

AMERICAN MUSEUM *Novitates*

PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT 79TH STREET, NEW YORK, N.Y. 10024
Number 2958, 64 pp., 11 plates
November 28, 1989

Permian Gastropoda of the Southwestern United States. 7. Pleurotomariacea: Eotomariidae, Lophospiriidae, Gosseletinidae

ROGER L. BATTEN¹

ABSTRACT

This is the concluding portion of a study of Permian pleurotomarian gastropods from the southwestern United States and involves four families: Eotomariidae, Raphistomatidae, Sinuopeidae, and Gosseletinidae. The gastropod fauna from this region is the richest and most diverse from the known Permian of the world. In this study, 12 genera (one is new, *Manzanospira*) and 51 species are described, 36 of which are new. Over 14,000 specimens were studied. The family Eotomariidae is represented by the tribe Eotomariides of the subfamily Eotomariinae (10 species are described, all of which are new). The tribe Eotomariides includes *Glabrocingulum* and *Ananias* (formerly included as a subgenus of *Glabrocingulum*). The new species are: *Glabrocingulum* (*Glabrocingulum*) *diablo*, *G. (G.) texanum*, *G. (G.) lupus*, *G. (G.) alveozonum*, *G. (Stenozone) carlsbadensis*, *Ananias labrectus*, *A. permianus*, *A. ootomaria*, and *A. appeli*. The tribe Ptychomphalides is represented by a single new species, *Ambozone dictyonema*. The subfamily Neilsoni-

inae includes 10 species of *Apachella* Winters, 1962, 5 of which are newly recognized: *Apachella exaggerata*, *A. glabra*, *A. mulensis*, *A. nodosa*, and *A. huecoensis*. *Peruvispira delicata*, also a member of this subfamily, is one of the most commonly encountered small-size snails of the Permian in western North America. Finally, two new species of *Hesperiella*, *H. permianus* and *H. wordensis* in the subfamily Agnesiinae, complete the family Eotomariidae.

The family Gosseletinidae is represented by *Platyzona* (four new species: *P. rotunda*, *P. cancellata*, *P. pagoda*, *P. anguispira*) and *Gosseletina* (one new species, *G. permiana*). The family Sinuopeidae is represented by a single new species of *Colpites*, *C. striata*. The family Raphistomatidae includes two subfamilies. The Omospirinae observed here are *Baylea* (one new species, *B. huecoensis*), *Callistadia* (one species), and *Hypselenotoma* (one new species, *H. ornata*). The other subfamily, Ruedemanniinae, is represented by the most diverse genus of the pleurotomarians of this

¹ Curator Emeritus, Department of Invertebrates, American Museum of Natural History.

study: *Worthenia* with 13 species, 9 of which are new, and by the new genus *Manzanospira* with three species, two of which are new. The new *Worthenia* species are: *W. kingi*, *W. alticarinata*, *W.*

crenulata, *W. multilineata*, *W. bicarinata*, *W. bialveozona*, *W. latialveozona*, and *W. planalveozona*. The new species of *Manzanospira* are: *M. carinata* and *M. wordensis*.

INTRODUCTION

This current study will complete the description of pleurotomarian gastropods from the southwestern Permian. The first half was published by the author in 1958. The Permian of the southwestern United States includes an enormous variety of ecologic niches and habitats ranging from hypersaline back-reef lagoons to deep-water organic mud bottoms. Gastropods are found in most of these, usually a few individuals representing a small number of species. However, in some formations such as the Hueco, they are found in enormous numbers, but again just a few species and genera are represented. In this particular case the Hueco appears to have been deposited in a high-energy, offshore basin.

At other localities the gastropods are highly diverse and found in fairly large numbers, usually associated with sponges. The richest occurrence is in the patch reefs of the Lower Getaway Limestone (AMNH locality 512) in the Guadalupe Mountains of west Texas. With some 150 species it is probably the most diverse of any known Paleozoic or Mesozoic gastropod fauna. Other "patch" reefs in the Leonard, Road Canyon, and Word Formations of the Glass Mountains also contain important, diverse gastropod faunas. There is a possibility that these "patch" reefs may be transported clasts (Yancey, 1988, personal commun.).

The modern study of the Permian fossils of the southwestern United States began in 1939 when G. A. Cooper went to the Glass Mountains to collect Permian brachiopods described by King (1931). Among his many contributions was the discovery that a staggering number of fossils were silicified and could be recovered by dissolving limestone blocks in several acids, with siliceous fossils as a residue. Over the next 30 years Cooper, and a number of other paleontologists, collected well over 73,000 pounds of limestone, primarily from the Permian sequences in the Glass Mountains of West Texas, producing

what certainly must be the largest collection of Permian fossils in the world. It is housed in the National Museum of Natural History in Washington, D.C. (Cooper and Grant, 1972). Cooper's primary contribution was the description of the enormous brachiopod fauna from these Permian deposits.

THE GASTROPOD STUDIES

The study of the gastropods of the southwestern U.S. Permian was initiated by J. B. Knight under an arrangement with G. A. Cooper (Cooper and Knight, 1946). Knight began his work in 1946 but soon realized that he would be unable to complete the task of studying the huge and growing collection of gastropods, and enlisted the help of two Columbia University graduate students, Ellis Yochelson and Roger Batten, in 1950. The first part of the study dealt with the euomphalaceans and several small superfamilies as a part of a doctoral dissertation (Yochelson, 1956). This was followed by a study of several pleurotomarian families also as a part of a doctoral dissertation (Batten, 1958). In 1960 Yochelson completed the study of the bellerophontids and patellaceans (Yochelson, 1960). Erwin in 1985 completed a study of the subulitaceans (Erwin, 1988a), the cerithiaceans, acteonaceans, and pyramidellaceans (Erwin, 1988b) and is completing a study of the loxonemataceans (in part). Several major groups of gastropods remain to be studied, including the superfamilies Neritacea and the Loxonematacea. Two studies of Permian gastropods of Arizona, made by students of N. D. Newell, should be mentioned here. The first was a study of the Kaibab gastropods of Walnut Canyon by Halka Chronic (1952) and the second a study of the Supai gastropods of eastern Arizona by S. S. Winters (1956, 1963). Both of these faunas are small by Glass Mountains standards but contain important elements of the Permian gastropod fauna.

MATERIALS AND METHODS

Most of the specimens used in this study are silicified and were retrieved as a part of the enormous collecting program initiated by G. A. Cooper as mentioned above. The specimens collected and processed by AMNH workers began with Newell's early collecting (with Cooper) in the Glass Mountains of west Texas in 1941 and in the years following the war. Newell and his students made large collections in the Sierra Diablo Mountains (Stehli, 1954) and in the Guadalupe Mountains (Newell et al., 1953). These collections are housed in the American Museum of Natural History and served as a major source for this study.

The localities of the fossils are listed in the hypodigm or occurrence sections following the descriptions of each species and each museum type number under the measurements section. The description of each of these localities is listed in Cooper and Grant (1972), Batten (1958), Yochelson (1956, 1960), and Stehli (1954). The localities not reported in those works are listed in the locality register at the end of this paper.

ABBREVIATIONS AND DEFINITIONS

Institutions

AMNH	American Museum of Natural History
BSAC	Bone Spring Formation, Apache Canyon, Sierra Diablo Mountains, Texas, Princeton University Collection now housed at the National Museum of Natural History, Washington, D.C.
Kriz	Kriz Collection, Princeton University, from the Bone Spring Formation (above), now housed at the National Museum of Natural History
LANHM	Los Angeles County Natural History Museum
NPAC	Princeton University, North Portal of Apache Canyon, Sierra Diablo Mts., Texas, now housed at the National Museum of Natural History
USNM	National Museum of Natural History, Washington, D.C.

Specimen Measurements

Note: All measurements in this study are in millimeters.

H	total height of the shell
W	total width of the shell

Hw	height of the adult whorl
SPANG	spiral angle, measured at suture contacts
SS	distance between the suture and the upper selenizone margin
SW	width of the selenizone
Wh	height of the outer whorl face or alveozone
CBS	distance between lower selenizone margin and place on whorl where whorls embrace (the suture position)

Note: Alveozone is that portion of the outer whorl face between the lower selenizone margin and the first major basal spiral element, usually distinctly marked by changes in the ornament pattern and shape.

THE SYNOPTIC CLASSIFICATION

Note: The numbers following the species citation date are the sample sizes used in this study.

Superfamily Pleurotomariacea

Family Eotomariidae Wenz, 1938

Subfamily Eotomariinae Wenz, 1938

Tribe Eotomariides Wenz, 1938

Glabrocingulum (*Glabrocingulum*) *coronatum* Chronic, 1952, 3353

Glabrocingulum (*Glabrocingulum*) *diablo*, n. sp., 483

Glabrocingulum (*Glabrocingulum*) *texanum*, n. sp., 111

Glabrocingulum (*Glabrocingulum*) *lupus*, n. sp., 6

Glabrocingulum (*Glabrocingulum*) *alveozonum*, n. sp., 13

Glabrocingulum (*Stenozone*) *carlsbadensis*, n. sp., 3

Ananias labrectus, n. sp., 1395

Ananias permianus, n. sp., 221

Ananias ootomaria, n. sp., 86

Ananias appeli, n. sp., 3

Tribe Ptychomphalides Wenz, 1938

Ambozone dictyonema, n. sp., 8

Subfamily Neilsoniinae Knight, 1956

Apachella translirata Winters, 1963, 175

Apachella franciscana Chronic, 1952, 1523

Apachella exaggerata, n. sp., 240

Apachella turbiniiformis Winters, 1963, 79

Apachella pseudostrigillata Girty, 1934, 73

Apachella glabra, n. sp., 451

Apachella mulensis, n. sp., 24

Apachella nodosa, n. sp., 679

Apachella prodontia Winters, 1963, 932

Apachella huecoensis, n. sp., 102

Neilsonia laticincta, n. sp., 2

Peruvipsira delicata Chronic, 1949, 1290

- Subfamily Agnesiinae Knight, 1956
Hesperella permianus, n. sp., 10
Hesperella wordensis, n. sp., 8
- Family Gosseletinidae Wenz, 1938
 Subfamily Coelozoninae Knight, 1945
Platyzona rotunda, n. sp., 15
Platyzona cancellata, n. sp., 36
Platyzona pagoda, n. sp., 16
Platyzona anguispira, n. sp., 3
- Subfamily Gosseletininae Wenz, 1938
Gosseletina permiana, n. sp., 35
- Family Sinuoidea Wenz, 1838
 Subfamily Platyschismatinae Wenz, 1938
Colpites striata, n. sp., 75
- Family Raphistomatidae Koken, 1896
 Subfamily Omospirinae Wenz, 1938
Baylea huecoensis, n. sp., 47
Baylea cf. *supracrenata* Weller, 1929, 1
Callistadia bella Knight, 1945, 58
Hypselenotoma ornata, n. sp., 27
- Subfamily Ruedemanniinae Wenz, 1938
Worthenia tabulata (Conrad), 1835, 86
Worthenia speciosa (Meek and Worthen), 1861, 145
Worthenia kingi, n. sp., 38
Worthenia alticarinata, n. sp., 273
Worthenia crenulata, n. sp., 24
Worthenia arizonensis Winters, 1962, 395
Worthenia multilineata, n. sp., 574
Worthenia bicarinata, n. sp., 3
Worthenia pilula, n. sp., 10
Worthenia corrugata Chronic, 1952, 54
Worthenia bialveozona, n. sp., 90
Worthenia latialveozona, n. sp., 243
Worthenia planalveozona, n. sp., 4
Manzanospira manzanicum Girty, 1909, 156
Manzanospira carinatum, n. sp., 5
Manzanospira wordensis, n. sp., 16

SYSTEMATIC PALEONTOLOGY

FAMILY EOTOMARIIDAE WENZ, 1938

SUBFAMILY EOTOMARIINAE WENZ, 1938

DESCRIPTION: Relatively low-spined to moderately high-spined pleurotomarians with medially located selenizones and moderately deep slits. Phaneromphalus to anomphalus with associated callus deposits. Spiral and/or collabral ornament may be developed.

DISCUSSION: This subfamily characteristically has a selenizone which is flush with the whorl surface, at or near the whorl periphery, with well-developed margins which may be complicated or simple in development, for

example, *Euconospira* Ulrich in Ulrich and Scofield (1897) (see Batten, 1958: 229) or *Glabrocingulum* Thomas, 1940, below.

The tribe Eotomariides and the subfamilies Neilsoniinae and Agnesiinae are described below. The tribe Ptychomphalides (including descriptions of *Spiroscala*, *Shwedagonia*, *Euconospira*, *Eirlysia*, and *Lacunospira*) were described by Batten (1958). *Ambozone dictyonema*, n. sp., is included in the present work as a member of this tribe because in the 1958 study it was believed that this species belonged to *Porcellia* LeVeille, 1835 (*Porcelliidae* Broili, 1924).

TRIBE EOTOMARIIDES WENZ, 1938

DESCRIPTION: Low- to moderately high-spined pleurotomarians with deep slits generating selenizones located at periphery of shell. Margins of selenizone rounded or flattened, uncomplicated.

DISCUSSION: This group of genera is separable from the ptychomphalids by the relatively invariate nature of the selenizone margin. The position of the selenizone varies as with the ptychomphalids but the margins are more simply constructed.

Glabrocingulum Thomas, 1940

TYPE SPECIES: *G. beggi* Thomas, 1940.

DESCRIPTION: Embryonic whorls globose, with dominant spiral ornament. Embryonic selenizone flat and ornamented by spiral threads. Moderately low- to high-spined shells with concave, flat, smooth, rather narrow selenizone at upper edge of outer whorl face, forming less than 45° angle. Slit moderately deep. Sutures sharply defined, whorls embrace at lower margin of outer whorl face (base of alveozone). Upper whorl face with both spiral and collabral ornament with strongest development near suture, weakest near selenizone. Alveozone gently concave with prominent ornament. Base rounded to slightly flattened with stronger ornament than alveozone. Anomphalus to widely phaneromphalus, with or without funicle.

DISCUSSION: The group of species belonging to this genus includes a wide spectrum of morphological variability. They are commonly found in most faunas of the Upper Paleozoic and in the Lower Mesozoic. Most

characters intergrade, resulting in overlapping of some features between many species, particularly in the Carboniferous. Three related genera, formerly considered subgenera, are *Glabrocingulum* Thomas, 1940, which contains species that are essentially low spired and have sutural nodes; *Ananias* Knight, 1945, high-spired turreted forms; and *Stenozone* Batten, 1972, large, mostly globose species with dominant spiral ornament found primarily in the Southern Hemisphere and in the Tethyan of eastern Asia.

THE SELENIZONE COMPLEX

Perhaps the most important character that holds these *Glabrocingulum* species together is the selenizone complex. The position that the selenizone occupies on the upper edge of the outer whorl face at the junction is invariable, forming a 45° angle with the nearly vertical outer whorl face. In general, the nature of the complex is somewhat controlled by the relative size, shape, and disposition of the upper and outer whorl face. The nature of the selenizone margins is entirely dependent on the degree of ornament development, weaker-ornamented species such as *Glabrocingulum diablo*, n. sp., have barely recognizable margins.

The selenizone may be more or less pronounced depending on the relative degree of ornament development. If the ornament is weakly developed or absent, the selenizone surface will form a continuum with the shell surface, as seen in *G. diablo*. When the ornament is fully developed the selenizone is raised above the shell surface, as in *G. grayvillense* Norwood and Pratten, 1855. The selenizone margins are usually well developed, probably because of the depth of the slit (shallow slits generate weak margins). In *Glabrocingulum* the selenizone margins are usually well rounded and smoothly sculptured, but the degree of emphasis again is related to the degree of ornament development.

In proportion to the general appearance of the whorl, the selenizone appears rather narrow, but this depends on the height of the whorl, the shape of adjacent shell surfaces, and ornament development.

The shape of the selenizone surface is somewhat variable. It can be stable or quite

variable within a population or a species. The margins are partly responsible for the appearance of the selenizone; strong margins make the selenizone appear more concave. The selenizone surface varies from flat to concave and has one or more revolving lirae. The selenizone is concave when narrow and somewhat flattened when broad and the margins are weak. Lunulae development is entirely related to the degree of collabral ornament development.

SHELL HEIGHT AND WIDTH

The primary attribute that distinguishes the genera *Glabrocingulum* and *Ananias* is the height of spire relative to width of shell (see Schindel, 1982). Several factors are involved in this feature. The most obvious is the position of the suture on the whorl.

The suture in the low-spired species (of *Glabrocingulum*) usually is placed at the lower margin of the selenizone; but in the early ontogeny of some species it may even obscure the selenizone. In the higher-spired species of *Ananias*, considered until this study as a subgenus of *Glabrocingulum*, the suture is positioned well below the lower selenizone margin even in early ontogeny. In the lower-spired species assigned to *Glabrocingulum*, it is in the middle of the alveozone. There is much variation of this feature and even in the lower-spired species there is a tendency for the adult whorl to uncoil; that is, the suture migrates down from the lower selenizone margin to the middle of the alveozone in some of the larger specimens of *G. grayvillense* from the Wayland Shale (Pennsylvanian) of North Central Texas. In the Lower Carboniferous *G. armstrongi* Thomas, 1940, from Scotland, there is a complete transition between the low-spired condition and the high-spired. This would require that high-spiredness be considered invalid as a subgeneric character. However, in most species throughout the range of the genus, this feature does separate *Ananias* and *Glabrocingulum*.

Another factor influencing shell height is the width of the outer whorl face (synonymous with the alveozone in this genus). The slope of this face, whether inward or outward, may be fairly consistent in some species such as *G. diablo* or it may vary within populations

as in *G. neotexanum*, n. sp. In some species (such as *G. coronatum*) the outer whorl face is very wide and nearly vertical, giving the shell a very high-spined appearance.

The shape and width of the upper whorl face also is involved in the height of the shell, measured from the upper selenizone margin to the suture. This distance (SS) is related to the angle the surface makes with the outer whorl face and the axis of the shell. Its maximum development can be seen in the species *G. lupus*, n. sp., and minimum development in *G. neotexanum*. The shape of this surface is also related to the whorl profile particularly in the turreted species of *Ananias*. In *Ananias welleri* Newell, 1935, it is formed by the placement of the suture at the lower whorl face angulation, or by an almost vertical outer whorl face or by a rather flattened, highly inclined upper whorl face which forms a low angle with the outer whorl face. In general, the outer whorl face is convex near the suture and concave near the selenizone. It may be equally convex and concave as in *G. armstrongi* or mostly concave with the convex portion confined to near the suture.

ORNAMENT

Thus far, I have discussed height of spire as being important in distinguishing subgenera. Another obvious feature, ornament, is far more difficult to analyze. It is variable but with repetitive patterns in each group. In the earliest species found in the Devonian, the ornament is subdued, consisting of very fine and evenly spaced spiral threads, with reduced collabral ornament, and with no sutural nodes. In the Mississippian and Pennsylvanian species of *Glabrocingulum*, a reticulate pattern is dominant, with interference nodes at intersections of collabral and spiral ornament, giving a beaded appearance. The intensity of this ornament increases toward the suture (see *G. grayvillense* in Schindel, 1982: fig. 3). Although this ornament pattern is common and highly distinctive, it is not representative of most species within the genus. For example, most Devonian and Permian species lack collabral ornament.

Ornament also seems dependent, in a general way, on the environment. Mississippian and Pennsylvanian species in Europe and

North America tend to have the strongly developed reticulate pattern, discussed above, when they occur in black shale facies. Those species living in high-energy situations near reefs, as in the Virgilian reefs (Magdalena Formation) of west Texas, have reduced ornament with spiral ornament missing, as in the case of the Permian species.

On the convex portion of the upper whorl surface, the ornament is at its fullest development, and is where sutural nodes will be found. They are formed in two ways: one, by the merging of several interference nodes developed on the spiral lirae which bunch up near the suture; and two, by a doming of the shell to form elongated ridges (pl. 2, figs., 1, 13) or by a combination of the two.

One or more spiral lirae are used to form these sutural nodes. The upper of these is usually the strongest in development (see the holotype *G. beggi* Thomas, 1940). In other cases, numerous weaker spiral threads of equal intensity may develop (see *G. armstrongi* Thomas, 1940, or *G. neotexanum*, n. sp.).

THE ALVEOZONE

The alveozone is concave in most species, varying in width and ornament. The ornament is distinctive, tending to resemble that of the lower upper whorl face near the selenizone. Without exception the spiral ornament is dominant. If collabral ornament is present, it tends to be more fully expressed near the lower margin where it grades into the basal ornament pattern. The spiral elements may be fine and uniformly spaced as in *G. (Stenozone)* Batten, 1972, or coarse and unevenly spaced as in *G. grayvillense* or *G. texanum*, n. sp.

THE BASE

The shape of the base is far less important in determining overall shape, but it may give the shell a more high-spined appearance if it is quite rounded as in *G. alveozonum*, n. sp. (pl. 3, fig. 8). The shape of the base varies from species to species depending on the roundness or turreted appearance of the whorl profile and on whether the shell is anomphalus, as in *G. grayvillense* or widely phaneromphalus, as in *G. umbilicatus* Batten, 1972.

The ornament, if present, tends to be more intense toward the upper margin of the base and, in some cases, near the umbilicus. It is less variable than in other parts of the whorl surface. A funicle is usually present, either as a slight thickening of the columellar lip, as in *G. grayvillense*, or as a very large callus occupying a large portion of the base as in *G. diablo*, n. sp. It may be sporadic in development within populations or uniformly developed within a species (see *G. diablo*). It tends to be more fully formed in those species having an open umbilicus.

PHYLOGENY

The earliest member of the *Ananias*-*Glabrocingulum* complex in North America is an undescribed species from the Devonian, Delaware Limestone of central Ohio. It is high spired and is assignable to *Ananias*; it has both collabral and spiral ornament with sutural nodes and a funicle. *G. subimbricata* (Whidbourne, 1891), and *G. victrix* (Whidbourne, 1891), are from Devonian strata in central Great Britain. They also are of the *Ananias* type and have evenly spaced fine spiral threads and faint collabral threads that are slightly reinforced growth lines. Some have faintly developed sutural nodes. They are phaneromphalus but have no funicle or columellar lip reflection. The early species of *Glabrocingulum* found in the Visean and Tournasian are heavily ornamented with interference nodes and sutural nodes very close to that found in *G. grayvillense*, are high spired, and show little relationship to the Devonian species. *G. beggi* and *G. armstrongi* are examples of this type in Europe. There is one undescribed low-spired form in the Visean of western England (Batten, 1966). Most lower Carboniferous species are high spired and well ornamented. However, *A. sowerbyi* (DeKoninck, 1843), and *A. grata* (DeKoninck, 1883), have all whorls (except the final one) with the whorl embracement at the lower selenizone margin, as in *Glabrocingulum*.

Pennsylvanian species that are low spired and well ornamented are found in black shales and limestones; this is true also of most of the Lower Carboniferous (Mississippian) species. For example, Sadlick and Neilson

(1963) and Gordon and Yochelson (1987) described several species from the Chainman Formation (Mississippian) of Utah which are very coarsely ornamented with interference nodes. The low-spired species with reduced ornament from western England is from the Hotwells Limestone, which is a warm shallow-water deposit near small reefs. In the Pennsylvanian of west Texas and New Mexico in the Magdalena group, unnamed species are also low spired and lack well-defined ornament (see also pl. 2, figs. 18, 19 from the Cambridge Limestone of Ohio). This suggests that there is a relationship between ornament and environment.

In brief, by Missourian time two distinct stocks are found in North America *G. grayvillense*, the low-spired form, and *A. welleri*, the high-spired form. These stocks persist until Guadalupian time. During the Permian a third and fourth stock emerge. *Ananias ootomaria*, n. sp., a moderately high-spired, globose form appeared in the west Texas Permian and probably was derived from the high-spired *A. permianus*, n. sp. Finally, the fourth stock, *G. (Stenozone) carlsbadensis*, n. sp., from the Middle Permian Carlsbad Limestone of New Mexico, characterized by reticulate ornament and rounded whorls, represents the *Stenozone* group found originally in the middle Permian (*Misellina claudiae* zone) of the Asian Tethys (Batten, 1972). The origin of that group is not certain.

THE TRIASSIC RHAPHISTOMELLA KITTL, 1891

Raphistomella radians (Wissmann, 1841), described from the Triassic of the Alps (see Zardini, 1978, for illustrations), is a low-spired species similar in shell shape to that of *G. grayvillense*. The collabral ornament also is similar in that there are sutural nodes and a convex alveozone has reduced ornament; there is no observed spiral ornament. The collabral elements are weaker than in the Pennsylvanian species on the upper and outer whorl surfaces but are stronger on the base. In all other essential features such as the depth of slit, selenizone development, tendency for the adult whorl to uncoil, and columellar lip reinforcement, this species has generic characteristics which are identical to that of *Gla-*

brocingulum and in fact they are synonymous. In all specimens that I have examined from the St. Cassian and in the photographs by Zardini, there is no continuous inductural-funicle deposit as illustrated in Kittl (1893) and in Knight et al. (1960). There is an open umbilicus surrounded by a ridge ornamented with elongate nodes. In many specimens from St. Cassian, there also are distinct nodes on the base adjacent to the circumbilical ridge which gradually fade out toward the periphery. The thickened columellar lip is reflexed at the junction of the lower and columellar lips.

The valid generic name of the Paleozoic species currently assigned to *Glabrocingulum* should be *Raphistomella*. However, for the sake of stability, I will ignore the priority of the latter generic name and continue to use *Glabrocingulum*. I lean on one important fact to justify this action: *Glabrocingulum* has been used widely in the literature throughout the world in the last 45 years. *Raphistomella* has been used a few times, mostly in faunal lists, since the beginning of the century.

PARALLELISM AND CONVERGENCE

There are several excellent examples of parallelism seen within the Permian species of *Glabrocingulum*, involving ornament, the

selenizone complex, and the inductural complex. The classic example of convergence between two families of gastropods is that of *Ananias welleri* Knight, 1945, and *Worthenia tabulata* Conrad, 1843. A multivariate study of this was done by Eldredge (1968).

Glabrocingulum (*Glabrocingulum*) *coronatum* Chronic, 1952

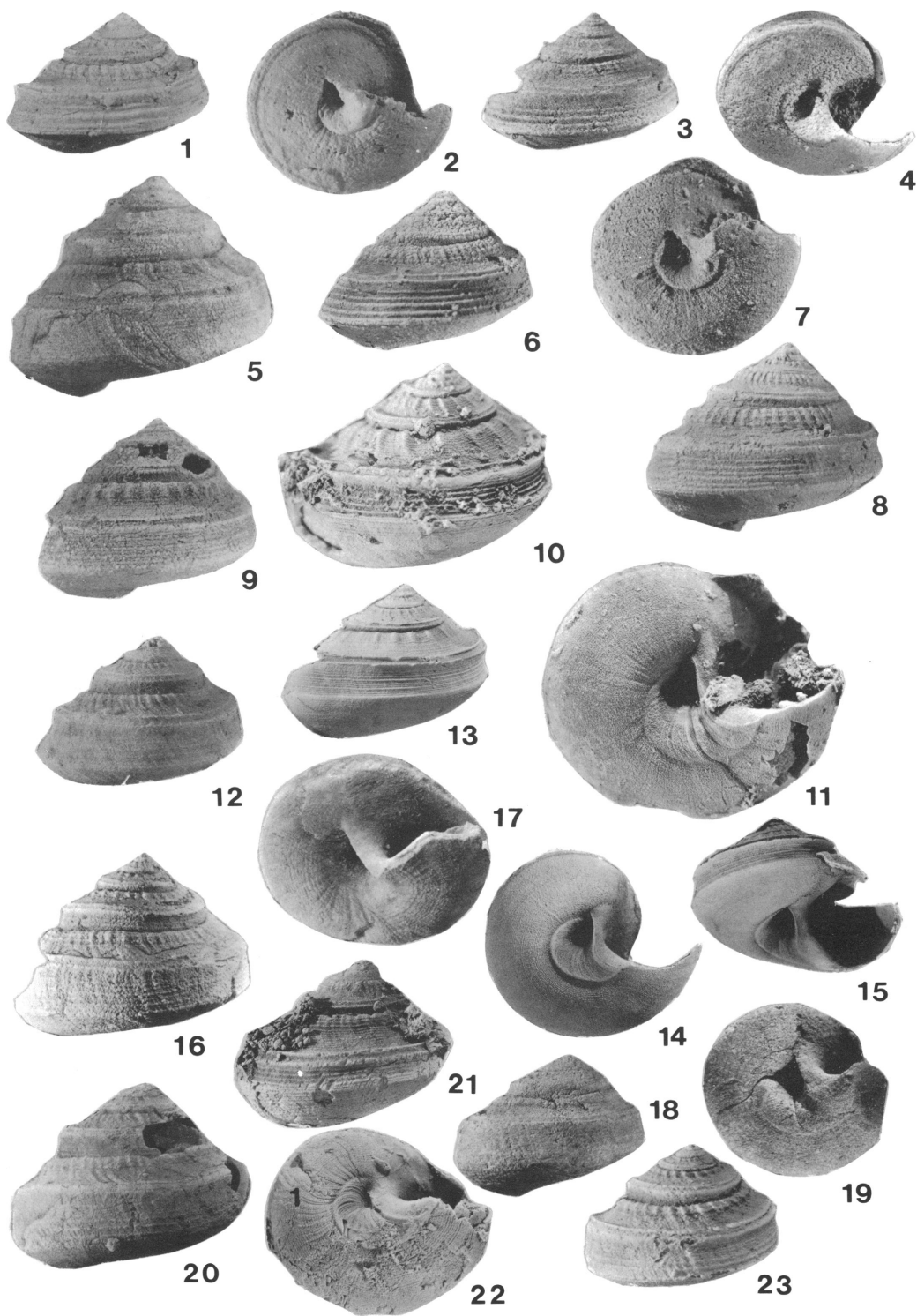
Plate 1, figs. 1–23;
plate 2, figs. 1–5

Glabrocingulum? *coronatum* Chronic, 1952: 118,
pl. 3, figs. 1–3.

DESCRIPTION: Moderate to low-spined forms which may uncoil in final whorl and which may develop spiral threads on alveozone. Selenizone develops on first two whorls and ornament one whorl later. Adults with five to seven whorls. Upper whorl surface (measurement SS) not high, forming low angle with outer whorl face (in most species this face synonymous with alveozone). Sutural nodes formed either by interference nodes (pl. 1, fig. 6), or by arching of surface (pl. 1, fig. 10). Collabral shell ornament restricted to sutural nodes, some specimens showing weakly developed collabral lirae that are slightly reinforced growth lines (pl. 1, fig. 23). Upper whorl surface with closely, evenly

Plate 1

Figs. 1–23. *Glabrocingulum* (*Glabrocingulum*) *coronatum* Chronic, 1952. Figs. 1, 2. USNM 431520, 707e, $\times 5$. 1. Side view, note prominent spiral threads in middle of alveozone and well-defined basal angulation. 2. Oblique basal view showing reflexed columellar lip and well-defined funicle ornamented with collabral ornament. Figs. 3, 4. USNM 431521, 707e, $\times 4$. 3. Side view. 4. Basal view, of same specimen, showing the very fine spiral ornament and deep groove marking the margin of the funicle. 5. AMNH 43600, 678, $\times 5$, side view showing flattened alveozone with fine spiral ornament. Figs. 6, 7. USNM 431522, 707e, $\times 4$. 6. Side view showing heavy development of spiral ornament on alveozone and narrow, numerous collabral sutural nodes. 7. Basal view, same specimen. 8. USNM 431523, 707e, $\times 4$, side view. 9. AMNH 43601, 678, $\times 5$, side view showing reduced ornament in the alveozone. Figs. 10, 11. AMNH 43602, 512, $\times 4$. 10. Side view, note even development of spiral ornament in the alveozone and the heavy sutural nodes. 11. Basal view of same specimen. 12. AMNH 43603, 678, $\times 5$, side view, note weakly developed ornament in the alveozone. Figs. 13–15. AMNH 43604, 512, $\times 3$. 13. Side view, note fine ornament in the alveozone. 14. Basal view of same specimen. 15. Oblique basal view of same specimen. Figs. 16, 17. AMNH 43605, 678, $\times 5$. 16. Side view, note nearly vertical outer whorl face. 17. Oblique basal view of the same specimen. Figs. 18, 19. USNM 431524, 7121b, $\times 4$. 18. Side view, note wide outer whorl face and reduced ornament. 19. Basal view of same specimen. 20. AMNH 43606, 678, $\times 5$, side view, note rounded lower periphery. Figs. 21, 22. AMNH 43607, 512, $\times 3$. Fig. 21. Side view, note narrow, concave alveozone and weakly formed sutural nodes. 22. Basal view of the same specimen. 23. AMNH 43610, 678, $\times 5$, oblique side view.



spaced spiral ornament more strongly developed from suture to upper convex surface (pl. 1, fig. 1). Upper whorl face with convex upper half and concave lower half. Outer whorl face flat or slightly concave, slopes inward, ornamented by strong spiral ornament (pl. 1, fig. 5). Ornament of outer whorl face more developed than on other surfaces; usually consists of evenly spaced threads which may be evenly developed or alternate with fine lirae. Basal angulation distinct and marked by rib or thread. Flatly rounded base usually ornamented by fine, evenly spaced lirae. Funicle variable in width and development, bordered by groove (pl. 1, fig. 14). Funicle constructed differently from that of most species in which middle or lower part of columellar lip is thickened (pl. 4, fig. 13; pl. 2, fig. 14). Funicle begins forming in penultimate whorl rather than in final whorl. Lower part of columellar lip thickened and becomes parietal wash surrounding umbilicus. Funicle may be ornamented by fine collabral threads or elongate nodes. *Phaneromphalus* or *cryptomphalus*.

