MEMOIR 19

PART I
The First Great Expansion of the Actinoceroids

PART II
Some Additional Whiterock Cephalopods

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PART I

THE FIRST GREAT
EXPANSION OF THE ACTINOCEROIDS

Abstract

The family Wutinoceratidae is developed in the White-rock stage of North America, and members of the family in other regions may indicate Whiterock equivalence of the containing beds. The Wutinoceratidae are discussed; new material, largely from the Whiterock of Nevada and Utah and from the Table Head of Newfoundland, yielded the several new species here described. Notes on occurrence and stratigraphy are included as well as a discussion of the evolution of the Actinoceratida in the Ordovician and some remarks upon the classification of the group. The thesis that the actinoceroids should be elevated in rank equivalent to the Nautiloidea from which they were removed is rejected. Fine structures of septa and the connecting ring are described for *Adamsoceras* cf. *isabelae.*

Introduction

Polydesinia, regarded as the oldest and most primitive of the actinoceroids, is known only from occurrences of eastern Asia in beds of either latest Canadian or earliest Ordovician age (Kobayashi, 1940). The next stage in the development of the actinoceroids is marked by the family Wutinoceratidae, which spread widely, being now known in eastern Asia, Tasmania, the Baltic region of Europe, and in the White-rock stage of Cooper (1956) in North America. New material here described has augmented the forms known from the Whiterock of Nevada and western Utah. Oddly, these forms seem confined to beds which are rather high in the White-rock there, the *Palliseria* zone of Nevada, and zone N (Hintze, 1952, 1953) of western Utah. There is one species, not very well known morphologically in the Oil Creek limestone of Oklahoma, and new material has added to the species known from the Table Head limestone of Newfoundland, where they range from beds 2 through 8 in the Lower Table Head formation (Whittington and Kindle, 1963). These are the only three regions in North America in which preserved limy sediments of Whiterock age are known. Intercontinental correlations are always hazardous, but the occurrence of the Wutinoceratidae in other parts of the world may well indicate that the beds containing them are equivalent to the Whiterock of North America.

The new material has supplied a basis for a review of some recently published ideas, in particular, the rejection of the Wutinoceratidae and two of its genera by Teichert (in Teichert et al., 1964).

We would reassert the validity of the family, defined primarily on the radial canal system; the close relationships of its three genera, which show some intergradation from the new material; and the desirability of recognizing this group as a taxonomic entity as well as one significant temporally.

ACKNOWLEDGMENTS

Some of the material here described was the gift of the late Dr. J. Lee Adams, whose collecting has supplied material of considerable value to several institutions and individuals, and the description of which has been a real contribution to paleontology. Through the kindness of Dr. G. A. Cooper, materials in the U.S. National Museum were loaned for study. Dr. G. Marshall Kay kindly offered other material which has contributed to the present work. Of special benefit in understanding the problem of the Pogonip stratigraphy has been a series of discussions with Dr. Reuben Ross and an opportunity to see some of the critical sections with him in the field. Dr. Lehi Hintze and colleagues at Brigham Young University contributed the two rare Utah species here described.

In collecting materials, I have had the aid of my wife and of Miss Michaele Huygen, my present laboratory assistant. Aid in collecting was also given by Dr. Reuben Ross and Mr. Leonard Wilson. Dr. Harry Whittington offered for study the Table Head cephalopods here described. Dr. William Ham supplied modern stratigraphic data on the stratigraphic position of *Nybyoceras* which appears to be a *Wutinoceras* and is the only actinoceroid so far known from the Whiterock of Oklahoma.

*Order Actinoceratida Hyatt 1900**

The order Actinoceratida consists of dominantly orthoconic cephalopods with siphuncles of broadly expanded segments within which annular deposits grow and may fill the siphuncle apically except for a siphonal vascular system consisting of a central canal, radial canals, and a perispatium. Cameral deposits are generally developed, and both siphonal and cameral deposits are apically concentrated to provide hydrostatic adjustment of the animal in life. Apices are short and blunt, and a few specimens are known in which a small cap-shaped "protoconch" covers the apex of the shell.

Serious problems have attended the distinction of true actinoceroids from some members of the Michelinoceratida which develop expanded siphonal segments and annular deposits within. Some forms even develop radial canals, and others show a juncture of the siphonal deposits simulating such canals. Such Michelinoceratida can, however, be distinguished by two important features: (r) there is no true perispatium developed and (2) apices of shells are small and slender down to a very small shell diameter. It may be noted also that the septa] furrow, generally developed in the Michelinoceratida, is commonly not evident in the true actinoceroids.

In both the Russian and the American treatises (Ruzhentev, Shimansky et al. 5962; Teichert et al., 1964), the proposal of Shimansky and Zuravleva (1961) of removing the actinoceroids and endoceroids from the Nautiloidea and treating them as equivalent to that group in rank has been adopted. It is claimed that these groups are morphologically distinctive, a claim that is belied for both groups by genera included in them which belong elsewhere. Forms develop in other orders which are so homeomorphic with both endoceroids and actinoceroids that not only have they been confused with them, but they were confused with them in these works. The forms mistakenly included in the endoceroids will be dealt with in detail in another work, but it may be noted here that it is easy to confuse both Protocycloceratidae and Baltoceratidae with the endoceroids, as in the case of the genus *Cyptendoceras; Boreoceras* belongs in the Ellesmeroceratidae, while the Narthecoceralidae have been found to be homeomorphs of the Endoceratida, belonging to the Michelinoceratida; here belong *Nartizecoceras* and *Tasmanoceras,* which were considered endoceroids. The actinoceroids in the above-mentioned works contain fewer errors, but it should be noted that Ortlionybyoceras belongs to the Proteoceratidae of the Michelinoceratida;*llz ounoceras* belongs to the Narthecoceratidae. *Hoeloceras,* treated as a synonym of *Lambeoceras,* has a free central tube but no annuli or perispatium are known, and the structures now known indicate that it is a "flatfish" development belonging not with the actinoceroids but with the Ruedemannocera tidae of the Discosorida. The actinoceroid nature of a number of other genera remains dubious. The evidence is still inconclusive for the late Paleozoic *Aploceras,* which may well be a relative of *Bergoceras* of the Pseudorthoceratidae. *Eskimoceras* is a straight annulated shell showing a siphuncle of expanded segments, but no siphonal deposits are known; it may stem from the Proteoceratidae.

Some other matters in the American Treatise require comment. The morphological terminology is unnecessarily ponderous and is not employed here. The virtue of substituting "body chamber" for the slightly longer "living chamber" would present an unnecessary suppression of a term which has been in use in English, with cognates in at least French and German works, for more than a century.

The first use of the term *Actinoceratida* (or variations of it) is not in Teichert (1933) but in Hyatt (19o0),* where it appears as a group of family rank, a division of the Annulosiphonata of the Cyrtochoanites. The placing of *Ordosoceras* in the Polvdesmiidae is not properly substantiated either here or by the original description or figures. It could as reasonably be an *Actinoceras* of the *anticostiense* group (Flower, 1957, p. 32). The suppression of the Wutinoceratidae is here contradicted and is discussed below. The significance of the primitive nature of thick rings or the evolution of the siphonal vascular system is not grasped. *Saffardoceras* is, as was pointed out earlier (Flower, 5957), based upon a distorted specimen of an *Actinoceras;* if the endogastric *Troostoceras* is to be recognized as an endogastric modification of *Actinoceras,* surely notice should be taken at the generic level of exogastric species described by Flower (1957). Uniting *Gonioceras* and *Lambeoceras* in the same family is a mistake; both are "flatfish" among the actinoceroids, but while *Gonioceras* apparently stems from *Arnzenoceras, Lambeoceras* is derived instead from the Actinoceratidae and is, indeed, close to *Koclioceras.* The assumption that *Deiroceras* has a smooth shell and is distinct from the fluted *Troedssonoceras* is unsubstantiated. While the late Paleozoic expansion of the actinoceroids is significant, the distinction of the Ravonnoceratidae from the ancestral Ormoceratidae is most tenuous morphologically and separation of the two families is of dubious merit. The diagram of phylogenv includes *Cyrtactinoceras, which* is not an actinoceroid and appears properlv in the text in the Proteoceratidae.

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*Hyatt's Actinoceratidae is our present order Actinoceratida, with the removal of *Discosorus*. Similarly, Teichert's (1933) Actin°. ceratoidea is the Actinoceratida with the removal of the Westonoceratidae. Hyatt's Actinoceratidae is as close to being the equivalent of the present Actinoceratida as anything proposed since. Distinctions and rules which would obscure this obvious truth are so much pedantry.

Actinoceroid Evolution

I have regarded *Polydesmia* as the oldest and most primitive of the actinoceroids. Though some problems still surround the exact occurrence of a number of its species, the genus is peculiar in several respects: The siphuncle is unusually large in proportion to the shell and is made up of very short segments. The rings are extremely thick, so thick that they have been interpreted as septal necks. Annuli extend forward in the siphuncle, which gave rise to my suggestion that *Polydesmia* might indicate an origin of the actinoceroids in *Bathmoceras,* the annuli being differentiated from what were in the beginning outgrowths of the connecting rings. The radial canals are fine, branching, forming what I called the *dendritic type.* They are not clearly evident in longitudinal sections. The juncture of the annular deposits in such sections has been misinterpreted as the radial canals; were this true, continuous radial canals could not possibly show in a cross section as they do.

The writer (Flower, 1957) suggested that the next stage in actinoceroid evolution was marked by the genera here included in the Wutinoceratidae. Rings are still thick, and one form studied in thinsection (there was not much available material, and most known specimens were types that could not be sacrificed for such a study) shows complex textural differentiation of regions in the ring, a phenomenon of which only rare vestiges have been found in younger actinoceroids (Flower, 1964a). More conspicuous is the fact that the radial canals are of the reticular type. The radial canals depart from the central canal at more than one point in the length of each segment, and members of the various series thus formed are interconnected longitudinally. The exact pattern remains to be worked out; there is evidently some variation in its details, but it appears to be a logical step in evolution lying between the numerous fine canals, the dendritic type in the archaic *Polydesmia,* and the simpler pattern of simple horizontal canals or of single or double arcs that prevail in Chazyan or younger actinoceroids. The Wutinoceratidae are here recognized as containing three genera. Siphuncle segments pass through the septa where they are oblique, and as a result there is a marked difference between the dorsal and ventral profiles of a segment; in particular, the apical end of the ring is broadly adnate to the next apical septum on the venter, but on the dorsum such adnation is narrow or wanting. Siphuncle segments may be broad and rapidly expanding, with rings recumbent on both dorsum and venter, or the necks may be free, like those of *Ormoceras,* and the segments spherical or even slightly longer than wide. Commonly, necks are more sharply recurved dorsally than ventrally, and the brims are longer dorsally. The development of this family seems to occupy a definite stratigraphic interval, the Whiterock stage of Cooper. Beyond this point, we are confronted with genera that are for the most part rather long-lived. The writer has noted species groups within *Actinoceras* that show some stratigraphic significance, but such divisions in other genera are not yet evident, though there are, of course, some small short-lived genera.

In North America, above the Whiterock belongs the Chazy. The actineroids known there are few, and with *Nybyoceras* and *Ormoceras,* which we might well expect, as logical descendants of *Wutinoceras* and *Adamsoceras,* we find *Gonioceras,* which, from all indications, should have descended from *Armenoceras. We* might hope to find between the Chazy and the Whiterock an interval in which the actinoceroids include *Ormoceras, Nybyoceras,* and *Armenoceras* but lack *Gonioceras.* Such an association is described by Endo (1932) from the Ssuyen limestone of Manchuria and though, in some localities, Wuting or older elements may have been included from failure to distinguish these underlying beds in the field, with this reservation, the fauna seems what one would hope to find between the Wuting—Whiterock and the Chazy.

Some reinvestigation of the relationships of the younger actinoceroids is still needed, and the canal pattern may show lineages to be distinct which are similar in the form of the siphuncle segments. It may be noted that two types persist in the Ordovician above the Whiterock, a system of straight "horizontal" canals normal to the central canal, which predominate in the Ormoceratidae and a system of single arcs, which prevail in the Armenoceratidae, Actinoceratidae, and derived types. It may be noted that some doubt surrounds the general development of the series of double arcs in the Ordovician; this concept seems to have been developed in part from an overgeneralization of the pattern shown in *Cyrtonybyoceras* and in part from such advanced forms as the Silurian genus *Elrodoceras,* though the matter is one plainly inviting closer study.

One important emendation should be made in the phyletic scheme proposed by Flower (1957, fig. I). In *Actinoceras* of the Black River species groups, the necks come to be short and strongly hooked on the venter. This trend is carried farther in *Kochoceras.* What was not realized is that similar necks in *Lambeoceras* suggest most strongly that it is derived from the Actinoceratidae and not from the Armenoceratidae, where brims are long and recumbent and the recurved brims are not bent apicad within the siphuncle, and that a similar condition suggests that *Huronia* has the same derivation. If so, an interesting possibility exists that *Huroniella* (supposedly intermediate between *Armenoceras* and *Huronia,* but which puts in an appearance only in the Silurian, though *Huronia* is known in the Red River faunas of the Ordovician) may be a homeomorph of *Huronia* rather than a relative. Although *Armenoceras* has canals forming arcs, usually apparently single arcs, there are some species in the Silurian having rather small siphuncle segments and simple horizontal canals, as in *Armenoceras vertebratum* (Hall) of the Irondequoit limestone, and these forms may not be true *Armenoceras* but derived from *Ormoceras* by broadening of the segments so that necks become recumbent.

A revision of the earlier figure of Flower (1957) is appended (fig. I).

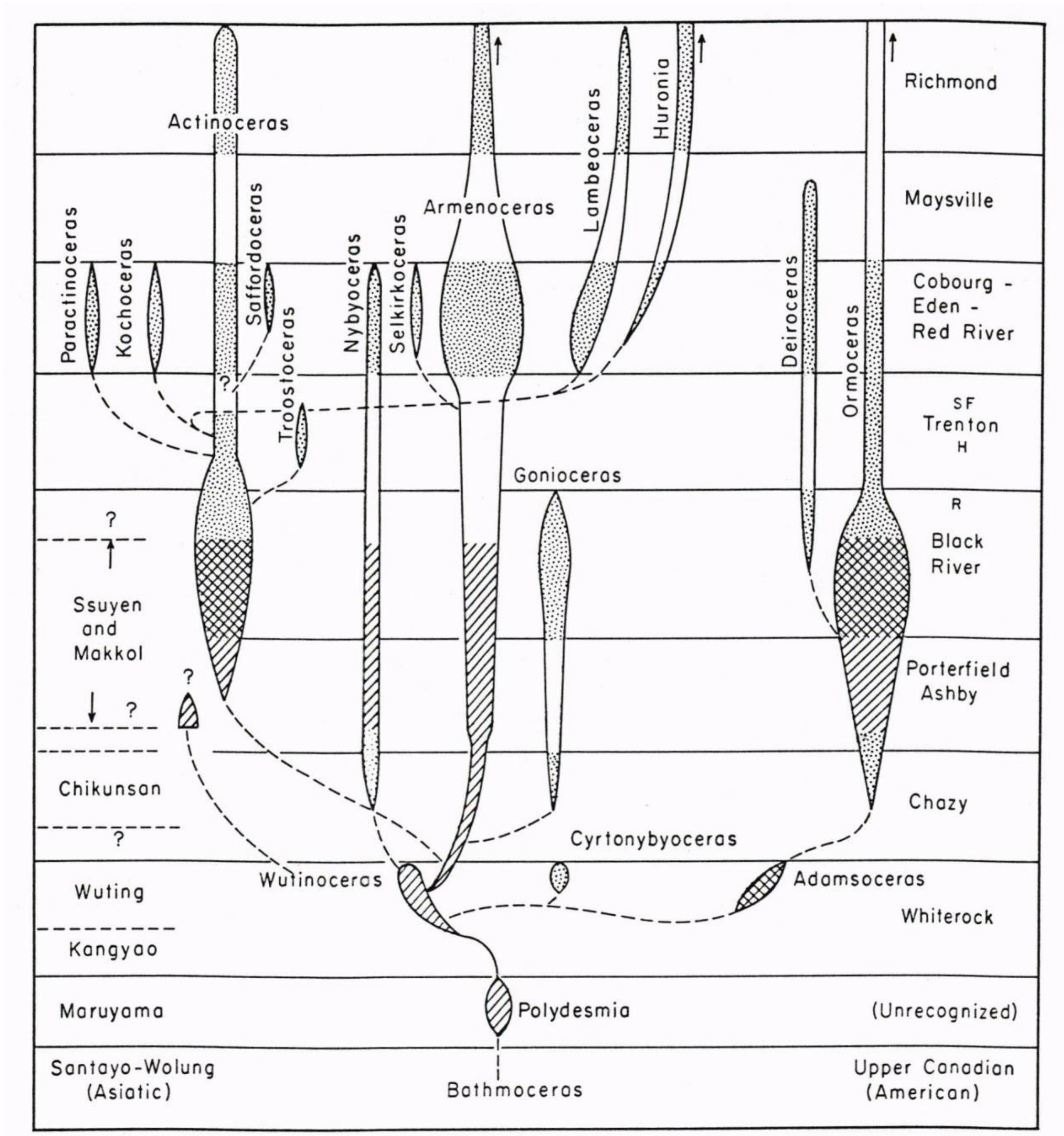

Figure I

EVOLUTION OF THE GENERA OF THE ACTINOCERATIDA IN THE ORDOVICIAN

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 (1956), and inclusion of the Rockland (R) in the Black River. Hull (H) and Sherman Fall (SF) are retained in the Trenton. A division is needed for the Cobourg—Red River equivalents, of which the Eden is regarded as a fades. (Modified from Flower, 1957).

Family Vutinoceratidae Shimizu and Obata, emend. Flower

As noted in the discussion of the Actinoceratida, the Wutinoceratidae are comprised of actinoceroids with reticular canals, and also show rings that are still of considerable thickness, which in thinsection may show textural differentiation of regions (Flower, 1964A), though material for such a study has been strictly limited; unfortunately most of the known specimens are types.

The three genera seemed, as first defined, readily distinguished as follows:

Wutinoceras—orthocones, generally depressed in section, with a large siphuncle of broad segments, the necks long, ranging from recumbent to narrowly free.
Adamsoceras—orthocones with small siphuncle segments, spherical, not wider than long, with necks free and brims not ordinarily longer than the necks.
Cyrtonybyoceras—shells exogastric cyrtocones, the siphuncle of short broad, broadly expanded segments with brims generally recumbent.

The new material here described shows that, as one might expect in a period in which differentiation of form of the siphuncle segments is near its beginning, there is some inter-gradation among these genera, to such an extent that proper generic assignment of the species presented some difficulties and required a review of the whole group. Insofar as form of the segments is concerned, there are found (I) forms with the brims long and generally adnate on both dorsum and venter, included in *Wutinoceras* and *Cyrtonybyoceras;* siphuncle segments are much broader than long and are commonly one half to one third the diameter of the shell; (2) forms in which the segments are still broad but commonly with the brims free on both sides; here the genotype of *Wutinoceras fits;* (3) forms with the brim short and free, as in *Ormoceras,* on the venter but on the dorsum brims may be free, though with the brim longer than the neck; they may be merely tangent to the septum, touching it at or near the tip of the neck but not throughout the length of the brim, or the brim may be recumbent, touching the septum through most if not all of its length; and (4) species with Ormoceras-like segments, not much wider than long, in which brims are free and brim and neck are short and sub-equal; indeed, some siphuncle segments in this group may have a maximum width slightly less than the length of the 'egment.

As noted in detail in the specific descriptions, one group if species of *Wutinoceras* with rather small siphuncle segments shows the variation noted under (3) above as varying erratically in the length of a single specimen. Such variation, best shown in W. *margaretae, is* not confined to that single pecies. We have found similar variation in *Cyrtonybyoceras urviseptatum,* through C. *haesitans* has shown only the :rictly recumbent brims noted in (I) above.

There is some indication, even from opaque sections alone, of variation in the thickness of the ring and the degree of complexity of the reticular canals; oddly, specimens that are simplest and thus theoretically most advanced in both respects are those of the Table Head limestone of Newfoundland.

Cross sections and suture patterns have shown some variation; in general, the actinoceroids tend to have broad sections with flattening more pronounced ventrally than dorsally, but in the Wutinoceratidae sections are prevalent in which the venter is narrowly rounded in contrast to the dorsum, and the section becomes higher than wide. *Cyrtonybyoceras haesitans* shows the greatest extent of both trends in the anterior part of its phragmocone. *Wutinoceras lobiferurn,* though more narrowly rounded dorsally than ventrally, develops striking dorsal lobes of the sutures, but similar though less pronounced lobes are present in other forms.

Siphuncles are generally close to the venter in the actinoceroids, particularly those of the Middle Ordovician, but we may note that the archaic *Polydesmia* has a subcentral siphuncle and that in the Wutinoceratidae, though the siphuncle may be ventral in the young, it is considerably removed from the venter rather consistently in late growth stages of the phragmocone. In C. *haesitans,* the expanded segments touch the ventral wall of the phragmocone in the first few camerae, but the siphuncle becomes well removed from the venter in later stages.

Curvature was considered a diagnostic feature of *Cyrtonybyoceras,* but two species of *Wutinoceras,* W. *margaretae* and W. *planiseptatum,* show very faint curvature, and the departure of the siphuncle from the plane of the section in *Adamsoceras attenuatum* indicates curvature there also. It seems unlikely that distortion of the specimen should be the real cause; curvature was not in a plane normal to the bedding.

Our present results confirm variation in details of outlines of siphuncle segments within a species, showing clearly that such fine distinctions as were employed by Shimizu and Obata in erecting genera and even families are unreliable and show further that some such variation is erratic rather than progressive in ontogeny. On the other hand, it is necessary to contradict Teichert's (Teichert et al., 5964) suppression of the family Wutinoceratidae and the treatment of *Wutinoceras as a* synonym of *Nybyoceras* and of *Adamsoceras as* a synonym of *Ormoceras.* While in one sense, whether one is to recognize genera or a family on the basis of only form of the siphuncle segments or whether the type of radial canal system is to be employed may be subjective, the present treatment of the Wutinoceratidae serves to unite a series of species that are closely related to such extent that decisions as to generic assignment have been difficult, and to recognize a group of forms having temporal significance. There can be little doubt that *Adamsoceras* is the immediate ancestor of *Ormoceras* or that *Wutinoceras* is the ancestor of *Nybyoceras* and, through that genus, of the Armenoceratidae.

The Wutinoceratidae so far known may be summarized as follows:

WUTINOCERAS

I. Broad segments, strongly recumbent brims

W. logani (nov.)	Newfoundland
W. paucicubiculatum (Teichert and Glenister)	Tasmania
W. multicubiculatum (Teichert and Glenister)	Tasmania
W. ulrichi (Foerste and Teichert)	Oklahoma

II. Large segments, rings free ventrally

W. lobiferum (nov.)	Nevada
W. davisi (nov.)	Utah
W. minore (nov.)	Newfoundland
W. foerstei (Endo)	Manchuria

III. Small segments, brims may be free dorsally, tangent or, rarely, adnate

W. margaretae (nov.)	Nevada
W. planiseptatum (nov.)	Nevada
W. lowelli (nov.)	Nevada
W. toquimense (nov.)	Nevada
W. huygenae (nov.)	Nevada

CYRTONYBYOCERAS

C. haesitans (Billings)	Newfoundland
C. barrandei Teichert	Newfoundland
C. adamsi (nov.)	Nevada
C. curviseptatum (nov.)	Nevada

ADAMSOCERAS

A. isabelae Flower 1957	Nevada
A. toquimense (nov.)	Nevada
A. gracile (nov.)	Nevada
A. attenuatum (nov.)	Nevada
A. lehmanense	Nevada
A. holmi (Troedsson)	Baltic
A. oelandicum (Troedsson)	Baltic
A. manchuriense (Endo)	Manchuria
A. johnstoni (Teichert and Glenister)	Tasmania

I have omitted *Orthoceras clouei* Barrande. Teichert (1933) restricted this species, removing the big cyrtoconic form to C. *haesitans* and a more slender cyrtocone to C. *barrandei;* forms remaining seem largely orthoconic, typical more of *Wutinoceras* than of *Cyrtonybyoceras.* It is worth noting that the remaining forms show variation and may not all be one species; in part, it possibly includes material of our *Wutinoceras logani.*

To shorten the tiresome measurements necessary in the description of these forms, *a siphonal formula* has been developed as follows:

4/4/1o:3/6/9; 6. or a/b/c:d/e/f; g, wherein a is distance from venter to septal foramen;
b, height across the septal foramen;
c, distance from foramen to dorsum;
d, distance from venter to expanded part of segment;
e, distance across expanded part of segment;
f, distance from expanded part of segment to dorsum; and
g, length of segment.

In many actinoceroids, and in most of the forms here dealt with, it is necessary to measure across the siphunde normal to the oblique septa; totals of measurement will thus exceed the shell height slightly.

Although little is known of the radial differentiation in the cameral deposits of actinoceroids, because these deposits show up well only under rather special conditions of preservation, the Wutinoceratidae show one very characteristic feature. On the venter the cameral deposits are small, thick close to the siphuncle, thin and disappear as they are traced along the free parts of the septa, and are wanting against the mural part of the septum. It is this condition that is responsible for the common occurrence of crushing of the ventral side of the shell which is shown in Endo's (1930) figure of *Wutinoceras foerstei* and the more marked crumpling of the septa ventrad of the siphuncle shown here in Pl. 15, figs. *5* and 6.

Stratigraphy of the Vutinoceratidae

The writer has found the Wutinoceratidae to be confined to the Whiterock stage in North America and suggests that its members in other regions indicate beds of the same age.

In western North America, the greater number of the known forms come from the Antelope Valley limestone. Some questions (Kay, 1962; Ross, 1965) have been raised as to whether this might be a Chazyan equivalent but a different fauna and facies. One cannot claim, however, that there is no place where a Whiterock fauna is not succeeded by one of definitely Chazy aspect; the Oil Creek limestone of Oklahoma is properly Whiterock and is succeeded by the McLish, which is quite certainly Chazyan. Legitimate questions remain, however, as to whether the appreciable thicknesses included in the Antelope Valley limestone (the type sections of the Antelope Valley and of the Whiterock stage are both in the Monitor range, on the west side of Antelope Valley about 4o miles west of Eureka, Nevada) include beds that are in part pre-Chazyan but in part may extend considerably higher in the Ordovician.

My own observations on the cephalopods have tended to support the thesis of Cooper, that this is a pre-Chazyan fauna, most strongly, but it must also be pointed out that the cephalopod evidence is so far largely concerned with forms from the lower part of the section, through the *Maclurites—Palliseria—Cirvanella* horizon.

Ross (1965) presented an analysis of the problem and some new interpretations. Kay (196z) presented a section of the Antelope Valley limestone at Ikes Canyon in the Toquima range of Nevada, a locality which has yielded the bulk of the material described here. His section may be summarized as follows:

Tan weathering gray limestone	5 feet
Leperditia—Sowerbyella zone	66 feet

Rhysostrophia zone	102 feet
Maclurites—Girvanella—Palliseria zone	1o7 feet
Sponge beds	152 feet
Asaphid zone	23o feet
Calcilutites with argillite beds	16o feet
Basal calcarenite	11 feet

A more detailed zonation is possible but this will serve as a frame of reference. The first specimens I received came from the late Dr. J. Lee Adams and were without close stratigraphic data; they were believed to have come mainly from the sponge beds. Other material came to light, also presumably from the sponge beds. After an opportunity to see the section with Dr. Reuben Ross and to do later collecting, I think it evident that there is a definite zonation of the cephalopods *in* the section, a matter which I shall leave largely for another time. It was something of a surprise, however, to find that all the actinoceroids of ascertainable position came from the *Maclurites—Palliseria—Girvanella* beds. True, many have been picked up loose, and some have been picked up at the level of the sponge beds. Their lithology, however, indicates in general a higher horizon. They come from a gray, dominantly light-gray-weathering limestone with tan-weathering stringers, and many show silica replacement of the shell parts, which weather tan to orange. This lithology is typical of the *Palliseria* beds but not of higher horizons. The same layers are the source also of some large endoceroids, and the horizon has yielded siphuncles of the genus *Rossoceras.* In this interval also there is a 2-foot laver of black granular limestone with some massive chert; this yielded the type of *Adamsoceras attenuation.* Two additional actinoceroids were seen in this horizon, but internal structure **was** lost by extensive recrystallization of the calcite.

Our material of *Wutinoceras lobifermn* is from a loose block from the upper 15 feet of the *Palliseria* zone. The types of *Cyrtonybyoceras adanisi, Wutinoceras lizzygenae, W. planiseptalum, and W. margaretae* are from rubble from this horizon on the north side of Ikes Canyon by the gate. Matrix, in several cases, contained the characteristic *Maclurites* and *Palliseria.*

The type of *Adamsoceras leonardi* is from the upper third of the *Palliseria* zone from the section at Meikeljohn Peak; this section has been described by Ross (1965). It seems likely that in these two sections, the *Palliseria* beds are equivalent, though in other regions Ross (1965) found them to act as a magnafacies, appearing in somewhat different parts of the columns in different regions.

The types of *Adamsoceras isabelae* and *A. gracile,* from the collection of the late Dr. J. Lee Adams, lack precise stratigraphic data. Lithology indicates that they also came from the *Palliseria* horizon of Ikes Canyon. The type of *Wutinoceras lowelli* was recorded as coming from the sponge beds; from lithology I would consider its ultimate origin also in this higher horizon. There is, oddly, no reliable record of actinoceroids below the *Palliseria* zone or lithological support for such an interpretation, in any material I have seen.

Actinoceroids are very rare in the Pogonip of western Utah. I have had but two fragmentary specimens. The type of *Wutinoceras davisi* lacks stratigraphic data, but from the lithology, is either the nodular limestones in black shales marking the beginning of zone N in the Ibex region, or from a black limestone in the upper third of the Lehman limestone. A second smaller fragment from the top 10 feet of the Lehman limestone is the type of *Adamsoceras lehmanense.* It is possibly of further interest to note that the actinoceroids of the Whiterock stage in Utah and Nevada have not been found in the lower part of the interval, zones L or M of the Utah sections, nor are they known definitely in Nevada below the *Palliseria* zone, which is always well above the base of the Antelope Valley limestone.

In Oklahoma only one member of this group is known, *Wutinoceras ulrichi* (Foerste and Teichert), originally assigned to the genus *Nybyoceras.* From locality data and information supplied by Dr. W. E. Ham, it is from the Oil Creek limestone and not, as I had formerly thought, from the McLish.

In Newfoundland, the lower Table Head beds yielded the material here described as *Wutinoceras logani, Adamsoceras billingsi, Cyrtonybyoceras curviseptatum,* and W. *ininore,* and the section at Point Riche yielded our specimen of *Cyrtonybyoceras haesitans.*

Teichert (1933) named *Cyrtonybyoceras barrandi,* a large form like C. *haesitans* but more slender, and restricted 0. *clouei* which he referred to *Cyrtonybyoceras.* The forms in the restricted C. *clouei* are, from differences in proportions, not all one species.

Intercontinental correlation of a unit as recently recognized as the Whiterock stage is necessarily rather tentative, but it now seems quite likely that Whiterock equivalents are to be found in some beds formerly regarded, as was the Whiterock itself, as Chazy equivalents. I have noted (Flower, 1957) that two species of *Ormoceras* from the Vaginatum limestone and the Aseri limestone (Platyutrus-kalk) of the Baltic region are, from their illustrations, *Adamsoceras* and suggest an equivalence that I think already has some support from the trilobite associations.

In eastern Asia,* the Wuting limestone, the source of

* Endo (1935) described additional fossils from the Ordovician of Manchuria and concluded, because he found additional *Nybyoceras* not in the Wuting formation but in the overlying Ssuyen formation, that *N. foerstei* probably also came from this higher formation. This conclusion now seems most improbable. The Wuting actinoceroids are Wutinoceratidae from the nature of the canal system. Of the Ssuyen species, *N. troedssoni, penhsiense, marginale, exortivum* and *aigawaense* are certainly more advanced actinoceroids with a more simplified canal system and seem reasonably assigned to *Nybyoceras. N. annectans is* an actinoceroid but is unusually small, faintly endogamic, and should possibly be set apart in a genus by itself. Of the other species, *N. compressum and N. tenuitubulatum* have smaller shells than do true actinoceroids, and proportionately small siphuncles; they may be Proteoceratidae, but the material is too fragmentary to permit a definite decision. In the same work, Endo assigns two species to *Arinenoceras; A. nanumatakawai* and *A. nakoi,* from the Kangyao limestone which lies beneath the Wuting limestone. The Kangyao formation contains a fauna composed largely of gastropods which Endo compared to the American Mosheim limestone. These two cephalopods offer perplexities; they are not demonstrably actinoceroids, but their position in beds of presumed Whiterock age leaves it unlikely that they are Proteoceratidae, none of which have been found elsewhere below the Chazy. The specimen which Endo figures from the Kangyao and Wuting limestones as *Orthis calligrama orthambonites* belongs (fide Cooper) to the genus *Orthambonites* which is abundant in the Whiterock, though species are known as young as the Wilderness stage.

Wutinoceras foerstei (Endo), would appear to be Whiterock. The associated *Armenoceras numatai is* rather ambiguous because only a natural horizontal section of the siphuncle is shown; it is, however, quite logically a small *Wutinoceras,* and the type has very much the appearance of *Wutinoceras* minore of the Table Head limestone here figured. *Ormoceras manchuriense* Endo of the same formation is, from the illustration, a good *Adamsoceras.*

I had followed Kobayashi in regarding *Polydesmia* of the Maruyama limestone, where it was reportedly in association with *Manchuroceras,* as the oldest actinoceroid. Some confusion has since developed, mainly from reports of *Polydesmia* not from the Maruyama bed or from the Wuting but from the Ssuyen limestone that overlies Wuting and contains a fauna of materially younger aspect, hard to place exactly, but in terms of American sections, it would seem to lie somewhere in the interval embraced by the beds from the Chazy to the Black River. Kobayashi (1940) noted that the early report of *Polydesmia* and *Manchuroceras* as coming from the same bed may be in error and that possibly equivalents of both the Maruyama bed and the Wuting limestone may have been attributed to the Ssuyen limestone in some localities. More field work is necessary to resolve these matters which is regrettably not possible at the present time. It is worth noting that the attribution of *Polydesmia* to the Ssuvcn, a formation overlying the Wuting limestone, is suspect.

Teichert and Glenister described actinoccroids from Tasmania which seem, from their evident reticular canals, to be Wutinoceratidae and to indicate Whiterock equivalents in that region also. Their *Nybyoceras multicubiculatum* and *N. paucicubiculatum* from Railton are typical of *Wutinoceras,* and their *Ormoceras johnstoni* from Zeehan is a good *Adamsoceras.* Reports of the general fauna at Railton are wanting; curiously, the fauna reported from Zeehan would suggest a younger age, but the *Adamsoceras* did not come from the same locality as did these fossils.

WUTINOCERAS SHIMIZU AND OBATA EMEND. FLOWER 1957

Genotype: *Nybyoceras foerstei* Endo

As emended, this genus contains straight Wutinoceratidae in which the siphuncle segments are generally broadly expanded, penetrating the septa where they are oblique, and with a broad area of adnation where the apical end of the ring meets the septum on the venter but not on the dorsum. Latitude in the form of the segments is allowed; we have found brims adnate to free, but more commonly free on the ventral side of the siphuncle. On the dorsum, necks may be adnate, free from the septum except at their tips (tangent), or may be free, but brims are longer in general than the necks. This last criterion has been employed in placing in *Wutinoceras* those species with rather small siphuncles, while those with shorter brims, not longer than the necks, and generally less broadly expanded segments are referred to *Adamsoceras.* In lengtii:v.idth ratio, there remains some intergradation not shared by the neck:brirn proportion. The known species are listed under the discussion of the Wutinoceratidae.

Wutinoceras logani Flower, n. sp.

Pl. Io, fig. 1-3; Pl. I t, fig. 1-7

This is a large shell, known as yet only from parts of phragmocones. The apex is blunt, the shell rapidly expanding in the early part and faintly exogastric. We do not have the whole of the apex, but 15 mm from the apical end of the specimen, the shell is 3o X 24 mm; it increases in 40 mm to 4o X 36 mm; in the next 6o mm to 53 x 48 mm where the siphuncle is 20 x 18 mm; in the next 45 mm to 55 and 50 mm, where the siphuncle is 24 X 22 mm; and continues for another 90 mm. While expansion is evidently slight there, the shell suffers from vertical crushing, but in the first 50 mm of this interval, it becomes 62 mm wide. The original height was probably about 54 mm.

Sutures slope dorsorad and are transverse as viewed from the dorsum. Our specimen is weathered on the ventral surface, which probably exaggerates the depth of the ventral lobes slightly. The camerae range from 10 to 12 mm long and show unusual uniformity in length except near the apex; there the first segment apparent on the surface is to mm, but the second is 12 mm.

The first siphuncle segment contracts from 14 to 7 rim; the second expands to a height of 17 mm. Near the anterior end of the apical part, 110 mm from the apex, a formula of 15/8/29:4/22/22; to is seen. Near the adoral end a segment expands from 11 to 24 mm, but crushing makes impossible more than an estimate that the position from the dorsum and the distance from the venter must be about the same as in the earlier stage.

The septal necks are strongly recurved on the venter, with the brim far longer than the neck but narrowly free. On the dorsum, tips of the apical necks join the septa but enclose a small free space; adorally, the recumbent condition is more nearly perfect. Though the early segments show some differences in length, the outline of the segments does not show the usual variation expected in near-initial stages of actinoceroids. The adoral extremity of the specimen plainly shows a siphuncle still filled with deposits, while anterior cameral deposits are wanting. The central canal is large; radial canals are coming to conform more closely than usual in actinoceroids of this age to a simple system ***ci*** horizontal canals, but there is still complex branching. The usual reticular condition is, however, definitely simplified here.

Discussion.—Though his descriptions are vague, this species is probably identical with what Barrande figured on pl. 433, fig. z as *Orthoceras clouei.* Teichert (1933) restricted this species, regarding the original of pl. 43[2] a[s] identical with 0. *haesitans* Billings, and removed the orig inal of pl. 434, fig. 5 *as Cyrtonybyoceras barrandei.* I agree that this is a form more slender, more gently curved, and more gently expanding than C. *haesitans,* as interpreted by Teichert and shown by our own material. Unfortunately, it leaves 0. *clouei* restricted to a series of specimens that sea' to show some variation, so the concept of the restricted species remains ambiguous.

Barrande's pl. 433, fig. 1 shows a large form, still rathe[1] rapidly expanding beyond a point at which our form s tubular. It shows adoral simplification of the siphuncle seg; ments, which are reduced in size, approaching those of *orntoceras.* We cannot, however, tell whether this specimen is curved. His pl. 433, fig. 1 seems a form similar to the one ain describing, showing a conical early part that becomes slender at a shell height of roughly 38 mm, though ours continues conical to a height of 45 mm. The originals of pl. 434, figs I to 4 show proportions suggesting that they are possibly parts of several species; his fig. 4 recalls the anterior part of our form, but it has five camerae in a length in which our specimen has three, though commensurate shell parts are compared. The original of Barrande's pl. 103, figs. 1-3 is different. I propose to give the form described herein a name and to restrict *Orthoceras clouei* to the original of pl. 434, fig. 4. The form is not obviously curved and is a *Wutinoceras* rather than a *Cyrtonybyoceras.*

Type and occurrence.—Holotype, Museum of Comparative Zoology, from the lower Table Head limestone unit 8 of Schuchert and Dunbar, 170 feet above base. Table Head section, Newfoundland.

Wutinoceras lohiferunt Flower, n. sp.

Pl. 2, fig. 8, 9; Pl. 3, entire;

We have of this form a phragmocone complete for a length of 16o mm, with an additional adoral 8o mm obliquely broken and weathered anteriorly. The phragmocone is close to the initial chamber at its base, some segments protruding apicad of the preserved shell wall. Near the base, the section is I 8 mm high and 20 mm wide, expanding in the first 6o mm to a height of 28 mm and a width of 25 mm, attaining a section with the dorsum faintly more narrowly rounded than the venter. In the next loo mm, it increases to a height of 42 mm and a width of 4o mm, where the narrowing of the dorsum is more pronounced. The sutures are transverse across the venter and slope slightly apicad toward the dorsum, and the dorsal surface shows prominent broad shallow lobes. The early part of the shell shows some wide variation in length of the early camerae, as is not uncommon in early stages of actinoceroids. Beyond these, the early camerae range from 4.5 to 5 mm in length over the first five camerae apparent externally, then become suddenly longer, beyond which they increase only gradually n length, varying from 8 to to mm. In the unsectioned 8o mm of the anterior part, which is not figured and which probably had an anterior diameter of about 45 mm, there s no further increase in length of camerae apparent.

A sagittal section (pl. 3, fig. 7) shows some irregularities in the early camerae and segments (pl. 2, fig. 8) and poor color differentiation. There is an apical bulbous end of the siphuncle, calcite-filled, without good differentiation of structure within; the next part is ambiguous but seems to show slit septa on the dorsum outlining two short, irregular, expanded segments, with the sutures, as far as they are clear, showing oddly sinuous courses on the dorsal side. Five anterior segments having the outline typical of the genus are shown in part. If this condition is not complicated by adventitious factors, a possibility I could not rule out altogether, we have here a larger bulbous apical chamber than has been found in previously described actinoceroid pices, followed by two short, irregular segments, a longer one, and beyond that another similar in form before the septa on the dorsal side develop the typical curvature. The greatest depth of the septa is in the dorsal fourth of the conch, which continues on throughout the rest of the apical portion but which comes to be reduced adorally.

Beyond the fifth apparent segment, the siphuncle shows the following measurements: 7/4/12:4/9/10; 7. Near the adoral end of the sectioned part, the measurements are 10/6/22:6/13/18; 9.

The expanded siphuncle segment is between a third and a half the height of the shell and of proportional width. The siphuncle is not compressed in section as is the shell; our several cross sections show it to be circular. Structures within the siphuncle are obscure apically but clearer adorally. The usual dark central canal is not evident; it was filled with calcite. Traces of the canal can be seen through several of the septal foramina where they slope dorsad adorally. Evidence of reticular canals is abundant. In grinding the specimen, photographic records were taken at several levels for the apical part of the anterior sectioned piece. Septal necks are free ventrally, the tip pointing obliquely out and apicad; on the dorsum, the brim is longer than the neck, and necks vary from free to recumbent. The camerae show hyposeptal deposits ventrad of the siphuncle that thicken toward the siphuncle but then thin again close to the neck. Thin episeptal deposits are present there also. On the dorsal side, cameral deposits are ambiguous and possibly wanting in the early camerae, but beyond the fifth, they are thick and nearly joined; adorally, they thin rapidly and are not evident at all in the anterior eight camerae shown.

Discussion.—This species is readily characterized by the proportions; most striking are the cross section and the development of prominent dorsal lobes. The species is unique in the Nevada forms for the very large size of the siphuncle, but it does not approach the condition found in *Wutinoceras logani* of Newfoundland.

Type and Occurrence.—The holotvpe, no. 437 in the collection of the writer, came from the top 15 feet of the *Palliseria* zone of the Antelope Valley limestone, from the main section on the north side of Ikes Canyon, Toquima Range, Nevada.

Wutinoceras davisi

Pl. 15, fig. 8-14

This is a slender species with a very smooth exterior and a very large siphuncle. The type contains only 3o mm of the shell wall and four camerae. The shell expands in width from 4o to 45 mm. The apparent corresponding heights are 32 and 36 mm, but the shell is oddly crushed, the venter showing septa and shell wall pressed against the siphuncle. The sutures slope gently orad from dorsum to venter, but there is no dorsal lobe apparent in dorsal view. The four camerae are subequal in length, five in a length equal to the adoral width. The septal foramen is well removed from the venter, and the siphuncle segments when expanded are more than a third of the shell height. The siphuncle expands from 7/8/21 to 5/15/17; 5, distance from the venter being necessarily approximate. On the venter, the brim is strongly recurved, the tip pointing back toward the septum; beyond it, the anterior end of the ring touches the septum. Apically, the ring shows a long area of adnation. On the dorsal side, the brim is longer than the neck and less strongly recurved, and the anterior end of the ring is free from the septum. Apically, its area of adnation is vestigial. The section shows a complex fibrous structure from many interconnecting radial canals. Calcite in the camerae seems completely inorganic. The exterior of the internal mold shows a ventral pit in each camera, evidently a region where cameral deposits do not form along the mural part of the septum.

Discussion.—Though we have only a small fragment for *a* type, this species is highly distinctive for the form of the siphuncle segments, their large size in proportion to the shell, and the much less oblique and much less vertically modified siphuncle at its passage through the septum than in any of our comparable specimens. The species is named for Mr. and Mrs. Lamar Davis of Black Rock in grateful recognition of a rescue.

Type and Occurrence.—The type is in the collection of Brigham Young University. It lacks data, but by lithology is either from the Kanosh shale low in zone N or from a black limestone in the upper third of the Lehman limestone.

Wutinoceras planiseptatum Flower. n. sp.

Pl. t, fig. 11-14; Pl. 6, fig. 12

This species is known from a portion of a phragmocone expanding from 36 and 37 mm to 46 and 49 mm in a length of t to mm. The cross section is slightly compressed and shows the venter more narrowly rounded than the dorsum. Sutures are poorly displayed, but there is evident a slight slope forward from dorsum to venter although there is plainly no prominent dorsal lobe. Camerae are short, varying rather erratically in length, from 3 to 5 mm in the apical part and from 6 to 7 mm in the adoral part. In vertical section, the septa attain their greatest depth well dorsad of the center and are then rather abruptly curved forward close to the dorsum. Their curvature from the point of greatest depth to the venter is quite gentle. Apically, a siphuncle segment shows the formula of 8/3/28:5.5/9/25; 14; adorally, it becomes 1o/4/33; 7/11.5/30 17. On the ventral side of the siphuncle necks are rather sharply recurved and free but with the brim exceeding the length of the neck. On the dorsal side, some necks are recumbent; others show the siphuncle wall joining the septum at or just beyond the tip of the neck. Apically, the ring is broadly adnate ventrally, narrowly so dorsally. The tube is straight, the canals reticular. Episeptal and hyposeptal deposits are evident on the dorsal side and impinge on the mural surface. Ventrad of the siphuncle no deposits are evident; there may be a ventral sinus in the deposits.

Discussion.—This is a distinctive form in that the siphuncle is exceptionally small, and vet the condition of the septal necks shows more abrupt recurvature than is usual even in *Wutinoceras.* Oddly, the form most comparable to this one in this respect is *W. logani,* in which the siphuncle is extremely large.

Type and Occurrence.—Holotype No. 1140 from the *Palliseria* bed of the Antelope Valley limestone, from rubble from the cliff forming the north wall of Ikes Canyon by the gate; Toquima Range, Nevada.

Wutinoceras inargaretae

Pl. 5, fig. 1-5

Of this form we know a portion of phragmocone a little over 150 mm long, broken obliquely at both ends. Near the anterior end, the cross section shows a height of 45 mm and a width of 41 mm. In a length of 95 mm, the height increases from 30 to 45 mm. In vertical section, the septa are symmetrically curved. Camerae vary somewhat erratically in length but range from 3 to 5 mm apically and 9 to 11 mm adorally. The siphuncle shows apical measurements of 8/3/20:5/8/17; 4; with distance from the venter necessarily estimated; adorally it shows 6/4/26:4/10/24.* On the venter, the neck is gently bent as in *Ormoceras.* On the dorsum, the brim is much longer than the neck; segments vary erratically in outline, some recumbent, some touching the septum at the tips of the necks. A few segments show the brim free. The tube is central, canals reticular; inorganic calcite largely fills the camerae, but episeptal and hyposeptal deposits appear dorsad of the siphuncle apically.

