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by WILLIAM E. KING

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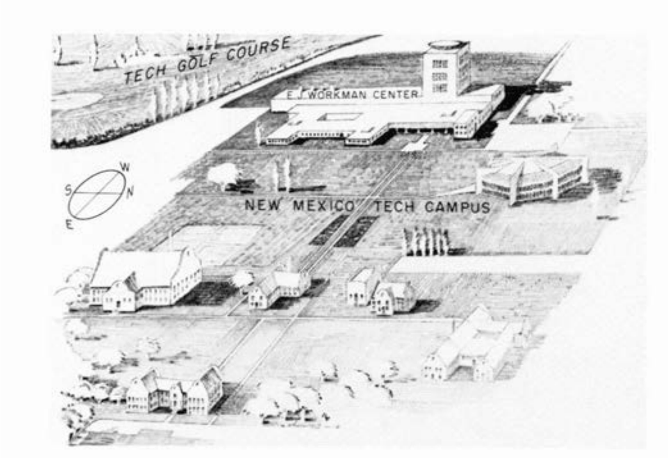

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Abstract

Fusulinids of the genera *Millerella* and *Eostaffella* occur in great abundance in the Arrey and Apodaca Formations of the type lower Derry Series of New Mexico and the type Marble Falls Formation of Texas. The lower part of the Marble Falls Formation is assigned to the Morrowan Series, and the upper part of the Marble Falls to the Atokan Series. Comparison of the two sections on the basis of the *Millerella-Eostaffella* fauna indicates that these primitive genera do have stratigraphic utility and that the Atokan species of the upper part of the Marble Falls Formation compare favorably with the species of the lower part of the Derry Series. The *Eostaffella* assemblage of the Morrowan part of the Marble Falls Formation is distinct from the Atokan assemblage of both localities. Most of the species discussed are found in the Carboniferous of Russia and Japan and were first described in the Russian literature. This group of fusulinids has value for the correlation of the Lower Pennsylvanian of the United States with the Carboniferous of Russia and Japan. One new species, *Millerella extensus* King, is described.

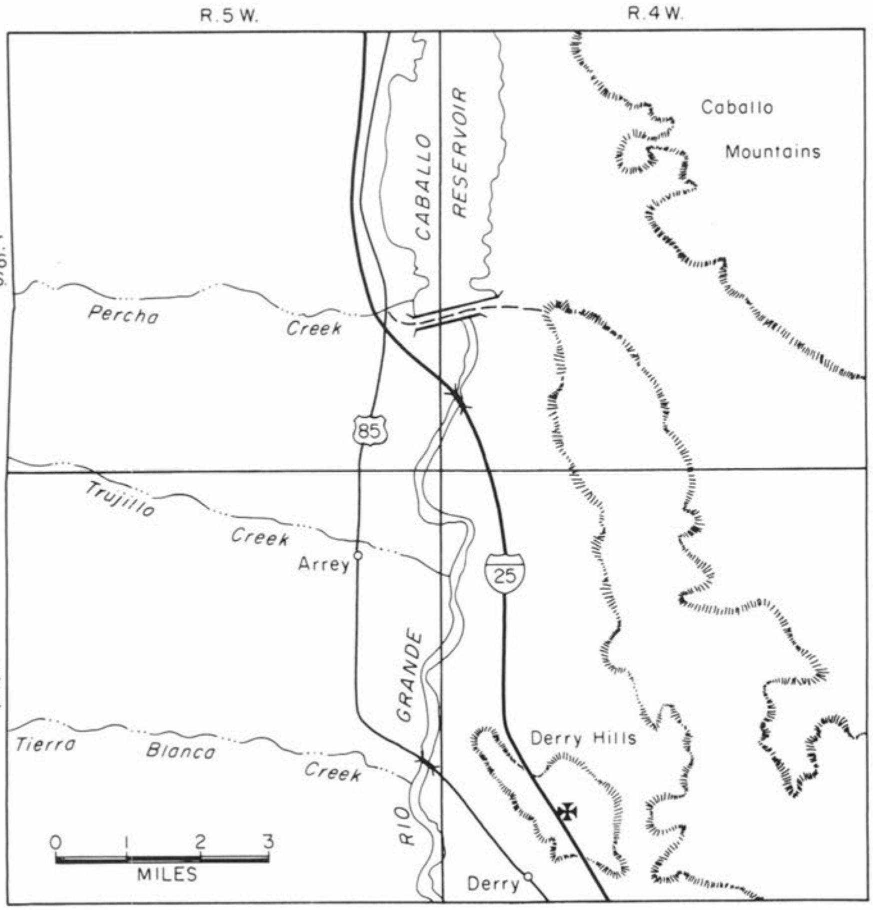

FIGURE 1—*Index map for Derry Series.*

Introduction

The purpose of this report is to present the stratigraphic occurrence of the primitive fusulinid genera *Millerella* and *Eostaffella* in the type Derry Series of New Mexico and in the type Marble Falls Formation of Texas to determine their value as zonation fossils to the Morrowan and Early Atokan. Because American paleontologists have devoted little attention to these genera, little is known of their range and potential as index fossils. Most stratigraphic paleontologists working in the Pennsylvanian consider the Morrowan Series to be that part of the Pennsylvanian stratigraphic section devoid of fusulinids more advanced than *Millerella* and *Eostaffella,* and regard the base of the Atoka Series closely coincident with the first appearance of *Profusulinella.*

The author hopes that detailed examination of the *Millerella-Eostaffella* fauna in many localities will yield information for identifying important and useful biozones of the Morrow and lower Atoka strata.

Russian and Japanese paleontologists are working extensively with the zoning objective in mind. This report, a beginning attempt to understand the significance of the genera, with information from two classic Lower Pennsylvanian sections, sheds some light on the abundance, variation and range of certain species of the genera.

The author believes the Derry Series of New Mexico is roughly equivalent to the Atoka Series of North America, as defined on the basis of fusulinids. Whether the lowest part of the Derry Series, which has only fusulinids more primitive than *Profusulinella,* is Morrowan in age is not known. However, on the basis of a comparison with the *Millerella-Eostaffella* fauna of the Marble Falls Formation and the lowest Derry Series, the questionable part of the lowest Derry Series would seem to be Atokan.

ACKNOWLEDGEMENTS

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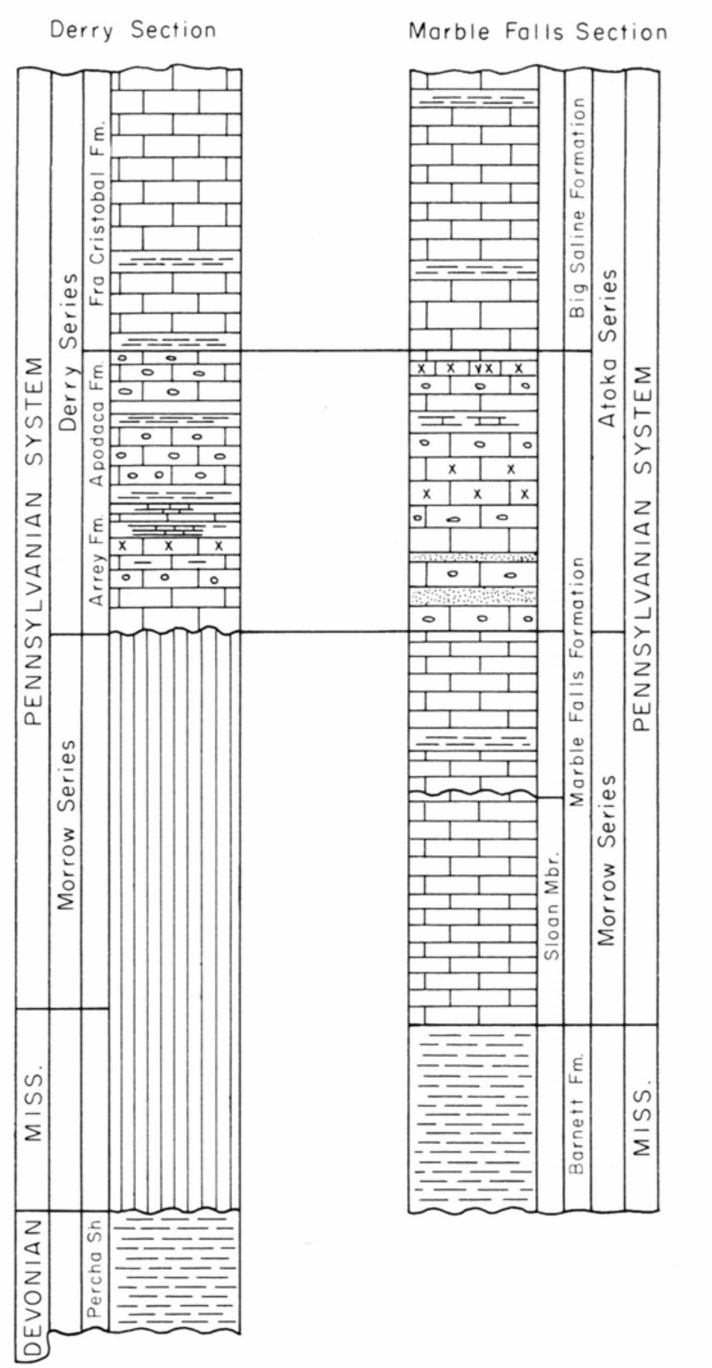
The author appreciates the aid received but accepts responsibility for any errors of fact or judgment which may occur in this report.

METHODS

Twenty-four rock samples were collected from the Arrey and Apodaca Formations of the type section of the Derry Series at about three and one-half foot intervals (fig. 2). Seventy-seven samples were collected from the type section of the Marble Falls limestone at about 4 1/2-ft. intervals (fig. 5).



Correlation of Derry and Marble Falls sections.

The small size of *Millerella* and *Eostaffella make* them difficult to orient in thin section. Therefore, 4 to i o random thin sections were made from the rock of each collection. In all, over 800 thin sections were available for study. Though not complete, collection coverage of the two stratigraphic sections was reasonably comprehensive.

Because more advanced and well-understood fusulinids, like *Fusulinella*, occur in the Hot Springs Formation overlying the Apodaca Formation of the type Deny Series, only the lower part of the Derry was considered in investigating the *Millerella-Eostaffella* fauna. Likewise, because the familiar fusulinid index fossil, *Fusulinella*, occurs in the Big Saline Formation (immediately younger than the Marble Falls Formation) of central Texas, the primitive genera of the beds stratigraphically higher than the Marble Falls Formation were not studied.

The present study includes *Millerella* and *Eostaffella* that occur with *Profusulinella*. *Profusulinella* first occurs in the Arrey Formation in bed 2 of Thompson, although some unidentifiable fragments suggest that it might be as low as bed I. The author found the first occurrence of the genus in the Marble Falls Formation in collection 44 of Plummer's bed II (Plummer, 195o, p. 51). Thus, the association of *Millerella-Eostaffella* has been studied for the questionable Morrowan part of the Derry Series, the Morrowan of the Marble Falls Formation, and the early part of the Atokan in both collection localities. The assemblage has been examined up to the strata where the better-understood and more reliable fusulinid index fossils are available.

The zone of chief utility of an understanding of the primitive genera will be in the Lower Pennsylvanian where they are abundant and often occur without highly evolved fusulinids. Moreover, the usefulness of this information for subsurface exploration of Lower Pennsylvanian rocks can be significant, because these genera are small enough to be recovered by the hundreds in well cuttings.

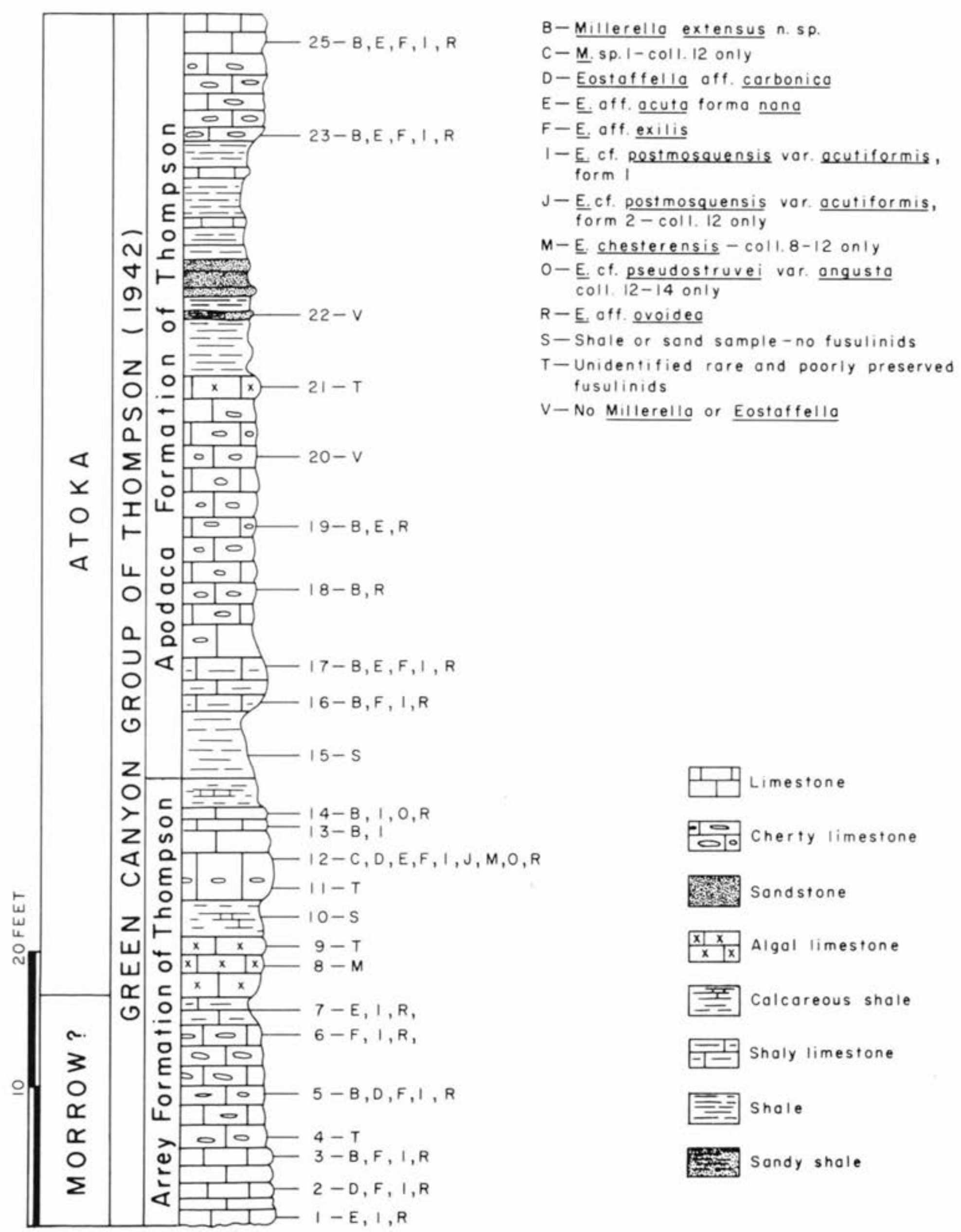


FIGURE 2—*Collection numbers and fusulinid occurrences in lower Derry Series.*

stratigraphy

LOWER DERRY SERIES

The Derry Series was named by M. L. Thompson (1942, p. 26-27) for the rocks between the base of the Pennsylvanian System and the basal part of the Pennsylvanian Des Moines Series in the central to extreme south-central areas of New Mexico. Thompson (1948, p. 68) later stated that the Derry Series included all rocks of south-central New Mexico of post-Morrowan and pre-Des Moinesian age.

