PERMIAN GASTROPODS AND CHITONS FROM PERAK, MALAYSIA

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ABSTRACT

ONE OF THE RICHEST PERMIAN gastropod faunas of Asia was found during intensive field work conducted by the Geological Survey of Malaysia. Discovered in the H. S. Lee Mine No. 8 near Kampar, Perak, it rivals any known Permian fauna with the exception of the Permian of west Texas. Twenty-eight species of bellerophontids and pleurotomarians are herein described, including one new genus, *Ambozone*, one new subgenus, *Glabrocingulum* (*Stenozone*), and 11 new species. The dominant pleurotomarian family is the Eotomariidae which is also the most diverse group in other Permian faunas. The fauna resembles those described from other regions of Southeast Asia, but includes genera hitherto known only from the Sosio beds of Sicily and the Permian of west Texas. The Malaysian fauna is important because it gives a much more complete picture of the Tethyan gastropods of eastern Asia and because of important new species which greatly enlarges our understanding of Upper Paleozoic gastropod phylogeny. The fauna also aids in demonstrating the existence of marine seaways from Sosio, Sicily eastward to Texas and possibly South America.

INTRODUCTION

FROM 1948 to the present, there have been a number of vigorous geological research programs conducted in Malaysia, primarily by the Geological Survey of Malaysia. Much of the paleontological studies has been done by Gobbett and others at the University of Malaysia and by paleontologists from the universities of Tokyo, Kyushu, Tohoku, Kyoto, and Hokkaido in Japan. An excellent review of the fossil record as elucidated by these studies can be found in Jones, Gobbett, and Kobayashi (1966, pp. 309–359), along with a complete bibliography.

The Permian fauna described below comes from several opencast mines in the Kinta Valley near Kampar, Perak, Malaysia. The most fossiliferous of these is Lee Mine No. 8 (Map of Malaya sheet 2n/9 [old series] MR 909356) approximately a mile and a half southwest of Kampar on the road to Tronoh Mines New Village. The fauna is from a light-colored limestone which weathers into a friable white rock resembling chalk (Jones, Gobbett, and Kobayashi, 1966, p. 328). The fauna is dominated by gastropods, but corals, scaphopods, clams, a few brachiopods, and cephalaopods are present along with fusulinids. Goniatites (*Stacheoceras*, *?Crimites*, and *Adrianites*) indicate a Middle Permian age. Numerous *Misellina claudiae* (Deprat) identified by Ishii (1966) suggest the limestone is of late Artinskian-early Guadalupian age (Jones, Gobbett, and Kobayashi, 1966, p. 328).

The majority of the species described herein come from the H. S. Lee Mine No. 8. A few species are described from a dark limestone which lies below the *Misellina claudiae* limestone and is presumed to be of lower Permian age (Jones, Gobbett, and Kobayashi, 1966, p. 324). These species come from the Nam Loong Mine No.1 in the Kinta Valley about a mile and a half west of Kampar (located at MR 909358 on the Map of Malaya, sheet 2n/9 [old series]).

Many of the specimens are very poorly preserved and distorted so that there is a considerable loss of information regarding the entire fauna. However, the bias does not appear to affect either large- or small-sized elements. A number of specimens are remarkably well preserved and have very delicate detail, such as ornament, growth lines, and early whorls; for example, see figure 21. Because the material is fragile and powdery, handling the specimens can destroy detail. There were several periods of alteration following deposition. The wall structure is not preserved, and this, along with the preservation of details, suggests that they are natural casts. The specimens are shot through with one to three sets of fractures which were filled with a different shade of calcite. Yet in many cases, growth lines are preserved even within the fractures.

The gastropod fauna from the Permian of Perak, Malaysia is, with one exception, the richest known from a well-documented horizon. To illustrate, the total gastropod fauna of Malaysia probably contains more than 100 species, whereas that of the Permian of Timor has about 40 species, and that of Cambodia about 60 species. The Sosio fauna from Sicily

contains about 20 species of pleurotomarians, whereas the Permian of Cambodia has about 13; this fauna from Perak has 22 species. By far the richest fauna comes from the Permian of west Texas where about 80 pleurotomarian species are known (most are undescribed), 36 species alone come from a single horizon in the Lower Guadalupian Lower Getaway Limestone. Although there are a few species in common with other faunas, such as those of western and eastern Australia, the character of the Malaysian fauna (in terms of the pleurotomarians) is strikingly different from any known.

Some of the genera, such as *Bellerophon*, *Retispira*, *Straparollus* (*Euomphalus*), *Glabrocingulum* (*Glabrocingulum*), *Worthenia*, *Platyzona*, *Borestus*, and *Phymatopleura* are common elements in most Permian faunas of the world. Several highly distinctive genera and one subgenus in the Malaysian fauna are found elsewhere only in the Permian of west Texas and in the "Carboniferous" of South America. *Glabrocingulum* (*Stenozone*) has recently been described by Sabattini and Noirat (1969) from the upper "Tepuel System" of central Patagonia, apparently of Upper Carboniferous age. This is, to my knowledge, the only occurrence of this subgenus outside of Southeast Asia. In addition to the Cambodian species, *Lacunospira* Batten, 1958 and *Lamellospira* Batten, 1958 are known only from the Permian of west Texas. *Shwedagonia* Batten, 1958 has been reported from the Maping Limestone of Kweichow Province, China by Grabau (*S. wongi*); from the Sosio Beds of Sicily by Gemmellaro (*S. mariana*); and from the Permian of west Texas by Batten (*S. elegans*). The new genus *Ambozone* is present in North American Upper Carboniferous and *A. rasmusseni*, new species, is the first Permian species known.

One of the most striking observations made during the present study is the remarkable resemblance of several Malaysian species to species found in the Permian of west Texas. *Shwedagonia collabra*, new species is almost identical to *S. elegans* Batten, 1956, which is most commonly encountered in the Artinskian and Kazanian. The only noticeable difference is the presence of reticulate ornament. *Lacunospira reticulata*, new species differs from *Lacunospira alta* Batten, 1958 in possessing spiral ornament, but in all other features they are quite similar. *Lamellospira anatola*, new species also differs from the nearly identical *Lamellospira conica* Batten, 1958 in some minor ornamental features. *Euconospira spiroperforata* Batten, 1958, and *Retispira lyelli* (Gemmellaro) are represented in both faunas. There can be no doubt that there was gene flow between the two areas.

The subgenus *G.* (*Stenozone*) represents an interesting radiation within the genus *Glabrocingulum* utilizing a combination of characters not seen before. The derivation of this cluster is uncertain, there is no morphotype within the other two subgenera (*G. Glabrocingulum* and *G. Ananias*) throughout their stratigraphic range to suggest a relationship. The earliest known species *G.* (*S.*) *argentinus* (Reed), 1927, from the Upper Carboniferous of Central Patagonia indicates that the morphotype became isolated and evolved in the Gondwana fauna province. All individuals known are very large-sized, at least twice as large as any known of the other two groups.

Another interesting genus from the Malaysian Permian is *Apachella*, originally described from the Permian of Arizona (Winters, 1963). Two species from the fauna show incipient siphonal canals (*A. bathysiphon*, new species and *Apachella* species B); whereas this feature is known in the murchisonids, it is unknown among pleurotomarians. Because of the nature of the gills in pleurotomarians, it is difficult to conceive that an inhalant siphon was functional in the usual sense (that is, for permitting a snail to live on soft substrate by raising the siphon above sediment-rich water or to be buried in sediment). It possibly served as a sensing organ. Another feature found in *Apachella* species B is the presence of varices which are rarely found in Paleozoic snail taxa.

Nonpleurotomarians within the fauna also show many features associated with Mesozoic groups. No attempt will be made here to discuss these since, at present, their study has not progressed far enough. Analysis and comparisons of the entire fauna will be included in the summary at the end of the systematics section.

MEASUREMENTS: Although this fauna is rich in diversity, the samples of most species are very small. There is an unusually high percentage of broken, unidentifiable, and distorted specimens caused by apparent local tectonic activity. Therefore, in most cases no quantitative studies to determine a more precise knowledge of variation or to make comparative analyses

are possible. In a few cases where a sufficiently large sample was present, such as in *G.* (*Glabrocingulum*) *sarrauti* (Mansuy), detailed measurements and quantitative studies were made. Results from these were incorporated in the text as general statements. The measurements, along with scattergrams and other material will be retained in the files of the Department of Invertebrate Paleontology, the American Museum of Natural History.[1]

[1]Unless otherwise noted, all specimens come from the *Misellina claudiae* zone in the Lee Mine No. 8, Kampar, Perak, Malaysia.

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I wish to thank most kindly Dr. Derek J. Gobbett of Cambridge University (formerly of the Geology Department, University of Malaysia) for bringing this very important fauna to my attention, for permitting me to study it, and for his patience during the five years since his first letter. Dr. Keiji Nakazawa of Kyoto University deserves special thanks for sending vital additional specimens collected during the Southeastern Asia Scientific Expedition made by members of Osaka City and Kyoto universities. I gratefully thank Mr. G. Robert Adlington for the high quality photographs made of rather poorly photogenic material. I gratefully acknowledge Drs. Niles Eldredge and Harold Rollins for providing many stimulating discussions covering the whole range of problems this fauna presented. Finally, I wish to thank the Council of the Scientific Staff, the American Museum of Natural History for providing funds that enabled me to study European types of Southeast Asia Permian molluscs.

SYMBOLS AND ABBREVIATIONS

The following institutional abbreviations are used in connection with the numbers of catalogued specimens:

AMNH, the American Museum of Natural History
UM, University of Malaysia, Geology Department Collections
KU, Kyoto University Collections, Japan

The following symbols are used in the measurements:

H, shell height, in most cases this measurement is approximate because one or more of the early whorls are missing
L, shell length in bellerophontids
SP ANG, spiral angle of shell
SW, selenizone width
W, shell width
TH, shell thickness in bellerophontids

SYNOPTIC CLASSIFICATION

Class Amphineura
- Subclass Polyplacophora
  - Order Neoloricata
    - Suborder Lepidopleuriina
      - Family Lepidopleuridae Pilsbry, 1892

Class Gastropoda
- Subclass Prosobranchia
  - Order Archeogastropoda
    - Suborder Bellerophontina
      - Superfamily Bellerophontacea
        - Family Bellerophontidae McCoy, 1851
          - Subfamily Bellerophontinae McCoy, 1851
            - *Bellerophon roemeri* Fliegel, 1901 (37)[a]
            - *Bellerophon equivicalus* Reed, 1944 (41)
            - *Bellerophon crassoides* Reed, 1925 (1)
          - Subfamily Knightitinae Knight, 1956
            - *Retispira lyelli* (Gemmellaro), 1890 (2)
            - *Retispira temnonema*, New Species (1)
    - Suborder Macluritina
      - Superfamily Euomphalacea
        - Family Euomphalidae DeKoninck, 1881
          - *Straparollus* (*Euomphalus*) Species (3)
        - Family Eotomariidae Wenz, 1938
          - Subfamily Eotomariinae Wenz, 1938
            - Tribe Ptychomphalides Wenz, 1938
              - *Mourlonia talboti* (Dickins), 1963 (3)
              - *Ambozone rasmusseni*, New Species (3)
              - *Glabrocingulum* (*Glabrocingulum*) *sarrauti* Mansuy, 1912 (24)
              - *Glabrocingulum* (*Stenozone*) *nodosuturala*, New Species (5)
              - *Glabrocingulum* (*Stenozone*) *brennensis* (Reed), 1944 (7)
              - *Glabrocingulum* (*Stenozone*) *pleurotomariformis* Delpey, 1942 (23)
              - *Euconospira Spiroperforata* Batten, 1958 (3)
              - *Shwedagonia collabra*, New Species (5)
              - *Lacunospira reticulata*, New Species (7)
          - Subfamily Neilsoniinae, Knight, 1956
            - *Apachella malaysia*, New Species (30)
            - *Apachella brachyisiphon*, New Species (4)
            - *Apachella* Species A (1)
            - *Apachella* Species B (2)
        - Family Lophospiridae Wenz, 1938
          - Subfamily Ruedemanniinae Knight, 1956
            - *Worthenia multicarinata* (Mansuy), 1912 (17)
            - *Worthenia cf. schirjaevensis* (Stuckenberg), 1905 (5)
        - Family Luciellidae Knight, 1956
          - *Luciellina* Species (7)
        - Family Gosseletinidae Wenz, 1938
          - Subfamily Coelozoninae Knight, 1956
            - *Platyzona nodohumerosa*, New Species (3)
            - *Platyzona eulkaiensis* (Reed), 1927 (5)

Family Phymatopleuridae Batten, 1956	
Phymatopleura Species	(8)
Borestus planiapicata (Wanner), 1942	(2)
Borestus rotundatus, New Species	(4)
Lamellospira anatola, New Species	(2)
Paragoniozona yunnania, New Species	(2)
Total specimens studied	257

[a]Numbers in parentheses are sample sizes.

SYSTEMATIC DESCRIPTIONS

CLASS POLYPLACOPHORA

ORDER LORICATA

SUBORDER LEPIDOPLEURINA

FAMILY LEPIDOPLEURIDAE PILSBRY, 1892

Figures 1, 2

DISCUSSION: Three well preserved, and three poorly preserved chiton plates are present in the Lee Mine collection. Two appear to be intermediate valves and the rest end valves. General ornament and other valve features suggest that they may belong to the family Lepidopleuridae (the most common family represented in the Paleozoic). Chitons are relatively rare in Paleozoic rocks perhaps because they live in high energy environments where they would tend to be destroyed. The chitons have been documented from the Permian of Germany and west Texas.

NUMBERED SPECIMENS: AMNH 29023–24.

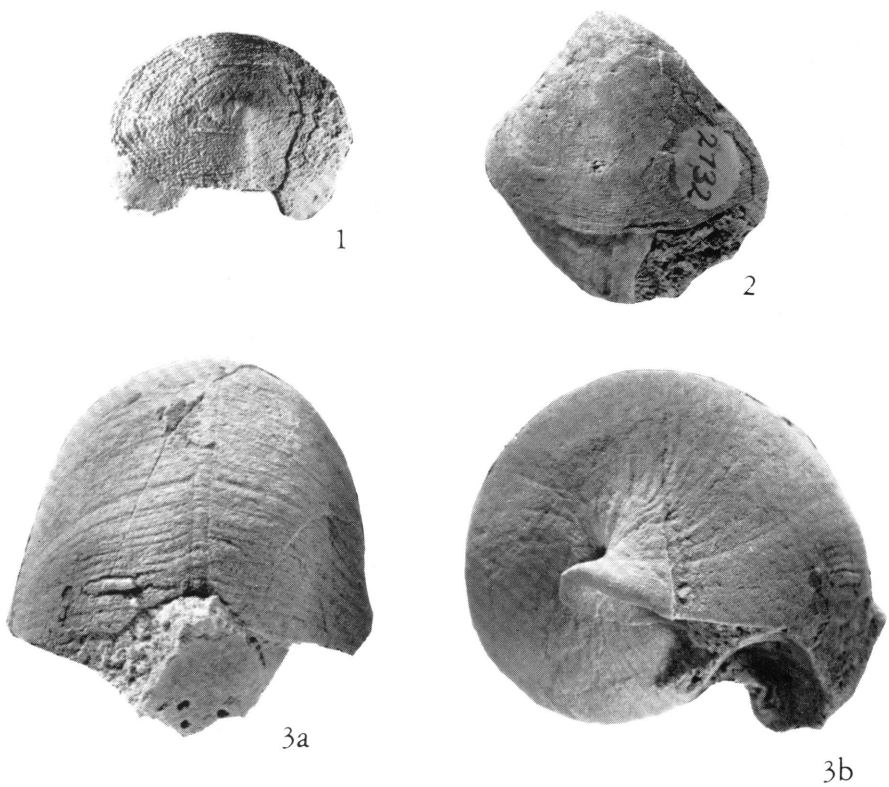
CLASS GASTROPODA

SUBCLASS PROSOBRANCHIA

ORDER ARCHEOGASTROPODA

SUBORDER BELLEROPHONTINA

DISCUSSION: In general, the faunas of Southeast Asia are poor in bellerophontid taxa, the Malaysian fauna for example has but four species representing two genera. Delpey, 1941, described four species from the Kazanian of Cambodia. They are moderately common in the Lee Mine fauna, being represented by more than 80 specimens. Throughout the Tethyan belt in central and eastern Europe the bellerophontids of the Bellerophon-Kalke also show very little diversity but are represented by large numbers of individuals. There are several exceptions; there appears to be a rather large number of species in the "upper Productus limestone" of the Salt Range (some 22 species



FIGS. 1–3. 1. An end valve of a lepidopleurid chiton, AMNH 29023, oblique top view. ×1. 2. An end valve of a lepidopleurid chiton, AMNH 29024, front view. ×2. 3a. *Bellerophon* (*Bellerophon*) *roemeri*, Fliegel, AMNH 29025, front view. 3b. Side view. Both ×3.

were described by Waagen, 1880). There also is a large bellerophontid assemblage in Permian rocks of the southwestern United States, see Yochelson, 1960.

FAMILY BELLEROPHONTIDAE M'COY, 1851

SUBFAMILY BELLEROPHONTINAE M'COY, 1851

BELLEROPHON MONTFORT, 1808

TYPE SPECIES: *B. vasulites* Montfort, 1808, p. 50.

