Fusulinidae From the Graford Formation and Winchell Limestone Canyon Group Upper Pennsylvanian in Brown County, Texas

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By DONALD A. MYERS

CONTRIBUTIONS TO PALEONTOLOGY

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Systematic descriptions of eight species, including five new species, of fusulinid Foraminifera from the lower part of the Canyon Group, Upper Pennsylvanian, central Texas

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FUSULINIDAE FROM THE GRAFORD FORMATION AND WINCHELL LIMESTONE, CANYON GROUP, UPPER PENNSYLVANIAN, IN BROWN COUNTY, TEXAS

By Donald A. Myers

ABSTRACT

Eight species of fusulinids referred to the genera *Oketaella, Kansanella,* and *Triticites* are found in the Graford Formation and Winchell Limestone of Brown and northern McCulloch Counties in north-central Texas. These formations represent the lower part of the Canyon Group of early Late Pennsylvanian age.

INTRODUCTION

Marine rocks of Middle and Late Pennsylvanian and Early Permian ages in north-central Texas contain an abundance of well-preserved fusulinid Foraminifera. The differences in the fusulinid faunas in the various subformational units are sufficiently distinct that the fusulinids may be used to identify the member, and in some instances, the individual bed from which collections were made. These faunal differences are apparent in assemblages; only rarely are they discernible in a few specimens.

The area of this report lies entirely within the Colorado River drainage basin in central Texas. It is bounded on the east by the base of the Graford Formation and on the west by the top of the Winchell Limestone. The north edge of the area is in Brown County, where the Graford Formation is overlapped by rocks of Cretaceous age. The south edge is in McCulloch County, near the town of Mercury (fig. 1).

This report describes fusulinids from the Graford Formation and Winchell Limestone, of early Late Pennsylvanian age, in Brown and McCulloch Counties, Tex. The fusulinid collections were made between 1950 and 1963.

Eargle (1960) has given a detailed account of the Pennsylvanian stratigraphy of the area, and only a general summary is presented in this report.

The Graford Formation, the lowermost formation assigned to the Canyon Group, is underlain by the Strawn Group, and is overlain by the Winchell Limestone of the Canyon Group. In midcontinent terminology, the Graford Formation is of early Missouri age. It lies at the base of the faunal zone of *Triticites*. The Graford Formation has been divided in ascending order into the Brownwood Shale, the Adams Branch Limestone, and the Cedarton Shale Members. Fusulinids are locally abundant in the Brownwood, common throughout the Adams Branch, and sparse in the Cedarton.

The Brownwood Shale Member, named by Drake (1893, p. 389–391) for exposures near Brownwood, is 225–300 feet thick in central and southern Brown County (Eargle, 1960, p. 64). It consists dominantly of gray to red shale and lenticular beds of sandstone, and it contains a few thin beds of limestone and calcareous shale in the lower part. About 50 feet below the top of the member there is a zone containing numerous marine fossils and a thin bed that is a coquina of fusulinids.

The Adams Branch Limestone Member was named by Drake (1893, p. 391) for rocks that crop out along the headwaters of Adams Branch west of Brownwood. The following stratigraphic section was measured by the writer in 1963. The rocks exposed in this section are fairly typical of outcrops of the member in Brown County, and the thickness of about 36 feet is in close agreement with that reported by Drake (1893, p. 391).

Section of the Adams Branch Limestone Member of the Graford Formation in cuts of the Gulf, Colorado and Santa Fe Railway along Adams Branch, 3 miles west-southwest of the traffic circle in Brownwood, Tex.

	ft
Top of Adams Branch Limestone Member.	
Limestone, poorly exposed, locally concealed	10 (est.)
Limestone, light-olive-gray, fine calcarenite; wavy bedded in lower 12 ft; beds 6–8 in. thick; medium- to light-gray shale partings between limestone beds; beds between 12 ft above base and top of unit are evenly bedded and are 6–18 in. thick, averaging about 1 ft thick; fusulinids are common in lower 14 ft and at the top of the unit	22
Limestone, yellowish-gray, fine calcarenite; locally contains minor amounts of pyrite; beds about 1 ft thick; contains algal plates and sparse fusulinids	2
Concealed; probably limestone to top of Brownwood Shale Member of the Graford Formation	2 (est.)
Total Adams Branch Limestone Member	36

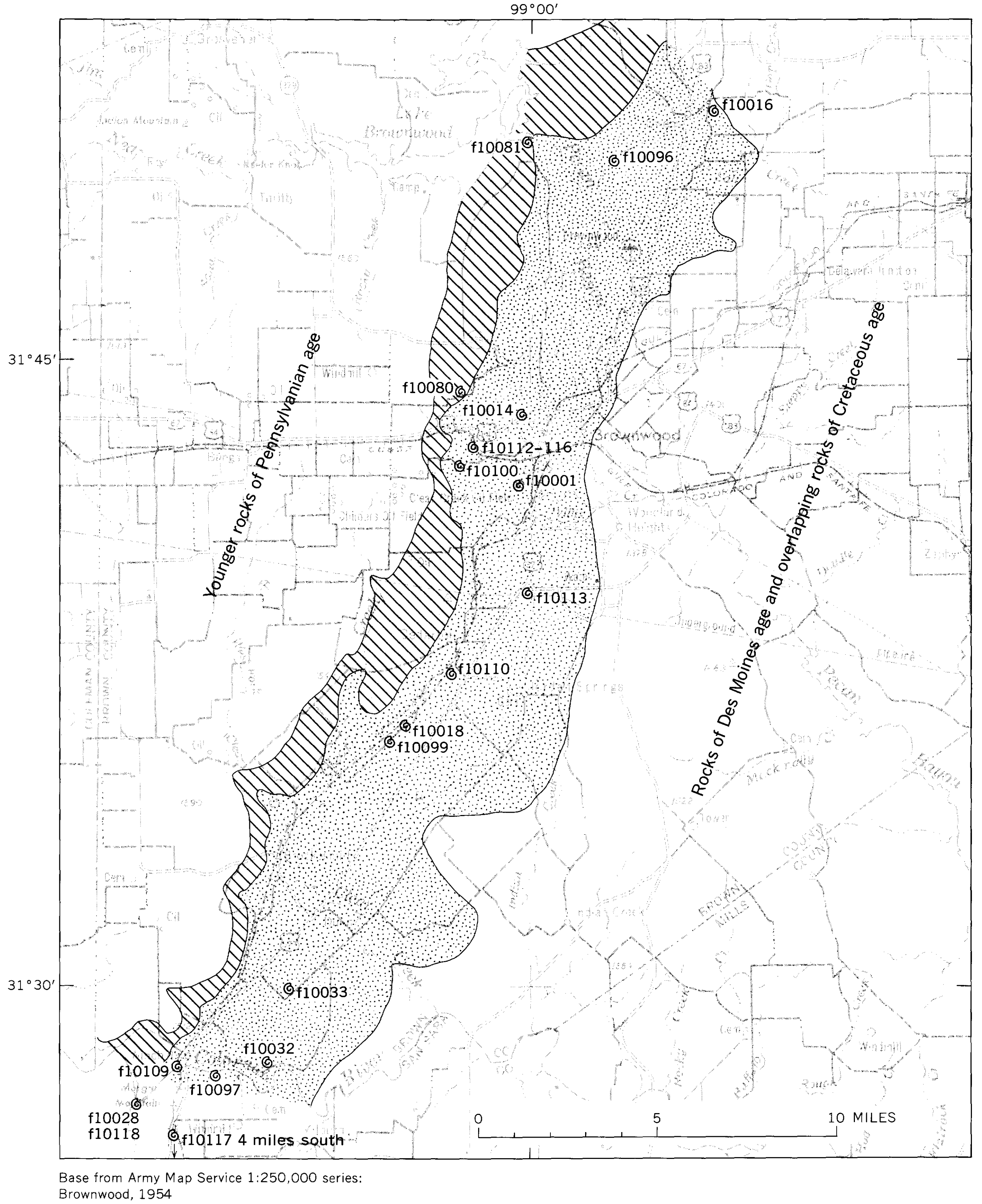


FIGURE 1.—Generalized outcrop areas of the Graford Formation (stippled) and the Winchell Limestone (crosshatch) in Brown County, Tex (from Cheney and Eargle, 1951). Numbers refer to localities from which collections of fusulinids were made.

The Cedarton Shale Member, named by Drake (1893, p. 391–392) for exposures near Cedarton, is 15–25 feet thick. Exposures of the Cedarton are generally limited to roadcuts and stream embankments. According to Eargle (1960, p. 65), gray shale near the base of the Cedarton grades upward into red shale containing lenticular beds of sandstone. Thin beds of argillaceous limestone occur near the middle of the member, but fusulinids have been found in these beds only in northern McCulloch County.

The Winchell Limestone was named by Nickell (1938, p. 105) and was defined by him as the uppermost member of the Graford Formation. He used the name for a "group of thin limestones separated by thick shale beds and thin sandstones in the Winchell area, in Brown County * * *" Eargle (1960, p. 63, 65) redefined the Graford Formation, restricting it to beds beneath the Winchell Limestone and elevated the Winchell to formational rank. According to Eargle, the Winchell is about 100 feet thick and consists of about one-third limestone, in two sequences of resistant beds, separated by shale. Fusulinids have been found at only two localities, both in the upper part of the Winchell.

PREVIOUS INVESTIGATIONS

Little information has been published on the fusulinid faunas from rocks of the Canyon Group. White (1932) described and illustrated several species of fusulinids from the Pennsylvanian and lower Permian rocks of central Texas, and he briefly discussed their stratigraphic distribution. Myers (1960) illustrated, but did not describe several species of fusulinids from the Canyon Group, and related them to the stratigraphic sequence. Myers (1966) described a new species of *Oketaella* from the Adams Branch Limestone Member of the Graford Formation. Other information has been restricted to incidental mention of fusulinids by various workers in conjunction with stratigraphic studies of the region.

