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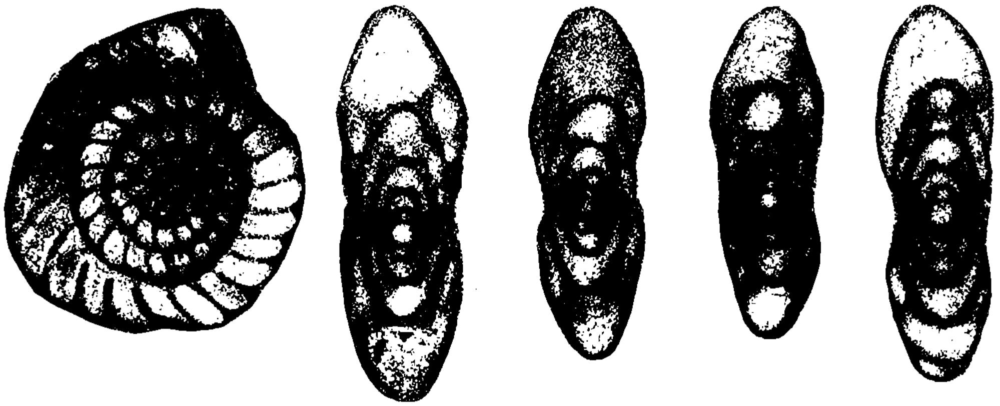
CALCAREOUS FORAMINIFERS AND ALGAE FROM THE TYPE MORROWAN (LOWER PENNSYLVANIAN) REGION OF NORTHEASTERN OKLAHOMA AND NORTHWESTERN ARKANSAS

JOHN R. GROVES



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Title Page Illustration

Specimens of *Millerella pressa* Thompson, ×100, from the Brentwood Limestone Member of the Bloyd Formation (see pl. 5, figs. 1–5).

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CALCAREOUS FORAMINIFERS AND ALGAE FROM THE TYPE MORROWAN (LOWER PENNSYLVANIAN) REGION OF NORTHEASTERN OKLAHOMA AND NORTHWESTERN ARKANSAS

JOHN R. GROVES[1]

Abstract—Type Morrowan (Lower Pennsylvanian) calcareous foraminifers and algae, here described in detail for the first time, are distinctive and thereby provide a basis for recognizing rocks of similar age in other areas of North America. Biostratigraphically important taxa within type Morrowan rocks include the foraminifers *Millerella pressa*, *M. marblensis*, *Eostaffella pinguis*, *Monotaxinoides transitorius*, *Planoendothyra spirilliniformis*, *P. evoluta*, *Hemigordius harltoni*, and the rhodophycophyte algae assigned to *Cuneiphycus texana*, *C. aliquantulus*, and a newly described genus. Of these taxa, the appearances of *Millerella pressa*, *M. marblensis*, and *Monotaxinoides transitorius* are most useful for distinguishing lower Morrowan from upper Chesterian rocks.

Furthermore, the occurrence of *Hemigordius harltoni* in the upper type Morrowan demonstrates that an informal, local, twofold biostratigraphic subdivision is possible. This species appears in the upper part of the Brentwood Limestone Member of the Bloyd Formation in northwestern Arkansas and at the base of the Brewer Bend Limestone Member of the Sausbee Formation in northeastern Oklahoma. Its appearance coincides closely with the base of the *Idiognathodus sinuosus* Conodont Zone and falls within the *Branneroceras branneri* Ammonoid Zone and the *Plicochonetes*? *arkansanus* Brachiopod Zone.

The primitive fusulinids *Eoschubertella*, *Pseudostaffella*, and *Profusulinella* were not recovered from type Morrowan rocks. Thus, no local evidence supports a Morrowan age for any part of the ranges of those taxa.

INTRODUCTION

The Morrowan Series is the standard of reference for Lower Pennsylvanian marine rocks in North America; yet, despite the importance of this series in North American and intercontinental stratigraphy, calcareous foraminifers and algae from the type Morrowan region of northeastern Oklahoma and northwestern Arkansas (text-fig. 1) have never before been described in detail. The paucity of studies of these microfossils is not restricted to the type region; few workers have attempted to examine Morrowan assemblages completely or critically anywhere in North America (see section on Previous Studies, below). Consequently, Morrowan foraminifers and algae are rather poorly understood in comparison with certain other biostratigraphically useful fossil groups (e.g., conodonts, ammonoids, brachiopods). The lack of detailed studies is reflected by the coarse resolution of existing foraminiferal zonations of the Morrowan interval. The widely used Zone of *Millerella* (Thompson, 1945, 1948) and Mamet Zone 20 (Mamet and Skipp, 1970; Mamet, 1975) assign the Morrowan to a single zone or portion of a zone, and thus provide no basis for subdividing it into finer biostratigraphic units. Both zones are based on appearances of genera without utilizing diagnostic Morrowan species. This contrasts with zonations based on conodonts, ammonoids, and brachiopods that use the ranges of key species to provide precise correlations within the Morrowan Series. The need for a better understanding of Morrowan foraminifers and algae is further underscored by recent heightened interest in the placement of the Mississippian–Pennsylvanian and Morrowan–Atokan/Derryan boundaries (e.g., Brenckle and others, 1977; Sutherland and Manger, in press; Brenckle, Groves and Skipp, 1982) where foraminifers are among the most useful fossil groups.

This study is a detailed account of the taxonomy and stratigraphic distribution of type Morrowan calcareous foraminifers, algae, and *incertae sedis*, which include 38 genera and 43 species. Lower type Morrowan rocks are distinguished from the underlying late Chesterian (Late Mississippian) Pitkin Limestone by local appearances of the foraminifers *Millerella pressa*, *M. marblensis*,

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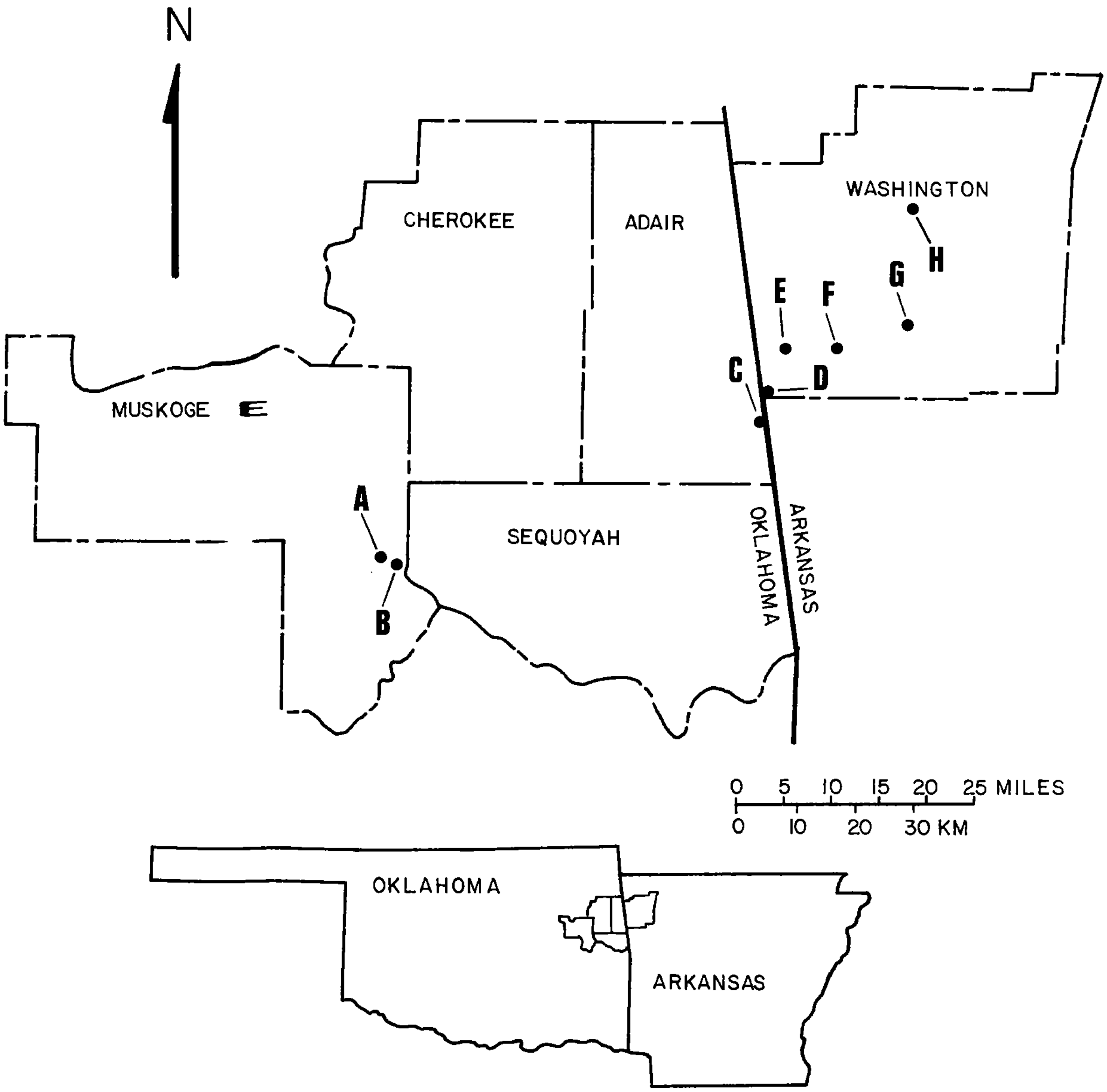


Text-figure 1. Index map of type Morrowan region showing locations of measured sections: *A*, Betsey Lee Creek; *B*, Webbers Falls Lock and Dam; *C*, Sawney Hollow; *D*, Evansville Mountain; *E*, Hale Mountain; *F*, Garrett Hollow; *G*, Lee Creek; *H*, Kessler Mountain.

Monotaxinoides transitorius, *Eostaffella pinguis*, *Planoendothyra evoluta*, *P. spirilliniformis*, and the algae *Cuneiphycus texana*, *C. aliquantulus*, and Genus A, species A, n. gen., n. sp. Furthermore, an informal, local, twofold biostratigraphic subdivision of the Morrowan is possible based on the appearance of *Hemigordius harltoni*. This species appears in the upper part of the Brentwood Limestone Member of the Bloyd Formation in northwestern Arkansas and at the base of the Brewer Bend Limestone Member of the Sausbee Formation in northeastern Oklahoma. Its appearance coincides closely with the base of the *Idiognathodus sinuosus* Conodont Zone and falls within the *Branneroceras branneri* Ammonoid Zone and the *Plicochonetes*? *arkansanus* Brachiopod Zone. The primitive fusulinids *Eoschubertella*, *Pseudostaffella*, and *Profusulinella* were not recovered from type Morrowan rocks. Accordingly, there is no local evidence supporting a Morrowan age for any portion of the ranges of those taxa.

Field work for this investigation was conducted during July 1979 and January and March 1980. The stratigraphic position of each sample has been painted in yellow on the outcrop to facilitate recollecting.

PREVIOUS STUDIES

The Lower Pennsylvanian sequence (text-fig. 2) in the type Morrowan region has been the focus of numerous lithostratigraphic and biostratigraphic investigations ever since the pioneering work of Simonds (1891). Only studies of calcareous foraminifers, algae, and other fossil groups of particular bearing on the present research are discussed herein. Henbest (1953, 1962a, 1962b) and Manger and Saunders (1980) provide extensive reviews of the published literature on type Morrowan rocks.

Foraminifers

Foraminifers from the type Morrowan region have received little attention. Cursory studies by Thompson (1944), Lane and others (1972), and Nodine-Zeller (1977) represent the entire published literature on this topic. Thompson (1944) studied millerellids from the Brentwood Limestone Member of the lower Bloyd Formation at Hale Mountain, Arkansas. He described and illustrated *Millerella marblensis, M. pressa, M.? advena* var. *ampla, M.? advena*, and *M. pinguis*, of which the latter two have their type locality within the Brentwood. Thompson sampled the Kessler Limestone Member of the upper Bloyd Formation but did not report foraminifers from that unit.

Lane and others (1972) were the first to report *Millerella* spp. from the Kessler. The discovery of this fauna in youngest type Morrowan rocks, to the exclusion of fusulinids, led them to assign all of the type Morrowan to that portion of the Zone of *Millerella* below the appearances of *Eoschubertella* and *Pseudostaffella*.

Foraminifers and calcareous algae from Chesterian and Morrowan rocks in Washington County, Arkansas, and Adair and Muskogee Counties, Oklahoma (text-fig. 1) were illustrated by Nodine-Zeller (1977). To date, her work represents the most comprehensive investigation of type Morrowan calcareous microfossils. Nevertheless, it lacks detailed stratigraphic and systematic treatment of the fossils and thus provides no basis for a better understanding of their taxonomy and stratigraphic distribution.

Morrowan calcareous foraminifers have been reported elsewhere in North America from Kansas (Thompson, 1944), Texas (Plummer, 1930, 1945; Thompson, 1942, 1947, 1948; Stewart, 1957; Moore, 1964; Lane and others, 1972; King, 1973), New Mexico (Thompson, 1948; King, 1973), Nevada (Rich, 1961, 1970; Slade, 1961; Cassity and Langenheim, 1966; Marshall, 1969; Brenckle, 1973), Utah (Thompson, 1945; Rich, 1970), Colorado (Thompson, 1945; Lehmann, 1953), Idaho (Mamet and others, 1971; Skipp and others, 1979, 1981; Skipp and Brenckle, 1979), Wyoming (Mamet, 1975), Alaska (Mamet and Armstrong, 1972; Armstrong and Mamet, 1977), and Oklahoma (Galloway and Harlton, 1928).

Algae

Kotila (1973) investigated the paleoecology of calcareous algae from the Morrowan of northeastern Oklahoma. He described and illustrated *Archaeolithophyllum, Cuneiphycus, Girvanella*, one unnamed genus, and the form genera *Osagia* and *Ottonosia*. The present study shows the algal flora in the type Morrowan region to be far more diversified than was suggested by Kotila.

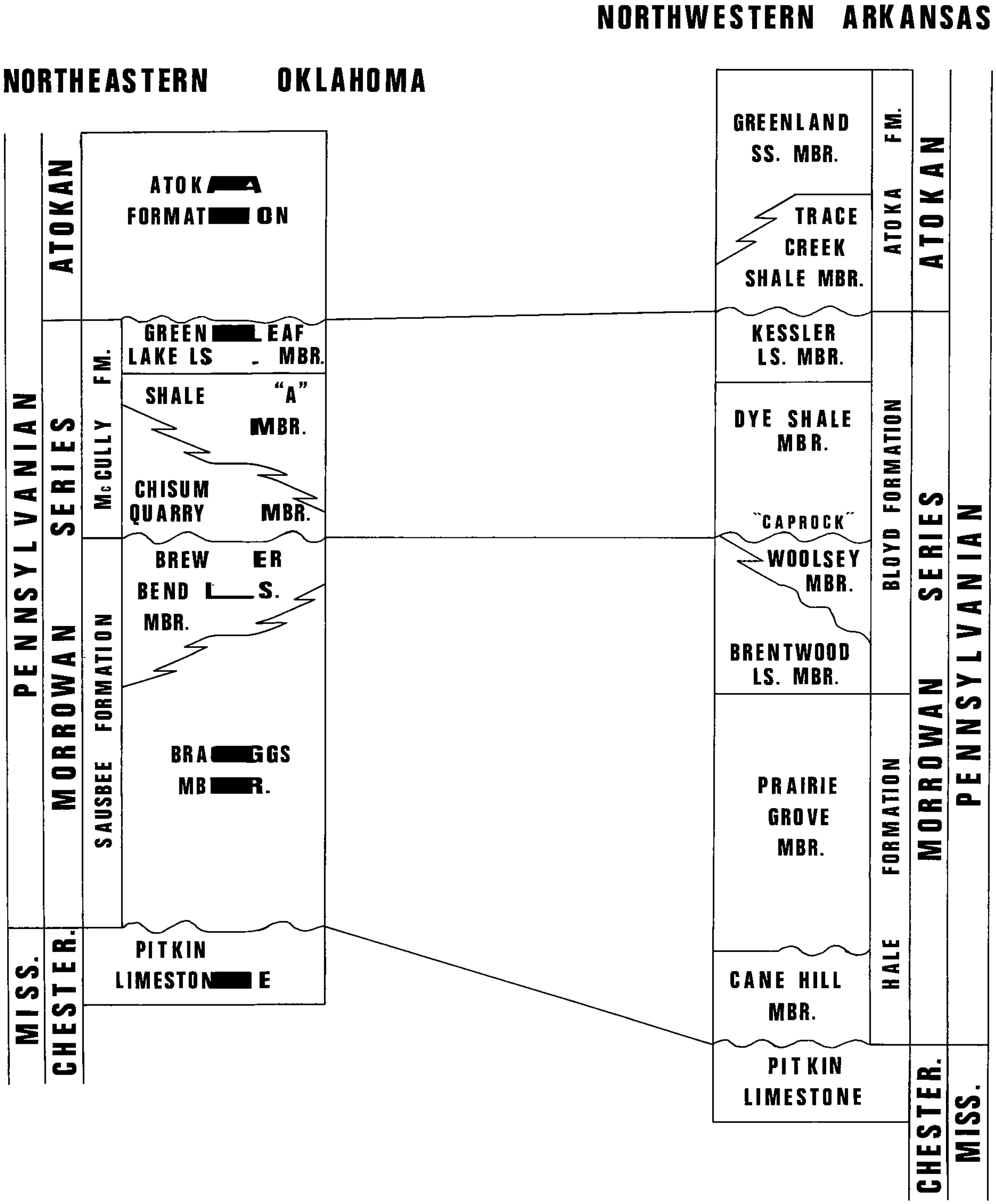
Morrowan algae described elsewhere in North America come from Texas (Johnson, 1960, 1963; Freeman, 1964), Nevada and Utah (Rich, 1967), and Alaska (Armstrong and Mamet, 1977).

Other Groups

Representatives of a number of other fossil groups from the type Morrowan region have been investigated to various degrees. They include conodonts (Lane, 1967, 1977; Lane and others, 1971; Lane and Straka, 1974; Grayson and Sutherland, 1977), ammonoids (Gordon, 1965, 1970; McCaleb, 1968; Quinn, 1970, 1971; Saunders and others, 1977; Manger and Saunders, 1980), ostracodes (Sohn, 1977; Knox, 1977), and brachiopods (Henry, 1973, 1974; Henry and Sutherland, 1977; Sutherland and Henry, 1980). Biostratigraphic zonations of the Morrowan based on these studies provide an excellent framework into which the results of this investigation can be integrated.

LOCALITIES

Material for this investigation was collected from eight previously measured sections in northwestern Arkansas and northeastern Oklahoma (text-fig. 1). The sections were measured by Patrick K. Sutherland and his students at The University of Oklahoma. Their locations are (1) Betsey Lee Creek, NW¼NW¼ sec. 33, T. 13 N., R. 20 E., Muskogee County, Oklahoma; (2) Webbers Falls Lock and Dam, SW¼SW¼SE½ sec. 34, and SE½SE¼SW¼ sec. 34, T. 13 N., R. 20 E., Muskogee County, Oklahoma; (3) Sawney Hollow, NE¼ sec. 10, T. 12 N., R. 33 W., Crawford County, Arkansas, continuing westward to SW¼ sec. 25, T. 15 N., R. 26 E., Adair County, Oklahoma; (4) Evansville Mountain, along Arkansas Highway 59, center S½ sec. 35, T. 13 N., R. 33 W., continuing northward to center S½ sec. 26, T. 13 N., R. 33 W., Washington County, Arkansas; (5) Hale Mountain, W½ sec. 7, T. 13 N., R. 32 W., Washington County, Arkansas; (6) Garrett Hollow, N½



Text-figure 2. Stratigraphic nomenclature and time-stratigraphic relations between Morrowan sequences in northeastern Oklahoma and northwestern Arkansas (modified from Sutherland and Henry, 1977).

sec. 10, T. 13 N., R. 33 W., Washington County, Arkansas; (7) Lee Creek, N½NE¼ sec. 25, T. 14 N., R. 31 W., Washington County, Arkansas; and (8) Kessler Mountain, S½SE¼ sec. 25, T. 16 N., R. 31 W., Washington County, Arkansas. The stratigraphic positions of samples collected from the Webbers Falls Lock and Dam, Betsey Lee Creek, Sawney Hollow, and Evansville Mountain sections are shown in text-figure 3.

STRATIGRAPHY

The term Morrow was first used to designate the sequence of rocks above the Mississippian Pitkin Limestone and below the Pennsylvanian Winslow Formation in northwestern Arkansas (Ulrich, 1904). Purdue (1907) elevated the term to group rank, and Moore and others (1944) subsequently elevated it to a series. The Morrowan is currently recognized as the base of the Pennsylvanian System and lies between the Upper Mississippian Chesterian and the Middle Pennsylvanian Atokan (=Derryan) Series. Sutherland and Henry (1977) broadened the definition of the type region of the Morrowan to include the fossiliferous carbonate-platform facies of northeastern Oklahoma 40 miles (64 km) to the southwest. Text-figure 2 summarizes the stratigraphic nomenclature and regional correlations between the northwestern Arkansas and northeastern Oklahoma sequences.

In northwestern Arkansas the Morrowan consists of the Hale Formation, which is subdivided into the Cane Hill and Prairie Grove Members, and the overlying Bloyd Formation, which is subdivided into the Brentwood Limestone, Woolsey, Dye Shale, and Kessler Limestone Members. The Trace Creek Shale Member, formerly included in the Bloyd Formation, was reassigned to the basal Atoka Formation of the Atokan Series by Sutherland and Grayson (1978). The Cane Hill Member of the Hale Formation was named by Henbest (1953) for "its typical development in the southern part of Washington County, in the vicinity of Cane Hill." It rests unconformably on the Chesterian Pitkin Limestone and reaches a thickness of 65 feet (20 m). It consists of ripple-marked and cross-bedded silty sandstone and fine-grained sandstone interbedded with shale. Calcareous layers are present locally. Conglomeratic lenses composed of rounded cobbles of the underlying Pitkin are also present locally at the base of the unit. The Cane Hill was not sampled for this investigation.

The Prairie Grove Member of the Hale Formation, named by Henbest (1953) for exposures at Evansville Mountain, ranges in thickness from 60 to 200 feet (20–61 m). It is composed of resistant, fine- to medium-grained calcareous sandstone and sandy carbonate packstone and grainstone. Distinguishing characteristics of the Prairie Grove are its coarsely pitted, "honeycomb" weathered surfaces and well-developed lamellar cross-bedding. The contact between the Prairie Grove and the underlying Cane Hill is unconformable at most localities. Evidence of the unconformity includes basal conglomerates, truncated strata, reworked fossil elements, and the variable age of the beds straddling the contact (Saunders and others, 1977; Manger and Saunders, 1980).

