Desmoinesian Fusulinids of Missouri

by

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ABSTRACT

Fusulinids representing 3 genera and 18 species, of which 3 are new, have been recognized in a detailed examination of 13 limestones in the middle Pennsylvanian, Desmoinesian section of Missouri. These forms occur in four distinct fusulinid zones. The lowest zone, which is essentially coextensive with the Cabaniss group, includes *Wedekindellina euthysepta*, *Fusulina euryteines*, and *F. leei*. The second zone, typical of the Fort Scott subgroup, is represented by an assemblage of *Fusulina lucasensis*, *Fusulina haworthi*, and *F. girtyi*. The third zone is in the Pawnee formation and is characterized by the occurrence of *Fusulina tumida* in association with *F. haworthi* and *F. girtyi*. The uppermost zone contains *Fusulina megista* and *F. acme* and is typical of the Altamont and Lenapah formations. The several limestone members within a given formation could not be distinguished from one another on the basis of currently accepted techniques and concepts in fusulinid differentiation. The large number of specimens available for study made possible the application of the "population" concept in fusulinid speciation instead of the more widely practiced "type" concept.

INTRODUCTION

The Missouri Geological Survey has directed particular attention during recent years to detailed stratigraphic analyses of the middle Pennsylvanian, Desmoinesian rocks in Missouri. Difficulties in correlating strata in some isolated exposures and in making precise stratigraphic interpretations have led to a need for additional knowledge of specific groups of fossils; fusulinids were chosen because of their proven stratigraphic usefulness in other areas.

Although fusulinids occur commonly in the Desmoinesian strata of Missouri, these fossils have received relatively little attention. Their presence has been noted incidentally in many stratigraphic and paleontologic reports, but with the exception of two unpublished master's theses (Johnson, 1939, and Orlansky, 1951) they have not been described systematically. Johnson described some Desmoinesian fusulinids from Boone County, Missouri, and Orlansky described a few Cherokee (Cabaniss) fusulinids from Vernon County, Missouri, and Bourbon County, Kansas. The illustrations of Johnson's fusulinids were published by Branson (1944), but no species were described.

In contrast to the lack of systematic work on the Desmoinesian fusulinids of Missouri, extensive studies have been made on fusulinids from equivalent strata in other midcontinent states—Iowa, Illinois, Oklahoma, and Texas. The first mention of Desmoinesian fusulinids of the midcontinent region was by Meek and Worthen (1873) who illustrated external views of two specimens. Staff (1912) published the first report on these fossils, but unfortunately his paper is poorly organized, the samples are mixed, the collecting localities are not noted, and, according to Girty (1914) and Beede (1916), the taxonomy is unsatisfactory. The study by Dunbar and Condra (1927) on the Pennsylvanian fusulinids from Nebraska was the first detailed work on midcontinent fusulinids; it included, however, only a few Desmoinesian species. Subsequent, brief but highly significant reports on middle Pennsylvanian fusulinids include those by Henbest (1928)—Illinois; Roth and Skinner (1930)—Colorado; and Thomas (1931)—Texas.

Monographic reports on fusulinid faunas have been published by White (1932), Thompson (1934), Needham (1937), and Dunbar and Henbest (1942). The paper by White on Pennsylvanian fusulinids of Texas and the one by Needham on fusulinids of New Mexico include only a few Desmoinesian forms. Thompson described several new species in his extensive work on the Desmoinesian fusulinids of Iowa. Dunbar and Henbest described the Pennsylvanian fusulinids of Illinois, most of which are Desmoinesian.

Several papers include data on Desmoinesian fusulinids from other areas. Thompson (1935, 1936a, 1936c, 1945a, and 1945b) described collections of Desmoinesian fusulinids from Oklahoma, Wyoming, Ohio, Utah and Colorado, and Oklahoma and Texas, respectively. Henbest (1953) noted the occurrence of previously described species in the Hartville formation, Wyoming. Alexander (1954) described several new species of Desmoinesian fusulinids from Oklahoma. Stewart (1958) and Myers (1960) described additional species of upper Desmoinesian fusulinids from Texas.

The collection on which this study is based contains samples from 116 localities that are scattered over an area which extends from western Missouri northeast to the Iowa state line; samples from a few isolated outcrops near St. Louis are included (Fig. 1). With the exception of those samples provided by K. G. Brill, Jr., St. Louis University, from the St. Louis outlier and one sample collected by M. L. Thompson from Henry County, all samples were collected specifically for this study by the writer from localities previously described by: Cline (1941), Cline and Greene (1950), Jeffries (1958), W. V. Searight (1955), and T. K. Searight (1958). About 1,400 fusulinid thin sections were prepared, and detailed measurements were made on approximately 170 specimens.

The relatively large amount of information that is available on Desmoinesian fusulinids in other areas when combined with this study should provide a basis for greatly increased understanding of Desmoinesian fusulinids throughout the midcontinent region.

Acknowledgments: Sincere appreciation is expressed to: M. L. Thompson, Illinois Geological Survey, for first suggesting the problem and for making many valuable suggestions as to speciation of the fusulinids included in this paper; to W. V. Searight, Missouri Geological Survey, who accompanied the author several times in the field and provided the stratigraphic information necessary to complete the collections; to K. G. Brill, Jr., St. Louis University, who provided

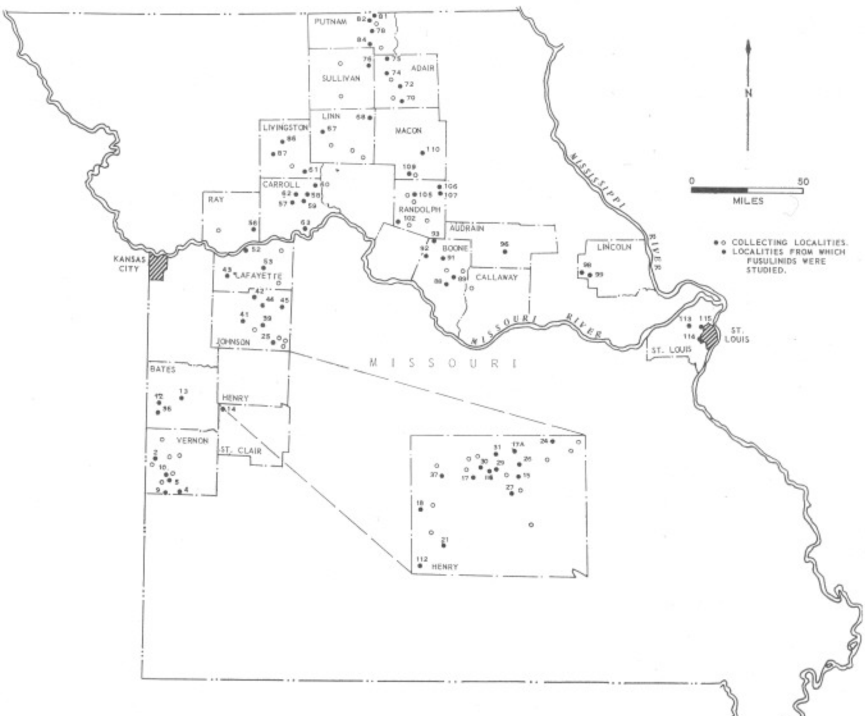


Fig. 1 Desmoinesian collecting localities.

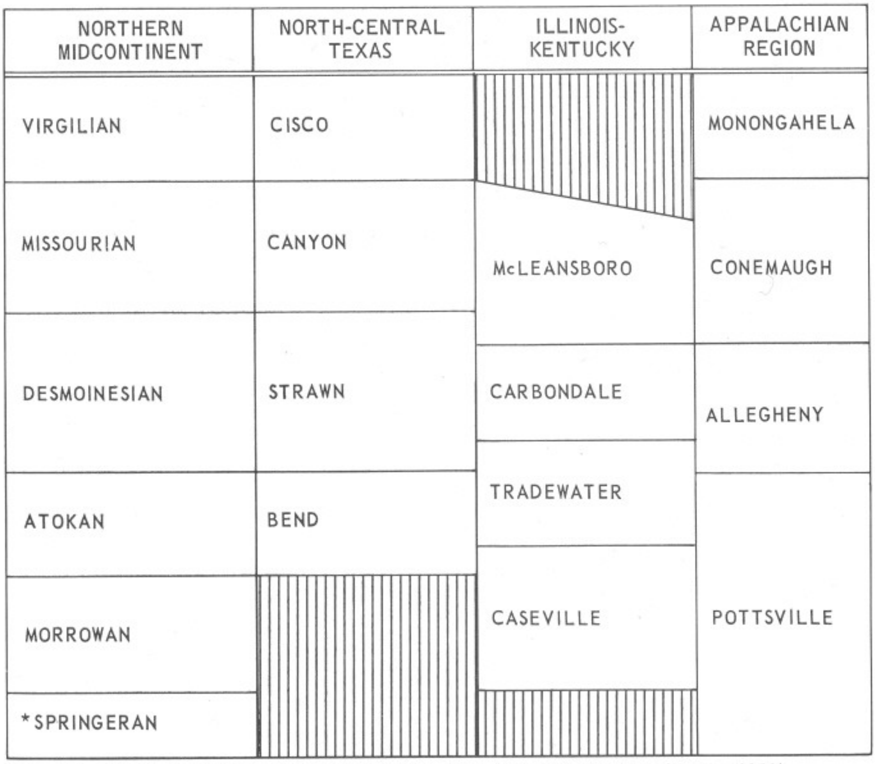
limestone samples of the Marmaton formation from the St. Louis outlier; and to R. M. Jeffords, Humble Oil & Refining Company, who advised on some editorial and taxonomic problems.

The Missouri Geological Survey and Water Resources financed the field work during the summer of 1957. Much of the laboratory work was done while the author held a Shell Oil Company fellowship at the University of Kansas for the academic year 1957-1958.

A representative collection and the type specimens have been filed in the collections of the University of Missouri, Columbia, Missouri.

STRATIGRAPHIC AND PALEONTOLOGIC SUMMARY

The Desmoinesian strata of Missouri (Fig. 2) are characterized by the cyclical sedimentation typical of the Pennsylvanian and lower Permian section in the midcontinent. Moore (1936, 1950, 1957) and



* *Recent studies of Springeran fossils indicate Late Mississippian age (Moore, 1958).*

Fig. 2 Correlation of the major units of the Pennsylvanian System of the midcontinent and eastern United States.

Weller (1931, 1956, 1957) have discussed the sedimentary framework of this area in detail. A generalized columnar section of the Desmoinesian Series of the northern midcontinent is shown in Figures 3 and 4.

On the basis of fusulinids, four zones can be recognized in the Desmoinesian of Missouri (Fig. 5). The lowermost zone (Fig. 3), which is typical of the Cabaniss group, contains in abundance specimens of *Wedekindellina euthysepta, Fusulina euryteines,* and *F. leei;* also present are *F.* sp. aff. *F. kayi, F. boonensis, F.* (?) *problematica,* and *F. cadyi.* These species or very closely related forms have been reported from the following limestones, all of which, except the Boggy

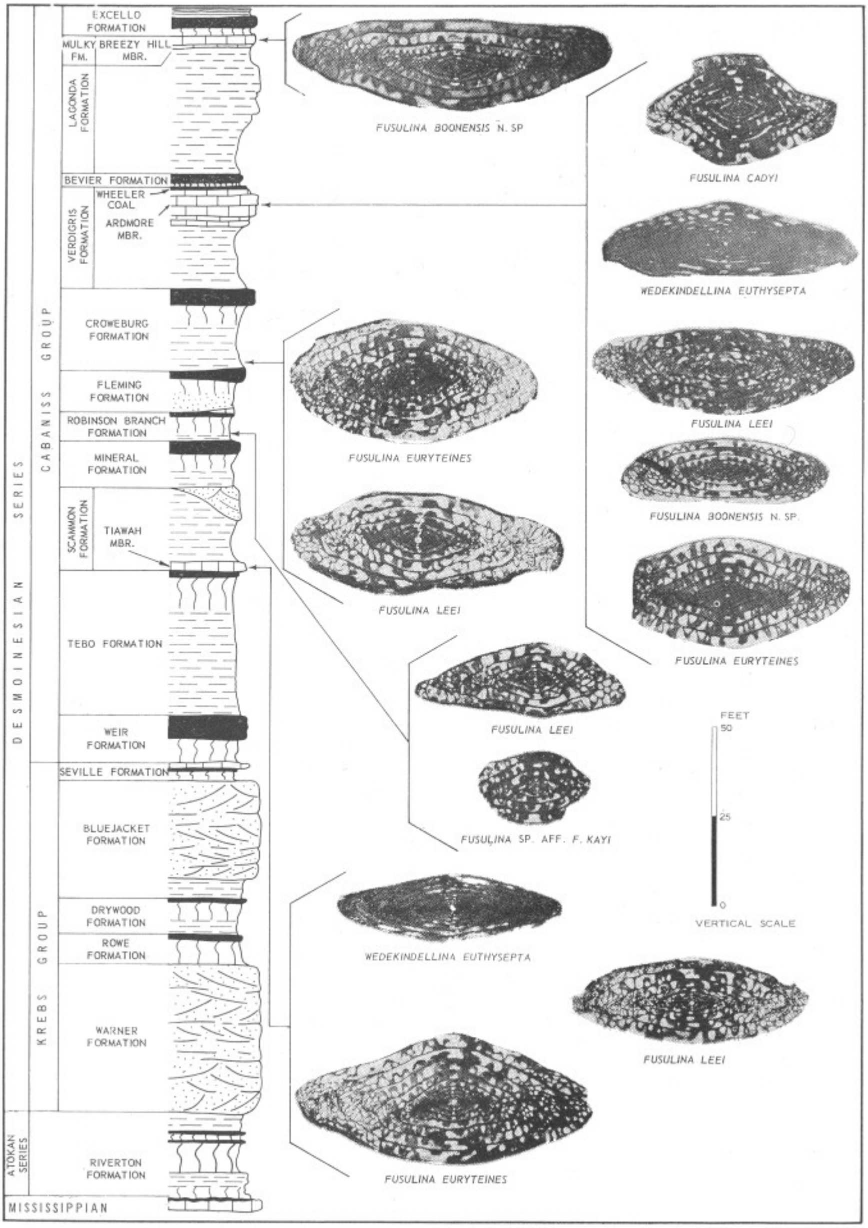


Fig. 3 Generalized columnar section of the Krebs and Cabaniss groups showing fusulinid occurrences. All figures x 10.

formation, are considered equivalent in age to some part of the Cabaniss of Missouri: a limestone 35 feet below the White Breast coal of

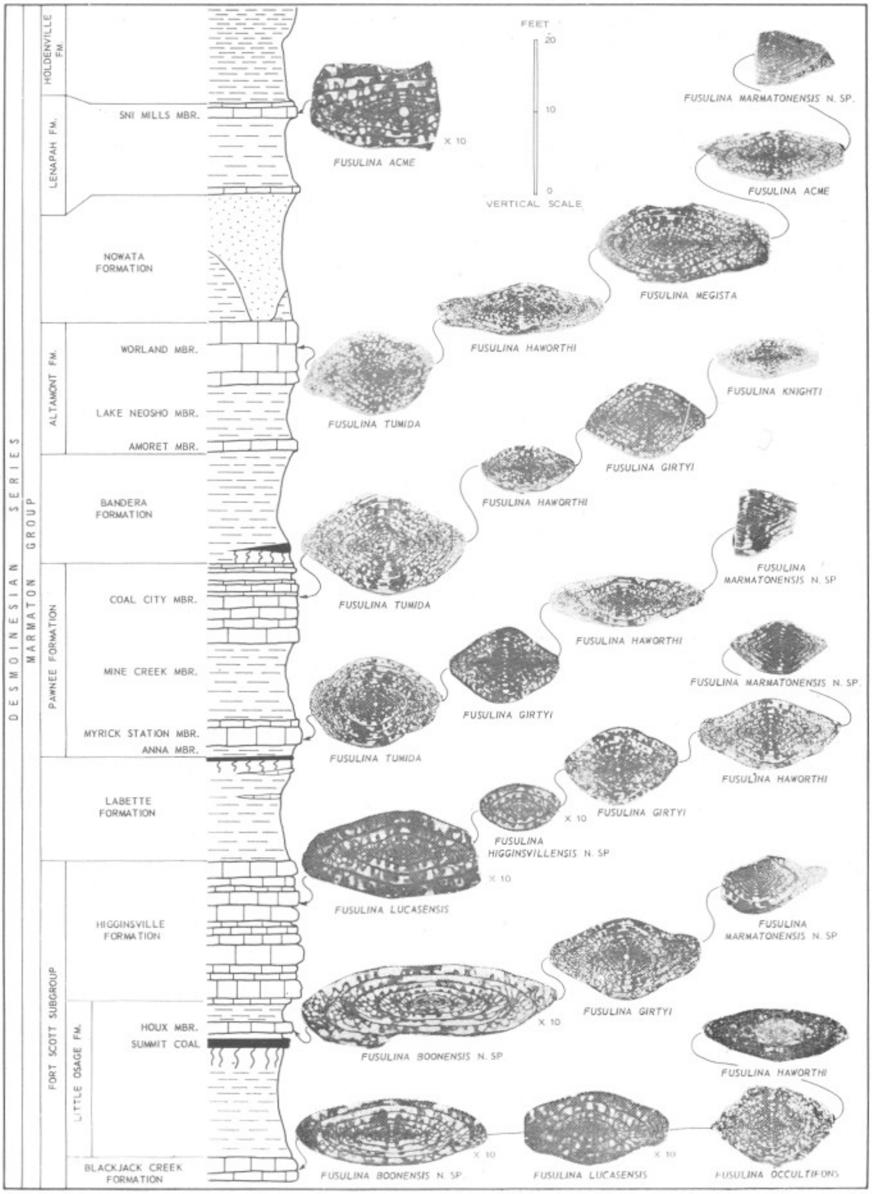


Fig. 4 Generalized columnar section of the Marmaton group showing fusulinid occurrences. All figures x 5 unless otherwise indicated.

Iowa (Thompson, 1934); the Hartville and Quadrant formations of Wyoming (Thompson and Scott, 1941); the Stonefort (Henbest, 1928) and the Curlew members of the Spoon formation of Illinois (Dunbar and Henbest, 1942); the upper Boggy formation (Thompson, 1935) and the Russell Creek member of the Senora formation of Oklahoma (Alexander, 1954); the Fleming cap rock of the Senora formation of Oklahoma (Alexander, 1954); a thin limestone 350 feet above the Mississippian limestone of Wyoming (Thompson, 1936a); a marl immediately above the Bluejacket member of the Boggy formation of Oklahoma (Alexander, 1954); the Dennis Bridge limestone of the Lazy Bend member, Millsap Lake formation, Texas (White, 1932); and the Vanport member of the Allegheny formation of Ohio (Smyth, 1957).

The second zone (Fig. 4, lower portion), which is characterized by specimens of *Fusulina lucasensis, F. haworthi,* and *F. girtyi* and by an absence of *F. tumida,* is typical of the Fort Scott subgroup. Also present are *F. boonensis, F. occultifons, F. marmatonensis, and F. higginsvillensis. Fusulina haworthi* and *F. girtyi* have also been reported from a limestone 18 feet above the Mystic coal in Iowa (Thompson, 1935); from the St. David, Brereton, and Bankston Fork members of the Carbondale formation of Illinois (Dunbar and Henbest, 1942); and from the Fort Scott formation of Kansas (Beede, 1916) and Oklahoma (Alexander, 1954). In addition, *F. haworthi* has been reported from the upper part of the Millsap Lake group of Texas (White, 1932) and *F. girtyi,* from the Hartville formation of Wyoming (Henbest, 1953). All these strata are reported as equivalent to beds in the lower or middle part of the Marmaton group of Missouri.

