Late Mississippian Gastropods of the Chainman Shale, West-Central Utah

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By MACKENZIE GORDON, JR., *and* ELLIS L. YOCHELSON

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Descriptions, geographic and stratigraphic distribution, and illustrations of 79 species of gastropods in eight assemblages, which are equated with established ammonoid and foraminiferal zones

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CONTENTS

ILLUSTRATIONS

[Plates follow index]

TABLES

LATE MISSISSIPPIAN GASTROPODS OF THE CHAINMAN SHALE, WEST-CENTRAL UTAH

By MACKENZIE GORDON, Jr., and ELLIS L. YOCHELSON

ABSTRACT

The Chainman Shale of Mississippian (Osagean to late Chesterian) age, well exposed in the Confusion Range of western Utah, has yielded a profusion of fossils during investigations conducted by the U.S. Geological Survey in the past 30 years. Conspicuous among these fossils are gastropods, which range in age from latest Meramecian to late Chesterian. In west-central Utah, not far from the State boundary, the Chainman outcrop belt stretches from Granite Mountain south to the northern part of the Needle Range, a distance of 69 miles (110 km). The Chainman thickens from north to south; the section at Granite Mountain is 1,315 feet (401 m) thick and that at Jensen Wash in the Burbank Hills, 2,203 feet (671 m).

The rocks of the Chainman Shale record a general though irregular shallowing of the area from moderate depths of 330 feet (100 m) or so to quite shallow depths of perhaps locally little more than 3–6 feet (1–2 m). Most of the gastropods occur with ammonoids in a facies of shale or shale containing phosphatic limestone concretions. In this lutaceous facies, *Glabrocingulum* is predominant and *Lunulazona* and *Retispira* are common; these genera are represented by a succession of species. A thick limestone unit is present in some areas in the upper part of the formation, particularly in the vicinity of Skunk Spring, where it is 318 feet (97 m) thick. This limestone unit represents a calcareous shoal facies having an entirely different gastropod fauna, characterized by *Catazona* and species of *Naticopsis*.

The Chainman Shale could be easily zoned by gastropods, but we are not proposing such a zonation. A framework of ammonoid and foraminiferal zones already is available, and we prefer to regard the gastropod assemblages as part of this framework. The assemblages are confined to the major ammonoid and foraminiferal zones, and only three of the gastropod species seem to range across major zonal boundaries. These species are *Bellerophon (Bellerophon) vespertinus* Gordon and Yochelson and *Straparollus (Euomphalus) intermedius* Gordon and Yochelson, both of which are present in Mamet Foraminifer Zones 17 and 18, and *Bellazona polita* n. sp., which locally seems to range from Mamet Foraminifer Zone 16s into the basal part of Zone 17.

Eight assemblages, seven of them in ascending stratigraphic order, are recognized within the gastropod fauna of the Chainman Shale; the eighth assemblage is a facies equivalent of the sixth highest. The seven mud-dwelling assemblages are characterized mainly by species of *Glabrocingulum* and *Lunulazona*, which together account for 80 percent of the gastropod specimens in our Chainman collections. The eighth assemblage, that in the shallow-water carbonate facies, is the one characterized by *Catazona* and species of *Naticopsis*.

The lowermost gastropod assemblage, that of *Lunulazona nodomarginata* (McChesney), includes 10 species and is restricted to the northern end of the study area, where it occurs in the upper part of the *Goniatites americanus* Ammonoid Zone, in beds equivalent to the lower part of Mamet's Foraminifer Zone 16i. We regard the entire *G. americanus* Zone as late Meramecian in age. All the zones higher in the Chainman are Chesterian in age. The second assemblage is that of *Lunulazona costata* Sadlick and Neilsen, which includes six gastropod species; it occurs in the *Goniatites granosus* Ammonoid Zone, equivalent to Mamet's Foraminifer Zone 16s.

Three gastropod assemblages are recognized within the *Paracravenoceras barnettense* Ammonoid Zone, equivalent to Mamet's Foraminifer Zone 17. The earliest, that of *Lunulazona sadlicki*, includes five species; the intermediate, that of *Glabrocingulum hosei* n. sp., four species; and the highest, that of *Glabrocingulum confusionense* n. sp., two species (the second being *G. hosei*).

Two laterally equivalent facies-controlled assemblages are present within the *Cravenoceras hesperium* Ammonoid Zone, most of which is equivalent to Mamet's Foraminifer Zone 18. The *Glabrocingulum quadrigatum* Sadlick and Neilsen assemblage, restricted to shale, includes 21 species. The equivalent assemblage, that of *Catazona rudilirata* Gordon and Yochelson, noted above, occurs in medium-grained gray limestone, associated with brachiopods. *Glabrocingulum* and *Lunulazona* are absent, and several species of *Naticopsis* are present among 18 species of gastropods; only two of these species are known to occur in the equivalent shale assemblage.

Finally, in Mamet's Foraminifer Zone 19, partly in limestone beds containing the ammonoid *Richardsonites merriami* (Youngquist) and in shale containing the productoid brachiopod *Carlinia phillipsi* (Norwood and Pratten), is a faunule totaling 19 species, eight of which are also found in the *Cravenoceras hesperium* Ammonoid Zone. In the basal part of the overlying Ely Limestone (Mississippian, Mamet Foraminifer Zone 19), gastropods are absent. At Granite Mountain, where this part of the sequence has been studied in detail, it consists of 140 feet (42.7 m) of coarse-grained limestone and some interbedded shale and sandstone.

The distribution of Chainman gastropods shows that speciation in many groups was as rapid as that in the ammonoids, perhaps in some groups even more rapid. For this reason, the gastropods are very useful at the species level as guide fossils. However, the susceptibility of gastropods to facies changes is greater than that of the ammonoids. Hence, gastropods must be used with caution, particularly where long-distance correlation is attempted.

Because of the large number of taxa present in the Chainman Shale, our investigation has provided the opportunity to reexamine some of the older studies of Mississippian gastropods in the United States and to reassess the generic assignment of many species. For each genus considered herein, a listing is given of the North American species judged to belong in that taxon. Although the arrange-

ment of genera and families is more or less traditional, some suborders have been rearranged in accordance with current views on systematics.

Most of this work is concerned with systematic description and illustration. Thirty-seven genera and subgenera belonging in 17 families occur in the Chainman fauna. Seventy-nine species are recognized in the study area. Of these, 13 have been previously described and 32 are named as new; 5 more are closely comparable with previously described species. The other 29 species are indicated by open nomenclature.

Two new genera are proposed in this paper: *Deseretospira* (type species, *D. monilifera* n. sp.) and *Bellazona* (type species, *Loxonema bella* Walcott, 1882); also one new subgenus: *Sinuitina (Vorticina)* (type species, *Sinuitina anneae* Conkin, 1957). Two new tribes are recognized: Deseretospirides (to include *Deseretospira, Wellergyi,* and *Platyteichum*) and Glabrocingulides (to include *Glabrocingulum* and *Eirlysia*).

New species described in this paper are: *Sinuitina (Sinuitina) crispa, S. (Vorticina) vortex, Euphemites cracens, Bellerophon (Bellerophon) needlensis, B. (B.) welshi, Retispira cincta, R. ordinata, R. jensenensis, R. stenopsis, Trepospira (Angyomphalus) regularis, T. (Trepospira) baconi, T. (T.) diadema, Mourlonia venusta, Ptychomphalina burbankensis, Deseretospira monilifera, Glabrocingulum (Glabrocingulum) granulosum, G. (G.) mephitifontis, G. (G.) confusionense, G. (Glabrocingulum?) hosei, Lunulazona sadlicki, L. utahensis, Euconospira desereti, E. gradilis, Bellazona polita, Straparollus (Euomphalus) nodibasis, Naticopsis (Naticopsis) confusionensis, N. (Naticopsis?) clinovata, Pseudozygopleura (Pseudozygopleura) repenningi, P. (Pseudozygopleura?) lauta, P. (Stephanozyga) claviger, Ianthinopsis gandyensis,* and *Girtyspira circumsecta.* A new name, *Retispira eliasi*, is proposed to replace *Bucanopsis (Retispira?) reticulata* Elias, 1958 [not *Bellerophon reticulatus* M'Coy, 1844], both of which belong in *Retispira*. A lectotype is designated for *Glabrocingulum (Ananias) nevadense* (Walcott), of late Meramecian age, from the Diamond Peak Formation of Nevada, and this species is figured by photographs for the first time.

INTRODUCTION

Monographic studies of western American Carboniferous gastropod faunas are practically nonexistent. In our previous effort to document the gastropods of the Amsden Formation of Wyoming (Gordon and Yochelson, 1975), the preservation of the specimens was such that we had to adopt an open nomenclature for all but three of the species; our study of gastropods from the Diamond Peak Formation of Nevada (Gordon and Yochelson, 1983) was limited to specimens from a single bed. Therefore, to be able to study the association and distribution patterns of a relatively large number of well-preserved gastropods through the thick Chainman Shale succession has been a source of satisfaction. We find that the gastropods are biostratigraphically diagnostic and are facies indicators.

The study area in west-central Utah, in which Mississippian and Pennsylvanian strata crop out in a belt that stretches for more than 66 miles (110 km), has provided a large number of well-preserved fossils of many groups. During the past 30 years, the extensive collections made from this area have, in addition to gastropods, included corals, sponges, bryozoans, brachiopods, pelecypods, cephalopods, pelmatozoans, arthropods, foraminifers, and conodonts. Because deposition was essentially continuous in this region through much of the Late Mississippian and Early and Middle Pennsylvanian, this outcrop belt has proved to be a particularly advantageous laboratory in which to study the sequence of faunas, particularly those extending across the Mississippian-Pennsylvanian boundary.

The gastropods upon which this study is based range in age from late Meramecian to late Chesterian. Eight gastropod assemblages are recognized, of which seven are in ascending sequence, the eighth being a facies equivalent of the sixth highest. These assemblages are equated with the sequence of ammonoid zones described by Gordon (1970, p. 821–822) from the same region. We do not propose a series of gastropod zones; the gastropod species have relatively short stratigraphic ranges similar to those of the ammonoid species and can be tied conveniently to the named ammonoid zones.

ACKNOWLEDGMENTS

The studies upon which this report is based began in support of the field mapping program of the U.S. Geological Survey (USGS) in this area, under the direction of Richard K. Hose. Hose and his associates provided several early collections that gave some inkling of the richness of the Chainman fauna. In 1957, Hose and Charles A. Repenning, USGS, measured selected sections with Gordon and helped obtain additional collections. Walter Sadlick, formerly of the University of Illinois at Chicago, pointed out valuable reference sections in the Burbank Hills and Needle Range. Also, John E. Welsh, formerly of Kennecott Copper Corporation, contributed a large fossil collection from the Burbank Hills. As the work progressed, Keith R. Moore, USGS, assisted in the field for several seasons, and Rudolph W. Kopf, Reed Christner, Richard Rieke, William E. McCaslin, and Charles E. Mason, all USGS, assisted for one season each. Photographs for this report were taken by Robert H. McKinney and Haruo E. Mochizuki, USGS.

Examination of comparative material from collections other than those of the U.S. National Museum (USNM) and the USGS was necessary. Matthew H. Nitecki, Field Museum of Natural History, Chicago, Ill., and Roger L. Batten, American Museum of Natural History, New York City, generously provided, for our examination, specimens that were in their care. P. K. Sutherland, Stovall Museum, University of Oklahoma,

Norman, made available to us some of the material described by Elias from the Redoak Hollow Formation. We also were able to examine types of related species at the British Museum (Natural History) thanks to H. W. Ball, Keeper of Palaeontology, and to Noel Morris. To all those who have helped us in our study of the Chainman gastropod fauna, we are deeply grateful.

PREVIOUS WORK

During the past 100 years, only nine papers have been published describing Late Mississippian gastropods from the Cordilleran geosyncline in the Western United States. In these papers, a total of 18 species from beds of Meramecian age and 23 from beds of Chesterian age were described and named. The number of papers describing Late Mississippian gastropods from the Midcontinent and Appalachian regions is much greater; consequently, the number of species named from these regions is also much larger. One of the more recent and comprehensive of these works is that by Thein and Nitecki (1974) on Chesterian Gastropoda of the Illinois basin. The bibliographic index by Yochelson and Saunders (1967) includes all the late Paleozoic species described in North America through the year 1966.

The following discussion deals with the gastropods from rocks of Late Mississippian (Meramecian and Chesterian) age in each of the Western States.

MERAMECIAN GASTROPODS

IDAHO

The earliest record of Late Mississippian gastropods in the far West is from rocks of late Meramecian age in southeastern Idaho. These gastropods were reported more than 100 years ago by Meek (1873, p. 433), who listed a small fauna of fossil invertebrates collected by F. H. Bradley on the divide between Ross Fork and Lincoln Valley. That Meek's report cited the locality as being in Montana is not surprising, because Idaho did not become a state until 18 years after the collection was made. The Ross Fork-Lincoln Valley divide now lies in the Fort Hall Indian Reservation, Idaho, roughly 100 miles (160k) south of the Idaho-Montana State line. The fossils listed by Meek included small mollusks, among which were the following gastropods: *Bellerophon* (2 spp.), *Euomphalus spergenensis* Hall, *Pleurotomaria* sp., *Holopea* sp., and *Platyceras* spp. Much of this collection is still preserved at the U.S. National Museum, but the gastropods have been removed and could not be found. Meek pointed out that this assemblage bears a remarkable resemblance to that found at Spergen Hill, Ind., which is now included in the Salem Limestone. The USGS uses the earlier name Salem Limestone (Cumings, 1901, p. 233), which has priority over the name Spergen Limestone (Ulrich, 1904, p. 110).

Rocks containing the fauna listed by Meek were assigned by Mansfield (1920, p. 35, 36) to the Brazer Limestone. Later studies by Sando, Dutro, and Gere (1959) showed that this assignment was incorrect, because the type Brazer is an equivalent of the Mission Canyon Limestone of Montana and does not contain beds as young as those containing the supposed Salem fauna. According to Mansfield (1920, p. 36), G. H. Girty unsuccessfully attempted to find Meek's locality and concluded that the locality data were inadequate and that the fossils probably were collected outside the Ross Fork drainage basin and outside the limits of the Fort Hall Reservation. However, Mansfield's geologic map shows two patches of Brazer Limestone in the vicinity of the Ross Fork-Lincoln Valley divide (Sando, 1965, p. E13), and the report of Bradley (1872), who made the collection, is fairly explicit about where it was made.

The corals from Meek's collection were studied by Sando (1965, p. E13), who assigned them to the *Faberophyllum* Zone, which occupies the lower half of the Monroe Canyon Limestone of the Chesterfield Range Group. The *Faberophyllum* Zone is widespread in the Cordilleran geosyncline and is late Meramecian (Late Mississippian) in age.

G. H. Girty (*in* Mansfield, 1927, p. 66–71, 426–432, pl. 25) described several gastropods from a similar Salem-like fauna in southeastern Idaho; he considered this fauna equivalent to that listed by Meek. Girty's fossils came from several localities in the Henry, Montpelier, and Slug Creek quadrangles, Idaho. His species, most of which were reassigned to other genera by Thein and Nitecki (1974), include the following:

Straparollus (Euomphalus) tricarinatus (Girty)
Rhineoderma pealeanum (Girty)
R. dinglense (Girty)
Gosseletina aspeniana (Girty)
Dictyotomaria brazeriana (Girty)
Wellergyi brazerianus (Girty)
Platyceras (Orthonychia) striatulum (Girty, including var. *gracile* (Girty)
Bulimorpha elegans Girty

Associated with these gastropods are other species not described by Girty, which we have determined as belonging in the following genera and subgenera: *Sinuitina*?, *Euphemites, Bellerophon (Bellerophon), Retispira, Straparollus (Straparollus), Trepospira (Angyomphalus)?, Baylea?, Spiroscala, Portlockiella?, Euconospira, Glabrocingulum (Glabrocingulum)?,*

Borestus, Amaurotoma, Yunnania, Platyceras (Platyceras), Anematina, Anomphalus, Naticopsis (Naticopsis), Murchisonia, Stegocoelia, Palaeostylus (Pseudozygopleura), Ianthinopsis, Girtyspira, Meekospira, and *Donaldina*, as well as several additional species that probably belong in new genera. Although most of the gastropod species resemble those from the Salem Limestone of Indiana, most probably are new taxa.

Girty (*in* Mansfield, 1927, p. 69) stated that the southwestern Idaho fauna was a pre-Chester fauna having Spergen affinities, and he tentatively correlated it with the fauna of the Salem Limestone. Additional faunal evidence from Girty's collections, however, suggests a post-Salem age. The abundance and diversity of gastropods in this fauna and the general similarity at the generic level between the Idaho and Indiana assemblages probably led Girty to correlate this fauna with the Salem fauna. Several other Mississippian gastropod assemblages from oolitic limestone are now known that contain an abundance of small mollusks and brachiopods, but only the assemblage of the Salem Limestone had been described in Girty's time.

The greatest diversity and number of invertebrate species was recognized in USGS collection 3023-PC from 6 3/4 miles (10.8 km) northwest of Henry, Caribou County, Idaho. Girty (*in* Mansfield, 1927, p. 69, 70) listed approximately 150 species of fossils that he had identified in this collection. Perhaps the most diagnostic forms are those that he listed as *Mesoblastus* n. sp. and *Productus brazerianus* n. sp.?, which indicate a probable late Meramecian to early Chesterian age. The presence of many forms that resemble Meramecian species and the general absence of several typical Chesterian genera, such as the productid *Diaphragmus*, suggest a Meramecian age for this fauna.

The collection containing the second largest number of invertebrate species is USGS collection 7607A–PC, from the NW 1/4 SW 1/4 sec. 13, T. 10 S., R. 43 E., Bear Lake County, Idaho. Here the coral *Faberophyllum* was found in loose blocks. Many of the gastropod species are the same as those in USGS collection 3202–PC. The conclusion, therefore, seems reasonable that this Salem-like fauna in southeastern Idaho occupies a single biostratigraphic zone within the *Faberophyllum* coral zone and is late Meramecian in age. As noted, this zone is now placed within the Monroe Canyon Limestone.

Although the Monroe Canyon Limestone gastropod fauna may contain more than 50 species and is only slightly older than the oldest gastropod assemblage in the Chainman Shale of Utah, not a single species is common to the two faunas.

NEVADA

Several late Meramecian gastropods were described and illustrated by Walcott (1884, p. 256–260) from the Diamond Peak Formation in the Eureka district of Nevada. Most of them came from the vicinity of a small conical hill in Windfall Canyon, about 3 miles (4.8 km) southeast of Eureka. We have examined Walcott's specimens and reassigned many of them as follows:

USGS colln. 651. Sandy to pebbly limestone in canyon on south side of conical hill. Collectors, C. D. Walcott and C. H. Haskell, 1882.
- *Glabrocingulum (Ananias) nevadense* (Walcott)
- *Platyceras (Platyceras) piso* Walcott
- *P. (Orthonychia?) occidens* Walcott
- *Naticopsis (Naticopsis) inornata* (Walcott)
- *Bellazona bella* (Walcott)
- *Soleniscus?* sp.

USGS colln. 652. Western slope of Richmond Mountain. Collector, C. D. Walcott, 1880.
- *Metoptoma peroccidens* Walcott

USGS colln. 655. Calcareous sandstone and conglomerate on east side of conical hill, west foot of Spring Mountain. Collector, C. D. Walcott, 1880.
- *Retispira textilis* (Hall)
- *Straparollus (Euomphalus) subrugosus* Meek and Worthen
- *Lunulazona nodomarginata* (McChesney)

USGS colln. 657. In canyon north of Pinto Peak. Collectors, C. H. Haskell and C. D. Walcott, 1882.
- *Bellerophon (Bellerophon) majusculus* Walcott

We found two of these species, *Lunulazona nodomarginata* and *Bellazona bella* in the lower part of the Chainman Shale at Granite Mountain, Utah.

ARIZONA

Nothing has been written specifically on the occurrence of Late Mississippian gastropods in Arizona. Yochelson (1962, 1969) published on the gastropods from the Redwall Limestone, a formation that ranges in age from Early Mississippian (Kinderhookian) to Late Mississippian (Meramecian). The best preserved specimens were collected on top of the Jerome Hill section, from residual chert derived from the Mooney Falls Member and Horseshoe Mesa Members of the Redwall. The upper part of the Mooney Falls and all of the Horseshoe Mesa Member are Meramecian in age. The faunal chart of Redwall gastropods (Yochelson, 1969, p. 440, table 26), however, indicates that most of the specimens are from the Mooney Falls Member. Most of the named species described by Yochelson (1962) are typical Early Mississippian (Osagean) forms; those spe-

cies that may have come from beds of Late Mississippian age cannot be distinguished.

CHESTERIAN GASTROPODS

UTAH

Sadlick and Nielsen (1963) described and figured some Late Mississippian pleutrotomariacean gastropods of the Chainman Shale from several localities in west-central Utah. *Lunulazona costata* Sadlick and Nielsen was described from the lower part of the formation on the basis of specimens collected in the foothills east of Granite Mountain, Juab County. *Lunulazona* sp. A [= *L. sadlicki* n. sp.] came from beds of Chesterian age that they identified as Chainman Shale, 0.3 miles (0.5 km) northeast of Leppy Peak, Elko County, Nev., near Wendover, Utah. *Mourlonia* sp. [= *Ptychomphalina* sp. of this report] is from that locality.

Glabrocingulum binodosum Sadlick and Nielsen was based upon specimens collected near the top of the Chainman in the Foote Range, Millard County, Utah, and *G. quadrigatum* Sadlick and Nielsen, also from the upper part of the Chainman, was described from specimens collected on the northern slope of the Burbank Hills, Millard County. Sadlick and Nielsen included in *G. quadrigatum* specimens from the northern part of the Confusion Range, which we herein place in another species (*Glabrocingulum (Glabrocingulum) confusionense* n. sp.). They also described but did not figure *Glabrocingulum*. n. sp. aff. *G. inflatum* (Elias) (probably = *G. (Ananias) seminudum* Gordon and Yochelson), from near the top of the formation on the southern slope of the Burbank Hills. Finally, Sadlick and Nielsen cited the occurrence of *Worthenia tenuilineata* Girty in the upper part of the Chainman. We herein assign this species to the subgenus *W. (Yochelsonospira)*. Sadlick and Nielsen's paper covers approximately 10 percent of the gastropod fauna of the Chainman Shale described in this report.

NEVADA

The first late Chesterian gastropod was described from Nevada only relatively recently. Mount (1973) described and illustrated *Straparollus (Euomphalus) pancakensis* from the *Adetognathus unicornis* Conodont Zone in the Pancake Range in northern Nye County. The gastropod was found 20 feet (6 m) above the base of the Ely Limestone.

Gordon and Yochelson (1983) described a large faunule of gastropods from a single bed, about 1.7 ft (0.5 m) thick, in the upper part of the Diamond Peak Formation at the northern end of the White Pine Range in White Pine County. This assemblage is associated with *Cravenoceras hesperium*, the name-bearer of the ammonoid zone of that name. This zone is Late Mississippian (late Chesterian) in age, though not latest Mississippian. More than half the species also occur in the Chainman Shale in west-central Utah; those that do are marked with an asterisk (*):

**Euphemites nevadensis* Gordon and Yochelson
**Bellerophon (Bellerophon) vespertinus* Gordon and Yochelson
**Retispira nolani* Gordon and Yochelson
**R. albapinensis* Gordon and Yochelson
**Straparollus (Euomphalus) intermedius* Gordon and Yochelson
S. (E.) aff. *S. (E.) pancakensis* Mount
**S. (E.)* n. sp. [= *S. (E.) nodibasis* n. sp.]
**Trepospira (Trepospira)* sp. [= *T. (T.) diadema* n. sp.]
**Glabrocingulum (Ananias) seminudum* Gordon and Yochelson
**G. (Glabrocingulum) quadrigatum* Sadlick and Nielsen
**Neilsonia* cf. *N. welleri* Thein and Nitecki
Hammatospira bellula Gordon and Yochelson
**Worthenia (Yochelsonospira) tenuilineata* Girty
**Catazona rudilirata* Gordon and Yochelson
Compsonema fragile Gordon and Yochelson
Platyceras (Orthonychia) sp.
**Strophostylus nevadensis* Gordon and Yochelson
S.? tantillus Gordon and Yochelson
Microdoma sp.
Naticopsis (Naticopsis) glomerosa Gordon and Yochelson
**N. (N.?)* n. sp. [= *N. (N.?) clinovata* n. sp.]
Turbonitella aff. *T. biserialis* (Phillips)
Platyzona sp.
Aclisina sp.
**Meekospira* sp.
Donaldina sp.

WYOMING

Late Chesterian gastropods were described from the Amsden Formation by Branson (1937) and by Gordon and Yochelson (1975), along with Pennsylvanian forms from the same formation. The poor preservation of this material made it very difficult to determine species, and an open nomenclature was generally used. The gastropods included one form, identified as *Bellerophon*? sp. indet., from the Moffat Trail Limestone Member in Teton County and several from the Horseshoe Shale Member in Teton and Fremont Counties. The genera and subgenera recognized in the Horseshoe include: *Euphemites, Bellerophon*

(Bellerophon), Retispira, Straparollus (Euomphalus), n. gen. aff. *Colpites, Dictyotomaria, Gosseletina?, Worthenia?, Strophostylus, Naticopsis (Naticopsis), N. (Jedria?), Palaeostylus (Pseudozygopleura) Ianthinopsis, Girtyspira,* and *Donaldina*. Three species have been described and named from this fauna:

Euphemites sacajawensis C. Branson
Straparollus (Euomphalus) xylacus Gordon and Yochelson

Dictyotomaria carlbransoni Gordon and Yochelson
One of the Wyoming forms, *E. sacajawensis*, occurs in the Chainman Shale of Utah.

MONTANA

Easton (1962, p. 98–101, pl. 13) described and figured several gastropods from rocks that he included in the Big Snowy Group in south-central Montana. We reexamined Easton's figured and unfigured specimens and offer the following revised identifications of the Late Mississippian (Chesterian) species. His paper gives details of the collecting localities.

From the Otter Formation in the measured section on Belt Creek, Cascade County (USGS colln. 14227–PC): Bellerophontacean, gen. and sp. indet.

From the Heath Formation (USGS colln. 13359–PC) and from overlying beds of Heath age, incorrectly attributed by Easton to the Cameron Creek Formation (now the Cameron Creek Member of the Tyler Formation) (see Sando, Gordon, and Dutro, 1975, p. A–51) in the measured section at Delpine, Meagher County (USGS collns. 13361–PC to 13363–PC):

Bellerophon (Bellerophon) sp.
Retispira? sp. indet.
Straparollus (Euomphalus) intermedius Gordon and Yochelson?
S. (E.) n. sp.
Trepospira (Angyomphalus) excavata (Easton)
Naticopsis (Naticopsis) sp.
Pseudozygopleura (Pseudozygopleura) sp.
P. (Stephanozyga) sp.

From the Heath Formation at localities in Fergus County (USGS collns. 13366–PC to 13368–PC, 13391–PC):

Euphemites sp.
Retispira cf. *R. nolani* Gordon and Yochelson
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Naticopsis (Naticopsis) suturicompta Yochelson and Dutro

From the Heath Formation in the measured section at Stonehouse Canyon, Golden Valley County (USGS collns. 13412–PC, 13414–PC):

Bellerophon (Bellerophon) sp.
Bellerophontacean, gen. and sp. indet.
Trepospira (Angyomphalus) excavata (Easton)
Glabrocingulum (Glabrocingulum) sp. indet.
Soleniscus spp.
Meekospira? sp. indet.

If those forms that are too poor to identify are eliminated, about 14 species constitute this Late Mississippian gastropod fauna. The straparollids and some of the bellerophontaceans are similar to Chainman species, but other elements of the Montana gastropod fauna are distinct.

PRESENT INVESTIGATION

The detailed work of the USGS in west-central Utah started in 1953, when R. K. Hose and his associates began mapping the geology of the Confusion Range. The first USGS collections that included gastropods were made that year. The writers visited the area in 1954 and made additional collections. In 1957, Gordon spent a large part of the spring and fall field seasons working with Hose and C. A. Repenning, measuring sections and collecting fossils, mostly from the Chainman Shale. Mapping and collecting by Hose and others continued at least through 1962. Additional studies in this area were made by Gordon in 1961, 1962, 1969, 1973 (with Yochelson), 1974, 1981, 1982, and 1983.

The early part of the work in this area focused particularly on the ammonoid succession, although fairly general collections of invertebrates were made. Some of the results of the cephalopod studies in this region have been published by Flower and Gordon (1959) and by Gordon (1970, 1971). The 1970 paper by Gordon was the one that proposed the ammonoid zonation for this region.

Geologic maps of parts of the Confusion Range showing outcrops of the Chainman Shale were published by Hose 1965a, b, 1974), by Hose and Repenning (1963, 1964), and by Hose and Ziony (1963). A summary of the structural geology of the range was also prepared by Hose (1977).

In 1973, the writers began the description of the Chainman gastropods. A major digression resulted from our decision to publish descriptions of a well-preserved gastropod faunule from the Diamond Peak Formation in the White Pine Range, Nev., before completing the Utah paper. The reason for this was that better preserved type lots of a few species were available in the Nevada material (see Gordon and Yochelson, 1983). The Utah study was taken up again late in 1981 and completed in 1983. When we started this study, so little was known of the Late Mississippian gastropods in the United States and so many species

had been assigned to the wrong genera that we found it necessary to reexamine many of the previously published species. The result is a paper of greater scope than had been intended originally.

Publication by Thein and Nitecki (1974) of a report on Chesterian gastropods from the Illinois basin gave a considerable boost to knowledge of the Chesterian fauna of the southern Midcontinent region. Along with the genera they described, they assigned and listed many of the previously described species. In their paper, Thein and Nitecki described and figured 75 species of Chesterian gastropods. If the 79 species described herein from the Late Mississippian of Utah, most of which are of Chesterian age and nearly all of which are different species than those occurring in Illinois, are added, one can begin to get an inkling of the diversity and complexity of the gastropod faunas in the United States during the latter part of the Mississippian Period.

TYPE AND TYPE LOT

As required by the International Code of Zoological Nomenclature, a holotype has been designated for each new species. Use of the term "paratype" varies considerably, some authorities holding this term to mean all specimens seen by the original author, apart from the holotype. However, a large number of specimens of some of the new species have been collected from many localities. Many of the specimens of the other new species are incomplete or worn and add nothing to the concept of the species. In general, we have restricted the term "paratype" to additional specimens from the locality that yielded the holotype. Commonly, more than one collection number is involved, because many of the better localities were collected several times. Occasionally, a figured paratype is from another locality, and additional specimens from that collection are designated as paratypes.

The term "hypotype" has no standing under the Code and is used in a variety of ways by authors. In our view, many specimens extend the known geographic or stratigraphic range of a previously described species but do not modify the interpretation of the taxonomic concept. To us, these are not hypotypes. Rarely, additional specimens do modify the concept presented by the original author; for such figured specimens, we use the term "hypotype."

DATA ON OCCURRENCE

Gastropods were obtained from 106 collections along the outcrop belt of the Chainman Shale. Each time a locality was visited, another collection number was assigned to the material. Thus, some localities have several collection numbers. Some collection numbers listed under "Occurrence" in the descriptive section are preceded by a question mark. This mark indicates that the material is poorly preserved and that assignment to the particular taxon is in question; it does not question geographic position of the collection. Details of geologic and geographic occurrence are given in the "Register of Localities."

The occurrences of the various gastropod faunules are summarized in the following section. All known occurrences of the taxon in the region are listed again in the systematic section. Most of the collections contain one or more fossil groups in addition to the gastropods. We have not indicated this information except in the most cursory way. In addition, about 160 additional collections made in the area during the past 30 years do not contain gastropods.

COMPOSITION OF THE FAUNA

Our study of the Chainman gastropods is based upon 106 collections made in the study area during the 30 years from 1953 to 1982. The gastropods occur in approximately 40 percent of the collections of invertebrate fossils made in this area. The 106 collections yielded 3,166 specimens of gastropods, which belong to 79 species referrable to 37 genera and subgenera.

The gastropod fauna of the Chainman Shale is dominated overwhelmingly by the pleurotomariaceans, which constitute 88.6 percent of the Chainman Shale specimens under study. Two genera predominate—*Glabrocingulum*, represented by nine species, and *Lunulazona*, by five species. The other superfamilies that compose this fauna are, in decreasing order of abundance, the bellerophontaceans (4.7 percent), murchisoniaceans (1.4 percent), neritaceans (1.3 percent), euomphalaceans (1.3 percent), subulitaceans (1.1 percent), loxonemataceans (0.5 percent), platyceratacean (0.4 percent), opisthobranchs (0.3 percent), and microdomataceans (0.1 percent).

Table 1 shows the distribution of genera (and subgenera) by number of specimens and percentage of the total of the more than 3,000 specimens collected for this study.

Three genera provide a continuum of species that are useful in dividing the Chainman Shale biostratigraphically. These genera are *Retispira*, represented by six species, *Glabrocingulum*, by nine species, and *Lunulazona*, by five species. The distribution of these species is discussed and shown in graphic form in the section on gastropod assemblages and their relationship to ammonoid and foraminiferal zones.

In the systematic section, the 79 species of gastropods collected in the Chainman Shale in the study area are

TABLE 1.—*Taxonomic relationships and relative abundance of gastropods in the Chainman Shale*

Family	Genus (and subgenus)	No. of specimens	Percentage
Sinuitidae	*Sinuitina (Sinuitina)*	2	0.06
	S. (Vorticina)	2	.06
	Euphemites	33	1.04
Bellerophontidae	*Bellerophon (Bellerophon)*	41	1.3
	Retispira	72	2.27
Sinuopeidae	*Rhineoderma*	1	.03
Raphistomatidae	*Trepospira (Angyomphalus)*	14	.44
	T. (Trepospira)	90	2.84
	Baylea	1	.03
Eotomariidae	*Mourlonia*	12	.38
	Ptychomphalus	14	.44
	Deseretospira	4	.13
	Glabrocingulum (Glabrocingulum)	1,810	57.19
	G. (Ananias)	42	1.33
	Neilsonia	5	.16
	Lunulazona	710	22.43
	Euconospira	10	.32
Lophospiridae	*Worthenia (Yochelsonospira)*	77	2.43
Phymatopleuridae	*Catazona*	12	.38
	Dictyotomaria	2	.06
Murchisoniidae	*Stegocoelia (Stegocoelia)*	6	.19
	Bellazona	35	1.11
Euomphalidae	*Straparollus (Euomphalus)*	42	1.33
Holopeidae	*Cinclidonema*	1	.03
Platyceratidae	*Platyceras (Platyceras)*	3	.09
	Strophostylus	10	.32
Elasmonematidae	*Anematina*	4	.13
Naticopsidae	*Naticopsis (Naticopsis)*	41	1.3
	N. (Jedria)	1	.03
Loxonematidae	*Loxonema*	6	.19
Pseudozygopleuridae	*Pseudozygopleura (Pseudozygopleura)*	7	.22
	P. (Stephanozyga)	3	.09
Subulitidae	*Bulimorpha*	2	.06
	Ianthinopsis	14	.44
	Soleniscus	10	.32
Meekospiridae	*Meekospira*	10	.32
	Girtyspira	8	.25
Family unknown	High-spired gastropods	9	.28
	Totals	3,166	100.02

described and figured. The number of specimens at each locality is recorded for all these species. One additional species, *Ptychomphalina* sp., known only by one specimen from the vicinity of Wendover, Nev., and described by Sadlick and Nielsen (1963) as part of the Chainman fauna, is redescribed, refigured, and reassessed herein.

DISTRIBUTION OF GASTROPODS IN THE STUDY AREA

The area under study includes the belt of Chainman Shale outcrops from Granite Mountain (T. 14 S., R. 16 W.) southwestward to the northern part of the Needle Range (north half of T. 25 S., R. 19 W.), an airline distance of approximately 70 miles (112 km). The study area is shown on the accompanying map (fig. 1). In the discussion that follows, we consider the various collecting localities and measured sections were measured through the Chainman Shale: Granite Mountain (eastern side); Skunk Spring in the Confusion Range; and Jensen Wash in the Burbank Hills. Fairly thick partial sections were measured northeast of Foote Ranch (eastern side of the Foote Range) and at Browns Wash-Wallet Gulch in the Confusion Range. Many of the gastropod collections are from or related to these measured sections.

GRANITE MOUNTAIN SECTION

The northernmost section studied is at Granite Mountain, at the northern end of the Confusion Range, in Juab County, Utah. A section measured here by Gordon and C. A. Repenning in 1957 shows a thickness of 1,315 feet (401 m) for the Chainman Shale. The section is on the eastern slope of Granite Mountain, in the N 1/2 sec. 18 (unsurveyed), T. 14 S., R. 16 W., as indicated in figure 2.

The lowest gastropod in the Granite Mountain section is a crushed pleurotomariacean (USGS colln. 28637–PC), identified as *Rhineoderma* sp., in float from a 3-ft (0.9-m) interval immediately below the base of the marker bed (Skunk Spring Limestone Member of Sadlick, 1966), 92 to 95 feet (28 to 29 m) above the base of the Chainman Shale.

A larger gastropod faunule in the Chainman Shale was found in a 5-foot (1.5-m) concretionary zone immediately overlying the 22-foot (6.7-m) marker bed, a massive grayish-black siliceous spiculitic limestone. The top of the marker bed is 111 feet (33.8 m) above the base of the formation. Occurring with ammonoids in the upper part of the *Goniatites americanus* Zone were the following gastropods (USGS colln. 17018–PC):

Sinuitina (Vorticina) vortex n. sp.
Euphemites sp. B
Retispira cf. *R. textilis* (Hall)
Trepospira (Angyomphalus) regularis n. sp.
Mourlonia venusta n. sp.
Glabrocingulum (Glabrocingulum) sp. A
Lunulazona nodomarginata (McChesney)
Bellazona bella (Walcott)
Ianthinopsis? sp.

Another zone of grayish-black concretions is 15 to 18 feet (4.6 to 5.5 m) above the top of the marker bed (USGS colln. 25558–PC) and contains ammonoids of the *Goniatites americanus* Zone. This unit also contains the following gastropods:

Trepospira (Angyomphalus) regularis n. sp.
Lunulazona nodomarginata (McChesney)
Glabrocingulum (Glabrocingulum) sp. A
Mourlonia venusta n. sp.
Loxonema sp.

A sample from the top 1 foot (0.3 m) of the marker bed yielded foraminifers that were assigned by B. L. Mamet (written commun., 1979) to his Foraminifer

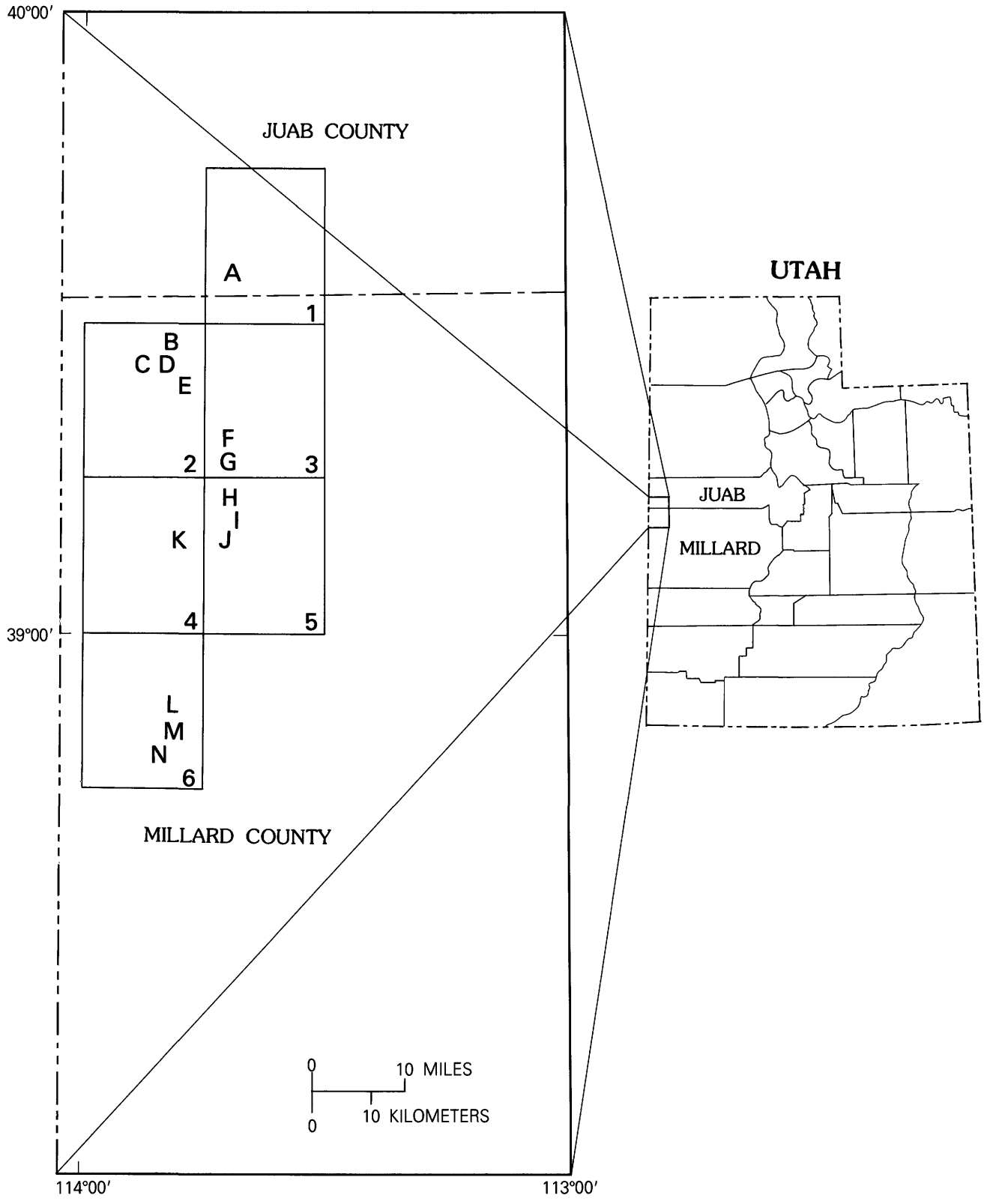

FIGURE 1.—Index map showing location of 15-minute quadrangles in western Utah that contain the Confusion Range and adjacent areas referred to in the text: 1, Granite Mountain; 2, Gandy; 3, Cowboy Pass; 4, Conger Range; 5, Conger Mountain; 6, Burbank Hills. Areas mentioned in the text are indicated on the appropriate quadrangle by letter: A, Granite Mountain measured section; B, area northeast of Foote Range; C, Foote Ranch partial section; D, Bishop Springs anticline; E, Indian Pass area; F, Skunk Spring measured section; G, southern part of Camp Canyon; H, Brown's Wash-Wallet Gulch partial section; I, Conger Spring area; J, area south of Conger Mountain; K, Coyote Pass area; L, Jensen Wash measured section; M, south slope of Burbank Hills; N, western part of Burbank Hills. The area referred to as "northern end of Needle Range" is in the Mormon Gap 7½-minute quadrangle southwest of the Burbank Hills 15-minute quadrangle.

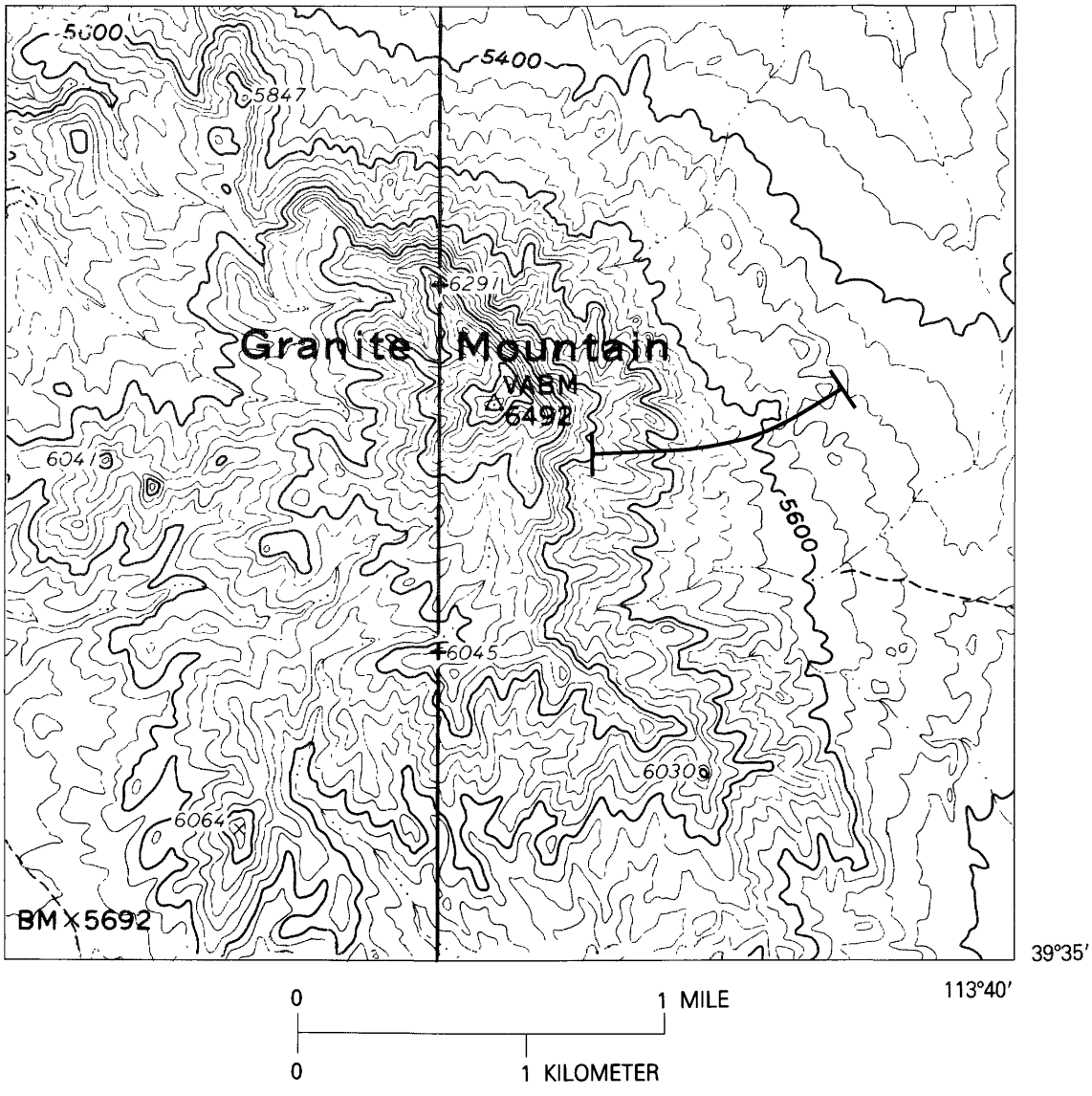

FIGURE 2.—Part of the Granite Mountain 15-minute quadrangle, enlarged to scale 1:31680 (2 inches = 1 mile), showing the position of Granite Mountain measured section.

Zone 16i. These two gastropod collections from the upper part of the *Goniatites americanus* Zone, therefore, are in that zone in which the position of the base of the Chesterian in the Illinois type section is uncertain (p. 0). The two gastropod species found elsewhere, *Lunulazona nodomarginata* (McChesney) and *Bellazona bella* (Walcott), both known from the Diamond Peak Formation in Nevada, and the first known also from the Moorefield Formation of Arkansas, come from beds of Meramecian age in those areas.

No gastropods have been found in the *Goniatites multiliratus* Zone, which immediately overlies the *G. americanus* Zone at Granite Mountain, where it is about 10 feet (3.0 m) thick. Several gastropod species, however, occur in the overlying *Goniatites granosus* Zone. The lowest occurrence of this zone, on a little saddle about 600 feet (200 m) north of the line of section, is 40 feet (12.2 m) above the top of the marker bed. The bed, less than a foot (0.3 mm) thick, contains crushed fragments of goniatites and foraminifers identified by Mamet as characteristic of his Zone 16s. The *Goniatites granosus* fauna occurs generally in soft brown shale, containing tan to yellow phosphatic concretions; the fossils weather free from the shale. Well-preserved gastropods were found 121 to 134 feet (36.9 to 40.8 m) above the top of the marker bed associated

with the ammonoids (USGS collns. 17012–PC, 17015–PC, 17020–PC, 17037–PC, 25562–PC). These gastropods include the following species:

Retispira cincta n. sp.
Glabrocingulum (Glabrocingulum) granulosum n. sp.
G. (G.) mephitifontis n. sp.
Lunulazona costata Sadlick and Nielsen
Bellazona polita n. sp.

The soft brown shale beds extend upward to 255 feet (77.7 m) above the top of the marker bed and are overlain by a dark-gary, very fine grained limestone that forms blocky ledges and is 39 feet (11.9 m) thick. B. L. Mamet (written commun., 1979) has reported his Zone 17 Foraminifera at 6.6 and 21.3 feet (2.0 and 6.5 m) above the base of this unit. A fossil collection (USGS colln. 17087–PC) from the top few inches of this unit, in a limestone bed containing the trace fossil *Zoophycus,* contained *Bellerophon (Bellerophon) vespertinus* Gordon and Yochelson, and another specimen, probably from the same horizon, was found loose (USGS colln. 28627–PC). Collections made at intervals through the middle and upper parts of the Chainman Shale have yielded gastropods, as follows:

From 299 to 300 feet (91.1 to 91.4 m) above the marker bed, in beds of limestone in dusky yellowish-brown silty claystone (USGS colln. 17088–PC):

Straparollus (Euomphalus) intermedius Gordon and Yochelson

Mamet (written commun., 1979) reported foraminifers of his Zone 17 at approximately this level.

From 457 to 459 feet (139.3 to 139.9 m) above the marker bed, in dusky brown argillaceous limestone (USGS colln. 17091–PC):

Lunulazona sadlicki n. sp.

From 464 to 474 feet (141.4 to 144.5 m) above the top of the marker bed, in limestone like that described immediately above, the following gastropods were collected (USGS colln. 17092–PC, 28628–PC):

Euphemites sp. indet.
Trepospira (Trepospira) sp.
Lunulazona sadlicki n. sp.
Cinclidonema sp.

The beds of this section for the next few hundred feet (100 m) are poorly fossiliferous. In a nearby section, measured by A. K. Armstrong and R. K. Hose, the impure limestones from roughly 525 to 930 feet (160 to 283 m) above the top of the marker bed were found by Mamet to be highly spiculitic; the spiculites continue for some distance farther upsection. At 687 feet (209.4 m) above the marker bed, a float limestone plate was recovered containing part of a goniatite, identified tentatively as *Paracravenoceras barnettense* (Plummer and Scott). This genus is typically found in Mamet Foraminifer Zone 17 and suggests that this zone may range at least that high.

A collection made 849 to 854 feet (258.8 to 260.3 m) above the marker bed in medium-dark-gray siliceous limestone interbedded with claystone and some black chert contained the following gastropods (USGS colln. 25249–PC):

Euphemites sacajawensis C. Branson
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen

This and the rest of the collections from the Chainman Shale higher in the Granite Mountain measured section are those normally found in the *Cravenoceras hesperium* Ammonoid Zone, which correlates with the lower part of Mamet's Foraminifer Zone 18.

At 942 to 943 feet (287.1 to 287.4 m) above the top of the marker bed, the following were collected (USGS colln. 17095–PC):

Retispira nolani Gordon and Yochelson
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Worthenia (Yochelsonospira) tenuilineata Girty

In a 22–foot (6.7–m) unit containing large caninoid corals, 1,018 to 1,040 feet (310.3 to 317.0 m) above the marker bed, the following gastropods were found (USGS collns. 17104–PC, 20547–PC, 25257–PC):

Catazona rudilirata Gordon and Yochelson
Straparollus (Euomphalus) nodibasis n. sp.
Naticopsis (Naticopsis) confusionensis n. sp.

At 1,050 to 1,054 feet (320.0 to 321.3 m) above the marker bed, a brownish to medium-gray limestone containing silicified fossils yielded (USGS colln. 17098–PC):

Straparollus (Euomphalus) nodibasis n. sp.

At 1,061 to 1,065 feet (323.4 to 324.6 m) above the top of the marker bed, a gray, partly siliceous, fine-grained limestone, weathering tan to orange, contained (USGS colln. 17099–PC):

Straparollus (Euomphalus) intermedius Gordon and Yochelson

A 3-foot (1-m) bed of medium-dark-gray, fine-grained limestone containing silicified fossils, 1,075 to 1,078 feet (327.7 to 328.6 m) above the top of the marker bed, has provided the following gastropods (USGS colln. 25252–PC):

Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Neilsonia sp.
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Stegocoelia (Stegocoelia?) sp.
Strophostylus cf. *S. nevadensis* Gordon and Yochelson
Naticopsis (Naticopsis?) clinovata n. sp.

Pseudozygopleura (Pseudozygopleura)? sp.
Meekospira sp.

Finally, a soft medium-dark-gray organic detrital limestone, 1,108 to 1108.5 feet (337.7 to 337.9 m) above the top of the marker bed contains (USGS colln. 17101–PC):

Platyceras (Platyceras) cf. *P. (P.) subrotundum* Snider

AREA NORTHEAST OF FOOTE RANGE

At the northern end of the valley between the Foote Range and Chevron Ridge are several Chainman outcrops on the valley floor, east of a narrow northwest-trending ridge that exposes beds of the upper part of the Chainman Shale and the lower part of the Ely Limestone. A collection from a small isolated patch of Chainman Shale in the NE 1/4 SW 1/4 SW 1/4 SE 1/4 sec. 24 contains the following two gastropod species from the upper part of the *Paracravenoceras barnettense* ammonoid Zone (USGS colln. 28623–PC):

Glabrocingulum (Glabrocingulum) confusionense n. sp.
G. (Glabrocingulum?) hosei n. sp.

G. (G.) confusionense was also reported by Sadlick and Nielsen (1963, p. 1098–1100, pl. 150, figs. 5–8) as *Glabrocingulum quadrigatum* n. sp. from an oil-company locality somewhere in sec. 24, T. 15 S., R. 18 W.; a more precise locality was not disclosed. We have examined the three specimens in this lot, included among the paratypes of *G. quadrigatum* and regard them as conspecific with *G. (G.) confusionense* n. sp.

Several collections were made in the E 1/2 sec. 25, T. 15 S., R. 18 W. The contact between beds of the *Paracravenoceras barnettense* and *Cravenoceras hesperium* Ammonoid Zones is exposed in this area. Fossils from the lower zone were collected in the SE 1/4 SE 1/4 SE 1/4 NE 1/4 sec. 25 (USGS colln. 25557–PC). These included the same two gastropod species:

Glabrocingulum (Glabrocingulum) confusionense n. sp.
G. (G?) hosei n. sp.

A short distance northwest of this locality, in the SW 1/4 SE 1/4 NE 1/4 sec. 25, Hose made collections from each of the two zones. The one containing *Paracravenoceras barnettense* (USGS colln. 19602–PC) yielded *Glabrocingulum (Glabrocingulum?) hosei* n. sp., and the other, from the basal 10 feet (3 m) of the *Cravenoceras hesperium* Zone (USGS colln. 19604–PC) contained two species:

Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Lunulazona utahensis n. sp.

FOOTE RANCH PARTIAL SECTION

Four miles (6.4 km) northeast of Foote Ranch is a much-visited fossil-collecting site, known as the Foote Ranch locality. In the early 1950's, weathered-out fossils, mostly brachiopods, were strewn about by the thousands, but visits by scores of collectors have taken their toll, and today one has to search to find a single loose fossil. The last mile of the access road from the Foote Ranch to this locality follows a northeast-trending wash cut through the Foote Range, about 2 miles (3.2 km) south of its northern tip. The collecting locality was about 50 to 100 yards (45 to 90 m) north of the wash, at the foot of the eastern slope of the range.

This area is in the Gandy NE 7 1/2-minute quadrangle, the geology of which was mapped by Hose and Ziony (1963). A partial section of the upper part of the Chainman Shale, measured by Hose and Gordon in 1957, together with a section measured by Gordon and T. W. Henry in 1983, provides documentation of the upper 469 feet (143.0 m) of this formation, in the SE 1/4 sec. 36, T. 15 S., R. 17 W. (see fig. 3). The lower part of the Hose-Gordon section began at a 1-foot-thick (0.3–m) bed of light-brown sandstone near the NW cor. sec. 31, T. 15 1/2 S., R. 17 W., and continued southwestward on the north side of the main wash. The 15 feet (4.6 m) of shale immediately overlying the sandstone bed contains abundant basal and other plates of *Agassizocrinus*. A bed of grayish-black, micritic, somewhat nodular limestone, containing *Leiorhynchoidea carbonifera* (Girty) and *Richardsonites merriami* (Youngquist) is 65 feet (19.8 m) above the sandstone bed.

A substantial part of the overlying section along the wash is missing because of faulting. To avoid this area, the Gordon-Henry section was measured up the eastern slope of the Foote Range, beginning about 500 feet (152 m) north of the wash and ending at the summit of the first ridge, capped by the basal bed of the Ely Limestone. The thickness of the Chainman Shale in this section, from the top of the *Agassizocrinus*-bearing shale to the base of the Ely, is 452.7 feet (138.0 m). An easily recognized limestone bed, 0.3 foot (0.1 m) thick, packed with narrow spiriferids, is 265.2 to 265.5 feet (80.8 to 80.9 m) below the top of the Chainman. Highly fossiliferous shale and some limestone is 14.5 to 51.5 feet (4.4 to 15.7 m) below the top of the formation; this interval provided the fossils at the nearby Foote Ranch locality. The top 14.5-foot (4.4-m)-thick unit of the Chainman is a moderately fossiliferous argillaceous platy limestone.

The key fossil-bearing beds in the measured sections are essential for determining the stratigraphic position of gastropods collected in the highly faulted Chainman Shale area in sec. 31, T. 15 1/2 S., R. 17 W., and the N 1/4 sec. 6, T. 16 S., R. 17 W., where the gastropods are fairly

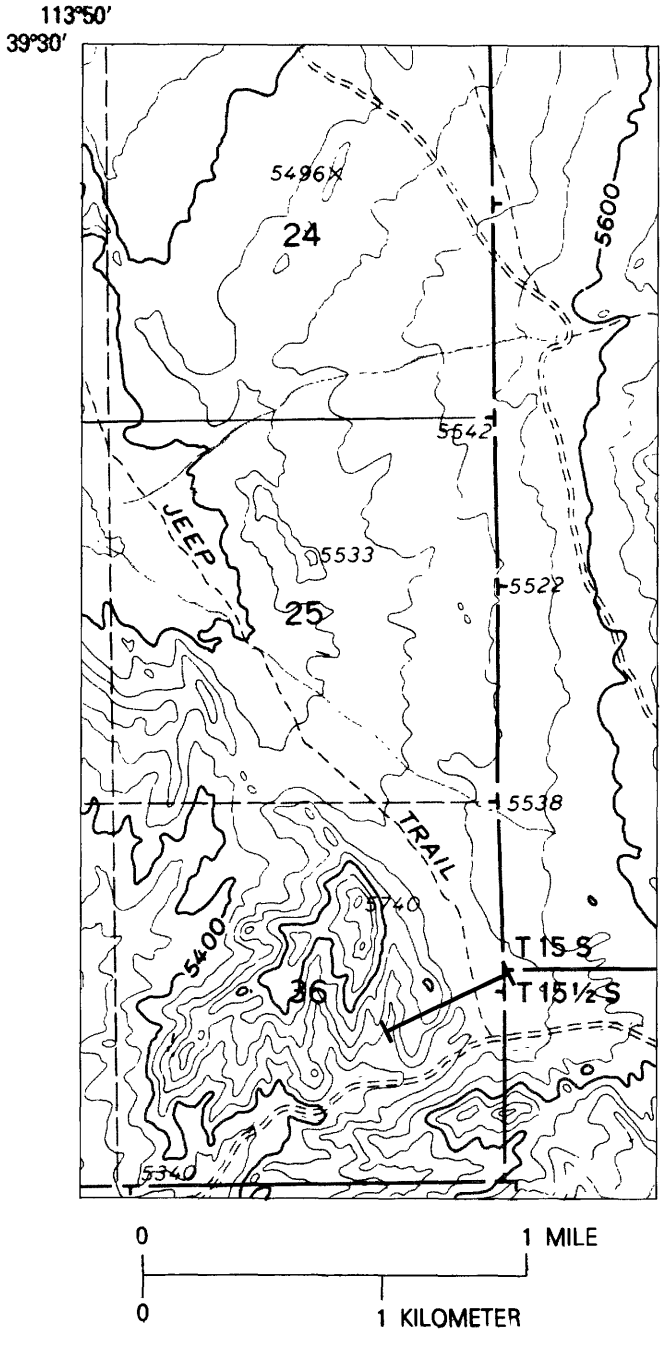

FIGURE 3.—Part of the Gandy 15-minute quadrangle, enlarged to scale 1:31680 (2 inches = 1 mile), showing the position of the Foote Ranch measured section.

common. The Ely Limestone in this area is downfaulted and locally thrust over the Chainman, and it cuts out some of the beds in the upper part of the Chainman (see map by Hose and Ziony, 1963).

The stratigraphically lowest collection, that farthest to the southeast, is from soft grayish-black shale in the NE 1/4 NE 1/4 sec. 6 (unsurveyed), about 1.5 miles (2.4 km) southeast of the Foote Ranch locality. This collection is estimated to be somewhere between 470 and 520 feet (143.3-158.5 m) below the top of the Chainman. Weathering from shale, along with *Cravenoceras hesperium* Miller and Furnish, are the following gastropods (USGS colln. 17032–PC):

Bellerophon (Bellerophon) sp. indet.
Trepospira (Trepospira) diadema n. sp.
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Worthenia (Yochelsonospira) tenuilineata Girty
Straparollus (Euomphalus) intermedius Gordon and Yochelson

Fossils of the *Agassizocrinus*-bearing shale were recognized in the SE 1/4 SE 1/4 sec. 31, T. 15 1/2 S., R. 17 W., weathering from the northern slope of a small ridge. Two specimens of *Worthenia (Yochelsonospira) tenuilineata* Girty were found at this locality, in USGS colln. 25259–PC.

Another collection, about 0.25 mile (0.4 km) southeast of the previous one, is from a limestone pod, roughly 4 feet (1.2 m) long and 0.5 foot (0.15 m) thick. The collection is near the saddle on the southwestern side of a prominent hill capped by a thrust-in block of Ely Limestone. It contains numerous valves of *Inflatia*, and because fragments of *Inflatia* shells are common in the measured section between the *Agassizocrinus*-bearing shale and the *Leiorhynchoidea-Richardsonites* limestone bed, the collection believed to belong stratigraphically in that part of the section. This collection, from the NE 1/4 NE 1/4 sec. 6 (unsurveyed), T. 16 S., R. 17 W., contains the following gastropods (USGS colln. 25274–PC):

Bellerophon (Bellerophon) welshi n. sp.
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Neilsonia sp. indet.
Worthenia (Yochelsonospira) tenuilineata Girty
Soleniscus sp. B
Meekospira sp.

The *Leiorhynchoidea-Richardsonites* bed has also yielded gastropods at an outcrop in a fault block in the SE 1/4 fractional sec. 31, T. 15 1/2 S., R. 17 W., where the bed is about 2 feet (0.6 m) thick. Species from two collections (USGS collns. 15370–PC, 17024–PC) include:

Glabrocingulum (Glabrocingulum) sp. C
Lunulazona? cf. *L. sablei* (Yochelson and Dutro)
Worthenia (Yochelsonospira) tenuilineata Girty
Ianthinopsis sp. A

Another fossil collection, including *Euloxoceras*, was made from a foot of shale about 25 feet (7.6 m) above the *Leiorhynchoidea-Richardsonites* bed. The gastropods include (USGS colln. 22883–PC):

Euphemites sp. A
Bellerophon (Bellerophon?) sp. A
Trepospira (Trepospira) diadema n. sp.
Glabrocingulum (Glabrocingulum) binodosum Sadlick and Nielsen
Ianthinopsis gandyensis n. sp.

The same horizon probably is represented by a collection (USGS colln. 25275–PC) in the NW 1/4 NW 1/4 sec. 6 (unsurveyed), T. 16 S., R. 17 W., in which *Euloxoceras* is associated with *Bellerophon (Bellerophon?)* sp. A.

The bed containing the narrow spiriferids is recognizable at several points within the faulted area. At one of them, in the NE 1/4 NE 1/4 fractional sec. 31, T. 15 1/2 S., R. 17 W., the 25 feet (7.6 m) of shale overlying the spiriferid bed contains the following gastropods, which weather out (USGS colln. 25551–PC):

Euphemites sp. A
Bellerophon (Bellerophon) vespertinus Gordon and Yochelson
Retispira nolani Gordon and Yochelson?
Trepospira (Trepospira) diadema n. sp.
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Worthenia (Yochelsonospira) tenuilineata Girty
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Ianthinopsis sp. B

At another locality, about 500 feet (152.4 m) west-northwest of the previous one and at a slightly higher level, but perhaps within the stratigraphic limits of the last collection, two gastropods species are present (USGS colln. 25553–PC):

Worthenia (Yochelsonospira) tenuilineata Girty
Naticopsis (Naticopsis) confusionensis n. sp.

A collection (USGS colln. 15372–PC) made by R. K. Hose from the uppermost beds of the Chainman Shale at the original Foote Ranch locality contains a single specimen of *Glabrocingulum (Glabrocingulum) binodosum*. Another collection (USGS colln. 22876–PC) from limestone in the uppermost 30 feet (9.1 m) of the formation contains several specimens of *Naticopsis (Naticopsis) confusionensis* n. sp.

BISHOP SPRINGS ANTICLINE

The elongate domelike structure known as the Bishop Springs anticline occupies a rather flat valley between the Foote Range at the west and Chevron Ridge to the east, both of which are formed by extensive exposures of Ely Limestone. The center of the dome contains an area, about half a mile (0.8 km) across, of Upper Devonian and Lower Mississippian Pilot Shale. This area is surrounded by a ring of outcrops of the Lower Mississippian Joana Limestone, elongate to the south, where it extends in a low ridge to about 2 miles (3.2 km) south of the Pilot Shale outcrop. Along the western limb of the anticline, the outcrop belt of the Chainman Shale has been narrowed greatly by faulting. The proximity of Lower Mississippian and Lower Pennsylvanian limestone beds here led Zeller (1957, p. 687, 688) to suggest that this was a positive area during the Late Mississippian into the Early Pennsylvanian; as a result, no Upper Mississippian sediments were deposited here. The Chainman Shale is present, however, in fault slices flanking the Bishop Springs anticline. Ironically, this is the one area in the entire Chainman outcrop belt where all the Late Mississippian ammonoid zones are present. All the gastropods found in this area are associated with ammonoids.

The earliest gastropods here are those of the *Goniatites granosus* Zone; they occur in association with *G. granosus* in an outcrop in the SW 1/4 SE 1/4 SE 1/4 sec. 7 (unsurveyed), T. 16 S., R. 17 W., about 3/8 mile (0.6 km) south-southwest of the abandoned oil well shown on the Gandy N.E. 7 1/2-minute quadrangle geologic map (Hose and Ziony, 1963). The gastropods include (USGS colln. 20446–PC):

Retispira cincta n. sp.
Glabrocingulum (Glabrocingulum) granulosum n. sp.
Lunulazona costata Sadlick and Nielsen
Straparollid steinkern

About 1.25 miles (2 km) to the north-northeast is a similar shoft-shale zone containing fossils of the *Goniatites granosus* Zone, but lacking gastropods. Thirty feet (9.1 m) higher in the section at that locality is a bed of medium-dark-gray limestone containing *Cravenoceras kingi* (Hall and Whitfield), marking the base of the *Paracravenoceras barnettense* Zone (USGS colln. 20455–PC). A single specimen of *Bellazona polita* n. sp. was found loose but associated with the limestone bed.

Most of the fossiliferous Chainman outcrops in the southern part of the Bishop Springs anticline are assignable to the upper part of the *Paracravenoceras barnettense* Zone and the lower part of the *Cravenoceras hesperium* Zone. One narrow north-heading elongate outcrop of soft olive-colored shale occurs near the western edge of the SE 1/4 SW 1/4 sec. 20 (unsurveyed), T. 16 N., R. 17 W. This outcrop is 2 3/8 miles (3.8 km) south-southeast of the abandoned Bishop Springs oil drill hole. The faunal assemblage at this locality includes the aulacocerid *Hematites barbarae* Flower and Gordon and the ammonoid *Paracravenoceras barnettense* (Plummer and Scott). The following gastropods are present (USGS colln. 20448–PC):

Glabrocingulum (Glabrocingulum) confusionense n. sp.
G. (G.?) hosei n. sp.