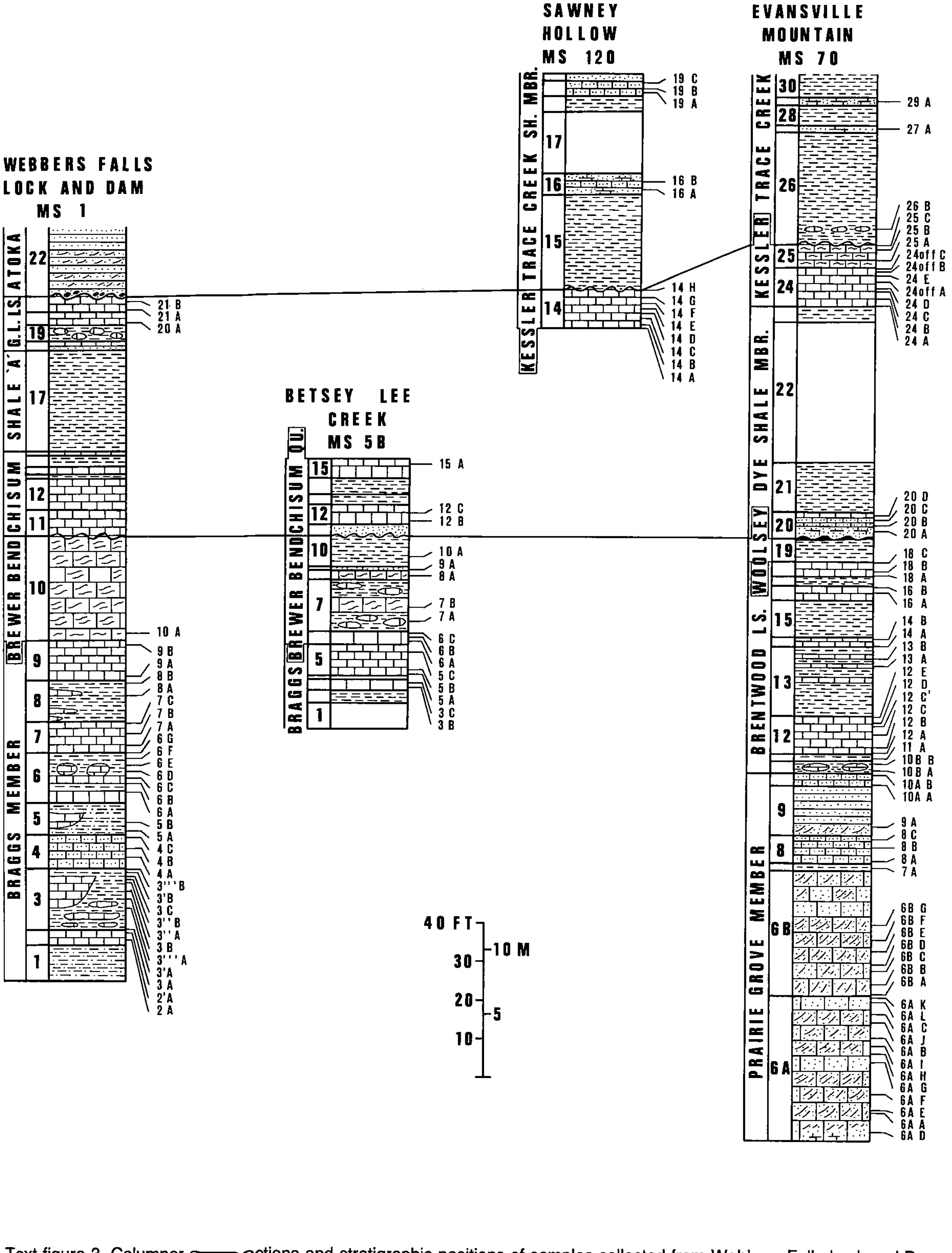
The Brentwood Limestone Member of the Bloyd Formation was named by Ulrich (1904) to replace the term Pentrimital Limestone of Owen (1858). It is 30–50 feet (9–15 m) thick and consists of alternating beds of dark shale and sandy crinozoan carbonate packstone and grainstone. The contact between the Brentwood and the underlying Prairie Grove is conformable.

Conformably overlying and interfingering with the Brentwood is the Woolsey Member, named by Henbest (1953). This member is a continental siltstone and shale unit that contains abundant plant fragments on shale partings. A thin coal seam, the Baldwin coal, occurs persistently at or near the top of the Woolsey across northwestern Arkansas. The Woolsey attains a thickness of up to 40 feet (12 m) but is only 7 feet (2 m) thick at Evansville Mountain, which is the only locality where the unit was encountered in this study. No samples were collected.

The Woolsey and overlying Dye Shale Member are separated by an unconformity that is recognized across northwestern Arkansas and northeastern Oklahoma. The Dye Shale, named by Henbest (1962b), consists of predominantly dark-gray to black marine siltstone and fissile shale with local lenses of limestone. It varies in thickness from 60 to 110 feet (18–34 m). A fossiliferous calcareous sandstone, the "caprock of the Baldwin coal," is present at the base of the Dye across the region. The "caprock" varies in thickness from 0 to 25 feet (8 m) and is the only portion of the Dye sampled for this study.

The Kessler Limestone Member overlies the Dye conformably. The Kessler, which was named and described by Simonds (1891), ranges from nearly pure oolitic grainstone to sandy algal wackestone and packstone interbedded with shale. This member reaches a thickness of 43 feet (14 m) but typically is 8–15 feet (2.5–3.7 m).

The Trace Creek Shale Member of the Atoka Formation overlies the Kessler. The Trace Creek, named by Henbest (1962b), varies in thickness from 20 to 70 feet (6–21 m) and consists of dark-gray to olive-green, noncalcareous, fissile shale interbedded with thin layers of sandstone, calcareous sandstone, and, rarely, sandy limestone. Henbest (1962b) considered the Trace Creek to be the highest unit in the type Morrowan Series. Recent investigations, however, have demonstrated that on physical evidence it is a facies of the Atoka Formation in Oklahoma (Sutherland and others, 1978) and that conodonts from the bas-



Text-figure 3. Columnar sections and stratigraphic positions of samples collected from Webbers Falls Lock and Dam, Betsey Lee Creek, Sawney Hollow, and Evansville Mountain localities. Small numerals to right of sections designate sample numbers.

al part of the Trace Creek correlate with faunas from the Atokan Series of the Ardmore Basin and frontal Ouachita Mountains of southern Oklahoma (Grayson and Sutherland, 1977; Sutherland and Grayson, 1978). Accordingly, the Trace Creek is now considered to mark the base of the Atokan Series of northwestern Arkansas.

Morrowan sandstones, shales, and limestones in northwestern Arkansas grade westward into a carbonate-platform facies in northeastern Oklahoma, where the percentage of sandstone is much lower. The terms Hale and Bloyd can be applied only as far west as western Adair County, Oklahoma (text-fig. 1). Recognizing this, Sutherland and Henry (1977) divided the Morrowan sequence in most of northeastern Oklahoma into the Sausbee and McCully Formations. The Sausbee is subdivided into the Braggs and Brewer Bend Limestone Members, and the McCully is subdivided into the Chisum Quarry, Shale "A," and Greenleaf Lake Limestone Members.

The Braggs Member of the Sausbee Formation rests unconformably on the Pitkin Limestone. It varies in thickness from 40 to 175 feet (12–53 m) and consists mostly of interbedded crinozoan–bryozoan limestone and shale. Thick algal layers and bryozoan–algal bioherms are developed in the upper part of the unit (Bonem, 1977).

The comformably overlying Brewer Bend Limestone Member is composed of algal wackestone to packstone with minor amounts of shale. It attains a thickness of 42 feet (13 m). The Braggs and Brewer Bend Limestone Members, taken together, make up a depositional package of nearly constant thickness in which the thicknesses of the members are inversely proportional.

The Chisum Quarry Member of the McCully Formation is separated from the underlying Brewer Bend by the same regional unconformity that separates the Woolsey and Dye Shale Members of the Bloyd Formation in northwestern Arkansas (Sutherland and Henry, 1977). It consists of bryozoan–crinozoan wackestone to grainstone interbedded with thin shale layers and varies in thickness from less than 1 foot to 36 feet (11 m). Much of the variation is attributable to the lensing nature of the limestone layers in the middle and upper parts of the unit.

The Shale "A" Member conformably overlies and interfingers with the Chisum Quarry. It consists of mostly noncalcareous, unfossiliferous shale, although several limestone lenses are present in the most southwesterly exposures. The unit varies in thickness from 25 to 40 feet (7.5–12 m) and averages about 30 feet (9 m). No samples were collected.

The Greenleaf Lake Limestone Member overlies the Shale "A" conformably. It reaches a thickness of 30 feet (9 m) but typically is much thinner owing to removal of its middle and upper parts by pre-Atoka erosion (Sutherland and Henry, 1977). It consists of interbedded crinozoan–bryozoan packstone and grainstone with little shale. The Morrowan sequence is unconformably overlain by the Atoka Formation across northeastern Oklahoma.

BIOSTRATIGRAPHIC SIGNIFICANCE OF THE BIOTA

Occurrences of calcareous microfossils are shown in tables 1 and 2 for northwestern Arkansas and northeastern Oklahoma, respectively. Data are reported only from the Evansville Mountain, Sawney Hollow, Webbers Falls Lock and Dam, and Betsey Lee Creek localities, since recoveries from the remaining four localities were generally poor. Occurrences of individual taxa that are described and (or) illustrated from localities not shown on tables 1 and 2 are mentioned separately in the systematic portion of the text.

Foraminifers are among the most useful fossil groups for distinguishing Upper Mississippian from Lower Pennsylvanian rocks (Brenckle and others, 1977), yet the practice of recognizing the Mississippian–Pennsylvanian boundary by the appearances of *Globivalvulina*, *Lipinella* (*sensu* Mamet; = *Lipininella* Cummings *nomen nudum*), and *Millerella*, as has been advocated by Mamet (Mamet and Skipp, 1970; Mamet, 1975), is not entirely satisfactory. Species of *Globivalvulina* do not occur in this study; the concept of *Lipinella* is not clear, because the genus has not been properly defined; and species of *Millerella* appear in late Chesterian rocks (Brenckle, 1977; Brenckle and Groves, 1981). The need to identify species that first occur in the Morrowan is apparent (Brenckle, 1977).

Lower Morrowan rocks in the type area are readily distinguished from those in the late Chesterian Pitkin Limestone (Brenckle, 1977) by the presence of the foraminifers *Millerella pressa*, *M. marblensis*, *M.* cf. *M. extensa*, *Monotaxinoides transitorius*, *Eolasiodiscus donbassicus*, *Eostaffella pinguis*, *Planoendothyra spirilliniformis*, *P. evoluta*, *Hemigordius harltoni*, *H.* sp. A., and the algae *Cuneiphycus texanus*, *C. aliquantulus*, *Donezella* aff. *D. lunaensis*, and Genus A species A, n. gen., n. sp. Of these, *Millerella pressa*, *M. marblensis*, and *Monotaxinoides transitorius* are reliable Lower Pennsylvanian indices elsewhere in North America.

Foraminifers are of demonstrated value in finely subdividing the Mississippian and Middle and Upper Pennsylvanian, yet existing zonations within the Morrowan (e.g., Zone of *Millerella*; Mamet Zone 20) assign the entire series to a single zone or portion of a zone. Thus they provide no means for recognizing finer biostratigraphic units. Both the Zone of *Millerella* (Thompson, 1945, 1948) and Mamet Zone 20 (Mamet and

Skipp, 1970; Mamet, 1975) are based on appearances of genera, with no utilization whatsoever of diagnostic Morrowan species. Although the argument can be made that foraminiferal evolution during the Morrowan was comparatively static, I believe the inability of previous workers to subdivide the Morrowan stems primarily from the lack of detailed studies of complete successions. The majority of past studies of Morrowan foraminifers have focused an inordinate amount of attention on a few selected genera (i.e., *Millerella, Eostaffella*) to the exclusion of other potentially useful taxa (e.g., Thompson, 1944; Marshall, 1969; King, 1973).

A striking change within the type Morrowan foraminiferal succession occurs in the upper part of the Brentwood Limestone Member of the Bloyd Formation of northwestern Arkansas (table 1, samples 70-14A through 70-16A). The change is marked by the local appearances of *Hemigordius harltoni, Millerella* cf. *M. extensa, Eolasiodiscus donbassicus, Monotaxinoides transitorius, Planoendothyra evoluta, Trepeilopsis minima, Calcivertella adherens,* and *Calcitornella* spp. *Calcivertella adherens, Trepeilopsis minima,* and *Calcitornella* spp. have been reported from Chesterian rocks elsewhere in North America (Armstrong and Mamet, 1977; Rich, 1980), whereas they and *Planoendothyra evoluta* and *Monotaxinoides transitorius* were recovered from basal Morrowan rocks of the Braggs Member of the Sausbee Formation of northeastern Oklahoma (table 2). Thus, the biostratigraphic value of these taxa within the Morrowan appears minimal.

The local appearance of *Hemigordius harltoni*, however, is potentially significant. Its appearance in the upper part of the Brentwood and at the base of the Brewer Bend Limestone Member of the Sausbee Formation of northeastern Oklahoma (table 2) coincides closely with the base of the *Idiognathodus sinuosus* Conodont Zone of Lane (1977; Lane and Straka, 1974) and falls within the *Branneroceras branneri* Ammonoid Zone (Saunders and others, 1977) and the *Plicochonetes*? *arkansanus* Brachiopod Zone (Henry and Sutherland, 1977). Accordingly, the appearance of *H. harltoni* provides the basis for an informal, local, twofold subdivision of the Morrowan Series in its type area. The interregional integrity of *H. harltoni* is still largely untested, but it appears promising. A specimen (illustrated as *Brunsia* sp. by Brenckle, 1973, pl. 10, fig. 33) was recovered from a level in the Bird Spring Formation of southern Nevada that Lane (personal communication, 1981) places slightly below the base of the *I. sinuosus* Zone. Specimens have also been recovered slightly below the *I. sinuosus* Zone from the Bloom Member of the Snaky Canyon Formation of east-central Idaho (J. F. Baesemann and P. L. Brenckle, personal communication, 1981). They occur abundantly in the type section of the Marble Falls Formation of central Texas within the *I. sinuosus* Zone (W. L. Manger, personal communication, 1981) and in Thompson's (1944) collections from the subsurface Kearny Formation of western Kansas (P. L. Brenckle, personal communication, 1981). The relation of the Kearny specimens to the conodont succession, however, cannot be determined.

The local appearances of *Millerella* cf. *M. extensa* and *Eolasiodiscus donbassicus* in the upper Brentwood are also potentially significant. *Millerella extensa* has previously been reported only from Atokan (= Derryan) rocks in Nevada (Marshall, 1969) and in Texas and New Mexico (King, 1973). Thus my specimens, if conspecific with true *M. extensa*, represent the oldest reported occurrence of the species. *Eolasiodiscus donbassicus* has never before been reported from North America, although Browne and Pohl (1973, pl. 26, fig. 4) illustrated a specimen that may be a juvenile of the species. This species occurs in the Soviet Union in Upper Serpukhovian (upper Lower Carboniferous) and Bashkirian (lower Middle Carboniferous) deposits that are roughly equivalent to the Morrowan (Reitlinger, 1956; Brazhnikova, *in* Wagner and others, 1979). Unfortunately, neither *M.* cf. *M. extensa* nor *E. donbassicus* was recovered from the northeastern Oklahoma sequence for stratigraphic comparison.

Recent heightened interest in the placement of the Morrowan–Atokan (= Derryan) boundary (e.g., Sutherland and Manger, in press) also bears on the present research. Many workers (e.g., Mamet and Skipp, 1970; Lane and others, 1972; Mamet, 1975; Webster and others, in press) equate the appearances of *Eoschubertella* and *Pseudostaffella* with the base of the Atokan/Derryan, whereas others (e.g., Thompson, 1945, 1948; Dunbar, 1963; Douglass, 1977) place the base of the Atokan/Derryan at the appearance of *Profusulinella*. Still others (e.g., Shaver and Smith, 1974; Knox, 1977; Ross and Bamber, 1978; Ross, 1979) suggest that *Profusulinella* may occur locally in rocks older than basal Atokan/Derryan. My detailed type Morrowan collections did not yield the primitive fusulinids *Eoschubertella, Pseudostaffella,* and *Profusulinella*. Thus there is no local evidence supporting a Morrowan age for any portion of the ranges of these taxa.

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SYSTEMATIC PALEONTOLOGY

General Statements

Systematic descriptions are based on examination of specimens in randomly oriented thin sections. Generic descriptions derive both from previously published works and from examination of the present material. Descriptions of species are based solely on examination of the present material, and in each case the number of individual specimens measured is indicated in parentheses (e.g., n = 8).

No attempt has been made to compile exhaustive synonymies. Rather, entries in a synonymy represent bibliographic citations to figured specimens mostly from North America. In many instances reference is made to previously published works that contain extensive synonymies.

Specimens are deposited in The University of Oklahoma Invertebrate Paleontology Repository (designated by the prefix OU).

Kingdom PROTISTA

Phylum PROTOZOA?

Order FORAMINIFERIDA?

Family TUBERITINIDAE

Genus **Tuberitina** Galloway and Harlton, 1928

Type species.—Tuberitina bulbacea Galloway and Harlton, 1928.

Description.—Test is composed of one or more hemispherical to flask-shaped chambers that are attached to a host by a basal disc. The wall is dark, microgranular calcite, thick, coarsely perforate.

Discussion.—Tuberitina differs from *Diplosphaerina* Derville (=*Eotuberitina* Miklukho-Maklay) in its thicker, coarsely perforate wall.

Tuberitina plana Reitlinger, 1950

Pl. 1, figs. 1, 3

Tuberitina collosa Reitlinger var. *plana* REITLINGER, 1950, p. 89, pl. 19, fig. 1.

Description (n = 8).—Chambers are hemispherical. Diameter is up to 242 μm. Height is up to 195 μm. Wall is dark, microgranular calcite, coarsely perforate, 10–15 μm thick.

Discussion.—The present specimens are assigned to *T. plana* on the basis of wall thickness and the shape of the tests. *Tuberitina plana* differs from *T. collosa* Reitlinger in its thinner wall and smaller size, and from *T. bulbacea* Galloway and Harlton by its hemispherical shape.

Occurrence.—The species is present in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation (table 2).

The species was originally described from the upper Middle Carboniferous (lower Moscovian) Vereiskiy Horizon of the northern Urals, U.S.S.R.

Genus **Diplosphaerina** Derville, 1952,
emend. Browne and Pohl, 1973

Type species.—Diplosphaera inaequalis Derville, 1931.

Description.—Test is composed of one or more hemispherical to flask-shaped chambers that are attached to a host by a basal disc. Wall is dark, microgranular calcite, thin, imperforate or very finely perforate.

Discussion.—Browne and Pohl's (1973, p. 193) emendation of *Diplosphaerina* includes in the genus forms that previously were referred to *Archaesphaera* Suliemanov, *Eotuberitina* Miklukho-Maklay, *Neotuberitina* Miklukho-Maklay, and *Tuberitina* Galloway and Harlton (part). Coarsely perforate *Tuberitina* is maintained as a separate genus. Browne and Pohl (1973, p. 193–195) and Rich (1980, p. 12–14) present discussions of the taxonomic status of *Diplosphaerina.*

Diplosphaerina inaequalis (Derville, 1931)

Pl. 1, figs. 2, 4

See Rich, 1980, p. 13–14, for synonymy.

Description (n = 34).—Chamber diameter is up to 219 μm. Chamber height is up to 215 μm. Wall is dark, microgranular calcite, imperforate or very finely perforate, 5–13 μm thick.

Discussion.—A broad range of morphologies is represented in the present material, owing to developmental lability and the variety of views that result from randomly oriented thin sections.

Occurrence.—Diplosphaerina inaequalis is one of the most abundant microfossils encountered in this study. It occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Greenleaf Lake Limestone Member of the McCully Formation (table 2).

Readers are referred to Brenckle, Marshall, Waller, and Wilhelm (1982) for the geographic and stratigraphic distribution of the species in North America.

Phylum PROTOZOA

Order FORAMINIFERIDA

Family PSEUDOAMMODISCIDAE

Genus **Pseudoglomospira** Bykova, 1955

Pl. 1, figs. 7, 8

Type species.—Pseudoglomospira devonica Bykova, 1955.

Description.—Test is free; it consists of a spherical proloculus followed by a glomospirally coiled non-septate second chamber that is semicircular or flattened in cross section. Wall is dark, microgranular calcite. Aperture is a simple opening at the end of the second chamber.

Discussion.—Pseudoglomospira differs from *Palaeonubecularia* Reitlinger, which has a coarsely agglutinated wall.

The material was not studied sufficiently for speciation.

Occurrence.—Representatives of the genus occur in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). They also occur in the Braggs Member of the Sausbee Formation (table 2).

Family PSEUDOAMMODISCIDAE?

Genus **Calcivertella** Cushman and Waters, 1928a

Type species.—Calcivertella adherens Cushman and Waters, 1928a.

Description.—Test is attached, composed of a spherical proloculus followed by a tubular second chamber that is nearly planispirally coiled about the proloculus in the early stages and arranged in a tight zigzag pattern in later stages. The final portion of the tubular chamber may meander freely. Wall is calcareous, very fine grained, imperforate. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—The zigzag pattern of the later stages of the tubular chamber distinguishes *Calcivertella* from *Calcitornella* Cushman and Waters. *Calcivertella* differs from *Ammovertella* Cushman by its calcareous wall.

Calcivertella adherens Cushman and Waters, 1928a

Pl. 1, fig. 13

See Rich, 1980, p. 46, for synonymy.

Description (n = 9).—Total length of the test is up to 490 μm. Zigzag portion of the test is tapered, roughly fan shaped. Rate of expansion of the tubular chamber is moderate. Diameter of the tube is 27–55 μm in the later stages. Wall is very fine grained, imperforate, copper brown to amber in transmitted light. Its thickness is 2–3 μm in the early stages, up to 15 μm in the later stages. Aperture was not observed.

Discussion.—Species of *Calcivertella* are particularly difficult to distinguish, owing to developmental lability and the limitations of studying specimens in thin sections. As a result, the genus is probably over-speciated (e.g., Rich, 1980, p. 46–47).

Occurrence.—The species is present in the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1) and the Braggs Member of the Sausbee Formation (table 2).

It was originally described from the Upper Pennsylvanian Graham Formation of the Cisco Group in Young County, Texas, and has been reported elsewhere in North America from Chesterian and Pennsylvanian rocks in Texas (Cushman and Waters, 1928a, 1930), Oklahoma (Galloway and Harlton, 1928), and Alabama (Rich, 1980).

Genus **Calcitornella** Cushman and Waters, 1928a

Pl. 1, figs. 9, 10

Type species.—Calcitornella elongata Cushman and Waters, 1928a.

Description.—Test is attached, composed of a spherical proloculus followed by a tubular second chamber that is nearly planispirally coiled in the early stages and wanders irregularly in later stages. Wall is calcareous, very fine grained, imperforate, copper brown in transmitted light. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—Calcitornella and *Apterrinella* Cushman and Waters are distinguished by the texture of the wall, which is pitted in *Apterrinella* and smooth in *Calcitornella* (Henbest, 1963). *Calcitornella* differs from *Calcivertella* Cushman and Waters in the zigzag pattern of the second chamber of the latter genus. It differs from *Pseudoglomospira* Bykova by its attached habit and growth in a single plane.

The material was not studied sufficiently for speciation.

Occurrence.—Calcitornella is present in the Brentwood Limestone, Dye Shale, and Kessler Limestone Members of the Bloyd Formation and the Trace Creek Shale Member of the Atoka Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Chisum Quarry and Greenleaf Lake Limestone Members of the McCully Formation (table 2).

