PERMIAN GASTROPODA OF THE SOUTHWESTERN UNITED STATES

3. BELLEROPHONTACEA AND PATELLACEA

ELLIS L. YOCHELSON

BULLETIN
OF THE
AMERICAN MUSEUM OF NATURAL HISTORY
VOLUME 119 : ARTICLE 4 NEW YORK : 1960

PERMIAN GASTROPODA OF THE SOUTHWESTERN UNITED STATES

PERMIAN GASTROPODA OF THE SOUTHWESTERN UNITED STATES

•

3. *BELLEROPHONTACEA AND PATELLACEA*

ELLIS L. YOCHELSON

United States Geological Survey

WITH NOTES ON PENNSYLVANIAN BELLEROPHONTACEA

BULLETIN

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY

VOLUME 119 : ARTICLE 4 NEW YORK : 1960

BULLETIN OF THE AMERICAN MUSEUM OF NATURAL HISTORY

Volume 119, article 4, pages 205–294, text figures 1–5,
plates 46–57, tables 1–25

Issued June 30, 1960

Price: 3.00 a copy

CONTENTS

INTRODUCTION

ABSTRACT

THE PRESENT STUDY includes two superfamilies of aspidobranch gastropods from the Permian of the southwestern United States. These are the Bellerophontacea, an abundant group having primitive bilateral symmetry, and the Patellacea, a rare group showing superficial, secondary bilateral symmetry. Where possible, species described from Permian outcrops outside North America have been tentatively assigned to the genera studied. Species currently assigned to the Pennsylvanian genera of Bellerophontacea in North America have been briefly reviewed. This is the first published summary of the bellerophontacean species in 60 years.

Following Knight's concept, I interpret the Bellerophontacea as being prosobranch gastropods. The slit suggests two gills, and phyletic considerations imply that these gills may have restricted them to a firm bottom in fairly clear water. The Recent Patellacea have a clinging habit, and there is strong suggestive evidence that the Permian species had a similar habit.

The Permian Bellerophontacea do not show phyletic size increase through time. The size of Permian species shows no clear trends either in the fauna as a whole or in a few selected species studied in more detail. Size frequency distribution in nine samples suggests that the occasional large specimen encountered is best considered as an extremely old individual. Size frequency studies may be of some use in differentiating between biocoenoses and thanatocoenoses.

Nine genera or subgenera of Bellerophontacea are described, one of which is new. Forty-five species of Bellerophontacea are discriminated. Thirty-three of these are considered new, five are redescribed, and seven are discussed but not named. The Patellacea are less varied, with two genera and seven species being recognized. Three species are new, two are redescribed, and two are unnamed. Occurrence data are presented for all species.

This is the third paper in a series planned by J. Brookes Knight, Ellis L. Yochelson, and Roger L. Batten that is designed to monograph the Permian gastropod fauna of the southwestern United States. To present the findings without excessive delay, the gastropods have been divided into major taxonomic units, each being published as completed. Much of the formal description is being written by Yochelson and Batten, but it is based on unpublished preliminary studies by Knight. The first two papers were published, respectively, by Yochelson (1956) and by Batten (1958).

The Bellerophontacea form a compact superfamily. The bilateral symmetry of the shell makes them a readily identifiable group, distinguished from almost all other mollusks except coiled cephalopods which, however, bear numerous internal septae and lack a slit. This study of Permian specimens, based to a large extent on well-preserved silicified material, has demonstrated that good specimens must be obtained before identification as to species, or in some cases even as to genus, should be attempted. The situation is by no means unique to the Permian, but for the first time it has been possible to demonstrate the pronounced ontogenetic change and individual variation previously suspected in some species.

Study of the Permian Patellacea adds to our knowledge of this group in the Paleozoic era. Although these specimens are also bilaterally symmetrical forms, they have nothing in common with the Bellerophontacea except that both are included in the Subclass Aspidobranchiata. Members of this superfamily are rare, and it is unlikely that the group will have much significance for stratigraphic correlations.

ACKNOWLEDGMENTS

Gratitude is expressed to Dr. Norman D. Newell, the American Museum of Natural History, for allowing examination of Permian specimens in the possession of the American Museum of Natural History. These were collected during the Permian reef-study project in west Texas sponsored jointly by the American Museum of Natural History and Columbia University and financed by the Humble Oil and Refining Company.

Dr. G. A. Cooper, United States National Museum, not only contributed numerous specimens from the Glass Mountains area of west Texas but spent much time discussing stratigraphic concepts. He and I spent several days examining outcrops in that area during the summer of 1956.

Mrs. A. F. Kemp, Seymour, Texas, contributed specimens from Baylor County, Texas. These aid in the interpretation of the pioneer work of C. A. White in that area.

By oversight, Dr. Carl C. Branson, Director, Oklahoma Geological Survey, was not thanked in part 1 of this work. Dr. Branson collected much of the material from the Hueco limestone in southeastern New Mexico. After having revisited these localities, I can appreciate the keen geologic sense required to interpret these localities and the considerable physical effort required to obtain specimens.

Colleagues in the United States Geological Survey have contributed numerous suggestions and useful comments. Publication is authorized by the Director, United States Geological Survey.

Finally, my two co-authors in the work, Dr. Roger L. Batten, University of Wisconsin, and Dr. J. B. Knight, Smithsonian Institution, retired, have helped in innumerable ways. In particular Dr. Knight is to be thanked. An unpublished manuscript of his on the Bellerophontacea of Wolfcamp age was generously turned over to me. Although I accept full responsibility for all new taxa described, many of the ideas concerning morphology of the genera have been taken almost unchanged from his manuscript.

The National Science Foundation is financing the greater part of the publication, on Grant G10187 to the American Museum of Natural History.

STRATIGRAPHIC CONSIDERATIONS

The present study does not suggest any modifications of the correlations presented by Yochelson (1956, pp. 186, 187). Rather, by showing further faunal similarities, it reënforces a correlation of the Hueco limestone with the Colina limestone, to the west, and the lower Permian shale limestone sequence in north central Texas, to the east. Batten (1958, p. 163) has indicated the stratigraphic position of some of the more important localities in the Glass Mountains and Guadalupe Mountains. Gilluly (1956) has described the geology of central Cochise County, Arizona, in detail, and Boyd (1958) has recently discussed back-reef relationships in the Guadalupe Mountains. The interested reader is referred to these papers for a general discussion of the stratigraphy. The notes given below are a few additional observations that do not change the regional picture.

In company with George Bachman, United States Geological Survey, I had the opportunity of visiting parts of Otero County, New Mexico, during the 1956 field season. We briefly examined the outcrops on the former McGregor Ranch, now part of the Pelagro artillery range under control of Fort Bliss, El Paso, Texas. This limited area includes U.S.N.M. localities 712b, 712c, 712h, 712i, and 712j. These are all probably within 100 to 200 feet of the same stratigraphic level. This series of localities also includes those from which Miller and Parizek (1948) described lower Permian cephalopods. The fauna observed is predominantly a productoid brachiopod assemblage, with relatively few mollusks. The gastropods consist of numerous *A.* (*Amphiscapha*) *proxima* Yochelson and few bellerophontaceans. Except for the absence of *Omphalotrochus*, in general terms the fauna seems to be similar to that mentioned for the lower part of the Hueco limestone (Yochelson, 1956, p. 192).

We also examined U.S.N.M. locality 712. This appears most similar lithologically to the lower part of the Hueco limestone (King and Knight, 1945), but, because of the isolated position of the outcrop, relationships cannot be determined conclusively. Later, I examined U.S.N.M. 712a. Again, because of its isolated position, this locality cannot be placed in the standard section with any degree of confidence. The lithology appears to be more like that of the middle part of the Hueco limestone than that of the lower part of the formation.

During the same field season, Dr. Frank Kottlowski, New Mexico Institute of Mining and Technology, generously guided me to the type locality of the Yeso formation (Needham and Bates, 1943, p. 1658), from which Girty (1909b) reported and described some fossils. The sequence consists of gypsum and gypsiferous limestone. In half a day, we were unable to find any fossils. If the outcrop bears any fossils, they are exceedingly rare.

I also spent two days at the type locality of the San Andres formation on the west flank of the San Andres Mountains (Needham and Bates, 1943, p. 1664). One bed containing productoid brachiopods was observed about 120 feet above the base of the formation exposed to the south of the road through Rhodes Pass. About 110 feet higher in the section, there is a massive limestone, 15 feet in thickness, bearing scattered silicified mollusks. Except for a bed bearing a few bryozoans near the top of the formation and scattered specimens of *Straparollus* (*Euomphalus*) *kaibabensis* (H. P. Chronic), these two beds contained the only larger fossils observed. Because of the massive nature of the mollusk-bearing bed, collecting was limited to the specimens that had partially weathered free. The results were discouraging, as only a handful of gastropods, none of which is germane to this particular study, was obtained.

More field work should be done, but observations at these two type sections cast doubt on the stratigraphic placement of gastropods listed by Girty (1909b) from the Manzano group. It may very well be that some of his collections, supposedly from the Yeso, are actually from the San Andres. Furthermore, distribution of fossils within the San Andres formation may be more restricted than has heretofore been considered.

METHODS AND PROCEDURES

The procedures followed in this paper are identical to those mentioned previously (Yochelson, 1956, pp. 181–183). Terminology mostly follows that employed by Knight (1941a) and L. R. Cox (1955). Morphologic terms applied to the bellerophontaceans which may not be clear to the reader are "lateral lips" and "anterior lips." Lateral lips refer to the parts of the aperture that join the body whorl and are seen in side view of the specimen. Anterior lips are the parts of the aperture on each side of the sinus and slit. The division between these two parts of the aperture is commonly arbitrary, but in the Euphemitinae the two parts of the lip join more or less abruptly. "Dorsum" is employed occasionally for the area of shell on each side of the selenizone and the area of the selenizone combined.

Three measurements chosen to characterize the Bellerophontacea are length, width, and thickness. The reference lines for these measurements are shown diagrammatically in figure 1. It is apparent that these are not comparable to the measurements used for asymmetrically coiled shells. For example, the morphologic equivalent of height in an asymmetric shell is here called width. The measurements of length, width, and height used for the Patellacea are again not comparable to those used for more conventional gastropods. Nevertheless it seems obvious what measurements are being taken, and there appears to be no need to coin new terms for these bilaterally symmetrical shells.

Except where it is specifically noted that measurements have been made with the use of a micrometer ocular, measurements have been taken with a vernier caliper accurate to 0.1 mm. The omission of the decimal point, in any measurement, indicates that the measurement is only approximate. Because of the bilateral symmetry of these gastropods, it is possible to measure half of an incomplete specimen and estimate its size. The mean (M), standard deviation (S), and coefficient of correlation (r) have been calculated for length, width, and thickness of three species

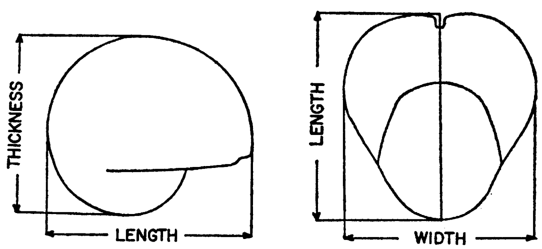


FIG. 1. Measurements of length, width, and thickness as used for bellerophontacean shells.

following the methods employed by Imbrie (1956). Statistical study has been limited to those few species having 10 or more undistorted specimens available from the same locality. In every case these are silicified specimens.

By prior agreement, types selected from the Princeton University collections and types selected from the Hueco limestone collections of the American Museum of Natural History have been presented to the United States National Museum. Other types belong to the American Museum of Natural History, to the Texas Bureau of Economic Geology, or to the United States National Museum.

The following abbreviations have been used for type designations, and for locality data:

A.M.N.H., the American Museum of Natural History
B.E.G., Bureau of Economic Geology, University of Texas, Austin, Texas
P.U., Geology Department, Princeton University, Princeton, New Jersey
U.S.G.S., United States Geological Survey, Washington, D. C.
U.S.N.M., United States National Museum, Washington, D. C.

Geographic and stratigraphic distribution of the species described or discussed is given in in the table facing this page.

As in a previous paper (Yochelson, 1956), an attempt has been made to assign Permian species previously described from outside North America into what is currently considered the proper genus. It is pertinent to repeat that these assignments are provisional and based in almost every case on the literature only, with virtually no study of specimens. The "Bibliographic index of Permian invertebrates" prepared by Branson (1948) has been an invaluable guide to the literature. To avoid unnecessary bibliographic work, references have not been given to the species listed by Branson. The literature outside North America has been searched through 1956.

The paper by Licharew and Netschajew (1956) is of particular interest. This is one of the few papers published dealing exclusively with the Bellerophontacea. The specimens described are from the Fergan area of the Union of Soviet Socialist Republics. The authors consider all species to be of Carboniferous age. The species from the upper Carboniferous *Pseudoschwagerina* zone are here considered to be of Permian age. Such a decision points again to the difference in opinion of many geologists as to the placement of the Pennsylvanian and Permian boundary. Of 35 species described or discussed by Licharew and Netschajew, 15 seem to be from beds here considered to be lower Permian.

Brief comment has been made on these species under the appropriate heading. Most of the species have been differentiated from the American Permian species. Some of the species of *Knightites* (*Retispira*) have not been differentiated, however, because the Russian authors do not commonly illustrate umbilical views that show important morphologic features. In general, there seems to be a close similarity between the American and Russian species of *K.* (*Retispira*).

TABLE 1
Faunal Distribution by Localities

Species	North Central Texas																			
	Admiral Formation			Belle Plains Formation	Clyde Formation												Lueders Limestone			
	Wildcat Creek Shale Member			Elm Creek Limestone Member	Talpa Limestone Member							Grape Creek Limestone Member								
	9800	9802 =42-T18	42-T20	42-T3	9854	199-T2-Q21-1.3A14	199-T5-1.3A14	199-T5-1.3A15	199-T7-P19-1.3A15	199-T13-P22	Stout Ranch	9863	199-T2-1.3A13	199-T9-1.3A12	199-T12-P22	Godwin Creek	199-T1-L16-1.3A419	199-T4-L16	199-T16-1.3A17	9862
Bellerophontacea																				
Sinuitina keytei Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites aequisulcatus H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites imperator Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites kingi Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites exquisitus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites crenulatus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites batteni Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites luxuriosus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites sparciliratus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis multinodosa Yochelson, new species	x	x	—	—	x	x	—	x	x	—	—	x	x	x	—	—	x	—	—	—
Euphemitopsis paucinodosa Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis subpapillosa (White)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia crassus Yochelson, new species	—	x	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia welleri Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia waageni Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia angustior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia americana Girty	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia fissus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia saundersi Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *huecoensis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *oteroensis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *parvicristus* Yochelson, new species	—	x	x	—	—	—	x	—	—	—	—	x	—	—	—	x	—	—	—	—
B. (*Bellerophon*) *lineatus* Yochelson, new species	—	—	—	x	—	x	x	—	x	—	—	—	—	—	x	—	x	x	—	—
B. (*Bellerophon*) *complanatus* Yochelson, new species	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *deflectus* H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *plummeri* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *kingorum* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *hilli* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) *westi* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) species	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus?*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *bransoni* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *medialis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—
K. (*Knightites*) *maximus* Yochelson, new species	—	—	—	x	—	x	x	x	x	x	x	—	—	x	—	—	—	x	—	—
K. (*Knightites*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *eximia* Yochelson, new species	x	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *fragilis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *modesta* (Girty)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *girtyi* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *texana* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Patellilabia junior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	x	x:
Patellacea																				
Metoloma texana Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis patella Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis parrishi Gurley	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis? beedei Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis? capitensis (Girty)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Species	West Texas Area: Glass Mountains																													
	Wolfcamp Formation												Leonard Formation											Word Formation						
	701f	701e	701g	701d	701a3	701k	701c	706x	707d	707o =3359	704v	707h	708e	707b	707q	702f	702d	702	702un	702ent	703b	703a =504	6694	703c =503	703	707e	706c	706	706e	7066
Bellerophontacea																														
Sinuitina keytei Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—
Euphemites aequisulcatus H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	—	—	—	—	x	x	—	—	—	—	—
Euphemites imperator Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	x	x	—	—	—	—	—
Euphemites kingi Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites exquisitus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	x	—	—	—	—	—	—
Euphemites crenulatus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	—	—	—	—
Euphemites batteni Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	x	—
Euphemites luxuriosus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites sparciliratus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	x	—
Euphemites species	—	—	—	—	—	—	—	x	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis multinodosa Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis paucinodosa Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis subpapillosa (White)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia crassus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia welleri Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	x	—	—	x	x	—	—	—	—	—
Warthia waageni Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—
Warthia angustior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia americana Girty	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia fissus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—
Warthia saundersi Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *huecoensis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *oteroensis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *parvicristus* Yochelson, new species	—	x	x	—	—	—	—	—	—	x	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *lineatus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *complanatus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *deflectus* H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	—	—	—	—
B. (*Bellerophon*) *plummeri* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	x	—	—	—	—
B. (*Bellerophon*) *kingorum* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	x	x	x	—	x
B. (*Bellerophon*) *hilli* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	x	x	—	x	x	—	—	—	—	—
B. (*Pharkidonotus*) *westi* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—
B. (*Pharkidonotus?*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	—	—	—	—
K. (*Knightites*) *bransoni* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *medialis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *maximus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *eximia* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *fragilis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *modesta* (Girty)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	x	x	—	—	—	—	—
K. (*Retispira*) *girtyi* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	x	—	x	x	—	—	—	—	x	—	—	—	—
K. (*Retispira*) *texana* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—
K. (*Retispira*) species 1	—	—	—	—	—	—	—	—	x	x	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Patellilabia junior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Patellacea																														
Metoloma texana Yochelson, new species	x	x	x	—	—	x	x	x	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis patella Yochelson, new species	—	—	x	x	x	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis parrishi Gurley	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—
Lepetopsis? beedei Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis? capitensis (Girty)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 1	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 2	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Species	West Texas Area: Hueco Mountains-Sierra Diablo Plateau																					
	Hueco Limestone											Bone Spring Limestone										
	712g =3071	712d	712f =53	391	717	721 =37	7003	6724	6681	24	626	625	655	3 =?14439	26a	433	592	716	14461	1	4	53
Bellerophontacea																						
Sinuitina keytei Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites aequisulcatus H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	x	—	—	—	—	—	—
Euphemites imperator Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	x	—	—	—	—	—	—
Euphemites kingi Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—
Euphemites exquisitus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	x	x	—	x
Euphemites crenulatus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites batteni Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites luxuriosus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites sparciliratus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis multinodosa Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis paucinodosa Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis subpapillosa (White)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia crassus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia welleri Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—
Warthia waageni Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	x	x	—	—	—	—	—
Warthia angustior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—
Warthia americana Girty	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia fissus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia saundersi Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *huecoensis* Yochelson, new species	x	—	—	—	x	x	x	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *oteroensis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *parvicristus* Yochelson, new species	x	x	x	x	—	—	—	x	x	x	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *lineatus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *complanatus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *deflectus* H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	x	—	x	—	x	x	—	—	—	—	—
B. (*Bellerophon*) *plummeri* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *kingorum* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *hilli* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) *westi* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	x	—	—	—	—	—
B. (*Pharkidonotus*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus?*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *bransoni* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *medialis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *maximus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *eximia* Yochelson, new species	x	x	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *fragilis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—
K. (*Retispira*) *modesta* (Girty)	—	—	—	—	—	—	—	—	—	—	—	—	x	x	x	x	x	—	—	—	x	—
K. (*Retispira*) *girtyi* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—
K. (*Retispira*) *texana* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Patellilabia junior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Patellacea																						
Metoloma texana Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis patella Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis parrishi Gurley	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—
Lepetopsis? beedei Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis? capitensis (Girty)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Species	West Texas Area: Guadalupe Mountains							New Mexico: Otero County												
	Bone Spring Limestone		Brushy Canyon Formation	Cherry Canyon Formation		Carlsbad Group		Hueco Limestone								Gym Limestone		Yeso Formation		San Andres Formation
	369 =369a =729	678	2931 green	519	512 =728	2966 green	3364	712 =3322	3323	712a	712b	712h	712i	712j	712c	725	726	3742d	15784	3738a green
Bellerophontacea																				
Sinuitina keytei Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites aequisulcatus H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites imperator Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites kingi Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites exquisitus Yochelson, new species	x	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites crenulatus Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites batteni Yochelson, new species	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites luxuriosus Yochelson, new species	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites sparciliratus Yochelson, new species	x	—	—	x	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemites species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—
Euphemitopsis multinodosa Yochelson, new species	—	—	—	—	—	—	—	x	x	—	x	x	x	x	x	—	—	—	—	—
Euphemitopsis paucinodosa Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphemitopsis subpapillosa (White)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—
Euphemitopsis species	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia crassus Yochelson, new species	—	—	—	—	—	—	—	—	x	x	—	—	—	—	—	—	—	—	—	—
Warthia welleri Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia waageni Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia angustior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia americana Girty	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia fissus Yochelson, new species	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Warthia saundersi Yochelson, new species	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *huecoensis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	x	—	—	—	x	—	—	—	—	—
B. (*Bellerophon*) *oteroensis* Yochelson, new species	—	—	—	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *parvicristus* Yochelson, new species	—	—	—	—	—	—	—	x	x	x	x	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *lineatus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *complanatus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *deflectus* H. P. Chronic	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *plummeri* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *kingorum* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *hilli* Yochelson, new species	—	x	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) *westi* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) species	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus?*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *bransoni* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	x	x	—	—	—	—	—	—
K. (*Knightites*) *medialis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *maximus* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Knightites*) species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *eximia* Yochelson, new species	—	—	—	—	—	—	—	x	—	—	x	—	—	—	x	x	x	—	—	—
K. (*Retispira*) *fragilis* Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *modesta* (Girty)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	x
K. (*Retispira*) *girtyi* Yochelson, new species	x	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *texana* Yochelson, new species	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 2	—	—	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—
Patellilabia junior Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Patellacea																				
Metoloma texana Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis patella Yochelson, new species	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis parrishi Gurley	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis? beedei Yochelson, new species	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis? capitensis (Girty)	—	—	—	—	—	x	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lepetopsis species 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Species	Arizona: Cochise County								
	Colina Limestone								
	8388	17394	17393	8502	8503	8505	8526	8527	8964
Bellerophontacea									
Sinuitina keytei Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites aequisulcatus H. P. Chronic	—	—	—	—	—	—	—	—	—
Euphemites imperator Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites kingi Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites exquisitus Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites crenulatus Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites batteni Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites luxuriosus Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites sparciliratus Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemites species	—	—	—	—	—	—	—	—	—
Euphemitopsis multinodosa Yochelson, new species	—	—	—	x	—	—	—	—	—
Euphemitopsis paucinodosa Yochelson, new species	—	—	—	—	—	—	—	—	—
Euphemitopsis subpapillosa (White)	—	—	—	—	—	—	—	—	—
Euphemitopsis species	—	—	—	—	—	—	—	—	—
Warthia crassus Yochelson, new species	—	—	—	—	—	—	—	—	—
Warthia welleri Yochelson, new species	—	—	—	—	—	—	—	—	—
Warthia waageni Yochelson, new species	—	—	—	—	—	—	—	—	—
Warthia angustior Yochelson, new species	—	—	—	—	—	—	—	—	—
Warthia americana Girty	—	—	—	—	—	—	—	—	—
Warthia fissus Yochelson, new species	—	—	—	—	—	—	—	—	—
Warthia saundersi Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *huecoensis* Yochelson, new species	—	—	x	—	x	x	x	—	x
B. (*Bellerophon*) *oteroensis* Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *parvicristus* Yochelson, new species	x	x	—	x	—	—	—	x	—
B. (*Bellerophon*) *lineatus* Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *complanatus* Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *deflectus* H. P. Chronic	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *plummeri* Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *kingorum* Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Bellerophon*) *hilli* Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) *westi* Yochelson, new species	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus*) species	—	—	—	—	—	—	—	—	—
B. (*Pharkidonotus?*) species	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *bransoni* Yochelson, new species	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *medialis* Yochelson, new species	—	—	—	—	—	—	—	—	—
K. (*Knightites*) *maximus* Yochelson, new species	—	—	—	—	—	—	—	—	—
K. (*Knightites*) species	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *eximia* Yochelson, new species	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *fragilis* Yochelson, new species	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *modesta* (Girty)	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *girtyi* Yochelson, new species	—	—	—	—	—	—	—	—	—
K. (*Retispira*) *texana* Yochelson, new species	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 1	—	—	—	—	—	—	—	—	—
K. (*Retispira*) species 2	—	—	—	—	—	—	—	—	—
Patellilabia junior Yochelson, new species	—	—	—	—	—	—	—	—	—
Patellacea									
Metoloma texana Yochelson, new species	—	—	—	—	—	—	—	—	—
Lepetopsis patella Yochelson, new species	—	—	—	—	—	—	—	—	—
Lepetopsis parrishi Gurley	—	—	—	—	—	—	—	—	—
Lepetopsis? beedei Yochelson, new species	—	—	—	—	—	—	—	—	—
Lepetopsis? capitensis (Girty)	—	—	—	—	—	—	—	—	—
Lepetopsis species 1	—	—	—	—	—	—	—	—	—
Lepetopsis species 2	—	—	—	—	—	—	—	—	—

ECOLOGICAL IMPLICATIONS

IT IS DIFFICULT to state much that is definitive about the ecology of the Permian Bellerophontacea. There are no living representatives of the superfamily, and the ecology of the more primitive of the living pleurotomariaceans, an allied superfamily, is not known in detail (Batten, 1958, p. 169). What little that can be said about the Permian Bellerophontacea might not apply to older genera, particularly to the curious cuneiform Pterothecinae of the Ordovician, Silurian, and Devonian.

The Bellerophontacea were almost without question benthonic animals. Older workers compared the bellerophontacean shell with that of the living heteropods and pteropods, which are specialized pelagic gastropods. Although there is a similarity in the bilateral symmetry of the shell in all three groups, it is superficial, not fundamental. There are good reasons for believing that the bellerophontaceans were not swimming animals, the most telling of which are the large size and heavy shell of some of the Permian specimens illustrated.

Bellerophontaceans occur in shales, limestones, and sandstones, but they are extremely rare in sandstones. Field observations suggest that they are more common in calcareous sedimentary rocks, whether they be limestones or calcareous shales, than in argillaceous sedimentary rocks. The number of observations is limited, however, and the suggestion may well be spurious.

Yonge (1947) has completed an outstanding work on the mantle cavity and ctenidia of mollusks, with particular emphasis on the aspidobranch gastropods. He has concluded that all the living aspidobranch gastropods, except the fresh-water Valvatacea, live on hard bottoms. Yonge (written communication, October, 1958) has indicated that the term "hard" is not necessarily synonymous with rocky substrate, although a rocky substrate is the preferred habitat for the Trochacea, one of the more important living superfamilies of aspidobranch gastropods. The nature of their gills is such as to prevent them from living for long times in turbid waters. Yonge writes, "I do certainly associate this limitation of habitat in the aspidobranchs with the form of the gill and in particular with its manner of attachment both by afferent and efferent membranes."

The framework of this paper is based on the work of Knight (1952) showing that the bellerophontaceans are prosobranch gastropods. They are interpreted by him as being basically like the most primitive of the living forms, but even more primitive in some of the features, such as shell coiling and musculature. If that assumption is correct, the gill structure should be aspidobranch and similar to, or even simpler than, that found in the living aspidobranch gastropods.

It logically follows that bellerophontaceans, too, should be limited to firm bottoms, at least as firm as those upon which the primitive aspidobranch-gilled pleurotomariaceans live today. Of course, the term "hard" bottom is subject to several different interpretations. The hard bottom of the functional morphologist may not be that of the ecologist, and the interpretation of either of these may not be what is meant when the term is used by the sedimentologist. Nevertheless it is possible that further work may show the slit-bearing gastropods to be useful as indicators of substrate hardness.

It has been suggested previously that locality A.M.N.H. 51 in the middle part of the Hueco limestone was essentially a life association (Yochelson, 1956, pp. 190, 191). There is even more of an indication that U.S.N.M. 712b in the Hueco limestone, possibly in the lower part of the formation, was also essentially a life association. The fact that the fauna of both these widely separated localities seems to be a biocoenosis, when taken with the lithic similarity of the Hueco over wide areas, adds additional evidence that, as a whole, the fauna of the Hueco limestone may not have undergone much transportation.

The fauna of U.S.N.M. locality 712b is most interesting in that it is composed almost exclusively of bellerophontaceans. Most of these are referred to a single species, *Knightites (Retispira) eximia*, new species (described on p. 273). A partially dissolved limestone block showing the silicified gastropods in place is illustrated on plate 55, figure 37. This block provides evidence that there was little, if any, sorting by currents at this locality. First, there are several different forms of shells present, although kinds other than bellerophontiform are in the minority. Second, the shells are randomly oriented in all three dimensions. Third, there is a definite size distribution, with small shells being much more abundant than larger shells. Fourth, few of the shells have the ornament worn. Most of the specimens are worn in some collections that can be demonstrated on other grounds to have been transported.

The ecological setting for the patellaceans is easier to describe and more circumscribed than that of the bellerophontaceans. All living patellaceans known to me are characterized by a clinging habit, for which the cap-shaped shell seems to be an ideal adaptive form. Although many Recent genera cling to rocks, other habitats are known. For example, *Acmaea insessa* Hinds clings to the stalks of seaweed, and *A. leucopleura* Gmelin attaches to the columella of larger gastropods.

Paleozoic patellaceans are exceedingly rare. The United States National Museum collection contains fewer than a dozen specimens, exclusive of the Permian material described herein. One possible reason for this paucity of specimens is that the rocky shore facies, the ideal ecologic niche for the patellaceans, is rarely preserved in the geologic record. The Permian occurrences of specimens are interpreted as habitats available for rock-clinging forms.

The preponderant number of Permian specimens come from the Wolfcamp formation in the Wolfcamp Hills of the Glass Mountains, west Texas. The strata exposed are shales interbedded with limestones. Most of the limestones swell into biohermal masses projecting up into the shales. The patellaceans almost all come from the silicified biohermal masses. In nearby areas, coarse conglomerates were contemporaneous and suggest fairly strong currents (Batten, 1958, p. 162). The few remaining occurrences in the post-Wolfcamp Permian are either from localities that were also patch reefs or bioherms or from localities where the evidence indicates that the fossils were swept from reefs and subsequently deposited (see also Yochelson, 1956, pp. 188–190).

Perhaps the only patellaceans in the Permian that cannot be interpreted as having lived on a bioherm are the few from north central Texas. In a similar setting of shale and shaly limestone deposition in Kansas from which Pennsylvanian patellaceans were described (Newell, 1935), a few granite cobbles have been collected (Norman Newell, oral communication, July, 1958). While it is not suggested that the specimens necessarily clung to these particular cobbles, this does indicate that even the environments that might have a "soft" bottom still might contain a few "hard" spots for clinging animals.

The number of specimens in the collections remains to be discussed. The patellaceans form an insignificant part of the total gastropod fauna known from the Permian. In a three-week period of preparing collections from a single new locality, the size of the patellacean collection was more than doubled. Such an increase in numbers emphasizes again how cautious one must be in evaluating the relative abundance of rare faunal elements.

The bellerophontaceans available for study also do not reflect the true abundance of the living animals. In the Permian, specimens are present locally in what can only be described as astronomical numbers. In the lower part of the Hueco limestone there is a coquina several feet thick, composed of large bellerophontacean steinkerns. This layer runs along the southern flank of the Sierra Diablo from Threemile Mountain near Van Horn, Texas, almost to Sierra Blanco about 30 miles west-northwest. The same layer crops out along the east face of the Sierra Diablo at least as far north as Marble Canyon, some 25 miles north of Threemile Mountain.

Most of the specimens in the coquina are poorly preserved. Occasional fairly well-preserved specimens indicate that several genera and species are present. In spite of the indeterminate nature of most of the specimens, the presence of abundant large bellerophontaceans appears to be a good local stratigraphic guide to the lower part of the Hueco limestone. No large accumulations of bellerophontaceans are known in the post-Hueco strata.

SLIT AND INDUCTURA IN PERMIAN BELLEROPHONTACEANS

So far as known, this is the first paper to present measurements of slit depth. To obtain these, a thread was laid along the body whorl from the interior of the aperture extending around the dorsum and out through the center of the slit to an imaginary line across the most anterior extensions of the lip. The total circumference and the total length of the slit and sinus were then both measured by the placing of the thread on a flat scale. This method is crude but seems to provide a moderately accurate result. More sophisticated methods of measuring along curved surfaces have been developed in the tool- and die-making industry and perhaps could be applied to this sort of study.

For many species, one complete unbroken specimen was available. For a few species an incomplete specimen was measured. If care is taken, fairly accurate measurements can be made on incomplete specimens. In the Bellerophontacea the selenizone commonly is a point of weakness, and the slit frequently may be broken back posteriorly. These broken slits give an order of magnitude for the slit depth and provide a maximum figure. It is easy to determine when one is dealing with true slit depth, because the slit thins anteriorly, as does the edge of the shell aperture.

Steinkerns in the Permian have also yielded information regarding slit depth. The nature of the mollusk shell is such, in contrast to the brachiopod shell, for example, that all shell layers exfoliate when broken from limestone, clinging to the exterior matrix rather than to the internal filling or steinkern. The result is a smooth steinkern. However, at the slit the shell is missing, and there is no separation between steinkern and exterior matrix. For this reason the trace of the slit will show as a roughened area on the steinkern. An example may be seen on plate 54, figure 15. Steinkerns from other geologic periods should be investigated for traces of the slit in bellerophontaceans and allied pleurotomariaceans to provide more information on this important morphologic feature.

Measurements of slit depth were made either on holotypes or on figured paratypes. In a few species, two specimens were measured. In only two species, in which all specimens are small and relative error might be much higher, were five or six individuals measured.

All measurements are given in terms of a percentage of the circumference of the body whorl. As specimens of different growth stages were measured, such a method of expression seemed to be the only one that at least partially took into consideration the ontogenetic stage of the specimen. In only one species, *Knightites* (*Retispira*) *eximia*, new species, was it possible to measure half a dozen specimens of various growth sizes. When the method of measurement used is considered, the data obtained suggest that there is little, if any, ontogenetic change in the relative depth of the slit and the sinus compared to the total circumference of the body whorl. Relative slit depth does not seem to show more individual variation than other quantitative features. More data on more species are needed before general conclusions can be drawn.

There is no way at the moment of measuring the depth of the slit apart from the depth of the slit and the sinus. Indeed, these two are so interrelated that it seems illogical to attempt any subdivision. In *Euphemitopsis* the depth of the sinus is relatively greater than in *B.* (*Bellerophon*), but for individual species of the two genera the total depth of the exhalant indentation is nearly the same.

The difference between the shallowest and the deepest relative slits in the Permian Bellerophontacea is far less than that found in the Permian Pleurotomariacea. For example, compare *Callitomaria stanislavi* (Batten, 1958, pl. 39, fig. 15). If the limited information permits the drawing of a general suggestion, it is that for the Permian bellerophontacean genera studied the presence of a slit was important, but its relative depth was much less important. Species with relative depths of from 5 to 15 per cent existed. Perhaps the most interesting detail is that for so many species the relative depth was essentially the same, namely, nearly 10 per cent of the circumference of the body whorl.

Knight (1952, p. 54) has published a restoration of the late Pennsylvanian bellerophontid *Knightites* (*Knightites*) *multicornutus* Moore, showing the inferred position of some of the soft parts and the inferred circulation of water currents within the mantle cavity. This model seems to hold generally for all Permian Bellerophontacea and probably for slit-bearing and deeply sinuate bellerophontaceans. The species illustrated is atypical in that it had special excavated inhalant prongs developed on the anterior margin of the lips. As the shell grew forward, these prongs were produced into short tubes. In some species, shorter, more cup-like swellings developed on the anterior lip to channel inhalant water [*Bellerophon* (*Pharkidonotus*)] or, much more commonly, there was no special modification of the anterior lip to channel inhalant water [*Bellerophon* (*Bellerophon*)].

The inductura is another morphologic feature of the bellerophontaceans that has been neglected by most earlier workers. It is particularly worthy of comment in connection with the Permian specimens, not only because it is notably thickened in some species, but because it is well preserved in some of the silicified material. In many specimens that are collected from limestones, the inductura may be obscured by the matrix or may be exfoliated.

Knight (1952, p. 53) has commented briefly on the inductura of some of the bellerophontaceans as a further line of evidence showing that these animals were prosobranch gastropods that had undergone torsion of the soft anatomy, rather than primitive untorted "amphigastropods." An inductura or "callus" is common to many living prosobranch gastropods. In life the asymmetrical shell commonly lies to the right of the foot when the animal is moving. When observed from above, the outer edge of the animal is anterior and the callus is posterior, with reference to the head. This arrangement of lip and inductura is precisely the same as that found in the bellerophontaceans, and, accordingly, the inductura is taken to indicate the posterior part of the shell.

A posterior inductura is found in all the Permian species examined. The Euphemitinae have both anterior and posterior inductural layers, which are discussed in more detail below (p. 232). The posterior inductura of most bellerophontaceans commonly does not extend far out of the aperture. Few inductura extend for more than one-quarter of the body whorl, and many are confined nearly to the plane of the aperture. In *Knightites* and *Bellerophon* (*Parkidonotus*) the inductura may be relatively thick and develop an elaborate shape. In the typical subgenus of *Bellerophon* and in most of the Euphemitinae, it is a relatively thin wash covering the exterior of the shell.

In living gastropods all secretion of calcium carbonate is carried on by the mantle (Graham, 1957, p. 136), with the possible exception of the calcification of the operculum. The presence of a posterior inductura indicates the presence of a posterior flap of the mantle. This mantle flap may not have extended out of the aperture in some species, but in others it may have extended far enough posteriorly so that the shell rested on this flap which in turn rested on the foot.

In most species lateral sinuses in the lateral lips at each end of the aperture are lined with an inductural deposit continuous with that on the early part of the body whorl. This lining indicates that the posterior mantle flap was relatively broad. The inductural lining is particularly well shown in *B.* (*Bellerophon*) *plummeri*, new species, in which the lateral sinuses are especially deep and the inductural deposits heavy. The thickening and slight reflection of the lateral lips seen in many bellerophontaceans are the result of inductural deposits thickened on the edges of the lips. It is premature to draw conclusions for all genera, but all the lower Paleozoic bellerophontaceans that I have examined in detail show some evidence of a posterior inductura. Nothing is known of this feature in the allied Helcionellacea.

SIZE OF PERMIAN BELLEROPHONTACEANS

NEWELL (1949) has suggested that many invertebrate groups undergo phyletic size increase with time. As the Permian period marks the last appearance of the Bellerophontacea, except for a few scattered species in the Triassic, and as members of the superfamily are abundant, the superfamily might provide some information on this hypothesis. The information given below for the various genera is based primarily on the collections studied and includes few inferences derived from the literature.

Average size is a most difficult concept to express, but by average, in most cases, I mean a typical specimen of the superfamily from the well-known fauna of the Pennsylvanian Wayland shale member of the Graham formation in north central Texas. Size increase is estimated in terms of length, except when another dimension is specifically referred to.

EUPHEMITINAE

The non-geniculate Permian *Euphemites* specimens commonly are no more than one-third larger than the average Pennsylvanian specimen. Most are the same size. Observations on the few specimens known from the Mississippian of Alaska and the Madison limestone of the western United States, together with illustrations of the European Carboniferous (Weir, 1931), show them to be no more than one-half smaller than the holotype of *Euphemites batteni*, new species.

The comparisons given above exclude the geniculate *Euphemites imperator*, new species, and the homologous Pennsylvanian species bearing a thick co-inductura, for example, *E. nodocarinatus* (Hall). The Permian specimens are the largest *Euphemites* known, but they are not more than half again as large as the Pennsylvanian specimens. *Euphemites imperator* is succeeded in the younger strata by several smaller species.

Euphemitopsis is unknown from the Pennsylvanian. Specimens of all species have nearly the same average size. The largest known specimen belonging to the species, *E. paucinodosa*, new species, is from the Leonard formation. Slightly smaller specimens occur in the Guadalupe and Ochoa series.

Most Permian specimens of *Warthia* are no larger than specimens of the only known Pennsylvanian species, *W. kingi* Moore. Specimens of *W. welleri*, new species, which are slightly more than twice as large as *W. kingi*, new species, are followed in time by *W. fissus*, new species, the smallest species known.

BELLEROPHONTINAE

The holotype of *Bellerophon (Pharkidonotus) westi*, new species, from the Bone Spring limestone, is two and one-half to three times as large as average Pennsylvanian specimens. *Bellerophon (Pharkidonotus?)* species are about twice average size, and *B. (Pharkidonotus)* specimens are from one-half of the size to about average size.

Bellerophon, sensu stricto, has been noted by Hayasaka (1943) and Hayasaka and Hayasaka (1953) as developing remarkedly large specimens in the Permian deposits of Kinsyôzan, Gihu Prefecture, Japan. Hayasaka has illustrated two specimens of *Bellerophon jonesianus* Koninck having a width of 95 and 120 mm., respectively. The largest American Permian specimen is an incomplete steinkern from the Hess limestone member of the Leonard formation on Dugout Mountain in the Glass Mountains of west Texas. In life this specimen must have had a length of at least 90 mm. Several other specimens from the coquina bed of Hueco limestone are nearly 75 mm. in length; larger ones have been observed in the field. However, the largest known Carboniferous specimen, the type of *B. (Bellerophon) giganteus* (Koninck, 1883, p. 165, pl. 36, figs. 1–2) from the Viséan of Belgium, is slightly larger than the Permian specimens noted above.

Except for these few exceptional specimens, the largest Permian forms are individuals of *B. (Bellerophon) lineatus* from north central Texas and *B. (Bellerophon) huecoensis* and *B. (Bellerophon) parvicristus* from the Hueco limestone. All specimens of this size have been collected from limestone. These average between 25 and 35 mm. in width. They may be compared with *B. (B.) giganteus* Worthen, not Koninck, which is based on steinkerns from Monroe County, Illinois. The types and other steinkerns from the Pennsylvanian of Kansas City, Missouri, are about the same size as the Permian steinkerns. Silicified specimens of the last two of these three Permian species are much smaller.

The remainder of the Permian specimens vary from the small *B.* (*B.*) *brewsterensis*, the smallest and youngest Permian species, through three to four orders of magnitude to *B.* (*B.*) *hilli* in the Leonard and Word formations. The size range is no larger than that found in Pennsylvanian collections.

Knightitinae

Because of the few specimens available, *Patellilabia* is readily compared with older specimens. The single upper Pennsylvanian species and the single lower Permian species have essentially the same average size.

In *Knightites* in the strict sense, the Hueco limestone species *K.* (*Knightites*) *bransoni* is smaller than the upper Pennsylvanian species *K.* (*Knightites*) *multicornutus* Moore. The north central Texas specimens of *K.* (*Knightites*) *maximus*, on the other hand, are from one and one-half to twice as large as the Pennsylvanian species. All the north central Texas specimens were broken from a dense limestone; all the Hueco specimens were collected free on the outcrop after weathering from a limy shale.

The youngest species, in the Leonard formation, is represented by a specimen slightly smaller than the type of *K.* (*Knightites*) *multicornutus*.

Retispira is similar to *Bellerophon* in that a considerable size range is shown in the Permian collections. The largest specimens are those of *K.* (*Retispira*) *fragilis* from the Bone Spring limestone. In life the largest must have been 50 mm. in width. Other species are represented by specimens with a maximum width of 25 mm.; most are far smaller. The smallest specimens occur in the Guadalupe series and are perhaps half of the size of average Pennsylvanian specimens.

Size Distribution Within Selected Collections

To pursue the question of size distribution further, size frequency distribution has been plotted for six collections of silicified specimens. These six collections are the only ones that contain a large number of specimens from one locality. The number of specimens has been plotted against the maximum width. Width is a convenient measurement and does not require that the specimens be perfect in every detail. Only on a few of the specimens measured was the aperture broken back a short distance. The six collections are plotted in figures 2 to 5.

Although each of these collections represents an instant in geologic time, in the terms of what is known of the life history of mollusks (Comfort, 1957), they must include many age classes. Boucot (1953, p. 28) has illustrated two curves showing the effect of different mortality rates in two age classes on the age range within a combined group of survivors. There are many possibilities regarding the mixing of age classes with varying mortality rates. The subject is so complex that in our present state of knowledge one must assume that enough age classes are represented for average mortality rates to prevail in the sample studied.

A second necessary assumption is that size is correlative with age. This may not be true in many cases. Many of the primitive mollusks, however, continue to grow throughout their life (Comfort, 1957), and, even if the rate of relative size increase decreases with increasing age, size at least bears some direct relationship to age.

Boucot (1953) has discussed the question of discrimination of life and death assemblages in fossil collections. The subject has also been treated briefly by Rigby (1958). One of the criteria Boucot suggests is a comparison of the shape of the size frequency curve with the ideal mortality curve. These six collections provide an opportunity to test his ideas.

All plots indicate that specimens smaller than 3.0 mm. are rare. They are also exceedingly rare in the collections that were not measured. Three possible reasons can be given for the virtual absence of the smaller individuals. First, the earlier stages, up to perhaps 0.5. mm., may have been pelagic rather than benthonic and thus not occur in the same habitat as the larger shells. Second, these are stages so small that light currents swept them away. Third, they may have been overlooked in the preparation of the collections. Probably all these factors have influ-

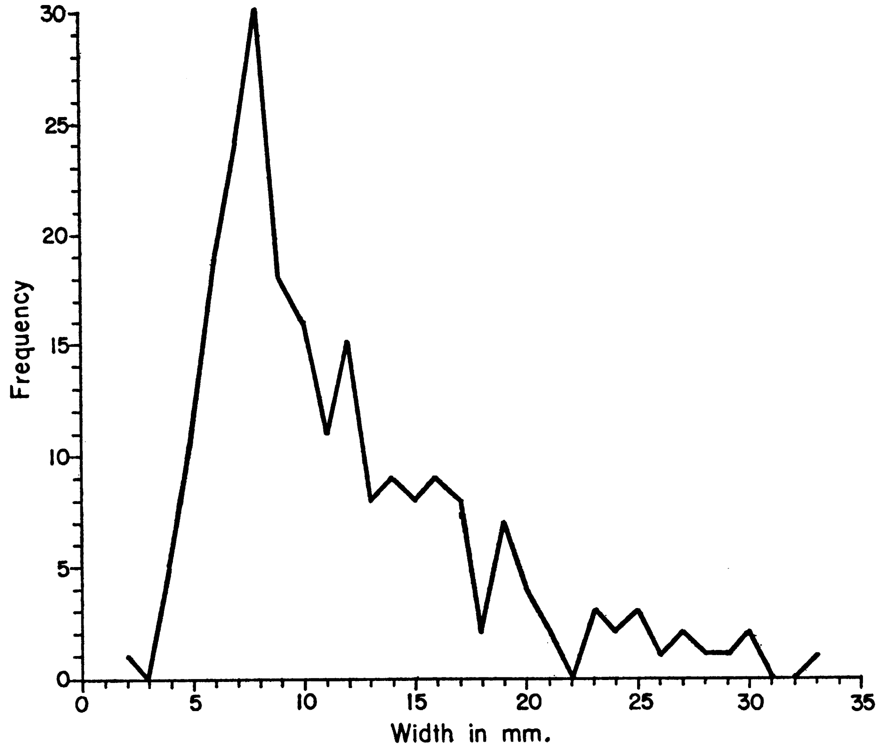


FIG. 2. Size frequency distribution of 213 specimens of *Knightites* (*Retispira*) *eximia*, new species, from U.S.N.M. 712b, Hueco limestone, plotted at 1.0-mm. class intervals.

enced the distribution of the smaller specimens.

Figure 2 is based on the distribution of 213 specimens of *Knightites* (*Retispira*) *eximia*, new species, from U.S.N.M. locality 712b. It is plotted from unpublished data compiled by Knight. This distribution is amazingly like that of the ideal mortality curve of Boucot (1953). It confirms the suggestion that this locality is a life association. Collecting at this locality was done only once because of the difficulty of access to it.

A similar distribution, though not so well defined, is shown in plot a of figure 3, which again confirms the suggestion that this locality is a life association (Yochelson, 1956, p. 190). The majority of blocks from this locality were obtained during one field season; a few were obtained during a second season.