The same cephalopods and *G. (G.) confusionense* n. sp. occur a quarter of a mile (0.4 km) to the east (USGS colln. 19603–PC).

Six collections were made in an outcrop of slightly younger rocks in the SE 1/4 NW 1/4 NW 1/4 sec. 20 (unsurveyed), T. 16 N., R. 17 W. The section in this fault block consists of nearly 30 feet (9.1 m) of dark-gray limestone alternating with brownish-gray shale, the limestone beds 6 inches to 1 foot (0.15 to 0.3 m) thick. The common ammonoid in the limestone beds is *Cravenoceras hesperium* Miller and Furnish. The gastropods are distributed as follows:

In the lowermost limestone bed, 1 foot (0.3 m) thick (USGS colln. 25260–PC):

Lunulazona utahensis n. sp.
Anematina sp.
Loxonema n. sp.

Five feet (1.5 m) higher, in 1 foot (0.3 m) of brownish-gray shale (USGS colln. 20443–PC):

Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Lunulazona utahensis n. sp.

In a 1-foot (0.3-m) limestone bed, 5 feet (1.5 m) higher still (USGS colln. 20444–PC):

Lunulazona utahensis n sp.

In a 6-inch (0.15-m) limestone bed, 27 feet (8.2 m) above the top of the lowermost limestone bed and 15 feet (4.6 m) above the top of 20444–PC (USGS colln. 20445–PC):

Lunulazona utahensis n. sp.

An earlier collection (USGS colln. 17022–PC) made from the lower half of this sequence contains both *G. (Glabrocingulum) quadrigatum* and *L. utahensis* n. sp.

INDIAN PASS AREA

The Chainman Shale is exposed at the western edge of Chevron Ridge in the vicinity of Indian Pass. A collection made by R. K. Hose from a coarse-grained grayish-black limestone bed between two quartzite beds in a fault block about 1 mile (1.6 km) north of Indian Pass (USGS colln. 16959–PC) included *Lunulazona? aff. L.? sablei* Yochelson and Dutro. As the bed also contains *Leiorhynchoidea carbonifera* (Girty) and only the uppermost beds of the Chainman are exposed in this area, this may be the same grayish-black limestone bed that carries *Richardsonites merriami* (Youngquist) in the Foote Ranch section. The bed containing narrow *Anthracospirifer* in the Foote Ranch measured section is also exposed in a fault block in this area. A collection made 1,500 feet (457 m) north of the west end of Indian Pass, 4 to 8 feet (1.2 to 2.4 m) below the top of the Chainman, contains the following gastropods (USGS colln. 17003–PC):

Retispira jensenensis n. sp.?
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Naticopsis (Naticopsis) confusionensis n. sp.

SKUNK SPRING SECTION

Several of our collections are from the vicinity of Skunk Spring, in the N 1/2 SE 1/4 sec. 28 (unsurveyed), T. 17 S., R. 16 W. A section was measured there by R. K. Hose in 1954, and he made many of the fossil collections in this area. The upper part of this section was measured along the northern slope of Willow Spring Canyon, shown on the geologic map of the Cowboy Pass S.W. quadrangle of Hose and Repenning (1964), about a quarter of a mile (0.4 km) north of Skunk Spring (fig. 4).

The lower 230 feet (70.1 m) of predominantly silty shale in the Skunk Spring section is barren of megafossils. The lower marker bed is at the top of a 20-foot (6.1-m) unit of limestone, the top of which is 247 feet (75.3 m) above the base of the Chainman Shale. The stratigraphically lowest gastropods in this section weather from soft clay shale and occur with goniatites of the *Goniatites granosus* Zone, 394 to 407 feet (120.1 to 124.1 m) above the base of the formation (USGS colln. 15354–PC), where a rare pleurotomariacean species was found:

Glabrocingulum (Glabrocingulum) mephitifontis n. sp.

The same interval, three-eighths of a mile (0.6 km) south of Skunk Spring has yielded another equally rare bellerophontacean species (USGS colln. 25261–PC):

Sinuitina (Sinuitina) crispa n. sp.

Fossils from the same zone were found also at a higher level in silty limestone three-eighths of a mile (0.6 km) north of Skunk Spring and 24 feet (7.3 m) west of the Camp Canyon road in a bed roughly 700 feet (213.4 m) above the base of the formation. Occurring with crushed shells of *Goniatites granosus* Portlock and *G. choctawensis* Shumard are poorly preserved specimens of *Bellazona polita* n. sp. (USGS colln. 14557–PC).

Most of the gastropods in the Skunk Spring section came from a massive limestone member at Willow Gap. Here, where the Willow Spring Canyon cuts through it, the member is 318 feet (96.9 m) thick. Sadlick (1966) called this limestone the Willow Gap Limestone Member. However, because this name was published only in abstract, it has not been accepted by the USGS. We regard this lenticular limestone mass as a large shoal in a shallow area of the Chainman sea. This limestone deposit is presently recognizable for a little more than 10 miles (16 km), from the large alluvial fan emanating

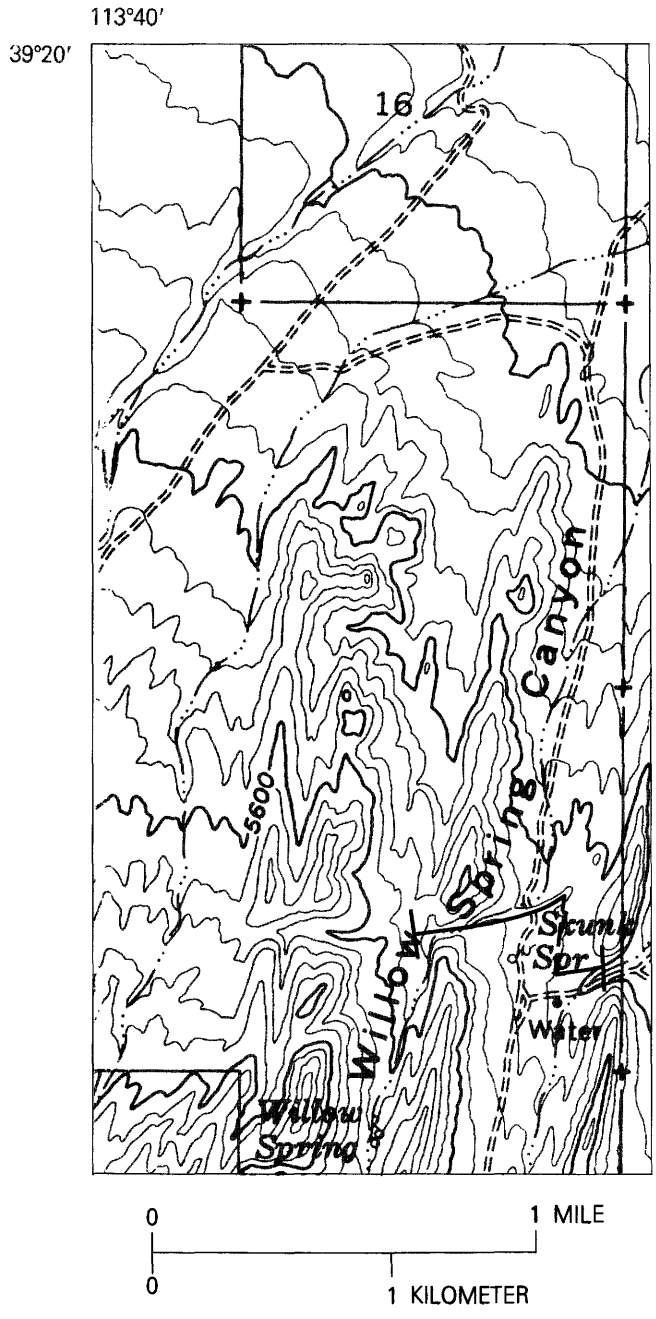

FIGURE 4.—Part of the Cowboy Pass 15-minute quadrangle, enlarged to scale 1:31680 (2 inches = 1 mile), showing the position of the Skunk Spring measured section.

from Cowboy Pass southwest to Brown's Wash south of Conger Mountain.

Fossils in this limestone are predominantly brachiopods, but a few gastropods are present in most collections. Samples collected by Gordon for foraminiferal study in 1969 were examined by Bernard Mamet (written commun., 1970), who reported that all of the limestone member belongs in his Foraminifer Zone 18. The base of this unit is 1,262 feet (384.6 m) above the base of the Chainman Shale. The fossil collections listed below are all from Willow Spring Canyon (Willow Gap). Intervals given are measured in vertical section from the base of the lowest massive limestone of the member.

In the lowermost 14 feet (4.3 m) of fine-grained dark-gray massive limestone, the following gastropods were collected (USGS colln. 15355–PC):

Bellerophon (Bellerophon) sp. indet.
Straparollus (Euomphalus) nodibasis n. sp.
S. (E.) intermedius Gordon and Yochelson?
Naticopsis (Naticopsis) cf. *N. (N.) genevievensis* Meek and Worthen
N. (N.?) clinovata n. sp.
Pseudozygopleura (Stephanozyga) claviger n. sp.

In another dark-gray fine-grained limestone unit, 44 to 76 feet (13.4 to 23.2 m) above the base of the member, a single gastropod occurs with the brachiopod faunule (USGS colln. 15356–PC):

Soleniscus sp. B

From medium-dark-gray dense limestone, 110 feet (33.5 m) above the base of the limestone member, a fossil collection (USGS colln. 25271–PC) includes the following gastropods:

Bellerophon (Bellerophon)? sp. indet.
Pleurotomariacean, gen. and sp. indet.
Strophostylus cf. *S. nevadensis* Gordon and Yochelson
Naticopsis (Naticopsis) cf. *N. (N.) genevievensis* Meek and Worthen?
Soleniscus? sp.
Girtyspira circumsecta n. sp.
Meekospira sp.

From similar fine-grained to dense limestone, 200 feet (61.0 m) above the base of the limestone member (USGS colln. 15358–PC):

Bellerophon (Bellerophon) vespertinus Gordon and Yochelson?
Straparollus (Euomphalus) nodibasis n. sp.
Catazona rudilirata Gordon and Yochelson

From 221 feet (67.4 m) above the base (USGS colln. 15359–PC):

Bellerophontacean, gen. and sp. indet.
Naticopsis (Naticopsis) confusionensis n. sp.

From 237 to 238 feet (72.2 to 72.5 m) above the base of the limestone member (USGS collns. 15361–PC, 25272–PC):

Bellerophon (Bellerophon) needlensis n. sp.?
B. (B.) sp. indet.
Naticopsis (Naticopsis) cf. *N. (N.) genevievensis* Meek and Worthen

From medium-dark-gray and pale-yellowish-brown dense to granular limestone 289 feet (88.1 m) above the

base of the limestone member (USGS collns. 15362–PC, 15375–PC):

Bellerophon (Bellerophon) sp. indet.
Catazona rudilirata Gordon and Yochelson
Straparollus (Euomphalus) nodibasis n. sp.
Naticopsis (Naticopsis) confusionensis n. sp.
N. (N.?) clinovata n. sp.
Pseudozygpleura (Stephanozyga) claviger n. sp.?

From the same unit, 300 feet (91.4 m) above the base of the limestone member (USGS collns. 15363–PC, 25563–PC):

Bellerophon (Bellerophon) sp. indet.
Straparollus (Euomphalus) nodibasis n. sp.
Strophostylus cf. *S. nevadensis* Gordon and Yochelson
Naticopsis (Naticopsis) confusionensis n. sp.
N. (N.) cf. *N. (N.) genevievensis* Meek and Worthen
Naticopsis (Jedria) sp.

Most of the bellerophontaceans in this limestone unit have been so damaged either by silicification or recrystallization, or both, that they have been generally rendered unidentifiable. The other species have been much less affected. Some of the naticopsids have undergone diagenesis, but most have well-preserved surfaces, the damage to the shells being mainly distortion due to partial crushing.

The uppermost 14.5 feet (4.4 m) of interbedded dense to sublithographic limestone and coarsely granular limestone contains large caninoid corals. This unit is overlain by a 5.5-foot (1.7-m) covered zone, probably of thin-bedded limestone, followed by a 2.4-foot (0.7-m) clastic limestone bed. This highest limestone is conglomeratic, the clasts ranging from granule to pebble size, the pebbles as much as 2.5 cm long. Limestone pebbles are subrounded to subangular; sparse small rounded chert pebbles are also present.

The uppermost unit in the Chainman, 253 feet (77.1 m) thick, is composed of grayish-black shale, mostly covered. At Willow Gap, it is in fault contact with the underlying limestone unit, as shown on the Cowboy Pass S.W. geologic map (Hose and Repenning, 1963). From 108 to 138 feet (32.9 to 42.1 m) above the base of the unit, the shale is interbedded with dark-gray silty limestone weathering tan and locally earthy and yellowish. Brachiopods of the *Rhipidomella nevadensis* Zone weather out from this limy interval. Two collections, one about in the line of section and the other approximately 1,000 feet (305 m) to the north, include the following gastropods (USGS collns. 14558–PC, 14559–PC):

Bellerophon (Bellerophon) sp. indet.
Glabrocingulum (Glabrocingulum) binodosum Sadlick and Nielsen
Naticopsis (Naticopsis) confusionensis n. sp.

The total thickness of the Chainman Shale in this section is 1,840 feet (560.8 m).

SOUTHERN PART OF CAMP CANYON

Another locality where gastropods were found in the *Goniatites granosus* Zone is 4.05 miles (6.5 km) south by road from the water tank at Skunk Spring in the northern part of the Conger Mountain quadrangle. This locality is just east of the Camp Canyon road and 1.9 miles (3.04 km) north-northeast of the place at which this road crosses the wash of Little Mile-and-a-Half Canyon, in the NE 1/4 SW 1/4 SE 1/4 sec. 17, T. 18 S., R. 16 S. The weathered-out fossils include two gastropods (USGS colln. 14553–PC):

Lunulazona costata Sadlick and Nielsen
Bellazona polita n. sp.

BROWN'S WASH–WALLET GULCH PARTIAL SECTION

About 1.4 miles (2.24 km) west of the summit of Conger Mountain is a large ravine, known as Wallet Gulch, cut into the upper beds of the Chainman Shale. It drains south from the western part of Conger Mountain, then turns abruptly west into a narrow defile cut through the Ely Limestone. The eastern side of this gulch is formed by a ridge of limestone that separates Wallet Gulch from Brown's Wash. A partial section was measured along the line indicated in figure 5. The limestone unit is 343 feet (104.6 m) thick and occupies the same part of the Chainman section that the similar limestone unit occupies in the Skunk Spring–Willow Gap section. Presumably, the limestone beds in these two areas are part of the same carbonate deposit. Two collections were made in the limestone unit. The lower one is from the basal 1 foot (30 cm) at midslope on the west side of Brown's Wash, due east of the ridge that flanks Wallet Gulch on the south. The fossils are coarsely silicified, which precludes identification of some of them.

This basal bed contains the following gastropods (USGS colln. 25566–PC):

Euphemites nevadensis Gordon and Yochelson?
Bellerophon (Bellerophon) sp. indet.
Retispira sp. indet.
Baylea? sp.
Catazona rudilirata Gordon and Yochelson
Dictyotomaria sp.
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Naticopsis (Naticopsis) confusionensis n. sp.
N. (N.?) clinovata n. sp.
Bulimorpha sp.
Meekospira? sp.
High-spired tiny gastropods, gen. and sp. indet.

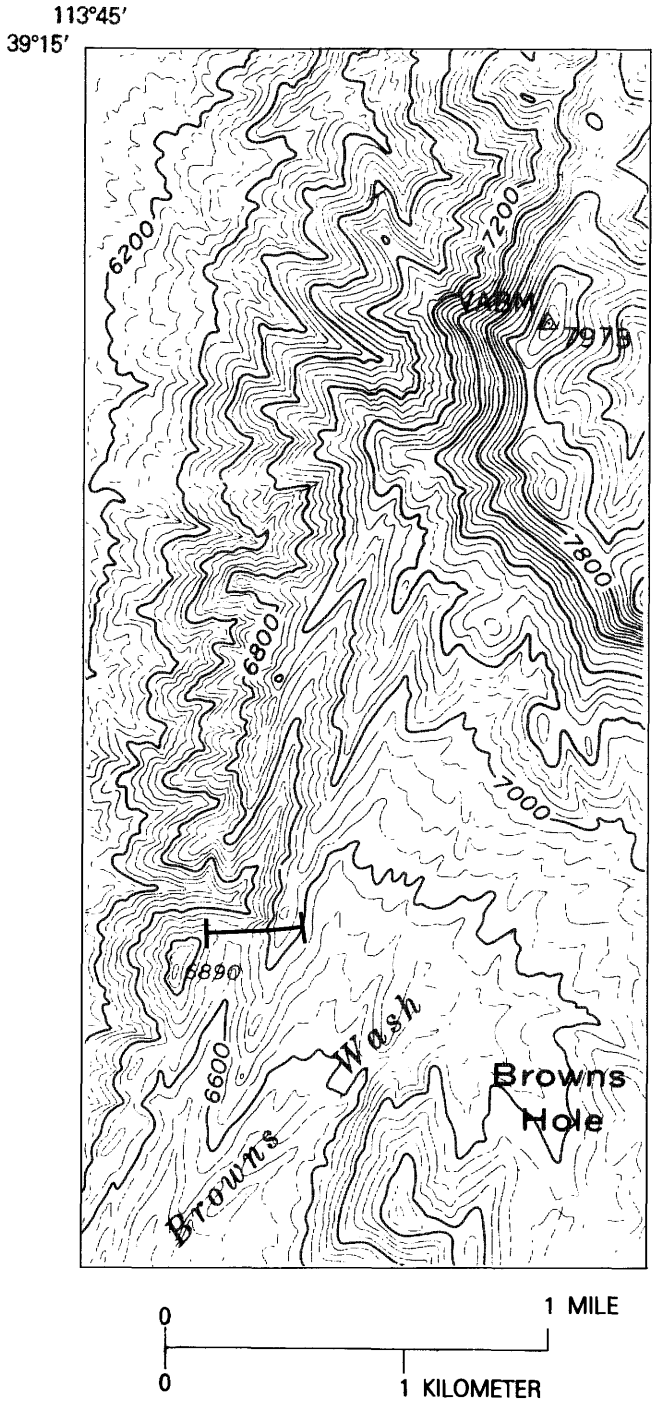

FIGURE 5.—Part of the Conger Mountain 15-minute quadrangle, enlarged to scale 1:31680 (2 inches = 1 mile), showing the position of the Brown's Wash–Wallet Gulch measured section.

The second collection was made from a limestone 15 feet (4.6 m) thick that caps the ridge between Brown's Wash and Wallet Gulch. Its base is 147 feet (44.8 m) above the base, and the top of it is 181 feet (55.2 m) below the top of the carbonate unit. Preservation of the fossils is similar to that below. The collection includes the following gastropods (USGS colln. 17214–PC):

Euphemites? sp. indet.
Retispira sp. indet.
Catazona rudilirata Gordon and Yochelson
Palaeostylus sp.
High-spired tiny gastropods, gen. and sp. indet.

The limestone unit is capped by 1.5 feet (0.5 m) of quartzitic sandstone, overlying which is 353 feet (107.6 m) of shale containing scattered beds of limestone and limestone, up to the base of the Ely Limestone. In the interval 11.5 to 41.3 feet (3.5 to 12.6 m) above the base of the shale sequence are weathered-out fossils, mostly brachiopods and two gastropod species (USGS colln. 15364–PC):

Worthenia (Yochelsonospira) tenuilineata Girty
Pseudozygopleura (Pseudozygopleura)? lauta n. sp.

From a siltstone, 4.5 feet (1.4 m) thick, the base of which is 134 feet (40.8 m) above the quartzitic sandstone bed, and in the overlying 33 feet (10.1 m) of clay shale, another brachiopod faunule contains the following gastropods (USGS collns. 15365–PC, 16997–PC, 25269–PC):

Bellerophon (Bellerophon) vespertinus Gordon and Yochelson?
?*Worthenia (Yochelsonospira) tenuilineata* Girty
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Strophostylus cf. *S. nevadensis* Gordon and Yochelson

CONGER SPRING AREA

The upper beds of the Chainman Shale are exposed in the vicinity of Conger Spring in the NE 1/4 NW 1/4 sec. 2, T. 19 S., R. 17 W. Brachiopods of these beds are those of the *Rhipidomella nevadensis* Zone, the uppermost brachiopod zone in the Chainman, particularly that part of the zone in which the productoid *Carlinia phillipsi* (Norwood and Pratten) also occurs. A small area of hillslope about 1,000 feet (305 m) south by east from the spring has provided a large collection of brachiopods (USGS colln. 17021–PC). A partial section measured by Gordon in June 1959, shows that a fauna is weathering from 14 feet (4.3 m) of greenish-gray shale, the top of which is 22 feet (6.7 m) below the base of the Ely Limestone. With these brachiopods are associated a few gastropods:

Trepospira (Trepospira) diadema n. sp.
Euconospira desereti n. sp.
Worthenia (Yochelsonospira) tenuilineata Girty
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Naticopsis (Naticopsis) confusionensis n. sp.
Soleniscus sp. B

AREA SOUTH OF CONGER MOUNTAIN

The southernmost point where one or more gastropods were found in the *Goniatites granosus* Zone is 2.4 miles (3.8 km) southwest of the southern end of Conger Mountain and 0.1 mile (0.16 km) east of the road in a 30-foot (9.1-m) interval of shale that begins 90 feet (27.4 m) stratigraphically above the top of the marker bed. The collection (USGS colln. 17250–PC) includes a specimen of *Retispira cincta* n. sp.

COYOTE PASS AREA

On the east slope of the Conger Range, a south-southwest-trending extension of the Confusion Range, in a small reentrant just east of Coyote Pass, are several exposures of Chainman Shale. About a quarter of a mile (0.4 km) east-southeast of Coyote Pass, is a low knoll where a dark-brownish-gray limestone bed crops out, which contains corals, brachiopods, and mollusks. The mollusks include the cephalopods *Rayonnoceras* sp. and *Richardsonites merriami* (Youngquist). The bed seems to occupy a slightly higher stratigraphic position than does the *R. merriami* bed in the northern part of the Foote Range, judging from the associated fossils. The following gastropods were found in this bed (USGS colln. 22880–PC):

Euphemites sp. A
E. cracens n. sp.
Bellerophon (Bellerophon) vespertinus Gordon and Yochelson?
Retispira sp.
Glabrocingulum (Ananias) seminudum Gordon and Yochelson
G. (Glabrocingulum?) sp. B
Euconospira gradilis n. sp.
Straparollus (Euomphalus) intermedius Gordon and Yochelson?
Soleniscus sp. B

The bed also contains the brachiopod *Rhipidomella nevadensis* (Meek), and, so far as could be determined, this bed occurs stratigraphically about 20 feet (6.1 m) above the first appearance of that species.

JENSEN WASH SECTION

The Chainman Shale is well exposed on the northern slope of the Burbank Hills in the E 1/2 sec. 35, T. 22 S., R. 18 W. A section was measured there in 1957 by Gordon, beginning in the SE 1/4 SE 1/4 sec. 35, continuing northwest into the NW 1/4 SE 1/4 sec. 35, and shifting northeastward along the upper of two beds that contain *Cravenoceras hesperium* Miller and Furnish and other ammonoids of that zone, the upper part of the section being measured in the NE 1/4 NE 1/4 sec. 35 (fig. 6). The total thickness of the Chainman Shale at

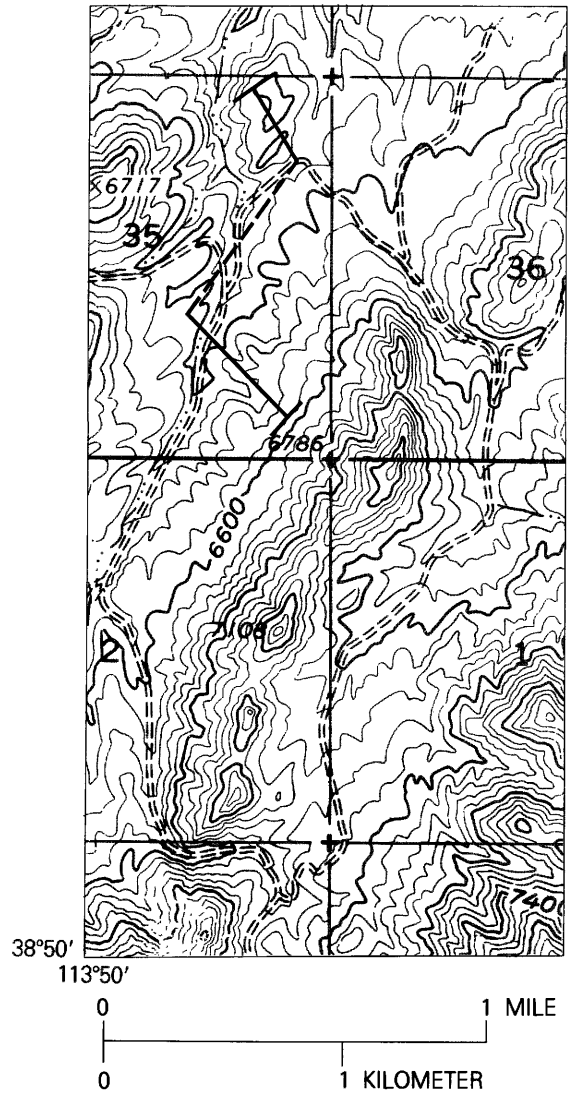

FIGURE 6.—Part of the Burbank Hills 15-minute quadrangle, enlarged to scale 1:31680 (2 inches = 1 mile), showing the position of the Jensen Wash measured section.

Jensen Wash is 2,203 feet (671.5 m). Five lithologic units containing gastropods were found in the line of section.

In this area, no gastropods were found in the lower third of the formation. Three ammonoid zones based upon species of the genus *Goniatites* are present. The earliest gastropods in the Chainman of this area appear in beds of middle Chesterian age. A 1.5-foot (0.5-m) calcareous shale bed, in the dark-gray silty shale sequence that occupies the lower part of the *Paracravenoceras barnettense* Ammonoid Zone, is 703 feet (214.3 m) above the base of the Chainman and 44 feet (13.4 m) above the lowest bed containing

Paracravenoceras. Common in this bed are two gastropod species (USGS collns. 17201–PC, 25546–PC):

Ptychomphalina burbankensis n. sp.
Lunulazona sadlicki n. sp.

Higher in the same ammonoid zone, a 20-foot (6.1-m) unit of soft dark-brownish-gray calcareous shale, 980 to 1,000 feet (298.7 to 304.8 m) above the base of the Chainman, contains innumerable pebble-sized dark-brown siliceous siltstone nodules and abundant well-preserved *Glabrocingulum* shells, together with a few other gastropods (USGS collns. 17194–PC, 25263–PC, 25264–PC, 28610–PC):

Retispira ordinata n. sp.
Trepospira (Trepospira) baconi n. sp.
Glabrocingulum (Glabrocingulum?) hosei n. sp.
Deseretospira monilifera n. gen., n. sp.

The brownish calcareous shale continues upward, but in the next 59 feet (18.0 m) it contains irregularly shaped calcareous concretions, larger and more sparsely scattered than the siliceous nodules below. Both the concretions and the shale contain abundant fossils, predominantly mollusks—*Paracravenoceras, Hematites*, nautiloids, gastropods, and taxodont and pectenoid pelecypods (USGS collns. 15165–PC, 15166–PC, 17055–PC, 17186–PC, 23846–PC, 25262–PC, 25284–PC, 28611–PC). Two species of gastropods occur here:

Glabrocingulum (Glabrocingulum) confusionense n. sp.
G. (G.?) hosei n. sp.

The same fossils are very sparse through the next 40 feet (12.2 m) of shale, which contains a few scattered sandstone layers and earthy limestone beds. Three collections from this same general locality (USGS collns. 17187–PC, 22856–PC, 25262–PC) include species from both intervals; all five species are represented.

The lowest fossiliferous bed assigned to the *Cravenoceras hesperium* Ammonoid Zone is 1,127 to 1,129 feet (343.5 to 344.1 m) above the base of the formation. A short distance higher stratigraphically, a 4.5-foot (1.4-m) bed of sandy limestone to calcareous sandstone containing well-preserved *Cravenoceras* aff. *C. hesperium* Miller and Furnish has its top 1,140 feet (347.5 m) above the base of the Chainman. In the Jensen Wash section, the only gastropods associated with the *Cravenoceras hesperium* Zone occur almost at the top of this zone. They are in a fossiliferous nodular shale, which weathers grayish orange to pale yellowish orange. Its yellowish tinge is distinctive in the weathered outcrop. The nodular shale is 16 feet (4.9 m) thick and is 1,620 to 1,636 feet (493.8 to 498.7 m) above the base of the Chainman. This is the same shale from which Sadlick and Nielsen (1963, p. 1100) collected the type specimens of *Glabrocingulum quadrigatum* Sadlick and Nielsen and is the key level along which Gordon's measured section was offset to the northeast to complete the upper part in a better exposed area. Collections were made from weathered exposures of this unit, beginning at the Sadlick-Nielsen locality 2-11 and continuing at intervals along the bed to the south-southwest for about half a mile (0.8 km). Gastropods from these collections (USGS collns. 17056–PC, 17188–PC, 17189–PC, 17208–PC, 17209–PC, 17219–PC, 25547–PC, 25550–PC) are listed below:

Euphemites nevadensis Gordon and Yochelson
Retispira jensenensis n. sp.
R. nolani Gordon and Yochelson
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Trepospira (Trepospira) diadema n. sp.
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Worthenia (Yochelsonospira) tenuilineata Girty
Stegocoelia (Stegocoelia) sp.
Pseudozygopleura (Pseudozygopleura) repenningi n. sp.
P. (P.)? lauta n. sp.
Ianthinopsis gandyensis n. sp.
I. sp. B?
Soleniscus sp. A
S. sp. B

The stratigraphically highest gastropod-bearing bed in the Chainman section at Jensen Wash is near the middle of a 56-foot (17.1-m), abundantly fossiliferous shale unit. Among numerous other brachiopods, the productoid *Carlinia phillipsi* (Norwood and Pratten) is common and characteristic. This unit is 2,067 to 2,123 feet (630.0 to 647.1 m) above the base of the formation; the top of the unit is 80 feet (24.4 m) below the top of the Chainman Shale. The grayish-tan calcareous siltstone bed from which the gastropods were weathering out in some numbers was covered and could not be found in place, but as near as could be determined, the bed is roughly 110 feet (33.5 m) below the top of the formation. The gastropods from four collections made in this unit (USGS collns. 17059–PC, 17217–PC, 25548–PC, 28612–PC) are as follows:

Euphemites sacajawensis C. Branson
Bellerophon (Bellerophon) vespertinus Gordon and Yochelson
Retispira stenopsis n. sp.
Glabrocingulum (Ananias) seminudum Gordon and Yochelson
Euconospira desereti n. sp.
Worthenia (Yochelsonospira) tenuilineata Girty
Platyceras (Platyceras) cf. *P. (P.) subrotundum* Snider

SOUTHERN SLOPE OF BURBANK HILLS

The same faunal horizon as that collected at several localities along the top of the *Cravenoceras hesperium* Zone at Jensen Wash is recognized in the southern part of the Burbank Hills, where the belt of Chainman Shale outcrop approaches the valley between the Burbank Hills and the Needle Range. In a section measured by a petroleum company, a collection was made by John E. Welsh, formerly of Kennecott Copper Corporation, and presented to the USGS. The gastropods in this collection (USGS colln. 17310–PC) are:

Bellerophon (Bellerophon) welshi n. sp.
Retispira nolani Gordon and Yochelson
Trepospira (Trepospira) diadema n. sp.
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
G. (G.) binodosum Sadlick and Nielsen
Worthenia (Yochelsonospira) tenuilineata Girty
Ianthinopsis gandyensis n. sp.

The higher fauna is also present in this area. A collection made by Gordon in the SW 1/4 SE 1/4 SE 1/4 sec. 29, T. 23 S., R. 18 W., includes several gastropods associated with rare *Rhipidomella nevadensis* (Meek). The locality is estimated as being 150 to 200 feet (45.7 to 61.0 m) stratigraphically below the top of the Chainman Shale. The gastropods in this collection (USGS colln. 25319–PC) are:

Retispira nolani Gordon and Yochelson?
Glabrocingulum (Ananias) seminudum Gordon and Yochelson
Euconospira desereti n. sp.
Worthenia (Yochelsonospira) tenuilineata Girty

WESTERN PART OF BURBANK HILLS

A large area of Chainman Shale crops out in the vicinity of Red Pass in the northwestern part of the Burbank Hills. A collection made in the SE 1/4 SE 1/4 NE 1/4 sec. 1, T. 22 S., R. 19 W., on the slopes of a high mound of upper Chainman Shale contained *Antiquatonia, Nuculopsis*, and *Cravenoceras hesperium* Miller and Furnish in some abundance (USGS colln. 25318–PC). Associated with these are two species of gastropods characteristic of this ammonoid zone:

Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Worthenia (Yochelsonospira) tenuilineata Girty

NORTHERN END OF NEEDLE RANGE

The southernmost exposures of this belt of Chainman Shale outcrop, in the northern part of the Needle Range, have provided a few more specimens of gastropods. The lowermost of three gastropod-bearing beds was collected in the *Paracravenoceras barnettense* Ammonoid Zone in the NW 1/4 sec. 26, T. 25 S., R. 19 W., about 200 yards (182.9 m) west of the access road and just south of a gully along which a section was measured in the early 1950's by a petroleum company. From dark-gray silty limestone and shale, in association with the fossil coleoid *Hematites barbarae* Flower and Gordon, a species of bellerophontacean was collected (USGS colln. 15157–PC):

Retispira ordinata n. sp.

From the upper part of the Chainman Shale along the same line of section, two collections were made in two 2-foot (0.6-m) beds, 13 feet (4.0 m) apart stratigraphically, in the N. 1/2 sec. 27, T. 25 S., R. 19 W. The upper bed contains the ammonoid *Richardsonites merriami* (Youngquist). Gastropods present in the two beds (USGS collns. 15160–PC, 15161–PC) are:

Bellerophon (Bellerophon) needlensis n. sp.
Retispira sp. indet.
Glabrocingulum? sp. indet.
Worthenia (Yochelsonospira) tenuilineata Girty
Straparollus (Euomphalus) sp.

GASTROPOD ASSEMBLAGES AND THEIR RELATIONSHIP TO AMMONOID AND FORAMINIFERAL ZONES

Analysis of the gastropod distribution data given in the preceding section of this report shows that eight distinct assemblages can be recognized in the Chainman Shale. Seven of these occur in stratigraphic succession; the eighth is a facies-controlled, carbonate-favoring faunule that shares the same stratigraphic zone as the penultimate mud-dwelling assemblage. One might consider the seven stratigraphically controlled assemblages as constituting a sequence of gastropod zones and propose formal names for them. However, as their ranges are identical with or very similar to those of previously named ammonoid zones and numbered foraminiferal zones, or within the bounds of these zones, no advantage would be realized. We prefer to consider the gastropod assemblages as integral components or representatives of the ammonoid zones and, similarly, of the equivalent foraminiferal zones.

The Bellerophontacea constitute approximately 5 percent of the Chainman gastropod fauna; the Pleurotomariacea, by far the most abundant group, constitute nearly 89 percent. Tables 2 and 3 show the distribution of species of these two superfamilies in the Chainman Shale; table 4 shows many of the other taxa. The ammonoid and foraminiferal zones are used as a framework for these tables. The remaining seven gastropod superfamilies account for only 6 percent of the fauna. The gastropods and the assemblages in which

TABLE 2.—*Biostratigraphic distribution of bellerophontaceans in the Chainman Shale*

Ammonoid zones	Foraminifer zones	*Sinuitina*	*Euphemites*	*Bellerophon (Bellerophon)*	*Retispira*
Richardsonites merriami	19		*E. sacajawensis* *E.* sp. A	*B. (B.) vespertinus* *B. (B.)* sp. A *B. (B.) needlensis*	*R. stenopsis* *R. jensenensis*
	?		*E. cracens*		
Cravenoceras hesperium	18		*E. nevadensis* *E.* cf. *E. sacajawensis*	*B. (B.) welshi* *B. (B.) vespertinus* *B. (B.) needlensis?*	*R. jensenensis* *R. nolani*
Paracravenoceras barnettense	17		*E.* sp. indet.	*B. (B.) vespertinus*	*R. ordinata*
Goniatites granosus	16s	*S. (Sinuitina) crispa*			*R. cincta*
Goniatites multiliratus	16i	*S. (Vorticina) vortex*	*E.* sp. indet.		*R.* cf. *R. textilis*
Goniatites americanus	15				

they occur are discussed in more detail below, in stratigraphic order from bottom to top. For convenience in reference, each assemblage is designated by an informal name, generally that of the characteristic or predominant species. A discussion of the geographic distribution and stratigraphic correlation of these assemblages is based in part upon the locality information in the preceding section.

(1) Lunulazona nodimarginata *assemblage*.—The lowest assemblage stratigraphically in the Chainman Shale is known only at Granite Mountain, where it occurs in the upper part of the *Goniatites americanus* Zone, specifically 3 to 15 feet (0.9 to 4.6 m) above the marker bed. Its stratigraphic range corresponds closely with the lower part of Mamet Foraminifer Zone 16i. The nominal species was described originally as *Pleurotomaria nodimarginata* McChesney from near Batesville, Ark., where it occurs in the "so-called Boone Chert" (Girty, 1915b), which is part of the Moorefield Formation (Gordon and Kinney, 1944).

TABLE 3.—*Biostratigraphic distribution of common pleurotomariaceans in the Chainman Shale*

Ammonoid zones	Foraminifer zones	*Trepospira*	*Euconospira*	*Lunulazona*	*Glabrocingulum*
Richardsonites merriami	19	*T. (Trepospira) diadema*	*E. desereti* *E. gradilis*		*G. (Ananias) seminudum* *G. (Glabrocingulum)* sp. B *G. (Glabrocingulum) binodosum*
	?	*T. (Trepospira) diadema*		*L.?* aff. *L.? sablei*	*G. (Glabrocingulum) binodosum*
Cravenoceras hesperium	*18*				*G. (Glabrocingulum) quadrigatum*
				L. utahensis	*G. (Glabrocingulum) quadrigatum*
Paracravenoceras barnettense	17	*T. (Trepospira) baconi* *T. (Trepospira)* sp.		*L. sadlicki*	*G. (Glabrocingulum) confusionense* *G. (Glabrocingulum?) hosei*
Goniatites granosus	16s			*L. costata*	*G. (Glabrocingulum) granulosum* *G. (Glabrocingulum) mephitifontis*
Goniatites multiliratus	16i	*T. (Angyomphalus) regularis*		*L. nodomarginata*	*G. (Glabrocingulum)* sp. A
Goniatites americanus					

TABLE 4.—*Biostratigraphic distribution of other pleurotomariaceans, eumphalaceans, neritaceans, and species from other superfamilies in the Chainman Shale*

Ammonoid zones	Foraminifer zones	Other pleurotomariacean genera	*Straparollus (Euomphalus)*	*Naticopsis*	Other superfamilies
Richardsonites merriami	19	*Worthenia tenuilineata*	*S. (E.)* sp.	*N. (Naticopsis) confusionensis*	
	?			*N. (Jedria?)* sp.	*Ianthinopsis gandyensis*
		Neilsonia sp.	*S. (E.) nodibasis*	*N. (Naticopsis?) clinovata*	*Pseudozygopleura repenningi*
					Stegocoelia sp.
Cravenoceras hesperium	18	*Worthenia tenuilineata*	*S. (E.) intermedius*	*N. (Naticopsis) confusionensis*	*Pseudozygopleura? lauta*
				N. (N.) cf. *N. (N.) genevievensis*	*Anematina* sp.
		Catazona rudilirata			*Loxonema?* sp.
Paracravenoceras barnettense	17	*Deseretospira monilifera*	*S. (E.) intermedius*		
		Ptychomphalina burbankensis			*Bellazona polita?*
Goniatites granosus	16s				*Bellazona polita*
Goniatites multiliratus					
	16i				*Loxonema* sp.
Goniatites americanus		*Mourlonia venusta*			*Bellazona bella*
	15	*Rhineoderma?* sp.			

The following gastropod species make up this assemblage in west-central Utah:

Sinuitina (Vorticina) vortex n. sp.
Euphemites sp. indet.
Retispira cf. *R. textilis* (Hall)
Trepospira (Angyomphalus) regularis n. sp.
Mourlonia venusta n. sp.
Lunulazona nodimarginata (McChesney)
Glabrocingulum (Glabrocingulum) sp. A
Loxonema sp.
Bellazona bella (Walcott)
Ianthinopsis? sp.

The same species of *Retispira, Lunulazona,* and *Bellazona* also were found by Walcott (1884) in what is now known as the Diamond Peak Formation in the Eureka mining district, Eureka County, Nev. These species occur in beds generally considered to be of late Meramecian age in both Nevada and Arkansas. This evidence supports the conclusions of Swann (1963, p. 18–21) regarding the type Chesterian section in western Illinois. Swann excluded the Aux Vases Sandstone and Levias Limestone Member of the Renault Formation from the type Chesterian because these units contain megafossils long regarded as Meramecian (Valmeyeran) in age. These two units belong in the lower part of Foraminifer Zone 16a of Mamet, according to Mamet and Skipp (1971, p. 1141, fig. 7). We regard the entire *Goniatites americanus* Zone, including the *Lunulazona nodimarginata* gastropod assemblage, as latest Meramecian in age.

(2) Lunulazona costata *assemblage*.—The gastropods of the *Lunulazona costata* assemblage occur in the soft clay shale beds in the middle part of the *Goniatites granosus* Zone, the ammonoid zone directly equivalent to Mamet Foraminifer Zone 16s. The gastropods were most common in exposures at Granite Mountain, Juab County, from about half a mile (0.8 km) north of the measured section south to a point 2.4 miles (3.8 km) southwest of the southern tip of Conger Mountain in Millard County, a distance of nearly 33 miles (52.8 km). The gastropod species from this zone are:

Sinuitina (Sinuitina) crispa n. sp.
Retispira cincta n. sp.
Straparollid, gen. and sp. indet.
Glabrocingulum (Glabrocingulum) granulosum n. sp.
G. (G.) mephitifontis n. sp.
Lunulazona costata Sadlick and Nielsen
Bellazona polita n. gen., n. sp.

A similar faunule, associated with ammonoids of the *Goniatites granosus* Zone, was also recognized in Nevada, about 1 mile (1.6 km) north of the ruins of Pogues Station on the old Pony Express route, not far from the southwestern corner of White Pine County. This occurrence is approximately 117 miles (187.2 km) due west of Skunk Spring, Millard County, Utah, one of the localities where members of this assemblage are present.

With the possible exception of *Bellazona polita*, all the species listed above are restricted to this zone. A specimen of *B. polita* was collected from a limestone bed containing *Cravenoceras kingi* (Hall and Whitfield), a bed that immediately overlies the shale of the *Goniatites granosus* Zone in the northern part of the Bishop Springs anticline. This specimen might have been reworked.

(3) Lunulazona sadlicki *assemblage*.—The lowest assemblage of early Namurian age is most characteristically represented in an impure limestone bed at the Jensen Wash section, Burbank Hills, Utah. The bed is in the lower part of the *Paracravenoceras barnettense* Zone, this zone being directly equivalent to Mamet Foraminifer Zone 17. Gastropods 457 to 534 feet (139.3 to 162.8 m) above the marker bed in the measured section at Granite Mountain also seem to belong to this assemblage. The assemblage contains the following species:

Euphemites sp. A?
Trepospira (*Trepospira*) sp.
Ptychomphalina burbankensis n. sp.
Lunulazona sadlicki n. sp.
Cinclidonema sp.

The holotype of *Lunulazona sadlicki* is from 3.5 miles (5.6 km) north of Wendover, Utah, 0.3 miles (0.5 km) northeast of Leppy Peak in Elko County, Nev. It occurs there with *Ptychomphalina* sp. and therefore seems to represent the same assemblage as the Jensen Wash occurrence, 133 miles (212.8 km) farther south and 14 miles (22.4 km) farther east.

(4) Glabrocingulum hosei *assemblage*.—Stratigraphically higher, but within the same goniatite zone, the 20 feet (6.1 m) of soft shale containing abundant siliceous nodules is crowded with specimens of *Glabrocingulum hosei* in the Jensen Wash measured section. The gastropods present in this assemblage are:

Retispira ordinata n. sp.
Trepospira (*Trepospira*) *baconi* n. sp.
Glabrocingulum (*Glabrocingulum*?) *hosei* n. sp.
Deseretospira monilifera n. gen., n. sp.

This assemblage has not yet been widely recognized in the region, in part because in some areas, such as Skunk Spring and Granite Mountain, the beds of the *Paracravenoceras barnettense* Zone are impure spiculitic shale, not a suitable habitat for most megafossils. Another possible reason for the scarcity of this assemblage is the faults that are common in areas where the gastropod-bearing beds are extensive, as in the Bishop Springs anticline; these faults may be responsible for the absence of the beds containing this particular assemblage. The presence of *Retispira ordinata* n. sp. at a locality in the Needle Range suggests that this assemblage may be represented there.

(5) Glabrocingulum confusionense *assemblage*.—At Jensen Wash, approximately the uppermost 100 feet (30.5 m) of the *Paracravenoceras barnettense* Zone contains two glabrocingulums in some abundance. These are:

Glabrocingulum (*Glabrocingulum*) *confusionense* n. sp.
G. (*G.*?) *hosei* n. sp.

These occur roughly in a 60 to 40 ratio, respectively. The beds that contain them in the Bishop Springs anticline area are exposed mostly in fault slices, but within these slices, the beds are in normal sequence; the assemblage is cut off abruptly at the base of the overlying *Cravenoceras hesperium* Zone. These gastropods are extremely useful in this area, together with the associated tela (guardlike hard parts) of the coleoid *Hematites*, for recognizing the upper part of the *Paracravenoceras barnettense* Zone. However, as at Skunk Spring and Granite Mountain, this part of the section consists almost exclusively of spiculitic shale in which fossils of any description are virtually absent.

This two-species assemblage has not been seen outside the west-central Utah region. In the Pancake Range in White Pine County, Nev., an entirely different fauna occupies the upper part of the *Paracravenoceras barnettense* Zone. The presence of this fauna of *Worthenia* (*Yochelsonospira*) *tenuilineata* Girty together with *Paracravenoceras barnettense* at a locality in the NE 1/4 sec. 21, T. 18 N., R. 56 E., on the eastern flank of the range, suggests a stratigraphic position at or near the top of the zone. Taxa present here are *Euphemites, Bellerophon* (*Bellerophon*), *Retispira, Straparollus* (*Euomphalus*), *Trepospira* (*Trepospira*), *Glabrocingulum* (*Ananias*), *Worthenia* (*Worthenia*), *Worthenia* (*Yochelsonospira*), *Deseretospira,* and *Meekospira*?. The coleoid *Hematites* is also present. This distinctively different and apparently geographically restricted Nevada fauna in the upper part of the *Paracravenoceras barnettense* Zone is in contrast to the more widely dispersed gastropod faunas below it.

(6A) Glabrocingulum quadrigatum *assemblage*.—The *Glabrocingulum quadrigatum* assemblage is found throughout the *Cravenoceras hesperium* Zone, which coincides with the lower and major part of Mamet Foraminifer Zone 18. The stratigraphic range of the nominal species coincides with that of the ammonoid zone. This assemblage is recognized from Granite Mountain southward to the southern slope of the Burbank Hills. The gastropod fauna is particularly abundant in the upper part of the ammonoid zone. In the Burbank Hills, the gastropods are restricted to a single 15-foot (4.6-m) unit of gray to tan shale at the top of the *Cravenoceras hesperium* Zone, but in the Bishop Springs anticline, Foote Range, and Granite Mountain

areas, they occur throughout the zone. Even in these more northern areas, however, the abundance of species is greater in the upper part of the zone.

The gastropod species of this assemblage include the following:

Euphemites nevadensis Gordon and Yochelson
E. sacajawensis C. C. Branson
Bellerophon (Bellerophon) welshi n. sp.
B. (B.) needlensis n. sp.
B. (B.) vespertinus Gordon and Yochelson
Retispira nolani Gordon and Yochelson
R. jensenensis n. sp.
Trepospira (Trepospira) diadema n sp.
Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen
Worthenia (Yochelsonospira) tenuilineata Girty
Neilsonia sp.
Stegocoelia (Stegocoelia?) sp.
Straparollus (Euomphalus) intermedius Gordon and Yochelson
Anematina sp.
Loxonema sp.
Pseudozygopleura (Pseudozygopleura) repenningi n. sp.
P. (P.?) lauta n. sp.
P. sp.
Ianthinopsis gandyensis n. sp.
Soleniscus sp. A
S. sp. B
Meekospira sp.

In addition to these species, a single specimen of *Glabrocingulum (Glabrocingulum) binodosum* Sadlick and Nielsen came from the southern slope of the Burbank Hills in a collection that was made by a petroleum company and donated to the USGS (USGS colln. 17310–PC). Because this species is typical of the next higher assemblage and because we have not been able to verify its occurrence elsewhere in the *Glabrocingulum quadrigatum* assemblage, it has not been included in the list above.

This assemblage is found in shale and in impure limestone beds in shale sequences. It occupies the same ammonoid and foraminiferal zone as the assemblage that follows, the two being differentiated mainly by the lithologic facies in which they occur.

(6B) Catazona rudilirata *assemblage*.—The *Catazona rudilirata* assemblage is best represented in the thick lenticular limestone deposit (Willow Gap Member of Sadlick, 1966) at Skunk Spring and Browns Wash; it also has been recognized in the section at Granite Mountain. Characteristic species in this assemblage, in addition to the nominal one, include *Straparollus (Euomphalus) nodibasis* n. sp. and several forms of *Naticopsis*. Ammonoids are extremely rare in this facies; the only one found, at Skunk Spring, was identified tentatively as *Cravenoceras hesperium* Miller and Furnish. Foraminifera of Mamet's Zone 18 occur throughout the section that contains this faunal assemblage. Gastropods of this assemblage are listed below:

Euphemites nevadensis Gordon and Yochelson?
Bellerophon (Bellerophon) sp. indet.
Retispira sp. indet.
Baylea? sp.
Dictyotomaria sp.
Catazona rudilirata Gordon and Yochelson
Straparollus (Euomphalus) nodibasis n. sp.
S. (E.) intermedius Gordon and Yochelson
Strophostylus nevadensis Gordon and Yochelson
Naticopsis (Naticopsis) confusionensis n. sp.
N. (N.) cf. *N. (N.) genevievensis* Meek and Worthen
N. (N.?) clinovata n. sp.
N. (Jedria?) sp.
Pseudozygopleura (Stephanozyga) claviger n. sp.
Bulimorpha sp.
Soleniscus? sp.
Girtyspira circumsecta n. sp.
High-spired tiny gastropods, gen. and sp. indet.

Coarse silicification, particularly of the bellerophontaceans and subulitaceans, precludes the identification of many specimens to species or even to genus. Much better preserved examples of the gastropods of this assemblage occur in the Diamond Peak Formation in the northern part of the White Pine Range, White Pine County, Nev. The writers have described 26 species of gastropods from a single bed in the NE 1/4 sec. 28, T. 19 N., R. 58 E., and have noted the similarity of this faunule to that of the limestone facies at Willow Gap in the Confusion Range (Gordon and Yochelson, 1983).

The gastropods found in the *Cravenoceras hesperium* Zone of the Confusion Range account for about half the species known from the Chainman Shale. The gastropod species recorded from the two lithic facies in this region, combined with those of the same ammonoid zone in Nevada described previously (Gordon and Yochelson, 1983) but not yet identified in western Utah, give a grand total of 47 gastropod species described and illustrated from this zone in the Great Basin.

(7) Glabrocingulum binodosum *assemblage*.—The beds overlying the *Cravenoceras hesperium* Zone occupy all but the basal 15 feet (4.6 m) of the Jensen Member of Arnold and Sadlick (1962), the type locality of this member being at Jensen Wash in the Burbank Hills; because of incomplete publication, however, the USGS has not recognized this member. These beds also include the *Rhipidomella nevadensis* Zone of Sadlick (1955, p. 54). In the lower part of this brachiopod zone

is a bed containing the ammonoid *Richardsonites merriami* (Youngquist). What is believed to be a single bed in the same stratigraphic position, and containing this ammonoid, is present in the Foote Range, Indian Pass, Coyote Pass, and Needle Range areas.

The gastropods of these uppermost beds of the Chainman Shale include some of the species that occur in the *Cravenoceras hesperium* Zone, along with others that are not known in the lower parts of the Chainman Shale, at least in west-central Utah. Along the east slope of the Foote Range and southward to Skunk Spring, the most characteristic species of this part of the section is *Glabrocingulum (Glabrocingulum) binodosum* Sadlick and Nielsen, commonly found about 20 to 25 feet (6.1 to 7.6 m) above the *Richardsonites merriami* beds. Farther south, at Coyote Pass, Jensen Wash, and the southern slope of the Burbank Hills, *G. (Glabrocingulum) binodosum* seems to have been replaced laterally by *G. (Ananias) seminudum* Gordon and Yochelson. For some reason, not yet fully explained, *G. (Ananias) seminudum*, which is a fairly common component of the *Catazona rudilirata* assemblage in the White Pine Range, Nev., is always found higher in the section in the Confusion Range and Burbank Hills, Utah.

The species found in the upper part of the Chainman Shale, between the top of the *Cravenoceras hesperium* Zone and the top of the formation, are listed below:

Euphemites sp. A
E. cracens n. sp.
E. sacajawensis C. C. Branson
Bellerophon (Bellerophon) sp. A
B. (B.) needlensis n. sp.
B. (B.) vespertinus Gordon and Yochelson
Retispira stenopsis n. sp.
Trepospira (Trepospira) diadema n. sp.
Lunulazona cf. *L. sablei* (Yochelson and Dutro)
Glabrocingulum (Ananias) seminudum Gordon and Yochelson
G. (Glabrocingulum) binodosum Sadlick and Nielsen
G. (G.) sp. B
Euconospira desereti n. sp.
E. gradilis n. sp.
Worthenia (Yochelsonospira) tenuilineata Girty
Straparollus (Euomphalus) sp.
S. (E.) intermedius Gordon and Yochelson
Naticopsis (Naticopsis) confusionensis n. sp.
Soleniscus sp. B

GASTROPODS AS GUIDE FOSSILS

Gastropods generally have been neglected in studies of Carboniferous biostratigraphy. The genera are relatively long ranging. The common impression has been that the species also are long ranging. Perhaps the most significant result of the present study is to show that, as guide fossils at the species level, gastropods can be almost as useful as foraminifers, ammonoids, or conodonts. Although we have chosen to integrate the gastropod assemblages with established ammonoid and foraminiferal zones, a zonal framework based upon the gastropods alone could have been established.

Within the framework of the Mamet foraminiferal zonation, so far as can now be determined, all but three of the gastropod species are restricted to a single zone. Within the framework of the ammonoid zones, most of the gastropod species also are restricted to one or another zone; three separate gastropod assemblages have been recognized within the *Paracravenoceras barnettense* Zone (=Mamet's Foraminifer Zone 17). Although some gastropod species range from the *Cravenoceras hesperium* Zone into the beds above that contain *Richardsonites merriami* and the brachiopod *Rhipidomella nevadensis*, both of these ammonoid assemblages occur within the worldwide *Eumorphoceras bisulcatum* (E_2) Ammonoid Zone.

DIVERSITY AND FACIES CONTROL

In general, gastropods in the Chainman Shale show much greater diversity than do ammonoids. The ratio of gastropod species in the Chainman Shale to ammonoid species is about 8 to 3. Ammonoids are found preferentially in basinal sedimentary rocks, such as dark-gray mudstone and impure limestone; gastropods also occur in those rocks. Ammonoids are very rare in shallow-marine limestone in a shoal or shelf environment; these environments normally are populated with brachiopods, bryozoans, and corals. Gastropods, on the other hand, are present in shelf and shoal limestone, locally in great numbers. Generally, they are represented by different species from those found in the basinal sedimentary rocks not far away. The diversity of species controlled by facies is well illustrated by the two different assemblages found in the *Cravenoceras hesperium* Zone. The *Glabrocingulum quadrigatum* assemblage occurs in mudstone and impure limestone, whereas the *Catazona rudilirata* assemblage occurs in a massive fine-grained limestone; both assemblages lived at the same time in the shallow shoal environment.

Where the two different lithic facies approach one another, the two faunal assemblages may replace one another. An example is found in the Granite Mountain section, where the upper part of the Chainman is more calcareous than in sections farther south. At 942 to 943 feet (287.1 to 287.4 m) above the limestone marker bed,

the *Glabrocingulum quadrigatum* assemblage is present. From 1,018 to 1,054 feet (310.3 to 321.3 m) above the marker bed, the *Catazona rudilirata* assemblage is present. At 1,075 to 1,078 feet (327.7 to 328.6 m) above the marker bed, the *Glabrocingulum quadrigatum* assemblage reoccurs, but associated with it are two species, *Strophostylus* cf. *S. nevadensis* n. sp. and *Naticopsis (Naticopsis?) clinovata* n. sp., that are more typical of the *Catazona rudilirata* assemblage. This association suggests that a delicate balance between the two facies existed at this locality. It also indicates that the gastropods were sensitive to slight changes in subtrate and water chemistry; therefore, they may be more reliable in identifying facies changes than the lithofacies alone would be.

SYSTEMATIC PALEONTOLOGY

[In the list of occurrences given for each species after its description and discussion, a question mark preceding the locality number questions the identification of the species at that locality, not the locality itself.]

Phylum MOLLUSCA

Class GASTROPODA

Subclass PROSOBRANCHIA

Order ARCHAEOGASTROPODA

Suborder BELLEROPHONTINA

Superfamily BELLEROPHONTACEA

Family SINUITIDAE

Subfamily BUCANELLINAE

Genus SINUITINA Knight, 1945

Discussion.—When the genus *Sinuitina* was first proposed (Knight, 1945, p. 333), only the type species was included, and emphasis was placed on a cordiform whorl profile as one of the generic features. In the two decades that followed, several other species were described or assigned to it. In spite of the small number of species within this genus, these species clearly belong in two groups. We hereby provide subgeneric names for these groups to emphasize features that otherwise might be ignored when additional species are described.

Our impression is that specimens of *Sinuitina* are rare, especially in comparison with other late Paleozoic bellerophontaceans; throughout the geologic range of this fossil genus, it is uncommon. Nevertheless, a species of each subgenus occurs in the Chainman Shale, providing the incentive to comment on divisions within the genus that are based mainly on differences in whorl profile. Although the subgeneric forms tend to intergrade, the two Chainman species seem to represent extremes of both shapes.

Subgenus S. (SINUITINA) Knight, 1945

Diagnosis.—Whorl profile broadly helmet-shaped, having a prominent somewhat flattened median crest which bears a pseudoselenizone. Collabral ornamentation prominent.

American Mississippian species of Sinuitina (Sinuitina).—

crispa, n. sp.
nudidorsa Rollins, 1975
venata (Girty), 1910 (*Oxydiscus*)

Sinuitina (Sinuitina) crispa n. sp.

Plate 1, figures 1–6

Diagnosis.—Moderately involute helmet-shaped bellerophontacean, having broad V-shaped sinus centering on raised flattened median dorsal crest.

Description.—Shell phaneromphalus, bilaterally symmetrical, umbilicus occupying slightly more than one-fourth length of conch. Earliest whorls unknown. Whorl profile helmet shaped, dorsum formed by raised gently convex ridge. Umbilicus deep, having prominent, narrow, carinate, flat shelf midway between suture and umbilical shoulder, so that each whorl is stepped; inner part of umbilical wall steep and concave, outer part steep and convex; umbilical shoulder strongly rounded. Periphery about one-third distance from umbilical shoulder to dorsum; flanks convex, curving inward and becoming concave near dorsum, then curving abruptly into gently convex dorsum. Aperture sinuate, total depth of sinus being about one-eighth of circumference of body whorl; deepest and most strongly curved part of sinus lying within dorsum, appearing as prominent pseudoselenizone.

Growth lines obscure in deepest part of umbilicus, where they are closely spaced and curving from opisthocline to prosocline, becoming stronger on umbilical shelf, and prominent on outer wall of umbilicus, where they are orthocline and continue straight across periphery; beyond periphery, growth lines curve gradually prosocline, degree of curvature increasing uniformly in rough logarithmic curve, uninterrupted by sides of dorsal zone, where they converge at angle near 80°; within pseudoselenizone, growth lines recurving sigmoidally, meeting in boardly acute angle at single discontinuous spiral lira, which bisects pesudoselenizone. Ornamentation of prominent raised rounded colabral costae, maintaining fairly uniform thickness and height from upper part of umbilical wall to sinus, widely and uniformly spaced except along sides of crest, where they are closer together; number of riblets on crest increases slightly by local intercalation on outer flanks.

Dimensions.—Measurements (in mm) of holotype and two paratypes from type locality are as follows:

USNM	210915	210916	210917
Length	21.4	13.6	13.3
Width	11.5	6.5	8.0
Diameter of umbilicus	[1]6.5	3.7	3.6

Discussion.—The primary types include six specimens. Two of them, which are incomplete, come from the *Goniatites granosus* Zone near Skunk Spring in the Confusion Range (USNM 210919, 210920). The better lot is from the same ammonoid zone in the Chainman Shale on the western side of the Pancake Range, in the NW 1/4 SW 1/4 sec. 1 (unsurveyed), T. 15 N., R. 54 E., about 1 mile (1.6 km) north-northeast of Pogues Station ruins, White Pine County, Nev. The holotype and three paratypes are from this locality (USGS colln. 22961–PC).

This species is readily distinguished from *Sinuitina* (*Vorticina*) *vortex* n. sp. and from other shells of that subgenus by its helmet-shaped whorl and raised dorsal crest, by the small carinate shelf within the umbilicus, and by the prominence of the collabral ornamentation over the dorsal region. It is most similar to the type species of *Sinuitina, S. cordiformis* (Newell), from the upper part of Missourian Series in northern Oklahoma, which it resembles in general shape and prominent collabral ornamentation. In *S. cordiformis*, however, the dorsum is not so highly raised and is more narrowly rounded than in our Chainman form, and the collabral costae are less regularly curved and more widely spaced over the flanks and increase in number dorsally, in contradistinction to the Utah species.

Types.—Holotype USNM 210915; paratypes USNM 210916–210920.

Occurrence and number of specimens.—USGS collection 25261–PC (2), Millard County.

Subgenus S. (VORTICINA) n. subgen.

Type species—*Sinuitina anneae* Conkin, 1957

Diagnosis.—Whorl profile a pointed arch; dorsum bluntly rounded, bisecting pseudoselenizone. Collabral ornamentation prominent on inner flanks, reduced on outer flanks and dorsum.

American Mississippian species of Sinuitina (Vorticina).—

anneae Conkin, 1957
cyrtolites (Hall), 1860 (*Bellerophon?*)
rugosiuscula (Winchell), 1862 [1863] (*Bellerophon*)
taeniata (Winchell), 1862 [1863] (*Bellerophon*)
vortex n. sp.

Discussion.—Because of the rarity of the Chainman Shale species and the remoteness of its type locality, a more easily accessible and well-known species has been designated as the type of this subgenus. *S.* (*V.*) *anneae* is from the Lower Mississippian New Providence Shale of Kentucky. We examined Conkin's types in the USNM. His description and illustrations accurately portray the key features of *S.* (*Vorticina*) and need no amplification. *Sinuitina keytei* Yochelson, from the Permian Leonard Formation of west Texas, *S.* (*V.*) *vortex* n. sp., from the Chainman Shale, *Bellerophon rugosiusculus* Winchell, from the Marshall Formation of Michigan, and *Bellerophon? cyrtolites* Hall, from the Rockford Limestone of Indiana, are included in this subgenus. From the limited fossil record of *Sinuitina*, it seems that *S.* (*Vorticina*) has a longer stratigraphic range than the typical subgenus.

As indicated by our use of subgenera, *S.* (*Vorticina*) does intergrade with the typical subgenus. However, the whorl profile in the form of a pointed arch distinguishes it from the broader shell of *S.* (*Sinuitina*).

Sinuitina (Vorticina) vortex n. sp.

Plate 1, figures 7–11

Diagnosis.—Narrowly sinuate bellerophontacean having whorls that form blunt pointed arch in cross section; riblets largely confined to lower flanks at maturity.

Description.—Shell phaneromphalus, moderately involute, umbilicus occupying slightly more than one-fourth of conch length. Umbilicus imperfectly known, but having narrow revolving angulation low on umbilical wall with steep slopes at either side. Whorl profile broadly and bluntly lenticular; periphery relatively close to umbilical margin; flanks above periphery arch convexly inward to narrow rounded dorsum. Shell without obvious ontogenetic change in profile other than narrowing of shell from moderately young to mature growth stages. Growth lines sigmoidal and slightly prosocline within umbilicus, changing curvature centering on umbilical angulation, orthocline from outer part of umbilical slope to periphery, then curving strongly and smoothly prosocline to dorsum, joining there forming simple V-shaped sinus, which in depth approximates one-eighth of body whorl length. Shell ornamented by widely spaced, low but distinct, riblets, prominent below periphery, but nearly obsolete on upper flanks at maturity.

Dimension.—Measurements (in mm) of the holotype and paratype are as follows: length 15.0 and 24.5; width 10.5 and 14.0; diameter of umbilicus (approximate) 4.0 and 7.5.

Discussion.—This species is based upon two specimens from the *Goniatites americanus* Zone in the section at Granite Mountain. The length/width ratios for

[1]Outer whorl slightly contorted; average of measurements of both sides.

the two specimens are 0.57 and 0.70, respectively, indicating a narrowing of the shell during growth.

The inflated, smoothly arched cross section, similar in shape to the so-called Gothic arch, is distinctive in this species and serves to distinguish it from Sinuitinas of the typical subgenus. In addition to the differences in conch shape that distinguish *S. (Sinuitina) crispa* n. sp., several differences in ornamentation can be noted. Not only is the collabral ornament continuous across the dorsum at maturity in *S. (S.) crispa,* but at comparable positions on the whorl flanks, the riblets in *S. (V.) vortex* are lower, finer, and more closely spaced. The small angulation within the umbilicus of this species is not nearly so prominent as the carinate shelf in *S. (S.) crispa.*

In comparing this species of *S. (Vorticina)* with other members of the subgenus, the Permian form *S. (V.) keytei* Yochelson is far more compressed. More similar in shape is *S. (V.) anneae* Conkin, from the New Providence Shale of Kentucky, but that species also is somewhat more narrowly lenticular and is much smaller; growth lirae on the upper part of the flanks of that species are less obscure and are geniculate at the periphery, rather than swept backward as in *S. (V.) vortex*. These last two features also differentiate *S. (V.) vortex* from *S. (S.) venata* (Girty), from the Fayetteville Shale of Arkansas.

We examined unpublished notes of G. H. Girty on H. W. Winchell's material from the Marshall Formation of Michigan. Girty reexamined the type specimens and prepared drawings. We can determine from this material that *Bellerophon rugosiusculus* Winchell and *B. rugosiusculus taeniatus* are representatives of *Sinuitina (Vorticina)*. The type lots for this species and subspecies may include more than one species. The holotype of *S. (V.) rugosiusculus* may be differentiated from *S. (V.) vortex* by its broader dorsum and the cancellate sculpture on its flanks.

Bellerophon? cyrtolites Hall, from the "Goniatite limestone," overlying the main part of the Rockford Limestone, at Rockford, Ind., is also transferred to this subgenus. In spite of the long synonymy that accompanies this species (see Yochelson and Saunders, 1967, p. 238), it is a poorly known form. The type was never figured and may be lost. Illustrations of topotypes by Meek and Worthen (1866a, pl. 14, figs. 8a, b) do not show all the critical features but do indicate a strongly angulated dorsum having flattened sides that form nearly a right angle at the crest. This shape distinguishes Hall's species from *S. (V.) vortex*.

Types.—Holotype USNM 210921; paratype USNM 210922.

Occurrence and number of specimens.—USGS collection 17018–PC (2), Juab County.

Subfamily EUPHEMITINAE

Genus EUPHEMITES Warthin, 1930

Discussion.—Our study of the bellerophontaceans of the Chainman Shale demonstrates that we must reevaluate our concept of the characters by which species are differentiated in *Euphemites*. We will discuss these characters in the order of their importance as we now view them.

