Whiterock (Lower Middle Ordovician) Cephalopod Fauna from the Ibex Area, Millard County, Western Utah

by

April VanCamp Gil

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The Juab Limestone, the middle unit of the Pogonip Group in the Ibex area, western Utah, has yielded a large cephalopod fauna completely Whiterock (lower Middle Ordovician) in aspect. The fauna is dominated by the Endoceratida, especially the families Padunoceratidae and Allotrioceratidae. *Rossoceras* and *Williamsoceras*, forms characteristic of the Whiterock, are particularily abundant. Michelinoceratida and Ellesmeroceratida, the dominant groups of the Canadian, are very minor constituents of the Juab fauna.

Cameroceras, previously known only from Chazyan and younger strata, is reported for the first time from the Whiterock Stage. This extends the geographic range of *Cameroceras* to Utah, and its geologic range to Zone L.

Evencoceras is reported for the first time from outside the Siberian Platform; it is removed from the Intejoceratidae and placed with *Rossoceras* and *Padunoceras* in the Padunoceratidae.

A new and perplexing genus, Genus A., is reported, which has characteristics that indicate it is an intermediate form between *Williamsoceras* and "*Kachina*", a manuscript genus of R.H. Flower. Correlation of the Juab Limestone with the Nora Formation of Queensland, Australia is indicated by this form and others which are congeneric.

New taxa proposed are: *Rossoceras* sp. A, *R.* sp. B, *Evencoceras* sp. A, *Cameroceras* sp. A, *C.* sp. B, and *C.* sp. C; and new genus A., n. sp. A. A new species of *Rossoceras*, which is a manuscript genus of R.H. Flower, is discussed under *Rossoceras* sp. B.

ACKNOWLEDGMENTS

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This project would have not been possible without Dr. Rousseau H. Flower (Senior Paleontologist Emeritus, New Mexico Bureau of Mines and Mineral Resources), my thesis advisor. His knowledge of Ordovician cephalopods is without equal. It has been a pleasure to be associated with such a man of science, and I am fortunate to have been able to study the "gas pipes" with him. He gave his time, experitise, and encouragement freely.

My good friend, Anita Gleason, was instrumental in helping me with computer problems, formatted Table 1, aided in preparation of plates, and allowed me to use her office and computer terminal. Peg Flower was also a source of inspiration, practical advice, and a valued friend. Kay Green kindly read and edited the manuscript. Cindie Salisbury drafted figures 1, 2, and 4, and Steve Munoz helped with photography. The Richard Matezuski Research Fund supplied partial funding for photographic supplies.

I would like to thank my family, who have been very supportive throughout the course of this project: my parents, Raymond and Dorothy VanCamp, who instilled in me an interest in science and the importance of education; and my husband, Manuel, who was an invaluable photographic and laboratory assistant and has been a constant source of inspiration and support. He deserves special thanks for his patience and understanding.

INTRODUCTION

Objective

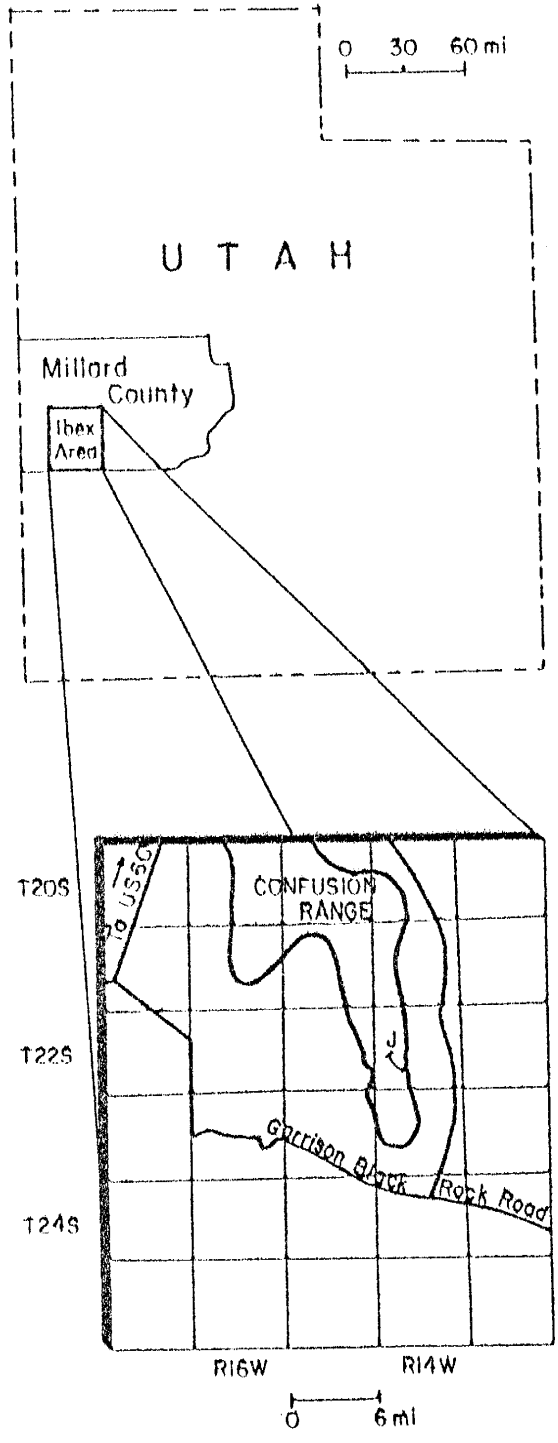
Cephalopod faunas of Whiterock age have an important role in our understanding of cephalopod phylogeny and evolution, and in correlation. A large fauna from the middle member of the Ordovician Pogonip Group of western Utah, the Juab Limestone, is examined in detail to document the taxonomy and internal morphology of the orthoconic nautiloid cephalopods. A manuscript, now in an advanced stage of preparation for publication, will formally present these results. These fossil cephalopods are from the Ibex area, an informal designation for an area in Millard County, western Utah, that contains virtually all fossil groups, and is a standard reference section for the Lower and Middle Ordovician. (See location map, Figure 1.) The area is the best known miogeoclinal reference assemblage in western North America for the study of Lower and Middle Ordovician biostratigraphy (Braithwaite, 1976), and contains the "most completely exposed and most continuously fossiliferous Lower Ordovician stratigraphic section in the western United States (Hintze, in Stokes, 1951)." The description and documentation of this fossil fauna fills an important gap in our knowledge of Whiterock cephalopods and their role in correlation.

Previous Work

Ibex Area

The region informally known as the Ibex area contains excellent outcrops of the Ordovician Pogonip Group. The Pogonip Group, defined originally by King (1876, 1878, p. 188) as the Pogonip Limestone, encompassed all strata between the Prospect Mountain Quartzite (Lower Cambrian) and the Eureka Quartzite

Figure 1--Location map of the Ibex area, western Millard county, Utah, showing Hintze's (1973) measured section J, the type section for the Juab Limestone. Cephalopod fauna described in this report was collected in sections 30 and 31 of T. 22 S., R. 14 W. of the Barn Quadrangle, Utah.


0 30 60 mi
UTAH
Millard County
Ibex Area
T20S
T22S
T24S
USGS
CONFUSION RANGE
Garrison Block
Rock Road
R16W
R14W
0 6 mi

(Middle Ordovician) in the White Pine mining district of eastern Nevada. No obvious break exists between Upper Cambrian and Lower Ordovician rocks in this area; therefore, both were included in the Pogonip Limestone. Since that time, the term has been used for various Ordovician strata in the Eureka district and in the Great Basin. Hague (1883) redefined Pogonip boundaries as the top of the Cambrian Dunderberg Shale and the base of the Middle Ordovician Eureka Quartzite. The United States Geological Survey uses the term in a broad sense (Wilmarth, 1957). Pogonip formations can be traced westward to central Nevada with little differences in lithology, fauna or thickness (Webb, 1956) and are also recognized in the Antelope, Monitor, Snake, and Toquima Ranges in Nevada, and in the Inyo Mountains in California (Keroher, et al., 1966). Sharp (1942, p. 657) provides a history of the use of the term "Pogonip".

The Ibex area of western Utah has been studied extensively, beginning with Hintze's work in 1947-1948. Hintze (1951) chose Ibex to serve as the type area for six new formations within the Pogonip Group because it has the best exposed and most continually fossiliferous Ordovician section in western Utah. He defined the lower boundary of the Pogonip Group in the Ibex area at the base of the Ordovician and selected the lithologic change which occurs below the *Symphysurina* faunal zone as the Cambrian- Ordovician boundary, and thereby restricted Pogonip to Ordovician age strata only.

Hintze's formations are: House Limestone; Fillmore Limestone; Wahwah Limestone; Juab Limestone; Kanosh Shale; and Lehman Formation (see Figure 2). This study deals with fossils collected from the middle unit of the Pogonip Group, the Juab Limestone (see Figure 3).

Deposition was apparently continuous in the Ibex area from Late Cambrian (Trempealeauan) through Middle Ordovician time (Hintze, et al., 1972). Miogeoclinal deposition resulted in thick shallow water carbonates which grade westward

Figure 2--Stratigraphic section of Ordovician formations in the Ibex area, Millard County, western Utah (from Ethington and Clark, 1981).

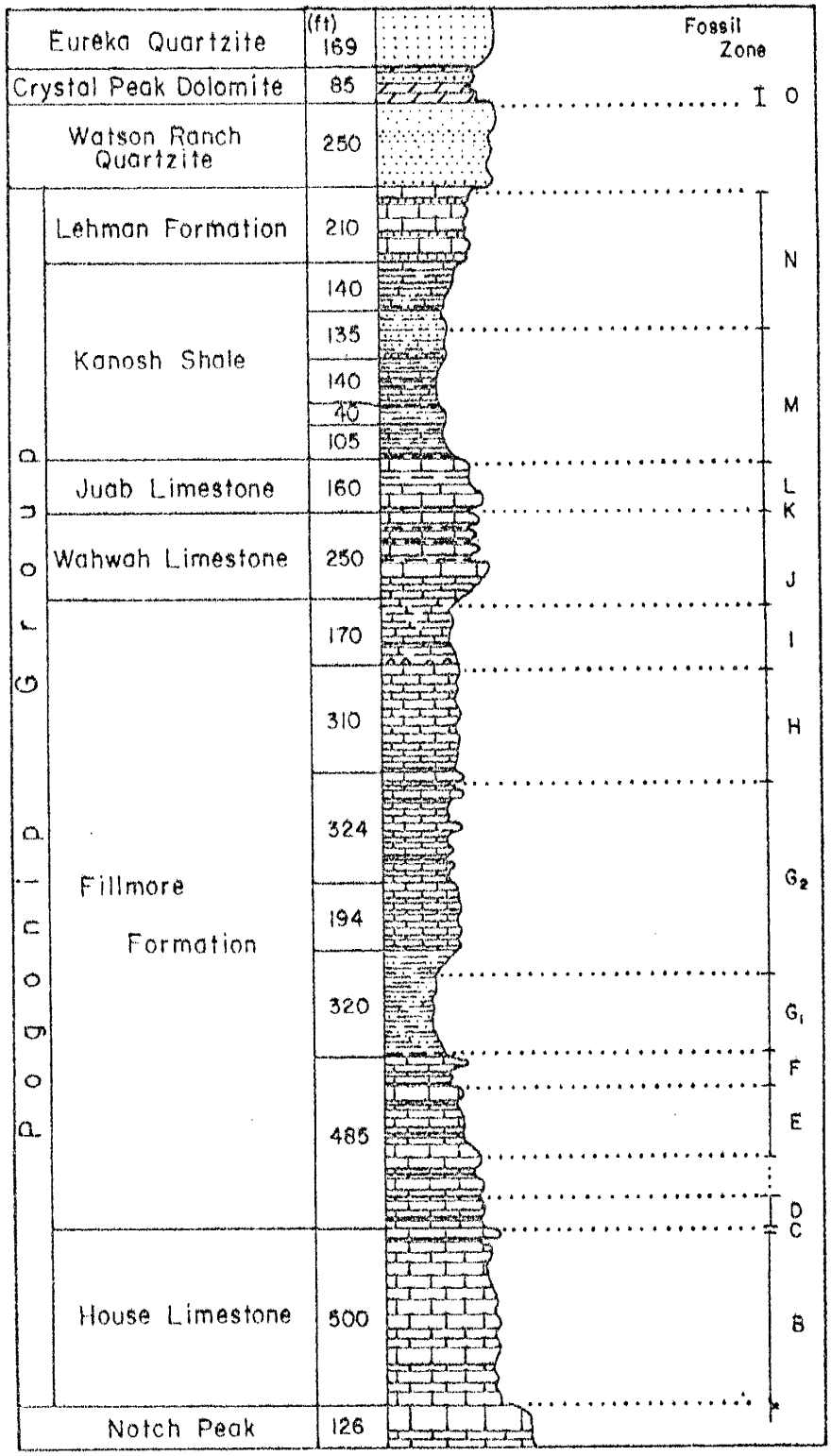

Eureka Quartzite
(ft)
169
Fossil Zone
Crystal Peak Dolomite
85
I
O
Watson Ranch Quartzite
250
Pogonip Group
Lehman Formation
210
N
Kanosh Shale
140
135
140
40
105
M
Juab Limestone
160
L
K
Wahwah Limestone
250
J
Fillmore Formation
170
I
310
H
324
G2
194
320
G1
F
485
E
D
C
House Limestone
500
B
Notch Peak
126

Figure 3--Fossil Mountain, Ibex area, western Millard County, Utah. White patch at top of Fossil Mountain is Eureka Quartzite, dark band just below top is Crystal Peak Dolomite, light ledges below are Watson Ranch Quartzite. The Lehman Formation and Kanosh Shale form slopes and ledges, and base of picture and low ledges in the foreground are Juab Limestone. Photograph courtesy of Lehi F. Hintze.

into a eugeoclinal sequence (Hintze, 1973a). Carbonates are the major sediments of the Pogonip Group (Webb, 1958). Detrital clastics are a minor component in the lower formations; the Wahwah Limestone contains considerable silt, which represents the first appreciable cratonic terrigenous detritus (Webb, 1958). However, the overlying Juab Limestone is clean (Hintze, 1951; Webb, 1958).

Stratigraphic sections were remeasured, additional surveys were added for more complete coverage, and permanent markers were established in each measured section to serve as reference for all collections (Hintze, et al., 1972; Hintze, 1973b). The interested reader is referred to Hintze's excellent and detailed descriptions of stratigraphic sections in his 1952 work and remeasured footages (1973b).

Juab Limestone

The type section of the Juab Limestone is located in the NE 1/4, section 31, T. 22 S., R. 14 W., and is included in Hintze's (1951) measured section J. The Juab Limestone is 157 feet thick at its type section (Hintze, 1973b). Here the Juab is very distinctive, both because of the lack of shaly detritus and the characteristic medium gray color and slabbly appearance; also, small nodules of limonite pseudomorphs after pyrite are common on weathered surfaces (Hintze, 1951, p. 58). Juab Limestone fossils are not silicified, and the ubiquitious trilobite fragments of the underlying Wahwah and Fillmore Formations are replaced by orthid brachiopods (Hintze, 1973b).

Correlatives of the Juab Limestone include the uppermost Garden City Formation of northeastern Utah (Ross, 1951) and the Joins Formation of Oklahoma (Webb, 1956). Recently, Sweet (1984) using conodonts and graphic correlation, correlated the Juab Limestone with the West Spring Creek Formation rather than the overlying Joins Formation.

Faunal Zones

Ross (1951, p. 26-29) recognized twelve faunal zones in the Garden City Formation and one in the Swan Peak beds in his documentation of the stratigraphy and trilobite fauna of northeastern Utah. Ross' zonations are not based solely on trilobites, but include other forms (i.e. brachiopods) which are useful in correlation. Ross placed the Canadian-Chazyan boundary between his zones K and L (the Whiterock Stage had not yet been recognized).

Hintze's (1952) study of Lower Ordovician trilobites resulted in the recognition of fifteen faunal zones in the Pogonip Group of west-central Utah and eastern Nevada; zones were defined mainly on the basis of trilobite assemblages rather than the stratigraphic range of any species, and other forms were also utilized. Hintze assigned letter designations to correspond to those of Ross (1951) as closely as possible for convenience of reference (Hintze, 1952, p. 5). Ross' Zone A was not recognized in the Ibex area at the time, but has since been found in the upper Crystal Peak Limestone.

Hintze's (1951) Ibex section biostratigraphic zone pertinent to this study is: Zone L, *Orthis sublata* biozone.

The Ibex section has been established as one of the world's most important Ordovician reference sections based on the variety of fossil forms present (Hintze, et al., 1972). A project to document fossil occurrences in the Ibex area was undertaken by a group of paleontologists, led by Hintze of Brigham Young University. Work on the following faunas has been completed: brachiopods, Jensen (1967); graptolites, Braithwaite (1969); bryozoa, Hinds (1970); crinoids, Lane (1970); pelecypods, Pojeta (1971); cystoids, Paul (1972); ostracods, Berdan (1976); conodonts, Ethington and Clark (1981); trilobites, Hintze (1951, 1952), Demeter (1973), Terrell (1973), and Young (1973).

Rigby (1958) has studied graptolites from the Ibex area and compared their

occurrences in Utah to Hintze's (1951) trilobite zones and noted that graptolite zones established in the Deepskill area in New York by Ruedemann (1919, 1947) seemed to correlate well with those from Utah. Rigby also studied receptaculitids (1962) and sponges (1965) from the area; corals were studied by Hintze and Rigby (1977). Roberts (1968) has presented preliminary results on his studies of reef-like structures formed by sponge-algal associations, and Church (1974) studied patch reefs in the Fillmore Formation. In addition, Hook and Flower (1977) discuss the late Canadian (zones J and K) cephalopod faunas from the region. Table 1 lists biostratigraphic zonations from a few of these faunal groups.

Hintze (in Hintze, et al., 1972; 1979) has discussed the importance of the Ibex area as a Lower Ordovician reference section and summarized the results of biostratigraphic studies on various fossil groups. All fossil groups are keyed to the trilobite zonation established by Ross (1951), Hintze (1952), and Hintze's (1973b) remeasured sections. Therefore, good stratigraphic control exists for work done in this area.

Flower (in Hintze, et al.; 1972) presented a summary of a preliminary study of the cephalopods from the Ibex area. He found the Juab Limestone Zone L to have a fauna of Whiterock aspect.

Whiterock Stage

Cooper (1956) recognized a post-Canadian and pre-Chazyan interval, which he termed the Whiterock Stage. (Figure 4 illustrates Ordovician series and stages.) He named the stage for Whiterock Canyon in the Monitor Range, Nevada, and noted that the brachiopod fauna of this stage was characterized by orthids, early strophomenids, plectambonitids, and a decline of the Syntrophiacea. The lower boundary of the Whiterock Stage is the top of the Canadian.

The Whiterock Stage has been recognized in North America in Newfoundland

TABLE 1 -- Biostratigraphic zonations and characteristic taxa of the Juab Limestone based on faunal studies in the Ibex area, western Millard County, Utah.

Faunal Group	Reference	Biozone
Brachiopods	Hintze (1951)	*Orthis subalata* (zone L)
	Jensen (1967)	*Anomalorthis* zone* (*Orthoambonites subalata* common)
Conodonts	Ethington and Clark (1981)	*Microzarkodia flabellum-Tripodus laevis*
Graptolites	Braithwaite (1976)	*Didymograptus nitidus-D. patulus* zone (zone six)
Ostracods	Berdan (1976)	*Tirisochilina juabaria*
Trilobites	Hintze (1951)	*Eleutherocentaus, Pseudomera*

* Note: this zone includes Juab Limestone and lower 495 feet of Kanosh Shale.

