Upper Cretaceous Gastropods From the Pierre Shale at Red Bird, Wyoming

GEOLOGICAL SURVEY PROFESSIONAL PAPER 393-B

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By NORMAN F. SOHL

STRATIGRAPHY, PALEONTOLOGY, AND SEDIMENTATION OF A CLASSIC REFERENCE LOCALITY OF THE PIERRE SHALE

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A discussion of the Pierre Shale gastropod fauna, including a description of 23 named species, occurring in the Red Bird section

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ABSTRACT

The Pierre Shale gastropod faunas show a great similarity at almost all stratigraphic levels over the whole of the western interior, from Colorado and Wyoming eastward to the Dakotas and eastern Montana. The equivalent Bearpaw Shale of Canada and Montana contains the same fauna. Aside from taxonomic uniformity, one consistent feature of the fauna is that the upper stratigraphic levels contain a greater abundance and diversity of gastropods than the lower stratigraphic levels. Compared to the overlying Fox Hills Sandstone there is a significant change, very few species being common to the two formations, and many genera that are common in one formation are absent in the other.

Contrary to published consensus the Pierre Shale gastropod fauna shows considerable similarity to the contemporaneous faunas of the gulf coast. This similarity increases to the south in Colorado, especially in the sandier units, such as the Larimer Sandstone Member of the Pierre Shale of the Front Range of Colorado. As an example, of the 53 gastropod genera represented in the Pierre Shale only 8 are not common to the gulf coast. Some genera, such as *Bullopsis*, *Oligoptycha*, *Belliscala*, *Lomirosa*, *Remera*, *Scobinodolus*, and *Napulus*, are known only from these two areas. In spite of these similarities, genera such as *Turritella* and *Pugnellus*, so common in the Coastal Plain Cretaceous sediments, are absent in the Pierre Shale, although in some nearshore sandier facies, such as the Lewis Shale, they may be abundant.

The gastropod fauna is consistent with a marine shallow-water environment and includes both epifaunal and infaunal elements. Feeding habits range from plant browsers to detritus feeders and carnivores. The absence of filter feeding snails may be a reflection of particle size of the sediment or excessive turbidity.

Gastropods occur through 1,700 feet of the 3,137-foot sequence of Pierre Shale in the Red Bird section. They first appear in the uppermost bed of the Mitten Black Shale Member and range upward to the lower part of the *Baculites grandis* zone beds. They are most abundant and diverse in the upper part of the section, especially in beds of the *Baculites baculus* zone.

In the Red Bird section, 23 distinct gastropod species occur. Several others are assignable only to genera because of poor preservation. Two-thirds of the gastropods belong to the subclass Streptoneura and one-third to the Euthyneura. Although four species are cited as new, only two, *Drepanochilus scotti* and *D. obesus*, are represented by sufficient material to name formally. These two species represent part of an evolving lineage characterized by a change from older to younger species in—

1. The upper whorl carination becoming proportionally closer to the suture,
2. Proportional narrowing of the intercarination area,
3. Progressive development of nodes on the upper body whorl carination, and
4. Loss on inner surface of expanded outer lip wing of a welt that parallels wing edge.

Of special note is the discovery of specimens retaining the muscle-scar pattern in species of the unusual siphonariid pulmonate gastropod *Anisomyon*. Although all retain the basic muscle-scar pattern with an interruption of the band in the right posterior quadrant, the amount of variation in positioning of other parts of the band is high.

Many of the species are figured for the first time since Meek's classic studies (1876); therefore the opportunity has been taken to illustrate photographically most of the type specimens.

INTRODUCTION

The primary purpose of this paper is to redefine, describe, and figure the gastropod species occurring in a complete section of the Pierre Shale in the vicinity of Red Bird, Niobrara County, Wyo. (secs. 13, 14, 23, T. 38 N., R. 62 W.). This work is a part of a larger investigation of the fauna and microflora recovered from the more than 3,000 feet of Pierre Shale at this locality. The detailed stratigraphy and associated problems have been outlined by Gill and Cobban (1966). The stratigraphic nomenclature and faunal zonation used in this paper are defined by the aforementioned authors.

To adequately discuss and define the gastropod species of the Red Bird section it has been necessary to include figures of the type material, most of which has not been figured since the time of Meek (1876). Collections from other areas of outcrop in the Fox Hills Sandstone and Pierre Shale have been studied, and some specimens from these formations have been included herein. The most valuable of these consist of the gastropod portions of more than 1,000 collections, made by W. A. Cobban and associates, from the Pierre Shale of the Front

Range in Colorado. All collections are precisely located stratigraphically and have formed the major basis for defining the total stratigraphic range of the species. Without them the present work could have been little more than an outline taxonomic contribution based on a few specimens.

ACKNOWLEDGMENTS

Grateful acknowledgment is made Dr. Harald Rehder, Division of Mollusks of the U.S. National Museum, who furnished specimens of *Vanikoro* for study and figuring. Dr. N. D. Newell, of the American Museum of Natural History, kindly arranged for the loan of some of the Hall and Meek types. The photographs were made by R. H. McKinney. Type specimens are deposited in the U.S. National Museum.

GENERAL REMARKS ON CRETACEOUS GASTROPODS OF THE WESTERN INTERIOR

Of the larger marine invertebrates in the western interior Cretaceous sequence, more concentrated work has been done on the ammonites than on any other group. To a large degree this has been because of their recognized stratigraphic utility. For the same reason *Inoceramus* among the clams has received considerable attention. Most of the gastropods described from these beds were first described by such men as Meek, Hayden, Evans, Shumard, C. A. White, Whitfield, and Stanton. A few additional gastropods have been described in recent years, but mainly as adjuncts to papers dealing primarily with ammonites. Thus, names proposed by Meek and other early authors have been handed down with relatively few nomenclatural changes, and most have been used in the broadest sense in faunal lists. Such usage without reappraisal of the species concept has engendered common misuse. This is especially unfortunate because many of these species are the types for genera to which species from Cretaceous sequences in areas as distant from the western interior as Africa have been assigned.

It is clear that some foreign authors have used these genera, not in the sense of the original author but in that of some subsequent author who may have misidentified his material. Commonly, such misuse can be ascribed to hazy definition of genera that results from inadequate original material. An indication of the extent to which reexamination and new material can change the assignment of some species is the example of *Fasciolaria buccinoides* Meek and Hayden from the Fox Hills Sandstone of South Dakota. Specimens collected recently by me (pl. 6, figs. 5, 9) show a denticulate inner surface of the outer lip and a highly denticulate parietal surface of the inner lip. These features, as noted in the discussion of *Trachytriton* below, ally *F. buccinoides* with the Tonnacea rather than the Fasciolariidae of the Buccinacea. The change in assignment is not only at the superfamily level, but shifts the species from the Order Neogastropoda to the Order Mesogastropoda.

Obvious reason for the lack of interest in the Cretaceous gastropods of the western interior are their generally poor state of preservation in many stratigraphic units, restricted local abundances, and difficulty of recovery when found. Most commonly gastropods are found in concretions which generally yield complete ammonites but only exfoliated snails. Even when exfoliated the ammonites may be indentified, but for confident placement of the gastropods it is usually necessary to have a knowledge of their apertural features in addition to their sculpture. Therefore, it usually takes great care and meticulous preparation to clean and recover the gastropods. Another, but less important, factor is that many snails are very small and thus easily overlooked.

Some workers may have been discouraged from giving the gastropods sufficient study by statements in the literature. For example, in summarizing the paleogeography of the Cretaceous of the western interior, Reeside (1957, p. 539) states that the Campanian-Maestrichtian faunas have a provincial aspect and that "among the gastropods the number of species common to the two regions [western interior and gulf coast] is almost infinitesimal in comparison to the total fauna." In fact, in comparing the faunas from these two areas Stephenson and Reeside (1958) list only two species of gastropods, *Capulus spangleri* and *Anisomyon borealis*, that are presently accepted as of common occurrence. The few others they list have been kept separate by later workers. At our present state of knowledge, one must admit that few species occur in common in the two regions. On the other hand, almost all genera occur in common and many species are closely related. For example, of the 16 genera in the Pierre Shale gastropod fauna at Red Bird, only *Atira*, *Trachytriton*, and *Serrifusus* are not also present on the Gulf and Atlantic Coastal Plains. Although *Trachytriton* and *Serrifusus* have been reported from the Cretaceous of New Jersey (Whitfield, 1892; Weller, 1907; Richards and Ramsdell, 1962), the reports are based on internal molds of dubious affinities. The same character is seen when the total Pierre Shale gastropod fauna is compared to the larger Campanian faunas of the Gulf and Atlantic Coastal Plains. I have tentatively identified 55 gastropod genera as present in the Pierre and Bearpaw Shales. Of these, 49 genera occur in both, and 18 are restricted solely to the two regions. Distinct differences are noted when faunal comparisons are made to other areas in North America. For example, only

5 gastropod genera of the 72 present in the Campanian-Maestrichtian rocks of Puerto Rico are to be found in the Pierre Shale. Similarly, the Pacific Coast fauna yields few close ties. With continued collecting, additional genera are found that occur both in the western interior and on the coastal plains. It is clear, therefore, that the endemic aspect of the marine Upper Cretaceous gastropod fauna of the western interior has been overemphasized.

PIERRE SHALE GASTROPODS

RED BIRD SECTION

DIVERSITY

The gastropod fauna of the Pierre Shale of the Red Bird section comprises 23 distinct species plus several specimens that are either placeable only to genus or are indeterminate. Four species appear to be new, but only two are judged to be represented by adequate material to merit formal description. Slightly more than two-thirds of the recognizable species belong to the Streptoneura (Prosobranchia) and one-third to the Euthyneura. Of the prosobranchs only one species, *Atira*? *nebrascensis*, belongs to the Archaeogastropoda. Most of the species belong in the Mesogastropoda, and only *Serrifusus*, *Anomalofusus*, *Graphidula*, and *Cryptorhytis* represent the Neogastropoda. It is unusual that almost one-third of the taxa represent euthyneurous snails. Sohl (1964, p. 158, and fig. 13) has noted that representation of this group in any assemblage in the geologic column rarely exceeds 6 or 8 percent. When one considers the size of the total fauna and the overall sparse record of gastropods, however, such figures are not likely to be very significant. If one considers not the total fauna but only the fauna of a given bed, no more than two euthyneuran species occur in any single collection.

Gastropods are not abundant at any individual stratigraphic level, but the greater diversity as well as the greater number appears to be in the two unnamed shale members. Collections from the *Baculites baculus* and *B. grandis* zones, in the upper part of the section, contain the most abundant and diverse gastropod assemblage. Although bed 93 has yielded only 7 species, it has the most diverse of all the gastropod assemblages.

ABUNDANCE AND OCCURRENCE

The earliest gastropods are found in bed 33 at the top of the Mitten Black Shale Member in the medial part of the *Baculites gilberti* zone. They have not been noted in the lower 1,071 feet of the Red Bird section which includes the Gammon Ferrugenous Member, the Sharon Springs Member, and all but the uppermost unit of the Mitten Black Shale Member (see table 1, and Gill and Cobban, 1966). Beginning with bed 33, gastropods occur sporadically through the Red Bird Silty Member, the lower unnamed shale member, the Kara Bentonite Member, and the lower half of the upper unnamed shale member. They last occur in bed 95 in the lower part of the *Baculites grandis* zone about 374 feet below the Pierre Shale-Fox Hills Sandstone contract. Thus, gastropods occur through 1,692 feet of the 3,137 feet, or somewhat more than half of the Red Bird Pierre Shale section.

PRESERVATION

Most of the gastropods are basically well preserved, with species such as *Atira*? *nebrascensis* retaining their lustrous nacreous layer. However, the difficulties inherent in extraction of complete specimens from the matrix are great. Most specimens exfoliated when the concretions were split. Even these, however, were useful when the surrounding matrix was retained because the external molds could be cleaned of shell and external impressions that retained the details of sculpture could be made (see pl. 7, fig. 20). In addition, internal molds were sectioned to determine the features of the columella.

NOTES ON ECOLOGY

Paleoecologic interpretations based upon so few specimens are naturally subject to limitations. Considered ecologically, one of the more interesting features of the fauna is the presence of *Anisomyon*, a member of the Siphonariidae. The siphonariids are at present patelliform pulmonates that cling to rocks or other hard objects in the intertidal zone. *Anisomyon* differs from the typical Siphonariidae in having the muscle scar interrupted at the posterior-lateral rather than anterior-lateral position (fig. 10). This interruption marks the position of the lung aperture. The presence of such a structure is suggestive that *Anisomyon* lived, as does *Siphonaria*, in the intertidal zone. The mere possession of such a "lung," however, does not restrict such forms to the intertidal zone. The majority of the Bassomatophora are amphibious, and *Siphonaria* itself is interpreted as a pulmonate thoroughly readapted to submerged life in which the "lung" is filled with water. *Anisomyon* occurs in the Red Bird Silty Member and in the upper unnamed shale member. Zapp and Cobban (1962, fig. 134.1) have shown that during the time of deposition of the Red Bird Silty Member (Parkman regression), the shoreline lay some 60 miles to the west of Red Bird. If this be so, then *Anisomyon* was most likely not an intertidal dweller. The associated mollusks are not diverse, but the presence of *Ostrea* and *Pteria* suggests shallow-water conditions.

TABLE 1.—*Disposition of the gastropod species in the members of the Pierre Shale of the Red Bird section. Secs. 13, 14, 23, T. 38 N., R. 62 W., Niobrara County, Wyo.*

Species	Mitten Black Shale	Red Bird Silty							Lower unnamed shale											Kara Bentonite	Upper unnamed shale								
	Baculites gilberti zone	*Baculites gregoryensis* zone					*Baculites scotti* zone				*Didymoceras nebrascense* zone	*Didymoceras stevensoni* zone		*Exiteloceras jenneyi* zone					*Baculites reesidei* zone	*Baculites eliasi* zone	*Baculites baculus* zone								*Baculites grandis* zone
Bed	33	36	41	46	47	50	52	54	54	55	58	59	59	61	64	65	65	67	75	85	87	89	91	91	91	93	93	93	95
USGS Mesozoic locality No.	D-1877	D-1887	D-1900	D-1904	D-1910	D-1917	D-1922	D-1924	D-1925	D-1926	D-1938	D-1939	D-1940	D-1942	D-1945	D-1637	D-1947	D-1948	D-1952	D-1967	D-1973	D-1978	D-1979	D-1981	D-2116	D-1982	D-1983	D-1984	D-1985
Atira? *nebrascensis* (Meek and Hayden)	--	--	--	--	--	--	--	--	--	--	×	×	×	×	--	×	--	--	--	--	×	--	--	--	--	--	--	--	--
Drepanochilus evansi Cossmann	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	×
D. scotti Sohl n. sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	--	--	--	--	--	--
D. nebrascensis (Evans and Shumard)	--	--	--	--	--	--	--	--	--	--	--	×	--	×	--	--	×	--	--	--	--	--	--	--	--	--	--	--	--
D. obesus Sohl n. sp.	--	--	--	--	--	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
D. sp.	--	--	--	--	--	--	×	--	--	--	×	--	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aporrhais biangulata Meek and Hayden	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	--
A. n. sp.	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vanikoropsis nebrascensis (Meek and Hayden)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--
Astandes densatus Wade	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	×	--
Euspira obliquata (Hall and Meek)	--	--	--	--	--	×	--	--	--	--	--	×	×	×	--	--	--	--	--	×	--	×	?	--	--	--	×	--	×
Trachytriton vinculum (Hall and Meek)	--	--	×	×	--	--	--	--	--	×	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Serrifusus dakotensis (Meek and Hayden)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	×
Anomalofusus? sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	--	--	--	--	--	--	--
Graphidula culbertsoni (Meek and Hayden)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×
G. cf. *G. alleni* (White)	--	--	--	--	--	--	--	--	--	--	--	×	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cryptorhytis cheyennensis (Meek and Hayden)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	×	--	--	--	--	--	--	--	--	--	--
Fusid gastropods indeterminate	--	--	--	--	--	--	--	×	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nonactaeonina attenuata (Meek and Hayden)	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Oligoptycha concinna (Hall and Meek)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	×	--	--
Ellipsoscapha occidentalis (Meek and Hayden)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	×
Bullopsis n. sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×
Anisomyon borealis (Morton)	--	--	--	--	×	--	--	--	--	--	--	--	--	--	--	--	×	×	--	--	--	--	--	--	--	--	--	--	--
A. centrale Meek	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	--	--	--	--	--	--
A. patelliformis Meek and Hayden	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	--
A. sp.	--	×	×	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	×	--	--	--	--	--	--	--	--	--	--

In total, the gastropods are those expectable in shallow marine waters, but the sparsity of the archaeogastropods is worthy of special comment. Only one species, *Atira*? *nebrascensis* (Meek and Hayden), represents this order in the fauna. Snails such as these are usually browsers on vegetation and are quite common, if not abundant, in most marine shallow-water fossil faunas. Although scarcity of archaeograstropods is negative evidence, it raises the question as to whether vegetation was abundant in these shallow waters. If vegetation was abundant, why are the plant browsers so scarce?

The feeding habits of the more common snails may be inferred from the habits of related living genera. For example, *Drepanochilus* (Yonge, 1937) probably plowed through the bottom at or just below the surface, feeding primarily on plant debris. The naticid *Euspira*, perhaps the most abundant species in the gastropod fauna, probably crawled shallowly below the sediment-water interface in search of bivalves into which it bored. The carnivorous Fasciolariidae, such as *Graphidula*, generally prey on live mollusks. The opisthobranchs, including *Nonacteonina* and *Oligoptycha*, range from deposit feeders to those that ingest whole organisms including bivalves, univalves, and forams.

In spite of the abundance of these potential predators, few of the Red Bird shells show bore holes. Similarly, I have seen no shells infected by the boring sponge *Cliona* that so commonly excavates marine shells in the coastal plain faunas. One thick-shelled specimen of *Serrifusus* did display several boring clams in its shell walls.

In summary, all the gastropods are forms consistent with a marine shallow-water environment and representative of both epifaunal and infaunal elements. Feeding habits range from plant browsers and detritus feeders to various kinds of carnivores. Finally, it may be significant that no filter feeder gastropods are present.

OTHER AREAS

Except for *Anomalofusus*? sp., *Aporrhais* n. sp., and *Bullopsis* n. sp., all the gastropod species of the Pierre Shale Red Bird sequence are known from other areas of the Pierre Shale, Bearpaw Shale, or Fox Hills Sandstone outcrop. Figure 1 indicates their total stratigraphic range and general geographic distribution.

COLORADO

A comparison of the Pierre Shale gastropod fauna from the Red Bird section with that from the Front Range of Colorado shows a close similarity at almost all stratigraphic levels.

Pierre Shale gastropods from the Front Range of Colorado

[Asterisk indicates species that occur in common between the Front Range and the Red Bird section of Wyoming. The numbers following the species name in the list below indicate the ammonite zones in which they occur in the Front Range Pierre Shale sections. These zones are 1. *Baculites obtusus*. 2. *B. mclearni*. 3. *B. asperiformis*. 4. *B. perplexus*. 5. *B. gregoryensis*. 6. *B.* n. sp. 7. *B. scotti*. 8. *Didymoceras nebrascense*. 9. *D. stevensoni*. 10. *Exiteloceras jenneyi*. 11. *Didymoceras cheyennense*. 12. *Baculites compressus*. 13. *B. cuneatus*. 14. *B. reesidei*. 15. *B. jenseni*. 16. *B. eliasi*. 17. *B. baculus*. 18. *B. grandis*. 19. *B. clinolobatus*]

Acmaea occidentalis (Meek and Hayden) 9, 10, 12, 13, 14
A. papillata (Meek and Hayden) 15
**Atira*? *nebrascensis* (Meek and Hayden) 10, 14, 15, 19
Margarites sp. 4, 9
Anchura haydeni White 13, 14, 15
"*Aporrhais*" *meeki* Whitfield 3, 4, 7
**Drepanochilus evansi* Cossmann (transitional form) 17, 18, 19
**D. scotti* Sohl 14, 15, 16, 17
**D. nebrascensis* (Evans and Shumard) 10, 11, 12, 13
**D. obesus Sohl* 7, 8
D. sp. 4
cf. *Confusiscala* n. sp. 14
**Astandes densatus* Wade 15
Capulus spangleri Henderson 14, 15
Xenophora cf. *X. leprosa* Morton 10, 11
**Vanikoropsis haydeni* Cossmann 10, 14, 15
Cypraea sp. A, 11
C. sp. B, 14
**Euspira obliquata* (Hall and Meek) 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 19
E. sp. 4
Gyrodes sp. 13, 14
Pseudamaura lirata (Wade)? 12
P. paludinaeformis (Meek and Hayden) 10
**Trachytriton vinculum* (Hall and Meek) 14?, 15, 5
**Serrifusus* sp. 14, 10?
Deussenia? sp. 14
**Graphidula culbertsoni* (Meek and Hayden) 19
Bellifusus 11, 15, 18, 9, 7, 19
B. sp. 6
Cryptorhytis cheyennensis (Meek and Hayden) 13, cf. 7, 12, 10, 14?, 11
C. flexicosta (Meek and Hayden) 19
Graphidula n. sp. 7, 8
Hydrotribulus? sp. 7, 12, 11, 13, 9
Drilluta? sp. 8
Napulus sp. 14
"*Volutoderma*" *clatworthyi* (Henderson) 14
Amuletum sp. 10, 15
Lutema minor (Meek and Hayden) 15
**Anisomyon borealis* Morton 4?, 10
**A. centrale* (Meek and Hayden) 7
A. subovatus (Meek and Hayden) 10, 11?, 14, 15
**Anisomyon* n. sp. 1
A. sp. 12, 4, 10, 9
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Acteon sp. 14, 10
Eoacteon 14
Cylindrotruncus? *glansoryza* (Whitfield) 11, 12, 15
**Ellipsoscapha*? *subcylindrica* (Meek and Hayden) 10, 14, 15(?)
**E. occidentalis* (Meek and Hayden) 10, 11, 14
Cylichna sp. 10, 11, 14, 15, 19
Tornatellaea? sp. 14, 15
Scobinodolus cf. S. guttatus Sohl 15
Ringicula (*Ringicula*) cf. *R.* (*R.*) *pulchella* Shumard 14

In addition to the above, there are a number of specimens of fusiform snails that I am unable to place until better preserved material is available. The list can only be viewed as provisional, and no doubt more thorough study will reveal new species and others will be reassigned.

The upper part of the section (*Exiteloceras jenneyi* through *Baculites clinolobatus* zones) contain both the greatest diversity and the greatest number of gastropods. The Rocky Ridge, Larimer, and Richard Sandstone Members (*Baculites reesidei* and *B. jenseni* zones) contain the greatest variety of all the units. These sandstones, as well as some lower units such as the Terry Sandstone Member, have yielded species belonging to *Cypraea*, *Xenophora*, *Anchura*, *Gyrodes*, *Napulus* and *Eulima*. These genera are either exceptionally rare or unknown elsewhere in the outcrop of the Pierre Shale and equivalent units.

The Pierre Shale gastropod fauna of the Front Range contains more species that are common to the gulf coast than do the Pierre Shale faunas to the north.

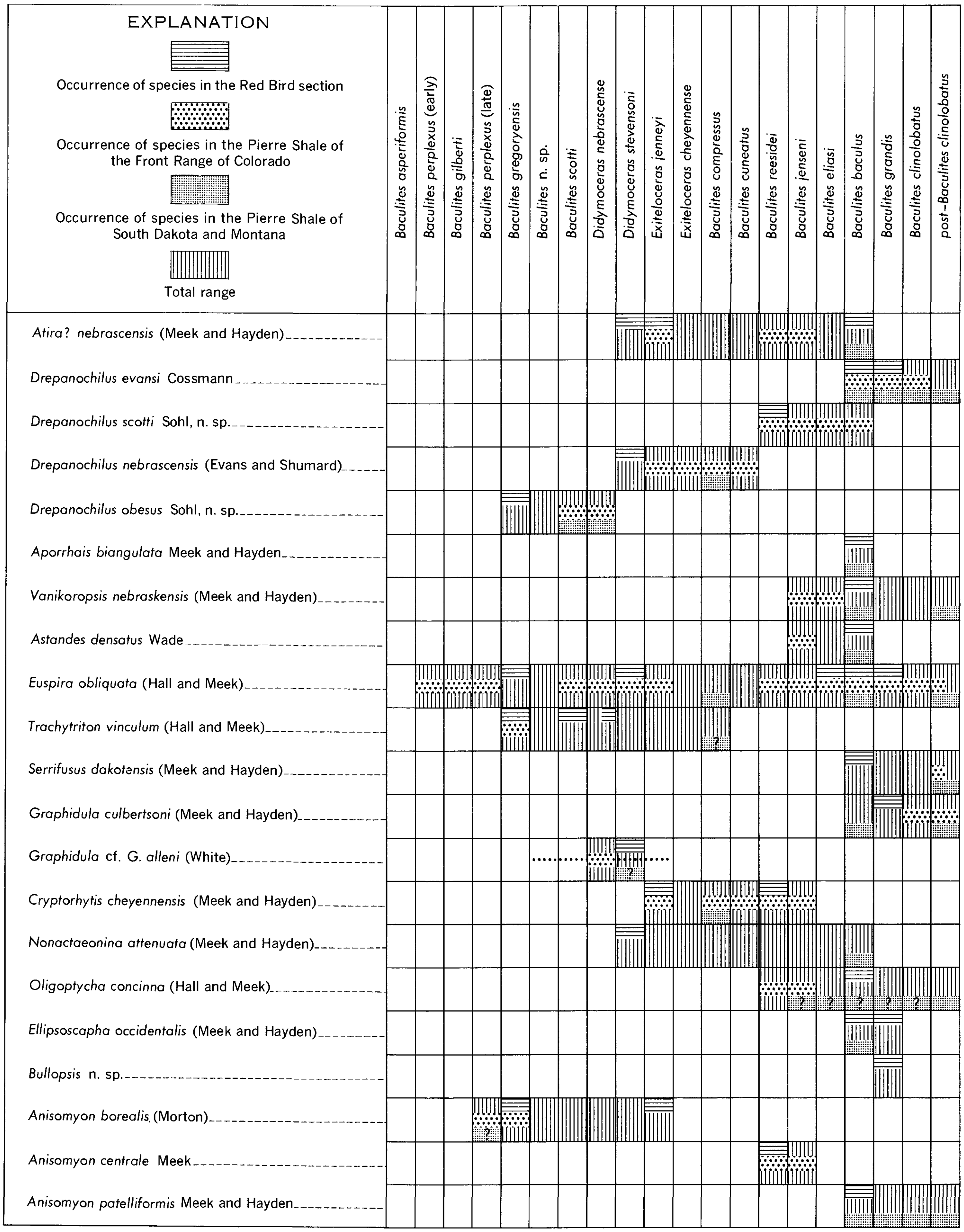

FIGURE 1.—Geographic and stratigraphic distribution of the gastropod species of the Pierre Shale of the Red Bird section.

This fact appears to indicate an influx of species from the gulf northward, especially during the time of deposition of the Rocky Ridge and Larimer Sandstone Members (*B. reesidei* zone). These affinities decrease in the stratigraphically higher Richard Sandstone Member. In spite of the many forms introduced in these sandstones, the fauna maintains its western-interior character. In terms of gastropods the medial part of the Pierre Shale of the Front Range represents a time of mixed faunas during which a normal Pierre Shale fauna was supplemented periodically by migrants from the gulf coast.

These middle sandstones are especially noteworthy biologically because of the diversity and abundance of opisthobranch gastropods.

The similarity between the Pierre Shale gastropod fauna of the Red Bird section of Wyoming and the Front Range of Colorado lies not only in the common occurrence of many species but also in the absence or rarity of gastropods in the lower part of the formation in both areas. In addition, in the faunas of both areas the most abundant gastropods are *Euspira*, *Drepanochilus*, and, perhaps, *Anisomyon*.

SOUTH DAKOTA AND MONTANA

The Gammon Ferruginous Member of the Pierre Shale north of the Black Hills at USGS 23478 has yielded the following gastropod fauna:

Cerithiopsis (*Cerithiella*?) n. sp.
Potamides n. sp. A.
Potamides n. sp. B.
Promathilda (*Clathrobaculus*) n. sp.
Drepanochilus sp. (*evansi* lineage)
Aporrhais? sp.
Acirsa (*Hemiacirsa*) n. sp.
Euspira cf. *E. obliquata* (Hall and Meek)
Lomirosa n. sp.
Rhombopsis? sp.
Bellifusus n. sp.
Remera cf. *R. stephensoni* Harbison
Graphidula cf. *G. obscura* (Wade)
Graphidula n. sp. (*culbertsoni* lineage)

This locality represents a level near the base of the Pierre Shale (zone of *Scaphites hippocrepis*, late or fine-ribbed form) at a position not well represented in terms of gastropods anywhere else in the western interior. The fauna contains some elements, such as *Promathilda*, that are virtually unknown elsewhere. Although all the genera represented are to be found in the Gulf Coastal Plain Upper Cretaceous, the closest specific ties remain with the higher beds of the Pierre Shale. For example, the *Drepanochilus* is of the western interior, not the gulf coast, type. One *Graphidula* and the *Bellifusus* represent new species that are obvious forerunners of species to be found at higher Pierre Shale levels. Except for the total absence of Euthyneura, in terms of general groups the fauna again is a typical Pierre Shale gastropod assemblage. No species definitely occur in common with the Red Bird fauna, but many are closely related.

Whitfield (1880) made a study of the fossil faunas from the Black Hills region that included 19 species of gastropods from the Pierre Shale. Some of the species (*Drepanochilus obesus*, *Graphidula culbertsoni*, *Anisomyon borealis*) occur in the Red Bird section but all are known from other areas of the Pierre Shale outcrop. The work describes relatively few gastropods that come from many zones and no large assemblage is given that would serve for comparison.

The following list is of gastropods in two collections from the *Baculites compressus* zone in the Wasta-Sage Creek area of South Dakota that represent the Pierre assemblage from the upper part of the middle Pierre Shale (USGS 23070, 23072). Species described by Evans and Shumard and Hall and Meek from "Sage Creek" are marked by an asterisk (*).

**Acmaea occidentalis* (Hall and Meek)
**Margaritella flexistriata* (Evans and Shumard)
Atira? *nebrascensis* (Meek and Hayden)
Belliscala? n. sp.
**Closteriscus tenuilineatus* (Hall and Meek)
**Drepanochilus nebrascensis* (Evans and Shumard)
**Euspira obliquata* (Hall and Meek)
**Pseudamaura paludinaeformis* (Hall and Meek)
Xenophora sp.
Trachytriton vinculum (Hall and Meek)
Cryptorhytis cheyennensis (Hall and Meek)
Mesorhytis? sp.
Oligoptycha concinna (Hall and Meek)

Except for *Euspira obliquata*, all the above species are restricted to the Pierre Shale and equivalents, and few are found at stratigraphic levels below the *B. compressus zone*. Of the 13 species listed, only 6 (*Atira*? *nebrascensis*, *Drepanochilus nebrascensis*, *Euspira obliquata*, *Trachytriton vinculum*, *Oligoptycha concinna*, and *Cryptorhytis cheyennensis*) are found also in the Red Bird section. In part this is explainable by the fact that three zones (*D. cheyennense*, *B. compressus*, and *B. cuneatus* zones) spanning the Sage Creek beds are missing in the Red Bird section. In other respects the fauna shows a dominance of Mesogastropoda and Neogastropoda characteristic of the other Pierre gastropod assemblages.

The high Pierre Shale gastropod assemblages are best typified by those of the *Baculites baculus* zone of the Cedar Creek anticline near Glendive, Mont. These beds yielded many fossils described by Meek and others from the general region 150 miles above the mouth of the Yellowstone. Meek and others have noted that there is an intermixture of fossils of Fox Hills type and of the Pierre Shale type in these beds. It is true that, in many ways, the gastropods of these upper Pierre beds are more advanced than typical Pierre species, but the gastropod assemblages of both formations are distinctive.

The following list was compiled from Meek, 1876, and is supplemented by identifications from USGS collections from the *Baculites baculus* of the Glendive area, Montana. An asterisk (*) preceding the species names indicates that the species range upward into the Fox Hills Sandstone.