The locality of the type section is on the steep west slope of the Derry Hills about three-fourths of a mile east of Derry, New Mexico (fig. r). Since the selection of the type locality, interstate highway 25 has been constructed through the region with a steep highway cut exposing the Percha Shale and the basal Derry Series. The sequence of beds Thompson described can be identified easily.

Because Thompson's report has long been out of print, his measured type section of the Derry series, occurring .o8 mile east of Derry, Sierra County, New Mexico, is reproduced below .

UNIT		THICK. (FT)
MUD SPRINGS GROUP		
Cuchillo Negro Formation (16.0 ft.)		
21	Limestone, gray to dark gray, fine grained, dense and hard; fusulinids abundant, especially in lower 8.0 feet; highly cherty throughout; upper 5.0 feet highly algal, dark gray, massive, and contains scattered fusulinids; long fusulinids very abundant in lower 2.0 feet; *Fusulinella*	13.0
20	Limestone, highly nodular to irregularly bedded; poorly exposed and forms slope; medium gray to gray; *Fusulinella, Eoschubertella*	3.0
Hot Springs Formation (24.0 ft.)		
19	Limestone, medium gray to gray; massively bedded; algal; contains discontinuous layers of gray to dark gray chert	4.5
18	Limestone, medium to light gray; dense and hard; scattered algae; one bed; *Fusulinella, Pseudostaffella, Millerella*	2.0
17	Covered. Greenish gray shale shows on slope	3.0
16	Limestone, dark gray in upper 5.0 feet; lower 8.0 feet light gray; massively bedded in beds up to 1.5 feet; highly fossiliferous; breaks down easily to slope; fusulinids in lower 2.0 feet, thin beds of chert scattered throughout; *Fusulinella, Millerella*	13.0
15	Shale, green to greenish yellow, fissile	1.5
GREEN CANYON GROUP		
Apodaca Formation (55.5 ft.)		
14 & 15	Limestone, greenish gray; highly siliceous dense, hard; lower 1.0 foot nodular, breaks down into slope	2.5
12	Limestone, gray to medium gray; dense and hard, massively bedded; highly cherty; chert beds and irregular masses up to 1.0 foot thick; lower 2.0 feet weathers out in slabby beds; *Profusulinella, Millerella*	6.5
11	Upper part poorly exposed, limestone and shale showing in places. Middle 5.0 feet sandy shale and sandstone; sandstone yellow. Lower 6.0 feet shale; dark gray to carbonaceous, fissile, with abundant fossils in base	17.0
10	Limestone or siltstone; argillaceous and micaceous; upper 1.0 foot algal; next 2.0 feet hard and silty; lower 10.0 feet contains nodular lime with wavily bedded argillaceous siltstone; entire exposure weathers with irregular thin beds, orange to dark brown on faces of cliff; highly cherty	20.5
9 & 8	Limestone, argillaceous and silty, interbedded with shale; weathers yellowish	4.0
7	Shale, bluish gray, fissile; abundant limestone nodules	5.0
Arrey Formation (32.0 ft.)		
6	Limestone, crinoidal; in beds (irregular) up to 1.0 foot thick, interbedded with highly calcareous and fossiliferous shale; shale more common in upper portion; *Millerella, Profusulinella*	5.0
5	Limestone, bluish gray to light gray, one massive bed; abundant concentric masses and irregular beds of chert up to 1.7 feet thick; weathered face of chert appears laminated; *Profusulinella, Millerella*	3.5
4	Shale, highly calcareous, interbedded with argillaceous limestone; fossiliferous; *Millerella*	2.5
3	Limestone, gray, fine grained, dense and hard, massively bedded; upper 1.0 foot and lower 1.0 foot highly nodular; algal throughout; *Millerella, Profusulinella*	4.5
2-A	Limestone and shale; limestone irregularly bedded; shale calcareous	2.0
2	Limestone, bluish gray, fine grained, dense and hard; extremely cherty; chert about 15 percent of entire bed; forms lower cliff on scarp; horn corals common; *Millerella*	9.0
1	Limestone, gray; upper 1.0 foot highly nodular, middle 3.0 feet massively bedded, in beds 1.0 foot thick, lower 1.0 foot highly nodular; fossiliferous throughout; *Millerella, Ozawainella* (?)	5.5
	Rests unconformably on Devonian shale	

Although the detailed problems of stratigraphy and the difficulties of widespread correlation of the Derry Series is outside the scope of this paper, some of the more pertinent references are reviewed below.

One of the early articles on the Pennsylvanian of New Mexico was by Gordon (1907). In nearby west Texas the Pennsylvanian strata were studied by Nelson (1940) and later by Harbour (1948). Thompson (1942) subdivided the Pennsylvanian and later (1948) discussed the fusulinids of the Lower Pennsylvanian. For discussions of the Pennsylvanian of south-central New Mexico, the reader is referred to Gehrig (1958), Kelley (1955), Kelley and Silver (1952), Kottlowski (1960b, 1963b), and Thompson and Kottlowski (1955). For important coverage of southwestern New Mexico, one may start with Kottlowski (1958, 1960, 1962, 1963, 1965), Zeller (1960, 1965) and Wilson (1969). Pray (1954, 1961) discusses the Lower Pennsylvanian of the Sacramento Mountains, and Kottlowski and others (1956) the strata of the San Andres Range. Meyer (1966) makes important observations on the Pennsylvanian of southeast New Mexico.

The detailed occurrence of the genera in the Derry Series is designated by letter in fig. 2.

The ranges of the genera are shown in fig. 3.

MARBLE FALLS FORMATION

The type locality for the Marble Falls Formation is located on the shore of Lake Marble Falls a fraction of a mile southeast of the business district of Marble Falls,

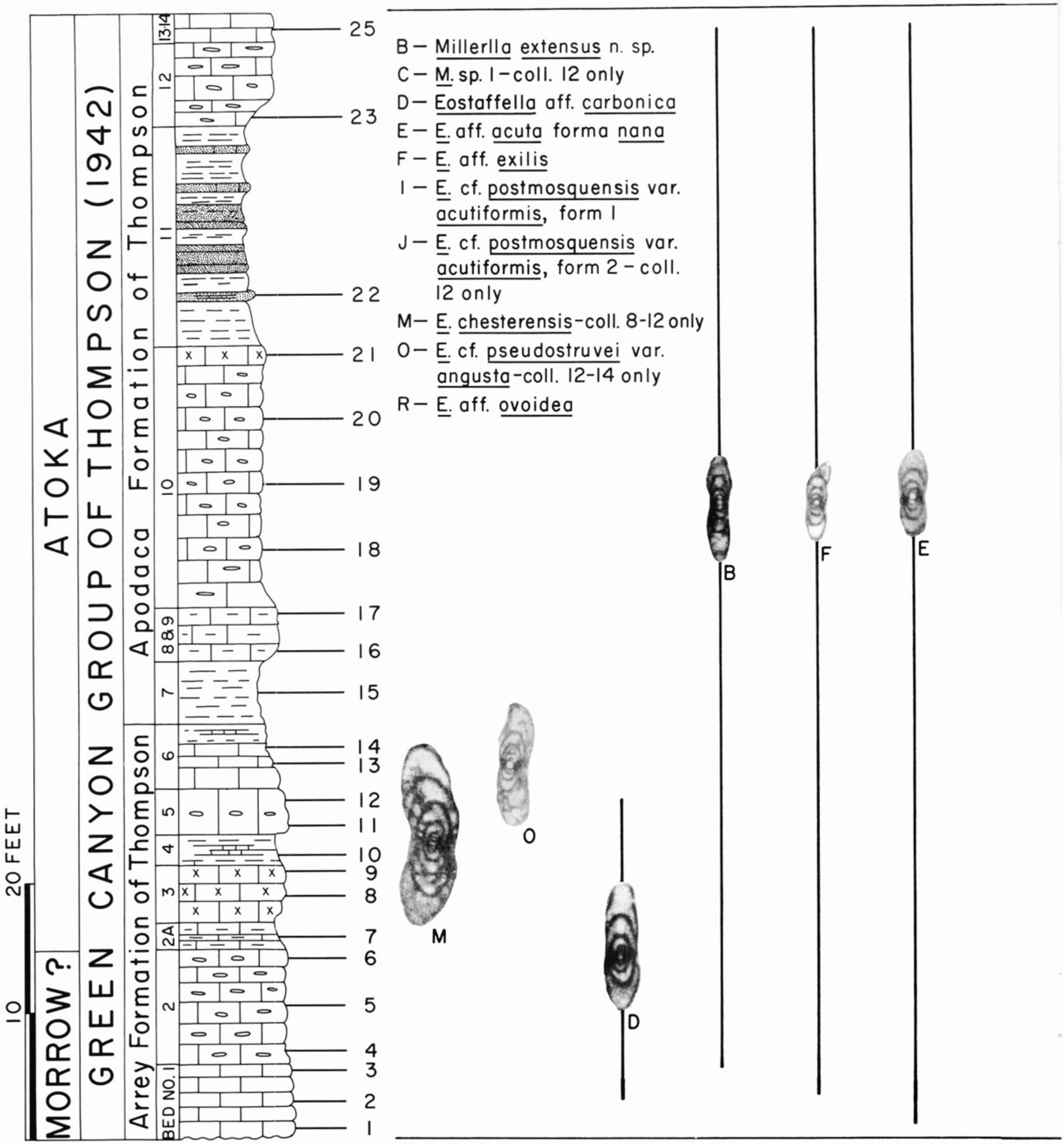
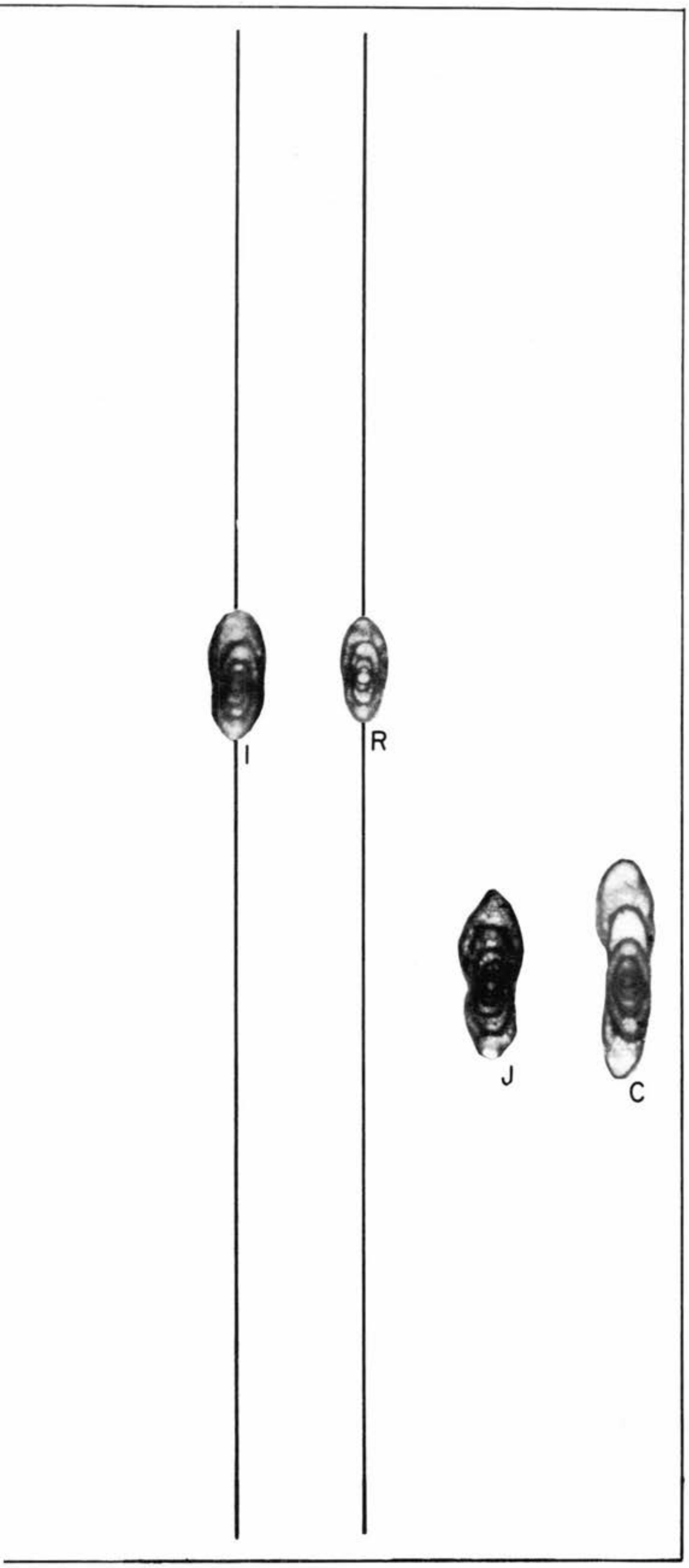


FIGURE 3—*Ranges of fusulinids in Green Canyon Group.*



Texas (Plummer 195o, pl. r). Even though the area of the type section is now flooded by waters of the lake, Plummer's stratigraphic section may be measured on the north shore of the lake.

The first historical account regarding the strata now called the Marble Falls Formation is that of Roemer (1847). Hill (1889, p. 289) named the beds "encrinital" or Marble Falls for the well-known exposures at the town of Marble Falls on the Colorado River. Dumble (189o) proposed the Bend Division. Paige (1911) restricted the Marble Falls and designated the overlying black shales the Smithwick. Udden and others (1916) included the lower brown shale, the Barnett Formation, in the Marble Falls. Plummer and Moore (1922, p. 33) restricted the Marble Falls to exclude the brown shale.

Cheney (194o) substituted the term Lampasas Series for the Bend Series and divided the Marble Falls into the Marble Falls group and the Big Saline group. In so doing, he restricted the Marble Falls group to the Morrowan. Spivey and Roberts (1946) rejected the assumption of Cheney that the Marble Falls is restricted to the Morrowan and, rather, placed it in the Atokan. Plummer (1947, 194713) described the Marble Falls rocks, consisting of the Sloan and Big Saline Formations, as partly Morrowan and partly Atokan.