Figure 4--Series and stages of the Ordovician system in North America and corresponding series in Great Britain (after Flower, 1957; Shaw, 1974; Whittington, et al, 1984).

North America			Great Britain
System	Series	Stage	Series
Ordovician	Cincinnatian	Richmond	Ashgill
		Maysville	
		Eden	Caradoc
	Champlainian	Trenton	
		Wilderness	
		Porterfield	
		Chazy	Llandeilo
		Whiterock	Llanvirn
	Canadian	Cassinian	Arenig
		Jeffersonian	
		Demingian	
		Gasconadian	Tremadoc

[Table Head Formation (Whittington, 1963, 1965)]; in Nevada [Antelope Valley Limestone (Kay and Crawford, 1964)]; in Oklahoma [Oil Creek and Joins Formations (Cooper, 1956)]; in Missouri and Illinois [Everton Formation (Witkze, 1980)]; in Alabama [Lenoir Formation (Bergstom, 1973); in central Tennessee [Wells Creek Dolomite (Sweet and Bergstrom, 1976)], and in the Ibex area of western Utah [Juab, Kanosh, and Lehman Formations (Flower, 1971)].

Whiterock conodonts have been examined and found to be more varied in the Great Basin than in Appalachia; also, based on evidence from conodont studies, the upper Beekmantown Group in Maryland and adjacent states has been determined to be Whiterock in age (Harris, et al., 1979).

The interval between the Canadian and the Chazyan is remarkable not only for the decline or extinction of various taxonomic groups of cephalopods, but also for the subsequent diversification of lineages which appear in the Chazyan (Flower, 1971). Contrast in the cephalopod faunas of Canadian and Chazy Stages in the Ordovician System prompted Flower (1957) to propose separation of the Canadian as a distinct system. No genera cross the Canadian-Chazyan boundary (Flower, 1971). The cephalopods of the Whiterock are distinctive, but are more similar to Chazyan than Canadian forms (Flower, 1968).

Flower (1968) described the known occurrences of actinoceroids, endoceroids, michilinoceroids (orthoceroids), ellesmeroceroids, tarphycerids, and discosorids; in 1971, he summarized the forms known from beds of Whiterock age. One family of ellesmeroceroids, the Baltoceratidae, survives into Whiterock time. Three new families, the Cyrtocerinidae, the Shideleroceratidae, and the Bathmoceratidae appear in the Middle Ordovician. The families Basslerocerati dae and Tarphyceratidae of the Tarphyceratida disappear at the base of the Whiterock (Flower, 1976a). Endoceroids were less effected at the close of the Canadian; a decline of Proterocameroceratidae, disappearance of Manchuroceratidae, and decline of

Piloceratidae characterized the Canadian (Flower, 1971).

Materials and Methods

The fossil collections described here were made by Dr. R.H. Flower (New Mexico Bureau of Mines and Mineral Resources) and colleagues under Lehi F. Hintze's (Brigham Young University) NSF grant GBI-3154. Cephalopods were collected in sections 30 and 31 of T. 22 S., R. 14 W. of the Barn Quadrangle, Utah. Locations of sample horizons are not precisely known stratigraphically.

The cephalopod collections are housed in the Paleontology Laboratory of the New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico. Figured and type specimens were given temporary catalog numbers. The collection is extensive; more than 150 specimens were sectioned and examined. Unfortunately, the majority were too fragmentary for identification, and approximately 60 specimens were utilized in this study. Hook and Flower (1977) documented a portion of the cephalopod fauna from the underlying Wahwah Limestone. Many specimens from the underlying formations (the Wahwah Limestone and Fillmore Formation) and the overlying Kanosh Shale and Lehman Limestone remain undescribed or in manuscript by Flower.

Specimens were cleaned in dilute hydochloric acid, soaked in varnish to harden them, then sectioned to allow observation of internal structures. Cut surfaces were ground by hand and etched gently with dilute hydrochloric acid to highlight structure. Specimens coated with iron oxide as a result of weathering were cleaned in dilute oxalic acid. Preparation for photography was made using a sublimate of ammonium chloride to whiten surfaces and provide contrast. Thin sections facilitated study of complex internal structures. Comparisons were made to specimens housed in the Paleontology Laboratory of New Mexico Bureau of Mines and Mineral Resources and others from the U.S. National Museum.

SYSTEMATIC PALEONTOLOGY

Order ELLESMEROCERATIDA Flower, 1950

Family BALTOCERATIDAE Kobayashi, 1935

Genus *Cyptendoceras* Ulrich and Foerste, 1935

Genotype: *Cyptendoceras ruedemanni* Ulrich and Foerste, 1935

1935. *Cyptendoceras* Ulrich and Foerste, p. 270.

1944. *Cyptendoceras* Ulrich and Foerste: Ulrich, Foerste, Miller, and Unklesbay, p. 113.

1955. *Cyptendoceras* Ulrich and Foerste: Flower, p. 365.

1964a. *Cyptendoceras* Ulrich and Foerste: Flower, p. 114-115.

1964. *Cyptendoceras* Ulrich and Foerste: Teichert, et al., p. K166.

1977. *Cyptendoceras* Ulrich and Foerste: Hook and Flower, p. 22-23.

DESCRIPTION -- Orthoconic shells with slightly depressed cross sections, large ventral siphuncles composed of tubular or faintly concave segments, and sutures which are transverse dorsally and laterally with a conspicuous ventral lobe. A ventral rod lies against the ventral wall of the siphuncle in some species. Cameral deposits confined to the ventral part of the shell and usually episeptal, but hyposeptal deposits may be present.

DISCUSSION -- Originally described as an endoceroid with holochoanitic necks (the ventral rod was mistakenly interpreted as endocones), Flower (1964a) removed *Cyptendoceras* from the Endoceratida based on the absence of endocones, the development of thin, ventrally concentrated cameral deposits, and the presence of a ventral rod; this evidence clearly places *Cyptendoceras* with *Rhabdiferoceras*, *Murrayoceras* and *Cartersoceras* of the Baltoceratidae. *Cyptendoceras* is distinguished from *Rhabdiferoceras* by the more rapid apical expansion of the ventral

rod; also, the septal necks in *Rhabdiferoceras* range from achoanitic to orthochoanitic; sutures are straight and transverse.

Cyptendoceras cf. *C. ruedemanni* Ulrich and Foerste, 1935

Fig. 15-1

1935. *Cyptendoceras ruedemanni* Ulrich and Foerste, p. 270, pl. 38, fig. 5.

1944. *Cyptendoceras ruedemanni* Ulrich and Foerste: Ulrich, Foerste, Miller, and Unklesbay, p. 113, pl. 60, figs. 1-3.

1964a. *Cyptendoceras ruedemanni* Ulrich and Foerste: Flower, p. 115, pl. 22, figs. 2, 10, 11,; pl. 23, figs. 18-20.

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-51, Juab Limestone, Ibex area, Utah.

DESCRIPTION -- Portion of phragmocone, enclosed in matrix, making the suture pattern undeterminable. Specimen is 68.5 mm in length, expanding from 2.2 mm to 8.0 mm in diameter. Septal spacing increases gradually from 1.8 mm to 2.5 mm adorally. The ventral siphuncle is filled with a ventral calcite rod 21 mm in length. The morphology of the rod at its apical end cannot be determined because of the oblique section. Anterior end of rod is pointed. Rod is 2 mm wide at its widest point, and decreases gradually to a sharp termination 26.2 mm vfrom the anterior of the specimen. Septa are strongly inclined near the siphuncle. Cameral deposits are largely, but not exclusively, episeptal, and partially obscure the nature of septa and septal necks. Recrystallization has largely destroyed the connecting rings.

DISCUSSION -- Hook and Flower (1976) describe a specimen which they assign to *Cyptendoceras ruedemanni*, based on the similarity of the profile of its rod. Their specific identification was tentative, but if correct, it extended the geographic range of *C. ruedemanni* from the Champlain Valley to New Mexico, and its geologic range upward to Zone J. Although the specimen described here is similar to *C. ruedemanni*, the likelihood of it being *C. ruedemanni* is remote, as *C.ruedemanni* is from the Fort Cassin Limestone (upper Canadian in age) of the Vermont and New York areas (R.H. Flower, personal communication). If, however, the identification presented here is correct, the geographic range is further extended to Utah and the geologic range is extended upward to include zone L as well as Zone J.

Cyptendoceras cf. *C. rhythmicum* Flower, 1964

Fig. 15, 2-3

1964a. *Cyptendoceras rhythmicum* Flower, p. 117-118, pl. 22, fig. 1, 3-9; pl. 23, fig. 1-4, 16, 17.

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-56; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This specimen is a portion of phragmocone with a small fragment of living chamber attached. The entire specimen measures 35 mm in length, and 14 mm high by 16 mm wide (estimated). Weathered on dorsum, broken obliquely orally, the rate of expansion is low. Suture pattern apparently straight and transverse dorsally, with a broad lobe ventrally. Specimen was ground to reveal the siphuncle, which is narrowly separated from ventral wall of shell. Siphuncle circular in outline. Ground section (Fig. 15-3) reveals empty siphuncle, which expands gradually from 4 mm to 4.5 mm. Septa closely spaced, approximately 5 camerae in a length of 10 mm. In early growth stages, septal

spacing is fairly uniform at about 2.3 mm. Camerae occurring mid-length of specimen show wide variation in spacing (from about 0.6mm to 4.5 mm). Orally, the final camerae is 1.6 mm in length. Preservation makes distinguishing septal necks from connecting rings difficult, but apparently septal necks are orthochoanitic, and connecting rings appear homogeneous. A small portion of living chamber is anterior of this final chamber. Shell is smooth.

DISCUSSION -- Although the only other known occurrence of *Cyptendoceras rhythmicum* is Zone N in the Ely Springs Range, Nevada (Flower, 1964a), this specimen exhibits the rhythmic variation in septal spacing which is a characteristic feature of this species.

Family BALTOCERATIDAE Kobayashi, 1935

Genus and species indeterminate

Fig. 5; Fig. 15, 5-7

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-60; J2-J3 (13-25 feet above base of the Juab Limestone) section 30, T. 22 S., 14 W., southern end Confusion Range, Ibex area, western Millard County, Utah. Collected by L.F. Braithwaite.

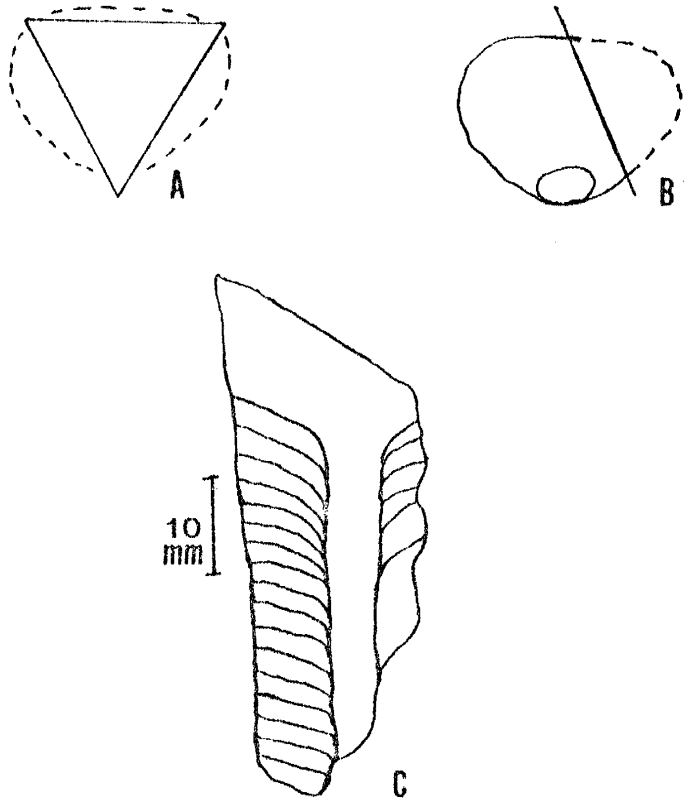
DESCRIPTION -- This specimen is characterized by a subtriangular cross section with pronounced flattening of the dorsum, and is a portion of phragmocone and living chamber, 58 mm in length. Specimen is badly weathered on one side, exposing the septa, which are closely spaced (Fig. 15-5); 13 occur in 41 mm (spacing approximately 3 mm apart). Siphuncle is exposed on venter, and measures approximately 5 mm wide at its apex. Sutures straight, with pronounced apical inclination near the siphuncle. Rate of expansion is approximately 1 mm in 20 mm. Figure 5 is a reconstruction of the original outline of the specimen, which is

Figure 5--Baltoceratidae, genus and species indeterminate, UTPO-60 (see also Figure 15-5 through 15-7).

A) Schematic transverse section at anterior end; triangle superimposed on outline of specimen (dashed line).

B) View of anterior end, showing position of siphuncle. Solid line represents plane of weathering on specimen.

C) Ventral view, showing inclination of septa in vicinity of siphuncle. Right side of specimen is missing (weathered).


A
B
10
mm
C

subtriangular in shape, with the apex of the triangle ventral. Siphuncle is approximately one-quarter conch diameter. Shell smooth; ectosiphuncle not known.

DISCUSSION -- Although this specimen probably represents a new genus, establishment of a formal name is postponed until more complete material is found. No other baltocerid has been described with a subtriangular cross section with the dorsum flattened. Foerste (1926) described a form (*Murrayoceras*) with a subtriangular cross section; however, it is flattened ventrally. It is tentatively placed within the Baltoceratidae based on its external morphology (smooth, orthoconic), and its large marginal siphuncle. Without knowledge of the ectosiphuncle, this specimen cannot be definately placed with the Baltoceratidae to the exclusion of the Ellesmeroceratidae.

Family BALTOCERATIDAE Kobayashi, 1935

Genus and species indeterminate

Fig. 15-4

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-58; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- Specimen is a portion of a small orthocone, 38 mm in length, weathered on the dorsum. Specimen expands from 11 mm by 9 mm to 15 mm by 13mm (estimated) in this length. Siphuncle ventral in position. Specimen was ground to reveal internal structures. Septa are closely spaced over the length of the specimen, 3 to 4 mm apart, and are steeply inclined. Siphuncle vacuosiphonate; septal necks appear to be orthochoanitic, with simple connecting rings. Anterior-most camerae filled with calcite.

DISCUSSION -- This specimen is poorly preserved and not identifiable beyond familial level. Its small size, crowded septal spacing, orthochoanitic septal necks, and siphuncle position places it within the Baltoceratidae.

Order ENDOCERATIDA Hyatt, 1900

Family ALLOTRIOCERATIDAE Flower, 1955

Genus *Williamsoceras* Flower, 1964

Genotype: *Williamsoceras adnatum*, Flower 1964

1964b. *Williamsoceras* Flower, p. 60.

1968. *Williamsoceras* Flower: Flower, p. 26.

DESCRIPTION -- Slender orthoconic endoceroids with holochoanitic to macrochoanitic septal necks and a ventral siphuncle. Endosiphuncular characteristics distinguish the genus: a high narrow ventral process about which endocones are deposited results in a crescentic endosiphocone which is shorter ventrally than dorsally. Near the apex, a series of buttresses widen apically. The endosiphocone terminates in the infula, a dark band which connects tubes arranged in an arc; these tubes lack diaphragms. The siphuncle does not exhibit a swollen *Nanno*-type apex, but tapers gradually to a small slender tip.

DISCUSSION-- *Williamsoceras* is known from the Garden City Formation of northern Utah, the Nora Formation of Queensland Australia (Hill, Playford and Woods, 1969, cited in Flower, 1976b), from the Kunda Stage of the Baltic, and the Juab Limestone of western Utah, and appears to be restricted to the Whiterock: however, no comparable forms have been reported from the Whiterock of Newfoundland (Flower, 1976a). *Williamsoceras* is also known form the "Caradoc" of Bolivia, which is probably also Whiterock in age (Flower, personal communication). It is characteristic form of the Whiterock Stage (Flower, 1976b).

Williamsoceras may form a link between the Canadian form, *Coreanoceras*, and the Chazyan forms *Allotrioceras* and *Mirabeloceras*; the latter two are more specialized than *Williamsoceras* (Flower, 1964). *Coreanoceras*, with short necks,

can be reasonably derived from the Proterocameroceratidae (Flower, 1976a).

Figure 6 contains diagrammatic cross sections of the species of *Williamsoceras* encountered in this study.

Williamsoceras adnatum Flower, 1964

Fig. 6,7; Fig. 16, 1-11

1964b. *Williamsoceras adnatum* Flower, p. 60, pl.2, figs. 1-7.

1968. *Williamsoceras adnatum* Flower: Flower, p. 28, pl. 17, figs. 1-15; p. 18, figs. 8-16, 24-26; pl. 19, figs. 1-8; text-fig. 2-4.

FIGURED SPECIMENS AND OCCURRENCE -- UTPO-3, UTPO-4, UTPO-7, UTPO-40; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- Four specimens of *Williamsoceras adnatum* are described and illustrated to show the tube and blade pattern. The first specimen (UTPO-40; Fig. 16, 8-11) is a portion of a siphuncle with only fragments of shell wall remaining, measuring 141 mm in length, partially enclosed in matrix, and weathered on the dorsum. The interior of the siphuncle is known from a series of transverse sections. A section 29 mm apicad of the anterior (Fig. 16-8) measures 31 mm wide, is weathered slightly to the right of the dorsum, and reveals the anterior termination of a high narrow ventral process. A second section, 43 mm apicad, shows the development of endocones draped over the ventral process which is 16 mm high and measures 7 mm at its base. Here the siphuncle measures 28 mm and 27 mm.

The third section, 29 mm further apicad (Fig. 16-9), reveals in esquisite detail the ventral process and the dark infula connecting the tubes, and measures 24.5 mm by 25 mm. A fragment of shell wall is preserved, and is in contact with the

Figure 6--Diagrammatic cross sections of siphuncles of *Williamsoceras adnatum, W. ankhiferum, W. ellipticum*, and *W. pedunculatum*.
Siphuncles are oriented with venter down.
Adapted in part from Flower, 1976b, p. 15.

A-C: *Williamsoceras adnatum*

A. Anterior section, showing growth of ventral process beginning

B. Section farther apicad, showing the ventral process more developed, the beginning of the infula, and the endociphocone complete dorsally and draped around the process.

C. Section more apicad, showing well developed tubes and connecting infula.

D-F: *Williamsoceras ankhiferum*

D. Anterior section, showing development of ventral process and infula. Limbs of infula widely separated at siphuncle margin.