The entirely different distribution shown by a of figure 5 correlates with the suggestion that this locality was a death assemblage (Batten, 1958, p. 169). All specimens were obtained during one field season. The other plots are inconclusive as to life or death assemblage based on the shape of the curve. It may be worth noting that A.M.N.H. 678 (fig. 3, b) was collected once, but that U.S.N.M. 703 (fig. 5, b) and U.S.N.M. 707e (fig. 3, c) have been recollected over many years.

The three curves in figure 4 show one other interesting feature. All are from the same locality. U.S.N.M. 728 was collected during one field season. A.M.N.H. 512 represents blocks of silicified material collected during three field seasons. Different personnel prepared the specimens from each year's collecting. Plots a and c of figure 4 are of the species from the United States National Museum and the American Museum of Natural History collections, respectively. Differences between them can best be interpreted in terms of personal bias. That is, plot c suggests that some of the smaller, and probably less impressive, specimens were not picked from the insoluble residue. Plot a shows similarity to the nearly

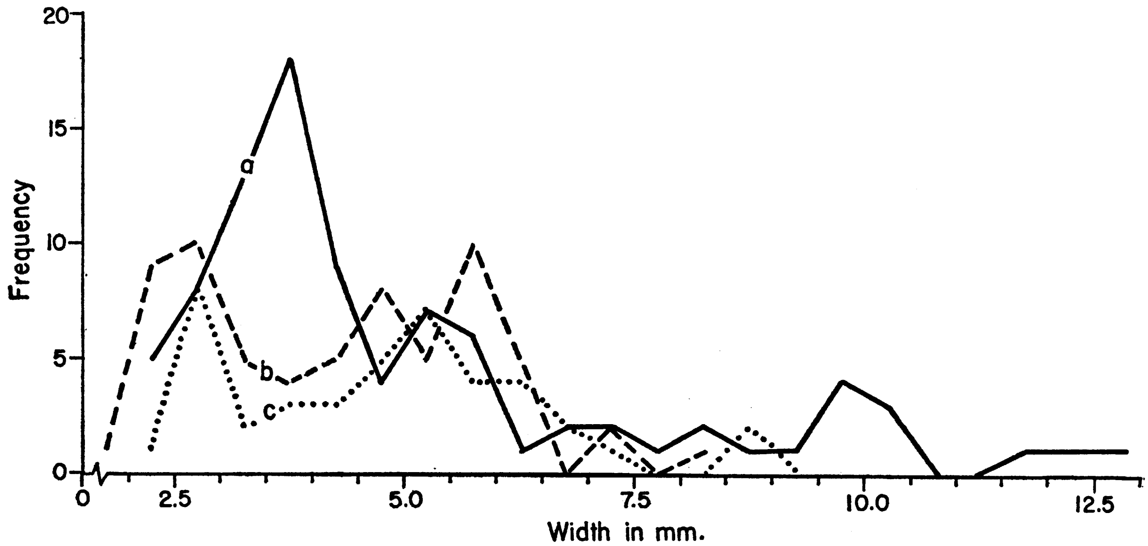


FIG. 3. Size frequency distribution of *Knightites* (*Retispira*) *girtyi*, new species, plotted at 0.5-mm. class intervals. A. A.M.N.H. 369, Bone Spring limestone, 90 specimens. B. A.M.N.H. 678, Cutoff shaly member, Bone Spring limestone, 64 specimens. C. U.S.N.M. 707e, Word formation, 43 specimens.

ideal distribution shown in figure 2. Plot b is of another species from the American Museum collections.

It is more difficult to interpret the plots in terms of sedimentary sorting. Figure 2 is well sorted in that most of the material is within one sedimentary grade size (Wentworth scale). It is poorly sorted in that the material is distributed through at least five classes. Figure 3, a, shows a similar plot to figure 2 but has material distributed through only three classes. Figure 4, c, shows an entirely different plot, but again has the material distributed within three sedimentary classes. It would seem that the shape of the size frequency curve, rather than its spread, may be the more important factor. For some of the species the total size range known from juve-

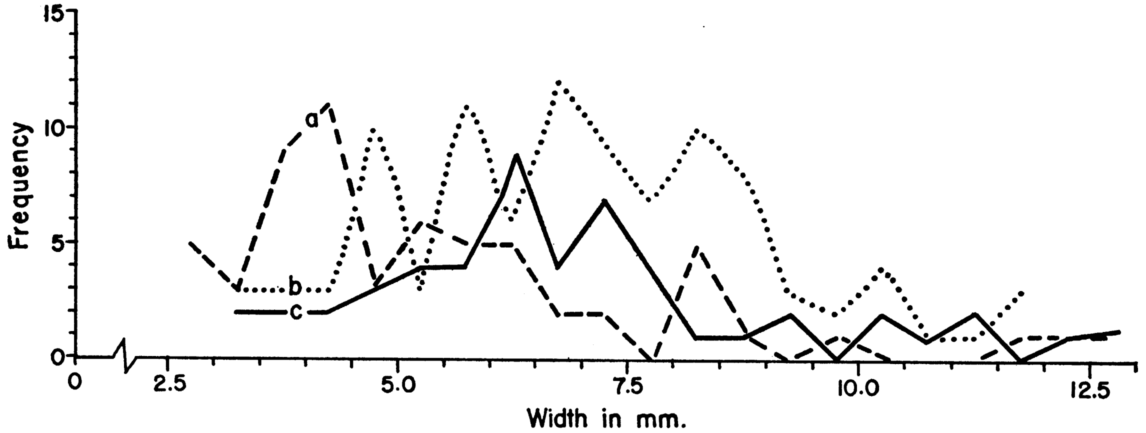


FIG. 4. Size frequency distribution of three collections from the Getaway limestone member of the Cherry Canyon formation plotted at 0.5-mm. class intervals. A. *Euphemites sparciliratus*, new species, U.S.N.M. 728, 51 specimens. B. A.M.N.H. 512, *Knightites* (*Retispira*) *texana*, new species, 62 specimens. C. A.M.N.H. 512, *Euphemites sparciliratus*, new species, 98 specimens.

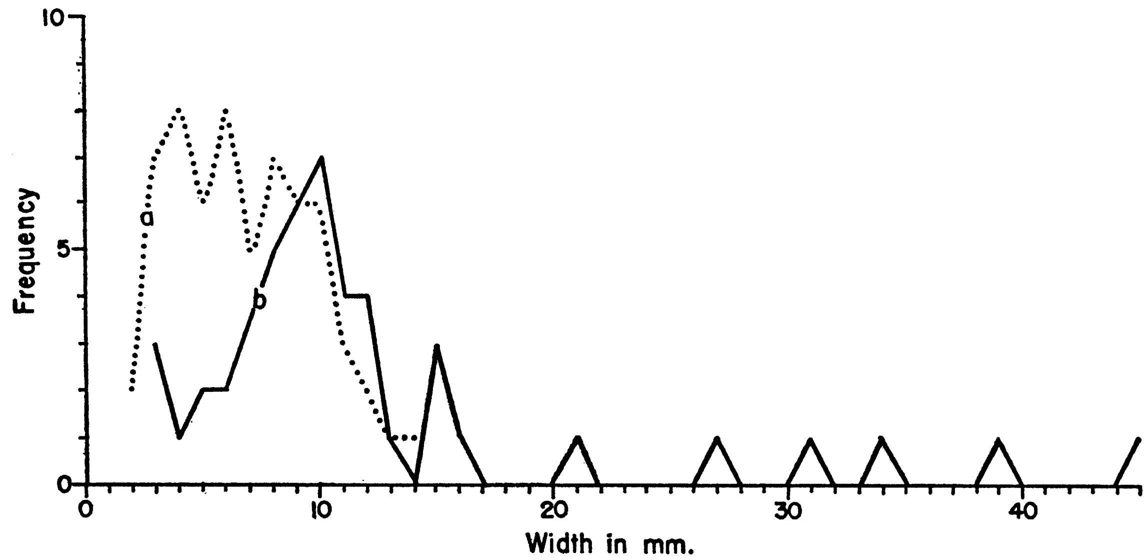


FIG. 5. Size frequency distribution of *Knightites* (*Retispira*) *modesta*, new species, plotted at 0.5-mm. class intervals. A. A.M.N.H. 592, Bone Spring limestone, 60 specimens. B. U.S.N.M. Word formation, 50 specimens.

nile to mature stages, above the 3.0-mm. minimum, may be through only one or two sedimentary size classes.

SUMMARY

There is no clear evidence that the Permian bellerophontaceans show phyletic size increase. Although in some species the Permian specimens are the largest known for the genus, they are succeeded in the fossil record by smaller species. The average size of the species and the size of specimens within any one species seem to be erratic, without any clear trends.

If any correlation is to be made, it is that size appears to be associated with the method of fossilization. All the larger specimens are calcareous and have been broken from limestone. The silicified specimens of a species seem to be invariably smaller than those broken from limestone. The species known only from silicified material have an average size distinctly smaller than that of the limestone specimens. The single exception, in which large specimens occur in silicified material, is P.U. 3, which, with A.M.N.H. 592, is thought to have been a thanatocoenosis.

There are suggestions that subconscious bias is present in some of the collections, with an emphasis having been placed on the obtaining of larger specimens. Although two papers have been written on exceptionally large specimens from the Permian, still larger specimens are known from the Mississippian, but these have not been particularly commented upon.

The plotting of frequency distribution in some cases may add information suggesting whether a collection represents a life association or a death assemblage. Such plotting is further helpful in providing data on survival. The sporadic occurrence of large specimens in the Permian can best be interpreted as that of the rare animals which managed to reach old age while most of their contemporaries perished early in life.

NOTES ON AMERICAN PENNSYLVANIAN BELLEROPHONTACEANS

ALTHOUGH BELLEROPHONTACEANS have been known in the Pennsylvanian strata of America for well over a century, the first having been described by Conrad in 1842, they have never been systematically studied. The treatment of the bellerophontaceans gives excellent examples of some of the worst practices of paleontology. Many of the supposedly common forms are actually so poorly known, in spite of repeated citations in synonymy, that no accurate descriptions and illustrations are available, and no accurate account of the stratigraphy of the type locality or the stratigraphic range of the species within the Pennsylvanian can be given.

Within the systematic portion of the present work, comparisons between Pennsylvanian and Permian bellerophonts are limited to the Pennsylvanian bellerophonts that are known to me from the types or from topotype specimens. Bellerophontaceans from the Hueco limestone and its equivalents are presumed to be new, although a slight possibility exists that some may be conspecific with earlier named upper Pennsylvanian species. The task of monographing the Pennsylvanian bellerophontaceans of this country, while it would be most interesting and valuable, would require several years. Under the circumstances, it seems best to present a brief summary of our knowledge of Pennsylvanian species, as a guide to future workers. The Pennsylvanian Bellerophontacea have not been reviewed since the summary given by Girty (1899).

SINUITINA

Only one species is known from Pennsylvanian strata. Newell (1935, pp. 349–350, pl. 36, figs. la–d) described *Tropidocyclus cordiformis*, the type species, from the Lansing shale, Missouri series, of eastern Oklahoma.

EUPHEMITES

Seven species are currently referred to *Euphemites*. Two of these, *Euphemites graffhami* and *Euphemites regulatus*, are excellently described and figured by Moore (1941, pp. 142–146) from the Deer Creek limestone, Virgil series, of eastern Kansas. *Euphemites callosus* (J. M. Weller) (1930, pp. 15–21), from the Carbondale group, middle Pennsylvanian of western Illinois, is equally well described and illustrated.

White (1881, p. xxx, pl. 4, figs. 1a–d) described *Bellerophon inspeciosus* from the Pennsylvanian near Taos, New Mexico. The species has since been referred to *Euphemites*. Seven syntypes are available in the United States National Museum collections catalogued under U.S.N.M. No. 8924. The Pennsylvanian stratigraphy near Taos is complex and has never been studied in detail. White's locality is vague; virtually all that can be said is that this species occurs in beds of middle or late Pennsylvanian age.

Four other species of this genus have been named from the Pennsylvanian of the interior United States. These are *Euphemites carbonarius* (Cox) (1857, p. 562), *Euphemites nodocarinatus* (Hall), *E. blaneyanus* (McChesney), and *E. vittatus* (McChesney). In an excellent paper on the occurrence of *Euphemites* in the Pennsylvanian of Texas, King (1940, pp. 150–153) discusses these species and that of White. King (1940, p. 151) notes that the type of *Bellerophon carbonarius* Cox is lost. I have briefly examined the Cox collection of the museum and library of the New Harmony Workingmen's Institute at New Harmony, Indiana. If the type was ever deposited there, it has been lost. King's remark that Cox's species "must be regarded as invalid and unrecognizable" is an unfortunate choice of words, as the species is still valid no matter what the status of the type. However, I fully agree with King that the name is a *nomen dubium* and must be abandoned for all practical purposes. Certainly the numerous citations of this species in the literature have no real meaning.

King does not illustrate types or topotype material, but confines his study to Texas specimens, relying solely on the literature for identification. For *E. inspeciosus* (White) and *E. nodocarinatus* (Hall) (1858, p. 723, pl. 29, figs. 15a–c) the illustrations are relatively good.

Hall's locality, "in the coal measure of Illinois and Iowa," leaves much to be desired. Inquiries to date have not yielded any further information on the stratigraphic occurrence of Hall's species or the location of his type specimens, if they are still extant.

McChesney's species, on the other hand, are most insecurely founded. *Euphemites blaneyanus* (McChesney, 1860, p. 58) is poorly illustrated in what is now a rare publication (McChesney, 1868, p. 12, fig. 5). *Euphemites vittatus* (McChesney, 1860, p. 59) has never been illustrated. The type locality of *E. vittatus* at the mouth of Rush Creek, near New Harmony, Indiana, is apparently inaccessible because of a shifting of the Wabash River, and the localities given for *E. blaneyanus* are vague. McChesney's type specimens apparently were lost in the Chicago fire of 1871. However, sulfur casts were reportedly made of some of McChesney's types (Kirk, 1955, p. 4). It has not yet been determined whether any of the gastropod species he named were cast, and if casts are available for study.

Fortunately, topotypes of *E. vittatus* have been obtained recently from the Workingmen's Institute of New Harmony and are deposited in the United States National Museum collections. A second species of *Euphemites* from the same locality fits the description of *E. blaneyanus*. These specimens have been used for comparison with the Permian species.

Warthia

Only one species of this genus has been reported from the Pennsylvanian. Moore (1940, pp. 147–149, pl. 3, figs. 11a–b, 12a–c, 13a–b) has described and fully illustrated *Warthia kingi* from the Deer Creek limestone, Virgil series, of eastern Kansas.

Bellerophon (Bellerophon)

Although many of the species of bellerophontaceans named in North America were originally referred to *Bellerophon*, only a few species are currently placed in the genus. A detailed study may show that a few more species are present in the Pennsylvanian than are currently in use. There is little doubt, however, that the genus is restricted, and that species are much less common than in the middle Paleozoic. The relatively large number of species from the Permian named in this paper, in relation to those from the Pennsylvanian, is an excellent example of a monographic burst (Cooper and Williams, 1952) that masks the decline of this genus before its extinction.

Of the few species referred to this genus, *Bellerophon crassus* Meek and Worthen (1860, p. 458) is certainly the most widely used name. The illustrations of the holotype by Meek and Worthen (1866, p. 131, fig. 16) are excellent. Two "varieties," *B. crassus incomptus* Gurley (1884, p. 9) and *B. crassus wewokensis* Girty (1912a, p. 138; 1915, pl. 19, figs. 1–3b), are in the literature, but the stratigraphic ranges of these two varieties in relation to the range of the typical form have not been investigated. Further, the individual variation of specimens in a large collection has never been investigated to determine if these varieties have any real biological meaning. Girty's types are available and catalogued under U.S.N.M. No. 119904. One of Gurley's type specimens has been refigured by Weller (1929, pl. 1, figs. 9a, 9b); the specimen is so incomplete that it may be impossible to compare it with better specimens.

Bellerophon graphicus Moore and *B. singularis* Moore (1941, pp. 127, 128), from the Deer Creek limestone, upper Pennsylvanian, of eastern Kansas, are well described and illustrated. Little is known of their stratigraphic range (Mudge and Yochelson, MS), but, for that matter, little is actually known of the stratigraphic range of any of the Pennsylvanian species. *Bellerophon stevensianus* McChesney (1860) is reasonably well described and figured (McChesney, 1868, p. 46, pl. 2, fig. 18). As with McChesney's other species, however, the type has been lost, and the species is not well founded. While it is not the purpose of the present review to draw any taxonomic conclusions, it may be useful to future workers to note that McChesney's illustrations suggest a compressed form with a prominent selenizone. I have examined half a dozen specimens, possibly topotypes, from Springfield, Illinois, all of which are well rounded over the dorsum. It may be that McChesney's type was distorted by lateral compression.

Of the three remaining species, *B. giganteus*

Worthen (1884, p. 2; Worthen, 1890, pl. 25, figs. 5, 5a) from the lower Coal measures, Monroe County, Illinois, is based on a large steinkern. The name has been used for other large steinkerns of bellerophontids. Unless topotype material showing the shell features can be obtained, the name should be considered as a *nomen dubium* and should be dropped from use in the present-day literature.

Bellerophon wabaunseensis Tasch (1953, p. 398, pl. 49, figs. 27–29), described from the upper Pennsylvanian, Dry shale, in eastern Kansas, is also based on steinkerns. The species is unrecognizable outside the type collection. Familiarity with the fauna of the upper Pennsylvanian of Kansas (Mudge and Yochelson, MS) suggests that the most common steinkerns are those of *Knightites* (*Retispira*). However, the species is left in *Bellerophon*, as steinkerns of these two genera can seldom be differentiated. It is suggested that the name be considered as a *nomen dubium* and not be used in future work.

The last species currently referred to the genus is *Bellerophon globosus* Stevens, from the "upper shales of the Coal measures at La Salle, Illinois." The species is incompletely described and has never been figured (Stevens, 1858, p. 258). Stevens describes the species as having a small umbilicus. The few specimens of *Bellerophon* that I have seen from La Salle, Illinois, are anomphalous. Stevens' type specimens appear to have been lost (J. M. Weller, personal communication, August, 1956). Except for two bibliographic citations, the species has not been used in American literature. It seems wise to ignore this specific name also and treat it as a *nomen dubium*.

BELLEROPHON (PHARKIDONOTUS)

This subgenus is represented in the American Pennsylvanian by two described species. The type species, *Pharkidonotus percarinatus* (Conrad, 1842), is well known, although the types have been lost. Excellent specimens have been figured by Knight (1941a, pl. 12, figs. 4a–f). *Bellerophon harrodi* Gurley is a junior subjective synonym of this species (Girty, 1915, p. 165; Weller, 1929, p. 215). The other species, *Bellerophon tricarinatus* Shumard (*in* Shumard and Swallow, 1858, p. 204), is not well known, though it has been widely cited in the literature. It was never figured, and the types have been lost. Shumard (*in* Shumard and Swallow, 1858, p. 204) states, "the specimen from which the description has been drawn is deprived of the test . . ." indicating that the species is based on a steinkern. The original locality is so vague that topotype specimens cannot be located with any certainty. It is suggested that this name be considered a *nomen dubium* and ignored in future studies.

KNIGHTITES (KNIGHTITES)

Knightites in the strict sense is limited to the type species in the Pennsylvanian, *K.* (*Knightites*) *multicornutus* Moore (1941, p. 153). The species is known from a single locality in the Deer Creek limestone, Virgil series, upper Pennsylvanian, of eastern Kansas.

KNIGHTITES (CYMATOSPIRA)

The type and only known Pennsylvanian species, *Bellerophon montfortianus* Norwood and Pratten (1855, p. 74, pl. 9, figs. 5a–c), has been extensively cited in the literature. In this case also the type specimens seem to have been lost. Investigation at New Harmony, Indiana, failed to produce any trace of Norwood and Pratten's material. Norwood and Pratten's types have also been reported to have been deposited at the Illinois State Museum. The species rests on insecure grounds until topotype specimens have been described and illustrated.

KNIGHTITES (RETISPIRA)

Many of the Pennsylvanian species originally referred to *Bellerophon* were later moved to *Patellostium*. Subsequently some of these were placed in *Bucanopsis*. In the present state of our knowledge it seems advisable to refer all these species to *Retispira*.

Retispira is based on *R. bellireticulata* Knight (1945, pp. 335–336, pl. 49, figs. 1a–c) from the equivalent of the Smithwick shale in west Texas. Probably the best known included species are those of Gurley, refigured by J. M. Weller (1929). His figures show that *Bellerophon textiliformis* Gurley (1883, p. 6) is referable to *Retispira*. Knight (1945, p. 336) and Sayre (1930, p. 129) have concluded that *K.* (*Retispira*) *bellus* (Keyes) (1894, p. 148, pl. 50 fig. 7) is a junior subjective synonym of this species. No attempt has been made to locate Keyes's types and confirm this synonymy.

Bellerophon nodocostatus Gurley (1884, p. 9) is also referable to *Retispira*. J. M. Weller (1929, p. 322) has concluded that *K.* (*Retispira*) *rugopleurus* (Gurley) (1884, p. 11) is a synonym of *K.* (*Retispira*) *nodocostatus*, being based on a water-worn larger specimen. Examination of plaster casts confirms this conclusion. Weller has redescribed and reillustrated Gurley's type specimens of both species.

J. M. Weller (1929, pp. 319–320) also suggested that this species "may prove to be identical with *B. kansasensis* Shumard," but "Until Shumard's species are better known, . . . it would be well to consider it as being distinct." This species was "obtained by Maj. Hawn from the valley of the Verdigris River, K. T." [Kansas Territory] (Shumard, 1858, p. 204). The description indicates that the species is referable to *Retispira*, but as with so many of Shumard's species, the type was never figured and has since been lost.

In the case of Shumard's species, as in so many of the others mentioned, it seems wise to allow the name to lapse from common use. First, there is considerable uncertainty as to just what he had. In view of the amount of variation shown in some Permian species of *Retispira*, unless one has authentic type material for comparison, there is little possibility of being able to recognize a species with assurance. Second, there is uncertainty as to the stratigraphic occurrence of the type.

In connection with the redescription of *Bellerophon tenuilineatus* (Gurley) (1884, p. 10), now placed in *Knightites* (*Retispira*), Weller (1929, p. 321) notes that any one of three species names in the literature (*B. perlatus* Conrad, *B. meekianus* Swallow, and *B. marconianus* Geinitz) might take priority over Gurley's name if these species were better known. No general opinions are given at this time, as each case must be decided individually, but certainly *Bellerophon perlatus* Conrad (1842, p. 270) gives an excellent example of a case in which a name should be allowed to lapse into obscurity and the fine print of bibliographies. None of Conrad's types is extant, and none of his locality descriptions is precise enough for one to collect topotype material with any assurance. Further, although several of Conrad's names have been widely used, this one has not. Recognition of this species would only lead to confusion and uncertainty.

Bellerophon meekianus Swallow (*in* Shumard and Swallow, 1858, p. 204) is another species of which the type is lost. According to J. M. Weller (personal communication) Swallow's types were lost either in a fire or when collections of the St. Louis Academy were moved to Washington University. Swallow's locality of "near Lexington," Missouri, is more precise than that of Conrad's for *B. perlatus*. At the United States National Museum there exists a separate copy of Shumard and Swallow's paper sent to F. B. Meek, into which pencil drawings of a few of these species have been inserted by Meek. Apparently these drawings are copies of illustrations which Swallow was preparing for publication but which were destroyed by fire. It may be possible to reëstablish this species on a firm foundation with the aide of topotype specimens and these pencil sketches.

Bellerophon marcouianus Geinitz (1866) p. 7, pl. 1, fig. 12) might also be reëstablished on somewhat firmer ground. The types are preserved in the collection of the Museum of Comparative Zoölogy at Harvard College (H. B. Whittington, personal communication). However, provisionally *Knightites* (*Retispira*) *tenuilineata* will be used until further investigation of the Pennsylvanian bellerophontaceans is carried out to determine whether or not any of these three specific names discussed above is a senior synonym.

Finally *Bellerophon subcordiformis* Herrick (1887, p. 18, pl. 2, figs. 7a–c), described from the Pennsylvanian strata of Flint Ridge, Ohio, may be referable to the subgenus. It is based on a single incomplete specimen; considerably more must be known about the species before it can be assigned with certainty. Some of Herrick's types are reported to have been deposited at Ohio State University, but I have not investigated this report further.

Patellilabia

The only described species of this genus is the type, *Patellilabia tentoriolum* Knight (1945, pp. 337–338, pl. 49, figs. 3a–f), from the upper Pennsylvanian of eastern Kansas. *Bellerophon ellipticus* McChesney (1860, p. 58) is relatively well figured (McChesney, 1868, pl. 3, figs. 1, 2), but again the types are lost. This species seemingly has faint undulations on the expanded aperture but none on the body whorl. If McChesney's figures are correct, his species is referable to *Patellilabia*.

Euphemitella

Tasch (1953, pp. 397–398) described his genus from the upper Pennsylvanian, Dry shale, of eastern Kansas. The type and only included species, *Euphemitella emrichi* Tasch, is based on steinkerns. Tasch's locality was revisited, but no specimens retaining the shell were collected. The generic characters are indeterminate, and the genus cannot be placed below the superfamilial level.

SYSTEMATIC PALEONTOLOGY

SUPRASPECIFIC DESCRIPTIONS

All the gastropods described in this paper are referred to the Superorder Prosobranchia Milne-Edwards, 1848, and the Order Aspidobranchiata Schweigger, 1820. Correspondence with L. R. Cox (June, 1958) of the British Museum (Natural History) indicates that this ordinal name is preferred to Archaeogastropoda Thiele, 1925. This classification recognizes two orders of prosobranch gastropods, Aspidobranchiata and Pectinibranchiata, based on characters of the gill rather than three orders based on characters of the radula.

The two superfamilies treated herein, the Bellerophontacea and the Patellacea, are each characterized by a bilaterally symmetrical shell. In the Bellerophontacea, this symmetry is primary. In the Patellacea, the shell symmetry is entirely a secondary development of the adult stage. Except that the two superfamilies belong to the same order, they have nothing in common. Their treatment together here is entirely one of convenience and is not meant to imply any phyletic relationship.

Superfamily **BELLEROPHONTACEA** M'Coy, 1851

Description: Prosobranch gastropods with a high order of primitive bilateral symmetry, the right and left sides of the shell mirror images except in a few aberrant genera; shell coiled commonly with several whorls, though reduced to a fraction of a whorl in a few specialized genera; outer lip emarginated.

Discussion: The outer lip of the bellerophontaceans is always emarginated. The details of the apertural emargination vary widely, taking the form of a U- or V-shaped sinus, a slit, or, quite rarely, one or more tremata. Shape of the emargination, together with whorl shape and ornament, gives a basis for classification. Currently, the superfamily is divided into three families, the Cyrtolitidae, the Sinuitidae, and the Bellerophontidae (Knight, Batten, and Yochelson, in press. Representatives of the Cyrtolitidae, characterized by wide umbilici and a shallow angular sinus, are known only from beds of late Cambrian to early Silurian age and are not discussed.

Bilaterally symmetrical bellerophontiform shells are also known from the early, middle, and, rarely, from the late Cambrian. In these forms, however, the outer lip is not emarginated. Recently, Knight and Yochelson (1958) placed these Cambrian gastropods in an allied superfamily, the Helcionellacea.

The shell of the bellerophontaceans varies from thin to quite thick; little is known of its structure and composition. Both Weller (1930, p. 20) and Moore (1941, p. 133) infer that the innermost shell layer of *Euphemites callosus* (Weller) is nacreous. However, the marked differences between the outer true shell layers and the lamellar inner layers of the shell lining, in *E. callosus*, may be caused by retained pigmentation in the outer layer, and further study, perhaps with the use of modern geochemical techniques, should be given before this report can be accepted without reservation.

Although many Paleozoic mollusks must have shown nacreous luster in life, few examples have been reported in the literature, and these examples are unconvincing, partly because the spaces between calcareous layers, occupied in life by interleaving layers of aragonite essential for the production of the interference colors of nacre, are almost always secondarily filled with calcareous matter having an index of refraction close to that of the calcareous layers themselves, and partly owing to an inherent instability of the original aragonitic shell layers which, after the death of the animal, were altered to calcite with corresponding loss of microscopic shell structure.

In some Paleozoic gastropods, Knight has been able to recognize an original nacreous layer (Knight, 1933, pl. 12, figs. 6a–b), but the criteria on which this recognition is based have not been investigated in the Bellerophontacea beyond the works cited above. In the Paleozoic species to which Knight has attributed a nacreous layer, the outer prismatic layer is sharply differentiated from the inner layer. Upon weathering, the outer prismatic layer of some species separates cleanly from the inner nacreous layer; each layer transmits light differently when examined in thin section. Though the outer prismatic layer is often pigmented, and the inner nacreous layer is not, this inner layer may actually appear darker in transmitted light at low magnification.

In spite of the difficulty of obtaining conclusive evidence of the original composition of fossil shells, Bøggild (1930, p. 299) stated that the bellerophontaceans were originally aragonite throughout, but possibly not nacreous. As a single exception, he reported an Ordovician bellerophontacean as composed exclusively of calcite. Stehli (1956, p. 1032), on the other hand, reported a Pennsylvanian bellerophontacean as containing a thin calcitic outer shell layer and a thicker aragonitic inner layer. There is no question but what further investigation into the structure and composition of the bellerophontacean shell would add significant details to a classification of the genera and might yield important new data on the position of the superfamliy within the aspidobranch gastropods.

Family **SINUITIDAE** Dall, 1913

Description: Bellerophontoid gastropods with a U-shaped sinus; whorls commonly compressed laterally, not inflated; anal emargination of most genera a shallow U-shaped sinus generating a pseudoselenizone, although some Euphemitinae develop a slit.

Discussion: Possession of a U-shaped sinus as an anal emargination marks this family as intermediate between the primitive bellerophontaceans, which bear only a rudimentary emargination in the aperture, and the true Bellerophontidae, which have a well-developed slit. The consistent occurrence of other characters, particularly the compressed shape of the whorls in the Sinuitinae and Bucanellinae, indicates that this group is most likely a single phyletic stock and not simply an evolutionary grade.

The Sinuitidae range from late Cambrian through Permian. The family as presently construed is divided into three subfamilies, the Bucanellinae, Sinuitinae, and Euphemitinae. The Sinuitinae, characterized by a sinus somewhat wider than that of the other subfamilies, range from late Cambrian through middle Devonian.

Subfamily **BUCANELLINAE** Koken, 1925

Description: Bellerophontoid gastropods with a narrow sinus in outer lip; phaneromphalous; ornamented by colabral lirae.

Discussion: The small, shallow sinus distinguishes members of this subfamily from those of the Sinuitinae, which possess a relatively deeper and wider sinus. The Bucanellinae lack extensive inductural deposits characteristic of the Euphemitinae. Even though members of the subfamily range from late Cambrian through middle Permian, the group is predominant in the early and middle Paleozoic. Of the genera included in the subfamily, only *Sinuitina* ranges above the Devonian.

Genus **SINUITINA** Knight, 1945

Type Species: *Tropidocyclus cordiformis* Newell, 1935.

Description: Bellerophontoid gastropods with compressed cordiform whorl section and a narrow, U-shaped sinus in the outer lip; widely phaneromphalous; narrow sinus on crest forming a pseudoselenizone; strong colabral ornament.

Discussion: The holotype of *Sinuitina cordiformis* (Newell) is exceedingly well preserved; there is no question as to the character of the genus. Slit and selenizone are absent, distinguishing *Sinuitina* from all the Bellerophontidae, and in particular from *Tropidodiscus* Meek and Worthen, 1866, which it resembles in shape. *Sinuitina* differs from *Bucanella* Meek, 1871, in having a cordiform or lanceolate cross section, rather than a trilobed cross section.

Bellerophon (*Tropidocyclus*) *punjabicus* Reed (1944, p. 350, pl. 148, figs. 17–17b) and *Tropidodiscus?* sp. indet. of Licharew and Netschajew (1956, p. 41, pl. 14, figs. 2, 3) both show a profile similar to that of *Sinuitina*. None of the illustrations shows growth lines, and the species cannot be definitely placed in this genus.

Range of the Genus: *Sinuitina* first occurs in the Devonian, and is not rare in the Mississippian. The type species is the only known Pennsylvanian species. The single Permian specimen described below extends the range of the genus into the Leonard formation.

SUBFAMILY **EUPHEMITINAE** KNIGHT, 1956

DESCRIPTION: Bellerophontoid gastropods with one or more inductural layers deposited on the outer shell surface; anomphalous or cryptomphalous; anal emargination a narrow sinus, developing into a slit in more advanced species; anterior lips thin; lateral lips thickened, and hooked or sickle-shaped when viewed in profile; growth lines on body whorl obscured by inductural deposits; ornament, when present, confined to inductural layers.

DISCUSSION: The Euphemitinae range from Mississippian through Permian. The earlier members of the subfamily are thought to be characterized by a sinus. The development of a slit occurs only in some of the later members of the group. It is this sinus that the Euphemitinae have in common with other genera of the Sinuitidae. The most characteristic feature of the subfamily is the extensive development of the inductural layer or layers completely covering the outer surface of the shell. This inductura is so prominent in the Euphemitinae as to suggest that this group might eventually be raised to the status of a separate family. Should study of Mississippian species indicate that a true slit is developed in some of these early forms, this would further reënforce the view that the taxon might be of familial rank.

Another important characteristic of the subfamily is the characteristic curved "sickle" shape of the lateral margin of the lip. These lateral salients are always placed relatively close to the body whorl, even in globose specimens, so that the aperture does not expand rapidly.

Stachella Waagen, 1880, possibly a representative of this subfamily, was originally described from the Bellerophonkalk of Germany and later reported from the Productus limestone of Pakistan. The genus is characterized by being distinctly asymmetrical (Knight, 1941a, p. 333). At one time during the present study, poorly preserved specimens from the Hueco limestone were tentatively referred to the genus. It now seems more likely that these specimens had part of the inductural layer removed. Partial removal of the inductura would provide spurious asymmetry to a specimen. An example is discussed under *Warthia welleri* (p. 255). Until convincing specimens have been collected there appears to be no basis for the recognition of *Stachella* in this country. Restudy of the type species of *Stachella* is needed; possibly the asymmetry of the types is also an artifact of preservation.

Euphemitella Tasch (1953, p. 397) is also excluded from this study. The genus is based on a species from the upper Pennsylvanian of Kansas. The type specimen is a steinkern lacking diagnostic characters. Knight, Batten, and Yochelson (in press) consider the genus to be of uncertain affinities. Judging by the relative abundance of the various species of bellerophontaceans in the lower Permian of Kansas (Mudge and Yochelson, MS), it seems probable that this genus is founded on the steinkern of a species of *Knightites* (*Retispira*).

The three genera recognized, *Euphemites*, *Warthia*, and *Euphemitopsis*, are distinguished by the nature of their ornament. The species of *Euphemites* may be arbitrarily broken into several groups, for example, globose and compressed forms, thick-shelled and thin-shelled forms, or geniculate and well-rounded forms.

The species of *Warthia* and *Euphemitopsis* may also be divided into similar groups. Because of the smaller number of species in these two genera, these groups would not be clear without their establishment first in *Euphemites*. It is conceivable that these groups represent phyletic lines. However, as the ornament pattern is closely tied to the soft anatomy of the living animal, I consider it to be of fundamental nature in distinguishing the genera. The groupings serve simply as an aid in distinguishing species and have no taxonomic significance.

GENUS **EUPHEMITES** WARTHIN, 1930

Euphemus M'Coy, 1844, *non Euphemus* Laporte-Castelnau, 1836.

TYPE SPECIES: *Bellerophon urii* Fleming, 1828.

DESCRIPTION: Bellerophontoid gastropods ornamented by spiral lirae on the inductura; shell commonly smoothly curved, but geniculate in some species; anal emargination varying among species from a shallow sinus to those with a relatively deep slit; ornamented by spiral lirae and nodes on one or more inductural layers (inductura, co-inductura) with the youngest inductural layer (perinductura) covering and obscuring the growth lines and selenizone.

DISCUSSION: Several authors have recognized that the spiral lirae characteristic of this genus are formed on the inductural layer rather than on the true outer shell layer. In a well-reasoned interpretation of *Euphemites callosus* (J. M. Weller), a species with a strongly developed "callus" or inductura, Moore (1941, pp. 129–142) has shown that not only is the inductura lirate, but the "callus" forms a second inductural layer which is also ornamented by lirae. The lirae on the second layer, named by Moore the "co-inductura," are similar to those on the inductura, but are discordant with the first set and separated from them by a narrow, smooth, nonlirate zone. In some species of *Euphemites* the outer margins of both the inductura and co-inductura show nearly parallel, lateral, lappet-like salients and a wide median emargination. These layers presumably were deposited by a flap of the mantle and extended backward from the aperture and up over the posterior of the shell.

Moore (1941) observed yet a third inductural layer, named by him the "perinductura." The perinductura overlies the true outer shell and underlies the inductura. In cross section, the laminae of the perinductura slope towards the aperture and extend to the margin, being exceedingly thin near the apertural margin. The perinductura is interpreted (Moore, 1941, p. 137) as being deposited by the anterior and anteriolateral portions of the mantle, reflected backward over the anterior part of the body whorl. It has long been known that growth lines on the anterior part of the body whorl of *Euphemites* are obscure; the presence of the periductural layer readily explains this obscurity. In *Euphemites*, the perinductura is smooth and unornamented, but in a few species it forms a series of nodes on each side of the selenizone.

Moore's hypothesis that two mantle flaps, anterior and posterior, deposited the inductural layers is accepted. Moore (1941, p. 138) has illustrated a cross section showing the various shell layers and the two mantle flaps.

Two interpretations for the formation of the posterior inductural and co-inductural layers have been considered by Knight (written communication). The first is that these two layers were secreted by discrete parts of the mantle separated by a portion with little or no secreting power. This hypothesis is inferentially supported by Moore (1941, p. 138, fig. 4). It is necessary to assume that the inner area secreting the co-inductura deposited a thicker layer than the outer area secreting the inductura. As the animal grew and the mantle moved forward, the co-inductural layer was deposited on the inductural layer previously deposited.

The second interpretation is that both layers were secreted by the same area of the posterior margin. The outer lappet-like edge of each layer is so similar as to imply a close genetic connection. It is suggested that the inductura was deposited when the mantle was fully extended, and the co-inductura when it was partially withdrawn into the aperture. These mantle positions may have been correlated with a fully extended locomotive stage and with a partially withdrawn resting or feeding stage. In a fully withdrawn protective stage, there probably was no secretion, possibly because this position would be occupied for relatively little time. The greater thickness of the co-inductura suggests that either the animal spent most of its life with the mantle partially withdrawn, or deposition was more rapid in this position, as a direct result of feeding.

This second hypothesis explains not only the similarity of the outer edge of each inductural layer, but also the discordance of the two sets of lirae. In the extended position, the mantle necessarily was expanded to cover a larger surface area, and the wrinkles in the mantle (undoubtedly the source of the lirae) were differently adjusted. Such an arrangement is related to the observation that in some species the lirae on the inductura are weaker and more rounded than those on the co-inductura.

It is germane here to digress into a brief discussion of the Cypraeacea, the common cowry shell. Many genera in the Cypraeidae and the allied Eratoidae are characterized by an inductural deposit that completely covers the shell in the adult stage. In specimens that are first being covered by inductura, a thin wash may be seen both to the right and to the left of the aperture, with the adapertural portion being free of inductural deposits. On specimens having the inductura fully developed, there is commonly a line extending across the adapertural portion of the shell. The gradual development of the inductural deposit in *Cypraea tigris* Lamarck is well illustrated by Johnstone (1957, p. 184) and discussed by Ray (1951), both in non-technical accounts of the cowries.

The conchological evidence shows clearly that deposition of the inductura is by two separate flaps of the mantle. Illustrations of the living animal, for example, Iredale (1935, pls. 8, 9), show that such is the case. In the cowries the mantle flaps are morphologically right and left. In *Euphemites*, the flaps were anterior and posterior. Nevertheless the analogy is striking. In *Trivia oryza* Lamarck, which has numerous spiral lirae on the inductura, discordance between the two sets of lirae is readily observed.

One collection of *Cypraea tigris* examined showed considerable variation in the position and shape of the line of juncture of the two inductural deposits. No line could be observed on some shells, but in others the line was essentially straight, and in still others it was irregularly sinuous. Such a variation suggests that the mantle flaps tended to encroach upon one another during deposition. There appears to be no published information as to the systematic value of the line of juncture. The few observations made suggest that it is likely to be only a feature of individual variation.

Most of the Cypraeidae are further characterized by change in the nature of the inductural deposit around the shell. In the money cowry, *Monetaria moneta* Lamarck, the inductura near the aperture is thick and white, but on the adapertural part of the shell it is thin and bright yellow. In the common *Cypraea tigris*, the inductural deposit near the aperture is thick and white and bears numerous serrations. Farther from the aperture, the inductural deposit is still almost as thick but is white, with large dark brown spots. Still farther from the aperture, the shell is thin and has a characteristic mottled brown color.

I have been unable to find any accounts of the secretion of the inductura in the cowries. The available information suggests that the mantle flap can deposit different-colored layers simultaneously. This implied differentiation of the mantle into several parts must be proved by histological examination and observation of the living animal. If such differentiation really is present, it would imply by analogy that the first hypothesis of the inductura and co-inductura formation in *Euphemites* is to be preferred over the second.

No studies comparable to that of Moore discussed above have been made on the species of *Euphemites* without a thick "callus." In this group the inductural layer, or layers, is thinner, and there is no discordance of lirae from within the aperture to their adapertural ends. This lack of discordance suggests that either the lirate inductura is the only layer present, or that the co-inductura is so thin as to be indistinguishable in thin section. Moore does not specifically discuss this matter, but on a drawing of a thin section of a specimen referred to *E. vittatus* (McChesney), he (Moore, 1941, p. 134, fig. 3b) has labeled the undivided outer shell layer in such a way as to indicate that both inductural deposits are present but indistinguishable. Observations on the body whorl of unusually well-preserved specimens referred to the same species suggest that two inductural layers are present. This must be confirmed by study of thin sections.

In *E. graffhami* Moore, the inductural layer within the aperture bears lirae, but the area in front of this lirate region is smooth. If such is not an effect of poor preservation, the inductura and perinductura may be smooth and the co-inductura lirate. In so broad a shell as *E. graffhami*, stretching of the mantle in the extended stage might have caused the smoothing of all lirae producing wrinkles in the inductura. Moore (1941, pp. 143–144) prefers the alternative explanation, namely, that the co-inductura is absent, the inductura limited to the aperture, and the perinductura more widespread than in other species.

Species of *Euphemites* may be arbitrarily divided into two groups: those that are geniculate and those that are smoothly curved when viewed in profile. Geniculation is the result of a thick co-inductura, or "callus," on the body whorl at or just within the aperture. The following American Pennsylvanian and Permian species have a thick co-inductura: *Euphemites callosus* (J. M. Weller), *E. graffhami* Moore, *E. inspeciosus* (White), *E. nodo-*

carinatus (Hall), and *E. imperator*, new species.

The following species are smoothly curved by reason of lack of a thick inductura; possibly some also lack the co-inductural layer: *Euphemites aequisulcatus* H. P. Chronic; *E. blayneyanus* (Gurley); *E. regularis* Moore; *E. vittatus* (Gurley); and *E. batteni*, *E. crenulatus*, *E. exquisitus*, *E. kingi*, *E. luxuriosus*, *E. robertsi*, and *E. sparciliratus*, all new species.

The Permian species of *Euphemites* studied may also be divided into those species that are more or less compressed versus more inflated species. Compressed species are *Euphemites inspeciosus* (White); *E. nodocarinatus* (Hall); and *E. batteni*, *E. exquisitus*, *E. kingi*, *E. luxuriosus*, all new species. All other species listed are moderately inflated to globose.

The number of lirae is still a third criterion for the grouping of species of *Euphemites*. This is even more arbitrary and less satisfactory than divisions on shape and character of co-inductura. Curiously enough, there seems to be no correlation between the compressed body form and the relative abundance of lirae. Several of the least globular species bear the most lirae. Five species [*E. callosus* (Weller); *E. graffhami* Moore; and *E. crenulatus*, *E. imperator*, *E. sparciliratus*, all new species] bear relatively few lirae. The other species listed above bear common to abundant lirae on the body whorl.

FOREIGN PERMIAN SPECIES: The following species, mostly listed by Branson (1948), appear to be referable to this genus:

Euphemites angustus Licharew, *in* Licharew and Netschajew (1956, p. 36, pl. 14, fig. 7)
Euphemites apertus (Waagen), 1880
Euphemites? baroghilensis (Reed) (1944, p. 352, pl. 59, figs. 8, 8a)
Euphemus carbonarius Ozaki, 1935
Euphemites chaldinensis (Krotow), 1885
Euphemites indicus (Waagen), 1880
Euphemites laevis (Waagen), 1880
Euphemites lenticularis (Waagen), 1880
Euphemites sundaicus Wanner, 1942
Euphemites weberi Licharew, *in* Licharew and Netschajew (1956, p. 36, pl. 14, fig. 7)
Euphemites wongi (Grabau), 1922

Neither *Euphemites weberi* nor *E. angustus* resembles closely the species described herein. The latter species shows affinities with the Pennsylvanian *E. nodocarinatus* (Hall).

AMERICAN PERMIAN SPECIES: *Euphemites carbonarius arenarius* (Shimer) has been named from the Rocky Mountain quartzite of southern Alberta. Though this formation has been considered by some workers to be of Pennsylvanian age, Shimer (1926), Wheeler (1942), and Raasch (1956) consider it to be Permian. The species in question is illustrated by a single oblique view. Remarks following the somewhat generalized description note that "This variety differs from *E. carbonarius* (Cox) principally in its greater size." Through the kindness of Drs. Hans Frebold and Peter Harker, Geological Survey of Canada, I have had the opportunity of examining Shimer's specimens. The species is distinct from those in the southwestern United States and has been differentiated from allied forms.

Euphemites carbonarius (Cox) is reported by E. B. Branson (1916, p. 659) from below the phosphate bed of the lower part of the Embar formation in Wyoming, but specimens are not illustrated. Undoubtedly another species, possibly *Euphemitopsis subpapillosus* (White), was misidentified. C. C. Branson (1930, p. 53) has also reported this species, but again without figuring a specimen.

Euphemites aequisulcatus H. P. Chronic, first described from the Kaibab limestone, is discussed below (p. 246).

Euphemites species of H. P. Chronic (1952, p. 113, pl. 12, fig. 2) is poorly preserved and cannot be assigned to any of the species described in the present paper.

Girty (1912b, p. 54, pl. 7, figs. 5–5b) has reproduced the original figures of *Euphemites inspeciosus* (White) with the remark, "A large *Euphemus*, probably the same species as that illustrated, is characteristic of the Park City formation but is less common than *E. subpapillosus*." Until specimens from the Park City formation can be examined and figured, the writer prefers to disregard this reference. So far as it is known, *E. inspeciosus* (White) is present only in beds of Pennsylvanian age.

Girty (1909b, p. 100) has reported *Euphemus inspeciosus?* White from both the Yeso and San Andres formations of New Mexico. Two of his collections have been examined. The specimens examined are not referable to

White's species, but if they were better preserved they might be placed in two of the new species proposed herein.

RANGE OF THE GENUS: The earliest known species of *Euphemites* occurs in the Tournasian or, approximately, lower Mississippian, of Europe. The genus ranges into middle Permian, being found in the Word formation and its equivalents.

EUPHEMITOPSIS YOCHELSON, NEW GENUS

TYPE SPECIES: *Euphemitopsis multinodosa* Yochelson, new species.

DESCRIPTION: Bellerophontoid gastropods ornamented by nodes on the perinductural layer; shell smoothly rounded, not geniculate; slit relatively narrow and giving rise to a depressed selenizone; ornamented by spiral lirae on the inductural layer or layers, and by nodes on the perinductura.

DISCUSSION: In general size, shape, and in any other morphologic features, *Euphemites* and *Euphemitopsis* are closely related. The two genera are readily distinguished by the character of the perinductural layer on the anterior one-third of the body whorl. In *Euphemites*, this layer is smooth; in *Euphemitopsis*, it is nodose. The nodes or pustules were secreted seemingly by the same anterior flap of the mantle that deposited the perinductura. When the anterior third of the body whorl is missing, it is impossible to separate species of *Euphemitopsis* from species of *Euphemites*. *Euphemitopsis* appears to lack a coinductural layer, or, if present, it is exceedingly thin and cannot be distinguished from the inductura. The available specimens are not suitable for thin-section study.