DISCUSSION: Upper Paleozoic species of *Bellerophon* are quite conservative with many overlapping characters. The selenizone, for example, may be a well-developed cord, a sharp, relatively deep striation, or there may be no spiral delineation at all. The selenizone itself may be raised and convex or flat, flush with the whorl surface and flat or depressed beneath the surface and flat or slightly concave. The more typical presentation is convex raised. All or some combination of these conditions may be found within a single sample of a species. Growth line development also shows much overlap between species. The principal variation involves relative coarseness, imbrication, and regularity of the growth increments. In addition, the condition of the umbilici is overlapping and one can observe a phaneromphalus, hemiomphalus, or anomphalus condition within a single species.

Within the species of *Bellerophon* in the Malaysian fauna, the over-all shape of the shell, width of the selenizone, and apertural thickening are conservative and nonoverlapping, hence would appear to be the most suitable characters to recognize species. When these characters are applied to the Permian *Bellerophon* species of other Tethyan faunas, many species appear to be distinct and restricted to stratigraphic and geographic units. For example, *B. (B.) blandfordianus* Waagen, 1880 is restricted to the Tatarian.

At present there are no discernible evolutionary trends within the genus and all variation described above can be observed in Mississippian species. The probabilities are high that many of the species in the Upper Paleozoic are invalid. This will not be answered until a complete monographic study is made.

Bellerophon (Bellerophon) roemeri Fliegel, 1901

Figure 3a, b

Bellerophon roemeri FLIEGEL, 1901, p. 111.
Bellerophon asiaticus ROEMER, 1880 (1880–1881), p. 9, pl. 3, fig. 2b.
Bellerophon orientalis DEKONINCK: WAAGEN, 1880, pl. 13, fig. 5, p. 147.
? *Bellerophon (Stachella) semiaurita* WAAGEN, 1880, p. 174, pl. 17, figs. 1, 2.
Bellerophon jonesianus DEKONINCK: WAAGEN, 1880, p. 135, pl. 13, figs. 1–2.
Bellerophon timorensis WANNER, 1922, p. 15, pl. 151, figs. 2–5.

DESCRIPTION: Globose to somewhat compressed forms with a narrow selenizone, raised and convex or flush with the whorl surface or slightly depressed and flattened; selenizone borders are striations more or less developed; ornament usually fine, slightly imbricated growth lines which may be evenly spaced or irregular and sinuous; slit extremely shallow; apertural lip heavily thickened with callus deposits extending from umbilical areas to center of shell; usually anomphalus but may be hemiomphalus or rarely phaneromphalus.

DISCUSSION: As mentioned in the discussion of the genus *Bellerophon*, there is much overlap of characters between species and no satisfactory taxonomy has been developed. See discussion under *B. (B.) equivicalus* for further information on this species.

SPECIMENS: 37.

MEASUREMENTS: AMNH 29025: H 18 mm., L 19 mm., TH 18 mm.

NUMBERED SPECIMENS: AMNH 29025, UM 2310, 2433–57.

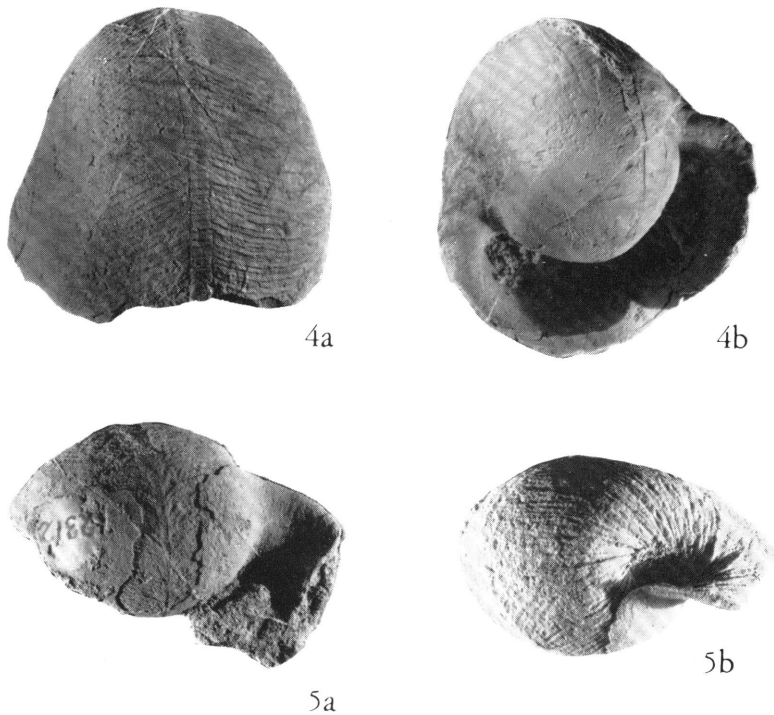
Bellerophon (Bellerophon) equivicalus Reed, 1944

Figure 4a, b

Bellerophon equivicalus REED, 1944, p. 348, pl. 59, fig. 5.

DESCRIPTION: Moderately large, globose forms with a relatively wide selenizone; selenizone margins usually marked by edges of growth lines, rarely by striations; selenizone usually flattened, flush with surface, lunulae tend to parallel growth lines, but may be slightly curved; depth of slit very shallow; imbricated growth lines well developed; ornament fairly coarse.

DISCUSSION: Some specimens that have a slightly depressed and concave selenizone tend to have somewhat coarser ornament. The selenizone apparently attains a given width



FIGS. 4–5. 4a. *Bellerophon* (*Bellerophon*) *equivacalus* Reed, AMNH 29026, front view. 4b. Oblique apertural view. 5a. *Bellerophon* (*Bellerophon*) *crassoides* Reed, AMNH 29027, oblique apertural view. 5b. Oblique back view. All ×1.

early in ontogeny, perhaps as a physiological response. Thereafter it is fairly stable in width compared to other characters which continue to grow isometrically. Rollins, Eldredge, and Spiller, 1971 reported a similar case of allometry in selenizone width from the Devonian of New York involving *Retispira leda*.

Bellerophon (*B.*) *equivicalus* differs from *B.* (*B.*) *roemeri* in having a much wider selenizone and, in general, lacking a defined selenizone margin. This species is much larger than *B.* (*B.*) *roemeri*. There is some progressive intensification of ornament with growth, not observed in *B.* (*B.*) *roemeri*. There is some overlap in the selenizone shape between the two species, but the majority of *B.* (*B.*) *equivicalus* specimens show flattened selenizones flush with the whorl surface. In forms having similar ornament to *B.* (*B.*) *roemeri* the selenizone is slightly convex and raised above the whorl surface. Because of the coarser ornament, imbricated growth increments are well developed.

SPECIMENS: 41.

MEASUREMENTS: AMNH 29026: H 42.7 mm., W 45.8 mm., L 46.6 mm., SW 2.9 mm.

NUMBERED SPECIMENS: AMNH 29026, UM 2293, 2295, 2300–01, 2313–16, 2401–03, 2447.

Bellerophon (*Bellerophon*) *crassoides* Reed, 1925

Figure 5a, b

B. (*Bellerophon*) *crassoides* REED, 1925, p. 65, pl. 8, fig. 4.

Bellerophon squamatus WAAGEN: GRABAU, 1931, p. 342, pl. 33, figs. 3–4.

DESCRIPTION: Relatively large, subquadrate forms with a narrow, flat, and depressed selenizone; lunulae subrectangular and widely spaced: growth increments large, imbricate and sinuous; parietal inductura moderately well developed.

DISCUSSION: This species is quite distinctive by virtue of its subquadrate shape and flattened whorl surface. It is quite rare, known from several specimens from Chitral described by Reed. It is conspecific with *B. squamatus* Waagen; Grabau, 1931, from the Jisu Hounguer limestone of Mongolia. It might be related to *Pharkidonatus acuticarinatus* Yin: Licharew and Netschajew, 1956, but their illustration indicated

that their specimen might be a steinkern. It is closely related to *B. complanatus* Yochelson, 1960. The general morphotype is unique among the species of the genus and appears to be a distinct Permian development.

Represented by a single distorted specimen:

MEASUREMENTS: H 20.6 mm., W 24.7 mm., TH 20.1 mm., SW 0.92 mm.

NUMBERED SPECIMEN: AMNH 29027.

SUBFAMILY KNIGHTITINAE KNIGHT, 1956

RETISPIRA KNIGHT, 1945

TYPE SPECIES: *Retispira bellireticulata* Knight, 1945, p. 335, pl. 49, figs. 1a–c.

DISCUSSION: This long-ranging genus (Devonian-Permian) is moderately conservative. Knight, Batten, and Yochelson (1960, p. I184) considered *Retispira* as a subgenus of *Knightites* Moore, 1941, believing that it represented a portion of an intergrading sequence of forms involving ornament and relative expansion of the aperture. As new species and studies have been made since 1960, evidence now suggests that *Retispira* should be recognized as a separate genus (Wilson, 1967, p. 473; Rollins, Eldredge, and Spiller. 1971, p. 137).

Retispira lyelli (Gemmellaro), 1889

Figure 6a, b

Bucania lyelli GEMMELLARO, 1889, p. 118, pl. 16, figs. 13–15: Gemmellaro; WANNER, 1922, p. 18, pl. 151, figs. 7a–c: Gemmellaro; DELPEY, 1942, p. 348, text fig. 23.

Bucania sosiensis GEMMELLARO, 1889, p. 118, pl. 7, figs. 24–26.

Bucania makatikhae JAKOWLEW and NETSCHAJEW, 1899, p. 88, pl. 4, fig. 2.

Bucania nodulosa MANSUY, 1914, p. 38, pl. 7, fig. 4a, b.

Knightites (Retispira) girtyi YOCHELSON, 1960, pp. 276–277, pl. 56, figs. 4–8.

DESCRIPTION: Relatively small compressed shells, tightly coiled and widely phanoromphalus; spiral ornament consisting of two orders of fine ribs, unevenly, but closely spaced; coarse collabral ribs forming reticulation with spiral elements, some periodic undulations; selenizone flat and raised above whorl surface, with numerous spiral threads as on whorl; slit moderately deep; thin inductural deposits.

DISCUSSION: This species is highly distinctive by virtue of its compressed whorl profile and wide umbilici, representing an extreme morphotype within the generic range. The same morphotype has been observed in several widely separated faunas. It is known from the Sakmarian of Ferghana, Uzbek as *Bucaniopsis orientalis* Licharew and Netschajew, 1956; as *Bucania lyelli* from the Guadalupian of Cambodia; Timor; the Salt Range; as *Bucania makatikhae* Jakowlew, and Netschajew, 1899 from the Donetz Basin and at Sosio as *Bucania sosiensis*. However, the species is best illustrated and discussed by Yochelson, 1960, pp. 276–277 as *Knightites (Retispira) girtyi*. In all cases the morphotype appears almost identical, with some minor variation in ornament pattern. For example, the two specimens from Malaysia have coarser and more rounded ornament with periodic collabral ribbing developed by an enlargement of a thread or by a doming of the wall, *R. girtyi*, on the other hand, has finer and more numerous ornament and no ribbing.

SPECIMENS: Two.

MEASUREMENTS: AMNH 29028: H 9.2 mm., W 9.6 mm., L 11.7 mm., SW 0.80 mm.

UNFIGURED SPECIMENS: H 9.4 mm., W 8.1 mm., L 12.5 mm., both specimens distorted.

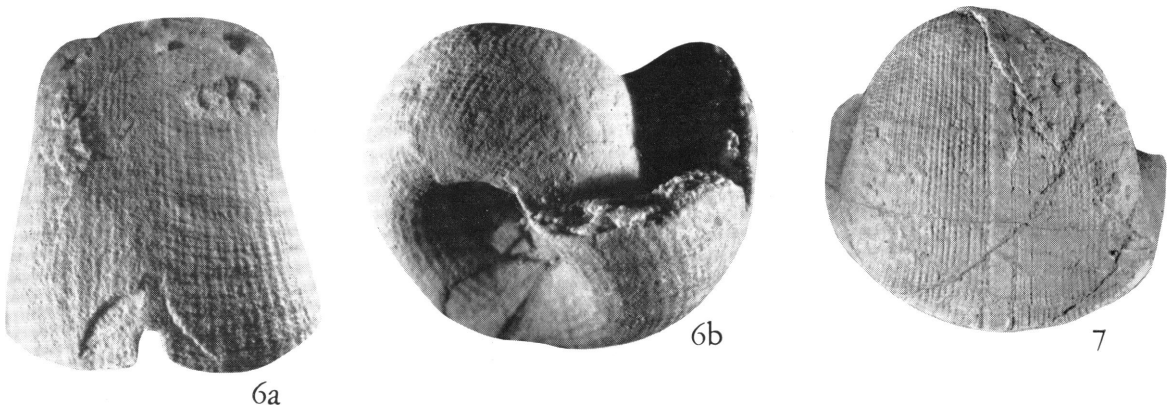
NUMBERED SPECIMENS: AMNH 29028; UM 3092.

Retispira temnomena, **new species**

Figure 7

DIAGNOSIS: Subquadrate whorl profile with a flattened whorl surface covered by numerous spiral threads: selenizone wide, convex, covered with five spiral threads; selenizone margins shallow troughs with fine threads; growth lines faint; spiral threads irregularly developed but generally alternate threads weaker, irregular development more noticeable in umbilical regions; umbilici widely phaneromphalus; inductura very thin in center of shell, thickening toward margin.

DISCUSSION: The nature and combination of characters is unique in this single specimen. I believe it important to describe it as a new species, in spite of a great deal of reluctance to recognise a formal taxon based on a single specimen. The principal characters are the subquadrate shell shape and an unusual ornament pattern. Spiral threads alternate in a first and second order pattern with some degree of irregularity, particularly striking in the umbilical



FIGS. 6–7. 6a. *Retispira lyelli* (Gemmellaro), AMNH 29028, front view. 6b. Oblique apertural view. Both ×4. 7. *R. temnonema*, new species, holotype, AMNH 29029. Note disrupted spiral ornament. ×1.

regions. The most interesting and unique aspect of the ornament is the manner in which the growth lines interrupt the spiral threads, see figure 7. At the intersection of a growth line with a spiral thread, there is a depression which is the trace of the growth line, hence is normal to the spiral thread. The depression completely cuts across second order spiral threads so that the bottom of the depression is at the same level as the general whorl surface. The spiral threads on the selenizone are continuous and no growth lines are seen.

To my knowledge, this phenomenon has been observed in only two species. *Retispira texana* Yochelson, 1960, from the Permian of west Texas and *R. exilis* DeKoninck from the Lower Carboniferous of Somerset, England.

SPECIMEN: One.

MEASUREMENTS: Holotype, AMNH 29029: H 30.5 mm., W 40.2 mm., L. 37.2 mm., SW 3.3 mm.

NUMBERED SPECIMEN: Holotype, AMNH 29029.

ETYMOLOGY: Derived from the Greek *temno*, to cut and *nema*, thread.

SUBORDER MACLURITINA

SUPERFAMILY EUOMPHALACEA

FAMILY EUOMPHALIDAE DEKONINCK, 1881

STRAPARALLUS (*EUOMPHALUS*) J. SOWERBY, 1814

TYPE SPECIES: *Euomphalus pentangulatus* J. Sowerby, 1814, p. 97, pl. 45.

Straparollus (*Euomphalus*) species

Figure 8

DESCRIPTION: Very low-spired forms with a subquadrate whorl profile; upper whorl face flat to gently convex; shoulder with a sharp keel; outer whorl face convex with the periphery below mid-whorl; base rounded; widely phaneromphalus.

DISCUSSION: The three specimens in the collection display rather typical conservative characters of the subgenus, found in the Permian. None of the Asian species seems to be similar but poor preservation of our specimens prevents comparisons.

SPECIMENS: Three.

NUMBERED SPECIMEN: AMNH 29030.

FAMILY EOTOMARIIDAE WENZ, 1938

SUBFAMILY EOTOMARIINAE WENZ, 1938

TRIBE PTYCHOMPHALIDES WENZ, 1938

MOURLONIA DEKONINCK, 1883

TYPE SPECIES: *Helix carinatus* J. Sowerby, 1812, vol. 1, p. 34, pl. 10.

DISCUSSION: To my knowledge, *Mourlonia sensu stricto* does not appear above the Artinskian. Dickins (1963, p. 126) reported that *Mourlonia maitlandi* (Etheridge), 1903, is found in the Byro group of the Australian Carnarvon Basin and from the Noonkanbah Formation of the Fitzroy Basin both considered to be Artinskian. In most other regions in the world the genus is not found above the Sakmarian.

Mourlonia talboti (Dickins), 1963

Figure 9

Ptychomphalina talboti DICKINS, 1963, pp. 125–126, pl. 24, figs. 12–19.

DESCRIPTION: Turbiniform with rounded whorls; early whorls unknown; whorl surface flattened early, convex later; surface above selenizone with asymmetrical collabral cords; slightly raised selenizone just below the periphery; selenizone margins rounded, well developed, selenizone gently concave with fine lunulae; base flatly rounded with numerous collabral threads similar in development to lunulae; phaneromphalus.

DISCUSSION: For reasons unclear to me Dickins placed *M. talboti* in the genus *Ptychomphalina*, which is generally accepted as a synonym of *Mourlonia* (see Batten, 1967).

Of the three specimens in the Permian collections, there is only a broken one preserved well enough to analyze. These specimens show somewhat coarser collabral ornament on the upper whorl surface compared with the types, and the surface is much flatter. This gives the shell shape a more conical appearance. Also the selenizone is below the periphery, whereas in the types it is somewhat above the periphery.

SPECIMENS: Three from the Lower Permian limestone at Nam Loong Mine, Perak.