The third zone (Fig. 4, middle portion), characterized by the appearance of *Fusulina tumida* and by more numerous specimens of *F. haworthi,* is limited in Missouri to the Pawnee formation. *Fusulina marmatonensis, F. knighti,* and *F. girtyi* are also reported from the Pawnee formation. *Fusulina tumida* has previously been reported from the Myrick Station member of the Pawnee formation of Oklahoma (Alexander, 1954).

The fourth and uppermost zone (Fig. 4, upper portion), containing specimens of *Fusulina megista* and *F. acme,* is typical of the Worland member of the Altamont formation and the Sni Mills member of the Lenapah formation. *Fusulina tumida, F. haworthi,* and *F. marmatonensis* are also present in the Worland. *Fusulina megista* has been reported previously from a limestone 50 feet above the Mystic coal of Iowa (Thompson, 1934); from the Pawnee formation of Kansas (Dunbar and Condra, 1927) and Oklahoma (Alexander, 1954); from the Wimer School member of the Labette formation of Oklahoma (Alexander, 1954); from the Piasa, Cutler, and Lonsdale members of the Modesto formation of Illinois (Dunbar and Henbest, 1942); from the Hartville formation of Wyoming (Henbest, 1953); and from the Village Bend member of the East Mountain formation and from the Capps member of the Lone Camp formation of Texas (Stewart, 1958). *Fusulina acme* has been reported from the Lonsdale and Piasa members of Illinois (Dunbar and Henbest, 1942); from the Hartville formation of Wyoming (Henbest, 1953); and from the Village Bend and Capps members of Texas (Stewart, 1958). All the occurrences of *F. megista* and *F. acme* listed above are in strata equivalent to the middle or upper part of the Marmaton group of Missouri.

Series	Group	FORMATIONS	*Eoschubertella gallowayi*	*Wedekindellina euthysepta*	*Fusulina euryteines*	*Fusulina leei*	*Fusulina(?) problematica*	*Fusulina sp. aff. F. kayi*	*Fusulina cadyi*	*Fusulina boonensis*	*Fusulina occultifons*	*Fusulina higginsvillensis*	*Fusulina marmatonensis*	*Fusulina lucasensis*	*Fusulina knighti*	*Fusulina haworthi*	*Fusulina girtyi*	*Fusulina tumida*	*Fusulina megista*	*Fusulina acme*
DESMOINESIAN SERIES	MARMATON GROUP	Holdenville																		
		Lenapah																		●
		Nowata																		
		Altamont											●			●		●	●	●
		Bandera																		
		Pawnee	●										●		●	●	●	●		
		Labette																		
		Higginsville										●	●	●	●	●	●			
		Little Osage								●			●	●			●	?		
		Blackjack Creek								●	●	●	●	●	●	●				
	CABANISS GROUP	Excello																		
		Mulky								●										
		Lagonda																		
		Bevier				●														
		Verdigris		●	●	●			●	●										
		Croweburg			●	●														
		Fleming																		
		Robinson Branch				●		●												
		Mineral																		
		Scammon		●	●	●	●													
		Tebo																		
		Weir																		

Fig. 5 Stratigraphic distribution of Desmoinesian fusulinids in Missouri.

SPECIATION

In most of the publications on fusulinids, emphasis has been on the morphologic details and the stratigraphic significance of these fossils. Few authors actually discuss the concept of speciation with regard to fusulinids or to the variation to be expected within a particular species; those who have considered speciation include Burma (1942, 1948, 1949), Mayr (1947, 1949), and Young (1960).

Fusulinid speciation has been dominated by too strict application of the "type" concept, whereby forms which differ only slightly from the single type specimen are assigned to a different species. A decided exception is the work by Burma (1942, 1948) who found notable variation within species of the genus *Triticites*. This is in accord with the concept of Mayr, Linsley, and Usinger (1953) that a species is not a fixed "type" but consists of a variable population. Certainly it is in accord with present concepts in paleontology to expect a considerable range of variation within a species, the degree of variation depending upon the nature of the group being studied.

Thompson (1936a) suggested that dimorphic forms of a single species might be represented by specimens from the Black Hills which he referred to *Fusulina distenta* Roth and Skinner and *F. euryteines* Thompson, the former a short form and the latter a long form. In the same publication, he noted the common occurrence together of several other pairs of fusulinid species, one a long and the other a short form. These pairs are: *Fusulina euryteines* Thompson and *F. pumila* Thompson; *F. mysticensis* Thompson and *F. megista* Thompson; and *F. girtyi* (Dunbar and Condra) and *F. stookeyi* Thompson. Dunbar and Henbest (1942), in studies on Pennsylvanian fusulinids of Illinois, noted the similarity between the two species *F. haworthi* (Beede), a long form, and *F. girtyi*, a short form. At the same time, however, they described a new species (*F. illinoisensis*) to include the forms intermediate in shape between *F. haworthi* and *F. girtyi*, even though they recognized the possibility that the three forms were merely variations of one species. Sadlick (1959), on the other hand, after his study of the Desmoinesian fusulinids from the Oquirrh formation and the Durst group of Utah, concluded that the long and short forms represent different lineages.

The present study of the fusulinids from the Cabaniss strata of Missouri provides evidence for a notable range in variation in fusulinid populations. Specimens of *Fusulina euryteines* Thompson are abundant in most samples, and along with the fusiform individuals of this species are forms which are subelongate fusiform and inflated fusiform (Fig. 6). Except for shape, all of these are morphologically the same as the original *F. euryteines*. Specimens exhibiting these various shapes appear to have the same relative abundance throughout the stratigraphic range of the species regardless of geographic location. Because of the large amount of material available for this study, a complete gradation between the elongate and the inflated forms can be demonstrated within a single stratigraphic unit. In addition, as the shape changes from elongate to inflated, the tunnel angle becomes smaller and the chomata become slightly more massive; the diameter of the proloculus, the height of volutions, the wall thickness, and the septal folds are similar regardless of shape. Subdivision of this compact group of fusulinids on the basis of conventionally used morphologic characteristics, therefore, does not appear warranted. Because of this, specimens formerly referred to the species *F. equabilis*, a form intermediate in shape which was described by Alexander (1954), and to

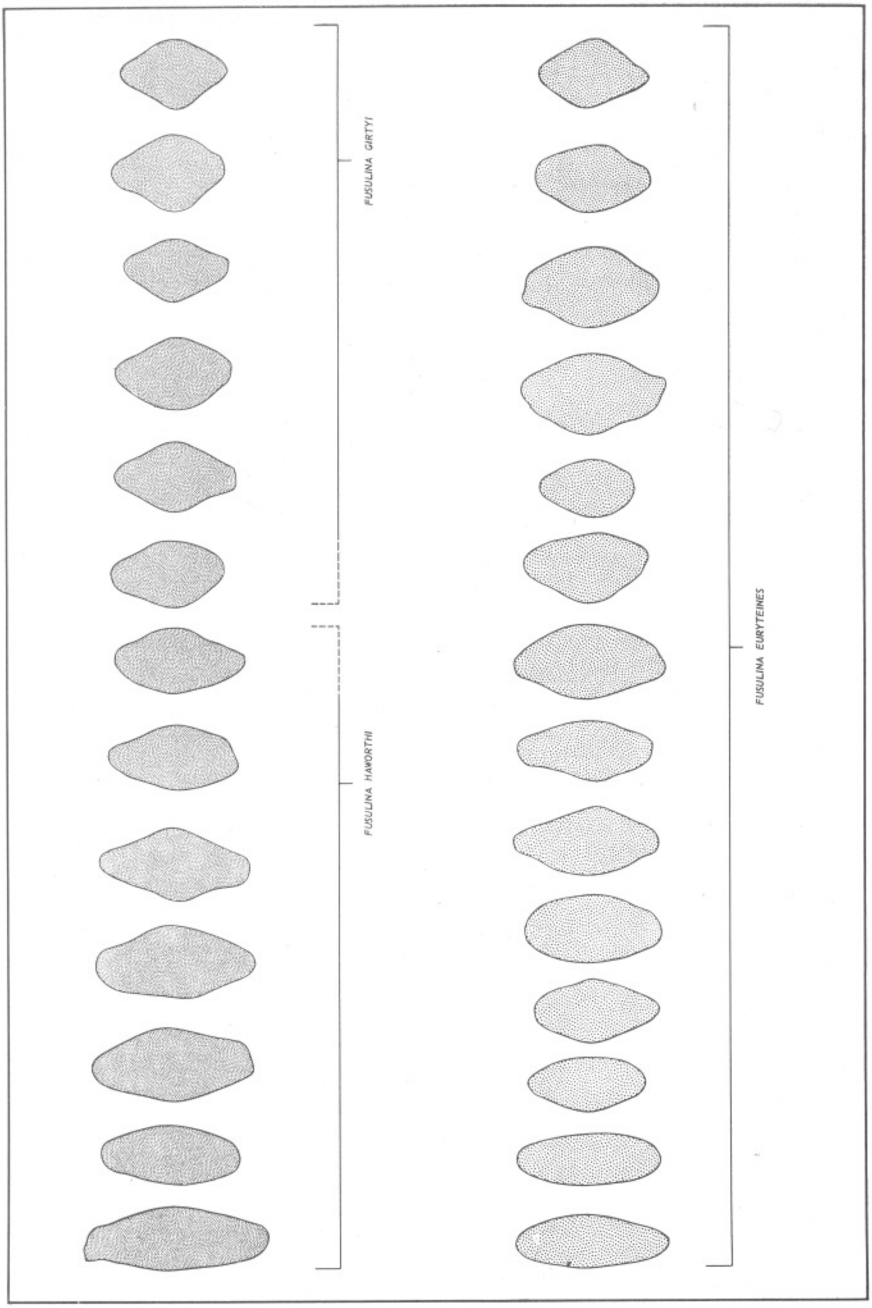


Fig. 6 Chart showing shape variations of specimens of *Fusulina euryteines*, *F. haworthi*, and *F. girtyi*.

F. distenta Roth and Skinner of Thompson are considered here as representatives of *F. euryteines*.

Similarly, a study of the *Fusulina haworthi-F. girtyi* assemblage from the Marmaton of Missouri shows a complete gradation in shape from the elongate fusiform *F. haworthi* to the inflated fusiform *F.*

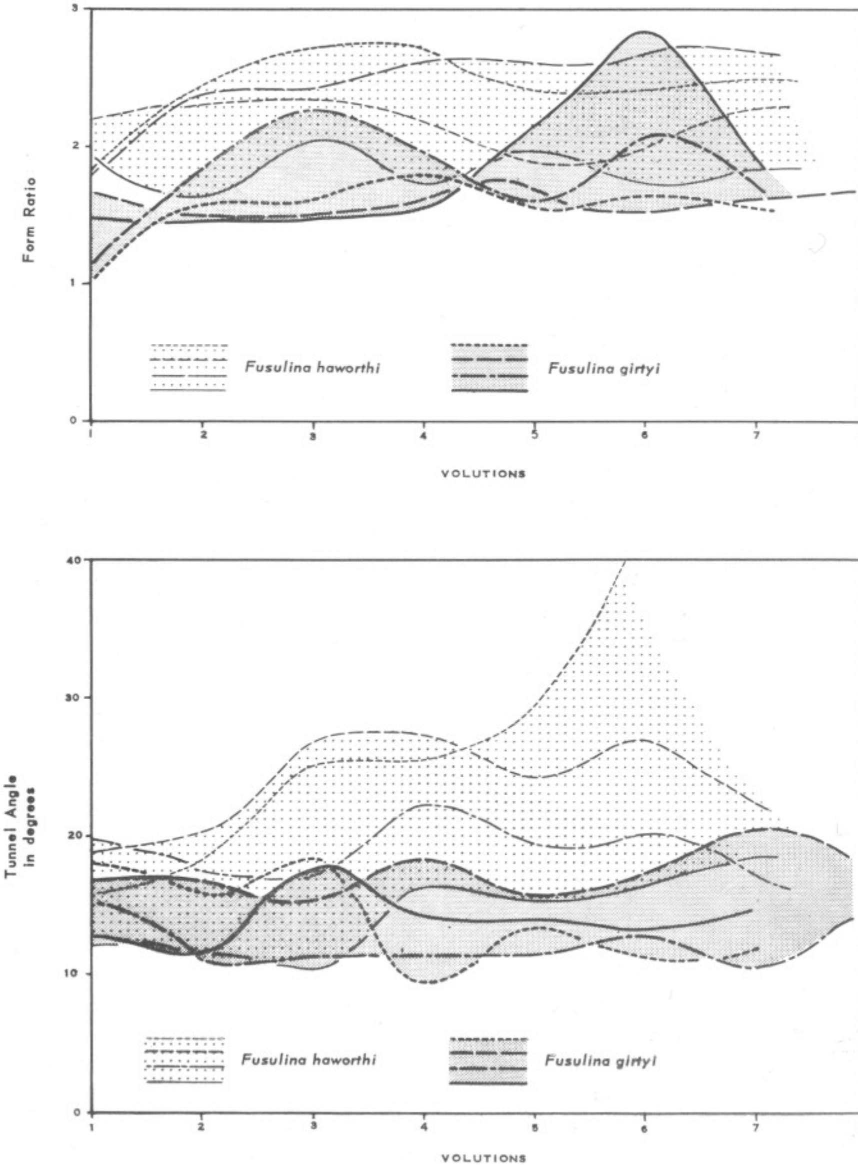
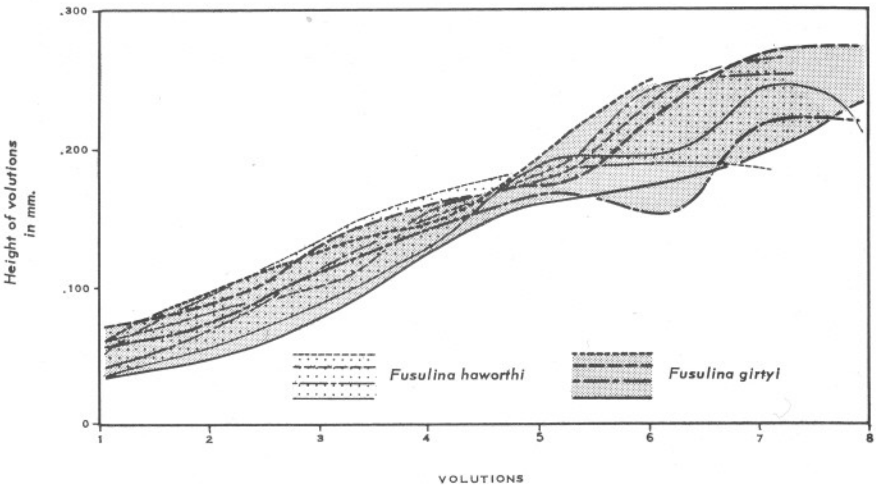


Fig. 7 Graphs of the form ratios and tunnel angles of specimens of *Fusulina haworthi* and *F. girtyi*.



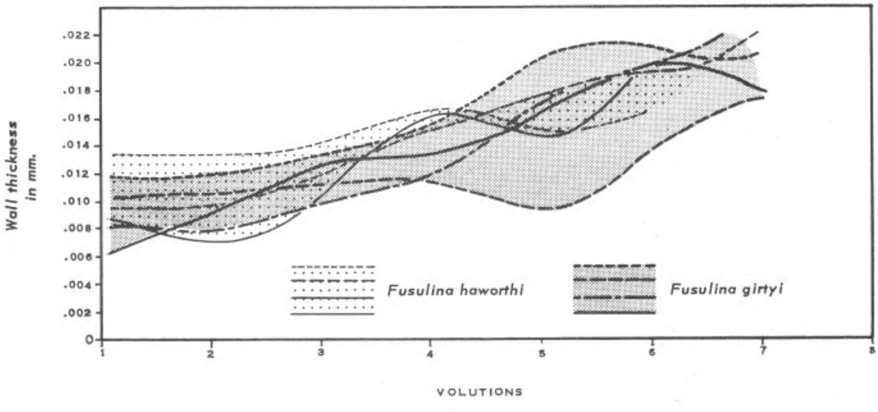


Fig. 8 Graphs of the wall thicknesses and volution heights of specimens of *Fusulina haworthi* and *F. girtyi*.

girtyi (Fig. 6). With the exception of the form ratios and tunnel angles, the measurements of these two species are very similar (Figs. 7 and 8); septal folding, which is very important in fusulinid taxonomy, is of equal intensity in the two species. Comparison of the stratigraphic ranges and geographic distribution of the species *F. haworthi*, *F. illinoisensis* Dunbar and Henbest, and *F. girtyi* indicates very little difference between the three species in this respect. Both *F. haworthi* and *F. girtyi* are recognized here, but *F. girtyi* is restricted to only the most inflated forms; *F. haworthi* is interpreted to include the remainder, including the majority of those forms formerly referred to the species *F. illinoisensis*.

Another problem in speciation arises with the recognition of *Fusulina marmatonensis*, n. sp. This species is unique among the Desmoinesian fusulinids because it is minute, has extremely large chomata, is highly inflated, is not abundant in any one sample, and in all cases is associated with numerous specimens of different species. *Fusulina marmatonensis* occurs with *F. occultifons* Alexander, *F. higginsvillensis*, n. sp., and *F. boonensis*, n. sp. in the Blackjack Creek formation; with *F. girtyi* in the Houx member of the Little Osage formation; with *F. girtyi*, *F. haworthi*, *F. higginsvillensis*, and *F. lucasensis* Thompson in the Higginsville formation; with *F. haworthi* in the Myrick Station member of the Pawnee formation; with *F. haworthi*, *F. girtyi*, and *F. tumida* in the Coal City member of the Pawnee formation; and with *F. haworthi* and *F. acme* in the Worland member of the Altamont formation. The fact that this species is not abundant in any collection and that it has a minute proloculus may be evidence that it represents the microspheric form of one of the species with which it is associated. *Fusulina marmatonensis*, however, is not always found in association with the same species, and it does not seem likely that the microspheric individuals of several different species would be enough alike to be placed within the same species. Also, microspheric forms of modern foraminifers are considerably larger when mature than are the corresponding megalospheric forms. *Fusulina marmatonensis* is invariably the smaller of the forms in each occurrence. Because it may never be possible to recognize microspheric individuals as such, the new species *F. marmatonensis* in here proposed, but the possibility that it may be a microspheric form of another species is noted.

SYSTEMATIC PALEONTOLOGY

Family **FUSULINIDAE** Möller, 1878

Subfamily **SCHUBERTELLINAE** Skinner, 1931

Genus EOSCHUBERTELLA Thompson, 1937

EOSCHUBERTELLA GALLOWAYI (Skinner)

Pl. 1, figs. 1, 2

Schubertella gallowayi SKINNER, 1931b, Jour. Paleontology, v. 5, p. 256, 257, pl. 30, figs. 1, 5, and 5a.