Euphemites nodocarinatus (Hall), a Pennsylvanian species, described from the "Coal Measures" of Iowa and Illinois, bears a single row of perinductural nodes on each side of the selenizone. These differ in number and position from the relatively abundant nodes seen on *Euphemitopsis*. Further, *Euphemites blaneyanus* (McChesney) and *E. vittatus* (McChesney), both common upper Pennsylvanian species, develop short *en-echelon* costae or pustules close to the umbilical region. This ornament is inductural in origin and is not to be confused with the perinductural ornament of *Euphemitopsis*.

As with the divisions seen among species of *Euphemites*, one may divide the Permian species into a compressed group, containing *Euphemitopsis* species, and a non-compressed group containing all other species. In an analogous manner, *E. circumcostatus* (Walter) may be differentiated as having fewer costae than any of the other species. None of the species shows geniculation.

FOREIGN PERMIAN SPECIES: No foreign species are known that can be referred to *Euphemitopsis* with certainty. *Euphemites wongi* (Grabau) has nodules along each side of the selenizone but lacks other ornament on the perinductural layer. *Euphemites romanoskyi* Netschajew (*in* Licharew and Netschajew, 1956, p. 37, pl. 12, figs. 2–7) may have perinductural nodes. Its shape is similar to that of *Euphemitopsis multinodosa*, new species, but the Russian species seems to differ in developing more lirae on the inductura.

AMERICAN PERMIAN SPECIES: *Euphemites subpapillosus* (White) is a well-known species here referred to *Euphemitopsis*. Knight (1953, pp. 85–86, pl. 25A, figs. 1–8) has redescribed the species and illustrated the lectotype and other specimens. Additional specimens from the southwestern United States are discussed below (p. 254).

Euphemites circumcostatus Walter (1953, pp. 695, 696) is also placed in this genus. This species is well described and excellently illustrated and is not here redescribed, though it is from the west Texas area. In 1956 I made an unsuccessful attempt to visit Walter's locality and collect additional specimens. Through the kindness of Mr. Walter, paratypes of his species have been deposited in the United States National Museum.

RANGE OF THE GENUS: As presently known, *Euphemitopsis* ranges through the Permian. Species are known from equivalents of all four series of the Permian recognized in west Texas. So far as known, *Euphemitopsis* does not occur in the Pennsylvanian.

GENUS WARTHIA WAAGEN, 1880

TYPE SPECIES: *Warthia brevisinuata* Waagen, 1880.

DESCRIPTION: Bellerophontoid gastropods lacking spiral ornament; shell compressed to subglobular, not geniculate; slit short and broad at base of U-shaped sinus; selenizone obscured by inductural layer; inductural layers smooth, lacking both lirate and pustulose ornament.

DISCUSSION: *Warthia* can best be described as being almost exactly like *Euphemites* in all features except ornament. *Warthia* seems to have been derived from *Euphemites* by loss of spiral lirae on the inductura and co-inductura. Commonly the slit is extremely short, if present at all. The selenizone or pseudoselenizone is even more obscure than in *Euphemites*, perhaps indicating a slightly thicker perinductura than in *Euphemites*. Moore (1941, p. 148) has demonstrated the presence of the perinductura on *W. kingi*, a Pennsylvanian species. There is no conclusive evidence as to the presence or absence of a co-inductura, though, if present, it must be thin, as shown by the absence of geniculation. No Permian specimens are suitable for sectioning.

A few species of *Warthia* appear quite similar to those referred to *Bellerophon*, *sensu stricto*. In almost all cases, however, the characteristic curved to hooked lateral lips lying close to the body whorl differentiate this genus from *Bellerophon*, with its straighter, more widely explanate, lateral lips.

It might be extremely difficult to decide whether specimens that did not show spiral lirae should be placed in *Warthia* or be considered as *Euphemites*, with the inductural layers not preserved. Theoretically, such a decision would be particularly difficult with silicified material. Actually, for fewer than half a dozen specimens was there any question as to generic placement, and for all practical purposes such a choice can be ignored.

Globose and compressed groups of *Warthia* may be recognized, paralleling those of *Euphemites*. Globose species are *Warthia crassa* and *W. welleri*, both new species. The other species (*W. kingi* Moore; *W.? americana* Girty; and *W. angustior*, *W. fissus*, *W. saundersi*, *W. waageni*, all new species) are more or less compressed to strongly compressed forms.

The similarity in form between some species of *Warthia* and some of *Euphemites* is most remarkable. The pairs *E. exquisitus* and *W. waageni*, and *E. batteni* and *W. saundersi* are particularly noteworthy. The hypothesis that *Warthia* is a polyphyletic assemblage of various *Euphemites* species that have independently lost spiral lirae has been considered and rejected. The presence of a smooth inductura suggests a narrow mantle different from the presumably wider mantle in *Euphemites*.

Actually some uncertainty surrounds *Warthia*. Waagen assumed that the genus differed from "true bellerophonts in the absence of a distinct slit-band on the peripheral part of the shell," undoubtedly because the selenizone is obscured by the perinductura. He discussed the Ordovician *Bellerophon bilobites* Sowerby, now the type of *Sinuites* Koken, 1896, as a possible type species, but remarked that M'Coy had "registered an observation" that this species showed a selenizone when well preserved. As a consequence, Waagen did not designate a type.

Koninck (1882, p. 81) subsequently selected *W. brevisinuata*, one of Waagen's three included species, as the type species. The choice was most unfortunate, as the holotype is poorly preserved and does not show many important details (Knight, 1941a, p. 384, pl. 6, figs. 5a–g). Further, it shows a break in the outer lip superficially resembling a broad, V-shaped sinus.

In view of the poor nature of the type material, one alternative is to consider *Warthia* Waagen as a *nomen dubium* and for all practical purposes to abandon its use. The other alternative, followed here, is to assume that *Warthia brevisinuata* is congeneric with the two other species described by Waagen and to derive the generic features from study of all three species. All these three species come from the same general area and are of the same age so that the possibility of their not being congeneric is further reduced.

FOREIGN PERMIAN SPECIES: The following species listed by Branson (1948) appear to be referable to this genus:

Bellerophon attalicus Enderle, 1901
Possibly *Bellerophon pudwae* Krotow, 1888
Warthia brevisinuata Waagen, 1880
Warthia lata Waagen, 1880
Warthia micromphala Waagen, 1880
Warthia polita Waagen, 1880
Warthia subcarinata Mansuy, 1912
Warthia undulata (Dana), 1847

AMERICAN PERMIAN SPECIES: *Warthia? americana* Girty, from the Guadalupe Mountains area is redescribed below (p. 257). There is some question as to the proper generic placement of this species, but provisionally it can remain in this genus.

Incomplete specimens called *Warthia* species A were mentioned and figured by Knight (1953, p. 86, pl. 25B, figs. 9–12) from the El Antimonio area, Sonora, Mexico. They cannot be assigned with certainty to any of the new species described.

Family **BELLEROPHONTIDAE** M'Coy, 1851

Description: Bellerophontid gastropods developing a true slit, which gives rise to a distinct selenizone; shape variable, but commonly not compressed; phaneromphalous, cryptomphalous, or anomphalous.

Discussion: The development of a slit is presumed to indicate more efficient channeling of exhalant water from the mantle cavity, and in turn would indicate better sanitation of the mantle cavity. Although there probably was only a slight advantage of the slit versus a more open sinus for the control of exhalant water from the mantle, the steady increase in the number of slit-bearing genera and the extinction of sinus-bearing genera through the Paleozoic suggest that such an advantage was significant.

Actually no detailed work has been done in plotting the relative time spans of sinuate and those of slit-bearing gastropods. Nevertheless, general studies leave no doubt that in the middle and late Paleozoic slit-bearing gastropods of all kinds, not just bellerophonts, were on the ascendency, and sinus-bearing aspidobranch gastropods were on the wane.

The Bellerophontidae range from late Cambrian through early Triassic. As construed by Knight, Batten, and Yochelson (in press), the family is divided into six subfamilies, based primarily on the shape of the shell and the aperture. Genera of four of these subfamilies are not known above the Devonian. The four subfamilies omitted from further consideration are: Tropidodiscinae, Bucaniinae, Carinaropsinae, and Pterothecinae.

Subfamily **BELLEROPHONTINAE** M'Coy, 1851

Description: Subglobular shells with a slit; selenizone distinct; whorls commonly broadly rounded; umbilici narrow or wanting; juncture of lateral and anterior lips nearly straight; ornamented commonly by growth lines alone, though a few genera bear spiral or transverse lirae or other ornament; inductura commonly limited to less than one-quarter of body whorl.

Discussion: Two of the most significant characters of the subfamily are the inductura and the shape of the outer lip. The inductura seems to be universally present. It also seems to be invariably limited to the apertural area. In this respect the mantle of the living animal must have been quite different from that of *Euphemites* and its allies. No evidence of an anterior mantle flap is evident.

The slight reflection of the posterior portions of the lateral lips are a related feature, as in some species they are covered by a thin inductural wash. Some of the Permian species, particularly *B.* (*Bellerophon*) *plummeri*, new species, show a relatively deep sinus on each side of the body whorl, when the aperture is viewed from the side. Similar sinuses appear in all the species studied, although in some they are represented by little more than a flattening of the curvature of the outer lip as it approaches the body whorl. Although the portion of the inductura deposited by the posterior flap is of limited extent, the inductural lining of these lateral sinuses implies that the mantle flap must have been relatively broad.

As a corollary of these sinuses, the apertures of the Bellerophontinae and Euphemitinae are different. In the latter, the edges of the lips are held close in to the body whorl, and the shell widens only gradually with each whorl. In the Bellerophontinae, on the other hand, the lips are more explanate, and commonly the shell widens more rapidly. Locally, it has even been possible to distinguish steinkerns of the two subfamilies (Yochelson and Dutro, 1960, p. 131).

With the exception of *Bellerophon*, genera of this subfamily do not range above the Silurian. The genera that are recognized are distinguished by asymmetry of the whorls and by modification of the mature aperture. The subfamily is closely knit.

Ptychobellerophon Delpey, a most peculiar bellerophontid from the Permian of Cambodia, is questionably placed in this subfamily. The genus has not as yet been recognized in American collections. It might be added, parenthetically, that the water circulation from one side of the aperture to the other, as postulated by Delpey (1942, fig. 25) for the type species, *P. gubleri*, does not seem plausible or even possible. Attempts have been made to have the type photographed. Unfortunately the type could not be located in the collections of the Sorbonne, and restudy of this interesting genus must be postponed.

Genus BELLEROPHON Montfort, 1808

Type Species: *Bellerophon vasulites* Montfort, 1808.

Description: Bellerophontid gastropods lacking a strongly flaring aperture; shell symmetrical, commonly subglobular; lateral lips slightly thickened and flattened in the plane of the aperture, flaring slightly, if at all; posterior of aperture covered with an inductura commonly not extending out of the aperture; ornament in most species colabral only.

Discussion: *Bellerophon*, the earliest named Paleozoic gastropod genus, is so well known as to require essentially no description. Actually, its usage has become more and more specialized as each genus of bellerophontid gastropods has been separated from it. As restricted and used here, *Bellerophon* is further divided into three subgenera. These are *Aglaoglypta* Knight, 1942, characterized by quincuncial ornament and confined to the later Devonian, *Pharkidonotus* Girty, 1912, and *Bellerophon, sensu stricto*, the last two of which are discussed below. Most species are referred to the typical subgenus, which makes it a large and somewhat awkward category. At the same time, there appear to be no obvious features for differentiation of additional subgenera.

Range of the Genus: As used here, *Bellerophon* ranges from Silurian through early Triassic. It is the only bellerophontid gastropod to occur in Mesozoic strata. The supposed Triassic bellerophontid *Atlantobellerophon* Trechmann, 1930, upon restudy has been found to be a low-spired shell (Marwick, 1953, pp. 73–74, pl. 8, figs. 13, 14).

Subgenus BELLEROPHON (BELLEROPHON) Montfort, 1808

Mogulia Waagen, 1880, p. 131.

Waagenellia Koninck, 1883, explanation of pl. 38, footnote.

Sphaerocyclus Perner, 1903, p. 131.

Type Species: *Bellerophon vasulites* Montfort, 1808.

Description: Bellerophontid gastropods with a smooth inductura; slit narrow, depth variable among species; selenizone distinct, commonly on a dorsal crest; narrowly phaneromphalous or anomphalous; lips flaring slightly near umbilici; inductura thin, extending only a short distance out of the plane of the aperture; ornament predominantly colabral, a few species developing spiral lirae.

Discussion: Although a few species are ornamented by spiral lirae, in the typical *Bellerophon*, ornament is limited to growth lines. Commonly these growth lines are distinct and accentuate the selenizone. The shell is subglobular and not geniculate, as the inductura is almost always relatively thin outside the aperture.

The species described show that subtle differences in gross shape, in the nature of the umbilici, and in the shape of the outer lips differentiate taxa that have stratigraphic significance. They also show that excellent material is needed before identification can be undertaken. It seems likely that similar critical examination applied to the Pennsylvanian species would increase the number of species recognized and at the same time increase the stratigraphic usefulness of the species.

Waagen erected the genus *Mogulia* because he thought that it differed from *Bellerophon* in lacking a slit. A reëxamination of the type species, *M. regularis* Waagen, has shown that a slit is present (Knight, 1941a, p. 200). Accordingly, *Mogulia* has been placed in the synonymy of *Bellerophon* (Knight, 1944, p. 443). *Waagenella* Koninck was proposed for those species of *Bellerophon* having an inductural layer deposited in the umbilical areas. This distinction does not appear to have much significance, and *Waagenella* has also been placed in the synonymy of *Bellerophon* (Knight, 1944, p. 443).

Sphaerocyclus Perner, 1903, was named for bellerophontid gastropods with open umbilici and with faint spiral lirae. Neither of these two characters seems to be particularly important at this stage of our knowledge, but further work on middle Paleozoic species may provide cause for recognizing *Sphaerocyclus*.

Knight (1944, p. 443) placed *Prosoptychus* Perner, 1903, in the synonymy of *Bellerophon*. Though there is much in common between the two genera, *Prosoptychus* is currently regarded as distinct because of its widely explanate aperture.

FOREIGN PERMIAN SPECIES: The following species, mostly listed by Branson (1948), are referred to *Bellerophon, sensu stricto:*

Bellerophon acuticarinatus advena Reed (1944, p. 349, pl. 59, fig. 4)
Bellerophon affinis Waagen, 1880
Bellerophon asiaticus Roemer, 1881
Bellerophon blandfordianus Waagen, 1880
Bellerophon cadoricus Stache, 1877
Bellerophon canevai Gortani, 1906
Bellerophon carnicus Gortani, 1906
Bellerophon clausus Gemmellaro, 1890
Bellerophon comelicanus Stache, 1877
Bellerophon convolutus Buch, 1842, *non* Eaton, 1832
Bellerophon crassoides Reed, 1925
Bellerophon cristatus Gemmellaro, 1890
Bellerophon cylindricus Gemmellaro, 1890
Bellerophon daubenyi Gemmellaro, 1890
Bellerophon decussatus, Tschernyschew, 1885
Bellerophon equivocalis Reed (1944, p. 348, pl. 59, figs. 5, 5a, 5b)
Bellerophon fallax Stache, 1877
Bellerophon ferganensis Netschajew (*in* Licharew and Netschajew, 1956, p. 10, pl. 2, fig. 5)
Bellerophon gümbeli Stache, 1877
Bellerophon impressus Waagen, 1880
Bellerophon italicus Gortani, 1906
Bellerophon jacobi Stache, 1877
Bellerophon jonesianus Koninck, 1883
Bellerophon kirhiscus Licharew (*in* Licharew and Netschajew, 1956, p. 9, pl. 3, figs. 3, 4)
Bellerophon komishani Licharew (*in* Licharew and Netschajew, 1956, p. 13, pl. 4, figs. 1, 2)
Bellerophon lamellosus Gemmellaro, 1890
Bellerophon mojsvari Stache, 1877
Bellerophon orientalis Koninck, 1883
Bellerophon planoconvexus Mansuy, 1912
Possibly *Bellerophon permianus* Netschajew, 1894
Bellerophon politus Waagen, 1880
Bellerophon romeri Fliegel, 1901
Bellerophon rossicus Stuckenberg, 1905
Bellerophon rotularis Merla, 1934
Bellerophon sextensis Stache, 1877
Bellerophon squamatus Waagen, 1880
Bellerophon squamatus mongoliensis Grabau, 1931
Bellerophon stanvellensis Etheridge, 1892
Bellerophon timorensis Wanner, 1922
Bellerophon timorensis gibber Wanner, 1922
Bellerophon timorensis umbilicatus Wanner, 1942
Bellerophon tommasii Gortani, 1906
Bellerophon triangularis Waagen, 1880
Bellerophon ulrici Stache, 1877
Bucaniopsis bellerophonoides Licharew (*in* Licharew and Netschajew, 1956, p. 23, pl. 9, figs. 1–3)

It is possible that many of the above-listed species are based on steinkerns and as such will prove to be *species dubiae*. The following species are clearly unrecognizable outside the type lot:

Bellerophon compressus Grabau, 1934, not Potiez and Michaud, 1838
Bellerophon nodulatum Reed, 1925
Bellerophon subcostatus Fliegel, 1901

Among the Russian species recently described, *Bellerophon komishami* appears to be similar to *B. deflectus* H. P. Chronic, but differs in having the inner edges of the lateral lips less strongly reflexed. *Bellerophon kirhisicus* shows similarities to *B. huecoensis* and *B. parvicristus*. The illustrations suggest that it is more globose than either of these species. Finally, *B. ferganensis* is too poorly preserved to be compared with any of the American species.

Bucanopsis bellerophonoides is tentatively referred to *Bellerophon*. That the authors had some qualms as to placement seems to be indicated by the specific name. The species seems to be narrowly phaneromphalous, as is *Bellerophon huecoensis*, new species. The two species differ in that *B. huecoensis* has a deeper sinus.

AMERICAN PERMIAN SPECIES: *Bellerophon depauperatus* C. C. Branson, 1930, is based on two steinkerns. Probably these two steinkerns are correctly referred to *Bellerophon*, but the specific name is a *nomen dubium* until well-preserved topotypes can be studied.

Bellerophon majusculus Walcott, as figured by Clifton (1942), is an unrecognizable steinkern. The specimen that Girty (1909b) figured (U.S.N.M. No. 119808), however, may represent a new species. Pending additional material, the species is not described.

Bellerophon crassus Meek and Worthen of White (1877, p. 157, pl. 12, fig. 1; U.S.N.M. No. 8489) is poorly preserved and cannot be assigned to species. *Bellerophon crassus* as figured by Girty (1909a; U.S.N.M. No. 119601) is assigned to *B. deflectus* H. P. Chronic. *Bellerophon crassus* Meek and Worthen discussed by White (1891, p. 26) is probably correctly referred to genus but is specifically indeterminate. *Bellerophon* —? of White (1891, p. 26; U.S.N.M. No. 21722) is indeterminate below family level.

Finally, *Bellerophon deflectus* H. P. Chronic described from the Kaibab limestone is discussed below (p. 263).

RANGE OF THE SUBGENUS: The range of the subgenus is identical with that of the genus. In the United States the youngest occurrences of *Bellerophon* reported are in the Triassic Dinwoody formation (Newell and Kummel, 1942, pp. 954–955). The long range of the subgenus leads one to suspect that perhaps more than one phyletic line is currently identified as *Bellerophon*.

SUBGENUS BELLEROPHON (PHARKIDONOTUS) GIRTY, 1912

TYPE SPECIES: *Bellerophon percarinatus* Conrad, 1842.

DESCRIPTION: Bellerophontid gastropods with colabral undulations and a tendency towards shouldering of the whorls; inductura commonly thick and pad-like, not extending far out of aperture; selenizone on a low dorsal crest; anomphalous.

DISCUSSION: *Pharkidonotus* when typically developed can be readily distinguished from *Bellerophon, sensu stricto*, both by the thick inductura and by the characteristic undulations on the upper whorl surface. In some species, however, these undulations are reduced. In a few others, the undulations die out with age. These species cannot be clearly separated from *Bellerophon, sensu stricto*, which makes the use of subgenera advisable. For most species, including those that are nearly smooth, the inductura remains thick and pad-like. In several cases, species essentially lacking colabral undulations have been referred to the subgenus *Pharkidonotus* by virtue of the presence of this inductura. Incomplete specimens in which the aperture is broken back appear to be strongly geniculated, but in unbroken specimens it may be observed that the inductura barely extends outside the aperture.

Some species of *Knightites* (*Retispira*) superficially resemble *Pharkidonotus*, but in these species the selenizone lies between two rows of knobs, rather than on a raised crest. These knobs further are essentially normal to the selenizone, rather than slightly curved as are the undulations in *Pharkidonotus*.

FOREIGN PERMIAN SPECIES: The following Permian species, mostly listed by Branson (1948), appear to be referable to *Pharkidonotus*. Although undulations are not strongly developed, they have the characteristic thick inductura.

Possibly *Bellerophon blandfordianus* Waagen, as illustrated by Renz, 1940
Bellerophon de-angelisi Gortani, 1905
Bellerophon galeatus Wanner, 1922
Bellerophon khairliensis Reed (1944, p. 348, pl. 59, figs. 1, 2)
Bellerophon galeatus expers Wanner, 1942

Pharkidonotus? acuticarinatus (Yin) as figured by Licharew and Netschajew (1956, p. 16, pls. 5, 6) is clearly a member of this subgenus. It is most similar to *Pharkidonotus?* species but lacks the umbilici characteristic of that species. The Russian species reported to occur with *Pseudoschwagerina princeps*, an indicator of early Permian age, shows similarity to undescribed species from the Pennsylvanian Smithwick shale of Texas.

AMERICAN PERMIAN SPECIES: So far as known, no previously described species are referable to this subgenus. *Bellerophon crassus* Meek and Worthen, discussed by White (1891; U.S.N.M. No. 21721), from north Texas includes several specimens of *Pharkidonotus*.

RANGE OF THE SUBGENUS: *Pharkidonotus* ranges from beds of late Mississippian age into the middle Permian.

SUBFAMILY KNIGHTITINAE KNIGHT, 1956

DESCRIPTION: Bellerophontid gastropods with distinct spiral ornament; aperture expanded to flaring; shell smoothly coiled; inductura restricted to aperture; selenizone depressed between bordering ridges; narrowly phaneromphalous.

DISCUSSION: In external appearance, members of this subfamily have much in common with the Bucaniinae. They differ, however, in lacking a sharp internal ridge on the inductura. The inductural deposits in the aperture and the shape of the lateral margins are much like those described for the Bellerophontinae. The presence of a distinct umbilicus, the slightly wider aperture in some cases, and especially the ornament distinguish members of the two subfamilies.

The Knightitinae range from Devonian to middle Permian. Whether one judges by number of species or number of specimens, this subfamily comprises the single most important group of bellerophontaceans in the upper Pennsylvanian. In the Permian, it is still the single most important element, but locally members of the Euphemitinae are more abundant. Both genera currently assigned to the subfamily occur in the Permian.

GENUS **KNIGHTITES** MOORE, 1941

TYPE SPECIES: *Knightites multicornutus* Moore, 1941.

DESCRIPTION: Bellerophontid gastropods having spiral and colabral ornament commonly elaborate; selenizone flattened, depressed slightly; inductura thickened markedly in some species; colabral ornament varying from growth lines through lirae to undulations, in a few species these undulations being produced into short tubes; spiral ornament variable among species.

DISCUSSION: Knight (1945, p. 335) briefly discussed the late Paleozoic bellerophonts and noted the perplexing picture presented by many of the ornamented taxa. Spiral and colabral ornament runs the gamut from essentially absent to the most bizarre and elaborate, with no obvious gaps. Other features, such as shape of the aperture, selenizone, and parietal inductura, also seem to vary, with no obvious interrelationships.

Since that time, further study has shown even more forcefully how complete this intergradation is. Accordingly, it has been necessary to reduce three genera to subgeneric rank. Young specimens of each subgenus are similar and cannot be definitely assigned. For the present only these three taxa are recognized, but eventually it may be possible to distinguish several other distinctive forms within this intergrading complex.

The three subgenera recognized are:

Knightites (*Knightites*): With prominent protuberances or open spines beside the selenizone; aperture expanding slightly, bearing undulations.

Knightites (*Retispira*): Areas beside selenizone varying from smooth to undulatory; aperture expanding slightly.

Knightites (*Cymatospira*): With strong undulations beside the selenizone; aperture flaring in mature stage, not undulating.

In this scheme *Retispira* Knight, 1945, is the most common form, with only a few species referred to the other subgenera. Indeed, *Cymatospira* Knight, 1942, is presently known only from the Pennsylvanian type species, *Bellerophon montfortianus* Norwood and Pratten, 1855. The recognition of *Cymatospira* is often difficult in all but well-preserved mature specimens.

The collections of *Knightites* (*Retispira*) from the Hueco limestone are valuable in providing a measure of the amount of ontogenetic change a species may undergo. If other of the more elaborately ornamented Pennsylvanian species show nearly the same amount of ontogenetic variation, there is little question but that members of this subgenus will be one of the more difficult of late Paleozoic gastropods to identify to the specific level.

Knightites in the broad sense differs from *Bucanopsis* Ulrich, *in* Ulrich and Scofield, 1897, the genus to which many late Paleozoic species have been referred, in lacking a sharp longitudinal ridge on the inner floor of the whorl. None of the late Paleozoic gastropods appears to have such an internal ridge. For this reason, derivation of the group from *Bucania* Hall, 1847, is more plausible than any relationship to *Bucanopsis* to which there is a superficial resemblance. Tentatively it is suggested that *Retispira* arose from *Bucania*, and in turn gave rise to *Cymatospira* and *Patellilabia* Knight, 1945 (see below, p. 243). In turn, *Cymatospira* may have given rise to *Knightites*, *sensu stricto*.

RANGE OF THE GENUS: As used here, *Knightites* ranges from Devonian through middle Permian.

SUBGENUS **KNIGHTITES (KNIGHTITES)** MOORE, 1941

TYPE SPECIES: *Knightites multicornutus* Moore, 1941.

DESCRIPTION: Bellerophontid gastropods with a slightly arched selenizone bordered by large protuberances or spines; parietal inductura distinct, but not greatly thickened; spiral ornament not strongly developed; transverse ornament, extreme undulations, highest near selenizone, and, rarely, spines; aperture expanding gradually with age, the undulations becoming somewhat irregular with increasing age.

DISCUSSION: The original diagnosis of this taxon emphasized the unusual tube-like projections characteristic of the type species. Here, the concept is expanded to include those species with rows of large knobs paralleling the selenizone. Both knobs and tubes are the result of intensification of the basic undulatory pattern of growth. The tube-like projections or "horns" have been interpreted by Knight (1941b, p. 158, fig. 7d) as the loci of paired inhalant canals.

Knightites (*Knightites*) has the parietal inductura less strongly developed than in *Cymatospira*, but more strongly developed than in *Retispira*. The ornament of this subgenus is strongly colabral as in *Cymatospira*, being more accentuated than in that subgenus. The aperture bears undulations and flares slightly; in *Cymatospira* the aperture expands rapidly and is without undulations.

Bucanopsis calamitoides Yin is referred to this subgenus. Specimens figured by both Yin (1932, pl. 1, fig. 14) and Licharew and Netschajew (1956, pl. 11, figs. 1–6) are similar to *Knightites* (*Knightites*) *medialis*, new species, but seem to lack the two different weights of spiral ornament.

RANGE OF THE SUBGENUS: *Knightites*, *sensu stricto*, occurs in beds of late Pennsylvanian and early Permian age.

SUBGENUS **KNIGHTITES (RETISPIRA)** KNIGHT, 1945

TYPE SPECIES: *Retispira bellireticulata* Knight, 1945.

DESCRIPTION: Bellerophontid gastropods without strong undulations or a flaring aperture; aperture expanding steadily, in all growth stages; ornament spiral only in some species, spiral and colabral in others; narrowly phaneromphalous; inductura thin.

DISCUSSION: *Knightites* (*Retispira*) differs from the other two subgenera essentially in lacking their distinctive characters. The colabral undulations never are so pronounced as in *Knightites*. Similarly, the aperture does not flare as in *Cymatospira*, nor is the inductura boss-like and thickened as in that subgenus. Species of *Retispira* may be divided into those with only spiral ornament and those with both spiral and colabral ornament, but there appears to be so much intergradation between these two groups that more formal attempts to differentiate them have been unsuccessful to date.

Many Permian collections from the Colorado Plateau area contain worn specimens of bellerophontaceans. In the absence of ornamentation it has been possible to distinguish worn specimens of *K.* (*Retispira*) from *B.* (*Bellerophon*) by their characteristic umbilici. A few species of *Bellerophon* are phaneromphalous or hemiomphalous, but the umbilical openings are narrower than those of *K.* (*Retispira*). This criterion cannot be used with steinkerns.

FOREIGN PERMIAN SPECIES: The following species, mostly listed by Branson (1948), appear to be referable to *K.* (*Retispira*). Most late Paleozoic species referred to *Bucanopsis* Ulrich, *in* Ulrich and Scofield, 1897, are to be placed in this subgenus.

Bellerophon sphaenoidalis Krotow, 1885
Bucaniopsis ferganensis Netschajew (*in* Licharew and Netschajew, 1956, p. 26, pl. 14, fig. 8)
Bucaniopsis globularis Netschajew (*in* Licharew and Netschajew 1956, p. 19, pl. 7, figs. 1–11)
Bucaniopsis globularis sulcata Licharew (*in* Licharew and Netschajew, 1956, p. 21, pl. 14, figs. 5, 6)
Bucaniopsis lineatocarinatus (Romanovsky) as figured by Licharew and Netschajew (1956, pl. 9, fig. 13)
Bucaniopsis mayensis Licharew (*in* Licharew and Netschajew, 1956, p. 22, pl. 8, figs. 4–6)
Bucaniopsis postelegans Netschajew (*in* Licharew and Netschajew, 1956, p. 21, pl. 8, figs. 1–3)
Bucanopsis angustifasciata (Waagen), 1880
Bucanopsis incerta (Lóczy), 1898
Bucanopsis integra (Waagen), 1880
Bucanopsis kattaensis (Waagen), 1880
Bucanopsis kattaensis carinata Wanner, 1942
Bucanopsis lyelli (Gemmellaro), 1890
Bucanopsis ornatissima (Waagen), 1880
Bucanopsis perornata (Wanner), 1942
Bucanopsis sosiensis (Gemmellaro), 1890
Bucanopsis suhaensis (Kittl), 1891
Bucanopsis textilis, (Etheridge, not Koninck)
Bucanopsis timorensis (Hamlet), 1928
Bucanopsis warthi (Waagen), 1891

The species of *Knightites* (*Retispira*) described by Licharew and Netschajew (1956) are difficult to compare with American species, in part because the authors do not make a point of illustrating umbilical features. All the Russian species seem to lack transverse undulations, although this may be a feature of the small size of figured specimens. Because so many species are similar in gross features, it seems best not to attempt comparison at this time. The figures of *Knightites* (*Retispira*) *lineatocarinatus* (Romanovsky) appear to include more than one species. Also, species similar to the compressed species *K.* (*Retispira*) *ferganensis* Netschajew do not appear in the American collections.

American Permian Species: *Bucanopsis modesta* Girty (1909b), described from the Manzano group of New Mexico, is discussed below (p. 275). *Retispira undulata* H. P. Chronic from the Kaibab limestone is placed in the synonymy of that species.

Bellerophon bellus Keyes of E. B. Branson (1916, p. 660, pl. 3, figs. 16, 17) is clearly a *Retispira* but cannot be otherwise identified. *Bellerophon* species, figured by Herrick (1900, pl. 2, fig. 25) from southeastern New Mexico, is a *Retispira* but is also indeterminate. *Bucanopsis* species of Girty (1909a, p. 481, pl. 23, figs. 14–146; U.S.N.M. No. 118364) shows fine spiral lirae and distinct umbilici. It cannot be assigned to species.

Bellerophon montfortianus Norwood and Pratten, figured by White (1891; U.S.N.M. No. 21702), is a representative of this subgenus. From the same area, Mrs. A. H. Kemp has collected specimens of *Knightites* (*Retispira*) *eximia*, new species. The White collection under this species also includes specimens questionably referred to *Bellerophon* and *Pharkidonotus*.

Patellostium aff. *nodicostatum* Gurly, discussed by Girty (1909b), probably belongs to this subgenus. I have been unable to locate specimens for reëxamination.

Range of the Subgenus: As used here, *Retispira* ranges from Devonian through middle Permian.

Genus **PATELLILABIA** Knight, 1945

Type Species: *Patellilabia tentoriolum* Knight, 1945.

Description: Bellerophontid gastropods with a flaring aperture, and ornament of numerous spiral lirae; slit short and narrow, generating a narrow, arched selenizone; aperture expanding markedly with maturity; ornament of spiral lirae and growth lines; inductura, thin to thickened and knob-like, essentially limited to the aperture.

Discussion: *Patellilabia* shares with *Knightites* (*Cymatospira*) an expanded aperture and a thickened inductura, but the absence of undulations from this genus readily differentiates it. It is more closely related to *K.* (*Retispira*) but is distinguished from that subgenus by its flaring aperture. Immature specimens of these two taxa, however, are distinguished with the greatest difficulty, if at all.

No previously described Permian species appear to be referable to this genus.

Range of the Genus: *Patellilabia* ranges from beds of late Pennsylvanian into beds of early Permian age.

Superfamily **PATELLACEA** Menke, 1828

Description: Bowl-shaped to cap-shaped gastropods without slit or apical perforation; apex commonly located more or less anteriorly; interior of shell with horseshoe-shaped muscle scar opening anteriorly; inner septum lacking; operculum lacking.

Discussion: The Patellacea are a relatively diversified group, the living genera being placed by Wenz (1938) in three families: the Patellidae, the Acmaeidae, and the Lepetidae. They are all characterized by a docoglossan type of radula. This radular type is considerably different from that of the other living aspidobranch gastropods. Its occurrence suggests that the patellaceans are a group far removed from the other living superfamilies of the Aspidobranchiata. Wenz (1938, p. 44) indicates that the Patellacea first occur in the Triassic, but Paleozoic genera are known that seem to be true patellids.

The cap-shaped shell form is by no means confined to this superfamily. Among other groups, the shell form is characteristic of certain genera of the Cocculinacea, a group with a rhipodoglossan type of radula, *Siphonaria* Sowerby, an air-breathing pulmonate secondarily returned to a marine habitat, and the allied class, the Monoplacophora. Eales (1950) has discussed secondary symmetry within the gastropods and listed those groups exhibiting it.

?Family **METOPTOMIDAE** Wenz, 1938

Description: Subcardiform to patelliform gastropods with muscle scar relatively high in shell; outer shell margin of some genera curved when viewed in profile; horseshoe-shaped muscle scar, opening anteriorly, the muscle being nearer the apex than the margin in many species.

Discussion: Early Mesozoic patellids are poorly known, and it seems best at this time only to compare Paleozoic with Tertiary and Recent forms. Muscle scars are known from only a few Paleozoic specimens, but there is some indication that the scar may be higher in the shell than in later representatives of the superfamily. This suggestion cannot be confirmed until the muscle scars are known for more genera. For convenience, the Paleozoic forms are tentatively placed in this family distinct from younger forms.

There is one further difference between Recent and Paleozoic forms. Some, if not all, Recent shells show a faint line connecting the two anterior ends of the horseshoe. This feature has not been observed in any of the fossils examined. Whether this is a feature that would not be preserved in fossils or is something more fundamental cannot be determined at this time. Doris Crofts, University of London, has suggested (oral communication) that this may be simply the line of attachment of the anterior part of the mantle, and the feature may have little if any taxonomic significance.

Although Wenz (1938) recognized the basic difference between the Monoplacophora, patelliform shells with six to eight discrete muscle scars, and the Patellacea, with a horseshoe-shaped muscle scar, he referred the Metoptomidae to the former group. The family, as recognized here, included *Metoptoma* Phillips, 1836, *Lepetopsis* Whitfield, 1882, and *Palaeoscurria* Perner, 1903. This last genus is known only from the Silurian and is not treated herein.

The difference between the relatively high muscle scar in *Lepetopsis* and the much lower scar in *Metoptoma*, coupled with the pronounced difference in shape and position of apex, may be fundamental. However, the erection of new families, or monotypical subfamilies within the Metoptomatidae, is not an attractive proposition in the present state of our knowledge. Eventually the family Patellidae may be extended back into the Paleozoic and *Lepetopsis* referred to it. Mesozoic genera of Patellacea need to be re-investigated before such action can be justified.

Genus **METOPTOMA** Phillips, 1836

Type Species: *Metoptoma oblongata* Phillips, 1836.

Description: Patelliform gastropods with subcardiform outline; protoconch unknown; apex moderately elevated, near or overhanging the steep posterior slope of shell; lateral slopes steep, inclined outward, straight or very gently convex; anterior slope in most species inclined nearly 45 degrees, very gently convex; greatest width of shell variable among species from near posterior to nearly central; margin of shell flaring in some species; posterior margin with a slight concavity in outline; muscle scar horseshoe-shaped, nearly central between apex and margin.

Discussion: The subcardiform outline of the margin separates this genus from other Paleozoic genera referred to the Patellacea. The apex is strongly posterior rather than subcentral as in many other patellids. Koninck (1883, pl. 50, figs. 10–13) has illustrated a well-preserved Viséan specimen showing the characteristic muscle scar.

Color pattern is not shown on any of the Permian specimens. In the British Museum I had the privilege of examining one lower Carboniferous specimen, *Metoptoma elliptica* Phillips, a low-spired, smooth shell, which does retain traces of the original pattern. The shell bears five wide bands radiating from the apex.

Metoptoma gigantea Mansuy from the Productus limestone of Cambodia is clearly not a representative of the genus. Although the biologic placement of this large, eccentrically coiled species is uncertain, it is here tentatively referred to the platyceratids.

Metoptoma koltschimensis Krotow from the Artinskian of Russia is so poorly illustrated as to be practically unrecognizable as a gastropod.

Range of the Genus: As described above, this genus ranges from the Mississippian to

Permian. No Triassic species are known that are referable to *Metoptoma*. The generic name has been used in North America for patelliform gastropods ranging in age from Cambrian to Mississippian, but it has not been reported from the Pennsylvanian.

GENUS **LEPETOPSIS** WHITFIELD, 1882

TYPE SPECIES: *Patella levettei* White, 1882.

DESCRIPTION: Patelliform gastropods with subelliptical to lozenge-shaped margin; position of apex nearly central to somewhat anterior, strongly anterior only in species doubtfully referred to the genus; shell commonly low in relation to height and width so that lateral surfaces slope at an angle of less than 45 degrees from the horizontal; muscle scar horseshoe-shaped, opening anteriorly and high in shell; outer surface smooth or marked by concentric ornamentation; ribs radial from apex, present in some species.

DISCUSSION: The low, nearly central apex, combined with the subelliptical to lozenge-shaped outline, readily differentiates this genus from *Metoptoma* Phillips. *Palaeoscurria* Perner is similar externally but is less well rounded on both anterior and posterior. Superficially, *Lepetopsis* appears to be similar to the Recent genus *Patella* Linnaeus. It differs in having the muscle scar rather high in the shell. So little is known of the Mesozoic Patellacea that it seems best at this time to consider *Lepetopsis* as a zoologically valid entity, even though the name may be found later to be a junior synonym of a geologically younger genus.

FOREIGN PERMIAN SPECIES: The following species, listed by Branson (1948), appear to be clearly referable to *Lepetopsis*:

Leptopsis petasus Mansuy, 1913
Lepetopsis stefaninii Greco, 1937
Patella anthracophila Roemer, 1881
Patella artiensis Stuckenburg, 1898

AMERICAN PERMIAN SPECIES: One specimen described and figured by White (1891, p. 25) as *Patella?* — ? is clearly referable to *Lepetopsis*. The specimen (U.S.N.M. No. 21697), an internal mold, shows the muscle scar quite clearly. H. P. Chronic (1952, p. 127) has mentioned and figured cf. *Lepetopsis* that also is a representative of the genus. Neither of these specimens is complete enough to be referred to species.

POSSIBLE TRIASSIC SPECIES: *Acmaea campannaeformis* Münster, as described and figured by Kittl (1891, p. 9), from the St. Cassian beds of Austria appears to be referable to *Lepetopsis*. *Scurria petricola* Kittl (1895, p. 133) also seems to be referable to this genus. Both these species should be re-investigated before they are definitely assigned to this genus.

In addition to the species assigned above, there appear to be two other groups of Permian and Triassic species, which are here tentatively placed under *Lepetopsis*. These are species having shells bearing distinct radial ribs, and those having the apex situated far anterior.

In the first group, one may place the Permian species *Lepetopsis dainelli* Greco, 1937, and *L. golowkinskyi* Netschajew, 1894. The Triassic species *Patella costulata* Münster and *P. granulata* Münster, as figured by Kittl (1891, pl. 1), as well as *P. crateriformis* Kittl and *P. crasseradiata* Kittl (1895, p. 111), also seem to belong to this category. Because no specimens of these species were available for study, it seems better to expand the generic concept of *Lepetopsis* to include these forms than to erect a new genus at this time. Study of muscle scars and other internal features may show that these species form a natural group distinct from *Lepetopsis*.

The second group includes *Capulus dalpiazi* Greco, *Capulus fucinii* Greco, and *Capulus? haworthi* Beede, all from beds of Permian age. The last-named species has been restudied by Knight (1940, p. 304) who doubtfully refers it to *Lepetopsis*. In these species, the apex is far to one end (presumably posterior) and is curved, so that superficially they resemble species of *Metoptoma*. Again, as there are no specimens available for study, it seems better to note this distinction without naming it. Considerably more trouble than benefit has resulted from workers' erecting genera based on species in the literature that they have not investigated personally.

RANGE OF THE GENUS: *Lepetopsis* is known to range from the Mississippian at least to Word time in the Permian. A restudy of the Triassic species noted above may extend its range into the Mesozoic.

DESCRIPTION OF SPECIES

SUPERFAMILY **BELLEROPHONTACEA** M'COY, 1851

FAMILY **SINUITIDAE** DALL, 1913

SUBFAMILY **BUCANELLINAE** KOKEN, 1925

GENUS **SINUITINA** KNIGHT, 1945

Sinuitina keytei Yochelson, new species

Plate 46, figures 1–3

DESCRIPTION: Phaneromphalous bellerophontoid gastropods having a narrow, V-shaped sinus and a lanceolate cross section; widely phaneromphalous, the umbilical walls nearly vertical and with sharp circumbilical angulations; whorl profile lanceolate, with steep, gently arched sides culminating at the slightly flattened keel; growth lines slightly parasigmoidal, but essentially normal to umbilical angulations for about one-half of width of shell, bending abruptly and converging to form a V-shaped sinus culminating on the flattened keel, the lowest portion of the V being rounded and giving rise to a pseudoselenizone; sinus less than one-tenth of circumference of whorl in depth; ornament, other than impressed growth lines, wanting.

DISCUSSION: *Sinuitina keytei* is readily distinguishable from *S. cordiformis* (Newell), the only known Pennsylvanian species, by being relatively narrower and having a fairly sharp keel on the dorsum, rather than a raised rounded ridge. The sinus is relatively deeper than that of *S. cordiformis* (Newell). Finally, the holotype of *S. keytei* is more than twice as large as the largest of the four known specimens of *S. cordiformis* (Newell). Measurements of the holotype of *S. keytei* in millimeters are: length, 22; width, 13; thickness, 16.

HYPODIGM: One specimen, listed below. It is broken from limestone but still retains some impressions of growth lines.

OCCURRENCE: *Leonard formation*: U.S.G.S. 6694, one.

NUMBERED SPECIMEN: Holotype, U.S.N.M. No. 119921.

SUBFAMILY **EUPHEMITINAE** KNIGHT, 1956

GENUS **EUPHEMITES** WARTHIN, 1930

Euphemites aequisulcatus H. P. Chronic

Plate 47, figures 29–34

Euphemites aequisulcatus H. P. CHRONIC, 1952, p. 113, pl. 1, figs. 1a–c.

DESCRIPTION: Small, globose Euphemitinae with fairly numerous lirae; globular, seemingly without geniculation, although in mature specimens there may be some slight thinning of an inductural layer; lateral lips hook-shaped to sickle-shaped, becoming more curved with increasing maturity; anterior lips straight for approximately half of their width, then curving back to form a distinct sinus, culminating in a wide, quite short slit and sinus forming slightly less than 10 per cent of circumference; selenizone flush, rarely bordered by spiral lirae; lirate inductura extending out of aperture for more than one-half of a whorl; ornamented by spiral lirae, commonly more than a dozen at the aperture, though there is considerable variation from this number, with additional lirae being added in the umbilical region in front of the aperture.

DISCUSSION: The globular shape of *Euphemites aequisulcatus* H. P. Chronic readily distinguishes it from all compressed species. The addition of lirae in characteristic arrangement at the umbilical areas distinguishes the species from *E. vittatus* (McChesney), *E. blayneyanus* (McChesney), and *E. crenulatus*. It is most similar to *E. sparciliratus* in size and shape, but the small number of lirae in that species serve to distinguish the two. The species is close to *E. kingi* but differs in being expanded at the early stages and in not having depressions or pseudo-umbilici at the junction of lateral lips. It differs from *E. arenarius* (Shimer) in being more globular and in not being geniculate.

The extreme variation in the number of lirae in specimens examined is most curious. Lirae vary from being nearly as few as in *E. sparciliratus* to almost as numerous as in *E. exquisitus*. It may be that more than one species is present, but several attempts to divide the group have been unsuccessful. An alternative explanation, which may be applied to some of the specimens at least, is that not all lirae were preserved during the silicification process, or that one entire lirate inductural layer is not preserved. If the underlying layer bore fewer lirae, this latter possibility would certainly explain the variation extremes.

The specimens discussed have been com-

TABLE 2

MEASUREMENTS (IN MILLIMETERS) OF *Euphemites aequisulcatus* H. P. CHRONIC

	Length	Width	Thickness	Locality
Figured hypotype	14.2	13.5	12.4	703c
Figured hypotype	13.8	13.2	12.1	703
	13.2	12.8	11.6	703c
	10.9	11.1	9.6	703c
	11.6	11.3	10.3	703c
	14.0	13.0	11.1	503
	8.2	8.9	6.9	503
	5.8	6.4	5.2	503
	14.4	13.7	12.9	703
	9.8	9.7	8.3	703
	10.3	10.7	9.4	703
	9.0	9.4	8.1	703
	9.6	10.0	8.4	703
	8.4	7.9	7.3	433
	7.5	7.3	6.6	433
	11.1	10.3	9.7	3

pared with four paratypes given by Chronic to the American Museum of Natural History. One of the paratypes shows slight depressions near the umbilical areas. In other respects it is comparable to the specimens included in the species. The paratypes are not so well preserved as the other specimens listed in the hypodigm.

HYPODIGM: The specimens illustrated by H. P. Chronic, four unfigured paratypes, and 63 other specimens, as listed below. All are fairly well silicified, but most are incomplete.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 433, seven; P.U. 3, one. *Leonard formation*: U.S.N.M. 702, one; U.S.N.M. 702d, one. *Word formation*: A.M.N.H. 503, 15; U.S.N.M. 703, 29; U.S.N.M. 703c, nine.

NUMBERED SPECIMENS: Hypotypes, U.S.N.M. Nos. 119939, 119940.

Euphemites imperator Yochelson, new species

Plate 46, figures 18–22; plate 48, figure 27

DESCRIPTION: Large, geniculate Euphemitinae with an exceedingly short slit; shell well rounded on dorsum, slightly to distinctly geniculate in profile view, one-quarter of the body whorl near the aperture being flattened; lateral lips distinctly curved, not known at extreme tips, but almost certainly hook-shaped; anterior lips essentially straight so that no sinus is formed; slit wide, distinct, but short, forming about 7 per cent of the total circumference; selenizone gently concave; lirate inductural layers, extending half of a whorl out of aperture, one layer seemingly stopping at about one-fourth of the distance of a whorl out of aperture; ornamented by about 18 lirae in the aperture, the lirae wide and flat, with interspaces one to one and one-half times the width of the lirae; shell thick.