Discussion.—Readers should be warned that in removing this specimen from a rather large slab, part of the venter was removed, but not much. The opposite side of the cut shows little material, with irregular lateral outlines; either the shell was abraded prior to burial or some styliotic solution acted on it afterward. The proportions characterize the species; it differs from *W. planiseptatum* clearly in the more even course of the septa as seen in vertical section, the cross section is less strongly narrowly rounded ventrally, and proportions of the siphuncle segments are rather different.

Type and Occurrence.—Collection of the writer, no. 1141. From the *Palliseria* zone of the Antelope Valley limestone, from rubble at the foot of the cliff forming the north wall of Ikes Canyon, by the gate; Toquima Range, Nevada. The specimen is named for my wife, who found it.

Wutinoceras huygenae

P1. 1, fig. I-5; Pl. 6, fig. 11

The type is an incomplete phragmocone 85 mm long, broadly depressed in section, greatest width above the middle, but with the venter slightly more flattened than the dorsum. In 7o mm, it expands from 3o and 31 mm to 36 and 40 mm, being nearly parallel-sided vertically but more expanding laterally. Camerae are 5 mm long apically and 6 mm adorally, and there are I I in a length of 65 mm, 5.5 in a length equal to the adoral height; 6.o in a length equal to the width. Sutures are transverse ventrally and laterally, but form broad prominent dorsal lobes, because of which the septa are quite gentle in curvature as they meet the dorsal wall, as seen in vertical section. The siphuncle segments are relatively small but are broadly expanded; on the dorsum, the brims are adnate throughout most of the length of the specimen but brims are free in a few segments. Basally, a segment shows a formula of 8/4/22:9/5.5/2o; 5. Adorall,v,

The venter was weathered or abraded prior to burial.

where the section is not quite central, the formula is 5:7.5/25:5/10/22.

Discussion.—The dorsal lobe recalls that of *A. lobiferum,* but in this form the proportions are quite different; here the section is broad, slightly flattened ventrally, the conch expands more rapidly laterally than vertically, the siphuncle segment is proportionally smaller in diameter, and dorsally the recumbent brims are perfectly developed throughout. The tube is straight, canals reticular, cameral deposits are episeptal and hyposeptal. W. *lowelli* has a larger siphuncle more removed from the venter and is less rapidly expanding laterally.

Type and Occurrence.—The holotype, no. 440 in the collection of the writer, is from the *Palliseria* zone of the Antelope Valley limestone, loose, from rubble by the gate from the north side at Ikes Canyon, Toquima Range, Nevada.

1Vutinoceras lowelli Flower, n. sp.

Plate 6, fig. 1-7

The type is a somewhat weathered part of a phragmocone in two portions, with a small bit missing between which crumbled, probably representing parts of two camerae. The specimen is 112 mm long, increasing from 32 and 34 mm to 40 and 44 mm, being slightly wider than high, but with dorsum and venter about equally rounded. The shell surface was apparently smooth, but is poorly displayed. Sutures are straight, slightly oblique, sloping gently forward from venter to dorsum. In the basal 62 mm there are nine camerae preserved and a part of a tenth; they vary slightly in length, but average 7 mm. The six camerae of the anterior portion are not materially longer. Basally the siphonal formula is I0/5.5/21:6/11/19; *7.* The first three camerae show the siphuncle moving appreciably away from the venter; beyond this point, there is no appreciable change in its position. Anteriorly a formula of 12/5/22:9/13/21; 7 is shown. The ventral side of the siphuncle shows the brim free and no longer than the neck. On the dorsum the brim is long, and there is erratic variation between brims that are adnate and those that are narrowly free. Except on the venter of the apical segments, where both episeptal and hyposeptal deposits are thick close to the siphuncle and thin, not attaining the mural part of the septum, calcite in the camerae has obscured the original cameral deposits. The ring is moderately thick, the radial canals are markedly dendritic, the central canal rather irregular in its course through the center of the siphuncle. Septa are shallow and the siphuncle segments are more transverse, less markedly oblique than in most species of this genus.

Discussion.—This species is distinctive in its proportions; the section, though slightly wider than high, fails to show the differentiation of rounding between the dorsal and ventral regions which is evident in most other species.

Type *and occurrence.—The* holotype is in the American Museum of Natural History, no. 28787. From the Pogonip of Ikes Canyon Toquima Range, Nevada, collected by Mr. James D. Lowell, for whom the species is named. The specimen was reportedly from the sponge beds, but from the matrix and deeply weathered condition of the specimen, I believe that it came originally from the *Palliseria* beds above.

Wt4tinoceras minore

Pl. 6, fig. *9;* Pl. I 1, fig. 8-1 1.

This is a small moderately expanding orthocone of circular or slightly depressed section, dorsal saddles, moderate expansion, a rather small ventral siphuncle, and camerae that are nearly uniform in length, not increasing proportionately to the increase in shell diameter.

The type preserves 37 mm of phragmocone and is weathered from the ventral side. At the base, the section is subcircular, 23 mm wide and 22 or 23 mm high, the venter being incomplete. In 65 mm, it increases in width to 34 mm, and the section seems similarly subcircular. In this length, there are seven camerae which increase from 4.5 to 5.o mm in length. The septa are shallow in curvature, there are about seven camerae in a length equal to the adoral shell width. The weathered surface shows short Armenoceras-like segments; a vertical section in the basal part shows segments 5/4/15: 2/10/12; 4-5. On the venter, the neck is free but hooked, the point extending slightly forward. On the dorsal side, the neck is recumbent. The interior of the siphuncle shows reticular canals. Good episeptal and hyposeptal deposits are present; they are even well shown at the anterior limit of the phragmocone of the type. This is certainly not an anterior limit of the phragmocone as shown both by the presence of cameral deposits and by the broken condition of anterior septa. The shell shows faint transverse markings.

Discussion.—This is evidently a distinct small species, well characterized, as noted in the beginning of the description. It is of interest to compare the anterior weathered section of the siphuncle with that of the type of *Wutinoceras numatai* (Endo); the two species are not identical but seem quite similar in general proportions.

Type and occurrence.—Holotvpe, Museum of Comparative Zoology, from unit 7 (Schuchert and Dunbar) of the Table Head limestone, Table Head, Newfoundland.

CYRTONYBYOCERAS TEICHERT

Genotype: *Orthoceras haesitans* Billings

This genus was erected for *Orthoceras haesitans* Billings as an exogastric, cyrtoconic actinoceroid with siphuncle segments like those of *Nybyoceras* in form. The siphuncle lies ventrad of the center but is ordinarily well removed from the venter. The siphuncle segments show a broad area of adnation ventrally. Septal necks are recumbent on both dorsum and venter in the genotype, but in other species, one or both may be narrowly free; in C. *adamsi,* the brim is free and scarcely longer than the neck on the ventral side but recumbent or only narrowly free on the dorsum.

Teichert (1933) recognized three species from the Table Head of Newfoundland: C. *haesitans,* the new species C. *barrandei,* based upon part of a form that is evidently more slender, and the restricted Barrande's 0. *clouei.* There is some doubt as to whether 0. *clouei* as restricted contains any true *Cyrtonybyoceras;* the shells appear straight, and one of the specimens is quite similar to the form here described as *Wutinoceras logani.* Descriptions are unfortunately somewhat approximate, but even as restricted it appears that 0. *clouei* contains specimens showing such variation in proportion as to suggest that more than one true species is involved.

Cyrtonybyoceras haesiians, as here conceived, is distinctive in its large size, the compressed condition of the shell, which increases adorally, and the progressive removal of the siphuncle from the venter in ontogeny. We would agree with Teichert that his C. *barrandei* is a different species, showing gentler curvature and expansion. A third form, here described, is a smaller slender gently curved species with a very strongly curved septa, C. *curviseptatum*. C. *adamsi* from Nevada is distinctive in the broader section and the less strongly recurved septa] necks. Some additional species here described approach *Cyrtonybyoceras* in cross section, and some show the faintest suggestion of curvature, but it was considered best to place them in *Wutinoceras* which they resemble in other features. It is worth noting, however, that there is this suggestion of a close relationship between these two genera, approaching intergradation.

Cyrionybyoceras haesiians (Billings)
Pl. 12, fig. 1-8

Orthoceras haesitans Billings, 1865, Geol. Sun·. Canada, Paleozoic Fossils, v. I, p. 254.
Orthoceras clouei Barrande, 1870, Syst. Sil. du Centre de la Bohéme, Céphalopodes, pl. 432, figs. 1-6 (not pls. 433 or 434).
Cyrtonybyoceras haesitans Teichert, 1933, Palaeontographica, Bd. 78, Abt. A, p. 146, pl. 12, fig. 35.

I am tentatively referring to this species a large specimen representing part of a phragmocone 195 mm long, which is gently exogastric, expanding more rapidly vertically than horizontally, and which shows an anterior lateral contraction that seems to have been partly original, though augmented by slight crushing. The shell expands from 26 and 27 mm at the base, being very slightly wider than high, to a height of 6z mm and a width of 54 mm in a length of 122 mm, beyond which the height increases to 70 mm, while the section narrows to an estimated 45 to 50 mm. The cross section shows an adoral increase in compression, and the venter comes to be markedly more narrowly rounded than the dorsum. Twenty-three camerae are preserved, which increase in length from 6 to 14 mm, as measured on the venter. Sutures show lateral lobes that tend to slope forward on the venter progressively with growth of the shell.

At the very base, the section is slightly wider than high, measuring z6 and 27 mm. A cut across the matrix concealing the septum revealed a protruding siphuncle segment, 14 X 15 mm, wider than high, and, where expanded, in contact with the ventral wall of the shell. The section of the shell is slightly more narrowly rounded ventrally than dorsally. A break 32 mm farther orad shows a septum 35 mm high and 35 mm wide, with the septa] foramen 6 mm from the venter, 7 mm across, and 23 mm from the dorsum. Here, the narrowing of the venter and flattening of ventrolateral zones are distinct. The anterior several camerae were sectioned vertically; here, the foramen is to mm from the venter, 8 mm high, and 24 mm from the dorsum, and the segment becomes 20 mm high, 4 mm from the venter and 19 mm from the dorsum. On both dorsum and venter, brims are long and recumbent. On the dorsum, the anterior end of the ring is broadly attached to the anterior septum; apically, there is a broad area of adnation ventrally, a shorter one dorsally. At the anterior end of the sectioned part, the cross section is 44 mm high and 41 mm wide, with marked narrowing of the venter and flattening of ventrolateral zones. Here the siphonal formula is 10/8/24:4/20/19; 7.

The section of the siphuncle shows thinner rings than usual for the Wutinoceratidae, though they broaden anteriorly where they join the septal necks. Radial canals appear mainly as single arcs, with only slight development of the reticular pattern.

Discussion.—*Billings* described this form without figuring it. Later, Barrande described *Orihoceras clouei* from Newfoundland. Teichert (1933) concluded that the large curved form that Barrande included under this name on his pl. 432 was identical with Billings' 0. *haesiians;* he figured a section of Billings' type and restricted Barrande's species O. *clouei* without, however, designating a type. Our specimen agrees with the figure of Billings' original specimen in general rate proportions insofar as they are shown. It differs from Barrande's figure, which seems more diagrammatic than most others, in the compression of the section and the narrowing of the venter. I have not been able to see Barrande's material, but if his drawing is correct as to cross section, he may have had a different species, though this seems unlikely.

Type and Occurrence.—The holotype is no. 721, in the Geological Survey of Canada. Figured specimen, hypotype, Museum of Comparative Zoology, from the Table Head beds at Point Riche, Newfoundland, collected by Dr. Harry Whittington.

Cyrionybyoceras adamsi Flower, n. sp.
Pl. 1, fig. 6-1o; P1.4, fig. 7

This form is known only from a portion of a phragmocone with a maximum length of 7o mm. It is a gently curved shell, distinctive in the genus for the slightly depressed cross section and the septal necks, which are free ventrally and variable dorsally, though commonly free or tangent there. The type expands from 23 and 25 mm to 3o and 33 mm in 45 mm; adorally the venter is incomplete. Curvature is very gentle. At a shell width of 34 mm there is an adoral decrease in the rate of lateral expansion; though the venter is wanting adorally, there is a suggestion of a similar decrease in vertical rate of expansion. Sutures slope forward from venter to dorsum; a broad lobe is evident in ventral view, but in dorsal view the sutures appear transverse. Camerae increase in length from 4 to 5 mm in the length of the specimen; adorally six and a half camerae occur in a length equal to the shell width. The siphonal formula is 4/4/15:2/9/13; 4 : 5 apically and 7/5 17:4/1015; 5 adorally. On the ventral side of the siphuncle necks are short, free, brim and neck subequal; on the dorsum the brim is longer than the neck, and varies from tangent to free, with one segment showing the brim largely recumbent (see pl. 4, fig. 7). Radial canals are reticular; the central canal, visible only in the apical part, being lost adorally in cutting the section, is essentially straight. The section shows of the siphuncle, hvposeptal deposits which thicken toward the ring, with episeptal deposits developed close to the siphuncle, but not extending to the angle of the septum or on the mural part. Dorsally, inorganic calcite complicates interpretation but there are certainly episeptal and hyposeptal deposits which join narrowly at the anterior corner, though no appreciable pseudoseptum is developed.

Discussion.—This *Cyrionybyoceras* is distinctive in the broad section, the free necks of the venter, and the largely free necks of the dorsal side of the siphuncle. Its depressed section sets it apart from its congeners.

Type and Occurrence.—The holotype, no. 439 in the collection of the writer, is from the *Palliseria* zone of the Antelope Valley limestone, from Ikes Canyon, Toquima Range, Nevada. It was picked up in rubble at the foot of the cliff forming the north wall of the canyon, by the gate.

Cyrtonybyoceras curvisepiaium Flower, n. sp.
Pl. 13, fig. 8-13

This is a slender *Cyrionybyoceras,* which shows exceptionally strong curvature of the septa, as seen in sagittal section. It is known from only the type, a portion of phragmocone gently expanding, gently curved, 140 mm in length, incomplete at both ends. The type expands from 24 and 25 mm to 35 and 36 mm in too mm. Sutures slope slightly orad from venter to dorsum but lobes are not evident. The camerae increase in length from 5 td 6 mm in the length of the specimen; adorally 6.5 camerae occupy a length equal to the shell height. Septa are deeply curved, Io mm deep where the shell is 35 mm high. The siphuncle is well removed from the venter; segments are of the *Nybyoceras* type, with the brims recumbent, extending far into the siphuncle adorally. The siphonal formula is 8/3/13:4/10/ to; 5 apically and 10/5/22:6/13.5/17.5; 6 adorally. Radial canals are reticulate, the central canal is largely straight but shows minor irregularities. Calcite in the camerae involves episeptal and hyposeptal deposits.

Discussion.—This species is distinctive in its slender form, the slight forward slope of septa from venter to dorsum, the slightly compressed section, the rather strongly curved septa, and the proportions of the siphuncle segments, particularly the recumbent brims of both the dorsal and ventral profiles.

Type and Occurrence.—Holotype, Museum of Comparative Zoology, from the lower part of the Table Head limestone, unit 3 of Schuchert and Dunbar, from the Table Head limestone of Newfoundland.

Genus ADAMSOCERAS FLOWER, 1957 Genotype: *Adamsoceras isabelae* Flower, 1957

Adamsoceras Flower, 7957, New Mexico Bur. Mines, Mem. 2, p. 25.

This genus was erected for Wutinoceratidae, with the typical thick rings and reticular canals, but with siphuncle segments resembling those of *Ormoceras* in general form. Brims are shorter than the necks and free on both the dorsal and ventral sides of the siphuncle. The maximum width or height of the siphuncle segment may be nearly equal to the length of two segments in *A. leonardi,* to one and a half segments in *A. isabelae,* while in the anterior parts of *A. gracile* and A. *aitenuatum* the segments are slightly longer than their maximum width. The known species have been listed under the discussion of the family Wutinoceratidae.

Adamsoceras isabelae Flower
Pl. 5, fig. 7

Adamsoceras isabelae Flower, 7957, New Mexico Bur. Mines Mem. 2, p. 25, Pl. 5 fig. 7-4, text fig. 3a.

This species has been adequately described, and there is no sense in repeating the description or illustration. We may add as a supplementary note the siphunal formula of 6/4.5/-^{2}7:4/9/^{2}3; 6-7 with the reservation that the space between the siphuncle and the venter seems to have been reduced slightly by crushing. Enlargement of the siphuncle segments is shown in Pl. 5, fig. 7.

Adamsoceras gracile Flower, n. sp.
Pl. 5, fig. 6, Pl. 6, fig. 8, Pl. 7, fig.

This species is known from part of a phragmocone largely complete over a length of 110 mm and incomplete for another 25 mm. The section is broader than high, the venter more narrowly rounded than the dorsum. In 110 mm, the shell expands from 31 and 41 mm to 34 and 43 mm. The exterior preserves large areas of a shell devoid of surface markings. A vertical section of the phragmocone shows parts of 20 camerae apparent, which increase rather markedly in length from 5 mm apically to 7.5 mm adorally. Septa join the shell wall at equivalent points in the length of the shell, so sutures are apparently transverse, though they are not seen externally. Apically, the septum is evenly curved, its depth of curvature about one fifth the shell height; adorally, it shows some marked flattening in the middle, and curvature is not much more than one fourth the shell height. Apically, seven camerae occupy a length equal to the shell height; adorally only five occur in a similar length.

Siphuncle segments are spheroidal showing a formula of 9/3/22; 7/7/20;5 apically and of 7/4/23; 4/9/22; 7 adorally.

Owing to the marked adoral increase in length of the camerae, the siphuncle segments, which apically are about one and a half times their length, have the greatest height equal to the length adorally and suggest siphuncles of *Deiroceras* rather than of typical *Ormoceras.* Brims are no longer than the necks. Siphonal deposits show a good straight central canal; radial canals are not well preserved but are apparently reticular, though tending toward the simple horizontal canals of *Ormoceras* adorally. Calcite in the camerae is largely inorganic, but there are thin episeptal and hyposeptal deposits in the apical camerae.

Discussion.—The type is an exceptionally slender, almost tubular shell, showing an adoral increase in length of the camerae out of proportion to the rate of expansion. Maximum and minimum diameters of the segments of the siphuncle remain nearly constant, while the segments lengthen in proportion adorally. This must have been quite a long, slender shell, though probably the early part was much more conical. I have wondered if *A. aiienuaium* could be an adoral part of this species, but if so, the whole shell was more than six feet long and slightly curved adorally. The two are best considered as distinct species in view of the lack of evidence connecting them.

Type and occurrence.—The holotype, no. 369 in the collection of the writer, was the gift of the late Dr. J. Lee Adams.

It is from the Antelope Valley limestone of Ikes Canyon, Toquima Range, Nevada. The precise stratigraphic origin is not known; it may have come from the *Palliseria* beds as did the other actinoceroids of known origin, but for this specimen the evidence supplied by lithology is not conclusive.

Adamsoceras attenuatuni Flower, n. sp.

P1. 2, fig. I, 2

We have of this form only part of a phragmocone from a late growth stage, in all 170 mm long, increasing in height from 47 to 65 mm in a length of 140 mm. The section is compressed, though somewhat irregular; perhaps there is some crushing involved; adorally, it has a height of 65 mm and a width of 5o mm. The center of the siphuncle is 20 mm from the venter, 45 mm from the dorsum. The suture pattern is not clear. Camerae range from t 1 to 14 mm but are largely 13 to 14 mm long in the anterior two thirds; parts of 14 camerae are preserved in the type. A nearly vertical section was made, though under some difficulties in holding the specimen properly. It shows the siphuncle at both ends, but not in the middle, an indication of slight curvature. Septa are deeply curved, somewhat variable, but show a suggestion of alteration by crushing only anteriorly. A septum at a shell height of 52 mm is 18 mm deep, equal to one and a half camerae. About four camerae occupy a length equal to the adoral shell height. Apicallv, a siphuncle segment **12** mm long expands from 6 to to mm; the outline is slender, reminding one as much of *Deiroceras as Ormoceras.* Anteriorly, a segment 13 mm long expands from 4 to tc mm. The septal formula is not given, as the sectional surface appears to be oblique to the plane of symmetry of the shell.

Discussion.—The type is the latest growth stage, in terms of size of cross section, found in the Antelope Valley limestone. **I** at first wondered whether it might be an extremely late growth stage of a species otherwise represented by specimens of only considerably smaller diameter, but if it is, the early stages known show little ontogenetic change in proportion of siphuncle segments, septa, or cross section, while this form is distinctive in the very slender siphuncle segments, the deeply curved septa, the compressed cross section, and the slight curvature indicated by the failure of our section to expose the siphuncle except at the two ends of the specimen. It is further worthy of note that this specimen shows similar siphuncle segments at both ends of a 140 mm interval. While in *Actinoceras* the anterior segments become simplified in form and reduced in size, so that anterior parts were described under a different generic name f, *Leurocycloceras),* our material fails utterly to support a similar interpretation of this specimen. Throughout the length of the specimen, the siphuncle segments are filled: large central canals are evident, but radial canals are not. Calcite within the camerae, however, is largely if not completely inorganic, and there is no clear evidence of cameral deposits here, as we may expect from such a large fragment; it therefore represents evidently only the anterior part of a phragmocone.

Adamoceras gracile is similar in general conformation of the siphuncle segments but is straight, almost tubular, has much shorter camerae, and a cross section broader than high and more narrowly rounded ventrally than dorsally.

Type and occurrence.—The unique type is no. 438 in the collection of the writer. It came from a loose piece of the Antelope Valley limestone from Ikes Canyon in the Toquima Range, Nevada. The piece, obtained above the sponge beds contained layers of gray limestone enclosing a 10-inch lay of black granular limestone with some chert. It is regarded as having come from some part of the *Palliseria* beds.

Adamsoceras leonardi Flower n. sp.

Pl. 4, fig. 1-6

We have of this form a phragmocone 130 mm long, bulk ends obliquely broken, the anterior end displaced along joint. A cross section 36 mm from the anterior extremity shows the section faintly askew, 42 by 46 mm, seemingly with the venter slightly more narrowly rounded than the dorsum. Apicad of this region, in a length of 65 mm, the shell height decreases decreases from 44 to 42 mm. Sutures are nearly transverse but slope slightly forward from venter to dorsum. Camerae vary rather erratically in length but are 4 to 6 mm in the apical part and 7 to 9 mm in the anterior part. Apically, the siphonal formula is 11/4/27:9/10/24; 4-6. Adorally, the formula is 9/4/28:5/11/26; 7-9. Necks are free and of the *Ormoceras* type. The tube is straight, canals less evidently reticular than usual, rings thick. Camerae have episeptal and hvposeptal deposits.

*Discnssion.—*This form shows rather close septa, and segments are broader in proportion to their length than in other species of *Adamsoceras.* It is assigned to that genus as the brims are short and free on both dorsum and venter. The proportions are distinctive.

Type and occurrence.—The holotype, no. 1142 in the collection of the writer, is from the upper part of the *Palliseria* zone of the Antelope Valley limestone from Meikeljohn Peak, near Beatty, Nevada. Ross (1964) indicates this zone as occupying 181 feet, beginning 314 feet above the base of the Antelope Valley limestone, with the base of the Eureka quartzite 18o feet higher.

Adamsoceras billingsi Flower

Pl. 14, fig. 1-7

Ormoceras allumettense Teichert, 1933, Palaeontographica, Bd. Abt. A, Pl. 9, fig. 6.

Adamsoceras billingsi Flower, 1957, N. Alex. Bur. Mines, Mem. p. 25.

This species is a slender, nearly tubular shell from its known part, but it has not been described in detail; **the** name was proposed as a substitute for the misidentification of a published specimen.

The specimen here figured permits a fuller description and shows some departures from the type in proportion. The hypotype preserves 170 mm of phragmocone, containing eighteen camerae which increases rather irregularly from 6 to 11 mm in length. The section is subcircular basally, 42 mm across; anteriorly, it is 47 x 46 mm, slightly depressed. Expansion and increase in length of the camerae from 6 to 11 mm are both largely confined to the apical third. Sutures *ate* straight and transverse. The septum is deeply curved as seen in section, the depth 12 mm at a diameter of 45. The phuncle segments resemble those of *Ormoceras.* Apically septal formula is 10/5/26:7/12/23; 7-9. Adorally the formula is 10/5/28:7/10/26; 11. Expansion of segments is fairly uniform throughout the length of the specimen, but adorally the segments are materially longer, and thus more slender in aspect. The tube is large and essentially straight. The canals are less markedly reticular than is usual for the Wutinoceratidae. The specimen shows only thin episeptal and hyposeptal deposits apically.

Discussion.—This species was named, since it had been figured mistakenly as *Ormoceras allumettense,* a smaller and much younger species from the Paquette Rapids beds of the Ottawa River. That form is a true *Ormoceras,* and one of rather different proportions. The type of *Adamsoceras billingsi* shows a 125-mm length of phragmocone, 48 mm high adorally and almost tubular in the adoral part. Our present form agrees with it in form and in curvature of septa, but the camerae are slightly shorter; the siphuncle segments of the type resemble those in the basal part of our specimen but are shorter than those in the more commensurate anterior part.

Type and occurrence.—Holotype, Canada Geological Survey, no. 620; Point Riche, Newfoundland; hypotype, Museum of Comparative Zoology, from unit 8 of Schuchert and Dunbar, Table Head, Newfoundland.

Adamsoceras lehmanense Flower, n. sp.
Pl. 2, fig. 3-7

We have only a fragment of this species, which is nevertheless distinctive in proportions. The type preserves only 40 mm of a phragmocone, with both ends broken obliquely. The rate of expansion is evidently very gentle, the shell height increasing from 30 to 31 mm in 30 mm; a width of 35 mm corresponds to the height of 30 mm; the section is somewhat more broadly rounded ventrally than dorsally. Sutures are poorly shown, but the septa clearly extend farther forward ventrally than dorsally. Five camerae occupy a length equal to the adoral shell height of 31 mm. Septa show a curvature equal to the length of one and a half camerae, and the apparent suture is inclined 20-25 degrees from the horizontal. The siphuncle shows strongly oblique segments, with a septal formula of 7/4/20:5/10/17; 7. The specimen shows some evidence of crushing which has distorted some siphuncle segments and has obscured the radial canal pattern, but there are traces of radial canals showing that they were numerous, apparently irregular, and almost certainly of the dendritic type. Ventrad of the siphuncle thin episeptal and hyposeptal deposits are visible, but they do not extend to the ventral wall of the camera. There are episeptal and hyposeptal deposits on the dorsum, showing considerable variation in thickness and surface contour.

Discussion.—This species is distinctive in the almost tubular form and the small strongly oblique siphuncle segments. The fragment which is the type evidently lay a considerable distance from the living chamber. The proportions are distinctive. It is the only *Adamsoceras* so far obtained from the Lehman limestone.

Type and occurrence.—*Holotype,* no. MCN 174, Geology Dept., Brigham Young University. It came from 10' below the top of the Lehman formation of the Ibex area of western Utah (see Hintze 1951, 1952) from sec. 30, T. 22 S., R. 14 W. Collected by Mr. Lee F. Brathwaite.

Adamsoceras toquimense Flower, n. sp.
Pl. 7, fig. 1-5

This is a very slender *Adamsoceras* with short camerae and a rather broadly expanded series of siphuncle segments. We have only the type, which is a small fragment of a phragmocone 32 mm long, expanding from 29 and 32 mm to 32 and 37 mm. The venter is slightly more flattened than the dorsum, sutures are nearly transverse, but show faint low ventral lobes. Camerae vary erratically in length from 6 to 7 mm. Septa are shallow, equal to about two thirds the length of a camera and about one seventh the shell height. The siphonal formula is 10/5/19:4/11/17; 6-7. Spetal necks are free on both dorsum and venter; the brims are slightly longer than the necks and slightly longer on the dorsum than on the venter; the siphuncle segment expands to slightly more than twice its diameter at the septal foramen, and the expanded part is equal to the length of one and a half segments.

Discussion.—*This* is a very slender species with a small rather broadly expanded siphuncle, unusually shallow septa, so that the siphuncle segment is much less markedly oblique than is usual.

Type and occurrence.—*The* holotype, U.S. National Museum no. 140169, is from one half mile south of Ikes Canyon, Toquima Range, Nevada. It is labeled as "above the sponge horizon," which suggests an origin in the overlying *Palliseria* zone.

Adamsoceras cf. isabelae Flower Pl. 6, fig. 10; Pl. 7, fig. 6, Pl. 8, fig. 3-5; Pl. 9, fig. 1-4

Under this designation is figured a portion of a phragmocone extending farther forward in the shell than the type of *A. isabelae.* The specimen consists of two apical camerae which are complete, showing a basal height of 45 mm and a width of 50 mm, with a septal foramen 10 mm from the venter, 6 mm across, 26 mm from the dorsum. Camerae are 6-8 mm long, the septa slope forward from venter to dorsum. An anterior portion consists of seven camerae and occupies a length of 58 mm. It is badly crushed, the crushing affecting the dorsal side mainly. The ventral part was sectioned to supply longitudinal sections of the siphuncle. Two thin sections were made, a horizontal section shown in Pl. 7, fig. 6, and a vertical section shown in Pl. 8, fig. 3. These sections show two unexpected features: (1) the thick rings show fine structure, with differentiation of a short anterior region, a long central region, and a short apical region and (2) the specimen exhibits one of the rare examples of retention of any layering in the septum. Both features were briefly described and illustrated by the writer; the specimen is more fully illustrated and described here. Before passing to morphological detail, it should be noted that the specimen shows the general features of *Adamsoceras isabelae,* but crushing of the anterior part of the type and the different crushing of the anterior part of this specimen leave specific determination somewhat doubtful; it is at least not comparable to any of the other species here described. The specimen, no. 379 in the collection of the writer is from the Antelope Valley limestone of Ikes Canyon, Toquima Range, Nevada. It has already been illustrated though less completely in Flower, 1964a, Pl. 2, fig. 8, and was the basis of text fig. 5, in the same work.

The main part of the septum is composed of clear calcite and is obviously recrystallized. Our one section (Pl. 8, fig. 3) shows on the apical face of the septum a clear calcitic layer which is at the most one-tenth the thickness of the septum proper, and separated from the main part of the septum by a thin dark band; it is not clear whether this dark band merely represents contact between two substances, or whether it is an actual layer in itself. This posterior layer of the septum can be traced on the apical septum of the section, to the limit of the section on the ventral side; in other septa it is cut off and on the dorsal side its continuity is lost by crushing. It appears that it extended some distance at least along the free part of the septum. It follows the curve of the septal neck, but disappears in all segments before reaching the tip of the neck. It is of interest to note that the conchiolin layer of *Nautilus* occupies this same position, but the posterior layer of *Adanisoceras fails* to show the dark or amber color which one would expect of conchiolin.

The tip of the neck is broad and excavated to receive the anterior end of the connecting ring. Some slight differences in outline are shown by the several necks in the sections, but the general pattern is quite uniform. The anterior end of the connecting ring, the basal zone, appears dark brown in our section and shows a texture peculiar to itself, with a combination of linear markings and markings normal to the two surfaces of the ring. The color is uniform, but the texture is not. There is some slight variation of the length of this part of the ring, but it is invariably quite short. The greater part of the ring appears relatively clear, and shows thin dark bands, some clear, some poorly defined at their margins, normal to the inner and outer surfaces. In some regions, these bands pass simply from one surface of the ring to another; in other sections, notably the portion shown in Pl. 9, fig. 3, the ring is divided obscurely into an inner and an outer zone, with more dark material in the inner zone.

At about the point at which the ring becomes adnate to the next apical septum, it undergoes another textural change. Here it is composed mainly of fibers extending longitudinally in the ring. The transition from the main part of the ring is abrupt as to texture but not as to color; the tip of the ring tends to become darker as it is traced toward its tip.

Surprisingly, the apical end of the ring is separated from the adapical septal neck by a band of material which appears on the anterior face of the septum some little distance outside of the point of juncture with the connecting ring. It is honey-colored in section, and shows fine structure of vertical and horizontal lamellae; mainly the vertical elements are present where it lies between the neck and the ring. This layer can be traced almost but not quite to the tip of the septal neck. It is best shown in our Pl. 8, fig. 5. The significance of these two layers supplementing the main part of the septum is not yet understood. Sections of other and younger actinoceroids have shown no analogous structures.

Thin sections were prepared from a specimen of a *Wutinoceras* from the Table Head limestone of Newfoundland. It showed such advanced silicification as to make interpretation hazardous; it is worth nothing however that in this form the ring is thinner, there are traces of the anterior and posterior layers of the septum, but differentiation of anterior and apical parts of the ring cannot be recognized with certainty.

Discussion.—This *Adantsoceras* was about the only specimen available without destroying a part of a type specimen. Between the two sections, general uniformity of the structures described above is evident in a series of seven siphuncle segments except that the anterior section (Pl. 7, fig. 6) is so cut by veins of calcite that the structures along the septa are obscured.

PART II

SOME ADDITIONAL WHITEROCK CEPHALOPODS

Abstract

Here are described and illustrated nautiloids from the Whiterock Stage, mainly of Nevada and Utah comprising 15 genera and 27 species. The Whiterock cephalopods are summarized, drawing upon some material not yet described. They tend to support equivalence of the Utah—Nevada region, the Joins and Oil Creek of Oklahoma, and the lower Table Head of Newfoundland as a pre-Marmor interval. Cephalopod evidence is so far wanting for the higher beds of the Antelope Valley limestone of Nevada.

Introduction

The preceding paper contains descriptions of the available actinoceroids of the Whiterock Stage of North America. This accompanying paper contains descriptions of some additional cephalopods from this same interval, belonging to other orders of the Nautiloidea. It must be emphasized that the forms described here are far from representing the complete fauna. A large amount of material was collected in the last two years, which will add materially to the knowledge of some species which have been long in manuscript, and will add new forms. Some knowledge of this undescribed material is involved in the general discussion of the faunas.

Without knowledge of the Whiterock faunas, the cephalopods of the latest Canadian and those of the Chazy present a marked contrast (Flower, 1954, fig. 3), marked by general though not universal extinction of Canadian lineages, and the appearance of new stocks of the magnitude of new families and orders, within which there is marked diversification. Unless spontaneous generation is involved, there are only a few possible explanations. First, the contrast may be due to incomplete knowledge of both late Canadian and Chazy cephalopods; to be sure our knowledge of both is imperfect, but it is not that imperfect; the writer has made and studied extensive collections from both horizons. Second, that such evolution as is required for the diversification of the Chazy faunas occurred in some other part of the world in late Canadian time. Though this matter was considered, no good support for such an interpretation could be found. Third, that there was a time interval not generally known from marine sediments containing these organisms. If this is true, we might hope that somewhere such beds would be recognized. Cooper (1956) proposed the Whiterock Stage as constituting such an interval, represented by essentially the Antelope Valley limestone in the Utah—Nevada region, by the Oil Creek and Joins formations of Oklahoma, and by the Table Head limestone of Newfoundland, but unknown elsewhere in North America. It was then a matter of particular interest to ascertain the cephalopod faunas of this interval, particularly to see whether they bridged the phyletic as well as the temporal gap between the late Canadian and the Chazyan faunas.* In the meantime subsequent investigations did reduce the contrast between late Canadian and Chazy faunas, but the attrition of the phyletic break was minor. The situation was reviewed by the writer (Flower, 1964, p. 15o ff), a summary which took into account a much less nearly complete knowledge of Whiterock cephalopods than is now achieved. It embodied the discovery of Michelinoceratida in the Cassinian (Flower 1962) where two families, the Michelinoceratidae and Troedssonellidae are found. The diagram accompanying this summary (Flower, 1964, p. 23, fig. 3) contained some errors introduced in numerous redraftings, mainly involving marking the appearance of several families one interval too low. Thus the Westonoceratidae and Cyrtogomphoceratidae should appear in the Mohawkian, not the Chazy, and the Allumettoceratidae and Proteoceratidae should appear in the Chazv, not in the Whiterock. Subsequent investigations have indicated some other modifications. The Narthecoceratidae have been found to stem not from some part of the Endoceratida, but from the Troedssonellidae of the Michelinoceratida. The Silurian genus *Humeoceras* proves, from new material, to be based upon a piloceroid siphuncle; in the original material leaching removed most of the endosiphuncle, but left the vertical tube and two vertical blades, which were silicified. It proves to be so similar to *Piloceras* that one could question the advisability of recognizing it as a separate genus, yet there are no forms from the top of the Canadian to this occurrence in the early Middle Silurian to supply a stratigraphic connection. The diagram is not redrafted at this time, as some other changes may be required, particularly when some Whiterock collections now on hand have been more thoroughly worked.

Meanwhile, also questions have been raised concerning the validity of the Whiterock as a pre-Chazy or pre-Marmor interval (Kay 196o, 1962) or whether, while valid in a large part, some upper beds have been included which may be Marmor or younger (Ross 1964, 1964A). It, therefore, seems pertinent to attempt an evaluation of the evidence offered by the cephalopods.

It is possible to predict in general terms what one might expect of the Whiterock cephalopods, if they are a post-Cassinian pre-Marmor* interval in geological time, and to see how well the cephalopod finds to date agree with such expectations.

The Whiterock Stage takes its name from Whiterock Canyon on the west side of Antelope Valley, west of Eureka, Nevada, and the Antelope Valley limestone has come to be considered essentially synonymous with the Whiterock Stage in its type region.

*In usage of either Chazy or Marmor the writer has reservations concerning the grouping of the Day Point with the Crown Point and Valcour. Both its brachiopods and its cephalopods are anomalous in relation to those of the overlying two limestones.

First, we would expect to find penetrating the White-rock some Canadian lineages unknown in the Chazy. We have such forms in described species of *Cyptendoceras* and *Rhabdiferoceras,* C. *rhythmicum,* C. kirki and R. *annuliferum,* described by the writer (Flower, 1964) from an association "above Receptaculites" from the north end of the Ely Springs Range of Nevada. With them was a *Lobosiphon* sp., a genus otherwise of Canadian range, and an *Aethiosolen cylindricus* otherwise known from the Whiterock. Subsequent finds have added *Rhabdiferoceras* to the White-rock fauna at Ikes Canyon, and an association quite similar to that of the Ely Springs Range has been found in the upper 15 feet of the Kanosh shale, in the middle of zone N (Ross 1951, Hintze 1952), and some similar forms are found in the overlying Lehman limestone, in the upper part of the same zone. It is thus possible to assign this fauna to zone N; and to establish it as a faunule in the Whiterock stage, rather than in the late Canadian.

There are a few other survivals of Canadian types not described at the present time. One is a small undescribed member of the Ellesmeroceratidae, certainly a new genus. This family is the dominant cephalopod stock in the Gas-conadian, and is represented by only a few isolated survi-vors in Demingian, Jeffersonian, and Cassinian faunas (Flower, 1964). Newfoundland has yielded an endoceroid siphuncle strongly reminiscent of the Canadian genus *Oderoceras.* The endoceroids with multiple blades and without good sheaths, the Interjoceratina of Balashov (196o) comprising the families Interjoceratidae, with short necks, and Evencoceratidae, with long necks, are seemingly common to the Canadian and the Whiterock, though strati-graphic data on the associated faunas and the ages of the genera from Siberia are not fully documented. It may be noted that endoceroids of this aspect occur in both the Canadian and in the Whiterock in North America. The Canadian forms will be described on another occasion.

We would, of course, expect to find representatives of those stocks which pass from Canadian into the Marmor stage. No genera make this transition, and there are only a few families known to do so. The Proterocameroceratidae of the Endoceratida are probably present in Whiterock faunas, but we can cite no definite form other than the *Oderoceras* noted above. The Baltoceratidae appear in the Demingian and extend into at least the .early Mohawkian, the Wilderness stage of Cooper (1956). The genus *Baltoceras* is common to the Whiterock and the Marmor, but occurs only in the Day Point limestone, the fauna of which is anomalous in both the brachiopods and the cephalopods. The writer (Flower, 1964) has suggested that it might be better grouped with the Whiterock. The Trocholitidae ap-pear in the Jeffersonian and extend into the Middle Silurian. The Whiterock genera thus far known are distinct from both those of the Canadian and those of the type Chazvan, of the Marmor stage, with the exception of one species assigned to *Discoceras.*

In the Michelinoceratida the Michelin oceratidae and Troedssonellidae as here defined, appear in the Cassinian and extend into beds which are probably considerably younger than the Chazy of North America_ *Michelinoceras,* as at present too broadly defined and emp:oved, makes the passage, but is not, in its present state very significant phyletically, extending into the Triassic.

It is reasonable to expect in the Whiterock some lineages even genera, previously unknown before the Marmor stage. Beginnings are here found for a few such genera, with the reservation that future work may show differences between Whiterock and Marmor species requiring sub-division of the genera. *Ruedemannoceras* is one such genus; the one Whiterock species is not very well known. *Discoceras* is another, a genus which ranges much later in the Ordovician of the Baltic region. It is, indeed, surprising that more genera extending higher into the Ordovician have not been found.

As one might expect, the Whiterock has yielded a number of genera unknown below or above its limits. We may list *Juaboceras, Williamsoceras, Cacheoceras, Rossoceras, Wutinoceras, Adamsoceras, Cyrtonybyoceras, Nevadaceras, Aethiosolen, Litoceras, Plectolites, Ikesoceras, Leonardoceras,* and may tentatively add *Bactroceras* and *Baltoceras,* with some reservations as to the ages of species on other continents.

Of these forms, we may hope to find some that could be identified reasonably as intermediate between Canadian ancestors and Chazyan descendants. *Juaboceras* is in most features, intermediate between the ancestral *Coreanoceras* and the Chazy *Emmonsoceras. Williamsoceras* supplies a transition between *Coreanoceras* and *Allotrioceras.* Quite probably *Leonardoceras* is intermediate between the ancestral *Bassleroceras* and the Chazy *Graciloceras.* In other instances the transitional nature of the Whiterock forms is less clearly evident. It should be noted that the cephalopods offer an exceptional opportunity in this respect, partly because phylogeny is more precisely known for them than for contemporaneous major fossil groups, partly because of the profound morphological changes involved, and partly be-cause the Canadian—Ordovician boundary marks a critical period in the evolution of the group.

Of the above genera, we might hope to find some serving to unite the faunas of the Whiterock of Nevada and Utah with the Joins and Oil Creek of Oklahoma and with the Table Head of Newfoundland. The three genera of the Wutinoceratidae serve in this way; we may note that *Litoceras* is common to these three regions, as is *Aethiosolen,* while *IVillianzsoceras* serves to unite Utah and Oklahoma.

While negative evidence is always of dubious value, it should be noted that the Whiterock cephalopods have so far failed to yield those morphologically more advanced fam-ilies of the Marmor stage as one would expect to be late rather than early in the development of these nautiloids and thus might be expected to be wanting in a pre-Chazy fauna. We have none of the more advanced families of the actinoceroids in which the rings have become thin and homogeneous. We lack the more advanced families of the Michelinoceratida with expanded siphuncles, the Allumet-toceratidae and Proteoceratidae. We have in northern Europe the beginning of the Clinoceratidae (Jaanusson, 196o) in the Aseri stage, but the derived Chazyan Hebe-toceratidae have not been found. In the Oncoceratida have mainly the Graciloceratidae, the archaic family of that order, with one doubtful member of the Oncoceratidae, not yet described. Some stocks which have not been found yet could be expected. Notably we should hope to find there the beginning of the Barrandeoceratida, and particularly *Plectoceras,* which is seemingly derived from the Canadian *Campbelloceras* of the Tarphyceratida.

Though correlation is not necessarily indicated in all cases, some of the Whiterock forms have congeners in the Baltic region. We may note that forms allied to, if not congeneric with *Williamsoceras,* have been figured but misidentified by Mutvei (1964) both from the Vaginatum limestone and the overlying Aseri stage. *Adamsoceras* shows the same distribution. Jaanusson (1960) has cited from the Lasnamagian the genera *Bactroceras, Ctenoceras, Baltoceras* (as *Cochlioceras),* and we may note that *"Conorthoceras" conicum* is possibly allied to *Aethiosolen. Discoceras* is dominantly a Baltic genus, but the age of some of the older species is in doubt. We may note also that Michelinoceratida with cameral deposits retarded and siphonal deposits suppressed are characteristic of the Orthoceras limestone sequence. In North America they are best developed in the Whiterock, but extend into the Chazv; oddly, we know of none higher in the Ordovician. The endoceroid *Dideroceras** and the family Lituitidae are unknown in North America; both extend into the Orthoceras limestone of central China.

Our knowledge of the Whiterock cephalopods for Oklahoma and Newfoundland is certainly extremely fragmentary; only for the Utah—Nevada regions is the material now available at all representative. It seems appropriate to note some stratigraphic relationships in these regions and the faunal role of the cephalopods as now apparent. In terms of the zones of Ross (1951) and Hintze (1952, 1953) it is now evident that zone J is late Cassinian, and K, which has a meager fauna, seems better grouped with it than with beds above. Zone L as developed in the upper Garden City limestone is marked by a sudden incursion of rather large endoceroids of the genera *Williamsoceras, Cacheoceras* and *Rossoceras.* Closely allied and possibly identical species of *Williamsoceras* and *Rossoceras* occur in the same zone in the Juab limestone of western Utah, where they are joined by a more varied assortment of cephalopods including *Plectolites, Juaboceras,* some new genera allied to *Williamsoceras,* Michelinoceratidae, Troedssonellidae, and Baltoceratidae. Zone M of western Utah in the lower Kanosh shale has as its only common cephaloped a large *Rossoceras,* a species distinct from that of the Juab limestone. The same zone, in the lower part of the Swan Peak quartzite, contains large endoceroids, but specimens are so badly crushed that specific comparison is impossible; there is a *Rossoceras* there, though most specimens are even generically undeterminable, and it could be the same species as that of the Kanosh.**

In western Utah, in lower zone N, shortly above the middle of the Kanosh shale, there appears a new and distinctive cephalopod fauna. *Rossoceras* disappears, and there are small endoceroids, Baltoceratidae, *Aethiosolen,* and in general, a cephalopod association suggestive of one received from U.S. National Museum from the Oil Creek limestone of Oklahoma. Some specimens reminiscent of this association, notably an *Aethiosolen,* have been found in the upper, generally relatively barren part of the Swan Peak quartzite, and suggest that its upper part may contain the lower part of zone N. The upper 15 feet of the Kanosh shale of the Ibex region has yielded an association with abundant small Baltoceratidae, a trocholitid, an endoceroid, reminiscent of the fauna noted above from the north end of the Ely Springs Range of the Pioche district of Nevada. Beds believed to be slightly higher, presumably the lower Lehman limestone, have yielded a coiled trocholitid, broad-whorled like *Litoceras,* but with prominent costae, like those of *Plectolites,* which may possibly require a new generic name; a similar form has been obtained from the lower reefy beds of the Nevada Test Site. The higher Lehman has yielded a sparse cephalopod assortment; it is the only certain source of a large *Wutinoceras,* but is dominated by endoceroids and Baltoceratidae. It is the upper Lehman which has yielded one possible member of the Oncoceratidae, not described at this time.

The Crystal Peak dolomite has yielded few cephalopods, not yet even prepared, but the forms so far found are Baltoceratidae and Michelinoceratidae, not obviously materially advanced beyond those of the Lehman faunas. The cephalopods support the Whiterock age of zones L through N, and probably 0, in the sense of a pre-Chazy interval.

Our knowledge of the cephalopod succession for central and western Nevada and California is very incomplete, and reasonably good collections have been obtained only from two sections, from Ikes Canyon of the Toquima Range, and from Meikeljohn Peak, near Beatty, Nevada.