Atira? nebrascensis (Meek and Hayden)
**Euspira obliquata* (Hall and Meek)
Aporrhais biangulata Meek and Hayden
**Drepanochilus evansi* (Evans and Shumard) (includes *Anchura sublevis and A.? parva*)
Astandes densatus (Wade)?
Vanikoropsis haydeni Cossmann
**Rhombopsis newberryi* (Meek and Hayden)
**R. subturritus* (Meek and Hayden)
**R. ? intertextus* (Meek and Hayden)
**Pseudobuccinum nebrascense* (Meek and Hayden)
**Graphidula culbertsoni* (Meek and Hayden)
Mesorhytis gracilenta Meek
Cryptorhytis flexicostata (Meek and Hayden)
**Amuletum minor* (Evans and Shumard)
Eoacteon n. sp.
Nonactaeonina attenuata (Meek and Hayden)
Ellipsoscapha occidentalis (Meek and Hayden)
E. n. sp.
**Oligoptycha concinna* (Hall and Meek)
Scobinodolus sp.
Anisomyon patelliformis Meek and Hayden
A. subovatus Meek and Hayden
A. alveolus Meek and Hayden
A. sexsulcatus Meek and Hayden

Of the 24 species listed above only 9 are to be found in the overlying Fox Hills Sandstone of the type area. This is not what should be expected in beds said to contain a mixed Fox Hills and Pierre fauna. Obviously, the snail assemblages are considerably different in the two formations. Similarly, of the 27 species described from the Fox Hills Sandstone by Meek (1876), only 9 are common to the 2 formations. However, the vast majority of genera occur in common. One obvious difference is the total absence in the Fox Hills of any species of *Anisomyon*, a genus so common in the Pierre Shale.

Compared with the gulf coast Campanian-Maestrichtian gastropod faunas, all genera except *Atira?*, *Vanikoropsis*, and *Pseudobuccinum* occur in common. *Atira*, *Aporrhais*, *Astandes*, *Mesorhytis*, *Nonactaeonina*, *Scobinodolus*, and *Anisomyon* do not occur in the Fox Hills Sandstone. Consequently, at the generic level, both the Fox Hills fauna and the gulf coast fauna show great similarities to the Pierre Shale assemblages.

BEARPAW SHALE OF MONTANA AND CANADA

Although the gastropod fauna of the Bearpaw Shale of Montana and Alberta, Canada, is closely related to that of the Pierre Shale, it is somewhat less diverse. The following tentative listing of gastropod species is compiled from Dowling (1917), Williams and Dyer (1930), and Landes (1940) for Canada and from a cursory examination of the Montana Bearpaw Shale collections of the U.S. Geological Survey at the U. S. National Museum. An intensive investigation would undoubtedly add a few more species to the list.

Atria? nebrascensis (Meek and Hayden)
Cerithioderma n. sp.
Drepanochilus evansi Cossmann
D. nebrascensis (Evans and Shumard)
Euspira obliquata (Hall and Meek)
Vanikoropsis tuomeyana (Meek and Hayden)
V. nebrascensis (Meek and Hayden)
Trachytriton vinculum (Hall and Meek)
Anomalofusus? sp.
Graphidula culbertsoni (Meek and Hayden)
Pseudobuccinum nebrascense (Meek and Hayden)
Paladmete n. sp.
Nonactaeonina attenuata (Meek and Hayden)
Ellipsoscapha occidentalis (Meek and Hayden)
Ellipsoscapha? subcylindrica (Meek and Hayden)
Oligoptycha concinna (Hall and Meek)
Anisomyon patelliformis Meek and Hayden
A. alveolus Meek and Hayden
A. centrale Meek

SUMMARY

The Pierre Shale gastropod fauna in the western interior maintains a significant uniformity both geographically and stratigraphically. Certain genera are common to all areas and stratigraphic levels of the formation. From a negative standpoint, but perhaps just as significantly, certain other types of snails are usually lacking. In general, the Archaeogastropoda are very poorly represented either in terms of diversity or in terms of individual specimens. Only 5 species of the order Archaeogastropoda are included among the 70 gastropod species of the Pierre fauna. In terms of number of species or in individual abundance the order Mesogastropoda is the best represented, *Euspira* and *Drepanochilus* being the two most abundant snails in the fauna. Neogastropods are moderately diverse but are not individually abundant. This is expectable for any group of carnivores. For the Subclass Euthyneura, the pulmonate group *Anisomyon* (Siphonariidae) is common to all levels in the Pierre Shale, but does not occur in the Fox Hills Sandstone. In addition to these patelliform snails, the bulloid euthyneurans (*Ellipsoscapha* and others) are to be found at most levels.

All the Pierre Shale gastropods are shallow-water types, but they represent a wide variety of feeding habits ranging from plant browsers to carnivores and, perhaps, parasites (*Eulima*). In spite of the strong evidence of very shallow water furnished by *Anisomyon*, other groups that one would associate with such condition are remarkably scarce or absent. For example, other patelliform snails are absent, except for rare specimens of *Acmaea*. There are no species of either the Littorinacea or Neritacea, both very common shallow water forms. Perhaps the lack of a rocky coast would account for the absence of many of the above forms, but why, then, are the ceritheaceans so uncommon? Although most Upper Cretaceous faunas contain turritellids, often in great abundance, none are known from the Pierre Shale. In addition, there are no Vermetidae and only a very few Cerithiidae and Cerithiopsidae. This sparsity is true not only of the shale but also of the sandier sequences of Colorado where one would expect representatives of such groups. However, *Turritella* is abundant in the near-shore sandy facies of the *Baculites baculus* zone (the Lewis Shale of south-central Wyoming, USGS D-4755). The general lack of turritellids and vermetids in the shale facies may reflect turbid water or suspended material not conducive to the support of such ciliary and mucous string feeders.

Much more study of this peculiar assemblage is needed before any answers can be found. Certainly, on the basis of groups represented, the Pierre Shale gastropod fauna bears little resemblance to the more normal shallow-water Cretaceous shelf faunas of the Gulf Coastal Plain. There, such groups as *Anisomyon* and *Drepanochilus* are uncommon, but archaeogastropods are abundant, if not diverse, and ceritheaceans are both abundant and diverse.

In spite of the many dissimilarities, however, it is clear that the Pierre Shale gastropod fauna is most similar taxonomically to the Upper Cretaceous faunas of the gulf coast. A few genera occur in common with the Pacific Coast Campanian-Maestrichtian faunas (Anderson, 1958). However, most, like *Euspira* and *Drepanochilus*, have little significance because such genera are found in most Upper Cretaceous gastropod faunas. Only *Atira* and *Serrifusus* indicate any significant relationship. In contrast, almost all genera in the Pierre Shale occur also in the Campanian-Maestrichtian beds of the Gulf Coastal Plain. Some genera, such as *Oligoptycha*, *Bullopsis*, *Margaritella*, *Belliscala*, *Lomirosa*, *Remera*, *Scobinodolus*, *Cylindrotruncus*, and *Napulus*, are unknown outside the two areas. The many common genera indicate a similar source for much of the fauna.

Certainly, the Pierre Shale fauna was occasionally replenished by invasions from the gulf coast, as is shown by the increased similarity of the two faunas toward the south, especially in the Rocky Ridge Sandstone and Larimer Sandstone Members of Colorado.

The fauna shows a dominance of species lineages that are restricted to the western interior, but are generically related to gulf coast lineages, suggesting a common source in earlier Cretaceous times. On this basic plan are superimposed a few exotic, perhaps boreal, migrants.

PROPOSED NEW SPECIES

Two new species are proposed—*Drepanochilus scotti* and *Drepanochilus obesus*.

CHANGES IN GENERIC OR SPECIFIC ASSIGNMENT

The following are changes in generic or specific assignment of previously described species (see also list on p. B19 for *Aporrhais*):

Old assignment	*New assignment*
Trochidae:	
Margarita nebrascensis Meek and Hayden.	*Atira? nebrascensis* (Meek and Hayden)
Aporrhaidae:	
Aporrhais sublevis Meek and Hayden.	*Drepanochilus evansi*
Anchura (*Drepanochilus*) *evansi pusilla* Stanton.	*Drepanochilus pusillus* (Stanton)
Anchura (*Drepanochilus*) *nebrascensis* Whitfield [non Evans and Shumard].	*Drepanochilus obesus* Sohl
Vanikoridae:	
Fossar? nebrascensis Meek and Hayden.	*Vanikoropsis*
Natica? ambigua Meek and *Hayden*.	*Vanikoropsis*
Natica haydeni Cossmann	*Vanikoropsis*
Natica praenominata Cossmann	*Vanikoropsis*
Naticidae:	
Natica Meeki Cossmann (=*Natica paludinaeformis* Hall and Meek).	*Pseudamaura*
Cymatiidae:	
"Fasciolaria" buccinoides Meek and Hayden from the Fasciolariidae to the Cymatiidae.	
Fasciolariidae:	
Serrifusus? crosswickensis Whitfield.	*Pterocerella*
Fasciolaria (*Piestochilus*) *alleni* White.	*Graphidula*
Actaeon (*Solidula*) *attenuatus* Meek and Hayden.	*Nonacteonina*

MEASUREMENTS OF SPECIMENS

Measurements of individual specimens of many species are given under a sidehead following the specific descriptions. Larger specimens were measured with vernier calipers, and the smaller forms were measured with the aid of a microscope equipped with a calibrated eyepiece. All measurements are in millimeters.

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The conchologic features measured vary with the individual groups. For example, the Aporrhaidae develop an expanded outer lip, and the set of measurements used to indicate the relation of the lip to the shell must be different from that used to measure a less complex group.

Listed below are the abbreviations used as headings of the column of measurements and their definitions.

DPW	Diameter of penultimate whorl, measured normal to teleoconch axis of coiling.
MD	Maximum diameter, measured normal to teleoconch axis of coiling.
MDW	Maximum diameter, including the length of an expanded outer lip or wing.
H	Total height of shell, measured parallel to axis of coiling.
HA	Height of aperture, measured parallel to axis of coiling.
HB	Height of body whorl, measured parallel to axis of coiling.
ML	Median line length, in *Anisomyon* measured parallel to an imaginary plane bisecting the anterior and posterior margins of the shell.
W	Width, in *Anisomyon* measured normal to ML half the distance between the anterior and posterior margins.
LC	Length of carination, in *Anisomyon* measured from apex to intersection of carination with posterior margin.
AM	Width of anterior margin, in *Anisomyon* measured normal to ML at anterior one-quarter of shell length.
PM	Width of posterior margin, in *Anisomyon* measured normal to ML at posterior one-quarter of shell length.
PA	Pleural angle, measured in degrees.

SYSTEMATIC DESCRIPTIONS

The arrangements of families and the grouping of genera follows the classification of Taylor and Sohl (1962). Morphologic terminology conforms to that used in the "Treatise on Invertebrate Paleontology" (Moore, 1960).

Abbreviations are as follows:

USNM	U.S. National Museum
ANSP	Academy of Natural Sciences of Philadelphia
AMNH	American Museum of Natural History
USGS	U.S. Geological Survey Mesozoic locality

Order ARCHAEOGASTROPODA

Superfamily TROCHACEA

Family TROCHIDAE

Subfamily MARGARITINAE

Genus ATIRA Stewart, 1927

Type by original designation: *Angaria ornatissima* Gabb, 1864

Diagnosis.—Small turbiniform phaneromphalous shells, aperture rounded. Umbilical margin angulate. Sculpture usually faint but present on umbilical walls.

Discussion.—Stewart (1927, p. 315) proposed *Atira* as a subgenus of *Margarites* "Leach" Gray. He included the type species *Angaria ornatissima* Gabb, and *Architectonica inornata* Gabb, both of the Upper Cretaceous of California. Whiteaves (1879) and White (1889) also cite the occurrence of the type species in the Upper Cretaceous of Sucia and Sheep Jack Islands, Vancouver, British Columbia.

Stewart (1927, p. 315) notes: "This genus differs from *Margarites* in having an angulated umbilicus. The angle is not ridged as in *Solariella.* The umbilicus is much narrower and the walls are more sloping than in *Gaza* Watson, which the fine sculpturing—particularly that of *M. inornatus*—somewhat resembles."

Atira? nebrascensis (Meek and Hayden)

Plate 1, figures 1–11

1856. *Turbo nebrascensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 64.

1860. *Margarita nebrascensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 185.

1876. *Margarita nebrascensis* Meek and Hayden, Meek, U.S. Geol. Survey Terr. (Hayden) Rept., v. 9, p. 298, pl. 19, figs. 8a, b, 9a (not 9b).

1880. *Margarita nebrascensis* Meek and Hayden, Whitfield, U.S. Geog. and Geol. Survey Rocky Mtn. Region (Powell), p. 432, pl. 12, fig. 15.

1918. *Eumargarita* (*Solariella*) *nebrascensis* Cossmann, Essais de paléoconchologie comparée, no. 11, p. 260.

1951. *Solariella nebrascensis* (Meek and Hayden). Collignon, Madagascar Service mines, Annales, Géol., pt. 19, p. 101.

Type locality.—"Yellowstone River, 150 miles from its mouth" (Meek, 1876, p. 299). This locality corresponds to the upper part of the Pierre Shale *Baculites baculus* zone in the vicinity of Glendive, Mont.

Diagnosis.—*Atira*-like with marginal umbilical crenulations developing from accentuated transverse riblets.

Description.—Moderately small turbiniform phaneromphalous shells with round-sided to gently angulate whorls. Shell about as wide as high, spire about one-half total shell height, pleural angle 80°–85°. Protoconch paucispiral, low, smooth surfaced, and round sided. Suture abuting. First one-half teleoconch whorl round sided, but gradually developing a flattened subsutural area that on second teleoconch whorl becomes a shelf 0.1 mm wide bounded by a strong spiral cord. This shelf rounds off on later whorls. Mature whorls rather well rounded, but some develop a slight flattening over periphery that is delimited above and below by a very weak angulation. Umbilicus broad and open, bounded by a rounded angulation; umbilical walls steeply sloping gently convex. Sculpture of first teleoconch whorl begins with a few weak spiral lines that strengthen to threads; thread at subsutural shoulder strongest. Faint but continuous transverse ribs begin on second teleoconch whorl. On third whorl, spiral cords remain stronger, but ribs strengthened to form low nodes at intersection with spiral threads over shelf and shoulder cord. Sculpture usually weak on penultimate and body whorl, especially over periphery and laterally on base. On body whorl, spiral sculpture consists of closely spaced round-topped spiral threads that are wider than their interspaces over most of surface; threads are about of equal strength over upper whorl surface and periphery, but broaden to cords or ribbons on umbilical wall. Transverse sculpture on body consists of low broad collabral ribs that are strongest near suture, die out on periphery, but again strengthen over base, becoming accentuated to narrower but sharper ribs over umbilical rim and wall. Growth lines steeply prosocline between suture and basal margin. Aperture incompletely known, subcircular in outline with outer lip more fully rounded than inner lip. Inner lip curved and presumably nonreflected.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurement of specimens" (p. B9).

Specimen and locality	H	MD
Holotype: USNM 249a—(*B. baculus* zone)	6. 3+	6. 4
Paratype: USNM 132951—(*B. baculus* zone)	6. 4+	7. 3
Glendive, Mont. (*B. baculus* zone)	5. 8+	5. 3
Do	6. 0	6. 0
Do	8. 3	7. 8
Red Bird (*Didymoceras stevensoni* zone)	7. 0+	7. 7
Do	6. 2	7. 2

Discussion.—*Atira? nebrascensis* is of questionable placement. It certainly does not belong in *Margarita*, where it was assigned by Meek, as it retains a crenulate umbilical margin. *Solariella* Woods, where it was placed by Cossmann (1915) and Collignon (1951), does possess such a character, but the crenulations of the umbilical margin of *Solariella* develop from a strong spiral rib that borders the umbilical margin, a feature somewhat analogous to that in *Architectonica*. In *Atira? nebrascensis* the umbilical crenulations develop from the strengthening of the transverse elements. The crenulations are variable (compare pl. 1, figs. 8, 11) and do not appear to be delimited by a single strong spiral rib. The umbilical wall sculpture and subangulate umbilical margin are like those in *Atira* Stewart.

Meek's (1876, p. 299) type specimens came from the Pierre Shale (Cretaceous No. 4 of Meek), "on the Yellowstone River 150 miles from its mouth" (=Glendive, Mont.). In addition, he figured an additional specimen (Meek, 1876, pl. 19, fig. 9b) from the Fox Hills Sandstone at Long Lake, S. Dak. This latter specimen represents a large undescribed species that lacks the umbilical nodings and subsutural sculpture of *Atira? nebrascensis*.

The illustrations of the type specimens given by Meek (1876, pl. 9, figs. 8a, b, 9a) are exaggerated. These specimens, one of which is here refigured (pl. 1, figs. 2–4), are little more than internal molds retaining only patches of shell material adhering to the surface. The description given above is based on the type specimens supplemented by additional specimens from the type area near Glendive, Mont., and from the Red Bird section of Wyoming.

The specimens from the Red Bird Pierre Shale section of Niobrara County, Wyo., compare closely with those of the type locality. They are found in both the lower and upper unnamed shale members (beds 58–87) from the *Didymoceras stevensoni* to the *Baculites baculus* zones. In the Pierre Shale of the Front Range of Colorado the species is found from the *Exiteloceras jenneyi* through the *Baculites clinolobatus* zones and is especially abundant in the *B. reesidei* and *B. jenseni* zones.

Types: Holotype USNM 249; paratype, USNM 132951; hypotypes USNM 249, 132668, 132669, 132670, 132983, 132950.

Occurrences: Wyoming: Pierre Shale (Red Bird section), *Didymoceras stevensoni* zone, USGS D–1939, D–1940; *Exiteloceras jenneyi* zone, D–1637, D–1942; *Baculites baculus* zone, D–1973. Colorado: Pierre Shale, *Exiteloceras jenneyi–B. clinolobatus* zones.

Order MESOGASTROPODA

Superfamily STROMBACEA

Family APORRHAIDAE

Representatives of this family are among the more common gastropods in the Cretaceous rocks of the western interior. Although the genera *Perissoptera*, *Cyphosolenus*, *Anchura*, *Aporrhais*, *Lispodesthes* and *Arrhoges* are all present, *Drepanochilus* is perhaps the most common aporrhaid. This is in direct contrast to the Upper Cretaceous sequence in the Gulf and Atlantic Coastal Plains where *Drepanochilus* is rare and the genera *Anchura* and *Graciliala* are common (table 2). In the western interior, *Graciliala* is absent and *Anchura* is found no farther north than the Front Range of Colorado in the Pierre Shale, although it is present in Minnesota in the Colorado Group.

Genus DREPANOCHILUS Meek, 1964

Type by original designation: *Rostellaria americana* Evans and Shumard 1857 (non d'Orbigny, 1842) =*Drepanochilus evansi* Cossmann, 1904.

Diagnosis.—Medium-sized high-spired shells with round-sided whorls. Initial sculpture of fine spiral threads. Sculpture of spire commonly dominated by transverse ribs that virtually disappear on body whorl; body whorl sculpture dominated by two or three spiral cords or carinations with upper carination continuous

TABLE 2.—*Distribution and abundance of aporrhaid genera in the Cretaceous rocks of North America*

Genus	Atlantic Coastal Plain	Gulf Coastal Plain	Western interior		West coast
			Northern part (Minnesota to Wyoming)	Southern part (Colorado to New Mexico)	
Anchura	Common, Cenomanian-Maestrichtian.	Common, Cenomanian-Maestrichtian.	Rare, Cenomanian (Minnesota).	Rare, Coniacian-Campanian.	Rare, Upper Cretaceous (California-British Columbia).
Helicaulax	----------	Rare, Maestrichtian.	----------	----------	
Drepanochilus	----------	Rare, Campanian-Maestrichtian.	Common, Campanian-Maestrichtian.	Common, Campanian.	Rare, Upper Cretaceous (California).
Graciliala	Common, Santonian-Maestrichtian.	Common, Santonian-Maestrichtian.	----------	Rare, Cenomanian (Kansas).	
Aporrhais	Rare	Rare	Rare	Rare	
Arrhoges	Rare, Santonian-Maestrichtian.	Common, Lower Cretaceous-Upper Cretaceous.	----------	Rare, Turonian	Rare, Cenomanian-Turonian (California).
Perissoptera	----------	----------	----------	Rare, Turonian (Utah).	Rare, Cenomanian (California).
Dicroloma	----------	----------	----------	----------	Rare, Upper Cretaceous (California).
Monocyphus	----------	Rare, Albian. (Texas).	----------	----------	
Lispodesthes	----------	Rare, Cenomanian (Texas).	----------	Rare, Turonian (Utah).	
Cyphosolenus	----------	Rare, Albian (Texas).	----------	----------	
Tessarolax	----------	----------	----------	----------	Common, Turonian (Lower California to British Columbia).
Tundora	----------	Rare, Campanian	----------	----------	
Pterocerella	Common, Campanian-Maestrichtian.	Common, Campanian-Maestrichtian.	----------	----------	

over single narrow upturned spur of the expanded outer lip. Anterior canal short to moderate length.

Discussion.—*Drepanochilus* is one of the more widespread Cretaceous and lower Tertiary aporrhaid genera. The typical subgenus has been reported in North America, Europe, and Africa with the subgenus *Tulochilus* Finlay and Marwick occurring in Paleocene rocks in North Dakota, Tunisia, New Zealand, and possibly California. Species of *Drepanochilus* are among the more widely distributed and most abundant gastropods found in the upper part of the Upper Cretaceous of the western interior. Concretions bearing little else than hundreds of specimens of *Drepanochilus* have been encountered in both the Fox Hills Sandstone and Pierre Shale from Colorado to Montana. Their abundance in this area stands in distinct contrast, however, to their rarity in the equivalent Campanian and Maestrichtian rocks of the Gulf and Atlantic Coastal Plains (Sohl, 1960, p. 99–101). Not only is there a disparity in abundance between the two areas, but no single species occurs in common. *Drepanochilus* is represented in these areas by two separate evolving lineages.

Evolution of western interior Drepanochilus.—The gulf coast species as shown by Sohl (1960, fig. 10) show a trend with time in which *Drepanochilus texanus* Stephenson, from the Kemp clay of Texas, develops from the older *D. quadriliratus* (Wade), from the *Exogyra cancellata* zone of Tennessee, by progressive suppression of the spiral cords of the body whorl. Progressive changes are also present in the western interior

Drepanochilus lineage. Figure 2 graphically presents the changes in the proportional distance of the upper body whorl carination from the suture and in the distance separating the two carinations. Except for the reversal in *D. nebrascensis*, the overall trend is for the upper whorl carination to move closer to the suture and the distance between the carinations to lessen with higher stratigraphic position. Other changes occur in that the older species have non-noded spiral carinations, a welt paralleling the lateral outer lip margin below the extended spike, and more obese whorls; whereas the younger species, such as *D. pusillus* and *D. evansi*, possess nodings on the spiral carinations, have a more angulate body, and lack a pronounced welt parallel to the margin of the lower part of the expanded outer lip.

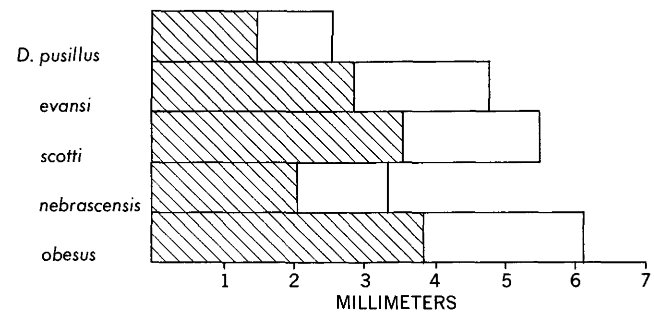

FIGURE 2.—Comparison of the suture to upper whorl carination and the intercarination distances in the Pierre Shale species of *Drepanochilus*. The left-hand margin of the graph represents the position of the suture; the shaded area, the average distance between the suture and the upper whorl carination; and the unlined portion is the average distance between the carinations. The species are arranged with the oldest at the bottom. All specimens measured were adult individuals.

Drepanochilus evansi Cossmann

Plate 3, figures 10–21

1857. *Rostellaria Americana* Evans and Shumard, Acad. Sci. St. Louis Trans., v 1, p. 42 [non *R. americana* d'Orbigny].
1860. *Aporrhais Americana* (Evans and Shumard). Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 423.
1860. *Aporrhais sublevis* Meek and Hayden, Acad Nat. Sci. Philadelphia Proc., v. 12, p. 178 (misprint *Aporrahais sublevata* appears on p. 428).
1864. *Anchura* (*Drepanochilus*) *americana* (Evans and Shumard). Meek, Smithsonian Misc. Colln. v. 7, p. 19.
1864. *Anchura? sublevis* Meek and Hayden. Meek, Smithsonian Misc. Colln. v. 7, p. 19.
1876. *Anchura* (*Drepanochilus*) *americana* (Evans and Shumard). Meek, U.S. Geol Survey Terr., (Hayden) Rept., v. 9, p. 324, pl. 32, figs. 8a, b.
1876. *Anchura? sublevis* (Meek and Hayden). Meek, U.S. Geol. Survey Terr., (Hayden) Rept., v. 9, p. 327, pl. 19, figs. 3a, b.
1879. *Anchura americana* (Evans and Shumard). White, U.S. Geol. Survey Terr., (Hayden), 11th Ann. Rept., 1877, p. 185.
1885. *Anchura americana* (Evans and Shumard). Whiteaves, Canada Geol. Survey, Contr. Canadian Paleontology, v. 1, pt. 1, p. 48–49.
1904. *Drepanochilus evansi* Crossmann, Essais de paléoconchologie comparée, v. 6, p. 75.
1917. *Anchura americana* (Evans and Shumard). Dowling, Canada Geol. Survey Mem. 93, p. 31, pl. 29, figs. 5, 5a.
1921. *Anchura* (*Drepanochilus*) *americana* (Evans and Shumard). Stanton, U.S. Geol. Survey Prof. Paper 128–A, p. 37, pl. 6, fig. 13.
1934. *Alaria* (*Anchura*) *nebrascensis* Coryell and Salmon (non Evans and Shumard), Am. Mus. Novitates 746, p. 10.
1940. *Drepanochilus* (*Drepanochilus*) *americanum* (Evans and Shumard). Wenz, Gastropoda, *in* Schindewolf, O. H. Handbuch der Paläozoologie, v. 6, pt. 4, p. 912, fig. 2683.
1944. *Drepanochilus americanum* (Evans and Shumard). Shimer and Shrock, Index Fossils of North America, p. 497, pl. 203, fig. 24.
1960. *Drepanochilus evansi* Cossmann. Sohl, U.S. Geol. Survey Prof. Paper 331–A, p. 100, pl. 11, figs. 23, 26

Type locality.—"Moreau and Grand Rivers" (Evans and Shumard, 1857). The type specimens cannot be located, but they obviously came from the Fox Hills Sandstone of South Dakota.

Diagnosis.—Shell above average size for genus, body whorl strongly bicarinate, upper carination noded by collabral transverse swellings.

Description.—Medium-size turriculate shell, spire a little more than half total shell height. Pleural angle 25°–30°. Protoconch consists of 2¼–2½ smooth naticoid whorls; the last whorl increases rapidly in size to almost the diameter of the first teleoconch whorl and is well rounded and smooth. Immediate preteleoconch whorl globose with well-rounded and smooth sides. Suture flush and straight, teleoconch whorls six to eight in number, whorl sides well rounded on spire. Body whorl bicarinate, whorl steeply sloping and flat above upper carination, flat to gently concave between carinations and broadly convex below, tapering to a narrow prolonged anterior pillar. Sculpture begins on first teleoconch whorl with about seven spiral threads with an eighth one interjected just below the suture after about seven and one-quarter turns; weak irregularly spaced arcuately opisthocyrt, opisthocline transverse ribs appear at this time. On second teleoconch whorl, transverse ribs become stronger and evenly spaced, forming an almost cancellate pattern with about 20 ribs on the whorl. Ribs continue to increase in strength until they become stronger, higher, and broader than the overriding spiral cords. Spiral threads increase in strength to narrow ribbons that are narrower than their interspaces, but do not increase in number until the teleoconch whorl, where secondary cords appear between the primaries. The secondary spiral cords increase in strength until they approximate the strength of the primaries; on the penultimate whorl there are generally

24–26 cords, but as many as 33 may be present. The transverse ribs also increase in number to a maximum of 28 on the penultimate whorl, but begin to weaken generally in late penultimate whorl stage as the ribs begin to die out below.

On the body whorl, spiral sculpture remains strong with a spiral carination developing and increasing in strength toward the outer lip about 3 mm below the suture. This carination carries several spiral ribbons or cords on its surface. A second carination develops lower on the whorl on the basal slope. This carination is continuous with the spiral cord that is situated at the suture of the preceding whorls. Fine spiral cords cover the base of the body. The upper carination carries out to the end of the extended outer lip spike and is the surface reflection of the incised groove of the inner surface of the outer lip. The lower carination is but an accentuated spiral cord that dies out at the outer lip margin.

The transverse ribs of the body are weak wide-spaced swellings, but they are accentuated to form nodes as they intersect the upper spiral carination, then carry weakly to the lower carination. Growth line is opisthoclinely opisthocyrt. Aperture lanceolate in outline narrowed anteriorly, slightly angulated posteriorly. Outer lip expanded to a broad wing that tapers to, and terminates in, a sharp pointed upward curving spine; lip thickened along edges with a narrow groove paralleling upper edge of wing; groove is continuous with carination of outer whorl surface. Upper edge of outer lip curving up to embrace lower one-third of penultimate whorl; lower edge of outer lip sinuous below lower carination, with a double concave sinus when viewed from outer surface. Inner lip with moderately thick, sharply marginal callus; parietal callus evanesces a short distance over body and has an arcuate margin that thins to a sharp edge over the short anterior siphonal area.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9). (See also fig. 3.)

Specimen and locality	H	MDW	HB
Hypotype:			
USNM 274—Fox Hills Sandstone, South Dakota	30.7	21.6+	15.0+
Do	27.1+	20.0	15.0
USNM 274 (Figured by Stanton, 1921)	24.0	16.3	10.2+
USGS 23513—Fox Hills Sandstone, South Dakota	21.1+	14.6+	--------
USGS 23342—Fox Hills Sandstone, South Dakota	22.2+	17.4+	--------
Do	23.6	?	--------
Do	22.2	14.8+	--------

Discussion.—*Drepanochilus evansi* is one of the larger species of the genus and is easily distinguished from the other western-interior species from lower stratigraphic positions by having a noded upper whorl carination. *Drepanochilus pusillus* (Stanton) (1921, p. 38) from the Paleocene Cannonball Member of the Fort Union Formation of South Dakota is consistently smaller in size (fig. 4), has coarser nodings of the upper carination (pl. 4, fig. 6), has more spiral cords at an earlier stage of growth, has a less sinuous trace of the

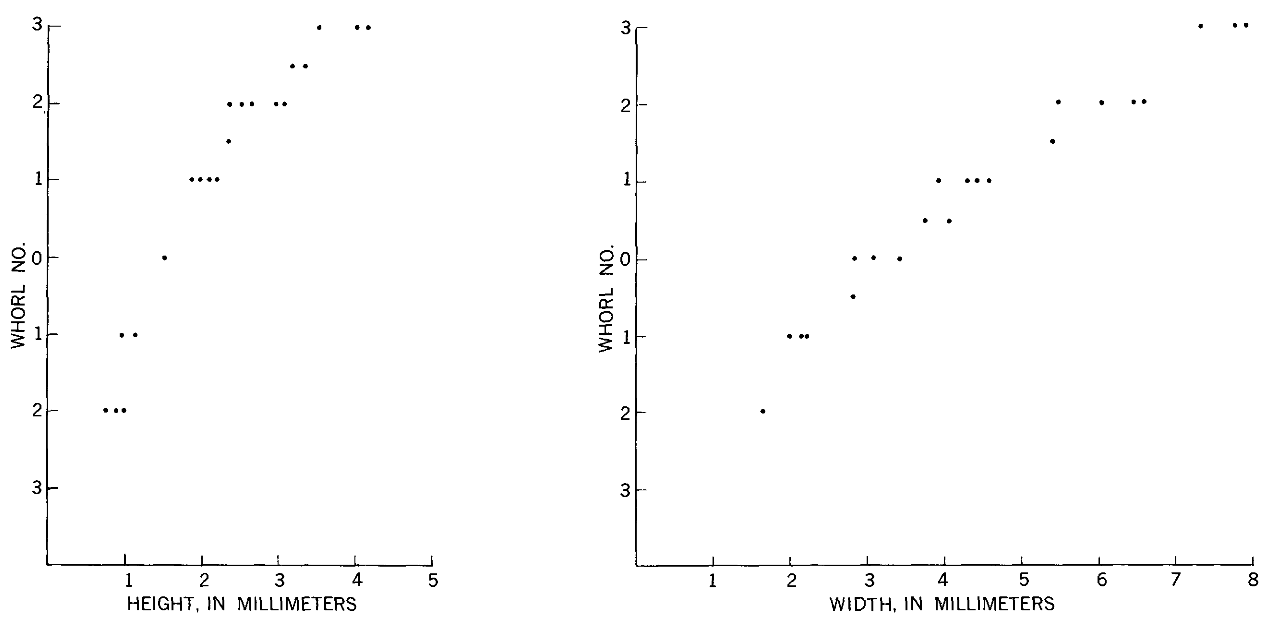

FIGURE 3.—Ontogeny of *Drepanochilus evansi* Cossmann. Measurements made using an arbitrary whorl height of 1.5 mm as the zero whorl.

lower part of the outer lip, and has a higher pleural angle. The ontogeny differs in that transverse ribs appear to be the first element of sculpture developed on *D. pusillus* (pl. 4, fig. 6), whereas spiral threads appear first on *D. evansi* (pl. 3, fig. 11). *D. nebrascensis* (Evans and Shumard) from the Pierre Shale at its type locality is a smaller species lacking nodes on the spiral carinae of the body (pl. 3, fig. 1). In addition, the spiral elements of the spire are finer, and the transverse ribs are more highly inclined.