TABLE 1.—CHART SHOWING LOCAL RANGES OF CALCAREOUS MICROFOSSILS IN NORTHWESTERN ARKANSAS

(Sample prefix 120, Sawney Hollow locality; sample prefix 70, Evansville Mountain locality; Cane Hill Member of Hale Formation and Woolsey Member of Bloyd Formation not sampled for this study and not shown on range chart)

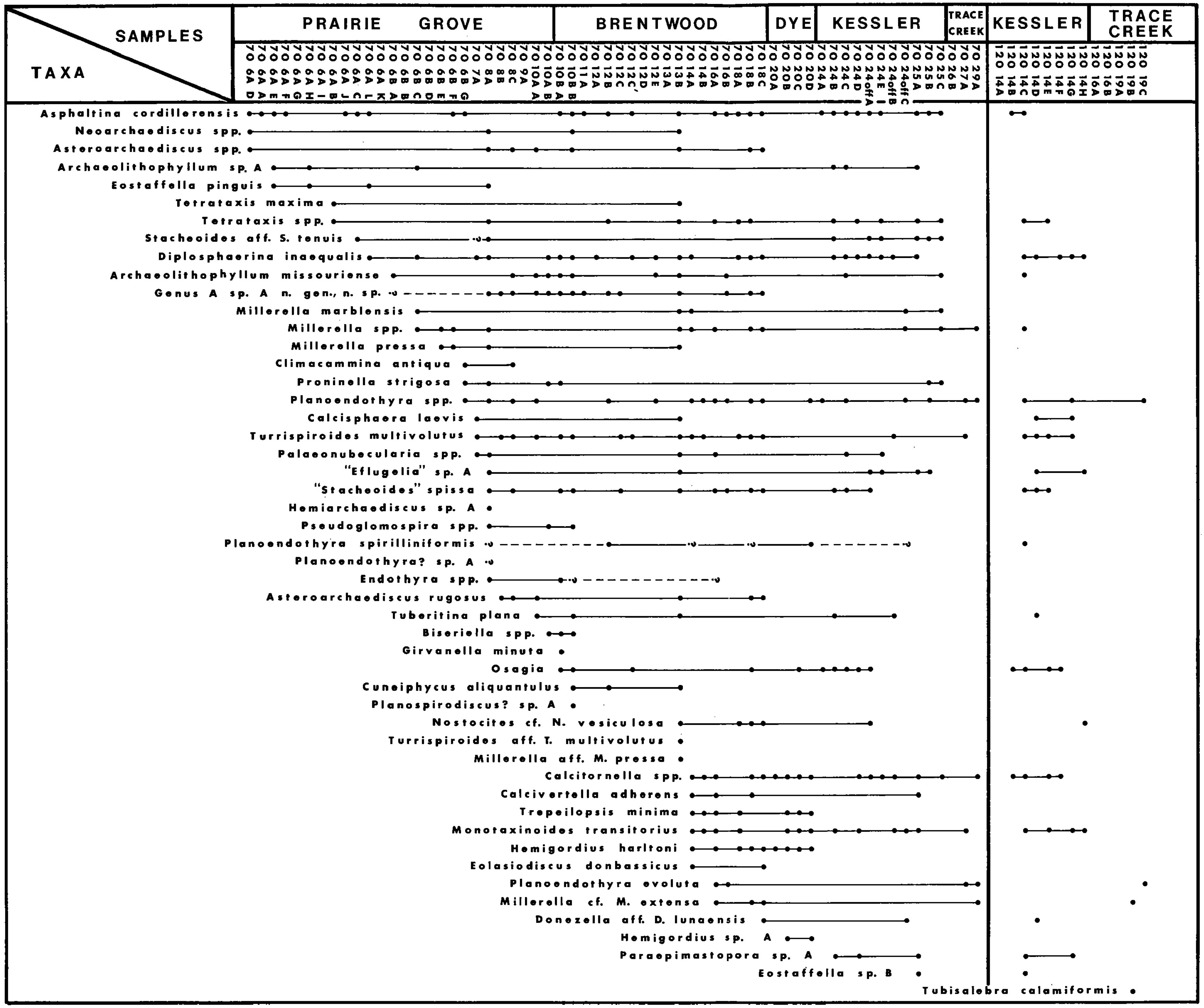
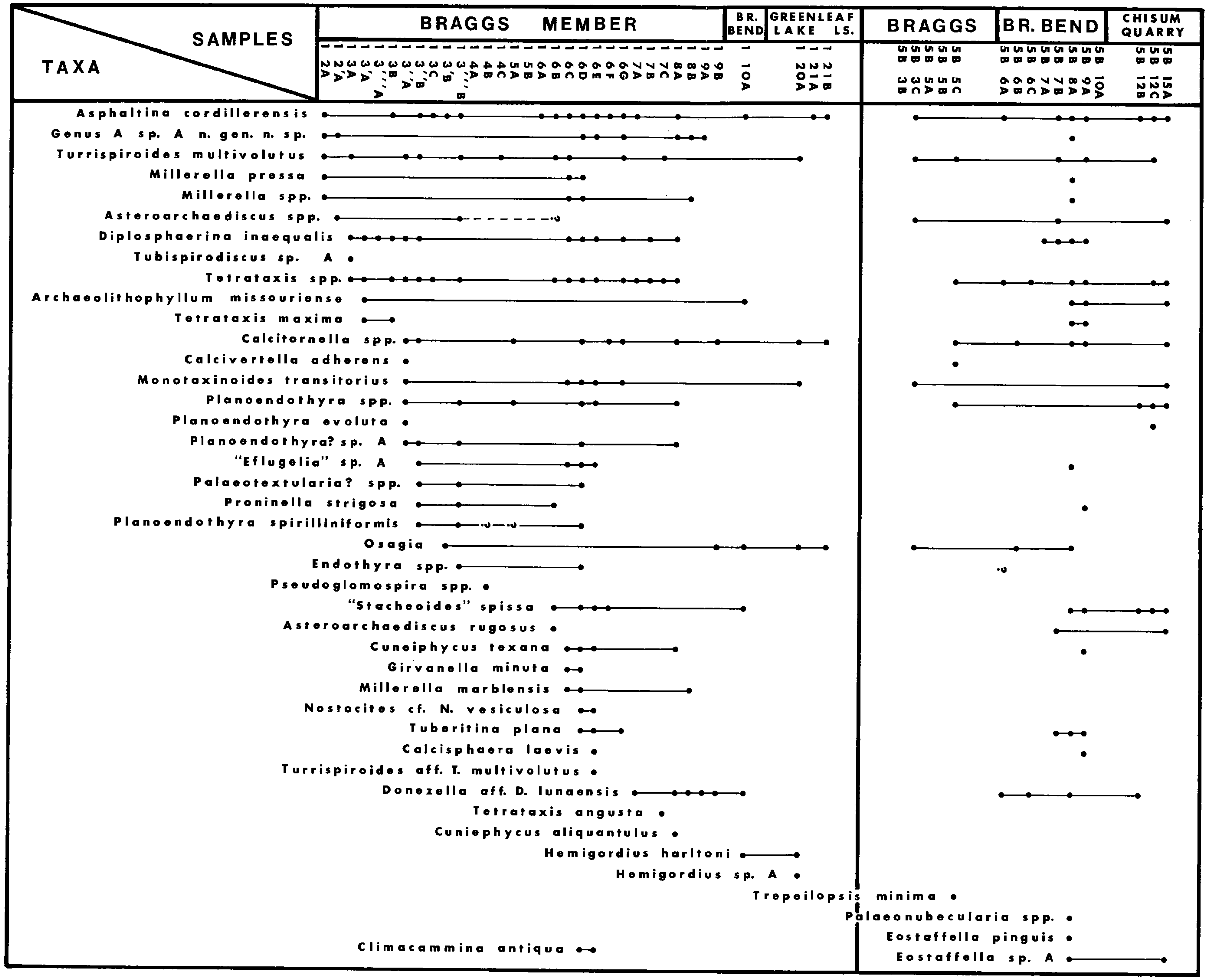


TABLE 2.—CHART SHOWING LOCAL RANGES OF CALCAREOUS MICROFOSSILS IN NORTHEASTERN OKLAHOMA

(Sample prefix 5B, Betsey Lee Creek locality; sample prefix 1, Webbers Falls Lock and Dam locality; Chisum Quarry Member of McCully Formation not collected at Webbers Falls Lock and Dam and not shown on range chart)



Genus **Trepeilopsis** Cushman and Waters, 1928a, *emend.* Browne and Pohl, 1973

Type species.—Turritellella grandis Cushman and Waters, 1927.

Description.—Test consists of a spherical proloculus followed by a tubular second chamber that is spirally coiled around a central host (typically a spine). The final portion of the tubular chamber may straighten and bend back across the previous coils. Wall is dark, microgranular calcite, undifferentiated. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—Plummer's (1945, p. 247) restudy of the type material of the type species of *Trepeilopsis* demonstrated that its wall is porcellaneous, not arenaceous as originally described (see Browne and Pohl, 1973, p. 214, and Rich, 1980, p. 47, for discussion). Accordingly, *Trepeilopsis* is distinguished from its arenaceous morphological analogue *Turritellella* Rhumbler and is a senior synonym of *Volvotextularia* Termier and Termier.

Trepeilopsis minima Dain, 1958

Pl. 1, fig. 11

Trepeilopsis mississippiana COOPER, 1947, (part), p. 87, pl. 20, figs. 36?, 37, 39; *not* 38, 40, 41.
Trepeilopsis grandis Cushman and Waters var. *minima* DAIN, *in* BYKOVA AND OTHERS, 1958, p. 11–12, pl. 1, fig. 13; BRAZHNIKOVA AND OTHERS, 1967, pl. 19, fig. 3.
Volvotextularia mississippiana (Cooper, 1947) MAMET, 1976, pl. 88, figs. 18–22; ARMSTRONG AND MAMET, 1977, p. 94, pl. 35, fig. 19.
"*Trepeilopsis*" spp. BRENCKLE, 1977, pl. 2, figs. 29, 30.
Trepeilopsis minima Dain, 1958. RICH, 1980, p. 47, pl. 21, figs. 35, 36, 39.

Description (n = 7).—The tubular chamber is initially irregularly coiled and then spirally coiled around a central host. The final portion may straighten and bend back across previous coils. Test length is 340 μm or more. Diameter of the final portion of the tubular chamber is 31–51 μm. Wall is undifferentiated microgranular calcite, 7–13 μm thick in the last coil. It appears dark reddish brown in transmitted light. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—The present specimens are assigned to *T. minima* on the basis of test length, tube diameter, and wall thickness. *Trepeilopsis minima* differs from *T. grandis* (Cushman and Waters) in its smaller size. Specimens that are probably conspecific with the present material have been described and illustrated as *Volvotextularia mississippiana* (Cooper) in Mamet (1976) and Armstrong and Mamet (1977). Although this species name would have priority over Dain's, examination of Cooper's type specimens demonstrates that the holotype (pl. 20, figs. 40, 41) and a paratype (pl. 20, fig. 38) belong to the questionable alga *Stacheia* Brady (P. L. Brenckle, personal communication, 1981). Cooper's other specimens with a true trepeilopsid coil are placed in Dain's species as shown in the synonymy.

Occurrence.—The species is present in the Brentwood Limestone and Dye Shale Members of the Bloyd Formation (table 1) and the Braggs Member of the Sausbee Formation (table 2).

It was first described from the upper Lower Carboniferous Beshevo Limestone (Protvin? Horizon), U.S.S.R., and has been reported from Chesterian to Atokan (= Derryan) rocks of Tennessee (Rich, 1980), the Canadian Cordillera (Mamet, 1976), and Alaska (Armstrong and Mamet, 1977).

Genus **Palaeonubecularia** Reitlinger, 1950

Pl. 1, figs. 5, 6

Type species.—Palaeonubecularia fluxa Reitlinger, 1950.

Description.—Test is typically encrusting; it consists of a spherical proloculus followed by a glomospirally coiled to meandering tubular second chamber. Wall is calcareous agglutinated with large adventitious grains, very thick. Aperture is a simple opening at the end of the second chamber.

Discussion.—*Palaeonubecularia* differs from *Pseudoglomospira* Bykova in having a thick agglutinated wall. *Pseudolituotuba* Vdovenko and *Vostokovella* Pronina are probably synonyms of *Palaeonubecularia.*

The material was not studied sufficiently for speciation.

Occurrence.—The genus occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Brewer Bend Limestone Member of the Sausbee Formation (table 2).

Family ENDOTHYRIDAE

Genus **Endothyra** Phillips, 1846, *emend.* Brady, 1876, *emend.* China, 1965

Pl. 2, figs. 6, 7

Type species.—Endothyra bowmani Phillips, 1846, *emend.* Brady, 1876, *emend.* China, 1965.

Description.—Test is discoidal, laterally compressed; it consists of a spherical proloculus followed by 3 or more mostly skew-coiled, involute volutions. The final volution may be nearly planispiral and partly evolute. Rate of expansion of the coil is moderate to rapid. Chambers are subquadratic to irregular and highly inflated. There are typically 6–12 chambers in the last volution. Septa are anteriorly directed, straight or slightly curved, of variable length. They may be thickened at their distal ends and (or) at the septal join. Secondary floor coverings and projections are weakly to very well developed. Wall is calcareous and consists of an original thin, dark layer underlain by a thicker, less dense layer, which are subsequently covered by secondary deposits. Aperture is a crescentic opening at the base of the last chamber.

Discussion.—*Endothyra* is one of the earliest described Carboniferous foraminifers. Several hundred species have been described under it, many of which are synonyms, and many of which have later been referred to other genera. As a result, taxonomic relations within the genus are highly confused, thus limiting their use for fine biostratigraphic subdivision. Mamet (*in* Armstrong and Mamet, 1977) provides an extensive discussion of *Endothyra*.

Endothyra is rare in the present material and was not studied sufficiently for speciation.

Occurrence.—The genus occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone Member of the Bloyd Formation (table 1). It also occurs in the Braggs Member of the Sausbee Formation and the Chisum Quarry Member of the McCully Formation (table 2).

Genus **Planoendothyra** Reitlinger, 1959

Type species.—*Endothyra aljutovica* Reitlinger, 1950.

Description.—Test is discoidal, laterally compressed, with a broadly rounded periphery. Initial volution is involute and highly skewed with respect to the outer planispiral, evolute volutions. Rate of expansion of the coil is very rapid. Chambers are mildly inflated to subglobular, typically very large. Septa are straight to slightly curved, anteriorly directed, relatively long, very slightly thickened at the join. Sutures between adjacent chambers are depressed. Wall is mostly homogeneous, dark, microgranular calcite, although it appears faintly layered in some specimens. Secondary floor coverings and lateral chamber fillings are weakly to very well developed. Aperture is a slit at the base of the last chamber.

Discussion.—The coiling distinguishes *Planoendothyra* from *Endothyra* Phillips, *emend.* Brady, *emend.* China, the latter of which is typically more or less involute and skew-coiled throughout. *Planoendothyra* differs from *Endostaffella* Rozovskaya in possessing well-developed endothyrid secondary deposits.

Planoendothyra spirilliniformis (Brazhnikova and Potievska, 1948)

Pl. 2, figs. 12–15

Endothyra spirilliniformis BRAZHNIKOVA AND POTIEVSKA, 1948, p. 97, pl. 5, figs. 2, 3.

Description (n = 5).—Mature test of 3½–4½ volutions is discoidal and slightly asymmetrically umbilicate. Periphery is broadly rounded in axial section, lobate in sagittal section. Diameter is 460–546 μm. Width is 195–234 μm. Width/diameter ratio is 0.42–0.48. Rate of expansion of the coil is very rapid. Height of the ultimate volution is 121–156 μm; 62–74 μm for the penultimate volution; 39–47 μm for the antepenultimate volution. Specimens of 3–3½ volutions have 7–9 chambers in the last whorl. Chambers are inflated to subglobular, relatively large. Septa are straight to slightly curved, anteriorly directed, slightly thickened at the join. Their length is one-half to one-third of chamber height. Wall is 12–15 μm thick in the last volution, mostly undifferentiated microgranular calcite. A thin, dark layer and lighter inner layer are faintly perceptible in some specimens. Secondary floor coverings and lateral chamber fillings are moderately well developed. Interior diameter of the proloculus is 20–25 μm. Aperture is a slit at the base of the last chamber.

Discussion.—*Planoendothyra spirilliniformis* differs from *P. evoluta* (Reitlinger) in its better developed secondary deposits, less evolute coil, and less compressed umbilical region. It is smaller and narrower than *P.*? sp. A described below.

Occurrence.—The species occurs in the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1) and in the Braggs Member of the Sausbee Formation (table 2). Questionable specimens were recovered from the Prairie Grove Member of the Hale Formation and the Dye Shale Member of the Bloyd Formation (table 1).

The species was first described from the Upper Bashkirian of the Donets Basin, U.S.S.R.

Planoendothyra evoluta (Reitlinger, 1950)

Pl. 2, figs. 8–10

Endothyra spirilliniformis Brazhnikova and Potievska var. *evoluta* REITLINGER, 1950, p. 36, pl. 6, fig. 9.

Description (n = 5).—Mature test of 3–4 volutions is discoidal and nearly symmetrically, deeply umbilicate. Periphery is very broadly rounded in axial section, lobate in sagittal section. Diameter is 359–437 μm. Width is 172–211 μm. Width/diameter ratio is 0.44–0.50. Initial volution is involute and highly skewed with respect to the outer planispiral, evolute volutions. Rate of expansion of the coil is very rapid. Height of the last volution is 105–125 μm; 59–74 μm for the penultimate volution; 39–43 μm for the antepenultimate volution. One specimen of 3½–4 volutions has 8 chambers in the last whorl. Chambers are inflated and relatively large. Septa are straight, anteriorly directed; their length is two-thirds or more of the chamber height. Wall is dark, microgranular calcite, undifferentiated, 12–15 μm thick in the last volution. Secondary deposits are weakly developed. Interior diameter of the proloculus is 20–25 μm. Aperture is a slit at the base of the last chamber.

Discussion.—Planoendothyra evoluta differs from *P. spirilliniformis* (Brazhnikova and Potievska) in having a more compressed umbilical region and more highly evolute outer whorls. It differs from *P.*? sp. A (described below) in its smaller size, weakly developed secondary deposits, more evolute coiling, and deep umbilici.

Occurrence.—The species occurs in the Brentwood Limestone Member of the Bloyd Formation and the Trace Creek Shale Member of the Atoka Formation (table 1). It also occurs in the Braggs Member of the Sausbee Formation and the Chisum Quarry Member of the McCully Formation (table 2).

It was originally described from the Lower Bashkirian of the southern Timan Upland, Komi A.S.S.R., U.S.S.R.

Planoendothyra? sp. A

Pl. 2, fig. 11; pl. 3, figs. 1, 2

Description (n = 5).—Mature test of 3½–4½ volutions is broadly discoidal, asymmetrically umbilicate, with a very broadly rounded periphery. Diameter is 441–604 μm. Width is 242–312 μm. Width/diameter ratio is 0.48–0.55. Initial 1–2 volutions are involute and strongly skew-coiled with respect to the outer volutions, which are nearly planispiral and partially evolute. The final half volution is offset laterally, which results in pronounced asymmetry of the test. Rate of expansion of the coil is very rapid. Height of the ultimate volution is 148–230 μm; 66–94 μm for the penultimate volution; 32–51 μm for the antepenultimate volution. Chambers are inflated, large, and relatively high. There are 7–9 in the last whorl. Septa are straight to slightly curved, anteriorly directed. Their length is two-thirds or more of the chamber height. Wall is mostly undifferentiated dark, microgranular calcite, 12–15 μm thick in the last volution. A thin, dark outer layer and a thicker, lighter inner layer are faintly perceptible in some specimens. Secondary floor coverings and lateral chamber fillings are well developed. Interior diameter of the proloculus is 20–27 μm. Aperture is a slit at the base of the last chamber.

Discussion.—The present species differs from *P. spirilliniformis* (Brazhnikova and Potievska) and *P. evoluta* (Reitlinger) in its larger size, larger width/diameter ratio, less evolute coiling, and asymmetrical final whorl. It is assigned with question to *Planoendothyra* because some specimens are only partially evolute in the final volution, and the coiling is more skewed in the final volutions than in typical *Planoendothyra*. The possibility exists that the species might belong in *Endothyra*.

Occurrence.—The species occurs in the Braggs Member of the Sausbee Formation (table 2). One specimen, assigned with question to the species, was recovered from the Prairie Grove Member of the Hale Formation (table 1).

Family ARCHAEDISCIDAE

Genus **Asteroarchaediscus** Miklukho-Maklay, 1956

Type species.—Archaediscus baschkiricus Krestovnikov and Theodorovich, 1936.

Description.—Test is discoidal to lenticular, with a rounded periphery, and consists of a spherical proloculus followed by a non-septate second chamber. Coiling is skewed and involute in the inner whorls, skewed or planispiral and involute to evolute in the outer whorls. The pattern of sutures between successive early whorls is characteristically "stellate" in axial section. Lumen is omega-shaped to subcrescentic, closed throughout the entire test or open in the final volution. Wall is single-layered, pseudofibrous calcite. Aperture is a simple opening at the end of the second chamber.

Discussion.—Some authors (e.g., Bozorgnia, 1973; Brenckle, 1973; Mamet, *in* Armstrong and Mamet, 1977) included in *Asteroarchaediscus* only those forms with completely closed lumina or with lumina open in the final volution but lower than the thickness of the surrounding wall. The concept of *Asteroarchaediscus* employed here is that of Browne and others (1977), who include in the genus forms with both completely closed lumina and open lumina (regardless of height) in the final whorl. As such, *Asteroarchaediscus* differs from *Neoarchaediscus* Miklukho-Maklay, which has an open lumen in the last few volutions.

Asteroarchaediscus is the most abundant archaediscid encountered in this study. Specimens assignable to the genus, but not sufficiently well oriented to permit speciation, are recorded in tables 1 and 2 as *Asteroarchaediscus* spp.

Asteroarchaediscus rugosus (Rauzer-Chernousova, 1948)

Pl. 3, figs. 3–7

See Browne and others, 1977, p. 209, for synonymy.

Description (n = 12).—Tests of 3½–4½ volutions are discoidal with rounded peripheries and straight-sided to slightly convex flanks. Diameter is 138–213 μm. Width is 60–93 μm. Width/diameter ratio is 0.35–0.53. Coiling is skewed throughout the entire test, involute in the inner whorls, evolute in the final 1½–2 whorls. Lumen is omega-shaped to subcrescentic, closed throughout the entire test or open only in the final half volution where it may be up to 25 μm high. Wall is 10–13 μm thick in the last volution. Interior diameter of the proloculus is up to 35 μm. Aperture is a low slit at the end of the second chamber.

Discussion.—*Asteroarchaediscus rugosus* is distinguished from *A. baschkiricus* (Krestovnikov and Theodorovich) by its smaller width/diameter ratio. Rich (1980) considered *A. rugosus* to be a junior synonym of *A. parvus* (Rauzer-Chernousova), citing minor differences in size as insufficient grounds for speciation, and placed the species within *Neoarchaediscus* Miklukho-Maklay. Both species satisfy the generic criteria of *Asteroarchaediscus* employed here, and they are maintained as separate species on the basis of differences in coiling. *Asteroarchaediscus rugosus* is skew-coiled throughout, whereas the final few volutions in *A. parvus* are planispiral. *Asteroarchaediscus rugosimilis* Brenckle and *A. gnomellus* Brenckle are both considered to be junior synonyms of *A. rugosus* (Browne and others, 1977; Brenckle, personal communication, 1981).

Occurrence.—The species is present in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone Member of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Chisum Quarry Member of the McCully Formation (table 2).

It was first described from the upper Lower Carboniferous Iagovkin Formation, central Kazakhstan, U.S.S.R., and has been reported elsewhere in North America from Chesterian and Morrowan rocks in Nevada (Brenckle, 1973), Kentucky (Browne and others, 1977), Arkansas (Brenckle, 1977), and the southeastern United States (Rich, 1980).

Genus **Neoarchaediscus** Miklukho-Maklay, 1956

Pl. 3, figs. 8, 9

Type species.—*Archaediscus incertus* Grozdilova and Lebedeva, 1954.

Description.—Test consists of a spherical proloculus followed by a non-septate second chamber. It is discoidal to lenticular with rounded periphery and straight-sided to convex flanks. Side thickenings are absent. Coiling is skewed and involute in the inner whorls, skewed to planispiral and evolute in the outer whorls. The pattern of sutures between successive early whorls is characteristically "stellate" in axial section. Lumen is subcrescentic to semicircular, closed in the inner whorls, open in the final 1½ or more whorls. Wall is single-layered, pseudofibrous calcite. Aperture is a simple opening at the end of the second chamber.

Discussion.—*Neoarchaediscus* differs from *Asteroarchaediscus* Miklukho-Maklay, which has a completely closed lumen or open lumen only in the final volution; and from *Hemiarchaediscus* Miklukho-Maklay, which has a completely open lumen. Specimens of *Planospirodiscus* Sosipatrova may have closed then open lumina, but they differ from *Neoarchaediscus* in their planispiral coiling.

Few specimens assignable to *Neoarchaediscus* were recovered in this study. They are not suitably oriented to permit speciation.

Occurrence.—*Neoarchaediscus* spp. occur in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone Member of the Bloyd Formation (table 1).

Genus **Planospirodiscus** Sosipatrova, 1962

Type species.—*Planospirodiscus tajmyricus* Sosipatrova, 1962.