E. Section farther apicad, showing development of endosiphocone.

F. Apical-most section; process more developed, limbs of infula widely separated at siphuncle margin.

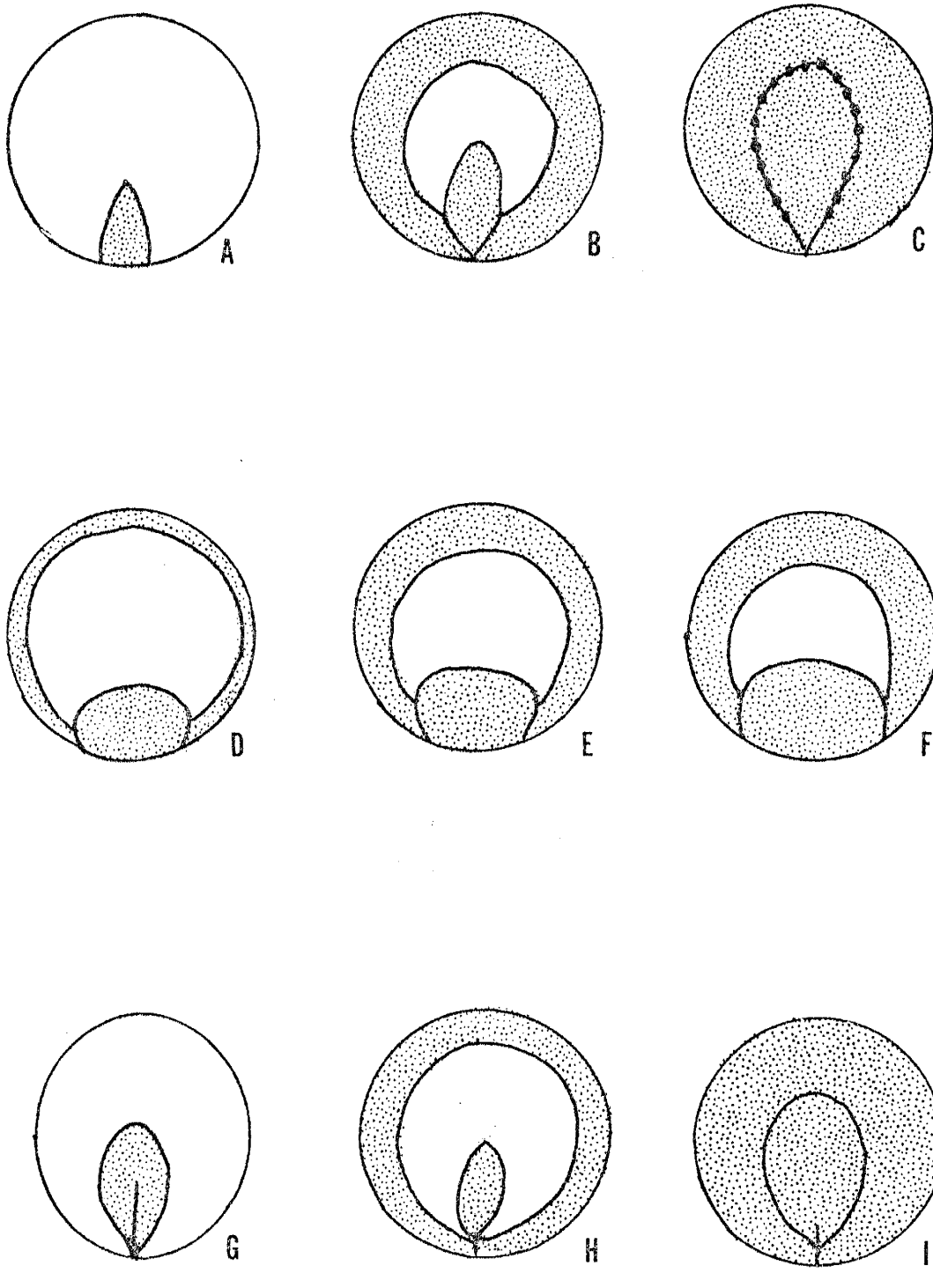
G. *Williamsoceras ellipticum*

Cross section apicad of the endosiphocone, showing compressed cross section, ventral process with median blade.

H-I: *Williamsoceras pedunculatum*

H. Anterior cross section, showing early development of endosiphocone and ventral process.

I. Section apicad of the endosiphocone showing development of infula and stalked ventral process.


A
B
C
D
E
F
G
H
I

siphuncle. Figure 16-10 is the posterior view of this same section. A thin section from this area shows good preservation of tube morphology (Fig. 16-11). The ends of the infula appear to meet ventrally, and are narrowly separated from the ventral margin. The ventral process is 9 mm high and less than 1 mm wide throughout its length.

The second specimen (UTPO-3; Fig. 16, 1-4) is a portion of a siphuncle approximately 143 mm in length (the apex is surrounded by matrix, thereby making exact determination of the length impossible). A section 33 mm apicad of the anterior (Fig. 16-1) measures 27.5 mm and 26 mm and shows a small ventral process which is 13 mm high and measures 3 mm at its base.

Approximately 10 mm apicad, a natural break occurs (Fig. 16-2); the ventral porcess is well developed, and extends well into the siphuncle interior.

Twenty-eight mm farther apicad, a second cross section measures 24.5 mm by 23 mm and is filled with coarsely crystalline calcite (Fig. 16-3). The venter is slightly flattened. Tubes and connecting infula are well developed although partially obscured by recrystallization, which also has destroyed the ventral margin.

The third section 82 mm further apicad shows advanced recrystallization; the cross section measures 20 mm by 18 mm (Fig. 16-4). The infula and ventral process are discernable, but recrystallization has obliterated the tubes.

A third specimen of *Williamsoceras adnatum* (UTPO-4; Fig. 16, 5-7) is a portion of siphuncle, enclosed in matrix, and approximately 77 mm long. The ventral surface is weathered, exposing an intersection of the infula with the siphuncle margin (Fig. 16-5). Internal morphology of the siphuncle is known from two transverse sections, the first of which is 25 mm apicad of the anterior end of the specimen (Fig. 16-6). Here the height is 15.5 mm and the width, 19 mm. Although the interior of the siphuncle is badly recrystallized, the infula can be traced, its limbs joining very near or at the margin of the siphuncle. Vestiges of

the median blade appear as a dark area.

A second section 40 mm apicad (Fig. 16-7) has suffered less from poor preservation; the infula here shows plainly. The cross section measures 13 mm by 15 mm wide. A large portion of the median blade (approximately 5 mm) is visable as a dark line extending into the interior of the siphuncle.

A fourth specimen (UTPO-7) is again a portion of siphuncle, approximately 90 mm in length. A thin section was made at approximately 26 mm from the apex; this is illustrated in Figure 7. Recrystallization has destroyed the finer structures; although the infula can be plainly seen, no tubes remain. The median blade of the ventral process is still present, as well as a dorsal blade. The specimen is essentially circular in outline, and measures 17 mm in diameter.

DISCUSSION -- These specimens illustrate the poor preservation so often seen in this fauna. Although recrystallization has obscured tubes, the infula and median blade of the ventral process are still recognizable and serve to identify this species as limbs of the infula meet very near the ventral siphuncle margin.

Williamsoceras ankhiferum Flower, 1968

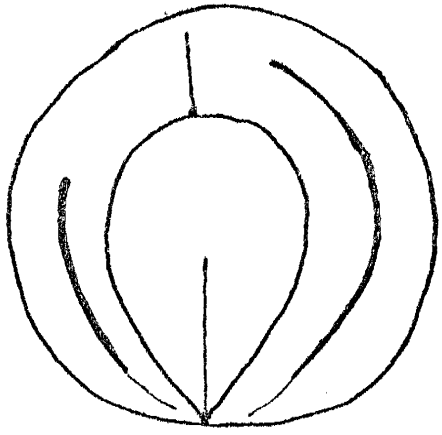
Fig. 6; Fig. 17, 1-4

1968. *Williamsoceras ankhiferum* Flower, p. 31, pl. 18, figs. 1-7.

TYPE AND OCCURRENCE -- UTPO-5, hypotype; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This specimen is a siphuncle, 109 mm in length, the internal structure of which is known from three transverse sections. Anterior portion of specimen is broken (Fig. 15-1).

Figure 7--Enlargement of thin section, approximately X 5, showing cross section of specimen number UTPO-7, *Williamsoceras adnatum*. Median blade of ventral process and infula well developed; dorso-lateral blade also present.



The first section, 42 mm apicad of the anterior break measures 25 mm and 29 mm (partially reconstructed) and shows a distinctly developed ventral process, which measures 7 mm by 9 mm (Fig. 17-2). The second section, 18 mm apicad, measures 21 mm and 23 mm, and clearly shows the broadly rounded infula (Fig. 17-3). A final section 21 mm further apicad, shows a reduction of endosiphocone to a smaller crescent (Fig. 17-4). The infula is well defined and its limbs are widely separated at the siphuncle margin. Also visible here are small tubes connected by the infula.

DISCUSSION -- The type and only other known specimen of *Williamsoceras ankhiferum*, described by Flower (1968) represented a portion of the endosiphuncle completely apicad of the endosiphocone. The specimen described here is important, not only because it doubles the known number of specimens of *W. ankhiferum*, but also because it illustrates the morphology of the species orad of the endosiphocone, and is therefore designated as a hypotype.

Williamsoceras cf. *W. ellipticum* Flower, 1976

Fig. 6; Fig. 17, 5-7

1976b. *Williamsoceras ellipticum* Flower, p. 36, pl. 9, figs. 1-5.

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-1; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This figured specimen is a portion of siphuncle, 156 mmm in length, partially enclosed in matrix, and weathered on the dorsal side (Fig. 17-5). It expands from 12 mm and 11.5 mm to 18 mm and 16.5 mm in 42 mm, the distance between two transverse sections. Advanced recrystallization by coarse

calcite and limonite has destroyed most internal structure. A transverse section 70 mm from the anterior end shows the limbs of the infula joining almost 2 mm from the siphuncle margin (Fig. 17-6); the section 42 mmm apicad reveals the limbs joining at the ventral margin (Fig. 17-7). Tubes, buttresses, and the ventral process are not preserved.

DISCUSSION -- The compressed cross section and general morphology of the infula justify assignment of this specimen to *Williamsoceras ellipticum*. The fact that the limbs of the infula join before reaching the ventral margin may indicate a new species. Although vagaries of preservation cannot be ruled out as the cause of this apparent abnormality, the structures involved appear original. Resolution of this problem awaits better preserved material.

Williamsoceras cf. *W. pedunculatum* Flower, 1968

Fig. 6; Fig. 17, 8-10

1968. *Williamsoceras pedunculatum* Flower, p. 30, pl. 17, figs. 16-25.

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-21; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This specimen is a portion of siphuncle, 84 mm long, and completely apicad of the endosiphocone (Fig. 17-8). The anterior portion is broken obliquely; approximate dimensions are 21mm and 18 mm. A transverse section 52 mm apicad of this break measures 17 mm and 16 mm (Fig. 17-9). Infular limbs connect with ventral process's median blade near the siphuncular ventral margin; ventral process appears stalked, but has been somewhat destroyed by recrystallization. The siphuncular outline is somewhat distorted probably due to

compaction or post mortem compression. Preservation of a dorsal blade is faint, due to recrystallization. A second transverse section (Fig. 17-10) measures 14 mm by 16 mm and is badly recrystallized. The apex is embedded in limestone, but apparently tapers gently.

DISCUSSION -- Unfortunately, the poor preservation and fragmentary nature of this specimen prevent its definite assignment to *Williamsoceras pedunculatum.* However, the stalked nature of the ventral process and the vestige of a dorsal blade, although faint, indicate its assignment here rather than to the similar *W. adnatum.*

Genus A., new genus

Genotype: Genus A., species A., new species

Fig. 8; Fig. 18, 1-11

DEFINITION -- This new genus is erected for small slender endoceroids characterized by the nature of their endosiphuncles; the phragmocone is not known. The endosiphuncle is characterized by petal or prism-like structures which extend outward from the center of the siphuncle towards its margin; the position of these structures lacks bilateral symmetery.

DISCUSSION -- This genus exhibits morphology intermediate between that of "*Kachina*" (Flower, in manuscript) and *Williamsoceras.* "*Kachina*" is known only from the Nora Formation of Queensland, Australia, and is characterized by numerous prisms which eminate from a large ventral process. Tubes are present on the margin of the prisms as well as on the infula. Genus A has prisms, but without tubes. *Williamsoceras* has an infula which connects an arc of tubes, but no prisms.

Dorsoventral orientation is not possible, due to the lack of septal ridges or

phragmocone, but it is assumed the large prism, which is outlined by the infula and exhibits a median blade, is ventral.

Genus A. is unusual in that it does not exhibit bilateral symmetry. Although unusual, this lack of symmetry is not unknown in endoceroids; Teichert and Crick (1974) describe an Ordovician endoceroid with a blade pattern oriented asymmetrically with regard to the dorsoventral plane of the siphuncle.

Genus A., species A., new species

Fig. 8; Fig. 18, 1-11

TYPES AND OCCURRENCE -- UTPO-23, UTPO-24, UTPO-25, designated as syntypes; from the Juab Limestone, Ibex area, Utah.

DEFINITION -- This species, the genotype of the genus, has the characteristics of the genus.

DESCRIPTION -- Genus A., species A. is known from three specimens, here designated as syntypes.

The first syntype (UTPO-23) is a portion of endosiphuncle enclosed in matrix, and 27 mm in length (Fig. 8; Fig. 18, 1-5). A series of four transverse sections were taken to expose internal morphology, which changes so rapidly and drastically that it is necessary to discuss each transverse section in detail although they are separated by only a few millimeters. The first section, taken at the anterior of the specimen (Fig. 18-1) shows a large ventral prism, with an infula, a shadow of median blade, and faint lines extending downward towards the venter from this prism. Faint vestiges of a central tube structure can be seen in all sections. A large calcite crystal fills the upper third of the prism. Ventral wall of siphuncle is weathered, and therefore is not as complete as dorsal side.

A second transverse section 19 mm apicad measures 10 mm by 12 mm, and

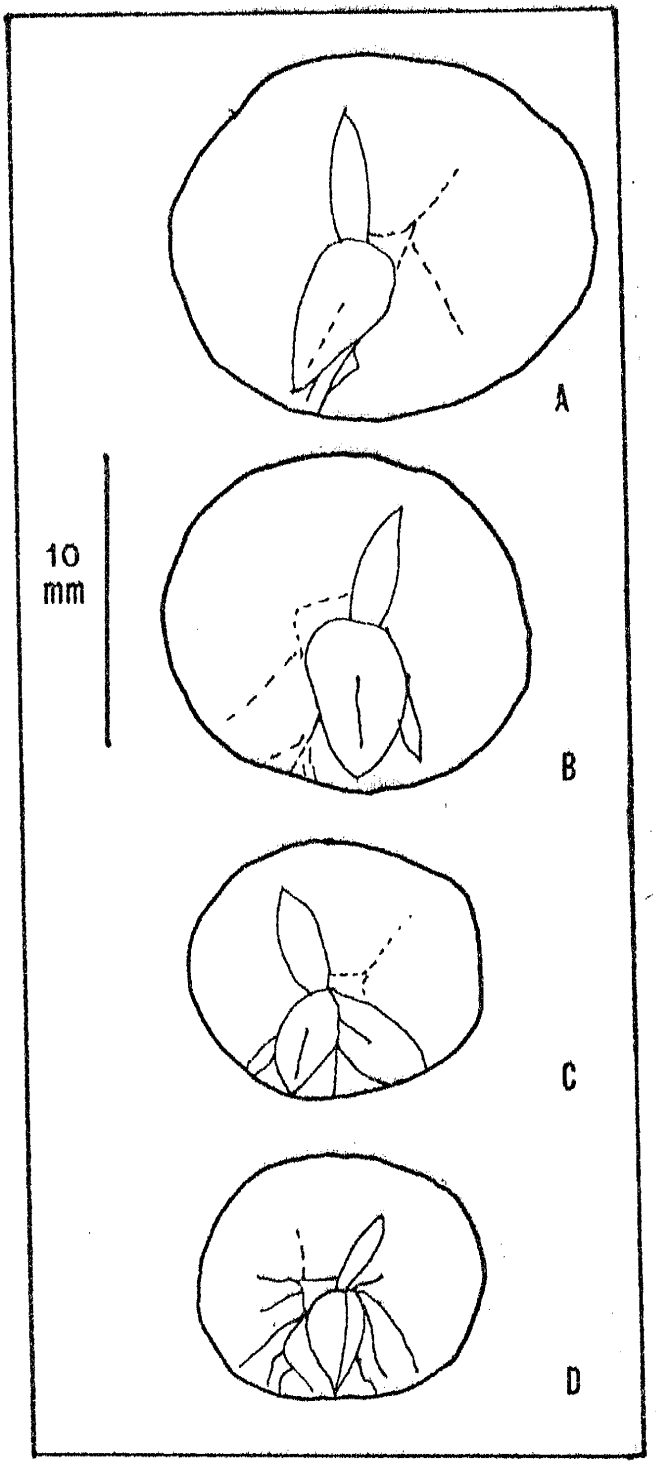
Figure 8--Series of transverse sections of Genus A., sp. A, new genus (UTPO-23, syntype #1). Venter (?) down.

A. Anterior cross section, showing a large ventral prism with infula.

B. Cross section 19 mm apicad; median blade of ventral prism developed.

C. Posterior view of (B). Third prism is present. Fine blades extend downward to siphucle margin.

D. Apical-most cross section; ventral prism smaller, with less pronounced central blade.


A
10
mm
B
C
D

reveals the median blade of ventral process in greater detail (Fig. 18-2). The central tube structure is also clearer here. Fine blades extend downward toward siphuncular margin.

The third transverse section shown in Figure 18-3 reveals how rapidly the character of the siphuncle changes; this is the opposite (posterior) view of the previous section. A third "prism" is developed here, and shows development of a median blade, not from the ventral margin, but from its junction with the ventral prism. The dorsal prism is offset, not placed centrally. Fine blades extend downward to the siphuncular margin.

The fourth transverse section, 13 mm apicad, is faintly reminiscent of Rossoceras, with its numerous blades (Fig. 18-4). The ventral prism is smaller, less oval and has a less pronounced central blade.

Figure 18-5 is an enlargement of a thin section taken between Figs. 18-3 and 18-4; the median blade is well developed, and the beginnings of numerous finely branching blades is apparent.

The second specimen (UTPO-24), herein designated as a second syntype, is illustrated in Figure 18, 6-8. It represents a section of siphuncle more orad than UTPO-23, and shows a well developed endosiphocone. Two transverse sections were made to reveal the endosiphocone; the first was taken 7 mm apicad of the anterior of the specimen. Figure 18-6 is the anterior view of this section; Figure 18-7 is the posterior view. Here the siphuncle measures 17.5 mm by 19 mm. The endosiphocone is slightly flattened ventrally. Two prism-like or teardrop structures originate from the cone and point toward the siphuncle margin. Assuming the siphuncle and endosiphocone are flattened ventrally (therefore allowing orientation), the larger prism is located slightly to the right of vertical on the dorsal side. The ventral prism is also located to the right of vertical ventrally.

A second transverse section, 18 mm apicad, shows increased development of

both ventral and dorsal prisms, and the dorsal prism originates further into the cone (Fig. 18-8). Prisms close completely before they reach the siphuncle margin.

The third specimen (UTPO-25), also designated as a syntype, is an endosiphuncle, 82 mm in length, and broken orally, near the apical termination of the endosiphocone (Fig. 18, 9-11). Specimen expands from 15 mm by 16 mm to 17 mm by 18 mm in this length. Transverse section 32 mm apicad of anterior end shows a central tube with downcurved edges, and a dorsal (?) prism which extends into the siphuncle cavity approximately 5.5 mm and is outlined by the infula (Fig. 18-10, anterior view, 18-11, posterior view). A blade extends to the siphuncle margin from the apex of the prism. Apical portion is broken longitudinally, revealing the central tube and prism.

DISCUSSION -- This new genus is presently known only from these three small specimens. Their small size and poor state of preservation (they are enclosed in matrix, and only by fortuitous sectioning is their internal structure revealed) makes them easily overlooked, in laboratory preparation as well as in field collecting. It is hoped that further work will bring more specimens to light and thereby increase our knowledge of this new, very interesting, enigmatic, and potentially biostratigraphically useful form.

Phylogenetic relationships are tentative, but this new genus may be a transitional form between *Williamsoceras* of the Allotrioceratidae and "*Kachina*", a genus in manuscript by Flower, which will probably be the type genus of a family yet to be erected. Genus A. is placed in the Allotrioceratidae for the present.