Drepanochilus sublevis (Meek and Hayden) (pl. 3, fig. 16) represents a form transitional between *D. evansi* and *D. scotti.* Meek and Hayden's type of *sublevis* came from 150 miles above the mouth of the Yellowstone in beds near the top of the Pierre Shale (*Baculites baculus* zone). Other specimens in the collections of the Geological Survey from this same zone near Glendive (pl. 3, figs. 13, 14) show similar suppression of the transverse elements, although not quite so extreme. *Anchura? sublevis* Whitfield (non Meek and Hayden) possesses the cancellate early sculpture and general spire sculpture of *D. evansi,* but is an immature specimen that cannot presently be properly placed.

The occurrences of individuals assignable to this species in the Red Bird section are restricted to a few generally small specimens from the *Baculites baculus* and *B. grandis* zones. All probably belong to the transitional types similar to those from the Pierre Shale of the Glendive region (pl. 3, figs. 13, 14) of eastern Montana (*B. baculus* zone). The specimen from locality D–1985, *B. grandis* zone, pl. 3, figure 20, in the upper unnamed tongue of the Red Bird section conforms to this type especially well in its weak spiral carinae and nodes.

Types. Holotype, lost; hypotypes, USNM 274, 132683, 132680, 132685, 132688, 132690, 132692, 132952.

Occurrences. Wyoming: Pierre Shale, Red Bird section (*Baculites grandis* zone), USGS D–1985; (*B. baculus*) USGS D–1983. Montana: Glendive area, upper part of the Pierre Shale (*B. baculus* zone). South Dakota: Fox Hills Sandstone and uppermost part of Pierre Shale. North Dakota: Fox Hills Sandstone, Colorado: Front Range, Pierre Shale (*B. baculus* zone), USGS D–1542 (*B. clinolobatus* zone), USGS D–3720, D–1294 and D–1545? Canada: Questionably present in the Bearpaw Shale of Alberta.

Drepanochilus scotti Sohl, n. sp.

Plate 4, figures 13, 14, 17–24

Type locality.—Pierre Shale (*Baculites jenseni* zone) 2.4 miles west-northwest of Niwot, on southeast side of Haystack Mountain in NE¼SW¼SE¼NW¼ sec. 27, T. 2 N., R. 70 W., Boulder County, Colo. (USGS D–335).

Diagnosis.—Shell large for genus, body whorl weakly bicarinate, transverse sculpture subdued, growth line sinuous.

Description.—Medium-sized turriculate shell, spire a little more than one-third total shell height. Pleural angle 22°–32°. Protoconch consisting of about 2½ smooth round-sided whorls with first whorl somewhat depressed. Teleoconch whorls about seven in number, have well-rounded sides. Body whorl bicarinate; upper spiral carination low, developing one-third to one-half whorl behind aperture. A second variable, weaker

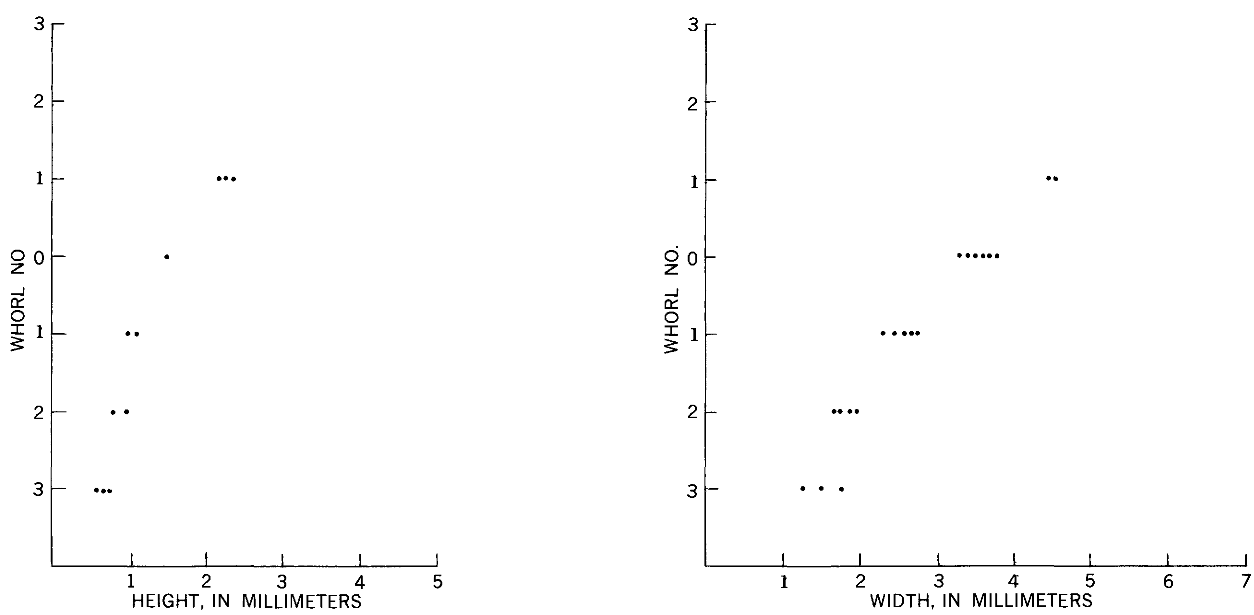

FIGURE 4.—Ontogeny of *Drepanochilus pusillus* (Stanton). Measurements made using the arbitrary whorl height of 1.5 mm as the zero whorl.

spiral carination develops low on whorl. Whorl profile flattens above and between carinations; body concavely tapers below to the pillar. Sculpture begins on first teleoconch whorl with three very faint threads over the rounded upper whorl surface; spiral threads strengthen and are added to until at the end of the whorl, eight spiral threads cover the surface. Low arcuately opisthocyrt opisthocline transverse ribs appear with the beginning of the second teleoconch whorl.

On later whorls, spiral elements increase in strength to rounded cords or flat-topped ribbons that override transverse ribs and are narrower than interspaces; ribbons may number 13–16 on the penultimate whorl. Secondary spirals may occur on body. Transverse ribs may number 26–29 per whorl; ribs decrease in strength until only an occasional faint transverse swelling may be present on the body whorl and last half of the penultimate whorl. The upper carination of the body whorl carries out to the spire that terminates the outer lip. Growth lines opisthoclinely opisthocyrt on spire. Aperture incompletely known but with outer lip expanded to a wing that embraces the lower part of the penultimate whorl above, is extended into an elongate tapering spike reinforced by the main spiral carination of the body with a corresponding incised groove interiorly.

Measurements.—No specimens are perfectly preserved. The maximum recorded height attained is estimated at 35 mm; maximum diameter about 16 mm, including the extended outer lip; and a body whorl about 12 mm in height. (See fig. 5.)

Discussion.—This species is easily distinguished from the *Drepanochilus* of higher stratigraphic positions in its lack of transverse ribs on the body whorl, non-noded spiral carination, less arcuate growth line, weaker spiral carination, more numerous transverse ribs on the spire, and in other details of sculpture. *Drepanochilus scotti* is a larger species than *D. nebrascensis* which occurs at lower stratigraphic level and has coarser sculpture with less highly opisthocline transverse ribs.

Drepanochilus scotti ranges through the *Baculites jenseni* and *B. eliasi* zones and occurs rarely in the upper part of the *B. reesidei* zone in Colorado. Only one questionably assigned specimen, an internal mold from the upper part of the *B. reesidei* zone, occurs in the Red Bird sequence, but it does conform in size and in faintness of the carinations to this species.

D. scotti appears to be ancestral to the typical *D. evansi* of the Fox Hills through transitional forms, such as those from the *B. baculus* and *B. clinolobatus* zones of the upper part of the Pierre Shale at such localities as Glendive, Mont., the Red Bird sequence of Wyoming, and the Front Range of Colorado. These transitional forms show an intermixture of characters of both species, being like *D. scotti* in their suppressed transverse sculpture but similar in body whorl features to *D. evansi*. The species is named for Glenn Scott of the U.S. Geological Survey, who collected the type material.

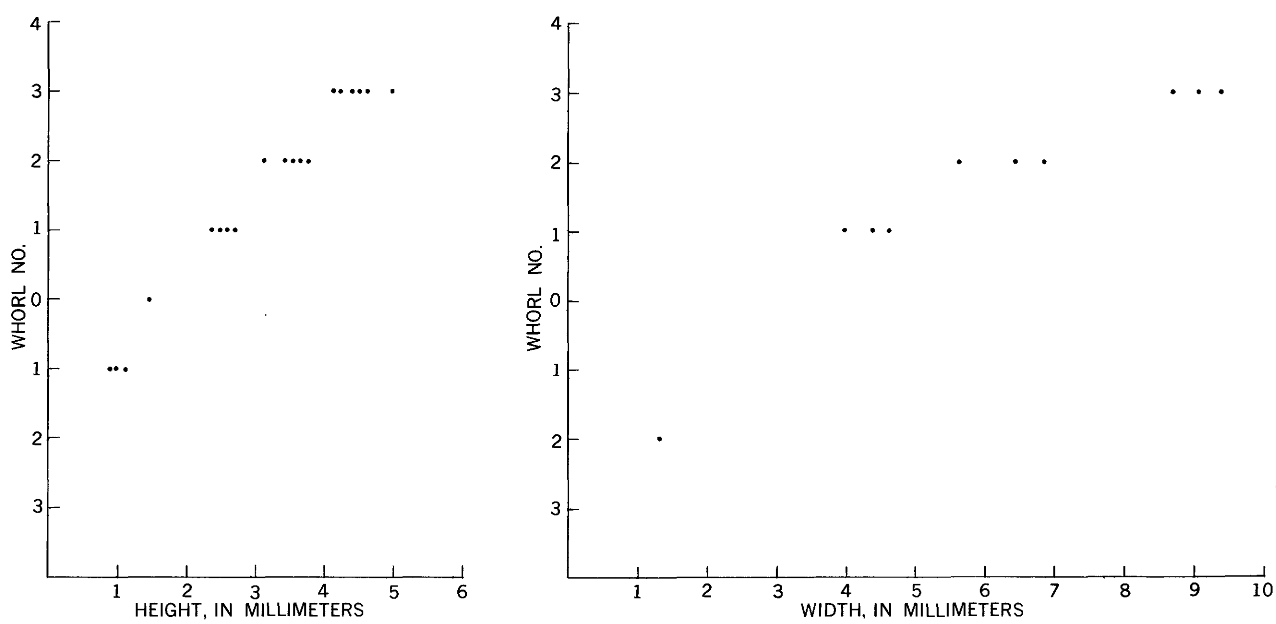

FIGURE 5.—Ontogeny of *Drepanochilus scotti* Sohl, n. sp. Measurements made using the arbitrary whorl height 1.5 mm as the zero whorl.

Types: Holotype, USNM 132958; paratypes, USNM 132682, 132686, 132689, 132694, 132954, 132957, 132959, 132960, 132962.

Occurrences: Colorado: Pierre Shale (*B. eliasi* zone), USGS 16093, D–476, D–1078, D–335; (*B. jenseni* zone), D–16093, D–374; (*B. reesidei* zone?) USGS D–1567, D–2820, D–728, D–631. Wyoming: Pierre Shale (*B. reesidei* zone, upper part), USGS D–1952.

Drepanochilus nebrascensis (Evans and Shumard)

Plate 3, figures 1–9

1854. *Rostellaria nebrascensis* Evans and Shumard, Acad. Nat. Sci. Philadelphia Proc., v. 7, p. 164.
1860. *Aporrhais nebrascensis* (Evans and Shumard). Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 423.
1864. *Anchura* (*Drepanochilus*) *nebrascensis* (Evans and Shumard). Meek and Hayden, Smithsonian Misc. Colln., v. 7, p. 19.
1876. *Anchura* (*Drepanochilus*) *nebrascensis* (Evans and Shumard). Meek (part), U.S. Geol. Surv. Terr. (Hayden) Rept., v. 9, p. 326, pl. 13, figs. 5a, b, c (figures questionably assigned to species).
1900. *Anchura nebrascensis* (Evans and Shumard). Knight, Wyoming Univ. Bull. 45, p. 154, pl. 9, fig. 7 (copy of Meek's 1876 figures).
1904. *Arrhoges* (*Drepanochilus*) *nebrascensis* (Evans and Shumard). Cossmann, Essais de paléoconchologie comparée, v. 6, p. 77.

Type locality.—"Sage Creek, Nebraska" (Evans and Shumard, 1854, p. 164). According to W. A. Cobban (written commun., 1964), the material from Sage Creek (now in the State of South Dakota) is from the *Baculites compressus* zone occurring in dark gray fossiliferous concretions.

Diagnosis.—Shells medium to small for genus, body with two strong carinations that lack nodes. Ridge on inner surface of outer lip near and parallel to edge.

Description.—Medium-sized turriculate spire slightly more than one-half total shell height. Pleural angle 20°–23°. Protoconch naticiform consisting of two smooth well-rounded whorls. Teleoconch of 4–6 convex sided whorls. Body whorl strongly bicarinate, whorl almost flat between suture and upper carination, concave between carinations and broadly concave below sloping to the anterior pillar. Sculpture of first teleoconch whorl begins with about six low spiral threads. After one-quarter of a turn, weak arcuate transverse ribs appear that strengthen until, at beginning of second teleoconch whorl, sculpture pattern is cancellate. Ribs continue to strengthen and on second and third whorls they are higher, broader, and stronger than the overriding spiral ribbons. By the penultimate whorl the ribs broaden, become lower and weaker. Spiral elements remain strong, but the ribbons become rounder topped and become wider spaced with occasional secondary spiral threads interpolated between the primaries. Spiral elements may increase from the 6 primaries to as many as 14 cords and threads on the penultimate whorl.

Ribs number on penultimate whorl from 16 to 24. Upper spiral carination of body whorl stronger than lower and carries out onto expanded outer lip continuing onto extremity, forming a slightly upcurved spike. Growth line opisthoclinely opisthocyrt. Aperture lanceolate in outline, narrowest anteriorly, angulated posteriorly, outer lip expanded to form a moderately broad wing, tapering to a sharp pointed, slightly upcurving spike, interiorly outer lip grooved in position of the upper whorl carination and with a ridge of callus extending posteriorly parallel to but about 1½ mm behind edge of outer lip. Ridge terminates at groove. Callus ridge commonly reflected as an irregular swelling on outer surface of wing.

Measurements.—The maximum size recorded for specimens from the type locality at the mouth of Sage Creek, South Dakota (USGS 23072) is 16 mm in height and 10.5 mm in diameter including the expanded outer lip (see also fig. 6).

Discussion.—The species occurs abundantly at the type area in concretions containing hundreds of individuals. Within such concretions considerable variation in both size and sculpture can be detected. Variation in size is shown in the measurements given above and on figure 6 (locality USGS 23072). Variation in sculpture primarily affects the strength of the spiral carinae and the transverse ribbing. On small specimens the spiral carinations of the body whorl may start at the beginning of the whorl or may be present over only the later half of the whorl. Transverse ribs are usually present on the penultimate whorl, but there is every gradation from strong to weak, and total absence of such ribs. The number of transverse ribs appears to vary more with stratigraphic position than within individual populations. The specimens from higher stratigraphic levels commonly have a greater number of ribs than those of the *B. compressus* zone.

The specimens figured by Meek (1876, pl. 19, figs. 5a–c) come from "Crow Creek, near Black Hills, from the upper beds of the Fort Pierre Group" (p. 327). According to W. A. Cobban (written commun., June 1964), there is a Crow Creek in the vicinity of Belle Fourche at the north end of the Black Hills. The creek, however, drains only areas of Greenhorn and Belle Fourche rocks of Turonian-Cenomanian age. Meek's "Crow Creek" specimens (pl. 3, fig. 7) compare favorably with specimens from the type area on Sage Creek (*B. compressus* zone) in size; but they have weak carinations and very fine highly inclined transverse sculpture, and in some ways more closely approximate specimens from the lower range of *D. americanus*

(*B. baculus-B. clinolobatus* zones). The matrix in which Meek's specimens occur is dark-gray concretionary sandstone similar to the Pierre concretions from other localities, but the concretion appears to have been much smoothed, perhaps by running water. Only small fragments of a few other mollusks save *Drepanochilus* are present and thus afford no aid in fixing the stratigraphic position. In view of their somewhat distinctive morphology and the inability to place accurately their occurrence either geographically or stratigraphically, assignment to a species is deferred until sufficient information is available.

The specimens assigned to this species by Whitfield (1880, p. 429) are herein redescribed as *Drepanochilus obesus*. Coryell and Salmon (1934, p. 10) assigned specimens from the Cedar Creek anticline near Glendive, Mont., to this species. They describe an indeterminate internal mold from the upper part of the Pierre Shale that, judging by the stratigraphic position, probably belongs in *D. evansi.*

Compared to *Drepanochilus obesus*, which occurs at a stratigraphically lower position, *D. nebrascensis* is smaller and more slender; the proportionally lower position of the peripheral carination (fig. 2) and smaller size and lack of peripheral nodings separate *D. nebrascensis* from *D. evansi;* and it is more slender, smaller, and has stronger peripheral carinations than *D. scotti.*

Drepanochilus nebrascensis ranges from the *Didymoceras stevensoni* zone up into the *B. reesidei* zones of Colorado, Wyoming, and South Dakota. The specimens from the Red Bird section from the *Didymoceras stevensoni* zone are immature and can only questionably be assigned to this species.

Types: Holotype, lost; hypotypes, USNM 132678, 132679, 132681, 132693, 132697, 132695, 132705, 132963.

Occurrences: Wyoming: Pierre Shale (Red Bird section), a questionable occurrence at USGS D-1939 (*Didymoceras stevensoni* zone). South Dakota: Pierre Shale (*Baculites compressus* zone). Colorado: Front Range (*Exiteloceras jenneyi* through *B. cuneatus* zones; especially common in *B. cuneatus* zone).

Drepanochilus obesus Sohl, n. sp

Plate 4, figures 15, 25–31

1880. *Anchura* (*Drepanochilus*) *nebrascensis* (Evans and Shumard). Whitfield, U.S. Geog. and Geol. Survey Rocky Mtn. Region (Powell), p. 429, pl. 12, figs. 2, 3.

Type locality.—Pierre Shale, Red Bird Silty Member, *Baculites gregoryensis* zone at sec. 13, 19, 23, T. 38 N., R. 62 W., Niobrara County, Wyo. Holotype, USNM 132642 (USGS Mesozoic loc. D-1917).

Diagnosis.—Shell large and obese for genus with a high pleural angle. Body whorl strongly bicarinate with upper carination proportionately low on whorl, and distance between carinations proportionately great (fig. 2). Transverse ribs highly inclined for genus, spiral sculpture of numerous fine spiral threads.

Description.—Shell of medium size, turriculate, with spire and body whorl height almost equal. Pleural angle 32°–33°. Protoconch unknown. Early sculpture of fine spiral ribbons that override very arcuate transverse ribs; at about 1.5 mm whorl height, ribs number 24–28 per whorl and spiral cords average 20 per whorl. Ribs become wider spaced on later whorls and may disappear on about the last one-quarter of the penultimate whorl. Spiral sculpture increases mainly by the addition of fine spiral threads between the cords. The penultimate whorl usually bears 22–26 cords and

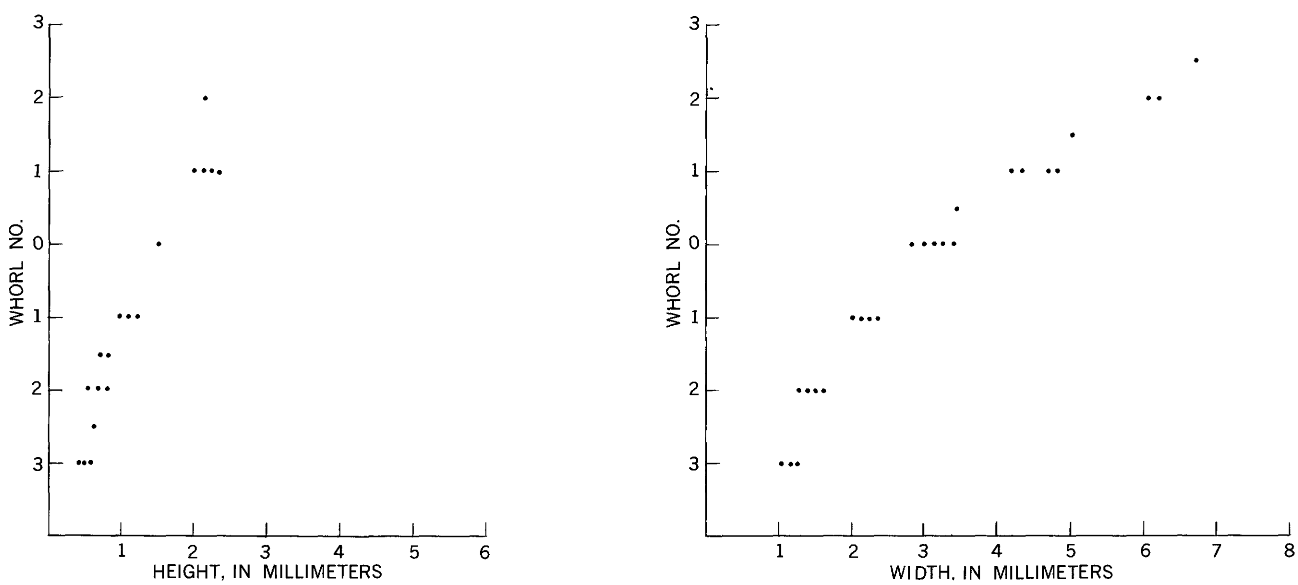

FIGURE 6.—Ontogeny of *Drepanochilus nebrascensis* (Evans and Shumard). Measurements made using the arbitrary whorl height of 1.5 mm as the zero whorl.

threads. Transverse sculpture absent on body whorl. Spiral sculpture of body whorl dominated by two prominent carinations; the posterior carination is strongest and continues to the spikelike termination of the outer lip; 20–24 spiral cords and threads occur on the rounded surface above the posterior carination, 6–8 threads are present on the broadly concave area between the carinations; the steep anterior slope is covered with spiral threads. Growth line strongly opisthocyrt, opisthocline in total. Aperture incompletely known, outer lip expanded to a broad wing that tapers to a slightly curving spike; interior of lip grooved along trend of spiral carination to spikelike termination and ridged along lower two-thirds of extent parallel to edge.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9).

Specimen and locality	HB	MDW
USNM 12309 (Whitfield, 1880)	91	112
Do	66	96
USGS D–1271—Colorado	74	104
USGS D–1917—Wyoming	107+	175

Discussion.—This species attains the largest size known for any member of the genus and has a higher pleural angle. Compared to *D. nebrascensis*, this is a much larger and more obese species. In convexity of whorl it is approached only by *D. scotti* from the *B. reesidei* through *B. eliasi* zones, but that species has more subdued spiral carinations and more direct transverse ribs. *D. evansi* has noded carinations, lacks a ridge near the lower margin of the outer lip, and the whorl between suture and carination is concave rather than convex in profile.

The ridge on the inner lip parallel to the outer extremity allies this species to *Drepanochilus nebrascensis*.

The figured specimens assigned by Whitfield and here refigured (pl. 4, figs. 30, 31) came from "East Fork of Beaver Creek, 3 miles west of Camp Jenny, Black Hills." W. A. Cobban (written commun., June 15, 1964) states that Whitfield's collections from Beaver Creek include species from the *Exiteloceras jennyi* and *Didymoceras stevensoni* zones and probably species as old as the *Baculites gregoryensis* zone. Although it is not possible to place Whitfield's specimens accurately, they obviously came from beds within the range of *D. obesus* and morphologically conform well to the species.

Types: Holotype, USNM 132642; hypotypes, 132675, 132700–132703.

Occurrences: Wyoming: Pierre Shale, Red Bird section, Red Bird Silty Member (*B. gregoryensis* zone), USGS D–1917. Colorado: Pierre Shale, Front Range (*Baculites scotti* and *Didymoceras nebrascense* zones). South Dakota: Pierre Shale (Whitfield 1880, p. 429, position uncertain).

Genus **APORRHAIS** Da Costa 1778

Type by monotypy, *Strombus pespelicani* Linne, 1758.

Diagnosis.—Medium-sized aporrhaids with surface covered by fine spiral cords. Transverse sculpture of poorly developed ribs normally absent on earliest whorls. Ribs accentuated to nodes where they cross spiral carination. Body whorl bicarinate to tricarinate Aperture expanded to a broad wing with three digitations, one extending posteriorly and adnate to spire, the other two extending laterally as continuations of spiral carinae of body. Anterior canal moderately short.

Discussion.—Numerous Cretaceous species in both hemispheres have been assigned to *Aporrhais*. Most, however, appear to belong in other genera. The species here described from the Pierre Shale of the western interior and one undescribed form from the Blufftown Formation (lower Campanian) of Alabama appear to be the only true members of the genus in the Cretaceous of North America. The following list is an attempt to assign the North American Cretaceous species commonly ascribed to *Aporrhais*.

To *Anchura* Conrad, 1860
- *Aporrhais angulata* Gabb, 1864 by Stewart, 1926 (California)
- *Aporrhais falciformis*, Gabb, 1864 by Gabb, 1868 (California)

To *Arrhoges* Gabb, 1868
- *Aporrhais californica* Gabb, 1864 by Stewart, 1926 (California)
- *Aporrhais travisensis* Stanton, 1947 (Comanche Peak Limestone, Texas)
- *Aporrhais tarrantensis* Stanton, 1947, assignment questionable (Comanche Peak Limestone, Texas)

To *Cyphosolenus* P. Fischer, 1884
- *Aporrhais neucensis* Stanton, 1947 (Comanche Peak Limestone, Texas)

To *Drepanochilus* Meek, 1864
- *Aporrhais sublevis* Meek and Hayden (Pierre Shale, Montana)

To *Graciliala* Sohl, 1960
- *Aporrhais decemlirata* Conrad, 1858

To *Monocyphus* Piette, 1876
- *Aporrhais brittsi* Stanton, 1947 (Edwards Limestone, Texas)
- *Aporrhais singleyi* Stanton, 1947 (Edwards Limestone, Texas)

Such species as *Aporrhais* (*Perissoptera*) *prolabiata* (White) of Stanton, 1894, *A.* (*Pterocerella*) *tippana* (Conrad) of Wenz, 1940, and *A.* (*Lispodesthes*) *nuptialis* (White) of Bergquist, 1944, are automatically assigned when the subgenera are raised to generic rank as is now generally accepted.

Generically indeterminate:

Aporrhais sp. Ravn, 1911 (Neocomian, Greenland)
A. spp. Ravn, 1918 (Senonian, Greenland)
A.? elpasensis Stanton, 1947
A.? kentensis Stanton, 1947 (may belong in the Colombellinidae)
A.? subfusiformis (Shumard) Stanton, 1947

Aporrhais biangulata Meek and Hayden

Plate 2, figure 8–18

1856. *Rostellaria biangulata* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 65.
1860. *Aporrhais biangulata* Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc. v. 12, p. 186.
1876. *Aporrhais biangulata* Meek and Hayden. Meek, U.S. Geol. Survey Terr. (Hayden), Rept. v. 9, p. 322, pl. 19, figs. 6a, b, c, fig. 37.
1904. *Chenopus* (*Chenopus*) *biangulata* (Meek and Hayden). Cossmann, Essais de paléoconchologie comparée, v. 6, p. 55.
1917. *Aporrhais biangulata* (Meek and Hayden). Dowling, Canada Geol. Survey Mem. 93, p. 46, pl. 29, figs. 6, 6a.

Type locality.—"Yellowstone River, 150 miles from its mouth" (Meek, 1876, p. 323). This locality is the upper part of the Pierre Shale (*Baculites baculus* zone) in the vicinity of Glendive, Mont.

Diagnosis.—Medium-sized *Aporrhais* with sculpture dominated by fine spiral sculpture giving rise to a bicarinate body whorl; transverse sculpture restricted to normally low collabral incomplete ribs accentuated over carination of spire but absent on body.

Description.—Medium-sized turriculate shells, spire slightly more than one-half total height. Pleural angle 28°–31°. Protoconch unknown, teleoconch whorls about seven in number, broadly rounded on sides with greatest curvature at about two-thirds to three-fourths below suture; a peripheral carination develops at this position, usually on the penultimate whorl. Body whorl bicarinate with upper carination strongest, whorl profile convex suture to carination, concave between carinations, steeply sloping and broadly concave below. Sculpture dominantly spiral consisting of numerous crowded spiral threads of variable strength that cover the whorl surface. Transverse sculpture of generally weak highly arcuate collabral ribs. Ribs restricted normally to medial half of whorl accentuated at periphery to subnodings. Aperture lanceolate, anteriorly extended to an elongate shallow canallike groove of the curved pillar, inner lip with moderately thick callus that is posteriorly, laterally, and anteriorly continuous with the expanded outer lip. Outer lip expanded to a broad flaring wing that extends upward adnate to the spire for nearly its full length. This flange is not grooved interiorly, lies at an angle to the lateral extensions, and is partly separated by a sulcus; lateral wing extension grooved interiorly in harmony with the lateral extension of the carinations of the body whorl, which terminate in blunted spikes separated by a broad shallow sulcus; posterior slope of wing broadly concave curving to the elongate curved anterior spike. Growth line strongly arcuate, opisthoclinely opisthocyrt.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9). (See also fig. 7.)

Specimen and locality	H	MDW	HB
Holotype: USNM 275—Pierre Shale (*B. baculus* zone), Montana	12.7+	9.8	6.4
Paratype:			
USNM 132964—Pierre Shale (*B. baculus* zone), Montana	14.7	12.9+	9.3
USNM 275—Pierre Shale (*B. baculus* zone), Montana	------	9.5	7.3
Do	------	15.4	------
USNM 132965—Pierre Shale (*B. baculus* zone), Montana	18.3	13.4+	------
Hypotype:			
USNM 132704—Pierre Shale, Montana	12.4	11.3	7.4
USNM 132696—Pierre Shale, Montana	19.1+	15.4	9.9
USNM 132699—Pierre Shale, Montana	14.4+	13.7+	7.4
USNM 132698—Pierre Shale, Montana	13.5	9.0+	9.0

Discussion.—This distinctive small species shows variation primarily in the strength of the transverse ribs which are barely developed on some specimens (pl. 2, fig. 15) but on others may be accentuated to rather strong nodes on the periphery (pl. 2, figs. 12, 18). Normally, ribs are restricted to the penultimate whorl; in a few specimens, ribs may be seen on the antipenultimate whorl.

No available specimen preserves a full wing or nuclear whorls. This is not surprising as the shell material is paper thin and exfoliates easily during preparation of the specimens or because of breakage before burial.

Compared with the type species, *Aporrhais pespelicani* (pl. 2, figs. 1–5) from the North Atlantic, it can readily be seen that *A. biangulata* conforms closely in shape of the wing. The main differences rest in the recent species having stronger tranverse sculpture, larger size, and a less arcuate and opisthocline growth line. Ontogeny of sculpture with early whorls lacking transverse ribs is, however, quite similar (compare pl. 2, fig. 1, and pl. 2, fig. 15).

Aporrhais biangulata in the Red Bird section is known from only one incomplete specimen from the upper unnamed member of the Pierre Shale in the *Baculites baculus* zone. The type specimens come from the same zone near Glendive, Mont., at Meek's locality "150 miles above the mouth of the Yellowstone." Figures 11 and 15–17 on plate 2 all come from his type lot of specimens. The specimens figured on plate 2, figures 10, 12, 14, 18, also come from Montana, presumably from about the same level, but adequate locality data are lacking.

Types: Holotype USNM 275; paratype, USNM 132964; 132965, 132967; hypotypes, USNM 132696, 132698, 132699, 132704, 132684.

Occurrences: Wyoming: Pierre Shale, Red Bird section (*Baculites baculus* zone), USGS D–1981. Montana: Pierre Shale (*Baculites baculus* zone), near Glendive.

Aporrhais n. sp.

Plate 2, figures 6, 7

Discussion.—One incomplete specimen from the uppermost beds of the Mitten Black Shale Member of the Red Bird section (D–1877) *Baculites gilberti* zone) possesses such distinctive characters that it is obviously a new species. However, it lacks an outer lip, and the formal naming of the taxon should await better preserved material. This is especially true inasmuch as the most distinctive character, the nodes upon the transverse ribs, are a feature to be found on *Aporrhais biangulata* (Meek and Hayden). This species, however, differs in its suppression of the transverse ribs with nodes commonly restricted to the penultimate whorl and in having a much more sinuous growth line.