DISCUSSION: Well-correlated characters include height of whorl compared to width of the outer whorl face (H, CBS); height of whorl compared to height of upper whorl surface (H, SS). The pleural angle averages 99–110°, but is highly variable. For example, at locality 678 the average is 110° while at locality 512 it is 99°. Chronic (1952) reported an average pleural angle of 107° in the Kaibab topotypes.

Several thousand specimens from the Leonard through the Road Canyon permit an examination of the variation of this species through time. It is remarkably variable considering the few characters responsible for overall appearance. The whorl profile is greatly affected by the roundness of the base and even more by the slope, width, and concavity of the outer whorl face, which becomes progressively narrower and more concave with time (pl. 1, figs. 5, 21). The 512 population shows far more variability in the relationship of the height of the upper whorl face to the width of the outer whorl face.

In the ornament, there is a time trend to develop more intense spiral threads in the progressively more concave alveozone (pl. 1, figs. 9, 21). Also there is a reduction in the intensity of sutural nodes and the develop-

ment of more numerous and finer spiral threads on the base (pl. 2, fig. 4). In the 512 population there is a great deal of variation in the shape and width of the alveozone and its contained ornament. The alveozone may be relatively wide and shallow to narrow and deep. The spiral threads vary from three to eight with additional spiral lirae.

It is possible that this species has ancestry close to the Wolfcampian *G. diablo*, n. sp.; with the development of a flattened and more nearly vertical outer whorl face, a basal angulation (resulting from the formation of a vertical outer whorl face and a flattened base), and the reduction of the funicle. These characters also separate the two species. Quantitatively, *G. coronatum* can be separated from *G. diablo* by whorl height and width and by the widths of the upper and outer whorl faces.

G. (G.) diablo has a strongly outward and downward sloping outer whorl face (pl. 2, fig. 8). The earliest populations of *G. coronatum* (loc. 707e) show this same feature but the slope is not as great (pl. 2, fig. 2).

Ornament of the outer whorl face in *G. diablo* consists of fine spiral threads which are more strongly developed than on the base. This condition, fairly rare in most species of the genus, suggests that it is apomorphic for the two species. By Road Canyon time (707e) these final spiral threads were replaced by a few coarser unevenly developed threads. The outer whorl face is nearly vertical and more strongly concave. By middle Guadalupian time (512) the face was predominantly concave with the upper edge more fully formed than the lower (pl. 2, fig. 1).

The upper whorl face in *G. diablo* has well-developed spiral threads on the upper convex surface and fine, numerous interference sutural nodes, features duplicated in the Road Canyon (707e) population of *G. coronatum*. This condition is also present in the Sierra Diablo (Cutoff shale) population (678), but some of the individuals in this population develop structural sutural nodes (pl. 1, fig. 23). This latter type of node is present in most Wordian populations and is correlated with the absence of strongly developed spiral threads near the suture which usually result in interference nodes.

One great difference between the two species is the greatly flattened base in *G. coro-*

natum even in the earliest populations. However, by Guadalupian time the base began to become more rounded with a wider umbilicus.

In quantitative studies, overall height and width of the shell gradually increase compared to the width of the outer whorl face going from the earlier strata to the more recent. This same observation can be made with total height and width of the shell. This is also true for CBS and SS with SS gaining in value. SS and H shows the reverse trend with SS gaining in value at the expense of H.

Ontogenetic differences between *G. diablo* and *G. coronatum* are seen in the SS/W and total height and width which are higher in *coronatum*. *G. lupus* differs from *G. coronatum* in being higher spired and with strongly developed sutural interference nodes developed on several very coarse spiral threads on the convex portion of the upper whorl surface. *G. texanum* is similar in shell shape but has only faint ornament.

RANGE: Hueco Limestone through Willis Ranch member of the Word Formation; from Arizona to the Glass Mountains.

OCCURRENCE: 369, 9; 391, 4; 501, 3; 503, 12; 509, 66; 512, 200; 519, 1; 592, 1; 631, 93; 678, 2375; 2019, 18; 703, 68; 703c, 3; 706, 1; 707b, 2; 707e, 267; 712, 5; 712j, 14; 722, 37; 722g, 15; 724, 6; 728, 153. 3353 specimens.

MEASUREMENTS: *Plate 1. 1, 2.* USNM 431520, 707e, H 4.40, W 6.00, SPANG 122°, SS 0.50, Hw 0.80, Wh 1.10; *3, 4.* USNM 431521, 707e, H 5.60, W 7.50, SPANG 107°, SS 0.70, Hw 1.10, Wh 1.50; *5.* AMNH 43600, 678, H 5.30, W 6.30, SPANG 110°, SS 0.50, Hw 0.80, Wh, 1.20; *6, 7.* USNM 431522, 707e, H 5.30, W 7.50, SPANG 112°, SS 0.70, Hw 1.10, Wh 1.40; *8.* USNM 431523, 707e, H 7.20, W 9.20, SPANG 117°, SS 1.20, Hw 1.50, Wh 1.60; *9.* AMNH 43601, 678, H 5.70, W 7.00, SPANG 112°, SS 1.00, Hw 1.40, Wh 1.30; *10, 11.* AMNH 43602, 512, H 9.00, W 11.80, SPANG 118°, SS 1.00, Hw 3.70, Wh 2.00; *12.* AMNH 43603, 678, H 4.90, W 6.00, SPANG 115°, SS 0.50, Hw 0.80, Wh 1.10; *13–15.* AMNH 43604, 512, H 8.50, W 11.60, SPANG 125°, SS 0.80, Hw 1.30, Wh 1.60; *16, 17.* AMNH 43605, 678, H 6.00, W 7.30, SPANG 114°, SS 0.60, Hw 1.10, Wh 1.40; *18, 19.* USNM 431524, 712b, H 5.30, W 7.00,

SPANG 112°, SS 0.50, Hw 0.90, Wh 1.20; *20.* AMNH 43606, 678, H 6.20, W 7.60, SS 0.70, Hw 0.90, Wh 1.40; *21, 22.* AMNH 43607, 512, H 9.10, W 12.20, SPANG 122°, SS 1.50, Hw 2.30, Wh 1.40; *23.* AMNH 43608, 678, H 4.60, W 5.80, SPANG 115°, SS 0.50, Hw 0.70, Wh 1.20 mm. *Plate 2. 1.* AMNH 43682, 512, H 7.00, W 6.20; *2, 3.* USNM 431525, 706, H 7.60, W 8.90, SPANG 91°, SS 0.80, SW 0.18, CBS 0.40; *4.* AMNH 43609, 512, H 6.80, W 7.00, SPANG 103°; *5.* AMNH 43608, 631, H 4.60, W 6.80, SPANG 128°.

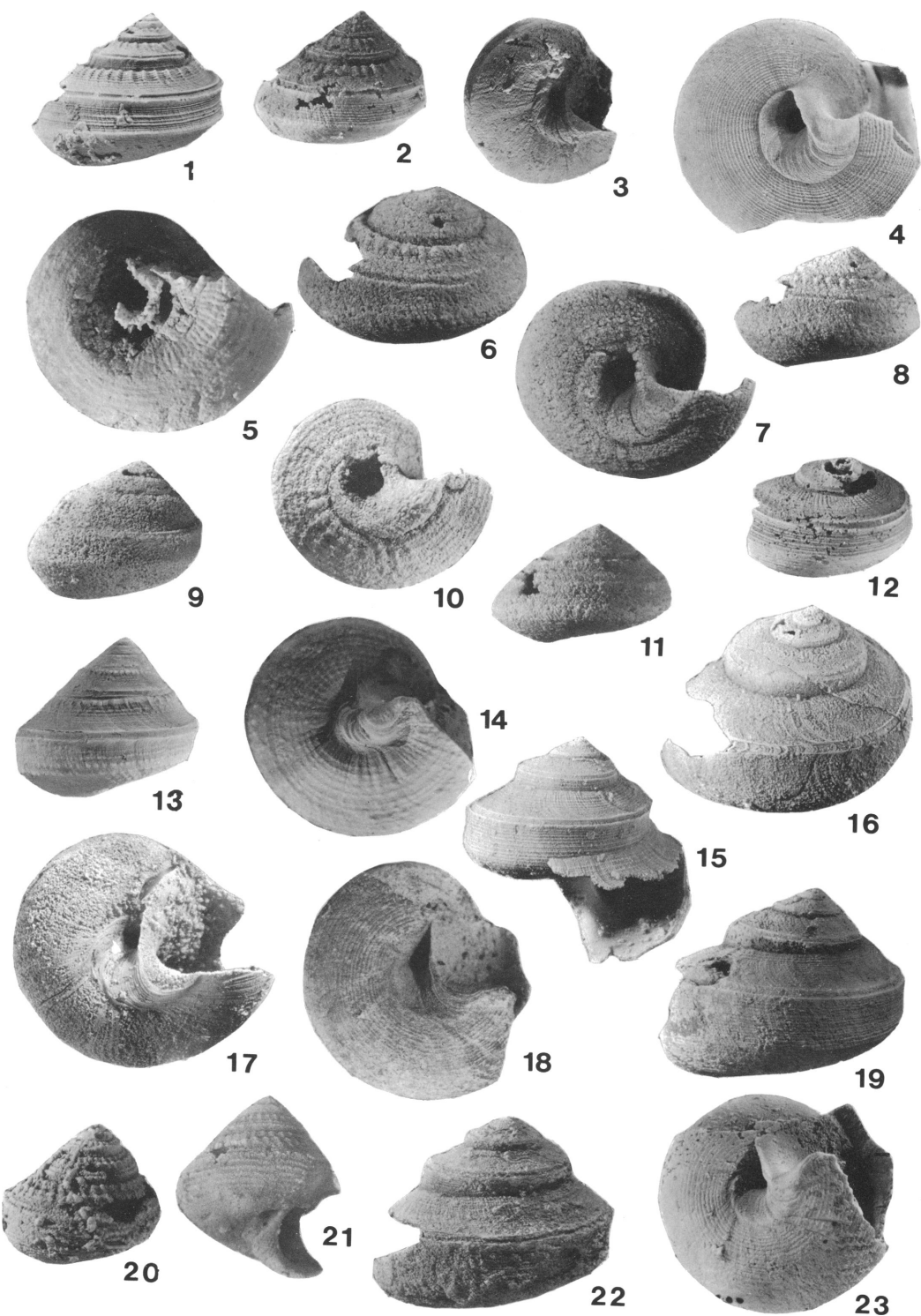
***Glabrocingulum (Glabrocingulum)*
diablo, new species**

Plate 2, figs. 6–8, 10, 11

DIAGNOSIS: Low-spired shells with sharply sloping outer whorl face, reduced spiral ornament, and large funicle.

DESCRIPTION: Sutures in contact with whorl just below lower selenizone margin. Height of upper whorl face short and outer whorl face relatively wide making selenizone appear high on whorl. Upper whorl surface mostly concave with very narrow and sharply defined convex surface adjacent to suture. This convex band with very fine spiral threads and collabral interference nodes. Concave portion of upper whorl surface usually with fine, evenly spaced spiral threads. Some specimens show progressively coarser spiral threads near upper selenizone margin: if outer whorl face is flattened or slightly convex, with sharper slope; if slightly concave slope more nearly vertical. Ornament of outer whorl face similar to that of upper whorl face. Margin between outer whorl face and base rounded and indistinct. Ornament on rounded base similar to that on outer whorl face except toward umbilicus spiral elements may intensify and collabral elements may appear, forming interference nodes. Umbilicus wide. Funicle very large, occupying almost half area of base and ornamented by collabral elements.

DISCUSSION: *G. diablo* is a distinct departure from its low-spired ancestors, by virtue of its rounded whorl profile and outward sloping outer whorl face. *G. lupus* is similar in having a somewhat rounded base and a flattened upper whorl face. The ornament of



the outer whorl face is similar in both species. The latter species is higher spired because it is slightly more turreted with a more nearly vertical outer whorl face. The most distinctive feature of *G. diablo* is the sharply sloping outer whorl face and the unusually wide and well-developed funicle. There is some variation in the overall width of the funicle and the amount of ornamentation. The umbilicus is wider than in most other species except for the Malaysian *G. umbilicatus* Batten, 1985.

Well-correlated characters include SS/h and SS/w (allometric height and width compared to height of the upper whorl face) and CBS/H (width of the outer whorl face to overall shell height), and (h/w)/(H/W) (allometric height and width to overall shell height and width). SS and CBS are best features for discrimination on the species level.

RANGE: Wolfcampian.

HYPODIGM: 701b, 3; 702, 1; 702t, 1; 703, 1; 707b, 1; 707e, 74; 712, 95; 712b, 186; 712d, 10; 712g, 2; 728, 70; NPAC, 11; Kriz, 27. 483 specimens.

MEASUREMENTS: Plate 2. 6, 7. holotype, USNM 431526, 712b, H 4.00, W 5.90, SPANG 30°; 8. paratype, USNM 431527, 712b, H 3.80, W 4.90, SPANG 120°.

ETYMOLOGY: Named for the Sierra Diablo Mountains of Texas.

***Glabrocingulum (Glabrocingulum) texanum*, new species**

Plate 2, figs. 9, 12, 15–19, 22, 23

DIAGNOSIS: Moderately high-spired shells with faint spiral ornament with no sutural nodes; a weakly formed funicle.

DESCRIPTION: Shells with almost vertical, well-developed outer whorl face with spiral threads. Sutures embrace the whorls just beneath selenizone. Some specimens begin to uncoil in adult whorl so that suture in adult shell is in midportion of alveozone. Upper whorl surface very gently concave to nearly flat and ornamented by very fine spiral elements closely spaced and equally well developed. Selenizone very narrow, concave, with fine spiral elements. Selenizone margins weakly formed, but distinct. Outer whorl face essentially vertical and slightly concave with numerous evenly developed fine spiral elements. Basal angulation relatively sharply defined, but rounded and without rib or other ornamental features, base flat to flatly rounded, with numerous, fine spiral elements. Phaneromphalus. Funicle occupies narrow area around umbilicus with fine collabral threads but no spiral ornament and separated from base by deep groove. Columellar lip reflexed near lower lip and thickened into narrow callus.

Plate 2

Figs. 1–5. *Glabrocingulum (Glabrocingulum) coronatum* Chronic, 1952. 1. AMNH 43682, 512, ×4, side view, note spiral ornament restricted to the center of the alveozone. Figs. 2, 3. USNM 431525, 706, ×3. 2. Side view, note evenly developed, weak spiral ornament in the alveozone. 3. Oblique basal view of same specimen. 4. AMNH 43609, 512, ×4, basal view, showing fine basal spiral ornament and the collabral ornament of the funicle. 5. AMNH 43610, 631, ×6, basal view, showing the large, depressed funicle with wavy collabral ornament. Figs. 6–8, 10, 11. *Glabrocingulum (Glabrocingulum) diablo*, n. sp., loc. 712b. Figs. 6, 7. Holotype, USNM 431526, ×6. 6. Oblique side view. 7. Oblique basal view. 8. Paratype, USNM 431527, 712b, ×6, side view. 10. USNM, 712b, ×6, basal view. (Fig. 11. Side view same specimen, ×5.) Figs. 9, 12, 15, 19, 22, 23. *Glabrocingulum (Glabrocingulum) texanum*, n. sp. 9. USNM 431528, paratype, BSAC, ×5, oblique side view. 12. USNM 431528, BSAC, ×5, oblique side view. Figs. 15–17, USNM 431530, BSAC, ×4. 15. Oblique apertural view. 16. Oblique side view, note whorl embracement in midalveozone. 17. Basal view, note large funicle and fine spiral ornament. Figs. 18, 19. Holotype, USNM 431531, Pu3, ×4. 18. Basal view showing hemiomphalus condition. 19. Side view showing fine spiral ornament and lacking of typical subsutural nodding. Figs. 22–23. USNM 431532, Pu3, ×4. 22. Side view. 23. Basal view. Figs. 13, 14. *Glabrocingulum (Glabrocingulum) sp.* Pennsylvanian Cambridge Limestone, Cambridge, Ohio, USNM 128064, ×4. 13. Side view. 14. Basal view showing funicle. Figs. 20, 21. *Glabrocingulum (Glabrocingulum) lupus*, n. sp. 20. Holotype, USNM 431533, 702, ×5, oblique side view. 21. USNM 431534, 712, ×6, apertural view.

DISCUSSION: This low-spired species appears to be high spired owing to the turreted shell shape. This shell shape suggests those of *Ananias*, however, the rate of whorl expansion and the position of the sutures on the whorl remain well within the range of *Glabrocingulum*. *Glabrocingulum* sp. on plate 2, figs. 13, 14, from the Pennsylvanian also shows this turreted shape but, again, the sutures rest almost on the lower selenizone margin. The most unique feature of this species is the lack of collabral ornament, including lack of sutural nodes, except on the funicle. No other species lacks the characteristic sutural nodes except for the two species of *G. (Stenozone)* Batten, 1972, described from the Permian of Malaysia. Also the selenizone is narrow for species of the genus, with unusually weak selenizone margins (reflecting lack of robust ornament). The ornament serves to separate this species from all others. This species resembles *Ananias gibber* Chronic, 1952, in the turreted shell shape but the latter species has coarse spiral and collabral ornament which is unevenly developed and lacks sutural nodes (according to Chronic).

RANGE: Wolfcampian–Leonardian.

HYPODIGM: 433, 10; 678, 1; 702, 1; 702ha, 1; 702t, 1; 721w, 4; 722u, 2; 726d, 20; BSACNP, 20; BSAC, 51. 111 specimens.

MEASUREMENTS: *Plate 2. 9.* USNM 431528, BSAC, H 6.00, W 7.00; *12.* USNM 431529, BSAC, H 4.50, W 5.00; *15–17.* USNM 431530, BSAC, H 8.50, W 8.50; *18, 19.* holotype, USNM 431531, Pu3, H 8.70, W 9.90, SPANG 118°; *22.* USNM 431532, Pu3, H 8.50, W 8.00.

ETYMOLOGY: Named for the state of Texas.

Glabrocingulum (Glabrocingulum)

***lupus*, new species**

Plate 2, figs. 20–21

DIAGNOSIS: Relatively high-spired shells with rounded whorl profile, well-developed collabral ornament on upper whorl surface.

DESCRIPTION: First three whorls without ornament, slit, or selenizone. Spiral ornament begins at whorl 3.5. Whorls embrace well below lower margin of selenizone with no indication of uncoiling on adult whorl. Whorl profile evenly rounded without basal angulation. Upper whorl surface gently con-

vex with spiral threads evenly spaced but more fully developed just under suture where collabral elements form strong interference nodes. Selenizone narrow with margins equal in development to spiral threads adjacent to them. Alveozone not well marked because of even development of whorl profile. Rounded base with spiral ornament only. Narrowly phaneromphalus. Columellar lip strongly re-flexed at parietal surface; funicle absent.

DISCUSSION: The six known specimens are so distinct that they cannot be accommodated in any of the other Permian species by virtue of the rounded whorl profile and related features. This species is stratigraphically the highest that falls within the range of the low-spired *Glabrocingulum* taxon, sensu stricto. It is not a member of the *Ananias* group because the whorls embrace just below the lower selenizone margin on all whorls, in contrast to *Ananias* where the sutures are located well below the middle of the alveozone. The sutural nodes are restricted to one dominant spiral thread adjacent to the suture plus a weaker thread below it, in contrast to *G. coronatum* where the nodes are developed on two or more spiral threads.

RANGE: Leonardian.

HYPODIGM: 56, 1; 701g, 2; 712, 3. 6 specimens.

MEASUREMENTS: *Plate 2. 20.* USNM 431533, 701g, H 7.00, W 8.00, SPANG 85°, SS 0.20; *21.* USNM 431534, 701g, H 5.00, W 7.00, SPANG 82°.

ETYMOLOGY: *Lupus*, Latin for wolf.

Glabrocingulum (Glabrocingulum)
***alveozonum*, new species**

Plate 3, figs. 4–10

DIAGNOSIS: High-spired shells with a deeply concave alveozone and with reticulate ornament.

DESCRIPTION: Moderately high-spired, somewhat turreted shells with inflated early whorls. Sutures are deeply impressed and whorls embrace well below lower selenizone in alveozone and adult whorl tends to uncoil. Upper whorl surface flat to concave, except near suture, forming low angle with axis. Spiral and collabral ornament reticulate and sutural nodes, if present, very weak. Selenizone

elevated above upper and outer whorl surfaces, flat to gently concave with well-developed margins. Alveozone nearly vertical and strongly concave; spiral and collabral ornament weaker compared to other surfaces; base of alveozone marked by well-developed basal angulation. Base flatly rounded with more strongly developed reticulate ornament. Phaneromphalus to hemiomphalus. Columellar lip reflexed but without callus or other parietal thickening.

DISCUSSION: This species, of all the low-spined groups of *Glabrocingulum*, comes closest to *Ananias* by virtue of the high-spined nature of the shell. Whorls embrace lower on the alveozone than any of the others, the alveozone is distinctive, and the sutural nodes are reduced or absent in spite of rather well-developed ornament. Still, the embracement is higher than on any known species of *Ananias*. The highly placed and flattened selenizone is similar to that seen in *G. carinatum*, n. sp., but the shell shape of the latter species is globose and the ornament is subdued with dominant spiral elements. There is some variation in the height of the spire depending, in part, on whether the adult whorl uncoils (pl. 3, fig. 6). In other specimens the rate of whorl expansion is quite rapid, which gives them a low-spined appearance (pl. 3, fig. 8). Ornament varies from well-developed reticulate to weaker with dominant spiral elements. This species is similar to *Ananias gibber* Chronic, 1952, in shape but has a more prominent upper and lower periphery, a more deeply concave alveozone, and more strongly developed collabral ornament. It resembles *A. wannensis* Newell, 1937, in the general nature of the ornament and the whorl embracement but differs in having a much narrower alveozone and strongly formed lower and upper periphery.

RANGE: Road Canyon Formation.

HYPODIGM: 503, 1; 703a, 1; 707e, 11. 13 specimens.

MEASUREMENTS: Plate 3. **4**, **5**. paratype, AMNH 43611, 509, H 8.20, W 9.30, SPANG 90°, SS 0.60, SW 0.25, CBS 0.60; **6**, **7**. paratype, USNM 431535, 703, H 7.30, W 6.30, SPANG 80°, SS 0.65, SW 0.25, CBS 0.60; **8**, **9**. holotype, AMNH 43612, 503, H 6.10, W 6.10, SPANG 80°, SS 0.60, SW 0.20, CBS 0.50; **10**. paratype, USNM 431536, 707e, H

4.00, W 4.50, SPANG 71°, SS 0.45, SW 0.15, CBS 0.35.

ETYMOLOGY: *Alveus*, Latin for trough; *zona*, Latin, for belt.

Glabrocingulum (*Stenozone*)

Batten, 1972

TYPE SPECIES: *G. (S.) nodosuturala* Batten, 1972: 21, figs. 14, 15.

DISCUSSION: Batten (1972) recognized this subgenus in the Malaysian Permian and noted that as of that time it was known only from southeastern Asia. It is now found in the Carlsbad and Yeso Limestones of Texas and New Mexico where it is fairly rare.

G. (Stenozone) carlsbadensis, new species

Plate 5, fig. 1

DIAGNOSIS: Rotelliform, low-spined shells with dominant spiral ornament and narrow selenizone just above shoulder.

DESCRIPTION: Early whorls are smooth; later whorls are evenly inflated. Sutures embrace whorl at or just below basal angulation. Whorl profile evenly inflated. Upper whorl surface evenly convex with slightly flattened area near selenizone and near suture. Spiral ornament consists of unevenly developed threads more fully formed on convex areas. Lower selenizone margin forms upper periphery of shell. Selenizone relatively narrow and concave with well-developed margins. Outer whorl face evenly rounded with unequally developed spiral threads. Base is rounded with ornament similar to rest of shell except spiral threads more heavily developed adjacent to umbilicus. Narrowly phaneromphalus.

DISCUSSION: This species is similar to *G. (S.) pleurotomariformis* Delpy, 1942, in its rotelliform shell shape and the narrow selenizone with well-developed margins, but differs in having spiral ornament rather than a strongly reticulate pattern (Batten, 1972: 24, fig. 20). It is unlike any of the known species of *Glabrocingulum* from the Upper Paleozoic of North America in that it lacks the typical sutural nodes, has a far narrower selenizone with strongly formed selenizone margins, and lacks any evidence of collabral ornament.

This is the first known occurrence of a Tethyan species of the genus in North America.

RANGE: Guadalupian.

HYPODIGM: 3 specimens from USGS 3364.

MEASUREMENTS: *Plate 5*. 1. holotype, USNM 431537, 3364, H 6.80, W 6.80, SPANG 86°, SS 6.50, SW 0.20, CBS 1.50; paratype, USNM 431538, 3364, H 6.40, W 7.10, SPANG 90°.

ETYMOLOGY: Named for the Carlsbad Limestone of New Mexico.

Ananias Knight, 1945

TYPE SPECIES: *Phanerotrema? welleri* Newell, 1935.

DESCRIPTION: Moderately high-spired, graduate, turreted-to-rounded eotomarians with a selenizone at the shoulder of the whorl.

Plate 3

Figs. 1–3. *Manzanospira carinatum*, n. sp. 1. Paratype, USNM 431606, 703c, $\times 4$, side view. 2. Holotype, USNM 431605, 703, $\times 4$, side view. 3. Paratype, AMNH 43685, 509, $\times 3$, side view. Figs. 4–10. *Glabrocingulum (Glabrocingulum) alveozonum*, n. sp. Figs. 4, 5. Paratype, AMNH 43611, 509, $\times 5$. 4. Side view. 5. Oblique basal view, note wide open umbilicus. Figs. 6, 7. Paratype, USNM 431535, 703, $\times 4$. 6. Side view, note narrow and concave alveozone. 7. Apertural view. Figs. 8, 9. Holotype, AMNH 43612, 503, $\times 5$. 8. Side view. 9. Oblique basal view. 10. Paratype, USNM 431536, 707e, $\times 6$, side view. Figs. 11–18. *Ananias labrectus*, n. sp. 11. Paratype, AMNH 43678, 512, $\times 5$, oblique side view, note strongly developed subsutural nodes. Figs. 12, 13. Holotype, USNM 431539, 703, $\times 3$. 12. Side view, note fine spiral ornament below the selenizone and low-whorl embracement causing a high-spined shell. 13. Oblique apertural view showing reflexed columellar lip. 14. Paratype, AMNH 43613, 512, $\times 5$, side view, showing wider alveozone. 15. Paratype, AMNH 43614, 519, $\times 3$, side view, note the high-whorl embracement causing a low-spined shell. 16. Paratype, USNM 431540, 703, $\times 2$, side view, note lack of prominent subsutural nodes and fine spiral ornament. 17. USNM 431541, 703, $\times 2$, side view, note stronger basal ornament. 18. USNM 431542, 703, $\times 2$, side view, note more globose whorls.

Plate 4

Figs. 1–7. *Ananias labrectus*, n. sp. 1. USNM 431543, 703, $\times 3$, oblique apertural view, showing strong basal ornament. 2. USNM 431544, 703, $\times 2$, side view, showing elongated subsutural nodes. 3. AMNH 43615, 512, $\times 2$, oblique apertural view, showing broad alveozone. Figs. 4, 5. AMNH 43616, 512, $\times 4$. 4. Side view, showing globose whorls. 5. Apertural view, showing strongly reflexed columellar lip. Figs. 6, 7. USNM 431545, Pu3, $\times 3$. 6. Side view, showing fine ornamentation. 7. Apertural view, showing funicle or callus obscuring the umbilicus. Figs. 8–19. *Ananias permianus*, n. sp. 8. Paratype, AMNH 43617, 369, $\times 3$, side view. 9. USNM 431546, paratype, 707e, side view, $\times 3$. Figs. 10, 11. USNM 431547, 702d, $\times 5$. 10. Side view. 11. Oblique apertural view. Figs. 12, 13. AMNH 43618, paratype, 519, $\times 3$. 12. Side view. 13. Apertural view. 14. AMNH 43619, holotype, 512, $\times 4$, side view. 15. AMNH 43620, paratype, loc. 46, $\times 4$, side view. Figs. 16, 17. AMNH 43621, 503, $\times 4$. 16. Side view. 17. Oblique basal view. Figs. 18, 19. AMNH 43622, 512, $\times 4$. 18. Side view. 19. Apertural view.

Plate 5

1. *Glabrocingulum (Stenozone) carlsbadensis*, n. sp. Holotype, USNM 431537, 3384, $\times 4$, oblique side view. Figs. 2–5. *Ananias ootomaria*, n. sp. 2. USNM 431548, holotype, 707e, $\times 3$, side view. Figs. 3, 4. USNM 431549, paratype, 703, $\times 3$. 3. Apertural view. 4. Side view. 5. USNM 431550, paratype, 703, $\times 3$, side view. Figs. 6–8. *Ananias appeli*, n. sp. 6. Holotype, AMNH 43623, 503, $\times 3$, side view. Figs. 7, 8. Paratype, AMNH 43624, 503c, $\times 3$. 7. Oblique side view. 8. Apertural view. Figs. 9–14. *Ambozone dictyonema*, n. sp. Figs. 9–11. Holotype, AMNH 43625, 512, $\times 3$. 9. Side view. 10. Top view. 11. Basal view. Figs. 12, 13. Paratype, AMNH 43681, 512, $\times 5$. 12. Side view. 13. Basal view. 14. Paratype, USNM 431552, 703a, $\times 5.5$, oblique side view. 15. *Apachella* sp. Tournasian (Lower Carboniferous), Piret Collection, Inst. Roy., Brussels, Belg., $\times 8.5$, side view. 16. *Sagana bellisculpta* Koken, 1896, Triassic Feuerkogel, Alps, Austria, Univ. Bonn, Germany, $\times 1$, side view. Figs. 17–19. *Apachella translirata* Winters, 1963. 17. AMNH 43626, 369, $\times 4.5$, side view. 18. USNM 431580, BSAC, $\times 4.5$, side view. 19. AMNH 43627, B 1886, $\times 4.5$, side view.