On the basis of paleontological studies, Thompson (1947) regarded the Big Saline limestone to be younger than the Marble Falls limestone. He also stated that the Sloan Member is Morrowan and that the beds of the Marble Falls above the Sloan are "unquestionably post-Morrowan" in age. Apparently he regarded the upper Marble Falls as Derryan, which would, in turn, be the Atokan of most authors, and that he regarded the Marble Falls limestone as a formation. Plummer (195o) included both the Sloan Member and the Big Saline Formation in the Marble Falls group and believed the Smithwick Shale to be younger than the Big Saline Formation.

Regardless of the age implications, Plummer's measured section of the type Marble Falls Formation (p. 50-52) is convenient and was used as the basis of the collections for this report, and is reproduced below. This section is measured from Alexander dam site to Marble Falls dam at Marble Falls, Texas along the north side of the Colorado River.

UNIT		THICK. FT	IN
	Marble Falls Formation (341 ft. 10 in).		
19	Limestone, dark gray, finely crystalline, uniformly grained; mottled with comparatively few algal markings; and forming upper falls at Marble Falls and top of cliff at mill site	20	—
18	Limestone, black, fine grained; contains much black chert and forms face of prominent cliff at Marble Falls	11	3
17	Limestone, black, fine grained, shaly, thin bedded, nodular beds separated by wavy partings containing fossils; *Linoproductus, Bellerophon, Cancrinella* (?), and many large corals, *Amplexocarina*?; coral zone about 3 feet above base	10	—
16	Limestone, bluish black, hard, fine grained (measured at old wagon road)	2	3
15	Limestone, dark gray and black, finely crystalline, varying from thin bedded to massively bedded. One massive layer 7 feet thick forms a steep cliff near the top of the bed. The upper surface of this bed is rough and nodular as if produced by sponge or chert nodules.		

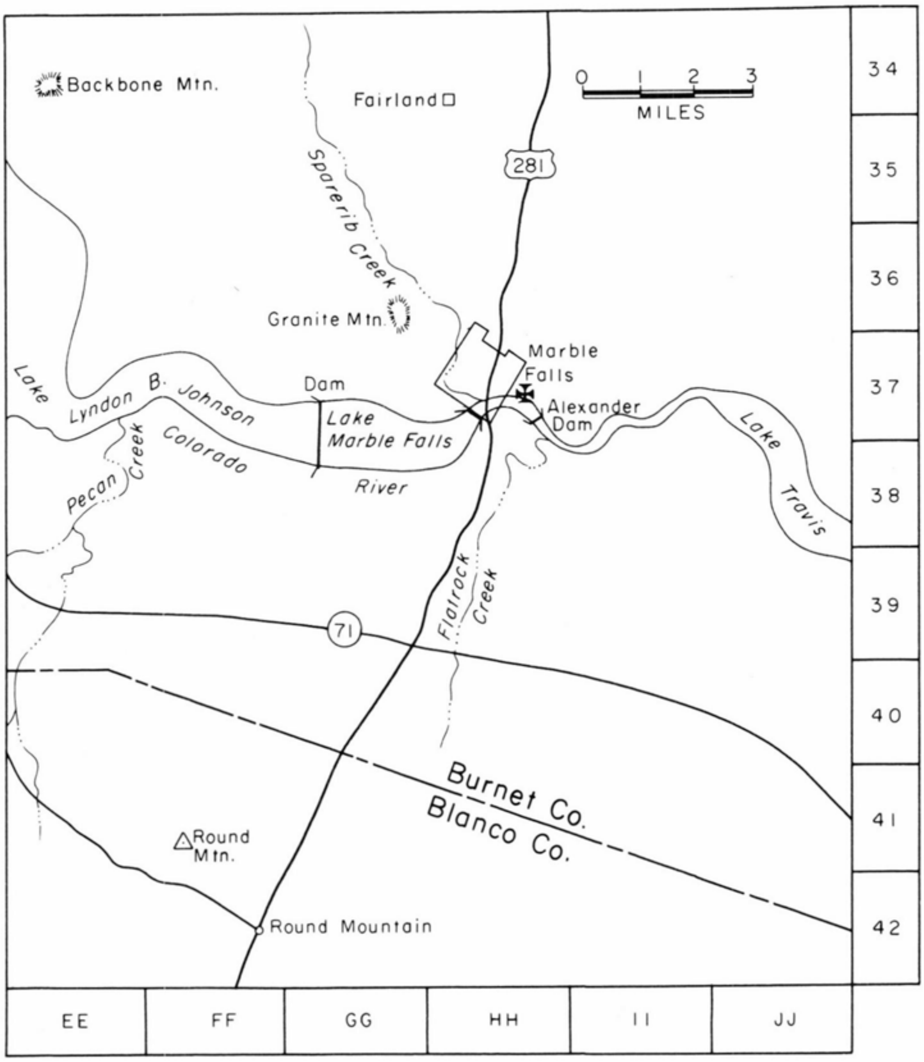


FIGURE 4—*Index map for Marble Falls Formation.*

UNIT		THICK. FT	IN
	Another massive ledge 3 feet thick at the base	36	—
14	Limestone, black, thin bedded, shaly, having irregular, wavy bedding planes and made up of beds 2 and 4 inches thick	4	—
13	Limestone, dark gray, weathering to bluish gray; finely and uniformly crystalline, fairly evenly bedded. The beds are 2 to 4 inches thick and form a cliff along the Colorado River bluff. The limestone is for the most part nonfossiliferous. Some layers contain small amounts of chert, show algal and sponge markings, and a few large, long crinoid stems. The surfaces of the ledges are marked by minute white blotches and weather to very rough, etched surface having minute sharp, serrate ridges separated by cusps and valley-like depressions. Surface appearance resembles the well-known ledges at Pedernales Falls.	34	6
12	"Upper Chert bed." Limestone, gray, fine grained, indistinctly bedded, cherty; contains more than 50 percent chert. Hard, forms distinct cliff along the bluff and a cascade in Colorado River. Surface of the limestone nodular, marked with chert nodules derived probably from sponge masses. The chert is brownish black, foraminiferal, and its surface is pitted with minute fossil cavities. In many cases it weathers to a tripoli-like cotton rock	7	2
11	"Blue Limestone bed." Limestone, light gray, weathering blue gray, and marked by minute white blotches. Hard, noncherty, uniformly finely crystalline, mostly unfossiliferous, fairly thick bedded. Breaks in large rectangular blocks and weathers on exposed surfaces to very roughly etched and serrately ridged surface; breaks with conchoidal fracture resembling in this respect Ellenburger limestone	10	5
10	"Algal bed." Limestone, black or dark chocolate, very fine grained. Breaks into small black chips, chert bearing. The chert is in the form of nodules and irregular-shaped, thin lentils. The chert is dense, black, and very sparingly fossiliferous, broken by many joints and cracks, but some layers will make building blocks. Contains corals (probably *Zaphrentis*), *Bellerophon, Marginifera,* echinoid spines, and Bryozoa. The most characteristic feature is the dark chocolate-colored blotches set in a light-gray background and giving to the surface of the rock a distinctly mottled appearance. These dark blotches are interpreted as algal markings. The algal markings extend through most of the ledge, 12 to 14 feet thick. The ledge breaks into more or less smooth-surfaced blocks which will make a good building stone and take a good polish, bringing out the characteristic mottled markings	22	4
9	Limestone, gray, massive, finely crystalline, containing thin stringers of chert, a fraction of an inch to 2½ inches thick. Amount of chert increases upward. No fossils	8	6
8	Limestone, gray, massive, fine grained, uniform. Mostly noncherty, occurring in layers 2 to 4 inches thick	4	—
7	Pebble conglomerate; made up of angular and little-rounded pebbles of limestone ¾ of an inch in size (maximum) in a matrix of sand made up of limestone grains and large quantities of small crinoid fragments	1	6
6	Nodular chert bed. Limestone, dark gray or black, fine grained, massive; contains stringers and nodules of chert which constitute more than 50 percent of the ledge. Weathers to a rough, nodular surface. Lower layers contain oolite	28	—
5	Sand, yellowish gray, consolidated, made up of coarse grains of limestone, small crinoid fragments, and small ¼ in limestone pebbles. The layer is porous and water bearing. Springs issue from this horizon	1	—
4	Limestone, gray, coarsely crystalline, massively bedded, nonfossiliferous, and containing no chert except a few indistinct sponge nodules containing sponge spicules appearing on the surface of a ledge 2 feet below the top of the bed. The bed is distinctly lighter in color than the layers above and below, so that it stands out as a light-gray band along the crest of a small anticline showing in the bluff on the south side of the river	5	—
3	Limestone, black or very dark gray, sub-crystalline, containing elongate and irregular-shaped darker masses interpretated as originating from sponge masses, but possibly of algal origin. The black masses are generally circular in cross section. They are 1½ inches in diameter, 8 to 10 inches long, and cylindrical or elbow shaped. Other masses have quite irregular shapes. Many are distinctly cherty and cut with many fine calcite veinlets. The bed contains a few fossils, namely, small and large crinoid stems, sponge masses, and a small linoproductid. The beds grade upward into slightly lighter gray, less cherty limestone; and the sponge masses are slightly smaller toward the top	10	—
2	Limestone, dark gray or black, fine grained, thin bedded. Beds in layers 3 to 6 inches thick. Fossiliferous containing in its upper portion *Ethelocrinus texasensis* Moore and Plummer, crinoid stems, Bryozoa, small *Punctospirifer,* a few small corals of *Michelinia* type, numerous corals belonging to the genus *Zaphrentis, Linoproductus* and other brachiopods. The bed also contains layers and lentils of chert which contain many minute fossils, crinoid fragments, brachiopods and Foraminifera. The upper thin layers have shale partings which contain crinoid stems and Foraminifera. The shaly layers weather more easily than the massive beds above, so that the massive ledge along the cliff side is undercut, and in places a shelter or grotto is produced	42	—
1	Limestone, dark gray, massive, fine grained, cliff forming, reef-like rock. The layer contains few thin cherty layers in the middle portion, but most of the rest of the thick cliff-forming ledge is nonbedded. Contains large and small crinoid stems, few if any other fossils, and but little chert. The rock is distinctly petroliferous, especially near its base, and when broken gives a distinct odor of oil. The ledge contains in its upper portion a lentil of thin, cherty beds that may possibly be the same beds described in layer No. 2, but are apparently separated from No. 2 by more massive beds. The ledge is cut by a nearly vertical fault at its west end. West of the fault is a distinct unconformity between this massive ledge and the overlying thin limestone beds of layer No. 2	83	6

More recent papers, and unpublished dissertations, many of which deal with the conditions of sedimentation and the environmental framework of the Lower Pennsylvanian of the Marble Falls area, are: Stewart (1957), Bell (1962), Stitt (1963), Freeman (1963), Freeman and Wilde (1963), Freeman (1964), Winston (1964, 1965), Zachry (1969, 1970), Namy (1970) and Gries (1970). A revision of stratigraphic nomenclature of the Lower Pennsylvanian of central Texas is undoubtedly forthcoming in print in the near future.

The stratigraphic occurrence of the *Millerella-Eostaffella* fauna is shown by letter designation in fig. 5.

The ranges of the fusulinids are shown in fig. 6.

Collections from beds 74 through 77 of the Marble Falls Formation are relatively poor in fusulinids. In this interval, the ranges of the fusulinids may be affected by ecological conditions as, indeed, is the case of the entire study.

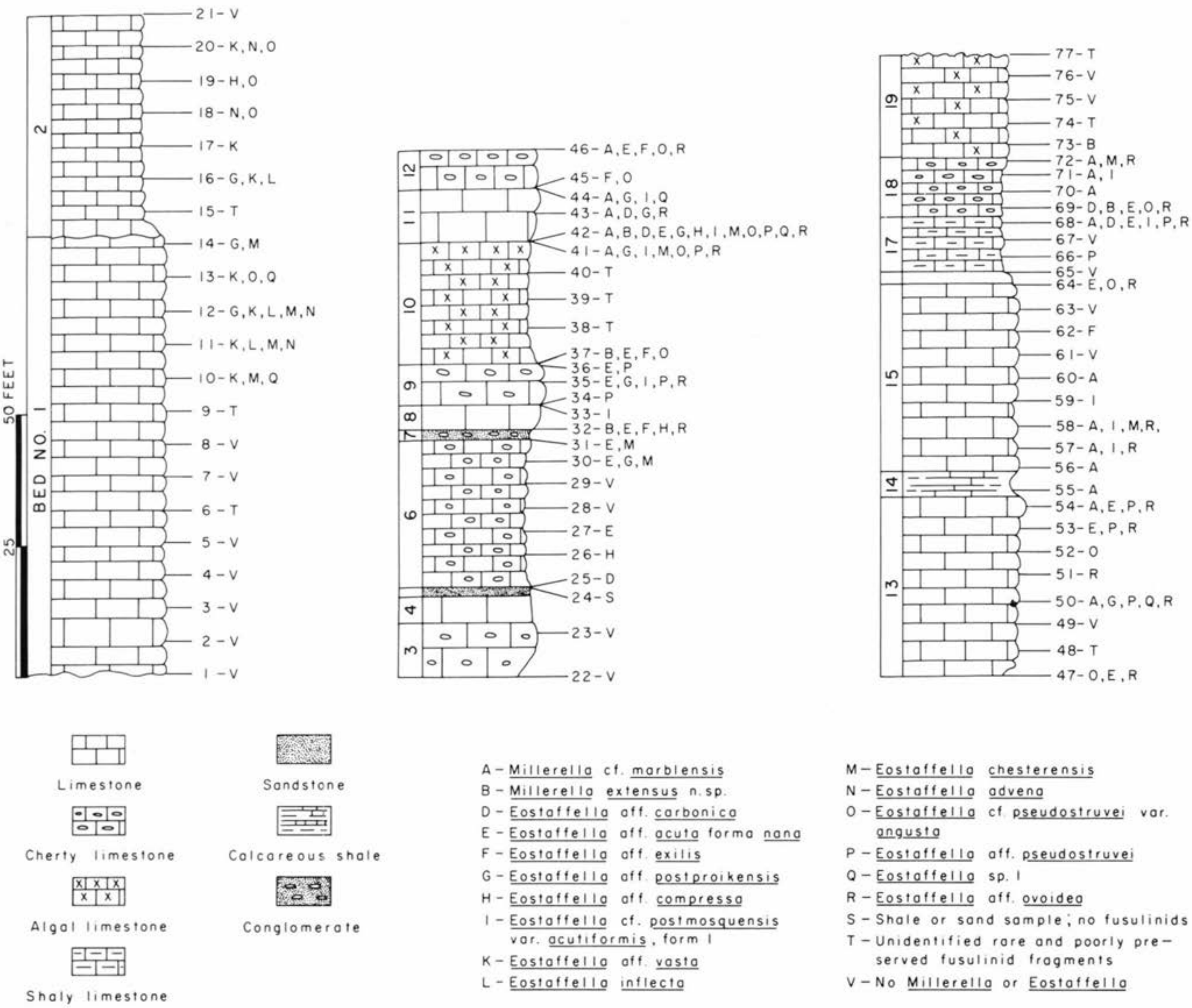


FIGURE 5—*Collection numbers and fusulinid occurrences in Marble Falls Formation.*

Paleontologic Considerations

Since the late 1940's a staggering number of publications on the primitive fusulinid *Millerella* and *Eostaffella* faunas have appeared in Russian and Japanese. Russian and Japanese paleontologists have zoned parts of the Carboniferous on the basis of these genera and have described many new species and varieties of the genera.