The Ikes Canyon section has been summarized by Kay (1962). The lower "asaphid beds" *(Nileus* beds, Ross, ms.) have yielded a small and anomalous cephalopod association, mainly from lenses of calcarenite and calcirudite containing *Michelinoceras Leonardoceras parvum, Litoceras* cf. *adamsi,* L. *huygenae, Bactroceras wilsoni* and fragments of endoceroids. Except for the *Litoceras* cf. *adamsi,* no species have been found in higher beds, nor have evident homologues of this fauna been found in other sections. The sponge beds can be subdivided into (1) lower nodular beds with abundant *Orthambonites minusculus,* (2) relatively barren platy beds (3) more nodular beds with the abundant sponge fauna (4) relatively barren upper beds. Species, however, are common at least to the first and third of these units. This is the main source of *Litoceras adanzsi* and *Plectolites costatus.* We have here *Aethiosolem kayi* and *A. cylindricus, Nevadaceras conicum, Ikesoceras ikesense,* large rather extensively replaced endoceroids in which there are apparently several genera represented, some Michelinoceratida and Baltoceratidae not yet completely studied. Above, massive cliff-forming beds of dominantly gray limestone are the source of most of the identifiable endoceroids. Siphuncles indicate the presence of *Rossoceras.** It is this interval which is the sole source of the actinoceroid genera

*I have suggested that *Nanno belmnitiforme* might belong to this genus; on the strength of this suggestion Teichert (1964) has sup-Pressed the name in favor of *Proterovaginoceras* Ruedemann. This may be true, but it is not evident that the necessary study of N. belmnitiforme has been made.

** This form I have described in manuscript in 1963, but much additional material that will permit a fuller description makes it desirable to delay publication of the species.

* Loose specimens from this interval, picked up lower down, supply the only certain basis, so far, of *Rossoceras in* the sponge beds (see Flower, 1964a).

Wutinoceras, Adamsoceras and Cyrtonybyoceras. Higher beds have not yet yielded any identifiable cephalopods.

At Meikeljohn Peak (see Ross 1964a) above the Ninemile formation of Canadian age, the Antelope Valley limestone begins with a few feet of black limestone, then a great thickness of reef beds; the edges of this reef have yielded a prolific cephalopod assemblage not yet fully prepared, but including the member of the Ellesmeroceratidae noted above, small orthocones of the Michelinoceratidae, some Baltoceratidae, and the coiled genera *Litoceras* and *Plectolites.* Overlying nonresistant dark beds with sponges have yielded only a few poorly preserved cephalopods, but above them the more resistant *Palliseria* beds have yielded large *Rossoceras* and the only actinoceroid from this section is from the upper third of this unit. Again, no cephalopods have been retrieved from succeeding beds.

We have noted *a Rossoceras* and an apparent *Ruedemannoceras* from what is possibly the equivalent of the upper *Palliseria* zone in the Inyo Range of California, and a broad-whorled trocholitid from the upper *Palliseria* beds of the Nevada Test Site associated with a good *Litoceras.*

Some problems attend the correlation of zones in Nevada with those of Utah as based on the brachiopods alone (Ross, 1964, 1964a) and the cephalopods also show some anomalies. *Rossoceras,* which characterizes the lower Whiterock, zones L and M in Utah, is definitely known only from the *Palliseria* beds, rather high in the sections in Nevada. *Litoceras* appears low in Nevada, but is not certainly known in Utah below zone N. The *Nileus* beds of Ikes Canyon contain a cephalopod association not suggestive of any association elsewhere in the general Utah—Nevada region.

Oddly, our next higher cephalopod fauna in Nevada is that of the Copenhagen limestone. The cephalopods there are yet incompletely known, but it might be noted that *Proteoceras* and *Centrocyrtoceras* occur, and these genera are elsewhere known together only in the type Chazyan of the Champlain Valley. This does not preclude, however, a higher assignment of this fauna, because cephalopods of the overlying Ashby and Porterfield stages are all but unknown.

In summary we may note that the cephalopod evidence thus far obtained is revealing a number of genera distinctive for the Whiterock stage, and supporting to some extent the equivalence of the three regions in which it has been recognized in North America, and showing some interesting affinities with the Baltic Orthoceras limestone faunas. The cephalopod material so far obtained fails, however, to involve some of the higher beds of the Antelope Valley limestone the pre-Marmor nature of which has been questioned.

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At an early stage in this investigation through the kindness of Dr. Reuben Ross and the Yale Peabody Museum of Natural History the cephalopods collected by Dr. Ross in connection with his study of the Garden City and Swan Peak formations were loaned for study. Additional material was collected with the help and guidance of Dr. James Stewart Williams and various colleagues and students of Utah State University. A significant collection of cephalopods was loaned by the U.S. National Museum through the kindness of Dr. G. A. Cooper, largely from the Pogonip of Nevada and Utah, but containing some significant material from Oklahoma also. Some cephalopods from Ikes Canyon were a gift from the late Dr. J. Lee Adams of Reno, Nevada. Dr. Lehi Hintze loaned material from the Ibex region of western Utah made in connection with his study of the Ordovician there, and he and various of his colleagues have from time to time contributed further, particularly significant material was collected by Dr. Keith Rigby and Dr. Lee Brathwaite. A National Science Foundation grant to Dr. Hintze and Brigham Young University made it possible to collect extensively in the Ibex region with the guidance and help of Dr. Hintze and various *of* his associates. Dr. Reuben Ross has submitted to me cephalopods from various parts of the Antelope Valley limestone in Nevada and its equivalents in California, has provided discussion in the field, and has guided me over several significant sections.

Both he and Mr. Leonard Wilson have given aid in collecting, without which the amount obtained would certainly have been very much smaller. Dr. Harry Whittington and Dr. G. Marshall Kay have submitted specimens for study from Nevada and from Newfoundland. Dr. William Ham has supplied some information on horizons and localities in Oklahoma, and Dr. Ham and Dr. Frederickson have loaned some significant material from the Whiterock of Oklahoma. In collecting I have been aided by by Miss Michaele Huygen, to whom I am also indebted for exceptionally faithful and reliable help in the laboratory. My wife aided in collecting, notably in northern Utah, in the Ibex region, and at Ikes Canyon. I wish also to thank Mr. A. J. Thompson for making possible some essential collecting in Utah and Nevada. Oddly, the study of the Whiterock cephalopods is an extension of a study concerning more particularly the subadjacent beds of Canadian age, and correlation of the divisions there with those of the El Paso group by means of the cephalopods. Results of this investigation have been gratifying but will be left for other publications.

It should be noted that the present descriptions do not by any means exhaust the collected materials, and extensive collections, mainly from the Ibex region of Utah and from Meikeljohn Peak in Nevada, are yet largely unworked. Indeed, in the light of such material some manuscript species are withheld from description because additional material has been obtained by which these species can be more fully described. Probably no other group than the Nautiloidea suffers so much from the necessity of describing species from sadly fragmentary material.

Lastly I wish to thank Mr. and Mrs. Lemar Davis of Black Rock, Utah, for a rescue when we acquired two **fiat** tires returning from the Ibex region.

CEPHALOPOD SYSTEMATICS

With various proposals as to major divisions of the Cephalopoda and of the Nautiloidea recently published, it should be noted that the classification here employed is that of Flower (1964, 1964a). For a number of reasons, some made apparent in the discussion of the orders below, it has proved impossible to accept the major categories as expressed in the Russian treatise (Ruzhentev et al., 1962) or in the American Treatise (Teichert et al., 1964), and have preferred a simpler morphological terminology than that of the latter work. Likewise, it should be noted that while the proposals of megataxa by Donovan (1941) are not without merit, and are certainly preferable to separation of only the actinoceroids and the endoceroids from the Nautiloidea, they cannot be accepted as they now stand. The origin of the Ammonoidea is still certainly a problem, though origin in the Barrandeoceratida is manily impossible, and the origin in either the Rutoceratida or from the Michelinoceratida through the bactritids is a matter on which the evidence is still ambiguous.

ORDER ELLESMEROCERATIDA

This order has been monographed previously (Flower, 1964) and there have been no significant changes of concept required. Baltoceratidae similar to those of the late Canadian extend into the Whiterock. As noted earlier, the occurrence at the north end of the Ely Springs Range, previously thought to be Canadian, is now reasonably interpreted as belonging in the Whiterock; from it were described *Cyptendoceras annuliferum,* C. *kirki,* and *Rhabdiferoceras annuliferum.* Forms of similar aspect await detailed study; they are largely from the higher 15 feet of the Kanosh shale, and from the overlying Lehman limestone, both placed in zone N by Hintze (1952, 1953). The lower beds of Ikes Canyon yielded *Bactroceras wilsoni,* the only member of the genus thus far recognized in North America, and Flower (1964) previously described *Baltoceras striatum* from the sponge beds of lkes Canyon. Recent collecting has yielded a small endogastric member of the Ellesmeroceratidae with conspicuous diaphrams in the siphuncle from the reefy beds of Meikeljohn Peak. Description is delayed as current collections, not yet fully prepared, promise to supply more complete material than is immediately available for description. *Rhabdiferoceras expansum* is here described from the sponge beds of Ikes Canyon.

FAMILY BALTOCERATIDAE

Genus RHABDIFEROCERAS Flower
Genotype: *Rhabdiferoceras annuliferum* Flower

Rhabdiferoceras Flower 1964, N.M. Bur. Mines, Mem. **12, p.** 118.

This is an orthoconic shell of slightly depressed section, simple transverse sutures and a ventral siphuncle the segments of which are faintly convex in outline. Within the siphuncle a ventral rod is developed.

The genus is now known from R. annuli ferule of the Ely Springs Range, R. *expansum* from Ikes Canyon, both regarded as Whiterock, and R. *whit fieldi* of the Fort Cassin beds and R. sp. from the Cassinian part of the El Paso group.

Rhabdiferoceras expansum Flower, n. sp.
P1. 15, fig. 1-4

This is a moderately expanding orthocone of circular section. The single known specimen has a maximum length of 42 mm, is circular in section, anteriorly 29 mm across, with a round ventral siphuncle, 11 mm wide and 10.5 mm high, the section not obviously flattened where it is tangent to the ventral wall. In the anterior 3o mm the shell width expands from 25 to 29 mm. The nine camerae in the length of 42 mm vary in length from 5 to 4 mm, tending to be slightly shorter anteriorly. In lateral view the sutures slope very faintly apicad from dorsum to venter; on the ventral side of the internal mold the exfoliated siphuncle segments are broadly elliptical. A vertical section failed to show sutures clearly but retained the siphuncle wall, showing short septal necks and segments which are slightly convex between the septa, as in the genotype of *Rhabdiferoceras.*

Discussion.—The fairly rapid expansion of the shell and the slightly oblique sutures characterize this species. In the genotype of *Rhabdiferoceras* the sutures are not known, but the shell is much more gently expanded, the height of the siphuncle is nearly half that of the shell, and the expansion of the shell is not markedly more rapid than that of the siphuncle. Reference of this form to *Rhabdiferoceras* without evidence of the rod is, of course, inferential, but seems reasonably safe, as no other cephalopod genus is recognized in the late Canadian or Whiterock having such a siphuncle outline.

Type and occurrence.—The holotype, in the collection of the writer, no. 369, is the gift of Dr. J. Lee Adams. It is from Ikes Canyon, Toquima Range, Nevada, from the Pogonip. Regrettably the precise stratigraphic origin is not known. Lithology is consistent with that of the sponge beds.

Genus BACTROCERAS Holm
Genotype: *Bactroceras anus Holm*

Bactroceras Holm, 1898, Geol. Forenig i Stockholm, bd. zo, p. 358. ---- Flower, 1964, New Mexico Bur. Mines, Mem. 12, p. 112. ---- Furnish and Glenister, in Teichert et al, 1964. Treatise of Invert. Paleont., part K, Mollusca, 3, p. 155.

Bactroceras is a smooth straight very slender baltoceratid, with rather long camerae, a siphuncle which is close to the venter, small in relation to that of *Baltoceras,* and with rather long septal necks, commonly one third to one fourth the length of a siphuncle segment. Furnish and Glenister (in Teichert et al., 1964) define it as having a siphuncle about one-twelfth the shell diameter. The form described below has a siphuncle almost twice as big, but is placed in *Bactroceras,* with the revision of allowing in it species with segments as large as one-sixth the shell diameter, but still with quite long septal necks; those of *Baltoceras* are extremely short. Previous records of the genus are from the Baltic *Orthoceras* limestone, the red and upper gray Lituites limestones, and an occurrence in New South Wales in beds regarded by Glenister as "lower Chazyan" in the broad sense. The species described below is the only occurrence of the genus in North America that has come to my knowledge.

Bactroceras wilsoni Flower, n. sp.

P1. 24, fig. 6, ro, I I; P1. 25, fig. 1-4

This is a moderately large orthocone of circular section, long camerae and rather deeply curved septa, with a small tubular marginal siphuncle about one sixth the shell diameter, with segments tubular, necks about one fourth the length of the siphuncle segment. There are two camerae in a length equal to the adoral shell diameter over much of the phragmocone, but adorally, at a shell diameter of 25-27 mm, camerae shorten, and there are 2.5 camerae in a similar length. Our specimens are all fragmentary but show a shell expanding 7-9 mm in a length of 100 mm, and known from portions of phragmocones ranging from 14 mm to 27 mm in diameter.

The holotype, no. 1144 (Pl. 25, fig. 1-3, Pl. 24, fig. 10, 11), is a portion of phragmocone 115 mm long, expanding from 14 mm at the base, where the siphuncle is 2.2 mm wide and 2.5 mm high, to 22 mm in 100 mm, where the siphuncle is not shown, but 6o mm from the base the siphuncle is 3.2 mm wide, 3.4 mm high in a shell 19 mm across. Sutures are straight and transverse, camerae occur five in the apical 4o mm, four in the anterior 45 mm. Where the camera is II mm long, the depth of curvature of the septum is 7 mm. A transverse longitudinal section was ground across the apical part, showing a siphuncle with a neck about one fourth the length of the camera (Pl. 24, fig.); a thin section was made of this surface (Pl. 25, fig. 3), showing more fully the neck and ring, but recrystallization has destroyed any original structures in the ring and has in parts, obscured differentiation of neck and ring, as on the right side of our figure.

One paratype, no. 1145 (P1. 25, fig. 4), shows a nearly sagittal natural section through a portion of a phragmocone 115 mm long. The shell expands from 19 mm at the base where the siphuncle is 4 mm high, to 27 mm where the siphuncle is 5 mm high, in a length of 10o mm. Two camerae occupy a length equal to an adoral shell diameter of 20 mm; two and a half camerae occupy a similar length at a diameter of 27 mm. Camerae actually shorten adorally; from I I mm in the early part to 8 mm, an indication of maturity.

A second paratype, no. 1146 (Pl. 24, fig. 6), is a part of a phragmocone 7o mm long sectioned vertically; displacement occurs along a joint, so that the plane of the section does not quite coincide with the siphuncle. Basally the shell is 22 mm across, the siphuncle 3.5 mm high, the camera 13 mm long; adorally the shell is 25 mm across, the siphuncle 4 mm high, the camera only 9 mm long.

These specimens, and several other more fragmentary specimens indicate some variation in proportions, but these forms seem reasonably interpreted as a single species. Though the siphuncle is somewhat larger in proportion to the shell than in species previously assigned to *Bactroceras*, being one-sixth rather than one twelfth the diameter of the shell, the species is better placed in this genus than anywhere else, and it seems appropriate to modify the generic description; the alternative course would be the erection of a new genus for this species.

Types.—Collection of the writer, nos. 1144 (holotype), 1145, 1146 (paratypes).

Occurrence.—This species is confined to the lower *Nileus* beds, the asaphid beds of Kay (1962) occupying the basal part of the section of the Antelope Valley limestone exposed on the north wall of Ikes Canyon, Toquima Range, Nevada. The species occurs in at least two horizons of persistent layers or intermittent lenses of coarse calcarenite, which are interspersed among the very thin black limestones which make up most of this part of the section. One of these (65/RJ 4-2) occurs 104 feet below collection D152003 which marks the base of thicker bedded more yellow-weathering limestones containing abundant silicified *Orthambonites minusculus*, and a limestone 185 feet below this horizon yielded additional specimens, including paratype no. 1145. As yet, no similar forms have been found in the Whiterock of Nevada or Utah at other localities.

ORDER ENDOCERATIDA Hyatt att 1900

The endoceroids of the Whiterock stage are still only partially known. Two characteristic genera described previously (Flower I964A), *Rossoceras* and *Williainsoceras*, are here more fully described and illustrated; additional genera here described include *Cacheoceras* and *Juaboceras.* There are also slender endoceroids of generalized aspect which may involve the Proterocameroceratidae, which are known to pass from the Canadian into the Chazyan, or the first of the true Endoceratidae, or possibly both.

It must be noted that the proposal of raising the Es doceratida in rank equal to that of the Nautiloidea, and removing it from that group has been opposed by some more recent findings, which show that the Endoceratida are not of exceptional morphological distinctness. Oddly, the American Treatise which accepted the elevation of the endoceroids, placed it mistakenly B*oreoceras* of the Ellesmeroceratidae, *Cyptendoceras* of the Baltoceratidae, and meanwhile other investigations revealed that the Narthecocertidae, which had been generally accepted as Endoceratida, prove to be homes morphs of the group, derived from the Troedssonellidae of the Michelinoceratida.

Rossoceras, as noted under the discussion of that genus, suggests most strongly that the Interjoceratina of Balashov 1960, supposedly a group with shell and siphuncle wall **of** endoceroid aspect, but differing from all previously known endoceroids in that the siphuncle was filled with longitudinal lamellae converging toward the center, may rest upon a misinterpretation, and that while these forms are singular' though not completely unique, in that sheaths are not de· veloped, they may be forms with normal endosiphocones and the supposed lamellae represent spaces between numerous branching blades of exceptional number and prominence. *Rossoceras* possesses a perfectly normal endosiphocone.

Probably there is no group of the cephalopods that has yielded more morphological surprises in recent years, one in which the taxonomy is more frustrating, being ham pered by the fragmentary material by which many species and genera are known. There have been several constructive efforts to bring this group into some degree of coherence, notably Flower (1955, 1958), Balashov (1960), and Teichert (1964). In the last several years new materials have come into the hands of the writer, including some rather remarkable new genera, the position of which in the order is not yet clear, which have led to the questioning off almost every concept underlying previously proposed classifications, without supplying a definite solution. It is, *indeed,* the hope of finding more complete material which might answer some of these questions that has led to delay in publication of the work on the El Paso endoceroids. At present, the two main lineages of the Proterocameroceratina and the Endoceratina seem valid, but Canadian departures from the general pattern of the Proterocameroceratidae have *exceeded* all previous expectations.

If any authorship for the Endoceratida is to be claimed, it should be attributed to Hyatt (1900). It is probably not generally understood what happened in Hyatt's contribution to the Zittel—Eastmann Textbook, but the classification contains some perplexities there on which I can offer a guess. This work was requested. Hyatt had in process a classification for the Nautiloidea in which prospective ordinal groups were given the endings *-ida.* On this pattern, he later superimposed his divisions of greater rank, of Orthochoanites, Cyrtochoanites, Holochoanites, and Schistochoanites. The work suffered further from shifts in rank of Cephalopoda and its divisions, Tetrabranchiata and Dibranchiata, and in the end the Endoceratida and equivalent groups appeared without designated rank, as divisions within suborders.

FAMILY MANCHUROCERATIDAE Kobayashi

Appearing in the later Canadian (Wolungian) of Manchuria and Korea, are some odd endoceroids known mainly from endosiphuncles, in which the endosiphuncle is thickened materially ventrally, so that the endosiphocone is crescentic. Blades are complex and variable; the tube of *Manchuroceras* at least, contains diaphragms. The ventral mass of *Coreanoceras is* reputedly invaded by a secondary minor endosiphocone, but while this is not impossible, the evidence presented could represent instead, solution in the center of a massive recrystallized part of the endosiphuncle, and might be an inorganic phenomenon. From the septal necks, known only for *Coreanoceras,* which are short of being holochoanitic, I had regarded the Manchuroceratidae as a breviconic development (imperfect in *Coreanoceras),* stemming from the Proterocameroceratidae, and independent of the true Piloceratidae. I have regarded the Chazy *Emmonsoceras (= Hudsonoceras* Flower) as a derived stock, in which shells became straight and slender, but the necks became long, while the endosiphuncle has the essential crescentic pattern of the Manchuroceratidae.

Since then, two interesting questions have developed. Our present genus, *Juaboceras,* lies stratigraphically between the previously known Manchuroceratidae and the Emmonsoceratidae. I have placed it in the former family, but future work might, if material came to light showing long necks, require reversal of this decision.

A second problem developed. In the endoceroids we are forced to work with such sadly fragmental material, that we must grasp at straws in tracing relationships. I had hoped that the combination of the short necks (demonstrable so far only for *Coreanoceras),* the broad cross section and the crescentic endosiphocones might distinguish this lineage from the true Piloceratidae. Subsequent finds have shown that in true Piloceratidae the cross section of the siphuncle may broaden; wedges may produce concavities of the endosiphocone on venter or dorsum or both, and thus, curiously, one could claim that the Manchuroceratidae are derived in part from the Piloceratidae; however, such a conclusion could not involve *Coreanoceras,* in which the necks are known to be short, but could conceivably involve the type genus, *Manchuroceras.*

Genus JUABOCERAS Flower, n. gen.

Genotype: *Juaboceras brathwaitei* Flower, n. sp.

This is an endoceroid known only from the anterior part of an endosiphuncle, for the siphuncle wall is unknown as to structure, and even the spacing of septa on its exterior is only most faintly indicated. The siphuncle is slender, faintly endogastric, and is circular in section at the base; adorally it is compressed, but it is uncertain that the compression is not the result of slight crushing. Anteriorly the endosiphocone agrees with the siphuncle in cross section, but apically the endocone material becomes thickened ventrally so that the cone is crescentic near its tip, as in *Manchuroceras* and *Coreanoceras.* Blades are poorly known, but a pair of blades extend downward from the two angles of the crescentic cone.

Discussion.—Nothing is known of the siphuncle wall, nor of the complete shell. In its large size and slender form, *Juaboceras* seems a possible connecting link between *Coreanoceras* and *Manchuroceras* of the Canadian, and the large slender straight *Emmonsoceras* of the Chazyan. Assignment to the Manchuroceratidae is tentative; should the septal necks in that family prove consistently short, and should those of *Juaboceras* be found to be long, the genus would be better assigned to the Emmonsoceratidae.

Juaboceras brathwaitei Flower, n. sp.

Pl. 16, fig. 1-8

The type is a portion of a siphuncle 168 mm long; 23 mm from the extreme apical end, which is broken obliquely, the section is circular and 44 mm in diameter; in 85 mm the section becomes compressed slightly, more narrowly rounded dorsally than ventrally, 56 mm high, 46 mm wide, and in 58 mm contracts to a width of 42 mm. The compression of the adoral part is progressive, and may be the result of slight crushing which increases adorally as the endosiphuncle thins. Septal ridges are obscure, only two are clearly shown; they are straight and transverse, and 11 mm apart where the siphuncle is 54 mm high. A section near the anterior end (Pl. 16, fig. 5) cuts the anterior end of an endosiphocone; here the endosiphuncle is slightly thicker ventrally than dorsally, and the section is slightly more broadly rounded on the venter. The next 85 mm are sectioned longitudinally but oblique to the axis; on the ventral side there is an abrupt thickening of the endosiphuncle material, as though a supplementary wedge develops on the venter where the cross section of the cone becomes concave. A cross section at the apical end of this interval (Pl. 16, fig. 7, 8,) shows the endosiphocone I I mm wide, 5 mm high centrally; the ventral side of the endosiphocone is broadly concave, the sides narrowly rounded ventrolaterally, arching over the convex dorsum, but with a faint middorsal concavity. The cross section shows sheaths, clearest externally and just outside the endosiphocone, with traces of two blades curving down from the ventrolateral angles; but clear only near the endosiphocone.

Discussion.—This was a giant among the endoceroids, for even assuming a siphuncle large in proportion to the shell diameter, perhaps slightly more than one third the shell height, we have no endosiphuncles known attaining a larger diameter, and with the general retardation of the endosiphuncle beyond the phragmocone, we must assume that this shell extended materially farther forward as a phragmocone, followed by a living chamber of significant proportions. 'While probably the apex was blunt, we cannot say how far apicad of the known part the siphuncle was slender, but such a length should, from our knowledge of comparable forms, have been appreciable. The shell probably attained a length of at least three feet and possibly as much as five.

In spite of subsequent search, after the type first came to my attention, we have been unable to find any more specimens which can be assigned to this species. It is named for Dr. Lee Brathwaite, who collected it, and whose contributions to the graptolities of the Ibex area of western Utah will serve as the most significant contribution to the correlation of the shelly and graptolite facies of the Canadian and Ordovician which we have vet received.

Type and occurrence.—The holotype is in the collection of the geology department of Brigham Young University; it is from the upper 20 feet of the Juab limestone, of the Ibex area of western Utah, from between the sections J and K of Hintze (1950.

FAMILY ALLOTRIOCERATIDAE

Genus WILLIAMSOCERAS Flower

Genotype: *Williamsoceras adnatum* Flower

Williamsoceras Flower, 1964, New Mexico Bur. Mines, Mem. 13, p. 6o.

This genus contains generalized smooth endoceroids, the gross features of the phragmocone not definitely known, but it has a ventral siphuncle of tubular or faintly concave segments, its wall holochoanitic to macrochoanitic. It is the nature of the endosiphuncle that characterizes the genus. There develops first a narrow vertical septum, extending from the ventral wall to about the center of the siphuncle. In cross section it shows a narrow median vertical black band; the remainder of the material is now light calcite indistinguishable from that forming the endocones. The septum is not extended at its base into a lining of the inside of the siphuncle. Endocones are next deposited; they are draped around the process, and the endosiphocone becomes crescentic in pattern; endocone material thickens around the end of the ventral septum. The crescentic endosiphocone is shorter ventrally than dorsally; near its tip it is crossed by a series of buttresses; these widen, and finally leave a series of tubes arranged in an arc; ventrally the tubes may be triangular in cross section dorsally they are round. Commonly tubes are outlined in black material and a black band, the infula, joins them, marking the course of the tip of the endosiphocone which appears as a circle or ellipse eccentric in the cross section, closer to the margin ventrally than dorsally. The tubes lack diaphragms. An interpretation of the endosiphuncle is shown in Text Figure 2 and 3; it must be noted that some matters indicated here are necessarily an assumption, notably the extension of the ventral septum farther forward distally than at its base.

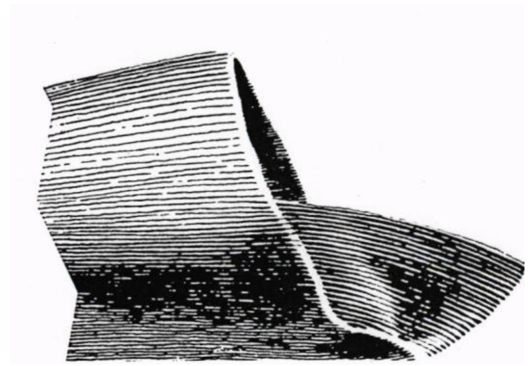

Figure 2
WILLIAMSOCERAS ADNATUM
Endosiphuncle, viewed from the side, venter below, showing anterior limits of the endocones and of the ventral process.

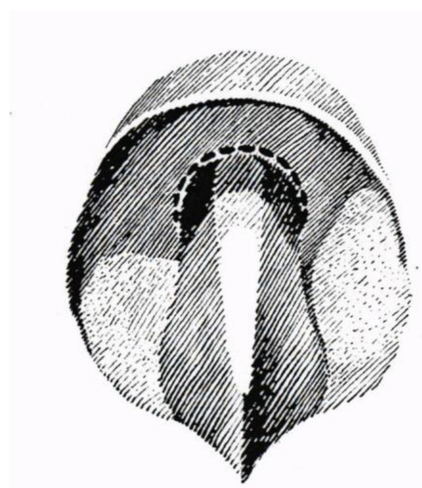

Figure 3
WILLIAMSOCERAS ADNATUM
Endosiphuncle, viewed from slightly above and from the anterior end, showing the widening of the ventral process, the separation of the tip of the endosiphocone into numerous tubes. The width of the ventral process conceals the ventral tubes here.

Our earliest growth stage for W. *adnatum* suggests that the siphuncle has a moderately small blunt tip and is not swollen as in the *Nanno-type* stage of the early Endoceratidae (see text fig. 4).

Discussion.—Williamsoceras has an endosiphuncle quite like that of the early, but not the late growth stage of *Allotrioceras;* there is a similar septum, with an arc of tube about it connected by an infula. However, in *Williamsoceras* the septum is shorter, its tip is not widened nor bifur-

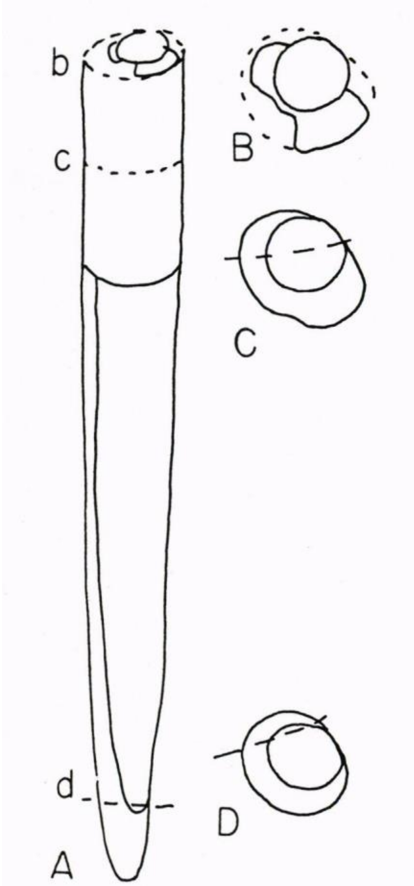

Figure 4
WILLIAMSOCERAS ADNATUM

Earliest observed growth stage of the siphuncle of *Williamsoceras amount, x* 1.5. The specimen as seen in A is viewed from an oblique dorsal side, normal to the longitudinal break in the lower three fourths. B represents an adoral view, the venter to the upper right; around the infula some material is broken away, and the original outline is restored. C shows a section at the position of the dotted line in the middle of the anterior portion; on it is indicated the approximate position of the surface shown at the anterior end of the break; in the lower part of A the surface passes to the far side of the siphuncle, and the recurvature of the infula results, the position of the surface being at the dotted line in D; below, the siphuncle passes above the preserved surface.

cated; the endosiphocone is shorter ventrally than dorsally, and there is no endosipholining of which, in *Allotrioceras,* the septum seems to be an extension. It was formerly suggested that the most likely origin of the Allotrioceratidae could be found in *Meniscoceras;* this interpretation involved the assumption that the septum was dorsal. It is here evident that a homologous septum springs from the venter in *Williamsoceras* (we had no certain criteria of orientation for *Allotrioceras)* and *Williamsoceras* suggests an origin not in *Meniscoceras* but in the Manchuroceratidae, and more specifically, probably in *Coreanoceras.*

Interpretation of *Coreanoceras* has involved some problems, for the solution of which no material was available. Kobayashi interpreted *Coreanoceras* as having a ventral process in the siphuncle around which crescentic cones were draped, but Postulated a secondary alveolus, like a small secondary endocone, within this process. The evidence for such a structure seemed ambiguous. One specimen figured by Kobayashi (1936, pl. 22, fig. I) shows a siphuncle in anterior view, exhibiting the crescentic section through the endosiphocone; the region below contains the ventral mass in the center of which is a pit in the endosiphuncle, but it shows a rough surface, and might well be the result of coarse recrystallization in the center of this mass, acted upon by chance weathering. Kobayashi's figure 6 on the same plate shows a longitudinal section through a siphuncle, in which on the ventral side, to the left of the figure, a shallow emargination of the ventral process is seen, with the normal endosiphocone on the right. In *Williamsoceras a* similar effect could be produced by a sagittal section showing the ventral process slightly shorter at its base than at its tip; if the plane of the section passed through the middle of the tip of the process but was a little to one side of the base, the emargination would be greater. It is clear in *Williamsoceras* that while the tip of the process extends slightly farther forward than does its base, there is no median region in which a conical cavity exists and around which material extends farther forward on the sides. The section shown by Kobayashi (1936, in pl. **22,** figs, 9, o) shows a dark spot on the ventral side of the siphuncle; it could be an alveolus, but it could also be a spot of dark calcite, or a cavity produced by solution prior to burial of the shell.

Without the ventral alveolus, *Coreanoceras* is quite logically the ancestor of the Allotrioceratidae, and the only changes required to produce *Williamsoceras* are the development of multiple tubes and the lengthening of the septal necks. As the blade pattern which Kobayashi illustrates, shows considerable variation in *Coreanoceras,* the minor differences presented by the known species of W*illiamsoceras* offer no theoretical difficulties.

Some problems remain concerning *Coreanoceras at* the specific level. In the original description of the genus and several of the species, a type was designated for *Coreanoceras kemipouense.* Later this designation was overlooked, and the same specimen was made the type of a separate species, C. *shorinense.* (Kobayashi, 1936, p. 186, p. 22, fig. 12-13, pl. 23, fig. o.) The cross section of this form shows ventral blades joined below, curving, the outer sides convex, but diverging above, a condition strongly reminiscent of the infula in *Williamsoceras.* Some sections show wider variation in the blade pattern than can be explained by differences in preservation, Kobayashi's (1936) pl. 23, fig. 1-3, also Text Fig. x, shows the lateral blades double in the lower half of the siphuncle, but other blades are wanting. His figures 5-6 of the same plate shows a transverse section close to the tip of the endosiphocone, the ventral as well as the dorsal side convex, the base of one lateral blade, and a prominent midventral blade which is bifurcated below. A third very different condition is shown in his figures 7 and 8 of the same plate, where the section through the endosiphocone is concave below, unusually broad and low; there is a portion of a simple ventral blade, but no lateral blades. The two longitudinal sections, show differences in the siphuncle wall; in his pl. 22 fig. II the septa] neck is quite short, in his pl. 22 fig. 13 the neck is subholochoanitic.

While one can say that *Williamsoceras* supplies something of a transition between the Manchuroceratidae and the Allotrioceratidae, perhaps a more precise statement would involve substituting *Coreanoceras* for the Manchuroceratidae. While the writer has accepted Kobavashi's (1935) use of the Manchuroceratidae as containing *Manchuroceras* and *Coreanoceras, Manchuroceras* differs from *Coreanoceras in* a number of features, the large size of the siphuncle, the absence of any known blades other than the one in the middle of the ventral process, the presence of diaphragms in the endosiphocone. The siphuncle wall and shell of *Manchuroceras* remain unknown.

Williamsoceras was first known from the upper 20' of the Garden City formation of northern Utah. Congeneric forms are now known, in the equivalent beds, Zone L, the Juab limestone of the Pogonip group farther west in Utah. Some poorly preserved endoceroid fragments from the Oil Creek formation of Oklahoma seem somewhat similar in aspect, but the material shows some puzzling features, is not too well preserved, and when more material is available may prove to be a form which though related, is not truly congeneric. No comparable forms have been reported from the Whiterock of Newfoundland, or equivalent beds in eastern Asia and Tasmania, but there are related forms in the Baltic region of Europe, but these forms, which include *Endoceras gladius* Holm, have been incorrectly treated as a synonym of *Nanno belemnitiforme* by Mutvei (1964).

The three species here described show some differences. In W. *adnatum* the infula appears adnate to the ventral wall of the siphuncle, but is actually narrowly tangent both to it and to the axis of the vertical septum. In W. *pedunculatum* the infula joins the axis of the ventral process well away from the ventral wall of the siphuncle, and thus the infula appears stalked. True blades are obscure and variable in W. *adnatum;* in W. *pedunculatum* there is a persistent dorsal blade. A similar dorsal blade and some erratically preserved lateral blades characterize W. ankhifermn, in which the limbs of the infula are narrowly separated at the ventral margin of the endosiphuncle. The genus is named for Dr. James Stewart Williams, who first called my attention to the cephalopods in the upper Garden City.

Williamsoceras adnatum Flower

Pl. 17, fig. 1-15; Pl. 18, fig. 8-16, 24-26; Pl. 19, fig. 1-8
Text fig. 2-4.

Williamsoceras adnatum Flower, 1964, N.M. Bur. Mines, Mem. 13, p. 10, pl. z, fig. 1-7.

The species is characterized primarily by the structure of the endosiphuncle, in which a ventral process, narrow anteriorly, has the distal part extended orad of the base, and the anterior limit of the endocone slopes gently apicad from the base of the ventral process to the dorsum. As the apex of the endosiphuncle is approached, the ventral process widens, its top becomes broadly rounded, the sides at first nearly vertical, and later becoming convex, as the dorsal endocones thicken, leaving a cavity near the tip of the endosiphocone which is a narrow crescent. The tip of the endosiphocone is attained first ventrally, and the dorsal termination lies much farther apicad. At the tip, the cavity of the endosiphocone is traversed by a series of transverse buttresses and is eventually divided into a series of tubes, transverse, slightly curved, lying along the infula which has, in cross section, the outline of a circle, slightly extended and pointed ventrally, lying within the circular siphuncle, the ventral ends narrowly separated. Dorsally the tubes remain transverse and curve with the outline of the infula, but on the ventral side the tubes are small and rounded, commonly with dark triangular surfaces, with one angle aligned with the infula, two others extending obliquely outward, being extended as vestiges of the varices or endosiphosheaths of the endosiphuncle.

A dark vertical blade forms the axis of the ventral process. The presence or absence of diaphragms crossing the tubes has been a matter of some perplexity; such diaphragms are suggested by the section shown in Pl. 18, fig. 27 and 28, (displacement may be the explanation) but are clearly absent in the section shown in Pl. 19, fig. 4. An additional specimen was sectioned to show the tubes dorsally on one side and ventrolaterally on the other; it lacks any trace of diaphragms; it is concluded that diaphragms are probably absent.

The several types show variable distortion, but apparently the siphuncle was originally subcircular or very slightly depressed in cross section. The observed surfaces of endosiphuncles are relatively smooth, showing septal ridges only very faintly; they are distant, 9 mm apart where the siphuncle is from 22 to 3o mm across, sloping forward from dorsum to venter; one endosiphuncle shows a conspicuous longitudinal band externally, the base of the median blade of the ventral process. The several specimens show a range of siphuncles from 9 to 3o mm across; with a rate of expansion of 1 mm in 10; the total length represented is thus 210 mm, to which may be added an unknown length for the missing apex, perhaps 100 mm more of the length of the anterior empty part of the siphuncle, and the living chamber can only be estimated, but complete shells were certainly in excess of 6o cm in length and 8o mm across. Shell fragments suggest that the conch was slightly depressed in cross section, and probably internal molds have the aspect of simple generalized straight endoceroids.

Detailed description of the material.—The holotvpe shown on Pl. 17, fig. 1-12, is a portion of an endosiphuncle 15o mm long increasing from a width of 15 mm and a height of 16 mm to a width of 28 mm and a height of 32 mm. The cross section is very slightly distorted. The anterior 85 mm of the siphuncle is exposed, and shown on P1. 17, figs. 1 and 2; the surface is smooth, with only faint annular ridges indicating the septation; evidently this is actually an endosiphuncle, and the connecting rings, now lost, were sufficient to smooth out the septal markings. A prominent narrow midventral furrow is shown on the specimen, indicating the base of the midventral blade. At the anterior end a cross section shows the ventral process narrow, rather high, with the median blade conspicuous, and the normal endocone material is shown only ventrally, and only on the left of the surface (Pl. 17, fig. 12). A second section, 9 on farther orad, shows the dorsal part only of the ventral process; neither its base nor the anterior endocones are developed this far forward (Pl. 17, fig. 1). A transverse section 43 mm from the anterior end is illustrated, the two sides, 2 mm apart slightly different, Pl. 17, figs. 3 and 4 show the ventral process greatly widened and the endosiphocone reduced to a narrow crescent, traversed dorsolaterally by one large buttress. The acute ends of the crescent are continued toward the venter as discontinous dark lines, the influla within which are seen a series of small triangular bodies, their centers light, the angles dark and somewhat extended. At the level of this section, the endosiphocone has already terminated ventrally; these bodies are endosiphotubes; the lower dark angles of their margins are aligned along the infula; the dorsolateral edges represent vestiges of endosiphosheaths; one is seen continuous with such a sheath extending through the greater part of the ventral process. The two sides of a second section, 5 mm apicad of the preceding one (Pl. 17, figs. 5-6), show further progress in the narrowing of the crescentic endosiphocone; its edges are somewhat more reduced, and these two surfaces show progress in the division of the endosiphocone into transverse oval elongate bodies; here the dorsal part of the endosiphocone is divided by further buttresses, and the merging of the cone into the multiple tubes is seen. Another section, 4 mm farther apicad, Pl. 17, fig. 7, shows further progress in the development of small flat curved tubes from the broader more elliptical bodies of the preceding section. Another surface 10 mm farther apicad (Pl. 17, fig. 8) shows the reduction of the tubes to narrow curved transverse elements, grading ventrolaterally into short nearly round tubes surrounded by dark material externally, largely triangular in section, the dorsal tubes narrow, transverse, light internally, with dark margins, and here and there widened so that the whole of the infula has a knotted or beaded appearance. Pl. 17, fig. 9 is a section 3o mm farther apicad, there has been some alteration here, and the homologues of the buttresses, the calcareous material separating the tubes, have developed dark outlines and might be misinterpreted for the tubes themselves, which are largely narrow, transverse and curved. A final section 58 mm farther apicad and close to the apical termination of the specimen (Pl. 17, fig. to) shows very similar features but the tubes are more readily identified. A longitudinal section was taken tangent to the left side of the infula as shown in Pl. 17, fig. 9. The section, ground progressively and photographed at several successive levels, shows the tubes to be without diaphragms; only the final surface is here reproduced (Pl. 19, fig. 4); the tubes are not continuous, the section being traversed by a joint along which slight displacement has occurred, but the simplicity of the tubes and absence of diaphragms are the more clearly evident from this condition.

One paratype, no. 343 (Pl. 17, fig. 13-15), is an anterior portion of an endosiphocone. The cross section is slightly distorted, but the fragment, 22 and 23 mm across at the base, shows a weathered cross section through about the middle of the endosiphocone, with the ventral process moderately widened, its blade evident, and the dorsal endocones moderately developed. In a mean distance of 3o mm orad, the siphuncle has widened to 22 and 26 mm, and the etched anterior surface shows the dorsal endocones extremely thin, the ventral process high and relatively narrow. its anterior surface, which is broken and now slightly etched, shows only a trace of the median blade. In ventral view, the anterior end of this specimen shows a V-shaped emargination at the base of the ventral process, marking the termination of the MO limbs of the infula.

A second paratype, no. 344, consists of a portion of an endosiphuncle apicad of the endosiphocone, shown in Pl, 18, figs 24-26; it is 40 mm long, increasing from 10 and 9.5 mm to 12 and 10.5 mm, very slightly depressed in cross section. Two sections were taken, one near the broken anterior end shown in figs. 24 and 25, and another 14 mm farther apicad, one surface of which is shown in fig. 26. Here, as in the holotype, the infula is a relatively large arc, nearly circular but somewhat more compressed than the cross section of the siphuncle, a dark band in which small tubes, variously elongated, can be seen. The features, comparable to those shown by the holotype, show the pattern uniform down to a region of much smaller cross section, a significant matter inasmuch as the possibility of early stages being different from the later stages must be considered.

A third paratype, no. 345, shown on Plate 19, figs. 1-3, 6-8, is the anterior portion of an endosiphuncle, the dorsal side of which is partially exposed on a weathered surface. A cross section near the base (Pl. 19, fig. 3), shows that the siphuncle has clearly been crushed vertically, evidently the result of compaction of the sediments, for the ventrolateral outline is most irregular and the infula is clearly distorted. The siphuncle in its present condition, widens from **29 to 32** mm in 63 mm, and at the anterior end shows only the ventral process which is here narrow, pointed above, and slightly curved. In spite of the distortion, this specimen showed a considerable portion of the ventral wall attached to the siphuncle, and this wall continues ventrolaterally far enough that longitudinal sections were taken of the middle part of the specimen in the hope of revealing the condition of the siphuncle wall. The results were successful, and the siphuncle is clearly shown to have holochoanitic septal necks, and while tracing of the individual layers composing the siphuncle wall is rather difficult owing to slight recrvstallizations it is evident that a dark inner apical surface of the connecting ring terminates rather abruptly about midway between the junctions of septa with the siphuncle margin. The free parts of the septa and the shell wall show evident replacement and a general loss of original textures. The several sections shown on Plate **19,** figs. 6-8, are of interest not only for showing variation in the appearance of the siphuncle wall, but also one of them, Plate 19, fig. 7, cuts several endosiphotubes for some distance, showing them to have thin but well defined walls, distinct from the vesicular calcite which surrounds them.

A fourth paratype, no. 346 (P1. 18, figs. 8-16, 27, 28) is a portion of an endosiphuncle 110 mm long increasing from 13 and 13 mm to 17 and 19 mm, the anterior end being slightly depressed and more broadly rounded dorsally than ventrally. The occurrence indicates slight flattening to be prevalent among the specimens, and the rather different cross section is thus regarded as adventitious rather than representing a real specific difference. The exposed siphuncle (Pl. 18, fig. 8), is weathered and slightly etched from the ventral side, but neither septal markings nor insertion of the ventral blade or the ends of the infula are evident externally. Two surfaces of a cut 6 mm from the anterior end (P1. 18, figs. 9-10) show progressive growth of the endosiphuncle, with the ventral process broadening, and ventrolaterally connected with the endocones by buttresses, closing off the small ventrolateral tubes. The ends of the infula are barely joined ventrally, and slightly straighter there than in the more dorsal portion. The two surfaces of the next cut, 21-23 mm farther apicad, are shown in Plate 18, figs. 11 and 12;

here the endosiphocone is confiined to the dorsal half of the siphuncle, ventrally the infula is apparent with the various tubes along its course rather variable in size and clarity, but generally showing the dark external triangular outlines noted in the holotype. The next cut, showing two surfaces 42-44 mm farther apicad, shows the division of the dorsal part of the endosiphuncle into transversely elongated curved tubes. Also, these surfaces show what appears to be one of a pair of dorsolateral blades, as a light band of calcite. The blade of the ventral process which in adoral sections extended for most of the height of the process, is now only seen in the basal half.

A transverse longitudinal section was made across the interval immediately apicad of the section shown on Pl. 18, fig. 14; this is shown in figs. 27 and 28, ground slightly lower in the latter figure, and in that figure the specimen is photographed slightly obliquely to show the cross section at the anterior end and the depth of the cut. The fact that anteriorly tubes are somewhat conical, and then become rather abruptly tubular, made it impossible for either section to cut the tubes in a perfect longitudinal section, and tracing of individual elements is difficult, but it is evident that the tubes are largely simple, though several possible diaphragms are shown. Comparable structures have not been found in other longitudinal sections in the species, as noted previously.

The longitudinal section of an interval 26 mm long is terminated apically by a cross section, the two surfaces of which are shown in Plate 18, figs. 15 and 16; the top of fig. 15 was subsequently largely lost in making the horizontal longitudinal sections shown in P1. 18, figs. 27, 28. They show the infula connecting the tubes, now quite small, a vestige of the median blade of the ventral process, and again obscure traces of one of a possible pair of dorsolateral blades. The general appearance of these sections is quite similar to the still earlier growth stage shown from another siphuncle, paratype no. 344, in Pl. 18, figs. 24-26.