MEASUREMENTS: AMNH 29031: H 14.5 mm., W 11.4 mm., Specimen broken.

NUMBERED SPECIMEN: AMNH 29031.

AMBOZONE, **NEW GENUS**

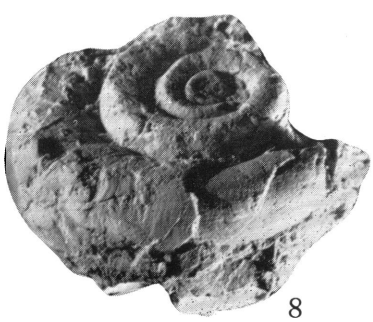
TYPE SPECIES: *Ambozone rasmusseni*, new species.

DIAGNOSIS: Planispiral to truncated, turbiniform shells with a selenizone having well-developed margins situated at or just below the periphery; early rounded whorls orthostrophic to planispiral; sutures sharply defined, deep; with or without nodes on upper and lower whorl surfaces; suture contact usually well above selenizone, concealing it; selenizone margins asymmetrical cords, concave above and below selenizone; slit usually deep; widely phaneromphalus; usually no ornament other than nodes and growth lines.

DISCUSSION: Several species described as *Porcellia* in the upper Paleozoic along with three specimens from the Lee Mine, share characters not seen in species of *Porcellia* and should be considered as a separate genus. The majority of *Porcellia* species (more than 20 are known) form a rather close-knit group, having a deep-set selenizone without distinctive margins. Most species have spiral and collabral ornament which tend to form reticulation. Most variation involves combinations of node development and emphasis of ornament.

The most important features of *Ambozone* are the presence of well-developed selenizone margins and a raised flat selenizone. All known species lack any ornament other than nodes near the suture and in some cases on the base. *Ambozone rasmusseni* is uncoiled in the later ontogenetic stages, but this and other axial changes are not unknown in the ptychomphalids (for example, *Schwedagonia* Batten, 1956, *Mourlonia* DeKoninck, 1883, and *Euconospira* Ulrich in Ulrich and Scofield, 1897).

The following species are referable to *Ambozone: A. peoriensis* (Worthen) 1884, *A. gilliana* White and St. John, 1867, both from the Pennsylvanian of North America; *A. geyeri* Heritsch, 1935 from the Lower Permian of Europe, *Porcellia verneuli* d'Orbigny, 1838 from



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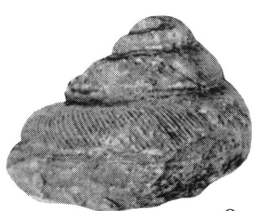

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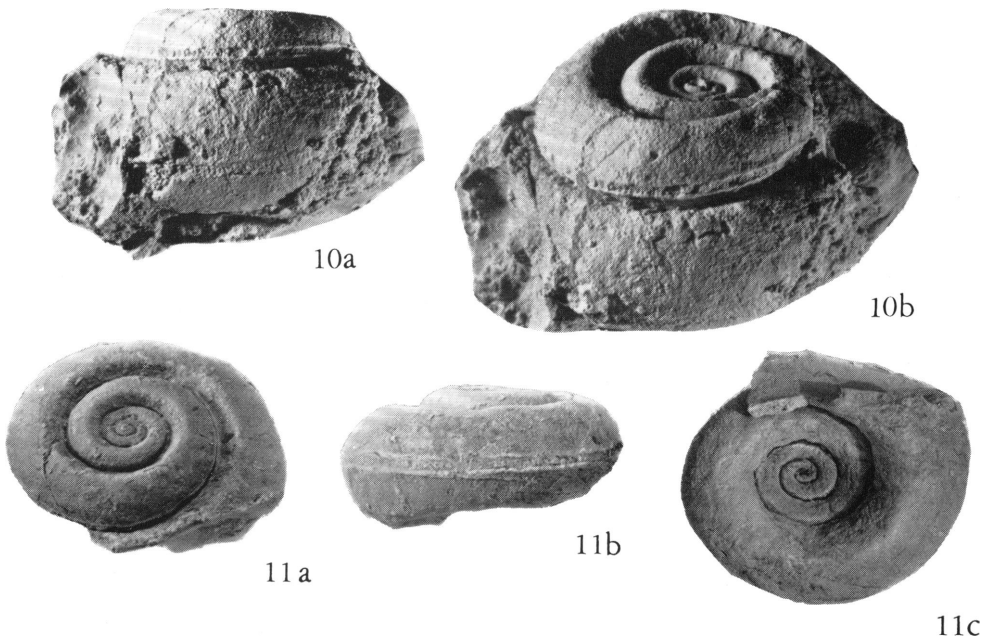
FIGS. 8–9. 8. *Straparollus* (*Euomphalus*) sp., AMNH 29030, oblique top view. ×1. 9. *Mourlonia talboti* (Dickins), AMNH 29031, side view. ×2.



FIGS. 10–11. 10a. *Ambozone rasmusseni*, new genus and new species, holotype, AMNH 29033, side view showing uncoiled final whorl. 10b. Oblique top view showing changes in coiling. Both ×2. 11a. *A. rasmusseni*, paratype, AMNH 29032, oblique top view. 11b. Side view. 11c. Basal view. All ×2.

the Lower Carboniferous of Europe may also belong to this genus but I have not had the opportunity to search for the holotype; *Porcellia nodosa* Delpey, 1942 from the Permian of Cambodia may also belong to this genus.

ETYMOLOGY: Derived from the Greek *ambon*, crest and *zone*, belt.

Ambozone rasmusseni, **new species**

Figures 10a, b, c; 11a, b

DIAGNOSIS: Truncated, turbiniform shells with selenizone at or just below the periphery; first five whorls coiled planispirally, later whorls uncoiled; sutural contact just below selenizone in later whorls. Sutures sharp and deeply incised; embryonic whorl globose as in *Mourlonia*, nepeonic whorls planispiral and rounded, neanic whorls planispiral and compressed so that highest exposed portion of whorl forms sharply angulate ridge; ephoebic whorls more rounded in profile but still retaining angulate ridge which, in turn, becomes point of sutural contact; selenizone margins are flangelike, and concave selenizone lunulate; base evenly rounded and probably narrowly phaneromphalus in orthostrophic stage; base of planispiral phase widely phaneromphalus; no ornament; parietal surface unknown.

DISCUSSION: The planispiral phase in this species could be mistaken for some species in *Porcellia* (such as *P. woodwardi* (Martin) or *P. lehoni* DeKoninck) on the basis of shape. There are, however, important differences such as the angulate upper whorl in *A. rasmusseni*, whereas the base is rounded, thus the illusion of isostrophy is destroyed. The most important difference is the nature of the selenizone which sets off this genus from *Porcellia*. *Ambozone rasmusseni* has a flat selenizone flush with the whorl surface with well-developed selenizone margins which is similar to *A. peoriensis* and *A. gilliana*. However, *A. rasmusseni* lacks the upper and lower whorl surface nodes and has a ridge instead. There may be some gentle undulations on the ridge but poor preservation prevents substantiation of this observation. The single most unique feature of the species is the late ontogenetic uncoiling, giving the appearance of a truncated specimen of *Mourlonia*.

SPECIMENS: Three.

MEASUREMENTS: Holotype, AMNH 29033: H 12.7 mm., W 17.6 mm., SW 0.5 mm.

Paratype, AMNH 29032: H 8.8 mm., W 17.2 mm., SW 0.5 mm.

Paratype, unfigured specimen: H 4.2 mm., W 8.2 mm., SW 0.3 mm.

NUMBERED SPECIMENS: AMNH 29033, 29032.

ETYMOLOGY: Named for Gerald Rasmussen.

GLABROCINGULUM THOMAS, 1940

TYPE SPECIES: *G. beggi* Thomas, 1940, pp. 39–40; pl. 2, fig. 1–a–d.

DISCUSSION: *Glabrocingulum* (*Glabrocingulum*) is one of the most common upper Paleozoic gastropods in terms of numbers of individuals. It is first known in the Upper Devonian of southwest England by two species, *G.* (*Glabrocingulum*) *subimbricata* and *G.* (*G.*) *victrix* described by Whidborne in 1892. It is relatively uncommon until Upper Carboniferous time. Little evolution or adaptive radiation is known in the genus (except for the origin of *G.* (*Ananias*)), until the Permian. In fact, with a few exceptions, pre-Permian species are remarkably stable with restricted morphological variation.

Much of the early variation involved two simple patterns; the most important one is the tendency to uncoil, particularly in the final ontogenetic stage. A variation of this uncoiling is seen in *G.* (*Ananias*) where uncoiling occurs very early in the ontogeny and thereafter the position of the suture is fixed lower on the whorl than in *G.* (*Glabrocingulum*) (see Eldredge, 1968, for a full discussion).

The other variant pattern involves changes in detail of ornament. Typically, there is reticulate ornament consisting of spiral and collabral threads, which may be equally well developed; or one or the other may be dominant. Frequently, interference nodes are present at the intersection of threads. Typically too, are strongly developed nodes adjacent to the suture. In the Lower Carboniferous of Europe, heavily ornamented species are most common, such as *G.* (*G.*) *beggi*. In North America both heavily ornamented forms [e.g., *G.* (*G.*) *quadrigatum* Sadlick and Neilson, 1963] and those with greatly reduced ornament [e.g., *G.* (*G.*) *stellaeformis* (Hyde), 1953 and *G.* (*G.*) *binodosum* Sadlick and Neilsen, 1963] are present.

Throughout the Upper Carboniferous, the dominant form in North America was *G.* (*G.*) *grayvillensis* (Norwood and Pratten), 1855, a species with many of the aspects of the European Lower Carboniferous species suggesting derivation from them and not from the North American forms mentioned above. This species occurs in astronomical numbers in molluscan shale faunas. A similar form is found in the Myachkovo horizon in the Moscow basin [*G.* (*G.*) *pakhiensis* Sinelnikova, 1967].

By Permian time three of four species appear in North America that are undoubtedly derived from *G.* (*G.*) *grayvillensis*. These species are very variable and two of them highly ornamented. The *G.* (*G.*) *grayvillensis* type of morphology is also found in Tethyan faunas but it is not as commonly encountered as in North America. This type includes: *G.* (*G.*) *retroplicata* (Gemmellaro), 1889 from the Sosio beds of Sicily, *G.* (*G.*) *sarrauti* (Mansuy), 1912, from the *Neoschwagerina* zone in Cambodia; Yunnan, China and from the Lee Mine in Malaysia. The latest known form of this group is an undescribed species in the Gujo Formation of Japan considered to be in the *Paleofusulina* zone.

Glabrocingulum (*Ananias*) has a somewhat similar history. It first appeared in the Tournaisian as several species in the Belgian section. There is no report of the subgenus in the later Lower Carboniferous. There are two species of *G.* (*Ananias*) in the Upper Carboniferous in North America, but they are not as common as *G.* (*Glabrocingulum*).

In the Permian, *G.* (*Ananias*) sharply increases its variability in several morphological complexes. Three species appear to have been derived from an Upper Carboniferous species [*G.* (*Ananias*) *welleri* (Newell), 1935]. The variability involves ornament development, suture position (which regulates relative height of the shell), relative height of whorl, and rate of whorl expansion. In one undescribed species a new character change can be observed. The final several whorls become much more rounded than the more typical tabulate species; this effect is heightened by an increase in shallowness of the alveozone. This trend continued until in a derived species, the final whorl is greatly enlarged and rounded, giving the shell an egg shape. The ornament in this final stage again is clearly derived from the original Upper Carboniferous stock, except that the spiral ornament is much finer.

A rather striking and similar sequence of form change involves a group of morphotypes in the southeastern Tethys and in the Southern Hemisphere. This group *G. (Stenozone)*, new subgenus consists of six rather different appearing species. Most are unusually large for the genus, varying in shape from normal, small trochiform, to almost globose and large, see figure 16. Sutural nodes are usually present; the selenizone is narrow with well-formed margins. The most important difference between these species and that of most other species of the genus is the dominance of spiral ornament. The alveozone is absent in all but the trochiform species.

In Australia, one of the more globose species has been described as *Platyteichum johnstonei* by Dickins, 1961 from the Cundlego Formation which is thought to be Artinskian. Other members of the group are found at Basleo, Timor [*G. (Stenozone) timorensis* (Hamlet), 1928]; in the Lee Mine fauna and in the Agglomerate slate of Kashmir [*G. (S.) Brennensis* (Reed), 1932]; in the Anthracolithic at Bokhara, Russia [*G. (S.) anatolica* (Enderle), 1901]; and in Sumatra [*G. (S.) orientalis* (Roemer), 1881].

Recently, *G. (S.) argentinus* (Reed), 1927 was reported by Sabattini and Noirat, 1969, from the upper sequence of the Tepuel System of central Patagonia. Most authors have considered these beds to be Upper Carboniferous or Lower Permian. If so, this is the earliest occurrence of the subgenus.

Glabrocingulum (Ananias) is less well represented in Tethyan faunas. Some of the species that have aspects of the North American morphotypes include: an undescribed species from the Crimea, *G. (A.) sarrauti* (Mansuy) Delpey, 1942 from Cambodia and *G. (A.) reticulata* Wanner, 1922 from Timor. Other illustrated species may belong to the subgenus but are too poorly illustrated to be certain. In any event, the subgenus generally is more conservative than *G. (Glabrocingulum)*.

Within the Permian species of the genus *Glabrocingulum*, there are several features worthy of note. In almost all species, the selenizones are considerably narrower than in earlier forms; this appears to be true throughout the world. It is also true of the known Triassic representatives. Less universal is the much more fully developed funicle compared with earlier species that have them.

Glabrocingulum (Glabrocingulum) sarrauti (Mansuy) 1912

Figures 12, 13

Pleurotomaria (Mourlonia) sarrauti Mansuy, 1912, p. 100, pl. 18, fig. 10a, b, c.

Ptychomphalus sisophonensis Delpey, 1942, p. 360, fig. 33.

Diagnosis: Low, conical turbiniform shells; strong nodes near suture; spiral ornament dominant, unevenly distributed: first two whorls smooth; third whorl with a spiral cord midway between suture and large selenizone margin; very large nodes developed by collabral cords; fourth whorl with additional weaker spiral cord adjacent to suture and with weaker collabral cords; large spiral cord and nodes midway between suture and selenizone accompanied by five spiral threads just below; final whorl with two main noded spiral cords, one near suture and one midway on upper whorl surface, many fine spiral threads above and below spiral cords; outer whorl face gently convex with five or so spiral cords alternating with five or so spiral threads; base rounded, with 10 or more spiral cords and alternating spiral threads, threads stronger near umbilicus and with weak nodes; anomphalus, hemiomphalus, or cryptomphalus; parietal lip reflexed into a large funicle outlined by a ridge, surface is convexo-concave and may have growth lamellae; no other parietal deposits or ornament resorption.

Discussion: There is subtle variability in over-all shell shape owing to the slope of the upper whorl face and the outer whorl face. The upper face may be gently convex, flat, or convexo-concave. The outer face is usually gently convex and about the same width as the upper surface. In some specimens, the outer whorl face flattens rapidly from the selenizone so that there is no boundary between the face and the base (see fig. 13); in other words, the base begins at the selenizone, giving a lenticular appearance to the shell. A combination of this type of base plus a convex upper whorl surface results in a more globular shell (see fig. 12).

There is considerable variation in details of the ornament; in some forms, the basal spiral cords are large and few in number, with relatively few alternating spiral threads. There is also some variation in the number and emphasis of the spiral elements between the selenizone and the lower major noded cord on the upper whorl face. In other forms, one or more strongly

developed spiral cords may appear between the two major noded cords, and/or above them. As a result, the nodes are elongated and give the appearance of collabral ribs near the suture. Other than the ribs, growth lines are the only expression of collabral development; see figure 13. However, in a few specimens, the growth lines bunch up to form collabral elements which interrupt the finer spiral threads to form pseudo-interference nodes; see figure 12a.

The funicle generally consists of two parts, a columellar callus on the axial stem, and a swollen parietal lip reflexed back over the columellar callus forming a parietal double funicle; see figure 13. This condition is found in low to high frequency rates in *G.* (*G.*) *gravyillensis* Norwood and Pratten, 1855 and other *G.* (*G.*) *beggi* Thomas, 1940 stock. As it is a unique feature, it is a compelling piece of evidence to suggest that *G.* (*G.*) *sarrauti* along with such other species as *G.* (*G.*) *ferghanicum* Licharew, 1967, and *G.* (*G.*) *retroplicata* Gemmellaro were derived from the Carboniferous *G.* (*G.*) *beggi* cluster.

Delpey in 1942 (p. 361, fig. 34) illustrated a high-spired form, which she identified as *Ptychomphalus sarrauti* Mansuy, 1912. One of the chief characters separating *G.* (*Glabrocingulum*) from *G.* (*Ananias*) is the placement of the suture relative to the selenizone. *Glabrocingulum* (*Glabrocingulum*) tends to have the suture placed at or immediately below the lower selenizone margin, except for some individuals and species that may slightly uncoil during the growth of the last whorl. *Glabrocingulum* (*Ananias*) on the other hand, has the suture placed well below the lower selenizone margin, generally in the center of the alveozone.[1] This causes the shell to be higher spired and more tabulate. Clearly, the illustration of Delpey is that of *G.* (*Ananias*).