I believe that *Eostaffella* Rauser-Chernoussova, 1948 holds priority over *Parainillerella* Thompson, 1951 although there is still disagreement about that priority (Thompson, 1964, p. C396). However, I tend to agree with Van Ginkel (1965, p. 7) that the concept of basing a generic definition on the involute or evolute character of whom is not a very satisfactory criterion for this group. Perhaps: Van Ginkel (1965) did a sensible thing in assigning forms previously called *Millerella* and *Eostaffella* to the single genus *Millerella. I* have accepted reluctantly the definitions of the two genera. The assignments of generic names follow the taxonomic revision of Rozovskaya (1963, p. 31-33).

Finally, I am certain that I have not seen all of the references, particularly the Russian literature, regarding this group of fossils, hence, have carefully refrained from using dogma in the section on descriptive paleontology. I used the terms "affinities with" and "comparable with" rather freely and, hopefully, wisely.

An examination of the charts showing occurrence and range (figs. 2, 3, 5 and 6) reveals the following:

1) *Eostaffella* aff. *vasta, E. inflecta* and E. *advena* are confined to the lower part of the Marble Falls Formation. These species were not found in the lower part of the Derry rocks.
2) *Eostaffella* sp. 1, E. aff. *postproikensis* and E. aff. *coinpressa* occur only in the middle part of the Marble Falls Formation and are not found in the lower part of the Derry rocks.
3) *Eostaffella* aff. *pseudostruvei* and *Millerella* cf. *marblensis* occur only in the upper part of the Marble Falls Formation and not at all in the lower part of the Derry Series.
4) *Millerella extensus* King, n. sp., is found sporadically in the Upper Marble Falls Formation and throughout the Derry Series, becoming very abundant in and above bed 6 of the Derry.
5) *Eostaffella* aff. *carbonica* ranges through the upper part of the Marble Falls Formation and throughout the lower beds of the lower part of the Deny Series.
6) *Eostaffella* aff. *exilis,* E. aff. *acuta* forma *nana,* and E. cf. *postmosquensis* var. *acutiformis,* form 1, occur in the upper part of the Marble Falls Formation and range throughout the lower part of the Derry Series.
7) *Eostaffella aff. ovoidea,* which could be easily confused with immature specimens of other species and perhaps has been, begins in the lower part of the Marble Falls Formation and ranges through the entire lower part of the Derry Series.
8) *Eostaffella chesterensis* ranges from the lower part of the Marble Falls Formation to the top of that section. It is found only in collections 8 through 12 in the lower part of the Deny Series, and probably has little stratigraphic value, with the possible exception of greater abundance in the Marble Falls Formation.
9) *Eostaffella* cf. *pseudostruvei* var. *angusta* ranges from the lower part to the upper part of the Marble Falls Formation and is found in collections 12-14 of the Derry Series. Again, the fact that it is much more abundant in the Marble Falls may be significant stratigraphically.
10) *Eostaffella* cf. *postmosquensis* var. *acutiformis,* form 2, and *Millerella* sp. x occur only in the lower to middle lower part of the Derry Series and are so scarce that they are not assumed, at this time, to have stratigraphic value.

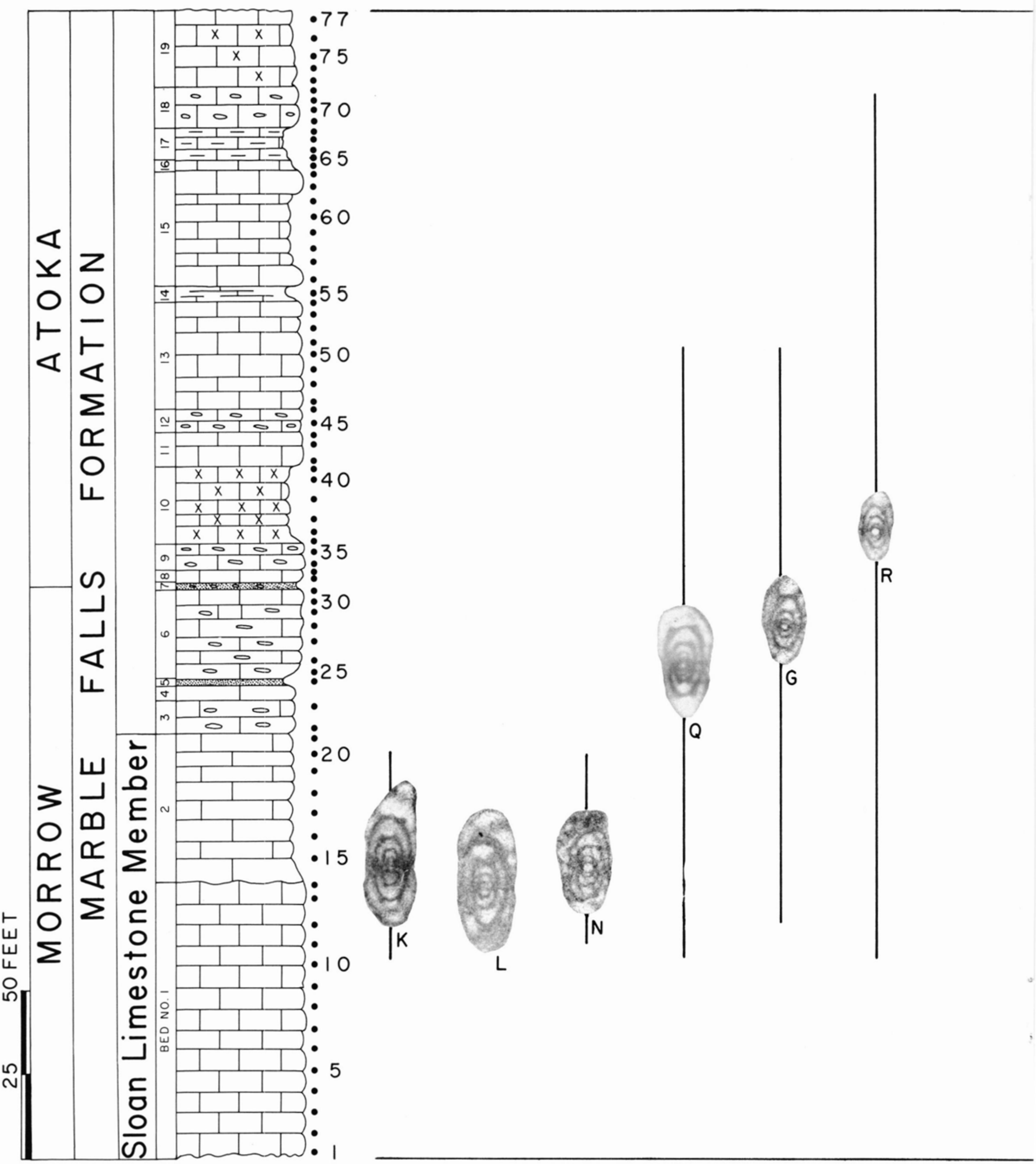
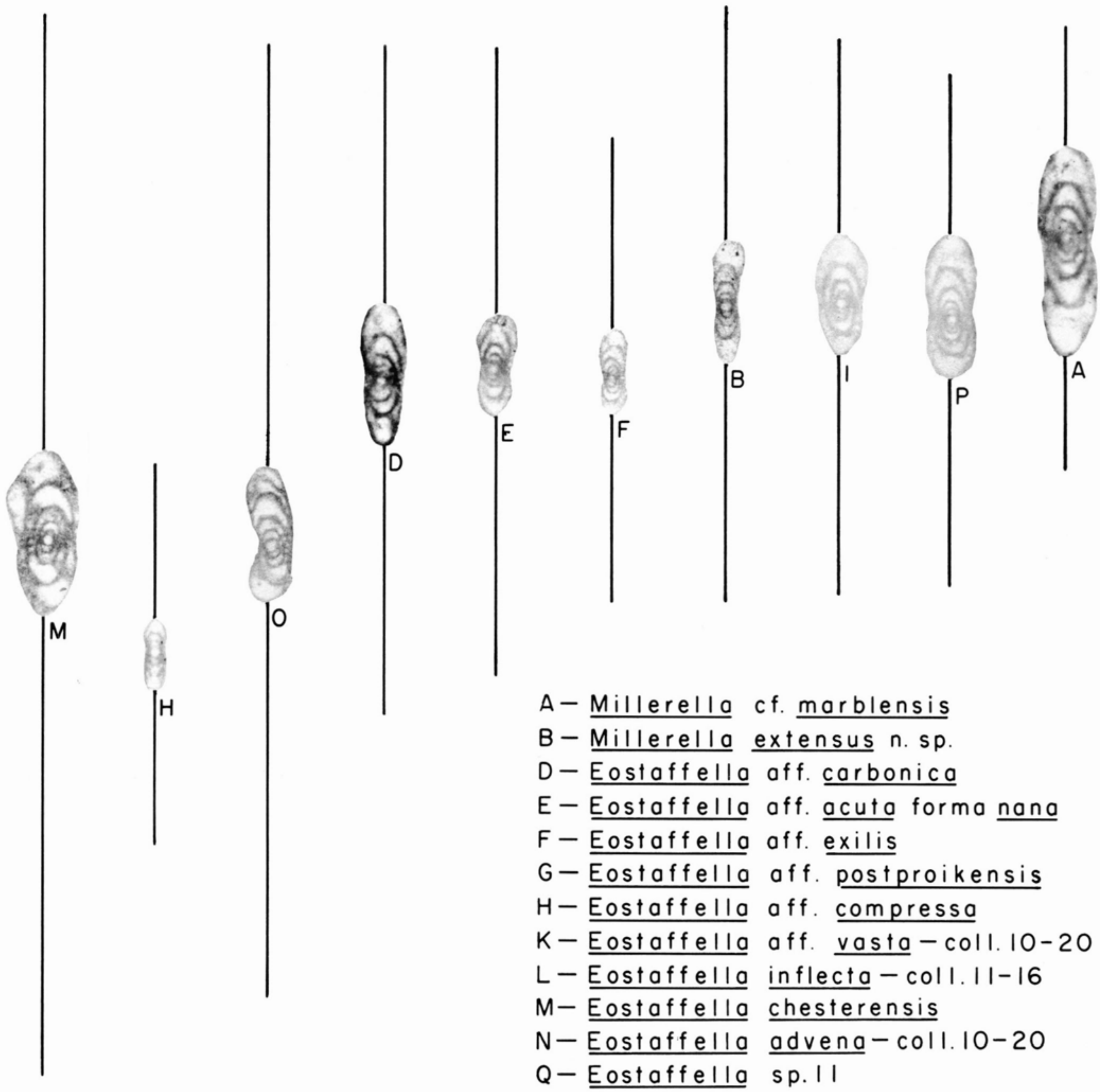


FIGURE 6—*Ranges of fusulinids*



A — Millerella cf. marblensis
B — Millerella extensus n. sp.
D — Eostaffella aff. carbonica
E — Eostaffella aff. acuta forma nana
F — Eostaffella aff. exilis
G — Eostaffella aff. postproikensis
H — Eostaffella aff. compressa
K — Eostaffella aff. vasta — coll. 10-20
L — Eostaffella inflecta — coll. 11-16
M — Eostaffella chesterensis
N — Eostaffella advena — coll. 10-20
Q — Eostaffella sp. 11
R — Eostaffella aff. ovoidea
I — Eostaffella cf. postmosquensis var. acutiformis, form I
O — Eostaffella cf. pseudostruvei var. angusta
P — Eostaffella aff. pseudostruvei

n Marble Falls Formation.

Summary

The *Millerella-Eostaffella* fusulinid fauna of the upper part of the Marble Falls Formation correlates with the lower Derry Series and supports the assumption of most authors that both stratigraphic sections are Atokan. The lower to middle part of the Marble Falls Formation has distinctive Morrowan species and an assemblage paleontologically distinguishable from the upper part of the Marble Falls and the Lower Derry Series. Possibly the fusulinid population described in this paper is sufficiently different from *Millerella-Eostaffella* assemblages occurring in younger upper Paleozoic strata to make the age recognizable even in the absence of the more highly evolved fusulinids. The systematic paleontological study of this group of fusulinids will facilitate the correlation of the Lower Pennsylvanian of the United States and the Carboniferous of Russia and Japan.

systematic Descriptions

Superfamily FUSULINACEA VON MÖLLER, 1878

Family OZAWAINELLIDAE

THOMPSON AND FOSTER, 1937

Genus MILLERELLA

THOMPSON, 1942

Millerella cf. *marblensis* Thompson

Plate 1, figures 1-9

Millerella marblensis Thompson, 1942, American Journal Science, v. 4o, n. 6 p. 405-407, pl. 1, figs. 3-14.

Diagnosis—The test is discoid and small for a fusulinid but quite large for the genus. In eight measured specimens, the average width is 0.509 mm, and the average axial length is 0.132 mm. Form ratios average .33 for the fourth volution. Representative measurements are shown in tabular form below.

The shell form is commonly involute for the first few volutions, becoming evolute in the outer volutions with a marked tendency to deviate from the axis of coiling. Volutions have bluntly pointed to arched peripheries (Van Ginkel, 1965, p. 4).

The proloculus is small, averaging 26 microns in outside diameter. The chomata are very poorly developed in inner volutions and form low asymmetrical mounds when present in outer volutions. The spirotheca is composed of a tectum, primatheca (Stewart, 1966), and outer tectorial layers, but it is usually not very clearly defined with reference to individual layers.

Septal counts average 8, 11, 14, and 18 from the first to the fourth volution, respectively.

Remarks—None of the specimens illustrated in this paper correspond closely with the holotype. In examining hundreds of thin sections from the Marble Falls Formation and the type Deny section, no specimen closely resembles the holotype. However, the specimens here referred to M. ***mar****blensis* are thought to be part of the same morphological group. M. *marblensis* differs from *Eostaffella carbonica* Grozdilova and Lebedeva (1950) in being larger for the same number of volutions and having differing form ratios. M. *marblensis* bears some resemblance to some specimens of *Eostaffella pressa* (Thompson, 1944), but more loosely coiled with outer volutions more highly evolute.

