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FORAMINIFERA FROM THE ATOKA FORMATION OF OKLAHOMA

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CONTENTS

(Roman figures refer to plates)

ILLUSTRATIONS

FORAMINIFERA FROM THE ATOKA FORMATION OF OKLAHOMA

By

J. J. Galloway[1] and Charles Ryniker[2]

ABSTRACT

Thirty-three species of lower Pennsylvanian foraminifera are described, six of which are new. Thirteen of the species are as yet known only from the lower Pennsylvanian. The walls of Pennsylvania foraminifera are mainly calcareous and fibrous, not arenaceous.

INTRODUCTION

The foraminifera described below are from an outcrop of Atoka shale, of lower Pennsylvanian age, about 500 feet below the base of the Hartshorne sandstone, in the middle of the Atoka formation, and came from one bed of clay shale, the base of which appears to be an algal reef. The outcrop is, by road, 2.8 miles southwest of Red Oak, Latimer County, Oklahoma, thence east 1.9 miles to a house, thence north one-half mile to a gully, on the middle of the north border of sec. 11, T. 5 N., R. 21 E.

The strata have a dip of 30° in a direction N. 10° W. The Atoka formation in this locality is mostly dark, gritty shales, with some beds of sandstone, and is over 1,000 feet thick.

The fauna in the outcrop consists of algae, foraminifera, porifera, crinoid fragments, brachiopoda, bryozoa, gastropoda, pelecypoda, and ostracoda. Calcareous, complanate, and ramose algae make up the bulk of the specimens. The fauna is a dwarf one, most of the specimens of all the classes being less than five mm. in length, with an occasional gastropod of normal size. The Atoka formation has only a few larger fossils, and small fossils are rare except at this locality.

There are thirty-three species herein described, of which six are new species. Of the thirty-three Atoka species, four have been reported from the Mississippian, seventeen from the middle Pennsylvanian, fifteen from the upper Pennsylvanian, four from the lower Permian, and one from the upper Permian. Very little work has been published on the ranges of Paleozoic foraminifera since the classic works of H. B. Brady and Valerian v. Möller, whose works are the

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most valuable ones in the study of Carboniferous and Permian, smaller foraminifera. The ranges for the species given in the table have been checked by the authors with outcrop and well material from Kansas, Oklahoma, and Texas.

The present study seems to show that Pennsylvanian foraminifera are long-ranging, both geographically and vertically, precisely like the larger Pennsylvanian fossils. It is therefore unreliable to place dependence upon a few of the common species for determination of exact horizons or for making long-distance correlation. According to our experience, dependence can be placed upon the whole faunal assemblage in any sample in correlating series over long distances, and for recognizing precise horizons in small areas.

Very few of the genera in the Atoka foraminifera are arenaceous, only *Tolypammina* and *Nodosinella*. The fundamental wall structure of most of the forms is calcareous and transversely fibrous, seen very well in the Endothyridae and the Fusulinidae. Outside of the fibrous layer may be a granular, calcareous layer, as seen in *Palaeotextularia, Deckerella,* and *Tetrataxis*. Foreign grains may be included in the walls, as in *Bradyina* (which was not found in the Atoka fauna), or entirely replace the original, calcareous wall, as in *Nodosinella*. There is no evidence from the Atoka foraminifera that calcareous forms were derived from arenaceous forms, but much evidence for the converse interpretation.

The Atoka specimens of *Schubertella* and *Fusulinella* show that the primary walls of those genera are transversely fibrous, with about 160 fibers to the mm., similar to the structure of most other Pennsylvanian foraminifera, but without the meshwork of *Fusulina,* in which there are from 30 to 60 meshes to the mm. *Schubertella,* a fusuline intermediate between *Endothyra* and *Fusulinella,* is recognized for the first time in America from this fauna.

There is no evidence from the Atoka foraminifera, or any other Paleozoic forms with which we are familiar, that chambered forms were derived from tubular forms. Both tubular and chambered forms have globular prolocula, but none of the many-chambered forms have a tubular, early stage, as would be expected if they had been derived from tubular forms. The interpretation has been made by Rhumbler and others that *Tetrataxis* has a tubular, early stage. Our studies show that *Tetrataxis* is chambered clear back to the proloculum, as shown by the figures on Plate III.

Endothyra is the principal, ancestral form found in the upper Paleozoic. The following phylogenetic lines are indicated: *Endothyra—Endothyrenella; Endothyra—Orobias; Endothyra—Globivalvulina—Tetrataxis; Endothyra—Stafella—Schubertella—Fusulinella—Fusulina.*

Synonymies and descriptions of genera are given where our interpretation is different from that of other, recent authors, and where adequate, generic descriptions have not been published.

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SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA d'Orbigny, 1826

Family SPIRILLINIDAE Rhumbler, 1895

Genus SPIRILLINA Ehrenberg, 1843

SPIRILLINA RADIATA n. sp.

Plate I, figs. 1 *a-c*

Test minute, nearly circular, biconcave, more concave on the ventral side; peripheral margin rounded; dorsal side ornamented with very fine, radial grooves extending outward from the inner side of the whorl to a distance of two-fifths of the width of the whorl; ventral side smooth, except for growth lines; whorls 8 to 10, gradually enlarging, each embracing about half of the previous whorl on both sides, turning to the left; wall calcareous, hyaline, with no trace of pores; aperture terminal, crescentic. Diameter, 0.24 to 0.29 mm.; thickness 0.05 mm. Rare.

This species is smaller, has more whorls, and is more ornamented than any previously described Paleozoic species of *Spirillina.*

SPIRILLINA CONCAVOCONVEXA n. sp.

Plate I, figs. 2 *a-c*

Test minute, nearly circular, concave on the ventral side, which is partially filled with a white, calcareous deposit concealing the spire, convex on the dorsal side, which is ornamented with conspicuous, fine, radial grooves extending outward from the inner side of the whorl to a distance of nearly one-half the width of the whorl; whorls 8 to 10, gradually enlarging, close coiled, scarcely embracing the previous whorl on the dorsal side, embracing slightly on the ventral side, turning to the left; wall calcareous, translucent, imperforate; aperture crescentic. Diameter, 0.14 to 0.28 mm.; thickness of last whorl, 0.04 to 0.05 mm. Common.

This species is obviously related to *S. radiata.* It appears somewhat like a *Cornuspira* from the ventral side.

SPIRILLINA sp. und.