Fusulinella gallowayi (Skinner). THOMPSON, 1935, Jour. Paleontology, v. 9 p. 298, 299, pl. 26, figs. 7-9.

Eoschubertella gallowayi (Skinner). THOMPSON, 1937, Jour. Paleontology, v. 11, p. 124, pl. 22.

Description.—*Eoschubertella gallowayi* (Skinner) is ovoid to inflated fusiform; the lateral slopes are strongly convex, and the poles are broadly rounded. The later volutions are slightly more elliptical than are the early volutions. The average length and width of three specimens are 1.0 mm and 0.6 mm respectively, giving a form ratio of 1.7. The subspherical to elliptical proloculus is large; the average outside diameter is 0.116 mm. The chambers increase in height very rapidly.

The spirotheca seemingly is composed of three layers: the upper tectorium, the tectum, and the lower tectorium. In a few specimens, however, the walls appear to have four layers, perhaps because of the secondary deposition of a more opaque layer on the lower tectorium or because of the lining of the wall by foreign material. The septa are straight throughout the shell. The tunnel is wide, and its path is very irregular. The chomata are massive and very high, locally reaching to the tops of the chambers.

Remarks.—*Eoschubertella gallowayi* is distinguished by its minute size, ovoid to inflated fusiform shape, three-layered wall, large proloculus, straight septa, loose coiling, and massive chomata. It is much larger, has more massive chomata, and has a smaller proloculus than *E. mexicana* Thompson. *Eoschubertella gallowayi* is somewhat similar to *E. texana* Thompson from the Marble Falls formation of the Llano area, Texas, but *E. gallowayi* includes larger specimens that have a greater form ratio and a more symmetrical coiling.

Occurrence.—This species was found in only two samples—in the Myrick Station member of the Pawnee formation (locality 102) and in a limestone questionably identified as a member of the Pawnee formation (locality 99). It has been reported previously from a marl overlaying the Bluejacket member of the Boggy formation in Oklahoma (Skinner, 1931b; Alexander, 1954).

Table 1

Average measurements from 3 specimens of *Eoschubertella gallowayi*

Volutions	1	2	3	4
Height of Volutions (in mm)	.032	.048	.064	.096
Form ratio	1.3	1.4	1.4	1.7
Tunnel Angle (in degrees)	21	22	25	62

Subfamily **Fusulininae** Möller, 1878

Genus WEDEKINDELLINA Dunbar and Henbest, 1933

Wedekindellina euthysepta (Henbest)

Pl. 1, figs. 11-15

Fusulinella euthusepta Henbest, 1928, Jour. Paleontology, v. 2, p. 80, 81, pl. 3, figs. 6-8; pl. 9, figs. 1, 2.
Wedekindella euthysepta (Henbest). Dunbar and Henbest, 1930, Am. Jour. Sci., 5th ser., v. 20, p. 357-364.
Wedekindia euthysepta (Henbest). Dunbar and Henbest, 1931, Am. Jour. Sci., 5th ser., v. 21, p. 458.
Wedekindellina euthysepta (Henbest). Dunbar and Henbest, 1933, Cushman Lab. Foram. Research Special Pub. no. 4, p. 134, key pl. 10, figs. 13-15.

Description.—The shell of *Wedekindellina euthysepta* (Henbest) is small and elongate fusiform; the lateral slopes are plane or slightly convex and the poles sharply pointed. The shell attains its characteristic shape at a very early stage and changes gross shape very little during growth. The average length and width of 10 specimens are 4.0 mm and 1.3 mm respectively, giving a form ratio of 3.1. The subspherical proloculus is small; the average outside diameter is 0.79 mm. The chambers increase in height uniformly throughout the growth of the shell.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The septa are thick, closely spaced, and not folded except near the poles where they are irregularly folded. The tunnel is narrow and increases slightly in size during growth of the shell. The chomata are asymmetrical in that they are steeper toward the tunnel and are approximately half the height of the chambers. Axial deposits fill the chambers along the axis and become heavier toward the poles.

Remarks.—All the specimens of *Wedekindellina* which were found in the Desmoinesian rocks of Missouri are referred to *W. euthysepta*. This species is characterized by its long, slender shape, heavy axial filling, and unfolded septa. *Wedekindellina euthysepta* closely resembles *W. henbesti* (Skinner) in shape, but *W. euthysepta* has heavier axial filling and less folded septa than does *W. henbesti*. *Wedekindellina euthysepta* is longer and more slender than *W. excentrica* Roth and Skinner and *W. coloradoensis* Roth and Skinner. The specimen illustrated on Plate 1, figure 14, appears to have been injured during growth of the last few volutions.

Wedekindellina euthysepta is commonly associated with *Fusulina euryteines* Thompson and *F. leei* Skinner in Missouri.

Occurrence.—*Wedekindellina euthysepta* is abundant in the Ardmore member of the Verdigris formation (localities 24, 30, 45, 60, 88a, and 93) and the Tiawah member of the Scammon formation (localities

4, 14, 21, and 27). This species has previously been reported from the Stonefort member of the Spoon formation, Illinois (Henbest, 1928); from a limestone 35 feet below the White Breast coal, Iowa (Thompson, 1934); from the Vanport member of the Allegheny formation, Ohio (Smyth, 1957); from the Fleming cap rock of the Senora formation of Oklahoma (Alexander, 1954); from the Hartville and Quadrant formations, Wyoming (Thompson and Scott, 1941); from the Dennis Bridge limestone of the Lazy Bend member of the Millsap Lake formation, Texas (White, 1932); and from the upper part of the Boggy formation, Oklahoma (Thompson, 1935).

Table 2

Average measurements from 10 specimens of *Wedekindellina euthysepta*

Volutions	1	2	3	4	5	6	7	8	9	10
Height of Volutions (in mm)	.025	.027	.033	.045	.049	.067	.078	.092	.100	.110
Form ratios	2.2	3.0	3.3	3.8	3.7	3.6	3.7	3.5	3.1	3.1
Thickness of Spirotheca (in mm)	....	.009	.009	.010	.011	.011	.012	.014	.014	....
Septal count	10	13	19	23	25	25	28	30	....	....
Tunnel Angle (in degrees)	16	14	16	19	20	19	19	19	25	22

Genus FUSULINA Fischer de Waldheim, 1829

FUSULINA EURYTEINES Thompson

Pl. 1, figs. 3-10

Fusulina euryteines THOMPSON, 1934, Iowa Univ. Studies Nat. History, v. 16, p. 310-313, pl. 22, figs. 4, 13, 14, and 18; 1936a, Jour. Paleontology, v. 10, p. 107-109, pl. 15, figs. 3-5.

Fusulina distenta Roth and Skinner. THOMPSON 1936a, Jour. Paleontology, v. 10, p. 106, 107, pl. 15, figs. 1, 2, and 8.

Fusulina equabilis ALEXANDER, 1954, Oklahoma Geol. Survey Circ. 31, p. 24-26, pl. 2, figs. 1-4.

Description.—The shell of *Fusulina euryteines* Thompson is small and varies in shape from inflated fusiform to elongate fusiform. The lateral slopes are plane on the more elongate specimens to slightly concave on the more inflated ones; the poles are bluntly pointed but are not often preserved. The early volutions are considerably more elongate than the later volutions. The average length and width of 10 specimens are 4.5 mm and 2.3 mm respectively, giving a form ratio of 2.0. The proloculus is moderate to large in size and spherical in shape; the average outside diameter is 0.147 mm. The expansion of the shell is uniform throughout growth.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The septa are moderately thick and are folded throughout the length of the shell. The tunnel width varies considerably depending on the shape of the shell; those which are elongate tend to have wide tunnels, and the shorter specimens have narrower tunnels. The chomata, which form high, steep-sided ridges on either side of the tunnel, are as much as three-fourths the height of the chambers. Axial fillings are common in the first 3 to 5 volutions but are not generally abundant.

Remarks.—*Fusulina distenta* of Thompson (the highly inflated variant), and *F. equabilis* Alexander (intermediate between *F. euryteines* and *F. distenta* of Thompson) are here referred to the species *F. euryteines*. Complete gradation exists between these species. *Fusulina euryteines* closely resembles *F. haworthi* (Beede) but is distinguished from it by having a slightly smaller size, smaller tunnel angle, lower and broader septal folding, and larger chomata. The inflated forms (*F. distenta* of Thompson) are smaller and have less highly folded septa, and a larger tunnel angle than does *F. girtyi* (Dunbar and Condra) which they resemble in shape. These inflated forms also somewhat resemble *F. distenta* Roth and Skinner; *F. euryteines*, however, has a larger proloculus and higher, narrow septal folds and is more loosely coiled.

Occurrence.—*Fusulina euryteines* is common in the Tiawah member of the Scammon formation (localities 14, 89, and 96), the Ardmore member of the Verdigris formation (localities 24, 30, 60, 89, 96, 109, and 110), and the "Fleming cap rock" (basal unit of the Crowburg formation, locality 17). This species has also been reported from a thin limestone 35 feet below the White Breast coal, Iowa (Thompson, 1934); from a thin limestone 350 feet above the Mississippian limestone, Black Hills, Wyoming (Thompson, 1936a); from the Stonefort member of the Spoon formation, Illinois (Henbest, 1928); and from the Russell Creek member of the Senora formation, Oklahoma (Alexander, 1954).

Table 3

Average measurements from 10 specimens of *Fusulina euryteines*

Volutions	1	2	3	4	5	6	7	8
Height of Volutions (in mm)	.040	.055	.070	.100	.131	.163	.200	.209
Form ratio	1.7	2.0	2.0	2.1	2.0	2.0	1.9	2.2
Thickness of Spirotheca (in mm)	.013	.010	.014	.013	.013	.015	.017	.019
Septal count	14	20	25	28	31	38	39	37
Tunnel Angle (in degrees)	16	17	17	18	19	22	21	25

FUSULINA LEEI Skinner

Pl. 2, figs. 8-11

Fusulina leei SKINNER, 1931b, Jour. Paleontology, v. 5, p. 257-258, pl. 30, figs. 4, 6.

Description.—The shell of *Fusulina leei* Skinner is of moderate size and is elongate fusiform; the lateral slopes are concave to convex to irregular, and the poles are bluntly pointed. Growth of many of the individuals of this species was quite irregular, and their form ratio varies considerably. The average length and width of 10 specimens are 4.2 mm and 1.5 mm respectively, giving a form ratio of 2.8. The proloculus, which is large for the size of the shell, averages 0.092 mm in outside diameter. The chambers increase irregularly in height toward the outer volutions. The earliest 3 or 4 volutions are tightly coiled; the later volutions are more loosely coiled.

The spirotheca is thin and is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The septa near the tunnel are thick and blunt due to the deposition of secondary material on them. The septa are folded throughout the length of the shell but this folding is very irregular and does not normally reach to the tops of the chambers. The tunnel is wide, especially in the outer volutions, and its path is normally straight. The chomata form massive ridges along either side of the tunnel and extend one-half to three-quarters the distance to the tops of the chambers.

Remarks.—*Fusulina leei* is distinguished by its small size, elongate shape, tight coiling of early volutions, irregular septal folding, and wide tunnel angle. Differentiation of this species from *F. rockymontana* Roth and Skinner is difficult. The principal differences appear to be the lower degree of septal folding of *F. rockymontana* and the tighter coiling in the early volutions of *F. leei*. *Fusulina leei* has a larger form ratio than does *F. kayi* Thompson.

Occurrence.—*Fusulina leei* occurs in the Tiawah member of the Scammon formation (localities 27 and 116), an unidentified limestone (locality 98), and the "Wheeler cap rock" (basal unit of the Bevier formation, locality 11), but is most common in the "Mineral cap rock" (basal unit of the Robinson Branch formation, locality 9), the "Fleming cap rock" (basal unit of the Croweburg formation, locality 112), and the Ardmore member of the Verdigris formation (localities 5, 24, 60, 89, 92, and 93). *Fusulina leei* has previously been reported from a marl immediately above the Bluejacket member of the Boggy formation, Oklahoma (Alexander, 1954); from a limestone 35 feet below the White Breast coal, Iowa (Thompson, 1934); from the Curlew member of the Spoon formation, Illinois (Dunbar and Henbest, 1942); and from the upper part of the Boggy formation, Oklahoma (Thompson, 1935).

Table 4

Average measurements from 10 specimens of *Fusulina leei*

Volutions	1	2	3	4	5	6	7
Height of Volutions (in mm)	.032	.040	.064	.093	.128	.150	.187
Form ratios	1.5	2.0	2.2	2.5	2.6	2.8	3.2
Thickness of Spirotheca (in mm)	.008	.007	.009	.009	.011	.012	....
Septal count	9	14	15	20	25	27	....
Tunnel Angle (in degrees)	18	21	23	25	28	28	....

FUSULINA(?) PROBLEMATICA Thompson

Pl. 2, fig. 1

Fusulina(?) problematica THOMPSON, 1934, Iowa Univ. Studies Nat. History, v. 16, p. 306-308, pl. 21, figs. 6, 9, 11, 16, and 17.

Description.—The shell of *Fusulina*(?) *problematica* Thompson is small and fusiform; the lateral slopes are convex and the poles pointed. The only specimen found is 2.8 mm in length and 1.3 mm in width, giving a form ratio of 2.2. The first volution of the specimen is coiled at an angle to the later volutions (asymmetrical coiling). The proloculus of this specimen is minute; 0.024 mm outside diameter. The early volutions are tightly coiled, but the shell begins to expand more rapidly after the fourth or fifth volution.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The spirotheca is very thin and is measurable on only two volutions. The septa are irregularly but moderately folded throughout the shell; the folds do not reach the tops of the chambers. The tunnel is narrow throughout growth, but the tunnel angle becomes smaller at the later stages. The tunnel path is irregular due to the asymmetrical coiling of the first volution. The chomata are massive and reach the height of the chambers adjacent to the tunnel. A short distance from the tunnel, the chomata abruptly taper off and then form on the floors of the chambers thick deposits which are maintained into the poles.

Remarks.—*Fusulina*(?) *problematica* is distinguished by its small size, its broad, irregularly folded septa, its minute proloculus, and its asymmetrically-coiled early volutions. This species is slightly smaller and has more massive chomata and a smaller proloculus than does *F. leei* Skinner; in addition, the early volutions of *F. leei* are symmetrical. *Fusulina*(?) *problematica* closely resembles *F. cadyi* (Dunbar and Henbest) but is smaller, more elongate, and has less highly folded septa and larger tunnel angles.

This species was found with numerous specimens of *Fusulina leei.* Thompson (1934, p. 308) mentions the possibility that *F.*(?) *problematica* may be a microspheric form of the more common species *F. leei.* The very small proloculus and the scarcity of *F.*(?) *problematica* in comparison with the large numbers of specimens of its so-called megalospheric counterpart, *F. leei,* are support for this supposition. It is preferable, however, to maintain the two species even though they may well be dimorphic forms of a single species.

Occurrence.—*Fusulina*(?) *problematica* occurs in the Tiawah member of the Scammon formation (locality 116). This species has previously been reported from a thin limestone about 35 feet below the White Breast coal, Iowa (Thompson, 1934).

Table 5

Measurements from one specimen of *Fusulina* (?) *problematica*

Volutions	1	2	3	4	5	6	7
Height of Volutions (in mm)	.032	.032	.051	.083	.083	.138	.154
Form ratios	1.4	1.5	1.4	1.9	1.7	2.2	2.2
Thickness of Spirotheca (in mm)	....	....	.007	....	.012	....	....
Tunnel Angle (in degrees)	....	34	24	22	20	19	20

FUSULINA sp. aff. F. KAYI Thompson

Pl. 2, figs. 5-7

Fusulina kayi THOMPSON, 1934, Iowa Univ. Studies Nat. History, v. 16, p. 303-305, pl. 21, figs. 1, 2, 4, 5, 8, 12-15, 19, 20.

Description.—In the "Mineral cap rock" (basal unit of the Robinson Branch formation) at locality 9, associated with the abundant *Fusulina leei* Skinner are a few specimens which are here referred to *Fusulina* sp. aff. *F. kayi.* The average length and width are 2.2 and 1.2 mm respectively, giving a form ratio of 1.8. These specimens resemble *F. kayi* Thompson in having moderately high, uniform septal folds, a short, blunt shape, and massive chomata. *Fusulina* sp. aff. *F. kayi,* however, is considerably smaller than the specimens of *F. kayi* illustrated by Thompson and, in addition, is shorter, has more uniformly folded septa, and is more loosely coiled in early volutions.

FUSULINA CADYI (Dunbar and Henbest)

Pl. 2, figs 2-4

Fusulinella cadyi DUNBAR AND HENBEST, 1942, Illinois Geol. Survey, Bull. 67, p. 96-98, pl. 4, figs. 20-28.

Description.—The shell of *Fusulina cadyi* (Dunbar and Henbest) is small and inflated fusiform; the lateral slopes are slightly concave and the poles, sharply pointed. Immature specimens are more elongate than mature specimens. The average length and width of 5 specimens are 2.5 mm and 1.3 mm respectively, giving a form ratio of 1.9. The spherical proloculus is minute; the average outside diameter is 0.022 mm. The axis of coiling of the first volution of all specimens is at a considerable angle to the axes of the later volutions (asymmetrical coiling). The chambers increase in height rapidly.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The tectum and diaphanotheca are not recognizable in the earlier volutions. The septa are irregularly and broadly folded throughout the length of the shell. The septal folds reach almost to the tops of the chambers, even in the tunnel region. The tunnel is narrow, and its path is irregular. The chomata form high, heavy ridges on either side of the tunnel; these chomata vary in size from ridges which are rather narrow to massive deposits which almost fill the chambers and which extend two-thirds the distance to the poles.

Remarks.—Although this species has in the past been referred to the genus *Fusulinella*, it is here assigned to the genus *Fusulina* because of its moderately high folded septa which are somewhat hidden by the secondary deposits.

Fusulina cadyi is distinguished by its inflated fusiform shape, its asymmetrically coiled early volutions, its minute proloculus, its narrow tunnel, and its broadly and moderately high folded septa. This species closely resembles *Fusulinella iowensis* Thompson in size, general shape, and development of heavy chomata. *Fusulina cadyi*, however, has much more highly folded septa and heavier secondary deposits than does *Fusulinella iowensis*. *Fusulina cadyi* is much more highly inflated than *F.*(?) *problematica* Thompson and has a more irregular tunnel path, lighter secondary deposits, and more highly folded septa than does *F. marmatonensis*, n. sp.

The sparse specimens of *F. cadyi* occur with numerous specimens of *F. euryteines* Thompson.

Table 6

Average measurements from 5 specimens of *Fusulina cadyi*

Volutions	1	2	3	4	5	6	7	8	9
Height of Volutions (in mm)	.030	.028	.031	.050	.075	.104	.124	.136	.160
Form ratios	0.6	1.1	1.4	1.6	1.8	1.9	1.7	1.8	1.7
Thickness of Spirotheca (in mm)	....	....	.008	.011	.009	.011	.013	.015	.014
Tunnel Angle (in degrees)	....	....	15	17	16	15	15	16	....

Occurrence.—*Fusulina cadyi* is present but not common in the Ardmore member of the Verdigris formation (localities 30 and 89) in the unidentified limestone (locality 98), and the Houx(?) member of, the Little Osage formation (locality 99). *F. cadyi* has previously been reported from the St. David member of the Carbondale formation, Illinois (Dunbar and Henbest, 1942), and from the Hartville formation, Wyoming (Henbest, 1953).