Family PADUNOCERATIDAE Balashov, 1960

Genus *Rossoceras* Flower, 1964

Genotype: *Rossoceras lamelliferum* Flower, 1964

1964b. *Rossoceras* Flower, p. 59.

1968. *Rossoceras* Flower: Flower, p. 32.

DESCRIPTION -- This is a genus of orthoconic, slender endoceroids, which may be quite long, and known mainly from endosiphuncles. The siphuncle is ventral, commonly in flattened contact with the shell, and consists of hemochoanitic necks supplemented by rings. Endosiphocone venter is flattened, to semicircular and crescentic. Cross section is depressed. Endosiphuncle is penetrated by numerous bifurcating blades which may be lost due to recrystallization, but usually vestiges of a mid-dorsal blade and a pair of downcurved lateral blades remain. The siphuncle gently tapers to a small, blunt tip.

DISCUSSION -- Study of this genus involves some problems due to advanced alteration and recrystallization which obscures the blades; also, specimens with portions of the shell preserved are rare. The large suite of specimens described in this report show varying stages of recrystallization.

Relationship to other endoceroid genera is not certain, but suppression of sheaths and strong development of multiple prominent blades indicated placement in the Padunoceratidae (Flower, 1968). This family is probably derived from the Proterocameroceratidae (Flower, 1976b).

Rossoceras seems indigenous to Utah and Nevada, and is apparently confined to the Whiterock Stage of these areas.

Rossoceras lamelliferum Flower, 1964

Fig. 19, 1-5

1964b. *Rossoceras lamelliferum* Flower, p. 59, pl. 4, figs. 2, 13-22.

1968. *Rossoceras lamelliferum* Flower: Flower, p. 33, pl. 15, fig. 15; pl. 20, figs. 1-9; pl. 21, figs. 1-24; pl. 22, figs. 6-18, 22-25; text-figs. 5,6.

FIGURED SPECIMENS AND OCCURRENCE -- UTPO-15 and UTPO-19; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION --The first specimen (UTPO-15) is a long slender siphuncle, partially embedded in matrix and partially weathered (Fig. 19, 1-3). The depressed siphuncle expands from 17 mm by 19 mm to 30.5 mm by 33 mm in 231 mm, the length of the specimen. A break occurs approximately 50 mm apicad of the anterior end of the specimen; this break exposes a portion of the endosiphocone, and reveals longitudinal striae unevenly spaced over the surface of the endosiphocone an average distance of <2 mm apart. The interior of the siphuncle is known from two of transverse sections, the first of which is approximately 133 mm apicad of the break (Fig. 19-2). Here the siphuncle measures 20.5 mm by 22 mm, and shows a small fragment of shell material almost in contact with the ventral side of the siphuncle. The specimen is very slightly flattened ventrally. Radiating outward from the central tube are numerous fine dark blades which bifurcate repeatedly. Siphuncle margin is surrounded by a light gray area which contrasts with the white calcite within. The blades are uniform in prominence. A section 57 mm apicad measures 17 mm by 19 mm (Fig. 19-3), and shows fine blades and the central tube. The specimen is incomplete apically.

The second specimen (UTPO-19) shows very good preservation of the fine

blades (Fig. 19-4,5). Specimen is a portion of siphuncle with fragments of shell attached, approximately 136 mm long and expands from a height of 14 mm and width of 17 mm to 17 mm by 19 mm in a length of 28 mm, the distance between two cross sections. Figure 19-4 shows the anterior view of this cross section which reveals the numerous fine bifurcating blades extending outward from the tube. The tube is located subcentrally, and is closer to the dorsum than to the venter (5.5 mm from the dorsum and 8.5 mm from the venter). Tube is oval in shape and does not exhibit downcurved edges seen in other specimens. A fragment of shell material is preserved and is in contact with siphuncle venter.

Figure 19-5 is a longitudinal section taken between the two cross sections, and shows the blades to be longitudinally complete structures. Septal necks appear to be hemichoanitic.

DISCUSSION -- *Rossoceras lamelliferum* is the most characteristic cephalopod of the Juab Limestone. Over 90 specimens were sectioned and studied; unfortunately, the vast majority of these were too poorly preserved to justify their inclusion here, and because they did not add materially to the concept of the taxon, they were omitted. Two of the best preserved specimens are figured and described here. In general, specimens have the following characteristics: they are long, slender, endosiphuncles; specimens not totally enclosed in matrix show septal ridges which are separated by slightly concave segments and slope toward the dorsum thereby allowing good dorsoventral orientation; angle of inclination of septal ridges is between 20 and 30 degrees; shells are not usually preserved; blades show varying stages of preservation, ranging from quite good, to very poor, some showing only vestiges of blades, with a middorsal blade and a pair of downcurved lateral blades commonly preserved, while the best preserved specimens exhibited the blades in exquisite morphologic detail.

Flower (1968) discussed the possibility that future work may indicate that

differences in the form of the endosiphotube may prove to be of consistant specific value. The endosiphotube, which is commonly downcurved at the sides and widened in the middle, may be perfectly transverse, with prominent horizontal lateral blades. These criteria, as predicted by Flower, remain fallible due to erratic preservation of blades and tubes.

Rossoceras sp. A., n. sp.

Fig. 20, 1-9, 13

TYPES AND OCCURRENCE -- UTPO-34; 15 feet below the top of the Juab Limestone; UTPO-32, UTPO-33, UTPO-35 from Juab Limestone, Ibex area, Utah. All specimens are designated as syntypes.

DEFINITION -- The species is characterized by a dark circular structure which surrounds the central tube.

DESCRIPTION -- This new species of *Rossoceras* is known from four specimens, which are designated as syntypes. The first syntype (UTPO-32) is part of a siphuncle, approximately 100 mm in length and partially weathered on the dorsum (Fig. 20-1). A transverse section (Fig. 20-2) taken 20 mm apicad of the anterior end, measures 12 mm by 17 mm. The section illustrates the central tube, a dorsal and two ventrolateral blades. The dark ring which characterizes this species is visible 3 mm from the siphuncular margin.

The second syntype (UTPO-33) is a well preserved portion of siphuncle, 107 mm in length (Fig. 20, 5-7). A series of transverse sections reveal internal structure. Specimen expands from 18 mm by 21 mm to 22 mm by 24 mm in this length, becomes less depressed (more circular) adorally, and is slightly flattened ventrally with traces of septal ridges which allow dorsoventral orientation (Fig. 20-7).

Series of transverse sections reveal circular structure around central tube; numerous bifurcating blades pass through this structure without interruption. First section taken at (a) on Figure 20-7; this section is illustrated in Figure 20-5. The cross section measures 42 mm by 47 mm. Another section, approximately 35 mm apicad, is illustrated in Figure 20-6; the location of this cross section is indicated as (b) on Figure 20-7. Position of circular ring varies predictably through the length of siphuncle; near anterior, the ring is approximately 5 mm from siphuncluar margin, and near the apex, 9 mm from the margin.

The third syntype (UTPO-34) is a fragmentary siphuncle enclosed in matrix, broken in several places, and measuring 101 mm in length (Fig. 20-13). A transverse section 53 mm from the anterior measures 14.5 mm wide by 13 mm high, and therefore has a slightly depressed cross section. The section here reveals a central tube, 2.5 mm wide, with downcurved edges. Surrounding the tube at a distance of 1.8 mm, is a dark circular structure, from which several blades emanate; some of these bifurcate.

A second transverse section, 48 mm further apicad, measures 12 mm wide by 10 mm high, and shows only a vestige of the central tube. The nature of the septal necks and conch are unknown due to the fragmentary condition of the specimen.

The fourth syntype of *Rossoceras* sp. A (UTPO-35) is a well-preserved portion of siphuncle, 82 mm in length, and expands from 18 mm by 20 mm to 20 mm by 23 mm (Fig. 20, 8-9). Siphuncle exterior is very nondescript, with no septal ridges present (Fig. 20-9). Transverse section 48 mm from anterior end shows beginnings of endosiphocone development, and the ring structure 4 mm inside the siphuncular margin (Fig. 20-8).

DISCUSSION -- These specimens do not exhibit the toothlike elevation of the endosiphuncle material on the midventral side of the endosiphocone which is

characteristic of *Rossoceras dentiferum*. Presence of the circular structure surrounding the endosiphotube serves to distinguish this new species from *Rossoceras lamelliferum*. These four syntypes are described here to show variablity within the species and contribute equally to the concept of this new species. Siphuncle measurements vary from approximately 10 mm in diameter to approximately 25 mm in diameter; rate of expansion is slow, as in other species of *Rossoceras*. The main distinguishing characteristic of *Rossoceras* sp. A is the presence of the unique circular ring structure surrounding the central tube. The overall dimensions, slightly depressed cross section, and the presence of numerous bifurcating blades places it within the genus *Rossoceras*. The ring is visable even when conditions of preservation are poor, as is indicated by its presence when blades are obscure or destroyed.

Rossoceras cf. *R.* species A., n. sp.

Fig. 20, 3-4; 10-12; 14-18

FIGURED SPECIMENS AND OCCURRENCE -- UTPO-10, UTPO-29 and UTPO-30; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- Four specimens are described here. The first (UTPO-29) is a portion of siphuncle, approximately 190 mm in length, enclosed in matrix ventrally, and weathered dorsally; it is illustrated in Figure 20, 14-16. A series of transverse sections taken at intervals along the siphuncle reveal internal morphology; the first at 108 mm apicad of the anterior is shown in Figure 20-14. The siphuncle is recrystallized but vestiges of lateral blades and the circular ring structure remain, as well as a small fragment of shell. A section 38 mm further apicad (Fig. 20-15) shows these same structures. A cross section taken near the apex (Fig. 20-16) is badly recrystallized, and these structures are lost.

The second specimen (UTPO-30) is a portion of siphuncle, approximately 153

mm in length, and expanding from 20 mm by 21 mm to 26 mm by 28 mm (estimated) in this length. The anterior 40 mm is broken, revealing the intact endosiphocone.

A transverse section 29 mm from the apex is shown in Figure 20-4. All that remains of the blades is a single dorsal blade. Central tube with downcurved edges is clear and circular ring structure is visable just inside (4mm) siphuncle margin.

A second transveise section 52 mm orad reveals a fluted endosiphocone (Fig. 20-3). This structure is apparently original, and not the result of postmortem crushing.

The third specimen (UTPO-10) is a portion of siphuncle, partially enclosed in matrix, and badly recrystallized (Fig. 20, 10-12). The specimen expands from 17 mm by 19 mm to 20 mm by 22 mm in a length of 110 mm, and is flattened ventrally. Length is approximately 98 mm; an oblique break in the specimen occurs at the anterior end. Section 56 mm from the anterior end shows the endosiphocone to be central, filled with matrix, and 7 mm in diameter (Fig. 20-10). Faint ventrolateral blade which does not touch anterior of endosiphuncle also apparent. The ring structure characteristic of this species is visable, although recrystallization has destroyed finer structure.

Section 40 mm further apicad measures 18 mm by 19 mm in cross section, and shows endosiphotube, crescentic in cross section, and downcurved dorsally (Fig. 20-11). Blades extend from each end of the endosiphotube, approximately 10 mm into the interior of the endosiphuncle. Septal ridges visable on exterior of siphuncle.

The final specimen (UTPO-9) is a portion of siphuncle, 182 mm in length, broken slightly at each end, and embedded in matrix (Fig. 20, 17-18). Transverse section 46 mm apicad of anterior measures 23 mm by 26 mm, and shows ventral

flattening of the endosiphuncle (Fig. 20-18). Blade replacement is more gradual toward the margin than near the center. Central tube measures 4 mm in width. Section 31.5 mm apicad measures 22 mm by 25 mm; here, faint blades are apparent through somewhat obscured by recrystallization (Fig. 20-17). Ring structure is visable, although destroyed somewhat by a solution cavity. Remainder of specimen (anterior portion) is a poorly preserved section 57 mm long.

DISCUSSION -- Although preservation is not optimum in these specimens, they are included here to illustrate the the fact that advanced recrystallization obscures the blades and ring structures equally; that is, if the blades are recognizable, the ring structure should be also. And, although recrystallization has obscured the blades, the central tube, with its downcurved edges is visable; this feature is characteristic of *Rossoceras*, and is useful even in specimens which are very poorly preserved.

Rossoceras sp. B., n. sp.

Fig. 21, 1-4

FIGURED SPECIMENS AND OCCURRENCE -- UTPO-41 and UTPO-42; from the uppermost Juab Limestone or lower Kanosh Shale, Ibex area, Millard county, Utah.

DEFINITION -- This species is characterized by its broad ventral flattening; morphology of the tube and traces of preserved blades observed indicate assignment to *Rossoceras*.

DESCRIPTION -- This manuscript species of Flower is represented here by two endosiphuncles, each illustrating approximately the same growth stages. Ventral flattening increases as ontogeny progresses, as evidenced by more pronounced

flattening adorally.

The first specimen (UTPO-42) shows faint septal ridges oblique laterally, approximately 7 mm apart (Fig. 21-4). Nine septal ridges are preserved over the 65 mm length of the specimen. Rate of expansion is approximately 1 mm in 13 mm; specimen expands from 21.5 mm wide by 15 mm high.

Interior of siphuncle is badly recrystallized; dark central "smear" is a remnant of central tube and base of lateral blades (Fig. 21-3).

The second specimen (UTPO-41) is again, an endosiphuncle, 93 mm in length, expanding from 20 mm wide by 16 mm high to 26 mm by 21 mm in this length. Seventeen septal ridges are preserved over the length of the specimen, and are more pronounced than those on the other specimen of *Rossoceras* sp. B; their inclination is approximately 40 degrees from horizontal (Fig. 21-1). They are 5 mm apart apically, spacing increasing slightly adorally.

Blade pattern is destroyed by recrystallization, but the central tube and vestiges of downcurved lateral blades are visable in a transverse section taken 34 mm orad of the apex (Fig. 21-2). Here the section measures 22 mm wide by 17 mm high.

DISCUSSION -- These specimens are from very high in the Juab Limestone, perhaps at the boundary between it and the overlying Kanosh Shale. This species of *Rossoceras* has been throughly documented, described, and illustrated in manuscript by Flower, and will be formally named in a forthcoming publication. The types of these manuscript forms were kindly loaned by Dr. Frederick Collier, of the U.S. National Museum.

Rossoceras spp.

Fig. 21, 9-15

FIGURED SPECIMENS AND OCCURRENCE -- UTPO-6, UTPO-14, UTPO-17, and UTPO-39; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- Three specimens, belonging to *Rossoceras*, but not assignable specifically are described here. The first specimen (UTPO-6) is a portion of siphuncle, 198 mm in length, and embedded in matrix. Apical dimenisons are 10 mm by 11 mm (slightly depressed), expanding to 13 mm by 14 mm in a length of 60 mm, the distance to a transverse section (Fig. 21-13). Lateral blades exposed measure 12 mm, with the tube centrally located laterally, measuring less than 1 mm wide. The tube is slightly closer to the venter than to the dorsum.

Expanding to 20 mm by 21 mm in a length of 77 mm, the next section orad shows development of the endosiphocone (Fig. 21-12). Blades extend laterally outward from the endosiphocone, but are not in contact with the interior of the endosiphuncle; blades measure 19.5 mm end-to-end, including 6.5 mm of endosiphocone. Faint traces of other blades are barely discernable extending ventrally from the endosiphocone. The anterior portion of this section shows movement of the position of one of the blades from 180 degrees to approximately 165 degrees of separation. The anterior is a broken section 22 mm long.

The second specimen (UTPO-14), illustrated in Figure 21, 14-15, is a portion of siphuncle weathered on the ventral surface, showing traces of septal ridges which slope upward ventrally, allowing orientation of the specimen (Fig. 21-14). Measures 65 to 81 mm in length (specimen is broken obliquely adorally). Endosiphocone width 20 mm, height 17 mm apically; 20 mm by 26 mm adorally (slightly depressed cross section). Sectioning of apical portion reveals faint line (blade?) connecting endosiphuncle wall with spiess in center; and additonal two

faint lines 120 degrees apart extend outward from the spiess but do not intersect endosiphuncle wall (Fig. 21-15). Spiess in center is subtriangular in shape. Recrystallization has reinforced lateral blades and obscured fine blades. Specimen is flattened on ventral side.

Ilustrated on Figure 21, 9-11 are two specimens which illustrate external morphology of the siphuncle, although they are not well preserved internally. The first specimen (UTPO-17) is a portion of a siphuncle with pronounced septal ridges preserved over the entire length of 55 mm (Fig. 21-9). Segments are slightly concave, and approximately 7 mm apart. Expands from 16 mm by 17.5 mm to 19 mm by 22.5 mm. Section 30 mm apicad of the anterior end measures 17 mm by 20 mm (Fig. 21-10), and is near the tip of the endosiphocone. Here two lateral blades extend outward from the center toward the siphuncle periphery. The second (UTPO-39) is a fragmentary siphuncle weathered on the dorsum (Fig. 21-11). Matrix material has separated from the siphuncular wall by a ventral fracture, thereby allowing observation of the siphuncle exterior.

DISCUSSION -- Without knowing the structure of the blades, which have been destroyed by recrystallization, these specimens are not assignable specifically. Structure of the necks and connecting rings is not known due to the lack of preserved shell material.

Specimen number UTPO-14 is included primarily to illustrate the morphology of the ventral wall where the siphuncle is in contact with the shell and because it is one of few present in the collection in which portions of the shell wall are preserved. Specific determination is not possible due to the advanced recrystallization which has taken place within the siphuncle.

As the septal ridges are an internal reflection of the septa, the suture pattern can be extrapolated from them. The suture pattern of *Rossoceras* is straight and trasverse dorsally and laterally, with a small ventral saddle.

cf. *Rossoceras*

Fig. 21, 5-8

FIGURED SPECIMENS AND OCCURRENCE -- UTPO-11 and UTPO-12; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- Described here are two specimens assigned to *Rossoceras.* The first specimen (UTPO-11) is very fragmentary; only a portion of siphuncle is preserved, and this portion is incomplete both apically and anteriorly (Fig. 21, 5-6). The specimen is noteworthy, however, in that the exterior surface of the endosiphocone is exposed, and reveals faint longitudinal striae along its length. Striae are rather unevenly located over surface of endosiphocone averaging 2.5 mm apart (Fig. 21-6). Figure 21-5 shows a transverse section taken 84 mm apicad of the anterior; specimen is weathered on one side (venter?), dimensions here are 30 mm by 23 mm (incomplete); the endosiphocone measures 17 mm by 16 mm. The specimen expands from 25 mm and 17 mm to 32 mm and 25 mm in a length of 110 mm.

The specimen is too incomplete and lacks the apical portion of the siphuncle which would allow its generic placement with confidence. It is shown here primarily to illustrate the longitudinal striae on the endosiphocone which mark the base of the blades; these structures may prove to be of taxonomic significance in the future.

The second specimen (UTPO-11) is a long slender siphuncle, 141 mm in length, partially enclosed in matrix, but exposed throughout its length by weathering (Fig. 21-7). Advanced recrystallization has almost obliterated internal structure; a faint central tube with lateral blades can barely be discerned (Fig. 21-8). Here the transverse section measures 8 mm by 7 mm. The specimen measures 9 mm by 8 mm orally, and tapers to 4 mm by 3 mm apically in 52 mm.

Apparently the specimen was lying on its side in the sediment, and the depressed section is primary.

Although preservation is poor, this specimen is the smallest seen in this study, and is valuable in that it illustrates what is believed to be the slender tip of *Rossoceras* (no swollen Nanno-type apex).