The specimens from the Lee Mine are very close to the illustration of the type of *G.* (*G.*) *sarrauti* (Mansuy, 1912, fig. 1b, c), a low-spired, lenticular form, in most details. The 24 specimens in our collection show a great deal of variation, but well within the range seen in other Permian species. Delpey also described *Ptychomphalus sisophonensis* (p. 350, fig. 33), which is a low-spired lenticular form, and from the few details discernible in her drawing, I have little hesitancy in assigning it to *G.* (*G.*) *sarrauti*. Delpey's treatment of the two species is puzzling as her illustrations and description of *P. sisophonensis* appear so close to Mansuy's illustrations and description that one thinks that perhaps an inadvertent switch was made. The spiral angle of *G.* (*Glabrocingulum*) tends to be more than 100 degrees, whereas that of *G.* (*Ananias*) tends to cluster around 80 degrees. Delpey's measurement of the specimen she attributes to *G.* (*G.*) *sarrauti* is 78 degrees, whereas that of *P. sisophonensis* is 100½ degrees. My measurements of *G.* (*G.*) *sarrauti* from the Lee Mine ranges from 101 to 109 degrees.

SPECIMENS: 24.

MEASUREMENTS: AMNH 29034: SP ANG 101 degrees, H 4.8 mm., W 7.1 mm., AMNH 29035: SP ANG 100 degrees, H 4.2 mm., W 4.5 mm.

NUMBERED SPECIMENS: AMNH 29034–35, UM 3099.

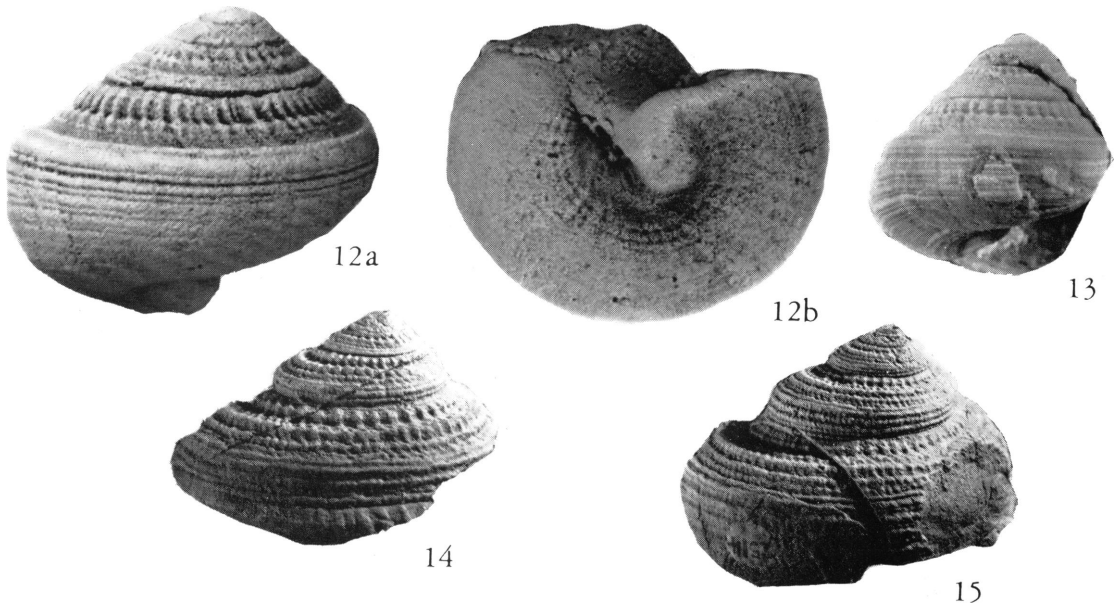
GLABROCINGULUM (*STENOZONE*), NEW SUBGENUS

TYPE SPECIES: *Glabrocingulum* (*Stenozone*) *nodosuturala*, new species.

DIAGNOSIS: Turbiniform to trochiform shells with a narrow selenizone; wide to narrow depression adjacent to suture; dominant spiral ornament; shell shape variable; early whorls smooth, flattened to gently convexo-concave; shell shape dependent, in part, by relative width of flat to concave area adjacent to suture and in part by the relative convexity of whorl; selenizone narrow, faintly to moderately strongly bordered; sutures embrace whorls slightly below lower selenizone margin; ornament dominantly spiral cords, collabral ornament subdued except for interference nodes; nodes common at ornament intersections, more strongly developed near suture and next to umbilicus; hemiomphalus to cryptomphalus; reflexed columellar lip with funicle or callus.

DISCUSSION: A group of species which appear to be related to *Glabrocingulum* are known from the Permian of Asia and South America. Their appearance and combination of morphological details are sharply set off from the *G.* (*G.*) *beggi* stock that dominated in North America and Europe. *Glabrocingulum* (*Stenozone*) shares the

[1]The term alveozone was defined by Batten (1966, p. 21) as the trough just below the selenizone in certain pleurotomarians and murchisonids which possess ornament differentiated from that on the base or upper whorl surface.



FIGS. 12–15. 12a. *Glabrocingulum* (*Glabrocingulum*) *sarrauti* (Mansuy), AMNH 29034, side view. 12b. Basal view. ×7. 13. *G.* (*Glabrocingulum*) *sarrauti* (Mansuy), AMNH 29035, side view. ×4. 14. *G.* (*Stenozone*) *nodosuturala*, new subgenus and new species, paratype, AMNH 29037, side view. Note large noded cord at suture. ×1.5. 15. *G.* (*Stenozone*) *nodosuturala*, holotype, AMNH 29036, side view. Note trough adjacent to suture. ×1.

following characters with *G.* (*Glabrocingulum*): they both possess distinctive columellar-funicular deposits; the selenizone is in the same position and the same angle with respect to the axis and suture; both usually have the strongest nodosity adjacent to the suture and, to a lesser extent, adjacent to the umbilicus. *Glabrocingulum* (*Stenozone*) differs from *G.* (*Glabrocingulum*) in the much narrower selenizone, in the curious depression adjacent to the selenizone, the expression of selenizone margins, the expression of the ornament pattern, and general shell shape.

In shell shape and type of dominant spiral ornament, *G.* (*Stenozone*) most resembles *Neoplatyteichum* Maxwell, 1964 (p. 20, pl. 4, figs. 18–24). Dr. Maxwell kindly sent latex impressions of the holotype and several paratypes. From the natural apertural breaks made during the lifetime of the individuals, they do not appear to indicate the presence of a selenizone. After using different methods of coating and lighting techniques, I was able to trace a few scattered growth lines over the upper and outer whorl surfaces. I am now positive that no selenizone exists on the specimens. Maxwell in describing the type species stated, "A weakly defined selenizone is developed near the periphery . . . growth lamellae are apparent on the later whorls but are not clearly defined. They cross the selenizone *without* noticeable deflection." (Italics mine.) I certainly agree completely. However, since the selenizone, by definition, represents the deflection of growth lines that trace a parallel-sided slit in the original aperture, it is impossible to have a selenizone without the traces of a slit. Therefore I conclude that *Neoplatyteichum* is not a pleurotomarian.

Recognition of *Neoplatyteichum* as a trochid gastropod (probably in the family Holopeidae) creates a very difficult problem of convergence, involving *G.* (*Stenozone*) *brennensis* (Reed) (see fig. 16), which is highly convergent in most respects on *N. dickinsi* (see page 23 for discussion of details). Surely, it cannot be due to some form of mimicry or convergence because of similar environments, as they do not occur together. Chance phenotypic expression of a number of characters in two species from different orders is equally difficult to accept.

Sabattini and Noirat, 1969 (pp. 107–108, pl. 2, figs. 6–9) refer a species from the Patagonian Permian to *Neoplatyteichum barrealensis*

(Reed), 1927. Although they mention the presence of a selenizone, their figure 8 shows growth lines which clearly indicate the lack of the characteristic sudden change in growth lines in the region of the selenizone. They do figure a steinkern (fig. 9) which does show a selenizone. However, since it is a steinkern of a part of a whorl, there is no way of knowing what genus it should be referred to. From the shape of figure 9, I would suspect that it does not belong to *N. barrealensis* because the whorl is not inflated. From the width and shape of the selenizone it might well be referred to *G.* (*S.*) *argentinus* (Reed), 1927.

The original figure of Reed of *N. barrealensis* (pl. 16, fig. 1) also shows growth increments which are not deflected to form a selenizone.

RANGE: ?Upper Carboniferous–Permian.

ETYMOLOGY: *Stenozone*, derived from the Greek, *stenos*, narrow and *zone*, belt.

Glabrocingulum (*Stenozone*) *nodosuturala*, **new species**

Figures 14, 15

DIAGNOSIS: Semitabulate forms with concave depression adjacent to suture, parital uncoiling and dominant spiral ornament; early whorls with convex upper whorl surfaces and sutures placed at lower margin of selenizone; from third whorl, suture migrates from lower selenizone margin to fourth major spiral cord below lower selenizone margin in final whorl; from third whorl a narrow deep depression containing one noded major and one minor spiral cord; upper whorl surface convex between depression and selenizone and with about four spiral cords; narrow selenizone with sharp margins; outer whorl face nearly vertical, gently convex with four spiral cords alternating with four spiral threads; base rounded, with 14 or so spiral cords alternating with spiral threads, ornament becomes reduced in intensity toward umbilicus; hemiomphalus to cryptomphalus; columellar lip reflexed and thickened; parietal deposits thin toward plane of aperture.

DISCUSSION: The very gradual, but minor, amount of uncoiling is one of the unique features of *G.* (*S.*) *nodosuturala*. Uncoiling is very common to *Glabrocingulum* but it usually occurs very early in ontogeny, as in *G.* (*Ananias*) where it stabilizes or in the latest ontogeny, as in some species of *G.* (*Glabrocingulum*). There is some variability between specimens in the relative width and depth of the trough adjacent to the suture. Immediately adjacent to the suture there is a relatively heavily noded spiral cord and in the deepest part of the trough there may be a noded spiral thread. At the lower or outer edge of the trough, there is a well-developed noded spiral cord, (see figs. 14–15). Spiral cord development also shows some variability regarding the degree of development in the same whorl position. Collabral threads form heavy noding at spiral intersections.

I am unable to relate these specimens to any Upper Paleozoic species illustrated in the literature. Reed (1932) illustrated a form he attributed to *Pleurotomaria* cf. *conglobata* Wanner (Reed, pl. 12, fig. 7) from the Agglomerate Slate of Kashmir, it is semitabulate with dominant spiral cords and a selenizone about in the same position as *G.* (*S.*) *nodosuturala*. Reed's figure differs in having no apparent collabral elements, being higher-spired, lacking a sutural trough, and having a wider selenizone. In any case, his figure does not appear to warrant assignment to *P. conglobata* Wanner, 1922.

Glabrocingulum (*S.*) *argentina* (Reed), 1927, bears a striking resemblance to *G.* (*S.*) *nodosuturala*, particularly to the illustration in Sabattini and Noirat (1969, pl. 1, fig. 5), which they describe from the Tepuel System and from the Esquina Gris Formation of central Patagonia and from the San Juan-Mendoza regions of Argentina. These units are currently assigned to the Upper Carboniferous. This certainly is an enigma particularly since they also describe a new species of *Callitomaria* which appears very close to species in Texas of Leonardian and Wordian age. Thus three of their species are known from Middle Permian in other areas.

SPECIMENS: Five.

MEASUREMENTS: Holotype, AMNH 29032: SP ANG 82 degrees, H 29.4 mm., W 35.1 mm. Paratype, AMNH 29037: SP ANG 80 degrees, H 20.0 mm. (broken specimen) W 27.3 mm. (broken specimen).

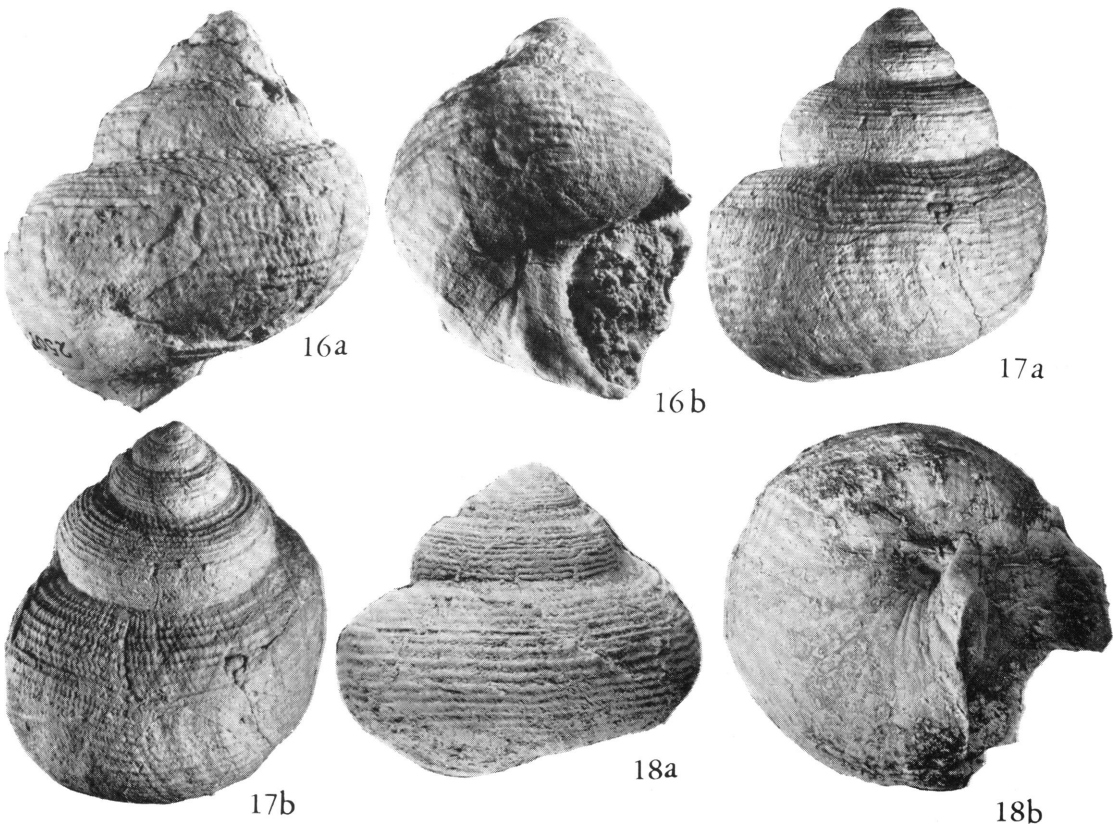
NUMBERED SPECIMENS: AMNH 29036–37. UM 2521.

ETYMOLOGY: *nodosuturala*, derived from the Latin *nodus*, knot and *sutura*, seam.

Glabrocingulum (*Stenozone*) *brennensis* (Reed), 1944

Figures 16–18

Pleurotomaria brennensis REED, 1932, pp. 64–65, pl. 12, figs. 2–4.



FIGS. 16–18. 16a. *Glabrocingulum* (*Stenozone*) *brennensis* (Reed), AMNH 29038, side view. 16b. Oblique basal view. Note thickened columellar lip. 17a. *G.* (*Stenozone*) *brennensis* (Reed) AMNH 29039, side view. 17b. Oblique side view. Note trough near suture in earlier whorls. 18a. *G.* (*Stenozone*) *brennensis* (Reed), AMNH 29040, side view. 18b. Basal view. All ×1.

DIAGNOSIS: Subglobular to globular shells with dominant spiral ornament and a well-defined selenizone; first two whorls smooth and with flattened to gently convex upper whorl surface; third whorl with well-developed spiral ornament and a narrow trough with a noded spiral cord adjacent to suture; later whorls with a more or less moderately wide trough adjacent to suture, usually with three or more spiral threads unevenly spaced and less pronounced than other spiral elements on upper whorl surface; upper whorl surface and outer whorl face subquadrate to subrounded to rounded, with seven spiral cords above the selenizone and nine spiral cords below; selenizone margins sharp and asymmetrical; base rounded with numerous spiral elements becoming progressively weaker toward the umbilicus; collabral threads form weak nodes at intersections with spiral elements, stronger near suture; cryptomphalus to anomphalus; columellar lip reflexed, thickened into a funicle; parietal callus thick, thinning toward apertural plane.

DISCUSSION: The seven specimens from the Lee Mine show a moderate degree of variability in several features. The spiral ornament generally is unevenly developed and spaced. In some forms spiral cords alternate with spiral threads, but the distance between them may be uneven. Some specimens have a more even development above the selenizone, others below the selenizone. Reed's illustrations indicate that the Kashmir specimens have a more sharply developed nodation especially near the suture. The collabral threads are heavier near the suture in most of the Lee Mine specimens. In the subrounded specimens, collabral elements may form interference nodes or elongated nodes which

persist between spiral elements. The trough adjacent to the suture may be shallow and almost flat; it tends to be quite narrow especially in the more globular forms. In the subquadrate or subrounded specimens, the trough is much broader and deeper.

This species does not appear to be represented in any fauna other than the Agglomerate Slate of Kashmir. As mentioned under the discussion of *G. (Stenozone)*, *G. (S.) brennensis* bears a remarkable resemblance to *Neoplatyteichum dickinsi* and *N. barrealensis*. Both have an area adjacent to the suture on the upper whorl surface which is differentiated from the geometry of that surface. In some specimens of *N. dickinsi* the area is flat but slopes up to the suture, others have a horizontal area. Both species are nearly globular with dominant spiral ornament. *Neoplatyteichum barrealensis* appears to have reduced spiral ornament on the base and a rather uneven spiral ornament all over the shell. This strong convergence between pleurotomarians and non-pleurotomarians is unique.

