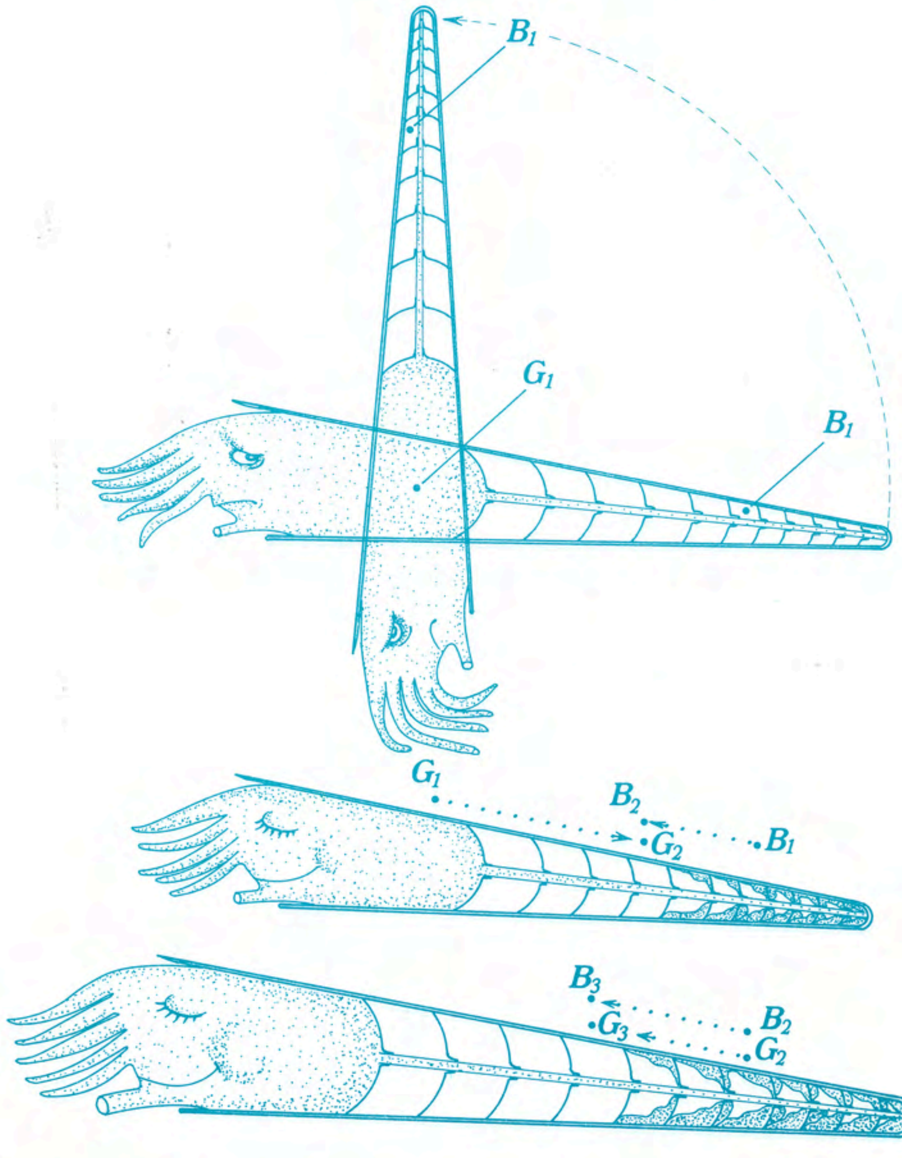
Late Canadian (Zones J, K) Cephalopod Faunas from Southwestern United States

by STEPHEN C. HOOK and ROUSSEAU H. FLOWER



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ABOUT THE SKETCH ON COVE R-

A simple orthocone with gas in the camerae would have an anterior center of gravity (G1) and an apical center of buoyancy **(B1).** Such a situation would cause the shell to occupy a vertical position, forcing the head into the mud on the sea floor—making the animal very unhappy and uncomfortable, as can be plainly seen from its expression.

Weighting the apex of the shell with cameral deposits or siphonal deposits, or both (only cameral deposits are shown here), would move the center of gravity backward, from 01 to G2, and move the center of buoyancy forward, from B1 to B2, permitting the animal to swim and move in a horizontal position—making it very happy and comfortable, as can be seen from the ecstatic expression.

Further growth of the shell requires further growth of the deposits, moving the center of gravity forward to midlength (from G2 to G3) and moving the center of buoyancy forward also from B2 to B3. Such an adjustment requires careful physiological skill. If the animal now has a rather smug expression, who can blame it?

As indicated elsewhere (Flower, 1955, fig. 1, p. 247), balance is attained completely by siphonal filling in the Endoceratida, by a combination of siphonal and cameral deposits in the Actinoceratida, and mainly by cameral deposits in the Michelinoceratida. However, Hook and Flower (1976) subsequently found that the Michelinoceratidae and Troedssonellidae probably spring from different parts of the Baltoceratidae, in which there are both cameral and siphonal deposits (rods, linings, and annuli in varying combinations) in a siphuncle close to the venter. In all instances, concentration of deposits on the ventral side of the shell assured stability, with the venter down and the dorsum up.

This illustration was first published in Geological Society of America Memoir 67, ***Treatise on*** *Marine Ecology and Paleoecology.*

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Preface

This study, for which the senior author is primarily responsible, explores in detail the internal morphology and taxonomic relationships of the Baltoceratidae and Protocycloceratidae of the Ellesmeroceratida (Flower, 1964a), and the Michelinoceratidae and Troedssonellidae, the first of the Michelinoceratida, in the latest Canadian of the southwestern United States. The work is a doctoral thesis by the senior author, under the direction of the associate author, who has found the detailed and painstaking work most gratifying. The material was disappointingly fragmentary, and much was so extensively replaced or otherwise altered that it presented most perplexing dilemmas. The morphological facts are, however, beyond dispute. Where one approaches possible transitions among major groups, the problem emerges, as it has here, as to which of the several major divisions some of these new forms should be assigned. Where major divisions are distinct, it is either because of spontaneous generation, sudden and drastic morphological mutations (both unlikely), or it is because we lack knowledge of transitional forms. It is intriguing to reflect that where taxonomic compartments seem perfect, it is not because of our knowledge but because of our lack of knowledge.

In this work new and surprising patterns of internal morphology have been found in the small orthoconic cephalopods of the latest Canadian, in contemporaneous faunas from New Mexico, west Texas, and western Utah. The various new forms often present a basis for conflicting interpretations. While alternate hypotheses of relationships can be derived from this material, this vexation is surely offset by the importance of recording the unexpected morphological variation found in this material.

In 1935 a joint paper by Flower and Caster on Conewango cephalopods was published; in this my position might well have been that of junior author. Kenneth Caster gave much support to this work that I cannot repay, but here I have had an opportunity to pass it on. The present study has made fullest use of the materials available, and has brought forth unexpected morphological surprises, based upon the only known latest Canadian cephalopod faunas preserved in limestones and, thus, suitable for study by thin sections. I have added some passages, mainly noting more of what we do not know, rather than what we do know.

I can only end by quoting from the introduction to the Conewango paper, "The principal author of this paper is such a student whose zeal and enthusiasm have been exceptional and whose sustained interest has been most gratifying."

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New Mexico Bureau of Mines
and Mineral Resources

Socorro, New Mexico
Dec. 2, 1975

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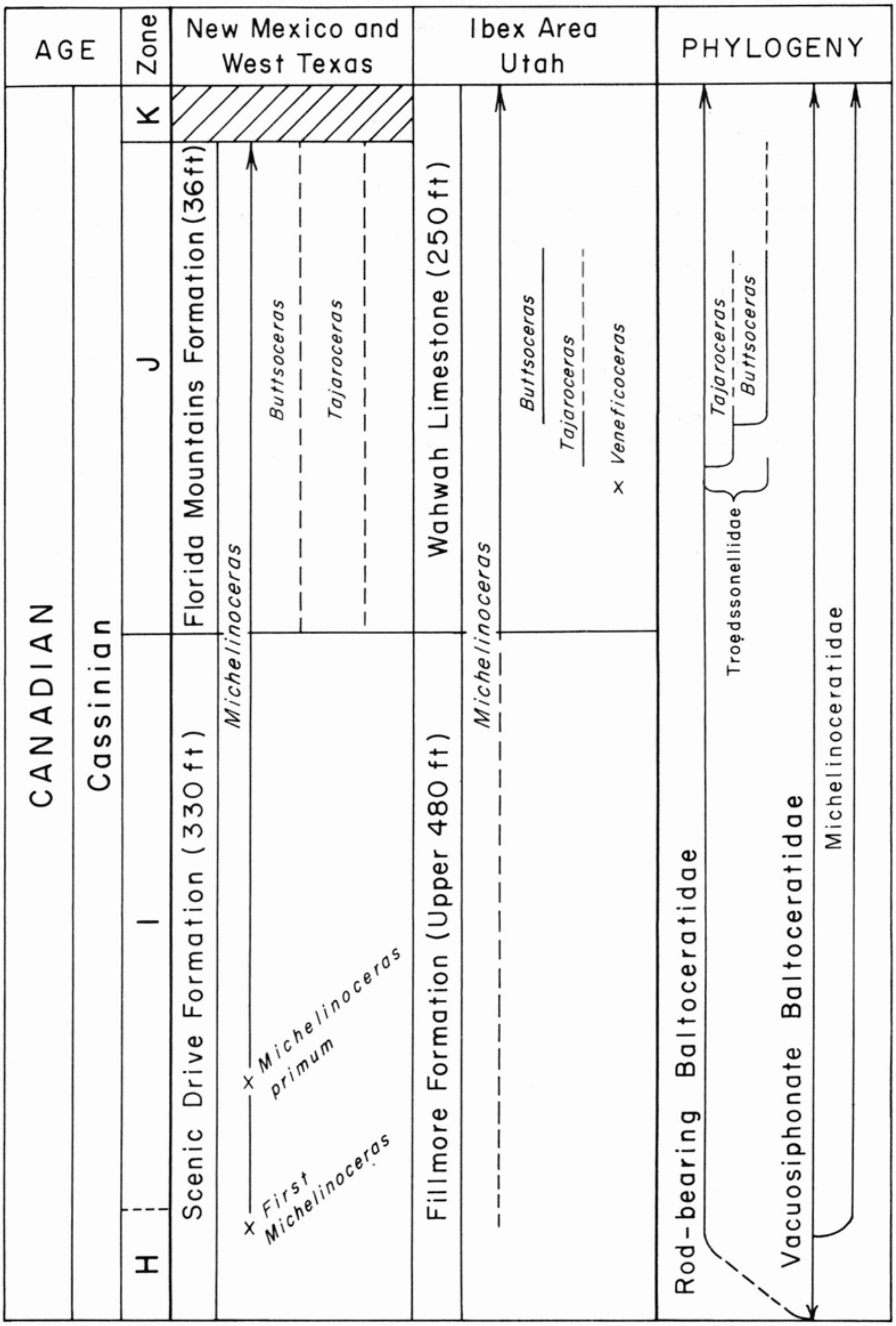

FIGURE 1—Schematic diagram of Late Canadian (late Early Ordovician) stratigraphy and phylogeny of the Baltoceratidae, Michelinoceratidae, and Troedssonellidae in the Wahwah Limestone and Florida Mountains Formation. Biostratigraphic ranges are dashed where inferred; arrows indicate continuance beyond Cassinian time; "x" indicates a single occurrence of a taxon. The lettered zones are the trilobite zones of Ross (1949, 1951) and Hintze (1951, 1952). Florida Mountains Formation not to scale. Modified from Hook and Flower, 1976.

Abstract

The Wahwah Limestone of western Utah and the Florida Mountains Formation of west Texas and southwestern New Mexico have yielded the only large, well-preserved cephalopod faunas of latest Canadian age (latest Early Ordovician) in North America. These faunas are completely Canadian in aspect and are dominated by the small orthocones belonging to the Ellesmeroceratida and the Michelinoceratida (= Orthoceratida). Surprisingly, the Tarphyceratida and Endoceratida, the dominant cephalopods of the Middle-Late Canadian, are minor faunal constituents in these faunas.

Analyses of more than 100 vertical (sagittal) thin sections of these orthocones revealed a morphological diversity previously unrecognized this early in the evolutionary history of the Cephalopoda. Complex patterns and combinations of cameral and siphonal deposits were observed in members of the Baltoceratidae, Protocycloceratidae, Michelinoceratidae, and Troedssonellidae. Three types of siphonal deposits (rods, annuli, and linings) and three types of cameral deposits (episeptal, hyposeptal, and mural) were observed in members of these families. The complexity of these patterns suggests a fairly long evolutionary history preceding the latest Canadian.

The derivation of the Troedssonellidae from the rod-bearing Baltoceratidae is further documented both stratigraphically and morphologically through the discovery of the new genus *Veneficoceras*, which is morphologically more similar to the rod-bearing Baltoceratidae than to the Troedssonellidae. The first North American representative of the genus *Manchuroceras*, previously known only from Manchuria and Australia and questionably from Siberia and Argentina, was discovered in the Florida Mountains Formation of west Texas.

New criteria based on thin- and opaque-section analyses are established for recognition of ventral lobes in suture patterns.

Twenty-five new taxonomic names are proposed, including 6 new genera and 19 new species. The new genera are *Amsleroceras, Rangeroceras, Veneficoceras, Bakeroceras, Wardoceras,* and *Enigmoceras.* The new species are *Amsleroceras gracile, Rangeroceras hintzei, Rhabdiferoceras planiseptatum, Veneficoceras susanae, Protocycloceras laswelli, P. rhabdiferum, Catoraphiceras ibexense, C. pearsonae, C. sinuatum, C. staceyae, Kyminoceras kottlowskii, Rudolfoceras keadyi, R. russelli, Bakeroceras wahwahense, Manchuroceras lemonei, Michelinoceras floridaense, M. melleni, Wardoceras orygoforme,* and *Enigmoceras diaboli.*

Introduction

PROBLEM AND PREVIOUS WORK

Although the publication of the nautiloid volume of the *Treatise on Invertebrate Paleontology* (Teichert and others, 1964) made a complete synthesis of cephalopod evolution possible (Teichert, 1967), the fact remains that very little detailed information is available on the evolution, morphology, and taxonomy of the cephalopods of the Late Canadian (late Early Ordovician). The Late Canadian is a critical time in the evolutionary history of the Cephalopoda because the close of the Canadian is marked by the extinction of 7 cephalopod families (Flower, 1964a, 1971, 1976c), whereas the Chazyan (Middle Ordovician) is marked by the appearance of 6 new cephalopod orders and 17 new families (Flower, 1964a); additionally, the Late Canadian marks the earliest known geological occurrence of cameral deposits in orthoconic cephalopods (Fenton and Fenton, 1958, p. 180; Flower, 1962, 1964a, b).

The contrast between the cephalopod faunas of the Canadian and Chazyan is so great that Flower (1957a, p. 17-18) proposed that the Canadian be recognized as a system distinct from that of the Ordovician proper. Later work (Flower, 1962) provided only minor faunal attrition with the recognition of two families of the Order Michelinoceratida (= Orthoceratida) in beds of Late Canadian age. The recognition of the Whiterock Stage (Cooper, 1956, p. 7) for rocks deposited during the interval of time between the Canadian and Chazyan provided the means to test Flower's proposal. Although the cephalopods of the Whiterock have proven to be highly distinctive, they are more similar to the cephalopods of the Chazyan than to those of the Canadian (Flower, 1968a, 1971, 1976a, b, c).

The use of the term Canadian goes much farther back than this. Bypassing various vicissitudes of usage, Ulrich (1911) proposed using both Ozarkian and Canadian as systems, between the Cambrian and Ordovician. Flower, the late Dr. Josiah Bridge, and others agreed that the Lower and Middle Ozarkian were equivalent to the Trempealeauian (Upper Cambrian), but that a Canadian succession was recognizable with the emendation that Ulrich's Lower Canadian and Upper Ozarkian are equivalents.

The origin of cameral deposits in the chambers of orthoconic cephalopods has long been a subject of controversy (for latest summary, Fischer and Teichert, 1969). However, their organic nature is now considered an established fact (Flower, 1964b; Gregorie and Teichert, 1965; Lowenstam, 1963; Fischer and Teichert, 1969). Cameral deposits, which are calcareous deposits secreted against the original walls of the camerae during the life of the animal, are interpreted as adaptive devices used to counteract the buoyant effect of gas in the camerae, thus maintaining the shell in a horizontal position during life (see cover illustration; Flower, 1955b, 1957b; Teichert and others, 1964; Teichert, 1967).

This report examines in detail the taxonomy and internal morphology of the cephalopod faunas of two formations of latest Canadian age from the southwestern United States: the Wahwah Limestone of western Utah and the Florida Mountains Formation of southwestern New Mexico and west Texas (Fig. 1). These two formations were chosen for study because they have yielded the only large well-preserved cephalopod faunas of latest Canadian age in North America. Also, good stratigraphic control is available for the specimens from the Wahwah Limestone (Hintze, 1973).

COLLECTIONS AND METHODS OF STUDY

The cephalopod collections described under Systematic Paleontology are presently housed in the Paleontology Laboratory of the New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico. All type and figured specimens have been given temporary catalog numbers. Eventually, all type specimens will be deposited in the U.S. National Museum, Washington, D.C.

The Wahwah Limestone collection was made by R. H. Flower and others under the auspices of the NSF Grant GB-3154, from Hintze's (1951, 1952) Ibex section J locality (NE1/4 sec. 31, T. 32 S., R. 14 W.), Millard County, Utah (Fig. 2). The Wahwah collection is stratigraphically keyed to Hintze's (1973) remeasured stratigraphic section J.

The Florida Mountains Formation collections were made by R. H. Flower and D. V. LeMone (University of Texas at El Paso) and are from two localities: one at the type locality for the formation in the Florida Mountains (NE'/4 sec. 6, T. 26 S., R. 7 W.), Luna County, New Mexico; the other in the Franklin Mountains (lat. 31° 44.4' N., and long. 106° 28.7' E.), El Paso County, Texas (Fig. 2).

The three collections are extensive—together they total over 400 specimens, and the collections from the Florida Mountains Formation represent 25 years of collecting by R. H. Flower. However, they consist almost entirely of small orthocones belonging to the Ellesmeroceratida and Michelinoceratida. The majority of the specimens are fragmentary and many are badly weathered. Fortunately, however, most are preserved as internal molds of phragmocones and, therefore, could effectively be studied in vertical (sagittal) thin section.

FIGURE 2—MAP SHOWING COLLECTING LOCALITIES. Wahwah Limestone at Ibex area. Florida Mountains Formation in Florida Mountains and Franklin Mountains.

Some 110 vertical thin sections were eventually made from a sample of approximately 150 of the best preserved specimens.

ACKNOWLEDGMENTS

This study would not have been possible without the generous financial support of the New Mexico Bureau of Mines and Mineral Resources. Oscar Paulson and Dave Kalvelage assisted with the photography. Richard Naff saw the manuscript through several drafts and made many useful suggestions concerning grammar and style. Without the fertile imagination of Jane Shaw Ward (1917), many of the new genera described here would be less colorfully and less appropriately named. We would also like to thank A. Gutjahr, F. Kottlowski, J. MacMillan, and W. J. Stone for advice and support throughout the duration of the project.

Stratigraphy

WAHWAH LIMESTONE

The Wahwah Limestone was named by Hintze (1951) for exposures of ledge-forming, quartz-silty calcisiltite in the Pogonip Group of western Utah (Figs. 1 and 2). The Wahwah contrasts topographically with the underlying, slope-forming Fillmore Formation and forms a series of conspicuous ledges, 6 to 9 ft (2 to 3 m) high. At its type locality (1/4 cor. sec. 5 and 6, T. 23 S., R. 14 W.), Hintze's (1951, 1952) measured section H in the Ibex area of western Utah, the Wahwah is 227 ft (69.2 m) thick and has a 1-ft-thick (0.3 m) marker bed characterized by an abundance of valves of the brachiopod *Hesperonomiella minor*, 190 ft (57.9 m) above its base.

The cephalopods studied for this report are from Hintze's (1951, 1952) measured section J (NE1/4 sec. 31, T. 22 S., R. 14 W.), where the Wahwah is approximately 250 ft (76.2 m) thick and ". . . is chiefly a quartz-silty calcisiltite with interbeds of thin-bedded calcarenite and intraformational conglomerate and a few beds of light olive fissile shale" (Hintze, 1973, p. 11). The *Hesperonomiella minor* coquina at section J is a bed 2 ft (0.6 m) in thickness, and is 215 ft (65.5 m) above the base of the Wahwah. Hintze (February 1967, written communication) also noted the occurrence of two continuous sponge-algal reefs, one 95 to 101 ft (29.0 to 30.8 m) above the base, the other 175 ft (53.3 m) above the base of the Wahwah at section J.

The Wahwah is abundantly fossiliferous and has a rich and varied fauna that includes graptolites, trilobites, conodonts, brachiopods, nautiloids, gastropods, and sponges. The description of the Wahwah cephalopods that follows is a small part of a much larger project to document the life forms in the entire Pogonip Group (Hintze and others, 1972). To date, the following fossil groups have been completely documented: brachipods, Jensen (1967); bryozoa, Hinds (1970); crinoids, Lane (1970); cystoids, Paul (1972); graptolites, Braithwaite (1976); pelecypods, Pojeta (1971); and trilobites, Hintze (1951, 1952), Demeter (1973), Terrell (1973) and Young (1973). Summaries of the various experts involved in this project can be found in Hintze and others (1972) and Hintze (1973).

Hintze (1951) correlated the fauna of the lower half of the Wahwah with Ross's (1949, 1951) faunal zone J. He used the *Hesperonomiella minor* coquina to mark the beginning of Ross's zone K, but added that "the bed has yielded none of the forms noted by Ross (1949, 1951) from his faunal zone K, but it occupies a similar stratigraphic position and is probably nearly equivalent" (Hintze, 1951, p. 17).

The Wahwah Limestone, according to Hintze and others (1972, p. 389), was "probably deposited in near shore shallow water of the continental shelf of the Ordovician miogeosyncline."

FLORIDA MOUNTAINS FORMATION

The Florida Mountains Formation, uppermost of the 10 formations comprising the El Paso Group, was named by Flower (1964a, p. 149) for exposures in the Florida Mountains of southwestern New Mexico (Figs. 1 and 2). Flower originally designated the formation as the Florida Formation; that name was pre-empted and LeMone (1969, p. 153) redesignated the formation as the Florida Mountains Formation and precisely located the type locality in the Florida Mountains.

The Florida Mountains Formation contains the youngest Canadian (late Early Ordovician) rocks in the southwestern New Mexico-west Texas area and is overlain with angular unconformity by the Upper Ordovician Second Value Formation of the Montoya Group. The formation is confined to a narrow outcrop belt that has been recognized only in the Florida Mountains of southwestern New Mexico and the Franklin Mountains and Beach Mountain of west Texas. The present study deals only with collections from the Florida Mountains and the Franklin Mountains.

At its type locality in the Florida Mountains (NE1/4 sec. 6, T. 26 S., R. 7 W.), the formation is approximately 47 ft (14.3 m) thick, is typically a slope former, and consists of fossiliferous calcarenite interspersed with dark calcilutite and some rarely exposed, white-weathering calcilutite (LeMone, 1976; Flower, 1969). In the Franklin Mountains it is approximately 39.3 ft (12.0 m) thick and consists of calcarenite interspersed with manly limestone and shale and contains a 6.5 ft (2 m) orange-weathering marker bed, 10 ft (3 m) below the top of the formation (LeMone, 1969, 1976).

The contained fauna is diverse and consists of nautiloids, brachiopods, cystoid and crinoid fragments, a starfish, trilobites, gastropods, sponges, and in the Florida Mountains, a large bivalved crustacean (Flower, 1964a, 1968b and LeMone, 1969). Its trilobite *genera—Pseudocybele, Goniotelina*, and *Pseudomera*equate with those of zone J in the Wahwah Limestone of western Utah, although species are largely distinct (Flower, 1968b). Zone K, which is faunally similar to zone J in western Utah, is probably not represented in the Florida Mountains Formation, purely on the basis of thickness (Flower, 1968a, p. 8). The formation is equivalent to unit C, beds 1-6 of Cloud and Barnes (1946).

LeMone (1976) interprets the Florida Mountains Formation as a foreland, tidal to subtidal, regressive facies of the Late Canadian.

Comparison of Faunas

The cephalopod faunas of both the Wahwah Limestone and the Florida Mountains Formation (Table 1) are completely Canadian in aspect; that is, there are no taxa in either formation that had previously been considered exclusively Chazyan or younger in age. Both faunas are dominated by small orthocones belonging to the Ellesmeroceratida and the Michelinoceratida; the endoceroids and the coiled forms are rare.

Although differences exist at the species level—the two formations share at best only the three species *Rhabdiferoceras planiseptatum*, n. sp., *Catoraphiceras* cf. *C. staceyae*, n. sp., and *Buttsoceras aff. B. novemexicanum—the* faunas of the two formations are virtually identical at the generic and familial levels. Discounting the coiled genera from the Wahwah, which are not described in this report but are presently in preparation by Flower, the cephalopod faunas of the Wahwah Limestone and the Florida Mountains Formation have eight of the nine genera known from more than one specimen in common. These genera *are Cyptendoceras, Rhabdiferoceras, Protocycloceras, Catoraphiceras, Rudolfoceras, Michelinoceras, Buttsoceras,* and *Tajaroceras.*

The differences at the species level in the two faunas may merely reflect the imperfections of paleontological species, especially those based on a few fragmentary specimens. On the other hand, the differences may in fact be real and, therefore, could have resulted from either wide geographic separation (Fig. 2) or environmental and facies differences. Environmentally, the differences are great enough in themselves to have produced differences at the species level; deposition of the Florida Mountains Formation is believed to have been in shallower water and to have been less continuous than that of the Wahwah Limestone (LeMone, 1976; Hintze and others, 1972, p. 389).

The important generalization that emerges from Table 1 is not that minor differences exist between the faunas at the species level, but rather that the two faunas are virtually identical at the generic and familial levels.

Differences at the species level also exist between the collections from the Florida Mountains and the Franklin Mountains, although both are from the same formation. The two collections have five genera in common (*Cyptendoceras, Protocycloceras, Catoraphiceras, Buttsoceras,* and *Michelinoceras),* but share only one species *(Buttsoceras novemexicanum).* The explanations advanced above also apply in this case. Again, however, these specific differences are minor, and the two collections are virtually identical at the generic and familial levels.

The Florida Mountains Formation and the Wahwah Limestone have yielded the only large, well-preserved cephalopod faunas of latest Canadian age in North America; in many parts of the continent equivalent beds have been eroded and in other places the uppermost Canadian is a barren dolomite, yielding insufficient faunal evidence as to precise age.

Comparable latest Canadian faunas have yielded few cephalopods, but many occurrences are poorly preserved. One is Oxford Township, Ontario, south of Ot-

TABLE 1—Nautiloid fauna of the Florida Mountains Formation and the Wahwah Limestone: x—this study; y—Flower (1964); m—Flower (in manuscript); *indicates taxon known from only one specimen.

	Florida Mountains Formation		Wahwah Limestone
Taxon	New Mexico	West Texas	Western Utah
ORDER ELLESMEROCERATIDA	x	x	x
Family BALTOCERATIDAE	x	x	x
**Amsleroceras*, n. gen.			x
**A. gracile*, n. sp.			x
Cyptendoceras	x	y	x
**C. floridaense*	y		
**C.* cf. *C. ruedemanni*	x		
**Rangeroceras*, n. gen.			x
**R. hintzei*, n. sp.			x
Rhabdiferoceras		x	x
R. planiseptatum, n. sp.			x
**Rioceras*?			x
**Veneficoceras*, n. gen.			x
**V. susanae*, n. sp.			x
Family PROTOCYCLOCERATIDAE	x	x	x
Protocycloceras	x	x	x
**P. laswelli*, n. sp.			x
**P.* aff. *P. laswelli*, n. sp.			x
P. rhabdiferum, n. sp.		x	
Catoraphiceras	x	x	x
**C. ibexense*, n. sp.			x
**C. pearsonae*, n. sp.			x
**C.* cf. *C. pearsonae*, n. sp.			x
**C. sinuatum*, n. sp.	x		
C. staceyae, n. sp.		x	
**C.* cf. *C. staceyae*, n. sp.			x
Kyminoceras	x		
K. kottlowskii, n. sp.	x		
Rudolfoceras	x		x
**R. keadyi*, n. sp.	x		
**R. russelli*, n. sp.			x
Family APOCRINOCERATIDAE?			x
**Bakeroceras*, n. gen.			x
**B. wahwahense*, n. sp.			x
ORDER ENDOCERATIDA		x	x
Family PROTEROCAMEROCERATIDAE		x	
**Clitendoceras* (=*Kirkoceras*)?		x	
**Phragmosiphon*?			x
*Family MANCHUROCERATIDAE		x	
**Manchuroceras*		x	
**M. lemonei*, n. sp.		x	
*Family ENDOCERATIDAE			x
ORDER TARPHYCERATIDA	x	x	m
Family TARPHYCERATIDAE			m
Deltoceras			m
Pionoceras			m
Family Trocholitidae			m
Curtoceras			m
Trocholitoceras			m
ORDER MICHELINOCERATIDA	x	x	x
Family MICHELINOCERATIDAE	x	x	x
Michelinoceras	x	x	x
**M. floridaense*, n. sp.	x		
**M. melleni*, n. sp.	x		
**Wardoceras*, n. gen.			x
**W. orygoforme*, n. sp.			x
Family TROEDSSONELLIDAE	x	x	x
Buttsoceras	x	x	x
?*B. adamsi*		x	
B. novemexicanum	x	x	
B. aff. *novemexicanum*			x
**B. williamsi*	x		
Tajaroceras		x	x
T. wardae			x
*ORDER Uncertain			x
**Enigmoceras*, n. gen.			x
**E. diaboli*, n. sp.			x

tawa, Canada. Here, *Buttsoceras* and some rod-bearing Baltoceratidae are known and a broad-whorled coiled form of the aspect of *Pionoceras* was seen. In western Newfoundland three discrete faunules have been found above the main *Cassinoceras wortheni* fauna; one contains *Buttsoceras,* a true *Pro terocameroceras,* and a small strongly costate, stout-whorled coiled shell that is probably a new genus. Cephalopods from the highest Canadian faunas of the Phillipsburg section of Quebec are virtually unknown and poorly preserved. While Upper Canadian faunas are known or are in the process of study from Spitzbergen and Scotland, there is no indication that any of these faunas are younger than the widespread faunas of zone I of western Utah, which continue with change into the Scenic Drive Formation of New Mexico, the Powell Limestone of the Ozarks and its equivalents in Virginia, the Fort Cassin Limestone of the Champlain Valley, the Solomons Corners and St. Armand Formations of the Phillipsburg region of Quebec, the *Cassinoceras wortheni* fauna of the St. George Group of western Newfoundland, and the Croisaphuill fauna of the Durness Group of northern Scotland.

In the southern Appalachians the Odenville Limestone of Alabama has yielded a cephalopod fauna with *Buttsoceras* and *Michelinoceras,* but the recovered material consists of silicified specimens on weathered surfaces; such material is usually unrewarding for thin-section study. The Smithville Formation and the equivalent Black Rock Formation of Arkansas have yielded supposedly latest Canadian cephalopods, but all of the Smithville material is so strongly silicified that fine structure is lost and thin sections are completely unrewarding. These two formations have yielded no material of the Michelinoceratidae or Troedssonellidae, and forms of the Baltoceratidae and Protocycloceratidae so far retrieved have small marginal siphuncles, and are unlike the more advanced forms with larger siphuncles, which, in this study, have shown complex and varied siphonal structures.

Siphonal and Cameral Deposits

Much of the morphologic variation observed in these small, Late Canadian orthocones probably developed in response to the problems of buoyancy control (Teichert, 1967) and rotational stability. Several independent lines of evidence, summarized in Flower (1975b, p. 832-835) and Teichert and others (1964, p. K 114-K123), indicate that the shell in orthoconic cephalopods was held horizontally during life, and the majority of fossil nautiloids resembled the living *Nautilus* in having gas in their camerae.

In order for an orthoconic cephalopod to maintain horizontal equilibrium, the buoyant effect of cameral gas had to be counterbalanced; that is, the center of buoyancy of the animal had to coincide with or lie vertically above the center of gravity at all growth stages (see cover illustration). Three of the earliest adaptive devices that evolved to regulate buoyancy in orthoconic cephalopods were 1) crowding of septa, a primitive feature, 2) deposition of ventrally concentrated, mineralized deposits in the siphuncle and camerae, and 3) periodic shell truncation (Teichert and others, 1964, p. K116, and Teichert, 1967, p. 203204). Among these Late Canadian orthocones only the second adaptive device, deposition of siphonal and cameral deposits, played a significant role, although the cyclic repetition of septa in *Enigmoceras,* n. gen. (Pl. 18, figs. 7-18, Fig. 13) suggests that it might have undergone periodic shell truncation.

SIPHONAL DEPOSITS

Three primary siphonal structures are recognized in these Late Canadian orthocones: rods, linings, and annuli. These structures were observed to occur either separately or in combination; in *Tajaroceras* (Fig. 3E) all three are developed in the same individual.

Rods, whose organic nature was first recognized by Flower (1964a), are the most abundant siphonal structure in these Late Canadian orthocones and are developed in the Baltoceratidae, Protocycloceratidae, Apocrinoceratidae?, and the Troedssonellidae. Rods are calcareous siphonal structures that are generally preserved as coarsely recrystallized calcite. They are usually round in cross section, lie against the ventral wall of the siphuncle, are blunt or pointed anteriorly, thicken apicad, and eventually may completely fill the apical part of the siphuncle. Their exact origin and mode of growth is not completely understood at present. However, one rod-bearing genus of the Baltoceratidae, *Rangeroceras*, n. gen. (Fig. 3D) has not only a ventral rod in which curved growth lamellae are preserved, but also dorsal siphonal annuli. Taken together these two siphonal structures suggest that the origin of some rods is to be found in annulosiphonate deposits whose structure has been destroyed during recrystallization.

However, the Late Canadian was apparently a time of intense morphological experimentation among the small orthocones in which only a finite number of solutions to the buoyancy and rotational problems were possible. We believe that the rod in *Rangeroceras,* n. gen. is a homeomorphic structure because there are several rod-bearing members of the Baltoceratidae and Protocycloceratidae which in thin section show both the termination of the rod and several empty siphuncle segments beyond; for example, *Amsleroceras,* n. gen. (Pl. 13, fig. 16; Fig. 6). If all rods had originated from the growth of annulosiphonate deposits, discrete annuli would be expected in the siphuncle segments immediately preceding the termination of the rod; to date none have been found. Thus, it is probable that most rods did not develop from annulosiphonate deposits, but in other ways that are not yet understood.

Annuli are the next most prevalent siphonal structure and were observed in the Baltoceratidae, Apocrinoceratidae?, Troedssonellidae, and Michelinoceratidae. Annuli may occur as discrete structures (Fig. 3G), or may fuse to form a lining on one side of the siphuncle (Fig. 3C, E) or on both (Fig. 3H).

Linings, *per se*, the parietal deposits of the *Treatise* (Teichert and others, 1964), were observed only in *Buttsoceras* (Fig. 3F) of the Troedssonellidae. In advanced growth stages diaphragms may fill the dorsal cavity in the lining (Fig. 3F). Linings may also result from the growth of annuli which have fused (Fig. 3H).

Siphonal deposits may occur as the only adaptive device to regulate buoyancy and provide rotational stability (Fig. 3A, F) or in combination with cameral deposits (Fig. 3B-E, G, H). In the Baltoceratidae, Protocycloceratidae, and Troedssonellidae siphonal deposits are volumetrically more significant, and therefore played a greater role in regulating buoyancy than in the Michelinoceratidae. The greater importance of siphonal deposits in the Baltoceratidae, Protocycloceratidae, and Troedssonellidae is not merely a reflection of greater relative siphuncle diameter in this group of families; it also reflects the fact that siphonal deposits are more highly developed and fill more of the siphuncle at equivalent growth stages in this group of families than in the Michelinoceratidae.

CAMERAL DEPOSITS

All three types of cameral deposits (episeptal, hyposeptal, and mural) are recognized in these Late Canadian orthocones. Well-developed cameral deposits were observed in members of the Baltoceratidae, Protocycloceratidae, Troedssonellidae, and Michelinoceratidae. The highly complex patterns of cameral deposits observed in the Michelinoceratidae suggest a fairly long evolutionary history preceding the latest Canadian that can be traced back at least as far as *Michelinoceras primum* (Flower, 1962; Fig. 1).

Cameral deposits seen in vertical thin section are comparatively thin and simple in the Baltoceratidae and Protocycloceratidae. Thin episeptal deposits are well documented in these two families in the plates that follow; whether episeptal deposits merge dorsally with mural deposits is a matter of conjecture. In general the dorsal shell wall of the Baltoceratidae and Protocycloceratidae described in this report has been destroyed by weathering or abrasion. In those few specimens in which the shell wall is intact, dorsal structures are ambiguous, as shown in Pl. 1, fig. 1. *Rangeroceras,* n. gen. (Fig. 3D) has the most complex cameral deposits of

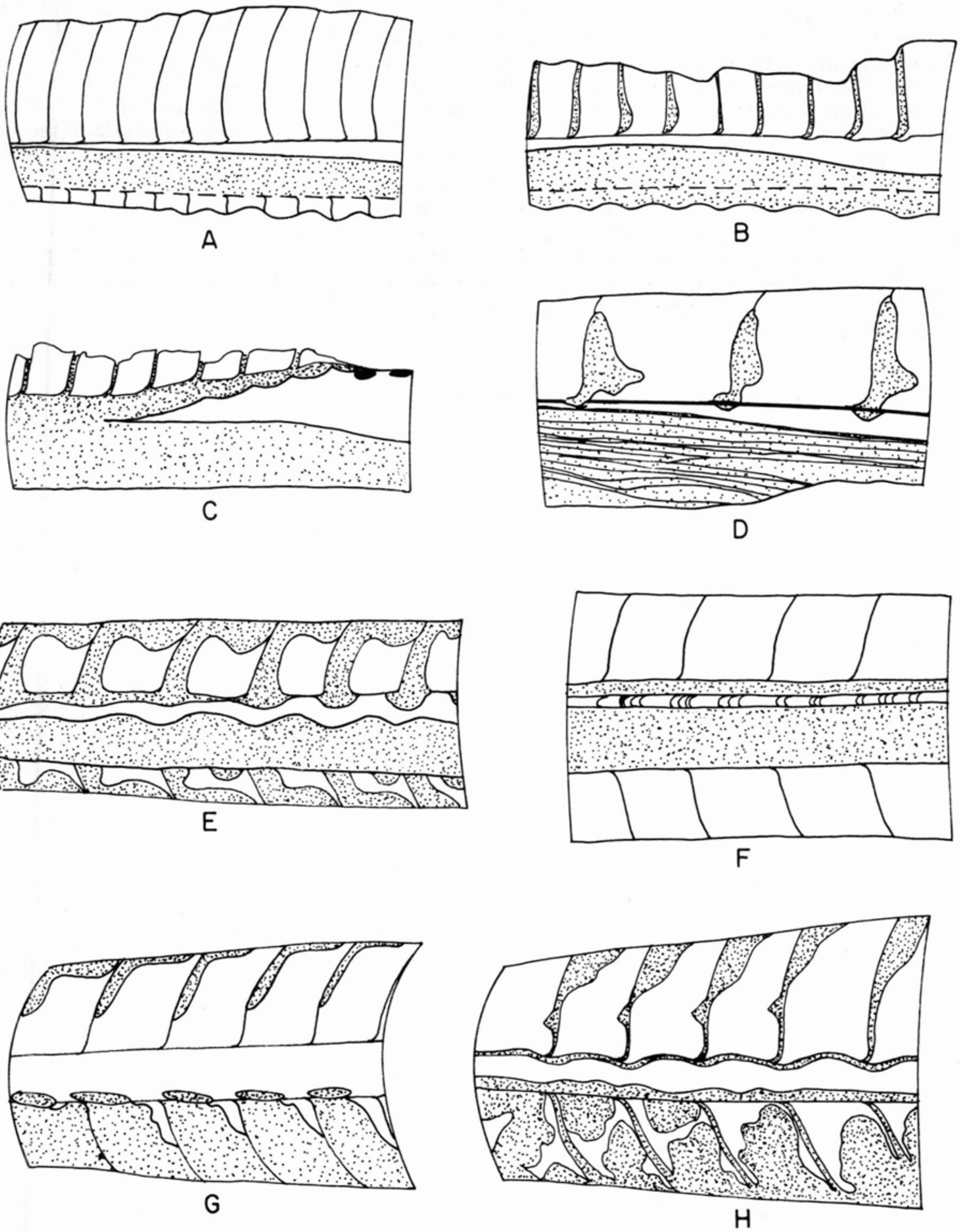

FIGURE 3—REPRESENTATIVE SIPHONAL AND CAMERAL DEPOSITS IN VERTICAL THIN SECTION. DRAWINGS BASED ON ACTUAL SPECIMENS; STIPPLED AREAS REPRESENT CAMERAL AND SIPHONAL DEPOSITS; SOLID DARK AREAS REPRESENT INTERPRETED STRUCTURES. A) *Protocycloceras laswelli,* n. sp., X2.5: ventral rod, no cameral deposits. B) *Protocycloceras rhabdiferum,* n. sp., X5.1: ventral rod, episeptal cameral deposits. C) *Veneficoceras susanae,* n. sp., X4.5: ventral rod and dorsal annuli(?), no cameral deposits. D) *Rangeroceras hintzei,* n. sp., X8.5: ventral rod and dorsal annuli, episeptal cameral deposits. E) *Tajaroceras wardae,* X3.4: ventral rod, dorsal annuli, and siphonal lining; episeptal and mural cameral deposits. F) *Buttsoceras williamsi,* X3.4: siphonal lining crossed by diaphragms, no cameral deposits. G) *Michelinoceras floridaense,* n. sp., X5.1: ventral annuli, episeptal and mural cameral deposits. H) *Wardoceras orygoforme,* n. sp., X3.4: siphonal lining; episeptal, mural, and hyposeptal cameral deposits.

the ellesmeroceroids described in this report, yet these pale in comparison to the highly complex deposits of the new michelinoceroid genus *Wardoceras* (Fig. 3H). Calcite between siphuncle and venter, presumably cameral deposits, often fills the ventral portion of the camerae (Fig. 3B). Hyposeptal deposits were not observed in any of the Baltoceratidae and Protocycloceratidae herein described.