Occurrence—M. marblensis has been reported from the Chester (Upper Mississippian) of Illinois, the type section of the Morrow of Arkansas, the Kearny Formation (Lower Pennsylvanian) of Kansas and the Belden Formation (Lower Pennsylvanian) of Colorado and Utah. The species has also been reported from the Arrey Formation of New Mexico, but the author did not find specimens that he would refer to M. *marblensis* in that formation. The species has been described from the *Millerella* Zone of the Taishaku limestone of western Japan (Sada, 1967, p. 14o). The range of the species in the Marble Falls Formation is from collection 41 of bed 10 to collection 72 of bed 18.

Measurements of Millerella *cf.* marblensis

Volutions	Specimen No. M68-24	M42-33	M41-1	M70-3	Specimen No. M68-24	M42-33	M41-1	M70-3
	Radius vector (mm)				Half length (mm)			
0	.014	.014	.012	.016	.020	.028	.018	.022
1	.037	.035	.035	.043	.030	.028	.022	.040
2	.064	.065	.065	.091	.044	.054	.046	.050
3	.107	.119	.111	.182	.062	.070	—	—
4	.184	.212	.220	.310				
5	.303	.286	—	—				
	Form ratio				Wall thickness (mm)			
1	.54	.80	.51	.51	.008	.005	—	—
2	.47	.43	.34	.44	.012	.008	.010	.008
3	.41	.45	.42	.27	.016	.013	.012	.012
4	.34	.33	—	—	.018	.018	.012	.018
5					.017	.016		

Millerella extensus King, n. sp.

Plate 1, figures 10-23

Diagnosis—The test is discoidal, small and slender, averaging 0.320 mm in width and 0.065 mm in axial length with a fourth volution form ratio that averages .22. The shell form is involute in early volutions, becoming highly evolute in outer volutions. There is a marked tendency for deviation from the early axis of coiling in specimens with more than four volutions. The peripheries are broadly pointed to arched.

The proloculus averages 21 microns in outside diameter. Chomata are not commonly developed but are quite prominent and symmetrical when they do occur, mainly in outer volutions. The spirotheca is composed of a tectum, primatheca, and rare thin outer tectorial deposits. The wall is not often clearly differentiated into the three layers and presents a gray to black homogeneous appearance.

Septal counts average 7, 10, 14, and 18 from the first volution through the fourth volution, respectively.

Designation of Holotype—Specimen 13 of plate 1 is hereby designated as the holotype of the species.

Remarks—M. extensus is somewhat similar to various specimens of *Novella intermedia,* Rauser-Chernoussova (1951), but is much less evolute than *N. intermedia* with differing form ratios.

Occurrence—This species is found in the Marble Falls limestone from collection 32 of bed 8 through collection 73 of bed 18. In the Derry section, the form occurs from collection 3 of bed r through collection 25 of bed 13-14. This species is not abundant in the Marble Falls rocks and not very common in the lower part of the Derry section. However, beginning with collection 14 of bed 6 in the Derry stratigraphic sequence, the species become very abundant. Perhaps more work on the stratigraphic occurrence and abundance of *Millerella in* the Morrow and lower Atoka rocks will verify the preliminary observation that *M. extensus* is significantly more abundant in the upper part of the section than in the lower, over a widespread area.

Measurements of Millerella extensus *King, n. sp.*

Volutions	Specimen No. D16-5	D17-1	D19-2	M32-7	Specimen No. D16-5	D17-1	D19-2	M32-7
	Radius vector (mm)				Half length (mm)			
0	.010	.011	.012	.009	.012	.018	.018	.013
1	.026	.031	.025	.028	.018	.018	.018	.017
2	.049	.053	.042	.055	.028	.020	.024	.029
3	.092	.087	.070	.087	.035	.028	.028	—
4	.174	.145	.106	.158			—	—
			.148					
	Form ratio				Wall thickness (mm)			
1	.46	.58	.72	.46	.007	.006	.006	.010
2	.37	.35	.43	.30	.008	.007	.006	.012
3	.30	.23	.34	.33	.012	.009	.009	.012
4	.20	.19	.28	—	.012	.009	.010	.010
5					.013	.009	.010	

Millerella sp. I
Plate 1, figures 24-25

Diagnosis—This species is a rather large form of *Millerella* but does not have the length of most of the specimens of *Millerella* cf. *marblensis* of this paper. The average width of the specimens is 0.521 mm and the average axial length is 0.082 mm in the third volution, where the form begins to become evolute. The more involute form, D12-3 (pl. 1, fig. 25), measures o.106 mm in length.

The form ratio averages .4o for the third volution, is .26 in the fourth, and is **.21** in the fifth volution of specimen D12-3, which is specimen number 24 on plate 1.

The proloculus averages 32 microns in outside diameter. Chomata are very well developed in specimen D 12-3 but not well represented in specimen D2-5. The spirotheca is dense and grey and does not show wall elements well.

Remarks—This species may be a variant of *Eostaffella carbonica* or may be closely related to *Millerella marblensis.* Because only two well-oriented specimens were available, the form was designated *Millerella* sp. I.

Occurrence—The species occurs in the lower part of the Derry from collection 12, which is from bed number 5. In addition to the two acceptable specimens, poorly oriented fragments that appear to be related to this form are present.

Genus EOSTAF FELLA RAUSER-CHERNOUSSOVA, 1948

Eostaffella aff. . carbonica Grozdilova and Lebedeva
Plate **2,** figures 1-7

Eostaffella carbonica Grozdilova and Lebedeva, 195o, Vses. Neftainoi Naucho-Issledov Geol.-Razved Inst., Trudy, vypusk 5o, p. 5¯44.

Diagnosis—The test is of moderate size for an *Eostaffella* with the width averaging 0.364 mm and the axial length averaging 0.077 mm for five measured specimens. The form ratio averages .32 for the third volution and .19 for the total shell form of 41/2 to 5 volutions.

The periphery of the volutions is arched to bluntly pointed. The first three or four volutions are involute, and the final volution becomes evolute.

The proloculus averages 28 microns in outside diameter. Chomata are either low or of moderate height with the shape highly variable. The wall structure appears to be homogeneous with the exception of M43-3, (pl. r, n. 25), which shows the tectum and primatheca well.

Septal counts average 7, **12,** 14, and 17 for the first through the fourth volutions, respectively.

Remarks—Although a little smaller, with a slightly smaller form ratio, these specimens compare well with those illustrated by Van Ginkel (1965). Because the publication by Grozdilova and Lebedeva (1950) was not available, the main reference used was Van Ginkel (1965, p. 44).

Occurrence—Eostaffella cf. *carbonica (Millerella* cf. *carbonica* of Van Ginkel, 1965), occurs in the Piedras Luengas Formation of the Moscovian, presumably upper Vereyan, of Spain (Van Ginkel, 1965, appendix 1). Aisenverg (1963, p. 73) lists E. *carbonica* from the Bashkirian Stage or the Atoka equivalents of the Carboniferous of Russia. In the Marble Falls stratigraphic sequence, the species is found from collection 25 of bed 6 through collection 69 of bed 18. In the Derry rocks, the species occurs from collection **2,** bed through collection **12,** bed 5.

Measurements of Eostaffella *aff.* carbonica

Volutions	Specimen No. M68-23	D2-12	M43-3	D2-13	Specimen No. M68-23	D2-12	M43-3	D2-13
	Radius vector (mm)				Half length (mm)			
0	.015	.015	.014	.012	.022	.019	.024	.019
1	.039	.043	.042	.040	.031	.019	.037	.027
2	.073	.076	.080	.072	.046	.032	.045	.044
3	.124	.127	.131	.132	—	.047	—	—
4	.216	.202	.230	.215				
	Form ratio				Wall thickness (mm)			
1	.56	.44	.57	.47	—	—	.007	.012
2	.42	.25	.46	.37	.014	.010	.010	.017
3	.37	.25	.34	.33	.016	.013	.014	.017
4		:23			.014	.014	.012	—

Eostaffella aff. *acuta* forma *nana* Kireeva
Plate 2, figures 8-20

Eostaffella acuta forma *nana,* Kireeva, 1949, Trudy, Geol. Inst. for Coal Exploration, vypusk 6, p. 3o, pl. r, fig. 7.

Diagnosis—The test is discoidal and small, averaging 0.252 mm in width and 0.082 mm in axial length for seven measured specimens. The form ratio averages **.29** for the fourth volution.

The volution peripheries are arched in the inner volutions, often becoming bluntly pointed in the last volution. The form of the shell is involute for the most part, but the last volution in some specimens becomes mildly evolute. The axis of coiling is quite straight.

The average outside diameter of the proloculus is 26 microns. The chomata are broad and low. Generally, the spirotheca does not show definable structure but, rather, is grey and indistinct.

Septal counts average 7, 11, and 14 for the first through the third volutions, respectively.
Remarks—The illustrated and measured specimens compare favorably with the smaller specimens of E. acuta forma nana that were described by Van Ginkel (1965, p. 39) as Millerella. The original reference by Kireeva (1949) was not available, hence the designation of affinities with the species.
Occurrence—Aisenverg (1963, p. 74) indicates a stratigraphic occurrence for this species in rocks assumed to be correlative with rocks of the upper Strawn and Lower Canyon Series of Texas. No indication is given that the species is present in Russian rocks that are equivalent to the Morrow and Atoka of the southwest. Van Ginkel (1965, appendix), on the other hand, notes the presence of this species in the Piedras Luengas Formation of Lower Moscovian (presumably upper Vereyan) of Spain where this species occurs with Profusulinella. In another collection of Van Ginkel from the Corisa Formation of Upper Moscovian Myachkovian age, the species occurs in the Zone of Fusulinella. E. acuta forma nana has a long stratigraphic range. The designation in the present paper extends its range stratigraphically downward. The species is found in close proximity to and within the occurrences of Profusulinella in the Marble Falls Formation and in the Derry section. In the Marble Falls Formation the range of the species is from collection 27 of bed 6 through collection 69 of bed 17, while in the Derry sequence of beds the range is from collection r of bed r through collection 25 of bed 13-14.
Eostaffella exilic Grozdilova and Lebedeva, 195o, Vses. Neftainoi Naucho-Issledov Geol.-Razved Inst., Trudy vypusk 5o, p. 16, pl. r, fig. 15.
Diagnosis—The shell averages 0.255 mm in average width and o.063 mm in average axial length for six measured specimens. The form ratio averages .32 in the fourth volution, and seldom does a specimen have more than four volutions.
The volution peripheries are arched in inner volutions, but the last volution is sometimes bluntly pointed. The shell is involute in inner whorls to gently evolute, occasionally, in the ultimate whorl.
The species has a proloculus averaging 20 microns in outside diameter. Chomata are poorly developed in general, but, when they are developed, they are broad and low. Wall structure is not discernible.

The septal count average is 7, Io, and 13 for the first through the third volution, respectively.
Remarks—The author's specimens are comparable in size to an illustrated specimen of Bogush and Yuferev (1962, pl. 6), but the measured specimens have smaller radius vectors than most of the illustrated specimens of Van Ginkel (1965, p. 45). Form ratios, however, correspond reasonably well.
Occurrence—The species is found in Namurian and Bashkirian age rocks of the Soviet Union (Aisenverg and others, 1963, p. 74) that are partly equivalent to the Morrowan and Atokan of the United States. Further, E. exilic is found in the Piedras Luengas Formation of Spain which is Moscovian age (Van Ginkel, 1965, appendix 1). In the Marble Falls Formation the species ranges from collection 32, bed 8 through collection 62, bed 15. The range in the Derry rocks is from collection 2, bed r through collection 25, bed 13-14.
Eostaffella aff. postproikensis, Vdovenko, 1967, in Brazhnikova, N. E., Vakarchak, G. I., Vdovenko, M. V. and others, Naukova Dumka, Kiev, p. 223, pl. LV, figures 11-17.
Diagnosis—The shell is lenticular to nearly rhomboidal, averaging o.129 mm in axial length and 0.261 mm in width for seven measured specimens. The form ratio is .57 in the third volution. The proloculus average measurement is 31 microns in outside diameter.
Coiling of the shell in most specimens is essentially planispiral, but some shells exhibit plectogyroid coiling (Stewart, 197o, p. 37) in the juvenarium. Volutions are bluntly pointed to

arched, and, except for a few instances of evolute whorls in the inner coiling, they are involute. Chomata are generally not well developed but are broad and low when present. Septal counts average 8, I I, 13, and 15 for the first through the fourth volution.

Remarks—The species is larger, has a differing form ratio, and has a different rate of expansion than E. advena (Thompson, 1944, p. 427).

E. aff. postproikensis is smaller than E. dogbendensis (Stewart, 1958) and shows a much more involute character of coiling.

Occurrence—The species is not found in the Derry section. In the Marble Falls Formation it occurs from collection 12, bed I through collection 50, bed 13.

Measurements of Eostaffella *aff.* acuta *forma* nana

Volutions	Specimen No. M46-37	M32-4	D17-2	D5-1	Specimen No. M46-37	M32-4	D17-2	D5-1
	Radius vector (mm)				Half length (mm)			
0	.012	.011	.014	.013	.011	.012	.011	.012
1	.032	.024	.035	.025	.027	.020	.023	.022
2	.058	.052	.058	.050	.038	.032	.033	.033
3	.107	.096	.089	.086		.047	.042	.037
4		.144	.145	.143				
	Form ratio				Wall thickness (mm)			
1	.38	.50	.31	.48	.009	.010	.008	.008
2	.47	.38	.40	.44	.014	.010	.012	.010
3	.36	.33	.37	.38	.017	.012	.012	.012
4		.33	.29	.25		.010	.014	.012

Eostaffella aff. *exilis* Grozdilova and Lebedeva
Plate 2, figures 21-32

Measurements of Eostaffella *aff.* exilis

Volutions	Specimen No. M32-14	M37-16	M37-46	D3-6	Specimen No. M32-14	M37-16	M37-46	D3-6
	Radius vector (mm)				Half length (mm)			
0	.009	.007	.011	.012	.011	.010	.010	.012
1	.026	.024	.024	.028	.022	.021	.022	.018
2	.047	.047	.042	.048	.029	.030	.034	.027
3	.078	.076	.075	.075	.037	.038	.040	.036
4	.120	.127	.115	.126				
	Form ratio				Wall thickness (mm)			
0	.42	.42	.42	.43	.007	.007	.006	.008
1	.46	.43	.53	.40	.009	.009	.010	.012
3	.37	.39	.45	.36	.011	.013	.012	.012
4	.31	.30	.35	.30	.013	.011	.012	.017

Eostaffella aff. *postproikensis* Vdovenko
Plate 2, figures 33-36

Measurements of Eostaffella *aff.* postproikensis

Volutions	M14-2	M42-5	M42-8	M42-20	M14-2	M42-5	M42-8	M42-20
	Specimen No. Radius vector (mm)				Specimen No. Half length (mm)			
0	.016	.016	.013	.017	.023	.015	.012	.024
1	.032	.031	.032	.037	.046	.024	.027	.053
2	.065	.051	.051	.072	.072	.045	.045	.072
3	.114	.080	.089	.126		.070	.053	
4		.128	.145					
	Form ratio				Wall thickness (mm)			
1	.69	.48	.37	.65	.012	.009	.009	.010
2	.71	.47	.53	.74	.012	.011	.012	.014
3	.63	.56	.51	.57	.014	.014	.014	.015
4		.55	.37			.015	.014	

Eostaffella aff. *compressa* Brazhnikova and Potievskaya

Plate 2, figures 27-41

Eostaffella compressa Brazhnikova and Potievskaya, 1951, Trudy, Akad. Nauk Geol. Inst., Strat. and Paleont. Ser., Tom 5, p. 91-92, pl. 1, figs. 10-13.