The specimen here discussed consists of about seven whorls, but is missing the apical tip, the expanded outer lip, and fragments of the surface. The shell is 17 mm high, with the body whorl 8 mm high and 7½ mm in diameter. The pleural angle is 22°. Sculpture of the early whorls is poorly preserved, but is dominated by strong transverse ribs that are overridden by low spiral cords. The ribs are accentuated to nodes at about the anterior three-quarters length of the whorl where they intersect a spiral subcarination. Below the nodings the ribs diminish to mere transverse swellings. On later whorls the ribs diminish in vigor, and on the latter half of the penultimate whorl they are irregularly spaced swellings. The spiral carination of the spire continues onto the body whorl, forming the upper whorl carination. The body whorl is bicarinate and covered by lesser spiral cords. The whorl profile is straight and steeply sloping between the suture and upper whorl carinations with an openly concave slope anteriorly. The specimen is broken at the lip, but the beginnings of the lip expansion can be seen as the upper suture of the body begins to rise adnate onto the penultimate whorl. The growth line is arcuately opisthocline above the nodes and steeply opisthocline below the nodes on the spire.

The generic placement of this species is in doubt. In general form, one is tempted to place it in *Drepanochilus*, especially because of the presence of ribs at an early stage of growth. However, the presence of the spiral carination at an early stage of growth and the nodings of the ribs are not unlike characters displayed by *Aporrhais pespelicani*, the type of species of *Aporrhais*. In addition, the slender spire argues for placement in *Aporrhais*, as the *Drepanochilus* from this part of the section have rather obese whorls.

Type: Figured specimen, USNM 132672.

Occurrence: Wyoming: Mitten Black Shale Member, Pierre Shale, Red Bird section (*Baculites gilberti* zone), USGS D–1877.

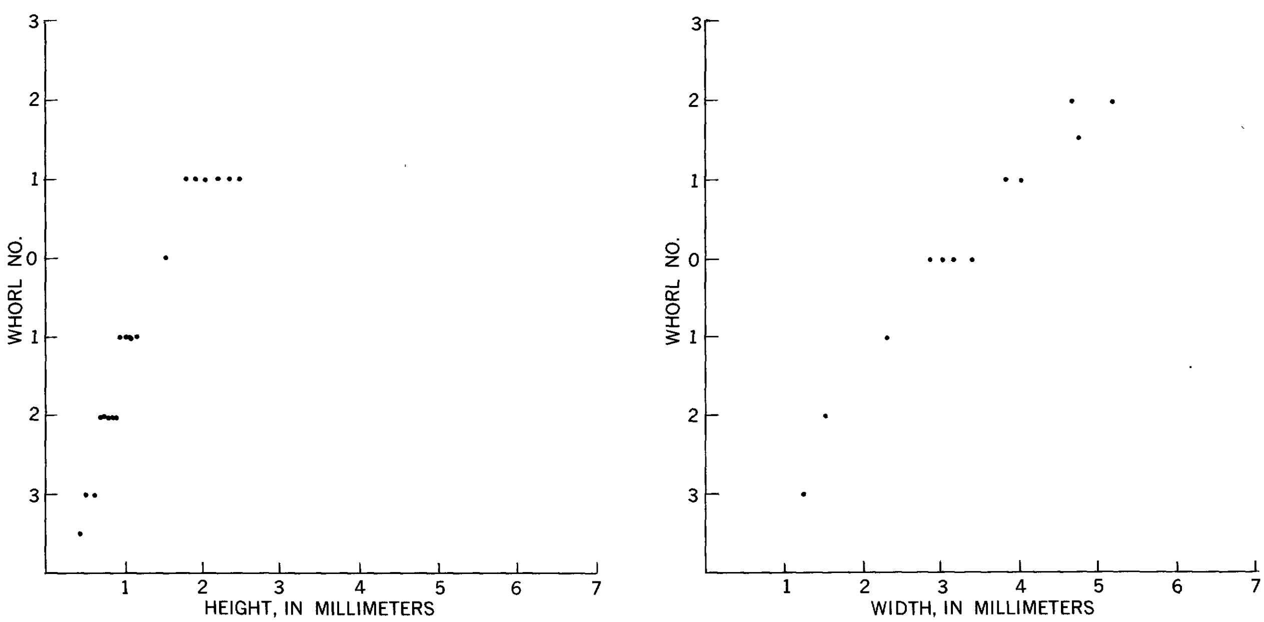

FIGURE 7.—Ontogeny of *Aporrhais biangulata* Meek and Hayden. Measurements made using the arbitrary whorl height of 1.5 mm as the zero whorl.

Superfamily HIPPONICACEA

Family VANIKORIDAE

Genus VANIKOROPSIS Meek, 1876

Type by original designation: *Natica toumeyana* Meek and Hayden, 1856.

Diagnosis.—Medium-sized thick naticiform shells. Sculpture dominated by strong broad spiral ribbons with transverse sculpture absent or as low and broad collabral rugosities. Umbilicus narrow.

Discussion.—Meek (1876) proposed this genus for thick unumbilicate shells, with strong growth rugae. He provisionally placed the genus in the Vanikoridae. Cossmann (1925) followed by Wenz (1941) assigned it to the Naticidae in part. They proposed such an assignment because of the supposed lack of an umbilicus.

Meek founded the genus on the holotype of *Vanikoropsis tuomeyana* from "the mouth of the Judith River * * * from the top of the Fox Hills Group." It is an incomplete specimen with a worn spire and with the body whorl broken back for about one-half whorl but, as figures (pl. 5, figs. 15, 16) of the holotype show, it possesses a narrow umbilical chink.

Fossar? nebrascensis Meek and Hayden (1860) (includes *Natica ambigua* Meek and Hayden (1856), *N. haydeni* Cossmann (1899) and *N. praenominata* Cossmann (1920)) is here included in *Vanikoropsis* because of similarities in shape, sculpture pattern, thickness of shell, and presence of an umbilical chink. The type species *V. toumeyana* differs from *V. nebrascensis* in its coarse growth rugae and its proportionally broader and more depressed spire. The low spire and breadth (pl. 5, fig. 15) of the holotype, however, are accentuated by wear of the spire and breakage of the body whorl.

Assignment of *Vanikoropsis* to the Naticidae is questionable, and I prefer to place it in the Vanikoridae. Cossmann (1925, p. 165) actually placed one of the here-included species (*Natica ambigua*) in *Vanikoro*. Compared with *Vanikoro* as exemplified by the type species *V. cancellata* (Chemnitz) (pl. 5, figs. 2–4), *Vanikoropsis* differs in having a thicker shell, a lower spire, and a more rounded aperture, especially the inner lip. As can be seen on some specimens of the Recent species *Vanikoro lygata* Recluz (pl. 5, figs. 11, 13), sculpture pattern can be similar in the two genera. Cossmann (1925, p. 41) lists a number of fossil species ranging from Jurassic (Portlandian) through the Upper Cretaceous as belonging in this genus, but they all appear to be globose nonumbilicate naticids with spiral sculpture that are not closely related to *V. toumeyana*.

Other Cretaceous species from the Western Hemisphere have been assigned to *Vanikoropsis* and *Vanikoro*, but most do not belong.

Vanikoro propinqua Cragin (1894) (from the Comanche series (Kiowa Shale) of Kansas (see Stanton, 1947, p. 104), has never been figured, but the description appears to be of an unrelated siphonostomous shell.

Vanikoro n. sp.? Spath (1936, 1946), from the Jurassic and Cretaceous of Greenland, is represented by incomplete internal molds which are impossible to place with confidence.

Vanikoropsis suciensis White (1889), from the Cretaceous of Sucia Islands, is an internal mold of uncertain affinities.

Vanikoro kiliani Wilckens (1910), from the Antarctic Upper Cretaceous, according to Wilckens figures, has a sinuate inner lip not typical of *Vanikoro*.

Vanikoro pulchella Whiteaves (1884), from the Queen Charlotte Islands of British Columbia, probably is a neritacean related to *Lyosoma* White.

Vanikoropsis nebrascensis (Meek and Hayden)

Plate 5, figures 1, 5–10, 12, 14, 17; plate 6, figures 1–4, 11

1856. *Natica? ambigua* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 64 (non Morris and Lycett, 1854).
1860. *Fossar? nebrascensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 423.
1864. *Vanikoro ambigua* (Meek and Hayden). Meek, Smithsonian Misc. Coll., v. 15, p. 18.
1876. *Vanikoro ambigua* (Meek and Hayden). Meek, U.S. Geol. Survey Terr. (Hayden) Rept., v. 9, p. 330, pl. 19, figs. 12a–d.
1880. *Vanikoro ambigua* (Meek and Hayden). Whitfield, U.S. Geog. and Geol. Survey Rocky Mtn. Region (Powell), p. 430, pl. 12, fig. 14.
1899. *Natica haydeni* Cossman, Rev. critique paléozoologie, v. 3, no. 3, p. 136.
1920. *Natica praenominata* Cossman, Rev. géologie, v. 1, no. 1, p. 69.
1925. *Vanikoro ambigua* (Meek and Hayden). Cossman, Essais de paléoconchologie comparée, v. 13, p. 165.

Type locality.—"Yellowstone River 150 miles above its mouth." The locality is near Glendive, Mont., in the upper part of the Pierre Shale (*Baculites baculus* zone).

Diagnosis.—Spire high and pleural angle low for genus. Transverse rugae uncommon.

Description.—Shells medium sized, naticiform, moderately thick; spire about one-third total shell height. Pleural angle 75°–80°. Protoconch is dome shaped and paucispiral with smooth-surfaced whorls. Suture impressed; whorls round sided. Sculpture dominated by spiral ribbons that cover the whorl; ribbons are broader than interspaces over whorl sides, but are narrower on base with interspaces equal to or wider than ribbons. Transverse sculpture restricted growth lines or broad usually discontinuous swellings. Growth lines prosocline, inclined about 15° to the axis of coiling. Aperture subovate, well rounded anteriorly, subangulate posteriorly. Inner lip broadly arched over parietal area, strongly curved anteriorly; parietal callus thin at edge. Umbilicus narrow, open, and free of callus.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9).

Specimen and locality	H	MD	H/MD	DPW	HB	HA	HB/MD
Holotype: USNM 267—Pierre Shale (*B. baculus* zone), Montana	15.6	11.0	1.3	8.6	10.5	8.3	1.1
Paratype:							
USNM 132967—Pierre Shale (*B. baculus* zone), Montana	13.2+	10.8	1.2	9.1	11.4	8.6	1.3
USNM 267—Pierre Shale (*B. baculus* zone), Montana	14.0+	13.5	-------	11.8	13.3	10.8	1.2
Hypotype: USNM 132663—Pierre Shale (*B. baculus* zone), Red Bird, Wyoming	19.3+	18.6	1.2	15.9	16.6	12.9	1.3
USGS 1896—Pierre Shale (*B. baculus* zone) Montana	14.4	13.4	1.3	10.0	13.0	10.8	1.2
Do	-------	10.7	1.2	9.1	10.1	8.5	1.2
USNM 21893—Fox Hills Sandstone, Montana	17.5	17.1	1.2	14.4	15.7	11.9	1.3
Do	16.5+	14.1	1.3	11.0	14.1	11.1	1.3
Hypotype: USNM 132664—Fox Hills Sandstone	22.4	20.5	1.2	17.2	21.0	16.0	1.3
Vanikoro cancellata (pl. 5, fig. 2)	13.5	14.1	.9	-------	-------	-------	-------
Vanikoro lygata (pl. 5, fig. 11)	19.0	20.7	.9	-------	-------	-------	-------

Discussion.—The assignment of *Vanikoropsis nebrascensis* to *Vanikoro* is untenable. In that genus the spire and protoconch are much depressed. The type species, *Vanikoro cancellata* (pl. 5, fig. 2), differs in its strong sculpture. *V. lygata* (pl. 5, fig. 11) is similar in adult sculpture, but both species differ greatly in body proportions, spire height (H/MD ratio of 0.9:1 vs. 1.2–1.3:1 for *V. nebrascensis*), and in having a much rounder aperture and thinner shell.

The synonymy of *Vanikoropsis nebrascensis* is complex. The combination *Natica ambigua* of Meek and Hayden (1856) is a homonym preoccupied by Morris and Lycett (1851) for a Jurassic species. In 1860, Meek and Hayden reassigned their species to *Fossar*, but as they pointed out, *Fossar ambigua* was preoccupied and they substituted the name *nebrascensis*. However, Meek in 1864 and later in 1876 reassigned the species to *Vanikoro* and resurrected the original name *ambigua*. This designation held until 1899 when Cossmann pointed out the homonymy of the original combination *Natica? ambigua* and substituted the name *Natica haydeni*.

In 1920, Cossmann again pointed out that *Natica? ambigua* Meek and Hayden was a homonym of Morris and Lycett's species. Cossmann evidently forgot his previous substitution of *Natica haydeni* and proposed the new name *Natica praenominata*. Later in 1925, Cossmann in his "Essais" again reassigned the species placing it in *Vanikoroa* (pro *Vanikoro*) and accepted the original name *ambigua*. In my opinion the first substituted name *nebrascensis* must stand for the species, and Cossmann's subsequent substitutions are invalid.

Specimens of *Vanikoropsis nebrascensis* are rare at individual collecting localities, but are widely distributed. As the measurements indicate, the available specimens vary greatly in size, but in body proportions they are very close. The largest specimens come from the Fox Hills Sandstone of North and South Dakota (pl. 5, figs. 7, 17), and the Pierre Shale of the Red Bird section. Thus, size appears to be no criteria of stratigraphic position. The specimens of the type lot are among the smaller specimens. Variation in sculpture primarily affects the strength and spacing of the spiral elements. Such variation is more noticeable on small specimens or at earlier stages of growth. In general, the spiral ribbons are stronger and more stable on the later whorls (pl. 5, fig. 17). The transverse rugae, when present, are strongest near the suture and are well displayed on one paratype (pl. 5, figs. 9, 10), on a specimen from an unknown locality in the Montana Group (pl. 5, fig. 8), and on a small specimen from the Pierre Shale at Glendive, Mont. The thickness of the shell behind the aperture is well shown by several specimens (pl. 5, figs. 1, 14).

The specimen from the Red Bird section when compared to the holotype is much larger and has stronger sculpture. When compared with specimens from other localities, especially those from the Fox Hills Sandstone, however, it fits well within the species.

As viewed here, *Vanikoropsis nebrascensis* (Meek and Hayden) ranges from the upper part of the Pierre Shale into the Fox Hills Sandstone and also occurs in equivalent formations in Wyoming, Colorado, Montana, and South Dakota.

Types: Holotype, USNM 267; paratype, USNM 132667, 132967; hypotypes, USNM 132663–132666, 132668.

Occurrences: Wyoming: Pierre Shale, Red Bird section (*Baculites baculus* zone), D–1983; Lewis(?) Shale USGS 28588. Montana: Bearpaw Shale, USGS 233361, 2891, 1212; Pierre Shale, USGS 1896 (*B. baculus* zone). South Dakota: Fox Hills Sandstone, USGS, 27487, 5925. Colorado: Pierre Shale (Front Range), *Baculites reesidei* and *B. jenseni* zones.

Superfamily CALYPTRAEACEA

Family TRICHOTROPIDAE

Genus ASTANDES Wade, 1917

Type by original designation: *Astandes densatus* Wade.

Discussion.—Wade (1926, p. 157) characterized *Astandes* as having a direct prosocline growth line, a D-shaped aperture, and an outer lip that is denticulate on its inner surface. Knowledge of the type species, *Astandes densatus*, is based solely upon the holotype (USNM 32944) (Sohl, 1960, p. 92). This specimen, from the Ripley Formation on Coon Creek, Tenn., as can be seen from Wade's (1917, p. 17, figs. 7, 8) original figures, possesses an incomplete aperture with the outer lip broken. I have been unable to verify the presence of denticles on the outer lip inner surface. Such denticles are certainly absent on *Tritonium cretaceum* Müller from the Upper Cretaceous, Aachen, Germany assigned to *Astandes* by Wade. In other genera, such as *Paladmete*, denticles are a variable feature even within individual species and therefore it should not be viewed as a generically significant feature of *Astandes*. The specimens described below from the Pierre Shale agree with the concept of the genus except for the denticulate outer lip.

Astandes densatus Wade

Plate 4, figure 1–5, 10, 12

1917. *Astandes densatus* Wade. Acad. Nat. Sci. Philadelphia Proc., v. 69, p. 299, pl. 17, figs. 7, 8.
1925. *Astandes densatus* Wade. Cossmann, Essais paléoconchologie comparée, v. 13, p. 273, pl. 8, figs. 18–19.
1926. *Astandes densatus* Wade. Wade, U. S. Geol. Survey Prof. Paper 137, p. 158, pl. 54, figs. 19, 20.
1926. *Astandes densatus* Wade. Wenz Gastropoda, *in* Schindewolf, Handbuch der Paläozoologie, v. 6, pt. 4, p. 892, fig. 2622.
1940. *Astandes densatus* Wade. Sohl, U.S. Geol. Survey Prof. Paper 331–B, p. 92.

Diagnosis.—High turbiniform shell, round-sided whorls, strong prosocline transverse ribs crossed by strong spiral ribbons and minor cords. Aperture D-shaped, anterior canal short.

Type locality.—Ripley Formation, Coon Creek, McNairy County, Tenn. (Wade, 1926, p. 158). This level may be equivalent to the *Baculites compressus* zone.

Description.—Medium-sized high turbiniform shell, spire two-fifths total shell height. Pleural angle 45°–48°. Protoconch unknown. Suture impressed. Whorls round sided, base broadly rounded but constricting rapidly. Sculpture consists of 18–20 strong round-topped collabral transverse ribs that are continuous from suture to well down on base. Spiral sculpture of strong raised spiral elements that are narrower than the spiral elements, but are broadly round topped to flat on their upper surfaces. These spirals are strongest over the periphrey where a few secondary threads may appear in the interspaces; on base, spacing of cords increases. Growth lines prosocline, becoming arcuate below periphery on basal slope. Aperture, broadly D-shaped, anterior canal very short, slightly twisted; inner lip smooth, callus thin at edge and on parietal surface, thickening within and over columellar lip. Outer lip incompletely known.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9).

Specimen and locality	H [1]	HB	MD	HB/MD
Holotype:				
USNM 32944—Ripley Formation, Mississippi	11+	7	8	0. 9:1
USNM 132929—Pierre Shale (*B. baculus* zone), Red Bird, Wyoming	16. 5	9	10	. 9:1
USNM 132969—Pierre Shale (*B. baculus* zone), Montana	14+	9	11	. 8:1
USNM 22850—Pierre Shale (*B. baculus* zone), Montana	12+	7	8	. 9:1
Hypotype: USNM 22970—Pierre Shale (*B. baculus* zone), Montana	15+	10	11	. 9:1

[1] Estimated.

All the specimens of *Astandes densatus* measured are incomplete, lacking either a part of the spire or outer lip. All the western-interior specimens are larger than the holotype from Tennessee, and they may represent a somewhat more mature stage of growth. With increased size the base of the whorls seems to become more rounded.

All the western-interior specimens occur at a higher stratigraphic position (*Baculites jenseni-B. baculus* zones) than the type specimen from the Ripley Formation on Coon Creek, Tenn. (=*Baculites compressus* zone?). Despite such differences, all specimens fall within a close proportional size range, and have a similar pattern of sculpture. There is insufficient material from the type locality to indicate range of variation of *Astandes densatus*, and it is the conservative course to consider all these specimens the same species.

Types: Holotype, USNM 32944 (Tennessee); hypotypes, USNM 22970, 132969 (Montana), USNM 132928, 132929 (Wyoming).

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1981, D–1984 (*Baculites baculus* zone). Montana: Pierre Shale, Glendive area, *B. baculus* zone. Colorado: Pierre Shale, Front Range (*B. jenseni* zone). Tennessee: Ripley Formation (Upper *Exogyra cancellata* zone).

Superfamily NATICACEA

Family NATICIDAE

Genus EUSPIRA Agassiz (in Sowerby), 1838

Type by subsequent designation Dall, 1915: *Natica glaucinoides* Sowerby, 1812.

Discussion.—Species of *Euspira* are the most common and widespread of the naticids in Upper Cretaceous rocks of North America. Sohl (1960, p. 122) has discussed the confusion of *Euspira* and *Lunatia* Gray, 1847, and accepted the latter as a synonym. It is under the name *Lunatia* that the western-interior species discussed below have usually been accepted.

These globose naticids are common through a long stratigraphic range. Their generalized smooth globose shells make for difficulty in separation to species. Probably some names have been applied solely on the basis of stratigraphic or geographic separation leading to a multiplicity of names for the same taxonomic unit. The following list is an attempt to assign western-interior Cretaceous species described as *Natica* or *Lunatia*.

Lunatia adnae Sidwell, 1932, Frontier Formation, Wyoming. This species is based on inadequate material, but the open and broad umbilicus suggest affinities with *Gyrodes* Conrad.

Natica? ambigua Meek and Hayden, 1856, is assigned to *Vanikoropsis nebrascensis* (Meek and Hayden) herein.

Amauropsis bulbiformis Sowerby of Stanton, 1893, has been renamed *Ampullospira stantoni* Cossmann and reassigned to the genus *Pseudamaura* by Sohl, 1960.

Euspira coalvillensis White. Stanton, 1893, assigns this species to *Lunatia utahensis* White.

Lunatia concinna Stanton (1893), non Hall and Meek, is from the Colorado Group of Utah. All specimens seen possess fine spiral striations, and except for being consistently of smaller size and more slender, they are similar to *Lunatia dakotensis* Henderson. They deserve to be redescribed as a new species of *Euspira*?.

Natica dakotensis Henderson, 1920. (=*Natica* (*Lunatia*) *occidentalis* Meek and Hayden, non Hall, 1845) is known only from the holotype (USNM 290) from the Fox Hills Sandstone of South Dakota. Cossmann's (1925, p. 54) assignment of this species to *Ampullospira* Harris, a synonym of *Pseudamaura* Fischer, is untenable, as the shells lack the channeled suture, shoulders, and umbilical characters of that genus. It appears to be closest to *Euspira* in most characters, but lacks inner lip callus.

Natica haydeni Cossmann, 1899, see *Vanikoropsis nebrascensis* (Meek and Hayden) in text.

Natica? occidentalis Hall, 1845 (non Meek and Hayden, 1856). Henderson (1935, p. 165) suggests this fossil is a Tertiary fresh-water species, perhaps assignable to *Viviparus*. D. W. Taylor, oral commun., May 1964, states the type locality is in the Pliocene of southwest Idaho.)

Natica paludinaeformis Hall and Meek, 1856 (non *N. paludinaeformis* d'Orbigny) from the Pierre Shale (*Baculites compressus* zone) of South Dakota was removed to *Amauropsis* by Meek in 1876. Cossmann, 1899, pointed out the homonym status of Meek's name and substituted *Natica meeki*. The species more properly belongs in *Pseudamaura*.

Natica praenominata Cossmann, 1929 (=*N. haydeni* Cossmann, 1899 (see *Vanikoropsis nebrascensis* in text)).

Natica subcrassa (Meek and Hayden), 1856. (Claggett Formation.) Subsequent authors have consistently assigned this species to *Lunatia*. The best preserved specimens of this species show a conspicuous shouldering of the whorl, a subshoulder constriction of the whorls, and a sharp-edged inner lip callus that evanesces anteriorly. These features are not typical of either *Euspira* or *Natica*.

Lunatia utahensis White, 1877. (Includes *Euspira coalvillensis* White, 1879; see Stanton, 1893.) This is an unumbilicate species from the Colorado Group that in apertural features seems close to *Eocernina* but has a much higher spire than typical for that genus. It does, however, belong in the Globulariinae.

Euspira obliquata (Hall and Meek)

Plate 1, figures 12–19

1856. *Natica obliquata* Hall and Meek [non Deshayes, 1866], Am. Acad. Arts and Sci. Mem., v. 5, p. 389, pl. 3, figs. 1a, b.
1856. *Natica concinna* Hall and Meek, Am. Acad. Arts and Sci. Mem., v. 5, p. 389, pl. 3, figs. 2a–d.
1856. *Natica moreauensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 64.
1860. *Natica* (*Lunatia*) *moreauensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 422.
1861. *Lunatia moreauensis* Gabb, Am Philos, Soc. Proc. v. 8, p. 58.
1876. *Lunatia concinna* (Hall and Meek). Meek, U.S. Geol. Survey Terr. (Hayden) Rept., v. 9, p. 314, 315, pl. 32, figs. 11a–c.
1880. *Lunatia concinna* (Hall and Meek). Whitfield, U.S. Geog. and Geol. Survey Rocky Mtn. Region (Powell), p. 430, pl. 12, fig. 13.
1885. *Lunatia concinna* (Hall and Meek) Whiteaves, Canada Geol. Survey, Contr. Canadian Paleontology, v. 1, pt. 1, p. 48.
1917. *Lunatia concinna* (Hall and Meek). Dowling, Canada Geol. Survey Mem. 93, p. 30, 46, pl. 29, figs. 4–4B.
1921. *Lunatia obliquata* (Hall and Meek). Stanton, U.S. Geol. Survey Prof. Paper 128–A, p. 35, pl. 6, figs. 10a, b.
1925. *Crommium* (*Amauropsella*) *concinna* (Hall and Meek). Cossmann, Essais de paléoconchologie comparée, v. 13, p. 45. (Assignment for Meek, 1876.)
1925. *Natica* (*Lunatia*) *concinna* (Hall and Meek). Cossmann, Essais de paléoconchologie comparée, v. 13, p. 134.
1960. *Euspira concinna* (Hall and Meek). Sohl, U.S. Geol. Survey Prof. Paper 331–A, p. 123.

Not:
1893. *Lunatia concinna* (Hall and Meek). Stanton, U.S. Geol. Survey Bull. 106, p. 134, pl. 29, figs. 9, 10.
1900. *Lunatia concinna* (Hall and Meek)?. Knight, Wyoming Univ. Bull. 45, pl. 8, fig. 5. (Illustration appears to have been taken from Stanton, 1893.)

Questionable assignment:
1918. *Natica* (*Lunatia*) *concinna* (Hall and Meek). Ravn, Medd. om Grønland, v. 56, p. 357, pl. 8, fig. 9.
1944. *Polinices concinna* (Hall and Meek). Bergquist, Jour. Paleontology, v. 18, no. 1, p. 26.

Type locality.—"Great Bend of the Missouri. From clay beds of division No. 4 of section" (Hall and Meek, 1856, p. 388). "The original typical specimen of *L. concinna* was found on Sage Creek, Dakota" (Meek, 1876, p. 315).

Diagnosis.—*Euspiras* with a moderately broad umbilicus, inner lip callus not invading umbilicus, parietal callus thin.

Description.—Medium-sized globose shells, spire one-third to one-quarter total shell height. Pleural angle

73°–108°. Sutures abutting to slightly impressed. Whorls well rounded. Surface smooth, sometimes with a few faint microscopic spiral threads. Growth lines prosocline. Aperture sublunulate, broader and more well rounded anteriorly; outer lip well rounded, inclined about 20°–22° to the axis of coiling. Inner lip almost straight over parietal and upper columellar area, lower columellar lip well rounded and slightly evanescing. Parietal callus rather thin extending only a slight distance out of the aperture. Umbilicus open, lacking callus infringement.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9). The measurements form the basis for the plots of specimens of *Euspira obliquata* given in figures 8 and 9.

Specimen and locality	PA	H	MD	HB	H/MD	H/HB
Holotype:						
AMNH 9465/1 (*Natica obliquata*)	96	9.8	8.0	7.2	1.22	1.36
AMNH 9364/1 (*Natica concinna*)	98	6.2	6.0	4.3	1.03	1.44
USNM 264 (*Natica moreauensis*)	91	21.5	19.5	14.5	1.10	1.41
USNM 264—Fox Hills Sandstone, South Dakota	73	19	15.5	13.0	1.23	1.19
Do	76	19	16	13.5	1.18	1.11
Do	82	17	15	12	1.13	1.25
Do	85	14.5	13	10	1.11	1.30
Do	96	12	11.5	9	1.03	1.28
USGS 27487—Fox Hills Sandstone, South Dakota	--------	20.5	19	16	1.08	1.19
Do	82	24	21	15.5	1.14	1.35
Do	95	20	18	15.0	1.11	1.2
Do	90	12	10	8.5	1.2	1.18
Do	--------	14.5	14	12.0	1.36	1.17
Do	92	20	19	15	1.05	1.26
USGS 27485—Fox Hills Sandstone, South Dakota	91	20	18	14	1.11	1.29
Do	108	16	17	13	.94	1.30
Do	102	--------	19	14	--------	1.36
Do	101	15.5	15	13	1.03	1.15
USGS 27490—Fox Hills Sandstone, South Dakota	91	26	22	18	1.18	1.22
Do	101	14.5	14	11	1.03	1.27
Do	96	20	20	19	1.0	1.05

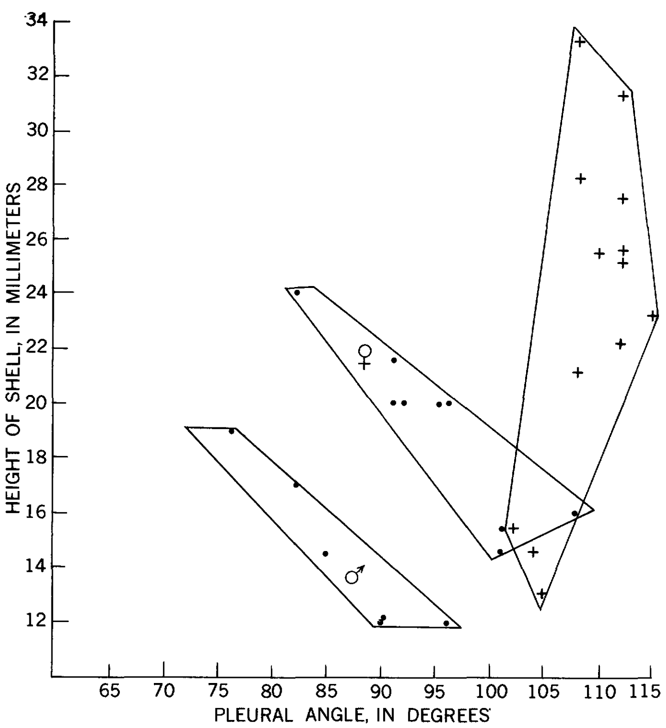

FIGURE 8.—Comparative plot between *Euspira obliquata* (Hall and Meek) (dots) and *Natica subcrassa* Meek and Hayden (crosses) of pleural angle versus height of shell. *Euspira obliquata* decreases in pleural angle with increase in size, whereas *N. subcrassa* remains virtually the same. The gap between the outlined areas of *E. obliquata* is interpreted as sexual dimorphism.

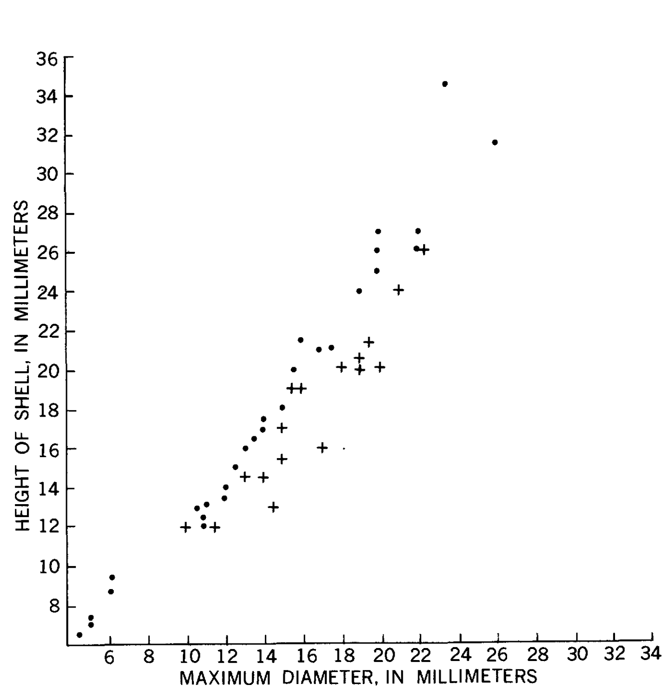

FIGURE 9.—Comparison of height-width variation between *Euspira obliquata* (Hall and Meek) and *Euspira rectilabrum* (Conrad). Crosses are plots of selected specimens of *E. obliquata* from the Fox Hills Sandstone of South Dakota. Dots are plots of a suite of specimens collected in the Ripley Formation on Coon Creek, McNairy County, Tenn. (*Exogyra cancellata* zone, USGS Mesozoic loc. 25406).