ACKNOWLEDGMENTS

The stratigraphic nomenclature used in this report is the revised terminology prepared by Eargle (1960), which is based on his geologic mapping in Brown and Coleman Counties and on that by Stafford (1960) and Terriere (1960, 1963). Much of the fusulinid material used in this report was collected by Eargle during his geologic mapping.

DESCRIPTION OF SPECIES

All figured specimens (pls. 1, 2) have been deposited at the U.S. National Museum. All localities mentioned in the text are plotted on figure 1 and are described on pages 14 and 16.

Measurements of specimens used to describe the various species have been plotted on semilogarithmic graphs (figs. 2–8). Graphical presentation of the data has been used in preference to the more conventional tabulation of data because the writer believes the former to be easier to compare and interpret and less susceptible to error in transcription. Semilogarithmic graphs were used in preference to nonlogarithmic graphs because, as pointed out by Burma (1942, p. 742), growth in organisms follows "more or less closely a logarithmic function." By plotting the data on a logarithmic scale, measurements of the inner volutions are given prominence proportionate to those of the outer volutions.

Terminology used in the descriptions of species is that of Dunbar and Henbest (1942, p. 35–48). The morphology of the fusulinid test and definition of terms are also given by Thompson (1964, p. C360–C381).

Genus OKETAELLA Thompson, 1951

Oketaella earglei Myers, 1966

Plate 1, figures 10–13

Staffella? sp. Myers, 1960, pl. 17, fig. 25.
Oketaella earglei Myers, 1966, p. B47–B50.

Description.—A small, subspherical to inflated fusiform species with rounded ends and a maximum length of about 0.9 mm (millimeter) and a maximum width of about 0.6 mm. Average length and width of 30 specimens are 0.7 mm and 0.5 mm, respectively, in mature specimens of two to three volutions.

The height of the volution increases from an average of 0.037 mm in the first whorl to 0.053 mm in the second, to 0.090 mm in the third. The form ratio averages 1.2 in the first whorl and 1.4 in the second and third whorls.

The proloculus is large for the genus. Its external diameter ranges from 0.085 to 0.158 mm and averages 0.124 mm. It is generally spherical, although it may be subquadrate in cross section. The wall of the proloculus is about 0.012 mm thick.

The chomata are low and broad. The tunnel is poorly defined. The tunnel angle averages about 33° in the first volution and about 38° in the second.

The septa are plane except in the polar regions where the fluting may be very weak or absent. Septal pores have not been noted. The number of septa ranges from 7 to 9 in the first volution, 11 to 15 in the second, and is about 18 in the third.

The spiral wall has an average thickness of 0.011 mm in the first volution, 0.016 mm in the second, and 0.018 mm in the third. It consists of a thin tectum, about 0.0063 mm thick, and a keriotheca about 0.0093 mm thick in the outer whorl. Ten alveoli occupy about 0.080 mm.

Discussion.—*Oketaella earglei* differs from other described species of *Oketaella* chiefly by its low and broad chomata and larger proloculus.

Age and distribution.—The illustrated specimens are from the upper part of the Adams Branch Limestone Member of the Graford Formation at locality f10109. Other specimens of this species have been noted in the upper part of the member elsewhere in Brown County and vicinity. Specimens referable to this species have also been noted in the Winchell Limestone; however, they are very sparse in that unit.

Figured specimens.—Holotype, USNM 642564; paratypes, USNM 642560, 642561; figured specimen USNM 686755.

Genus KANSANELLA Thompson, 1957

Kansanella voluminosa Myers, n. sp.

Plate 1, figures 1–9; text figure 2

Kansanella cf *K. neglectus* (Newell). Myers, 1960, p. 43, pl. 16, fig. 6.

Kansanella ex gr. *K. osagensis* (Newell). Myers, 1960, p. 43, pl. 16, figs. 7, 8.

Description.—An elliptical to subcylindrical species, with bluntly rounded to pointed ends, that averages about 8.5 mm long and 2.3 mm wide in mature specimens. Maximum and minimum length of 30 specimens was 11.2 mm and 6.4 mm, respectively. Maximum and minimum width of 33 specimens was 3.0 mm and 1.8 mm respectively. The form ratio of the exterior whorl ranges from 2.6 to 4.4 and averages about 3.7.

Most mature specimens have seven volutions, but some have six or, more rarely, eight. The height of the volution increases rapidly from an average of 0.048 mm in the second volution to 0.218 mm in the seventh. In the eighth volution, the height averages 0.240 mm and may be as much as 0.360 mm. The form ratio increases at a fairly uniform rate from about 1.4 in the first volution to 3.9 in the eighth volution.

Most proloculi are spherical. The external diameter of 45 proloculi ranged from 0.073 to 0.194 mm and averaged 0.128 mm. The thickness of the proloculus wall of 39 specimens ranged from 0.006 to 0.024 mm and averaged 0.014 mm.

The tunnel angle increases uniformly from about 18° in the first volution to 27° in the third; it increases to an average of 36° between the third and fourth volutions. Thence, it increases uniformly to 58° in the seventh volution. An angle as high as 93° has been recorded in the sixth volution. The path of the tunnel is generally straight, although in some specimens there may be lateral shifting.

The chomata are well developed in all whorls except the penultimate. In the juvenile whorls they are low broad ridges that extend to the poles; in later whorls they are distinct asymmetric leveelike ridges having the steep side toward the tunnel. The chomata generally occupy 40–70 percent of the height of the chamber.

The septa are strongly and irregularly fluted. The fluting is most nearly regular in the inner whorls, and it becomes extremely variable in intensity in the outer whorls. In some specimens, the fluting in the outer two or three whorls may be very strong; in others, the fluting may be plane. Septal pores are not common; however, they have been noted in a few specimens in the outermost whorls. The pores range from 0.012 to 0.024 mm in diameter. The number of septa increases from 9 or 10 in the first whorl to about 30 in the seventh whorl.

The spiral wall increases in thickness from an average of 0.011 mm in the first volution to 0.067 mm in the eighth volution. It consists of a thin tectum and a keriotheca in which 10 alveoli occupy 0.122–0.150 mm in the outer volutions.

Measurements of this species are shown in figure 2.

Discussion.—*Kansanella voluminosa* is similar to *K. neglecta* (Newell), 1934; however, *K. voluminosa* is larger, has a lower form ratio, and has a greater height of volution in all whorls. From *K. plicatula* (Merchant and Keroher), 1939, it may be distinguished by its slightly smaller size, lower form ratio, larger proloculus, and by its more strongly developed chomata. The intensity of the septal fluting of *K. voluminosa* is most similar to that of *K. osagensis* (Newell), however, *K. osagensis* is much more slender, has a smaller proloculus, and has a higher form ratio in all volutions.

Age and distribution.—This species has been found in the lower part of the Adams Branch Limestone Member near Brownwood at localities f10001, f10013, f10112, f10113, and f10114. Specimens referable to the genus *Kansanella* have not been found above the basal few feet of the Adams Branch Limestone Member in Central Texas.

Types.—Holotype, USNM 686749; paratypes, USNM 686746–686748, 686750–686754.

Genus TRITICITES Girty, 1904

Triticites procerus Myers, n. sp.

Plate 2, figures 1–6, 8; text figure 3

Description.—A slender fusiform species, with rounded to slightly pointed ends, that averages 5.7 mm in length and 1.6 mm in width in mature specimens of six to seven volutions. The form ratio of the exterior whorl ranges from 3.2 to 5.0 and averages 3.7. The axis is straight or slightly arcuate.

Most mature specimens have six volutions, but some have five or seven. The rate of coiling is generally uniform from the second volution to maturity, although