The first specific character is shell shape. Most gastropods grow uniformly; allometric growth or ontogenetic change is the exception rather than the rule. This is essentially true of the bellerophontaceans; wide species tend to remain wide during growth and narrow species, narrow. Almost no attention has been given to ontogenetic change in defining species. Studies of many species of *Euphemites* have convinced us that whorl profile is probably one of the most important features for differentiating species. Reliance on shape, nevertheless, must be tempered with an appreciation for possible change during growth. In the Chainman species *Euphemites* sp. A, juvenile specimens possess umbilical depressions, whereas in mature individuals, the depressions have disappeared and the profile is smoothly rounded. In addition to changes in the umbilical area, smaller individuals are slightly less inflated on the flanks than are larger ones. Geniculation as the result of change in the logarithmic growth spiral is an important feature in some members of this genus but apparently does not occur in any of the species described from the Mississippian rocks of North America.

Second in importance to shape is the ornamentation surrounding the umbilical region. In *Euphemites* sp. A, the lirae remain fairly constant and rarely are interrupted in the columellar area. However, in Pennsylvanian species of similar shape, such as *E. blaneyanus* (McChesney) or *E. vittatus* (McChesney), pustules, nodes, or short lirae en echelon low on the flanks are characteristic.

Third in importance in differentiating species of *Euphemites* is the number, strength, and spacing of the longitudinal lirae that characterize this genus. Because the number of lirae is an easily observable character, it has been used widely in species differentiation, but this character is rather variable. In *Euphemites* sp. A, we find a range in number of lirae from 22 to 28. Much of the difference in number seems to be individual variation, but a tendency also exists during the growth of individuals toward some irregularity in the development of lirae. Most commonly, new lirae are added near the umbilical region, but, occasionally, a single lira may die out or be inserted locally on the dorsum. Although the number of lirae may increase with growth, within *E.* sp. A, we have observed small

specimens having 28 lirae and much larger ones having only 23 lirae.

Spacing of the lirae also may be a deceptive character. The spacing is a function partly of the shape of the shell and partly of the shape of the lirae. Because of this, one species may have not only more lirae but more widely spaced lirae than another species. *Euphemites incarinatus* Easton, from the Pitkin Limestone of Arkansas, is ornamented by more than 40 lirae, but these are exceedingly fine and, relative to their size, they are more widely spaced than those of *E.* sp. A.

We regard, therefore, the number, strength, and spacing of the longitudinal lirae as useful but not infallible specific characters. A general study of *Euphemites* might show some developmental trends involving the lirae, but our brief review of Mississippian and Pennsylvanian species has not demonstrated any yet. Perhaps if lineages within the genus were established on whorl profile and shape, general patterns of ornamentation might then be recognized.

The least important character in differentiating species of *Euphemites*, involves the selenizone, its width, elevation, and its relationship to the slit and apertural margin. Like the liration, all these features are variable. The number of lirae on the dorsum that occupy the selenizone width commonly may vary by one in the same population. The fine lira bordering either side of the selenizone is not always continuous with one of the lirae ornamenting the main part of the dorsum; on some specimens, it may be present between two more prominent dorsal lirae. It would seem, therefore, that the number of lirae within the selenizone area varies with spacing of lirae over the dorsum, but the relative width of the selenizone remains fairly constant. Elevation of the selenizone also seems to vary; some specimens from a single locality have the selenizone elevated and others do not. On *Euphemites randolphensis* (Weller), however, the selenizone occupies a generally elevated area. On most *Euphemites*, the slit is relatively short; on some, it may approximate one-sixth of a whorl.

American Mississippian species of Euphemites.—
compressus Elias, 1958 [probably not recognizable]
cracens n. sp.
galericulatus (Winchell), 1862 (*Bellerophon*) [synonym: *Bellerophon nautiloides* Winchell, 1862]
incarinatus Easton, 1943
?lentiformis (S. Weller), 1916 (*Euphemus*)
nevadensis Gordon and Yochelson, 1983
randolphensis (S. Weller), 1920 (*Euphemus*)
sacajawensis C. Branson, 1937
sedaliensis (Miller and Gurley) 1896 (*Bellerophon*)
subglobosus Hyde, 1953

Ten bellerophontacean species described from Mississippian rocks in the United States belong in this genus. Five of them occur in the Lower Mississippian. One of the lowest stratigraphically is *Euphemites subglobosus* Hyde, from the Byer Member of the Logan Formation in Ohio. This species is recognized by its subglobose shape, its diameter/width ratio being 0.75; by its flat sides without umbilical depressions; and by its longitudinal sculpture of 25 to 30 lirae in mature shells. The selenizone is raised near the aperture and marked by a faint median ridge; the slit is shallow.

Much less well understood is *Bellerophon sedaliensis* Miller and Gurley, from the Chouteau Limestone of Missouri, the type lot of which was interpreted by Branson as containing two distinct species. According to Branson (1938, p. 103, 104), one of the two syntypes figured by Miller and Gurley (1896, p. 21, pl. 3, figs. 9, 10) is an internal mold of *Bellerophon blairi* Miller and Gurley. The other has longitudinal lirae, and we consider it to be a *Euphemites*. It is the one figured by Miller and Gurley (1896) on their plate 13, figure 13 and by Branson (1938) on his plate 14, figure 14. A specimen from Cooper County, Mo. (USNM 66828), 14 mm in length and 10 mm in width, was collected and identified as *E. sedaliensis* (Miller and Gurley) by Charles Schuchert. This specimen shows that the mature shell has a slightly galeiform shape, having a narrow dorsum somewhat flattened on top, and rather widely spaced longitudinal lirae. This shape is similar to that of *E. galericulatus* (Winchell).

Euphemites galericulatus (Winchell) and *E. nautiloides* (Winchell), both from the Marshall Formation of Michigan, are inadequately known by present standards, and the types were never figured. We have examined unpublished notes of G. H. Girty, which record his restudy of Winchell's material. Girty concluded that *E. nautiloides* was based upon poorly preserved specimens of *E. galericulatus,* which is somewhat variable in width. If so, the attempt by Hyde (1953, p. 322, 323, pl. 46, figs. 21–26) to differentiate the two species according to Winchell's measurements, and the comments of Elias (1958, p. 2) on Hyde's probable mixture of two species are inapplicable. As we now understand this species, *E. galericulatus* includes specimens having a galeiform shape and many lirae, those lirae on the flanks being irregular and oblique to those on the principal part of the shell. Herrick's (1888, pl. 2, fig. 34; pl. 9, figs. 32a, b) illustrations of *E. galericulatus* add little to our understanding of the species. Furthermore, the specimens illustrated by Butts (1941, pl. 125, figs. 19–22) as *E. galericulatus* and deposited in the USNM, specimens that we have examined, are not correctly identified. At least one has ornamentation like that of *Retispira*; all are specifically indeterminate.

The rest of the species of *Euphemites* are from the Upper Mississippian. The one Meramecian form, *Euphemites lentiformis* (Weller), from the Ste. Genevieve

Limestone in Illinois, is small, subdiscoidal, lenticular in cross section, has a very narrow dorsum, and is ornamented by very faint lirae. It is strikingly different from other species of *Euphemites* and probably should not be included in the genus.

The earliest Chesterian species is *E. randolphensis* (S. Weller), from the basal part of the Okaw Limestone of Illinois; it has a small- to medium-sized subglobose shell generally having a slightly raised mid-dorsum, bulging flanks, and well-developed umbilical depressions, all of which tend to give the whorl a trilobed cross section. On some specimens, this trilobation is accentuated by a pair of swellings, one on each flank, on the smooth part of the whorl, just beyond the longitudinal lirations, of which approximately 30 occur on an average specimen. This species was described and illustrated in detail by Thein and Nitecki (1974, p. 38–42).

Euphemites incarinatus Easton, from the Pitkin Limestone of Arkansas, is a subglobose to globose species, narrower in the early stages, without umbilical depressions, and ornamented by more than 40 longitudinal lirae on the adult shell. The selenizone must be flush with the shell surface and not carinate, as this feature is so obscure that it never has been differentiated. On a broadly subglobose specimen in the USNM collection, 22 mm long, the lirae are very fine and faint and the overall shape is remarkably like that of *Bellerophon*, especially where the lirae are absent or obscured by wear.

Euphemites compressus Elias, from the Redoak Hollow Member of the Goddard Shale, Oklahoma, is inadequately known. Elias's species was illustrated only from the holotype, an incomplete juvenile shell, 4 mm long; in our opinion, it cannot be distinguished from the young stages of several other species. According to P. K. Sutherland (written commun., 1974) of the University of Oklahoma, this specimen is lost and no additional specimens are known. In 1954, Gordon and C. W. Tomlinson visited Elias's localities in the Redoak Hollow but found no additional gastropods. We are informed also by Sutherland (oral commun., 1973) that Elias and C. C. Branson searched for remnants of the limonitic sandstone that had provided Elias's original material, also without success. It seems, therefore, that no material is available to represent this species, and we recommend that the name *E. compressus* Elias be restricted to the holotype, if it still exists.

Of the nine named Mississippian species reviewed above, one (*E. compressus*) is unrecognizable, one (*E. nautiloides*) is probably synonymous with another (*E. galericulatus*), one (*E. sedaliensis*) is poorly understood, and a fourth (*E. lentiformis*) is not a typical *Euphemites*. Five species seem to be reasonably well established. We recognize five others from the Chainman Shale of Utah. Two of these are previously named western species, *E. nevadensis* Gordon and Yochelson and *E. sacajawensis* C. Branson, and another *E. cracens*, is described as new; two others are new, but the material is inadequate to be formally named. One specimen, from the *Lunulazona sadlicki* assemblage at Granite Mountain (USGS colln. 17092–PC) is unidentifiable but seems closest to *E.* sp. A. Three silicified specimens from the Wallet Gulch section (USGS colln. 17214–PC) were identified as *Euphemites*? sp. indet.

Euphemites cracens n. sp.

Plate 2, figures 9–11

Diagnosis.—Somewhat compressed bellerophontaceans having well-rounded dorsum, ornamentation of fine, widely spaced lirae, and umbilical indentations.

Description.—Early growth stages unknown. Shell smoothly curved in longitudinal profile, not geniculate. Dorsum rounded, following arc of small circle, flanks somewhat flattened so that profile in cross section is distinctly compressed; periphery more than three-fourths of distance from dorsum to axis of coiling. Umbilical depression at either side of shell shallow and relatively narrow. Growth lines distinct, visible beneath covering inductura of mature part of shell; orthocline from umbilicus to beyond periphery, then curving smoothly prosocline and forming wide shallow U-shaped sinus over dorsum. Longitudinal ornamentation of fine lirae, relatively low and narrow, having interspaces three or four times width of each lira; 24 lirae present on holotype, those nearest umbilici somewhat irregularly interrupted during development. Shell surface smooth near aperture, but selenizone present, bounded by very fine lira at either side, corresponding in width to slightly less than six middle lirae on dorsum. Slit depth and other apertural details unknown. At least one-fourth of mature body whorl covered by thin smooth inductura.

Dimensions.—Holotype, partly crushed on one side near aperture, measures 10.4 mm in length and 8.2 mm (twice half width) in width.

Discussion.—This species is known only from two specimens. The holotype is well preserved and comes from the northeastern end of the Foote Range, a few feet above a bed containing the ammonoid *Richardsonites merriami* (Youngquist). The paratype, poorly preserved, was found in a bed containing *R. merriami* in the Conger Range, 21.5 miles (34.4 km) due south of the first locality. Both specimens are associated with *Euphemites* sp. A. They are readily distinguished from that species by a more slender delicate shell, a more narrowly rounded dorsum, and umbilical depressions at maturity; narrow lirae and wide interspaces in *E. cracens* contrast with the fairly thick lirae and narrower interspaces of *E.* sp. A.

This species is not as compressed as *E. galericulatus* (Winchell), *E. sedaliensis* (Miller and Gurley), and *E. subglobosus* Hyde, all of which have length/width ratios of about 0.75 in comparison with 0.79 for *E. cracens*. *E. galericulatus* differs further in its galeiform shape and irregular oblique lirae on the lower flanks. Specimens of *E. sedaliensis* differ in having a more narrowly rounded dorsum and much broader umbilical depressions. *E. subglobosus* differs also in having more closely spaced lirae over the dorsum.

The only moderately narrow Pennsylvanian species, *E. multiliratus* Sturgeon, from the Vanport Limestone of Ohio, is somewhat less compressed than the Chainman form but is otherwise similar in shape. It has more numerous lirae than *E. cracens*.

Types.—Holotype USNM 210923; paratype USNM 210924.

Occurrence and number of specimens.—USGS collections 22880–PC (1), 22883–PC (1), Millard County.

Euphemites nevadensis Gordon and Yochelson

Plate 2, figures 5, 6

Euphemites nevadensis Gordon and Yochelson, 1983, p. 973–974, figs. 1A–G.

Discussion.—This species was described from the Diamond Peak Formation in east-central Nevada. Additional specimens have been identified in the collections from the Chainman Shale, and one is figured from the Jensen Wash section, Burbank Hills.

Euphemites nevadensis probably belongs to the same species group as *E. vittatus* (McChesney) and *E. blaneyanus* (McChesney). It is well rounded across the dorsum, and it is not geniculate. This species differs from those two common Pennsylvanian species in lacking any indication of lateral nodes in the columellar area. Presumably the difference between a smooth inductural layer and one bearing nodes is related to a different configuration of the area of the mantle that deposited this layer.

Figured specimen.—USNM 211078.

Occurrence and number of specimens.—USGS collections 17056–PC (1), 17188–PC (1), 17209–PC (1), 17219–PC (1), 25547–PC (1), 25550–PC (2), ?25566–PC (4), Millard County.

Euphemites sacajawensis C. C. Branson

Plate 2, figures 14, 15

Euphemites sacajawensis C. C. Branson, 1937, p. 658, 659, pl. 89, fig. 25 [not figs. 24, 33]; Gordon and Yochelson, 1975, p. F10, F11, pl. 1, figs. 7–9 [not figs. 6, 11–13].

Discussion.—The primary types of this species from the Amsden Formation of Wyoming were redescribed and refigured by Gordon and Yochelson (1975, p. F10, pl. 1, figs. 6–9, 11–13), who suggested that two different forms might be represented. The holotype would constitute one form and the figured paratypes, the other. At that time, the unfigured paratypes were not available, but we have since had the opportunity to study them. The holotype is a distinct specimen. However, we believe that all but one of the paratypes represent a second species of *Euphemites*. The remaining paratype is a steinkern, probably of the gastropod we described in the Amsden report as *Knightites* (*Retispira*) sp. A. We recommend, therefore, that the characters of *E. sacajawensis* be restricted in concept to the holotype; our description of that species in the Amsden report was based solely upon that specimen, a small globose *Euphemites* having deep infundibuliform umbilical depressions and ornamented by 22 strong rounded spiral lirae having interspaces about twice as wide as the lirae. Although the paratypes are well enough preserved to define another species, it is not appropriate to do so here.

The globose shells from the Heath Formation of Montana described by Easton (1962, p. 98, pl. 13, figs. 9, 10) as *E. sacajawensis* C. Branson lack the infundibuliform umbilical depressions and have 22 to 28 elevated, flat-sided spiral lirae. They probably represent still another species, closely related to if not identical with *Euphemites* sp. A in the Chainman Shale.

Specimens from the Burbank Hills, Utah, occur in the *Glabrocingulum* (*Ananias*) *seminudum* assemblage, the stratigraphically highest gastropod faunule in the Chainman Shale. The shells have prominent infundibuliform umbilici and 22 or rarely 23 longitudinal lirae. As these are the principal characters upon which the identification of *E. sacajawnesis* rests, we are reasonably certain in referring these Utah shells to Branson's species. The umbilici, however, seem a little wider than in the holotype of *E. sacajawensis*. One other specimen, in the *Glabrocingulum quadrigatum* assemblage in the section at Granite Mountain is also referred to this species.

Figured specimen.—USNM 210932.

Occurrence and number of specimens.—USGS collections 25249–PC (1), Juab County; 17059–PC (2), 17217–PC (4), 25548–PC (1), Millard County.

Euphemites sp. A

Plate 2, figures 1–4

Discussion.—Specimens of a well-rounded *Euphemites* occur in the upper part of the Chainman Shale in the general area and can be described as follows: Globose bellerophontaceans ornamented by numerous closely spaced longitudinal lirae. Shell

smoothly curved, without geniculation. Earliest growth stages unknown. Whorls anomphalous, having shallow umbilical indentations in immature stage which are lacking at maturity; shell becoming inflated with growth so that mature profile in cross section is approximately semicircular from columellar areas across dorsum. Ornamentation of 22 to 28 prominent coarse lirae, more or less uniformly spaced across dorsum but a little closer near umbilical region, having interspaces approximately twice as wide as individual lirae. Lirae distinctly elevated, having straight nearly vertical sides and rounded on top; each lira continuous for at least one whorl, new lirae added rarely in columellar areas and even less commonly on dorsum. Mature part of aperture covered by smooth inductura.

This material, despite including shells as long as 18 mm, contains no complete specimens, so the details of the smooth area near the aperture, the selenizone, and the lip are not available. Most of the specimens are otherwise well preserved.

In its globose shape and the coarseness of its lirae, this species shows some similarity to *Euphemites sacajawensis* C. C. Branson, which was based upon a specimen from the Amsden Formation of Wyoming. It differs from *E. sacajawensis*, however, in lacking infundibuliform umbilical depressions and in the shape of its spiral lirae, which are straight-sided and lathlike, rather than low and rounded. These lirae of *E.* sp. A resemble those seen on the specimens from the Heath Formation of Montana, specimens that Easton (1962, p. 98) referred to *E. sacajawensis* but that we do not include in that species. Study of larger suites of specimens from both Montana and Utah is necessary to show whether or not they are conspecific.

Figured specimens.—USNM 210925, 210926.

Occurrence and number of specimens.—USGS collections 17189–PC (1), 22880–PC (7), 22883–PC (2), 25551–PC (1), Millard County.

Euphemites sp. B

Plate 1, figures 27, 28

Discussion.—A single steinkern, having patches of shell adhering at the umbilical region on both sides and to a partial external mold, differs in several characters from the common *Euphemites* sp. A. This specimen is 10.3 mm long and 9.7 mm wide. It was collected from the uppermost fossiliferous bed of the *Goniatites americanus* Zone in the Granite Mountain section and is presumably late Meramecian in age. Although comparisons of shape are difficult because all our specimens of *Euphemites* sp. A retain their shell, this form seems slightly less globose than that species. The sculpture differs in that the longitudinal lirae are narrower and the interspaces wider than in *E.* sp. A, and the lirae around the umbilicus are broken into a succession of short dashlike segments, rather than being only locally interrupted as in *E.* sp. A.

The specimen is particularly interesting because the inner part of the slit is preserved on the steinkern. This is approximately parallel sided, 2 mm wide, and has a U-shaped rather than V-shaped termination; what remains of the slit is 4.5 mm long. The outer lip is broken back, so an exact measurement cannot be taken, but part of the curved lip near the umbilicus is preserved. Although the slit depth is thus less than the maximum during life, probably little shell was lost by this breakage. The slit depth was somewhat less than one-fourth whorl, but certainly deeper than in *E.* sp. A.

Figured specimen.—USNM 210927.

Occurrence.—USGS collection 17018–PC, Juab County.

Family BELLEROPHONTIDAE

Subfamily BELLEROPHONTINAE

Genus BELLEROPHON Montfort, 1808

Subgenus B. (BELLEROPHON) Montfort, 1808

Discussion.—In contrast to genera such as *Euphemites* or *Knightites, Bellerophon* (*Bellerophon*) has a shell that lacks prominent ornamentation. The other two currently recognized subgenera of *Bellerophon, B.* (*Aglaoglypta*) and *B.* (*Pharkidonotus*), bear quincuncial ornament or nodelike irregularities, respectively. The typical shell of *Bellerophon* (*Bellerophon*) has a surface that ranges from polished to slightly roughened by irregularly spaced growth lines; no strong collabral ornament is developed. A few species have been described as *Bellerophon* in which sublamellose transverse ornamentation is rather prominent, and these species are tentatively included in the typical subgenus. Several other species included in this genus combine prominent transverse costae and a wide deep umbilicus; we believe that these should be reassigned but consider the problem as outside the scope of this paper. So far as we can determine, *Bellerophon mansfieldianus* Girty, from the Madison Limestone of Idaho, is the only described American species that belongs in this category.

Because the ornamentation of the shell in this subgenus is relatively simple, considerably more emphasis than usual must be placed on shell shape. Shells of typical *Bellerophon* (*Bellerophon*) range in cross section from subhemispherical to bell- or helmet-shaped. Some important differences occur in the umbilical region and adjacent parts of the aperture. The type species of *Bellerophon* (*B. vasulites* Montfort) is minutely phaneromphalous. Most species included in the sub-

genus, however, are anomphalous, some having shallow umbilical depressions and others lacking depressions.

Some differences also may be observed in the posterior part of the aperture, particularly where the inner lip joins the main body of the shell. In some species, the inner lip is produced posteriorly at either side as a flaring shelf, particularly in specimens that are phaneromphalous or possess prominent umbilical depressions. Other species have the inner lip massive and subcylindrical, joining the shell at a fairly narrow angle without flaring; this feature is particularly characteristic of species in which umbilical depressions are small or lacking. If the inner part of the lip adjacent to the columellar region is essentially straight, the approximate angle that it makes relative to the axis of coiling may vary between species. In many species, this part of the lip is not straight but is sinuate and reflexed backward to form a shallow excavation adjacent to the columellar region. Although details of this area have been neglected in most descriptions of Mississippian and Pennslyvanian forms, they have been used to differentiate North American Permian species.

Another important feature for distinguishing species of *Bellerophon* is the selenizone and its various characteristics. We would place weight on whether the selenizone is essentially flush with the dorsal shell surface or raised in some way. The selenizone of several species is raised and flat topped. In some species, the selenizone is delineated at either side by shallow sulci. In still other species, the selenizone is bordered by a prominent raised cord at either side. Lunulae are generally rare on the *Bellerophon* selenizone.

As in most emarginate gastropods, the relative depth of the slit remains an untested specific character. Our impression is that the selenizone in most *Bellerophon* species is relatively narrower than that of other late Paleozoic bellerophontaceans. A few species do have a relatively wide selenizone; this may be a significant species character.

The inductura is of little significance as a species characteristic in *Bellerophon* (*Bellerophon*). It commonly is present as a thin unornamented sheet, which extends only a short distance outside the aperture. Prominent development of a boss is rare in this subgenus.

Finally, we return to the subject of surface ornamentation, which at the outset we said is not a major character in differentiating species of *Bellerophon*. It nevertheless has some utility. Some *Bellerophon* shells are smooth and have very fine growth lines or striae. Other species have what might be described as microlamellae, which are slightly raised on the adapertural side. Still others are sublamellose, and some are fully lamellose. All these characters in combination with one another are useful for distinguishing between the various species of *Bellerophon* (*Bellerophon*).

American Mississippian species of Bellerophon (Bellerophon).—
chesterensis S. Weller, 1920
claxtonensis Thein and Nitecki, 1974
gibsoni White, 1882
majusculus Walcott, 1884
?*mansfieldianus* Girty, 1927
menardensis Thein and Nitecki, 1974
needlensis n. sp.
panneus White, 1862
pitkinensis Snider, 1915
scissilis Conrad, 1844 (as *B. scissile*)
spergenensis Gordon and Yochelson, 1983
[n. nom. for *B. sublaevis* Hall, 1856, not Potiez and Michaud, 1838]
vespertinus Gordon and Yochelson, 1983
welshi n. sp.

Although 35 bellerophontaceans in the United States were described as *Bellerophon* from Mississippian rocks (Yochelson and Saunders, 1967, p. 37–39), probably no more than 11 valid species of *B.* (*Bellerophon*) are represented in the Mississippian as presently defined. To these we add in this report two more named species. Other bellerophontaceans originally described as *Bellerophon* are transferred to different genera in this report and are discussed under those genera.

Although we agree that *Bellerophon bilabiatus* White and Whitfield and *B. vinculatus* White and Whitfield, from the English River Formation of Iowa, *B. helena* Hall, from the Bedford Shale of Ohio, and *B. jeffersonensis* Weller and *B. ulrichi* Weller, from the Glen Park Limestone of Missouri, should be included in *Bellerophon* (*Bellerophon*), they all come from rocks formerly included in the Kinderhookian but now regarded as Late Devonian in age.

The remaining *Bellerophon* species from rocks still considered to be Early Mississippian in age are poorly established. Moreover, no anomphalous *Bellerophon* has been described in the Early Mississippian of North America. *B.* (*B.*) *panneus* White occurs in the upper Devonian English River Formation at Burlington, Iowa, but the imperfect and distorted types come from a somewhat higher horizon, according to Weller (1900, p. 114). Weller (1901, p. 203, pl. 20, figs. 14, 18) illustrated one of White's types and suggested that the specimen illustrated by Keyes (1894 [1895], pl. 50, fig. 3) as *B. bilabiatus* was a good example of *B. panneus*. The shell of this species is medium sized, a little wider than long, broadly umbilicate, having a narrow selenizone

that is subcarinate toward the aperture and a broad notch on the outer lip.

Bellerophon blairi Miller and Gurley, from the Chouteau Limestone of Missouri, as redescribed and figured by Branson (1938, p. 103, pl. 14, figs. 2–4), has a compressed shell with a flaring aperture. It does not belong in the genus *Bellerophon*, but, from the information available, we are unable to assign it to any of the explanate bellerophontacean genera. *Bellerophon scotti* Branson, from the Northview Shale of Missouri, was described from steinkern and cannot be compared. One cannot even be certain that this is a *Bellerophon*.

Bellerophon whittleseyi Winchell, from the "Marshall Sandstone" of Cuyahoga County, Ohio, was based upon a unique specimen figured by Whittlesey (1851, p. 219, figs. 1, 2) as a goniatite. The illustrations and Winchell's subsequent description show some significant discrepancies, which we are unable to resolve. Relying on the illustrations alone, we would conclude that the specimen is a platyceratid rather than a bellerophontacean; we cannot, however, exclude its being a *Sinuitina*, as is suggested by Winchell's statement that it resembles *B. rugosiusculus* Winchell. We are transferring this species arbitrarily to *Platyceras*, and we recommend that this specific name not be used again until such time as Whittlesey's specimen is reexamined.

Owen (1852, p. 627) listed as *Bellerophon hiulcus* Sowerby? (originally one of Martin's species), a poorly preserved steinkern from the Keokuk rapids of the Mississippi River. This record was cited as "*Bellerophon hiuleus* Owen" by Weller (1898, p. 139) in his bibliographic index of North American Carboniferous invertebrates. Owen's specimen was unidentifiable and certainly provided no basis for recognizing this northwest European bellerophontacean in the American Midcontinent.

Four species of *Bellerophon* (*Bellerophon*) were described from rocks of Meramecian (early Late Mississippian) age in the United States. The most common of these is *B.* (*B.*) *spergenensis* Gordon and Yochelson [=*B.* (*B.*) *sublaevis* Hall, 1856, not *B. sublaevis* Potiez and Michaud, 1838] from the Salem Limestone of Indiana. This is a moderate-sized smooth subglobose species having the last whorl somewhat inflated, the inner lip of the aperture meeting the umbilical areas at a very low angle to the axis of coiling, a narrow flat to slightly raised selenizone, and a relatively shallow slit.

The rest of the Meramecian bellerophons are generally large species. *B.* (*B.*) *scissilis* Conrad was described from Ste. Genevieve, Mo. Although Conrad did not figure this species or identify the formation and precise locality from which he obtained his type, his description fits a large species of *B.* (*Bellerophon*) that occurs in a shale bed approximately in the middle of the Ste. Genevieve Limestone in quarries in the northern environs of Ste. Genevieve, Mo. Silicified red-weathering shells of this handsome species in USNM and USGS collections reach a maximum length of slightly more than 85 mm. Many have parts of the raised selenizone weathered away, accounting for the "profound channel" mentioned in Conrad's description; actually the slit is relatively short. The shell is subglobose, the aperture is flared adjacent to the umbilical areas, and the surface is distinctly lamellose.

B. (*B.*) *gibsoni* White is a slightly smaller species, inadequately based upon a steinkern, from the St. Louis Limestone in the vicinity of Greencastle, Ind. Knight (1947, pl. 42, figs. 3a–c) figured another steinkern, from Greencastle Junction, that seems to be the same as White's form. Until its external characters are determined, one cannot separate this species readily from *B.* (*B.*) *scissilis*. Undescribed silicified specimens from St. Louis Limestone at other localities in the northern Midcontinent are present in the USNM collection; these certainly differ from *Bellerophon scissilis*, but it is not clear whether or not they are conspecific with *B.* (*B.*) *gibsoni*.

The largest North American Mississippian species is *B.* (*B.*) *majusculus* Walcott, from the Diamond Peak Formation in the Eureka District, Nev., the holotype of which is 105 mm long. This narrowly subglobose shell has well-rounded dorsolateral slopes and a prominent raised carina set off by shallow sulci.

Four species were described from rocks of Chesterian age in the United States. *B.* (*B.*) *chesterensis* S. Weller, from the basal part of the Okaw Limestone of Illinois, is a small rotund anomphalous species having a low crest and a thickened inner lip that joins the columellar area at an angle of roughly 60° to the axis of coiling; its narrow convex selenizone becomes somewhat elevated during growth. *B.* (*B.*) *claxtonensis* Thein and Nitecki from the Golconda Formation and Menard Limestone of Illinois has an anomphalous shell, highly arched dorsally, slightly longer than wide, and having a narrow, slightly raised selenizone terminating in a short slit, the smooth surface of the shell ornamented only by indistinct growth lines. *B.* (*B.*) *menardensis* Thein and Nitecki from the Menard Limestone, intermediate in general shape between *B.* (*B.*) *chesterensis* and *B.* (*B.*) *claxtonensis*, has an evenly round whorl profile tending to flatten somewhat toward the aperture. The narrow selenizone is flush with the whorl surface except near the aperture, where it is slightly elevated and bordered by shallow grooves. The umbilical depressions are closed by thickened shell and a parietal inductura covers about one-fifth of the last whorl. *B.* (*B.*) *pitkinensis* Snider, from the Pitkin Limestone in Oklahoma,

was poorly illustrated, and its description is lacking in various details. It has a subglobose shell bearing a prominent dorsal carina that widens anteriorly and is set off by shallow sulci.

Diagenesis in the Willow Gap Member of Sadlick (1966) in the Confusion Range has strongly affected some of the Chainman bellerophons. Many are coarsely silicified and some have the external shell layer leached. For this reason, most of the specimens could only be identified as *Bellerophon* (*Bellerophon*) sp. indet., as in USGS collections (number of specimens in parentheses) 14558–PC (1), 15355–PC (1), 15361–PC (2), 15362–PC (3), 15363–PC (1), 17023–PC (1), 25563–PC (4), or *B.* (*Bellerophon*)? sp. indet. as in USGS collection 25271–PC (1).

Bellerophon (Bellerophon) vespertinus Gordon and Yochelson

Plate 1, figures 24–26

Bellerophon (*Bellerophon*) *vespertinus* Gordon and Yochelson, 1983, p. 975–976, figs. 1 H–N.

Discussion.—This species was described from east-central Nevada. Specimens are common, though scattered through many localities, in the upper part of the Chainman Shale; indeed, this is the most abundant of the bellerophontacean species, and a few good specimens have been obtained. However, the bellerophontaceans do not begin to approach the abundance of *Glabrocingulum* in the gastropod fauna.

The raised selenizone distinguishes *B.* (*Bellerophon*) *vespertinus* from *B.* (*B.*) *welshi*, and the subquadrate shape further contrasts with the rounded profile of that species. This subquadrate shape also distinguishes this species from *B.* (*B.*) *needlensis*, which has a narrower dorsum. However, these details of shape are subject to the vagaries of preservation. For a time, some of the Utah specimens were thought to constitute a distinct species, being laterally compressed and bearing a channeled selenizone. Other Utah specimens do show areas where the selenizone is raised; still other associated specimens are not compressed (pl. 1, figs. 24–26). This is an excellent example of the advantage of having a large sample for study.

Figured specimen.—USNM 210934.

Occurrence and number of specimens.—USGS collections 17087–PC (2), Juab County; ?15358–PC (1), ?16997–PC (1), ?17059 (1), 17217–PC (3), ?22880–PC (1), 25551–PC (18) Millard County.

Bellerophon (Bellerophon) welshi n. sp.

Plate 1, figures 12–14

Diagnosis.—Medium-sized globose *Bellerophon*, having semi-oval transverse whorl profile; surface smooth but microscopically sublamellose; selenizone narrow, flush.

Description.—Shell broadly rotund; transverse whorl section gently convex over dorsum, more strongly rounded dorsolaterally, and sloping steeply and nearly straight on flanks, forming smooth curve between columellar areas. Selenizone narrow, flat-topped, generally flush with surface but raised slightly locally, particularly in more juvenile part. Aperture reinform in section; shell anomphalous; lip thick adjacent to columellar areas, projecting outward and forward at angle of about 45° to axis of coiling. Inner side of aperture covered by thin inductura, extending considerably farther up lateral slopes than on dorsum. Outer lip unknown. Surface smooth, verging on polished. Growth lines faint and closely spaced, but appearing microscopically sublamellose, bowing gently toward aperture, but essentially orthocline from columellar areas to about half distance to selenizone, then curving gently prosocline for remainder of distance, becoming a little more strongly arched adjacent to selenizone. Lunulae within selenizone evenly curved and of same strength as growth lines. Slit not known but probably relatively shallow and probably less than one-quarter whorl in depth.

Dimensions.—Holotype, lacking final one-quarter volution of shell, measures 20.7 mm in length and 23.5 mm in width.

Discussion.—The holotype is a well-preserved but incomplete specimen collected in the Burbank Hills; several poorly preserved specimens are also referred to this species. Traces of coloration may be present in the holotype, as the main part of the shell is dark-grayish-brown and the inductura is chocolate brown.

In the development of an apertural inductura and in having a flush selenizone, this species is similar to *B.* (*Bellerophon*) *spergenensis* Gordon and Yochelson. However, that form is narrower and more highly arched over the dorsum. The Chainman shell is also somewhat like *B.* (*B.*) *chesterensis* Weller, except that the Illinois species is more semicircular in profile, has a narrow raised rounded selenizone throughout growth, and an inner lip with an even greater angle (60°) to the axis of coiling. Perhaps the species most like *B.* (*B.*) *welshi* is *B.* (*B.*) *menardensis* Thein and Nitecki. Both species have a broad rounded whorl profile and generally flush selenizone. *B.* (*B.*) *menardensis* differs in having a less smooth outer shell surface and in the narrower angle the inner lip makes with the axis of coiling of the shell.

B. (*B.*) *welshi* is distinguished from all the other Chainman species by having a broad curvature of the transverse whorl profile and the flush selenizone. It is named for J. E. Welsh, who collected the holotype.

Types.—Holotype USNM 210928; paratypes 210929, 210933.

Occurrence and number of specimens.—USGS collections 17310–PC (2), 25274–PC (1), Millard County.

Bellerophon (Bellerophon) needlensis n. sp.

Plate 1, figures 18–20

Diagnosis.—Medium-sized globose *Bellerophon* having strongly oblique inner lip and narrowly arched whorl profile; surface smooth except for closely spaced growth lines; selenizone narrow, convex.

Description.—Shell slightly longer than wide, rather highly arched; transverse whorl profile somewhat bell shaped, having rather narrow rounded dorsum curving to sloping, nearly flat sides that flare very slightly near aperture. Arcuate dorsal profile interrupted medially by slightly raised narrow convex selenizone; lunulae well formed, rather irregularly spaced. Shell anomphalous; shallow cavity present at either side behind inner margin of lip, but no true umbilical depression. Inner part of lip thick, joining main part of shell approximately at 45° to axis of coiling. Growth lines forming shallow adaperturally convex curve for approximately three-fourths distance across shell, curving gently prosocline on dorsum, but more steeply near selenizone so as to meet it at low angle; growth lines very fine and closely spaced, but some coarser ones irregularly interspersed; none appear lamellose, even microscopically. Aperture imperfectly known, but judging from growth lines, marked by a medial narrow subtriangular notch; depth of slit unknown but presumably relatively short.

Dimensions.—Holotype is 33.5 mm long, 30.0 mm wide, and 25.5 mm high at right angles to length.

Discussion.—This species is based upon two specimens from the northern part of the Needle Range. They occur in the upper part of the Chainman Shale, 10 to 12 feet (3.0–3.7 m) below a bed containing the ammonoid *Richardsonites merriami* Youngquist. Two more specimens, one fairly complete, from the upper part of the Willow Gap Member of Sadlick (1966) in the Skunk Spring section also belong in this species.

B. (B.) needlensis is differentiated from *B. (B.) welshi* n. sp. by its more highly and narrowly arched oval whorl profile and its distinctly raised selenizone. Two other Chainman species, *B. (B.) vespertinus* Gordon and Yochelson and *B. (Bellerophon?)* sp. also have raised selenizones, but the oval profile of *B. (B.) needlensis* distinguishes it from the more trapezoidal whorl profile of both these taxa. *B. (B.) chesterensis*, from the Okaw Limestone of Illinois, is about half the size of *B. (B.) needlensis*; it has a slightly lower selenizone and is intermediate in shape between *B. (B.) needlensis* and the two species mentioned above.

Types.—Holotype USNM 210930; paratype 210931.

Occurrence and number of specimens.—USGS collections 15160–PC (2), ?25272–PC (2), Millard County.

Bellerophon (Bellerophon?) sp. A

Plate 1, figures 15–17, 21–23

Discussion.—Another *Bellerophon* is known from a few fragments and from a single immature specimen, 5.8 mm long and 5.5 mm wide, collected from shale overlying the *Richardsonites merriami* bed in the Foote Range measured section. This species has a subtrapezoidal whorl profile, thick shell, rugose outer surface, and a prominent raised and rounded median crest occupied by the selenizone. The crest is wider, more elevated, and therefore more prominent than the one in *B. (B.) vespertinus* n. sp., and the flanks are more flattened. The aperture is slightly inflected at the umbilical areas and shows a tripartite shouldered profile on the outer side. The shell surface is uneven, forming irregularly spaced collabral ridges or small varices at points of interruption of growth. Also present are numerous tiny collabral lamellae.

The shapes suggest that these specimens could be immature individuals of *B. (B.) majusculus* Walcott, described from the lower Carboniferous of the Eureka district, Nevada, but the holotype of that species is 20 times larger than our most complete specimen, and its whorl profile is a little more rounded. A comparison of these dissimilar ontogenetic stages in the absence of well-preserved intermediate growth stages is not warranted.

The shouldered profile of the Utah shell also resembles that of the subgenus *B. (Pharkidonotus)* Girty, but that group is only known in rocks of Pennsylvanian and Permian age. As the shape of mature specimens of this species is not known, we cannot place it with certainty in either subgenus of *Bellerophon*.

Figured specimens.—USNM 210935, 211085, 211086.

Occurrence and number of specimens.—USGS collections 22883–PC (2), 25275–PC (5 fragments), Millard County.

Subfamily KNIGHTITINAE

Genus RETISPIRA Knight, 1945

Discussion.—*Retispira* has been used both as a subgenus and a genus. We follow Batten (1972, p. 13) in treating it as a full genus. It is by all standards the most complex genus within the subfamily Knightitinae. Our study of the Chainman Shale gastropod fauna

led us to examine many Mississippian and Pennsylvanian species of *Retispira*. These species have many features in common, and we do not feel prepared to recognize any separate phylogenetic stocks. However, as a consequence of our close examination of the well-preserved Chainman specimens, we did observe features that clarified our general understanding of the group.

The relative importance of various morphologic features in differentiating species cannot be ranked with certainty, but general shape obviously must be of prime significance. Specimens of *Retispira* range from relatively narrow compressed forms to those that expand at a fairly rapid rate and approach a lenticular shape. This rate or degree of lateral expansion is not exploited widely as a specific character, and its delineation is still highly qualitative. Associated with general expansion is presence or absence of geniculation, which may result either from flattening to form an explanate aperture or from the development of a prominent boss. None of the Chainman specimens that we describe develops a prominent inductural boss within the aperture, but at least one has this incipient feature some distance back within the aperture. We suspect that development of a boss may be a feature of maturity and also that it may be more common in the broader species.

All the species that we examined show an ontogenetic change in the whorl profile. In general, shells are narrowly rounded dorsally in the juvenile state, become more inflated as maturity approaches, and eventually may have a rather flat dorsum. Ontogenetic change seems to have been generally neglected in descriptions of bellerophontaceans, and we emphasize it here. Any meaningful comparison of species should be made with specimens of the same approximate size.

The umbilical region of *Retispira* ranges from phaneromphalous to anomphalous. Most species have a narrow to minutely phaneromphalous umbilicus. This latter condition is difficult to differentiate from an umbilical depression in which none of the inner whorls are visible. The expansion of the inner part of the lip commonly marks the umbilical region, and, when broken specimens are examined, this area of the shell is difficult to interpret. Although a moderately wide umbilicus may be an important differentiating character, we are less certain of the significance of a narrow umbilical chink versus a false umbilicus.

The shape and ornamentation of the selenizone have been neglected as significant characters. The Chainman Shale species include those that have a flattened flush selenizone and those that have the selenizone arched. This obvious character is reinforced further by more subtle differences in the size and spacing of the lunulae and the degree to which spiral lirae occur on the selenizone. In general, all specimens of *Retispira* in which the slit is known have an emargination that is quite short and generally less than one-sixth of a whorl in depth. Although we have not investigated this matter in detail, we suspect that some importance may be attached to the relative width of the selenizone as well as to its profile.

The reticulate ornamentation is probably the most obvious feature of this genus. The ornament is best considered by studying its two components independently. In this group, the term "collabral ornamentation" is particularly appropriate, for only the occasional growth line reaches the size of a lira. We observe consistent differences in the size of such lirae among species and also note differences in the number of threads interspersed between lirae. The precise spacing of collabral lirae changes with the ontogenetic stage. The lirae generally become more widely spaced as the animal matures but subsequently tend to decrease in spacing in even older specimens. Commonly, the distribution of the lirae shows some individual variation, so we would place greater emphasis on the general texture of the sculpture rather than on a count of the number of collabral lirae in a given length of shell.

On close inspection, the collabral ornamentation varies in shape as well as in size. Each individual lira is typically asymmetrical, having its steeper side toward the aperture. None of the species of *Retispira* from the Chainman Shale seems to be lamellose or even sublamellose, but, where seen under magnification, species differ in the degree of prominence of the growth lines, some tending toward sublamellose. Whether the collabral ornamentation is subdued or prominent is, of course, partly related to the weight of the lirae. However, as a result of the asymmetry of the sculptural elements, the finer lirae on some forms may appear more prominent than the actually coarser lirae on other forms.

Spiral lirae are of several sizes. We have found it useful to recognize coarse, regular, and fine lirae, and three similar divisions among threads; distinctions among these sizes are arbitrary but do provide a meaningful basis for making comparisons among species. Grouping the lirae by size provides more data than simply counting the number of lirae. Ontogenetic change in the ornamentation is common. During growth, most species add spiral lirae and increase the size of those elements present earlier, though the ornament does not necessarily coarsen continuously as the age of the animal increases.

The intersection of collabral and spiral ornamentation forms the reticulate pattern. This pattern may be nearly square, transversely rectangular, or elongate

parallel to the spirals. Characteristically, this pattern changes with ontogeny, and undoubtedly this change is one of the principal features in making the group so confusing at first glance. The intersection of the two directions of lirae is commonly simple, and only rarely do species develop interference nodes or pustules. However, a change may take place laterally in some species so that the dorsum and upper flanks are reticulate but the intersections near the umbilical areas are pustulose. Analysis of the reticulate pattern into its components is certainly an important tool for differentiating species.

North American Mississippian species of Retispira.—
albapinensis Gordon and Yochelson, 1983
barquensis (Winchell), 1862 (*Bellerophon*)
beedia (Bell), 1927 (*Bucanopsis*)
cincta n. sp.
eliasi n. nom for *Bucanopsis* (*Retispira*?) *reticulata* Elias, 1958 [*not Bellerophon reticulatus* McCoy, 1844]
jensenensis n. sp.
lineolata (Hall), 1859 (*Bellerophon*)
michiganensis (Winchell), 1862 (*Bellerophon*)
minima (Bell), 1911 (*Bucanopsis perelegans*, var.)
missouriensis (Swallow), 1863 (*Bellerophon*)
monroensis (S. Weller), 1916 (*Bellerophon*)
nolani Gordon and Yochelson, 1983
ordinata n. sp.
ornata (S. Weller), 1920 (*Bucanopsis*)
perelegans (White and Whitfield), 1862 (*Bellerophon*)
stenopsis n. sp.
textilis (Hall *in* Miller), 1877 (*Bellerophon*)
waverliensis (Hyde), 1953 (*Bucanopsis*)

Fourteen species of bellerophontaceans that belong in *Retispira* have been described previously from the Mississippian rocks of North America; eight were assigned by Thein and Nitecki (1974, p. 51) to *Retispira*, of which we retain six, proposing a new name for one of them. We also are describing four new species from Utah. We include in *Retispira* all but one of the species listed by Yochelson and Saunders (1967, p. 54) under *Bucanopsis*, which is an early Paleozoic genus not found in upper Paleozoic rocks. *Bucanopsis deflectus* S. Weller, from the English River Formation of Iowa, is not included here because it occurs in beds now considered to be Late Devonian in age. We also refer to *Retispira* several of those species listed by Yochelson and Saunders (1967, p. 39–44) under *Bellerophon* (*Bellerophon*).

Three species of Kinderhookian age belong in this subgenus. *Bellerophon lineolatus* Hall, from the Rockford Limestone of Indiana, has never been figured. The whereabouts of the type specimen or specimens is not known; the species is not listed in the catalogue of types in the American Museum of Natural History (Whitfield and Hovey, 1898–1901), where many of Hall's types reside. Hall's description is sufficient for recognition of the species as a *Retispira*, but not detailed enough to permit distinguishing it from other species in the subgenus. We hereby restrict the name to the type lot and suggest that it not be used further until the type lot, if it still exists, has been redescribed and figured.

Bucanopsis perelegans White and Whitfield, from the Prospect Hill Sandstone Member of the Hannibal Formation of Iowa, has a subglobose shell, which bears a slightly raised flat selenizone bordered by a narrow groove at either side. The sculpture consists of fine, closely spaced spiral lirae crossed by slightly finer collabral threads that give the surface a minutely cancellated appearance, at least on external molds. Weller (1901, p. 178, 179, pl. 15, figs. 23, 24) figured the largest of the syntypes. We have examined several topotypes in the USGS collections.

Bucanopsis waverliensis Hyde, from the Byer Member of the Logan Formation of Ohio, is known only from incomplete specimens. Its shape and cancellate ornamentation is in accordance with *Retispira*, to which it is here transferred. This subglobose species has a slightly raised, narrow selenizone, at either side of which are 12 primary spiral lirae, between each pair of which are three to five additional spiral threads near the aperture and one to three farther back. Collabral lirae form a cancellate pattern of squares and transverse rectangles with the primary spiral lirae.

Two Osagean species were described from the Marshall Formation of Michigan (Winchell, 1862). These are *Bellerophon michiganensis* Winchell and *B. barquensis* Winchell, which we hereby transfer to *Retispira*. Winchell's types were borrowed by G. H. Girty for study some years ago, and we have been fortunate in having access to Girty's unpublished notes and figures. Girty's figures of *R. michiganensis* and topotypes from Battle Creek, Mich., in the USNM collection show this to be a globose species, generally somewhat wider than long. The narrow selenizone is gently convex but subdued. A delicate pattern of alternating spiral lirae and threads of at least three orders is crossed by finer collabral lirae. The slit seems to be shallow.

R. barquensis is not established so clearly. Winchell (1862, p. 427) stated that it differed from *R. michiganensis* in having a constricted aperture and a single set of lirae. Girty's notes show that he suspected that *R. barquensis* might be a synonym of *R. michiganensis*, the constriction of the aperture being an individual variation on the type, and the lack of finer threads a

condition of preservation. However, he believed that the material was insufficient for a final decision.

Two species are known from Meramecian rocks in the United States. The earlier is *R. textilis* (Hall), from the Salem Limestone of Indiana. Hall's species should not be confused with *Bucania textilis* Koninck, from the Viséan of Belgium, which likewise belongs in *Retispira* and is, therefore, a secondary homonym, as Hall's *textilis* was proposed in 1877 (*in* Miller, 1877, p. 254–256) and Koninck's in 1883. The Indiana shell is subglobose and has a generally flush or only slightly raised selenizone, without flanking grooves. The spiral ornamentation includes lirae and threads of three ranks, but the overall aspect of the collabral lirae is that of fairly coarse cancellation. The intersections of the spiral and collabral lirae tend to form tiny nodes.

Bellerophon monroensis S. Weller (1916), from the Ste. Genevieve Limestone in Illinois, is a fairly narrow species that Weller referred to *Bellerophon* despite the presence of faint longitudinal lirae on parts of the holotype. These lirae show on a plaster impression of this specimen that we examined. Topotypes of this species in the USGS collection show that it has a faint delicate cancellate ornamentation. Characteristic of this species is the parabolic whorl section and the rounded longitudinally threaded selenizone that is slightly more convex than the general curvature of the whorl.

Bucanopsis perelegans var. *minima* Beede, from beds presumably of the Windsor Group on Coffin Island, Magdalen Islands, Quebec, is probably Late Mississippian in age. In general shape, it resembles Weller's figure of *Bucanopsis perelegans* White and Whitfield, but that is the only close similarity. We regard it as a valid species of *Retispira*. The shells are tiny, about 3 mm long but relatively wide, and have a delicate cancellate sculpture at either side of a very narrow raised selenizone. According to Beede, 16 or 17 fine spiral threads occur in the space of 1 mm, and 10 collabral lirae in the same space. Like *R. textilis* (Hall), this species tends to form nodes at the intersections of the spiral and collabral lirae.

Another Canadian species, *Bucanopsis beedia* Bell, from the upper beds of the Windsor Group of Nova Scotia, comes from rocks now regarded as early Namurian (middle Chesterian) in age. This species also belongs in *Retispira*. It has a broadly expanded whorl bearing a raised flat-topped selenizone. The ornamentation is of fine closely spaced lirae of unequal strength, crenulated microscopically by growth lines and crossed by a few broader sulci of growth; about eight lirae occur in the space of 1 mm. Until the relative stratigraphic position of *R. minima* is known and young shells of *R. beedia* are studied, one cannot say certainly that *R. minima* is not just an immature *R. beedia*.

Five previously described species from Chesterian rocks in the United States complete the roster of North American Mississippian species of *Retispira*. Three of them, *R. nolani* Gordon and Yochelson and *R. albapinensis* Gordon and Yochelson, both described from the Diamond Peak Formation in Nevada, and *R. eliasi* n. nom., from the Redoak Hollow Member of the Goddard Shale, are discussed elsewhere in this report. *Bucanopsis ornatus* S. Weller, from the basal part of the Okaw Limestone of Illinois, has a broad globose shell on which the selenizone is not prominent but rather is slightly raised to very slightly depressed and gently convex. The collabral ornamentation in this species is also very obscure. The spiral ornamentation, although it includes lirae and threads of first through third orders, is rather widely spaced. Further details have been given by Thein and Nitecki (1974, p. 51–55).

Bellerophon missouriensis Swallow was never figured and remains unrecognized since its original description. The description is sufficient to identify it as a cancellate carinate bellerophontacean, which prompts us to transfer it to *Retispira* but does not distinguish it from other species of this genus. Why Swallow (1863, p. 100) would propose *B. missouriensis* as the name for a shell that "is common in the upper beds of the Archimedes Limestone at Chester, Illinois" and was not cited from anywhere else is not clear. No doubt, this specimen was destroyed, along with other Swallow types, in the fire at the University of Missouri in 1892. We believe that there is no likelihood of ever recognizing Swallow's species and recommend that the name be limited to use with the missing type lot.

Nomenclatural note.—A new name, *Retispira eliasi* n. nom., is here proposed to replace *Bucanopsis* (*Retispira*?) *reticulata* Elias (1958, p. 3, 4, pl. 1, figs. 5–7), which is a junior secondary homonym of *Bellerophon reticulatus* McCoy (1844, p. 25, pl. 2, fig. 5). The species described by Elias and by McCoy are obviously distinct, but both belong in *Retispira* as interpreted here.

We examined the types of *R. eliasi*, which consist of eight incomplete external molds in limonitic sandstone (Univ. Oklahoma colln. 7062). This species is rather small, its diameter at maturity less than its width. The selenizone has the same gently convex curvature in cross section as the rest of the shell. The sculpture consists of closely spaced spiral lirae of two or three ranks crossed by somewhat wider spaced steplike collabral lirae, having finer threads interspersed, which are broadly convex anteriorly at either side of the rather narrow lunulae. Elias (1958, pl. 1, fig. 5) designated one of the figured fragments as the holotype.

Retispiras from three collections in the Chainman Shale could not be identified to species and are listed as

Retispira sp. indet. These specimens are from USGS collections 15161–PC (4), 17214–PC (1) and 25566–PC (1).

Retispira cincta n. sp.

Plate 2, figures 32–35

Diagnosis.—Bellerophontacean having well-rounded whorl profile and reticulate ornamentation bisected by beltlike convex selenizone, covered with fine longitudinal lirae and studded with coarse lunulae.

Description.—Shell expanding uniformly, not geniculate, narrowly and deeply phaneromphalus; margin of umbilicus well rounded and not set off from flanks, umbilicus partly concealed by inner lip. Maximum shell width just beyond columellar area. Earliest growth stages unknown. Whorl profile changing gradually with growth, that of juvenile stage following approximate arc of circle, except for marked interruption at selenizone; profile of mature stage somewhat more arched, having dorsum less well rounded and accordingly height of selenizone not quite as marked. Selenizone moderately broad, strongly convex, raised and prominently weltlike in younger stages; also convex at maturity but not so obviously set off from overall curvature of dorsum. Slit depth not known. Growth lines straight, orthocline in upper part of umbilicus and across flanks, arching gradually in vicinity of selenizone to form 70° angle with it. Details of aperture unknown. Inductura present, probably extending short distance out of aperture, moderately thin across dorsum and flanks, only slightly thicker in columellar area.

Collabral ornamentation consisting of fairly coarse lirae, asymmetrical in cross section and having the steeper side toward the aperture; lirae are fairly closely spaced and interspersed with sparse threadlike growth lines. Approximately 15 prominent spiral lirae present on dorsum and flanks on each side of selenizone in early stages, intersecting collabral lirae to form pattern of tiny squares or transverse rectangles, second-order lirae and finer threads being scarce at this state. During growth, number and strength of spiral lirae increase, pattern becoming one of longitudinally elongate rectangles. Selenizone ornamented by coarse well-formed lunulae, irregularly spaced and interspersed with fine threadlike lunulae, and as many as 13 equally fine spiral threads. In mature shell, total number of spiral lirae about 80.

Dimensions.—Holotype, a mature specimen lacking part of final whorl, measures 10.7 mm in length, 10.3 mm in width, and 7.1 mm in height (at right angles to length).

Discussion.—This species is based upon three specimens, all from the *Goniatites granosus* Zone. The holotype, from the Granite Mountain section, is fairly complete and preserves in detail the sculptural features. The paratypes are from two localities in the Foote Range area, on the western side of the Bishop Springs dome.

The distinguishing feature of this species is the convex, longitudinally lirate lunulae-studded selenizone. The convexity of the selenizone distinguishes it from those of the Chainman forms, *R. ordinata* n. sp., *R.* sp. A, and *R.* sp. B, all of which have flat- or nearly flat-topped selenizones. The only other Chainman species having a convex selenizone is *R. jensenensis* n. sp., but that species lacks the coarse lunulae that give the selenizone of *R. cincta* its beltlike appearance. *R. cincta*, likewise, is broader and has somewhat more rounded flanks than does *R. jensenensis*.

R. monroensis (S. Weller), from the Ste. Genevieve Limestone in Monroe County, Ill., has a slightly raised convex selenizone, bearing inconspicuous ornamentation. The shell seems to be slightly more compressed at maturity than that of *R. cincta*, but, because of insufficient comparative material, we cannot be certain of that detail. Both spiral and collabral ornamentation are more closely spaced in Weller's species. *R. minima* (Beede) is superficially similar in having a raised selenizone but differs in being flat topped, in lacking prominent lunulae, and in having a wider shell.

Although *R. waverliensis* (Hyde) is somewhat similar in shape to *R. cincta*, the ornamentation is strikingly different. The Chainman species emphasizes the collabral element, does not have a square reticulation, and the lunulae are stronger.

Types.—Holotype USNM 210937; paratypes USNM 210938, 210939.

Occurrence and number of specimens.—USGS collections 17012–PC (1), Juab County; 17250–PC (1), 20446–PC (1), Millard County.

Retispira ordinata n. sp.

Plate 2, figures 22–29

Diagnosis.—Bellerophontacean having cancellate ornamentation supplemented by third- and fourth-order spiral lirae; selenizone flat, set off by narrow sulci.

Description.—Shell uniformly coiled, not geniculate; whorl profile simple, in early whorls approximately following evenly curved arc from umbilical areas outward and upward, then curving smoothly inward; curvature interrupted only slightly by selenizone; sloping flanks becoming flatter and dorsum narrower and flatter at maturity. Selenizone generally flat, set off from main body of shell by narrow, shallow longitudinal depressions, slightly raised above surface of whorl in juvenile

specimens, flush to slightly depressed in maturity. Shell anomphalous, but having umbilical depressions that become fairly deep in mature stage. Lip not known in detail; inner part appearing subparallel to axis of coiling and apparently staying approximately in one plane as it swings forward, so that little sinuousity develops in columellar area. Growth lines numerous, approximately orthocline from umbilical area to a point about five-sixths distance from umbilical area to selenizone, then curving prosocline to approach selenizone at angle of about 45°.

Surface ornamentation complex, of several intersecting elements. Collabral ornamentation of low rounded costae becoming somewhat lamellose and less regularly spaced near aperture, together with sublamellose growth lines between costae, more prominent than normal growth lines of fine threadlike size. Longitudinal lirae also of several sizes, including 15 or 16 of primary and secondary orders crossing transverse costae to form network pattern; intercalated with these are threads of third and fourth orders, the finest approximating size of growth lines; quatrordinal arrangement best developed on dorsolateral areas; areas immediately adjacent to selenizone and around umbilical depressions limited more to smaller size threads. Selenizone ornamented by well-formed lunulae, including some prominent lunulae in semiregular pattern, separated by numerous finer ones; 11 very fine longitudinal threads also present on selenizone, central thread slightly coarser than others. Total of longitudinal elements of all sizes on specimens ranging roughly from 150 to 180.

Inductura smooth, prominent, extending out of aperture to point where its edge forms right angle with outer lip, this edge being nearly orthocline across shell; inductura thin outside of aperture and on columellar walls but thickened over dorsum of penultimate whorl so that in profile inner part of whorl appears geniculate.

Dimensions.—Holotype measures 17.5 mm in length, 17.5 mm in width (twice half width), and 11.0 mm in height (at right angles to length); slit depth is 5.5 mm.

Discussion.—This species is based upon specimens from the *Paracravenoceras barnettense* Zone in the Burbank Hills. Ten specimens are present in three collections from a shale bed containing small limestone nodules in which *Glabrocingulum hosei* n. sp. is very abundant.

Retispira ordinata is easily recognized by its fairly broad shell, flat selenizone set off by bordering narrow sulci, and the spiral lirae and threads of four distinct sizes. *R. cincta* n. sp. and *R. jensenensis* n. sp. have narrower shells with convex selenizones and fewer coarser spiral lirae. The unnamed *R.* sp. also has a flat selenizone, but this is not set off by bordering sulci. Furthermore, the spiral lirae are fewer and coarser.

Specimens of *R. ordinata* change in whorl profile from moderately globose in the immature and early mature shell to, by full maturity, a gabled (fastigiate) dorsum having a narrow flattened zone on top and nearly flat sloping flanks. Two fairly large paratypes from the *Paracravenoceras barnettense* Zone in the Needle Range show this character.

Early mature specimens of this species might be confused with fully mature specimens of *Retispira michiganensis* (Winchell). A comparison with probable topotypes of Winchell's species, from Battle Creek, Mich., shows that the two species at the same size are generally similar in shape. First- through third-order spiral lirae are present on the dorsum and upper flanks of *R. michiganensis*, but the presence of fourth-order threads is not certain. The principal difference between the two species, aside from the smaller size of *R. michiganensis* and its lack of a fastigiate stage, lies in its much finer and more closely spaced collabral ornamentation. In contrast, the early mature shell of *R. ordinata* has coarser, more ridgelike collabral elements.

Retispira ornata (S. Weller) differs from *R. ordinata*, which occurs in rocks of about the same age, in its more obscure selenizone and collabral ornamentation, rather widely spaced spiral lirae, and more inflated whorl profile. *R. textilis* (Hall) has a generally flush or only slightly raised selenizone, as does *R. ordinata*, but this is not set off by sulci. Moreover, the ornamentation is more coarsely cancellate in Hall's species, even though third-order spiral threads may be present. Hall's description mentions 30 longitudinal lirae at either side of the selenizone, about half the number normally present in *R. ordinata*. *R. textilis* neither reaches the size of *R. ordinata* nor develops the fastigiate whorl profile in late maturity.

R. eliasi n. nom. from Oklahoma has a broad, evenly rounded whorl profile not interrupted by the selenizone in contrast to the somewhat irregular curvature of *R. ordinata*. The Oklahoma shell also differs by not developing fourth-order spiral threads and in having finer, more subdued collabral threads that are generally absent on the flanks. Furthermore, in *R. ordinata*, the selenizone bears only fine spiral threads and is clearly set off from the rest of the dorsum, whereas in *R. eliasi*, the selenizone has three fairly strong spiral lirae and two alternating finer threads, the ornamentation of the selenizone thus being similar to that of the dorsum and upper flanks.

Types.—Holotype USNM 210940; paratypes USNM 210941–210945.

Occurrence and number of specimens.—USGS collections 15157–PC (3), 17187–PC (2), 17194–PC (2), 25264–PC (6), Millard County.

Retispira nolani Gordon and Yochelson

Plate 2, figures 18–21

Retispira nolani Gordon and Yochelson, 1983, p. 976–977, figs. 1 O–Q.

Discussion.—This species occurs in the Burbank Hills, but the primary types are from White Pine County, Nev. Two of the three Utah specimens are illustrated on plate 2. *R. nolani* is easily distinguished from most species of *Retispira* in the Chainman Formation by its broad shell. Its flat selenizone distinguishes it from *R. cincta*, which also has a broad shell.

R. ordinata n. sp., the species most like *R. nolani*, likewise has a flat selenizone and might have been the progenitor of *R. nolani*. *R. ordinata* can be distinguished by the somewhat fastigiate whorl profile in mature specimens, its flattened sloping flanks contrasting with the rounded flanks of *R. nolani*. At comparable growth sizes, the collabral ornament and selenizone are more prominent in *R. ordinata*. In *R. nolani*, fewer spiral elements are present, but they are more uniform in size and generally are more prominent than in *R. ordinata*. This is reflected in the selenizone, which in *R. ordinata* normally is ornamented by 11 lirae or threads and in *R. nolani*, by five. A more prominent boss also is present within the aperture of *R. nolani*.

At the type locality in east-central Nevada and in the Burbank Hills, *R. nolani* is restricted to the *Cravenoceras hesperium* Zone. At all the localities where it has been found, specimens are associated with this ammonoid.

Figured specimens.—USNM 210951, 210952.

Occurrence and number of specimens.—USGS collections 17095–PC (1) Juab County; 17188–PC (1), 17189–PC (1), 17310–PC (1), ?25319–PC (1), ?25551–PC (2), Millard County.

Retispira jensenensis n. sp.

Plate 2, figures 12, 13

Diagnosis.—Moderately phaneromphalous bellerophontacean having gently sinuate aperture; spiral ornamentation predominant on convex selenizone.

Description.—Shell evenly coiled, not geniculate, somewhat compressed, moderately phaneromphalous; umbilical walls nearly vertical, rounding fairly abruptly into flanks but without circumbilical angulation. Greatest shell width immediately adjacent to umbilical area. Early growth stages unknown; whorl profile narrowly arched in juvenile shell, approaching shape of a pointed arch; mature profile more inflated and rounded dorsally. Selenizone continuous with profile of dorsum in early stages but conspicuously convex in more mature stages, nearly semicircular in cross section. Growth lines straight, orthocline adjacent to umbilicus and gently sigmoidal on upper flanks and dorsum, having adaperturally bowed segment at middorsum; juncture with selenizone at angle of approximately 80°. Slit depth unknown; other apertural details lacking.

Collabral ornamentation of closely spaced, slightly asymmetrical lirae; finer threads not visible. Spiral ornamentation of about 25 first-order lirae on each side of selenizone, more or less uniformly spaced along dorsum and flanks, interspaces three or four times width of lirae but more closely spaced in umbilical area. As many as 40 first- and second-order lirae may be present at either side of selenizone. Intersection of collabral and spiral elements forming fine reticulate pattern over most of shell surface, beaded adjacent to umbilici. Selenizone ornamented by about seven to nine fairly coarse spiral threads; lunulae not apparent. Parietal inductura present, details unknown.

Dimensions.—Incomplete holotype has dimensions (in mm) as follows: length 6.3, width 5.2, height (at right angles to length) 5.1.

Discussion.—The holotype of this species is a well-preserved but incomplete shell from the upper part of the *Cravenoceras hesperium* Zone in the Jensen Wash section, Burbank Hills. A specimen from the Indian Pass section, having slightly coarser longitudinal sculpture, is included.

The convex selenizone marks *Retispira jensenensis* as distinct from *R. ordinata, R. nolani*, and *R.* sp. Although the shape of its selenizone is similar to that in *R. cincta*, it lacks the prominent lunulae that identify that species. Well-preserved specimens of both species are generally similar in ornamentation, but their whorl profiles are distinct, that of *R. jensenensis* being narrower and more highly arched.

Types.—Holotype USNM 210946; paratypes USNM 348021, 363082.

Occurrence and number of specimens.—USGS collections 17003–PC (1), 17188–PC (1), 17189–PC (1), Millard County.

Retispira stenopsis n. sp.

Plate 2, figures 7, 8

Diagnosis.—Compressed bellerophontacean having weltlike selenizone; profile in cross section trending toward weak ventrolateral shoulders; shell ornamented by fine spiral lirae.

Description.—Shell narrow, having low rate of expansion. Nucleus and early growth stages unknown. Umbilici prominent, wide and deep; umbilical walls evenly convex. Whorl profile with periphery just above umbilici, curving upward and ever more gently inward from periphery in low, increasingly flattening arch. At mid-dorsum, wide raised welt, hemisperical in cross section, is formed by selenizone. Details of inner and outer lips unknown; incomplete margins suggesting extension of lateral lips outward, partially obscuring umbilici.

Slit depth unknown, but less than one-fourth circumference of whorl and probably much shorter; selenizone at mid-dorsum strongly arched upward, slightly raised, occupying essentially entire width of welt; lunulae obscure or absent. Ornament of fine closely spaced spiral lirae, subequal in width, though varying irregularly across dorsum, rounded in profile; interspaces narrower than lirae; collabral lirae exceedingly fine and generally obscure, an occasional thread visible at wide irregularly spaced intervals. Inductura thin, not extending outside aperture.

Dimensions.—Holotype, lacking outer margins of aperture, measures (in mm): length 12.8, width 9.2, depth 9.2.

Discussion.—*Retispira stenopsis* is one of the more distinctive species of Bellerophontacea in the Chainman gastropod fauna and is characterized especially by its predominance of spiral lirae as well as by its steeply sloping flanks. *Retispira jensenensis*, also a narrow species having a convex selenizone, is distinguished from *R. stenopsis* by its much more prominent collabral sculpture and by the fact that its selenizone is not weltlike, but narrowly rounded at the apex of a gothic-arch profile so that it is continuous with the flanks.

Retispira nolani is more globose in outline and has a narrower selenizone; this selenizone is slightly raised but not weltlike as in *R. stenopsis*. *R. ordinata* is also wider and has a flattened selenizone, smaller umbilici, and prominent reticulate ornament. The single specimen compared with *R. textilis* (Hall) is wider and also shows prominent reticulate ornament similar to that of *R. ordinata*.

Perhaps the species most like *R. stenopsis* in the Chainman Shale is *R. cincta*. It, too, shows a weltlike raised selenizone. Its ornament, however, is somewhat cancellate, having fairly strong collabral lirae rather than only closely spaced spiral lirae. More subtle differences are seen in whorl profile, in that the umbilici of *R. cincta* seem to be slightly smaller and the shell slightly wider, resulting in a less archlike profile. The strong lunulae of *R. cincta* also are distinctive.

All the specimens of *R. stenopsis* are from a single locality on the northeast side of Jensen Wash, Burbank Hills; they occur in the *Rhipidomella nevadensis* Zone within the range of the brachiopod *Carlinia phillipsi* (Norwood and Pratten).