Plate I, fig. 3

Test subcircular, biconcave, nearly always distorted in this fauna; whorls four to six, each embracing about half of the previous whorl; surface showing irregular growth lines; wall calcareous, silicified in most of the specimens, hyaline, with no trace of pores; aperture terminal, crescentic. Diameter, 0.3 to 0.45 mm. Common.

This species may have been attached to plants in life. It is one of the common Pennsylvanian forms variously identified as *Cornuspira, Ammodiscus, Hemigordius, Serpula* and *Trochammina*. It is similar to, but probably not identical with, the recent *Spirillina vivipara* Ehrenberg.

Genus AGATHAMMINA Neumayr, 1887

AGATHAMMINA MAGNATUBA n. sp.

Plate I, figs. 4 *a-c*

Test elongate, robust; tube making about two coils, constricted where it bends sharply, not much flattened or embracing; wall calcareous, opaque, very thick, not arenaceous or agglutinated; surface punctate; aperture round, terminal. Length of figured specimen, 0.63 mm.; diameter of tube, 0.2 mm. Very rare.

This species differs from *A. pusilla* (Geinitz), (which has as a synonym *A. protea* Cushman and Waters) from the Permian of Germany and Texas, in the larger diameter of the tube, the tube of that species being from 0.07 to 0.08 mm. in diameter.

Genus AMMONEMA Eimer and Fickert, 1899

AMMONEMA FILUM (Schmid)

Plate I, fig. 5

Serpula filum Schmid, Neues Jahrb., 1867, p. 583, pl. 6, fig. 48. (Upper Permian, Germany.)

Orthovertella protea Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 2, June, 1928, p. 45, pl. 6, figs. 3, 4. (Upper Pennsylvanian, Texas.)

Test free, consisting of an early portion coiled glomospirally, and an evolute later portion; tube enlarging very gradually, 0.1 mm. in diameter in the coiled portion; wall calcareous, opaque, imperforate, not arenaceous; surface smooth; aperture terminal, round. Length, 0.4 mm. Rare.

There seems to be no difference between the European and American forms. The ends of our specimens are broken off.

Genus AMMOVERTELLA, Cushman, 1928

Genoholotype, *Ammovertella inversa* (Schellwien)=*Psammophis inversus* Schellwien, Palaeontographica, vol. 44, 1898, p. 266, pl. 23, fig. 10. (Upper Pennsylvanian, Auernigian, Carnic Alps.) *Psammophis* Schellwien is a homonym of *Psammophis* Boie, 1827, a genus of snakes.

Ammovertella Cushman, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 1, 1928, p. 8.

Calcitornella Cushman and Waters, Contrib. Cushman Lab. Foram. Res. vol. 4, pt. 2, 1928, p. 45, pl. 6, fig. 5.

Calcivertella Cushman and Waters, ibid., p. 48, pl. 6, fig. 7.

Plummerinella Cushman and Waters, ibid., p. 49, pl. 6, fig. 6.

Apterrinella Cushman and Waters, ibid., vol. 4, pl. 3, 1928, p. 64.

Test attached, without wall on the attached side, tubular, gradually enlarging, the early portion planispiral in the microspheric form, of one or several whorls, later portion folded back and forth or irregularly meandering; wall calcareous, imperforate (siliceous and finely fragmental according to Schellwien); surface smooth, punctate or tuberculate; aperture the open end of the tube. Length up to 3 mm. —Shales. —Pennsylvanian of the Carnic Alps, New South Wales, Texas, Oklahoma, and Kansas.

Ammovertella is probably not a foraminifer at all, but a worm. The pattern made by the meandering tube has been used for generic as well as for specific distinctions, which distinctions are probably not valid for species and surely not for genera. The size of the tube is a better specific character, although not particularly reliable. It is possible that *Calcitornella elongata* Cushman and Waters, *Calcitornella heathi* Cushman and Waters, *Calcivertella adherens* Cushman and Waters, *Plummerinella complexa* Cushman and Waters, *Ammovertella undulata* Galloway and Harlton, and *Ammovertella latimerensis* Galloway and Harlton, are all merely individual variations of *Ammovertella inversa* (Schellwien). Nearly all of these forms are found in the same sample. Although they are apparently confined to the Pennsylvanian, these forms are of little value for stratigraphic correlation. They have been found in the lower and middle Pennsylvanian of Oklahoma, middle and upper Pennsylvanian of Texas, upper Pennsylvanian of Kansas, and upper Pennsylvanian of the Carnic Alps and in New South Wales. Typical examples of *A. inversa* (Schellwien) occur in the upper Pennsylvanian, Shawnee formation of Kansas.

AMMOVERTELLA UNDULATA Galloway and Harlton

Plate I, fig. 6

Ammovertella undulata Galloway and Harlton, Journ. Pal., vol. 2, no. 4, 1928, p. 341, pl. 45, fig. 2.

Test minute, firmly attached to other fossils, consisting of a coiled portion of about one whorl, which is followed by four to seven regular

undulations which do not touch each other, the tube and the undulations gradually increasing in size; the tube is flattened on the attached side; wall calcareous, readily soluble in acid, imperforate, not arenaceous, yellow in color; surface smooth except for growth lines; aperture semicircular, the open end of the tube. Length, 0.25 mm.; diameter of tube, 0.025 to 0.035 mm. Rare.

AMMOVERTELLA ADHERENS (Cushman and Waters)

Plate I, fig. 7

Calcivertella adherens Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 2, 1928, p. 38, pl. 6, fig. 7. (Upper Pennsylvanian, Young Co., Texas.)

Plummerinella complexa Cushman and Waters, ibid., p. 49, pl. 6, fig. 6. (Upper Pennsylvanian, Young Co., Texas.)

Test minute, adhering to other fossils, consisting of a planispiral early portion of one whorl, which is followed by a closely undulating portion, the sides of which are nearly parallel, and a later, meandering portion; wall calcareous, imperforate, yellow; aperture the open end of the tube. Length, 0.3 mm.; diameter of tube in the middle portion, 0.02, increasing to 0.05 mm. at the aperture, in our specimens.

Whether or not the early undulating portion of the test is also coiled or merely undulating is scarcely of specific, much less of generic importance.

AMMOVERTELLA LATIMERENSIS Galloway and Harlton

Plate I, figs. 8, 9

Ammovertella latimerensis Galloway and Harlton, Journ. Pal., vol. 2, no. 4, 1928, p. 342, pl. 45, figs. 3, 4.