DISCUSSION -- Although poor preservation makes taxonomic assignment difficult in this specimens, they contribute to knowledge of the morphology in anterior- and posterior-most portions of siphuncles.

aff. *Rossoceras*

Fig. 19, 9-11

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-37; from Hintze's (1951) measured sections J6-J7, 53-62 feet below the Kanosh Shale in the Juab Limestone, south end of the Confusion Range, section 30, T. 22 S., R. 14 W., the Barn Quadrangle, Ibex area, Utah.

DESCRIPTION -- This specimen is characterized by pronounced flattening of the dorsum, not the venter, as is the case with all other known species of *Rossoceras*. Apparently, this flattening is primary. The specimen is a portion of siphuncle 119 mm long, expanding from 24 mm high by 31 mm wide to 25 mm high by 38 mm wide. In cross section, the specimen becomes more flattened (depressed) adorally. Septal ridges, inclined at approximately 30 degrees from horizontal, are spaced at about 15 mm apart (Fig. 19-11). Eight septal ridges are present. Venter partially obscured by matix. Interior of siphuncle badly recrystallized; blades are faint. Figure 19-9 shows the anterior. Endosiphotube also faint, but visable in a cross section taken at (a) on Figure 19-11; this is illustrated in Figure 19-10.

DISCUSSION -- Dorsal flattening of this specimen, which appears to be a primary characteristic, may prove to be of generic significance. It is left within *Rossoceras* until further collecting and study determines the importance of this characteristic.

Genus *Evencoceras* Balashov, 1960

Genotype: *Evencoceras angarense*, Balashov, 1960

1960. *Evencoceras* Balashov, p. 131.

1964. *Evencoceras* Balashov: Teichert, et al., p. K187, fig. 124.

1976. *Evencoceras* Balashov: Flower, p. 21-24.

DESCRIPTION -- Orthoconic longicones with circular cross sections. The siphuncle is broad, about one-half the diameter of the conch, and slightly ventral in position. Siphuncle interior is filled with radial, longitudinal blades of variable width and thickness, and extend outward from the endosiphotube, which lacks its own wall and is irregular in cross section. Calcareous material extends toward the siphuncle center as a series of discrete lobes; the cone and tube are irregularily quadrangular in cross section. Septal necks vary from achoanitic to hemichoanitic, connecting rings are thick and bulging.

DISCUSSION -- Based on the following evidence, and following Flower (1976b), *Evencoceras* is removed from the Intejoceratidae and placed in the Padunoceratidae:

1) *Intejoceras*, the genus upon which the Intejoceridae is based, is not demonstrably an endoceroid; it has cameral deposits.
2) Although the family Padunoceratidae was obstensibly erected for forms with holochoanitic septal necks, this condition is not reflected in Balashov's plates; therefore, placement of

the achoanitic to hemichoanitic *Evencoceras* with the Padunoceratidae does not indicate revision of the definition of the family is necessary.

3) *Rossoceras* and *Evencoceras* show remarkable morphological similarity, especially in the presence of multiple prominent blades and in the absence of sheaths. And, although the cone in *Evencoceras* is irregular in cross section and in *Rossoceras* the cone is relatively smooth, this morphological similarity indicates placement in the same family.

4) *Padunoceras*, the type genus for the family, has a subtriangular tube and cone, and blades which show little branching. *Evencoceras* is reported from the Middle Mamyr' and *Padunoceras* from the Upper Mamyr' which are believed to be upper Canadian and Middle Ordovician, respectively. The stratigraphic position of a number of the Siberian cephalopods has some difficulties, and both of these may be of Whiterock age (R.H. Flower, personal communication).

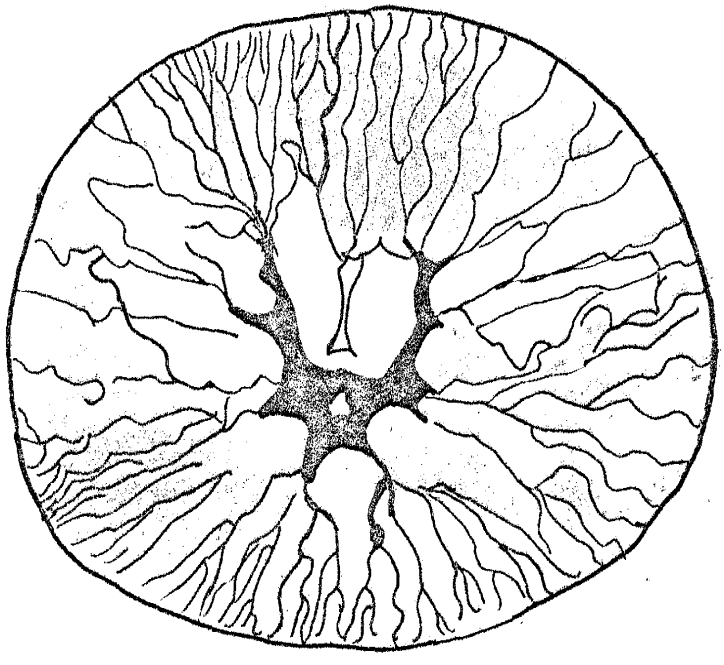
Evencoceras sp. A., new species

Fig. 9; 19, 6-8

TYPE AND OCCURRENCE -- UTPO-8, holotype; from the Juab Limestone, Ibex area, Utah.

DEFINITION --This new species of *Evencoceras* is unique in that the siphuncle has a depressed cross section and is slightly flattened on the venter.

Figure 9--Enlargement of thin section of *Evencoceras* sp. A., new species. Cross section taken about mid-length of specimen, showing characteristic branching pattern of blades. (See also Figure 19-6.)



5 mm

DESCRIPTION -- This new species is known from the holotype which is a portion of well preserved siphuncle, approximately 110 mm long. The interior is known from a series of transverse sections, the first taken 43 mm from the anterior end, measuring 18 mm by 21 mm (Fig. 19-8). This section reveals the central endosiphocone which is roughly round, but lobed in outline, due to the extension of the endosiphucle material between the blades. Blades branch outward in a dendritic pattern toward the interior siphuncular margin; branching occurs at about half the distance from the margin to the center, and slightly closer to the margin on the venter. A large lobe occurs on the dorsum. No shell material is preserved. Venter is more flattened than dorsum.

A second section taken 28 mm farther apicad measures 17.5 mm by 20 mm, and is shown in Figure 19-7. Here the blades bifurcate more repeatedly. A thin section section taken here (Figures 9 and 19-6) illustrates the nature of the blades, and shows a roughly quadrangular central dark area with prominent blades extending from the corners, the dorsum, and the venter.

DISCUSSION -- Although the nature of the shell and therefore the septa, septal necks, suture patterns, etc. are not known, the siphuncle is very well preserved, revealing in detail the polygonal cone, the obscurely quadrangular tube, and extensions of the endosiphuncle inward as lobes between the blades; these features are characteristic of *Evencoceras*. And, although based on only one specimen, the depressed cross section is unique, and will serve to distinguish this new species of *Evencoceras*.

Previously, *Evencoceras* has been known only from the Siberian Platform. Its occurrence in the Whiterock of Utah is significant and extends its geographic range into North America.

Family ENDOCERATIDAE Hyatt, 1883

Genus *Cameroceras* Conrad, 1842

Genotype: *Cameroceras trentonense* Conrad, 1842

1842. *Cameroceras* Conrad, p. 267.

1847. *Cameroceras* Conrad: Hall, p. 221.

1955. *Cameroceras* Conrad: Flower, p. 346-348.

(See this publication for complete list of references to 1955.)

1964. *Cameroceras* Conrad: Teichert, et al, p. K-174.

DESCRIPTION -- This genus was originally erected for straight endoceroids having a marginal siphuncle and longitudinal septum forming a roll or involution with the margin of the siphuncle. As now understood, the genus includes large straight conchs with circular or slightly depressed cross sections; sutures may be simple and straight, or with a slight ventral lobe. The siphuncle is large, as much as half the diameter of a mature conch, and is usually marginal. Siphuncle tapers gently, without a swollen apex (see Figure 10). Septal necks are holochoanitic, and endosiphocones are simple.

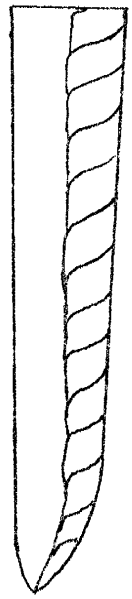
Definition of this genus is hereby amended to include specimens with slightly compressed cross sections and marginal to submarginal circular siphuncles. Future work may justify separation of these compressed forms into a separate genus; for the present, the lack of a suitable suite of specimens upon which to base a new genus indicates this separation is unwarranted.

DISCUSSION -- There has been some confusion regarding the use of *Cameroceras* as a generic name; it has been varyingly reported as a genus either related to *Endoceras* or synonomous with it (Flower, 1955). Teichert (in Teichert, et al., 1964) reported that S.A. Miller in his North American Geology and Paleontology

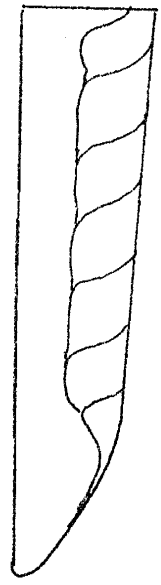
Figure 10--Diagrammatic vertical sections of apices of phragmocones:

A) *Cameroceras*-type apex; siphuncle tapers gently.

B) *Nanno*-type apex; siphuncle has a swollen apex. After Flower, 1976b, p. 15.



A



B

(1899) had designated *Endoceras annuliferum* as the type. Therefore, *Endoceras* is an annulated form and *Cameroceras* is smooth. Also, juvenile *Endoceras* have been described as *Cameroceras*. R.H. Flower (personal communication) is convinced based on intensive collection from the basal Denmark Member of the Sherman Fall Formation (Trenton in age) that *Cameroceras trentonense* and the bulk of *Endoceras proteiforme* are the apical ends and anterior parts of the same species or group of species; specimens found there show variation in proportions, and evidence is insufficent to show whether there are several species, or variation within a single species.

Cameroceras sp. A., n. sp.

Fig. 22, 1-6

TYPES AND OCCURRENCE -- UTPO-43, holotype; from 10 feet below the top of the Juab Limestone, Ibex area, Utah.

DEFINITION -- *Cameroceras* sp. A. is unique in its compressed cross section and wide cameral spacing; these characteristics distinguish it from other species of the genus.

DESCRIPTION --This new species is known from a single specimen, a phragmocone, which is 187 mm in length. The apical end was not preserved; the result of an oblique break (Fig. 22-1). A break in the specimen 23 mm from the apex measures 29 mm wide by 31 mm high and shows the circular siphuncle 12 mm in diameter, and is in contact with the venter (Fig. 22-3). A small central tube is present. White calcite fills the siphuncle at this point.

A second section 18 mm orad measures 32 mm wide by 34 mm high (Fig. 22-4). Here the siphuncle remains circular in outline, and measures 14 mm in diameter. This section exposes the apical-most portion of the spiess. The endosipho-

cone is subcentral; it is slightly closer to the dorsal than to the ventral side of the siphuncle.

A third transverse section 23 mm orad measures 34 mm wide by 36 mm high (Fig. 22-5). Here the siphuncle measures 15 mm in diameter; the circular spiess which is 4 mm in diameter, is located 5 mm from the dorsum and 6 mm from the venter. A sagittal section was made here through the siphuncle; thin sections from this area revealed holochoanitic septal necks (Fig. 22-2). The connecting rings are dark, simple in structure, and preserved over about two-thirds of the length of this section.

A fourth transverse section 27 mm orad measures 39 mm high by 39 mm wide. Here the endosiphocone, which is in broad contact with the venter, measures 17 mm high by 17.5 mm wide and is slightly depressed.

Cameral spacing increases anteriorly from 5.5 mm to 9 mm. The suture pattern is straight, transverse, and unmodified in the region of the siphuncle.

DISCUSSION -- Although not an optimum condition, erection of this new species based on this one specimen is indicated by its unique cross section and cameral spacing. Also, both phragmocone and siphuncle are well preserved, and details of structure are known.

Cameroceras sp. B., n. sp.

Fig. 23, 1-7

TYPES AND OCCURRENCE -- UTPO-45, holotype, from the Juab Limestone; UTPO-46, paratype, from 30' below the top of the Juab Limestone, Ibex area.

DEFINITION -- This new species of *Cameroceras* is characterized by its compressed cross section which becomes more circular adorally; the position of the

siphuncle, which is broadly exposed on the venter; the circular endosiphocone, which is central in position; and the inclination of septae in the vicinity of the siphuncle.

DESCRIPTION -- Two specimens of *Cameroceras* sp. B. are described; one designated as the holotype, and the other as a paratype. Septal necks are holochoanitic and connecting rings appear homogeneous, although these are recrystallized. The first specimen, UTPO-45, is a phragmocone, 225 mm in length (Fig. 23-1). At the apex, the shell measures 33 mm by 30 mm. The ventral side of the specimen is slightly weathered, exposing the siphuncle. The siphuncle measures 17 mm by 14 mm at the apex, and is in broad contact with the venter (Fig. 23-5)

A transverse section 40 mm orad measures 38 mm by 36 mm (estimated); here the siphuncle measures 20 mm in diameter and is circular (Fig. 23-4). The circular endosiphocone is well developed, 5 mm in diameter, and 8 mm from the dorsum.

Thirty-four mm orad, the shell has expanded to 40 mm wide (Fig. 23-4). The height is incomplete, due to weathering of the ventral side, but is also approximately 40 mm. The siphuncle is 22 mm wide and 22 mm high (estimated). Endosiphocone dimensions are 11 mm by 12 mm; the endosiphocone is very slightly closer to the venter than to the dorsum.

Expanding to 37 mm by 45 mm in a length of 45 mm, the next section anterior has been seriously damaged by crushing and weathering of the dorsum (Fig. 23-3). Estimated siphuncular dimensions are: 27 mm by 25 mm.

The final portion of the specimen, 100 mm in length, shows severe flattening of the dorsum, contains seven camerae, and measures 632 mm in width (Fig. 23-2). The siphuncle is broadly exposed on an internal mold of the venter. Cameral spacing gradually increases from 8 mm apically to 14 mm anteriorly.

The second specimen of *Cameroceras* sp. B. (UTPO-46), a portion of

phragmocone which represents an earlier ontogenetic stage than UTPO-45, is 52 mm in length, and expands from 22 mm wide by 24 mm high to 24 mm by 26 mm in this length. Sutures are clear and well preserved over the exterior of the specimen. Cameral spacing increases gradually from 4 mm apically to 4.5 mm adorally. Sutures are straight and transverse. Siphuncle 7 mm wide by 8 mm high at the apex or approximately one-third of conch (Fig. 23-7).

Siphuncle exposed on ventral margin of phragmocone (Fig. 23-6). No endosiphuncular tube visable. Shell smooth, not annulated.

DISCUSSION -- The body chamber and apex are not known for this new species of *Cameroceras*, as is the case for many Endoceratidae; the position of the siphuncle within the shell, the nature of sutures, and the compressed cross section which becomes more flattened anteriorly are characteristics which distinguish this new species.

Cameroceras sp. C., n. sp.

Fig. 23, 9-11

TYPE AND OCCURRENCE -- UTPO-44; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This new species is based on a single specimen, an endosiphuncle, 175 mm in length. Broken obliquely on the anterior end, the specimen is partially enclosed in matrix.

A transverse section 34 mm from the apex measures 20 mm by 19 mm and expands to 23 mm by 22 mm in a length of 32 mm (Fig. 23-11). Here the endosiphocone is just free from the venter (less than 1 mm), and is 7 mm high by 4 mm wide. The shape of the endosiphocone is elliptical and narrower on the dorsal than ventral side.

Fourteen mm orad, a transverse section of the siphuncle measuring 24 mm by 23 mm shows the endosiphocone, which measures 7 mm by 6 mm, and is more broadly rounded ventrally than dorsally (Fig. 23-10). A shattered interval, 30 mm orad, is 25 mm by 23 mm, and exposes the endosiphocone, which measures 12 mm by 11 mm.

The anterior portion of the specimen (Fig. 23-9), 65 mm in length, measures 25 mm by 24 mm, and becomes more circular, as does the endosiphocone, which measures 19 mm in diameter. The endosiphuncle is thicker on the dorsum (8 mm) than on the venter (less than 1 mm). Here the endosiphocone has been partially filled with sediment (the light gray area) and with recrystallized calcite (darker area), resulting in a fortuitous structure.

DISCUSSION -- This species is not formally named nor a holotype designated as a solitary fragmentary endosphiuncle is all that is known. The characteristics of the siphuncle, described above, are unique, and not assignable to any described species of *Cameroceras*.

Cameroceras sp. indeterminate

Fig. 22, 7-9

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-47; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This specimen is a portion of phragmocone, 127 mm in length, expanding from 44 mm by 53 mm to 48 mm (estimated) by 61 mm (Fig. 22-7). At a transverse section located 83 mm apicad of the anterior end the siphuncle measures 28 mm by 31 mm, and is in broad contact with the venter; the endosiphocone measures 17 mm by 19 mm, and is slightly flattened ventrally (Fig. 22-9). A longitudinal section made here (Fig. 22-8) reveals the apical termination of endosiphocone and holochoanitic septal necks. Siphuncle is tubular. Cameral spacing increases slightly from 11 mm to 12 mm adorally. The specimen is weathered dorsally and broken both apically and orally.

DISCUSSION -- The fragmentary condition of this specimen and particularily the lack of an apical portion make specific assignment impossible. This specimen is included here primarily in the interest of completeness.

cf. *Cameroceras*

Figs. 23-8, 24-4

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-48 and UTPO-61; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- Two specimens are described here; the first (UTPO-48) is a poorly preserved mold approximately 120 mm in length, and badly weathered dorsally. The siphuncle is in broad contact with the venter, and cameral spacing is approximately 20 mm (Figure 23-8). Shell width is 65 mm and height 50 mm

(estimated) at a transverse section 23 mm orad of the apical portion of the specimen. Internal structure of the specimen not preserved. From cameral spacing and estimated dimensions, it is probable that this is a portion of the phragmocone close to the living chamber.

The second specimen, UTPO-61, is part of an internal mold, with a portion of siphuncle and phragmocone preserved. Figure 24-4 shows the venter; specimen is anterior of the endosiphocone. Approximately 100 mm in length, the specimen expands from 35 mm by 47 mm to 42 mm by 53 mm, and is badly weathered dorsally. Siphuncle measures 20 mm by 21 mm apically and 33 mm by 35 mm orally.

DISCUSSION -- These specimens are included here for the sake of completeness, more than because of any new data which they reveal. Their external form is very similar to *Cameroceras* sp. A and sp. B; without internal structures, assignment to either of these or to another published species of *Cameroceras* is not possible.

Family ENDOCERATIDAE

Genus and species indeterminate

Fig. 24-2

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-62; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This specimen is large (352 mm long) internal mold, slightly compressed in cross section, expanding from 80 mm by 110 mm to 83 mm by 132 mm. Rate of expansion is low. Transverse sutures are well preserved over the lateral portions of the specimen; the dorsum is badly weathered, and the venter appears slightly abraded. Siphuncle not known.

DISCUSSION -- Although the siphuncle is not known, the external morphology, including size and suture pattern indicate placement in the Endoceratidae.

Order ENDOCERATIDA

Family, genus, and species indeterminate

Fig. 24-1

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-63; from the Juab Limestone, Ibex area, Utah.

DESCRIPTION -- This specimen is a large, mature endoceroid and has a long portion of siphuncle with attached living chamber, measuring 358 mm in length. Siphuncle length is approximately 233 mm to base of living chamber. Both siphuncle and living chamber are broken obliquely. Septal ridges are visable over the surface of the siphuncle: nine are preserved, and are approximately 22 mm apart. Angle of inclination of septal ridges is approximately 25 degrees. Width adorally is approximately 165 mm, height 82 mm (reconstructed height approximately 150 mm). Specimen is weathered on the dorsum. Apical siphuncle measurements: height = 64 mm, width = 63 mm. Siphuncle is slightly compressed to circular, and appears to have been in contact with the shell. Endosiphuncle not known.