Description.—Test consists of a spherical proloculus followed by a planispirally coiled, evolute, non-septate second chamber. It is discoidal with rounded periphery and concave, straight-sided, or slightly convex flanks. Side thickenings are absent. Lumen is a subcrescentic low opening in all volutions except the initial one, where it may be closed. Its height in the last volution is less than the thickness of the surrounding wall. The wall is single-layered, pseudofibrous calcite. Aperture is a simple opening at the end of the second chamber.

Discussion.—*Planospirodiscus* differs from *Hemiarchaediscus* Miklukho-Maklay in its planispiral coiling, and from *Tubispirodiscus* Browne and Pohl in its low lumen and lack of depressed sutures in the outer whorls.

Planospirodiscus? sp. A

Pl. 3, fig. 12

Description (n = 1).—Test of 4 volutions is narrowly discoidal with rounded periphery and slightly convex flanks. Diameter is 275 µm. Width is 85 µm. Width/diameter ratio is 0.31. Coiling is slightly turned in the initial volution, planispiral and evolute in the outer volutions. Lumen is semicircular, closed in the initial volution, open in the outer volutions. Its height is 28 µm in the last whorl. Wall is 10 µm thick in the last volution. Interior diameter of the proloculus is 48 µm. Aperture was not observed.

Discussion.—The present specimen is assigned with question to *Planospirodiscus* because of its high lumen in the last volution. There is insufficient material for comparison.

Occurrence.—The specimen was recovered from the Brentwood Limestone Member of the Bloyd Formation (table 1).

Genus **Tubispirodiscus** Browne and Pohl, 1973

Type species.—*Tubispirodiscus simplissimus* Browne and Pohl, 1973.

Description.—Test is narrowly discoidal, composed of a spherical proloculus followed by a nonseptate second chamber. Flanks are straight-sided, without thickenings. Periphery is broadly rounded. Second chamber is planispirally coiled and evolute throughout the entire test. Sutures are slightly depressed in the outer volutions. Lumen is relatively high and open throughout the entire test. Its floor is flat or slightly convex. Wall is undifferentiated pseudofibrous calcite. Aperture is a semicircular opening at the end of the second chamber.

Discussion.—The distinctive features of *Tubispirodiscus* are its planispiral evolute coil and high, open lumen. These features distinguish the genus from *Planospirodiscus* Sosipatrova, which is planispiral with a very low, slit-like lumen.

Tubispirodiscus sp. A

Pl. 3, fig. 13

Description (n = 1).—Test is narrowly discoidal, evolute, and has 3½ planispirally coiled volutions. Diameter is 273 μm. Width is 78 μm. Width/diameter ratio is 0.28. Periphery is broadly rounded. Sutures are slightly depressed in outer volutions. Flanks are straight-sided, without thickenings. Lumen is semicircular to subcrescentic, open throughout the entire test, 38 μm high in the last volution. Wall is 10–13 μm thick in the last volution, slightly thicker in the penultimate volution. Interior diameter of the proloculus is 38 μm. Aperture was not observed.

Discussion.—Despite having fewer volutions, the present specimen is significantly larger than mature specimens of *Tubispirodiscus simplissimus* Browne and Pohl.

The lumen and proloculus of the specimen are lined with a reddish-brown secondary deposit, which should not be confused with an inner, dark, microgranular wall layer.

Occurrence.—The specimen was recovered from the Braggs Member of the Sausbee Formation (table 2).

Genus **Hemiarchaediscus** Miklukho-Maklay, 1957

Type species.—*Hemiarchaediscus planus* Miklukho-Maklay, 1957.

Description.—Test is discoidal to lenticular, composed of a spherical proloculus followed by a non-septate second chamber. Periphery is broadly rounded. Flanks are straight-sided to convex, without thickenings. Coiling is skewed and involute in the inner whorls, skewed to nearly planispiral and evolute in the outer whorls. Lumen is subcrescentic to semicircular, open throughout the entire test. Wall is single-layered calcite. Aperture is a semicircular opening at the end of the second chamber.

Discussion.—The concept of *Hemiarchaediscus* employed here is that of Browne and others (1977, p. 188–190), which includes in the genus forms that otherwise resemble *Archaediscus* Brady but lack an inner, dark wall layer. The validity of *Hemiarchaediscus* is unclear, owing to confusion surrounding the nature of the wall in *H. planus* Miklukho-Maklay, type species of the genus.

Hemiarchaediscus sp. A

Pl. 3, fig. 14

Description (n = 1).—Test of 3½ volutions is discoidal with broadly rounded periphery and straight-sided flanks. Diameter is 178 μm. Width is 73 μm. Width/diameter ratio is 0.41. Coiling is skewed throughout the entire test and mostly evolute. Lumen is semicircular, open throughout the entire test. Its height is 18 μm in the last volution. Wall is 7–10 μm thick in the last volution. Interior diameter of the proloculus is 28 μm.

Discussion.—The present specimen is assigned to *Hemiarchaediscus* because of its single-layered wall and completely open lumen. There is insufficient material for comparison.

Occurrence.—The specimen was recovered from the Prairie Grove Member of the Hale Formation (table 1).

Family BISERIAMMINIDAE

Genus **Biseriella** Mamet, *in* Armstrong and Mamet, 1974

Pl. 3, figs. 10, 11

Type species.—*Globivalvulina parva* Chernysheva, 1948.

Description.—Test is roughly hemispherical, composed of a spherical proloculus followed by a biserial, trochospiral succession of inflated chambers. Chamber size expands very rapidly. The final few chambers may be nearly uncoiled. Wall is undifferentiated dark, microgranular calcite. Aperture is a slit at the base of the last chamber.

Discussion.—Mamet (*in* Armstrong and Mamet, 1974, p. 660) stated that *Biseriella* links *Biseriammina* Chernysheva and *Globivalvulina* Schubert phylogenetically. *Biseriella* differs from *Biseriammina* in its loose trochospiral coil and from *Globivalvulina* in its undifferentiated wall.

Only three specimens were recovered. The paucity of material precludes speciation.

Occurrence.—The specimens were recovered from the uppermost Prairie Grove Member of the Hale Formation and the basal Brentwood Limestone Member of the Bloyd Formation (table 1).

Family EOSTAFFELLIDAE

Genus **Eostaffella** Rauzer-Chernousova, 1948

Type species.—*Staffella* (*Eostaffella*) *parastruvei* Rauzer-Chernousova, 1948.

Description.—Test is discoidal to lenticular, typically biumbilicate. Coiling is involute and generally planispiral throughout. Periphery is rounded to subangular in axial section, smooth in sagittal section. Rate of expansion of the coil is moderate. Chamber shape is subquadratic. Septa are long, straight, normal to the wall or slightly anteriorly directed. Wall is calcareous, three-layered: it consists of a primary thin, dark layer and a thicker, light inner layer, which are overlain by a light secondary layer in the inner volutions. Pseudochomata or chomata are weakly to very well developed. Aperture is a slit at the base of the last chamber.

Discussion.—*Eostaffella* is distinguished from *Millerella* Thompson by its completely involute coiling and straight septa. It differs from *Eostaffellina* Reitlinger, which has a very broadly rounded axial outline; from *Mediocris* Rozovskaya, which has dense secondary fillings in the umbilical region; and from *Endostaffella* Rozovskaya, which is strongly skew-coiled in the initial volution, partly evolute in some cases, and has poorly developed secondary deposits.

Thompson (1951) erected *Paramillerella* to include involute forms previously assigned to *Millerella*. As such, most species of *Paramillerella* belong to *Eostaffella* (see Brenckle, 1973, p. 74–75, for discussion).

Eostaffella pinguis (Thompson, 1944)

Pl. 4, figs. 1, 2

Millerella pinguis THOMPSON, 1944, p. 425–427, pl. 1, figs. 18, 19, 20?

Paramillerella pinguis (Thompson). THOMPSON, 1951, pl. 13, fig. 18.

Eostaffella cf. *E. pinguis* (Thompson, 1944). BRENCKLE, 1973, p. 75, pl. 10, fig. 29.

Description (n = 4).—Mature test of 4½–5 volutions is broadly discoidal, symmetrically umbilicate, completely involute. Diameter is 396–584 μm. Width is 179–254 μm. Width/diameter ratio is 0.42–0.50. Periphery is broadly rounded to subrounded in axial section. Height of the last volution is 78–137 μm; 55–82 μm in the penultimate volution; 35–47 μm in the antepenultimate volution. Wall is 10–12 μm thick in the last volution. Chomata/pseudochomata are well developed. Interior diameter of the proloculus is 20–30 μm.

Discussion.—No well-oriented sagittal specimens were recovered. Consequently, observations on the nature of the chambers, septa, and aperture cannot be given.

Eostaffella pinguis differs from other representatives of the genus encountered in this study in its rounded to subrounded periphery.

Occurrence.—The species was originally described from the Brentwood Limestone Member of the Bloyd Formation at Hale Mountain, Arkansas. It was not recovered from the Brentwood in this study. Specimens were recovered from the Prairie Grove Member of the Hale Formation (table 1) and the Brewer Bend Limestone Member of the Sausbee Formation (table 2).

The species has been reported elsewhere in North America from the Morrowan Ely Formation of east-central Nevada (Brenckle, 1973).

Eostaffella sp. A

Pl. 4, figs. 8–12

Description (n = 5).—Mature test of 4–5½ volutions is discoidal, rhombiform, planispirally coiled, slightly umbilicate. Specimens with 4–4½ volutions are completely involute with angular to subangular periphery. The final half volution is partially evolute and subrounded in one (unfigured) specimen with 5 volutions. Diameter is 495–693 μm. Width is 203–254 μm. Width/diameter ratio is 0.37–0.53. Height of the last volution is 110–144 μm; 74–98 μm in the penultimate volution; 39–59 μm in the antepenultimate volution. One poorly oriented specimen has 21 chambers in the last volution; 19 in the penultimate volution; 13 in the antepenultimate volution. Wall is 10–12 μm thick in the last volution. Chomata/pseudochomata are very well developed. Interior diameter of the proloculus is 20–39 μm. Aperture was not observed.

Discussion.—*Eostaffella* sp. A differs from *E. pinguis* and *E.* sp. B in its rhombiform shape, angular to subangular periphery, and better developed chomata/pseudochomata.

Occurrence.—The species occurs in the Brewer Bend Limestone Member of the Sausbee Formation and the Chisum Quarry Member of the McCully Formation (table 2).

Eostaffella sp. B

Pl. 4, figs. 6, 7

Description (n = 5).—Mature test of 4½–5 volutions is discoidal, planispirally coiled, involute, weakly umbilicate. Diameter is 378–426 μm. Width is 125–160 μm. Width/diameter ratio is 0.32–0.41. Periphery is subangular in axial section. Height of the last volution is 78–105 μm; 47–62 μm in the penultimate volution; 31–51 μm in the antepenultimate volution. Wall is 7–8 μm thick in the last volution. Chomata/pseudochomata are moderately well developed. Interior diameter of the proloculus is 20–27 μm.

Discussion.—Comparison with *Eostaffella* sp. B is given in the discussions under *E. pinguis* and *E.* sp. A.

No sagittally oriented specimens were recovered.

Occurrence.—The species occurs in the Kessler Limestone Member of the Bloyd Formation (table 1).

Family EOSTAFFELLIDAE?

Genus **Millerella** Thompson, 1942

Type species.—Millerella marblensis Thompson, 1942.

Description.—Test is discoidal, consisting of a spherical proloculus followed by several nearly planispirally coiled volutions. Mature specimens (i.e., 4½ or more volutions) are evolute or partly evolute in the final 2 or more volutions. Periphery is rounded to subangular in axial section, smooth in sagittal section. Test is symmetrically umbilicate. Rate of expansion of the coil is moderate to moderately rapid. Chambers are subquadratic, typically higher than wide. Septa are long, curved, anteriorly directed. Wall is calcareous, three-layered; it consists of a primary thin, dark layer and a thicker, light inner layer, which are overlain by a light secondary layer in the inner volutions. Chomata are weakly to very well developed. Aperture is a small opening at the base of the last chamber.

Discussion.—Millerella is distinguished from *Eostaffella* Rauzer-Chernousova (=*Paramillerella* Thompson, part) by its evolute outer volutions and curved septa. Some authors (e.g., Dunbar, 1963; Douglass, 1977) have suggested that *Millerella* and *Eostaffella* may be synonyms. I do not share this view, but juvenile specimens (i.e., those having 4 or fewer volutions) of *Millerella* and *Eostaffella* may be impossible to distinguish from one another, especially in axial view. *Millerella* differs from *Ozawainella* Thompson in its rounded to subangular periphery and evolute outer volutions.

According to Mamet and Skipp (1970) and Mamet (1975), *Millerella sensu stricto* first occurs in the Pennsylvanian of North America, and most of the species assigned to *Millerella* from the Chesterian (see Cooper, 1947; Zeller, 1953) belong within *Eostaffella* or "*Zellerina*" (Mamet and Skipp, 1970; Armstrong and Mamet, 1977). Nevertheless, true *Millerella* does occur in Chesterian rocks (Brenckle, 1977, p. 75, pl. 3, figs. 16–20; Baxter and Brenckle, 1981; Brenckle and Groves, 1981), and using the presence of the genus as an indicator of the Pennsylvanian is erroneous.

Skinner and Wilde (1954, pl. 49, fig. 3) illustrated one specimen of *Millerella marblensis* Thompson with a coarsely perforate wall from the Atoka Formation of Coal County, Oklahoma. It is noteworthy that among the present specimens, many of which are excellently preserved, none shows any trace of perforations, nor is a perforate wall illustrated or mentioned in other published works on *Millerella* (e.g., Moore, 1964). Examination of the type material of *M. marblensis* from the Marble Falls Formation of Texas also failed to demonstrate wall perforations. I believe that the pores in Skinner and Wilde's specimen may be the result of post-depositional dissolution or other alteration and that a perforate wall should not be considered characteristic of the genus until such time as it is shown definitively in well-preserved material.

The systematic position of *Millerella* is unclear. Thompson (1948, p. 26–27) placed *Millerella* in the subfamily Ozawainellinae Thompson and Foster and subsequently (Thompson, *in* Loeblich and Tappan, 1964, p. C394) elevated Ozawainellinae to family rank within the superfamily Fusulinacea von Möller. *Millerella* is here placed with question in the family Eostaffellidae Mamet on the basis of its three-layered eostaffellid wall and basal aperture. It clearly should not be retained within the Fusulinacea, all the members of which have perforate antethecae rather than basal apertures (Thompson, *in* Loeblich and Tappan, 1964, p. C394).

Millerella marblensis Thompson, 1942

Pl. 4, figs. 13–17; pl. 5, fig. 10?

Millerella marblenis THOMPSON, 1942, p. 405–407, pl. 1, figs. 4, 5, 7, 8?, 9?, 10?, 11–13; THOMPSON, 1944, p. 420–423, pl. 1, figs. 1, 3, 4, pl. 2, figs. 1, 2, 4?, 5?, 7, 8, 14?; THOMPSON, 1948, p. 76, pl. 2, fig. 2, pl. 23, figs. 1, 5, 7, 19?, 26, 30?, 31, pl. 24, figs. 2, 3, 5; THOMPSON, 1951, pl. 13, fig. 17, pl. 14, figs. 3, 4?, 5; SKINNER AND WILDE, 1954, pl. 49, fig. 3; RICH, 1961, pl. 142, figs. 1, 6, 7?, 8?; SLADE, 1961, p. 60, pl. 7, fig. 3?; MOORE, 1964, p. 298–305, pl. 47, figs. 1–24, pl. 48, figs. 1–23; THOMPSON, *in* LOEBLICH AND TAPPAN, 1964, fig. 298–4a; ROSS AND SABINS, 1965, p. 183–184, pl. 21, fig. 21?; CASSITY AND LANGENHEIM, 1966, p. 941, pl. 110, fig. 4?; MARSHALL, 1969, p. 112, pl. 1, figs. 1–5; NODINE-ZELLER, 1977, pl. 2, figs. 1, 2, 26?, pl. 3, fig. 1?.

Millerella sp. aff. *M. marblensis* Thompson. MARSHALL, 1969, p. 113–114, pl. 1, fig. 14.

?*Millerella marblensis robusta*, n. subsp. MARSHALL, 1969, p. 113, pl. 1, figs. 6–13.

Millerella cf. *marblensis* Thompson. KING, 1973, p. 13, pl. 1, figs. 1, 2, 5, 6?, 7–9.

Millerella cf. *M. marblensis* Thompson. NODINE-ZELLER, 1977, pl. 1, fig. 19?, pl. 2, fig. 25.

Description (n = 12).—Mature test of 4½–5½ volutions is narrowly discoidal, symmetrically umbilicate, planispirally coiled. The final 1–1½ volutions are highly evolute. Diameter is 480–632 μm. Width is 121–195 μm. Width/diameter ratio is 0.24–0.33. Periphery is rounded to subrounded in axial section, smooth in sagittal section, typically inflated in the last half volution. Height of the last volution is 101–137 μm; 62–90 μm in the penultimate volution; 43–62 μm in the antepenultimate volution. Chambers are subquadratic, much higher than wide. One sagittally oriented specimen (assigned with question to the species) has 21 chambers in the last volution, 17 in the penultimate volution, 13 in the antepenultimate volution. Septa are curved anteriorly, and their length is nearly equal to chamber height. Wall is 7–13 μm thick in the last volution. Chomata are weakly developed. Interior diameter of the proloculus is 27–39 μm. Aperture is a low opening at the base of the last chamber.

Discussion.—Considerable confusion is reflected in many authors' concepts of *M. marblensis*. This is due, at least in part, to the wide variety of morphotypes originally figured by Thompson (1942). Some of the figured paratypes may not be congeneric with *Millerella* as presently interpreted (pl. 1, figs. 6, 10). Later works by Thompson (1944, p. 425; Thompson, *in* Loeblich and Tappan, 1964, fig. 294; Thompson, 1948, text-fig. 2) more clearly expressed his concept of the species, but they have been largely overlooked. The concept of *M. marblensis* employed here includes forms that are relatively narrow, evolute in the final 1–1½ volutions, with rounded to subrounded periphery. As such, *M. marblensis* differs from *M. pressa* Thompson, which is only partially evolute in the last volution, with subrounded to subangular periphery. Sagittally oriented specimens of *marblensis* and *pressa* may be impossible to distinguish from one another in samples that contain both species, as is the case in this study. *Millerella marblensis* differs from *M. extensa* Marshall, which is smaller and narrower.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and in the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs Member of the Sausbee Formation (table 2).

Millerella marblensis was first described from the Atokan (=Derryan) part of the Marble Falls Formation of central Texas. It is widely distributed in Lower and Middle Pennsylvanian rocks in central and western North America.

Millerella pressa Thompson, 1944

Pl. 4, fig. 4; pl. 5, figs. 1?, 2–5

Millerella pressa THOMPSON, 1944, p. 423–425, pl. 2, figs. 16–20, 22, 23; THOMPSON, 1948, pl. 2, fig. 1; THOMPSON, *in* LOEBLICH AND TAPPAN, 1964, fig. 298–4c; MAMET, *in* ARMSTRONG AND MAMET, 1977, p. 90, pl. 35, figs. 1?, 2?; NODINE-ZELLER, 1977, pl. 3, fig. 18.

Millerella marblensis Thompson. RICH, 1961, pl. 142, fig. 2 (only); ROSS AND SABINS, 1965, pl. 21, figs. 18, 22?, 24?, 26, 27 (only).

Millerella sp. cf. *M. pressa* Thompson. NODINE-ZELLER, 1977, pl. 3, fig. 10?.

Millerella sp. NODINE-ZELLER, 1977, pl. 1, figs. 10–12, 13?, 18?, pl. 2, fig. 12?, pl. 3, fig. 2.

Description (n = 10).—Mature test of 4½–5 volutions is discoidal, symmetrically umbilicate, planispirally coiled. The final 1–1½ volutions are partly evolute. Diameter is 449–674 μm. Width is 140–195 μm. Width/diameter ratio is 0.31–0.38. Periphery is subrounded to subangular in axial section, smooth in sagittal section. Height of the last volution is 94–156 μm; 59–105 μm in the penultimate volution; 39–59 μm in the antepenultimate volution. Chambers are subquadratic, much higher than wide. Three sagittal specimens (assigned with question to the species) have 18–21 chambers in the last volution, 16–20 in the penultimate volution, 13–16 in the antepenultimate volution. Septa are curved anteriorly, and their length is nearly equal to chamber height. Wall is 7–13 μm thick in the last volution. Chomata are weakly developed. Interior diameter of the proloculus is 23–43 μm. Aperture is a low opening at the base of the last chamber.

Discussion.—*Millerella pressa* differs from *M. marblensis* Thompson in its less evolute coil and more angular periphery. The species is larger, wider, and less evolute than *M. extensa* Marshall. It is the most abundant representative of the genus encountered in this study.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone Member of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation (table 2).

The species has been reported from Morrowan and Atokan (=Derryan) rocks in Nevada (Rich, 1961), Alaska (Armstrong and Mamet, 1977), and Arizona (Ross and Sabins, 1965). The type material of the species was described from the subsurface Morrowan part of the Kearny Formation of western Kansas.

Millerella aff. **M. pressa** Thompson, 1944

Pl. 4, figs. 3, 5

Description (n = 3).—Mature test of 4½–5 volutions is discoidal, deeply umbilicate, and planispirally coiled with slight asymmetry in the initial volution. Diameter is 465–515 μm. Width is 178–198 μm. Width/diameter ratio is 0.35–0.43. Periphery is subangular in axial section. Height of the last volution is 109–137 μm; 47–70 μm in the penultimate volution; 35–39 μm in the antepenultimate volution. Wall is 10–15 μm thick in the last volution. Chomata are moderately well developed. Interior diameter of the proloculus is 27 μm.

Discussion.—The present specimens differ from those assigned to *M. pressa* Thompson in their slightly greater width/diameter ratio and apparently depressed umbilici. Partial recrystallization of their umbilical regions precludes positive determination.

No sagittally oriented specimens were recovered.

Occurrence.—All the specimens were recovered from the Brentwood Limestone Member of the Bloyd Formation (table 1).

Millerella cf. **M. extensa** Marshall, 1969

Pl. 5, figs. 6–9

Millerella extensa MARSHALL, 1969, p. 116–117, pl. 1, figs. 25–27.

Millerella extensus KING, 1973, p. 13–14, pl. 1, figs. 10–23.

Description (n = 6).—Mature test of 3½–4½ volutions is discoidal, symmetrically umbilicate, planispirally coiled. The final volution is moderately to highly evolute. Diameter is 257–339 μm. Width is 78–105 μm. Width/diameter ratio is 0.30–0.31. Periphery is subrounded to subangular in axial section, smooth in sagittal section. Height of the last volution is 51–74 μm; 35–51 μm in the penultimate volution; 23–35 μm in the antepenultimate volution. Chambers are subquadratic, slightly higher than wide. There are 17–18 chambers in the last volution, 15–16 in the penultimate volution, 12–13 in the antepenultimate volution. Septa are slightly curved, and their length is nearly equal to chamber height. Wall is 5–8 μm thick in the last volution. Chomata are weakly developed. Interior diameter of the proloculus is 20–27 μm. Aperture is a low opening at the base of the last chamber.

Discussion.—Millerella extensa resembles *M. marblensis* Thompson in shape but is smaller and narrower. King (1973) named *M. extensus* from collections from the type Derryan of New Mexico and the Marble Falls Formation of central Texas. His species is here considered to be a junior synonym of *M. extensa* Marshall. The present specimens are similar to both Marshall's and King's material but are smaller.

Occurrence.—The species occurs in the upper part of the Brentwood Limestone Member of the Bloyd Formation and the Trace Creek Shale Member of the Atoka Formation (table 1).

The type material of the species was described from the Derryan (= Atokan) Bird Spring Formation of southern Nevada. The only other reported occurrences are King's specimens from New Mexico and Texas.

Family TETRATAXIDAE

Genus **Tetrataxis** Ehrenberg, 1854

Type species.—Tetrataxis conica Ehrenberg, 1854, *emend.* Nestler, 1973.