Test attached to complanate algae by the whole of the lower side, the early part planispirally coiled, in one or two whorls, the later part broadly and closely undulating and frequently overgrowing the spire, making a suboval form; tube gradually increasing in size; wall calcareous, white or yellow, imperforate; surface smooth except for growth lines; aperture terminal, constricted on the lower side. Length, up to 0.5 mm.; diameter of tube, 0.02 to 0.08 mm., averaging 0.04 mm.

This species is very similar to *A. heathi* (Cushman and Waters), but seems to differ from that species in the smaller tube, more regularly undulating form, and especially in being attached to solid objects, whereas *A. heathi* was attached to soft objects which have disappeared.

AMMOVERTELLA ELONGATA (Cushman and Waters)

Plate I, figs. 10, 11

Calcitornella elongata Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 2, 1928, p. 47, pl. 6, fig. 5. (Upper Pennsylvanian, Texas.)

Test attached to algae or other fossils by the whole of one side, the early portion of one or two whorls, closely coiled planispirally, the later portion evolute, elongate and irregularly meandering; enlarging very gradually, with prominent growth lines; wall calcareous, white imperforate, some of the wall material spreading out on the substratum beyond the proper wall; surface smooth; aperture terminal, semicircular. Length, up to 3 mm.; diameter of tube, 0.06 to 0.14 mm., averaging 0.1 mm. Abundant.

In some specimens the tube bends back upon itself, as in the type figure, but this feature can scarcely be a good specific character, much less a generic one, in such an irregular form. The tube is two to three times the diameter of the tubes of the above three species.

Family AMMODISCIDAE Rhumbler, 1895

Genus TOLYPAMMINA Rhumbler, 1895

TOLYPAMMINA INCLUSA (Cushman and Waters)

Plate I, figs. 12, 13

Psammosphis inclusus Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 3, 1927, p. 148, pl. 26, fig. 12. (Middle Pennsylvanian, Young Co., Texas.)

Test attached, mainly to calcareous algae, by the whole of its length, without any lower wall, consisting of a small proloculum and a gradually enlarging tube which is coiled in about one whorl at the initial end and later is irregularly folded or meandering; wall finely arenaceous with siliceous cement, the cement spreading out slightly on both sides of the tube; the substratum dissolves away in acid, leaving the specimen intact; aperture the open end of the tube. Length, up to 1.5 mm.; diameter of tube, from 0.08 to 0.25 mm., averaging 0.16 mm. wide in the adult portion of sixteen specimens. Abundant.

This is one of the very few really agglutinated foraminifera in the Atoka formation. If the genotype of *Ammovertella* is agglutinated, that genus is a synonym of *Tolypammina*.

TOLYPAMMINA CONFUSA (Galloway and Harlton)

Plate I, fig. 14

Ammovertella ? confusa Galloway and Harlton, Journ. Pal., vol. 2, no. 4, 1928, p. 344, pl. 45, fig. 5. (Middle Pennsylvanian, Love Co., Okla.)

Test attached to crinoid stems, echinoid spines, bryozoa or other cylindrical objects, consisting of a long, meandering tube in a confused mass; wall finely arenaceous, insoluble in acid, yellowish; aperture semicular, the open end of the tube. Diameter of tube, 0.7 to 0.1 mm.

This species differs from *T. inclusa* not only in selecting a different host, but also in the smaller tube and confused shape.

Family ENDOTHYRIDAE Rhumbler, 1895

Genus ENDOTHYRA Phillips, 1846

ENDOTHYRA ROTHROCKI Harlton

Plate II, figs. 1 *a-c*, 2, 3

Endothyra rothrocki Harlton, Journ. Pal., vol. 1, no. 4, 1928, p. 306, pl. 52, fig. 3. (Upper Pennsylvanian, Jack Co., Texas.)

Test subcircular in side view, but little more than the last whorl visible from either side, nautiloid and biumbilicate, nearly bilaterally symmetrical in the last whorl, the plane of coiling swinging 10° to 30° as the whorls are added; periphery lobulate; peripheral margin rounded; chambers 7 to 9 in the last whorl, slowly increasing in size as added, inflated; sutures deep, radial; wall entirely calcareous, readily and completely soluble in acid, rather thin, translucent, only one layer visible in thin sections, which is very minutely granular or fibrous but not arenaceaus, with meshwork structure in places; surface punctate; aperture a high, lunate slit at the base of the last septal face, on the periphery. Diameter, 0.4 to 0.5 mm. Common.

This species differs from *E. bowmani* (Phillips) in the greater symmetry, less rapidly enlarging chambers, smaller size and higher aperture. The change in the plane of coiling as the whorls are added is a common and nearly constant feature in the genus.

ENDOTHYRA WHITESIDEI n. sp.

Plate II, figs. 4 *a-c*

Test nautiloid, biumbilicate, two whorls of chambers showing, last whorl slightly asymmetrical, the adult coiled in a different plane from that of the early whorls; peripheral margin rounded; chambers 7, rarely 8, in the last whorl, slowly increasing in size as added, inflated; sutures deep, oblique and curved; wall calcareous, readily and completely soluble in acid, rather thin, translucent, with indistinct meshwork structure; surface clearly punctate; aperture a high arch one-third to one-half as high as the septal face and about half as wide as the septal face, situated nearly medially at the base of the septal face. Diameter, about 0.6 mm. Common.

This species differs from *E. bowmani* (Phillips) and *E. rothrocki* Harlton in the curved, oblique sutures, which constitute the most diagnostic character, and the high aperture. The high aperture is suggestive of *Endothyranella*, but in a series of fourteen specimens none are evolute. It is named for Mr. Robert M. Whiteside, of Oklahoma City, Okla., who first discovered the microfauna of the Red Oak locality.

Genus ENDOTHYRANELLA Galloway and Harlton n. gen.

Genoholotype, *Endothyranella powersi* (Harlton)=*Ammobaculities powersi* Harlton, Journ. Pal., vol. 1, no. 1, 1927, p. 21, pl. 3, fig. 3. (Lower Pennsylvanian, Love Co., Okla.)

Test free, coiled in the early part, evolute and rectilinear in the later part; the coil consists of about three whorls, with five to ten slightly inflated chambers to a whorl, the plane of coiling rotating from 10° to 30° from the plane of the previous whorl, the earlier whorl or whorls partly or completely embraced by the last whorl, so that the coil appears nearly planispiral from the outside; chambers little or much inflated; peripheral margin rounded; sutures conspicuous; wall calcareous, imperforate, opaque or translucent, not arenaceous, consisting of transverse fibers, much as in *Fusulinella* and *Fusulina*, which may become granular during fossilization or weathering, and appearing arenaceous on casual study; surface smooth, glisteny, punctate, becoming roughened by weathering or by attachment of grains from the embedding rock; aperture single, a high arch at the base of the septum in the coiled portion, gardually becoming central to the septum and finally terminal and round or oval in the evolute portion. Length, up to 2 mm.