A specimen collected by Ross, in the collections of the Yale Peabody Museum (Pl. 19, fig. 5) represents a portion of a siphuncle 85 mm long, weathered from the dorsal side and showing the adnate condition of the ventral process adorally, a natural section through the tip of the ventrolateral part of the endosiphocone, and, in midlength, a portion of the infula.

Types and occurrence.—The types are nos. 342-346 in the collection of the writer, and are from the upper 20 feet of the Garden City limestone, Green Canyon, in the northern outskirts of Logan, Utah. One paratype (Pl. 19, fig. 5) is in the Yale Peabody Museum.

Williansoceras cf. adnatum
Pl. 19, Fig. 9, 1 o

Under this name is figured and described a small fragment of a siphuncle 8o mm long, increasing in width from 6 to 12 mm. The exposed surface shows a siphuncle slightly displaced by a joint near midlength, and bearing two clear external longitudinal grooves with a fainter one between. A cross section shows the two grooves to be the ends of the infula, and the fainter middle groove the base of the median blade of the ventral process. The cross section shows the siphuncle broken longitudinally so that the dorsal part is missing. The preserved part and a restoration of the remainder are shown in P1. 19, figs. 9, 10. The specimen is of particular interest in that the break is independent of infula and the blades and shows the absurdity of Mutvei's assertion that blades are only fracture lines in the endosiphuncles.

Figured specimen.—Collection of the writer, no. 347. From the top 20 feet of the Garden City limestone, Green Canyon near Logan, Utah.

Williamsoceras pedunculatum Flower, n. sp.
Pl. 17, fig. 16-25

This species is characterized by an infula the two limbs of which join the median blade of the ventral process, and the ventral process appears stalked, being set narrowly in an emargination of the endocones rather than broadly attached to the ventral surface of the siphuncle.

The holotype, Pl. 17, figs. 22-25, is a portion of a siphuncle which lay on its side in the sediments, and compaction has made it rather strikingly compressed in section. It expands from 19 and 15 mm to 21 and 16 mm in 34 nun, the distance between the two transverse sections; the entire fragment has a maximum length of 58 mm; the exposed ends are broken obliquely. The anterior section, figs. 22 and 23, show a moderate thickness of endocone material, interrupted dorsolaterally by a dark band, evidently a blade; it is not evident, however, whether this is a middorsal blade slightly askew, as seems probable from the paratype, or one of a pair of dorsolateral blades. The ventral process is rather more rounded in cross section and somewhat broader than that of W. *adnatunt at* a corresponding position in the endosiphocone; its dark median blade extends for most of the height of the process; in fig. 23 it appears widened, but this is merely the development of some adventitious dark calcite, and is in no way analogous to the supposed ventral alveolus of *Coreanoceras.* The limbs of the infula join the median ventral blade, and the continuation of the blade to the ventral surface of the endosiphuncle is obscure. The two surfaces of the more apical section, shown in fig. 24 and 25 of the same plate, show the endosiphocone reduced to the dorsal half of the siphuncle; from its lower angles the curved ends of the infula can be traced, and in the infula, toward the venter, a number of small tubes can be seen. The enlarged ventral process is well rounded distally, the median blade extends for only half of its height. A clear growth line suggests the median process here to be narrower at an early growth stage than it is in the anterior section. The ends of the infula meet the ventral process barely before the process joins the siphuncle margin.

The paratype, shown on figs. 16-21 of the same plate, is 3 siphuncle depressed in section. Compaction of sediments is the probable cause, as the siphuncle was oriented vertically in the strata. Adorally the dorsal surface is irregular, due to solution or abrasion prior to burial. The siphuncle is a fragment *75* mm long, expanding from 9 and I I mm to 16 and 18 mm in a length of 52 mm. The siphuncle is embedded in limestone, and its structure is known only from a series of cross sections. A section 14 mm from the anterior extremity, which is weathered irregularly and obliquely, is shown in

Pl. 17, fig. 16. Here the endocones are developed, emarginate ventrally, receiving the pointed base of the ventral process the blade of which is not evident. Portions of two rather assymmetrically placed blades are seen dorsally; later sections indicate the blade slightly to the left of the center is probably middorsal. The symmetry is a little more evident from fig. 17 of the same plate, taken from a section 8 mm farther apicad, and showing cones slightly thicker and the ventral process slightly larger. The next section, fig. 18, is 8 mm farther apicad, showing the endosiphocone reduced to a small crescent, the limbs of the infula joined before attaining the venter; the median blade is still not preserved, but a middorsal blade is clear, and more symmetrical in position than in anterior sections. Figure 19, which lies 14 mm farther apicad, shows the middorsal blade, the curved infula, the downcurved edges of which are rather obscure, there being rather extensive recrystallization in the ventral process. It is, however, evident that the limbs join each other somewhat farther from the venter than before. The next surface, fig. zo, lies 19 mm farther apicad. Again ventral recrystallization obscures the ends of the infula, but the upturned band in the ventral part of the siphuncle is largely the preservation of a growth line of .the ventral process. The last section, fig. 21, shows more recrystallization, and the left side of the infula is distorted. This surface lies 9 mm from the weathered apical end, where the infula appears as a ring, pointed ventrally, but with dorsal and ventral blades clearly preserved.

Types and occurrence.—All material is from the top 20 feet of the Garden City formation from Green Canyon, near Logan, Utah. The holotype and paratvpe nos. 349, 350 are in the collection of the writer.

Williamsoceras ankhiferum Flower, n. sp.

Pl. 18, fig. 1-7

The type and only known specimen is a portion of a siphuncle 75 mm long, increasing from 9 and 11 mm to 16 and 18 mm. The cross section is scarcely distorted, and the section is broader than high, with the venter conspicuously flattened. A ventrolateral surface exposed by weathering is shown in Pl. 18, fig. 2; to the left of the center are two narrow grooves with a third fainter one between which mark the venter; the two strong grooves are the ends of the infula, the central one marks the base of the median blade of the ventral process. The specimen represents part of the endosiphuncle apicad of the endosiphocone. The infula is low but narrow, more so adorally than adapically, the two limbs showing only slight curvature as they approach the venter. The ventral process is lower and narrower though broader ventrally, than in related species. The tubes of the infula are very narrow and inconspicuous. A middorsal blade is consistently present, and the species shows evidence of lateral blades not noted in the associated forms. The ventral process has a median blade.

Figures i and 3 of Plate 18 show cross sections near the two extremities of the type natural size. Figures 4-7 show a series of sections X2. Figure 4 is the same surface as that shown in fig. 1, a section of Io mm from the obliquely weathered anterior end. The section shows the infula high and narrow, the limbs converging below and only faintly curved, and quite widely separated at the ventral margin. The ventral process shows the median blade dark below, only faintly indicated above, and portions of growth lines are preserved. The infula is dark, but contains several small light spots; the tubes it contains are exceptionally narrow and narrowly separated; individual tubes are made out only with difficulty. The dorsal blade is broad, dark, and from it extend vestiges of the growth lines. On the venter, dark bands represent additional traces of sheaths; on the right are seen two blades, curved rather like the prongs of a tuning fork, attached at the siphuncle margin, and one continues to the infula while the other does not. A trace of another blade is seen on the lower left, which fails to correspond in position to those on the right. Figure 5 shows a surface apicad of the long portion shown in fig. z; the same section as is shown XI in Fig. 3. The infula is here broader, though the limbs still show a ventral reduction in curvature and are well separated from each other and from the median blade of the ventral process. The limbs of the infula show feathering of the edges, vestiges of the sheaths, more clearly than they did in the preceding section. The dorsal blade is persistent, traces of lateral blades are obscure, but those on the left of this figure correspond to those on the right of fig. 4. Opposite sides of a cut near the apex, 14 mm apicad of fig. 5, are shown in figs. 6 and 7. Here the infula is more broadly rounded, though the wide separation of its tips on the ventral margin persists. The ventral process shows only the base of its blade, and there is evident recrystallization within its broader distal portion.

The dorsal blade persists, showing feathering of its edges; several curved dark bands represent sheaths in the endocones, and variable vestiges of lateral blades are seen.

Discussion.—The wide separation of the ends of the infula, the extremely narrow tubes lying within it, so narrow that they are made out only with difficulty, the persistent dorsal blade and evidence of lateral blades distinguish this species; the form of the infula is, however, enough alone to indicate this to be a form quite distinct from the preceding species. Owing to the obscurity of the tubes in the infula, sections of this form approach more closely in appearance those of some *Coreanoceras* than do other species of the genus, but the presence of numerous tubes, though they are smaller and less conspicuous than those of other species, indicate that this form is referable to *Williamsoceras.*

Type and occurrence.—The holotype, no. 351 in the collection of the writer, is from the upper 20 feet of black limestone forming the uppermost beds in the Garden City limestone, from Green Canyon, Logan, Utah.

A recent find indicates the presence of this or a closely similar species in the Juab limestone of the Ibex region of western Utah.

Genus CACHEOCERAS Flower, n. gen.

Genotype: *Cacheoceras trifidum* Flower, n. sp.

The genus is known only from the endosiphuncle. It resembles *Williamsoceras* in showing a ventral process and a clear infula which, as in W. *adnatum,* is tangent to the interior of the siphuncle on the venter. It differs from *Williamsoceras,* however, in that the endocones are interrupted by similar dorsolateral processes. Numerous tubes around the infula are suggested rather than demonstrated by the material, which is somewhat replaced; there are no arcs of tubes and no infula about the dorsolateral processes.

Discussion.—This is a somewhat puzzling genus, possibly because it is yet known from one species and one rather recrystallized specimen. It is believed to be a further specialization stemming from *Williamsoceras;* indeed, I had formerly placed the genotype there with doubt, but to do so would require a broader definition of the genus than is reasonable. Our one species is from zone L of the Garden City limestone; the genus has not yet been identified elsewhere with certainty, though it is suggested by a specimen recently collected from the Juab limestone of western Utah.

Cacheoceras trifidum Flower, n. sp.
Pl. 18, fig. 17-23

This form is represented by a single endosiphuncle, *77* nun long, increasing from a height of 5 and a width of 6 mm near the obliquely broken base to a height of 8 and a width of to mm in a length of 5o mm, orad of which the siphucle is incomplete dorsally, but it extends forward on the venter for an additional 17 mm and the anterior limit of the ventral part of the endosiphuncle is not quite attained at the anterior end of the specimen.

Sections show the symmetry of the internal structures slightly askew, a condition resulting from slight crushing of the endosiphuncle. An anterior cut, the two sides of which are shown in Pl. 18, in figs. 18 and 19, shows a large ventral process, well rounded, limited by the ends of the infula, and the dorsal endocones which are modified by having two smaller dorsolateral processes, their bases pointed, embedded in the endocones, and apparently not quite attaining the edge of the siphuncle. A second pair of sections taken at midlength shown in figs. **20** and **21** shows the ventral process conspicuously outlined and greatly enlarged, bounded by the infula, in which individual tubes are not clear, but are suggested by the rather angular outline. The dorsolateral processes are enlarged also; one is of dark, the other light calcite, and at the top of the ventral process a tiny cavity remains. Two surfaces taken in the basal quarter, shown in figs. **22** and 23, show more recrystallization and structures are less obviously interpreted, but again the large rounded slightly irregular outline of the infula and the ventral process can be seen, and in fig 22 the two dorsal processes now continguous with one another, can be identified.

Discussion.—This form seems, as noted under the generic discussion, allied to *Williamsoceras*, from which it is distinguished by the two dorsolateral processes. I had originally placed it with question in that genus, but this procedure requires excessive broadening of the definition of the genus. Recrystallization leaves the details of morphology of the type vexingly ambiguous; one could perhaps claim that the ventral process is inflated, the dorsolateral processes rounded, and that Pl. 18 fig. **20** shows only two tubes clearly. However, it can be seen by comparison with W. *adnatum*, that the ventral process is narrow, but that endocones superimposed on it widen its tip, as in Pl. 18, figs. *9* and 1 o, and thus, with minor recrystallization, may present sections open to misinterpretation.

Type and occurrence.—The holotype, no. 348 in the col. lection of the writer, is from the upper **20** feet of the Garden City limestone, certainly within zone K of Ross (1961) from Green Canyon, just north of Logan, Utah.

Family PADUNOCERATIDAE?
Genus ROSSOCERAS Flower

Genotype: *Rossoceras lamelliferum* Flower, n.. sp.

Rossoceras Flower, 1964. N.M. Bur. Mines, Mem. 13, p. 59.

This is a genus of straight, slender endoceroids attaining considerable size. The shell is poorly known, but indications are that it was depressed in section, with straight transverse sutures or with broad lobes on the venter. The siphunde is ventral, commonly flattened where it touches the ventral wall of the shell. The siphuncle wall consists of essentially hemichoanitic necks supplemented by rings which extend for the length of nearly one and a half segments and so the apical end of one ring overlaps and lies against the inner (siphonal) surface of the adoral end of the next adapical ring. Commonly the apical end of a neck shows darker color and slightly different texture, and is perhaps comparable to the eyelet developed in other Endoceratida where the segmental elements of the siphuncle are prolonged and overlap.

The endosiphuncle shows a cone in which the venter is first flattened, then becomes gradually slightly concave in cross section toward the tip, the cone thus grading from round with the venter slightly flattened, to semicircular and crescentic, the sides downturned at its tip, and terminates in a tube which is transverse; the ends commonly downcurved. Blades show a remarkable diversity owing to conditions of replacement, but it is evident that under the conditions of least alteration the cross section will show numerous blades which bifurcate repeatedly as they are traced from the tube to the siphuncle margin. Recrystallization may obscure all or parts of this pattern, but commonly there will be vestiges of (x) a middorsal blade, (2) a pair of downcurved lateral blades. (See Text Figure 5.)

The apex has not been observed, but it is evident that

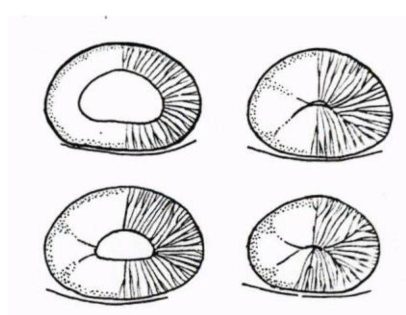

Figure *5*
ROSSOCERAS LAMELLIFERUM

Cross sections of *Rossoceras lamelliferum at* two prints in the endosiphocone, near tip of the cone, and across the tube. Fine blades are shown on the right of each figure; the left shows the appearance under recrystalization, where only stronger bases of blades may be preserved.

the siphuncle tapers gently to a small diameter, comparable with that of Canadian Proterocameroceratidae, in which a fairly small blunt tip, in contrast to the large blunt there is apices of the piloceroids or the swollen tip of the older Endoceratidae.

Discussion.—The genus is described here from only one species, which is the most characteristic cephalopod of the upper beds of the Garden City limestone, zone L of Ross (1951) of northern Utah. Description of other species is withheld, as more and better material of them has recently become available. It is possibly this same species that is the most abundant endoceroid on the same zone (L) in the Juab limestone of western Utah. In zone M, in the Kanosh shale, there occurs another and larger species; possibly it is this same form which is represented by large siphuncles in zone M of the lower Swan Peak quartzite, but specimens thus far found there are so crushed as to defy specific determination. In Utah the genus has not been found in higher beds. Oddly, the best material of the genus in central Nevada is from the *Palliseria—Maclurites—Girvanella* beds, and it is this horizon rather than the sponge beds below, which has yielded most of the determinable specimens of large endoceroids. Endoceroids, and possibly *Rossoceras,* are present in the sponge beds, but specimens are crushed, fragmentary, and endosiphucles show advanced recrystallization. The *Palliseria* horizon at Meikeljohn Peak has also yielded this genus, and I have had specimens from several other localities. In the northern Ingo Mountains of California a *Rossoceras* occurs in association with *Ruedeinannoceras* sp., in beds reasonably equated with the *Palliseria* beds of Ikes Canyon and Meikeljohn Peak, occuring below beds yielding the first *Rhysostrophia* found in the section there (Ross 1964A).

Recognition of this genus involves some very practical problems, as our material shows that under advanced alteration the numerous fine blades which characterize it may be altered, and the final result of such alteration may be a coarsely recrystallized siphuncle in which dark bands, which mark the position of the bases of the stronger blades, may be retained as shadow blades, and may appear extended to the siphuncle margin, though commonly they are widened distally and their margins there are most obscure. Such *a* pattern may simulate one found in Canadian Proterocameroceratida in which a trifid arrangement of blades appears to be the normal condition

Cross sections of the best preserved *Rossoceras* endosiphuncles show a blade pattern very suggestive of the genera on which Balashov (1960) based the Interjoceratina, which was defined as a group of the Endoceratida with shell and siphuncle like previously known endoceroids, but with the siphuncle filled not by conical increments of growth but by longitudinal lamellae growing in from the siphuncle wall toward the center of the siphuncle. In *Rossoceras,* there are perfectly normal endosiphocones, the surfaces smooth adorally in young stages, faintly striated at maturity, and in old age may be fluted. Such fluting is not Confinedto this group. El Paso piloceroids awaiting description show even more marked fluting at maturity. Modification of the section of the endosiphocone near its tip is now comparable to but not identical with that which Balashov figured for *Padunoceras,* which shows a trifid pattern. *Rossoceras* has normal endosiphocones, but longitudinal sections, as do those of the three genera of the Interjoceratina, fail to show sheaths. Similar absence of sheaths in other endoceroids has been observed by the writer, particularly in early stages, and the suggestion has been made that such endosiphuncles grew gradually without resting stages such as sheaths have been believed to represent.

The inference is that possibly the whole of the Interjoceratina have been based upon a misinterpretation of numerous radial blades for spaces between originally discrete longitudinal lamellae.

Closer comparison with the genera of the Interjoceratina shows such differences that *Rossoceras* cannot be considered identical with any of its genera. *Interjoceras* has a large subcentral siphuncle in a slightly curved shell, with achoanitic necks, thick rings outlining concave segments. In the material so far figured, the siphuncle may weather in such a way as to suggest actinosiphonate deposits of the Oncoceratida but the sectioned material so far illustrated shows details rather poor and is, I believe, material considerably altered from its original condition. It is faintly suggestive of sections of some of the Narthecoceratidae, but a relationship here seems most unlikely. *Evencoceras* shows a siphuncle more like that of *Rossoceras* in aspect in cross section, but lacks the dominantly trifid arrangement of the bases of the blades, and the tip of the endosiphocone is irregular in the one example figured. One figure suggests that the septa are widened or even possibly split, where they bend around the suphuncle forming the necks. In *Padunoceras,* in which the necks are long, the tip of the cone may be trifid, the tube lies dorsad of the siphuncle center, and the blades show a characteristic pattern not closely similar to those of any other genus.

Relationships of these genera to other endoceroids are not yet certainly understood. The general suppression of sheaths and the development of numerous and unusually prominent blades would suggest that the group is a natural one, though it should not be given a rank equal to the entire remainder of the order Endoceratida. The writer prefers to leave the question until it is possible to publish yet another genus, known from the El Paso limestone now by several manuscript species from three main horizons there, which seems to contribute not so much to the solution, as to the complexity of this problem.

Rossoceras lamellif eruin Flower,

Pl. 15, fig. 15; P1. 20, fig. 1-9; Pl. 21, fig. 1-24;
Pl. 22, fig. 6-18, 22-25; Text figs. 5, 6

Rossoceras lamelliferun Flower, 1964, N. Mex. Bur. Mines, Mem. 13, p. 59, pl. 4, Fig. 2, 13-22.

This species is known from endosiphuncles, all from the top 20' of the Garden City formation. The several specimens show some variation in proportions in which compaction and tectonic distortion are involved, and show also considerable variation in fine structure in which replacement and recrystallization are involved, and are described individually below.

Siphuncles are slender, the rate of expansion varying from z to 3 mm in a length of 5o mm; ordinarily siphuncles are slightly flattened ventrally, and adorally the increase in height is reduced, so that anterior sections show a progressive increase in width in relation to height. Such siphuncles as have been observed showing surfaces or other evidence of spacing of the septa, exhibit relatively smooth surfaces; unlike the Pogonip species, septal ridges are extremely low in relief, and the usual concavity between septal ridges is here practically wanting. Our two specimens showing septa indicate that the septal ridges are separated by a distance equal to half the width of the siphuncle at that point.

Endosiphuncles have been observed ranging from 7 and 10.5 mm to z6 and 34 mm which would encompass a length of about 55o mm; the largest specimens show only the anterior end of the endosiphocone, orad of which there was a length of phragmocone and siphuncle in which the endosiphuncle is not developed, which cannot be estimated except by comparison, but was probably far in excess of zoo mm, and a living chamber. The earliest stage observed, with a siphuncle 7 by 10.5 mm, was evidently in a shell approximately 18 mm wide and 15 mm high; the latest observed stage suggests around a siphuncle 34 mm wide and z6 mm wide in a shell 8o to 100 mm wide and 6o-8o mm high. A fragment of the dorsal part of a phragmocone was found associated with this species, but could not be identified with certainty with *Rossoceras* to the exclusion of the associated W*illiamsoceras.* It shows a width of 8o mm and evidence of a depressed cross section and straight transverse sutures. The shell was evidently smooth.

The features of the siphuncle wall and endosiphuncle are essentially those described for the genus. The slender endosiphocone conforms to the depressed cross section of the siphuncle anteriorly, but as it is traced toward its apex the ventral side becomes first flattened and then slightly concave, terminating in an endosiphotube which is transverse, the narrow sides slightly downcurved in early growth stages, but nearly transverse in later stages, where the siphuncle is 3o mm or more in width. There is commonly a prominent middorsal blade, and from the sides of the tube extend blades, one pair downturned and losing its identity in its numerous branches as it approaches the siphuncle margin, another less curved and pointing obliquely upward. The tube is without diaphragms, and sections have shown only longitudinally continuous structures in its walls.

An early growth stage is shown by a specimen 5o mm long. At the anterior end, the siphuncle is 9 by II mm, contains a small elliptical section through an endosiphocone, 4 by 3 mm 4 mm from one side, the apparent venter, and o.8 mm from the other; **2:** mm farther apicad the section is 1o.5 by 7 mm slightly distorted, the cone a mm wide and mm high, 4 mm from the venter, 2 mm from the dorsum. The siphuncle extends 27 mm farther apicad, is evidently slender, is weathered obliquely at the apical end. It suggests that siphuncles had slender apices comparable to those of the Proterocameroceratina. It is illustrated in Text Figure 6. No apical inflation of the siphuncle has been observed.

Details are best discussed in terms of the individual syntypes.

Syntype no. 357 is a portion of a siphuncle shown in

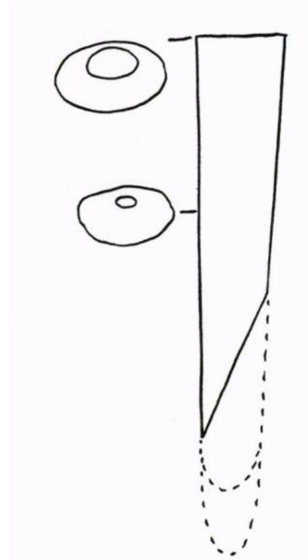

Figure 6

ROSSOCERAS LAMELLIFERUM

Outline drawing of proportions of the earliest observed growth stage, with position of two cross sections indicated. Based upon syntvpe no. 365.

dorsal view in Pl. **20,** fig. I; the surface is extremely free from relief, septal ridges are faintly raised and narrow, spaced 16 mm apart. The siphuncle fragment is 13o mm long, broken obliquely anteriorly exposing an oblique section, not illustrated, showing only very thin endosiphuncle material around what is evidently close to the anterior end of the endosiphocone. The height here at the center is 24 mm, the estimated width is 35 mm. A section 82 mm farther apicad, 20 mm orad of the base of the specimen as shown in Pl. 20, fig. I, is shown in fig. 3 of the same plate; here the cross section of the endosiphocone is strongly flattened ventrally, the surface of the cone is irregular, numerous radial lamellae are seen in the dark portion of the siphunde, but are absent in the white portions which show more advanced alteration. A further section, shown in fig. 4 of the same plate shows the endosiphocone considerably smaller, the radial lamellae are more pronounced, and are shown in part in further enlargement in fig. 5. Only a small portion of siphuncle, with a maximum length of 4 mm, and an irregular weathered surface, exists apicad of this section. The siphuncle at this point is 21 mm high and 26 mm wide, in approximately 100 mm the adoral height of 24 mm and estimated width of 35 mm are attained. The siphuncle is slightly distorted, and both of the cross sections show slight displacement along an irregular largely vertical calcite vein-Two thinsections were taken from an interval 22 mm long and located zo mm orad of the base of Pl. 20, fig. I. One of these is shown in enlargement in fig. 2 of the same plate. The shell wall is calcitic and shows only coarse calcite crystals; the same is true of the free part of the septum, which extends steeply to the siphuncle; this condition is found in the ventrolateral part of the shell. The siphunde wall shows layering (Pl. 20, fig. 2) that at first seemed rather ambiguous, but at the adoral end of the figure can be seen a termination of the septal neck on the outside of the siphuncle, and a termination of a connecting ring at the same point on the inside. In the lower part of the figure the tips of both the ring and neck can be seen again; here the tip of the ring lies definitely some distance orad of the tip of the neck. Clearly, though septal necks extend for less than the length of a segment, the ring extends apicad from its inception where the septum joins the siphuncle, overlapping the anterior end of the next adapical ring, and terminates at or shortly before the termination of the next adapical septal neck. The tip and apical portion of the ring is composed of somewhat darker material than is the remainder of the ring; though this region is without clearly defined boundaries, it seems comparable to the eyelet developed in the apical end of rings in some other Endoceratida.

A second syntype, no. 358, is a portion of a siphuncle of much smaller size, retaining most of the length of the endosiphocone. The siphuncle is 45 mm long, expanding from **a** height of **12** and a width of 14 mm to a height of 16 mm and an estimated width of 18 mm. A longitudinal section was cut of the anterior 4o mm, one side of which is shown in Pl. 20, fig. 6, while the opposite surface was made into a thinsection shown in its entirety in Pl. 21, fig. 9; the two ends are shown in greater enlargement in Pl. 15, fig. 15, and in Pl. zo, fig. 9, which shows a vertical section cutting the siphuncle off center and showing on one side a section through the ventrolateral walls of the siphuncle, a situation which accounts for the narrow cameral space and steeply inclined septa. Adapical terminations of the ring are not as dear in this section as in that from the preceding specimen, but the termination of the septal neck is clear in the anterior segement particularly, and the anterior rather abrupt limit of the connecting rings are shown in three regions in the illustration. A cross section at the base of the portion shown in Pl. 20, fig. 6 is illustrated in fig. 7; and a further section, taken 11 mm farther apicad is shown in fig. 8. Both show variable preservation of the fine radial blades largely preserved dorsally, but lost ventrally by recrystallization.

A third syntvpe, no. 359, is shown in section in Pl. 21, figs. 1-8; it is embedded in matrix and several sections are illustrated. The siphuncle is a fragment 120 mm long expanding from 12 and 14 mm to 16 and 18 mm. The two surfaces of the anterior section, shown in Pl. 21, figs. 1-2, show a narrow tube, the ends downcurved, with downcurved, ventrolateral blades and straight dorsolateral blades, clear basally, dividing distally so that there is no one of their branches which retains marked prominence; a mid-dorsal blade remains relatively strong among a number of dorsolateral blades. Below the tube there is an irregular dark cavity filled with apparent matrix; its irregularity indicates it to be a solution feature, and it plainly cannot be interpreted as an original ventral alveolus. A second cut qfl mm farther apicad is shown in fig. 3 of the same plate; here numerous blades are evident ventrally and laterally. A section taken 20 mm farther apicad is shown in fig. 4; here among numerous radial blades the two lateral pair attain somewhat greater prominence than do the others. Fig. *5 is* from the opposite side of the same cut as fig. 4, showing further variation in the appearance of the blades. An apical section is shown in fig. 6, 45 mm farther apicad. A vertical section was taken near midlength of the specimen, shown in Pl. 21, fig. 8. Figure 7 of the same plate shows the cross section at the adoral end of this interval, which is essentially the apical side of a cut the adoral side of which is shown in fig. 3. The tube appears as a thin dark band lacking any trace of diaphragms, endosiphosheaths are not visible, and the surface is essentially parallel to any radial lamellae in the vicinity of its plane.

Some portions of the siphuncle surface have been exposed by etching; they show fine longitudinal texture, and the insertion of the middorsal blade remains prominent externally, although in cross sections this blade fails to show consistent prominence over the others.

A fourth syntype, no. 36o, consists of a portion of a siphuncle 175 mm long embedded in matrix, expanding from 14 and 15 to 23 and 24 mm. It was studied from a series of cross sections the more important of which are shown in Pl. 21, figs. 20-24. The specimen is in two parts, originally separated by a crack along which some soltuion had occurred, with the result that the two parts do not fit perfectly. A section close to the anterior end, shown in Pl. 21, fig. 20 shows considerable silicification which has obscured most of the fine radial structure. The flattened tube with the sides downturned merges into lateral downcurved blades, the peripheral parts of which are not preserved, and there is a trace of a middorsal blade. Fine radial blades are apparent close to the circumference, and extend closer to the center on the upper left than elsewhere. Two short thick dark lines descending a short distance below the base of the tube are probably parts of the ventral blade system, here preserved by early replacement which left them carbonized, and thus resistant to destruction in subsequent alteration which destroyed the remainder of the blades ventrally. A second section 55 mm farther apicad shown in Pl. 21, fig. 21, shows the tube wide centrally, narrowing laterally and merging into the lateral downcurved blades; one side shows a straight dorsolateral blade slightly stronger than the numerous radial blades; there is no middorsal blade more prominent than several other blades which are dorsal in position. A third section 47 mm farther apicad shown in Pl. 21, fig. 23, shows a tube less widened vertically in its center, and numerous blades, although there is considerable recrystallization. A further section 15 mm farther apicad shown in Pl. 21, fig. 23, shows again the transverse tube merging laterally into downcurved lateral blades, with dorsal and dorsolateral blades generally straight. An apical section 52 mm farther apicad shows a small tube narrowed laterally, surrounded by numerous fine radial blades; the downcurved lateral blades are prominent largely because they modify the otherwise simple radial pattern.

Syntype no. 361, shown in Pl. 21, fig. 16-19, is a portion of siphuncle 65 mm long expanding from 13 and 14 mm to 15 and 16 mm in a length of 57 mm. Sections were taken near the ends and again at the middle. The anterior section shown in Pl. 21, fig. 16, shows a small tube, the edges narrowed, scarcely downturned; white calcite below the tube has destroyed the original textural pattern, but elsewhere grey calcite shows numerous radial lamellae, the blades. On the left there is a vestige of a straight dorsolateral blade, and at the lower right there is a suggesting of a downcurved ventrolateral blade, but differentiation of these portions is not clear. Two sections at midlength appear in figs. 17 and 19, showing the tube here narrower, higher, variable preservation of numerous fine radial markings, but without structures which would suggest those blades which are stronger basally in the preceding specimens. An apical section shown in fig. 18 shows more advanced replacement. While this form is slightly different in the relatively high cross section and the absence of definite flattening of the ventral face, it is clearly allied **to** the above forms, and is illustrated to show the obscuring of the blades that accompaniaes advanced replacement.

Syntype no. 362 (Pl. 21, figs. 10-15,) is slightly in excess of 113 mm long, expanding in that length from 22 and 22 to 24 and 28 mm; in the basal 33 mm the section becomes 23 mm high and 25 mm wide. There is clearly some distortion which perhaps accounts for the unusual height in the early part, and distortion has reduced flattening of the venter. The adoral cut, opposite sides of which are shown in Pl. 21, figs. to and II, traverses the endosiphocone close to its apex. A longitudinal section taken in the succeeding apical part is shown in fig. I *5;* here the tube is, as usual, thin and nondescript, there are incomplete traces of slender conical endosiphosheaths. A section at the apical end of this interval, 8o mm apicad of figs. ro and I1, is shown in figs. 12 and 13; fig. 14 shows a section 33 mm farther apicad. The tube is extremely flattened, fine radial lamellae are evident in the gray parts of the siphuncle, traces of stronger ventrolateral and dorsolateral blades are present, but variable in expression.

Syntype no. 363 (Pl. 22, figs. 9-18,) is a portion of siphuncle 15o mm long, expanding from 20 and 25 mm to 23 and 3o mm in a length of 145 mm. An adoral section shown in Pl. 22, fig. 9, shows the endosiphotube unusually transverse, with shadows of two straight lateral blades and a dorsal blade. Fine radial lamellae are apparent in the exterior, but absent centrally; evidently the center is recrystallized. A second section, shown in fig. 10, is 8o mm apicad of the first one; it shows the erratic distribution of the light calcite, only a basal trace of the dorsal blade, and lateral blades are preserved differently on the two sides. On the left there can be traced from the side of the tube one horizontal blade, and one that is directed obliquely downward; on the opposite side the horizontal blade is not apparent, but the downturned one clearly is divided distally. Apicad of this region a portion of the siphuncle was ground progressively from the dorsal side, and photographs were taken at intervals when the plane of the section approached the very flat tube. A section dorsad of the tube cutting the dorsal blade, is shown in fig. 17, while fig. 18 shows a cross section at the apical end of the interval, indicating the position of the section. Such sections show the middorsal blade quite clearly. Figure 12 shows the section essentially at the plane of the tube, with the appearance of the cross sections at the ends, the adoral end in fig. II, and the apical end in fig. 12. Plainly, there are no transverse elements in the tube. A section 5o mm apicad of fig. 10 is shown in fig. 14; here the transverse tube has its sides curved slightly upward; on the left two lateral blades are apparent, on the right only the homologue of the lower blade of the left is seen; grey calcite surrounds a dorsal blade and shows some of its divisions.

Figure 15 is a section 3: mm farther apicad, here showing two ventral blades joined at the ventral side; a vestige of one such band is shown in fig. 14. The sides of the tube are downcurved, only basal vestiges of the la blades remain. A final section, 10 mm farther apicad and close to the broken apical end, is shown in fig. 16; here the same ventral pattern is maintained, better traces lateral and dorsal blades remain. It is uncertain whether the peculiar ventral condition shown in fig. 14-16 is original. It is without a counterpart in other specimens, but is certainly persistent over a considerable length, and it would seem easier to account for it as an original structure rather than as a replacement phenomenon.

Several features of this specimen are anomalous, and it may prove to represent a distinct species, but while the presence of perfectly horizontal lateral blades, the somewhat more broadly depressed cross section, and the remarkable features of the ventral blades in apical section indicate differences, there are both practical difficulties in identification of material and the possibility that the remarkable ventral blades might be adventitious, which indicate that formal designation of this as a second species of *Rossoceras* should be delayed until still more material is available.

Specimen no. 364, shown in P1. 22, figs. 22-25, is a portion of a siphuncle with a maximum length of 110 mm expanding from 20 and 25 mm to 25.5 and 31 mm in a length of 5o mm. The adoral part is broken obliquely. A cross section 50 mm from the base, illustrated in Pl. 22, fig. 22, shows the endosiphocone smaller, still markedly flat on the venter, numerous fine lamellae, with horizontal blades. Figure 24 shows two oblique cuts made across the ventral.. side of the siphuncle of the anterior part; fig. 25 shows the same section with the middle ground farther, the longitudinal structures are a number of blades developed ventrally, but close to the endosiphocone there is considerable recrystallization resulting in white calcite in which such structures are lost.

Discussion.—This species may be rather too broadly interpreted, but from the present evidence separation of the specimens into two possible groups is not consistently possible. Differences within the species exist. Those dealing with rate of expansion and cross section seem unreliable in the light of evidence that compaction of sediments and slight distortion, probably connected with thrusting, are known to affect other specimens in the same section. Differences in the form of the endosiphotube, commonly downcurved **at** the sides and slightly widened at the middle, in contrast to those in which the tube is perfectly transverse and the prominent lateral blades are horizontal, seem possible specific criteria, but are fallible in view of the erratic preservation of the blades. Should future work show these differences to be constant and of specific value, restriction of the present species will be facilitated by the recognition here of only a series of syntypes, without designation of holotype. Curiously, the Pogonip specimens, which are believed to come from a slightly higher horizon and represent different species, all show siphuncle exteriors in which there is some appreciable concavity between the septal ridges, and the ridges are relatively prominent.

Syntypes.—Collection of the writer, nos. 357-365. All are from the top 20 feet of the Garden City formation from Green Canyon, Logan, Utah.

Rossoceras cf. lamelliferum

Pl. 22, fig. 6-8, 19-21

Two siphuncles from the upper 20 feet of the Garden City formation seen anomalous in that ventral flattening of endosiphocone is slight and is confined to the apical part of the cone, the adoral half, or more, lacking any such falttening whatsoever.

Two specimens showing such features are here illustrated. No. 336 (Pl. 22, figs. 19-21) is a portion of a siphuncle 85 mm long expanding from 19 and 20 mm to 28 and 3o mm. The anterior end, not figured, shows a section close to the anterior end of the endosiphocone. A section 3o mm farther apicad, shown in Pl. 7, fig. 19, shows the cross section of the cone elliptical, and about half the size of the siphuncle. Another section, fig. 20, lies 4o mm farther apicad; shows the endosiphocone smaller with only the faintest vestige of ventral flattening. A third section, shown in fig. 21, is 14 mm still farther apicad, close to the apical end of the specimen. Here the central cavity is flattened ventrally, arched above, subtrianguler, and is apparently a section at the apical end of the cone close to its juncture with the endosiphotube. This section shows vestiges of the ventrolateral downcurved blades; the anterior sections show possible vestiges, visible only distally, of the dorsal blade. A second similar siphuncle is shown in Pl. 22, figs. 6-8, No. 367. It has a maximum length of 50 mm and is 21 mm high and 23 mm wide near the anterior end. The anterior section shows an endosiphocone with no ventral flattening though it is half the size of the siphuncle; the apical section shows the cone not far orad of its tip, well rounded dorsally, lightly concave ventrally.

Figured specimens.—Both specimens are from the upper 20 feet of the Garden City formation from Green Canyon, near Logan, Utah.

Rossoceras dentifernum Flower, n. sp.

Pl. 22, fig. 1-5

This species is characterized by a short narrow median Aeration of endosiphuncle material on the midventral side of the endosiphocone. The two known specimens are both short fragments. The holotvpe, shown in Pl. 22, figs. 1-2, s a short portion with a maximum length of 45 mm, feathered at both ends, the apical surface strongly oblique. lie adoral end is 24 by 27 mm, elliptical, without apparent flattening of the venter, showing an endosiphocone here 12 mm high and 14 mm wide, flattened moderately in the midventral region but with a small median extension which on cross section is narrow, pointed, and toothlike, though it doubtless a ridge continuous longitudinally. The apical side of the specimen, shown in Pl. 22, fig. 2, shows the process still present, though it is a slight median convexity on the generally convex surface of the ventral endosiphuncle material. Blades are not clearly evident in the material.

A second smaller siphuncle shown in P1. 22, figs. 3-5, is a portion which fortunately remains relatively intact from an origninally considerably longer portion which was etched, and so fragile that much of it was reduced to fragments. This portion, 25 mm long and 18 by 19 mm near the anterior end, shows a similar tooth-like ridge on the ventral side of the endosiphocone, and its longitudinal continuity is shown in fig. 5.

Types.—Holotype and paratype, Yale Peabody Museum.

Occurrence.—Both specimens are from the upper part of the Garden City formation. The holotvpe is from the east side of Hillyard's Canyon, in the southeast quarter of Sec. 17, T. 15 S., R. 41 E. The paratype is from the upper beds of the Garden City at Green Canyon, near Logan, Utah.

ORDER MICHELINOCERATIDA
(=ORTHOCERATIDA)

This is the order of the generalized *"Orthoceras";* it begins with orthocones with relatively small tubular siphuncles, usually somewhat removed from the venter, with rings thin and homogeneous; specialized forms develop siphuncles with expanded segments in several lineages, one shows lengthening of the necks, some shells become cyrtoconic or may even develop contracted aperatures.

Owing to the impingement of the structure of cameral and siphonal deposits on the taxonomy of the group, many difficulties exist. The significance of these structures did not come to be recognized until the 1930's, and many species are described for which there is no information available on these structures. Also, students of the group encounter perplexities stemming from conflicting interpretations of some structures and problems of nomenclature.

Balance in cephalopod shells is a factor. Uncertainty surrounds the point in cephalopod evolution at which gas first developed in the camerae; septation probably began for other physiological reasons, but it may be noted that even with gas in the camerae, the phragmocones of the earliest cephalopods, of the families Plectronoceratidae, Balkoceratidae, and Ellesmeroceratidae may not have been significantly buoyant. Phragmocones are rarely long (Flower, 1964), septa are extremely close, and if the gas space in the shallow camerae is further reduced by the presence of cameral tissue, which we have reason to believe was an archaic cephalopod feature, available space for gas is even further decreased, and buoyancy may have been negligible. With increased length of the phragmocone, which is found in the higher Ellesmeroceratida, notably the Baltoceratidae and Protocycloceratidae, the phragmocone became buoyant, and in these straight shells there developed a mechanism to weigh the apical part of the phragmocone by cameral and siphonal deposits. It is in these groups also, that the camerae begin to lengthen. A similar situation was met in the archaic Endoceratida by the development of the endocones. In the primitive Tarphyceratida, the Bassleroceratidae, where no weighing of the apex developed, exogastric curvature and finally, coiling, compensate for the lack of weighing of the apex; these various devices developed preventing the necessity of holding the longer shells vertically in life (Flower, 1955b).

This preface is relevant, because the first of the Michelinoceratida developed undoubtedly from the higher Baltoceratidae. The oldest member of the order, *Michelonoceras* primum, is known to have annuli in the siphuncle and deposits in the camerae. In the latest Cassinian, *Buttsoceras,* the first of the Troedssonellidae appears; this genus has similar cameral deposits, and develops instead of annuli, a nonsegmental lining in the siphuncle of very thin growth increments. These two structural types are the only ones known in the Micheloceratida prior to the close of Canadian time.

It is apparently in beds immediately succeeding the Canadian, the Whiterock and to a lesser extent in the younger Chazy of North America, and the upper Vaginatum limestone, the Aserian and Lasnamagian of the Baltic region, that there develop orthocones with seemingly tubular empty siphuncles in which no siphonal deposits are known, and in which cameral deposits are greatly retarded in development so that they are confined to extreme apical parts of shells; there are some forms here in which such deposits may be suppressed completely or else they are confined to apical parts of phragmocones which have not yet been studied from sections. It may be noted that from apparent chronology, orthocones with such reduction or obliteration of deposits are specialized and not primitive. Also, if such orthocones maintained the shell in a horizontal position some special adaptation was necessary which cannot be inferred from the hard parts, probably an increase of proportion of fluid to gas in the apical part of the phragmocone. Possibly such adjustment was subject to alteration in the life of the animal. We cannot prove that a similar adjustment was not possible in the older Michelinoceratida or even their ancestors in the Baltoceratidae, but with calcareous deposits in those groups, there was a demonstrable mechanism provided by shell parts which would permit stabilization of shells in a horizontal position in life without necessary adjustment of the proportion of fluid and gas, but such adjustment as changes in fluid-gas proportions could have supplemented such balance and could have provided adjustment to varying conditions of depth and pressure as might be useful.

By Chazy time other specializations had developed. We find there a few forms with simple exteriors and tubular presumably empty siphuncles. We find forms with deposits unknown or poorly known, with slightly expanded siphuncle segments, for which Kobayashi proposed the genera *Sactorthoceras** and *Sigmorthoceras.* The Proteoceratidae with expanded siphuncle segments and annular deposits are represented there by *Stereospyroceras* and *Proteoceras.* There appear small slender *Kionoceras* with tubular siphuncles. There are similar species in northern Europe in the Folkeslunda limestone.

Above the Chazy in North America there are few orthocones known with tubular siphuncles. We may note that the *Kionoceras* lineage continues, we find a scattering of species assigned to *Anasmoceras* and *Metaspyroceras,* and in the Red River and Cincinnatian we find *Pleurothoceras,* but such forms are few and are minor rather than dominant constituents of the cephalopod faunas. Instead, the common orthocones from Black River to Richmond are forms with more or less expanded segments which I would assign largely to the Proteoceratidae. Proper analysis of the Middle Ordovician forms is *yet* to be made, adequate collections not being available, but we may note that *Orthonybyoceras* is the dominant genus of the cephalopods of the type Cincinnatian, and between this genus and *Isorthoceras,* the common orthocones of the Trenton may be accommodated. Common annulated Mohawkian shells have largely if no completely expanded segments, and such forms as I have studied seem referable to *Tofangoceras* or to Gorbyoceras of the Proteoceratidae.

The Troedssonellidae range from late Canadian through the Lasnamagian in Sweden, and into the lower Chasmops limestone of Norway. I would regard *Stereoplasmocerina,* with a similar lining, but with expanded segments, as representing a lineage derived from the Troedssonellidae, differentiated by expanded segments. Probably *Striatoceras (=Greenlandoceras)* belongs to this lineage, which may prove to include some orthocones with expanded segment with no known deposits (only anterior parts of phragmocones have been sectioned,) such as *Eskimoceras.* Another lineage derived from the Troedssonellidae is the family Narthecoceratidae. Everyone including the writer had regarded *Narthecoceras* as an endoceroid. New material has shown that it differs from the Endoceratida in that rings are thin and homogeneous and cameral deposits are developed. Further examination shows that *Narthecoceras* and associated Endoceratidae have endosiphuncles differing widely in habit, and that fine structures of endosiphuncles are widely different. The Narthecoceratidae show every indication of being a lineage of the Michelinoceratida, and an obvious origin is found in the Troedssonellidae.

In northern Europe Michelinoceratida with simple tubular siphuncles are all but unknown above the Orthoceras limestone sequence in the Ordovician. In the Middle Ordovician of Norway Sweet (1958) described a few species assigned to *Kionoceras, Protokionoceras,* and *Polygrammoceras,* genera supposedly with tubular siphuncles, distinguished by specialized surface patterns, but found no such forms with smooth shells, and even these ornamented species were described from external features, and interiors of phragmocones have not been illustrated nor noted in descriptions. Strand (1933) in studying the Upper Ordovician of Norway, found three species which he referred to *Geisonoceras,* and a very few assigned to *Spyroceras, Protokionoceras,* and *Polygrammoc- eras;* again interiors of phragmocones are not illustrated nor are they noted in the descriptions.

In central China the Orthoceras limestone (Yu, 1930) contains orthocones with apparently empty siphuncles and apically contracted cameral deposits; this fauna is almost certainly contemporaneous with the Lasnamagian of northern Europe, at the very youngest. It may be noted that the Ordovician of Manchuria and Corea *(see* Kobayashi, pa ticularly 1934) has yielded very few Michelinoceratida with simple tubular siphuncles.

Such forms must have existed throughout the Ordovician' for the orthocones with tubular siphuncles become rife in the Middle Silurian faunas, but above the Chazy and the Lasnamagian they are extremely scarce in the Ordovician' or else they exist but have largely escaped description; this last seems unlikely, in view of the attention which has be given the Ordovician cephalopod faunas by a number of careful investigators throughout the world.