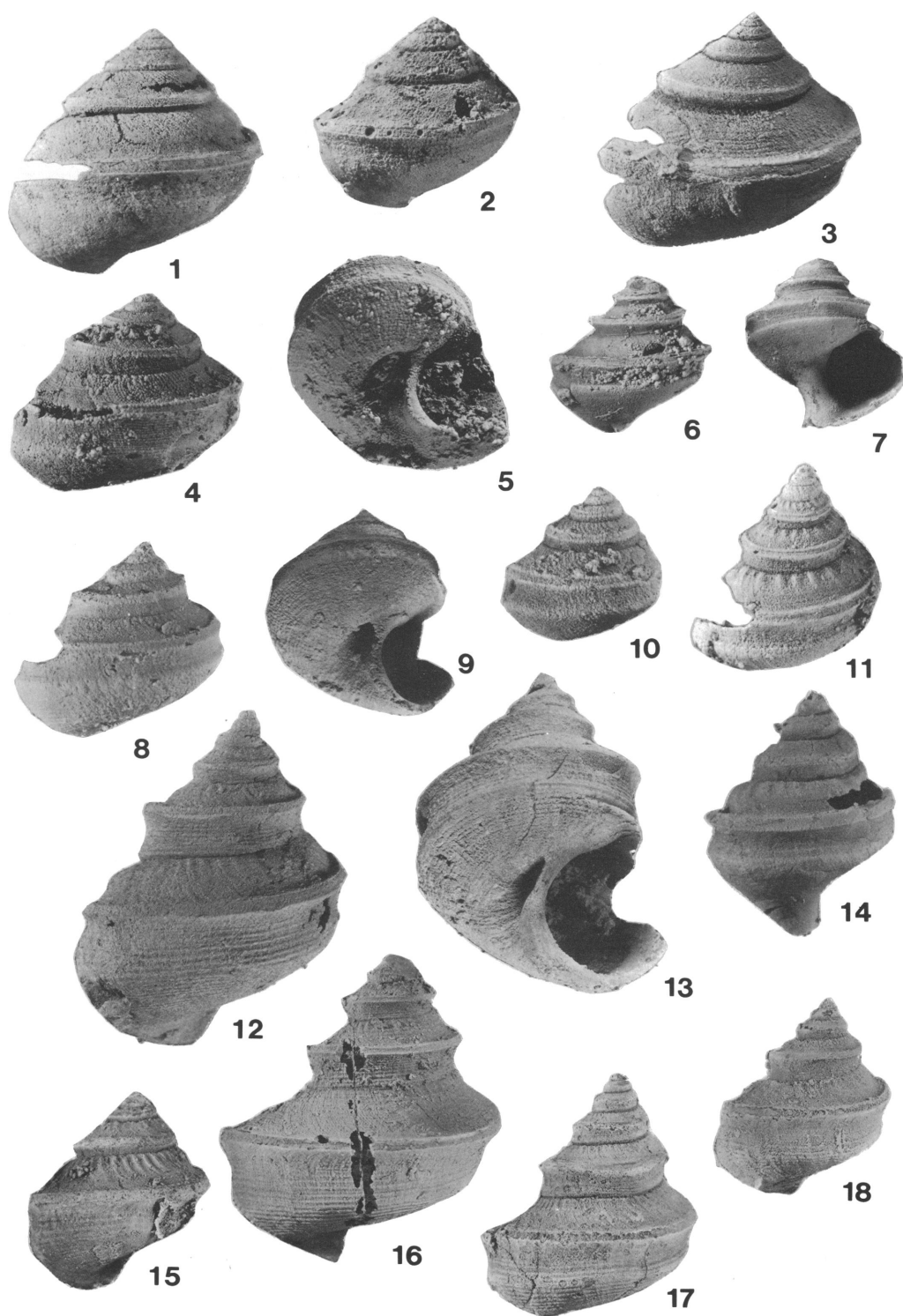


Plate 3

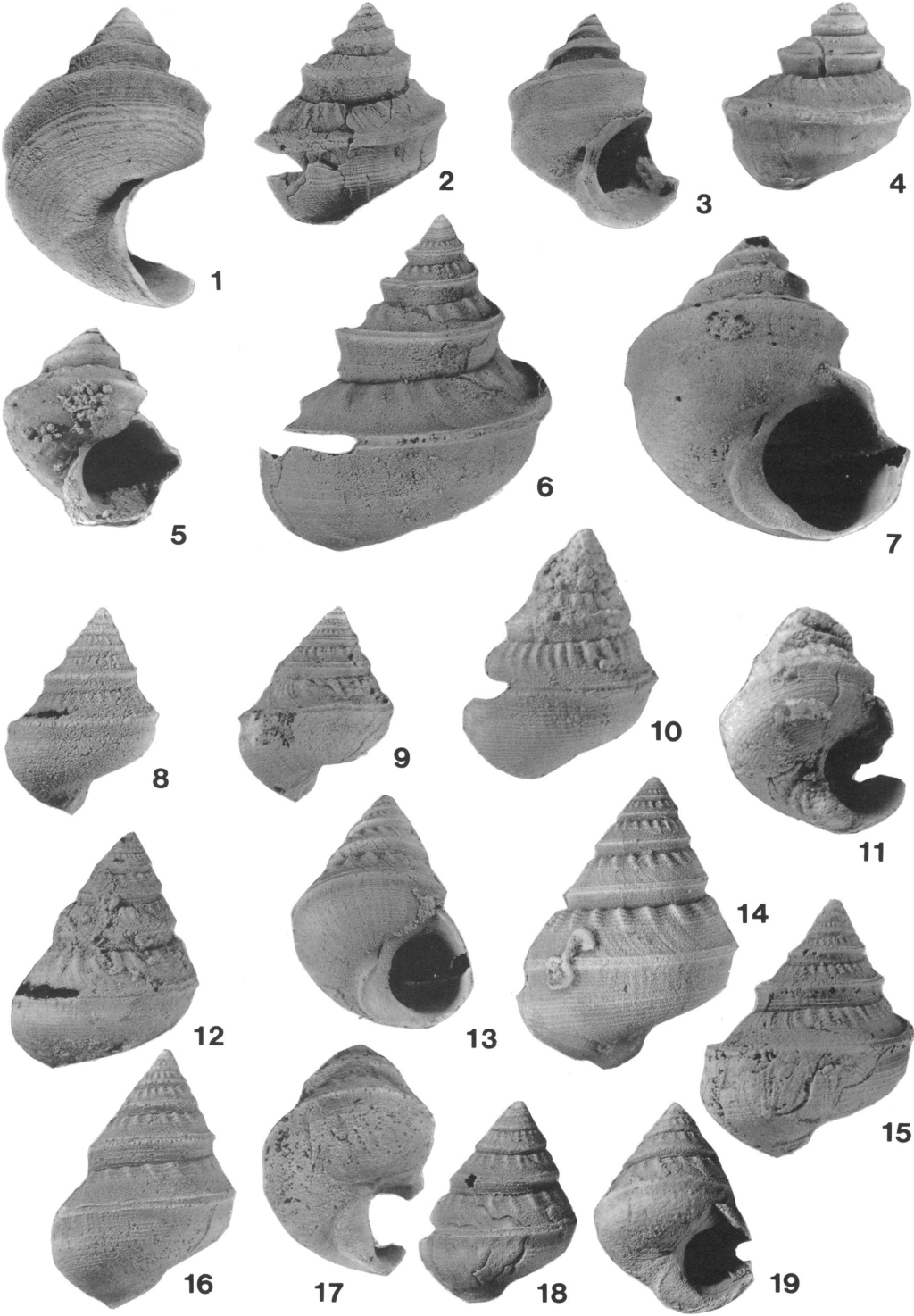


Plate 4

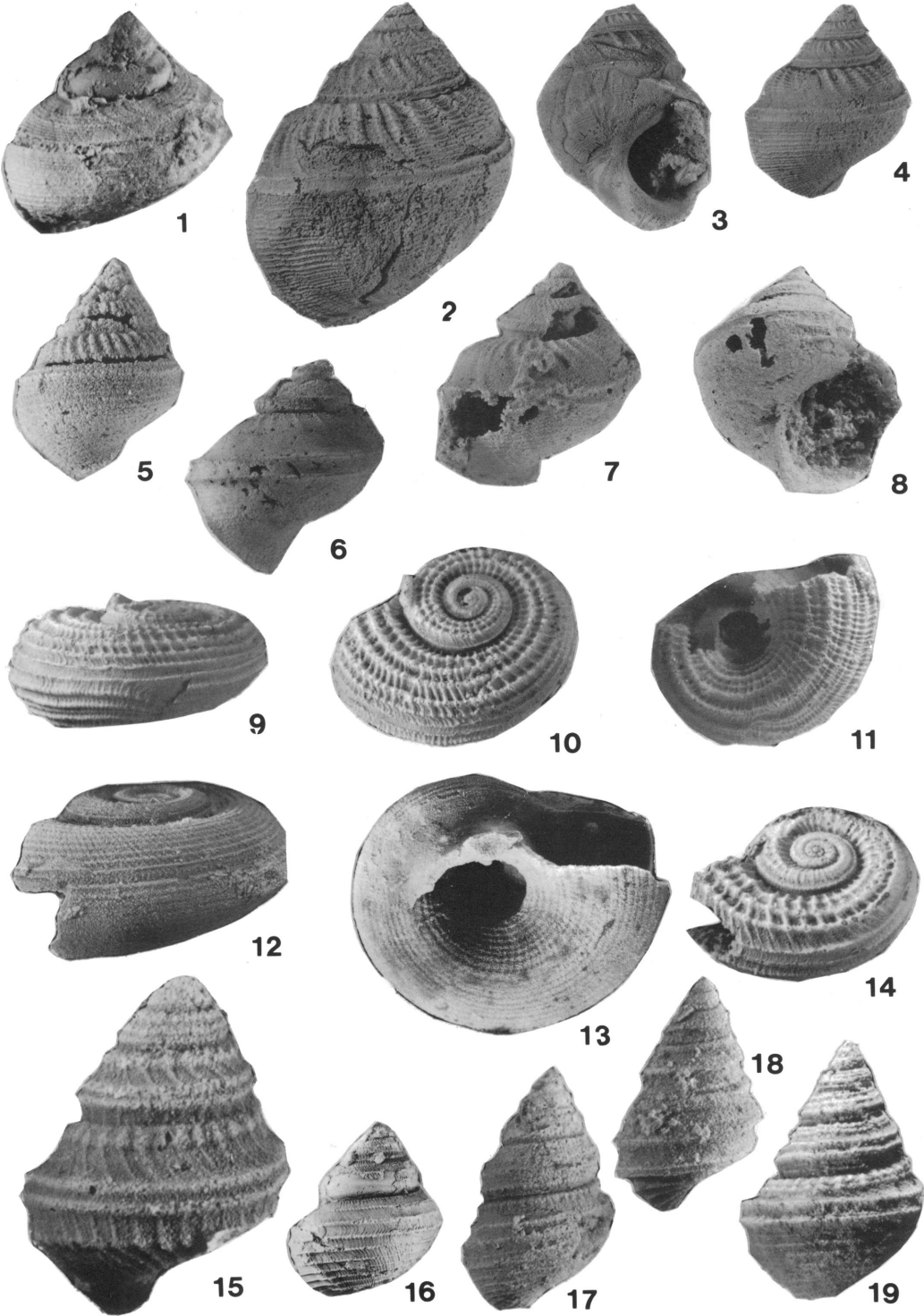


Plate 5

Whorls embrace above, at, or just below the basal angulation. The selenizone is relatively narrow but variable in width and is concave, flat, or slightly convex, and forms an almost 45° angle with the outer whorl face. The selenizone margins are usually well developed. The ornament is quite variable ranging from reticulate to dominantly collabral above the selenizone to dominantly spiral below the selenizone. *Anomphalus* to *phaneromphalus*. The columellar lip is reflexed and may have a callus or funicle.

DISCUSSION: Until this study, *Ananias* had been recognized by most students as a subgenus of *Glabrocingulum* (see Schindel, 1982, for further discussion). Many studies of this genus were based on Pennsylvanian species which have reticulate ornament, narrow, concave selenizones, and well-developed funicles, all of which converge on species of both *Glabrocingulum* and *Worthenia* deKoninck, 1883. In the Permian, reticulate ornament was rare, with very subtle, unevenly developed patterns. The selenizone became quite variable in width and shape and the funicle became weaker with time and disappeared by Guadalupian time. All of these features clearly indicate a disjunction of generic proportions and it is evident that the two groups should be separated into distinct genera.

Ananias can first be recognized in the Lower Carboniferous as *Ananias atomarium* (Phillips, 1836), from Great Britain; it ranges into the Triassic.

***Ananias labrectus*, new species**

Plate 3, figs. 11–18;
plate 4, figs. 1–7

DIAGNOSIS: Turreted shells with nearly vertical outer whorl faces; with reduced surface ornament; sutural nodes well developed; with or without a funicle.

DESCRIPTION: Early whorls are rounded with strongly formed spiral ornament. Whorls embrace at or just below the basal angulation. Sutures sharply defined. Upper whorl surface is convexo-concave with strongly developed sutural nodes on the convex portion. Spiral ornament is weakly developed particularly in the concave portion. The selenizone is flattened or either slightly concave or convex.

The margins are rounded to sharply formed. The outer whorl face is flat to slightly concave and nearly vertical. Spiral ornament is weak to absent adjacent to the selenizone, becoming more strongly developed near the basal angulation. On some shells weakly formed collabral ornament may produce a weak reticulate pattern. The base is gently rounded to flattened with spiral ornament more strongly developed than on the rest of the whorl and consists of threads or striations evenly spaced to irregular. Narrowly *phaneromphalus* to *cryptomphalus*. The columellar lip is weakly to strongly reflexed with or without a thickened funicle.

DISCUSSION: There is some variation in the relative width of the selenizone which is correlated with its shape. For example, when the selenizone is wide, the shape is flattened or slightly convex. If it is narrow the shape is concave. The sutural nodes tend to become more numerous and less intense on the adult whorl. Forms with a flattened outer whorl face tend to have more strongly developed convexo-concave upper whorl faces, thus appearing more turreted in shell shape.

The funicle, if developed, does not obscure the umbilicus but a part of the reflexed columellar lip above the funicle will hide the umbilicus. There is a transition beginning in the Road Canyon to reduce the well-developed funicle so that by Guadalupian time (Lower Getaway) the dominant form has no funicle.

This species differs from those in the Pennsylvanian by having very weak to no surface ornament other than the sutural nodes. *A. gibber* Chronic, 1952, differs from this species by having far stronger surface ornament on the upper whorl surfaces and by being more turreted.

RANGE: Wolfcampian through Middle Guadalupian.

HYPODIGM: 702, 11; 702a, 2; 702d, 11; 703, 26; 703c, 4; 707a, 1; 707d, 14; 707e, 7; 707ha, 1; 710d, 59; 721J, 5; 721U, 12; 728, 57; 735a, 4; 735b, 1; 14439, 37; 46, 43; 369, 202; 433, 222; 503, 1; 512, 61; 519, 5; 592, 85; 678, 11; 6983, 1; Pu3, 429; BSNP, 94. 1395 specimens.

MEASUREMENTS: Plate 3. 11. paratype, AMNH 43678, 512, H 7.00, W 6.20, SPANG 78°; 12, 13. holotype, USNM 431539, 703,

H 17.80, W 14.00, SPANG 77°; **14.** paratype, AMNH 43613, 512, H 8.00, W 6.20, SPANG 78°; **15.** paratype, AMNH 43614, 519, H 11.30, W 9.50, SPANG 878°; **16.** paratype, USNM 431540, 703, H 26.40, W 22.20, SPANG 115°; **17.** USNM 431541, 703, H 20.00, W 15.80, SPANG 122°; **18.** USNM 431542, 703, H 16.70, W 14.70, SPANG 103°. *Plate 4.* **1.** USNM 431543, 703, H 12.00, W 12.00, SPANG 71°; **2.** USNM 431544, 703, 18.80, W 14.50, SPANG 78°; **3.** AMNH 43615, 512, H 15.50, W 10.80, SPANG 73°; **4, 5.** AMNH 43616, 512, H 11.60, W 9.80, SPANG 89°; **6, 7.** USNM 431545, Pu3, H 18.40, W 14.80, SPANG 73°.

ETYMOLOGY: *Labium*, Latin for lip; *rectus*, Latin for straight.

Ananias permianus, new species

Plate 4, figs. 8–19

DIAGNOSIS: High spired shells with rounded whorls, dominant spiral ornament, well-developed funicles.

DESCRIPTION: Early whorls are smooth and rounded. The shell is high spired with the axial translation rate higher than the rate of whorl expansion. Whorls embrace in the middle of the alveozone. Sutures are sharp and deeply impressed. Sutural nodes composed of both structural upwelling and reinforcement of collabral ornament. Upper whorl face convex except immediately adjacent to the upper selenizone margin which may be flattened to gently concave. Collabral ornament consists of sutural nodes. Spiral ornament consists of threads more strongly developed adjacent to the suture and weaker near the selenizone. There may be a very slight concave development adjacent to the lower selenizone margin forming a weak alveozone. The basal angulation is rounded so that the outer whorl face and base blend together forming an inflated whorl profile. The base is rounded with spiral ornament only. The columellar lip has a well-developed funicle bounded by a sharp ridge. The upper part of the lip is reflexed obscuring a narrow umbilicus. Parietal inductura covers ornament in the plane of the aperture.

DISCUSSION: There are several interesting morphoclines within this species. The axial

translation rate varies from slow to fast in relation to the rate of whorl expansion resulting in some shells that are gradate and turreted (pl. 4, fig. 9 or 15) to high spired with small whorl widths (pl. 6, fig. 16). Sutural nodes vary from coarse and few in number per whorl (pl. 4, fig. 14) to numerous and fine (pl. 4, fig. 10). The alveozone may be concave with finer ornament (pl. 4, fig. 14) or almost nonexistent with spiral ornament developed the same as the base (pl. 4, fig. 10). The funicle is invariant in development.

This species possesses derived characters that are distinct from those of any previously known species. The main feature is the inflated whorl profile with the outer whorl face blending into the base, without a well-developed alveozone as seen on all other species. The whorl embracement at the middle section of the alveozone reduces the turreted appearance noted in such species as *A. labrectus*. There are a number of specimens that converge on that species such as seen in figure 15 on plate 4. However, even on those specimens the base is rounded without a bordering basal angulation. Also the funicle shows no variation as seen in *A. labrectus*. *A. permianus* is quite similar to *A. ootomaria*, n. sp., in the inflated whorl profile, funicle, and dominance of spiral ornament, but the latter species carries the exaggerated globosity of the whorl further.

RANGE: Leonardian–Guadalupian.

HYPODIGM: 369, 1; 433, 2; 655, 6; 592, 5; 678, 12; 512, 73; 702, 13; 702a, 2; 702c, 1; 702d, 20; 703a, 1; 703b, 6; 707d, 7; 707e, 2; 710d, 23; 722u, 3; 721n, 10; 721j, 6; 728, 28. 221 specimens.

MEASUREMENTS: *Plate 4.* **8.** paratype, AMNH 43617, 369, H 10.30, W 7.70, SPANG 64°; **9.** paratype, USNM 431546, 707e, H 9.70, W 7.60, SPANG 73°; **10, 11.** USNM 431547, 702d, H 7.60, W 5.80, SPANG 65°; **12, 13.** paratype, AMNH 43618, 519, H 12.50, W 9.00, SPANG, 61°; **14.** holotype, AMNH 43619, 512, H 11.8, W 8.80, SPANG 58°; **15.** paratype, AMNH 43620, 46, H 10.30, W 8.20, SPANG 64°; **16, 17.** AMNH 43621, 503, H 8.40, W 6.10, SPANG 62°; **18, 19.** AMNH 43622, 512, H 10.20, W 7.50, SPANG 60°.

ETYMOLOGY: Named for the Permian System.

Ananias ootomaria, new species

Plate 5, figs. 2–5

DIAGNOSIS: Globose pleurotomarians with concave-to-flattened selenizone located above midwhorl.

DESCRIPTION: Early whorls are smooth and rounded, becoming turreted and finally rounded in the adult whorl. A shallow slit generates a selenizone varying in width and shape. Collabral nodes are well developed on the upper portion of the whorl adjacent to the suture. Spiral ornament of either threads or striation are fairly uniformly distributed over the whorl surface. Anomphalus. The columellar lip is reflexed and thickened with a large funicle bordered by a ridge separating the base ornament. Parietal inductura limited to plane of aperture. Adult whorl with a rounded boss, or tooth, at the margin of the aperture, formed by the parietal inductura, which tapers toward to the funicle and is absent above the funicle.

DISCUSSION: *A. ootomaria* is the extreme derived condition of a sequence of variable character complexes observed in *A. permianus* in the Permian. That species retains its alveozone despite the inflation of the whorls. The ever present funicle and dominant spiral ornament of the two species reveal a close genetic relationship. But bivariate analysis of many features indicates that the two groups are well separated. For example, plots of CBS/SS show that the rates of change between CBS and SS in *A. ootomaria* are far slower than in other species of the genus. *A. permianus* is spired higher and uncoils in the final third and fourth whorls of growth to reveal about one-half the alveozone which enhances the high-spired appearance of the shell. The early whorls are quite similar to those of other species of the genus: turreted with a flattened upper whorl surface and the selenizone on the upper periphery. It tends to have finer sutural nodes. *A. ootomaria* may uncoil but only in the last half-whorl and only slightly below the lower margin of the selenizone. *A. appeli* lacks a funicle and has a wider and more flattened selenizone.

The tooth, or boss, which is developed in the adult aperture adjacent to the outer lip on the parietal surface immediately within the aperture is quite variable in shape, rang-

ing from rounded to elongate. It appears similar to "guide" teeth found in neritaceans with well-developed opercula. The shells are quite thick, yet a number of specimens show that they were broken during life and repaired.

RANGE: Wolfcampian–Guadalupean.

HYPODIGM: 503, 3; 512, 1; 512f, 1; 703c, 8; 703, 27; 707e, 10; 710d, 6; 721j, 17; 721s, 2; 721u, 6; 722n, 1; 725d, 5. 86 specimens.

MEASUREMENTS: *Plate 5. 2.* holotype, USNM 431548, 707e, H 16.30, W 13.60, SPANG 79°; *3, 4.* paratype, USNM 431549, 703, H 14.40, W 11.20, SPANG 76°; *5.* paratype, USNM 431550, 703, H 10.00, W 8.20, SPANG 78°.

ETYMOLOGY: *Oon*, Greek for egg, *tomos*, Greek for cut.

Ananias appeli, new species

Plate 5, figs. 6–8

DIAGNOSIS: Globular shells with reflexed columellar lip; wide, flattened selenizone.

DESCRIPTION: Moderately high-spired forms with inflated whorls. Whorls embrace just beneath the lower selenizone margin. Early whorls are turreted. The upper whorl face is evenly convex but may be slightly flattened adjacent to the upper selenizone margin. Sutural nodes formed by collabral cords are confined to the upper portion of the upper whorl face. The outer whorl face is convex to flattened and the base merges with the outer whorl face without a basal periphery or margin. The selenizone is wide with weakly developed margins and is flattened to slightly concave. Ornament consists of very faint spiral elements, slightly stronger on the base. Phaneromphalus to hemiomphalus. The columellar lip is slightly reflexed and may partially cover the umbilicus.

DISCUSSION: This species represents a columellar lip variant pattern noted in *A. labrectus*. In that species, specimens which lost the funicle and developed a strong reflection of the columellar lip, became progressively more common in populations during the Leonardian, culminating in the Lower Getaway with almost half the population with this condition. *A. appeli* is similar to *A. ootomaria* in being globose with sutural nodes equally developed and with spiral ornament evenly formed over the shell. It differs in

lacking a funicle and having a reflexed columellar lip. It further differs in having a selenizone which is much wider in proportion with weak selenizone margins and a flatter selenizone surface. The shell is much thinner and does not show the break and repair scars so common to *A. ootomaria*. This species is confined to the Road Canyon Formation.

RANGE: Road Canyon Formation.

HYPODIGM: 503, 1; 503c, 2. 3 specimens.

MEASUREMENTS: Plate 5. 6. holotype, AMNH 43623, 503, H 11.70, W 9.80, SPANG 98°; 7. paratype, AMNH 43624, 503c, H 12.80, W 11.70, SPANG 97°.

ETYMOLOGY: Named for the Appel Ranch, formerly the Word Ranch in the Glass Mountains, Texas.

TRIBE PTYCHOMPHALIDES WENZ, 1938

DISCUSSION: This tribe was studied in my first paper on pleurotomarians (Batten, 1958) and includes the genera *Euconospira* Ulrich in Ulrich and Scofield, 1897, *Spiroscala* Batten, 1956, and *Shwedagonia* Batten, 1956. *Mourlonia* deKoninck, 1883, another important member of the tribe, was not found in the southwestern U.S. Permian faunas and is not known in North America in the Upper Paleozoic or in the South American Andes in the Upper Paleozoic. It is present in the Tethyan faunas (Batten, 1972) and in the Southern Hemisphere including the Patagonian basin of South America (Dickens, 1963).

In the Malaysian Permian study, Batten (1972: 14) described the new genus *Ambozone* for low-spired to planispiral forms with raised, *Mourlonia*-like selenizone margins. The species included had previously been placed in *Porcellia* Leveille, 1835 (family Porcellidae Broili, 1924). The latter genus includes species that have a depressed selenizone located in midwhorl without selenizone margins. Specimens from the west Texas Permian, which in the initial sorting of the faunas by Knight in 1949 and later by Batten in the mid-1950s were considered to belong to *Porcellia*, clearly belong to *Ambozone*.

Ambozone Batten, 1972

TYPE SPECIES: *Ambozone rasmusseni*, Batten, 1972: 15.

DISCUSSION: As discussed above, the sele-

nizone complex of forms designated members of this genus are clearly eotomarian, similar to *Euconospira* or *Mourlonia*. In addition, the selenizone is not exactly midwhorl; the lower selenizone margin forms the periphery. The early globose whorls also are like those of *Mourlonia*. The known species of this genus tend to have reduced ornament with nodes present near the suture and perhaps on the base. The strongly developed reticulate ornament of *A. dictyonema*, n. sp., has not been seen in other species. It is very similar to that developed in *Eirlysia reticulata* Batten, 1958, but important shell features such as the presence of an alveozone, a flattened base, an orthostrophic shell, and a narrow umbilicus serve to separate the two genera.

Ambozone dictyonema, new species

Plate 5, figs. 9–14

DIAGNOSIS: Low-spired to planispiral shells with well-developed spiral collabral ornament forming nodes at intersections.

DESCRIPTION: The early whorls are smooth and planispiral. The third to fifth whorls are planispiral and may uncoil to form low spiral shells. Whorls embrace on the selenizone or on the lower margin. Sutures sharply depressed. The convex upper whorl surface has 1–5 spiral cords; numerous collabral cords form interference nodes. The selenizone is above the periphery and is raised and flat to concave and bordered by spiral cords. The lower selenizone margin marks the periphery. The rounded base has 3–10 spiral cords, with collabral cords forming interference nodes. Widely phaneromphalus. Early whorls exposed in the umbilicus. No parietal deposits.

DISCUSSION: There is a tremendous amount of variation in the ornament pattern between all specimens. Some have only one or two spiral cords on the upper whorl surface with strongly formed interference nodes, while others with numerous spiral cords have very reduced ornament, including the selenizone margins. It differs from the type species *A. rasmusseni* Batten, 1972, in being more planispiral and with strongly developed ornament.

RANGE: Leonardian–Wordian.

HYPODIGM: 504, 2; 512, 2; 702, 1; 702a, 1; 703a, 2. 8 specimens.

MEASUREMENTS: *Plate 5. 9–11.* holotype, AMNH 43625, 504, H 5.50, W 11.80, SW, 0.45; paratype, USNM 431552, 703a, H 2.20, W 4.50, SW 0.50; *12, 13.* paratype, AMNH 43681, 512, H 4.70, W 9.00, SS 1.30, SW 0.30. *14.* paratype, USNM 431551, 703a, H 2.50, W 6.30, SW 0.25.

ETYMOLOGY: *Dictyos*, Greek for net.

SUBFAMILY NEILSONIINAE
KNIGHT, 1956

DISCUSSION: This subfamily was recognized by the Treatise authors (Knight et al., 1960) on the basis of the high-spined shell, the selenizone placed near the periphery, dominant collabral ornament on the upper whorl surface, and the presence of an alveozone. *Peruvispira* has the selenizone just above the periphery (which is low on the whorl) with the lower selenizone margin on the periphery. *P. delicata* Chronic, 1949, is a common species in the limestone facies in the Carboniferous and Permian of the western regions of North America and South America only in the Andes Mountains. It is of small size in these regions. Large-size species have been assigned to this genus particularly in Australia and New Zealand (Dickens, 1963) and have been recognized in South Africa and Argentina east of the Andes Mountains (mostly in the Patagonian basin). I am unsure that these later species should be included in this genus since the small-size species (including the type *P. delicata* Chronic, 1949, from the Peruvian Permian) form an inter-related group.

Neilsonia Thomas, 1940, pl. 7, fig. 18, with its selenizone straddling the periphery, is the earliest-appearing genus and its apomorphic features suggest that *Peruvispira* and *Apachella* were derived from forms having features similar to those possessed by that genus. Sadlick and Nielson (1963) described *Lunulazona* from the Chainman Formation of the Confusion Range of Utah which has a wide selenizone also straddling the periphery which is low on the whorl. Gordon and Yochelson (1987), in a further study of the genus from the Chainman, added to the concept by assigning several species of *Mourlonia* and *Bembexia* to it. I believe that all species so assigned fit as closely to the original concept

of *Neilsonia* by Thomas and I believe that *Lunulazona* is synonymous with *Neilsonia*.

Apachella Winters, 1956

TYPE SPECIES: *A. translirata*, Winters, 1956: 30, pl. 3, figs. 1, 2.

DESCRIPTION: High-spined to pupaeform with narrow-to-wide and flat-to-concave selenizone forming the shoulder. The alveozone varies in width and depth depending on the shape of the whorl. Sutures embrace whorls well below the selenizone, usually on the basal angulation. The upper whorl surface is convexo-concave with either spiral and/or collabral ornament adjacent to the suture. A very shallow anal slit generates a concave selenizone with sharply defined margins. The lower margin forms, or is close to, the whorl periphery. The base is rounded to somewhat flattened with heavily developed spiral ornament. The columellar lip is usually straight. The parietal inductura is thin or wanting. Anomphalus to narrowly phaneromphalus. Inductural teeth may form either at the junction of the lower and columellar lips or in the plane of the aperture at the junction of the parietal surface and the upper lip.

DISCUSSION: The origin of *Apachella* is unknown. It clearly is similar to *Peruvispira* Chronic, 1949, in the shape of the shell, presence of an alveozone, and details and position of the selenizone. The ornament patterns are more fully developed in *Apachella* and the shell shapes differ in the rates of whorl expansion and translation. Undescribed specimens in the Peret Collection at the Royal Institute of Brussels from the type Tournasian are probably congeneric (pl. 5, fig. 15). The genus first appears in the Magalena Limestone (Penn.) in west Texas and by Hueco time (Lower Permian) it had diversified and dominated some Hueco faunas. It currently is unknown above the Guadalupian. However, *Sagena bellisculpta*, described by Koken from the Triassic of the Alps, appears to be congeneric (pl. 5, fig. 16), but I have not been able to study the species. The photograph shows a selenizone with the lower margin forming the whorl periphery; the slit appears shallow and the ornament is very close to that of *Apachella exaggerata*, n. sp.

Apachella is one of the most variable of all

eotomarian genera in both shell shape, ornament patterns, and apertural modifications. *A. translirata* represents a very high-spired, turreted species while *A. nodosa* is low spired and trochoid, converging on the shape and ornament pattern of *Phymatopleura*.

Apachella translirata Winters, 1963

Plate 5, figs. 17–19;
plate 6, figs. 11, 12

Apachella translirata Winters, 1963: 30, pl. 3, figs. 1, 2.

DESCRIPTION: Small high-spired shells with a prominent spiral rib and collabral nodes or threads adjacent to the suture on the upper whorl surface. Early whorls are smooth. Whorls embrace on the first spiral cord below the basal angulation. Sutures are deeply incised. The upper whorl surface is convexo-concave with collabral threads on the convex portion. In some populations, there are one or two weakly developed spiral threads which form weak interference nodes on this convex surface. The concave portion is without ornament other than growth lines. The lower selenizone margin forms the upper periphery so that the concave selenizone forms the base of the upper whorl surface. The outer whorl face is represented by a very narrow, concave alveozone which also is unornamented or with a few fine spiral threads. The aperture of the adult may flare outward. The base is flatly rounded to rounded with very strongly developed spiral cords. Anomphalus to narrowly phaneromphalus. The columellar lip is straight and slightly reflexed. The parietal inductura is thin to wanting. The shell is thin and the aperture shows no thickening of any form.

DISCUSSION: This species was first described by Winters from the Supai of central Arizona. It is common in the Wolfcampian and Leonardian of West Texas and New Mexico. In later populations in the Yezo Formation, for example, the rate of whorl expansion increases so that the shell is more robust. In the Hueco populations the upper whorl face is more fully developed so that the relative position of the selenizone appears lower on the whorl; also the alveozone is wider and more concave. The thickened and flaring aperture in the 712t population develops

a tremata in the slit, which is unique to this species (pl. 6, figs. 11, 12). The closest species is *A. franciscana* Chronic, 1952, which differs primarily in the presence of spiral lirae adjacent to the suture rather than collabral nodes.

