one in the actinoceroids known to extend beyond the close of the Lower Devonian. Indeed, it seemed at first possible that *Macroloxoceras* might supply something of a link, both morphologically and stratigraphically, between the youngest known *Ormoceras*, from the Onondaga limestone, Middle Devonian, of New York, and *Rayonnoceras*, which appears in beds probably as old as late Middle Mississippian. However, in spite of the rather large siphuncle segments and the massive deposits within, details of structure proved to be unlike those of any known actinoceroid. The massive deposits grow mainly forward, scarcely apicad, from their points of origin at the septal foramina. Adjacent deposits meet in the anterior ends of the siphuncle segments, close to the point at which the anterior end of the connecting ring meets the septal neck. The canals are unlike those known in any actinoceroid. No true central canal is enclosed by deposits. Instead, the cavity of the siphuncle is expanded in each segment. One series of canals passes from the anterior end of the central cavity through the deposit, curving forward as it progresses and joining the connecting ring close to its anterior end, shortly apicad of the tip of the septal neck. Another series leaves the central cavity just apicad of the middle of the siphuncle seg-

ment, curves apicad, and joins the connecting ring just orad of the point at which the ring joins the adapical septum in its area of adnation. The pattern suggests that were the siphonal deposits only a little more massive, anterior and posterior canals would join some distance before they attained the axis of the siphuncle, and the point of juncture would lie in the anterior third of the siphuncle segment. No perispantium is present.

These features are widely at variance with those of any known actinoceroids, but comparable structures are found in two fairly well-known Mississippian genera, and possibly in a third, which is as yet less adequately known. Two of the genera, *Bergoceras* and *Paraloxoceras*, previously were assigned to the Pseudorthoceratidae (Flower 1939). They were regarded as derivatives of the Pseudorthoceratinae, partly because no other connection seemed possible, and partly because of the indication of strong concentration of siphonal deposits on the ventral side of the siphuncle. These two genera were peculiar in that the siphonal deposits were unusually massive and were penetrated by canals. The possibility of considering them as a distinct subfamily in the Pseudorthoceratidae was rejected at that time (1939) largely because of the limited material from which the structures were observed. Analysis of these genera shows much in common with *Macroloxoceras*, and a relationship is now clearly indicated.

Bergoceras Flower (1939) is known only from *B. antilope* de Koninck. As far as can be ascertained, the species is known only from de Koninck's material. The shell is a smooth slender cyrtococone, slightly type in cross-section, with generalized sutures and a subcentral siphuncle. The siphuncle segments are subspherical and contain annular deposits beginning at the septal foramen, from which they grow forward in the segment, thickening rapidly as they grow. Present observations show the deposits extending scarcely more than half the length of the siphuncle segment, but there is no assurance that the condition shown is necessarily a mature one. Rather, it is believed that with further growth deposits fused near the anterior ends of the siphuncle segments. Except for the extreme thickness of the deposit, the growth pattern is essentially pseudorthoceroid. Dorsoventral differentiation of growth of the deposits is not known in the genus. The known sections of the siphuncle are horizontal and not vertical.

Paraloxoceras Flower (1939) shows comparable structures. This genus, again, is based upon a single known species, *P. konincki*, which is known only from a single specimen. The type preserves only a portion of an orthococone of a straight cephalopod, smooth and generalized in external features. A vertical longitudinal section shows a siphuncle slightly ventrad of the shell center, its segments being broadly rounded, spheroidal, and somewhat larger in proportion to the shell than those of *Bergoceras*. Massive annular deposits develop in the siphuncle. They grow forward along the inside of the connecting ring, and in early growth stages resemble those observed in *Bergoceras*. In *Paraloxoceras*, however, the deposits could be observed growing to completion in apical siphuncle segments. There they joined near the anterior ends of the segments. Deposits were markedly thicker ventrally than dorsally; enough so to suggest the growth pattern of the Pseudorthoceratinae. Where deposits are strongly developed, the cavity within has the form of an irregular tube quite dif-

ferent from the central canal of actinoceroids, but similar to to the cavity left within the deposits observed in certain Discosorida, in particular *Faberoceras* and *Discosorus*. However, the canals which pass from the central cavity to the connecting ring are unlike any structures observed in actinoceroids or discosorids. A canal extends from the central cavity through the siphonal deposit, originating near the anterior end of the siphuncle segment. It divides, one branch curving apicad and meeting the connecting ring just orad of its juncture with the adapical septum. Another curves orad and joins the ring near its anterior end. A third branch, joining the ring near shortly orad of the middle of the segment, is suggested, but the evidence is not conclusive.

So similar is the structure of *Paraloxoceras* to that of *Macroloxoceras*, that close affinities of the genera are evident. It remains, however, to review the position of both these genera, together with the less adequately known *Bergoceras*, which doubtless is allied to them. Possible affinities with both the Actinoceratida and the Pseudorthoceratidae must be considered.

In this connection it is necessary to take note of Schindewolf's (1941) suggestion that possibly the Carboniferous actinoceroids are not related to those of the earlier Paleozoic, but are developed independently from the Michelinoceratida. Reevaluation of the evidence indicates that *Rayonnoceras* has a large blunt apical end, in which the first siphuncle segment is broadly expanded, the septal necks being strongly recurved. In this respect *Rayonnoceras* is in close accord with the older actinoceroids and contrasts strikingly with the early stages of contemporaneous Michelinoceratida, in which the apical caecum may be slightly swollen but remains relatively small, and the first septal necks are not recurved. Likewise, the annular deposits of *Rayonnoceras* are comparable to those of actinoceroids. The perispantium is developed, and the canals are of the horizontal type characteristic of the Ormoceratidae, to which *Rayonnoceras* has been assigned previously. Such canals are found in a long lineage, traceable back to the oldest known *Ormoceras* in the Chazyan.

Schindewolf presented figures and descriptions of species which he believed supplied something of a transition from the Michelinoceratida to the actinoceroids. Both forms are of Mississippian age; hence the suggestion that the Carboniferous actinoceroids may actually be phyletically distinct from those of the earlier Paleozoic.

The two forms which Schindewolf presents in this connection represent two species, one of them new, and are the basis of two new genera. They can be evaluated only to a limited extent. Both are represented only by short portions of phragmocones showing an apical chamber and only a short series of later camerae. Throughout their length gradual ontogenetic changes are apparent. It is not, however, evident that the features shown in the latest stages of these specimens are not further modified before a stable adult stage is reached which will be maintained throughout an appreciable series of camerae. As a consequence, final evaluation of these forms with reference to genera and species known from adult, but not comparable early stages cannot be reached, at least from the published information now available.

Schindewolf's *Pseudocyrtoceras*, based upon *Cyrtoceras acus* de Koninck, is described only briefly in a footnote and is illustrated by a line drawing of a vertical section of a specimen indicated as *Pseudocyrtoceras* cf. *acus*. Some difficulty

will attend the recognition of *Pseudocyrtoceras*, for *C. acus* is designated as its genotype; yet its diagnosis depends apparently upon a specimen only tentatively identified with that species. Adult structures of *C. acus* are not known in detail, but de Koninck's illustrations suggest that it is a true *Bergoceras* (Flower, 1939). Schindewolf's figured specimen is inconsistent with this genus. This problem is not of immediate concern in the matter under discussion here; namely, what the relationships of Schindewolf's specimen may be. Schindewolf's figure shows a vertical section of a slender shell, slightly curved apically, containing an apical chamber and 15 later camerae. The whole specimen is tiny, about 30 mm long, attaining an adoral shell height of only 10 mm. Experience indicates that in the Michelinoceratida, in general, mature features are not displayed in specimens of such small dimensions. The siphuncle begins with a small round caecum, very slightly distended in the apical chamber, but with septal necks essentially parallel to the shell axis. Subsequent siphuncle segments are slender, their slight expansion in the camerae being outlined by the faintly convex connecting rings. Necks are not recurved, and no area of adnation is developed. Later segments show progressive increase in convexity of their outlines, but even the last one shown fails to show necks which are definitely recurved or an area of adnation. The segment has a generally convex outline suggestive of early stages in *Pseudorthoceras*. The siphuncle contains an organic lining, continuous throughout its length. As in the early stages of *Pseudorthoceras*, this lining is present only against the ventral side of the siphuncle. Initial stages of American Pennsylvanian *Pseudorthoceras* have been observed (Miller, Dunbar, and Condra, 1933) showing apical curvature analogous to that shown by *Pseudocyrtoceras*, though less pronounced. Indeed, *Pseudocyrtoceras* cf. *acus* resembles young stages of *Pseudorthoceras* in so many features that one well may wonder whether the genera are actually distinct. Certainly assignment of *Pseudocyrtoceras* cf. *acus* to the subfamily Pseudorthoceratinae is evident.