Cameral deposits are well developed and often highly complex in the michelinoceroids (Fig. 3E-H), although they are apparently absent altogether in *Buttsoceras williamsi* (Fig. 3F). All three types of cameral deposit were observed in the michelinoceroids, although hyposeptal deposits are rare and confined to *Wardoceras,* n. gen. (Fig. 3H) and to some specimens assigned to *Buttsoceras novemexicanum* (Pl. 10, figs. 1-4).

Cameral deposits in the Michelinoceratidae are normally thin and relatively simple in the dorsal half of the camerae, but quite complex and thick ventrally, often filling the ventral half of the camerae. Highly lobate, *Pseudorthoceras-like* mural deposits are developed in *Wardoceras,* n. gen. (Fig. 3H) and suggested in *Tajaroceras* (Pl. 21, fig. 13). Mural deposits in *Tajaroceras* (Pl. 21, figs. 12, 13) on the dorsal side of the siphuncle have their own nongradational boundaries distinct from those of the episeptal deposits and in some camerae are actually separated from the episeptal deposits by matrix. This separation suggests that mural deposits are not necessarily mere extensions of episeptal deposits onto the mural part of the septum, but may be distinct deposits.

Taxonomic Summary

The cephalopod faunas of both the Florida Mountains Formation and the Wahwah Limestone are dominated by small orthocones belonging to the Orders Ellesmeroceratida and Michelinoceratida (= Orthoceratida). The endoceroids are practically nonexistent and the coiled forms are rare.

Order ELLESMEROCERATIDA

Family BALTOCERATIDAE

The Baltoceratidae in the Florida Mountains Formation and the Wahwah Limestone consist almost entirely of rod-bearing orthocones with ventral siphuncles. However, this numerical dominance of rod-bearing forms over those with empty siphuncles (vacuosiphonate forms) may represent a preservation bias because there are many smooth orthocones in the collections that could not be identified because weathering had destroyed their siphuncles. Rods, of course, not only afford greater resistance to weathering, but also generally insured that the shells landed venter down in the sediments.

The origin and mode of growth of rods are not completely understood at present. Discovery of curved growth lamellae in the rod of *Rangeroceras,* n. gen. (Fig. 3D) combined with small dorsal siphonal annuli suggests an origin in annular deposits. This mode of growth was apparently not common because 1) growth lamellae have been observed in only the one specimen, 2) thin sections of several rod-bearing genera show both the termination of the rod and several empty siphuncle segments beyond, and 3) rods stratigraphically precede annuli (Fig. 1 and Flower 1964). If all rods had grown through coalescence of annular deposits, then discrete annuli should be found in the siphuncle segments immediately preceding the termination of the rod; to date none have been found.

Discovery of the curved growth lamellae and dorsal annuli in the siphuncle of *Rangeroceras*, n. gen. (Fig. 3D) and the suggestion of annuli that have fused to form a siphonal lining with the rod of *Veneficoceras*, n. gen. (Fig. 3C) placed new demands on the taxonomy which required redefinition of the Baltoceratidae to include forms with siphonal annuli, thus blurring the boundary between the Baltoceratidae and the Michelinoceratida. In the case of *Veneficoceras,* n. gen., assignment to the Baltoceratidae was based on its large, marginal siphuncle and ventral rod; for *Rangeroceras,* n. gen., it was based on the rod, depressed cross section, layered rings, and apparently submarginal siphuncle.

One interesting fact about these two genera is that they appear to be transitional into two different families of the Michelinoceratida: *Veneficoceras* into the Troedssonellidae and *Rangeroceras* into the Michelinoceratidae. This fact in itself argues for the creation of two families within the Baltoceratidae—one for the rod-bearing genera and one for vacuosiphonate genera. When combined with other evidence suggesting the origin of the Troedssonellidae from the rod-bearing Baltoceratidae (Hook and Flower, 1976, and Figs. 1 and 4 herein), and the Michelinoceratidae from the vacuo siphonate forms (Flower, 1962, 1964a), the need for taxonomic revision of the Baltoceratidae becomes increasingly apparent.

Flower (1964b, p. 31) noted the practical difficulties involved in separating the rod-bearing genera of the Baltoceratidae into a distinct family. The main deterents then and now are the fragmentary nature of the material on which genera are based, and a figured specimen of *Baltoceras* (Schindewolf, 1942, p. 329, fig. I) in which a rod-like structure is shown in the siphuncle. If *Baltoceras* is a rod-bearing genus, then the Baltoceratidae should be used for rod-bearing genera and a new family should be erected for the vacuosiphonate genera. Given these circumstances, Flower (1964b, p. 31) concluded that ". . . the question is best avoided by the recognition of the rods as appearing in some specialized members of a group for which the family name Baltoceratidae is retained."

Three new genera *(Amsleroceras, Rangeroceras,* and *Veneficoceras)* and four new species *(Amsleroceras gracile, Rangeroceras hintzei, Rhabdiferoceras planiseptatum*, and *Veneficoceras susanae)* belonging to the Baltoceratidae are herein described and illustrated.

Family PROTOCYCLOCERATIDAE

The Protocycloceratidae are well represented in the two formations and are particularly abundant in the Florida Mountains Formation, where they were probably the dominant cephalopods. Shells range from straight to slightly exogastric; septal necks are short and straight, and rings are predominantly thin and homogeneous. Rod-bearing species are known with certainty in only two genera, *Protocycloceras* and *Catoraphiceras*. The genus *Catoraphiceras* is now known to be more abundant than previously thought as a result of new criteria for the recognition of ventral lobes (see p. 20).

Flower (1964a), in his monographic treatment of the Ellesmeroceratida, indicated that the Protocycloceratidae were probably a grouping of homeomorphs of diverse origin. Nowhere is this more apparent than in the genus *Protocycloceras.* Flower (1964a) recognized three morphologic types in *Protocycloceras* all of which could be of diverse origin: 1) forms with empty siphuncles that could be derived through *Walcottoceras* and the Ellesmeroceratidae; 2) forms with diaphragms that may be a distinct lineage stemming from the Ellesmeroceratidae or a modification of the vacuosiphonate forms; and 3) forms with a ventral rod, possibly derived from the rod-bearing members of the Baltoceratidae. Two other possibilities, based on the present study, should be added to the list: 4) species of *Protocycloceras* with empty siphuncles could be derived from the vacuosiphonate Baltoceratidae; or 5) parallel evolution between the Baltoceratidae and Protocycloceratidae in which both had evolved the same mechanisms for regulating buoyancy and maintaining rotational stability may be involved. At the present state of knowledge choice among the possibilities outlined above is impossible. No concrete solutions to this problem are likely to be forthcoming until the detailed internal morphology of both the Baltoceratidae and Protocycloceratidae is chronologically well known.

Nine new species *(Protocycloceras laswelli, P. rhabdiferum, Catoraphiceras ibexense, C. pearsonae, C. sinuatum, C. staceyae, Kyminoceras kottlowskii, Rudolfoceras keadyi,* and *R. russelli)* belonging to the Protocycloceratidae are described and illustrated in this report.

Family APOCRINOCERATIDAE?

Flower (Flower and Teichert, 1957, p. 136) established the Family Apocrinoceratidae for small annulated orthocones with short necks and thick rings expanded into the camerae. He suggested that the Apocrinoceratidae represented a lineage derived from the Protocycloceratidae by expansion of siphuncle segments into the camerae and that the Apocrinoceratidae were an evolutionary dead end. Flower (Flower and Teichert, 1957; Flower, 1964a) included three genera *(Desioceras, Glenisteroceras,* and *Apocrinoceras)* in the Apocrinoceratidae. The *Treatise* (Teichert and others, 1964) abandoned the Apocrinoceratidae and assigned *Apocrinoceras* to the Protocycloceratidae, *Desioceras* to the Ellesmeroceratidae, and *Glenisteroceras* to the ?Troedssonellidae. In our use of the Apocrinoceratidae we have followed Flower (Flower and Teichert, 1957; Flower, 1964a).

Two specimens from the Wahwah Limestone are tentatively assigned to the Apocrinoceratidae. Both are annulated and have thin rings expanded into the camerae and are interpreted as transitional forms between the Protocycloceratidae and the Apocrinoceratidae. *Bakeroceras,* n. gen., is the earliest known annulated orthocone to develop annuli within its siphuncle.

One new genus *(Bakeroceras)* and one new species *(Bakeroceras wahwahense)* tentatively assigned to the Apocrinoceratidae are herein described and illustrated.

Order ENDOCERATIDA

The endoceroids are remarkable in their scarcity in both the Florida Mountains Formation and the Wahwah Limestone. There are only four endoceroids in the entire collection, two from the Florida Mountains Formation of west Texas and two from zone K in the Wahwah Limestone of western Utah, yet all four are important, and each is anomalous.

The one small piloceroid endosiphuncle from the Florida Mountains Formation is the first representative of *Manchuroceras* in North America. *Manchuroceras* had previously been known only from Manchuria and Australia and questionably from Argentina and Siberia. The other small endosiphuncle from the same locality is tentatively identified as *Clitendoceras (= Kirkoceras)?* sp., a genus previously not known to occur above the Middle Canadian (Hintze's zones E-F).

The other two endoceroids are both from high in zone K in the Wahwah Limestone of western Utah. One specimen is tentatively identified by Flower as *Phragmosiphon?* sp., a genus previously not known to occur above the Middle Canadian (approximately zone E) and previously known only from Maryland. The other specimen from the Wahwah is an unnamed new genus with macrochoanitic necks, a condition previously not reported below the Whiterock Stage (zones L-0) in Utah.

The absence of the endoceroids from both the Wahwah and the Florida Mountains Formation is a mystery, particularly since the endoceroids are so abundant both above and below these formations. Part of the answer may lie in the small size of the two endosiphuncles from the Florida Mountains Formation, one of which is 27 mm long, the other, 38 mm. The two zone K endoceroids are large specimens, less likely to be overlooked in the field, but they occur in the sparsely fossiliferous portion of the Wahwah.

One new species *(Manchuroceras lemonei)* of endoceroid is described and illustrated in this report.

Order TARPHYCERATIDA

Coiled cephalopods are only minor faunal constituents in both the Wahwah Limestone and the Florida Mountains Formation. Several coiled species have come from the Wahwah (Hintze and others, 1972) that will be described in another work (Flower, in preparation). Included are *a Deltoceras,* previously known only from the St. George Group of Newfoundland, and *a Pionoceras* of the Tarphyceratidae and *Curtoceras, Trocholitoceras,* and a new genus of the Trocholitidae showing the rapid vertical enlargement of *Eurystomites,* but with a dorsal instead of ventral siphuncle. The Florida Mountains Formation has yielded only unidentifiable fragments of coiled cephalopods.

Order MICHELINOCERATIDA
(= ORTHOCERATIDA)

The michelinoceroids are more abundant and more diverse in the Late Canadian than previously thought and are not, as Teichert (1967) suggested, insignificant constituents of Late Canadian faunas. At least two families, the Troedssonellidae and the Michelinoceratidae, are present in the Wahwah Limestone and the Florida Mountains Formation. Complex patterns of siphonal and cameral deposits present in several species suggest a long evolutionary history preceding the latest Canadian. The earliest known michelinoceroids occur low in the Scenic Drive Formation of west Texas (Hook and Flower, 1976, and Fig. 1).

Family MICHELINOCERATIDAE

The genus *Michelinoceras* has been broadly defined in this report and is used for smooth orthocones, circular in cross section, with central siphuncles containing annuli which may or may not grow forward and fuse, and cameral deposits. In this usage *Michelinoceras* is extended to include *Geisonoceras* on the basis of internal features, simply because at present no clear line can be drawn between these genera. Also, the specimens studied are fragmentary and many have undergone complex histories of diagenesis, making interpretation of internal structures ambiguous at best.

For the purposes of this report it is more important to define the present usage given to *Michelinoceras* than to justify it; proper splitting of the Late Canadian Michelinoceratidae must proceed with caution, taking into account as many species as possible and making sure that genera are based on species that are adequately known internally. For the present, the importance of these specimens lies in their morphological variation, rather than in their proper generic and familial assignments.

The taxonomic problems surrounding the transition of the Baltoceratidae into the Michelinoceratida have been previously discussed in the section on the Baltoceratidae. Problems were also encountered in the familial assignment of michelinoceroids with siphonal linings. For the purposes of this report, genera with siphonal linings were assigned to the Michelinoceratidae only if the lining could be shown to have an origin in annular deposits; otherwise, they were assigned to the Troedssonellidae.

One new genus *(Wardoceras)* and three new species *(Michelinoceras floridaense, M. melleni,* and *Wardoceras orygoforme)* belonging to the Michelinoceratidae are herein described and illustrated.

Family **TROEDSSONELLIDAE**

Hook and Flower (1976) have stratigraphically and morphologically documented the most likely evolutionary path leading from the rod-bearing Baltoceratidae to the Troedssonellidae. Their intermediate genus *Tajaroceras* is, however, morphologically more similar to *Buttsoceras* and the Troedssonellidae than to the rod-bearing Baltoceratidae. *Veneficoceras,* n. gen., whose marginal siphuncle is interpreted to contain both a ventral rod and dorsal annuli, seemingly supplies the morphological transition between the rod-bearing Baltoceratidae and *Tajaroceras* (Fig. 4) and indicates that siphonal annuli could have developed prior to the migration of the siphuncle to a more central position. The evolutionary picture presented in Figs. 1 and 4 is stratigraphically well documented with all transitional forms making their first appearance in the Wahwah Limestone prior to that of their supposed progeny and is therefore a classic example of "phyletic gradualism" (Eldredge and Gould, 1972, p. 89).

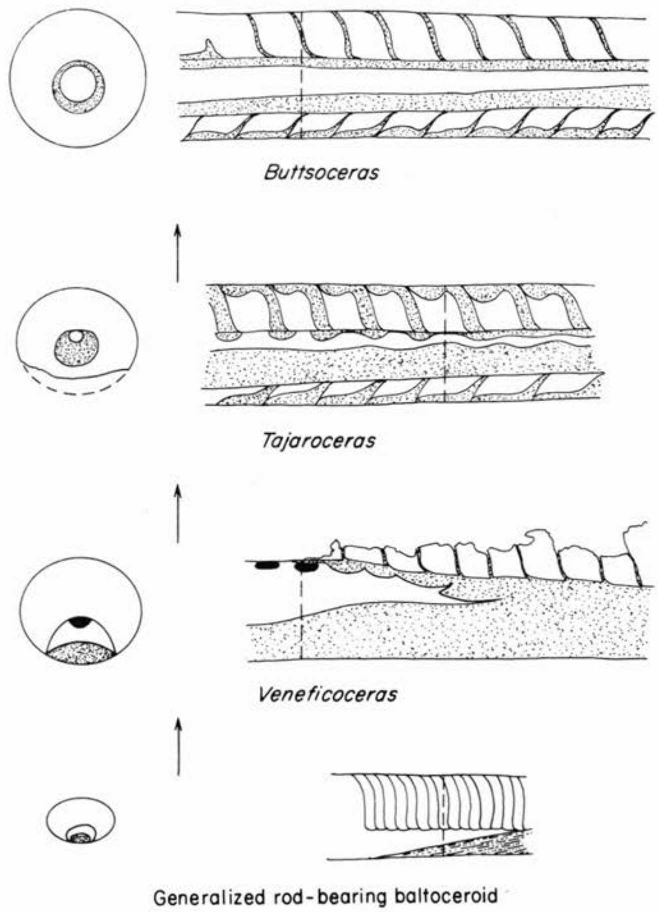

FIGURE 4—EVOLUTION OF THE TROEDSSONELLIDAE FROM THE ROD-BEARING BALTOCERATIDAE. Schematic view of the proposed line of descent leading from the rod-bearing Baltoceratidae through *Veneficoceras* and *Tajaroceras* into *Buttsoceras* and the Troedssonellidae. Dashed lines show approximate position of cross sections relative to vertical thin sections; stippled areas represent siphonal and cameral deposits. Drawings based on specimens described in this report; annuli (dark areas) are interpreted, although not actually observed, in the siphuncle of *Veneficoceras.*

Criteria for Recognition of Ventral Lobes

Within the existing taxonomic framework of the cephalopods, suture patterns are often generic characteristics. This is particularly true in the Protocycloceratidae where the genus *Catoraphiceras* is distinguished from *Protocycloceras* merely on the basis of its suture pattern: in *Protocycloceras* sutures are straight and transverse; in *Catoraphiceras* they form ventral lobes.

Recognition of ventral lobes in well-preseved material (Fig. 5A) is generally not difficult. However, many specimens are so badly weathered (Fig. 5B) that their suture patterns have been destroyed. Two criteria for recognizing ventral lobes in vertical section are illustrated in Fig. 5C, D. Both criteria are based on the simple fact that a ventral lobe is not merely the result of a plane curved septum intersecting the shell wall at an acute angle, but rather the result of an abrupt reversal of curvature of the septum in the vicinity of the siphuncle. This abrupt reversal of curvature causes the septum to swing apicad around the ventral side of the siphuncle.

Fig. 5C shows an opaque section of a specimen, venter on left, ground in a vertical plane that has not yet reached the siphuncle, in which the septa show the reversal of curvature and apicad swing around the siphuncle. As a result of this apicad swing around the siphuncle, necks on the ventral side of the siphuncle are apicad of (below) those on the dorsal side of the siphuncle, as shown in Fig. 5D.

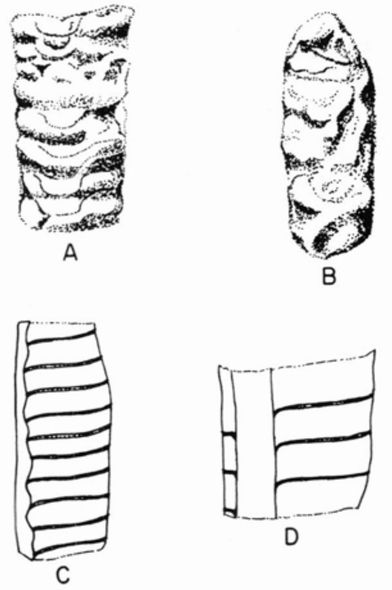

FIGURE 5—CRITERIA FOR RECOGNITION OF VENTRAL LOBES. A) Ventral view of a well-preserved specimen of *Catoraphiceras* in which ventral lobes are evident. B) Ventral view of a poorly-preserved specimen with a submarginal siphuncle in which the suture pattern is not evident. C) Opaque section through B, venter on left, that has been ground in a vertical plane that has not yet reached the siphuncle. Note the apicad (downward) swing of the septa in the vicinity of the siphuncle. D) Schematic drawing of a vertical thin section through *Catoraphiceras*, venter on left. Note that necks on the ventral side of the siphuncle are apicad of (below) those on the dorsal side of the siphuncle. Drawings based on specimens described in this report.

Conclusions

Thin-section analysis of the cephalopod faunas of the Late Canadian Wahwah Limestone and Florida Mountains Formation of the southwestern United States revealed a morphological diversity previously unrecognized this early in the evolutionary history of the Cephalopoda (Teichert and others, 1964; Teichert, 1967). Complex patterns and combinations of cameral and siphonal deposits were observed in members of the Baltoceratidae and Protocycloceratidae of the Ellesmeroceratida and in members of the Michelinoceratidae and Troedssonellidae of the Michelinoceratida. The complexity of these patterns and combinations suggests a fairly long evolutionary history preceding the latest Canadian and indicates that the Late Canadian, rather than the Middle and Late Ordovician as stated by Teichert (1967, p. 170), may have been the time of greatest differentiation in the basic morphological patterns in the history of the cephalopod evolution.

The cephalopod faunas of both the Wahwah Limestone and the Florida Mountains Formation are completely Canadian in aspect and are dominated by the small orthocones belonging to the Baltoceratidae, Protocycloceratidae, Michelinoceratidae, and Troedssonellidae. A total of 23 cephalopod genera representing at least 10 families and 4 orders are recognized in these two formations (Table 1). Surprisingly, the Endoceratida and the Tarphyceratida, the dominant cephalopods of the Middle and Late Canadian (Flower, 1976c), are rare in both formations. The endoceroids are repre sented by only four specimens in the collections; however, one of these, a small nondescript endosiphuncle, turned out to be the first representative of the Late Canadian genus *Manchuroceras* in North America. *Manchuroceras* has a rather curious distribution and was previously known only from Manchuria and Australia and questionably from Siberia and Argentina. Tarphyceratida are represented by only unidentifiable fragments in the Florida Mountains Formation, although several coiled species have come from the Wahwah Limestone (Hintze and others, 1972, p. 395; Flower, in preparation) but are not described in this report.

The material studied was disappointingly fragmentary and much of it was so extensively replaced or recrystallized that it often presented perplexing taxonomic difficulties. These difficulties were particularly acute at the boundary between the Baltoceratidae and the Michelinoceratida where several transitional genera occur. Among these transitional genera, *Veneficoceras* and *Tajaroceras* must rank first in importance because they morphologically and stratigraphically document the evolution of the Troedssonellidae from the rod-bearing Baltoceratidae during Late Canadian time (Figs. 1 and 4; Hook and Flower, 1976) and, therefore, represent a classic case of phyletic gradualism. Additionally, new criteria based on thin- and opaque-section analyses are developed for recognition of ventral lobes in the suture patterns of orthoconic cephalopods.

Systematic Paleontology

Order ELLESMEROCERATIDA

Family BALTOCERATIDAE

GENUS *AMSLEROCERAS*, n. gen.

TYPE SPECIES: *Amsleroceras gracile*, n. sp.
Fig. 6

DESCRIPTION—The genus *Amsleroceras* is erected for generalized rod-bearing members of the Baltoceratidae with straight, transverse sutures and concave siphuncle segments composed of short straight necks and thin homogeneous rings. The shell is orthoconic, depressed in cross section, and has a medium-sized (approximately 0.3 of shell width), circular siphuncle slightly removed from the venter. Septa are moderately curved; ventrally concentrated episeptal cameral deposits are developed in the type species.

DISCUSSION—A *Amsleroceras* is a generalized rod-bearing baltoceroid that shows closest affinities to *Cyptendoceras,* particularly in the concave siphuncle segments. However, *Amsleroceras* lacks the ventral lobe of *Cyptendoceras* and, for that matter, of *Murrayoceras* and *Cartersoceras. Rhabdiferoceras* is the only other previously described rod-bearing genus with straight, transverse sutures; *Amsleroceras* lacks the flat septa and thicker, more fully developed cameral deposits of that genus and has concave, rather than straight or slightly convex, siphuncle segments.

DERIVATION OF NAME—The genus *Amsleroceras* is named in honor of Col. and Mrs. H. S. Amsler of Canton, Mississippi.

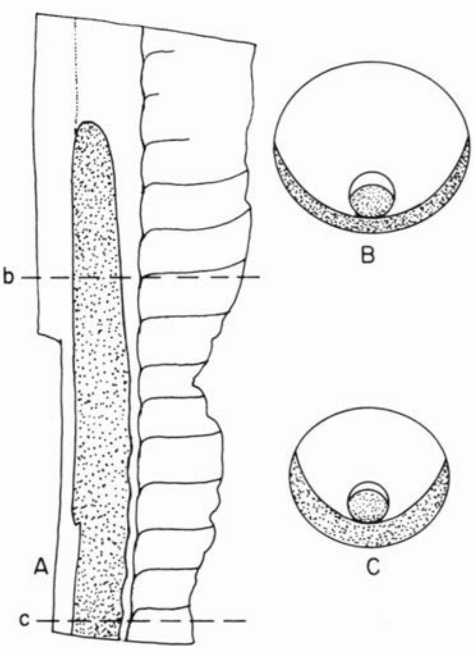

FIGURE 6—*Amsleroceras*, N. GEN. A) Vertical thin section through anterior 36 mm of type species, venter on left, X2.3. B) Cross section at b, venter down, X2.3. C) Cross section at c, venter down, X2.3. Cameral and siphonal deposits are stippled.

Amsleroceras gracile, n. sp.
Pl. 13, figs. 15, 16

DESCRIPTION—The only known specimen of *Amsleroceras gracile* is a portion of a phragmocone, 74 mm long. The cross section taken 36 mm from the anterior end of the specimen (Pl. 13, fig. 15) shows the shell to be depressed, having a height estimated at 8 mm and a width of 9 mm, and the siphuncle to be circular, 2.7 mm in diameter, and removed from the venter by 0.5 mm. The thin, ventral band of crescent-shaped calcite is interpreted as an organic cameral deposit because of its symmetrical distribution around the siphuncle and because thin episeptal deposits line the septa in the thin section chip.

The vertical thin section through the anterior 36 mm of the specimen (Pl. 13, fig. 16) shows ten regularly spaced septa devoid of cameral deposits between siphuncle and dorsum and the ventral rod of coarse calcite within the siphuncle. Curvature of the septa is equal to approximately three-quarters of the length of a camera. Both adorally and adapically, three and one quarter camerae occur in a length of 10 mm. Siphuncle segments are slightly concave and composed of short straight necks and thin homogeneous rings.

The ventral rod almost completely fills the siphuncle in the apical 15 mm of the thin section, thins rapidly over the next 15 mm, and terminates bluntly 6 mm from the anterior end of the specimen. Apically, the rod has an undulating dorsal profile; undulations are one camera in length and parallel the shape of the siphuncle segments. Adorally, the rod has a smooth, somewhat irregular surface. In cross section (Pl. 13, fig. 15), the rod is round and convex.

During recrystallization the ventral wall of the siphuncle was obliterated and calcite of the rod now merges with that of the cameral deposits. Growth of cameral deposits between siphuncle and venter has just kept pace with that of the rod.

Sutures are assumed to be straight and transverse because no abrupt change in curvature of the septa was observed while the thin section was being ground.

DISCUSSION—As presently conceived, the distinctive characteristics of *Amsleroceras gracile* are the blunt termination of the ventral rod and the equal relative growth rates of the rod and cameral deposits between siphuncle and venter. However, future finds may alter this diagnosis because, at present, both the genus and the species are known from only one specimen.

TYPE AND OCCURRENCE—Holotype, no. 1694, from the Wahwah Limestone, section J, Ibex area, Utah.

GENUS *CYPTENDOCERAS* Ulrich and Foerste

TYPE SPECIES: *Cyptendoceras ruedemanni*
Ulrich and Foerste

Cyptendoceras Ulrich and Foerste, 1935, p. 270.
_____ Ulrich and others, 1944, p. 113.
_____ Flower, I955a, p. 365.
_____ Flower, I 964a, p. 114-115.
_____ Teichert and others. 1964, p. K 166.

DESCRIPTION—This genus was erected for slender orthocones with depressed cross sections, ventral siphuncles composed of tubular or faintly concave segments, and sutures forming broad, conspicuous lobes on the venter.

DISCUSSION—Cyptendoceras was originally thought to be an endoceroid with holochoanitic necks, and the *Treatise* (Teichert and others, 1964) treats it as a member of the Proterocameroceratidae. Flower (1964a) in his monographic treatment of the Ellesmeroceratida discovered that *Cyptendoceras* had short necks and thin rings and lacked endocones. Flower's thin sections revealed that instead of endocones, *Cyptendoceras* developed a ventral rod within its siphuncle and ventrally concentrated cameral deposits. *Cyptendoceras* was therefore removed from the Endoceratida and placed in the Baltoceratidae.

There still may be some question regarding whether a new generic name should be proposed for rod-bearing genera resembling *Cyptendoceras*. However, Ulrich and Foerste (1933, p. 270, 271) in their original description of *Cyptendoceras ruedemanni*, the type species for the genus, describe a ". . . whitish calcite filling the basal part of the siphuncle along a diagonal line sloping downward from the ventral toward the dorsal side of the siphuncle at an angle of about 65 degrees with the horizontal. This whitish calcite is regarded as originally an organic deposit; later recrystallized." There can be little doubt that what they described is a ventral rod. Therefore, in this report we have followed Flower (1964a) and consider *Cyptendoceras* to be a rod-bearing genus.

Cyptendoceras cf. *C. ruedemanni*

Ulrich and Foerste Pl. I 1,
figs. 2-5

Cyptendoceras ruedemanni Ulrich and Foerste, 1935, p. 270, p1. 38, fig. 5.
_____ Ulrich and others, 1944, p. 113, pl. 60, figs. 1-3.
______ Flower, I964a. p. 115, pl. 22, figs. 2, 10, 11; p1. 23, figs. 18-20.

DESCRIPTION—This specimen is a portion of a phragmocone of a smooth orthocone, 13 mm long. Sutures form broad, shallow lobes that are quite conspicuous in the ventral view (Pl. 11, fig. 2). The cross section of the shell (Pl. 11, fig. 3) is depressed, expanding from 6.0 X 6.7 mm to 8.0 by 8.3 mm over the length of the fragment. The true shape of the siphuncle was not observed, but is presumably also depressed in section. The siphuncle is, however, slightly removed from the venter. As seen in vertical thin section (Pl. 11, figs. 4, 5) the height of the siphuncle remains essentially constant (as measured from neck to neck) at 1.5 mm.

In vertical thin section (Pl. 11, figs. 4, 5) the ventral rod fills about three-fourths of the siphuncle apically, diminishes in height steadily but irregularly, and terminates approximately 5 mm from the anterior end of the section.

Septal necks are short and straight. Those on the ventral side of the siphuncle are shorter than those on the dorsal side and are directly across from them. That is, if the septa are projected across the siphuncle, the ventral necks occupy the point of intersection of the projection with the siphuncle wall. Connecting rings are preserved only in the second and third camerae from the apical end of the specimen. Here they are relatively thin and homogeneous and are expanded into the siphuncle forming concave siphuncle segments.

Septa have only moderate curvature, equal to less than half the length of a siphuncle segment. Spacing of septa is very regular, with the length of a camerae increasing steadily orad. Thin episeptal cameral deposits, which do not quite reach the siphuncle, are developed on the apical two septa.

DISCUSSION —The specific identification of this specimen is based on a similarity of the profile of its rod to that of Flower's (1964a; p1. 23, figs. 18-20) *Cyptendoceras ruedemanni*. The unusual, "stair-stepping" dorsal profile appears to be unique to *C. ruedemanni* among the Baltoceratidae. However, the specific identification must remain tentative because the plane of the longitudinal section in Flower's specimen is not vertical and because Ulrich and Foerste's (1935) original description of *C. ruedemanni* indicates that its rod has a straight dorsal profile. If the specific identification proves to be correct, the geographic range of *C. ruedemanni* is extended from the Champlain Valley to New Mexico, and its geologic range is extended upward to include zone J as well as zone I.

OCCURRENCE—Figured specimen, no. 1629, is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

Cyptendoceras? sp.

Pl. 12, figs. 6-11

DESCRIPTION—This specimen is a portion of an orthoconic phragmocone, 17 mm long, in which sutures form broad, moderately deep lobes on the venter (Pl. 12, fig. 8). Apically, the dorsal two-thirds of the shell has been destroyed by weathering, but anteriorly (Pl. 12, fig. 10) the shell is complete and has a depressed cross section, measuring 10 by 12 mm.

A vertical thin section (Pl. 12, fig. 11) was made through the entire specimen. The thin section shows the siphuncle to be composed of tubular segments, removed from the venter by approximately 0.5 mm. The siphuncle expands in height from 2.2 to 2.6 mm over the length of the section. Septal necks are short and straight. Rings are relatively thin, but preservation makes it impossible to tell whether they are layered or homogeneous. Necks are shorter on the vertral side of the siphuncle and are below those on the dorsal side by a distance equal to half the length of a camera.

Septa have very shallow curvature and are spaced quite closely; 5 occur in a length of 10 mm. Cameral deposits are not developed over the length of this fragment. There is no evidence of a rod in the siphuncle.

DISCUSSION—Without evidence of a ventral rod, this specimen cannot be assigned with certainty to any of the rod-bearing genera. However, it does not fit into either of the vacuosiphonate, lobate genera recognized by Flower (1964a); *Metabaltoceras* has vestigial necks and *Cyrtobaltoceras* is exogastric.

In general features and proportions it agrees most closely with the specimen described elsewhere in this report as *Cyptendoceras* cf. *C. ruedemanni*. It differs in having tubular siphuncle segments, a deeper ventral lobe, no demonstrable rod, and no demonstrable cameral deposits. The lack of cameral deposits and a rod may well be a function of growth stage, while the deeper lobe and tubular segments may only be specific differences. Hence, this specimen is tentatively assigned to *Cyptendoceras.*

OCCURRENCE—Figured specimen, no. 1711, is from 50 ft (15.2 m) above the base of the Wahwah Limestone, Ibex area, Utah.

GENUS *RA NGEROCERAS,* n. gen.

TYPE SPECIES: *Rangeroceras hintzei,* n. sp.
Fig. 7

DESCRIPTION—The genus *Rangeroceras* is erected for smooth, rod-bearing orthocones, depressed in cross section, in which siphonal annuli are so dorsally retarded that they do not begin to grow until the rod has almost completely filled the siphuncle. Growth lamellae in the rod suggest an origin in annulosiphonate deposits. The siphuncle is of moderate size (approximately 0.25 of shell diameter) and slightly removed from the venter. Siphuncle segments are tubular and composed of short straight necks and thin rings that may show layering. Only episeptal cameral deposits are so far known. Sutures are transverse and may be sinuous.

***DISCUSSION—Rangeroceras** is* a genus that cannot be neatly pigeonholed taxonomically. Tentative assignment to the Baltoceratidae is based on its submarginal siphuncle, thin layered rings, and ventral rod. However, the dorsal annuli and ventral growth lamellae that suggest an origin in annulosiphonate deposits are anomalous and suggest instead assignment to the Michelinoceratidae.

If assignment to the Baltoceratidae is correct, then the interpretation of siphonal structures in *Rangeroceras* raises questions as to the origin of the ventral rod in the Baltoceratidae. Are rods, the existence of which is so carefully documented in this report and by Flower (1964a), distinct structures or are they merely preservation phenomena in which replacement and recrystallization have destroyed the annulosiphonate growth

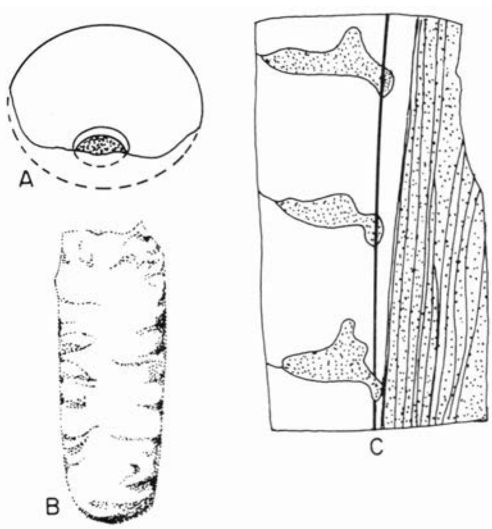

FIGURE 7—*Rangeroceras,* N. GEN. A) Cross section at anterior end of C, venter down, X3. B) Dorsal view of anterior 42 mm of type species, X1.1. C) Vertical thin section through apical 19 mm of type species, venter on right, X3.8. Cameral and siphonal deposits are stippled in A and C.

lamellae? The answer would appear to be that the rod is a distinct structure, because there are several rod-bearing members of the Baltoceratidae and Protocycloceratidae which in thin section show both the termination of the rod and several empty siphuncle segments beyond. Therefore we believe that the rod in *Rangeroceras is* a homeomorphic structure and cannot be used to interpret the manner of growth of all rods.

DERIVATION OF *NAME—Rangeroceras* *is* named for the range ranger who ranged the ranges in the Tajar stories (Ward, 1917).

Rangeroceras hintzei, n. **sp.**

P1. 18, figs. 1-6

DESCRIPTION—The holotype and only known specimen of *Rangeroceras hintzei is* a portion of a ventrally weathered phragmocone, 83 mm long. The shell is depressed in cross section; 19 mm from the apical end of the specimen (Pl. 18, fig. 3) the shell has a width of 8 mm and a height estimated at 7.5 mm. Using this estimate, the siphuncle, which has a width of 2 mm, is only slightly removed from the venter, by a distance equal to approximately half its width.

A vertical thin section (P1. 18, fig. 4) through the apical 19 mm of the specimen shows the ventral rod, dorsal annuli, and portions of six septa. The rod completely fills the siphuncle apically and decreases in height orad. Curved growth lamellae, which suggest an origin in annular deposits, are preserved within the rod over the entire length of the thin section. Both rod and dorsal annuli are composed of an amber-colored, organic rich calcite that is texturally different from the white calcite of necks, septa, and cameral deposits.

Siphuncle segments are presumably tubular and composed of short, straight necks and thin rings that show some indication of layering. The layering in the rings is suggested by a color difference rather than a textural difference.

Septa are only very slightly curved. Only episeptal cameral deposits are evident from the thin section (Pl. 18, fig. 4) and these are bulbous and confined to small areas adjacent to the siphuncle. Sutures (P1. 18, fig. 2) are transverse and apparently sinuous.

DISCUSSION—This species was originally questionably assigned to *Michelinoceras* because of the dorsal annuli and suggestion of ventral annuli. However, the depressed cross section, submarginal siphuncle, ventral rod, and thin layered rings are too anomalous for such a generic assignment and led to the erection of the new genus, *Rangeroceras,* within the rod-bearing Baltoceratidae.

TYPE AND OCCURRENCE—Holotype, no. 1687, from the Wahwah Limestone, section J, Ibex area, Utah.

GENUS *RHABDIFEROCERAS* Flower emend.

TYPE SPECIES: *Rhabdiferoceras annuliferum* Flower

Rhabdiferoceras Flower, 1964a, p. 118, fig. 38.
____ Flower, 1968a, p. **23.**

DESCRIPTION—Rhabdiferoceras *is* emended to contain smooth rod-bearing orthocones with circular to depressed cross sections; straight transverse sutures; medium to large (0.25 to 0.35 of conch diameter), circular or depressed siphuncles slightly removed from the venter; septal necks ranging from vestigial to orthochoanitic; thin rings; and thin episeptal and mural cameral deposits. Siphuncle segments range from tubular to slightly expanded into the camerae. In vertical thin section the dorsal profile of the rod varies from straight to undulatory; undulations are one camera in length and parallel to the outline of the ring. Septa in vertical thin section range from straight and transverse to slightly curved.