Diagnosis—E. aff. compressa has an average width of o.194 mm and an average axial length of 0.054 mm. The form ratio for the second volution averages .36. The relatively large proloculus averages 32 microns in outside diameter.

The volution peripheries are arched to subrounded, but the extremities of a few are somewhat concave. The shell is slightly evolute in outer volutions. Some shifting of the axis of coiling is evident.

Chomata are not usually well developed, but, in an occasional specimen, are high and narrow. The spirotheca does not show differentiation.

Remarks—These forms compare well with E. compressa, as described and illustrated by Van Ginkel (1965, p. 40). The author also compared his specimens with Coogan (1958, p. 3o6), whose illustrations were after Putrja (1956, pl. 3). The photographs of the original designation of the species (Brazhnikova, 1951) are inadequate for comparative purposes (Van Ginkel, 1965, p. 41).

Occurrence—Aisenverg (1963, p. 74) notes the occurrence of E. compressa in Upper Namurian rocks partly equivalent to the Morrow and in Bashkirian rocks which partly correlate with the Atoka. Van Ginkel (1965, appendix) found the species in the Lena Formation of the Lower Moscovian, Kashirian and in the Perapertü Formation of Lower Moscovian, probably Vereyan. In the Marble Falls Formation the species is found from collection 19, bed 2 through collection 42, bed 11. The species has not been found in the Deny stratigraphic succession.

Eostaffella cf. postmosquensis var. acutiformis Kireeva

Form

Plate 2, figures 42-46; Plate 3, figures 1-7

Eostaffella postmosquensis var. acutiformis, Kireeva, 1951, in RauserChernoussova and others, Akad. Nauk SSSR, Inst. Geol. Nauk, Minist. Neftianoi Prom. SSSR, p. 49-5o, pl. 1, figs. 3-4.

Diagnosis—The test averages 0.310 mm in width and 0.113 mm in axial length for seven measured specimens. The form ratio averages .36 in the third volution and .32 in the fourth volution.

The species has a general lenticular shape with bluntly pointed to arched volution peripheries. The shell is involute with the poles slightly umbilicate. The axis of coiling, unlike some of the close relatives of this species, is quite stable and straight. The proloculus has an average outside diameter of 31 microns. Chomata are quite well developed, broad and low and at the sides of a rather wide tunnel. The spirotheca is generally not differentiated, although the tectum and

primatheca are reasonably clear in some specimens.
Septal counts average 7, 12, 14, and 17 from the first through the fourth volution.
Remarks—The specimens of the present author compare favorably with those illustrated by Kireeva (1951). The species differs from E. pseudostruvei Rauser-Chernoussova and Beljaev, in having a more acute shape, a generally smaller shell, a more stable axis of coiling, and a differing form ratio.
Occurrence—Aisenverg (1963, p. 77) lists the species as present in the upper part of the Namurian, partly equivalent to the Morrowan and throughout the Bashkirian, partly equivalent to the Atokan. In the Marble Falls Formation the species ranges from collection 33, bed 8 through collection 71, bed 18. In the Derry rocks the species is found from collection i, bed i through collection 25, bed 13-14.
Diagnosis—These specimens, here referred to E. postmosquensis var. acutiformis, have five volutions instead of the usual four of the form described above. The diameter of the proloculus averages 11 microns. The radius vector averages

Measurements of Eostaffela *aff.* compressa

Volutions	Specimen No. M32-8	M32-26	M32-27	M26-1	Specimen No. M32-8	M32-26	M32-27	M26-1
	Radius vector (mm)				Half length (mm)			
0	.015	.018	.017	.013	.017	.014	.011	.012
1	.050	.032	.043	.035	.028	.019	.020	.021
2	.080	.055	.056	.059	—	—	—	—
3	.122	.090	.098	.099				
	Form ratio				Wall thickness (mm)			
1	.34	.44	.32	.35	.011	.011	.009	.009
2	.35	.35	.36	.36	.013	.012	.010	.009
3					.012	.014	.010	.010

Measurements of Eostaffella *cf.* postmosquensis *var.* acutiformis, *Form 1*

Volutions	Specimen No. M41-7	M41-12	D2-2	D3-7	Specimen No. M41-7	M41-12	D2-2	D3-7
	Radius vector (mm)				Half length (mm)			
0	.016	.014	.015	.016	.015	.018	.015	.016
1	.032	.037	.030	.041	.027	.027	.030	.024
2	.063	.066	.056	.069	.043	.044	.048	.044
3	.114	.107	.099	.116	.063	.054	—	
4	.190	.181	.168					
	Form ratio				Wall thickness (mm)			
1	.47	.49	.50	.40	.009	.012	.011	.009
2	.43	.41	.54	.36	.015	.016	.014	.012
3	.38	.41	.29	.38	.017	.018	.017	.014
4	.33	.30	—		.012	.020	.013	

Eostaffella cf. *postmosquensis* var. *acutiformis* Kireeva
Form 2
Plate 3, figures 8-9

29, 55, 83, 137, and 216 microns for the first through the fifth volution, respectively. Half length figures have averages of 20, 28, 38, and 53 microns for the first through the fourth volution, respectively.
The form ratio averages .68, .52, .46, .39, and .25 for the first through the fifth volution, respectively.
Wall thickness averages are r r, 13, 14, 16, and 14 microns for the first through the fifth volution.
The species has bluntly pointed peripheries, and the shell poles are gently umbilicate. The axis of coiling is quite straight.
Chomata are reasonably well developed and are generally broad and low.

The spirothecal layers are not well differentiated.
Remarks-This form of the species is larger than the specimens considered under form 1, but similar in most respects and believed to be a larger form of the same species and variety.
Occurrence-The author has only two well-oriented specimens, and they occur in the Derry rocks from collection 12 of bed 5.

Eostaffella aff. vasta Rozovskaya

Plate 3, figures 10-14

Eostaffella vasta Rozovskaya, 1963, Akad. Nauk SSSR, Paleont. Inst. Trudy, v. 97, p. 98, pl. z8, figs. 3-4.

Diagnosis-The test is quite large for an Eostaffella, averaging 0.449 mm in width and 0.145 mm in axial length for seven measured specimens. The form ratio averages .33 in the fourth volution. The shape of the shell is quite regular in the first three and one-half volutions and is involute with broadly rounded volutions that touch the poles. The periphery of the last half volution may flare widely and often has a bluntly pointed shape. The axis of coiling deviates moderately to radically from a straight line.

The proloculus of a well-oriented specimen (pl. 3, fig. I o) measures about 37 microns. Chomata are distinct, broad and low. The spirotheca shows fair to good differentiation of tectum and primatheca in several specimens.

The septal count has an average of 9, 11, 15, and 15 for the first through the fourth volution, respectively. 17

Remarks-Although the author's specimens are not quite as large as those of Rozovskaya and have a smaller form ratio, the similarity of morphology is striking. Insufficient comparative material necessitates the affinities designation between the Marble Falls specimens and E. vasta.

Occurrence-E. aff. vasta occurs in the lower part of the Marble Falls Formation from collection 10, bed I through collection 20, bed 2.

Eostaffella inflecta (Thompson)

Plate 3, figures 15-16

Eostaffella inflecta (Thompson), 1945, Kansas Geol. Sur. Bull. 60, p. 44-46, pl. 1, figs. 1-7, pl. 5, figs. 2-3, text fig. 11.

Diagnosis-The test is small but quite robust for the genus. Mature specimens of four to four and one-half volutions measure about 0.160 mm to 0.170 mm in length and 0.440 mm in width. The form ratio varies from .35 to .39 for four and one-half volutions.

The shell is discoidal and only slightly umbilicate with a straight axis of coiling. Volution peripheries are broadly rounded. The first volution is evolute, but the remaining volutions are involute to only slightly evolute.

The outside diameter of the proloculus is 28 to 34 microns. Chomata are not well developed in every chamber but are massive when found.

Wall structure is usually not differentiated.

Remarks-The form ratios of the Marble Falls specimens are not as large as those listed by Thompson (1945, p. 44) for type E. inflecta fusulinids, but that discrepancy is due to a difference in measuring technique. E. inflecta differs from E. pingus (Thompson, 1944), which is discussed on page 42.5 of Thompson's 1944 publication. Its shell is smaller for corresponding volutions and is more evolute than E. pingus. The species has a larger form ratio for corresponding volutions, more highly umbilicate axial regions, a more broadly rounded periphery and a more highly evolute shell than E. advena (Thompson, 1944).

Occurrence-E. inflecta occurs in the Marble Falls Formation from collection II of bed 1 through collection 16 of bed 1. The species also occurs in the Belden Formation of Colorado and Utah (Thompson, 1945, p. 46) and in the Lower Pennsylvanian of Powwow Canyon in the Hueco

Mountains of Texas. Cooper (1947) described the species from the Chester of Illinois, and Sada (1964) noted an occurrence of the species in the Carboniferous of Japan.

Eostaffella chesterensis (Cooper)

Plate 3, figures 17-22

Eostaffella chesterensis (Cooper) 1947, Journal of Paleontology, v. 21, p. 85, pl. 19, figs. 1-5.

Diagnosis-The shell averages 0.128 mm in axial length and 0.372 mm in width, if specimen number i8 of plate 3 is not considered for the moment. The average form ratio for the fourth volution is .36.

The shape of the shell is variable with broadly rounded

Measurements of Eostaffella *aff.* vasta

Volutions	M11-3	M11-7	M12-3	M13-4	M11-3	M11-7	M12-3	M13-4
	Radius vector (mm)				Half length (mm)			
0	.011	.018	—	.019	.016	.014	.013	.019
1	.030	.034	.028	.045	.024	.022	.023	.034
2	.054	.066	.071	.071	.032	.039	.046	.069
3	.095	.122	.120	.134	.048	.072	.071	.086
4	.176	.205	.196	.248	.063			
5	.295							
	Form ratio				Wall thickness (mm)			
1	.53	.41	.46	.41	.009	.009	.009	.012
2	.44	.33	.32	.48	.011	.012	.012	.015
3	.34	.32	.38	.51	.016	.014	.015	.024
4	.27	.35	.36	.35	.018	.019	.018	.022
5	.21				.016			

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to bluntly pointed peripheries. While inner volutions are involute, the last volution becomes gently evolute in some specimens. The umbilication of the polar areas is often unequal, and the axis of coiling is quite unstable in most specimens.

The outside diameter of the proloculus averages 29 microns. Chomata are poorly developed, and the wall is only rarely differentiated.

Septal counts average 8, 11, 12, and 14 from the first volution to the fourth, respectively.

Remarks—Specimen 18 of plate 3 is not atypical of some of the forms of the species found in the Deny collections. Though having more volutions than most of the Marble Falls specimens and differing measurements, this specimen is believed to be in the same morphological unit. E. chesterensis differs from E. inflecta in that the former has less stability of coiling, a plectogyroid juvenarium and a smaller form ratio. The species is smaller than E. kanmerai Igo (1957) and has a much more unstable axis of coiling.

Occurrence—The type specimens of E. chesterensis (Cooper) are from the Kincaid Formation of the Chester series of Illinois. In the Marble Falls Formation the species occurs from collection r o, bed i through collection 72, bed 18. In the Derry section the range is from collection 8, bed 3 through collection 12, bed 5, but most of the specimens are fragmental.

Eostaffella advena (Thompson)

Plate 3, figures 23-24, 29-30

Eostaffella advena (Thompson) 1944, Kansas Geol. Survey Bull. 52, p. 427-429, pl. r, figs. 10-14.

Diagnosis—The test measures 0.161 mm in axial length and 0.311 in width as an average of four measured specimens. The form ratio average is .42 in the third volution.

The shell is discoidal and involute in both inner and outer volutions. The juvenarium may be slightly plectogyroid in some specimens, but the axis of coiling is not highly unstable. The peripheries of the volutions are arched in most volutions.

The outside diameter of the proloculus averages 36 microns. The chomata are very poorly

developed, unlike the holotype specimen but corresponding well with paratypes.
The spirotheca is indistinct and differentiation cannot be observed.
Septal counts in a typical specimen are 9, 13, and 16 for the first through the third volution.
Remarks—E. advena differs from E. postproikensis in possessing a greater form ratio, in having slightly thicker walls, and in being larger.
Occurrence—The species is found in the upper part of the Brentwood Limestone Member of the Bloyd Shale on Hale Mountain near Morrow, Arkansas (Thompson, 1951). The species has also been reported from the Kearny Formation of Kansas (Thompson, 1944, p. 415). In the Marble Falls Formation, the species is present from collection 11, bed through collection 20, bed 2. I did not find this species in the Derry section.
Measurements—Following are measurements for two typical specimens: radius vector in mm from the proloculus through the fourth volution, .021, .041, .077, .133, and .187; half length in mm for the first through the fourth volution, .016, .030, .054, and .o71; form ratio for the first through the fourth volution .40, .39, .42, and .71; wall thickness for the first through the fourth volution in mm, .011, .012, .014, and .014.
Eostaffella cf. pseudostruvei var. angusta Kireeva
Plate 3, figures 25-28; Plate 4, figures 1-6
Eostaffella pseudostruvei var. angusta Kireeva, 1951, in RauserChernoussova and others, Akad. Nauk SSSR, Inst. Geol. Nauk, Minist. Neftianoi Prom SSSR, p. 58-59, pl. I, figs. 29-3I
Diagnosis—The shell averages 0.085 mm in axial length and 0.307 mm in width for seven measured specimens. The form ratio average of the fourth volution is .29.
The shell form is discoidal and involute in inner volutions, normally becoming slightly evolute in the last volution. The axis of coiling is crooked with many specimens exhibiting a plectogyroid juvenarium. The peripheries of the volutions are arched to bluntly pointed.
The average outside diameter of the proloculus is 32 microns.
The spirotheca is undifferentiated. Chomata are very poorly developed but are broad and low when present.
Septal counts average 7, I0, 13, and 15 for the first through the fourth volution.
Remarks—The species is particularly like that illustrated by Kireeva (1951) as specimen 30 on plate 1. The species is larger, has a more evolute character, and has a less stable axis of coiling than E. postmosquensis var. acutiformis Kireeva. It is more evolute than E. pseudostruvei RauserChernoussova and Beljaev, with a smaller form ratio and a less stable axis of coiling.
Occurrence—Aisenverg (1963, p. 78) indicates that the species and variety ranges through the upper two-thirds of the Namurian and through the Bashkirian of the Soviet Union. These units are partly equivalent to the Morrowan and Atokan of the United States. The type variety comes from the

Measurements of Eostaffella chesterensis

Volutions	Specimen No. M72-8	M72-9	M42-28	D12-8	Specimen No. M72-8	M72-9	M42-28	D12-8
	Radius vector (mm)				Half length (mm)			
0	.017	.011	.015	—	.023	.016	.021	.015
1	.042	.019	.035	.030	.032	.026	.030	.024
2	.072	.044	.065	.055	.053	.039	.067	.040
3	.120	.080	.107	.097	.065	.055	.081	.056
4	.215	.152	.197	.161		.069		.071
5		.237		.246				
	Form ratio				Wall thickness (mm)			
1	.55	.84	.60	.50	.010	.010	.010	.008
2	.45	.59	.46	.44	.011	.010	.013	.009
3	.43	.49	.63	.42	.014	.012	.014	.017
4	.30	.36	.41	.37	.018	.014	.017	.017
5		.29		.29		.014		.022

Middle Carboniferous of the Russian Platform. The species is found in Spain (Van Ginkel, 1965, appendix) in the Piedras Luengas Formation of Lower Moscovian, presumably upper Vereyan age. In the present collections the variety is found from collection 13, bed I through collection 69, bed 18 of the Marble Falls Formation and from collection 12, bed 12 through collection 14, bed 6 of the Derry.