Another form described by Schindewolf suggests *Macroloxoceras*, *Paraloxoceras*, and *Bergoceras* much more closely. This is *Pseudactinoceras promiscuum* Schindewolf, based upon a small portion of a phragmocone showing parts of 11 camerae, of which the first is apparently the apical chamber. The specimen is very small, about 20 mm long, and attains an adoral shell height of 11.5 mm. The shell expands fairly rapidly throughout the length of the specimen; the apex is slightly curved and evidently exogastric, for the siphuncle, though central in the early stages, comes to lie slightly closer to the convex side than to the other, and it is the convex side also, against which cameral deposits are extremely thick. Early siphuncle segments are slender, the septal neck straight; indeed, their tips converge slightly toward the center, and the segment is scarcely expanded at all within the camerae. Later segments become increasingly expanded in the camerae, the brims becoming longer than the length of the neck. The segment becomes broadly rounded, with a slight flattening of its outline over the region of maximum expansion. The adoral end of the connecting ring is either adnate to the septum or narrowly separated from it. Its apical end meets the septum well outside the septal foramen; consequently a broad area of adnation is developed there. In outline the siphuncle segments show a marked resemblance to those of *Macroloxoceras* and *Paraloxoceras*, but there is also some re-

semblance to the segments of *Rayonnoceras*. Deposits within the siphuncle are apparently wanting in the earlier siphuncle segments. The fifth segment shows a parietal deposit, originating at the septal neck, growing forward over the length of the ring, and becoming fused at the next septal foramen with the succeeding deposit. The deposit is greatly thickened over the expanded part of the segment, resembling that found in the simpler species of the Lower Devonian genus *Anastomoceras*. In later segments the deposits tend to grow by a slight addition of material to their apical ends, so that one will extend apicad from the center of origin as well as orad. Schindewolf (1941, p. 234, fig. 13) represents the deposits of anterior segments as meeting at or close to the middle of the segments, at the point where radial canals extend from the central cavity of the siphuncle to the connecting ring. One can see, however, some indication of a branching of the canals, more analogous to that of *Paraloxoceras* and *Macroloxoceras* than to that of *Rayonnoceras*. Further, in the earlier segments at least, the canals leave the central cavity close to the anterior end of the segment. Although the siphuncle of this form resembles that of *Rayonnoceras*, a number of features suggest that the resemblance may be homeomorphic, and that *Pseudactinoceras* may be allied to *Macroloxoceras*, *Paraloxoceras*, and *Bergoceras* rather than to *Rayonnoceras*. The early stages of these genera are unknown, but those of *Pseudactinoceras* show a number of pseudorthoceroid features completely at variance with those of *Rayonnoceras* or of any other actinoceroid. The early siphuncle segments are slender, the necks not recurved. Siphonal deposits are wanting in early siphuncle segments, appearing on the venter in the fifth segment, and on the dorsum in the ninth. Siphonal deposits which are incomplete or wanting in apical siphuncle segments have been observed in the Pseudorthoceratidae and other Michelinoceratida, but actinoceroids, including *Rayonnoceras*, show such deposits developed not only at the first septal foramen, but often also in the apex of the siphonal caecum. These differences suggest that *Pseudactinoceras* is a pseudorthoceroid, and that its resemblance to *Rayonnoceras* may be purely homeomorphic. It is evident that *Pseudactinoceras* is a pseudorthoceroid, and that it is closely related to the three genera discussed above, since it has broadly expanded siphuncle segments and siphonal deposits which form a thick lining penetrated by radial canals of a highly distinctive type. Probably the genus is valid. However, it must be noted that since the type of *Pseudactinoceras promiscuum* supplies evidence only of early growth stages, comparison with other genera for which a series of fairly uniform epebic camerae are known, but for which early stages have not been identified, involves some uncertainties. Conceivably the anterior unknown part of the shell could be slightly curved, and the late stages could be similar to those of *Bergoceras*. Anterior straightening of the shell is possible; if so, the adult stages might be indistinguishable from those of *Paraloxoceras*. Identity with *Macroloxoceras* is less likely, in view of the broader siphuncle segments of that genus, the more depressed cross-section of the shell, and the upper Devonian age of the only known species of that genus.

Family PSEUDORTHOCERATIDAE Flower and Caster

Redefinition of this family is not necessary; it has previously been treated extensively by the writer (Flower, 1939).

Subsequently, Schmidt (1956) has recognized some new and some old species from the Mississippian of Europe as belonging to the family. Shimansky (1954) has described some new species and genera from the Permian of Russia. It is not necessary to review these works, save to note with regret that Shimansky's proposal of a family Mooreoceratidae does not seem to be well established. Indeed, there is even yet a lack of good evidence to indicate that *Pseudorthoceras* and *Mooreoceras* might not be based respectively upon early and late growth stages of the same generic group, which would show a central siphuncle in the young and an eccentric one in the later stages, with coexisting ontogenetic changes from a shell of circular section and simple sutures to one of depressed section and sinuate sutures.

It is now evident, however, that the genera *Bergoceras* and *Paraloxoceras* differ sufficiently from the Pseudorthoceratinae, in which they were originally placed, to form with *Macroloxoceras*, and possibly *Pseudactinoceras*, a new subfamily. Marked dorsoventral differentiation in the growth of the deposits evinced in *Paraloxoceras* was an important factor in assigning this genus to the Pseudorthoceratinae. It is now apparent that such differentiation is only minor in the unquestionably allied *Macroloxoceras*, and the origin of all these genera in the Pseudorthoceratinae now seems doubtful. It is, therefore, necessary to erect a new subfamily for the reception of these genera.

Subfamily **MACROLOXOCERATINAE** Flower, n. subf.

Members of this subfamily are Pseudorthoceratidae characterized by very broadly expanded, generally spheroidal siphuncle segments in the adult, with brims longer than the necks and usually with an extensive area of adnation. Parietal deposits grow mainly, but not exclusively, forward, fusing in the anterior ends of the segments; deposits are extremely thick in the expanded part of the segment and are pierced by two series of radial canals, one terminating in the anterior part of the ring, close to the tip of the septal neck, the other terminating just anterior to the beginning of the area of adnation. The anterior and posterior canals appear to join in the anterior third of the segment.

The Cayutoceratinae may develop similar rounded segments, but show no canals and exhibit a differentiation of materials in the deposit not evident in the Macroloxoceratinae. The Pseudorthoceratinae show more extreme dorsoventral differentiation in the growth of the deposit, which remains thin and shows no evidence of canals. The Dolorthoceratinae lack this extreme dorsoventral differentiation of the deposit but have thinner deposits, without traces of canals; the siphuncle segments are uniformly more slender in that group.

In the Macroloxoceratinae are included the following genera, which can be differentiated as follows:

Macroloxoceras. Orthocones strongly depressed in section; siphuncle segments with brims long but free; deposits show apical and adoral canals as discrete. Sutures with ventral lobes.

Paraloxoceras. Cross-section depressed only slightly, sutures unlobed, siphuncle segments similar to those of *Macroloxoceras* in form, but with canals united in the central part of the deposit.

Bergoceras. Shells slightly curved, siphuncle subcentral,

segments broadly expanded, deposit thick. Canals have not been observed, as deposits thus far observed are probably immature, and occupy only slightly more than the apical half of the segment.

Pseudactinoceras. Known only from an extremely early growth stage; therefore, not conclusively distinct from the preceding forms. Apparent differences consist of the slight flattening of the expanded part of the segment, the less markedly anterior fusion of the deposits in the latest growth stages. The canal pattern is not well known here, but both canals seem to be less markedly concentrated in the anterior end of the siphuncle segment.

It may be noted that it might seem proper and desirable to conform to the projected new Rules of Zoological Nomenclature, which regards family and subfamily names as identical for purposes of synonymy, and to employ Schindewolf's Pseudactinoceratidae here as a subfamily. This course seems undesirable, however, for although there is little reason to doubt the affinities of *Pseudactinoceras* with these other genera, this genus is known, as yet, only from such early stages that even the erection of a genus on the material is seriously open to criticism. Although the writer has no doubt as to the affinities of the genus with this subfamily, the known features leave this conclusion an inference rather than a demonstrated fact. The basing of any higher categories on this genus is unwise, as it is not certain that the known specimen attains a real adult condition.

The establishment of the affinities of the Macroloxoceratinae with the Pseudorthoceratidae and the Michelinoceratidae does not eliminate completely the possibility that *Rayonnoceras* could be derived from this stock. The writer prefers the alternate hypothesis of derivation of *Rayonnoceras* from *Ormoceras*, even though the stratigraphic gap from earlier Middle Devonian to Middle Mississippian presents an anomalous break, within which no transitional forms are known. However, the broadly inflated siphuncle of *Rayonnoceras* in its apical camera is actinoceroid and at variance with the general pseudorthoceroid pattern shared by at least *Pseudactinoceras* of the Macroloxoceratinae. The same may be said for the development of large actinoceroid annular deposits in the first septal foramen of *Rayonnoceras*. In defense of Schindewolf's conclusions, it must be pointed out that *Rayonnoceras* and the Macroloxoceratinae converge to a remarkable extent. Some specimens of *Rayonnoceras* certainly show annular deposits fusing anterior to the middle of the segments, and the position of radial canals there brings their general pattern very close to that of the Macroloxoceratinae. Flattening of the expanded part of the latest known segments of *Pseudactinoceras* brings its siphuncle segments very close in outline to those of *Rayonnoceras*. In *Macroloxoceras* the persistence of the ring as a dark band is suggestive of the development of a perispantium, although close examination leads to the conclusion that the resemblance is probably adventitious. Also, the presence of structures resembling ormooceroid radial canals in one section of *Macroloxoceras* (pl. 13, fig. 7) suggests *Rayonnoceras* again. The apparent resemblance is shown once more by a section attributed to *Rayonnoceras giganteum* by Schmidt (1956, p. 59, fig. 4). This section, however, is not demonstrably from the early part of an individual which is a typical *Rayonnoceras* in later stages, and is believed instead to be a fragment from a species of *Paraloxo-*

ceras, for the posterior canals are indicated, and the form of the cavity left within the deposits is typical of that genus and at variance with any undoubted *Rayonnoceras*.

Genus **MACROLOXOCERAS** Flower, n. gen.

Genotype: **Macroloxoceras magnum** Flower, n. sp.

The shell is orthoconic, strongly depressed in cross-section, with marked flattening of the venter. The sutures have broad lobes across the entire ventral face; otherwise they are straight and transverse. The siphuncle is well ventrad of the center, its segments large, broadly expanded, and spheroidal in outline. Observed stages range from those showing segments very similar in outline to those of *Ormoceras* to later ones in which expansion of the siphuncle is greater, and in which the apical ends of the rings meet the septa with broad areas of adnation. Deposits in the siphuncle are annular, initiated at the septal foramen, thick from an early growth stage, extending slightly apicad as well as strongly orad, the adjacent deposits meeting at or close to the tip of the septal neck. Canals are of two series. One extends from the anterior end of the cavity within the deposit and joins the connecting ring just apicad of the septal neck; the other leaves the central cavity near midlength of the siphuncle segment, curves apicad, and joins the ring just anterior to the beginning of the area of adnation. Longitudinal dark bends in sections at the septal foramen may indicate the original outline of a central tube, which may partly be invaded by organic deposits. Episeptal deposits are well developed in the camerae; smaller hyoseptal deposits are apparent only in relatively early parts of the phragmocone.