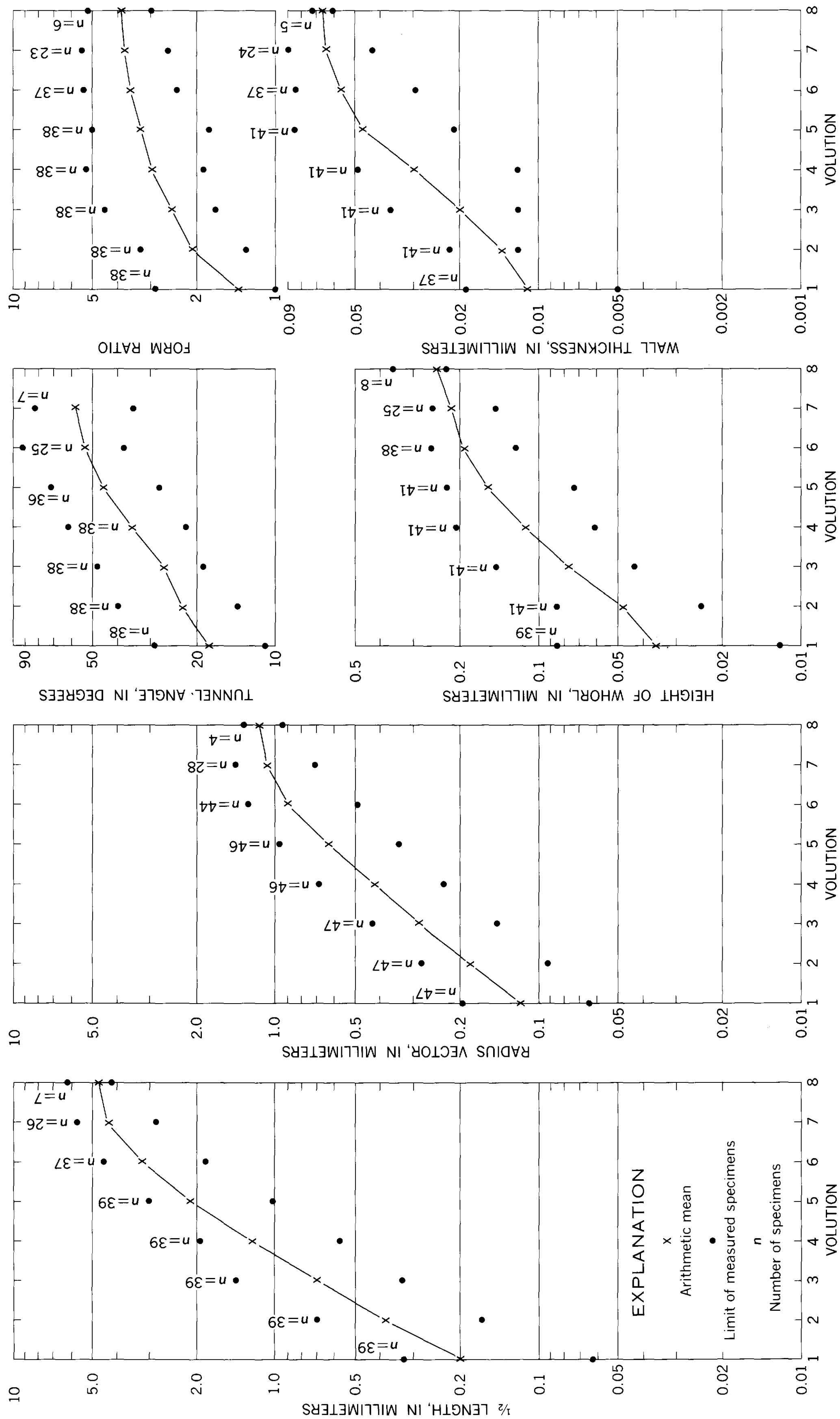


FIGURE 2.—Measurements of *Kansanella voluminosa* Myers, n. sp.

the seventh whorl may be somewhat more tightly coiled than the preceding ones. The form ratio ranges from 1.0 to 1.9 in the first whorl to a maximum of 4.6 in the fifth whorl, 4.2 in the sixth, and 5.0 in the seventh.

The proloculus is spherical; its outside diameter ranges from 0.056 to 0.126 mm and averages 0.099 mm. The thickness of the proloculus wall averages 0.011mm.

The tunnel is broad. The tunnel angle ranges from an average of 23° in the first volution to an average of 67° in the sixth. The greatest change in tunnel angle is between the third and fourth volutions where the angle averages 34° and 47°, respectively. The path of the tunnel is relatively straight; however, there may be slight lateral shifting in the outermost whorls.

The chomata are well developed in all whorls but the penultimate. They generally occupy about half the height of the chamber, and in the earlier whorls extend almost to the poles of the volution. In the later whorls, the chomata are less broad and form distinct leveelike ridges on the floor of the volution.

The septa in the axial region of the test may be weakly and irregularly fluted, but are generally plane except in the polar regions where they are weakly fluted. Septal pores were noted in the outer whorls of a few specimens, where they range from 0.007 to 0.018 mm in diameter. The number of septa in a single specimen gradually increases from 10 in the first volution to 26 in the sixth (pl. 2, figs. 6, 8).

The spiral wall is thin, ranging from 0.007–0.012 mm in the first volution to 0.050–0.084 mm in the outer whorl of mature specimens. It consists of a thin tectum and a keriotheca in which 10 alveoli occupy 0.087–0.136 mm in the sixth whorl.

Measurements of this species are shown in figure 3.

Discussion.—*Triticites procerus* is one of the earlier species referable to the genus *Triticites.* It is characterized by the very thin wall, by the fusulinelloid chomata in the early whorls, by the small proloculus, by the close spacing and small size of the alveoli, and by the weak to plane septal fluting. *T. procerus* is most similar to *T. ohioensis* Thompson, 1936 (of Thompson, 1957), but is somewhat smaller, has a larger proloculus, larger tunnel angle, and thicker spiral wall.

Age and distribution.—*Triticites procerus* has been found in a limestone lentil about 60 feet above the base of the Brownwood Shale Member at localities f10016 and f10097. It has also been found at the typical sections of the Palo Pinto Limestone of Plummer and Hornberger (1935), in Palo Pinto County, at locality f10098.

Types.—Holotype USNM 686756; paratypes USNM 686757–686762.

Triticites procerus Myers, var. A

Plate 2, figures 7, 13; text figure 4

Description.—A subcylindrical to fusiform form with rounded ends; mature specimens average 6.6 mm in length and 1.8 mm in width. The form ratio of the exterior whorl ranges from 2.8 to 4.6 and averages 3.9.

Most mature specimens have six whorls. The rate of coiling increases rather uniformly from the first whorl to the last. The form ratio increases uniformly from 2.2 in the first whorl to 2.6 in the third; it increases to 3.3 in the fourth whorl and to 4.0 in the fifth. In most specimens, the form ratio decreases to an average of 3.9 in the sixth whorl.

The proloculus is spherical; its external diameter ranges from 0.097 to 0.170 mm and averages 0.122 mm.

The tunnel angle increases more or less uniformly from an average of 24° in the first whorl to 75° in the sixth. The path of the tunnel is straight.

The chomata are well developed in all whorls but the penultimate, where they may be poorly developed. In the juvenile whorls, the chomata are broad ridges that may extend to the poles; in later whorls, they form distinct leveelike symmetric to slightly asymmetric ridges. They generally occupy about half the height of the chamber.

The septa are irregularly fluted. The fluting is moderate to strong in the polar regions of the test and weak to moderate in the equatorial regions. No septal pores were noted. The number of septa increases from about 10 in the first volution to about 23 in the fifth.

The spiral wall is about 0.012 mm thick in the first volution. It increases uniformly in thickness from 0.014 mm in the second volution to an average of 0.055 mm in the sixth. It consists of a thin tectum and a keriotheca in which 10 alveoli occupy 0.136–0.152 mm in the fifth volution.

Measurements of this species are shown in figure 4.

Discussion.—*Triticites procerus* Myers, var. A, from the Cedarton Shale Member differs from typical *T. procerus* of the Brownwood Shale Member (pl. 2, figs. 1–6, 8) only in minor details, but these differences apparently have stratigraphic value; hence, the Cedarton form has been described separately from the Brownwood form. From the Brownwood form of *T. procerus,* the Cedarton form differs in having a slightly greater form ratio, somewhat larger proloculus, slightly coarser alveolar texture in the keriotheca, and minor variance in the tunnel angle. The differences between the two forms are so slight that the writer does not believe that they are of subspecific value.

Age and distribution.—The material came from about the middle of the Cedarton Shale Member,

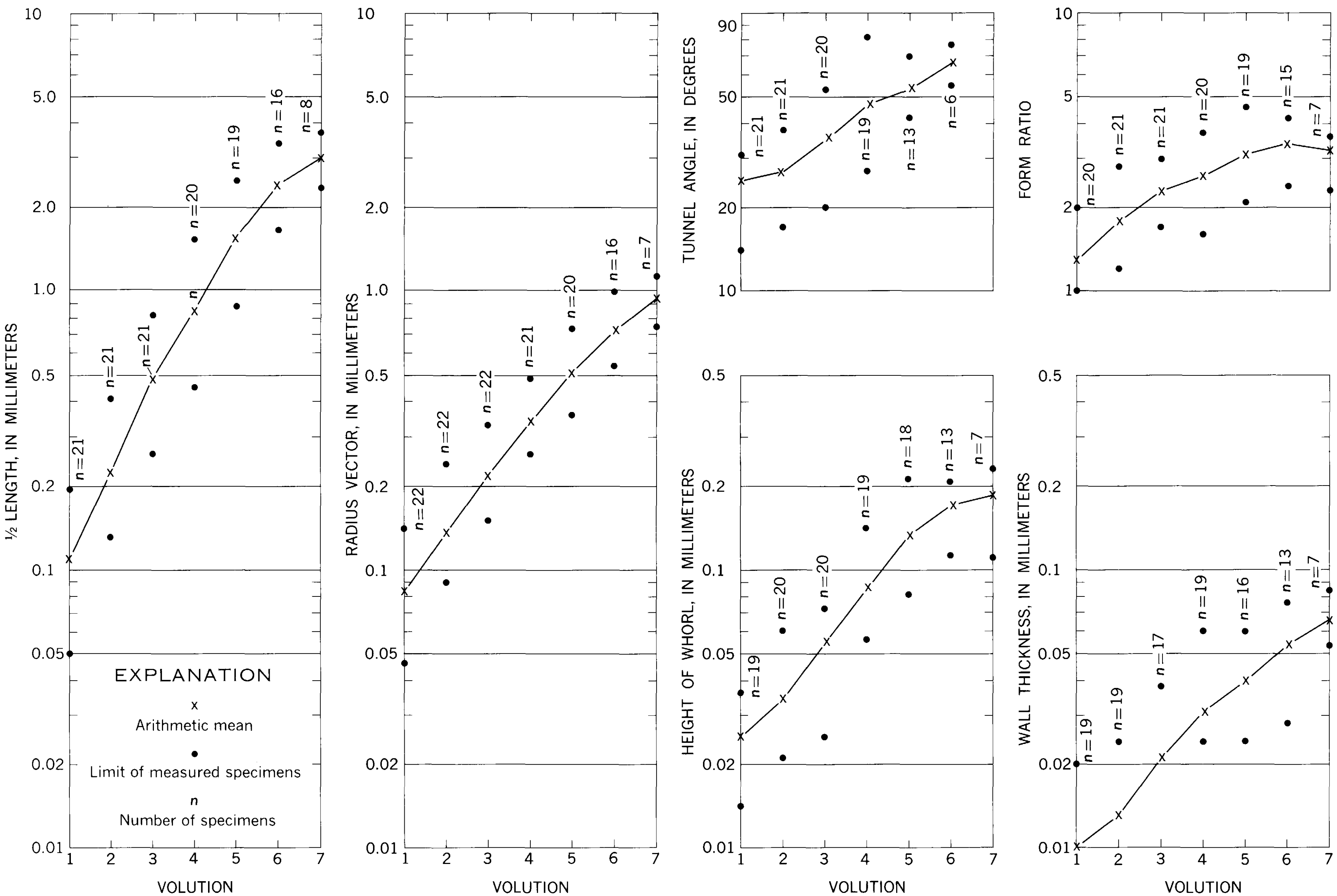


FIGURE 3.—Measurements of *Triticites procerus* Myers, n. sp. Lower limit of volutions 1, 2, and 3 on wall thickness graph is 0.007 mm.