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In Spain the species is found in the lower to middle part of the Bashkirian (Van Ginkel, 1965, appendix). In the present study, the species was found in the Marble Falls Formation from collection 34, bed 8 through collection 68, bed 17. The species has not been found in the Derry section.

Measurements of Eostaffella *aff.* pseudostruvei

Volutions	Specimen No. M36-8	M36-15	M36-20	M36-26	Specimen No. M36-8	M36-15	M36-20	M36-26
	Radius vector (mm)				Half length (mm)			
0	.009	.014	.012	.013	.014	.019	.015	.013
1	.021	.037	.035	.032	.025	.028	.020	.021
2	.039	.059	.059	.057	.044	.058	.040	.041
3	.073	.100	.095	.088	.057	.064	.051	.054
4	.126	.177	.158	.160	.065			
5	.201							
	Form ratio				Wall thickness (mm)			
1	.66	.51	.43	.41	.011	.010	.008	—
2	.64	.47	.34	.37	.012	.010	.011	.010
3	.60	.58	.42	.47	.013	.013	.013	.012
4	.45	.36	.32	.34	.014	.017	.014	.017
5	.32				.017			

Measurements of Eostaffella *cf.* pseudostruvei *var.* angusta

Volutions	Specimen No. M19-27	M19-30	D7-5	D14-7	Specimen No. M19-27	M19-30	D7-5	D14-7
	Radius vector (mm)				Half length (mm)			
0	.014	.020	—	.014	.015	.025	.010	.014
1	.034	.044	.025	.032	.027	.032	.014	.020
2	.066	.079	.043	.053	.034	.044	.030	.030
3	.117	.140	.068	.087	.047	.053	.044	.037
4	.182	.208	.119	.138				
5			.202	.192			.053	.045
	Form ratio				Wall thickness (mm)			
1	.44	.57	.40	.44	.012	.010	.009	.007
2	.41	.41	.33	.38	.014	.016	.012	.009
3	.29	.31	.44	.34	.012	.017	.015	.013
4	.26	.25	.37	.27	.015	.014	.018	.016
5			.26	.23			.011	.011

Eostaffella aff. pseudostruvei Rauser-Chernoussova
and Beljaev

Plate 4, figures 7-17

Eostaffella pseudostruvei, Rauser-Chernoussova, 1936, Akad. Nauk SSSR, Bull. Poliarnaja Komissia, p. 179-18o, pl. 1, fig. 7.

Diagnosis-The shell size averages 0.114 mm in axial length and 0.365 mm in width for seven measured specimens. The average form ratio of the fourth volution is .36.

The shell form is discoidal and involute with volution peripheries being arched to broadly rounded. The axis of coiling is moderately irregular.

The average size of the proloculus is 24 microns, but most are in the range of 24 to 28 microns. Spirothecal layers are not distinct. The chomata are moderately well developed and are broad and low.

Septal counts average 7, 12, 16, and 18 for the first through the fourth volution.

Remarks-Because the original reference was not available to me, the designation of affinities with the species seems appropriate. I compared my specimens with those illustrated and

described in Brazhnikova and others (1967, pl. 20, figs. I I-13) and with Bogush and Yuferev (1962), and found a good degree of affinity. This species resembles some of the specimens of Millerella tortula Zeller, (1953) from the Mississippian type Chester rocks, but is generally larger. The species differs from E. postmosquensis var. acutiformis Kireeva as previously noted in the remarks section under the description of that variety. It differs from E. pseudostruvei var. angusta Kireeva as mentioned in the remarks section of the description of that variety.
Occurrence-Aisenverg (1963, p. 78) indicates that the species is present in the Visean, partly equivalent to the Chesteran of the United States, and in the Namurian and Bashkirian, partly equivalent to the Morrowan and Atokan, respectively.
Eostaffella sp. I
Plate 4, figures 18-19
Diagnosis-The shell measures 0.172 mm in average length and 0.392 mm in average width. The form ratio averages .74 in the fourth volution.
The shell form is discoidal and involute with the volution peripheries being arched to bluntly pointed. The axis of coiling is regular.
The average size of the proloculus is 25 microns in outside diameter.
Spirothecal layers are not distinct. The chomata are quite well developed and are generally broad and low.
Measurements-The average radius vectors in mm are .032, .061, .103, and .172, for the first through the fourth volution, respectively. Half lengths in mm average .015, .031, .052, and .074, respectively, for the first through the fourth volution. Form ratio averages from the first through the fourth volution are .46, .51, .50, and .43 and wall thicknesses for the same volutions average .008, .011, .015, and .018.
Remarks-The species resembles some specimens of Eostaffella postmosquensis var. evoluta Potievska, 1958.
Occurrence-The species is found in the Marble Falls Formation from collection 10, bed I through collection 50, bed 13.
Eostaffella aff. ovoidea (Rauser-Chernoussova)
Plate 4, figures 20-37
Eostaffella prisca var. ovoidea Rauser-Chernoussova, 1948, Akad. Nauk SSSR, Inst. Geol. (Trudy), geol. ser., v. 62, p. 16, 17, pl. 3, figs. 21-22.
Eostaffella ovoidea (Rauser-Chernoussova) Rozovskaya, 1963, Akad. Nauk SSSR, Paleont. Inst., Trudy, v. 97, p. 99, pl. 18, figs. 5-9.
Diagnosis-The shell averages o.098 mm in axial length and 0.202 mm in width for seven measured specimens. The

average form ratio for the third volution is .44 and is .36 for the fourth volution.
The shell form is discoidal and involute with the peripheries of volutions arched to bluntly pointed. The axis of coiling is straight to moderately unstable.
The proloculus averages 25 microns in outside diameter. Chomata are broad and low, when present, but are poorly developed in most specimens. The wall layers are not differentiated, except in a few specimens.
Septal counts average 6, 11, and 14 for the first through the third volution, respectively.
Remarks—The species bears definite affinities to one of the specimens illustrated by Rauser-Chernoussova (1948, pl. 3, fig. 22). In addition, the author compared his specimens with descriptions and illustrations by Rauser-Chernoussova and others (1951, pl. I, fig. 7) and Rozovskaya (1963, pl. 8, figs.
5-9).

Occurrence—The species is noted by Aisenverg (1963, p. 77) in the Visean, Namurian and Bashkirian of the Soviet Union, partly equivalent to the Chesteran, Morrowan and Atokan, respectively, of the United States. In the Marble Falls Formation, the species is present from collection 32, bed 8 through collection 72, bed 18; while it occurs in the Deny section from collection 1, bed i through collection 25, bed 13-14.

Measurements of Eostaffella *aff.* ovoidea

Volutions	M35-31	M43-1	D2-7	D19-6	M35-31	M43-1	D2-7	D19-6
	Radius vector (mm)				Half length (mm)			
0	—	.012	.013	.013	.012	.014	.016	.018
1	.022	.028	.030	.034	.022	.022	.029	.022
2	.044	.052	.058	.055	.037	.033	.042	.040
3	.076	.080	.095	.091	.048	.042		
4	.134	.117						
	Form ratio				Wall thickness (mm)			
1	.55	.50	.53	.53	.009	.010	.007	.007
2	.50	.42	.50	.40	.010	.014	.013	.009
3	.49	.41	.44	.44	.014	.017	.012	.013
4	.36	.36			.012	.013		

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Catalog of Illustrated Specimens

All specimens are in the collection of the Department of Earth Sciences, New Mexico State University, Las Cruces, New Mexico. The prefix M denotes a Marble Falls collection and D indicates a Derry collection.

Millerella cf. *marblensis* Thompson

CATALOG NO.	TYPE	PLATE & FIGURE		BED
M41-1		1	6	11
M42-33		1	2	11
M42-34		1	8	11
M55-5		1	5	14
M65-19		1	9	15
M68-13		1	4	17
M68-24		1	1	17
M68-46		1	7	17
M70-3		1	3	18

Millerella extensus King, n. sp.

D14-1	paratype	1	23	6
D14-6	paratype	1	21	6
D16-2	holotype	1	13	8 & 9
D16-3	paratype	1	18	8 & 9
D16-4	paratype	1	17	8 & 9
D16-5	paratype	1	10	8 & 9
D16-6	paratype	1	15	8 & 9
D16-7	paratype	1	22	8 & 9
D17-1	paratype	1	11	8 & 9
D18-4	paratype	1	16	10
D19-2	paratype	1	14	10
D19-5	paratype	1	12	10
M32-7	paratype	1	20	8
M69-19	paratype	1	19	18

Millerella sp. 1

D12-3		1	25	5
D12-5		1	24	5

Eostaffella aff. *carbonica* Grozdilova & Lebedeva

D2-12		2	1	1
D2-13		2	3	1
M43-3		2	2	11
M46-31		2	4	12
M68-19		2	5	17
M68-23		2	6	17
M68-35		2	7	17

Eostaffella aff. *acuta* forma *nana* Kireeva

D1-1		2	15	1
D3-3A		2	14	1
D5-1		2	19	2
D12-10		2	11	5
D17-2		2	16	8 & 9
M20-17		2	17	2
M30-6		2	12	6
M32-4		2	13	8
M32-19		2	10	8
M35-18		2	20	9
M46-23		2	9	12
M46-37		2	8	12
M68-41		2	18	17

Eostaffella aff. *exilis* Grozdilova & Lebedeva

CATALOG NO.	TYPE	PLATE & FIGURE		BED
D3-1		2	31	1
D3-4		2	22	1
D3-5		2	21	1
D3-6		2	30	1
M32-14		2	26	8
M32-16		2	27	8
M37-4		2	23	9
M37-7		2	29	9
M37-10		2	24	9
M37-16		2	25	9
M37-39		2	32	9
M37-46		2	28	9

Eostaffella aff. *postproikensis* Vdovenko

M12-22		2	36	1
M14-2		2	35	1
M42-20		2	33	11
M42-25		2	34	11

Eostaffella aff. *compressa* Brazhnikova & Potievskaya

M19-2		2	39	2
M26-1		2	40	6
M32-8		2	37	8
M32-26		2	38	8
M32-27		2	41	8

Eostaffella cf. *postmosquensis* var. *acutiformis* Kireeva—Form 1

D2-2		2	42	1
D3-7		2	44	1
D12-11		2	45	5
D12-12		3	4	5
M35-15		3	5	9
M35-24		3	7	9
M41-11		3	6	11
M41-12		2	43	11
M42-3		3	3	11
M57-4		3	2	15
M68-3		3	1	17
M68-5		2	46	17

Eostaffella cf. *postmosquensis* var. *acutiformis* Kireeva—Form 2

D12-1		3	9	5
D12-7		3	8	5

Eostaffella aff. *vasta* Rozovskaya

M11-3		3	12	1
M11-7		3	10	1
M12-3		3	11	1
M16-1		3	13	2
M17-2		3	14	2

Eostaffella inflecta (Thompson)

M12-12		3	15	1
M16-4		3	16	2

Eostaffella chesterensis (Cooper)

CATALOG NO.	TYPE	PLATE & FIGURE		BED
D12-8		3	18	5
M41-2		3	22	11
M42-28		3	21	11
M72-8		3	20	18
M72-9		3	19	18
M72-17		3	17	18

Eostaffella advena (Thompson)

M11-4		3	29	1
M11-10		3	30	1
M11-11		3	23	1
M12-8		3	24	1

Eostaffella cf. *pseudostruvei* var. *angusta* Kireeva

D3-8A		3	26	1
D7-5		4	2	2A
D14-7		4	1	6
M19-17		3	28	2
M19-27		3	27	2
M19-28		4	6	2
M19-30		4	3	2
M20-10		4	5	2
M37-40		3	25	9
M41-4		4	4	11

Eostaffella aff. *pseudostruvei* Rauser-Chernoussova & Beljaev

M36-8		4	8	9
M36-9		4	15	9
M36-10		4	13	9
M36-14		4	17	9
M36-15		4	9	9
M36-17		4	14	9
M36-18		4	10	9
M36-20		4	7	9
M36-24		4	12	9
M36-26		4	11	9
M36-29		4	16	9

Eostaffella sp. 1

CATALOG NO.	TYPE	PLATE & FIGURE		BED
M1-16		4	19	1
M42-10		4	18	11

Eostaffella aff. *ovoidea* (Rauser-Chernoussova)

D2-7		4	35	1
D5-4		4	28	2
D12-4		4	30	5
D14-3		4	29	6
D16-8		4	31	8 & 9
D16-9		4	33	8 & 9
D16-14		4	32	8 & 9
D19-6		4	27	10
M35-8		4	36	9
M35-28		4	37	9
M35-31		4	24	9
M41-15		4	20	11
M42-8		4	21	11
M42-14		4	34	11
M42-30		4	26	11
M42-57		4	25	11
M43-1		4	22	11
M44-12		4	23	12