Discussion. *Macroloxoceras* is distinguished from *Paraloxoceras* by the strong flattening of the cross-section and by the development of prominent ventral lobes. Siphuncle segments of the two genera are comparable in outline and in the general form of the siphonal deposits. However, in *Macroloxoceras* the anterior and posterior canals are not closely connected or joined near the anterior end of each segment. Siphonal deposits leave a cavity in the siphuncle, which is widened markedly in the anterior end of each segment, and does not resemble the irregular crooked tube developed in some *Discosorida*. *Bergoceras* is distinguished by its curvature and more generalized cross-section and sutures. That its deposits do not join is a distinction probably more apparent than real. *Pseudactinoceras* is known only from very early growth stages. The cross-section is much more evenly rounded and less strongly flattened ventrally. The siphuncle segments, where most expanded, show a slight flattening of outline. Siphonal deposits show radial canals apparently limited to the anterior part of the segment. Differences in cross-section might appear to be less when comparable growth stages of the two genera are known, but the differences in siphuncle outline and the pattern of the canals are more likely to hold for commensurate parts of the two genera.

Macroloxoceras is known as yet only from the two species described below, of late Upper Devonian age.

Macroloxoceras magnum Flower, n. sp.

Pl. 13, fig. I, 3-8.

This is a very large orthocone of strongly depressed section. The holotype, 240 mm long, increases from 37 and 56 mm,

at the base, to an anterior width of 100 mm, at the anterior end, where the height, here reduced by weathering of the dorsum, is estimated at 42 mm. Only the extreme base of the living chamber is retained, and the species must have attained an additional 140 mm adorally, attaining a width of at least 120 mm, even allowing for some adoral reduction in the rate of expansion. The paratype is an earlier portion of a phragmocone, broken obliquely adorally, with a basal width of 36 mm, which must have increased to 56 mm in the length of 90 mm. The cross-section is similarly depressed, but details of the cross-section are less clear. Camerae increase in length from 8 mm, at a shell width of 36 mm, to 17 mm, at a shell width of 94 mm. Sutures, straight and transverse dorsally, develop broad prominent rounded lobes across the entire ventral surface.

The cross-section shows the venter moderately convex in the center and strongly rounded laterally. That at the base of the holotype, 37 mm high and 56 mm wide, shows slight dorsolateral flattening and strong rounding of the middorsal region (pl. 13, fig. 5), but in the length of four camerae, 42 mm farther orad, the dorsolateral flattening is greatly reduced, and the cross-section, here 42 mm high and 62 mm wide, is much more evenly rounded (pl. 13, fig. 6).

The 14 camerae of the holotype increase adorally in length from 10 to 19 mm. The septa are slightly curved in the vertical plane and, because of the pronounced ventral lobe, slope markedly forward from venter to dorsum in vertical section. A vertical section made through the basal four camerae of the holotype (pl. 13, fig. 7) shows strongly rounded siphuncle segments, broader than long. The basal septal foramen is subcircular, 5 mm across, it mm from the venter, and 21 mm from the dorsum in the plane of the septum. Adorally it is 6 mm across, 13 mm from the venter, and 27 mm from the dorsum. Necks are recurved and free, the brim equal to, or very slightly longer than, the length of the neck. Segments expand in the camerae and are broadly rounded in outline, one 10 mm long increasing from 5 to 16 mm in height. The apical end of the ring joins the adapical septum for an area of adnation which is only slightly greater than the brim ventrally, but which is nearly three times the length of the brim on the dorsum. The annular deposit on the venter shows an initial massive part, thickened both orad and apicad of its point of origin at the septal foramen, but extending orad only a third of the length of the segment, and extending apicad only to the tip of the septal neck. From the anterior side of this deposit, a thinner mass extends forward until it meets the next adoral deposit. On the dorsum the deposit is not extended forward in this way, but the initial massive part of it is somewhat thicker. At the first complete septal foramen, the deposit is thick, and a vertical dark line is clear on one side, obscure on the other. This possibly is the boundary of the original central canal. Within the cavity of the first segment, the central canal is outlined, though surrounded here largely by matrix. Anterior segments show on the venter but not on the dorsum, a thin band of calcite extending from near the middle of the connecting ring toward the center of the siphuncle and simulating the radial canal of an actinoceroid.

The paratype shows a series of eight siphuncle segments of an earlier growth stage, here exposed in a horizontal longitudinal section (pl. 13, fig. 3, 4). These segments are not as strongly expanded as may be expected in those of an earlier growth stage. The second segment here increases from 3.5

mm to 9 mm in width, in a length of 7.5 mm, whereas the last complete one, to mm long, increases from 4 mm to 12 mm. Segments are subspherical in outline, strongly resembling those of typical *Ormoceras* in outline, with the area of adnation slightly developed, the brim and the length of the neck subequal. Deposits are massive, more advanced in growth than in the section from the base of the holotype, and show fusion of adjacent segmental elements just apicad of the tip of the septal neck. The massive deposits appear to close the septal foramina completely in some segments, but not in others. In any case, longitudinal dark bands outline a central tube at the region of the septal foramen, variously expressed in successive segments. The deposits leave a cavity in the expanded part of each segment, which is wide anteriorly, narrowed posteriorly. From its anterior end, short dark tubes curve forward to join the connecting ring near the tip of the septal neck. From about the middle of each segment, other similar dark bands curve apicad, joining the ring just anterior to the beginning of the area of adnation. No structures comparable to the more normal horizontal tubes of *Paraloxoceras* extending from the middle of the connecting ring straight toward the center of the siphuncle, are at all evident here, suggesting that they may be adventitious structures in that genus.

Discussion. The large size, strongly depressed section, and gentler curvature of the septa in a horizontal longitudinal section distinguish *M. magnum* from the following species, the only congeneric one so far recognized. The characters of the genus will, of course, separate both species from other orthoconic cephalopods.

Types. Holotype and paratype, collected by Dr. W. A. MacQuown, to be deposited in the collections of the Paleontological Research Institution.

Occurrence. Both specimens are from talus boulders near Sweetwater Lake, about 25 miles northeast of Glenwood Springs, Colorado. As noted before, both talus boulders are derived apparently from the Dyer dolomite member of the Chaffee limestone, late Upper Devonian, which is essentially equivalent to the Ouray limestone of southern Colorado and the Percha shale of New Mexico.

Macroloxoceras minor Flower, n. sp.

Pl. 13, fig. 2.

The holotype is a portion of a phragmocone showing a nat-

ural longitudinal, essentially horizontal section through the siphuncle. It represents the ventral part of the shell, from which weathering has removed the dorsum. A basal portion 22 mm long retains only parts of seven camerae; the anterior 30 mm shows the entire shell width at the level of the siphuncle, which, by analogy, probably represents the actual maximum width of the shell. It increases from 19 to 26 mm in the basal 27 mm, a rate of slightly less than 1 mm in a length of 5 mm. At the base of this portion, the siphuncle is only 5 mm from the venter, which evidently was strongly flattened in cross-section. Apparently the dorsum was more arched, and at a width of 19 mm the shell height was between 12 and 14 mm. The anterior seven camerae show a gradual adoral increase in length from 4 to 5 mm. Curvature of the septa in the horizontal plane is rather pronounced, the septal depth being 4 mm where the shell is 25 mm in width; this is slightly less than the length of a camera. Siphuncle segments are rounded, very broad, and more comparable to those of the anterior camerae than to those of the earlier camerae of *M. magnum*. A segment near the anterior end of the specimen, 5 mm long, increases to a maximum width of 7 mm. The septal foramen is not preserved but was clearly not over 3 mm across. There is clear evidence of extensive deposits in the siphuncle, which evidently were more extended forward than backward from the septal foramen, and were very massive; however, weathering slightly below the center leaves the structural details obscure. There is indication of episepal deposits in the camerae.

Discussion. This species, though much smaller than any known part of *Macroloxoceras magnum*, shows a siphuncle in which the segments are short and broad. In this respect, it is more closely approximated by late than by early growth stages of *M. magnum*, a clear indication of the specific difference of this specimen. Further, in a horizontal plane at the level of the siphuncle, *M. minor* shows a much greater depth of the septa. The form of the siphuncle, the evident strongly depressed shell cross-section, with the venter strongly flattened, and the rather rapid rate of lateral expansion indicate affinities of this form with *Macroloxoceras magnum*, and are at variance with the features of other comparable genera.

Holotype. New Mexico Bureau of Mines and Mineral Resources.

Occurrence. From the upper 20 feet of the Percha shale, from exposures on the west side of the Mimbres Valley, about 5 miles east of Santa Rita, New Mexico.

References

- Flower, R. H. (1939) *Study of the Pseudorthoceratidae*, *Palaeontographica Americana*, v. 2, n. 10, 214 p., 9 pl., 22 fig.
- Miller, A. K., Dunbar, C. O., and Condra, G. E. (1933) *The nautiloid cephalopods of the Pennsylvanian system in the mid-continent region*, *Nebraska Geol. Survey Bull.*, ser. 2, v. 9, 940 p., 24 pl., 32 fig.
- Schindewolf, O. H. (1949) *Über das Apikalende der Actinoceren (Cephal., Nautil.)*, *Reichsanstalt für Bodenforschung, Jahrb. für 1941*, Bd. 62, p. 207-247, pl. 8-11, 15 fig.
- Schmidt, H. (1956) *Orthocone cephalopoden aus dem deutschen Unterkarbon*, *Palaeont. Zeitschr.*, Bd. 30, p. 41-68, pl. 2-4.
- Shimansky, B. H. (1954) *Priamie nautiloidiei i yaktritoidei cakmarckogo i artiskogo iarucob luzhnogo Urala*, *Akad. Nauk S.S.S.R.*, tom. 44, p. 3-156, pl. 1-12.