The following table summarizes the data given above on *Euspira obliquata* and compares them to data assembled for other associated or related naticid species.

	PA		H	MD	HB	H/MD	MD/HB
	Range	Avg	Range	Range	Range	Range	Range
Euspira obliquata	73–108	91	6.2–26.0	6.0–22	4.3–19	0.94–1.36	1.11–1.44
E. rectilabrum	73–99	81	6.7–31.5	5.8–21	5.8–21	1.13–1.58	.75–1.33
E.? dakotensis	65	65	23	19	15	1.21	1.26
Natica subcrassa	102–112	108	13–31	12–3.25	10.6–20.8	.96–1.19	1.09–1.20

Discussion.—Considered ontogenically, this species usually increases proportionally more in height than width with increased size. This change is accompanied by a decrease in pleural angle through growth (figs. 8, 9). There are so many exceptions to this generality, however, that some explanation is necessary. Such differences may be due to sexual dimorphism, as many recent relatives of *Euspira* show morphologic distinctions; the female has more inflated whorls and thus yields a lower spire and higher pleural angle.

Sculpture is normally lacking, but an occasional specimen may show fine spiral threads. Another peculiarity is the rare specimen showing somewhat irregular low ribs that run across the whorl oblique to the axis, but for the most part at right angles to the growth lines (pl. 1, fig. 16). Such ribs usually do not carry on for more than one-half whorl. A similar feature has been noted on the holotype of *Euspira? dakotensis* (Henderson) (pl. 1, fig. 21).

Euspira obliquata is one of the most common gastropods in the marine Campanian to Paleocene rocks of the western interior and has had a most troubled taxonomic history. As interpreted here, three separately described species are involved: *Natica obliquata* Hall and Meek, *N. concinna* Hall and Meek, and *N. moreauensis* Meek and Hayden. Most references in faunal lists and taxonomic treatments refer to this species as *Lunatia concinna*. In 1876, Meek redescribed *Natica concinna*, assigning it to *Lunatia*, but noted that *Euspira* might eventually replace *Lunatia*. The specimens he figured and described at this time, those that almost all subsequent authors have relied upon as typical of *L. concinna*, are those upon which *N. moreauensis* Meek and Hayden (1856) was based. Meek (1876, p. 314), however, stated:

This shell varies somewhat in form; some individuals being proportionally a little shorter, and having the body-volution more ventricose than others. For a long time, it was believed to be distinct from *N. concinna* and consequently the name *N. moreauensis* was proposed for it. Since seeing a good series of specimens, however, * * * I am led to believe that it is not specifically distinct from the type of *N. concinna* which is now believed to be a young individual.

Meek (1876, p. 315) after synonymizing *N. moreauensis* with *N. concinna* then discusses *N. obliquata.*

Lunatia obliquata (=*Natica obliquata*, Hall and Meek) is also a very closely allied type, so much so, indeed, that I have sometimes suspected that both the original *E. concinna* and the shell here ranged under that name, should be regarded as belonging to that species. In one character, however, *E. obliquata* seems to present a rather marked and important difference: that is, in having a well-defined opercular groove along the columella, not seen in the original *E. concinna.*

The holotypes of both *N. concinna* and *N. obliquata* are preserved in the collections of the American Museum of Natural History. Both specimens represent immature forms (see measurements and pl. 1, figs. 12, 13, 18, 19).

All subsequent authors except Stanton in 1921 accepted Meek's figures of 1876 as typical of *L. concinna.* Stanton (1921) was evidently the first to reexamine all the primary type material. He concluded that the two species *concinna* and *obliquata* were synonymous and by virtue of page preference accepted *obliquata.* Concerning the confused status of the involved species he stated (Stanton, 1921, p. 35): "Meek's final opinion was that *L. moreauensis* is a synonym of *L. concinna*, though he also called attention to the close relationship with *L. obliquata*, which seemed to differ chiefly in the presence of 'an opercular groove along the columella.' " Stanton then states that he has compared the type specimens. On page 36, he concludes, "My opinion is that the Fox Hills specimens which have been called *L. moreauensis* and *L. concinna* * * * should be referred to *L. obliquata.*"

Stanton observed that in specimens he examined, most lacked an opercular groove but one had it. He could not separate them on other grounds. In addition, he thought, as did Whitfield and Hovey (1898, p. 429), that the specimen preserved as the type species of *L. concinna* was perhaps a recent shell because of the exceptional state of preservation. I cannot agree with the latter conclusion. The shell is well preserved and of a milky-gray porcelaneous look, but I have seen exactly this same type of shell preservation at many outcrops of the Fox Hills Sandstone in the Dakotas. I do, however, accept Stanton as the first revisor and accept his designation of *obliquata* as the preserved name, although the more common use of *concinna* offers room for argument.

Euspira dakotensis (Henderson) (=*Natica occidentalis* Meek, non Hall) has a lower pleural angle (see section on measurements), a proportionally higher spire and possesses spiral sculpture.

Euspira rectilabrum (Conrad) from the Gulf Coastal Plain region is closely allied in form and occurs in correlative units. That species differs primarily from *N. obliquata* in its narrower umbilicus, thick callus on the parietal area, and in having a proportionately higher spire (fig. 9).

Natica subcrassa Meek and Hayden is a naticid commonly occurring with *Euspira obliquata.* However, it is easily distinguished by its lower spire, larger size, thicker shell, heavier parietal callus, slight constriction of the upper whorl, higher pleural angle, and more highly inclined outer lip. (fig. 8).

Euspira obliquata is one of the most common and widespread gastropods in the Upper Cretaceous of the western interior. It occurs at least as low as the *Baculites perplexus* zone in the Pierre Shale of Colorado and as high as the Fox Hills of the Dakotas. Stanton has reported it from the Paleocene Cannonball Member of the Fort Union Formation in North Dakota. Reference to the presence of this species in Turonian of Utah (Stanton, 1893) and the Coleraine Formation of Stauffer (in Stauffer and Thiel, 1933) (Cenomanian) in the Mesabi Range of Minnesota (Bergquist, 1944) is erroneous. The species is known to occur in equivalent units of the Pierre and Fox Hills from Colorado in the south to Canada in the north (Whiteaves, 1885, Dowling, 1917, and others). The specimen from Greenland assigned to this species by Ravn (1918) lacks the aperture and cannot be placed generically with confidence.

Euspira obliquata is well represented in the Red Bird section, but all specimens are small.

Types: Holotype, AMNH 9465; holotype of *Natica concinna* Hall and Meek, AMNH 9364; holotype *Natica moreauensis* Meek and Hayden, USNM 264; hypotypes, USNM 12250 (Whitfield, 1880, pl. 12, fig. 13), USNM 132708, 132709.

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1917 (*B. gregoryensis* zone); USGS D–1939, D–1940 (*Didymoceras stevensoni* zone); USGS D–1967 (*Baculites eliasi* zone); USGS D–1970, D–1978, D–1983 (*Baculites baculus* zone); USGS D–1985 (*Baculites grandis* zone). Colorado: Pierre Shale (*Baculites perplexus* zone through *B. clinolobatus* zones), Milliken Sandstone Member of the Fox Hills Sandstone, Mesaverde (upper). Montana: Pierre Shale (*Baculites baculus* zone), Bearpaw Shale, Claggett Shale. North Dakota: Fox Hills Sandstone and Cannonball Member of Fort Union Formation (Paleocene). South Dakota: Pierre Shale (upper part) and Fox Hills Sandstone. Canada: Bearpaw Shale.

Superfamily TONNACEA

Family CYMATIIDAE

Genus TRACHYTRITON Meek 1864

Type by original designation: *Buccinum*? *vinculum* Hall and Meek, 1856.

Diagnosis.—Fusiform shells sculptured by strong ribbons and round-topped transverse ribs. Outer lip denticulate within; inner lip with well-margined evanescing columella and smooth parietal surface.

Discussion.—The shape of the shell, the denticulations of the inner surface of the outer lip, and the broad well-defined inner lip callus are all features allying *Trachytriton vinculum* (Hall and Meek) with the Cymatiidae. However, other typical features, such as parietal teeth or nodes, are lacking.

Other North American species assigned to this genus must all be questioned. *Trachytriton*? *holmdelense* Whitfield, *T.*? *multivaricosum* Whitfield, *T. atlanticum* Whitfield, all from the Upper Cretaceous of New Jersey, are based on internal molds of fusiform outline that not only lack the characters of *Trachytriton* but are unassignable to family.

Trachytriton? sp. Stephenson (1952, p. 181) from the Woodbine Formation of Texas is based on an incomplete specimen with strong transverse sculpture, weak spiral threads, and thin inner lip callus. It may belong in the Fusidae.

Tritonium (*Trachytriton*) *tejonensis* Gabb (1869), from the Eocene, Tejon Formation of California, has been placed as a synonym under *Olequahia hornii* (Gabb) by Stewart (1927, p. 382).

We are thus left with only the type species as a North American representative.

Trachytriton vinculum (Hall and Meek)

Plate 6, figures 10, 14–17

1856. *Buccinum*? *vinculum* Hall and Meek, Am. Acad. Arts Sci. Mem., v. 5, p. 390, pl. 3, figs. 5a, b.

1860. *Fusus vinculum* (Hall and Meek). Meek and Hayden, Acad. Nat. Sci. Philadelphia, Proc., v. 12, p. 1-85.

1864. *Trachytriton vinculum* (Hall and Meek). Meek, Smithsonian Misc. Colln., v. 7, p. 22 and 37.

1876. *Trachytriton vinculum* (Hall and Meek). Meek, U.S. Geol. and Geog. Surv. Terr. (Hayden) Rept., v. 9, p. 304, pl. 19, figs. 7a–d.

1903. *Pirene* (*Trachytriton*) *vinculum* (Hall and Meek). Cossmann, Essais de paléoconchologie comparée, v. 5, p. 110, pl. 4, fig. 18.

1941. *Argobuccinum* (*Trachytriton*) *vinculum* (Hall and Meek). Wenz, Gastropoda, *in* Schindewolf, O. H., Handbuch der Paläozoologie, v. 6, pt. 5, p. 1057, fig. 3021.

Type locality.—Pierre Shale, "Great Bend of the Missouri River." (*Baculites gregoryensis* or *B. scotti* zones)

Diagnosis.—Same as for genus.

Description.—Medium-sized fusiform shells with spire a little less than one-half total shell height. Protoconch unknown. Pleural angle 35°–40°. Whorls rounded, suture impressed. Body with a well-rounded periphery tapering below to a rather broad pillar. Sculpture of collabral, rounded and broad transverse ribs that are strongest on the earlier whorls. Spiral sculpture dominated by spiral ribbons that are narrower than interspaces, but which override the transverse ribs; ribbons number 6–7 on penultimate whorl. On body, transverse sculpture weak; spiral ribbons narrower or cordlike on base with occasional fine threads in interspaces. Growth lines broadly opisthocyrt on whorls of spire; on body, growth lines strongly prosocline for first few millimeters below suture, arcuately and gently opisthocline over periphery and upper part of basal slope, and for the most part prosocline on pillar. Aperture lanceolate; outer lip denticulate within, thin at edge serrated by the termination of spiral ribbons; inner lip with a broad sharply margined callus. Parietal callus smooth surfaced and broad. Columellar lip smooth.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9).

Specimen and locality	H	MD
Hypotype:		
USNM 261—Pierre Shale, South Dakota	35	15.5
USNM 132985—Pierre Shale, South Dakota	43+	24.9
USNM 132644—Pierre Shale, Red Bird, Wyoming	------	16.7
USNM 132645—Pierre Shale, Red Bird, Wyoming	------	16.3

Discussion.—*Trachytriton vinculum* is a rare species, and as known, is restricted to the Pierre Shale.

The specimens from the Red Bird Silty Member compare well with Meek's hypotypes figured on plate 6, figures 16 and 17, from the Pierre Shale of the Great Bend of the Missouri River. The specimen from USGS D–1926 (pl. 6, fig. 14) shows the impression of the teeth on the interior of the outer lip typical of *Trachytriton.* The other specimen from USGS D–1904 (pl. 6, fig. 15) has somewhat stronger transverse ribs at a later stage of development, and the whorls appear to be slightly more rounded than on Meek's material.

One additional internal mold from locality USGS D–1900 (USNM 132646) probably belongs to this species. It shows strong denticulate varices occurring at about one-half whorl intervals on the last three whorls.

The only other superficially similar species in the Cretaceous faunas of the western interior is *Fasciolaria buccinoides* Meek and Hayden (pl. 6, figs. 5–9). It, however, possesses weaker transverse sculpture and thinner lip callus than *Trachytriton vinculum* and also has two plications on the inner lip. Cossmann (1901, p. 51) assigned that species (*F. buccinoides*) to *Mazzalina* of the Fasciolariidae. It approaches that genus in several characters, but it has two columellar plications that are constant in strength and placement. More significantly, there are nodes and teeth on the parietal wall and denticulations on the inner surface of the outer lip (pl. 6, figs. 5, 9) that were not noted by Meek. These features suggest placement of "*Fasciolaria*" *buccinoides* in the Cymatiidae of the Tonnaca rather than in the Fasciolariidae.

Types: Holotype, unknown; hypotypes, USNM 261, 132644, 132645, 132984, 132985, mentioned specimen 132646.

Occurrence: Wyoming: Pierre Shale, Red Bird section, USGS D–1900, D–1904 (*Baculites gregoryensis* zone), USGS D–1926 (*Baculites scotti* zone), USGS D–1938 (*Didymoceras nebrascensis* zone). Colorado: Pierre Shale, Front Range (*Baculites gregoryensis* zone). South Dakota: Pierre Shale.

Order NEOGASTROPODA

Suborder STENOGLOSSA

Superfamily BUCCINACEA

Family FASCIOLARIIDAE

Subfamily FUSININAE

Genus SERRIFUSUS Meek, 1876

Type by original designation: *Fusus dakotensis* Meek and Hayden, 1856.

Diagnosis.—"Shell short-fusiform; body volution large, and bi- or tricarinate, with carinae more or less nodose; spire and canal moderate, the latter bent and more or less twisted; outer lip broadly but slightly sinuous in outline, between the upper carina and the suture" (Meek, 1876, p. 373).

Discussion.—Meek proposed *Serrifusus* as a monotypic subgenus of *Fusus.* Most subsequent authors have considered it close to *Fusus*, but Cossmann (1901, p. 8) thought it most closely approached *Buccinofusus* Conrad.

Five North American Cretaceous species have been assigned to this genus, but most probably belong in other genera. These species are:

Serrifusus dakotensis var. *vancouverensis* Whiteaves 1879, from the Upper Cretaceous Middle Shale, Division D, on Hornby Island (Maestrichtian?) of Vancouver Island area, Canada. This species is close to the type species.

Serrifusus? crosswickensis Whitfield, 1892, from the Navesink Formation of New Jersey, an indeterminate internal mold possibly belonging to *Pterocerella.*

Serrifusus (*Lirofusus*) *nodocarinatus* Whitfield, 1892, from the Navesink Formation of New Jersey. This species is based on a poorly preserved indeterminate specimen.

Serrifusus tennesseensis Wade, 1926, from the Ripley Formation of Tennessee, has been placed in *Hercorhyncus* by Sohl (1964, p. 222).

Serrifusus joaquinensis Anderson, 1958, from the Campanian, Panoche Formation of California, appears to be correctly assigned.

I know of no correctly assigned species outside North America. The genus has a western distribution, and as presently known, is restricted to the Campanian and Maestrichtian stages of the Upper Cretaceous.

Serrifusus dakotensis (Meek and Hayden)?

Plate 6, figure 12, 13, 18–21

1856. *Fusus Dakotensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 65.
1860. *Fusus* (*Neptunea*) *Dakotensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 421.
1964. *Tudicla? Dakotensis* (Meek and Hayden). Meek, Smithsonian Misc. Colln., v. 7, p. 23.
1876. *Fusus?* (*Serrifusus*) *Dakotensis* Meek and Hayden, Meek, U.S. Geol. and Geog. Survey Terr. (Hayden) Rept., v. 9, p. 374, pl. 31, fig. 11; pl. 32, figs. 6a, c.
1876. *Fusus?* (*Serrifusus*) *goniophorus* Meek, U.S. Geol. and Geog. Survey Terr. (Hayden) Rept., v. 9, p. 375, pl. 32, fig. 7a (7b?) cited under *Fusus* (*Serrifusus*) *Dakotensis* var.
1901. *Serrifusus dakotensis* (Meek and Hayden). Cossmann, Essais de paléoconchologie comparée, v. 4, p. 8, pl. 7, fig. 7.
1941. *Fusinus* (*Serrifusus*) *dakotensis* (Meek and Hayden). Wenz, Gastropoda, *in* Schindewolf, O. H., Handbuch der Paläozoologie, v. 6, pt. 5, p. 1262, fig. 3594.
1945. *Fusus dakotensis* Meek and Hayden. Morgan and Petsch, South Dakota Geol. Survey Rept. Inv. 49, pl. 5, fig. 4; pl. 6, fig. 4.

Type locality.—"Moreau River, Dakota" (Meek, 1876, p. 377). The holotype is from the Fox Hills Sandstone of South Dakota.

Diagnosis.—Strongly bicarinate whorls covered by finer spiral lirations.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9).

Specimen and locality	H	MD
Holotype: USNM 256—Fox Hills Sandstone, South Dakota	71.5+	47.0
Paratype: USNM 132971—Fox Hills Sandstone, South Dakota	35.3	22.0+
Hypotype: USNM 132643—Pierre Shale (*B. baculus* zone), Red Bird, Wyoming	59.3+	44.0

Discussions.—The specimen from the Red Bird section (pl. 6, fig. 20) is much worn. The external surface has evidently been worn or dissolved to such an extent that there is no evidence of spiral sculpture except for the carinations. On the other hand, the specimen does compare closely with Meek's holotype (pl. 6, fig. 18) in size, outline, and possession of a bicarinate body having strong nodes on the upper carina.

My main reservation in assigning the specimen from locality USGS D–1982 to Meek's species *Serrifusus dakotensis* is that there appears to be an undescribed species of *Serrifusus* in the "Fox Hills Formation" of Wyoming. This specimen (pl. 6, fig. 13) can presently only be located geographically as coming from Niobrara County, Wyo., and in terms of stratigraphic position is probably closer to that of the Red Bird section than is that of Meek's type material which comes from the Moreau River in the type Fox Hills area. The Wyoming specimen (USNM 32150) is incomplete, but has a bicarinate whorl that is noded at the shoulder and thus seems to be a true *Serrifusus*. Compared with the type species, however, it has decidedly suppressed spiral sculpture. This raises the question, then, that perhaps the Red Bird specimen is not so worn but that, in spite of its closeness in shape to the type specimens, it belongs to another undescribed species with subdued spiral sculpture.

Types: Holotype, USNM 256; Paratype, USNM 132971; figured specimen, USNM 132643.

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1982 (*Baculites baculus* zone), USGS D–1985 (*Baculites grandis* zone), and questionably from the Fox Hills Sandstone. South Dakota: Fox Hills Sandstone. North Dakota: Fox Hills Sandstone. Colorado: Fox Hills Sandstone.

Genus ANOMALOFUSUS Wade, 1916

Type by original designation: *Anomalofusus substriatus* Wade.

Diagnosis.—High spired fusiform shells, protoconch naticoid proportionally large. Whorls rounded to slightly shouldered above. Sculpture cancellate developing to dominantly spiral ribbons with secondary threads between. Columella slightly twisted lacking plications; outer lip dentate within. Varices common.

Discussion.—*Anomalofusus* is a moderately common genus in the Campanian-Maestrichtian rocks of the Gulf Coastal Plain. It has never previously been noted in the Cretaceous of the western interior, and the assignment of the specimen described below is very tenuous.

Anomalofusus? sp.

Plate 7, figure 20

Discussion.—One incomplete specimen consisting of an internal and external mold is present in the collections from USGS D–1948 (*Exiteloceras jenneyi* zone) that may belong in *Anomalofusus*. The specimen is 21 mm high and has a maximum diameter of about 8.5 mm. It has four well-rounded whorls with a slight tendency for constriction on the last whorl. Sculpture consists of about eight raised strong spiral ribbons that override round-topped opisthcyrt transverse ribs on the whorls of the spire. The ribs are more widely spaced than the ribbons. On the body whorl, spiral cords are wider spaced and stronger above, becoming narrower, closer spaced, and weaker on the medial and anterior parts of the whorl. Transverse ribs die out just below the periphery of the whorl.

In many respects, such as lack of columellar plications, shape, and size, this specimen approaches

Anomalofusus, but lacking material that preserves a protoconch, its assignment is very tenuous. It differs from typical *Anomalofusus* in that it has a lesser tendency for development of a whorl shoulder, the transverse ribs remain strong to a later growth stage, and the spiral ribbon interspaces lack secondary threads. One might suggest that the specimen represents the early developmental stages of a *Graphidula*. However, the whorls of the Red Bird specimen are more rounded, and as can be observed on the internal mold, there are no columellar plications.

Better preserved material must be found before this species can be described and placed with confidence.

Types: Figured specimen, USNM 132927.

Occurrence: Wyoming: Pierre Shale, Red Bird section, USGS D-1948 (*Exiteloceras jenneyi* zone).

Subfamily FASCIOLARIINAE

Genus GRAPHIDULA Stephenson, 1941

Type by original designation: *Graphidula terebreformis* Stephenson.

Diagnosis.—Medium-sized slender elongate fusiform shells. Spire usually longer than aperture. Sculpture ornate with transverse elements commonly becoming subdued on later whorls. Aperture lanceolate, posteriorly angulate, siphonal canal elongate and straight. Columella straight, at maturity bearing one plait, but plait not visible at aperture.

Discussion.—*Piestochilus* Meek and *Graphidula* Stephenson appear to be closely related genera. Sohl (1964, p. 211) has discussed their relationships and reassigned the Cretaceous species from North America. In general, *Piestochilus*, as exemplified by the type species *P. scarboroughi* (Meek and Hayden), is lower spired than *Graphidula*, having an apical angle that approaches 45° as against 20°–25° in *Graphidula*. In spite of the differences in outline the two genera are closely similar in apertural features.

Graphidula is a common element in the Campanian-Maestrichtian faunas of the Gulf and Atlantic Coastal Plains from New Jersey to Texas. The range of the genus seems to be similar in the western interior. The earliest *Graphidula* I know comes from the Gammon Ferruginous Member near the base of the Pierre Shale in the Black Hills area and ranges through the Fox Hills Sandstone. *Graphidula culbertsoni* discussed below is one of the more widespread and abundant of the gastropods, especially in the northern part of the western interior.

Graphidula culbertsoni (Meek and Hayden)

Plate 7, figures 21–24, 29–31

1856. *Fusus culbertsoni* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 66.

1857. *Fusus haydeni* Evans and Shumard, St. Louis Acad. Sci. Trans., v. 1, p. 41.

1876. *Fasciolaria (Piestochilus) culbertsoni* (Meek and Hayden). Meek, U.S. Geol. and Geog. Survey Terr. (Hayden) Rept., v. 9, p. 360, pl. 32, figs. 1a–f, text fig. 44.

1879. *Fasciolaria (Piestochilus) culbertsoni* (Meek and Hayden). White, U.S. Geol. and Geog. Survey Terr. (Hayden), 11th Ann. Rept., p. 185.

1880. *Fasciolaria (Piestochilus) culbertsoni* (Meek and Hayden). Whitfield, U.S. Geol. and Geog. Survey, Rocky Mtn. Region (Powell), p. 423, pl. 12, fig. 11.

1901. *Cryptorhytis (Piestochilus) culbertsoni* (Meek and Hayden). Cossmann, Essais de paléoconchologie comparée, v. 4, p. 59, text fig. 18.

1962. *Fasciolaria (Piestochilus) culbertsoni* (Meek and Hayden. Kellum, Michigan Acad. Sci., v. 47, p. 66, pl. 2, figs. 2, 3.

1964. *Graphidula culbertsoni* (Meek and Hayden). Sohl, U.S. Geol. Survey Prof. Paper 331-B, p. 211.

Type locality.—"Moreau River; from the Fox Hills Group" (Meek, 1876, p. 362).

Diagnosis.—Shell large for genus, whorls round sided, transverse ribs restricted to earlier growth stages.

Measurements.—No specimens are complete, but the largest specimen noted must have attained a length of at least 90 mm, a maximum width of 23 mm, and a body whorl about 50 mm in height.

Discussion.—One specimen, missing both extremities but preserving other features diagnostic of *Graphidula culbertsoni*, has been recovered from the Red Bird section (USGS D-1985).

This species is one of the more abundant highly variable species in the Upper Cretaceous of the western interior. The most consistent feature is the spiral ornament consisting on the early whorls of thin spiral ribbons that are somewhat wider than their interspaces; on later whorls these ribbons become wider spaced and may also become more subdued. The holotype (pl. 7, fig. 22) from the Fox Hills Sandstone is decidedly atypical. It possesses strong transverse ribs at a much later stage than most specimens. More typically, transverse ribs are restricted to only the first few whorls or may not be present at all. The holotype also is atypical in its small size, but its relationship to large individuals, such as that figure on plate 7, figure 30, is obvious when compared with Meek's (1876, pl. 32, fig. 1e) paratype, herein (pl. 7, fig. 24), which combines the coarse transverse ribs of the early whorls with a body whorl that retains only spiral sculpture.

The plaits of the columellar surface also vary. Near the aperture all specimens have only one weak plication; however, a range from none to three or four plaits may occur on the very earliest whorls. These variations all occur within suites of specimens from the same locality.

Although all specimens show a similar ontogeny with the height of the whorl increasing proportionally more rapidly in later growth stages, the range of variation in whorl height is moderately high.

This is one of the more abundant and widely distributed species of gastropods in the northern part of the western interior, ranging from the *Baculites baculus* zone of the Pierre Shale through the Fox Hills Sandstone in South Dakota, North Dakota, Wyoming, Montana, and Colorado.

Fasciolaria (*Piestochilus*) *alleni* White (1880) from the Yellowstone River of Montana (pl. 7, figs. 33, 34) is more slender with a lower pleural angle and lacks transverse sculpture, but is similar in other respects and probably belongs to the same lineage. *Fasciolaria* (*Piestochilus*) *galpiniana* (Meek and Hayden) from the Fox Hills Sandstone of South Dakota possesses sculpture similar to *Graphidula*, but the anterior canal is short and curved and probably the species belongs in an entirely different genus. The gulf coast Cretaceous species of *Graphidula* (Sohl, 1964) all possess stronger transverse sculpture at a later stage than *G. culbertsoni*, *Graphidula pergracilis* (Wade) being the most closely similar species. *Graphidula pergacilis*, however, not only retains transverse sculpture to a later stage, but has wider spaced spiral sculpture and whorls that are less constricted posteriorly. Several undescribed species of *Graphidula* are present in beds of equivalent age in Montana and South Dakota. In the Pierre Shale at Glendive, Mont. (USGS 12 and USGS 3896), a related form occurs that differs in its straighter growth line and in having secondary spiral cords on the whorl sides. In the Fox Hills Sandstone of South Dakota (USGS 27491, 27485, 27484), another undescribed species occurs that is characterized by its lack of transverse sculpture, its thin spiral thread sculpture, and by its well-rounded whorls that are strongly constricted subsuturally.

Types: Holotype, USNM 258; paratype, USNM 132973; hypotypes, USNM 132647–132651.

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1985 (*Baculites grandis* zone), Fox Hills Sandstone. North Dakota: Fox Hills Sandstone. Montana: Pierre Shales (*B. baculus* zone). Colorado: Pierre Shale, Front Range (*Baculites clinolobatus* zone), Fox Hills Sandstone.

Graphidula cf. G. alleni (White)

Plate 7, figures 25–28, 32

1880. *Fasciolaria* (*Piestochilus*) *alleni* White, U.S. Geol. and Geog. Survey Terr. (Hayden), 12th Ann. Rept., 1878, pt. 1, p. 34, 35, pl. 12, fig. 1a.

Type locality.—"Cretaceous strata, valley of Yellowstone River, Montana" (White, 1880, p. 35). Probably Campanian in age, but exact stratigraphic level uncertain.

Discussion.—In 1880, White described and figured a fusiform snail from an undefined stratigraphic position in Montana. The holotype (USNM 8046) is accompanied in the type collections of the U.S. National Museum by a second specimen. The holotype consists of six whorls with corroded shell material irregularly adhering. Surface sculpture can be seen only over a part of the body whorl (pl. 7, fig. 34). White's original illustration is a reconstruction. The second specimen is a smaller shell that again retains only patches of shell and is partially embedded in a fossiliferous concretionary matrix that contains *Euspira obliquata* (Hall and Meek), *Cylichna* sp., and indeterminable fragments and molds of other mollusks. The assemblage has the aspect of a Pierre Shale fauna.

Compared to *Graphidula culbertsoni* which they approach in form, the shells are more slender with a pleural angle of 18°–19° as compared to 22°–27° for *G. culbertsoni*. In addition, the whorls of *G. alleni* appear to be proportionally more elongate at the same stage of growth and flatter sided. Neither specimen bears any trace of transverse sculpture, except for the strong sinuous growth lines typical of the genus.

Several poorly preserved specimens (pl. 7, figs. 26–28) from the *Didymoceras stevensoni* zone of the lower unnamed shale member of the Pierre Shale in the Red Bird section of Wyoming closely approach *Graphidula alleni*. All lack transverse sculpture even on the earlier whorls, have flat-sided proportionally elongate whorls and irregular spiral cords, and possess the single strong columellar plication of *Graphidula*. A similar form occurs in the *Didymoceras nebrascense* zone of the Tepee-Butte limestone (of local usage) of the Pierre Shale of the Front Range of Colorado (pl. 7, fig. 32). Poorly preserved specimens probably belonging to this same group range from the *Baculites scotti* zone through the *Exiteloceras jenneyi* zone in the Front Range, but their condition is such that identification is tenuous at best.

Types: Figured specimens, USNM 132673, 132674, 132707, 132974.

Occurrences: Wyoming: Pierre Shale, Red Bird section, D-1939; D–1940 (*Didymoceras stevensoni* zone). Colorado: Pierre Shale, Front Range (*Didymoceras stevensoni* zone and possibly *Baculites scotti* through *Exiteloceras jenneyi* zones. Montana: Position uncertain.

Genus CRYPTORHYTIS, 1876

Type by original designation: *Rostellaria fusiformis* Hall and Meek, 1854 (non *R. fusiformis* Pictet and Roux, or *R. fusiformis* Whitfield, 1892). =*Gladius*? *cheyennensis* Meek and Hayden, 1860.

Discussion.—Confusion as to the relationship of this genus has arisen primarily because of the poor state of preservation of the type material. The holotype of the type species is an internal mold retaining only parts of the shell. Sohl (1964, p. 231) has discussed the history of assignment of *Cryptorhytis* to the Fasciolariidae and Vasidae by various authors. He accepted Meek's statement that the columellar plait lies high on the columella and suggested that the genus lies close to *Ornopsis*. Reexamination of the type material, however, shows that the plication lies somewhat below the middle of the apertural length in a position similar to that in *Bellifusus*. In possession of a columellar constriction and sinuate ribs the two are further similar. This suggests the possibility of synonymizing *Bellifusus* with *Cryptorhytis*, but until better preserved specimens of *C. cheyennensis* (Meek and Hayden) are available, the two genera should be kept separate.

Cryptorhytis cheyennensis (Meek and Hayden)

Plate 7, figures 15–19

1854. *Rostellaria fusiformis* Hall and Meek, Am. Acad. Arts and Sci. Mem. 5, p. 393, pl. 3, fig. 10 [non Pictet and Roux, 1842].
1860. *Gladius? Cheyennensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 422.
1864. *Gladius Cheyennensis* Meek and Hayden, Meek, Smithsonian Misc. Coll n., v. 7, p. 20.
1876. *Fasciolaria? (Cryptorhytis) Cheyennensis* (Meek and Hayden). Meek, U.S. Geol. and Geog. Survey Terr. (Hayden) Rept., v. 9, p. 365, pl. 19, fig. 13.
1880. *Fasciolaria (Cryptorhytis) fusiformis* (Hall and Meek). Whitfield, U.S. Geog. & Geol. Survey Rocky Mtn. Region (Powell), p. 421, pl. 12, fig. 12.
1901. *Cryptorhytis cheyennensis* (Meek and Hayden). Cossmann Essais de paléoconchologie comparée, v. 4, p. 56, 57. (Also spelled *cheyemensis.*)
1944. *Piestochilus (Cryptorhytis) fusiformis* (Meek and Hayden), (error for Hall and Meek). Wenz, Gastropoda, *in* Schindewolf, O. H., Handbuch der Paläozoologie, v. 6, pl. 6, p. 1308, fig. 3728.

Type locality.—"Sage Creek. Upper clay or upper part of division No. 4 of section". (Hall and Meek, 1854, p. 393.) The original specimen was from the *Baculites compressus* zone.