Description.—Test is conical, composed of a spherical proloculus followed by several trochospirally coiled volutions. There are four chambers per volution. Chambers are elongate, nearly crescent-shaped in axial section, with an apertural flap that projects into the umbilical cavity. Flanks are straight-sided to convex, rarely concave. Apex is generally angular. Sutures between adjacent chambers are depressed. Wall is calcareous, two-layered: it consists of a dark, inner, microgranular layer and a yellowish, pseudofibrous outer layer. The pseudofibrous outer layer is restricted to the ventral part of each chamber and is well developed in the umbilical region. Aperture is a slit-like opening into the umbilicus, covered ventrally by the apertural flap.

Discussion.—Tetrataxis differs from *Polytaxis* Cushman and Waters in possessing fewer chambers per volution and from *Pseudotaxis* Mamet in its two-layered wall.

Tetrataxis is speciated by dimensions and apical angle, which can be accurately measured only in perfect axial sections. Many species have been described from poorly oriented sections, and the genus is grossly over-speciated (Mamet, *in* Armstrong and Mamet, 1977, p. 97). Only mature, well-oriented specimens were speciated in this study. Occurrences of other specimens are recorded in tables 1 and 2 as *Tetrataxis* spp.

Tetrataxis maxima Schellwien, 1898

Pl. 5, figs. 11–13

Tetrataxis maxima SCHELLWIEN, 1898, p. 274, pl. 24, figs. 5–10.

Description (n = 4).—Test has 6–9 volutions. Diameter is 1.08–1.39 mm. Height is 0.44–0.59 mm. Height/diameter ratio is 0.37–0.46. Apical angle is 101–125°. Flanks are straight-sided to slightly convex. The inner, dark wall layer is 12–20 μm thick, and the outer, pseudofibrous layer is 31–40 μm thick in the umbilical region.

Discussion.—The present specimens are slightly flatter, but otherwise they fall well within the range of variation of the type material. *Tetrataxis maxima* is distinguished from most other species of the genus by its large size and large apical angle.

Occurrence.—The species is present in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone Member of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation (table 2).

The type material of the species was described from the Upper Carboniferous of the Carnic Alps.

Tetrataxis angusta Vissarionova, 1948

Pl. 5, fig. 16

See Armstrong and Mamet, 1977, p. 97, for synonymy.

Description (n = 1).—Test has 7–8(?) volutions. Diameter is 0.76 mm. Height is 0.54 mm. Height/diameter ratio is 0.72. Apical angle is 58°. Flanks are straight-sided to slightly convex. Apertural flaps are weakly developed. The inner, microgranular wall layer is 12 μm thick, and the outer, pseudofibrous layer is 12 μm thick.

Discussion.—Tetrataxis angusta differs from *T.*

maxima Schellwien in its smaller size and steeper cone.

Occurence.—The specimen was recovered from the Braggs Member of the Sausbee Formation (table 2).

The species was originally described from the lowermost Moscovian (Middle Carboniferous) of the southern part of the Moscow Basin, U.S.S.R. *Tetrataxis* specimens of the group *T. angusta* (i.e., *T. acutus* Durkina; *T. gigas* Brazhnikova; *T. submedia* Brazhnikova) have been reported elsewhere in North America from Meramecian through Morrowan rocks in Alaska (Armstrong and Mamet, 1977) and Nevada (Brenckle, 1973).

Family PALAEOTEXTULARIIDAE

Genus **Palaeotextularia** Schubert, 1921

Type species.—*Palaeotextularia schellwieni* Galloway and Ryniker, 1930, by designation.

Description.—Test is rectilinear, tapered. It consists of a spherical proloculus followed by a series of biserially arranged, inflated chambers. Sutures between chambers are deeply depressed. Wall consists of an inner, yellowish, pseudofibrous layer and an outer, dark, microgranular layer that contains adventitious grains. Septa are long, curved, thickened at their distal ends. Aperture is a low crescentic slit at the base of the last chamber.

Discussion.—*Palaeotextularia* differs from *Cribrostomum* Möller, which has a cribrate aperture; from *Climacammina* Brady, which is biserial then uniserial with a cribrate aperture; and from *Deckerella* Cushman and Waters, which is biserial then uniserial with a double slit aperture.

Palaeotextularia? sp.

Pl. 5, fig. 17

Discussion.—The biserial parts of *Climacammina* and *Deckerella* and the early part of *Cribrostomum* may be impossible to distinguish from *Palaeotextularia.* Accordingly, the present specimens are assigned with question to the genus, and no attempt to speciate them was made.

Occurrence.—Three specimens were recovered from the Braggs Member of the Sausbee Formation (table 2).

Genus **Climacammina** Brady, *in* Etheridge, 1873

Type species.—*Textularia antiqua* Brady, *in* Young and Armstrong, 1871, *emend.* Cummings, 1956.

Description.—Test consists of a spherical proloculus followed by a biserial then uniserial succession of chambers. Biserial stage is tapered, subconical, with inflated chambers. Uniserial stage is roughly cylindrical with at least two flattened, slightly inflated chambers. Sutures between adjacent chambers are depressed. Wall is composed of an inner, yellowish, pseudofibrous layer and an outer, dark, microgranular layer that contains adventitious grains. Aperture is cribrate.

Discussion.—*Climacammina* differs from the morphologically similar genus *Koskinobigenerina* Eickhoff in its two-layered wall; from *Deckerella* Cushman and Waters in its cribrate aperture; and from *Cribrostomum* Möller in its biserial then uniserial arrangement of chambers. Immature specimens cannot be distinguished from *Palaeotextularia* Schubert.

Climacammina antiqua
(Brady, *in* Young and Armstrong, 1871),
emend. Cummings, 1956

Pl. 5, figs. 14, 15

See Rich, 1980, p. 16, for synonymy.

Description (n = 5).—Test consists of the proloculus followed by 15–19 biserially arranged and 3–8 uniserially arranged chambers. Length is 1.81–2.93 mm. Width is 0.72–0.84 mm. Biserially arranged chambers are inflated, separated by long, curved septa that are thickened at their distal ends. Uniserially arranged chambers are flattened, nearly discoidal. Inner pseudofibrous wall layer is 15–28 μm thick. Outer, microgranular layer is 39–70 μm thick. Wall is significantly thicker in the apertural region. Aperture is cribrate.

Discussion.—*Climacammina antiqua* differs from *Climacammina* of the group *C. moelleri* Reitlinger in its smaller width/length ratio. Species included in the latter group are relatively squat, broad forms. *Cimacammina magna* Roth and Skinner, described from the Pennsylvanian McCoy Formation of Colorado, is probably conspecific with the present specimens.

Occurrence.—The species is present in the Prairie Grove Member of the Hale Formation and the Braggs Member of the Sausbee Formation (tables 1, 2).

The species was originally described from the Lower Limestone Group (Lower Carboniferous) of Scotland. It has been reported elsewhere in North America from Chesterian rocks in the southeastern United States (Rich, 1980) and the Pennsylvanian of Colorado (Roth and Skinner, 1930).

Family LASIODISCIDAE

Genus **Eolasiodiscus** Reitlinger, 1956

Type species.—*Eolasiodiscus donbassicus* Reitlinger, 1956.

Description.—Test consists of a spherical proloculus followed by a tubular second chamber. Coiling is evolute, nearly planispiral to slightly trochospiral. Sutures between adjacent whorls are slightly depressed. Tubular chamber is semicircular to sub-crescentic in axial section. Wall is calcareous, two-layered; it consists of an inner, dark, microgranular layer and an outer, pseudofibrous layer. An umbilical filling is formed on the ventral side of the test. Primary aperture is a simple opening at the end of the tubular chamber. Supplementary apertures are tiny slit-like openings along the sutures on the dorsal surface of the test.

Discussion.—Eolasiodiscus is distinguished from *Monotaxinoides* Brazhnikova and Yartseva by its supplementary apertures, and from *Turrispiroides* Reitlinger by its supplementary apertures and two-layered wall. Browne and Pohl (1973, p. 207) suggested that the seeming presence of supplementary apertures may be an artifact of sagittal orientation of specimens in thin sections, and they placed *Eolasiodiscus* in synonymy with *Monotaxinoides*. Their interpretation is not followed here, since several sagittally oriented specimens were recovered that do not show traces of supplementary apertures. Such specimens were referred to *Monotaxinoides*.

Eolasiodiscus donbassicus Reitlinger, 1956

Pl. 6, figs. 3, 4

Eolasiodiscus donbassicus REITLINGER, 1956, p. 76, pl. 2, figs. 1, 3, 4.

Eolasiodiscus ex gr. *donbassicus* Reitlinger. BRAZHNIKOVA, *in* WAGNER AND OTHERS, 1979, pl. 5, figs. 17, 18.

Description (n = 3).—Test consists of a spherical proloculus followed by 9–10 nearly planispirally coiled volutions. Diameter is 277–296 μm. Rate of expansion of the coil is moderate and regular throughout the entire test. Chamber width (measured in sagittal section parallel to the dorsal surface of the test) is at least 18–25 μm in the last volution. Primary aperture was not observed. Supplementary apertures are tiny slit-like openings along the sutures on the dorsal surface of the test. Diameter of the proloculus is 18–27 μm.

Discussion.—Eolasiodiscus donbassicus differs from *E. galinae* Reitlinger in its smaller supplementary apertures. The present specimens are similar to, but much larger than, a specimen figured by Browne and Pohl (1973, pl. 26, fig. 4). Their specimen has only 6 volutions and thus could be a juvenile *E. donbassicus*.

Occurrence.—The species is present in the Brentwood Limestone Member of the Bloyd Formation (table 1). It was originally described from the Bashkirian (Middle Carboniferous) "donetsellovye" beds of the northwestern Donets Basin, U.S.S.R.

Genus **Monotaxinoides** Brazhnikova and Yartseva, 1956

Type species.—Monotaxinoides transitorius Brazhnikova and Yartseva, 1956.

Description.—Test consists of a spherical proloculus followed by a tubular second chamber that is trochospirally coiled in a low cone. Some specimens may be nearly flat. Sutures between adjacent whorls are slightly depressed. Shape of the tubular chamber is semicircular to sub-crescentic in axial section. Wall is calcareous, two-layered; it consists of a dark, microgranular inner layer and a pseudofibrous outer layer. An umbilical filling is formed on the ventral side of the test. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—Monotaxinoides is distinguished from *Howchinia* Cushman by its relatively low cone. According to Mamet (*in* Armstrong and Mamet, 1977, p. 99), *Howchinia* and *Monotaxinoides* constitute an evolutionary continuum of progressive flattening of the spire. Thus, the distinction between the two genera is arbitrary. *Monotaxinoides* differs from *Turrispiroides* Reitlinger in its two-layered wall and umbilical filling and from *Eolasiodiscus* Reitlinger in lacking supplementary apertures.

The outer pseudofibrous wall layer described by Brazhnikova and Yartseva (1956) was not observed among the present specimens. Rather, the wall in most specimens appears dark, microgranular, and homogeneous. In a few specimens it is reddish brown. The presence of well-developed umbilical fillings demonstrates that the pseudofibrous layer has been recrystallized and is no longer recognizable.

Monotaxinoides transitorius Brazhnikova and Yartseva, 1956

Pl. 3, figs. 15–19

Monotaxinoides transitorius BRAZHNIKOVA AND YARTSEVA, 1956, p. 65, pl. 1, figs. 2, 3, 5, 8; BROWNE AND POHL, 1973, pl. 26, figs. 8, 9; BRAZHNIKOVA, *in* WAGNER AND OTHERS, 1979, pl. 9, fig. 5.

Monotaxinoides multivolutus (Reitlinger). MAMET, 1976, pl. 86, fig. 4, pl. 87, fig. 4, pl. 88, figs. 1–4.

Description (n = 8).—Test of 9–10 volutions consists of a spherical proloculus followed by a trochospirally coiled tubular chamber. Its shape is that of a low cone. Diameter is 218–305 μm. Height is 50–75 μm. Chamber height (measured in axial section parallel to the dorsal surface of the test) is 17–28 μm. Wall is dark, microgranular calcite, apparently homogeneous, 5–8 μm thick in the last volution. Umbilical filling is well developed in the ventral cavity. Interior diameter of the proloculus is 12–23 μm. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—Monotaxinoides transitorius is distinguished from *M . priscus* Brazhnikova and Yartseva by its smaller proloculus and greater number of whorls and from *M. gracilis* (Dain) by its thinner wall and steeper cone.

Mamet (1976, pl. 88, figs. 1–3) illustrated specimens with well-developed umbilical fillings under the name *Monotaxinoides multivolutus* (Reitlinger). His specimens compare favorably with the present specimens, as well as the holotype of *M. transitorius*. Brazhnikova and Yartseva (1956, p. 65) noted the morphologic similarity between *M. transitorius* and *Ammodiscus multivolutus* Reitlinger but observed that *A. multivolutus* lacks a pseudofibrous wall layer and umbilical filling. Accordingly, Mamet's specimens are referred to *M. transitorius*, whereas *A. multivolutus* is referred to *Turrispiroides* Reitlinger.

Occurrence.—The species is present in the Brentwood Limestone, Dye Shale, and Kessler Limestone Members of the Bloyd Formation, and the Trace Creek Shale Member of the Atoka Formation (table 1). It also occurs in the Braggs Member of the Sausbee Formation and the Chisum Quarry and Greenleaf Lake Limestone Members of the McCully Formation (table 2).

The type material of the species was described from the upper Lower Carboniferous (limestone D_5^7 of the C_1^4 Suite) of the Donets Basin, U.S.S.R. The species has been reported elsewhere in North America from the Ettrain Formation (Atokan/Derryan) of the Canadian Cordillera (Mamet, 1976).

Family LASIODISCIDAE?

Genus **Turrispiroides** Reitlinger, *in* Rauzer-Chernousova and Fursenko, 1959

Type species.—*Turrispira mira* Reitlinger, 1950.

Description.—Test consists of a spherical proloculus followed by a tubular second chamber. Coiling is evolute, nearly planispiral to slightly trochospiral. Sutures between adjacent whorls are slightly depressed. Tubular chamber is semicircular to sub-crescentic in axial section. Wall is dark, microgranular calcite, undifferentiated. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—Browne and Pohl (1973) placed *Turrispiroides* and *Eolasiodiscus* Reitlinger in synonymy with *Monotaxinoides* Brazhnikova and Yartseva. Their interpretation is not adopted here, since *Turrispiroides* clearly possesses an undifferentiated wall and *Monotaxinoides* has a two-layered wall and an umbilical filling. *Turrispiroides* differs from *Eolasiodiscus* in its single-layered wall and single, primary aperture.

Turrispiroides multivolutus (Reitlinger, 1949)

Pl. 2, figs. 1–5

Ammodiscus multivolutus REITLINGER, 1949, p. 155–156, figs. 2a–c.

Turrispiroides Reitlinger. BRENCKLE, 1973, p. 24–25, pl. 1, figs. 36?, 37, 38, 39?, 40.

Monotaxinoides Brazhnikova and Yartseva. BROWNE AND POHL, 1973, pl. 26, fig. 6.

Monotaxinoides spp. BRENCKLE, 1977, pl. 2, figs. 6–10.

Turrispiroides? sp. RICH, 1980, p. 39, pl. 16, figs. 29, 31.

Description (n = 7).—Test consists of a spherical proloculus followed by a tubular second chamber that is coiled in a very low cone. Mature specimens possess 9–11 whorls. Diameter is 234–312 µm. Height is 39–55 µm. Rate of expansion of the tubular chamber is rapid in the initial 3 whorls, moderate to low in the final 2–3 whorls. Chamber height (measured in axial section parallel to the dorsal surface of the test) is 20–30 µm in the last volution. Wall is 5 µm thick in the last volution. Interior diameter of the proloculus is up to 18 µm. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—*Turrispiroides multivolutus* differs from *T. mira* (Reitlinger) in possessing more whorls and in coiling in a very low cone. Additionally, the wall in *T. mira* (as reported by Reitlinger, 1950) is more than four times the thickness of that in *T. multivolutus*.

Specimens illustrated as *Monotaxinoides multivolutus* (Reitlinger) by Mamet (1976, pl. 88, figs. 1–4) should be referred to *Monotaxinoides transitorius* Brazhnikova and Yartseva, as discussed above.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation, the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation, and the Trace Creek Shale Member of the Atoka Formation (table 1). It also occurs in the Braggs Member of the Sausbee Formation and in the Chisum Quarry and Greenleaf Lake Limestone Members of the McCully Formation (table 2).

The species was first described from the lower Middle Carboniferous of the central Ural region, U.S.S.R. It has been reported elsewhere in North America from Chesterian and Morrowan rocks in Nevada (Brenckle, 1973), Kentucky (Browne and Pohl, 1973), Arkansas (Brenckle, 1977), and the southeastern United States (Rich, 1980).

Turrispiroides aff. **T. multivolutus** (Reitlinger, 1949)

Pl. 1, fig. 12

Description (n = 2).—Test of 9½ or more volutions is coiled in a very low cone. Diameter is 366–441 µm. Height is 58–75 µm. Tubular chamber expands rapidly in the initial 3 volutions, less rapidly in the outer volutions. Chamber height (measured in axial section parallel to the dorsal surface of the test) is 20–40 µm in the last whorl. Wall is 5–10 µm thick in the last whorl. Interior diameter of the proloculus is 20 µm or more. Aperture was not observed.

Discussion.—The present specimens differ from specimens assigned to *T. multivolutus* (Reitlinger) in their larger size and slightly thicker walls.

They may be an ecological variant of the latter species.

Occurrence.—Specimens were recovered from the Brentwood Limestone Member of the Bloyd Formation and the Braggs Member of the Sausbee Formation (tables 1, 2).

Family HEMIGORDIOPSIDAE

Genus **Hemigordius** Schubert, 1908, *emend.* Zaninetti, Brönnimann, Huber, and Moshtaghian, 1978

Type species.—*Cornuspira schlumbergeri* Howchin, 1895.

Description (modified from Zaninetti and others, 1978).—Test is narrowly discoidal to lenticular, consisting of a spherical proloculus followed by a non-septate second chamber. Coiling is irregular; it ranges from planispiral to sigmoidal with all intermediate combinations. The initial few volutions in some specimens may be streptospirally coiled. Test may be entirely involute with well-developed side thickenings, or mostly evolute with only rudimentary side thickenings. Wall is dark, undifferentiated calcite. Aperture is a simple opening at the end of the second chamber.

Discussion.—As emended by Zaninetti and others (1978, p. 876–877), *Hemigordius* includes a broad spectrum of coiling groups and forms with poorly developed to very well-developed side thickenings. *Hemigordius* differs from *Pseudoammodiscus* Conil, which is planispiral and lacks side thickenings, and from *Hemigordiopsis* Reichel, which is completely involute with rudimentary "septa" that divide the second chamber into "pseudochambers" (Nikitina, 1969). *Hemigordius* is distinguished from *Brunsia* Mikhailov by its side thickenings.

Hemigordius harltoni Cushman and Waters, 1928a

Pl. 6, figs. 1, 2, 5–9

Hemigordius harltoni CUSHMAN AND WATERS, 1928a, p. 43, pl. 5, figs. 8, 9; CUSHMAN AND WATERS, 1928b, p. 370, pl. 49, figs. 1, 2; CUSHMAN AND WATERS, 1930, p. 60–61, pl. 5, figs. 2, 3; TOOMEY, 1972, p. 296, pl. 2, figs. 16–18.

Cornuspira harltoni (Cushman and Waters). GALLOWAY AND HARLTON, 1928, p. 340–341, pl. 45, figs. 1a–c.

Brunsia sp. BRENCKLE, 1973, p. 76, pl. 10, fig. 33.

Description (n = 6).—Test of 5–9 volutions is narrowly discoidal with an irregular peripheral outline. Diameter is 175–277 μm. Width (measured through the juvenarium) is 45–60 μm. Coiling is streptospiral to sigmoidal and involute in the initial 2–3 volutions, sigmoidal to nearly planispiral and evolute in the outer volutions. The final 1–2 volutions may be offset with respect to the previous whorls, resulting in asymmetry of the test. Side thickenings envelope the initial 2–4½ volutions of typical specimens. Other specimens have only rudimentary side thickenings. Sutures are depressed in the outer, evolute volutions. Rate of expansion of the tubular chamber is moderate. Chamber height is 20–35 μm in the last volution; 18–28 μm in the penultimate volution; 13–20 μm in the antepenultimate volution. Chamber shape is semicircular to nearly circular in axial section. Wall is 2.5–5 μm thick in the last volution. Interior diameter of the proloculus is up to 43 μm. Aperture is a simple opening at the end of the second chamber.

Discussion.—*Hemigordius harltoni* differs from *H. simplex* Reitlinger and *H.* sp. A (this study) in its early streptospiral to sigmoidal coiling, and from *H. liratus* Cushman and Waters in its rounded periphery.

Specimens referred to *H. harltoni* by various authors vary in size from about 175–1000 μm. The present specimens are smaller than the types but compare well with specimens illustrated by Galloway and Harlton (1928) and Toomey (1972).

Occurrence.—The species occurs in the Brentwood Limestone and Dye Shale Members of the Bloyd Formation (table 1). It also occurs in the Brewer Bend Limestone Member of the Sausbee Formation and the Greenleaf Lake Limestone Member of the McCully Formation (table 2).

The species was originally described from the Upper Pennsylvanian Graham Formation of the Cisco Group, Jack County, Texas. It occurs elsewhere in North America in upper Morrowan through Upper Pennsylvanian rocks in Texas (Cushman and Waters, 1928a, 1928b, 1930; author's unpublished information), Oklahoma (Galloway and Harlton, 1928), Kansas (Toomey, 1972; Brenckle, personal communication, 1981), Nevada (Brenckle, 1973), and Idaho (Brenckle, personal communication, 1981).

Hemigordius sp. A

Pl. 6, figs. 10–15

Description (n = 9).—Test of 4½–6 volutions is discoidal with a rounded periphery and straight-sided to convex flanks. Diameter is 135–200 μm. Width is 35–53 μm. Width/diameter ratio is 0.23–0.40. Coiling is slightly sigmoidal to planispiral. Side thickenings are moderately well developed; they envelope each successive volution except the final one, which in some specimens is evolute with depressed sutures. Tubular chamber is semicircular to sub-crescentic in axial section. Rate of expansion of the tubular chamber is moderate. Volution height is 12–20 μm in the last volutions; 10–15 μm in the penultimate volution; 7–10 μm in the antepenultimate volution. Wall is copper brown to amber in transmitted light, 2.5–5 μm thick in the last volution. Interior diameter of the proloculus is up to 30 μm. Aperture is a simple opening at the end of the tubular chamber.

Discussion.—Hemigordius sp. A differs from *H. harltoni* Cushman and Waters in its slightly sigmoidal to planispiral coiling and smaller size. The present specimens resemble *H. discoideus* (Brazhnikova and Potievska) as illustrated by Reitlinger (1950, pl. 3, figs. 13, 14), but they are significantly smaller.

Occurrence.—The species is abundant in the Greenleaf Lake Limestone Member of the McCully Formation (table 2). Two specimens were recovered from the "caprock" bed of the Dye Shale Member of the Bloyd Formation (table 1).

Kingdom PLANTAE

Division CHLOROPHYTA

Family DASYCLADACEAE

Genus **Paraepimastopora** Roux, 1979

Type species.—Epimastopora kansasensis Johnson, 1946b.

Description.—Thallus is cylindrical, nonbifurcating, unsegmented; it consists of a central stem and radially arranged, non-ramified branches in closely spaced whorls. The branches are straight, isodiametric, perpendicular to the central axis, and round to polygonal in tangential section. Sporangia are unknown.

Discussion.—Paraepimastopora differs from *Epimastopora* Pia and *Epimastoporella* Roux in its straight, isodiametric branches. The branches in *Epimastopora* are halter-shaped, whereas in *Epimastoporella* they are ovoidal or lemon-shaped.