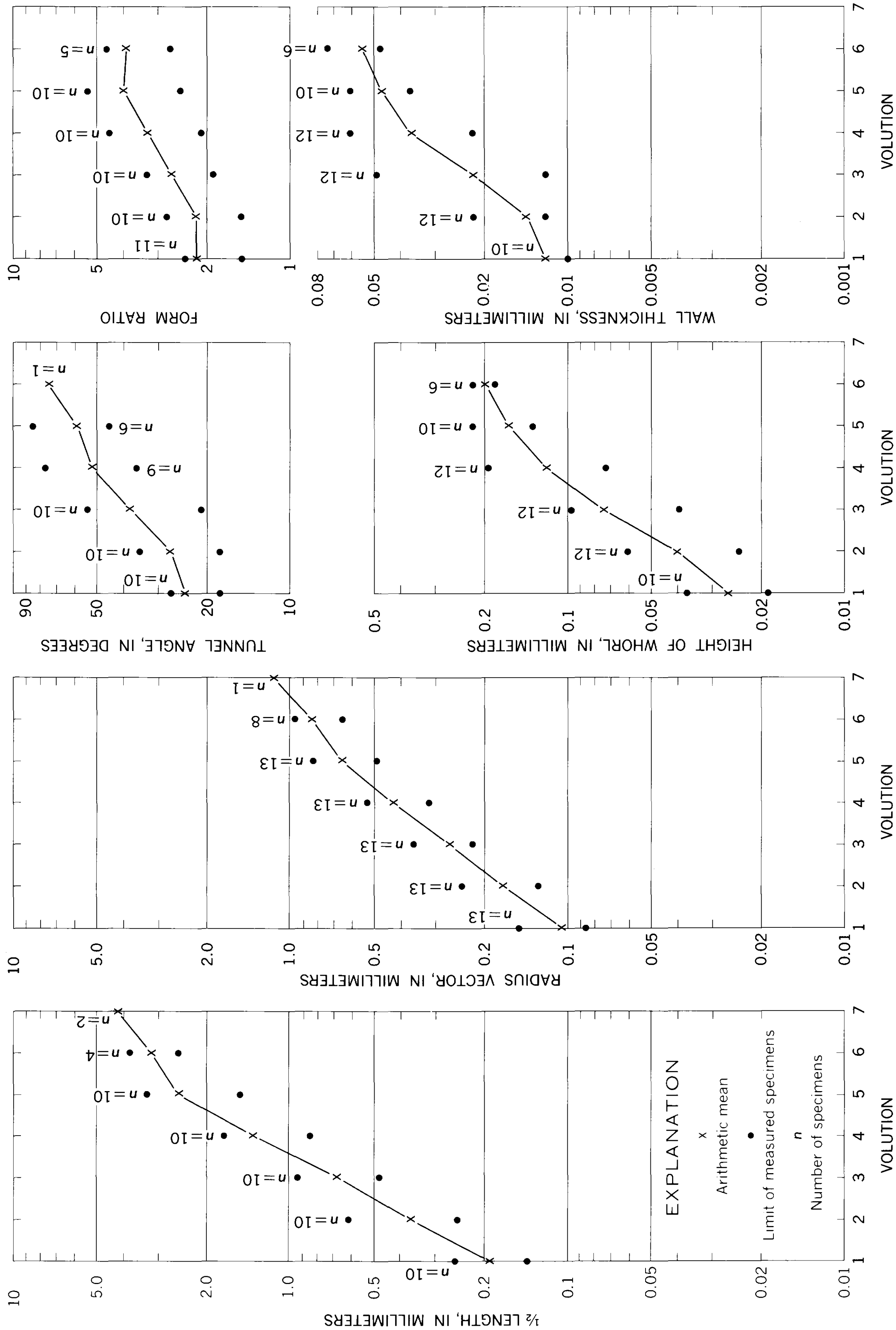


FIGURE 4.—Measurements of *Triticites procerus* Myers, var. A.

south-southwest of Mercury, McCulloch County, locality f10117.

Figured specimens.—USNM 686763, 686764.

Triticites nebraskensis Thompson, 1934

Plate 2, figures 9–11, 14, 15; text figure 5

Triticites irregularis (Schellwien and Staff, 1912, first form). White, 1932, p. 47–49, pl. 4, figs. 1–3.
Triticites irregularis (Schellwien and Staff, 1912, second form)? White, 1932, p. 49–50, pl. 4, figs. 4–6.
Triticites ex gr. *T. irregularis* (Schellwien and Staff, 1912). Myers, 1960, pl. 16, figs. 14, 15.

Description.—An elliptical to fusiform species, with rounded ends, which in mature specimens of six whorls averages 3.9 mm in length and 1.2 mm in width. The form ratio of the exterior whorl of mature specimens ranges from 2.4 to 3.8 and averages 3.0. The axis is straight to slightly arcuate.

Most mature specimens have six whorls, but some have five or seven. The rate of coiling is uniform in the first five whorls, but declines somewhat in the sixth. The form ratio ranges from 1.0 to 2.4 in the first whorl to a maximum of 4.2 in the fifth. The form ratio shows the greatest rate of increase in the first three whorls—from an average of 1.3 in the first to an average of 2.5 in the third. It increases more slowly, to an average of 3.2, in the sixth whorl.

The proloculus is spherical; its external diameter ranges from 0.061 to 0.122 mm and averages 0.097 mm. The thickness of the proloculus wall averages 0.013 mm.

The tunnel is broad. The tunnel angle ranges from an average of 21° in the first volution to an average of 50° in the fourth. A single specimen measured 74° in the fifth volution. The tunnel angle increases at a more or less uniform rate throughout the test. The path of the tunnel is relatively straight; however, there may be slight lateral shifting in the outermost whorls.

The chomata are well developed. They generally occupy from two- to three-fifths of the height of the chamber, and in the earlier whorls may extend almost to the poles of the volution. In the later whorls, though still broad, the chomata usually do not extend more than a fraction of the distance to the poles, and they form distinct leveelike ridges on the floor of the volution.

The septa are plane throughout the axial regions of the test but become weakly fluted in the polar extremities. No septal pores were observed. The number of septa increases gradually from about 7 in the first volution to about 17 in the fifth.

The spiral wall is thin, ranging from 0.012 to 0.024 mm in thickness in the early volutions. It gradually increases in thickness to about 0.050 mm in the fifth whorl. It consists of a thin tectum and keriotheca in which 10 alveoli occupy 0.136–0.152 mm in the sixth whorl. Preservation of the alveoli is such that they are rarely discernible.

Measurements of this species are shown in figure 5.

Discussion.—The primitive character of *Triticites nebraskensis*, one of the earlier species of the genus *Triticites*, is indicated by the very thin wall, by the fusulinelloid chomata in the early whorls, by the small proloculus, and by the close spacing of the alveoli. *T. nebraskensis* may be distinguished from the other members of this group chiefly by its small size and by its elliptical axial cross section.

Triticites nebraskensis from the Brownwood Shale Member has a thicker wall and larger tunnel angle in all volutions than the form of *T. nebraskensis* from the Cherryvale Shale of Iowa and Missouri as described by Thompson (1957, p. 319). The size of the test, the form ratio, and the number and height of volutions are about the same in both forms. The average diameter of the proloculus of the Cherryvale Shale form described by Thompson is 0.072 mm; that of the Brownwood Shale Member form is 0.097 mm. The above differences between the two forms are slight; they are believed to be due to geographic or environmental factors, and are not of specific or subspecific value.

Age and distribution.—*Triticites nebraskensis* has been found in a 6-inch-thick argillaceous limestone bed, a coquina of fusulinids assigned to this species, about 50 feet below the top of the Brownwood Shale Member of the Graford Formation at locality f10014, west of Brownwood. It has also been found in less abundance in a limestone lentil about 60 feet above the base of the Brownwood Shale Member at locality f10032, and at locality f10096.

Figured specimens.—USNM 686765–686769.

Triticites submagdalium Myers, n. sp.

Plate 2, figures 12, 16–19; text figure 6

Triticites irregularis Myers, 1960, pl. 16, figs. 16–17.

Description.—An elongate subcylindrical species, with bluntly rounded ends, as much as 8 mm long and 2 mm wide in mature specimens of six volutions. The form ratio of the exterior whorl ranges from 3.6 to 5.9 and averages 4.3. The axis is straight to slightly arcuate.

Most mature specimens have six volutions. The rate of coiling is generally uniform from the second whorl to maturity. The form ratio increases uniformly from an average of 1.7 in the first volution to an average of 4.2 in the fifth, and decreases to an average of 4.1 in the sixth.