Disscusion.—Three poorly preserved specimens from the Pierre Shale of the Red Bird section, Wyoming, are here assigned to *Cryptorhytis cheyennensis*. They display the typical whorl shape, posterior whorl constriction, and strong transverse ribs of that species. The type material is from the *Baculites compressus* zone of Sage Creek. Meek's figured specimen of 1876 (pl. 19, figs. 3a, b) from the Pierre Shale of the South Fork of the Cheyenne River, however, cannot be as precisely located, except that it probably came from some level between the *Didymoceras stevensoni* and *Baculites compressus* zones. The Red Bird specimens come from the *Exiteloceras jenneyi* and *Baculites reesidei* zones, respectively.

Type: Holotype, AMNH 5370; figured specimens, USNM 289, USNM 132921, 132922.

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1945, (*Exiteloceras jennyi* zone) and USGS D–1952 (*Baculites reesidei* zone). South Dakota: Pierre Shale (*Baculites compressus* zone). Colorado: Pierre Shale (Front Range) (*Exiteloceras jennyi, Baculites compressus, Baculites reesidei,* and *Baculites jenseni* zones).

Indeterminate fusiform gastropods

Two internal molds from the Pierre Shale at USGS D–1925 and USGS D–1924 represent, respectively, an unknown high slender fusiform snail and a lower spired neogastropod, possibly akin to *Cryptorhytis*. Both are too poorly preserved to warrant figuring.

Subclass EUTHYNEURA

Order CEPHALASPIDEA

Superfamily ACTEONACEA

Family ACTEONIDAE

Genus NONACTEONINA Stephenson, 1941

Type by original designation: *Nonacteonina graphoides* Stephenson, 1941.

Discussion.—Stephenson erected this genus for many of the Cretaceous species previously assigned to *Acteonina* d'Orbigny. It differs most strikingly from *Acteon* Montfort in having a smooth columella.

Acteon (Solidula?) attenuatus Meek and Hayden (pl. 8, fig. 2) is from the upper part of the Pierre Shale (*Baculites baculus* zone) on the "Yellowstone River, one hundred and fifty miles from its mouth" near Glendive, Mont. It appears to lack any trace of columellar plications, and has the slender elongate whorls and punctate spiral sculpture similar to *Nonacteonina.*

Nonacteonina attenuata (Meek and Hayden)?

Plate 8, figures 1, 2

1858. *Actaeon (Solidula?) attenuatus* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 10, p. 54.
1860. *Solidula attenuata* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 185.
1876. *Actaeon attenuatus* Meek and Hayden. Meek, Rept. U.S. Geol. Survey Terr. (Hayden) Rept., v. 9, p. 281, pl. 19, fig. 17a, b.
1917. *Actaeon attenuatus* Meek and Hayden. Dowling, Canada Geol. Survey Mem. 93, p. 30, pl. 28, fig. 9 (figure copied from Meek, 1876).
1934. *Acteonina attenuatus* (Meek and Hayden). Warren, Royal Soc. Canada, Trans., 3d ser., v. 28, p. 93 (occurrence questionable).

Type locality.—From beds of the upper part of the Pierre Shale (*Baculites baculus* zone) on the "Yellowstone River, one hundred and fifty miles from its mouth."

Discussion.—The shell here discussed is closely allied to *Nonacteonina attenuata* Meek and Hayden, but is too poorly preserved for confident placement. The shell of the Red Bird specimen is longer than the holotype from the Pierre Shale of Montana, but the proportions are similar. Although the body whorl of the Wyoming specimen (pl. 8, fig. 1) is preserved only as an internal mold, the shell material adhering to the spire shows the punctate spiral sculpture typical of the species.

Warren (1934, p. 93) stated that he had seen specimens from the Bearpaw Shale of Canada that reached 3 cm in length. Neither of Pierre specimens figured here approaches such a size, but there are specimens of a *Nonacteonina* in the collections of the U.S. Geological Survey from the Bearpaw Shale of Montana that attain such a size. These specimens, however, appear to belong to an undescribed species characterized by a higher pleural angle and by spiral grooves that are crossed by very low transverse lines. The specimens from the Bearpaw Shale of Canada mentioned by Warren may belong to this same species.

Types: Holotype, USNM 285; figured specimen, USNM 132676.

Occurrences: Wyoming: Pierre Shale, Red Bird section, D–1940 (*Didymoceras stevensoni* zone). Montana: Pierre Shale (*Baculites baculus* zone).

Family Ringiculidae

Genus Oligoptycha Meek, 1876

Type by original designation: *Actaeon concinnus* Hall and Meek, 1854.

Diagnosis.—Globose shell, spire depressed. Sculpture of incised spirals consisting of a series of chainlike links. Outer lip thickened to a rounded rim at mature stage, interiorly smooth to denticulate. Columella has a strong anterior fold and bears from zero to two weaker parietal folds.

Discussion.—The distribution, relationships, and developmental history of the genus has been discussed by Sohl (1964, p. 295). *Oligoptycha* is restricted to the Upper Cretaceous of North America.

Oligoptycha concinna (Hall and Meek)

Plate 8, figures 3–6

1854. *Acteon concinnus* Hall and Meek, Am. Acad. Arts and Sci. Mem., v. 5, p. 390, pl. 3, fig. 4.

1856. *Avellana subglobosa* (Meek and Hall). Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 64.

1860. *Cinulia concinna* (Hall and Meek). Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 12, p. 424.

1876. *Cinulia* (*Oligoptycha*) *concinna* (Hall and Meek). Meek, U.S. Geol. Survey Terr., (Hayden) Rept., v. 9, p. 284, pl. 31, figs. 6a, b, c.

1895. *Cinulia* (*Oligoptycha*) *concinnus* (Hall and Meek). Cossmann, Essais de paléoconchologie comparée, v. 1, p. 121, pl. 7, fig. 15.

1941. *Oligoptycha concinna* (Hall and Meek). Stephenson, Texas Univ. Bull. 4101, p. 390.

1957. *Oligoptycha concinna* (Hall and Meek). Popenoe, California Univ. Pubs. Geol. Sci., v. 30, no. 6, p. 431, pl. 50, figs. 3, 4.

1959. *Cinulia* (*Oligoptycha*) *concinna* (Hall and Meek). Zilch, Gastropoda, *in* Schindewolf, O. H., Handbuch der Paläozoologie, v. 6, pt. 2, fig. 61.

1964. *Oligoptycha concinna* (Hall and Meek). Sohl, U.S. Geol. Survey Prof. Paper 331–B, p. 295.

Type locality.—The type specimens came from the upper part of the Pierre Shale on "Sage Creek" South Dakota (*Baculites compressus* zone).

Diagnosis.—*Oligoptycha* having a single strong inclined fold low on the inner lip and a nondenticulate inner surface of the outer lip.

Description.—Small globular shells with a low spire. Suture incised. Protoconch unknown. Sculpture dominated by spiral incised ribbons that are constricted to series of chainlike links where crossed by growth lines. Spiral grooves closest spaced over medial part of whorl. Aperture narrows posteriorly, broadens anteriorly. Outer lip well rounded, thickened by a rounded callus ridge, inner surface nondenticulate. Inner lip having a thick well-margined callus that extends over parietal surface and onto body a short distance above, but covers whorl base below and is continuous with callus ridge of outer lip. Columellar lip bears one strong thick plait that is inclined anteriorly into aperture.

Discussion.—The small internal mold figured (pl. 8, fig. 6) from the Red Bird section appears to conform closely to the characters of *Oligoptycha concinna* (Hall and Meek). This species was originally described from specimens from the Pierre Shale on Sage Creek in South Dakota. Meek (1876, p. 284) based his expanded descriptions and discussion primarily on specimens from the Fox Hills Sandstone of the type area. The specimen (USNM 129866) from the Fox Hills Sandstone near Wakpala, S. Dak., figured on plate 8, figure 4, is larger in size than the holotype (pl. 8, fig. 3) or the specimens illustrated by Meek in 1876, but displays the character of the species well.

The holotype (pl. 8, figs. 3, 4) is a shell representing an early mature growth stage with inner lip callus just beginning to develop and the outer lip has not yet thickened.

Types: Holotype, AMNH 9491; hypotypes, USNM 291, 129866, 132662.

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1978, D–1983 (*Baculites baculus* zone). South Dakota: Pierre Shale and Fox Hills Sandstone. Montana: Bearpaw Shale. Colorado: Pierre Shale (*Baculites reesidei* and *B. jenseni* zones). Canada: Bearpaw Shale.

Superfamily PHILINACEA

Family SCAPHANDRIDAE

Genus ELLIPSOSCAPHA Stephenson, 1941

Type by original designation: *Cylichna striatella* Shumard, 1861.

Diagnosis.—Subelliptical, involute, tightly coiled shells with a moderately small apical pit. Sculpture of punctate spiral grooves. Aperture narrow and curving over upper surface and broadening below to a rounded anterior margin. Inner lip callused over columellar area and bears a low weak fold.

Discussion.—Stephenson (1941, p. 391) proposed this genus to include a group of species from the Coastal Plains and the western interior. Among these was *Ellipsoscapha occidentalis* (Meek and Hayden) from the Pierre Shale that is described below.

Scaphander Montfort is similar to *Ellipsoscapha*, but has an imperforate apex and is umbilicate. *Bulla* Linnaeus is grossly like *Ellipsoscapha*, but lacks spiral sculpture on the middle of the whorl and has callus distributed over the parietal as well as the columellar surfaces. *Haminea* is more ovate in outline and has a broader apical perforation.

Ellipsoscapha occidentalis (Meek and Hayden)

Plate 7, figures 7, 9–14

1856. *Bulla occidentalis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 69.
1861. *Bulla nebrascensis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 13, p. 427.
1876. *Haminea occidentalis* (Meek and Hayden). Meek, U.S. Geol. Survey Terr. (Hayden) Rept., v. 9, p. 271, pl. 18, figs. 11a, b, 12a, b.
1885. *Haminea occidentalis* (Meek and Hayden). Whiteaves, Canada Geol. Survey, Contr. Canadian Paleontology, v. 1, pt. 1, p. 45.
1895. *Roxania occidentalis* (Meek and Hayden). Cossmann, Essais de Paléoconchologie comparée, v. 1, p. 99.
1917. *Haminea occidentalis* (Meek and Hayden). Dowling, Canada Geol. Survey Mem. 93, p. 30, pl. 28, figs. 7, 7a, 7b.
1941. *Ellipsoscapha occidentalis* (Meek and Hayden). Stephenson, Texas Univ. Bull. 4101, p.392.

Type locality.—The type specimen came from the upper beds of the Pierre Shale on the "Yellowstone River, 150 miles above its mouth" near Glendive, Mont. (*Baculites baculus* zone).

Description.—Medium-sized elliptical involute shells. Protoconch submerged, not visible. Whorls have well-rounded sides, shell broadest medially and posteriorly rounding down into a narrow moderately deep apical pit. Sculpture of narrow, variably spaced, incised grooves; grooves closer spaced on upper rounded surface of whorl, but wide spaced on wall of umbilical pit. Growth lines very gently prosocline over whorl sides. Aperture narrow, curving posteriorly, terminating in rounded margin at apical pit; aperture broadens rapidly below midwhorl and well rounded anteriorly; columellar lip callused and relatively straight.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9). All specimens are from the type locality.

Specimen	H	MD
Syntype: USNM 278	12	7.8
Do	12.2	8.7
Lectotype: USNM 132652	11.6	7.9
Syntype: USNM 132975	11.4	8.0

Discussion.—Seven specimens are in the type lot USNM 278) used by Meek in defining this species. I am unable to identify confidently the three specimens he figured (Meek, 1876, pl. 18). Schuchert and others (1905, p. 108) in their catalogue of type specimens in the U.S. National Museum cite a holotype and paratypes, but no specimen was segregated as holotype or marked in any special manner. One of the seven specimens retains most of its shell material (pl. 7, figs. 7, 11), and I hereby designate it as lectotype (USNM 132652).

The specimens from the Red Bird section (pl. 7, figs. 10, 12–14) here included in *Ellipsoscapha occidentalis* are internal molds, and most are smaller in size than the specimens from the type lot. However, they agree in body proportions and in the reflection of the ornament on the internal molds.

Compared to the other species of *Ellipsoscapha* from the Upper Cretaceous of the western interior *E. occidentalis* is smaller in size, less slender or cylindrical, apically blunter, and has a proportionally shorter columella than *E. subcylindrica* (Meek and Hayden) from the Pierre Shale at the mouth of the Milk River, Montana. *Ellipsoscapha*? minor (Meek and Hayden), from the Fox Hills Formation, is more globular in outline, posteriorly more attenuated, and has a more highly inclined columellar lip.

Types: Lectotype, USNM 132652, syntypes, USNM 278, 132975; hypotypes, USNM 132653, 132654, 132671.

Occurrences: Wyoming: Pierre Shale, Red Bird section D–1983 (*Baculites baculus* zone), D–1985 (*Baculites grandis* zone). Montana: Pierre Shale (*Baculites baculus* zone), Bearpaw Shale. Canada: Bearpaw Shale.

Superfamily BULLACEA

Family BULLIDAE

Genus BULLOPSIS Conrad, 1858

Type by monotypy, *Bullopsis cretacea* Conrad.

Diagnosis.—Apically truncate bulloid shells with an open apical depression. Sculpture of incised spiral grooves. Columella with two strong oblique plications.

Discussion.—The familial affinities of *Bullopsis* have been discussed by Sohl (1964, p. 306).

This is the first report of this genus outside the Upper Cretaceous of the Mississippi embayment region of the Gulf Coastal Plain. The type species *B. cretacea* is from the Owl Creek Formation of Mississippi. Only one additional species, *B. demersus* Sohl, from the Ripley Formation of the same area, is known.

The species described below appears to represent a separate species, but the material is insufficient to assign a new name.

Bullopsis n. sp.

Plate 7, figures 4–6

Diagnosis.—A *Bullopsis* with incised spiral lines covering shell surface.

Description.—Medium-sized apically truncate subglobose shells. Spire depressed, apical depression broad with heterostrophic protoconch visible at center. Suture in an impressed groove. Teleoconch of about four whorls. Body whorl with upper surface rounded and decreasing with increased curvature into the apical depression; whorl sides well rounded. Sculpture consists of shallowly impressed spiral grooves that cover the surface; spiral grooves are weak over the curved upper whorl surface, but are wider spaced and stronger over the basal slope. Growth lines rather straight and gently prosocline. Aperture expands rapidly anteriorly, narrowly rounded posteriorly; columella with two low parallel oblique plications.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9).

Specimen and locality	H	MD	H/MD
Bullopsis n. sp. (USNM 132661), Pierre Shale, Red Bird, Wyoming	12. 6	9. 9	1. 3
Bullopsis cretacea (topotype), Owl Creek Formation, Mississippi	13. 4	10. 0	1. 3
Do	13. 0	10. 1	1. 3
Do	17. 8	13. 5	1. 3

Discussion.—Compared with topotypes of the type species *Bullopsis cretacea* Conrad, from the Owl Creek Formation of Mississippi, this species compares favorably in size and proportions (see measurements) and in apical features (compare pl. 7, fig. 3, and pl. 7, fig. 4). *Bullopsis* n. sp. from the Pierre Shale of the Red Bird section, however, has stronger spiral sculpture that covers the shell surface and has weaker lower columellar plications than *B. cretacea*. *Bullopsis demersus* Sohl from the Ripley Formation of Tennessee, is smaller, lacks spiral sculpture on the medial part of the whorl, has a narrower apical pit, and has stronger columellar plications.

The description and discussion given above are based upon the sole specimen from the upper unnamed member of the Pierre Shale of the Red Bird section. The specimen is an internal mold that preserves the reflection of the surface sculpture and has parts of the shell still attached. The inner lip has been excavated from the rock matrix sufficiently to show the columellar folds, but their low character may in part be due to mechanical breakage during excavation. Specific variation cannot be ascertained with the available material and therefore assignment of a new name is withheld until more material is available.

Types: Figured specimen, USNM 132661.

Occurrence: Wyoming: Pierre Shale, Red Bird section, D–1985 (*Baculites grandis* zone).

Order BASSOMATOPHORA

Superfamily SIPHONARIACEA

Family SIPHONARIIDAE

Genus ANISOMYON Meek and Hayden, 1860

Type by original designation: *Helcion patelliformis* Meek and Hayden, 1856.

Diagnosis.—Medium-sized patelliform shells having a medial or midanterior apex that is reflexed posteriorly at tip. Muscle scar horseshoe shaped having enlarged anterior ends joined by line and broken and offset on right posterior side.

Discussion.—Anisomyon is restricted to the Cretaceous and is one of the more widely distributed gastropod genera in the western interior. In addition, it has been reported from the west coast and the Gulf and Atlantic Coastal Plains. Some of the species are of questionable placement because the internal muscle pattern is unknown.

The following is an annotated list of species described as *Anisomyon* from the Cretaceous rocks of North America.

Anisomyon alveolus Meek and Hayden: Pierre Shale, Bearpaw Shale, western interior, and Canada.

A. apicalis Sidwell: Carlile Shale, western interior.

A. borealis (Morton): Pierre Shale, western interior and questionably Gulf Coastal Plain.

A. centrale Meek: Coloradoan(?), Bearpaw, Pierre Shale, western interior, and Canada.

A? cragini Twenhofel: Comanchean, Kansas.

A. frontierensis Sidwell: Frontier Formation, Wyoming.

A. haydeni Shumard: Nacatoch Sand, Texas, and questionably in Mount Laurel Sand of Delaware.
A. jessupi Richards and Shapiro: Mount Laurel Sand, Delaware.
A. meekii Gabb: Lower Cretaceous, California and Canada.
A. patelliformis Meek and Hayden: Pierre Shale, western interior. Smoky River Formation, Canada.
A. shumardi Meek and Hayden: Pierre Shale, western interior.
A. sexsulcatus Meek and Hayden: Pierre Shale, western interior.
A. subovatus Meek and Hayden: Pierre Shale, western interior.
A. wieseri Wade: Ripley Formation, Gulf Coastal Plain.
A. sp. Stephenson: Snow Hill Marl Member, Black Creek Formation. Atlantic Coastal Plain outside North America.

Of the species listed above, *Anisomyon wieseri* Wade belongs in *Siphonaria* (see Sohl, 1960, p. 47, 52). Of the other species, several have the general features of apex and shell form of *Anisomyon;* but until their muscle-scar patterns are known, acceptance in *Anisomyon* must be questioned.

Anisomyon borealis (Morton)

Plate 8, figures 7–16; plate 9, figures 3–11

1842. *Hipponyx borealis* Morton, Acad. Nat. Sci. Philadelphia Jour., v. 8, p. 210, pl. 11, fig. 6.
1856. *Helcion carinatus* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 6, p. 68.
1860. *Anisomyon borealis* (Morton). Meek and Hayden, Am. Jour. Sci. and Arts, v. 28, 2d ser., p. 35.
1876. *Anisomyon borealis* (Morton). Meek, U.S. Geol. Survey Terr. (Hayden) Rept., v. 9, p. 288, pl. 18, fig. 9a–e.
1877. *Anisomyon borealis* (Morton), White, U.S. Geog. Surveys West 100th Meridian (Wheeler), v. 4, Paleontology, pt. 1, p. 193, pl. 18, figs. 9a, b. (Assignment very questionable.)
1880. *Anisomyon borealis* (Morton). Whitfield, U.S. Geog. and Geol. Survey Rock Mtn. Region (Powell), p. 436, pl. 12, figs. 21–23.
1941. *Anisomyon borealis* (Morton)? Stephenson, Texas Univ. Pub. 4101, p. 397, pl. 74, figs. 16, 17.

Type locality.—"Great Bend of the Missouri below Fort Pierre; from the base of the Fort Pierre Group" (Meek, 1876, p. 289).

Diagnosis.—Base circular in outline, apex well forward with a posterior medial carination (fig. 10).

Description.—Meek's (1876, p. 288) description is as follows:

> Shell thin, bonnet shaped, the summit being prominent, with a general forward obliquity, and located in advance of middle; immediate apex very small, abruptly pointed, and having the characteristic abrupt backward curve well-marked; base nearly circular, anterior and anterior-lateral slopes abrupt and distinctly concave; posterior and posterior-lateral slopes convex, the former being carinated along the middle, and the latter usually supporting a few very obscure radiating ridges; surface, when slightly worn, appearing smooth, but in well-preserved examples marked by fine, inconspicuous lines of growth, which are crossed by similar closely arranged, radiating striae, scarcely visible without the aid of magnifier; radiating from the apex may also be seen six equidistant deeply-impressed hair-lines, four of which pass down the posterior and lateral slopes, and two down the anterior-lateral.

To the above must be added: shell margin subround in outline rising anteriorly, so that apex to anterior-margin distance is less than anterior-lateral margin to apex; impressed lines uncommon on shell interior, but carination strongly impressed. Muscle scars consisting of a strong upper left scar that tapers posteriorly, ending in enlarged scars just left of posterior carination; scars interrupted and offset over carination; scar thin and curved at lower right, enlarging over medial right

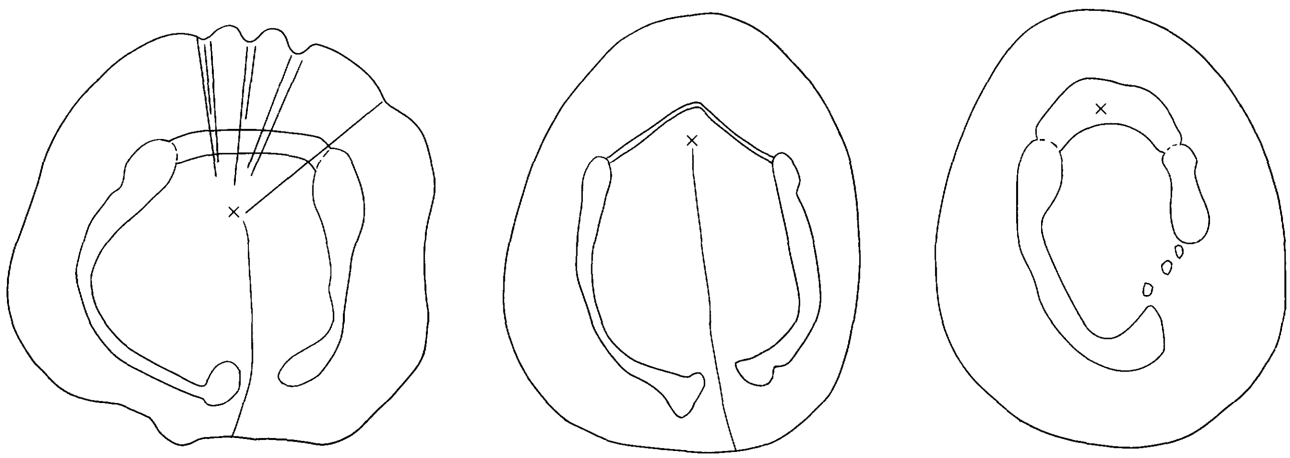

FIGURE 10.—The muscle-scar pattern of some species of *Anisomyon* Meek and Hayden. Figure on left is *A. centrale* Meek, center *A. borealis* (Morton), right *A. patelliformis* Meek and Hayden. The X on the central anterior of the figures indicates the position of the apex. The curved posteriorly directed lines indicate the position of the carination, which is lacking in *A. patelliformis*. Slightly reduced from natural size.

side and anteriorly rounded; enlarged right- and left-anterior scars joined by a thin scar running across just anterior and below apex.

Measurements.—Explanation of measurements and symbols used in the following tables appears in the section "Measurements of specimens" (p. B9).

Specimen and locality	ML	W	H	LC
Hypotype:				
USNM 132706—Pierre Shale, Wyoming	51	50. 5	26	43
USNM 132658—Pierre Shale (*E. jenneyi* zone), Red Bird, Wyoming	60	57	27+	------
USNM 132656—Pierre Shale (*E. jenneyi* zone), Red Bird, Wyoming	------	------	------	33
USNM 132977—Pierre Shale, South Dakota	48	46	22. 5	45
USNM 248	44	------	19. 0	43

Discussion.—The additional information as to musculature was taken from the specimen illustrated on plate 8, figure 12, which comes from shale exposures 2 miles northeast of Harper station, Wyoming. The characteristic uncoiled but reflexed protoconch typical of *Anisomyon* is best exhibited by the specimen figured on plate 8, figure 8, from the Pierre Shale at the Great Bend of the Missouri River. This specimen plus that figured from the same locality on plate 9, figures 3, 4, 8, exhibit sculpture to the best advantage.

Except for the medioposterior carination, sculpture appears to be very variable. Although the lack of impressed lines may, as Meek noted, be due to wear of the surface, the lack of secondary radiating ridges on the specimen (syntype of *H. carinatus*) USNM 132976 (pl. 9, figs. 7, 9) cannot be explained, due to wear. This specimen possesses the carination and the impressed lines, but lacks the radiating ridges present on so many other specimens. On all specimens where present, the impressed lines are strongest near the apex and decrease in strength marginward. The radiating ridges in contrast are generally strongest away from the apex.

In shape, this species is rounder in outline than most other species of *Anisomyon*. Although usually rather high in outline, some specimens are proportionally low (compare plate 8, figures 8, 9).

Compared to other species, *Anisomyon borealis* is proportionally lower than *A. centrale* or *A. shumardi*, has a less central apex, and lacks the strong impressed line on the posterior slope of these species. *Anisomyon subovatus*, *A. patelliformis*, *A. haydeni*, and *A. alveolus* are all lower and more lenticular in outline and have a much more subdued and noncarinate sculpture.

This is one of the more widely distributed gastropod species occurring in the lower part of the Pierre Shale and equivalents in Colorado, South Dakota, and Wyoming. It occurs in the Red Bird Silty Member (*Baculites gregoryensis* zone), D–1910, and the overlying unnamed member, D–1947, 1948 (*Exiteloceras jenneyi* zone) of the Red Bird section.

Types: Holotype, lost; hypotypes, USNM 248 (2), USNM 28586, 132655–132658, 132706, 132976–132978.

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1910 (*Baculites gregoryensis* zone), USGS D–1947, D–1948 (*Exiteloceras jenneyi* zone). Colorado: Pierre Shale, Front Range (*Baculites perplexus* and *Baculites gregoryensis* zones). South Dakota: Pierre Shale, near base.

Anisomyon centrale Meek

Plate 9, figures 1, 2; pl. 10, figs. 1–15; pl. 11, figs. 1–7, 9

1871. *Anisomyon centrale* Meek, U.S. Geol. and Geog. Survey Terr., 4th Ann. Rept., p. 312.

1877. *Anisomoyon centrale* Meek. White, U.S. Geog. Surveys West 100th Meridian (Wheeler), v. 4, Paleontology pt. 1, p. 194, pl. 18, figs. 8a, b. (Assignment questionable)

1879. *Anisomyon centrale* Meek. White, U.S. Geol. and Geog. Survey Terr. (Hayden), 11th Ann. Rept., 1877, p. 206, 225, 303, pl. 9, fig. 1a–d.

1885. *Anisomyon centrale* Meek. Whiteaves, Canada Geol. Survey, Contr. Canadian Paleontology, v. 1, pt. 1, p. 47, pl. 7, figs. 1, 1a, 2, 2a.

1917. *Anisomyon centrale* (Meek). Dowling, Canada Geol. Survey Mem. 93, p. 30, pl. 28, figs. 12–12b.

Type locality.—"Box Elder and Colorado City, Colorado" (Meek, 1871, p. 312).

Diagnosis.—Subconical shell about as wide as high, apex central, with strong grooves on anterior slope (figs. 10, 11).

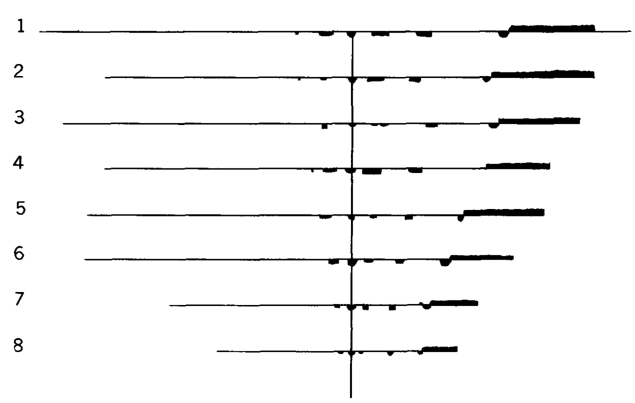

FIGURE 11.—Diagram of sculpture pattern of *Anisomyon centrale* Meek and Hayden. Length of horizontal lines equivalent to circumference of aperture of individual specimen. Vertical line connects position of anterior radial groove. Shaded areas below horizontal lines, mark width and position of lateral radial grooves. Shaded areas above horizontal line mark position and width of right posterior platform. Specimen numbers: 1. USGS, D–1382 (*Baculites jenseni* zone) Wyoming. 2. USGS, D–16217 (*B. reesidei* zone) Colorado. 3. Same locality, aberrant form. 4. Lectotype, USNM 12430a, Pierre Shale, Colorado. 5. USGS, D–2819 (*B. reesidei* zone) Colorado. 6. Cotype USNM 12430b, Pierre Shale, Colorado. 7. USGS, D–2701 (*B. reesidei* zone) Colorado. 8. USGS, D–372 (*B. reesidei* zone) Colorado.

Description.—Medium-sized subconical shells about as wide as high with a straight anterior slope and broadly convex posterior lateral slopes; left-lateral slope less steep than right. Apex approximately central in position; nucleus unknown, but apex asymmetrically reflexed posteriorly. Sculpture dominated by radial grooves; main groove deep and strong with a broadly concave base and is situated at about mid-anterior slope; minor incised grooves variable in number and strength, covering about one-half of left-anterior quadrant and all right-anterior quadrant. Usually, a carination is present on right-posterior slope forming posterior limit of a broad raised platformlike area covering medial one-half of right-posterior quadrant. Concentric sculpture usually limited to growth lines and low welts that are strongest over raised radial welt of right-posterior quadrant.

Growth lines faint to moderately prominent; lines nearly straight between radiating grooves, but flexed over grooves and very sharply flexed toward apex over posterior carination. Aperture subcircular in outline; in profile, anterior margin higher than posterior. Muscle scars consist of two prominent strong muscle scars on the anterior-lateral flanks joined by moderately wide scar band on the anterior slope. On left-lateral flank behind the broad anterior scar a moderately broad scar band continues posteriorly, being first directed down and posteriorly at an angle of about 30° from the horizontal, then becoming virtually horizontal and continuing almost to the posterior carination, where it is interrupted. On the right-posterior flank, muscle scars again begin just beyond the umbonal ridge but higher on the shell than those of the left-posterior flank, then curve downward, then swing up to the main right interior scar.

Measurements.—Explanation of measurements and symbols used in the following table appears in the section "Measurements of specimens" (p. B9). (See also fig. 11.)

Discussion.—*Anisomyon centrale*, as is typical of other species of the genus, shows considerable variability in most aspects of sculpture. In form it is consistently subcircular. Most available specimens are internal molds, but a few possess at least a part of the shell (pl. 11, figs. 1–4); in general, the radiating grooves are less pronounced on the shells than on the internal molds. The shell itself is rather thin, and the muscle scars are not deeply impressed. When observable, the muscle scars are preserved as shell material adhering to the internal molds.

Small specimens closely approach a circular outline, but in larger individuals there is an increasing tendency toward asymmetry. At all stages of growth the right-posterior area is largest and deviates most from the overall circularity of the aperture, making the posterior half of the shell broader than the anterior. Proportions of height to length vary greatly, but, in general, the smaller specimens are proportionately higher, usually with height nearly equal to width (pl. 10, fig. 5), whereas some larger specimens (pl. 9, fig. 2) have a length 1½ to almost twice the height (see measurements). The specimen from the Pierre Shale of the Front Range figured on plate 11, figure 3 (USGS 16217, USNM 132713) is the most atypical not only in its low spire but in its subdued sculpture and long anterior slope.

The apex is broken on almost all available specimens, but the specimen from USGS locality D–372, figured on plate 10, figure 9, shows it to be well reflexed toward the posterior and skewed to the left of the median plane. It is suggestive that the larval shell was a simple cup shape similar to that in some of the nudibranchs. This has, however, never been seen on actual specimens.