DISCUSSION—As originally defined (Flower, 1964a) *Rhabdiferoceras* had only one specimen that could be unequivocally assigned to it, the type species. Of the three other specimens previously assigned to *Rhabdiferoceras* (Flower, 1964a and 1968a): *R.* sp. is annulated and better assigned to *Protocycloceras rhabdiferum,* n. sp.; *R. expansum* is known from an anterior fragment that does not possess a rod; and details of the internal morphology of *R.? whitfieldi are* unknown.

As emended the genus now contains the most abundant of the Cassinian rod-bearing Baltoceratidae. If the rod-bearing members of the Baltoceratidae are ever separated into a family of their own, *Rhabdiferoceras* should serve as the name-bearer for the new family because the name in Greek means rod-bearer.

Rhabdiferoceras planiseptatum, n. sp.

P1. 1, figs. 1-5; P1. 7, figs. 6, 7;
P1. 12, figs. 3-5, 12-17; P1. 13, figs. 5, 6, 12-14

DESCRIPTION—Rhabdiferoceras planiseptatum is a smooth shelled, rod-bearing orthocone with straight, transverse sutures. The shell is depressed in cross section and has a moderately large (0.25 to 0.35 of conch diameter) circular to depressed siphuncle slightly removed from the venter. The siphuncle contains a ventral rod that is round and convex in cross section. In vertical thin section the rod has a straight to slightly sinusoidal dorsal profile. Siphuncle segments vary within an individual from tubular to slightly expanded into the camerae. Necks are short and straight, but not vestigial. Rings are relatively thin and homogeneous, but this may be due to incomplete preservation. Thin episeptal and mural deposits, which lag behind growth of the rod, are known from all specimens assigned to *R. planiseptatum.* Spacing of septa is commonly irregular. In vertical thin section septa range from straight and transverse to straight and slightly inclined dorsad or slightly curved, often within the same specimen.

Holotype, no. 1638 (Pl. 1, figs. 1-5): The holotype is a portion of a phragmocone 29 mm long. The shell is depressed in section; the apical cross section (Pl. 1, fig. 5) has a height of 5.0 mm and a width of 5.5 mm. Here, the siphuncle is also depressed in section, measuring 1.0 X 1.5 mm, and is removed from the venter by approximately 0.25 mm. Anteriorly (Pl. 1, fig. 3), the shell wall has been destroyed. The siphuncle, however, is complete and is circular with a diameter of 2.3 mm. Sutures are straight and transverse.

The vertical thin section (Pl. 1, fig. 1) through the apical 20 mm of the specimen shows many of the features characteristic of the species: 1) short, straight necks and thin, homogeneous rings; 2) tubular siphuncle segments; 3) thin episeptal cameral deposits that thicken against the mural part of the septum; 4) a ventral rod in the siphuncle with a slightly undulate dorsal surface; 5) straight, transverse septa; and 6) irregular spacing of the septa (beginning with the most apical complete camera and working orad, septa are spaced 2.3, 2.3, 2.1, 2.1, 2.3, 2.5, 2.0, and 2.5 mm apart). The holotype is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Paratype, no. 1622 (Pl. 7, figs. 6, *7):* This paratype is a portion of a phragmocone, 22 mm long, known only from its thin section. Septa show very shallow curvature; only the most apical septa have developed cameral deposits. Siphuncle segments are expanded apically and are tubular adorally. The shape of the siphuncle segments is reflected by the dorsal surface of the rod; apically the rod has an undulating surface, undulations are one camera in length; adorally, the rod has a straight surface. The shell and siphuncle expand from a height of 5.2 and 1.8 mm to a height of 8 and 2.4 mm, respectively, over a length of 22 mm. Growth of the rod can be clearly seen to precede that of the cameral deposits. Septa are irregularly spaced: 2.4, 2.4, 2.4, 2.1, 1.6, 2.0, 1.7, 1.7, 1.3, 1.7, and 1.5 mm. This paratype is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Paratype, no. 1664 (Pl. 13, figs. 5, 6): This specimen is a portion of a phragmocone, 29 mm long, depressed in cross section. The anterior cross section (Pl. 13, fig. 5) measures 7.8 X 8.3 mm and has a circular siphuncle, 2.8 mm in diameter. Here, the rod fills about half the siphuncle and has a round, convex dorsal surface.

In vertical thin section (Pl. 13, fig. 6) the dorsal surface of the rod varies from undulating to straight, again reflecting variation in the shape of siphuncle segments. Septa vary from straight to slightly curved and have thin episeptal cameral deposits. Septa are again irregularly spaced, measuring: 1.8, 1.5, 1.8, 1.8, 1.7, 1.7, 1.8, 2.1, 2.1, 2.0, and 2.0 mm. This paratype is from Hintze's (1952) collecting locality J-16, 127 ft (38.7 m) above the base of the Wahwah Limestone, Ibex area, Utah.

Paratype, no. 1685 (P1. 12, figs. 3-5): This paratype is also a fragment of a phragmocone, 19 mm long. The thin section (Pl. 12, fig. 4) shows the siphuncle increasing in height from 1.6 to 2.2 mm over a length of 19 mm. Apically the rod has an undulating dorsal surface, while adorally, it is straight. Septa are straight and transverse and have thin episeptal cameral deposits. Necks are short and straight; rings are not preserved. Septa are fairly regularly spaced: 2.2, 1.8, 2.2, 2.1, 2.3, 2.8, and 2.9 mm. This paratype is from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Paratype, no. 1709 (Pl. 12, figs. 12, 13): This paratype is a tiny fragment of a phragmocone, only 12 mm long. The anterior cross section (Pl. 12, fig. 12) shows a circular siphuncle, 2.3 mm in diameter, slightly removed from the venter. The vertical thin section (Pl. 12, fig. 13) shows only features characteristic of the species: short, straight necks; thin, homogeneous rings; ventral rod, here filling about 90% of the siphuncle; and straight, transverse septa with thin episeptal cameral deposits. Spacing of septa is regular: 1.4, 1.5, 1.6, 2.1, and 2.6 mm. This paratype is from the Wahwah Limestone, section J, Ibex area, Utah.

Paratype, no. 1714 (Pl. 13, figs. 12-14): This paratype is a 33-mm-long portion of a phragmocone. A vertical thin section (Pl. 13, fig. 13) was made through the anterior 18 mm of the specimen. The cross section (P1. 13, fig. 12) at the apical end of the thin section shows the siphuncle to be depressed, measuring 1.7 X 2.0 mm, and slightly removed from the venter. Here, the shell has a width of 5.8 mm. Apically, the rod fills about three-fourths of the siphuncle; adorally, it thins rapidly over the length of the section and merges with calcite that occupies the space between the siphuncle and venter, presumably recrystallized cameral deposits. Necks are short and straight. Rings, though thickened by inorganic calcite in the apical camerae, are apparently thin and homogeneous. Siphuncle segments are tubular. The rod has a straight dorsal profile and is rounded, convex up, in cross sections. Spacing of septa is moderately irregular: 1.7, 1.9, 1.9, 1.7, 1.9, 1.5, and 1.9 mm. This paratype from the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1677 (Pl. 12, figs. 14-17): This specimen is a portion of a dorsally weathered phragmocone, 20 mm long. The apical and anterior cross sections (Pl. 12, figs. 15, 16) show the siphuncle to be circular, increasing in diameter from 1.8 to 2.0 mm over a length of 14 mm, and removed from the venter by less than 0.5 mm. Septa are straight and transverse and have thin episeptal cameral deposits. The rod thins rapidly and has an essentially straight dorsal surface. Calcite in the siphuncle in the anterior cross section (Pl. 12, fig. 15) is ambiguous, but the rod appears to have a straight to slightly concave up dorsal surface. Necks are short and straight; rings are thin and homogeneous. Spacing of septa is irregular: 1.8, 2.3, 1.8, 2.0, 1.4, 1.4, and 1.4 mm. This specimen is from 70 ft (21.3 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

DISCUSSION—Rhabdiferoceras planiseptatum has been defined rather broadly to accommodate specimens of moderately different proportions because the available material is so fragmentary and often badly weathered. The variability in the shape of the septa in vertical thin section, particularly within an individual, is probably the result of the plane of the section not coinciding with the plane of symmetry, thus intersecting septa at different angles.

R. planiseptatum is the most common of the Baltoceratidae in the study areas, particularly in the Ibex area. This numerical dominance may be more apparent than real, because there are many smooth shelled orthocones from the Florida Mountains Formation that cannot be identified because their siphuncles are not preserved.

TYPES AND OCCURRENCE—The holotype, no. 1638, and one paratype, no. 1622, are from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. The remaining paratypes and figured specimen are from the Wahwah Limestone, section J, Ibex area, Utah.

cf. *Rhabdiferoceras planiseptatum, n.* sp.
P1. 12, figs. 1, 2

DESCRIPTION—This specimen is a portion of a phragmocone, 27 mm long, weathered from the ventral side down to the siphuncle. Weathering has destroyed so much of the siphuncle that it is not possible to determine from the vertical thin section (Pl. 12, fig. 2) whether the siphuncle contained a ventral rod. Septa, in vertical section, are straight and only slightly inclined apicad and are covered with thin episeptal cameral deposits that thicken against the mural part of the septum. Necks are short and straight; rings are thin and homogeneous. In the weathered ventral view (Pl. 12, fig. 1), the septa are rather steeply inclined apicad toward the siphuncle. Septal spacing is irregular: 2.4, 2.4, 2.4, 2.2, 1.8, 1.6, 2.0, 1.8, and 1.8 mm.

DISCUSSION—From the information supplied by the thin section, there is little doubt that this specimen should be assigned to *R. planiseptatum.* However, the inclination of the septa in the ventral view (Pl. 12, fig. 1) suggests that the intersection of the septa with the shell wall would produce a suture with a shallow ventral lobe. But the septa of *R. planiseptatum* have never been observed in a horizontal plane, and it is possible that the septa in this specimen change curvature to the extent that the suture would be transverse.

OCCURRENCE—Figured specimen, no. 1724, is from 90 ft (27.4 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

?*Rhabdiferoceras planiseptatum, n.* sp.
P1. 12, fig. 21

DESCRIPTION—This specimen is a short fragment of a poorly preserved phragmocone, 12 mm long, that is now a thin section. The vertical thin section (Pl. 12, fig. 21) shows a rather large siphuncle of tubular segments in which there is a band of white calcite lying against its ventral wall. This band of calcite has a sharp, distinct, undulating dorsal surface and thickens apically, terminating abruptly against matrix. Necks are short and straight. Septa have a very slight curvature and thin episeptal cameral deposits. Rings are thin and homogeneous. Septa are spaced 2.0, 1.8, 3.0, and 3.0 mm apart.

DISCUSSION—This specimen is questionably assigned to *R. planiseptatum* because it is impossible to tell from this fragment whether the band of calcite in the siphuncle is an organically precipitated rod that has been dissolved apically. Its position within the siphuncle and its sharp, distinct dorsal surface indicate that it is organic. In all other respects its internal morphology agrees with that of *R. planiseptatum.*

OCCURRENCE—Figured specimen, no. 1672, is from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

GENUS *RIOCERAS* Flower

TYPE SPECIES: *Rioceras nondescriptum* Flower

Rioceras Flower, 1964a. p. 102, fig. 35.

DESCRIPTION—The genus *Rioceras* was erected for slender orthocones with subcircular cross sections, large siphuncles slightly removed from the venter, short necks and moderately thick rings, straight transverse sutures, and empty siphuncles.

DISCUSSION—Rioceras is a small generalized baltoceroid with an empty siphuncle. Known specimens are few and confined to the Middle and Upper Canadian. Flower (1964a) attributes their scarcity to their small size, fragmentary preservation, and general obscurity rather than to real rarity.

Rioceras? sp.
P1. 12, figs. 18-20

DESCRIPTION—The figured specimen (Pl. 12, fig. 19) is a portion of a phragmocone of a slender, smooth orthocone. 30 mm long. The siphuncle is large, apparently circular, slightly removed from the venter.

The anterior cross section (Pl. 12, fig. 18) shows the shell to be abraded from the ventral side and weathered from the dorsal side, giving the shell a slightly crushed look. Here the shell has a width of 11 mm and a height estimated at 9.5 mm, while the siphuncle, which is probably slightly removed from the venter, is circular and has a diameter of 3 mm.

A vertical thin section (P1. 12, fig. 20) was made through the anterior 15 mm of the shell because weathering has destroyed most of the siphuncle in the apical half of the specimen. This section revealed seven irregularly spaced septa with curvature ranging from straight and slightly inclined to slightly curved. All seven septa have thin episeptal cameral deposits on them. The cameral deposits are of uniform thickness except just dorsad of the siphuncle where they form small, rounded but pronounced bumps.

The dorsal wall of the siphuncle is composed of vestigial necks and thin, homogeneous connecting rings. Rings range from straight to slightly expanded into the camerae.

Sutures are assumed to be straight and transverse at least on the venter because the septa did not show any abrupt change in curvature as the thin section was ground. There is no indication of organic deposits within the siphuncle.

DISCUSSION—Flower (1964a, b) indicated that a ventral rod was a difficult feature to use taxonomically because it was so rarely preserved and its absence in an anterior portion of a phragmocone is inconclusive. However, there is one empirical criterion that can be employed in differentiating rod-bearers from non-rod-bearers. In all but one of the ellesmeroceroid species that develop ventral rods, growth of cameral deposits between siphuncle and dorsum lags behind growth of the rod by at least several camerae. The one known exception to this criterion is *Catoraphiceras pearsonae*, n. sp.

It appears unlikely, then, that this specimen is a rod-bearer because cameral deposits are developed on all seven of its septa between siphuncle and dorsum and there is no trace of a rod in the siphuncle. The specimen differs from *Rioceras* only in having thin, homogeneous rings, which may be the result of incomplete preservation.

OCCURRENCE—Figured specimen, no. 1674, is from a zone 65 to 75 ft (19.8 to 22.9 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

GENUS *VENEFICOCERAS*, n. gen.

TYPE SPECIES: *Veneficoceras susanae,* n. sp.
Fig. 8

DESCRIPTION—The genus *Veneficoceras* is erected for rod-bearing members of the Baltoceratidae with large, marginal siphuncles in which the rod, in vertical thin section, appears to bifurcate into a dorsal and ventral rod. In cross section the dorsal and ventral rods are probably continuous, forming a lining within the siphuncle that is thicker ventrally. The dorsal rod is interpreted to have an origin in annulosiphonate deposits.

DISCUSSION—Although it is impossible from the single known specimen of *Veneficoceras* to determine the precise manner of growth of the dorsal rod, its vertical profile is sufficiently different from that of the rod proper to indicate a different mode of growth. The dorsal rod (Pl. 13, figs. 1, 2) thins anteriorly and is thickest just orad of the septal necks. By analogy with *Tajaroceras* (Pl. 21, fig. 13), which shows a similar growth pattern, this dorsal rod is interpreted to have formed by annuli growing forward from the foramina and fusing.

Regardless of the origin of the dorsal rod, *Veneficoceras* is the earliest known genus with a marginal siphuncle to have distinct deposits on both the dorsal and ventral sides of the siphuncle. This is the necessary first step in the line leading to *Tajaroceras* and the Troedssonellidae (Fig. 4). With migration of the siphuncle to a more central position, cameral deposits, which cannot be demonstrated in this specimen of *Veneficoceras susanae*, would probably become necessary to maintain rotational stability of the shell.

DERIVATION OF NAME—The genus *Veneficoceras* is named for the witch in the Tajar stories (Ward, 1917).

Veneficoceras susanae, n. sp.
P1. 13, figs. 1-4

DESCRIPTION—The holotype and only known specimen of *Veneficoceras susanae is* a portion of a phragmocone, 40 mm long. A vertical thin section was made through the anterior 28 mm of the specimen.

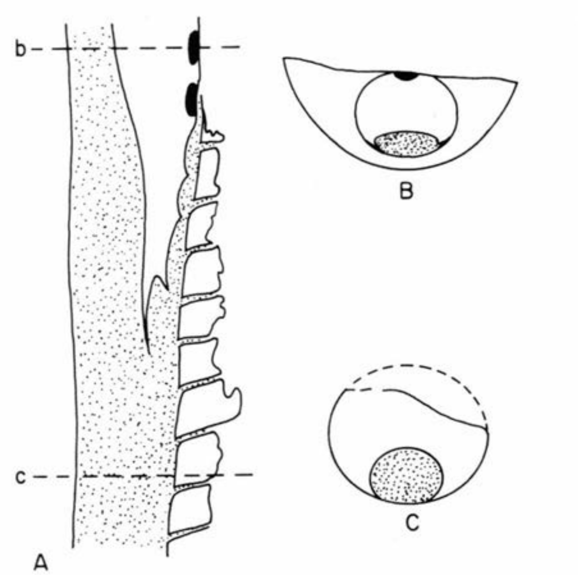

FIGURE 8—*Veneficoceras,* N. GEN. A) Vertical thin section through anterior 28 mm of type species, venter on left, X3.8. B) Cross section at b, venter down, X3. C) Cross section at c, venter down, X3. Cameral deposits and septa are stippled; interpreted structures are solid.

At the apical end of the thin section (Pl. 13, fig. 3), the siphuncle is in flattened contact with the venter and has a height of 3.3 mm and a width of 4.3 mm. Here, the shell has a width of 8.3 mm. At the anterior end (Pl. 13, fig. 4), the siphuncle is circular, 5.6 mm in diameter, and in tangential contact with the venter. Apically, the rod completely fills the siphuncle; anteriorly, it fills about one-third of it and has a flattened dorsal surface.

In vertical thin section (Pl. 13, fig. 1), the rod consists of recrystallized, coarse, white calcite that completely fills the siphuncle in the apical half of the specimen. About 14 mm from the apical end, the rod abruptly bifurcates into two "rods," one dorsal, the other ventral. The ventral rod is the thicker of the two, has a smooth, slightly curved dorsal surface, and decreases in height very rapidly over the remaining length of the section. The dorsal rod thins anteriorly, has a sinusoidal profile, and is thickest just ventrad of each septal neck.

By analogy with *Tajaroceras* (Pl. 21, fig. 13), which shows a similar mode of growth in the siphuncle, the dorsal rod may have an origin in annulosiphonate deposits and may be continuous in cross section with the rod proper, forming a lining within the siphuncle.

Necks are short and straight; rings are thin and apparently homogeneous. Siphuncle segments are expanded into the camerae apically and are tubular anteriorly. Septa show a range of curvature: apically, they are slightly curved; anteriorly, they are straight and slightly inclined from dorsum to venter.

Cameral deposits cannot be conclusively demonstrated from this specimen, although in shape and boundaries the calcite on the second and third septa from the apical end of the thin section suggests that cameral deposits are developed.

DISCUSSION—Much of the variation seen in the shape of the siphuncle segments and in the curvature of the septa may result from the plane of the section intersecting the plane of symmetry at a slight angle.

Although the calcite on the second and third septa suggest true cameral deposits, this evidence is suspect because there is no calcite whatsoever on the first septum. Unfortunately, the apical 12 mm of the specimen is so recrystallized that all internal structure has been obliterated.

TYPE AND OCCURRENCE—HolOtype, no. 1693, is from 50 ft (15.2 m) above the base of the Wahwah Limestone, Ibex area, Utah.

Baltoceratidae, new genus, new species
Pl. 17, fig. 14; fig. 9

DESCRIPTION—This unnamed new genus is represented by a single specimen, a portion of a phragmocone, 15 mm long. The specimen (Pl. 17, fig. 14) is a smooth orthocone that has weathered from the dorsal side to expose a siphuncle of broadly expanded segments. Coarsely crystalline calcite fills the siphuncle; about 5 mm from the anterior end, weathering has exposed a suggestion of a central tube within the siphuncle. The tube extends apicad for a length of three camerae, then passes out of the plane of weathering. Ten camerae are exposed over the length of the specimen; septa have moderate curvature, equal to about half the length of a camera. Thin calcareous deposits line the septa and thicken toward the mural part of the septum; these are interpreted as true cameral deposits. A cross section was made near the apical end of the specimen that, amazingly, showed the siphuncle to be in contact with the venter. Details of the ectosiphuncle are unknown.

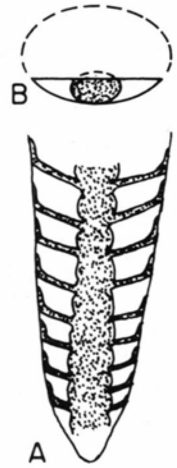

FIGURE 9—BALTOCERATIDAE, UNNAMED NEW GENUS. A) Weathered dorsal view, X2.7. B) Cross section near anterior end of A, venter down, X2.7. Cameral and siphonal deposits are stippled.

DISCUSSION—This specimen was originally assigned to the Order Michelinoceratida on the basis of its expanded siphuncle segments. The discovery of a marginal rather than a central siphuncle necessitated reassignment.

There is no existing taxonomic receptacle other than the Baltoceratidae for a Cassinian form such as this one that has a smooth exterior and a marginal siphuncle. This new genus may represent a development of the Baltoceratidae paralleling that of the Protocycloceratidae and the Apocrinoceratidae. However, this explanation does not account for the apparently organic calcite in the siphuncle of this specimen. In habit and weathering this calcite is very similar to that observed in *Buttsoceras*.

OCCURRENCE—Figured specimen, no. 1701, is from 54 ft (16.5 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Baltoceratidae, genus and species indeterminate
Pl. 13, figs. 7-1 1

DESCRIPTION—This specimen is an internal mold of a smooth, orthoconic phragmocone, 21 mm long. Sutures form broad, shallow lobes on the dorsum (Pl. 13, fig. 8) and apparently form narrow lobes on the venter. Although the suture pattern has been destroyed by weathering on the ventral side of the shell (Pl. 13, fig. 7), the septa were observed to change curvature (Pl. 13, fig. 11) as the siphuncle was approached during grinding of the vertical thin section.

Both the shell and siphuncle are depressed in section. The apical septal view (Pl. 13, fig. 9) shows the shell to have a height of 6.5 mm and a width of 7.5 mm, while the siphuncle measures 2.0 X 2.5 mm and is slightly removed from the venter.

A vertical thin section was made through the entire specimen, but only the apical 12.5 mm of it is illustrated (Pl. 13, fig. 10). Septa have only a very slight curvature and are without cameral deposits between siphuncle and dorsum. However, the fine-grained calcite between the siphuncle and venter is interpreted as cameral deposits (P1. 13, fig. 11). Siphuncle segments are broader than high and are tubular on the dorsal side of the siphuncle but faintly expanded on the ventral side. Septal necks are short and straight and are slightly lower on the ventral side of the siphuncle. Preservation of rings makes it impossible to tell their true thickness and composition, but they are generally thin and homogeneous. There is no evidence of organic deposits within the siphuncle.

DISCUSSION—Among the lobate Baltoceratidae this specimen shows closest affinities to *Cyptendoceras.* However, the development of cameral deposits over its entire length suggests that it does not possess a ventral rod. Without development of a rod, it cannot be assigned to *Cyptendoceras*. Within the vacuosiphonate Baltoceratidae, *Metabaltoceras* differs in having vestigial necks and straight, transverse, dorsal sutures, and *Cyrtobaltoceras* differs in being exogastric.

OCCURRENCE—Figured specimen, no. 1717, is from the Wahwah Limestone, section J, Ibex area, Utah.

Family PROTOCYCLOCERATIDAE

GENUS *PROTOCYCLOCERAS* Hyatt TYPE

SPECIES: *Orthoceras lamarcki* Billings

Protocycloceras Hyatt, 1900, p. 518.
______Ruedemann, 1906, p. 438.
______Grabau and Shimer. 1910, p. 55.
______ Foerste, 1921, p. 268.
______ Foerste, 1924, p. 202.
______ Croneis, 1926, p. 185-192.
______ Miller, Dunbar, and Condra, 1933, p. 69.
______ Ulrich and Foerste, 1933, p. 288.
______Kobayashi, 1935, p. 746.
______Ulrich and others, 1944, p. 78.
______ Nikiforovoi, 1955, p. 89-90.
______Ruzhenstev and others, 1962, p. 95.
______Flower, 1964a, p. 131-133.
______Teichert and others, 1964, p. K I52.

DESCRIPTION—Protocycloceras is used for annulated orthocones with circular or depressed cross sections, transverse sutures, relatively large siphuncles somewhat removed from the venter, and short necks. Rings are variably thin and may be layered. Siphuncle segments range from slightly convex to tubular to slightly concave. Rods are developed in certain specialized species and may occur alone or in combination with cameral deposits.

DISCUSSION—As employed here and by Flower (1964a) the species attributed to *Protocycloceras* are probably not a natural grouping, but rather a group of homeomorphs. The late Cassinian forms described in this report can be divided into two generalized morphologic types: those with ventral rods and those with empty siphuncles. Further subdivision within these two groups can be made on the basis of the presence or absence of cameral deposits.

Flower's (1964a) study indicated that there were three morphologic types in *Protocycloceras* that could all be of diverse origin: 1) forms with empty siphuncles that could be derived through *Walcottoceras* and the Ellesmeroceratidae; 2) forms with diaphragms (Flower's pl. 30, fig. 13) that may be a distinct lineage or a modification of the vacuosiphonate forms; and 3) forms with a ventral rod, possibly derived from the rod-bearing Baltoceratidae. Two other possibilities should be added to this list: 4) the vacuosiphonate *Protocycloceras* could have evolved from the vacuosiphonate Baltoceratidae; or 5) in part, we may be looking at a case of parallel evolution between the Baltoceratidae and the Protocycloceratidae.

At the present state of knowledge it is impossible to choose among the possibilities outlined above. The question is further complicated by the discovery of rods within the siphuncles of two species attributed to *Catoraphiceras, C. staceyae, n.* sp. and *C. pearsonae,* n. sp. No solutions are likely to be forthcoming until the detailed internal morphology of at least the Protocycloceratidae and the Baltoceratidae is stratigraphically well known.

Protocycloceras laswelli, n. sp.
Pl. 15, figs. 1-3

DESCRIPTION—Protocycloceras laswelli is a prominently annulated, rod-bearing orthocone without known cameral deposits. Both shell and siphuncle are circular in cross section. The ventral rod has a shallow, median depression in cross section.

The only known specimen of *P. laswelli* is an internal mold of a phragmocone, approximately 100 mm long. Its cross section is circular; 25 mm from the anterior end of the specimen (Pl. 15, fig. 3), the shell has a diameter of 14 mm. Here, the siphuncle is circular, 3.5 mm in diameter, and slightly removed from the venter. The rod, which fills two-thirds of the siphuncle, is rounded, convex, and has a shallow median depression.

Three vertical thin sections were made (Pl. 15, figs. 1, 2) that encompass all but the anterior 12 mm and the apical 10 mm of the specimen. The rod is evident in all three thin sections as recrystallized calcite. Apically the rod has an undulating dorsal profile and almost completely fills the siphuncle. The rod does not begin to diminish in height until 35 mm from the anterior end of the thin sections, where it begins to thin rapidly, although it does not terminate within the length of the thin sections.

Necks are very short (but not vestigial) and straight. Rings are thin and homogeneous. Siphuncle segments are tubular and wider than long. The ventral siphuncle wall is gone and calcite of the rod merges with calcite between siphuncle and venter. If the calcite between siphuncle and venter represents recrystallized cameral deposits, they are anomalous and do not show in cross section (Pl. 15, fig. 3).

Septa are moderately curved; curvature is equal to approximately half the length of a siphuncle segment. Septa are without demonstrable cameral deposits, unless the irregular calcite in the apical camerae (Pl. 15, fig. 2) represents lobes of asymmetrical cameral deposits; however, this seems unlikely from the position of the calcite against the connecting rings.

Annuli are prominent and variable in spacing, ranging from four per adoral diameter, adorally, to five per adoral diameter, apically. The suture pattern was not observed but is assumed to be straight and transverse.

DISCUSSION—*Protocycloceras laswelli* is anomalous among the rod-bearers in having a rod developed over such an extensive length of phragmocone that is without demonstrable cameral deposits. Only one other specimen, a paratype of *P. affine* (Flower, 1964a, p. 126), has been observed to have a shallow median, dorsal depression in its rod. *P. affine,* however, is readily distinguished from *P. laswelli* on the basis of its well developed cameral deposits and numerous diaphragms within its siphuncle.

TYPE AND OCCURRENCE—Holotype, no. 1681, is from 90 ft (27.4 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Protocycloceras aff. P. laswelli, n. sp.
Pl. 15, figs. 4-7

DESCRIPTION—This specimen is an annulated, rod-bearing orthocone 76 mm long. Both shell and siphuncle are circular and the siphuncle is slightly removed from the venter. Necks are short and straight; rings are thin and homogeneous. Siphuncle segments are concave, with rings expanded into the siphuncle. Cameral deposits are not developed.

Annuli are indistinct because of abrasion and weathering. However, they do show well enough to be distinguished in left lateral view of the anterior 27 mm of the specimen (P1. 15, fig. 7). Here, four annuli are found in a length equal to the adoral diameter of the shell. The cross section at the anterior end of Pl. 15, fig. 7 is not illustrated, but shows the shell to have a diameter of 13 mm; the siphuncle, which is removed from the venter by 0.5 mm, has a diameter of 4 mm.

The plane of the cross section 18 mm from the apical end of the specimen (P1. 15, figs. 4, 5) intersected the ventral rod, which fills approximately one-third of the siphuncle and has a round, convex dorsal surface. Both shell and siphuncle are circular, measuring 11 and 3.5 mm in diameter, respectively. The siphuncle is removed from the venter by approximately 0.5 mm. No cameral deposits are evident from these cross sections.

Four vertical thin sections were cut that encompass the entire length of the specimen; Pl. 15, fig. 6 is a composite of these thin sections and shows the apical 55 mm of the specimen. Weathering has destroyed most of the ventral siphuncle wall. The rod, however, is evident over the apical 25 mm of the specimen and has a dorsal profile best described as smooth curve diminishing in height orad.

Siphuncle segments are broader than long and noticeably expanded into the siphuncle. Septal necks are short and straight; rings are thin and homogeneous. Septa are curved, curvature equal to less than half the length of a siphuncle segment. Cameral deposits are not developed over the entire length of the specimen. In fact there is absolutely no calcite in any of the camerae. If cameral deposits were developed between siphuncle and venter, which seems doubtful from the cross sections, they were destroyed by weathering.

Sutures were not evident on the surface of the specimen, but are assumed to be straight and transverse because no change in curvature of the septa was noted while the thin sections were being ground.

DISCUSSION—This specimen is similar to *P. laswelli* in having a ventral rod and no demonstrable cameral deposits over a considerable length of phragmocone. It differs in having longer necks, slightly thicker rings, concave siphuncle segments, a larger siphuncle in proportion to diameter, and no median depression in its rod. These differences are great and appear to warrant a new species for this form. Erection of a new species is withheld for the present in hopes that more and better preserved material will be found that will not only clarify the amount of intraspecific variation allowable in *P. laswelli,* but also show whether cameral deposits are developed or not.

OCCURRENCE—The figured specimen, no. 1680, is from the lower of the continuous reefs, 95 to 101 ft (29.0 to 30.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Protocycloceras rhabdiferum, n. sp.
Pl. 5, figs. 1-14

DESCRIPTION—*Protocycloceras rhabdiferum* is a rod-bearing *Protocycloceras* with a circular siphuncle of moderate size (about 0.25 of the conch diameter) slightly removed from the venter. In vertical thin section septa are straight and transverse, necks are short and straight, and rings are thin and homogeneous. Thin episeptal cameral deposits are developed between siphuncle and dorsum that lag behind the growth of the rod. Siphuncle segments are tubular. Spacing of septa is often irregular. Sutures are assumed to be straight and transverse.

Holotype, no. 1646 (P1. 5, figs. 1-4): The holotype at first appeared to be too badly weathered to be of any significance. Unexpectedly, it made a spectacular thin section (Pl. 5, figs. 3, 4) in which rod and cameral deposits show up stark white against a background of black matrix.

The vertical thin section revealed twenty camerae in a length of 34 mm. Annuli, which are not evident in the weathered dorsal view (P1. 5, fig. 2) are distant and so low as to be inconspicuous. Septa are straight and transverse and are covered with thin episeptal deposits that thicken toward the siphuncle. The siphuncle wall is composed of short necks and thin, homogeneous rings. Siphuncle segments are tubular and slightly wider than long.

The siphuncle is circular and slightly removed from the venter. Apicad, it is 1 mm across and 0.5 mm from the venter; orad, it is 2.5 mm across and 0.8 mm from the venter. The orad cross section (Pl. 5, fig. 1) is incomplete dorsally, but has a width of 9 mm.

The rod, in vertical thin section (P1. 5, figs. 3, 4), completely fills the siphuncle apicad and thins to a feather's edge orad. The dorsal surface of the rod is a gently undulating, smooth curve.

Coarse, white calcite fills the space between the siphuncle and the venter. Structurally, this calcite is the same as that in the rod and is presumed to be recrystallized cameral deposits.

Spacing of septa is not uniform, especially in the early stages where they tend to be farther apart than in the later, more mature part of the shell.

Paratype, no. 1647 (Pl. 5, figs. 5-7): This paratype is a portion of a phragmocone, approximately 50 mm long, that shows essentially the same features as the holotype. The vertical thin section (P1. 5, fig. 7) made through the apical 32 mm of the specimen shows considerable variation in spacing of septa, especially apicad, where they are widely spaced. Septa range from straight and transverse to straight and slightly inclined apicad and all have developed thin episeptal cameral deposits that thicken toward the siphuncle. Extensive replacement has made the rod difficult to see, but its dorsal surface is delineated by a thin, white line, which separates organic calcite from matrix. Necks are short and straight; rings are thin and homogeneous. Siphuncle segments are tubular apically and slightly expanded into the camerae orally.

A cross section at the oral end of the thin section (Pl. 5, fig. 6) shows the shell, incomplete dorsally, to have a width of 8 mm. The siphuncle is circular, 3 mm in diameter, and is removed from the venter by 0.7 mm. Here, the rod fills about two-thirds of the siphuncle and has a rounded, convex surface.

Paratype, no. 1648 (Pl. 5, figs. 8-14): This paratype is also a dorsally weathered portion of a phragmocone, 60 mm long. From its anterior cross section (Pl. 5, figs. 12, 13) it was originally thought to have two rods, one dorsal, the other ventral. Both of these "rods" turned out to be adventitious; the plane of the cross section had intersected two pods of inorganic calcite (Pl. 5, fig. 14). The real rod was not discovered until the specimen was sectioned longitudinally. The siphuncle (Pl. 5, figs. 12, 13) is distorted and appears to be depressed in cross section. There is some variation in the spacing of the septa; camerae with the greatest length appear about mid-length.

The suture pattern of *P. rhabdiferum* was not directly observed on any of the three known specimens. Sutures are assumed to be straight and transverse, at least on the venter, because no change in curvature of the septa was observed while the vertical thin sections were being ground.

DISCUSSION-This species is assigned to *Protocycloceras* and not to a new genus on the basis of Flower's (1964a, b) discovery of a ventral rod within the siphuncle of *P. affine*. Flower's reinterpretation of *P. affine* suggests not only a rod but also diaphragms within its siphuncle.

P. rhabdiferum can be distinguished from other species of rod-bearing *Protocycloceras*, described elsewhere in this report, on the basis of the shape of its rod, flat septa, and development of cameral deposits. However, *P. rhabdiferum* does not differ significantly in vertical thin section from *Catoraphiceras staceyae*, n. sp., particularly the specimen described as *Catoraphiceras* cf. *C. staceyae*, n. sp. This close resemblance makes it imperative to note changes in the curvature of the septa while thin sections are being ground (Fig. 5).

TYPES AND OCCURRENCE-The holotype, no. 1646, and both paratypes, nos. 1647, 1648, are from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Protocycloceras spp.

Pl. 1, figs. 6, 7, 13-20; Pl. 2, figs. 15-20; Pl. 14, figs. 10, 11; Pl. 15, fig. 21

Eight annulated orthocones that are too fragmentary to be placed in any of the described species of *Protocycloceras* are given the identification letters A through F and are briefly described below. The specimens are not all conspecific and one, *Protocycloceras* sp. F, may represent a new species. These eight specimens are illustrated to show some of the morphologic variation found in *Protocycloceras*.

Protocycloceras sp. A

P1. 2, figs. 15-20

DESCRIPTION-Under this designation are figured two specifically identical fragments of very slender, weakly annulated orthocones. The first specimen, no. 1654 (P1. 2, figs. 19, 20), is an imperfectly silicified, badly weathered phragmocone, 50 mm long, in which the apical portion of the shell is preserved. This "protoconch" is 3 mm long and expands very rapidly, at an angle of 34 degrees. The remainder of the shell expands slowly, at an angle of less than 5 degrees.

A cross section (Pl. 2, fig. 20), 40 mm from the apical end of the specimen, shows the shell to be circular, 4.8 mm in diameter. The siphuncle is circular 1 mm in diameter, and subcentral, 1.5 mm from the venter.

The two septa exposed apically have very little curvature. Otherwise, details of internal morphology are unknown.

The second specimen, no. 1655 (P1. 2, figs. 15-18) is a portion of a phragmocone, 8 mm long. The shell is circular in cross section with a diameter of 3.5 mm apically and 4 mm orally. The anterior cross section (Pl. 2, fig. 18) shows a circular siphuncle, 0.8 mm in diameter and 1.2 mm from the venter. Sutures are straight and transverse.

DISCUSSION-Although these two specimens are specifically identical, they could not be placed with certainty in any existing species of *Protocycloceras* because nothing is known of their internal morphology and because they are such apical fragments that it is impossible to place them in species based on more anterior portions of the shell.

OCCURRENCE-Both specimens are from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Protocycloceras sp. **B**

P1. 14, figs. 10, 11

DESCRIPTION-This specimen is an internal mold of a portion of a phragmocone and living chamber that is crushed apically. Annuli are prominent and preserved only on the apical end of the specimen, where they show some distortion ventrally and laterally. Dorsally (Pl. 14, fig. 10), they are straight and transverse which is probably their original condition. The apical cross section is highly distorted, while the anterior cross section (Pl. 14, fig. 11) is symmetrical and depressed in section, measuring 16 X 17 mm. A cross section taken 17 mm from the apical end of the specimen is also depressed in section, measuring 14.5 X 16 mm, and shows a subcentral, circular siphuncle, 3.8 mm in diameter and 5 mm from the venter. A vertical thin section through the apical 17 mm of the specimen showed a tubular siphuncle in which neither necks nor rings could be differentiated; all septa had been destroyed.

DISCUSSION—This specimen is one of more than twenty internal molds of annulated orthocones preserved as the nuclei of concretions. Unfortunately they are either all or in large part living chambers, and in those that represent phragmocones, internal structure is largely destroyed.

OCCURRENCE—Figured specimen, no. 1658, is from the Wahwah Limestone, section J, Ibex area, Utah.

Protocycloceras sp. C and D
Pl. 1, figs. 6, 7

DESCRIPTION—Two almost identically preserved and weathered specimens of different species are described together. Both are essentially horizontal sections through phragmocone and living chamber. The plane of the section through both specimens exposes the siphuncle and is, therefore, below the plane of greatest width of the shell.

Protocycloceras sp. C, no. 1640 (Pl. 1, fig. 7) is an annulated orthocone 47 mm long. Annuli are prominent, low, and rounded. Adorally, three and one-half annuli occupy a length equal to the adoral shell diameter; apically, four do.

The phragmocone has a maximum length of 30 mm and expands conically from 6 to 10 mm. The living chamber has a maximum length of 19 mm, is tubular, 10 mm across, and is approximately twice as long as the adoral width of the phragmocone.

Spacing of the septa corresponds to that of the annuli; the septa join the shell wall at the midpoint of the concave interareas. Curvature of the septa is at least equal to the length of a camera.

The siphuncle is central throughout, no more than 2 mm across. Calcite in the camerae is mainly inorganic, as shown by its absence in the apical two camerae. Calcite in the siphuncle is probably inorganic, but apical segments where organic deposits might be expected are not exposed.

Protocycloceras sp. D, no. 1641 (Pl. 1, fig. 6), is an annulated orthocone 50 mm in length. The septate portion of the shell is 30 mm long and expands more rapidly than in the previous specimen, from 4 mm apically to 8 mm at the base of the living chamber. Also, unlike the previous specimen, the living chamber expands conically from 8 to 10 mm over a length of 20 mm. The living chamber is approximately twice the length of the adoral width of the phragmocone.

The annuli, which are not as prominent or rounded, are variable in spacing. The number of annuli in a length equal to the adoral shell width increases apicad, from four and one-half in the living chamber to five at midlength and five and one-half farther apicad.