Glabrocingulum (S.) brennensis and *G. (S.) nodosuturala* are closely related and undoubtedly were derived from a common stock. The flattened to slightly convex upper whorl surfaces in the early whorls are nearly identical, as is the whorl ornament. Both have a trough adjacent to the suture with differentiated spiral and collabral elements. Both are noded, particularly on the upper whorl surface. However, *G. (S.) nodosuturala* has a predominantly subquadrate shell shape with a flattened base, whereas *G. (S.) brennensis* has a more globose shell shape with a rounded base. The ornament of *G. (S.) nodosuturala* is very strongly developed and the sutural trough occupies a large part of the upper whorl surface. In *G. (S.) brennensis* the ornament is subdued and the trough near the suture is quite narrow. Some convergence on *G. (S.) nodosuturala* is heightened owing to two extreme individuals which have an unusually wide sutural trough and much coarser ornament. The overlap is not sufficiently great to suspect that we are viewing a single highly variable species. For example, the extreme forms mentioned above still retain more even development of ornament compared to any specimen of *G. (S.) nodosuturala*.

In some respects, *G. (S.) brennensis* resembles *Mourlonia (Pseudobaylea) freneyensis* Dickins, 1963. The height of spire is similar, their flatly rounded bases are comparable, and both have dominant spiral ornament. *Mourlonia (P.) freneyensis* has a selenizone higher on the whorl relative to the periphery, a more sharply bordered selenizone, and a much flattened, sloping upper whorl face.

SPECIMENS: Seven.

MEASUREMENTS: AMNH 29038: SP ANG 104 degrees, H 37.9 mm., W 33.9 mm. AMNH 29039: SP ANG 90 degrees, H 51.0 mm., W 49.8 mm.

NUMBERED SPECIMENS: AMNH 29038–39, UM 3098.

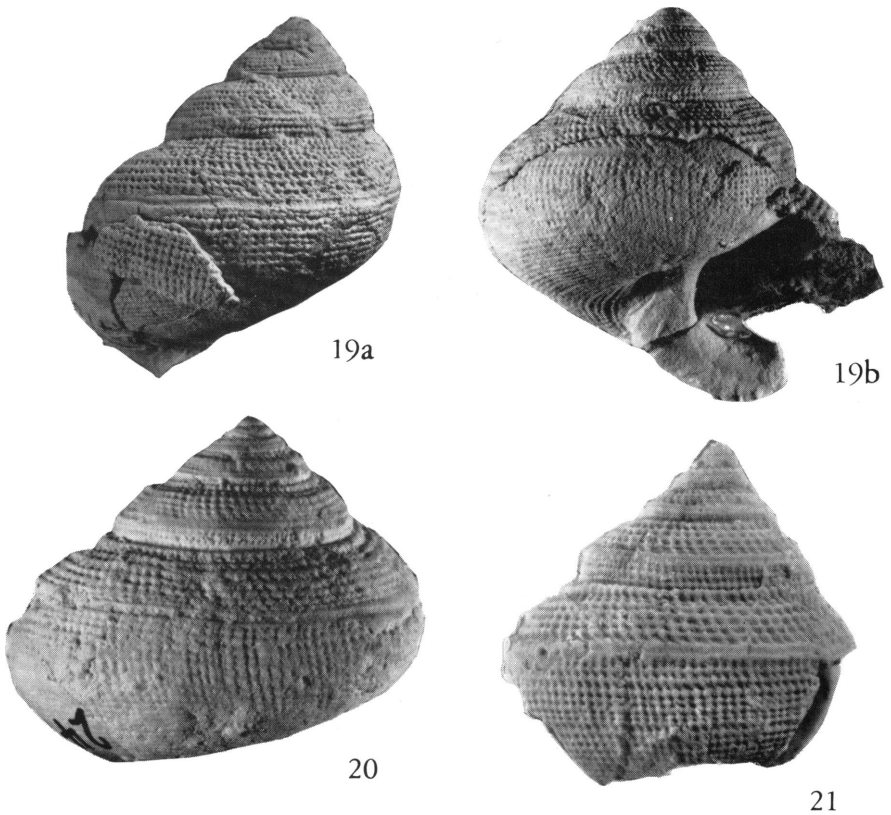
Glabrocingulum (Stenozone) pleurotomariformis (Delpey), 1942

Figures 19–21

? *Worthenia pleurotomariformis* DELPEY, 1942, p. 357–358, fig. 30.

DIAGNOSIS: First several whorls with flat to gently convex upper whorl surface, without ornament; next several whorls tabulate with ornament; trough adjacent to suture; ornament reticulate forming sharp nodes; later whorls with gently to strongly convex upper whorl surfaces, with either a very narrow sutural trough or a single strong spiral cord adjacent to suture; outer whorl face and base continuous and rounded or base slightly flattened; selenizone margins more strongly developed than other spiral elements, some margins noded; cryptomphalus to hemiomphalus; ornament resorbed on parietal surface; columellar lip reflexed and expanded into a large callus.

DISCUSSION: The most outstanding feature of this species is the sharply developed reticulate ornament which is quite evenly formed particularly in later ontogeny. However, the collabral elements are somewhat reduced on the base except near the umbilicus. The early ontogenetic similarities with that of other species of *G. (Stenozone)* is noteworthy, particularly the characteristics of the unique sutural trough which persists as a separate entity throughout the shell, even though in some specimens the trough is much reduced and the contained spiral cord occupies most of the area adjacent to the suture. It is interesting to see the interplay of morphology between the three species, with *G. (S.) brennensis* displaying the extreme of shell globosity and weakly formed ornament; *G. (S.) pleurotomariformis* is less globose but with the



FIGS. 19–21. 19a. *G.* (*Stenozone*) *pleurotomariformis* (Delpey), AMNH 29041, side view. 19b. Oblique apertural view. Both ×2. 20. *G.* (*Stenozone*) *pleurotomariformis* (Delpey), AMNH 29042, side view. ×3. 21. *G.* (*Stenozone*) *pleurotomariformis* (Delpey), AMNH 29043, side view. ×4.

most even ornament, whereas *G.* (*S.*) *nodosuturala* is the most subquadrate and with the most uneven ornament.

Glabrocingulum (*Stenozone*) *pleurotomariformis* is quite similar to *P. banschangensis* Reed, 1944 (pl. 57, fig. 4) but that species has more inflated whorls, the selenizone is lower on the whorl and it appears to have spiral ornament only.

Although the illustration of *G.* (*S.*) *pleurotomariformis* is at variance with the 23 specimens in the Malaysian collection, I believe they are conspecific. In particular, Delpey's illustration shows rather weakly formed ornament which does not form nodes; the selenizone is quite high on the whorl compared to our specimens. Although the whorls are more compressed than most of the Lee Mine specimens, there are several specimens in the collection that do show some compression (see fig. 19). The columellar calluses show the same degree of expression. Delpey provisionally placed the species in *Worthenia*; her illustration, however, shows an unornamented selenizone, which appears to be either flat or concave. In her description she does not mention any selenizone characteristics. By definition, the selenizone in *Worthenia* must be convex and ornamented by nodes (however, there are a few species that do not have nodes due to the absence of collabral ornament).

SPECIMENS: 23.

MEASUREMENTS: AMNH 29041: SP ANG 102 degrees, H 24.1 mm., W 21.9 mm., AMNH 29042: 77 degrees, H 14.2 mm., W 15.8 mm. AMNH 29043: 96 degrees, H 12.1 mm., W 12.8 mm. (broken).

NUMBERED SPECIMENS: AMNH 29041–43, UM 2471, 2475, 2478.

22a 22b

FIG. 22a, b. 22a. *Euconospira spiroperforata* Batten, 1958, specimen from Müller Collection, Bonn, Germany. Apertural view. Note narrow dark color bands which are essentially normal to the growth lines. 22b. Oblique apertural view. Note narrow groove on columellar callus. Both $\times 1.5$.

EUCONOSPIRA ULRICH IN ULRICH AND SCOFIELD, 1897

TYPE SPECIES: *Pleurotomaria turbiniformis* Meek and Worthen, 1861; p. 461.

Euconospira spiroperforata Batten, 1958

Euconospira spiroperforata BATTEN, 1958, p. 230, pl. 40, fig. 12–14.

Figure 22

DISCUSSION: *Euconospira* is represented by two specimens: a fragment of a late ontogenetic stage and a specimen with three preserved late whorls. This latter specimen is in the private collection of Klaus Müller at the Institut für Paläontologie, Bonn, Germany, and is from the H. S. Lee Mine No. 8. It is a unique specimen in that it has well-preserved color pattern. The color pattern resembles others seen in various species of the genus but the dark bands are very narrow and more normal to the growth lines. The position of the selenizone, shallowness of the selenizone, lack of a well-developed alveozone, shape of the whorl, and flatness of the base is very similar to that of *E. spiroperforata* Batten, 1958 from the Permian of west Texas.

The whorl surface is rather flat to gently convex down to the angulate periphery, which is low on the whorl. The selenizone is just above the periphery and is marked by distinct, rounded cords. Immediately adjacent to and under the upper selenizone margin is a groove; just above the lower selenizone margin is another cord which is smaller and inset in relation to the margin. Between these two cords is a flat or gently convex unornamented area representing the largest portion of the selenizone. The groove and cord mark the shape of the growth line clusters, reflecting the attitude of the mantle during deposition of the shell.

The columellar lip is reflexed and thickened by callus deposits which form concave surfaces on the apertural side of the lip as well as on the umbilical side. Just within the umbilical area and beyond the outer side of the columellar lip is a deep groove which continues, apparently, up the columella into earlier whorls. This groove is so definite that it suggests that there might have been some function. Ornament as in *E. spiroperforata* from Texas appears to be confined to slightly thickened growth lines, particularly near the suture.

SPECIMENS: Three.

NUMBERED SPECIMEN: AMNH 29044.

SHWEDAGONIA BATTEN, 1956

TYPE SPECIES: *Shwedagonia elegans* Batten, 1956, p. 43.

DISCUSSION: The genus *Shwedagonia* displays some very interesting features. Most unique for Paleozoic archeogastropods is the gradual slowing of axial growth resulting in a shell shape not unlike the Shwe Dagon pagoda in Rangoon, Burma. The other feature is the complex region of the selenizone which consists of two normal

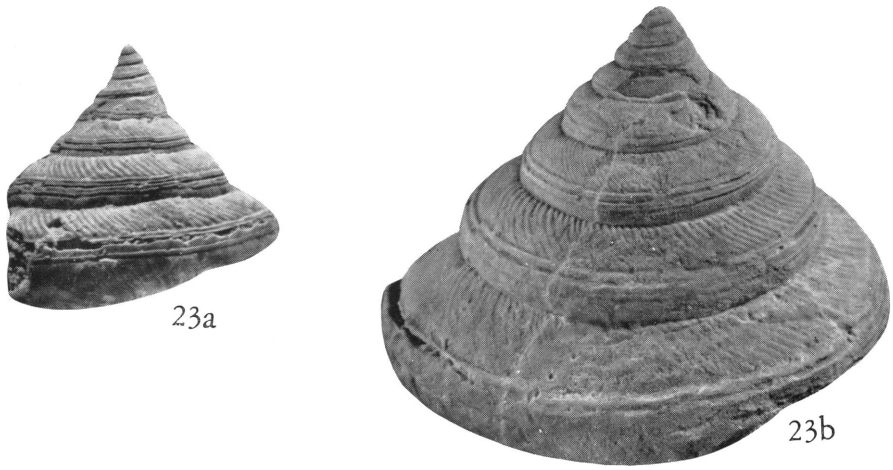


FIG. 23a, b. 23a. *Shwedagonia collabra*, AMNH 29046, side view. ×2. 23b. AMNH 29046, oblique side view. ×3.

selenizone margins separating a very narrow slit immediately below the upper margin and a vertical, unornamented area between the slit and the lower margin (see fig. 23a). The genus was probably derived from *Euconospira*, which does show a number of different selenizone complexes. It is interesting to note that the first four whorls have a simple selenizone that is composed of two spiral cords serving as selenizone margins and a rather narrow unornamented selenizone; see figure 23a. It is not until the fifth whorl that the unique selenizone complex develops.

Three of the species of *Shwedagonia* are known from the Tethyan region: *S. mariana* Gemmellaro, 1889 from the Sosio beds of Sicily, *S. wongi* Grabau, 1936, and *S. collabra*, new species. The only other known species is *S. elegans* Batten, 1956, from the Leonardian and Wordian of west Texas.

Shwedagonia collabra, **new species**

Figure 23

DIAGNOSIS: Turbiniform shells with collabral ornament; orthostrophic with even to slightly attenuated axial translation; early whorls with convexo-concave lightly ornamented upper whorl surfaces; later whorls with a convex upper whorl surface having strong, asymmetrical collabral ornament; base flatly rounded with numerous collabral threads; anomphalus or phaneromphalus; no parietal deposits or resorption.

DISCUSSION: Three of the five specimens in our sample are normally orthostrophic. The others show a slight amount of ontogenetic slowing of axial growth; see figures 23a, b. All are remarkably uniform in most features except that one specimen is phaneromphalus. There are but three previously described species of *Shwedagonia*: *S. wongi* (Grabau) from the Maping Limestone of Nantan, Kweichow Province, China, which is a very low-spired form with collabral ornament well developed near the suture; *S. mariana* Gemmellaro, 1889 from the Sosio Beds of Sicily has very faint spiral and collabral ornament; *S. elegans* Batten, 1956 from the Permian of west Texas has collabral ornament much like that of *S. collabra* but the base has reticulate ornament, is more widely phaneromphalus, and more strongly coeloconoid.

The depth of the slit in *S. collabra* is unknown, but there is a suggestion that perhaps it is one or more whorls in depth. If this is so, it is the deepest known slit and presents the interesting problem of having some of the visceral mass exposed when alive.

SPECIMENS: Five.

MEASUREMENTS: Holotype, AMNH 29045: SP ANG 113 degrees, H 25.5 mm., W 27.0 mm., SW 1.8 mm. Paratype, AMNH 29046; SP ANG 100 degrees, H 15.0 mm. W 16.0 mm., SW 0.9 mm.

NUMBERED SPECIMENS: AMNH 29046–47.

ETYMOLOGY: *collabra* derived from the Latin *co*, together and *labrum*, lip.

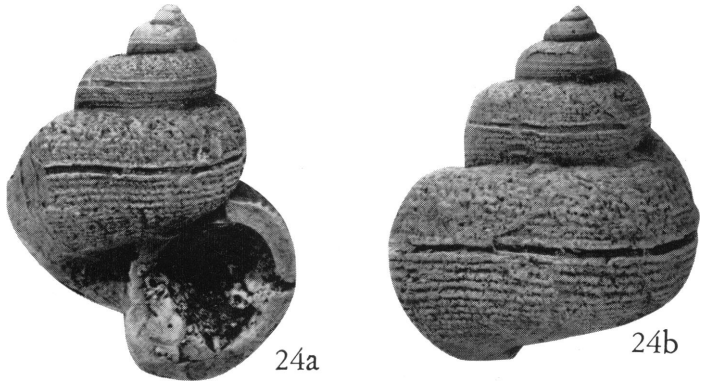


FIG. 24a, b. 24a. *Lacunospira reticulata*, holotype, AMNH 29047, apertural view. 24b. Side view. Both ×2.

LACUNOSPIRA BATTEN, 1958

TYPE SPECIES: *Lacunospira alta* Batten, 1958, pp. 237–238, pl. 42.

Lacunospira reticulata, **new species**

Figure 24a, b

DIAGNOSIS: Globose, trochiform shells with well-developed, rounded, spiral, and collabral ornament; shell thick, early whorls not well preserved, presumably smooth, without ornament, as in other eotomarians; inflated, globose whorl shape; sharp, deep sutures situated well below selenizone; selenizone situated slightly above periphery; asymmetrical selenizone margins elongated, tapering upward on whorl face, tapering inward toward selenizone; 10 or so rounded spiral threads above selenizone; 20 or so below selenizone; collabral threads almost equal in development to spiral; collabral ornament interrupts spiral ornament at juncture points; hemiomphalus to phaneromphalus; parietal deposits gradational, thin to moderately thick.

DISCUSSION: Although the specimens in the sample are not preserved in their entirety, enough characters are present to distinguish this species from others described. *Lacunospira* has been known from only the Permian of the southwest United States. Poorly preserved and illustrated specimens from the central Himalayas (the "*Productus*" shale in the Lissar Valley) have been described by Diener (1903, pl. 5, figs. 1–3) as *Pleurotomaria* cf. *punjabica* Waagen, 1880. These specimens appear to be related to *Lacunospira reticulata*, new species but the illustrations are not sufficiently detailed to be sure.

In a search of the literature, I have been unable to find another species comparable with *L. reticulata*. Maxwell (1964) has illustrated several specimens from the Permian Burnett Formation of the Yarrol region of Australia which have similar shell shapes (pl. 4, figs. 4–6) and described as *Montospira montoensis* and *Pseudobaylea poperimensis*. The selenizone complex in *M. montoensis* is much wider and shallower than in *L. reticulata* and *P. poperimensis* has the selenizone placed much higher on the whorl and with differently constructed selenizone margins. Fletcher in 1958 (p. 129, pl. 9, figs. 9–11) described *Mourlonopsis strzeleckiana* (Morris) from the Permian of New South Wales which has a very similar shell shape and a nearly vertical columellar lip also similar to *L. reticulata*. The selenizone, however, is narrower and lower on the whorl. Since his specimen is a steinkern, the critical characters of the ornament and selenizone complex are unknown.

SPECIMENS: Seven.

MEASUREMENTS: Holotype, AMNH 29047: SP ANG 62 degrees, H 25.4 mm., W 21.8 mm., SW 0.5 mm.