Paraepimastopora sp. A

Pl. 6, fig. 19; pl. 7, fig. 1

Description (n = 4).—The branches are arranged in closely spaced whorls that alternate so that they appear as spiralled rows around the central stem. They are 27–51 μm in diameter. The distance between adjacent branches in a whorl is 11–16 μm. Thickness of the cortex is at least 550 μm.

Discussion.—The present material is not sufficiently abundant to permit speciation. The specimens resemble *P. regularis* (Johnson) in diameter and in the regular arrangement of the branches.

Occurrence.—Specimens were recovered from the Kessler Limestone Member of the Bloyd Formation (table 1).

Family DASYCLADACEAE?

Genus **Donezella** Maslov, 1929

Type species.—Donezella lutugini Maslov, 1929.

Description.—Thallus is cylindrical, bifurcates at an angle of 45–90°, and is subdivided into cylindrical cells by evenly spaced, perforate partitions. It is slightly constricted where partitions meet the tube wall. Wall is calcareous, two-layered; it consists of an outer, yellowish, hyaline layer and an inner, dark, porous layer. Pores in the inner layer are straight and non-bifurcating. Reproductive structures are unknown.

Discussion.—Donezella differs from *Beresella* Machaev in its bifurcating thallus and from *Dvinella* Khvorova in its bifurcating thallus and non-bifurcating pores of the inner wall layer. Khvorova (1949), Mamet and Rudloff (1972), and Mamet and Roux (1975b) further discuss the morphologies of *Donezella*, *Beresella*, and *Dvinella*.

Donezella aff. **D. lunaensis** Rácz, 1965

Pl. 6, figs. 16–18

See Mamet and Roux, 1975b, p. 265, for synonymy.

Description (n = 12).—Outside diameter of the tube is 70–160 μm. Cell length is 78–133 μm. Thickness of the partitions is 8–28 μm, typically 15 μm. Thickness of the outer wall layer is 5–16 μm, typically 8 μm or less. Thickness of the dark inner wall layer is 11–32 μm, typically 20 μm.

Discussion.—The diameters of the tubes in the present material are intermediate between those in *D. lutugini* Maslov and *D. lunaensis* Rácz. The present specimens compare well with specimens figured as *Donezella* aff. *D. lunaensis* Rácz by Mamet and Roux (1975b, pl. 13, figs. 13–18).

Occurrence.—The species occurs in the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Chisum Quarry Member of the McCully Formation (table 2).

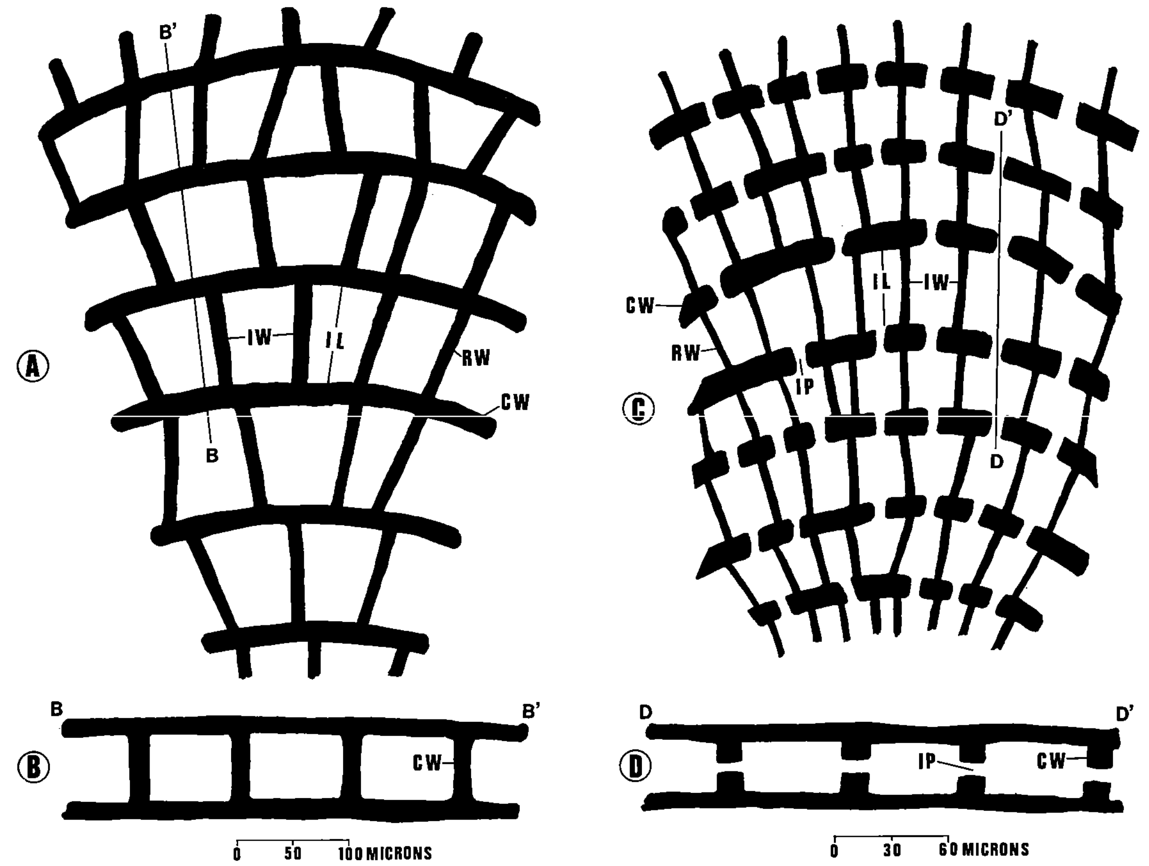
Division RHODOPHYCOPHYTA

Family undetermined

Genus **Cuneiphycus** Johnson, 1960

Type species.—Cuneiphycus texana Johnson, 1960.

Description (text-fig. 4).—Thallus is a complex network of irregular, sheet-like layers of cells, one cell thick. Sheets form through the growth of arcuate rows of cells. Cells are wedge shaped; they appear as tapered rectangles in horizontal section (text-fig. 4A), square to rectangular in vertical section (text-fig. 4B). Wall is calcareous, light to dark brown in transmitted light, sparry, undifferentiated. Concentric walls (i.e., walls separating rows of cells) are generally thicker than radial walls (i.e., walls separating cells within a row). Intercellular pores are absent. Reproductive structures are unknown.



Text-figure 4. Comparison of *Cuneiphycus* Johnson (left) and Genus A, n. gen. (right). *CW*, concentric wall; *RW*, radial wall; *IW*, internal cell width; *IL*, internal cell length; *IP*, intercellular pore. *A*, *C*, horizontal sections; *B–B′*, *D–D′*, vertical sections cut perpendicular to concentric layers.

Discussion.—Johnson (1960, p. 54) originally described *Cuneiphycus* as a low bushy plant: "slender, probably segmented, consisting of cylindrical or wedge-shaped, branched members." Kotila (1973) and Wray (1977) subsequently demonstrated that the plant actually consists of a three-dimensional network of cell layers. It seems likely that the layers or sheets became established on fine-grained calcareous substrates and served to bind sediment. With continued sedimentation the sheets became buried, and branches (or daughter sheets?) grew up through the sediment until they reestablished the horizontal sheet-like growth habit on the sediment surface. Alternation of sheet growth and branching probably yields the complex network seen in thin section.

Cuneiphycus resembles Genus A, n. gen., in cell arrangement and possibly in growth habit. Genus A, n. gen., however, possesses pores that connect contiguous cells in adjacent rows. The cell walls in Genus A, n. gen., are heavily calcified and yellowish (hyaline), whereas in *Cuneiphycus* they are less heavily calcified and are light to dark brown (sparry).

Cuneiphycus texana Johnson, 1960

Pl. 8, figs. 5, 10, 11

Cuneiphycus texana Johnson, 1960, p. 54, pl. 21, figs. 1–3; Johnson, 1963, pl. 5, figs. 1–3.

Description (n = 11).—Internal length of cells is 47–144 μm, typically 70–100 μm. Internal width of cells is 23–90 μm, typically 30–70 μm. Concentric wall thickness is 12–32 μm. Radial wall thickness is 7–23 μm.

Discussion.—*Cuneiphycus texana* is locally a major constituent in carbonate grainstone and packstone (boundstone?) facies. It typically occurs as fragments measuring up to 1 cm in the greatest dimension.

Cuneiphycus texana differs from *C. aliquantulus* Johnson in having larger cells.

Occurrence.—The species is extremely abundant in the Braggs Member of the Sausbee Formation (table 2).

The type material of the species was described from the Marble Falls Formation (Lower–Middle Pennsylvanian) of central Texas.

Cuneiphycus aliquantulus Johnson, 1960

Pl. 9, figs. 1, 2

Cuneiphycus aliquantulus JOHNSON, 1960, p. 58, pl. 22, figs. 1–3; RÁCZ, 1965, p. 88, pl. 8, figs. 6, 7.

Description (n = 5).—Internal length of cells is 31–59 µm. Internal width of cells is 15–32 µm. Concentric wall thickness is 8–20 µm. Radial wall thickness is 7–12 µm.

Discussion.—*Cuneiphycus aliquantulus* differs from *C. texana* Johnson in having smaller cells.

Occurrence.—The species is rare in the lower part of the Brentwood Limestone Member of the Bloyd Formation (table 1). A single specimen was recovered from the Braggs Member of the Sausbee Formation (table 2).

The species was originally described from the Hueco Mountains of Texas (Lower–Middle Pennsylvanian?).

Genus A, n. gen.

Description (text-fig. 4).—Thallus is a sheet-like layer of cells, one cell thick. Cells are aligned side by side in arcuate rows. They are rectangular to wedge-shaped, appearing square to rectangular in horizontal section (text-fig. 4C) and rectangular in vertical section (text-fig. 4D). Cell length is generally greater than cell width. Intercellular pores connect contiguous cells in adjacent rows. Wall is calcareous, yellowish, hyaline, undifferentiated. Concentric walls (i.e., walls separating rows of cells) are typically much thicker than radial walls (i.e., walls separating cells within a row). Reproductive structures are unknown.

Discussion.—Polished rock slabs, which provide a three-dimensional view of the specimens, show that the thalli occur typically as unbranched, abraded fragments. Accordingly, the plants are interpreted to have grown as discrete sheets on the sediment surface, although some views in thin section suggest that the thalli may be connected by slender branches.

The genus is distinguished from *Cuneiphycus* Johnson by its intercellular pores. Sections that do not pass through the pores may be difficult to identify positively.

Representatives of the genus were illustrated by Maslov (1973, p. 27, pls. 21, 63) under the names "*Cribroporidium*," "*Contortoporidium*," and "*Coneiphycus*." Unfortunately, he published no formal descriptions of these genera. The genus will be formally described in a forthcoming publication by B. L. Mamet and me.

Representatives of the genus have been recognized elsewhere in Lower and Middle Pennsylvanian rocks of the Marble Falls Formation (central Texas), the Bloom Member of the Snaky Canyon Formation (east-central Idaho), and the Middle Carboniferous of the Donets Basin, U.S.S.R. (author's unpublished information; Maslov, 1973).

Genus A, sp. A, n. gen., n. sp.

Pl. 10, figs. 1–9

Description (n = 18).—Internal length of cells is 19–62 µm, typically 25–50 µm. Internal width of cells is 12–51 µm, typically 15–30 µm. Diameter of intercellular pores is 4–12 µm. Concentric wall thickness is 8–24 µm, typically 15 µm or more. Radial wall thickness is 4–12 µm, typically less than 8 µm.

Discussion.—The species is widespread in carbonate wackestones, packstones, and grainstones, but it is not a major rock-building organism. Specimens occur typically as broken fragments measuring less than 1 cm in the greatest dimension.

Occurrence.—The species occurs abundantly in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone Member of the Bloyd Formation (table 1). It also occurs in the Braggs Member of the Sausbee Formation (table 2).

Genus **Archaeolithophyllum** Johnson, 1956a

Type species.—*Archaeolithophyllum missouriensum* Johnson, 1956a (recte *Archaeolithophyllum missouriense*).

Description.—Thallus is an irregular sheet or crust of cells. It is differentiated into a thick central hypothallium and a thinner outer perithallium. The hypothallium is coaxial, that is, consisting of arcuate layers of cells. Its cells are large, polygonal, typically hexagonal both in transverse and longitudinal section. Perithallial cells are smaller, rectangular, aligned in rows parallel to the outer surface of the thallus. The wall is calcareous, undifferentiated. Sporangia are collected into conical conceptacles with a single aperture, which are distributed over the upper surface of the thallus.

Discussion.—Johnson (1956a) originally assigned *Archaeolithophyllum* to the crustose coralline algae (Corallinaceae) on the basis of its remarkable similarity to the Holocene coralline *Lithophyllum*. He (1963, p. 6) later placed *Archaeolithophyllum*, with *Cuneiphycus* Johnson and *Foliophycus* Johnson, under "red algae of uncertain affinities." The taxonomic position of the genus is still unclear, and recent authors (e.g., Wray, 1971, 1975, 1977; Riding, 1975) refer to its representatives informally as ancestral corallines.

Archaeolithophyllum is distinguished from most other Paleozoic red algae by its lamellar growth form, coaxial tissue, and perithallium with conceptacles. It differs from *Principia* Brenckle in its coaxial tissue, hexagonal cells, and sheet-like growth habit.

Archaeolithophyllum missouriense Johnson, 1956a

Pl. 9, figs. 3, 4, 6

Archaeolithophyllum missouriensum JOHNSON, 1956a, p. 54, pl. 14, figs. 1–3, 5; JOHNSON, 1956b, pl. 68, fig. 5; JOHNSON, 1960, pl. 16, figs. 1, 2, pl. 17, fig. 2; JOHNSON, 1961, pl. 22, figs. 1, 2; JOHNSON, 1963, pl. 2, figs. 1, 2; RÁCZ, 1965, p. 86–87, pl. 10, figs. 4–6.

Archaeolithophyllum missouriense Johnson, 1956a. WRAY, 1964, p. 7–8, pl. 1, figs. 1, 3–7.

Description (n = 13).—Internal length of hypothallial cells is 42–129 μm, typically 50–90 μm. Internal width of hypothallial cells is 19–74 μm, typically 30–55 μm. Length of perithallial cells is 19–24 μm. Width of perithallial cells is 11–16 μm. Hypothallial and perithallial cell walls are nearly equally thick: 4–12 μm, typically 8 μm or less. Reproductive structures were not observed.

Discussion.—*Archaeolithophyllum missouriense* is distinguished from *A. delicatum* Johnson by its thicker thallus and larger hypothallial cells. Both species grew free or attached as single crusts on the depositional surface. *Archaeolithophyllum missouriense* and *A. lamellosum* Wray differ in size and growth habit. The latter species is much smaller and grew as foliate, multilayered crusts.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Chisum Quarry Member of the McCully Formation (table 2).

The species was first described from the Missourian (Upper Pennsylvanian) Exline Limestone of Missouri. It occurs in Upper Mississippian rocks and is abundant in Pennsylvanian and Permian carbonate-shelf facies (Wray, 1977).

Archaeolithophyllum sp. A

Pl. 9, figs. 5, 7, 9

Description (n = 3).—Hypothallial cell length is 31–40 μm. Hypothallial cell width is 12–35 μm. Perithallial cells were not measured confidently. Wall is up to 8 μm thick.

Discussion.—The present specimens closely resemble *A. delicatum* Johnson in the small size of their thalli and hypothallial cells. They also resemble *A. lamellosum* Wray in cell size but do not occur in multiple layers. Unfortunately, there is insufficient material for positive identification.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1).

Division CYANOPHYTA

"Section" POROSTROMATA

Genus **Girvanella** Nicholson and Etheridge, 1878

Type species.—*Girvanella problematica* Nicholson and Etheridge, 1878.

Description.—Thallus consists of a simple, nonbranching tube that lacks partitions and is of uniform diameter. The tubes grow in encrusting masses, intertwined with other algae and encrusting foraminifers or alone as felt-like networks or crusts. The wall is calcareous, dark, microgranular, undifferentiated.

Discussion.—Despite its simplicity, the morphology of *Girvanella* has been interpreted quite differently by various authors. Some (e.g., Rothpletz, 1891; Maslov, 1949; Wood, 1957, 1963; Wray, 1977) report that the tubes are branched, whereas others (e.g., Mamet and Roux, 1975a; Armstrong and Mamet, 1977) contend they are not. Examination of the present material and published photomicrographs has failed to demonstrate unequivocal branching. Rather, I believe the appearance of branching may be caused by the chance intersection of diverging and cross-cutting tubes with the plane of the thin section (e.g., Wood, 1957, pl. 5, fig. 5, and pl. 6, fig. 1). Maslov (1949, p. 89) reported transverse partitions in two specimens; however, no published illustrations document their existence. If such partitions were present in living *Girvanella* they invariably have been obliterated by diagenesis and are of no consequence in characterizing fossil material. An extensive revision of the taxonomy of the genus is presented by Mamet and Roux (1975a).

Girvanella is distinguished from *Mitcheldeania* Wethered, *Ortonella* Garwood, *Garwoodia* Wood, and similar forms primarily by its non-branching habit. Representatives of the genus commonly occur in encrusting masses with other algae and foraminifers. These associations have been referred to the form-genera *Osagia* Twenhofel and *Ottonosia* Twenhofel (Henbest, 1963).

Girvanella minuta Wethered, 1890

Pl. 9, figs. 8, 10

Girvanella minuta WETHERED, 1890, p. 280, pl. 11, figs. 6a, b.

Girvanella staminea GARWOOD, 1931, p. 139–140, pl. 13, fig. 1; WOOD, 1963, p. 268–269, pl. 38, fig. 2, pl. 39, fig. 2; MAMET AND ROUX, 1975a, p. 140–141, pl. 1, figs. 1–8.

Girvanella maplewoodensis JOHNSON, 1946a, p. 169, pl. 30, fig. 4.

Description (n = 3).—The tubes are intertwined in encrusting, felt-like masses. Their interior diameter is 5–8 µm. The wall is less than 3 µm thick.

Discussion.—The remarkable constancy of the diameters of tubes within a cluster led early workers to erect a number of narrowly defined species that differ in tube diameter by only 1 or 2 µm. In practice, differences of 1 or 2 µm fall within the range of measurement error and cannot form the basis for reliable speciation. Several authors (e.g., Maslov, 1949; Wood, 1963; Mamet and Roux, 1975a) have sought to reduce the proliferation of names by broadening the range of tube diameters for a single species. The proposal followed here is that of Maslov (1949), which recognizes *G. minuta* as having priority over *G. staminea* Garwood and *G. maplewoodensis* Johnson for *Girvanella* with internal tube diameters of 6–9 µm. Thus defined, *G. minuta* differs from other representatives of the genus in its minute tubes.

Occurrence.—The species is present in the Brentwood Limestone Member of the Bloyd Formation (table 1) and the Braggs Member of the Sausbee Formation (table 2).

It was originally described from the Jurassic of Great Britain and ranges at least as low as the Tournaisian (Lower Carboniferous) (Mamet and Roux, 1975a).

Kingdom PLANTAE?

Division RHODOPHYCOPHYTA?

Family AOUJGALIACEAE

Genus **Stacheoides** Cummings, 1955

Type species.—*Stacheia polytrematoides* Brady, 1876.

Description.—Thallus is fusiform to irregularly shaped and consists of irregular, reticulate cells that concentrically encrust a central host or hosts. Cell walls are composed of roughly concentric and radial elements, of which the concentric are typically thicker. Wall is calcareous, undifferentiated, yellowish, hyaline. Apical pores (reproductive structures?) are present in subconical protuberances at the periphery of the thallus.

Discussion.—*Stacheoides* differs from *Epistacheoides* Petryk and Mamet in lacking a thick outer zone of radially oriented elements, and from *Pseudostacheoides* Petryk and Mamet in its reticulate cellular arrangement. *Stacheoides* differs from *Aoujgalia* Termier and Termier in its less regular growth habit.

Stacheoides aff. **S. tenuis** Petryk and Mamet, 1972

Pl. 7, figs. 2, 4, 6, 8

Stacheoides tenuis PETRYK AND MAMET, 1972, p. 787, pl. 6, figs. 1–6, pl. 7, figs. 1–4, 5?, 6; MAMET AND RUDLOFF, 1972, p. 90, pl. 7, figs. 4–8; RICH, 1974, p. 371–372, pl. 4, figs. 1–3, 4?; MAMET, 1976, pl. 30, fig. 3, pl. 32, fig. 2, pl. 35, fig. 2, pl. 67, fig. 2; BRENCKLE, 1977, pl. 4, figs. 13–15; ARMSTRONG AND MAMET, 1977, p. 106, pl. 17, fig. 8, pl. 38, figs. 8?, 9?, 10; MAMET AND ROUX, 1977, p. 225, pl. 2, figs. 10–14; PERRET AND VACHARD, 1977, p. 32–33, pl. 5, fig. 5.

Stacheoides? spissa PETRYK AND MAMET, 1972, pl. 7, fig. 9 (only).

Description (n = 15).—Cell height (= laminar cell thickness of Petryk and Mamet, 1972) is 23–63 µm, typically 30–50 µm, and is variable along the length of the cell. Radial-element thickness is 7–20 µm, typically 10–12 µm. Concentric-element thickness is 7–28 µm, typically greater than 15 µm. Subconical protuberances at the periphery of the thallus are 420–450 µm in diameter.

Discussion.—Petryk and Mamet (1972, p. 787) distinguished *S. tenuis* by its minute cell size, even vesiculation, and concentration of tubes and protuberances. The present specimens resemble the type material with respect to vesiculation and concentration of protuberances but differ in having larger cells and thicker concentric and radial elements. The present material is intermediate between *S. tenuis* and *S. meandriformis* Petryk and Mamet in cell size and element thickness.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Kessler Limestone Member of the Bloyd Formation (table 1).

Stacheoides tenuis has been reported elsewhere in North America from Early and Late Mississippian rocks of the northern Cordillera (Petryk and Mamet, 1972; Mamet and Rudloff, 1972; Mamet, 1976; Armstrong and Mamet, 1977), Arkansas (Brenckle, 1977), and the southeastern United States (Rich, 1974). The species was originally described from the Viséan (Lower Carboniferous) Mount Head Formation of southwestern Alberta.

"Stacheoides" spissa Petryk and Mamet, 1972

Pl. 8, figs. 1–4

Stacheoides? spissa PETRYK AND MAMET, 1972, p. 785, pl. 5, figs. 1–7; MAMET, 1976, pl. 50, figs. 1, 2.

Description (n = 6).—Thallus consists of concentric layers of cells. The layers are discrete; that is, each layer has its own upper and lower walls that are separated from the walls of underlying and overlying layers by a thin micritic film. Thickness of layers is 35–78 µm. They are internally divided into roughly rectangular cells by irregularly spaced partitions. Thickness of partitions is up to 20 µm. Wall is yellowish undifferentiated calcite, 11–20 µm thick.

Discussion.—This species differs from true *Stacheoides* and other aoujgalids in the discrete concentric banding of the cell layers. In contrast, adjacent concentric layers in true aoujgalids share a common wall that forms the top of the underlying cell and the bottom of the overlying cell. *"Stacheoides" spissa* may be referrable to *Fasciella* Ivanova (= *Shartymophycus* Kulik), which also constructs a thallus of discrete concentric layers. The nature of the internal structure of the layers in *Fasciella* is unclear, but in some specimens it appears to be like that in *"S." spissa* (cf. Mamet and Roux, 1975a, pl. 14, figs. 2, 7, 16, 17). *"Stacheoides" spissa* is here maintained separately from *Fasciella,* pending better understanding of the internal morphology of the latter taxon.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It is abundant in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Chisum Quarry Member of the McCully Formation (table 2).

It was first described from the Viséan (Lower Carboniferous) Mount Head Formation of southwestern Alberta. It has been reported elsewhere in North America from the Viséan Etherington Formation, also of southwestern Alberta (Mamet, 1976).

Family UNGDARELLACEAE?