Types.—Holotype USNM 210947; paratypes USNM 210948–210950, 211087.

Occurrence and number of specimens.—USGS collections 17059–PC (21), 17217–PC (5), 25548–PC (12), 28612–PC (6), Millard County.

Retispira cf. R. textilis (Hall)

Plate 2, figures 30, 31, 36

Bellerophon textilis Hall *in* Miller, 1877, p. 243.
Knightites (Retispira) textilis (Hall). Yochelson and Saunders, 1967, p. 116 (see for full synonymy).

Discussion.—A sixth species of this genus is represented in the Chainman Shale by a steinkern, 9 mm long, that retains part of the shell; it is from the top of the *Goniatites americanus* Zone of late Meramecian age in the Granite Mountain section and is the oldest representative of this genus in the fauna. Although the specimen is not complete enough to identify with certainty, the characters preserved are shared by the American Midcontinent species *R. textilis* (Hall), and none differentiate it from that species.

This Utah specimen has a smooth well-inflated profile, unlike the narrower *R. jensenensis* n. sp. Judging from the absence of any interruption in the curvature of the dorsum on the steinkern, the selenizone seems to have been flush; this feature serves to dintinguish *R.* cf. *R. textilis* from *R. cincta* n. sp., which shows a general similarity in shape. A patch of shell retaining the ornament is present in the columellar area, and the intersections of transverse and collabral elements are nodose or pustulose adjacent to the inner lip. The pattern appears rather coarsely cancellate in contradistinction to the fine predominantly spiral lineation in the umbilical area of *R. ordinata* n. sp. The ornamentation is more like that of *R. cincta* than any other Chainman species, but in *R. cincta*, the cancellation is a little finer and is not pustulose at the intersections. A thin inductura is present.

In only two Mississippian species are the intersections of spiral and collabral lirae reported to show a tendency to develop tiny nodes or pustules. These are *R. textilis* (Hall) and *R. minima* (Beede). The latter species, from eastern Canada, is based on tiny specimens that are much wider than *R. textilis* and the Chainman specimen.

Walcott (1884, p. 257, pl. 18, fig. 18) figured as *Bellerophon textilis* Hall? a specimen from the Diamond Peak Formation at Conical Hill, near Eureka, Nev. The beds at this locality are also late Meramecian in age. We have examined this lot of four specimens (a

fifth is a *Bellerophon*) under USNM 14421. These specimens, which clearly belong in *Retispira*, range in length from about 17 to 23 mm and appear rather coarsely cancellate. One of them shows some tiny pustules at the intersections of the spiral and collabral lirae. The specimens are preserved in calcareous sandstone, and all are at least partly distorted. Their large size and poor preservation preclude direct comparison either with the Chainman Shale specimen or typical examples from the Midcontinent. Nevertheless, we feel that Walcott's questioned specific determination should stand.

Figured specimen.—USNM 210936.

Occurrence.—USGS collection 17018–PC, Juab County.

Retispira sp.

Plate 2, figures 16, 17

Discussion.—One small incomplete specimen, 4.4 mm long, from a bed containing *Richardsonites merriami* (Youngquist) in the Conger Range, shows that still another species of *Retispira* is present in the upper part of the Chainman Shale. The specimen is globose and has relatively deep umbilical depressions. Ornamentation consists primarily of two sizes of alternating spiral lirae; collabral ornamentation is less obvious. The selenizone is narrow and flush with the dorsum; lunulae are obscure, and the selenizone of this immature individual can be distinguished only with difficulty on the ornamented dorsum; it is not set off by bordering shallow grooves as in *R. ordinata* n. sp. The inflated shape distinguishes it from *R. nolani*.

Figured specimen.—USNM 210953.

Occurrence and number of specimens.—USGS collections 22880–PC (1), 25319–PC (1), Millard County.

Suborder PLEUROTOMARIINA

Superfamily PLEUROTOMARIACEA

Discussion.—Since the last major revision of Paleozoic gastropod classification (Knight, Batten, and Yochelson, 1960), much additional information on the Pleurotomariacea has accumulated, including descriptions of new genera and reassignment of taxa already in the literature. It has become increasingly difficult for new concepts of the significance of various mophologic features to be used within this older classification. In the Pleurotomariacea, primary and nearly exclusive emphasis on the position of the selenizone has not stood the tests of time and use and seems to us to be an unsatisfactory factor for major grouping.

We think that subdivisions within the Pleurotomariacea depend upon several factors that should be assigned nearly equal weight. Not only is the position of the selenizone on the whorl important, but its position relative to immediately adjacent parts of the whorl profile should be considered. Furthermore, whether the selenizone is broad or narrow, distinctly flattened, concave, or convex may be just as significant as its position. Arrangement by selenizone position alone, without reference to general shell shape, has resulted in a classification that has produced some rather strange bedfellows—seemingly similar shells that other criteria would not find at all closely related. We conclude that the proportions and curvatures of the whorl surface and its parts cannot be considered simply as generic features but should be given greater emphasis in defining higher categories.

As a consequence of our study, we have modified the 1960 classification of the pleurotomariaceans in several aspects. However, we confined our investigations almost exclusively to Carboniferous genera that occur in the Chainman Shale, or to closely related taxa. In no way should our systematic modifications be considered a full revision of the superfamily. Study of both older and younger genera will determine whether or not our proposed revisions are a step forward in understanding this complex superfamily.

Family SINUOPEIDAE

Subfamily TURBONELLININAE

Genus RHINEODERMA Koninck, 1883

Rhineoderma? sp.

Discussion.—This record is based upon a crushed specimen of pleurotomariacean from dark-gray silty limestone below the base of the marker bed (Skunk Spring Limestone Member of Sadlick, 1966) in the measured Chainman Shale section at Granite Mountain. This specimen is nearly flattened, 23.5 mm in diameter, and preserves much of the final whorl from suture to selenizone. The approximately 12 to 13 spiral lirae on the upper whorl surface are crossed by weaker and more closely spaced, gently sigmoidal prosocline radial lirae. Near the selenizone, the radial lirae curve more strongly backwards, suddenly reversing direction and forming fine lunulae at the selenizone. At the intersection of the spiral and radial lirae, small interference nodes are present. The base is obscured but seems to be similar to the upper whorl face in ornamentation.

The ornamentation of this species is close to that of *Rhineoderma pealeanum* (Girty), particularly Girty's paratype, which is larger than the holotype and has a diameter of 14.5 mm. The Granite Mountain specimen lacks the spire, so we feel it necessary to question even the generic assignment. Nevertheless, the sculpture is

so close to that of *Rhineoderma* that we can think of no other genus in which to place it. This gastropod is stratigraphically the lowest one yet found in the Chainman Shale in western Utah; it is Meramecian in age.

Described specimen.—USNM 388227.

Occurrence.—USGS collection 28637–PC, Juab County.

Family RAPHISTOMATIDAE

Subfamily LIOSPIRINAE

Genus TREPOSPIRA Ulrich in Ulrich and Scofield, 1897

Subgenus T. (ANGYOMPHALUS) Cossman, 1916

Discussion.—This subgenus differs from the typical one in having subsutural radial ridges ornamenting the upper whorl surface and in having an open umbilicus. The earliest of the Chainman species has these characters and also shows radial wrinkles or lirae rimming the umbilicus.

American Mississippian species of Trepospira (Angyomphalus).—

?*discus* Girty, 1910
excavata (Easton), 1962 (*Angyomphalus*?)
penelenticulata Rollins, 1975
regularis n. sp.

Trepospira (*Angyomphalus*?) *discus* Girty from the Fayetteville Shale of Arkansas is placed here provisionally; it is an extremely depressed form and was based upon a poorly preserved holotype. The umbilical area on this shell is moderately wide, but one cannot determine whether or not the umbilicus was open; also, no radial subsutural riblets are visible on the upper whorl surface.

T. (*A.*) *penelenticulata* Rollins from the Wassonville Limestone of Iowa is the earliest known form. Depressed-lenticular in shape, it has faint subsutural threads and a narrow selenizone.

T. (*A.*) *excavata* (Easton) from the Heath Shale of Montana, is widely umbilicate, has well-developed subsutural radial ridges, and certainly belongs in this subgenus. Another shell, from the Lower Mississippian in northern Alaska, was described by Yochelson and Dutro (1960, p. 136) as *Trepospira* (*Angyomphalus*?) sp. Although immature, it clearly possesses the characters of this subgenus.

We do not follow Thein and Nitecki (1974, p. 18) in referring *Trepospira* (*Angyomphalus*) *kentuckiensis* Thein and Nitecki and *Mourlonia*? *stellaeformis* Hyde to this subgenus. *T.* (*A.*) *kentuckiensis* we regard as a *Mourlonia* and *M.*? *stellaeformis* as belonging in *Glabrocingulum* (*Glabrocingulum*). They are discussed under those genera.

Trepospira (Angyomphalus) regularis n. sp.

Plate 3, figures 19–26

Diagnosis.—Depressed lenticular, narrowly phaneromphalous pleurotomariacean gastropods; shell ornamented by short subsutural ridges.

Description.—Low-spired shell having pleural angle of approximately 145°. Nucleus unknown. Early whorls having slightly higher spire and slightly more inflated upper whorl surface than more mature stages, and at least two of them unornamented. Sutures distinct, smooth. Upper whorl surface of final whorl having narrow flattened zone immediately adjacent to suture, inclined so as to embrace penultimate whorl just above periphery; remainder of upper whorl surface simple, gently arched downward with curvature increasing toward periphery. Periphery bluntly rounded. Basal whorl surface curving inward and downward from periphery, flattening slightly just before reaching rounded margin of umbilical area. Umbilicus poorly known but definitely phaneromphalous, narrow, not covered with inductura; a narrow spiral cord present within depressed area.

Growth lines faint, closely spaced so that shell surface appears smooth and almost polished; their course orthocline from suture for about one-third of distance across upper whorl surface, then sweeping prosocline to upper edge of selenizone, joining at an angle of about 45°; below selenizone, growth lines curving opisthocline to umbilical area; growth lines unknown within umbilicus. Outer lip not known. Selenizone relatively wide, it upper edge far up on upper whorl surface and its lower edge just below periphery, nearly flush with whorl surface except that upper edge is raised slightly; lunulae absent. Shell ornamented by band of elongate raised lirae normal to suture and extending from suture for about one-fourth total width of upper whorl surface; spacing increasing with size of shell, but showing some irregularity, a typical mature whorl bearing about 30 ridges. Radial ridges also present rimming umbilicus in immature shells. Shell thin, of at least two layers, the outer one extremely thin.

Dimensions (in mm).—

USNM	210964	210961	210962	210963
Height -----	12.5	8.7	7.7	2.4
Width ------	23.8	15.1	13.3	4.0

Discussion.—This species was found in a fossiliferous concretionary bed of the *Goniatites americanus*

Zone of the Granite Mountain section, just above the marker bed. The zone is regarded as latest Meramecian in age. *Trepospira (Angyomphalus) regularis* is easily distinguished from other *Trepospira* in higher beds in the Chainman Shale by its open umbilicus and its subsutural short radial ridges, some 30 on the final whorl. The two species of *Trepospira (Trepospira)* described below differ from *T. (Angyomphalus) regularis* in bearing 14 to 17 rounded subsutural nodes and in having the umbilical area covered by an inductura.

Trepospira (Angyomphalus) regularis n. sp. differs from both *T. (A.) excavata* (Easton) and *T. (A.?) discus* Girty in having both upper and lower surfaces of approximately the same convexity; the latter two species have the upper surface less convex than the lower. Moreover, *T. (A.?) discus* lacks radial ridges on the upper surface *T. (A.?)* sp. described by Yochelson and Dutro (1960, p. 136) from the Lower Mississippian of Alaska is an immature shell slightly more than 4 mm wide. Comparing it with our figured specimen of *T. (A.) regularis* at approximately the same size, we find that the Alaska specimen is more depressed, has more crowded and presumably more numerous subsutural riblets, and lacks the tiny radial riblets that ring the umbilicus in the immature Utah shell.

Types.—Holotype USNM 210961; paratypes USNM 210962–210965.

Occurrence and number of specimens.—USGS collections 17018–PC (10), 25558–PC (4), Juab County.

T. (TREPOSPIRA) Ulrich in Ulrich and Scofield, 1897

Discussion.—The typical subgenus is more characteristic of Pennsylvanian rocks; in fact, the two Chainman species described below are the first authentic *Trepospira (Trepospira)* from rocks of Mississippian age. This subgenus is distinguished from *T. (Angyomphalus)* by the presence of subsutural nodes rather than radial ridges and by having the umbilicus closed by a callus deposit.

Four previously named American species include *T. (T.) discoidalis* Newell from the Eudora Shale of Kansas; *T. (T.) illinoiensis* (Worthen), the most ubiquitous Pennsylvanian species; *T. (T.) minima* Hoare from the Seville Limestone and Robinson Branch Formation of Missouri; and *T. (T.) sphaerulata* (Conrad), the type species, described originally from western Pennsylvania.

We do not include in this subgenus *T. (T.) chesterensis* Thein and Nitecki from the Golconda Limestone of Illinois, the types of which we regard as immature representatives of *Glabrocingulum (Glabrocingulum)*.

Trepospira (Trepospira) baconi n. sp.

Plate 3, figures 27–31

Diagnosis.—Extremely low-spired cryptomphalous smooth pleurotomariacean gastropods having moderately large nodes near suture, of which 14 to 17 are on final whorl.

Description.—Shell bluntly lenticular in cross section, extremely low spired, pleural angle near 140°. Nucleus simple, orthostropic; first three whorls lacking ornamentation and very slightly raised above general level of upper surface. Whorl profile narrowly parabolic from suture to lowest point of base, except for slight flattening at selenizone near edge of upper whorl surface; periphery rounded subacute; inner part of base curved very slightly upward to umbilicus. Umbilicus marked by sharp circumbilical angulation, forming nearly a right angle. Base cryptomphalous, umbilical depression partly filled by inductural deposit reaching almost to circumbilical angulation. Columellar lip straight, outer lip unknown.

Shell smooth, except for growth lines and subsutural nodes. Growth lines closely spaced but faint; unknown near suture, distinctly prosocline near middle of upper whorl surface and curving very slightly below this so as to form angle of approximately 45° with upper edge of selenizone; opisthocline below selenizone, forming 30° angle with lower edge of selenizone, then curving forward to lowest point on base and finally curving prosocline to form broad shallow prong. Selenizone flattened and broad inclined at about 45° to axis of coiling; upper edge distinctly raised above whorl surface; lower edge at periphery, not set off from base; lunulae absent, growth lines on selenizone as obscure on those on upper surface of shell. Whorl ornamented by nodes immediately subsutural in position, circular in cross section and rising to a rounded tip, uniformly spaced, interspaces only slightly wider than nodes. Nodes seemingly at an approximately logarithmic spacing; mature whorl bearing about 15 nodes.

Dimensions.—Holotype measures 11.5 mm in height and 23.2 mm in width.

Discussion.—*Trepospira (Trepospira) baconi* is the earliest known species of the typical subgenus of *Trepospira*. The type lot is from three collections made from the same locality in the Burbank Hills. This locality in the lower middle part of the Chainman Shale has also yielded *Glabrocingulum (Glabrocingulum) hosei* n. sp., *Hematites barbarae* Flower and Gordon, and *Paracravenoceras barnettense* (Plummer and Scott) and is of middle Chesterian (early early Namurian) age correlated with the lower *Eumorphoceras* (E_1) Zone.

The species is a strongly depressed form, resembling the common *T.* (*T.*) *illinoiensis* (Worthen) in shape. It can be distinguished from the four presently known Pennsylvanian species by the wide spacing, relatively large size, and small number of subsutural nodes; the numbers of nodes on the final whorl of each of these species are given in the comparisons under *T.* (*T.*) *diademe* n. sp.

This species is named for C. S. Bacon, Jr., who published, in 1948, the first study on the geology of the Confusion Range, Utah.

Types.—Holotype USNM 210966; paratypes USNM 210967–210969, 364701.

Occurrence and number of specimens.—USGS collections 15166–PC (1), 17187–PC (1), 17194–PC (2), 25264–PC (3), 28610–PC (1), Millard County.

Trepospira (Trepospira) diadema n. sp.

Plate 3, figures 32–36

Diagnosis.—Pleurotomariacean gastropods having low-spired cryptomphalous smooth shell ornamented by a subsutural ridge bearing small nodes.

Description.—Shell depressed, sublenticular, having lower surface slightly more convex than upper, of approximately six whorls including nucleus. Nucleus of uncertain size, orthostrophic. Early whorls smooth, convex, slightly higher spired than more mature part of shell. Characteristic subsutural ornamentation appearing at approximately end of third whorl, at same stage as increase of pleural angle, which reaches 125° at maturity. Body whorl embracing penultimate whorl between periphery and upper edge of selenizone. Sutures smooth, not impressed, although presence of subjacent ridge causes suture to appear impressed. Mature whorl profile adjacent to suture horizontal for an exceedingly short distance, then rising to cross narrow ridge; between outer edge of ridge and selenizone, profile forming very gently parasigmoidal curve, verging on flattened; upper whorl suface interrupted near periphery by upper (inner) edge of slightly raised selenizone; periphery subangular and located just within lower edge of selenizone; profile convex below periphery, having exceedingly faint change in slope at lower edge of selenizone, curving downward and inward in gradually reduced curvature toward columellar area; columellar depression absent or very shallow. Base cryptomphalous, probably consisting of thin inductura over anomphalous base. Shell smooth except for growth lines and subsutural ridge. Growth lines gently opisthocline to prosocline near suture, bowing toward aperture and recurving strongly near selenizone; similar on base but orthocline near columellar area, forming narrow arch over selenizone. Slit depth unknown. Subsutural ridge nodose; 16 nodes on final whorl of holotype; nodes small, tending to be elongate parallel to ridge; interspaces about three times width of nodes in intermediate growth stages, but narrowing as nodes become longer with increasing maturity. Some shells having shallow depressions on upper whorl surface below subsutural ridge, coordinate with interspaces between nodes.

Dimensions.—The holotype is 6.2 mm high and 12.8 mm wide. A large paratype is 12.0 mm high and 23.4 mm wide.

Discussion.—This species is fairly common in a 15-foot (4.6-m) thickness of brown shale at or near the top of the *Cravenoceras hesperium* Zone in the Burbank Hills; it also occurs sparingly above and below this unit. It seems to be restricted roughly to the upper 600 feet (183 m) of the formation in this area. The type lot was collected by J. E. Welsh along with the types of *Bellerophon* (*Bellerophon*) *welshi* n. sp. (USGS colln. 17310–PC).

Trepospira (*Trepospira*) *diadema* differs from *T.* (*T.*) *baconi* n. sp. in having a gently parasigmoidal to flat upper whorl surface at maturity, smaller nodes on the subsutural ridge, a better defined selenizone, a more acute periphery and a very shallow umbilical depression or none at all, in contrast to the convex upper whorl surface, large nodes, very subdued selenizone, more rounded periphery, and fairly deep umbilical depression of the earlier species.

T. (*T.*) *diadema* is similar in shape to the widespread Pennsylvanian species *T.* (*T.*) *illinoisensis* (Worthen) (see Yochelson and Saunders, 1967, p. 236, 237, for synonymy). That latter species, however, has gently convex whorls, more nodes on the final whorl (17 to 24 on the hypotypes that Girty (1915a, p. 158) described as *Trepospira depressa* (Cox) and 27 to 29 on specimens described by Hoare (1961, p. 149)), more rounded lunulae in the selenizone, and a relatively deep umbilical depression, all of which serve to distinguish it from *T.* (*T.*) *diadema*.

Another Pennsylvanian species, *T.* (*T.*) *discoidalis* Newell from Kansas, resembles *T.* (*T.*) *diadema* in having a concave zone just below the subsutural ridge, but, as the spire in Newell's species is somewhat higher, the concavity is slightly more accentuated. These two species are also distinguished by the presence of a moderately deep umbilical depression and many more subsutural nodes (25 to 40 on the final whorl in the type lot) on the Kansas species.

The type species of the subgenus, *T.* (*T.*) *sphaerulata* (Conrad), is characterized by its relatively higher spire and numerous, closely spaced subsutural nodes. *T.* (*T.*) *minima* Hoare differs in having radially elongate lirae on the early whorls, lirae that become nodes by the

sixth volution; this volution bears 30 to 32 nodes. The umbilicus appears to be filled with a thin inductura, so this species, bearing lirae on its early whorls, cannot be referred to *T.* (*Angyomphalus*).

Types.—Holotype USNM 210970; paratypes USNM 210971–210975.

Occurrence and number of specimens.—USGS collections 17021–PC (1), 17023–PC (1), 17056–PC (2 steinkerns), 17188–PC (1, 5 steinkerns), 17209–PC (1, 3 steinkerns), 17219–PC (14 steinkerns), 17310–PC (16, 23 steinkerns), 22883–PC (1), 25547–PC (4), 25550–PC (8), 25551–PC (1), Millard County.

Trepospira (Trepospira) sp.

Plate 3, figure 18

Discussion.—This record is based upon a single partly crushed shell from a bed containing *Lunulazona sadlicki* n. sp. in the section at Granite Mountain. Although the specimen has been depressed by crushing, its spire seems to have been moderately high. A tiny smooth nucleus of about 1 1/2 whorls is preserved at the apex of the shell. There are about 4 1/2 postnuclear whorls. The early whorls show faint low straight radial ribs, best preserved on the third whorl, where the ribs extend about halfway from the suture to the outer edge. The fourth whorl is poorly preserved. The final half whorl has 16 radially elongate elliptical nodes just below the suture.

Having radial ribs on the early postnuclear whorls and nodes on the mature part, this shell seems transitional from *T.* (*Angyomphalus*) to *T.* (*Trepospira*). We favor referring it to the latter subgenus because of its moderately high spire and the presence of nodes on the final volution.

Figured specimen.—USNM 211027.

Occurrence.—USGS collection 28628–PC, Juab County.

Subfamily OMOSPIRINAE

Genus BAYLEA Koninck, 1883

Discussion.—This genus includes subturbiniform, moderately high spired, turreted pleurotomariaceans having a narrow ramp adjacent to the suture and a narrow selenizone located at the outer edge of the sloping upper whorl face. The outer whorl face is steeply sloping and tends to be rather high; the base is well rounded and imperforate. Sculpture consists primarily of spiral cords; collabral lirae normally are weak. The shell from the Chainman Shale described below, although poorly preserved, has the turreted whorls typical of *Baylea*.

North American Mississippian species included in Baylea.—

angulosa Rollins, 1975
coheni Yochelson, 1962
minuta (S. Weller), 1916 (*Mourlonia*)
sinuata (S. Weller), 1916 (*Ptychompalus*)
okawensis Thein and Nitecki, 1974
trifibra Rollins, 1975

Another Mississippian species was described as *Baylea* sp. from Sonora, Mexico (Knight, 1953, p. 74, pl. 8, C, figs. 15, 16), and Jerome Hill, Ariz. (Yochelson, 1962, p. 78, pl. 17, fig. 8).

Baylea? sp.

Plate 7, figures 29, 30

Discussion.—A unique specimen from the base of the Willow Gap Member of Sadlick (1966) in the Wallet Gulch measured section is referred questionably to *Baylea*. Like other gastropods in this bed, the shell is rather coarsely silicified. It consists of three whorls—part of the spire is missing—and measures 4.3 mm in length and 3.2 mm in width. The shell shape is similar to that of the type species *Baylea yvanii* Léveillé, from the Tournaisian of Belgium, but the Utah specimen is considerably smaller.

A description of the Chainman species follows: The upper whorl face of *Baylea*? sp. is narrow and sloping, nearly flat or slightly concave in profile; the outer whorl face is steep, vertical to slightly overhanging, and marked at the lower edge by an angulation approximately where the succeeding whorl attaches. The base slopes inward at about 45° and seems to be narrowly umbilicate; the aperture is somewhat trapezoidal because of the angulation but is suboval within. Whorls are ornamented by a few spiral lirae, but the exact number cannot be determined owing to the coarse silicification. Any collabral sculpture that might have been present has been obliterated.

The rather angular whorls in this species are somewhat reminiscent of *Murchisonia* and allied genera, but the whorls increase more rapidly in size than in the Murchisoniacea, and the apical angle is broader. Although this species cannot be identified with certainty, it is quite distinct from all other gastropods of the Chainman fauna.

Figured specimen.—USNM 211070.

Occurence.—USGS collection 25566–PC, Millard County.

Family EOTOMARIIDAE Wenz

Discussion.—Since publication of the last major classification of Paleozoic Gastropoda (Knight, Batten, and Yochelson, 1960), opinion about classification of the Paleozoic pleurotomariaceans has ranged from the suggestion that no separate family is needed for the bulk

of Paleozoic genera (Dickens, 1963, p. 118) to a stout defense of the established classification (Batten, 1967, p. 262). Obviously, no classification can remain static as additional genera are added. Furthermore, opinions shift about the significance to be assigned to various features of morphology.

The principal area of contention is the Eotomariidae. This family was given the following diagnosis by Knight, Batten, and Yochelson (1960, p. I202): "Shell turbiniform to trochiform; labral slit invariably present, generating concave selenizone bordered by threads at approximately mid-height of whorl." We are not convinced that the Eotomariidae constitutes a natural grouping. However, because the family includes genera that do not occur in the Carboniferous rocks that form the basis for our recent studies, our revisions of classification will be limited to lower taxonomic levels. This family name may be used for those gastropods that have a peripheral selenizone separating upper and basal whorl surfaces; only rarely is a short segment of outer whorl face present.

In the 1960 classification, subdivisions were based primarily on whorl shape. We now think it more reasonable to consider the form and size of the selenizone as at least as significant as whorl shape. Our treatment shows some inconsistency in that selenizone features that in our view distinguish higher taxa among the pleurotomariaceans are accorded less significance among the bellerophontaceans. However, the selenizone in bellerophontaceans is far less variable, and the number of genera and species far fewer than among the pleurotomariaceans, where the need for criteria to subdivide the superfamily is therefore much greater.

In 1938, Wenz divided the family Pleurotomariidae into 10 subfamilies, among which were Eotomariinae, Ptychomphalinae, and Ptychomphalininae. Knight, Batten, and Yochelson (1960, p. I203, I204) raised the Eotomariinae to family rank and included it in three subfamilies, Eotomariinae, Agnesiinae, and Neilsoniinae. The Eotomariinae, being the most extensive, was divided into two tribes, Eotomariides and Ptychomphalides. As the result of various rearrangements and synonymies, Wenz's Ptychomphalinae and Ptychomphalininae were both included in the tribe Ptychomphalides by Knight, Batten, and Yochelson (1960). These changes in rank were perfectly legitimate, although somewhat confusing because family-group names based on *Ptychomphalus* Agassiz and *Ptychomphalina* Fischer are involved. In one partial revision, Sadlick and Neilson (1963, p. 1090) suggested that the Ptychomphalides be returned to subfamily rank to contain four Mesozoic genera referred to the tribe. Ptychomphalinae Wenz was thus restored and included under the Eotomariidae.

For the present, we continue to recognize the four subfamilies of the Eotomariidae, and we add a fifth. We are making minor modifications to Neilsoniinae and more extensive revision of Ptychomphalinae and Eotomariinae. This report is not concerned with any genera referable to Agnesiinae.

Subfamily PTYCHOMPHALINAE Wenz

Tribe MOURLONIIDES Yochelson and Dutro

Diagnosis.—Subglobose pleurotomariaceans having flat or gently convex peripheral selenizone.

Description.—Shell moderately low-spired. Whorl cross section inflated, upper whorl surface distinctly arched; periphery at upper, middle, or lower edge of selenizone; base also well rounded and anomphalous to minutely phaneromphalous. Selenizone flat or close to curvature of whorl, flush or raised slightly, nearly parallel to axis of coiling in inclination. Ornamentation weak, having collabral elements predominant.

Discussion.—Recognizing the need for at least one additional tribe within the subfamily, Yochelson and Dutro (1960, p. 136) inadvertently used the name Mourlonides for part of the group that Knight, Batten, and Yochelson (1960, p. I202–I204) referred to Ptychomphalides. Yochelson and Dutro should have used Ptychomphalinides Wenz for the tribe name, because the oldest family-group name must be used, even if the name-bearer has been placed in subjective synonymy. In 1974, we examined key types in the British Museum (Natural History), London, and concluded that *Mourlonia* and *Ptychomphalina* were distinct genera, independently confirming the view of Dickens (1978). We regard them as belonging in different family-level taxa. We are retaining Mourloniides Yochelson and Dutro for one of these groups. If Ptychomphalinae is raised to its former subfamily rank, as seems to have been the intent of Sadlick and Nielsen (1963, p. 1090), it would include the tribes Mourloniides and Ptychomphalides, and we so subdivide it.

We continue to follow Knight, Batten, and Yochelson (1960, p. I202–I203) in associating *Taeniospira* and *Tropidostropha* with *Mourlonia*, but this is purely a matter of convenience. We have no new information on either genus but believe that careful restudy might result in the transfer of one or both of these genera out of this tribe.

Genus MOURLONIA de Koninck, 1883

Diagnosis.—Medium-sized to large subglobose pleurotomariaceans having generally smooth turbiform shape and bearing selenizone at periphery either conforming to curvature of shell or flat; either one or

both sides of selenizone may be slightly raised; either edge may be precisely at periphery. Shell ornamented by collabral and spiral lirae; spirals commonly subdued or absent.

Discussion.—We examined the holotype and other specimens of the type species of this genus, *Helix carinatus* J. Sowerby, in the collection of the British Museum (Natural History), along with other material referred to various species of *Mourlonia* in the same collection. From this study followed our decision to recognize *Ptychomphalina* again as a distinct genus and to redefine *Mourlonia*. We believe that de Koninck (1883, p. 77–98), in his first interpretation of his genus, included too many species in *Mourlonia* (57 in all) and set the style for a rather loose treatment of the genus that has been evident ever since.

Dickens (1963, p. 118), in connection with the description of Permian species from Australia that he assigned to *Mourlonia*, considerably expanded the concept of this genus. He suggested that *Platyteichum* Campbell (1953) be reduced to subgeneric rank under *Mourlonia*; Knight, Batten, and Yochelson (1960, p. I206) placed that genus in the Eotomariides. Dickens also proposed two new taxa as subgenera of *Mourlonia*, *M.* (*Pseudobaylea*) and *M.* (*Woolnoughia*). Through the kindness of Dr. Dickens, we had the opportunity of examining plaster casts of the type species of both subgenera.

Without elaborating reasons in detail, we would place *Pseudobaylea* near *Glabrocingulum* and would place *Woolnoughia* with more question near *Worthenia*. We agree with Dickens (1963) that *Platyteichum* is probably not very closely allied to *Glabrocingulum*. It is a fully distinct genus, allied to our new genus *Deseretospira*.

We would refer to other genera most of the American late Paleozoic species that have been included in *Mourlonia* (Yochelson and Saunders, 1967, p. 129, 130; Thein and Nitecki, 1974, p. 83). We are transferring (1) *Mourlonia angulata* Easton and *Mourlonia? reloba* Yochelson and Dutro to *Ptychomphalina*; (2) *Pleurotomaria mississippiensis* White and Whitfield and *Mourlonia northviewensis* S. Weller to *Worthenia*; and (3) *Mourlonia solida* Hyde to *Spiroscala*.

"*Mourlonia*" *textus* Hyde may not even be a pleurotomariacean; the drawing that supposedly shows a selenizone (Hyde, 1953, pl. 46, fig. 5) is not convincing. The specimen certainly is not a *Mourlonia*; pending restudy, we are unable to reassign the species. *Mourlonia? cancellata* Chronic is known only from the upper whorl surface. Until more morphologic information is available, its generic status must remain in doubt.

American Mississippian species of Mourlonia.—

iowensis (Worthen), 1890 (*Pleurotomaria*)

kentuckiensis (Thein and Nitecki), 1975 (*Trepospira [Angyomphalus]*)

textiligera (Meek), 1872 (*Pleurotomaria*)

venusta n. sp.

We examined a plaster cast of *Pleurotomaria iowensis* Worthen from the Keokuk Limestone of Iowa. This poorly known species might be a *Mourlonia*, and we hereby transfer it to that genus. The species is large and subglobose, but no distinguishing features are preserved on the type. Until this speies is better established, we would restrict the name to the type lot.

Pleurotomaria textiligera Meek, from the Waverly Group at Medina, Ohio, has a shell similar in shape to that of *Mourlonia*. Although we did not see the holotype or topotypes of this species, we examined a lot of nine specimens in the USGS collection, collected by Girty from the upper Sharpsville Sandstone on the Black River, near Homerville, Medina County, about 20 miles (32 km) southwest of the type locality. One of these specimens is almost identical in size, shape, and sculptural details with that shown in Meek's original figure. We unhesitatingly assign this lot to *Mourlonia* and, on the basis of this information, herein transfer Meek's species to that genus.

Several unnamed species, described or mentioned in the literature, apparently belong in *Mourlonia*. One of them was described and figured by Thein and Nitecki (1974, p. 84, 85, fig. 29) as *Mourlonia* sp. indet. from the lower point of the Golconda Limestone of Illinois. In our opinion, it is correctly referred to this genus.

Two specimens were described as *Bembexia* sp. by Girty (1915b, p. 37) in his paper on the fauna of the "so-called Boone Chert" of Arkansas (now regarded as a weathered zone in the Spring Creek Member of the Moorefield Formation). One is a *Mourlonia*, a crushed shell (USNM 168478), probably subglobose originally, bearing a slightly raised flat selenizone bordered at either side by a thread along a slight angulation; rather fine parabolic lunulae mark this selenizone; growth lirae are fine on the base and are coarser but separated by wide interspaces above the selenizone. The other specimen is a large steinkern, unrecognizable as to genus; the possibility exists, however, that it might represent the same species.

Girty had intended to use the name *Bembexia magna* for an undescribed species of *Mourlonia* from northeastern Oklahoma. However, his provisional use of this name for a fragmental specimen from the "Middle Boone Limestone" (a unit of Warsaw age within the Boone Formation) from the Batesville District, Ark. (Girty, 1929a, p. 94), which he thought might be the same species, irrevocably attached the name *Bembexia magna* to a poorly preserved *Ptychomphalina*.

We also tentatively transfer *Trepospira (Angyomphalus) kentuckiensis* Thein and Nitecki to *Mourlonia*. Certainly that species is not a *Trepospira,* and its shape and the configuration of its selenizone, as illustrated by Thein and Nitecki, suggest *Mourlonia.*

Mourlonia venusta n. sp.

Plate 4, figures 28–30

Diagnosis.—Globose pleurotomariaceans bearing reticulate ornamentation in early and middle growth stages but becoming nearly smooth at maturity.

Description.—Nucleus not known in detail, probably orthostrophic. Upper whorl surface of early whorls well rounded and ornamented by obscure growth lines. Shell expanding more rapidly after earliest growth stages, coordinate with development of spiral ornament; pleural angle nearly 100°; body whorl embracing penultimate whorl at middle of selenizone. Sutures faint, not impressed. Whorl profile consisting of three segments of different curvature: upper segment extending from suture to upper edge of selenizone and essentially following gentle arc so that shell extends farther laterally than downward; second segment limited to selenizone, more rounded than whorl segment above and having slight change in slope at its upper edge and an even fainter change at its lower edge, which also forms periphery; third and basal segment from lower edge of selenizone to columellar area, consisting of well-rounded curve following arc of circle of smaller diameter than that of upper whorl surface. Base marked by tiny umbilical chink, partly covered by slight reflexion of inner lip. Slip depth unknown. Selenizone broad, convex, not bordered, and flush except at most mature stage, where it is slightly depressed; lunulae closely spaced but not prominent, U-shaped and very deep.

Growth lines proscline and straight from suture at angle of approximately 15° from vertical for about three-fourths of width of upper whorl surface, then gradually curving more strongly prosocline and just before reaching selenizone, sweeping backward; below selenizone, strongly forward opisthocline for short distance downslope, curving increasingly toward orthocline to columellar area. Ornamentation changing markedly with growth stages; on upper whorl surface, early stages ornamented by low, closely spaced relatively prominent growth lirae, having interspaces about twice width of lirae; later stage ornmented by growth lines and approximately four prominent spiral lirae, forming reticulate pattern with growth lirae; number of spiral lirae gradually increasing to about 10 and becoming predominant; with increasing maturity, spiral lirae gradually disappearing, those near suture persisting longest, concomitant with decrease in prominence of growth lirae; at maturity, shell is nearly smooth; ornament of basal surface comparable with that of upper surface, except finer; threads of both surfaces somewhat irregular in course.

Dimensions.—Holotype measures 15.5 mm in height and 17.2 mm in maximum width.

Discussion.—This species was found associated with *Lunulazona nodimarginata* (McChesney) in the upper part of the *Goniatites americanus* Zone in the Granite Mountain section.

Mourlonia venusta is distinguished from most other mourlonias by the well-developed spiral lirae on the early whorls. *Mourlonia textiligera* (Meek) also has well-developed spiral lirae throughout growth but differs in being higher than wide and in having a nearly flat sloping upper whorl surface, giving the spire a broadly conical appearance. Spiral sculpture also is present on the type species of the genus *Mourlonia carinata* (J. Sowerby) but is subordinate to the collabral ornament and lacking on many species. *M. venusta* also is more globose than *M. carinata,* and its selenizone is flush with the whorl, rather than slightly raised as in *M. carinata.* No spiral lirae have been observed on any of the unnamed species cited above.

Type.—Holotype USNM 210976; paratypes USNM 210977.

Occurrence and number of specimens.—USGS collections 17018–PC (8), 25558–PC (4), Juab County.

Tribe PTYCHOMPHALIDES Wenz

Discussion.—*Ptychomphalus* is restricted to rocks of Mesozoic age. However, the name has been used for five Carboniferous species, which are reassigned herein. We assign *Ptychomphalus laudenslageri* Sayre, from the Upper Pennsylvanian Drum Limestone of Kansas, to *Neilsonia* because of its high spire, impressed selenizone, and characteristic ornamentation. The remaining four species were all described by Weller (1916) from one locality in the Ste. Genevieve Limestone (Upper Mississippian) in Illinois. *Ptychomphalus sinuatus,* the first of these, was transferred to *Baylea* by Thein and Nitecki (1974, p. 81); however, we believe that it is a tiny *Glabrocingulum* (*Glabrocingulum*) and herein transfer it to that genus. On the basis of our examination of topotypes, we transfer *P. wortheni* to *Borestus,* and *P.? fountainensis* questionably to *Yunnania. P. depressus* is arbitrarily transferred with question to *Portlockiella.* This last species is inadequately illustrated and is not represented in the collections from the Ste. Genevieve Limestone that we examined. The tribe Ptychomphalides, as interpreted in this report, is thus not represented in American Carboniferous rocks.

Subfamily EOTOMARIINAE Wenz

Tribe PTYCHOMPHALINIDES Wenz

Diagnosis.—Globose pleurotomariaceans having raised peripheral concave selenizone, generally bordered by flanges.

Description.—Shell expanding rapidly. Upper whorl surface inflated; lower whorl surface about same width as upper. Flanges normally raising selenizone distinctly above general curvature of whorl surface; selenizone itself concave, peripheral, having either upper or lower edge forming widest part of shell; flanges nearly equal in extension from whorl. Base anomphalous to minutely phaneromphalous. Ornamentation predominantly collabral.

Discussion.—Defining the geometry of the selenizone is a complex issue and one that bears on the problem of distinguishing this tribe from the Mourlonides. In *Mourlonia* and allied taxa, the selenizone normally is flush with the whorl and is flat to slightly convex, though it may also be very slightly concave. In *Ptychomphalina* and its allies, the selenizone is always raised. In some forms, the selenizonal area is far extended from the general surface of the shell and is obviously flangelike. In *Ptychomphalina,* the selenizone is raised only a short distance above the general whorl surface, and in many species it is concave in profile between its upper and lower margins. One might argue that this form of selenizone is actually bordered by spiral lirae rather than being raised. However, we judge that lirae would be rounded and would have a convex profile on both their inner and outer faces. In contrast, the outer surface of a flange curves outward to nearly horizontal, relative to the axis of coiling, and the inner surface follows the curvature of the selenizone, which more commonly than not is concave.

The width of a selenizone may be significant in relation to the degree to which the selenizonal area is raised above the general shell surface. Perhaps a wide selenizone, as seen in *Mourlonia*, cannot be raised to any great extent, because it might form a zone of potential weakness. On the other hand, a narrow selenizone, as seen in *Schwedigonia* or *Spiroscala*, may be raised with less danger of weakening the shell. Possibly, a very narrow selenizone must be strongly flanged for strength, but this remains for future investigators to consider.

In addition to *Ptychomphalina*, we are assigning to this tribe *Nodospira* Yochelson and Dutro (1960), a genus that was not in the "Treatise on Invertebrate Paleontology" classification. Other genera may be included when the details of their selenizones are better known. Genera that have a very narrow, strongly flanged selenizone may belong here or may constitute yet another group.

Bembexia, Clathrospira, and *Eotomaria* of the Eotomariides are similar to *Ptychomphalina* in having a flanged concave selenizone, as defined above. However, they are easily distinguished because the selenizone is distinctly inclined, the lower edge of which obviously forms the periphery. We examined topotype material of the type species of *Bembexia* and suggest that much American usage of this genus is incorrect; we do not regard any American Carboniferous species as properly referred to this genus.

Genus PTYCHOMPHALINA Fischer, 1885

Diagnosis.—Subglobose pleurotomariaceans having a narrow raised concave selenizone, peripheral in position.

Description.—Shell moderately low spired; whorl profile relatively simple, inflated. Upper whorl surface having approximately same gently convex curvature as basal surface. Selenizone narrow compared with height of whorl, concave between weak flanges bordered at either side by shallow groove. Base anomphalous to narrowly phaneromphalous. Collabral ornament predominant, prominent.

Discussion.—This genus was placed in the synonymy of *Mourlonia* by Thomas (1939, p. 58). Knight (1944, p. 457) and Knight, Batten, and Yochelson (1960, p. I203) followed this synonymy without any discussion. Data on Paleozoic pleurotomariaceans have increased markedly since 1960, and we now know considerably more about diversity at the generic level than was recognized previously. We agree with Dickens (1978) that *Ptychomphalina* is distinct from *Mourlonia*. This agreement is based on our independent comparison of the type material of the type species of *Mourlonia* and *Ptychomphalina* at the British Museum (Natural History).

Mourlonia has a relatively wide selenizone, whose outer surface has nearly the same curvature as the whorl; it may be flush with the whorl or slightly raised above the whorl surface at one or both margins. *Ptychomphalina* has a narrower, distinctly concave, and weakly to distinctly flanged selenizone. The two taxa were placed in synonymy because they both possess a peripheral selenizone and an inflated lower part of the shell. By emphasizing the character of the selenizone rather than the overall shape, we suggest that the seemingly close relationship of *Ptychomphalina* to *Mourlonia* is questionable.

Dickens (1957, p. 47) removed *Ptychomphalina* from synonymy with *Mourlonia*, placing emphasis on differences in ornament of the type species as they were

illustrated by Knight (1941, pl. 29). Dickens also suggested that variation in the character of the umbilicus that Thomas had used as one of the reasons to synonymize this name was not as significant as first judged. Knight, Batten, and Yochelson (1960) did not follow Dickens (1963, p. 118), who again emphasized the distinctiveness of *Ptychomphalina* from *Mourlonia* but did not elaborate upon his earlier discussion. However, Batten (1966, p. 26, 27) redescribed the type species of both *Mourlonia* and *Ptychomphalina*, refiguring the type species of *Ptychomphalina* and placed them both in *Mourlonia*. In a short paper, Batten (1967, p. 262) took exception to Dickens' view; he emphasized the intergradation at the generic level between the type species of the two taxa in features of the umbilicus and whorl shape.

As for other related genera, the poorly known Permian genus *Spiroraphella* Grabau seems to have more in common with *Ptychomphalina* than with *Mourlonia*, but without authentic specimens at hand, we cannot be certain. In contrast, the Silurian genus *Promourlonia* Longstaff seems to agree with our concept of *Mourlonia*. The Silurian genus *Eocryptaulina* Foerste has a shape similar to that of *Ptychomphalina*, but the ornamentation is far more prominent.

American Mississippian species of Ptychomphalina.—

angulata (Easton), 1943 *(Mourlonia)*
burbankensis n. sp.
magna (Girty), 1927 *(Bembexia)*

The tiny specimen that Thein and Nitecki (1974, p. 83) described as *Mourlonia angulata* Easton, from the Glen Dean Limestone of Illinois, has a depressed selenizone and therefore probably does not belong to that species, nor to *Ptychomphalina* as here defined.

Bembexia magna Girty from the "Middle Boone Limestone" (of early Warsaw age) of the Batesville district, Arkansas, also belongs here. Girty (1929a, p. 94) described this species under the heading "*Bembexia magna* Girty, n. sp., MS?" Although he intended only provisional use of this manuscript name, he gave a short description of the rather poorly preserved and incomplete Arkansas shell, which is therefore the holotype of this species. We removed some of the matrix from this partly crushed specimen (USNM 166717) and found that it is a rather low-whorled shell having a raised concave peripheral selenizone bordered by threads; the principal ornament is of collabral lirae separated by wider interspaces.

In addition to the Mississippian species, *Mourlonia? reloba* Yochelson and Dutro from the Permian Siksikpuk Formation of Alaska, is another American form that has a raised concave selenizone; it is transferred herein to *Ptychomphalina*.

Ptychomphalina burbankensis n. sp.

Plate 3, figures 37–39

Diagnosis.—Slightly inflated pleurotomariaceans having a moderately narrow concave peripheral selenizone and a nearly flat upper whorl surface.

Description.—Shell low-spired, subglobose, expanding rapidly; pleural angle approximately 95°. Nucleus and early whorls unknown, holotype retaining about four whorls. Suture distinct; body whorl embracing previous whorl at or just below lower flange bordering selenizone. Profile of upper whorl surface simple, inclined outward and downward, very slightly convex from suture almost to lower edge, there curving horizontally to form an extremely narrow flange. Selenizone relatively narrow, concave between two low flanges, shallow, and slightly inclined, having lower flange at periphery. Whorl profile below lower flange curving downward and inward, forming distinct and uniform arch to columella, basal surface being much more inflated than upper whorl surface. Base anomphalous. Inner columellar lip straight, without inductura. Outer lip unknown; slit not visible but less than one-quarter whorl in depth.

Growth lines prosocline on upper whorl surface, forming an approximate 70° angle with suture, continuing straight for inner three-fourths of this surface, and then curving to meet upper flange at an approximate 60° angle; strongly opisthocline below lower flange, forming angle of 10°-15° with edge of flange, extending forward and slightly downward a short distance before bending abruptly downward, orthocline to steeply prosocline on base. Ornament poorly known, probably exclusively collabral; upper surface bearing fine lirae having interspaces about twice their width but becoming increasingly obscure with growth; ornament on upper flange more prominent than on surface above; lunulae obscure; basal surface having growth lines of varying prominence, some appearing lamellose, but no other ornament.

Dimensions.—The holotype has a height of 17.2 mm and maximum width of 14.5 mm, but, if the shell were complete, these dimensions would be closer to 18 and 16 mm, respectively.

Discussion.—This species is based on specimens in two collections from a bed carrying the *Lunulozona sadlicki* assemblage within the *Paracravenoceras barnettense* Zone in the Burbank Hills measured section. The preservation is poor; even the best specimens in this assemblage are slightly cracked and expanded.

Ptychomphalina burbankensis is clearly distinguished from *Mourlonia venusta* n. sp., a species of similar shape and size, by its less inflated upper whorl surface, somewhat narrower selenizone, which is con-

cave in profile, and its lack of spiral lirae. *Ptychomphalina angulata* (Easton) from the Pitkin Limestone of Arkansas differs from *P. burbankensis* in having a somewhat narrower pleural angle, a slightly more inflated upper whorl surface, and more prominent collabral ornament. *P. magna* (Girty) from the Boone Formation of Arkansas has a more depressed whorl and a more shallowly concave selenizone set off by angulations from the whorl surface above and below, and more prominent collabral ornament.

Types.—Holotype USNM 210978; paratypes USNM 210979, 211058.

Occurrence and number of specimens.—USGS collections 17201–PC (2), 25546–PC (12), Millard County.

Ptychomphalina sp.

Plate 4, figures 18–20

Mourlonia sp. Sadlick and Nielsen, 1963, p. 1102, pl. 149, figs. 11–13.

Discussion.—This unique specimen, 16 mm in maximum width, has a prominent raised narrow concave selenizone bordered at either side by a flange. Therefore, it does not belong in *Mourlonia* as defined in this paper. The selenizone is narrower and more extended than that of *Ptychomphalina burkankensis* n. sp., and the whorls are more depressed, but the resemblance to *Ptychomphalina* is striking, and we believe that it belongs in that genus. The pleural angle is 105°. The final whorl is biconvex and embraces the preceding whorl immediately below the selenizone. The upper whorl face is sigmoidal in outline, rather flat and narrowly ramplike near the suture, moderately convex just below it, and fairly flat or gently convex across midslope, then flaring out to form the upper surface of the upper flange of the selenizone. Below the selenizone, the whorl slopes strongly inward and is gently concave, then rounds into the base, which is gently convex, becoming almost flat in the columellar area. The upper and lower parts of the final whorl at either side of the selenizone are approximately equal in height.

Growth lines are approximately orthocline at the suture, though curving prosocline at an angle of approximately 25° to a plane through the vertical axis of the shell on much of the upper whorl slope; near the selenizone, they curve to about 45° in crossing the upper flange; they quickly curve to opisthocline over the selenizone and are at an angle of about 45° in that direction on the lower flange of the selenizone; they curve toward orthocline over the concave part below the selenizone, and, becoming orthocline at the point of greatest convexity on the base, they continue straight to the columellar area. Principal ornament is of raised lirae following the course of growth lines, separated by interspaces three to four times as wide; where these lirae cross the flanges bordering the selenizone, they give a minute beaded appearance. Lunulae not observed within the narrow selenizone. Shell consists of two layers; the outer layer is about one-third the thickness of the shell, but its ornament is far more prominent than that on the inner layer.

We know of no other American species that resembles this shell, with the possible exception of *Mourlonia angulata* Easton, as pointed out by Sadlick and Neilsen (1963, p. 1102). We place that species also in *Ptychomphalina*. It has a more rounded periphery and a depressed selenizone, without the prominent flanges of the Utah species.

Ptychomphalina sp. is known only from one specimen collected along with the type lot of *Lunulazona sadlicki* n. sp. from limestone deposited in a euxinic facies of the Chainman Shale about 400 feet (122 m) above the top of the Joana Limestone. It was found in the Leppy Range, near Wendover, Nev. Even though this species does not occur within the area of our study, it was included by Sadlick and Neilsen (1963) as part of the Chainman gastropod fauna.

Figured specimen.—USNM 134170.

Occurrence.—Sadlick and Neisen locality 7–1, 0.3 mile (0.48 km) N. 55° E. from Leppy Peak, about 3.5 miles (5.6 km) north of Wendover, Nev., approximately in SW 1/4 SE 1/4 sec. 28, T. 34 N., R. 70 E., Elko County.

Tribe DESERETOSPIRIDES, new tribe

Diagnosis.—Bluntly conical pleurotomariaceans having depressed concave peripheral selenizone between two raised flangelike borders. Shell trochiform; spire medium in height to moderately high spired. Upper whorl surface gently convex, nearly flat; outer whorl face composed of selenizone, only; base slightly flattened. Selenizone prominent, moderately broad, concave between bordering flanges. Ornament of spiral lirae, generally few and varying in number on upper surface; more numerous and consistent in number on basal surface.

Discussion.—Within the Eotomariinae, a grouping of genera that have a concave selenizone, no place is currently available to accommodate those forms in which the peripheral selenizone is essentially vertical but distinctly concave between an upper and lower flange. Therefore, we are proposing here a new tribe based upon our new genus *Deseretospira*. So far as we can determine, this tribe occurs only in the late Paleozoic; however, we have not investigated Devonian or Triassic genera in detail and do not know whether the range of this tribe includes those systems.

In addition to the type genus, we include *Wellergyi* Thein and Nitecki (1974, p. 96), from the Upper Mississippian and Pennsylvanian of the United States. We have examined specimens from Monroe County, Ill., of *W. chesterensis* Thein and Nitecki, the type species of this genus. These specimens, like the type lot, are less well preserved than the material upon which *Deseretospira* is based; therefore, we prefer to use the Chainman Shale material as the source of the name of the tribe.

Platyteichum Campbell from the Permian of Australia also fits into this tribe. It is somewhat higher spired than the type genus, has more numerous spiral lirae on the upper whorl surface, and does not seem to have collabral ornament. In spite of the considerable difference in time and distance between *Platyteichum* and the other two genera, the relationship appears to us to be very close. *Deseretospira* is intermediate in size between the tiny *Wellergyi* and the moderately large *Platyteichum*.

Genus Deseretospira n. gen.

Type species.—*Deseretospira monilifera* n. sp.

Diagnosis.—Bluntly conical pleurotomariaceans having flanged selenizone on periphery and numerous flat, shallowly stepped spiral lirae on base. Upper whorl surface essentially straight in profile throughout most of its length; earlier growth stages inclined more toward horizontal than later stages. Outer whorl face composed entirely of concave selenizone, bordered by distinct flanges above and below, and protruding from general whorl profile. Base flattened, covered by about a dozen flattish spiral lirae.

Discussion.—*Deseretospira* is a distinctive shell, richly ornamented and showing moderate ontogenetic change, which gives it a shape slightly reminiscent of a beehive. It is known only from the type species. When additional species are found, we suggest that details of ornament, such as number and spacing of spiral lirae, be used to differentiate the taxa at this lower level.

Wellergyi Thein and Nitecki has a smaller, high-spired shell than *Deseretospira* and does not show pronounced ontogenetic change; it also has few spiral lirae, especially on the basal surface. In spite of general similarity in size and shape, differentiation of *Neilsonia* from *Wellergyi* is easy. The selenizone in *Neilsonia* is wider than that in *Wellergyi,* but is flat and bordered by lirae; in *Neilsonia,* an additional short segment of outer whorl face is present below the selenizone. *Deseretospira* differs from *Platyteichum* by its lower spire, less inflated base, and distinct reticulate pattern on the upper whorl surface formed by the intersection of the spiral lirae with collabral threads; *Platyteichum* lacks collabral ornament and also is narrowly phaneromphalous.

Deseretospira is homeomorphic with *Dictyotomaria* Knight; in size, shape, and in most details of ornament, the resemblance is remarkable. However, in *Dictyomaria,* the selenizone is flat and sunk below the level of the outer whorl face; that characteristic allies the genus to *Borestus*. The selenizone in *Deseretospira* is distinctly raised from the general whorl surface by flanges at either side and is concave between them.

Phymatopleura Girty is as elaborately ornamented as *Deseretospira,* though somewhat higher and more conical. The broad flat selenizone of *Phymatopleura* is readily distinguished from the flange groove of *Deseretospira*. A review of the North American species of *Phymatopleura* suggests that the genus was interpreted by many workers in a relatively broad sense and that several of the Pennsylvanian species now included in it are not correctly placed.

Rhineoderma has an ornament like that of *Deseretospira,* but the beaded texture of the upper whorl surface is even more pronounced. *Rhineoderma* is low spired and more globose than *Deseretospira,* and the slightly sunken selenizone low on the whorl readily distinguishes it from *Deseretospira*. Almost certainly, *Rhineoderma* does not belong in the Sinuopeidae; placement in another pleurotomariacean subfamily is warranted. The generic name has been used in a somewhat different sense in North America from that in Europe. It has also been used, we believe incorrectly, for low-spired species having more incised whorls and prominent spiral ornament. *Rhineoderma dinglense* (Girty) from the so-called Brazer Limestone of Idaho and *R. piasaense* (Hall) from the St. Louis Limestone of Illinois are representative of this group. Although their ornament and shape are unlike those of *Deseretopsira,* their selenizones are similar to that of our new genus. Perhaps another new genus within the Deseretospirides should be named to accommodate these low-spired species.

Deseretospira monilifera n. sp.

Plate 7, figures 9–15

Diagnosis.—Bluntly conical Deseretospirides having five beaded spiral lirae on upper whorl surface and about a dozen inclined gently stepped lirae on base.

Description.—Nucleus unknown; early whorls having upper whorl surface less inclined than that in more mature stages, so profile is bluntly conical; pleural angle approximately 95°. Body whorl embracing penultimate whorl at lower edge of selenizone; suture obscure. Upper whorl surface gently inclined and inflated on early whorls; details of ornament unknown; mature

upper whorl surface beginning at flat, nearly horizontal sutural ramp, having main part of surface inclined 45° from axis of coiling and straight in profile except for interruptions by spiral lirae; outer part curving concavely to form short, prominent, nearly horizontal flange. Selenizone shallowly concave between bordering flanges; upper flange forming periphery; lower flange gently inflated, inclined at about 45° for short distance, then bending abruptly inward at first spiral lirae and at successive lirae progressively increasing inclination toward horizontal, so that general aspect is of shell having nearly flat base. Base cryptomphalous; innermost part inclined very slightly upward adjacent to columella.

Growth lines orthocline on ramp, bending to prosocline, about 30° from vertical with little change of inclination until just before flange, where they curve to meet edge of flange at 45°; lunulae wide, shallowly U-shaped; growth lines steeply opisthocline on lower edge of flange, almost immediately curving to orthocline and then steeply prosocline before crossing first spiral lira; nearly straight on main part of base and inclined about 30° to edge of lower flange, but gently curved to form shallow sinus, concave adaperturally. Five spiral cords ornamenting upper whorl surface, nearly uniformly spaced between suture and flange, progressively finer toward flange; upper two lirae coarsely beaded, middle lira finely beaded; spiral lirae crossed by finer collabral threads, forming an elongate rectangular pattern; interspaces between collabral threads about five times width of threads; lunulae closely spaced, fine. Basal surface covered by 11 to 13 fairly closely spaced, asymmetrically flattened coarse lirae, shallowly stepped, having at least relief on side toward columella, increasing in height toward columella. Shell substance of at least two layers, outer layer about one-third thickness of inner layer.

Dimensions.—The holotype and figured paratype, respectively measure (in mm): height 11.8 and 14.6, maximum width 12.2 and 15.

Discussion.—This species is based upon four specimens, all from the same locality, but from different collections. They came from a 20-foot (6.1-m) interval in the Jensen Wash section, Burbank Hills about 100 to 120 feet (30.1–36.6 m) below the top of the *Paracravenoceras barnettense* Zone, in the lower middle part of the Chainman Shale. *Deseretospira monilifera* occurs with *Glabrocingulum* (*Glabrocingulum*) *hosei* n. sp. in a ratio of roughly 1 to 300 specimens and can be easily be overlooked because of similarity in its size and general appearance to G. (*G.*) *hosei*. It differs from *G.* (*G.*) *hosei* in its bluntly conical shape, shorter base, beading of the lirae, and position of the selenizone lower of the whorl.

Several species of *Dictyotomaria* and, to a lesser extent, *Phymatopleura* also are similar to *Deseretospira monilifera* in general shape and ornament. We would thus urge caution in attempting to identify species that do not preserve the selenizone, which is raised in *Deseretopsira* and depressed in the other two genera.

Types.—Holotype USNM 210980, paratypes USNM 210981–210983.

Occurrence and number of specimens.—USGS collections 17187–PC (1), 22857–PC (1), 25262–PC (1), 25264–PC (1), Millard County.

Tribe GLABROCINGULIDES, new tribe

Diagnosis.—Turbiniform to trochiform pleurotomariaceans having moderately narrow peripheral selenizone at upper angulation; selenizone concave, bordered by projecting flanges and commonly tilted outward slightly; ornament of spiral and collabral lirae.

Description.—Shell expanding rapidly; spire conical to gradate; upper whorl surface convex to concave. Selenizone narrow, shallowly concave; flanges raising it only slightly above general curvature of whorl surface; outer face including part of whorl below selenizone several times width of selenizone. Base shallowly inflated, anomphalous to minutely phaneromphalus, columellar lip commonly reflexed; outer lip having slit less than one-quarter whorl in depth. Spiral lirae generally present, strongest near suture and on base, crossed by collabral lirae that are strongest near suture on upper whorl surface.

Discussion.—The tribe Eotomariides, as presently constituted (Knight, Batten, and Yochelson, 1960, p. I204), ranges from Middle Ordovician through Permian; *Eotomaria*-like gastropods are now known in the late Early Ordovician. We recognize a close relationship between *Eotomaria* and *Clathrospira* of Ordovician to Silurian age and would restrict the tribe Eotomariides to pleurotomaricaceans of this type. The predominantly Devonian genus *Bembexia* is far closer to *Mourlonia* than to other genera; we base this opinion on examination of a topotype specimen and not on the common usage of *Bembexia* in the American literature. *Platyteichum*, we believe, is related to our new genus *Deseretospira*, for which we are erecting another tribe.

We believe that the two remaining genera formerly included in the Eotomariides, *Glabrocingulum* and *Eirlysia*, form a compact group characterized by a concave selenizone at the upper angulation. We regard these taxa as distinct enough to be removed from close association with the early Paleozoic genera. In the Pennsylvanian of North America, *Glabrocingulum* is the single most abundant gastropod genus.

Genus GLABROCINGULUM Thomas, 1940

Glabrocingulum is the most abundant gastropod genus in the Chainman shale, accounting for more than half the gastropods collected. Seven named species are recognized, belonging in two subgenera. Three additional taxa are also described under open nomenclature; these may be valid species. All our specimens are referred to one or another of these 10 taxa, with the exception of a single poorly preserved specimen from the northern Needle Range (USGS collection 15161–PC), which we are able to identify only as *Glabrocingulum*? sp.

Subgenus G. (GLABROCINGULUM) Thomas, 1940

Diagnosis.—Fairly short-spired trochiform pleurotomariaceans, having concave selenizone between bordering flanges at upper angulation of whorl; upper whorl face gently concave to flat, base rounded; succeeding whorls attaching immediately or a little below selenizone; inner lip recurved over narrow umbilicus; outer lip having deep slit.

Discussion.—This subgenus differs from *G.* (*Ananias*) in its shorter and less gradate spire and generally sparser sculpture. Some species that we include in *G.* (*Glabrocingulum*) have extremely depressed spires; others are small, the shape and position of the selenizone being the unifying character. On typical shells from the Chainman Shale, the spire and base are about the same depth. The Utah specimens show considerable variety, and the species change relatively rapidly through time and make useful guide fossils. We recognize nine species within the formation.

American Mississippian species of Glabrocingulum (Glabrocingulum).—

binodosum Sadlick and Nielsen, 1963
chesterense (Thein and Nitecki), 1974 (*Trepospira* [*Trepospira*])
confusionense n. sp.
ellenae (Conkin), 1957 (*Bembexia*)
granulosum n. sp.
hosei n. sp.
inflatum Sadlick and Nielsen, 1963
mephitifontis n. sp.
minutum Rollins, 1975
quadrigatum Sadlick and Nielsen, 1963
sinuatum (S. Weller), 1916 (*Ptychomphalus*)
stella (Winchell), 1862 [1863] (*Pleurotomaria*)
stellaeforme (Hyde), 1953 (*Mourlonia*?)

Trepospira (*Trepospira*) *chesterensis* Thein and Nitecki (1974, p. 79, figs. 25a–f) was based upon "one fairly good and three more or less fragmentary specimens" from two localities in the Golconda Limestone in southern Illinois. These specimens are clearly low-spired glabrocingulums. We have examined a lot of more than 500 specimens from a locality in the NE 1/4 NE 1/4 sec. 26, T. 4 S., R. 9 W. in Monroe County, Ill., collected by G. H. Girty and Stuart Weller in 1912. Many are abraded and have the selenizone worn down to a smooth raised band. Unabraded specimens have an ornament of fine collabral lirae crossed by spiral lirae, minutely nodose at the intersections, particularly near the suture; these shells all preserve a raised concave selenizone bordered by a lira at either side and tilted outward slightly.

Bembexia ellenae Conkin from the New Providence Shale of Kentucky is also hereby transferred to *G.* (*Glabrocingulum*). We examined the primary types (USNM 127325–127329) and find that this species differs from most other species of *G.* (*Glabrocingulum*) in its strong nodose spiral lirae of variable thickness and in its turbiform shape.

Ptychomphalus sinuatus S. Weller from the Ste. Genevieve Limestone in Illinois is a tiny species having the shape of *G.* (*Glabrocingulum*). We examined topotypes collected by Weller and Girty and here transfer it to *G.* (*Glabrocingulum*).

Pleurotomaria stella Winchell from the Marshall Formation of Michigan likewise belongs in this subgenus, having much the same shape as *G.* (*G.*) *grayvillense* (Norwood and Pratten), according to unpublished notes of G. H. Girty, who examined Winchell's type material. *G.* (*G.*) *stella* differs from *G.* (*G.*) *grayvillense* in lacking spiral ornament and in lacking any sort of umbilical opening; in the Michigan species, this opening is covered by the reflexed apertural lip. Girty's unpublished figures of Winchell's holotype and a slightly larger specimen confirm that this is a tiny *Glabrocingulum*.

A similar species, described as *Mourlonia*? *stellaeformis* Hyde from the Byer Member of the Logan Formation of Ohio, was transferred to *G.* (*Glabrocingulum*) by Sadlick and Nielsen (1963, p. 1095).

Sadlick and Nielsen (1963, p. 1097, 1102) referred *Baylea* [*Trepospira*] *inflata* Elias (1958, pl. 1, figs. 8, 9) to *G.* (*Glabrocingulum*), and this species should be attributed to them. In his text, Elias (1958, p. 5–7) described this species as *Baylea* [*Trepospira*] *stellaeformis* (Hyde), and at the end of his description, he said that "It is identical with the Waverlyan species in all respects." The fact that he cited his figured specimens as "*Baylea* [*Trepospira*] *inflata* n. sp." in the plate description does not constitute the valid establishment of a new species according to Article 13 (a) of the International Code of Zoological Nomenclature (International Trust for Zoological Nomenclature, 1961, p. 13). It was not until Sadlick and Nielsen (1963, p. 1097) referred to Elias's description and illustrations and pointed out

differences between *G. (G.) inflatum* and *G. (G.) stellaeforme* (Hyde) that the Oklahoma species took on any validity. We therefore recognize this species as *G. (G.) inflatum* Sadlick and Nielsen.

Glabrocingulum (Glabrocingulum) granulosum n. sp.

Plate 6, figures 1–3, 12

Diagnosis.—Glabrocingulums ornamented by alternating strong and weak spiral lirae, nodose at intersections of weaker collabral threads.

Description.—Nucleus unknown; earliest known whorls orthostrophic, at least two of them unornamented and having a rather strongly inflated upper whorl surface; more mature whorls ornamented primarily by spiral lirae. Shell moderately high spired; pleural angle approximately 90°. Sutures distinct; body whorl embracing penultimate whorl distinctly below selenizone, though juncture seemingly is at lower flange in earlier stages. Mature whorl profile simple; upper whorl surface inclined uniformly outward and downward from suture to outer edge, where it flattens abruptly to form upper bordering flange of concave selenizone. Selenizone forming upper part of outer whorl face, moderately narrow, distinctly concave between narrow, relatively high, sharp bordering flanges, edges of which are almost vertical but having lower flange at periphery; below selenizone, outer whorl profile inclined steeply inward and downward, smoothly for about one-third of distance to columellar area, then curving gradually inward and following approximate arc of circle, so that basal whorl surface is poorly delineated from outer face. Base probably anomphalous, though a tiny umbilical chink may be present. Columellar lip not known in detail, but seemingly simple; depth of slit and other aperture details unknown.

Growth lines slightly curved, sweeping prosocline from suture and reaching selenizone at angle of about 45°; steeply opisthocline immediately below selenizone but turning to orthocline at about one-sixth distance from selenizone to columella and continuing straight to columellar area, selenizone having well formed, closely spaced, fine lunulae. Upper whorl surface ornamented by spiral lirae, five being prominent on early whorls, and additional lirae intercalated on more mature whorls so that body whorl bears spiral lirae of two sizes; lirae bearing small nodes at each intersection with growth lirae, which are so closely spaced that interspaces are barely wider than nodes. Lower part of shell below selenizone ornamented similarly but with less obvious distinction between first- and second-order spiral lirae, of which about 15 are present on lower surface of body whorl; lirae on body whorl bearing fine interference nodes where crossed by growth lines.

Dimensions.—The incomplete holotype, lacking approximately the last one-half whorl, measures 16.5 mm in height and 17.0 mm in maximum width.

Discussion.—This species occurs at Granite Mountain, where it is sparse in most collections from the early Chesterian *Goniatites granosus* Zone. We also collected it in the same zone in the Pancake Range, White Pine County, Nev., about 1 mile (1.6 km) north-northeast of the ruins of Pogues Station.