DISCUSSION -- The septal spacing and angle of inclination, as well as the ventral position of the siphuncle suggest *Rossoceras*; without the apical portion of the siphuncle, this placement is impossible to verify. This specimen is important because it shows the relative proportions of mature living chamber to the siphuncle and remainder of phragmocone.

Order MICHELINOCERATIDA Flower, 1950

Family MICHELINOCERATIDAE Flower, 1950

Genus *Michelinoceras* Foerste, 1932

Genotype: *Orthoceras michelini* (Barrande, 1866)

1932. *Michelinoceras* Foerste, p. 72.

1952. *Michelinoceras* Foerste: Basse, p. 492.

1962. *Michelinoceras* Foerste: Ruzhentsev, et al., p. 107.

1962. *Michelinoceras* Foerste: Flower, p. 10, 11.

1964. *Michelinoceras* Foerste: Teichert, et al., p. K225.

1968. *Michelinoceras* Foerste: Flower, p. 41.

1977. *Michelinoceras* Foerste: Hook and Flower, p. 43.

DESCRIPTION -- Foerste separated true *Orthoceras*, which has distinct vertical impressions or grooves near midlength of the living chamber with corresponding grooves on the shell's interior cast, from those species in which the siphuncle is similar in its tubular form, and the camerae are similarly elongated verticaly, but without grooves. These forms were placed in *Michelinoceras*, and following Hook and Flower (1977), *Michelinoceras* is used here for smooth circular orthocones with small central or subcentral tubular siphuncles.

DISCUSSION -- *Michelinoceras* has been broadly interpreted here to include forms in which siphuncle segments are cylindrical or slightly expanded into the camerae, septal necks are orthochoanitic, connecting rings thin and homogenous, cameral deposits well-developed.

Michelinoceras sp. indeterminate

Fig. 24-5

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-53; from the Juab Limestone, Ibex area, western Millard County, Utah.

DESCRIPTION -- This specimen is a small orthoconic shell, enclosed in matrix and sectioned sagitally, and approximately 43 mm in length. Twenty-one camerae are preserved within this length. Siphuncle is filled with matrix and shows no primary structures (ie. was empty or vacuosiphonate). Septal necks are orthochoanitic. Siphuncle segments are slightly concave apically but tubular orally. Episeptal, hyposeptal, and mural deposits all well developed. Cameral deposits quickly thicken on mural part of septum; therefore, a variation in deposit thickness exits as the deposit encircles the shell. Siphuncle subcircular (slightly to the left in Figure 24-5). Connecting rings faint, not well preserved, but apical thickening of connecting rings apparent. Recrystallization makes interpretation difficult. Episeptal and mural deposits separated by matrix in camerae; this is evidence of the distinct and separate origin of episeptal and mural deposits.

Faint thickening of dorsal connecting rings apically may be a lining formed by fused annuli. Ventral camerae are almost completely filled with cameral deposits.

Cameral spacing increases adorally regularly from <1 mm to 2.5 mm. No living chamber preserved. Specimen not complete enough to allow specific determination.

DISCUSSION -- Morphology and relative development of cameral deposits indicates the following sequence of deposition (secretion) of the deposits:

1) mural
2) episeptal
3) hyposeptal

Practice followed here is after Hook and Flower (1977), which broadly defines *Michelinoceras* as circular orthocones where annuli may fuse to form a lining, rather than vacuosiphonate forms, as discussed in both the American and Russian treatises (Teichert, et al., 1964; Ruzhentsev, et al., 1962).

Family MICHELINOCERATIDAE

Genus and species indeterminate

Fig. 24-3

DESCRIPTION -- The specimen figured and described here is a small orthocone, 32 mm long. The siphuncle is approximately 30% of shell width. Specimen is exposed in a longitudinal section close to the venter; the plane of the section is not vertical, and therefore, the siphuncle is not exposed completely to the apex. Specimen is badly recrystallized, obliterating camerae; siphuncle appears void of deposits and may be very faintly annulated.

DISCUSSION -- In overall form, size, and relative dimensions, this orthocone strongly resembles UTPO-53, *Michelinoceras* sp. It is included here for completeness.

FIGURED SPECIMEN AND OCCURRENCE -- UTPO-54; from the Juab Limestone, Ibex area, Utah.

TAXONOMIC SUMMARY

The cephalopod fauna of the Juab Limestone is dominated by endoceroids, specifically the genera *Rossoceras* and *Williamsoceras* of the families Paduncoceratidae and Allotrioceratidae, respectively. The orders Michelinoceratida and Ellesmeroceratida are poorly represented. Coiled forms are in preparation by Flower.

Classification of major categories employed here is that of Flower and Kummel (1950) and Flower (1964a; 1964b; 1968); the Endoceratida are retained as an order of the subclass Nautilida.

Order ELLESMEROCERATIDA

Family BALTOCERATIDAE

In this report, the Baltoceratidae consist entirely of the rod-bearing genus *Cyptendoceras*, two species of which are described. The lack of vacuosiphonate forms may be due to preservational bias; as discussed by Hook and Flower (1976), rods afford greater resistance to weathering and also insure that the shells were oriented venter down in the sediments. Small orthocones belonging to the Baltoceratidae, but indeterminable generically were also present. No new forms are described.

Order ENDOCERATIDA

Endoceroids are by far the dominant element of the fauna. This may be due in part to preservational bias; small ellesmeroceroids and michelinoceroids are poorly preserved. Endoceroids are characterized by large siphuncles, which contained substantial parts of the visceral mass, not only the siphuncular chord

(Teichert, et al., 1964). Commonly only the siphuncle is preserved, rarely with a fragment of shell wall attached. The shell walls must have been fragile; the siphuncles, which were robust, were more commonly preserved.

Flower (1968) has discussed the perplexing problems that plague study of this group:

> Probably there is no group of the cephalopods that has yielded more morphological surprises in recent years, or one in which the taxonomy is more frustrating, being hampered by the fragmentary material by which many species and genera are known.

His observations are still true twenty years later.

Three families of Endoceratida, the Allotrioceratidae, Padunoceratidae, and Endoceratidae were found to occur in the Juab Limestone.

The taxonomy used here is not a form taxonomy, but one based on the valuable morphological criteria supplied by endosiphuncles. Features of the endosiphuncle have long been considered as valid criteria for distinguishing genera (Ruedemann, 1903, 1905; Kobayashi, 1935; Flower, 1955, 1965; Balashov, 1962; and many others), and despite arguments to the contrary (Mutvei, 1964; Dzik, 1984), reputable workers use endosiphuncular characters as valuable taxonomic criteria.

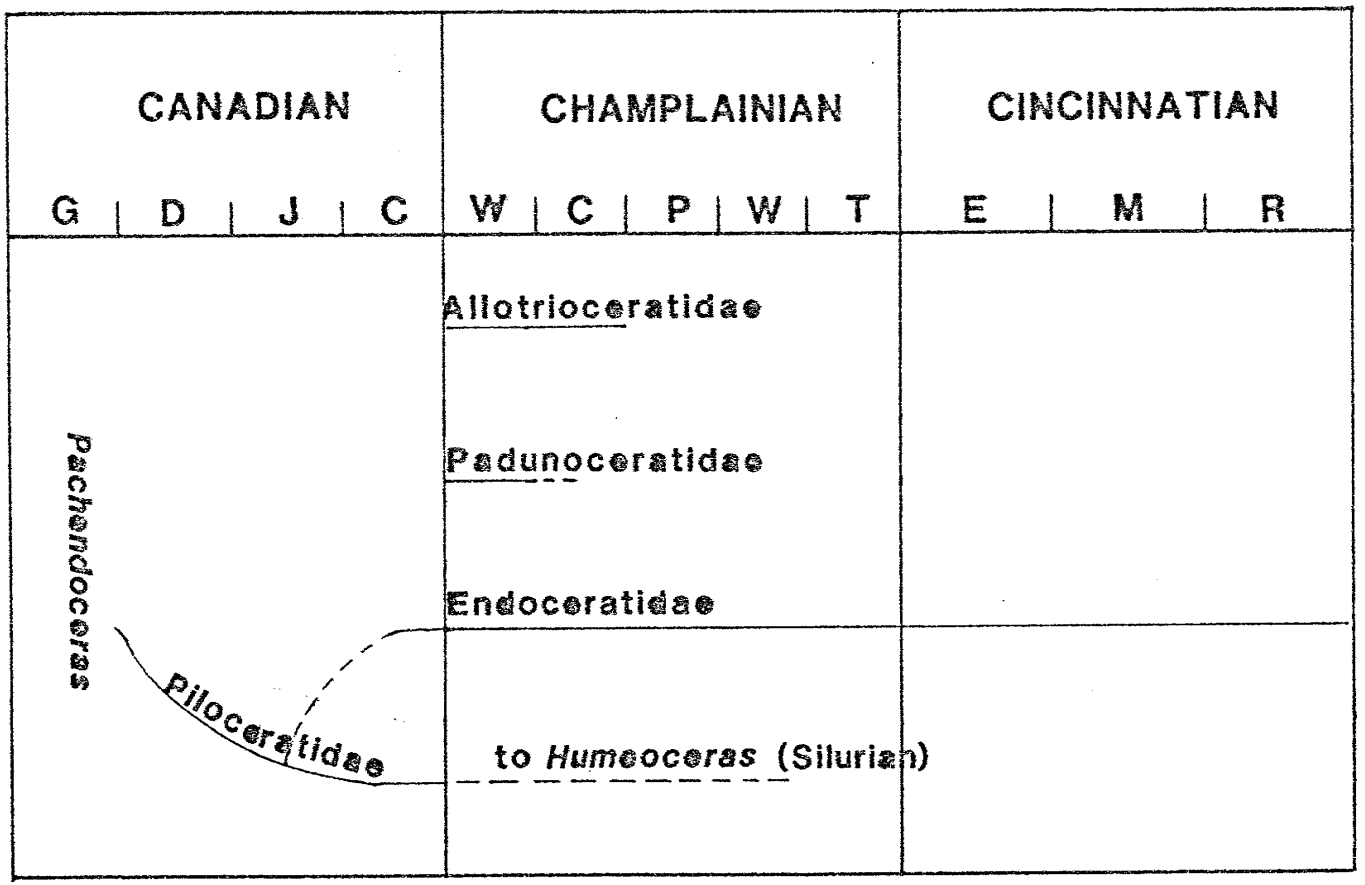
The abundance of endoceroids in the Juab Limestone is in sharp contrast to their scarcity in the underlying Wahwah Limestone (Hook and Flower, 1976).

Figure 11 shows the possible origin and ranges of families of the Endoceratida found in this study.

Family ALLOTRIOCERATIDAE

This family is represented in this study by the genus *Williamsoceras*. *Williamsoceras adnatum* is the most common species; no new species of

Figure 11--Ranges and origin of families of Endoceratida found in this study. Adapted from Flower, 1976a.


CANADIAN
CHAMPLAINIAN
CINCINNATIAN
G | D | J | C
W | C | P | W | T
E | M | R
Allotrioceratidae
Padunoceratidae
Endoceratidae
Pachendoceras
Pilocerat idae
to Humeoceras (Silurian)

Williamsoceras are described. A specimen of *W. ankhiferum* is designated as a hypotype.

Contrary to statements made by Dzik (1984) Flower based *Williamsoceras* on several specimens (Flower, 1964b; 1968; 1976b). *Williamsoceras* does not exhibit a *Nanno*-type protoconch, but rather tapers gently to a slender point. Dzik apparently does not recognize the fact that siphonal deposits are of critical significance in cephalopod taxonomy, and are stable within species. He has reverted to the form taxonomy of the last century.

A new genus, Genus A., is tentatively assigned to this family, based on its complex endosiphuncle containing an infula.

Family PADUNOCERATIDAE

The Padunoceratidae are very well represented in this report; *Rossoceras* is the most common cephalopod in the Juab Limestone. *Rossoceras lamelliferum* is the most prevalent species. [*Rossoceras* was based on a large suite of specimens (Flower, 1964b), not the "single isolated siphuncle' as cited in Dzik (1984).] Specimens of *R. lamelliferum* were extremely numerous, and were included only if they added materially to the concept of this species. A new species of *Rossoceras*, *R.* sp. A, is described and illustrated. *Rossoceras* is characteristic of the Whiterock Stage in North America (Flower, 1976a).

Evencoceras sp. A, new species, is described. *Evencoceras* has previously been known only from the Siberian Platform.

Family ENDOCERATIDAE

Fragmentary phragmocones and siphuncles of *Cameroceras* represent this family in the Juab Limestone. They are small in number, but form an important

component of the fauna, as they extend the range of *Cameroceras* into the Whiterock Stage. *Cameroceras* is now known from basal Juab to within 10 feet of the top.

Order MICHELOCERATIDA

This order is poorly represented in the Juab fauna; only two specimens are described, both from the Michelinoceratidae.

Family MICHELINOCERATIDAE

Following Hook and Flower (1976), the genus *Michelinoceras* is broadly defined to include smooth orthocones, circular in cross section with well developed cameral deposits which preceed annuli in growth. Annuli may form a lining in advanced growth stages.

CONCLUSIONS

The cephalopod fauna in the Juab Limetone is dominated by endoceroids. *Rossoceras lamelliferum* is the most common form. This dominance may be due to preservational bias; large robust endoceroid siphuncles are heavily calcified and preserve well. Overall, preservation was poor in the specimens studied; material was fragmentary and badly recrystallized. The Michelinoceratida and Ellesmeroceratida are minor parts of the fauna. A total of fifteen species representing six genera in five families and three orders were found.

The genus *Cameroceras* is reported for the first time from the Whiterock Stage, extending its range geologically into zone L and geographically into western Utah.

The Russian genus, *Evencoceras*, is now known from outside the Siberian Platform. Following Flower (1976b) it is removed from the Intejoceratidae and placed in the Padunoceratidae based on the absence of sheaths and the strong development of blades.

The fauna was determined to be completely Whiterock in aspect, and correlation with the Nora Formation of Queensland, Australia is indicated, based on the presence of the congeneric forms *Williamsoceras* and Genus A.

Perplexing questions were raised by a comparison of the results obtained here with those of Hook and Flower (1976). They found the Wahwah Limestone, which is immediately beneath the Juab Limestone, to be practically devoid of endoceroids, and yet endoceroids form the major component of the cephalopod fauna in the Juab Limestone. The Wahwah fauna is dominated by small orthocones belonging to the Baltoceratidae and Michelinocertidae, but these forms are a very minor component of the Juab cephalopods.

Future studies should concentrate on collecting with precise stratigraphic con-

trol; without this, phylogenetic studies are impossible. The dominance of *Rossoceras lamelliferum* and its presence in large numbers may indicate ontogenetic study is possible.

APPENDIX A

Morphologic Terminology

The terms used here are those in common usage by cephalopod workers. The following definitions are after Flower (1964, p. 48-52), Teichert, et al (1964, p. K54-K59), and the Glossary of Geology (Bates, R.L., and Jackson, J.A., eds., 1980). This list is not intended to be comprehensive. Figures 12 and 13 illustrate the morphology and terminology used to describe endoceroid siphuncles and michelinoceroids, respectively; figure 14 shows the type and position of cameral deposits in the michelinoceroids.

achoanitic - describes septal necks which are vestigal or absent.

annulosiphonate deposits - type of cameral deposit shaped like ring and attached to inside of septal neck.

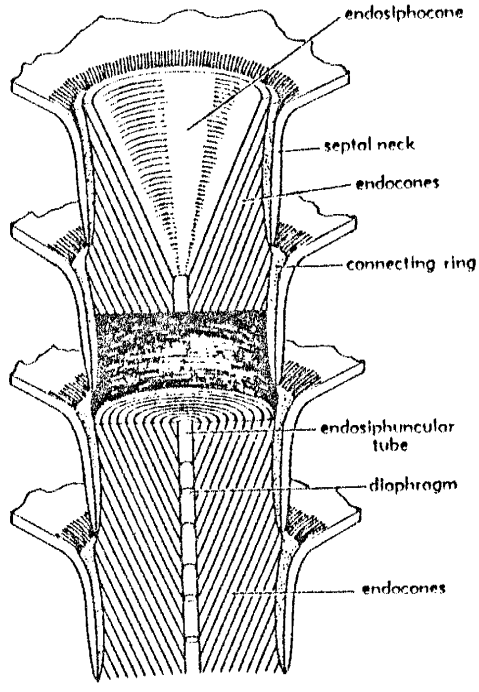
annulus - thin, ring-shaped endosiphonal deposit, semicircular in cross section, on inner side of septal neck.

apex - the first formed, pointed end of an elongated or conical organism (ie. a straight or slightly curved cephalopod shell).

blades - shortened form of endosiphoblades; blades are tabular, longitudinally continuous structures in endoceroid siphuncles, extending from the central tube to the siphuncle margin; where multiple tubes exist, they may form a band connecting the tubes. This structure is the infula (Flower, 1964).

camera - space enclosed between two septa, not including siphuncle; it represents an earlier portion of the living chamber subsequently closed off by a septum.

Figure 12--Schematic representation of structures found in endoceroid siphuncles; terms defined in Morphologic Terminology. From Teichert, et al., 1964, p. 160.


endosiphocone
septal neck
endocones
connecting ring
endosiphuncular tube
diaphragm
endocones

cameral deposits - calcareous deposits secreted against original walls of camerae during life of animal.

compressed - describes the shape of a transverse section in a chambered cephalopod conch or siphuncle in which the dorsoventral diameter is greater than the lateral diameter.

conch - shell wall; does not include endosiphonal and cameral deposits.

connecting ring - segmentally repeated tubular membrane secreted within the wall of the siphonal strand; connects septal neck with septum immediately behind (apicad). Composed of calcite and organic matter; may be homogenous or complex in structure.

depressed - describes the shape of a transverse section in a chambered cephalopod conch in which the dorsoventral diameter is less than the lateral diameter.

dorsum - the upper surface of a bilaterally symmetrical animal.

ectosiphuncle - wall of siphuncle consisting of septal necks and connecting rings.

endoceroid - generalized term for members of the order Endoceratida.

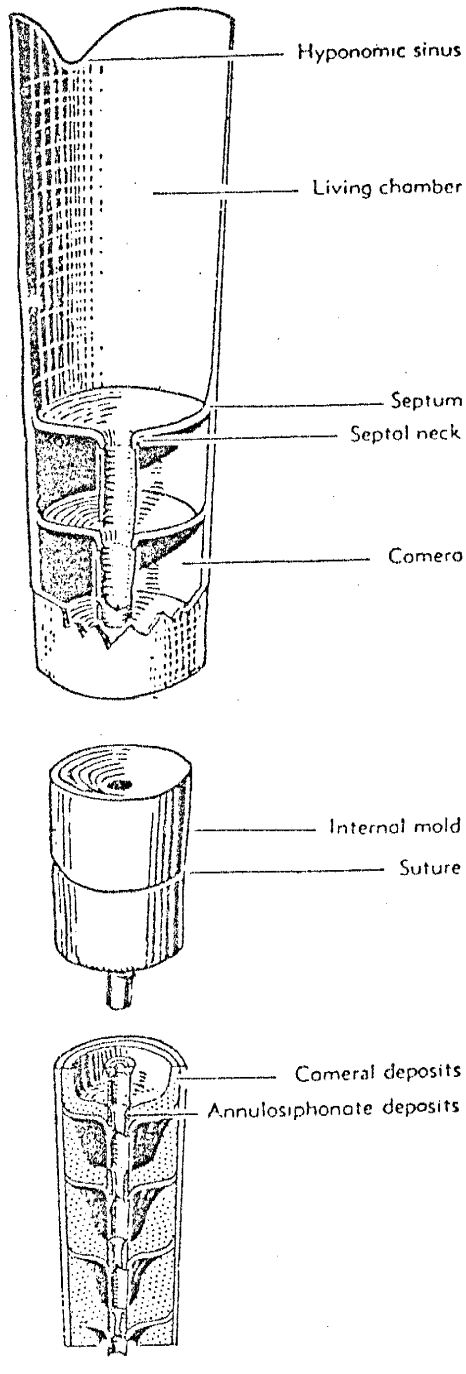
endocone - one of series of calcareous cones formed in adapical portion of siphuncle in endoceroids; points apically, separated by by dark growth lines or endosiphoblades.

endogastric - shell curved with venter concave.

endosiphoblade - see blade.

endosiphocone - conical cavity found at anterior end of endoceroid siphuncle, usually filled with matrix after death of the animal; also called spiess.