Spacing of the camerae is closer and more variable and does not necessarily correspond to the spacing of the annuli. Curvature of the septa is equal to less than half the length of a camera.

The siphuncle is exposed throughout the length of the phragmocone and apically is closer to the right shell wall; farther orad it is central. Siphuncle segments are broader than high.

DISCUSSION—These specimens, although impossible to place in any of the described species of *Protocycloceras*, are important because they show the relative proportions of the mature living chamber to the phragmocone.

OCCURRENCE—Both specimens are from the Florida Mountains Formation. *Protocycloceras* sp. C, no. 1640, is from the Franklin Mountains locality; *Protocycloceras* sp. D, no. 1641, is from the Florida Mountains locality.

Protocycloceras sp. E
Pl. 15, fig. 21

cf. *Protocycloceras affine* Ulrich and others, 1944, p. 81. pl. 41, figs. 9-13: pl. 42, fig. 10.

DESCRIPTION—This specimen is a portion of an annulated orthocone, 23 mm long, preserved as an external cast. No internal structures are preserved. The surface of the specimen bears thirteen prominent annuli which slope slightly apicad from left to right as oriented in Pl. 15, fig. 21. The surface is also finely lirate. Lirae are parallel to annuli; five occur in a length of 2 mm.

DISCUSSION—This is the only specimen in the entire cephalopod fauna to exhibit any surface ornamentation. Although this ornamentation may have been common, this specimen cannot be placed in any of the other annulated species described in this report because nothing is known of its internal morphology. Ulrich and others (1944) reported lirae on only one of their annulated species, *Protocycloceras affine*.

OCCURRENCE—Figured specimen, no. 1707, is from 65 ft (19.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Protocycloceras sp. F
P1. 1, figs. 13-20

DESCRIPTION—This species is known from a single, silicified, incomplete phragmocone 22 mm long. The shell is depressed in cross section, increasing in height from 9.0 to 11.0 mm and in width from 11.5 mm to 13.0 mm over its entire length. The specimen shows seven conspicuous, transverse annuli; four annuli occur in a length equal to the adoral shell diameter. A cross section (Pl. 1, figs. 18, 19) taken 16 mm from the apical end of the specimen shows a siphuncle of moderate size (0.3 of conch diameter) in contact with the venter. Here, both shell and siphuncle are depressed in section, measuring 10.0 X 12.5 mm and 3.0 X 3.5 mm, respectively.

A vertical thin section (Pl. 1, fig. 20) of the apical 16 mm of the specimen shows short, straight necks and thick, layered rings. The rings have three layers: an inner and outer dark layer sandwiched around a light, crystalline layer. Septa are largely destroyed, but those remaining show very little curvature. Siphuncle segments are tubular and wider than long. Calcite within the siphuncle and camerae is badly recrystallized; cameral and siphonal deposits cannot be conclusively demonstrated.

DISCUSSION—This species, although poorly known internally, is morphologically isolated from species of

Protocycloceras described elsewhere in this report on the basis of its thick, layered rings. It cannot be placed in any of Ulrich and others' (1944) species because so little is known of their species' internal morphology. Until better preserved and less fragmentary material is found, this species will have to remain unnamed.

OCCURRENCE—Figured specimen, no. 1642, is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

GENUS *CATORAPHICERAS* Ulrich and Foerste

TYPE SPECIES: *Catoraphiceras lobatum* Ulrich and Foerste

Catoraphiceras Ulrich and Foerste, 1935, p. 226.
____ Ulrich and others, 1944, p. 75.
____ Flower, 1964a, p. 134.
____ Teichert and others, 1964, p. K152.

DESCRIPTION—The genus *Catoraphiceras* is here employed for annulated orthocones whose sutures form ventral lobes. Cross sections are known to range from depressed to circular, although all species described in this report have depressed cross sections. Siphuncles are moderately large (0.25-0.35 of conch diameter) and somewhat removed from the venter. Septal necks are short; rings are thin but may show layering. Some species develop ventral rods and cameral deposits, while those with empty siphuncles have thus far failed to yield demonstrable cameral deposits.

DISCUSSION—The scope of *Catoraphiceras* as used here is broader than that of Flower (1964a). This broadened scope is intended to accommodate both rod-bearing and non rod-bearing species, thus providing a parallelism with the genus *Protocycloceras*. These two genera differ only in suture pattern and intergrade with one another. In specimens in which the suture pattern is not evident, it becomes imperative that vertical thin sections be ground and that any change in curvature of septa be noted while the thin section is being ground (Fig. 5).

Catoraphiceras ibexense, n. sp.

P1. 14, figs. 3-6

DESCRIPTION—The holotype and only known specimen of *C. ibexense* is a portion of a phragmocone preserved as an internal mold that is incomplete dorsally. This fragment has a maximum length of 24 mm and expands in width from 8.5 to 11 m over the anterior 18 mm of the shell.

Annuli are low, rounded, and prominent; throughout the length of the specimen four annuli occupy a length equal to the adoral shell width. Sutures form narrow, deep lobes on the venter (Pl. 14, fig. 3) and are straight and transverse laterally.

The shell is depressed in section; orally (Pl. 14, fig. 4), it has a height of 8.5 mm and a width of 11 mm. Here, the siphuncle is also depressed in section, measuring approximately 2 X 3 mm, and is slightly removed from the venter.

A vertical thin section (Pl. 14, figs. 5, 6) made through the apical 9 mm of the specimen exposed four camerae. Septa are slightly curved and devoid of cameral deposits. Siphuncle segments are slightly expanded into the camerae in the apical two segments and tubular in the anterior two.

Septal necks are short and straight; those on the ventral side of the siphuncle are only about half the length of those on the dorsal side and are lower by about half the length of the siphuncle segment. Connecting rings are thin and homogeneous. There is no evidence of organic deposits within the siphuncle or on the septa.

DISCUSSION—C. *ibexense* is unlike any of the seven previously described species of *Catoraphiceras* that can be assigned to the Ellesmeroceratida—C. *vaginatum* is an endoceroid and according to Flower (1975b) should be assigned to *Lobocyclendoceras* Balashov, 1968. *C. lobatum* and *C. cushingi* have circular cross sections. Of the remaining five species: 1) *C. foerstei* has sutures that form lateral saddles; 2) *C. osagenense* has concave siphuncle segments; 3) *C. resseri* has a very broad ventral lobe; 4) the one known specimen of *C. sordidum*, according to Ulrich and others, 1944, leaves much to be desired in terms of preservation, making specific comparisons difficult; and 5) *C. colon* is known from a single living chamber, making comparisons almost impossible. Nothing is known of the internal morphology of any of these species.

Of the three other new species of *Catoraphiceras* described, *C. staceyae* and *C. pearsonae* have ventral rods, and *C. sinuatum* has thicker, layered rings and sinuous siphuncle segments.

TYPE AND OCCURRENCE—Holotype, no. 1713, is from the Wahwah Limestone, section J, Ibex area, Utah.

Catoraphiceras pearsonae, n. sp.

Pl. 15, figs. 8-10

DESCRIPTION—Catoraphiceras pearsonae is an annulated, rod-bearing orthocone whose sutures form narrow, shallow lobes on the venter. In vertical thin section, the rod has an irregular, dorsal profile similar to that of a specimen previously described as *Cyptendoceras* cf. *C. ruedemanni.*

The holotype of *Catoraphiceras pearsonae is* a weakly annulated portion of a phragmocone, 17 mm long. Annuli are straight and transverse; approximately two and one-quarter occur in a length equal to the adoral conch width.

Both shell and siphuncle are depressed in cross section. In the apical cross section (Pl. 15, fig. 9), the shell has a height of 7.0 mm and a width of 7.3 mm; the corresponding measurements for the siphuncle, which is slightly removed from the venter, are 2.0 and 2.1 mm (0.28 of conch diameter). Here, the rod fills about two-thirds of the siphuncle and has a round, convex surface. Cameral deposits show as ventrally concentrated white calcite.

A vertical thin section (Pl. 15, fig. 10) made through the entire length of the specimen shows the rod extending orad for a distance of 10 mm and merging ventrad with cameral deposits between siphuncle and venter. These cameral deposits precede the rod in growth and extend the full length of the specimen. The rod has an irregular "stair-stepping" dorsal profile similar to that of *Cyptendoceras* cf. *C. ruedemanni* (Pl. 11, fig. 5).

Septa are straight and slightly inclined between dorsum and siphuncle. Calcite on the septa is interpreted as episeptal cameral deposits because it has sharp boundaries and decreases symmetrically in size orad. However, the calcite on the second septum from the apical end of the specimen is anomalously short. The distribution of these cameral deposits indicates that they grew from dorsum toward venter. Septal necks are short and straight. Those on the dorsal side of the siphuncle are about twice as long and slightly above those on the ventral side. Connecting rings are thin and ambiguous but apparently layered. Most rings can be divided into an inner dark layer and an outer crystalline layer. Siphuncle segments are generally tubular, although some show slight expansion into the siphuncle, and are about as wide as long.

Sutures were not directly observed on the specimen, but apparently form narrow, shallow lobes on the venter as evidenced by the position of the necks on either side of the siphuncle.

DISCUSSION—Catoraphiceras pearsonae is *easily* identified on the basis of the shape of its rod in vertical thin section. The difficulty in identification arises in being able to distinguish the ventral lobe of the sutures (Fig. 5). *C. pearsonae* with its shallow ventral lobe is transitional with *Protocycloceras* and, in fact, this species was originally assigned to *Protocycloceras.*

If the calcitic deposits on the septa of this specimen have been correctly interpreted, then *Catoraphiceras pearsonae* is the only known rod-bearing species in which growth of cameral deposits between siphuncle and dorsum precedes growth of the rod.

TYPE AND OCCURRENCE—Holotype, no. 1710, is from 80 ft (24.4 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Catoraphiceras cf. *C. pearsonae*, n. sp.

P1. 15, figs. 11-16

DESCRIPTION—This figured specimen is preserved as an internal mold of an annulated orthocone, 22 mm long. The shell is depressed in cross section and expands over its entire length from a height of 7 mm and a width of 8 mm to a height of 7.5 mm and a width estimated at 9 mm. The siphuncle is also depressed in section, measuring 2 X 2.5 mm apically and 2.5 X 3 mm orally, and is slightly removed from the venter.

A vertical thin section (P1. 15, fig. 16) made through the apical 16 mm of the specimen revealed eight irregularly spaced septa of very slight curvature. The second septum from the apical end has what appears to be a thin episeptal cameral deposit on it.

Siphuncle segments are very slightly expanded into the camerae. Connecting rings are thin and homogeneous. Necks are short and straight; those on the ventral side of the siphuncle are shorter and slightly below those on the dorsal side.

Matrix in the siphuncle abutts the ventral wall of the siphuncle except in the apical 3 mm of the thin section where it abutts crystalline calcite. The boundary between matrix and calcite is a distinct, irregular curve, suggesting the possibility that it is a rod similar to that of *Cyptendoceras* cf. *C. ruedemanni* (P1. 11, figs. 4, 5). Calcite between the siphuncle and the venter may well be recrystallized cameral deposits.

The suture pattern was not directly observed on this specimen. However, while the thin section was being ground, the septa were observed to change curvature in the vicinity of the siphuncle and swing slightly apicad, forming shallow ventral lobes on the venter.

DISCUSSION—This specimen is tentatively referred to *Catoraphiceras pearsonae* on the basis of the profile of its rod in vertical thin section. This peculiar "stair-stepping" profile has thus far been observed only in C. *pearsonae* and *Cyptendoceras* cf. C. *ruedemanni*. This specimen differs from the holotype of *Catoraphiceras pearsonae* in having thinner rings that are expanded into the camerae, a larger siphuncle in proportion to shell diameter, and slightly curved rather than straight septa.

OCCURRENCE—Figured specimen, no. 1712, is from 55 ft (16.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Catoraphiceras sinuatum, **n.** sp.

P1. 2, figs. 21-23; Pl. 3, figs. 1-3

DESCRIPTION—Catoraphiceras sinuatum is known from a single, annulated, internal mold 45 mm long. Annuli are very prominent; five occur in a length equal to the adoral width and are about the same size as the concave interspaces.

Sutures describe wide, deep lobes on the venter. The one lobe visible in the ventral view (Pl. 2, fig. 21) measures 5 mm wide and 4 mm deep. Sutures are apparently straight and transverse laterally and assumed to be straight and transverse dorsally.

Both shell and siphuncle are depressed in cross section. Apically, the shell has a width of 18 mm and a height of 12.5 mm. Orad, a distance of 39 mm, these diameters are 20 mm and 18 mm, respectively. The siphuncle, which is only slightly removed from the venter, measures 5.5 mm X 5 mm, apically, and 7 mm X 6 mm, orad.

A vertical thin section (Pl. 3, fig. 1) was made through the apical 25 mm of the specimen. Although septa were largely destroyed by invading sediments, many necks and rings remain. Necks are short, extending about one-third the length of a segment, and are slightly curved, convex side out. Rings are thin, but can be differentiated into an inner, thin opaque layer and an outer thicker, light granular zone. Thickening of the ring apicad in some segments is adventitious. Taken together, the necks and rings have a sinuous outline, convex in the region of the neck, concave apicad. Necks on the ventral side of the siphuncle are approximately the same length as those on the dorsal side and are directly across from them in vertical thin section.

Cameral and siphonal deposits are wanting, possibly because this portion of the phragmocone is too far orad to have developed them.

DISCUSSION—The deep ventral lobe and unusual siphuncle segments combined with large size make *Catoraphiceras sinuatum* the most easily recognizable of the new species of *Catoraphiceras*. The layered rings and slightly curved necks appear to be a modification unique to this species.

TYPE AND OCCURRENCE—Holotype, no. 1657, is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

Catoraphiceras staceyae, n. sp.

P1. 2, figs. 1-14; P1. 11, figs. 12-14

DESCRIPTION—Catoraphiceras staceyae is a small, slender species distinguished by a depressed cross section and a ventral rod in its siphuncle. The siphuncle is of moderate size (0.25 to 0.3 of the shell diameter), subcircular to depressed in cross section, and slightly removed from the venter. Sutures form narrow deep lobes on the venter, broad low saddles laterally, and broad shallow lobes on the dorsum. Septa are flat in vertical thin section and develop thin, episeptal cameral deposits between siphuncle and dorsum. Necks are short and straight; rings are thin and homogenous.

Holotype, no. 1652 (Pl. 2, figs. 28-31): The holotype is a portion of a silicified phragmocone, 29 mm long. Sutures describe narrow, fairly deep lobes on the venter (Pl. 2, fig. 28), broad low saddles laterally (Pl. 2, fig. 29), and broad shallow lobes on the dorsum (Pl. 2, fig. 30).

Camerae are short. About midlength, where they are exposed on the dorsum, they are 1 mm long. Approximately five camerae are found in a length equal to the adoral width of the shell. Annuli are low, rounded, and transverse; throughout the length of the specimen, three annuli are found in a length equal to the adoral width of the shell.

The shell is depressed in cross section and expands at a moderate rate. Apically, the shell has a height of 4 mm and a width of 5 mm; orally, these figures have increased to 7 and 8 mm, respectively.

The siphuncle, which can only be seen in the anterior view (Pl. 2, fig. 31), is subcircular, approximately 2 mm in diameter and is slightly removed from the venter. Details of the internal morphology of the holotype are unknown.

Paratype, no. 1643 (Pl. 2, figs. 1-5): This paratype is a portion of a slender phragmocone, 39 mm long. The shell is depressed in cross section and expands from a height of 4 mm and a width of 5 mm to a height of 8 mm and a width of 9.5 mm over a length of 32 mm. Annuli are low, rounded and transverse; four occupy a length equal to the adoral width of the shell. Septa, as seen on the weathered dorsum (P1. 2, fig. 2), are closer than annuli; five occur in a similar length. Sutures on the dorsum form broad, shallow lobes.

A cross section 26 mm from the apical end of the specimen (Pl. 2, fig. 4) shows the siphuncle slightly removed from the venter. Here, both shell and siphuncle are depressed, measuring 7 X 9 mm and 2 X 2.5 mm, respectively.

A vertical thin section (Pl. 2, fig. 5) through the apical 26 mm of the specimen confirmed the presence of the ventral rod in the siphuncle. The rod has a round convex surface in cross section (Pl. 2, fig. 4). Necks are short and straight; rings are thin and homogeneous. Septa are flat and all but the most adoral septa are lined with thin, episeptal cameral deposits.

Paratype, no. 1644 (Pl. 2, figs. 11-14): This paratype is a portion of a phragmocone at about the same growth stage as that of the preceding paratype. It is 38 mm long and depressed in cross section, measuring 4 X 4.5 mm apically and 7.5 X 9.5 mm orally. A cross section 4 mm from the apical end (Pl. 2, fig. 11) has a height of 4.6 mm and a width of 5.0 mm and shows the siphuncle, whose boundaries are indistinct, to be slightly removed from the venter. Throughout the length of the specimen five annuli and four camerae occupy a length equal to the adoral width of the shell. Sutures form broad, shallow lobes on the dorsum and are not evident ventrally or laterally.

Paratype, no. 1645 (Pl. 2, figs. 6-10): This paratype is a portion of a phragmocone, 26 mm long, representing a somewhat later growth stage than the preceding two paratypes. The specimen is incomplete apicad where only the vertical diameter of 4 mm could be measured. The cross section at the anterior end of the specimen (Pl. 2, fig. 9) has a height of 7.5 mm and a width of 9 mm. Here, the siphuncle is subcircular, approximately 2.3 mm across, and slightly removed from the venter. Throughout the length of the specimen five camerae and four annuli occupy a length equal to the adoral width of the shell.

The vertical thin section (P1. 2, fig. 10) made through the entire length of the specimen is almost identical to that of paratype, no. 1643. The thin section shows the rod of clear calcite lying against the ventral wall of the siphuncle and thinning rapidly orad, flat septa, thin episeptal cameral deposits, short straight necks, and thin, homogeneous rings. Necks on the ventral side of the siphuncle are slightly shorter than those on the dorsal side and are directly across from them.

Figured specimen, no. 1621 (P1. 11, figs. 12-14): This specimen is a very fragile portion of a phragmocone, 53 mm long. Annuli are low, round and transverse; orally, four annuli occur in a length equal to the adoral height, apically, three and one half. Sutures form broad, shallow lobes on the dorsum (Pl. 11, fig. 14). The shell expands from a width of 5 to 12 mm over the apical 45 mm of the specimen. The cross section 45 mm from the apical end of the specimen has a height of 10 mm and a width of 12 mm. Septa become crowded in the anterior 8 mm of the specimen.

DISCUSSION—This species is assigned to the genus *Catoraphiceras* on the basis of its suture pattern. Among the annulated orthocones of the Ellesmeroceratida, the suture pattern of *Catoraphiceras* is unique. Eventually, as knowledge of the stratigraphy, morphology, and evolution of the rod-bearers increases, this species will undoubtedly be separated into a new genus.

TYPES AND OCCURRENCE—The holotype, all three paratypes, and the figured specimen are from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Catoraphiceras cf. *C. staceyae*, n. sp.

P1. 14, figs. 15-18

DESCRIPTION—This specimen is a portion of a prominently annulated orthocone, 57 mm long. The cross section (Pl. 14, fig. 18) 30 mm from the apical end of the specimen shows the shell to be incomplete dorsally, but with a width of 13.7 mm, and to have a circular siphuncle, 3.2 mm in diameter, slightly removed from the venter. The opposing cross section (not shown) intersected the rod, which is round, convex and fills approximately one-third of the siphuncle.

Two vertical thin sections (Pl. 14, figs. 16, 17) were made that cover the full length of the specimen. The rod almost completely fills the siphuncle apically, begins to thin rapidly 12 mm from the apical end, and terminates approximately 17 mm farther orad. The rod has a smooth, straight dorsal surface and is composed of coarse, recrystallized calcite that merges ventrally with calcite of cameral deposits.

Siphuncle segments are tubular and broader than high. Necks are short and straight on the dorsal side of the siphuncle and vestigial and lower on the ventral side. Rings are relatively thin and homogeneous.

Septa are straight and transverse between siphuncle and dorsum and without demonstrable cameral deposits. The calcite between siphuncle and venter is interpreted as organic because the septa on the thin section chip show a marked ventral thickening. If all the calcite on the ventral side of the siphuncle is organic, then these cameral deposits precede the rod in growth.

Sutures form narrow lobes on the venter and are unknown laterally and dorsally. The ventral suture pattern, though not observed directly, is substantiated by changes in curvature of the septa on the thin section chip and by the position of the necks on the ventral side of the siphuncle (See Fig. 5).

Spacing of septa is not uniform. This is evident not only from the varying lengths of the camerae, but also from the relative position that the septa join the venter (Pl. 14, fig. 16)—some join at the troughs, others at the crests of the annuli.

DISCUSSION—Work on this specimen was completed prior to development of the criterion for determining ventral lobes, and this specimen was originally assigned to *Protocycloceras rhabdiferum.* It was only in reviewing the specimen that its ventral lobe was discovered, necessitating the generic change to *Catoraphiceras.*

This specimen differs from the typical *C. staceyae* in being more prominently annulated and in having a circular siphuncle and thicker rings.

OCCURRENCE—Figured specimen, no. 1689, is from a zone 55 to 65 ft (16.8 to 19.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Catoraphiceras **spp .**

Pl. 2, figs. 24-27; Pl. 14, figs. 1, 2;
P1. 15, figs. 17-20

DESCRIPTION—Three fragmentary annulated orthocones whose sutures describe ventral lobes are briefly described below.

Figured specimen, no. 1653 (Pl. 2, figs. 24-27): This specimen was a portion of a phragmocone, 21 mm long, that was destroyed in grinding the thin section. Eight very low, transverse annuli separated by pencil-thin interareas cover the adoral 18 mm of the shell; four annuli occur in a length equal to the adoral shell height. Both shell and siphuncle are depressed in cross section; anteriorly (Pl. 2, fig. 27) the shell has a height of 7.5 mm and a width of 8.0 mm while the siphuncle measures 2.0 X 2.3 mm and is 0.5 mm from the venter. Sutures describe shallow, angular lobes on the venter (Pl. 2, fig. 24), broad shallow lobes on the dorsum, and low saddles laterally. This specimen is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

Figured specimen, no. 1665 (Pl. 15, figs. 17-20): This figured specimen is preserved as an internal mold of a living chamber, 11 mm long, that is complete apically, abutting the last formed septum, but incomplete adorally. Annuli are prominent, round, and transverse; four annuli occur in a length equal to the adoral diameter. The shell is depressed in cross section and expands from an apical height of 6.0 mm and width of 7.0 mm to an anterior height of 6.5 mm and width of 8.0 mm. The apical septal view (Pl. 15, fig. 20) shows the impression of a submarginal siphuncle, also depressed in section, measuring 1.3 X 1.7 mm. The preserved septal surface has moderate curvature and its suture forms a wide shallow lobe on the venter (Pl. 15, fig. 19); laterally and dorsally the suture is not preserved. This specimen does not agree in general proportions with *C. colon,* the only previously described specimen of *Catoraphiceras* from the Pogonip Group, which is also preserved as a living chamber. From 40 ft (12.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1670 (Pl. 14, figs. 1, 2): This specimen is from Hintze's original Ibex section *J* collections and was identified by Hintze (1952, p. 40) as *Catoraphiceras* sp. The figured specimen is a partially silicified internal mold of a phragmocone that consists of four etched camerae and is so fragmentary that comparisons at the specific level are impossible. Three of the camerae are still articulated and are shown in ventral view (Pl. 14, fig. 2). The fourth and anteriormost camera is disarticulated and is shown in septal view (P1. 14, fig. 1). The shell is depressed in cross section and anteriorly has a height of 7 mm and a width of 8 mm. The siphuncle is also depressed in cross section, measuring 2.2 X 2.5 mm, and is slightly removed from the venter. Sutures form narrow, deep ventral lobes. This specimen is from Hintze's (1952) collecting locality J-6, 26 ft (7.9 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

DISCUSSION—Although these three specimens may represent new species, they are either so fragmentary or poorly preserved that specific comparisons are difficult. They are illustrated more for completeness than anything else and bring to twelve the total number of Wahwah Limestone and Florida Mountains Formation specimens assigned to *Catoraphiceras.*

OCCURRENCE—Figured specimen, no. 1653, is from the Florida Mountains Formation, southwest New Mexico; figured specimens, no. 1665 and 1660, are from the Wahwah Limestone, Ibex area, Utah.

GENUS *KY MINOCERAS* Teichert and Glenister

TYPE SPECIES: *Kyminoceras forresti*
Teichert and Glenister

Kyminoceras Teichert and Glenister, 1954, p. 42.
______ Flower, 1964a, p. 130.
______ Teichert and others, 1964, p. K I54.

DESCRIPTION—The genus *Kyminoceras* contains annulaced orthocones with small (0.2 of conch diameter) marginal to submarginal siphuncles, circular to subcircular cross sections, and cylindrical siphuncle segments composed of short necks and thin, homogeneous rings. Cameral and siphonal deposits are unknown.

DISCUSSION—Kyminoceras includes species formerly assigned to *Protocycloceras*. The distinction between the two genera is based primarily on siphuncle size. While this distinction is not morphologically profound, it does afford a limited basis for separation of an otherwise very large and heterogeneous generic grouping.

Kyminoceras kottlowskii, n. sp.

Pl. 3, figs. 4-8; Pl. 4, figs. 1-3, 9-12

DESCRIPTION—Kyminoceras kottlowskii is a prominently annulated orthocone that has a circular cross section and a small (about 0.2 of conch diameter), circular siphuncle, slightly removed from the venter. Spacing of annuli exactly corresponds to that of the camerae; septa generally join the shell wall at concave interareas. Siphuncle segments are tubular, longer than wide. Septa are slightly curved between siphuncle and dorsum and are straight and slightly inclined apicad between venter and siphuncle. Both siphuncle and camerae are apparently devoid of organic deposits.

Holotype, no. 1649 (Pl. 3, figs. 4-8): The holotype is a portion of a phragmocone, 27 mm long, embedded in matrix. The shell is circular in cross section and increases in diameter from 6 to 7.5 mm over a length of 19 mm. The siphuncle is small (about 0.2 of the shell diameter), circular, and removed from the venter by a distance approximately equal to its diameter; apicad, it is 1.3 mm across, orad, 1.5 mm.

Orad, three camerae and three annuli occupy a length equal to the adoral shell diameter. About midlength there is a break in the pattern, and the septa, instead of joining the venter in the center of each concave interarea, become farther apart, two and one-half camerae in a length of three annuli. Apicad, the pattern of spacing becomes three and three again.

The siphuncle wall is composed of short necks and thin homogeneous rings. Siphuncle segments are about one and one-half times longer than wide. The calcite that completely fills the siphuncle is invaded from both ends by matrix and is most probably adventitious.

Septa are straight and slightly inclined apicad between venter and siphuncle as seen in the vertical thin section (P1. 3, figs. 6-8). Between siphuncle and dorsum the septa are curved; curvature is equal to less than half the length of the camerae. Calcite within the camerae is inorganic.

Sutures were not observed, but they are assumed to be straight and transverse to correspond with the annuli.

Paratype, no. 1650 (Pl. 4, figs. 1-3): The paratype shows some variation in spacing of annuli, is not as slender, and has a slightly larger siphuncle than the holotype. However, its internal morphology is virtually identical to that of the holotype. Over a length of 23 mm the paratype increases in diameter from 5 to 8 mm, while its siphuncle increases from 1.2 to 1.8 mm over the 17 mm of length of the vertical thin section (Pl. 4, fig. 2). Annuli and camerae correspond in spacing; through out the length of the thin section, four occupy a length equal to the adoral shell diameter. No cameral or siphonal deposits are evident.

Figured specimen, no. 1651 (Pl. 4, figs. 10-12): This specimen is tentatively assigned to *K. kottlowskii* on the basis of its thin section (Pl. 4, fig. 12), which, although off center and missing the siphuncle apicad, shows the same internal morphology as the holotype and paratype. This specimen differs in having a depressed cross section (Pl. 4, figs. 9, 11). Its apical cross section (Pl. 4, fig. 9) measures 3.4 X 4 mm and has a circular siphuncle, 0.8 mm across, approximately 0.5 mm from the venter. Twenty-two millimeters farther orad, the shell has a width of 6 mm and a height estimated at 5.7 mm and a siphuncle 1.4 mm in diameter. Three annuli and three camerae are found in a length equal to the adoral width of the shell. Cameral and siphonal deposits are not evident.

DISCUSSION—There is some question as to the proper generic assignment of this species. Teichert and Glenister (1954, p. 42) defined *Kyminoceras* to include annulated ellesmeroceroids with small siphuncles that were either ". . . marginal or situated close to the shell wall." They restricted the genus *Protocycloceras* to ". . . species with large siphuncles or small siphuncles removed from the venter." With these guidelines, this species can be assigned to either *Protocycloceras* or *Kyminoceras*. In assigning this species to *Kyminoceras* we have followed the *Treatise* (Teichert and others, 1964), which draws the boundary between *Protocycloceras* and *Kyminoceras* primarily on the basis of siphuncle size. *Protocycloceras* is restricted to forms with ventral, but not marginal, siphuncles approximately 0.3 of the conch diameter; *Kyminoceras* is restricted to forms with siphuncle either marginal or situated close to the shell wall that are about 0.2 of the conch diameter.

Teichert and Glenister (1954) and Flower (1964a) recognize seven species in *Kyminoceras*. Unfortunately, nothing is known about the internal morphology of six of these species; only the type species, *K forresti*, is known in enough detail to permit comparisons. *K kottlowskii* differs from the type species in having straight, transverse annuli, necks of constant length, and cylindrical siphuncle segments.

OCCURRENCE—All three specimens are from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

GENUS *RUDOLFOCERAS* Ulrich, Foerste, Miller, and Unklesbay

TYPE SPECIES: *Orthoceras cornu-oryx* Whitfield

Orygoceras Ruedemann, 1906, p. 449 (not *Orygoceras* Brusinia, 1882)
Rudolfoceras Ulrich and others, 1944, p. 55-56.
_____ Flower, I964a, p. 129.
_____ Teichert and others, 1964, p. K 154.

DESCRIPTION—Rudolfoceras contains annulated, exogastric cyrtocones with cross sections that range from compressed to depressed. Siphuncles are submarginal and composed of either cylindrical or concave segments. Septal necks are short and straight; connecting rings are thin and homogeneous. Thin episeptal cameral deposits are known in one species.

DISCUSSION—The scope of *Rudolfoceras* as defined above is only slightly greater than that of Flower (1964a) and Teichert and others (1964). The additional information was supplied by the thin section of *R. keadyi*, n. sp., which shows thin, ventrally concentrated episeptal cameral deposits on the apical septa.

Rudolfoceras keadyi, *n.* sp.

P1. 1, figs. 8-12; Pl. 11, fig. 1

DESCRIPTION—Rudolfoceras keadyi is a slender, annulated, exogastric cyrtocone of circular cross section that may have a ventral rod within its siphuncle.

The only known specimen of *R. keadyi is* an internal mold of a phragmocone, 26 mm long. The shell is straight over the initial 19 mm of the specimen, then becomes faintly exogastric. The cross section is circular increasing in diameter from 6 mm apically to 7.5 mm, 19 mm from the apical end of the specimen, to 8.5 mm at the anterior end.

Annuli are low, round and transverse; fifteen occur over the length of the specimen. Adorally, four annuli occupy a length equal to the adoral shell diameter; apically, this figure decreases to three and one-half. Spacing of annuli exactly corresponds to that of the septa; septa join the shell at the concave interareas. Sutures, therefore, are straight and transverse.

The siphuncle is circular, moderate in size (0.25 of shell diameter), and slightly removed from the venter. The vertical thin section through the apical 14 mm of the specimen (Pl. 11, fig. 1) shows the siphuncle to be 1.5 mm in diameter and 1.3 mm from the venter, apically, and 2.0 mm in diameter, 1.5 mm from the venter, orally. Siphuncle segments are longer than wide and range from cylindrical to slightly expanded into the camerae. Necks are short and straight; rings are thin and homogeneous.

The septa are slightly curved, curvature equal to less than half the length of a camera, between dorsum and siphuncle, and are straight and inclined apicad between venter and siphuncle. Cameral deposits are not developed between siphuncle and dorsum. However, the calcite that completely fills all the camerae between siphuncle and venter may be recrystallized cameral deposits.

The thin section is ambiguous as to the origin of the calcite in the siphuncle. This calcite is concentrated ventrally, thins orally, and has an undulating dorsal surface—all characteristic of organically precipitated rods. However, it terminates abruptly with an appreciable thickness, does not have a sharp, clear dorsal boundary, and is invaded by matrix in the apical siphuncle segment. The thin section is slightly off center; this may account for the absence of the calcite in the apical segment.

DISCUSSION—R. *keadyi* can be distinguished from the seven other previously described species of *Rudolfoceras* (see Flower, 1964a) on the basis of its moderate curvature, relative spacing of septa and annuli, circular cross section, and straight transverse annuli. It can be distinguished from *R. russelli*, n. sp. in vertical thin section by its lack of cameral deposits between siphuncle and dorsum and by the inclination and length of the septa between venter and siphuncle.

TYPE AND OCCURRENCE—Holotype, no. 1639, is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

Rudolfoceras russelli, n. sp.

Pl. 14, figs. 7-9

DESCRIPTION—Rudolfoceras russelli is an annulated, exogastric cyrtocone of moderate curvature, depressed in cross section, possessing a small, subcircular siphuncle, slightly removed from the venter.

The only known specimen of *R. russelli* is a portion of a phragmocone, 30 mm long. A vertical thin section was made through the apical 15 mm of the specimen. The cross section (P1. 14, fig. 8) at the anterior end of the thin section shows the shell to have a width of 5.4 mm and to be incomplete dorsally. Here, the siphuncle is depressed in section with a height of 1.0 mm and a width of 1.1 mm and is slightly removed from the venter.

The vertical thin section (Pl. 14, fig. 7) first revealed the exogastric curvature of the shell. Septa have only the slightest curvature between dorsum and siphuncle, and are short, straight, and transverse between siphuncle and venter. Thin episeptal and hyposeptal deposits are developed between siphuncle and dorsum. Calcite, reasonably cameral deposits, completely fills the apical camerae between siphuncle and venter.

Siphuncle segments are longer than wide and are tubular. Necks are short and straight, directly across from one another, and virtually the same length on both sides of the siphuncle. Rings are thin and homogeneous. Sutures are assumed to be straight and transverse because the septa consistently join the shell at concave interareas and the annuli are straight and transverse.

DISCUSSION—The combination of cameral deposits, shape and relative position of septa, and tubular siphuncle segments composed of short necks and thin, homogeneous rings makes *R. russelli an* easily identifiable species. It is readily distinguished from *R. keadyi*, n. sp. on the basis of its cameral deposits and more pronounced exogastric curvature.

TYPE AND OCCURRENCE—Holotype, no. 1671, is from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Rudolfoceras? sp.

P1. 19, fig. 3

DESCRIPTION—This figured specimen is a slender, annulated cyrtocone 26 mm long, exposed as a naturally weathered, longitudinal section. Annuli are small and inconspicuous and are best seen near the apical end of the specimen. Weathering has destroyed about half the shell and removed the siphuncle. In the plane of weathering the shell expands from 1.5 to 5 mm over the length of the specimen.

DISCUSSION—Without knowledge of the position of the siphuncle, assignment to *Rudolfoceras*, which is exogastric, has to be tentative. However, there are only three cyrtocones in the entire cephalopod fauna and they are all probably congeneric.

OCCURRENCE—Figured specimen, no. 1688, is from the Wahwah Limestone, section J, Ibex area, Utah.

Family APOCRINOCERATIDAE?

GENUS *BA KEROCERAS*, n. gen.

TYPE SPECIES: *Bakeroceras wahwahense*, n. sp.
Fig. 10

DESCRIPTION--Bakeroceras is an annulated orthocone with a depressed cross section; circular siphuncle of moderate size slightly removed from the venter; short septal necks, ranging from straight to slightly curved; thin connecting rings expanded into the camerae; and annulosiphonate deposits that consist of a ventral rod-like structure and dorsal annuli in the type species.

DISCUSSION—Flower (Flower and Teichert, 1957) established the Family Apocrinoceratidae for small annulated orthocones with short necks and Thick rings expanded into the camerae. He suggested that the Apocrinoceratidae represented a lineage derived from the Protocycloceratidae by expansion of siphuncle segments into the camerae. He included three genera-*Apocrinoceras*, *Desioceras*, and *Glenisteroceras*, each known from a single specimen—in the family and

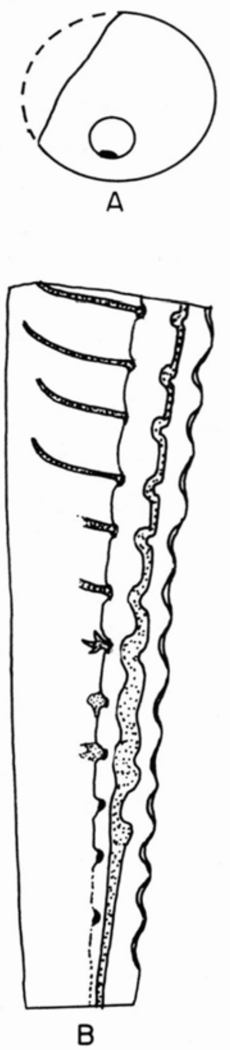

FIGURE 10—*Bakeroceras*, N. GEN. A) Cross section at anterior end of B, venter down, X2.7. B) Vertical thin section through type species, venter on right, X3.6. Rod and septa are stippled; annuli are solid.

indicated that they were a highly specialized family that gave rise to nothing higher.

Bakeroceras with its thin rings and expanded siphuncle segments is transitional between the Protocycloceratidae and the Apocrinoceratidae, and assignment to either family can be equally justified using these criteria. However, *Bakeroceras* also develops siphonal annuli, which are unknown in both the Protocycloceratidae and the Apocrinoceratidae.

Tentative assignment to the Apocrinoceratidae indicates acquiescence to the unknown. The expected range of internal morphology of the Protocycloceratidae is well known and documented, while that of the Apocrinoceratidae is not.

DERIVATION OF *NAME—Bakeroceras* is named for Buddy Baker, a former geology major at Sul Ross, who first introduced the senior author to paleontology.

Bakeroceras wahwahense, n. sp.
P1. 19, figs. 8-12

DESCRIPTION—The holotype and only known specimen of *Bakeroceras wahwahense* is an internal mold of a portion of a phragmocone, 30 mm long. The shell is prominently annulated, orthoconic, and depressed in cross section. Five annuli occur in a length of 10 mm. The siphuncle is circular and removed from the venter by a distance equal to less than half its diameter.

The anterior cross section (Pl. 19, fig. 9) has a height of 7.3 mm and an estimated width of 10 mm. The siphuncle is circular, 2 mm in diameter, and 0.7 mm from the venter. The plane of the cross section intersects the siphuncle at a foramina and shows a small area of ventrally concentrated calcite within the siphuncle. This calcite is interpreted as an annulosiphonate deposit.

A vertical thin section (Pl. 19, fig. 10) was made through the entire length of the specimen. Most of the dorsal half of the shell was destroyed before burial, and a complex history of diagenesis makes interpretation of internal structures, particularly siphonal structures, difficult.

Septa between dorsum and siphuncle are best preserved in the anterior end of the thin section, where they are essentially straight and transverse. Septa between siphuncle and venter are also straight and transverse and join the shell at concave interareas. Cameral deposits are not discernible.

Septal necks are short and range from straight (orthochoanitic) to slightly curved (cyrtochoanitic). Near the apical end of the thin section necks on the dorsal side of the siphuncle have been dissolved. Calcite was later deposited around the periphery of the resulting cavity. Necks on the ventral side of the siphuncle near the anterior end of the thin section were also dissolved; the cavity, however, was later filled with invading sediments. Connecting rings are thin and homogeneous and are expanded into the camerae, making the siphuncle segments fusiform.

Calcite within the siphuncle can be divided into three distinct types of deposits: 1) small, apically concentrated annuli; 2) an animal burrow through the median part of the siphuncle; and 3) a "lining" on the ventral side of the siphuncle that extends the entire length of the thin section.

The annuli (Pl. 19, fig. 11) are well-behaved, extend forward from the necks, decrease in size orad, and are absent in the anterior half of the thin section. The median calcite (Pl. 19, fig. 10), interpreted as an animal burrow, has irregular boundaries and passes in and out of the plane of the thin section.