NUMBERED SPECIMENS: AMNH 29047, 29073; UM 2483–84.

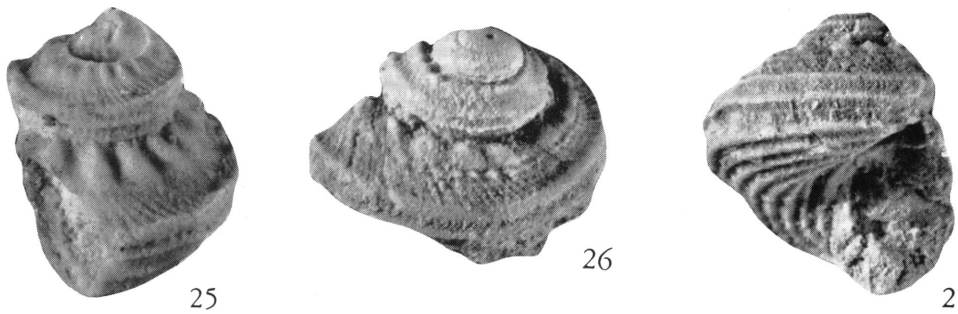
ETYMOLOGY: *reticulata*, from the Latin *reticulum*, net.

SUBFAMILY NEILSONIINAE KNIGHT, 1956

APACHELLA WINTERS, 1956

TYPE SPECIES: *Apachella translirata* Winters, 1956; p. 44.

DISCUSSION: A group of undescribed, highly



FIGS. 25–27. 25. *Apachella malaysia*, holotype, AMNH 29048, oblique side view. ×8. 26. *A. malaysia*, new species, paratype, AMNH 29049, oblique side view. Note rounded sutural nodes compared with figure 25. ×9. 27. *A. malaysia*, new species, paratype, AMNH 29050, apertural view. ×9.

variable species are known from the Lower and Middle Permian of the southwest United States. One of the more obvious variables is the shell shape which may be pupaeform, turreted, tabulate, or rotund. The selenizone is quite prominent and is usually raised and set apart by strong margins. The selenizone is almost vertical and at or slightly above the periphery. The sutural position varies between species but commonly is at the lower alveozone margin; hence, most species are relatively high spired. The base tends to have strong spiral elements. In most species there are sutural nodes or very sharply defined ornament.

One of the more interesting variant patterns involves axial growth. Some species have uniform axial growth of varying degrees of translation, so that some forms are higher spired than others. In several species, axial growth is either speeded up or slowed down during late ontogeny, resulting in coeloconoid or pupaeform shells.

Some of the tabulate species resemble some Permian species of *Glabrocingulum* (*Ananias*) and it is probable that *Apachella* was derived from such a stock during early Permian time. Since most species are concentrated in the southwest United States and because the earliest species is found there, it is likely that the area served as the point of origin.

The species described below add a different morphological field than has been previously known within this genus.

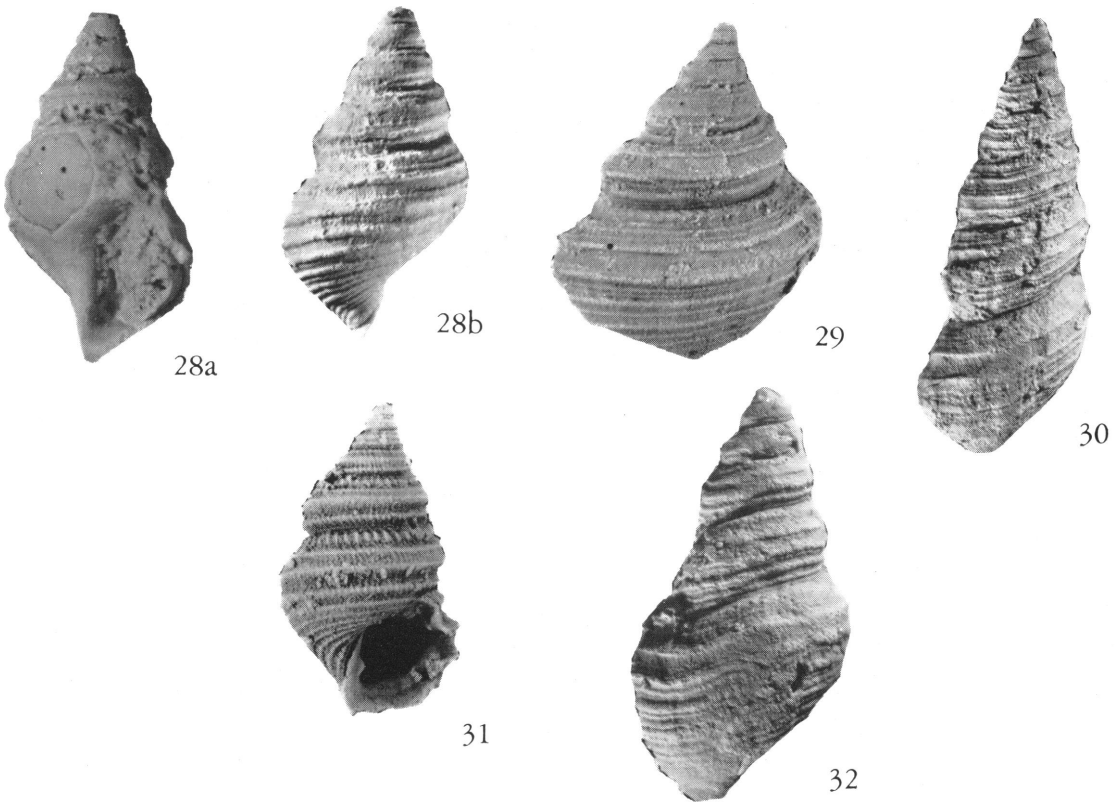
Apachella malaysia, new species

Figures 25–27

DIAGNOSIS: Trochiform shells with a prominent selenizone, strongly developed sutural nodes, and basal spiral ornament; upper whorl face convexo-concave; sutures deep, embracing whorls at lower alveozone margin; large sutural nodes elongate or rounded; three to four spiral threads on concave portion of outer whorl face near selenizone; selenizone raised and prominent with strong margins; alveozone deep and may have a single central spiral thread; collabral threads not as strong as above selenizone; base with dominant spiral cords, columellar callus thins to parietal region; no parietal deposits or resorption.

DISCUSSION: This species is quite distinct in that it is the only species of *Apachella* which is trochiform and moderately low spired. It is most similar to *Pleurotomaria retroplicata* Gemmellaro, 1889 from the Sosio Beds of Sicily. *Pleurotomaria retroplicata* is trochiform and with very large sutural nodes as in *A. malaysia*. Both share dominant spiral ornament on the base. However, *P. retroplicata* does not appear to have any reticulation or collabral elements other than growth increments. The most striking difference is in the position and development of the selenizone. In *P. retroplicata* the selenizone is quite narrow with short, thin selenizone margins. The selenizone is above the periphery and inclined about 45 degrees to the outer whorl face. I believe the species should be assigned to *Glabrocingulum* (*Glabrocingulum*), but without a study of the types it would be unwise to formalize this conclusion.

There are several kinds of variations observable in the 30 specimens in our sample. The most obvious is the mode and development of the sutural nodes. If they are rounded and compact, they tend to be less well developed and more



FIGS. 28–32. 28a. *Apachella brachysiphon*, holotype AMNH 29051, apertural view. ×6. 28b. Side view, ×6. 29. *A. brachysiphon*, new species, paratype, AMNH 29052, side view. ×6. 30. *A. brachysiphon*, new species, paratype, AMNH 29053, side view. ×2.5. 31. *Apachella* sp. AMNH 29054, oblique apertural view. This is an undescribed species from the Permian of west Texas. ×5. 32. *A. brachysiphon*, new species, paratype, AMNH 29055, side view. ×4.

numerous. If they are elongate and gradational, they tend to be well developed to the point that they dominate the upper whorl surface from the suture almost to the selenizone. These large nodes are fewer in number compared with the rounded type.

Another variant pattern is the development of reticulation. In the round-noded specimens reticulation is present. In the elongate-noded types, spiral threads are lacking. All specimens show little variation in sutural position on the whorl.

SPECIMENS: 30.

MEASUREMENTS: Holotype, AMNH 29048: SP ANG 72 degrees, H 6.0 mm., W 5.1 mm., SW 0.3 mm. Paratype, AMNH 29049: SP ANG 90 degrees, H 5.7 mm., W 4.8 mm., SW 0.3 mm.

NUMBERED SPECIMENS: AMNH 29048–50.

ETYMOLOGY: *malaysia*, named for the country.

Apachella brachysiphon, new species

Figures 28–30, 32

DIAGNOSIS: Moderate to high-spired shells with a short inhalant siphonal canal; early whorls inflated, without ornament except for selenizone margins; later whorls with an upper whorl face flat to convexo-concave, with a weak spiral thread adjacent to suture accompanied by a spiral cord, two or more spiral threads unevenly distributed on face down to selenizone; selenizone margins rounded, well developed; selenizone with weak lunulae, lower margin marks periphery; alveozone poorly developed, ornamented with one or more spiral cords and threads; flattened to rounded base with dominant spiral ornament; columellar lip slightly thickened, culminating in a short siphonal notch; ornament resorbed on parietal surface.

DISCUSSION: Variation in several character complexes appears related to the height of the shell. In relatively low-spired shells, the shell shape is nearly tabulate with a definite alveozone. From two to five spiral threads are unevenly spaced and developed on the upper whorl surface. Only three spiral cords are present in this morphotype, one adjacent to the suture, one in the center of the alveozone and one marking the base of the alveozone (see fig. 29). The base has alternating light and heavy spiral threads rather evenly spaced.

Higher-spired shells tend to have reduced ornament on the upper whorl surface and no discernible alveozone, because the whorl profile is gently rounded from the lower selenizone margin to the base. Spiral cords are evenly developed on the lower whorl face and base. The whorl profile tends to be rather evenly inflated (see fig. 30).

The most important feature in this species is the presence of a weakly formed siphonal notch. Because all archeogastropods known are holostomous, it is difficult to assess this feature. Faint grooves and markings parallel to the axis of the notch suggest that the mantle fold was mobile along the notch—a characteristic seen in some siphonal canals in mesogastropods.

Several members of the family Plethospiridae (superfamily Murchisoniacea), such as the Devonian *Diplozone* Perner, 1907 and *Plethospira* Ulrich in Ulrich and Scofield, 1897 have an ill-defined siphonal canal along with a selenizone situated near the whorl periphery. However, such details of the selenizone complex as the margins, shape of the lunulae, and the angle in relation to the axis; formation and ontogenetic sequence of ornament; and shape of the aperture are typical of the eotomarians in general, and to several species of *Apachella* in particular. The siphonal canal in the plethospirids is rounded and quite broad, whereas in *A. brachysiphon* it is angulate and restricted. I cannot believe they are homologous. In addition, an undescribed species of *Apachella* from the Permian of west Texas does appear to have a siphonal canal just below a columellar tooth (see fig. 31). Apertural teeth are known in a few groups of archeogastropods (e.g., subfamily Chilodontinae, family Trochidae).

Siphons are usually present in gastropods that either burrow or live on a soft substrate. However, in the case of *A. brachysiphon*, the construction of the presumed bipectinate gill and the position of the exhalant currents situated about 90 degrees from the siphonal canal would make it appear unlikely that it was an infaunal filter-feeder. It seems more probable that the siphon had a sensory function, perhaps bearing chemoreceptors as in the modern genus *Trivia*.

Yonge (personal commun.) and others have stressed that the paired bipectinate ctenidia of primitive gastropods are inefficient in removing particulate matter from incurrent water and therefore tend to live in clear water, preferably on a hard substrate. However, the dominant element in many upper Paleozoic shales is archeogastropods. It is difficult to conceive that all of these shales represent hard substrate.

I have been unable to relate this species to any other described and illustrated forms.

SPECIMENS: Four.

MEASUREMENTS: Holotype, AMNH 29051: SP ANG 63 degrees, H 8.2 mm., W 5.0 mm., SW 0.5 mm.

Paratype, AMNH 29052: SP ANG 22 degrees, H 21.4 mm., W 9.8 mm., SW 1.2 mm.

Paratype, AMNH 29053: SP ANG 35 degrees, H 14.3 mm., W 8.1 mm., SW 0.9 mm.

Paratype, AMNH 29055: SP ANG 62 degrees, H 7.5 mm., W 6.2 mm., SW 0.6 mm.

NUMBERED SPECIMENS: AMNH 29051–53, 29055.

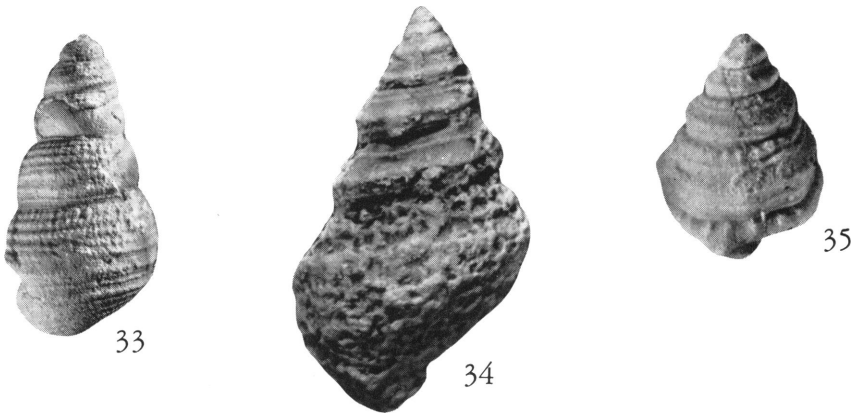
ETYMOLOGY: *brachysiphon*, from the Greek *brachys*, short and *siphon*, pipe.

Apachella species A

Figure 33

DIAGNOSIS: A high-spired shell with dominant spiral ornament; sutural contact on lower margin of alveozone; upper whorl face convex with four noded spiral cords; selenizone situated slightly below the periphery; selenizone with central thread; alveozone narrow, shallow, and poorly defined, with one spiral cord accompanied by adjacent spiral threads; base rounded with dominant spiral ornament; hemiomphalus; holostomous.

DISCUSSION: The rather low placement of the nearly vertical selenizone is at variance with the majority of *Apachella* species. However, there is a pupaeform species that does have a similar selenizone complex. The noded ornament and central thread on the selenizone also is known within the genus. Further, the shell shape is



FIGS. 33–35. 33. *Apachella* sp. A, AMNH 29056, side view, ×3. 34. *Apachella* sp. B, AMNH 29057, side view, ×7. 35. *Apachella* sp. B, AMNH 29058, oblique side view. ×8.

suggestive of ?*A. arizonensis* Winters, 1963; pl. 4, figure 33. Nonetheless, I am not certain of the correct taxonomic position of this shell.

SPECIMEN: One.

MEASUREMENTS: AMNH 29056: SP ANG 37 degrees, H 10.9 mm., W 6.4 mm., SW 0.7 mm.

NUMBERED SPECIMEN: AMNH 29056.

Apachella species B

Figures 34, 35

DIAGNOSIS: Moderately high-spired shells with poorly developed siphonal notch and incipient varices; early whorls smooth and inflated; upper whorl surface flattened or slightly convexo-concave; sutures placed in lower portion of alveozone; a heavy, noded spiral cord near suture; lower selenizone margin heavier than upper; alveozone with central spiral thread; base gently rounded; basal ornament unknown; inner lip deflected into a short siphonal notch.

DISCUSSION: This species has several features similar to *A. brachysiphon*. The most important of these is a similar but not so narrow siphonal notch. They both have a noded sutural cord, which is not as well developed in *A. brachysiphon*. Both have a heavier lower selenizone margin and dominant spiral ornament. *Apachella brachysiphon* has more numerous and unevenly developed spiral elements which are more massive. I believe these features are sufficient to recognize a specific level discontinuity.

The most striking difference is the presence of weakly formed varices. There are about six varices per whorl. In the earlier whorls they are contiguous, but on the penultimate and final whorls of the one complete specimen, the varices are offset. True varices are unknown in archeogastropods and are rare in Paleozoic gastropods in general (a single undescribed neogastropod is known from the Permian of west Texas). The presence of varices in *Apachella* is another indication of the unusual "experimentation" within the genus.

SPECIMENS: Two.

MEASUREMENTS: AMNH 29057: SP ANG 58 degrees, H 7.5 mm., W 4.5 mm., SW 0.3 mm. AMNH 29058: 57 degrees, H 4.0 mm., W 2.7 mm., SW 0.2 mm.

NUMBERED SPECIMENS: AMNH 29057–58.

FAMILY LOPHOSPIRIDAE WENZ, 1938

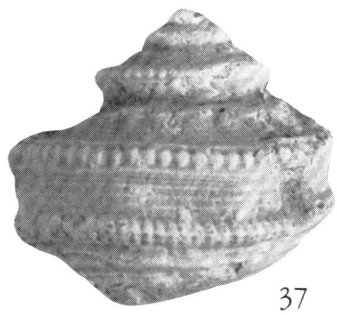
SUBFAMILY RUEDEMANNIINAE KNIGHT, 1956

WORTHENIA DEKONINCK, 1883

TYPE SPECIES: *Turbo tabulatus* Conrad, 1835, p. 267.

DISCUSSION: *Worthenia* is first encountered in the Lower Carboniferous (Tournasian) of western Europe where there is about eight rather diverse species. During the Upper Carboniferous, very few species are known and the group is quite conservative. In the Permian of west Texas there are about six species which are either trochiform or tabulate. One undescribed species has a concave outer whorl face which has a strong upper margin formed by a rounded selenizone and a lower margin equal in development to the upper one. The species is rather low-spired giving a subquadrate whorl profile.