Habitat. Shallow water shales and limestones.

Range. Upper Mississippian to Upper Pennsylvanian.

This genus was derived from *Endothyra*. Young specimens differ from *Endothyra* in the high arched or round aperture. It seems probable that *Endothyra ameradensis* Harlton, *Endothyra ovata* Waters, *Endothyra media* Waters, *Endothyra grandis* Waters, *Haplophragmoides marga* Harlton, and *Haplophragmoides ciscoensis* Harlton are all young specimens of *Endothyranella*.

This genus differs from *Ammobaculites* in not being planispirally coiled, but more particularly in the structure of the walls, those of *Ammobaculites* being plainly agglutinated throughout, while in *Endothyranella* the wall is fundamentally calcareous, secreted by the animal, and like that of most Carboniferous genera, as *Endothyra, Globivalvulina, Orobias,* and *Fusilinella*. Arenaceous forms do occur in the Pennsylvanian which are indistinguishable from *Ammobaculites,* as *Ammobaculites stenomeca* Cushman and Waters. If such forms were derived from *Haplophragmoides* they are *Ammobaculites,* but if they result by addition of sand grains to the walls of *Endothyranella,* they belong to *Endothyranella.* Partly arenaceous forms, which were clearly derived from calcareous forms by the addition of foreign grains to the outside of the wall, are retained in the genera from which they were derived, as are partly arenaceous species of *Sigmoilina, Quinqueloculina, Triloculina* and *Pyrgo.*

ENDOTHYRANELLA MINUTA (Waters)

Plate II, figs. 5 *a-c*, 6 *a-c*

Ammobaculites minuta Waters, Journ. Pal., vol. 1, no. 2, 1927, p. 133, pl. 22, figs. 3 a, b. (Lower Pennsylvanian, Dornick Hills formation, SE.¼ Sec. 30, T. 3 S., R. 2 E., Carter Co., Okla.)

Test biformed, crosier shaped; early portion coiled in about three whorls, the plane of coiling swinging about 30° from one whorl to the next, showing about two whorls on one side and one whorl on the other, about seven chambers to a whorl; later portion evolute, rectilinear, consisting of three to seven inflated chambers which gradually enlarge, and which are about three-fifths as long as in transverse diameter, each slightly embracing the previous one; wall calcareous, fibrous in well-preserved specimens, finely granular in corroded or recrystallized specimens, not arenaceous; surface smooth, conspicuously punctate in well preserved specimens, uneven in poorly preserved specimens; color horn-brown in well preserved specimens, white or yellow in weathered specimens; aperture in the young, a high arch at the base of the septal face, in the adult, terminal, round, with slight lip, varying considerable in size in different specimens. Length, 0.6 to 0.75 mm.; diameter of early portion, 0.25 mm.; diameter of rectilinear portion, 0.2 mm. Rare.

Although the original description and figures are inadequate, the Atoka form seems to be identical with Waters' species, which came from about the same horizon. *E. minuta* is very similar to *E. powersi,* from the same general region and horizon, but seems to differ in being smaller in all dimensions, having fewer chambers to a whorl, there being eight to ten to a whorl in *E. powersi,* and the chambers are less closely appressed. *E. stormi* (Cushman and Waters), from the Middle Pennsylvanian of Texas, may be identical with *E. minuta.*

Genus OROBIAS Eichwald, 1860

OROBIAS RADIATA (Brady)

Plate II, figs. 8 *a, b*

Involutina radiata Brady, Rep. Brit. Assoc. (Exeter), 1869, p. 379.
Endothyra radiata Brady, Pal. Soc. Mono., 1876, p. 97, pl. 5, figs. 10-12 (Mississippian, England.)

Orobias radiata Galloway and Harlton, Jour. Pal., vol. 2, no. 4, 1928, p. 350, pl. 45, figs. 12 *a-c.*

Test planispiral, involute, depressed, discoidal, unequally biconvex, with small umbilici; peripheral margin sharply angled; periphery very little lobulate; chambers very short and closely appressed, some overlapping more than others toward the umbilical region, about 16 in the last whorl; sutures distinct, very little depressed, curved, not limbate but appearing to be on account of the darker color; wall calcareous, fibrous, thin, often depressed between the sutures, brownish in well preserved specimens, white in recrystallized specimens; surface punctate; aperture an arched slit at the base of the septal face. Diameter, 0.4 mm. Rare.

This species has been reported from the Mississipian and lower Pennsylvanian.

OROBIAS CISCOENSIS (Harlton)

Plate II, figs. 9 *a, b*

Staffella ciscoensis Harlton, Jour. Pal., vol. 1, no. 4, 1928, p. 307, pl. 52, figs. 9 *a-c.*

Orobias ciscoensis Galloway and Harlton, Jour. Pal., vol. 2, no. 4, 1928, p. 350, pl. 45, figs 11 *a-c.*

This species is very similar to *O. radiata,* differing in the larger number of chambers to a whorl, there being 20 to 25 in *O. ciscoensis.* It may be identical with *O. velebitana* (Schubert), from which it differs mainly in the smaller size. Diameter, 0.4 mm. Rare. It ranges throughout the Pennsylvanian.

OROBIAS WAAGENI (Schwager)

Plate II, figs. 7 *a, b*

Fusulinella waageni Schwager, Pal. Indica, ser. 13, vol. 1, 1888, p. 990, pl. 128, fig. 10. (Permian, India.)

Orobias waageni Galloway and Harlton, Jour. Pal., vol. 2, no. 4, 1928, p. 351, pl. 46, figs. 3 *a, b.* (Middle Pennsylvanian, Oklahoma.)

Test planispiral, involute, discoidal, unequally biconvex, neither umbilicate nor umbonate; peripheral margin sharply rounded; periphery slightly lobulate; chambers closely appressed, some overlapping more than others toward the umbilical region, 14 or 15 in the last whorl; sutures distinct, slightly curved, slightly depressed, of a darker color than the wall between the sutures and so sometimes appearing limbate; wall calcareous, fibrous, thin, often depressed between the sutures, translucent and brownish in color in well preserved specimens, white in recrystallized specimens; surface punctate; aperture and arched slit at the base of the apertural face. Diameter, 0.5 mm. Rare.