Figure 13--Drawing of michelinoceroid, showing location of structures defined in Morphologic Terminology. From Moore, Lalicker, and Fisher, 1952, p. 348.


Hyponomic sinus
Living chamber
Septum
Septal neck
Camera
Internal mold
Suture
Cameral deposits
Annulosiphonate deposits

endosiphuncular - refers to stuctures within the siphuncle.

endosiphotube - tube connecting apices of endocones; also, without individual endocones, the tube extending to the tip of the conical apex of the endoceroid endosiphuncle. It may vary widely in cross section and may or may not appear to have a definite wall of its own.

episeptal deposits - cameral deposits on concave side of septum.

exogastric - shell curved with dorsum concave.

height - dorsoventral diameter of cephalopod conch or siphuncle; number listed first in diameter descriptions (height by width).

hemichoanitic - descriptive term for septal necks which extend backward (apicad) one-half to three-fourths of the distance to preceding septum.

holochoanitic - descriptive term for septal necks which extend backward (apicad) for the length of one siphuncle segment.

hyposeptal deposits - cameral deposits on convex side of septum.

infula - dark, longitudinally continuous band connecting multiple tubes in endosiphuncles of specialized endoceroids.

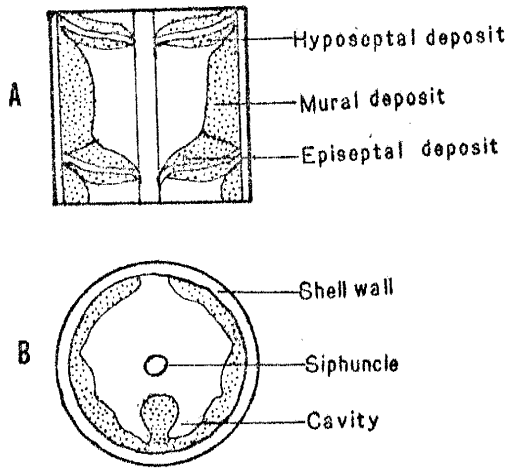
living chamber - large aseptate anterior space in conch open at aperture, occupied by body of cephalopod.

lobe - backward (apicad) convex undulation of suture.

macrochoanitic - descriptive of septal necks that reach backward (apicad) beyond preceding septum and are invaginated into preceding septal neck.

Figure 14--Longitudinal (A) and transverse sections (B) of orthoconic cephalopod, showing location of cameral deposits described in Morphologic Terminology. Adapted from Moore, Lalicker, and Fisher, 1952, p. 348.

Types of Cameral Deposits



michelinoceroid - generalized term for members of the order Michelinoceratida.

mural deposits - cameral deposits along the part of the septum attached to wall of conch.

orad - toward aperture or mouth of shell.

orthochoanitic - septal necks bent so as to be parallel to the siphuncle axis and moderately short.

orthocone - straight conch.

phragmocone - part of cephalopod shell traversed by septa, in contrast to the adoral living chamber; chambered portion of shell.

septum - one of a series of partitions dividing the phragmocone into camerae, generally divisible into a mural part, a free part, and a septal neck.

septal foramen - opening in septum allowing passage of siphuncular cord.

septal neck - portion of septum which is bent apically around the siphonal strand at the foramen; ordinarilly considered part of the siphuncle.

septal ridges - a raised structure found on the external surface of endoceroid siphuncles which was formed at the junction of the septa and the siphuncle.

sheaths - short for endosiphosheaths; thin, dark layer separating individual endocones.

siphuncle - long slender or thick tube extending through all camerae from apex to base of living chamber of cephalopod shell and consisting of soft and shelly parts, including septal necks, connecting rings, calcareous deposits, and siphuncular cord.

spiess - endosiphocone.

suture - line of junction of free part of septum and inner side of phragmocone wall; visable on internal molds.

tube - shortened form of endosiphotube; a central tube free in the siphuncle.

vacuosiphonate - descriptive term meaning empty siphuncle; siphuncle without linings, annulae, endocones, etc.

venter - the underside of a bilaterally symmetrical animal.

ventral lobe - main adapical infliction of suture on venter.

width - lateral diameter of cephalopod conch or siphuncle.

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Figures 15-24

Unless otherwise noted, cross sections are oriented with venter down, specimens are unwhitened, oriented with apex down, and reduced to 0.9.

Figure 15

1) *Cyptendoceras* cf. *C. ruedemanni*, UTPO-51
longitudinal section, showing ventral rod, X 1.8.

2-3) *Cyptendoceras* cf. *C. rhythmicum*, UTPO-56

2) Ventrolateral view, siphuncle slightly to right of center; shows uneven septal spacing, X 2.

3) Same specimen, ground to siphuncle; orthochoanitic septal necks and rhythmic variation in septal spacing, X 2.

4) Baltoceratidae, genus and species indeterminate, UTPO-58
Illustrates empty siphuncle, orthochoanitic septal necks and steep angle of septal inclination. Anterior-most camerae filled with calcite, X 2.2.

5-7) New genus, new species, UTPO-60.
Specimen whitened, X 2.

5) Dorsolateral view, weathering has exposed septa.

6) Ventral view, showing steep inclination of sutures in vicinity of siphuncle.

7) Lateral view, showing transverse suture pattern.

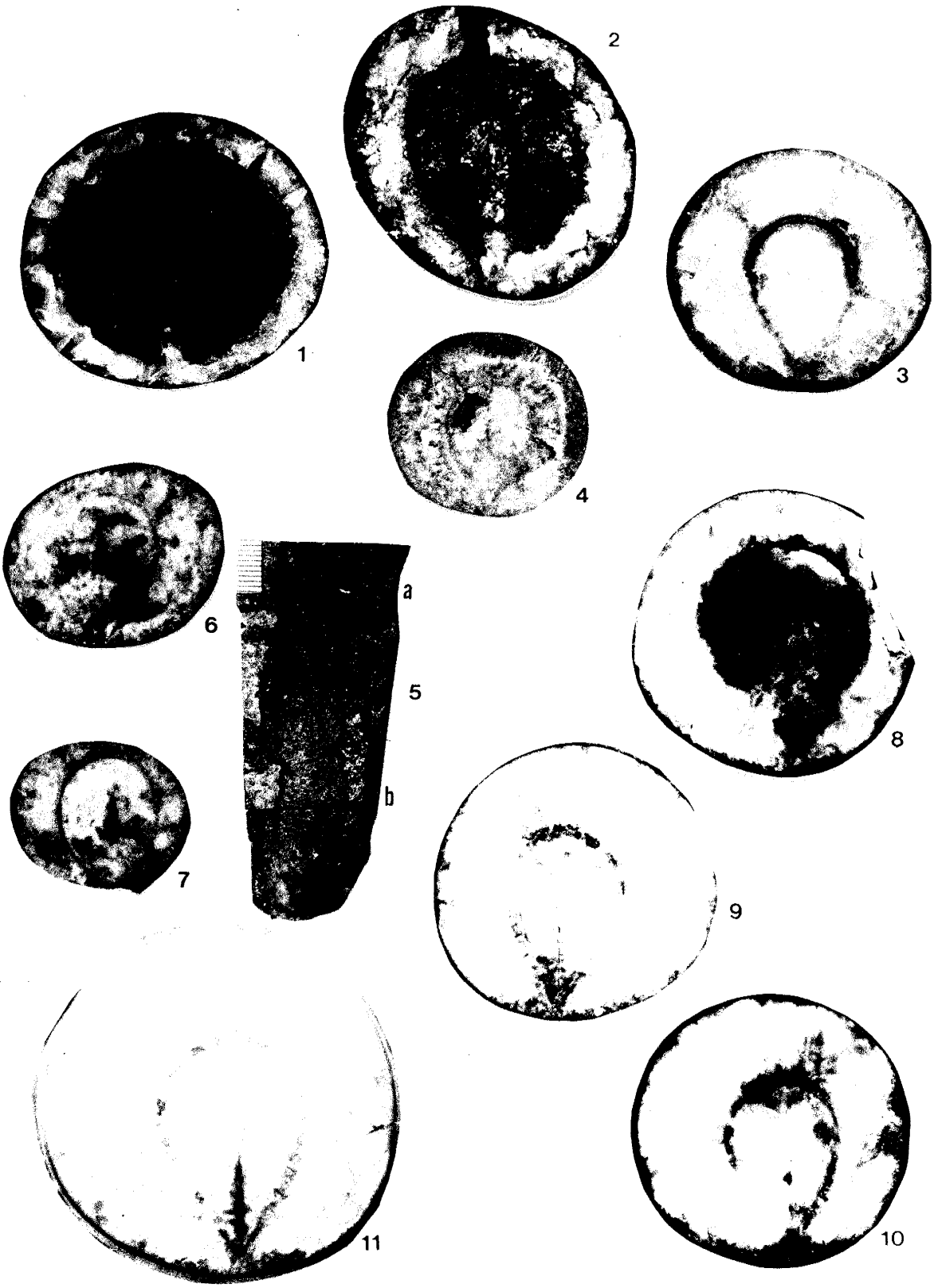
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Figure 16

Williamsoceras adnatum

1-4) Cross sections, venter down, UTPO-3, X 2.

1) Section at anterior end of specimen. Ventral process extends into siphuncle interior.

2) Section farther apicad where natural break occurs.

3) Section approximately 20 mm apicad, showing development of tubes and infula. Calcite crystals fill siphuncle. Faint dark blades extend toward siphuncle margin from infula.

4) Apical section; recrystallization has destroyed tubes, infula is faint dark line.

5-7) *Williamsoceras adnatum*, UTPO-4.

5) Ventral view, showing location of two transverse sections. Limbs of infula visible as two dark longitudinal lines extending the length of the specimen, scale is 10 mm.

6) Cross section taken near anterior end at (a); recrystallization has destroyed finer structures. Infula visible as faint gray arc, central blade of ventral process visible in center as dark line, X 2.2.

7) Cross section taken at (b); infula is clear,

as is central portion of median blade, X 2.2.

8-11) *Williamsoceras adnatum*, UTPO-40

8) Cross section of siphuncle 79 mm from anterior end of specimen, X 2.

9) Transverse section 28 mm apicad. Tubes, infula, and median blade of ventral process clearly visible, X 2.

10) Posterior view of (9), X 2.

11) Enlargement of thin section taken near (10), approximately X 2.5.

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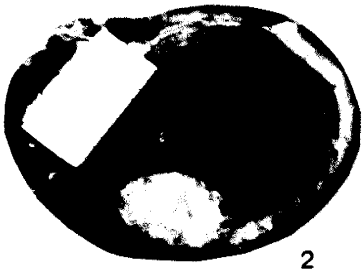

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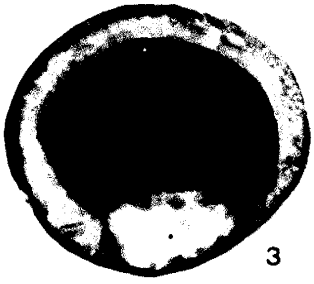

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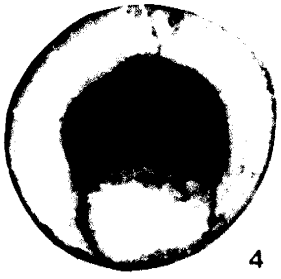

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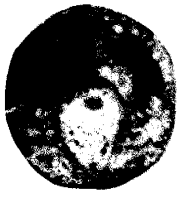

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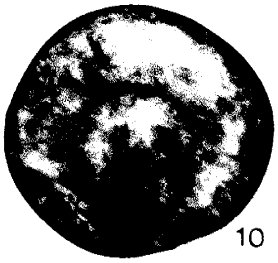

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Figure 17

1-4) *Williamsoceras ankhiferum* (hypotype), UTPO-5

1) Dorsal view of entire specimen, apex on right, scale is 10 mm.

2) Transverse section 42 mm apicad of anterior end; shows beginning development of ventral process, scale is 10 mm.

3) Transverse section 18 mm apicad; ventral process larger, endocones are developed dorsally and laterally, scale is 10 mm.

4) Cross section 21 mm apicad, showing limbs of infula widely separated at ventral margin, scale is 10 mm.

5-7) *Williamsoceras* cf. *W. ellipticum*, UTPO-1

5) Dorsal view, showing locations of transverse sections, scale is 10 mm.

6) Transverse section taken at (a); note compressed cross section, X 2.

7) Transverse section taken at (b); infula and dorsal blade preserved. Dark areas are limonite, X 2.

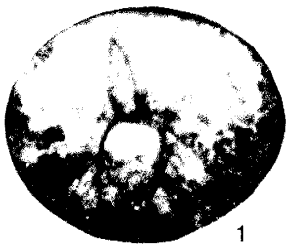
8-10) *Williamsoceras* cf. *W. pedunculatum*, UTPO-21

8) Whole specimen, ventral view, showing location of cross sections. Odd shape is not primary, but is due to oblique

nature of cuts made to extract specimen from matrix, scale is 10 mm.

9) Transverse section taken at (a). Distorted cross section due to oblique nature of section. Ventral process appears stalked. Dorsolateral blade visible, X 1.8.

10) Transverse section taken at (b). Preservation is poor, but infula visible, X 2.2.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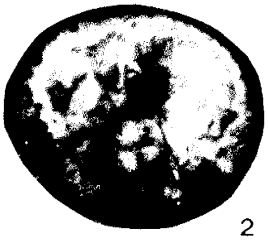
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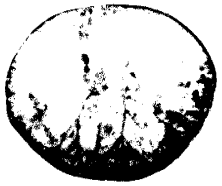
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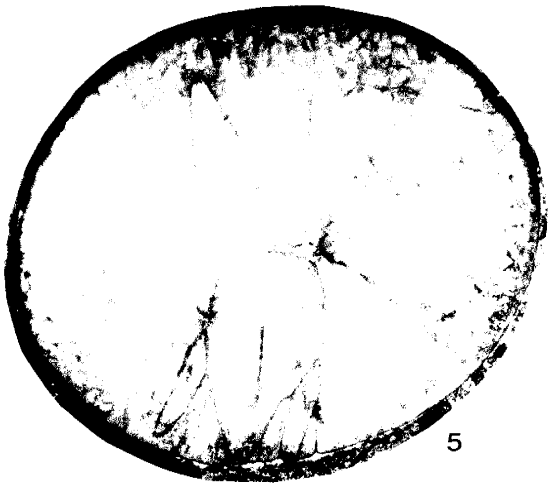
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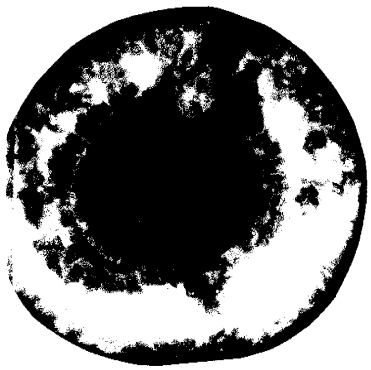
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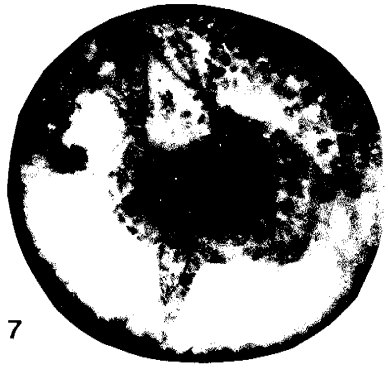
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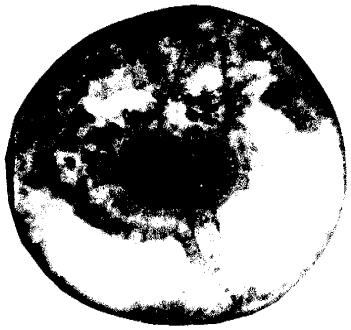
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Figure 18

Genus A., species A., new genus and species

1-5) Syntype #1, UTPO-23

1) Transverse section at anterior end, X 3.

2) Transverse section 13 mm apicad, anterior view, X 3.

3) Posterior view of same section as (2), X 3.

4) Transverse section 13 mm apicad, X 3.

5) Enlargement of thin section taken between (2) and (3), X 6.

6-8) Syntype #2, UTPO-24, X 3.

6) Transverse section taken at anterior end of specimen.

7) Transverse section 17 mm farther apicad.

8) Posterior view of (7).

9-11) Syntype #3, UTPO-25

9) Ventral (?) view, shows location of transverse section, scale is 10 mm.

10) Anterior view of cross section, X 3.

11) Posterior view of same cross section, X 3.


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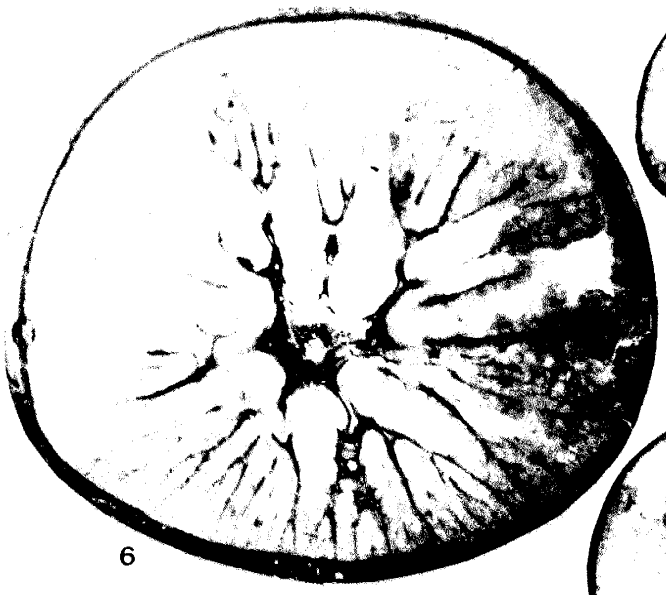
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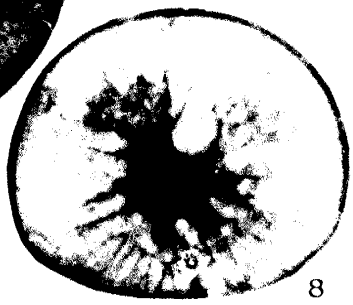
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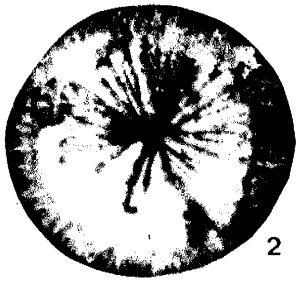
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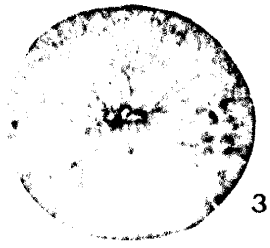
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Figure 19

1-3) *Rossoceras lamelliferum*, UTPO-15

1) Entire specimen, lateral view, venter on right, scale is 10 mm.