G. (G.) granulosum n. sp. seems to be most similar to *G. (G.) ellenae* (Conkin) from the New Providence Shale of Kentucky in having two sizes of nodose spiral lirae on the body whorl. The upper whorl surface in *G. (G.) ellenae* is convex, bearing two or three prominent spiral lirae in the early whorls and six on the body whorl. In *G. (G.) granulosum*, the upper whorl surface slopes flatly, bearing five spiral lirae on the early whorls and 10 on the body whorl. On other species of *G. (Glabrocingulum)*, such as *G. (G.) confusionense* n. sp. and *G. (G.) quadrigatum* Sadlick and Nielsen, that have several nodose spiral lirae on the upper whorl surface, these lirae grade downward in size from the suture to the selenizone.

Types.—Holotype USNM 210984; paratypes USNM 210985–210987.

Occurrence and number of specimens.—USGS collections 17012–PC (7), 17015–PC (2), 17020–PC (2), Juab County; 20446–PC (1) Millard County.

Glabrocingulum (Glabrocingulum) mephitifontis n. sp.

Plate 6, figure 15; plate 7, figures 6–8

Diagnosis.—Moderately small glabrocingulums having flat to slightly concave upper whorl surface ornamented by numerous fine collabral lirae, dying out toward selenizone, and crossed by a pair of subsutural spiral lirae; 9 or 10 fairly strong spiral cords on base.

Description.—Shell trochiform; pleural angle approximately 70°. Nucleus unknown. Suture distinct, slightly impressed, joining previous whorl at upper edge of selenizone on early postnuclear whorls and moving rapidly downward with growth, so that within one volution, suture is below selenizone. Upper surface of early whorls gently concave from suture to outer edge, more mature stage having extremely narrow subsutural shelf followed by inclined surface showing essentially no curvature until just before selenizone, where surface flares almost horizontally to form prominent raised narrow flange. Selenizone relatively narrow, gently concave between two prominent flangelike lirae, inclined generally outward and down at angle of nearly 45° so that lower flange of selenizone forms periphery. Outer whorl face below selenizone very slightly concave in upper part, below which inclined

steeply downward and gently inward about 15° from vertical, followed by a shorter segment inclined about 30° from vertical, rounding smoothly into base. Except for interruptions by spiral ornament, base forming arc of circle in profile, rounding into depression where it joins columella. Base anomphalous. Columellar lip short, without inductura; other details of aperture unknown.

Growth lines nearly orthocline from suture across narrow ramp, curving distinctly prosocline at its outer edge, and crossing upper whorl surface with slight curvature at about 45° to upper flange of selenizone; lunulae extremely obscure; growth lines strongly opisthocline immediately below lower flange for about half distance across outer whorl face, gradually curving to orthocline, and proceeding approximately straight to columella. Ornament on upper whorl surface of two spiral lirae, one at edge of ramp particularly prominent; rounded collabral lirae forming nodes on first two spiral lirae and having interspaces about twice as wide as lira, strongest between suture and upper spiral lira, much less prominent between the spiral lirae, and obscure below; outer whorl face having one obscure and two prominent spiral lira below selenizone; base ornamented by approximately nine more closely spaced and cordlike lirae.

Dimensions.—Holotype, 9.3 mm in height and 8.7 mm in width.

Discussion.—*G. (G.) mephitifontis* n. sp., the *Glabrocingulum* of Skunk Spring, Confusion Range, is a rare species in the Chainman Shale, limited to the early Chesterian *Goniatites granosus* Zone. A small incomplete paratype was collected at Granite Mountain together with *G. (G.) granulosum* n. sp. Integradation between those two species is out of the question because they are two of the most unlike in the whole spectrum of Chainman *Glabrocingulum* species.

In having two spiral lirae near the summit of the upper whorl face, *G. (G.) mephitifontis* is like *G. (G.) binodosum* Sadlick and Nielsen, another Chainman species, but the latter form is much lower spired, wider than high, has a strongly oblique columella, and occurs much higher stratigraphically in the Chainman. *G. (G.) inflatum* Sadlick and Nielsen from the Redoak Hollow Member of the Goddard Shale of Oklahoma also is similar in having two spiral lirae, but the upper whorl surface is more concave, the collabral lirae weaker, and the outer face below the selenizone seems to be devoid of spiral lirae; the base is not known. The Oklahoma species also occurs higher stratigraphically, being late Chesterian in age.

Types.—Holotype USNM 210988, paratype USNM 210989.

Occurrence and number of specimens.—USGS collections 17012–PC (1), ?17037–PC (1), Juab County; 15354–PC (1), Millard County.

Glabrocingulum (Glabrocingulum) confusionense n. sp.

Plate 5, figures 1–9; plate 6, figures 13, 14

Glabrocingulum quadrigatum Sadlick and Nielsen, 1963 [part], p. 1098–1102, pl. 150, figs. 5–8 [not figs. 1–4, 9–12].

Diagnosis.—Glabrocingulums having selenizone at angulation slightly inclined at maturity; essentially flat and sloping upper whorl surface bearing three to five spiral lirae, the upper of which are nodose. Nucleus sunken.

Description.—Shell moderately low, trochiform; pleural angle about 92°; suture distinct. Nucleus tiny, bulbous, of about 1 1/2 smooth whorls projecting above first postnuclear whorl, which commonly is partly sunken within second whorl. Rest of whorls show minor ontogenetic change, in early stages embracing near upper part of selenizone, so that sutural edge of upper whorl surface appears ramplike; with growth, point of juncture gradually moves to below selenizone; at maturity, upper edge of whorl appears as a coronate ridge. Upper whorl surface inclined outward and downward with essentially no inflation, flaring out abruptly to nearly horizontal on top of prominent flange. Selenizone narrow, gently concave between two sharp prominent bordering flanges, nearly vertical at earlier stages, but inclined about 15° from vertical at maturity, lower flange forming periphery. Outer whorl face and base not distinctly separable below flange; upper segment arbitrarily separated by spiral lirae, about twice width of other segments and inclined inward roughly 30° from vertical, followed by shorter segment of essentially same inclination and then a smooth well-rounded curve, approaching arc of circle. Base anomphalous but having shallow umbilical depression. Columellar lip thickened and reflexed, bearing an elongate excavation below umbilical depression. Slit depth less than one-quarter whorl; other details of aperture unknown.

Growth lines on upper whorl surface curving smoothly prosocline from suture to flange describing uniform gentle arc; lunulae faint, symmetrical, well formed, nearly semicircular and very closely spaced; below flange, growth lines opisthocline at approximately 45°, curving very rapidly to orthocline and, in early growth stages, proceeding straight to base; at more mature stages, swinging to form wide shallow sigmoidal curve occupying much of base. Ornament of upper surface composed most commonly of four spiral lirae, highest lira, adjacent to suture, cordlike, size of

lirae decreasing down whorl face, a thread common between lowest lira and flange. Flange four times as high as coarsest spiral lira. Collabral ornament finer than spiral lirae and separated by interspaces about four times as wide, becoming smaller toward flange. Intersection of spiral and collabral elements marked by nodes, extremely prominent near suture but decreasing in size downwhorl, minute and irregularly spaced on lowest spiral lira. Below selenizone and on base, about 16 lirae are present, the two highest lirae more widely spaced than any of others, those lower on whorl having interspaces about twice their width but those near columella more widely spaced and coarser; all these lirae are nodose, but nodosity is particularly prominent on lowermost ones.

Dimensions.—The primary types are almost complete and undistorted, and the measurements give a reasonable idea of the original variation in shape. The first three types are from USGS collection 17187–PC; the last is from collection 23846–PC (measurements in mm):

USNM	210995	211028	210994	210999
Height -----	16.8	15.3	14.8	11.8
Width ------	15.6	15.1	14.5	[2]12.8

Discussion.—*G*. (*G*.) *confusionense* n. sp. is one of two species included in the primary types of *G*. (*G*.) *quadrigatum* Sadlick and Nielsen (1963, p. 1098–1102). The holotype and five paratypes of *G*. (*G*.) *quadrigatum* came from Sadlick and Nielsen's locality 2–1 in the Burbank Hills, which they recorded as 465 feet (141.7 m) below the top of their uppermost member of the Chainman Shale. Another lot of three specimens collected by geologists of the California Oil Company in sec. 24, T. 15 S., R. 18 W., north of the Bishop Springs anticline in the Confusion Range was also included among the designated paratypes of *G*. *quadrigatum*; in our opinion, these specimens belong in *G*. (*G*.) *confusionensis* despite strong similarities in ornamentation to *G*. (*G*.) *quadrigatum*. We are describing this new species from our own material from the Burbank Hills, but we refigure for comparison on plate 5, figures 4–6, the specimen from the Confusion Range illustrated by Sadlick and Nielsen (1963, pl. 150, figs. 5–8).

In the Burbank Hills, *G*. (*G*.) *confusionense* sp. occurs in approximately the upper 100 feet (30 m) of the *Paracravenoceras barnettense* Zone, where it is associated with *G*. (*G*.?) *hosei* n. sp. and the coleoid cephalopod *Hematites barbarae* Flower and Gordon. *G*. (*G*.) *quadrigatum*, as restricted in this report, occurs higher stratigraphically most commonly in the upper part of the *Cravenoceras hesperium* Zone; in the Confusion Range it is fairly widespread in this ammonoid zone.

The two species are distinguished by their early whorls and ornament of the upper whorl surface. *G*. (*G*.) *confusionense* has four, five, or three lirae on the upper whorl surface, in descending order of frequency among individuals; *G*. (*G*.) *quadrigatum* has five to nine lirae and threads on the mature upper whorl surface, most commonly six or seven. The nucleus of *G*. (*G*.) *confusionense* generally is set off by an abrupt widening of the first postnuclear whorl, the minute bulbous nucleus standing up like a tiny finial. In *G*. (*G*.) *quadrigatum*, the nucleus passes without significant change in coiling into the postnuclear whorls. Also, specimens of *G*. (*G*.) *confusionense* generally are a little larger than those of *G*. (*G*.) *quadrigatum*.

Young shells of *G*. (*G*.) *granulosum*, particularly those not well preserved, can be mistaken for *G*. (*G*.) *confusionense*, as they commonly have five lirae on the early whorls. However, *G*. (*G*.) *granulosum* generally has strong nodose lirae on the lower part of the upper whorl surface, and intercalated fine lirae commonly appear early in this species and contrast with the spiral lirae of *G*. (*G*.) *confusionense*, which decrease in size downslope and almost never are intercalated.

Type.—Holotype USNM 210994; paratypes USNM 134182–134184, 210995–210999, 21102, 364705, 364706.

Occurrence and number of specimens.—USGS collections 15165–PC (43), 15166–PC (1), 17055–PC (27), 17186–PC (3), 17187–PC (55), 19603–PC (1), 20448–PC (8), 23846–PC (40), 25262–PC (87), 25557–PC (15), 28611–PC (7), 28623–PC (14), Millard County.

Glabrocingulum (Glabrocingulum) quadrigatum Sadlick and Nielsen

Plate 5, figures 10–15; plate 6, figures 11, 16, 19

Glabrocingulum quadrigatum Sadlick and Nielsen, 1963 [part], p. 1098–1102, pl. 150, figs. 1–4, 9–12 [not figs. 5–8].

Glabrocingulum (Galbrocingulum) quadrigatum. Gordon and Yochelson, 1983, p. 982–984, fig. 3CC.

Diagnosis.—Glabrocingulums having slightly inclined selenizone at maturity. Nucleus merging evenly with postnuclear whorls. Upper whorl surface bearing five to seven spiral lirae, upper lirae nodose.

Description.—Shell of moderate height trochiform; pleural angle ranging from 75° to 91°, but 91° in holotype; suture distinct. Nucleus small, turbiform, smooth, of approximately 1 1/2 whorls, passing without obvious interruption into postnuclear whorls. Early

[2]Columella arches.

whorls embracing approximately at top of selenizone, but without appearing ramplike; point of juncture gradually moving to position below selenizone during growth, so that selenizone partly overhangs uppermost coronate spiral cord. Upper whorl surface having ramplike shelf on later whorls, but main part nearly flat, inclined outward and downward, and terminating in slight flare at upper flange of selenizone. Selenizone narrow, gently concave between two narrow prominent bordering flanges, vertical in early whorls, but inclined outward and downward at about 15° angle, so that lower flange is at periphery of shell. Below flange, outer whorl face flat to slightly concave, inclined downward and slightly inward, commonly separated from base by weak angulation. Base gently convex, anomphalous, but having shallow umbilical depression. Columellar lip thickened and reflexed, partly covering umbilical depression. Depth of slit not clearly shown, but growth lines indicate it approximates one-sixth whorl; other details of aperture not known.

Growth lines gently prosocline across upper whorl face, curving evenly from suture to flange, which they approach at approximate 30° angle; lunulae fine, faint, closely spaced, almost semicircular; below flange, growth lines are opisthocline, beginning at 45° to lower flange and curving to approximately orthocline as they cross subangulation between outer whorl face and base; on base, growth lines are gently curved sigmoidally, shallowly bowed adapically and then adaperturally toward columella.

Five fine spiral lirae normally appearing on first postnuclear whorl and continuing on to later whorls. Small nodes beginning on second postnuclear whorl at intersections of upper two spiral lirae and growth lirae, becoming much stronger on later whorls; other cords also bearing small nodes on later whorls. Outer face generally bearing one to five fine spiral lirae; 10 to 15 stronger lirae ornamenting base, strongest at subangulation and becoming weaker toward columella, locally an occasional very fine intercalated thread. Interspaces between lirae several times wider than lirae.

Dimensions.—Dimensions (in mm) of the holotype from Nevada (USNM 134176) are given below, but all the Nevada paratypes (USNM 134177–134181) lack part of the base. Measurements (in mm) of three hypotypes from Utah (USNM 211000–211002) are also given below:

USNM	134176	211000	211001	211002
Height -----	6.4	10.5	10.1	17.4
Width ------	8.0	10.8	10.0	15.2

Discussion.—The description of this species is based upon the holotype, paratypes from the type locality, and better preserved supplementary specimens from the same 15-foot (4.6-m) stratigraphic zone at other localities in the Burbank Hills. As we pointed out in our discussion of *G. (G.) confusionense* n. sp., Sadlick and Nielsen (1963, p. 1098–1102) included two somewhat similar species in *G. (G.) quadrigatum*. These species came from beds roughly 500 feet (152 m) apart stratigraphically (in the Burbank Hills). Much of Sadlick and Nielsen's original description of *G. (G.) quadrigatum*, as well as the name they selected, is particularly applicable to the lower species. This species, for which we are proposing the name *G. (G.) confusionense*, is restricted to the *Paracravenoceras barnettense* ammonoid zone; it typically has four spiral lirae on the upper whorl surface. The holotype of *G. (G.) quadrigatum,* however, has six spiral lirae on that surface. It is a specimen of the stratigraphically higher species, which is restricted to the *Cravenoceras hesperium* ammonoid zone. This shell always has more than four spiral lirae ornamenting the upper whorl surface.

Our specimens show that *G. (G.) quadrigatum* has five to seven spiral lirae on the upper whorl surface; *G. (G.) confusionense* has three to five. A paratype of *G. (G.) quadrigatum* illustrated by Sadlick and Nielsen (1963, pl. 150, figs. 9–12) has five spiral lirae on the upper whorl surface. All the specimens from the type locality tend to be low spired and to have five or six lirae, but others from nearby localities within the same stratigraphic zone have five to seven lirae. Those having the greatest number of spiral lirae are generally higher spired. They are fairly common in the Foote Range and have six to seven lirae on the upper whorl surface; occasionally finer lirae are intercalated with coarser ones. A typical specimen bearing seven lirae is illustrated on plate 6, figure 11. In addition to the seven lirae on the upper whorl surface, the shell has two strong flanges bordering the selenizone, five fairly fine lirae on the outer whorl face, and 14 or 15 coarse lirae on the base; these lirae become finer toward the columella, but include two or three fine intercalated threads.

The nuclear whorls of *G. (G.) quadrigatum* pass without significant change in inclination into the early postnuclear whorls; this fracture also distinguishes *G. (G.) quadrigatum* from *G. (G.) confusionense*, in which the nucleus stands above the very low sloping first postnuclear whorl, which is shallowly immersed in the steepersloping second postnuclear whorl.

G. (G.) quadrigatum ranges rather widely through the *Cravenoceras hesperium* Zone and, so far as we have been able to determine, is restricted to that zone.

Types.—Holotype USNM 134176; paratypes USNM 134177–134181; hypotypes USNM 211000, 211001, 211002.

Occurrence and number of specimens.—USGS collections 17095–PC (13), 25249–PC (5), 25252–PC (2), Juab County; ?17022–PC (7), 17023–PC (76), 17056–PC (8), 17188–PC (12), 17209–PC (5), 17219–PC (26), 17310–PC (52), ?19604–PC (1), ?20443–PC (3), 25274–PC (5), 25318–PC (9), 25547–PC (21), 25550–PC (70), 25551–PC (11), Millard County.

Glabrocingulum (Glabrocingulum) binodosum Sadlick and Nielsen

Plate 5, figures 28–35; plate 6, figures 17, 18

Glabrocingulum binodosum Sadlick and Nielsen, 1963, p. 1096–1098, pl. 149.

Discussion.—To summarize the salient features of this species, *G. (G.) binodosum* has a low-spired shell, having a pleural angle of approximately 100°; the upper whorl face is gently convex. The selenizone is flat to gently concave, tilted at approximately 30° to the vertical axis of the shell, bordered by narrow shallow flanges. Below the selenizone, the outer whorl face commonly is shallowly concave and then curves convexly, before rounding into the base, which has a shallow umbilical depression partly covered by the reflexed inner lip. The outer lip is thin.

Our specimens show that *G. (G.) binodosum* commonly has two or three spiral lirae, or rarely four, just below the suture on the upper whorl face; the lirae farther from the suture are a little finer and more closely spaced. As many as three lirae may be conspicuously nodose (pl. 5, fig. 32–35). The nodes are closely spaced, occurring where growth lirae cross the spiral lirae. Lunulae are visible on some specimens, generally those having more prominent growth lirae. The base and adjacent part of the outer whorl face bear 10 to 16 spiral lirae, finer toward the umbilicus, barely visible on some specimens, but commonly bearing tiny irregularly spaced nodes.

This species is distinguished from all other glabrocingulums in the Chainman Shale by its low spire, obtuse pleural angle, and gently convex upper whorl face. Its subdued spiral scupture, absent on the outer part of the upper whorl face and upper part of the outer whorl face, is also distinctive. *G. (Ananias) seminudum* n. sp. is closest in ornamentation to *G. (G.) binodosum* but has a higher stepped spire, more closely spaced spiral lirae on the upper whorl slope, lower pleural angle, and more prominent flanges and spiral cords on the base.

G. (G.) binodosum is not a common species and seems to be restricted to the upper part of the Chainman Shale. At its type locality in the Foote Range, this gastropod occurs 20 to 30 feet (6.1 to 9.1 m) above the *Richardsonites merriami* bed, or about 275 to 285 feet (84 to 87 m) below the top of the Chainman. From the southern Burbank Hills, a single specimen was collected along with *G. (G.) quadrigatum* Sadlick and Nielsen and *Cravenoceras hesperium* Miller and Furnish from near the top of the *C. hesperium* Zone. Sadlick and Nielsen (1963, p. 1098) reported *G. (G.) binodosum* from the same area, 15 to 20 feet (4.6 to 6.1 m) below the Chainman-Ely contact. These records indicate that it may range through the upper 500 feet (152 m) of the formation in this region.

Types.—Holotype USNM 134172; paratypes USNM 134173–134175; hypotypes USNM 211004, 211059.

Occurrence and number of specimens.—USGS collections 14559–PC (1), 17310–PC (1), 22883–PC (19), Millard County.

Glabrocingulum (Glabrocingulum) sp. A

Plate 7, figure 21

Discussion.—Another *Glabrocingulum* occurs in the *Lunulazona nodimarginata* assemblage in the upper part of the *Goniatites americanus* Zone in the Granite Mountain section. Most of the specimens are steinkerns, but remnants of the ornament are preserved on the figured specimen. These remnants of ornamentation, because of their low relief, are believed to represent the inner shell layer, the outer shell layer having been exfoliated. This specimen is turbiform, has slighly more than four whorls, and measures 10.5 mm in height and 11.0 mm in maximum width; the pleural angle is approximately 90°. The upper whorl surface is gently convex, sloping about 5° below horizontal at the suture, and flaring slightly at the selenizone, the lower edge of which forms the periphery. The selenizone is concave between two slightly projecting flanges. The base is well rounded, curving rather evenly downward and inward to a low point of greater convexity, then continuing upward and inward to the columellar areas. The inner lip is curved.

On the upper whorl surface near the aperture, eight poorly preserved spiral lirae are present, the outer two more closely spaced than the others; these lirae seem gradationally smaller outward from the suture. On the base, between the selenizone and the lowest point on the basal surface near the aperture, approximately 16 poorly preserved lirae and finer threads are present, those nearest the selenizone alternating in strength. These lirae and threads are crossed by collabral threads that are nearly orthocline at the suture and curve to meet the upper edge of the selenizone at an angle of 45°. These collabral threads are obscure immediately below the selenizone, but over the first spiral ornament on the base, they are opisthocline. However, within a very short distance, the collabral threads curve to orthocline before they die out. At the intersections of the spiral and collabral threads, tiny nodes are

present. The lunulae have not been preserved, but the inner end of the slit indicates that they were shallowly U-shaped. The aperture is marked by a narrow groove that apparently represents a thickened cord just within the outer lip. The slit is well preserved, approximately one-fifth of a whorl in depth, and narrowly rounded at the inner end.

G. (*G.*) sp. A, as perhaps might be expected, is closest to its stratigraphically near neighbor, *G.* (*G.*) *granulosum* n. sp. of the *Goniatites granosus* Zone. Both species have a roughly similar shape and have an ornament of numerous spiral lirae on both upper and lower whorl surfaces. *G.* (*G.*) *granulosum* differs in having a flatter sloping upper whorl surface, intercalation of narrow threads between wider lirae on this surface, and a more coarsely lirate base. *G.* (*G.*) sp. A has 16 lirae on the base; specimens of *G.* (*G.*) *granulosum* of the same size have about 10.

The number of lirae on the upper whorl surface of *G.* (*G.*) sp. A also is similar to that of *G.* (*G?*) *hosei* n. sp. and *G.* (*G.*) *quadrigatum* Sadlick and Nielsen, middle and late Chesterian species, respectively, both of which may be distinguished by their more gently sloping whorls and finer lirae; *G.* (*G.?*) *hosei* differs in its general lack of collabral lirae and nodosity. *G.* (*G.*) *mephitifontis* n. sp., *G.* (*G.*) *confusionensis* n. sp., and *G.* (*G.*) *binodosum* Sadlick and Nielsen all have fewer lirae on the upper whorl surface than does *G.* (*G.*) sp. A. *G.* (*G.*) *binodosum* is lower spired than *G.* (*G.*) sp. A.

Figured specimen.—USNM 211004.

Occurrence and number of specimens.—USGS collections 17018–PC (8), 25558–PC (1), Juab County.

Glabrocingulum (Glabrocingulum) sp. B

Plate 7, figures 16, 17

Discussion.—Another species of *Glabrocingulum* is represented by a few very poorly preserved specimens collected east of Coyote Pass in the Conger Range and associated with *Richardsonites merriami* (Youngquist) in a 6-inch (0.15-m) bed, approximately 400 feet (121.9 m) below the top of the Chainman Shale. Several specimens shown worn remnants of a concave selenizone, but only one preserves details of ornament. This specimen (pl. 7, figs. 16, 17) retains a row of relatively large nodes along a subsutural ramp, below which the upper whorl surface is strongly concave, flaring outward at its lower edge to form the upper flange of the selenizone. The selenizone is narrow, slightly raised, and concave between the two flanges. The lower whorl profile is narrowly horizontal on the underside of the lower flange, then bends abruptly downward and is rather evenly convex inward to the columella. The final whorl embraces the penultimate whorl just below the selenizone. Except for the subsutural nodes and their downward prolongations, which are prosocline at an angle of about 65° to the horizontal, no collabral ornament is preserved on the upper whorl surface. One patch of worn shell on the final whorl shows three or four fine spiral lirae, widely spaced on the concave slope below the subsutural nodes. On the lower whorl surface, some coarser spiral lirae are preserved, crossed by collabral lirae that are approximately orthocline near the columella; their intersections appear nodose.

The aperture on the outer lip of this specimen is distorted by a calcite veinlet; allowing for the width of the veinlet, the shell measures 7.2 mm in height and 6.8 mm in width.

This species is unlike any of the other Chainman species of *Glabrocingulum* in having a concave upper-whorl surface terminating above in a coronet. It occurs with *G.* (*Ananias*) *seminudum* and might possibly be merely an extreme variant of that species. A similar coronation is present below the suture on an undescribed species of *Glabrocingulum* from the upper part of the Pitkin Limestone in north-central Arkansas, but the degree of development of this feature varies considerably among individuals of the same population. The Arkansas material does not have the strongly concave upper-whorl profile of the Utah shell.

Figured specimen.—USNM 211005.

Occurrence and number of specimens.—USGS collection 22880–PC (8), Millard County.

Glabrocingulum (Glabrocingulum) sp. C

Plate 6, figure 21

Discussion.—Yet another Chainman form of *Glabrocingulum,* is represented by a unique specimen collected by R. K. Hose from a 30-foot (10-m) interval in the Foote Ranch measured section, 160 to 190 feet (48.8 to 57.9 m) stratigraphically above the *Richardsonites merriami* bed. This specimen is broken and could not be extracted from its hard limestone matrix, but the well-preserved upper surface and part of the base of the final whorl are exposed. The upper whorl surface is very gently convex in profile and marked by many fine threadlike prosocline growth lines that begin at an angle of 65° to the suture and curve gradually back to meet the outer edge of this surface at an angle of approximately 30°. The growth lines are locally irregular in their orientation and tend to bunch and thicken subsuturally into closely spaced radially elongate nodosities, forming a slightly raised narrow band adjacent to the suture. No recognizable spiral ornament is present, but light reflected on this surface in some orientation seems to delineate faint microscopic spiral lines, about 7 in the space of 1 mm. The base is imperforate but slightly depressed in the columellar area. It is ornamented by growth lines similar to those on the upper

surface. Although the shell is essentially smooth, the growth lines are thicker at intervals and form a faint collabral ornament. No well-developed spiral ornament occurs on the base, but the growth lines are faintly but regularly thickened at intervals to produce the effect of weak spiral sculpture. The specimen is 13 mm in width; the height cannot be measured because the apex is buried.

The absence of any clearcut spiral or collabral lirae ornamenting the surface of this species distinguishes it from all the other species in the Chainman Shale. It is closest to *G. (Ananias) seminudum,* which differs in having a gradate shell bearing two or three spiral lirae on the upper whorl face and base.

Figured specimen.—USNM 211006.

Occurrence.—USGS collection 15370–PC, Millard County.

Glabrocingulum (Glabrocingulum?) hosei n. sp.

Plate 5, figures 16–27; plate 6, figure 20

Diagnosis.—Glabrocingulums having gradual downward shift of subsutural placement of whorls; ornament mainly of spiral lirae ranging from 8 to 11 on upper surface of body whorl.

Description.—Shell trochiform; pleural angle approximately 88°. Sutures distinct, becoming impressed and prominent with increasing maturity. Shell showing ontogenetic change, each whorl embracing progressively lower on preceding whorl. Nucleus simple, orthostrophic, at least first two whorls lacking any ornament; coincident with appearance of ornament, whorl developing subsutural ramp, which disappears with increasing maturity; upper whorl surface simple below ramp or suture, inclined approximately 45° and not inflated, trending straight for its entire length except just before selenizone, where it flares abruptly to nearly horizontal, forming upper flange. Selenizone raised slightly between flanges, narrow, concave, but generally inclined outward at about 30° to vertical at maturity, lower flange forming periphery. Outer and basal whorl faces not clearly separate, arbitrarily divided on basis of prominence of spiral ornament. Outer whorl face below flange simple, inclined inward at about 30° from vertical, occupying segments approximately two-fifths of total height between lower flange and base of columella. Basal surface beginning with short segment inclined 45°, followed by series of segments between spiral lirae, each trending more toward horizontal than preceding segment, but still inclined about 20° above horizontal at lowest point. Base anomphalous, but showing narrow umbilical chink behind slightly reflexed columellar lip; inductura lacking; basal lip simple; slit in outer lip about one-fifth of whorl in depth.

Growth lines on upper surface prosocline, at angle of about 45° to suture, sweeping gently back toward flange and meeting it at angle of 30°, most of curvature in outer quarter of upper whorl surface; lunulae in selenizone symmetrical, closely spaced, obscure; growth lines below selenizone trending steeply opisthocline at 45° to edge of flange, curving rapidly to orthocline, and continuing to steeply prosocline, about 15° from vertical and trending straight across base to columella. Ornament primarily of spiral lirae on upper and basal surfaces, some lirae being somewhat nodose or subcontinuous; mature upper whorl surface having prominent coarse lira adjacent to suture, which on earlier whorls is on edge of ramp; a second lira lies just below, separated by interspace about twice as wide as lira; a third smaller lira occurring about the same distance below second; between these three lirae and selenizone are five to eight spiral threads, the number remaining more or less constant in individual specimens but spacing increasing with maturity; spiral lirae intersected by fine growth lines that form prominent minutely nodose pattern on upper three lirae and some fine nodes at intersection with spiral threads. Outer whorl face having one weak lira at juncture with base and three to four threads above and below. Basal whorl surface bearing at least nine coarse spiral lirae, all minutely and closely noded, spaced on upper part of this surface so that interspaces equal width of two lirae, becoming gradually closer spaced toward columella.

Dimensions.—Measurements (in mm) of holotype and two figured paratypes are as follows:

USNM	210990	210992	210991
Height	19.0	19.0	15.1
Width	17.7	21.5	14.4

Discussion.—This species is abundant at its type locality in the Burbank Hills measured section, particularly in a 20-foot (6.1-m) interval of soft brown shale and small calcareous nodules about 100 feet (30.1 m) below the lowest bed containing *Cravenoceras hesperium* Miller. In this interval, *G. (G.?) hosei* is the only *Glabrocingulum,* but immediately above, in the uppermost 100 feet (30.1 m) of the *Paracravenoceras barnettense* Zone, it is less common, its numbers being almost equal to those of *G. (G.) confusionense* n. sp. It ranges northward nearly to the northernmost Chainman Shale outcrops in the Confusion Range; in this area, it is even less common but again is found in numbers approximately equal to those of *G. (G.) confusionense. G. (G.?) hosei* was not found in the Granite Mountain or Skunk Spring sections, where the rocks of

this part of the formation consist of impure spiculitic limestone rather than soft shale. Its abundance at the type locality makes it by far the most common gastropod in the Chainman Shale in western Utah.

G. (G.?) hosei n. sp. is distinguished from the other named species in the Chainman Shale fauna by its subdued ornament of numerous fine spiral threads on the lower part of the upper whorl surface. In number of lirae on the upper whorl surface, it is most like *G. (G.) granulosum* n. sp., but the lirae are not intercalated or as generally nodose as in that species. In detail, the two uppermost lirae on this surface range from being interrupted and broken into elongate segments to nearly uniformly spaced nodes. The strong tendency for the spire of *G. (G.?) hosei* to elongate in late maturity is not characteristic of most species of the subgenus; large specimens may superficially resemble *G. (Ananias)* in this tendency.

Types.—Holotype USNM 210990; paratypes USNM 210991–210993.

Occurrence and number of specimens.—USGS collections 15165–PC (62), 15166–PC (8), 17055–PC (12), 17187–PC (52), 17194–PC (226), 19602–PC (3), 20448–PC (4), 22857–PC (1), 23846–PC (17), 25262–PC (72), 25264–PC (540), ?25284–PC (1), 25557–PC (24), 28610–PC (75), 28611–PC (37), 28623–PC (2), Millard County.

Subgenus G. (ANANIAS) Knight, 1945

Discussion.—Two subgenera are recognized within the genus *Glabrocingulum*. Compared with *Glabrocingulum (Glabrocingulum)*, which is distinguished by its more or less conical spire, the subgenus *Glabrocingulum (Ananias)* is far less common in Carboniferous rocks. This subgenus is characterized by its gradate spire, generally higher than that of the typical subgenus because each mature whorl meets the preceding one well below the selenizone. The ornament in *G. (Ananias)* seems to be relatively finer than that of *G. (Glabrocingulum)* and apparently does not develop the nodes at the intersection of spiral and collabral lirae that are present on many species of the typical subgenus.

We recognize two American Mississippian species that are referrable to *G. (Ananias)*. One is *Pleurotomaria nevadensis* Walcott from beds of late Meramecian age in the Diamond Peak Formation. This species occurs near Eureka, Nev., associated with *Lunulazona nodimarginata* (McChesney) and *Bellazona bella* (Walcott), both of which are present in the Chainman Shale in Utah in the upper part of the *Goniatites americanus* Zone. We select as lectotype the specimen illustrated by Walcott (1884, p. 259, pl. 24, figs. 2, 2a) from the type lot of *Pleurotomaria nevadensis*. Walcott's types (USNM 14413) are mostly exfoliated and appear to have been cracked out of limestone. The lectotype (pl. 7, figs. 31–33) is useful for comparison with our various Utah species of *G. (Glabrocingulum)*. Although partly crushed and largely exfoliated, it retains a strip of shell running irregularly downward through several whorls; this strip preserves the ornament rather well. The most notable feature of the specimen is its large size. The lectotype is more than 3.5 cm high and superficially resembles a large *Worthenia;* five or six fine spiral lirae occur between the selenizone and the succeeding whorl. Another specimen, somewhat smaller, retains a patch of shell in the columellar area, which preserves what appears to be a narrow umbilical chink.

Nine paralectotypes are in the type lot. Two of these, however, one a broadly conical fragment of an immature shell, may not be conspecific. Five of the paralectotypes are larger than the average Chainman Shale specimen of typical *G. (Glabrocingulum)* but are smaller than the lectotype. One of them is an uncrushed steinkern, and three of the remaining four specimens retain some small amounts of shell; one small specimen retains much of its shell.

Two specimens of intermediate size in the type lot, which also retain most of their shell but which are not believed to belong in this species, we are leaving unassigned; possibly they represent two different genera. The two specimens from the Park City Formation that Girty (1910, p. 46, pl. 6, figs., 4, 5) tentatively assigned to this species are indeterminate steinkerns of pleurotomariacean gastropods.

The other species, *G. (Ananias) seminudum* Gordon and Yochelson, 1982, occurs in the Diamond Peak Formation of east-central Nevada and the Chainman Shale of Utah. The species is somewhat puzzling, as it combines the stepped whorls of *G. (Ananias)* with the sparser nodose spiral lirae of *G. (Glabrocingulum)*.

Glabrocingulum (Ananias) seminudum Gordon and Yochelson

Plate 6, figures 4–10

?*Glabrocingulum* n. sp. aff. *G. inflatum* Sadlick and Nielsen, 1963, p. 1102.

Glabrocingulum (Ananias) seminudum Gordon and Yochelson, 1983, p. 981–982, fig. 32BB, EE, FF.

Discussion.—This species was described from 12 specimens (USNM 211060–211062, 307482–307485) collected from the Diamond Peak Formation in east-central Nevada where it occurs with *Cravenoceras hesperium* Miller and Furnish. It has been identified in the Chainman Shale of Utah in a slightly higher stratigraphic zone. In the Burbank Hills, *G. (Ananias) seminudum* occurs in the upper part of the Chainman, associated with *Rhipidomella nevadensis* (Meek), esti-

mated at 200 to 300 feet (61 to 91 m) below the top of the formation. The Burbank Hills specimens are smaller than the Nevada ones and have finer spiral lirae. They may not be fully mature but have gradate larger whorls. One of them is figured on plate 6, figures 4–7. For comparison, the holotype is refigured (pl. 6, figs. 8–10).

G. (A.) seminudum is easily distinguished from *G. (A.) nevadense*, the only other Mississippian species of the subgenus, by the sparser spiral lirae and coarser lirae on the base; most younger species of *G. (Ananias)* have fine crowded spiral lirae. *G. (A.) seminudum* is referred to *Ananias* because of its stepped mature whorls, but the spiral ornament closely resembles that of the typical subgenus *G. (Glabrocingulum)*.

Two Chainman species of *G. (Glabrocingulum)* have similar ornamentation, *G. (G.) binodosum* Sadlick and Nielsen and *G. (G.) mephitifontis* n. sp. The first of these is easily distinguished from *G. (A.) seminudum* by its lower spire, wider pleural angle, lack of stepped whorls, relatively wider selenizone, and faint spiral ornament on the base. *G. (G.) mephitifontis*, in contrast, is similar to *G. (A.) seminudum* in having a narrow spire with a pleural angle of 70°, two spiral lirae on the upper whorl surface, and the final whorl meeting the preceding one below the selenizone in the middle of the outer whorl face. It is distinguished from *G. (A.) seminudum* by its whorls, which are not distinctly stepped, and the well-developed collabral lirae extending outward from the suture on the upper whorl surface, instead of only growth lirae as in *G. (A.) seminudum*.

Figured specimen.—USNM 211063.

Occurrence and number of specimens (Chainman Shale).—USGS collections 17059–PC (8), ?17217–PC (2), 22880–PC (7), 25319–PC (11), 25548–PC (8), 28612–PC (6), Millard County.

Subfamily NEILSONIINAE

Discussion.—Typical *Neilsonia* Thomas has a peripheral selenizone that is raised and gently concave in profile, and fairly prominent collabral ornament. It is allied closely to the Permian genus *Peruvispira* Chronic, which differs primarily in having the body whorl embracing well below the selenizone and in being somewhat less prominently ornamented. *Lunulazona* is similar to those two genera but is somewhat lower spired, more prominently ornamented, and has a raised flattened selenizone.

If these three genera are considered representative of the subfamily, the remaining taxa currently placed in the same subfamily by Knight, Batten, and Yochelson (1960, p. I207)—*Pagodina* Wanner, *Apachella* Winters, and *Pareuryalox* Haas—differ markedly from them in emphasizing spiral ornamentation at the expense of collabral features. Both *Neilsonia* and *Peruvispira* have an angulation some distance below the selenizone at the juncture of the outer and basal whorl faces, but this feature is related to shape rather than to ornament. Obviously, some further subdivision, or an alternative arrangement, is needed to recognize these distinctions. *Pagodina, Apachella,* and *Pareuryalox* are not within the scope of this paper, the first two being Permian in age and third Triassic. We therefore leave further consideration of this question to other workers.

Sadlick and Nielsen (1963, p. 1090) compared *Lunulazona* with *Nodospira*, as well as with *Neilsonia*, and we concur with the differences that they cited. Nevertheless, although the subsutural nodes and collabral ornament of *Nodospira* show a vague similarity to those of *Lunulazona,* the two genera are probably no more closely related than at the family level. In this report, we are assigning *Nodospira* to the Ptychomphalinides of the Eotomariinae.

Genus NEILSONIA Thomas, 1940

Diagnosis.—Moderately high-spired, tiny pleurotomariaceans, generally of four, rarely more, whorls, having a tiny row of nodes just below suture; two, or commonly three, keels ornamenting whorls. Selenizone low on outer whorl and just above suture on spire.

American Mississippian species of Neilsonia.—
insculpta (Hall), 1857 (*Murchisonia*)
welleri Thein and Nitecki, 1974

Discussion.—*Murchisonia uninodocarinata* Hyde was referred to *Neilsonia* by Thein and Nitecki (1974, p. 91). Its high spire of at least eight whorls and details of the sculpture, as illustrated by Hyde (1953, pl. 46, fig. 16), suggest a closer relationship to the Murchisoniidae than to the Neilsoniinae. We regard *Pleurotomaria nodimarginata* McChesney and *Neilsonia? springeri* Yochelson, both of which were included tentatively in *Neilsonia* at one time or another, as typical representatives of *Lunulazona*.

Easton (1942, pl. 11, fig. 5) figured a poorly preserved *Neilsonia* from the Pitkin Limestone of Arkansas.

Neilsonia sp.

Plate 7, figure 28

Discussion.—This record is based upon five poorly preserved specimens from two localities, both in rocks of the *Cravenoceras hesperium* ammonoid zone. The three specimens from the Granite Mountain locality are coarsely silicified; the two specimens from the Foote Range locality are calcareous but partly limonitic, broken, and partly obscured by matrix. None of them shows growth lines. Nevertheless, the shape

and what remains of the ornament are similar enough to authentic specimens of *Neilsonia* for us to have some confidence in the generic identification.

The most complete shell, of 3 1/2 whorls, measures 2.5 mm in length and 1.2 mm in width; the pleural angle approximates 45°; the overall appearance is step-like. The upper whorl surface is concave, curving from the suture downward and then gently outward to the outer edge, which is a fairly sharp angulation. The narrow area immediately below this, assumed to be the selenizone, is also concave between the upper bordering lira and an equally strong one beneath; this lower angulation is the periphery. The width of the presumed selenizone is about one-third that of the upper whorl surface. The basal angulation of the outer whorl face is a little less wide than the periphery, and the space between it and the edge of the selenizone is slightly narrower than the selenizone. The base is phaneromphalous, flattened, and inclined gently downward. The inner lip is vertical, and its lower tip seems slightly reflexed.

Gordon and Yochelson (1983, p. 984) described *Neilsonia* cf. *N. welleri* Thein and Nitecki from the same ammonoid zone in the Diamond Peak Formation of Nevada. The Nevada specimens are distinctly higher spired than this species, and the upper edge of the selenizone, not the lower, forms the periphery.

Figured specimen.—USNM 348022.

Occurrence and number of specimens.—USGS collections 25252–PC (3), Juab County; 25274–PC (2), Millard County.

Genus LUNULAZONA Sadlick and Nielsen, 1963

Diagnosis.—Moderately high-spired pleurotomariaceans, rhomboidal in profile, having raised, slightly concave to flat peripheral selenizone; prominent collabral ornament.

Description.—Upper surface nearly flat in profile; outer whorl face limited to raised selenizone; basal whorl surface slightly more inflated than upper one. Base anomphalous. Body whorl embracing penultimate whorl at lower edge of selenizone, which forms periphery; selenizone raised, flattened to very slightly concave. Ornament generally prominent, strongest on upper whorl surface, may include riblets and subsutural nodes.

Discussion.—When first proposed, *Lunulazona* Sadlick and Nielsen (1963, p. 1089, 1090) was assigned to the Eotomariinae, although assignment to the Neilsoniinae was considered by its authors. Because this genus is based on moderately high-spired shell, we herein assign it to the Neilsoniinae. Addition of other species to *Lunulazona* in the present report has somewhat broadened the concept of that taxon. Apparently it evolved as a separate stock, diverging from the *Neilsonia-Peruvispira* line in Late Mississippian time.

The generic description above is little changed from that of Sadlick and Nielsen, but we place more emphasis on the nature of the selenizone than on the ornament. Sadlick and Nielsen, for example, emphasized the lunulae on the selenizone as an important character. We find that the strength of the lunulae varies with the species and include some species that have relatively weak lunulae, such as *Pleurotomaria nodomarginata* McChesney.

In expanding our concept of *Lunulazona,* we are including species that have been referred to *Mourlonia* and *Bembexia* by previous authors. This decision raises the question of the differences between *Lunulazona* and these two genera.

In our view, *Lunulazona* includes subconical shells having a distinctly flat upper whorl profile, in contrast to *Mourlonia,* which includes subglobose shells having a distinctly convex upper whorl profile. Subsutural riblets or nodes are commonly present in *Lunulazona* but not in *Mourlonia,* which may have spiral lirae in addition to collabral lirae. Finally, the shells of *Mourlonia* are typically fairly large, whereas those of *Lunulazona* rarely exceed 15 mm in height.

Bembexia differs from both genera in having a concave selenizone between moderately strong threads; as we have said earlier in this paper, we do not regard this genus as occurring in Carboniferous rocks.

American Mississippian species of Lunulazona.—
- *costata* Sadlick and Nielsen, 1963
- *lativittata* (Girty), 1910 *(Bembexia)*
- *nodomarginata* (McChesney), 1859 *(Pleurotomaria)*
- *?sablei* (Yochelson and Dutro), 1963 *(Mourlonia)* [*M. minuta* Yochelson and Dutro, 1960, not Weller, 1915]
- *sadlicki* n. sp.
- *springeri* (Yochelson), 1973 *(Neilsonia ?)*
- *utahensis* n. sp.

In addition to the type species, *Lunulazona costata* Sadlick and Nielsen from the Chainman Shale, and two other species described below from the same formation, we include in this genus *Bembexia lativittata* Girty from the Fayetteville Shale of Arkansas, which was placed in *Mourlonia* by Yochelson (1969a, p. 29); *Bembexia nodomarginata* (McChesney) from the Moorefield Shale of Arkansas, which was assigned to *Neilsonia* by Thein and Nitecki (1974, p. 91); *Neilsonia? springeri* Yochelson from the Crawfordsville Shale of Indiana; and, with question because of its wider selenizone and less rhomboidal shape, *Mourlonia sablei* Yochelson and Dutro from the Lisburne Group of Alaska.

In addition to the American species, we examined the type of *Pleurotomaria lirata* Phillips from the *Dibunophyllum* Zone in Yorkshire, England, in the collection of the British Museum (Natural History) and recognize this species as a typical *Lunulazona*. Less certainly, but probably also belonging in this genus is the holotype of *Pleurotomaria undulata* Phillips, in the same collection.

Lunulazona nodomarginata (McChesney)

Plate 4, figures 21–23

Pleurotomaria nodomarginata McChesney, 1859, p. 70; 1865, pl. 7, figs. 1a–c; 1868 [1867-1869], p. 47, pl. 7, figs. 1a–c; Walcott, 1884, p. 259, pl. 18, fig. 15.

Bembexia nodomarginata (McChesney). Girty, 1911, p. 91, pl. 7, figs. 1–5; 1915b, p. 36, pl. 2, fig. 7; Croneis, 1930, p. 54, pl. 13, fig. 17.

Bembexia nodomarginata (McChesney). Snider, 1915, p. 116.

Neilsonia nodomarginata (McChesney). Thein and Nitecki, 1974, p. 91.

Diagnosis.—Moderately small turbiform pleurotomariaceans having raised, nearly flat selenizone; upper whorl slope ornamented by prosocline lirae thickening subsuturally to elongate nodes, alternating with shorter finer lirae.

Description.—Shell inflated turbiform, pleural angle approximately 65°. Nucleus unknown; at least two early whorls having a smooth inflated upper whorl surface. Suture obscure; body whorl embracing penultimate whorl at lower edge of selenizone. Whorl profile undergoing minor ontogenetic change; mature upper whorl surface straight, not deviating essentially from inclination indicated by pleural angle, except just below suture where inclination is slightly shallower; profile of early whorls obviously composed of two segments of different inclination. Selenizone raised, slightly flanged and gently concave in early stages, gradually becoming flat and vertical or even inclined inward at maturity; periphery probably at upper edge of selenizone. Whorl profile below selenizone curving inward strongly and downward, flattening as it approaches columellar area. Base probably anomphalous.

Growth lines prosocline, at angle of about 70° to suture, straight across inner half of upper whorl surface, then curving to form approximate 45° angle with outer edge. Lunulae strongly arched, symmetrical, fine. Below selenizone, growth lines steeply opisthocline, forming approximately 75° angle with outer edge and continuing for short distance before bending orthocline and proceeding straight to columella. Ornament prominent in early growth stages consisting of raised collabral ridges thickening to subsutural nodes, becoming very fine or dying out near selenizone, alternating with fine lirae that reach upward only to lower edge of nodose band; lirae on base moderately strong near selenizone, becoming finer toward columella.

Dimensions.—The specimen figured from the Chainman Shale measures: height 6.8 mm, maximum width 6.3 mm; Walcott's figured specimen seems proportionately wider, but the lower part of the shell is buried in matrix so the height cannot be measured accurately.

Discussion.—The type lot of this species from the "Hamilton Group" near Batesville, Ark., was lost in the Chicago fire of 1871. However, McChesney's description is clear, and his illustrations are adequate enough to show that *Pleurotomaria nodomarginata* belongs in *Lunulazona*. Walcott (1884, p. 259) described this species from the Eureka District, Nev., from beds now known as the Diamond Peak Formation, of late Meramecian age. The specimens from the Chainman Shale of Utah in the Granite Mountain section occur in the upper part of the *Goniatites americanus* Zone, also of late Meramecian age.

The typical form of *L. nodomarginata,* according to McChesney's description, has the subsutural nodes alternating with finer lirae (McChesney called them striae). McChesney (1859, p. 70) said: "These [lirae], when seen through a lens, present somewhat the appearance of projecting lamellae. At the upper edge of the volution every alternate [lira] is elevated, forming a sort of elongate node, which are sometimes elevated so as to present the appearance of a band of nodes; the [lirae] between die out at the commencement of the nodes."

Girty (1911, p. 91, 92, pl. 7, figs. 1–4) repeated McChesney's original description and reproduced his illustrations. The specimen illustrated by Girty (1911, pl. 7, fig. 5) from Spring Creek, Ark., fits McChesney's concept of the species. Although partly decorticated, it retains details of the sculpture on the penultimate whorl, showing the alternating nodose and non-nodose lirae.

Other specimens referred to this species, which also came from Spring Creek, about 1 mile (1.6 km) above Ruddell's Mill, were illustrated later by Girty (1915b, p. 36, 37, pl. 2, fig. 7). These are silicified and have very prominent subsutural nodes but lack collabral lirae. We examined these specimens and believe that during the process of silicification these shells lost their outermost shell layer and therefore part of their ornament. We agree with Girty in referring them to *L. nodomarginata.*

We also examined material from other localities in the vicinity of Batesville, Ark., and from the Moorefield Formation about 3 3/4 miles (6 km) southeast of Chouteau, Mayes County, Okla. We found that two

undescribed species of pleurotomariaceans, similar in general shape and size to *L. nodomarginata,* occur with it at these localities. They bear a superficial resemblance to *L. nodomarginata,* and poorly preserved material might easily be confused with it. Both undescribed species lack subsutural nodes, and their collabral lirae reach from suture to selenizone, as well as occurring on the base. One taxon is slightly larger and more tumid than *L. nodomarginata* and has a slightly wider concave selenizone bordered by low flanges; we regard this species as belonging in *Ptychomphalina.* The other species is subconical and similar in shape to *L. nodomarginata* but has rather prominent subequal collabral lirae separated by fairly wide interspaces and bears a flanged selenizone. Its generic position, however, is less certain; in the two characters noted, it seems to be intermediate between *Lunulazona* and *Ptychomphalina.*

The Nevada specimens, described and figured by Walcott (1884, p. 259, pl. 18, fig. 15), agree with McChesney's description and illustrations. A photograph of the specimen from Diamond Peak Formation near Eureka (USNM 14414), which Walcott illustrated by a drawing, is shown in the current report on plate 4, figure 23. Walcott's specimens were collected by him in 1880 at the small conical hill at the western foot of Spring Mountain, east of Secret Canyon road, Eureka district, Nev.

Specimens from the Smithwick Shale in San Saba County, Tex., figured by Plummer and Moore (1921) as *Bembexia nodimarginata*, probably belong to a different genus. We examined part of Plummer and Moore's material in the U.S. Geological Survey collections and find that their shell is indeed subconical and ornamented by prominent collabral lirae; however, it is larger, lacks subsutural nodes on alternating lirae, and has an elevated concave selenizone bordered by a lira at either side. It seems to be congeneric with the second of two undescribed Arkansas-Oklahoma shells mentioned above.

This species differs from the type species of *Lunulazona, L. costata* Sadlick and Nielsen, in having well-developed subsutural nodes, much finer lirae on the upper whorl surface, particularly near the selenizone, and very fine subdued lunulae.

Figured specimen.—USNM 211007.

Occurrence and number of specimens.—USGS collections 17018–PC (19), 25558–PC (2), Juab County.

Lunulazona costata Sadlick and Nielsen

Plate 4, figures 31–33, 36

Lunulazona costata Sadlick and Nielsen, 1963, p. 1091–1093, pl. 148, figs. 1–11, text-figs. 2–5.

Discussion.—The excellent description and illustrations of this species given by its authors are readily available and need not be repeated here. We have included several illustrations of specimens to supplement those given in the original publication. After examining several dozen specimens from the Chainman Shale, we need only make minor comments. First, the prominent lunulae on the selenizone are a constant feature of ornamentation, as was indicated by the authors. Second, the selenizone apparently is never convex but may be almost flat; slight concavity is the characteristic condition. Third, the ornamentation, especially on the upper-whorl surface, is variable; it consists mainly of collabral riblets, somewhat nodelike near the suture, some splitting into two below the nodes, alternating with finer threads, most of them intercalated between the riblets and not reaching the suture; on the lower whorl, these riblets are reduced in strength and are indistinguishable from growth lirae. Fourth, a considerable number of our specimens show evidence of shell breakage and rehealing during life. In other facies, species of *Glabrocingulum* that have a comparable size and shell thickness show a lower incidence of breakage. Species of *Lunulazona* from other parts of the Chainman Shale also show a lower incidence of shell breakage. We are unable to provide any definite reason for the phenomenon.

This species is relatively common in the *Goniatites granosus* Zone at Granite Mountain and is rare elsewhere. We found examples as far south in the Confusion Range as 4 miles (6.4 km) south of Skunk Spring.

Figured specimens.—USNM 211007, 211008.

Occurrence and number of specimens.—USGS collections 17012–PC (101), 17015–PC (47), 17020–PC (16), Juab County; 14553–PC (1), 20446–PC (2), Millard County.

Lunulazona sadlicki n. sp.

Plate 4, figures 24, 25, 34, 35

Lunulazona sp. A. Sadlick and Nielsen, 1963, p. 1093, 1094, pl.148, figs. 12, 13; pl. 150, fig. 13.

Diagnosis.—Rhomboidal pleurotomariaceans having moderately broad selenizone only slightly raised but covered with prominent chevronlike lunulae.

Description.—Shell moderately high spired, pleural angle approximately 75°; outline nearly diamond shaped. Nucleus and early whorl unknown. Body whorl embracing penultimate whorl at lower edge of selenizone. Whorl profile simple, upper whorl surface flattened and essentially straight, inclinded at nearly 60° to horizontal except for abrupt outward flare to form obscure flange at selenizone; outer whorl face limited to selenizone, slightly sunken and concave between upper

and lower borders, each marked by spiral lira; below selenizone, basal surface curves steeply downward, degree of inward curvature increasing gradually toward columella. Base anomphalous.

Growth lines on upper whorl surface prosocline, forming angle of about 45° with suture, proceeding straight for approximately inner two-thirds of upper surface, then curving slightly more shallowly prosocline before meeting outer angulation; lunulae very broad and chevron shaped; growth lines below selenizone very steeply opisthocline for a short distance, curving rapidly to orthocline, and proceeding straight across basal surface to columella. Ornament of prominent rounded collabral lirae, irregularly spaced but most commonly having interpaces three to five times width of lirae; lunulae coarser and more uniformly spaced, their interspaces about three times as wide as lunulae; additional ornament of elongate raised ridges extending from near suture down upper whorl face, some on collabral lirae and some interspaced between them, but with no regularity of pattern.

Dimensions.—The holotype is slightly crushed and measures 14.3 mm in height, its maximum width about 11 mm.

Discussion.—This species was described and figured by Sadlick and Nielsen (1963), who did not propose a name for it. We recognize as possibly conspecific several poorly preserved specimens in the *Paracravenoceras barnettense* Zone, which are associated with the types of *Ptychomphalina burbankensis* n. sp. We believe that this is an easily recognizable species and propose to name it for Walter Sadlick. We choose as the holotype the specimen (USNM 134171) figured by Sadlick and Nielsen (1963, pl. 150, fig. 13). The other specimen from the same locality (USNM 134169) figured by them (1963, pl. 148, figs. 12 and 13) is designated the paratype. Both specimens lack the apical area and are slightly crushed but preserve surface detail extremely well.

Lunulazona sadlicki n. sp. differs from *L. costata* in being larger, in having a flatter upper whorl surface, and in having a wider, more obviously bordered and slightly more concave selenizone. The subsutural ornament is more prominent than that of *L. costata,* being in the form of elongate collabral ridges extending about one-third the length of the whorl surface. The broad chevron-shaped lunulae of *L. sadlicki* also contrast with the narrower U-shaped lunulae of the type species.

Lunulazona nodomarginata is a smaller shell having its prominent ornament confined mainly to the nodes near the suture. *Lunulazona sadlicki* differs from *L. utahensis* in being larger and higher spired and in having much more prominent collabral ornament. The upper whorl surface of that species is slightly more inflated, and its selenizone flat between bordering lirae.

We considered the possibility that the features that distinguish *L. sadlicki* from other smaller species of the genus might result from continued growth, as the early growth stages of this species are not known. However, comparison of the younger whorls of these two specimens with whorls of other species at the same size permits us to rule out ontogenetic change as being responsible for these differences. It is worth repeating that the four species occur at four different levels within the Chainman Shale, each one associated with a different ammonoid zone.

In addition to the other three Utah species, *L. sadlicki* differs from *L.? sablei* (Yochelson and Dutro) from the Lisburne Limestone of Alaska in being higher spired and in having a relatively narrower selenizone, which is nearly vertical, rather than inclined. *L. lativittata* (Girty) from the Fayetteville Shale of Arkansas has a selenizone similar in width and inclination to that of *L. sadlicki,* but the shell is higher spired and its sutures are slightly impressed; it is a much smaller species than *L. sadlicki.*

Types.—Holotype USNM 134171; paratype USNM 134169.

Occurrence and number of specimens.—Sadlick and Nielsen locality 7–1 (holotype and paratype), 0.3 miles (0.5 km) N. 55° E. from Leppy Peak, about 3.5 miles (5.6 km) north of Wendover, approximately in SW 1/4 SE 1/4 sec. 28, T. 34 N., R. 70 E., Elko County, Nev. USGS collections 17091–PC (1), 17092–PC (1), 28628–PC (1), Juab County, Utah; ?17201–PC (3), 25546–PC (2), Millard County, Utah.

Lunulazona utahensis n. sp.

Plate 4, figures 1–4, 16, 17

Diagnosis.—Moderately low-spired pleurotomariaceans having broad blunt angulation just below peripheral selenizone; ornament of fine closely spaced collabral lirae.

Description.—Shell moderately low-spired, pleural angle approximately 90°. Nucleus and early whorls unknown. Body whorl embracing penultimate whorl at or just below lower margin of selenizone. Whorl profile simple, upper whorl surface inclined nearly at pleural angle, remaining constant in slope throughout length, except near outer edge where if flares outward to upper angulation; outer face consisting entirely of selenizone, very steeply inclined downward and nearly vertical, flat and relatively broad, between bordering lirae; basal whorl surface beginning with sulcate segment immediately below selenizone followed by broad blunt

angulation, which is obscure in early growth stages; below angulation, basal surface curving strongly inward to columella; essentially no inflation of base and upper whorl surface tending to give shell rhomboidal profile. Base anomphalous. Columellar lip extremely short, straight, not appreciably reflexed. Slit depth and other details unknown, but slit certainly did not exceed one-eighth whorl in length.

Growth lines forming angle of about 60° with suture, straight for extremely short distance, then bending abruptly prosocline and crossing upper whorl surface at approximate 45° angle, curving to slightly greater angle just before crossing spiral lira at upper angulation; selenizone having broad, extremely shallow lunulae; growth lines steeply opisthocline to orthocline on outer edge of base, at angulation bending abruptly to steeply prosocline, beyond which they proceed straight inward and downward. Ornament consisting exclusively of coarse threads to fine lirae, rather regular in spacing, interspaces two to three times width of lirae.

Dimensions.—Holotype and figured paratype, respectively, measure: length 7.9 and 7.4 mm, maximum width 7.5 and 7.1 mm.

Discussion.—This species is common, associated with *Cravenoceras hesperium* Miller and Furnish and *"Fayettevillea"* n. sp. in the lower part of the *Cravenoceras hesperium* Zone in the vicinity of the Bishop Springs dome, Foote Range. Most of our specimens are steinkerns, because the shell is easily peeled when attempts are made to extract a specimen from limestone matrix.

Considerable variation is noted among individuals in the relative strength of collabral ornament on various parts of the shell. On most specimens, the ornament of the upper whorl surface is of fairly constant weight. However, the lunulae and the ornament of the base may be either stronger or weaker than that of the upper surface. This variation is not related to preservation or loss of the outer shell layer.

Lunulazona utahensis is distinguished readily from other members of this genus in western Utah by the flat selenizone bordered by spiral lirae and by an obscure angulation on the basal surface. It is smaller, lower spired, and less prominently ornamented than *L. sadlicki*. It differs from the type species *L. costata* in being also lower spired, but, more importantly, in its possession of more regular collabral elements and in the presence of a slight angulation on the basal surface; the selenizone of *L. costata* is clearly raised above the general surface of the whorl rather than flat and bordered as in *L. utahensis*. *L. nodomarginata* is distinguished from *L. utahensis* by its higher spire and by the more prominent subsutural ornament that includes nodes. *L.? sablei* (Yochelson and Dutro) is a closely similar Alaska species that differs from *L. utahensis* principally in being slightly higher spired. The selenizone of *L.? sablei* is not bordered by spiral lirae, but the holotype of that species may have lost the outer shell layer; paratypes provide no information on this point. Finally, *L. lativittata* (Girty) is a distinctly higher shell, though its selenizone is flat and bordered by spiral lirae as in *L. utahensis*.

Types.—Holotype USNM 211010; paratypes USNM 211011–211013, 364702, 364703.

Occurrence and number of specimens.—USGS collections 17022–PC (30), 19604–PC (2), 20443–PC (7), 20444–PC (23), 20445–PC (18), 25260–PC (388), Millard County.

Lunulazona? aff. L.? sablei (Yochelson and Dutro)

Plate 4, figures 26, 27

Mourlonia minuta Yochelson and Dutro, 1960, p. 136, pl. 13, figs. 4, 5 (not *M. minuta* Weller, 1915)
Mourlonia sablei Yochelson and Dutro, 1963, p. 725.

Description.—Shell turbiform, moderately low spired, stepped, having wide flat peripheral selenizone; pleural angle roughly 80°. Nucleus and earliest whorls unknown but probably orthostrophic. Suture obscure at bottom of angulation, body whorl embracing at lower edge of selenizone. Whorl profile in three distinct segments, middle one being selenizone; upper whorl surface simple, sloping fairly straight from suture to upper edge of selenizone, steeping slightly with maturity, and subsutural part becoming slightly flattened; outer face composed entirely of broad flat selenizone, nearly vertical but inclined outward slightly and set off by a well-formed lira above and below; basal surface including a short upper segment inclined inward about 30° from vertical, bending abruptly to a long, gently inflated lower segment. Slit depth and details of aperture unknown.

Growth lines on upper whorl surface inclined 60° to suture, prosocline, fairly straight across upper whorl surface but curving more strongly prosocline just above selenizone; lunulae well curved, symmetrical, fairly shallow; growth lines steeply opisthocline immediately below lower bordering lira of selenizone, becoming rapidly steeper downward to angulation, there bending to orthocline and proceeding straight to columella. Base anomphalous. Ornament exclusively collabral, having lirae on upper whorl surface separated by interspaces about three times as wide; strongest subsuturally and becoming fine and weak near selenizone; pattern similar on base but lirae coarser, more regular, and slightly more prominent as size of shell increases.

Dimensions.—The larger figured specimen measures 8.0 mm in height and 7.5 mm in maximum width.

Discussion.—The Chainman Shale specimens are similar to the holotype of *L.*? *sablei* (Yochelson and Dutro) from the Lisburne Limestone of northern Alaska. On the type specimen of *L.*? *sablei*, growth lines above the selenizone as well as the lunulae are distinct, whereas the lunulae are faint in the Utah material. In both, the selenizone is raised and flattened rather than bordered by sharp spiral lirae as in *L. utahensis*. Such differences depend, in part, upon the quality of preservation of the shell surface. Although the holotype of *L.*? *sablei* is well preserved, no information is available as to the amount of individual variation in the strength or ornament in the species.

The selenizone of both *L.*? *sablei*, and our Utah specimens is approximately 1½ times as wide as that of *L. utahensis* at comparable growth stages. We consider this character sufficiently significant to question the placement of the species in *Lunulazona*. Nevertheless, we recognize the possibility that this species may have evolved from *L. utahensis*. Other differences also are noted between *L. utahensis* and *L.*? aff. *L.*? *sablei*. Lunulae on *L. utahensis* are much stronger than on *L.*? aff. *L.*? *sablei*. The other Utah species of *Lunulazona* differ in their more rhomboidal outlines, as well as their more prominent collabral ornament and need not be compared further.

This species is common at one locality in the Foote Range in a 6-inch (15-cm)-thick bed, where it is associated with *Richardsonites merriami* (Youngquist) and *Glabrocingulum* (*Glabrocingulum*) sp. C.; it occurs also in what may be a continuation of the same bed near Indian Pass.

Figured specimens.—USNM 211015, 211016.

Occurrence and number of specimens.—USGS collections 15370–PC (35), 16959–PC (5), 17024–PC (2), Millard County.

Genus EUCONOSPIRA Ulrich in Ulrich and Scofield, 1897

Discussion.—This genus includes turbiform to trochiform subconical pleurotomariaceans having a raised two-flanged narrowly concave selenizone at the periphery, the periphery itself being very low on the whorl. At one extreme are broadly conical shells having a flat base and ornamented both by spiral and collabral lirae, such as the large Late Pennsylvania (Missourian) species *Euconospira missouriensis* (Swallow). At the other extreme are shells that expand to some extent with growth and have more sloping, somewhat overhanging whorls and rounded bases, such as *E. disjuncta* Girty. Some of these have rather straight whorl slopes, and some are without spiral lirae.

Because the Mississippian species seem to be limited to the turbiform shells generally lacking spiral lirae, we considered the possibility of subdividing this genus on the basis of these differences. However, a survey of the material in the collection of the USNM shows that these characters are interchangeable; all types are found in Pennsylvanian and Permian rocks, so we must abandon the idea of subgenera. The type species, *Euconospira turbiniformis* (Meek and Worthen), combines the conical spire and ornament of both spiral and collabral lirae with a convex base; spiral lirae also are found on some shells having stepped spires. We therefore regard this genus as varying broadly between the extremes cited above.

American Mississippian species of Euconospira.—
desereti n. sp.
disjuncta Girty, 1910
gradilis n. sp.
sturgeoni Thein and Nitecki, 1974
waterlooensis (S. Weller), 1916 (*Bembexia*)

Euconospira disjuncta is from the lowermost part of the Fayetteville Shale of Arkansas, *E. sturgeoni* is from the Glen Dean Limestone of Illinois, and *E. waterlooensis*, which was referred to *Euconospira* by Thein and Nitecki (1974, p. 86), is from the Ste. Genevieve Limestone in Illinois.

Thein and Nitecki (1974, p. 88–90) described and figured three additional species as *Euconospira* sp. indet. The first species, from the Golconda Formation of Illinois, has the same apical angle as *E. waterlooensis* and certainly is very closely related to, or conspecific with, that species. The second species is from the same formation and, as they pointed out, is like *E. disjuncta*, except that the selenizone is covered by the succeeding whorl. The third species, from the lower part of the Okaw Limestone ("Marigold oolite") is not a *Euconospira* but probably belongs in *Spiroscala*.

Euconospira desereti n. sp.

Plate 4, figures 5–11, 15

Diagnosis.—Turbiform pleurotomariaceans having prominent flanged selenizone and closely spaced, coarse collabral ornament.

Description.—Nucleus unknown. Shell conical in general shape, with gently convex base; pleural angle approximately 70°, or slightly greater. Whorls in early part of shell embracing preceding whorl at or just below lower edge of selenizone; more mature whorls embracing slightly lower on preceding whorl. Suture not prominent. Profile of upper whorl surface nearly flat, except in early whorls which are gently convex, inclined at slightly steeper angle than pleural angle as lowermost part of this surface turns abruptly outward and nearly horizontal to form narrow flange; outer whorl face includes concave selenizone in upper part, bordered below by another flange extending a little farther laterally than upper flange and forming periph-

ery; lower side of this flange having little curvature, extending farther inward than upper flange, bending abruptly downward to lower segment of outer whorl face, which is about as high as width of flange above it, delineated from base by fairly sharp basal angulation accentuated by slight thickening at maturity; basal surface inclined strongly inward and gently downward, having slight convexity for more than three-fourths of its total width, inner part curving upward and flattening. Base anomphalous, having little or no depression in columellar area.