The proloculus is spherical; its external diameter ranges from 0.098 to 0.146 mm and averages 0.122 mm. The thickness of the proloculus wall averages 0.012 mm.

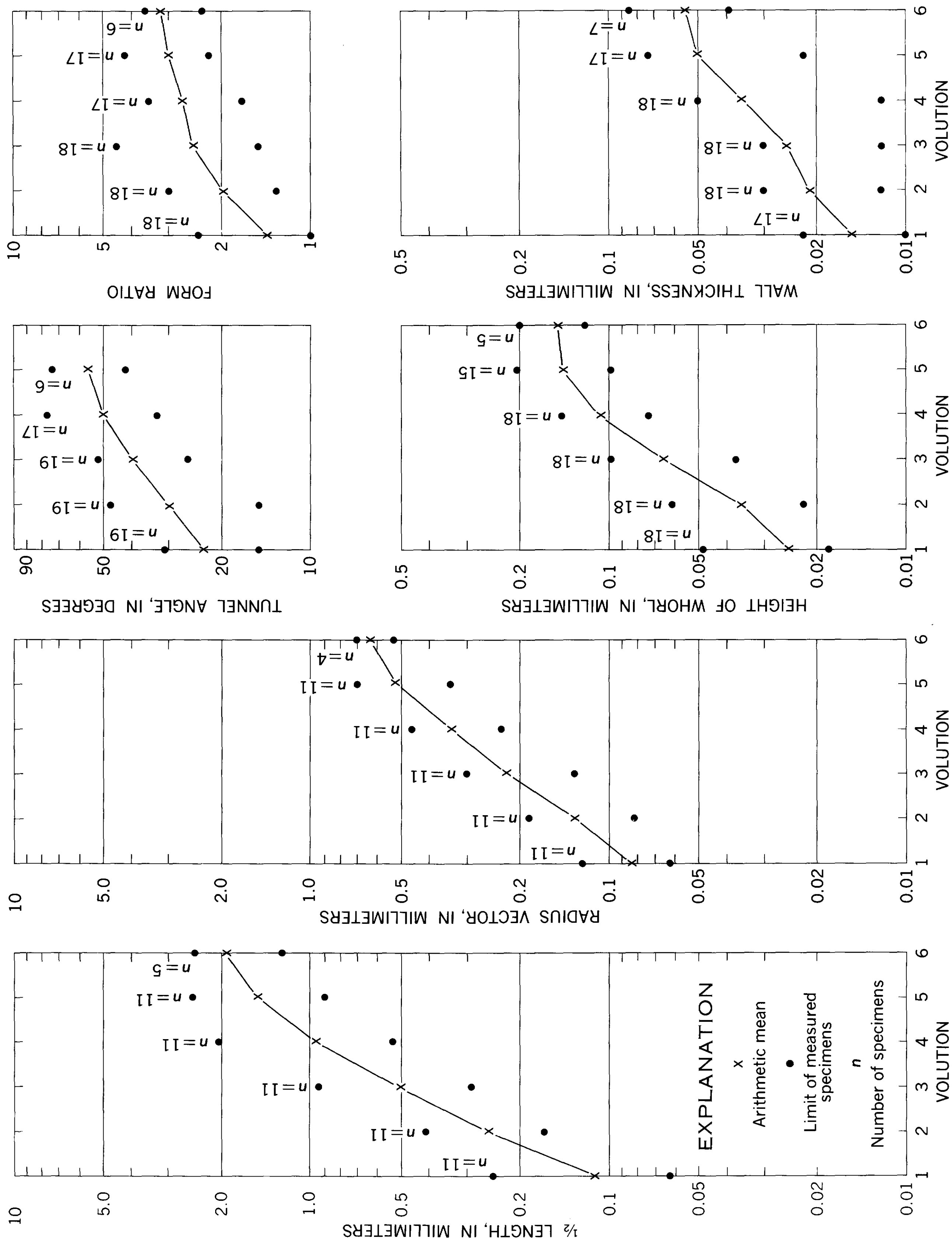


FIGURE 5.—Measurements of *Triticites nebraskensis* Thompson, 1934.

The tunnel is broad. The tunnel angle increases uniformly from an average of 30° in the first volution to 48° in the third. It increases abruptly to 67° in the fourth volution and is about 80° in the fifth. The path of the tunnel displays lateral shifting in the outer whorls of most specimens.

The chomata are low and broad. In the earlier whorls the epithecal deposits that form the chomata extend to the poles. In later whorls, these deposits form distinct leveelike ridges on either side of the tunnel. The chomata occupy about half the height of the chamber in the earlier whorls; they decrease in height in later whorls, and they may be absent in the penultimate whorl.

The septa are weakly to moderately fluted along the axis and in the polar regions. They are plane to weakly fluted in the outer whorls. The number of septa gradually increases from 7 to 10 in the first volution to about 20 in the sixth. Septal pores were not noted.

The spiral wall is about 0.012 mm thick in the first volution and gradually increases to about 0.060 mm in the sixth. The spirotheca consists of a thin tectum and a keriotheca in which 10 alveoli occupy 0.136–0.174 mm in the outer whorls of mature specimens.

Measurements of this species are shown in figure 6.

Discussion.—Triticites submagdalium is a member of the group of *T. irregularis.* It most closely resembles *T. procerus;* however, it may be distinguished from that species by its somewhat larger form ratio, by the much larger tunnel angle in the fifth whorl, and by the more rapid rate of uncoiling. From *T. nebraskensis* it may be distinguished by its greater size, greater form ratio, faster rate of uncoiling, and greater tunnel angles.

Age and distribution.—This species has been found in the Brownwood Shale Member of the Graford Formation in a limestone lentil about 60 feet above the base of the member at locality f10033.

Types.—Holotype, USNM 686771; paratypes, USNM 686770, 686772–686774.

Triticites muscerda Myers, n. sp.

Plate 2, figures 20–27, 29, 31; text figure 7

Triticites ohioensis Thompson, 1936. Myers, 1960, p. 43, pl. 16, figs. 1–4.

Description.—An elliptical to subcylindrical species with rounded ends. It averages 6.2 mm in length and 1.8 mm in width. The form ratio of the exterior whorl ranges from 2.4 to 5.1 and averages 3.4.

Most mature specimens have six whorls, but they may have seven or eight. The rate of coiling increases at a uniform rate to the sixth whorl and decreases somewhat in the outer whorls. The form ratio increases uniformly from an average of 1.8 in the first whorl to an average of 3.3 in the fifth; the rate decreases to an average of 3.6 in the seventh whorl.

The proloculus is usually spherical, although in a few specimens it may be elliptical. The outside diameter ranges from 0.097 to 0.215 mm and averages 0.129 mm. The wall of the proloculus has an average thickness of about 0.012 mm.

The tunnel angle increases at a fairly uniform rate from about 21° in the first whorl to about 57° in the fifth; the rate of increase diminishes in the sixth whorl where the average is 61°. A single specimen has a tunnel angle of 72° in the seventh whorl. The path of the tunnel is generally straight, although lateral shifting of the tunnel has been noted in the outer whorls.

The chomata are well developed in all whorls but the penultimate. In the earlier whorls the chomata are broad ridges that extend to the poles of the volution; in the later whorls, the chomata form distinct leveelike ridges having the steep side toward the tunnel. They generally occupy from half to three-fourths of the height of the chamber.

The septa are weakly to moderately fluted; the strongest fluting is in the axial and polar regions of the inner whorls. Fluting may be absent in the outer whorls, especially in the equatorial regions of the test. Septal pores are sparse, occurring mostly in the outer whorls where they average 0.012 mm in diameter in the sixth whorl. The number of septa increases at an irregular rate from an average of 9 in the first whorl to an average of 26 in the sixth whorl. A single specimen had 28 septa in the seventh whorl.

The spiral wall increases in thickness from 0.012 mm in the first whorl to 0.056 mm in the sixth. It is composed of a thin tectum and a keriotheca in which 10 alveoli occupy 0.90–0.152 mm in the outer volutions of mature specimens.

Measurements of this species are shown in figure 7.

Discussion.—Triticites muscerda Myers, n. sp., most closely resembles *T. ohioensis* Thompson, 1936. *T. muscerda* has a larger proloculus and has fewer volutions and fewer septa per volution. From other members of the group of *T. irregularis, T. muscerda* may be distinguished by its larger size, its larger proloculus, and by the shape of the volutions in axial sections.

Age and distribution.—This species has been found near the top of the Adams Branch Limestone Member of the Graford Formation at many localities. The specimens used for description of this species came from localities f10018, f10028, f10099, f10100, f10110, f10115, and f10116.

Types.—Holotype, USNM 686778; paratypes, USNM 686775–686777, 686779–686784.