The ventral "lining" is more difficult to interpret, but is believed to be a true annulosiphonate deposit because: 1) the "lining" is symmetrical—its dorsal profile is parallel to the shell outline (Pl. 19, fig. 12)—and lies within the plane of the siphuncle; 2) it thins anteriorly and is thickest at the septal necks; 3) it is ventrally concentrated (Pl. 19, fig. 9), although the specimen was oriented with its left lateral side down in the sediment; and 4) at least in part, the "lining" has a sharp, regular dorsal profile (Pl. 19, fig. 12). Also, there are no known ellesmeroceroids in which annulosiphonate deposits develop first on the dorsal side of the siphuncle. The animal burrow is always between the "lining" and the dorsal side of the siphuncle and deviates course when it comes in contact with the "lining." This course deviation indicates that the "lining" was in the siphuncle before the animal burrowed into it.

Over the anterior half of the thin section the "lining" has a very irregular dorsal profile, which is uncharacteristic of an organically precipated structure. This we attributed to partial solution during diagenesis. Lemone (1975, personal communication) using petrographic evidence alone concluded that this irregular surface was a secondary feature due to solution activity.

The origin of the "lining" is not altogether evident from this thin section. However, there are seemingly only two choices based on contemporary genera: either it resulted from annuli that grew forward from the foramina and fused, or it is a rod. From the distribution of the deposit, the "lining" is more likely to have resulted from discrete annuli that grew both forward and backward and eventually fused.

DISCUSSION—The discovery of endosiphonal annuli in this specimen indicates that annuli developed independently within the Apocrinoceratidae? as well as within the rod-bearing Baltoceratidae during late Cassinian time. This development in the Baltoceratidae gave rise to the Troedssonellidae; in the Apocrinoceratidae?, it apparently gave rise to nothing higher.

TYPE AND OCCURRENCE—Holotype, no. 1673, is from the Wahwah Limestone, section J, Ibex area, Utah.

Apocrinoceratidae?, genus and species indeterminate
Pl. 14, figs. 12-14

DESCRIPTION—This specimen is a portion of an annulated orthocone, 18 mm long, preserved as an internal mold of a phragmocone. The specimen is badly weathered, but annuli are distinct in the ventral view (Pl. 14, fig. 13).

The anterior cross section (Pl. 14, fig. 12) is complete and shows both shell and siphuncle to be depressed in cross section. The shell has a height of 6.7 mm and a width of 8.0 mm. The siphuncle is submarginal, 0.5 mm from the venter, and has a height of 1.7 mm and a width of 2.0 mm.

A vertical thin section (Pl. 14, fig. 14) made through the anterior 7 mm of the specimen revealed three and one-half camerae. Septa are curved between dorsum and siphuncle, curvature equal to less than half the length of a siphuncle segment, and essentially straight and slightly inclined apicad between venter and siphuncle. Necks are orthochoanitic; those on the ventral side of the siphuncle are shorter, thinner, and directly across from those on the dorsal side. Connecting rings are thin and homogeneous and expanded into the camerae. Cameral and siphonal deposits are not developed.

A vertical, opaque section (not illustrated) through the apical 11 mm of the specimen shows the same internal morphology and also fails to reveal any cameral or siphonal deposits.

DISCUSSION—This specimen undoubtedly represents a new genus. However, the morphologic information provided by this badly weathered fragment is incomplete and not sufficent for establishment of a new genus. Assignment to the Apocrinoceratidae is tentative and based on the expansion of the connecting rings into the camerae.

OCCURRENCE—Figured specimen, no. 1708, is from the Wahwah Limestone, section J, Ibex area, Utah.

Order ENDOCERATIDA

Family PROTEROCAMEROCERATIDAE

GENUS *CLITEN DOCERAS (=KIRKOCERAS)* Ulrich and Foerste

TYPE SPECIES: *Clitendoceras saylesi* Ulrich and Foerste

Clitendoceras Ulrich and Foerste, 1935, p. 268.
Kirkoceras Ulrich and Foerste, 1935, p. 277.
____ Ulrich, Foerste, and Miller. 1943, p. 45.
Clitendoceras Flower, 1955a, p. 365.
Kirkoceras Flower, 1955a, p. 366.
Clitendoceras Nikiforovoi, 1955, p. 55.
____ Flower. 1956. p. 87.
____ Ruzhentsev and others, 1962, p. 309.
____ Teichert and others, 1964, p. K 166.
Kirkoceras Teichert and others, 1964, p. K 170.
Clitendoceras Balashov, 1968, p. 56.

DESCRIPTION—Clitendoceras (= Kirkoceras) is used for slightly crytoconic, endogastric conchs with circular or compressed cross sections. Siphuncles are slender, marginal, and compressed or circular in cross section. The endosiphuncles expand at a rapid rate in early stages, contract adaperturally, and are covered with oblique septal ridges.

DISCUSSION—This description of *Clitendoceras (=Kirkoceras)* is a composite of the *Treatise* (Teichert and others, 1964) descriptions of *Clitendoceras* and *Kirkoceras*. As originally defined, *Clitendoceras* was based on a portion of a phragmocone including siphuncle, while *Kirkoceras* was known from an isolated siphuncle. Flower (1956) acknowledged that it was impossible to distinguish siphuncles of *Kirkoceras* from those of *Clitendoceras*. The *Treatise* has essentially followed suit, indicating that *Kirkoceras* may be synonymous with *Clitendoceras*. The Russian treatise (Ruzhentsev and others, 1962) does not indicate synonymy, primarily because *Kirkoceras* is listed as occurring outside the U.S.S.R.

Clitendoceras (=Kirkoceras)? sp.
Pl. 6, figs. 1-6

DESCRIPTION—This specimen is the apical end of a silicified endosiphuncle 27 mm long, compressed in cross section. The endosiphuncle is initially blunt, expands very rapidly over a distance of 8 mm, after which expansion slows and becomes essentially conical. A cross section (Pl. 6, fig. 6) 14 mm from the apical end of the specimen has a height of 11.0 mm and a width of 10.5 mm; the naturally weathered anterior cross section (Pl. 6, fig. 4) has a height of 13 mm and a width of 12.5 MM.

The endosiphuncle is only faintly endogastric. In profile (Pl. 6, fig. 2) both the venter and the dorsum are initially convex; the venter becomes straight after a length of 3 mm, the dorsum after a length of 8 mm. Also in profile, two faint, oblique ridges near the apical end of the specimen slope apicad from the venter making an angle of 57 degrees with respect to the venter. These ridges may represent setal ridges. Very fine longitudinal markings of unknown origin, best seen in the lateral and dorsal views (Pl. 6, figs. 2, 3), cover the surface of the endosiphuncle.

The apex of the endosiphuncle (Pl. 6, fig. 5) shows a quadrate fracture pattern that apparently follows the internal blade pattern. These fractures make angles of approximately 45 degrees with respect to the sagittal plane.

The cross section (Pl. 6, fig. 6) 14 mm from the apical end of the specimen also revealed a crescent-shaped tube, dorsad of center, and remnants of two dorsolateral blades. The absence of the ventro-lateral blades could be the result of either an ontogenetic change in blade pattern or destruction during recrystallization.

DISCUSSION—Flower (in preparation) restricts the genus *Clitendoceras (= Kirkoceras)* to faintly endogastric endoceroids with slender, ventral siphuncles, circular or compressed in cross section, with endosiphuncles that show considerable variation. The endosiphotube may lie dorsad of or at the center and may be circular, depressed, or compressed; cones may be simple or extended forward dorsally; and blades show three blade patterns, which may form an ontogenetic sequence: 1) two horizontal blades; 2) three blades, with a median dorsal blade and two ventral blades; and 3) two vertical blades. Flower has also found that *Clitendoceras* is confined in age to the Demingian (zones E-F_1).

This specimen resembles *Clitendoceras* in gross aspect only. It is faintly endogastric, compressed in cross section, and, as in the type species of *Clitendoceras*, *C. saylesi* (Ulrich and Foerste, 1935), has a nearly straight ventral profile with a convex dorsum. This specimen differs in being more robust, in having a crescent-shaped tube and a quadrate blade pattern, and in occurring much higher in the section (zone J).

This specimen may be the apical end of a relatively large *Clitendoceras* or, if not, perhaps a new genus. The fine longitudinal markings are unknown on the endosiphuncles of *Clitendoceras*.

OCCURRENCE—Figured specimen, no. 1625, is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

GENUS *PHRAGMOSIPHON* Flower

TYPE SPECIES: *Phragmosiphon septiferum* Flower

Phragmosiphon Flower, 1956, p. 81.
_____ Teichert and others, 1964, p. K 170.

DESCRIPTION—The siphuncle is externally simple; cross section is compressed; dorsum and venter are equally rounded. The cone is cuneate in cross section, the venter acutely rounded, the oblique sides strongly flattened, dorso-lateral region strongly rounded, and dorsum slightly flattened. The cone terminates in a centrally located, simple tube. Cross section shows a remarkable number of blades.

DISCUSSION—The generic description is essentially that of Flower (1956) and is accepted without emendation. *Phragmosiphon* was previously known from only three specimens, all from the middle Canadian Rockdale Run Formation of Maryland.

Phragmosiphon? sp.
Pl. 19, fig. 7

DESCRIPTION—This figured specimen is a portion of a slender endosiphuncle, 100 mm long. In the plane of weathering it expands from 12 to 15 mm over the length of the specimen. The endosiphuncle appears to be subcircular in cross section and terminates in a simple, central tube. Near the tip of the speiss two slightly flattened zones appear, which are either ventrolateral or dorsolateral, and supply the only clue to the orientation of the specimen. Similar but more pronounced flattened zones are known in only one genus, *Phragmosiphon*, which also has a series of characteristic blades.

DISCUSSION—In tentatively assigning this specimen to *Phragmosiphon*, we are assuming that the absence of blades is the result of calcitic replacement in which advanced recrystallization has destroyed the blade pattern. Also, this specimen is materially younger than the previously known specimens of *Phragmosiphon*.

OCCURRENCE—Figured specimen, no. 1730, is from high in zone K, Wahwah Limestone, section J, Ibex area, Utah.

Family MANCHUROCERATIDAE

GENUS *MANCHUROCERAS* Ozaki
(= GRA BA UOCERAS, LIAOTUNGOCERAS Shimizu and Obata)

TYPE SPECIES: *Piloceras wolungense* Kobayashi

Manchuroceras Ozaki, 1927, p. 45.
_____ Kobayashi, 1935, p. 736.
Grabauoceras Shimizu and Obata, 1936a, p. 18.
Liaotungoceras Shimizu and Obata, 1936a, p. 19.
Grabauoceras Shimizu and Obata, I936b, p. 101.
Manchuroceras Obata, 1939, p. 96-97.
_____ Ulrich, Foerste, and Miller, 1943, p. 18.
Liaotungoceras Ulrich, Foerste, and Miller, 1943, p. 49.
Manchuroceras Teichert, 1947, p. 424-425.
_____ Flower, 1955a, p. 367.
_____ Ruzhentsev and others, 1962, p. 310.
_____ Teichert and others, 1964, p. K 179.

DESCRIPTION—The genus *Manchuroceras* contains medium sized, straight to endogastric brevicones. Siphuncles are large, subcircular to depressed in cross section, and often ventrally flattened. Septal necks are probably holochoanitic; septa are oblique to the axis of the siphuncle, ascending from dorsum to venter. Endo-cone is dorsad of center. Endosiphuncular wedge on the ventral side of the endocone results in a crescent-shaped cross section.

DISCUSSION—The generic description given above is essentially that of Kobayashi (1935) and is accepted without emendation. The genus *Manchuroceras* was previously known only from Manchuria and Australia and questionably from Argentina and Siberia.

Manchuroceras lemonei, n. sp.
Pl. 6, figs. 7-13

DESCRIPTION—*Manchuroceras lemonei* is known from a single, silicified endosiphuncle approximately 38 mm long. Its apical end was not preserved and a small portion of its oral end was destroyed in preparation.

The endosiphuncle initially expands very rapidly, vertically at an angle of 42 degrees and horizontally at 49 degrees. This expansion abruptly decreases after a length of 13 mm to approximately 12 degrees vertically and horizontally. Apically, the natural, weathered cross section (Pl. 6, fig. 13) is circular, 7 mm in diameter. Twenty-seven millimeters farther orad, the siphuncle is depressed in cross section and has a height of 18.2 mm and a width of 20.1 mm.

The surface of the endosiphuncle is covered with thirteen septal ridges that slope apicad from the venter, making an acute angle of 44 degrees with respect to the ventral profile (Pl. 6, fig. 8). Dorsally, these ridges form broad, shallow lobes; midventrally, the ridges split, forming chevron-shaped, flattened areas on the venter. Presumably, these flattened areas where in intimate contact with the conch.

The endosiphocone (P1. 6, fig. 12) is also depressed in cross section, is concave dorsally, and terminates dorsad of center, approximately 12 mm from the apical end of the specimen. Twenty-three millimeters from the apical end of the specimen the endosiphocone has a height of 9 mm and a width of 12 mm. Here, the dorsal wall of the endosiphuncle is 1.3 mm thick; the lateral wall, 3.2 mm; and the ventral wall, 7.3 mm. This pronounced ventral thickening is caused by a single, round, midventral ridge that tapers apically from 6 to 4 mm and makes the endocone concave ventrally.

The opposing cross sections (Pl. 6, figs. 10, 11) 13 mm from the apical end of the specimen proved to be unrewarding. Here, the endosiphuncle is only slightly depressed in section with a height of 16.0 mm and a width of 16.2 mm. Recrystallization is advanced and has obliterated structures in the ventral two-thirds of the specimen. The ventral one-third shows only the sheaths of concentric endocones.

DISCUSSION—The genus *Manchuroceras* was first described by Ozaki (1927) and was based on an endosiphuncle from the Wolungian limestone (upper Canadian) of Manchuria. Since then, nine species of *Manchuroceras* have been described from China (Obata, 1939 and Chang, 1965) and two from Tasmania (Teichert, 1947). Balashov's (1961) *Manchuroceras asiaticum* is a puzzling, slender form that is almost assuredly a new genus. Harrington and Leanza (1957) list one unfigured and undescribed specimen as *Liao-tungoceras* sp. among the Arenigian faunas of Argentina. Hill, Playford and Woods (1969) illustrate two specimens that they attribute to *Manchuroceras adnatum* (Flower); their assignment involves some misunderstanding, and the genus in question is *Wil-liamsoceras*, not *Manchuroceras.*

Manchuroceras lemonei marks the first reported occurrence of the genus in North America..The holotype differs in general from the described Asiatic species in being much smaller, more breviconic, and broader in cross section. Also, its septa slope apicad from the venter at a steeper angle. *M. lemonei* differs from the Tasmanian species in having a blunter apex and in having its septa slope apicad at a steeper angle.

TYPE AND OCCURRENCE—Holotype, no. 1624, is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Family ENDOCERATIDAE

New genus, new species
P1. 19, figs. 1, 2; Fig. 11

DESCRIPTION—This unnamed new genus is represented by four fragments from a single individual totaling approximately 75 mm in length. The conch was almost completely destroyed before burial, although fragments of shell still adher to portions of the siphuncle.

The siphuncle is slightly depressed in cross section and expands from a height of 12.0 mm and a width of 12.5 mm to a height of 12.5 mm and a width of 13.0 mm over the 22 mm of length of thin section (Pl. 19, fig. 1). The siphuncle is in flattened contact with the venter (Pl. 19, fig. 2) and has simple endocones.

The vertical thin section (Pl. 19, fig. 1) through the apical 22 mm of the specimen shows macrochoanitic septal necks, one and one-quarter camerae long. Connecting rings are thin and form a lining on the internal surface of the necks. The endocones have a straight ventral margin and an undulating dorsal margin. Septa are not preserved.

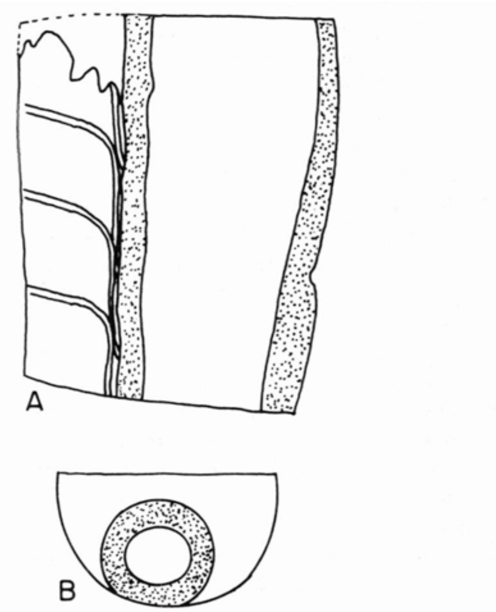

FIGURE 11—ENDOCERATIDAE, UNNAMED NEW GENUS. A) Vertical thin section through apical 22 mm of specimen, venter on right, X3.6. B) Cross section at apical end of A, venter down, X1.8. Endocones are stippled.

DISCUSSION—This is the first macrochoanitic endoceroid found below the Whiterock in the Pogonip Group and is undoubtedly a new genus. Flower (in preparation) has only two other Canadian endoceroid genera with macrochoanitic necks. Both are from the First Piloceroid zone of the El Paso Group and neither is congeneric with this specimen.

OCCURRENCE—Figured specimen, no. 1729, is from high in zone K, Wahwah Limestone, Ibex area, Utah.

Order TARPHYCERATIDA

Family, genus, and species indeterminate
Pl. 6, fig. 28

DESCRIPTION—This specimen is a poorly preserved, internal mold of a tarphycone with maximum diameter of 36 mm. Little more than half of the outer whorl remains, of which two-thirds is living chamber, the remainder divided into six shallow camerae, no more than 2 mm long. Cross sections revealed that most of the chambered part of the shell, including the siphuncle, is gone. However, the living chamber is almost completely intact. The adoral end of the living chamber is compressed in cross section and has a height of 12 mm, a width of 10 mm, and a shallow impressed zone, 1.5 mm high and 3 mm wide.

DISCUSSION—Flower (1968b) noted that only fragments of coiled cephalopods have ever been found in the Florida Mountains Formation. This specimen is the best of those fragments, but is so incomplete that it cannot be placed with certainty in either the Tarphyceratidae or the Trocholitidae.

OCCURRENCE—Figured specimen, no. 1636, is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Order MICHELINOCERATIDA = ORTHOCERATIDA)

Family MICHELINOCERATIDAE

GENUS *MICHELINOCERAS* Foerste TYPE SPECIES: *Orthoceras michelini* Barrande

Michelinoceras Foerste, 1932, p. 72.
_____ Basse, 1952, p. 492.
_____ Ruzhentsev and others, 1962, p. 107.
_____ Flower, 1962, p. 10, I I.
_____ Teichert and others, 1964, p. K225.
_____ Flower, 1968a, p.41.

DESCRIPTION—The genus *Michelinoceras* is used here for smooth, circular orthocones with small central or subcentral tubular siphuncles. Siphuncle segments are cylindrical or slightly expanded into the camerae and are composed of short straight necks and thin, homogeneous connecting rings. Cameral deposits are well developed and precede annuli in growth. In advanced growth stages, annuli may fuse forming a continuous lining within the siphuncle. Sutures are straight and transverse.

DISCUSSION—For the purposes of this report, the genus *Michelinoceras* has been broadly defined and includes species that should properly be assigned to other genera, notably *Geisonoceras*. However, the specimens studied are fragmentary and most have undergone complex histories of diagenesis, making interpretation difficult. Extensive taxonomic revision and proposal of new generic names are postponed until the Michelinoceratida of the Late Canadian are better known. For the present the importance of these specimens lies in their morphological variation, rather than in their proper generic assignment.

Michelinoceras floridaense, n. sp.
Pl. 8, figs. 1-8

DESCRIPTION—Michelinoceras floridaense is known from a single specimen, a smooth orthocone, 47 mm long, with straight, transverse sutures. The shell (Pl. 8, fig. 1) is circular in cross section and increases in diameter from approximately 5 mm apically to 8 mm orad. The siphuncle is small, circular, and slightly eccentric. A vertical thin section (Pl. 8, fig. 5) through the anterior 38 mm of the specimen shows the siphuncle increasing in diameter from 1.0 to 1.5 mm. Apically, the siphuncle is 2 mm from the venter and 2.5 mm from the dorsum; orally, it is 3 mm from the venter and 3.5 mm from the dorsum.

Siphuncle segments are essentially tubular—although there is a slight dorsal expansion of the rings into the camerae—and longer than wide. Curvature of the septa is moderate, equal to slightly more than half the length of a siphuncle segment. Apically, three camerae occupy a length equal to the adoral conch diameter; adorally, this figure has increased to three and one-half.

Cameral deposits are well developed over the entire length of the thin section (Pl. 8, figs. 5, 6). On the dorsal side of the siphuncle they are L-shaped and can be differentiated into episeptal and mural deposits. Ventrally, the deposits are thicker, almost completely filling the siphuncle, and in part may be supplemented by inorganic calcite.

Septal necks are short and straight; rings are thin and homogeneous. Annuli are developed within the siphuncle along the ventral siphuncle wall. These deposits originated in the vicinity of the septal necks (Pl. 8, fig. 8), grew forward, and, apically, have fused, forming a continuous lining on the ventral side of the siphuncle. Cameral deposits clearly precede annuli in growth.

DISCUSSION—The long, slender, ventrally concentrated annuli are the most distinctive feature separating *M. floridaense* from the other species of *Michelinoceras* described in this report. The distribution of annuli in the anterior end of the vertical thin section (Pl. 8, figs. 7, 8) indicates that the annular growth pattern of *M. floridaense* may also be distinctive. Apparently, a new annulus did not begin to grow until the preceding annulus had grown to approximately half the length of the intervening siphuncle segment.

TYPE AND OCCURPENCE—Holotype, no. 1635, is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

Michelinoceras melleni, n. sp.
P1. 9, figs. 2-9

DESCRIPTION—Michelinoceras melleni is a smooth orthocone, initially circular, later becoming compressed, in cross section. The siphuncle is small, circular, and central. Siphuncle segments are convex and composed of short necks and thin, homogeneous rings. Episeptal and mural cameral deposits are well developed. Siphonal annuli, which fuse ventrally, may also be developed. Sutures are straight and transverse.

The holotype and only known specimen of *M. melleni* is a portion of an orthonic phragmocone, 47 mm long. The shell is initially circular, later becoming subcircular, in cross section; the apical cross section (Pl. 9, fig. 4) is circular, 4.3 mm in diameter; the anterior cross section (Pl. 9, fig. 2) is subcircular, apparently compressed in section and has a height of 6 mm and a width of 5.5 mm. Two vertical thin sections (Pl. 9, figs. 5, 6), encompassing the entire length of the specimen, were cut under the assumption that the conch was compressed in cross section anteriorly. The distribution of cameral deposits within the thin section confirms that this orientation is correct.

These two thin sections revealed twenty-four camerae that maintain an almost constant growth rate of two and one-half camerae per adoral diameter. Curvature of septa is slight, equal to less than one-third the length of a camera.

Siphuncle segments are slightly convex, with rings expanded into the camerae, and are longer than wide. The segments are constricted at the foramina and are fusiform in longitudinal section. Maximum diameter of the segments occurs about midlength in each segment and increases from 0.8 mm in the most apical camera to 1.4 mm in the most orad camera.

Cameral deposits are found throughout the length of the specimen, indicating an advanced growth stage. Ventrally, they completely fill the camerae. Dorsally, lobate, L-shaped episeptal and mural cameral deposits fill progressively less and less of the adoral camerae. Hyposeptal deposits are not evident.

The siphuncle wall is composed of very short necks and thin, homogeneous connecting rings. Calcite within the siphuncle is difficult to interpret because of recrystallization and solution. However, the calcite within the four most apical siphuncle segments (Pl. 9, fig. 9) is interpreted as organic because of its sharp, symmetrical boundaries and its position against the siphuncle walls. This organic calcite consists of two distinct types of deposits: 1) a lining on the ventral side of the siphuncle and 2) annuli on the dorsal side. The annuli are long and slender and resemble those of *M. floridaense.* Orad of these four siphuncle segments there is some offset along a joint and interpretation of calcite as organic cannot be made with any degree of certainty.

DISCUSSION—Siphonal structures are difficult to interpret in this specimen; if the apical calcite has been correctly interpreted as organic, it is nonetheless anomalous in being thickest near the center of the siphuncle segment and thinnest near the necks. *M. melleni* differs from the other michelinoceroids described in this report in having completely expanded siphuncle segments. Flower's (1962) *Michelinoceras buttsi* differs in having hyposeptal deposits and subcircular annuli concentrated at the foramina on both sides of the siphuncle.

TYPE AND OCCURRENCE—Holotype, no. 1637, is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

Michelinoceras spp.

Pl. 4, figs. 4-8; Pl. 11, figs. 6-8;
Pl. 17, figs. 1-13; Pl. 19, figs. 4-6

DESCRIPTION—Nine specifically unnamed michelinoceroids are figured and briefly described under this designation. The specimens are fragmentary portions of orthoconic phragmocones that are illustrated to show the morphologic diversity that the michelinoceroids had attained by late Canadian time.

Figured specimen, no. 1616 (Pl. 11, figs. 6-8): This specimen is a tiny fragment of an internal mold of a phragmocone, 9.5 mm long. Both conch and siphuncle are circular in cross section (Pl. 11, figs. 6, 7) and respectively increase in diameter from 5.7 mm and 1.3 mm to 6.0 mm and 1.4 mm over the length of the specimen. The siphuncle is subcentral and provided the orientation for the vertical thin section (Pl. 11, fig. 8). The thin section revealed portions of five camerae, spaced two and one-half per adoral diameter. Calcite within the camerae is ambiguous, but is interpreted as organic because vestiges of mural and episeptal deposits are evident in the third camera from the apical end. Siphuncle segments are fusiform, about twice as long as wide, and slightly expanded into the camerae. Septal necks are short and straight; rings are thin and homogeneous. A thin lining, thickest just orad of the septal necks is developed against the ventral wall of the siphuncle. This specimen is from the Florida Mountains Formation, south of Deming, New Mexico.

Figured specimen, no. 1656 (Pl. 4, figs. 4-8): This specimen is a portion of a phragmocone, 125 mm long. Sutures are straight and transverse. Cross sections (Pl. 4, figs. 4, 6, 8) were made 4 mm, 55 mm and 100 mm from the apical end of the specimen. These cross sections are all somewhat distorted but show that the shell had a circular, subcentral siphuncle. A vertical opaque section (Pl. 4, fig. 5) extending from 5 mm to 100 mm from the apical end of the specimen shows extensive recrystallization. However, with the exception of cameral deposits, essential features of internal morphology can be distinguished. Septal necks are short and slightly cyrtochoanitic; rings, thin and homogeneous. Siphuncle segments are longer than wide and expand into the camerae ventrally and are straight dorsally. A thin, ventral siphonal lining extends the full length of the section; siphonal deposits are not evident dorsally. Septa have moderate curvature, equal to approximately half the length of a siphuncle segment. This specimen is from the orange-weathering silts in the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Figured specimen, no. 1678 (**Pl.** 19, figs. 4-6): This specimen is a portion of a phragmocone, 38 mm long. Sutures (Pl. 19, fig. 4) are straight and transverse. The conch is circular in cross section (Pl. 19, fig. 5) and increases in diameter from 4.8 to 6.0 mm over the anterior 16 mm of the specimen. The siphuncle is subcentral and circular, increasing from 1.1 to 1.3 mm in diameter over the same length. The vertical thin section (Pl. 19, fig. 6) through the anterior 16 mm of the specimen revealed seven camerae, spaced approximately two and one-half per adoral diameter. Episeptal and mural cameral deposits are well developed on both sides of the siphuncle; and small, spur-like hyposeptal deposits are developed only on the two most anterior septa. Necks are short and straight. Rings are gone, but apparently outlined tubular siphuncle segments that are two times longer than wide. A vertical thin section was attempted through the apical 20 mm of the specimen but was off-center and is not illustrated. This section did, however, reveal small, ventral, subcircular annuli on the three most apical septal necks. This specimen is from the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1699 (Pl. 17, figs. 1, 2): This species is known from a naturally weathered, longitudinal section through 18 mm of an orthocone. The most striking features of the resulting thin section (Pl. 17, fig. 1) are the expanded siphuncle segments composed of cyrtoconic necks and thin, homogeneous necks and the complete siphonal lining. Episeptal and mural cameral deposits are developed, but are difficult to distinguish orally because of advanced replacement and recrystallization. The proper orientation of the specimen is unknown, but the right side of the thin section is believed to be more ventral than the left on the basis of cameral deposits and thickness of the lining. This specimen is from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1702 (Pl. 17, figs. 4-6): This specimen is a portion of a phragmocone, 16 mm long. Sutures are straight and transverse. The conch is circular (Pl. 17, fig. 6) and increases in diameter from 7.0 to 7.8 mm over the length of the specimen. Both episeptal and mural deposits are developed on both sides of the siphuncle (Pl. 17, fig. 5). Small, ventral, lenticular annuli are developed against the four most apical septal necks. Siphuncle segments are tubular, about one and one-half times longer than wide. Necks are short and straight; rings are thin and homogeneous. Curvature of septa is equal to half the length of a siphuncle segment. Three camerae are found in a length equal to the adoral conch diameter. This specimen is from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1703 (Pl. 17, figs. 8-10): This specimen is a portion of a phragmocone 23 mm long. The shell is circular in cross section and has a diameter of 5.5 mm at the anterior end of the specimen (Pl. 17, fig. 9). The siphuncle is also circular, 1.5 mm across anteriorly, and subcentral. Siphuncle segments (Pl. 17, fig. 8) are straight ventrally and convex dorsally. Septal necks are correspondingly orthochoanitic ventrally and cyrtochoanitic dorsally. Connecting rings are thin and homogeneous. Annuli are confined to the ventral side of the siphuncle and are found in all siphuncle segments. Orally, the annuli are small and lenticular; apically, they are bulbous and have fused, forming a ventral lining within the siphuncle. Cameral deposits may be developed, but cannot be conclusively demonstrated from this thin section. This specimen is from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1720 (Pl. 17, figs. 11-13): This specimen is also a portion of phragmocone, 48 mm long. The shell wall was partially destroyed before burial so that the shape of the cross section is unknown. The siphuncle is circular, 3 mm across at the anterior end of the specimen (Pl. 17, fig. 11), subcentral, and composed of tubular segments that are slightly constricted at the foramina. Septal necks are short and straight; rings are thin and homogeneous. Annuli are developed on both sides of the siphuncle; ventrally, they are bulbous and have fused in an irregular manner, forming a discontinuous ventral lining; dorsally, they are lenticular or subcircular and confined to the region of the necks. Septa are almost straight and have a slight apicad inclination between shell wall and siphuncle. Cameral deposits are difficult to interpret, but apparently are composed of thin episeptal and mural deposits complimented by small hyposeptal deposits close to the siphuncle. This specimen is from the Wahwah Limestone, zone K, section J, Ibex area, Utah.

Figured specimen, no. 1727 (Pl. 17, fig. 7) and no. 1728 (P1. 17, fig. 3): These two specimens were originally thought to represent different species. Closer examination, based on the type, shape, and distribution of cameral deposits and the shape of siphuncle segments, indicated that the two were conspecific. A final examination, based on preservation, growth stage, and size, leads inescapably to the conclusion that these two specimens are from the same individual, separated from one another by no more than two camerae.

Both shell and siphuncle are circular in cross section; the siphuncle is central. Sutures are straight and transverse. Siphuncle segments are two times longer than wide and are straight ventrally and slightly expanded dorsally. There is a slight constriction of the siphuncle segments at the foramina that is more pronounced on the dorsal side. Necks are orthochoanitic ventrally and slightly cyrtochoanitic dorsally. Siphonal deposits completely fill the siphuncle apically (Pl. 17, fig. 7) and can be divided into a ventral lining and dorsal annuli, orad (Pl. 17, fig. 3). The ventral lining is thickest dorsad of the necks, while the dorsal annuli are elongate bodies that grow forward and thin from the necks. Well defined episeptal and mural deposits are developed between siphuncle and dorsum. The irregular calcite that almost completely fills the ventral camerae and apparently swings around the siphuncle and is visible near the dorsal wall side of the siphuncle is interpreted as organic cameral deposits similar to those found in *Pseudorthoceras* (Flower, 1955b). This species may be congeneric with *Wardoceras,* n. gen. These specimens are from the Wahwah Limestone, section J, Ibex area, Utah.

DISCUSSION—As indicated in the introduction, these specimens are figured primarily to show the morphologic variation that the michelinoceroids had already attained by late Canadian time. Many of the specimens represent new species, some even new genera. However, taxonomic revision cannot and should not be undertaken until the michelinoceroids of the Canadian and Whiterock are better known.

OCCURRENCES—TWO of the figured specimens are from the Florida Mountains Formation, one from each of the two localities. The remaining seven figured specimens are from the Wahwah Limestone of western Utah.

GENUS *WARDOCERAS*, n. gen.

TYPE SPECIES: *Wardoceras orygoforme*, n. sp.
Fig. 12

DESCRIPTION—The genus *Wardoceras* is erected for smooth orthocones with small, circular, subcentral siphuncles. Siphuncle segments are straight ventrally, scarcely contracted at the septal necks, and slightly expanded dorsally. Siphonal deposits form a continuous lining on both sides of the siphuncle that, apically, fails to thicken materially; the lining does, however, thicken slightly over and just orad of the septal necks, suggesting an origin in annular deposits. Cameral deposits are well developed and consist of episeptal, hyposeptal, and mural deposits. Ventrally, episeptal deposits are thin; mural deposits are massive, lobate, and completely fill the apical camerae; hyposeptal deposits are present only apically where they form bosses midway between siphuncle and venter. Dorsally, episeptal deposits thicken abruptly halfway between siphuncle and dorsum and continue against the mural part of the septum; hyposeptal deposits are present only apically and appear as spurs one-third of the way to the dorsum. Septal necks are short and straight; connecting rings are thin and homogeneous. Sutures are straight and transverse.

DISCUSSION—As presently conceived, the most diagnostic features of *Wardoceras* are its unusual cameral deposits, which in better preserved material may show patterns similar to those of *Pseudorthoceras* (Fig. 12D), and its siphonal lining that, apically, fails to thicken materially. Assignment of *Wardoceras* to the Michelinoceratidae, rather than the Troedssonellidae, is based on the rhythmical thinning and thickening of the lining (which suggests an origin in annular deposits), its small siphuncle, and greater relative importance of cameral deposits in regulating buoyancy.

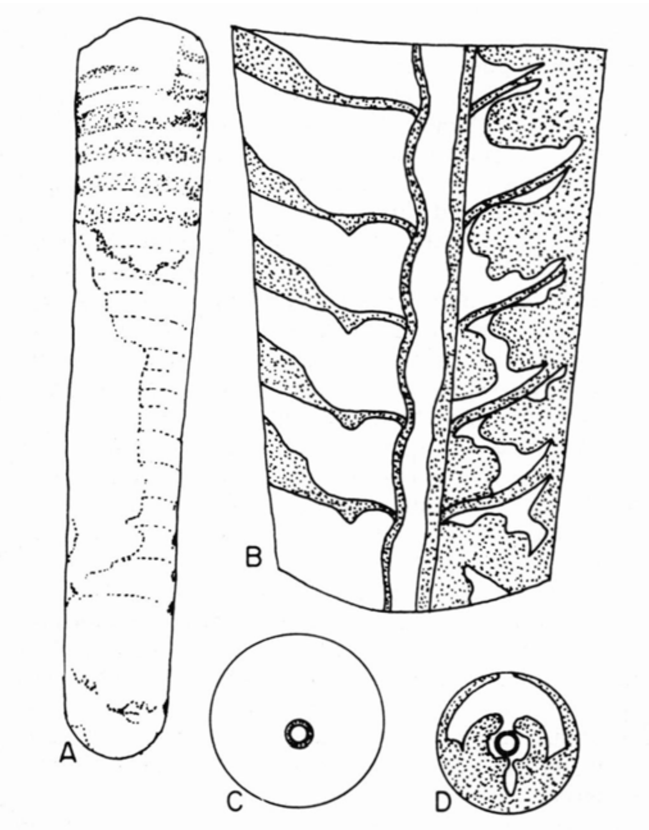

FIGURE 12—*Wardoceras*, N. GEN. A) Ventral view of type species, X0.9. B) Vertical thin section of type species, venter on right, X3.6. C) Cross section near anterior end of A, venter down, X1.8. D) Interpreted cross section, venter down, with *Pseudorthoceras*-like cameral deposits. Cameral and siphonal deposits are stippled.

DERIVATION OF NAME— *Wardoceras* is named for Jane Shaw Ward, author of the Tajar stories.

Wardoceras orygoforme, n. sp.

Pl. 20, figs. 1-7

DESCRIPTION— *Wardoceras orygoforme* is known from a single specimen, a portion of a phragmocone, 97 mm long. The exterior of the shell (Pl. 20, figs. 1, 2) is smooth, but differential weathering has left cameral deposits standing in relief on the internal mold, giving the appearance of annuli.

The shell is essentially circular in cross section and has a small (0.22 of shell diameter), circular, subcentral siphuncle. The cross section (Pl. 20, fig. 3) 5 mm from the anterior end of the specimen has a diameter of 13.5 mm. Here, the siphuncle is 3.0 mm in diameter and 4.5 mm from the venter. A thin lining of crystalline calcite completely encircles the inside of the siphuncle.

Three vertical thin sections (Pl. 20, figs. 4, 5) were made through the apical 80 mm of the specimen. A thin siphonal lining, thicker ventrally, is developed throughout the length of the thin sections. Surprisingly, the lining, which thins regularly over the apical 45 mm of the specimen, is thickest over the anterior 35 mm of the thin sections. The lining also thickens and thins rhythmically and is thickest just orad of the septal necks, suggesting an origin in annular deposits.

Cameral deposits are well developed throughout the length of the thin sections. Ventrally, calcite of cameral deposits almost completely fills the apical camerae; adorally, this calcite can be differentiated into thin episeptal deposits, massive *Pseudorthoceras-like* mural deposits and bosses of hyposeptal deposits midway between siphuncle and venter. Dorsally, thin episeptal and mural deposits are augmented by small, spurlike hyposeptal deposits.

Siphuncle segments are gently fusiform and longer than wide. Ventrally, the segments are almost straight; dorsally, they are more noticeably expanded into the camerae. Septal necks are short and straight and slightly longer on the ventral side of the siphuncle. Connecting rings are thin and homogeneous. Curvature of septa is equal to approximately three-fourths the length of a siphuncle segment. Apically, three and one-half camerae are found in a length equal to the adoral shell diameter; adorally, this figure has decreased to three. Sutures are straight and transverse.

DISCUSSION— *Wardoceras orygoforme* is named for Ruedemann's (1906) genus *Orygoceras*, which was originally set apart as an orthoconic genus that was smooth externally and annulated internally.

TYPE AND OCCURRENCE—Holotype, no. 1517, is from 85 ft (25.9 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Family TROEDSSONELLIDAE GENUS

BUTTSOCERAS Ulrich and Foerste TYPE

SPECIES: *Orthoceras? adamsi* Butts

Buttsoceras Ulrich and Foerste, 1933, p. 288.
_____ Ulrich and Foerste, 1935, p. 265.
_____ Ulrich and others, 1944, p. 63.
_____ Miller. 1943, p. 102.
_____ Flower and Kummel, 1950, p. 608.
_____ Flower and Teichert, 1957, p. 34.
_____ Flower, 1962, p. 3-4.
_____ Ruzhentsev and others, 1962, p. 95.
_____ Teichert and others, 1964, p. K235.
_____ Flower, 1962, p. 143.

DESCRIPTION—The genus *Buttsoceras* contains slender orthocones, circular or subcircular in cross section, with large subcentral siphuncles. Siphuncle segments are tubular and composed of short, straight necks and thin, homogeneous connecting rings. A lamellar lining within the siphuncle thickens apically and either fills the siphuncle completely or leaves a narrow cavity dorsad of center that may be crossed by diaphragms. Both hyposeptal and episeptal cameral deposits are known to develop.

DISCUSSION—*Buttsoceras* is a genus particularly characteristic of the closing phases of the Cassinian. It is a good index fossil for the late Canadian because it is abundant, widespread, generally large, and easily recognized.