Growth lines simple on upper whorl surface, sweeping gently and uniformly prosocline from suture, forming angle of 45° with outer edge of upper flange bordering selenizone; orthocline on lower surface of lower flange of selenizone, bending steeply prosocline to form angle of nearly 80° with lower edge of flange; continuing straight for one-third distance across basal surface, then curving gently to form broad, exceedingly shallow sinus, its greatest depth coinciding with change of slope on basal surface, finally continuing straight to columellar area. Ornamented by collabral lirae separated by slightly wider interspaced paralleling growth lines. Selenizone relatively narrow, strongly concave between bordering flanges so as to be nearly semicircular in profile; lunulae prominent, symmetrical, strongly curved and closely spaced but having some individual variation in shape; slit depth unknown. Inner lip variable, partly reflexed on some specimens; outer lip unknown.

Dimensions.—Holotype and figured paratype measure, respectively: height 12.5 and 9.0 mm, and greatest width 12.7 and 10.2 mm.

Discussion.—This species is based upon a lot of five specimens collected near the top of the formation in the Burbank Hills. One of the paratypes shows vestiges of the original color pattern (pl. 4, figs. 8, 15). This pattern consists of alternating dark and light curved splotches on the upper whorl surface, following the general curvature of the growth lirae, the dark splotches normally covering four to six interspaces and the light splotches, three to four interspaces.

E. desereti differs from *E. disjuncta* Girty in having a smaller pleural angle and a generally constant inclination of the whorl slope during growth. *E. disjuncta* has a broad, somewhat stepped spire, and the whorl slope increases steadily with growth. Although the apical angle in the holotype is slightly less than 80° and the pleural angle is 87°, the upper whorl face on one side of the final whorl of the holotype diverges at an angle of 102° to that face on the other side of the same whorl; this angle contrasts with 74° for the final whorl of the holotype of *E. desereti*. *E. disjuncta* also has faint spiral lirae on the early whorls not present on *E. desereti*.

E. sturgeoni Thein and Nitecki differs from *E. desereti* in having a narrower pleural angle, ranging from about 65° to 70° in the Illinois species and 70° to 80° in the Utah form, and in having finer collabral lirae. *E. waterlooensis* (S. Weller) is based on an immature specimen having an apical angle of 48°. Its narrow shape and finer collabral lirae readily distinguish it from *E. desereti*.

Types.—Holotype USNM 211020; paratypes USNM 211021, 211022, 364704.

Occurrence and number of specimens.—USGS collections 17021–PC (1), 17217–PC (5), 25319–PC (1), 28612–PC (2), Millard County.

Euconospira gradilis n. sp.

Plate 4, figures 12–14

Diagnosis.—Moderately high-spired turbiform pleurotomariaceans having slightly stepped spire.

Description.—Nucleus and early whorls unknown, shell conical, turbiform; height slightly greater than width; pleural angle approximately 65°; body whorl embracing penultimate whorl just below basal angulation so that on spire periphery overhangs early part of succeeding whorl. Sutures distinct, slightly impressed. Whorl profile simple; upper whorl surface nearly flat, uniform from suture to near edge, where bordered by narrow flange; outer whorl face consisting of concave selenizone between two flanges, lower one at periphery, and a segment about twice width of selenizone, inclined at about 20° to axis of coiling, straight, bordered below by basal angulation bearing cord; basal surface gently inflated but essentially inclined 45° to axis of coiling. Base anomphalous.

Growth lines simple on upper whorl surface, sweeping gently prosocline from suture to form angle of about 50° with upper edge of selenizone; lunulae deep and U-shaped; growth lines opisthocline on flange below selenizone, curving to steeply prosocline on outer whorl face, meeting basal angulation at angle of about 60°, continuing straight onto base for about one-third distance across it, then curving to orthocline and continuing inward; younger stages curving prosocline just before reaching columella, but mature stages reducing and then nearly losing this inner gentle curvature. Ornament predominantly collabral; upper surface of whorl bearing low, rounded, fairly coarse lirae and interspaces twice to three times width of lirae, this ornament becoming obscure at maturity; lunalae strong; ornament also strong on lower part of outer whorl face and outer edge of base, more prominent than on upper surface, but diminishing rapidly in height inward, merging into growth lines for most of width of base; two or three spiral lirae crossing collabral elements, but not apppearing too persistent throughout growth; some

faint spiral lines also visible on inside surface of base where shell has flaked off internal mold.

Dimensions.—Holotype measures 10.3 mm in height (apex missing) and 10.1 mm in greatest width.

Discussion.—This species is based on a specimen from a bed bearing the ammonoid *Richardsonites merriami* (Youngquist) in the Conger Range. Although additional representatives have not yet been found, this unique specimen is easily distinguished from *Euconospira desereti* n. sp. and, in fact, from all other *Euconospira* known to us. Its name refers to the somewhat steplike spire.

Euconospira gradilis differs from *E. desereti* n. sp. in having a relatively higher shell with a smaller pleural angle, a slightly impressed suture, and a lower locus of embracement of the whorls, so that each whorl overhangs the upper part of the succeeding one. The prominence of a cordlike angulation below the selenizone also distinguishes this species from others in the Chainman Shale. The course of the growth lines on the upper whorl surface is slightly steeper in this species and markedly different on the base, as *E. desereti* lacks any distinct basal reentrant. Finally, the ornament of this species is finer, especially on the base, than on *E. desereti*.

Perhaps the most closely related species is *E. disjuncta* Girty, which also has overhanging whorls and, locally, faint spiral sculpture. However, *E. disjuncta* is a much broader shell, the holotype having a pleural angle of 87°, in comparison with 65° for the type of *E. gradilis*. The divergence of slope on the final whorl of *E. disjuncta* is 102° in comparison with 90° for *E. gradilis*.

Type.—Holotype USNM 211023.

Occurrence.—USGS collection 22880–PC, Millard County.

Family LOPHOSPIRIDAE
Subfamily RUEDEMANNINAE

Genus WORTHENIA Koninck, 1883

Discussion.—Late Paleozoic pleurotomariaceans that may be described in general as turreted and having most of the volume of their whorl below the peripheral selenizone have not been subjected to any modern attempt at systematic subdivision. The description of *Yochelsonospira* Thein and Nitecki (1974, p. 98–100) provides a needed taxon for the nontabulate forms. We concur fully with those authors in placing *Yochelsonospira* under the Ruedemanninae. However, we believe that the distinctions from *Worthenia*, stated as "***being more conical and by lacking a lower angulation on the outer face" (Thein and Nitecki, 1974, p. 100), are gradational characters. It seems to us more reasonable at the current state of our knowledge to regard *Yochelsonospira* as a subgenus of *Worthenia*, thus considering the presence or absence of a lower angulation as a subgeneric feature. Although no abrupt separation exists between the two subgenera, the literature indicates that *W.* (*Yochelsonospira*) is more commonly a Mississippian taxon and *W.* (*Worthenia*) typically a Pennsylvanian and Permian one.

As members of the typical subgenus, among those American species listed by Yochelson and Saunders (1967, p. 241–244), we would include: *W. castlemanensis* Linz from the Conemaugh Formation of Maryland, *W. subscalaris* (Meek and Worthen) from the Pennsylvanian of Illinois, and probably *W. speciosa* (Meek and Worthen) from the same area. *Worthenia tabulata* (Conrad), the type species of this genus was described originally from western Pennsylvania. It is the most common and widespread member of this genus in North America and has been reported throughout the Pennsylvanian System and into the Early Permian. Casual observation of several populations identified as this species convinces us that this long-ranging taxon could readily be divided into several species having shorter geologic ranges.

We also examined younger Permian species of *Worthenia* listed by Yochelson and Saunders (1967), and we question whether any of them is correctly assigned to this genus. New generic taxa may have to be erected to accommodate them. However, it is beyond the bounds of this paper to discuss and reassign them.

Worthenia? marcouiana (Geinitz) from the Late Pennsylvanian of Nebraska has a concave selenizone. It is reassigned herein to *Glabrocingulum* (*Ananias*); Yochelson examined the type specimen at Harvard University's Museum of Comparative Zoology. *Worthenia textiligera* (Meek) from the "Waverly Group" of Ohio has closely spaced spiral ornament and a slight subsutural ramp, and the raised selenizone is gently convex; we here reassign it to *Mourlonia*. *Worthenia longi* Bell from Subzone B of the lower part of the Windsor Series, Nova Scotia, has the distinctive stepped outline of *Borestus*; the figures and description given by Bell (1930, p. 625, pl. 23, figs. 12–14) suggest that it has a shallow concave selenizone near the middle of the outer face, so we hereby transfer it to *Borestus*.

Pleurotomaria (*Cyclonema?*) *strigillata* Herrick from the "Waverly Group" of Ohio was transferred to *Worthenia* by Hyde (1953, p. 327). We examined specimens from near Granville, Licking County, Ohio, which may be topotypes. This species is moderately high spired, has four spiral carinae on the angulations, three of them prominent; the sinus is narrow and moderately deep, centering on the most prominent carina, the third counting downward from the suture; it is not a selenizone. We know of no genus to which this species

can be assigned and for the present must classify it as *"Worthenia" strigillata.*

Subgenus W. (YOCHELSONOSPIRA) Thein and Nitecki, 1974

Discussion.—Although the differences from *Worthenia* listed by Thein and Nitecki would seem sufficient to separate two taxa of generic rank, our examination and redescription of *Worthenia (Yochelsonospira) tenuilineata* (Girty), given below, shows that they probably do not have high taxonomic value. The absence of a lower angulation in this group is most interesting. In the position at which this angulation would be expected to develop in *W. (Worthenia),* the spiral ornamentation is more widely spaced than elsewhere, and secondary lirae are present. Clearly, because of the wide spacing of the lirae, this general region of the shell was secreted by a part of the mantle that was not greatly wrinkled and thus under slight tension. It would take little change in the growth pattern for a broad angulation to form in this shell area.

Type species.—*Yochelsonospira pagoda* Thein and Nitecki [=*Worthenia tenuilineata* Girty].

American Mississippian species of Worthenia (Yochelsonospira).—

mississippiensis (White and Whitfield), 1862 (*Pleurotomaria*)
nauvooensis (Worthen), 1884 (*Pleurotomaria*)
northviewensis (S. Weller), 1899 (*Mourlonia*)
tenuilineata Girty, 1929 [synonym: *Yochelsonospira pagoda* Thein and Nitecki, 1974.]
thomasi Elias, 1958

Two of these species are assigned unquestionably to this subgenus: *Mourlonia northviewensis* S. Weller from the Northview Shale of Missouri, and *Worthenia tenuilineata* (Girty), which is a senior synomym of the type species, from the uppermost part of the Fayetteville Shale of Arkansas. Three other species, discussed below, are assigned with less certainty to the subgenus.

We examined a plaster cast of the holotype of *Pleurotomaria mississippiensis* White and Whitfield from the Kinderhookian Series of Iowa. This species certainly does not belong in *Mourlonia*, its last generic assignment, perhaps by mistaken identity, as Knight (1944, pl. 185, figs. 1, 2), in referring it to *Mourlonia*, illustrated this species by inadvertently reproducing Meek's figures of *Pleurotomaria textiligera* Meek. The shape of the spire of *P. mississippiensis* is like that of *Worthenia*, but the base and sculptural details are not preserved on the plastoholotype. We are arbitrarily assigning *P. mississippiensis* to *W. (Yochelsonospira)* because of its Early Mississippian age, but more details are needed before its status can be established firmly.

Pleurotomaria nauvooensis Worthen from the Keokuk Formation of Illinois is fairly large and has a shape resembling that of *W. (Yochelsonospira);* we questionably assign it to the subgenus. The illustration of the type is that of a steinkern lacking a basal angulation. Topotype specimens in the collection of the USNM are also steinkerns. Until this species can be redescribed from authentic well-preserved specimens, we recommend that use of the name be confined to the type lot.

Worthenia thomasi Elias from the Redoak Hollow Member of the Goddard Shale of Oklahoma is known from a single fragment of an external mold. If this specimen is a *Worthenia,* it may be assigned to *W. (Yochelsonospira)* because the reconstructed outline drawing provided by Elias (1958, text-fig. 4) shows no basal angulation, and none appears on the photograph of the fragment (Elias, 1958, pl. 2, fig. 15). *W. thomasi* is so poorly known that we recommend that this name also be restricted to its type lot. As noted earlier, the likelihood of obtaining topotypes from Elias's Redoak Hollow localities is virtually nil.

Worthenia (Yochelsonospira) tenuilineata Girty

Plate 7, figures 1–5

Worthenia tenuilineata Girty, 1929b, p. 141, figs. 16–18.
Yochelsonospira pagoda Thein and Nitecki, 1974, p. 101, 102, fig. 39 a–d.
Worthenia (Yochelsonia) tenuilineata. Gordon and Yochelson, 1983, p. 985, figs. 3V–X, NN–PP.

Diagnosis.—Wide, slightly turreted, subconical pleurotomariaceans having sloping flat whorls and rounded base, ornamented by numerous spiral lirae crossed by growth lirae.

Description.—Nucleus orthostrophic, smooth, probably about two whorls, passing gradually into postnuclear whorls. Shell having slightly turreted appearance, showing subtle but distinct ontogenetic change; pleural angle near 80°. Whorl profile of early growth stages simple, inclined, selenizone nearly flat and of essentially same inclination; succeeding whorl embracing at base of selenizone; sutural area and selenizone on later whorls becoming more prominent and whorl embracing lower. Mature whorl profile having obscure suture, but bordering suture distinct and incised, set off from rest of whorl by a nearly horizontal ramp occupying almost one-sixth of total width of upper whorl surface, causing slightly turreted aspect of whorls; upper whorl face beyond ramp bending abruptly downward and outward at approximately 45° inclination, continuing straight to outer edge where it flares slightly and thickens; periphery rounded, formed by selenizone; outer whorl face immediately below periphery curving

abruptly inward for short distance, then downward and gently inward for most of its length, and finally inward to form elongate sigmoidal curve; junction with basal surface fairly well rounded, base gradually flattening toward columella and forming approximate 20° angle with horizontal. Slit and details of apertural lips not preserved.

Growth lines obscure across ramp, prosocline at 45° angle to angular margin of ramp, having slight curvature across main part of upper whorl surface, but swinging backward more strongly adjacent to selenizone; below selenizone, steeply opisthocline for short distance, but approximately orthocline across rest of outer whorl face, gently sigmoidal crossing basal curvature, then orthocline for most of distance across base. Surface ornamentation finely reticulate, consisting of narrow collabral threads having slightly wider interspaces crossed by spiral threads that appear on first postnuclear whorl and continue to aperture; intersections of two sets of threads minutely beaded; collabral threads slightly stronger on upper whorl face.

Dimensions.—The two illustrated Chainman Shale specimens (USNM 211018 and 211019, from the Foote Range and the Burbank Hills, respectively) and the holotype from Arkansas (USNM 119394) have the following measurements:

USNM	211018	119394	211019
Height	18.0	15.1	14.2
Maximum width	15.5	14.5	14.0

Discussion.—Our specimens were compared with the holotype (USNM 119394) from the upper part of the Fayetteville Shale in northwestern Arkansas. The Arkansas specimen comes from a lower stratigraphic horizon, where it was associated with the lower *Eumorphoceras* (E_1) Zone ammonoids *Cluthoceras glicki* (Gordon) and *Tumulites varians* McCaleb, Quinn, and Furnish. In Utah, this species is restricted to equivalents of the upper *Eumorphoceras* (E_2) Zone; that is, it is common locally in the *Cravenoceras hesperium* Zone and continues upward stratigraphically beyond the highest occurrence of *Richardsonites merriami* (Youngquist) in the various Chainman sections.

The holotype has 17 spiral threads on the upper whorl face, including the ramp, two fairly strong threads and, locally, two very fine flanking threads in the selenizone, and about 40 threads on the outer face and base, some them very fine and intercalated between stronger ones. The specimen illustrated on plate 7, figures 3–5, has 18 threads on the upper whorl face, four on the selenizone, and 37 on the outer face and base. The number of threads on the upper whorl face, in our specimens, ranges from 14 to 20 and on the outer face and base, from 36 to 45.

We compared the holotype of *Worthenia* (*Yochelsonospira*) *pagoda* Thein and Nitecki with that of *W. tenuilineata* Girty and regard them as conspecific. *W.* (*Y.*) *northviewensis* (S. Weller) differs from this species in being lower spired, having the whorls more deeply incised, and in lacking the sutural ramp.

Other species assigned provisionally to *W.* (*Yochelsonospira*) are not well understood and are therefore difficult to compare. *W.* (*Y.*) *thomasi* Elias is represented only by a fragment of an external mold bearing finely reticulate sculpture similar to that of *W.* (*Y.*) *tenuilineata,* but Elias's reconstructed outline drawing of this species is markedly different in shape. *W.* (*Y.*) *mississippiensis* (White and Whitfield), of which the base and surface sculpture are unknown, differs from *W.* (*Y.*) *tenuilineata* in having a somewhat steeper upper whorl face and in being much larger. *W.* (*Y.*) *nauvooensis* (Worthen) is known only from steinkerns and therefore cannot be compared.

Pleurotomaria nevadensis Walcott, from the Late Mississippian Diamond Peak Formation of Nevada, is superficially similar to *W.* (*Y.*) *tenuilineata* because of its closely spaced ornament. The shell, however, is much larger and has a narrower pleural angle and a concave selenizone. It is reassigned in this report to *Glabrocingulum* (*Ananias*) and is briefly redescribed on p. 66.

Figured specimens.—USNM 211018, 211019.

Occurrence and number of specimens.—USGS collections 17095–PC (1), Juab County; 15161–PC (2), 15364–PC (1), ?16997–PC (1), 17021–PC (2), 17023–PC (35), 17024–PC (1), 17056–PC (2), 17059–PC (1), 17209–PC (1), 17217–PC (2), 17219–PC (2), 17310–PC (5), 25259–PC (1), 25274–PC (8), 25318–PC (2), 25319–PC (5), 25547–PC (1), 25551–PC (2), ?25553–PC (1), Millard County.

Family PHYMATOPLEURIDAE

Genus CATAZONA Gordon and Yochelson, 1983

Discussion.—The Phymatopleuridae constitute a closely knit group of pleurotomariaceans having a relatively narrow selenizone that tends to be flat except for bordering lirae. Several different shell shapes and relative heights of spire occur in the family, and distinction between the genera is not entirely obvious. *Catazona* resembles *Borestus* Thomas, 1940, in having a turbinate shell that develops a flat or gently concave, approximately vertical outer whorl face, clearly bounded by upper and lower angulations. The shell thus has a somewhat turreted appearance. In *Borestus,* the selenizone is in the middle of the outer whorl face.

In *Catazona*, it is at the bottom of this face, adjacent to the suture of the succeeding whorl. So far, only one species of *Catazona* is known, originally described from the Diamond Peak Formation in eastern Nevada.

Catazona rudilirata Gordon and Yochelson

Plate 7, figures 22–27

Catazona rudilirata Gordon and Yochelson, 1983, p. 986, figs. 3 GG–JJ.

Diagnosis.—Phymatopleurids having sloping upper whorl surface ornamented by four strong spiral cords; outer whorl surface vertical, bordered by keels, bisected by spiral cord, lower half occupied by selenizone. Base anomphalous, with channeled umbilical depression and bearing five or six spiral cords. Collabral growth lirae threadlike.

Description.—Shell low spired, pleural angle near 95°. Nucleus and early whorls unknown. Suture obscure; body whorl embracing penultimate whorl at lower edge of selenizone. Upper whorl face having flat, nearly horizontal ramp adjacent to suture, occupying about one-fourth of total width of this face, ending abruptly at a spiral cord; beyond cord, inner half of upper whorl surface is straight and inclined downward at approximately 45°, bisected by a second cord, ending at a third, and finally curving downward and outward for about one-fourth of total surface width of this face to form prominent protruding flange. Outer whorl face below upward-curved flange narrow, inclined inward but nearly vertical above selenizone, which is about twice as wide and more distinctly inclined. Basal surface consisting of at least four beveled segments, separated by cords, each segment being more strongly inclined toward the horizontal than the preceding one. Base anomphalous, having faint broad umbilical depression bordered by a cord. Inner lip curved, flattened. Inductural deposit covering flat part of inner lip and base of columella. Outer lip and slit unknown, but slit depth probably much less than one-sixth of whorl.

Growth lines not preserved on upper surface, flange, and upper part of outer whorl face; selenizone raised slightly, relatively broad; lunulae well formed, symmetrical, closely spaced, moderately prominent. Growth lines on inner half of base prosocline, straight. Ornament on upper surface consisting of three spiral cords; four or five on basal surface, those on base slightly larger and more rounded in profile than those on upper surface.

Dimensions.—Both figured specimens measure 12.0 mm in height; their respective widths are 13.0 mm and 14.2 mm.

Discussion.—The description above is based on specimens from the Confusion Range, Utah. These consist of five lots of somewhat varied preservation, four from the Willow Gap Member of Sadlick (1966) at Wallet Gulch and Skunk Spring and one from an equivalent level in the Granite Mountain measured section. One is an incomplete specimen preserved in limestone, of which the shell substance is recrystallized calcite; this and another lot were found in the Skunk Spring section. Some parts of the ornament are well preserved, but other parts have been lost by breakage along cleavage faces. The lunulae of the selenizone are well preserved, but the edges of the selenizone are missing so that it appears narrow. The other two lots are silicified specimens from the Wallet Gulch section. These specimens preserve no growth lines and several are broken, but collectively they illustrate the base and show the selenizone to be a wide band.

The type lot from the Diamond Peak Formation exposed in the White Pine Range, Nev., is under USNM numbers 307494 and 307495.

Figured specimens.—USNM 211024, 211025.

Occurrence and number of specimens.—USGS collections 17104–PC (1), Juab County; 15358–PC (1), 15362–PC (1), 17214–PC (7), 25566–PC (2), Millard County.

Genus DICTYOTOMARIA Knight, 1945

Discussion.—Our arguments for considering *Dictyotomaria* a full genus, rather than a subgenus of *Glyptotomaria* Knight, as suggested by Batten (1958, p. 210), were given in an earlier paper (Gordon and Yochelson, 1975, p. F16). This genus includes depressed turbiform to subtrochiform shells having a sloping upper whorl surface, more steeply sloping outer face, and a gently convex base. Sculpture consists normally of sharp collabral and spiral lirae. Growth lirae are straight below the suture, curve backward to the selenizone, and are straight below it, also forming a shallow sinus on the base. The selenizone, located at the middle of the outer face, is bordered by a cord at either side, and the collabral lirae form lunulae within it. The base normally has a narrow umbilicus or umbilical chink. The poorly preserved Chainman shells referred questionably to this genus are unusual in that the pleural angle is comparatively small for the genus.

North American Mississippian species of Dictyotomaria.—

brazeriana (Girty), 1927 (*Phanerotrema*)
carlbransoni Gordon and Yochelson, 1975
meekana (Hall), 1857 (*Pleurotomaria*)
wortheni (S. Weller), 1916 (*Ptychomphalus*)
yochelsoni Thein and Nitecki, 1974

Elias (1958, p. 9, pl. 1, fig. 14; pl. 2, fig. 7) cited as "*Phymatopleura brazerianum* var. *springerensis* n. var." a single tiny shell from the Redoak Hollow

Member of Goddard Shale in southern Oklahoma, having a maximum diameter of 2 mm. As this name was published prior to 1961, according to the International Code of Zoological Nomenclature (International Trust for Zoological Nomenclature, 1961, p. 45), it is subject to interpretation as either a subspecific or intrasubspecific entity. Elias stated that the Redoak Hollow shell is so similar in all respects to *P. brazeriana* that it can be identified with it assuredly. Then, he went on to point out that it differs in one respect, the presence of a low revolving costa in the selenizone. However, Elias's illustrations are insufficient to confirm this. Because we know of no *Dictyotomaria* having a spiral cord within the selenizone, we conclude that the variety *springerensis* is probably not a valid subspecies of *Dictyotomaria brazeriana* and do not, therefore, follow Thein and Nitecki (1974, p. 108) in referring Elias's taxon to this genus.

Thein and Nitecki (1974, p. 108) also referred *Ptychomphalus depressus* S. Weller to *Dictyotomaria*, but we are omitting this species because the presence of a selenizone, let alone its precise position, is not known, nor is the configuration of the collabral lirae. A relationship to some other pleurotomariacean such as *Portlockiella* cannot be precluded at present, or even some nonpleurotomariacean genus like *Yunnania*.

Dictyotomaria? sp.

Plate 7, figures 34–36

Discussion.—Occurring with *Catazona rudilirata* in the basal bed of Willow Gap Member of Sadlick (1966), in the Wallet Gulch section, is a smaller, more slender, spirally lirate shell having the upper whorl surface sloping at 52° to the horizontal and a fairly short nearly vertical face below the periphery. The specimen consists of approximately four whorls; the nucleus is not preserved. The pleural angle is 57° in the figured specimen. Although silicification has obliterated fine details of the shell, five or six cords can be discerned, ornamenting the sloping whorl face, the strongest cord being at the periphery. On the vertical outer face, just below this cord, is a depressed spiral zone believed to be the selenizone. Perhaps two more cords occur in the lower part of this face. Collabral lirae cannot be distinguished anywhere on the shell.

The succeeding whorl is inserted immediately below the angulation that forms the lower boundary of the outer whorl face. The base is gently convex and seems to be ornamented by several fine spiral cords, but these likewise have been obscured by the silicification. The columella is somewhat twisted and the outer lip recurved, partly concealing a narrow depressed area; a tiny umbilicus may be present. The height of the figured specimen is 6.4 mm and the width 4.9 mm.

On the basis of the general configuration of the shell and the possible presence of a selenizone, we questionably refer this shell to *Dictyotomaria*, which it resembles more than any other genus. A small even more poorly preserved specimen also is referred here.

Figured specimen.—USNM 211071.

Occurrence and number of specimens.—USGS collection 25566–PC (2), Millard County.

Superfamily MURCHISONIACEA

Discussion.—Yochelson (1984) suggested a major review of the present arrangement of some of the high-level taxa within the Archaeogastropoda, which is followed herein and accounts for the change in systematic position of the Murchisoniacea. When the "Treatise" (Knight, Batten, and Yochelson, 1960) was written, the view prevailed that the prosobranchs could be divided into archaeogastropods and caenogastropods, the latter equivalent to the Mesogastropoda and Neogastropoda then in use. The murchisoniaceans were viewed as a transitional group between the two suborders, for, although they possessed a selenizone, some members of the superfamily had features suggesting a siphonal canal and hence an exhalent siphon.

Additional data, partly from the Mesozoic, suggest that lumping of the Neogastropoda with the Mesagastropoda was a retrograde step in classification. It now seems clear that most of the genera within these taxa are post-Paleozoic in their origin. In his speculation on high-level classification, Yochelson (1984) broadened considerably the limits of morphologic types placed within the early Pleurotomariacea. He also suggested that all slit-bearing groups be placed in the same suborder, so that Pleurotomariacea, Bellerophontacea, and Murchisoniacea would be linked together. We follow that course here, for it is our view that, in a sense, the Murchisoniacea are merely a convenient way of distinguishing exceptionally high-spired pleurotomariaceans. Accordingly, we abandon the suborder Murchisoniina.

Family MURCHISONIIDAE

Genus STEGOCOELIA Donald, 1889

Subgenus S. (STEGOCOELIA) Donald, 1889

Discussion.—This subgenus includes small, moderately high spired shells having rounded whorls ornamented by prominent threads or carinae. A short slit and selenizone occur above the periphery. A thin parietal inductura is present at the aperture, covering part of the columellar area. Thein and Nitecki (1974, p. 161–166) recognized three species in the Late Mississippian of Illinois and Kentucky.

American Mississippian species of Stegocoelia (Stegocoelia).—

illinoisensis (S. Weller), 1916 (*Solenospira*)
kentuckiensis Thein and Nitecki, 1974
okawensis Thein and Nitecki, 1974

Chesterian species of *S. (Hypergonia)* and of the allied genus *Aclisina* were discussed by Thein and Nitecki (1974).

Stegocoelia (Stegocoelia) sp.

Plate 9, figures 16, 17

Discussion.—One tiny murchisoniid shell came from a bed near the top of the *Cravenoceras hesperium* Zone in the Burbank Hills section. The specimen is incomplete, retaining nearly four whorls, and measures 4 mm in height. A selenizone cannot be determined clearly, making generic reference uncertain. We refer it to *Stegocoelia* mainly because of its strong spiral lirae, which occur over the entire whorl. Sutural areas are incised, but the sutures are faint and smooth. The whorl profile beneath the lirae is smoothly curved but not greatly inflated; the basal whorl surface is slightly flattened, but the juncture of the outer and basal surfaces is well rounded, if the lira in this region is ignored. The periphery occurs a little below midwhorl. The columellar lip is straight and does not appear reflexed; the outer lip is unknown.

Four spiral lirae ornament the whorls, two of them near the suture, the subsutural one faint. The third lira is at the periphery and separated by a relatively wide space from the second lira. The fourth lira is midway between the periphery and the next suture. The base is ornamented by three lirae that are equally spaced and progressively lower toward the center. Growth lines curve strongly from opisthocline to prosocline on the base; they cannot be observed clearly on the upper part of the whorl. Impressions that follow growth lines are steeply opisthocline on the periphery and lower part of the whorl.

A second lot of five poorly preserved, silicified specimens was collected near the top of the Chainman Shale in the measured section at Granite Mountain. These specimens are from a stratigraphic position similar to that of the specimen described above and seem to represent the same species.

A substantial number of American Mississippian high-spired gastropods have been referred to *Murchisonia* or to the generally similar *Stegocoelia,* but our material is too poor to make any meaningful comparisons.

Figured specimen.—USNM 211036.

Occurrence.—USGS collections 25252–PC (5), Juab County; 17209–PC (1), Millard County.

Genus BELLAZONA, n. gen.

Diagnosis.—Simple meekospiriform shells bearing a selenizone; whorls gently convex; base anomphalous, basal lip moderately well rounded; sutures very slightly impressed. Shell surface polished; ornament obscure or absent; selenizone located low on whorl, suture at its midline.

Type species.—Loxonema bella Walcott, 1884.

Discussion.—Although there might be some hesitancy in proposing a new genus while some older generic concept not rigorously defined might be extended, we feel that the term "unique" can be aptly applied to *Bellazona.* The shape of this genus simulates that of *Loxonema* and *Meekospira*, but the presence of a selenizone readily distinguishes *Bellazona.* However, none of the pleurotomariaceans described from the Paleozoic approach this shell form. Among the murchisoniaceans, as presently constituted, the Silurian genus *Leptorima* has the selenizone high on the whorl. Other genera, such as the Devonian *Ptychocaulus* and the early Carboniferous *Cerithioides*, have the selenizone lower on the whorl but not at the suture as in *Bellazona*; they differ further in having a turritelliform shape.

Except for the type species and one additional new species, no other taxa are assigned to this genus. Walcott overlooked the faint selenizone on his material. Mid-Paleozoic species variously assigned to *Subulites*, *Loxonema*, and *Meekospira*, among other genera, should be examined for this feature. Such a search cannot be made from published illustrations and must be deferred until type material of the described species is available.

Bellazona bella (Walcott)

Plate 9, figures 11–15

Loxonema bella Walcott, 1884, p. 258, pl. 14, figs. 1, 1a.

Diagnosis.—Narrowly meekospiriform selenizone-bearing gastropod shell having well-rounded lip.

Description.—Earliest whorls consisting of approximately one low smooth nuclear whorl followed by much higher, smooth postnuclear whorls. Shell like that of *Meekospira;* apical angle about 25°. Whorl profile simple; periphery very low on whorl, slightly below upper edge of selenizone, so that outer whorl face is nearly flat except immediately above slightly sunken sutural area. Whorl surface below periphery, curving smoothly inward and continuing downward; basal part of whorl somewhat less arched. Body whorl embracing penultimate whorl at midline of selenizone. Selenizone obscure, set off only by faint groove above and below. Shell surface polished. Growth lines closely spaced and faint, orthocline near suture, very steeply prosocline

for most of their length, then curving to more strongly prosocline near selenizone, which they join at nearly a 45° angle; lunulae obscure; below selenizone, growth lines curving from opisthocline at 45° to orthocline, continuing straight across anomphalous base. Whorls ornamented by five or more exceedingly faint spiral lirae above selenizone and at least one on base. Aperture seemingly without inductura; slit depth unknown.

Dimensions.—Walcott's type specimen is 17.5 mm long and 6.5 mm wide.

Discussion.—Welcott apparently described this species from a single well-preserved specimen, USNM 14410. It came from a small conical hill on the east side of Secret Canyon road, about 3 miles southeast of Eureka, Nev. The Mississippian beds at that locality are currently assigned to the Diamond Peak Formation and are late Meramecian in age.

The holotype is moderately well preserved, though it is attached to a piece of matrix for part of its length. For most of the length on one side, the shell is broken away, but 11 postnuclear whorls occur. On the other side and around the circumference of the body whorl, shell is present. The aperture is broken, and the shell is exfoliated just behind it. The shell surface is polished, and the selenizone is even more obscure than in the other species, *B. polita*, so that Walcott's error in assigning his shell to *Loxonema* is understandable. The holotype shows exceedingly faint spiral lirae, but we cannot find these on the specimens from the Chainman Shale, specimens on which the surface is fairly well preserved; we are inclined to place little emphasis on these faint lirae as a specific character.

The Utah specimens of *B. bella* are from the measured section at Granite Mountain at or near the top of the *Goniatites americanus* Zone and immediately above the limestone marker bed in the lower part of the Chainman Shale. The apex is missing on all specimens, but fragments of the shell surface are preserved, several of which show the selenizone. The figured specimen retains approximately seven whorls.

Figured Utah specimen.—USNM 211037.

Occurrence and number of specimens.—USGS collection 17018–PC (4), Juab County.

Bellazona polita n. sp.

Plate 9, figures 22–25

Diagnosis.—Moderately wide meekospiriform selenizone-bearing gastropods having poorly rounded basal lip.

Description.—Nuclear whorls unknown; early and mature stages showing consistent growth pattern with no evidence of ontogenetic change. Shell form similar to that of *Meekospira;* apical angle 35°. Whorl profile simple, almost flat from suture to periphery, then curving slightly inward for short distance so that suture is obvious but not impressed. Selenizone occupying approximately one-fifth of outer whorl; body whorl embracing penultimate whorl at midline of this feature; periphery occurring in upper part of selenizone, which follows general contour of whorl surface and is delimited only by faint groove above and below. Whorl profile below selenizone curving smoothly into anomphalous base; basal surface more flattened than peripheral area above it. Shell surface smooth, polished, ornamented only by faint closely spaced growth lines. Growth lines orthocline from suture to about halfway down side of whorl, then curving gradually to become steeply prosocline, meeting selenizone at angle of approximately 60°; lunulae well curved but faint; below selenizone, growth lines opisthocline at angle of about 45° but rapidly curving forward to become orthocline on inner half of basal surface. Base ornamented by three or more faint spiral grooves. Aperture seemingly without inductura. Slit depth unknown.

Dimensions.—The holotype, which lacks the apex, measures 17 mm in length and 8.3 mm in width.

Discussion.—*Bellazona polita* is fairly widespread in the Chainman Shale; we found it from Granite Mountain southward nearly to Conger Mountain. Although not abundant, it is more common than other high-spired gastropods in the fauna. Most of the specimens are from the *Goniatites granosus* Zone, but two lots are from the *Paracravenoceras barnettense* Zone. One is an incomplete specimen preserving part of the selenizone and is found in association with *Cravenoceras kingi* (Hall and Whitfield). The other lot consists of poorly preserved and partly crushed specimens from about the same stratigraphic level near Skunk Spring. This species is distinguished from *B. bella* (Walcott) by its apical angle, which is about 10° wider than that of *B. bella*, and by its less well-rounded base.

Types.—Holotype USNM 211038; paratypes USNM 211039–211041.

Occurrence and number of specimens.—USGS collections 17012–PC (17), 17015–PC (8), 17020–PC (2), 25562–PC (1), Juab County; 14553–PC (2), 14557–PC (4), 20455–PC (1), Millard County.

Suborder "MACLURITINA"

Discussion.—Since 1960, the Euomphalacea have been combined with the Macluritacea under the suborder Macluritina. We have reservations whether the two superfamilies are in fact closely related. Most euomphalaceans are low spired and dextral in coiling. Some euomphalaceans do have a flat or nearly flat basal surface, resembling that of *Maclurites*. This

shape could result from a sedentary life habit in which the base of the shell rested on the substrate. The base need not indicate close relationship to the presumed hyperstrophically coiled Macluritacea. Our use of quotation marks in the subordinal assignment indicates our disbelief in this relationship, but, at this time, we cannot suggest any reassignment of the Euomphalacea to a larger group.

Superfamily EUOMPHALACEA
Family EUOMPHALIDAE
Genus STRAPAROLLUS DeMontfort, 1810

Subgenus S. (EUOMPHALUS) J. Sowerby, 1814

Discussion.—*Straparollus* is a long-ranging genus of distinctive but limited shell characters. It is recognized easily and is rarely confused with other gastropod genera. Currently, it is divided into six subgenera, on the basis of the spire configuration and angularity and the smoothness or nodosity of the whorls. These subgenera are: *S. (Straparollus), S. (Euomphalus), S. (Philoxene), S. (Serpulospira), S. (Amphiscapha),* and *S. (Cylicioscapha).* For the distinguishing characters of these taxa, the reader is referred to Yochelson (1956) and Knight, Batten, and Yochelson (1960). Linsley and Yochelson (1973, p. 19) suggested that *Philoxene* not be used as a separate taxon, and the interested reader is referred to their work. Only *S. (Euomphalus)* has been found in the Chainman Shale of Utah; it is represented by three species described below.

Shells of this subgenus have low to depressed spires and an angulation at the junction between the upper and outer whorl faces. *S. (Euomphalus)* generally has a widely phaneromphalus base, which in some species is marked by a subangulation and may bear nodes; some forms also have nodes along the outer edge of the upper whorl face. The name *S. (Phymatifer)* has been used for species having nodes top and bottom, but we are following Knight, Batten, and Yochelson (1960) in regarding *S. (Phymatifer)* as a junior synonym of *S. (Euomphalus).*

Species of *S. (Euomphalus)* having a depressed spire and whorls that are angular both below and above are very similar to *S. (Amphiscapha).* We refer such forms to *S. (Euomphalus)* if the whorls of the spire are shallowly stepped; if steps are absent and the whorls tilt toward the apex, the shells belong in *S. (Amphiscapha).* One Chainman species of this type seems almost intermediate between *S. (Euomphalus)* and *S. (Amphiscapha)* and was named *S. (Euomphalus) intermedius* by Gordon and Yochelson (1983). The other Chainman species is more typical of the subgenus, as it has a low elevated spire and nodes along the rounded base. This species is named *S. (Euomphalus) nodibasis* n. sp.

American Mississippian species of Straparollus (Euomphalus).—

angularis Weller, 1900
boonensis (Swallow), 1863 (*Euomphalus*)
brooksensis Yochelson and Dutro, 1960
exortivus (Dawson), 1868 (*Euomphalus*)
illinoisensis Thein and Nitecki, 1974
intermedius Gordon and Yochelson, 1983
latus (Hall), 1858 (*Euomphalus*)
multistriatus (E. Branson), 1938 (*Euomphalus*)
nodibasis Gordon and Yochelson, n. sp.
obtusus (Hall), 1858 (*Euomphalus*)
pancakensis Mount, 1973
planodorsatus (Meek and Worthen), 1961 (*Euomphalus*)
roberti (White), 1862 (*Euomphalus*)
similis Meek and Worthen, 1862
subplanus (Hall), 1852 (*Euomphalus*)
tricarinatus (Girty), 1927 (*Phymatifer?*)
utahensis Hall and Whitfield, 1877
xylacus Gordon and Yochelson, 1977 [n. name for *S. (E.) calix* Gordon and Yochelson, 1975, *not calyx* Phillips, 1836].

Omitted from the list are (1) *Euomphalus luxus* White, 1877, a junior synonym of *Straparollus (Euomphalus) subplanus,* according to Yochelson (1962, p. 77); (2) *E. perspectivus* Swallow, 1863, a synonym of *S. (E.) planodorsatus;* and (3) *Straparollus similis* var. *planus* Meek and Worthen, 1861, a variant of *S. (E.) similis. Euomphalus boonensis* Swallow is known only from the original description, which suggests that it was a very typical *S. (Euomphalus);* it was never figured, and the type presumably was destroyed in a fire at the University of Missouri along with other Swallow types. Because its provenance was listed only as the "Encrinital Limestone" in Missouri, it probably can never be recognized.

Straparollus (Euomphalus) nodibasis n. sp.

Plate 3, figures 6, 11–17

Straparollus (Euomphalus) n. sp. Gordon and Yochelson, 1983, p. 979.

Diagnosis.—Low-spired euomphalid gastropod, lacking basal angulation, ornamented by nodes on basal surface.

Description.—Nucleus and earliest growth stages unknown; early whorls narrowly rounded on top; whorl becoming steplike at early stage. Sutures distinct, not channeled or incised. Upper whorl surface arches outward and gently downward from suture for more than two-thirds of whorl width, beyond which it flattens and curves concavely upward to form inner and upper edge of carina separating upper and outer whorl surfaces. Upper surface becoming less arched but more steeply

inclined with maturity; carina low in early whorls, located on strong angulation in mature whorls. Outer whorl surface steeply inclined outward and downward, becoming slightly bowed near periphery, which is below midwhorl, and curving inward near base, following arc of circle which continues up steeply into umbilicus, so that no basal angulation is formed. Body whorl embracing penultimate whorl above periphery. Umbilicus rather widely phaneromphalus.

Shell ornamented by closely spaced faint growth lines over entire whorl, which become stronger in late maturity, and by moderately large nodes on lowest part of whorl. Growth lines on upper whorl surface straight, gently prosocline, approaching angulation of whorl at angle of approximately 60°, nearly orthocline on upper one-third of outer whorl face, and just above periphery curving to prosocline, at approximately 30° to vertical, continuing in this direction into umbilicus, but becoming orthocline again a short distance before reaching umbilical suture. Nodes slightly elongate parallel to growth lines; interspaces wider than nodes, reaching maximum width, twice those of nodes. Fifteen or more nodes on mature whorl.

Dimensions.—The holotype measures 7.1 mm wide and 5.0 mm high; a large paratype (USNM 210959) is 36 mm wide and 22.5 mm high.

Discussion.—The whorl profile of this Chainman species is similiar to that of *S. (Euomphalus) brooksensis* Yochelson and Dutro, another Late Mississippian form, but the latter species lacks nodes on the basal surface. *S. (E.) planodorsatus* (Meek and Worthen), from the Chesterian Series of Illinois, differs in having a weak circumbilical angulation as well as in lacking the basal nodes. The only North American species of Mississippian age that seems to have a nodose character similar to that of the Chainman species is *S. (E.)* sp. B of Knight (1953, p. 76) from Sonora, Mexico. Knight's material is so incomplete, however, that no further meaningful comparisons can be made.

A somewhat similar Pennsylvanian species was described from the "Lower Coal Measures" of Alton, Ill., as *S. (E.) pernodosus* Meek and Worthen. This species is slightly larger, the upper carina is more rugose, and the base upon which the nodes are located is narrower and flanked toward the umbilicus by a concave zone, inside of which the whorl rounds rather rapidly into the umbilicus. The nodes are elongate in the direction of the whorl. *S. (E.) nodibasis* differs from this species primarily in that the base is flatter and the nodes are near the umbilicus and are transversely elongate.

A straparollid similar to *S. (E.) nodibasis* occurs in northern England and is called *S. (E.) nodosus* (Sowerby). A large incomplete specimen of this shell in the U.S. National Museum collection (USNM 6346) measures 83 mm in diameter. The eight nodes on the base are rounded to longitudinally elongate. These nodes contrast with those of the Utah species, which number about 12 to 15 on each whorl and which tend to elongate transversely.

The subgenus *Phymatifer* Koninck, based upon a nodose species of straparollid, has been considered a subjective synonym of *Euomphalus* for many years. Eventually it might find utility again, if the various species of nodose euomphalids can be shown to represent a single lineage. The use of Koninck's subgenus for the Chainman Shale species, however, poses difficulties, because typical *Phymatifer* has nodes on both the upper and lower whorl surfaces. The significance that might be placed on nodose ornament in these gastropods needs careful study.

Only a few specimens of this easily recognized species were found. The species ranges nearly throughout the Willow Gap Member of Sadlick (1966) at Skunk Spring, where the top 10 feet (3 m) of this unit contains many large corals of the genus *Caninia* (K_2 Zone of Dutro and Sando, 1963, p. 1974). At Granite Mountain, *S. (E.) nodibasis* has been found in a similar *Caninia*-bearing unit and also in another bed a few feet higher stratigraphically.

Types.—Holotype USNM 210958; paratypes USNM 210959, 210960.

Occurrence and number of specimens.—USGS collections 17098–PC (1), 17104–PC (1), Juab County; 15355–PC (1), 15358–PC (1), 15362–PC (1), 15375–PC (1), ?17188–PC (1), 25563–PC (1), Millard County.

Straparollus (Euomphalus) intermedius Gordon and Yochelson

Plate 3, figures 1–5, 7–10

Straparollus (Euomphalus) intermedius Gordon and Yochelson, 1983, p. 977–978, pl. 2, figs. 12–23.

Discussion.—This species is placed in *S. (Euomphalus)* because the spire is stepped for the last several volutions, the umbilicus is deeper than in typical *S. (Amphiscapha)*, and the whorl is tilted slightly toward the umbilicus rather than toward the apex as in typical *S. (Amphiscapha)*. Its depressed spire and fairly sharp upper carina suggests *S. (Amphiscapha)*, and it seems to be intermediate between these two subgenera of *Straparollus*. The stratigraphic position in the Upper *Eumorphoceras* (E_2) Ammonoid Zone not far below the first appearance of *S. (Amphiscapha)* agrees with this concept. *S. (Amphiscapha)* is typically a Pennsylvanian subgenus, but we have identified it in the lowermost Ely Limestone at Granite Mountain and in the Diamond Peak Formation in the Carlin region of Nevada; at both these occurrences, it is in uppermost Mississippian strata.

In western Utah, *S. (E.) intermedius* is known from several localities. Six specimens were associated with the ammonoid *Carvenoceras hesperium* Miller and Furnish collected from the Foote Range at the northwestern side of the Bishop Springs dome. These specimens were obtained from a shale, and the imbrications along the carina are particularly well developed, even on young specimens. These imbrications result from interruption of growth accompanied by slight flaring of the lip at the upper angulation; some specimens have more than 40 such expansions. Some specimens appear darker on the upper and outer whorl faces than on the umbilical surface; this difference could reflect an original color pattern.

One figured specimen (pl. 3, figs. 7–10) lacks the rugosity. The nucleus and early whorls are fairly well preserved in this specimen; they are depressed and flat topped. This shell comes from a limestone bed in the Conger Range containing the ammonoid *Richardsonites merriami* (Youngquist) and is therefore in a higher ammonoid zone than that of the Foote Range lot. In this and other specimens from higher beds, the shape of the conch is similar to that seen in the type lot, but serrations are very poorly developed and appear only as slight irregularities along the carina between the upper and outer whorl faces. The smoother surface of these specimens probably is not due to preservation in limestone, because rugose specimens occur in limestone in the *Cravenoceras hesperium* Zone. Whether or not partial weathering is responsible for these differences is not clear. We currently are including the smoother specimens in the same species as the more rugose ones, though eventually another name might be justified.

Among described species, *S. (E.) intermedius* is most similar to *S. (E.) subsulcatus* Knight from the Middle Pennsylvanian; the primary difference is in the greater arching of the umbilical walls of the Chainman form. Another species comparably depressed is *S. (E) xylacus* Gordon and Yochelson, from the Amsden Formation of Wyoming. That species differs in having a flatter, less saucer-shaped upper surface, an obtuse upper angulation that lacks imbrications, and a relatively deep umbilicus that is infundibuliform in general aspect.

S. (E.) illinoisensis Thein and Nitecki from the Menard Limestone of Illinois has a shell of similar shape in that its spire is depressed. However, it differs from *S. (E.) intermedius* by its larger overall size, its slightly lower conch, and the lack of serrations along the upper carina; in addition, it has an impressed suture and a flat sloping base, rather than the somewhat convex base of *S. (E.) intermedius*.

S. (E.) n. sp. B. of Easton (1962, p. 99) from the Cameron Creek Member of the Tyler Formation of Montana, is superficially similar to *S. (E.) intermedius* but differs in being relatively higher, in having the outer whorl face inclined toward the base, and in having a sharp carina. Better material is needed to determine whether this species should be referred to *S. (Amphiscapha)*.

Figured specimens.— USNM 210954–210957.

Occurrence and number of specimens.— USGS collections 17088–PC (2), 17099–PC (1), 25252–PC (1), Juab County; ?15355–PC (2), 15365–PC (1), 17003–PC (2), 17021–PC (2), 17023–PC (6), 17029–PC (5), 22880–PC (1), 25547–PC (3), 25551–PC (1), 25566–PC (6), Millard County.

Straparollus (Euomphalus) sp.

Plate 8, figures 21–24

Description.— Conch depressed turbinate; spire broadly subconic, of moderate height; pleural angle about 100°. Only last two whorls fairly well preserved. Whorl attaching a little above periphery of preceding one; suture rather deeply impressed; upper whorl face sloping gently upward for a short distance from suture, forming a narrow tilted ramp bounded by a narrow rounded ridge; beyond this ridge, whorl slopes downward at approximately 45° to periphery, forming a faint sigmoidal curve, convex part near ramp and concave part near periphery. Fairly sharp angulation, almost a keel at periphery; whorl rounded below, a little less convex in middle, but not flattened. Base broadly phaneromphalous, umbilicus occupying nearly one-third of width; aperture vaulted above, rounded below. Growth lines indistinct, nearly obliterated by partial silification of shell, but, where visible, appearing orthocline to slightly opisthocline.

Dimensions.— The specimen measures (in mm): height 14.0, width 25.5; height of aperture 10.0; width of aperture 9.5.

Discussion.— A third species assignable to *S. (Euomphalus)* is represented by a unique specimen from a bed in the northern part of the Needle Range. This bed also contains the ammonoid *Richardsonites merriami* (Youngquist).

This species is clearly distinct from the two previously described forms, differing from *S. (E.) intermedius* Gordon and Yochelson in having a raised spire and from *S. (E.) nodibasis* n. sp. in the absence of nodes on the base. Otherwise, it is similar to these forms in shape. It differs from *S. (E.) pancakensis* Mount in that the upper ridge on the whorl is near the suture, rather than midway along the slope of the upper whorl surface, as in that species. More specimens are needed to determine the range of variation in this species before it can be formally named.

Figured specimen.—USNM 348023.

Occurrence.—USGS collection 15161–PC (1), Millard County.

Suborder TROCHINA
Superfamily PLATYCERATACEA
Family PLATYCERATIDAE
Genus PLATYCERAS Conrad, 1840

Subgenus P. (PLATYCERAS) Conrad, 1840

Discussion.—Coiling of the early whorl or whorls distinguishes the typical subgenus from *P. (Orthonychia)*. The genus *Platyceras* is rare in the Chainman Shale. A single specimen of *P. (Orthonychia)* has been described from the *Cravenoceras hesperium* zone in east-central Nevada (Gordon and Yochelson, 1983). Other Chesterian species have been noted by Thein and Nitecki (1974).

American Mississippian species of Platyceras (Platyceras).—

circulare Rowley, 1901
haliotoides Meek and Worthen, 1866
latum Keyes, 1889
nasutum Miller, 1891
oxynotum Girty, 1929
reversum Hall, 1860
subelegans Girty, 1910
subrotundum Snider, 1915

Platyceras encloides S. Weller, *P. evolutus* S. Weller, and *P. glenparkensis* S. Weller from the Glen Park Limestone Member of the Sulphur Springs Formation at Glen Park, Mo., and *Platyceras pulcherrimum* Rowley from the Saverton Shale and Louisiana Limestone near Louisiana, Mo., were listed in *P. (Platyceras)* by Yochelson and Saunders (1967); all are from rocks now considered Upper Devonian. The species listed above need review because some of them were founded on a single specimen and because the shape and growth lines in *Platyceras* are commonly influenced by the echinoderm to which this gastropod attached itself.

Platyceras (Platyceras) cf. P. (P.) subrotundum Snider

Plate 8, figures 1–4

Platyceras subrotundum Snider, 1915, p. 118, pl. 7, figs. 10, 11.

Platyceras (Platyceras) subrotundum. Thein and Nitecki, 1974, p. 122–123, fig. 50.

Discussion.—Two specimens of *Platyceras* occur in the Chainman Shale and a third is questionably identified. The first two are moderately well preserved but not complete; the greatest dimension of the figured specimens measures 18 mm. The early whorls are in contact; they are coiled in a plane nearly parallel to that of the upper whorl surface, which is so very gently convex as to be nearly flat. At maturity, the early whorls seem to be depressed with respect to the upper whorl surface, but the specimen is not complete enough for us to be certain. The whorls expand rapidly in width, and the mature whorls seem somewhat geniculate; this feature could be caused, however, by slight postburial compaction of the shell. The outer whorl face, including the periphery, is well rounded; the whorl cross section is suboval. The columellar lip is thickened and the outer lip crushed in this specimen. The shell surface is smooth; growth lines form a prominent sinus at the periphery and a second shallower sinus on the upper whorl face at maturity.

Despite the relatively good preservation of two of the three specimens, the rarity of this species precludes any estimate of the amount of individual variation. The shells seem very similar to those of *Platyceras (Platyceras) subrotundum* Snider, particularly as interpreted by Thein and Nitecki (1974, p. 122, fig. 50 a–e) and on the basis of specimens from the Glen Dean Limestone of Illinois. This species is the only *Platyceras (Platyceras)* formally named from Chesterian rocks in the United States. Snider's specimens are from the Mayes Formation, Fayetteville Shale, and Pitkin Limestone in eastern Oklahoma. Only the lack of sufficient well-preserved specimens from the Chainman Shale precludes a more positive determination of this species.

The figured specimen was found weathered out approximately 50 feet (15.2 m) below the top of the Chainman Shale, associated with the brachiopod *Carlinia phillipsi* (Norwood and Pratten) in the Jensen Wash measured section in the Burbank Hills. The second specimen is from approximately the same stratigraphic position in the measured section at Granite Mountain. A similar specimen, lacking most of the shell, has been identified from the lower part of the Ely Limestone at Granite Mountain.

The platyceratids were a group of gastropods that lived commensally on crinoids (Keyes, 1888; Bowsher, 1955, p. 1–9); they are exceptionally rare on other pelmatozoans. Their extreme rarity in the Chainman Shale corresponds to the scarcity of crinoid remains in most of this formation. These gastropods, however, were not found with the one crinoid genus, *Agassizocrinus*, that is in great abundance locally. This crinoid genus unlike other crinoid genera may not have provided a desirable site for *Platyceras*.

Figured specimen.—USNM 211029.

Occurrence and number of specimens.—USGS collections 17059–PC (1), 25548–PC (1), Millard County; 17101–PC (1), Juab County.

Genus STROPHOSTYLUS Hall, 1859

Discussion.—This genus includes platyceratacean that resemble in outline the neritacean genus *Naticopsis* but that differ in having fewer whorls, a more irregular flaring shape, a twisted columella, and in lacking a thick inductura.

North American Mississippian species of Strophostylus.—

chesterensis Thein and Nitecki, 1974
nevadensis Gordon and Yochelson, 1983
?tantillus Gordon and Yochelson, 1983
wortheni (S. Weller), 1916 (*Naticopsis*)

Thein and Nitecki (1974, p. 139) included *S. splendens* Girty, 1915, in this genus, but in this paper we transfer that species to *Naticopsis* (*Naticopsis*).

Strophostylus cf. S. nevadensis Gordon and Yochelson

Plate 8, figures 6–8

Strophostylus nevadensis Gordon and Yochelson, 1983, p. 988, figs. 3T, U.

Discussion.—Specimens of *Strophostylus* were collected at three localities in Utah, all of them from beds in the upper part of the *Cravenoceras hesperium* Ammonoid Zone. The shells are naticiform, rapidly flaring, and anomphalous, having two to three postnuclear whorls, the nucleus consisting of 1 1/4 smooth whorls, as closely as can be determined. The early whorls are somewhat raised and tilted. The largest specimen, slightly distorted, is about 14.5 mm high and 14.5 mm wide. Most shells are much smaller; the one figured is 4.9 mm high and 4.8 mm wide. The final volution is well rounded, gently convex above, moderately convex at the periphery, and more strongly convex at the base. In the early part of the shell, the whorl joins the preceding one almost at the top of the upper whorl surface; however, as the shell grows, the line of juncture moves gradually downward to the periphery of the whorl, giving the short spire a tilted appearance. The columella is slightly twisted and reflexed toward the outer lip.

The shell surface is smooth and polished. Growth lines are very fine, strongest near the suture, where they emerge at an angle of about 45°, are curved and prosocline, becoming straighter across the periphery and base. These lines are crossed by very faint spiral lirae. No inductura is present.

In shape, this species is similar to *Strophostylus wortheni* (S. Weller) from the Ste. Genevieve Limestone of Illinois; it differs mainly in that the western shells are subequal in height to width, whereas *S. wortheni* is wider than high and has a lower spire. Our shells are most like *S. nevadensis* Gordon and Yochelson from the *Cravenoceras hesperium* Zone in the Diamond Peak Formation in the White Pine Range, Nev. They are particularly like the paratype of that species, which has a slightly elevated spire. In this regard, however, they differ slightly from the holotype of *S. nevadensis* (USNM 307498), in which the spire is almost flush with the upper surface of the final whorl. More material is needed both from the Nevada and Utah localities to determine whether this difference is intraspecific or whether two species are actually involved. For this reason, we only compare the Utah shells with those of the Nevada species, rather than making a positive identification.

Figured specimen.—USNM 211079.

Measured specimen.—USNM 341966.

Occurrence and number of specimens.—USGS collections 25252–PC (2), Juab County; 25269–PC (1), 25271–PC (3), 25563–PC (4), Millard County.

Family HOLOPEIDAE
Subfamily GYRONEMATINAE

Genus CINCLIDONEMA Knight, 1945

Discussion.—To the best of our knowledge, the only species of this genus thus far described is the type species, *Cinclidonema texanum* Knight, from the Middle Pennsylvanian of Texas. The taxon we describe below constitutes the first report of *Cinclidonema* from the Mississippian. However, another Mississippian species, from the "so-called Boone Chert" (Moorefield Formation) near Batesville, Ark., also belongs in this genus. Girty (1915b, p. 37) described five specimens from one locality as *Pleurotomaria* aff. *carbonaria* Norwood and Pratten but did not illustrate any of them. Apparently, the numerous spiral lirae led him to believe that a selenizone was present. Reexamination of this material shows no indication of a selenizone, and we regard this lot as typical *Cinclidonema.*

Apart from the shape, the spiral lirae, which are closely spaced from the suture to the innermost part of the base, constitute the most characteristic feature of the genus. These prominent lirae are papillose or pustulose where crossed by the growth lines.

Cinclidonema sp.

Plate 7, figures 18–20

Discussion.—This identification is based on a single crushed shell from the Granite Mountain section. During life, the specimen was turbiform, having an elongated subglobose body whorl. The periphery is high on the whorl, and the body whorl embraces the penultimate whorl at or just below the periphery. The outer lip is prosocline, inclined about 30° from vertical; the inner lip does not appear to be thickened. A small umbilical chink is present. Numerous closely spaced spiral lirae are present, having interspaces about the same width

as the raised ornament. Growth lines are equally prominent and closely spaced so that the surface is covered with a network. At the intersection of the spiral and inclined elements, the surface is roughened. In *C. texanum*, the surface is distinctly papillose, whereas in this species, the network intersections are more pustulose, being lower and broader; in the type species, the growth lines are finer.

Figured specimen.—USNM 211026.

Occurrence.—USGS collection 28628–PC (1), Juab County.

Superfamily MICRODOMATACEA
Family ELASMONEMATIDAE

Genus ANEMATINA Knight, 1933

Discussion.—This genus contains small gastropods having a spire of moderate height, a fairly smooth surface ornamented only by fine collabral threads, and a minute umbilicus.

American Mississippian species of Anematina.—
micula (Girty), 1909 (*Macrocheilus*?)
proutana (Hall), 1856 (*Holopea*)
rockymontana (Shimer), 1926 (*Loxonema*)

Anematina sp.

Plate 8, figure 5

Discussion.—This record is based upon four tiny gastropods, the best preserved of which is figured. It is a shell of approximately four whorls, from the lower part of the *Cravenoceras hesperium* Ammonoid Zone, in the Foote Range, where it occurs with *Loxonema lautum* n. sp. The shell is 1.8 mm high and 1.15 mm wide, the spire accounting for 27 percent of the height. The whorls are gently convex, the suture not impressed. The surface is smooth, and the shell is so minute that growth lines have not been observed. This species is known only from one locality.

Figured specimen.—USNM 348024.

Occurrence and number of specimens.—USGS collection 25260–PC (4), Millard County.

Suborder NERITOPSINA
Superfamily NERITACEA
Family NERITOPSIDAE
Subfamily NATICOPSINAE
Genus NATICOPSIS M'Coy, 1846

Subgenus N. (NATICOPSIS) M'Coy, 1846

Discussion.—This subgenus includes moderately low-spired *Naticopsis* in which the smoothly curved whorl profile is not excessively elongated either laterally or vertically.

North American Mississippian species of Naticopsis (Naticopsis).—
buttsi Gordon and Yochelson, 1982
carleyana (Hall), 1857 (*Natica*)
clinovata n. sp.
confusionensis n. sp.
dubia Rowley, 1901
genevievensis Meek and Worthen, 1867
glomerosa Gordon and Yochelson, 1983
hartti Bell, 1929
howi Dawson, 1868
inornata (Walcott), 1894 (*Platystoma*)
madisonensis Worthen, 1884
mariona Thein and Nitecki, 1974
picta Girty, 1912
splendens (Girty), 1915 (*Strophostylus*)
suturicompta Yochelson and Dutro, 1960
variata (Phillips), 1836 (*Natica*) of Rollins, 1975
waterlooensis S. Weller, 1916
ziczac Whitfield, 1882

Naticopsis depressus Winchell, 1863, from the "Chonopectus sandstone" (English River Formation) of Iowa, and *N. paucivolutus* S. Weller, 1906, from the Glen Park Limestone Member of the Sulphur Springs Formation of Missouri, were listed by Yochelson and Saunders (1967, p. 140, 142) as Mississippian species of *Naticopsis* (*Naticopsis*) but are from beds now considered to be very Late Devonian in age.

We hereby transfer *Platyostoma inornatum* Walcott, from the Diamond Peak Formation of Nevada, to *N.* (*Naticopsis*). The holotype (USNM 14407) is mainly a steinkern, but a few fragments of thick smooth shell adhere on the basal part. The upper surface of the whorl is rather flat, and the spire is higher than that of *N.* (*N.*) *madisonensis*. The base of the steinkern has a depression similar to that in *N.* (*N.*) *madisonensis* because the shell and inductura are missing. The height of the specimen is 43 mm and the width 41 mm. The associated fauna is late Meramecian in age.

During this study, a few observations were made on some of the other species of *N.* (*Naticopsis*) listed above, and these observations may be of some use to future workers. *N.* (*N.*) *madisonensis* Worthen, from the St. Louis Limestone in Illinois, is a large oblongly ovate species. A cast of the holotype in the USNM collection (69172) has a greatest dimension of 56 mm, measured along the final whorl but diagonal to the shell axis; measurements of height and width are 53 and 54 mm, respectively. What Worthen interpreted as a deep umbilicus seems to be a depression due to partial collapse of the middle of the base of the shell; it may also be due in part to loss of the inductura and perhaps the underlying shell.

N. (*N.*) *picta* Girty, from Chesterian rocks in Indiana, has a very low spire, as the final whorl joins the penultimate whorl well above the periphery; the spe-

cies seems to have a fairly wide inductura. It also has raised growth lirae that ramify toward the base, particularly in the subsutural region. The holotype (USNM 144816) is ornamented by color markings having a zigzag pattern. (*N.*) *ziczac* Whitfield, from the Maxville Limestone of Ohio, has a shell with ornamentation similar to that of *N.* (*N.*) *picta*, but the zigzag pattern is incised on the shell surface rather than being expressed as color markings. We do not agree with the interpretation of Girty (1912, p. 339) that these are growth striae.

Easton (1962, p. 100, pl. 13, fig. 13a, b) described and figured as *Naticopsis* cf. *N. remex* (White) a specimen from the Heath Formation of south-central Montana. White's Upper Carboniferous species came from the lower part of the Aubrey Group of Arizona. All but one of White's eight syntypes (USNM 8063) are steinkerns, some retaining patches of shell. The one fairly complete specimen has a low broad spire, the sutures not impressed, the upper whorl face broad, and the aperture flaring. We refer this entire lot to *Planospirina remex* (White). The Montana specimen (USNM 118874) differs in having a higher spire of well-rounded whorls, an impressed suture, subsutural riblets on the early whorls, and a prominent subsutural ramp. We transfer Easton's shell to the synonymy of *N. suturicompta*, with which it agrees in all salient characters.

Finally, judging from the illustrations of Bell (1929, pl. 31, figs. 12–15), more than one species may have been included in *N. howi* Dawson from the lower part of the Windsor Series of Nova Scotia. Part of this material may belong in *Naticopsis*, but in the subgenus *N.* (*Marmolatella*); other specimens may be *Strophostylus*. However, until authentic material is restudied, the species should be retained in the typical subgenus.

Naticopsis (Naticopsis) confusionensis n. sp.

Plate 8, figures 13–18, 26

Diagnosis.—Subglobose *Naticopsis* having an extremely well-rounded whorl profile; spire of moderate height; surface polished; inductura absent.

Description.—Earliest growth stage not known; juvenile and more mature whorls exceptionally well rounded, their profile essentially following arc of circle throughout its length; spire of moderate height, occupying nearly one-quarter of height of shell. Sutures not impressed, smooth, but nevertheless apparent. Final whorl embracing penultimate whorl at periphery. Mature lip having only slight basal thickening; inductura seemingly absent. Shell without ornamentation, surface polished; growth lines closely spaced, very fine, simple, steeply prosocline from suture to base of columella. Shell structure of at least two layers; outer layer quite thin and possibly darker colored near suture than on principal part of whorl.

Dimensions.—The holotype and figured paratype are, respectively 12 and 8.2 mm in length and 11.3 and 8.0 mm in width.

Discussion.—The three primary types are single specimens from three localities in the upper part of the Chainman Shale. The holotype is from the *Caninia*-bearing limestone unit in the Granite Mountain measured section. Also included in this species but with some question are four specimens from a bed in the Willow Gap Member of Sadlick (1966) in the Skunk Spring measured section. These differ from the typical form in having somewhat lower spires.

Within the Chainman fauna, the smaller naticopsids can be confused easily with specimens of *Ianthinopsis*. This similarity is superficial, because well-preserved specimens of *Ianthinopsis* have a parietal fold on the columella; moreover, the whorls increase in size more slowly in that genus. For many species of *Naticopsis*, virtually the only distinguishing feature is the shape of the whorl. We lack any precise practical method, other than pure description, for expressing subtle changes in shape.

N. (*N.*) *carleyana* (Hall), from the Salem Limestone of Indiana, is similar in shape to *N.* (*N.*) *confusionensis* but differs from it in having a somewhat lower spire, the final whorl attaching to the penultimate whorl a little above the periphery, in having tiny riblets adjacent to the suture, and in having over the columella a thick inductura that becomes concave toward the basal lip.

Other Late Mississippian species that differ from *N.* (*N.*) *confusionensis* in having subsutural riblets are *N.* (*N.*) *suturicompta* Yochelson and Dutro, from the Alapah Limestone of northern Alaska, *N.* (*N.*) *genevievensis* Meek and Worthen, from Chesterian rocks in Missouri and Illinois, *N.* (*N.*) *buttsi* Gordon and Yochelson (1982b) from beds of St. Louis age in the Greenbrier Limestone of southwestern Virginia, and *N.* (*N.*) *glomerosa* Gordon and Yochelson (1983) from the Diamond Peak Formation in east-central Nevada.

Most of the North American Late Mississippian species now included in *Naticopsis* (*Naticopsis*) have smooth shells without subsutural ornamentation, each succeeding whorl smoothly appressed at the suture. Several species among these differ from *N.* (*N.*) *confusionensis* in having a decidedly elongated oval shape. These include *N.* (*N.*) *hartti* Bell, from the lower part of the Windsor Series of Nova Scotia, *N.* (*N.*) *splendens* (Girty), from the Batesville Sandstone of Arkansas, and *N.* (*N.*) *waterlooensis* Worthen, from the Ste. Genevieve Limestone of Illinois. *N.* (*N.*) *splendens* closely resembles *N.* (*N.*) *confusionensis* in general shape of the whorl, in having a polished finely striate surface, and in the apparent lack of an inductura. It

differs in having a shell about half the size of that of *N.* (*N.*) *confusionensis*, a lower spire, and recurved and shallowly sigmoidal growth lines on the base.