RANGE: Leonardian–Wordian.

OCCURRENCE: 53, 1; 369, 86; 391a, 1; 433, 5; 501, 1; 504, 2; 512, 15; 678, 1; 2022, 9; 702, 1; 702g, 1; 703, 3; 707d, 1; 707e, 5; 721j, 17; 721t, 1; 725d, 10; 728, 1; 729, 4; 710d, 8; 3364, 1; Pu3, 1. 175 specimens.

MEASUREMENTS: Plate 5. 17. AMNH 43626, 369, H 7.80, W 5.10, SPANG 43°, SS 0.65, SW 0.35, CBS 1.20; 18. USNM 431552, SPAC, H 8.3, W 5.10, SPANG 40°, SS 0.95, SW 0.25, CBS 1.10; 19. AMNH 43627, B188-6, H 9.30, W 6.50, SPANG 46°, SS 0.85, SW 0.55, CBS 0.85. Plate 6. 11, 12. USNM 434065, 721j, H 7.10, W 5.10, SPANG 41°, SS 0.90, SW 0.22, CBS 0.30.

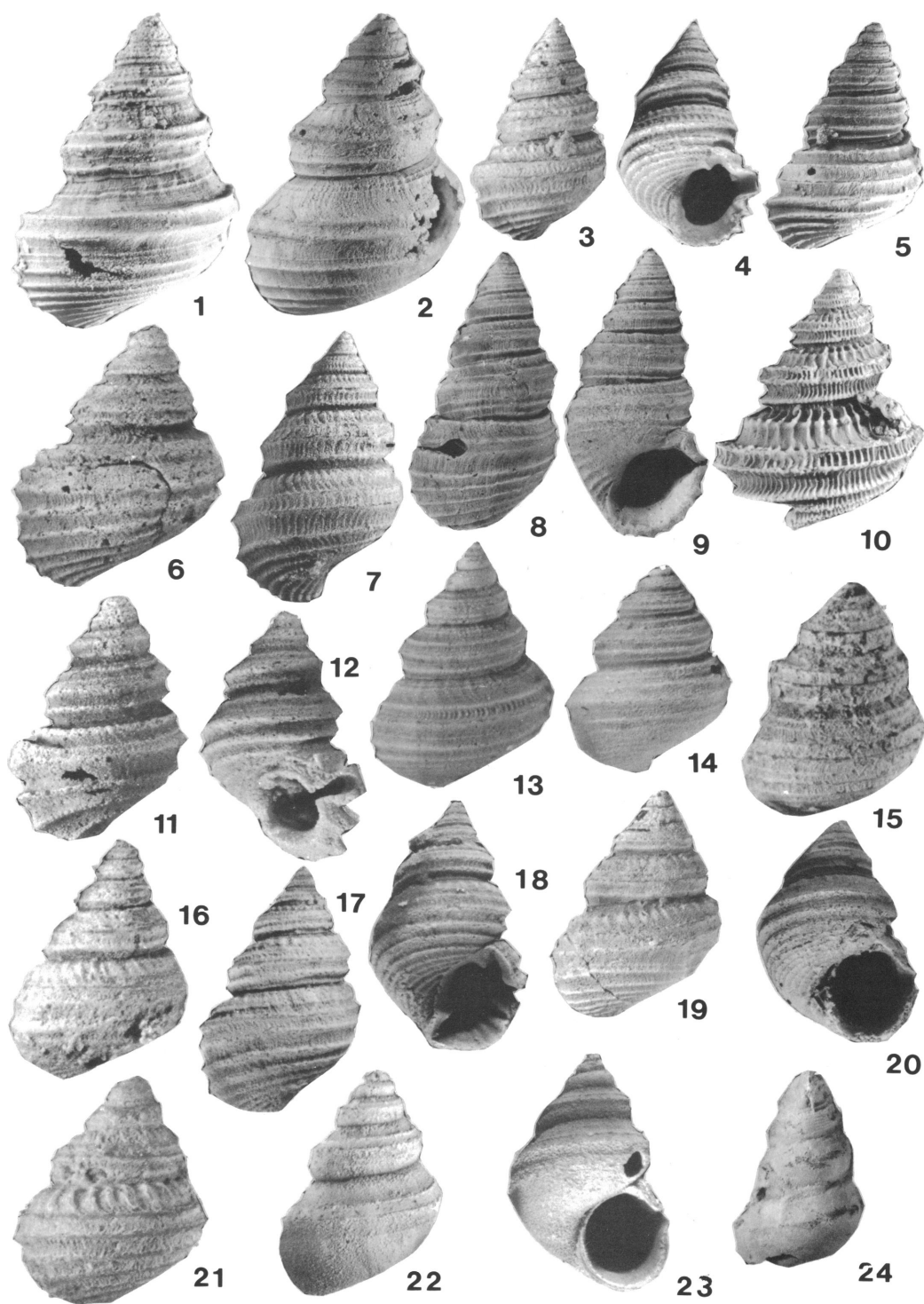
Apachella franciscana Chronic, 1952

Plate 6, figs. 1, 2

Ananias franciscana Chronic, 1952: 114, pl. 2, figs 5, 6.

DESCRIPTION: High-spired, turreted shells with two or three spiral threads adjacent to the suture. The sutures are sharply depressed. Whorls embrace just below the first spiral element on the base. The upper whorl surface is convexo-concave, sloping at about a 45° angle to the axis. Two or three spiral threads are on the upper part of the convex surface. Some shells with very fine spiral elements on the concave portion of the upper whorl face. The slit is relatively deep. The lower selenizone margin forms the upper shell periphery and is more strongly developed than the upper selenizone margin. The selenizone is relatively wide and concave. The concave alveozone is variable in width and is either unornamented or with one or more spiral elements. The flatly rounded to rounded base has spiral ornament only. The columellar lip is reflexed, either totally or just the lower portion so that it has a twisted appearance.

DISCUSSION: This species is most similar to *A. translirata* Winters, 1963, but differs primarily in having spiral ornament adjacent to the suture rather than collabral elements and lacking a spiral cord adjacent to the seleni-



zone. *A. franciscana* is represented by numerous populations and individuals and is wider in stratigraphic distribution. Early populations tend to have narrower selenizones and are higher spired than later populations.

RANGE: Wolfcampian to Guadalupian.

OCCURRENCE: 53, 230; 364, 2; 369, 1; 391, 116; 503g, 1; 505, 1; 512, 28; 655, 10; 678, 101; B1886, 15; 702, 14; 702t, 2; 703a, 6; 703c, 2; 707a, 1; 707e, 38; 710d, 408; 712, 5; 712d, 20; 712f, 200; 712g, 28; 716, 1; 722g, 6; 726, 6; Pu3, 4; PUAC, 5; 1102, 1; 3322, 30; LANHM, 251. 1523 specimens.

MEASUREMENTS: Plate 6. 1. AMNH 43628, 503, H 17.30, W 12.80, SPANG 49°, SS 1.80, SW 0.90, CBS 1.27; 2. USNM 431553, 707e, H 12.50, W 9.10, SPANG 46°, SS 1.20, SW 0.70, CBS 1.50.

***Apachella exaggerated*, new species**

Plate 6, figs. 3–10

DIAGNOSIS: Moderately high-spired shells with strongly developed spiral, collabral ornament.

DESCRIPTION: Well-developed ornament ranging from threads to coarse cords. Whorls embrace on the third spiral cord below the selenizone on the base, resulting in a high-spired shell. Whorls are evenly inflated so that the periphery is in midwhorl. The con-

cave selenizone has lunulae varying in development depending on the collabral ornament. There is one spiral cord midway between the suture and the upper margin of the selenizone. It may be a thread reinforced by collabral nodes or a well-defined cord. Between the lower selenizone margin and the first basal cord there may be a spiral thread. There are a total of 7–9 spiral cords on the lower whorl surface and base, which become progressively closer together toward the umbilicus. The collabral ornament varies from fine threads to coarse cords or even bladelike growth surfaces, or cup-shaped flanges. It tends to be more strongly developed near the suture and on the first spiral cord. Phaneromphalus to hemiomphalus. The thinly formed parietal inductura is restricted to the apertural region. A parietal tooth just inside the aperture near the juncture of the parietal surface and the upper lip may or may not be present. An apertural tooth located on the underside of the upper spiral cord and a columellar tooth located just below the center of the columellar lip may be present. The columellar and lower lip surfaces are thickened and a trough is present on the edge of the lower aperture.

DISCUSSION: This is a remarkably variable species in several distinctive features. The shell shape varies from relatively high spired

←

Plate 6

Figs. 1, 2. *Apachella franciscana* Chronic, 1952. 1. AMNH 43628, 503, $\times 3.5$, side view. 2. USNM 431553, 707e, $\times 3.5$, side view. Figs. 3–10. *Apachella exaggerated*, n. sp. Figs. 3, 4. Holotype, AMNH 43629, 512, $\times 3.5$. 3. Side view. 4. Apertural view, note apertural tooth. 5. Paratype 3, AMNH 43632, 512, $\times 3$, side view. 6. Paratype, USNM 431560, 721z, $\times 4.5$, side view. 7. Paratype 4, AMNH 43633, $\times 4$, side view showing pupaeform shell shape. Figs. 8, 9. Paratype, USNM 431582, 721z, $\times 2$. 8. Side view, note tremata near the margin of the adult whorl. 9. Apertural view, note absence of apertural teeth. 10. Paratype, AMNH 43631, 512, $\times 4.5$, side view. Figs. 11, 12. *Apachella translirata* Winters, 1963. USNM 434065, 721j, $\times 4.5$. 11. Side view showing flared aperture. 12. Apertural view showing thickened outer lip and tremata. Figs. 13–15. *Apachella turbiniformis* Winters, 1963. 13. USNM 431554, 703a, $\times 5.5$, oblique side view. 14. USNM 431556, 728, $\times 5.5$, side view. 15. AMNH 43635, 512, $\times 7$, side view, note this specimen is relatively high spired compared to that of fig. 13 or 14. Figs. 16–21. *Apachella pseudostrigillata* Girty, 1934. 16. USNM 431557, 728, $\times 8$, side view. Figs. 17, 18. AMNH 43637, 512, $\times 4.5$. 17. Side view. 18. Apertural view, note tooth on the lower columellar lip and on inner lip near the upper outer lip. Figs. 19, 20. USNM 431558, 703, $\times 3$. 19. Side view. 20. Apertural view, note absence of apertural teeth. 21. USNM 431559, 3364, $\times 6$, side view. Figs. 22–24. *Apachella glabra*, n. sp. Figs. 22, 23. Holotype, USNM 434056, Kriz Coll., $\times 3.5$. 22. Side view. 23. Apertural view. 24. Paratype, USNM 434057, 3364, $\times 3.5$, side view, note faint spiral ornament on third whorl.

with a high axial translation rate and a lower whorl expansion rate which produces a more turreted shell (pl. 6, fig. 5) to a lower-spired shape with a lower axial translation rate and a faster whorl expansion rate, producing a more trochiform shell (pl. 6, fig. 6). In some specimens the axial translation rate is faster in early ontogeny, slowing in later ontogeny producing a pupaeform shell (pl. 6, fig. 7). The slit in the adult whorl may widen to form a foramen and then narrow to a very thin gap at the aperture (pl. 6, figs. 8, 9). The ornament affects the whorl shape. In specimens that have reduced ornament, the whorl profile is evenly rounded, except for the midwhorl selenizone complex. When the ornament is highly developed the whorl profile becomes subquadrate (pl. 6, fig. 7). This species is unique compared to others within the genus. The ornament pattern is similar to that of *Manzanospira manzanicum* Girty but the selenizone is much wider and flat in that species. The highly developed collabral ornament serves to separate this species from such species as *A. lirata*, *A. translirata*, and *A. franciscana* Chronic.

RANGE: Leonardian to Middle Guadalupian.

HYPODIGM: 512, 131; 512b, 1; 519, 1; 678, 14; 702a, 3; 703, 11; 703a, 3; 703b, 1; 703c, 1; 708u, 2; 710d, 55; 716u, 1; 721j, 4; 721s, 5; 721u, 1; 728, 6. 240 specimens.

MEASUREMENTS: *Plate 6. 3, 4.* holotype, AMNH 43629, H 9.20, W 5.80, SPANG 38°, SS 0.75, SW 0.55, CBS 1.30; *5.* paratype 3, AMNH 43632, H 11.10, W 7.40, SPANG 34°, SS 0.80, SW 0.65, CBS 1.65; *6.* paratype 1, AMNH 43630, H 11.70, W 9.20, SPANG 37°, SS 1.10, SW 0.75, CBS 2.20; *7.* paratype 4, AMNH 43633, H 10.20, W 6.50, SPANG 37°, SS 0.75, SW 0.60, CBS 1.60; paratype 5, AMNH 43634, H 4.90, W 4.00, SPANG 53°, SS 0.30, SW 0.40, CBS 0.85; *8, 9.* paratype, USNM 431582, 721z, H 15.10, W 8.0, SPANG 40°, SS 1.00, SW 0.60, CBS 2.10; *10.* paratype 2, AMNH 43631, H 8.60, W 7.00, SPANG 44°, SS 1.10, SW 0.55, CBS 1.50.

ETYMOLOGY: *Exaggero*, Latin for exceed.

Apachella turbiniformis Winters, 1963

Plate 6, figs. 13–15

Apachella turbiniformis, Winters, 1963: 33, pl. 3, figs. 6–8.

DESCRIPTION: Turbiniform shells with dominant spiral ornament. The whorls are evenly inflated. Whorls embrace on the second major cord beneath the selenizone on the base. The sutures are deeply impressed. The upper whorl surface is convex with 1–3 spiral cords with the first element at the suture most strongly developed. There may be one or several spiral threads developed between the major cords. The selenizone margins are sharply formed and may even be developed into flanges. The concave selenizone may have strongly developed lunulae and a mid-selenizone spiral thread may form interference nodes with the lunulae. The whorl periphery is marked by the lower selenizone margin. The flattened to slightly concave alveozone has several unevenly developed spiral threads. The lower margin of the alveozone is marked by a strong spiral cord. The rounded base has 8–12 evenly developed and spaced spiral cords. Hemiomphalus to narrowly phaneromphalus. There is parietal resorption of the basal ornament in the plane of the aperture. The columellar lip is straight and slightly reflexed.

DISCUSSION: There is considerable variation in the ornament pattern. The majority of the specimens tend to have one or two spiral cords on the upper whorl surface, alternating with one or two spiral threads. Some specimens have a single spiral cord near the suture or three well-developed cords evenly distributed over the upper whorl surface. Collabral nodes or threads may be present and more strongly developed near the suture. The selenizone margins can be almost flange-like or reduced to low, rounded cords. The alveozone may have a single or up to four spiral threads. The development of the ornament affects the whorl profile and ultimately the shell shape.

The hypodigm described by Winters (1963: 33), from the Supai Formation of Central Arizona, shows less variation in ornament with usually two spiral cords equally well developed on the upper whorl surface near the suture. The lower selenizone margin is more fully developed than the upper one.

RANGE: Leonardian–Guadalupian.

OCCURRENCE: 369a, 1; 369, 11; 503, 3; 512, 15; 702, 8; 703a, 1; 703, 2; 703c, 2; 708, 26; 708u, 7; 728, 3. 79 specimens.

MEASUREMENTS: *Plate 6. 13.* USNM

431554, 703c, H 7.20, W 5.4, SPANG 45°, SS 0.55, SW 0.40, CBS 1.10; USNM 431555, 703, H 4.80, W 3.60, SPANG 44°, SS 0.35, SW 0.30, CBS 0.85; **14.** USNM 431556, 728, H 5.50, W 4.50, SPANG 50°, SS 0.40, SW 0.25, CBS 0.75; **15.** AMNH 43635, H 5.50, W 4.00, SPANG 48°, SS 0.50, SW 0.25, CBS 0.60; AMNH 43636, 369, H 6.00, W 5.30, SPANG 50°, SS 0.55, SW 0.25, CBS 0.70.

Apachella pseudostrigillata (Girty, 1934)

Plate 6, figs. 16–21

Pleurotomaria strigillata Girty, 1909b: 471, pl. 24, figs. 21, 21a [not Herrick, 1883].

Pleurotomaria pseudostrigillata, Girty, 1934: 541.

DESCRIPTION: Medium to high-spired shells with variably developed spiral and collabral ornament. Moderately turreted. Whorls embrace on or slightly below the lower margin of the alveozone. Whorls are evenly inflated. Sutures are deeply impressed. The upper whorl surface with one or two spiral elements or lacking spiral ornament. Strongly formed collabral cords or numerous weak collabral threads or nodes are more strongly expressed near the suture and weak to absent near the selenizone. The lower selenizone margin forms the whorl periphery. The selenizone margins are well developed, rounded cords. The concave selenizone is usually ornamented by lunulae and there may be a median spiral thread which may cause interference nodes with the lunulae. The concave alveozone is narrow with a weak median spiral thread. Five to 12 spiral cords ornament the rounded to somewhat flattened base. Hemiomphalus to cryptomphalus. A well-developed parietal inductura covers the basal ornament in the plane of the aperture. The columellar lip is slightly reflexed and may bear a tooth on the lower half. A tooth may form at the junction of the upper and columellar lip on the parietal surface. One or more elongated teeth may appear just below the selenizone on the inner lip. The lower portion of the inner lip may be considerably thickened with an opercular trough developed around the outer margin of the aperture.

DISCUSSION: This species as described here comes closest to that of *Pleurotomaria strigillata* Girty (1909b), in having strongly developed collabral nodes or cords on the upper whorl surface and coarse spiral cords on the

base. There is a persistent spiral thread on the alveozone which is unique (pl. 6, fig. 13). This is one of the most variable species of the genus in terms of ornament expression and shell shape, which ranges from squat, low spired, and turbiniform shape to high spired and turriculate (pl. 6, figs. 17, 21). The ornament varies from no spiral cords on the upper whorl surface but with coarse collabral nodes to a surface with two spiral threads near the suture with the collabral ornament reduced to numerous fine threads or reinforced growth lines. Another set of variables involves features within the aperture. In many specimens the aperture has only a slightly reflexed columellar lip and the parietal inductura only a slight thickening of the lower, inner lip. In some specimens there is a single columellar tooth and in others a full complement of four teeth as described above (pl. 6, fig. 18). The teeth are developed such that they channel and isolate exhalant and inhalant currents. It is impossible to ascribe any function to this channeling since these are not consistent characters even within populations of the species.

RANGE: Gaudalupian.

OCCURRENCE: 503, 4; 512, 4; 655, 11; 678, 18; 702, 24; 703, 1; 707e, 4; 728, 2; 3364, 5. 73 specimens.

MEASUREMENTS: *Plate 6. 16.* USNM 431557, 728, H 4.90, W 3.80, SPANG 48°, SS 0.50, SW 0.20, CBS 0.50; **17, 18.** AMNH 43637, 512, H 8.0, W 5.3, SPANG 46°, SS 0.95, SW 0.50, CBS 0.75; **19, 20.** USNM 431558, 703, H 11.60, W 8.60, SPANG 48°, SS 1.35, SW 0.75, CBS 1.25; **21.** USNM 431554, 3364, H 5.50, W 4.80, SPANG 52°, SS 0.55, SW 0.45, CBS 0.65.

Apachella glabra, new species

Plate 6, figs. 22–24

DIAGNOSIS: High-spired, turriculate, smooth shells with faint spiral ornament.

DESCRIPTION: Whorls embrace on the base well below the alveozone or periphery. The whorl profile is evenly inflated except for the selenizone and a very shallow, poorly defined alveozone. The upper whorl surface is evenly rounded and slightly convexo-concave. One or two faint spiral threads may be present near the suture. The selenizone margins are rounded cords. The strongly concave selenizone lacks ornament. The alveozone is a

slightly concave trough without a marked lower margin; the upper margin is the lower selenizone margin which also marks the periphery of the whorl. The rounded base may have 8–20 very fine spiral threads which are evenly distributed. The shells lack collabral ornament. Hemiomphalus to anomphalus. The columellar lip is slightly reflexed and thickened. The lower lip is considerably thickened with an opercular trough around the lower margin of the aperture.

DISCUSSION: This species is one of the highest spired of the genus with the whorl embracement well down on the base (pl. 6, fig. 24). The lack of collabral ornament is unique as is the very faintly developed spiral ornament (when present). A number of specimens are devoid of any ornament. The shell shape is similar to some of the higher-spired specimens of *A. pseudostrigillata* Girty but the lack of ornament serves to separate this species.

RANGE: Leonardian.

HYPODIGM: 433, 56; BSAC, 261; BSNP, 80; 702, 3; 703a, 2; 703b, 3; 3364, 36; 14439, 10. 451 specimens.

MEASUREMENTS: *Plate 6. 22, 23.* holotype, USNM 434056, BSAC, H 10.20, W 7.30, SPANG 46°, SS 0.85, SW 0.60, CBA 1.2; paratype, AMNH 43638, 433, H 10.30, W 6.70, SPANG 39°, SS 1.30, SW 0.65, CBS 1.40; *24.* paratype, USNM 434057, 3364, H 8.80, W 5.50, SPANG 31°, SS 0.70, SW 0.35, CBS 1.10; paratype, USNM 431561, 14439,

H 9.00, W 7.00, SPANG 43°, SS 0.65, SW 0.50, CBS 1.50; paratype, USNM 431562, BSAC, H 10.20, W 8.60, SPANG 42°, SS 0.85, SW 0.35, CBS 1.60.

ETYMOLOGY: *Glabra*, Latin for smooth or bare.

***Apachella mulensis*, new species**

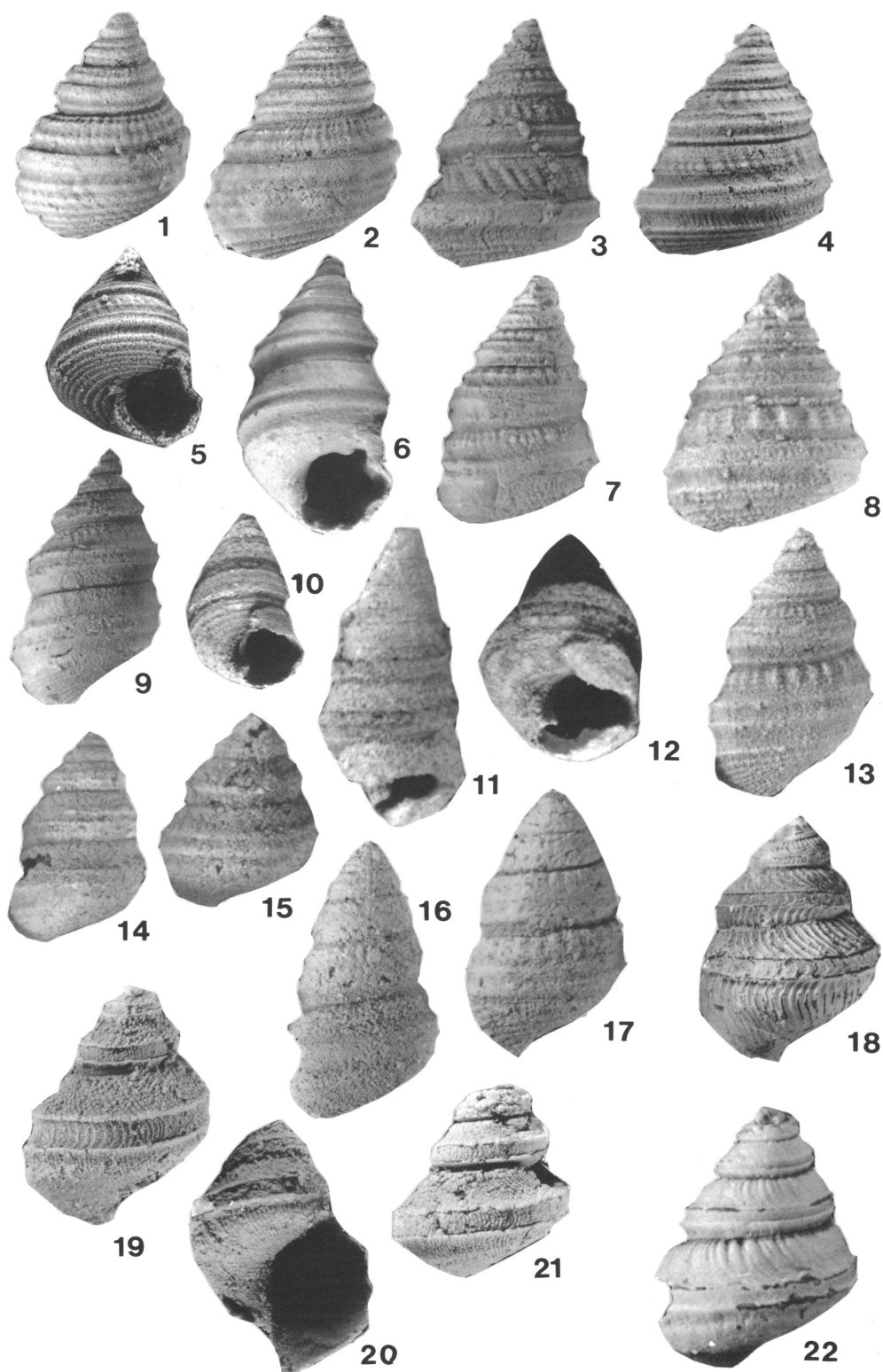
Plate 7, figs. 1, 2

DIAGNOSIS: Relatively low-spired, trochiform shells with dominant spiral ornament.

DESCRIPTION: Whorls embrace on the first spiral cord below the lower alveozone margin. The whorls are evenly inflated with the selenizone raised above the whorl surface. The sutures are deeply incised at the bottom of a deep trough. The upper whorl surface is evenly rounded but interrupted by two strongly developed spiral cords; the largest is in the center of the surface, the next strongest is midway between the suture and the large spiral cord. Other spiral elements may be intercalated between these major cords. Collabral ornament is strongly developed on these cords, forming prominent nodes. There is a deep trough between the major spiral cord on the upper whorl surface and the selenizone with a spiral thread in the bottom. The selenizone is raised above the whorl surface and appears flattened. The selenizone margins are large spiral cords that are rounded on the upper and lower surfaces but flat over the selenizone, partially obscuring the concave

→
Plate 7

Figs. 1, 2. *Apachella mulensis*, n. sp. 1. Holotype, AMNH 43639, 2019, ×3, oblique side view. 2. Paratype, AMNH 43683, 2019, ×3, side view. Figs. 3–8. *Apachella nodosa*, n. sp. 3. Holotype, AMNH 43640, 509, ×5.5, side view. Figs. 4, 5. Paratype, USNM 434058, 707e, ×5.5. 4. Side view. 5. Apertural view; note absence of tooth. 6. Paratype, AMNH 43644, 503, ×5.5, apertural view showing columellar and apertural teeth; note also the high-spired shell. 7. Paratype, AMNH 43642, 678, ×7, side view, note high-spired shell. 8. Paratype, AMNH 43641, 509, ×5.5, side view, note large subsutural nodes. Figs. 9–13. *Apachella huecoensis*, n. sp. Figs. 9, 10. Holotype, USNM 431563, 702. 9. ×6, side view. 10. ×5, apertural view, note columellar tooth. Figs. 11, 12. Paratype, USNM 434059, 703, ×8. 11. Side view, note exposed siphonal trough. 12. Apertural view, note thickened lips and the columellar tooth enlarged and twisted into a wall of the siphonal trough. 13. Paratype, AMNH 43646, 592, ×5.5, side view showing maximum development of subsutural nodes. Figs. 14–17. *Apachella prodontia* Winters, 1963. 14. USNM 431564, 712d, ×6, side view. 15. USNM 431565, 712f, ×7, side view. 16. USNM 434060, 712f, ×4.5, side view. 17. USNM 431566, 712f, ×5.5, side view, note pupaeform shell shape. 18. *Neilsonia* sp. AMNH 43691, Muldraugh Formation (Mississippian), Martinsville, Indiana, ×4, side view showing narrow, ill-defined alveozone. Figs. 19–21. *Neilsonia laticincta*, n. sp. Figs. 19, 20. Holotype, USNM 431567, 707d, ×6. 19. Side view. 20. Apertural view. 21. Paratype, USNM 431568, side view. 22. *Peruvipsira delicata* Chronic, 1949, USNM 431569, 701, ×7, side view.



selenizone. The alveozone is a narrow trough ornamented by a single centrally located spiral thread. The evenly rounded base is ornamented by 8–10 spiral cords evenly developed and distributed. Collabral threads and cords develop nodes on the spiral cords and form almost flangelike cords between them. Hemiomphalus to cryptomphalus. The parietal surface is confined to the plane of the aperture and has resorbed the ornament. The columellar lip is straight and slightly reflexed. The lower lip is thickened with a trough developed at the intersection with the columellar lip.

DISCUSSION: This species is confined to the Colina Limestone of southeastern Arizona. It is described here to illustrate the broad range of variation of the genus. It is at an extreme end of the morphological spectrum involving shell shape. The gross, globular shape is quite similar to that found in *Ananias ootomaria*, n. sp. The shape is the result of the rapid whorl expansion rate. The selenizone is quite different from the other species in that the margins are very massive with the vertical surface markedly flattened and overlapping and obscuring a portion of the concave selenizone. The net appearance of the raised selenizone is flattened and quite similar to that of *Manzanospira manzanicum* Girty.

RANGE: Middle Permian (Kaibab Alpha).

HYPODIGM: 2019. 24 specimens.

MEASUREMENTS: *Plate 7. 1.* holotype, AMNH 43639, 2019, H 10.60, W 8.00, SPANG 50°, SS 1.75, SW 0.55, CBS 1.3; *2.* paratype, AMNH 43683, 2019, H 12.40, W 9.70, SPANG 47°, SS 1.30, SW 0.55, CBS 1.20.

ETYMOLOGY: *Mulensis*, named for the Mule Mountains of Arizona.

***Apachella nodosa*, new species**

Plate 7, figs. 3–8

DIAGNOSIS: Low- to high-spired shells with raised selenizone, well-developed collabral nodes on upper whorl surface.

DESCRIPTION: A variable axial translation rate causes the shell shape to vary from a low, turbiniform, and coeloconoid shell to a high-spired, slightly pupaeform to turriculate shell. The whorls embrace just below the lower

margin of the alveozone. The whorl profile is uneven with a convexo-concave upper whorl surface, a narrow, flattened outer whorl face, and a flattened lower whorl face. The upper whorl surface has 2–14 spiral threads with the strongest developed on the convex portion near the suture. Collabral nodes or cords are best developed on the convex portion of the upper whorl surface and may form interference nodes with the spiral elements. The concave portion of the upper whorl surface has reduced ornament with no collabral ornament and only one or two spiral threads. The gently concave selenizone is raised above the whorl surface, disrupting the whorl profile. The selenizone margins are weakly formed rounded cords. The alveozone is a narrow, unornamented trough. The lower alveozone margin is a rounded cord about the same intensity as the lower selenizone margin. The base is flat to flatly rounded with 5–10 equally developed and spaced spiral cords. Anomphalus, narrowly phaneromphalus or cryptomphalus. The parietal surface has resorbed ornament within the plane of the aperture. The columellar lip is curved and slightly reflexed. There may be a tooth developed on the lower portion of the columellar lip. The lower lip may be thickened. There may be a tooth at the juncture of the upper lip and parietal surface.

DISCUSSION: This is a highly variable species in terms of the shell shape caused by variations in the axial translation rate and whorl expansion rate. At one extreme, the axial translation rate slows with ontogenetic growth at the same time that the whorl expansion rate speeds up, resulting in a turbiniform, coeloconoid shell with a flattened base (pl. 7, fig. 4). At the other extreme, the axial translation rate speeds up at the same time that the whorl expansion rate slows down to produce a slightly pupaeform shell if the axial translation rate varies or a turreted shell if the axial translation rate is constant (pl. 7, figs. 6, 7). One of the distinguishing features of the species is the raised selenizone combined with the development of strong collabral ornament on the upper whorl surface. *A. pseudostrigillata*, which also has well-developed collabral ornament on the upper whorl surface differs in having the selenizone flush with the whorl surface but with strongly de-

veloped spiral ornament on the upper whorl surface as well as the base. *A. huecoensis* has shell shapes resembling this species but lack the intense ornamentation all over the shell. Again, as with other species described above, inner apertural thickening and teeth may be present or totally absent (pl. 7, figs. 5, 6).

RANGE: Leonardian–Guadalupean.