36



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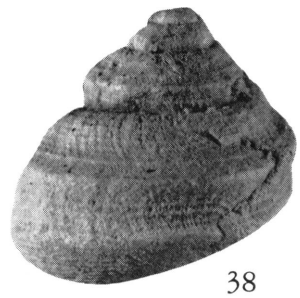


38

FIGS. 36–38. 36. *Worthenia multicarinata* (Mansuy), 1912, AMNH 29059, side view. Note the disappearance of selenizone nodes and uncoiling of final whorl. ×4. 37. *W. multicarinata* (Mansuy), 1912, AMNH 29060, side view. ×6. 38. *W. schirjaevensis* (Stuckenberg), 1905, AMNH 29061, side view. ×4.

This gives the shell a rectangular appearance (see fig. 37) and is the dominant shell shape in the Permian and Triassic. A single species of this type, for example, is found in the Lower Triassic (Scythian). By late Triassic this type underwent a minor diversification which gave rise to at least one family (the Schizogoniidae).

Worthenia multicarinata (Mansuy), 1912

Figures 36, 37

Pleurotomaria multicarinata MANSUY, 1912, p. 101, pl. 18, fig. 13.

Worthenia multicarinata (Mansuy): DELPEY, 1942, p. 356–357, fig. 29.

DIAGNOSIS: Moderately low to high-spired shells with a quadrate whorl shape; last several whorls becoming uncoiled in adult forms; convexo-concave upper whorl surface forming a low angle to axis; a weak spiral cord with weak nodes adjacent to suture on upper whorl surface; just below is a row of very prominent, rounded nodes which become elongated and weakly developed on final whorl; concave portion of upper whorl face adjacent to selenizone with three or more spiral threads variable in distribution; selenizone flat and unornamented in first several whorls, with elongated prominent nodes later, with three or more spiral threads, on final whorl nodes gradually become reduced, more numerous, irregular, and finally disappear; outer whorl face concave, with three spiral threads variable in development and distribution; lower margin about equal in development to upper margin with more numerous, weaker nodes reinforced at intersections with three or so spiral threads; base with 14 or more spiral cords and threads variably developed and distributed; hemiomphalus or cryptomphalus; collabral cords near umbilicus; columellar lip slightly reflexed; parietal deposits abrupt and thick within plane of aperture.

DISCUSSION: Five of the 17 specimens in our collection are adult shells. These show an unusual amount of variation involving all ornamentation. Nodation is particularly variable ontogenetically, weak in early whorls, robust during ephoebic stages, and weaker during final growth. Even the nodes on the selenizone (which normally are conservative and independent of ornament variation elsewhere on the shell) become weaker on the final whorl. By the last quarter whorl they are converted to reinforced lunulae and then disappear completely (see fig. 36). The distribution and development of spiral ornament is especially variable in comparison with the majority of known species of *Worthenia*, which tend to be quite conservative.

Our specimens are quite similar to that illustrated by Mansuy (pl. 18, fig. 13) in general ornament pattern, development of the selenizone, and in basal features. They differ in being somewhat more quadrate in whorl profile owing to more prominent upper and lower outer whorl face margins. Still, they fall well within the range of species characteristics of *W. multicarinata*. The specimen illustrated by

Delpey, 1941 (p. 357, fig. 29) is difficult to interpret; the over-all shell shape is similar, but the lower margin of the outer whorl face does not appear to be as fully developed as in other known specimens. Also the illustration lacks the very conspicuous nodation seen in our material and in Mansuy's figure.

The gross plan of this species resembles that of some Upper Triassic species such as *W. joannis austriae* Klipstein, *W. subgranulata*, and *W. liebensis* Laube. I believe that they are genetically linked and that *W. multicarinata* may have given rise to this important Triassic group. There are two undescribed species which are very similar in the Permian, one from the Guadalupian of west Texas and the other from the Crimea.

SPECIMENS: 17.

MEASUREMENTS: AMNH 29059: SP ANG 85 degrees, H 16.9 mm., W 15.2 mm. (broken). AMNH 29060: SP ANG 86 degrees, H 7.6 mm., W 7.9 mm.

NUMBERED SPECIMENS: AMNH 29059-60.

Worthenia cf. *schirjaevensis* (Stuckenberg), 1905

Figure 38

Mourlonia schirjaevensis STUCKENBERG, 1905, p. 97, pl. 12, fig. 11

Worthenia schirjaevensis (Stuckenberg): DELPEY, 1942, p. 355, fig. 27.

DIAGNOSIS: Sutural nodes strong to absent, formed by wall doming rather than thickening of ornament; six to nine spiral threads on convexo-concave upper whorl surface; selenizone margins weak; lunulae formed by growth increments alone; concave outer whorl face with two to three spiral cords in medial region, with several spiral threads above and below cords, lower margin angulate with spiral threads less well developed than on upper margin; base with 12 or more spiral cords.

DISCUSSION: There is a group of species found in the Permian and Triassic that should be considered as a unique group, in addition to the *W. multicarinata* set. The principal character complex involves the selenizone which is devoid of the nodes so typical of *Worthenia*. The center of the selenizone is the exact edge of the upper and outer whorl faces. The selenizone thus is angulate (45 degrees) and the parts on each of the faces are flat or slightly concave. This type is known from the Permian of west Texas, Sicily, and from the Upper Triassic of the Alps.

This species tends to be low-tabulate to trochiform with convexo-concave upper whorl faces and with a concave outer whorl face. The base tends to be flatly rounded. Our specimens differ from the type in having a gentler, less angulate shape and a shallower outer whorl face. The illustration of Delpey is difficult to interpret, so that I am unsure of the relationship of our sample to hers; indeed, there is some doubt that her specimens should be included in this species.

SPECIMENS: Five.

MEASUREMENTS: AMNH 29061: SP ANG 90 degrees, H 7.6 mm., W 7.5 mm.

NUMBERED SPECIMEN: AMNH 29061.

FAMILY LUCIELLIDAE KNIGHT, 1956

LUCIELLINA KITTL, 1900

TYPE SPECIES: *Luciellina contracta* Kittl, 1900, p. 7, pl. 1, fig. 11.

DISCUSSION: The type species was described from the Rothe Kalke of Upper Triassic age from Hungary. In 1966 Batten (p. 35) identified the genus from the Lower Carboniferous (Visean) of western England. The specimens described below are remarkably similar to the English morphotypes. No formal taxon will be made because of the poor preservation of the growth lines in the critical selenizone region.

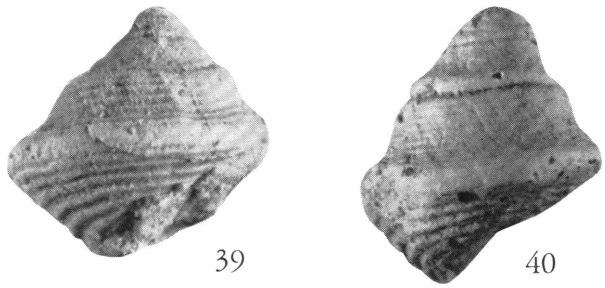
The most important feature in this genus is the wide range of variation in the selenizone complex. In the greatest majority of pleurotomarians, the selenizone is very conservative and little variation can be recognized within families. *Luciellina* is one of those rare exceptions.

Luciellina species

Figures 39, 40

DIAGNOSIS: Turbiniform, flat-based shells with dominant spiral ornament; flattened upper whorl surface becoming concave near periphery; a presumed pseudoselenizone situated at periphery; seven to 12 spiral threads evenly spaced and developed on upper whorl surface, growth lines tend to cluster periodically forming weak nodes near suture; sutures situated on or just above periphery; periphery extended to form a rounded flange; base flat with about eight rounded spiral cords; hemiomphalus to cryptomphalus; parietal surface not preserved.

DISCUSSION: As far as I am aware, this is the



FIGS. 39–40. 39. *Luciellina* sp., AMNH 29062, side view. ×9.
40. *Luciellina* sp., AMNH 29063, side view. ×9.

first report of the genus in the Permian and I cannot relate any described species to the seven specimens in our collection. Only a single specimen (see fig. 40) is well enough preserved to show the existence of a possible pseudoselenizone on the periphery. However, this does not mean that the species cannot be properly assigned to *Luciellina* since the shell shape is so highly distinctive. The shell shape is quite variable owing to changes in axial growth affecting height and changes in the degree of peripheral development causing an appearance of a wider shell. These changes are reflected in the wide range of spiral angles (63°–86°). The shape of the outer whorl face is quite variable ranging from almost flat to convexo-concave. This also affects shell shape reflected in a triangular to a more tabulate expression. Ornament variation is primarily involved with relative development of spiral elements.

SPECIMENS: Seven.

MEASUREMENTS: AMNH 29062: SP ANG 86 degrees, H 3.3 mm., W 3.2 mm. AMNH 29063: SP ANG 69 degrees, H 3.5 mm., W 3.5 mm.

NUMBERED SPECIMENS: AMNH 29062–63.

FAMILY GOSSELETINIDAE WENZ, 1938

SUBFAMILY COELOZONINAE KNIGHT, 1956

PLATYZONA KNIGHT, 1945

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

DISCUSSION: This genus is very conservative; there are few species, and characters even on a detailed level are the same or similar from Lower Carboniferous to Permian. However, within populations, there is considerable variation in ornament pattern. For example, cords or threads may be evenly developed and evenly spaced over the whorl surface or alternating with weaker elements which are intercalated during ontogeny or grouped with gaps between. In addition, the lunulae in all species appears to be unrelated to collabral ornament, the usual condition in many pleurotomarians.

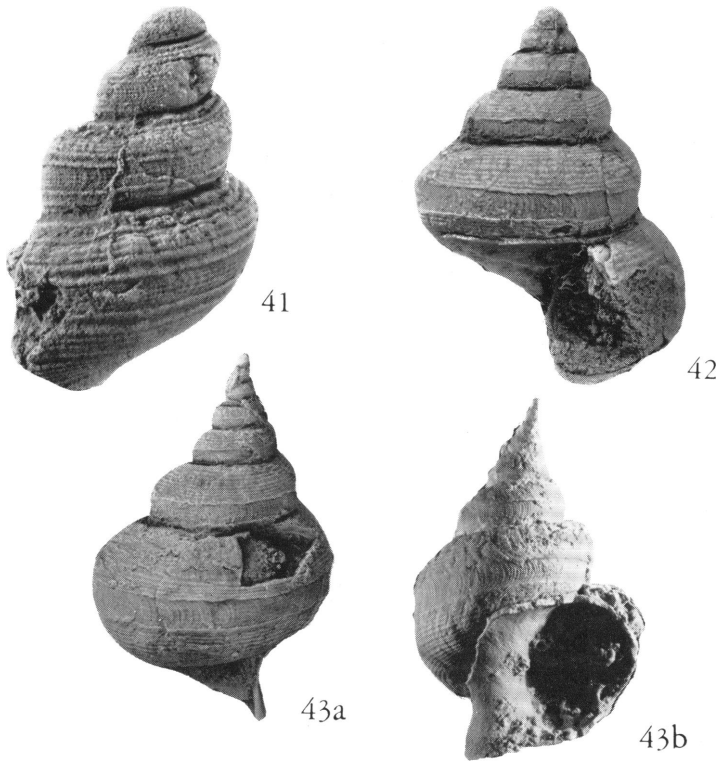
It is a widespread genus known from the United States, western Europe, Crimea, and Asia. Most species are trochiform with some degree of modification in axial growth (see fig. 43). The unusually high-spired species *P. nodohumerosa*, new species, is quite distinctive and has only been seen in a few specimens from west Texas Permian.

Platyzona nodohumerosa, **new species**

Figure 41

DIAGNOSIS: High-spired forms with weak to moderately well-developed nodes on the upper whorl face adjacent to the periphery; early whorls rounded; upper whorl surface flattened to gently convex, six to seven rounded spiral cords unevenly developed with a gap between the sutural cords and the next cord below; broad to narrow nodes formed at periphery of upper whorl; outer whorl face nearly vertical, sloping inward toward base; selenizone width increasing more slowly than other whorl features; selenizone margins are strong, rounded cords; six to seven spiral cords on selenizone form reticulation with lunulae; lunulae strong collabral cords more fully developed than growth lines on rest of whorl; sutural contact just below outer whorl face; 14 or so spiral cords on base; hemiomphalus; aperture elongate with ornament resorbed on parietal surface.

DISCUSSION: The high-spired, tightly coiled shell shape is the most distinctive feature of this



FIGS. 41–43. 41. *Platyzona nodohumerosa*, holotype, AMNH 29064, side view. Note broad nodes just above selenizone. ×3.5. 42. *Platyzona eulkaiensis* (Reed), 1927, AMNH 29065, apertural view. ×2. 43a. *Platyzona eulkaiensis* (Reed), 1927, AMNH 29066, oblique side view. 43b. Apertural view. 43a and b ×2.

species; most other species tend to have more inflated whorls and a rate of spiral expansion less intense. The ornament pattern is similar to some other species of the genus [for example, *P. tornatilis* (Phillips), 1836], with the exception of the nodes on the edge of the upper whorl surface. An identical morphotype was described by Stuckenberg as *Murchisonia* sp. from Samara, Russia (1905, pl. 12, fig. 13). This species is very similar to an undescribed form from the Permian of the Crimea.

SPECIMENS: Three.

MEASUREMENTS: Holotype, AMNH 29064: SP ANG 43 degrees, H 13.3 mm., W 9.1 mm.

NUMBERED SPECIMENS: AMNH 29064, 29074.

ETYMOLOGY: *nodohumerosa*, derived from the Latin *nodus*, knot and *humerus*, shoulder.

Platyzona eulkaiensis (Reed), 1927

Figures 42, 43

Pleurotomaria (*?Wortheniopsis*) *eulkaiensis* REED, 1927, p. 96, pl. 10, fig. 10.

Pithodea khmeriana Mansuy: DELPEY, 1942, p. 362, fig. 38.

DIAGNOSIS: Moderately high-spired, trochiform shells with globose whorls having evenly spaced spiral threads; early whorls isometrically developed along axial translation or allometrically developed; suture placed just below selenizone; whorl shape globose, rounded, with 12–14 evenly spaced spiral threads, some weaker than others; selenizone bordered by spiral cords; six or so spiral threads evenly spaced on selenizone, weaker than lunulae; about 20 evenly spaced and developed spiral threads on rounded base; phaneromphalus, with spiral threads on whorl surfaces within umbilicus; parietal callus gradate, thick.

DISCUSSION: Of the five specimens in this sample, four are typically orthostrophic and isometric; see figure 42. One specimen shows very rapid axial translation in early ontogeny, with a

FIG. 44. *Phymatopleura* sp., AMNH 29068, side view. ×8.

pronounced slowing in later whorls (see fig. 43). This specimen is somewhat higher-spired and with narrower whorls; except for these features it falls well within the morphological range of the species. *Platyzona khmeriana* (Mansuy), 1913 is quite low-spired, with a rapid log-spiral translation, but ornament details are similar to those of other species. I would consider *P. khmeriana* a valid species. *Platyzona khmeriana* (Mansuy) identified by Delpey appears to fall well within the range of *P. eulkaiensis* because of the height of the spire, rate of whorl expansion, and whorl profile.

SPECIMENS: Five.

MEASUREMENTS: AMNH 29065: SP ANG 53 degrees, H 23.1 mm., W 19.9 mm., SW 2.5 mm. AMNH 29066: 48 degrees, H 31.1 mm., W 19.9 mm., SW 2.3 mm.

NUMBERED SPECIMENS: AMNH 29065-66. UM 2586.

FAMILY PHYMATOPLEURIDAE BATTEN, 1956

PHYMATOPLEURA GIRTY, 1939

TYPE SPECIES: *Orestus nodosus* (Girty), 1912, p. 137.

Phymatopleura species

Figure 44

DIAGNOSIS: Trochiform shells with dominant spiral ornament; the upper whorl face is convex with five or so spiral cords, collabral cords slightly less well developed, forming nodes at intersections with spiral cords; selenizone with lunulae well developed and a medial spiral thread which forms nodes with the lunulae; selenizone margins rounded, similar to spiral cords, base flat or slightly concave with 10 or so spiral threads; anomphalus; parietal surface unknown.

DISCUSSION: The eight specimens in our sample are too poorly preserved to warrant a formal name. Nonetheless, enough features are present to assign them to *Phymatopleura*. In particular, the very typical development of the lunulae and the medial spiral thread invariably present in species of the genus. Another typical feature is the nodation, best developed near the suture.

This species is unique in having a rather even convex upper whorl surface giving the shell an almost beehive shape. The base is flat or concave, a feature not seen in other species. Other than *P. variata* DeKoninck, 1843, from the Lower Carboniferous of Belgium, the genus has not been reported outside of North America.

SPECIMENS: Eight.

MEASUREMENTS: AMNH 29067: SP ANG 76 degrees, H 5.0 mm., W 4.7 mm.

NUMBERED SPECIMEN: AMNH 29067.