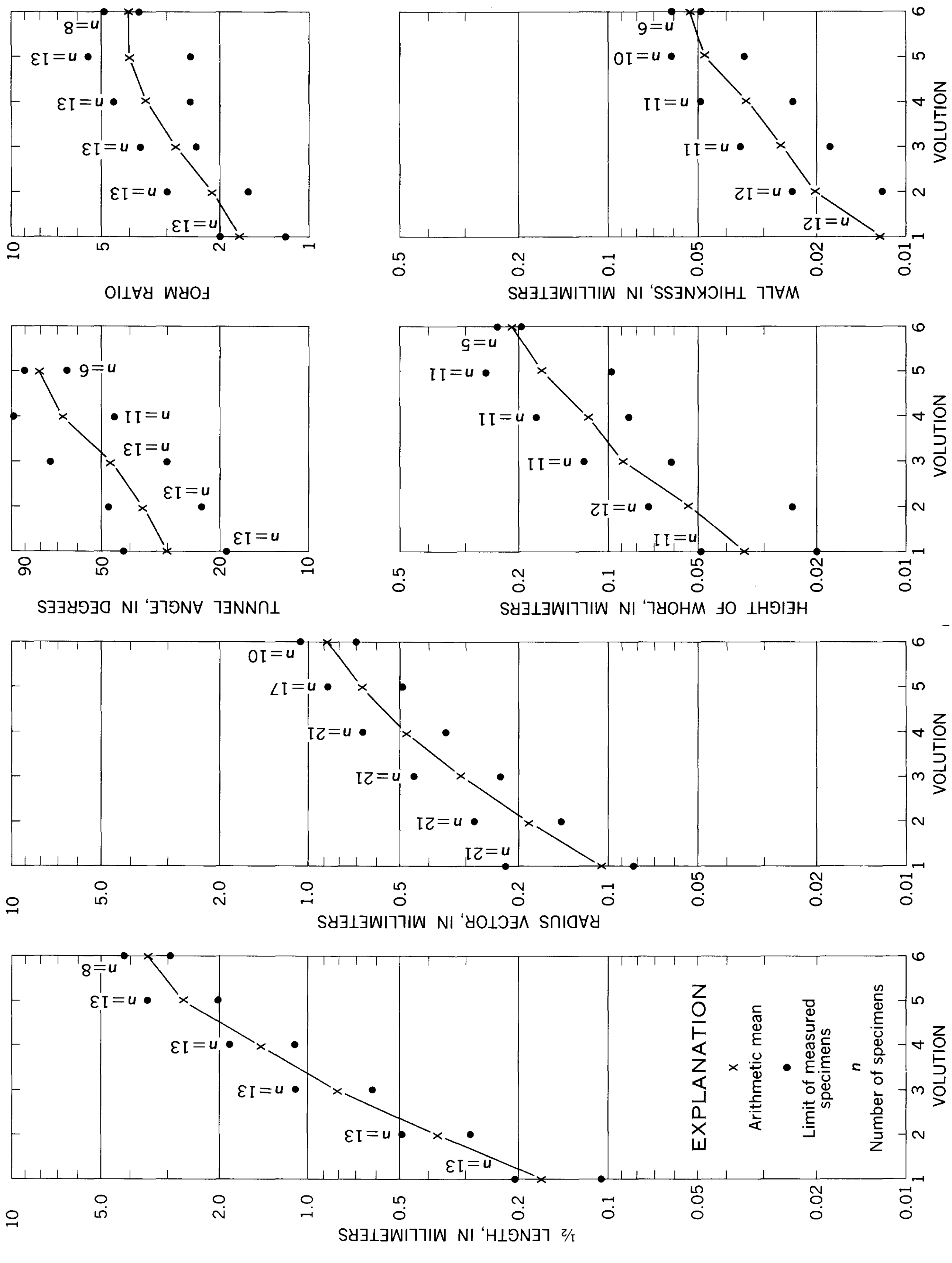


FIGURE 6.—Measurements of *Triticites submagdalium* Myers, n. sp.

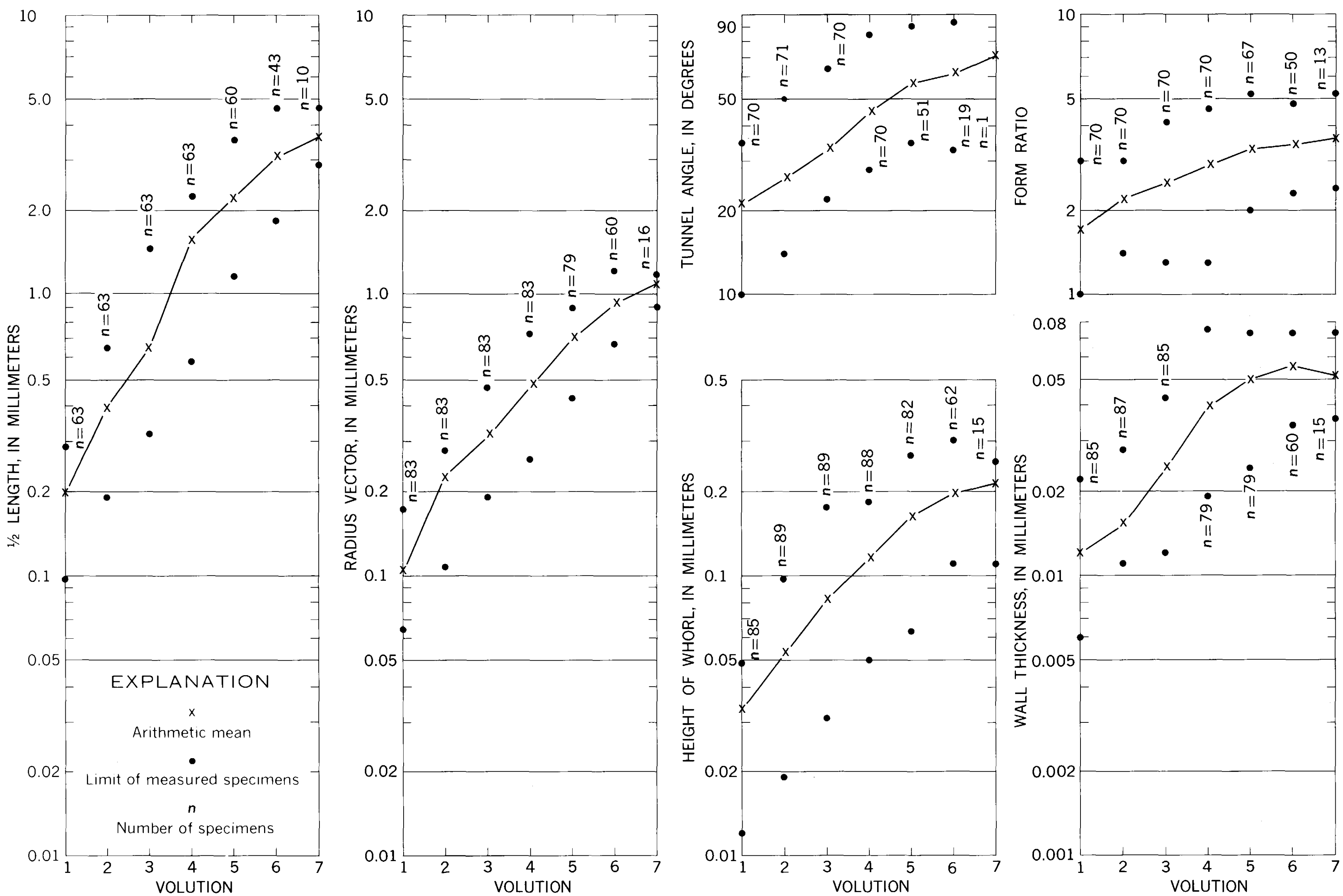


FIGURE 7.—Measurements of *Triticites muscerda* Myers, n. sp

Triticites exilimuratus Myers, n. sp.

Plate 2, figures 28, 30, 32–36; text figure 8

Triticites ex gr. *T. irregularis* (Schellwien and Staff), 1912. Myers, 1960, p. 43, pl. 17, figs. 19, 20, 22–24.

Description.—An elliptical fusiform to subcylindrical species with bluntly rounded to pointed ends; mature specimens average about 3 mm in length and about 1.1 mm in width. The form ratio of the exterior whorl ranges from 2.2 to 3.2 and averages 2.9.

Most mature specimens have five or six volutions. The rate of coiling increases in an almost parabolic curve from an average volution height of 0.021 mm in the first volution to an average volution height of 0.126 mm in the sixth volution. The form ratio increases uniformly from an average of 1.5 in the first volution to 2.8 in the sixth.

The proloculus is spherical; in 41 specimens the external diameter ranged from 0.055 to 0.110 mm and averaged 0.073 mm. In these specimens the thickness of the proloculus wall ranged from 0.008 to 0.012 mm and averaged 0.009 mm.

The tunnel angle increases from an average of 21° in the first volution to an average of 46° in the fifth. The path of the tunnel is generally straight.

The chomata are well developed. In the earlier whorls the chomata extend to the poles; in later whorls, they form distinct leveelike ridges having the steep side toward the tunnel. They generally occupy more than half the height of the chamber.

The septa are plane or weakly fluted in the equatorial regions of the test and moderately fluted in the polar regions. Septal pores have not been noted. The number of septa increases uniformly from an average of 9 in the first volution to an average of 24 in the sixth.

The spiral wall is composed of a thin tectum that is about 0.005 mm thick in the outer whorls, and an alveolar keriotheca in which 10 alveoli occupy 0.100–0.136 mm in the outer whorls. The wall is very thin for a triticite. Its thickness averages 0.007 mm in the first whorl and increases gradually to an average of 0.049 mm in the sixth whorl.

Measurements of this species are shown in figure 8.

Discussion.—*Triticites exilimuratus* differs from other members of the group of *T. irregularis* in being somewhat smaller and in having a lower form ratio, a smaller proloculus, a narrow tunnel that increases uniformly in width from the first volution to the outer volutions, and a thinner wall.

Age and distribution.—*Triticites exilimuratus* has been found in the Winchell Limestone at localities f10080 and f10081. Poorly preserved specimens referable to this species have also been found in the Cedarton Shale Member of the Graford Formation at locality f10118, at about the middle of the member. The Cedarton forms are somewhat smaller and usually have one less volution than the Winchell forms; in other characteristics, the forms are virtually the same.

Types.—Holotype, USNM 686785; paratypes, USNM 686786–686791.

COLLECTING LOCALITIES

The following register of collecting localities has been compiled in large part from notes taken by the collector and is arranged in stratigraphic sequence starting with the oldest units. Localities from the same member have been placed in numerical order. The "f" preceding the digits identifies the locality as a U.S. Geological Survey Foraminifera collecting locality; the localities are shown on figure 1.