HYPODIGM: 369, 39; 369a, 1; 503, 34; 503d, 3; 504, 18; 509, 62; 512, 1; 592, 1; 678, 264; 702c, 1; 703, 9; 703b, 2; 703c, 2; 707e, 25; 712, 1; 721j, 6; 721s, 3; 722g, 34; 728e, 46; 728h, 125; 738b, 2; 3364. 679 specimens.

MEASUREMENTS: Plate 7. 3. holotype, AMNH 43640, 509, H 6.50, W 5.00, SPANG 45°, SS 1.00, SW 0.5, CBS 0.65; 4, 5. paratype, USNM 434058, 707e, H 5.50, W 4.70, SPANG 55°, SS 1.00, SW 0.40, CBS 0.60; 6. paratype, AMNH 43644, 503, H 5.40, W 3.70, SPANG 36°; 7. paratype, AMNH 43642, 678, H 6.20, W 3.70, SPANG 33°, SS 0.65, SW 0.25, CBS 0.50; 8. paratype, AMNH 43641, 509, H 5.00, W 4.00, SPANG 53°, SS 0.60, SW 0.25, CBS 0.6; paratype, AMNH 43643, 678, H 5.50, W 3.70, SPANG 41°, SS 0.50, SW 0.25, CBS 0.50.

ETYMOLOGY: *Nodosus*, Latin for knot.

***Apachella huecoensis*, new species**

Plate 7, figs. 9–13

DIAGNOSIS: High-spired shells with raised selenizone low on whorl.

DESCRIPTION: High-spired shells with whorl embracing just below the lower alveozone margin. Sutures are sharply incised. The upper whorl surface is convexo-concave with the convex portion near the suture with numerous fine spiral threads. Weak collabral elements form interference nodes with the spiral threads. The concave portion may have numerous spiral threads or it may be devoid of ornament. The selenizone is concave and the selenizone margins are sharply formed cords. The concave alveozone may be devoid of ornament or with fine spiral threads. The lower alveozone margin is a weaker cord than the upper margin (lower selenizone margin). The rounded to somewhat flatly rounded base has from 8 to 20 spiral threads which may be more strongly developed near the umbilicus. Anomphalus to cryptomphalus. The columellar lip is curved and slightly reflexed

usually with a tooth on the lower third. The parietal inductura is thin to thick with a tooth at the junction of the outer lip. The inner, lower lip may be thickened.

DISCUSSION: This group is one extreme of two species which have raised selenizones. It has reduced ornament on the upper whorl surface consisting of numerous spiral and collabral threads. *A. nodosa*, the other species with the raised selenizone, has very strongly developed collabral cords on the upper whorl surface and stronger spiral elements. It is more variable in shell shape with much variation in the axial translation rate forming low-spired shells with flattened bases to high-spired shells with rounded bases. There is some variation in axial translation rate in *A. huecoensis* so that in some forms such as the type, there may be pupaeform shells (pl. 7, fig. 9). Some specimens have a spiral cord developed on the convex portion of the upper whorl surface and these tend to be lower spired and with a more flattened base. As in other species of this genus, *A. huecoensis* may or may not have apertural thickening and teeth. In some specimens the columellar tooth has been elongated and the inner lip modified into a siphonal trough (pl. 7, fig. 12). In addition, there is an elongated tooth or fold opposite the columellar fold on the lower outer lip, below the selenizone, which forms a pronounced siphonal groove that appears to be functional. I have noted this in other species of the genus as well. The puzzling thing is that if these teeth and grooves are functional, why don't most specimens of the species have them?

RANGE: Wolfcampian–Guadalupean.

HYPODIGM: 369, 8; 369a, 1; 503, 15; 503c, 2; 512, 2; 592, 6; 678, 5; 702, 13; 703, 1; 706b, 8; 712, 6; 712g, 18; 721j, 13; Pu3, 2; 14439, 2. 102 specimens.

MEASUREMENTS: Plate 7. 9, 10. holotype, USNM 431563, 702base, H 5.00, W 3.70, SPANG 40°, SS 0.65, SW 0.35, CBS 0.65; paratype, AMNH 43645, 503, H 4.80, W 3.30, SPANG 43°, SS 0.65, SW 0.25, CBS 0.45; 11, 12. paratype, USNM 434059, 703, H 4.20, W 7.20, SPANG 34°. 13. paratype, AMNH 43646, 592, H 6.5, W 4.30, SPANG 41°, SS 0.65, SW 0.40, CBS 0.90.

ETYMOLOGY: Named for the Hueco Mountains, Texas.

Apachella prodontia, Winters, 1963

Plate 7, figs. 14–17

Apachella prodontia Winters, 1963: 54, pl. 4, figs. 1a, 2.

DESCRIPTION: Shells with a variable axial translation rate so that some shells are orthostrophic while others are slightly coeloconoid or pupaeform (see pl. 7, figs. 14, 17). The sutures are sharply defined in a shallow trough. The whorls are evenly inflated. Whorls embrace at or just below the lower alveozone margin. The upper whorl surface is convexo-concave. There is a spiral cord on the convex portion adjacent to the suture. Collabral threads form weak to strong subsutural nodes on this spiral cord. The concave portion is smooth without ornament. The concave selenizone has spiral cords for margins. The lower margin forms the periphery. The alveozone is narrow and shallow. The lower margin is a cord. The base is rounded with four or more spiral threads that are evenly spaced and developed, or with just a single thread or two adjacent to the umbilicus. The aperture may have a well-developed tooth just inside the upper lip adjacent to the sutural position; it is more consistently found in the Supai Formation populations. Hemiomphalus to phaneromphalus. The columellar lip is slightly reflexed.

DISCUSSION: These small shells are distinctive because of the rounded whorls without collabral ornament except on the sutural cord. *A. translirata* Winters, 1963, also has a sutural cord with collabral nodes but the shell shape is turreted and it has spiral cords on the base. *A. glabra*, n. sp., also shows some variation in axial translation rate to produce slightly coeloconoid or pupaeform shells but it totally lacks ornament of any kind.

Variation in axial translation rate is expressed by a slowing down of the rate during ontogeny to produce a pupaeform shell, or by speeding up during ontogeny to produce a coeloconoid shell. Most specimens are orthostrophic. Another obvious variation involves the number and expression of spiral ornament on the base and the presence or absence of an apertural tooth.

RANGE: Wolfcampian–Leonardian.

OCCURRENCE: 53, 100; 391, 35; 391a, 1; 503c, 5; 512f, 30; 708o, 1; 712, 6; 712a, 36;

712c, 74; 712d, 32; 712f, 503; 712g, 6; 726, 10; 727, 9; 728, 30; Kriz, 40; Pu3, 14. 932 specimens.

MEASUREMENTS: *Plate 7. 14.* USNM 431564, 712d, H 5.2, W 3.50, SPANG 41°, SS 0.65, SW 0.35, CBS 0.30; *15.* USNM 431565, 712d, H 4.80, W 3.50, SPANG 44°, SS 0.55, SW 0.25, CBS 0.15; *16.* paratype, USNM 434060, 712f, H 9.00, W 5.30, SPANG 40°, SS 1.10, SW 0.50, CBS 0.70; *17.* USNM 431566, 712f, H 9.0, W 5.3, SPANG 33°, SS 1.30, SW 0.70, CBS 0.70.

Neilsonia Thomas, 1940

TYPE SPECIES: *Neilsonia roscobiensis* Thomas, 1940: 46.

DISCUSSION: The species described from the Scottish Lower Carboniferous by Thomas are large sized. The selenizone is relatively wide and flat with lunulae; it is located at the periphery of the shell so that the center of the selenizone marks the position of the periphery (pl. 7, fig. 18). The dominant ornament is collabral cords located on the upper portion of the upper whorl surface and forming nodes near the suture. Spiral ornament is developed on the base and in the concave portion of the upper whorl surface near the selenizone. The genus is found in North America in the Pennsylvanian and Permian of Texas and New Mexico but it is very uncommon and sporadic in distribution.

Neilsonia laticincta, new species

Plate 7, figs. 19–21

DIAGNOSIS: Globose, low-spined shells with a wide flat selenizone on the periphery of the shell.

DESCRIPTION: Globose trochiform to turreted shells with a relatively rapid whorl expansion rate compared to that of other species. Whorl profile is globose with the upper whorl surface convex. The sutures are sharply defined and deep. The upper whorl surface has collabral threads evenly developed from suture to selenizone. The slit is unknown but lunulae on the selenizone suggest that it was shallow. The selenizone is extremely wide, occupying up to 25% of the whorl surface. It is flat to slightly convex following the whorl surface. It is located over the periphery of the shell. The margins are sharply defined but

not formed of spiral cords. The alveozone is narrow and shallow and separated from the base by a weakly developed spiral thread. The base is rounded to flatly rounded and ornamented by weak collabral threads. Anomphalus to narrowly phaneromphalus. The parietal surface has resorbed the ornament. The lower lip may be flattened and modified into a siphonal notch. The columellar lip is thickened into a callus.

DISCUSSION: This species is placed in *Neilsonia* because of the nature of the selenizone complex. In that respect it is closest to the type species *N. roscobiensis* which has the widest selenizone of all known species. In other respects this species is very similar to *Peruvispira*, particularly in the convexo-concave shape of the upper whorl surface and the collabral ornament on its upper portion, the narrow alveozone, and the turreted shell shape. Only one other species, represented by a few specimens, is similar; it is undescribed from the Neilson Shell bed of the Lower Limestone Group (Lower Carboniferous) at Waukmill, Lanarkshire, Scotland.

RANGE: Wolfcampian.

HYPODIGM: 707d, 2.

MEASUREMENTS: Plate 7. 19, 20. holotype, USNM 431567, 707d, H 5.80, W 4.90, SPANG 54°, SS 0.43, SW 0.72, CBS 0.58; 21. USNM 431568, 707d, H 5.60, W 4.42, SPANG 50°, SS 0.58; CBS 0.29.

ETYMOLOGY: *Latus*, Latin for wide or broad; *cingulum*, Latin for belt or zone.

Peruvispira Chronic, 1949

TYPE SPECIES: *P. delicata* Chronic, 1949: 146; 1953: 139, pl. 28, figs. 9–12.

DESCRIPTION: Turreted, turbiniform shells with the selenizone on the periphery. Sutures are deeply impressed within a sharply defined trough. The upper whorl surface is concavo-convex with collabral ornament confined to the upper whorl surface. Spiral ornament is weaker in development but may be more universal on the shell. Whorls embrace on the lower margin of the alveozone. The selenizone is at the periphery of the shell or the lower margin of the selenizone may form the periphery. The selenizone is narrow and concave and may have lunulae. The slit is deep. Anomphalus. The columellar and lower lips

are thickened into an arcuate callus. The parietal surface is depressed with resorbed growth lines or ornament.

DISCUSSION: Several species of *Peruvispira* are found in the Permian of the southern continents. In Patagonia (Sabattini and Noirat, 1969), southern Africa (Reed, 1931), and Australia (Dickens, 1963) there are reports of large size species. The type species, *P. delicata* Chronic, 1949, is small (3.0–7.0 mm in height) and very uniform in features throughout its range from southern Peru to central Nevada. All of the species show very little variation in their characteristics. The type species is widely distributed in western North and South America and occurs in large populations. Statistical studies shows almost complete overlap in population features over its entire range.

Peruvispira delicata Chronic, 1949

Plate 7, fig. 22; plate 8, fig. 1

Peruvispira delicata Chronic, 1949: 146, pl. 28, figs. 9–12.

DESCRIPTION: Small, turreted shells with the selenizone on the periphery and with collabral cords developed on the upper whorl surface. Sutures are sharply defined and in a narrow, deep sutural trough. Whorls embrace on or just below the lower margin of the alveozone. The upper whorl surface is flat, slightly globose, or convexo-concave. Collabral cords develop on the upper half of the whorl surface, but collabral elements may develop over the entire surface. Spiral threads may develop on all of the upper whorl surface. The selenizone margins are bladelike spiral cords. The selenizone has lunulae and may have a medial thread. The alveozone is narrow and may be shallow or deep. Spiral threads may be present. The base is flatly rounded to rounded and has both spiral and collabral ornament which may be reticulate. Anomphalus. The columellar lip is reflexed and thickened to form a callus. The parietal inductura varies from a thin wash to a thick pad. There may be a thickening which forms a tooth-and-groove near the junction of the parietal and upper lips.

DISCUSSION: This is a remarkable species in that it is widely distributed in the western mountain ranges of North and South Amer-

ica and is found in strata from the Pennsylvanian through Guadalupian showing little morphological variation, yet occurs in fairly large populations. The populations in the Wolfcampian type sections in the Glass Mountains have thinner selenizone margins, weaker collabral ornament, and slightly less rounded bases than the type population of Peru. The populations in the Word Formation of the Glass Mountains have more flattened upper whorl surfaces with collabral cords restricted to the upper part of the surface, with stronger selenizone margins and flattened bases and deeper alveozones compared to the Wolfcampian populations. The presence of an apertural tooth-and-groove on some specimens presents the same problem seen in species of *Apachella* where the question of function can't be resolved because not all individuals possess these structures.

RANGE: Pennsylvanian–Guadalupian.

OCCURRENCE: 329, 3; 503, 3; 509, 1; 512, 16; 512f, 1; 592, 5; 625, 8; 629, 122; 631, 53; 632, 73; 678, 18; 701, 308; 701c, 9; 701d, 36; 701e, 18; 702d, 1; Hess Ranch, 1; 702e, 2; 702f, 4; 703, 14; 703a, 1; 703c, 1; 706b, 22; 706c, 72; 707a, 2; 707e, 1; 708u, 1; 716, 3; 721u, 1; 724, 4; 728, 80; 728f, 400; Moore #18, 8. 1290 specimens.

MEASUREMENTS: *Plate 7. 22.* USNM 431569, 701, H 4.90, W 3.70, SPANG 49°,

SS 0.70, SW 0.35, CBS 0.40. *Plate 8. 1.* AMNH 43690, 629, H 8.30, W 5.80, SPANG 48°, SS 1.25, SW 0.45, CBS 0.60.

SUBFAMILY AGNESIINAE

KNIGHT, 1956

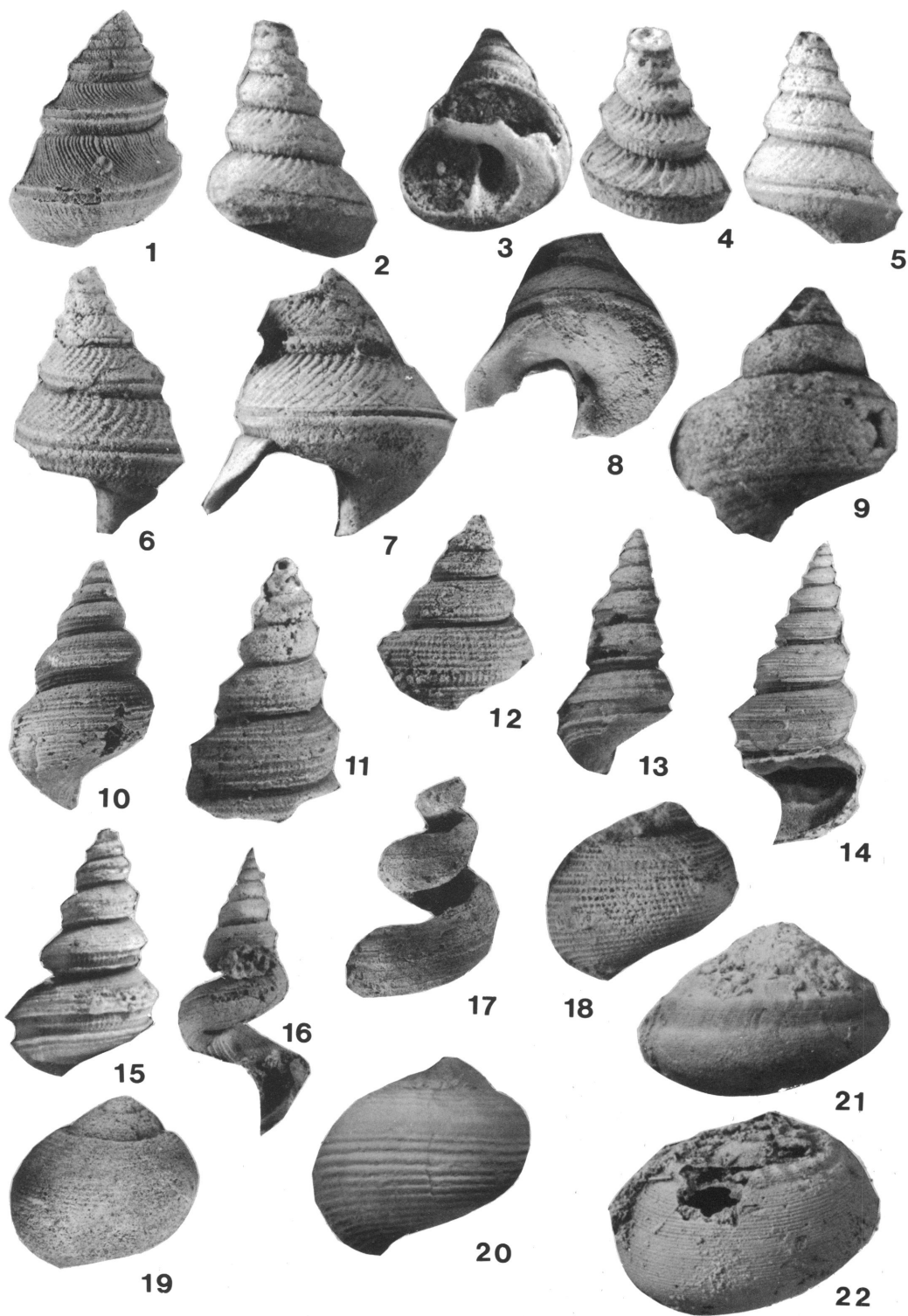
DISCUSSION: This subfamily is based on included genera that are sinistral or hyperstrophically coiled (see Batten, 1966: 38 for a full discussion). *Agnesia* DeKoninck, 1883, and *Enantiostoma* Koken, 1896, appear to be normal, orthostrophic shells that are sinistral. *Hesperiella* Holzapfel, 1889, contains two groups of species. One, including *H. permianus*, n. sp., is hyperstrophic with the early embryonic whorls buried in the apex, so that there is a 180° change in the axis of coiling. Usually this condition is accompanied by a circumbilical ridge on the base of adult whorls. The growth lines or lunulae in the selenizone are asymmetrical. In the other group of species including *H. wordensis*, n. sp., the shells are normally orthostrophic and sinistral. Knight (1945: 148) originally made the suggestion that the hyperstrophically coiled forms were in fact dextral rather than being sinistral as they appear using the normal orientation.

Hesperiella Holzapfel, 1889

TYPE SPECIES: *Pleurotomaria contraria* deKoninck, 1843: 401, pl. 34, fig. 7 (subsequent designation by Knight, 1945: 337).

Plate 8

1. *Peruvispira delicata* Chronic, 1949, AMNH 43690, 629, ×5, side view. Figs. 2–5. *Hesperiella permianus*, n. sp. Figs. 2, 3. Holotype, USNM 431570, 703a, ×7.5. 2. Side view. 3. Oblique side view, not circumbilical ridge and wide umbilicus. 4. Paratype, USNM 431572, 703a, ×8, side view, note fine spiral ornament on upper whorl surface and planispiral searly whorls. 5. Paratype, USNM 431571, 703a, ×8, note evenly inflated whorls and low periphery. Figs. 6–8. *Hesperiella wordensis*, n. sp. 6. Holotype, USNM 431573, 707d, ×5, side view. Figs. 7, 8. Paratype, USNM 431574, 703a, ×4. 7. Side view. 8. Oblique basal view note closed umbilicus. 9. *Platyzona rotunda*, n. sp., holotype, AMNH 43647, 51, ×10, side view. Figs. 10–12. *Platyzona cancellata*, n. sp. 10. Holotype USNM 431575, 721u, ×2.5, side view. 11. Paratype, USNM 431577, 721u, ×4, side view, note unevenly spaced spiral elements. 12. Paratype, USNM 434061, 721j, ×4, side view, note evenly rounded whorls and cancellate ornament. Figs. 13–15. *Platyzona pagoda*, n. sp. 13. Holotype, USNM 431578, ×4, side view. 14. Paratype, USNM 431576, ×2, apertural view. 15. Paratype, USNM 434062, 721s, ×7.5, side view. Figs. 16, 17. *Platyzona anguispira*, n. sp. 16. Holotype, USNM 431579, 702ent, ×1.5, apertural view. 17. Paratype, AMNH 43650, 503, ×2, side view. Figs. 18–20. *Gosseletina permiana*, n. sp. 18. Holotype, USNM 431581, 701g, ×4, side view, note reticulate ornament. 19. Paratype, AMNH 43651, 2033, ×4, side view. 20. Paratype, USNM 434063, 712h, ×1.2, side view, note coarse spiral cords. Figs. 21, 22. *Colpites striata*, n. sp. 21. Holotype, AMNH 43652, 512, ×3, side view. 22. Paratype, AMNH 43653, 512, ×4.5, oblique side view, note fine spiral striae.



DISCUSSION: Several of the species belonging to this genus show changes in the axial translation rate so that pupaeform to coeloconoid shells result. There are also some variations to be noted in the details of the selenizone. Most species have narrow, concave selenizone, such as the two species described below, while others may have wider selenizone which is strongly bordered. Ornament patterns tend to be conservative.

***Hesperiella permianus*, new species**

Plate 8, figs. 2–5

DIAGNOSIS: High-spined coeloconoid shells with dominant collabral ornament.

DESCRIPTION: Embryonic whorls hyperstrophic and globose, buried in apex. Second whorl planispiral with inflated whorl, larger than third whorl. Sutures sharp, located in shallow trough. Whorls embrace at or just below lower alveozone margin. Upper whorl surface evenly convex, but slightly flattened adjacent to suture. Collabral cords evenly spaced over surface, strongly developed near suture but weaker near selenizone. Spiral threads evenly developed and distributed over surface. Periphery low on shell and marked by upper selenizone margin. Selenizone narrow, concave, with or without median spiral thread. Selenizone margins formed by complex spiral cords consisting of overlapping growth lamellae. Alveozone narrow and concave with very strong, nearly vertical collabral cords. Widely phaneromphalus. Base flatly rounded with weak collabral and spiral threads, and with a circumbilical ridge.

DISCUSSION: Because this species is hyperstrophic, the illustrations should be upside down, since these are dextral shells. However, I will follow convention and retain the sinistral-appearing orientation. This species displays considerable variation in the axial translation and whorl expansion rates. The embryonic whorls are hyperstrophic to almost planispiral. The whorl expansion rate decreases to the third whorl and then gradually increases to keep pace with ontogenetic growth. The axial translation rate slows down until the fifth whorl in some specimens, then increases to form the coeloconoid shell. Other shells show only a uniform translation rate

which causes a normal orthostrophic shell to develop.

RANGE: Leonardian–Wordian.

HYPODIGM: 702, 3; 703, 1; 703a, 5; 708u, 1. 10 specimens.

MEASUREMENTS: Plate 8. 2, 3. holotype, USNM 431570, 703a, H 5.40, W 4.00, SPANG 41°, SS 0.70, SW 0.30, CBS 0.45; 4. paratype, USNM 431572, 703a, H 4.20, W 3.50, SPANG 42°, SS 0.50, SW 0.25, CBS 0.45; 5. paratype, USNM 431571, 702, H 5.00, W 3.80, SPANG 41°, SS 0.90, SW 0.20, CBS 0.30.

ETYMOLOGY: Named for the Permian System.

***Hesperiella wordensis*, new species**

Plate 8, figs. 6–8

DIAGNOSIS: Turbiniiform, sinistral shells with evenly inflated whorls and reflexed columellar lip.

DESCRIPTION: Early whorls normally orthostrophic. Axial translation and whorl expansion rates uniform to produce turbiniiform shell. Sutures shallow. Whorls embrace at or just above lower margin of alveozone. Upper whorl surface broad and evenly convex. Collabral cords evenly spaced and developed from suture to selenizone. Spiral threads evenly distributed over surface, may form reticulation with collabral elements. Periphery low on whorl and marked by upper margin of selenizone. Alveozone narrow and ornamented by both collabral and spiral elements. Base flatly rounded and ornamented by spiral and collabral threads or cords which become less well developed toward umbilicus. Anomphalus to cryptomphalus. Curved columellar lip reflexed.

DISCUSSION: This species differs from *H. permianus* in the orthostrophic nature of the embryonic whorls as opposed to the hyperstrophic condition in that species. The planispiral second whorl in the latter species is incrementally larger than the third whorl, while in *H. wordensis* all whorls become progressively larger with ontogeny. The rates of axial translation and whorl expansion are uniform in this species so that the shell is orthostrophic. Collabral ornament is more uniformly developed in this species. The base is anomphalus with a reflexed columellar lip

in comparison to *H. permianus* which is widely phaneromphalus with a circumbilical ridge.

RANGE: Leonardian–Wordian.

HYPODIGM: 702, 3; 703a, 1; 703b, 1; 707d, 2; 721j, 1. 8 specimens.

MEASUREMENTS: *Plate 8. 6.* holotype, USNM 431573, 707d, H 9.0, W 6.3, SPANG 55°, SS 1.2, SW 0.40, CBS 0.40; *7, 8.* paratype, USNM 431574, 703a, H 10.0, W 8.0, SPANG 60°, SS 1.75, SW 0.50, CBS 0.75.

ETYMOLOGY: Named for the Word Formation.

FAMILY GOSSELETINIDAE WENZ, 1928

SUBFAMILY COELOZONIINAE KNIGHT, 1956

Platyzona, Knight, 1945

TYPE SPECIES: *Pleurotomaria trilineata* Hall, 1858: 25.

DISCUSSION: As discussed by Batten (1972: 34), this genus is very conservative in its morphological range; for example, ornament patterns are similar in species from the Devonian through mid-Permian, when it became extinct. However, within species there is a considerable amount of variation involving ornament pattern, axial translation, whorl expansion rates, and shell shape. Shells can vary from low spired turbiniform to high spired and uncoiled. The genus is widespread throughout the Northern Hemisphere but occurs only sporadically with faunas.

Platyzona rotunda, new species

Plate 8, fig. 9

DIAGNOSIS: Trochiform, low-spired shells with selenizone flush with, or slightly raised above, whorl surface.

DESCRIPTION: Early whorls smooth. Sutures sharply defined and deep. Whorls embrace at lower margin of selenizone. Whorls evenly inflated. Upper whorl surface convex with four or more spiral threads or cords. Narrow trough marks lower margin of surface. Outer whorl face nearly vertical and slightly convex. Upper and lower margin of outer whorl face are marked by spiral threads. Selenizone, flush with outer whorl face or slightly raised above it, conforms to convexity of surface. Details obscured but selenizone appears to have several spiral threads dis-

tributed across its width. Selenizone margins weakly formed spiral threads. Alveozone narrow and ornamented by two spiral threads, lower one better developed and marks margin of shell base. Base flatly rounded and narrowly phaneromphalus to cryptomphalus with 6–8 spiral cords. Columellar lip reflexed.

DISCUSSION: None of the specimens in the collections are preserved well enough to be sure of ornament details. For example, col-labral ornament could not be detected. However, the shape and position of the selenizone plus the low spires make these shells highly distinctive. This species has the lowest-spired shells thus far known in the genus. It is somewhat similar to *P. tornatilis* (Phillips) in that the selenizone is nearly flush with the whorl surface. However, in that species the selenizone is without ornament other than lunulae. It is also similar to *P. cirriformis* (J. B. Sowerby) in shell shape but that species lacks strong spiral ornament present in *P. rotunda* and is higher spired.

RANGE: Wolfcampian.

HYPODIGM: 51, 12; 391, 1; 391a, 2. 15 specimens.

MEASUREMENTS: *Plate 8. 9.* holotype, AMNH 43647, 51, H 4.20, W 3.60, SPANG 53°, SS 0.50, SW 0.70, CBS 0.50; paratype, AMNH 43648, 51, H 5.20, W 4.70, SPANG 56°, SS 0.90, SW 0.70, CBS 0.50; paratype, AMNH 43649, 391a, H 4.80, W 3.70, SPANG 49°, SS 0.70, SW 0.60, CBS 0.25.

ETYMOLOGY: *Rotundus*, Latin for round.

Platyzona cancellata, new species

Plate 8, figs. 10–12

DIAGNOSIS: High-spired shells with evenly inflated whorls; cancellate ornament.

DESCRIPTION: High-spired shells with globose whorls which may uncoil at adult whorl. Sutures deeply set in narrow trough. Whorls embrace on second to fourth spiral cord or thread beneath lower selenizone margin except on penultimate whorl where embracement is at fifth or sixth spiral element. Upper whorl surface, outer whorl face, and base evenly rounded. Upper whorl surface has 8–10 evenly spaced and developed spiral cords or threads. Collabral cords or threads usually equally developed, but may be weaker, forming interference nodes. Selenizone with me-

dial cord marking the shell periphery. Selenizone either flush with whorl surface and slightly convex or somewhat depressed beneath surface and flat to slightly concave. Selenizone with up to four spiral threads which, with medial cord, form interference nodes with lunulae. Rounded base with 15–23 spiral threads evenly developed and spaced or alternating stronger and weaker threads. Hemiomphalus. Columellar lip straight and slightly reflexed. Parietal inductura thin.

DISCUSSION: The ornament is one of the most variable features of this species. The holotype (pl. 8, fig. 10) shows evenly developed spiral and collabral ornament over the whorl surface, yet within the same population there are forms such as the paratype (pl. 8, fig. 11) which show alternating spiral cords and threads unevenly developed. The selenizone also shows a considerable amount of variation ranging from being convex and flush with the whorl surface with weakly developed margins and multiple spiral threads to one that is depressed below the whorl surface and is flat-to-concave with strongly formed margins and just a single medial thread. Some specimens show a tendency to uncoil in the last whorl (pl. 8, fig. 11). The ornament and whorl shape are similar to that of *P. eulkaensis* (Reed, 1927), but that species has a stronger development of spiral ornament over collabral (growth lines or lightly developed threads) and is lower spired with whorl embracing on the lower selenizone margin.

RANGE: Leonardian–Wordian.

HYPODIGM: 369, 5; 391a, 1; 503, 9; 509, 1; 702, 1; 721j, 12; 721s, 3; 721u, 2; 729, 1. 36 specimens.

MEASUREMENTS: *Plate 8. 10.* holotype, USNM 431575, 721s, H 15.80, W 9.50, SPANG 44°, SS 2.00, SW 1.00, CBS 1.00; *11.* paratype, USNM 431577, 721s, H 15.20, W 7.50, SPANG 27°, SS 1.20, SW 1.00, CBS 1.00; *12.* paratypes, USNM 434061, 721u, H 7.5, W 7.00, SPANG 44°, SS 1.40, SW 0.80, CBS 1.00.

ETYMOLOGY: *Cancellus*, Latin for lattice.

***Platyzona pagoda*, new species**

Plate 8, figs. 13–15

DIAGNOSIS: High-spired shells with evenly developed spiral ornament and depressed selenizone.

DESCRIPTION: Evenly inflated whorls. Sutures sharply depressed in a trough. Whorls embrace on first spiral cord of base. Shallow, narrow trough on upper whorl surface adjacent to suture. Upper whorl surface with 4–8 spiral cords or threads uneven in development and arrangement, collabral ornament growth lines alone or collabral threads which may form reticulation with spiral ornament. Selenizone in center of outer whorl face, occupies most of it. Selenizone with medial thread serving as periphery of shell, lunulae form interference nodes with it. Selenizone depressed beneath whorl surface. Prominent selenizone margins formed by spiral cord and one or more spiral threads. There may be up to four spiral elements on flat selenizone. Base convexo-concave. Just under selenizone base convex with several spiral cords or threads. Lower edge of this surface marked by prominent spiral cord which serves as contact point for whorl embracement. Under this cord, base concave and ornamented by unevenly developed spiral threads or cords. Hemiomphalus. Columellar lip straight and reflexed with thin parietal inductura.

DISCUSSION: The principal variation involves the spiral ornament which ranges from fairly evenly developed spiral threads in the specimens from locality 592 to very unevenly developed spiral ornament in the 707d population. In some specimens collabral ornament may develop to form reticulation with spiral ornament (pl. 8, fig. 15). There is some variation in the depth of the selenizone beneath the whorl surface. In the 702d population it is quite deep, but in specimens from 592 and 721j the selenizone is nearly flush with the surface. This species most closely resembles *P. nodohumerosa* Batten, 1972, from the Malaysian Permian in the uneven development of spiral ornament but differs from that species in being higher spired, with more evenly inflated whorls and with a parietal inductura.