DISCUSSION: *Euphemites imperator* is readily distinguishable from other Permian species both by its large size and by its relatively few lirae. Among Pennsylvanian geniculate species, it differs from *E. nodocarinatus* (Hall) and *E. callosus* (Weller) in lacking nodes bordering the selenizone. *Euphemites imperator* appears to be less geniculate than either *E. graffhami* Moore or *E. inspeciosus* (White). *Euphemites arenarius* (Shimer) has the dorsum slightly more flattened and bears smaller, more numerous lirae on the inductura.

The holotype has the following dimensions: length, 52.4 mm.; width, 55 mm.; thickness, 39 mm.

HYPODIGM: Eleven specimens, as listed below. All are silicified, but all are broken, those from the Bone Spring limestone being particularly incomplete.

OCCURRENCE: *Bone Spring limestone*: A.M.N.H. 433, one; P.U. 3, six; U.S.G.S. 14439, one. *Leonard formation*: A.M.N.H. 504, one. *Word formation*: A.M.N.H. 503, one; U.S.N.M. 703, one.

Numbered Specimens: Holotype, U.S.N.M. No. 119929; figured paratypes, U.S.N.M. Nos. 119927a, 119928; unfigured paratypes, U.S.N.M. Nos. 119927b–119927d.

Euphemites kingi Yochelson, new species
Plate 47, figures 5–11

Description: Slightly compressed Euphemitinae having a distinct slit and fairly numerous lirae; shell moderately compressed, uniformly coiled; anterior lips curving backward and, forming a shallow sinus, culminating in a distinct slit; selenizone relatively wide, flush; sinus and slit forming nearly 15 per cent of total circumference; lateral lips sickle-shaped, the juncture of lips and body whorl arched, not depressed; lirae inductura extending for an unknown, but presumably slight, distance out of aperture; ornamented by lirae on inductura, probably a dozen or more in number.

Discussion: The relatively compressed shape of *Euphemites kingi* is distinctive and unique among Pennsylvanian and most Permian taxa. The Permian forms which are not globular (*E. exquisitus*, *E. batteni*, and *E. luxuriosus*) bear more lirae than *E. kingi*.

The holotype measures: length, 13.0 mm.; width, 11.1 mm.; thickness, 11.4 mm. Corresponding measurements in a figured paratype are 8.5 mm., 7.4 mm., and 7.9 mm.

Hypodigm: Four specimens, as listed below. All are silicified and well preserved.

Occurrence: *Bone Spring limestone*: P.U. 3, four.

Numbered Specimens: Holotype: U.S.N.M. No. 119932; figured paratype, U.S.N.M. No. 119933a.

Euphemites exquisitus Yochelson, new species
Plate 46, figures 4–9

Description: Slightly compressed Euphemitinae with a moderately wide slit and numerous lirae; shell somewhat compressed, but smoothly rounded across dorsum, not geniculate; lateral lips gently curved, bending abruptly near their juncture with median lips, but not forming a hook shape; juncture of lateral lip and body whorl marked by a distinct depression and, rarely, even a small umbilicus; median lips nearly straight, bending inward for a short distance and forming a shallow, relatively narrow sinus which is followed by an exceedingly short slit; slit and sinus nearly 9 per cent of total circumference; selenizone broad and flush to slightly depressed; lirate inductura extending out of aperture for nearly one-half of circumference of body whorl, ornamented at the aperture by about two dozen fine, rounded lirae, the interspaces being one and one-half to two times the width of the lirae, and a few additional lirae which are added in the umbilical region on the body whorl; shell thin.

Discussion: *Euphemites exquisitus* is, as its name implies, one of the most striking of the species encountered. The numerous sharp lirae and somewhat compressed shape mark it as distinctive. It differs from the upper Pennsylvanian species *E. regulatus* Moore in having more numerous lirae and in having the lirae continuous, without a smooth area separating the inductura and perinductura. Nevertheless, the excavated nature of the umbilicus in both species indicates close relationships. Its numerous fine lirae distinguish it from other Pennsylvanian species. *Euphemites exquisitus* differs from *E. luxuriosus* in bearing significantly fewer spiral lirae. It is most similar to *E. batteni* but differs from that species in having somewhat more numerous lirae.

Euphemites exquisitus is one of the few species of Permian *Euphemites* for which a growth series and a large number of specimens are available. These show that the ontogeny of the species is simple and that, with the exception of one feature, there is little individual variation in the species. This one exception is in the nature of the umbilical area. Most specimens have this region excavated, there being some variation in the width of the excavation. Several specimens, one of which is illustrated on plate 46, figure 7, are unique, however, in developing true umbilici. So far as it is known, these are the only specimens of *Euphemites* that develop true umbilici, though many specimens, when partially exfoliated or preserved as subinternal molds, show pseudo-umbilici. As the specimens are otherwise similar to others placed in the species, it is considered as an extreme in individual variation. At one locality (P.U. 3) only one specimen out of more than 50 shows this feature; at A.M.N.H. 678, nearly half of the specimens are umbilicate.

TABLE 3

MEASUREMENTS (IN MILLIMETERS) OF *Euphemites exquisitus* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	17	15.2	14.1	3
Figured paratype	24.5	20.3	19.8	3
Figured paratype	—	19.5	22.0	14439
Unfigured paratype	26	23.3	20.6	3
	33.7	27.5	28.6	503
	18	18.4	15.9	3

HYPODIGM: Seventy-five specimens, as listed below. All specimens are silicified. Though lirae are preserved on many specimens, the shells are thin and fragile, and the silicification is not of first quality.

OCCURRENCE: *Bone Spring limestone*: A.M.N.H. 369a, two; A.M.N.H. 678, 13; P.U. 1, one; P.U. 3, 46; P.U. 53, two; U.S.G.S. 14439, five; U.S.G.S. 14461, one. *Leonard formation:* U.S.N.M. 702, two. *Word formation:* A.M.N.H. 503, three.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119922; figured paratypes, U.S.N.M. Nos. 119923a, 119923b, 119924a; unfigured paratypes, U.S.N.M. Nos. 119923c–119923f, 119924b.

Euphemites crenulatus Yochelson, new species
Plate 47, figures 22–28

DESCRIPTION: Moderately large Euphemitinae, with several rows of nodes near the umbilical regions; shell well rounded across dorsum, slightly geniculate when viewed in profile; lateral lips nearly straight, abruptly hooked near junction with anterior lips when viewed in profile; median lips unknown; sinus and slit unknown, but presumably more than 15 per cent of circumference in depth; selenizone relatively wide, nearly flush; umbilical regions slightly depressed; non-lirate inductural layers not certainly known; lirate inductural layer or layers extending out of aperture and covering half of body whorl; ornament consisting of thin, high lirae, commonly 16 in number, the interspaces being two to three times the width of a lira, and three to four rows of nodes at the umbilical regions near the end of the inductural layers, these nodes in line with lirae closer to the aperture; seemingly without interruption of lirae at geniculation; shell relatively thick.

DISCUSSION: The combination of large size, well-rounded dorsum, and rows of nodes near the umbilici marks this as a unique form in the Permian fauna. This species differs from *Euphemites arenarius* (Shimer) in having a more rounded profile and in being ornamented by fewer, coarser lirae, in addition to the pustules. *Euphemites crenulatus* is distinguished from *E. imperator* by this pustulose ornament; in other features, they are similar. The limitation of nodose ornament to the umbilical area distinguishes this taxa from taxa of *Euphemitopsis*. *Euphemites crenulatus* seems most similar to *E. vittatus* (McChesney) of Pennsylvanian age, but that form is commonly smaller, has a shorter slit, thicker inductural layers, and fewer spiral lirae, although the last two points must be confirmed by further study of Pennsylvanian specimens. Measurement of the slit in *E. crenulatus* is not entirely satisfactory, being based on one broken, crushed specimen, but the evidence indicates a deep slit.

The holotype measures: length, 25 mm.; width, 24.6 mm.; thickness, 20 mm. A crushed paratype has a length of about 35 mm.

HYPODIGM: Five silicified specimens, as listed below. All are more or less well preserved, though incomplete.

OCCURRENCE: *Word formation:* U.S.N.M. 703, four; U.S.N.M. 703c, one.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119937; figured paratypes, U.S.N.M. No. 119938a; unfigured paratypes, U.S.N.M. Nos. 119938b–119938d.

Euphemites batteni Yochelson, new species
Plate 46, figures 10–17

DESCRIPTION: Somewhat compressed Euphemitinae, having a wide slit and fairly numerous fine lirae; shell compressed laterally, flattened slightly across the dorsum, not geniculate; lateral lips curved, not hooked; anterior lips and slit unknown; slit and sinus probably nearly 10 per cent of circumference; selenizone relatively wide, bordered, and carrying two spiral lirae; umbilical areas with a wide, shallow excavation; lirate inductura extending slightly more than half of a whorl out of aperture; inductural layers thin, ornamented by spiral lirae, commonly 12 to 16 in number on the dorsum and lateral slopes but seemingly absent near the umbilical depressions, the lirae themselves being relatively sharp, the interspaces two to four times as wide as the individual lira; shell exceedingly thin.

DISCUSSION: *Euphemites batteni* is closely allied to *E. exquisitus* but differs from that species in having relatively fewer lirae and a slightly wider selenizone which causes the flattening of the dorsum. At one locality it occurs with *E. luxuriosus*, but is readily distinguishable by the more numerous and smaller lirae of that species. The species is also closely related to *E. regulatus* Moore from the upper Pennsylvanian but differs from that species in lacking a smoothed area between the inductura and the co-inductura. In *E. batteni*, as in many of the other Permian *Euphemites*, it is impossible to prove the existence of two lirate inductural layers, although their presence is suspected.

HYPODIGM: Fifty-six specimens, as listed below. All are silicified, and preservation varies from fairly good to fairly poor. None shows the aperture unbroken.

OCCURRENCE: *Word formation:* U.S.N.M. 706c, one; U.S.N.M. 706e, two; U.S.N.M. 707e, 15. *Cherry Canyon formation:* A.M.N.H. 512, 29; U.S.N.M. 728, nine.

NUMBERED SPECIMENS: Holotype, A.M.N.H. No. 28184; figured paratypes, A.M.N.H. Nos. 28184:1, 28184:2, U.S.N.M. Nos. 119925a, 199925b, 119926a; unfigured paratypes, U.S.N.M. Nos. 119926c–119925h, 119926b–119926o.

Euphemites luxuriosus Yochelson, new species

Plate 47, figures 1–4

DESCRIPTION: Slightly compressed Euphemitinae ornamented by extremely numerous fine lirae; moderately well rounded, and regularly coiled; lateral lips strongly curved, not hooked; anterior lips unknown; slit unknown, but sinus and slit presumably much less than 15 per cent of circumference; selenizone wide, flush; umbilical area shallowly excavated; lirate inductural layers confined to aperture; ornamented by low, fine, exceedingly numerous lirae, more than two dozen in number; shell thin.

DISCUSSION: In general size, shape, and nature of umbilical area, *Euphemites luxuriosus* is closely related to *E. regulatus* Moore, *E. exquisitus*, and *E. batteni*. It is distinguishable from the other species by having finer, more numerous lirae. *Euphemites arenarius* (Shimer) bears relatively fine lirae but is geniculate. In this line of *Euphemites* species there appears to be a tendency for the lirae to increase in number and become smaller in the younger species, but *E. batteni* with fewer lirae than *E. exquisitus* is at variance to the trend, even though it occurs in younger beds.

It is possible, of course, that the form described as *Euphemites luxuriosus* is not a true species but is simply an artifact of preservation. This possibility has been seriously considered, but the available specimens of *E. luxuriosus* do not support the consideration that they are specimens of *E. batteni* incom-

TABLE 4

MEASUREMENTS (IN MILLIMETERS) OF *Euphemites batteni* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	18.3	17.2	15.4	512
Figured paratype	—	10.2	11.2	512
Figured paratype	11	10.4	10.6	512
Figured paratype	18	16	17.3	707e
	19.5	16.6	18.0	512
	14.0	13.2	11.5	512

pletely silicified. If they were incompletely preserved, one would expect the shell to be thinned and even more fragile than it is.

HYPODIGM: Three silicified specimens, as listed below. All have the aperture broken.

OCCURRENCE: *Cherry Canyon formation:* U.S.N.M. 728, three.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119930; figured paratype, U.S.N.M. No. 119931a; unfigured paratype, U.S.N.M. No. 119931b.

Euphemites sparciliratus Yochelson, new species
Plate 47, figures 12–19

Bellerophontid gastropod, NEWELL AND OTHERS, 1953, pl. 23, fig. 37.

DESCRIPTION: Small, globose Euphemitinae ornamented with few coarse lirae; shell inflated and well rounded; lateral lips gently curved, not sickle-shaped; anterior lips inclined strongly inward towards the slit, slightly curved, culminating at a short, distinct slit; sinus and slit forming nearly 10 per cent of total circumference; selenizone flush to slightly depressed; lirate inductura extending one-quarter whorl out of aperture; ornamented by strong spiral lirae, commonly four to eight in number, widely spaced on the inductura, those nearest the selenizone being the most prominent.

DISCUSSION: The small number of lirae is the most distinctive feature of *Euphemites sparciliratus* and readily distinguishes it from other Pennsylvanian and Permian species. These lirae are less numerous than in *E. aequisulcatus* H. P. Chronic. The short slit and flush selenizone further serve to differentiate *E. sparciliratus*, as in *E. aequisulcatus* the slit

TABLE 5
MEASUREMENTS (IN MILLIMETERS) OF *Euphemites sparciliratus* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	10.0	9.9	9.2	512
Figured paratype	4.9	4.8	4.4	512
Figured paratype	8.4	8.2	7.5	512
	8.5	8.3	7.7	512
	8.3	8.2	7.3	512
	9.2	9.0	8.4	512
	8.5	8.2	7.3	512
	9.1	8.3	8.0	512
	6.2	6.0	5.5	512
	10.7	10.5	9.4	512
	8.3	8.0	7.4	512
	6.5	6.4	5.5	512
	5.6	5.3	4.7	512
	6.6	6.5	5.7	512
	6.7	6.6	5.9	512
	7.8	7.5	7.0	512
	6.7	6.5	5.8	512
	11.6	10.1	9.8	512
	10.9	10.1	9.6	728
	5.8	5.7	5.0	728
	8.4	8.7	7.3	728
	4.9	4.8	4.4	728
	5.9	5.6	4.9	728
	6.7	6.5	5.7	728

Locality A.M.N.H. 512

$N = 18$

M length = 6.5 mm.	S length = ±1.89 mm.	r length/width = 0.98
M width = 5.6 mm.	S width = ±1.68 mm.	r length/thickness = 0.97
M thickness = 6.3 mm.	S thickness = ±1.69 mm.	r width/thickness = 0.97

is slightly longer and the selenizone concave. *Euphemites vittatus* (McChesney) and *E. blayneyanus* (McChesney), both common Pennsylvanian forms, besides having more numerous lirae have a slightly less globular shape.

HYPODIGM: Two hundred and forty-two silicified specimens as listed below. Specimens from the Word formation are all poorly silicified. Specimens from the Cherry Canyon formation are well silicified, but many were badly worn prior to silicification.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 369a, five. *Word formation:* U.S.N.M. 706, one; U.S.N.M. 706c, five; U.S.N.M. 706e, six. *Cherry Canyon formation:* A.M.N.H. 512, 152; A.M.N.H. 519, three; U.S.N.M. 728, 70.

NUMBERED SPECIMENS: Holotype, A.M.N.H. No. 28185; figured paratypes, A.M.N.H. Nos. 28185:1, 28185:2, U.S.N.M. Nos. 119934a, 119934b; unfigured paratype, U.S.N.M. No. 119934c.

Euphemites species

Plate 47, figures 20, 21

DISCUSSION: In addition to the species described above, there are a few scattered specimens from rocks of Wolfcamp age which may represent another species. Specimens are compressed and bear numerous fine lirae. Beyond this, little more information can be obtained except that the anterior part of the body whorl is smooth, indicating that the specimens clearly belong to *Euphemites* rather than *Euphemitopsis.*

HYPODIGM: Eight specimens, as listed below. Two are immature silicified specimens; six are incomplete calcareous specimens.

OCCURRENCE: *Wolfcamp formation:* U.S.N.M. 706x, six; U.S.N.M. 707h, one. *Hueco limestone:* U.S.N.M. 712c, one.

NUMBERED SPECIMENS: Figured specimens, U.S.N.M. No. 119935, 119936a.

EUPHEMITOPSIS YOCHELSON, NEW GENUS

Euphemitopsis multinodosa Yochelson, new species

Plate 48, figures 1–12

DESCRIPTION: Globose Euphemitinae with many pustules on the perinductura and a deep slit; shell well inflated, globose, slightly geniculate; lateral lips sharply bent, not truly "sickle-shaped," their juncture with body somewhat thickened; anterior lips little arched, near center curving in to form a shallow sinus which culminates in a narrow deep slit; slit and sinus forming nearly 20 per cent of circumference; ornament borne on two or more inductural layers; spiral lirae formed on higher inductural layer, the lirae being low and rounded, but distinct, and varying in number from eight in early growth stages to a maximum of 17 at maturity, the number varying at all growth stages, the mature growth stage commonly bearing 12 to 14 lirae; perinductural ornament consisting of numerous small nodes or pustules elongating slightly near the edge of the inductura; area immediately behind apertural lips smooth and unornamented, the growth lines clearly visible.

DISCUSSION: *Euphemitopsis multinodosa* is readily distinguishable from *E. circumcostata* (Walter) as that species has fewer, stronger lirae, and a relatively wider shell. This species is similar to *E. subpapillosa* (White), however, and the two are distinguished with difficulty. In *E. subpapillosa* (White) the slit is significantly shorter and slightly wider than in *E. multinodosa.* The two species differ further in that the lirae are more numerous on *E. multinodosa,* the nodes smaller and more numerous, and the shell is slightly less well rounded, than in *E. subpapillosa.*

There is slight indication that the specimens from the Admiral formation bear finer ornament than do those from younger beds. Pending additional study of further specimens, the specimens from north central Texas are placed in one species.

HYPODIGM: Seven hundred and thirty specimens, as listed below. Even though many specimens are available, the species is not so well known as one might assume. Most of the specimens from north central Texas are more or less covered with a yellow earthy matrix, difficult to remove. The preponderant number of specimens actually add little to the concept of the species. In a like manner, many of the specimens from the Hueco limestone are defective. Here, the calcareous shells have weathered free from the matrix, and, during the weathering process, the shells have been somewhat eroded so that most are identifiable

TABLE 6

MEASUREMENTS (IN MILLIMETERS) OF *Euphemitopsis multinodosa* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	17.7	17.3	14.6	199-T9-1.3A12
Figured paratype	18.5	18.2	14.8	712c
Figured paratype	16.9	18.2	13.3	199-T2-1.3A13
Figured paratype	14.4	15.0	11.5	199-T2-1.3A13
Figured paratype	17.2	16.9	14.3	199-T2-1.3A13
Figured paratype	18.6	18.5	14.3	199-T2-1.3A13
Unfigured paratype	12.8	12.7	10.1	199-T2-1.3A13
	15.9	16.9	15.0	9800
	13.4	18.1	16.5	9800
	9.7	10.2	8.1	9800
	8.2	8.9	7.1	9800
	10.8	11	9.8	9800
	17.8	18	15.3	712h
	17.3	18	15.9	712h
	18.5	19.6	15.3	712h
	15.2	16.3	13.3	712h
	15.2	16	13.8	712h
	11.8	11	9.0	712h
	15.2	17.8	14.1	9863
	7.7	8	6.6	712b
	5.3	5.7	5.0	712b
	8	8.3	6.7	712b

to species only because of the few better specimens associated. In addition, there are 38 specimens from the Hueco limestone in the northeast quarter of section 15, T. 22 S., R. 10 E., Otero County, New Mexico. Although they probably belong to this species, they are not well enough preserved to be identified with certainty.

OCCURRENCE: *Admiral formation:* B.E.G. 42-T18, one; U.S.G.S. 9800, 328; U.S.G.S. 9802, two. *Clyde formation:* U.S.G.S. 9863, 84; B.E.G. 199-T2-Q21-1.3A14, two; B.E.G. 199-T2-1.3A13, 16; B.E.G. 199-T5-1.3A14, 12; B.E.G. 199-T7-P19-1.3A13, four; B.E.G. 199-T9-1.3A12, four; U.S.N.M., from bluff on Miller Creek, Stout Ranch, Baylor County, Texas, one. *Lueders limestone:* B.E.G. 199-T1-L16-1.3A19, three. *Hueco limestone:* U.S.N.M. 712, 12; U.S.N.M. 712b, 24; U.S.N.M. 712c, seven; U.S.N.M. 712h, 153; U.S.N.M. 712i, 58; U.S.N.M. 712j, six; U.S.N.M. 3323, nine. *Colina limestone:* U.S.G.S. 8502, four.

NUMBERED SPECIMENS: Holotype, B.E.G. No. 13652; figured paratypes, B.E.G. Nos. 13654–13656, U.S.N.M. No. 112117; unfigured paratypes, B.E.G. Nos. 13651, 13653, 13657, U.S.N.M. Nos. 112115, 112116, 112118–112120, 115402–115406.

Euphemitopsis paucinodosa Yochelson, new species

Plate 47, figures 38–41

DESCRIPTION: Globose Euphemitinae with few large pustules on the perinductura; shell well inflated, seemingly with very slight geniculation; lateral lips sickle-shaped, standing out from penultimate whorl, junction with anterior lips unknown; anterior lips unknown; slit and sinus unknown, but presumably short; selenizone depressed, bordered by lirae; ornament, probably borne on two or more layers, consisting of sharp spiral lirae, commonly 11 to 13, the number remaining nearly constant throughout ontogeny, with only a rare lira dying out or being intercalated; inductura thin, the line of inductura and co-inductura joining smoothly; ornament on perinductural layer consisting of large nodes arranged in spiral lines, with four lines, counting from each umbilicus, there then being a smooth area, and another line of nodes

TABLE 7

MEASUREMENTS (IN MILLIMETERS) OF *Euphemitopsis paucinodosa* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	21	21	18	707q
Figured paratype	13	14	10	707q
Unfigured paratype	11	10	9	707q
Unfigured paratype	14	—	12	707q
Unfigured paratype	29	26	21	707q

on each side of the selenizone; shell relatively thick.

DISCUSSION: The large side of the nodes and their limited distribution distinguish *Euphemitopsis paucinodosa* from *E. circumcostata* (Walter). It is most similar to *E. subpapillosa* (White), but it has larger nodes on the perinductura and seems to have a few more spiral lirae. The lines of nodes along the edges of the selenizone appear to be unique to this species.

HYPODIGM: Fourteen specimens, as listed below. All are silicified and weathered from a yellow earthy matrix; all have the aperture broken.

OCCURRENCE: *Leonard formation:* U.S.N.M. 707q, 14.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 11941; figured paratype, U.S.N.M. No. 119942a; unfigured paratypes, U.S.N.M. Nos. 119942b–119942m.

Euphemitopsis subpapillosa (White)

Plate 48, figures 13, 14

Bellerophon carbonareous Cox, var. *subpapillosus* WHITE, 1876, p. 92.

Euphemites subpapillosus (White) KNIGHT, 1953, pp. 85–86, pl. 25a, figs. 1–8. (Synonymy given by Knight is followed and is not repeated.)

DISCUSSION: Knight (1953) has clarified our knowledge of this species by redescribing and reillustrating the type lot. The specimens illustrated in the present paper supplement our knowledge of the geologic and geographic occurrence of the species and add a few morphologic details. All the type specimens have the perinductural area worn, but those illustrated show the nodes clearly. The spiral arrangement of the nodes is clear; the lirae bordering the selenizone are also quite clear. It is these features that distinguish this species.

HYPODIGM: The specimens examined by Knight (1953), those listed in his synonymy, and 30 specimens listed below. The specimens listed have the calcareous shell mashed and broken, or are silicified and broken.

OCCURRENCE: *Yeso formation:* U.S.G.S. 3742d green, 15; U.S.G.S. 15784, 11. *Epitaph dolomite:* U.S.G.S. 8527, four.

NUMBERED SPECIMENS: Hypotypes, U.S.N.M. Nos. 119977, 119978.

Euphemitopsis species

Plate 47, figures 35–37

DISCUSSION: At least one other species of this genus is known from the Permian, based on incomplete material. The species is relatively large but seemingly has a thin shell. It is very slightly compressed, with just the faintest indication of umbilical depressions. The lateral lips are curved; anterior lips, sinus, and slit are unknown. The selenizone is relatively narrow. All inductural layers are thin. Ornament consists of eight thin spiral lirae on each side of the selenizone, the selenizone being bordered by one pair of lirae. On the anterior quarter of the shell, at least five of the lirae on each side break up into lines of small spiral nodes; the ornament near the selenizone on the perinductura is unknown. The small size of the nodes distinguishes this species from *Euphemitopsis subpapillosa* (White) and *E. paucinodosa.* The shape of the shell and the spiral arrangement of the nodes distinguish it from *E. multinodosa.* The species is close to *Euphemites exquisitus* in shape, but that species lacks perinductural nodes. Length, width, and thickness of the specimen in millimeters are 26.0, 23.4, and 20.8, respectively.

HYPODIGM: One somewhat crushed, silicified specimen.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 369, one.

TABLE 8

MEASUREMENTS (IN MILLIMETERS) OF *Warthia crassus* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	17.1	15.7	15.0	9854
Figured paratype	17	15.4	13.5	9802
Figured paratype	14.4	12.5	12.4	9802
Figured paratype	18.1	16.4	16.0	17393
	12	11.4	10.8	712a
	—	12.5	12.2	712b

NUMBERED SPECIMEN: Hypotype, A.M.N.H. No. 28186.

GENUS **WARTHIA** WAAGEN, 1880

Warthia crassus Yochelson, new species

Plate 49, figures 14–20

DESCRIPTION: Smooth Euphemitinae having a flush selenizone; shell well rounded, globular; lateral lips joining anterior lips at an angle of nearly 90 degrees; strongly hooked for a short distance, then bending back gradually to form a wide sinus culminating in a shallow slit; slit and sinus forming nearly 10 per cent of circumference of body whorl; selenizone flush, not well exposed on most of the shell; distinct inductura developing in mature stage.

DISCUSSION: The globular shape of *Warthia crassus* distinguishes it from the distinctly compressed species *W.? americana* Girty, *W. angustior*, and *W. fissus*. It has the lateral slopes more rounded than in *W. saundersi*. *Warthia crassus* is similar to *W. waageni*, but can be distinguished by its possession of a thick, distinct inductura and its smooth, flush selenizone in contrast to the more welt-like selenizone of that species. It is most similar to *W. welleri*, but that species is more globose, has a thicker inductura, and does not have hook-shaped lateral lips. It is also quite similar to *W. kingi* Moore from the upper Pennsylvanian of Kansas, but that species lacks a true slit.

HYPODIGM: One hundred and sixty-five specimens. Specimens from the Hueco limestone and the Clyde formation are silicified; most are broken. Specimens from the Admiral formation are all covered by a more or less thick coat of clayey matrix. Approximately a dozen specimens have been cleaned to show the characters of the species.

OCCURRENCE: *Admiral formation:* U.S.G.S. 902, 156. *Clyde formation:* U.S.G.S. 9854, one. *Hueco limestone:* U.S.N.M. 712a, seven; U.S.N.M. 3323, one.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 112501; figured paratypes, U.S.N.M. Nos. 112502a, 112502b, 119953; unfigured paratypes, U.S.N.M. No. 112503.

Warthia welleri Yochelson, new species

Plate 48, figures 20–26

?*Warthia* species H. P. CHRONIC, 1952, p. 113, pl. 2, figs. 3a–4.

DESCRIPTION: Globose, smooth Euphemitinae with a short slit and a thick inductura; shell relatively globular and well rounded on dorsum and sides, slightly geniculate when viewed from side; lateral lips gently sickle-shaped, their juncture with median lips at an angle of nearly 135 degrees; anterior lips not produced forward, essentially straight across margin of aperture to near dorsum where they bend in abruptly to form a distinct slit; slit and sinus forming nearly 7.5 per cent of body-whorl circumference; selenizone flush, covered for three-fourths of body whorl by an inductural layer or layers; inductura thick in mature stage, just extending out of aperture.

DISCUSSION: This species has a globular shape, smooth whorls, and sickle-shaped lateral lips; in every way it is a typical *Warthia*. It is readily distinguishable from most other American Permian species by its well-rounded, globular shape, in contrast to the more or less compressed shapes of the others. *Warthia welleri* is most similar to *W. kingi* Moore, of Pennsylvanian age, but differs in possessing a distinct slit.

H. P. Chronic's specimen is incomplete but may belong to this species. It appears to

TABLE 9

MEASUREMENTS (IN MILLIMETERS) OF *Warthia welleri* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	30.8	27.5	28.7	503
Figured paratype	54	56	44	703b
	12.6	13.0	11.5	703
	17.8	16.4	15.4	4

be slightly more globose than specimens placed in *W. waageni.*

HYPODIGM: Fourteen specimens, as listed below. All are silicified; two are excellently preserved. One specimen from U.S.N.M. 702 is immature and quite incomplete; seven others are exfoliated.

OCCURRENCE: *Bone Spring limestone:* P.U. 4, two. *Leonard formation:* U.S.N.M. 702, one; U.S.N.M. 703b, two. *Word formation:* A.M.N.H. 503, one; U.S.N.M. 703, eight.

NUMBERED SPECIMENS: Holotype, A.M.N.H. No. 28187; figured paratypes, U.S.N.M. Nos. 119979a, 119980a; unfigured paratypes, U.S.N.M. Nos. 119979b, 119980b–119980i.

Warthia waageni Yochelson, new species

Plate 49, figures 21–26

DESCRIPTION: Inflated, smooth Euphemitinae having an exceedingly short slit; shell somewhat inflated, more rounded on the dorsum than on the sides; umbilical areas flattened; lateral lips curved, but not strongly sickle-shaped, joining anterior lips at an angle of nearly 100 degrees; anterior lips not produced forward, at about midpoint of their length curving back to form a wide sinus, culminating in a wide, shallow slit; sinus and slit forming nearly 7.5 per cent of body-whorl circumference; wide selenizone raised, welt-like, clearly visible for more than half of a whorl on some specimens; inductural layer, or layers, thin; shell moderately thin.

DISCUSSION: The wider dorsum distinguishes *Warthia waageni* from *W.? americana* Girty; the sinus of this species appears to be relatively the wider of the two. *Warthia waageni* is less globose than *W. welleri* and has a shorter and wider slit. This species is similar to *W. crassus;* the latter is the more globose of the two. The lateral lips of *W. waageni* are slightly more curved, and the slit is slightly deeper, than are the corresponding features in *W. crassus.* A significant difference between the two is the raised selenizone of *W. waageni* compared to the flush selenizone of *W. crassus.* Poorly preserved specimens of the two species cannot be readily distinguished. *Warthia saundersi* differs in being slightly narrower than *W. waageni.*

Warthia waageni occurs at the same locality as *W. angustior.* The two taxa are readily distinguished by the more compressed shape and relatively deeper slit of *W. angustior.* Juvenile specimens of *W. waageni* show the more inflated shape of that species and are readily separated from *W. angustior.* The large suite of specimens available show that the species undergoes little ontogenetic change.

Three silicified specimens of *Warthia* are known from the Colina limestone (U.S.G.S. 8501). They bear some resemblance to either *W. crassus* or *W. waageni* but are too incomplete to be specifically identified.

HYPODIGM: Eighty-two specimens, as listed below. All are silicified. About half are more or less complete, though only three show the aperture unbroken.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 433, 23; A.M.N.H. 592, two; P.U. 3, 51; U.S.G.S. 14439, six.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119954; figured paratypes, U.S.N.M. Nos. 119955a, 119955b; unfigured paratypes, U.S.N.M. Nos. 119955c–119955f.

Warthia angustior Yochelson, new species

Plate 49, figures 1–6

DESCRIPTION: Somewhat compressed, smooth Euphemitinae developing a deep slit, but essentially no sinus; dorsum rounded, lateral slopes flattened, so that shell as a whole is compressed; lateral lips commonly

TABLE 10

MEASUREMENTS (IN MILLIMETERS) OF *Warthia waageni* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	20.0	16.8	17.2	3
	18.8	16.5	16.9	3
	20.5	17.9	18.0	3
	21.8	19.1	20.6	3
	21.7	19.6	20.6	3
	16.4	14.0	14.6	3
	10.5	9.3	—	3

distinctly sickle-shaped, joining anterior lips at an angle of nearly 135 degrees; anterior lips straight to near dorsum where they curve back abruptly to form a short sinus, culminating in a relatively deep slit; slit and sinus forming nearly 10 per cent of body-whorl circumference; selenizone narrow, flush, visible for less than one-quarter of a whorl; inductura thin to wanting; shell moderately thin.

DISCUSSION: *Warthia angustior* is known from only one locality, where it is rare and associated with numerous specimens of *W. waageni.* The two are easily distinguished, *W. waageni* being the more globular. Not enough information is available for the possible question of inter-species competition to be considered. Presumably, this one locality may have included several micro-environments or was a thanatocoenosis (Yochelson, 1956, p. 189).

Warthia angustior is distinguishable from *W.? americana* Girty by its essential lack of a sinus. It is similar to *W. fissus*, but that species is more compressed and has the lateral and anterior lips joining at a narrower angle. The possibility that the forms called *W. fissus* may be simply a younger stage of *W. angustior* has been seriously considered but rejected. The juvenile stages of *W. angustior* are less compressed than those of *W. fissus. Warthia angustior* also shows some similarity to *W. saundersi*, but that species is somewhat wider.

Length, width, and thickness in millimeters of the holotype are 15.1, 12.4, 12.9, respectively. Corresponding measurements in the figured paratype are 15.8, 12.4, and 13.5.

HYPODIGM: Two excellently preserved silicified specimens, as listed below.

OCCURRENCE: *Bone Spring limestone:* P.U. 3, two.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119949; figured paratype, U.S.N.M. No. 119950.

Warthia? americana Girty

Plate 49, figures 7, 8

Warthia americana, GIRTY, 1909a, pp. 481, 482, pl. 23, figs. 15–17b.

DESCRIPTION: Compressed, seemingly smooth Euphemitinae with a short slit; body whorl strongly compressed; anterior lips gently produced forward, curving inward near the dorsum to form a wide, shallow sinus, culminating in a short slit; sinus and slit nearly 10 per cent of body-whorl circumference; selenizone wide and raised, welt-like near aperture, unknown on remainder of shell; shell structure unknown; ornament unknown, but possibly smooth.

DISCUSSION: In shape *Warthia? americana* is most similar to *Warthia angustior.* The two species differ in that *W. angustior* has a relatively narrow sinus and deep slit, and *W.? americana* has a wide sinus and shallow slit. The other American Permian species are not compressed laterally and are subglobular to globular when viewed from above.

Warthia? americana is known only from the type lot consisting of three steinkerns. Two specimens are small and incomplete at the aperture. The largest of the three displays the character of the sinus and slit well and retains a few small patches of smooth shell near the aperture. These patches of shell may not be the inductura plastered on the outer shell layer, and in any case they add little to the concept of the species. This specimen is

TABLE 11

MEASUREMENTS (IN MILLIMETERS) OF *Warthia fissus* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	8.6	6.1	7.4	512
Figured paratype	6.4	4.5	5.8	512
	7.0	4.9	6.4	512
	7.5	5.2	6.5	512
	6.5	4.6	5.7	512
	5.6	3.8	4.7	512
	6.2	4.2	5.3	728
	6.8	4.9	6.1	728
	6.4	4.1	5.4	728
	4.8	3.6	4.3	728
	5.4	4.3	4.7	703

Locality A.M.N.H. 512
$N=10$

M length = 6.1 mm.	S length = ±1.10 mm.	r length/width = 0.91
M width = 4.2 mm.	S width = ±0.87 mm.	r length/thickness = 0.93
M thickness = 5.3 mm.	S thickness = ±0.95 mm.	r width/thickness = 0.90

here designated as lectotype. It may be that this species is referable to *Euphemites*, but, until additional specimens are found, the species is questionably referred to *Warthia.*

Approximate dimensions, in millimeters, for the lectotype are: length, 17; width, 11; thickness 14.

HYPODIGM: Three steinkerns, as listed below. Two are quite small and do not add significantly to our knowledge of the species.

OCCURRENCE: *Probably Brushy Canyon formation:* U.S.G.S. 2931 green, three.

NUMBERED SPECIMENS: Lectotype, U.S.N.M. No. 118365a; unfigured lectoparatypes, U.S.N.M. Nos. 118365b, 118365c.

Warthia fissus Yochelson, new species

Plate 48, figures 15–19

DESCRIPTION: Compressed, smooth, small Euphemitinae possessing a deep slit; shell strongly compressed on lateral slopes, though the dorsum is well rounded; lateral lips not thickened at juncture with whorl, close in to penultimate whorl, essentially straight for their entire length, joining the anterior lips at a rounded obtuse angle of nearly 100 degrees; anterior lips not produced forward, essentially straight from umbilici to near dorsum where they curve abruptly inward to form a moderately deep slit with essentially no development of a sinus; sinus and slit nearly 10 per cent of body-whorl circumference; selenizone flush, forming most of dorsum, but visible only for first quarter of whorl on some specimens; shell smooth, moderately thin, structure unknown, except that an inductural layer or layers covers most of the selenizone.

DISCUSSION: Although the slit and sinus total about the same proportion of the shell in *Warthia fissus* as in *W.? americana* Girty, the slit is much deeper and the sinus narrower in this species than in the latter. The two species show similar shapes, *W. angustior* being slightly wider. *Warthia crassus* and *W. intracostata* are distinctly more globular than this species. *Warthia waageni* approaches *W. fissus* in shape, being somewhat more globular, but is clearly distinct in having a significantly shorter sinus and slit.

Measurements given in table 11 were made with a micrometer ocular.

HYPODIGM: Twenty-five specimens, as listed below. All are silicified, none shows growth lines, and few have the aperture unbroken.

OCCURRENCE: *Word formation:* U.S.N.M. 703, one. *Cherry Canyon formation:* A.M.N.H. 512, 15; U.S.N.M. 728, nine.

NUMBERED SPECIMENS: Holotype, A.M.N.H. No. 28189; figured paratype, A.M.N.H. No. 28189:1.

Warthia saundersi Yochelson, new species

Plate 49, figures 9–13

DESCRIPTION: Somewhat compressed, smooth Euphemitinae having the dorsum well rounded; shell smoothly curved, without a thick inductura; well rounded on the dorsum, but with nearly straight lateral slopes; lateral lips curved, joining anterior lips at an angle of nearly 135 degrees; anterior lips straight for about two-thirds of their length, then curving abruptly inward to form a sinus, culminating in a short slit; selenizone seemingly flush.

DISCUSSION: *Warthia saundersi* differs from *W. welleri* and *W. crassus* in being less globular, with essentially straight lateral slopes. Its dorsum is more rounded than that of *W. angustior* or *W. fissus*. This species is also somewhat wider than *W.? americana* Girty. *Warthia saundersi* lacks the thickened inductura of *W. kingi* Moore and *W. welleri*. It is most similar to *W. waageni*. This species is slightly more rounded and has a slightly wider sinus.

Warthia fissus and *W. saundersi* occur at the same locality but are distinct, clear-cut species. Because of the difference in shape between the two, there is virtually no chance that the smaller *W. fissus* is simply an ontogenetic stage of the larger *W. saundersi*.

Measurements of length, width, and thickness in millimeters are 15.0, 12.7, and 18.4 for the holotype and 14.6, 12.3, and 13.2 for the figured paratype.

HYPODIGM: Five specimens, as listed below. All are silicified, and with one exception all have the aperture broken.

OCCURRENCE: *Cherry Canyon formation:* A.M.N.H. 512, two; U.S.N.M. 728, three.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119952; figured paratype, U.S.N.M. No. 119951a; unfigured paratype, U.S.N.M. No. 119951b.

FAMILY **BELLEROPHONTIDAE** M'COY, 1851

SUBFAMILY **BELLEROPHONTINAE** M'COY, 1851

GENUS **BELLEROPHON** MONTFORT, 1808

SUBGENUS **BELLEROPHON** MONTFORT, 1808

Bellerophon (Bellerophon) huecoensis Yochelson, new species

Plate 52, figures 9–19, 21

DESCRIPTION: Large, inflated, bellerophontid gastropods having umbilical chinks, but lacking spiral ornament; shell showing essentially no ontogenetic change; whorl profile moderately well arched, approaching the arc of a circle, the arc being interrupted only by the raised selenizone; the lateral slopes slightly flattened, but no line of demarcation between the lateral slopes and the upper surface; anterior lips straight except for a relatively wide, exceedingly shallow, V-shaped sinus; slit and sinus shallow, approximately 12 per cent of circumference of body whorl; selenizone convex; lateral lips thickened slightly and reflexed so that narrow umbilici are developed, the size of the opening showing much individual variation; interior of lateral lips curved, but not excavated; spiral ornament lacking; mature stage characterized by increasing rugosities of growth lines, so that the exterior of some of the largest specimens is slightly undulatory.

DISCUSSION: The above description is based primarily on silicified specimens from Otero County, New Mexico. Most of these are small, and only one approaches the size

TABLE 12

MEASUREMENTS (IN MILLIMETERS) OF *Bellerophon huecoensis* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	31.7	29.3	27.5	712g
Figured paratype	13.5	13.8	11.5	712g
Figured paratype	—	36.6	—	717
Figured paratype	37	34	29	8526
Unfigured paratype	9.5	10.0	8.4	712
Unfigured paratype	10.6	10.9	8.7	712b
	13	12.0	10.8	712g

of specimens from the Sierra Diablo. For the most part, the few Sierra Diablo specimens available are large and are incompletely silicified, or are steinkerns bearing patches of the shell. Nonetheless, in so far as I am able to study them, they are conspecific with the smaller individuals from other localities.

Bellerophon (*Bellerophon*) *huecoensis* differs from *B.* (*Bellerophon*) *oteroensis* in possessing a wider selenizone. Except for this feature, there appears to be no difference between the two species. It is distinguished from *B.* (*Bellerophon*) *kingorum*, *B.* (*Bellerophon*) *hilli*, and *B.* (*Bellerophon*) *plummeri* in having narrow umbilical chinks rather than being anomphalous. This same feature distinguishes it from *B.* (*Bellerophon*) *parvicristus* with which it commonly occurs. In addition, *B.* (*Bellerophon*) *huecoensis* is slightly more inflated.

This species is similar to *B.* (*Bellerophon*) *lineatus* and *B.* (*Bellerophon*) *deflectus* H. P. Chronic. It is distinguished from *B.* (*Bellerophon*) *lineatus* in lacking spiral ornament and differs from *B.* (*Bellerophon*) *deflectus* in having a lower median crest. The two species are also slightly less inflated when viewed from the anterior. Both of these other species have narrow umbilical chinks; differentiation among the three is exceedingly difficult. The phaneromphalous condition distinguishes this species from all American Pennsylvanian species except *B.* (*Bellerophon*) *crassus* Meek and Worthen. That species appears to be less inflated.

HYPODIGM: Sixty-three specimens, as listed below. Most are silicified, but, except for the holotype, the majority are broken and poorly silicified.

OCCURRENCE: *Colina limestone:* U.S.G.S. 8503, one; U.S.G.S. 8505, one; U.S.G.S. 8526, six; U.S.G.S. 8964, one; U.S.G.S. 17393, one. *Wolfcamp formation:* U.S.N.M. 704v, one. *Hueco limestone:* A.M.N.H. 626, four; U.S.G.S. 7003, seven; U.S.N.M. 712, six; U.S.N.M. 712b, 13; U.S.N.M. 712g, 11; U.S.N.M. 717, four; U.S.N.M. 721, four; U.S.N.M. 3071, three.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 115197; figured paratypes, U.S.N.M. Nos. 115221, 115225, 120001a, 120002a; unfigured paratypes, U.S.N.M. Nos. 115198, 115222a–115222e, 115223a–115223n, 115224a, 115224b, 115226a–115226c, 120001b–120001d, 120002b–120002f.

Bellerophon (Bellerophon) oteroensis
Yochelson, new species
Plate 53, figures 10–12

DESCRIPTION: Inflated bellerophontid gastropods having an extremely narrow slit; whorl profile of upper surface well arched in all known growth stages, without any differentiation of the lateral slopes; lateral lips reflexed without thickening so that umbilical chinks are developed; interior of lateral lips curved, but without excavation; with essentially no development of an anterior sinus; depth of slit unknown, but probably less than 10 per cent of body-whorl circumference; selenizone narrow, convex, just raised above general level of shell surface; ornamented by numerous fine growth lines; inductura thin.

DISCUSSION: In most respects, this species is similar to *Bellerophon* (*Bellerophon*) *huecoensis*. It differs from that species only in having a lower and narrower selenizone. No mature specimens of *B.* (*Bellerophon*) *oteroensis* are known, and it cannot be observed if the lateral lips thicken with age.

The narrow slit and selenizone distinguish this species, with one exception, from the other Permian *Bellerophon* species, and no detailed comparison need be made. *Bellerophon* (*Bellerophon*) *plummeri* also has a narrow selenizone which is nearly flush, but the pronounced reflection of its lateral lips and their inductural cover distinguish the two species.

Length, width, and thickness in millimeters of the holotype are 18.0, 18, and 15.1, respectively.

HYPODIGM: Twelve specimens, as listed below. With one exception all are juveniles, and most of these are incomplete.

OCCURRENCE: *Hueco limestone:* U.S.N.M. 712a, 12.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 115227; unfigured paratypes, U.S.N.M. Nos. 115228a–115228j.

Bellerophon (Bellerophon) lineatus
Yochelson, new species
Plate 52, figures 20, 22–26

DESCRIPTION: Large, bellerophont gastropods ornamented by spiral lirae; earliest growth stages unknown, but early growth stages essentially similar to more mature stages, the principal difference being that the ornament is relatively coarser at maturity; whorl profile varying somewhat from moderately well rounded to widely subcordiform, both whorl forms characterized by a high, distinct, median crest; slit depth unknown except that it is significantly less than 20 per cent of body-whorl circumference; selenizone convex to flat on median crest; median lips straight for approximately one-half of their total length, then gradually curving backward to form a wide, V-shaped sinus; lateral lips reflexed slightly, but seemingly not developing an umbilical chink except in the more mature stages, thickened and excavated slightly on the interior, forming an elongate depression; ornamented by numerous spiral lirae, in some specimens so closely spaced that the lirae are wider than the interspaces, several of the lirae approximately at the junction of the upper and lateral surfaces, which is also the area of beginning curvature of the growth lines, being somewhat coarser than those on either side.

DISCUSSION: The spiral lirae, as indicated by the name, are an important feature of this species and readily distinguish it from other Permian species. The ornament differentiates this species from American Pennsylvanian species, all of which seem to have the ornament limited to growth lines. Conversely, in the partial or total absence of the shell by exfoliation it is impossible to distinguish this species from several of the other large Permian bellerophontid species. In particular, *B.* (*Bellerophon*) *lineatus* is quite similar in general shape to *B.* (*Bellerophon*) *deflectus* H. P. Chronic and *B.* (*Bellerophon*) *parvicristus*. All three species are fairly well inflated, but the lateral slopes seem to be more distinctly set off in this species than in the other two.

In order to show the distribution of Permian bellerophontaceans, taxonomic liberty has been taken with the material from north central Texas. Because of poor preservation, many of the specimens in the collections do not show the lirae. However, when one specimen that showed the lirae has been found from a locality, the assumption has been made that all specimens belong to this species.

One specimen in a collection of five steinkerns from the basal part of the Hess limestone member, Leonard formation, U.S.N.M. 715a, retains a patch of shell showing spiral ornament. This specimen is tentatively included in the species, although it may represent still another species. It is significant in giving further evidence of the variety of species in the lower Permian strata.

HYPODIGM: Eighty-three specimens, as listed below. All are from limestone, and most are steinkerns; many of those not steinkerns are incomplete.

OCCURRENCE: *Belle Plains formation:* B.E.G. 42-T3, five. *Clyde formation:* B.E.G. 199-T2-Q21-1.3A14, eight; B.E.G. 199-T5-1.3A14, 28; B.E.G. 199-T7-P19-1.3A15, 15; B.E.G. 199-T12-P22, five. *Lueders limestone:* B.E.G. 199-T4-L16, 12; B.E.G. 199-T1-L16-1.3A19, 10.