This species ranges throughout the Pennsylvanian and into the Permian, but is more common in the upper Pennsylvanian. It is obviously similar to *O. radiata,* but differs in being more compressed and having the sutures more curved, and is not umbilicate.

Genus GLOBIVALVULINA Schubert, 1920

GLOBIVALVULINA BULLOIDES (Brady)

Plate III, figs. 1 *a-c*

Valvulina bulloides Brady, Pal. Soc. Mono., 1876, p. 89, pl. 4, figs. 12-15. (Upper Pennsylvanian of Iowa.)

Globivalvulina bulloides Harlton, Journ. Pal., vol. 1, no. 1, 1927, p. 23, pl. 5, fig. 2. (Middle Pennsylvanian, Oklahoma.)

Test concave on the ventural side, strongly convex on the dorsal side, oval in dorsal view; chambers five or six, rapidly enlarging, closely appressed, inflated, arranged in a trochoid spire, four in the last whorl; sutures depressed on the dorsal side, obscure on the ventral side; wall calcareous, not arenaceous or agglutinated, consisting of an inner, hyaline, fibrous layer, and an outer, opaque, finely granular layer; surface minutely but plainly punctate; aperture a two-lobed or three-lobed, elongate opening between the last and the previous chambers, nearly centrally located. Length, about 0.4 mm. usually. Rare.

The chambers are more inflated in the upper Pennsylvanian and lower Permian specimens. This species appears to have been derived from *G. cora* Harlton by the more rapid enlargement of the chambers, which in turn was derived from *Endothyra*. It developed into the next described species.

GLOBIVALVULINA BISERIALIS Cushman and Waters

Plate II, figs. 10 *a, b*, 11; Plate III, figs. 2 *a-c*

Globivalvulina biserialis Cushman and Waters, Contrib. Cushman, Lab. Foram. Res., vol. 4, pt. 3, 1928, p. 64, pl. 8, fig. 7. (Upper Pennsylvanian, Graham formation, Young Co., Texas.)

Test oval in dorsal view; dorsal side highly inflated; ventral side concave; chambers 8 to 11, rapidly enlarging, slightly inflated on the dorsal side, about twice as broad as long, arranged in a trochoid spire in the young and added alternately on one side and then on the other (biserially) in the later stages; sutures depressed and plainly visible on the dorsal side, very obscure on the ventral side; wall calcareous, not agglutinated or arenaceous, composed of an inner, hyaline, porous or fibrous layer, and an outer, darker, granular layer which also appears like a meshwork; surface smooth, minutely but plainly punctate; aperture opening into a three-lobed vestibule between the chambers in the middle of the ventral side of the test. Length, 0.4 to 0.6 mm.; height, 0.2 to 0.3 mm. Common.

This species has the young stages like *G. bulloides*, from which it was derived by the development of biserial arrangement of chambers, but they are not the same species, since the two are frequently of the same size. It is very little if any, different from *G. gaptankenses* Harlton (which has as a synonym, *G. ovata* Cushman and Waters), the chambers of that species being apparently more inflated.

Genus TETRATAXIS Ehrenberg, 1843

TETRATAXIS LATA Spandel

Plate III, figs. 3 *a-c*, 4

Tetrataxis conica Ehrenberg var. *lata* Spandel, Festschrift Naturhist. Gesell. Nuremberg, 1901, p. 186, figs. 6 *a, b*. (Upper Pennsylvanian, Hooser, Kansas.)

Test free, round in dorsal view, low conical in edge view with very slightly concave profile from apex to base; ventral side nearly flat to concave, with deep vestibule in the middle; whorls 4 to 6, with 5 chambers in a whorl in the early part of the test, reducing to 4 to a whorl in the later whorls; chambers arcuate regularly arranged in spirals from the proloculum onward, the circumferential breadth of the chambers regularly increasing; the earliest chambers are not tubular as some authors have thought; wall entirely calcareous, the outer layer finely granular but not agglutinated, the lower or inner layer hyaline and fibrous, amber colored in some specimens, white in others, probably those which have been recrystallized; chambers semicircular in shape on the ventral side, with small valvular projection extending into the vestibule; vestibule irregularly quadrilateral in shape, with lobes extending outward at the sutures; aperture a narrow slit under the valvular projection, opening into the vestibule, rarely visible; surface smooth finely punctate. Diameter of figured specimen, 0.7 mm.; height, 0.45 mm. Abundant.

Although Spandel's species is not adequately described, the Atoka specimens seem to agree in all respects.

TETRATAXIS CORONA Cushman and Waters

Plate III, figs. 5 *a-c*

Tetrataxis corona Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 3, 1928, p. 65, pl. 8, fig. 10. (Upper Pennsylvanian, Graham formation, Young Co., Texas.)

Test free, round in dorsal view, depressed, with straight or slightly concave profile from apex to base; ventral side flat, with shallow, two-lobed vestibule; whorls 5 or 6, with four chambers to a whorl in the early part, gradually decreasing in number to three and finally to two chambers in the last whorl; chambers arcuate, increasing in breadth as added, regularly arranged in spirals from the proloculum onward, with no tubular chamber as is sometimes postulated for this genus; wall entirely calcareous, consisting of an inner, hyaline, fibrous layer, and an outer, finely granular layer, not arenaceous as is sometimes stated for this genus; surface smooth, finely punctate, amber colored or white; the chambers on the ventral side have a prominent projection extending into the vestibule, in which several of the earlier chambers

are visible; aperture opening into the vestibule, not visible from the outside. Diameter of figured specimen, 0.7 mm.; height, 0.27 mm. Rare.

Although the ventral side of the type of this species was not figured, the specimen broken and the chambers shown as if irregularly arranged, whereas they must be regularly spiral, as in the early part at least of all other species of *Tetrataxis,* and the number of chambers in the last whorl is not given, there seems to be little doubt of the identity of the Atoka specimens. The early portion is not arenaceous in our specimens, but clearly calcareous. Perhaps the type had some clay adhering to both surfaces.

TETRATAXIS CONCAVA n. sp.