2) Transverse section, taken at (a); fine blades radiate outward from central tube toward siphuncle margin, X 2.

3) Transverse section taken at apex; tube is centrally located, X 2.

4-5) *Rossoceras lamelliferum*, UTPO-19, scale is 10 mm.

4) Transverse section; shows siphuncle in contact with shell wall. Portion of shell preserved.

5) Longitudinal section taken apicad of (4). Illustrates longitudinal nature of blades. Septal necks also visible. Venter on right.

6-8) *Evencoceras* sp. A., new species, UTPO-8

6) Holotype, enlargement of thin section, approximately X 5. Dendritic pattern of blades characteristic of this species displayed. Central white areas are coarse calcite crystals.

7) Transverse section, taken near apex. Blades bifurcate as they reach the siphuncle margin, X 2.3.

8) Transverse section near anterior end of specimen. Endosiphocone developed, X 2.3.

9-11) aff. *Rossoceras*, UTPO-37

9) Anterior view, venter down. Specimen is flattened on the dorsum, X 1.

10) Cross section taken at (a), venter down, X 1.

11) Ventral view of entire specimen, showing location of cross section (10), X 1.

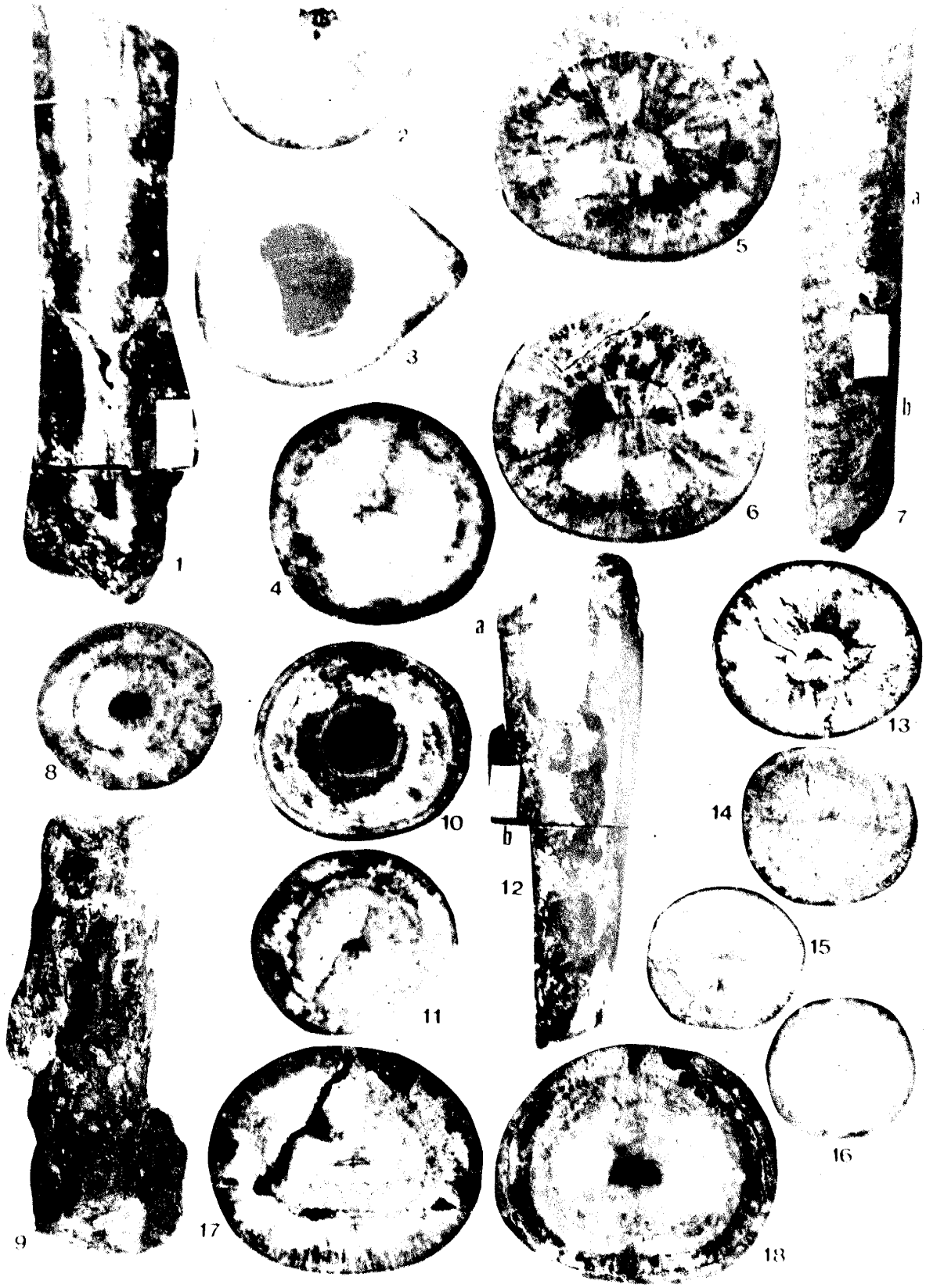
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Figure 20

1-2) *Rossoceras* sp. A., new species,
Syntype #1, UTPO-32

1) Dorsal view of entire specimen, showing location (a) of cross section, scale is 10 mm.

2) Cross section taken at (a), venter down. Dorsal portion of specimen weatered. Dark area is limonite. Central tube, a few blades, and ring stucture visible, X 2.5.

3-4) *Rossoceras* cf. *R.* sp. A.,
new species, UTPO-30, X 2.

3) Transverse section taken 25 mm from anterior end of specimen, near apical termination of fluted endosiphocone.

4) Transverse section taken 28 mm from apex. Although recrystallization has destroyed blades, the ring structure is still visible.

5-7) *Rossoceras* sp. A., new species
Syntype #2, UTPO-33, X 2.

5) Transverse section taken at (a); central tube with downcurved edges visible, as well as fine blades and ring structure, which is near the siphuncle margin.

6) Transverse section from (b); ring structure is nearer the central tube.

7) Entire specimen, lateral view, venter on right; septal ridges present over length of siphuncle, scale is 10 mm.

8-9) *Rossoceras*, species A., new species
Syntype #4, UTPO-35

8) Transverse section 30 mm from apex. Blades are largely lost due to recrystallization. Note ring structure, X 2.

9) Entire specimen, lateral view, venter on right, showing location of cross section (8), X 1.

10-12) *Rossoceras* cf. *R.* sp. A.,
new species, UTPO-10

10) Transverse section taken at (a), near apical termination of endosiphocone. Faint dorso- and ventro-lateral blades preserved, X 2.

11) Transverse section taken at (b); central tube with downcurved edges and blades visible; ring structure just within siphuncle margin, X 2.

12) Entire specimen, ventrolateral view, scale is 10 mm.

13) *Rossoceras* sp. A., new species
Syntype #3, UTPO-34
Transverse section, taken about midlength of specimen; ring structure, central tube, and blades clearly preserved, X 2.5.

14-16) *Rossoceras* cf. *R.* sp. A., new species, UTPO-29. Series of cross sections, X 1.2.

14) Section 17 mm from apex; recrystallization has destroyed fine blades. Lateral blades and ring preserved.

15) Section 37 mm orad.

16) Section 65 mm orad, near apex. Poor preservation has destroyed internal structure.

17-18) *Rossoceras* cf. *R.* sp. A., new species, UTPO-9, X 2.

17) Transverse section approximately 80 mm apicad of anterior end. Ring structure is partially destroyed by solution cavity.

18) Section 46 mm from anterior end, near apical termination of endosiphocone.

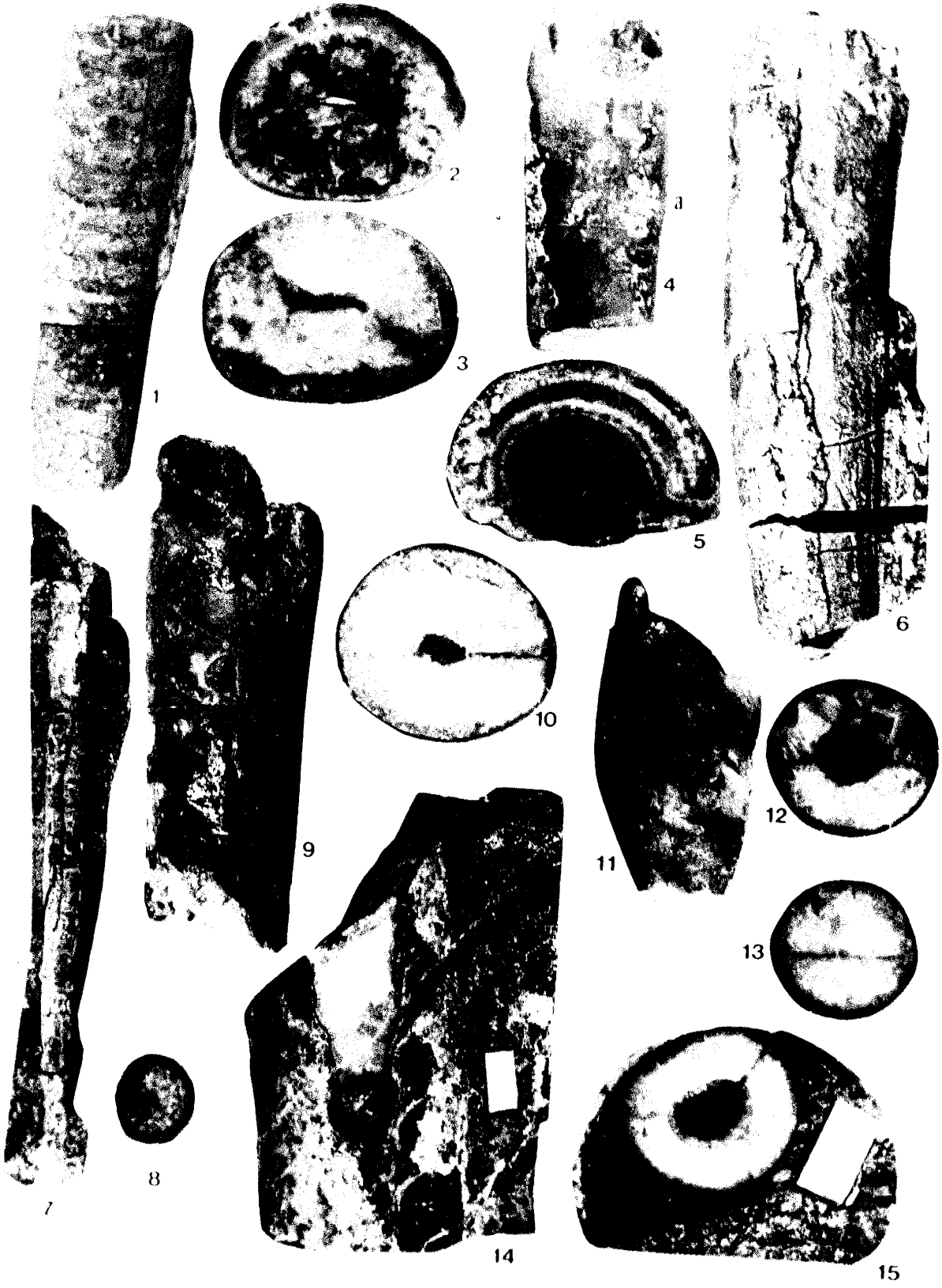
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Figure 21

1-2) *Rossoceras* sp. B., new species, UTPO-41

1) Dorsal view, showing location of transverse section (2), X 1.
2) Transverse section, showing pronounced ventral flattening, X 2.

3-4) *Rossoceras* sp. B., new species, UTPO-42

3) Transverse section taken at (a) on 4; blades destroyed, flattened on venter, X 2.
4) Entire specimen, dorsal view, X 1.

5-6) cf. *Rossoceras*, UTPO-11

5) Transverse section; endosiphocone well developed, X 1.5.
6) Exterior lateral view; longitudinal striae apparent along length of endosiphocone, scale is 10 mm.

7-8) *Rossoceras* sp., UTPO-12

7) Entire specimen, partially enclosed in matrix, lateral view, X 1.
8) Cross section taken near apex, X 2.

9-10) *Rossoceras* sp., UTPO-17

9) Exterior of entire specimen, lateral view, showing septal ridges which slope upward on venter (left), X 1.

10) Transverse section, showing lateral blades, X 2.

11) *Rossoceras* sp., UTPO-39

Oblique lateral view of external wall of siphuncle, showing ventral lobe in septal ridges, X 1.

12-13) *Rossoceras* sp., UTPO-6, X 1.2.

12) Transverse section, showing circular cross section.

13) Section near apex, showing traces of lateral blades and central tube.

14-15) *Rossoceras* sp., UTPO-14, scale is 10 mm.

14) External ventral view, showing portion of shell wall.

15) Transverse section at bottom (apex) of (14), venter up; shows position of siphuncle within phragmocone.

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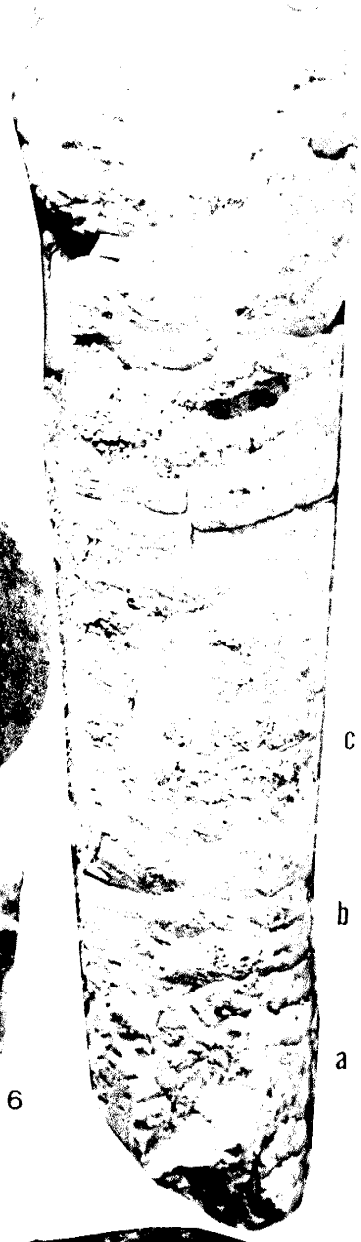

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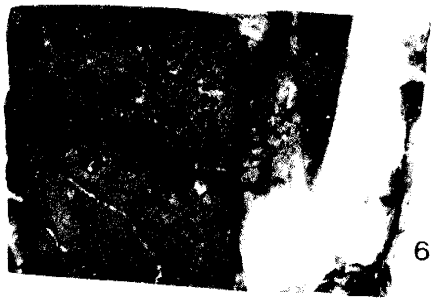

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Figure 22

1-6) *Cameroceras* sp. A., new species, UTPO-43

1) Ventral view of entire specimen, whitened, X 1.
2) Enlargement of thin section, approximately X 3; septal necks holochoanitic, connecting rings are black and not completely preserved.
3) View at break near apex (a), X 1.5.
4) Transverse section taken at (b); section cuts septa obliquely, resulting in the semicircular outline above the siphuncle, X 1.5.
5) Transverse section taken at (c); endosiphocone well developed, X 1.5.
6) Longitudinal section taken between (b) and (c); showing apical termination of endosiphocone, X 1.5.

7-9) *Cameroceras* sp., UTPO-47, scale is 10 mm.

7) Ventral view, entire specimen, showing location of cross section.
8) Longitudinal section made between cross section and apex. Septal necks appear holochoanitic.
9) Transverse section, showing ventral position of siphuncle.


a
b
c
1
2
3
4
5
6
7
8
9
10
11

Figure 23

Cameroceras sp. B., new species

1-5) Holotype, UTPO-45

1) Entire specimen, ventral view, showing location of transverse sections; siphuncle is broadly exposed on venter, scale is 10 mm.
2) Anterior view,new body chamber; siphuncle barely visible, and filled with matrix, X 1.2.
3) Transverse section taken at (a); endosiphocone developed, X 1.2.
4) Transverse section taken at (b); tube is slightly subcentral in position, X 1.2.
5) Natural break in specimen near (c), x 1.2.

6-7) Paratype, UTPO-46, X 2.

6) Entire specimen, ventral view. Siphuncle broadly exposed.
7) Apical view.

8) cf. *Cameroceras*, UTPO-48, X 0.5.

Poorly preserved mold; ventral view.

9-11) *Cameroceras* sp. C., new species, UTPO-44

Series of cross sections, X 2.

9) Section near anterior, showing endosiphocone and circular cross section.

10) Section more apicad, showing ventral position of tube and increasingly compressed cross section. Matrix and calcite fill siphuncle, creating a fortuitous structure.

11) Section near apex, showing small tube. Cross section more compressed.


2
3

Figure 24

1) Order Endoceratida, family, genus and species indeterminate, UTPO-63
Ventral view, specimen whitened; siphuncle with portion of living chamber attached, X 0.7.

2) Family Endoceratidae, genus and species indeterminate, ventral view, UTPO-62, scale is 10 mm.

3) Family Michelinoceratidae, genus and species indeterminate, section ground slightly to reveal siphuncle, UTPO-54, X 2.

4) cf. *Cameroceras*, ventral view, UTPO-61, scale is 10 mm.

5) *Michelinoceras* sp., UTPO-53
Section ground to reveal subcentral siphuncle and cameral deposits, X 2.

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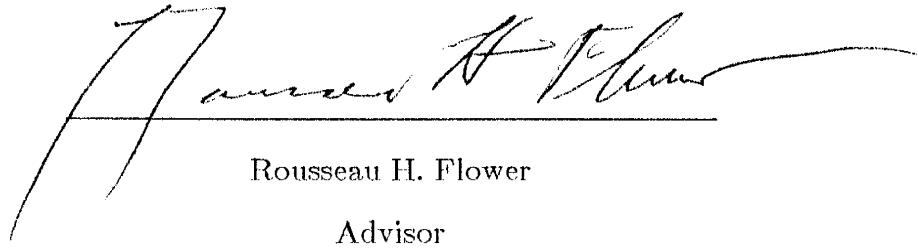
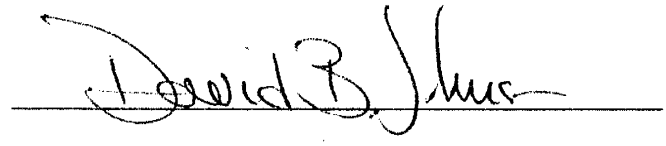


Rousseau H. Flower

Advisor



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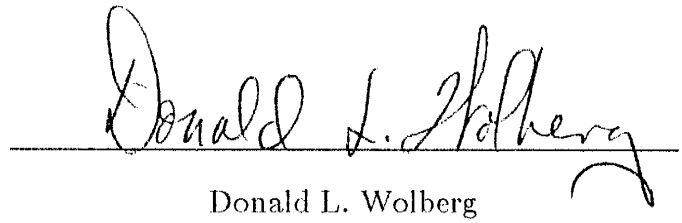

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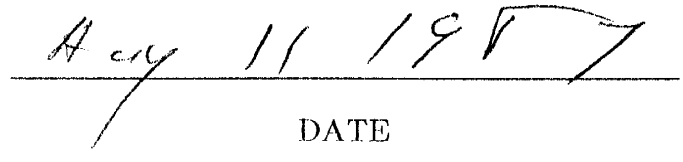

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