Types.—Holotype USNM 211030; paratypes USNM 211031, 211032.

Occurrence and number of specimens.—USGS collections 25257–PC (1), 20547–PC (1), Juab County; 14559–PC (1), 15159–PC (1), 15359–PC (1), 15362–PC (1), ?15363–PC (4), 17003–PC (1), 17021–PC (1), 22876–PC (4), Millard County.

Naticopsis (Naticopsis) cf. N. (N.) genevievensis Meek and Worthen

Plate 8, figures 19, 20, 25

Naticopsis littonana var. *genevievensis* Meek and Worthen, 1867, p. 268.

Naticopsis (*Naticopsis*) *genevievensis* Gordon and Yochelson, 1982a, p. 217, 218, text-fig. 1A–M.

Discussion.—A second species of *Naticopsis* in the Chainman differs in shape from *N.* (*Naticopsis*) *confusionensis* in being slightly less well rounded and in having the final whorl attach to the penultimate whorl a short distance above the periphery; specimens also reach twice the size of *N.* (*N.*) *confusionensis*. These differences are relatively minor and might be attributed to individual variation or preservation, except for one additional feature. Growth lines are somewhat more prominent in this species than on the polished shell of *N.* (*N.*) *confusionensis*. Near the suture, these growth lines are strengthened into subsutural riblets, separated by incised interspaces. So far as can be determined, subsutural ornamentation occurs at all growth stages. The shell is moderately thick, being about 0.8 mm on the upper part of the whorl and twice that thickness on the base. The height of an average specimen is about 25 mm.

The ornamentation is similar to that found in *N.* (*N.*) *suturicompta* Yochelson and Dutro, from the Alapah Limestone of northern Alaska. In that species, a narrow but distinct flattening of the whorl is present in the subsutural region. This nearly flat ramp is absent in the Utah specimens. Gordon and Yochelson (1982a) showed that American Midcontinent shells of this type, which occur in the *Goniatites granosus* Zone and its equivalents, can be referred to *N.* (*Naticopsis*) *genevievensis* Meek and Worthen, a previously unillustrated species. The Utah shells in this category are similar to *N.* (*N.*) *genevievensis*. However, because our specimens come from somewhat younger beds and because none is complete or undistorted, we merely suggest a comparison with Meek and Worthen's species.

The Utah specimens are not well preserved; only three show the surface sculpture well. Of these, one is partly crushed; the other two figured specimens are an immature one and a fragment of a mature shell. All were collected from the Willow Gap Member of Sadlick (1966) near Skunk Spring, Confusion Range.

Figured specimens.—USNM 211033, 211034.

Occurrence and number of specimens.—USGS collections 15355–PC (1), 15362–PC (1), 15363–PC (1), ?25271–PC (1), 25272 (4), Millard County.

Naticopsis (Naticopsis?) clinovata n. sp.

Plate 8, figures 34–38

Naticopsis (*Naticopsis*?) n. sp. Gordon and Yochelson, 1983, p. 989, fig. 2G, H.

Diagnosis.—*Naticopsis* having the aperture slightly extended in an obliquely outward direction; surface with subsutural riblets on early whorls, slightly irregular in the subsutural area and near the aperture of larger whorls.

Description.—Nucleus and early growth stages not known; spire low; more mature whorls moderately well rounded, extended downward so that whorl profile approximates a shortened teardrop shape. Sutures not impressed; body whorl embracing penultimate whorl above periphery. Outer lip strongly inclined about 25° from vertical. Inductura thick near central area of inner lip, extending only short distance outside aperture. Shell surface relatively smooth, but developing short curved subsutural riblets on early whorls and irregular roughening of growth lines in more mature stage; irregularities most evident on thin outer shell layer; growth lines quite obscure except in mature stage.

Dimensions.—The holotype is slightly greater than 10.2 mm in height and slightly greater than 10.5 mm in width. A larger paratype is 15.2 mm in height but is partially eroded on one side and on the apex; the height/width ratio is about 0.9.

Discussion.—This species has the final whorl extended diagonally rather than well rounded as in *N.* (*N.*) *confusionensis* and is readily distinguished from that taxon. It has subsutural ornament, as in specimens tentatively attributed to *N.* (*N.*) *genevievensis,* and differs from that species in its distinctive oblongly ovate shape. The Utah paratype (USNM 211035) lacks subsutural riblets but seems to have lost the outer shell layer in the apical part of the shell.

In its configuration, *N.* (*N.*?) *clinovata* seems closest to *N.* (*N.*) *madisonensis* Worthen, but the holotype of that latter species is 3 1/2 times the size of our specimen, is poorly preserved, locally distorted by crushing, and has some of the shell missing, affording little basis for comparison. Neither species has a well-rounded whorl as in the typical subgenus, but the whorl is not extended enough to warrant assignment to *N.* (*Jedria*).

Almost all the specimens are from the Willow Gap Member of Sadlick (1966) near Skunk Spring, Confu-

sion Range; one, described and figured in Gordon and Yochelson (1983, p. 989, fig. 2G, H) is from USGS collection 23837–PC in the Diamond Peak Formation, White Pine County, Nev.

Types.—Holotype USNM 211074; paratypes USNM 211035, 307505.

Occurrence and number of specimens.—USGS collections 15355–PC (1), 25252–PC (1), 25566–PC (14), Millard County.

Subgenus N. (JEDRIA) Yochelson, 1952

Naticopsis (Jedria?) sp.

Plate 8, figures 9–12, 32, 33

Discussion.—A single *Naticopsis*, from the Skunk Spring section, Confusion Range, represents a different taxon from those previously described. The body whorl is extended downward rather than outward, and the specimen is relatively compressed for its height. The body whorl shows a suggestion of a swelling on the outer whorl face above the periphery. These features are all indicative of the subgenus *Jedria* rather than of *Naticopsis* sensu stricto. Finally, the growth lines near the suture are impressed, another character common to many species of the subgenus.

The earliest growth stages are not preserved, but at least three whorls are present. The whorl enlarges at a moderate rate for the genus. The spire is low, the suture distinct. Adjacent to the suture, the upper whorl face is inclined downward at an angle of about 15°. The juncture with the outer whorl face is rounded but relatively abrupt, and that face is straight for about half its length. Just above the periphery, it swells outward, the periphery itself being well rounded and continuous with the area below it, which approaches the arc of a circle in its curvature. The outer lip is steeply prosocline, inclined about 20° from the axis of coiling. The inductura is prominent and extends from the juncture of lip and shell along the inner surface nearly to the base of the aperture. Near the periphery, the inductura is thickened and subangular. The shell is smooth except for the prominent incised growth lines on the upper surface.

Figured specimen.—USNM 348026.

Occurrence.—USGS collection 25563–PC (1), Millard County.

Order MESOGASTROPODA

Discussion.—Cox (1960) proposed the order Caenogastropoda for all prosobranch gastropods that were not assigned to the Archaeogastropoda. This order was used by Knight, Batten, and Yochelson (1960), but it has not been accepted by most subsequent workers and has found no utility among students of modern-day gastropods. To us, it seems appropriate to drop the concept of Caenogastropoda and revert to older assignments. Considerable question exists whether the Paleozoic forms placed in the mesogastropods are really the ancestors for these predominantly late Mesozoic to Holocene gastropods. Uniting many high-spired gastropods in "*** an admittedly polyphyletic assemblage ***" (Cox, 1960, p. 259) does not resolve the issue.

Superfamily LOXONEMATACEA
Family LOXONEMATIDAE

Genus LOXONEMA Phillips, 1841

Discussion.—This genus includes high-spired gastropod shells that are commonly fairly large, reaching 6 to 8 cm in height. Ornament is predominantly collabral, forming a broad, moderately shallow median sinus, below which the growth lines generally are opisthocline. The genus ranges from the Middle Ordovician to the Late Mississippian. Two small species seem to represent this genus in the Chainman Shale.

American Mississippian species of Loxonema.—
difficile Sardeson, 1902
knighti Yochelson, 1962
pikense Hyde, 1953
tenuilineatum (Shumard), 1855 (*Chemnitzia*)
yandellanum Hall, 1857

Loxonema missouriensis Williams, listed by Yochelson and Saunders (1967, p. 121) among the late Paleozoic species, comes from the Louisiana Limestone of Missouri, now considered Late Devonian in age. *L. delphicola* Hall, a Middle Devonian species, was figured by Herrick (1893, pl. 20, fig. 15) from the Lower Mississippian of Ohio. Topotypes of Hall's species are moderately slender and have prominent strongly curved growth lines, and slight sulcation below the suture. Herrick's drawing depicts a shell having much more inflated whorls than typical *L. delphicola* and no apparent subsutural banding; the growth striae appear weaker, more closely spaced, and less curved. Herrick's specimen is not conspecific and should be removed from the synonymy of Hall's species. Lacking authentic specimens of Herrick's material, we prefer not to assign it to a species.

Loxonema yandellanum Hall from the Salem Limestone at Spergen Hill, Ind., was transferred to *Palaeozygopleura* by Thein and Nitecki (1974, p. 179). This species is characterized by numerous and faint collabral riblets or lirae. We have examined more than 50 topotypes that agree in shape with this species; in all, the collabral sculpture is obscure to absent. We were unable to determine whether this condition is due to solution or abrasion, but many other species in the fauna show a similar obscurity of sculpture. We feel

that because of the pendulent shape of the whorls—that is, the periphery low on the mature whorl and the exceedingly fine axial sculpture—this species should be left for the present in *Loxonema*.

Loxonema sp.

Plate 9, figure 37

Discussion.—Two specimens from a concretion about 15 feet (4.6 m) above the limestone marker bed of the Chainman Shale in the Granite Mountain measured section belong to the genus but are not preserved well enough to name formally. The better preserved individual, missing part of the spire, has six whorls and is 7.5 mm high and 2.4 mm wide. The whorls are well rounded, almost moniliform in appearance, with distinct sutures. The shell itself is moderately thick so that the steinkern shows a distinct gap between the whorls. The area of the periphery is slightly flattened. Whorls are ornamented by very fine rounded collabral threads, having interspaces two to three times the width of the threads. The threads are almost orthocline at a deeply impressed suture, swing backward to form a shallow, broad, bow-shaped sinus over the rounded periphery, and become opisthocline over the basal part of the whorl. The smooth columella is slightly inclined toward the aperture; the aperture is subcircular.

This shell can be distinguished from most other high-spired gastropods in the Chainman Shale by the absence of riblets of any kind, the only sculpture being that of delicate collabral lirae. It differs from *Loxonema*? sp. in having more evenly curved and coarser collabral lirae, about 15 in the space of 1 mm where the whorl is about 2 mm wide.

Figured specimen.—USNM 348027.

Occurrence and number of specimens.—USGS collection 25558–PC (2), Juab County.

Loxonema? sp.

Plate 9, figure 36

Discussion.—This record is based upon specimens from the lower part of the *Cravenoceras hesperium* Ammonoid Zone, associated with *Lunulazona utahensis* n. sp. in the Bishop Springs anticline on the eastern side of the Foote Range. Only one specimen retains the shell and shows surface sculpture. It is a small shell of six whorls, 5.0 mm high and 1.8 mm wide, the tip of the spire broken off. Whorls are well rounded and slightly inclined, the sutures deeply impressed. Sculpture consists of exceedingly fine rounded collabral lirae, spaced somewhat irregularly; interspaces of similar width to lirae; 22 of these lirae occur in the space of 1 mm on the final whorl. These growth lirae are prosocline at an angle of about 30° near the suture and form a moderately deep rounded sinus centering about one-third of the distance from suture to suture and just above the periphery of the whorl; on the lower half of the whorl, the lirae are opisthocline and relatively straight.

This species is distinguished by its asymmetrically curved opisthocyrt collabral lirae. It can be confused only with *Loxonema* sp., which occurs four ammonoid zones lower.

Figured specimen.—USNM 348025.

Occurrence and number of specimens.—USGS collection 25260–PC (4), Millard County.

Family PSEUDOZYGOPLEURIDAE

Genus PSEUDOZYGOPLEURA Knight, 1930

Discussion.—This genus includes collabrally ribbed, anomphalous, high-spired gastropods having a shallow labral sinus and pseudozygopleurid nucleus of 4 to 4 1/2 whorls, the last two bearing tiny curved to sinuous axial riblets, which are markedly more delicate than those on the postnuclear whorls that immediately follow. Because nuclear whorls of late Paleozoic gastropods are rarely preserved and, if preserved, are generally abraded, uncertainty exists about which American Mississippian species belong in this genus. Indeed, which genera should be included in the Pseudozygopleuridae is uncertain.

Horný (1954) proposed the genus *Palaeozygopleura* for similar high-spired gastropods having a nucleus of 2 to 2 1/2 smooth whorls; he proposed the family Palaeozygopleuridae to contain this and allied genera. Horný's genus was based upon Early Devonian gastropods from Czechoslovakia, but he included in it some early Carboniferous species from the British Isles. Prior to this paper, no paleontologist recognized a pseudozygopleurid nucleus in an American Mississippian species. Thein and Nitecki (1974, p. 179–184), however, placed most of the known Late Mississippian species in *Palaeozygopleura*, describing this sort of nuclear whorl in *P. venusta* Thein and Nitecki and *P. welleri* Thein and Nitecki and suggesting that the same sort of nucleus occurs also in *Loxonema wortheni* S. Weller. We examined well-preserved topotype specimens of *L. wortheni* from the Ste. Genevieve Limestone at Waterloo, Ill., in the USGS collection and agree that this species probably belongs in *Palaeozygopleura,* along with *P. venusta* and *P. welleri.*

Subgenus P. (PSEUDOZYGOPLEURA) Knight, 1930

Discussion.—So far, the only western species that certainly belongs in this subgenus by virtue of having a pseudozygopleurid nucleus is *Pseudozygopleura (Pseudozygopleura) repenningi* n. sp., described below from the Chainman Shale in the Burbank Hills, Utah.

We place two other species from the same formation in the same subgenus but with question. So far no specimens of these two have been found that have the nuclear whorls preserved.

Pseudozygopleura (Pseudozygopleura) repenningi n. sp.

Plate 9, figure 1

Diagnosis.—Small, very high spired gastropod having pseudozygopleurid nuclear whorls; postnuclear whorls ornamented by fairly straight, thick, nearly orthocline ribs.

Description.—Nucleus of slightly more than four whorls, initial part smooth, last two whorls ornamented by tiny, fairly straight to opisthocyrt axial riblets. Collabral ornamentation developing abruptly on postjuvenile whorls and remaining essentially constant at all later stages. Apical angle of mature shell approximately 15°, slightly greater in early stages. Suture distinct, not impressed. Whorl profile almost flat, slightly inflated between sutures; periphery obscure, very low on whorl; basal whorl surface flattened, though not known in detail. Umbilical condition unknown.

Shell ornamented by prominent thick ribs, nearly vertical and straight across most of whorls, but appearing faintly sigmoidal at full maturity; approximately 16 ribs per whorl, spacing and number remaining fairly constant so that individual ribs appear aligned in ridges extending along length of the shell; ribs reaching almost from suture to suture, relatively constant in height throughout length of each whorl, steeply opisthocline to almost orthocline, except in most mature stage when upper part of ribs is flatter and wider. Interspaces approximately 1 1/2 times as wide as adjacent ribs. Growth lines unknown.

Discussion.—This description is based on a unique specimen from a bed at or near the top of the *Cravenoceras hesperium* Zone in the Burbank Hills. Although this shell preserves the nuclear whorls, it lacks some of the later whorls, and the aperture is slightly distorted by compression; the number of whorls, including the nuclear ones is 11. The specimen is 7 mm long and 2.2 mm wide.

Although the tiny axial riblets on the nucleus of this species do not appear sinuous like those in *P. (P.) semicostata* (Meek), the type species of *Pseudozygopleura*, this nucleus is certainly of the pseudozygopleurid type. Several American Pennsylvanian species referred to this subgenus seem similar to our shell. The wide, relatively straight, elongate ribs distinguish this species from those referred to *Loxonema*, for in that genus the ribs are shallower, more closely spaced, and become increasingly arcuate with growth.

Type.—Holotype USNM 211044.

Occurrence.—USGS collection 17209–PC, Millard County.

Pseudozygopleura (Pseudozygopleura?) lauta n. sp.

Plate 9, figures 6, 7

Diagnosis.—Very high spired gastropods having sloping, asymmetrically convex whorls, ornamented by closely spaced, slightly arcuate costae.

Description.—Shell high spired, apical angle nearly 20°. Nucleus and early whorls unknown. Whorl profile inflated, asymmetrically convex, flat adjacent to suture and inclined strongly downward for about one-eighth of total length, then curving gradually outward, following a gentle arc, degree of curvature increasing toward periphery. Periphery low on whorl, about two-thirds of distance below suture; whorl profile more strongly curved below periphery, then curving more abruptly into flattened anomphalous base. Suture distinct; body whorl embracing penultimate whorl just above curvature into base. Upper part of columellar lip straight; other apertural details unknown.

Growth lines forming extremely shallow sinus, having its upper and lower ends parallel to shell axis and its greatest depth across periphery. Growth lines obscure, except in maturity, and generally replaced by collabral costae. Costae low, rounded, asymmetrical in cross section, being steeper adapically, and closely spaced, having intercostal spaces approximately as wide as costae. Costae weak near suture, prominent over convex part of whorl, continuing strongly almost to base. More than 35 costae occur at maturity.

Dimensions.—The holotype, an incomplete apical part of shell, is 8.5 mm high and 3.8 mm wide. Fragmental paratypes indicate that shells of this species may have exceeded 35 mm in height.

Discussion.—This species is based on one well-preserved, though incomplete, specimen from the Burbank Hills and four partly crushed paratypes from the Confusion Range. On several paratypes, the costae are less prominent than those on the holotype at comparable growth stages. This difference might suggest that the Confusion Range specimens belong to different species from that of the holotype, but close examination of details of whorl profile, apical angle, and trend of costae on the Confusion Range specimens shows these features to be identical with those on the holotype. Perhaps on the paratypes, a thin outer shell layer, on which the costae were sharper, has been removed. However, even allowing for this difference in preservation of inner and outer shell layers, the larger specimens show more obscure costae. We conclude that this is an example of obsolescence of the costae on the later

whorls, a relatively common feature on some mature pseudozygopleurids.

Although, in the absence of nuclear and other early whorls, we cannot assign this species to this genus with certainty, its occurrence in the same stratigraphic unit as *P. (Pseudozygopleura) repenningi* n. sp. indicates that an assignment to this same subgenus is reasonable.

Types.—Holotype USNM 211042; paratypes USNM 211043.

Occurrence and number of specimens.—USGS collections 15364–PC (4), 17208–PC (1), Millard County.

Pseudozygopleura (Pseudozygopleura)? sp.

Plate 9, figure 18

Discussion.—A single silicified specimen from a bed in the upper part of the Chainman Shale in the section at Granite Mountain is related to the two preceding species. Like the type of *P. (P.)? lauta* n. sp., it lacks the nucleus and at least part of the first postnuclear whorls. This incomplete shell is slender, 7.1 mm high, and 2.8 mm wide. Its sloping whorls are gently convex, the periphery two-thirds to three-fourths of the distance from the suture to the following suture. The surface of the shell is ornamented by fairly high, narrowly rounded axial ribs, of which 18 are on the last whorl. These ribs are gently opisthocyrt and slightly opisthocline. Interspaces are subequal to the ribs and seem to be V-shaped. The ribs reach the area covered by the next suture but die out rather quickly on the smooth imperforate base. The initial part of the columella is fairly straight. The anterior part of the base and outer lip is broken off.

This species differs from *P. (P.)? lauta* n. sp. in being more slender and in having fewer and coarser ribs.

Figured specimen.—USNM 348030.

Occurrence.—USGS collection 25252–PC, Juab County.

Subgenus P. (STEPHANOZYGA) Knight, 1930

Discussion.—Members of this subgenus have larger, broader shells and a wider apical angle than does *P. (pseudozygopleura)*. The collabral lirae are weak on the upper whorl surface, but rather strong nodes ornament the periphery of the slightly overhanging whorls and extend onto the lower whorl surface.

Thein and Nitecki (1974, p. 185, 186, figs. 82, 83) figured and briefly described two species from the Golconda Limestone of Kentucky as *P. (Stephanozyga)* sp. indet. 1 and 2. The first species resembles slightly the shell described below from the Chainman Shale, but the specimen is too poorly preserved to compare in detail. We follow Knight (1930, p. 62) in regarding this taxon as a subgenus of *Pseudozygopleura*.

Pseudozygopleura (Stephanozyga) claviger n. sp.

Plate 9, figures 2, 3

Diagnosis.—High-spired gastropod ornamented by unusually large riblike nodes that are slightly asymmetrical in vertical profile and occur 10 to the whorl.

Description.—Shell high-spired; protoconch and early whorls unknown; apical angle nearly 20°. Body whorl embracing below periphery and immediately below curved junction of outer and basal surfaces of penultimate whorl, so that profile of shell is sinuate rather than convex. Suture obscure, slightly wavy, located just below row of nodes on outer whorl face. Whorl profile below suture and between nodes flattened and nearly vertical for about one-third of distance down whorl side, then gradually bending outward to gently inflated periphery located about two-thirds of distance downside of whorl, and below periphery, curving gradually inward. Junction of outer and basal surfaces of whorl abruptly and strongly arched; basal surface inclined about 15° from horizontal; other details of base unknown.

Ornament of prominent axially elongate nodes on outer whorl face, commonly 10 per whorl, more or less aligned in vertical rows from whorl to whorl. Individual nodes slightly asymmetrical in outline, beginning about one-third of distance below suture, ending just above junction with basal surface, expanding uniformly so that maximum width is at or just above periphery; interspaces in this zone less than half the width of nodes; greatest height of nodes in plane of maximum whorl width; nodes symmetrically convex in horizontal section, tapering more abruptly downward than upward.

Discussion.—This species is based upon two incomplete specimens, each having about four whorls. These specimens are from the Willow Gap Member of Sadlick (1966), in the Skunk Spring measured section, Confusion Range. The holotype is 14 mm long and has a maximum diameter of 6.7 mm; in the paratype, these dimensions are 16 mm and 7.7 mm respectively. A poorly preserved specimen, overgrown by a bryozoan, collected from a different bed in the same member is referred to this species with question.

The nodose character of the ornamentation readily distinguishes *P. (S.) claviger* from all other high-spired gastropods in the fauna. Thein and Nitecki (1974, p. 184–186) described specimens of *P. (Stephanozyga)* from the Golconda Limestone of Chesterian age near Claxton, Ky. Another lot of specimens in the collections

of the USNM, from mid-Chesterian rocks near Scottsburg, Ky., resembles our western species in having 10 to 12 large nodes ornamenting each whorl. These specimens are rather crudely silicified and weathered; this difference in preservation from our material makes specific comparison uncertain. Also in the USNM collection is another specimen of this subgenus, collected by Ulrich from the Ste. Genevieve Limestone near Princeton, Ky.; this is a further downward extension of the range. In the USGS collection are specimens collected by Ulrich from the Ste. Genevieve Limestone, 2 miles (3.2 km) south of Ste. Genevieve, Mo.

This subgenus *P.* (*Stephanozyga*) is not common; species assigned to it constitute a highly specialized group perhaps derived from *P.* (*Pseudozygopleura*) or a common ancestor. In particular, it is easy to envision an ancestor similar to the thick-ribbed *P.* (*P.*) *repenningi* that could have given rise to both that species and the nodose *P.* (*S.*) *claviger* by only a minor modification of the ornamentation.

Types.—Holotype USNM 211045; paratype USNM 211046.

Occurrence and number of specimens.—USGS collections 15355–PC (2), ?15375–PC (1), Millard County.

Superfamily SUBULITACEA
Family SUBULITIDAE
Subfamily SUBULITINAE

Genus BULIMORPHA Whitfield, 1882

Discussion.—This genus includes fusiform subulitids having slender shells with gently convex smooth whorls, the last whorl accounting for more than half the shell height; broken shells show a siphonal fold.

American Mississippian species of Bulimorpha.—
bulimiformis (Hall), 1857 (*Bulimella*)
elegans Girty, 1927
elongata (Hall), 1857 (*Bulimella*)
minor Thein and Nitecki, 1974
whitfieldi S. Weller, 1916

This genus is poorly understood, and limitations of individual variation have not been carefully studied. Most species are inadequately known, and no comparison among them seems appropriate.

Bulimorpha sp.

Plate 9, figures 4, 5

Discussion.—This species occurs in the basal bed of the Willow Gap Limestone Member of Sadlick (1966) in the Wallet Gulch measured section, Confusion Range. Specimens are coarsely silicified and only fairly well preserved. The shell is slender, fusiform, consisting of at least five whorls; pleural angle 32°. Measurements (in mm) of two specimens are, respectively: length 6.5 (anterior edge of aperture missing) and 6.8 (tip of spire missing); length of final whorl 4.1 and 4.6; length of spire 2.4 and 2.2 (tip of spire missing); and width 2.7 and 2.7. The whorls are gently convex, the suture well marked but not deeply impressed. The final whorl is long, accounting for nearly two-thirds of the length of the shell. The aperture is narrowly suboval, pointed posteriorly and rounded anteriorly, extending slightly more than one-third the length of the shell. Whether a siphonal notch is present cannot be determined.

The only previously described western Mississippian species of *Bulimorpha* is *B. elegans* Girty from beds of Meramecian age in Idaho. Girty's species is more than twice the size of this one and has a proportionally higher spire and shorter aperture. The Utah species is more like *B. minor* Thein and Nitecki from the lower part of the Okaw Limestone ("Marigold Oolite") of Illinois, but it is slightly larger and less slender than the holotype of *B. minor*.

Figured specimen.—USNM 211072.

Measured specimen.—USNM 211073.

Occurrence and number of specimens.—USGS collection 25566–PC (2), Millard County.

Subfamily SOLENISCINAE

Genus IANTHINOPSIS Meek and Worthen, 1866

Discussion.—This genus includes species having shells of various shapes, from globular to fusiform and high spired. The surface is normally smooth but exceptionally bears faint spiral ridges. A siphonal fold commonly is present on the last two whorls but is barely, if at all, visible within the aperture and is resorbed in the early whorls. The Chainman specimens described below do not show the siphonal fold clearly within the aperture.

North American Mississippian species of Ianthinopsis.—
gandyensis n. sp.
keyesi (Rowley), 1900 (*Macrochilina*)
littonanus (Hall), 1857 (*Natica*)
melanoides (Whitfield), 1882 (*Polyphemopsis*)
pinguis (Winchell), 1863 (*Macrocheilus*)
reticulatus (Hyde), 1953 (*Strobeus*)
stinesvillensis (Cumings), 1906 (*Macrocheilus*)
subcorpulentus (Whitfield), 1882 (*Macrocheilus*)
tantillus (Rowley), 1900 (*Macrochilina*)

Like *Bulimorpha,* this genus and its various species are inadequately studied. Additional data on some of

the species listed may be obtained from Thein and Nitecki (1974, p. 192–196).

Ianthinopsis gandyensis n. sp.

Plate 9, figures 30–33

Diagnosis.—Broad subglobose smooth shells having small sharp spire rising above slightly flattened upper whorl surface.

Description.—Nucleus and early whorls smooth, well-rounded; periphery at or below midwhorl in early stages but gradually rising with growth; pleural angle about 105°. Suture distinct, though not impressed. Mature whorl profile nearly horizontal adjacent to suture, gently convex; spire prominent above upper whorl surface; upper surface at its outer edge curving abruptly but smoothly into outer whorl face, periphery high on mature whorl, below which whorl curves gradually inward, curvature increasing toward base. Columella without plications, covered with thin inductura extending short distance outside aperture, lower part of aperture unknown, possibly protruding in short siphon. Surface smooth; growth lines extremely fine, closely spaced, essentially orthocline from suture to below periphery, gradually curving to strongly prosocline.

Dimensions.—Holotype and figured paratype have heights (incomplete) of 9.5 and 12 mm and widths of 9 and 10 mm, respectively.

Discussion.—The three primary types were collected in shale a few feet above the *Richardsonites merriami* bed in the Foote Range. Other specimens are mainly steinkerns, and one squashed example is doubtfully referred. The lowest occurrence noted is in the upper part of the *Cravenoceras hesperium* Zone.

This extremely low-spired and broad-whorled form resembles several common Middle to Late Pennsylvanian species assigned to the genus more than it does American Mississippian species. The whorl shape also is similar superficially to that of *Naticopsis*, but the rate of whorl expansion is more gradual in *Ianthinopsis*.

Many of the Mississippian species currently assigned to *Ianthinopsis* may be incorrectly placed. Among those that probably belong in this genus, both *I. littonanus* (Hall), from the St. Louis Limestone of Indiana, and *I. reticulatus* (Hyde), from the Logan Formation at Sciotoville, Ohio, are more slender than the Chainman form.

Types.—Holotype USNM 211047; paratypes USNM 211048, 211049.

Occurrence and number of specimens.—USGS collections ?17209–PC (1), 17219–PC (1), 17310–PC (1), 22883–PC (3), Millard County.

Ianthinopsis sp. A

Plate 9, figures 26, 27

Discussion.—Another species of *Ianthinopsis* occurs at a locality in the Foote Range associated with *Richardsonites merriami*. It is readily distinguished from *I. gandyensis* by its narrowly bulliform shape. The specimens are mainly steinkerns with small fragments of thin shell adhering to them and are thus inadequate for assigning a formal name. The largest specimen, is figured and measures 6.6 mm in height and 4.5 mm in width and probably has about five postnuclear whorls, the spire occupying a little less than half the height; the pleural angle is approximately 55°. A simple orthostrophic nucleus is present but not clearly delimited from the more mature whorls.

The whorl profile is smoothly curved and slightly asymmetrical so that the upper part is shorter and more strongly arched than the lower part; the periphery is slightly above midwhorl. The whorls embrace below the periphery so that the sutural area is slightly sunken. A small inductura seems to be present near the upper part of the aperture. The columella appears straight; a short siphon is present at the base of the aperture. Growth lines are not visible, and no further apertural details are available.

The absence of an obvious columellar plication differentiates this species from specimens in the fauna assigned to *Soleniscus*.

Figured specimen.—USNM 211050.

Occurrence and number of specimens.—USGS collection 15370–PC (5), Millard County.

Ianthinopsis sp. B

Plate 8, figures 30, 31

Discussion.—An incomplete specimen of *Ianthinopsis* was collected in the Foote Range, weathering out just above a bed of narrow anthracospirifers that is some distance above the *Richardsonites merriami* bed, in what B. L. Mamet (written commun., 1975) regards as the lower part of Foraminifer Zone 19. The shell is broadly bulliform, the nucleus and part of the first postnuclear whorl missing, 4-1/3 whorls remaining, the final half whorl and lower part of outer lip broken off. It is 13.1 mm long and 11.5 mm in diameter, probably lacking a little more than a millimeter of its original length at this diameter. The periphery remains at or below midwhorl during growth, and the pleural angle is 77°. The mature whorl meets the preceding whorl at an angle of about 65° to the shell axis, forming a faint narrow sloping flat zone bordered by a similarly narrow zone of greatest curvature, below which the whorl

is gently convex in profile; the periphery is a little below midwhorl. The columella shows no plications and is covered by a thin inductura, which probably did not extend much beyond the aperture; the lower part of the columella is missing. The early whorls (2 1/3) are ornamented by closely spaced collabral lirae, nearly orthocline at the suture and curving to fairly strongly prosocline as they cross the whorl; the more mature two whorls are smooth.

Another specimen, slightly less well preserved, was collected in the Burbank Hills. It is referred questionably to this taxon and is illustrated on plate 8, figures 27 and 28.

This species is distinguished easily from *Ianthinopsis gandyensis* n. sp. by its more regular growth pattern, narrower pleural angle, lower position of the periphery on the later whorls, and the presence of collabral lirae on the early whorls. It has a broader shell than *Ianthinopsis* sp. A.

Figured specimens.—USNM 211053, 211057.

Occurrence.—USGS collection ?17208–PC (1), 25551–PC (1), Millard County.

Ianthinopsis? sp.

Plate 9, figures 20, 21

Discussion.—A single specimen of subulitacean was found in the *Lunulazona nodomarginata* assemblage in the upper part of the *Goniatites americanus* Zone of late Meramecian age in the Granite Mountain measured section. It is a small subglobose species having about four whorls, the spire occupying three-tenths the height of the shell; the pleural angle is about 80°. The nucleus is not preserved; the early whorls are well rounded, the suture a little above the periphery; the final whorl meets the penultimate whorl at the periphery, the suture lying in the obtusely angular depression where the adjacent whorls meet. Below the suture, where the slope of the upper whorl surface is approximately 40° to the axis of coiling, the mature whorl profile is rather evenly convex, the periphery being near midwhorl; this curvature continues on to the lower part of the whorl but is slightly less pronounced, then increases to round into the base. The columella has no visible plications or inductura, and no siphon seems to be present. The shell surface is smooth; growth lines are exceedingly fine, aligned orthocline to a little below the periphery, where they die out; they are slightly more pronounced subadjacent to the suture. The specimen is 5.0 mm in height and 4.3 mm in maximum width.

This species has a much smaller and more delicate shell than *Ianthinopsis gandyensis* n. sp. and differs also in being higher than wide and in having a proportionately longer spire and smaller pleural angle. The species that occurs higher in the section, which we have identified as *Ianthinopsis* sp., differs from this shell in its more slender bulliform shape, longer spire, and smaller pleural angle.

Figured specimen.—USNM 211051.

Occurrence.—USGS collection 17018–PC, Juab County.

Genus SOLENISCUS Meek and Worthen, 1861

Discussion.—This genus is distinguished from *Ianthinopsis* by its generally more slender fusiform shell and the presence of a small siphonal notch visible within the aperture. A siphonal canal occurs on the columella within the shell and a siphonal fold above it. The shell surface is smooth.

North American Mississippian species of Soleniscus.—

glaber Cumings, 1906

Elias (1958, p. 21, pl. 2, figs. 8–10) described and figured as a variety of *Soleniscus* (*Macrocheilus*) *regularis* (Cox) specimens from the Redoak Hollow Formation of southern Oklahoma. Cox's species, described as *Loxonema regularis* Cox from the "Coal Measures" of Kentucky, was transferred to *Ianthinopsis* by Hoare (1961, p. 192, 193). Elias's shells may belong in more than one taxon, and none of them approach the slender shape of *I. regularis* (Cox); they certainly are not conspecific with Cox's species. Whether or not they are congeneric with Cox's species cannot be determined at present.

Easton (1962, p. 101, pl. 13, fig. 19) described and figured as *Soleniscus* sp. indet. a silicified specimen from the Heath Formation of south-central Montana. Another unnamed species was described and illustrated from the lower part of the Okaw Limestone ("Marigold Oolite") in Illinois by Thein and Nitecki (1974, p. 197–198). One poorly preserved Chainman specimen from the Skunk Spring–Willow Gap measured section in USGS collection 25271–PC is listed in this report as *Soleniscus*? sp.

Soleniscus sp. A

Plate 9, figure 35

Discussion.—One small silicified specimen of five whorls preserves much of the aperture and has a distinct siphonal notch; the upper half of the columellar lip is reflexed to form a prominent fold. This shell has the highest spire of all the presumed neogastropods in the Chainman fauna, the spire accounting for almost half its length of 6.5 mm. The shell is partly crushed, which precludes providing a formal name for this taxon. The whorl profile is gently arched between shal-

low sutures; the apical angle is relatively small, probably less than 20°.

Although *Soleniscus,* as currently interpreted, is uncommon in beds of Mississippian age, and, although the relatively narrow width of this shell is not particularly characteristic of the genus, the details of the aperture make any other placement unlikely. It does not belong in the superficially similar genus *Bulimorpha,* which has a much more elongate body whorl and has the columellar fold hidden when the aperture is complete. *Soleniscus glaber* Cumings, from the Salem Limestone of Indiana, is comparable in size with this specimen, but wider.

This taxon in external shape is most similar to the totally unrelated genus *Anematina.* It can be distinguished from the common Mississippian species *A. proutana* (Hall) from the Salem Limestone of Indiana by its less well rounded whorls as well as by its basal siphonal notch.

This Chainman specimen comes from the upper part of the *Cravenoceras hesperium* Zone (middle E_2) in the Burbank Hills.

Figured specimen.—USNM 211052.

Occurrence.—USGS collection 17188–PC, Millard County.

Soleniscus sp. B

Plate 9, figure 34

Discussion.—A second species of *Soleniscus* in the Chainman Shale, from the Conger Mountain section, Confusion Range, is larger than *S.* sp. A and has a bulliform shape. The earliest whorls are not known; the younger and more mature whorls do not show any ontogenetic change in the position of the periphery, so that the apical angle remains fairly constant at about 70°. The final whorl embraces the penultimate whorl slightly below the periphery, so that the obscure suture lies at the bottom of a shallow trough. The whorl profile is moderately elongate and maintains an essentially uniform curvature from suture to base. A single fold is present low on the columella; no evidence exists for the presence of a siphon. Growth lines are orthocline and are closely spaced on the smooth shell surface. A small inductura probably is present, near the upper part of the columellar lip. The most complete specimen is 15.5 mm long and 10.1 mm wide; it lacks the tip of the apex, which probably would add another 1 mm to the length.

This species can be confused with only one other Chainman gastropod, the bulliform shell described as *Ianthinopsis* sp. A, which is less than half the size of *Soleniscus* sp. B and seems to be without a columellar fold in the aperture.

Figured specimen.—USNM 211054.

Occurrence and number of specimens.—USGS collections 15356–PC (1), 17021–PC (2), 17208–PC (1), 22880–PC (2), 25274–PC (2), ?25550–PC (1), Millard County.

Family MEEKOSPIRIDAE

Genus MEEKOSPIRA Ulrich in Ulrich and Scofield, 1897

Discussion.—This genus includes high-spired subulitaceans having shells of approximately 10 whorls, the spire longer than the final whorl. The shell is narrowly conical and its surface smooth and polished. No columellar fold nor anterior notch are present.

North American Mississippian species of Meekospira.—

bambooformis Thein and Nitecki, 1974
batteni Thein and Nitecki, 1974
evansvillensis Thein and Nitecki, 1974
minuta Weller, 1916
mississippiensis Thein and Nitecki, 1974

Meekospira sp.

Plate 9, figure 10

Discussion.—This species is represented in the Chainman fauna by eight incomplete specimens. They are moderately slender, having apical angles of approximately 17°; the whorls are moderately well arched. Details of the aperture are not available, and the specimens are too poorly preserved to support a name for this species.

The most similar described American Mississippian species, *M. minuta* Weller from the Ste. Genevieve Limestone of Illinois, is readily distinguished. It has a smaller shell, a narrower apical angle, and slightly flattened whorls.

Other shells having fairly high spires are included currently in *Ianthinopsis.* One of these shells, described originally as *Macrochilina worthenanus* Miller from the St. Louis Limestone in Illinois, is similar to *Meekospira* in configuration. It differs from the Chainman species in being slightly wider. Two other species, *Ianthinopsis subcorpulentus* (Whitfield) from the Maxville Limestone of Ohio and *I. keyesi* (Rowley) from the lower part of the Burlington Limestone of Missouri, seem to be intermediate between *Meekospira* and *Soleniscus* in having strongly inflated whorls. This feature distinguishes them from the Chainman *Meekospira.* All four of these named species require further study before they can be assigned to the genus with any degree of confidence.

Figured specimen.—USNM 211055.

Occurrence and number of specimens.—USGS collections 25252–PC (5), Juab County; 25274–PC (3), Millard County.

Meekospira? sp.

Plate 9, figures 8, 9

Discussion.—A presumably smooth but coarsely silicified high-spired gastropod is referred with some question to *Meekospira*. Prior to this present study, it would have been assigned to *Meekospira* without hesitation, but the presence in the Chainman Shale of a similar shell form (*Bellazona*) bearing a selenizone and, therefore, obviously belonging in a different superfamily creates greater uncertainty in assignment of poorly preserved specimens of high-spired gastropods.

The shell, from the basal bed of the Willow Gap Limestone Member of Sadlick (1966) in the Wallet Gulch measured section, consists of approximately four whorls; part of the apex and the front edge of the aperture are missing. The remaining part of the shell measures 16.6 mm parallel to the axis of coiling. Sutures are fairly distinct but not channeled, and the whorls are gently convex. The pleural (apical) angle is 26°. The aperture is teardrop shaped, having a curved and thickened inner lip, which suggests that the columella is slightly twisted.

In general appearance, this form most closely resembles another Chainman species, *Bellazona bella* (Walcott) and could easily be mistaken for it. It differs most obviously in the curved and thickened inner lip. In *B. bella* and *B. polita*, the inner lip is approximately straight. *B. bella* is limited to the upper part of the *Goniatites americanus* Zone (Mamet Foraminifer Zone 16i), and *B. polita*, to the *Goniatites granosus* Zone (Mamet Foraminifer Zone 16s). *Meekospira*? sp. occurs several hundred feet and two ammonoid zones higher, in the *Cravenoceras hesperium* Zone (Mamet Foraminifer Zone 18).

On the basis of the single specimen at hand, the similarity of the curved inner lip to some other species of *Meekospira* prompts this generic assignment, although *Meekospira*? sp. might have a selenizone.

Figured specimen.—USNM 211056.

Occurrence.—USGS collection 25566–PC, Millard County.

Subclass OPISTHOBRANCHIA

Order and Family UNKNOWN

Discussion.—In a review of Paleozoic genera, Kollmann and Yochelson (1976) concluded that *Girtyspira* could be assigned to the opisthobranchs, partly because of the presence of a flattened subsutural ramp. They did not propose any classification to accommodate the few Paleozoic genera assigned to this subclass; *Girtyspira* previously has been considered a subulitacean allied to *Meekospira*. Our material adds little new data and, although we accept assignment of *Girtyspira* to the opisthobranchs, we cannot refine the concept further.

Genus GIRTYSPIRA Knight, 1936

Discussion.—This genus includes small fusiform shells having a spire of moderate height marked by a narrow subsutural ramp. The height of the final whorl is notably greater than that of the spire. The aperture is pyriform, and the columellar lip arcuate and without a fold.

American Mississippian species of Girtyspira.—
canaliculata (Hall), 1857 (*Bulimella*)
circumsecta n. sp.
pygmaea (S. Weller), 1916 (*Solenospira*)

Girtyspira circumsecta n. sp.

Plate 9, figures 28, 29

Diagnosis.—Small fusiform gastropod having prominent ramp; outer lip rather markedly prosocyrt.

Description.—Protoconch unknown, whorls expanding at relatively slow rate so that at least four occur on fairly small shell. Sutures distinct; whorl embracing previous one a short distance below ill-defined periphery. Upper whorl surface forming prominent narrow ramp, nearly horizontal to axis of coiling except at outer edge, which forms abrupt rounded juncture with outer whorl face; outer whorl face broadly arched, having approximately uniform curvature from below ramp to beginning of basal lip; periphery below midwhorl. Growth lines forming 30° angle with suture, strongly opisthocline crossing ramp, but curving more strongly downward at juncture of ramp and outer face, continuing opisthocline at high angle to below periphery, then arching to steeply prosocline on lower part of shell. Base anomphalous; inner lip straight. Shell thin, ornamented only by faint, closely but irregularly spaced growth lines.

Discussion.—This new species, specimens of which were found in the Foote Range, differs from *Girtyspira canaliculata* (Hall) in having a lower spire and a slightly less elongate whorl. The specimen illustrated by Thein and Nitecki (1974, p. 218, fig. 98) is a steinkern and could as well belong to this species as to the slightly older form from the Salem Limestone.

Types.—Holotype, USNM 348028; paratypes USNM 348029.

Occurrence and number of specimens.—USGS collection 25271–PC (8), Millard County.

Order UNCERTAIN

Superfamily, family, and genus UNKNOWN

Gastropod, gen. and sp. indet.

Plate 9, figure 19

Discussion.—This record is based upon high-spired specimens etched from limestone blocks from the base of the Willow Gap Member of Sadlick (1966). Silicification has obliterated the sculptural detail of the tiny shells, so that neither spiral nor collabral lirae can be discerned on any of them. Most specimens consist of approximately six whorls, ranging from 4.2 to 5.0 mm in length and 1.3 to 1.5 mm in greatest width. The pleural angle is approximately 9°. The whorls are gently convex, and sutures seem to be fairly deeply impressed.

This species is the smallest and the slenderest high-spired gastropod in the Chainman Shale and is distinct from the other high-spired forms in this formation. In its size and slenderness, it is similar to taxa like *Donaldina americana* Thein and Nitecki from the lower part of the Okaw of Illinois. The deterioration during diagenesis that these specimens have undergone, however, precludes close comparison with any described species.

Figured specimen.—USNM 211069.

Occurrence and number of specimens.—USGS collections 17214–PC (1), 25566–PC (8), Millard County.

REGISTER OF LOCALITIES

[All measurements originally made in U.S. customary units. Metric-conversion table follows the Register.]

14553–PC. Millard County, Conger Mountain Quad. 4.05 mi south of Skunk Spring by road, probably in the NE 1/4 sec. 17, T. 18 S., R. 16 W., immediately east of road. Fossils weathering from 25–30 ft of shale, between two limestone beds. *Goniatites granosus* zone. Collected by M. Gordon, Jr., and E. L. Yochelson, July 17, 1953.

14557–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring section, about 3/8 mi northwest of Skunk Spring, and 0.05 mi north of Willow Gap gully mouth. Platy limestone about 25 ft west of road and 0.3 mi north of Skunk Spring; approximately 700 ft above base of Chainman Shale. Collected by M. Gordon, Jr., and E. L. Yochelson, July 17, 1953.

14558–PC. Millard County, Cowboy Pass SW Quad. Willow Gap section, 3/8 mi northwest of Skunk Spring (gully mouth is 0.25 mi by road north of Skunk Spring, 1,200 ft west of road and along strike 100–300 ft south of gap). Fossils weathering from about 30 ft of yellowish earthy limestone, the base of which is about 125 ft above a 320-ft section of massive brownish-gray limestone interbedded with shale and shaly limestone. *Rhipidomella nevadensis* Zone. Collected by M. Gordon, Jr., and E. L. Yochelson, July 17, 1953.

14559–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Willow Gap section, 3/8 mi northwest of Skunk Spring, about 700 ft north of gap and about 200 ft west of thick massive limestone unit. Same interval as 14558–PC and about 1,000 ft farther north along strike from it. *Rhipidomella nevadensis* Zone. Collected by M. Gordon, Jr., and E. L. Yochelson, July 17, 1953.

15157–PC. Millard County, Richfield 2° Army Map Service sheet. Needle Range, northern part, limestone bed roughly 200 yds west of road and a short distance south of gully in the NW 1/4 sec. 26, T. 25 S., R. 19 W., along which oil company section was measured. Third shale ridge west of road. *Paracravenoceras barnettense* Zone. Collected by I. G. Sohn and R. Kopf, Aug. 9, 1954.

15159–PC. Millard County, Richfield 2° AMS sheet. Needle Range, northern part, in N 1/2 sec. 27, T. 25 S., R. 19 W. Detrital limestone bed containing *Diaphragmus*, 3–10 in. thick, at oil-company stake #529 in oil-company measured section. Upper part of Chainman Shale; approximately 300 ft stratigraphically below base of Ely Limestone (according to W. Sadlick). Collected by M. Gordon, Jr., and I. G. Sohn, Aug. 9, 1954.

15160–PC. Millard County, Richfield 2° AMS Sheet. Needle Range, northern part, same area as 15159–PC, but about 200–300 ft southeast across gully. From nodular black shale beds through a 2-ft interval, about 15 ft stratigraphically below the bed of 15159–PC. Upper part of Chainman Shale. Collected by M. Gordon, Jr., and I. G. Sohn, Aug. 9, 1954.

15161–PC. Millard County, Richfield 2° AMS sheet. Needle Range, northern part, same general area as 15159–PC. From nodular limestone, 2-ft interval, 3 ft stratigraphically below bed of 15159–PC and roughly 100 ft northwest of 15160–PC. Bed containing *Richardsonites merriami* in upper part of Chainman Shale. Collected by M. Gordon, Jr., Aug. 9, 1954.

15165–PC. Millard County, Burbank Hills Quad. NW 1/4 NE 1/4 SE 1/4 sec. 35, T. 22 S., R. 18 W., Jensen Wash, Burbank Hills. Fossils weathering out from shale with limestone concretions in area just east of wash and 0.6 mi by road south of sharp turn out of first wash, near faulted face of Joana Limestone. Collecting area of ridged high ground. Fossils from about 600–630 ft stratigraphically above the top of the 5-ft limestone marker bed in the Chainman Shale; in middle part of Chainman Shale. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., B. W. Gordon, I. G. Sohn, and R. W. Kopf, Aug. 11, 1954.

15166–PC. Millard County, Burbank Hills Quad. Jensen Wash, same general locality and stratigraphic zone as 15165–PC, but south of a gully and a small fault and generally southeast of 15165–PC along an area 150 yds long, roughly, trending southwest across the ridge and gully and truncated at the southwest end by the main wash. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., I. G. Sohn, and R. W. Kopf, Aug. 11, 1954.

15354–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section, probably in N 1/2 SE 1/4 sec. 28, T. 17 S., R. 16 W. Upper cephalopod zone in lower part of Chainman Shale, 20 ft below "upper marker" bed at Skunk Spring. Collected by R. K. Hose and D. L. Durham, July 17, 1954.

15355–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section of Chainman Shale, unit 9, 1,268 ft above base of formation. Collected by R. K. Hose and D. L. Durham, July 16, 1954.

15356–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section of Chainman Shale, unit 12, lower half, 1.322–1,338 ft above base of formation. Collected by R. K. Hose and D. L. Durham, July 17, 1954.

15358–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section of Chainman Shale, unit 17, 1,462 ft above base of formation. Collected by R. K. Hose and D. L. Durham, July 17, 1954.

15359–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section of Chainman Shale, unit

17, 1,483 ft above base of formation. Collected by R. K. Hose and D. L. Durham, July 17, 1954.

15361–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section of Chainman Shale, unit 17, 1,499 ft above base of formation. Collected by R. K. Hose and D. L. Durham, July 17, 1954.

15362–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section of Chainman Shale, unit 19, 1,551 ft above base of formation. Collectors, R. K. Hose and D. L. Durham, July 17, 1954.

15363–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section of Chainman Shale, unit 19, 1,559 ft above base of formation. Collected by D. L. Durham and R. K. Hose, July 17, 1954.

15364–PC. Millard County, Conger Mountain Quad. Confusion Range, Wallet Gulch partial measured section of Chainman Shale, unit 4, west-northwest of Conger Mountain, in sec. 26 (unmapped), T. 18 S., R. 17 W., upper 350 ft of Chainman Shale. Collected by R. K. Hose, July 27, 1954.

15365–PC. Millard County, Conger Mountain Quad. Confusion Range, Wallet Gulch partial section of the Chainman Shale, unit 13, 2.5 mi west-northwest of Conger Mountain, sec. 26 (unmapped), T. 18 S., R. 17 W. Collected by R. K. Hose, July 27, 1954.

15370–PC. Millard County, Gandy NE Quad. Foote Range, nearly 1 mi southeast of well-known Foote Ranch collecting locality, in fractional sec. 31, T. 15 1/2 S., R. 17 W. Measured section 4 mi east-northeast of Foote Ranch, from zone constituting units 9–13, which is 110–140 ft below the top of the Chainman Shale. Includes bed containing *Richardsonites merriami*. Collected by R. K. Hose, Sept. 24, 1954.

15372–PC. Millard County, Gandy NE Quad. Foote Range, approximately in center of SE 1/4 sec. 36, T. 15 S., R. 18 W. Original Foote Ranch collecting locality, 30–50 ft below top of Chainman Shale. Collected by R. K. Hose and D. L. Durham, Sept. 27, 1954.

15375–PC. Millard County, Cowboy Pass SW Quad. Confusion Range, Skunk Spring measured section, unit 19, 1,551 ft above base of formation. Collected by R. K. Hose and D. L. Durham, July 17, 1954.

16959–PC. Millard County, Cowboy Pass NW Quad. West side of Chevron Ridge, about 1 mi north of Indian Pass, in sec. 15 (unsurveyed), T. 16 S., R. 17 W. From concretionary bed between two quartzite beds in upper part of Chainman Shale. *Richardsonites merriami* Zone. Collected by R. K. Hose, May 22, 1957.

16997–PC. Millard County, Conger Mountain Quad. Confusion Range, Wallet Gulch measured section, along slope and to top of ridge at south side of Wallet Gulch. Fossils weathering from shale and nodular limestone in 20-ft interval immediately below highest quartzitic bed in Chainman Shale, 160–180 ft below top of Chainman. Collected by M. Gordon, Jr., and R. K. Hose, May 13, 1957.

17003–PC. Millard County, Cowboy Pass NW Quad. Confusion Range, 1,500 ft north of west end of Indian Pass, 4–8 ft below top of Chainman Shale. Collected by M. Gordon, Jr., and R. K. Hose, May 14, 1957.

17012–PC. Juab County, Granite Mountain Quad. Roughly 500 ft north of Granite Mountain measured section. Fossils weathering from shale containing reddish-brown sideritic claystone nodules, 119–132 ft above top of limestone marker bed, *Goniatites granosus* Zone. Collected by M. Gordon, Jr., and R. K. Hose, May 15, 1957.

17015–PC. Juab County, Granite Mountain Quad. Slopes on south side of ridge in the NE 1/4 NE 1/4 SW 1/4 sec. 7 (unsurveyed), T. 14 S., R. 16 W., 4,000 ft N. 22° E. of high point on Granite Mountain. Fossils weathering from about 20-ft interval of shale. Stratigraphically equivalent to 17020–PC. *Goniatites granosus* Zone. Collected by M. Gordon, Jr., and C. L. Repenning, May 16, 1957.

17018–PC. Juab County, Granite Mountain Quad. 4,650 ft due north of high point on Granite Mountain. At cleft through marker bed in the SE 1/4 SW 1/4 NW 1/4 sec. 7 (unsurveyed), T. 14 S., R. 16 W. Concretions, 3.5–5 ft above top of marker bed. *Goniatites americanus* Zone. Collected by M. Gordon, Jr., and C. L. Repenning, May 16, 1957.

17020–PC. Juab County, Granite Mountain Quad. 4,350 ft. N. 2° W. of high point on Granite Mountain in the NW 1/4 NW 1/4 sec. 7 (unsurveyed), T. 14 S., R. 16 W. Fossils weathering out of 18-ft interval of shale containing red sideritic claystone concretions; base of shale is 93 ft stratigraphically above top of marker bed. *Goniatites granosus* Zone. Collected by M. Gordon, Jr., and C. L. Repenning, May 16, 1957.

17021–PC. Millard County, Conger Mountain Quad. Confusion Range, 1,000 ft south by east from Conger Spring. From Chainman Shale containing a few resistant quartzitic siltstone ledges, weathering rusty brown; probably 150–300 ft below top of Chainman Shale. *Rhipidomella nevadensis* Zone. Collected by M. Gordon, Jr., C. L. Repenning, and R. K. Hose, May 17, 1957.

17022–PC. Millard County, Gandy SW Quad. 150 ft west of road, near southern end of Bishop Springs anticline, on east side of Foote Range, in SE 1/4 NW 1/4 NW 1/4 sec. 20 (unsurveyed), T. 16 S., R. 17 W. Collected by M. Gordon, Jr., C. L. Repenning, and R. K. Hose, May 19, 1957.

17023–PC. Millard County, Gandy NE Quad. Foote Range, about 1.5 mi southeast of Foote Ranch locality, in the NE 1/4 NE 1/4 sec. 6 (unsurveyed), T. 16 S., R. 17 W. Shale containing *Cravenoceras hesperium*. Collected by M. Gordon, Jr., R. K. Hose, and C. L. Repenning, May 19, 1957.

17024–PC. Millard County, Gandy NE Quad. Foote Range, about 0.9 mi southeast of Foote Ranch collecting locality, near center of fractional sec. 31, T. 15 1/2 S., R. 17 W. Same as 15370–PC. *Richardsonites merriami* bed. Collected by M. Gordon, Jr., R. K. Hose, and C. L. Repenning, May 19, 1957.

17037–PC. Juab County, Granite Mountain quad. Chainman Shale, Granite Mountain measured section. *Neoglyphioceras cloudi utahense* in shale, 55 ft stratigraphically below base of massive blocky limestone unit. *Goniatites granosus* Zone. Collected by M. Gordon, Jr., May 20, 1957.

17055–PC. Millard County, Burbank Hills Quad. Jensen Wash, same locality as 15165–PC in the NE 1/4 SE 1/4 sec. 35, T. 22 N., R. 18 W. Shale containing gastropods and *Hematites*. Collected by M. Gordon, Jr., R. K. Hose, and R. J. Ross, June 6, 1957.

17056–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section. Chainman Shale in the SE 1/4 SW 1/4 NE 1/4 NE 1/4 sec. 35, T. 22 S., R. 18 W.; same as Sadlick and Nielson (1963) locality 2–11. Collected by M. Gordon, Jr., R. K. Hose, and R. J. Ross, June 6, 1957.

17059–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section. Fossils from upper slope of valley cut in small hill in the NW 1/4 NE 1/4 NE 1/4 sec. 35, T. 22 S., R. 18 W., 90–110 ft below top of Chainman Shale. Collected by M. Gordon, Jr., R. J. Ross, and R. K. Hose, June 6, 1957.

17087–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. Unit 18 of section; fossils from top 6-in. *Taonurus* bed, 405 ft above base of Chainman Shale. Top of rock bench in the SE 1/4 SE 1/4 NE 1/4 sec. 18 (unsurveyed), T. 14 S., R. 16 W. Collected by M. Gordon, Jr., and C. L. Repenning, June 12, 1957.

17088–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. Unit 19 of section; corals 5–6 ft stratigraphically above base of unit. Gastropods from float in lower 6 ft of unit, 405–411 ft above base of Chainman Shale. Collected by M. Gordon, Jr., June 12, 1957.

17091–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. Unit 24 of section, a 2-ft-thick argillaceous limestone bed, 568 ft above base of Chainman Shale. SW 1/4 SE 1/4 NE 1/4 sec. 18 (unsurveyed), T. 14 S., R. 16 W. Collected by M. Gordon, Jr., and C. L. Repenning, June 12, 1957.

17092–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. Unit 26 of section lower 10 ft, 575–585 ft above base of Chainman Shale. Collected by M. Gordon, Jr., and C. L. Repenning, June 12, 1957.

17095–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. 1-ft-thick bed containing silicified brachiopods and gastropods 150 ft above base of unit 33 and 1,051 ft above base of Chainman Shale. Collected by M. Gordon, Jr., and C. L. Repenning, June 12, 1957.

17098–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. Base to lower half of unit 36, 1,148–1,153 ft above base of Chainman Shale. Collected by C. L. Repenning, June 12, 1957.

17099–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. Lower 3 ft of unit 37, 1,158–1,161 ft above base of Chainman Shale. Collected by M. Gordon, Jr., and C. L. Repenning, June 12, 1957.

17101–PC. Juab County, Granite Mountain Quad. Granite Mountain measured section. Unit 39, 23-23 1/2 ft above base, 1,129 ft above base of Chainman Shale. Mostly productoid brachiopods from limestone below shaly layer. Collected by M. Gordon, Jr., and C. L. Repenning, June 12, 1957.

17104–PC. Juab County, Granite Mountain Quad. Granite Mountain section. Unit 34, large coral bed. Two ridges south of line of section and part on ridge 150 ft to south, in the SE 1/4 SE 1/4 NW 1/4 sec. 18 (unsurveyed), T. 14 S., R. 16 W. Collected by M. Gordon, Jr., and C. L. Ropenning, June 13, 1957.

17186–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section. Fauna from *Hematites*-bearing shale unit, from east slope of Jensen Wash at bend in wash, 3/5 mi upstream from where road enters wash. From unit 27, which is 1,060–1,100 ft above base of Chainman Shale, but about 150 ft south of line of measured section. Collected by M. Gordon, Jr., and R. Christner, Sept. 17, 1957.

17187–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section. Unit 26, large *Hematites* fauna from 50-ft-thick shale interval. On brown hill in middle of large gully, the next one north of the broader gully of 17186–PC, in the NE 1/4 SW 1/4 SE 1/4 sec. 35, T. 22 S., R. 18 W. Collected by M. Gordon, Jr., and R. Christner, Sept. 17, 1957.

17188–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section. Small tributary of main gully about 600 ft west of road. Roughly 800 ft northwest of 17186–PC. Same fauna and interval as 17056–PC. Collected by M. Gordon, Jr., and R. Christner, Sept. 17, 1957.

17189–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section. Fossils weathering from slope 100–200 ft south-southeast of 17188–PC and probably several feet lower in section. Collected by M. Gordon, Jr., and R. Christner, Sept. 22, 1957.

17194–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section, unit 25. Same locality as 17187–PC, but from nodule-bearing shale 20–25 ft thick at top of knoll within gully, directly underlying shale of 17187–PC. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., and R. Christner, Sept. 19, 1957.

17201–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section; 1.5-ft-thick bed 702 ft above base of Chainman Shale. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., and R. Christner, Sept. 20, 1957.

17208–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section; unit 42, a 16-ft-thick fossiliferous nodular shale, base of which is 1,623 ft above base of Chainman Shale. Collected by M. Gordon, Jr., and R. Christner, Sept. 22, 1957.

17209–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section; offset section of upper part of Chainman Shale where road descends south to main wash. Same locality and interval as 17056–PC, base of which is 1,623 ft above base of Chainman Shale. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., and R. Christner, Sept. 23, 1957.

17214–PC. Millard County, Conger Mountain Quad. Wallet Gulch measured section; 15-ft-thick limestone, top of which is 181 ft stratigraphically below base of lowest quartzite in Wallet Gulch Section. This limestone makes a little cliff at crest of ridge. Roughly in SW 1/4 NE 1/4 sec. 27, T. 18 S., R. 17 W. About 2 mi west of 8,070-ft summit of Conger Mountain. Collected by M. Gordon, Jr., Sept. 25, 1957.

17217–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section; offset on north side of Jensen Wash. 56-ft-thick shale interval, containing 3–4-ft *Michelinia* zone, 26 ft below top of interval; limestone containing corals 80 ft below top of Chainman Shale. Same locality and unit as 17059–PC. *Rhipidomella nevadensis* Zone. Collected by M. Gordon, Jr., and R. Christner, Sept. 26, 1957.

17219–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section, NW 1/4 SW 1/4 SE 1/4 sec. 35. Same stratigraphic unit as 17188–PC and same general vicinity. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., and R. Christner, Sept. 26, 1957.

17250–PC. Millard County, Conger Mountain Quad. Confusion Range, 2.4 mi southwest of end of Conger Mountain, 0.1 mi east of road. Probably in NE 1/4 sec. 14 (unsurveyed), T. 19 S., R. 17 W. Fossils weathering from 30-ft interval of shale, base of which is 90 ft above top of limestone marker bed. *Goniatites granosus* Zone. Collected by M. Gordon, Jr., and R. Christner, Oct. 7, 1957.

17310–PC. Millard County, Burbank Hills Quad. Fossils weathered out from shale at stake 158 + 20 in oil-company section measured in south Burbank Hills, eastern side. Upper part of Chainman Shale. *Cravenoceras hesperium* Zone. Collected by J. E. Welsh in the late 1950's.

19602–PC. Millard County, Gandy NE Quad. Northeast of Foote Range, Bishop Springs anticline area, in the SW 1/4 SE 1/4 NE 1/4 sec. 25, T. 15 S., R. 18 W. Middle of Chainman Shale in fault block. Upper part of *Paracravenoceras barnettense* Zone. Collected by R. K. Hose, 1959–1960.

19603–PC. Millard County, Gandy NE Quad. East of Foote Range, at south end of Bishop Springs anticline in the NE 1/4 SW 1/4 SE 1/4 sec. 20 (unsurveyed), T. 16 S., R. 17 W. near road.

19604–PC. Millard County, Gandy NE Quad. SW 1/4 SE 1/4 NE 1/4, sec. 25, T. 15 S., R. 18 W., Bishop Springs area; basal 10 ft of *Cravenoceras hesperium* Zone. Collected by R. K. Hose, 1959–1960.

20443–PC. Millard County, Gandy NE Quad. Probably near center of NW 1/4 sec. 20, T 16 S., R 17 W. East of Foote Range, about 200 ft west of road and about 1 3/4 mi south of abandoned oil-well site on Bishop Springs anticline. Limestone bed 1 ft thick, 5 ft above top of ammonoid bed. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., and R. Rieke, July 26, 1961.

20444–PC. Millard County, Gandy NE Quad. Same locality as collection 20443–PC but from a 1-ft limestone bed stratigraphically 5.0 ft higher. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., and R. Rieke, July 26, 1961.

20445–PC. Millard County, Gandy NE Quad. Same general locality as 20443–PC; a 6-in. bed 27 ft stratigraphically above the top of the ammonoid bed; 15 ft above top of bed of 20445–PC. *Cravenoceras*

Hesperium Zone. Collected by M. Gordon, Jr., and R. Rieke, July 26, 1961.

20446–PC. Millard County, Gandy NE Quad. In SW 1/4 SE 1/4 SE 1/4 sec. 7, T. 16 S., R. 17 W., 430 ft west of curve in road where road starts through the Joana Limestone, on west flank of Bishop Springs anticline. A zone 20 ft stratigraphically above and 30 ft west of 19600–PC. 80 ft above the marker ledge to base of 10-ft zone containing *Goniatites granosus* capped by thin rusty platy limestone layer. Collected by M. Gordon, Jr., and R. Rieke, July 26, 1961.

20448–PC. Millard County, Gandy NE Quad. West edge of SW 1/4 SE 1/4 sec. 20, T. 16 S., R. 17 W., east of Foote Range, southern end of Bishop Springs anticline. Fossils weathering from soft olive shale, 20 ft west of road. Same as 19603–PC. Upper part of *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., R. K. Hose, and R. Rieke, July 27, 1961.

20547–PC. Juab County, Granite Mountain SW Quad. Eastern slope of Granite Mountain, E 1/2 SE 1/4 NW 1/4 sec. 18, T. 14 S., R. 16 W. Fossils from 30 ft of shale and limestone containing large *Caninia* corals, a soft zone below which tributary spurs extend eastward. Collected by M. Gordon, Jr., Helen Duncan, R. Lewandowski, and R. Rieke, Aug. 11, 1961.

22857–PC. Millard County, Burbank Hills Quad. About 100–200 ft east of Jensen Wash; hill in drainage near center SE 1/4 sec. 35, T. 22 S., R. 18 W. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., and Darcy Closs, Sept. 30, 1962.

22876–PC. Millard County, Gandy NE Quad. *Schizophoria* bed, 20 ft of brown shale and overlying 1-ft-thick platy limestone bed containing *Flexaria*, at mouth of wash near center NE 1/4 SE 1/4 sec. 36, T. 15 S., R. 18 W. See measured section of 1957 and earlier. Upper part of Chainman Shale. Collected by M. Gordon, Jr., Darcy Closs, and D. Wiese, Oct. 6, 1962.

22880–PC. Millard County, Conger Range NE Quad. Coyote Pass area, NW 1/4 SW 1/4 SW 1/4 sec. 7, T. 19 S., R. 17 W. On top and east side of a little low ridge, a 0.5-ft limestone bed containing *Richardsonites merriami* (Youngquist) and associated shale, approximately 190 ft below base of Ely Limestone. *Rhipidomella nevadensis* Zone. Collected by M. Gordon, Jr., Darcy Closs, and D. Wiese, Oct. 7, 1962.

22883–PC. Millard County, Gandy NW Quad. East slope of Foote Range. Fauna of small mollusks weathering from shale on small knoll 25–30 ft stratigraphically below massive outcrop of Ely Limestone; base showing fault face and breccia, approximately on south line, sec. 31, T. 15 1/2 S., R. 17 W., about 100 yds south of 22870–PC and about 50 ft higher in altitude. Collected by M. Gordon, Jr., Darcy Closs, and D. Wiese, Oct. 8, 1962.

23846–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section, unit 26. Little shale hill in tributary drainage on east side of Jensen Wash about 100 yds from center of wash. Fossils weathering out on western slope of hill. Same locality as 17056–PC and 17217–PC. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 14, 1969.

25249–PC. Juab County, Granite Mountain SW Quad. Base of southernmost of four ridges that extend eastward from Granite Mountain, about 2,600 ft S. 64° E. of summit, on crest of ridge. Fossils from 5-ft interval of medium- to fine-grained gray limestone, weathering orange. Base of bed is 33 ft stratigraphically below top of Chainman Shale and 170 ft above base of bed containing *Caninia*. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 16, 1973.