Plate III, figs. 6 *a-c*

Test free or attached to algae or sponges by the ventral side, round in dorsal view; dorsal side depressed, concave from apex to base; ventral side concave, with wide, open vestibule; whorls about 8, with 6 chambers to a whorl in the earlier whorls, gradually decreasing to 5 and to 4 in the final whorl; chambers arcuate in shape, becoming relatively broader as added, regularly arranged in spirals, the early ones after the procloculum not tubular, but arcuate; chambers on the ventral side broad circumferentially, short radially, with prominent projection extending out into the vestibule, the projections of many of the chambers prior to the last whorl are visible, which might give the erroneous impression that there are many chambers to a whorl; wall entirely calcareous, with outer granular, not arenaceous, layer, and inner, hyaline, fibrous layer; surface smooth, finely punctate, amber colored or white; aperture a narrow slit visible under the valvular flaps, opening into the vestibule. Diameter of figured specimen, 1.15 mm.; height, 0.4 mm. Abundant.

This species differs from *T. maxima depressa* Schellwien in the fewer chambers in the later whorls. It may be identical with *T. scutella* Cushman and Waters, which the authors say has 4 chambers to a whorl throughout. The figures are inadequate for identification.

Family NODOSINELLIDAE Rhumbler, 1895

Genus NODOSINELLA Brady, 1876

NODOSINELLA cf. CYLINDRICA Brady

Plate IV, figs. 1, 2

Nodosinella cylindrica Brady, Pal. Soc. Mono., 1876, p. 104, pl. 7, figs. 4-7. (Pennsylvanian, England and Wales.)

Test subcylindrical or slightly compressed; chambers 7 to 9, each one-fourth to one-half as high as wide; sutures shallow, indistinct; wall siliceous, insoluble in acid, finely arenaceous or silicified; surface nearly

smooth or granular; aperture terminal, round. Length, up to 1 mm.; diameter, up to 0.4 mm. Rare.

Our specimens are too imperfect for certain identification. The longer specimen figured was found in a shale sixty feet below the horizon containing all the other foraminifera.

NODOSINELLA cf. CONCINNA Brady

Plate IV, figs. 3, 4

Nodosinella concinna Brady, Pal. Soc. Mono., 1876, p. 106, pl. 7, figs. 11-15. (Upper Mississippian, England and Scotland.)

Test consisting of two or three pyriform chambers of variable length, one to two times as long as wide; wall insoluble in acid, finely arenaceous or silicified, hyaline with opaque specks, or white. Length of longer specimen, 1.2 mm.; greatest width, 0.35 mm. Rare.

The imperfect specimens of *Nodosinella* found in the Atoka lend some support to the prevailing idea that the walls of this genus are arenaceous.

Genus BULLOPORA Quenstedt, 1856

BULLOPORA WAPANUCKAENSIS Galloway and Harlton

Plate IV, figs. 5, 6

Bullopora wapanuckaensis Galloway and Harlton, Jour. Pal., vol. 2, no. 4, 1928, p. 345, pl. 45, fig. 6. (Lower Pennsylvanian, Pittsburg Co., Oklahoma.)

Test attached by the whole of one side to ramose objects, calcareous algae, echinoid spines, crinoid stems, etc., elongate, generally straight, tapering; chambers 3 to 7, inflated, about as wide as long, regularly enlarging, slightly appressed; sutures deep; wall calcareous, apparently imperforate, yellowish in color, thin and frequently collapsed, some of the wall material spreading out around the test where it is attached to the host; surface smooth, punctate; aperture generally absent, sometimes terminal and rounded. Length, up to 1 mm.; width of later chambers, 0.25 mm. Common.

This form is very similar to *Webbina irregularis* Howchin (not d'Orbigny), from the Mississippian limestone of England (Howchin, Jour. Roy. Micr. Soc., pt. 2, 1888, p. 539, pl. 9, figs 16, 17).

BULLOPORA REDOAKENSIS Galloway and Harlton

Plate IV, figs. 7, 8

Bullopora redoakensis Galloway and Harlton, Jour. Pal., vol. 2, no. 4, 1928, p. 345, pl. 45, figs. 7 *a-c*.

Test attached to complanate, calcareous algae, elongate, curved, tapering, chambers 6 to 10, inflated, irregularly increasing in size,

closely appressed but not embracing, shorter than wide; sutures deep; wall calcareous, apparently imperforate; surface smooth, punctate, speckled in weathered specimens, yellowish in color; aperture normally absent, sometimes terminal and rounded. Width of chambers, 0.12 to 0.4 mm. Common.

This species differs from *B. wapanuckaensis* in the shorter chambers, their variation in size and arrangement, and in choosing a flat host.

BULLOPORA MODESTA n. sp.

Plate IV, fig. 9

Test minute, attached by the whole of one side to complanate, calcareous algae, consisting of a few globular chambers, which gradually increase in size and are added in a zagzag or irregular manner, some of the chambers separated by short stolons and others just touching; wall calcareous, apparently imperforate, some of the wall material spreading out on the host beyond the proper wall of the test; surface smooth, punctate, yellowish in color; aperture apparently absent. Length of type specimen, 0.4 mm.; diameter of chambers, 0.07 to 0.12 mm. Rare.

The above three species of *Bullopora* are anomalous for foraminifera in lacking any normal aperture, and at the same time the wall seems to be imperforate.

Genus TUBERITINA Galloway and Harlton, 1928

TUBERITINA BULBACEA Galloway and Harlton

Plate IV, figs. 10-12

Tuberitina bulbacea Galloway and Harlton, Jour. Pal., vol. 2, no. 4, 1928, p. 346, pl. 45, figs. 8 *a-d*. (Upper Pennsylvanian, Hoxbar formation, Carter Co., Okla.)

Test attached in life by a basal disc, and consisting of one or several bulbous chambers, which enlarge as added, each attached to the preceding by a basal disc; wall calcareous, fibrous, probably perforate; surface conspicuously punctate; aperture absent. Length of single chamber, 0.4 to 0.6 mm.; diameter, up to 0.3 mm. or more. Rare.

This species occurs throughout the Pennsylvanian, but is more common in the middle part.

Family TEXTULARIIDAE d'Orbigny, 1846

Genus PALAEOTEXTULARIA Schubert, 1920

Genotype (here named and designated), *Palaeotextularia schellwieni* n. sp.=*Textularia textulariformis* Schellwien (not *Cribrostomum textulariforme* Möller), Palaeontographica, vol. 44, 1898, p. 268, pl. 23, fig. 11. (Upper Pennsylvanian, Auernigian, Carnic Alps.)