FUSULINA BOONENSIS, n. sp.

Pl. 3, figs. 1-8

Description.—The shell of *Fusulina boonensis* is small and elongate fusiform to subcylindrical; the lateral slopes are plane to broadly convex, and the poles are bluntly rounded throughout growth. The average length and width of 10 specimens are 3.8 mm and 1.3 mm respectively, giving a form ratio of 2.9. The shell attains its characteristic shape as early as the second or third volution and maintains this shape throughout the remainder of growth. The proloculus is small and spherical to subspherical in shape; the average outside diameter of the proloculus is 0.074 mm.

The spirotheca is thin and is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium; the wall structure, however, is not well preserved in the first 3 or 4 volutions. The septa are short and closely spaced. The uniformly folded septa are low and extend only one-third to one-half the height of the chambers in the central portion of the shell. The tunnel is straight and well defined, and the tunnel angle increases rapidly but uniformly. The chomata form high, steep-sided ridges which are only slightly asymmetrical, being steeper toward the tunnel. The chomata extend to approximately half the height of the chambers in the early volutions but form very low, narrow ridges in the outer volutions.

Remarks.—*Fusulina boonensis* is distinguished by its small size, its elongate fusiform to subcylindrical shape, its low but very uniform septal folding, and its wide tunnel angle. *Fusulina boonensis* is distinguished from *F. higginsvillensis*, n. sp., by having a larger form ratio, larger tunnel angle, and lower, broader septal folding. *Fusulina boonensis* is apparently closely related to *F.*(?) *arenaria* Thompson which it resembles in gross appearance. Closer inspection reveals that specimens of *F. boonensis* have a much smaller form ratio, have higher, more uniformly folded septa, and are generally smaller in size. The later volutions of *F.*(?) *arenaria* contain septal folds which resemble those of the early volutions of *F. boonensis* in intensity.

Occurrence.—*Fusulina boonensis* occurs in the Ardmore member of the Verdigris formation (locality 15), the Breezy Hill member of the Mulky formation (localities 26, 29, and 31), the Blackjack Creek formation of the Fort Scott subgroup (localities 10 and 13), and the Houx member of the Little Osage formation of the Fort Scott subgroup (locality 91). Locality 91 is the type locality of *F. boonensis.*

Table 7

Measurements from 10 specimens of *Fusulina boonensis*, n. sp.

Specimen 1 is the holotype

Specimen	Loc.	Strat. Position	L. (mm)	W. (mm)	Ratio	Vols.	Diam. Prol. (mm)
1	91	Houx mbr.	3.9	1.3	3.0	8	.067
2	91	Houx mbr.	4.6	1.3	3.5	8½	.069
3	91	Houx mbr.	2.4	1.3	1.9	9	.061
4	91	Houx mbr.	3.6	1.3	2.8	8	.077
5	15	Ardmore mbr.	5.9	1.7	3.5	9½	. . .
6	15	Ardmore mbr.	3.5	1.2	2.9	6½	.096
7	31	Breezy Hill mbr.	3.5	1.4	2.6	7	.077
8	31	Breezy Hill mbr.	. . .	0.9	. . .	4	.098
9	10	Blackjack Cr. fm.	3.3	1.2	2.8	7½	.072
10	10	Blackjack Cr. fm.	. . .	1.4	. . .	8	.053
Average			3.9	1.3	2.9	7½	.074

Height of volutions (in mm)

Specimen	1	2	3	4	5	6	7	8	9
1	.032	.032	.048	.072	.080	.096	.144	.160	. . .
2	.018	.018	.029	.045	.083	.085	.144	.122	. . .
3	.028	.024	.021	.048	.059	.093	.109	.136	.152
4	.024	.029	.040	.059	.072	.093	.138	.167	. . .
5	.032	.032	.037	.040	.064	.085	.114	.122	.160
6	.029	.035	.056	.077	.104	.117	. . .	. . .	. . .
7	.018	.029	.059	.085	.098	.138	.133	. . .	. . .
8	.045	.056	.085	.109	. . .	. . .	. . .	. . .	. . .
9	.027	.027	.048	.067	.083	.117	.117	.109	. . .
10	.027	.029	.045	.064	.093	.104	.133	.144	. . .
Average	.028	.031	.047	.067	.081	.103	.103	.137	.156

Form ratio of volutions

Specimen	1	2	3	4	5	6	7	8
1	1.1	1.9	2.7	3.5	3.8	3.5	3.3	3.0
2	1.0	1.6	2.3	2.4	3.2	3.3	3.5	3.4
3	0.8	1.3	2.2	2.4	2.3	2.6	2.6	1.9
4	1.8	2.7	2.8	3.0	2.7	3.0	2.4	2.8
5	1.2	1.6	2.7	3.0	2.9	3.5	3.5	3.4
6	1.3	2.3	3.1	3.4	3.3	3.4	. . .	. . .
7	1.4	1.9	2.4	3.2	3.1	3.4	. . .	. . .
8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
9	1.8	3.1	2.9	4.0	3.5	4.4	. . .	. . .
10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Average	1.3	2.1	2.6	3.1	3.1	3.4	3.1	2.9

Table 7 continued

Thickness of spirotheca (in mm)

Speci-men	Prol.	1	2	3	4	5	6	7	8
1	...	...	...	...	.007	.008	.011	.012	...
2	...	...	...	...	.008	.013	.013	.019	.015
3	...	...	...	...	.009	.008	...	.010	.011
4	...	...	...	...	.009	.012	.014	.013	.017
5	...	...	...	.015	...	.014	.016	.015	.019
6	...	...	...	.015	.010	.014	...	...	...
7	.008	...	...	...	.009	.014	.013	...	...
8	.027	...	...	.027	.024	...	...	...	...
9	.012	...	...	.010	...	.015	.013	.012	...
10	.012	...	...	...	...	...	.011	...	...
Average	.014	...	...	.016	.010	.012	.013	.013	.015

Septal count

Speci-men	1	2	3	4	5	6	7
8	8	10	13	20	..	..	..
10	8	9	12	16	19	24	27
Average	8	9	12	18	19	24	27

Tunnel angle (in degrees)

Speci-men	1	2	3	4	5	6	7	8
1	17	32	33	44	43	38	60	..
2	18	31	30	27	43	42	48	..
3	..	23	23	26	26	30	32	32
4	..	34	34	36	42	40	44	..
5	..	16	27	28	38	35	39	40
6	29	30	36	45	48	..	..	..
7	29	27	29	28	33	50	..	..
8	..	..	..	..	..	..	..	..
9	..	23	25	32	27	33	32	..
10	..	..	..	..	..	..	..	..
Average	23	27	29	33	37	38	42	36

FUSULINA OCCULTIFONS Alexander

Pl. 4, figs. 1-6

Fusulina occultifons **ALEXANDER, 1954, Oklahoma Geol. Survey Circ. 31, p. 40, 41, pl. 4, figs. 1-4.**

Description.—The shell of *Fusulina occultifons* Alexander is moderately large and is inflated fusiform to subspherical; the lateral slopes are plane to strongly convex and the poles are bluntly pointed. The average length and width of five specimens are 4.2 mm and 3.0 mm respectively, giving a form ratio of 1.4. The spherical proloculus is typically minute but in some specimens is quite large; the average outside diameter is 0.123 mm. The chambers increase very rapidly in height during growth of the shell, thus, accounting for the spherical shape.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The spirotheca is relatively thin. The septa are long and moderately thick in the region of the tunnel. Neighboring septa often converge upon one another thus indicating that the folding is intense, even over the tunnel. The tunnel is very narrow throughout the shell and is commonly difficult to locate because of the intensity of septal folding. The chomata vary from low, indistinct mounds to very high, narrow ridges. It is probable that the secondary material which is normally deposited as chomata accumulated on the bordering septa instead.

Remarks.—*Fusulina occultifons* is distinguished by its inflated fusiform to subspherical shape, intense septal folding, normally small proloculus, and indistinct chomata. The specimens which are here referred to *F. occultifons* compare very closely with the types illustrated by Alexander (1954, pl. 4, figs. 1-4) except that in the forms included here the proloculus is considerably larger. *Fusulina occultifons*, although similar in shape to *F. girtyi*, has less distinct chomata and epithecal deposits and has more intensely folded septa.

Occurrence.—*Fusulina occultifons* is abundant in the Blackjack Creek formation of the Fort Scott subgroup at locality 10, but it has not been found in any other Missouri locality. The type specimens are from the upper Fort Scott formation, Oklahoma (Alexander, 1954).

Table 8

Average measurements from 5 specimens of *Fusulina occultifons*

Volutions	1	2	3	4	5	6	7	8
Height of Volutions (in mm)	.044	.073	.132	.190	.238	.243	.292	.283
Form ratios	1.5	1.9	1.9	1.8	1.6	1.5	1.4	1.3
Thickness of Spirotheca (in mm)	.005	.016	.013	.017	.017	.018	.022	.020
Septal count	9	16	20	27	36	43	..	..
Tunnel Angle (in degrees)	19	20	18	16	14	17	18	..

FUSULINA HIGGINSVILLENSIS, n. sp.

Pl. 4, figs. 7-15

Description.—The shell of *Fusulina higginsvillensis* is small and ellipsoidal; the lateral slopes are strongly convex and the poles are bluntly pointed. The early volutions are elongate with more sharply pointed poles. The uniform development of the shell of *F. higginsvillensis* is noteworthy, and as a result of this uniformity the form ratios are quite constant after the second volution. The average length and width of 9 specimens are 2.2 mm and 1.0 mm respectively, giving a form ratio of 2.2. The proloculus is minute and is spherical to subspherical in shape; the average outside diameter of 9 specimens is 0.061 mm.

The spirotheca is thin and is composed of four layers; the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. Septal folding is irregular but intense, the folds reaching about half the height of the chambers. The tunnel is straight and in most specimens is well defined. The tunnel angle is moderately large but increases at a relatively slow rate. The chomata form high, narrow, steep-sided, slightly asymmetrical ridges which extend about half the distance to the tops of the chambers.

Remarks.—*Fusulina higginsvillensis* is distinguished by its rather small size, ellipsoidal shape, intense, but irregular septal folding, and low form ratio. This species is smaller, has a smaller form ratio, and has less intense but more irregular septal folding than does *F. boonensis*, n. sp. It has a much smaller form ratio, is considerably smaller, and has a smaller tunnel angle than does *F.* (?) *arenaria* Thompson although the septal folding of the two species is somewhat similar. *Fusulina higginsvillensis* more closely resembles *F.* (?) *rickerensis* Thompson than any other species. The ellipsoidal shape, the small size, the minute proloculus, and the moderate tunnel angle are similar in the two species; the septal folding of *F. higginsvillensis*, however, is much more intense than that of *F.* (?) *rickerensis*.

Occurrence.—*Fusulina higginsvillensis* is present in the Blackjack Creek formation of the Fort Scott subgroup (localities 10 and 13) and in the Labette formation (locality 52) but is most common in the Higginsville formation of the Fort Scott subgroup (localities 2, 41, 43, and 61). Locality 41 is the type locality of *F. higginsvillensis*.

Table 9

Measurements from 9 specimens of *Fusulina higginsvillensis*, n. sp.

Specimen 8 is the holotype

Specimen	Loc.	Strat. Position	L. (mm)	W. (mm)	Ratio	Vols.	Diam. Prol. (mm)
1	43	Higginsville fm.	2.6	1.3	2.0	8	.059
2	43	Higginsville fm.	...	1.2	...	6	.075
3	2	Higginsville fm.	1.8	1.0	1.8	6	.061
4	2	Higginsville fm.	...	1.0	...	6½	.064
5	52	Labette fm.	2.1	1.2	1.8	7½	.067
6	52	Labette fm.	2.1	1.1	1.9	6½	.069
7	52	Labette fm.	...	1.2	...	6	.090
8	41	Higginsville fm.	2.6	1.3	2.0	7	.059
9	41	Higginsville fm.	...	1.0	...	6	.069
Average			2.2	1.0	2.2	6½	.061

Table 9 continued

Height of volutions (in mm)

Specimen	1	2	3	4	5	6	7	8
1	.027	.032	.048	.059	.067	.112	.149	.141
2	.037	.040	.053	.077	.117	.146	...	...
3	.037	.035	.067	.093	.122	...	...	...
4	.027	.029	.053	.083	.112	.120	...	...
5	.035	.037	.040	.075	.104	.125	.144	...
6	.029	.043	.077	.117	.120	.117	...	...
7	.043	.040	.059	.064	.101	.106	...	...
8	.027	.029	.053	.075	.104	.133	.154	...
9	.027	.029	.077	.072	.098	.120	...	...
Average	.032	.034	.058	.079	.105	.122	.149	.141

Form ratio of volutions

Specimen	1	2	3	4	5	6	7	8
1	1.1	1.2	1.7	2.0	2.3	2.1	1.9	2.0
2	...	...	...	...	...	...	...	...
3	1.3	1.5	1.9	2.5	2.1	...	...	...
4	...	...	...	...	...	...	...	...
5	0.8	1.2	1.5	1.9	1.8	1.9	1.8	...
6	1.2	1.7	2.1	2.1	2.0	...	...	...
7	...	...	...	...	...	...	...	...
8	1.1	1.6	1.9	1.9	2.2	2.1	2.0	...
9	...	...	...	...	...	...	...	...
Average	1.1	1.4	1.8	2.0	2.0	2.0	1.9	2.0

Thickness of spirotheca (in mm)

Specimen	Prol.	1	2	3	4	5	6	7
1	.011	...	...	.005	.014	.017	.018	.021
2	.008	...	.009	.012	.008	.017	.022	...
3	.013	...	...	.010	.013	.018	...	...
4	.012	...	...	...	.020	...	...	...
5	...	...	...	.015	.016	.017	.020	...
6	.011	...	...	...	.014	.020	.017	...
7	.011	...	...	.009	.008	.013	.010	...
8	...	...	.007	.007	.010	.014	.018	.015
9	.009	...	...	.007	.012	...	...	...
Average	.011	...	.008	.009	.012	.016	.017	.018

Table 9 continued

Septal count

Speci-men	1	2	3	4	5	6
1	..	..	..	..	..	..
2	6	11	14	17	21	23
3	..	..	..	..	..	..
4	8	10	11	15	18	..
5	..	..	..	..	..	..
6	..	..	..	..	..	..
7	8	12	16	21	25	32
8	..	..	..	..	..	..
9	..	12	14	17	21	24
Average	7	11	13	17	21	26

Tunnel angle (in degrees)

Speci-men	1	2	3	4	5	6	7
1	..	20	23	24	26	24	28
2	..	..	..	..	..	..	..
3	..	24	26	31	32	..	..
4	..	..	..	..	..	..	..
5	18	24	21	22	24	..	..
6	26	23	22	28	..	..	..
7	..	..	..	..	..	..	..
8	..	26	23	24	33	28	..
9	..	..	..	..	..	..	..
Average	22	23	23	25	28	26	28

FUSULINA MARMATONENSIS, n. sp.

Pl. 5, figs. 6-16

Description.—The shell of *Fusulina marmatonensis* is of medium size and is highly inflated; the lateral slopes are plane to slightly concave and the poles are sharply pointed. Specimens of this species attain their characteristic inflated shape after the first to second volution. The average length and width of 8 specimens are 3.4 mm and 2.1 mm respectively, giving a form ratio of 1.6. The proloculus is minute and spherical; the average outside diameter is 0.032 mm. The first volution is coiled on an axis which is at a considerable angle to that of the remainder of the shell. The chambers increase in height very uniformly.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The tectum and the diaphanotheca are not recognizable in the first 4 or 5 volutions of any specimen. The septa are loosely and broadly folded throughout the shell. The folds commonly reach from one-half to three-quarters the height of the chambers. The tunnel is very narrow and increases in width very slowly at successive growth stages. The chomata are massive and often extend to the tops of the chambers, particularly in the earlier volutions. These chomata maintain their height approximately one-quarter of the distance to the poles, then they abruptly taper off to a rather thick film which lines the chamber floors in the poles. Axial deposits are not present.

Remarks.—*Fusulina marmatonensis* is distinguished by its inflated fusiform shape, asymmetrical coiling of the first volution, small proloculus, massive chomata, and broad, irregular septal folding. This species is somewhat similar to *F. cadyi* (Dunbar and Henbest) but differs in being more highly inflated and in having a straighter tunnel, less highly folded septa, and much more massive chomata. *Fusulina marmatonensis* is larger and more highly inflated and has more massive chomata than does *F.* (?) *problematica* Thompson.

Occurrence.—*Fusulina marmatonensis* is present in the Blackjack Creek formation (locality 10), the Houx member of the Little Osage formation (localities 96 and 105), and Higginsville formation (localities 13, 17, 39, 41, and 91) of the Fort Scott subgroup; the Myrick Station (localities 43, 53, 56, 91, and 114) and Coal City (localities 52 and 82) members of the Pawnee formation; and the Worland member of the Altmont formation (localties 56, 62, 74, 76, and 86). Locality 43 is the type locality.

Table 10

Measurements from 9 specimens of *Fusulina marmatonensis*, n. sp.

Specimen 1 is the holotype

Specimen	Loc.	Strat. Position	L. (mm)	W. (mm)	Ratio	Vols.	Diam. Prol. (mm)
1	43	Myrick Sta. mbr.	4.5	2.6	1.7	11	.056
2	39	Higginsville fm.	4.0	2.2	1.8	10½	. . .
3	39	Higginsville fm.	1.9	1.5	1.3	8½	. . .
4	41	Higginsville fm.	2.8	2.0	1.4	10	.030
5	91	Higginsville fm.	2.2	1.6	1.4	9½	.021
6	17	Higginsville fm.	3.2	2.0	1.6	10	. . .
7	13	Higginsville fm.	3.5	2.4	1.5	9½	.032
8	13	Higginsville fm.	4.8	2.4	2.0	11	. . .
Average			3.4	2.1	1.6	10	.032

Height of volutions (in mm)

Specimen	1	2	3	4	5	6	7	8	9	10	11
1	. . .	.043	.045	.061	.090	.114	.128	.152	.144	.242	.276
2	. . .	.029	.051	.059	.077	.133	.141	.144	.168	. . .	. . .
3	. . .	.029	.021	.043	.069	.104	.125	.133	.168	. . .	. . .
4	. . .	.029	.051	.067	.077	.114	.130	.160	.184	.181	. . .
5	. . .	.051	.037	.061	.075	.093	.122	.162	.176	. . .	. . .
6	. . .	.037	.048	.059	.088	.098	.125	.138	.181	.218	. . .
7	.029	.032	.051	.067	.109	.133	.136	.189	.229	. . .	. . .
8	. . .	.035	.032	.048	.064	.093	.149	.146	.162	.202	.270
Average	.029	.035	.042	.058	.081	.110	.132	.153	.176	.210	.273

Table 10 continued

Form ratio of volutions

Speci-men	1	2	3	4	5	6	7	8	9	10
1	0.5	1.4	1.7	1.7	1.8	1.7	1.8	1.9	1.9	1.9
2	...	1.1	1.5	2.2	2.2	2.1	2.0	1.8	1.8	...
3	...	1.1	1.3	1.7	2.0	1.7	1.5	1.3	...	...
4	0.5	1.4	1.8	1.6	1.7	1.7	1.5	1.5	1.5	1.4
5	0.5	1.2	1.2	1.4	1.5	1.8	2.0	1.8	...	...
6	...	1.3	1.4	1.8	2.0	2.0	2.0	2.0	1.7	...
7	1.2	2.0	2.2	2.1	2.1	2.0	1.6	1.9	...	...
8	1.0	1.4	1.6	1.8	2.3	2.0	1.9	2.0	2.1	...
Average	0.7	1.3	1.5	1.7	1.9	1.8	1.7	1.7	1.8	1.6

Thickness of spirotheca (in mm)

Speci-men	1	2	3	4	5	6	7	8	9	10
1	...	...	...	...	.010	.012	...	.015	.012	.015
2	...	...	...	...	.010	.016	.013	...	...	...
3	...	.010	.008	.008	...	.010	.013	.013	...	...
4	...	...	...	...	.007	.008	.014	.018	.015	...
5	...	...	...	...	.007	.012	.013	.016	.020	...
6	...	...	...	.012	...	.010	.017	.015	.020	.020
7	...	...	.005	...	...	...	...	...	...	...
8	...	...	...	...	...	...	...	.022	.016	.019
Average	...	.010	.006	.010	.008	.011	.014	.016	.016	.018

Septal count

Speci-men	Loc.	Strat. Position	1	2	3	4	5	6
9	10	Blackjack Creek fm.	10	..	..	25	34	36

Tunnel angle (in degrees)

Speci-men	1	2	3	4	5	6	7	8	9	10
1	..	10	17	19	16	13	13	15	12	16
2	..	22	19	14	12	12	13	12	14	..
3	..	..	17	12	17	11	14	14	..	..
4	..	19	11	13	12	9	10	15	16	..
5	..	12	15	13	12	11	12	15	..	..
6	..	25	15	14	16	12	10	15	16	..
7	..	20	17	13	13	15	12	..	..	..
8	..	26	27	12	17	11	15	17	17	24
Average	..	19	17	13	14	11	12	14	15	20

FUSULINA LUCASENSIS Thompson

Pl. 5, figs. 17-20

Fusulina lucasensis THOMPSON, 1934, Iowa Univ. Studies Nat. History, v. 16, p. 309, 310, pl. 22, figs. 2, 9, 12, 17, and 19.