Brownwood Shale Member of the Graford Formation

f10014. Brown County. Collected from a 6–in. limestone bed that is a fusulinid coquina, 53 ft below the top of the member. Roadcut of U.S. Highways 67 and 84 in steep hill overlooking Brownwood, 1 mile west of junction with State Highway 279 and crossing of Gulf, Colorado and Santa Fe Railway. Collected by D. H. Eargle, Apr. 20, 1950.

f10016. Brown County. Collected from 6–in. bed of impure ferruginous limestone, which is a coquina of fusulinids, and from overlying brown-weathering 4-in clay bed 0.7 mile northeast of Owens, 0.2 mile south of road crossing, in ditch on east side of road. Collected by D. H. Eargle, July 11, 1951.

f10032. Brown County. Fusulinids occur in gray-weathering limestone. North of east-trending road in badland type of topography, 2.1 miles S. 85° E. of Winchell. Collected by D. A. Myers, May 8, 1953.

f10033. Brown County. Limestone slightly above the middle of the Brownwood Shale Member. On old Brownwood-Brady highway, 0.7 mile northeast of right-angle bend of highway; 3.8 miles N. 55° E. of Winchell; 3.4 miles S. 15° E. of Brookesmith. Collected by D. H. Eargle and D. A. Myers, May 7, 1953.

f10096. Brown County. Fusulinid-bearing fossiliferous limestone about 2 ft thick. In bed of small dry creek 2.5 miles southwest of Owens on Cox and McGinnis Ranch (1951). Collected by D. H. Eargle, July 11, 1951.

f10097. McCulloch County. Calcareous siltstone and shale containing calcareous concretions. On south side of Colorado River, on river bend convex to the south; 0.2 mile southeast of junction of Colorado River and Crooked Branch (Rough Hollow); 0.7 mile southeast of Winchell; 0.1 mile east of old Winchell crossing on the Colorado River. Collected by D. A. Myers and D. H. Eargle, May 7, 1953.

f10098. Palo Pinto County. Typical sections of Palo Pinto Limestone (Plummer and Hornberger, 1935, p. 47). 4-in.-thick lenticular limestone ledge about midway up west wall of quarry, beneath a layer of bellerophontid and other gastropods, and brachiopods, mostly *Composita.* Collected by D. A. Myers, June 18, 1953.

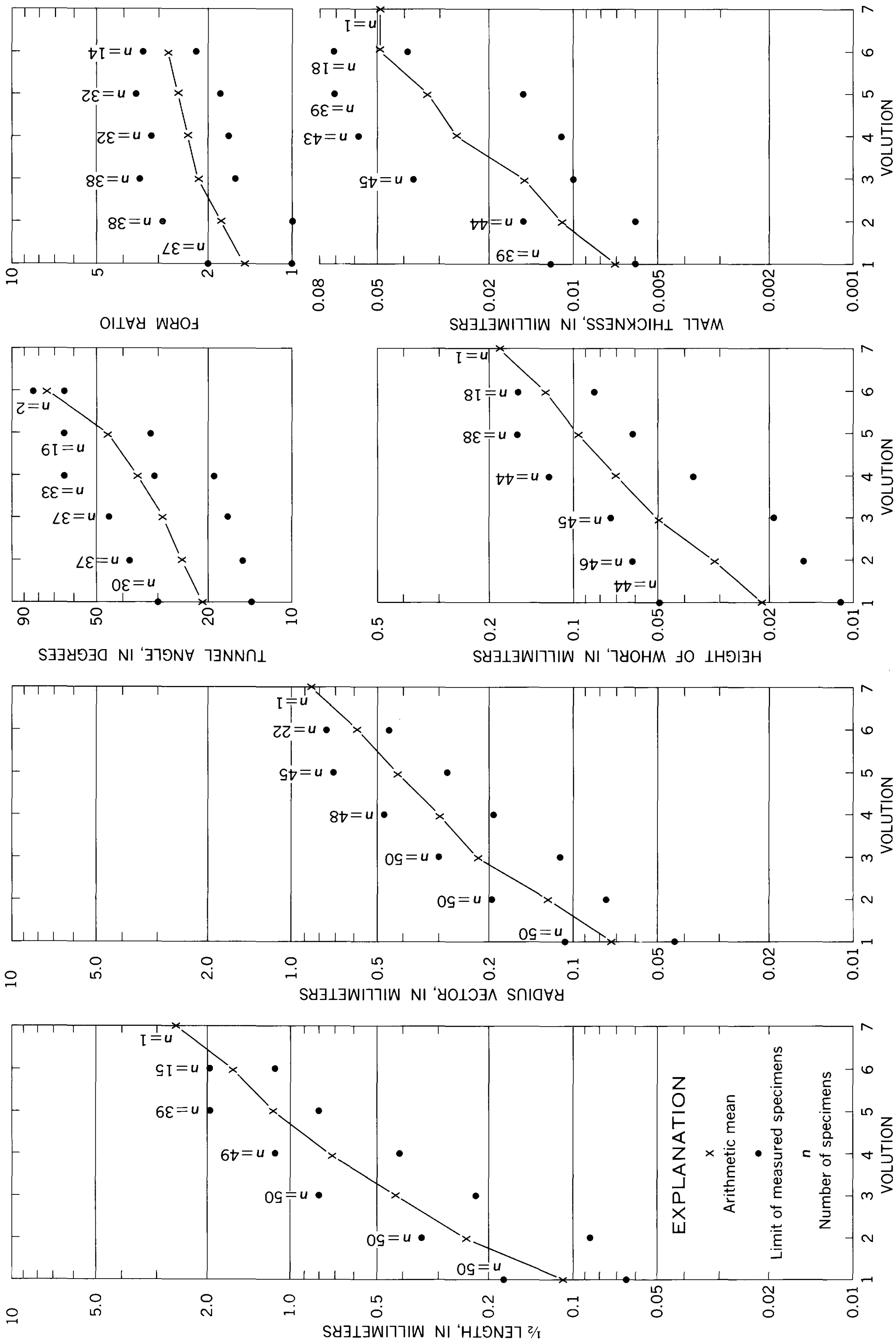


FIGURE 8.—Measurements of *Triticites exilimuratus* Myers, n. sp.

PLATES 1 and 2

PLATE 1

FIGURES 1–9. *Kansanella voluminosa* Myers, n. sp. (× 10) (p. C4).

1–5. Axial sections.

1. USNM 686746 from USGS loc. f10114, slide 8.
2. USNM 686747 from USGS loc. f10113, slide 3.
3. Note septal pores in the outer whorls. USNM 686748 from USGS loc. f10112, slide 5.
4. Holotype, USNM 686749 from USGS loc. f10114, slide 5.
5. USNM 686750 from USGS loc. f10112, slide 12.

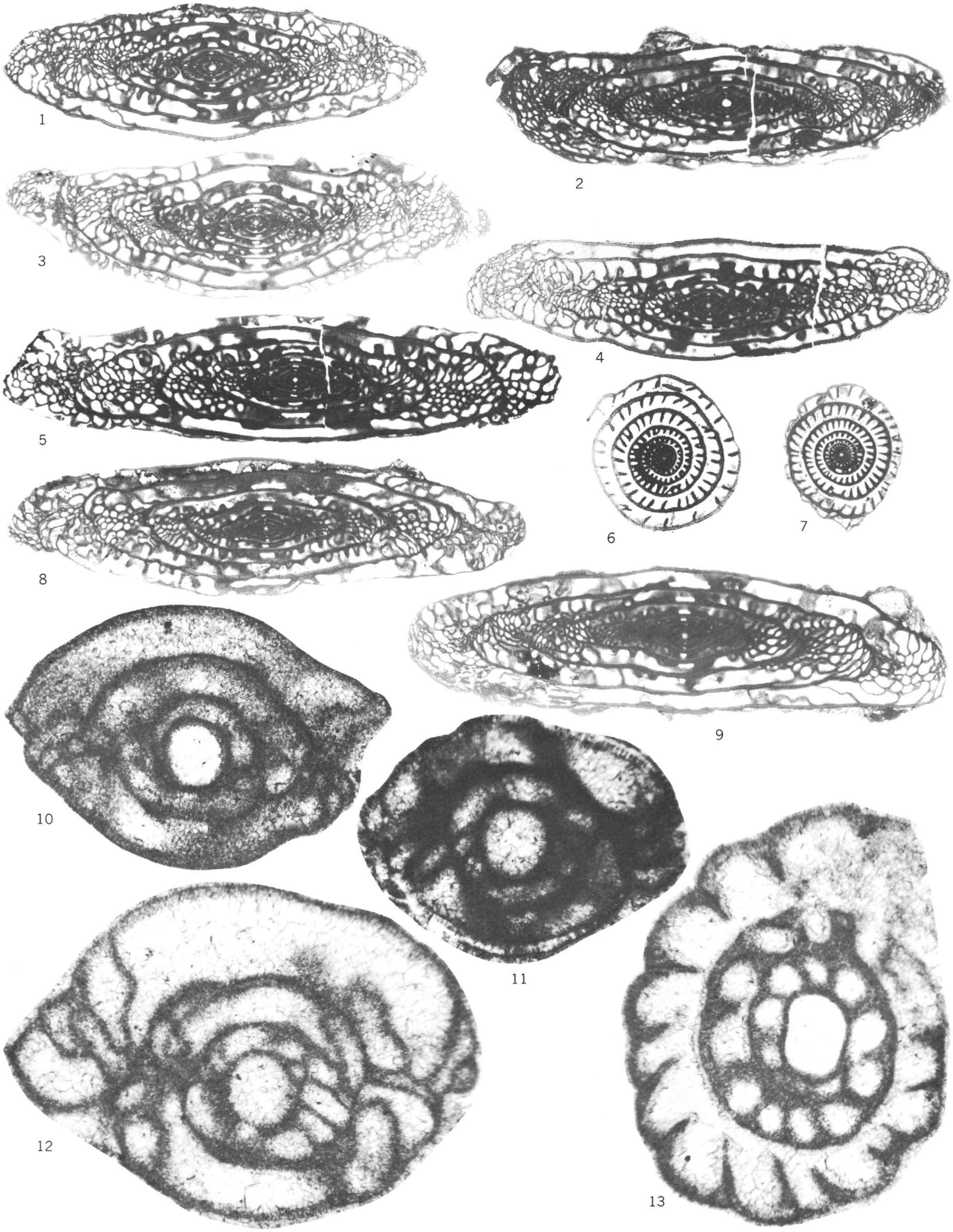
6. Equatorial section. USNM 686751 from USGS loc. f10001, slide 9.
7. Equatorial section. USNM 686752 from USGS loc. f10013, slide 8.
8. Axial section. USNM 686753 from USGS loc. f10001, slide A.
9. Axial section. USNM 686754 from USGS loc. f10013, slide 1.