Palaeotextularia Schubert, Pal. Zeitschr., vol. 3, no. 2, 1920, p. 183. No species were named by Schubert, but the type cannot be *Textularia curneiformis* Jones, since Schubert explicitly omitted that species from his new genus. Cushman designated (Foram. Class. Econ. Use, 1928, p. 119) *Textularia cuneiformis* Jones, a not definitely recognizable form, as the genotype of *Geinitzina*. If that species turns out to be biserial, the name *Geinitzina* will have to replace *Palaeotextularia*, even though Spandel meant his genus to embrace only uniserial forms.

Textularia (part), Paleozoic species, of authors.

Test free; chambers biserial; wall consisting of two layers, an inner, calcareous, hyaline, fibrous or finely perforate layer, and an outer, darker, granular, mostly calcareous layer, in which are embedded, or to which may be attached, foreign grains; aperture single, round or slit-like, at the base of the septum. Length, up to 1.5 mm.—Ordovician of Wales; Mississippian of Russia, England, Scotland and Belgium; Pennsylvanian of the Carnic Alps, Texas, Oklahoma and Kansas; Permian of England and Germany.

The wall structure of *Palaeotextularia* is more like that of other Paleozoic foraminifera, such as *Cribrostomum, Deckerella, Climacammina* and *Tetrataxis* than that of *Textularia*.

PALAEOTEXTULARIA GRAHAMENSIS (Cushman and Waters)

Plate IV, figs. 13 *a-c*, 14

Textularia grahamensis Cushman and Waters, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 3, 1927, p. 151, pl. 27, figs. 3 *a, b*. (Upper Pennsylvanian, Young Co., Texas.)

Test rapidly tapering, slightly concave down the middle; edges rounded; chambers 4 to 8 on a side, the early ones nearly twice as wide as high, the later ones becoming proportionately higher; sutures slightly depressed, nearly straight toward the edges of the test, those of one series nearly parallel with those on the opposite series; wall calcareous, soluble in acid leaving a slight, argillaceous residue, with inner hyaline, fibrous layer and outer, opaque, granular layer with some embedded foreign particle, not composed almost entirely of agglutinated sand grains as in *Textularia*; surface somewhat rough, speckled or mottled, the specks being white calcite in a dark, amber-colored, calcareous ground mass; aperture single, arched, at the base of the septal face. Length, up to 1.25 mm. Common.

Genus DECKERELLA Cushman and Waters, 1928

DECKERELLA CLAVATA Cushman and Waters

Plate IV, figs. 15 *a, b*

Deckerella clavata Cushman and Waters, Journ. Pal., vol. 2, no. 2, 1928, p. 130, pl. 19, figs. 1, 2, f. (Middle Pennsylvanian, Parker Co., Texas.)

Test elongate, slightly compressed, with rounded edges, the biserial portion rapidly tapering, with a depression down the middle, and consisting of six or seven pairs of chambers in the megaspheric form, the uniserial portion subcylindrical, consisting of one to three chambers; sutures in the biserial portion curved in the middle of the test, nearly straight toward the edge, slightly depressed; surface uneven and speckled, the specks being white calcite in the dark-amber colored, calcareous groundmass; wall calcareous, thick, breaking down completely in acid, consisting of an inner, hyaline, fibrous or porous layer and an outer, granular layer, with included grains of calcite and possibly some quartz; aperture in the adult double, the openings parallel, elongate, curved on the outer side and straight on the inner side. Length, up to 2 mm. Common.

Family FUSULINIDAE Moller, 1877

Genus STAFFELLA Ozawa, 1925

STAFFELLA MOLLERI Ozawa

Plate II, figs. 12 *a, b*

Staffella mölleri Ozawa, Jour. Coll. Sci. Imp. Univ. Tokyo, vol. 42, art. 6, 1925, p. 19, pl. 2, fig. 9.—Galloway and Harlton, Jour. Pal., vol. 2, no. 4, 1928, p. 354, pl. 46, figs. 5 *a-c*.

Test nautiloid, slightly umbilicate, with axial diameter the shorter, 0.6 to 0.7 of the median diameter; peripheral margin round; periphery slightly lobulate; chambers 12 to 16 in the last whorl; sutures distinct, depressed; wall calcareous, thick, homogeneous or fibrous, with indications of meshwork; septa thick, not folded, thickened on both sides of the aperture, forming chomata which enclose a large spiral tunnel; surface smooth and punctate; aperture curved, at the opening of the tunnel. Axial diameter, 0.3 mm.; median diameter, 0.45 mm. Rare.

Genus SCHUBERTELLA Staff and Wedekind, 1910

Genotype (monotypic), *Schubertella transitoria* Staff and Wedekind, Bull. Geol. Inst. Univ. Upsala, vol. 10, 1910, pp. 112, 121, pl. 4, figs. 7, 8. (Upper Pennsylvanian, Spitzbergen.)

Neofusulinella Deprat, Com. Ren. Acad. Sci., Paris, vol. 154, 1912, p. 1549; Mem. Serv. geol. Indochine, vol. 2, fasc. 1, 1913, p. 40, pl. 7, figs. 6-16. Type, *N. praecursor* Deprat, Pennsylvanian, Moscovian, Cammon, Indo-China. Ibid., vol. 4, fasc. 1, 1915, p. 10.

Boulotnia Lee, Pal. Sinica, ser. B, vol. 4, fasc. 1, 1927, p. 10, pl. 2, figs. 1-4. Genoholotype. *B, willsi* Lee, upper Pennsylvanian, South Manchuria.

Depratella Ozawa, Contrib. Cushman Lab. Foram. Res., vol. 4, pt. 1, 1928, p. 9. Genoholotype, *Neofusulinella giraudi* Deprat, Mem. Serv. geol. Indochine, vol. 4, fasc. 1, 1915, p. 11, pl. 1, figs. 6-11. Lower Permian, Cammon, Indo-China.—Ozawa, in Cushman, Foraminifera, 1928, p. 134.

Test small, nautiloid in early stages, fusiform in later stages; the axis of the early stage in the microspheric form oblique to the axis of the adult stage; septa primary meridional only, plane or slightly folded in the median portion, and folded at the extremities; buccal rings (annuli, chomata) well formed; wall calcareous, thin as compared with that of *Fusulinella,* consisting of very thin outer layer (tectum) and thicker inner layer (osseum, diaphanotheca), which is composed of very small, transverse fibers, and without deposition layers (tectoria); aperture a thin slit; buccal aperture elongate or round; septal pores absent. Length, up to 5 mm.—Limestones and shales.—Upper Mississippian, Pennsylvanian, and lower Permian.