Description.—*Fusulina lucasensis* Thompson is extremely small and is fusiform to elongate fusiform. The lateral slopes are slightly convex and the poles are pointed; the outer volutions, however, are commonly abraded and the true shape lost. The mature shape is reached after the first or second volution, and after this the form ratio changes very little. The average length and width of 10 specimens are 3.6 mm and 1.3 mm respectively, giving a form ratio of 2.8. The proloculus is minute and spherical to subspherical in shape; the average outside diameter is 0.085 mm. The chambers increase in height very rapidly due to the abrupt expansion of the shell in early volutions.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The spirotheca is thick relative to the small size of the shell. The septa are short, thick, closely spaced, and are loosely but intensely folded; the folds reach almost the entire height of the chambers from pole to pole. The tunnel increases in width in a uniform manner during growth of the shell but always remains narrow. The chomata are high, narrow, and irregular in shape except in the outer volutions where they are very low and broad.

Remarks.—*Fusulina lucasensis* is distinguished by its small size, loose coiling, narrow tunnel, high but loosely folded septa, and relatively thick spirotheca. It somewhat resembles *F. truncatulina* Thompson but is distinguished from that species by its slightly larger size, more intense and uniform septal folding, looser coiling, and smaller proloculus. *Fusulina lucasensis* is smaller and has a smaller form ratio and narrower tunnel than *F. leei* Skinner; it also lacks the tightly coiled early volutions which are so diagnostic of *F. leei.* Immature specimens of *F. haworthi* (Beede) may be confused with *F. lucasensis* but they have a much larger proloculus and are much more tightly coiled at early stages than is *F. lucasensis. Fusulina lucasensis* is very similar to *F. kayi* Thompson but, according to Thompson (1934, p. 310), it has a smaller proloculus, larger tunnel angle, and thicker diaphanotheca than *F. kayi.*

Occurrence.—*Fusulina lucasensis* occurs sparsely in the Blackjack Creek formation (localities 52 and 63) and the Houx member of the Little Osage formation of the Fort Scott subgroup (locality 96), but is most diagnostic and very abundant in the upper few feet of the Higginsville formation of the subgroup (localities 52, 61, 67, 72, 75, and 91). The uppermost part of the Higginsville is commonly oolitic, and the specimens of *F. lucasensis* are abraded. *Fusulina lucasensis* has previously been reported from a limestone 10 feet below the Mystic coal (St. David equivalent), Iowa (Thompson, 1934); from the

St. David member of the Carbondale formation, Illinois (Dunbar and Henbest, 1942); and from one locality of the Brereton member of the Carbondale formation, Illinois (Dunbar and Henbest, 1942).

Table 11

Average measurements from 10 specimens of *Fusulina lucasensis*

Volutions	1	2	3	4	5	6	7
Height of Volutions (in mm)	.032	.044	.069	.103	.141	.170	.192
Form ratios	1.2	1.7	1.9	2.1	2.1	2.6	2.5
Thickness of Spirotheca (in mm)	.005	.012	.013	.015	.017	.021	. .
Septal count	8	13	20	23	28	32	26
Tunnel Angle (in degrees)	18	21	24	29	27	30	. .

FUSULINA KNIGHTI Dunbar and Henbest

Pl. 5, figs. 1-5

Fusulina knighti DUNBAR AND HENBEST, 1942, Illinois Geol. Survey Bull. 67, p. 112, 113, pl. 6, figs. 14-21.

Description.—*Fusulina knighti* Dunbar and Henbest is small and elongate fusiform with sharply pointed poles; the lateral slopes are plane to slightly convex. The outer volution is often crushed, making the specimen appear longer than normal. The first few volutions are tightly coiled, but rapid expansion occurs at approximately the fourth or fifth volution. The average length and width of 10 specimens are 3.8 mm and 1.3 mm respectively, giving a form ratio of 2.9. The proloculus is spherical and moderate in size; the average diameter is 0.109 mm. The chambers increase in height very slowly for the first 4 to 5 volutions, then increase abruptly.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. Dunbar and Henbest (1942, p. 112-113) reported the spirotheca to be as thick, as 0.035 mm. They included, however, the upper and lower tectoria in their measurements; in the present study, only the tectum and the diaphanotheca are included. The septa are rather thin and closely spaced and are intensely folded throughout the shell; the high folds are closely spaced from pole to pole. The tunnel angle is large but increases irregularly throughout growth of the shell. The chomata are commonly very low indistinct ridges which are sometimes difficult to identify. Axial filling is heavy in some specimens, but it does not extend into the polar region.

Remarks.—*Fusulina knighti* is distinguished by its small size, its high, closely packed septal folds, and its elongate shape. It is smaller and more elongate than *F. haworthi* (Beede), and it is very similar in size and shape to *F. leei* Skinner and *F. lucasensis* Thompson but has more intensely folded septa than either.

Occurrence.—*Fusulina knighti* is not abundant in any of the collections studied. It has been identified, however, from the Blackjack Creek (localities 25, 39, and 44) and Higginsville (localities 18 and 61) formations of the Fort Scott subgroup, and the Myrick Station (locality 42) and Coal City (locality 78) members of the Pawnee formation. *Fusulina knighti* has previously been described from the Higginsville formation, St. Louis, Missouri, and from the Bankston Fork member of the Carbondale formation, Illinois (Dunbar and Henbest, 1942).

Table 12

Average measurements from 10 specimens of *Fusulina knighti*

Volutions	1	2	3	4	5	6	7
Height of Volutions (in mm)	.034	.043	.062	.095	.135	.170	.165
Form ratios	1.2	1.7	2.1	2.5	2.9	2.9	...
Thickness of Spirotheca (in mm)	.011	.008	.012	.013	.014	.016	...
Septal count	10	15	17	21	23	23	...
Tunnel Angle (in degrees)	17	23	25	31	34	30	...

Fusulina haworthi (Beede)
emend. Dunbar and Henbest, 1942

Pl. 6, figs. 1-13

Girtyina haworthi Beede, 1916, Indiana Univ. Studies, v. 3, p. 14.
Fusulina haworthi (Beede). Dunbar and Henbest, 1942, Illinois Geol. Survey Bull. 67, p. 119-121, pl. 12, fig. 1; pl. 14, figs. 1-18.
Fusulina stookeyi Thompson, 1934, Iowa Univ. Studies Nat. History, v. 16, p. 316-318, pl. 22, figs. 3, 15, 16, and 21.
Fusulina illinoisensis Dunbar and Henbest, 1942, (in part), Illinois Geol. Survey Bull. 67, p. 118-119, pl. 11, figs. 26-30; pl. 13, figs. 1, 2.

Description.—*Fusulina haworthi* (Beede) is moderately large and elongate fusiform to inflated fusiform; the lateral slopes vary from slightly convex to slightly concave and the poles are bluntly pointed. The average length and width of 10 specimens are 5.6 mm and 2.7 mm respectively, giving a form ratio of 2.1. The proloculus is large and spherical to subspherical in shape; the average outside diameter is 0.180 mm. The shell increases in size slowly but uniformly.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The spirotheca is thin relative to the large size of the shell. The septa are closely spaced and are long and thin in the tunnel region. The septal folds are narrow, closely spaced, and commonly extend to the top of the chambers. The tunnel is narrow and is often indistinct because of the intensity of the septal folding. The chomata of this species are situated on the highly folded septa and, thus, do not form distinct ridges.

Remarks.—*Fusulina haworthi* is distinguished by its moderately large size, large proloculus, narrow, high septal folds, and narrow tunnel angle. *Fusulina haworthi* has a larger form ratio, a larger tunnel angle, and lighter epithecal deposits than does *F. girtyi* (Dunbar and Condra); there appears, however, to be a complete series of gradational forms between these two species. Dunbar and Henbest (1942, p. 118) proposed the species *F. illinoisensis* to include forms which they recognized as intermediate in development between *F. haworthi* and *F. girtyi*. Because it is so difficult to identify and its recognition does not enhance the stratigraphic value of the species involved, *F. illinoisensis* is not recognized here. *Fusulina haworthi* is similar in size and shape to *F. euryteines* Thompson, but specimens of the former are much more intensely folded, have less distinct chomata, and larger proloculi.

Occurrence.—Specimens of *Fusulina haworthi* are abundant in the Blackjack Creek (localities 2, 25, 29, 31, 39, 44, 52, and 88b) and Higginsville (localities 2, 13, 17a, 18, 25, 37, 39, 43, 61, and 91) formations of the Fort Scott subgroup, the Myrick Station (localities 17a, 42, 43, 52, 53, and 114) and Coal City (localities 53, 56, and 82) members of the Pawnee formation, the Worland member of the Altamont formation (localities 36, 52, 76, and 86), and the Lake Neosho member of the Altamont formation (locality 74). *Fusulina haworthi* has previously been reported from the lower Fort Scott formation, Kansas (Beede, 1916); from the upper Millsap Lake formation, Texas (White, 1932); from a limestone 18 feet above the Mystic coal, Iowa (Thompson, 1934); from the lower Fort Scott formation (Blackjack Creek member), Oklahoma (Alexander, 1954); and from the St. David and Brereton members of the Carbondale formation, Illinois (Dunbar and Henbest, 1942).

Table 13

Average measurements from 10 specimens of *Fusulina haworthi*

Volutions	1	2	3	4	5	6	7	8
Height of Volutions (in mm)	.051	.073	.103	.134	.171	.196	.216	.196
Form ratio	1.7	2.1	2.2	2.3	2.3	2.3	2.3	2.2
Thickness of Spirotheca (in mm)	.011	.011	.011	.013	.015	.018	.019	..
Septal count	13	23	26	36	38	..	..	..
Tunnel Angle (in degrees)	17	17	19	20	21	24	24	..

FUSULINA GIRTYI (Dunbar and Condra)

Pl. 7, figs. 1-8

Fusulina ventricosa MEEK AND WORTHEN (not *Fusulina ventricosa* MEEK AND HAYDEN, 1858), 1873, Illinois Geol. Survey, v. 5, p. 560, pl. 24, figs. 8a and 8b.

Girtyina ventricosa (Meek and Worthen). STAFF, 1912, Palaeontographica, Band 59, p. 164, 165, pl. 18, figs. 2, 5, and 7.

Girtyina ventricosa (Meek and Worthen). CADY, 1925, Illinois Geol. Survey Rept. Inv. no. 2, p. 8, text-fig. 2, A and B.

Fusulinella girtyi DUNBAR AND CONDRA, 1927, Nebraska Geol. Survey, 2nd ser., Bull. 2, p. 76-78, pl. 2, figs. 1-4.

Fusulinella (Girtyina) ventricosa (Meek and Worthen). HENBEST, 1928, Jour. Paleontology, v. 2, p. 83, pl. 9, figs. 3, 4, and 6. (Not pl. 10, figs. 1, 5-7.)

Beedeine girtyi GALLOWAY, 1933, A manual of Foraminifera, p. 401, 402, pl. 36, figs. 1-7.

Fusulina girtyi (Dunbar and Condra). THOMPSON, 1934, Iowa Univ. Studies Nat. History, v. 16, p. 314-316, pl. 22, figs. 1, 5, 7, and 20.

Description.—The shell of *Fusulina girtyi* (Dunbar and Condra) is of medium size and inflated fusiform in shape; the lateral slopes are plane to slightly concave and the poles bluntly pointed. The characteristic inflated fusiform shape is present in the earliest volutions. The average length and width of 10 specimens are 4.2 mm and 2.6 mm respectively, giving a form ratio of 1.6. The proloculus is moderately large and spherical; the average outside diameter is 0.158 mm. The chambers increase slowly but uniformly.

The spirotheca, which is thin for the size of the shell, is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The short, closely spaced septa are thick due to the deposition of secondary material on them; they are narrowly and intensely folded throughout the shell. The tunnel is narrow and normally straight, although it follows an irregular course in some specimens. Thick chomata border the tunnel, thus, distinctly outlining it. Secondary deposits line the chambers and fill the early volutions in some specimens.

Remarks.—*Fusulina girtyi* is distinguished by its medium size, inflated fusiform shape, intense septal folding, heavy secondary deposits in the tunnel region and early volutions, and narrow tunnel angle. It is distinguished from *F. haworthi* (Beede) by its narrower tunnel angle, smaller form ratio, and heavier secondary deposits. This species is very similar in shape, size, and degree of septal folding to *F. occultifons* Alexander but differs in having a smaller tunnel angle and heavier secondary deposits. *Fusulina girtyi* slightly resembles in size and shape *F. distenta* Roth and Skinner and the inflated forms of *F. euryteines* Thompson but differs from these species in its more intense septal folding, smaller tunnel angle, and heavier secondary deposits. *Fusulina* *girtyi* is larger and has more intensely folded septa and heavier secondary deposits than *F. curta* Thompson.

Occurrence.—Specimens of *Fusulina girtyi* are not abundant at any one locality but are present in the Houx member of the Little Osage formation of the Fort Scott subgroup (localities 61, 63, 88b, 105, 106, 107, and 113), and the Higginsville formation of the Fort Scott subgroup (localities 2, 13, 17a, 18, 25, 31, 37, 39, 41, 84, and 91), and the Myrick Station (localities 42, 53, 58, 67, 72, 75, 84, and 114) and Coal City (localities 52, 56, 59, and 82) members of the Pawnee formation. This species has previously been reported from the Brereton (Herrin), Bankston Fork, and St. David members of the Carbondale formation, Illinois (Dunbar and Henbest, 1942); from the Fort Scott formation, Kansas (Dunbar and Condra, 1927); from the Hartville formation, Wyoming (Henbest, 1953); from the lower Fort Scott (Blackjack Creek member) and upper Fort Scott (Higginsville member), Oklahoma (Alexander, 1954); and from a limestone 18 feet above the Mystic coal, Iowa (Thompson, 1935).

Table 14

Average measurements of 10 specimens of *Fusulina girtyi*

Volutions	1	2	3	4	5	6	7	8	9	10
Height of Volutions (in mm)	.050	.069	.100	.128	.158	.178	.206	.237	.236	.249
Form ratio	1.4	1.5	1.7	1.7	1.7	1.9	1.6	1.7	1.7	...
Thickness of Spirotheca (in mm)	.009	.010	.014	.014	.015	.018	.017	.019	.017	...
Septal count	13	22	28	32	40	45	58	..	..	..
Tunnel Angle (in degrees)	15	14	14	12	13	14	15	14	17	..

FUSULINA TUMIDA Alexander

Pl. 7, figs. 9-12

Fusulina tumida ALEXANDER, 1954, Oklahoma Geol. Survey Circ. 31, p. 43, 44, pl. 4, figs. 9-12.

Description.—*Fusulina tumida* Alexander is large and inflated fusiform to subspherical; the lateral slopes vary from slightly concave to moderately convex, and the poles are bluntly pointed. The immature specimens are slightly more elongate and resemble *F. haworthi* (Beede). The average length and width of 9 specimens are 5.2 mm and 3.2 mm respectively, giving a form ratio of 1.6. The proloculus is moderately large and is spherical to subspherical in shape; the average outside diameter is 0.199 mm. The chambers increase in height uniformly.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The spirotheca is thin in comparison with the large, inflated shell and does not increase in thickness during growth of the shell. The septa are short and closely spaced; they are folded into numerous high, narrow folds which divide the major chambers vertically into numerous chamberlets of a honeycomb nature. The tunnel is narrow and its path is rather irregular. The chomata are very irregular in size and shape.

Remarks.—*Fusulina tumida* is distinguished by its large size, inflated fusiform to spherical shape, large number of volutions, intense septal folding, and narrow, irregular tunnel. There is seemingly a complete gradation between this species and *F. girtyi* (Dunbar and Condra), for the larger forms of *F. girtyi* are very difficult to distinguish from *F. tumida*. Typical specimens of *F. tumida*, however, are larger, have more volutions, and have more intensely folded septa than do specimens of *F. girtyi*. It is possible that *F. tumida* represents the end member of a *F. haworthi-F. girtyi-F. tumida* series, all of which species appear to be closely related. *Fusulina tumida* is larger, has a smaller form ratio, and has a smaller tunnel angle than does *F. haworthi*. It is similar to *F. occultifons* Alexander in general shape and intensity of folding but is considerably larger and more tightly coiled and has a larger proloculus and a slightly larger form ratio.

Occurrence.—Specimens of *Fusulina tumida* have been obtained from a limestone questionably identified as the Houx member of the Little Osage formation of the Fort Scott subgroup (localities 88b and 105). These are the only positive identifications made of this species from horizons older than the Myrick Station member of the Pawnee formation. *Fusulina tumida* is present in the Myrick Station (localities 42 and 58) and Coal City (localities 52, 53, and 56) members of the Pawnee formation and the Worland member of the Altamont formation (localities 52, 56, 74, 86, and 115). This species has previously been reported from the Myrick Station, Oklahoma (Alexander, 1954).

Table 15

Average measurements of 9 specimens of *Fusulina tumida*

Volutions	1	2	3	4	5	6	7	8	9	10
Height of Volutions (in mm)	.064	.077	.096	.131	.161	.180	.206	.240	.234	.258
Form ratio	1.5	1.8	1.8	1.7	1.8	1.6	1.6	1.7	1.6	1.7
Thickness of Spirotheca (in mm)	.017	.015	.017	.018	.021	.020	.019	.021	.021	...
Septal count	12	20	25	34	35	37	46	43	48	..
Tunnel Angle (in degrees)	17	17	14	14	14	14	17	16	15	..