25252–PC. Juab County, Granite Mountain SW Quad. Same ridge as 25249–PC on lower part of slope above saddle; 12-15-in.-thick bed of fossiliferous dark-brownish-gray silty limestone containing silicified productoids; 132 ft below base of massive gray coarse-grained crystalline limestone, forming cliff at base of Ely Limestone. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 16, 1973.

25257–PC. Juab County, Granite Mountain SW Quad. Eastern slope of Granite Mountain, roughly 1,500 ft east by north of summit, on northernmost of four ridges that extend eastward from main part of Granite Mountain, same as original section measured in 1957. At narrow saddle above top of limestone bed which is at base of *Caninia* zone. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 17, 1973.

25259–PC. Millard County, Gandy NE Quad. SW 1/4 SE 1/4 sec. 31, T. 15 1/2 S., R. 17 W. On northeast slope of hill, roughly 800 ft southwest of road and 800 ft north of south line of partial township. *Agassizocrinus* weathering out of shale slope. Upper part of Chainman Shale. Collected by E. L. Yochelson and K. R. Moore, Aug. 18, 1973.

25260–PC. Millard County, Gandy NE Quad. *Cravenoceras* bed in SE 1/4 NW 1/4 sec. 20 (unsurveyed), T. 16 S., R. 17 W., on southwest side of Bishop Springs anticline at southeast side of Foote Range, same locality and bed as 17022–PC. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., E. L. Yochelson, and K. R. Moore, Aug. 18, 1973.

25261–PC. Millard County, Cowboy Pass SW Quad. Skunk Spring section. Fossils weathering from shale containing sideritic concretions, 0.35 mi south of Skunk Spring. Approximately in middle of south line of SE 1/4 sec. 27 (unsurveyed), T. 17 S., R. 16 W. Roughly 350–400 ft above base of Chainman Shale. *Goniatites granosus* Zone. Collected by M. Gordon, Jr., E. L. Yochelson, and K. R. Moore, Aug. 18, 1973.

25262–PC. Millard County, Burbank Hills Quad. In SE 1/4 NW 1/4 sec. 20 (unsurveyed), T. 16 S., R. 17 W., on southwest side of Bishop Springs anticline at southeast side of Foote Range; same locality and bed as 17022–PC. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., E. L. Yochelson, and K. R. Moore, Aug. 18, 1973.

25263–PC. and 25264–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section. Same locality and unit as 17194–PC. Collected by M. Gordon, Jr., E. L. Yochelson, and K. R. Moore, Aug. 18 and 19, 1973.

25269–PC. Millard County, Conger Mountain Quad. Wallet Gulch, 50–100 ft above bottom, on east slope roughly 400 ft north of right-angle bend, NW 1/4 NE 1/4 sec. 27 (unsurveyed), T. 18 S., R. 17 W. Productoids weathering from shale on slope. About 700 ft north of section measured in 1954; same unit as 15365–PC. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 20, 1973.

25271–PC. Millard County, Cowboy Pass SW Quad. Section on south side of Willow Spring Canyon about 700 ft northwest of Skunk Spring. Fossils from bed in soft limestone zone, 85 ft above massive limestone at base of Willow Spring Member of Sadlick (1966), approximately 110 ft above base of "member." NW 1/4 SE 1/4 sec. 28 (unsurveyed), T. 17 S., R. 16 W. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 22, 1973.

25272–PC. Millard County, Cowboy Pass SW Quad. Section on south side of Willow Spring Canyon, about 800 ft north-northwest of Skunk Spring. Fossils from limestone bed in soft zone, 188 ft stratigraphically above base of interval collected in 25271–PC, 50–80 ft above wash. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 22, 1973.

25273–PC. Millard County, Gandy NE Quad. Foote Range, west side of northeast-trending ridge north of middle of NE 1/4 NE 1/4 sec. 6 (from base of interval collected in 25271–PC, 50–80 ft above wash. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 22, 1973.

25274–PC. Millard County, Gandy NE Quad. Foote Range, west side of northeast-trending ridge north of middle of NE 1/4 NE 1/4 sec. 6 (unsurveyed), T. 16 S., R. 17 W. From limestone bed about 6 in. thick and exposed for 4 ft, containing brachiopod and mollusk

fauna, on shale slope, about 100 yds south of saddle. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 24, 1973.

25275–PC. Millard County, Gandy NE Quad. On west side of little embayment of west slope of Foote Range in NW 1/4 NE 1/4 sec. 6 (unsurveyed), T. 16 S., R. 17 W., about 450 ft N. 60° W. of 25274–PC and roughly 25–30 ft higher in altitude; on slope 15–30 ft below massive sandstone(?) bed. Collected by K. R. Moore, Aug. 24, 1973.

25284–PC. Millard County, Burbank Hills Quad. On north slope of east tributary of drainage over area 100 yds square, beginning at Jensen Wash. NE 1/4 SW 1/4 SE 1/4 sec. 35, T. 22 S., R. 18 W. Fossils weathering from brown shale containing limestone concretions. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., and K. R. Moore, Aug. 26, 1973.

25318–PC. Millard County, Burbank Hills Quad. Upper part of slope of south-trending spur of Chainman Shale ridge about 100 yds S. 30° W. of triangulation marker at top of ridge (not on map); SE 1/4 SW 1/4 NE 1/4 sec. 1, T. 22 S., R. 19 W. Altitude about 6,050–6,090 ft. Spur is of dark-brown shale, darker than rest of ground. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 12, 1974.

25319–PC. Millard County, Burbank Hills Quad. South-southeast-trending ridge, just east of drainage, 100 ft from jeep trail shown on map in SW 1/4 SE 1/4 SE 1/4 sec. 29, T. 23 S., R. 18 W. Fossils weathering from brown shale at north end of limestone outcrop; bed estimated about 100 ft below top of Chainman Shale. *Carlinia phillipsi* beds. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 13, 1974.

25546–PC. Millard County, Burbank Hills Quad. Jensen Wash measured section, unit 13. Fossil from platy silty limestone on north bank of wash, SW 1/4 SE 1/4 SE 1/4 sec. 35, T. 22 S., R. 18 W. About 1,000 ft east of Jensen Wash. Same locality and unit as 17201–PC. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., and W. E. McCaslin, September 15, 1974.

25547–PC. Millard County, Burbank Hills Quad. Jensen Wash section. From Sadlick and Nielsen (1963) locality 2–11 in the SW 1/4 NE 1/4 NE 1/4 sec. 35, T. 22 S., R. 18 W. Through about 15 ft of brown-weathering shale below dark-gray shale, northeast across gully from road. Same as 17056–PC and 17209–PC. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., and W. E. McCaslin, September 15, 1974.

25548–PC. Millard County, Burbank Hills Quad. On slope about 300 ft north of Jensen Wash, in SW 1/4 NE 1/4 NE 1/4 sec. 35, T. 22 S., R. 18 W. Fossils weathering out 15–60 ft below 4-ft-thick limestone bed at top of ridge below downfaulted block (about 25–30 ft of throw). Same as 17217–PC. *Carlinia phillipsi* beds, *Rhipidomella nevadensis* Zone. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 15, 1974.

25550–PC. Millard County, Burbank Hills Quad. At a patch of light-brown shale just above thin limestone bed in first drainage 800 ft west of Jensen Wash. About in middle of western side of NW 1/4 SW 1/4 SE 1/4 sec. 35, T. 22 S., R. 18 W. Drainage runs north and then curves into Jensen Wash. Same unit as 25547–PC but to south. *Cravenoceras hesperium* Zone. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 15, 1974.

25551–PC. Millard County, Gandy NE Quad. On west limb of Bishop Springs anticline, on slope along east side of north-trending drainage, 1,700 ft north of south line and 2,450 ft east of west line of partial sec. 31, T. 15 1/2 S., R. 17 W., 2 1/4 mi southeast of northwest tip of Foote Range. *Anthracospirifer* bed and overlying 30 ft of shale, at northwest strike and dip 73° E. on geologic map (Hose and Ziony, 1963). Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 17, 1974.

25553–PC. Millard County, Gandy NE Quad. West side of wash on east base of Foote Range, 1,800 ft north of south line and 2,150 ft east of west line of partial sec. 31, T. 15 1/2 S., R. 17 W. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 18, 1974.

25557–PC. Millard County, Gandy NE. Quad. Foote Range. Tan patch of shale 400 ft N. 70° W. from sec. cor. R. 18 W./R. 17 W. and sec. 30/31 in R. 17 W. (corner is ticked but not shown on geologic map (Hose and Ziony, 1963); marker is dated 1959). *Paracravenoceras barnettense* Zone, upper part. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 18, 1974.

25558–PC. Juab County, Granite Mountain SW Quad. On line of Granite Mountain measured section. Fossils from concretions on north bank of drainage, about 15 ft above top of marker bed approximately 1,800 ft due south of northeast corner sec. 18 (unsurveyed), T. 14 S., R. 16 W. *Goniatites americanus* Zone. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 19, 1974.

25562–PC. Juab County, Granite Mountain SW Quad. On north side of drainage in NE 1/4 SW 1/4 SE 1/4 sec. 7, T. 14 S., R 16 W., on northeast side of Granite Mountain. Zone of brown shale containing orange-weathering concretions; fossils weathering from shale and on limestone plates. *Goniatites granosus* Zone. Collected by M. Gordon, Jr., Sept. 19, 1974.

25563–PC. Millard County, Cowboy Pass SW Quad. Skunk Spring section. In Willow Gap Member of Sadlick (1966) (Chainman Formation), 20–22 ft below top, 100–200 ft north of gravel barrier that diverts Willow Spring drainage; SW 1/4 SW 1/4 NE 1/4 sec. 28 (unsurveyed), T. 17 S., R. 16 W., 1,550 ft northwest of Skunk Spring. Approximately the same bed as 15363–PC. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 20, 1974.

25566–PC. Millard County, Conger Mountain Quad. Confusion Range, Wallet Gulch section; just below top of ridge, on east slope of ridge east of Wallet Gulch and in line with main part of Wallet Gulch; from lowest bed in a limestone cliff, about 6–8 ft high. SW 1/4 NW 1/4 sec. 27 (unsurveyed). Same limestone unit as 17214–PC, but from basal bed of unit and several hundred feet northeast of that collection and in line with main part of Wallet Gulch. Collected by M. Gordon, Jr., and W. E. McCaslin, Sept. 20, 1974.

28610–PC. Millard County, Burbank Hills Quad. Jensen Wash section. Small soft shale hill on line of measured section, NW 1/4 SE 1/4 SE 1/4 sec. 35, T. 22 S., R. 18 W. Same locality and stratigraphic interval as 17194–PC. Collected by M. Gordon, Jr., and T. W. Henry, Aug. 12, 1982.

28611–PC. Millard County, Burbank Hills Quad. Same locality as 28610–PC, but from dip slope of hill and 30 ft upsection. Same locality and stratigraphic unit as 17187–PC. *Paracravenoceras barnettense* Zone. Collected by M. Gordon, Jr., and T. W. Henry, Aug. 12, 1982.

28612–PC. Millard County, Burbank Hills Quad. Jensen Wash section, upper part. Same locality and stratigraphic unit as 17059–PC, 17217–PC, and 25548–PC. Collected by M. Gordon, Jr., and T. W. Henry, Aug. 12, 1982.

28623–PC. Millard County, Gandy NE Quad. Small outcrop of soft brown shale just north of main wash, in southern part of sec. 24, 630 ft north of south line and 2,400 ft west of east line of sec. 24; NW 1/4 SW 1/4 SE 1/4 sec. 24, T. 15 S., R. 18 W. *Paracravenoceras barnettense* Zone, upper part. Collected by M. Gordon, Jr., T. W. Henry, and Mark Rich, Aug. 14, 1982.

28628–PC. Juab County, Granite Mountain SW Quad. Granite Mountain measured section. Near center sec. 18, T. 14 S., R. 16 W. Same locality and unit as 17092–PC. Dark jointed fine-grained limestone and shale, containing *Lunulazona sadlicki*; includes *Bactrites* from fine-grained brownish-gray limestone 10 ft above gastropod bed. Collected by M. Gordon, Jr., and T. W. Henry, Aug. 15, 1982.

28637–PC. Juab County, Granite Mountain SW Quad. Granite Mountain measured section on east slope of cuesta formed by west-

dipping marker limestone bed (Skunk Spring Limestone Member of Sadlick, 1966). Float from 3-ft interval of silty shale immediately below basal chert of marker bed, 92–95 ft above base of Chainman Shale. Collected by M. Gordon, Jr., Aug. 16, 1982.

Metric-Conversion Table

U.S. customary units used in the preceding Register may be converted to metric units by using the following conversion table:

To convert U.S. customary unit:	To metric unit:	Multiply by:
Mile (mi)	Kilometer (km)	1.61
Yard (yd)	Meter (m)	.914
Foot (ft)	Meter (m)	.305
Inch (in.)	Centimeter (cm)	2.54

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INDEX

[Italic page numbers indicate major references]

PLATES 1–9

Contact photographs of the plates in this report are available, at cost, from the U.S. Geological Survey Library, Federal Center, Denver, CO 80225.

PLATE 1

FIGURES

1–6. *Sinuitina* (*Sinuitina*) *crispa* n. sp. (p. 27).

1, 3. Ventral views (× 4) of two incomplete paratypes (USNM 210919, 210920) from USGS colln. 25261–PC, Skunk Spring section, Confusion Range.

2, 6. Side and ventral views (× 1½) of holotype (USNM 210915) from USGS colln. 22961–PC, near Pogues Station ruins, Pancake Range, Nev.

4, 5. Side and ventral views (× 1½) of paratype (USNM 210916) from same collection as holotype.

7–11. *Sinuitina* (*Vorticina*) *vortex* n. sp. (p. 28).

7, 8, 11. Side (× 1½), oblique (× 4), and ventral (× 1½) views of paratype (USNM 210922) from USGS colln. 17018–PC, Granite Mountain section.

9, 10. Side and ventral views (× 2) of holotype (USNM 210921) from same collection.

12–14. *Bellerophon* (*Bellerophon*) *welshi* n. sp. (p. 36).

Side, apertural, and abapertural views (× 1½) of holotype (USNM 210928) from USGS colln. 17310–PC, Burbank Hills.

15–17, 21–23. *Bellerophon* (*Bellerophon*?) sp. A (p. 37).

15, 16. Apertural and abapertural views (× 2) of specimen (USNM 211085) from USGS colln. 25275–PC, Foote Range.

17. Oblique view (× 1) of fragment (USNM 211086) showing raised selenizone, from same collection.

21–23. Side, apertural, and abapertural views (× 5) of small specimen (USNM 210935) from USGS colln. 22883–PC, Foote Range.

18–20. *Bellerophon* (*Bellerophon*) *needlensis* n. sp. (p. 37).

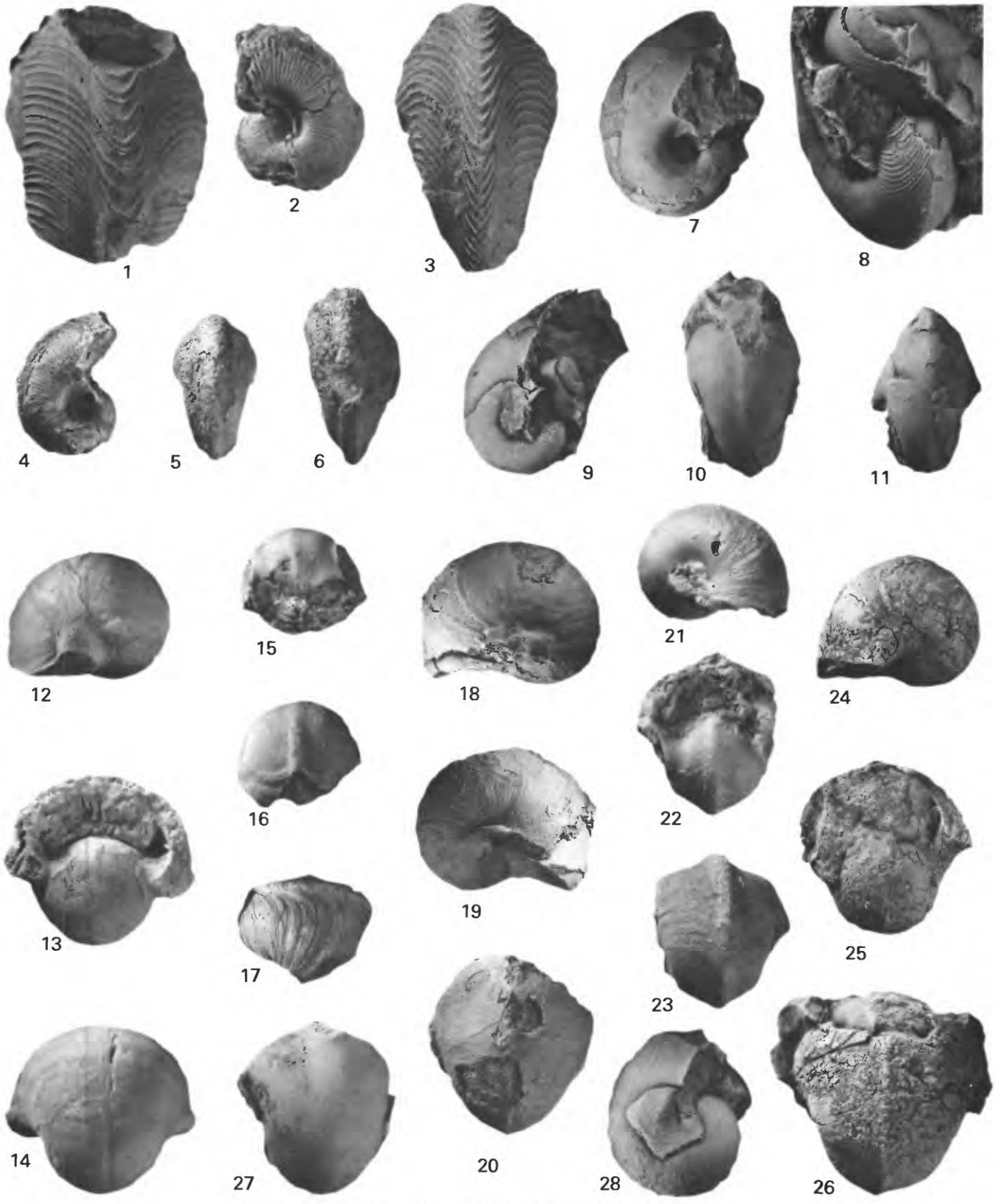
Side, opposite side, and apertural views (× 1) of holotype (USNM 210930) from USGS colln. 15160–PC, Needle Range.

24–26. *Bellerophon* (*Bellerophon*) *vespertinus* Gordon and Yochelson (p. 36).

Side, apertural, and abapertural views (× 2) of specimen (USNM 210934) from USGS colln. 17087–PC, Granite Mountain section.

27, 28. *Euphemites* sp. B (p. 33).

Abapertural and side views (× 3) of specimen (USNM 210927) from USGS colln. 17018–PC, Granite Mountain section.



SINUITINA, BELLEROPHON, EUPHEMITES

PLATE 2

FIGURES 1–4. *Euphemites* sp. A (p. 32).

1, 2. Side and abapertural views (× 2) of specimen (USNM 210925) from USGS colln. 22880–PC, Conger Range.

3, 4. Side and abapertural views (× 4) of small specimen (USNM 210926) from USGS colln. 17189–PC, Jensen Wash section, Burbank Hills.

5, 6. *Euphemites nevadensis* Gordon and Yochelson (p. 32).
Abapertural and side views (× 2) of a specimen (USNM 211078) from USGS colln. 25547–PC, Jensen Wash section, Burbank Hills.

7, 8. *Retispira stenopsis* n. sp. (p. 43).
Side and abapertural views (× 2) of holotype (USNM 210947) from USGS colln. 17217–PC, Jensen Wash section, Burbank Hills.

9–11. *Euphemites cracens* n. sp. (p. 31).
Abapertural, side, and apertural views (× 3) of holotype (USNM 210923) from USGS colln. 22883–PC, Foote Range.

12, 13. *Retispira jensenensis* n. sp. (p. 43).
Abapertural and side views (× 4) of holotype (USNM 210946) from USGS colln. 17188–PC, Jensen Wash section, Burbank Hills.

14, 15. *Euphemites sacajawensis* C. C. Branson (p. 32).
Abapertural and side views (× 2) of specimen (USNM 210932) from USGS colln. 17217–PC, Jensen Wash section, Burbank Hills.

16, 17. *Retispira* sp. (p. 45).
Abapertural and side views (× 5) of specimen (USNM 210953) from USGS colln. 22880–PC, Conger Range.

18–21. *Retispira nolani* Gordon and Yochelson (p. 43).

18, 19. Side and abapertural views (× 3) of incomplete specimen (USNM 210951) from USGS colln. 17189–PC, Jensen Wash section, Burbank Hills.

20, 21. Abapertural view (× 4) and side view (× 2) of specimen (USNM 210952) from USGS colln. 17310–PC, Burbank Hills.

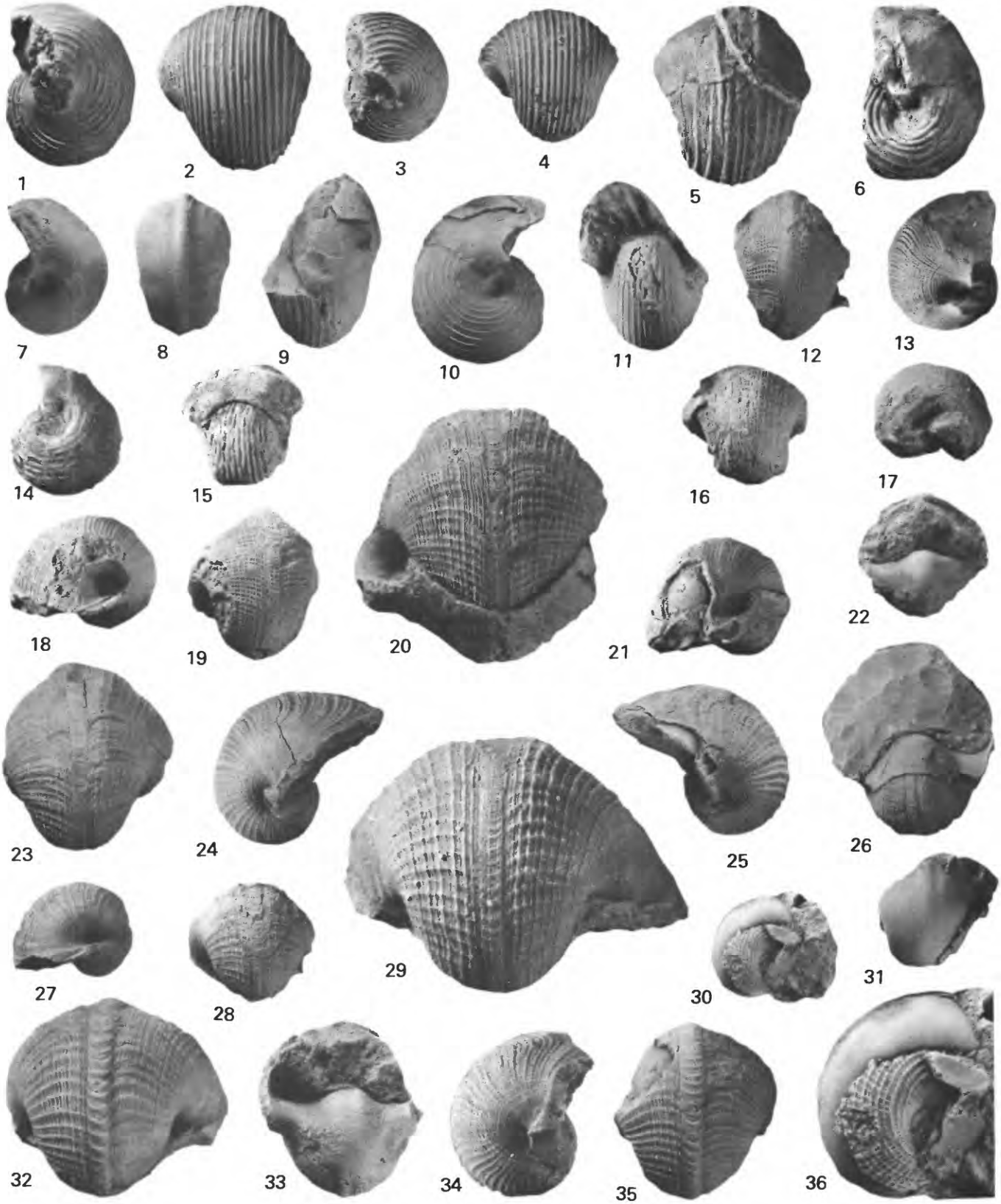
22–29. *Retispira ordinata* n. sp. (p. 41).

22, 27, 28. Abapertural, side, and apertural views (× 2) of a small paratype (USNM 210941) from USGS colln. 17187–PC, Jensen Wash section, Burbank Hills.

23–26, 29. Abapertural, side, opposite side, and apertural views (× 2) and posterior view (× 4) of holotype (USNM 210940) from USGS colln. 17194–PC, from same locality.

30, 31, 36. *Retispira* cf. *R. textilis* (Hall) (p. 44).
Side and abapertural views (× 2) and larger side view (× 4) of specimen (USNM 210936) from USGS colln. 17018–PC, Granite Mountain section.

32–35. *Retispira cincta* n. sp. (p. 41).
Posterior view (× 4) and apertural, side, and abapertural views (× 3) of holotype (USNM 210937) from USGS colln. 17012–PC, Granite Mountain section.



EUPHEMITES, RETISPIRA

PLATE 3

FIGURES 1–5, 7–10. *Straparollus* (*Euomphalus*) *intermedius* Gordon and Yochelson (p. 83).

1–3. Apical, abapertural, and basal views (× 2) of typical specimen (USNM 210954) from USGS colln. 17023–PC, Foote Range.

4, 5. Apical and apertural views (× 2) of specimen (USNM 210955) from same collection.

7–10. Apertural, apical, abapertural, and basal views (× 2) of less rugose specimen (USNM 210957) from USGS colln. 22880–PC, Conger Range.

6, 11–17. *Straparollus* (*Euomphalus*) *nodibasis* n. sp. (p.82).

6, 11. Basal and abapertural view (× 1 1/2) of incomplete paratype (USNM 210960) from USGS colln. 17098–PC, Granite Mountain section.

12, 13. Apical and abapertural views (× 1) of large paratype (USNM 210959) from USGS colln. 15358–PC, Skunk Spring section, Confusion Range.

14–17. Apical, abapertural, basal, and apertural views (× 4) of holotype (USNM 210958) from USGS colln. 15355–PC, Skunk Spring Section, Confusion Range.

18. *Trepospira* (*Trepospira*) sp. (p.49).

Oblique apical view (×1 1/2) of unique crushed specimen (USNM 211027) from USGS colln. 28628–PC, Granite Mountain section.

19–26. *Trepospira* (*Angyomphalus*) *regularis* n. sp. (p.46).

19, 23, 24. Apical, basal, and abapertural views (× 5) of small paratype (USNM 210962) from USGS colln. 17018–PC, Granite Mountain section.

20–22. Abapertural, apical, and basal views (× 2) of holotype (USNM 210961) from same collection.

25, 26. Apical and basal views (× 2) of another paratype (USNM 210963) from same collection.

27–31. *Trepospira* (*Trepospira*) *baconi* n. sp. (p. 47).

Abapertural view (× 3) and oblique, apical, abapertural, and basal views (× 1 1/2) of holotype (USNM 210966) from USGS colln. 25264–PC, Jensen Wash section, Burbank Hills.

32–36. *Trepospira* (*Trepospira*) *diadema* n. sp. (p.48).

32, 33. Apical and abapertural views (× 2) of holotype (USNM 210970) from USGS colln. 17310–PC, Burbank Hills.

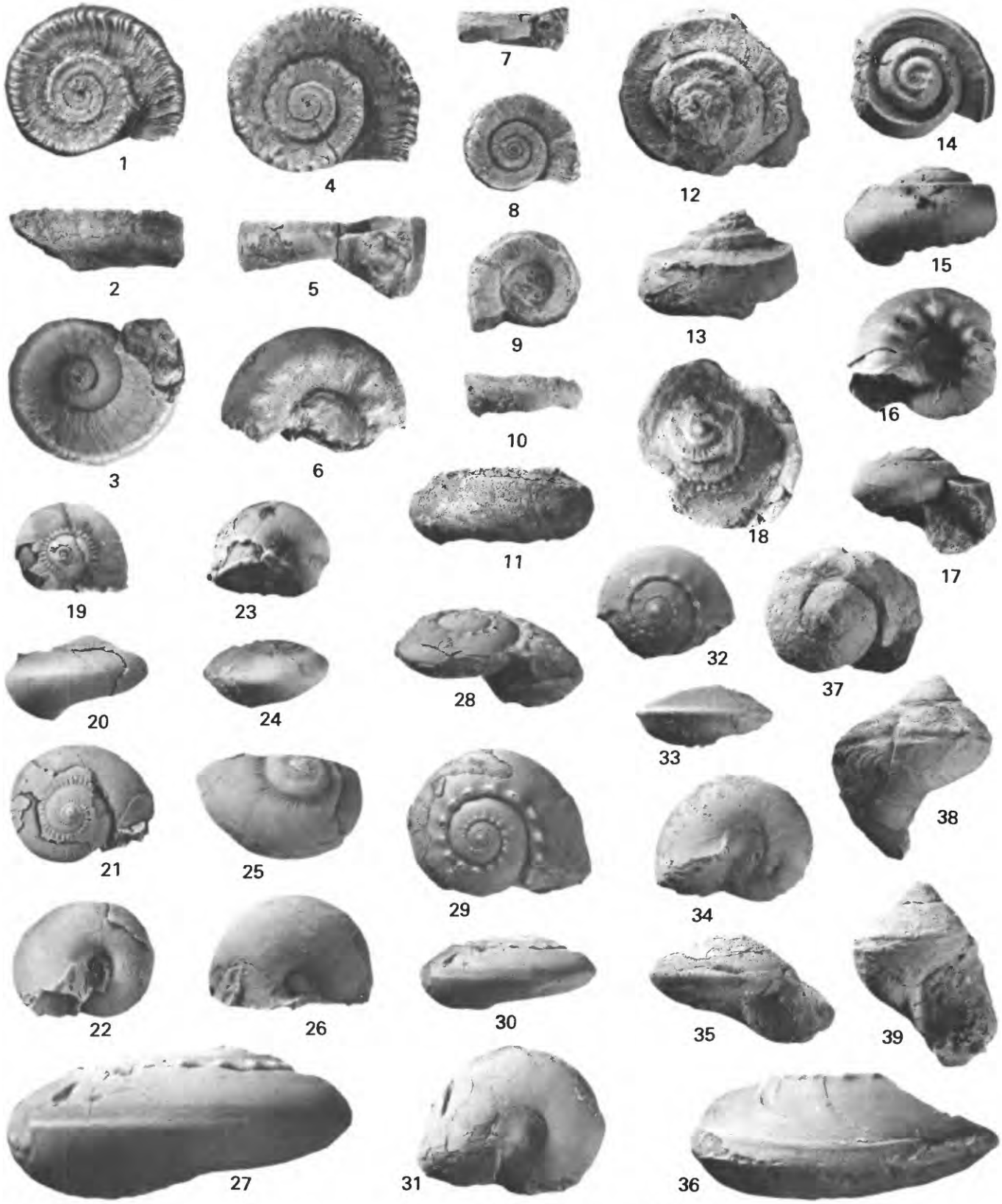
34. Basal view (× 3) of another paratype (USNM 210971) from same collection.

35. Apertural view (× 1 1/2) of paratype (USNM 210974) from USGS colln. 17188–PC, Jensen Wash section, Burbank Hills.

36. Oblique view (× 3) of fragment showing selenizone (USNM 210972) from USGS colln. 17310–PC, Burbank Hills.

37–39. *Ptychomphalina burbankensis* n. sp. (p. 54).

Apical, side, and apertural views (× 2) of holotype (USNM 210978) from USGS colln. 17201–PC, Jensen Wash section, Burbank Hills.



STRAPAROLLUS, TREPOSPIRA, PTYCHOMPHALINA

PLATE 4

FIGURES 1–4, 16, 17. *Lunulazona utahensis* n. sp. (p.71).

1–4. Apical, apertural, abapertural, and basal views (× 3) of holotype (USNS 211010) from USGS colln. 20443–PC, Foote Range.

16, 17. Apical and abapertural views (× 3) of paratype (USNM 211012) from USGS colln. 17022–PC, same locality.

5–11, 15. *Euconospira desereti* n. sp. (p.73).

5–7. Apical, apertural, and basal views (× 3) of paratype (USNM 211021) from USGS colln. 17217–PC, Jensen Wash section, Burbank Hills.

8, 15. Oblique and apical views (× 3) of same specimen unwhitened to show color pattern.

9–11. Apical, abapertural, and basal views (× 3) of holotype (USNM 211020) from same collection.

12–14. *Euconospira gradilis* n. sp. (p.74).

Apical, abapertural, and basal views (× 3) of holotype (USNM 211023) from USGS colln. 22880–PC, Conger Range.

18–20. *Ptychomphalina* sp. (p.55).

Apical, abapertural, and basal views (× 2) of specimen (USNM 134170) figured by Sadlick and Nielsen (1963) as *Mourlonia* sp. from their locality 7–1, in the Chainman Formation near Leppy Peak, Elko County, Nev.

21–23. *Lunulazona nodomarginata* (McChesney) (p.69).

21, 22. Apical and apertural views (× 4) of specimen (USNM 211007) from USGS colln. 17018–PC, Granite Mountain section.

23. Enlarged abapertural view (× 4) of specimen (USNM 14410) figured by Walcott (1884), from USGS colln. 655 (Old Series). Diamond Peak Formation, conical hill near Eureka, Nev.

24, 25, 34, 35. *Lunulazona sadlicki* n. sp. (p.70).

24, 25. Apical and abapertural views (× 2) of holotype (USNM 134171) from Sadlick and Nielsen (1963) locality 7–1, Chainman Formation near Leppy Peak, Elko County, Nev.

34, 35. Basal and abapertural views (× 2) of paratype (USNM 134169) from same locality.

26, 27. *Lunulazona*? aff. *L.*? *sablei* (Yochelson and Dutro) (p.72).

26. Apical view (× 6) of specimen (USNM 211015) from USGS colln. 15370–PC, *R. merriami* bed, Foote Range.

27. Abapertural view (× 9) of another specimen (USNM 211016) from same collection.

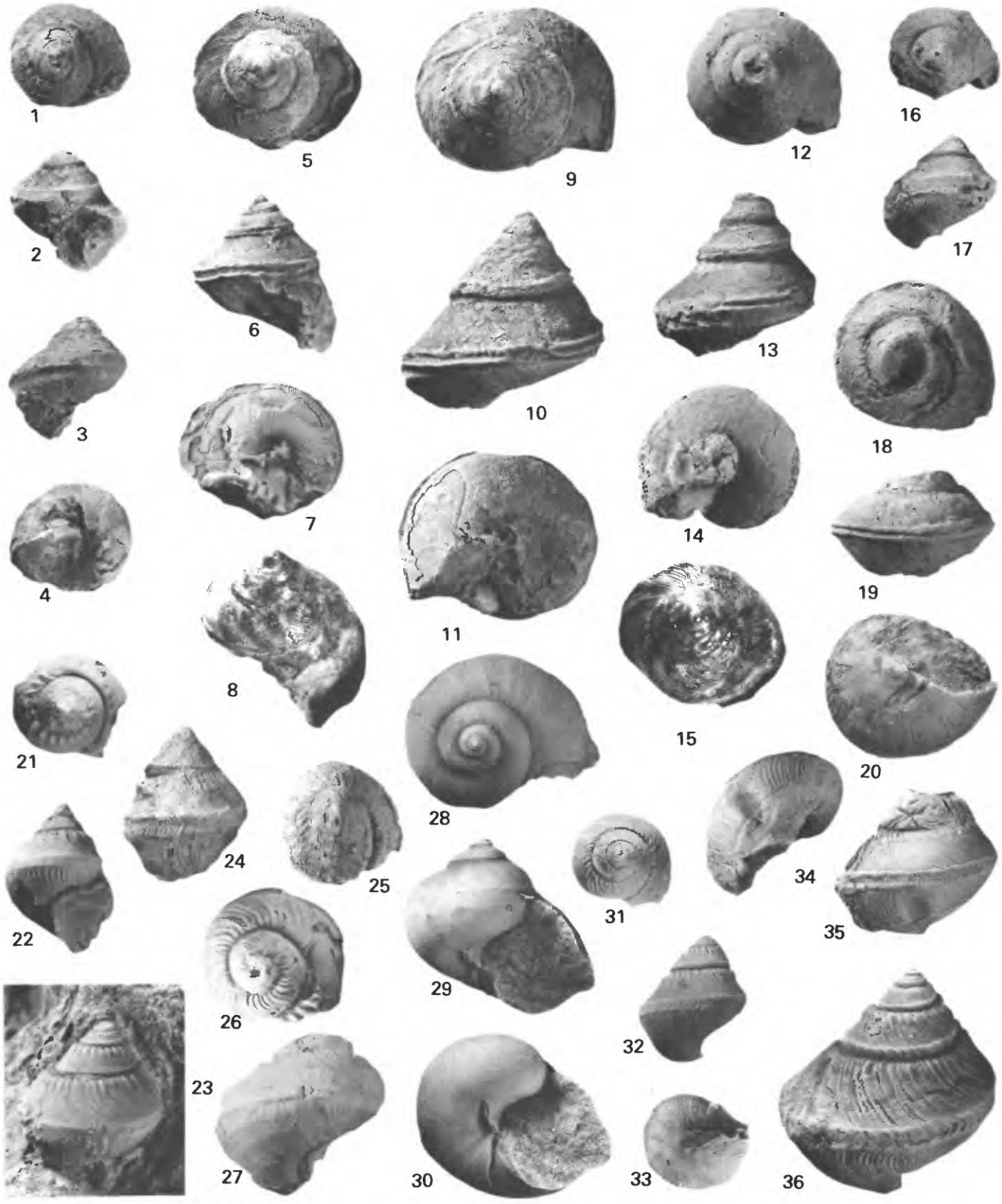
28–30. *Mourlonia venusta* n. sp. (p.52).

Apical, apertural, and basal views (× 2) of holotype (USNM 210976) from USGS colln. 17018–PC, Granite Mountain section.

31–33, 36. *Lunulazona costata* Sadlick and Nielsen (p.70).

31–33. Apical, abapertural, and basal views (× 2) of specimen (USNM 211008) from USGS colln. 17015–PC, Granite Mountain section.

36. Abapertural view (× 4) of specimen (USNM 211007) from USGS colln. 17012–PC, Granite Mountain section.



LUNULAZONA, EUCONOSPIRA, PTYCHOMPHALINA, MOURLONIA

PLATE 5

FIGURES 1–9. *Glabrocingulum* (*Glabrocingulum*) *confusionense* n. sp. (p. 60).

1–3. Apical, side, and basal views (× 2) of holotype (USNM 210994) from USGS colln. 17187–PC, Jensen Wash section, Burbank Hills.

4–6. Apical, abapertural, and basal views (× 2) of paratype (USNM 210995) from same collection.

7–9. Same views (× 2) of another paratype (USNM 210999) from USGS colln. 23846–PC, same locality.

10–15. *Glabrocingulum* (*Glabrocingulum*) *quadrigatum* Sadlick and Nielsen (p. 61).

10–12. Apical, apertural, and basal views (× 3) of hypotype (USNM 211000) from USGS colln. 17310–PC, Burbank Hills.

13–15. Apical, abapertural, and basal views (× 4) of another hypotype (USNM 211001) from same collection.

16–27. *Glabrocingulum* (*Glabrocingulum*?) *hosei* n. sp. (p. 65).

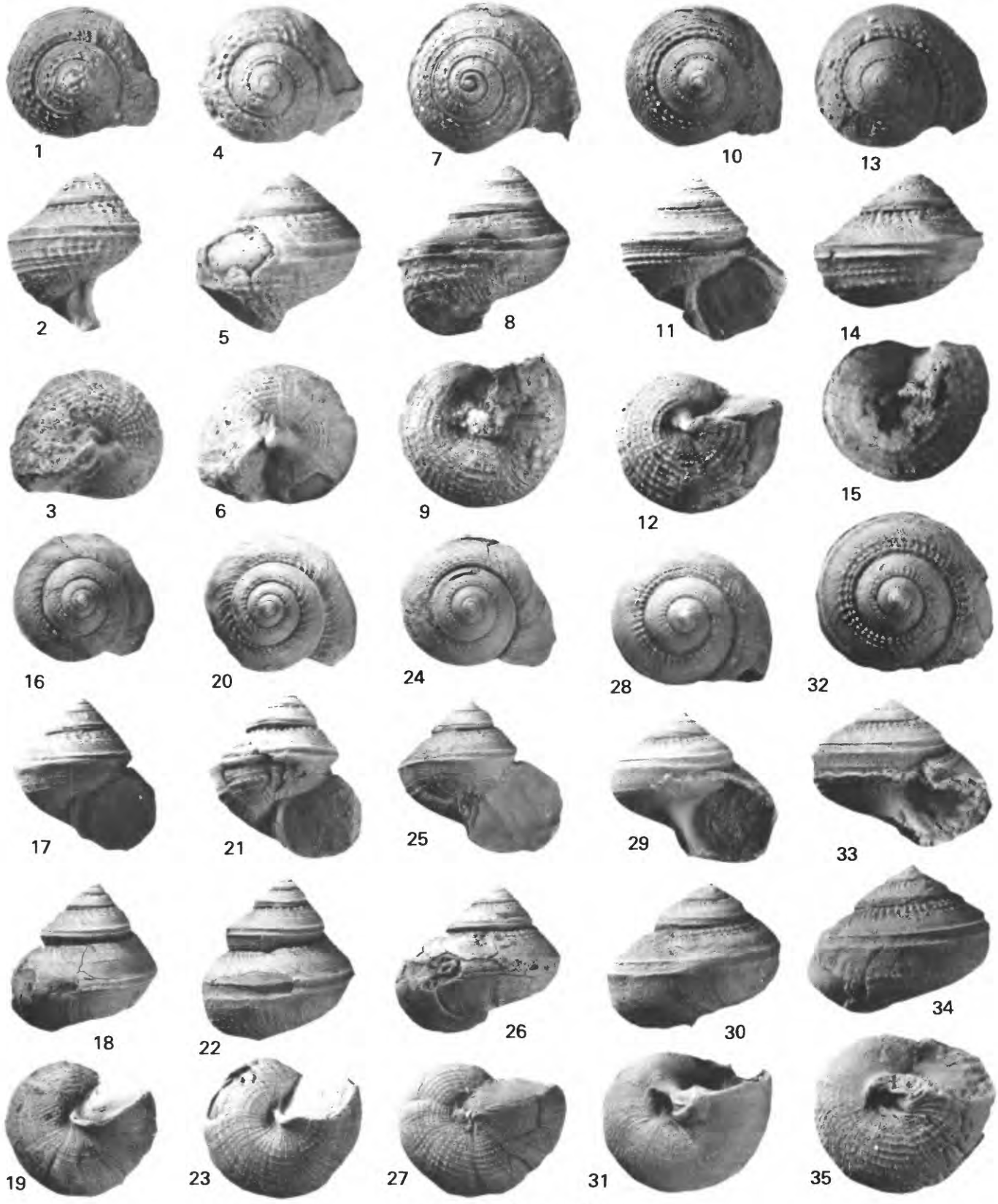
16–19. Apical, apertural, abapertural, and basal views (× 1 1/2) of holotype (USNM 210990) from USGS colln. 25264–PC, Jensen Wash section, Burbank Hills.

20–27. Same views (× 2) of two paratypes (USNM 210991, 210992) from same collection.

28–35. *Glabrocingulum* (*Glabrocingulum*) *binodosum* Sadlick and Nielsen (p. 63).

28–31. Apical, apertural, abapertural, and basal views (× 3) of a hypotype (USNM 211059) from USGS colln. 22883–PC, Foote Range.

32–35. Same views (× 4) of another hypotype (USNM 211004) from same collection.



GLABROCINGULUM

PLATE 6

FIGURES 1–3, 12. *Glabrocingulum* (*Glabrocingulum*) *granulosum* n. sp. (p. 59).
Apical, basal, and apertural views (× 2) and larger oblique view (× 4) of holotype (USNM 210984) from USGS colln. 17020–PC, Granite Mountain section.

4–10. *Glabrocingulum* (*Ananias*) *seminudum* Gordon and Yochelson (p. 66).
4–7. Apertural, apical, side, and basal views (× 4) of a specimen (USNM 211063) from USGS colln. 25319–PC, Burbank Hills.
8–10. Enlarged apertural, apical, and basal views (× 2) of holotype (USNM 211060) from USGS colln. 23836–PC, Diamond Peak Formation, White Pine Range, Nev.

11. *Glabrocingulum* (*Glabrocingulum*) *quadrigatum* Sadlick and Nielsen, variant (p. 61).
Abapertural view (× 2) of a hypotype (USNM 211002) from USGS colln. 17023–PC, Foote Range.

13, 14. *Glabrocingulum* (*Glabrocingulum*) *confusionense* n. sp. (p. 60).
Oblique views (× 5) showing typical spires of two paratypes (USNM 210997, 210998) from USGS colln. 15165–PC, Jensen Wash section, Burbank Hills.

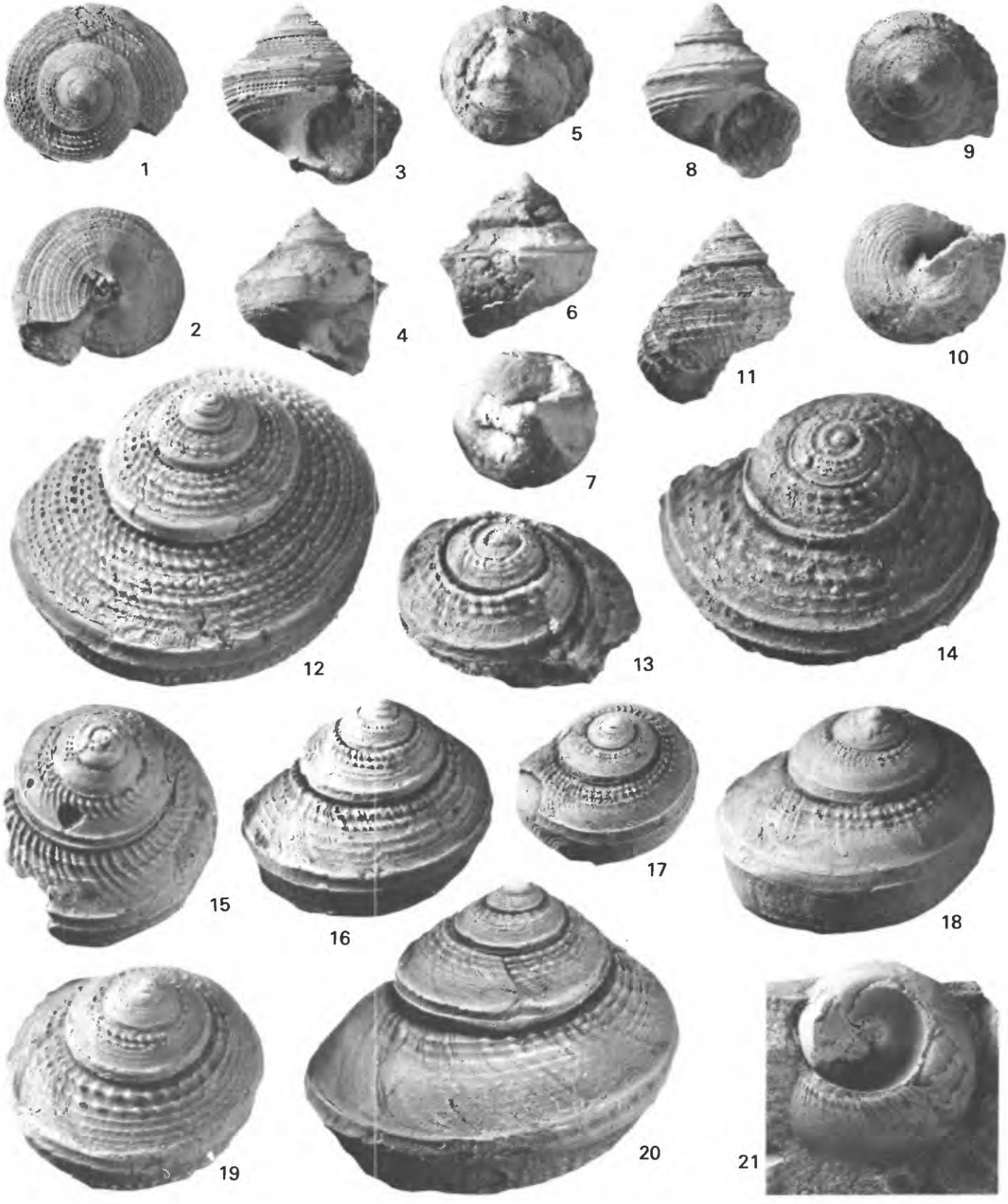
15. *Glabrocingulum* (*Glabrocingulum*) *mephitifontis* n. sp. (p. 59).
Oblique view (× 5), showing details of spire of holotype (USNM 210988) from USGS colln. 15354–PC, Skunk Spring section, Confusion Range.

16, 19. *Glabrocingulum* (*Glabrocingulum*) *quadrigatum* Sadlick and Nielsen (p. 61).
Oblique views (× 5) of two hypotypes showing details of typical spire (USNM 211000, 211001) from USGS colln. 17310–PC, Burbank Hills.

17, 18. *Glabrocingulum* (*Glabrocingulum*) *binodosum* Sadlick and Nielsen (p. 63).
Oblique views (× 4, × 5) of two hypotypes (USNM 211004, 211059) from USGS loc. 22883–PC, Foote Range.

20. *Glabrocingulum* (*Glabrocingulum*?) *hosei* n. sp. (p. 65).
Oblique view (× 4), showing details of spire of holotype (USNM 210990) from USGS colln. 25264–PC, Jensen Wash section, Burbank Hills.

21. *Glabrocingulum* (*Glabrocingulum*) sp. C. (p. 64).
Apical view (× 3) of broken specimen showing sculptural details (USNM 211006) from USGS colln. 15370–PC, Foote Range.



GLABROCINGULUM

PLATE 7

FIGURES

1–5. *Worthenia* (*Yochelsonospira*) *tenuilineata* Girty (p.76).
1, 2. Apical and side views (× 2) of well-preserved specimen (USNM 211018) from USGS colln. 17023–PC, Foote Range.
3–5. Apical, apertural, and basal view (× 2) of another specimen (USNM 211019) from USGS colln. 17310–PC, Burbank Hills.

6–8. *Glabrocingulum* (*Glabrocingulum*) *mephitifontis* n. sp. (p. 59).
Apical, apertural, and basal views (× 3) of holotype (USNM 210988) from USGS colln. 15354–PC, Skunk Spring section, Confusion Range.

9–15. *Deseretospira monilifera* n. gen., n. sp. (p. 56).
9–12. Apical, apertural, basal, and oblique views (× 2) of holotype (USNM 210980) from USGS colln. 25264–PC, Jensen Wash section, Burbank Hills.
13–15. Enlarged oblique, apertural, and basal views (× 2) of paratype (USNM 210981) from USGS colln. 22857–PC, same locality.

16, 17. *Glabrocingulum* (*Glabrocingulum*) sp. B (p. 64).
Apertural and apical views (× 3) of specimen (USNM 211005) from USGS colln. 22880–PC, Conger Range.

18–20. *Cinclidonema* sp. (p. 86).
Oblique apical, abapertural, and apertural views (× 1) of specimen (USNM 211026), from USGS colln. 28628–PC, Granite Mountain section.

21. *Glabrocingulum* (*Glabrocingulum*) sp. A (p. 63).
Adapertural view (× 3) of specimen (USNM 211004) from USGS colln. 17018–PC, Granite Mountain section.

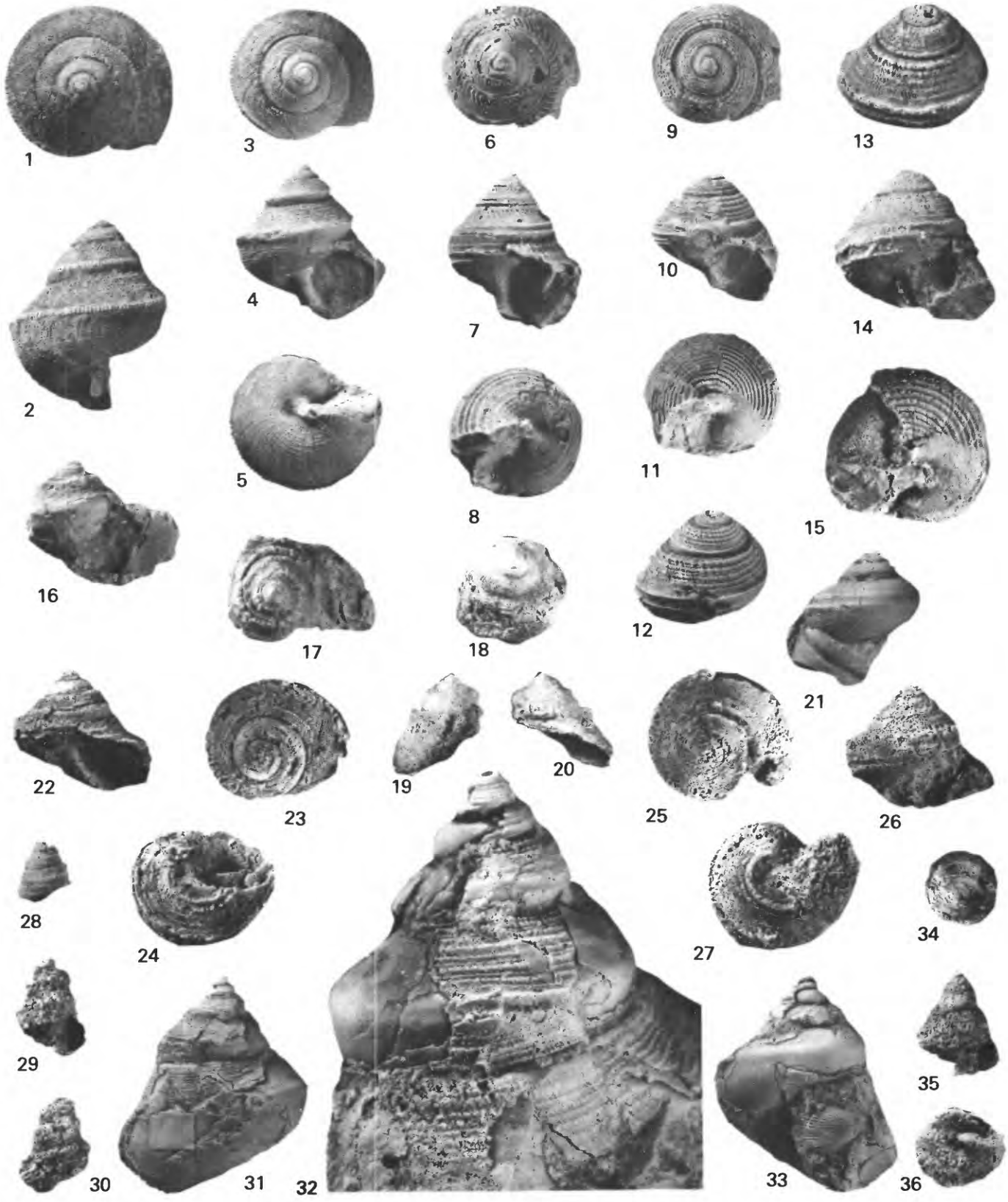
22–27. *Catazona rudilirata* Gordon and Yochelson (p.78).
22–24. Apical, apertural, and basal views (× 2) of silicified specimen (USNM 211024) from USGS colln. 17214–PC, Wallet Gulch section.
25–27. Same views (× 2) of another silicified specimen (USNM 211025) from same collection.

28. *Neilsonia* sp. (p. 67).
Side view (× 5) of silicified specimen (USNM 348022) from USGS colln. 25252–PC, Granite Mountain section.

29, 30. *Baylea*? sp. (p. 49).
Abapertural and apertural view (× 4) of silicified specimen (USNM 211070) from USGS colln. 25566–PC, Wallet Gulch section.

31–33. *Glabrocingulum* (*Ananias*) *nevadense* (Walcott) (p. 66).
Abapertural view (× 1), view showing details of spire (× 3), and apertural view (× 1) of lectotype (USNM 14110) from USGS colln. 651 (Old Series). Diamond Peak Formation at conical hill near Eureka, Nev. Included for comparison.

34–36. *Dictyotomaria?* sp. (p. 79).
Apical, apertural, and basal views (× 3) of silicified specimen (USNM 211071) from USGS colln. 25566–PC, Wallet Gulch section.



WORTHENIA, GLABROCINGULUM, DESERETOSPIRA, CINCLIDONEMA, CATAZONA, NEILSONIA, BAYLEA?, DICTYOTOMARIA?

PLATE 8

FIGURES

1–4. *Platyceras* (*Platyceras*) cf. *P.* (*P.*) *subrotundum* Snider (p. 85).
Side, abapertural, basal, and apertural views (× 2) of fairly well preserved specimen (USNM 211029) from USGS colln. 17059–PC, Jensen Wash section, Burbank Hills.

5. *Anematina* sp. (p. 87).
Abapertural view (× 5) of a specimen (USNM 348024) from USGS colln. 25260–PC, Foote Range.

6–8. *Strophostylus* cf. *S. nevadensis* Gordon and Yochelson (p. 86).
Apical, apertural, and abapertural views (× 4) of well-preserved specimen (USNM 211079) from USGS colln. 25252–PC, Granite Mountain section.

9–12, 32, 33. *Naticopsis* (*Jedria*?) sp. (p. 90).
Apical, apertural, abapertural, and basal views (× 1), and apertural and apical views (× 2) of specimen (USNM 348026) from USGS colln. 25563–PC, Skunk Spring section, Confusion Range.

13–18, 26. *Naticopsis* (*Naticopsis*) *confusionensis* n. sp. (p. 88).
13–15, 26. Apical, apertural, and abapertural views (× 2) and larger apical view (× 4) of holotype (USNM 211030) from USGS colln. 20547–PC, Granite Mountain section.
16–18. Apical, apertural, and abapertural views (× 2) of paratype (USNM 211031) from USGS colln. 17021–PC, Conger Spring area, Confusion Range.

19, 20, 25. *Naticopsis* (*Naticopsis*) cf. *N.* (*N.*) *genevievensis* Meek and Worthen (p. 89).
19, 25. Apical (× 3) and larger apical (× 5) views of incomplete immature paratype (USNM 211034) from USGS colln. 15362–PC, Skunk Spring section, Confusion Range.
20. Side view (× 2) of specimen (USNM 211033) from USGS colln. 15355–PC, Skunk Spring section, Confusion Range.

21–24. *Straparollus* (*Euomphalus*) sp. (p. 84).
Abapertural, apical, apertural, and basal views (× 1) of specimen (USNM 348023) from USGS colln. 15161–PC, Needle Range.

27, 28. *Ianthinopsis* sp. B? (p. 96).
Apical and abapertural views (× 2) of specimen (USNM 211053) from USGS colln. ?17208–PC, Jensen Wash section, Burbank Hills.

30, 31. *Ianthinopsis* sp. B (p. 95).
Abapertural view (× 3) and abapertural and apertural views (× 2) of specimen (USNM 211057) from USGS colln. 25551–PC, Foote Range.

34–38. *Naticopsis* (*Naticopsis*?) *clinovata* n. sp. (p. 89).
34, 35. Apical and abapertural views (× 2) of holotype (USNM 211074) from USGS colln. 25252–PC, Granite Mountain area.
36–38. Apical, abapertural and apertural views (× 2) of paratype (USNM 211035) from USGS colln. 15355–PC, Skunk Spring section, Confusion Range.

PLATYCERAS, ANEMATINA, STROPHOSTYLUS, NATICOPSIS, STRAPAROLLUS, IANTHINOPSIS

PLATE 9

FIGURE

1. *Pseudozygopleura (Pseudozygopleura) repenningi* n. sp. (p. 92).
   Side view (× 4) of holotype (USNM 211044) from USGS colln. 17209–PC, Jensen Wash section, Burbank Hills.

2, 3. *Pseudozygopleura (Stephanozyga) claviger* n. sp. (p. 93).
   2. Side view (× 2) of holotype (USNM 211045) from USGS colln. 15355–PC, Skunk Spring section, Confusion Range.
   3. Side view (× 2) of paratype (USNM 211046) from same collection.

4, 5. *Bulimorpha* sp. (p. 94).
   Abapertural and apertural views (× 4) of silicified specimen (USNM 211072) from USGS colln. 25566–PC, Wallet Gulch section, Confusion Range.

6, 7. *Pseudozygopleura (Pseudozygopleura)? lauta* n. sp. (p. 92).
   Abapertural views (× 4, × 8) of holotype (USNM 211042) from USGS colln. 17208–PC, Jensen Wash section, Burbank Hills.

8, 9. *Meekospira?* sp. (p. 98).
   Abapertural and apertural views (× 2) of silicified specimen (USNM 211056) from USGS colln. 25566–PC, Wallet Gulch section, Confusion Range.

10. *Meekospira* sp. (p. 97).
   View (× 3) of specimen (USNM 211055) from USGS colln. 25274–PC, Foote Range.

11–15. *Bellazona bella* (Walcott) (p. 80).
   11, 12. Abapertural and apertural views (× 3) of specimen (USNM 211037) from USGS colln. 17018–PC, Granite Mountain.
   13, 15. Side views (× 2, × 3) of holotype (USNM 14410) from USGS colln. 651 (Old Series). Diamond Peak Formation at conical hill near Eureka, Nev.
   14. Abapertural detail (× 4) of holotype.

16, 17. *Stegocoelia (Stegocoelia)* sp. (p. 80).
   Views (× 5) of a specimen (USNM 211036) from USGS colln. 17209–PC, Jensen Wash section, Burbank Hills.

18. *Pseudozygopleura (Pseudozygopleura)?* sp. (p. 92).
   View (× 4) of unique specimen (USNM 348030) from USGS colln. 25252–PC, Granite Mountain section.

19. Indeterminate high-spired gastropod (p. 99).
   View (× 3) of coarsely silicified slender shell (USNM 211069) from USGS colln. 25566–PC, Wallet Gulch section, Confusion Range.

20, 21. *Ianthinopsis?* sp. (p. 96).
   Abapertural and apertural views (× 3) of specimen (USNM 211051) from USGS colln. 17018–PC, Granite Mountain section.

22–25. *Bellazona polita* n. sp. (p. 81).
   22. Abapertural view (× 3) of incomplete paratype (USNM 211040) from USGS colln. 17012–PC, Granite Mountain section.
   23. Apertural view (× 3) of another paratype (USNM 211039) from same collection.
   24, 25. Side and apertural views (× 3) of holotype (USNM 211038) from same collection.

26, 27. *Ianthinopsis* sp. A (p. 95).
   Abapertural and apertural views (× 5) (a *Posidonia* is in the aperture, not an operculum) of specimen (USNM 211050) from USGS colln. 15370–PC, Foote Range.

28, 29. *Girtyspira circumsecta* n. sp. (p. 98).
   Apertural and abapertural views (× 3) of holotype (USNM 348028) from USGS colln. 25271–PC, Skunk Spring section, Confusion Range.

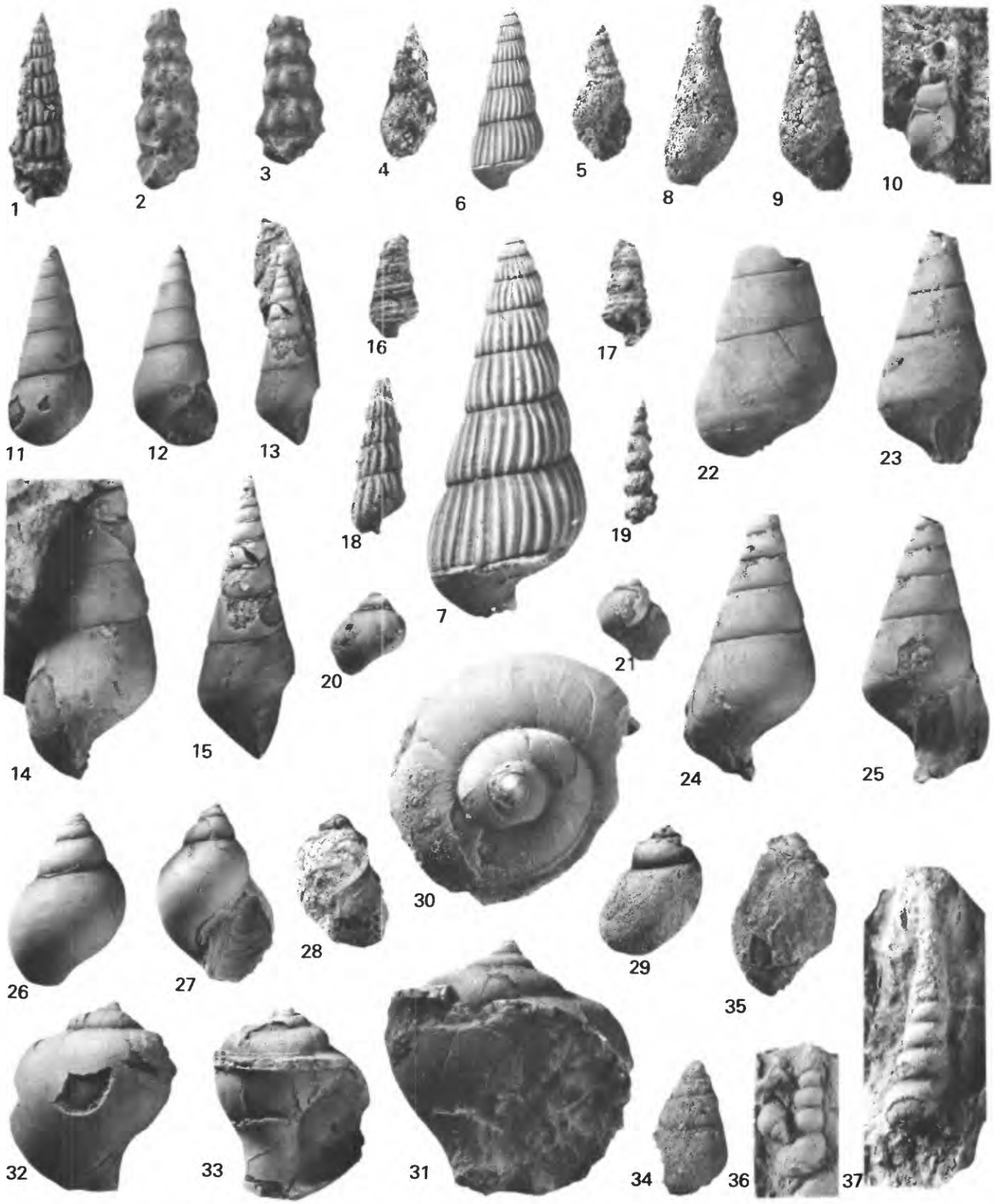
30–33. *Ianthinopsis gandyensis* n. sp. (p. 95).
   30, 31. Apical and apertural views (× 5) of holotype (USNM 211047) from USGS colln. 22883–PC, Foote Range.
   32, 33. Abapertural and apertural views (× 3) of paratype (USNM 211048) from same collection.

34. *Soleniscus* sp. B (p. 97).
   Abapertural view (× 5) of specimen (USNM 211054) from USGS colln. 17021–PC, Conger Mountain section, Confusion Range.

35. *Soleniscus* sp. A (p. 96).
   Side view (× 2) of specimen (USNM 211052) from USGS colln. 17188–PC, Jensen Wash section, Burbank Hills.

36. *Loxonema?* sp. (p. 91).
   View (× 4) of specimen (USNM 348025) with *Anematina* sp. from USGS colln. 25260–PC, Bishop Springs anticline, Foote Range.

37. *Loxonema* sp. (p. 91).
   View (× 12) of specimen (USNM 348027) from USGS colln. 25558–PC, Granite Mountain.



PSEUDOZYGOPLEURA, BULIMORPHA, MEEKOSPIRA?, MEEKOSPIRA, BELLAZONA, STEGOCOELIA, IANTHINOPSIS?, IANTHINOPSIS, GIRTYSPIRA, SOLENISCUS, LOXONEMA?, LOXONEMA