Clarification of the evolution and classification of this order is beset by differences of interpretation of genera and

* *Sactorthoceras* is rather broadly drawn, and possibly contains three generic groups rather than one: (t) forms with tubular siphuncles constricted at septal foramena, (2) forms with slightly convex segments, (3) forms with tubular segments but very short camerae.

problems of nomenclature. Properly, our present Michelinoceratida is close to the Orthoceratida of Hyatt (19oo).* Owing to the confusion then surrounding the name *Orthoceras* which it seems was based legalistically on a rudistid, and the later attempt to replace it by *Orthoceros,* the writer (Flower in flower and Kummel, 1950) bypassed the name compl**etely** and used the order Michelinoceratida rather than Orthoceratida. Subsequently there was indication of possible action of the International Commission of Zoological Nomenclature to use its plenary powers to validate *Orthoceras,* with *0. regulare* as its type. 0. *regulare* was restudied **by** Troedsson (1931) who called attention to the three longitudinal internal thickenings of the living chamber. F$_{o}$erste (1932) therefore proposed the genus *Michelinoceras ba*sed upon *Orthoceras* Barrande for "generalized" forms lacking such modifications of the living chamber. Unfortunately, neither of these type species was adequately known internally. Descriptions and figures involved only sections of the anterior parts of phragmocones, not demonstrably far enough apicad from the living chamber to show cameral or siphonal deposits. It may be noted that both proposals preceded the appreciation of the role of cameral and siphonal deposits in cephalopod taxonomy, and involved the natural assumption which now seems highly suspect, that simple orthocones without any more internal structures than septa and a tubular siphuncle were simple, generalized, and primitive. It now seems that though they are simple morphologically, they are derived.

When it was proposed that the International Commission validate *Orthoceras,* based upon 0 *regulare,* I opposed such action, simply because 0. *regulare* was not adequately !mown internally. Only anterior parts of the phragmocone had been studied by section, and the condition of possible cameral and siphonal deposits, which are ordinarily absent in the anterior camerae (ordinarily in the anterior 10-12 camerae) was unknown. True, our knowledge of 0. *michelini* was about as bad, but it seemed unwise to bring into general use two poorly known genera when one was more than enough. Interestingly, it became possible later to restudy 0. *regulare* (Flower 1962a), and the results show a marked retardation of cameral deposits so that they are extremely apically confined and have revealed no siphonal deposits whatsoever.**

Troedsson (1931) recognized as significant three longitudinal internal thickenings of the living chamber in 0. *regulare,* and described 0. *bifoveatum* which has only two such thickenings. Balashov (1956) has proposed for this species the new genus *Bifoveoceras.* As far as the writer can determine, each of these two genera is now known from a single species. It seems rather a shame to devote all this fuss to validating *Orthoceras,* having in it only one species, and after paying this lip-service to matters of priority, going on and using another name for *"Orthoceras"* in the old broad sense. In defining *Michelinoceras* there are some differences of interpretation evident. The writer, regarding small thickenings at the septal foramens as annuli (Barrande, pl. 381, fig. 5) regarded *Michelinoceras michelini* as having annuli, but lacking demonstrable cameral deposits; the specimens which Barrande illustrated show calcite in the camerae, but the pattern seems to be one of an inorganic structure, calcite deposited in closed camerae. Others have apparently taken the opposite view, and interpreted the camerae as having organic deposits and the siphuncle as being empty. *(See* Sweet in Teichert et al., 1964.) The matter can only be settled by restudy of the species.*

Incomplete knowledge and varied interpretations of species and genera leave any classification of the Micheloceratida a matter in which confusingly different conclusions may result, and material by which such confusion could be eliminated is not readily available. The following remarks, combining various recent interpretations, are focused largely upon Sweet (in Teichert et al., 1964), mainly for brevity. In that work the Orthoceratida (contracted to Orthocerida, somebody's syntax is showing) is used in place of Michelinoceratida, on the basis of the prospective use of plenary powers of the International Commission of Zoological Nomenclature to validate *Orthoceras* based upon 0. *regulare.* The Orthoceratidae is used for forms with tubular empty siphuncles. It is divided into subfamilies. The Orthoceratinae is used for orthocones with longitudinal internal thickenings of the living chamber, and contains the genera *Orthoceras* and *Bifaveoceras,* which I think would be better treated together as a single genus. Doubtfully assigned is *Ctenoceras.* Noetling (1894) described this genus as having somewhat similar modifications in the living chamber of a shell with annuli. Interiors of the phragmocone have not been described or illustrated. The writer has some reservation as to the organic reality of the structures figured by Noetling, having observed a similar phenomenon in crushed specimens of *Stereospyroceras clintoni* of the Chazy, a genus of the Proteoceratidae. Sweet (1958) has figured as *Ctenoceras* sp. B. a specimen from the lower Chasmops beds of Norway showing a siphuncle with a lining. Whether this is true *Ctenoceras* or not is uncertain; what is clear is that this form is one pertaining to the family Troedssonellidae.

The subfamily Michelinoceratinae is defined as containing forms with tubular empty siphuncles and generally well-developed cameral deposits. Whether *Michelinoceras* has these structures involves matters of interpretation which cannot now be clarified. A few notes may be added on the genera included here. *Arkonoceras* is a slender compressed shell; it has thin cameral deposits apically concentrated and not yet described; no annuli are known in the siphuncle. *Balticoceras,* presumably a shell strongly flattened on one

*This appears as a group or undesignated rank. The endings are those in general use for ordinal groups. I would suggest that Hyatt's contribution to the Zittel—Eastmann textbook suffered from last minute emendations, possibly involving insertion of the Holochoanites, Orthochoanites, etc., which appear as suborders, and possibly involving also downgrading in rank the higher categories of Nautiloidea and Ammonoidea. In any case, there seems little point in recognizingt Orthoceratida and attributing it to Kuhn (1940) Teichert et al., 1964, p. K233) instead of Hyatt (1900).

**Some of Troedsson's original material was made available. With it were some very small apical parts of phragmocones, which reputedly belonged on larger specimens. This may have been so, but they did not fit, and identity with the specimen or even with the species seemed suspect, so they were not sectioned for this study.

* This is not so easy as it might seem. Bohemian material is not widely available; I have found none that I could obtain, and in view of the immense number of species of *Orthoceras* which Barrande described, it is no easy matter to select other than the type material which is certainly assignable to *Orthoceras michelini.*

side, has the siphuncle unknown and no known cameral deposits. I have found shells of this aspect in the Cincinnatian, where they are internal molds of *Orthonybyoceras* the upper surfaces of which have been planned on bedding plane surfaces. I believe the type of *Balticoceras* to be a result of similar inorganic features of preservation. *Bitauniceras* Shimizu and Obata is based upon a long slender shell from the Permian of Timor, with long camerae and a tubular siphuncle. We do not know enough of the phragmocone to even be certain that the apparent absence of cameral and siphonal deposits is real. *Eotripteroceras* is based on a small species of the Chazy, the bottom flat, as in *Allurnettoceras,* and a tubular siphuncle not far from the venter. Oddly, no additional material has since come to light. *Hesperoceras* is an orthocone of quadrate section, presumably compressed, with a small central siphuncle of unknown structure. *Plagiostomoceras* is a slender genus of the Silurian, cameral and siphonal deposits are not known, again only anterior parts of phragmocones have been sectioned, with growth lines sloping conspicuously forward on the antisphonal side of the shell.

Pleurorthoceras is adequately known, having characteristic cameral deposits and as far as is known, an empty siphuncle. *Trematoceras,* known internally only from an apical portion, shows good cameral deposits and presumably an empty siphuncle.

Sinoceras has rather long septal necks, the siphuncle empty, cameral deposits retarded and apically concentrated. It belongs, certainly, with the Orthoceras limestone species in which siphonal deposits are suppressed and cameral deposits retarded.

The subfamily Kionoceratinae is defined on the basis of longitudinal markings. What is not noted is that the Silurian forms show a general uniformity of internal pattern, with faintly expanded segments, annuli and cameral deposits generally apicallv concentrated. Many of the shells are gently curved. Ohioceras owes its apparent shortness to cameral deposits more advanced than usual; they thicken rapidly in camerae near the base of the figured specimen, and thus internal molds present a false aspect of an unusually short shell.

The Leurocycloceratinae is used for annular shells, and in it is placed *Leurocycloceras, Anaspyroceras, Bohemites* (unknown internally), and *Metaspyroceras.* Internally, *Leurocycloceras* seems allied to *Pleurorthoceras,* and it is difficult to reach any conclusions as to the affinities of the other genera.

The Spooceratidae contain the remarkable *Sphooceras,* based upon the truncated 0. truncaturn Barrande. No related species are known.

The Sactorthoceratidae which I proposed is troublesome, largely because *Sactorthoceras* as originally defined contains three distinct stocks: (1) forms with geniculate necks at septal foramena, (2) forms with suborthochoanitic necks and faintly convex segments, (3) forms with tubular but very short segments. We do not know enough of the phragmocones of any of these species to make any pronouncement as to deposits, except that such structures have not yet been observed.

The Lamellorthocereic';-e are a valid family of the Devonian, with tubular siphuncles apparently empty (reasonably long portions of phragmocones are known) and characteristic lamellar cameral deposits.

The Brachycycloceratidae contain shells interpreted as being slender and annular in the young, gibbous in the adult, with moulting of the early part. The interpretation is convincing, but it should be noted that internal structures have been represented only by drawings, and it is uncertain how much of the interpretation is imaginary.

The Geisonoceratidae are defined as a family containing orthocones with tubular siphuncles with annuli and with good cameral deposits. As originally defined, it contained a disparate lot of genera, for some of which cameral: and siphonal deposits were not known. Recognition of the family involves acceptance of the interpretation of *Michelinoceras* as having no annuli in the siphuncle, discussed above. It may be noted that 0. *micromegas,* the type of *Joachimoceras* is illustrated as having small thickenings in the septal foramena which are like those of O. michelini in appearance, yet the two seem to be interpreted in opposite ways. *Striatoceras* and *Protokionoceras* placed here, belong with the kionoceroids. The interior of *Geisonocerina* is inadequately known.

The Dawsonoceratidae combine annuli with short re. cumbent necks and annulated shells. It is unfortunately not evident whether D*awsonocerina,* placed here, possesses such an internal pattern; it would be hard to place the genus anywhere else.

The family Troedssonellidae is here correctly defined; **is** it are placed *Buttsoceras* and *Troedssonella* which belong, but *Glenisteroceras* has thick rings, not a lining, and belongs in the Ellesmeroceratida in the Apocrinoceratidae. We have noted above that *Ctenoceras* as interpreted by Sweet belongs here, though it would probably be better to employ a new generic name.

Flower (1962) described *Engorthoceras* based upon *thoceras wortheni.* Sweet has correctly pointed out there is no such species. The species intended was *Orthoceras wortheni.* As *Engorthoceras* has no standing as of Flower (1962), the genus is here proposed with the characters of that publication but with *Orthoceras winchelli,* as the type. It is the only known genus of the Engorthoceratidae.

The Clinoceratidae begin with *Clinoceras,* of probably Whiterock age (it is cited from the Lasnamägian by Jaanusson), with the derived *Whiteavesites* and *Whitfieldoceras.* No comments are needed concerning the Paraphragmitidae, small annulated shells with siphuncle at first tubular, later of expanded segments. The Offleyoceratidae is a small Silurian family with long septal necks.

Members of the Michelinoceratida in the Whiterock Stage are still only most incompletely known. *Nevadaceras* and *Aethiosolen* seem characteristic of the interval. *Michelinoceras* as broadly employed here has no stratigraphic significance, owing to the present wide range of the genus: We may note the presence of *"Michelinoceras"* here with cameral and siphonal deposits retarded or obliterated, a general stock seemingly particularly widely developed in early post-Canadian strata. An annulated shell of the Troedssonellidae has been found in the Whiterock but is not described here, as more material is now available which may add to the knowledge of the species and the genus.

The Pseudorthocerataceae contain, as there treated, what I believe to be two independent lineages of orthocones in which siphuncle segments develop annuli and are expanded. The first is the Proteoceratidae, which begins in the Ordovician, and shows deposits thickened at the septal foramena. To this lineage belong not only the genera there assigned, but *Orthonybyoceras* and some Silurian genera which Teichert and Glenister assigned to the Pseudorthoceratidae. I would agree that the Mysterioceratidae is a family by itself. Quite a number of recently proposed genera involve such poor illustrations that it is difficult to evaluate them. It may be noted that with the possible exception of *Allanoceras,* which might be allied to *Virgoceras,* and like it should probably be referred to the questionable Geisonoceratidae, there are no demonstrable Pseudorthoceratidae prior to Devonian time, though in the Late Paleozoic, a number of genera have been added as the result of recent investigations.

FAMILY MICHELINOCERATIDAE

Genus MICHELINOCERAS Foerste

As noted in the discussion of the Michelinoceratida, there have been varied interpretations of the structure of *Michelinoceras.* I am employing it here, rather broadly including forms with known annuli and cameral deposits, as well as for forms with deposits retarded to apically unknown parts or suppressed completely. I believe that future work will show forms with tubular siphuncles, annuli of the siphuncle suppressed, and cameral deposits retarded and thus confined apically to be a group particularly characteristic of the Whiterock and Chazy in North America and the upper Vaginatum limestone, Aseri, and Lasnamägian in the Baltic. Separation of such forms generically is desirable, but at the present time we have so many inadequately known species that proposal of a new name for such forms would probably cause more confusion than it would eliminate.

Michelinoceras toquimense Flower, n. sp.

Pl. 24, fig. 1-5

This is a small slender orthocone, some specimens showing irregular curvature, subcircular, apparently smooth externally, slender, with long camerae strongly curved septa, a small tubular siphuncle slightly eccentric, regarded as probably ventrad of the center of the siphuncle. The holotype shows a phragmocone of 64 mm expanding from 4.5 to 9.0 mm; apically a camera is 3.5 mm long, the siphuncle lies 1.2 mm from the venter, is 1.0 mm across, and 3.8 mm from the dorsum. Adorally the siphuncle is 1.5 mm from the venter, 1.2 mm across, and 6.3 mm from the dorsum in a camera 4.5 mm long. Septa are deeply curved, depth equal to more than half the length of the camera. Camerae average two in a length equal to the adoral shell diameter. There is calcite in camerae and siphuncle which shows no trace of any original siphonal or cameral deposits. The apical part of the specimen is gently exogastric.

A paratype showing less definite curvature and poorer preservation of the interior expands from 5 to II mm in a length of 6o mm; the interior is more poorly preserved, but proportions of camerae and siphuncle are similar. The exterior shows an irregular form as shown in our figure. A second paratype expands from 4 to 7 mm in a length of 4o mm; the surface shown is a natural longitudinal break.

Discusson.—This is a small species, from the size limits of our several specimens of somewhat irregular form, but characterized by gentle expansion and proportions of the septa and siphuncle.

The holotype, two paratypes, and several smaller fragments, are all from a calcarenite in the *Nileus* beds (assaphid beds of Kay) the lower exposed part of the Antelope Valley limestone of Ikes Canyon, Toquima Range, Nevada, roughly 112 feet below the thicker bedded yellow weathering layers with abundant *Orthambonites ininusculus.* The types are in the collection of the writer, holotvpe no. 1148, paratypes no. 1149, 1150.

*Michelinoceras(?)*sp.

Pl. 8, fig. 2

Under this designation is figured, x 1, a living chamber of a small smooth orthocone from the Sponge bed of the Antelope Valley limestone of Ikes Canyon. Internal structure is unknown, and consequently the generic position is uncertain. There is a small subcentral siphuncle. Such shells are surprisingly scarce in the Ikes Canyon section; neither are they abundant in the Whiterock beds of western Utah. They are abundant in the reef beds of Meikeljohn Peak, Nevada, but this material is vet unworked, though extensive collections are in the process of preparation. The figured specimen is no. 28787 in the collections of the American Museum of Natural History, and is from material submitted for study by Dr. G. Marshall Kay.

Genus AETHIOSOLEN Flower, n. gen.

Genotype: *Aethiosolen whittingtoni* Flower

This genus is erected for orthocones with annuli, a small central tubular siphuncle, no known cameral or siphonal deposits. As originally conceived, it was restricted to rather rapidly expanding forms of conical aspect, like *A. whiffingtoni* and *A. priamus* (Billings), and to forms with fine transverse markings. Such species, however, are connected on one extreme with (I) more slender forms, some with fine transverse markings, and (2) others which lack any fine markings. On the other extreme, the conical Newfoundland species approach and possibly merge with more conical forms, with only faint annuli or nearly smooth, including *Orthoceras* conicum Hisinger, for which Troedsson indicated his intention of erecting a genus to be called *Conorthoceras.* Future work may well indicate the desirability of recognizing three genera here, but I am uncertain, from material on hand, that such a separation could be made clearly.

Two of the species described here, *A. kayi* and *A. cylindricus,* were first referred in manuscript to *Anaspyroceras;* but additional material has failed to produce evidence of longitudinal markings which characterize this genus.

Aethiosolen includes annulated orthocones with transverse fine markings or none. As now used, it may be subject to closer restriction. Oddly, it is a genus which is common to the Table Head limestone, the Oil Creek limestone, and occurs in western Utah in the Ibex region in lower zone N of Hintze, and may extend higher. Two of the species here described are from the sponge beds of Ikes Canyon.

Aethiosolen whittingtoni Flower, n. sp.
P1. 13, fig. 5-7; Pl. 14, fig. 8, 9

This is an essentially straight shell with low rather broad rounded annuli essentially transverse, with I mm greater than the height, a subcentral siphuncle of segments nearly as broad as long, very slightly constricted at the septal foramena, subcentral, without certain organic deposits; camerae with episeptal deposits.

The holotype (L/8/477) is a portion of a phragmocone with a maximum length of *65* mm, increasing in 5o mm from II and 12 to 21 and 22 mm. Annuli are rounded, rather broad, low, spaced 4.5 in a length equal to the adoral shell width of 20 mm; four in a similar length basally. Sutures are transverse, spaced so as to fall in the inter-spaces between annuli. Septa show curved depth equal adorally to one third the length of a camera. The siphuncle segments are short and broad, 4.5 mm long adorally, 4.2 mm wide, faintly contracted at the septa] foramena, but with outline between foramina essentially straight. The apical part of the siphuncle is filled with calcite which terminates adorally in a forward projecting rounded lobe, suggesting possibly (but not conclusively) a section through a ventral rod such as is possessed by some Baltoceratidae. Calcite in the apical camerae obscures septa and possible cameral deposits.

A paratype (L/3/95) is a portion of phragmocone 4o mm long expanding from an estimated 1 o to 17 mm. Again 4.5 annuli occupy a length equal to the adoral shell width, the specimen, cut longitudinally horizontally, shows 12 camerae. Episeptal deposits, thin adorallv. are thickened rapidly apically, somewhat compounded in the section with inorganic calcite. The subtubular siphuncle, very faintly constricted at the septal foramina, contains calcite, with some considerable replacement, but original organic structures are not clearly evident.

A second paratype (L/8/10) is a small fragment of an early portion of the shell, increasing from 7 to Io mm in 20 mm. Here three camerae occupy a length equal to the adoral shell width, the siphuncle segments are faintly fusiform in outline. Again episeptal deposits are evident, calcite is present in the siphuncle, but no pattern of organic structures is evident there. Again, septa are spaced with the annuli, sutures lying in the interspaces.

Discussion.—This is a conical essentially straight shell with rather broadly rounded annuli, distinguished from all but *Aethiosolen conicum* by the generic characters, and separated from that species by the slender form, straighter shell, more broad rounding of the annuli.

Types.—Holotype and two paratvpes Museum of Comparative Zoology.

Occurrence.—From the Table Head beds of Newfoundland. Holotype—L/8/477; paratypes L/3/95, L/8/10.

Aethiosolen priamus (Billings)
Pl. 13, fig. 1-4

Orthoceras Priamus Billings, 1865, Geol. Surv. Canada, Pal. Foss, vol. 1, p. 253, fig. 239.

Of this form, only a single specimen is available for description. It is a conically expanding shell, 65 mm long, expanding from 8 and 9 mm to 24 and 25 mm in 50 mm; the anterior end broken and incomplete. Annuli are low, rounded, rather narrow with broader concave interspaces, ranging from 3 to 5 mm from crest to crest; there are four annuli apically in a length equal to an adoral shell height of 15 mm, and five in an adoral shell height of 24 mm. The shell is very faintly curved, the annuli slope slightly apicad from the concave to the convex side. Sutures are straight, lying in the interspaces between annuli. The nine camerae occupy the basal 30 mm, increasing in length from 3 to 4 mm. The siphuncle is subcentral. The specimen was not sectioned to ascertain the siphuncle segments.

Discussion.—This form, which expands with an apical angle of about 17°, is more rapidly expanding than *A. whittingtoni,* slightly curved, has annuli low, somewhat narrow, with broad concave interspaces. The proportions distinguish the two species readily.

Holotype.—Museum of Comparative Zoology, Harvard University.

Occurrence.—From the Table Head beds of Newfoundland. L/2/3.

Aethiosolen kayi Flower, n. sp.
Pl. 23, fig. 9-11

This species is based upon a small portion evidently from the adoral part of a phragmocone. The type is slightly distorted, increasing from 29 and 38 mm to 35 and 44 mm in a length of 45 mm, and shows seven low rather narrowly rounded annuli separated by broader concave interspaces. Annuli average 6 mm apart, and there are five interspaces in a length equal to the adoral shell height. The siphuncle is tubular, 5 mm across, 7 mm from one side, the presumed venter, and 21 mm from the other at the adoral end of the specimen. Calcite fills the camerae, and matrix fills the siphuncle. There is no indication of either cameral or siphonal deposits. The shell surface is not preserved in detail, but there is a suggestion in a faint roughness on the annuli of longitudinal markings.

Holotype.—Columbia Univ. no. 28784, from the sponge beds of the Antelope Valley limestone, from Yellow Gulch, one half mile above its mouth, one half mile north of Ikes Canyon, Toquima Range, Nevada.

Aethiosolen cylindricus Flower, n. sp.
Pl. 8, fig. 1; Pl. 23, fig. 8, 16

The type of this species is a basal portion of a living chamber, 37 mm long at the wall, 34 mm across at the base where the septum is 9 mm deep and shows a slightly compressed septal foramen 6 x 7 mm, 9 mm from one side, the supposed venter, and 22 mm from the other. The specimen shows four annuli with three interspaces in the length of 29 mm, the specimen widening irregularly adorally from 9 to 11 mm between crests. Also, the interspaces become more concave adorally, and the living chamber was possibly slightly contracted adorally. At the anterior end, in an interspace, the internal mold measured 29 mm across. Both the suture and the annuli are essentially transverse. The specimen is an internal mold, showing none of the fine surface features. A second slightly crushed specimen, somewhat weathered, is figured from the north end of the Ely Springs Range; it agrees in general with the holotype in size, aspect and also in spacing of the annuli.

This form and *A. kayi* occur together, but the species may be readily distinguished. The type of *A. cylindricus* is evidently a mature living chamber from the slight adoral contraction and the adoral widening of the spacing of the annuli, but it represents a shell of somewhat smaller diameter than the portion of phragmocone by which *A. kayi* is represented; that species evidently attains maturity at a considerably larger diameter, and at stages commensurate with *cylindricus* shows a shell which is normally gently expanding, and in which annuli are considerably more closely spaced.

Types.—Holotype, collection of the writer no. 378, from the sponge beds of the Pogonip group, Ikes Canyon. Collected by Dr. J. Lee Adams. The paratype, from the north end of the Ely Springs Range, is in the U.S. National Museum. This association has been discussed in the introduction.

Genus NEVADACERAS Flower, n. gen.

Genotype: *Nevadaceras conicum* Flower, n. sp.

This genus, erected for a single Whiterock species, consists of large conically expanding compressed orthocones, sutures sloping somewhat forward from dorsum to venter, the tubular siphuncle about half way between the center and the venter. Early portions of the phragmocone which might show deposits in siphuncle or camerae are yet unknown. Likewise, the mature living chamber is unknown, so it is uncertain whether it is conical as is the phragmocone, more slender, or even slightly contracted. Oddly, no genus has been erected for conically expanding compressed Michelinoceratidae with tubular siphuncles between the center and venter. *Mesnaquaceras* is similarly compressed but the shell has low annuli and is of the aspect of "*Cycloceras*;" sutures are straight and transverse; annular deposits occur in the siphuncle, which is not strictly tubular, and cameral deposits seem concentrated on the antisiphonal side, suggesting that possibly the siphuncle is dorsal; the two genera are not at all close in general aspect.

Nevadaceras conicum Flower, n. sp.

Pl. 7, fig. 7-10

This is a straight cephalopod of compressed section, fairly rapid conical expansion, and a tubular siphuncle well removed from the venter, of the aspect of the Michelinoceratidae. The one species is known from a single fragment of a phragmocone expanding from 31 and 42 mm to 46 and 55 mm in the anterior length of 60 mm; not including an apical portion which is broken obliquely. The cross section is compressed, the dorsum considerably more broadly rounded than the venter. Sutures are distant, rather irregular in spacing, the four camerae varying in depth from 13 to 16 mm. The septa are very deep, the anterior one 25 mm deep in a shell 46 to 55 mm. The siphuncle is tubular, orthochoanitic, necks parallel to shell axis and about one sixth the length of the segment. The siphuncle is 6 mm across and is removed from the venter by 13 mm apically and 19 mm adorally. No deposits are apparent in either siphuncle or camerae.

Sutures are oblique, rising to a saddle on the venter, but sloping gently apicad across the sides, and without the dorsal saddle that one would expect in a shell of such strongly compressed section.

Discussion.—No genus has been defined for a member of the Michelinoceratida which is compressed and conically expanding with a tubular siphuncle between the center and venter. Unfortunately, our single fragment leaves us in doubt as to some crucial characters of this form, the nature of the deposits in the earlier part of the phragmocone, and whether the living chamber is simple or whether it shows some marked modification at maturity. As yet, no other species with these characters has come my attention. *O. conicum* Hisinger is strongly striate externally and is not strongly compressed. Other species from the Othoceras limestone, where one might hope that similar things might be found, are not closely comparable.

Type.—U.S. National Museum.

Occurrence.—From the Pogonip group, "limestone above the Deepkill graptolite horizon," Pablo Canyon, Tonopah Quadrangle, Nevada. A portion of a living chamber of this species has been found in the sponge beds of the Antelope Valley of Ikes Canyon, Toquima Range, Nevada. It is too poor to deserve illustration.

COILED NAUTILOIDS

The Tarphyceratida begin with the cvrtoconic Bassleroceratidae, exogastric cyrotocones with ventral tubular siphuncles with thick, layered rings. They are known only in the Middle and Upper Canadian. From them developed the coiled Tarphyceratidae, with similar ventral siphuncles, which *may* become central secondarily; this group also is confined to the Middle and Upper Canadian. Appearing in the Jeffersonian, but more widely developed in the Cassinian is the family Trocholitadae, in which the siphuncle assumes a dorsal position, though it remains ventral in part of the first whorl, at least in the older genera. This family continues on into the Ordovician and Silurian, and two genera here described characterize the Whiterock, *Litoceras* and *Plectolites.* Sweet (1958) has shown that the Lituitidae belong to the Tarphyceratida; they reputedly emerge in the Late Canadian and extend well up into the Ordovician, but are definitely known mainly in the Baltic region, extending, oddly, into central China, but not into North America.

Emerging from the Tarphyceratida is the order Barrandeoceratida, coiled genera beginning in the Chazy, differing from the Tarphyceratida in their thin homogeneous rings. The Chazy has yielded two genera with ventral siphuncles, *Plectoceras,* and *Avilionella,* assigned to the Plectoceratidae, and two with central siphuncles, *Barrandeoceras* and *Centrocyrtoceras,* with subcentral siphuncles assigned to the Barrandeoceratidae. Reasonably, *Plectoceras may* be developed from *Campbelloceras* of the Tarphyceratidae by thinning of the thick rings to thin homogeneous structures. Oddly, *Plectoceras is* to be expected in Whiterock faunas. Two species here described were at first assigned to this genus tentatively, but assignment could not be proved, as internal structures were destroyed. Subsequent finds revealed the fact that *Plectolites* approaches these species very closely in section, rate of expansion and general aspect, and in the light of such species not all of which are described here, the assignment of these more imperfectly known species to *Plectolites* is justified, while we have no basis, in terms of known species of equivalent age, to support their assignment to *Plectoceras.*

A last genus, *Crenuloceras, is* a large exogastric shell, cyrtoconic or gyroconic, rapidly expanding adorally, with a frilled surface like that of the much smaller *Zitteloceras.* It is imperfectly known, and its assignment in terms of proposed families and even orders is consequently yet uncertain. It is included here as it resembles the coiled genera more closely than any other contemporaneous forms.

ORDER TARPHYCERATI DA
Family TROCHOLITIDAE
Genus LITOCERAS Hyatt

Genotype: *Nautilus whiteavesi H*vatt

Litoceras Hyatt, 1883, Boston Soc. Nat. Hist., Proc., vol. 22 p. z68.
---- Hyatt, 1894, Amer. Phil. Soc., Proc., vol. 32, p. 474
----Whiteaves, 1898, Ottawa Naturalist, vol. 12, p. 121.
----Ulrich, Foerste, Miller and Furnish, 1942, Geol. Soc. Amer., Special Papers, no. 37, p. 77.

Litoceras is here recognized as a trocholitid in which whorls are rapidly enlarging, developing a nephritic whorl, broader than high, at the end of the first volution, where the siphuncle, ventral initially, becomes dorsal by the completion of the second volution. Early whorls are quite rapidly enlarging, producing a rather stout-w horled shell. At maturity the living chamber may become free. Internal molds are commonly smooth, with straight transverse sutures, or faint ventral saddles may develop. The shell surface shows growth lines, sloping apicad from the umbilical shoulder to the hyponomic sinus, growth lines may become fasciculate, and costae may develop which are not, however, prominent, and are not ordinarily evident on the internal mold.

Discussion.—There has been much confusion as to the scope and range of *Litoceras,* which is even not now completely removed, as it depends upon restudy of a series of species from Newfoundland, and apparently all of the types cannot be identified with certainty. Hyatt based his genus on *Nautilus versutus* Billings, sp. in 1883. In 1894 he figured some sections, discussed some species and stated that the specimen he had in mind in describing the genus was not true *L. versutus,* and he coined for it the name of *Litoceras whiteavesi.* Whiteaves, 1898, asserted that Hyatt was incorrect in this assumption, and that the specimens he saw involved the true type of *N. versutus.* Ulrich, Foerste, and Miller and Furnish (1942) overlooked Whiteaves' discussion, accept as the type of *Litoceras, L. whiteavesi;* this is eminently proper, for Hyatt definitely indicated that the genus was based upon a specimen attributed to this species, and not necessarily the true species.

U.F.M. and F. (1932), have assigned species to *Litoceras* which are clearly both from the Table Head, division L and from the St. George beds, division H. It is not, however, certain that these species all pertain to *Litoceras,* some remain poorly known, most remain poorly illustrated, and indeed, the more recent illustrations fail to demonstrate the features of *Litoceras,* as originally defined, in at least those species which are certainly Canadian in age.

The identity of the genus has thus been a source of confusion for a long time; the writer had fully expected to find *Litoceras* a genus ranging from the Late Canadian into the Whiterock, but late Canadian species which, from general proportions and exposed weathered sections were at first believed to represent *Litoceras,* proved to belong elsewhere.

As here employed, *Litoceras* fits Hyatt's description and his diagrams of the cross section of 1894. It is believed to be confined to the Whiterock Table Head limestone in Newfoundland. We have one poor specimen representing the genus from either the Joins or Oil Creek limestones of Oklahoma. In western Utah the genus appears, though it is rare, low in zone N in the Kanosh shale; it may be represented by some fragmentary specimens also in the overlying Lehman limestone, not as yet studied thoroughly. The genus appears in Ikes Canyon in the Toquima range low in the asaphid beds, is better represented in the sponge beds, but has not been found higher in the section. At Meikeljohn Peak, it occurs in the reef beds which are low in the Antelope Valley limestone. From the region of the Nevada Test Site has come one specimen, differing from the others in the more gently enlarging later whorls, which is apparently from the uppermost beds of the *Palliseria* zone. The genus, as here redefined, appears one characteristic of the Whiterock interval, and common to Nevada, western Utah, southern Oklahoma and Newfoundland.

In the confusion surrounding the Newfoundland species, it may be noted that in our present concept of *Litoceras,* the figure of *L. versutum* shows features suggesting that it is a separate genus, notably the extremely close septa. From the only available figure of *L. calciferum,* also from the St. George beds, it is not evident where the siphuncle lies, and thus whether or not it's a trocholitid, or whether it is possibly a *Pionoceras.* Should the above conclusions be incorrect, a new generic name would be required for the specimens here assigned to *Litoceras;* their faunal and stratigraphic significance would remain unchanged.

Litoceras adamsi Flower, n. sp.

Pl. 27, fig. 5, 6, 9-11; Pls. 28, 29 (entire)

This is a large *Litoceras,* specimens occurring up to 110 mm across. Except in the early whorl and a half, the whorls are broadly rounded laterally, well arched ventrally, and show a broad, well-rounded impressed zone dorsally. Lateral expansion is fairly rapid throughout growth up to the last quarter volution, where it is reduced rather sharply. The sutures are straight and transverse, and in the last whorl average 10-11 mm in length; finally, a series of greatly shortened gerontic camerae develop. The living chamber, rarely complete, occupies a little more than three eighths of the outer volution; our one mature example shows the ventral profile near its aperture slightly irregular, and with a definite preoral thickening of the shell; the feature is reminiscent of mature living chambers of *Agoniatites*. Clearly, there is no freeing of the living chamber in mature shells.

Actual proportions are the real criteria of the species; these matters are shown in the description of the several types, recorded below. It should be noted that in this species there is a general rounding of the venter, as seen in cross section, and this feature together with the deep camerae distinguish the present form from *"Litoceras" versutum* Billings.

"L." calciferum is rather poorly known; it appears to be somewhat similar to the present species in general proportions, but has the sutures sloping forward on the venter, a height-width relationship of the whorl of 25 and 42 mm, with a 3 mm impressed zone, rather less than in our species.

Holotype.—MCZ no. 9402. (Pl. 28, fig. 1-3, 5), is a good internal mold, 92 mm across, showing the whorl near the aperture with a height of 40 mm and a width estimated at 40 mm; in the last quarter volution the shell seems to contract slightly laterally; this may be adventitious, however, a result of slight crushing, weathering or both. The living chamber as preserved is a quarter of a volution, with a height of 37 mm and a width of 50 mm at its base. The three adoral camerae are markedly shortened, occupying a length of 6 mm; the next earlier cameraes 3 mm, the next 7 mm, the next 10 mm, and next earlier quarter volution the camerae average 10-11 mm in length on the venter.

A cross section was taken, nearly horizontal in reference to pl. 28, fig. 2, which is shown in fig. 5. It shows the following measurements at half whorl intervals:

WHORL		IMPRESSED ZONE		
HEIGHT	WIDTH	WIDTH	HEIGHT	DISC
3	7	0	0	5.5
—	(not preserved)		—	—
7	9	4?	2?	14
10	16	10	1.5?	22
15	26	14	3.0	32
22	34	17	5.0	49
33	46	27	7.0	73

Paratype, MCZ no. 9403, Pl. 28, fig. 6, 8-10. This is a somewhat smaller shell, incomplete adorally, and with the anterior part of the living chamber present only dorsolaterally. It is notable in that one side of the living chamber preserves part of the shell surface, showing rugose growth lines and faint vestiges of costae. Anterior camerae average 10-11 mm in length on the venter; the very last camera is shortened only to 9 mm; the specimen obviously is a very slightly earlier growth stage than the holotype. The disc is 92 mm, which would probably be increased to 110 had the ventral part of the anterior end of the living chamber been preserved. Dorsolaterally the living chamber occupies nearly half a volution. At its base the disc is 75 mm, the whorl 5o mm wide and 34 mm high. A cross section shows the following measurements:

WHORL		IMPRESSED ZONE			SIPHUNCLE	
HEIGHT	WIDTH	HEIGHT	WIDTH	DISC	DIAM.	FROM DORSUM
34	50	8	26	75	4	2
21	36	5	20	50	3	2
14	24	2	14	34	2	1
11	18	1.2	12	22	1	0.5
8	12	?	?	14	?	?

The earliest whorl visible in cross section is incomplete on one side, but shows the venter flat, but without an impressed zone. At the next half volution the shell is destroyed, but the disc at the first volution, if it was complete, would be not over 6 mm.

Paratype (MCZ 9404, pl. 27, fig. 9-11); a coiled shell with a disc of 8o mm at the base of the living chamber, whorl 54 mm wide, 4o mm high. Only a quarter of a volution of the living chamber is preserved ventrally, forming a disc of 93 mm, but dorsolaterally the shell is seen continuing for another eighth of a volution. At the base of the living chamber are three abbreviated gerontic camerae occupying a length of 8 mm; ephebic camerae measure 10-11 mm in length on the venter in the last whorl as in other specimens. The shell surface is preserved in part showing growth lines a low obscure costae on the living chamber.

A cross section shows the following dimensions at half-whorl intervals. Early stages, as usual, are incomplete.

WHORL		IMPRESSED ZONE			SIPHLINCLE	
HEIGHT	WIDTH	HEIGHT	WIDTH	DISC	DIAM.	FROM DORSUM
39	54	11	36	6x7	3	82
23	38	7	22	4	2	54
18	29	5	16	?	?	38
11	17	3	12	1	1	25
7	11	1	7	1.2	0.4	16

The shell surface is largely removed, but is present ventrally where the internal mold is contracted near the aperture.

Paratype, RHF no. 373, Pl. 29, figs. 9-I I, is an internal mold in which the living chamber occupies three-eighths of the last volution, increasing from a disc of 8o mm with a whorl 54 mm wide and 36 mm high, to a disc of I I o, with the whorl 4o mm high and an estimated 48 mm wide. The whorl seems to narrow slightly on the anterior part of the living chamber, and the ventral profile shows a shallow concavity, internally, a slight flattening externally beyond which expansion is resumed. A similar variation in shape I have observed in mature living chambers of a few other coiled shells, but it is not common, and is not shown elsewhere in this species. At the base of the living chamber, the last camera is 9 mm, preceding camerae are between 10 and 11 mm in length for the preceding half whorl. The specimen has not attained, in spite of the anterior part of the living chamber, such maturity as to result in the extremely shortened anterior camerae shown by the holotype. A cross section shows the following dimensions at intervals of a half volution:

WHORL		IMPRESSED ZONE			SIPHUNCLE	
HEIGHT	WIDTH	HEIGHT	WIDTH	DISC	DIAM.	DIST. DORSUM
7	5	—	—	10	—	—
8	14	1	7	16	1	0.5
10	17	2	9	24	1	0.7
14	29	4	15	34	2	1.0
25	44	6	18	54	25	2.0
36	52	8	30	82	6	3.0

A paratype of unusual significance is USNM no. 140353 shown in two cross sections, one central and one eccentric, on Pl. 29, figs. 4 and 5. The specimen when complete, was 76 mm across, but most unprepossessing externally. One side was embedded in matrix, the other rather deeply weathered on the outer whorls. A cross section shows in addition to the four sections of the two outer whorls, two more sections showing parts of two additional inner whorls; though these last are incomplete, they are the only indications so far found of such early stages in this species. Measurements are as follows:

WHORL		IMPRESSED ZONE		
(HEIGHT)	WIDTH	(HEIGHT)	WIDTH	DISC
29	44	7	26	62
17	36	3	15	42
12	26	2	12	29
8	14	1	3	19
6	11	—	—	12
4	8	(scarcely concave)		6.5
2	4	(convex)		2.5

The earliest cross section visible must lie in the first half, possibly in the first quarter of a volution; though incomplete, it is plainly convex dorsally. The center and siphuncle are not preserved. The next half whorl is broadly rounded ventrally, strongly rounded on the sides, and the dorsum is essentially flat. A spot of calcite lies against the venter, but its irregularity shows that it is not the true siphuncle; beyond this point, the whorls are typical in proportions of those seen in larger specimens noted above. The siphuncle remains large, separated from the dorusm by less than its own diameter.

A small specimen (USNM no. 140354. loc. 482d) pl. 29, figs. 6-8, consists only of a portion of phragmocone 54 mm across. The strong flattening of the venter, at first thought to indicate a different species, is the result of slight distortion. A cross section, shows four cross sections of whorls, the earlier parts being destroyed. In the last half volution where the shell is 52 mm across, the whorl is 32 mm wide, 22 mm high, with an impressed zone 20 mm wide and 7 mm deep.

Discussion.—Oddly, there have been previously only the scantest illustrations of any good *Litoceras. Hyatt (1894)* presented a very few line drawings, Ulrich, Foerste, Miller, and Furnish illustrate one side of the type of L. *versutum,* and a lateral view, not very helpful, of *L. calciferum.* L. *whiteavesi* Hyatt remains unillustrated. L. versutum is a larger species at maturity than is *L. adamsi,* and shows a marked flattening of the venter in the last half whorl.

Hyatt, who has a way of being right on his observations, reports the siphuncle as ventrocentren in the second whorl, a condition plainly not found in *adamsi.* Sutures are reported as sinuous, and the mature camerae a quarter of an inch long, are a little shorter.

Our several specimens of *L. adamsi* have shown some slight variation in aspect, notably the flattening of the venter shown on Pl. 29, fig. 6, which proves to be the result of slight distortion, and the apparent development of slight ventral saddles in Pl. 27, fig. 5, which proves to be also adventitious, resulting in part from slight ventrolateral weathering. Cross sections were made of most of the specimens, in part in search of early stages, and in part as an aid in comparing the cross sections of the whorls.

Types.—Holotype and two paratypes, Harvard Museum of Comparative Zoology, nos. 9402-9404; paratypes, collection of the writer, material collected and presented by Dr. J. Lee Adams, nos. 373-376; U.S. National Museum nos. 140353-140355.

Occurrence.—All material of known stratigraphic origin is from the sponge beds, zone N of Hintze, of Whiterock age, occuring with *Cybelopsis* and *Kawina billingsi* in an interval of about 150 feet, below the Maclurites–Palliseria–Girvanella zone (Kay, *fide litt.*), which in turn underlies the *Rysostrophia* zone. Types include material from Ikes Canyon, and from Yellow Gulch, one-half mile north of Ikes Canyon in the Toquima Range, Nevada. One figured specimen is from the southern end of the Confusion Range, just west of Ibex, Utah; an unfigured rather poor specimen if from the Mazouka Canyon, Inyo Range, California, some miles up from Independence Railway, 194 station. This last is quite poor, and with more adequate material might prove to be a distinct species; lateral expansion seems less, but the whole specimen is badly distorted.

Litoceras cf. *adamsi*

Pl. 23, fig. 13-15

This is a *Litoceras* of interest for its appearance extremely low in the section of Ikes Canyon; it is from a calcarenite lens estimated at 150 feet below the top of the *Nileus* ("asaphid") beds. The exposed surface shows a somewhat weathered lateral view of a shell 57 mm across at the anterior end of the phragmocone, retaining part of the living chamber, and a maximum diameter across the shell of 69 mm. Sutures, where best shown, are straight and transverse, and camerae show a maximum ventral length of 6 mm. A cross section was made, which shows whorls typical of *Litoceras,* and quite close in proportion to those of *L. adamsi,* though with some indication that the incomplete anterior whorl, involving part of the living chamber (which is apparently not mature) may show a narrower and higher whorl than is typical of that species.

The cross section fails to show the first whorl; the first complete cross section of a whorl is 11 mm wide, 8 mm high, 7 mm, high in the impressed zone, shows a siphuncle 1.2 mm high, 0.5 mm from the dorsum, slightly compressed in section, and was a shell evidently 15 mm across the disc. At the next half whorl the width is 16 mm, the height 12 mm, 9 mm in the impressed zone, the siphuncle is 1.2 mm high, 0.8 mm from the dorsum, and the disc is

24 mm across. At the next half whorl the width is 26 mm, the height 16 mm, 12 mm in the impressed zone, the siphuncle, 2 mm across, is 1 mm from the dorsum, and the disc is 36 mm. Attached to the outer side of the preceding half whorl is part of a succeeding whorl, suggesting a sharp reduction in rate of increase of shell width; a feature not entirely reliable as the cross section is somewhat distorted throughout.

Discussion.—In general this species agrees with less distorted specimens on which *Litoceras adamsi* is based, which are from the sponge beds, some 200-250 feet higher in the section. This specimen seems worthy of particular note, as it occurs in the cephalopod association other members of which are peculiar to the *Nileus* beds, and not known from higher horizons or, as yet at least, from other regions where the lower Antelope Valley limestone is exposed.

Figured specimen.—No. 1152, collection of the writer, from a calcarenite, marked XO, about 150 feet below the top of the *Nileus* beds, the lowest zone of the Antelope Valley limestone exposed in Ikes Canyon, Toquima Range, Nevada.

Litoceras huygenae Flower, n. sp.
Pl. 25, fig. 5, 6

This is a large *Litoceras,* the type is an internal mold of a big coiled shell, 126 mm across, showing the living chamber becoming free in the last preserved quarter volution, beyond a point where the shell is 110 across. The early part of the last whorl shows straight transverse sutures and camerae which increase from 12 mm to 15 mm in length in the first quarter of the last volution, then shorten gradually adorally, the last camera being 11 mm long on the venter. A cross section shows rather poor preservation, but just beyond the base of the living chamber the whorl is 50 mm wide, 36 mm high, 29 mm high in the impressed zone; the whorl is here markedly higher in proportion to the width than in *L. adamsi.* A half whorl is 33 mm wide, 22 mm high, 18 mm at the impressed zone, and a half whorl earlier the whorl is poorly preserved, but shows a width of 22 mm, a height of 18 mm, and, surprisingly, there is no impressed zone apparent. Earlier whorls, if any, are not preserved.

Discussion.—This is a larger species than *L. adamsi,* and one in which the whorl is considerably higher in relation to its width at maturity than in that species.

Type and occurrence.—Holotype 1151, Collection of the writer. From the lower *Nileus* "asaphid" beds of Ikes Canyon, Toquima Range, Nevada. The type was from 2-5 feet above the supposed basal calcarenite of the Antelope Valley limestone, marked XO, presumably about 150 feet below the rubbly limestone with abundant *Orthambonites minusculus.*

Litoceras sp. (Nevada)
Pl. 24, fig. 12, 13

This is a form showing unusually gentle enlargement for the genus, but typical in cross section and in size. The figures specimen is a badly weathered internal mold of a phragmocone which shows a maximum diameter of 75 mm, which was probably 85 or 90 mm when the outer whorls were complete. The cross section shows a first whorl 6 mm wide, 3 mm high, the dorsum flat, the siphuncle slightly ventrad of the center. The next whorl is 12 mm wide, 8 mm high, 7 mm high at the impressed zone which is broad and shallow; the siphuncle is large, and narrowly separated from the venter. The next whorl is 16 mm wide, 18 mm high, 16 mm at the impressed zone; the following whorl, incomplete ventrally and laterally, was probably 3o mm wide when complete, 3o mm high, and 27 mm high at the impressed zone.

Discussion.—This form is of interest as it shows the characters in size and breadth of whorl of *Litoceras,* but is in certain respects and prophetic of the younger genus *Trocholites, in* that the later whorls become higher in proportion to the width than are the early whorls, and are, at maturity, about as high as wide. *Trocholites* differs, however, in several respects; none of the species attain a size comparable to this one and the whorls of the mature shell are more numerous and are much more gently enlarging. Further, in *Trocholites* the siphuncles is not ventrad of the center in the first whorl.

Figured specimen.—U.S. National Museum, from the Antelope Valley limestone, unit I of Johnson and Hibbard (1957) *(see also* Ross, 1964) from the south flank of Red Mountain, I mile northwest of Mercury, Nevada. This unit contains the upper part of the *Palliseria* zone, which probably yielded these specimens, and also younger beds with *Anomalorthis.* It is notable that this appears to be the youngest occurrence of recognizable coiled cephalopods in the Antelope Valley limestone. We have no other forms in Nevada which are certainly above the sponge beds, though it is not impossible that some poorly documented forms assigned to *Plectolites* may be from a similarly high horizon.