The most constant feature of the radiating sculpture is the strong deep anterior groove commonly flanked by broader grooves on either side and the swollen raised platform of the right-posterior quadrant. Figure 11 shows these features to be present on all specimens, but that they vary in strength and width generally with size of the specimen. The lateral grooves of the internal molds on specimens retaining the shell, however, are not simple troughs but are divided by a central rib (fig. 11, specimen 3). This feature is well

Specimen and locality	H	AM	PM	ML	W	ML/W
Lectotype: USNM 12430—Pierre Shale, Colorado	24. 6	24. 5	27	29. 4	29. 8	0. 98
Syntype: USNM 132979—Pierre Shale, Colorado	19. 0	23	23	23. 9	22. 2	1. 07
Hypotype: USNM 132660—Pierre Shale, Red Bird, Wyoming	31. 0+	30	32+	36. 1+	37. 5	. 99
USGS D–1382—Pierre Shale (*B. jenseni* zone), Colorado	29	27	37	36	32	1. 12
Do	31. 2	27	36	38. 9	39. 2	. 99
Do	21	25	29. 5	37. 0	33	1. 12
Do	22	21. 1	26	32. 5	31	1. 05
USGS 16217—Pierre Shale (*B. reesidei* zone), Colorado	24	24	27. 5	33	31	1. 06
Do	18	22	26	35. 5	33. 5	1. 06
USGS D–372—Pierre Shale (*B. reesidei* zone), Colorado	16	-------	-------	21	20. 5	1. 02

displayed by the specimens figured on plate 11, figures 1–4. Growth lines commonly are strongly flexed up over this ridge. The significance of the anterior groove is questionable. The raised platform of the right posterior margin, however, is associated with the interruption of the muscle-scar band (see figs. 10, 11) and has functional significance. This band is delimited on its anterior side by a radiating groove, but on its posterior side it is bounded by a low to well-marked carination not unlike that seen on *Anisomyon borealis*. The interruption of the muscle-scar band coincides with the lung aperture of these pulmonates.

In outline, *Anisomyon shumardi* Meek and Hayden from the Pierre Shale of the Great Bend of the Missouri is perhaps the species most similar to *A. centrale*. *Anisomyon shumardi*, however, has a much less central apex and lacks the strong radiating grooves. *Anisomyon sexsulcatus* Meek and Hayden from the Pierre Shale near Glendive, Mont., is lower in outline with a less central apex and has scattered radiating grooves.

White (1877, pl. 18, figs. 8a, b) assigned internal molds from Gallinas Creek, N. Mex., to *A. centrale*. He noted that the molds were in clay and compressed and thus did not show their true outline. These specimens must be assigned with question, for the apex appears to be subcentral and no trace of musculature remains. Whiteaves (1885, pl. 7, figs. 1, 2) figured specimens from the Bearpaw Shale of Canada that conform well to the species.

Types: Meek's 1871 description was based on two specimens (USNM 12430) from the Pierre Shale of "Box Elder and Colorado City, Colorado." White (1879, pl. 9, figs. 1a–d) produced illustrations of the type specimens prepared by Meek just before his death. I hereby designate the specimen illustrated by White (1879) on plate 9, figs. 1a, and 1b, as lectotype, USNM 12430. Syntype, USNM 132979. Hypotypes: USNM 132659, 132710, 132713, 132716, 132925, 132926 (Pierre Shale, Colorado); USNM 8659 (New Mexico, White, 1875); USNM 132660, 132715 (Pierre Shale, Wyoming).

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–1952 (*Baculites reesidei* zone). Colorado: Pierre Shale, Front Range (*Baculites reesidei* and *B. jenseni* zones). New Mexico: Gallinas Creek (questionable occurrence). Canada: Bearpaw Shale (Whiteaves, 1885; Dowling, 1917).

Anisomyon patelliformis Meek and Hayden

Plate 11, figures 8, 10–17

1856. *Helcion patelliformis* Meek and Hayden, Acad. Nat. Sci. Philadelphia Proc., v. 8, p. 68.

1860. *Anisomyon patelliformis* Meek and Hayden, Am. Jour. Sci., v. 29, p. 35, pl. 1, figs. 1–3.

1876. *Anisomyon patelliformis* Meek and Hayden. Meek, U.S. Geol. Survey Terr. (Hayden) Rept., v. 9, p. 290, pl. 18, figs. 5a–c, e.

1880. *Anisomyon patelliformis* Meek and Hayden. Whitfield, Geol. and Geol. Survey Rocky Mtn. Region (Powell), p. 435, pl. 12, figs. 17, 18.

1895. *Anisomyon patelliformis* Meek and Hayden. Cossmann, Essais de paléoconchologie comparée, pt. 1, p. 138, pl. 7, fig. 18.

1917. *Anisomyon patelliformis* Meek and Hayden. Dowling, Canada Geol. Survey Mem. 93, p. 30, 46, pl. 29, figs. 1–1c.

1959. *Anisomyon patelliformis* Meek and Hayden. Zilch, Gastropoda, *in* Schindewolf, O. H., Handbuch der Paläozoologie, v. 6, pt. 2, p. 82, fig. 266.

Type locality.—"Yellowstone River, 150 miles above its mouth" (Meek, 1876, p. 290). This locality is in the upper part of Pierre Shale (*Baculites baculus* zone) in the vicinity of Glendive, Mont.

Diagnosis.—Apex at about anterior one-third shell; profile moderately low, posterior slope well rounded. Surface smooth, devoid of all sculpture except for few faint radiating lines. Aperture outline widest posteriorly (see fig. 10).

Discussion.—One internal mold from the Red Bird section at USGS D–2116 may belong to *Anisomyon patelliformis*. It is larger and laterally less expanding than is typical for the species, but is close in position of apex and lack of sculpture. Whitfield's (1880) specimen of *A. patelliformis* comes from the Old Woman Creek of Wyoming near Red Bird and gives ample proof of the presence of the species in this area (pl. 11, fig. 8).

Lack of a strong posterior carination and incised grooves separates the species readily from *A. centrale* and *A. borealis*. Its muscle-scar pattern (fig. 10, and pl. 11, figs. 8, 16) is especially distinctive in that the connection between the anterior enlarged scars rides high on the shell even to the point of being behind the apex (pl. 11, fig. 8). On other specimens, however, the scar crosses at the apex (pl. 11, figs. 13, 16).

Types: Holotype, USNM 246; paratype, USNM 132980, 132981; hypotype, USNM 12268, 132982.

Occurrences: Wyoming: Pierre Shale, Red Bird section, USGS D–2116, (*Baculites baculus* zone). South Dakota: Fox Hills Sandstone. Montana: Pierre Shale (*Baculites baculus* zone).

Anisomyon sp.

Discussion.—Incomplete internal molds probably representing species of *Anisomyon* occur in the Pierre Shale of the Red Bird section in collections USGS D–1887 (*Baculites gilberti* zone), USGS D–1900 (*Baculites gregoryensis* zone), and D–1952 (*Baculites reesidei* zone).

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PLATES 1-11

PLATE 1

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5. Back view of a specimen (× 5) showing an early stage of sculpture development. Pierre Shale, *Didymoceras stevensoni* zone, Red Bird section, Wyoming. USGS D–1940, USNM 132668.

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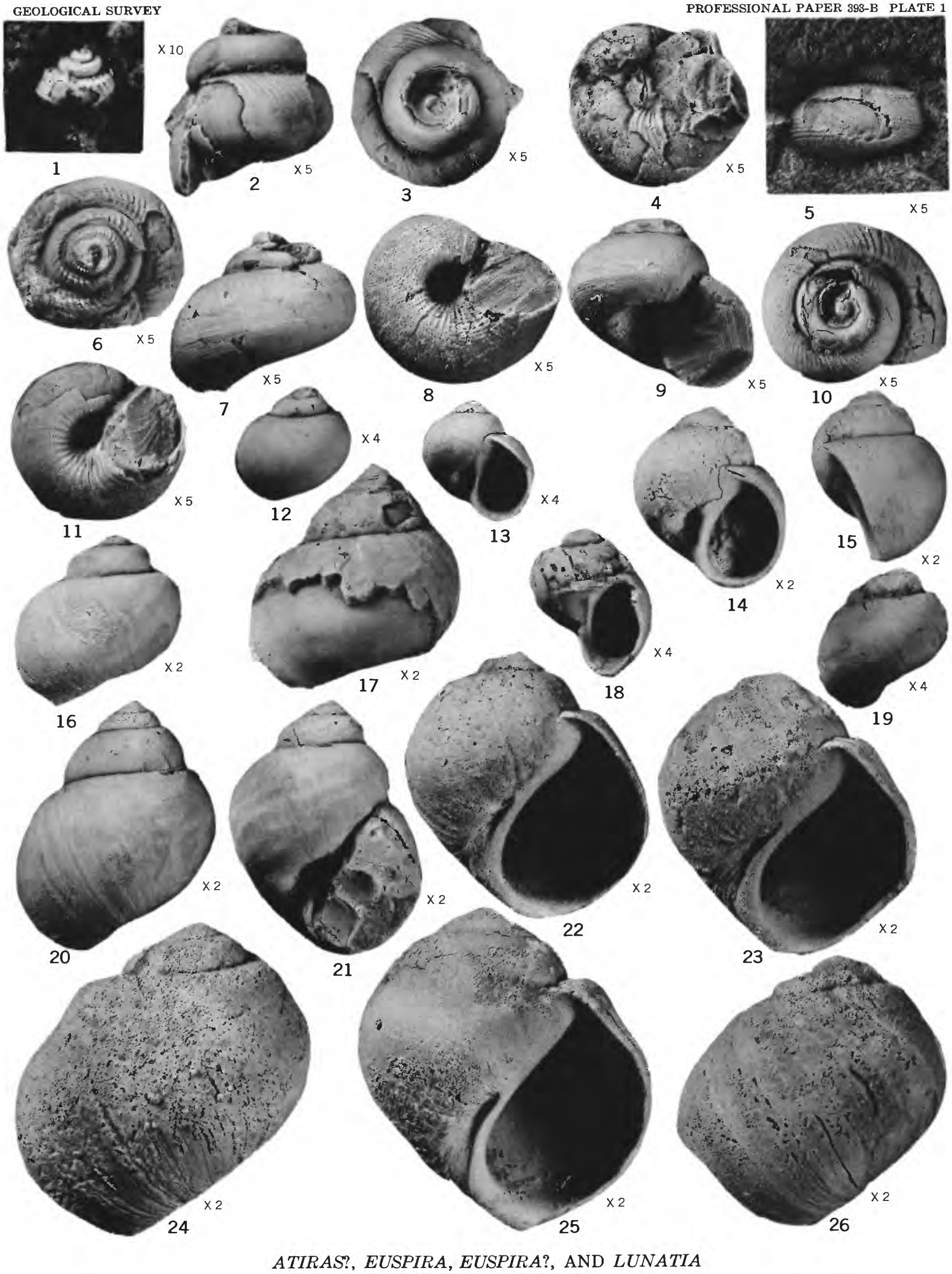

ATIRAS?, *EUSPIRA*, *EUSPIRA*?, AND *LUNATIA*

PLATE 2

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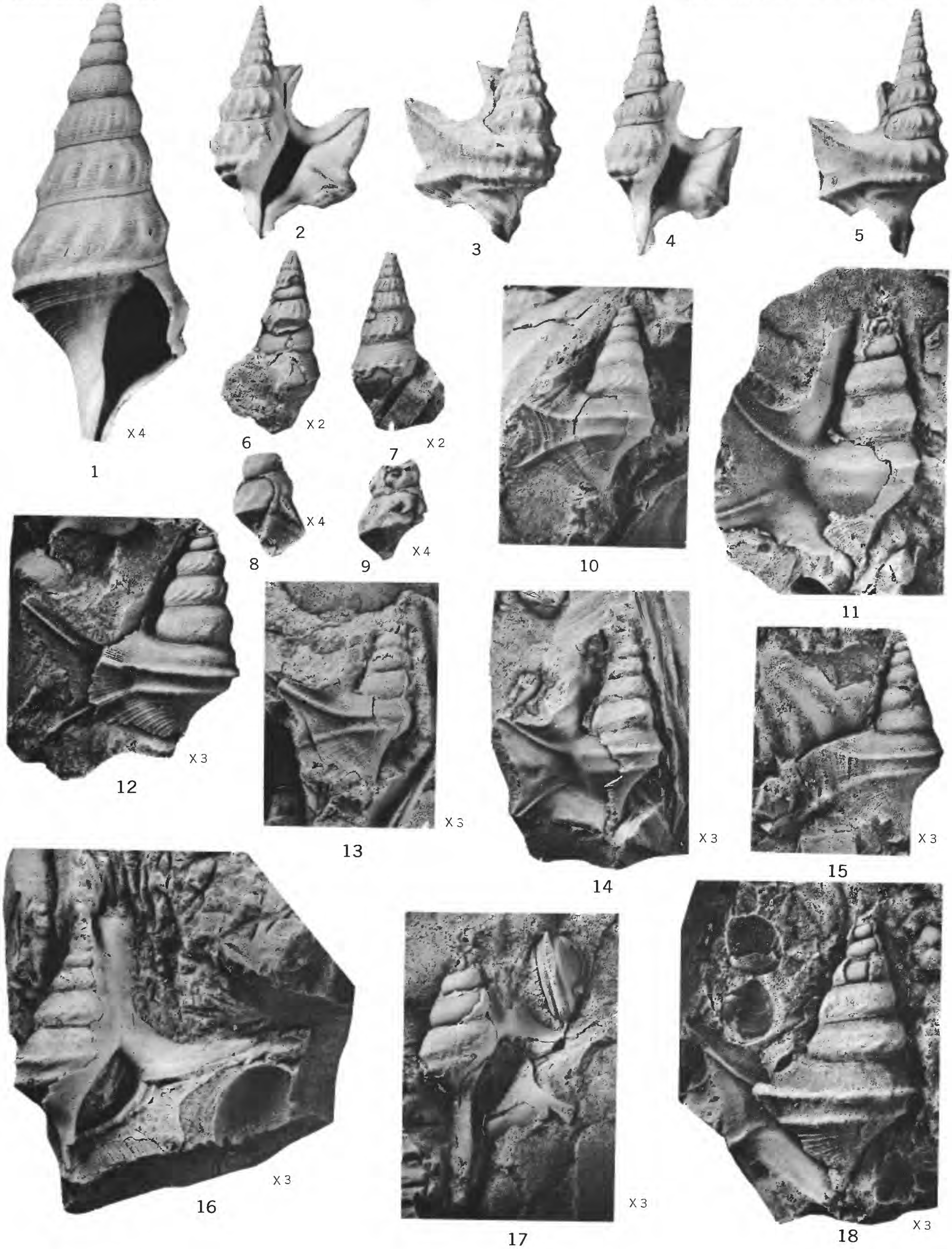
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APORRHAIS

PLATE 3

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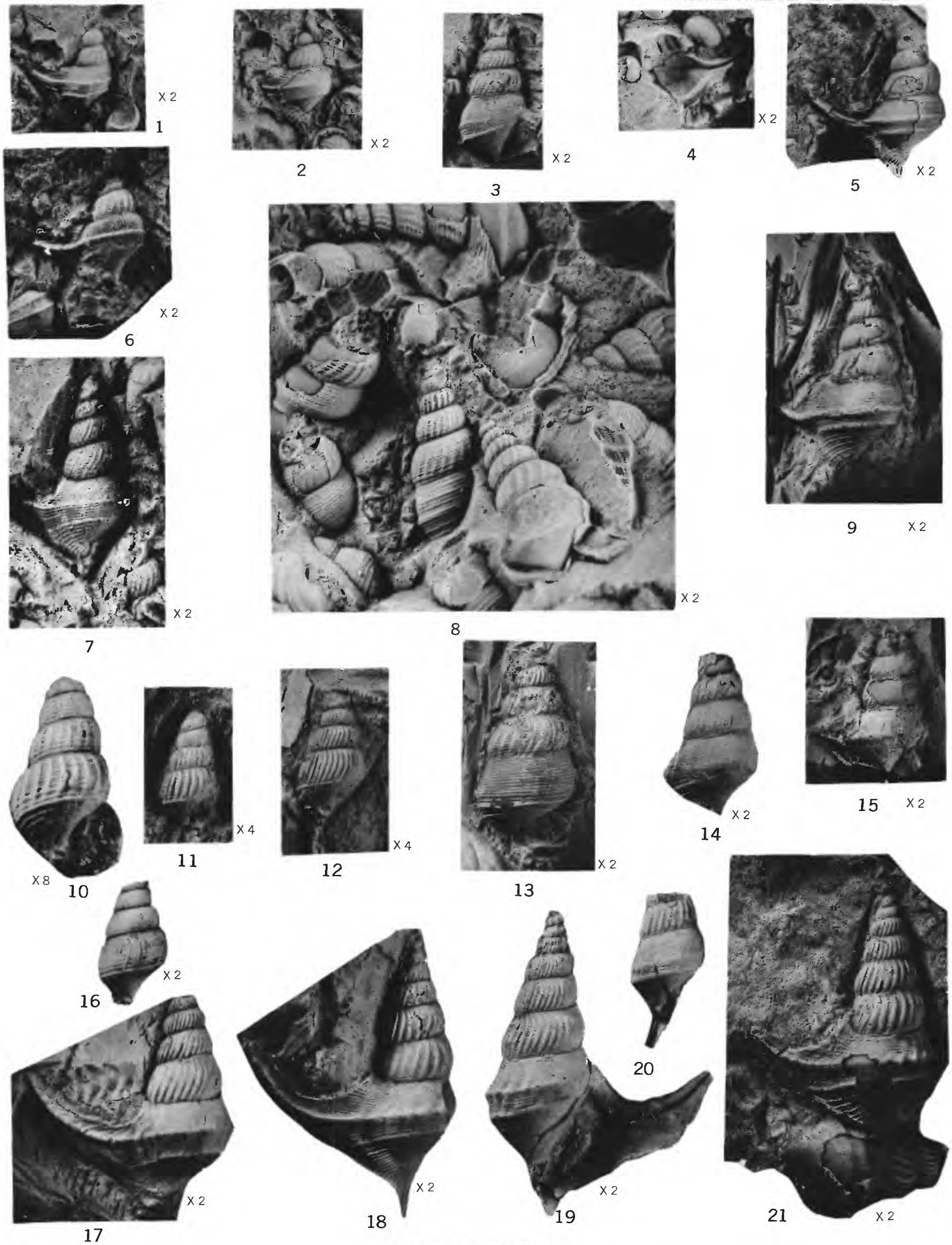

DREPANOCHILUS

PLATE 4

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12. Back view of the holotype (× 3) from the Ripley Formation on Coon Creek, McNairy County, Tenn. USNM 32944.

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11. Back view of a specimen (× 2) from the same locality. USGS 16011, USNM 132687.

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14. Back view of a specimen (× 4) from the Pierre Shale (*Baculites eliasi* zone), south bank of reservoir No. 3, sec. 19, T. 9 N., R. 68 W., Larimer County, Colo. USGS 16093, USNM 132694.

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19. Back view of a paratype (× 2) from the same locality. USGS D–335, USNM 132682.

20. Apertural view of a paratype (× 2) from the same locality. USGS D–335, USNM 132962.

21. Back view of the holotype (× 2) from the same locality. USGS D–335, USNM 132958.

22. Apertural view of a paratype (× 2) from the Pierre Shale (*Baculites eliasi* zone), Larimer County, Colo. USGS 16093, USNM 132686.

23. Apertural view of a paratype (× 2) from the Pierre Shale (*Baculites eliasi* zone), Boulder County, Colo. USGS D–335, USNM 132959.

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25. Back view of a specimen (× 2) from the Pierre Shale (*Baculites scotti* zone), NW¼NW¼, sec. 19, T. 7 S., R. 68 W., Douglas County, Colo. USGS D–392, USNM 132703.

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28. Back view of the holotype (× 2) from the Pierre Shale (*Baculites gregoryensis* zone), Red Bird section, Wyoming. USGS D–1917, USNM 132642.

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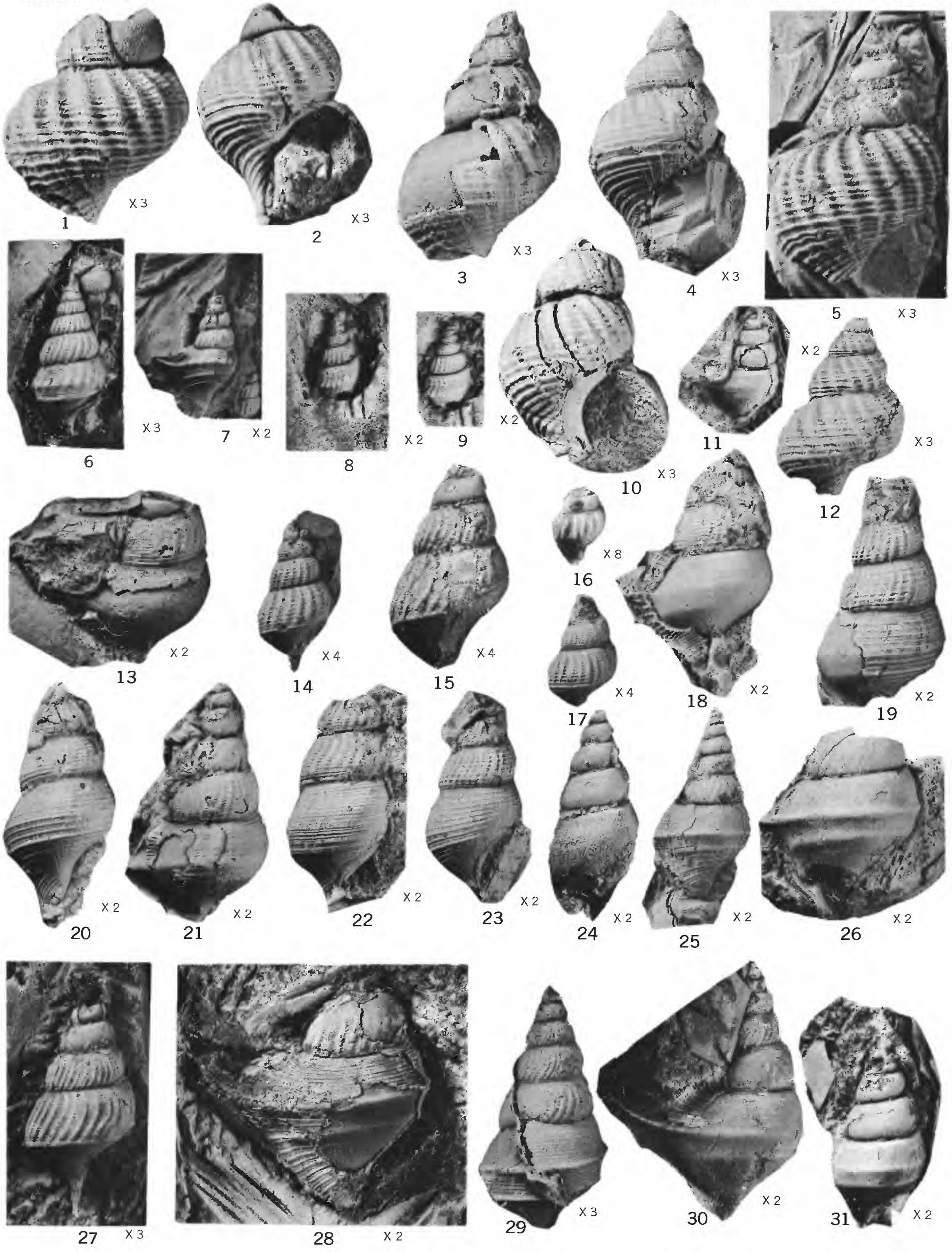
31. Back view of a specimen (× 2) figured by Whitfield (1880, pl. 12, fig. 3) from the same locality. USNM 12309.



ASTANDES AND *DREPANOCHILUS*

PLATE 5

FIGURES 1, 5–10, 12, 14, 17. *Vanikoropsis nebrascensis* (Meek and Hayden) (p. B22).

1, 8. Front and back views of a specimen (× 3) from the Pierre Shale (probably the *Baculites baculus* zone), Glendive area, Montana. USNM 19068.

5, 6. Back and front views of the holotype (× 3) of *Natica*? *ambigua* Meek and Hayden (1856) (=*Fossar nebrascensis* Meek and Hayden, 1860). From the Pierre Shale (*Baculites baculus* zone) near Glendive, Mont. USNM 267.

7. Apertural view of a specimen (× 3) from the Fox Hills Sandstone, Trail City Member, breaks of a small tributary of the Grand River, SW¼, sec. 14, T. 20 N., R. 25 E., Corson County, S. Dak. USGS 27487, USNM 132664.

9, 10. Front and back views of a paratype (× 3) from the Pierre Shale (*Baculites baculus* zone) near Glendive, Mont. USNM 132967.

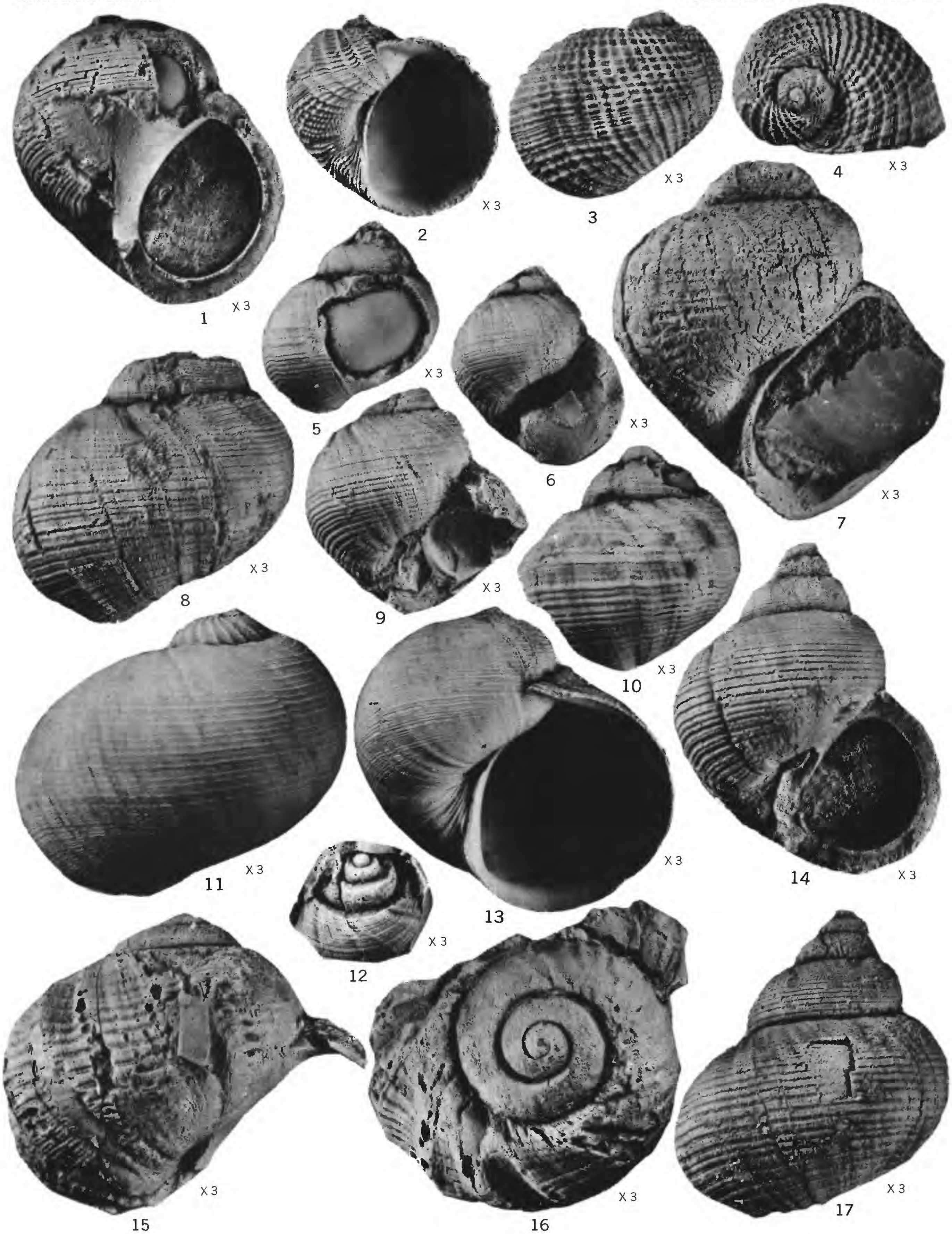
12. Oblique apical view of a rubber mold (× 3) from the Pierre Shale (*Baculites baculus* zone), Iron Bluff on Yellowstone River, 8 or 9 miles above Glendive, Mont. USGS 3896, USNM 132666.

14, 17. Apertural and back view of a specimen (× 3) showing the thickness of the shell. Fox Hills Sandstone, SE¼, sec. 31, T. 20 N., R. 25 E., Standing Rock Reservation, S. Dak. USGS 35925, USNM 132665.

2–4. *Vanikoro cancellata* Lamarck (p. B23). Apertural, back, and apical views of a specimen (× 3), a recent shell from Vanikoro Island, Santa Cruz Islands, Southwest Pacific Ocean. USNM Div. Mollusks 217209.

11, 13. *Vanikoro lygata* Recluz (p. B23). Back and apertural views of a specimen (× 3) from Osima, Osumi, Japan. USNM Div. Mollusks 343593.

15, 16. *Vanikoropsis tuomeyana* (Meek and Hayden) (p. B22). Apertural and apical views of the incomplete holotype (× 3) from "mouth of the Judith River * * * at the horizon of the top of the Fox Hills group," Montana (Meek, 1876, p. 332).



VANIKOROPSIS AND *VANIKORO*

PLATE 6

FIGURES 1–4, 11. *Vanikoropsis nebrascensis* (Meek and Hayden) (p. B22).

1. Back view of a specimen (× 3) from the Pierre Shale (*Baculites baculus* zone), Iron Bluff, Yellowstone River, 8 or 9 miles above Glendive, Mont. USGS 3895, USNM 132667.

2, 3. Back and front views of a specimen (× 3) from the Pierre Shale (*Baculites baculus* zone), Red Bird section, Wyoming. USGS D–1983, USNM 132663.

4, 11. Front and back views of a paratype (× 3) from the Pierre Shale (*Baculites baculus* zone) near Glendive, Mont. USNM 132967.

5–9. *Fasciolaria buccinoides* Meek and Hayden (p. B29).

5, 9. Apertural view of an internal mold and rubber impression of the external mold of a specimen (× 3) from the Fox Hills Sandstone, Trail City Member, 1.5 miles north-northwest of White Horse Lake, Dewey County, S. Dak. Note pustules on parietal lip. USGS 27485, USNM 132677.

6. Front view of an incomplete paratype (× 2) that shows the placement of the columellar plications. Fox Hills Sandstone, Moreau River, South Dakota. USNM 132972.

7, 8. Front and back views of the holotype (× 2) from the Fox Hills Sandstone, Moreau River, South Dakota, USNM 272.

10, 14–17. *Trachytriton vinculum* (Hall and Meek) (p. B28).

10. Front view of an internal mold (× 1) from the Pierre Shale (*Baculites gregoryensis* or *B. scotti* zone) of the Great Bend of the Missouri River, South Dakota. USNM 132984.

14. Back view of a specimen (× 1) from the Pierre Shale (*Baculites scotti* zone), Red Bird section, Wyoming. USGS D–1926, USNM 132645.

15. Back view of a specimen (× 1) from the Pierre Shale (*Baculites gregoryensis* zone), Red Bird section, Wyoming. USGS D–1904, USNM 132644.

16. Front view of the specimen (× 1) figured by Meek (1876, pl. 19, fig. 7b.) Pierre Shale (*Baculites gregoryensis* or *B. scotti* zone), Great Bend of the Missouri River, South Dakota. USNM 132985.