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PLATES 1-13

WITH EXPLANATIONS

PLATE 1

Figures	Page
1-4. <i>Actinoceras margaretae</i> Flower, n. sp.	34
<p>1-3. Three views of exterior of an essentially complete mature shell, the holotype, all slightly more than half natural size, photographed from specimen in natural color. 1. Ventral view, showing lobes of sutures. 2. Lateral view, venter on left, showing slight exogastric curvature of early portion, and fusiform shape of anterior portion, both phenomena modified slightly by vertical pressure. 3. Dorsal view, showing relatively transverse sutures. 4. Vertical section through the anterior end of the phragmocone of the same specimen, x r, showing adoral reduction in size of the siphuncle segments and anterior, mature, crowded camerae. Calcite in the apical camerae is inorganic, but apically organic deposits are developed in the siphuncle. Recrystallization of all calcite here has partially obscured the form of the siphuncle segments, but traces of the canal system remain. For section of apical part, see pl. 2, fig. 8; cross-sections shown in text fig. 3C-E. Holotype, collection of the writer; from the Lowville of Ottawa, Ontario.</p>	
5. <i>Ormoceras neumani</i> Flower, n. sp.	27
<p>Enlargement of a nearly vertical section through the anterior end of the holotype, x4.5, with venter on right. Relatively large but discrete annuli are seen on the venter. The white band of calcite in the dorsal part of the siphuncle is inorganic, but it encloses incipient annuli, which show as dark calcite around the basal four septal necks. Holotype, U. S. National Museum; from the Newmarket limestone, Pinesburg Station quarry, Washington County, Maryland. See also pl. 5, fig. 9; pl. 6, fig. 6.</p>	





PLATE 2

Figures	Page
1-5. <i>Actinoceras gradatum</i> Flower, n. sp.	36
<p>I. Dorsal view of holotype, about X⁷/8, a nearly complete phragmocone. In the basal third, part of the dorsum is removed, and parts of several siphuncle segments are exposed. 2. Vertical section, X 1, dorsum on left, through apical part of the same specimen. The part of the dorsum, missing in fig. 2, was replaced prior to cutting the section. The large, broad siphuncle is occupied by coarsely recrystallized annular deposits, but the large apical cavity and parts of the canals are retained. 3. Vertical section through anterior part of the same specimen, X 1; dorsum, <i>here</i> weathered and incomplete, on the left. The anterior limits of the siphonal deposits are shown, with adoral reduction of size and extent of expansion of the siphonal segments. 4. Cross-section of shell, X 1, taken 1 mm apicad of fig. 3, venter on left, through the expanded part of a segment. Note ventral concentration of cameral deposits, bilateral symmetry of radial canals, the dorsal position of the cavity of the siphuncle, here not quite reduced to the central canal, and its ventral concave outline. 5. Cross-section 12 mm apicad of fig. 4, and just anterior to fig. 2, X 1, taken through the narrow anterior part of a segment. The central canal is dorsad of the center of the siphuncle, its ventral side concave; no radial canals are cut by this section. Cameral deposits are confined to the venter. The cross-section of the siphuncle shows lateral alate expansions not previously observed. Holotype, collection of the writer; from the Lowville beds of Ottawa, Ontario.</p>	
6. <i>Gonioceras chaziense</i> Ruedemann	50
<p>Apical view of a holotype, X 1, venter or flattened side at right, showing cross-section and siphuncle in the median part of the shell. Below, the median part only of one lateral flange is retained; that of the opposite side above is completely wanting. Collection of the writer; from the Valcour limestone, Little Monty Bay, southeast of Chazy, New York. See also pl. 5, fig. 5-7; pl. 7, fig. 1-2; pl. 8, fig. 4-7; pl. 9, fig. 4.</p>	
7. <i>Actinoceras nutabile</i> Flower, n. sp.	38
<p>Dorsal view of holotype, about X 3/5, showing transverse dorsal sutures and fusiform outline of mature shell. G. W. Sinclair collection; from the Simard limestone, Ste. Anne de Chicoutimi, Quebec. See also pl. 4, fig. 4-5; pl. 5, fig. 8.</p>	
8. <i>Actinoceras margaretae</i> Flower, n. sp.	34
<p>Vertical section, X 1, of apical part of holotype, venter on right, showing large apical siphuncle segments, with large apical cavity in the first; central canal dorsal in early segments, later moving to a central position. Slight crushing has increased the original concave dorsal profile. Holotype, collection of the writer; from the Lowville limestone of Ottawa, Ontario. Same specimen as pl. 1, fig. 1-4.</p>	

PLATE 3

Figures	Page
1-5. <i>Actinoceras aequale</i> Flower, n. sp	35
<p>1-3. Three views of exterior of a nearly complete mature shell, the holotype, photographed in natural color, all slightly less than half natural size; extreme anterior end of specimen not shown. 1. Dorsal view, showing transverse sutures. 2. Lateral view, dorsum on left, showing progressive anterior crushing of dorsal side of living chamber. 3. Ventral view, showing broad lateral lobes. 4. Cross-section of shell taken 95 mm from apical end, X I, with venter on right, showing ventral protuberance of siphonal deposits. 5. Longitudinal vertical section of anterior part of phragmocone, venter on right, X I, immediately anterior to fig. 4, showing adoral reduction in size of the siphuncle segments, and anterior limits of annular deposits in the siphuncle. Holotype, collection of the writer; from the Lowville of Ottawa, Ontario.</p>	
6. <i>Actinoceras abortivum</i> Flower, n. sp.	39
<p>Lateral view of holotype; the venter, on left, complete; part of the dorsum, on right, removed by weathering, x 1. Collection of the writer; from the Black River beds of the Paquette Rapids of the Ottawa River, Ontario. See also pl. 11, fig. 5-6.</p>	



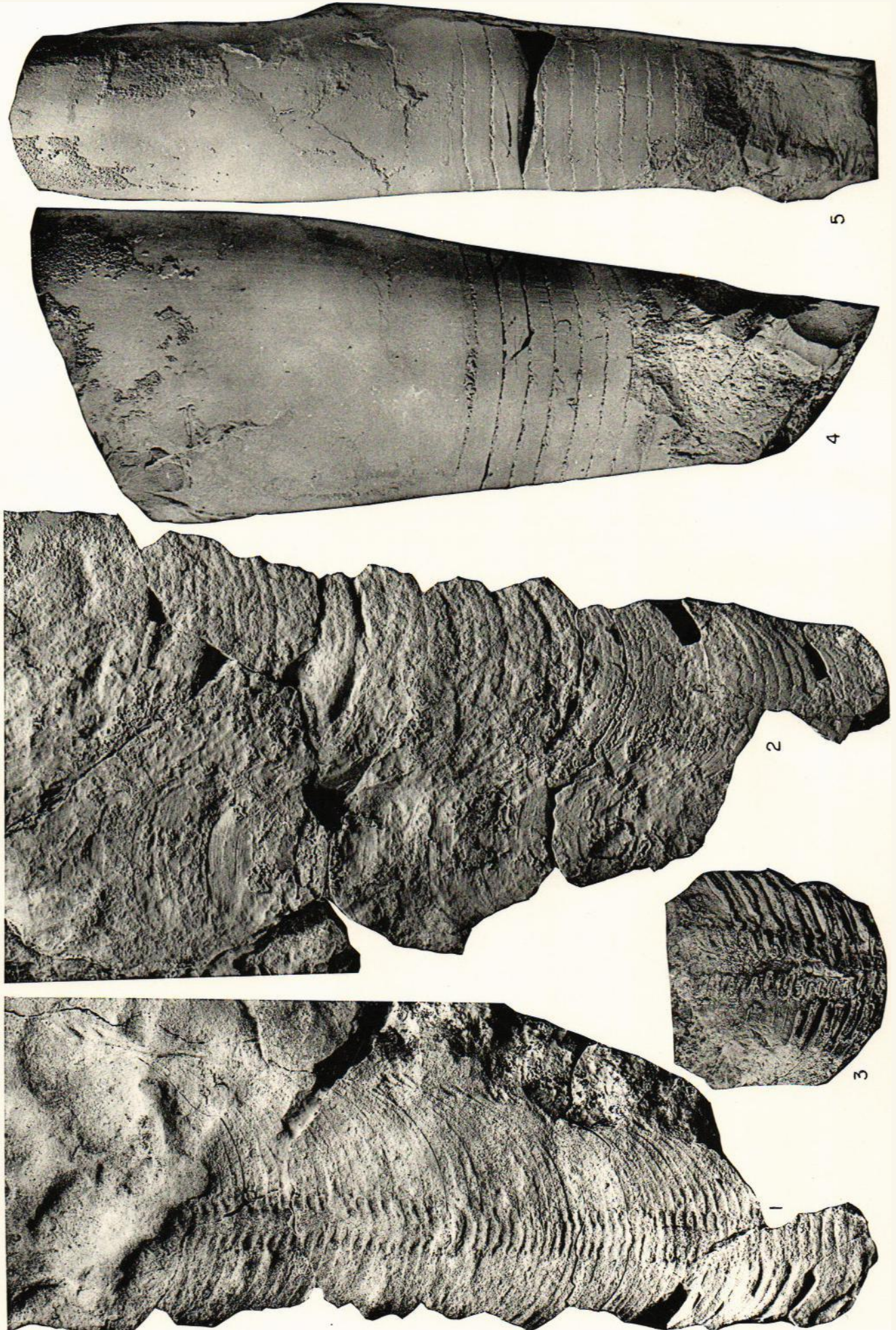


PLATE 4

Figures	Page
1-2. <i>Gonioceras quadratum</i> Flower, n. sp.	52
1. Dorsal view of holotype, showing an obliquely weathered surface, with lateral flanges removed on the left side. Those of the right side are concealed beneath the matrix. 2. Opposite flattened side of shell, showing surface of internal mold, with lateral flanges of sutures preserved on the left side. Both X i. Holotype, collection of the writer; from the Chaumont limestone near Watertown, New York.	
3. <i>Gonioceras multiseptatum</i> Flower, n. sp.	52
Natural weathered horizontal section through the holotype, viewed from the convex side and exposing the siphuncle, X 1. Collection of the writer; from beds probably of Lowville age, North Litchfield, New York.	
4-5. <i>Actinoceras mutabile</i> Flower, n. sp.	38
4. Ventral view of holotype, X I, showing prominent ventral lobes of sutures and fine longitudinal markings of the shell interior, here impressed upon the internal mold. 5. Lateral view of same, X I, venter on left, showing shell form, modified adorally by crushing of the dorsal part of the living chamber. Holotype, G. W. Sinclair collection; from the Simard limestone, Ste. Anne de Chicoutimi, Quebec. See also pl. 2, fig. 7; pl. 5, fig. 8.	