Litoceras sp. (Oklahoma)
P1. 24, fig. 14-16

A single badly weathered internal mold of a coiled nautiloid from one mile southwest of Crusher, Oklahoma, supplies the only *Litoceras* so far known from the Simpson group of Oklahoma. The specimen is so weathered on both lateral surfaces that it gives, externally, no real idea of the original cross section, but shows a coiled phragmocone with a disc of 68 mm, with sutures apparently straight and transverse or nearly so. A cross section taken through the center of the shell exposes three whorls. The cross section, best shown for the second whorl, is broad, reniform, the venter broadly arched, sides particularly narrowly rounded ventrolaterally, the dorsum of the second whorl transverse, that of the third deeply concave to receive the second whorl. The siphuncle lies separated from the dorsum by about half its own diameter. The second whorl is 20 mm wide and Io mm high, with the siphuncle 3 mm across, I mm from the dorsum. The next whorl shows a height of 36 mm, the impressed zone is 4.5 mm deep, the siphuncle 6 mm high and 2 mm from the dorsum. The sides of this whorl are weathered, but an original width of 40-45 mm is a reasonable reconstruction, though it may have been still broader.

Figured specimen.—I mile southwest of Crusher, Oklahoma, University of Oklahoma collection; presumably from the Joins formation (Ham, *fide litt.).*

Genus DISCOCERAS Barrande

Genotype: *Clymenia antiquissima* Eichwald

Discoceras Barrande, 1867, Système Silurièn du Centre de la Bohâme, Vol. 2, Céphalopodes, texte 1, p. 95. (Proposed as a subgenus of *Lituites*)
——— Angelin, 1880, Fragmenta Silurica, p. 9.
——— Zittel, 1884, Handb. Paleont., v. 2, p. 377.
——— Remelé, 1886, Zeitschr. d. d. Geol. Gesellschaft, bd. 28, p. 468.
——— Schröder, 1891, Pal. Abhandlungen, von Dames und Kayser, N. G., Bd. 1, heft 4, 1891.
——— Hyatt, 1894, Amer. Phil. Soc., Proc., v. 32, p. 500.
——— Koken, 1896, Die Lietfossilien; Leipzig, p. 51.
——— Miller, S. A., N. A. Geol. and Paleont., 2nd appendix, p. 772.
——— Grabau and Shimer, 1910, North American Index Fossils, v. 2, p. 72.
——— Foerste, 1925, Dennison Univ. Bull., Sci. Lab., Jour., v. 21, p. 58.
——— Foerste, 1929, *Ibid*., v. 24, p. 176.
——— Teichert, 1929, Paleont. Zeitschr., Bd. 12, p. 275, p. 284.
——— Strand, 1933, Norsk Geol. Tiddskr., bd. 14, p. 32 (reduces *Schroederoceras* to synonomy).
——— Miller, Youngquist and Collinson, 1954, Geol. Soc. Amer., Mem. 62, p. 115.
——— Balashof, 1953, Trudy V.N.I.G.R.I., n. s., no. 78, p. 250.
——— Sweet, 1958, Norsk Geol. Tiddskr., bd. 38, h. 1, p. 98.

An excellent survey of the genus is presented by Sweet which need not be repeated except to note that the write] is in complete agreement with the definition and scope of the genus as treated in that work.

Discoceras is, from its dorsal siphuncle, a member of the Trocholitidae. Strand (1933) has figured *a* thinsection of siphuncle showing the thick connecting rings of the Tar phyceratida. The shell is coiled, the beginning rather rapidly expanding, later whorls relatively gently enlarging beyonc the first volution. The shell is strongly costate, sutures arc relatively simple, in general displaying lateral lobes Nvherc the sides are distinctly flattened, but they may be vestigal in broader whorled forms. There is wide variation in the aspect of the shell in cross section, ranging from forms of quadrate whorl, the dorsum slightly excavated, sides flattened anc divergent from dorsum to venter, venter strongly flattened, but among the species there is wide variation with a grout of species at one extreme with whorls markedly quadrate; and at the other a group with the whorls strongly rounded,

The previously described species of *Discoceras* have been reviewed by Strand (1933) and Sweet (1958) and are only listed here:

D. antiquissimum (Eichwald 1840), Upper Ordovician, Esthonia, Sweden, Norway (Gastropod limestone).
D. angulatum (Saemann 1852), Gastropod limestone, Norway.
D. hyatti Strand 1933, Gastropod limestone, Norway.
D. tubulatum (Hyatt 1894), Gastropod limestone, Norway.
D. roemeri Strand 1933, Gastropod limestone, Norway.
D. arcuatum (Lossen 1860), Cephalopod shale, Norway.
D. boreale Sweet 1958, Cephalopod shale, Norway.
D. boreale var. *amplicameratum* Sweet 1958, Ampyx limestone, Norway.
D. depressum Sweet, 1958, Ogygiocaris shale, Norway.
D. fleischeri Sweet, 1958, encrinite ls and gagnum shale, Norway.
D. ievesense (Balashov 1953), Johvils., Esthonia, lower Chasmops limestone, Norway.
D. rarospira (Eichwald 1860) Ordovician, Esthonia, lower Chasmops limestone, Norway.
D. vesenbergense (Balashov 1953) Ordovician, Esthonia.
D. spongistratum (Balashov 1953) Ordovician, Esthonia.
D. gubkovense (Balashov 1953) Ordovician, Esthonia.
D. tammikuense (Balashov 1953) Ordovician, Esthonia.
D. tammikuense var. *chrevitzaense*, Ordovician, Esthonia.
D. danklenmanni (Remelé, 1890) Ordovician, Esthonia.
D. vasalemmense (Balashov 1953) Ordovician, Esthonia.
D. juliformis (Salter in Reed, 1912), Ordovician, Spiti, central Himalaya Region.
D. yunanensis Reed (1917), Ordovician, Yunan, China.
D. eurasiaticum Frech (1911), Western Hupeh, China.
D. (?) sp. Thomas and Teichert (1947), Bengigo, Victoria, Australia.
D canadense (Whiteaves, 1897) Red River of Manitoba; Ordovician of Baffin Island.

The species described below is of Whiterock age, and cannot be separated generically from *Discoceras* on the basis of whorl, section, suture, rate of enlargement or general aspect. The extension of costae as sharp frills may be a difference more apparent than real; it is one apparent here only because the shell can be separated from the matrix by etching; normal separation might obscure similar sharply extended ridges.

While *Discoceras* ranges widely in the European Ordovician, particularly in the Baltic and Scandinavian regions, and certainly species extend high into the Ordovician, current records seem ambiguous as to the age of some of the older species from the old "Orthoceras limestone". If some species are as old as the Platyurus-kalk or Aseri limestone, which the writer regards as a probable Whiterock equivalent, they may well be as old as the species described here.

Discoceras perornatus Flower, n. sp.

Pl. 26, fig. 1-6

This is a shell of two and a quarter whorls, attaining a disc of 80 mm, with the whorl 128 mm wide and 26 mm high at the aperture. Except in the first half whorl, enlargement is gradual, and both height and width of the whorl contract slightly over the anterior 25 mm of the shell. The surface is marked thoroughly by strong costae which slope strongly back from the umbilical shoulders to the venter, forming there a conspicuous hyponomic sinus. The costae are 8 mm apart at the base of the last whorl, increasing to 10 mm at the middle, and 12 mm at the anterior portion, where spacing is slightly irregular. Early whorls show in addition fine threadlike markings parallel to the costae. At the anterior end of the basal quarter of the last whorl, the shell is silicified, and etching has shown the costae to be extremely extended on the venter, where they are slightly crenulate. The surface here shows instead of the transverse markings visible elsewhere fine shallowly excavated longitudinal grooves spaced 5 mm apart. No such markings are apparent on the anterior half of the whorl.

A cross section was made showing the following measurements at half whorl intervals:

WHORL HEIGHT	WHORL WIDTH	IMPRESSED ZONE	DISC
4	3.5	0	7
8	8	1	14
11	9	1	25
16	18	1	40
23	26	4	59

The cross section is slightly restored in the above; there is evident some crushing. Calcite in places is such that the shell wall and the interior of the whorl are not differentiated and the long costae of the venter, which apparently shorten gradually toward the umbilical shoulders, produce odd modifications in the cross section, as can be seen from the illustration. The whorl is rounded, with a slight but conspicuous flattening of the venter in the last whorl; the sides are not conspicuously flattened, and the point of greatest width is not, as in more typical species, at all close to the ventral face. The siphuncle, observed in cross section, is close to the venter, but is not apparent in the first whorl. The septa, well shown in the base of the last whorl, are straight and transverse laterally and ventrally, without lateral lobes. The living chamber, which is apparently complete adorally, comprises about a quarter of the last volution. The slight contraction of the aperture has been noted above. There is no trace of adoral decrease in coiling or freeing of the mature living chamber.

Discussion.—As already noted in the generic discussion the strong costae give this species the aspect of *Discoceras*. It is somewhat atypical in the narrow condition of the early whorls, the broad rounding of the mature whorl. However, it may be that we have here the sort of proterogenetic progress which has been noted in coiled ammonoids; curiously, much of the discussion of the problem which has been somewhat obscured by ardent supporters of either proterogenesis or palingenesis, has obscured that fact that while septa and internal features are commonly palingenetic, ornament and cross section in nautiloids as well as in ammonoids may show proterogenetic trends.

The variations in cross section seem insufficient for separating this form into a genus by itself. Likewise, the extension of the costae into frills seems insufficient; the presence of such frills is, indeed, apparent here largely because the shell was slightly silicified, and the frills could be removed by etching; more usual methods of preparation would not have shown their true nature clearly, and it is by no means certain that other species of *Discoceras* may not be similarly marked.

Type and occurrence.—The unique holotype, Columbia Univ. no. 28782, is from the sponge bed of the Pogonip group, (zone N of Hintze) with *Cybelopsis* and *Kawina billingsi*, 400-450 feet above the base of the Antelope Valley limestone, the total thickness of which is 850 feet in this region, from Yellow Gulch, on the east face of Cooper Mountains, one-half mile above the mouth of the gulch, which is a half-mile north of Ikes Canyon; Toquima Range, Nevada.

Genus PLECTOLITES Flower, n. gen.

Genotype: *Plectolites costatus* Flower, n. sp.

This is a coiled trocholitid, strongly costate, the whorl enlarging rapidly vertically, resulting in shells which in size and general aspect are reminiscent of *Plectoceras*. The siphuncle is dorsal from the first quarter whorl. The whorls in cross section are broad and depressed in the young, but height soon outstrips the width. The cross section is somewhat variable in several species. In *P. costatus* the mature whorls tend to narrow from the umbilical shoulders to the venter, which may be even subangular, but we are including species here in which the whorl is more evenly rounded. There are forms allied, in which the venter is flattened though rather narrow, and others in which the broad low cross section is maintained to a later growth stage; whether these should be included here or whether a new genus should be erected for them is a matter vet to be decided.

I am tentatively referring to this genus two species based upon specimens from the Whiterock of Nevada of considerable size, but which have lost their internal structure. The position of the siphuncle and their assignment position to this genus are an assumption. Originally I had placed both of these species tentatively in *Plectoceras*, but with more material, it has become evident that *Plectolites*, with dorsal siphuncles, may approach these forms closely in general proportions, and we have vet to find demonstrable true *Plectoceras* in the Antelope Valley limestone.

In addition to *P. costatus* of the sponge beds of the Antelope Valley limestone, the two species here tentatively assigned to this genus, one from Whiterock Canyon, one from the north end of the Ely Springs Range of Nevada, it may be noted that the genus is present in the Juab limestone of western Utah, where certainly two additional species occur, in the lower Kanosh, and less distinctly allied forms of broader, lower rounded whorls occur in the middle and upper Kanosh and in the Lehman limestone, also in what appears to be the *Palliseria* zone of central Nevada.

Plectolites costatus Flower, n. sp.

P1.26, fig. 7-to; Pl. 27, fig. 1-8; Pl. 29, fig. 12, 13

The type is a strongly costate shell preserving two and a half whorls, with the dorsal part of the living chamber continuing for a length which would bring the complete shell to between two and three-fourths to three whorls. The present disc is it o mm, the complete restored shell would have been about 128 mm across. Costae mark the surface throughout; they are strong, slope backward from umbilical shoulder to venter, and on the venter they are sharply elevated; from the base of the last whorl to the adoral part, the costae average 12 mm from crest to crest; nowhere are their margins as sharp and narrow as in the associated *Discoceras perornatus*. Interspaces show finer transverse markings parallel to the costae. Septa are not well displayed, but in the first quarter of the last whorl show broad shallow lateral lobes, and were 9-to mm apart on the venter.

A cross section of the shell shows whorls broadly depressed at first, lacking an impressed zone, with the siphuncle dorsal at the earliest observed stage, which is certainly in the first half whorl and probably in the first quarter whorl. In the second whorl a shallow impressed zone develops, which continues throughout, though the anterior part of the living chamber is probably becoming less coiled. In the last whorl the height of the section increases and surpasses the width, a condition which is probably progressively greater in the last quarter whorl, where only the dorsum of the living chamber is preserved.

A cross section shows the following dimensions at half whorl intervals:

WHORL		IMPRESSED ZONE			
WIDTH	HEIGHT	DEPTH	WIDTH	DISC	SIPHUNCLE
7	4	0		(5.5)	1.0
11.5	7	0		11	1.8
16	10	1		21	–
20	15	1.2		38	2.5 askew
34	30.5	1.8	12	47	4.0
30(e)	32	4	18	64	5 (3.5 from dorsum)

From Yellow Gulch, Toquima Range, a distorted living chamber crushed laterally, shows costae somewhat more clearly than those in the anterior part of the holotvpe; they become rather broadly rounded. The living chamber, though crushed, shows the impressed zone the evident greatest width of the shell here in the dorsal third, the narrowing of the elevated venter.

A third specimen, incomplete, and attaining a disc of too mm, shows the costae of the inner whorls clearly, the shallow lateral lobes of the septa, and in cross section, though only the outer whorl and a half are preserved, shows two slightly later stages in the development of the height of the venter and compression of cross section; being 26 mm wide and 29 mm high in the penultimate section, 32 wide and 36 high anteriorly. USNM unnumbered; Ikes Canyon, Sponge bed.

A third paratype represents a somewhat flattened shell, one side embedded in matrix, the other, the figured surface, with the adoral half whorl deeply weathered. A cross section at a disc of 95 mm shows the last half whorl evidently higher than wide, the greatest width near the umbilical shoulder, but evidently somewhat distorted; the height 39 mm, the estimated width 27 mm, with an impressed zone 18 mm wide and 4 mm deep, receiving a previous whorl the dorsal part of which is missing, but showing a width of 19 mm and a height apparently of the same dimension. At the intervening half whorl width and height are 29 mm, subequal, the impressed zone 9 mm wide and 7 mm deep, evidently narrowed by distortion, the specimen is of interest in showing the singular increase in vertical enlargement in the last whorl. Collection of the writer, from the Sponge bed, Ikes Canyon, Toquima Range, collected by Dr. J. Lee Adams.

Discussion.—The development of broad whorls in the young with a narrowing, an outstripping of the width by the height, is characteristic of *Trocholitoceras,* particularly *Trocholitoceras walcotti,* but this species is distinctive in the rapid initial enlargement of the whorls, the failure of the siphuncle to be other than dorsal except possibly in the first quarter whorl, and the development of prominent costae. As yet no congeneric species are known.

All specimens are from the sponge bed of the Pogonip at Ikes Canyon, Toquima Range, Nevada.

Types.—Holotype, Columbia Univ. no. 28783, paratypes, collection of the writer, no. 37, and U.S. National Museum no. 140352. Both specimens are from 400-550 feet above the base of the Antelope Valley limestone, there 85o feet thick, in association with sponges and pliomerids, apparently zone N of Hintze, with *Cylelopsis* and *Kawina billingsi.* From one-half mile above the mouth of Yellow Gulch, one-half mile north of Ikes Canyon, Toquima Range, Nevada (Kay, *fide litt.*)

Plectolites (?) kirki Flower, n. sp.

Pl. 30, fig. 3-5

This is a large coiled shell, represented by a single specimen. It shows a maximum disc of 130 mm, but the anterior part has the venter wanting, and a dorsolateral portion of the aperture is shown which, with the outline projected, is restored as representing a shell extending about 45 degrees farther, with a disc of 160 mm, the last whorl being estimated at 55 mm in height, 50 mm in width, with the greatest width attained on the ventral third of the shell. The exterior indicates one and a half whorls. A cross section was taken, which shows three whorls at half-whorl intervals, surrounding an umbilical perforation 15 mm across; probably this is made abnormally large by destruction of the early whorls. At half whorl intervals the following dimensions are attained:

WHORL WIDTH	WHORL HEIGHT	IMPRESSED ZONE	DISC
25	21	not evident	25
30	26	not evident	70
52	46	12 w; 9 deep	105

The aperture would lie close to the completion of the next half whorl. In cross section the whorls are broadly rounded; at the earliest stage observed the maximum width is attained ventrad of the center, but the point of greatest width is central in the next half whorl, slightly dorsad of the center in the next half whorl, and there is indication that it lies one-third or less of the distance from the umbilical shoulder toward the venter, near the aperture. It is in the last quarter whorl also that the venter develops a slight flattening; previously it was evenly rounded in cross section.

The surface shows low broad costae which slope markedly apicad from the umbilical shoulder to the venter; costae are broad, low, rather variable in spacing but averaging 10 mm apart on the venter in the last whorl. In earlier portions they are not preserved clearly. No trace remains of septa or siphuncle; consequently the generic affinities of this shell remain uncertain.

Discussion.—This is a large coiled species, quite one of the most impressive from the Ordovician of Nevada. In the absence of the siphuncle of the unique specimen, we are faced with uncertainty as to the position of the species. Trocholitidae known to agree at all closely with the present form in whorl section size and general aspect belong to *Plectolites.*

Type and occurrence.—The type, USNM no. 140356, is from high cliffs, north end of the Ely Springs Range, Highland Peak quadrangle, Nevada. The associated fauna, in particular the presence of ostracodes in some variety, suggests Whiterock rather than Canadian Age (Cooper, *fide litt.,* 1962).

Plectolites(?) perplexus Flower, n. sp.

Pl. 30, fig. 1, 2

This is a rather poor internal mold of a coiled cephalopod, with apparently a large umbilical perforation; about a whorl and a quarter preserved, the whorl elliptical, rather strongly compressed in section, and without an apparent impressed zone. At the apparent completion of the first half whorl the umbilicus is 30 mm across. Apparently the whorl enlarges quite rapidly, in less than a quarter volution, to a height of 10 mm, increases to 16 and 10 mm in the first quarter, 25 and 18 in the next quarter, 31 and 21 in the next quarter. The anterior end of the ventral part of the living chamber shows a whorl 40 mm high, and the shell measures 100 mm across. The sutures appear straight and transverse, camerae are 6 mm long ventrally at the first point at which they can be estimated, and increase to only 7 mm near the base of the living chamber. Though two cross sections were made, one essentially horizontal in reference to Pl. 17, fig. 1, and the other vertical to that one, and cutting the whorl at the base of the same figure, no trace of the siphuncle has been found.

Discussion.—No other shells from the Ordovician of Nevada are closely similar to this one in proportions and aspect. *Plectolites(?) kirki* has whorls as broad as high, with a good impressed zone.

Though this species is assigned to *Plectolites*, it must be noted that the generic assignment is inferrential without knowledge of the siphuncle. In critical inspection of genera of similar aspect, one is faced immediately with the practical problem that while the difference between Plectoceratidae and Tarphyceratidae is a fundamental one, the two families having such different types of rings that they are assigned to different orders, the difference is not one readily demonstrated, and requires exceptionally well preserved material.

Type and occurrence.—The unique holotype is from the *Orthidiella* zone, Whiterock Canyon, Monitor Range, Roberts Mountains quadrangle, Nevada, USNM no. 140355.

ORDER AND FAMILY UNCERTAIN

Genus CRENULOCERAS Flower, n. gen.

Genotype: *Crenuloceras giganteum* Flower, n. sp.

Shell strongly curved, apparently gyroconic when complete, though only the last quarter volution, representing a crushed living chamber, has so far been found. Whorl cross section and features of the phragmocone are unknown. The shell is characterized by closely spaced transverse crenulate raised bands or short frills, very much like those in typical *Zitteloceras*. Possibly ventrolateral nodes or faint costae were developed.

Discussion.—This genus is erected for the single species described below which, while it is inadequately known morphologically, is so unlike anything previously known that a new generic name must be coined for it if it is to be described at all. However, lacking as it does any features of the phragmocone, it is not even possible to prove that it is a cephalopod, a conclusion supported only by its large size and the agreement of its shell with that of associated cephalopods in preservation phenomena. Accepting the form as a cephalopod, another embarrassment is faced, for except for its giant size and its apparent gyroconic rather than cyrtoconic form, it could not be distinguished from *Zitteloceras*. On the other hand not only is it a giant in relation to all known members of that genus, but it is stratigraphically isolated. As at present known, *Zitteloceras* is mainly developed in Black River, early Trenton and Richmond faunas, with a single tiny species known from the Chazyan.

Crenuloceras giganteunt Flower, n. sp.

Pl. 23, fig. 12

Under this name is described a shell which was evidently very large and gyroconic when complete. The type is a shell crushed laterally so that the original nature of the cross section is highly uncertain. The shell surface is preserved with amazing fidelity, showing narrow rounded raised transverse ridges which are strongly crenulate, the arrangement of successive round crests and sinuses irregular and only most poorly aligned.

The type has a maximum length of 13o mm, shows a lateral surface of a crushed shell about 38 mm high basally, increasing to 7o mm near the anterior end, and describes an arc of nearly 90 degrees. Nodose expansions of the shell occur on the ventrolateral area, but are so irregular that, from our one specimen, it is not evident whether they are natural or adventitious. Five frills occur anteriorly in a length of 15 mm.

Holotype.—U.S. National Museum

Occurrence.—U.S. National Museum no. 2324. "Highest beds of the Pogonip, Ikes Canyon, Toquimo Range, Nevada." Both Dr. G. A. Cooper and the writer regard this specimen as derived from the sponge beds and certainly not from the Maclurites beds, or from any higher horizons. Lithology is quite distinctive.

ORDER ONCOCERATIDA

This order contains dominantly exogastric cyrtocones and brevicones with ventral siphuncles, slender in the young, but with more or less expanded segments in the adults of all but the simplest family; in several lineages the rings are secondarily thickened into actinosiphonate deposits. The family Graciloceratidae, in which the siphuncle is tubular throughout life, is regarded as the ancestral stock, from which developed the Oncoceratidae and Valcouroceratidae of the Chazyan. As yet, the Whiterock has yielded only the two forms described below, both of which belong in the Graciloceratidae, and one possible member of the Oncoceratidae, known only from our specimen from the top 1 o feet of the Lehman limestone of western Utah, not described at this time.

FAMILY GRACILOCERATIDAE

This family contains slender exogastric cyrtocones with ventral tubular siphuncles composed of moderately short necks and thin homogeneous rings. Flower and Kummel (195o) placed this and the Bassleroceratidae in the order Bassleroceratida, but this small order proved awkward subjectively, and Rower *(in* Flower and Teichert, 1957, p. 138) placed the Bassleroceratidae with the Tarphyceratida and the Graciloceratidae with the Oncoceratida. No changes of phyletic relationships were involved; it was merely a regrouping of families to eliminate one small order. Both the Russian and the American Treatises have placed the Bassleroceratidae with the Ellesmeroceratida, a course which does not seem preferable as it broadens the Ellesmeroceratida beyond definition, and separates the cyrtoconic Bassleroceratidae from their coiled descendants of the Tarphyceratidae. Should such a course be followed consistently, several short-lived coiled lineages should be separated from the Oncoceratida in which they are now and, I think wisely, retained.

Leonardoceras, described below, is possibly the most primitive of the Graciloceratidae, having a shell form much like that of the ancestral *Bassleroceras* of the Canadian. *Ikesoceras* is a more specialized genus by its broad triangular section.

Genus LEONARDOCERAS Flower, n. gen.

Genotype: *Leonardoceras parvum* Flower, n. sp.

This is a slender exogastric cyrtocone, strongly compressed in section, the venter faintly more narrowly rounded than the dorsum. Sutures are closely spaced, show prominent lateral lobes. The siphuncle is extremely small and is close to the venter. The living chamber is short, the length about equal to the height of the shell at the anterior limit of the phragmocone, and is slightly contracted vertically at the aperture, the curvature of the venter being increased slightly. The shell is smooth.

Discussion.—This genus is erected for a species which has much the aspect of a tiny *Bassleroceras,* with unusually close septa, and unusually short living chamber, and one contracted slightly at the mature aperture. The siphuncle is abnormally small and poorly outlined for the Bassleroceratidae, and this genus is believed to have a siphuncle of small tubular segments, with the connecting rings thin and homogeneous; where the rings are thick, as in the Bassleroceratidae, the siphuncle is commonly well preserved, and indeed, may be preserved where septa are destroyed. *Leonardoceras* is regarded as the most primitive of the Graciloceratidae, having apparently the small siphuncle with homogeneous and thin rings which distinguish that family from the Bassleroceratidae, but in form it recalls *Bassleroceras,* which is quite possibly the ancestor of the Graciloceratidae in the Bassleroceratidae.

Leonardoceras parvum Flower, n. sp.

Pl. 24, fig. 7-9

Only the type is known which consists of a living chamber, five attached camerae and ventral fragments of two more camerae. It is, in all 23 mm long, well curved, cyrtoconic, strongly compressed, the venter slightly more narrowly rounded than the dorsum, and sides converging very faintly from the greatest width, in the dorsal third, toward the strongly rounded venter and dorsum. The five camerae show deep lateral lobes, with dorsal and ventral saddles subequal; they average just over 1.5 mm in length on the venter, where the five occupy a length of *7* mm, and a length of 4.5 mm on the dorsum. The last camera is 0.5 mm, materially shorter than the others. The living chamber shows a maximum length of 13 mm, which is reduced to 12 mm on the venter, owing to the ventral saddle, and to to mm on the dorsum. At the base of the five camerae the shell is 12 mm high and *7.5* mm wide; this increases to 13 mm high and 8 mm wide at the base of the living chamber; beyond, the height of the living chamber increases to 14 mm and then, from increased curvature of the ventral profile, is reduced to 13 mm at the aperture. The lateral faces converge most gently from the basal third of the living chamber to the aperture. Part of the aperture is preserved, but it is imperfect; the hyponomic sinus is shallow. The base of the specimen retains parts of two additional camerae which together occupy a length of 3.8 mm ventrolaterally. At the base the siphuncle can be seen; it is small, very faintly compressed 0.8 mm high and 1.2 mm from the venter.

Discussion.—The proportions characterize this species, which resembles a diminutive *Bassleroceras.* Only the type is known, and as yet no other species of the genus are known.

Type and Occurrence.—From the Antelope Valley limestone, Nileus beds (asaphid beds of Kay) about 112 feet below the top of the unit, from the north wall of Ikes Canyon, Toquima Range, Nevada. Collection of the writer no. 1147.

Genus IKESOCERAS

Genotype: *Ikesoceras iksense*

This is a small slender exogastric shell of broadly triangular section, the dorsum flat, the sides subacute, the venter a rounded obtuse angle. The siphuncle is orthocohoantic, tubular, slightly removed from the venter. Sutures describe broad lobes on the dorsum, evenly rounded, and similar lobes on the venter are flattened midventrally. The aperture described a broad shallow dorsal sinus, and is unknown on the ventral side. No surface markings are known.

Discussion.—This shell looks much like a *Tripteroceras* except for the position of the siphuncle, which indicates an orientation, the reverse of that of *Tripertoceras.* We have only the one species represented by two specimens. No closely allied forms are known.

From the exogastric curvature and ventral tubular siphuncle this genus is referred to the Graciloceratidae of the Oncoceratida.

Ikesoceras ikesense Flower, n. sp.

Pl. 23, fig. 1-7

Only two specimens are so far known. The holotype is 44 mm in length with a section at the base broadly triangular, the ventral angle obtuse and actually broadly rounded, the lateral angles narrowly rounded, 22 mm wide and 13 mm high, showing a siphuncle 2 mm from the venter and 2 mm across. Horizontally the shell expands from 22 to 25 mm in width; a corresponding increase in height is suggested, but most of the venter of the living chamber is lost. The shell is gently curved exogastrically. Four camerae occupy the basal 5 mm; the first two are 3 mm long, the last two shortened, suggesting that the specimen was mature. On the dorsum sutures form broad lobes, subacute saddles mark the lateral region, and on the venter a broad lobe is developed, but is extended very slightly forward midventrally. The aperture on the dorsum shows a broad lobe, slightly broader than the pattern of the suture. Ventrally most of the living chamber is lost, and a hyponomic sinus is reasonable but not demonstrable. No trace of surface markings remains.

Type and occurrence.—Holotype, collection of the writer, from the sponge beds of the Antelope Valley limestone, Ikes Canyon, Toquima Range, central Nevada. A second more poorly preserved fragment is from below the main sponge beds and shortly above the asaphid beds, in nodular layers with abundant *Orthambonites minusculus*. Nos. 1137 and 1138, collection of the writer.

ORDER DISCOSORIDA

This order has been revised by Flower and Teichert (1957). The genus *Ruedemannoceras* was then known only from two occurrences, the Chazy of the Champlain Valley and the Murfreesboro limestone of the Tennessee basin. We have since had a fragmentary form from the Camp Nelson limestone of Kentucky. The related *Franklinoceras* formerly known only in the Chazy of the Champlain Valley, essentially a *Ruedemannoceras* of compressed rather than depressed section, has since been recognized in an apparently Chazy fauna, with associated *Proteoceras* of Chazy aspect, in the Seward Peninsula region of Alaska. If, as is believed, from the association with a *Rossoceras,* and occurrence beneath beds yielding *Rhysostrophia,* the present find is to be placed as equivalent with the *Palliseria* zone of the central Nevada sections in the Whiterock Stage, the specimen described below is the oldest of the Discosorida so far recognized. Morphology would suggest that the Ruedemannoceratidae were developed from the Plectronoceratidae of the Upper Cambrian, and are the only lineage thus derived directly, retaining expanded siphuncle segments; other cephalopods developed through the Ellesmeroceratidae. No forms connecting the Plectronoceratidae with the Chazy Ruedemannoceratidae have yet been found in the Canadian. Oddly, we might reasonably expect *Franklinoceras* to be older than *Ruedemannoceras* from its narrow shell section, which is the dominant condition in the older cephalopods.

FAMILY RUEDEMANNOCERATIDAE
Genus RUEDEMANNOCERAS

Ruedemannoceras? sp.
Pl. 15, fig. *5-7*

Of this form we have only a small part of a phragmocone, curved quite strongly apically, the anterior half showing a reduction of curvature but an increase in the rate of expansion. At the base a septum is *7* mm across, *5* mm high; in cross section the venter is more flattened than the dorsum. The septal foramen is central, 0.9 mm wide, o.8 mm high. In a length of 14 mm, the shell becomes 12 mm wide and 10 mm high in section, with the venter and dorsum about equally rounded, the septal foramen 1.5 mm across, circular, 3 mm from the venter, 6 mm from the dorsum. There is indication of expansion of the siphuncle segments, but the details of structure are not shown. The anterior septa are quite flat, and the anterior camera is I mm long.

Discussion.—Though we have here only a rather poorly preserved silicified fragment of a phragmocone, it is of interest as the only indication of the Discosorida in the present faunas. It has the general proportions of *Ruedemannoceras,* and is tentatively assigned to that genus.

Figured specimen.—U.S. National Museum. From USGS locality D1007 from about 300 feet below the top of the Badger Flat limestone, northern Inyo Mountains, Independence Quadrangle, Inyo County, California, California coord., zone 4, E. 2,274,000 ft., N. 575,700 ft. Collected by Dr. Reuben Ross *(see* Ross 1964a, p. C38, C40.)

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PLATES 1-30

WITH EXPLANATIONS

Except where otherwise indicated, all figures are natural size.

PLATE 1

Wutinoceras huygenae Flower, n. sp.

P. 10

1. dorsum
2. lateral; venter at left
3. venter
4. sagittal section
5. anterior, venter below

see also Pl. 6, fig. 11

Holotype, no. 440, collection of the writer.

Cyrtonybyoceras adamsi Flower, n. sp.

P. 12

6. apical
7. ventral
8. lateral, venter on left
9. dorsal
10. sagittal section

see also Pl. 4, fig. 7

Holotype, no. 439, collection of the writer.

Wutinoceras planiseptatum Flower, n. sp.

P. 10

11. cross section at anterior end
12. sagittal section apicad of 11
13. sagittal section; anterior part opposite side of section shown in fig. 12
14. cross section near apical end

see also Pl. 6, fig. 12

All from the *Palliseria* zone of the Antelope Valley limestone
Ikes Canyon, Toquima Range, Nevada.

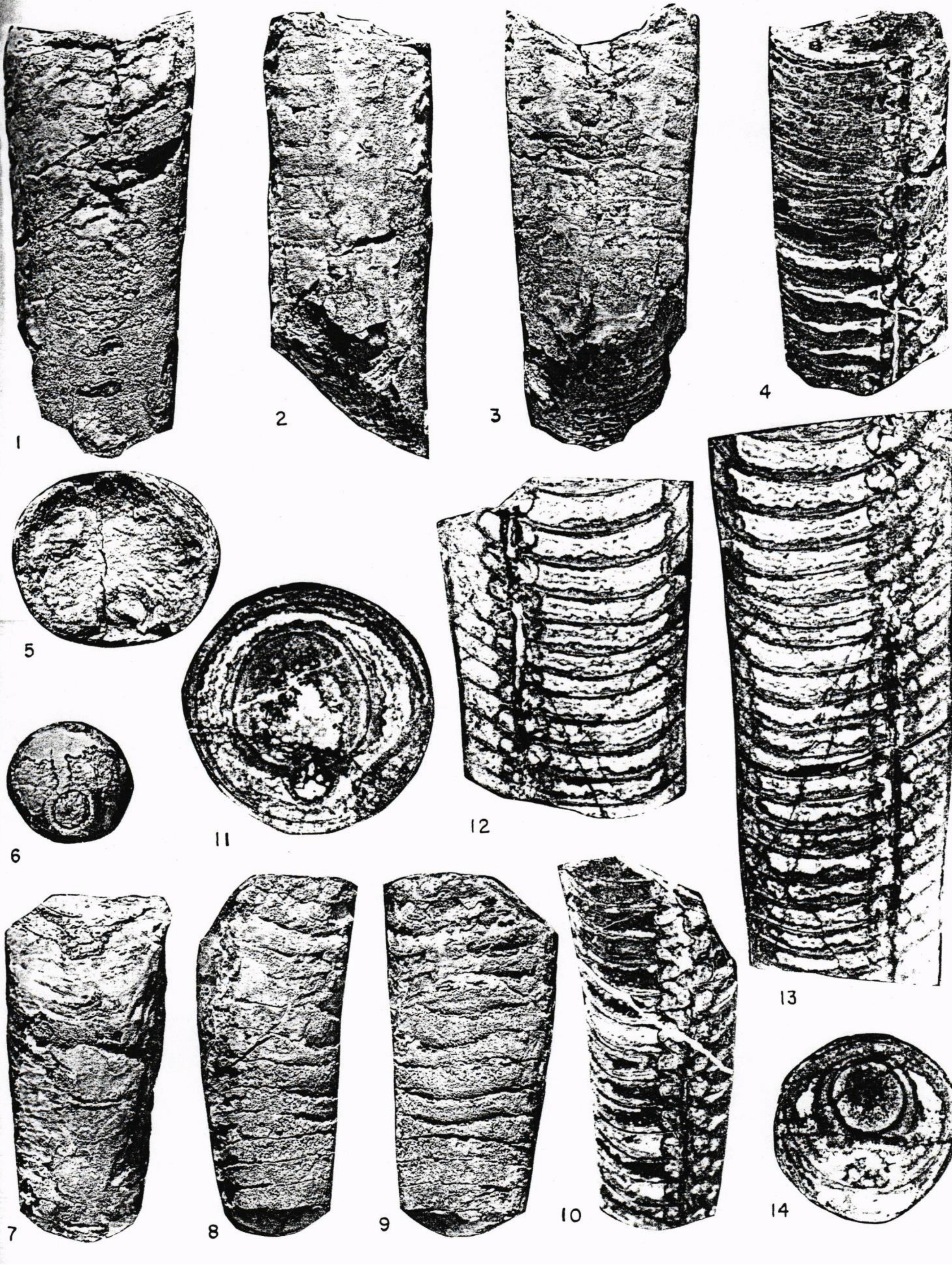
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PLATE 2

Adamsoceras attenuatum Flower, n. sp.

P. 14

1. an oblique longitudinal section; the siphuncle, in the plane of the section at the two ends, is not in the plane in the center, showing slight curvature;

2. two apical siphuncle segments, about ×3.5, prior to grinding to the level shown in fig. 1.

Holotype, no. 438, collection of the writer from the *Palliseria* zone, Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada.

Adamsoceras lehmanense Flower, n. sp.

P. 15

3-7. opposite sides of sagittal section, ×2; the section shows very slight displacement along several joints; 5, exterior; 6, base, an oblique section; 7, longitudinal section, ×1, same surface as fig. 4.

Holotype, from 10 feet below the top of the Lehman limestone, Ibex area, Utah, Brigham Young University collection.

Wutinoceras lobiferum Flower, n. sp.

P. 9

8-9. apical part ×2, prior to grinding to level shown in fig. 9 and in Pl. 3, fig. 7; 9, same part, ground to sagittal plane, ×3.5, showing features of apical segments.

Top 15 feet of the *Palliseria zone,* Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada. No. 437, collection of the writer. See also Pl. 3.

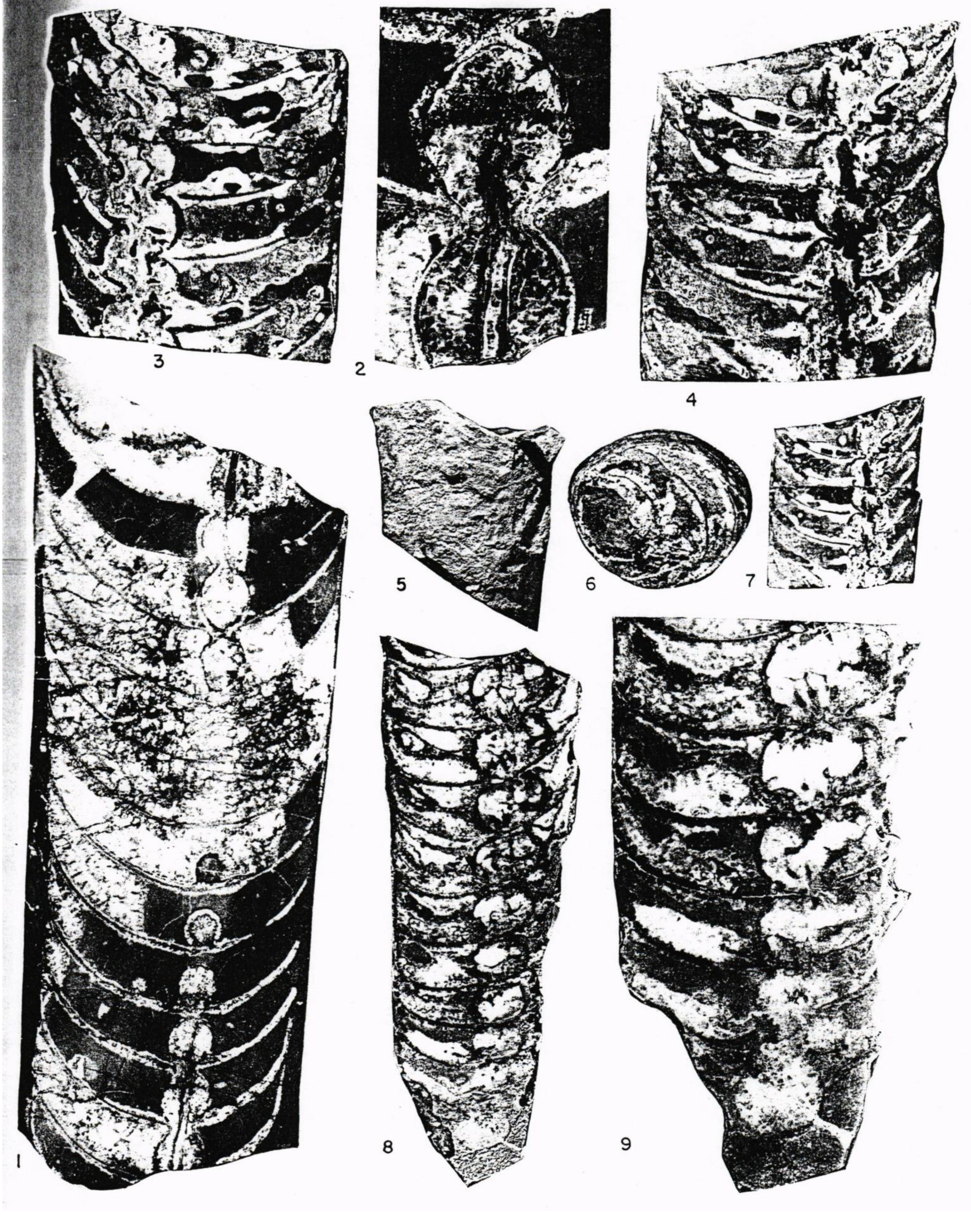
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PLATE 3

Wutinoceras lobiferum Flower, n. sp.

P. 9

1-2. opposing surfaces of a cross section 180 mm from the apical end, showing narrow dorsum and a section showing variation in the size of the siphuncle, depending on the position of the cut

3. break along septum at the position of the break in fig. 7

4. ventral view

5. lateral view, venter at left

6. dorsal view

7. sagittal section; the two parts were ground separately and the planes are not quite parallel

8-9. progressively ground sections, approaching the central section, shown in fig. 7, of the apical part of the adoral piece of fig. 7

see also Pl. 2, fig. 8-9

Top 15 feet of *Palliseria* zone, Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada. Holotype, no. 437, collection of the author.


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PLATE 4

Adamsoceras leonardi Flower, n. sp.

P. 14

1. sagittal section $\times 1$, venter at left
2. enlargement of part of siphuncle from fig. 1, $\times 7$, oblique
3. lateral view, venter at left
4. ventral view
5. dorsal view
6. cross section near anterior end, orad of fig. 1

From the upper third of the *Palliseria* zone, Antelope Valley limestone, Meikeljohn Peak, near Beatty, Nevada. Holotype, no. 1142, collection of the writer.

Cyrtonybyoceras adamsi Flower n. sp.

P. 12

7. Enlargement of apical part of siphuncle of holotype, $\times 9$, showing details of form of segments. Note variation of brims on the dorsal side, to the left. See Pl. 1, fig. 6-10.

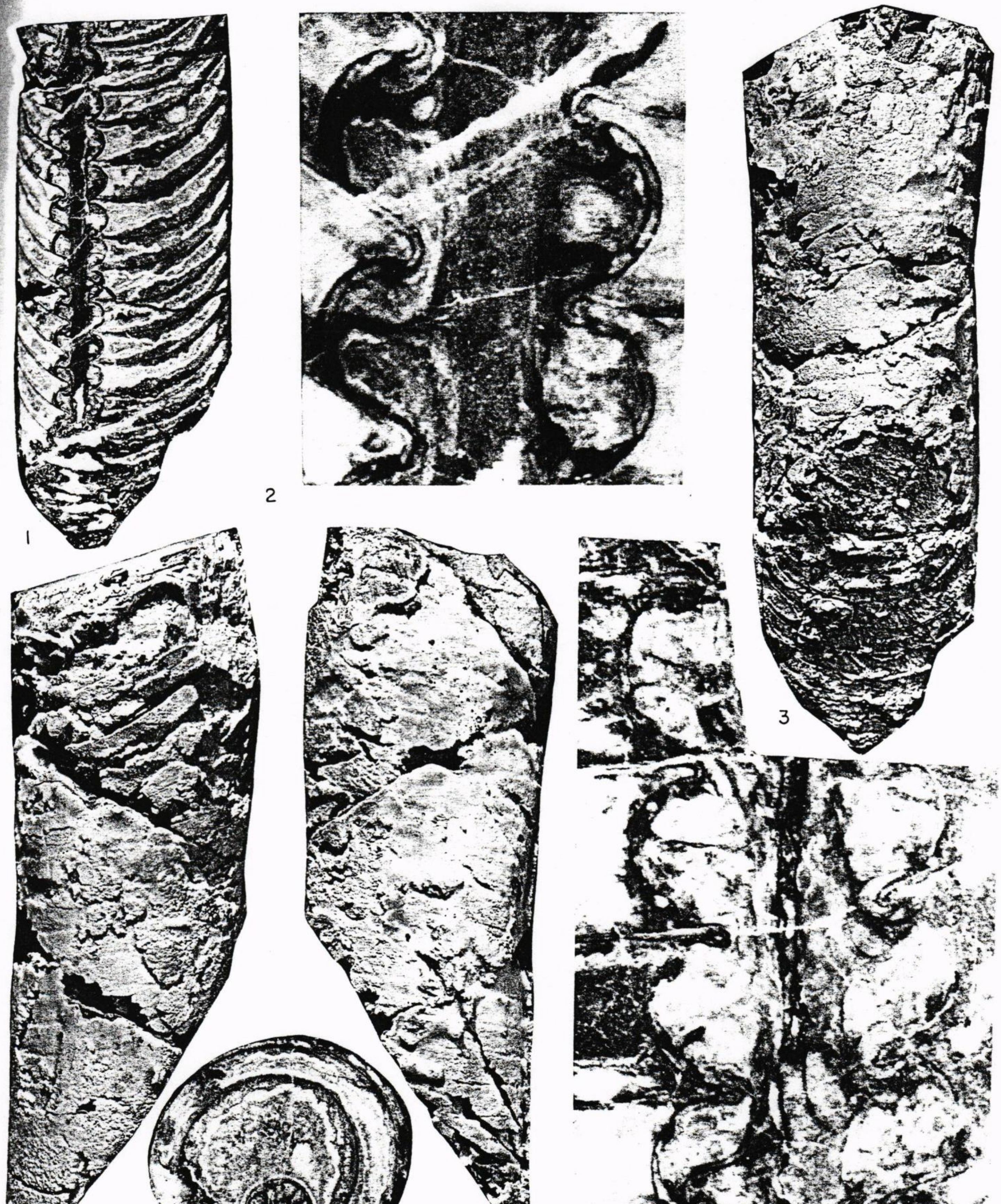
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PLATE 5

Wutinoceras margaretae Flower, n. sp.

P. 10

1-5. opposite sides of a sagittal section; fig. 1 shows a greater length and an eccentric cut through the siphuncle; fig. 2 shows a shorter central section through the siphuncle; 3, anterior end, showing cross section; 4, enlargement, about ×7, of anterior part of siphuncle, showing variation in the form of the septal necks, free in the first segment, broadly tangent in the next two, recumbent in the last; 5, enlargement, ×7, of part near the apical end, showing further erratic variation in the conformation of the segments, which are recumbent apically on the dorsum, nearly so on the venter; adorally, brims are free on the venter, varying erratically on the dorsum. Holotype, no. 1141.

Adamsoceras gracile Flower, n. sp.

P. 13

6. enlargement of part of the siphuncle, ×7, from the section shown on Pl. 7, fig. 11. Holotype, no. 297.

Adamsoceras isabelae Flower

P. 13

7. enlargement, ×7, of part of the siphuncle showing *Ormoceras*-like necks and proportions of the segments. The section is sagittal, but from the absence of the central canal, not quite central. From the holotype, no. 119.

All are from the Antelope Valley limestone of Ikes Canyon, Toquima Range, Nevada, *W. margaritae* certainly and the others presumably from the *Palliseria* zone.