Bellerophon (Bellerophon) parvicristus
Yochelson, new species

Plate 51, figures 1–9, 11–13, 18

DESCRIPTION: Slightly compressed, anomphalous, bellerophontid gastropods having the selenizone slightly raised and the lateral lips only slightly reflexed; lateral slopes some-

TABLE 13

MEASUREMENTS (IN MILLIMETERS) OF *Bellerophon* (*Bellerophon*) *lineatus* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	45	40.3	36	199-T-5
Figured paratype	15.5	14	13.8	199-T-5
Figured paratype	23.5	22	20.0	199-T7-P-19
	24	30	21	199-T7-P-19
	50	43.2	35	199-T2-Q-21
	35	33	32	199-T4-L-16

TABLE 14

MEASUREMENTS (IN MILLIMETERS) OF *Bellerophon* (*Bellerophon*) *parvicristus* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	28	34	24.2	9802
Figured paratype	14.3	12	10.4	9863
Figured paratype	18	18.3	14.4	712a
Figured paratype	62	65	49	6724
Figured paratype	24.0	25.5	19.3	17394
Unfigured paratype	13.5	12.5	10.1	712b
Unfigured paratype	14.9	15	12.5	712b
Unfigured paratype	10.0	10.1	8.0	712b
Unfigured paratype	12.6	12.0	9.7	712
Unfigured paratype	10.1	10.5	8.4	712
Unfigured paratype	12.0	12.1	10.3	9802
	15.7	14.8	13.0	3323
	11.5	11.5	10.2	3323
	9.2	9.0	7.5	3323

what compressed, anterior slopes moderately well rounded; depth of slit and sinus unknown, but almost certainly less than 10 per cent of body-whorl circumference; median lips with an exceedingly shallow sinus, just forming a V shape; selenizone flush in early stages, becoming raised and convex with increasing maturity; lateral lips little curved but slightly reflexed, covered with a thin inductural deposit; seemingly with only a thin inductural deposit within the aperture.

DISCUSSION: The slightly compressed shape, with the anomphalous condition, readily differentiates *B.* (*Bellerophon*) *parvicristus* from *B.* (*Bellerophon*) *huecoensis* with which it is commonly associated at many of the localities studied. The raised selenizone, among other characters, distinguishes this species from *B.* (*Bellerophon*) *plummeri*, *B.* (*Bellerophon*) *hilli*, and *B.* (*Bellerophon*) *oteroensis*. *Bellerophon* (*Bellerophon*) *kingorum* differs from *B.* (*Bellerophon*) *parvicristus* in being more globose and having more of a welt-like selenizone.

In the absence of the characteristic ornament, it is difficult to differentiate *B.* (*Bellerophon*) *lineatus* from *B.* (*Bellerophon*) *parvicristus*. That species, however, is slightly less inflated and in early growth stages appears to have the selenizone higher and wider. *Bellerophon* (*Bellerophon*) *deflectus* is also difficult to differentiate from *B.* (*Bellerophon*) *parvicristus*. There are no major differences between the two species, but rather there are a series of slight differences. The selenizone in *B.* (*Bellerophon*) *parvicristus* appears to be slightly wider and slightly higher than in *B.* (*Bellerophon*) *deflectus*. On the other hand, *B.* (*Bellerophon*) *deflectus* appears to be slightly more inflated. At comparable growth stages, *B.* (*Bellerophon*) *parvicristus* has the lateral lips, if not more reflexed, at least more thickened by inductural deposit. It need not be necessary to point out, in view of these slight differences, that extreme care should be used before specimens of unknown stratigraphic position are assigned to one species or the other.

Bellerophon (*Bellerophon*) *parvicristus* shows similarities to the common Pennsylvanian species *B.* (*Bellerophon*) *crassus* Meek and Worthen. The principal difference is that this species is phaneromphalous, and *B.* (*B.*) *parvicristus* is anomphalous. *Bellerophon* (*Bellerophon*) *crassus incomptus* (Gurley) differs in having the selenizone flush over the dorsum. *Bellerophon* (*Bellerophon*) *crassus wewokensis* Girty has a slightly narrower and slightly higher selenizone and seems to be a little more inflated. *Bellerophon* (*Bellerophon*) *singularis* Moore is smaller and has a flush selenizone. *Bellerophon* (*Bellerophon*) *graphicus* Moore is more compressed, with the lateral slopes more strongly inclined than in *B.* (*Bellerophon*) *parvicristus*.

HYPODIGM: Two hundred and forty-six

specimens, as listed below. Quality and size of specimens available vary enormously. In spite of the large number of specimens, the preponderant number are inferior for study. Those from north central Texas are in a yellow earthy matrix. Those from the Hueco limestone in west Texas are poorly silicified or are steinkerns. Those from the Hueco limestone in New Mexico vary from well silicified to quite poor. Most are immature. Finally, specimens from the Colina limestone are silicified; the silicification commonly is of a poor quality.

OCCURRENCE: *Admiral formation:* B.E.G. 42-T20, one; U.S.G.S. 9802, one. *Clyde formation:* B.E.G. 199-T5-1.3A15, two; U.S.G.S. 9863, 51. *Wolfcamp formation:* U.S.N.M. 701g, eight; U.S.N.M. 701-l, two; U.S.N.M. 707d, four; U.S.N.M. 707o, four; U.S.N.M. 3359, eight; U.S.N.M. from just east of Godwin Creek, Baylor County, Texas, one. *Hueco limestone:* A.M.N.H. 391, five; P.U. 24, 14; P.U. 37, eight; U.S.G.S. 6681, three; U.S.G.S. 6724, one; U.S.N.M. 712, 15; U.S.N.M. 712a, nine; U.S.N.M. 712b, 27; U.S.N.M. 712d, seven; U.S.N.M. 712f, nine; U.S.N.M. 712g, 20; U.S.N.M. 3322, 10; U.S.N.M. 3323, 20. *Colina limestone:* U.S.G.S. 8388, one; U.S.G.S. 8502, two; U.S.G.S. 8527, one; U.S.G.S. 17394, 12.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 115197; figured paratypes, U.S.N.M. Nos. 115221, 115225, 119994a, 119995; unfigured paratypes, B.E.G. No. 13658, U.S.N.M. Nos. 115198, 115222a–115222e, 115223a–115223n, 115224a, 115224b, 115226a–115226c, 119995.

Bellerophon (Bellerophon) complanatus
Yochelson, new species

Plate 50, figures 13–16

DESCRIPTION: Bellerophontid gastropods with the upper surface gently curved and the lateral surfaces abruptly curving in to the umbilici; early growth stages unknown; upper whorl surface little curved, only gently arched to midline, bending down abruptly to the lateral slopes, there being a slight increase of curvature of the upper surface before this bending so that no true angulation is formed; lateral slopes nearly flat, inclined inward to a wide, shallow umbilicus; slit depth unknown; selenizone convex, raised just above the general shell surface; lateral lips straight, except for an extremely shallow, narrow, V-shaped sinus close to the selenizone, other apertural characteristics unknown; ornament, faint growth lines only.

DISCUSSION: The more or less subquadrilateral whorl profile of *B.* (*Bellerophon*) *complanatus* marks it as unique among the Permian gastropods, and no further comparisons need be made. No Pennsylvanian species are known that are similar to it in shape. Indeed, this form is so distinctive one might seriously consider distinguishing it as a separate subgenus or genus. Because of the small number of specimens and the dearth of information about the apertural characters it seems wiser at this time to expand the concept of *Bellerophon* to include this species.

There is some indication that an inductura spread from the aperture and deposited a ridge high on the lateral slope at the point of juncture with the upper surface. Unfortunately the type is not complete enough to confirm this observation. Length, width, and thickness in millimeters are 14.2, 13.6, 13.2 and about 12, 14, and 12.8 for the holotype and paratype, respectively.

HYPODIGM: Two calcareous specimens, as listed below. One is excellently preserved; the other, poorly preserved.

OCCURRENCE: *Admiral formation:* U.S.G.S. 9802, two.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 112548; figured paratype, U.S.N.M. No. 112549.

Bellerophon (Bellerophon) deflectus
H. P. Chronic

Plate 51, figures 10, 14–17, 19–25

Bellerophon (*Bellerophon*) *crassus* Meek and Worthen, GIRTY, 1909a, p. 479, pls. 16, 19f–g.

Bellerophon (*Bellerophon*) *deflectus* H. P. CHRONIC, 1952, p. 111, pl. 1, figs. 2–5.

DESCRIPTION: Unornamented, large, bellerophontid gastropods having the selenizone on a raised crest and a sub-cardiform apertural opening; shell not rounded in profile, being higher than wide, the upper surface rising gradually to the median crest, raised above the general level of the shell; lateral surfaces flattened, though not set off from the upper surface by an angulation; selenizone convex, located on median crest; slit extremely short, less than 5 per cent of total body-whorl circumference; interior of body with a thick callus, about one-fourth of a whorl within aperture, bending abruptly to a thin callus wash extending to aperture; anterior lips nearly orthocline, curving inward to form a V-shaped sinus near the median crest; lateral lips thickened and reflexed, relatively thicker in juvenile stages, the mature stage bearing umbilical chinks; interior of lateral lips excavated into a shallow circular depression, just within the aperture; color pattern spiral, superficially resembling ornament, consisting of at least 14 alternating light and dark stripes on each side of the median crest, the dark bands interrupted by the more prominent growth lines.

DISCUSSION: The prominent median crest of *B.* (*Bellerophon*) *deflectus* distinguishes this species from *B.* (*Bellerophon*) *plummeri*, *B.* (*Bellerophon*) *oteroensis*, and *B.* (*Bellerophon*) *hilli*. The specimens are larger than *B.* (*Bellerophon*) *kingorum* and have a relatively wider selenizone and are not flattened on the lateral slopes below the selenizone as is that species.

Bellerophon (*Bellerophon*) *deflectus* is similar to *B.* (*Bellerophon*) *lineatus* except for the spiral ornament of that species. A few incompletely silicified specimens of *B.* (*Bellerophon*) *deflectus* were interpreted at first as bearing several spiral lirae. Now it seems more reasonable that such supposed lirae are actually a result of slight differences in silification following the lines of ornament, which emphasizes still further the necessity for care in the interpreting of silicified specimens and the comparing of silicified specimens and calcareous specimens.

Differentiation from *B.* (*Bellerophon*) *parvicristus* is difficult. That species is slightly less inflated, has a slightly wider selenizone, and is anomphalous. In many other respects the two species are identical, and differentiation should not be attempted on incomplete specimens. *Bellerophon* (*Bellerophon*) *huecoensis* has a median crest, but this is much lower, and the shell is more inflated. The sinus is wider in that species.

As an additional character, *B.* (*Bellerophon*) *deflectus* is larger in average size than any of the Permian species except *B.* (*B.*) *lineatus*.

The specimen figured by Girty (1909a; U.S.N.M. No. 119601) is incomplete, but part of the whorl showing a narrow selenizone and distinct growth lines is well preserved, proving the identity of his specimens. The west Texas material has been compared with one of H. P. Chronic's paratypes.

The slightly compressed shape and large average size differentiate *B.* (*Bellerophon*) *deflectus* H. P. Chronic from all Pennsylvanian species except *B.* (*Bellerophon*) *crassus* Meek and Worthen. It differs from that species in having the selenizone more raised and crest-like.

HYPODIGM: The specimens figured by H. P. Chronic (1952), and 138 specimens, as listed below. All my specimens are silicified. Approximately half are quite incomplete, and about one-third of the remainder are juveniles. In addition, one incomplete, poorly silicified specimen from U.S.G.S. locality 8515, Epitaph dolomite, shows similarity to this species. The specimen is too poor to be identified with certainty.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 433, 46; A.M.N.H. 592, three;

TABLE 15

MEASUREMENTS (IN MILLIMETERS) OF *Bellerophon* (*Bellerophon*) *deflectus* H. P. CHRONIC

	Length	Width	Thickness	Locality
Figured hypotype	53	48	37	3
Figured hypotype	53	50	41	3
Figured hypotype	17	17.1	13.8	3
Figured hypotype	18.0	16.7	15.1	3
Figured hypotype	29	35	23.1	703c
	23	23.9	18.7	3
	10.0	12.0	12.8	3
	17.6	17.0	15.2	433

TABLE 16

MEASUREMENTS (IN MILLIMETERS) OF *Bellerophon (Bellerophon) plummeri* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	13.5	14.9	11.5	703
Figured paratype	23	20.7	19.4	703
Figured paratype	29	24.3	22.8	703
Unfigured paratype	30	27.8	27	703
Unfigured paratype	13.3	15.6	17	703
	12.3	13.0	10.5	707e

A.M.N.H. 625, one; P.U. 3, 58; U.S.G.S. 14439, 27. *Word formation:* U.S.N.M. 703, two; U.S.N.M. 703c, one.

NUMBERED SPECIMENS: Figured hypotypes, U.S.N.M. Nos. 119996a, 119997a–119997d, 119998; unfigured hypotypes, U.S.N.M. Nos. 119996, 119997e–119997l.

Bellerophon (Bellerophon) plummeri
Yochelson, new species

Plate 52, figures 1–8

DESCRIPTION: Moderately well-rounded, bellerophontid gastropods having a narrow, flush selenizone and strong reflection of the lateral lips; shell subglobular except for slight median flattening; anterior lips well curved, bending back near selenizone to form a distinct, V-shaped sinus; relative depth of slit unknown, but probably 15 per cent, and certainly more than 10 per cent, of circumference of body whorl; selenizone flush with shell, narrow; lateral lips reflexed, each developing a pronounced reëntrant at their juncture with the surface of body whorl, the inner surface of the lateral lips correspondingly strongly bent, rather than smoothly arched within aperture; anomphalous, with a moderately thin inductura about one-fourth of a whorl within the aperture, extending outward as a thin wash, this wash covering the reëntrants in the lateral lips and just extending out of the aperture.

DISCUSSION: The pronounced sinuses of the lateral lips at their junction with the body whorl are the most distinctive features of the species and make it readily identifiable. Some specimens of *B. (Bellerophon) parvicristus* develop a somewhat similar, but less pronounced, fold in each lateral lip, but that species is distinguished by having a raised selenizone and by being slightly compressed rather than nearly globular.

Bellerophon (Bellerophon) plummeri occurs at the same locality as specimens of *B. (Bellerophon) hilli* and *B. (Bellerophon) kingorum. Bellerophon (Bellerophon) hilli* is differentiated by having a wider raised selenizone. *Bellerophon (Bellerophon) kingorum* has a flush selenizone, but is slightly compressed. In addition, at three localities it has been observed that the silicified shells of *B. (Bellerophon) plummeri* are relatively thick, strong, and well silicified. The shells of the other two species are commonly thinner and less well silicified. Such a difference suggests that there may have been some slight structural or chemical differences in the shell of this species, allowing for better silicification.

Bellerophon (Bellerophon) lineatus and *B. (Bellerophon) deflectus* H. P. Chronic are readily distinguished by their raised, wider selenizone, more compressed shape, and larger average size. *Bellerophon (Bellerophon) huecoensis* and *B. (Bellerophon) oteroensis* are slightly more arched across the median area than *B. (Bellerophon) plummeri* and have umbilical chinks. The narrow selenizone of *B. (Bellerophon) oteroensis* is similar to that of *B. (Bellerophon) plummeri*, but other characters mark the two species as distinct. The lateral sinuses are more prominent in this species than in any of the American Pennsylvanian species examined.

HYPODIGM: Fourteen specimens, as listed below. All are well silicified, but most have the aperture broken back.

OCCURRENCE: *Word formation:* U.S.N.M. 703, 11; U.S.N.M. 703c, one; U.S.N.M. 707e, two.

NUMBERED SPECIMENS: Holotype, U.S.N.M.

No. 120000; figured paratypes, U.S.N.M. Nos. 119999a, 119999b; unfigured paratypes, U.S.N.M. Nos. 119999c–119999k.

Bellerophon (Bellerophon) kingorum
Yochelson, new species

Plate 50, figures 1–9, 11, 12

DESCRIPTION: Sturdy, thick-shelled bellerophonts with a strongly convex selenizone and only slight reflection of the lateral lips; shell well rounded, globular except for raised median selenizone, without any differentiation of lateral slopes; anterior lips with a short, V-shaped sinus; slit approximately 9 per cent of body-whorl circumference; selenizone narrow, but strongly raised so that it appears as a median welt; minutely phaneromphalous in early growth stage, becoming anomphalous or cryptomphalous, with some individual variation at the size at which umbilici are lost; lateral lips only slightly reflexed, and little thickened.

DISCUSSION: With many of the Permian bellerophontaceans, it has been more or less difficult to determine to which species young specimens should be assigned, but in *B.* (*Bellerophon*) *kingorum* the young specimens are readily identifiable. The prominent, welt-like selenizone rising abruptly above the otherwise smoothly inflated whorl surface is distinctive. It is the adult specimens, in which this selenizone is less welt-like, that are more difficult to differentiate from other species. The possibility remains, although it is thought to be slight, that some of the specimens assigned to this taxon may actually belong in another species.

Bellerophon (*Bellerophon*) *crassus wewokensis* Girty is the only Pennsylvanian taxon close to *B.* (*Bellerophon*) *kingorum*. This form has the lateral lips more reflexed and is more globose. *Bellerophon* (*Bellerophon*) *singularis* Moore is about the same size but has a flush selenizone.

The somewhat globular shape distinguishes *B.* (*Bellerophon*) *kingorum* from *B.* (*Bellerophon*) *complanatus*. Its raised selenizone differentiates it from *B.* (*Bellerophon*) *plummeri* and *B.* (*Bellerophon*) *oteroensis*, both of which have the selenizone flush. The species is significantly more globose and has a relatively narrower selenizone than either *B.* (*Bellerophon*) *lineatus* or *B.* (*Bellerophon*) *deflectus* H. P. Chronic. The average size of specimens is appreciably smaller in this species than in either of the other species. It is also more globose than *B.* (*Bellerophon*) *parvicristus* and has the lateral lips less reflexed.

Bellerophon (*Bellerophon*) *huecoensis* shows strong similarities to *B.* (*Bellerophon*) *kingorum*, but the two species are relatively easy to differentiate. *Bellerophon* (*Bellerophon*) *huecoensis* has narrow umbilical chinks at all growth stages. In specimens of *B.* (*Bellerophon*) *kingorum* this feature is either never present or lost at an early growth stage.

Finally *B.* (*Bellerophon*) *huecoensis* can be

TABLE 17

MEASUREMENTS (IN MILLIMETERS) OF *Bellerophon* (*Bellerophon*) *kingorum* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	10.7	10.1	9.1	706
Figured paratype	11.1	10.2	10.0	706
Figured paratype	7.0	6.8	6.6	707e
Figured paratype	6.0	5.6	5.2	707e
Unfigured paratype	8.4	8.1	7.1	707e
Unfigured paratype	4.9	4.7	4.5	707e
Unfigured paratype	5.8	5.2	5.0	707e
Unfigured paratype	6.8	6.5	6.3	706
	6.8	6.9	6.3	706c
	6.9	6.7	6.3	706c
	5.4	5.3	5.1	706c
	11.4	10.4	9.6	703c

TABLE 18

MEASUREMENTS (IN MILLIMETERS) OF *Bellerophon* (*Bellerophon*) *hilli* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	20.2	19.3	16.3	703
Figured paratype	50	47	34.5	703
Figured paratype	7.9	7.7	6.7	703
Figured paratype	8.5	8.2	7.0	703
Unfigured paratype	12	11.5	10.5	703
Unfigured paratype	11	11.0	8.4	703
Unfigured paratype	10.7	9.8	8.8	703
	9	8.7	7.3	702

distinguished from *B.* (*Bellerophon*) *hilli*, as it is distinctly more globose and has a raised rather than a flush selenizone.

The specimens show some interesting features of silicification. Originally the specimens from locality U.S.N.M. 707e were considered as a distinct species. The silicified specimens were not so well preserved, having a more porous texture. At the same time they had the growth lines more strongly impressed, and some specimens showed differences on the lateral lips. It seems more likely that these differences are due to the incomplete silification of the inductura. The phenomenon of growth lines' acting as loci for differential silicification of the shell has been observed in other Permian gastropods.

HYPODIGM: Sixty specimens, as listed below. Most of these are excellently silicified, and many have the aperture unbroken.

OCCURRENCE: *Word formation:* U.S.N.M. 703c, three; U.S.N.M. 706, five; U.S.N.M. 706b, three; U.S.N.M. 706c, 18; U.S.N.M. 707e, 31.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119943; figured paratypes, U.S.N.M. Nos. 119944a, 119945b; unfigured paratypes, U.S.N.M. Nos. 119944b, 119945b–119945e.

Bellerophon (Bellerophon) hilli

Yochelson, new species

Plate 53, figures 1–9

DESCRIPTION: Slightly compressed, anomphalous, bellerophontid gastropods having the selenizone flush; shell showing essentially no ontogenetic change except in the earliest stages; possessing two faint depressions at the umbilici which are later covered by the thickened lateral lips; whorl profile well arched across the dorsum, somewhat less well rounded on the lateral slopes except in the more mature stages where these slopes become slightly more rounded; anterior lips with essentially no development of sinus; slit narrow, 20 per cent of body-whorl circumference in depth; selenizone flush to concave, slightly below general surface of the shell; lateral lips curving back from anterior lips, their junction with the body whorl straight and simple in early growth stages, becoming slightly reflexed with increasing age and correspondingly slightly thickened; interior of lateral lips curved but not excavated; ornament lacking except for faint growth lines.

DISCUSSION: The flush narrow selenizone at once distinguishes this species from most other Permian *Bellerophon* species. Comparisons need be made only with *B.* (*Bellerophon*) *oteroensis* and *B.* (*Bellerophon*) *plummeri*. *Bellerophon* (*Bellerophon*) *hilli* is differentiated from the former in being anomphalous rather than narrowly phaneromphalous and from the latter in having the lateral lips only slightly reflexed, not developing a wide distinct sinus near the juncture on the body whorl.

The species does show some slight ontogenetic change, with young shells less well rounded than the mature individuals. They are not subtriangular as are juveniles of *B.* (*Bellerophon*) *parvicristus*.

Among Pennsylvanian species, only *B.* (*Bellerophon*) *crassus incomptus* (Girty) and *B.* (*Bellerophon*) *singularis* Moore are characterized by a flush selenizone. The first taxon is too poorly known for precise comparison but seems to have the lateral lips strongly reflexed. The second species also has the lateral lips slightly more reflexed and has a shorter slit.

In spite of the long stratigraphic range of this species, there is little question as to the accuracy of identification. Specimens from the Cutoff shaly member of the Bone Spring limestone and the Getaway limestone member of the Cherry Canyon formation are reasonably well preserved.

HYPODIGM: One hundred and two specimens, as listed below. All are silicified. Preservation varies from poor to excellent, but almost all are broken back at the aperture.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 655, five; A.M.N.H. 678, four. *Leonard formation:* A.M.N.H. 504, one; U.S.N.M. 702, 28; U.S.N.M. 702un, two; U.S.N.M. 703a, eight; U.S.N.M. 703b, four. *Word formation:* A.M.N.H. 503, 14; U.S.N.M. 703, 19; U.S.N.M. 703c, four. *Cherry Canyon formation:* A.M.N.H. 512, 12; U.S.N.M. 728, one.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119961; figured paratypes, U.S.N.M. Nos. 119960a–119960c; unfigured paratype, U.S.N.M. No. 119960d.

SUBGENUS **PHARKIDONOTUS** GIRTY, 1912

Bellerophon (Pharkiodonotus) westi

Yochelson, new species

Plate 50, figures 17–20

DESCRIPTION: Bellerophontid gastropods developing a narrow selenizone on a low crest between two rows of relatively high nodes; early growth stages unknown; selenizone extremely narrow, situated on a low, sharp, median crest, the crest itself being somewhat nodose at maturity, but losing those nodes with increasing age; with numerous closely spaced transverse plications on the upper surface and upper part of the lateral surfaces, these plications being strengthened as they cross the upper angulation or shoulder, so that they appear as two rows of large nodes paralleling the median crest; nodes relatively large and as high as the median crest, except in the gerontic stage in which the nodes gradually disappear, leaving the crest in the center of a wide, low depression between two bordering ridges; upper part of lateral slopes flattened, inclined nearly 45 degrees to the upper surface, then curving inward to a moderately narrow umbilicus, the transverse ridges dying out approximately at the point where curvature begins; growth lines normal to selenizone except in proximity of crest where they curve slightly backward; depth of slit unknown; aperture not flaring, but reflexed at its inner edges, partially covering the umbilici; a thick, pad-like callus developing within the shell about one-fourth of a whorl behind the aperture, and having a thin callus wash spreading almost to the aperture; gerontic aperture ornamented by low, wide ridges, at a wide angle to the growth lines, interrupted periodically by the growth lines, ornament lacking on other parts of shell.

DISCUSSION: It is unfortunate that no specimens are available that show the early growth stages of *Pharkidonotus westi*, as the later growth stages indicate extensive ontogenetic change. This ontogenetic change is significantly more than has been previously attributed to species of the subgenus. Although some details are obscured by incomplete preservation, the change from knobs to ridges bordering the selenizone, coupled with the development of ornament, is most impressive. So far as is known, no other species of *Pharkidonotus* show any similar ornament.

The holotype is broken, but some estimate of size can be made. The dimensions are approximately: width, 63 mm.; length, 55 mm.; thickness, 32 mm.

Although there is similarity in the size of mature shells, *Bellerophon* (*Pharkidonotus*) *westi* is distinguishable easily from *Knightites* (*Retispira*) *fragilis*, with which it occurs, by its prominent transverse undulations. The strength of these undulations and the lack of spiral ornament distinguish the species from *Knightites* (*Retispira*) *wordensis*. In over-all size this species also approaches *K.* (*Knightites*) *maximus* but differs from that species not only in the character of the ornament, but also by not having the aperture flared. Further, the inductura is not knob-like as it is in species of *K.* (*Knightites*).

Bellerophon (*Pharkidonotus*) *westi* is distinct from the two presently recognized

American Pennsylvanian species, *Bellerophon (Pharkidonotus) percarinatus* (Conrad) and *Bellerophon (Pharkidonotus) tricarinatus* (Shumard). In both of these species, the median crest is relatively high in comparison with transverse plications. In the Permian species, it is relatively much lower.

HYPODIGM: Three incomplete, silicified specimens, as listed below. One is excellently preserved, the second is fair, and the third is so worn that it is only questionably placed in this species.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 592, one; P.U. 3, two.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119946; unfigured paratype, U.S.N.M. No. 119947.

Bellerophon (Pharkiodonotus) species

Plate 49, figures 27–29; plate 50, figure 10

DISCUSSION: In addition to the above-described species, there are additional specimens of this genus known from the west Texas area. It seems likely that several different species are present. Unfortunately, the material available does not allow description at this time, because of the small number of specimens, and they are all treated under one heading. Only the two illustrated specimens are well preserved.

The specimens are similar in general form to *Bellerophon (Pharkidonotus) westi.* They have a narrow selenizone on a high crest, situated between two rows of nodes formed from transverse ridges. The specimens seem to differ from that species in having these plications relatively more elongate. However, all the specimens listed below are smaller than those of *B. (P.) westi* and thus are not strictly comparable. Part of the supposed difference may be the result of change during ontogeny. In the present state of our knowledge these specimens are important in extending the known stratigraphic and geographic range of the subgenus. A discrimination of the species must await additional material.

The approximate measurements, in millimeters, of length, width, and thickness are 23, 26, and 15, and 16, 23, and 12 for the figured specimens from the Admiral formation and Bone Spring limestone, respectively.

HYPODIGM: Seven specimens, as listed below. Those from north central Texas are naturally etched from limestone. Those from west Texas are coarsely silicified. All are small, and none show growth lines. Most, in addition, are so worn that finer details are lost.

OCCURRENCE: *Admiral formation:* U.S.G.S. 9800, four. *Bone Spring limestone:* A.M.N.H. 678, two. *Word formation:* U.S.N.M. 707e, one.

NUMBERED SPECIMENS: Figured specimens, U.S.N.M. Nos. 114260, 119956a; unfigured specimens, U.S.N.M. No. 114261, 119956b.

Bellerophon (Pharkidonotus?) species

Plate 50, figures 21–24

DISCUSSION: Besides those taxa discussed above, there are two specimens that may represent another species and perhaps another genus. The specimens bear a narrow selenizone on a relatively high crest. The anterior slopes are smooth and flattened for most of their width, bending more or less abruptly to the steeply inclined lateral slopes. They are widely phaneromphalous. A thick, knob-like callus is present but is confined within the aperture. The mature aperture does not flare. Growth lines are unknown.

The species is similar to typical *Pharkidonotus* in possessing a subquadrate whorl profile. It differs from *Pharkidonotus* in being widely phaneromphalous, lacking transverse ridges on the anterior slopes, and having a high, narrow crest. Because of this crest, the species does not appear to be allied to *Bellerophon* in the strict sense. It is most similar in shape and size to *B. (Bellerophon) deflectus* H. P. Chronic. It differs in having the lateral slopes more nearly vertical and in being widely umbilicate. It may be that this is a species of a new genus distinct from *Bellerophon.* Until better material is available, the species and genus are better treated informally. The measurements of the most complete specimen are estimated as: length, 57 mm.; width, 53 mm.; thickness, 46 mm.

HYPODIGM: Two coarsely silicified specimens, as listed below. One is fairly complete; the other is quite incomplete. In addition, fragments of a large bellerophontacean showing a narrow selenizone on a crest are known from A.M.N.H. 369a, Bone Spring limestone. They may not be the same species but are

TABLE 19

MEASUREMENTS (IN MILLIMETERS) OF *Knightites* (*Knightites*) *bransoni* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	21.7	30	—	712i
Figured paratype	22	—	14.1	712i
Figured paratype	28.5	43	14	712i
Unfigured paratype	28	44	17.2	712i
Unfigured paratype	24	34	12	712i
Unfigured paratype	21	32	14	712i

too incomplete to be described or placed elsewhere.

OCCURRENCE: *Word formation:* A.M.N.H. 503, one; U.S.N.M. 703, one.

NUMBERED SPECIMENS: Figured specimens: A.M.N.H. No. 28188, U.S.N.M. No. 119948.

SUBFAMILY **KNIGHTITINAE** KNIGHT, 1956

GENUS **KNIGHTITES** MOORE, 1941

SUBGENUS **KNIGHTITES** MOORE, 1941

Knightites (Knightites) bransoni
Yochelson, new species

Plate 53, figures 13–17

DESCRIPTION: Moderately small bellerophontaceans, developing protuberances along selenizone that coalesce to form two revolving ridges; earliest growth stages unknown; shell expanding uniformly except at mature stages, at which aperture flares slightly; anterior lips nearly straight, with only slight development of a sinus by rounding of the corners of the slit; slit deep, approximately 20 per cent of body-whorl circumference; selenizone moderately narrow, flush in early growth stages, but becoming raised with increasing maturity; whorl profile well rounded in early stages, becoming somewhat more angular with increasing maturity as the lateral slopes become flatter and join the upper surface at a low angle; narrowly phaneromphalous, details of the umbilicus not well known; upper whorl surface flattened in maturity, with the selenizone lying in a trough bordered by two parallel carinae; lateral lips curved inward around the body of the shell, not covering the parietal wall, developing a thick inductura extended in the plane of the aperture, the central part of the inductura further expanded to form a wide, rounded tooth; ornamented by numerous spiral lirae, seemingly all of one size, and slight transverse undulations in the early growth stages, culminating inward in distinct protuberances near the selenizone, the protuberances eventually coalescing to form two spiral carinae having irregular upper surfaces, the coalescing concomitant with increasing angularity of the shell.

DISCUSSION: *Knightites* (*Knightites*) *bransoni* is readily distinguishable from the other species placed in this subgenus. It is most similar to *K.* (*Knightites*) *maximus* but differs from that form in the rate of development. Mature specimens of *K.* (*Knightites*) *bransoni* have developed the characteristic carinae that parallel the selenizone, while specimens of *K.* (*Knightites*) *maximus* of the same size have discrete paired protuberances. It also appears to have a relatively more expanded aperture than any other species of the subgenus. The species lacks the pronounced development of protuberances or "horns" characteristic of the type species, *K.* (*Knightites*) *multicornus* Moore. Finally, although the spiral ornament of *K.* (*Knightites*) *bransoni* is not well known, unlike that of *K.* (*Knightites*) *medius*, it all seems to be of the same strength.

HYPODIGM: Twenty-six specimens as listed below. All are calcareous, and have the shell more or less eroded off so that several are steinkerns and most are sub-internal molds.

OCCURRENCE: *Hueco limestone:* U.S.N.M. 712i, 24; U.S.N.M. 712j, two.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119963; figured paratypes, U.S.N.M. Nos. 119962a, 119962b; unfigured paratypes, U.S.N.M. Nos. 119962c–119962w.

Knightites (Knightites) medius
Yochelson, new species
Plate 53, figures 22, 23

DESCRIPTION: Large bellerophonts having a strong, high ridge on each side of the selenizone and spiral lirae of two orders of magnitude; earlier growth stages unknown; slit and sinus unknown; selenizone moderately narrow, flush, lying in a flat-bottomed trough between two high, revolving ridges, the total width of this flattened area being about three times the width of the selenizone; lateral slopes nearly flat, meeting the upper whorl surface at approximately a 60-degree angle, the extreme edges of the aperture flaring very slightly, if at all; narrowly phaneromphalous, the umbilici resulting from reflection of the aperture; interior of aperture with a thick callus extended in the plane of the aperture; the callus forming a large, rounded, tooth-like protuberance; immature growth stages with numerous closely spaced, transverse undulations, becoming higher inward, but curving down abruptly at their inner edge to the flattened upper whorl surface; with increasing maturity the inner part of these undulations coalescing to form relatively narrow, high, revolving ridges having pustulose upper surfaces, and paralleling the selenizone, the undulations on the sides of the shell dying out simultaneously with formation of these ridges; ornamented in all growth stages with spiral lirae on the lateral slopes, this ornament of two orders of magnitude, having two to six exceedingly fine lirae, separated by slightly coarser lirae, the two orders of lirae being recognizable throughout all known growth stages; upper surface smooth except for lirae bordering the selenizone.

DISCUSSION: This species is readily distinguishable from the type species, *Knightites (Knightites) multicornus*, by its lack of distinct "horns." *Knightites (K.) medius* is readily distinguished from *K. (K.) maximus* by its characteristic ornament of spiral lirae of two orders of magnitude and lesser development of transverse undulations.

As do many other members of the genus, *K. (K.) medius* shows considerable ontogenetic change. The earlier stages are characterized by faint, transverse undulations culminating in large nodes paralleling the selenizone. These nodes soon coalesce to form a ridge, and simultaneously virtually all of the transverse undulations die out.

The measurements in millimeters of the holotype are estimated as: length, 42; width, 65; thickness, 27. An unfigured paratype is estimated to be 33, 40, and 22 mm., respectively, for the same measurements.

HYPODIGM: Four calcareous specimens, as listed below. Adhering matrix has been cleaned from two of the specimens. All have the aperture broken.

OCCURRENCE: *Clyde formation:* U.S.G.S. 9863, four.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 115219; unfigured paratype, U.S.N.M. No. 115220.

Knightites (Knightites) maximus
Yochelson, new species
Plate 54, figures 10–17

DESCRIPTION: Large, bellerophontid gastropods with two thick rugose ridges paralleling the raised selenizone; early growth stages unknown; mature stages expanding uniformly except for slight expansion of the aperture in the most mature specimens; slit depth, not certainly known, but about 20 per cent of body-whorl circumference; selenizone rounded and raised, welt-like at maturity; whorl profile flat on each side of the selenizone, then rising to cross each of the bordering ridges, so that the selenizone lies slightly above the floor of a trough when viewed in profile; outer edges of ridges paralleling selenizone relatively steep, the shell then curving outward and gradually downward so that the lateral slopes are subrounded; aperture flaring slightly at maturity; narrowly phaneromphalous only in mature stage, umbilical chinks being formed by reflection of the outer lip; lateral part of outer lip slightly reflexed, parietal lip with a small sinus on each side of penultimate body whorl; with a strong, knob-like callus extending in the plane of the aperture and limited to the aperture; transverse ornament undergoing pronounced ontogenetic change, the early growth stages marked by transverse undulations which become stronger inward and

TABLE 20

MEASUREMENTS (IN MILLIMETERS) OF *Knightites* (*Knightites*) *maximus* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	64	70	37	199-T2-Q21-1.3A14
Figured paratype	—	65	25	199-T13-P22
Figured paratype	22	27	13	199-T7-P19-1.3A15
Figured paratype	45	55	31	199-T4-L16
Figured paratype	57	65	34	199-T7-P19-1.3A15
	40	60	25	199-T5-1.3A14
	—	85	36	199-T5-1.3A14
	63	72	33	199-T4-L16

terminate in rounded knobs forming two rows paralleling the selenizone; with increasing maturity the inner portion of these undulations becoming more pronounced until eventually these coalesce and form two spiral ridges, the upper surface of these ridges being somewhat undulatory, the outer part of the transverse undulations meanwhile staying the same relative size; with spiral ornament of numerous fine lirae on the lateral slopes, the upper surface between the spiral ridges smooth and unornamented.

DISCUSSION: This species is one of the most elaborate in the Permian, with transverse undulations, spiral lirae, and two prominent spiral ridges. The coalescing of the inner edges of the transverse undulation forming the spiral bands distinguishes this and other species of *Knightites*, *sensu stricto*, from *Knightites* (*Retispira*). Although some species of *Retispira* develop distinct nodes paralleling the selenizone, they do not have the characteristic undulatory ridges.

Knightites (*Knightites*) *maximus* differs from *K.* (*Knightites*) *bransoni* in having the transverse undulations more strongly developed. It differs from *K.* (*Knightites*) *medius* in having only one set of spiral lirae rather than two sets. The lack of extension of the nodes into "horns" and the relatively much larger size at maturity distinguish the species from *K.* (*Knightites*) *multicornus* Moore.

The United States Geological Survey collections contain one fairly large bellerophontacean steinkern from U.S.G.S. 7028 in the Sierra Diablo area of western Texas. It is referable almost certainly to this subgenus and perhaps to this species, but better specimens are needed to confirm the occurrence. This specimen is the only one outside the north central Texas area that can be even questionably referred to the species.

HYPODIGM: Forty-seven specimens, as listed below. Some of the included specimens are steinkerns otherwise unidentifiable from the same locality as specimens with the shell preserved. Few of the specimens are complete.

OCCURRENCE: *Belle Plains formation:* B.E.G. 42-T-3, two. *Clyde formation:* B.E.G. 199-T2-Q21-1.3A14, seven; B.E.G. 199-T5-1.3A14, two; B.E.G. 199-T5-1.3A15, six; B.E.G. 199-T7-P19-1.3A15, 14; B.E.G. 199-T9-1.3A12, one; B.E.G. 199-T13-P-22, five. *Lueders limestone:* B.E.G. 199-T4-L16, 10.

NUMBERED SPECIMENS: Holotype, B.E.G. No. 13671; figured paratypes, B.E.G. Nos. 13672–13675; unfigured paratype, B.E.G. No. 13676.

Knightites (Knightites) species

Plate 54, figures 7, 8

DISCUSSION: In addition to the three species of Wolfcamp age described above, another species of the typical subgenus is known from beds of Leonard age. The single specimen is incomplete and does not warrant being formally named, but it is significant in extending the range of the subgenus.

The specimen is narrowly phaneromphalous. Whorl profile is strongly trapezohedronal, with the upper whorl surface essentially straight and the lateral slopes joining it at a sharp high angle and proceeding downward with little curvature. Closely spaced, large protuberances are developed along the angulations. Other details cannot be observed because of incompleteness and poor preservation of the specimen. Thickness, width, and length in millimeters are estimated as 23, 40, and 35, respectively.

Because of its unusual whorl profile, the species shows some similarity to *Pharkidonotus*. In this species, however, it is clear that the nodes are circular in plan and are not connected to transverse undulations. Except for the nodes, the shell appears to be smooth.

HYPODIGM: A single calcareous specimen as listed below.

OCCURRENCE: *Leonard formation:* U.S.N.M. 707q, one.

NUMBERED SPECIMEN: Figured specimen, U.S.N.M. No. 119959.

SUBGENUS **RETISPIRA** KNIGHT, 1945

Knightites (Retispira) eximia
Yochelson, new species

Plate 55, figures 1–37

DESCRIPTION: Moderately large, narrowly phaneromphalous bellerophontids ornamented by spiral lirae and numerous transverse undulations; shell uniformly arched across dorsum and down lateral slopes, except for slight flattening at area of selenizone, curving rather abruptly inward at umbilici, but not forming sharp angulations, the profile modified by strong, transverse undulations, or protuberances, and becoming lower and less arched in gerontic stages in which undulations die out; aperture expanding uniformly with growth, not flaring; narrowly phaneromphalous, the umbilici partially covered by lateral lips; lateral lips extended and flattened in plane of aperture, not truly reflexed and not forming sinuses; anterior lips nearly straight, with only slight rounding of corners of slit; slit short, about 10 per cent of body-whorl circumference; selenizone flattened, flush to sunk slightly below general whorl surface, commonly bordered by lirae; inductura covering inner surface of lateral lips and extended slightly in plane of aperture, thickened and knob-like within the aperture; ornamented by numerous spiral lirae, somewhat more widely spaced on lateral slopes than near selenizone, some specimens with faint smaller lirae intercalated on the slopes, the space between lirae three to five times the width of a lira, ornamented also by growth lines which rarely interrupt the spiral lirae; shell modified by transverse undulations, strongest near the selenizone and dying out rapidly along the lateral slopes, so that selenizone area is in a depressed trough between sets of undulations, the undulations commonly in opposition on each side of the selenizone but occasionally alternating, and commonly continuous, but occasionally offset on lateral slopes; shell thin.

DISCUSSION: *Knightites* (*Retispira*) *tenuilineata* (Gurley), *K.* (*Retispira*) *bellireticulata* (Knight), *K.* (*Retispira*) *fragilis*, and *K.* (*Retispira*) *texana* are all distinguishable from *K.* (*Retispira*) *eximia* by their lack of transverse undulations.

The species is more similar to *K.* (*Retispira*) *nodocostata* (Gurley) and *K.* (*Retispira*) *modesta* (Girty). Girty's Permian species differ in not having the transverse undulations developed until the later growth stages and then are not so strongly developed. *Knightites* (*Retispira*) *nodocostata* (Gurley) differs from *K.* (*Retispira*) *eximia* in having the selenizone raised on a crest during early growth stages and in having the transverse undulations less well developed.

Although phylogeny is not implied (too little is known about the species involved),

TABLE 21

MEASUREMENTS (IN MILLIMETERS) OF *Knightites* (*Retispira*) *eximia* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	27.5	29.2	16.6	712b
Figured paratype	25.8	29.2	16.6	712b
Figured paratype	20.1	22.7	14.4	712b
Figured paratype	20.8	24.4	13.8	712b

it is convenient to remember that some of the Pennsylvanian and Permian species fall within a series. The series begins with *K.* (*Retispira*) *bellireticulata* which has the selenizone forming a relatively high crest and has cancellate ornament of growth lines intersecting spiral lirae. In the younger Pennsylvanian *K.* (*Retispira*) *nodocostata* (Gurley), the selenizone is still on a crest, and the intersecting growth lines have developed into lirae or narrow ridges. In this species, the transverse undulations are prominent, and the selenizone is flush, depressed below the highest point of these undulations, except in the earliest growth stages. Next in line comes *K.* (*Retispira*) *eximia.* The Word formation and its equivalents contain *K.* (*Retispira*) *modesta* (Girty). This species does not develop transverse undulations until later growth stages, and has a raised selenizone which gradually becomes flush as the undulations start. Finally, the youngest species, *K.* (*Retispira*) *texana*, lacks transverse undulations.

HYPODIGM: Three hundred and seventy-four specimens, as listed below. In addition, a few other specimens attached to incompletely dissolved blocks have not been counted. These are all from localities that are listed below.

Except for the few from the Admiral formation, all are silicified specimens. Preservation varies from poor to excellent, although few have the aperture unbroken. Several specimens have been bored, possibly by bryozoans or barnacles.

OCCURRENCE: *Hueco limestone:* A.M.N.H. 53, one; U.S.N.M. 712, 105; U.S.N.M. 712b, 223; U.S.N.M. 712c, two; U.S.N.M. 712d, eight; U.S.N.M. 712g, two; U.S.N.M. 717, three. *Gym limestone:* U.S.N.M. 725, nine; U.S.N.M. 726, one. *Admiral formation:* U.S.G.S. 9800, 13; U.S.G.S. 9802, six; U.S.N.M. 50 yards east of Godwin Creek, Baylor County, Texas, one.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 114265; figured paratypes, U.S.N.M. Nos. 114266a, 114266b, 114268a–114268f, 114269a, 114273, 119991; unfigured paratypes, U.S.N.M. Nos. 114267, 114269, 114270, 114271, 114272, 114274, 115229, 115230, 115239.

Knightites (Retispira) fragilis

Yochelson, new species

Plate 54, figures 1–6, 9

DESCRIPTION: Large, smooth, minutely phaneromphalous bellerophontids; shell smooth, without transverse undulations, depressed along dorsum when viewed in profile, otherwise well rounded, the aperture expanding rapidly so that specimens are significantly wider than thick; inner edges of lateral lips strongly reflexed to form deep sinuses near the body whorl covering most of the umbilical openings, the reflexed area not thickened; interior of lateral lips and penultimate whorl covered by a thin inductura which extends just out of the aperture; anterior lips nearly straight, with sinus small and shallow, limited to area near slit; depth of slit and sinus unknown; selenizone narrow, flush in early stages, slightly depressed at maturity; ornament predominantly of growth lines, but a few specimens showing faint spiral lirae; shell thin.

DISCUSSION: It is unfortunate that specimens of this species are not better preserved. Silicification seems to be fairly good, although the virtual lack of spiral ornament might be attributed to its loss during silicification. Half of the specimens are incomplete. None of the larger specimens is well enough preserved to be measured, and the juvenile and immature specimens do not give a meaningful picture of the species. The shell is so delicate compared to that of other species of *Retispira* that only the smaller specimens have been preserved reasonably intact. Fragments of the larger specimens indicate that in life they must have had a width of nearly 4 inches. This is certainly the largest *Retispira* known, although the largest specimens of *Knightites* (*Retispira*) *modesta* (Girty) approach a 3-inch width.

Knightites (*Retispira*) *modesta* (Girty) can be distinguished from *K.* (*Retispira*) *fragilis* by the character of the lateral lips and the umbilici. In the first species the lips are slightly reflexed and cover little of the umbilicus. In this species they are strongly reflexed and virtually conceal the umbilici. The lack of transverse undulations distinguishes the species from *K.* (*Retispira*) *eximia.* The umbilici and the characteristic distinct expansion of the aperture distinguish *K.* (*Retispira*) *fragilis* from *Bellerophon*, with which worn specimens lacking the ornament might be confused.

Comparison with Pennsylvanian species is comparatively easy. In size alone the specimens of *K.* (*Retispira*) *fragilis* are distinctive, being more than four to six times as large as the average Pennsylvanian specimens. This species is also essentially unornamented; most Pennsylvanian species bear elaborate ornaments.

HYPODIGM: Eighteen silicified specimens, as listed below.

OCCURRENCE: *Bone Spring limestone:* P.U. 3, 18.

NUMBERED SPECIMENS: Holotype, U.S.N.M. 119957; figured paratypes, U.S.N.M. Nos. 119958a, 119958b; unfigured paratypes, U.S.N.M. Nos. 119958c–119958e.

Knightites (Retispira) modesta (Girty)

Plate 56, figures 15–32

Bucanopsis modesta GIRTY, 1909b, pp. 103, 104, pl. 11, fig. 1.

Retispira undulata H. P. CHRONIC, 1952, pp. 113–114, pl. 2, figs. 1a, 1b.

DESCRIPTION: Large, nearly smooth, phaneromphalous bellerophontids having a depressed selenizone at maturity; shell well rounded when viewed from side, except in maturity when it begins to become geniculate; dorsum well rounded in early growth stages, becoming flatter with increasing age, and at maturity having the central portion bearing the selenizone depressed in a shallow spiral trough; lateral slopes well arched between upper surface and edges of relatively wide umbilici; aperture expanding fairly rapidly, not flaring; phaneromphalous, the umbilici essentially unrestricted by the reflection of the lateral lips; lateral lips flattened and reflexed slightly at junctures with body whorl, so that wide shallow lateral sinuses are formed, the lips not thickened markedly; anterior lips nearly straight, with development of shallow sinus in immediate vicinity of slit; depth of slit and sinus about 10 per cent of body-whorl circumference; selenizone narrow, changing markedly with ontogeny, strongly convex in early growth stage, but gradually becoming lower so that it is nearly flush in half-grown individuals, with increasing maturity remaining flat to gently convex but sinking slightly below general shell surface in a narrow trough; aperture with an inductural deposit thickest on the body whorl and thinner on interior of lateral lips, the inductura not extending out of the plane of the aperture; in late growth stages, the inductura thickening markedly, so that shell is geniculate when viewed from side; ornamented by numerous fine spiral lirae and growth lines; more mature shells developing low, transverse undulations, weaker on the slopes and slightly more prominent on the upper whorl surface, in late maturity these undulations being replaced by narrow, frill-like varices; shell moderately thick.