RANGE: Leonardian.

HYPODIGM: 592, 1; 702d, 11; 721j, 2; 721s, 2. 16 specimens.

MEASUREMENTS: *Plate 8. 13.* holotype, USNM 431578, 702d, H 10.90, W 4.8, SPANG 28°, SS 0.80, SW 0.90, CBS 1.00; *14.* paratype, USNM 431576, 702d, H 10.40,

W 4.60, SPANG 33°, SS 1.20, SW 1.20, CBS 1.00; 15. paratype, USNM 434062, 721s, H 4.80, W 2.80, SPANG 28°, SS 0.60, SW 0.50, CBS 0.20.

ETYMOLOGY: Persian; *but*, idol; *kadah*, temple.

***Platyzona anguispira*, new species**

Plate 8, figs. 16, 17

DIAGNOSIS: Uncoiled shell with evenly developed spiral ornament and raised selenizone without obvious margins.

DESCRIPTION: First nine whorls orthostrophic and turreted, at least three whorls uncoiled without whorl contact. The first nine whorls contact on third spiral thread below selenizone. Whorls evenly inflated. Upper whorl surface evenly convex with evenly spaced and developed spiral threads that encircle entire whorl, including umbilical side. Shallow trough on uncoiled whorls, just above middle of surface that lacks ornament. Selenizone low on whorl so that upper margin marks whorl periphery. Shallow, narrow, unornamented trough just above and below selenizone. Selenizone margins formed of spiral threads. Selenizone convex conforming with whorl surface, ornamented by three centrally located spiral threads. In final, uncoiled whorl, spiral ornament adjacent to and including umbilical surface becomes more intense, developing spiral cords which alternate with threads. Aperture not preserved but no parietal deposits appear to have formed.

DISCUSSION: This species is highly distinctive in that the last several whorls are openly uncoiled owing to a very abrupt increase in the axial translation rate. There is a tendency for uncoiling in *P. cancellata*, n. sp., but only a slight increase in axial translation rate is noted in the final whorl translation; however, all whorls are in contact. No other species thus far recognized shows any form of disjunct uncoiling. The highly uncoiled nature of the shell in *P. anguispira*, is, in fact, unusual among pleurotomarians. Other features such as ornament are within the range of known species. However, the raised selenizone is unique among the known species of the genus. Several species, *P. cirriformis* (J. Sowerby) from the European Carboniferous, and *P. nodohumerosa* Batten, 1972, have se-

lenizones that are flush with the whorl surface but no species has it raised above the surface.

HYPODIGM: 503, 1; 702ent, 1; 703, 1. 3 specimens.

MEASUREMENTS: Plate 8. 16. holotype, USNM 431579, 702ent, H 3.95, W 1.48, SPANG 36°, SS 1.40, SW 1.00, CBS 1.00; 17. paratype, AMNH 43650, 503, H 19.10, W 16.40, SPANG 45°, SW 1.50.

ETYMOLOGY: Latin *anguis* for snake; *spiralis*, coil.

SUBFAMILY GOSSELETININAE WENZ, 1938

Gosseletina Fischer, 1887

TYPE SPECIES: *Pleurotomaria callosa* de-Koninck, 1843: 406.

DISCUSSION: This genus is not well represented anywhere in the Permian. It has been reported from the Russian Permian in two places. In the Crimea in an unpublished report by O. Toumansky and from the Upper Permian of Kirilov on the Kolva River by Licharew in 1913. It is found as scattered, isolated individuals throughout the Mississippian and Pennsylvanian in North America.

***Gosseletina permiana*, new species**

Plate 8, figs. 18–20

DIAGNOSIS: Globular shells with dominant spiral ornament.

DESCRIPTION: Globose shells with evenly inflated whorls. Sutures sharply defined and in narrow, shallow trough. Whorls embrace just below lower selenizone margin. Whorl surface ornamented by evenly developed and spaced spiral threads or coarse cords. Collabral ornament may be growth lines only or threads of equal intensity as the spiral ornament. Selenizone is high on whorl, located about midway between suture and broad periphery at midwhorl. Selenizone either flush with whorl surface or slightly depressed beneath it; ornamented by single medial thread or with several fine spiral elements. Selenizone margins marked by spiral threads of equal intensity as other spiral threads. Phaneromphalus or hemiomphalus. Rounded base with spiral ornament that becomes progressively finer toward umbilicus. Straight columellar lip slightly reflexed. Parietal surfaces without resorption or deposition.

DISCUSSION: Most species of the genus have some form of sutural nodes along with spiral ornament, for example, the Pennsylvanian *G. spironema* (Meek and Worthen, 1866). *Gosseletina permiana*, n. sp., lacks the type sutural nodes but has stronger spiral ornament than all previously described species.

Most variation within this species involves ornament development, in the form of more or less well-developed spiral cords with fewer or more numerous elements. On those specimens with coarser spiral threads, the collaral ornament is also more intense, but if spiral ornament consists of cords, no collaral ornament is present.

RANGE: Wolfcampian–Guadalupian.

HYPODIGM: 369a, 1; 391, 10; 512, 2; 2033, 1; Hueco, Otero, NM, 18; 701g, 1; 701e, 1; 725d, 1. 35 specimens.

MEASUREMENTS: *Plate 8. 18.* holotype, USNM 431581, 701g, H 6.70, W 7.20, SPANG 81°, SS 0.60, SW 0.30, CBS 0.35; *19.* paratype, AMNH 43651, 2033, H 8.10, W 8.00, SPANG 95°, SS 1.00, SW 0.40, CBS 0.40; *20.* paratype, USNM 434063, H 20.70, W 22.20, SPANG 120°, SS 3.00, SW 1.50.

ETYMOLOGY: Named for the Permian System.

FAMILY SINUOPEIDAE WENZ, 1938

SUBFAMILY PLATYSCHISMATINAE
WENZ, 1938

Colpites Knight, 1936

TYPE SPECIES: *Naticopsis monilifera* White, 1880.

DISCUSSION: This genus is quite rare. It is known from the Pennsylvanian of Missouri and is represented by few specimens noted below. It is distinctive in having a U-shaped sinus just above midwhorl and a crown of subsutural nodes.

Colpites striata, new species

Plate 8, figs. 21, 22; plate 9, fig. 1

DIAGNOSIS: Rotelliform to globose shells with fine spiral ornament.

DESCRIPTION: Rotelliform, low turbini-form to semiglobose shells with fine spiral threads evenly developed over whorl surfaces. Sutures sharp and deeply set in trough. Whorls embrace just below U-shaped sinus.

Upper whorl surface convexo-concave. Convex portion adjacent to suture with coarsely formed sutural nodes. Concave portion just below, terminates in prominent rounded shoulder which forms upper edge of outer whorl face. Broad, U-shaped sinus formed on this shoulder. This sinus does not form selenizone or pseudoselenizone. Outer whorl face narrow, almost vertical, slightly inflated. Lower margin of outer whorl face a very large, prominent periphery. Base flatly rounded with very broad U-shaped sinus. Large funicle occupies about half of base and bounded by narrow trough. Curved columellar lip reflexed and thickened. No parietal deposits or resorption noted.

DISCUSSION: There is much variation in the shape of the shell, ranging from a rotelliform with two marked interruptions of the whorl profile (the upper rounded shoulder and the broadly rounded lower periphery) to more evenly globose with reduced interruptions. The sutural nodes on all shells are uniformly developed and spaced.

This species differs from the type species, *C. monilifera* (White, 1880), and *C. minuta* Knight, 1933, in the presence of fine spiral threads over the whorl surface and the well-developed shoulder and lower periphery.

RANGE: Wolfcampian–Guadalupian.

HYPODIGM: 503, 2; 512, 32; 702, 4; 703, 14; 703c, 1; 712g, 8; 728, 14. 75 specimens.

MEASUREMENTS: *Plate 8. 21.* holotype, AMNH 43652, 512, H 7.10, W 10.30, SPANG 108°, SS 0.70, SW 0.30; *22.* paratype, AMNH 43653, 512, H 6.20, W 8.60. *Plate 9. 1.* paratype, AMNH 43685, 503, H 1.12, W 15.80, SPANG 55°.

ETYMOLOGY: *Stria*, Latin for stripe or fluting.

FAMILY RAPHIOMATIDAE KOKEN, 1896

DISCUSSION: This family includes genera that have very short anal slits or sinuses. Most have either a sinus or a pseudoselenizone to mark the excurrent channel. The subfamily Liospirinae Knight, 1956, includes the genus *Trepsira*, Ulrich and Scofield, 1897, widely distributed and commonly encountered in the Upper Paleozoic but absent in the Permian deposits included in this study. The subfamily Omospirinae Wenz, 1938, includes *Bay-*

lea deKoninck, 1883 and *Callistadia* Knight, 1945, which are present in the Permian faunas of this study and which have well-developed selenizones. *Hypselentoma* Weller, 1929, lacks a true selenizone and has a U-shaped or asymmetric sinus; some species have a pseudoselenizone.

SUBFAMILY OMOSPIRINAE WENZ, 1938

Baylea DeKoninck, 1883

TYPE SPECIES: *Trochus yvanii* LeVeille, 1835.

DISCUSSION: This genus is very widespread throughout the Upper Paleozoic. Its chief distinguishing feature is the selenizone located on the upper margin of the outer whorl face, which is tilted at a 45° angle to the nearly vertical outer face. An exhaustive study of variation within this genus was made by Weller in 1929. Much of the variation involves features of ornament which is observed in the Permian species of this study.

Baylea huecoensis, new species

Plate 9, figs. 2, 3

DIAGNOSIS: Turreted shells with dominant spiral ornament.

DESCRIPTION: Turreted shells with spiral cord adjacent to sutures. Sutures sharply defined in narrow, deep trough. Whorls embrace on or just above lower alveozone margin. Upper whorl surface convexo-concave. Convex portion with flattened area immediately adjacent to suture with spiral thread on flat area and another on edge of flat area. Concave portion of upper whorl surface has three or four spiral elements that decrease in development toward the selenizone. Collabral threads form interference nodes on all these spiral elements, and also swing back near suture and then forward on convex portion of upper whorl surface, indicating a sub-sutural sinus. Concave selenizone with spiral cords for margins. Lunulae well developed. Concave alveozone occupies most of outer whorl face and with a medial spiral cord, above which three or more spiral threads unevenly distributed. Lower margin of alveozone a spiral cord. Growth lines in alveozone swing sharply opisthocline and turn abruptly prosocline at two spiral cords just under al-

veozone on base, forming a secondary sinus on aperture. Rounded base with 10 or more evenly spaced and developed spiral cords. Anomphalus. Columellar lip reflexed and thickened into callus.

DISCUSSION: The most noticeable variation in this species is in the spiral ornament. On some specimens the prominent spiral cord on the convex portion of the upper whorl surface may be replaced by two weak threads. The medial spiral cord in the alveozone may be reduced to a weak thread and the cord forming the lower alveozone margin may be either a single spiral thread or several weak threads.

The most outstanding features of this species are the secondary sinus adjacent to the suture and another on the edge of the base. Weller (1929) (pl. 3, fig. 11) illustrated a faint sinus on the base in *B. giffordi* (Worthen, 1884). It is similar to that in *B. huecoensis* but not as deep and is asymmetrical.

This species resembles *B. giffordi* from the Pennsylvanian of Illinois in the spiral ornament pattern on its turreted shell. It differs in having weaker collabral nodes on the upper whorl surface (*B. huecoensis* has only interference nodes, not sutural nodes) and lacks heavy nodding on the lower alveozone margin that *B. giffordi* has.

RANGE: Wolfcampian-Leonardian.

HYPODIGM: 700f, 1; 7011, 1; 702, 3; 712, 1; 712g, 40; 3364, 1. 47 specimens.

MEASUREMENTS: Plate 9. 2. holotype, USNM 434066, 700f, H 7.60, W 6.50, SPANG 57°, SS 1.00, SW 0.35, CBS 1.20; 3. paratype, USNM 431583, 712g, H 7.20, W 5.20, SPANG 52°, SS 0.75, SW 0.20, CBS 1.10.

ETYMOLOGY: Named for the Hueco Mountains of west Texas.

Baylea cf. *supercrenata* Weller, 1929

Plate 9, fig. 4

Yvania supercrenata Weller, 1929: 22.

DESCRIPTION: Turbiniform shells with strong spiral ornament. Sutures deeply incised. Whorls embrace on upper cord of lower alveozone margin. Upper whorl surface convexo-concave. Convex portion with two spiral cords adjacent to suture. Concave portion lacks ornament. Concave selenizone with

spiral cords for margins. Alveozone strongly concave with two spiral cords for a lower margin. Base flatly rounded with five spiral cords. Phaneromphalus. Aperture not preserved.

DISCUSSION: The single well-preserved specimen is immature but has most of the features of *B. supercrenata*. It lacks collabral ornament other than exceedingly fine growth lines, as does the hypodigm of the species from the Colchester Limestone of western Illinois.

RANGE: Pennsylvanian–Permian.

OCCURRENCE: 703. 1 specimen.

MEASUREMENTS: Plate 9. 4. USNM 431584, 703, H 3.20, W 3.70, SPANG 78°, SS 0.50, SW 0.15, CBS 0.65.

Callistadia Knight, 1945

TYPE SPECIES: *Callistadia bella* Knight, 1945: 578.

DISCUSSION: Knight described this monotypic genus from collections made by Knight and others at Princeton University in the mid-1940s from the Bone Spring Formation in the vicinity of Apache Canyon in the northern part of the Sierra Diablo Mountains in western Texas, these collections are now housed at the National Museum. The genus *Callistadia* most closely resembles *Glabrocingulum* in general shell shape and in the location of the selenizone on the upper edge of the outer whorl face. However, *Glabrocin-*

gulum has a narrower, more concave selenizone, rarely marked by spiral ornament and with a deeper slit.

Callistadia bella Knight, 1945

Plate 9, figs. 5, 6

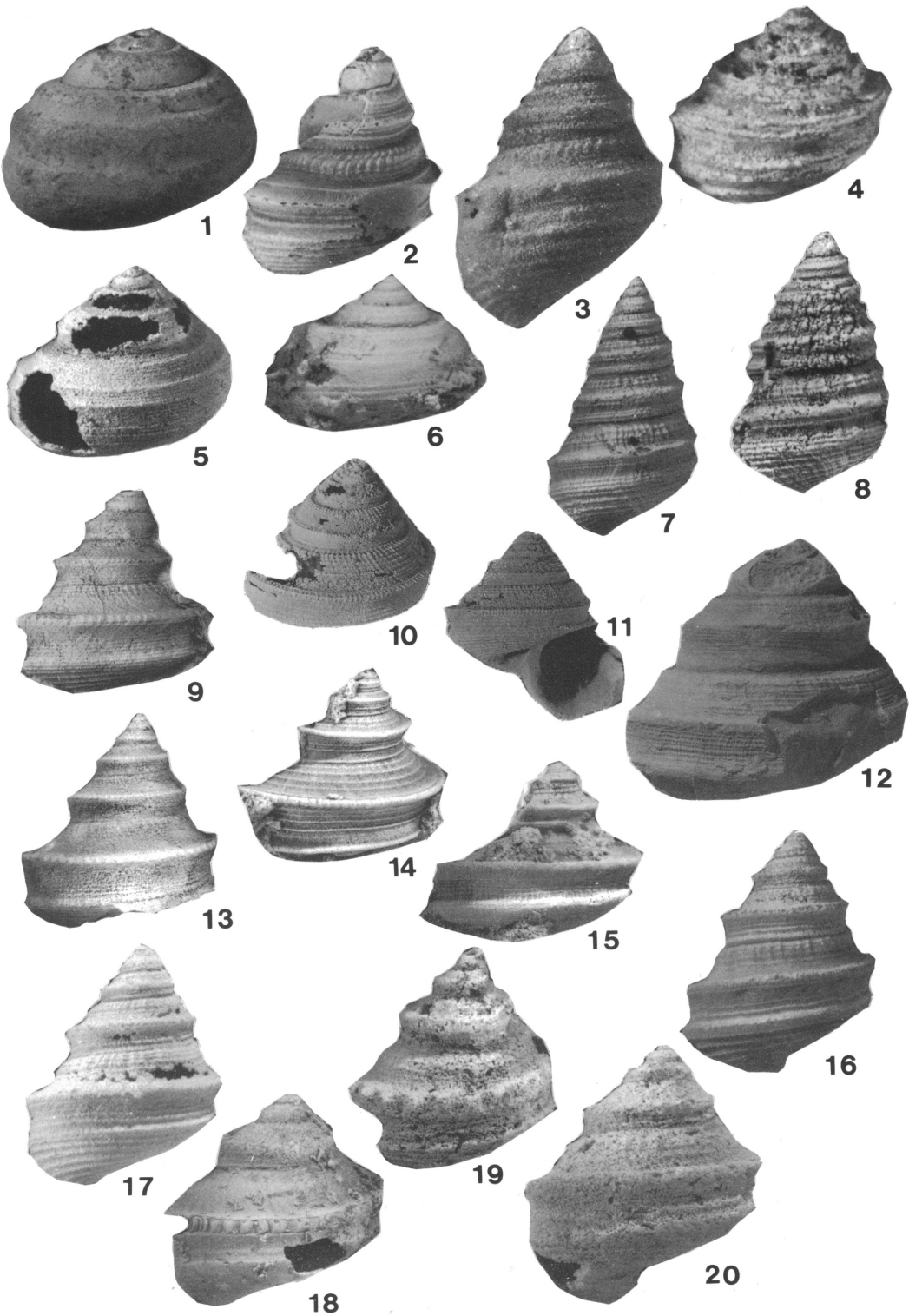
Callistadia bella Knight, 1945: 577, fig. 72.

DESCRIPTION: Turbiniiform shell with dominant spiral ornament. Sutures shallow in a narrow, sharply defined trough. Whorls embrace on outer whorl face. Upper whorl surface flattened to concave. Flattened portion adjacent to suture with three or more spiral threads or cords. Concave portion occupies more than half of lower surface and has numerous spiral threads. A spiral cord or several threads divides flat and concave portions. Concave-to-flat selenizone forms upper margin of outer whorl face with two or more spiral threads unevenly distributed on it. Selenizone margins spiral threads or cords. Outer whorl face flat to slightly concave with numerous spiral threads. Flatly rounded base with numerous spiral threads. Margin of base is rounded. Phaneromphalus. Parietal surface without resorption or callus deposits.

DISCUSSION: The spiral ornament displays the most obvious variation between populations. For example, on the upper whorl surface there may be a single spiral cord marking the margin of the flattened portion or there may be several spiral threads (pl. 9, figs. 5,

Plate 9

1. *Colpites striata*, n. sp., paratype, AMNH 43685, 503, ×3, side view. Figs. 2, 3. *Baylea huecoensis*, n. sp. 2. Holotype, USNM 434066, 700f, side view, note sutural sinus shown by growth lines. 3. Paratype, USNM 431583, 712g, ×4, side view. 4. *Baylea* cf. *supercrenata* Weller, 1929, USNM 431584, 703, ×8.5, oblique side view. Figs. 5, 6. *Callistadia bella* Knight, 1945. 5. USNM 431585, NPAC, ×4, oblique side view. 6. AMNH 43686, 512, ×4, side view, note two spiral threads near suture. Figs. 7, 8. *Hypselentoma ornata*, n. sp. 7. Holotype, USNM 431586, 369, ×3.5, side view. 8. Paratype, AMNH 43655, 369, ×4.5, side view. 9. *Worthenia tabulata* Conrad, 1835, USNM 431588, 703, ×2.5, side view. Figs. 10–12. *Worthenia speciosa* (Meek and Worthen, 1861). Figs. 10, 11. USNM 431590, 712g, ×2. 10. Oblique side view. 11. Apertural view, note wide umbilicus. 12. USNM 431591, 9862, ×1, side view, note trough adjacent to the suture. Figs. 13, 15. *Worthenia kingi*, n. sp. 13. Holotype, USNM 431592, Kriz Coll., ×1.25, side view. 14. Paratype, USNM 431593, 703a, ×1.25, oblique side view. 15. Paratype, USNM 434064, 702, ×2.25, side view, note turned-up shoulder on adult whorl. Figs. 16, 17. *Worthenia alticarinata*, n. sp. 16. Holotype, USNM 431594, 712f, ×3, side view. 17. Paratype, USNM 431595, 721f, ×4, side view. Figs. 18, 19. *Worthenia crenulata*, n. sp. 18. Holotype, AMNH 43656, 512, ×3, oblique side view. 19. Paratype, USNM 431598, 738, ×5.5, oblique side view. 20. Paratype, USNM 431597, 721j, ×4, side view.



6). The lower margin of the outer whorl face may be marked by a spiral cord or a series of fine spiral threads. The selenizone, if concave, may have lunulae and there are collabral threads or even faint nodes on the upper whorl surface. If the selenizone is flat there are fine spiral threads on the surface and no collabral ornament either on the selenizone in the form of lunulae or on the upper whorl surface. There is much variation of whorl embracement; some specimens are low spired because the whorls embrace just under the selenizone (in populations from 701e and 503). If the whorls embrace on the lower margin of the outer whorl face, the shell will be high spired (as in specimens from the Bone Spring Limestone in the Sierra Diablo Mountains).

RANGE: Wolfcampian–Leonardian.

OCCURRENCE: 369, 1; 433, 5; 503, 10; 512, 4; 517, 1; 592, 1; 701e, 1; 702, 7; 703, 3; 703c, 1; Pu NPAC, 5; Kriz Coll., 15; 14439, 4. 58 specimens.

MEASUREMENTS: *Plate 9. 5.* USNM 431585, NPAC, H 8.20, W 9.20, SPANG 86°, SS 0.90, SW 0.45, CBS 1.00; *6.* AMNH 43686, 512, H 6.70, W 8.00, SPANG 90°, SS 0.80, SW 0.35, CBS 1.20.

Hypselentoma Weller, 1929

TYPE SPECIES: *Pleurotomaria prehumerosa* Meek, 1872.

DISCUSSION: This genus is found sporadically throughout the Upper Paleozoic in North America. It is conservative and represented by only a few species.

Hypselentoma ornata, new species

Plate 9, figs. 7, 8

DIAGNOSIS: High-spired, turreted shells with dominant spiral ornament.

DESCRIPTION: Turreted shells with spiral ornament which forms nodes with collabral ornament on upper whorl surface. Sutures deeply set in narrow sutural trough. Whorls embrace on base just below alveozone. Upper whorl surface with two or more spiral cords on convex portion forming nodes with collabral threads. Concave portion of upper whorl surface without ornament. Periphery at upper shoulder which is raised into a rounded protrusion composed of several spi-

ral threads. An asymmetrical U-shaped sinus formed by growth lines at this shoulder. Alveozone on nearly vertical outer whorl face concave and without ornament. Lower margin of alveozone a large spiral cord composed of several spiral threads. Eight or more spiral cords on flatly rounded base. Columellar lip slightly reflexed and thickened. Lower lip thin at margin of aperture.

DISCUSSION: There is some development of the ornament on the upper whorl surface where there may be two dominant spiral threads or cords on the convex portion or three or more weaker threads distributed unevenly across the surface, including the concave portion. There is some variation in the rate of whorl expansion causing some specimens to be lower spired. This species differs from the type species, *H. prehumerosa* is having spiral ornament developed near the suture and having a strongly bordered, concave alveozone.

RANGE: Leonardian.

HYPODIGM: 369, 2; 509, 6; 707e, 19. 27 specimens.

MEASUREMENTS: *Plate 9. 7.* holotype, USNM 431586, 707e, H 10.20, W 6.00, SPANG 48°, SS 0.90, SW 0.20, CBS 1.00; paratype, USNM 431587, 707e, H 10.20, W 5.80, SPANG 44°; *8.* paratype, AMNH 43655, 369, H 9.50, W 6.70, SPANG 43°, SS 0.80, SW 0.30, CBS 1.00.

ETYMOLOGY: *Ornamentum*, Latin for decoration.

FAMILY LOPHOSPIRIDAE WENZ, 1938

SUBFAMILY RUEDEMANNIINAE KNIGHT, 1956

Worthenia DeKoninck, 1883

TYPE SPECIES: *Turbo tabulata* Conrad, 1835: 267.

DISCUSSION: There are about six species of *Worthenia* in the Lower Carboniferous of Western Europe where it was first recognized. Most species develop a selenizone by the third whorl. The early whorls tend to be globose and the concave-to-flat selenizone has strongly developed spiral cords for margins. By the fourth whorl a medial lirae forms with interference nodes developing at the intersection with collabral ornament. In one group,

represented by *W. tabulata*, the selenizone becomes convex at the fourth whorl and the interference nodes become larger. In at least one species, *W. crenulata*, n. sp., they are almost spinose. In another group represented by *W. corrugata* Chronic, 1953, the concave-to-flat selenizone is retained through adulthood but with the medial spiral lirae migrating to $\frac{1}{3}$ the distance down from the upper margin. This lira also forms the periphery of the shell and the margin of the upper whorl surface, thus $\frac{2}{3}$ of the selenizone is on the outer whorl face. Therefore, the selenizone appears to be convex when it is really bent and concave. *W. multilineata*, n. sp., is by far the most variable species of the genus ranging from low-spined shells with reduced ornament to high-spined shells with well-developed ornament. Without a large number of samples, end members of a series of morphoclines within the species could have mistakenly been recognized as separate species.

There have been several proposals of subgenera to this genus. *W. (Yochelsonospira)* Thein and Nitecki, 1974, was based on the lack of a well-developed spiral cord to mark the lower margin of the alveozone, described as *Y. pagoda* from the Chester of Illinois (see *W. Kingi*, n. sp., below). Yin and Yochelson (1983) described *Humiliworthenia* from the Anisian of Quizhou, China for high-spined species, that is, with the whorl embracement at or below the lower margin of the alveozone (see *W. alticarina*, n. sp., below). The overlapping sequence of species in this study tends to show that these features are well within the species range of *Worthenia* and I believe that, with our new knowledge of the Permian species of this study, these two subgenera are not recognizably distinct.

Worthenia tabulata (Conrad), 1835

Plate 9, fig. 9

Turbo tabulata Conrad, 1835.

Worthenia tabulata Ulrich in Ulrich and Scofield, 1897.

DESCRIPTION: High-spined, gradate shells. Sutures shallow and confined in a narrow trough. Whorls embrace on lower margin of alveozone. Early whorls rounded with a flat-to-concave selenizone on medial periphery. Upper whorl surface gently convex to con-

vexo-concave with spiral ornament. Convex portion, or that portion nearest the suture, with stronger spiral ornament forming interference nodes with collabral elements equal in development to spiral. Concave portion, or that portion nearest selenizone with numerous spiral threads weakly developed or absent. Adult convex selenizone ornamented by raised, cup-shaped nodes formed at intersection of lunulae with a medial cord or thread. Medial thread forms exact margin of upper whorl surface and outer whorl face. Concave alveozone with numerous fine spiral threads, collabral elements growth lines alone. Lower margin of alveozone which forms margin of base equally well developed as shoulder where selenizone is located. Flatly rounded base with numerous spiral cords or threads more strongly developed near upper margin of base. Cryptomphalus. Straight columellar lip reflexed and thickened. Lower lip slightly curved downward. Thin parietal inductura partially covers ornament within plane of aperture.

DISCUSSION: This description is based on Permian samples which include both silicified specimens and those collected loose on the outcrop from various shales, particularly in the Wolfcampian. This description differs from that which would apply to Pennsylvanian specimens in that the Pennsylvanian material is primarily from shales and the ornament is much more strongly developed. The specimens from Permian shales also show more strongly developed ornament but not to the extent found in the Pennsylvanian.

Variation involves relative development of the ornament particularly on the upper whorl surface. If it is evenly convex, the spiral threads are evenly developed over the entire surface. If the upper whorl surface is convexo-concave, the spiral threads or cords are restricted to the convex portion near the suture and the concave portion may lack spiral ornament entirely.

The ontogeny of the selenizone is significant in that the early whorls are globose with a rounded whorl profile. The selenizone appears at the third whorl periphery and is concave with strongly developed margins. One-half whorl later a medial thread appears. These features are very *Mourlonia*-like. By the fourth whorl, the selenizone has migrated

to the newly formed shoulder and lunulae and interference nodes appear on the medial thread. Very quickly, by the fifth whorl, the selenizone is evenly convex with the interference nodes expanded to occupy half the space between lunulae.

There is a very great difference in size between the larger specimens from shales, such as R. C. Moore's locality in the Camp Creek Shale or the *Uddenites* Zone at the Taylor Ranch in the Wolfcamp Hills, and the much smaller-sized silicified specimens. I can only guess that this is either a collecting bias and/or a preservation bias. Linsley (personal commun., 1988) suggests that it might be an eco-phenotype, a likely possibility.

RANGE: Widely distributed in the Pennsylvanian and Permian of the U.S., particularly common in shales of the midcontinent.

OCCURRENCE: 701u, 1; Kriz, 17; 703, 4; 703c, 5; Word no. 1, 4; 707d, 2; 707e, 1; 707g, 11; 721j, 2; 14439, 2; Moore 27, 1; 9832, 1; Moore Camp Creek, 3; 9880, 26; 391a, 6. 86 specimens.

MEASUREMENTS: *Plate 9. 9.* USNM 431588, 703, H 16.60, W 15.00, SPANG 65°, SS 1.60, SW 0.70, CBS 2.40; USNM 431589, Moore 9880, H 80.99, W 70.14, SS 9.50, CBS 14.55.

Worthenia speciosa
(Meek and Worthen), 1861
Plate 9, figs. 10–12

Pleurotomaria speciosa Meek and Worthen, 1861.
Worthenia speciosa Ulrich in Ulrich and Scofield, 1897.

DESCRIPTION: Turbiniform shells with spiral and collabral ornament nearly equal in development. Sutures shallow but sharply defined. Whorls embrace progressively downward during ontogeny from lower selenizone margin, at fourth whorl, to lower margin of alveozone in adult whorl. Deep subsutural trough or flattened area of upper whorl surface bordered by very large spiral cord. Upper whorl surface below this cord gently convexo-concave. Spiral threads on cord and convex portion of upper whorl surface form interference nodes with collabral threads. From 7 to 10 variably developed and spaced spiral threads with interference nodes. Selenizone margins simple spiral cords. Lu-

nular nodes rounded. Shoulder sharply and strongly developed with nodes and medial thread of selenizone forming lower margin of upper whorl surface. Concave outer whorl face slopes downward with lower margin of alveozone less prominent than shoulder. Flatly rounded base and alveozone ornamented by spiral and collabral threads or cords with interference nodes. Phaneromphalus to hemiomphalus. Columellar lip reflexed but not thickened. A thin parietal wash obscures ornament within plane of aperture.

DISCUSSION: This species is more compact in shell shape than the turreted *W. tabulata* because the whorls embrace higher on the whorl in that species. The large subsutural trough and cord which bounds it add to the illusion of near globosity. The ornament is more evenly developed over the shell than in the type species. There are fewer differences between the Pennsylvanian and Permian forms than seen in *W. tabulata*, except for slightly less well-developed ornament in the Permian populations.

This species is found sporadically in faunas of the Pennsylvanian but is much less commonly encountered than the type species. However, it is twice as commonly found in the Permian.

RANGE: Pennsylvanian–Permian.

OCCURRENCE: 390, 2; 678, 5; 701e, 2; 702t, 7; Moore 18, 1; 199-T-13-P22, 2; 199-T-13-P22, 4; 9802, 34; 9862, 1; 9880, 3; 42-T-18, 5; 42-T-18, 1; 199-T-7-P19, 3; 199-T-7, 1; 707d, 1; 712, 3; 712f, 4; 712g, 12; Word No. 1, 3; 721j, 1; 724, 1; 3322, 14; 753, 1. 145 specimens.

MEASUREMENTS: *Plate 9. 10, 11.* USNM 431590, 712g, H 14.80, W 13.50, SPANG 68°, SS 1.80, SW 0.70, CBS 0.90; 12. USNM 431591, 9863, H 43.30, W 48.10, SPANG 72°, SS 6.80, SW 2.20, CBS 6.80

Worthenia kingi, new species
Plate 9, figs. 13–15

DIAGNOSIS: Tabulate shells with noded, corded, basal angulation.