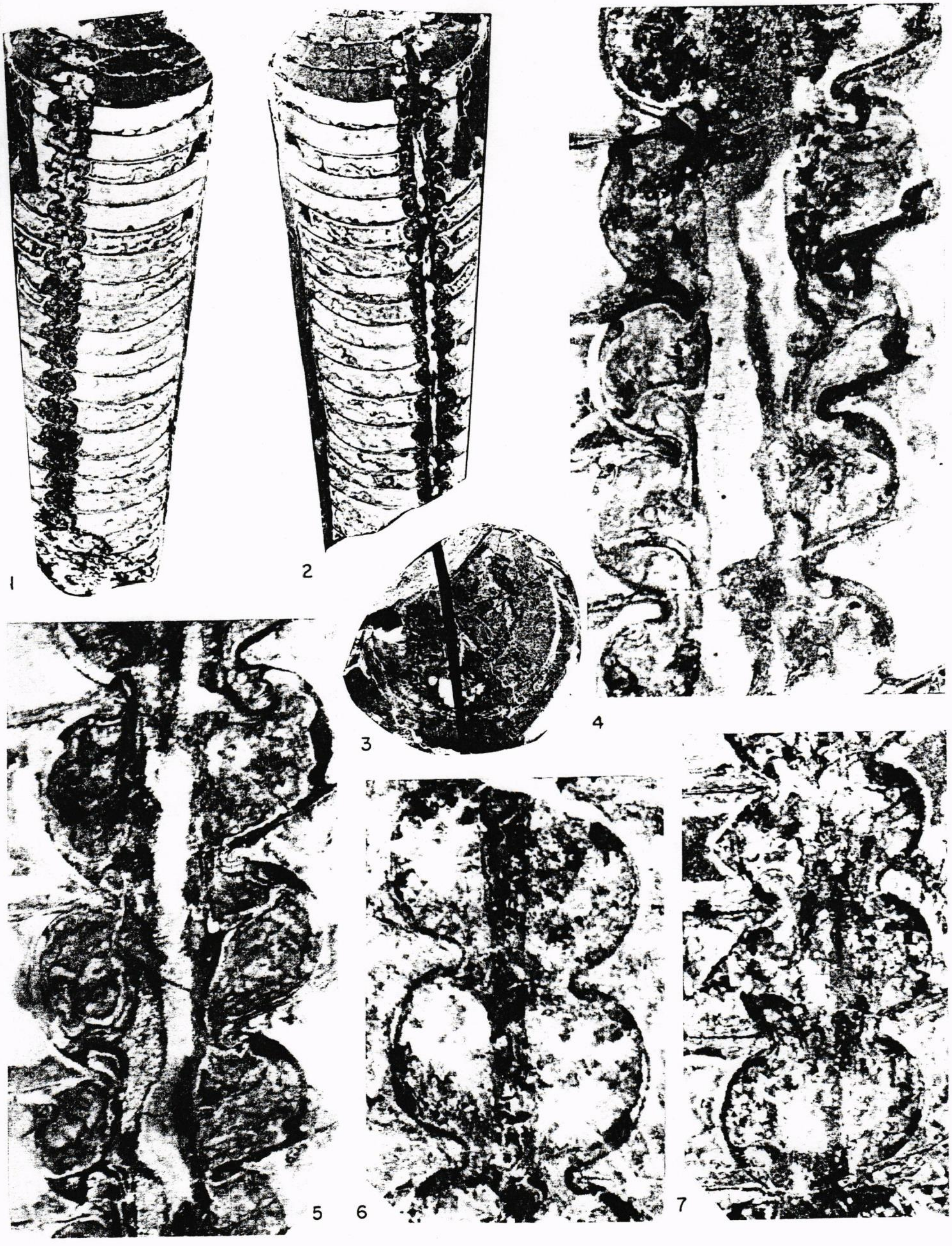
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PLATE 6

Wutinoceras lowelli Flower, n. sp.

P. 11

1-7. opposite sides of section of anterior part; 3-4, similar sections of apical part; about two camerae, crumbled by weathering are missing between these sections; 5, anterior view; 6, anterior view of apical part; 7, apical view.
Holotype, American Museum of Natural History.

Adamsoceras gracile

P. 13

8. anterior view, with venter below; see pl. 5, fig. 6, and pl. 7, fig. 11. Holotype, no. 369.

Wutinoceras minore

P. 11

9. vertical section from apical part of the holotype; see Pl. 11, fig. 8-11.

Adamsoceras cf. *isabelae* Flower

P. 15

10. apical septum, anterior view, of specimen from which thinsections on pl. 7, fig. 6, pl. 8, fig. 3-5, and pl. 9, fig. 1-4 were made

Wutinoceras huygenae

P. 10

11. enlargements of siphuncle, ×6; from section of holotype, no. 440, shown on pl. 1, fig. 4.

Wutinoceras planiseptatum

P. 10

12. enlargement of siphuncle, ×7; holotype, no. 1140, from anterior part of section shown on pl. 1, fig. 13.

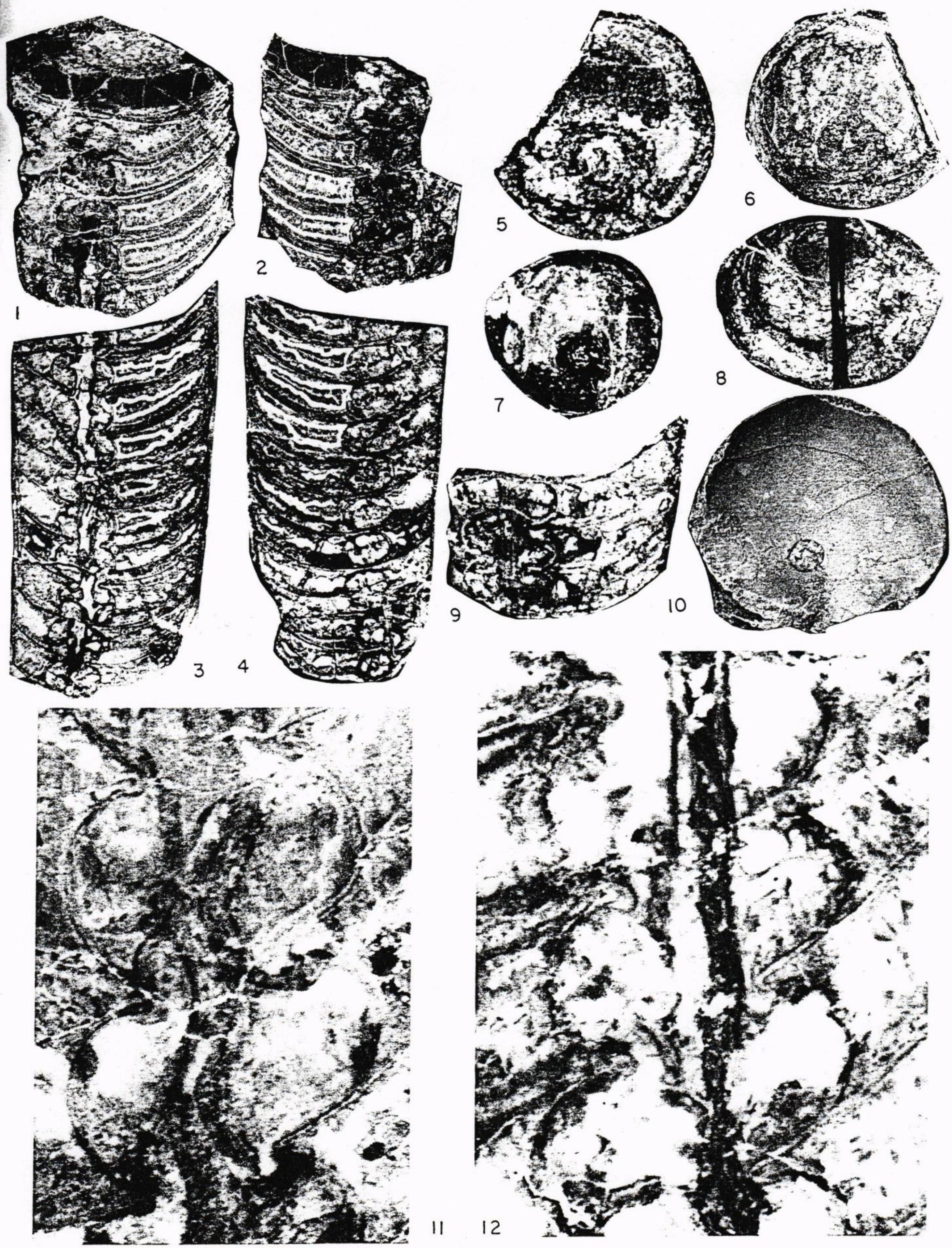
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PLATE 7

Adamsoceras toquimense Flower, n. sp.

P. 15

1. lateral view of part of phragmocone, venter on right, ×1.
2. ventral view, showing exfoliation of the ventrally concentrated cameral deposits, ×1
3. base of the same specimen, ×1, venter above
4. lateral view, ×1, showing sagittal section of all except the basal camera
5. enlargement of siphuncle, ×3, from fig. 4, showing short free necks and reticular radial canals

All from holotype, USNM no. 140169, from above the sponge horizon, Pogonip group (probably high in zone N), ½ mile south of Ikes Canyon, Toquima Range, Nevada.

Adamsoceras cf. *isabelae* Flower

P. 15

6. a vertical longitudinal thinsection through the siphuncle, the venter at the left, ×4; the specimen is traversed by several calcite veins, but exhibits central and parts of radial canals, perispatium, thick connecting rings and septa. See Pl. 6, fig. 10 and Pl. 8, fig. 3-5.

Lower Rysostrophia zone, Pogonip group, Ikes Canyon, Toquima Range, Nevada.

Nevadaceras conicum Flower, n. sp.

P. 43

7. dorsal view ×1
8. vertical section ×1 from ventral half of the shell
9. anterior view, ×1, venter above
10. lateral view, ×1, venter at left, showing expansion and slope of sutures

All from the holotype, USNM, from the Pogonip group "limestone above the Deepkill graptolite horizon," Pablo Canyon, Tonopah quadrangle, Nevada.

Adamsoceras gracile Flower, n. sp.

P. 13

11. vertical section of the holotype, ×1, with the venter at the left, from the upper Pogonip limestone, Ikes Canyon, Toquima Range, Nevada. No. 297, collection of the writer. See also Pl. 5, fig. 6 and Pl. 7, fig. 11.

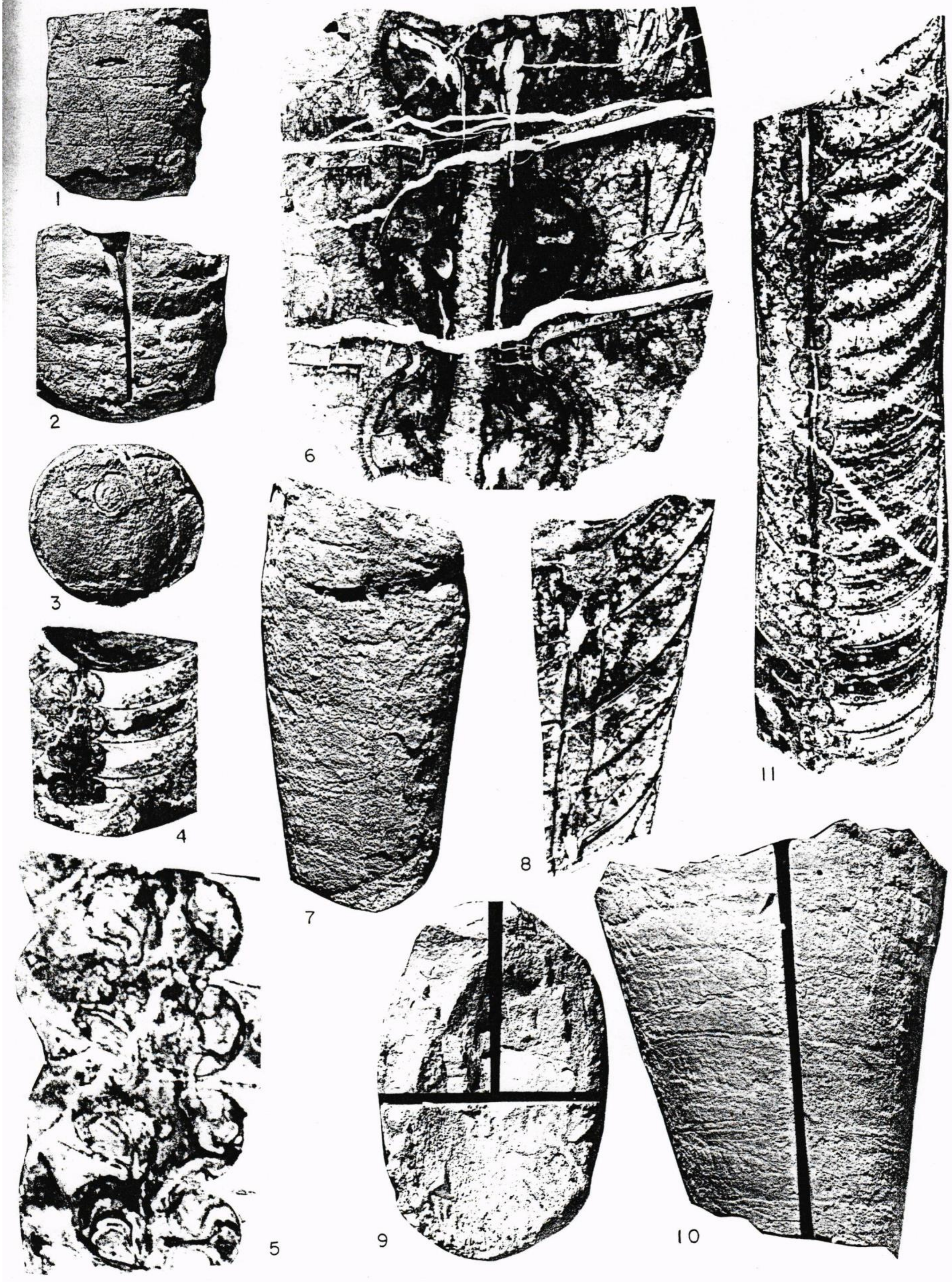
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PLATE 8

Aethiosolen cylindricus Flower, n. sp.

P. 42

1. A living chamber, viewed from the dorsal side, slightly crushed and weathered, but agreeing with the holotype in general proportions and the distant spacing of the adoral annuli; USNM, from USGS locality 2175, north end of the Ely Springs Range, Nevada, "above Receptaculites."

Michelinoceras(?) sp.

P. 41

2. A living chamber with a fragment of one short camera, possibly mature; No. 28787, Columbia University. From the sponge beds (zone N), Antelope Valley limestone, Pogonip group, from half a mile above the mouth of Yellow Gulch, half a mile north of Ikes Canyon, Toquima Range, Nevada.

Adamsoceras cf. *isabelae* Flower

P. 15

3. Thinsection, ×4, part of the same specimen as Pl. 11, fig. 6; lying apicad of the part there figured (reversed).
4. Section from the upper right of fig. 3, showing part of central and radial canal system, perispatium lined on its left margin by lamellae of the perispatial deposit, showing connecting ring, the free part with transverse fibers, the distal (lower) end darker, with longitudinal lamellae, narrowly separated from the adapical septum; the septum shows the concave tip and the thin supplementary layer on its apical surface (about ×13).
5. Enlargement of the same section, the distal part of the ring lightened by retouching, showing textures in greater detail. Note variable expression of inner and outer layers in the free part of the ring, the supplementary layer between the apical end of the ring and the septum is shown, and cameral deposits formed in the angle, here very similar in texture to the siphonal (left) margin of the perispatium in texture; about ×28.

See also, Pl. 6, fig. 10, Pl. 7, fig. 6, and Pl. 9, fig. 1-4.

Figured specimen, no. 379, collection of the writer, from the Whiterock, high Pogonip, from Ikes Canyon, Toquima Range, Nevada.

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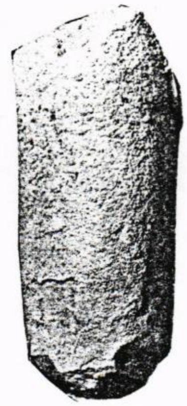

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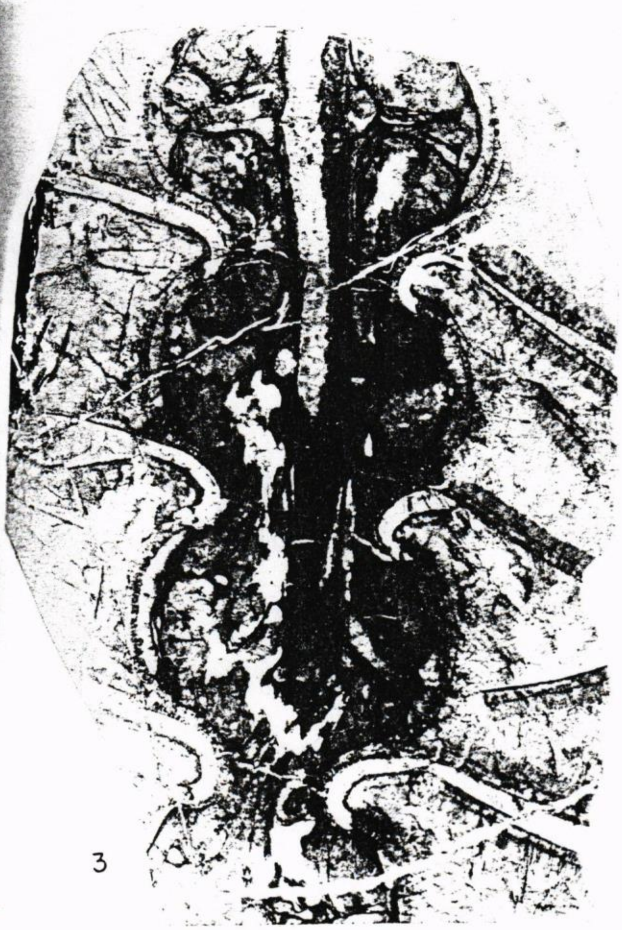

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PLATE 9

Adamsoceras cf. *isabelae* Flower

P. 15

1. Enlargement, ×12, from the lower part of Pl. 11, fig. 6, showing fibers traversing the free part of the ring and also part of the canal system.
2. Another part from the lower part of Pl. 11, fig. 6, showing more typical development of the tip of the neck and differentiation of anterior part of ring, as well as inner calcitic part of the tip of the ring; ×12.
3. Further enlargement of part of fig. 1, showing further textural details. Cameral deposit, the stutzring, lies on the apical side of the anterior septum; the thin apical layer of the septum is not here apparent. The ring around the septal neck has been retouched slightly; about ×23.
4. Further enlargement of part of fig. 2, showing septal neck, tip of apical layer of septum, apex of anterior ring with inner calcitic light section, anterior end of next ring with differentiation of the anterior part and its reception in the concave end of the neck; about ×25.

From no. 379, collection of the writer, from the Whiterock of Ikes Canyon, Toquima Range, Nevada. See also pl. 6, fig. 10, pl. 7, fig. 6, pl. 8, fig. 3-5.

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PLATE 10

P. 8

Wutinoceras logani Flower, n. sp.

Exterior of the holotype, prior to sectioning.

1. dorsum
2. lateral view, dorsum on left, showing slope of the sutures
3. venter; the ventral lobes are exaggerated by weathering

Museum of Comparative Zoology, from 17 feet above the base of unit 8 (Schuchert and Dunbar) of the Table Head limestone, Table Head, Newfoundland.

See also Pl. 11.

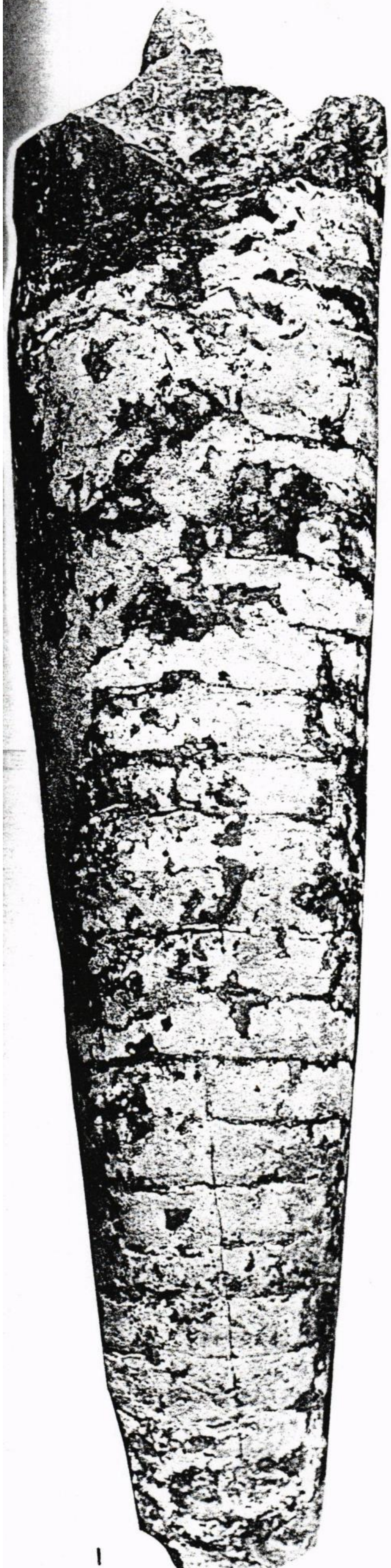

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PLATE 11

Wutinoceras logani Flower, n. sp.

P. 8

1. vertical section of the anterior end of the holotype, venter at right; proportions are modified by slight crushing
2. cross section at the base of fig. 1 before vertical section was made; compare pattern of radial canals
3. cross section, 15 mm farther apicad
4. half of the surface opposing that in fig. 3 and the anterior end of fig. 4 (the apparent lobation of the siphuncle is actually lobation of the siphonal deposit, with the dark perispatium outside it; in some sections the connecting ring is not well differentiated from the matrix outside of it)
5. vertical section of the apical part of the holotype ×1, venter on left
6. enlargement, ×2, of the anterior part of fig. 5, showing outline of siphuncle segments and radial canals in more detail
7. enlargement of the apical part of fig. 5, ×2, showing variation in form of the early siphuncle segments, which suggests that this is an early growth stage, though the small initial chamber is missing

Holotype, a portion of phragmocone, Museum of Comparative Zoology, from 170 feet above the base of unit 8 (Schuchert and Dunbar) of the Table Head limestone, Table Head, Newfoundland. See also Pl. 10.

Holotype, a portion of phragmocone.

Wutinoceras minore Flower, n. sp.

P. 11

8. dorsal view
9. ventral side, weathered anteriorly, and exposing siphuncle segments which in this view resemble those of *Armenoceras*
10. septum at base of the anterior part, venter below.
11. septum at the apical end of the specimen, venter below.

Museum of Comparative Zoology, from unit 7 (Schuchert and Dunbar), Table Head Limestone, Table Head, Newfoundland.

See also Pl. 6, fig. 9.

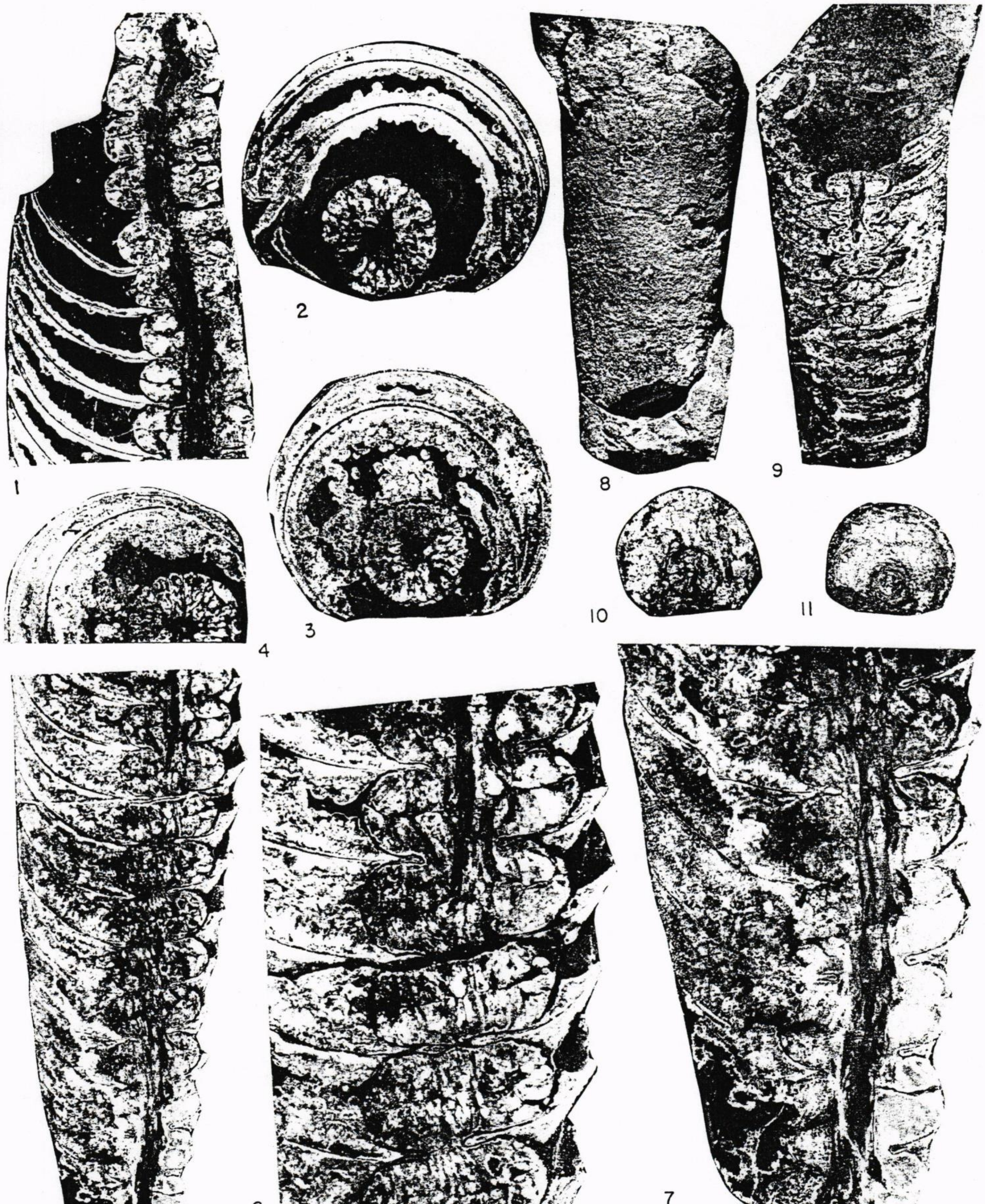
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PLATE 12

Cyrtonybyoceras haesitans (Billings)

P. 12

Hypotype, a relatively complete phragmocone showing some slight crushing anteriorly.

1. dorsal view
2. lateral view, dorsum on left
3. ventral view
4. septum at the break at the base of the anterior two thirds of the specimen, venter on left
5. section at the break near the apical end, venter on left
6. septum at the extreme base; a cross section was made through an apically protruding siphuncle segment, venter on left

7-8. opposite sides of a sagittal section through the middle portion, the fifth through ninth camerae, showing siphuncle segments and canals; note the discrepancy of points of origin of the canals, characteristic of the reticular canal pattern, in the two sections from the central canal

Museum of Comparative Zoology, from the lower Table Head limestone of Point Riche, Newfoundland.


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PLATE 13

Aethiosolen priamus (Billings)

P. 42

1. ventral view
2. ventrolateral view
3. dorsal view
4. lateral view, venter at left

Hypotype, Museum of Comparative Zoology, from 3 feet above the base of unit 2 (Schuchert and Dunbar) of the Table Head limestone, Table Head, Newfoundland.

Aethiosolen whittingtoni Flower, n. sp.

P. 42

5. vertical section of the paratype, ×2, venter on left (apical camarae show thin episeptal deposits on the ventral side only, the siphuncle filling is inorganic)

Museum of Comparative Zoology, from 95 feet above the base of unit 3 (Schuchert and Dunbar) of the Table Head limestone, Table Head, Newfoundland.

6. holotype, lateral view, venter on left
7. dorsal view

Holotype, Museum of Comparative Zoology, from 477 feet above the base of unit 8 (Schuchert and Dunbar), of the Table Head limestone, Table Head, Newfoundland. (See also Pl. 14, fig. 8, 9)

Cyrtonybyoceras curviseptatum Flower, n. sp.

P. 13

8. dorsum
9. lateral view, dorsum at left
10. ventral view
11. vertical section, venter on left
12. cross section at anterior end of fig. 11, venter on left
13. cross section at apical end of fig. 11, venter on left

Holotype, Museum of Comparative Zoology, from 95 feet above the base of unit 3 (Schuchert and Dunbar), Table Head limestone, Table Head, Newfoundland.


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PLATE 14

Adamsoceras billingsi Flower

P. 14

1-3. Three external views of the hypotype; 1, lateral view, venter on left; 2, dorsal view; 3, ventral view.

4. Vertical section of the anterior portion, venter on left.

5-6. Opposite sides of a vertical section near basal part; fig. 5 is central and shows the central canal, fig. 6 is slightly eccentric; the two figures together show the dendritic radial canals.

7. Vertical section, venter on left, of the apical four camerae; the section does not quite attain the center.

Aethiosolen whittingtoni Flower, n. sp.

P. 42

8. Vertical section, ×2, of a paratype. Calcite in the siphuncle is inorganic, cameral deposits are present, but recrystallized and apparent only on right side of the figure, the apparent venter.

9. Vertical section of the holotype, ×2, venter on right.

Museum of Comparative Zoology; both are from division 8 of Schuchert and Dunbar of the Table Head limestone, Table Head, Newfoundland. Fig. 8 is from 10 feet above the base, fig. 9 is 477 feet above the base of this unit.

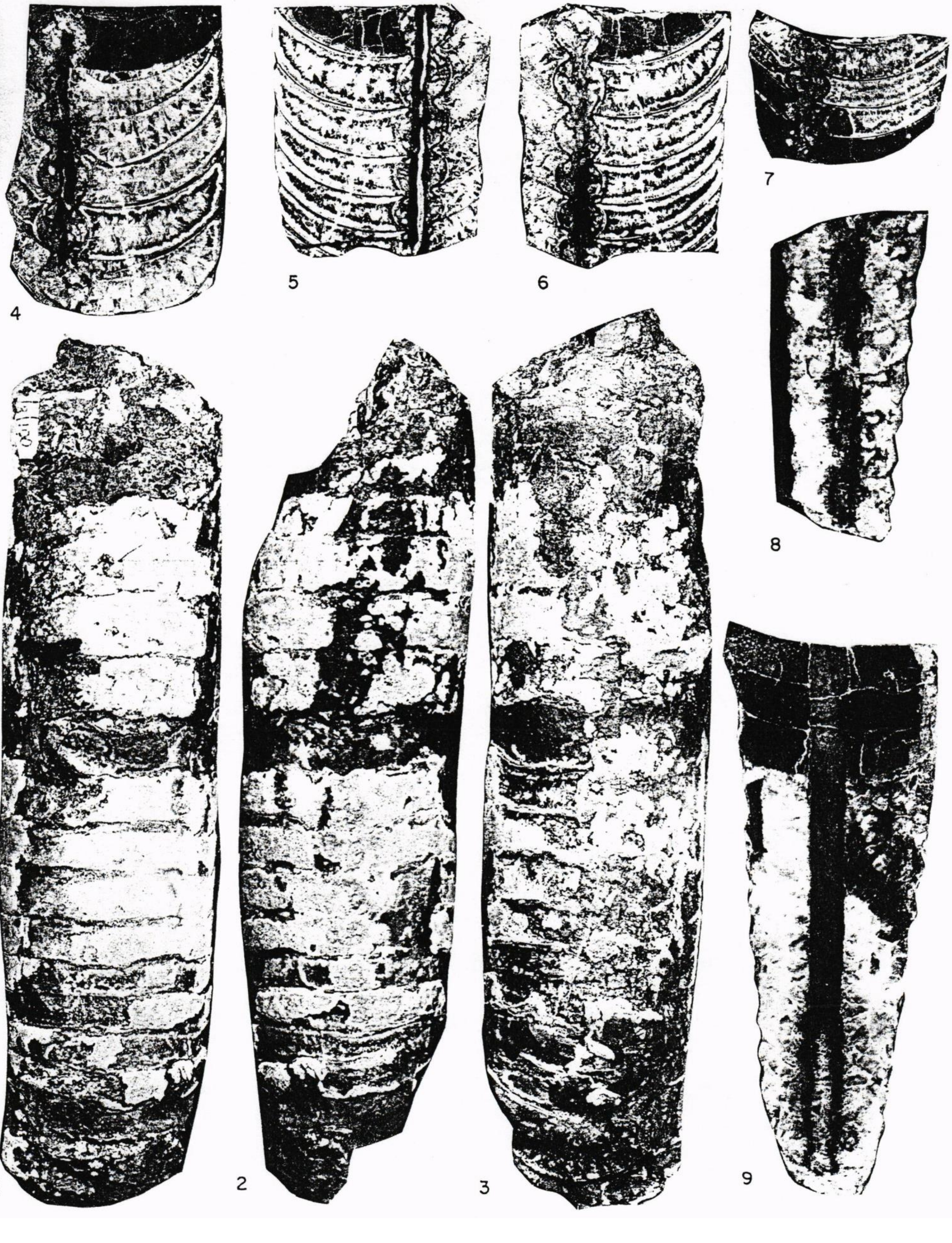
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PLATE 15

Rhabdiferoceras expansum Flower, n. sp.

P. 23

1-4. Holotype, a fragment of a phragmocone. 1. Ventral view, ×1 2. Adoral view, showing size and position of the siphuncle. 3. Vertical section, siphuncle on right, venter below. 4. Same, ×2. No. 369.

Collection of the writer, gift of Dr. J. Lee Adams, from the sponge beds of the Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada.

Ruedemannoceras? sp.

P. 53

5-7. A small portion of a phragmocone, silicified, etched from the matrix. 5, ventral view, ×2, 7, lateral, venter on left, ×2, 8, adoral view, venter below. U.S. National Museum. From USGS D 1007Co, approximately 350 feet below the top of the Badger Flat limestone, Independence quadrangle, Inyo County, California, believed to represent the equivalent of the *Palliseria* zone; U.S. National Museum.

Wutinoceras davisi

P. 9

8-14. Holotype, a portion of a phragmocone, Brigham Young University. 8. Ventral view; 9, lateral view, venter at left; 10, dorsal view; 11, adoral view, venter below; 12, apical view, venter below. 13, Vertical section through center of siphuncle showing central and some radial canals, ×2. 14, Opposite side of the section, showing an eccentric section through the siphuncle.

Origin doubtful; believed by lithology to come from the lower part of zone N in the Kanosh shale, of the Ibex region of Utah. An alternate possible origin is a black limestone high in the Lehman limestone.

Rossoceras lamelliferum Flower, n. sp.

P. 33

15. Vertical thinsection through shell and siphuncle wall, taken from the ventrolateral portion of the shell; the outline of the segments shows slight but inconspicuous expansion beyond the limit of the septal necks; recrystallization has obscured the layers in the siphuncle wall, and apically the connecting ring is poorly defined. The section is from a relatively early growth stage, the apical part of Pl. 6, fig. 9, the complete specimen shown in Pl. 5, fig. 6-8, and overlapping slightly the anterior section shown in Pl. 20, fig. 2. × 10.5.

Syntype No. 358, from the uppermost 20 feet of the Garden City formation, Green Canyon, Logan, Utah.


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PLATE 16

Juaboceras brathwaitei Flower, n. sp.

P. 25

Holotype, an endosiphuncle retaining most of the length of the endosiphocone. Brigham Young University, no. MCN2, 44. From 23 feet below the top of the Juab limestone, from section J of Hintze (1952, 1953) Ibex area, western Utah.

1. lateral view, venter on left
2. dorsal view
3. apical end, venter below
4. adoral end, venter below, showing anterior lateral crushing
5. cross section near anterior end, venter at left
6. longitudinal section, slightly oblique to the vertical axis, apical of fig. 4
7. cross section at the base of Fig. 6.
8. enlargement of fig. 7, ×2, showing traces of sheaths and blades

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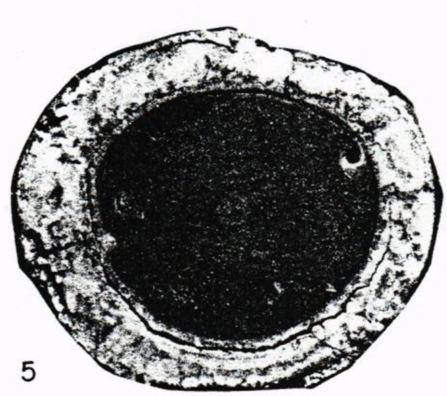

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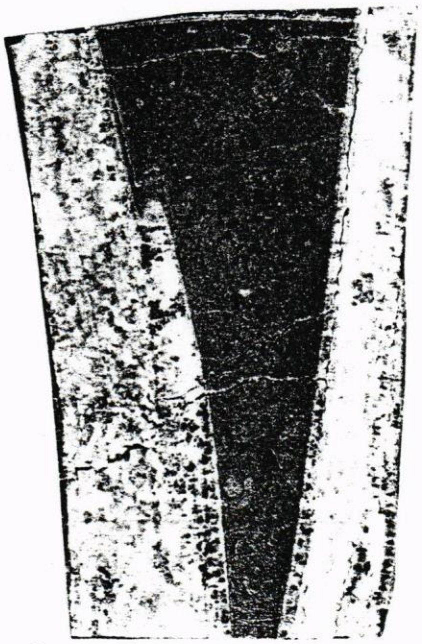

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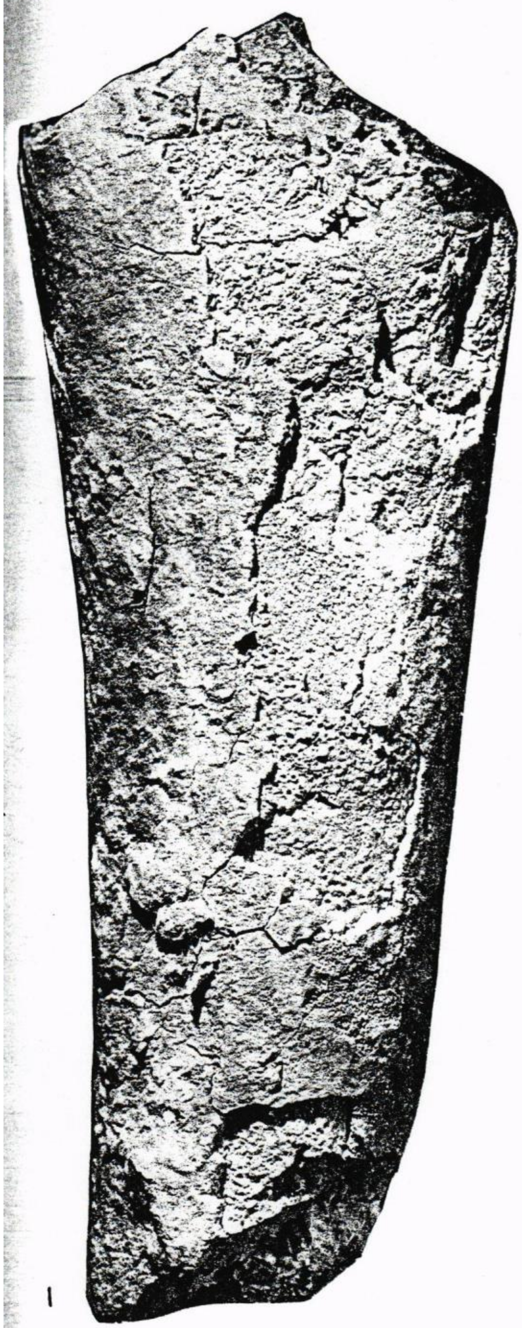

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PLATE 17

Williamsoceras adnatum Flower, n. sp.
P. 28

1. Ventral view of anterior exposed portion of the endosiphuncle, ×1, showing the extremely faint annuli marking spacing of septal ridges and the prominent midventral line marking the base of the median blade of the ventral process.
2. Lateral view of the same portion, ×1, venter on left. The oblique anterior limit of the endosiphocone is shown, sloping apicad from tthe venter to dorsum. The portion shown is a true endosiphuncle, without septa, septal necks, or connecting rings; the connecting rings act as cushions, smoothing out on the endosiphuncle the more abrupt septal ridges which would be found on the true siphuncle exterior.

3-4. Two surfaces, 2 mm apart, from opposite sides of a cut 40 mm from the anterior end of Figures 1-2; in Fig. 3, the crescentic cavity of the endosiphocone has terminated ventrally and the infula is developed, its two limbs most narrowly separated ventrally, the tubes along its course best seen on the left side, triangular, with the dark edges more or less extended. The endosiphocone is slightly more restricted in Fig. 4; in both, one dorsolateral buttress marks the beginning of the division of the dorsal part of the endosiphocone into multiple transverse tubes; below, tubes are already well separated and triangular in outline.

5-6. Two opposing surfaces, 5 adoral, 6 adapical, of a cut, the two surfaces 2 mm apart and 6 mm apicad of Figs. 3 and 4. Here division of the dorsal part of the endosiphocone into curved transverse tubes is more advanced.

7-8. Surfaces, 7 adoral, 8 adapical, of a cut 4 mm farther apicad, showing progressive reduction in size of the tubes. In Fig. 8 dark calcite in the center of the ventral process develops, simulating the matrix.

9. Section 29 mm farther apicad. Here the dark line of the infula is distinct. The buttresses, separating various of the tubes, have become outlined in dark material, adventitious, and some irregularities develop of no organic significance.
10. Section 54 mm farther apicad, showing tubes of the infula at the earliest growth stage retained in the type.
11. Cross section, ×1, taken 10 mm orad of the anterior end of Fig. 1-2; here only the dorsal portion of the ventral processes is extended this far forward.
12. Cross section at anterior end of Fig. 1-2, showing the ventral process high and narrow, its base preserved, and on the lower left the anterior end of the ventral part of the normal endocones, which in Fig. 2, show their anterior limit sloping apicad from venter to dorsum.

All from the holotype, no. 342, collection of the writer. See also Pls. 18 and 19.

Williamsoceras adnatum Flower, n. sp.
P. 28

13-15. A portion of the anterior part of an endosiphocone, slightly distorted. The anterior end, in Fig. 13, shows the view into the etched anterior end of the endosiphocone, with the ventral process high and narrow, the endocones extremely thin anteriorly. In the ventral view, Fig. 14, the midventral part shows the ends of the infula barely separated ventrally. The apical weathered end, Fig. 15, shows a section farther apicad, where the ventral process and the dorsal cones are enlarged, restricting the endosiphocone to a crescent.

Paratype, no. 343, collection of the writer.

Williamsoceras pedunculatum Flower, n. sp.
P. 30

16-21. A series of cross sections from the paratype, no. 350, collection of the writer, all ×2.

16. Adoral section, showing section where the endosiphocone is relatively large, the ventral process lying in an angular notch in the endocones, connected with the venter by a single blade. Traces of dorsolateral blades are seen; the dorsum was abraded prior to burial.
17. A section 8 mm farther apicad, showing the endosiphocone more reduced.
18. Section 88 mm farther apicad, the endisiphocone reduced to a thin dorsal crescent. In 17 and 18 are apparent a blade, oblique in Fig. 16, is here apparently middorsal in position, the eccentricity of adoral sections being the result of slight distortion. The ends of the infula join a single ventral blade.
19. Section 14 mm farther apicad, showing dorsal blade and dorsal part of infula, but the lower part of the infula and the ventral blade are obscured by recrystallization; curiously, a growth line of the ventral process is retained.
20. Section 22 mm farther apicad, with dorsal blade and dorsal part of the infula clearer than before, the venter still altered by recrystallization.
21. Apical section, with advanced recrystallization and distortion of the left side of the infula. Paratype, no. 350; all sections ×2.

Williamsoceras pedunculatum Flower, n. sp.
P. 30

22-25. Sections of the holotype, a specimen which lay on its side, with compression of sediments resulting in a compressed cross section. All sections ×2: 22 and 23 are opposing surfaces of an anterior cut, 22 the more anterior, showing the pedunculate ventral process with its median blade, a slightly askew dorsal blade, the crescentic section of the endosiphocone, the ends continued as the infula. 24-25, two opposing sections in which the endosiphocone is greatly restricted, and the infula, with some of the tubes within it, clearly preserved; ventrally the ends of the infula are narrowly joined to the ventral process close to the siphuncle margin. No. 349, collection of the writer.

All specimens are from the black limestone comprising the upper 20 feet of the Garden City Limestone at Green Canyon, near Logan, Utah.

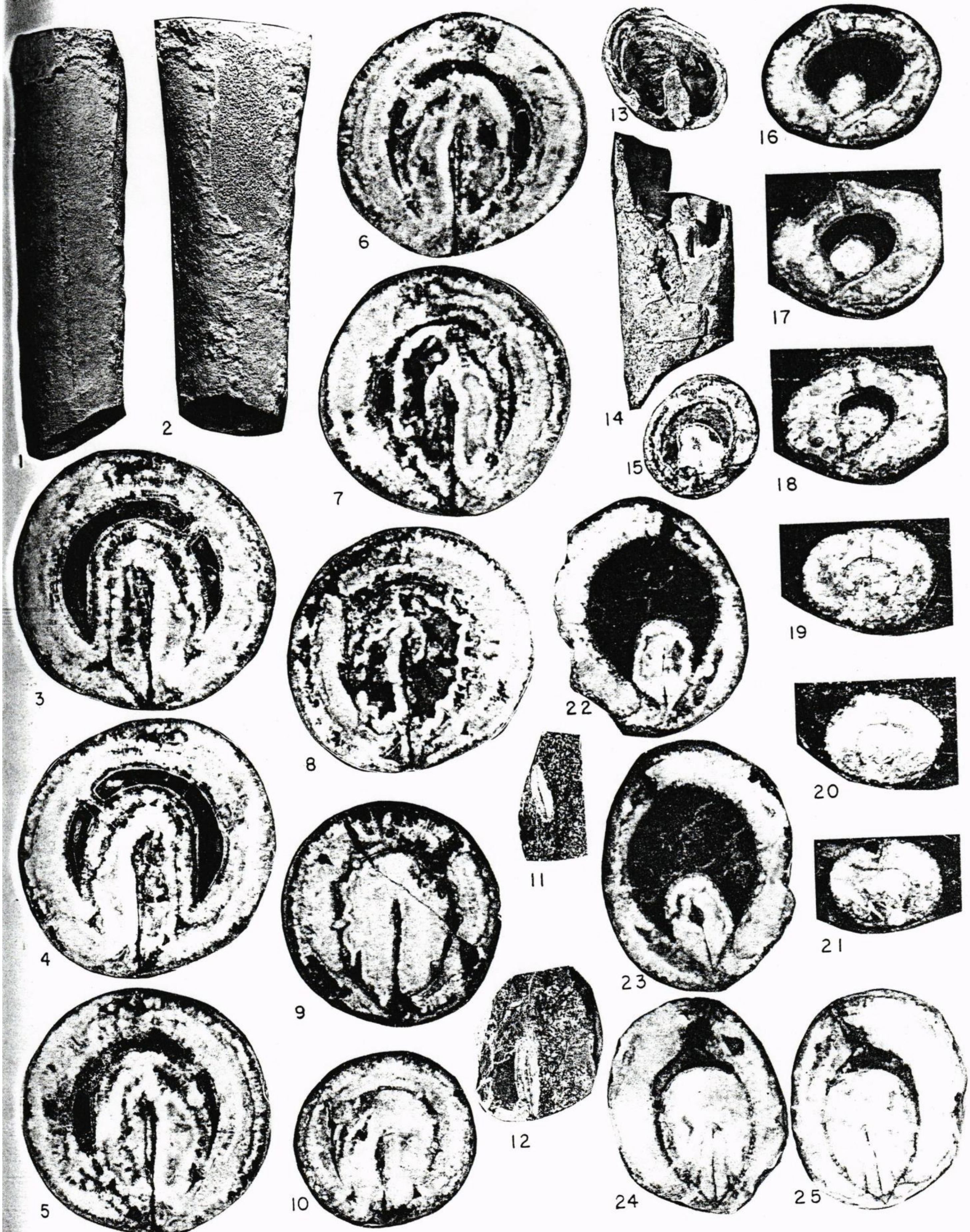
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PLATE 18

Williamsoceras ankhiferum Flower, n. sp.
P. 31

1-7. 1, Adoral cross section of the holotype, ×1, venter below. 2, exposed surface of portion of the type, ×1. Left of the center two close essentially continuous lines mark the termination of the two limbs of the infula; the less continuous line between is the base of the ventral process. 3, cross section at apical end of Fig. 2, ×1. 4, enlargement, about ×2.6, of the section shown in Fig. 1, showing details of infula, ventral process containing growth lines and its median blade, strong dorsal blade and traces of lateral blades, both with feathering from growth lines; portions of a few growth lines appear as dark concentric bands. 5, enlargement of Fig. 3, ×2.6, showing the more broadly rounded infula, strong dorsal blade, basal trace only of the ventral blade, traces of lateral blades on the left, continuous with those on the right in Fig. 4. 6-7, opposite sides of a cut near the extreme apical end of the type, 12-13 mm apicad of the portion shown in Fig. 2, showing further rounding of the upper part of the infula, but with the lower limbs straightening as they converge, and still quite widely separated at the siphuncle margin; irregular traces of growth lines in the endocones, pesistent dorsal blade and traces of lateral blades. The angular course of the infula indicates the several tubes; laterally feathering results from their extension in growth lines of the endosiphuncle. Holotype, no. 351, collection of the writer.