DISCUSSION: *Knightites* (*Retispira*) *modesta* is most similar to *K.* (*Retispira*) *fragilis* in being a well-rounded shell. It differs in having wider umbilici and a shallower sinus in the lateral lips on each side of the body whorl. Well-preserved specimens which bear the characteristic spiral lirae are easily differentiated.

The umbilici are characteristic of the species and show essentially no change in rela-

TABLE 22

MEASUREMENTS (IN MILLIMETERS) OF *Knightites* (*Retispira*) *modesta* (GIRTY)

	Length	Width	Thickness	Locality
Holotype	7.4	7.8	6.0	3738a
Figured hypotype	23.5	22.3	18.5	703
Figured hypotype	9.8	9.2	7.3	703
Figured hypotype	38	43.7	30.0	703
	13.7	12.8	11.0	703c

TABLE 23

MEASUREMENTS (IN MILLIMETERS) OF *Knightites (Retispira) girtyi* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	7.9	7.0	6.7	703b
Figured paratype	15	13	12	369
Unfigured paratype	6.0	5.7	5.1	703b
	14.7	12.6	12.2	369
	10.9	9.1	9.2	369
	13.5	12.0	6.4	369
	13.7	12.3	6.8	369
	4.9	5.0	3.0	369

tive size throughout ontogeny. The apertural margin, however, does undergo some variation. At maturity the shells show a tendency to form weak, transverse undulations. At a still later growth stage a narrow varix or varices are formed, projecting as a short frill or frills above the general surface of the shell. Commonly only one varix is formed, but one of the specimens illustrated shows three. These undulations are not nearly so pronounced as those in *K. (Retispira) eximia.*

The presence of both transverse undulations and spiral ornament distinguishes this species from the Pennsylvanian *K. (Retispira) bellireticulata* (Knight) and *K. (Retispira) tenuilineata* (Gurley), both of which bear only spiral ornament. The Pennsylvanian species *K. (Retispira) nodocostata* (Gurley) has the transverse undulations more prominent in the earlier growth stages than does *K. (Retispira) modesta* (Girty).

It is conceivable that the specimens from the Bone Spring limestone may represent another species. All specimens from that formation are immature. In so far as they can be compared, they are conspecific with those from the Glass Mountains. Because many species of *Retispira* show pronounced ontogenetic change, the possibility must always remain that later collections from this formation which contain mature specimens will prove this to be a distinct species.

In 1956, George Bachman, United States Geological Survey, and the author attempted to visit the Caballos Mountains to obtain additional topotypical specimens. Heavy rains which washed out the roads foiled our attempt. Even if the area can be visited, it seems unlikely that Girty's locality will be recovered because the original description is vague. Kelley and Silver (1952, p. 103) indicate that in the Caballos Mountains the Yeso formation does not contain marine fossils but that the overlying San Andres formation is abundantly fossiliferous.

HYPODIGM: The holotype and the specimens as listed below. All specimens are silicified, with the quality of preservation varying from excellent to quite poor. The specimens from the Sierra Diablo area are smaller and not so well preserved as those from the Glass Mountains. All are incomplete.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 433, 13; A.M.N.H. 592, 95; A.M.N.H. 655, 11; P.U. 3, 13; P.U. 4f, eight; P.U. 26a, 23; U.S.G.S. 14439, one. *Leonard formation:* A.M.N.H. 504, one; U.S.N.M. 703b, two. *Word formation:* A.M.N.H. 503, 24; U.S.N.M. 703, 67; U.S.N.M. 703c, 14.

NUMBERED SPECIMENS: Figured hypotypes, U.S.N.M. Nos. 119971a–119971e, 119973a, 119973b; unfigured hypotypes, U.S.N.M. Nos. 119972, 119975.

Knightites (Retispira) girtyi
Yochelson, new species

Plate 56, figures 4–8

DESCRIPTION: Small, slightly compressed, phaneromphalous bellerophontids ornamented by numerous spiral lirae; shell uniformly coiled, not geniculate; compressed in shape, the lateral lips close to the body whorl; dorsum well rounded, curving smoothly into the lateral slopes; lateral slopes nearly straight, so that shell is strongly compressed, the lower part of the lateral slopes falling into the umbilici; phaneromphalous, the umbilici relatively wide, deep, and with steep walls; lateral lips short, not reflexed except just at the body-whorl juncture, so that only small sinuses are formed; anterior lips straight, with no development of a sinus; slit approximately 5 per cent of body-whorl circumference; selenizone varying from very slightly raised to convex to flush; inductura extremely thin, seemingly not extending over interior of lateral lips, extending less than one-quarter whorl out of the aperture; ornament of numerous spiral lirae of two orders of magnitude covering the shell from the selenizone into the umbilicus, the coarser lirae commonly having one to two finer lirae intercalated, the interspaces between the coarser lirae being three to four times the width of a lira.

DISCUSSION: The absence of transverse ornament differentiates this species from *Knightites* (*Retispira*) *eximia*, *K.* (*Retispira*) *modesta* (Girty), and *Knightites* (*Retispira*) *nodocostatus* (Gurley). It is distinguishable from *K.* (*Retispira*) *fragilis* by its prominent umbilici. The spiral ornament of *K.* (*Retispira*) *girtyi* is also characteristic of *K.* (*Retispira*) *tenuilineata* (Gurley), *K.* (*Retispira*) *bellirecticulata* (Knight), and *K.* (*Retispira*) *texana*. All three species are significantly more inflated than this species. In addition, these three species have relatively narrower umbilici than does *K.* (*Retispira*) *girtyi*.

To even a greater extent in this species than in *Knightites* (*Retispira*) *modesta* (Girty), one is left with the uncomfortable feeling that much more needs to be known about the ontogeny of the species. The preponderant number of specimens are tiny. Only about a dozen specimens are as large as the holotype. Comparison with other species of *Retispira* strongly suggests that even the larger specimens are far from mature. As all specimens show the same characters, there is no course but to assign them to a single species, with the knowledge that further collecting may require revision of the concept.

HYPODIGM: Three hundred and forty-four specimens, as listed below. All are fair to poorly silicified. All collections appear to have been sorted after death, so that only juveniles and an occasional larger specimen are present.

OCCURRENCE: *Bone Spring limestone:* A.M.N.H. 369, 155; A.M.N.H. 369a, 23; A.M.N.H. 678, 80; U.S.N.M. 729, 24. *Leonard formation:* U.S.N.M. 702, 25; U.S.N.M. 702d, 12; U.S.N.M. 702ent, one; U.S.N.M. 702f, one. *Word formation:* U.S.N.M. 707e, 23.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119965; figured paratype, A.M.N.H. No. 28190; unfigured paratype, U.S.N.M. No. 119966.

Knightites (Retispira) texana
Yochelson, new species

Plate 57, figures 14–16, 20–27

Bellerophont gastropod, NEWELL AND OTHERS, 1953, pl. 23, fig. 38.

DESCRIPTION: Well-rounded, phaneromphalous bellerophontids having a raised selenizone; shell showing little ontogenetic change, the aperture expanding slowly but uniformly with growth; dorsum well rounded except near selenizone, the lateral slopes not quite so well rounded but still distinctly arched, curving in rather abruptly to the deep aperture; lateral lips relatively close to body whorl, reflexed, forming wide but extremely shallow sinuses at juncture with body whorl; anterior lips straight, with essentially no development of sinus; slit short, about 10 per cent of body-whorl circumference; selenizone of moderate width, bordered by two parallel striations, distinctly arched in early growth stages, the selenizone becoming less arched and lower with increasing age, at maturity being flush with the whorl surface but set off from it by the striations; phaneromphalous, the umbilici distinct but narrow enough so that it is difficult to see earlier whorls within, inductural deposit within aperture extremely thin; ornamented by numerous distinct spiral lirae, at least 15 on each side of the selenizone, most of the lirae being of the same strength, although some of these lirae have a finer set intercalated, the lirae closely spaced near the selenizone but slightly more widely spaced near the umbilici; with increasing maturity the lirae tending to become beaded where crossed by the growth lines.

DISCUSSION: *Knightites* (*Retispira*) *texana* is easily distinguishable from *K.* (*Retispira*) *eximia* by the prominence of transverse ornament in the latter species and its absence in the former. It is less compressed and has wider umbilici than *K.* (*Retispira*) *girtyi* and

TABLE 24

MEASUREMENTS (IN MILLIMETERS) OF *Knightites* (*Retispira*) *texana* YOCHELSON, NEW SPECIES

	Length	Width	Thickness	Locality
Holotype	7.0	7.4	5.7	512
Figured paratype	7.8	7.7	6.3	728
Figured paratype	3.8	14.2	11.7	512
	8.5	8.3	6.8	512
	8.9	8.5	7.0	512
	6.5	6.2	5.0	512
	4.8	4.3	3.7	512
	6.1	5.9	5.9	512
	6.0	5.7	4.8	512
	4.7	4.5	3.8	512
	6.7	6.3	5.5	512
	6.1	5.9	4.8	512
	6.8	6.4	5.4	512

Locality A.M.N.H. 512
$N=12$

M length = 7.3 mm.	S length = ±2.24 mm.	r length/width = 0.98
M width = 7.0 mm.	S width = ±2.60 mm.	r length/thickness = 0.98
M thickness = 5.5 mm.	S thickness = ±2.07 mm.	r width/thickness = 0.97

is significantly smaller and more elaborately ornamented than *K.* (*Retispira*) *fragilis.*

Knightites (*Retispira*) *texana* and *K.* (*Retispira*) *modesta* (Girty) are closely related; there are only slight differences in shape between the two. In *K.* (*Retispira*) *modesta* the dorsum is flattened to a slight extent, so that the shell appears to be relatively wider than that of *K.* (*Retispira*) *texana. Knightites* (*Retispira*) *texana* also has the lateral slope leading into the umbilicus strongly but smoothly arched, whereas in the other species this area is subangular.

The absence of transverse undulations distinguishes this species from Pennsylvanian *K.* (*Retispira*) *nodocostata* (Gurley). It is less readily distinguishable from *K.* (*Retispira*) *bellireticulata* (Knight) and *K.* (*Retispira*) *tenuilineata* (Gurley). The latter species differs in having the selenizone flush in all growth stages. The former species has the selenizone raised on a more prominent crest and seems to have smaller umbilici.

Knightites (*Retispira*) *texana*, like *K.* (*Retispira*) *girtyi*, is not well represented by larger individuals. Unlike that species, however, the specimens of *K.* (*Retispira*) *texana* show a better distribution of the various size classes and less evidence of sorting. A few specimens over 10 mm. in length are known. It is unfortunate that both these common species are not better known.

HYPODIGM: One hundred and eighteen specimens, as listed below. All are silicified, and preservation of most is good.

OCCURRENCE: *Cherry Canyon formation:* A.M.N.H. 512, 81; U.S.N.M. 728, 36. *Word formation:* U.S.N.M. 706, one.

NUMBERED SPECIMENS: Holotype, A.M.N.H. No. 28191; figured paratypes, A.M.N.H. No. 28191:1, U.S.N.M. Nos. 119985a, 119986a; unfigured paratypes, U.S.N.M. Nos. 119985, 119986.

Knightites (Retispira) species 1

Plate 57, figures 28, 31

DISCUSSION: In addition to *Knightites* (*Retispira*) *eximia*, another species of *Retispira* occurs in beds of early Permian age. This species differs from *K.* (*Retispira*) *eximia* in lacking transverse undulations. Early growth stages are most similar to those of *K.* (*Retispira*) *girtyi* in that they are compressed and ornamented by spiral lirae. They differ in having growth lines prominent, so that the ornament is reticulate. In older growth stages the shell is less compressed, and the lirae are noded where they are interrupted by the growth lines. The species is not named at this time.

HYPODIGM: Fourteen specimens, as listed below. The first two are large calcareous specimens; the others are silicified juveniles. Because of the large size difference and the differences in preservation, there is question as to whether these all belong to a single species.

OCCURRENCE: *Wolfcamp formation:* U.S.N.M. 707o, one; U.S.N.M. 3359, one; U.S.N.M. 707d, seven. *Leonard formation:* U.S.N.M. 707b, five.

NUMBERED SPECIMEN: Figured specimen, U.S.N.M. No. 119988.

Knightites (Retispira) species 2

Plate 56, figures 1–3

DISCUSSION: The Capitan limestone has produced specimens of one extremely interesting species. Only a few obviously immature examples are available, and the species is not named.

The species is strongly compressed, with a well-rounded dorsum, so that the lateral slopes are distinctly set off from the upper surface. These slopes are extensive, curving in gradually and fairly uniformly to the comparatively narrow umbilici. The selenizone is wide and strongly convex. It is more welt-like than that of any of the Permian bellerophontaceans described. Ornament consists of at least five strong spiral lirae on each side of the selenizone. Two or three finer lirae lie between most pairs of stronger lirae. Growth lines indicate that the outer lip was essentially straight.

HYPODIGM: Seven specimens, as listed below. All are calcareous and were broken from a limestone matrix. None preserves the aperture.

OCCURRENCE: *Capitan formation:* U.S.N.M. 3364, seven.

NUMBERED SPECIMENS: Figured specimens, U.S.N.M. Nos. 119976a, 119976b.

GENUS **PATELLILABIA** KNIGHT, 1945

Patellilabia junior Yochelson, new species

Plate 53, figures 18–21

DESCRIPTION: Bellerophontid gastropods with an expanded aperture at maturity, a selenizone on a raised ridge in a trough, and an exceedingly large, knob-like inductura within the aperture; early growth stages unknown; whorl profile well arched except for flattening at the dorsum; umbilical condition unknown, the lateral lips not reflexed over the umbilici; mature aperture expanding markedly, the bulk of the flaring anterior to the coil of the shell, the shell uniformly coiled until this expansion occurs; slit depth about one-sixth of total body-whorl circumference; selenizone convex, raised slightly, and located in a median trough, the trough becoming deeper and wider with increasing maturity, the edges of the trough bordered by a spiral ridge on each side, these ridges also increasing in size with increasing maturity; ornamented by numerous spiral lirae; interior of aperture with a large, subquadrangular inductura extending in the plane of the aperture but not protruding out of the aperture.

DISCUSSION: *Patellilabia junior* is closely related to the type and only other described species, *P. tentoriolum* Knight, from the upper Pennsylvanian of Missouri and Kansas. The principal difference between these two species is that, in *P. tentoriolum*, the aperture is expanded both anteriorly and posteriorly, behind the main body of the coil. In *P. junior*, the apertural expansion seems to be limited to the anterior portion of the shell, with essentially no posterior expansion.

Measurements in millimeters of the steinkern figured on plate 53, figure 21, are approximately: length, 42; width, 40; thickness, 20.

The species is readily differentiated from species of *Knightites* (*Knightites*) by its characteristic pattern of spiral lirae. It is less well differentiated from species of *K.* (*Retispira*) which lack transverse ornamentation. The two groups can be distinguished at maturity by the flare of the aperture of *P. junior*. It remains doubtful that forms such as *K.* (*Retispira*) *tenuilineatas* (Gurley) and immature specimens of *P. junior* can be differentiated.

HYPODIGM: Twenty-one specimens, as listed below. All specimens are calcareous from limestones and shales. Most are incomplete and exfoliated.

OCCURRENCE: *Lueders limestone:* B.E.G. 199-T1-L16, one; B.E.G. 199-T1-L16-1.3A19, 12; B.E.G. 199-T16-1.3A17, one; U.S.G.S. 9862, seven.

NUMBERED SPECIMENS: Holotype, B.E.G.

No. 13669; figured paratypes, B.E.G. Nos. 13662, 13670, U.S.N.M. No. 112627; unfigured paratypes, U.S.N.M. Nos. 112628a–112628f.

SUPERFAMILY PATELLACEA MENKE, 1828

?FAMILY METOPTOMATIDAE WENZ, 1938

GENUS METOPTOMA PHILLIPS, 1836

Metoptoma texana Yochelson, new species

Plate 56, figures 9–14

DESCRIPTION: Subcardiform gastropods with greatest width of shell anterior; protoconch unknown; apex seemingly smooth; posterior slope steep, overhung by apex in juvenile stage, gradually growing outward so that posterior slope of mature stage is nearly 30 degrees from vertical; lateral slopes inclined outward, uniformly nearly 30 degrees from vertical in all growth stages; anterior slope inclined 45 degrees, straight or very gently convex; outer margin not flaring but slightly thickened; margin of anterior and lateral slopes horizontal when viewed in profile, posterior margin having an extremely wide, shallow sinus extending its entire width; lateral slopes almost parallel, the width of shell being nearly constant from posterior to near center; muscle scar unknown; outer surface with distinct, nearly uniformly spaced cords subparallel to outer margin.

DISCUSSION: The straight sides, almost parallel for much of the length of the shell, are quite distinctive, and this feature seems to separate the species from others referred to the genus. The Permian species also appear to be higher than Mississippian specimens examined. The external surface of specimens may be variable, as there are included within this species two shells with a nearly smooth outer surface and others with lamellae developed at what was the margin at former growth stages. On the other hand, the smoother shells are poorly preserved, and the absence of projecting lamellae may be a phenomenon of silicification. Shell interiors are not well preserved, and no muscle scars are available for study.

Only one specimen retains the early portion of the shell. This is smooth and bulbous. It cannot be determined if this is the protoconch or if a larval shell such as occurs in *Lepetopsis* and *Platyceras* (*Orthonychia*) (Yochelson, 1956, pl. 23, figs. 27–29) was present and later decollated.

The holotype measures approximately 21 mm., 19 mm., and 10 mm. for length, width, and height, respectively. The largest known paratype has measurements of 35 mm., 27.3 mm., and 17 mm.

HYPODIGM: Fifteen specimens, as listed below. All but two are silicified.

OCCURRENCE: *Wolfcamp formation:* U.S.N.M. 701c, two; U.S.N.M. 701f, one; U.S.N.M. 701g, one; U.S.N.M. 701k, seven; U.S.N.M. 701-l, one; U.S.N.M. 706x, two; U.S.N.M. 708e, one.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119967; figured paratypes, U.S.N.M. Nos. 119968, 119969; unfigured paratype, U.S.N.M. No. 119974.

GENUS LEPETOPSIS WHITFIELD, 1882

Lepetopsis patella Yochelson, new species

Plate 57, figures 1, 2, 4–7

DESCRIPTION: Patelliform gastropods with lozenge-shaped aperture; apex somewhat steeper than rest of shell, so that profile of earliest portion of shell is concave; apex located anteriorly; anterior, posterior, and lateral surfaces straight in mature stage, sides and anterior having slope of nearly 45 degrees, posterior slope nearly 30 degrees from horizontal; sides subparallel, with both anterior and posterior ends of shell smoothly rounded, so that in outline the shell is lozenge-shaped; muscle scar horseshoe-shaped, not extending onto anterior slope, relatively wide, and expanding at both ends, located within apical portion of shell; mature shell commonly smooth, although some specimens develop concentric growth lamellae by periodic slight flaring of margin.

DISCUSSION: In outline, this species is quite similar to *Lepetopsis peregrina* Newell, from the Stanton formation, Pennsylvanian of Kansas. It is differentiated from that species in having a much longer muscle scar. This muscle scar also differentiates *L. patella* from *L. parrishi* (Gurley) which has a longer scar. The average size of the specimens included in this species is nearly twice that of those referred to *L. peregrina*. *Lepetopsis patella* shows some variation in height of

TABLE 25

MEASUREMENTS (IN MILLIMETERS) OF *Lepetopsis patella* YOCHELSON, NEW SPECIES

	Length	Width	Height	Locality
Holotype	15.0	10.4	4.8	701g
Figured paratype	25.8	17.3	9.5	701g
Figured paratype	15.0	10.0	4.2	701g
Figured paratype	10.7	7.0	3.8	701g
Unfigured paratype	12.8	7.8	3.9	701g
Unfigured paratype	12.5	9.5	3.6	701g
Unfigured paratype	8.7	6.0	2.8	701g

cone, some specimens being only slightly raised. All show the characteristic lozenge shape, but again there is some slight individual variation.

There is some question as to whether the paratype figured on plate 57, figures 5 and 6, is a representative of this species. It differs from other members of the hypodigm in having strong projecting lamellae and in having the apex higher and more centrally located. Possibly the differences between the figured paratype and the other specimens are due to growth, as this paratype is nearly twice the size of the next largest specimen. At the moment the erection of one species rather than two seems preferable.

HYPODIGM: Twenty-six specimens, as listed below. All are silicified, and, while many lack the apex and are poorly preserved, a few are excellent. Two other specimens from U.S.N.M. 701k, Wolfcamp formation, are tentatively referred to this species.

OCCURRENCE: *Wolfcamp formation:* U.S.-N.M. 701a3, two; U.S.N.M. 701d, four; U.S.N.M. 701g, 19; U.S.N.M. 707d, one.

NUMBERED SPECIMENS: Holotype, U.S.N.M. No. 119982; figured paratypes, U.S.N.M. Nos. 119983a–119983c; unfigured paratype, U.S.N.M. No. 119983.

Lepetopsis parrishi Gurley

Plate 57, figures 30, 33, 34

Lepetopsis parrishi GURLEY, 1884, p. 7.

Lepetopsis parrishi Gurley, NEWELL, 1935, p. 351, pl. 35, figs. 1–2.

DESCRIPTION: Small, subelliptical, patelliform gastropods with convex sides and a nearly complete muscle scar; apex moderately high, situated strongly anterior; anterior surface sloping nearly 30 degrees from vertical; lateral surfaces nearly straight, gently convex outward, sloping at approximately 45 degrees; posterior slope straight, inclined 30 degrees from horizontal for approximately one-third of the distance from apex to margin, there then being a faint but distinct break in slope, the lower two-thirds of the slope being very gently convex and slightly steeper than that above; margin flat, not thickened, smoothly and regularly elliptical; muscle scar horseshoe-shaped, located on interior near change in slope, nearly closed at anterior end by expansion into two distinct muscle spots, fainter at posterior; ornamentation lacking.

DISCUSSION: Several specimens from the Permian of the west Texas area are so similar to Gurley's species, as figured and described by Newell (1935), as to be considered conspecific. In particular, details of the muscle scar appear nearly identical in the Pennsylvanian and Permian forms. The Word specimen is not so well preserved as the specimen from the Bone Spring limestone, but the specimen from the Getaway limestone member of the Cherry Canyon formation clearly shows the muscle scar.

The figured specimen measures: length, 11.0 mm.; width, 9.3 mm.; height, 3.9 mm.

HYPODIGM: Three specimens, as listed below. All are silicified and well preserved. Four additional specimens from U.S.N.M. 706b, Word formation, are poorly preserved and are only tentatively referred to this species.

OCCURRENCE: *Bone Spring limestone:* U.S.N.M. 716, one. *Word formation:* U.S.N.M. 706, one. *Cherry Canyon formation:* U.S.N.M. 728, one.

NUMBERED SPECIMEN: Figured hypotype, U.S.N.M. No. 119990.

Lepetopsis? beedei Yochelson,
new species

Plate 57, figures 17–19

DESCRIPTION: Patelliform gastropods with elongate aperture and high posterior apex; lateral slopes inclined nearly 35 degrees from vertical; posterior slope very steep, near apex changing to a slope of nearly 45 degrees, so that in profile the slope appears concave; anterior slope 10 to 15 degrees from horizontal for approximately half of length, then steepening so that in profile this slope appears convex; muscle scar strongly impressed, extending along most of length of side and flaring slightly at each end, seemingly narrower than in forms with lower apex; shell smooth, without concentric undulations or radial lirae.

DISCUSSION: The distinctly posterior position of the apex, as shown by the muscle scar, readily distinguishes *Lepetopsis? beedei* from *L. patella*, *L. parrishi* (Gurley), and other typical members of the genus. The apex is higher than in many of the other species. *Lepetopsis? beedei* is similar to *L.? haworthi* (Beede) but differs from that species in having the anterior more elongated and in lacking fine radial ornament. Nevertheless, the two species are so similar that Knight's (1940, p. 302) surmise that the apex is posterior in *L.? haworthi* seems to be confirmed. A topotype specimen of *L.? haworthi* collected by the writer does not show the muscle scar.

The holotype measures: length, 8.3 mm.; width, 6.0 mm.; height, 4.0 mm. The paratype is broken at the margin; dimensions are estimated as 10 mm., 6.5 mm., and 3.5 mm., respectively.

Lepetopsis? capitensis (Girty)

Plate 57, figures 9–12

Patella capitensis GIRTY, 1909a, p. 465, pl. 8, figs. 8–8b.

DESCRIPTION: Small patelliform gastropods with fine, radially arranged ornamentation and a relatively high apex; protoconch unknown; apex subcentral, presumably closer to anterior; sides curved near apex, concave outward, then straight to margin; anterior and lateral surfaces sloping nearly 20 degrees from vertical, posterior surface sloping 30 to 40 degrees from vertical; aperture subelliptical in general shape, not known in detail; ornamentation consisting of radial ridges closely and regularly spaced around the shell, with finer ribs intercalated but seemingly absent on the posterior slope.

DISCUSSION: The above description is based on examination of Girty's holotype and is presumably the only specimen that was known to him. No others have been found in the collections studied. The generally high shape and the fine radial ornamentation readily differentiate this species from all others referred to the genus.

This species is doubtfully referred to the genus, as the general shape and the ornamentation are quite suggestive of the fissurellids, a group of pleurotomarian gastropods that are characterized by an apical trema and a limpet-like shape. Unfortunately, the apex of *Lepetopsis? capitensis* is broken, so that it is not possible to determine if a trema was present. The possibility is noted here, because, if this is a fissurellid, then it is the oldest one known. If this species is a patellid, then certainly it is referable to the first group of species mentioned in the discussion of *Lepetopsis* (p. 245).

There is still another possibility regarding placement of this species. Knight (oral communication) has suggested that similarly ornamented shells from the Bone Spring limestone are barnacle plates. These other specimens differ in being lower and in having two posteriorly projecting spines.

HYPODIGM: One specimen, as listed below. The specimen has been broken from limestone and is quite good except that the apex is broken.

OCCURRENCE: *Carlsbad group:* U.S.G.S. 2966 green, one.

NUMBERED SPECIMEN: Holotype, U.S.N.M. No. 118345.

Lepetopsis species 1

Plate 57, figures 3, 8, 13

DISCUSSION: The Wolfcamp formation contains one specimen different enough from *Lepetopsis patella* to be considered a distinct species. The specimen is relatively longer, narrower, and higher than specimens referred to *L. patella*. It is possible that this difference in shape might be due to crowding during growth. Living patellids commonly are gregarious. Until a larger population sample is available, this possibility cannot be investigated, and for that reason the specimen is not formally assigned to a species.

The specimen is unique among the Permian Patellacea in preserving the protoconch. This is a tiny, elongate, closed tube slightly eccentric to the left of the body whorl. The specimen expands so rapidly from this larval shell that it can hardly be said to coil for as much as one-half of a whorl. This protoconch appears to be similar to that reported by Newell (1935, p. 352) for the Pennsylvanian species *L. peregrina.*

The length, width, and height of the specimen are 12.0 mm., 5.7 mm., and 5.6 mm., respectively.

HYPODIGM: One excellently silicified specimen, as listed below.

OCCURRENCE: *Wolfcamp formation:* U.S.N.M. 701g, one.

NUMBERED SPECIMEN: Figured specimen, U.S.N.M. No. 119984.

Lepetopsis species 2

Plate 57, figures 29, 32

DISCUSSION: In addition to the other specimens of *Lepetopsis* described herein, there is one specimen that does not seem to be referable to any of the species in the Permian fauna. The aperture of the specimen is subelliptical and rounder than in other species. It is markedly different from the associated elongate shells of *L. patella.* The apex is relatively much higher than in any other species studied except *L.? capitensis.* The apex is subcentrally located. The shell is smooth, except for the faintest of concentric ornament. Although this may represent a new species, the single specimen does not seem to warrant a formal name.

HYPODIGM: One specimen, as listed below. The shell illustrated is silicified and etched free, but the interior is filled with matrix.

OCCURRENCE: *Wolfcamp formation:* U.S.N.M. 701g, one.

NUMBERED SPECIMEN: Figured specimen, U.S.N.M. No. 119989.

OTHER *Lepetopsis* SPECIMENS

DISCUSSION: In addition to the specimens discussed above, a few other specimens are known that cannot be assigned to species. Because Paleozoic patellid gastropods are so rare, their occurrences are noted below:

Clyde formation: U.S.G.S. 9848, three; these are low steinkerns with the apex distinctly anterior. The aperture is elongate subelliptical, suggesting that they are not referable to *L. parrishi* Gurley.

Wolfcamp formation: U.S.N.M. 708v, one; incomplete and so poorly preserved it cannot be tentatively referred to a species.

Leonard formation: U.S.N.M. 702b, one; a very low, large, incomplete specimen, which may represent a new species.

Leonard formation: U.S.N.M. 703b, one; a large specimen somewhat higher than the specimen from U.S.N.M. 702b.

Word formation: U.S.N.M. 703c, one; a juvenile with a shape similar to that of *L. patella,* but so small that one cannot be sure of the specific identification.

Word formation: U.S.N.M. 706e, one; a specimen that shows some similarity to *L. parrishi* Gurley but is poorly preserved and cannot be identified.

Carlsbad group: U.S.N.M. 3364, two; both are small and incomplete but are smooth shells not referable to *L.? capitensis* (Girty).

REGISTER OF LOCALITIES

THE AMERICAN MUSEUM OF NATURAL HISTORY

53. Hueco limestone: Same as U.S.N.M. 712f.

369. Bone Spring limestone: Top of Shirttail Canyon, above the drilling well (now abandoned), Humble Oil and Refining Co., E. P. Crowden A. No. 14E, Peere Oil Co. (Rig. No. 17), Guadalupe Mountains, Texas.

369a. Bone Spring limestone: Float blocks above drilling well in Shirttail Canyon; probably from same stratigraphic unit as A.M.N.H. 369.

391. Hueco limestone: 1.1 miles northwest of Ruddy Tanks, Aldwell Ranch, about 5 miles southeast of the Hueco Inn, Hueco Mountains, El Paso and Hudspeth counties, Texas.

433. Lower part of Bone Spring limestone (molluscan ledge, about 100 feet above base): On south side of mouth of Apache Canyon on county line, Sierra Diablo area, Texas.

503. Word formation, near top of limestone no. 1: Same as U.S.N.M. 703, but from a different lens.

504. Uppermost part of Leonard formation: Same as U.S.N.M. 703a.

512. Cherry Canyon formation, Getaway limestone member: Near break in the slope on middle leader on the west side of the airway station road, between the highway and the pipeline road, on the crest of the ridge, Guadalupe Mountains, Texas.

519. Cherry Canyon formation, Getaway limestone member: On west slope of outlier due northeast of BM 5315 in right-angle bend in Highway 62, approximately 0.5 mile east of airway station, Guadalupe Mountains, Texas.

592. Bone Spring limestone (molluscan ledge): Between the north and middle branches of Black John Canyon, Van Horn quadrangle, Texas.

625. Lower part of Bone Spring limestone: South side of the mouth of Victorio Canyon, 220 feet above the top of the clastic beds, Van Horn quadrangle, Texas.

626. Hueco limestone, marly beds at top of lower clastic member: South side of the mouth of Victorio Canyon, Sierra Diablo, Van Horn quadrangle, Texas.

655. Bone Spring limestone: 80 feet above the base on the northernmost of the Baylor Hills on west side of Highway 54.

678. Bone Spring limestone, Cutoff shaly member: On slope 1 mile southwest of point 6910 and 0.2 mile west of fault in front of Cutoff Mountain, Guadalupe Mountains, New Mexico.

TEXAS BUREAU OF ECONOMIC GEOLOGY

(Stratigraphic data checked by Raymond C. Moore)

42-T3. Belle Plains formation, Elm Creek limestone member: At the falls of Elm Creek, Coleman County, Texas.

42-T-18. Admiral formation, Wildcat Creek shale member: Same as U.S.G.S. 9802.

42-T20. Admiral formation, Wildcat Creek shale member: Santa Anna Road, 1.5 miles east of Coleman, Coleman County, Texas.

199-R1-L16-1.3A19. Lueders limestone: Quarry east and above Elm Creek, Runnels County, Texas.

199-T2-1.3A13. Clyde formation, Grape Creek limestone member: Little bluff on Colorado River, Runnels County, Texas.

199-T2-Q21-1.3A14. Clyde formation, Talpa limestone member: Big bluff on Colorado River, Runnels County, Texas.

199-T4-L16. Lueders limestone: Elm Creek on Geisecke Ranch, Runnels County, Texas.

199-T5-1.3A14. Clyde formation, Talpa limestone member: Along Colorado River at Mustang Creek, Runnels County, Texas.

199-T5-1.3A15. Clyde formation, Talpa limestone member: Along Colorado River below Mustang Creek, Runnels County, Texas.

199-T7-P19-1.3A15. Clyde formation, Talpa limestone member: Herring's Bluff on Colorado River, Runnels County, Texas.

199-T9-1.3A12. Clyde formation, Grape Creek limestone member: Hall's Bluff, north of Hall's Ranch, Runnels County, Texas.

199-T12-P22. Clyde formation, Grape Creek (?) limestone member: Pony Creek near Colorado River, Runnels County, Texas.

199-T13-P22. Clyde formation, Talpa limestone member: Pony Creek near Colorado River, Runnels County, Texas.

199-T16-1.3A17. Lueders formation: From Mustang Ford to mouth of Spur Creek, Runnels County, Texas.

PRINCETON UNIVERSITY

1. Bone Spring limestone, Victorio Peak (?) gray member: Downfaulted hills north of mouth of Apache Canyon, just north of Van Horn quadrangle, Texas.
3. Bone Spring limestone (molluscan ledge about 100 feet above base): Northwest wall of Apache Canyon near mouth, just north of Van Horn quadrangle, Texas.
4. Bone Spring limestone, upper beds of Victorio Peak gray member: On small nose at 4700-foot elevation, southeast wall of Apache Canyon, about 0.75 mile due north of "A" in Apache Peak, Van Horn quadrangle, Texas.
24. Hueco limestone, basal clastic beds: At base of Canyon directly under "n" in Apache Spring, Van Horn quadrangle, Texas.

26a. Bone Spring limestone: On northwest slope of Apache Canyon, not far from P.U. 3, Van Horn quadrangle, Texas.

37. Hueco limestone (just above conglomerate): On Eagle Butte, north side of Texas and Pacific Railway just west of Van Horn quadrangle, Texas.
53. Bone Spring limestone, Victorio Peak gray member: *Note* that by error Yochelson (1956, p. 265, and table 1, facing p. 184) listed this as Hueco limestone.

UNITED STATES GEOLOGICAL SURVEY

2931 green. Guadalupe Mountains, Texas: West side of road at entrance to Guadalupe Canyon; lower half of great sandstone series.

2966 green. Carlsbad group: Summit of El Capitan, Guadalupe Mountains, Texas.

3738a green. San Andres formation: Pass through Caballos Mountains, west of Upham, New Mexico; limestone within the red beds and 100 feet below top of section.

3742d green. San Andres formation, 850 feet above massive red sandstone: San Andres Mountains, east of Engle; foothills at edge of Jornada, New Mexico.

6681. Hueco limestone about 400 feet below top: Marble Canyon, Van Horn quadrangle, Texas.

6694. Leonard formation, 300–400 feet above base: Faulted block north of road near Sullivan Peak, west of Marathon, Texas.

6724. Hueco limestone: Marble Canyon, Van Horn quadrangle, Texas.

7003. Hueco limestone: Reëntrant in west side of small mesa about 1 mile north of "P" in Pacific, Sierra Blanca quadrangle, Texas.

7028. Hueco limestone: East end of butte about 1 mile northwest of Eagle Flat station (Texas and Pacific Railway), just west of Van Horn quadrangle, Texas.

8388. Colina (?) limestone: East side of small canyon in limestone butte, 4 miles north of Mule Mountains, SW. ¼, sect. 21, T. 21 S., R. 23 E., Benson quadrangle, Arizona.

8501. Colina limestone: 800 feet south-southwest of BM 5700, on steep cliff, T. 21 S., R. 23 E., Pearce quadrangle, Arizona.

8502. Colina limestone: Same as U.S.G.S. 8501, 100 feet stratigraphically higher.

8503. Colina limestone: From about 15 feet stratigraphically below BM 5700, in T. 21 S., R. 23 E., top of big butte, Benson quadrangle, Arizona.

8505. Colina limestone: NE. ¼ sect. 7, T. 21 S., R. 23 E., Benson quadrangle, Arizona.

8515. Epitaph dolomite, uppermost part: Base of small spur on dip of Colina Ridge in NW. ¼ sect. 35, T. 20 S., R. 22 E., Benson quadrangle, Arizona.

8526. Colina limestone, lower part: Low slopes of hogback about 200 feet due north of common south corners of R. 22 and R. 23 E., T. 20 S., Benson quadrangle, Arizona.

8527. Colina limestone, upper part: Crest of ridge north of U.S.G.S. 8526, Benson quadrangle, Arizona.

8964. Colina limestone, about 225 feet above buse: In measured section on Colina Ridge, 4000 feet south of Horquilla Peak, Benson quadrangle, Arizona.

9800. Admiral formation, limestone bed in Hords Creek limestone member: 3.05 miles slightly north of east of center of Coleman, on east-west-trending road 0.4 mile east of crossing of Hords Creek, Coleman County, Texas.

9802. Admiral formation, local soft shaly limestone in Wildcat Creek shale member, approximately 15 feet below base of Overall limestone member: 4.9 miles west of south from center of Coleman, 0.45 mile (240 feet) south of Gulf, Colorado, and Santa Fe Railway 0.55 mile east-northeast of road crossing of railway just south of point where U. S. Highway 67 turns west-southwest on approaching railway, Coleman County, Texas.

9848. Clyde formation, Talpa limestone member, 60 to 65 feet below top: 6.9 miles due east of center of Ballinger and 3.2 miles due south of Bunoit, just north of east-west secondary road crossing of Mustang Creek at point 3.8 miles (airline) above its mouth, Runnels County, Texas.

9854. Clyde formation, Talpa limestone member, about 90 feet below top: 8.25 miles southeast of center of Ballinger, north end of Herrings Bluff on east side of Colorado River, 1.0 mile southeast of mouth of Mustang Creek, Runnels County, Texas.

9862. Lueders limestone, about 75 feet below top: 3.3 miles due north of center of Ballinger on Elm Creek, Texas, just below crossing of north-south road, 0.7 mile west of Abilene Southern Railroad, Runnels County, Texas.

9863. Clyde formation, Grape Creek limestone member, topmost bed: 12.8 miles south of east of center of Ballinger, 4.4 miles south-southwest of Talpa on west side of Grape Creek, 1 mile west of Runnels-Coleman county line, Runnels County, Texas.

14439. Bone Spring limestone: North portal of Apache Canyon on outside of east rim, second nose north of lower bench; 4.6 miles east and 0.2 mile north of northwest corner of Van Horn quadrangle, Texas.

14461. Bone Spring limestone: North wall of Apache Canyon, up a nose the base of which is 4.8 miles east and 0.6 mile south of northwest corner of Van Horn quadrangle, Texas.

15784. Yeso formation, Joyita Sandstone member: NE. $\frac{1}{4}$ sect. 32, T. 6 S., R. 9 E., Carrizozo quadrangle New Mexico.

17393. Colina limestone, 60–70 feet above base: From east-facing slope 10 feet below top of hill, on northeast side of Walnut Gap about 0.75 mile from U. S. Highway 86, Dragoon quadrangle, Arizona.

17394. Colina limestone: Isolated low hill lying on longitude 110° 00′ W. northeast of unimproved road in Government Draw, Benson quadrangle, Arizona.

UNITED STATES NATIONAL MUSEUM

701a[3]. Wolfcamp formation (bed 9): From biohermal mass on slope just south of forks of canyon, 0.4 mile north 81° west of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701c. Wolfcamp formation (beds 9–12): Crest of hill facing and forming north side of canyon, on west side of tributary arroyo 0.2 mile up canyon from entrance, Wolfcamp Hills, 15 miles (by road) northeast of Marathon, Hess Canyon quadrangle, Texas.

701d. Wolfcamp formation (beds 9–12): Two small hills 1 mile northwest of Wolfcamp, west end of Wolfcamp Hills, 15 miles (by road) northeast of Marathon, Hess Canyon quadrangle, Texas.

701f. Wolfcamp formation, Reefy beds with *Parenteletes* in Uddenites zone: 0.35 miles north 21° east of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701g. Wolfcamp formation (bed 9): Patch of gray-brown limestone with numerous *Orthotichia* in south gully near its head, south branch canyon, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701k. Wolfcamp formation (bed 12): West side of hill, 0.97 mile south 82° west of Hill 5060, at 4750-foot elevation, west end of Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701-l. Wolfcamp formation (bed 2): About 4625-foot elevation on south side of hill, 0.87 mile south 69° west of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

702. Leonard formation, upper part (original Leonard of P. B. King): Slopes on south side of road 0.2 to 0.5 mile east of Split Tank, 1.5 miles northeast of road fork near old Word Branch, about 19 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

702b. Leonard formation, upper part (lower part of original Leonard of P. B. King): 0.5 mile east of Split Tank, 19 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

702d. Leonard formation (Hess limestone member, eastern facies): Crest of hill 3.8 miles (airline) north 67° east of Hess ranch house, 0.4 mile southwest of head of south branch of Hess Canyon, Hess Canyon quadrangle, Texas.

702ent. Leonard formation: From smooth greenish gray limestone with abundant *Enteletes*, patch just west (50 yards) of gully 0.5 mile east of Split Tank, about 100 feet above the conglomerate at base of King's Leonard, Hess Canyon quadrangle, Texas.

702f. Leonard formation, Hess limestone member (fossil bed): 0.5 mile southwest of Hill 5821, 4.4 miles north 66.5° east of Hess ranch house, Hess Canyon quadrangle, Texas.

702un. Upper part of Leonard formation: *Institella* beds of original Leonard formation of King at U.S.N.M. 702.

703. Word formation (limestone no. 1): Lens with goniatites in platy limestone near top of slope 0.5 mile southwest of road forks just northeast of old Word Ranch, Hess Canyon quadrangle, Texas.

703a. Uppermost part of Leonard formation (*Aulosteges* beds): On northwest side of road between road fork and sheep tank near old Word Ranch, about 17 to 18 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

703b. Leonard formation, upper part (lower part of original Leonard of King): On southeast side of road between road fork and sheep tank at old Word Ranch, Hess Canyon quadrangle, Texas.

703c. Word formation (limestone no. 1): Crest of slope 0.25 to 0.5 mile southwest of road fork near old Word Ranch, 17 to 18 miles north-northeast of Marathon, Hess quadrangle, Texas. Sponge bed. Basal portion, dark platy, is called Word no. 1 by P. B. King, just above reefy beds on crest of slope on north side of road, 0.25 mile southwest of road fork near old Word Ranch, Hess Canyon quadrangle, Texas.

703e. Word formation (limestone no. 2): About 1.4 miles west-southwest of Split Tank, Hess Canyon quadrangle, Texas.

704v. Wolfcamp formation: 5100-foot elevation in arroyo at base of Hill 5816, Hess Canyon quadrangle, Texas.

706. Word formation (lower part of limestone no. 3): North slope of hill on south side of Hess Canyon, 4 miles north 35° east of Hess Ranch, 14 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

706b. Word formation (limestone no. 3 and limestone no. 4): 0.2 mile west of junction of Hess Canyon with south branch of Hess Canyon, Hess Canyon quadrangle, Texas.

706c. Word formation (about middle of limestone no. 2): Southwest slope and crest of hill 3.7 miles north 36° east (airline) of Hess ranch house, Hess Canyon quadrangle, Texas.

706e. Word formation (top of limestone no. 3): East side of small arroyo 4.1 miles (airline) north 34° east of Hess ranch house, Hess Canyon quadrangle, Texas.

706x. Wolfcamp formation (bed 12 to top): Just west of canyon just above sharp elbow, 0.5 mile north 76° west of Hill 5060, Wolfcamp Hills, Hess Canyon, Texas.

707b. Leonard formation (top of limestone no. 1): North side of arroyo 4.1 miles (airline) due north of Decie ranch house, 1 mile northwest of entrance to Sullivan Ranch Canyon, Altuda quadrangle, Texas.

707d. Wolfcamp formation (top): Knob on west side of entrance to Sullivan Ranch Canyon, 3.5 miles north 7° east of Decie ranch house, Altuda quadrangle, Texas.

707e. Word formation (lower): 5.3 miles (airline) north 5° west of Decie ranch house, 0.9 mile (airline) south 25° east of Sullivan Peak, on nose of foothill southeast of Sullivan Peak, Altuda quadrangle, Texas.

707h. Wolfcamp formation: Small knob 0.5 mile southeast of Hill 5300, 2.7 miles (airline) north 12° west of Decie Ranch House, Altuda quadrangle, Texas.

707o. Wolfcamp formation (lower 30 feet of shale below Hess limestone member of Leonard formation): 100 yards south 81° east of Hill 4902, 3 miles north of Decie Ranch, 1.3 mile southwest of Hill 5300, Altuda quadrangle, Texas.

707q. Leonard formation: Base of hill just east of Clay Slide, Altuda quadrangle, Texas.

708e. Leonard formation, first limestone: Bioherm at 4815- to 4860-foot elevation, about 0.25 mile east-southeast of Hill 5300 north of Decie Ranch, Altuda quadrangle, Texas.

708v. Leonard formation, just above base of Leonard formation of P. B. King: Loose pieces on south slope of gully just above basal conglomerate, 2.0 miles north 65° east of Split Tank, Hess Canyon quadrangle, Texas.

712. Hueco limestone: From an isolated hill 0.7 mile south of railway station at Orogrande, near the center of sect. 25, T. 22 S., R. 8 E., from bed just below top of hill; just south of small hill of trachyte-porphyry, Orogrande quadrangle, New Mexico.

712a. Hueco limestone (25 feet below siltstone, 200 feet below "cephalopod bed"): North center of sect. 24 near crest of hill in southeast and south of monument and pin at quarter corner at sect. 13 and sect. 24, T. 23 S., R. 8 E., Orogrande quadrangle, New Mexico.

712b. Hueco limestone (about 700 feet above Powwow conglomerate member and probably below "cephalopod bed"): In the NE. $\frac{1}{2}$ SW. $\frac{1}{2}$, sect. 25, T. 22 S., R. 8 E., near Orogrande, Otero County, New Mexico.

712c. Hueco limestone (about 200 feet below "cephalopod bed"): In the SE. $\frac{1}{2}$, sect. 8, T. 22 S., R. 10 E., Otero County, New Mexico.