17. Back view of a specimen (× 1) figured by Meek (1876, pl. 19, fig. 7a), from the same locality. USNM 261.

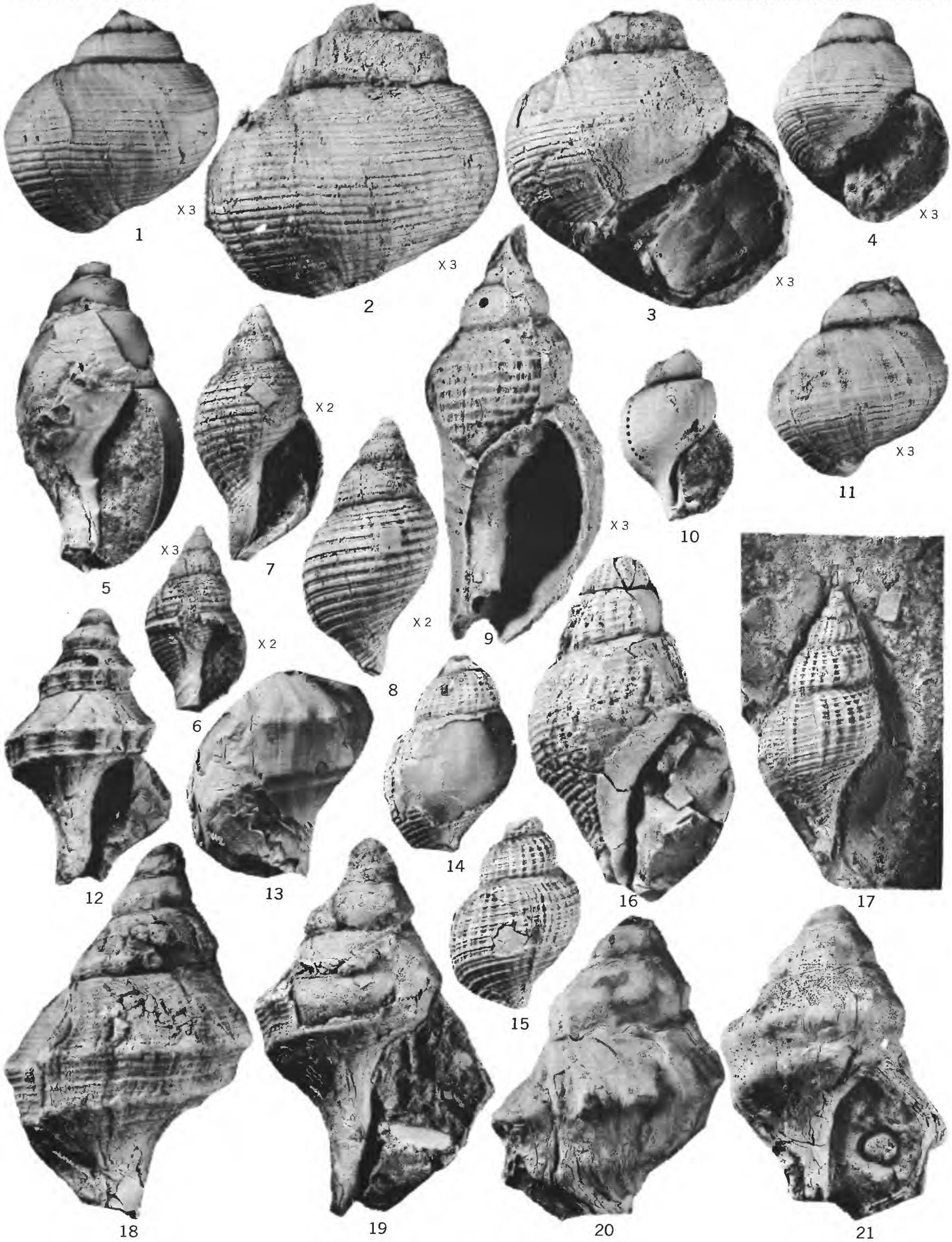
12, 13, 18–21. *Serrifusus dakotensis* (Meek and Hayden)? (p. B30).

12. Front view of a paratype (× 1) from the Fox Hills Sandstone, Moreau River, South Dakota. USNM 132971.

13. Back view of a specimen (× 1) from the Fox Hills Sandstone, Niobrara County, Wyo. USNM 32150.

18, 19. Back and front views of the holotype (× 1) from the Fox Hills Sandstone, Moreau River, South Dakota. USNM 256.

20, 21. Back and front views of a specimen (× 1) from the Pierre Shale (*Baculites baculus* zone), Red Bird section, Wyoming. USGS D–1982, USNM 132643.



VANIKOROPSIS, FASCIOLARIA, TRACHYTRITON, AND *SERRIFUSUS*

PLATE 7

FIGURES 1–3, 8. *Bullopsis cretacea* Conrad (p. B35, B36).

1. Back view of a topotype (× 2) from the Owl Creek Formation, Tippah County, Miss. USGS 594, USNM 20438.

2, 3. Apertural and apical views of a specimen (× 4) from the Owl Creek Formation of Tippah County, Miss. USGS 25422, USNM 130624.

8. Back view of a topotype (× 2) from the same locality as fig. 1. USGS 707, USNM 130622.

4–6. *Bullopsis* n. sp. (p. B36). Apical, apertural, and back views of a specimen (× 3) from the Pierre Shale (*Baculites grandis* zone), Red Bird section, Wyoming. USGS D–1985, USNM 132661.

7, 9–14. *Ellipsoscapha occidentalis* (Meek and Hayden) (p. B35).

7, 11. Front and apical views of the lectotype (× 4) figured by Meek (1876, pl. 18, fig. 12a, b?). Pierre Shale (*Baculites baculus* zone) near Glendive, Mont. USNM 132652.

9. Back view of a syntype (× 4) from the same locality. USNM 132975.

10. Front view of a specimen (× 4) from the Pierre Shale (*Baculites baculus* zone), Red Bird section, Wyoming. USGS D–1983, USNM 132653.

12. Back view of a specimen (× 4) from the same locality. USGS D–1983, USNM 132654.

13, 14. Front and back views of a specimen (× 3) from the Pierre Shale (*Baculites grandis* zone), Red Bird section, Wyoming. USGS D–1985, USNM 132671.

15–19. *Cryptorhytis cheyennensis* (Meek and Hayden) (p. B33).

15. Back view of an internal mold (× 1) from the Pierre Shale (*Baculites reesidei* zone), Red Bird section, Wyoming. USGS D–1952, USNM 132921.

16, 17. Front and back views of a specimen (× 1) from the Pierre Shale (*Exiteloceras jenneyi* zone), Red Bird section, Wyoming. USGS D–1945, USNM 132922.

18, 19. Back and front views of a specimen (× 1) figured by Meek (1876, pl. 19, fig. 13) from the Pierre Shale (*Baculites compressus* zone), Sage Creek, South Dakota. USNM 289.

20. *Anomalofusus*? sp. (p. B30). Back view of a rubber mold (× 3) from the Pierre Shale (*Exiteloceras jenneyi* zone), Red Bird section, Niobrara County, Wyo. USGS D–1948, USNM 132927.

21–24, 29–31. *Graphidula culbertsoni* (Meek and Hayden) (p. B31).

21. Back view of a specimen (× 1) from the Fox Hills Sandstone, Trail City Member, 1.5 miles north-northwest of White Horse Lake, Dewey County, S.Dak. USGS 27485, USNM 132650.

22. Back view of the holotype (× 1½) from the Fox Hills Sandstone, Moreau River, South Dakota. USNM 258.

23. Back view of a specimen (× 1) from the Pierre Shale (*Baculites baculus* zone), Red Bird section, Wyoming. USGS D–1985, USNM 132647.

24. Front view of a paratype (× 1) from the Fox Hills Sandstone figured by Meek (1876, pl. 32, fig. 1e). USNM 132973.

29. Front view of a specimen (× 1) from the Fox Hills Sandstone, Trail City Member, Grand River, 0.4 mile west of Bullhead, Corson County, S.Dak. USGS 27484, USNM 132648.

30. Back view of a specimen (× 1) from the Fox Hills Sandstone, Trail City Member, White Horse Ridge, NW¼ sec. 20, T. 16 N., R. 26 E., Dewey County, S.Dak. USGS 27491, USNM 132649.

31. Back view of a specimen (× 1) from the same locality. USGS 27491, USNM 132651.

25–28, 32. *Graphidula* cf. *G. alleni* (White) (p. B32).

25. View of a rubber mold of a specimen (× 2) from the Pierre Shale (*Didymoceras stevensoni* zone), Red Bird section, Wyoming. USGS D–1939, USNM 132707.

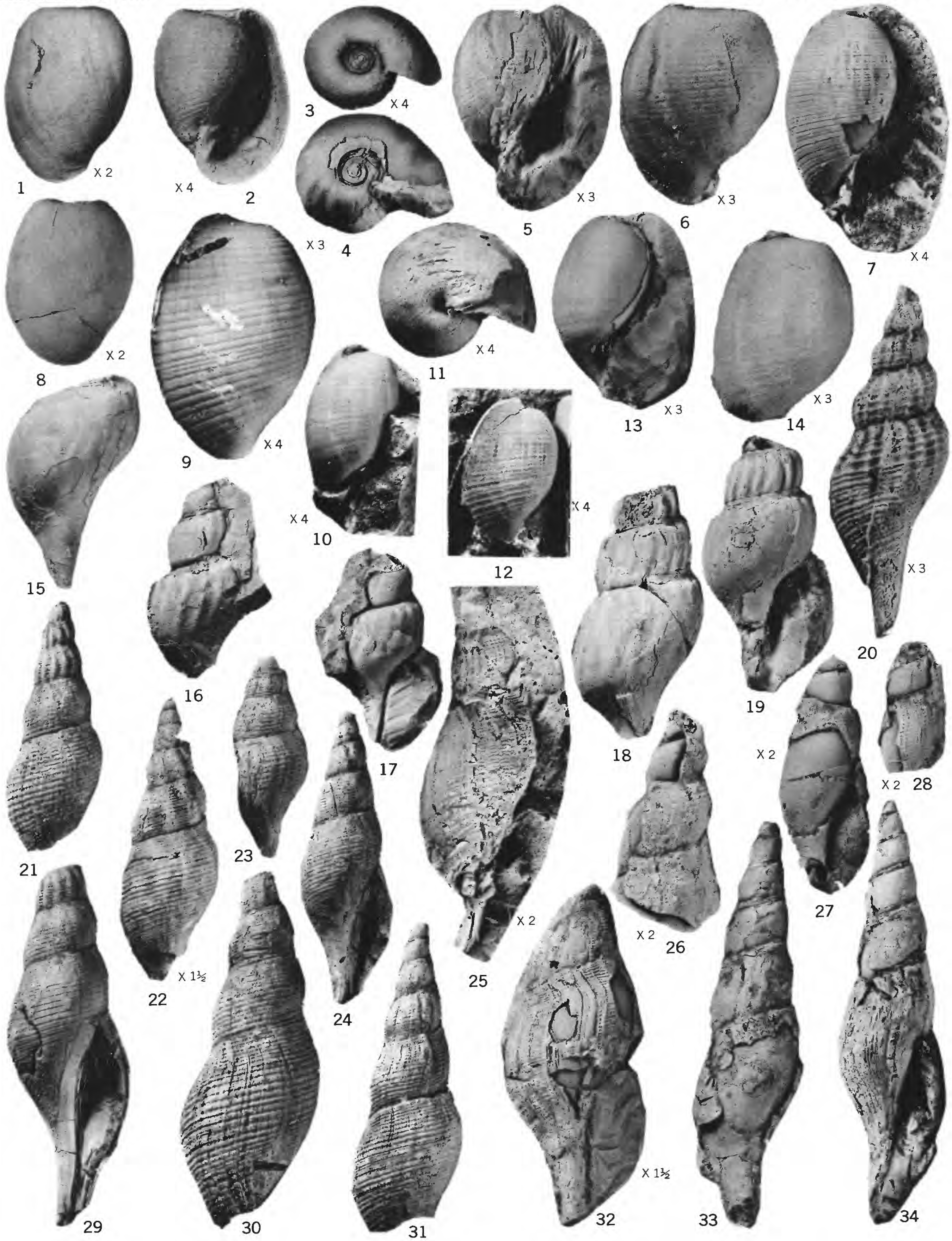
26. View of an incomplete specimen (× 2) from the same locality. USGS D–1940, USNM 132674.

27. Apertural view of a specimen (× 2) from the same locality. (Internal mold belonging to specimen from which mold in fig. 25 was made.) USGS D–1940, USNM 132707.

28. View of a fragmentary specimen (× 2) from the same locality. USGS D–1940, USNM 132673.

32. Apertural view of an incomplete specimen (× 1½) from the Pierre Shale (*Didymoceras nebrascense* zone), 2 miles north of Kassler, Jefferson County, Colo. USGS D–284, USNM 132974.

33, 34. *Graphidula alleni* (White) (p. B32). Back and front views of the holotype (× 1) from "Cretaceous strata, valley of the Yellowstone River, Montana" (White, 1880, p. 35). USNM 8046.



BULLOPSIS, ELLIPSOSCAPHA, CRYPTORHYTIS, ANOMALOFUSUS?, AND *GRAPHIDULA*

PLATE 8

FIGURES 1, 2. *Nonacteonina attenuata* (Meek and Hayden)? (p. B33).

1. Back view of an incomplete internal mold (× 3) from the Pierre Shale (*Didymoceras stevensoni* zone), the Red Bird section, Wyoming. USGS D–1940, USNM 132676.
2. Back view of the incomplete holotype (× 3) from the Pierre Shale (*Baculites baculus* zone) near Glendive, Mont. USNM 285.

3–6. *Oligoptycha concinna* (Hall and Meek) (p. B34).

3. Apertural view of the holotype (× 6) from the Pierre Shale (*Baculites compressus* zone?) on Sage Creek, South Dakota. AMNH 7471/1.

4, 5. Apertural and back views of a specimen (× 6) figured by Popenoe (1957, pl. 50, fig. 3) from the Fox Hills Sandstone near Wakpala, South Dakota. USGS 5954, USNM 129866.

6. Back view of a specimen (× 6) from the Pierre Shale (*Baculites baculus* zone), Red Bird section, Wyoming USGS D–1978, USNM 132662.

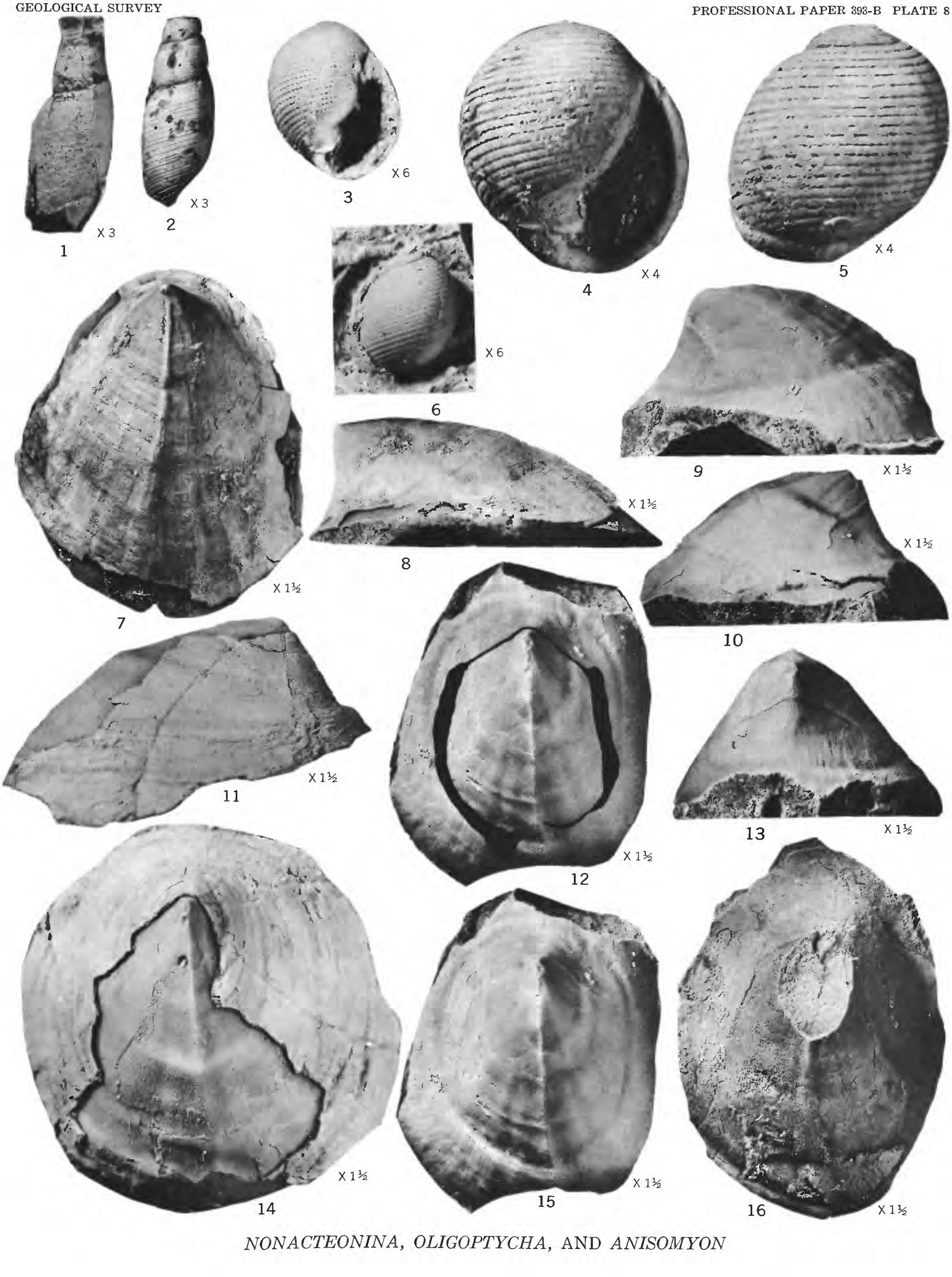
7–16. *Anisomyon borealis* (Morton) (p. B37).

7, 8. Apical and left views of a specimen (× 1½) from the Pierre Shale at the Great Bend of the Missouri River, South Dakota. A syntype of *Helcion carinatus* Meek and Hayden. USNM 132977.

9, 10, 12, 13, 15. Left side, right side, apical, and front views of a specimen (× 1½) from the Pierre Shale about 2 miles northeast of Harper Station, Wyo. Note muscle-scar pattern. USGS 1723, USNM 28586.

11, 14. Right side and apical views of a specimen (× 1½) from the Pierre Shale on divide between Skull and Beaver Creeks, 8 miles northwest of Newcastle, Wyo. USGS 11191, USNM 132706.

16. Apical view of a specimen (× 1½) from the Pierre Shale (*Baculites gregoryensis* zone), Red Bird section, Wyoming. USGS D–1910, USNM 132655.



NONACTEONINA, OLIGOPTYCHA, AND *ANISOMYON*

PLATE 9

FIGURES 1, 2. *Anisomyon centrale* Meek (p. B38). Apical and right-side views of the specimen (× 1½) mentioned by White (1879, p. 303), as from the Pierre Shale on "Box Elder Creek, Colorado." USNM 132659.

3–11. *Anisomyon borealis* (Morton) (p. B37).

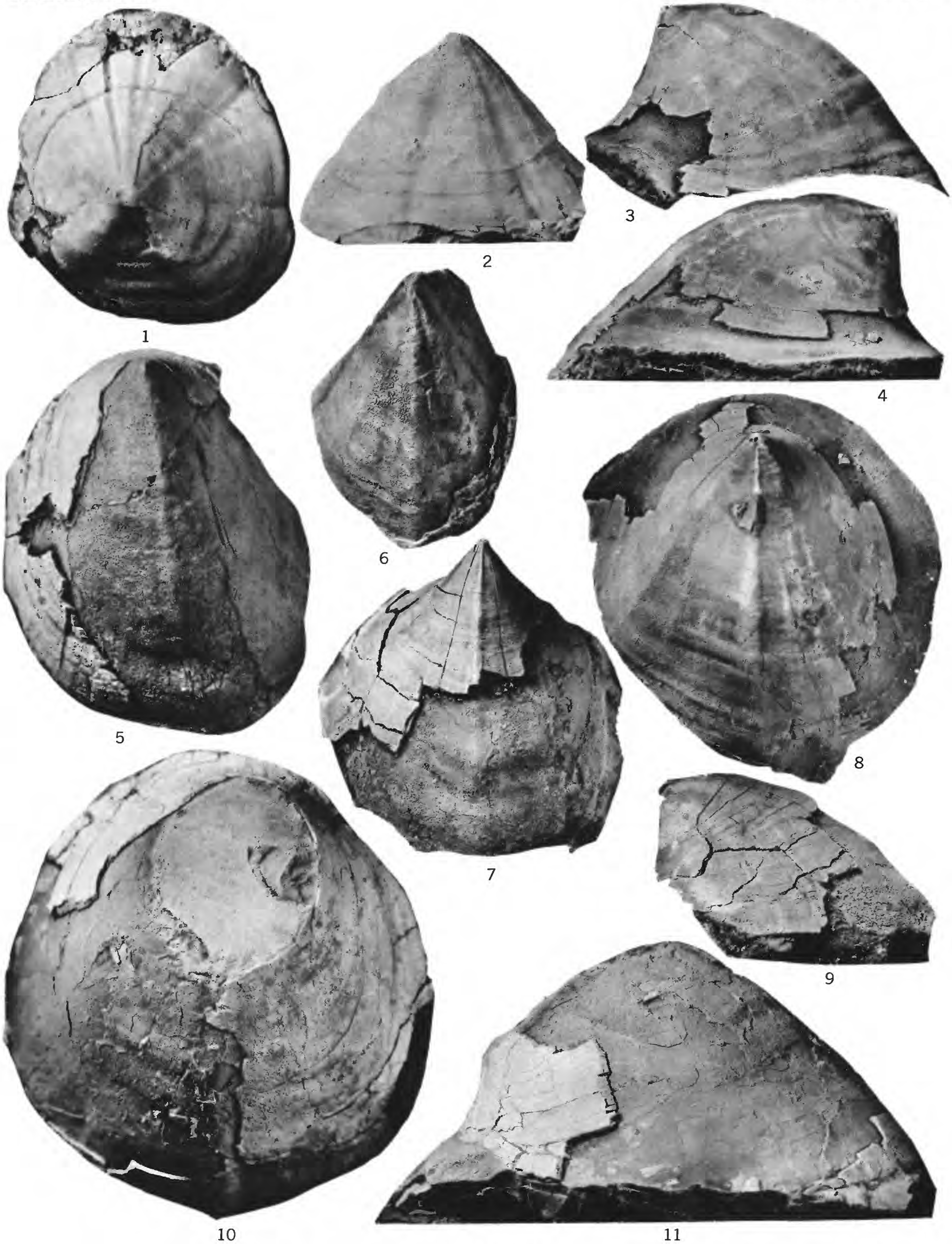
3, 4, 8. Left side, right side, and apical views of a syntype (× 1½) of *Helcion carinatus*, figured by Meek (1876, pl. 18, figs. 9a–c), Pierre Shale (*Baculites gregoryensis* zone?), Great Bend of the Missouri River, South Dakota. USNM 132976.

5. Apical view of a specimen (× 1½) from the Pierre Shale, 1 mile northwest of Spencer Siding on divide between headwaters of Blacktail Creek and Stockade Beaver Creek, Wyoming. USGS 13876, USNM 132657.

6. Apical view of a specimen (× 1½) from the Pierre Shale (*Exiteloceras jenneyi* zone), Red Bird section, Wyoming. USGS D–1948, USNM 132656.

7, 9. Apical and left side views of a syntype (× 1½) of *Helcion carinatus* from the Pierre Shale (*Baculites gregoryensis* or *B. scotti* zones), Great Bend of the Missouri, South Dakota. USNM 132978.

10, 11. Apical and left side views (× 1½) from the Pierre Shale (*Exiteloceras jenneyi* zone), Red Bird section, Wyoming. USGS D–1947, USNM 132658.



ANISOMYON

PLATE 10

FIGURES 1–15. *Anisomyon centrale* Meek (p. B38).

1–3. Apical, anterior, and left side views of the lectotype (× 1½) figured by White (1879, pl. 9, figs. 1a, b) from the Pierre Shale, Box Elder Creek, Colorado. USNM 12430.

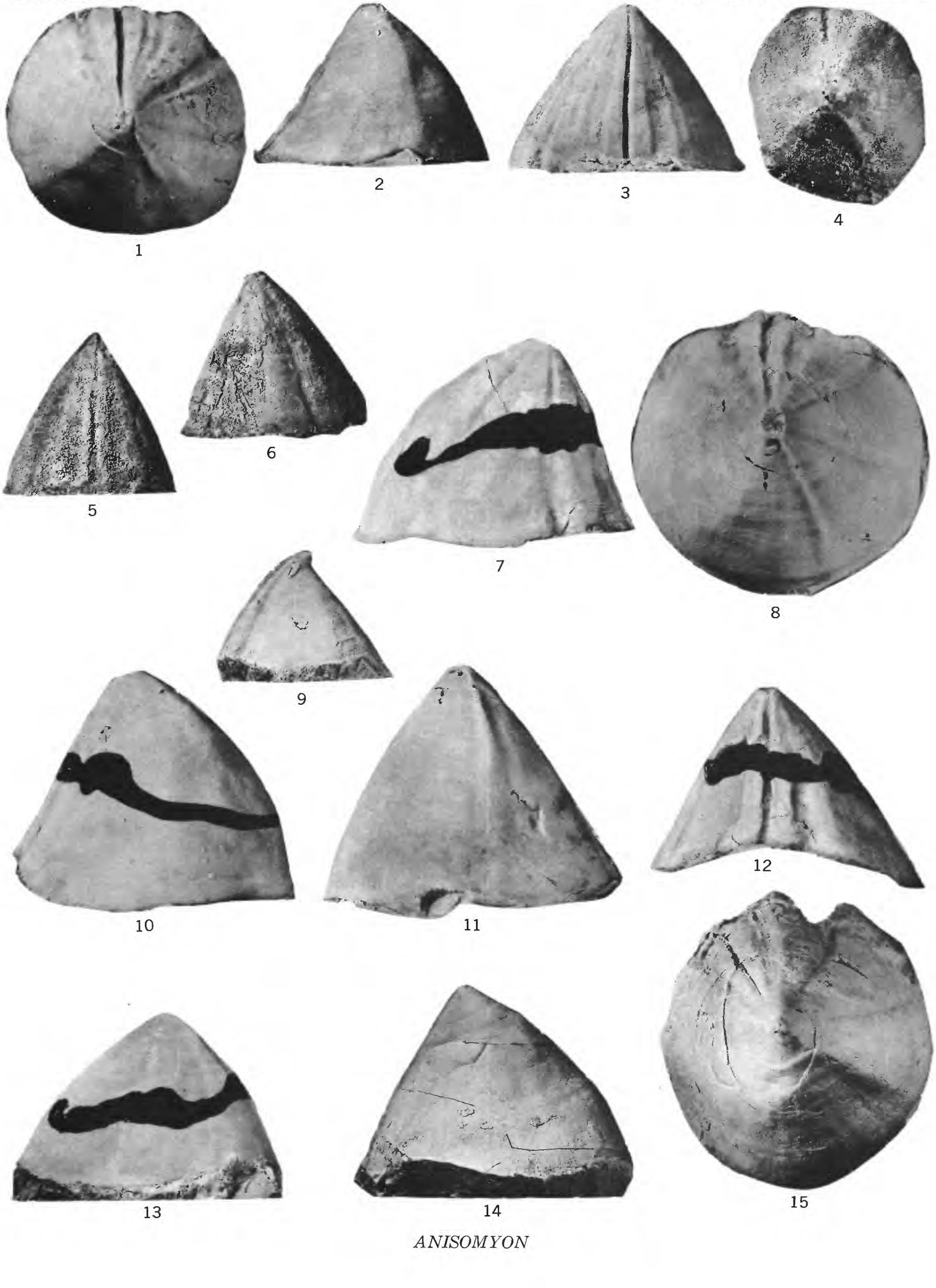
4, 5, 6. Apical and anterior views of a syntype (× 1½) figured by White (1879, pl. 9, figs. c, d) from the Pierre Shale, Box Elder Creek, Colorado. USNM 132979.

7, 8, 10–12. Right side, apical, left side, back, and front views of a specimen (× 1½) from the Pierre Shale (*Baculites jenseni* zone), one-half mile east of Horse Creek, Laramie County, Wyo. USGS D–1382, USNM 132715.

9. Left side view of a specimen (× 1½) from the Pierre Shale (*Baculites reesidei* zone), 0.8–0.2 mile south of Round Butte, Larimer County, Colo. USGS D–372, USNM 132926.

13. Right side view of a specimen (× 1½) from the Pierre Shale (*Baculites reesidei* zone), Round Butte, Larimer County, Colo. USGS 16217, USNM 132716.

14, 15. Left side and apical views of a specimen (× 1½) from the Pierre Shale (*Baculites reesidei* zone), Red Bird section, Wyoming. USGS D–1952, USNM 132660.



ANISOMYON

PLATE 11

FIGURES 1–7, 9. *Anisomyon centrale* Meek (p. B38).

1, 2. Apical and right side views of a specimen (× 1½) from the Pierre Shale (*Baculites reesidei* zone), 0.2–0.8 mile south of Round Butte, Larimer County, Colo. USGS D–372, USNM 132925.

3, 4. Right side and apical views of a specimen (× 1½) from the Pierre Shale (*Baculites reesidei* zone), Round Butte, Larimer County, Colo. USGS 16217, USNM 132713.

5, 6, 7. Apical, left, and right side views of a specimen (× 1½) from the Larimer Sandstone Member of the Pierre Shale (*Baculites reesidei* zone), NE¼NW¼, sec. 1, T. 8 N., R. 69 W., Larimer County, Colo. USGS D–2819, USNM 132710.

8, 10–17. *Anisomyon patelliformis* Meek and Hayden (p. B40).

8. Apical view of a specimen (× 1½) figured by Whitfield (1880, pl. 12, figs. 17, 18) from the Pierre Shale (probably the *Baculites baculus* zone) on Old Woman Fork, Wyoming. Note muscle-scar crossing behind apex. USNM 12268.

10, 11. Right-side and apical views of a paratype (× 1½) from the Pierre Shale (*Baculites baculus* zone) near Glendive, Mont. USNM 132981.

12, 13, 16. Left side, right side, and apical views of a paratype (× 1½) showing well-developed muscle scars. Locality same as above. USNM 132980.

14, 17. Left side and apical views of a specimen (× 1½) from the Pierre Shale (*Baculites baculus* zone), Red Bird section, Wyoming. USGS D–2116, USNM 132982.

15. Apical view of the holotype (× 1½) from the Pierre Shale (*Baculites baculus* zone) near Glendive, Mont. USNM 246.

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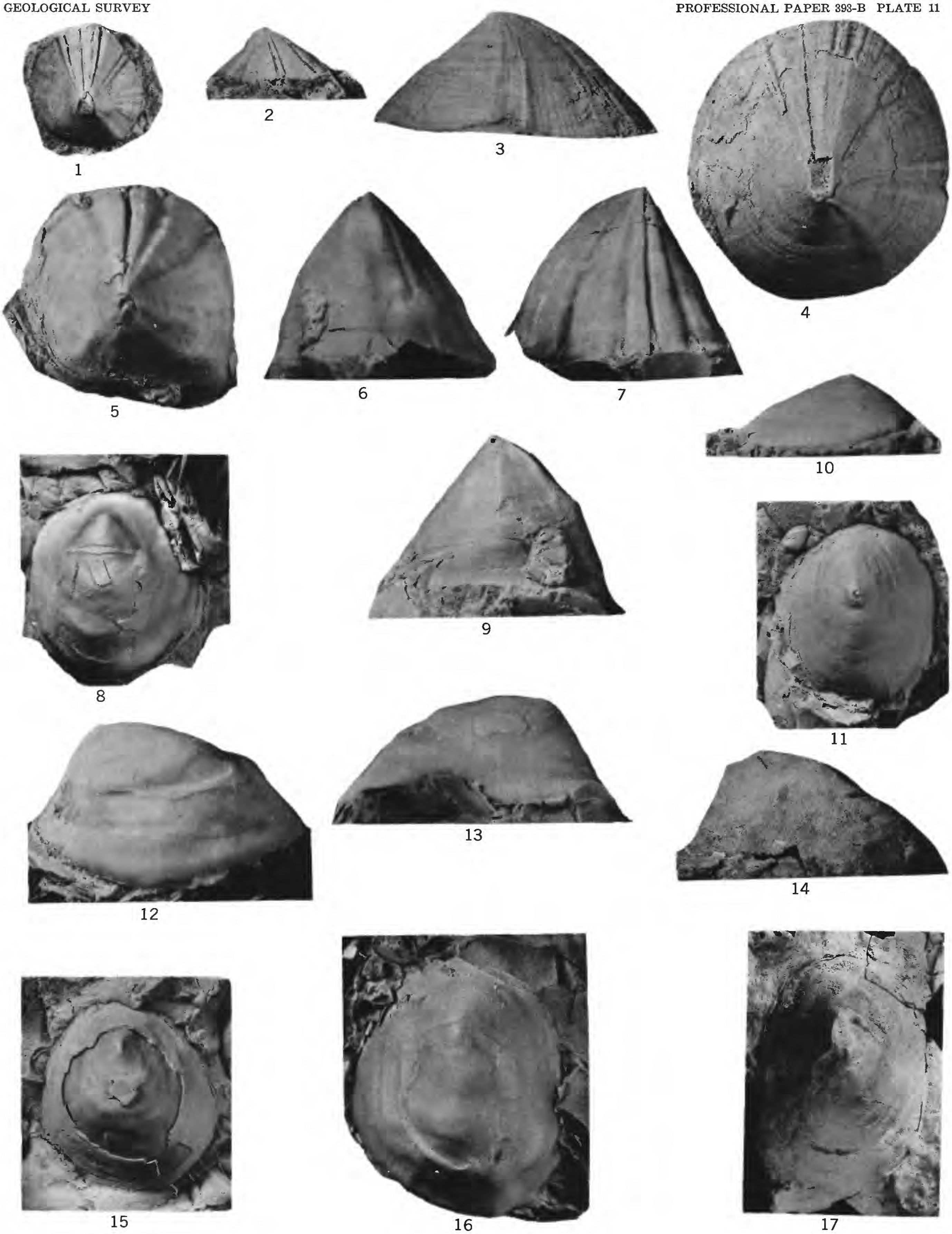

ANISOMYON