PLATE 5

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1-4. <i>Adamsoceras isabelae</i> Flower, n. sp.	25
<p>Holotype, an epehebic portion of the phragmocone, showing vertical crushing which increases progressively adorally. 1. Dorsal view, showing broad saddles, X 1. 2. Lateral view, dorsum on left, showing progressive adoral crushing of the shell. 3. Ventral view, showing broad lobes, X I. Crushing has increased the original rate of lateral expansion of the shell. 4. Vertical section from early portion of the type, slightly less than x2. On the venter, at the right, slight crushing has distorted septa and has brought the ventral surface closer to the siphuncle, within which can be seen the complex reticulate radial canal system. Holotype, collection of the writer; from Ikes Canyon, Toquima Range, Nevada, probably from the sponge bed in the upper part of the Pogonip group, in strata of Whiterock age.</p>	
5-7. <i>Gonioceras chazien se</i> Ruedemann	50
<p>A portion of a phragmocone, retaining appreciable parts of the lateral flanges, gently etched, and photographed unwhitened. All X I. 5. Viewed from flat, supposed ventral side. 6. Adoral end of specimen, the more flattened side, here made slightly convex by slight distortion, beneath. 7. Convex side, showing minor differences in suture pattern from flattened side shown in fig. 5. Hypotype no. 2, collection of the writer; from massive dove-gray reefy limestones of the Valcour limestone, near Little Monty Bay, southeast of Chazy, New York. See also pl. 2, fig. 6; pl. 7, fig. 1-2; pl. 8, fig. 4-7; pl. 9, fig. 4.</p>	
8. <i>Actinoceras mutabile</i> Flower, n. sp	38
<p>Vertical section of all but two anterior camerae of the holotype, venter on left, showing rapid ontogenetic reduction in size of siphuncle segments and corresponding changes in their outlines. Probably the apex of the specimen is not far removed from the original shell apex. If so, siphonal deposits are nowhere developed to completion in the species, and cameral deposits are possibly represented by calcite between the siphuncle and the venter but are wanting dorsally. Collection of G. W. Sinclair; from the Simard limestone, Ste. Anne de Chicoutimi, Quebec. Same specimen as pl. ² fig. 7; pl. 4, fig. 4-5.</p>	
9. <i>Ormoceras neumani</i> Flower, n. sp.	27
<p>Holotype, X I, a phragmocone, broken and slightly displaced, seen from a section, natural and gently etched anteriorly, but ground over the remaining three-fourths of the specimen. The plane of the section is nearly vertical, the venter on the right. U. S. National Museum; from the Newmarket limestone of the Pinesburg Station quarry, Maryland. See also pl. I, fig. 5; pl. 6, fig. 6.</p>	



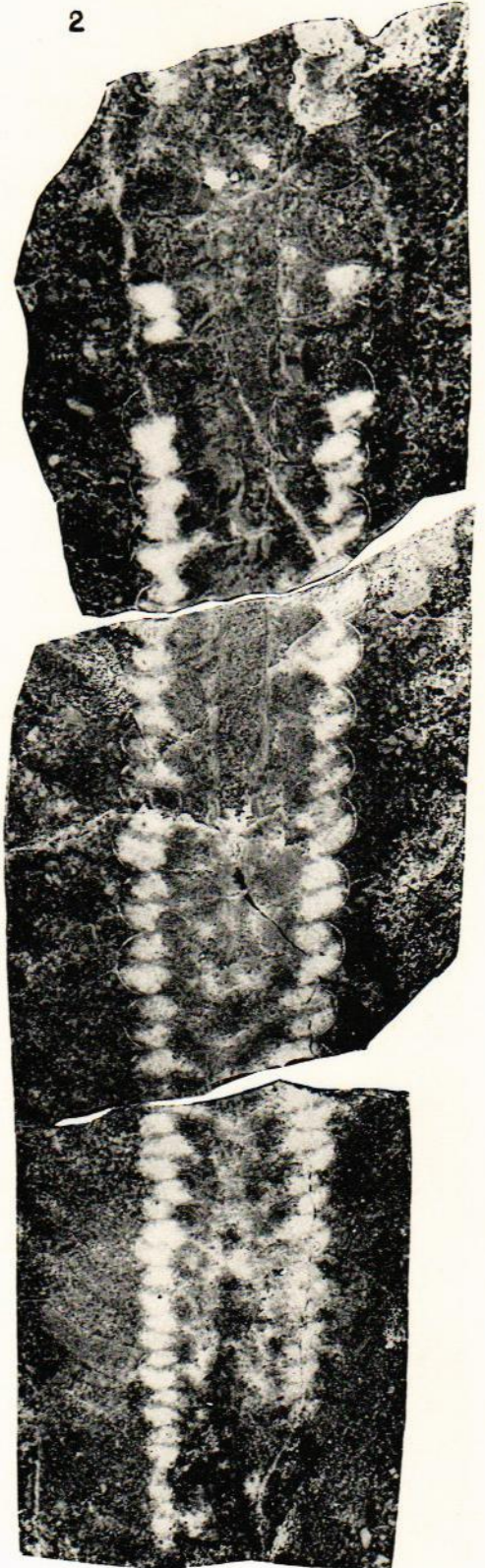


PLATE 6

Figures	Page
1-5. <i>Actinoceras winstoni</i> Flower, n. sp.	39
<p>1-3. Three views of the holotype, about x1/2, a shell with the left side a natural weathered section, the opposite side irregular and considerably modified by stylolitic solution. 1. Left side, with basal part sectioned, showing the position of the siphuncle. 2. Ventral view, without the basal sectioned portion shown in fig. 1. 3. Right side of specimen. 4. A paratype, viewed from the dorsal side, X7/8, the anterior part a natural weathered transverse longitudinal section, the apical part ground down to point of maximum width of the siphuncle segments. The section is too close to the venter to show the maximum width of the shell. 5. Vertical section, X I, through apical part of the holotype, venter on right, including basal sectioned portion as shown in fig. 1, but with the section continuing through camerae not sectioned in that figure. Though somewhat displaced apically, the siphuncle shows apical long, broad segments of gently sinuate outline modified adorally into smaller, shorter, less smoothly rounded segments. Holotype and paratype, collection of the writer; from beds of Hull age, Ste. Anne River, south of St. Casimir, Quebec. See also pl. 7, fig. 4; pl. 9, fig. 8.</p>	
6. <i>Ormoceras neuntani</i> Flower, n. sp.	27
<p>Enlargement, X2.5, from apical part of holotype, showing siphuncle segments of appreciable breadth, with small annuli on the dorsum, at left, and more advanced and larger annuli on the venter, at right. U. S. National Museum; from the Newmarket limestone, Pinesburg Station quarry, Maryland. See also pl. 1, fig. 5; pl. 5, fig. 9.</p>	

PLATE 7

Figures	Page
I-2. <i>Gonioceras chaziense</i> Ruedemann	50
<p>Composite photograph of a portion of a phragmocone, X 1, on which the entire lateral flange is preserved. The left two-thirds of the figure shows the appearance of the actual specimen, photographed in natural color to show septa through the translucent shell wall, and lighted to show fine longitudinal imbricating lines of the shell wall in the median part of the shell, here accentuated by very gentle etching. The left side of the specimen is wanting. It has been restored by superimposing a normal photograph of the specimen on a reversed print from the same negative. Hypotype no. 3, collection of the writer; from the Valcour limestone, Little Monty Bay, southeast of Chazy, New York.</p> <p>2. Anterior part of a natural section, here enlarged X2.5 to show the outline of the siphuncle segments; shown in natural size in pl. 8, fig. 4. Collection of the writer; from the Crown Point limestone, from the type section of the Chazyan, southwest of Chazy, New York. See also pl. 2, fig. 6, pl. 5, fig. 5-7; pl. 8, fig. 4-7; pl. 9, fig. 4.</p>	
3. <i>Actinoceras sinclairi</i> Flower, n. sp.	37
<p>Holotype, about X 0.8, a siphuncle exposed by weathering from the dorsal side and retaining parts of the anterior camerae. Only at the extreme anterior end is the specimen weathered below the center of the siphuncle; elsewhere the maximum width of its segments is shown. The siphuncle is close to the venter, and the preserved shell fails to attain the original maximum shell width. Collection of the writer; from the Simard limestone, Ste. Anne de Chicoutimi, Quebec.</p>	
4. <i>Actinoceras winstoni</i> Flower, n. sp.	39
<p>Vertical section, X 1, of the anterior part of phragmocone of the holotype, venter on left, showing siphuncle segments decreasing anteriorly in size and extent of expansion in the camerae, until they attain size and outline previously considered typical of the genus <i>Leurorthoceras</i>. Collection of the writer; from the Hull beds, Ste. Anne River, south of St. Casimir, Quebec. See also pl. 6, fig. 1-5; pl. 9, fig. 8.</p>	
5. <i>Armenoceras australe</i> Flower, n. sp.	46
<p>Holotype, X 1, a portion of a phragmocone ground in a nearly horizontal longitudinal section. The three pieces, here opposed, were ground separately and do not all attain the same depth. The anterior section alone is noticeably eccentric; for this reason it shows a markedly smaller central cavity in the siphuncle than does the next adjacent piece. Collection of the writer; from the Second Value formation, from the base of the third unit of the Upham limestone facies, from the south end of the Franklin Mountains, near the Scenic Drive, El Paso, Texas. See also pl. 8, fig. 1.</p>	