Williamsoceras adnatum Flower, n. sp.
P. 28

8-16,
27, 28.

8. Ventral view of the siphuncle, ×1, showing relationship of the main cross sections shown in later figures.

9-10. Enlargements of adoral and adapical sides of anterior section, about ×2.6, showing progressive development of buttresses crossing the ventral limbs of the endosiphocone, and the beginning of tubes; the median blade of the ventral process is clear.

11-12. Two surfaces of the next section, 20-22 mm farther apicad, showing further reduction of the endosiphocone and the extension of its lower edges as the infula, in which individual tubes with triangular feathering can be seen.

13-14. Opposing surfaces of a cut 40-42 mm farther apicad, showing progressive development of curved transverse tubes in the dorsal part of the endosiphocone, here essentially reduced to a series of tubes aligned along the infula.

15-16. Two surfaces 25-27 mm farther apicad, showing reduction of all tubes to a relatively small diameter, their alignment along an infula essentially circular in section; ×2.6; 27 and 28 are two photographs of a region apicad of fig. 14, in the second piece from the bottom of fig. 8, ground from the dorsal side. The plane of the section was kept essentially tangent to the dorsal part of the infula, and anomalies in the longitudinal features stem from the fact that the infula is tubular apically, expanded conically adorally. Fig. 28 is ground slightly deeper than Fig. 27, and photographed obliquely, showing at the adoral end the surface shown in Fig. 14, but steeply inclined. Apparent diaphragms are doubtful, being more probably interpreted as representing the plane of the section cutting walls of the tubes. Paratype, no. 346, collection of the writer. See also Plates 11 and 19.

Cacheoceras trifidum Flower, n. sp.
P. 32

17-23.

17. Exposed surface of the holotype siphuncle. The median longitudinal line proves to be the base of the pedunculate dorsolateral process shown in the upper left of Fig. 18; the apparent symmetry of the siphuncle is false, and slight crushing is involved, as shown by the assymmetry of the cross sections. Lines at the side indicate the position of the cross sections shown in figs. 18-23.

18-19. Two opposing surfaces from the anterior cut indicated on Fig. 17, showing the large adnate ventral process and the more narrowly attached dorsolateral processes, with the cavity of the endosiphuncle still relatively large.

20-21. Surfaces of cut at midlength of the type; the ventral process is large, outlined by the infula, the course of which is slightly angular owing to the several tubes, though the tubes themselves are quite obscure. Dorsad of the ventral process is the last apical vestige of the endosiphocone.

22-23. Surfaces from apical cross section. Recrystallization has obscured many details, but the large ventral process and the infula remain clear in both sections, and dorsolateral processes are present, though less clearly outlined.

No. 348, collection of the writer.

Williamsoceras adnatum Flower, n. sp.
P. 28

24-26. Three sections ×2, from a paratype, no 344, showing a relatively early growth stage with the regular circular infula and the several tubes along its course. Figs. 24 and 25 are opposing surfaces of an anterior section, showing some variation of details, Fig. 26 is 16 mm farther apicad. All specimens are from the black limestone comprising the upper 20 feet of the Garden City limestone in Green Canyon, near Logan, Utah.

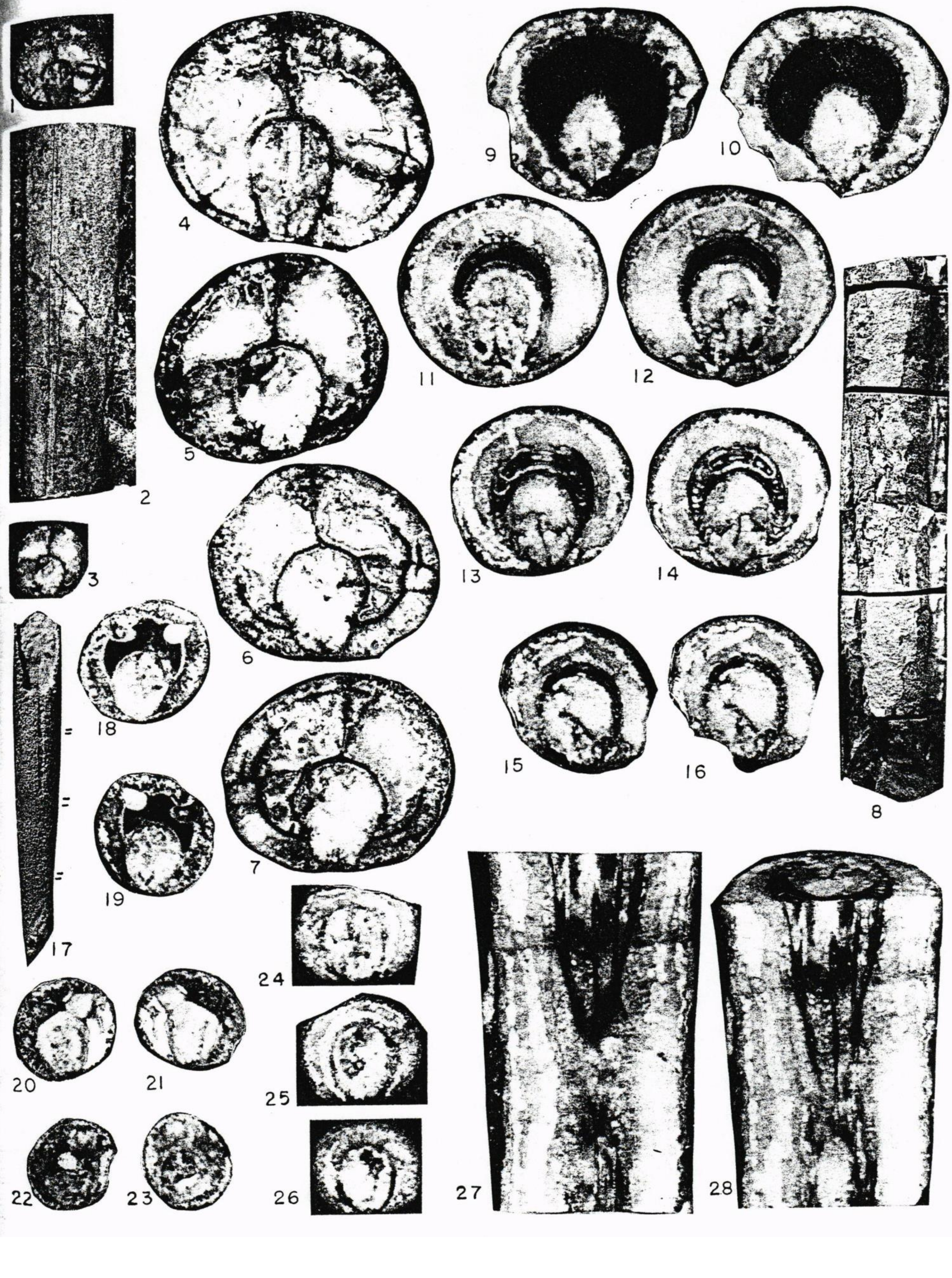
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PLATE 19

Williamsoceras adnatum Flower, n. sp.

P. 28

1-3, 6-8.

1. Anterior cross section of the specimen, a portion of a siphuncle, showing the anterior extension of the ventral process beyond the dorsal endocones.

2. View of the greater part of the specimen, apicad of Fig. 1, a siphuncle viewed from its weathered dorsal side.

3. Cross section ×2 taken from near the base of Fig. 2. The upper surface is weathered, but the irregular lateral outline indicates crushing of the specimen, in the process of which the infula was greatly distorted, though its individual tubes are largely preserved. The ventral wall of the shell is partially preserved below.

6. A longitudinal section, ×5, taken obliquely through one side of fig. 2, showing the septa, continued as holochoanitic necks, the clear dark adoral terminations of the connecting rings and a section cutting the endosiphocone obliquely.

7. Another similar section, retaining more of the shell wall, showing the holochoantic necks, the adoral dark terminations of the connecting rings, and cutting some of the tubes of the infula, in which thin straight tube walls can be seen.

8. Enlargement, about ×9, of a third longitudinal section from the same specimen, showing in greater detail holochoanitic necks their tips narrowly separated from apical necks by the base of the connecting ring, the tips of the rings darkened, corresponding to the eyelets in other endoceroids, but the dark regions are here not sharply defined adorally.
Paratype, No. 345, collection of the writer.

Williamsoceras adnatum

P. 28

4. Enlargement, about ×3, of a vertical longitudinal section taken essentially tangent to the one longitudinal (the left) side of the infula shown in Pl. 17, Fig. 9, and extending apicad from the section shown in that figure. The portion of the siphuncle is slightly displaced by a joint, but the continuity of tubes and absence of diaphraghams is shown. No. 342.

Williamsoceras adnatum Flower, n. sp.

P. 28

5. A portion of a siphuncle ×1, viewed from the dorsal weathered side, ×1. Adorally the sides of the ventral process are clearly defined, and its adnate condition shown. Yale Peabody Museum collection.

Williamsoceras cf. *adnatum*

P. 30

9-10. 9, view of exposed surface of a siphuncle fragment in the matrix. It is slightly displaced below, but throughout its length are longitudinal grooves at the left of the center, two fairly strong, and third between fainter and intermittent. The strong grooves mark the ends of the infula, the faint one between the base of the median blade of the ventral process. 10, sketch of cross section taken through the middle of the specimen, showing this to be only a ventral part of a siphuncle with the dorsal side irregularly split away. The course of the infula and ventral blade are clear, and the missing dorsum is reconstructed in dotted lines. No. 347, collection of the writer.

All specimens are from the black limestone comprising the upper 20 feet of the Garden City limestone, from Green Canyon, near Logan, Utah.

PLATE 20

Rossoceras lamelliferum Flower, n. sp.

P. 33

1. Dorsal view $\times 1$ of portion of siphuncle surface, showing extremely shallow relief of the surface, with distant septal ridges indicated by only very faint lines. A small apical portion is not included.
2. Thinsection, $\times 12$, of the same specimen, the longitudinal section being nearly normal to the surface shown in Fig. 1 and ventrolateral showing shell wall at left and calcite of the endosiphuncle to the right. r—termination of connecting rings; n—termination of septal neck.
3. Cross section, $\times 1$, 20 mm orad of the base of Fig. 1, venter and portion of the shell wall below. Displacement occurs along a calcite vein.
4. Cross section, $\times 1$, at base of Fig. 1, 20 mm apicad of Fig. 3, showing apical reduction of the endosiphocone, the surface of which is here strongly irregular.
5. Enlargement of a portion of Fig. 4, from the upper right part of that figure, but here oriented with the dorsum to the lower left, showing fine bifurcating blades. Syntype 357.
6. Vertical section of a syntype, no. 358, showing anterior end of endosiphocone, venter and portion of shell wall on the left, $\times 1$.
7. Cross section $\times 1$, at the base of Fig. 6; venter below.
8. Cross section $\times 1$, 11 mm apicad of Fig. 8, showing endosiphocone smaller.
9. Vertical section, $\times 12$, taken from surface opposing that shown in Fig. 6; shell wall to the right, endosiphuncle to the left; n—indicates tip of the septal neck; r—indicates tip of the connecting ring. Anterior ends of connecting rings are quite clear, occuring at junction of septal neck with the remainder of the siphuncle. From syntype no. 358.

Both 357 and 358 from the uppermost 20 feet of the Garden City formation, Green Canyon, Logan, Utah.

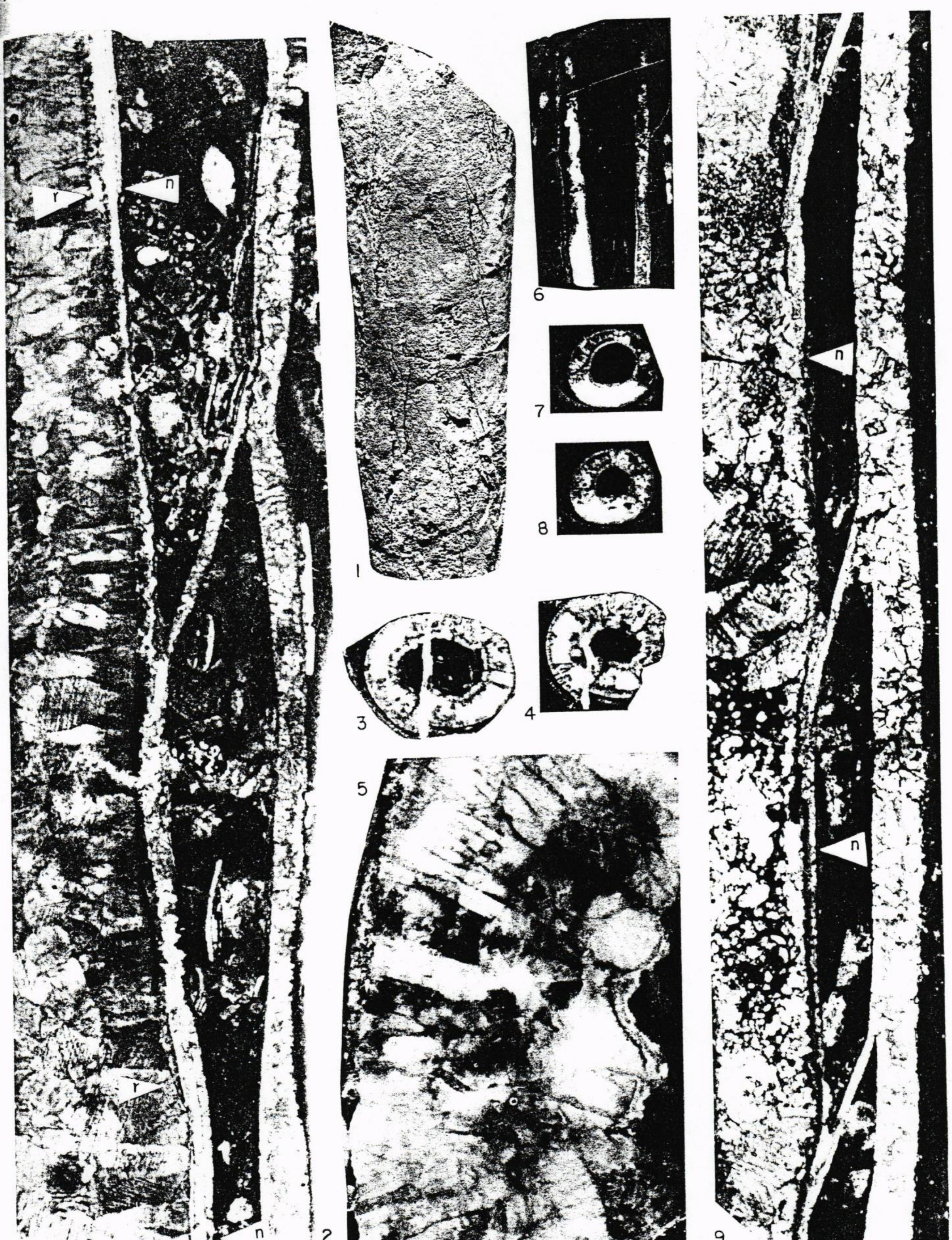
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PLATE 21

Rossoceras lamelliferum Flower, n. sp.

P. 33

1-8. Selected cross sections from syntype no. 359. All $\times 2$. 1 and 2 are opposing surfaces of a section at the anterior end showing preservation of blades under slight silicification; bases of dorsolateral and ventrolateral blades and all of the mid-dorsal blade are clear. 3, section 40 mm farther apicad; 4, section 20 mm farther apicad; 5, apical side from the same cut; 6, apical cross section, 45 mm farther apicad; 6, cross section, the apical side of the cut shown in Fig. 3, showing depth of grinding; dorsum at right; 7, longitudinal section apicad of Fig. 7, dorsum at left.

9. Longitudinal thinsection from syntype no. 358, venter on left, $\times 4$, venter on right.

10-15. Sections from a large siphuncle, syntype no. 362; 10, anterior cross section, $\times 1$, cutting endosiphocone near its tip; 11, adapical opposing surface of the same cut, $\times 2$, showing variable preservation of fine lamellae, most persistent peripherally; 12, cross section $\times 2$, 80 mm. farther apicad; 13, same, $\times 1$; 14, section 35 mm further apicad, $\times 1$; 15, Longitudinal section orad of Fig. 12-13, attaining inconspicuous endosiphotube, showing traces of endosiphosheaths.

16-19. Four sections from a somewhat more altered siphuncle, $\times 2$; 16, adoral; 17 and 19, opposing surfaces from cut at midlength; 18, apical section. Syntype no. 361.

20-24. A series of cross sections from syntype 360; 20, adoral section, showing considerable replacement by silica, retaining vestiges of bases of primary blades; 21, section 55 mm farther apicad; 22, section 47 mm apicad of Fig. 21; 23, section 15 mm farther apicad; 24, section 52 mm farther apicad, near apex. The series shows highly variable preservation of numerous radiating bifurcating blades, tube transverse, with slightly downturned edges, generally with downcurved ventrolateral and straight dorsolateral blades stronger than the others.

The series shows the depressed tube with downturned edges, commonly straight dorsolateral and downcurved ventrolateral blades can be traced from its ends. In contrast to the specimen shown in Figs. 1-6, the greater prominence of the dorsal blade and two pairs of lateral blades is here relatively slight. Fig. 24 is believed to show the condition closest to that of the original; here blades are numerous and uniform in prominence. Syntype no. 360.

All from syntypes nos. 358-362. Upper 20 feet of Garden City formation, Green Canyon, Logan, Utah.

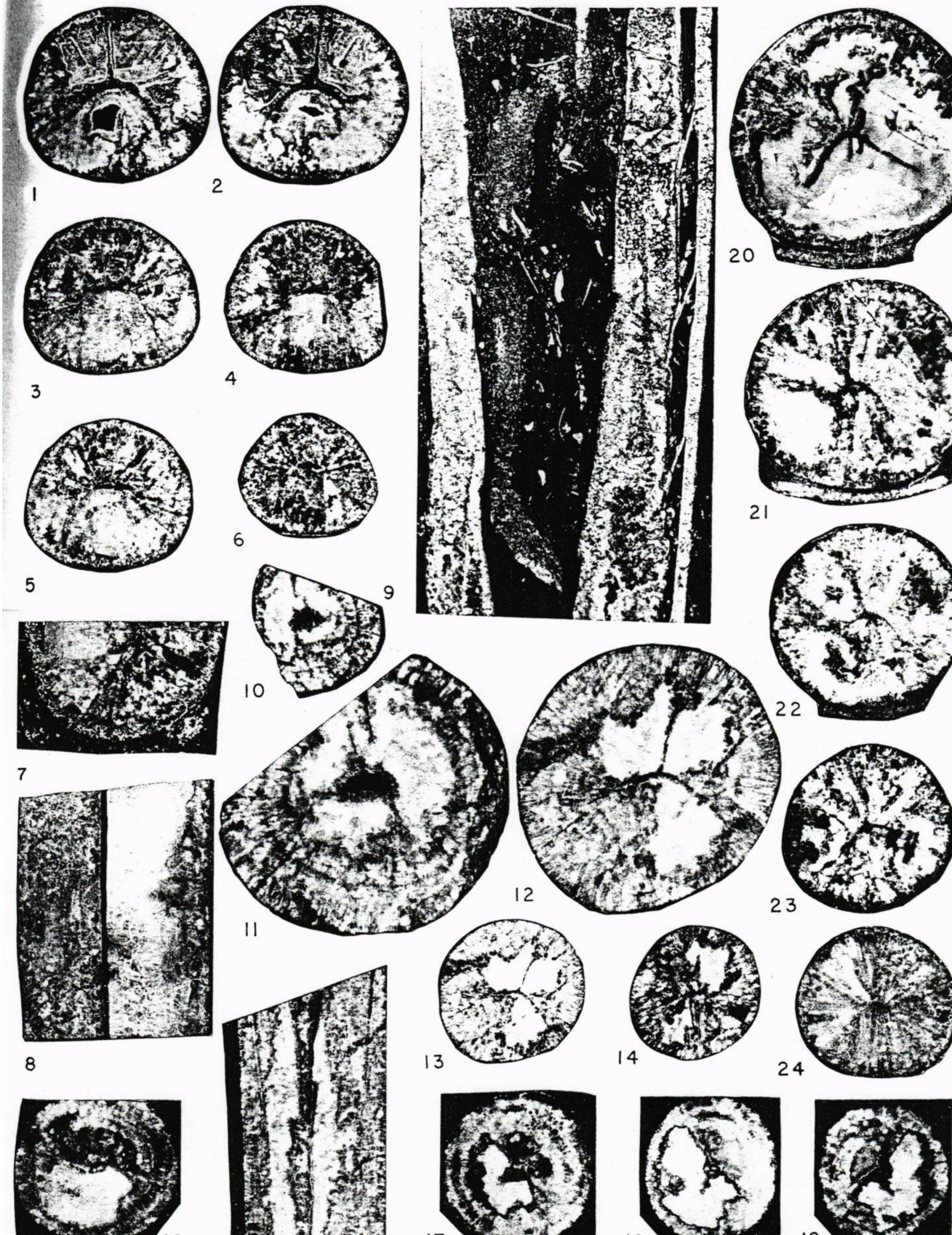
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PLATE 22

Rossoceras dentiferum Flower, n. sp.

P. 37

1-2. Adoral and apical ends of the holotype, a portion of siphuncle 45 mm long, showing cross sections at two regions in the endosiphocone. Yale Peabody Museum. From the Garden City formation, east side of Hillyard's Canyon, ⅛ mi north of the head of the canyon.

3-5. Paratype, a fragment showing the endosiphocone at a considerably earlier growth stage, ×1; 3, adoral view, 4 adapical view, 5, view from dorsal side, showing the narrow ridge on the ventral side of the endosiphocone. Garden City formation, top of unit, Green Canyon, Logan, Utah. Yale Peabody Museum.

Rossoceras cf. *lamelliferum*

P. 37

6-8. Sp. no. 367, a small portion of siphuncle ×1; 6, adoral view, 7, ventral view, showing obscure septal ridges, 8, apical view showing marked concavity on the ventral side of the endosiphocone. Uppermost 20 feet of the Garden City limestone, Green Canyon, Logan, Utah.

Rossoceras lamelliferum

P. 33

9-18. Syntype, no. 363, showing a series of sections, ×2.

9. Section close to anterior end, showing prominent horizontal blades and flat transverse tube, also a dorsal blade, also fine lamellae in peripheral part.

10. Section 80 mm farther apicad, with traces of horizontal and downturned lateral blades, with fine lamellae in the gray portion.

11-13. Anterior cross section, transverse longitudinal surface and apical cross section, 11 and 13 showing the position of the section shown in 12, attaining the endosiphotube.

14. Cross sections 50 mm apicad of fig. 10, showing vestige of middorsal blade, its branches, two pairs of lateral blades.

15. Section 30 mm farther apicad, the sides of the tube downcurved, peculiar ventral blades joined peripherally.

16. Section near apical end, 10 mm farther apicad from fig. 15; showing joined ventral blades and stronger vestiges of dorsal and lateral blades.

17-18. Horizontal longitudinal section taken well above the endosiphotube, from the same portion as fig. 11-3; fig. 18 shows a cross section, indicating the height of the plane of the section.

From the uppermost 20 feet of the Garden City formation, Green Canyon, Logan, Utah.

Rossoceras cf. *lamelliferum*

P. 37

19-21. Sections of a siphuncle atypical in faint ventral flattening of the endosiphocone, cross sections ×2; no. 365; 19, section 50 mm. from anterior end, showing no ventral battening and lacking clear blades; 20, section 14 mm farther apicad, with ventral flattening most faintly developed; 21, section 14 mm farther apicad, showing a section close to juncture of endosiphocone and endosiphotube, with slight ventral flattening, and a vestige of one ventrolateral blade.

From the top 20 feet of the Garden City formation, Green Canyon, Logan, Utah.

Rossoceras lamelliferum Flower, n. sp.

P. 33

22-25. Sections of syntype no. 364; 22, cross section ×2, 55 mm from extreme anterior end; 23, cross section 30 mm farther apicad, showing section closer to the tip of the endosiphocone, which is here semicircular; horizontal lateral blades and a middorsal blade are prominent; 24, 25 two sections, ×1, of anterior part. In fig. 24, two planes are cut obliquely, being nearly tangent to the ventral surface of the endo siphuncle at the middle; in fig. 25, the middle portion has been ground down nearly to the level of the two ends; both show continuous longitudinal lamellae of the blades, which are largely lost in areas of white calcite.

From the top 20 feet of the Garden City formation, Green Canyon, near Logan, Utah.

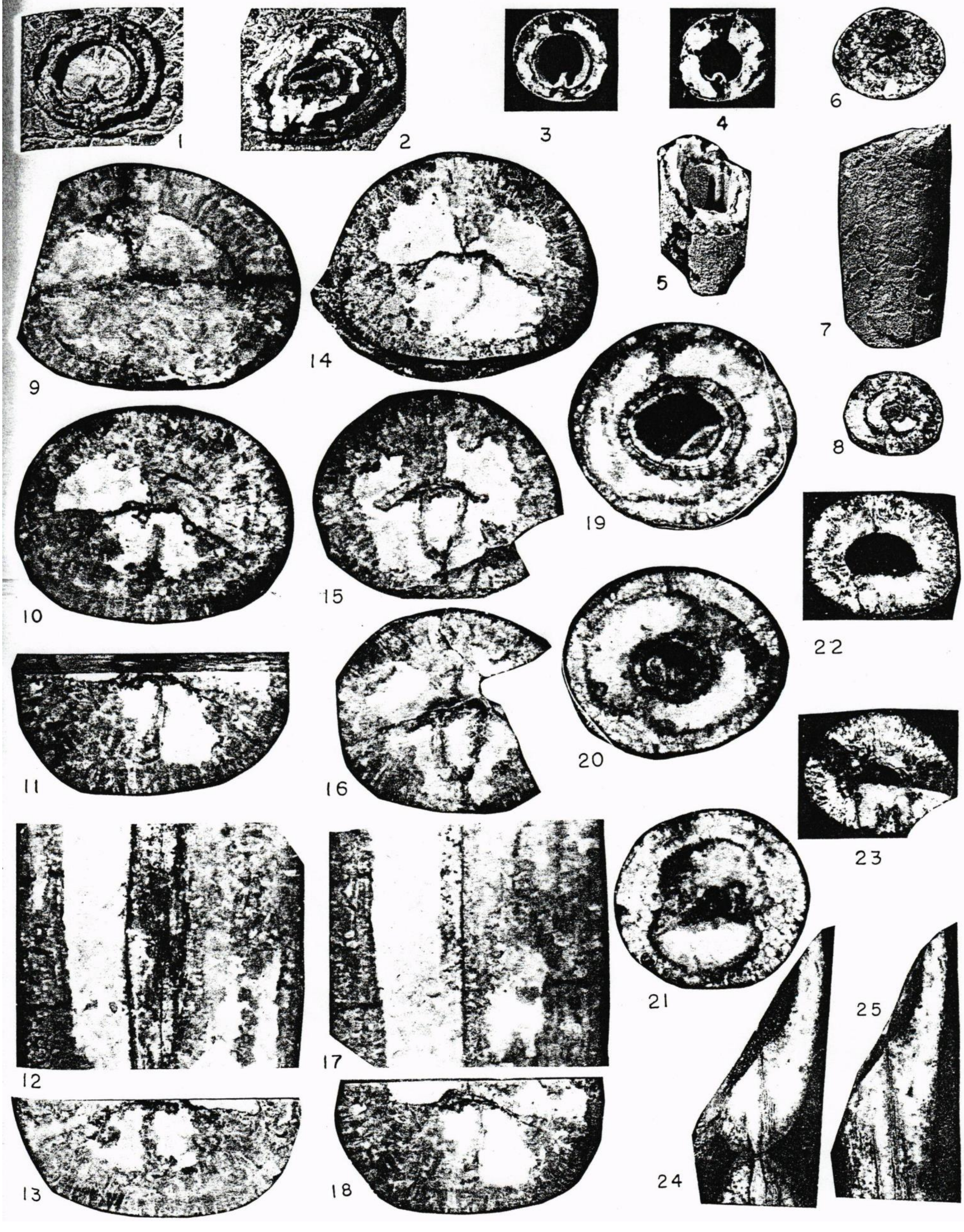
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PLATE 23

Ikesoceras ikesense Flower, n. sp.

P. 52

1-5. Holotype; 1, ventral view; 2, lateral, venter on left; 3, dorsum, all ×1; 4, basal view, ×2, venter above; 5, lateral ×1, venter at right.

No. 1137, collection of the writer, from the main sponge beds of the Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada. After photographing the specimen, a transverse section was made, ground from the ventral side, exposing the siphuncle, which is not reproduced.

6-7. Paratype, a silicified somewhat crushed specimen; 6, dorsal view, ×2; 7, ventral view, ×2, showing tubular siphuncle.

No. 1138, collection of the writer, from below the main sponge beds of the same section.

Aethiosolen cylindricus Flower, n. sp.

P. 42

8. septal view, venter below

16. lateral view; holotype, a living chamber, no. 378; from the sponge beds of Ikes Canyon.

Aethiosolen kayi Flower, n. sp.

P. 42

9. lateral view

10. adoral view

11. vertical section

Holotype, American Museum of Natural History No. 28784

Sponge beds, Antelope Valley ls., Ikes Canyon, Nev.

Crenuloceras giganteum Flower, n. sp.

P. 51

12. Holotype, USNM no. 2324, showing the lateral surface of a somewhat crushed shell. Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada; presumably from the sponge beds.

Litoceras cf. *adamsi* Flower

P. 46

13-14. opposite sides of a cross section (note trace of a more anterior whorl at the top of fig. 14)

15. lateral view

A somewhat crushed specimen, no. 1152, collection of the writer from about 150 feet below the top of the Nileus beds, Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada.


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PLATE 24

Michelinoceras toquimense Flower, n. sp.

P. 41

1, 3. exterior (1) and vertical section (3) of a paratype ×2, no. 1149

2. vertical section of the holotype, ×2. no. 1148

4. base of specimen shown in fig. 1, showing cross section and position of the siphuncle, ×2

5. paratype, no. 1150, a specimen broken longitudinally and showing part of the siphuncle

All are from the asaphid (Nileus) beds, the lower part of the Antelope Valley limestone as exposed at Ikes Canyon, Toquima Range, Nevada.

Bactroceras wilsoni Flower, n. sp.

P. 24

6. paratype, an anterior portion of phragmocone sectioned vertically, venter and siphuncle on the left; the specimen is displaced slightly along the irregular calcite, which marks a joint, and the siphuncle is displaced slightly there. Paratype no. 1146.

10. cross section, ×2, from holotype, no. 1144

11. transverse longitudinal section ground from the apical part of the holotype, ×2, prior to making the thinsection shown on Pl. 25, fig. 3. See also, Pl. 25, fig. 1-4.

Leonardoceras parvum Flower, n. sp.

P. 52

7-9. holotype, no. 1147, ×2, lateral view, venter on right; 8, ventral view; 9 apical view

From the lower asaphid beds of the Antelope Valley limestone, Ikes Canyon, Toquima Range, Nevada.

Litoceras sp.

P. 47

12-13. A badly weathered specimen from the Palliseria zone, unit 1 of Johnson and Hibbard, south flank of Red Mountain, 1 mile northwest of Mercury, Nevada.

12. Lateral view; 13, cross section, both ×1

Litoceras sp.

P. 47

14-16. a badly weathered internal mold from 1 mile south of Crusher, Oklahoma, reputedly from the Joins formation; 14, adoral view; 15, side view; 16, cross section. Figured specimen, University of Oklahoma.


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PLATE 25

Bactroceras wilsoni Flower, n. sp.

P. 24

1-2. opposite sides of the holotype, no. 1144, 1, showing an internal mold, with venter to right of the center, 2 showing the opposite weathered surface

3. longitudinal horizontal thinsection through siphuncle, from the apical part of the holotype, about ×27

4. lateral view of a paratype, showing a surface weathered down to the siphuncle, on the left. No. 1145

See also pl. 24, fig. 6, 10, 11.

Litoceras huygenae Flower, n. sp.

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5. lateral view of holotype, no. 1151

6. cross section through holotype

All specimens are from the "asaphid" (Nileus) beds, comprising the lower exposed part of the Antelope Valley limestone at Ikes Canyon, Toquima Range, Nevada.

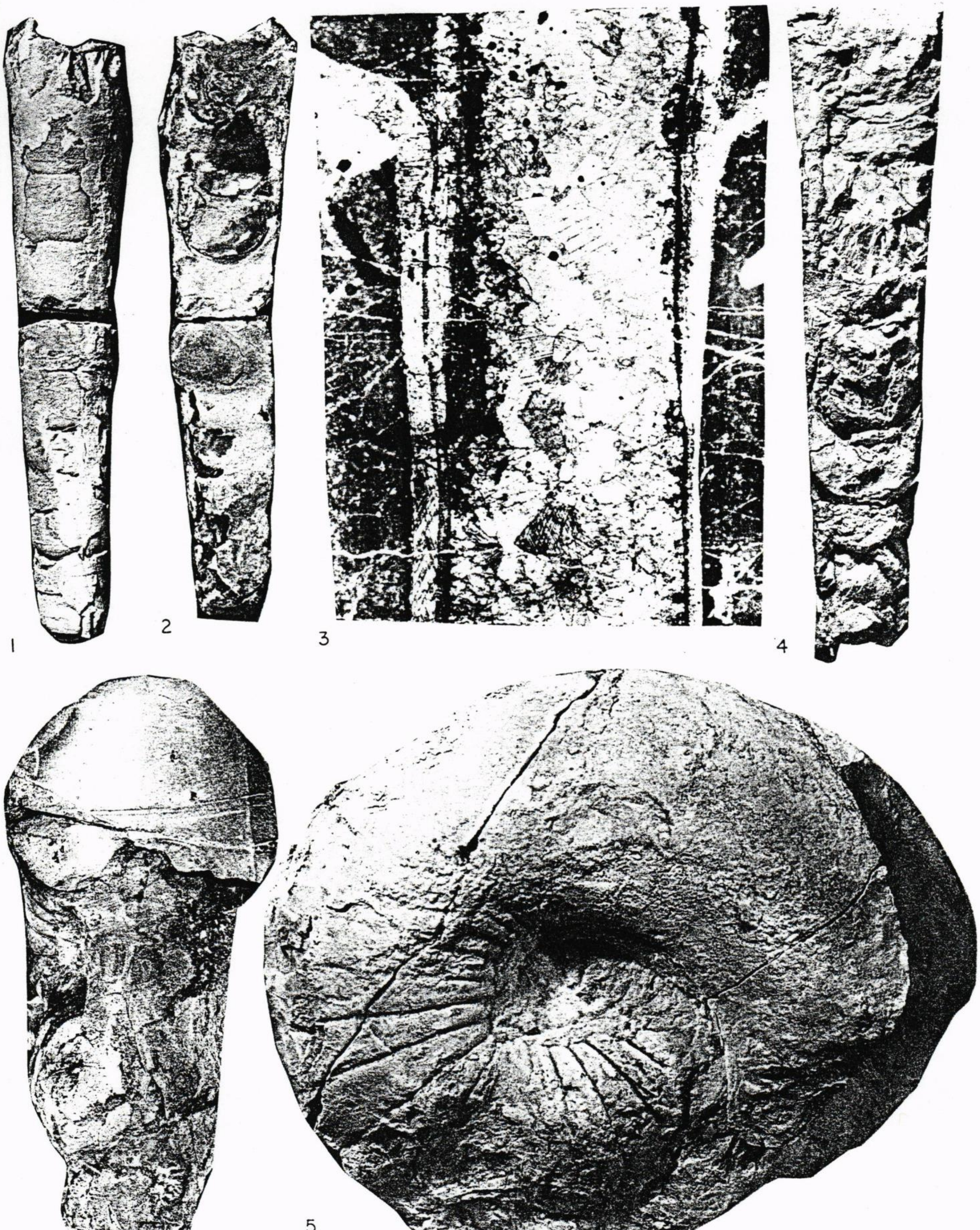
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PLATE 26

Discoceras peronatus Flower, n. sp.

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1. lateral view of holotype ×1, unwhitened, showing septa in the lower part of the specimen
2. same, whitened; septa do not show, but ornament details are shown with greater clarity
3. cross section, ×1, taken horizontally in reference to figs. 1 and 2
4. ventral view of surface, from the lower part of figs. 1 and 2, showing narrow costae, distant longitudinal furrows and faint transverse markings
5. adoral view, facing the slightly contracted mature aperture
6. ventral view of anterior part, orad of fig. 4

Holotype, Columbia, Univ. no. 28782.

Plectolites costatus Flower

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7. holotype, adoral view, ×1
8. cross section, taken horizontally with reference to fig. 7 (note eccentricity of siphuncle in second whorl from the top)
9. lateral surface; early whorls are well exposed, but the anterior part, above, is crushed, and costae are obscured
10. opposite side of the same specimen, showing clear costae on the anterior surface

Holotype, Columbia Univ., no. 28783.

Both specimens are from 400-550 feet above the base of the Antelope Valley limestone, there 850 feet thick, in association with sponges and pliomerids, apparently zone N of Hintze, with *Cybelopsis* and *Kawina billingsi*. From one-half mile above the mouth of Yellow Gulch, one-half mile north of Ikes Canyon, Toquima Range, Nevada (Kay, *fide litt*).


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PLATE 27

Plectolites costatus Flower, n. sp.

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1. Lateral view of a portion of a living chamber, slightly crushed laterally, but showing ornament clearly.
2. Apical view of the same specimen, showing the present condition of the cross section; though still broadest near the umbilical shoulders, slight distortion has altered the impressed zone as well as the venter.

   Collection of the writer, no. 377.

3. Lateral view of a somewhat weathered individual.
4. Cross section of the same individual. Though there is slight distortion, the two last half whorls show progressive increase of shell height over the shell width. USNM no. 140352.

7-8. A small portion of an immature individual, showing the strong costae of young stages. From Ibex section K of Hintze, at 1590 feet, Zone N, Lehman formation. Geology Dept., Brigham Young Univ.

Litoceras adamsi Flower, n.s.

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5-6. Two views of a portion of a phragmocone; 5, lateral view; the apparent forward slope of anterior sutures on the venter is adventitious, due to slight ventrolateral weathering. 6, Cross section. Collection of the writer, no. 375.

9-11. A paratype, MCZ no. 9404. 9, lateral view, showing some surface markings. 10, Anterior view. 11, cross section, taken horizontally with reference to fig. 9. Calcite complicates recognition of earlier whorls; earliest whorls are plainly missing.

All material is from the sponge bed of the high Pogonip. Figs. 1, 2, 5, 6, and 9-11 are from Ikes Canyon, Toquima Range, Nevada; figs. 3-4 are from Yellow Gulch, one-half mile north of Ikes Canyon and one-half mile above the mouth of the canyon.

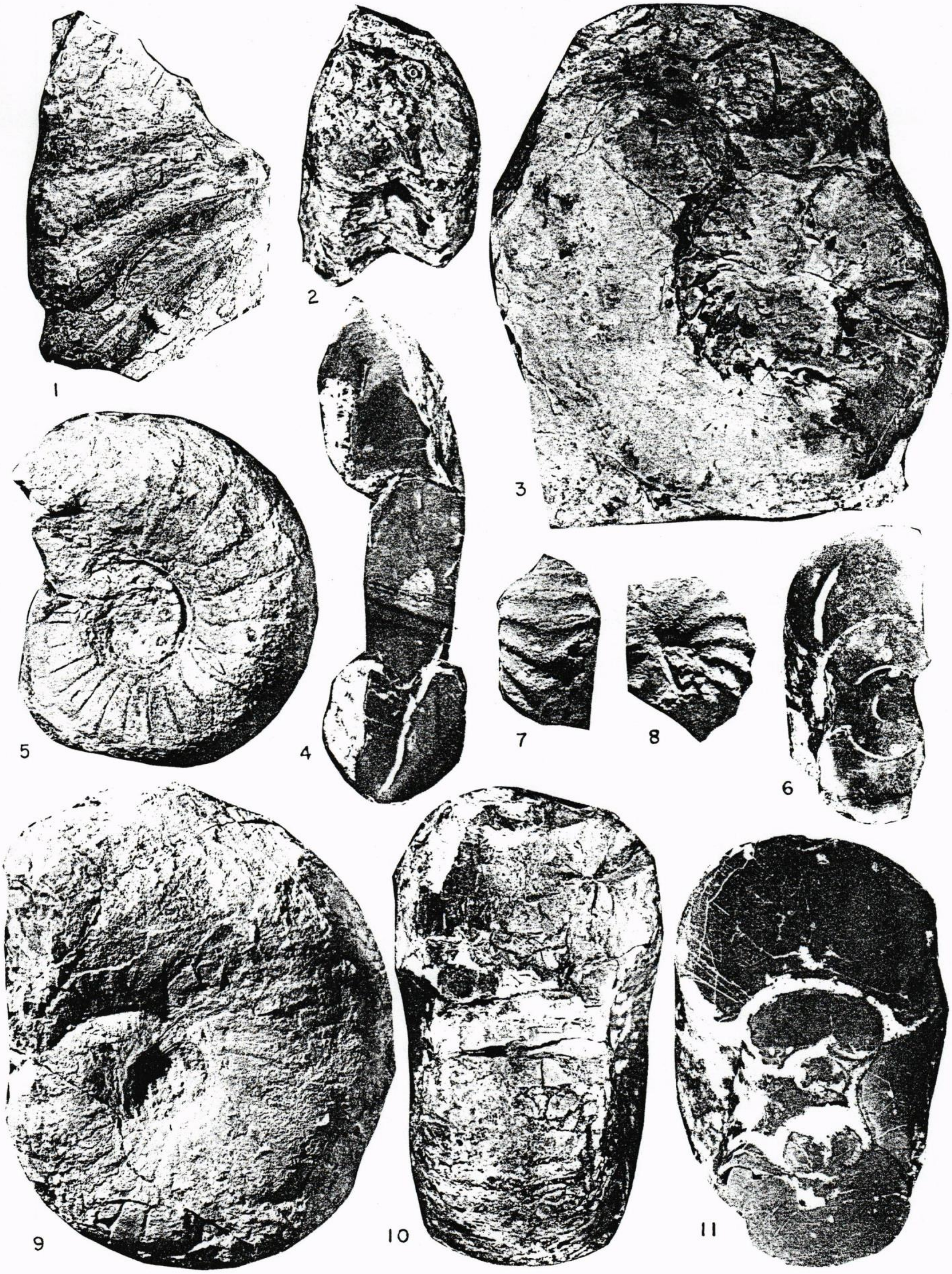
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PLATE 28

Litoceras adamsi Flower, n. sp.

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1-3, 5. Holotype, MCZ no. 9402. 1, ventral view showing base of living chamber and adoral shortened camerae; 2, lateral view; 3, adoral view showing on the left the lateral rate of expansion of the shell; 5, cross section, taken essentially horizontally with reference to fig. 2.

4, 7. A young individual; 4, cross section; 7, lateral view prior to sectioning. No. 376, collection of the writer.

6, 8-10. A paratype showing portions of the shell surface, and essentially the entire length of the living chamber near the umbilical shoulder, MCZ no. 9403; 6, cross section, taken horizontally with reference to fig. 9; 8, adoral view; 9, lateral view, unwhitened, showing sutures; 10, ventral view at base of living chamber, showing absence of mature shortened camerae.

All are from the sponge bed. All are from Ikes Canyon; Toquima Range, Nevada.


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PLATE 29

Litoceras adamsi Flower, n. sp.

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1. lateral view of a specimen showing portions of two whorls
2. same specimen, viewed from the internal side
3. same specimen, photographed unwhitened and inverted, showing outlines of whorls somewhat more clearly than fig. 2.

No. 374, collection of the writer. Sponge bed, Ikes Canyon, Toquima Range, Nevada.

4. cross section, $\times 1$, slightly off center
5. restored cross section from the same specimen; the cross section is completed by superimposing a proper photograph on a reversed print from the same negative; USNM no. 140353 (same horizon and locality as figs. 1-3)
6. ventral view of another specimen, in which appreciable flattening of the venter is developed by slight distortion
7. cross section of the same specimen
8. lateral view of the same specimen; USNM no. 140354 (from USNM no. 482d, from the southern end of the Confusion Range, just west of Ibex, Utah)
9. lateral view of a large relatively complete shell, slightly under natural size, photographed unwhitened to show the sutures (note the slight modification of the ventral outline and thickening of the shell near the aperture)
10. same specimen, lateral view, photographed whitened, showing full size
11. cross section, taken horizontally in reference to figs. 9 and 10, showing cross section of whorls and position of siphuncle

No. 373, collection of the writer. From the sponge beds of Ikes Canyon, Toquima Range, Nevada.

Plectolites costatus Flower, n. sp.

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12. lateral view of a portion from an immature individual, showing costae of the early whorls
13. ventral view of the same specimen

From Ibex section K of Hintze at 1590 feet above the base of the section. Geology Dept., Brigham Young Univ.

PLATE 30

Plectolites (?) perplexus Flower, n. sp.

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1. lateral view, ×1, showing the only exposed surface
2. cross section taken horizontally with reference to fig. 1 (the apparent larger whorl shown on the left is presumably adventitious, as in roundness it is not in accord with earlier portions)

Holotype, USNM no. 140355, from the *Orthidiella* zone, Whiterock Canyon, Roberts Mts., Nevada.

Plectolites (?) *kirki* Flower, n. sp.

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3. lateral view, ×1 of holotype
4. ventral view, from left anterior side of fig. 3
5. cross section, taken horizontally with reference to fig. 3

Holotype, USNM no. 140356, from high cliffs, north end of the Ely Springs Range, Highland Peak quadrangle, Nevada.


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