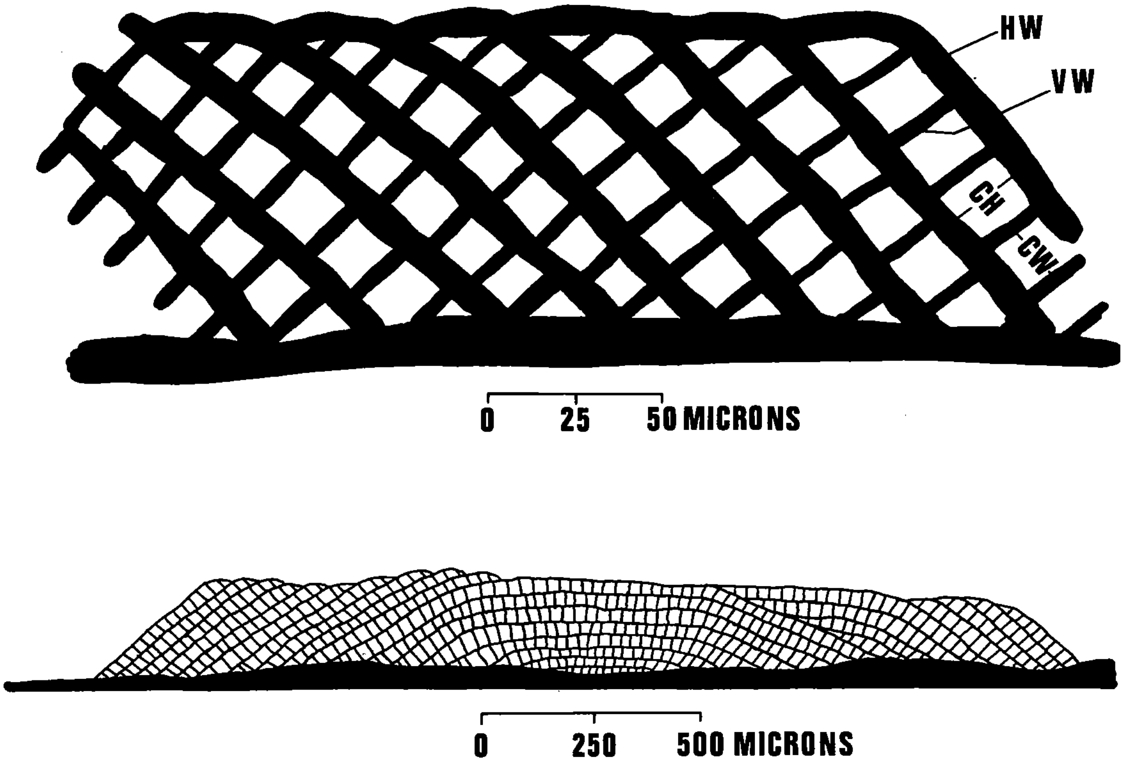
Subfamily STACHEIINAE?

Genus "**Eflugelia**" Vachard, *in* Massa and Vachard, 1979

Type species.—*Cuneiphycus johnsoni* Flügel, 1966.

Description (text-fig. 5).—Thallus consists of encrusting layers of cells that grow in an offlapping pattern over a flat surface. Its growth is "hemi-radial" (i.e., accretion of offlapping layers within an arc of 180°) or radial (i.e., accretion of offlapping layers in all directions). Layers are parallel and maintain nearly constant height throughout the thallus. Cells are rectangular, regularly arranged. Their height is slightly greater than their width. Wall is calcareous, hyaline, undifferentiated. Horizontal walls are typically thicker than vertical walls. Reproductive structures are unknown.

Discussion.—The taxonomic status of *"Eflugelia"* is unclear. The concept of *"Eflugelia"* employed here includes forms that encrust flat surfaces by "hemi-radial" or radial accretion of offlapping layers of cells. This concept apparently agrees with Vachard's intended concept of the



Text-figure 5. *"Eflugelia"* Vachard. *HW*, horizontal wall; *VW*, vertical wall; *CH*, cell height; *CW*, cell width.

genus (Vachard, *in* Massa and Vachard, 1979, p. 34, pl. 9, fig. 10). Unfortunately, the holotype of *Cuneiphycus johnsoni* Flügel, the type species of "*Eflugelia*," is probably referrable to *Fourstonella* Cummings, whereas the paratypes of *C. johnsoni* agree more closely with Vachard's concept of "*Eflugelia*." Thus, *Eflugelia sensu stricto* may be a junior synonym of *Fourstonella*. Until the taxonomic problems are resolved, I am retaining the term "*Eflugelia*" for forms that fit Vachard's intended concept of the genus and differ clearly from *Fourstonella*.

"*Eflugelia*" is distinguished from *Fourstonella* by its growth habit, which in *Fourstonella* is that of unidirectional accretion of offlapping layers of cells around a central host. "*Eflugelia*" differs from *Cuneiphycus* Johnson, which is a branching sheet-like form, one layer thick. The internal structure, descriptive terminology, and growth habit of "*Eflugelia*" are illustrated in text-figure 5.

"**Eflugelia**" sp. A

Pl. 8, figs. 6–9

Description (n = 8).Thallus encrusts a flat or nearly flat surface, typically an invertebrate skeleton. Cell height is 12–25 μm. Cell width is 7–16 μm. Thickness of horizontal wall is 7–13 μm. Thickness of vertical wall (albeit poorly preserved) is 2.5–5 μm.

Discussion.—The present specimens have smaller cells but otherwise resemble specimens figured as *Cuneiphycus johnsoni* Flügel by Flügel (1966, pl. 2, figs. 2—5 only), Toomey (1969, pl. 151, figs. 3, 4), and Mamet and Roux (1977, pl. 9, figs. 8–11); and specimens figured as *Eflugelia johnsoni* (Flügel) by Vachard (*in* Massa and Vachard, 1979, pl. 9, fig. 10) and Flügel and Flügel-Kahler (1980, pl. 8, figs. 9, 10?).

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation (table 2).

Incertae Sedis

Genus **Calcisphaera** Williamson, 1880

Type species.—*Calcisphaera laevis* Williamson, 1880.

Description.—The form is a hollow, smooth sphere. Its wall is calcareous, dark, microgranular, undifferentiated, and finely perforate.

Discussion.—*Calcisphaera* is a controversial taxon both with respect to its nomenclatorial status and its biological affinities. Williamson (1880, p. 520) erected the genus, supposing it to belong to the Radiolaria. Since then, the genus has been described under several names and referred to both plant and animal groups. Nomenclatorial histories of *Calcisphaera* are presented by Baxter (1960) and Armstrong and Mamet (1977). Several workers have demonstrated the resemblance between calcispheres and reproductive cysts of Holocene dasycladacean algae (Rupp, 1967; Rezak, *in* Ginsburg and others, 1971; Marszalek, 1975; Wray, 1977).

If the pores are not preserved, *Calcisphaera* may be impossible to distinguish from transverse sections of *Earlandia* Plummer.

Calcisphaera laevis Williamson, 1880

Pl. 10, figs. 12, 13

See Armstrong and Mamet, 1977, p. 110, for synonymy.

Description (n = 11).—The outside diameter of the sphere is up to 140 μm. The wall is 20–35 μm thick. Inner and outer surfaces of the sphere are smooth. No pores were observed.

Discussion.—*Calcisphaera laevis* differs from *C. pachysphaerica* (Pronina) in its smaller diameter.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation (table 2).

The type material of the species was described from the Carboniferous of Great Britain.

Genus **Asphaltina** Mamet, *in* Petryk and Mamet, 1972

Type species.—*Asphaltina cordillerensis* Mamet, *in* Petryk and Mamet, 1972.

Description.—Thallus(?) is a cluster of nearly parallel, intertwined, closely packed, cylindrical to subcylindrical tubes. Individual tubes are divided by thin partitions that are irregularly spaced and randomly oriented. Small nodes are present on the interior of the cylinder walls in some specimens. Wall is calcareous, two-layered; it is composed of a thin, dark outer layer and a thicker, pseudofibrous inner layer. Reproductive structures are unknown.

Discussion.—*Asphaltina* differs from *Sphaeroporella* Antropov in its cylindrical rather than ovoid or cystoid cells; from *Asphaltinella* Mamet and Roux in its two-layered wall; and from *Wetheredella* Wood in its two-layered imperforate wall and partitions.

Asphaltina cordillerensis Mamet, *in* Petryk and Mamet, 1972

Pl. 7, figs. 3, 5, 9

Asphaltina cordillerensis MAMET, *in* PETRYK AND MAMET, 1972, p. 795–797, pl. 10, figs. 3–6; MAMET AND RUDLOFF, 1972, p. 88, pl. 10, figs. 8–11; ARMSTRONG

AND MAMET, 1974, p. 657, fig. 7a; RICH, 1974, p. 373, pl. 5, figs. 3?, 4?, 5?, 6?, 8?, 10?; MAMET AND ROUX, 1975a, p. 164, pl. 12, fig. 2; ARMSTRONG AND MAMET, 1975, p. 15, fig. 11g; MAMET, 1976, pl. 87, fig. 2; BRENCKLE, 1977, pl. 4, figs. 18, 21; ARMSTRONG AND MAMET, 1977, p. 109, pl. 39, figs. 12–14; MAMET AND ROUX, 1978, p. 77–78, pl. 4, figs. 8–10.

Description (n = 13).—Thickness of the partitions is 4–20 μm. The dark outer layer of the tube wall is 3–5 μm thick, whereas the thickness of the inner pseudofibrous layer is 27–74 μm, typically 40–60 μm. Interior diameter of the tubes is 148–332 μm, typically 200–300 μm.

Discussion.—Representatives of the species are among the most abundant microfossils encountered in this study. They were apparently tolerant of a wide range of environmental conditions, as they are found in carbonate rocks of all grain sizes and textures.

Occurrence.—The species occurs in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Chisum Quarry and Greenleaf Lake Limestone Members of the McCully Formation (table 2).

The type material of the species was described from the Viséan (Lower Carboniferous) Mount Head Formation of Alberta.

Genus **Proninella** Reitlinger, *in* Menner and Reitlinger, 1971

Type species.—Proninella tamarae Reitlinger, *in* Menner and Reitlinger, 1971.

Description.—Thallus(?) consists of sinuous, irregularly branching tubes that are divided into a series of oblong cells by irregularly spaced, perforate partitions. Tubes are constricted where partitions intersect the wall. Wall is calcareous, yellowish, hyaline, undifferentiated.

Discussion.—Specimens assume a wide range of appearances in thin section, owing to the highly irregular branching of the tubes and the irregular spacing of the partitions. These features distinguish *Proninella* from the Palaeoberesselleae (see Mamet and Roux, 1974). Mamet and Roux (1978, p. 83) interpreted *Pokorninella* Vachard to be a junior synonym of *Proninella*. Their interpretation is followed here.

Proninella strigosa (Vachard, *in* Perret and Vachard, 1977)

Pl. 9, figs. 11, 12

Pokorninella strigosa VACHARD, *in* PERRET AND VACHARD, 1977, p. 122–123, pl. 7, figs. 2–4.

Description (n = 8).—Branching of the tubes is highly irregular. Their external diameter is 59–195 μm, typically 50–90 μm. Thickness of the partitions is 15–27 μm. Wall thickness is 8–15 μm.

Discussion.—According to Mamet and Roux (1978, p. 86), *Proninella strigosa* differs from *P. enigmatica* Mamet and Roux in its less regular cells and partitions. Both species have similar dimensions.

Occurrence.—The species is present in the Prairie Grove Member of the Hale Formation and the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation (table 2).

The type material of the species was described from the lower Namurian Ardengost Limestone in the Pyrénées of southern France.

Genus **Nostocites** Maslov, 1929.

Type species.—Nostocites vesiculosa Maslov, 1929.

Description (text-fig. 6).—Thallus(?) is a sheet of loosely packed barrel-shaped cells, one cell thick. The cells appear circular in horizontal section, subrectangular to rectangular in vertical section. Dark, subcylindrical inclusions (pores?) are present in the centers of the cells. Wall is calcareous, yellowish, hyaline, undifferentiated. Reproductive structures are unknown.

Discussion.—Maslov (1929) and Mamet and Roux (1978) interpreted *Nostocites* to be a chain-like arrangement of round to oblong cells. Examination of the present material demonstrates that the thallus(?) is in fact a sheet of loosely packed, cylindrical or barrel-shaped cells. Poorly oriented sections that are diagonal to the plane of the sheet yield a chain-like appearance (e.g., Mamet and Roux, 1978, pl. 6, fig. 3). The morphology and descriptive terminology of *Nostocites* are shown in text-figure 6.

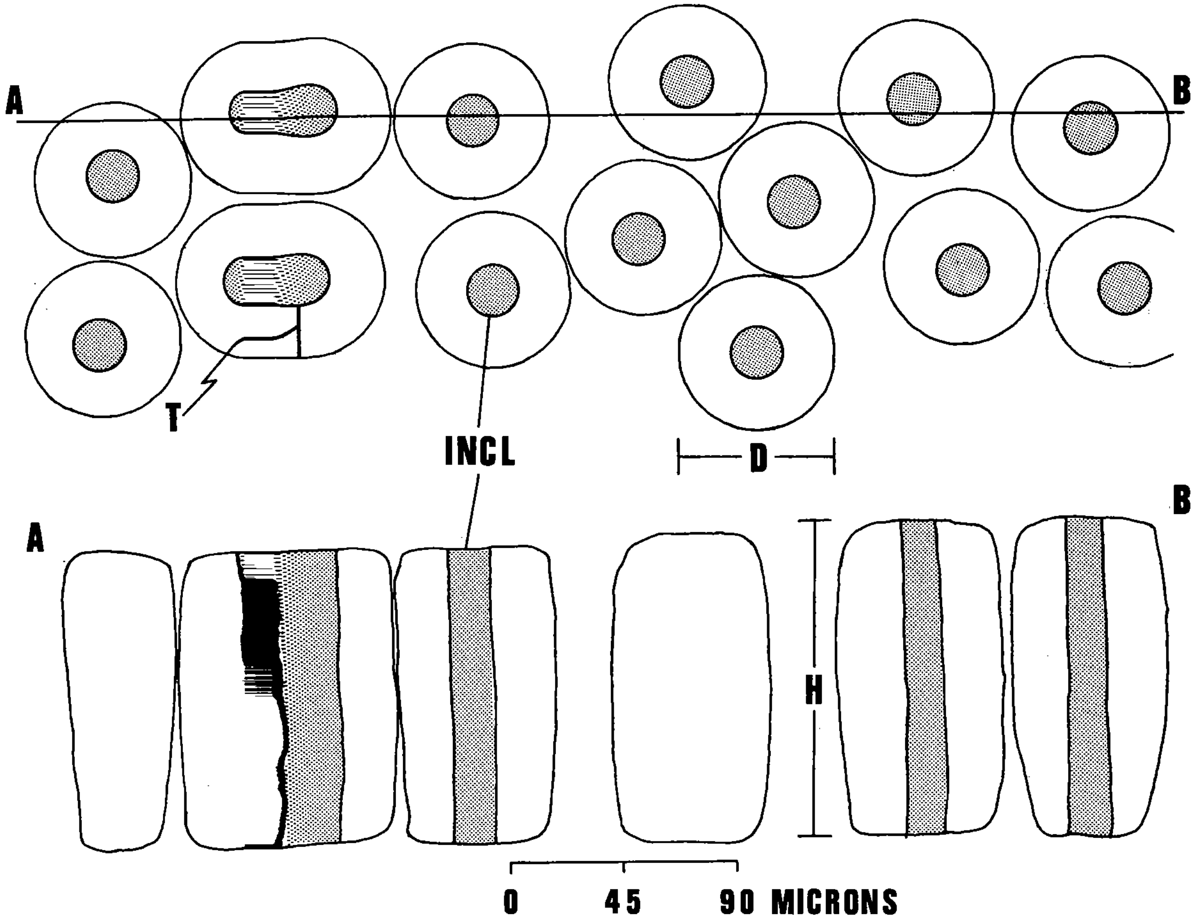
Nostocites resembles *Litostroma* Mamay in its general organization. The cells in *Litostroma*, however, are tightly packed and polygonal (rather than circular) in horizontal section. Vertical sections through *Nostocites* and *Litostroma* cannot readily be distinguished from one another (e.g., Mamay, 1959, figs. 3, 4).

Nostocites cf. **N. vesiculosa** Maslov, 1929

Pl. 7, figs. 7, 10–12

Nostocites vesiculosa MASLOV, 1929, p. 1538, pl. 70, figs. 2–7, 8, 10, text-figs. 1–3, 7; MASLOV, *in* ORLOV (ed.), 1963, p. 46, fig. 29; MAMET AND ROUX, 1978, p. 80, figs. 1?, 2, 3.

Description (n = 10).—Cell diameter is 39–98 μm, typically 50–70 μm. Height is 117–149 μm. Diameter of subcylindrical inclusions (pores?) is 15–20 μm. Wall is up to 40 μm thick.



Text-figure 6. *Nostocites* Maslov. Horizontal view, above; vertical view, below. *INCL*, inclusion; *D*, cell diameter; *H*, cell height; *T*, wall thickness.

Discussion.—The present material differs from the type material in its slightly larger cells.

Occurrence.—The species occurs in the Brentwood Limestone and Kessler Limestone Members of the Bloyd Formation (table 1) and the Braggs Member of the Sausbee Formation (table 2).

It was originally described from the Carboniferous of the Donets Basin, U.S.S.R. and has been illustrated elsewhere from Viséan (Lower Carboniferous) rocks of Great Britain (Mamet and Roux, 1978).

Form-Genus **Osagia** Twenhofel, 1919

Pl. 10, figs. 10, 11

Type species.—*Osagia encrustata* Twenhofel, 1919.

Description.—Colonies are spherical, ellipsoidal, or biscuit-shaped nodules composed mostly of girvanellid algae and encrusting foraminifers. Nodules vary in size from less than 1 mm to several centimeters. Nuclei may be fragments of invertebrate skeletons, detrital grains, or other algae.

Discussion.—*Osagia* differs from the form-genus *Ottonosia* Twenhofel in that it completely encrusts its host. *Ottonosia,* in contrast, encrusts only the upper surface of its host and typically forms a larger colony. The distinction between the genera is purely arbitrary, as there is no biological basis for separating them.

Occurrence.—*Osagia* is present in the Brentwood Limestone, Dye Shale, and Kessler Limestone Members of the Bloyd Formation (table 1). It also occurs in the Braggs and Brewer Bend Limestone Members of the Sausbee Formation and the Greenleaf Lake Limestone Member of the McCully Formation (table 2).

Family Salebridae Bogush and Brenckle, 1982

Genus **Tubisalebra** Bogush and Brenckle, 1982

Type species.—Tubisalebra conitabulata Bogush and Brenckle, 1982.

Description (modified from Bogush and Brenckle, 1982).—Skeleton consists of a chain of cylindrical, chevron-shaped, or coronal segments. Internally, the segments are composed of a longitudinally partitioned central tube that is surrounded by a cluster of nearly parallel, non-partitioned tubes. Segments are joined by flat, meniscus-shaped, or tapering connecting layers. Skeletons are typically fragmented, so that only unconnected segments are preserved.

Discussion.—Tubisalebra differs from the related genera *Salebra* Bogush and *Spumisalebra* Bogush and Brenckle in lacking vesicles. *Salebra* consists of a longitudinally partitioned central tube that is surrounded by a cluster of both tubes and vesicles, whereas *Spumisalebra* consists of a longitudinally partitioned tube surrounded only by vesicles.

Tubisalebra calamiformis Bogush and Brenckle, 1982

Pl. 10, figs. 14–17

Tubisalebra calamiformis Bogush and Brenckle, 1982, pl. 6, figs. 2–7, pl. 7, figs. 1–8.

Description (n = 4).—Segment height is 390–450 µm. Segment diameter is 195–281 µm. Large and small diameters of the central tube are 86–105 and 59–78 µm, respectively. Internal diameter of the non-partitioned tubes is 16–27 µm. Wall thickness of the central tube is 10–13 µm. Wall thickness of the non-partitioned tubes is 7–10 µm. Connecting layers are flat to weakly meniscus-shaped.

Discussion.—Tubisalebra calamiformis differs from *T. conitabulata* Bogush and Brenckle and *T. ruficoronae* Bogush and Brenckle in the cylindrical shape of the segments. Segments in *T. conitabulata* are chevron-shaped, whereas in *T. ruficoronae* they are coronal.

Occurrence.—The species is present in the Trace Creek Shale Member of the Atoka Formation (table 1). Specimens 15–17 of plate 10 come from the Trace Creek of the west branch of Sawney Hollow (not mentioned in the section on Localities): SE¼NE¼SW¼ sec. 25, T. 15 N., R. 26 E., Adair County, Oklahoma.

Bogush and Brenckle (1982) report specimens from the late Kinderhookian through early Meramecian of Missouri, Illinois, and Alaska.

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PLATES

Plate 1

(Sample prefixes are same as those of tables 1 and 2)

Figures 1, 3.——*Tuberitina plana* Reitlinger, 1950, ×200. *1*, vertical section (OU9790), sample 120-14D, Kessler Limestone Member of Bloyd Formation. *3*, vertical section (OU9791), sample 120-14D, Kessler Limestone Member of Bloyd Formation.

Figures 2, 4.—*Diplosphaerina inaequalis* (Derville, 1931), ×200. *2*, vertical section (OU9831), sample 1-6C, Braggs Member of Sausbee Formation. *4*, vertical section through three chambers (OU9884), sample 5B-8A, Brewer Bend Limestone Member of Sausbee Formation.

Figures 5, 6.—*Palaeonubecularia* spp., ×40. *5*, section through proloculus (OU9708), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *6*, oblique section (OU9677), sample 70-7A, Prairie Grove Member of Hale Formation.

Figures 7, 8.—*Pseudoglomospira* spp., ×100. *7*, oblique section through proloculus (OU9680), sample 70-8A, Prairie Grove Member of Hale Formation. *8*, oblique section through proloculus (OU9694), sample 70-10B-B, Brentwood Limestone Member of Bloyd Formation.

Figures 9, 10.——*Calcitornella* spp. *9*, oblique section, ×130 (OU9767), sample 70-24B off, Kessler Limestone Member of Bloyd Formation. *10*, oblique section, ×200 (OU9715), sample 70-14B, Brentwood Limestone Member of Bloyd Formation.

Figure 11.—*Trepeilopsis minima* Dain, 1958, ×200, axial section (OU9711), sample 70-14A, Brentwood Limestone Member of Bloyd Formation.

Figure 12.—*Turrispiroides* aff. *T. multivolutus* (Reitlinger, 1949), ×200, axial section (OU9705), sample 70-13B, Brentwood Limestone Member of Bloyd Formation.

Figure 13.—*Calcivertella adherens* Cushman and Waters, 1928, ×200, near horizontal section (OU9711), sample 70-14A, Brentwood Limestone Member of Bloyd Formation.


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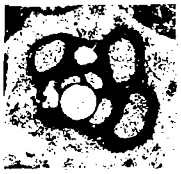
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Plate 2

(Sample prefixes are same as those of tables 1 and 2)

Figures 1–5.—*Turrispiroides multivolutus* (Reitlinger, 1949), ×200. *1*, axial section (OU9727), sample 70-18B, Brentwood Limestone Member of Bloyd Formation. *2*, axial section (OU9729), sample 70-18C, Brentwood Limestone Member of Bloyd Formation. *3*, axial section (OU9875), sample 5B-3C, Braggs Member of Sausbee Formation. *4*, axial section (OU9727), sample 70-18B, Brentwood Limestone Member of Bloyd Formation. *5*, sagittal section (OU9726), sample 70-18B, Brentwood Limestone Member of Bloyd Formation.

Figures 6, 7.—*Endothyra* spp., ×100. *6*, sagittal section (OU9839), sample 1-6D, Braggs Member of Sausbee Formation. *7*, oblique section (OU9690), sample 70-10B-A, Brentwood Limestone Member of Bloyd Formation.

Figures 8–10.——*Planoendothyra evoluta* (Reitlinger, 1950), ×100. *8*, axial section (OU9897), sample 5B-12C, Chisum Quarry Member of McCully Formation. *9*, sagittal section (OU9776), sample 70-27A, Trace Creek Shale Member of Atoka Formation. *10*, axial section (OU9716), sample 70-16A, Brentwood Limestone Member of Bloyd Formation.