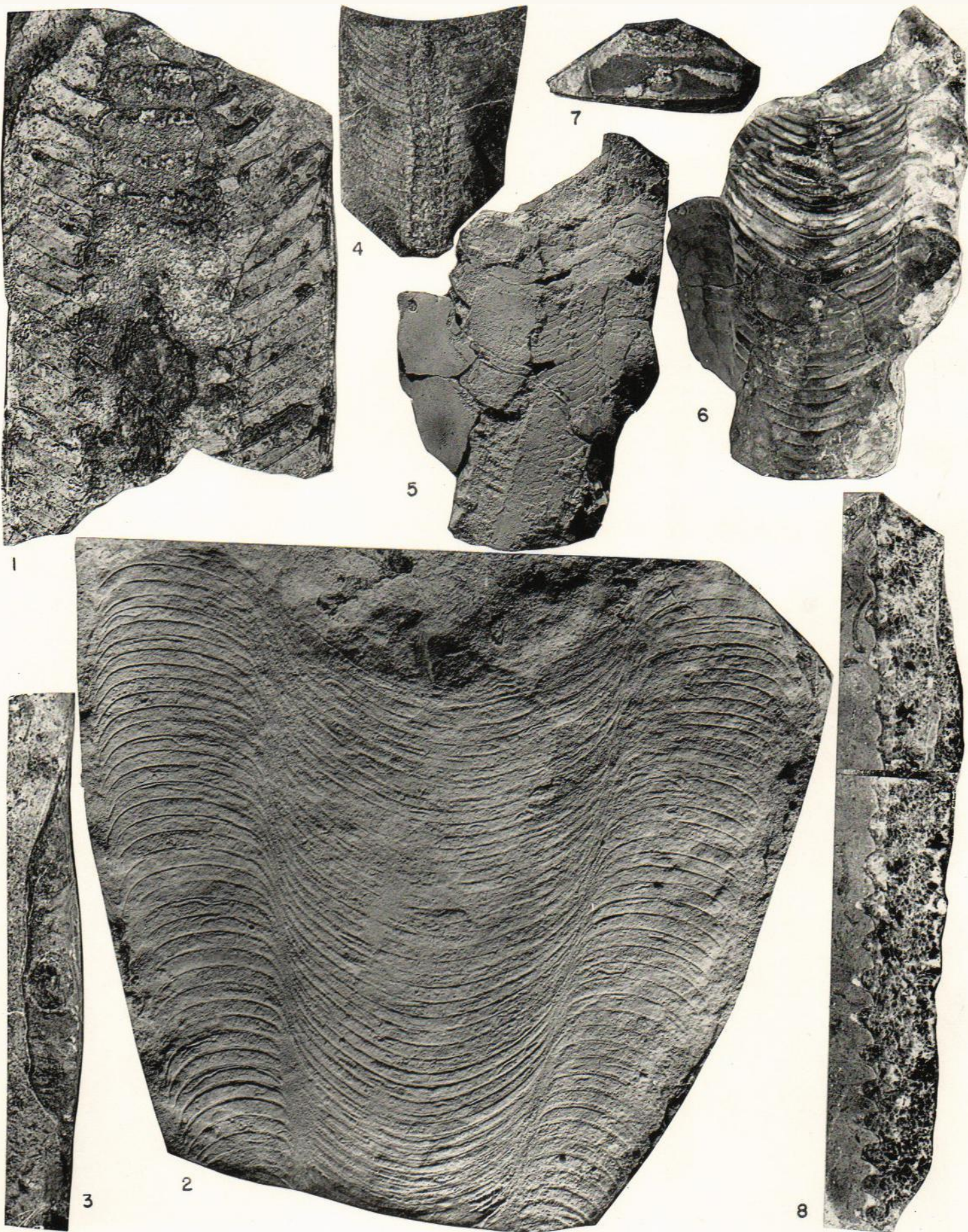


PLATE 8

Figures	Page
I. <i>Armenoceras cf. australe</i>	46
Natural horizontal section, X 1, passing through center of siphuncle apically, slightly eccentric adorally; naturally weathered section of a specimen tentatively assigned to this species, showing cameral deposits. Collection of the writer; from the Upham limestone facies, Second Value formation, Montoya group, from the southwestern part of the Florida Mountains, New Mexico.	
2-3. <i>Goniceras anceps</i> Hall	52
An exceptionally well-preserved phragmocone, X1.2. Ventral view of a naturally weathered specimen, retaining most of the mural parts of the septa. 3. Naturally weathered cross-section, with flattened ventral side to the right. The convex side, embedded in matrix, is irregular and incomplete, and was probably abraded prior to burial. The cross-section is oblique; the uppermost side of the specimen lies farther forward than the lower side; its lateral flange is therefore slightly longer than that at the bottom of the figure. Hypotype, collection of the writer; from the Chaumont limestone at the Natural Bridge, Perch River, near Limerick, New York.	
4-7. <i>Goniceras chaziense</i> Ruedemann	50
4. A naturally weathered section exposing a series of siphuncle segments, but lacking the lateral flanges. Collection of the writer; from the Crown Point limestone, from the type section of the Chazyan, southwest of Chazy, New York. 5. Flattened side of hypotype no. 1, whitened, showing smooth original shell surface on the left side; elsewhere exfoliation exposes the septa. Slightly less than X I. 6. The same view of the same specimen, X I, photographed in natural color, after slight etching to bring out the sutures more clearly. 7. Cross-section from a break at the middle of the same specimen, flattened side beneath, showing nature of cross-section of shell, with lateral flanges largely wanting, and size and position of siphuncle. Collection of the writer; from the Valcour limestone near Little Monty Bay, southeast of Chazy, New York. See also pl. 2, fig. 6; pl. 5, fig. 5-7; pl. 7, fig. 1-2; pl. 9, fig. 4.	
8. <i>Actinoceras huronioides</i> Flower, n. sp.	37
An isolated siphuncle, X I.2, here seen in section, preserving outline of siphuncle segments on one side, the other side weathered and incomplete. The early segments are sinuate in outline. Later segments show an increase in the length of the neck, which is becoming straight, and a gradual reduction of the brim, until anterior segments consist of a long, slender anterior portion outlined by the neck, and an apical expanded portion formed by the connecting ring alone. Holotype, collection of the writer; from the Simard limestone, Ste. Anne de Chicoutimi, Quebec.	

PLATE 9

Figures	Page
<i>Actinoceras incantatum</i> Flower, n. sp.	40
1. Horizontal longitudinal section through phragmocone of an extremely dolomitized specimen. 2. Cross-section, the surface of which opposes the base of fig. 1. Both X 1. Paratype, New Mexico Bureau of Mines and Mineral Resources; from the Upham dolomite facies, Second Value formation, Montoya group, from Mud Springs Mountain, New Mexico. See also pl. 11, fig. 1-2.	
3. <i>Ormoceras dartoni</i> Flower, n. sp.	27
Longitudinal, essentially horizontal section of a portion of a phragmocone, X I. Cameral deposits are supplemented by inorganic calcite in the camerae on the left. Holotype, collection of the writer; from the top of the first member of the Upham limestone facies, Second Value formation, Montoya group, from the southern end of the Franklin Mountains, near the Scenic Drive, El Paso, Texas.	
4. <i>Gonioceras chaziense</i> Ruedemann	50
A naturally weathered horizontal section, X 1. Hypotype, collection of the writer; from the Crown Point limestone, from the type section of the Chazyan, southwest of Chazy, New York. See also pl. 2, fig. 6; pl. 5, fig. 5-7; pl. 7, fig. 1-2; pl. 8, fig. 4-7.	
5. <i>Gonioceras pamehense</i> Flower, n. sp.	51
Holotype, a natural horizontal section, X I, through a phragmocone, preserving lateral flanges with remarkable perfection on the left, although those in the upper left are slightly displaced. New York State Museum; from the Pamela limestone near Perch Lake, New York.	
6. <i>Selkirkoceras burnamense</i> Flower, n. sp.	49
A nearly horizontal section through the holotype siphuncle, the left side slightly more dorsal than the right, with part of shell wall preserved on the right, but with apical siphuncle segment slightly abraded in the lower left. Slight crushing is evinced by the fracture and displacement of central and radial canals. Holotype, collection of the writer; from the Burnam limestone, Llano uplift, Burnet County, Texas.	
7. <i>Armenoceras barnesi</i> Flower, n. sp.	47
An essentially horizontal section through a phragmocone, X 1, the left side slightly closer to the venter than the right, displaying cameral deposits and double arcs of the siphonal vascular system. Holotype, collection of the writer; from the Burnam limestone, Llano uplift, Burnet County, Texas.	
8. <i>Actinoceras winstoni</i> Flower, n. sp.	39
A portion of a phragmocone, X 1, sectioned horizontally through the siphuncle. Paratype, collection of the writer; from beds of Hull age, along the Ste. Anne River, south of St. Casimir, Quebec.	