712d. Basal middle part of Hueco limestone: 0.5 mile north-northeast of Hueco Inn, east of highway, Hueco Mountains, Texas.
712f. Milddle part of Hueco limestone: Hill 1 mile north of Ruddy Tank, west of road, 4.5 miles southeast of Hueco Inn, Hueco Mountains, Texas.
712g. Lower part of Hueco limestone (near base, above Powwow conglomerate member): Head of Powwow Canyon about 0.25 mile due west of BM 5067, Hueco Mountains, Texas.
712h. Hueco limestone ("cephalopod bed"): In the SW. ¼, sect. 20, T. 22 S., R. 10 E., Otero County, New Mexico.
712i. Hueco limestone ("cephalopod bed"): McGregor Ranch, south line of SW. ¼ sect. 20, T. 22 S., R. 10 E., Otero County, New Mexico.
712j. Hueco limestone: Center of sect. 9, T. 22 S., R. 10 E., Otero County, New Mexico.
715a. Leonard formation, basal part of Hess limestone member: Under highest part of mountain, Dugout Mountain, Hess Canyon quadrangle, Texas.
716. Bone Spring limestone (lower 100 feet): Nose of Victorio Peak above Figure 2 Ranch headquarters, Van Horn quadrangle, Texas.
717. Hueco limestone: Threemile Mountain northwest of Van Horn, Van Horn quadrangle, Texas.
725. Gym limestone (bed 22 of Bogart): Tres Hermanas Mountains, east of northernmost peak, sect. 30, T. 27 S., R. 8 W., New Mexico.
726. Gym limestone (bed 32 of Bogart): Florida Mountains, south 22° east of Gym Peak, in the N. ½, sect. 18, and NW. ¼, sect. 17, T. 26 S., R. 7 W., New Mexico.
728. Cherry Canyon formation, Getaway limestone member: Same as A.M.N.H. 512.
729. Bone Spring limestone: Same as A.M.N.H. 369.
3071. Hueco limestone: Same as U.S.N.M. 712g.
3322. Hueco limestone: Same as U.S.N.M. 712.
3323. Hueco limestone: Crest of small hill 1.4 miles east of Orogrande, from center of north line of SW. ¼, SW. ¼, NW. ¼, sect. 25, T. 22 S., R. 9 E., Otero County, New Mexico.
3364. Carlsbad group: 100 yards north of entrance to Carlsbad Caverns National Park, from rubble on slope of cliff to east of road, White's City, New Mexico.

REFERENCES CITED

BATTEN, R. L.
1958. Permian Gastropoda of the southwestern United States, pt. 2. Pleurotomariacea: Portlockiellidae, Phymatopleuridae, and Eotomariidae. Bull. Amer. Mus. Nat. Hist., vol. 114, art. 2, pp. 159–246, 17 figs., pls. 32–42.

BØGGILD, O. B.
1930. The shell structure of the mollusks. Skr. K. Danske Vidensk. Selsk. Skrifter, Naturvidensk. Math. Afhandl., ser. 9, vol. 2, pp. 232–326, pls. 1–15.

BOUCOT, A. J.
1953. Life and death assemblages among fossils. Amer. Jour. Sci., vol. 251, no. 1, pp. 25–40; correction, vol. 251, no. 3, p. 248.

BOYD, D. W.
1958. Permian sedimentary facies, central Guadalupe Mountains, New Mexico. Bull. New Mexico Bur. Mines and Min. Resources, no. 49, 100 pp.

BRANSON, C. C.
1930. Paleontology and stratigraphy of the Phosphoria formation. Missouri Univ. Studies, vol. 5, no. 2, pp. 1–99.
1948. Bibliographic index of Permian invertebrates. Mem. Geol. Soc. Amer., no. 26, 1049 pp.

BRANSON, E. B.
1916. The lower Embar of Wyoming and its fauna. Jour. Geol., vol. 24, pp. 639–664.

CHRONIC, H. P.
1952. Molluscan fauna from the Permian Kaibab formation, Walnut Canyon, Arizona. Bull. Geol. Soc. Amer., vol. 63, pp. 95–166, 15 figs., 10 pls., map.

CLIFTON, R. L.
1942. Invertebrate faunas from the Blaine and the Dog Creek formations of the Permian Leonard series. Jour. Paleont., vol. 16, no. 6, pp. 685–699, pls. 101–104.

COMFORT, A.
1957. The duration of life in molluscs. Proc. Malacol. Soc. London, vol. 32, pt. 6, pp. 219–241.

CONRAD, T. A.
1842. Observations on the Silurian and Devonian systems of the United States, with descriptions of new organic remains. Jour. Acad. Nat. Sci. Philadelphia, vol. 8, pp. 228–280, pls. 12–17.

COOPER, G. A., AND ALWYN WILLIAMS
1952. Significance of the stratigraphic distribution of brachiopods. Jour. Paleont., vol. 26, no. 3, pp. 326–337.

COX, E. T.
1857. A description of some of the most characteristic shells, of the principal coal seams in the western basin of Kentucky. Third Rept. Geol. Surv. Kentucky, vol. 3, pp. 566–576, pls. 8–10.

COX, L. R.
1955. Observations on gastropod descriptive terminology. Proc. Malacol. Soc. London, vol. 31, pts. 5–6, pp. 190–202.

DALL, W. H.
1913. Gastropoda. *In* Eastman, Charles R. (ed.), Text-book of paleontology (adapted from the German of Karl A. von Zittel). London, vol. 1, 839 pp.

DELPEY, GENEVIÈVE
1942. Les gastéropodes Permiens du Cambodge. Jour. Conchyl., Paris, vol. 84, pp. 345–369.

EALES, N. B.
1950. Secondary symmetry in gastropods. Proc. Malacol. Soc. London, vol. 28, pts. 4–5, pp. 185–196.

FLEMING, JOHN
1828. A history of British animals, exhibiting the descriptive characters and systematical arrangement of the genera and species of quadrupeds, birds, reptiles, fishes, Mollusca, and radiata of the United Kingdom; including the indigenous, extirpated and extinct kinds, together with periodical and occasional visitants. London.

GEINITZ, H. B.
1866. Die Carbonformation der Dyas in Nebraska. Verhandl. K. Leopoldino-Carolinischen Deutschen Akad. Naturf., vol. 32, xii+92 pp., 5 pls.

GILLULY, JAMES
1956. General geology of central Cochise County, Arizona. Prof. Paper U. S. Geol. Surv., no. 281, 169 pp., 9 text figs., 13 pls.

GIRTY, G. H.
1899. Preliminary report on Paleozoic invertebrate fossils from the region of the McAlester coal field, Indian territory. Ann. Rept. U. S. Geol. Surv., vol. 19, pt. 3, pp. 539–600.
1909a. The Guadalupian fauna. Prof. Paper U. S. Geol. Surv., no. 58, 651 pp., 31 pls.
1909b. Paleontology of the Manzano group. *In* Lee, W. T., and G. H. Girty, The Manzano group of the Rio Grande Valley, New Mexico. Bull. U. S. Geol. Surv., no. 389, pp. 40–141, 12 pls.

1912a. On some new genera and species of Pennsylvanian fossils from the Wewoka formation of Oklahoma. Ann. New York Acad. Sci., vol. 21, pp. 119–156.
1912b. Paleontologic determinations. *In* Boutwell, J. M., Geology and ore deposits of the Park City district, Utah, with contributions by L. H. Woolsey. Prof. Paper U. S. Geol. Surv., no. 77, pl. 7.
1915. Fauna of the Wewoka formation of Oklahoma. Bull U. S. Geol. Surv., no. 544, pp. 5–271, 35 pls.

GRAHAM, ALASTAIR
1957. The molluscan skin with special reference to prosobranchs. Proc. Malacol. Soc. London, vol. 32, pt. 4, pp. 135–143.

GURLEY, W. F. E.
1883. New Carboniferous fossils. Privately printed, Bull. no. 1, pp. 1–9.
1884. New Carboniferous fossils. Privately printed, Bull. no. 2, pp. 1–12.

HALL, JAMES
1847. Descriptions of the organic remains of the lower division of New York system (equivalent of the lower Silurian rocks of Europe). *In* Paleontology of New York. Albany, vol. 1.
1858. Palaeontology of Iowa. Rept. Geol. Surv. Iowa, vol. 1, pt. 2, pp. 473–724, pls. 1–29.

HAYASAKA, ICHIRÔ
1943. On some Permian gastropods from Kinsyôzan, Akasaka-Mat., Gihu Prefecture. Mem. Fac. Sci., Taihoku Imp. Univ., ser. 3, vol. 3, no. 2, pp. 23–48, pls. pls. 1–5.

HAYASAKA, ICHIRÔ, AND SHÔZÔ HAYASAKA
1953. Fossil assemblages of molluscs and brachiopods of unusually large sizes from the Permian of Japan. Proc. Paleont. Soc. Japan, new ser., no. 10, pp. 37–44, pl. 5.

HERRICK, C. L.
1887. A sketch of the geological history of Licking County, accompanying an illustrated catalogue of Carboniferous fossils from Flint Ridge, Ohio. Bull. Sci. Lab. Denison Univ., vol. 2, pp. 5–51, 65–68, pls. 1–5.
1900. The geology of the white sands of New Mexico. Jour. Geol., vol. 8, pp. 112–128.

IMBRIE, JOHN
1956. Biometrical methods in the study of invertebrate fossils. Bull. Amer. Mus. Nat. Hist., vol. 108, art. 2, pp. 211–252.

IREDALE, TOM
1935. Australian cowries. Australian Zool., vol. 8, pt. 2, pp. 96–135, pls. 8–9.

JOHNSTONE, KATHLEEN Y.
1957. Sea treasure, a guide to shell collecting. Boston, 242 pp., ill., 8 pls.

KELLEY, VINCENT C., AND CASWELL, SILVER
1952. Geology of the Caballo Mountains. Univ. New Mexico Publ. Geol., no. 4, 286 pp.

KEYES, C. R.
1894. Paleontology of Missouri, pts. I and II. Missouri Geol. Surv., vol. 4, pp. 1–271, pls. 1–32; vol. 5, pp. 1–266, pls. 33–56.

KING, P. B., AND J. B. KNIGHT
1945. Geology of Hueco Mountains, El Paso and Hudspeth counties, Texas. Prelim. Map Oil and Gas Invest. U. S. Geol. Surv., no. 36 (in two sheets), sheet 2, Stratigraphic sections of upper Paleozoic rocks.

KING, R. H.
1940. The gastropod genus *Euphemites* in the Pennsylvanian of Texas. Jour. Paleont., vol. 14, no. 2, pp. 150–153, pl. 24.

KIRK, EDWIN
1955. Publications by Shumard and McChesney concerning crinoids and other fossils. Univ. Kansas Paleont. Contrib., Echinodermata, art. 2, pp. 1–4.

KITTL, ERNST
1891. Die Gastropoden der Schichten von St. Cassian der Südalpinen Trias., pt. 1. Ann. K. K. Naturhist. Hofsmus., Vienna, vol. 6, pp. 166–262, 11 figs., pls. 1–7.
1895. Die triadischen Gastropoden der Marmolata and vermandter Fundstetter in der weissen Riffkalken Südtirols. Jahrb. K. K. Geol. Reichsanst., vol. 44, pp. 99–182, 12 figs., 6 pls.

KNIGHT, J. B.
1933. The gastropods of the St. Louis, Missouri, Pennsylvanian outlier. V. The Trocho-turbinidae. Jour. Paleont., vol. 7, no. 1, pp. 30–58, pls. 8–12.
1940. Gastropods of the Whitehorse sandstone. *In* Newell, N. D., Invertebrate fauna of the later Permian Whitehorse sandstone. Bull. Geol. Soc. Amer., vol. 51, pp. 261–336, 10 pls.
1941a. Paleozoic gastropod genotypes. Special Papers Geol. Soc. Amer., no. 32, 510 pp., 32 figs., 96 pls.
1941b. Physiological significance of paired tubular prominences in bellerophontids. *In* Moore, R. C., Upper Pennsylvanian gastropods from Kansas. State Geol. Surv. Kansas Bull., no. 38, pp. 156–161, fig. 7.
1942. Four new genera of Paleozoic Gastro-

poda. Jour. Paleont., vol. 16, no. 4, pp. 487–488.
1944. Paleozoic Gastropoda. Assisted by Josiah Bridge. *In* Shimer, H. W., and R. R. Shrock, Index fossils of North America. New York, pp. 437–479, pls. 174–196.
1945. Some new genera of the Bellerophontacea. Jour. Paleont., vol. 19, no. 4, pp. 333–340, pl. 49.
1952. Primitive fossil gastropods and their bearing on gastropod classification. Smithsonian Misc. Coll., vol. 117, no. 13, 56 pp., 2 pls.
1953. Gastropoda. *In* Cooper, G. A., *et al.*, Permian fauna at El Antimonio, western Sonora, Mexico. *Ibid.*, vol. 119, no. 2, pp. 83–91.
1956. New families of Gastropoda. Jour. Washington Acad. Sci., vol. 46, no. 2, pp. 41–42.

KNIGHT, J. B., R. L. BATTEN, AND E. L. YOCHELSON
[In press.] Paleozoic Gastropoda. *In* Treatise on invertebrate paleontology, I, Mollusca. Lawrence, Kansas.

KNIGHT, J. B., AND E. L. YOCHELSON
1958. A reconsideration of the relationships of the Monoplacophora and the primitive Gastropoda. Proc. Malacol. Soc. London, vol. 33, pt. 1, pp. 37–48, pl. 5.

KOKEN, ERNST
1896. Die Leitfossilien. Leipzig.
1925. *In* Perner, Jaroslav, Die Gastropoden des baltischen Untersilurs. Mem. Acad. Sci. Russie, ser. 8, Cl. Phys.-Math., vol. 37, no. 1, pp. 1–326, 44 figs., pls. 1–41.

KONINCK, L. G. DE
1882. Notice sur la famille des Bellerophontidae suivie de la description d'un nouveau genre de cette famille. Ann. Soc. Geol. Belgique, vol. 9, pp. 72–90.
1883. Faune du calcaire carbonifère de la Belgique, 4e partie, Gasteropodes (suite et fin). Ann. Mus. Roy. d'Hist. Nat. Belgique, ser. paleont., vol. 8.

LICHAREW, B. K., AND A. B. NETSCHAJEW
1956. Gastropods from the middle and upper Carboniferous of Fergan, pt. 1. Superfamily Bellerophontacea. Trudy U.S.S.R. Geol. Surv. Inst., new ser., vol. 16, 41 pp., 14 pls. [In Russian.]

MCCHESNEY, J. H.
1860. Descriptions of new species of fossils from the Paleozoic rocks of the western states. Ext. Trans. Chicago Acad. Sci., vol. 1, pp. 1–56. [Kirk, 1955, gives information regarding the true dates of McChesney's publications.]
1868. Descriptions of fossils from the Paleozoic rocks of the western states, with illustrations. Trans. Chicago Acad. Sci., vol. 1, pp. 1–57, pls. 1–9.

M'COY, FREDERICK
1844. A synopsis of the characters of the Carboniferous limestone fossils of Ireland. Dublin.
1851. On some new Silurian Mollusca. Ann. Mag. Nat. Hist., ser. 2, vol. 7, pp. 45–63.

MARWICK, JOHN
1953. Divisions and faunas of the Hokonni system (Triassic and Jurassic). Paleont. Bull., New Zealand Geol. Surv., no. 21, 141 pp., 17 pls.

MEEK, F. B.
1871. A preliminary list of fossils collected by Dr. Hayden in Colorado, New Mexico and California, with brief descriptions of a few of the new species. Proc. Amer. Phil. Soc., vol. 11, pp. 425–431.

MEEK, F. B., AND A. H. WORTHEN
1860. Descriptions of new Carboniferous fossils from Illinois and other western States. Proc. Acad. Nat. Sci. Philadelphia, pp. 447–472.
1866a. Descriptions of invertebrates from the Carboniferous system. Geol. Surv. Illinois, vol. 2, pp. 145–411, pls. 14–20, 23–32.
1866b. Contributions to the paleontology of Illinois and other western states. Proc. Acad. Nat. Sci. Philadelphia, pp. 245–273.

MENKE, C. T.
1828. Synopsis methodica molluscorum generum omnium et specierum earum, quae in museo Menkeano adservantur; cum synonymia critica et novarum specierum diagnosibus. Pyrmont.

MILLER, A. K., AND E. J. PARIZEK
1948. A lower Permian ammonoid fauna from New Mexico. Jour. Paleont., vol. 22, no. 3, pp. 350–358, pls. 56–58.

MILNE-EDWARDS, HENRI
1848. Sur la classification naturelle des mollusques gasteropodes. Ann. Sci. Nat., Paris, ser. 3, vol. 9, pp. 102–112.

MONTFORT, P. D. DE
1808. Conchyliologie systématique, et classification méthodique des coquilles; offrant leurs figures, leur arrangement générique, leurs descriptions caracteristiques, leurs noms; ainsi que leur synonymie en plusieurs langues. Paris, vol. 1, Coquilles univalves, cloisonnée.

MOORE, R. C.
1941. Upper Pennsylvanian gastropods from Kansas. Bull. State Geol. Surv. Kansas, no. 38, pp. 121–164, 7 figs., pls. 1–3.

MUDGE, M. R., AND ELLIS L. YOCHELSON
[MS.] Stratigraphy and paleontology of the uppermost Pennsylvanian and lowermost Permian systems in Kansas. Prof. Paper U. S. Geol. Surv., no. 323.

NEEDHAM, C. E., AND R. L. BATES
1943. Permian type sections in central New Mexico. Bull. Geol. Soc. Amer., vol. 54, no. 11, pp. 1653–1667.

NEWELL, N. D.
1935. Some mid-Pennsylvanian invertebrates from Kansas and Oklahoma, II. Stromatoporoidea, Anthozoa, and Gastropoda. Jour. Paleont., vol. 9, no. 4, pp. 341–355, pls. 33–36.
1949. Phyletic size increase, an important trend illustrated by fossil invertebrates. Evolution, vol. 3, no. 2, pp. 103–124.

NEWELL, N. D., AND BERNHARD KUMMEL, JR.
1942. Lower Eo-Triassic stratigraphy, western Wyoming and southeast Idaho. Bull. Geol. Soc. Amer., vol. 53, no. 6, pp. 937–995.

NEWELL, N. D., AND OTHERS
1953. The Permian reef complex of the Guadalupe Mountains region, Texas and New Mexico. San Francisco, 236 pp., 32 pls.

NORWOOD, J. G., AND HENRY PRATTEN
1855. Notice of fossils from the Carboniferous series of the western states belonging to the genera *Spirifer*, *Bellerophon*, *Pleurotomaria*, *Macrocheilus*, *Natica*, and *Loxonema*, with descriptions of eight new characteristic species. Jour. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 3, pp. 71–77, pl. 9.

PERNER, JAROSLAV
1903. Gasteropodes. *In* Barrande, Joachim, Systeme Silurien du centre de la Bohême, vol. 4. Prague, vol. 1, text, Patellidae and Bellerophontidae, pls. 1–89.

PHILLIPS, JOHN
1836. Illustrations of the geology of Yorkshire, or a description of the strata and organic remains accompanied by a geological map, sections and diagrams, and figures of the fossils. London.

RAASCH, G. O.
1956. The Permian Rocky Mountain group in Alberta. Guidebook Alberta Soc. Petrol. Geol., no. 6, pp. 114–119.

RAY, H. C.
1951. Cowries. Jour. Bombay Nat. Hist. Soc., vol. 49, no. 4, pp. 663–669.

REED, F. R. C.
1944. Brachiopoda and Mollusca from the Productus limestones of the Salt Range. Palaeont. Indica, Mem. Geol. Surv. India, new ser., vol. 23, mem. 2, 596 pp., 65 pls.

RIGBY, J. KEITH
1958. Frequency curves and death relationships among fossils. Jour. Paleont., vol. 32, no. 5, pp. 1007–1009.

SAYRE, A. N.
1930. Fauna of the Drum limestone of Kansas and western Missouri. Univ. Kansas Sci. Bull., vol. 19, no. 8, pp. 75–160, 21 pls.

SCHWEIGGER, A. F.
1820. Handbuch der Naturgeschichte der Skelettlosen ungegliederten Thier. Leipzig, 776 pp.

SHIMER, H. W.
1926. Upper Paleozoic faunas of the Lake Minnewanka section, near Banff, Alberta. Bull. Geol. Surv. Canada, no. 42, pp. 1–84, 8 pls.

SHUMARD, B. F., AND G. C. SWALLOW
1858. Descriptions of new fossils from the Coal Measures of Missouri and Kansas. Trans. St. Louis Acad. Sci., vol. 1, pp. 198–227.

STEHLI, F. G.
1956. Shell mineralogy in Paleozoic invertebrates. Science, vol. 123, no. 3206, pp. 1031–1032.

STEVENS, R. P.
1858. Description of new Carboniferous fossils from the Appalachian, Illinois, and Michigan coal fields. Amer. Jour. Sci., ser. 2, vol. 25, pp. 258–265.

SWALLOW, G. C.
1858. *In* Shumard, B. F., and G. C. Swallow, Descriptions of new fossils from the Coal Measures of Missouri and Kansas. Trans. St. Louis Acad. Sci., vol. 1, pp. 198–227.

TASCH, PAUL
1953. Causes and paleoecological significance of dwarfed fossil marine invertebrates. Jour. Paleont., vol. 27, no. 3, pp. 356–444, 6 figs., pl. 49.

THIELE, J.
1925. Mollusca. *In* Kukenthal, W., Handbuch der Zoologie. Berlin, vol. 5, pp. 1–96.

TRECHMANN, C. T.
1930. *Atlantobellerophon*, a new gastropod

from the Rhaetic of New Zealand. Trans. Proc. New Zealand Inst., vol. 61, pp. 140–143, pl. 25.

ULRICH, E. O., AND W. H. SCOFIELD
1897. The lower Silurian Gastropoda of Minnesota. Final Rept. Minnesota Geol. Surv., vol. 3, pt. 2, pp. 813–1081.

WAAGEN, W. H.
1880. *Productus* limestone fossils. Palaeont. Indica, Mem. Geol. Surv. India, ser. 13, Salt-Range fossils, vol. 1, pt. 2, pp. 73–183, pls. 7–16.

WALTER, J. C., JR.
1953. Paleontology of Rustler formation, Culberson County, Texas. Jour. Paleont., vol. 27, no. 5, pp. 679–702, 3 figs., pls. 70–73.

WARTHIN, A. S., JR.
1930. Micropaleontology of the Wetumka, Wewoka, and Holdenville formations. Bull. Oklahoma Geol. Surv., no. 53, 94 pp.

WEIR, JOHN
1931. The British and Belgian Carboniferous Bellerophontidae. Trans. Roy. Soc. Edinburgh, vol. 56, pt. 3, pp. 786–861, 9 pls.

WELLER, J. MARVIN
1929. On some of Gurley's unfigured species of Carboniferous *Bellerophon*. Trans. Illinois State Acad. Sci., vol. 21, pp. 313–325, pl. 1.
1930. A new species of *Euphemus*. Jour. Paleont., vol. 4, no. 1, pp. 14–21, fig. 1, pl. 2.

WENZ, W.
1938. Gastropoda. *In* Schindewolf, O. H. (ed.), Handbuch der Paläozoologie. Berlin, vol. 6, pt. 1, pp. 1–240.

WHEELER, H. E.
1942. Age of the Rocky Mountain quartzite in southern Alberta. (Abstract.) Bull. Geol. Soc. Amer., vol. 53, no. 12, pt. 2, p. 1839.

WHITE, C. A.
1876. Invertebrate palaeontology of the Plateau province. *Chapter 3 in* Powell, J. W., Report on the geology of the eastern portion of the Uinta Mountains and a region of the county adjacent thereto. U. S. Geol. and Geogr. Surv. of the Territories, pp. 74–135.
1877. Report upon the invertebrate fossils collected in portions of Nevada, Utah, Colorado, New Mexico, and Arizona by parties of the expeditions of 1871, 1872, 1873, and 1874. U. S. Geol. and Geogr. Surv. West of 100th Merid., vol. 4, pt. 1, 219 pp., 21 pls.
1881. Report on the Carboniferous invertebrate fossils of New Mexico. *Ibid.*, vol. 3, suppl. append., pp. i–xxxviii, pls. 3–4.
1882. Fossils of the Indiana rocks. Eleventh Ann. Rept. Dept. Geol. and Nat. Hist. Indiana, pp. 347–402, pls. 37–43.
1891. The Texas Permian and its Mesozoic types of fossils. Bull. U. S. Geol. Surv., no. 77, 51 pp., 4 pls.

WHITFIELD, R. P.
1882. On the fauna of the lower Carboniferous limestones of Spergen Hill, Ind., with a revision of the descriptions of its fossils hitherto published, and illustrations of the species from the original type series. Bull. Amer. Mus. Nat. Hist., vol. 1, art. 5, pp. 39–97, pls. 6–9.

WORTHEN, A. H.
1884. Descriptions of two new species of Crustacea, 51 species of Mollusca, and three species of crinoids from the Carboniferous formation of Illinois and adjacent states. Bull. Illinois State Mus. Nat. Hist., no. 2, pp. 1–27.
1890. Description of fossil invertebrates. Geol. Surv. Illinois, vol. 8, pp. 69–154, pls. 9–14, 18–28.

YIN, T. H.
1932. Gastropoda of the Penchi and Taiyan series of North China. Paleont. Sinica, ser. B., vol. 11, fasc. 2.

YOCHELSON, E. L.
1956. Permian Gastropoda of the southwestern United States. Part 1. Euomphalacea, Trochonematacea, Pseudophoracea, Anomphalacea, Craspedostomatacea, and Platyceratacea. Bull. Amer. Mus. Nat. Hist., vol. 110, art. 3, pp. 173–260, figs. 1–4, pls. 9–24.

YOCHELSON, E. L., AND J. T. DUTRO, JR.
1960. Late Paleozoic Gastropoda from northern Alaska. Prof. Paper U. S. Geol. Surv., no. 334-D, pp. 111–147, figs. 23–29, pls. 12–14.

YONGE, C. M.
1947. The pallial organs in the aspidobranch gastropods and their evolution throughout the Mollusca. Phil. Trans. Roy. Soc. London, ser. B, biol. sci., vol. 232, pp. 443–528.

PLATES 46–57

PLATE 46

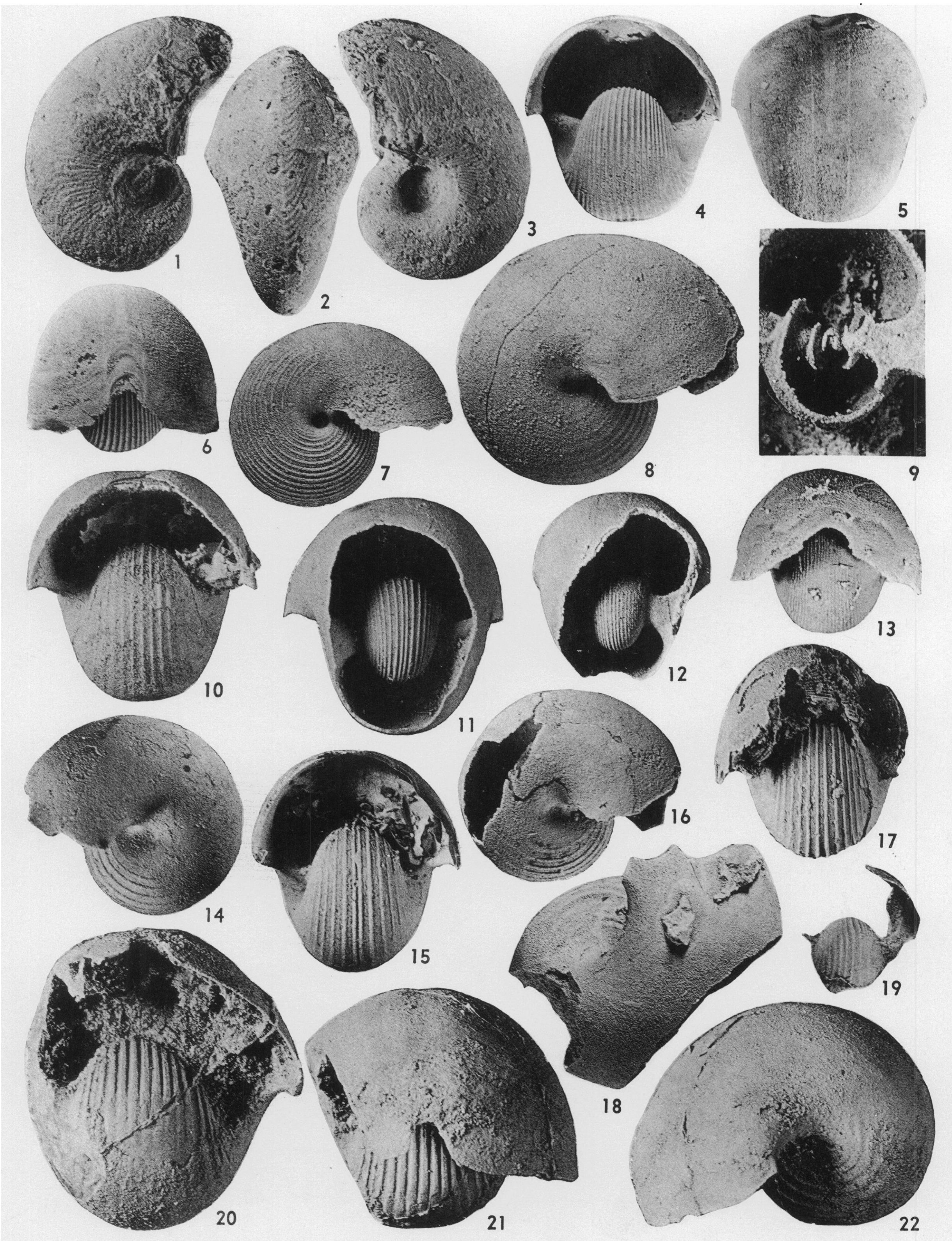
1–3. *Sinuitina keytei* Yochelson, new species. 1. Right side view, holotype, U.S.G.S. 6694, Leonard formation, U.S.N.M. No. 119921. 2. Adapertural view, same specimen. 3. Left side view, same specimen.

4–9. *Euphemites exquistus* Yochelson, new species. 4. Apertural view, holotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119922. 5. Adapical view, same specimen. 6. Anterior view, same specimen. 7. Right side view of paratype showing minute umbilicus, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119923a. 8. Right side view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119923b. 9. View of broken paratype showing early whorls, U.S.G.S. 14439, Bone Spring limestone, U.S.N.M. No. 119924a.

10–17. *Euphemites batteni* Yochelson, new species. 10. Apertural view of paratype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119925a. 11. Adapertural view of paratype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119925b. 12. Adapertural view of paratype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28184:1. 13. Anterior view of paratype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28184:2. 14. Left side view of holotype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28184. 15. Apertural view, same specimen. 16. Right side view, same specimen. 17. Apertural view, U.S.N.M. 707e, Word formation, U.S.N.M. No. 119926a.

18–22. *Euphemites imperator* Yochelson, new species. 18. Left side view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119927a; see also plate 48, figure 27. 19. Apertural view of paratype, U.S.G.S. 14439, Bone Spring limestone, U.S.N.M. No. 119928. 20. Apertural view of holotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119929. 21. Anterior view, same specimen. 22. Left side view, same specimen.

18–22 are natural size; 1–8, 10, 11, and 14–17 are twice natural size; 12 and 13 are three times natural size; 9 is four times natural size.



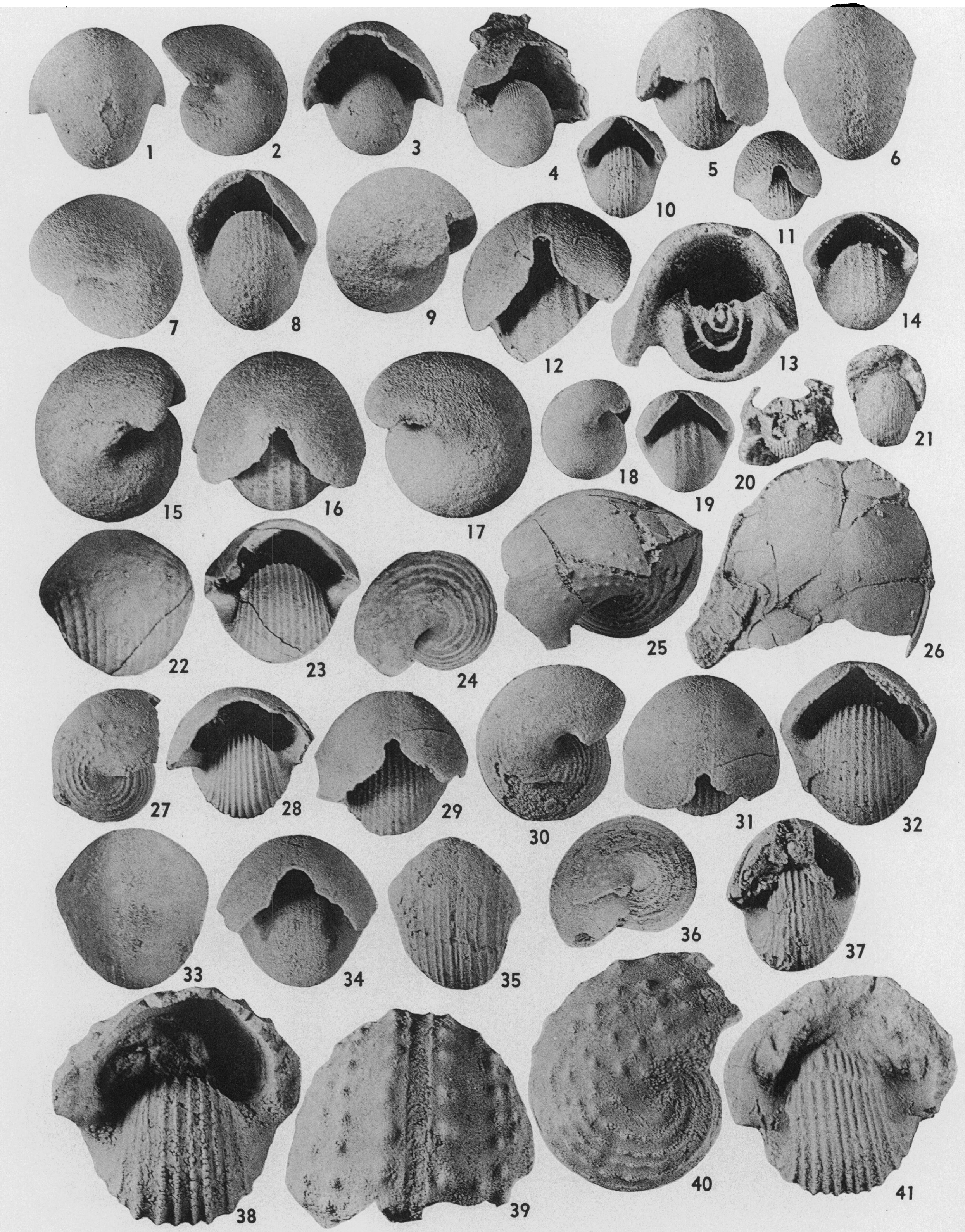

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41

PLATE 47

1–4. *Euphemites luxuriosus* Yochelson, new species. 1. Adapertural view of holotype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119930. 2. Left side view, same specimen. 3. Apertural view, same specimen. 4. Slightly oblique apertural view of paratype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119931a.

5–11. *Euphemites kingi* Yochelson, new species. 5. Anterior view of holotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119932. 6. Adapertural view, same specimen. 7. Left side view, same specimen. 8. Apertural view, same specimen. 9. Right side view, same specimen. 10. Apertural view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119933a. 11. Anterior view, same specimen.

12–19. *Euphemites sparciliratus* Yochelson, new species. 12. Apertural view of paratype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119334a. 13. Interior view of broken paratype showing early whorls, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119334b. 14. Apertural view of paratype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28185:1. 15. Right side view of holotype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28185. 16. Anterior view, same specimen. 17. Left side view, same specimen. 18. Right side view of paratype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28185:2. 19. Apertural view, same specimen.

20, 21. *Euphemites* species. 20. Adapertural view, U.S.N.M. 707h, Wolfcamp formation, U.S.N.M. No. 119935. 21. Apertural view, U.S.N.M. 706x, Wolfcamp formation, U.S.N.M. No. 119936a.

22–28. *Euphemites crenulatus* Yochelson, new species. 22. Adapertural view of holotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119937. 23. Apertural view of same specimen. 24. Left side view of same specimen. 25. Left side view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119938a. 26. Anterior view, same specimen; note crescent-shaped end of slit. 27. Right side view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119938b. 38. Apertural view, same specimen.

29–34. *Euphemites aequisulcatus* H. P. Chronic. 29. Anterior view of hypotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119939. 30. Right side view, same specimen. 31. Anterio-adapertural view, same specimen. 32. Apertural view, same specimen. 33. Posterior view of hypotype, U.S.N.M. 703c, Word formation, U.S.N.M. No. 119940. 34. Anterior view, same specimen.

35–37. *Euphemitopsis* species. 35. Adapertural view, A.M.N.H. 369, Bone Spring limestone, A.M.N.H. No. 28186. 36. Left side view, same specimen. 37. Apertural view, same specimen.

38–41. *Euphemitopsis paucinodosa* Yochelson, new species. 38. Apertural view of holotype, U.S.N.M. 707q, Leonard formation, U.S.N.M. No. 119941. 39. Anterio-adapertural view, same specimen. 40. Right side view, same specimen. 41. Apertural view of paratype, U.S.N.M. 707q, Leonard formation, U.S.N.M. No. 119942a.

20, 21, 23–28, and 35–37 are natural size; 1–11, 18, 19, 29–34, and 38–40 are twice natural size; 12, 15–17, and 41 are three times natural size; 13 and 14 are four times natural size; 22 is six times natural size.

PLATE 48

1–12. *Euphemitopsis multinodosa* Yochelson, new species. 1. Anterior view of paratype, U.S.N.M. 712c, Hueco limestone, U.S.N.M. No. 112117. 2. Left side view, same specimen. 3. Apertural view, same specimen. 4. Apertural view of paratype, B.E.G. 199-T2-1.3A13, Clyde formation, B.E.G. No. 13655. 5. Apertural view of paratype B.E.G. 199-T2-1.3A13, Clyde formation, B.E.G. No. 13654. 6. Adapertural view, same specimen. 7. Apertural view of paratype, B.E.G. 199-T2-1.3A13, Clyde formation, B.E.G. No. 13652. 8. Anterior view of paratype, B.E.G. 199-T2-1.3A13, Clyde formation, B.E.G. No. 13655. 9. Left side view of holotype, B.E.G. 199-T2-1.3A12, Clyde formation, B.E.G. No. 13652. 10. Apertural view, same specimen. 11. Adapertural view, same specimen. 12. Anterio-adapertural view, same specimen.

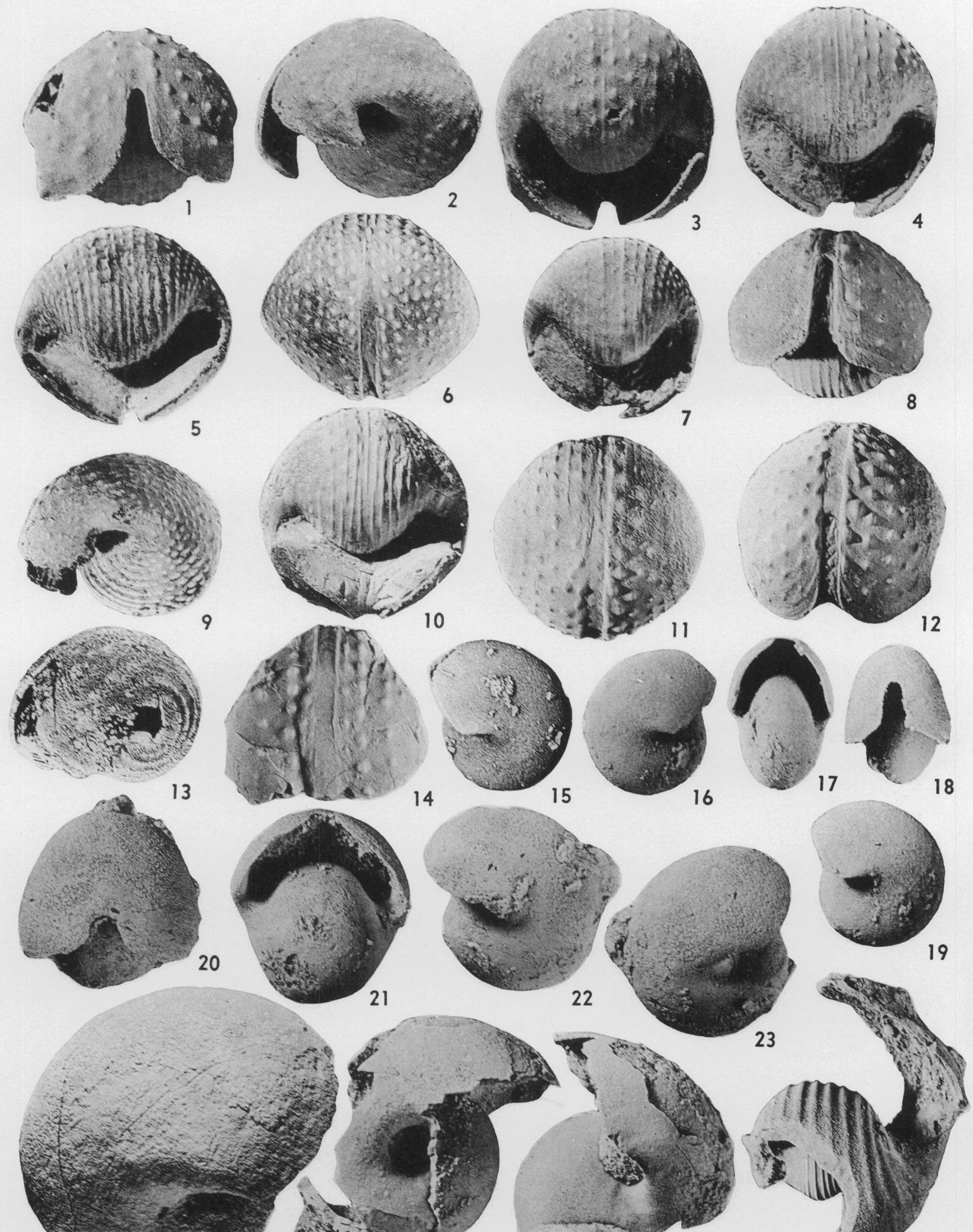
13, 14. *Euphemitopsis subpapillosa* (White). 13. Oblique left side view of hypotype, U.S.G.S. 15784, Yeso formation, U.S.N.M. No. 119977. 14. Anterio-adapertural view of hypotype, U.S.G.S. 3742 green, San Andres formation, U.S.N.M. No. 119978.

15–19. *Warthia fissus* Yochelson, new species. 15. Left side view of holotype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28189. 16. Right side view, same specimen. 17. Apertural view, same specimen. 18. Anterior view, same specimen. 19. Left side of paratype. A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28789:1.

20–26. *Warthia welleri* Yochelson, new species. 20. Anterior view of holotype, A.M.N.H. 503, Word formation, A.M.N.H. No. 28187. 21. Apertural view, same specimen. 22. Left side view, same specimen. 23. Right side view, same specimen. 24. Right side view of paratype, U.S.N.M. 703b, Leonard formation, U.S.N.M. No. 119979a. 25. Right side view of paratype, U.S.N.M. 702, Leonard formation, U.S.N.M. No. 119980a; note pseudo-umbilicus formed by exfoliation of shell layers. 26. Left side view, same specimen.

27. *Euphemites imperator* Yochelson, new species, apertural view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119927a; see also plate 46, figure 18.

20–27 are natural size; 1–14 are twice natural size; 15–18 are three times natural size; 19 is four times natural size.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

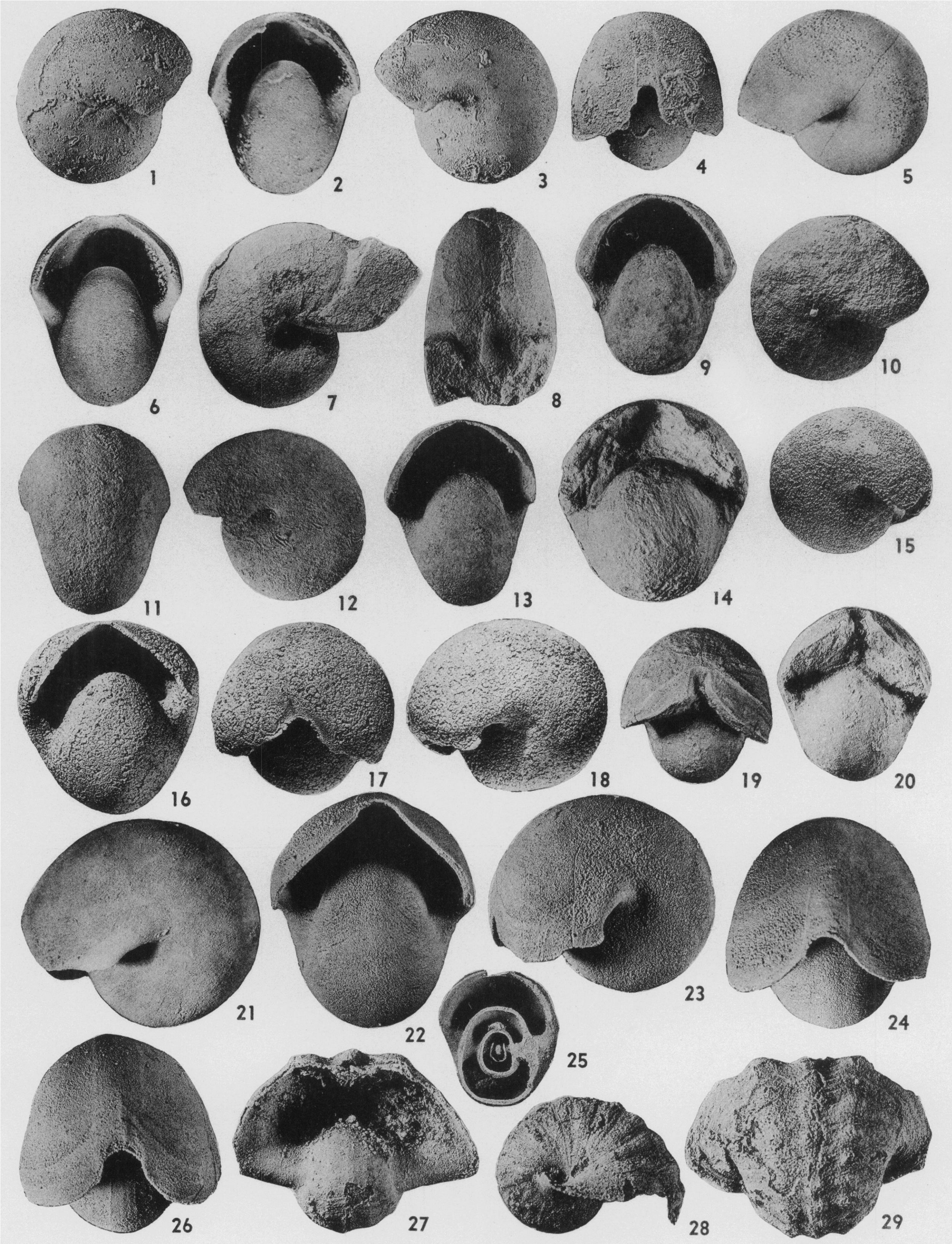

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

PLATE 49

1–6. *Warthia angustior* Yochelson, new species. 1. Right side view of holotype, P.U. 3, Bone Spring limestone. U.S.N.M. No. 119949. 2. Apertural view, same specimen. 3. Left side view, same specimen. 4. Anterior view, same specimen. 5. Left side view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119950. 6. Apical view, same specimen.

7, 8. *Warthia? americana* Girty. 7. Right side view of lectotype, U.S.G.S. 2931 green, probably Brushy Canyon formation, U.S.N.M. No. 118365a. 8. Anterior view, same specimen; note impression of slit on steinkern.

9–13. *Warthia saundersi* Yochelson, new species. 9. Apical view of paratype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119951a. 10. Right side view, same specimen. 11. Adapertural view of holotype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119952. 12. Left side view, same specimen. 13. Apertural view, same specimen.

14–20. *Warthia crassus* Yochelson, new species. 14. Anterior view of paratype, U.S.G.S. 9802, Admiral formation, U.S.N.M. No. 112502a. 15. Right side view of paratype, U.S.G.S. 11393, Colina limestone, U.S.N.M. No. 119953. 16. Apertural view of holotype, U.S.G.S. 9854, Clyde formation, U.S.N.M. No. 112501. 17. Anterior view, same specimen. 18. Left side view, same specimen. 19. Anterior view of paratype, U.S.G.S. 9802, Admiral formation, U.S.N.M. No. 112502. 20. Apertural view, same specimen.

21–26. *Warthia waageni* Yochelson, new species. 21. Left side view of holotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119954. 22. Apertural view, same specimen. 24. Anterior view, same specimen. 23. Left side view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119955a. 25. Cross section of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119955b. 26. Anterior view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119955a.

27–29. *Bellerophon* (*Pharkidonotus*) species. 27. Anterior view, U.S.N.M. 707e, Word formation, U.S.N.M. No. 119956a. 28. Right side view, same specimen. 29. Adapertural view, same specimen.