FUSULINA MEGISTA Thompson

Pl. 8, figs. 6-11

(?) *Fusulinella meeki robusta* DUNBAR AND CONDRA, 1927, Nebraska Geol. Survey, 2nd ser., Bull. 2, p. 80-82, pl. 15, figs. 7, 8.
Fusulina megista THOMPSON, 1934, Iowa Univ. Studies Nat. History, v. 16, p. 320-323, pl. 23, figs. 4-6.

Description.—The shell of *Fusulina megista* Thompson is large and is elongate fusiform to ellipsoidal; the lateral slopes are plane to strongly convex, and the poles are bluntly pointed. The external shape remains somewhat the same throughout growth. The average length and width of 10 specimens are 8.1 mm and 2.9 mm respectively, giving a form ratio of 2.8. The proloculus is large and spherical in shape; the average outside diameter is 0.205 mm. The chambers increase in height uniformly.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The spirotheca is moderately thick. The septa are thin and closely spaced and, because of the intensity of the septal folding, frequently converge upon one another within the tunnel. The septa are so intensely folded that the chambers are divided into numerous chamberlets of a honeycomb nature, similar to those of *Fusulina tumida* Alexander. The tunnel is moderately narrow and is usually straight. The chomata are formed by deposition of secondary material against neighboring septal folds. Because of the septal folding throughout the tunnel area and the lack of distinct chomata, the tunnel is not always clearly outlined. The early volutions are commonly heavily filled with secondary deposits.

Remarks.—The specimens regarded here as *Fusulina megista* closely resemble the specimen illustrated by Dunbar and Condra (1927, pl. 15, figs. 7, 8) and identified as *Fusulinella meeki robusta* Dunbar and Condra, which was later referred by Thompson (1934) to *Fusulina megista*. *Fusulina megista* is distinguished by its large size, large proloculus, highly folded septa, and ellipsoidal shape. It is distinguished from *F. mysticensis* Thompson by having a smaller form ratio and smaller tunnel angle. *Fusulina megista* is larger and has a smaller form ratio and heavier secondary deposits than does *F. acme* Dunbar and Henbest.

Occurrence.—Specimens of *Fusulina megista* are abundant in the Worland member of the Altamont formation (localities 12, 68, 70, 72, 78, 81, and 82). *Fusulina megista* has previously been reported from a limestone 50 feet above the Mystic coal, Iowa (Thompson, 1934); from the Pawnee formation, Kansas (Dunbar and Condra, 1927); from the Piasa, Cutler, and Lonsdale members of the Modesto formation, Illinois (Dunbar and Henbest, 1942); from the Pawnee member of the Oolagah formation and Wimer School member of the Labette formation, Oklahoma (Alexander, 1954); from the Village Bend member of the East Mountain formation and the Capps member of the Lone Camp formation, Texas (Stewart, 1958); and from the Hartville formation, Wyoming (Henbest, 1953).

Table 16

Average measurements of 10 specimens of *Fusulina megista*

Volutions	1	2	3	4	5	6	7	8	9	10
Height of Volutions (in mm)	.047	.059	.078	.117	.164	.204	.221	.228	.250	.223
Form ratio	1.5	1.8	1.9	2.2	2.3	2.3	2.7	2.5	3.1	...
Thickness of Spirotheca (in mm)	.011	.011	.014	.017	.018	.020	.021	.023	.022	...
Septal count	15	23	27	31	39	45	47	49	..	..
Tunnel Angle (in degrees)	13	14	15	18	14	18	19	17	..	..

FUSULINA ACME Dunbar and Henbest

Pl. 8, figs. 1-5

Fusulinella haworthi (Beede), DUNBAR AND CONDRA, 1927, Nebraska Geol. Survey, 2nd ser., Bull. 2, p. 82-84, pl. 2, figs. 6-11.

Fusulina acme DUNBAR AND HENBEST, 1942, Illinois Geol. Survey Bull. 67, p. 122, 123, pl. 15, figs. 1-18; pl. 16, fig. 14.

Description.—*Fusulina acme* Dunbar and Henbest is of medium size and is cylindrical to elongate fusiform; the lateral slopes are gently convex and the poles bluntly rounded. The shell of *F. acme* is elongate at all growth stages. The average length and width of 10 specimens are 5.7 mm and 2.1 mm respectively giving a form ratio of 2.7. The proloculus is moderately large and spherical to subspherical in shape; the average outside diameter is 0.142 mm. The chambers increase in height uniformly.

The spirotheca is composed of four layers: the upper tectorium, the tectum, the diaphanotheca, and the lower tectorium. The tectum and the diaphanotheca of the early volutions are not distinguishable. The septa are thin except where they are coated with a layer of secondary deposits. Because of the intensity of the folding, the septa frequently converge upon one another in the tunnel region. The septa are highly and uniformly folded throughout the length of the shell and reach the tops of the chambers. The tunnel is moderately narrow and straight. The chomata adjoin neighboring septal folds and are sometimes difficult to recognize. Axial deposits have not been observed in specimens of this species.

Remarks.—*Fusulina acme* is distinguished by its medium size, its elongate fusiform to cylindrical shape, and its intensely and uniformly folded septa. It differs from *F. haworthi* (Beede) in having more intense septal folding and a larger form ratio. Specimens of *F. acme* have a smaller form ratio and are much more uniform in development than specimens of *F. lonsdalensis* Dunbar and Henbest and *F. eximia* Thompson, and are much shorter and have a much larger form ratio than *F. mysticensis* Thompson. *Fusulina acme* most closely resembles *F. megista* Thompson but differs from the latter species in its smaller size, more uniform septal folding, and tighter coiling.

Occurrence.—*Fusulina acme* occurs in the Worland member of the Altamont formation (localities 56, 62, 74, and 115) and in the Sni Mills member of the Lenapah formation (locality 80, Appanoose County, Iowa). *Fusulina acme* has previously been described from the Lonsdale and Piasa members of the Modesto formation, Illinois (Dunbar and Henbest, 1942); from the Hartville formation, Wyoming (Henbest, 1953); and from the Village Bend member of the East Mountain formation and Capps member of the Lone Camp formation, Texas (Stewart, 1958).

Table 17

Average measurements of 10 specimens of *Fusulina acme*

Volutions	1	2	3	4	5	6	7	8	9
Height of Volutions (in mm)	.041	.050	.074	.115	.155	.190	.220	.243	.253
Form ratio	1.7	2.3	2.5	2.7	3.0	2.9	2.7	2.4	. . .
Thickness of Spirotheca (in mm)	. . .	.012	.014	.016	.018	.020	.022	.026	. . .
Septal count	13	20	23	26	31	38	42	45	. .
Tunnel Angle (in degrees)	16	19	20	22	22	26	19	23	. .

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APPENDIX

Collecting Localities

*indicates units sampled
All localities are in Missouri except where otherwise indicated.
Strata thicknesses are given in tenths of feet.

M2—SW NW sec. 8, T. 35 N., R. 33 W., Vernon County
Small quarry 0.4 mile south of U. S. Hwy. 54

Higginsville fm.	limestone	16.0*
Little Osage fm.	black shale	11.0
Blackjack Creek fm.	limestone	4.0*
Excello fm.	black shale	4.0

M4—SE SE sec. 17, T. 34 N., R. 32 W., Vernon County
Sharp north turn on Mo. Hwy. 43, 0.5 mile east of Bronaugh

Scammon fm.		
Tiawah mbr.	limestone	Exposed*

M5—SW SW sec. 7, T. 34 N., R. 32 W., Vernon County
One mile east and 1.0 mile north of Bronaugh

Bevier fm.	brown shale	1.0
Verdigris fm.		
Ardmore mbr.	limestone	2.0*
	black shale	1.5
	limestone	0.8
Croweburg fm.	black shale	5.0

M9—SW SW sec. 18, T. 34 N., R. 32 W., Vernon County
Ellis mine on Supplementary Rd. N., 0.7 mile west of Bronaugh

Verdigris fm.	sandstone	4.0
Croweburg fm.	coal	0.8
	underclay	1.4
	limestone	1.0*
Fleming fm.	shale, coal, underclay	5.0
	sandstone	3.0
Robinson Branch fm.	black shale	4.9
	limestone	1.5*
Mineral fm.	coal	1.5

M10—SE NW sec. 7, T. 34 N., R. 32 W., Vernon County
Jones mine and quarry

Blackjack Creek fm.	limestone	11.0*
Excello fm.	black shale	4.0
Mulky fm.	coal	1.0

M11—SW corner SW SE SW sec. 3, T. 36 N., R. 33 W., Vernon County
Railroad cut on Kansas City Southern R.R., 1.5 miles north of Richards

Bevier fm.		
"Wheeler cap rock"	limestone & black shale	Exposed*
Verdigris fm.		
Wheeler	coal	Exposed

M12—Center south line SW sec. 33, T. 40 N., R. 33W., Bates County
Road intersection, 2.0 miles south of Amoret

Altamont fm.		
Worland mbr.	limestone	3.0*
Lake Neosho mbr.	shale	2.0
Amoret mbr.	limestone	5.0*

M13—SW SE sec. 19, T. 40 N., R. 31 W., Bates County
Alvis quarry on Mo. Hwy. 52, 3.0 miles west of Butler

Labette fm.	shale	6.0
Higginsville fm.	limestone	21.0*
Little Osage fm.	shale	12.0
Blackjack Creek fm.	limestone	3.0*

M14—SE SE sec. 5, T. 39 N., R. 28 W., St. Clair County
Stripping dumps southeast of Appleton City

Scammon fm.		
Tiawah mbr.	limestone	Exposed*

M15—NW NW NE sec. 8, T. 42 N., R. 25 W., Henry County
One-half mile north and 1.2 miles west of Drakes Chapel

Bevier fm.?	limestone	0.5
	shale	1.0
Verdigris fm.		
Wheeler	coal	0.2
Ardmore mbr.	limestone	7.0*

M17—SW SE sec. 34, T. 43 N., R. 28 W., Henry County
Abandoned strip pit 1.0 mile northwest of main quarry

Croweburg fm.		
"Fleming cap rock"	limestone	Exposed*

M17a—NE SE sec. 11, T. 43 N., R. 36 W., Henry County
One-half mile south and 0.5 mile east of Shawnee Mound

Pawnee fm.		
Myrick Station mbr.	limestone	2.0*
Labette fm.	shale	6.5
	limestone	2.0
	black shale	2.0
Higginsville fm.	limestone	14.0*

M18—E½ SW sec. 34, T. 43 N., R. 28 W., Henry County
Quarry, 5.0 miles south of Urich

Labette fm.		
Englevale mbr.	sandstone	6.0
	black shale	3.0
	limestone	1.5
Alvis	coal	0.5
	underclay	2.0
Higginsville fm.	limestone	15.0*

M21—SE sec. 2, T. 40 N., R. 28 W., Henry County

Power Coal Company strip mine high walls

Scammon fm.	shale & clay	6.0
Tiawah mbr.	limestone	2.0*
	black shale	2.6
Tebo fm.	coal	2.5
	shale & clay	12.0

M24—SE SW sec. 36, T. 44 N., R. 25 W., Henry County

Abandoned part of strip mine on north side of road

Verdigris fm.		
Ardmore mbr.	limestone	15.0*
	black shale	2.0
	limestone	0.8*
	black shale	12.0

M25—SE SW sec. 14, T. 44 N., R. 25 W., Johnson County

Roadcut from abandoned house to creek

Higginsville fm.	limestone	4.0*
Little Osage fm.	brown shale	4.0
Houx mbr.	limestone	0.5
	underclay	5.0
	shale	8.0
Blackjack Creek fm.	limestone	4.0*
Excello fm.	black shale	3.0
Mulky fm.	coal	0.8
	underclay	3.0

M26—S½ sec. 24 and NE sec. 25, T. 43 N., R. 26 W., Henry County

South of road in west branch of Tebo Creek and small eastern tributary.

Higginsville fm.	limestone	?*
Little Osage fm.	black shale	?
Blackjack Creek fm.	limestone	?*
Mulky fm.	coal	?
Breezy Hill mbr.	limestone	?*

M27—NE NW sec. 24, T. 42 N., R. 26 W., Henry County

Creek bank just off road

Scammon fm.		
Tiawah mbr.	limestone	Exposed*

M29—NE SE sec. 29, T. 43 N., R. 26W., Henry County

On supplementary Rd. N., 0.5 mile north of Huntingdale

Blackjack Creek fm.	limestone	1.0*
Excello fm.	black shale	5.0
Mulky fm.	coal	0.2
	covered	10.0
Breezy Hill mbr.	limestone	0.5*

M30—NE SW sec. 25, T. 43 N., R. 27 W., Henry County

Dirt road, 10.5 feet from top of hill

Verdigris fm.		
Ardmore mbr.	limestone	Exposed*

M31—C. E½ sec. 17, T. 43 N., R. 26 W., Henry County

North of house which is 0.5 mile north of section line

Higginsville fm.	limestone	2.0*
Little Osage fm.	black shale	2.0
	covered	10.0
Blackjack Creek fm.	limestone	3.0*
	covered	14.0
Excello fm.	brown shale	5.0
Mulky fm.		
Breezy Hill mbr.	limestone	1.0*
Lagonda fm.	sandstone, shale	69.0
Bevier fm.	limestone	0.2*
Verdigris fm.		
Wheeler	coal	0.2
	underclay	3.0
Ardmore mbr.	limestone	7.0*

M36—SW SW SW sec. 5, T. 39 N., R. 33 W., Bates County

Along Kansas City Southern R.R., just north of graded crossing northeast of Worland. (Type locality of Worland member.)

Altamont fm.		
Worland mbr.	limestone	Exposed*

M37—C. east line sec. 31, T. 43 N., R. 27 W., Henry County

In ditch on west side of road

Higginsville fm.	limestone	6.0*
Little Osage fm.	black shale	12.0
Blackjack Creek fm.	limestone	2.0
Excello fm.	black shale	6.0
Mulky fm.	coal	0.5

M39—NE sec. 13, T. 45 N., R. 26 W., Johnson County

Roadcut in quarry on east side of road, 4.5 miles south of Warrensburg.

	covered	10.0
Labette fm.	black shale	7.0
	limestone	0.5*
	gray clay	4.0
Higginsville fm.	limestone	15.0*
	covered	20.0
Blackjack Creek fm.	limestone	4.5*
Excello fm.	black shale	1.5
Mulky fm.	coal	0.1
Lagonda fm.	gray shale	25.0
	limestone	0.3*

M41—SW SW sec. 13, T. 46 N., R. 27 W., Johnson County

Roadcut on U. S. Highway 50, 6.0 miles west of Warrensburg

Labette fm.	black shale	1.0
Higginsville fm.	limestone	17.0*
Little Osage fm.	black shale	3.0
Houx mbr.	limestone	0.5*
Summit	coal	0.1
	black shale	3.0

M41 continued

Blackjack Creek fm.	limestone	0.5*
	brown shale	3.0
	limestone	2.0*

M42—SW NE sec. 8, T. 47 N., R. 26 W., Johnson County

In quarry on east side of road, 2.5 miles northwest of Fayetteville

Pawnee fm.		
Coal City mbr.	limestone	1.0*
Mine Creek mbr.	shale	2.5
Myrick Station mbr.	limestone	10.0*
Anna mbr.	black shale	6.0
	limestone	0.1*
Labette fm.		
Lexington	coal	0.5
	black shale	2.0
	limestone	0.4*
	clay	3.5
Higginsville fm.	limestone	6.0*

M43—SE NW sec. 32, T. 49 N., R. 26 W., Lafayette County

Outcrops just east of bridge on U. S. Highway 40, 3.0 miles west of Odessa

Pawnee fm.		
Myrick Station mbr.	limestone	4.0*
Anna mbr.	brown shale	1.5
	black shale	1.0
Labette fm.		
Lexington	coal	1.0
Englevale mbr.	sandstone	2.0
Higginsville fm.	limestone	4.0*
Little Osage fm.	brown shale	1.0
	gray shale	5.0

M44—NW SE sec. 21, T. 47 N., R. 25 W., Johnson County

In creek bed at bridge, 0.6 mile east of abandoned church (Type locality of Blackjack Creek formation.)

Blackjack Creek fm.	limestone	Exposed*

M45—SE sec. 16, T. 46 N., R. 24 W., Johnson County

At intersection of W. Allen and N. Monroe Streets, Knobnoster, and in roadcut of U. S. Highway 50.

Lagonda fm.	brown shale	10.0
Bevier fm.	coal	0-2.0
	gray shale	5.0
	limestone	0.3*
Verdigris fm.		
Wheeler	coal	2.0
	underclay	2.0
Ardmore mbr.	limestone	2.0*
	gray shale	3.0
Croweburg fm.	coal	0.1

M52—SW NW sec. 5, T. 50 N., R. 27 W., Lafayette County

Quarry and adjacent ravine on west bank of stream entering Missouri River at Macedonia School (now a residence), 1.0 mile southwest of Myrick Station.

Altamont fm.		
Worland mbr.	limestone	5.0*
Bandera fm.	clay with coal smuts	15.0
Pawnee fm.		
Coal City mbr.	limestone	5.0*
Mine Creek mbr.	shale	9.0
Myrick Station mbr.	limestone	6.0*
Labette fm.	shale & coal smuts	2.5
	limestone	0.4*
	clay	2.5
Higginsville fm.	limestone	5.0*
Little Osage fm.	shale	20.0
Houx mbr.	limestone	4.5*
	covered	10.0
Blackjack Creek fm.	limestone	3.0*

M53—SW SW NW sec. 11, T. 49 N., R. 26 W., Lafayette County

In south face of quarry, 1.5 miles southwest of Higginsville

Pawnee fm.		
Coal City mbr.	limestone, shale	6.5*
Mine Creek mbr.	gray shale	5.0
Myrick Station mbr.	limestone	5.0*
Anna mbr.	black shale	2.0
Labette fm.		
Lexington	coal	1.5
	covered	4.0
Higginsville fm.	limestone	3.0*

M56—N½ SW sec. 13, T. 52 N., R. 26 W., Ray County

Mine shaft, 0.5 mile east of Lakeview

Altamont fm.		
Worland mbr.	limestone	2.0*
Lake Neosho mbr.	shale	0.5
Amoret mbr.	limestone	2.0
Bandera fm.	shale	26.0
Pawnee fm.		
Coal City mbr.	limestone	4.0*
Mine Creek mbr.	shale	5.0
Myrick Station mbr.	limestone	5.5*
	covered	?
Higginsville fm.	limestone	?*

M57—NE SE sec. 8, T. 54 N., R. 23 W., Carroll County

Railroad cut approximately 100 yards southwest of road crossing

Bandera fm.?	gray clay	1.0
Pawnee fm.	limestone, some shale	10.5*
Labette fm.	shale	5.0
Higginsville fm.	limestone	3.0*

M58—NE NW SW sec. 7, T. 54 N., R. 22 W., Carroll County
Small quarry on south side of east-west road. (Type locality of Tina mbr., Cline, 1941, p. 29.)