Figures 12–15.——*Planoendothyra spirilliniformis* (Brazhnikova and Potievska, 1948), ×100. *12*, axial section (OU9818), sample 1-3‴B, Braggs Member of Sausbee Formation. *13*, axial section (OU9789), sample 120-14C, Kessler Limestone Member of Bloyd Formation. *14*, sagittal section (OU9678), sample 70-8A, Prairie Grove Member of Hale Formation. *15*, sagittal section (OU9727), sample 70-18B, Brentwood Limestone Member of Bloyd Formation.

Figure 11.—*Planoendothyra*? sp. A, ×100, sagittal section (OU9816), sample 1-3‴B, Braggs Member of Sausbee Formation.


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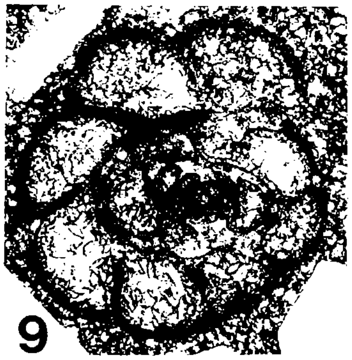
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Plate 3

(Sample prefixes are same as those of tables 1 and 2)

Figures 1, 2.—*Planoendothyra*? sp. A, ×100. *1*, axial section (OU9816), sample 1-3″B, Braggs Member of Sausbee Formation. *2*, axial section (OU9815), sample 1-3″B, Braggs Member of Sausbee Formation.

Figures 3–7.—*Asteroarchaediscus rugosus* (Rauzer-Chernousova, 1948), ×200. *3*, axial section (OU9683), sample 70-8C, Prairie Grove Member of Hale Formation. *4*, axial section (OU9728), sample 70-18B, Brentwood Limestone Member of Bloyd Formation. *5*, axial section (OU9687), sample 70-10A-A, Prairie Grove Member of Hale Formation. *6*, sagittal section (OU9685), sample 70-8C, Prairie Grove Member of Hale Formation. *7*, axial section (OU9730), sample 70-18C, Brentwood Limestone Member of Bloyd Formation.

Figures 8, 9.—*Neoarchaediscus* spp., ×200. *8*, axial section (OU9706), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *9*, sagittal section (OU9679), sample 70-8A, Prairie Grove Member of Hale Formation.

Figures 10, 11.—*Biseriella* spp., ×100. *10*, tangential section (OU9694), sample 70-10B-B, Brentwood Limestone Member of Bloyd Formation. *11*, sagittal section (OU9688), sample 70-10A-B, Prairie Grove Member of Hale Formation.

Figure 12.—*Planospirodiscus*? sp. A, ×200, axial section (OU9694), sample 70-10B-B, Brentwood Limestone Member of Bloyd Formation.

Figure 13.—*Tubispirodiscus* sp. A, ×200, axial section (OU9806), sample 1-3A, Braggs Member of Sausbee Formation.

Figure 14.—*Hemiarchaediscus* sp. A, ×200, axial section (OU9678), sample 70-8A, Prairie Grove Member of Hale Formation.

Figure 15–19.—*Monotaxinoides transitorius* Brazhnikova and Yartseva, 1956, ×200. *15*, axial section (OU9845), sample 1-6E, Braggs Member of Sausbee Formation. *16*, axial section (OU9711), sample 70-14A, Brentwood Limestone Member of Bloyd Formation. *17*, axial section (OU9724), sample 70-18A, Brentwood Limestone Member of Bloyd Fromation. *18*, axial section (OU9724), sample 70-18A, Brentwood Limestone Member of Bloyd Formation. *19*, axial section (OU9845), sample 1-6E, Braggs Member of Sausbee Formation.


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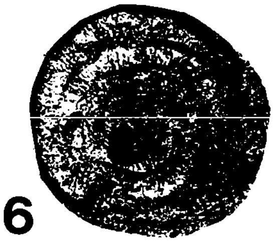
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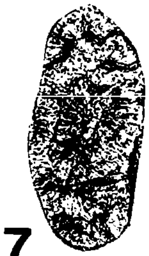
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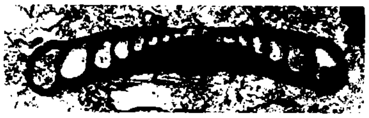
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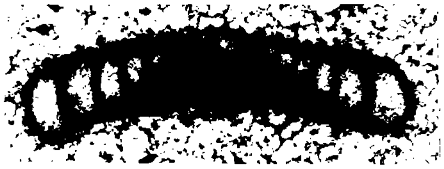
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Plate 4

(Sample prefixes are same as those of tables 1 and 2)

Figures 1, 2.—*Eostaffella pinguis* (Thompson, 1944), ×100. *1*, axial section (OU9669), sample 70-6A-L, Prairie Grove Member of Hale Formation. *2*, axial section (OU9678), sample 70-8A, Prairie Grove Member of Hale Formation.

Figures 3, 5.—*Millerella* aff. *M. pressa* Thompson, 1944, ×100. *3*, axial section (OU9709), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *5*, axial section (OU9709), sample 70-13B, Brentwood Limestone Member of Bloyd Formation.

Figure 4.—*Millerella pressa* Thompson, 1944, ×100, axial section (OU9709), sample 70-13B, Brentwood Limestone Member of Bloyd Formation.

Figures 6, 7.—*Eostaffella* sp. B, ×100. *6*, axial section (OU9789), sample 120-14C, Kessler Limestone Member of Bloyd Formation. *7*, axial section (OU9789), sample 120-14C, Kessler Limestone Member of Bloyd Formation.

Figures 8–12.—*Eostaffella* sp. A, ×100. *8*, axial section (OU9901), sample 5B-15A, Chisum Quarry Member of McCully Formation. *9*, axial section (OU9900), sample 5B-15A, Chisum Quarry Member of McCully Formation. *10*, axial section (OU9885), sample 5B-8A, Brewer Bend Limestone Member of Sausbee Formation. *11*, axial section (OU9898), sample 5B-15A, Chisum Quarry Member of McCully Formation. *12*, axial section (OU9899), sample 5B-15A, Chisum Quarry Member of McCully Formation.

Figures 13–17.—*Millerella marblensis* Thompson, 1942, ×100. *13*, axial section (OU9708), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *14*, axial section (OU9707), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *15*, axial section (OU9708), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *16*, axial section (OU9708), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *17*, axial section (OU9709), sample 70-13B, Brentwood Limestone Member of Bloyd Formation.

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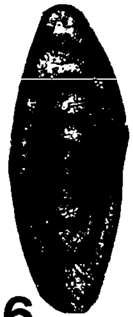
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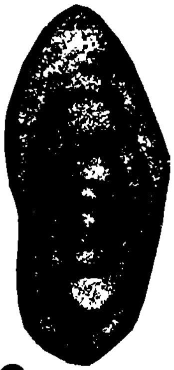
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Plate 5

(Sample prefixes are same as those of tables 1 and 2)

Figures 1?, 2–5.—*Millerella pressa* Thompson, 1944, ×100. *1*, sagittal section (OU9704), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *2*, axial section (OU9705), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *3*, axial section (OU9707), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *4*, axial section (OU9709), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *5*, axial section (OU9707), sample 70-13B, Brentwood Limestone Member of Bloyd Formation.

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Figure 10?.—*Millerella marblensis* Thompson, 1942, ×100, sagittal section (OU9709), sample 70-13B, Brentwood Limestone Member of Bloyd Formation.

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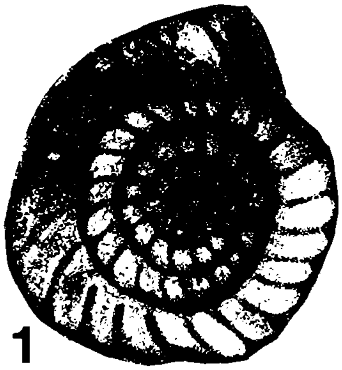
Figures 14, 15.—*Climacammina antiqua* Brady, 1871, ×25. *14*, axial section (OU9843), sample 1-6D, Braggs Member of Sausbee Formation. *15*, axial section (OU9847), sample 1-6E, Braggs Member of Sausbee Formation.

Figure 16.—*Tetrataxis angusta* Vissarionova, 1948, ×40, near axial section (OU9857), sample 1-7C, Braggs Member of Sausbee Formation.

Figure 17.—*Palaeotextularia*? sp., ×40, axial section (OU9816), sample 1-3″B, Braggs Member of Sausbee Formation.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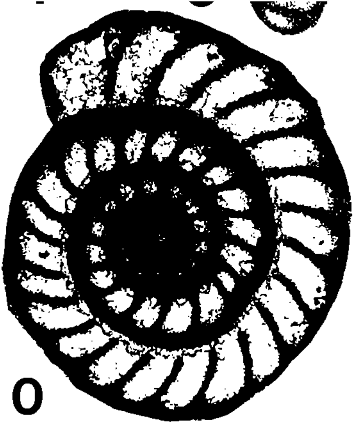
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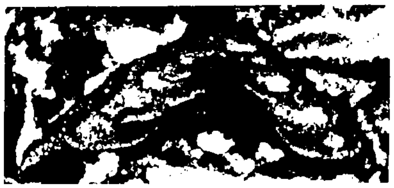
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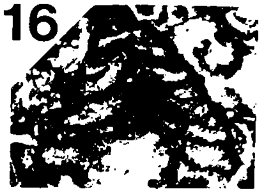
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(Sample prefixes are same as those of tables 1 and 2)

Figures 1, 2, 5–9.—*Hemigordius harltoni* Cushman and Waters, 1928, ×200. *1*, axial section (OU9722), sample 70-18A, Brentwood Limestone Member of Bloyd Formation. *2*, axial section (OU9722), sample 70-18A, Brentwood Limestone Member of Bloyd Formation. *5*, axial section (OU9722), sample 70-18A, Brentwood Limestone Member of Bloyd Formation. *6*, axial section (OU9722), sample 70-18A, Brentwood Limestone Member of Bloyd Formation. *7*, axial section (OU9722), sample 70-18A, Brentwood Limestone Member of Bloyd Formation. *8*, sagittal section (OU9739), sample 70-20D, Dye Shale Member of Bloyd Formation. *9*, sagittal section (OU9736), sample 70-20C, Dye Shale Member of Bloyd Formation.

Figures 3, 4.—*Eolasiodiscus donbassicus* Reitlinger, 1956, ×200. *3*, sagittal section (OU9818), sample 1-3′′′B, Braggs Member of Sausbee Formation. *4*, sagittal section (OU9712), sample 70-14A, Brentwood Limestone Member of Bloyd Formation.

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Figures 16–18.—*Donezella* aff. *D. lunaensis* Rácz, 1965, ×40. *16*, axial section of large fragment with smaller fragments scattered in matrix (OU9878), sample 5B-6A, Brewer Bend Limestone Member of Sausbee Formation. *17*, axial section (OU9862), sample 1-9A, Braggs Member of Sausbee Formation. *18*, axial section (OU9880), sample 5B-6C, Brewer Bend Limestone Member of Sausbee Formation.

Figure 19.—*Paraepimastopora* sp. A, ×40, tangential section (OU9749), sample 70-24D, Kessler Limestone Member of Bloyd Formation.


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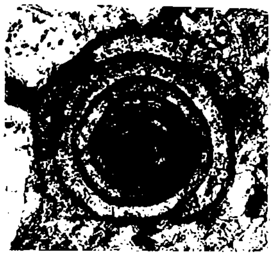
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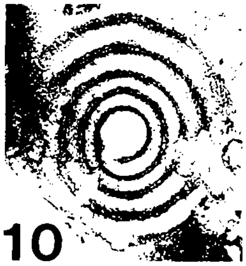
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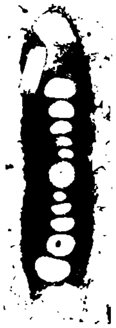
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Plate 7

(Sample prefixes are same as those of tables 1 and 2)

Figure 1.—*Paraepimastopora* sp. A, ×25, near axial section (OU9743), sample 70-24B, Kessler Limestone Member of Bloyd Formation.

Figures 2, 4, 6, 8.—*Stacheoides* aff. *S. tenuis* Petryk and Mamet, 1972, ×40. *2*, tangential section (OU9756), sample 70-25F, Kessler Limestone Member of Bloyd Formation. *4*, tangential section (OU9759), sample 70-25A, Kessler Limestone Member of Bloyd Formation. *6*, tangential section (OU9755), sample 70-25F, Kessler Limestone Member of Bloyd Formation. *8*, tangential section (OU9757), sample 70-25A, Kessler Limestone Member of Bloyd Formation.

Figures 3, 5, 9.—*Asphaltina cordillerensis* Mamet, 1972, ×40. *3*, near transverse section (OU9705), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *5* diagonal section (OU9705), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *9*, near transverse section (OU9743), sample 70-24B, Kessler Limestone Member of Bloyd Formation.

Figures 7, 10–12.—*Nostocites* cf. *N. vesiculosa* Maslov, 1929, ×40. *7*, oblique section (OU9727), sample 70-18B, Brentwood Limestone Member of Bloyd Formation. *10*, horizontal section (OU9724), sample 70-18A, Brentwood Limestone Member of Bloyd Formation. *11*, vertical section (OU9841), sample 1-6D, Braggs Member of Sausbee Formation. *12*, horizontal section (OU9705), sample 70-13B, Brentwood Limestone Member of Bloyd Formation.


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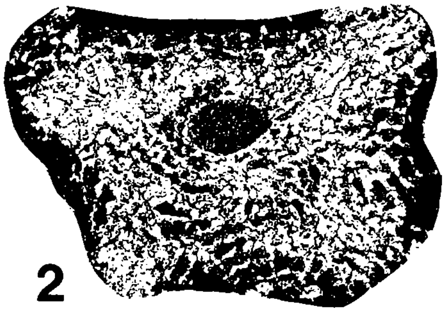
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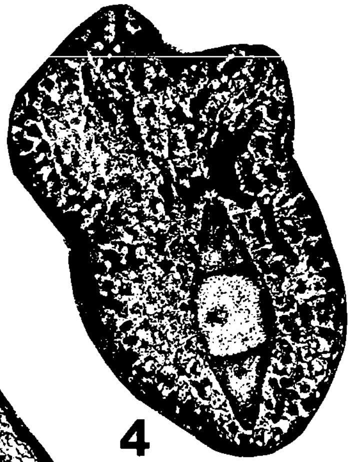
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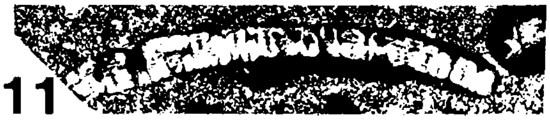
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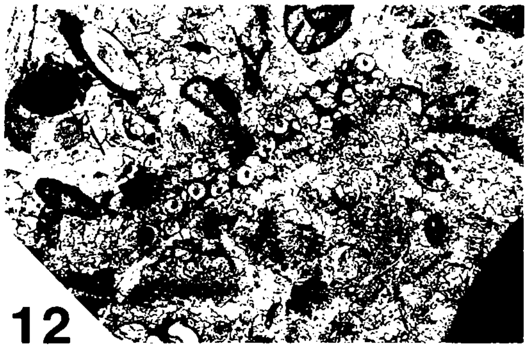
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Plate 8

(Sample prefixes are same as those of tables 1 and 2)

Figures 1–4.—"*Stacheoides*" *spissa* Petryk and Mamet, 1972, ×40. *1*, tangential section (OU9828), sample 1-6B, Braggs Member of Sausbee Formation. *2*, tangential section (OU9705), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *3*, tangential section (OU9704), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *4*, tangential section (OU9679), sample 70-8A, Prairie Grove Member of Hale Formation.

Figures 5, 10, 11.—*Cuneiphycus texana* Johnson, 1960. *5*, horizontal section, ×100 (OU9829), sample 1-6C, Braggs Member of Sausbee Formation. *10*, randomly oriented fragments in matrix, ×40 (OU9832), sample 1-6C, Braggs Member of Sausbee Formation. *11*, randomly oriented fragments in matrix, ×25 (OU9831), sample 1-6C, Braggs Member of Sausbee Formation.

Figures 6–9.—"*Eflugelia*" sp. A, ×40. *6*, vertical section (OU9751), sample 70-24E, Kessler Limestone Member of Bloyd Formation. *7*, vertical section (OU9766), sample 70-24A off, Kessler Limestone Member of Bloyd Formation. *8*, vertical section (OU9816), sample 1-3″B, Braggs Member of Sausbee Formation. *9*, vertical section (OU9752), sample 70-24E, Kessler Limestone Member of Bloyd Formation.

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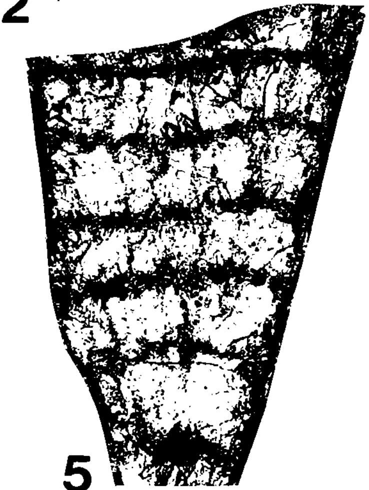

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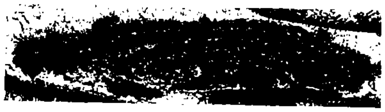

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Plate 9

(Sample prefixes are same as those of table 1 and 2)

Figures 1, 2.—*Cuneiphycus aliquantulus* Johnson, 1960. *1*, horizontal section, ×100 (OU9696), sample 70-12A, Brentwood Limestone Member of Bloyd Formation. *2*, near horizontal section, ×40 (OU9694), sample 70-10B-B, Brentwood Limestone Member of Bloyd Formation.

Figures 3, 4, 6.—*Archaeolithophyllum missouriense* Johnson, 1956, ×40. *3*, oblique section (OU9685), sample 70-8C, Prairie Grove Member of Hale Formation. *4*, oblique section (OU9687), sample 70-10A-A, Prairie Grove Member of Hale Formation. *6*, oblique section (OU9690), sample 70-10B-A, Brentwood Limestone Member of Bloyd Formation.

Figures 5, 7, 9.—*Archaeolithophyllum* sp. A. *5*, oblique section, ×40 (OU9746), sample 70-24C, Kessler Limestone Member of Bloyd Formation. *7*, oblique section, ×40 (OU9662), sample 70-6A-E, Prairie Grove Member of Hale Formation. *9*, oblique section, ×100 (OU9672), sample 70-6B-C, Prairie Grove Member of Hale Formation.

Figures 8, 10.—*Girvanella minuta* Wethered, 1890. *8*, random section, ×40 (OU9829), sample 1-6C, Braggs Member of Sausbee Formation. *10*, random section, ×200 (OU9842), sample 1-6D, Braggs Member of Sausbee Formation.

Figures 11, 12.—*Proninella strigosa* (Vachard, 1977). *11*, randomly oriented fragments in matrix, ×40 (OU9878), sample 5B-6A, Brewer Bend Limestone Member of Sausbee Formation. *12*, randomly oriented fragments in matrix, ×25 (OU9827), sample 1-6B, Braggs Member of Sausbee Formation.


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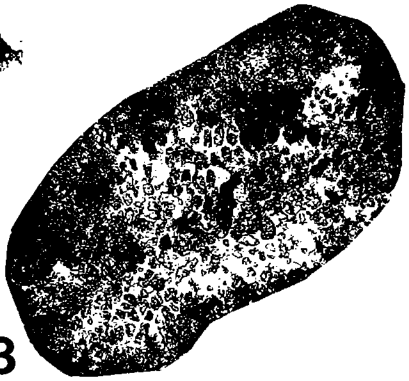
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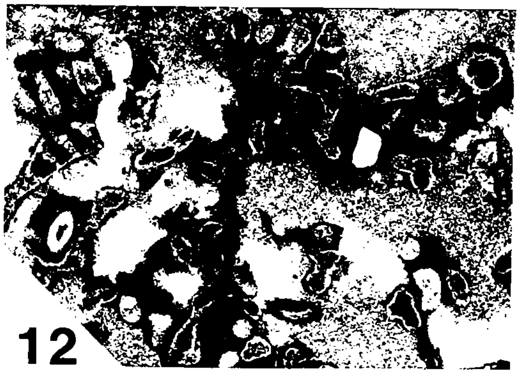
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Plate 10

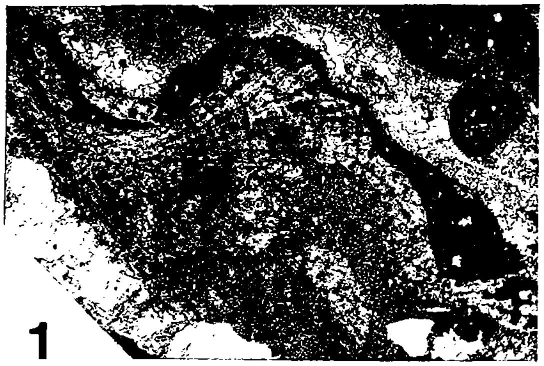
(Sample prefixes are same as those of tables 1 and 2)

Figures 1–9.—Genus A, species A, n. gen., n. sp. *1*, oblique section, ×40 (OU9690), sample 70-10B-A, Brentwood Limestone Member of Bloyd Formation. *2*, near-horizontal section of fragments in matrix, ×40 (OU9909), sample 10568-14 (Hale Mountain), Brentwood Limestone Member of Bloyd Formation. *3*, near-horizontal section, ×40 (OU9903), sample 10568-11 (Hale Mountain), Brentwood Limestone Member of Bloyd Formation. *4*, near-horizontal section, ×40 (OU9909), sample 10568-14 (Hale Mountain), Brentwood Limestone Member of Bloyd Formation. *5*, oblique section, ×40 (OU9907), sample 10568-14 (Hale Mountain), Brentwood Limestone Member of Bloyd Formation. *6*, near-horizontal sections of fragments in matrix, ×40 (OU9907), sample 10568-14 (Hale Mountain), Brentwood Limestone Member of Bloyd Formation. *7*, oblique section, ×40 (OU9693), sample 70-10B-B, Brentwood Limestone Member of Bloyd Formation. *8*, oblique section, ×40 (OU9691), sample 70-10B-A, Brentwood Limestone Member of Bloyd Formation. *9*, oblique section, ×25 (OU9911), sample 10568-14 (Hale Mountain), Brentwood Limestone Member of Bloyd Formation.

Figures 10, 11.—*Osagia*, ×40. *10*, tangential section (OU9749), sample 70-24D, Kessler Limestone Member of Bloyd Formation. *11*, tangential section (OU9793), sample 120-14E, Kessler Limestone Member of Bloyd Formation.

Figures 12, 13.—*Calcisphaera laevis* Williamson, 1880, ×200. *12*, section nearly through center (OU9704), sample 70-13B, Brentwood Limestone Member of Bloyd Formation. *13*, section nearly through center (OU9797), sample 120-14G, Kessler Limestone Member of Bloyd Formation.

Figures 14–17.—*Tubisalebra calamiformis* Bogush and Brenckle, 1982, ×100. *14*, transverse section (OU9912), sample 120-19B, Trace Creek Shale Member of Atoka Formation. *15*, transverse section (OU9913), sample 169-27, Trace Creek Shale Member of Atoka Formation. *16*, longitudinal section (OU9913), sample 169-27, Trace Creek Shale Member of Atoka Formation. *17*, longitudinal section (OU9913), sample 169-27, Trace Creek Shale Member of Atoka Formation.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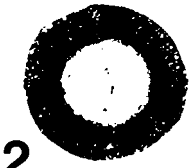
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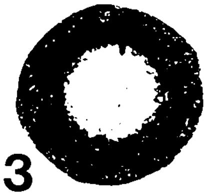
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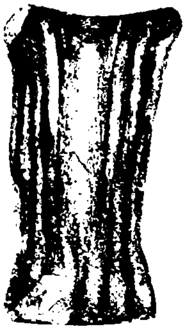
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