DESCRIPTION: Gradate to tabulate shells with basal angulation as equally well developed as shoulder. Sutures deeply set in a narrow trough. Whorls embrace just below basal

angulation (lower margin of alveozone). Upper whorl surface gently convex to slightly convexo-concave. Five or more spiral cords or threads evenly developed and spaced and form interference nodes at intersections with collabral ornament. Shoulder is a keel with well-developed selenizone margins separated by narrow troughs from selenizone interference nodes. Keel may be drawn out into a flange (pl. 9, fig. 14). Outer whorl face (includes all of alveozone) is strongly concave with four or more spiral threads or cords which may be unevenly spaced and have interference nodes. Lower margin of alveozone (or basal angulation) is a keel composed of a strongly developed spiral cord with interference nodes which parallel keel on shoulder. Base flatly rounded to flat with eight or more spiral cords or threads which may be intercalated with finer spiral ornament. Phaneromphalus to hemiomphalus. Columellar lip slightly reflexed. Parietal deposits obscure basal ornament within aperture.

DISCUSSION: The shells of this species are tabulate, like the type species *W. tabulata*, but the upper whorl surface is flatter and slopes more gently from the axis. The outer whorl face is more strongly concave and the base is flatter giving the shells a more steplike appearance. The most obvious distinguishing feature that separates this species from all others except for *Worthenia bicincta*, n. sp., is the strongly developed lower margin of the alveozone which has well-developed interference nodes on the spiral cord, and is as well developed as the shoulder. In addition, the development of a keel on some specimens is unique among the known species of the genus.

RANGE: Wolfcampian–Guadalupian.

HYPODIGM: 42, 1; 503, 8; 678, 1; B1886-6, 3; Kriz, 2; 701e, 1; 701g, 1; 710d, 1; 712g, 2; 702, 5; 702d, 8; 703b, 3; 707e, 1; 721j, 1. 38 specimens.

MEASUREMENTS: *Plate 9. 13.* holotype, USNM 431592, Kriz, H 27.85, W 26.15, SPANG 67°, SS 3.20, CBS 5.25; *14.* paratype, USNM 431593, 703a, H 13.60, W 15.40, SPANG 51°, SS 1.80, SW 0.70, CBS 3.30; *15.* USNM 434064, 702, H 16.50, W 18.30, SPANG 96°, SS 1.60, SW 0.65, CBS 2.30.

ETYMOLOGY: Named for P. B. King.

***Worthenia alticarinata*, new species**

Plate 9, figs. 16, 17

DIAGNOSIS: High-spired, turreted shells with steep sloping upper whorl surfaces.

DESCRIPTION: High-spired shells with a lower whorl expansion rate compared to axial translation rate. Sutures deep in a narrow trough. Whorls embrace at or below lower alveozone margin. Upper whorl surface evenly convexo-concave and slopes steeply downward and outward from suture. Convex portion with four or more spiral cords with interference nodes at intersections with collabral threads. These nodes may coalesce to form elongate ridges. Concave portion has numerous fine spiral threads. Selenizone with lunulae thickened to form elongate interference nodes (normal to margins) with numerous fine spiral threads on selenizone. Alveozone varies in width with two spiral cords just below median with several fine spiral threads above median. Lower margin of alveozone is a large spiral cord with several spiral threads on it. Base flatly rounded with eight or more spiral threads or cords which become finer in development and more numerous toward umbilicus. Anomphalus. Columellar lip reflexed. Parietal deposits tend to obscure ornament within aperture.

DISCUSSION: The shell shape of this species varies considerably due to the varying rates and combinations of the whorl expansion rate and the axial translation rate which produce a high or lower shell. In addition, the slope of the upper whorl surface varies along with the width of the outer whorl face. This produces a higher-appearing shell, for example, if the slope of the upper whorl surface is steep and the outer whorl face is wide (pl. 9, fig. 16). There also is much variation in the ornament. In some shells from 721j, the spiral and collabral ornament is very fine with no sutural nodes and the outer whorl is wide. The holotype shows strongly developed spiral ornament and sutural nodes while the outer whorl face is relatively narrow. This ornament variation affects the appearance of the selenizone with strong nodes in the holotype to an almost smooth selenizone in the 712j paratype.

This species differs from the type *W. tabu-*

lata in having a lower whorl expansion rate and higher axial translation rate and a much steeper-sloping upper whorl surface.

RANGE: Wolfcampian–Guadalupian.

HYPODIGM: 503, 3; 678, 30; 712, 14; 712a, 21; 712b, 17; 712c, 10; 712d, 21; 712f, 103; 712g, 31; 703, 1; 721j, 8; 728, 14. 273 specimens.

MEASUREMENTS: *Plate 9. 16.* holotype, USNM 431594, 712f, H 12.30, W 9.10, SPANG 54°, SS 1.20, SW 0.60, CBS 1.80; *17.* paratype, USNM 431595, 712f, H 8.00, W 6.70, SPANG 45°, SS 0.70, SW 0.30, CBS 1.70; paratype USNM 431596, 721j, H 10.30, W 8.10, SPANG 53°, SS 1.10, SW 0.35, CBS 1.50.

ETYMOLOGY: *Altus*, Latin for high; *carina*, Latin for keel.

***Worthenia crenulata*, new species**

Plate 9, figs. 18–20

DIAGNOSIS: Low-spired shells with large nodes on selenizone.

DESCRIPTION: Relatively low-spired shells produced by a faster whorl expansion rate compared to axial translation rate. Sutures deeply inset. Whorls embrace at, or just below, lower margin of selenizone. Upper whorl surface gently convex or convexo-concave. If the latter, convex portion with several spiral threads. The concave portion with finer spiral ornament or none at all. If the upper whorl surface convex, there may be numerous, irregularly developed and spaced spiral threads. Upper margin of selenizone forms shoulder. Margins are spiral cords. Convex selenizone, with widely spaced lunulae, heavily reinforced and domed into irregular, sand dune-shaped or symmetrical, conically shaped nodes. Outer whorl face narrow and alveozone gently concave with several spiral cords and threads of varying degrees of development; or it may have irregularly developed faint spiral threads. Rounded to flatly rounded base with either spiral cords which become finer toward umbilicus, or very faint spiral threads irregularly developed and spaced. Hemiomphalus. Columellar lip reflexed and thickened with or without a funicle. Parietal deposits thickened and appear to obscure ornament within the aperture.

DISCUSSION: This species exhibits a wide

range of ornament pattern ranging from subdued spiral ornament, if the shell is low spired with a convex upper whorl surface, to well-developed spiral ornament if the shell is higher spired and with a convexo-concave upper whorl surface.

The shell is low spired and trochiform as in *W. speciosa* but differs in having reduced ornament, without interference nodes, and with wider-spaced and more intense nodes on the selenizone. In fact, the wide spacing and intense development of the selenizone nodes is more than in any other known species including *W. multicarinata* (Mansuy) from the Tethys of southeast Asia.

RANGE: Leonardian–Guadalupian.

HYPODIGM: 51, 3; 369, 1; 512, 2; 703c, 6; 712j, 3; 712z, 1; 728, 3; 738, 5. 24 specimens.

MEASUREMENTS: *Plate 9. 18.* holotype, AMNH 43656, 512, H 11.80, W 12.00, SPANG 74°, SS 1.50, SW 0.70, CBS 1.60; *19.* paratype, USNM 431598, 738, H 7.3, W 6.1, SPANG 64°, SS 0.7, SW 0.35, CBS 1.2; *20.* paratype, USNM 431597, 712j, H 11.60, W 9.80, SPANG 71°, SS 1.30, SW 0.60, CBS 1.90.

ETYMOLOGY: Latin, *crena*, notch, rounded projection.

***Worthenia multilineata*, new species**

Plate 10, figs. 1–5

DIAGNOSIS: Tabulate shells with large, convex selenizone ornamented by numerous fine spiral threads.

DESCRIPTION: Low- to high-spired turreted shells. Sutures sharply defined and shallow. Whorls embrace progressively lower on alveozone during ontogeny, midalveozone early, at, or below lower margin of alveozone at adult stages. Upper whorl surface convexo-concave; convex portion has three or more spiral cords which form interference nodes with collabral ornament. Concave portion with variable ornament with one or more spiral cords and finer threads. Large convex selenizone forms shoulder. Selenizone with five or more spiral threads which form very fine interference nodes with growth lines on some specimens; others with a single medial spiral thread and well-developed lunulae. Flat-to-concave alveozone with one or more spiral cords or threads, or no ornament. Lower al-

veozone margin is rounded with several spiral threads. Base is flatly rounded with 10 or more spiral cords which become finer near umbilicus. Hemiomphalus. Columellar lip is reflexed and thickened into a callus.

DISCUSSION: This species, along with *W. schirjaeensis* (Stuckenberg), is included within the subgroup of the genus lacking prominent nodes on the selenizone. It differs from that species in being more tabulate with a convexo-concave upper whorl surface and with a more concave alveozone.

There is a considerable amount of variation in the ornament pattern involving the relative development of spiral ornament on the upper whorl surface and the outer whorl face. There is a complete range of ornament from reduced to absent spiral ornament with growth lines alone (pl. 10, fig. 4) to evenly developed spiral threads over the surfaces to one or more spiral cords alternating with several levels of spiral elements developed either in patterns or at random. There also is variation in the height of the shell. In some collections such as that from 2019 (Colina Limestone at Warren, Ariz.), the shells are high-spired owing to the lower whorl embracement beneath the lower margin of the alveozone on the base (pl. 10, fig. 3). In other populations, such as 369 (Bone Springs Formation, Guadalupe Mountains, Texas), the whorl embracement is consistently in the center of the alveozone, resulting in a lower-spired shell. In the 512 collection there are some shells that have a very rapid whorl expansion rate in relation to the axial translation rate resulting in low-spired shells. The lower margin of the alveozone may be a distinct spiral cord as in the holotype, or may be a rounded, wide area separating the outer whorl face from the base (pl. 10, fig. 2). If the lower margin of the alveozone is broadly rounded in the adult stage, earlier whorls are marked by a sharply defined alveozone with one or two spiral cords.

This species is the most variable in general appearance of *Worthenia* as now constituted. Without large and numerous samples, at least six species could be recognized representing end-members of a series of morphoclines within this species.

RANGE: Wolfcampian–Guadalupean.

HYPODIGM: 369, 13; 512, 136; 512f, 2; 592,

2; 655, 1; 678, 41; 2019, 94; 2022, 5; 2035, 75; B188-6, 17; 7011, 3; 702, 1; 702d, 2; 702f, 1; 703, 17; 703a, 5; 703b, 3; 703c, 5; 706c, 5; 710, 41; 710d, 13; 716, 2; 721j, 12; 727, 8; 728, 61; 738b, 3; 6938, 2; LANHM, 4. 574 specimens.

MEASUREMENTS: *Plate 10. 1.* holotype, AMNH 43657, 512, H 13.50, W 10.90, SPANG 52°, SS 1.20, SW 0.70, CBS 1.50; paratype, AMNH 43658, 369, H 7.90, W 6.90, SPANG 58°, SS 0.70, SW 0.50, CBS 1.30; *2.* paratype, USNM 431599, 701L, H 7.10, W 6.50, SPANG 50°, SS 1.00, SW 0.40, CBS 0.70; *3.* paratype, AMNH 43684, 2019, H 12.02, W 9.00, SPANG 50°, SS 1.30, SW 0.60, CBS 2.20; paratype, AMNH 43659, 512, H 11.10, W 8.00, SPANG 64°, SS 1.20, SW 0.40, CBS 1.40; *4.* paratype, AMNH 43660, 512, H 9.30, W 6.70, SPANG 44°, SS 0.40, SW 0.60, CBS 1.50; *5.* paratype, AMNH 43661, 512, H 10.20, W 9.20, SPANG 56°, SS 0.70, SW 0.70, CBS 1.70.

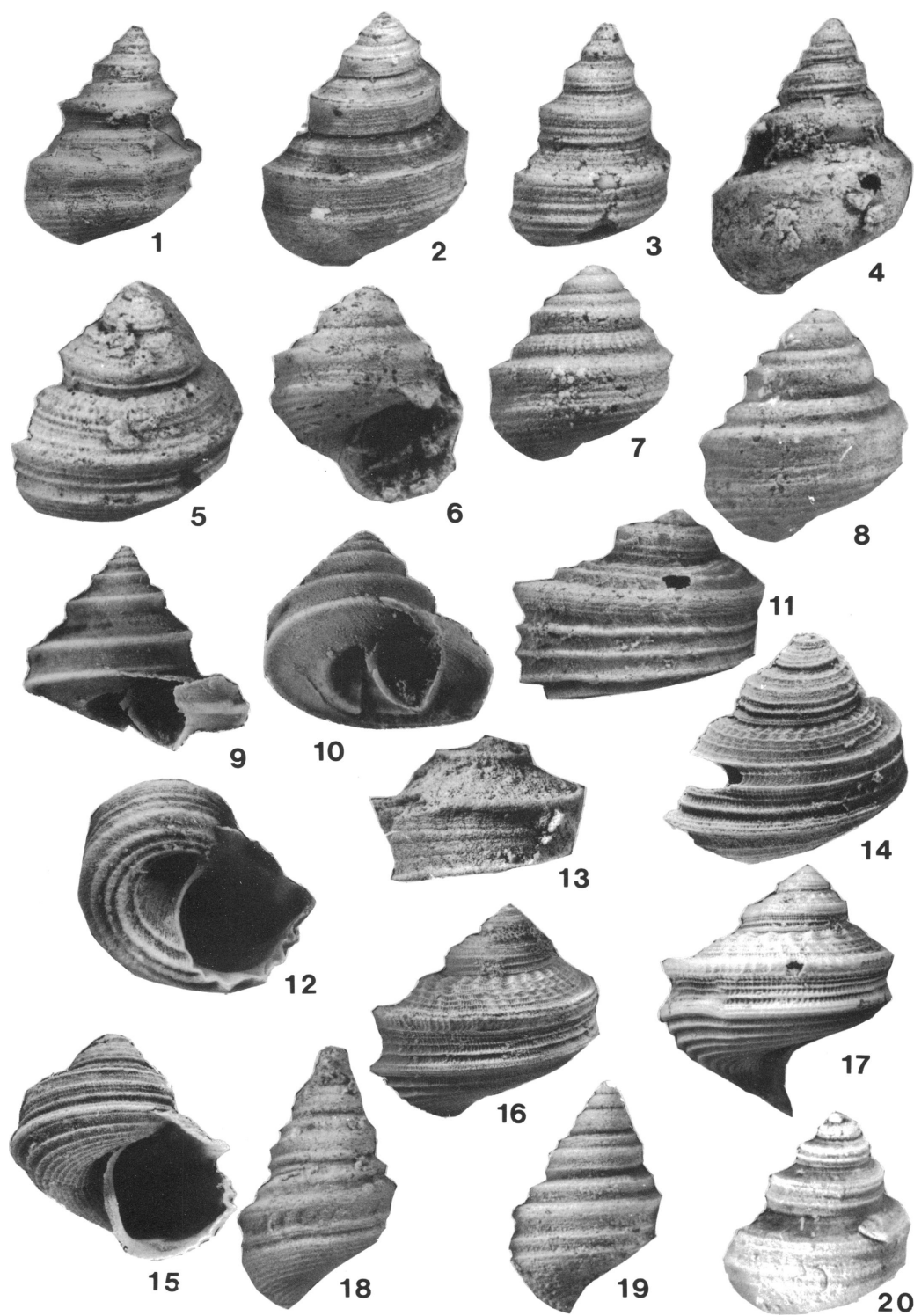
ETYMOLOGY: *Multi*, Latin for many; *lineus*, Latin for lines.

Worthenia arizonensis (Winters), 1963

Plate 10, figs. 6–8

Worthenia arizonensis, Winters, 1963: 35, pl. 2, figs. 5a–7.

DESCRIPTION: Relatively low-spired shells with axial translation rate that slightly decreases ontogenetically to produce a slightly pupaeform shell. First three whorls globose and devoid of ornament with periphery at midwhorl. Sutures sharply defined and deep. Whorls embrace at midwhorl periphery on the early whorls, gradually migrating downward across outer whorl face to lower margin of alveozone at final whorl. Upper whorl surface slopes sharply downward and is convexo-concave. Convex portion composed of a large subsutural spiral cord covered with numerous spiral threads which form elongate subsutural nodes with collabral threads. Concave portion with fine spiral threads alone. Convex selenizone forms shoulder and has numerous spiral threads on it. Lunulae may form very fine interference nodes with collabral growth lines or may be absent. Concave alveozone on outer whorl face has centrally placed spiral cord with several spiral threads above and below. Lower margin of



alveozone rounded and not well developed; marked by a spiral cord equal in development to eight found on rounded base. Anomphalus to hemiomphalus. Columellar lip reflexed and thickened into a callus or funicle.

DISCUSSION: This species is unique in several important aspects. The first three or more whorls retain their larval globular shapes without ornament or other features. The whorls embrace high on the whorl so that the overall shell shape is blunted compared to that of other species. In addition, the decreasing axial translation rate causes the shell to be even lower appearing in profile. Even more outstanding is the absence of any nodding on the selenizone so that the spiral threads are the only ornament on many of the specimens. The shape is somewhat reminiscent of *W. schirjaevensis* (Stuckenberg, 1905), which also lacks nodes on the selenizone, but that species is higher spired with an early migration downward of the whorl embracement and the upper whorl surface is gently convex. The specimens from the west Texas populations are similar to those from the Arizona populations in the blunted early whorls and the details of the selenizone. However in Winters' figure 6 he illustrated a specimen that lacks the blunt early whorls and appears to lack the globose second and third whorls. I believe that it is a member of *W. multilineata*.

RANGE: Wolfcampian–Guadalupian.

OCCURRENCE: 52 (=712e), 17; 369, 240; 396a, 12; 391, 4; 417, 1; 512, 6; 585, 2; 592, 1; 678, 67; 703, 2; 703a, 5; 703b, 1; 710d, 6; 712j, 25; 724, 4; Kriz, 2. 395 specimens.

MEASUREMENTS: *Plate 10. 6.* AMNH 43662, 592, H 5.70, W 4.50, SPANG 76°, SS 0.50, SW 0.30, CBS 0.70; *7.* AMNH 43663, 369, H 5.70, W 5.20, SPANG 72°, SS 0.70, SW 0.30, CBS 0.70; *8.* AMNH 43664, 369, H 6.00, W 4.60, SPANG 71°, SS 0.80, SW 0.40, CBS 0.80.

Worthenia bicarinata, new species

Plate 10, figs. 9, 10

DIAGNOSIS: Sharply tabulate shells with very fine spiral ornament, weakly formed subsutural nodes, fine spiral threads on selenizone.

DESCRIPTION: Sharply tabulate shells resulting from nearly horizontal upper whorl surfaces and bases with vertical outer whorl faces. Sutures shallow but sharply defined. Whorls embrace on outer portion of lower alveozone margin, but last $\frac{1}{10}$ of adult whorl uncoiled so that embracement is below lower alveozone margin on base. Upper whorl surface very gently convexo-concave forming a high angle with axis, with extremely fine, numerous spiral threads. Collabral elements appear to be reinforced growth lines which are

←

Plate 10

Figs. 1–5. *Worthenia multilineata*, n. sp. 1. Holotype, AMNH 43657, 512, $\times 2.5$, side view. 2. Paratype, USNM 431599, 7011, $\times 4.5$, oblique side view, note rounded base with ill-defined lower alveozone margin. 3. Paratype, AMNH 43684, 2019, $\times 2.5$, side view, note coarse spiral ornament and high-spired shell. 4. Paratype, AMNH 43660, 512, $\times 5$, side view, note lack of ornament on adult whorl and ill-defined lower alveozone margin. 5. Paratype, AMNH 43661, 512, $\times 5$, oblique side view, note low-spired shell. Figs. 6, 8. *Worthenia arizonensis* Winters, 1963. 6. AMNH 437662, 592, $\times 6.5$, apertural view. 7. AMNH 43663, 369, $\times 5$, side view. 8. AMNH 43664, 369, $\times 5.5$, side view. Figs. 9, 10. *Worthenia bicarinata*, n. sp., holotype, USNM 431600, 703, $\times 3$. 9. Apertural view. 10. Oblique basal view showing circumbilical ridge. Figs. 11–13. *Worthenia pilula*, n. sp. Figs. 11, 12. Holotype, AMNH 43665, 512, $\times 3.5$. 11. Side view. 12. Oblique basal view. 13. Paratype, AMNH 43666, 678, $\times 3.5$, side view, note fine spiral ornament compared to holotype. Figs. 14–17. *Worthenia corrugata* Chronic, 1953. Figs. 14, 15. AMNH 43669, 512, $\times 2$, immature shell. 14. Oblique side view showing the flat selenizone with asymmetrically placed spiral thread. 15. Apertural view. 16. AMNH 43668, 512, $\times 3$, adolescent shell, side view, note flat selenizone on upper and outer whorl surfaces. 17. AMNH 43667, 512, $\times 2$, note convex, noded selenizone in this adult shell. Figs. 18, 20. *Worthenia bialveozona*, n. sp. 18. Holotype, AMNH 43670, 512, $\times 5$, side view. 19. Paratype, AMNH 43687, 512, $\times 2$, side view. 20. Paratype, AMNH 43688, 512, $\times 6$, side view, note low-spired shell and reduced ornament.

slightly stronger on convex portion near selenizone, forming very weak subsutural nodes. Convex selenizone forms shoulder. Selenizone with numerous fine spiral elements on it. Outer whorl face vertical and concave alveozone has four or more spiral cords in deeper part with finer spiral threads on either side near margins. Ornament of alveozone strongest on shell. Lower alveozone margin marks edge of base and composed of a very large spiral cord equal in strength as shoulder-selenizone cord. Flattened base concavo-convex with numerous spiral striations. Wide umbilicus with broad circumbilical ridge around it followed by a trough which lacks spiral ornament. Columellar lip reflexed.

DISCUSSION: This species is similar to *W. multilineata* and *W. schirjaeensis* in having a convex selenizone with numerous spiral threads and lacking selenizone nodes or reinforced lunulae which is so typical of most species of the genus and is yet another example of the subgroup discussed under *W. multilineata*. It differs from those species in being strongly tabulate owing to the nearly horizontal upper whorl surface and base and the vertical outer whorl face.

There are several features which are unique (autapomorphous) to this species. The very fine spiral ornament in general, and, in particular, the fine spiral striations, are a form of negative spiral ornament on the base. The B188-6 specimens have stronger spiral threads on the lower alveozone margin. That plus the spiral cords on the alveozone are the most developed of ornament on the shells. The very wide umbilicus which exposes the internal sutures of the early whorls is unknown in other ruedemannians.

RANGE: Wordian.

HYPODIGM: B188-6, 2; 703, 1. 3 specimens.

MEASUREMENTS: Plate 10. 9, 10, holotype, USNM 431600, 703, H 15.35, W 17.45, SPANG 69°, SS 1.40, SW 0.50, CBS 2.70.

ETYMOLOGY: *Bi-*, Latin for two; *carina*, Latin for keel.

***Worthenia pilula*, new species**

Plate 10, figs. 11–13

DIAGNOSIS: Low-spined, subdiscoid shells with large, rounded shoulder and strong spiral ornament.

DESCRIPTION: Three first whorls globose with whorl embracement at midwhorl periphery. Fourth whorl with flat selenizone ornamented by several spiral threads on a shoulder. Sutures sharp and shallow. Whorls embrace just above lower margin of alveozone. Upper whorl surface flat to gently convexo-concave, at right angle to axis. Two or three spiral cords or threads on convex portion, concave portion unornamented. Some specimens with faint to moderately developed collabral ornament on upper whorl surface more fully developed on convex portion, forming weak subsutural nodes. Outer whorl face vertical, at right angles to upper whorl surface. Large, convex selenizone forms shoulder and has numerous spiral threads over its surface. Alveozone flat to gently concave with two or more large spiral cords; some specimens with additional fine, spiral threads. Lower alveozone margin a very large spiral cord equal in development to one above. Base flat-to-concave forming a right angle to outer whorl face. Base with four strongly formed spiral cords or eight or more spiral threads. Widely phaneromphalus. Area surrounding umbilicus is devoid of ornament. Columellar lip straight. Parietal inductura thick, covering large ornamental features.

DISCUSSION: The most variable feature is the ornament development ranging from strong spiral cords on the outer whorl face and the base to reduced spiral ornament of more numerous and evenly spaced threads. The upper whorl surface may be essentially flat, with reduced ornament to slightly convexo-concave with more fully developed ornament. Collabral ornament, if present, is confined to the upper whorl surface.

The shell shape is unique in being very low spired with the most rapid whorl expansion rate of any of the known species of the genus. *W. multicarinata* (Mansuy), illustrated by Batten (1972: 32, fig. 37) is the closest in whorl profile but is high spired with well-developed sutural nodes, which *W. pilula* lacks.

Again, this species belongs to the subgroup which lacks sutural nodes. However, even in early ontogeny it consistently has a convex selenizone.

RANGE: Wolfcampian–Guadalupian.

HYPODIGM: 369, 1; 678, 4; 710d, 3; 721j, 1; 738b, 1. 10 specimens.

MEASUREMENTS: *Plate 10. 11, 12.* holotype, AMNH 43665, 512, H 9.20, W 10.70, SPANG 88°, SS 1.20, SW 0.40, CBS 2.70; *13.* paratype, AMNH 43666, 678, H 6.40, W 8.20, SPANG 118°, SS 0.70, SW 0.50, CBS 0.90.

ETYMOLOGY: *Pihula*, Latin (dim) for pill.

Worthenia corrugata Chronic, 1952

Plate 10, figs. 14–17

Worthenia corrugata Chronic, 1952: 122, pl. 4, fig. 1a–c.

DESCRIPTION: Trochiform shells with shoulder and lower alveozone margin equal in development. Early whorls globose. Sutures sharp and deep. Whorls embrace on lower alveozone margin. Upper whorl surface convexo-concave; convex portion with four or more spiral cords combined with alternating spiral threads. Subsutural nodes are formed by doming of shell at regular intervals and enhanced by several collabral threads. Entire upper whorl surface covered by fine collabral threads. Concave portion has numerous fine spiral threads same size as collabral elements. Concave selenizone has a spiral thread one-third way down from upper margin and this thread marks precise edge of upper whorl surface and outer whorl face which marks shoulder. One-third of selenizone rests on upper whorl surface at about 45° and two-thirds of selenizone vertical, concave, and forming upper portion of outer whorl face. In early ontogeny selenizone vertical and forms upper portion of outer whorl face. In adult shells spiral thread on selenizone develops lunulae which expand to form nodes. Areas between nodes develop additional spiral threads. Alveozone has three or more spiral cords or threads with closely spaced collabral threads. Lower margin of alveozone same size as shoulder and composed of a very large spiral cord with several fine spiral threads evenly distributed over its surface. Flatly rounded base has 13 spiral cords which become finer near umbilicus. Phaneromphalus to hemiomphalus. Columellar lip reflexed and thickened into a thin, concave funicle. Parietal inductura thin.

DISCUSSION: There are several variable features involving the ornament. The subsutural nodes are composed of periodic doming of the shell to produce elongate ridges which

vary from narrow elongate structures to broad, poorly defined mounds. The spiral elements of the upper whorl surface and outer whorl face range from evenly developed cords which alternate regularly with threads to dominant threads or dominant cords.

The most important variable is the selenizone. In the early ontogenetic stages it is concave to flat and almost vertical on the outer whorl face (pl. 10, figs. 14, 15). By the fourth whorl the spiral thread dividing the selenizone develops and forms the shoulder so that one-third of the concave selenizone rests on the upper whorl surface and two-thirds on the outer whorl face (pl. 10, fig. 16). The development of reinforced lunulae on the adult shell and the addition of spiral threads and finally nodes, produce a convex selenizone (pl. 10, fig. 17).

The strong ornamentation and the uniqueness of the selenizone distinguish this species from *W. tabulata* which has a consistently convex and noded selenizone. In addition, the type species has subsutural nodes which are formed of reinforced interference nodes with collabral ornament.

RANGE: Leonardian–Guadalupian.

OCCURRENCE: 503, 4; 503d, 1; 512, 22; 519, 2; 702, 1; 702c, 3; 702um, 2; 703, 3; 710d, 5; 721m, 1; 728, 8; 738b, 3. 54 specimens.

MEASUREMENTS: *Plate 10. 14, 15.* AMNH 43669, 512, H 6.80, W 7.10, SPANG 71°, SS 0.75, SW 0.60, CBS 1.20; *16.* AMNH 43668, 512, H 13.50, W 14.65, SPANG 80°, SS 1.30, SW 0.90, CBS 2.10; *17.* AMNH 43667, 512, H 18.58, W 17.15, SPANG 71°, SS 1.70, SW 1.00, CBS 2.50.

Worthenia bialveozona, new species

Plate 10, figs. 18–20

DIAGNOSIS: High-spired shells with broad alveozone bisected by large spiral cord.

DESCRIPTION: High-spired shells with whorl embracement in lowermost margin of alveozone. Early whorls smooth, globose. Sutures sharp, shallow. Convexo-concave upper whorl surface slopes sharply downward. Convex portion with well-developed spiral cord in middle with upper portion sloping toward suture. Concave portion smooth and both portions with fine spiral threads. Convex selenizone with several fine spiral threads on its surface and selenizone separated from

margins by narrow troughs. Concave alveozone very broad, sloping inward toward base; divided by large spiral cord (covered with a few spiral threads) in lower $\frac{1}{3}$ of alveozone. Upper $\frac{2}{3}$ of alveozone has fine spiral threads and lower $\frac{1}{3}$ is smooth. Base rounded with 14 or so spiral cords or threads evenly developed. Columellar lip reflexed and thickened. Cryptomphalus. Parietal surface with resorbed ornament.

DISCUSSION: This group of specimens is fairly uniform with little variation in ornament or general shell characteristics. The whorl expansion rate and the axial translation rates vary somewhat (pl. 10, fig. 20). The shells resemble *W. kingi* in the whorl profile, particularly in the sloping upper whorl surface and the spiral cord near the suture. It differs in having a broad, bipartite alveozone and a parietal surface with resorbed ornament rather than a parietal deposit covering ornament. This species differs from all others of *Worthenia* in having the very wide, bipartite alveozone.

RANGE: Leonardian–Guadalupian.

HYPODIGM: 369, 2; 503, 2; 512, 51; 678, 1; 703, 25; 728, 6; 3364, 3. 90 specimens.

MEASUREMENTS: *Plate 10.* **18.** holotype, AMNH 43670, 512, H 9.0, W 5.20, SPANG 38°, SS 0.70, SW 0.30, CBS 1.30; **19.** paratype, AMNH 43687, 512, H 6.50, W 4.80, SPANG 44°, SS 0.70, SW 0.35, CBS 1.10; **20.** paratype, AMNH 43688, 512, H 5.70, W 5.20, SPANG 50°, SS 0.40, SW 0.35, CBS 1.00.

ETYMOLOGY: *Bis*, Latin for two or divided; *alveus*, Latin for trough or channel; *zona*, Latin for belt.