Pawnee fm.		
Myrick Station mbr.	limestone	2.0*
Anna mbr.	gray clay	3.0
Labette fm.		
Lexington	coal	0.1
	underclay	4.0
Higginsville fm.	limestone	2.0

M59—NE NE SE sec. 12, T. 54 N., R. 23 W., Carroll County
Just south of road intersection, on west side of road

Pawnee fm.		
Coal City mbr.	limestone	2.0*
Mine Creek mbr.	shale	2.0
	covered	5.0
Labette fm.		
Lexington	coal	0.1
	clay	4.0
Higginsville fm.	limestone	2.0*

M60—SE NE SE sec. 17, T. 55 N., R. 21 W., Carroll County
In strip mine, 0.5 mile west of Grand River

Verdigris fm.		
Ardmore mbr.	limestone	Exposed*
(14.0 feet above Croweburg coal)		

M61—Sec. 21, T. 56 N., R. 22 W., Livingston County
Outcrop south of Supplementary Rd. H, 0.6 mile east of Supplementary Rd. J

Pawnee fm.		
Myrick Station mbr.	limestone	1.0*
	covered	5.0
Higginsville fm.	limestone	8.0*
Little Osage fm.		
Flint Hill mbr.	sandstone	5.0
	covered	15.0
Houx mbr.	limestone	1.5*
	shale	3.0
Summit	coal	0.5
	clay	1.0
	covered	4.0
Blackjack Creek fm.	limestone	1.0*
	covered	5.0

M62—NE NE NW sec. 9, T. 54 N., R. 23 W., Carroll County
Railroad cut on Chicago, Burlington, and Quincy Railroad

Nowata fm.	red shale	3.0
Altamont fm.		
Worland mbr.	limestone	2.0*
Lake Neosho mbr.	shale	5.0
Amoret mbr.	limestone	1.0*
Bandera fm.	clay, shale	8.0

M63—NE NW sec. 17, T. 52 N., R. 22 W., Carroll County
Outcrop east of road, 1.0 mile northwest of Wakenda

Little Osage fm.		
Houx mbr.	limestone	2.5*
	black shale	3.5
Summit	coal	0.2
	covered	6.0
Blackjack fm.	limestone	2.5*
Excello fm.	black shale	1.0
Mulky fm.	underclay	3.0
Breezy Hill mbr.	limestone	0.8
Lagonda fm.	shale	20.8

M67—NW sec. 27, T. 59 N., R. 21 W., Linn County
Outcrop along Supplementary Rd. V

Altamont fm.	shale	1.5
	limestone	0.3
Bandera fm.	clay, shale	20.0
Pawnee fm.	limestone	8.0*
Labette fm.	clay, shale	
	2 coal streaks	7.0
Higginsville fm.	limestone	3.5*
Little Osage fm.	siltstone	12.0

M68—NE NE sec. 2, T. 59 N., R. 18 W., Linn County
Small quarry on northwest side of road, 0.5 mile northeast of New Boston

Altamont fm.		
Worland mbr.	limestone	1.0-2.0*

M70—NW sec. 14, T. 61 N., R. 16 W., Adair County
Base of quarry, 1.0 mile southeast of Yarrow

Altamont fm.		
Worland mbr.	limestone	4.0*

M72—SW sec. 14, T. 62 N., R. 16 W., Adair County
In spillway of dam at Youngstown

Altamont fm.		
Worland mbr.	limestone	3.5*
Lake Neosho mbr.	shale, clay	8.0
Amoret mbr.	limestone	1.2*
Bandera fm.	shale	5.0
Pawnee fm.		
Coal City mbr.	limestone	3.5*
Mine Creek mbr.	shale	1.0
Myrick Station mbr.	limestone	3.5*
Anna mbr.	shale	3.5
Labette fm.	clay	4.0
Higginsville fm.	limestone	3.0*

M74—NE sec. 23, T. 63 N., R. 17 W., Adair County
Outcrop along east-west road

Altamont fm.		
Worland mbr.	limestone	1.0*
Lake Neosho mbr.	shale	11.0*
Amoret mbr.	limestone	1.5*
Bandera and		
Pawnee fms.	shale	16.5
Myrick Station mbr.	limestone	2.0*
Labette fm.	shale	5.0

M75—NW sec. 21, T. 64 N., R. 17 W., Adair County
Outcrop about 4 miles northwest of Shibley Point

Pawnee fm.		
Myrick Station mbr.	limestone	3.0*
Anna mbr.	black shale	1.0
Labette fm.		
Lexington	coal	3.0
	clay	1.0
Higginsville fm.	limestone	5.0*

M76—NW SE sec. 25, T. 64 N., R. 18 W., Sullivan County
On east side of Supplementary Rd. F, about 4 miles north of Green Castle

Altamont fm.		
Worland mbr. (?)	limestone	Exposed*

M78—SE NW sec. 29, T. 66 N., R. 18 W., Putnam County
Quarry about 2 miles west of Hartford

Altamont fm.		
Worland mbr.	limestone	1.0-3.0*
Bandera fm.	gray-green shale	5.0-7.0
Pawnee fm.		
Coal City mbr.	limestone	2.0-3.0*

M80—SW sec. 16, T. 67 N., R. 16 W., Appanoose County, Iowa
Small quarry just south of road

Pleasanton group		
Unnamed fm.	shale	24.0
Exline mbr.	limestone	1.0*
	shale, clay	4.5
Marmaton group		
Appanoose subgroup		
Lenapah fm.		
Sni Mills mbr.	limestone	1.7*
	clay, shale	15.0
	covered	10.0
Altamont fm.		
Worland mbr.	limestone	3.0

M81—SW SW sec. 30, T. 67 N., R. 17 W., Putnam County
Quarry just northeast of corner in road

Altamont fm.		
Worland mbr.	limestone	4.0*

M82—NE SW sec. 12, T. 66 N., R. 18 W., Putnam County
Outcrop in roadcut and stream bank

Altamont fm.		
Worland mbr.	limestone	3.0*
Lake Neosho mbr.	brown shale	3.0
Amoret mbr.	limestone	0.5
Bandera fm.	coal	0.1
	red & green shale	25.0
Pawnee fm.		
Coal City mbr.	limestone	3.0*

M84—NE SE sec. 26, T. 65 N., R. 18 W., Putnam County
Outcrop in roadcut on north-south road just north of Burns School

Pleasanton group		
Unnamed fm.	sandstone	15.0
Exline mbr.	limonitic limestone	1.0
Marmaton group		
Appanoose subgroup		
Holdenville-Lenapah fms.	covered	20.0
	sandstone	7.0
Bandera fm.?	covered	14.0
Pawnee fm.		
Coal City mbr.	limestone	1.0*
	shale, clay	4.0
Mine Creek mbr.	limestone	1.0*
	shale	4.0
Myrick Station mbr.	limestone	0.8*
Anna mbr.	shale	1.5
Labette fm.		
Lexington	coal	2.5
	shale, clay	6.0
Higginsville fm.	limestone	3.0*

M86—C. NW sec. 21, T. 58 N., R. 24 W., Livingston County
Outcrop at water level just south of bridge

Altamont fm.		
Worland mbr.	limestone	Exposed*

M87—NW SW sec. 17, T. 57 N., R. 24 W., Livingston County
Outcrop in pasture east of road just north of bridge

Altamont fm.		
Worland mbr.	limestone	Exposed*

M88a—NE SW sec. 8, T. 48 N., R. 12 W., Boone County
South pit of Columbia Brick and Tile Company, east of Columbia

(Covered)	shale	3.0
Verdigris fm.		
Ardmore mbr.	limestone	7.0*
	black shale	4.0
Croweburg fm.	coal	1.0
	underclay	3.5
Scammon fm.		
Tiawah mbr.	limestone	2.0*
Cheltenham fm.	clay	17.0

M88b—NE SW sec. 8, T. 48 N., R. 12 W., Boone County
North pit of Columbia Brick and Tile Company, east of Columbia

Higginsville fm.	limestone	2.0*
Little Osage fm.	gray & maroon shale	9.0
Houx mbr. (?)	limestone	2.0*
	black shale	1.5
Summit	coal	0.1
	clay	3.5
Blackjack Creek fm.	limestone	1.2*
Lagonda fm.	shale	25.0

M89—N½ SE NE sec. 27, T. 49 N., R. 12 W., Boone County
Outcrop in tributary to Hinkson Creek

Verdigris fm.	shale, limestone	10.0*
	covered	5.0
Scammon fm.		
Tiawah mbr.	limestone	1.0*

M91—C. sec. 13, T. 50 N., R. 13 W., Boone County
Outcrop along northwest side of U. S. Hwy. 63

Pawnee fm.		
Myrick Station mbr.	limestone	6.5*
	covered	5.0
Higginsville fm.	limestone	3.0*
Little Osage fm.	covered	5.0
Houx mbr.	limestone	2.0*
	black shale	3.0
Summit	coal	2.0
	underclay	2.0

M92—C. sec. 12, T. 50 N., R. 14 W., Boone County
Abandoned strip mine, 1.0 mile east of Harrisburg

Verdigris fm.	limestone	1.0*
	shale	1.0
	limestone	1.0*
	black shale	1.0
Croweburg fm.	coal	1.0

M93—C. NE sec. 7, T. 51 N., R. 13 W., Boone County
Outcrop along road west of Rucker

Verdigris fm.		
Ardmore mbr.	limestone, shale	7.0*
	brown & black shale	15.0
	limestone	0.8*
	black shale	2.0
	brown shale	1.0
Croweburg fm.	coal	1.5

M96—SW NE SW sec. 13, T. 51 N., R. 9 W., Audrain County
Clay pit northeast of Mexico

Higginsville fm.	limestone	2.0*
Little Osage fm.	shale	6.0
Houx mbr.	limestone	1.0*
	black shale	3.0
Summit	coal	0.2

M96 continued

	underclay	6.0
Blackjack Creek fm.	limestone	4.0
Excello fm.	brown shale	5.0
Mulky fm.	coal	1.0
	underclay	2.0
Lagonda fm.	brown shale	4.0
	limestone, shale	2.5*
	gray shale	2.0
Verdigris fm.		
Ardmore mbr.	limestone	1.0*
	brown shale	5.0
Croweburg fm.	coal	0.1
	gray clay	5.0
Scammon fm.		
Tiawah mbr.	limestone	1.0-2.0*
Cheltenham fm.	clay	4.0

M98—NE NE SE sec. 34, T. 50 N., R. 3 W., Lincoln County

Strippings along old mine road on Flamm farm

Unidentified	limestone	Float*

M99—SW SE NW sec. 26, T. 49 N., R. 1 E., Lincoln County

Pawnee fm. (?).* On road at top of draw

Little Osage fm.

Houx mbr. (?).* Near bottom of draw.

M102—NW SW sec. 36, T. 53 N., R. 16 W., Randolph County

In abandoned quarry on west side of road

Altamont fm.		
Worland mbr.	limestone	2.0*
Lake Neosho mbr.	brown shale	6.0
Amoret mbr.	limestone	1.0*
Bandera fm.	brown shale	5.0
Pawnee fm.		
Coal City mbr.	limestone	4.0*
Mine Creek mbr.	shale	1.0
Myrick Station mbr.	limestone	3.0*
Labette fm.	shale, clay	6.0

M105—SW SW NW sec. 9, T. 54 N., R. 14 W., Randolph County

Outcrop 4.0 miles northeast of Huntsville

Little Osage fm.		
Houx mbr.	limestone	2.5*
	black shale	2.5
Summit	coal	1.0
	gray clay	10.0
Blackjack Creek fm	limestone	4.0*
Excello fm.	black shale	2.0

M106—SE SE NE sec. 35, T. 55 N., R. 12 W., Randolph County

In creek bed at bridge on Supplementary Rd. K

Little Osage fm.		
Houx mbr.	limestone	3.0*

M107—SE SE NW sec. 2, T. 54 N., R. 13 W., Randolph County
In bed of north-south road on north side of bridge

Little Osage fm.		
Houx mbr.	limestone	Exposed*

M109—SE NE SW sec. 22, T. 56 N., R. 15 W., Macon County
Roadcut to strip mine, 2.5 miles west of Ardmore and 1.0 mile north of College Mound

Verdigris fm.		
Ardmore mbr.	limestone	3.0*
	shale	1.0*
	limestone	0.3*
	brown shale	3.0

M110—NW NW NE sec. 31, T. 56 N., R. 14 W., Macon County
In road and ditch just east of bridge

Verdigris fm.		
Ardmore mbr.	limestone	Exposed*

M112—SW NE sec. 17, T. 40 N., R. 28 W., Henry County
Outcrop in strip mine (collected by W. V. Searight)

Croweburg fm.		
"Fleming cap rock" (?)	limestone	Exposed*

M113—SE NW sec. 36, T. 46 N., R. 5 E., St. Louis County
On west side of Lindbergh Blvd., about 20 yards north of Dorsett Road (collected by K. G. Brill, Jr.)

Little Osage fm.		
Houx mbr.	limestone	Exposed*

M114—SE SE sec. 14, T. 45 N., R. 6 E., St. Louis County
Southwest corner of Forest Park on Daniel Boone Expressway (U. S. Hwy. 40), St. Louis (collected by K. G. Brill, Jr.)

Pawnee fm.		
Myrick Station	limestone	Exposed*

M115—SE sec. 14, T. 46 N., R. 6 E., St. Louis County
Southeast corner of intersection of Mark Twain Expressway (U. S. Alt. 40, Interstate Hwy. 70) and Florissant Rd., Cool Valley.

Altamont fm.		
Worland mbr.	limestone	Exposed*

M116—SE sec. 36 T. 43 N., R. 27 W., Henry County
Dump of strip mine (collected by M. L. Thompson)

Scammon fm.		
Tiawah mbr.	limestone	Exposed*

PLATES

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are unretouched photographs

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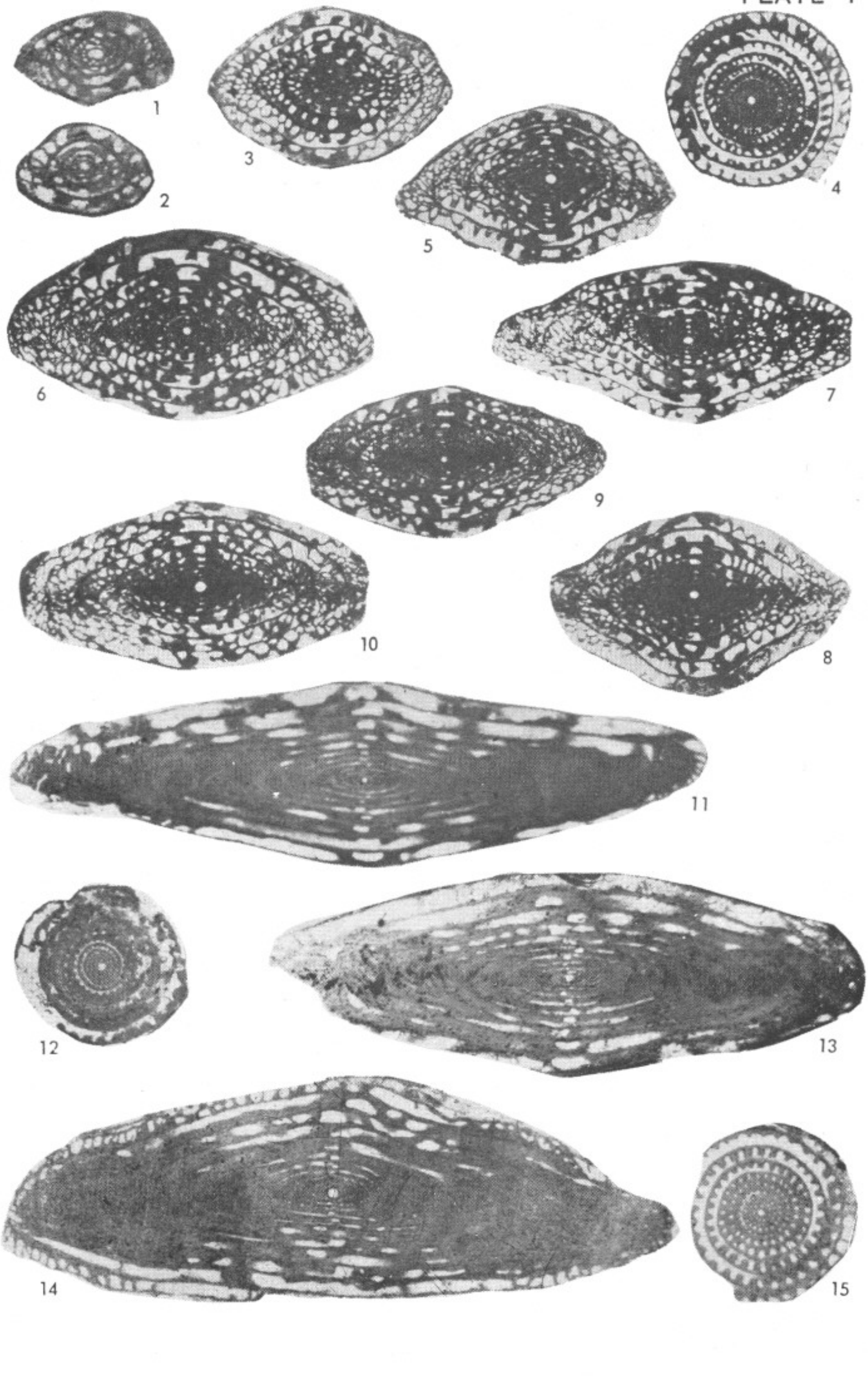
PLATE 1