10–13. *Oketaella eargleі* Myers, 1966 (× 100) (p. C3).

10–12. Axial sections.

10. Characteristic lack of septal fluting and large proloculus. USNM 686755 from USGS loc. f10109, slide 34.
11. Paratype showing alveolar wall in outer whorl. USNM 642564 from USGS loc. f10109, slide 24.
12. USNM 642560 from USGS loc. f10109, slide 28.

13. Equatorial section. USNM 642561 from USGS loc. f10109, slide 36.



KANSANELLA AND *OKETAELLA* FROM THE ADAMS BRANCH LIMESTONE MEMBER OF THE GRAFORD FORMATION

PLATE 2

[All figures × 1]

FIGURES 1–6, 8. *Triticites procerus* Myers, n. sp. (p. C4).
From the Brownwood Shale Member of the Graford Formation.
1. Axial section of the holotype. USNM 686756 from USGS loc. f10097, slide 4.
2–5. Axial sections.
2. USNM 686757 from USGS loc. f10097, slide 5.
3. USNM 686758 from USGS loc. f10098, slide 2.
4. USNM 686759 from USGS loc. f10016, slide 3.
5. USNM 686760 from USGS loc. f10097, slide 1. Note the septal pores in the outer whorls.
6. Equatorial section. USNM 686761 from USGS loc. f10098, slide 3.
8. Equatorial section. USNM 686762 from USGS loc. f10016, slide 10.

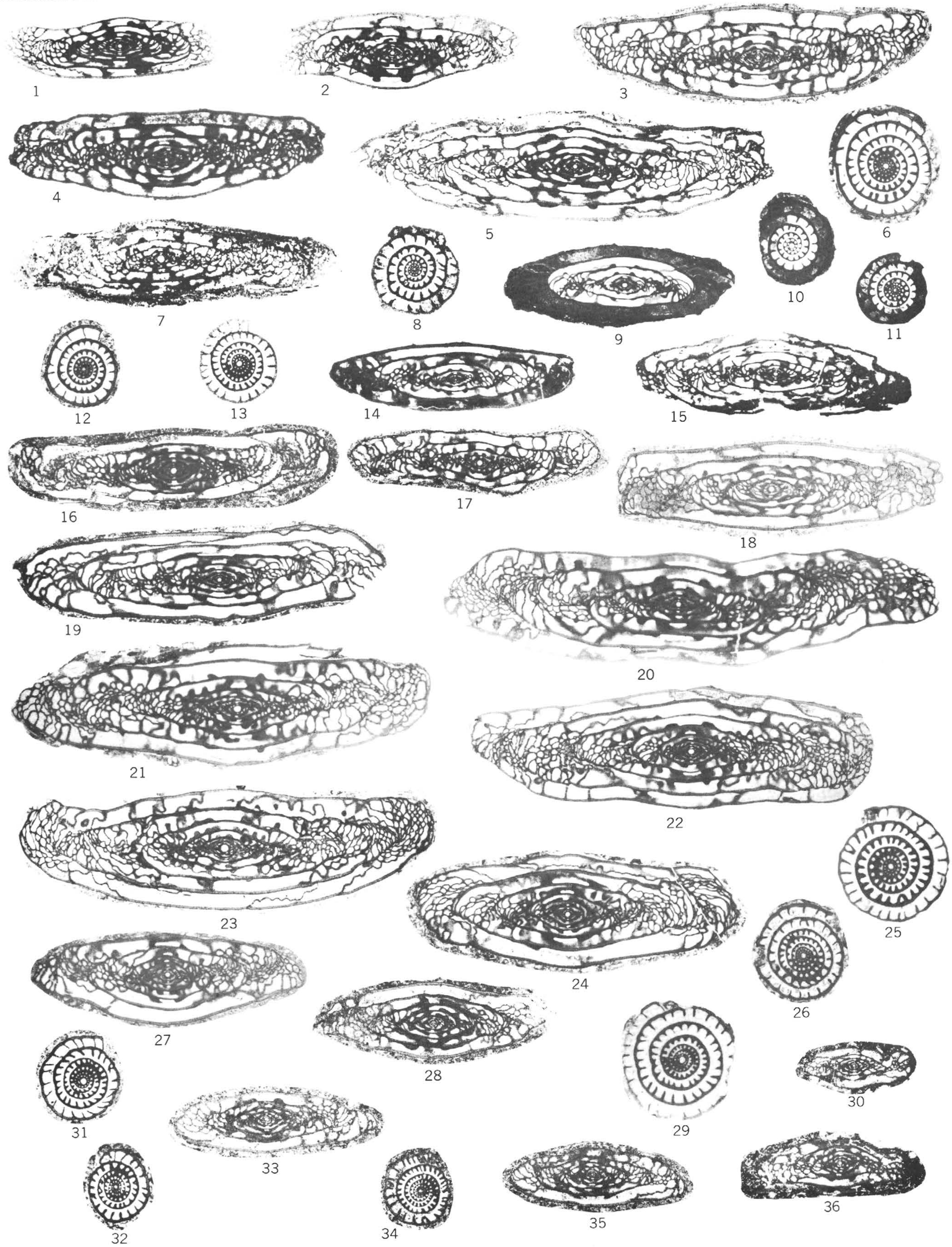
7, 13. *Triticites procerus* Myers, var. A (p. C6).
From the Cedarton Shale Member of the Graford Formation.
7. Axial section. USNM 686763 from USGS loc. f10117, slide 8.
13. Equatorial section. USNM 686764 from USGS loc. f10117, slide 3.

9–11, 14, 15. *Triticites nebraskensis* Thompson, 1934 (p. C9).
From the Brownwood Shale Member of the Graford Formation.
9. Axial section. USNM 686765 from USGS loc. f10096, slide 2.
10. Equatorial section. USNM 686766 from USGS loc. f10096, slide 6.
11. Equatorial section. USNM 686767 from USGS loc. f10014, slide 4.
14. Axial section. USNM 686768 from USGS loc. f10096, slide 4.
15. Axial section. USNM 686769 from USGS loc. f10014, slide 12.

12, 16–19. *Triticites submagdalium* Myers, n. sp. (p. C9).
From the Brownwood Shale Member of the Graford Formation.
12. Equatorial section. USNM 686770 from USGS loc. f10033, slide 19.
16. Axial section of the holotype. USNM 686771 from USGS loc. f10033, slide 8.
17. Axial section. USNM 686772 from USGS loc. f10033, slide 3.
18. Axial section. USNM 686773 from USGS loc. f10033, slide 1.
19. Axial section. USNM 686774 from USGS loc. f10033, slide 7.

20–27, 29, 31. *Triticites muscerda* Myers, n. sp. (p. C11).
From the Adams Branch Limestone Member of the Graford Formation.
20. Axial section. Note septal pores in the outer whorls. USNM 686775 from USGS loc. f10018, slide 16.
21. Axial section. USNM 686776 from USGS loc. f10099, slide 23.
22. Axial section. USNM 686777 from USGS loc. f10018, slide 36.
23. Axial section of the holotype. USNM 686778 from USGS loc. f10100, slide 8.
24. Axial section. USNM 686779 from USGS loc. f10116, slide 6.
25. Equatorial section. USNM 686780 from USGS loc. f10018, slide 10.
26. Equatorial section. USNM 686781 from USGS loc. f10116, slide 7.
27. Axial section. USNM 686782 from USGS loc. f10115, slide 5.
29. Equatorial section. USNM 686783 from USGS loc. f10099, slide 21.
31. Equatorial section. USNM 686784 from USGS loc. f10115, slide 8.

28, 30, 32–36. *Triticites exilimuratus* Myers, n. sp. (p. C14).
Specimens illustrated as figures 30 and 36 are from the Cedarton Shale Member of the Graford Formation; all others are from the Winchell Limestone.
28. Axial section of the holotype. USNM 686785 from USGS loc. f10081, slide 6.
30. Axial section. USNM 686786 from USGS loc. f10118, slide 4.
32 Equatorial section. USNM 686787 from USGS loc. f10081, slide 22.
33. Axial section. USNM 686788 from USGS loc. f10080, slide 25.
34. Equatorial section. USNM 686789 from USGS loc. f10080, slide 29.
35. Axial section. USNM 686790 from USGS loc. f10080, slide 17.
36. Axial section. USNM 686791 from USGS loc. f10118, slide 1.



TRITICITES FROM THE GRAFORD FORMATION AND WINCHELL LIMESTONE

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