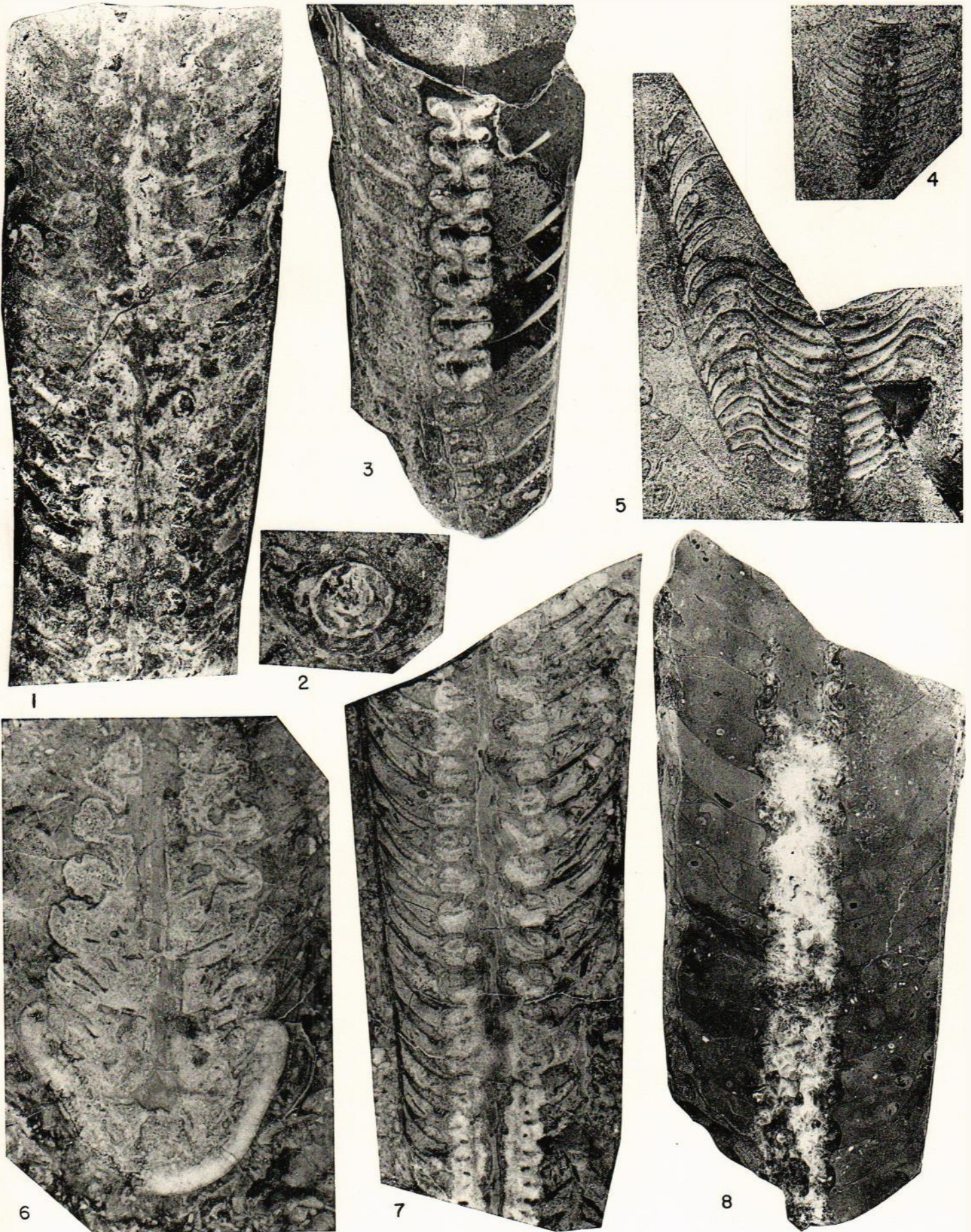


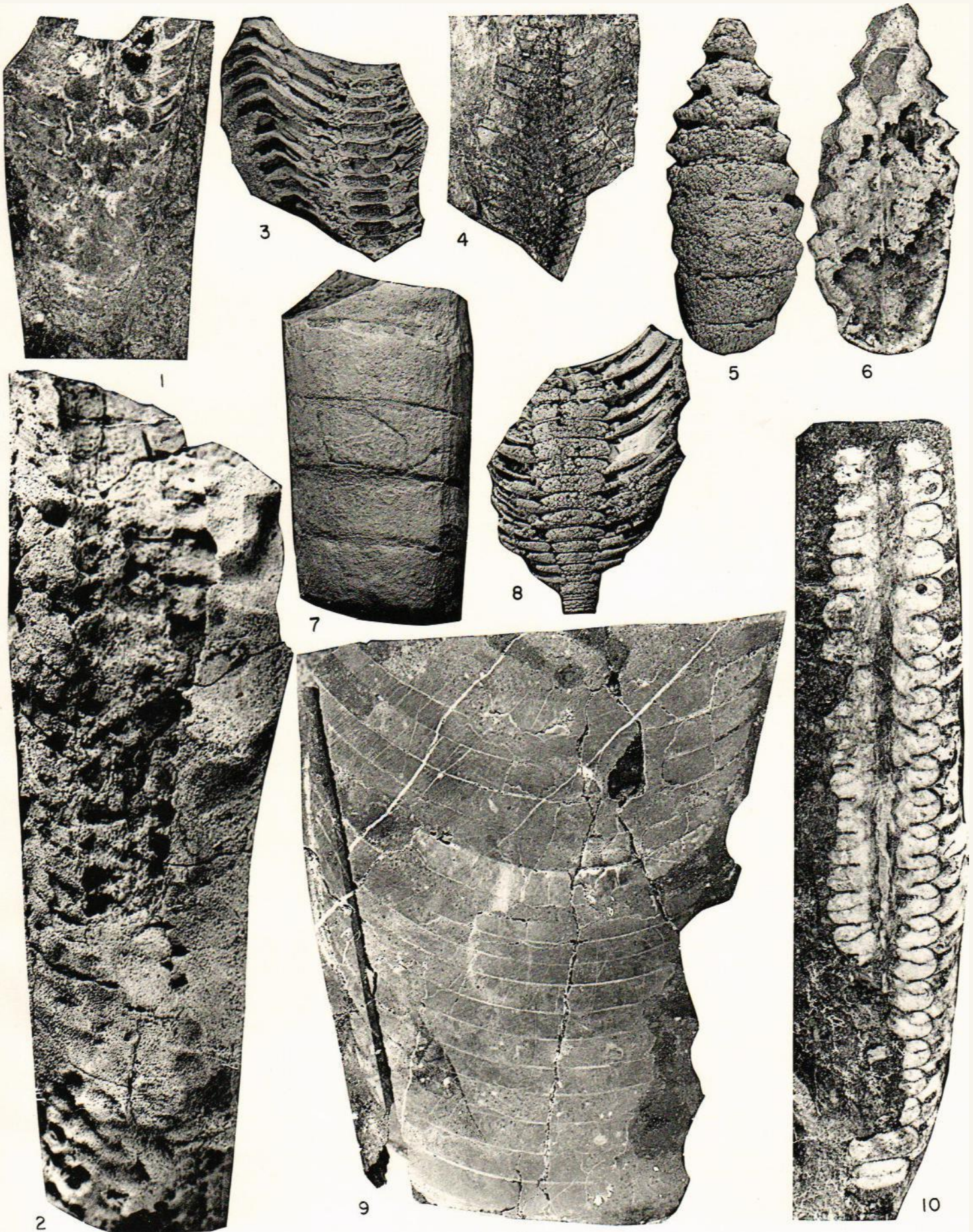


PLATE 10

Figures	Page
I, 3. <i>Armenoceras lenticontractuin</i> Flower, n. sp.	45
<p>Horizontal longitudinal section through the holotype siphuncle, X I; the anterior part shown in fig. 1, the remaining apical part in fig. 3, which adjoins the base of fig. i. The section does not quite attain the center of the adoral portion, and apicad of the short interval where deposits are immature, the section fails to attain the central canal. Holotype, New Mexico Bureau of Mines and Mineral Resources; from the <i>Rhynchotrema capax</i> zone of the Aleman formation, Montoya group, from the top of the Cooks Range, New Mexico.</p>	
2, 8. <i>Armenoceras callaghani</i> Flower, n. sp.	44
<p>A naturally weathered phragmocone, viewed from the dorsal side, X I, showing proportions of septa and siphuncle. The normal epebic portion is shown in fig. 2, whereas fig. 8 shows the anterior mature, crowded, and incomplete septa characteristic of this species. New Mexico Bureau of Mines and Mineral Resources; from the lower 2 feet of the Upham limestone facies, Second Value formation, from near the top of the Cooks Range, New Mexico.</p>	
4-7. <i>Goniceras obtusum</i> Flower, n. sp.	53
<p>o. A portion of a phragmocone approaching the apex of the shell, with a small apical siphuncle segment, the dorsal profile curving apically and approaching the profile of the flat ventral side. 4. Ventral view, showing the flat ventral side of the shell. 5. Oblique dorsolateral view. 6. Apical view. 7. Lateral view. 10. Dorsal view. Holotype, collection of the writer; from Black River beds, from the Paquette Rapids of the Ottawa River, Ontario.</p>	
9. <i>Nybyoceras montoyense</i> Flower, n. sp.	24
<p>Vertical longitudinal section through the holotype, X 1, an epebic portion of a phragmocone, venter on right. New Mexico Bureau of Mines and Mineral Resources; from the third member of the Upham limestone facies, Second Value formation, Montoya group, from the southern end of the Franklin Mountains, near the Scenic Drive, El Paso, Texas.</p>	