BORESTUS THOMAS, 1940

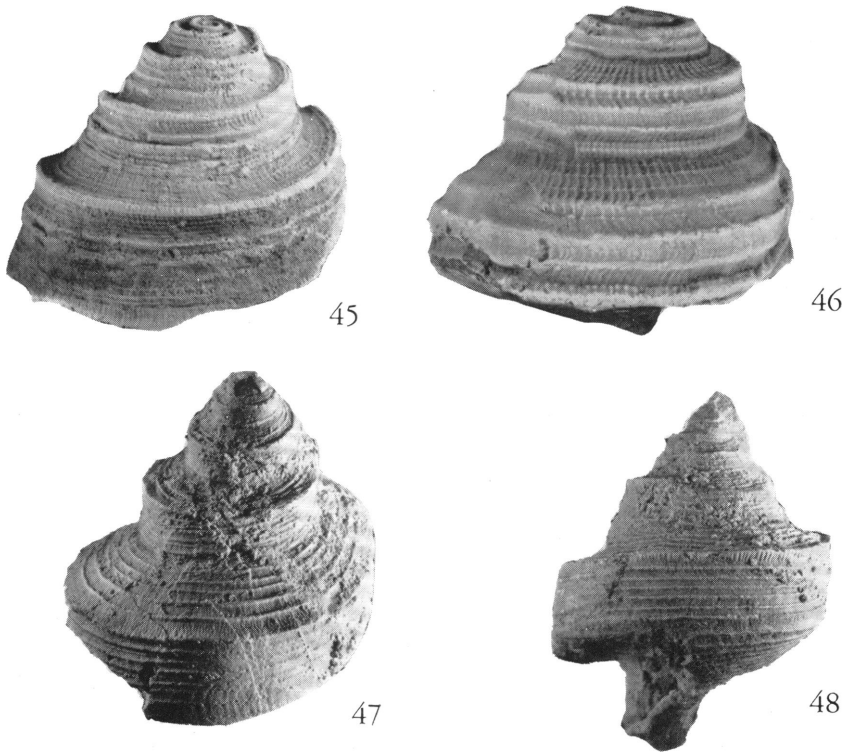
TYPE SPECIES: *Borestus wrighti* Thomas, 1940, p. 54, pl. 3, figs. 1a–b.

Platypleurotomaria WANNER, 1942, p. 157, pl. 1, figs. 13–14.

DISCUSSION: Wanner in 1942 described *Platypleurotomaria* as a new genus. The chief characteristics he used were the planispiral embryonic whorls and the location of the selenizone just under the upper keel, with the upper selenizone margin forming it. Knight, Batten, and Yochelson (1960) believed that the selenizone was in fact in the center of the almost vertical outer whorl face. Further, that the upper margin of the true selenizone is what Wanner considered the lower selenizone margin.

Re-examination of the types (the holotype is at the Paleontological Institute at Bonn, Germany; the paratype is at the Geological Institute at Amsterdam) conclusively shows that the selenizone is indeed in the central portion of the outer whorl face; see figures 45 and 46.

I have shown elsewhere (Batten, 1966, pp. 100–101) that, even within single populations of pleurotomarians, planispiral embryonic whorls are present along with orthostrophic early whorls, and within my experience, the planispiral condition is not of generic significance. This is borne out by the fact that the Malaysian specimens described below are similar in most respects to *B. planiapicata* with the exception that they are orthostrophic throughout and have



FIGS. 45–48. 45. *Borestus planiapicata* (Wanner), 1941, Bonn type No. 58, figure 14, plate 1, holotype. Oblique side view. ×1.5. 46. *B. planiapicata* (Wanner), 1941, Amsterdam Geological Institute, figured paratype 13a–b, plate 1, side view. ×4. 47. *B. planiapicata* (Wanner), AMNH 29064, oblique side view. ×2. 48. *B. planiapicata* (Wanner), 1941, AMNH 29069, side view. ×2.

somewhat different ornament. Thus in respect for conservatism we believe our specimens and those of Wanner's properly belong to *Borestus* and that our specimens fall within the range of *B. planiapicata.*

Borestus planiapicata (Wanner), 1942

Figures 45–48

Platypleurotomaria planiapicata WANNER, 1942, p. 157, pl. 1, figs. 13–14.

DESCRIPTION: Tabulate shells with a selenizone flush with surface of outer whorl face; early whorls rounded, unornamented, either orthostrophic or planispiral; spiral ornament developing earlier than collabral; collabral threads on upper whorl face may become wavy and bifurcated near outer edge, one to 11 unequally developed and spaced spiral cords; outer whorl face flat, to gently convex, nearly vertical; two or more spiral cords variously expressed; no apparent collabral ornament below shoulder; selenizone may have a medial cord equal in development to others on outer whorl face; base with numerous spiral threads; anomphalus; parietal surface unknown.

DISCUSSION: Except for the discrepancy of the development of the earlier whorls, our specimens are quite similar to the type except that the type has less well-developed ornament. The selenizone is situated just slightly above the center of the outer whorl face and in almost precisely the position of the type. The most striking feature of the Malaysian specimens is the very curious wavy collabral elements on the outer margin of the upper whorl surface. The Malaysian forms have finer and more numerous collabral elements that are more irregular than the type, which does not display bifurcation and appears to be less wavy. The type has numerous fine but widely spaced spiral threads

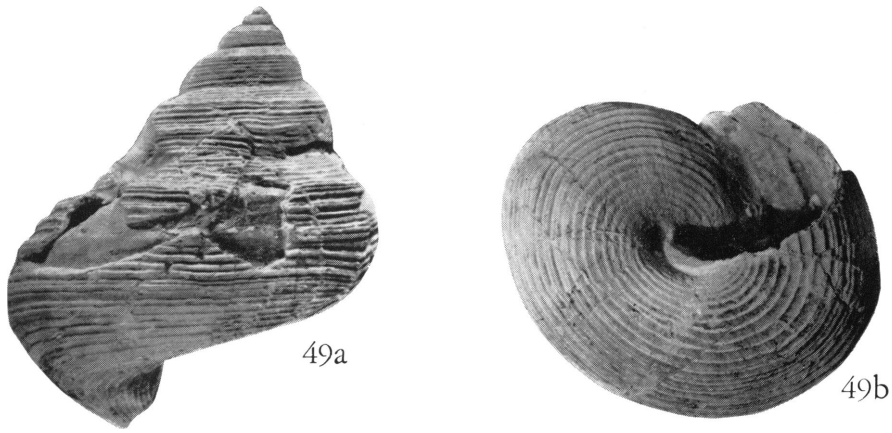


FIG. 49a, b. 49a. *Borestus rotundatus*, holotype, AMNH 29070, side view. 49b. Basal view. Both ×1.5.

on the upper whorl surface, whereas on our specimens there are from one to 11 cords and threads. The Malaysian forms have a selenizone flush with the surface and the margins are about equal in intensity to the other spiral cords on the outer face. *B. planiapicata* resembles *Murchisonia volgensis* Stuckenberg, 1905 (pl. 12, fig. 18) in shape and in the wavy collabral elements on the upper whorl surface, but lack of detail in his illustrations prevents further comparisons.

SPECIMENS: Two.

MEASUREMENTS: AMNH 29068: SP ANG 63 degrees, H 24.1 mm., W 21.1 mm., SW 1.3 mm. AMNH 29069: SP ANG 67 degrees, H 19.8 mm., W 14.5 mm., SW 0.9 mm.

NUMBERED SPECIMENS: AMNH 29068-69.

Borestus rotundatus, **new species**

Figure 49

DIAGNOSIS: Large, inflated trochiform shells with strongly developed spiral cords; early whorls smooth and rounded; sutures placed just above base of whorl; upper whorl face narrow, concave or broad, and gently concave to flat, five to eight spiral cords unevenly spaced and developed; outer whorl face rounded, 11 to 14 spiral cords unevenly spaced and developed; flattened selenizone just above periphery, with three to four spiral cords; base rounded with 20 or so evenly formed spiral cords; hemiomphalus.

DISCUSSION: The growth lines are so faint on the outer whorl face (as well as over the other portions of the shell) that it is very difficult to locate the selenizone; only one small area on a single specimen showed that the selenizone is just above the periphery in about the same place as in *B. planiapicata*. The slit is very shallow. The selenizone can readily be recognized by the three or four spiral cords on it which are more evenly developed and closer together than adjacent cords on the outer whorl face. The variable expression of the spiral cords and the shape of the upper whorl face give the specimens quite a different appearance. This variation is unusual for the genus which is quite conservative within species. It would be very difficult to identify this species unless the selenizone can be firmly established. The shape and ornament is quite similar to some species of *Shansiella*, *Yunnania*, or "*Cyclonema*" of authors. *Borestus rotundatus* is closest to *Pleurotomaria sumatrensis* Roemer, 1880, which is described as having a selenizone on the upper periphery, but his illustration (of a very poorly preserved or drawn shell) gives the impression of the slit being in the middle of the outer whorl face.

SPECIMENS: Four.

MEASUREMENTS: Holotype, AMNH 29070 SP ANG 69 degrees, H 42.8 mm., W 36.9 mm.

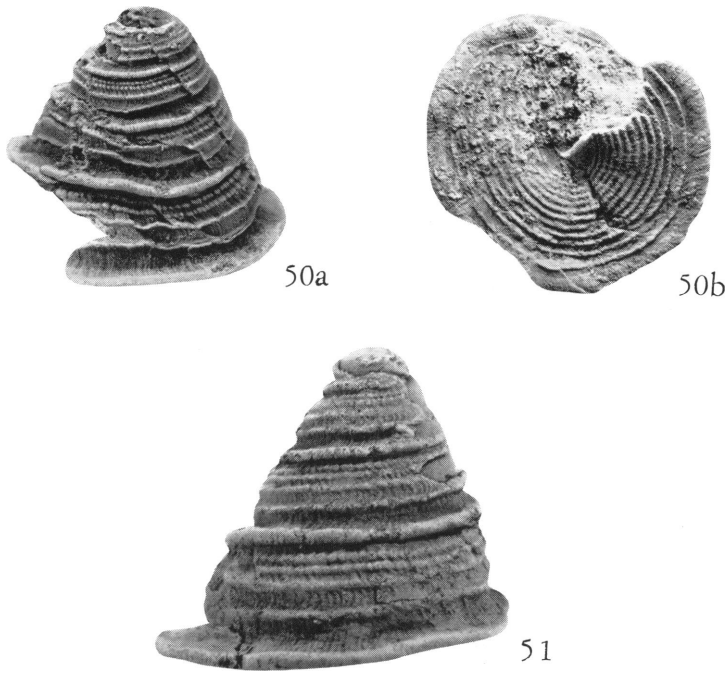
NUMBERED SPECIMENS: AMNH 29070, 29075. UM 2600.

ETYMOLOGY: *rotundatus* from the Latin *rotundus*, round.

LAMELLOSPIRA BATTEN, 1958

TYPE SPECIES: *Lamellospira conica* Batten, 1958, pp. 217–221, pl. 38, figs. 1–17.

DISCUSSION: This genus is atypical of most Paleozoic pleurotomarians by virtue of its



FIGS. 50–51. 50a. *Lamellospira anatola*, paratype, AMNH 29072, oblique side view. 50b. Basal view. Both ×3. 51. *L. anatola*, new species, holotype, AMNH 29071, side view. ×5.5.

conical shape, prominent peripheral flange, and a flat to concave base. Besides the new species *L. anatola*, there are two other species, *L. conica* and *L. cincta* from the Permian of west Texas (Wordian and Guadalupian).

Lamellospira anatola, **new species**

Figures 50, 51

DIAGNOSIS: Conical forms with a large peripheral flange, flat base, spiral and collabral ornament; early whorls unknown; whorl face gently convex; two spiral cords lie between suture and selenizone; collabral cords form nodes with spiral cords; sutural contacts just below flange; selenizone situated in middle of whorl face, selenizone margins sharp and well defined; peripheral flange prominent and ornamented with collabral threads only; base flat with 12 or so spiral cords; growth lines on base form broad sinus; minutely phaneromphalus; parietal surface unknown.

DISCUSSION: This species is remarkably similar to *L. conica* Batten, 1958, from the Permian of west Texas in over-all shell shape, prominent peripheral flange, position of the selenizone and in having dominant spiral ornament on the base. It differs from it in possessing two spiral cords above the selenizone adjacent to the suture; having well-developed collabral ornament and lacking spiral threads on the flange. Since only two specimens are known, nothing can be said regarding variation. I am unable to relate this species to any other described taxa.

SPECIMENS: Two.

MEASUREMENTS: Holotype, AMNH 29071: SP ANG 130 degrees, H 8.6 mm., W 9.1 mm., SW 0.7 mm.

Paratype, AMNH 29072: 120 degrees, H 10.5 mm., W 14.5 mm., SW 0.8 mm.

NUMBERED SPECIMENS: AMNH 29071–72.

ETYMOLOGY: *anatola* from the Greek *anatole*, east.

PARAGONIOZONA NELSON, 1947

TYPE SPECIES: *Paragoniozona nodilirata* Nelson, 1947, p. 461, pl. 65, fig. 2.

DISCUSSION: *Paragoniozona yunnania*, new species, is tentatively assigned to this genus because the selenizone is slightly below the periphery, a feature previously unknown within the genus.

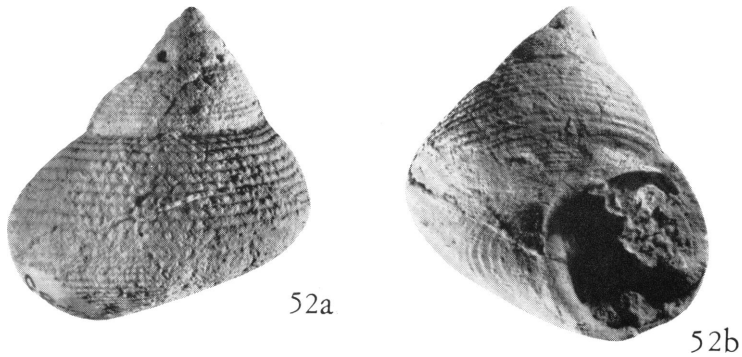


FIG. 52a, b. 52a. *Paragoniozona yunnania*, new species, holotype, AMNH 29076, side view. Note faint lunulae just below periphery in center of specimen. 52b. Oblique apertural view. Both ×3.

There is some justification for this decision, in that there is some variation in the position of the selenizone in described species. This observed variation appears related to the shape of the whorl and the placement of the periphery.

If this assignment is correct, *P. yunnania* represents a morphotype quite apart from the known species of *Paragoniozona*. The species then would serve as another example of a Tethyan restricted form as seen in *Glabrocingulum* (*Stenozone*).

Paragoniozona yunnania, new species

Figure 52a, b

DIAGNOSIS: Trochiform shells with dominant spiral ornament and selenizone just below periphery; early whorls with flat outer whorl faces; upper whorl surface with narrow, flat area adjacent to suture with noded spiral cord; outer whorl face inflated, somewhat flattened with 11–12 rounded, noded spiral cords; selenizone margins weaker than ornament; concave selenizone situated just below periphery, with large medial cord; base flatly rounded, with about 16 spiral cords less strongly noded than on upper whorl surface; anomphalus; columellar lip thickened, reflexed; ornament resorbed on parietal surface.

DISCUSSION: This species is quite similar to *Turbonellina orientalis* Licharew, 1967, from the Carboniferous of Ferghana, which has an inflated whorl profile, dominant spiral ornament, a flatly rounded base, and what appears to be a reflexed columellar lip. Collabral noding is not so well developed in *T. orientalis* and the spiral cords are sharper and somewhat weaker. I am unsure of the position of the selenizone in *T. orientalis*, but it appears to be close to but above the periphery. *Paragoniozona yunnania* has a well-developed selenizone immediately under the periphery, with its upper margin on the periphery. The depth of the slit is unknown, however, as the lunulae are strongly arcuate, the slit probably is relatively deep. This is based on the observation that less arcuate lunulae in most genera possessing a selenizone tend to be associated with very shallow slits and vice versa.

None of the species of *Turbonellina* described prior to *T. orientalis* have strong ornament and none have a medial element on the selenizone or on the pseudoselenizone (even though other genera of the family do have these traits). The most important character of *Turbonellina* is the extreme shallowness of the slit which may generate only a pseudoselenizone.

Paragoniozona on the other hand, does have strong noded ornament and a medial selenizone element. The selenizone, however, is at or above the periphery and the slit is moderately deep. *Turbonellina orientalis*, from what I can judge, appears to have the selenizone at or above the selenizone and apparently has a medial selenizone element. If this statement is true, *T. orientalis* could be placed in *Paragoniozona*.

It is important to note that *P. yunnania* has a selenizone slightly below the periphery, a feature not previously observed in species of *Paragoniozona*. This is a considerable discrepancy since the selenizone and associated characters are quite conservative (see Batten, 1967).

However, I am relatively sure that the depth of the slit, another conservative feature of the selenizone complex, is similar to *Paragoniozona*. *Turbonellina* as mentioned above has a very shallow slit or a notch. Taking such shell features into account as the depth of slit, the medial selenizone cord, the reflexed and well-developed columellar lip, ornament pattern, shell shape, and whorl profile, it seems more rational to assign the species in question to *Paragoniozona*. In that way the only modification of the generic diagnosis would be to add that the position of the selenizone may also be slightly below the periphery.

Other than *T. orientalis*, no other pleurotomarian species can be compared with *P. yunnania*. Both of these species are convergent on *Yunnania* Mansuy, 1912 so that positive identification is impossible without ascertaining the presence or absence of a selenizone or pseudoselenizone.

SPECIMENS: Two.

MEASUREMENTS: AMNH 29076: SP ANG 74 degrees, H 19.6 mm., W 18.4 mm.

NUMBERED SPECIMENS: AMNH 29076, UM 2486.

ETYMOLOGY: Named after the trochid genus *yunnania*, which is named for the Chinese province.

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