There has been considerable debate in the literature (Flower, 1962; Teichert, 1967) over the proper systematic position of *Buttsoceras* and the Troedssonellidae. The evidence provided by this study and presented in detail elsewhere (Hook and Flower, 1976) indicates that *Buttsoceras* and the Troedssonellidae are true members of the Order Michelinoceratida. The genus *Tajaroceras* provides the transition, linking *Buttsoceras* to the rod-bearing Baltoceratidae on the one hand and to the Michelinoceratida on the other.

?Buttsoceras adamsi (Butts)

Pl. 6, figs. 22-27; Pl. 10, figs. 7, 8

Orthoceras? adamsi Butts, 1926, p. 99, 100, pl. 22, figs. 22, 23. *Buttsoceras adamsi* Ulrich and Foerste, 1933, p. 288.
_____ Ulrich and Foerste, 1935, p. 265.
_____ Miller, 1943, p. 102.
_____ Ulrich and others, 1944, p. 63; pl. 24, figs. 1-4, 6-11.
_____ Flower, 1962, p. 7; pl. 3, figs. I, 2, 5-17.

DESCRIPTION—Three etched, silicified orthocones from the Florida Mountains Formation are figured and briefly described. Although differing in general proportions, they all possess straight transverse sutures, circular cross sections, and small central or slightly eccentric siphuncles. A vertical thin section (Pl. 10, figs. 7, 8) was made through one of the specimens but is ambiguous and inconclusive because of advanced replacement.

Figured specimen, no. 1630 (Pl. 6, figs. 26, 27): This specimen is a portion of a phragmocone, 29 mm long. The shell is circular in cross section and increases in diameter from 7.0 mm to 9.5 mm over the length of the specimen. Sutures are straight and transverse. The siphuncle is central and subcircular, measuring 1.5 X 1.0 mm at the anterior end of the specimen. Two and one half camerae occupy a length equal to the adoral shell diameter.

Figured specimen, no. 1631 (Pl. 6, figs. 22, 23): This specimen is a portion of a slender phragmocone, 28 mm long. Sutures are straight and transverse. The shell is circular in cross section and expands from 4.5 to 6.5 mm in diameter over the length of the specimen. The siphuncle is small, circular, and central. Two camerae occupy a length equal to the adoral shell diameter.

Figured specimen, no. 1634 (Pl. 6, figs. 24, 25; Pl. 10, figs. 7, 8): This specimen is a portion of a slightly crushed phragmocone, 29 mm long. Sutures are straight and transverse. The shell is apparently circular in cross section and expands from 7 to 8 mm in diameter over the length of the specimen. The siphuncle is small, circular, and subcentral. A vertical thin section (Pl. 10, figs. 7, 8) was made through the anterior 22 mm of the specimen. Advanced replacement made interpretation of internal structures almost impossible. However, septal necks are distinct and are orthochoanitic. Curvature of septa is equal to approximately half the length of a siphuncle segment. Cameral deposits cannot be distinguished and siphonal structures are ambiguous. Two and one-half camerae occupy a length equal to the adoral shell diameter.

DISCUSSION—These three specimens are questionably placed in *Buttsoceras adamsi* because at present there is no other defined taxon for *Buttsoceras-like* orthocones with small siphuncles. *B. adamsi* is a too broadly defined species, especially in light of the diversity that the michelinoceroids had already attained by late Canadian time. However, these three specimens are too fragmentary for proper distinction of species and preservation is so poor that in the one sectioned specimen organic calcite cannot be differentiated from inorganic calcite.

OCCURRENCE—All three specimens are from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Buttsoceras novemexicanum Flower

Pl. 6, figs. 14-16; Pl. 7, figs. 1-5; Pl. 9, fig. 1;
Pl. 10, figs. 1-4; Pl. 11, figs. 9-11

Buttsoceras novemexicanum Flower, 1962, p. 5-7; pl. I, figs. 1-12; pl. 2, fig. 9: pl. 3, fig. 21.

DESCRIPTION—The SIX specimens briefly described herein supplement Flower's (1962) description of *B. novemexicanum* and extend its known geographic range from western New Mexico to west Texas.

Figured specimen, no. 1617 (Pl. 10, fig. 2): This specimen is a portion of a phragmocone, 35 mm long. Both conch and siphuncle are circular in cross section. The siphuncle is large (approximately 0.38 of the adoral shell diameter) and subcentral. At the anterior end of the specimen the siphuncle has a diameter of 6 mm and is 4.7 mm from the venter, while the conch has a diameter estimated at 16 mm. The vertical thin section (Pl. 10, fig. 2) through the entire specimen shows the siphonal lining to extend unusually far forward on the venter and to be absent on the dorsum. Cameral deposits are well developed, consist of episeptal, mural and hyposeptal deposits, and apparently extend beyond the terminus of the lining. Hyposeptal deposits are small, triangular bodies that are developed on both sides of the siphuncle. Siphuncle segments are square, with length and width almost equal in each segment. Necks are short and straight; rings are thin and homogeneous. Curvature of septa is equal to slightly less than half the length of a siphuncle segment. Three and one-half camerae are found in a length equal to the adoral shell diameter. This specimen is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Figured specimen, no. 1618 (Pl. 10, figs. 3, 4): This specimen is a portion of a dorsally weathered phragmocone, now two vertical thin sections, 73 mm long. The siphuncle is large, circular, and apparently subcentral. The lining in the siphuncle (P1. 10, fig. 3) again extends far forward on the ventral side, although cameral deposits precede it in growth. Episeptal, mural, and hyposeptal cameral deposits are well developed on both sides of the siphuncle and are similar in shape and distribution to those of the previous specimen. Advanced solution and recrystallization have obscured structure in the apical thin section (P1. 10, fig. 4), but a small dorsal cavity is apparent in the siphonal lining in the two most apical siphuncle segments. This cavity is similar to that developed in *Tajaroceras wardae* (Pl. 21, fig. 13). Necks are short and straight; rings are thin and homogeneous. Siphuncle segments are wider than long. Curvature of septa is equal to approximately half the length of a siphuncle segment. Three and one-half camerae occupy a length equal to the adoral shell diameter. This specimen is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Figured specimen, no. 1619 (Pl. 10, fig. 1): This specimen is a tiny fragment of a phragmocone, 16 mm long. Two internal features shown in vertical thin section are anomalous: first, the siphuncle is completely filled by siphonal deposits at a growth stage in which cameral deposits are still quite thin; second, siphuncle segments, instead of being tubular, are straight ventrally and expanded dorsally. Also, camerae are farther apart; two and one-half occupy a length equal to the adoral shell diameter. This specimen is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Figured specimen, no. 1626 (Pl. 9, fig. I; Pl. 11, figs. 9-11): This specimen, a portion of a phragmocone, 185 mm long, is the largest cephalopod known from the Florida Mountains Formation and is the second largest orthocone in the study collections. Two vertical thin sections were cut through the anterior 42 mm of the specimen. The cross section (Pl. 11, fig. 9) at the apical end of the thin sections shows thin calcite completely lining the inside of the siphuncle and thickening ventrally into a rodlike structure, which is texturally different from that of the lining. Thirty-two millimeters farther orad (Pl. 11, fig. 10) both "rod" and lining have thinned considerably, and the "rod" has become a thin, finger-like projection. In vertical thin section (P1. 11, fig. 11) there is also a textural difference between "rod" and lining, but this difference is only apparent in the apical 20 mm of the thin section and may, therefore, be adventitious. The dorsal profile of the "rod" is a smooth curve that terminates against the most oral septal neck of the specimen. The dorsal lining has an undulating surface, is thickest just ventrad of the septal necks, and terminates approximately two camerae behind the "rod." Ventral septa are largely destroyed, but those on the dorsal side of the siphuncle are slightly thickened by episeptal cameral deposits. Siphuncle segments are tubular, wider than long, and composed of short, straight necks and thin rings. Curvature of septa is equal to approximately half the length of a siphuncle segment. Three and one-half camerae are found in a length equal to the adoral shell diameter. This specimen is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Figured specimen, no. 1627 (Pl. 6, figs. 14-16): This specimen is a portion of an etched, silicified phragmocone, 40 mm long. The specimen (Pl. 6, figs. 14, 15) has weathered from the dorsal side exposing eight septa and the siphuncle. Septa are thickened by episeptal cameral deposits. The cross section (Pl. 6, fig. 16) at the anterior end of the specimen shows a large, circular siphuncle, 6 mm in diameter. The shell is probably also circular and has a horizontal diameter of 15 mm. Both siphonal lining and cameral deposits are evident in the cross section. Throughout the length of the specimen three camerae are found in a length equal to the adoral shell diameter. This specimen is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Figured specimen, no. 1633 (P1. 7, figs. 1-5): This specimen, a portion of a phragmocone, 23 mm long, is questionably assigned to *B. novemexicanum*. The specimen is anomalous in many respects, and preservation makes interpretation of internal structures impossible.

The shell is essentially circular in cross section and expands from a diameter of 5.4 mm to 7.0 mm over the length of the specimen. The siphuncle is large (although not as large proportionately as in previous specimens), compressed in cross section, and eccentric. Apically, the siphuncle has a height of 1.8 mm, a width of approximately 1.5 mm, and is 1.6 mm from the venter; adorally, these figures have increased to 2.4 mm, 2.0 mm, and 2.6 mm, respectively. Necks are short and straight; rings are thin and homogeneous. Siphuncle segments are tubular and longer than wide. Curvature of septa is equal to less than half the length of a siphuncle segment. Apically, two and one-half camerae occupy a length equal to the adoral shell diameter; adorally, the camerae are closer, with three camerae occupying a similar diameter.

Polygonal bodies of calcite within the siphuncle (Pl. 7, fig. 4) were originally thought to be organic structures, similar to those of *Bajkaloceras* (Balashov, 1961). However, they proved to be a preservation phenomenon. As grinding of the longitudinal section progressed (Pl. 7, fig. 1), these polygonal bodies disappeared, and no vestige of their structure can be seen in the thin section (Pl. 7, figs. 2, 5).

Extensive replacement, solution, and recrystallization make interpretation of siphonal structures impossible. The anterior cross section (Pl. 7, fig. 4) indicates that there is a calcitic lining within the siphuncle that leaves only a small, crescent-shaped, dorsal cavity unfilled. The thin section (P1. 7, fig. 2) shows only irregularly bounded calcite against the ventral wall of the siphuncle. This calcite may represent an organic deposit, later partially dissolved, or it may be entirely inorganic in origin. This specimen is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

DISCUSSION—These six specimens, although varying in proportions, growth stages, and preservation, share one unifying characteristic—growth of cameral deposits preceded that of the lining. Flower (1962) considered this differential growth to be the primary factor in distinguishing *B. novemexicanum* from *B. williamsi*. The material illustrated here indicates that *B. novemexicanum* may be too broadly defined. However, these six specimens are inadequate in themselves for establishment of any new species within *Buttsoceras;* this, unfortunately, will have to await a thorough study of the Odenville *Buttsoceras*.

One typographical error in the original description of *B. novemexicanum* (Flower, 1962) should be corrected: lines 5, 6, and 7 of the left hand column of page 6 should read: ". . . they tend to range closer in early stages, however, and curvature of septa is nearly equal to *half* the length of a camera."

OCCURRENCE—All six figured specimens are from the Florida Mountains Formation. Only one, no. 1633, is from the Florida Mountains section; the remaining five specimens are from the Franklin Mountains section.

Buttsoceras aff. B. novemexicanum Flower
Pl. 16, figs. 1-10

Buttsoceras novemexicanum Flower. 1962, p. 5-7; pl. I, figs. 1-12; pl. 2, fig. 9; pl. 3, fig. 21.

DESCRIPTION—Three very large specimens of *Buttsoceras* from the Wahwah Limestone are briefly described. The three are probably not all conspecific and represent at least one new species. Establishment of a new species for figured specimen, no. 1666, is withheld for the present because of poor preservation that makes interpretation of internal structures ambiguous.

Figured specimen, no. 1666 (Pl. 16, figs. 1-3, 10): This specimen, a portion of a phragmocone, 210 mm long, is the largest orthocone in the Wahwah Limestone and Florida Mountains Formation collections and is the largest *Buttsoceras* ever described.

Cross sections (P1. 16, figs. 2, 3) were cut 72 mm and 102 mm from the anterior end of the specimen through a portion of the shell in which weathering had not yet reached the siphuncle; a vertical thin section (P1. 16, fig. 10) was later made through this 30 mm of the shell. The siphuncle is large, circular, and eccentric, apparently closer to the venter than the center of the shell. Apically (Pl. 16, fig. 3), the shell is at least 16.7 mm across and the siphuncle has a diameter of 8.7 mm and is 4 mm from the venter. Anteriorly (Pl. 16, fig. 2), the shell is 22 mm across; the siphuncle is 9 mm in diameter and 4 mm from the venter. Chalcedony within the camerae and siphuncle has obscured cameral and siphonal deposits in the two cross sections.

Chalcedony has obscured only the siphonal deposits in the vertical thin section (P1. 16, fig. 10). Cameral deposits consisting of episeptal and mural deposits are developed ventrally. Septa are straight and inclined apicad at an angle of 50 degrees with respect to the shell wall. Septal necks are anomalously long, extending one-third the length of a siphuncle segment. Rings are thin, but show indications of layering. Siphuncle segments are tubular, wider than long. The deposit within the siphuncle is rod-like, fills approximately 95 percent of the siphuncle, and has a straight dorsal profile in vertical section. This specimen is from the lower of the continuous reefs, about 95 ft (29.0 m), above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1668 (Pl. 16, figs. 6-9): This specimen is a portion of a phragmocone, 125 mm long. Cross sections (Pl. 16, figs. 7, 8) 56 mm and 10 mm from the apical end of the specimen show a large (0.39 of conch diameter), circular, subcentral siphuncle and, apparently, a circular shell. The shell expands from 18 to 19 mm in diameter and the siphuncle, from 7 to 7.5 mm over a length of 46 mm. The siphuncle is empty orally and completely filled by white calcite apically.

In vertical thin section (Pl. 16, fig. 9) this white calcite completely fills the apical half of the siphuncle and is invaded by matrix in the oral half. This calcite is presumed to be of organic origin by analogy with other specimens assigned to *Buttsoceras*. However, this cannot be proved from this thin section.

Siphuncle segments are tubular, longer than wide, and composed of short necks and thin rings. Septa are straight and gently inclined between shell and siphuncle. Thin episeptal cameral deposits are developed on both sides of the siphuncle. This specimen is from 150 ft (45.7 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Figured specimen, no. 1669 (Pl. 16, figs. 4, *5):* This specimen is a poorly preserved phragmocone, 170 mm long, in which internal structures are not preserved. A cross section (Pl. 16, fig. 5) 10 mm from the apical end of the specimen shows a slightly crushed, apparently circular shell 17.5 mm in diameter and a large, circular siphuncle, 6.5 mm across and 4.5 mm from the venter. This specimen is from the upper continuous reef, 175 ft (53.3 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

DISCUSSION—These three specimens are not all conspecific, and at least one of them represents a new species. Two of the three specimens are referred to *Buttsoceras novemexicanum* on the basis of development of cameral deposits; the third, which is poorly preserved, is referred to *B. novemexicanum* on the basis of association and large size.

The three specimens are so large that they could not be easily overlooked in the field; consequently, their stratigraphic range is interpreted as a very good approximation of the true stratigraphic range of *Buttsoceras*.

OCCURRENCE—All three figured specimens are from the Wahwah Limestone, section ***J,*** Ibex area, Utah.

Buttsoceras williamsi Flower
Pl. 6, figs. 17-21; Pl. 10, figs. 5, 6

Buttsoceras williamsi Flower, 1962, p. 4, 5; pl. 2, figs. 1-8, 10-12.

DESCRIPTION—Buttsoceras williamsi is represented by a single specimen, a portion of a phragmocone 53 mm long. A portion of the specimen 31 mm long that terminates 4 mm from the apical end of the specimen was sectioned. The shell is circular in cross section (Pl. 6, figs. 18, 20, 21) and expands in diameter from 12 mm to 13 mm. The siphuncle is large (0.42 of conch diameter), circular, and eccentric. Apically, the siphuncle is 4 mm across, 3 mm from the venter, and 5 mm from the dorsum; anteriorly, it is 5.5 mm in diameter, 3 mm from the venter, and 4.5 mm for the dorsum. Septa are almost straight and only slightly inclined apicad between shell wall and siphuncle. Approximately two and one-half camerae are found in a length equal to the adoral conch diameter. Cameral deposits are not developed.

The siphuncle wall is composed of short, straight necks and thin homogeneous rings. Siphuncle segments are gently fusiform with rings slightly expanded into the camerae. The width and length of each siphuncle segment are approximately equal.

The cross sections (Pl. 6, figs. 17, 18, 20, 21) show a dorsal cavity within the siphonal lining that is crescent-shaped, 3 mm across, apically, and figure-eight shaped, 2 mm across, orally. In vertical section (Pl. 6, fig. 19) this cavity decreases in height orad, from 1.0 mm to 0.5 mm. Anteriorly, it is crossed by numerous diaphragms; apically, it is sediment filled. A vertical partition at the anterior end of the thin section separates the dorsal cavity into two lateral subcavities.

The calcite of the lining has two distinct textures that can be related to structural events. Apically, the lining is composed of coarsely crystalline, white calcite; adorally, of polygonal bodies of white calcite. These two distinct textures are apparently the result of two structural events that are recorded by the reverse offsets on the joint set that crosses the specimen at an angle of approximately 105 degrees.

DISCUSSION—This *Buttsoceras is* assigned to *B. williamsi* because of its complete lack of cameral deposits at a growth stage in which the siphonal lining is fully developed. This is the first specimen of *B. williamsi* known to develop diaphragms and it extends the known geographic range of the species from southeastern Idaho to southwestern New Mexico.

The orad decrease in height of the dorsal cavity probably does not reflect the true shape of the cavity, but rather is the result of the specimen being ground down to three different planes because of offsets on the joint set.

OCCURRENCE—Figured specimen, no. 1632, is from the Florida Mountains Formation, east side of the Florida Mountains, south of Deming, New Mexico.

GENUS *TAJAROCERAS* Hook and Flower

TYPE SPECIES: *Tajaroceras wardae* Hook and Flower

Tajaroceras Hook and Flower, 1976, p. 295, 296.

DESCRIPTION—This genus contains slender orthocones of *Buttsoceras* aspect, distinguished from *Buttsoceras* in vertical thin section by the presence of a ventral rod and dorsal annuli within its siphuncle. In advanced growth stages the annuli grow forward, fuse, and form a continuous, nonsegmental lining separated from the rod by a small tube that is dorsad of center.

The shell is smooth, apparently circular in cross section and has a large (at least 0.35 of shell diameter), circular, subcentral siphuncle. Septal necks are short and straight; rings are thin and homogeneous. Camerae contain episeptal and mural cameral deposits.

DISCUSSION— *Tajaroceras* is interpreted as a genus intermediate between the rod-bearing Baltoceratidae and *Buttsoceras* and, hence, the Troedssonellidae (Hook and Flower, 1976). Hook and Flower present a detailed history of the controversy surrounding the proper taxonomic position of *Buttsoceras,* then stratigraphically and morphologically document the probable evolution of *Buttsoceras* from the rod-bearing Baltoceratidae through *Tajaroceras.* This evolutionary picture is further documented in Figs. 1 and 4.

Tajaroceras is now known from five specimens, four from the Wahwah Limestone of western Utah and one from the Florida Mountains Formation of west Texas. Two of the Wahwah specimens are referred to *T. wardae;* the remaining three are poorly preserved and not specifically determined. The descriptions and illustrations of *T. wardae* are repeated here for ease of comparison.

DERIVATION OF *NAME—Tajaroceras* is named for Jane Shaw Ward's (1917) delightful children's character, the Tajar. "The Tajar is something like a tiger, something like a jaguar, and something like a badger. If you should see him once, you would forget what he looked like, if you should see him twice, you would forget to forget and that would be quite fatal."

Tajaroceras wardae Hook and Flower
Pl. 21, figs. 1-14

Tajaroceras wardae Hook and Flower, 1976, p. 296-299; pl. 1. figs. 1-7; pl. 2. figs. **1-9.**

DESCRIPTION—Tajaroceras *wardae is* at present known from only two specimens, both from the Wahwah Limestone.

The holotype (Pl. 21, figs. 7-14) is a portion of a phragmocone, approximately 70 mm long. The shell is orthoconic, smooth externally, and most probably circular in cross section. The siphuncle is large, at least 0.35 of conch diameter, circular, and subcentral.

Three cross sections were made through the shell, one 4 mm from the apical end of the specimen, the second at 26 mm, and the third at 54 mm. These cross sections (Pl. 21, figs. 7-10) show the shell increasing in diameter from 6.5 to 10.5 mm, while the siphuncle increases from 2.5 to 3.8 mm in diameter.

The opposing cross sections at 26 mm (Pl. 21, figs. 7, 8) suggest two disparate siphonal structures: the cross section looking apicad (P1. 21, fig. 8) indicates the presence of a ventral rod filling roughly two-thirds of the siphuncle, while the section looking orad (Pl. 21, fig. 7) suggests a lining within the siphuncle that has left only a small dorsal cavity unfilled. The two vertical thin sections (Pl. 21, figs. 12, 13) revealed that both of these interpretations are correct and are a function of where the cross section is cut. The siphuncle contains both a ventral rod, which is the dominant siphonal structure, and dorsal annuli. Apically, these annuli have grown forward, fused and formed a continuous lining with the rod. After the annuli fuse there is only a small cavity, dorsad of center, separating the ventral rod from the dorsal annular lining (Pl. 21, fig. 14).

Apically (P1. 21, figs. 13, 14) the rod has an undulating dorsal profile; these undulations are one camera in length and correspond to slight dorsal expansion of the rings into the camerae. Proceeding anteriorly in the thin sections, the dorsal profile of the rod changes from undulating to irregular to straight.

This midlength irregularity is difficult to interpret, but may be entirely adventitious because it occurs at a glued break in the specimen, so that the two halves of the thin section are not ground down to exactly the same plane, and it occurs at a point where the texture of the rod changes from coarsely crystalline to finely crystalline and partially replaced calcite. However, the annuli in this region also become irregular in size and shape. Another possible explanation for this region is that it represents an abnormal condition perhaps caused by injury or disease, although injury to such an internal part seems unlikely.

Septal necks are short and straight; rings are thin and homogeneous. Siphuncle segments are straight ventrally, slightly expanded into the camerae dorsally, and are slightly longer than wide.

Only episeptal and mural cameral deposits are developed. The distribution of cameral deposits in cross section (P1. 21, fig. 8) combined with asymmetric ventral deposits in the apical camerae (Pl. 21, fig. 13) suggests the possibility that lobate, *Pseudorthoceras-like* cameral deposits are developed. Mural deposits on the dorsal side of the shell (Pl. 21, figs. 12, 13) have their own nongradational boundaries, distinct from those of the deposits on the septum proper. In the third and fourth camerae from the anterior end of the specimen (Pl. 21, fig. 12) the mural deposits are actually separated from the episeptal deposits by a small, matrix-filled space.

Curvature of septa is equal to approximately half the length of a camera. Exactly three camerae are found in a length equal to the adoral shell diameter.

The paratype (Pl. 21, figs. 1-6) is a portion of a phragmocone, 102 mm long. The shell is orthoconic, smooth externally, and circular in cross section. The siphuncle is large, at least 0.35 of the shell diameter, circular, and subcentral. Two vertical thin sections were made through the midpart of the shell, with cross sections cut 36, 50, and 74 mm from the apical end of the specimen.

The shell increases in diameter from 14 to 15 mm over the anterior 24 mm of the thin section, while the siphuncle increases from 5 to 6 mm in diameter. The cross sections (Pl. 21, figs. 3-5) show a ventral rod, subquadrate in section, filling about two-thirds of the siphuncle.

The thin sections (P1. 21, fig. 2) first revealed the dorsal annuli within the siphuncle, which are discrete, crescent-shaped bodies confined to the foramina. The rod has an undulating dorsal profile; undulations exactly parallel the dorsal expansion of rings into the camerae. Necks are short and straight; rings are thin and homogeneous. Cameral deposits are badly recrystallized, but involve at least episeptal deposits.

Siphuncle segments are straight ventrally, slightly expanded into the camerae dorsally and slightly longer than wide. Two and one-half camerae are found in a length equal to the adoral shell diameter.

DISCUSSION—These two specimens show considerable variation in internal morphology and future work may indicate that they are not conspecific. Major differences include 1) the shape of the rod in cross section, 2) the shape of annuli in vertical thin section, and 3) the growth rate of the annuli relative to that of the rod. At present the material of *Tajaroceras* is inadequate to determine the limits of specific variation and, therefore, both specimens are assigned to *Tajaroceras wardae.*

TYPES AND OCCURRENCE—Holotype, no. 1675, is from a zone 55 to 65 ft (16.8 to 19.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. Para-type, no. 1663, is from the Wahwah Limestone, section J, Ibex area, Utah.

Tajaroceras spp.

P1. 11, figs. 15, 16; Pl. 16, fig. 14

DESCRIPTION—Two poorly preserved specimens are described.

Figured specimen, no. 1620 (Pl. 11, figs. 15, 16): This figured specimen is a portion of a siphuncle, 60 mm long, with bits of septa clinging to its ventral surface. A vertical thin section (Pl. 11, fig. 16) through the middle 22 mm of the specimen shows the ventral rod filling approximately 80 percent of the siphuncle and four small dorsal annuli. The rod has an undulating dorsal profile and is composed of coarsely crystalline calcite. Septal necks cannot be distinguished from the thin homogeneous rings because of recrystallization. Siphuncle segments are wider than long and are straight ventrally. This specimen is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas.

Figured specimen, no. 1698 (Pl. 16, fig. 14): This specimen is a portion of a phragmocone, 80 mm long. Two vertical thin sections were made through the apical 43 mm of the specimen. These thin sections, shown in composite in Pl. 16, fig. 14, show the ventral rod and elongate dorsal annuli within the siphuncle. Necks are short and straight; rings are thin and homogeneous. Siphuncle segments are tubular, longer than wide. Calcite on the portions of septa still extant, indicate that episeptal cameral deposits were developed. This figured specimen is from the upper continuous reef, 175 ft (53.3 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

DISCUSSION—Although poorly preserved, these two specimens are important because the first extends the geographic range of *Tajaroceras* from Utah to west Texas and the second establishes an upper limit on the stratigraphic range of *Tajaroceras* in the Wahwah Limestone.

OCCURRENCE—Figured specimen, no. 1620, is from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas; figured specimen, no. 1698, is from 175 ft (53.3 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Tajaroceras? sp.

P1. 16, figs. 11-13

DESCRIPTION—This figured specimen is a portion of a phragmocone, 18 mm long. The shell is subcircular in cross section and expands from a height of 9.7 mm and a width of 10.0 mm to a height of 11.7 mm and a width of 11.8 mm. The siphuncle is large (0.4 of shell diameter), circular, and eccentric. Apically (Pl. 16, fig. 13) the siphuncle has a diameter of 4.0 mm; adorally (Pl. 16, fig. 11), 4.6 mm.

Calcite that completely fills the siphuncle in both cross sections has an irregular circumference as the result of partial solution. In vertical thin section (Pl. 16, fig. 12) the solution channel extends the full length of the specimen, is more pronounced on the ventral side, and makes interpretation of siphonal structures difficult. However, there is a rodlike structure, similar in habit to the ventral rod of the Baltoceratidae, lying against the ventral wall of the siphuncle and filling approximately four-fifths of it. Between this rodlike structure and the dorsal wall of the siphuncle, replacement is advanced making interpretation of structure difficult. Within this area, however, faint growth lamellae are evident under high magnification that suggest an origin in annular deposits that have grown forward and fused.

Siphuncle segments are longer than wide, are straight ventrally, and gently expanded into the camerae dorsally. Necks are short and straight; rings are thin and homogeneous.

Septa are straight ventrally and slightly curved dorsally. Cameral deposits are developed on both sides of the siphuncle and include only episeptal and mural deposits. Approximately two and one-half camerae occur in length equal to the adoral shell diameter.

DISCUSSION—This specimen is questionably assigned to *Tajaroceras,* rather than *Buttsoceras,* because of the ventral rodlike structure, the suggestion of annular deposits, and the similarity of its cameral deposits to t hose of the holotype of *Tajaroceras wardae.*

OCCURRENCE—Figured specimen, no. 1682, is from he Wahwah Limestone, section J, Ibex area, Utah.

Troedssonellidae, genus and species indeterminate P1. 17, figs. 15-17

DESCRIPTION—This figured specimen is a tiny fragment of an orthocone, 11 mm long. The siphuncle (Pl. 17, fig. 15) is small (0.22 of shell height), circular and contains a lining that has left only a small dorsal cavity unfilled. A longitudinal section (Pl. 17, fig. 17) that is not quite vertical in orientation shows the lining to be composed of coarsely crystalline calcite that maintains a fairly constant thickness over the length of the specimen. There are no traces of growth lamellae within the lining and it does not thicken near the foramina.

Siphuncle segments are tubular and two times longer than wide. Necks are short and straight; rings are thin and homogeneous. Lobate episeptal and mural deposits are well developed ventrally. Curvature of septa is equal to less than half the length of a siphuncle segment. Two camerae occur in a length equal to the adoral shell width.

DISCUSSION—This specimen is obviously a member of the Troedssonellidae and was initially assigned to *Buttsoceras adamsi.* However, the lobate cameral deposits are wrong for *Buttsoceras* and more suggestive of specimens here assigned to *Michelinoceras* spp. The dorsal deposits, which are quite distinctive in the specimens assigned to *Michelinoceras* sp., have been destroyed by weathering in this specimen.

This specimen is inadequate for both generic and specific assignment and is illustrated to show more of the morphologic variation that the Order Michelinoceratida had attained by late Canadian time.

OCCURRENCE—Figured specimen, no. 1700, is from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah.

Order UNCERTAIN

GENUS *ENIGMOCERAS*, n. gen.

TYPE SPECIES: *Enigmoceras diaboli,* n. sp.
Fig. 13

DESCRIPTION—The shell is straight, very slightly broader than high. Basal septa are oblique, sloping strongly forward on the siphonal side of the shell; later septa are more nearly transverse. Only septal necks of the siphuncle are known. They are short and point ventrad (siphonward) apically, and are short and parallel to the shell axis orad. Septa are secreted in cycles of three or four, followed by a longer, aseptate portion; three such cycles are known in the type species. The siphuncle is moderately large (approximately 0.3 of shell height) and migrates from a submarginal to a subcentral position.

DISCUSSION—This genus is so totally unlike any other described cephalopod from either younger or older beds that its affinities cannot be determined. The cyclic repetition of septate and aseptate portions of the shell suggests that shell truncation may be involved. Yet this idea leads to difficulty because three cycles are *preserved* in the one known specimen of *Enigmoceras*. The rapid ontogenetic progression of the siphuncle from a submarginal to a subcentral position is unknown in any other Canadian cephalopod. Until more material is

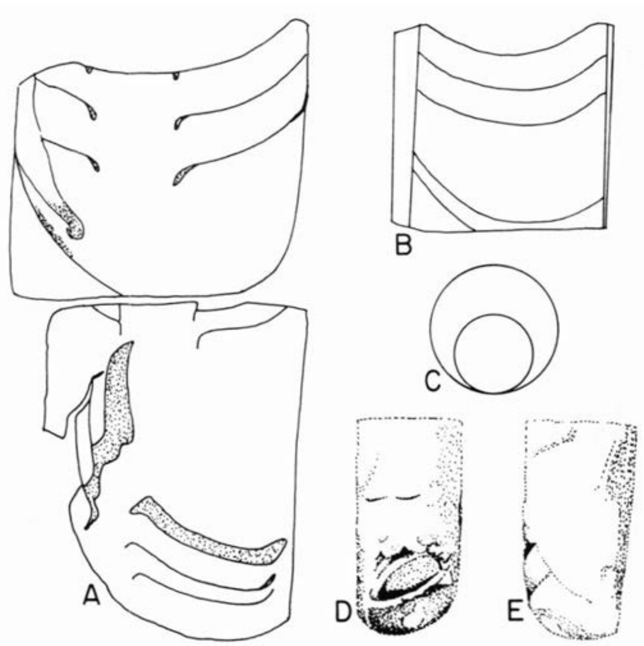

FIGURE 13—*Enigmoceras,* N. GEN. A) Composite vertical? thin section through type specimen, venter on left, X2.4. B) Thin section chip from anterior end of A, X1.8; note length of second septum from apical end. C) Cross section 16 mm from apical end of type species, venter down, X1.2. D) Ventral view of type species, X0.9. E) Lateral view of type species, venter on left, X0.9. White calcite is stippled.

found that will clarify the relationship of *Enigmoceras* to the rest of the cephalopoda, it will have to remain a most unusual beast.

DERIVATION OF NAME—The genus is named *Enigmoceras* simply because it is an enigma.

Enigmoceras diaboli, n. sp.
P1. 18, figs. 7-13

DESCRIPTION—The holotype and only known specimen of *Enigmoceras diaboli* is a portion of a phragmocone, 38 mm long. The shell is smooth externally and slightly depressed in cross section; orally, the shell has a width of 18 mm and a height of 17.3 mm.

Basal septa are oblique and swing far forward on the siphonal (ventral?) side of the shell (Pl. 18, fig. 8). In the composite, vertical? thin section (Pl. 18, fig. 7) septa appear to be secreted in cycles of three or four, followed by an aseptate portion of the shell. Three such cycles are evident in the thin section.

In the apical (first) cycle, the siphuncle is submarginal and has short septal necks that point toward the siphonal side of the shell. The septa swing far forward on the siphonal side of the shell and have moderate curvature on the antisiphonal side of the shell.

In the second cycle, septa are more nearly transverse on the antisiphonal side of the shell and necks are hemichoanitic and parallel to the shell axis in the first two camerae, where the siphuncle is subcentral. The third and last septum in this cycle has short necks that outline a submarginal siphuncle.

The last cycle is composed of at least three septa in which both siphonal and antisiphonal segments appear transverse (Pl. 18, fig. 7). The siphuncle is again subcentral. Necks are short, point into the siphuncle, and are reinforced by additional calcite that is probably inorganic in origin.

Along with migration of the siphuncle, torsion may also have taken place. As is evident from the composite thin section (Pl. 18, fig. 7) the two halves are not ground down to the same plane. The plane through the upper half had to be altered from that of the lower half during final grinding in order to intersect the siphuncle; so the two planes, rather than being parallel, intersect one another at an angle of approximately 30 degrees.

Connecting rings are not preserved and cameral deposits are not developed in any of the three cycles.

DISCUSSION—This specimen was at first thought to be a thick-shelled orthocone that was crushed apically. Later, when the cross section was cut and showed no trace of the siphuncle, the specimen was thought to be adventitious. An adventitious origin is opposed by the cyclic repetition of septa and the continuity of the cylindrical surface of the shell margin. However, what was first thought to be a thick outer shell turned out to be the living chamber of another, larger orthocone that the specimen had washed into.

Whether shell truncation took place or not is only speculation. The cyclic repetition of septate and aseptate portions of the shell suggests shell truncation, but the presence of three cycles in one specimen argues against it.

Until more material is found that will answer some of these questions, *Enigmoceras diaboli* will remain a species of uncertain origin.

TYPE AND OCCURRENCE—Holotype, no. 1705, is from the Wahwah Limestone, section J, Ibex area, Utah.

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Plates

PLATES 1-21

Specimens described as whitened are coated with a thin sublimate of ammonium chloride.

PLATE 1

Figures		*Page*
1-5	*Rhabdiferoceras planiseptatum*	25
	Holotype, no. 1638, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **1)** vertical thin section, venter on right, ×6. **2)** vertical opaque section, venter on left, ×3. **3)** anterior cross section, venter down, ×4. **4)** ventral view, whitened, ×2. **5)** apical cross section, venter down, ×4. See also Pl. 7, figs. 6, 7; Pl. 12, figs. 3-5, 12-17; and Pl. 13, figs. 5, 6, 12-14.	
6	*Protocycloceras* sp. D	32
	Figured specimen, no. 1641, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **6)** naturally weathered longitudinal section, ×2.5.	
7	*Protocycloceras* sp. C	32
	Figured specimen, no. 1640, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **7)** naturally weathered longitudinal section, ×2.5.	
8-12	*Rudolfoceras keadyi*, n. sp.	38
	Holotype, no. 1639, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **8)** ventral view, whitened, ×2. **9)** lateral view, venter on left, whitened, ×2. **10)** dorsal view, whitened, ×2. **11)** septal view, venter down, 17 mm from apical end of specimen, ×4. **12)** apical view, venter down, ×2. See also Pl. 11, fig. 1 (same specimen).	
13-20	*Protocycloceras* sp. F	32
	Figured specimen, no. 1642, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **13)** ventral view, specimen inverted, whitened, ×2. **14)** lateral view, venter on right, whitened, ×2. **15)** dorsal view, whitened, ×2. **16)** lateral view, venter on left, whitened, ×2. **17)** anterior view, venter down, whitened, ×2. **18-19)** opposing cross sections, venters down, 16 mm from apical end of specimen, ×2. **20)** vertical thin section through apical 16 mm of specimen, venter on left, ×5.	

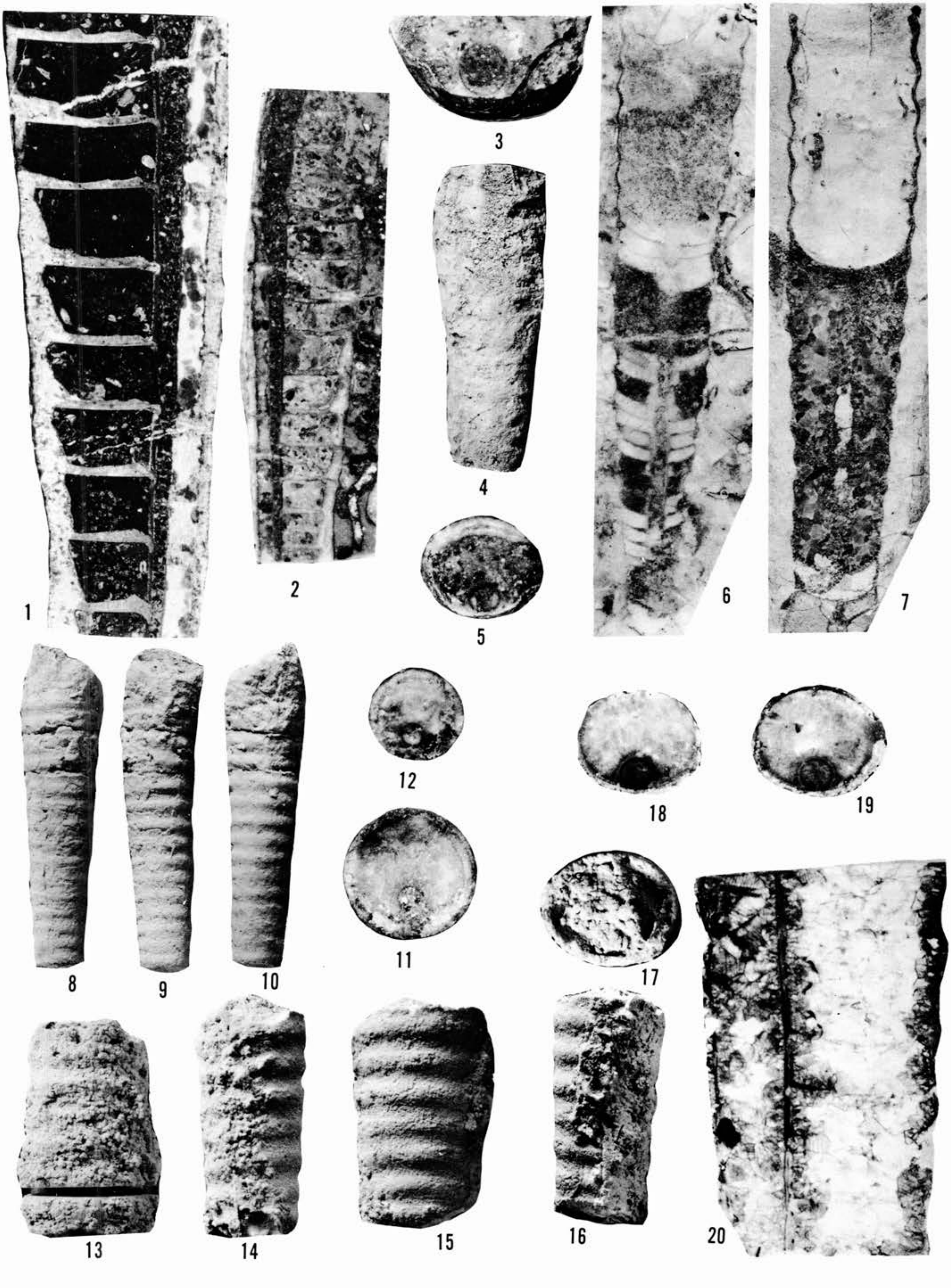
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PLATE 2

Figures		*Page*
1-14, 28-31	*Catoraphiceras staceyae,* n. sp.	35

Paratype, no. 1643, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **1)** ventral view, whitened, ×1.5. **2)** dorsal view, whitened, ×1.5. **3)** lateral view, venter on left, whitened, ×1.5. **4)** cross section 26 mm from apical end of specimen, venter down, ×4. **5)** vertical thin section through apical end of specimen, venter on left, ×4.5.