26 is natural size; 15 is one and one-half times natural size; 1–14, 16–25, and 27–29 are twice natural size.

PLATE 50

1–9, 11, 12. ***Bellerophon (Bellerophon) kingorum*** Yochelson, new species. 1. Right side view of paratype, U.S.N.M. 707e, Word formation, U.S.N.M. No. 119444a. 2. Apertural view, same specimen. 3. Adapertural view, same specimen. 4. Right side view of paratype, U.S.N.M. 707e, Word formation, U.S.N.M. No. 119944b. 5. Anterior view, same specimen. 6. Apertural view, same specimen. 7. Anterior view of holotype, U.S.N.M. 706e, Word formation, U.S.N.M. No. 119943. 8. Adapertural view, same specimen. 9. Right side view, same specimen. 11. Apertural view of paratype, U.S.N.M. 706, Word formation, U.S.N.M. No. 119945a. 12. Oblique adapertural view, same specimen.

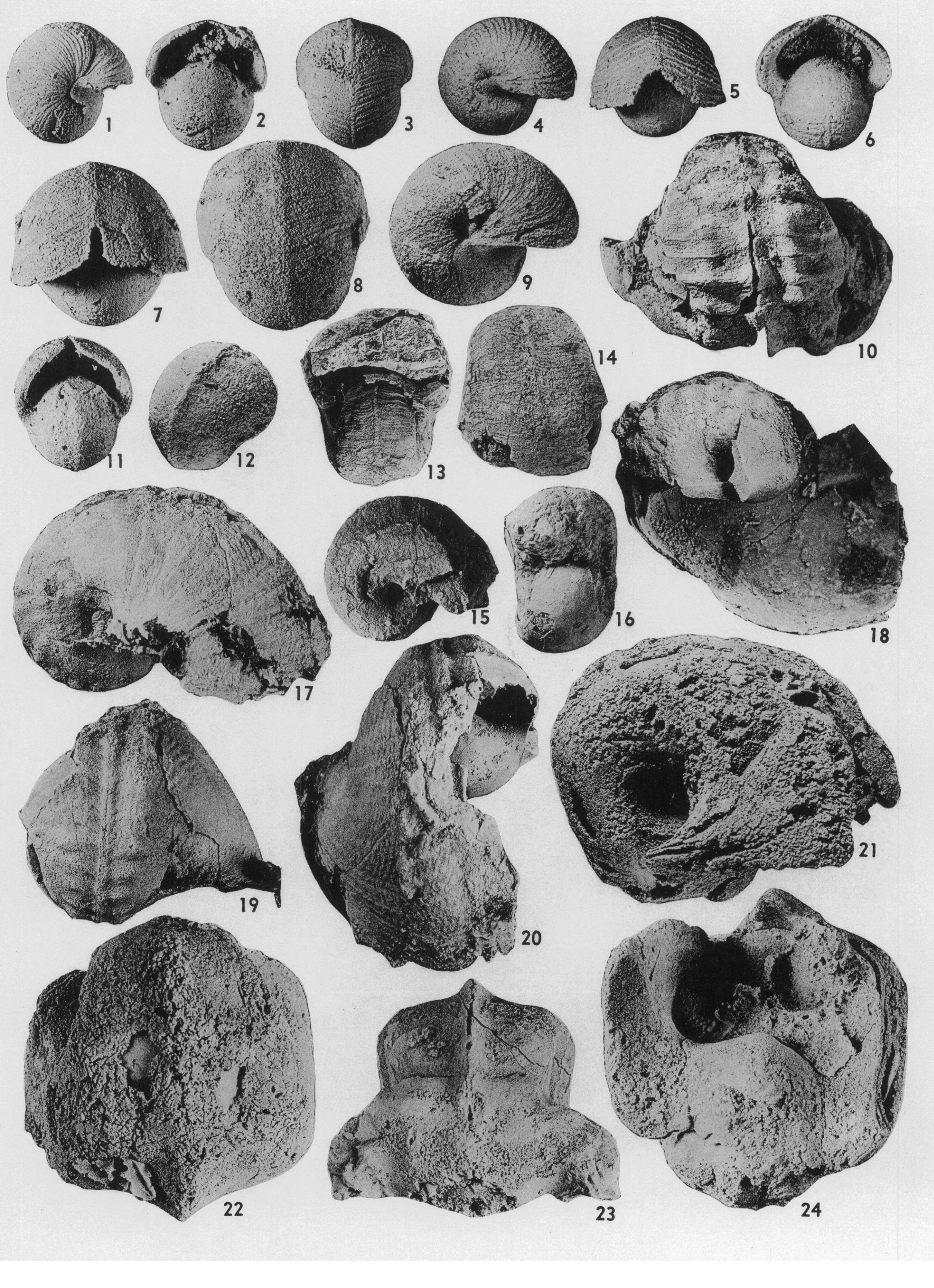
10. ***Bellerophon (Pharkidonotus)*** species, adapertural view, U.S.G.S. 9800, Admiral formation, U.S.N.M. No. 114260.

13–16. ***Bellerophon (Bellerophon) complanatus*** Yochelson, new species. 13. Apertural view of holotype, U.S.G.S. 9800, Admiral formation, U.S.N.M. No. 112548. 14. Adapertural view, same specimen. 15. Right side view, same specimen. 16. Apertural view of slightly crushed paratype, U.S.G.S. 9802, Admiral formation, U.S.N.M. No. 112549.

17–20. ***Bellerophon (Pharkidonotus) westi*** Yochelson, new species. 17. Right side view of holotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119946. 18. Left side view showing inductura, same specimen. 19. Posterior view, same specimen. 20. Adapertural view, same specimen.

21–24. ***Bellerophon (Pharkidonotus?)*** species. 21. Right side view, A.M.N.H. 503, Word formation, A.M.N.H. No. 28188. 22. Adapertural view, same specimen. 23. Anterior view of broken specimen, showing inductura, U.S.N.M. 703, Word formation, U.S.N.M. No. 119448. 24. Apertural view, A.M.N.H. 503, Word formation, A.M.N.H. No. 28188.

18–24 are natural size; 11–16 are twice natural size; 7–9 are three times natural size; 1–6 are four times natural size.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

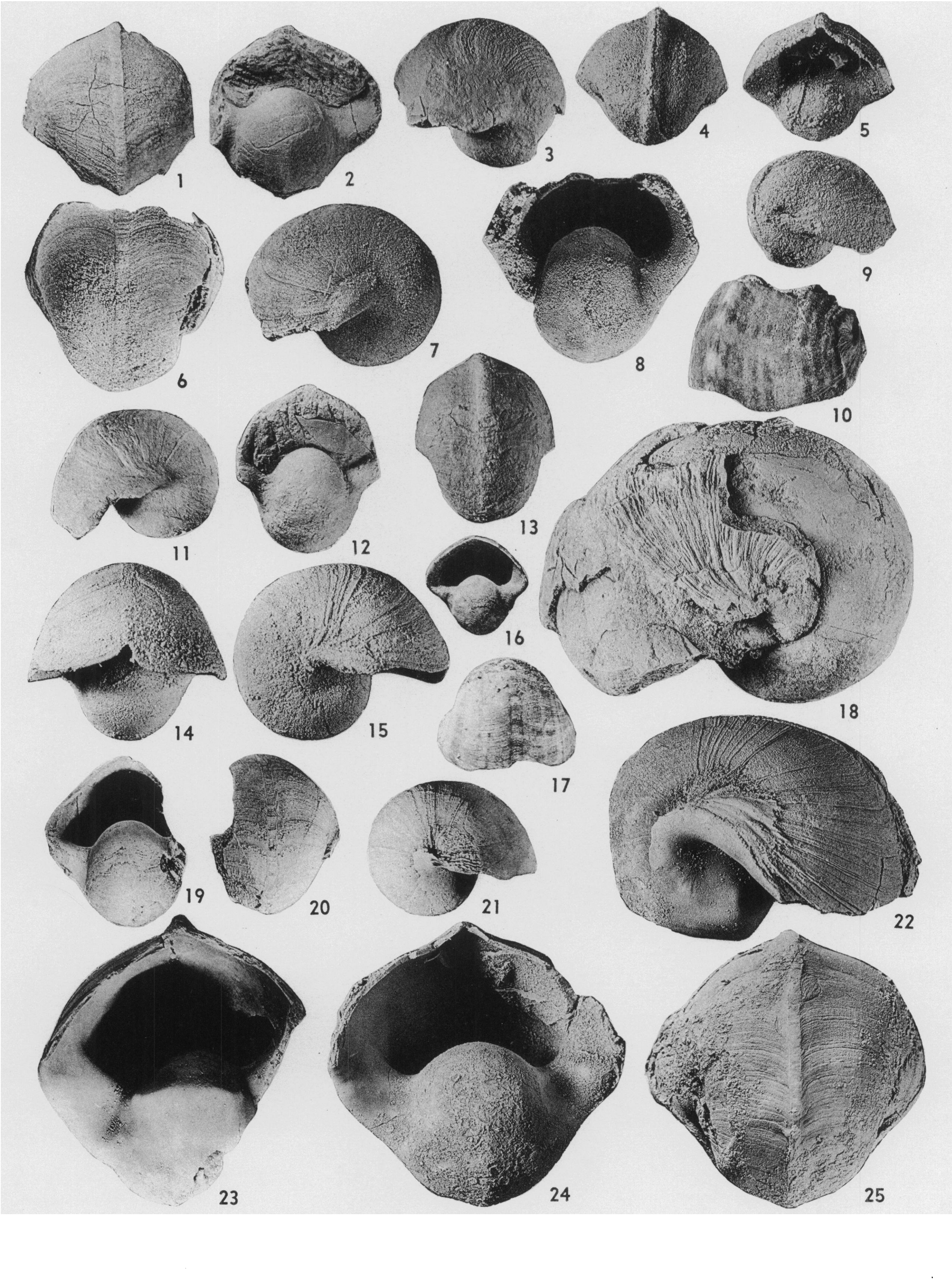

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

PLATE 51

1–9, 11–13, 18. *Bellerophon* (*Bellerophon*) *parvicristus* Yochelson, new species. 1. Adapertural view of holotype, U.S.G.S. 9802, Admiral formation, U.S.N.M. No. 112540. 2. Apertural view, same specimen. 3. Left side view, same specimen. 4. Adapertural view, U.S.G.S. 17394, Colina limestone, U.S.N.M. No. 119994a. 5. Apertural view, same specimen. 6. Adapertural view of paratype, U.S.N.M. 712a, Hueco limestone, U.S.N.M. No. 112544. 7. Left side view, same specimen. 8. Apertural view, same specimen. 9. Right side view, U.S.G.S. 17394, Colina limestone, U.S.N.M. No. 119994a. 11. Left side view of paratype, U.S.G.S. 9863, Clyde formation, U.S.N.M. No. 112542. 12. Apertural view, same specimen. 13. Adapertural view, same specimen. 18. Left side view of paratype, U.S.G.S. 6724, Hueco limestone, U.S.N.M. No. 119995.

10, 14–17, 19–25. *Bellerophon* (*Bellerophon*) *deflectus* H. P. Chronic. 10. Oblique view of fragment of hypotype, showing ornament on selenizone and lateral slope, U.S.G.S. 14439, Bone Spring limestone, U.S.N.M. No. 119996a. 14. Anterior view of hypotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119997a. 15. Right side view, same specimen. 16. Apertural view of hypotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119997b. 17. Adapertural view of same specimen, showing color markings. 19. Apertural view of hypotype, U.S.N.M. 703c, Word formation, U.S.N.M. No. 119998. 20. Adapertural view, same specimen. 21. Right side view, same specimen. 22. Right side view of hypotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119997c. 23. Apertural view, same specimen. 24. Apertural view of hypotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119997d. 25. Adapertural view, same specimen.

1–5, 9, 10, 16, and 18–25 are natural size; 17 is one and one-half times natural size; 6–8, and 11–15 are twice natural size.

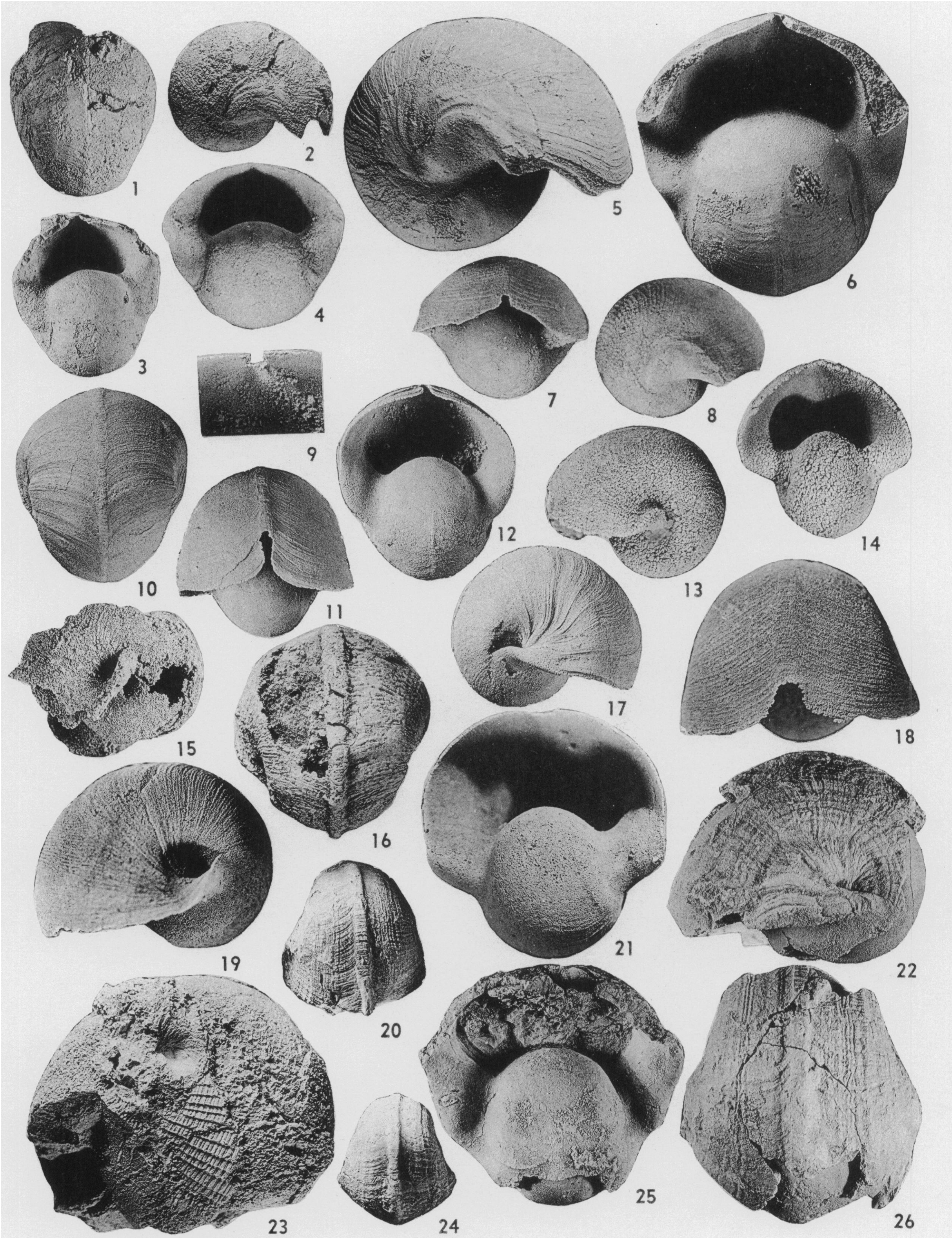
PLATE 52

1–8. *Bellerophon* (*Bellerophon*) *plummeri* Yochelson, new species. 1. Adapertural view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119999a. 2. Right side view, same specimen. 3. Apertural view, same specimen. 4. Apertural view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119999b. 5. Right side view of holotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 120000. 6. Apertural view, same specimen. 7. Apertural view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119999b. 8. Right side view, same specimen.

9–19, 21. *Bellerophon* (*Bellerophon*) *huecoensis* Yochelson, new species. 9. Enlargement of apertural interior of holotype, showing thinning of shell near start of the slit, U.S.N.M. 712g, Hueco limestone, U.S.N.M. No. 115197. 10. Adapertural view, same specimen. 11. Anterior view, same specimen. 12. Apertural view, same specimen. 13. Left side view of paratype, U.S.N.M. 712, Hueco limestone, U.S.N.M. No. 115225. 14. Apertural view, same specimen. 15. Left side view of paratype, U.S.N.M. 717, Hueco limestone, U.S.N.M. No. 120001a. 16. Adapertural view of paratype, U.S.G.S. 8526, Colina limestone, U.S.N.M. No. 120002a. 17. Right side view, U.S.N.M. 712g, Hueco limestone, U.S.N.M. No. 115197. 18. Anterior view of paratype, U.S.N.M. 712g, Hueco limestone, U.S.N.M. No. 115221. 19. Left side view, same specimen. 21. Apertural view, same specimen.

20, 22–26. *Bellerophon* (*Bellerophon*) *lineatus* Yochelson, new species. 20. Adapertural view of paratype, B.E.G. 119-T5-1.3A15, Clyde formation, B.E.G. No. 13661. 22. Left side view of holotype, B.E.G. 199-T5-1.3A15, Clyde formation, B.E.G. No. 13659. 23. Slightly oblique left side view of specimen tentatively referred to the species, U.S.N.M. 715a, Leonard formation, U.S.N.M. No. 120003a. 24. Adapertural view of paratype, B.E.G. 199-T7-P19-1.3A15, Clyde formation, B.E.G. No. 13666. 25. Adapertural view of holotype, B.E.G. 199-T5-1.3A15, Clyde formation, B.E.G. No. 13659. 26. Apertural view of paratype, B.E.G. 199-T2-Q21-1.3A14, Clyde formation, B.E.G. No. 13660.

1–3, 10–12, 15–17, and 21–26 are natural size; 4–9 and 20 are twice natural size; 13, 14, 18, 19, and 21 are three times natural size.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26

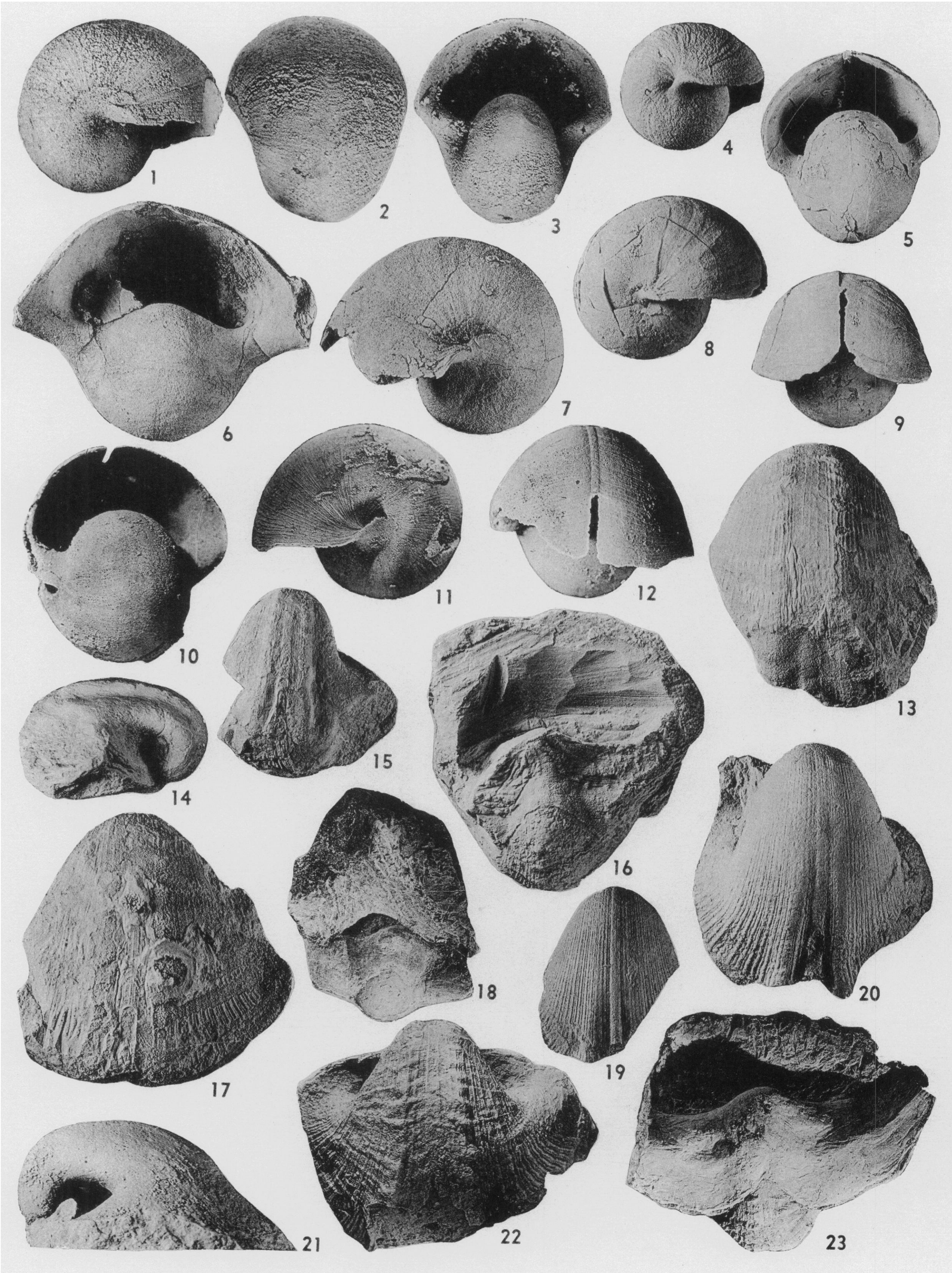

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

PLATE 53

1–9. *Bellerophon* (*Bellerophon*) *hilli* Yochelson, new species. 1. Right side view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119960a. 2. Adapertural view, same specimen. 3. Apertural view, same specimen. 4. Right side view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119960a. 5. Apertural view of holotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119961. 6. Apertural view of paratype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119960c. 7. Left side view, same specimen. 8. Right side view of holotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119961. 9. Anterior view, same specimen.

10–12. *Bellerophon* (*Bellerophon*) *oteroensis* Yochelson, new species. 10. Apertural view of holotype, U.S.N.M. 712a, Hueco limestone, U.S.N.M. No. 115227. 11. Left side view, same specimen. 12. Apertural view, same specimen.

13–17. *Knightites* (*Knightites*) *bransoni* Yochelson, new species. 13. Adapertural view of paratype, U.S.N.M. 712i, Hueco limestone, U.S.N.M. No. 119962a. 14. Left side view of paratype, U.S.N.M. 712i, Hueco limestone, U.S.N.M. No. 119962b. 15. Adapertural view, same specimen. 16. Apertural view of holotype, U.S.N.M. 712i, Hueco limestone, U.S.N.M. No. 119963. 17. Adapertural view, same specimen.

18–21. *Patellilabia junior* Yochelson, new species. 18. Apertural view of paratype, U.S.G.S. 9862, Lueders limestone, U.S.N.M. No. 112627. 19. Adapertural view of paratype, B.E.G. 199-R1-L16, Lueders limestone, B.E.G. No. 13670. 20. Adapertural view of holotype, B.E.G. 199-T1-L16, Lueders limestone, B.E.G. No. 13669. 21. Side view of paratype, B.E.G. 199-T16-1.3A17, Lueders limestone, B.E.G. No. 13662.

22, 23. *Knightites* (*Knightites*) *medius* Yochelson, new species. 22. Adapertural view of holotype, U.S.G.S. 9863, Clyde formation, U.S.N.M. No. 115219. 23. Apertural view, same specimen.

6, 7, 14, 15, and 18–23 are natural size; 5, 8–13, 16, and 17 are twice natural size; 4 is three times natural size; 1–3 are four times natural size.

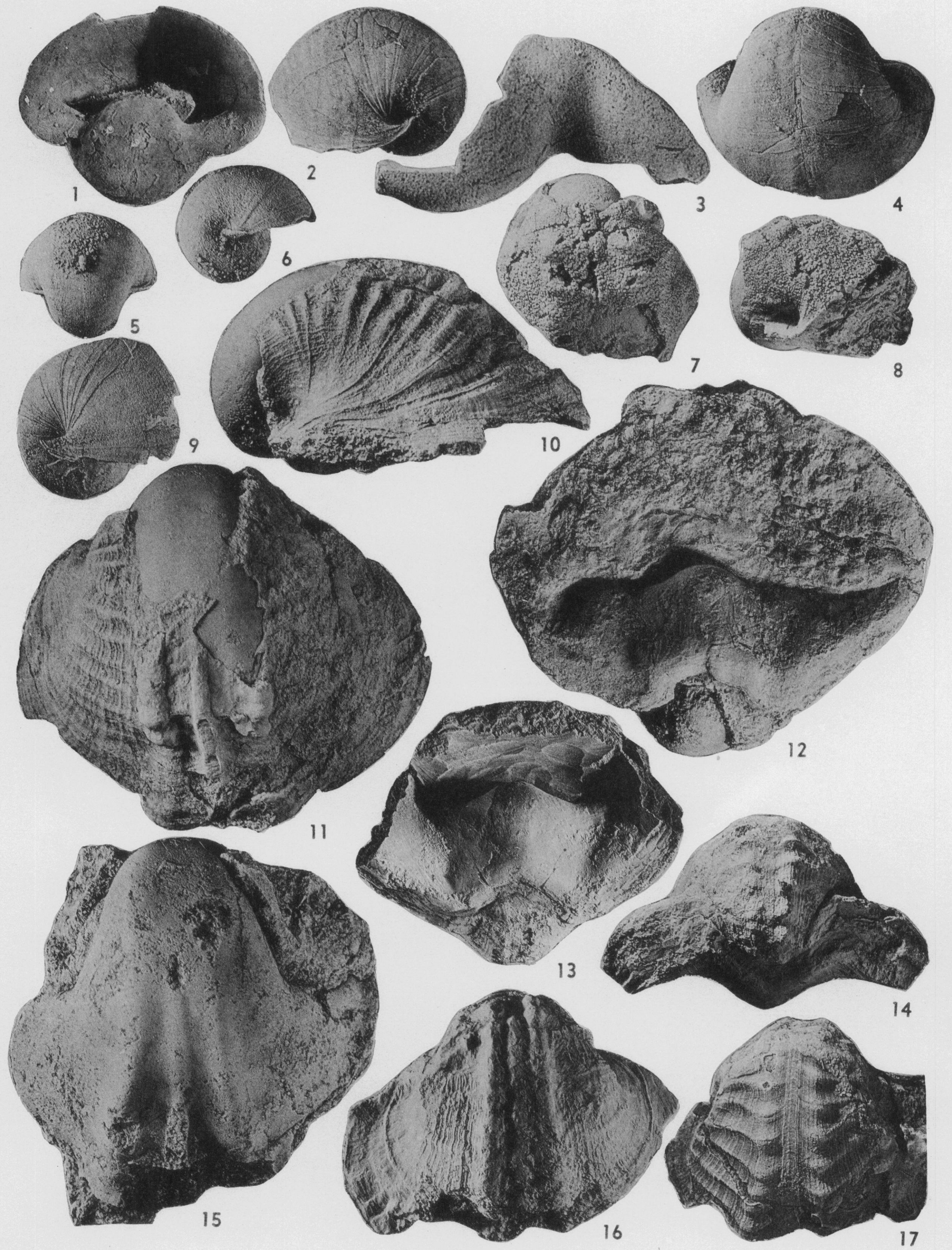
PLATE 54

1–6, 9. *Knightites (Retispira) fragilis* Yochelson, new species. 1. Apertural view of holotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119957. 2. Left side view, same specimen. 3. Interior of aperture of paratype, showing channeling of lateral lip within aperture and large size of mature specimens, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119958a. 4. Adapertural view of holotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119957. 5. Adapertural view of paratype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119958b. 6. Right side view, same specimen. 9. Right side view of holotype, P.U. 3, Bone Spring limestone, U.S.N.M. No. 119957.

7, 8. *Knightites (Knightites)* species. 7. Adapertural view, U.S.N.M. 707q, Leonard formation, U.S.N.M. No. 119959. 8. Right side view, same specimen.

10–17. *Knightites (Knightites) maximus* Yochelson, new species. 10. Right side view of holotype, B.E.G. 199-T2-Q21-1.3A14, Clyde formation, B.E.G. No. 13671. 11. Adapertural view, same specimen. 12. Apertural view, same specimen. 13. Apertural view of paratype, B.E.G. 199-T4-L16, Lueders limestone, B.E.G. No. 13675. 14. Posterior view, same specimen. 15. Adapertural view of paratype, showing trace of slit on steinkern, B.E.G. 199-T7-P19-1.3A15, Clyde formation, B.E.G. No. 13673. 16. Adapertural view of paratype, B.E.G. 199-T13-P33, Clyde formation, B.E.G. No. 13672. 17. Adapertural view of paratype, B.E.G. 199-T7-P19-1.3A15, Clyde formation, B.E.G. No. 13674.

1–4 and 7–15 are natural size; 5, 6, and 16 are twice natural size.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

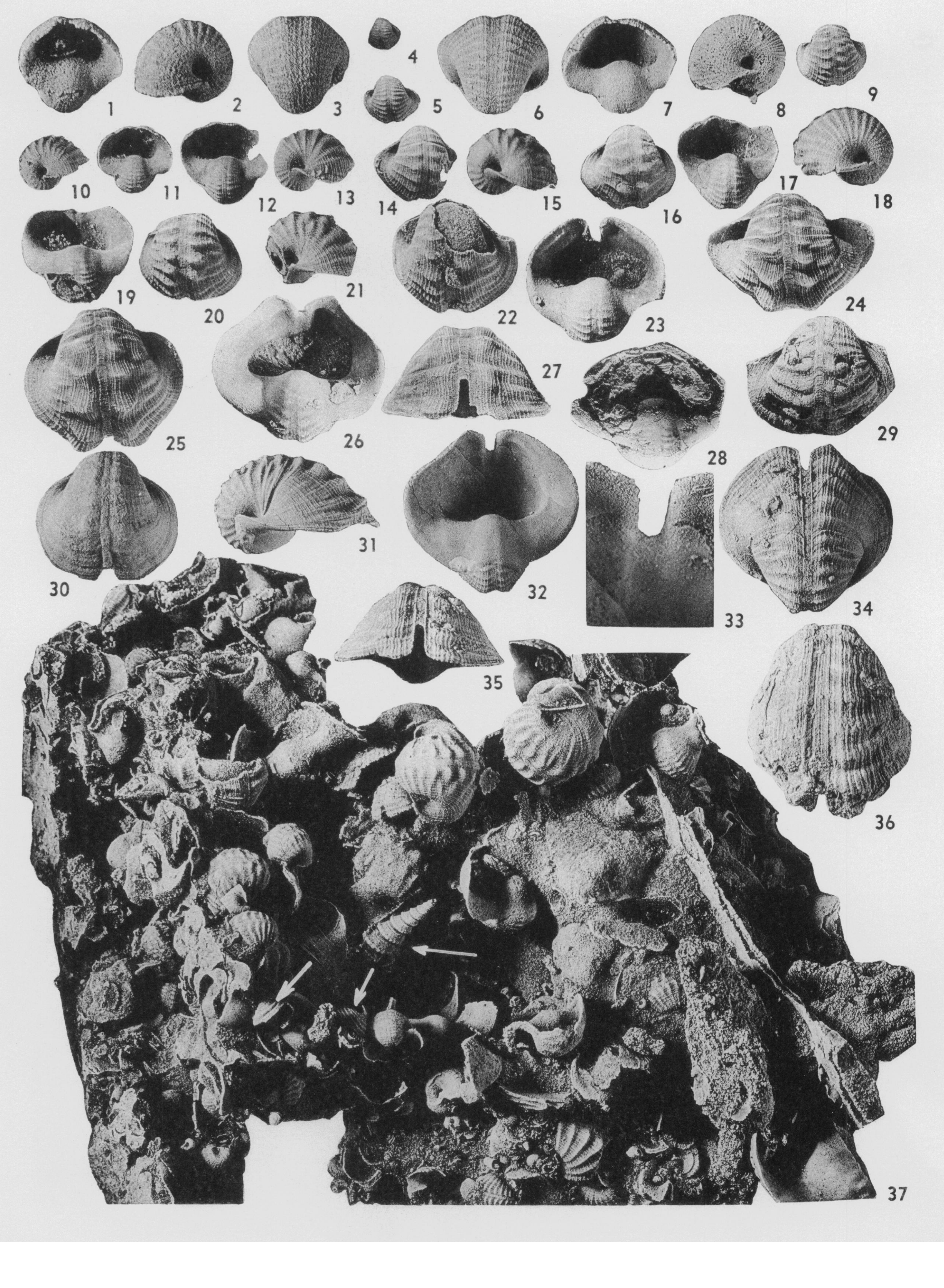

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37

PLATE 55

1–37. *Knightites* (*Retispira*) *eximia* Yochelson, new species. 1. Apertural view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114268f. 2. Left side view, same specimen. 3. Adapertural view, same specimen. 4. Very slightly oblique adapertural view, same specimen. 5. Very slightly oblique adapertural view, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114268e. 6. Adapertural view, same specimen. 7. Apertural view, same specimen. 8. Left side view, same specimen. 9. Adapertural view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114268d. 10. Right side view, same specimen. 11. Apertural view, same specimen. 12. Apertural view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114268c. 13. Right side view, same specimen. 14. Adapertural view, same specimen. 15. Right side view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114268b. 16. Adapertural view, same specimen. 17. Apertural view, same specimen. 18. Left side view, same specimen. 19. Apertural view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114268a. 20. Adapertural view, same specimen. 21. Right side view, same specimen. 22. Adapertural view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114266b. 23. Apertural view, same specimen. 24. Posterio-adapertural view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. 114266a. 25. Adapertural view, same specimen. 26. Apertural view, same specimen. 27. Anterior view, same specimen. 28. Apertural view of paratype, U.S.G.S. 9800, Admiral formation, U.S.N.M. No. 114273. 29. Adapertural view, same specimen. 30. Adapertural view of paratype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114269. 31. Right side view of holotype, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 114265. 32. Apertural view, same specimen. 33. Detail of slit, same specimen. 34. Adapertural view, same specimen. 35. Anterior view, same specimen. 36. Adapertural view of paratype, U.S.N.M., from east of Godwin Creek, Baylor County, Texas, Admiral formation, U.S.N.M. No. 119991. 37. Partially dissolved limestone block, showing random arrangement and lack of sorting of silicified specimens; arrows point to *Euphemites*, *Taosia*, and *Glabrocingulum*, U.S.N.M. 712b, Hueco limestone, U.S.N.M. No. 119992.

4, 5, 9–27, 30–32, 34, 35 and 37 are natural size; 6–8, 28, 29, and 36 are twice natural size; 1–3 and 33 are three times natural size.

PLATE 56

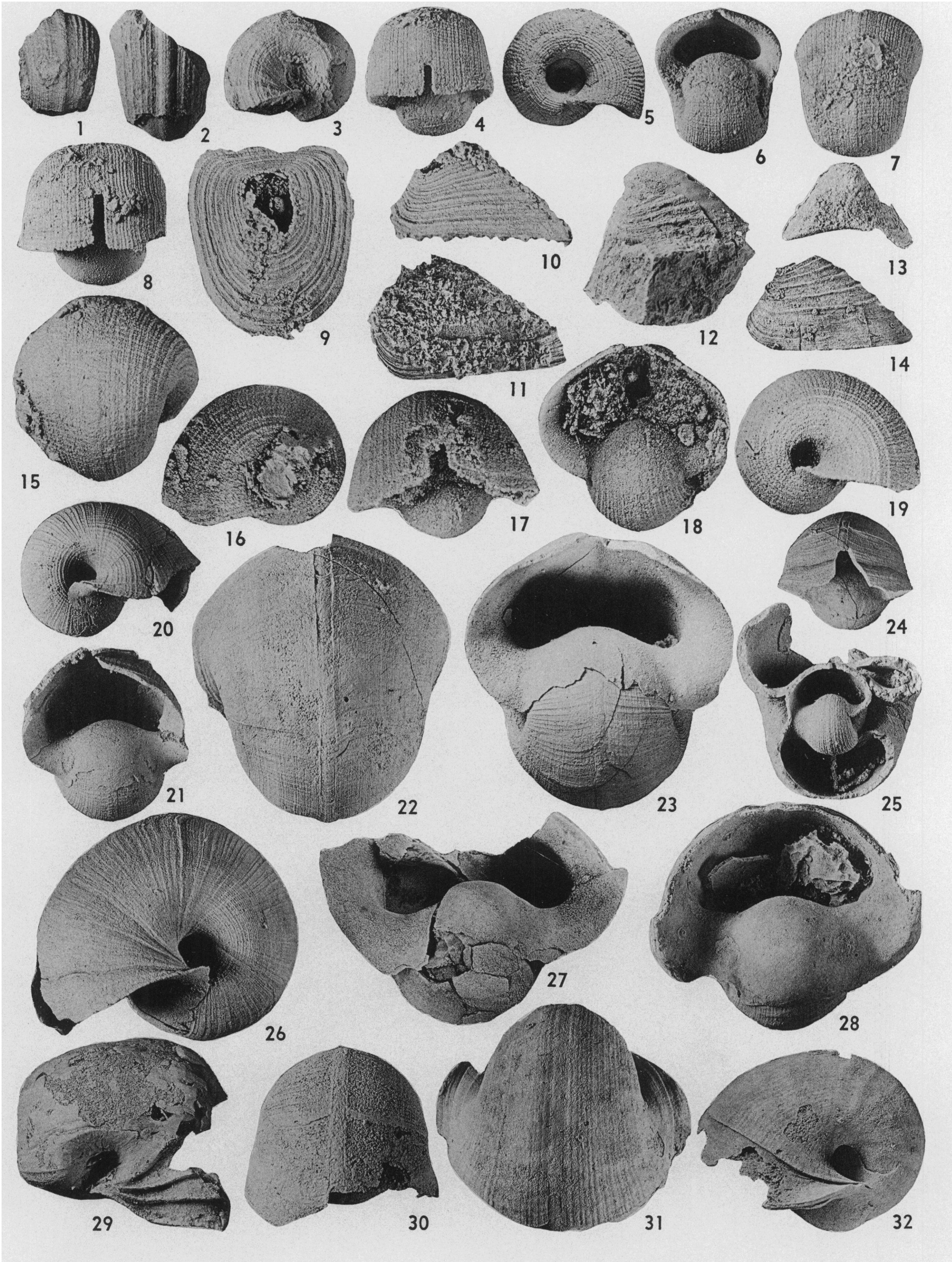
1–3. *Knightites* (*Retispira*) species 2. 1. Adapertural view, U.S.N.M. 3364, Carlsbad group, U.S.N.M. No. 119976a. 2. Adapertural view, U.S.N.M. 3364, Carlsbad group, U.S.N.M. No. 119976b. 3. Left side view, same specimen.

4–8. *Knightites* (*Retispira*) *girtyi* Yochelson, new species. 4. Anterior view of holotype, U.S.N.M. 703b, Leonard formation, U.S.N.M. No. 119965. 5. Right side view, same specimen. 6. Apertural view, same specimen. 7. Adapertural view, same specimen. 8. Anterior view of paratype, A.M.N.H. 369, Bone Spring limestone, A.M.N.H. No. 28190.

9–14. *Metoptoma texana* Yochelson, new species. 9. Apical view of holotype, U.S.N.M. 701k, Wolfcamp formation, U.S.N.M. No. 119967. 10. Right side view, same specimen. 11. Right side view of paratype, showing virtual absence of projecting lamellae, U.S.N.M. 701-l, Wolfcamp formation, U.S.N.M. No. 119968. 12. Side view of paratype, U.S.N.M. 701g, Wolfcamp formation, U.S.N.M. No. 119969. 13. Posterior view of paratype showing curvature of posterior margin and apparent absence of protoconch (the right side of the specimen is broken), U.S.N.M. 701c, Wolfcamp formation, U.S.N.M. No. 119970a. 14. Right side view of paratype, U.S.N.M. 701c, Wolfcamp formation, U.S.N.M. No. 119971b.

15–32. *Knightites* (*Retispira*) *modesta* (Girty). 15. Adapertural view of holotype, U.S.G.S. 3738 green, San Andres formation, U.S.N.M. No. 119809. 16. Left side view, same specimen. 17. Apertural view, same specimen. 18. Apertural view, same specimen. 19. Right side view, same specimen. 20. Right side view of hypotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119971a. 21. Apertural view, same specimen. 22. Adapertural view of hypotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119971b. 23. Apertural view, same specimen. 24. Anterior view, same specimen, showing right anterior lip unbroken. 25. Broken hypotype, showing early whorls, U.S.N.M. 703c, Word formation, U.S.N.M. No. 119973a. 26. Left side view of hypotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119971b. 27. Slightly oblique apertural view of hypotype, showing inductura, U.S.N.M. 703c, Word formation, U.S.N.M. No. 119973a. 28. Apertural view of hypotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119971c. 29. Right side view of hypotype showing several varices, U.S.N.M. 703, Word formation, U.S.N.M. No. 119971d. 30. Posterio-adapertural view of worn hypotype, showing superficial similarity to *Bellerophon*, U.S.N.M. 703, Word formation, U.S.N.M. No. 119971e. 31. Adapertural view of hypotype, U.S.N.M. 703, Word formation, U.S.N.M. No. 119971c. 32. Left side view, same specimen, showing varix.

11, 14, 24, 26–29, 31, and 32 are natural size; 9 and 10 are one and one-half times natural size; 8, 12, 13, 22, 23, 25, 26, and 30 are twice natural size; 2–7, 20, and 21 are three times natural size; 1 and 15–19 are four times natural size.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

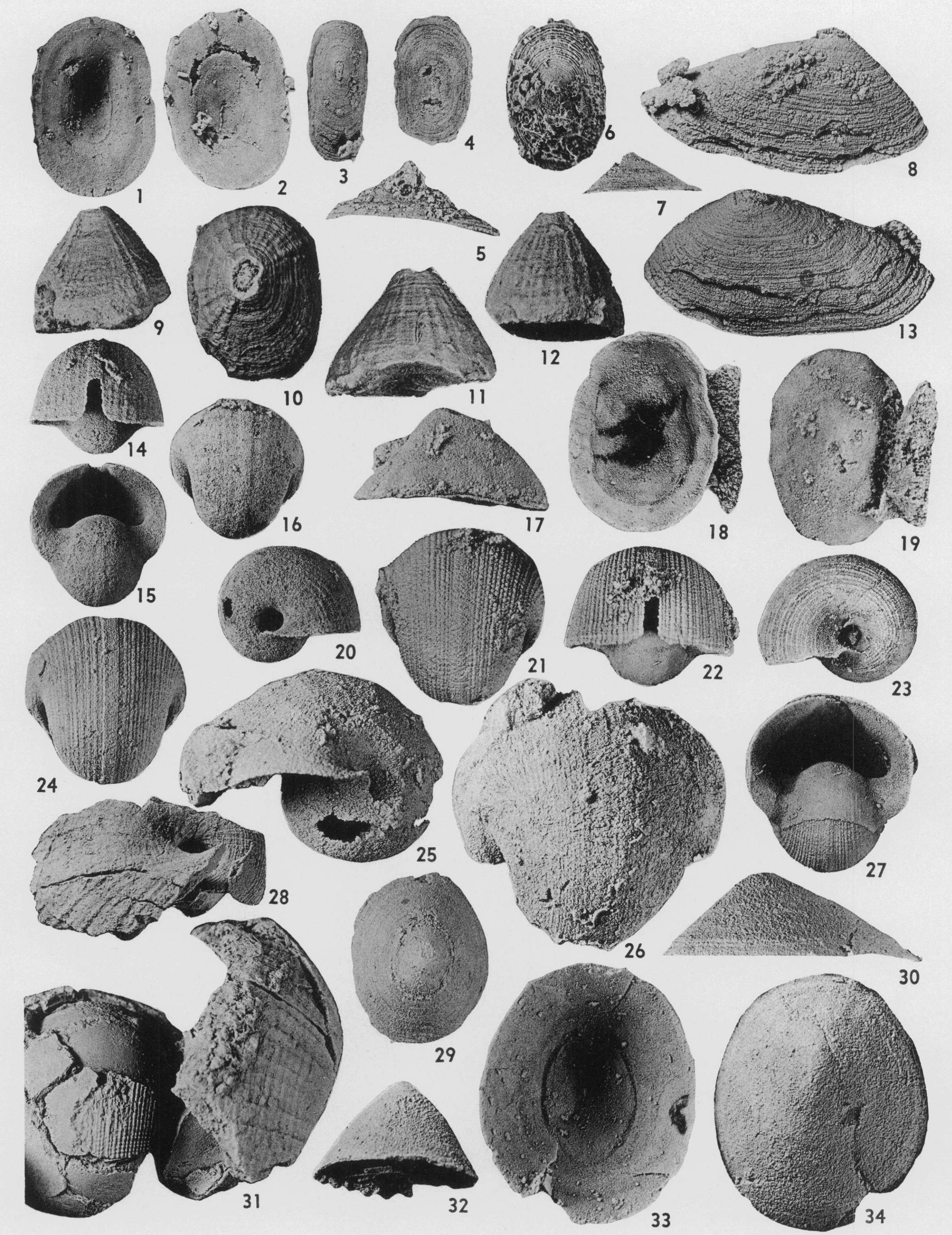

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34

PLATE 57

1, 2, 4–7. *Lepetopsis patella* Yochelson, new species. 1. Interior view of holotype, U.S.N.M. 701g, Wolfcamp formation. U.S.N.M. No. 119982. 2. Interior view of paratype, showing faint muscle scar, U.S.N.M. 701g, Wolfcamp formation, U.S.N.M. No. 119983a. 4. Apical view of paratype, U.S.N.M. 701g, Wolfcamp formation, U.S.N.M. No. 119983b. 5. Left side view of paratype, U.S.N.M. 701g, Wolfcamp formation, U.S.N.M. No. 119983c. 6. Apical view, same specimen. 7. Left side view of paratype, U.S.N.M. 701g, Wolfcamp formation, U.S.N.M. No. 119983b.

3, 8, 13. *Lepetopsis* species 1. 3. Apical view, U.S.N.M. 701g, Wolfcamp formation, U.S.N.M. No. 119984. 8. Right side view, same specimen. 13. Left side view, same specimen.

9–12. *Lepetopsis? capitensis* (Girty). 9. Posterior view of holotype, U.S.G.S. 2966 green, Carlsbad group, U.S.N.M. No. 118345. 10. Apical view, same specimen. 11. Right side view, same specimen. 12. Anterior view, same specimen.

14–16, 20–27. *Knightites* (*Retispira*) *texana* Yochelson, new species. 14. Anterior view of paratype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119985a. 15. Apertural view, same specimen. 16. Adapertural view, same specimen. 20. Right side view, same specimen. 21. Adapertural view of holotype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28191. 22. Anterior view, same specimen. 23. Left side view, same specimen. 24. Adapertural view of paratype, A.M.N.H. 512, Cherry Canyon formation, A.M.N.H. No. 28191:1. 27. Apertural view, same specimen. 25. Left side view of paratype, U.S.N.M. 706c, Word formation, U.S.N.M. No. 119986a. 26. Adapertural view, same specimen.

17–19. *Lepetopsis beedei* Yochelson, new species. 17. Right side view of holotype, U.S.N.M. 728, Cherry Canyon formation, U.S.N.M. No. 119987. 18. Interior view, same specimen. 19. Top view, same specimen.

28, 31. *Knightites* (*Retispira*) species 1. 28. Left side view, U.S.N.M. 707o, U.S.N.M. No. 119988. 31. Adapertural view of same specimen, with part of inductura removed from early whorls to show juvenile ornament.

29, 32. *Lepetopsis* species 2. 29. Apical view, U.S.N.M. 701g, Wolfcamp formation, U.S.N.M. No. 119989. 32. Right side view, same specimen.

30, 33, 34. *Lepetopsis parrishi* Gurley. 30. Left side view of hypotype, U.S.N.M. 716, Bone Spring limestone, U.S.N.M. No. 119990. 33. Interior view, same specimen. 34. Apical view, same specimen.

5, 6, and 28 are natural size; 31 is one and one-half times natural size; 1–4, 7, and 24–27 are twice natural size; 14–16 and 20–23 are three times natural size; 8, 13, 17–19, 29, 30, and 32–34 are four times natural size; 9–12 are six times natural size.