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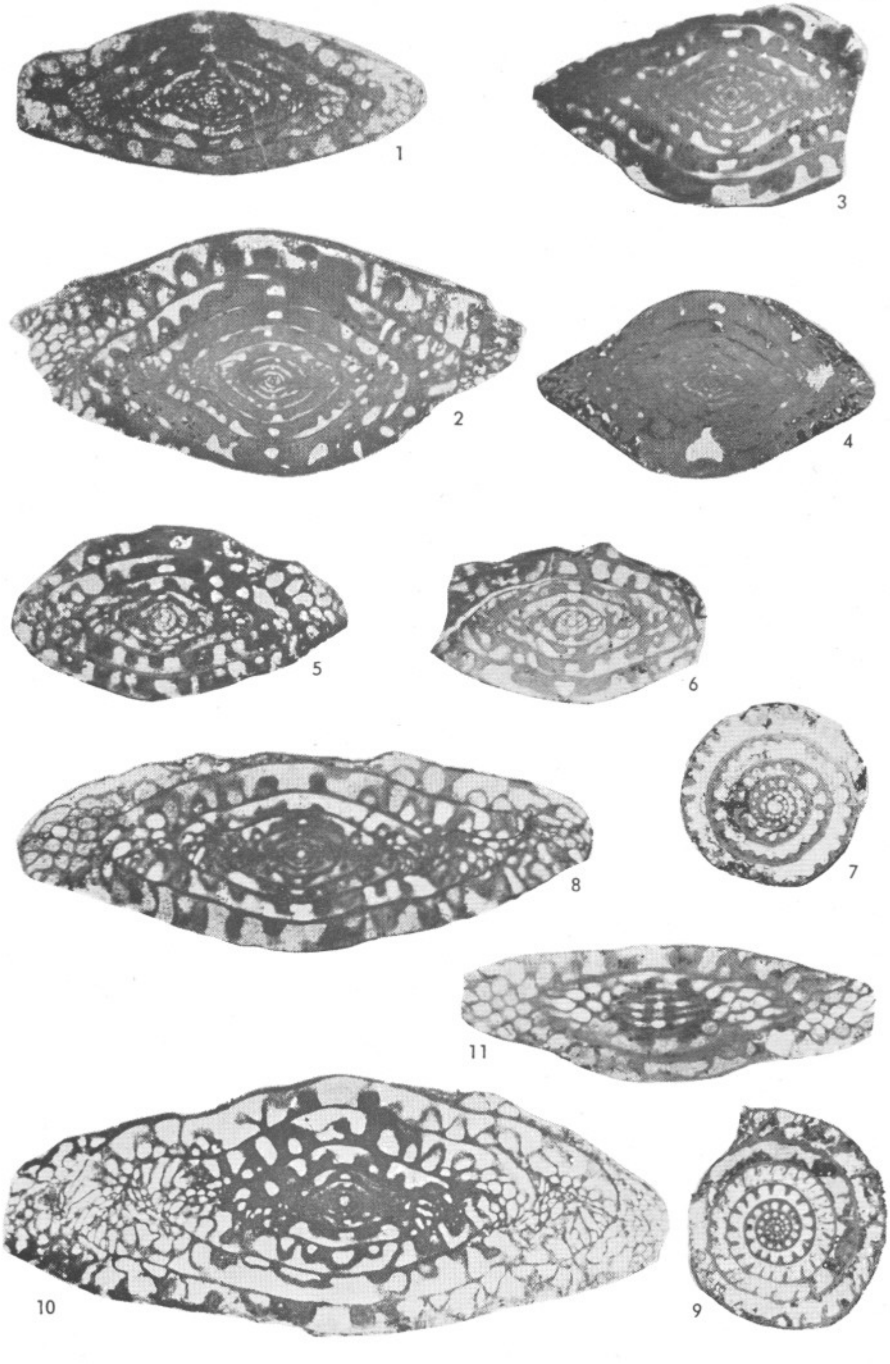

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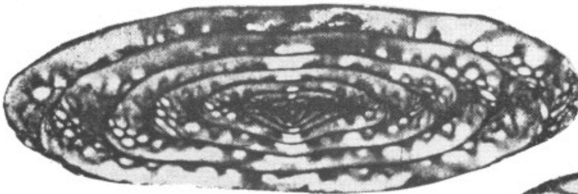

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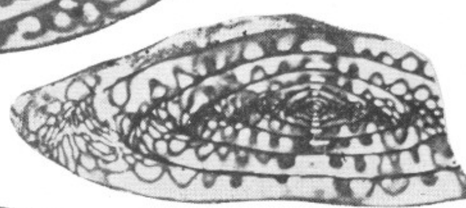

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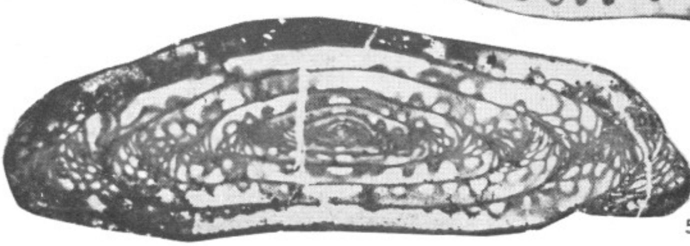

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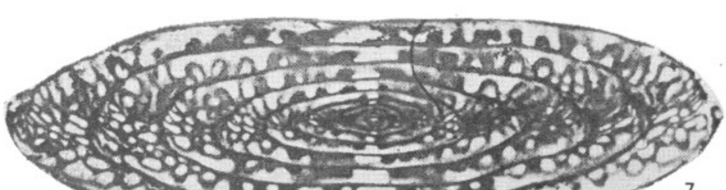

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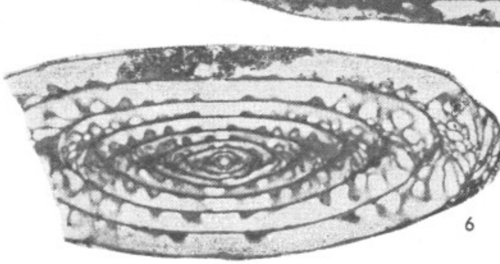

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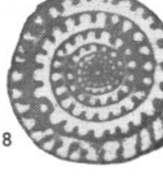

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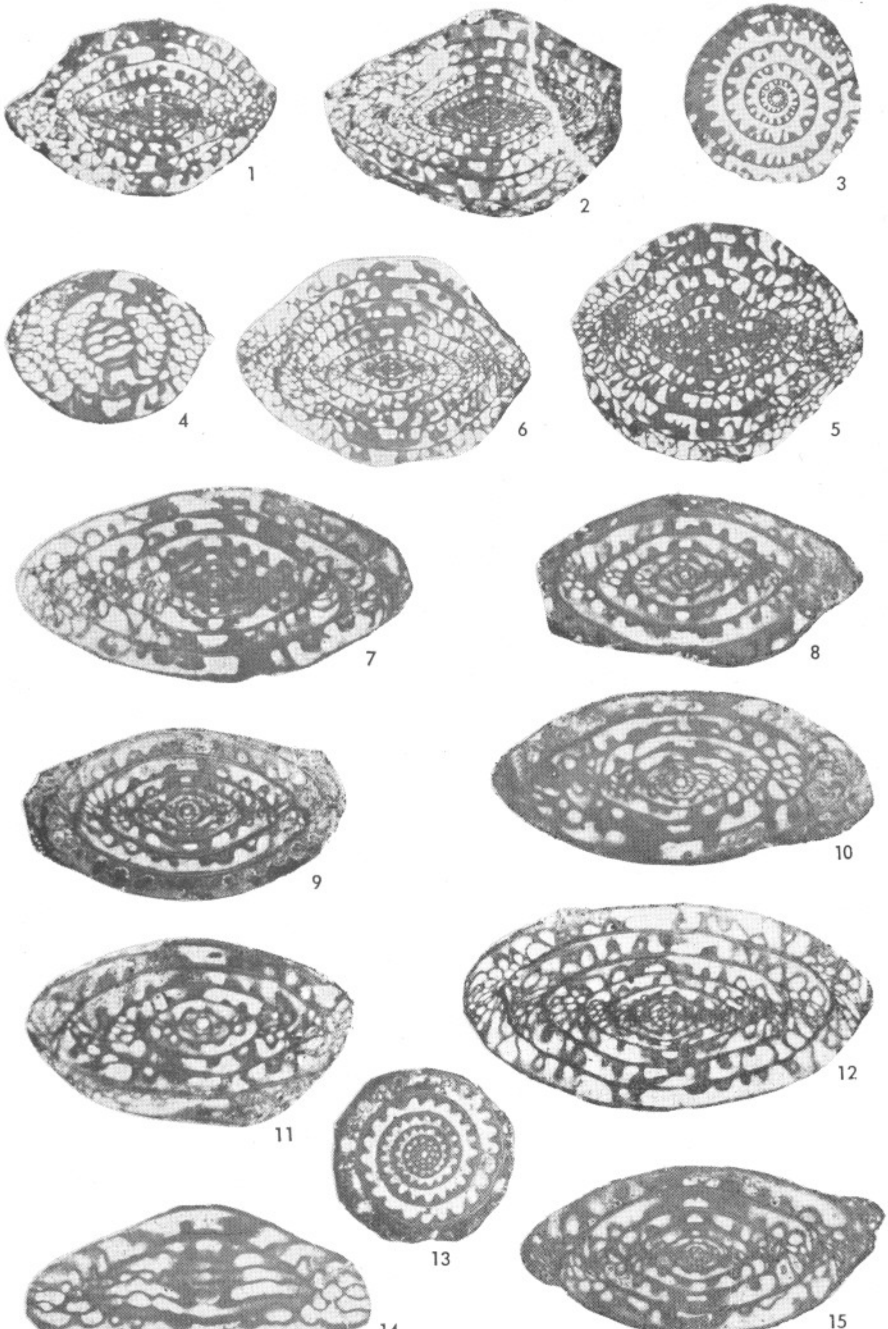

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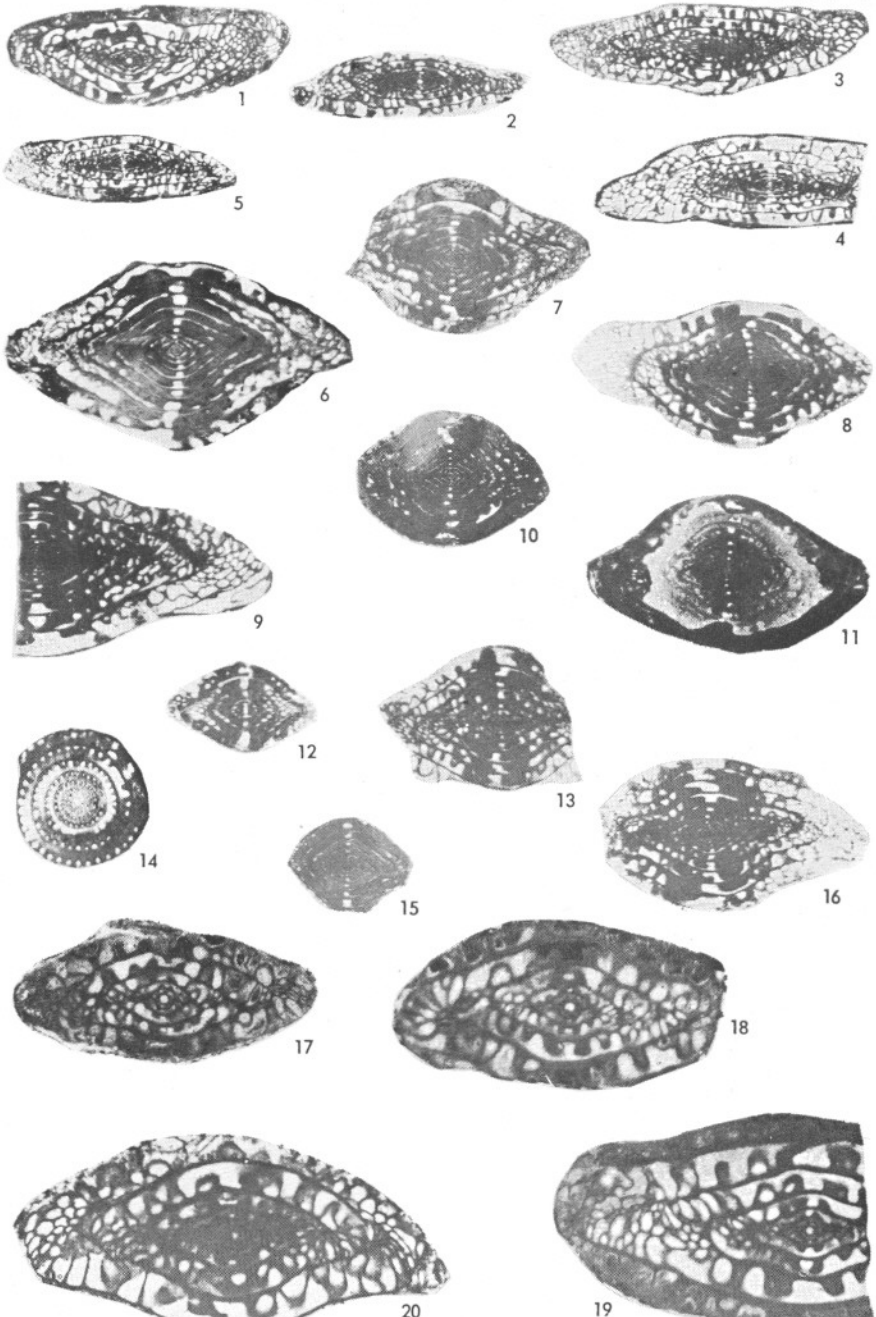
PLATE 5



EXPLANATION OF PLATE 6

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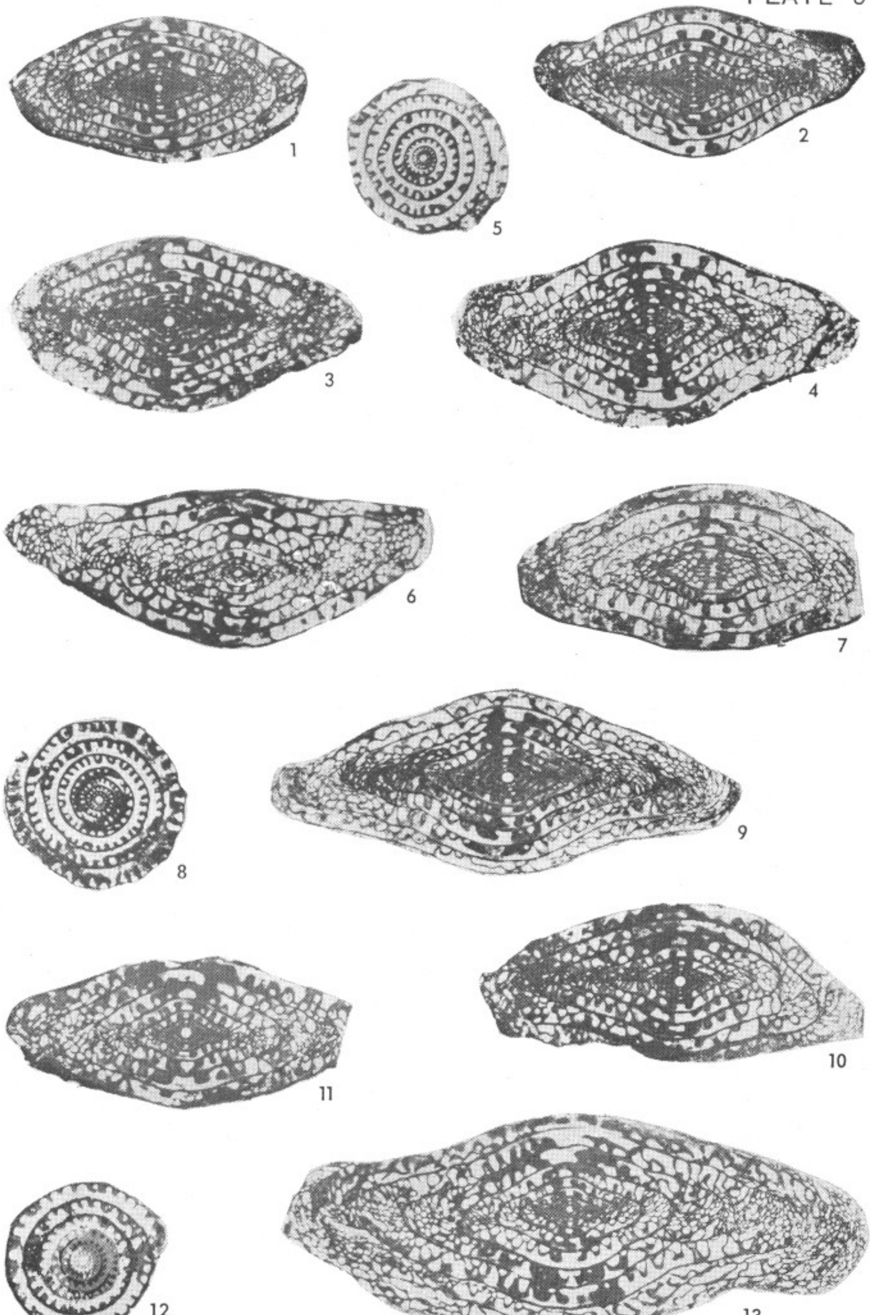
PLATE 6



EXPLANATION OF PLATE 7

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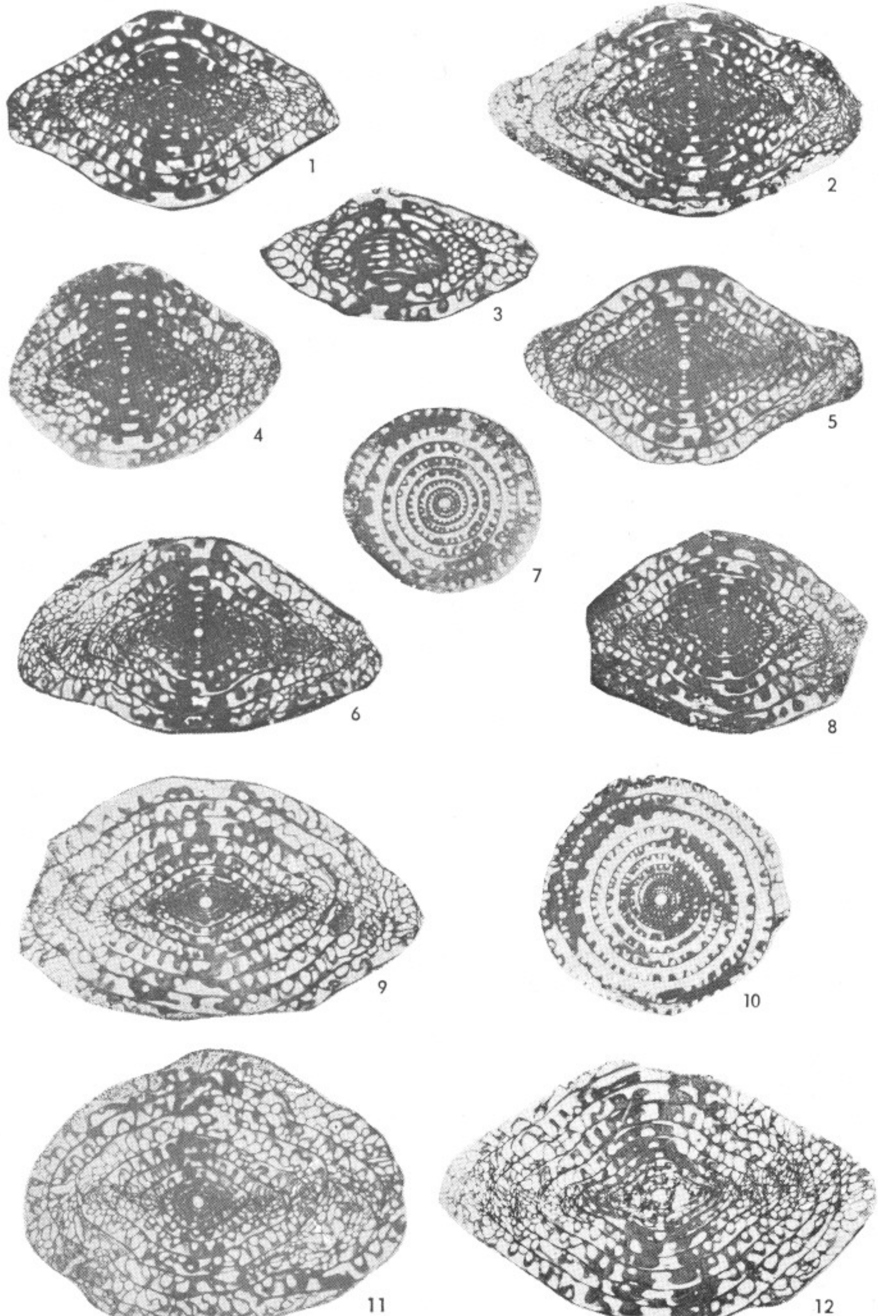
PLATE 7



EXPLANATION OF PLATE 8

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PLATE 8