Paratype, no. 1645, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **6)** lateral view, venter on right, whitened, ×2. **7)** ventral view, whitened, ×2. **8)** lateral view, venter on left, whitened, ×2. **9)** anterior cross section, venter down, ×2. **10)** vertical thin section of entire specimen, venter on right, ×4.

Paratype, no. 1644, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **11)** septal view 4 mm from apical end of specimen, venter down, ×4. **12)** dorsal view, whitened, ×1.5. **13)** lateral view, venter on right, whitened, ×1.5. **14)** ventral view, whitened, ×1.5.

Holotype, no. 1652, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **28)** ventral view, whitened, ×2. **29)** lateral view, venter on left, whitened, ×2. **30)** dorsal view, whitened, ×2. **31)** anterior view, venter down, whitened, ×2.

See also Pl. 11, figs. 12-14.

15-20 *Protocycloceras* sp. A 31

Figured specimen, no. 1655, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **15)** ventral view, whitened, ×5. **16)** lateral view, venter on left, whitened, ×5. **17)** dorsal view, whitened, ×5. **18)** anterior view, venter down, ×5.

Figured specimen, no. 1654, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **19)** weathered dorso-lateral view, ×2. **20)** cross section 39 mm from apical end of specimen, venter down, ×4.

21-23 *Catoraphiceras sinuatum,* n. sp. 34

Holotype, no. 1657, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **21)** ventral view, whitened, ×2. **22)** apical cross section, venter down, ×2. **23)** septal view 39 mm from apical end of specimen, venter down, ×2. See also Pl. 3, figs. 1-3 (same specimen).

24-27 *Catoraphiceras* sp. 36

Figured specimen, no. 1653, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **24)** ventral view, whitened, ×2. **25)** lateral view, venter on left, whitened, ×2. **26)** dorsal view, whitened, ×2. **27)** anterior view, whitened, venter down, ×2.

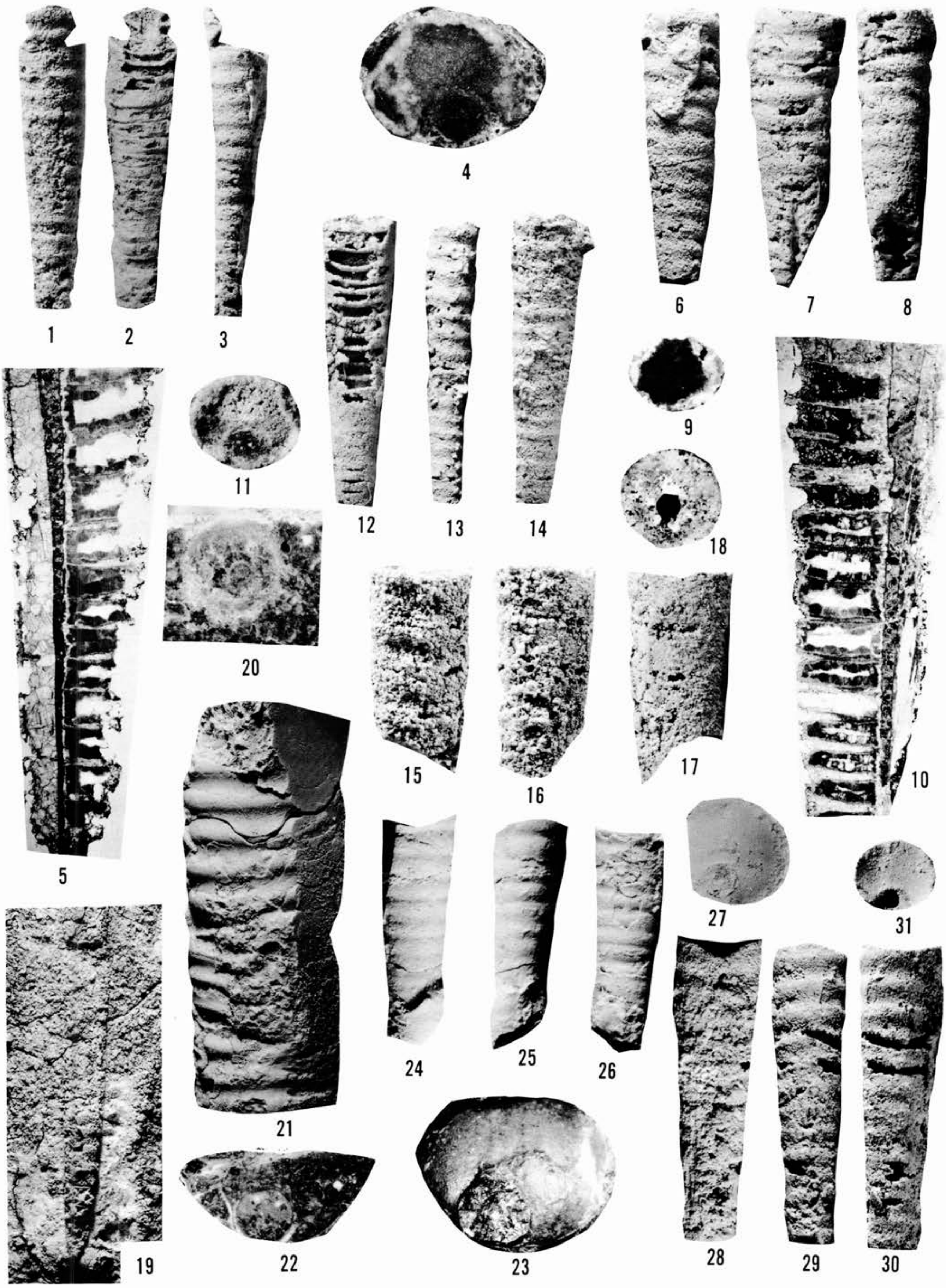
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PLATE 3

Figures		*Page*
1-3	*Catoraphiceras sinuatum,* n. sp.	34
	Holotype, no. 1657, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **1)** vertical thin section through midpart of fig. 2, venter on right, ×9. **2)** vertical opaque section, venter on right, ×3. **3)** enlargement of thin section, ×20. See also Pl. 2, figs. 21-23 (same specimen).	
4-8	*Kyminoceras kottlowskii,* n. sp.	37
	Holotype, no. 1649, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **4)** ventro-lateral view, whitened, ×2. **5)** apical cross section, venter down, ×3. **6)** vertical thin section, venter on left, ×5. **7)** enlargement of thin section, venter on left, ×18. **8)** enlargement of thin section, venter on left, ×13. See also Pl. 4, figs. 1-3, 9-12.	

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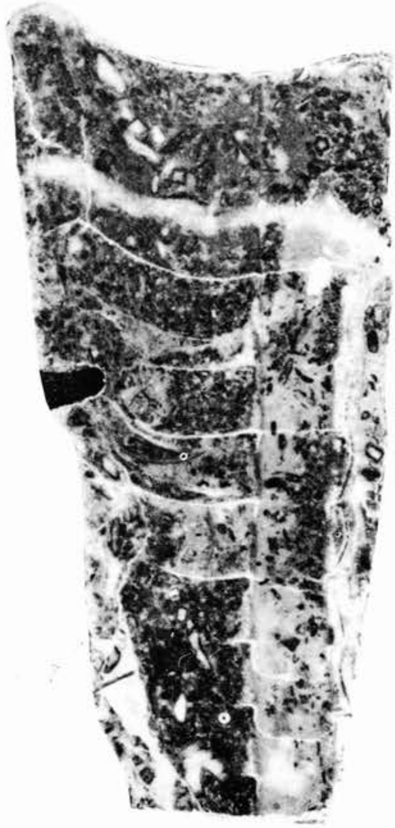

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PLATE 4

Figures		*Page*
1-3, 9-12	*Kyminoceras kottlowskii,* n. sp.	37
	Paratype, no. 1650, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **1)** ventral view, whitened, ×3. **2)** vertical thin section, venter on left, ×5.7. **3)** enlargement of thin section, venter on left, ×17.	
	Figured specimen, no. 1651, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **9)** apical cross section, venter down, ×5. **10)** lateral view, venter on right, whitened, ×3. **11)** anterior cross section, venter down, ×3. **12)** anterior portion of thin section, venter on left, off center, ×10.	
	See also Pl. 3, figs. 4-8.	
4-8	*Michelinoceras* sp.	44
	Figured specimen, no. 1656, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **4)** anterior cross section of fig. 5, venter down, ×2. **5)** vertical opaque section, venter on right, ×2. **6)** apical cross section of fig. 5, venter down, ×2. **7)** dorsally weathered apical portion of specimen, ×1.5. **8)** cross section 4 mm from apical end of specimen, venter down, ×3.	


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PLATE 5

Figures		*Page*
1-14	*Protocycloceras rhabdiferum*, n. sp.	30

Holotype, no. 1646, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **1)** anterior cross section, venter down, ×5. **2)** weathered dorsal surface, whitened, ×1.5. **3)** vertical thin section, venter on left, ×2. **4)** enlargement of thin section, venter on left, ×6.

Paratype, no. 1647, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **5)** weathered dorsal surface, ×2. **6)** cross section at anterior end of fig. 7, venter down, ×3. **7)** vertical thin section, venter on left, ×4.

Paratype, no. 1648, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **8)** weathered dorsal surface, ×1.5. **9)** vertical opaque section, venter on right, ×2. **10)** vertical thin section, venter on left, ×2. **11)** enlargement of thin section, venter on left, ×6.8. **12)** anterior cross section, venter down, ×4. **13)** enlargement of siphuncle, ×11.5. **14)** enlargement of opaque section, venter on right, ×10.

PLATE 5

PLATE 6

Figures		*Page*
1-6	*Clitendoceras* (=*Kirkoceras*)? sp.	40

Figured specimen, no. 1625, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **1)** ventral view, whitened, X2. **2)** lateral view, venter on left, whitened, X2. **3)** dorsal view, whitened, X2. **4)** anterior view, venter down, X2. **5)** apical view, venter down, X2. **6)** cross section 14 mm from apical end of specimen, venter down, X3.

7-13 *Manchuroceras lemonei,* n. sp. 42

Holotype, no. 1624, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **7)** dorsal view, whitened, X1.5. **8)** lateral view, venter on right, whitened, X1.5. **9)** ventral view, whitened, X1.5. **10-11)** opposing cross sections 13 mm from apical end of specimen, venters down, X2. **12)** anterior view, venter down, whitened, X1.5. **13)** apical view, venter down, whitened, X1.5.

14-21 *Buttsoceras novemexicanum* Flower 47

Figured specimen, no. 1627, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **14)** ventro-lateral view, whitened, X1.5. **15)** dorso-lateral view, whitened, X1.5. **16)** anterior view, venter down, whitened, X1.5.

See also Pl. 7, figs. 1-5; Pl. 9, fig. 1; Pl. 10, figs. 1-4; and Pl. 11, figs. 9-11.

17-21 *Buttsoceras williamsi* Flower 49

Figured specimen, no. 1632, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **17-18)** opposing apical cross sections, venters down, X2. **19)** vertical opaque section, venter on right, X2. **20-21)** opposing cross sections at anterior end of fig. 19, venters down, X2. See also Pl. 10, figs. 5, 6 (same specimen).

22-27 ?*Buttsoceras adamsi* (Butts) 47

Figured specimen, no. 1631, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **22)** longitudinal view, whitened, X2. **23)** anterior cross section, whitened, X2.

Figured specimen, no. 1634, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **24)** ventral view, whitened, X2. **25)** anterior cross section, venter down, whitened, X2. See also Pl. 10, figs. 7, 8 (same specimen).

Figured specimen, no. 1630, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **26)** longitudinal view, whitened, X2. **27)** anterior cross section, whitened, X2.

28 Order Tarphyceratida, fam., gen. and sp. indet. 43

Figured specimen, no. 1636, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **28)** lateral view, X1.5.

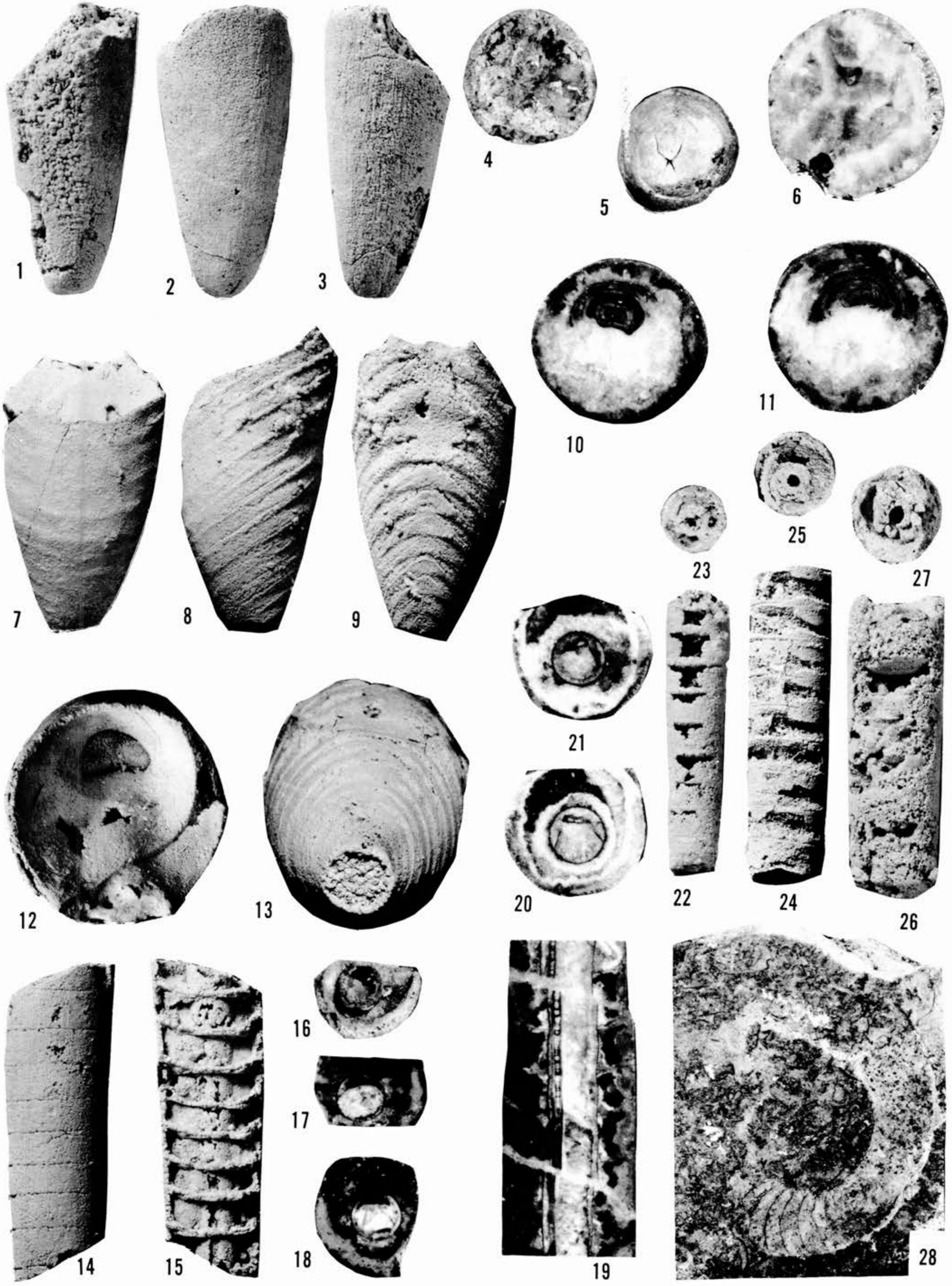
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PLATE 7

Figures		*Page*
1-5	*Buttsoceras novemexicanum* Flower	47

Figured specimen, no. 1633, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **1)** vertical opaque section, venter on right, ×5. **2)** vertical thin section, venter on right, ×5.5. **3)** thin section of anterior cross section, venter down, ×8. **4)** anterior cross section, venter down, ×5. **5)** enlargement of vertical thin section, venter on right, ×14.

See also Pl. 6, figs. 14-16; Pl. 9, fig. 1; Pl. 10, figs. 1-4; and Pl. 11, figs. 9-11.

6-7	*Rhabdiferoceras planiseptatum,* n. sp.	25

Paratype, no. 1622, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **6)** vertical thin section, venter on right, ×5. **7)** enlargement of thin section, venter on right, ×10.

See also Pl. 1, figs. 1-5; Pl. 12, figs. 3-5, 12-17; and Pl. 13, figs. 5, 6, 12-14.


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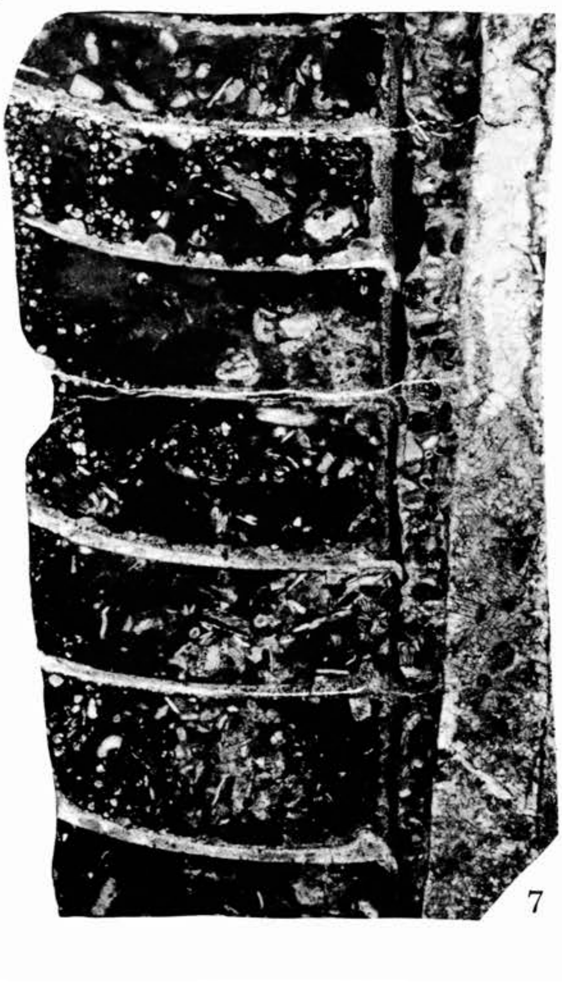
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PLATE 8

Figures		*Page*
1-8	*Michelinoceras floridaense,* n. sp.	43

Holotype, no. 1635, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **1)** ventral view, whitened, X2. **2-3)** opposing cross sections 18 mm from anterior end of specimen, venters down, X3. **4)** septal view 9 mm from apical end of specimen, venter down, X3. **5)** vertical thin section, venter on right, X2.5. **6)** enlargement of thin section, venter on right, X6.2. **7)** further enlargement of thin section, venter on right, X10.5. **8)** enlargement of thin section, venter on right, X27.

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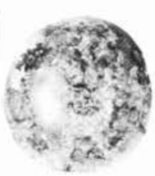

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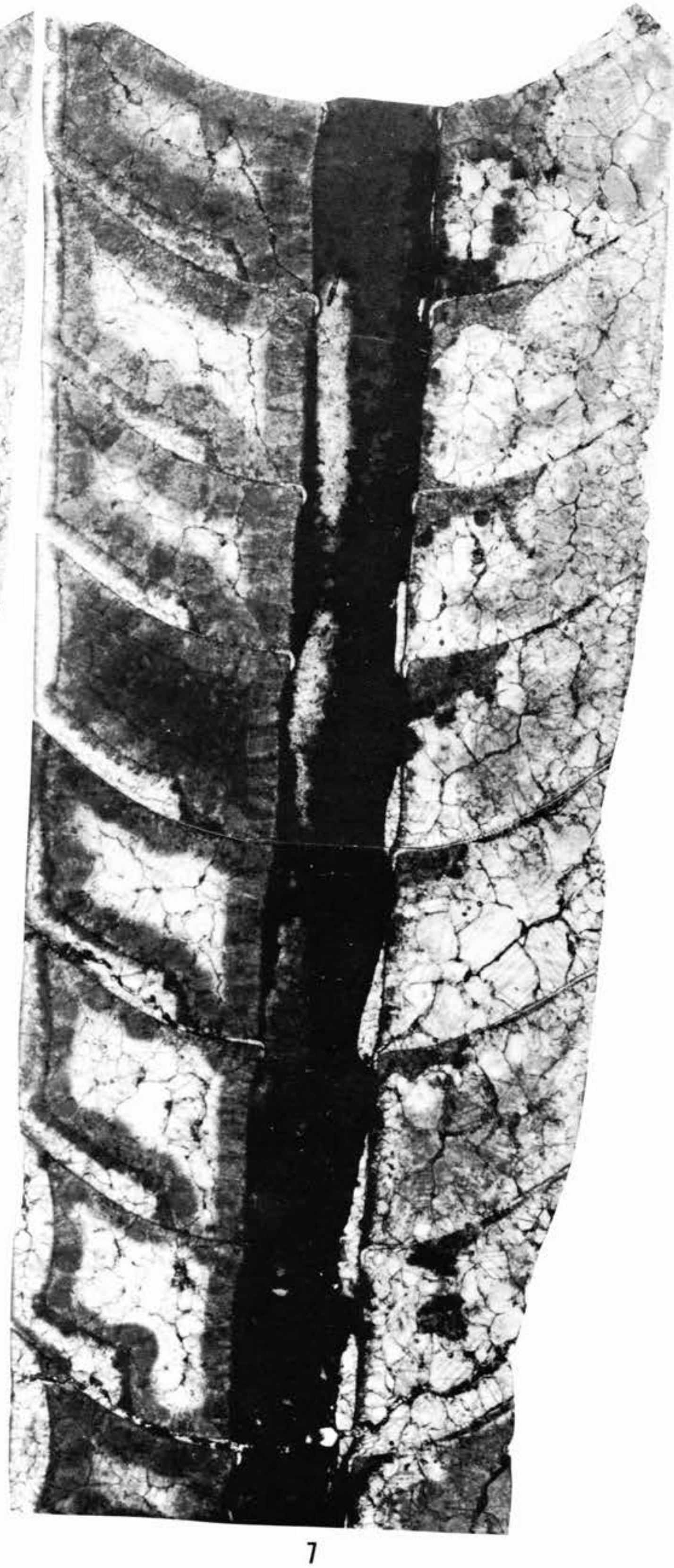

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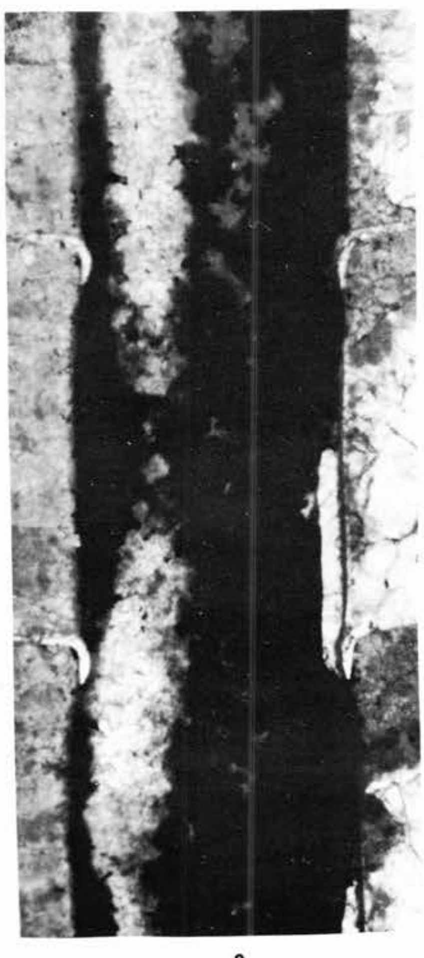

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PLATE 9

Figures		*Page*
1	*Buttsoceras novemexicanum* Flower	47
	Figured specimen, no. 1626, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **1)** ventral view, ×1. See also Pl. 11, figs. 9-11 (same specimen). See also Pl. 6, figs. 14-16; Pl. 7, figs. 1-5; and Pl. 10, figs. 1-4.	
2-9	*Michelinoceras melleni,* n. sp.	43
	Holotype, no. 1637, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **2)** anterior cross section of fig. 3, venter down, ×4. **3)** ventral view of anterior 25 mm of specimen, whitened, ×2. **4)** apical cross section of fig. 3, venter down, ×4. **5)** vertical thin section made from fig. 3, venter on right, ×4. **6)** vertical thin section of apical end of specimen, venter on right, ×6. **7)** enlargement of fig. 6, venter on right, ×12. **8)** enlargement of fig. 5, venter on right, ×6. **9)** enlargement of fig. 5, venter on right, ×28.	

PLATE 9

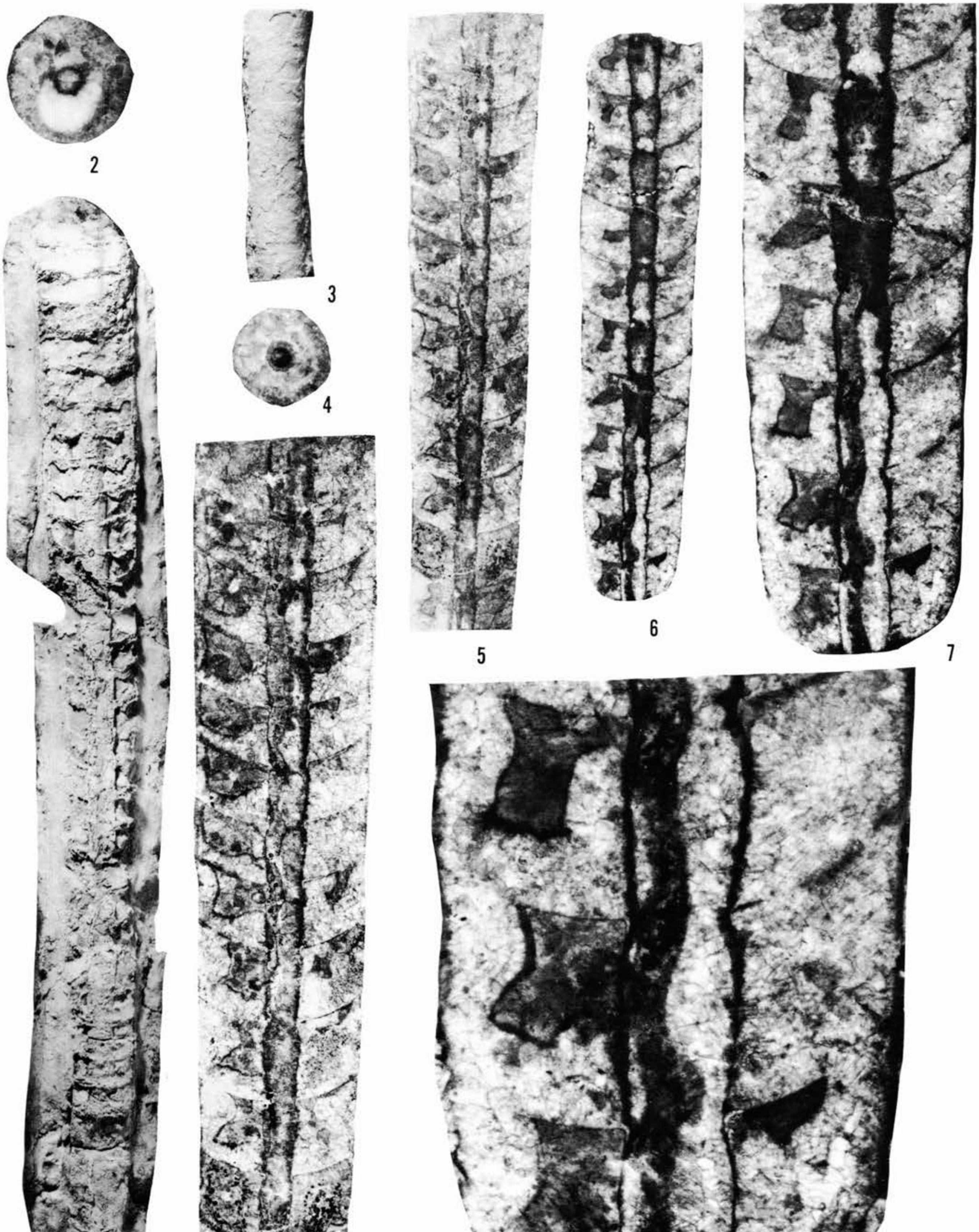

PLATE 10

Figures		*Page*
1-4	*Buttsoceras novemexicanum* Flower	47

Figured specimen, no. 1619, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **1)** vertical thin section, venter on left, ×4.

Figured specimen, no. 1617, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **2)** vertical thin section, venter on left, ×3.

Figured specimen, no. 1618, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **3)** vertical thin section through anterior 45 mm of specimen, venter on right, ×2.5. **4)** vertical thin section through apical 26 mm of specimen, venter on left, ×4.

See also Pl. 6, figs. 14-16; Pl. 7, figs. 1-5; Pl. 9, fig. 1; and Pl. 11, figs. 9-11.

5, 6 *Buttsoceras williamsi* Flower 49

Figured specimen, no. 1632, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **5)** vertical thin section, venter on left, ×3. **6)** enlargement of thin section, venter on left, ×10. See also Pl. 6, figs. 17-21 (same specimen).

7, 8 ?*Buttsoceras adamsi* (Butts) 47

Figured specimen, no. 1634, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **7)** vertical thin section through anterior 22 mm of specimen, venter on left, ×4. **8)** enlargement of thin section, venter on right, ×10. See also Pl. 6, figs. 24, 25 (same specimen).

See also Pl. 6, figs. 22, 23, 26, 27.

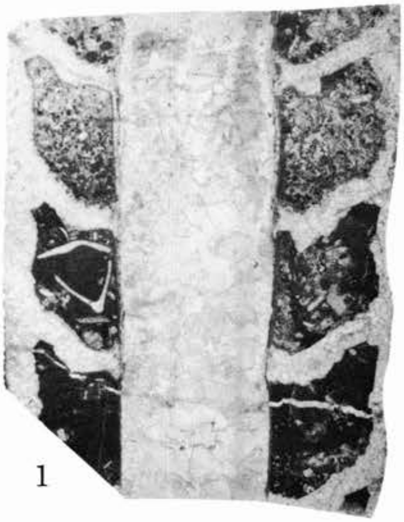
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PLATE 11

Figures		*Page*
1	*Rudolfoceras keadyi,* n. sp. Holotype, no. 1639, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **1)** vertical thin section through apical 14 mm of specimen, venter on right, ×7. See also Pl. 1, figs. 8-12 (same specimen).	38
2-5	*Cyptendoceras* cf. *C. ruedemanni* Ulrich and Foerste. Figured specimen, no. 1629, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **2)** ventral view, whitened, ×3. **3)** apical view, venter down, whitened, ×3. **4)** vertical thin section, venter on left, ×5. **5)** enlargement of thin section, venter on left, ×10.	23
6-8	*Michelinoceras* sp. Figured specimen, no. 1616, from the Florida Mountains Formation, east side of the Florida Mountains, New Mexico. **6)** anterior cross section, venter down, ×3. **7)** apical cross section, venter down, ×3. **8)** vertical thin section, venter on left, ×7.	44
9-11	*Buttsoceras novemexicanum* Flower. Figured specimen, no. 1626, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **9)** cross section at apical end of fig. 11, venter down, ×1.5. **10)** cross section at break in fig. 11, venter down, ×1.5. **11)** composite vertical thin section through anterior 42 mm of specimen, venter on left, ×3. See also Pl. 9, fig. 1 (same specimen). See also Pl. 6, figs. 14-16; Pl. 7, figs. 1-5; and Pl. 10, figs. 1-4.	47
12-14	*Catoraphiceras staceyae,* n. sp. Figured specimen, no. 1621, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **12)** ventral view, whitened, ×1.5. **13)** lateral view, venter on left, whitened, ×1.5. **14)** dorsal view, whitened, ×1.5. See also Pl. 2, figs. 1-14.	35
15, 16	*Tajaroceras* sp. Figured specimen, no. 1620, from the Florida Mountains Formation, east side of the Franklin Mountains, El Paso, Texas. **15)** ventral view, whitened, ×1. **16)** vertical thin section, venter on right, ×4,	51

PLATE 11

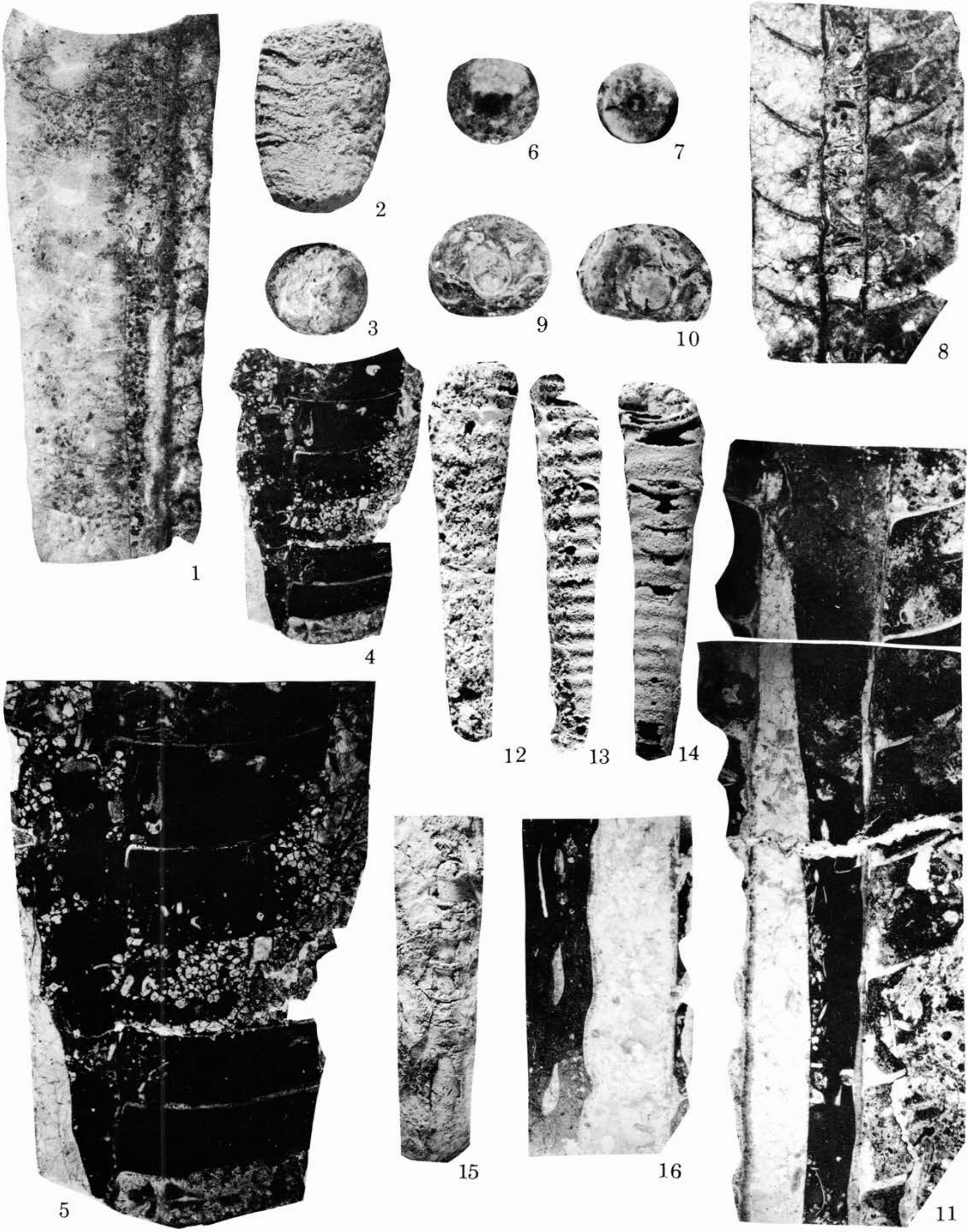

PLATE 12

Figures		*Page*
1-2	cf. *Rhabdiferoceras planiseptatum*, n. sp.	26
	Figured specimen, no. 1724, from 90 ft (27.4 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **1)** ventral view, X2. **2)** vertical thin section through entire specimen, venter on right, X5.	
3-5, 12-17	*Rhabdiferoceras planiseptatum*, n. sp.	25
	Paratype, no. 1685, from the Wahwah Limestone, section J, Ibex area, Utah. **3)** dorsal view, X4. **4)** vertical thin section through entire specimen, venter on right, X5. **5)** anterior cross section, venter down, X4. Paratype, no. 1709, from the Wahwah Limestone, section J, Ibex area, Utah. **12)** anterior cross section, venter down, X3. **13)** vertical thin section, venter on right, X10. Figured specimen, no. 1677, from the Wahwah Limestone, section J, Ibex area, Utah. **14)** dorsal view, X2. **15)** anterior cross section, venter down, X5. **16)** apical cross section, venter down, X5. **17)** vertical thin section, venter on left, X6. See also Pl. 1, figs. 1-5; Pl. 7, figs. 6, 7; and Pl. 13, figs. 5, 6, 12-14.	
6-11	*Cyptendoceras?* sp.	23
	Figured specimen, no. 1711, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **6)** dorsal view, whitened, X2. **7)** lateral view, venter on left, whitened, X2. **8)** ventral view, whitened, X2. **9)** lateral view, venter on right, whitened, X2. **10)** anterior cross section, venter down, X2. **11)** vertical thin section through entire specimen, venter on left, X5.	
18-20	*Rioceras?* sp.	27
	Figured specimen, no. 1674, from a zone 65 to 75 ft (19.8 to 22.9 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **18)** anterior cross section, venter down, X3. **19)** dorsal view, X1.5. **20)** vertical thin section through anterior 15 mm of specimen, venter on left, X5.	
21	?*Rhabdiferoceras planiseptatum*, n. sp.	26
	Figured specimen, no. 1672, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **21)** vertical thin section through entire specimen, venter on right, X5.	