PLATES 1-4

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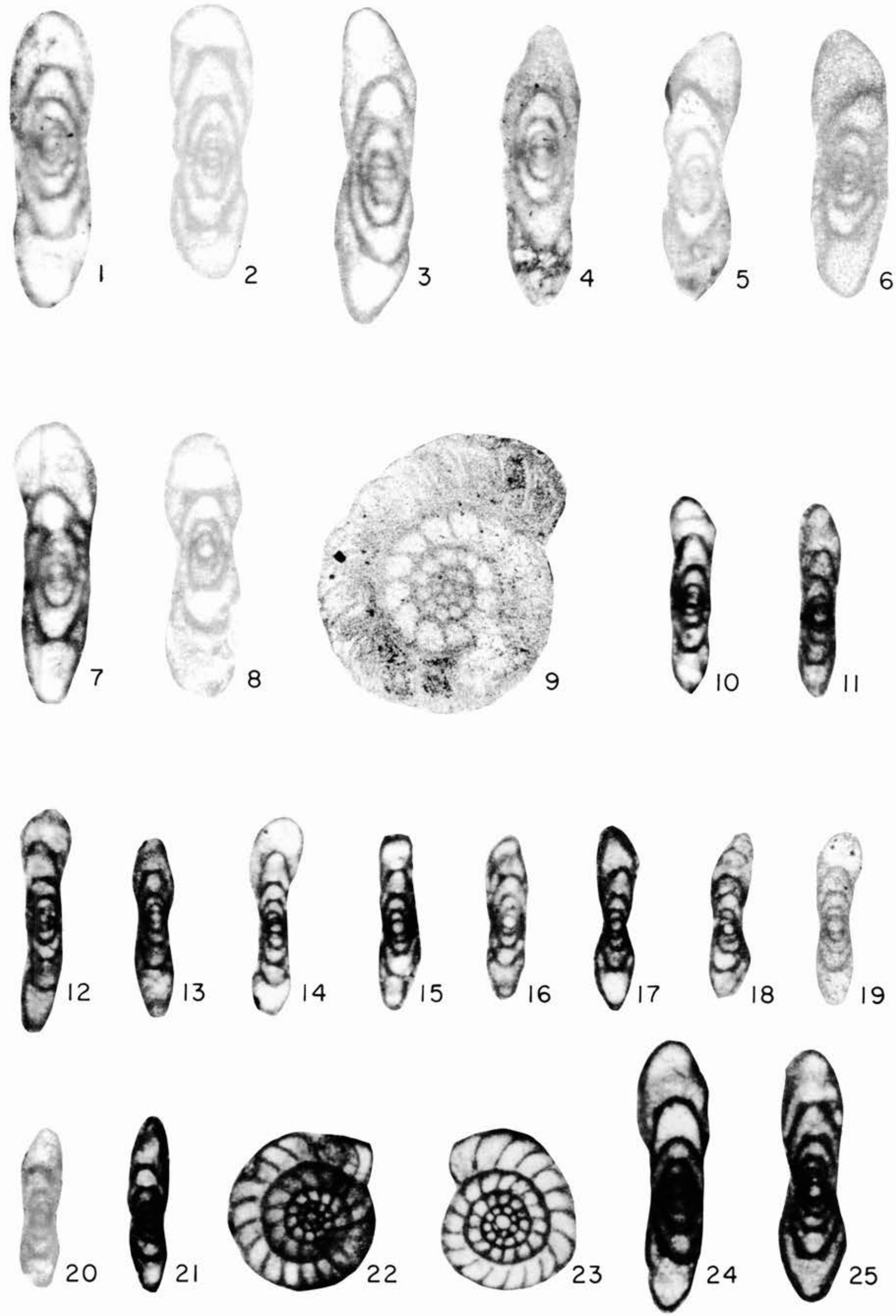
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PLATE 2
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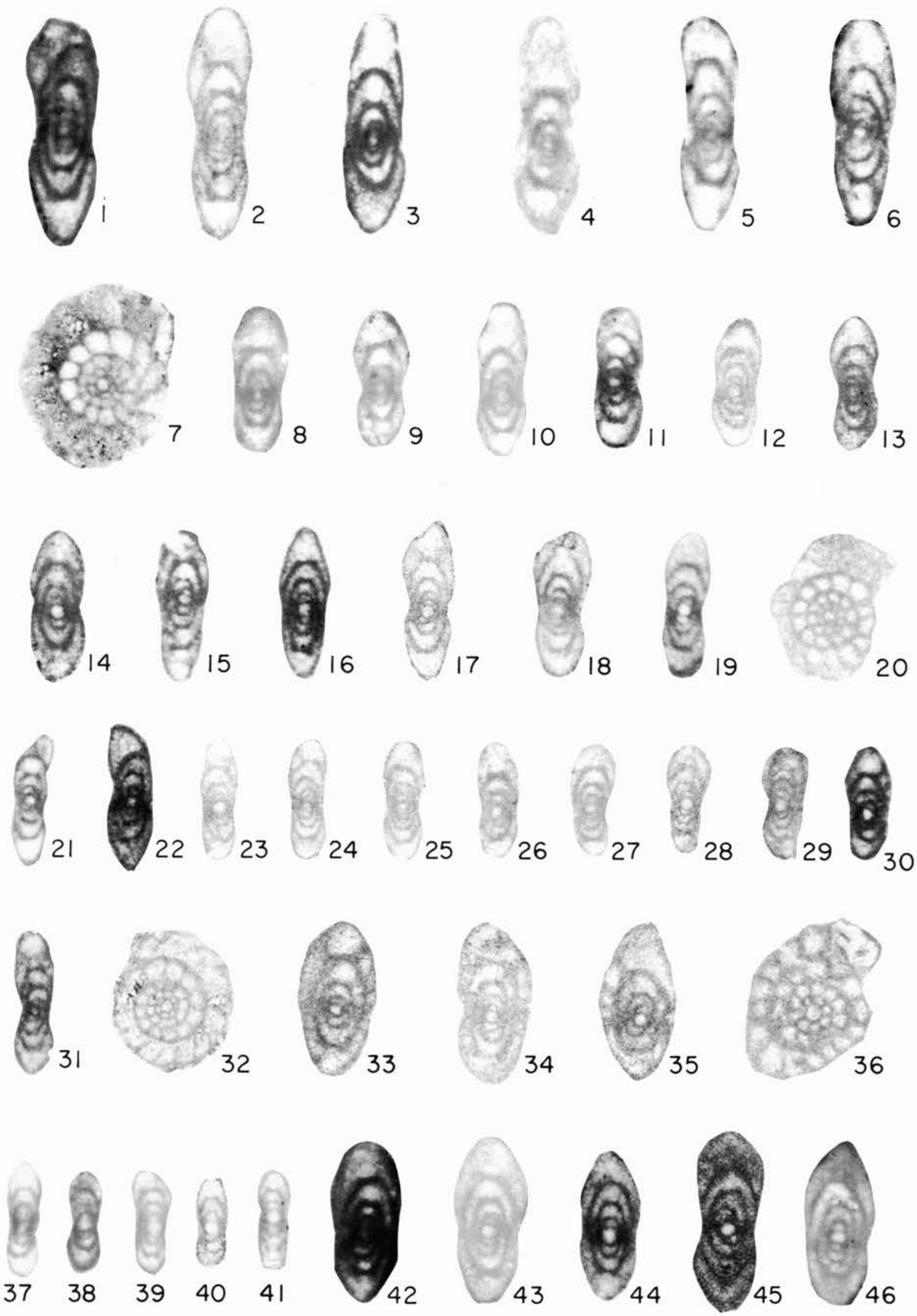
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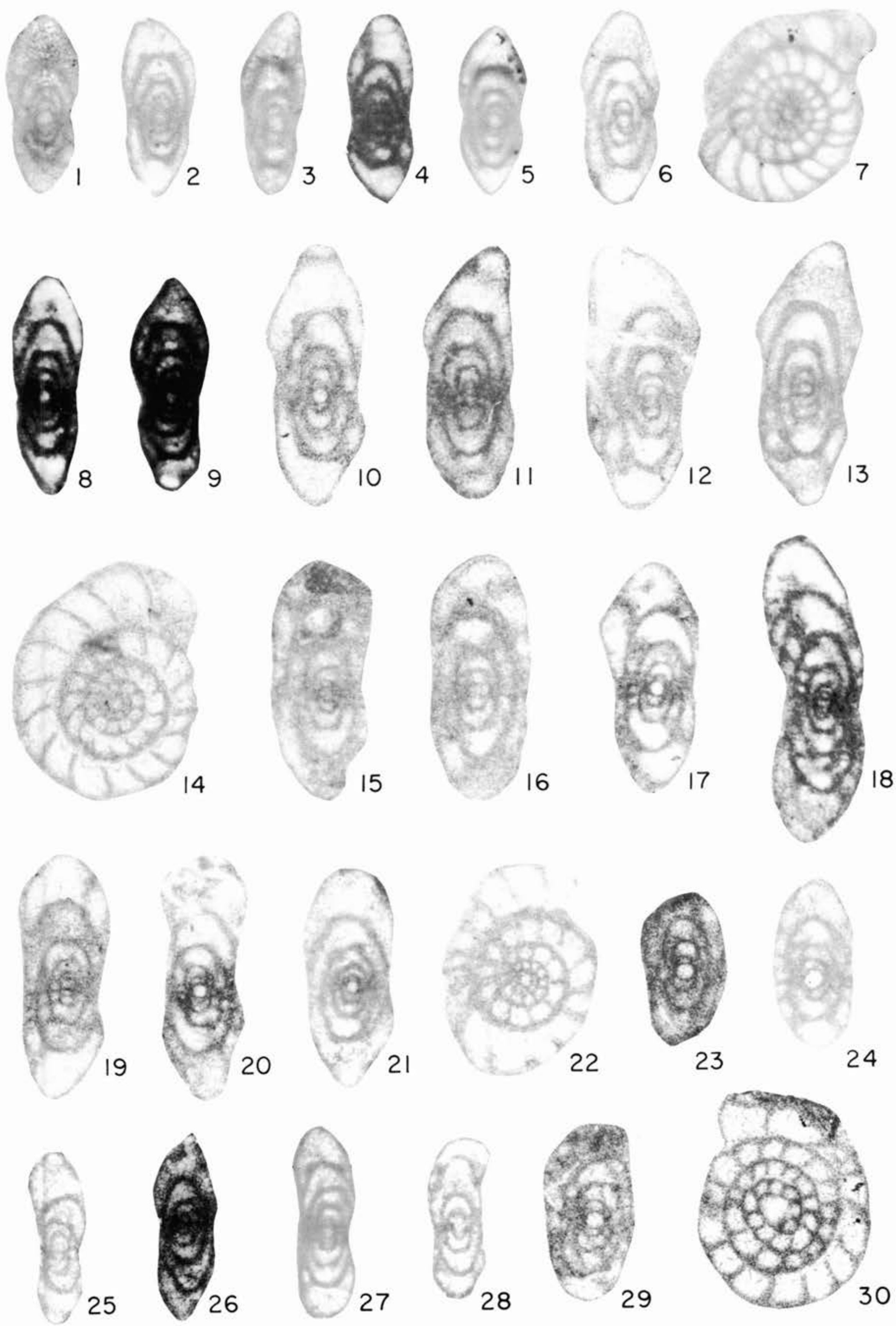
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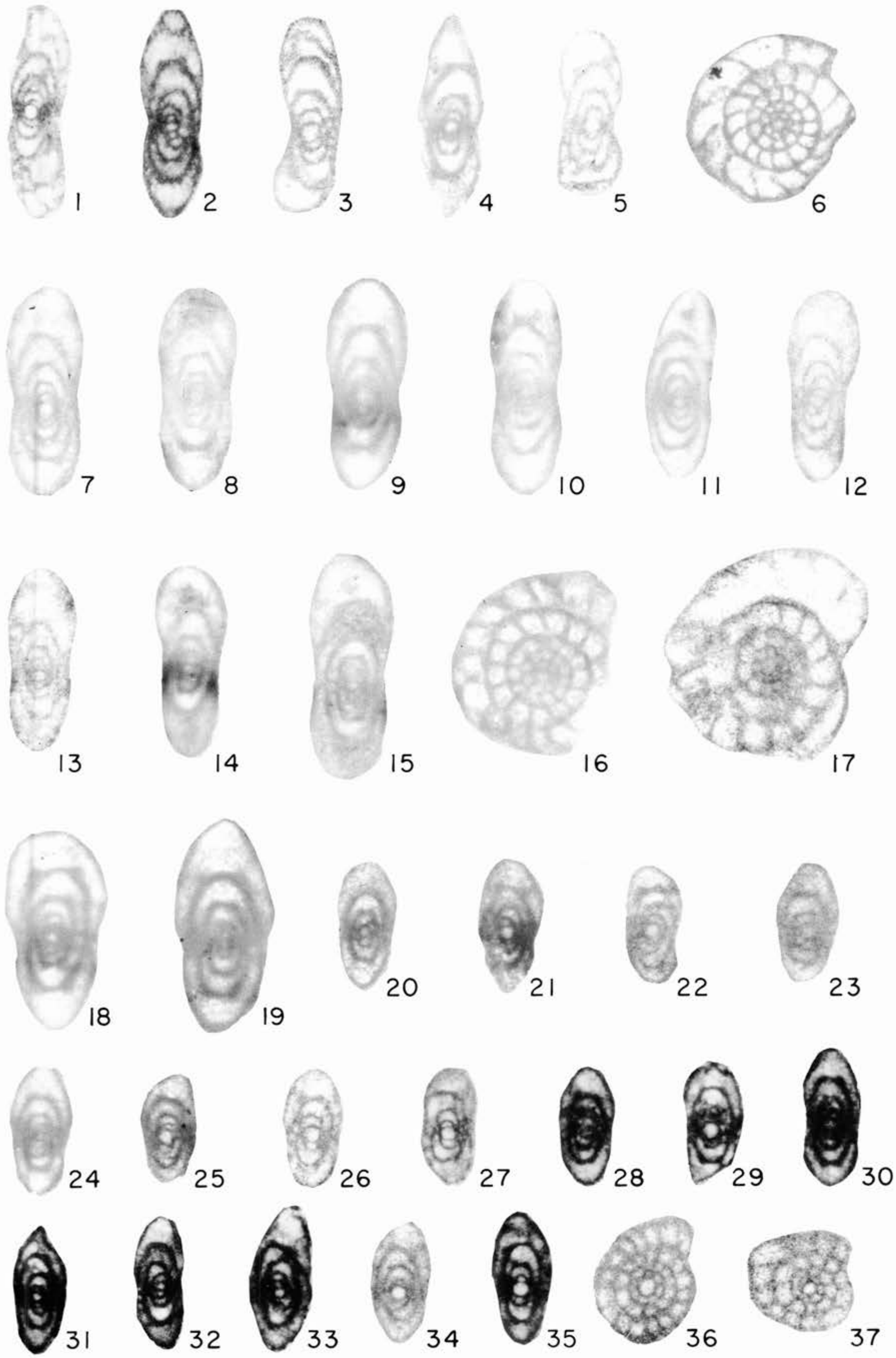
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