PLATE II

Figures	Page
1-2. <i>Actinoceras incantatum</i> Flower, n. sp.	40
<p>T. A nearly horizontal longitudinal section through the apical portion of the holotype, X 1, showing outline of siphuncle segments and canal system.</p> <p>2. Naturally weathered section of holotype, x 1, photographed prior to cutting the section shown in fig. 1. The midventral region is slightly to the left of the top of the figure, this view being essentially dorsal. New Mexico Bureau of Mines and Mineral Resources; from the upper part of the Upham dolomite facies, Second Value formation, Montoya group, from Mud Springs Mountain, New Mexico. See also pl. 9, fig. 1-2.</p>	
3, 8. <i>Gonioceras paquettense</i> Flower, n. sp.	53
<p>3. Holotype, X 1, a portion of a phragmocone viewed from the weathered convex side, preserving complete lateral flanges on the left. 8. Paratype, x 1, viewed from the convex side, retaining only the median lobe of the phragmocone and showing slender apical siphuncle segments which enlarge gradually adorally, attaining the broad segments of the adult at the middle of the specimen. Both are from the collection of the writer; from the Black River beds of the Paquette Rapids of the Ottawa River, Ontario. See also pl. 12, fig. 8-9.</p>	
4. <i>Gonioceras brainerdi</i> Flower, n. sp.	51
<p>Holotype, a naturally weathered horizontal section through a portion of the phragmocone, x 1, exposing the siphuncle, but with only a small part of the lateral flange preserved in the upper right. Collection of the writer; from the Crown Point limestone, from the type section of the Chazyan, southwest of Chazy, New York.</p>	
5-6. <i>Actinoceras abortivum</i> Flower, n. sp.	39
<p>Holotype, X 1, an isolated siphuncle, with apical broad segments broadly in contact with the venter, rapidly modified to much smaller adoral ones.</p> <p>4. Ventral view, showing strong flattening of earlier segments. 6. Dorso-lateral view, X 1, showing a naturally weathered, somewhat oblique section exposing part of the canal system. The central canal widens to a broad anterior cavity filled with dark matrix, <i>seen</i> in part in the three anterior segments. Holotype, collection of the writer; from the Black River beds of the Paquette Rapids of the Ottawa River, Ontario. Lateral view shown in pl. 3, fig. 6.</p>	
7. <i>Deiroceras</i> , sp.	29
<p>Lateral view of a portion of a phragmocone slightly flattened laterally by pressure, X 1, combining the large siphuncle and deep camerae of typical <i>Deiroceras</i> with the longitudinal markings of typical <i>Troedssonoceras</i>. G. W. Sinclair collection; from the upper Trenton of Lake St. John, Quebec.</p>	
9. <i>Lambeoceras rotundum</i> Flower, n. sp.	54
<p>Horizontal section, X 1, taken at point of greatest shell width, from the anterior part of the holotype. This overlaps in part the section (shown in pl. 12, fig. o) at another level, which exposes the siphuncle. From the Upham limestone facies, Second Value formation, from the southern end of the Franklin Mountains, near the Scenic Drive, El Paso, Texas. See also pl. 12, fig. 7, 10.</p>	
10. <i>Armenoceras vesperale</i> Flower, n. sp.	46
<p>A natural, nearly horizontal section, X 1, showing siphuncle segments, and septa attaining the margin of the shell on the left. Stylolitic solution results in the loss of part of the siphuncle in the lower right. Canals of the single-arc type are dearly displayed. Holotype, New Mexico Bureau of Mines and Mineral Resources; from the upper part of the Upham limestone facies, Second Value formation, Montoya group, from near the top of the Cooks Range, New Mexico.</p>	



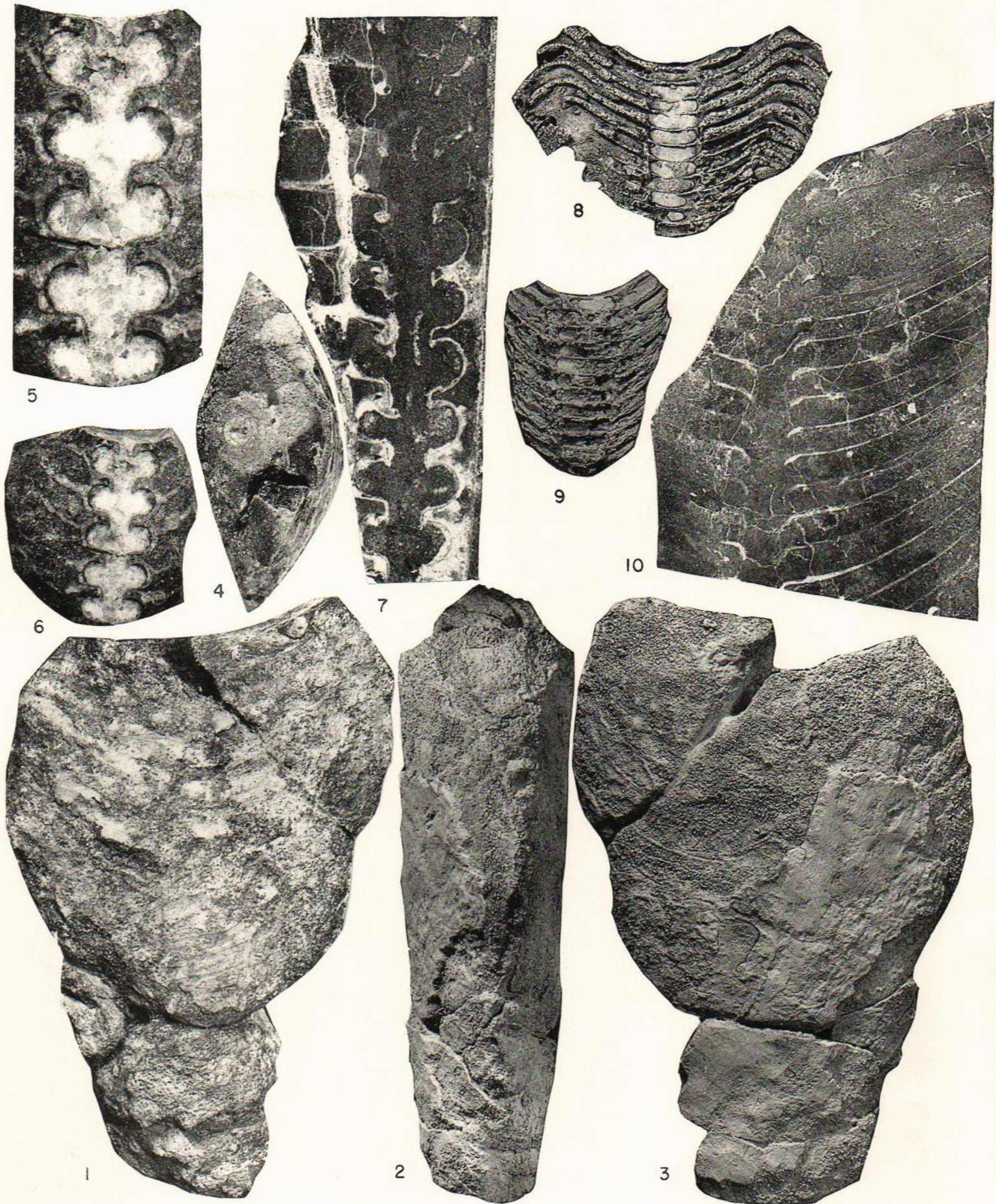


PLATE 12

Figures	Page
1-6. <i>Lambeoceras armstrongi</i> Flower, n. sp.	55
<p>1-3. Three views of the exterior of the holotype, X I, a weathered internal mold of a phragmocone. I. Ventral <i>view</i>, photographed in natural color to show traces of sutures which have practically no relief here. 2. Lateral view, venter on right. 3. Dorsal side, retaining part of the smooth shell surface. 4. Apical view of septum, X i, at midlength of the type, the venter on the left. 5-6. Horizontal section through the siphuncle, from the apical part of the type. 5. Portion of siphuncle segments, X2, showing details of outline of siphuncle segments. Organic deposits in the siphuncle show coarse replacement, and the canal system is not preserved. 6. Entire section, X I, showing size of siphuncle and episeptal deposits in the camerae. Holotype, New Mexico Bureau of Mines and Mineral Resources; from transition beds between the Cable Canyon and Upham facies, Second Value formation, Montoya group, from near the top of the Cooks Range, New Mexico.</p>	
7, 10. <i>Lambeoceras rotundum</i> Flower, n. sp.	54
<p>7. Vertical section through the apical part of the holotype, about X2, showing siphuncle. Only early growth stages of siphonal deposits are developed here, appearing only as small annuli on the dorsal side of anterior segments, and wanting ventrally. Io. Horizontal section, XI, through anterior part of type at the level of the siphuncle, showing septal necks and anterior mature camerae. Connecting rings are destroyed. Holotype, New Mexico Bureau of Mines and Mineral Resources; from the Upham limestone facies, Second Value formation, Montoya group, from the southern end of the Franklin Mountains, near the Scenic Drive, El Paso, Texas.</p>	
8-9. <i>Gonioceras paquettense</i> Flower, n. sp.	53
<p>8. A naturally weathered portion of a phragmocone, X I, viewed from the weathered dorsal side, showing siphuncle and nearly complete lateral flanges. 9. Another specimen, X x, viewed from the weathered dorsal side, lacking lateral flanges, but showing a marked decrease in size of apical siphuncle segments, and approaching close to the initial part of the shell. Both are paratypes, collection of the writer; from the Black River beds of the Paquette Rapids of the Ottawa River, Ontario. See also pl. 11, fig. 3, 8.</p>	

PLATE 13

Figures	Page
1,5-8. <i>Macroloxoceras magnum</i> Flower, n. sp.	67
<p>The holotype, a portion of a late growth stage of a phragmocone, retaining a small part of the base of a living chamber. 1. Dorsal view of entire specimen, $\times 1$, showing actual size. 5. Septum, $\times 1$, from the base of the type, showing narrow rounding of lateral and middorsal regions, with dorsolateral as well as ventral flattening. 6. The fifth septum, $\times 1$, showing a more evenly rounded cross-section, with dorsolateral flattening lost. 7. Vertical section, $\times 1$, through the basal four camerae, showing siphuncle segments more broadly expanded here than in the earlier growth stage shown in fig. 3. Apparent radial canals pass directly to the middle of the ventral side in the two adoral segments; apically a part of the central canal is calcified, and portions of anterior and posterior canals penetrate the siphonal deposits. Paleontological Research Institution; from the Dyer dolomite member of the Chaffee limestone, near Sweetwater Lake, Colorado.</p>	
2. <i>Macroloxoceras minor</i> Flower, n. sp.	68
<p>Holotype, $\times 1$, viewed from the dorsal side, weathered to just below the maximum width of the siphuncle segments. New Mexico Bureau of Mines and Mineral Resources; from the upper 20 feet of the Percha shale, from the west side of the Mimbres Valley, about 5 miles east of Santa Rita, New Mexico.</p>	
3-4. <i>Macroloxoceras magnum</i> Flower, n. sp.	67
<p>A portion of a phragmocone cut horizontally through the center of the siphuncle. In fig. 3 the entire specimen is shown, $\times 1$, showing episeptal deposits and siphuncle segments with essentially mature siphonal deposits. Parts of the 3d through the 6th segments are shown ($\times 2.5$) in fig. 4, showing anterior and posterior radial canals, and dark bands at the septal foramina (in some cases overgrown by the white calcite of the siphonal deposits), which probably mark the original exterior of the central canal. Paratype, deposition, and occurrence as in fig. 1.</p>	