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PLATE 13

Figures		*Page*
1-4	*Veneficoceras susanae,* n. sp. . . . . Holotype, no. 1693, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **1)** vertical thin section through anterior 28 mm of specimen, venter on left, X5. **2)** enlargement of thin section, venter on left, X10. **3)** cross section 14 mm from apical end of specimen, venter down, X4. **4)** anterior cross section, venter down, X4.	27
5, 6, 12-14	*Rhabdiferoceras planiseptatum,* n. sp. . . . . Paratype, no. 1664, from 127 ft (38.7 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **5)** anterior cross section, venter down, X4. **6)** vertical thin section through entire specimen, venter on left, X4. Paratype, no. 1714, from the Wahwah Limestone, section J, Ibex area, Utah. **12)** cross section 13 mm from apical end of specimen, venter down, X4. **13)** vertical thin section through anterior 18 mm of specimen, venter on left, X4. **14)** dorsal view, X1. See also Pl. 1, figs. 1-5; Pl. 7, figs. 6, 7; Pl. 12, figs. 3-5, 12-17.	25
7-11	Baltoceratidae, gen. and sp. indet. . . . . Figured specimen, no. 1717, from the Wahwah Limestone, section J, Ibex area, Utah. **7)** ventral view, whitened, X2. **8)** dorsal view, whitened, X2. **9)** apical view, venter down, X2. **10)** vertical thin section through entire specimen, venter on right, X10. **11)** opaque section showing change in curvature of septa in the vicinity of the siphuncle, venter on left, X4.	28
15, 16	*Amsleroceras gracile,* n. sp. . . . . Holotype, no. 1694, from the Wahwah Limestone, section J, Ibex area, Utah. **15)** cross section 40 mm from apical end of specimen, venter down, X2. **16)** vertical thin section through anterior 36 mm of specimen, venter on left, X3.	22

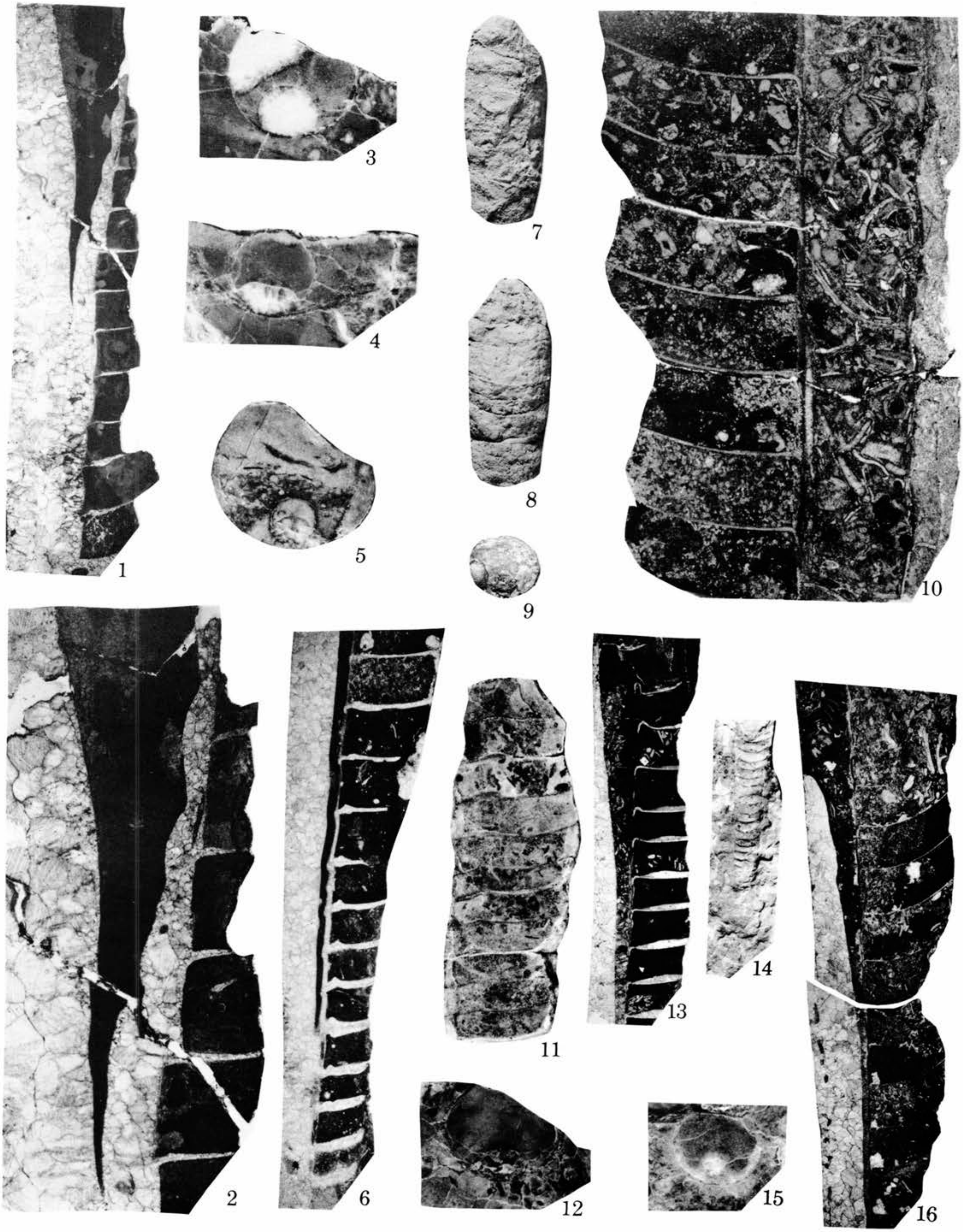
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PLATE 14

Figures | *Page*

1-2 *Catoraphiceras* sp. 36
Figured specimen, no. 1670, from 26 ft (7.9 m) above the base of the Wahwah Limestone, Ibex area, Utah. **1)** ventral view, ×5. **2)** anterior view, venter down, ×5.

3-6 *Catoraphiceras ibexense,* n. sp. 33
Holotype, no. 1713, from the Wahwah Limestone, section J, Ibex area, Utah. **3)** ventral view, whitened, ×2. **4)** anterior view, venter down, whitened, ×2. **5)** vertical thin section through apical 9 mm of specimen, venter on left, ×5. **6)** enlargement of thin section, venter on left, ×10.

7-9 *Rudolfoceras russelli,* n. sp. 38
Holotype, no. 1671, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **7)** vertical thin section through entire specimen, venter on right, ×5. **8)** anterior cross section, venter down, ×5. **9)** dorsal view, ×1.5.

10-11 *Protocycloceras* sp. B 31
Figured specimen, no. 1658, from the Wahwah Limestone, section J, Ibex area, Utah. **10)** ventral view, whitened, ×1.5. **11)** anterior cross section, venter down, ×2.

12-14 Apocrinoceratidae?, gen. and sp. indet. 40
Figured specimen, no. 1708, from the Wahwah Limestone, section J, Ibex area, Utah. **12)** anterior cross section, venter down, ×3. **13)** ventral view, whitened, ×3. **14)** vertical thin section through anterior 7 mm of specimen, venter on left, ×10.

15-18 *Catoraphiceras* cf. *C. staceyae,* n. sp. 35
Figured specimen, no. 1689, from a zone 55 to 65 ft (16.8 to 19.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **15)** dorsal view, ×1.5. **16)** vertical thin section through anterior 26 mm of specimen, venter on left, ×4. **17)** vertical thin section through apical 29 mm of specimen, venter on left, ×4. **18)** cross section 29 mm from apical end of specimen, venter down, ×3.

PLATE 14

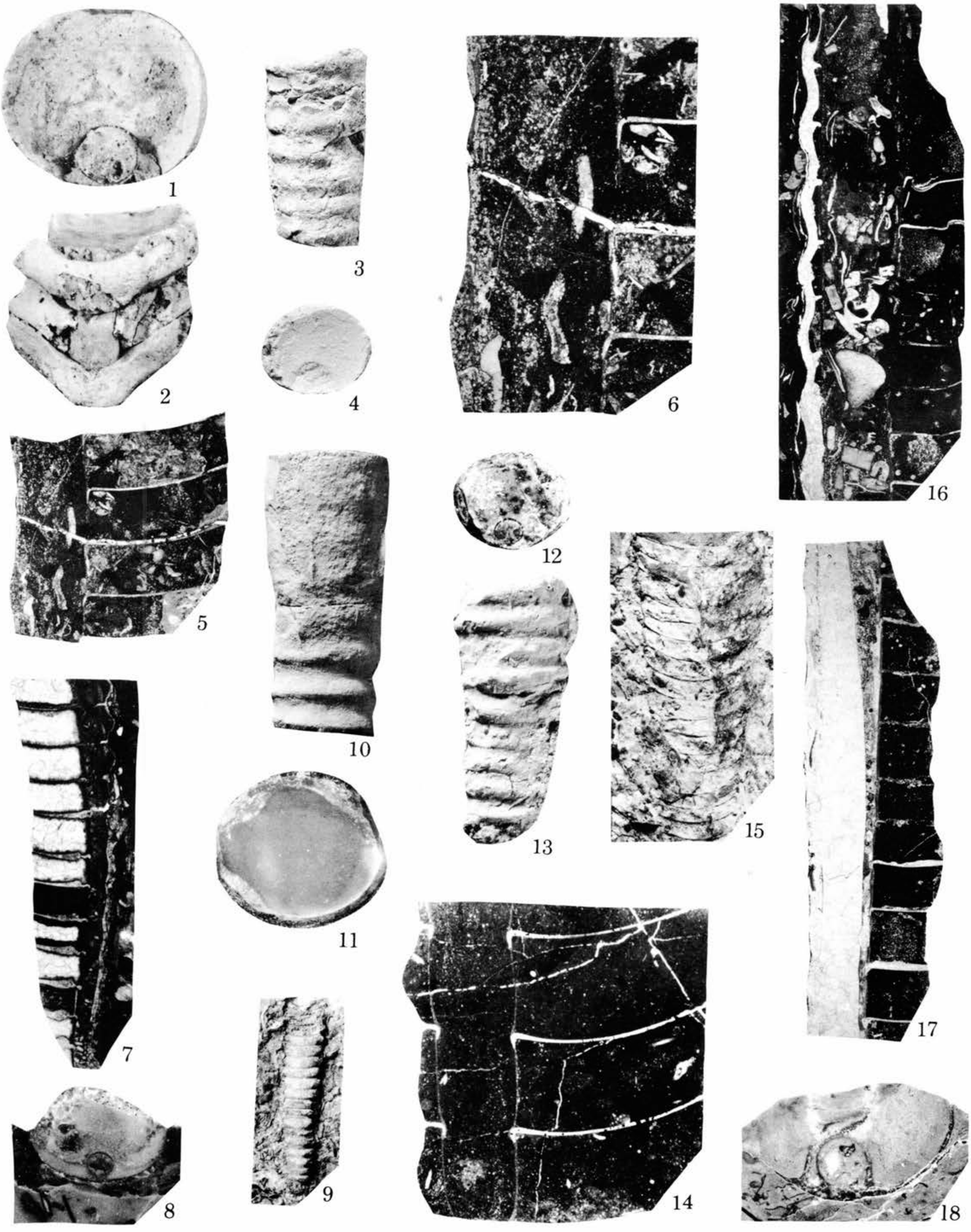

PLATE 15

Figures | *Page*

1-3 *Protocycloceras laswelli,* n. sp. 29

Holotype, no. 1681, from 90 ft (27.4 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **1)** composite vertical thin section extending from 44 to 88 mm from the apical end of the specimen, venter on right, ×3. **2)** vertical thin section through apical 15 mm of specimen, venter on left, ×5. **3)** cross section 75 mm from apical end of specimen, venter down, ×2.

4-7 *Protocycloceras* aff. *P. laswelli,* n. sp. 30

Figured specimen, no. 1680, from the lower of the continuous reefs, 95 to 101 ft (29.0 to 30.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **4, 5)** opposing cross sections 18 mm from apical end of specimen, venters down, ×2. **6)** composite vertical thin section through apical 55 mm of specimen, venter on right, ×3. **7)** lateral view of anterior 27 mm of specimen, venter on right, whitened, ×2.

8-10 *Catoraphiceras pearsonae,* n. sp. 33

Holotype, no. 1710, from 55 ft (16.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **8)** ventral view, whitened, ×2. **9)** apical cross section, venter down, ×3. **10)** vertical thin section through entire specimen, venter on left, ×4.

11-16 *Catoraphiceras* cf. *C. pearsonae,* n. sp. 34

Figured specimen, no. 1712, from 55 ft (16.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **11)** lateral view, venter on left, whitened, ×2. **12)** ventral view, whitened, ×2. **13)** dorsal view, whitened, ×2. **14)** anterior cross section, venter down, ×2. **15)** apical cross section, venter down, ×2. **16)** vertical thin section through apical 16 mm of specimen, venter on left, ×2.

17-20 *Catoraphiceras* sp. 36

Figured specimen, no. 1665, from 40 ft (12.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **17)** dorsal view, whitened, ×3. **18)** lateral view, venter on right, whitened, ×3. **19)** ventral view, whitened, ×3. **20)** apical view, venter down, whitened, ×3.

21 *Protocycloceras* sp. E 32

Figured specimen, no. 1707, from 65 ft (19.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **21)** longitudinal view, whitened, ×2.

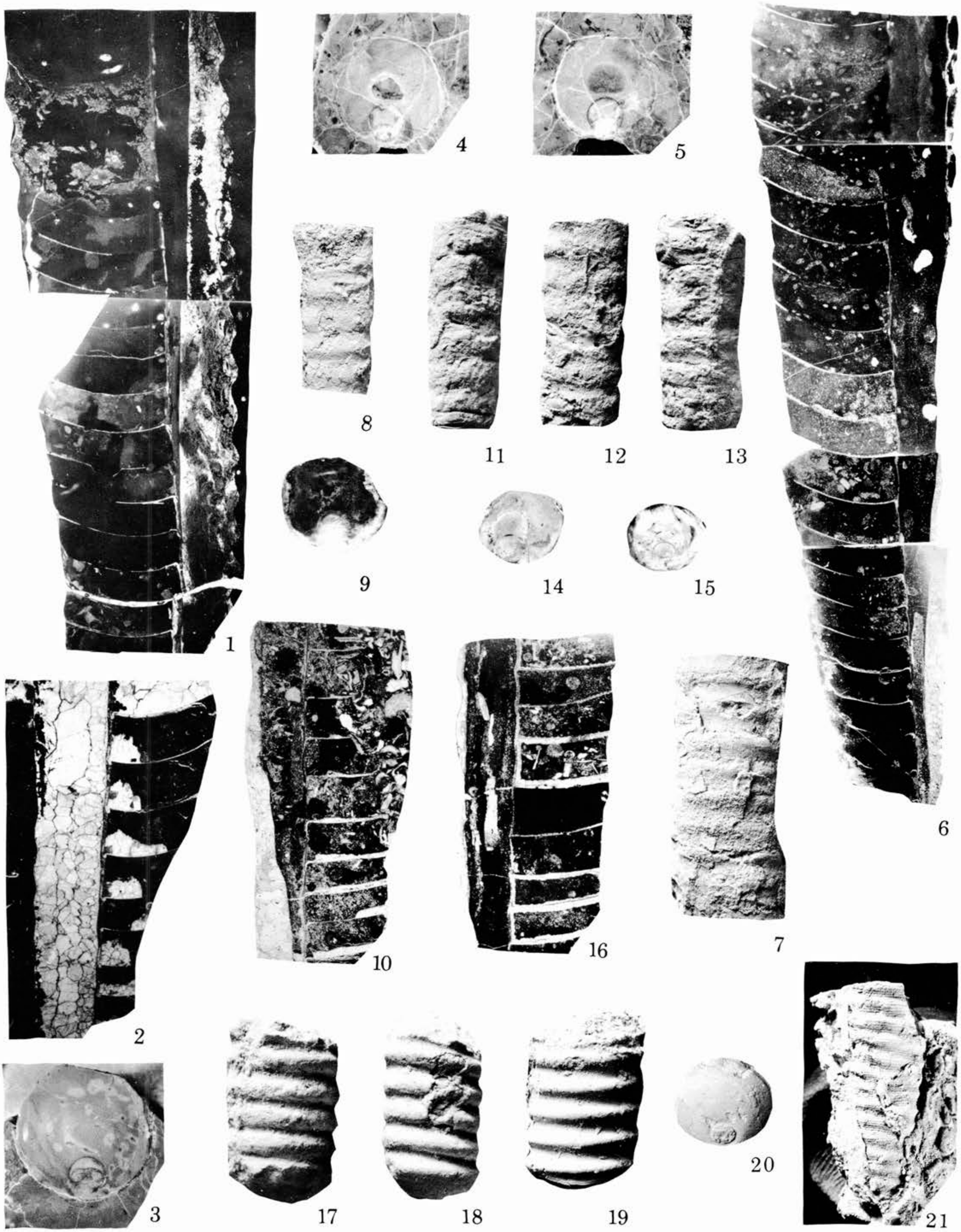
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PLATE 16

Figures		*Page*
1-10	*Buttsoceras* aff. *B. novemexicanum* Flower	49

Figured specimen, no. 1666, from the lower of the continuous reefs, about 95 ft (29.0 m) above the base of the Wahwah Limestone. **1)** weathered dorso-lateral view, ×1. **2)** cross section 138 mm from apical end of specimen, venter down, ×1.5. **3)** cross section 108 mm from apical end of specimen, venter down, ×1.5. **10)** vertical thin section extending from 108 to 138 mm from apical end of specimen, venter on left, ×3.

Figured specimen, no. 1669, from the upper continuous reef, 175 ft (53.3 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **4)** lateral view, venter on right, ×1. **5)** cross section 10 mm from apical end of specimen, venter down, ×2.

Figured specimen, no. 1668, from 150 ft (45.7 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **6)** dorsal view, whitened, ×1. **7)** cross section 56 mm from the apical end of specimen, venter down, ×2. **8)** cross section 10 mm from apical end of specimen, venter down, ×2. **9)** vertical thin section extending from 10 to 56 mm from apical end of specimen, venter on right, ×1.5.

11-13	*Tajaroceras?* sp.	51

Figured specimen, no. 1682, from the Wahwah Limestone, section J, Ibex area, Utah. **11)** anterior cross section, venter down, ×3. **12)** vertical thin section through entire specimen, venter on left, ×3. **13)** apical cross section, venter down, ×3.

14	*Tajaroceras* sp.	51

Figured specimen, no. 1698, from the upper continuous reef, 175 ft (53.3 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **14)** composite vertical thin section through apical 43 mm of specimen, venter on right, ×3.

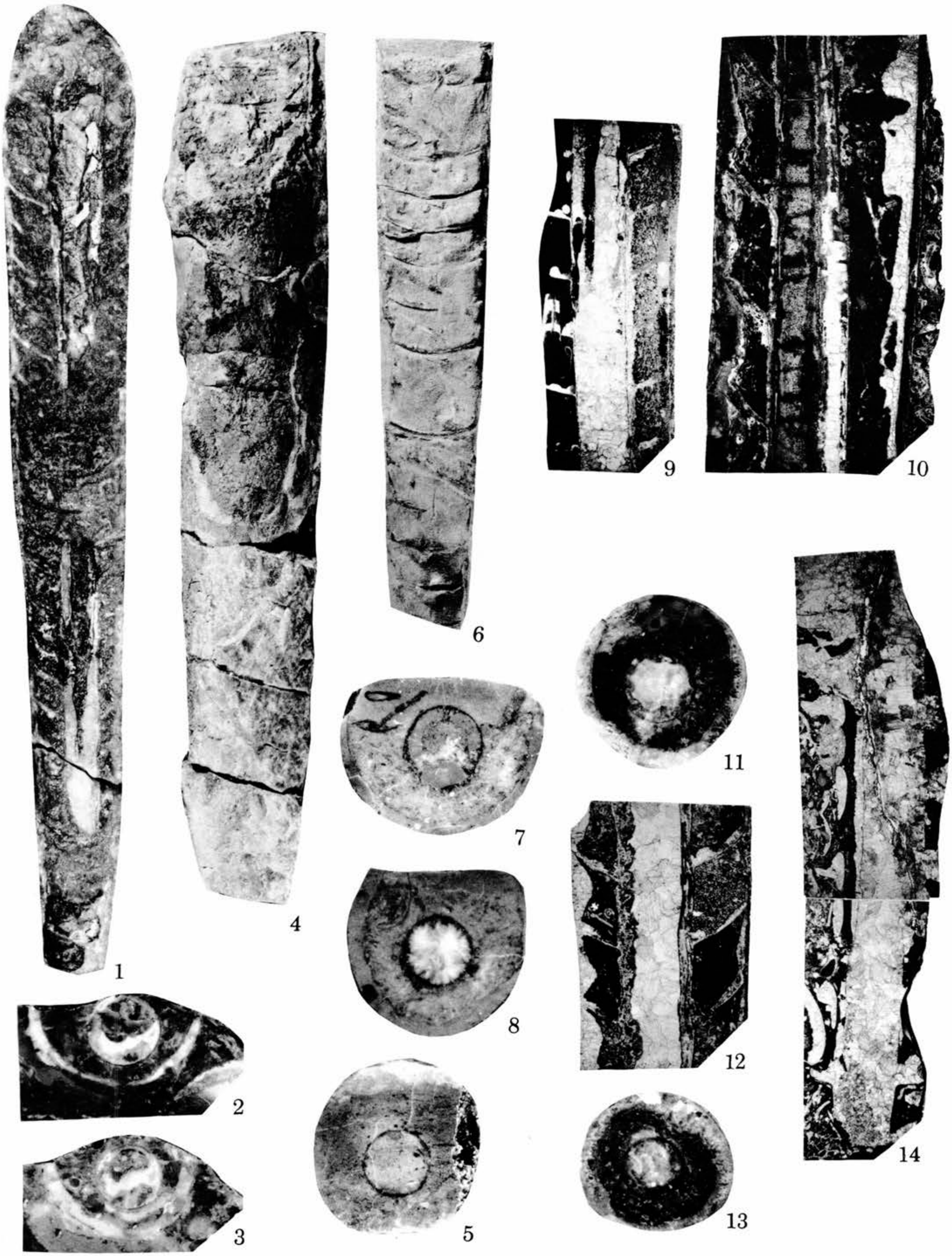
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PLATE 17

Figures | | *Page*

1-13 *Michelinoceras* spp. 44

Figured specimen, no. 1699, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **1)** vertical thin section through entire specimen, venter on right, X5. **2)** enlargement of thin section, venter on right, X15.

Figured specimen, no. 1728, from the Wahwah Limestone, section J, Ibex area, Utah. **3)** vertical thin section, venter on left, X5.

Figured specimen, no. 1702, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **4)** lateral view, venter on left, whitened, X3. **5)** vertical thin section through entire specimen, venter on left, X5. **6)** apical cross section, venter down, X5.

Figured specimen, no. 1727, from the Wahwah Limestone, section J, Ibex area, Utah. **7)** vertical thin section, venter on left, X5.

Figured specimen, no. 1703, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **8)** vertical thin section through entire specimen, venter on left, X5. **9)** anterior cross section, venter down, X5. **10)** apical cross section, venter down, X5.

Figured specimen, no. 1720, from the Wahwah Limestone, section J, Ibex area, Utah. **11)** vertical opaque section, venter on left, X2. **12)** vertical thin section, venter on right, X4. **13)** lateral view, venter on left, whitened, X1.

14 Baltoceratidae, n. gen., n. sp. 28

Figured specimen, no. 1701, from 54 ft (16.5 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **14)** weathered dorsal view, X3.

15-17 Troedssonellidae, gen. and sp. indet. 52

Figured specimen, no. 1700, from 50 ft (15.2 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **15)** apical cross section, venter down, X5. **16)** weathered dorsal view, X3. **17)** vertical thin section through entire specimen, venter on right, X10.

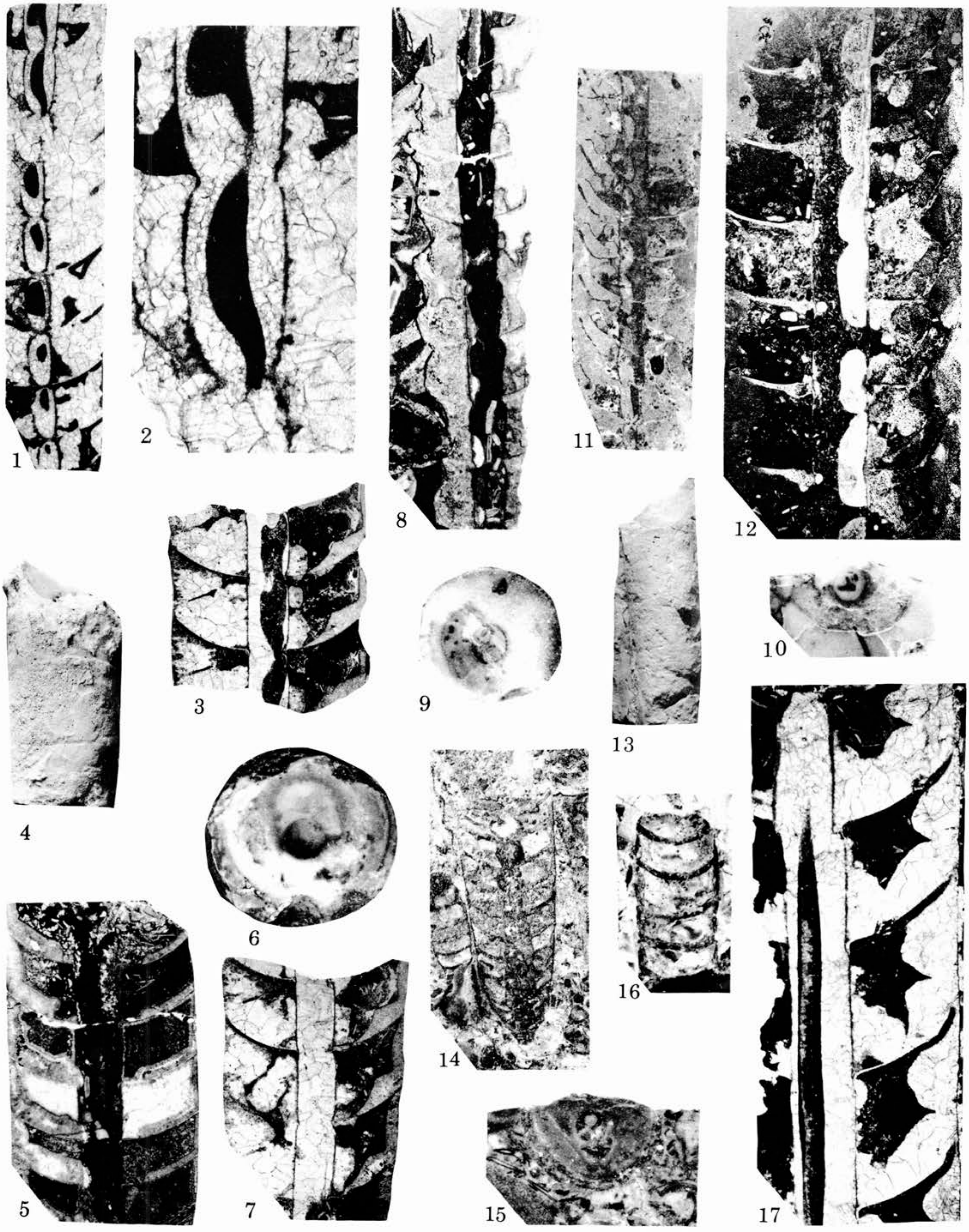
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PLATE 18

Figures		*Page*
1-6	*Rangeroceras hintzei,* n. sp.	24

Holotype, no. 1687, from the Wahwah Limestone, section J, Ibex area, Utah. **1)** ventral view, ×1. **2)** dorsal view of anterior 42 mm of specimen, whitened, ×1.5. **3)** cross section 19 mm from apical end of specimen, venter down, ×4. **4)** vertical thin section through apical 19 mm of specimen, venter on right, ×5. **5)** enlargement of thin section, venter on right, ×10. **6)** further enlargement of thin section, venter on right, ×28.

7-13	*Enigmoceras diaboli,* n. sp.	53

Holotype, no. 1705, from the Wahwah Limestone, section J, Ibex area, Utah. **7)** composite vertical? thin section, venter on left, ×4. **8)** ventral view, whitened, ×1.5. **9)** lateral view, venter on left, whitened, ×1.5. **10)** dorsal view, whitened, ×1.5. **11)** apical view, venter down, whitened, ×1.5. **12)** cross section 16 mm from apical end of specimen, venter down, ×2. **13)** anterior cross section, venter down, whitened, ×1.5.

PLATE 19

Figures | *Page*

1-2 Endoceratidae, n. gen., n. sp. 42

Figured specimen, no. 1729, from high in zone K, Wahwah Limestone, section J, Ibex area, Utah. **1)** vertical thin section through apical 22 mm of specimen, venter on right, ×4. **2)** apical cross section, venter down, ×2.

3 *Rudolfoceras?* sp. 38

Figured specimen, no. 1688, from the Wahwah Limestone, section J, Ibex area, Utah. **3)** longitudinal view, ×2.

4-6 *Michelinoceras* sp. 44

Figured specimen, no. 1678, from the Wahwah Limestone, section J, Ibex area, Utah. **4)** ventral view, ×2. **5)** cross section 20 mm from apical end of specimen, venter down, ×6. **6)** vertical thin section through anterior 16 mm of specimen, venter on left, ×6.

7 *Phragmosiphon?* sp. 41

Figured specimen, no. 1730, from high in zone K, Wahwah Limestone, section J, Ibex area, Utah. **7)** weathered longitudinal view, ×1.

8-12 *Bakeroceras wahwahense,* n. sp. 39

Holotype, no. 1673, from the Wahwah Limestone, section J, Ibex area, Utah. **8)** lateral view, venter on left, whitened, ×1.5. **9)** anterior cross section, venter down, ×3. **10)** vertical thin section through entire specimen, venter on right, ×4. **11)** enlargement of thin section, venter on right, ×15. **12)** further enlargement of thin section, venter on right, ×37.

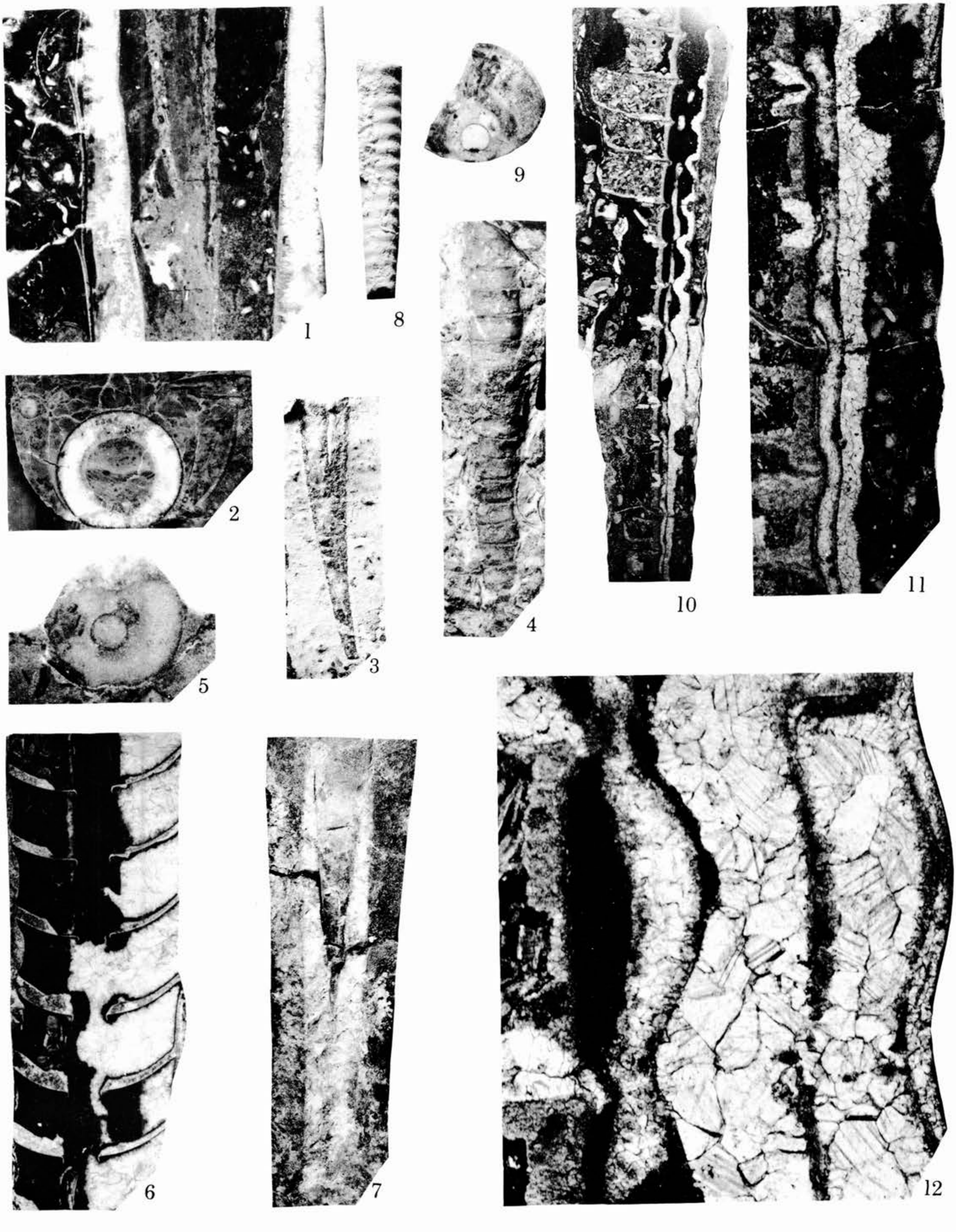
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PLATE 20

Figures		*Page*
1-7	*Wardoceras orygoforme*, n. sp.	46

Holotype, no. 1517, from 85 ft (25.9 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **1)** ventral view, whitened, ×1. **2)** dorsal view, whitened, ×1. **3)** cross section 92 mm from apical end of specimen, venter down, ×2. **4)** vertical thin section through apical 16 mm of specimen, venter on right, ×4. **5)** composite vertical thin section extending from 16 to 90 mm from apical end of specimen, venter on right, ×4. **6)** enlargement of thin section near apical end of fig. 5, venter on right, ×10. **7)** enlargement of thin section near anterior end of fig. 5, venter on right, ×10.

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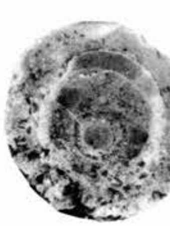

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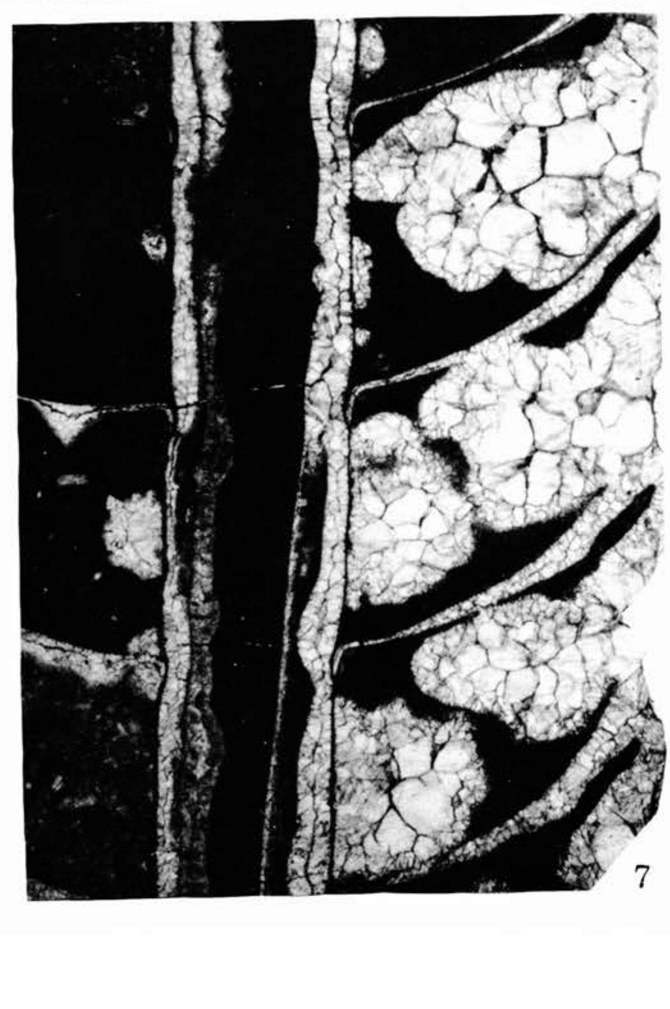

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PLATE 21

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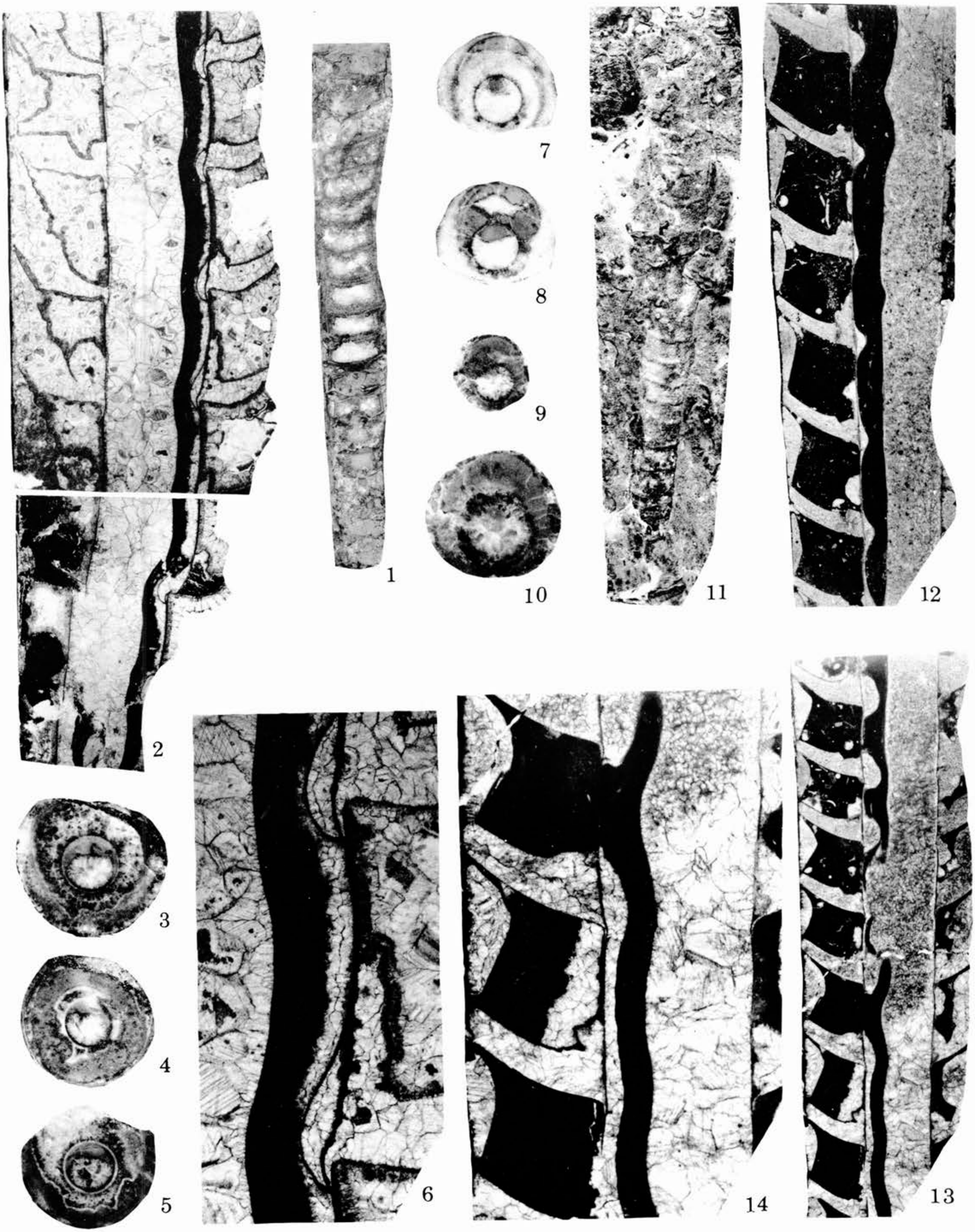
1-14	*Tajaroceras wardae* Hook and Flower	50

Paratype, no. 1663, from the Wahwah Limestone, section J, Ibex area, Utah. **1)** weathered dorsal view, ×1. **2)** composite vertical thin section extending from 36 to 74 mm from apical end of specimen, venter on left, ×4. **3)** cross section 74 mm from apical end of specimen, venter down, ×2. **4, 5)** opposing cross sections 50 mm from apical end of specimen, venters down, ×2. **6)** enlargement of thin section, venter on left, ×13.

Holotype, no. 1675, from a zone 55 to 65 ft (16.8 to 19.8 m) above the base of the Wahwah Limestone, section J, Ibex area, Utah. **7, 8)** opposing cross sections 26 mm from apical end of specimen, venters down, ×3. **9)** cross section 4 mm from apical end of specimen, venter down, ×3. **10)** enlargement of fig. 9, venter down, ×5. **11)** ventral view, ×1.5. **12)** vertical thin section extending from 26 to 54 mm from apical end of specimen, venter on right, ×4. **13)** vertical thin section extending from 4 to 26 mm from apical end of specimen, venter on right, ×4. **14)** enlargement of apical end of fig. 13, venter on right, ×10.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Index

Composition: Text in 8 and 10 pt. Times Roman, leaded one-point; subheads 12 pt. Times Roman
Index in 8 pt. Press Roman, leaded one-point
Display heads in 24 pt. Times Roman, letterspaced

Presswork: Miehle Single Color Offset

Binding: Sewn with softbound cover

Paper: Cover on 17 pt. Kivar
Text on 60 lb. White Offset
Plate Section on 70 lb. Velcoat Matte