***Worthenia latialveozona*, new species**

Plate 11, figs. 1–4

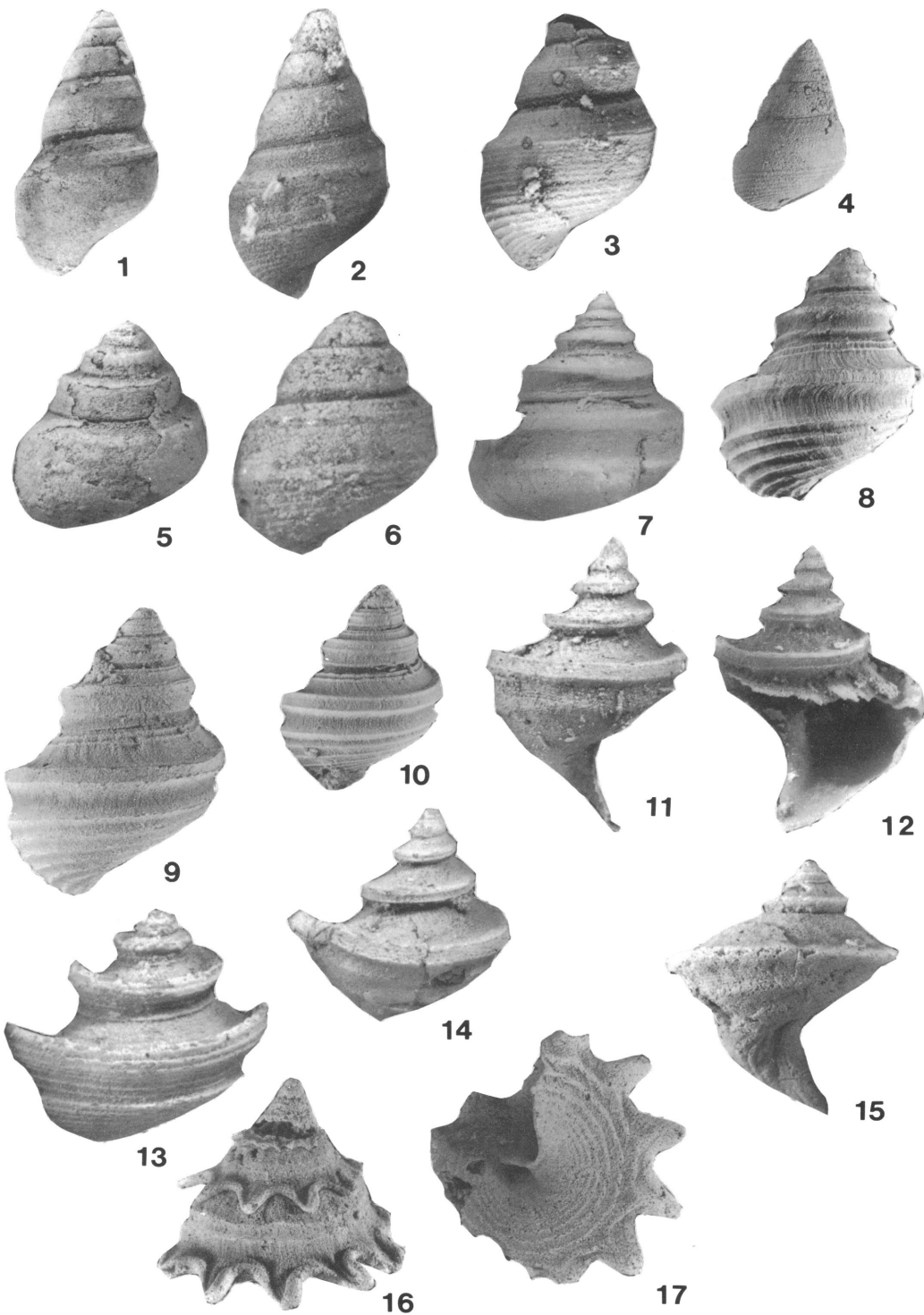
DIAGNOSIS: High-spined shells with wide alveozone divided by medial spiral cord, with dominant spiral ornament.

DESCRIPTION: High-spined shells with whorl embracement below lower alveozone margin on base. Sutures sharply defined and shallow. Early whorls smooth with periphery low on whorl. Upper whorl surface gently concave to flat except for narrow trough adjacent to suture with two spiral cords on edge. Upper whorl surface has numerous very fine, spiral threads and some specimens with fine subsutural nodes formed by faint collabral threads. Convex selenizone with medial thread locating edge of shoulder. Concave-to-flat outer whorl face; alveozone occupies over $\frac{1}{3}$ of whorl width and has numerous fine spiral threads. Lower alveozone margin ill-defined and rounded to conform to curvature of shell to rounded base. Base has numerous fine spiral threads more fully developed than those on rest of whorl. Hemiomphalus to cryptomphalus. Columellar lip reflexed and slightly thickened. Parietal inductura thin.

DISCUSSION: Most variation involves subtle changes in the emphasis of the spiral ornament which may be heavier on the upper part of the upper whorl surface to form weak

→
Plate 11

Figs. 1–4. *Worthenia latialveozona*, n. sp. **1.** Holotype, AMNH 43671, 512, $\times 5$, side view. **2.** Paratype, USNM 431603, 728, $\times 6$, side view. **3.** Paratype, AMNH 43672, 512, $\times 6$, side view. **4.** Paratype, USNM 431601, 712g, $\times 4$, side view, note collabral ornament just below suture. Figs. 5–7. *Worthenia planalveozona*, n. sp. **5.** Holotype, AMNH 43673, 512, $\times 3.5$, side view. **6.** Paratype, AMNH 43674, 369a, $\times 7.5$, side view. **7.** Paratype, AMNH 43654, 512, $\times 3.5$, side view. Figs. 8–10. *Manzanospira manzanicum* Girty, 1909. **8.** AMNH 43675, 512, $\times 5$, side view. **9.** AMNH 43676, 512, $\times 5$, side view. **10.** AMNH 43677, 512, $\times 5$, side view. Figs. 11–15. *Manzanospira wordiana*, n. sp. Figs. **11, 12.** Holotype, USNM 431604, 703, $\times 3.5$. **11.** Side view. **12.** Apertural view. **13.** Paratype, AMNH 43679, 678, $\times 7.5$, side view. **14.** Paratype, AMNH 43680, 503, $\times 6$, side view, note subsutural collabral ornament. **15.** Paratype, USNM 431602, 721j, $\times 4$, apertural view, note subumbilical spiral ornament and reflexed columellar lip with callus. Figs. **16, 17.** *Lacunospira spinosa*, n. sp., holotype, USNM 431607, 721z, $\times 2$. **16.** Side view. **17.** Basal view.



subsutural nodes and on the base. Some specimens from the Hueco Limestone populations have the shoulder reduced and with the whorl periphery low on the shell and marked by the lower alveozone margin. Other specimens have a narrow trough just below the selenizone and just above the lower alveozone margin which isolates the finely packed spiral threads on the central portion of the alveozone. Still other specimens have their basal ornament more fully developed.

This species is similar to *W. bialveozona* in that the alveozone is much broader than in other species of the genus. It differs from that species in lacking the well-developed spiral cord which divides the alveozone into two portions, and in the lack of intense spiral ornament. In addition, it is more high spired by virtue of the axial translation rate being faster than the whorl expansion rate.

RANGE: Wolfcampian–Guadalupean.

HYPODIGM: 369, 5; 512, 24; 712a, 18; 712c, 13; 712d, 20; 712f, 125; 728, 38. 243 specimens.

MEASUREMENTS: *Plate 11*. 1. holotype, AMNH 43671, 512, H 8.80, W 4.80, SPANG 33°, SS 0.60, SW 0.40, CBS 1.20; 2. paratype, USNM 431603, 728, H 6.70, W 4.30, SPANG 43°, SS 0.60, SW 0.20, CBS 1.10; 3. paratype, AMNH 43672, 512, H 7.10, W 4.30, SPANG 39°, SS 0.60, SW 0.30, CBS 1.10; 4. USNM 431601, 721g, H 6.70, W 4.20, SPANG 38°.

ETYMOLOGY: *Latus*, Latin for broad; *alveus*, Latin for channel; *zona*, Latin for belt.

***Worthenia planalveozona*, new species**

Plate 11, figs. 5–7

DIAGNOSIS: Low-spired tabulate shells with dominant fine spiral ornament and large, flat alveozone.

DESCRIPTION: Low-spired tabulate shells with wide, flat alveozone which slopes downward and outward to low whorl periphery. Sutures sharp and deep. Whorls embrace at or just below lower alveozone margin on base. Upper whorl surface is concave and covered with fine spiral threads with first two adjacent to suture more fully developed. Convex selenizone forms shoulder with a medial spiral thread. Outer whorl face slightly concave to flat and wider than upper whorl surface, and slopes downward and outward to lower al-

veozone margin which is also the whorl periphery. Alveozone has numerous very fine spiral threads which may be separated from selenizone and lower alveozone margin by narrow grooves. Lower alveozone margin weak and rounded to conform with rounded base. Base has spiral cords or threads stronger in development than other portions of whorl. Hemiomphalus to cryptomphalus. Columellar lip reflexed and thickened into a callus which builds into a funicle in umbilical region. Parietal regions with resorbed ornament.

DISCUSSION: These shells superficially resemble those of the genus *Phymatopleura* Girty, 1939, in that the flattened outer whorl face slopes downward and outward to the low whorl periphery, but the selenizone is on a shoulder rather than on the whorl periphery. It resembles *W. bialveozona* and *W. latialveozona* in having a very wide alveozone thus indicating a relationship (in addition, they share a dominance of spiral ornament). However, the tabulate, almost quadrate, shell shape, with the outward-sloping outer whorl face, is unique to this species.

The variation in this species involves the relative intensity of spiral ornament. In the 369a specimen the ornament has rather strongly developed basal and alveozone spiral elements compared to the 512 specimens which have very fine spiral threads.

RANGE: Leonardian–Guadalupean.

HYPODIGM: 369a, 1; 503, 1; 512, 2. 4 specimens.

MEASUREMENTS: *Plate 11*. 5. holotype, AMNH 43673, 512, H 8.50, W 7.80, SPANG 64°, SS 0.50, SW 0.30, CBS 2.20; 6. paratype, AMNH 43674, 369a, H 5.10, W 4.50, SPANG 60°, SS 0.30, SW 0.25, CBS 1.30; 7. AMNH 43654, 512, H 10.0, W 9.00, SPANG 58°, SS 0.80, SW 0.60, CBS 1.63.

ETYMOLOGY: *Planus*, Latin for flat; *alveus*, Latin for trough or channel; *zona*, Latin for belt.

***Manzanospira*, new genus**

TYPE SPECIES: *Phanerotrema manzanicum* Girty, 1909b: 96, pl. 11, figs. 3, 4.

DIAGNOSIS: Shells varying from globose to turreted with vertical, wide, and flat or convex selenizones raised on keels.

DESCRIPTION: Low- to high-spired shells with well-developed alveozones. Early whorls smooth, globular; in some specimens this condition may extend to third whorl. Upper whorl surfaces convexo-concave. Flat selenizone wide and vertical. Margins tend to be lightly developed spiral cords. Flat or convex selenizone surface with from one to four fine spiral threads or unornamented and without lunulae.

DISCUSSION: The presence of a number of species within the genus *Worthenia* which have flat or convex selenizones that lack the selenizone nodes has been a puzzle (Batten, 1972: 33). The discovery of *M. carinata*, n. sp., and *M. wordiana*, n. sp., confirms the presence of three species with flat selenizones in the Permian of the western United States.

Platyworthenia Chronic, 1952, was erected for specimens with a curious planispiral early whorl complex. In addition, the selenizone is unornamented, similar to that of *W. multilineata*. Knight et al. (1964) placed this genus in synonymy with *Worthenia*. There are no representatives of *Platyworthenia* in any of the equivalent beds to the Kaibab Formation. The selenizone is similar to this *Manzanospira* but the planispiral early whorls are unique.

RANGE: Permian.

ETYMOLOGY: *Spiralis*, Latin for coil; Manzano, the name of a group of Permian strata in eastern New Mexico.

Manzanospira manzanicum

(Girty), 1909b

Plate 11, figs. 8–10

Phanerotrema manzanicum Girty, 1909b: 44, pl. 11, figs. 3, 4.

DESCRIPTION: Moderately high-spired, turreted forms with wide, flat-to-slightly-concave selenizone forming shoulder. Whorls embrace at or just below the basal angulation. Convexo-concave upper whorl surface has two spiral elements adjacent to suture and may have weakly developed collabral ornament. Selenizone wide and usually flat or concave without ornament; margins weakly formed. Alveozone wide, concave, without ornament. Rounded base has strongly developed spiral cords. Hemiomphalus to nar-

rowly phaneromphalus. Columellar lip slightly reflexed. Parietal inductura thin.

DISCUSSION: This is a highly distinctive species found scattered through the Permian of the Southwest. Its turreted shape and extended selenizone along with an unornamented alveozone and with strongly developed spiral cords on the base distinguish it as a species. In many features, this species falls within the spectrum of *Apachella*: overall shell shape, alveozone, details of the upper whorl surface, and very strongly developed spiral ornament on the base. However, the selenizone, particularly in the lower Getaway populations, is highly different in the width, flatness, and details of the margins. Even on exceptionally well-preserved specimens from locality 512, the selenizone shows no indication of growth lines or any form of ornament. This suggests that a secondary deposit is formed over the selenizone during growth. Since the selenizone is the dominant apomorphic feature of the eotomarians, this anomalous selenizone for species considered to be members of *Apachella* and *Worthenia* clearly indicates separation as a distinct genus along with other species discussed below.

RANGE: Wolfcampian through middle Guadalupian.

OCCURRENCE: Girty described this species from the Abo Formation (Wolfcampian) and the Yeso Formation (Leonardian) of the Manzano group of New Mexico; 369, 2; 503, 4; 514, 123; 519, 2; 703, 1; 707e, 3; 721u, 1; 728, 5; 731, 15. 156 specimens.

MEASUREMENTS: Plate 11. 8. holotype, AMNH 43675, 512, H 14.50, W 11.50, SPANG 42°, SS 0.85, SW 0.60, CBS 0.90; 9. paratype, AMNH 43676, 512, H 9.00, W 6.65, SPANG 51°, SS 0.90, SW 0.35, CBS 0.85; 10. paratype, AMNH 43677, 512, H 5.70, W 4.90, SPANG 51°, SS 5.50, SW 3.50, CBS 7.00.

Manzanospira wordensis, new species

Plate 11, figs. 11–15

DIAGNOSIS: Low-spired shells with flange-like shoulder with flat, vertical selenizone ornamented by spiral threads.

DESCRIPTION: Low-spired, pagodalike shells with selenizone serving as whorl periphery and shoulder. First three whorls are globular

and orthostrophic with whorl embracement at midwhorl. Sutures sharp and shallow. Whorl embracement of later whorls varies from midalveozone to base just under the lower alveozone margin. Upper whorl surface gently convexo-concave, ornamented by fine, spiral threads. Convex portion with or without subsutural collabral nodes. Concave portion is usually unornamented but may have several fine spiral threads. Shoulder drawn out into flange with vertical, flat selenizone at its terminus. Flange may be extended, curved upward and inward. Selenizone flat with one to three spiral threads. Concave alveozone slopes inward and has numerous fine spiral threads or several spiral cords. Lower alveozone margin is weakly developed compared to shoulder and marked by several fine spiral threads. Flatly rounded base has 10 or more spiral threads or cords. Phaneromphalus to hemimophalus. Columellar lip reflexed but not thickened. Parietal deposits thin to wanting.

DISCUSSION: The ornament is quite variable ranging from spiral cords to fine, numerous spiral threads. Collabral ornament, if present, is restricted to subsutural threads which may sweep across the upper whorl surface almost to the selenizone (pl. 11, fig. 14). There is considerable variation in the development of the shoulder-selenizone complex. In some specimens the shoulder is drawn out into a curved flange (pl. 11, fig. 13), while in others the shoulder is slightly extended so that the selenizone is placed nearly vertically to the axis (pl. 11, fig. 12).

This species differs from *M. manzanicum* in the high angle that the upper whorl surface makes with the axis compared to that species where the surface slopes sharply downward at a steep angle, thus causing a higher shell shape. The ornament is much more fully developed in that species, particularly on the upper whorl surface and the base. The selenizone in this species as well as in *M. manzanicum* and *M. carinata* are very similar.

RANGE: Wordian.

HYPODIGM: 503, 2; 678, 12; 703, 1; 721j, 1. 16 specimens.

MEASUREMENTS: *Plate 11. 11, 12.* holotype, USNM 431604, 703, H 9.70, W 8.00, SPANG 77°, SS 0.75, SW 0.50, CBS 1.00; *13.* paratype, AMNH 43679, 678, H 5.60, W 5.90,

SPANG 60°, SS 0.70, SW 0.30, CBS 0.40; *14.* paratype, AMNH 43680, 503, H 6.30, W 5.10, SPANG 50°, SS 0.80, SW 0.40, CBS 0.40; *15.* USNM 431602, 721j, H 10.80, W 9.10, SPANG 76°, SS 1.10, SW 0.40, CBS 1.00.

ETYMOLOGY: Named for the Word Formation in the Glass Mountains, Texas.

Manzanospira carinata, new species

Plate 3, figs. 1-3

DIAGNOSIS: Relatively low-spired globose shells with fine spiral threads.

DESCRIPTION: Early whorls with flattened upper whorl surfaces. Upper whorl face convex except adjacent to selenizone where it is either flat or concave. Ornament dominantly fine spiral threads or striae, but growth lines may be somewhat strengthened to form weak collabral ornament. No sutural nodes. Selenizone margins are weakly developed. Wide selenizone flat and extended beyond whorl surface, ornamented with three spiral threads. Outer whorl face slightly concave, narrow. Spiral ornament somewhat stronger in alveozone compared to other parts of shell. Lower margin of alveozone rounded, blends evenly onto base and ornamented with a few spiral threads. Base rounded giving whorl profile globose appearance. Basal ornament of spiral threads. Columellar lip reflexed causing a hemiomphalus condition. Phaneromphalus.

DISCUSSION: This is the most globose species of the genus. It somewhat resembles *Glabrocingulum armstrongi* Thomas, 1940 but that species has strongly developed collabral ornament causing strong beading of the interference nodes. Also, the latter species is more turreted, with a concave, narrow selenizone typical of the genus. The selenizone is much different than that of any other member of *Glabrocingulum* or that seen in *Ananias*, and signifies, by the key characteristic of the flat selenizone with spiral ornament, a member of *Manzanospira*.

RANGE: Upper Leonardian.

HYPODIGM: 503, 3; 703, 1; 703c, 1. 5 specimens.

MEASUREMENTS: *Plate 3. 2.* holotype, AMNH 43692, 503, H 7.50, W 8.00, SPANG 90°, SS 1.10, SW 0.40, CBS 0.30; *1.* paratype,

USNM 431606, 703c, H 9.40, W 9.90, SS 1.60, SW 0.50, CBS 0.20; 3. AMNH 43689, 503, H 6.30, W 6.20, SPANG 93°.

ETYMOLOGY: *Carina*, Latin for keel.

ADDENDA

FAMILY PHYMATOPLEURIDAE

Batten, 1956

Lamellospira Batten, 1958

TYPE SPECIES: *Lamellospira conica* Batten, 1958: 217–221.

DISCUSSION: This genus is represented in the west Texas Permian by three species. *L. conica*, the type species, is widely distributed and fairly common throughout the study sections. The other two, *L. cincta* Batten, 1958, and *L. spinosa*, n. sp., are known from several specimens in the Word Formation. Another species, *L. anatola* Batten, 1972, is known from the Permian of southwest Asia.

Lamellospira spinosa, new species

Plate 11, figs. 16, 17

DIAGNOSIS: Conical shells with flat base and wide peripheral flange with large spines.

DESCRIPTION: Early whorls globose, somewhat enlarged. Sutures sharp in deep trough. Whorls embrace below flange on base. Upper whorl surface flattened to slightly convex. Concave selenizone with marginal spiral cords on midwhorl line. Alveozone slightly concave terminating in very wide flange with spines drawn out at ¼-whorl intervals. Lower alveozone margin rims peripheral flange and spines as a spiral cord. Base flat with five or more spiral cords less intense near umbilicus; first cord just under flange outlines trace of spines on flange. No other shell ornament. Anomphalus. Columellar lip curved and slightly thickened.

DISCUSSION: This species is virtually identical to that of the type, *L. conica*, in terms of the placement of the selenizone, lack of ornament except on the base, shape of the shell, nature of the early ontogenetic whorls, and details of the columellar lip. The chief difference is the much-enlarged peripheral flange and the development of spines on the flange. The other species have very similar flanges to the type species but differ in the position of the selenizone, presence of col-

labral ornament (in *L. anatola*), and details of the flange.

RANGE: Leonardian (Road Canyon Formation).

HYPODIGM: 712z, 2. 2 specimens.

MEASUREMENTS: Plate 11. 16, 17. holotype, USNM 431607, 721z, H 13.00, W 16.80, SPANG 56°, SS 1.20, SW 1.00, CBS 3.20.

ETYMOLOGY: *Spinosa*, Latin for thorn.

ACKNOWLEDGMENTS

As in 1958, I gratefully acknowledge the support of the American Museum of Natural History for permitting me to continue, beyond my retirement, the research which resulted in the publication of this study. I thank Dr. Richard E. Grant and Mr. Fred Collier of the National Museum of Natural History, Washington, D.C., for their patience in extending loans (some dating back over 30 years) representing the bulk of the specimens used for this study. I thank Dr. Niles Eldredge for granting me the opportunity of completing this study using facilities under his charge. Mr. Andrew Mandel provided exceptionally fine photographs for over half the illustrations used in this paper.

I thank Drs. Thomas Yancey (Texas A&M University), Robert Linsley (Colgate University), and Douglas Erwin (Michigan State University) for their thoughtful reviews of this paper. They suggested many ideas and indicated needed corrections.

LOCALITY REGISTER

Note: All localities included in this study are detailed in Batten (1958), Finks (1960), Yochelson (1956, 1960), and Cooper and Grant (1972). The localities listed below are those which have not previously been reported in those works.

AMERICAN MUSEUM OF NATURAL HISTORY

417. Carlsbad Limestone. El Paso Gap Quadrangle, west Texas. North side of Devils Den Canyon, NE ¼, NW ¼, NE ½, Sec. 20, T26S, R21E.

503c. Word Formation (Ls number 2), same as 703c.

503d. Road Canyon Formation, same as 703d.

503g. Hess Formation, same as 703g.

514. Getaway Limestone. Second ledge up from

floor on east side of Guadalupe Canyon, half mile SW of benchmark 5426 on hwy 62, Guadalupe Mountains, Texas.

517. Getaway Limestone. At benchmark 4944, 1 mi north of Signal Peak Station on hwy 62, Guadalupe Mountains, Texas.

585. Getaway Limestone = 512.

2019. Colina Limestone. Middle of section line, NE ¼, NW ¼, Sec. 24, T23S, R21E, Bisbee Quadrangle (1958 ed.), 1 mi NE of Warren, Arizona.

2022. Fort Apache Limestone. North of road US 60 on hill 5980, 3 mi east of Cedar Creek, T6N, R21E, 110°11'30"W, 33°57'45"W, White River, Arizona.

2035. Upper Magdalena Limestone (Pennsylvanian?), saddle of isolated hill, 400 yd north of hwy 62, 1 mi west of Powwow tanks at road intersection. Hueco Mountains, Texas.

NATIONAL MUSEUM OF NATURAL HISTORY

702g. Leonard Formation (Hess member). Near Hess Ranch House, Hess Canyon quadrangle, Glass Mountains, Texas.

708o. Skinner Ranch Formation. 1½ mi South 82° Skinner Ranch house (Iron Mountain Ranch), Glass Mountains, Texas.

710. Cathedral Mountain Formation. Hill 2 mi north of Lenox, Altuda Quadrangle, Glass Mountains, Texas.

722. Phosphoria Formation. 100 ft above road, upper end of Torrey Lake, Dubois, Wyoming.

722u. Word Formation. 2 mi west of old Word Ranch house on road to Hess Ranch. Glass Mountains, Texas.

725d. Bone Springs Limestone. East side of hill 4402, west side of hwy 54, near benchmark 3806, Van Horn quadrangle, Texas.

735a. Road Canyon Formation. At Old Word ranch house, Hess Canyon quadrangle, Glass Mountains, Texas.

BSAC. Bone Springs Limestone. North side of entrance of Apache Canyon, Sierra Diablo Mountains, Texas.

BSACNP. Bone Springs Limestone, same as BSAC.

BSNP. Bone Springs Limestone, same as BSAC.

NPAC. Bone Springs Limestone, same as BSAC.

PUAC. Bone Springs Limestone, same as BSAC.

Kriz. Bone Springs Limestone, same as BSAC.

LOS ANGELES COUNTY NATURAL HISTORY MUSEUM

LANHM. Bird Springs Limestone. Cottonwood Pass, Spring Mountains, Nevada.

UNIVERSITY OF TEXAS

42-T-3. Admiral Formation (Elm Creek Ls), at falls in Elm Creek, Coleman Co., Texas.

42-T-18. Admiral Formation. 5 mi SSW Coleman, Coleman Co., Texas.

199-T-7-p.19. Talpa Formation. Herring Bluff, Colorado River, Runnels Co., Texas.

199-T-13-p.22. Talpa Formation. Pony Creek near the Colorado River, Runnels Co., Texas.

9832. Waldrip Limestone member, Harperville Formation, Waldrip, McCulloch Co., Texas.

9863. Talpa Formation, Runnels Co., Texas.

9880. Saddle Creek Limestone. West side of Saddle Creek, NW of Marion School, 1 mi north of Walker ranch house, McCulloch Co., Texas.

UNIVERSITY OF KANSAS

Moore 18. Word Formation (Limestone #3), same as USNM 706b.

Moore 27. Word Formation (Limestone #2), same as USNM 706c.

Moore Camp Creek. Pueblo Formation, Camp Creek, Coleman Co., Texas.

REFERENCES

- Batten, R. L.
1958. Permian Gastropoda of the southwestern United States. 2. Pleurotomariacea. Portlockiellidae, Phymatopleuridae and Eotomariidae. *Bull. Am. Mus. Nat. Hist.* 114(1): 159-246.
1966. The Lower Carboniferous gastropod fauna from the Hotwells Limestone of Compton Martin, Somerset. *Pts. 1-2, Palaeont. Soc. Monographs*, 509, 513: 109 pp., 10 pls.
1972. Permian Gastropoda from Perak, Malaysia. Part 1. Chitons bellerophontids, euomphalids and pleurotomarians. *Bull. Am. Mus. Nat. Hist.* 147(1): 1-44, 52 figs.
- Broili, F.
1924. Die Fauna der Pachycardientuffe der Seiser Alp. *Palaeontographica* 54: 69-138.
- Chronic, B. J.
1949. Gastropoda. *In* N. D. Newell, B. J. Chronic, and T. G. Roberts, *Upper Paleozoic of Peru*, pp. 46-173, pls. 5-35. New York: Columbia Univ. Dissertations.
1953. Upper Paleozoic of Peru. *In* N. D. Newell, B. J. Chronic, and T. G. Roberts, *Upper Paleozoic of Peru*. *Geol. Soc. Am., Mem.* 58: 276 pp., 44 pls.

- Chronic, H.
1952. Molluscan Fauna from the Permian Kaibab Formation, Walnut Canyon, Arizona. *Bull. Geol. Soc. Am.* 63: 95–166.
- Cooper, G. A., and R. E. Grant
1972. Permian Brachiopods of West Texas, Part 1. *Smithson. Contrib. Paleobiol.* 14: 230 pp.
- Cooper, G. A., and J. B. Knight
1946. Permian studies at the Smithsonian Institution. *J. Paleontol.* 20(6): 625–626.
- Dickens, J. M.
1963. Permian pelecypods and gastropods from Western Australia. *Bull. Bur. Min. Res.* 63: 152 pp., 26 pls.
- Eldredge, R. N.
1968. Convergence between two Pennsylvanian gastropod species: a multivariate mathematical approach. *J. Paleontol.* 42(1): 186–196, pl. 33.
- Erwin, D. H.
1988a. The Permian gastropods of the southwestern United States. Part 5. The subulitacea. *J. Paleontol.* 62(1): 56–69, 4 pls.
1988b. The Permian gastropods of the southwestern United States. Part 4. The Cerithiacea, Subulitacea, Pyramidellacea and Acteonacea. *J. Paleontol.* 62(4): 566–575, 2 pls.
- Finks, R. M.
1960. Late Paleozoic sponge faunas of the Texas Region. *Bull. Am. Mus. Nat. Hist.* 120(1): 1–160, 50 pls.
- Girty, G. H.
1909a. Paleontology of the Manzano Group. *In* W. T. Lee and G. H. Girty, The Manzano Group of the Rio Grande Valley of New Mexico. *U.S.G.S. Bull.* 389: 41–136, pls. 6–12.
1909b. The Guadalupian fauna. *U.S.G.S. Prof. Pap.* 58: 651 pp., 31 pls.
1934. *Pleurotomaria pseudostrigillata*, nom. nov. Girty, 1934; *Chonetes acanthophorus*. *Wash. Acad. Sci. J.* 24(12): 54.
- Gordon, M., and E. L. Yochelson
1987. Late Mississippian gastropods of the Chainman Shale of west-central Utah. *U.S.G.S. Prof. Pap.* 1368: 112 pp., 9 pls.
- King, R. E.
1931. The geology of the Glass Mountains, Texas. Pt. 2. *Univ. Tex. Bull.* 3042: 245 pp., 44 pls.
- Kittl, E.
1893. Die Gastropoden des Schichten von St. Casian der Sudalpinen Triassic. *Ann. der M. K. Naturhistorischen hofmuseums*, Bd. 9: 35–97, pls. 5–9.
- Knight, J. B.
1945. Some new genera of Paleozoic gastropods. *J. Paleontol.* 19(4): 333–340, pl. 49.
- Knight, J. B., R. L. Batten, and E. L. Yochelson
1960. Part I. Mollusca. *In* R. C. Moore (ed.), *Treatise on invertebrate paleontology*. *Geol. Soc. Am. and Univ. Kansas Press*: I169–I351, figs. 89–216.
- Newell, N. D., J. Keith Rigby, A. G. Fischer, A. J. Whiteman, J. D. Hickox, and J. S. Bradley
1953. The Permian Reef Complex of the Guadalupe Mountains region, Texas and New Mexico. *San Francisco: W. H. Freeman*, 236 pp.
- Norwood, J. G., and H. Pratten
1855. Notice of fossils from the Carboniferous of the western states. *Acad. Nat. Sci. Philadelphia J.* 2nd ser., 2(1): 30–72.
- Reed, F. R. C.
1931. New fossils from the Productus Limestone of the Salt Range. *Palaeontol. Indica.* 17.
- Sabattini, N., and S. Noirat
1969. Algunos Gastropoda de las superfamilias Eomphalacea, Pleurotomariacea y Platyceratacea del Paleozoico Superior de Argentina. *Ameghiniana* 6(2): 98–118, pls. 1–2.
- Sadlick, W., and M. F. Neilson
1963. Ontogenetic variation of some Middle Carboniferous pleurotomarian gastropods. *J. Paleontol.* 37(5): 1083–1103.
- Schindel, D. E.
1982. Punctuations in the Pennsylvanian evolutionary history of *Glabrocingulum* (Mollusca: Archaeogastropoda). *Bull. Geol. Soc. Am.* 93: 400–408, 8 figs.
- Stehli, F. G.
1954. Lower Leonardian Brachiopoda of the Sierra Diablo. *Bull. Am. Mus. Nat. Hist.* 105(3): 263–357, pls. 18–27.
- Thomas, E. G.
1940. Revision of the Scottish Carboniferous Pleurotomariidae. *Trans. Geol. Soc. Glasgow* 20(1): 30–72.
- Ulrich, E. O., and W. H. Scofield
1897. Lower Silurian gastropods from Minnesota. *Minn. Geol. Surv.* 3(2): 813–1081.
- Weller, J. M.
1929. The gastropod genus *Yvania*. *Illinois St. Geol. Surv., Rep. Invest.* 18: 45 pp., 3 pls.

- Winters, S. S.
1956. New Permian gastropod genera from eastern Arizona. *Wash. Acad. Sci. J.* 42(2): 44–45.
1963. Supai Formation (Permian) of eastern Arizona. *Geol. Soc. Am. Mem.* 89: 1–99, pls. 1–9.
- Yin, H., and E. L. Yochelson
1983. Middle Triassic gastropods from Quinyan, Guizhou Province, China. *J. Paleontol.* 57(1): 162–187.
- Yochelson, E. L.
1956. Permian gastropods from the southwestern United States, Part 1. Euomphalacea, Trochonematacea, Pseudophoracea, Anomphalacea, Craspedostomatacea and Platyceratacea. *Bull. Am. Mus. Nat. Hist.* 110(3): 177–275, pls. 9–24.
1960. Permian gastropods from the southwestern United States, Part 3. Bellerophonacea and Patellacea. *Bull. Am. Mus. Nat. Hist.* 119(4): 209–293, pls. 37–47.
- Yochelson, E. L., and H. Yin
1983. Middle Triassic Gastropoda from Quingyan, Guizhou Province, China. *J. Paleontol.* 57(1): 162–187.
- Zardini, R.
1978. *Rossili Cassiani Atlanti dei Gastropodi della Formazione de S. Cassiano Raccolti della Regione Dolomitica Attorno a Cortina d'Ampezzo.* Cortina, Italy: Zardini, 58 pp.

Recent issues of the *Novitates* may be purchased from the Museum. Lists of back issues of the *Novitates*, *Bulletin*, and *Anthropological Papers* published during the last five years are available free of charge. Address orders to: American Museum of Natural History Library, Department D, Central Park West at 79th St., New York, N.Y. 10024.