The oblique nucleoconch distinguishes *Schubertella* from *Fusulinella.*

SCHUBERTELLA TRANSITORIA Staff and Wedekind

Plate V, figs. 1-5

Schubertella transitoria Staff and Wedekind, Bull. Geol. Inst. Univ. Upsala, vol. 10, 1910, pp. 112, 121, pl. 4, figs. 7, 8. (Upper Pennsylvanian, Spitzbergen.)

Neofusulinella giraudi Deprat, Mem. Serv. geol. Indochine, vol. 4, fasc. 1, 1915, p. 11, pl. 1, figs. 6-11. (Lower Permian, Indo-China.)

Test minute, regularly elliptical, in the adult, less symmetrical in the young stages, varying from 0.27 to 1 mm. in length, averaging 0.7, and from 0.16 to 0.5 mm. in median diameter, averaging 0.4 mm. the ratio of median to axial diameter ranging from 1:1.2 to 1:1.9, averaging 1:1.6 in 20 measured specimens; whorls 5 or 6; chambers varying from 16 to 24 in the last whorl, the larger number in the larger specimens; septa nearly straight at the surface, much thickened and slightly undulating at the base, forming strong chomata which bound a prominent tunnel, as seen in weathered specimens; sutures not depressed; surface smooth, minutely punctate; aperture an arch at the end of the tunnel, scarcely discernible even in perfect specimens.

The median section of a microspheric specimen 0.5 mm. in median diameter, has a round proloculum 0.05 mm. in diameter, which is followed by an endothyrine stage; whorls 4; chambers in the whorls, 12, 15, 18 and 20; septa nearly radial, short and thick, without pores; wall

thin, calcareous, with radial fibers, not arenaceous. A megaspheric specimen, 0.5 mm. in diameter, has a proloculum 0.073 mm. in diameter.

The axial section of a specimen 1 mm. in axial diameter has an oval proloculum, 0.05 mm. by 0.06 mm.; the nucleoconch is endothyrine, with its axis at an angle of 25° from that of the adult stage; whorls 4; septa not folded except at the axial ends; wall thin, 0.025 mm. in thickness, finely fibrous, 200 fibers in 1 mm.; chomata prominent, finely granular, extending nearly to the axis of the test; tunnel angle, 20° to 25°. Common.

The Atoka specimens seem to be identical in every respect with the upper Pennsylvanian forms from Spitzbergen and the lower Permian specimens from Indo-China.

Genus FUSULINELLA Moller, 1877

Fusulinella Moller, Neues Jahrb., 1877, p. 144. No species named.

Genotype (first species, designated by Douville, 1906), *Fusulinella bocki* Moller, Mem. Acad. Imp. St. Petersbourg, ser. 7, vol. 25, no. 9, 1878, p. 101, pl. 5, fig. 3; pl. 14, figs. 1-4. (Middle Pennsylvanian, Kresty, Twer, Russia.)—Douville, Com. Ren. Acad. Sci., Paris, 1906, p. 258.—Ozawa, Jour. Coll. Sci. Imp. Univ. Tokyo, vol. 45, art. 4, 1925, pp. 7, 24; art. 6, 1925, p. 17.—Lee, Pal. Sinica, ser. B, vol. 4, fasc. 1, 1927, p. 12.—Dunbar and Condra, Nebr. Geol. Surv., Bull. 2, ser. 2, Dec., 1927, p. 61.—Henbest, Jour. Pal., vol. 2, no. 1, 1928, p. 70.

Test fusiform in the adult; microspheric nucleoconch nearly symmetrical; megaspheric nucleoconch globular; septa primary meridional only, nearly straight as seen at the surface, more or less folded at their inner edges and at the ends of the test; chomata well developed, enclosing a spiral tunnel; wall calcareous, not arenaceous, consisting of a very thin, dark lamella (tectum), below which is a thin, light-colored median lamella (diaphanotheca), which is composed of transverse fibers, 140 to 180 in 1 mm.; the tectum and diaphanotheca curve down into the septa; outside of the tectum is a lamella, which is continuous across the septa and sutures, is somewhat thicker than the diaphanotheca, and is composed of transverse fibers exactly like those of the diaphanotheca and apparently continuous with them; below the diaphanotheca is a finely granular, secondary layer (tectorium), which thickens as it passes around the inner edges of the septa, and extends down the septa and spreads out on the floor of the chamber, forming the chomata and secondary deposit; septa not perforate; aperture an arch at the end of the tunnel, rarely seen. Length, up to 5 mm.—Lower and middle Pennsylvanian; upper Pennsylvanian and Permian doubtful.

FUSULINELLA EUTHUSEPTA Henbest

Plate V, figs. 6-11

Fusulinella euthuscpta Henbest, Jour. Pal., vol. 2, no. 1, 1928, p. 80, pl. 8, figs. 6-8; pl. 9, figs. 1, 2, 5. (Lower Pennsylvanian, Illinois.)

Test small, fusiform, symmetrical or with both ends curved in the same direction, usually swollen in the middle, varying from 1 mm. to 5 mm. in length, most of the specimens 4 mm. in length, and from 0.4 mm. to 1.4 mm. in median diameter, adult specimens averaging 1.3 in median diameter, the ratio of the median to the axial diameter ranging from 1:2.2 in the young to 1:3.5 in adults, averaging 1:3 for adults; whorls up to 10, usually 7; chambers in the last whorl varying from 25 to 32; septa nearly straight at the surface, except at the ends, where they curve, much thickened and slightly undulating at the base, forming strong chomata which bound a prominent tunnel, as seen in weathered specimens; sutures not depressed, marked by a thin line; surface smooth, minutely punctate; aperture an arch at the end of the tunnel, rarely seen.

The median section of a microspheric specimen has a round proloculum 0.07 mm. in diameter; in three median sections the chambers regularly increase from 10 in the first whorl to 28 in the last whorl; septa thick, pointing forward about 10°, more nearly radial in the early whorls. The following table gives the number of chambers per whorl in three specimens:

WHORL	NUMBER OF CHAMBERS		
	I	II	III
1	10	?	?
2	14	?	10
3	16	16	15
4	18	19	21
5	25	24	23
6	27	26	26
7	28	27	28

The median section shows well the structure of the walls of *Fusulinella*, as illustrated on Plate V, figs. 11, 11*a*, the outer, fibrous lamella, the dark line (the tectum), the light-colored, fibrous lamella (the diaphanotheca), and the inner, finely granular layer (the secondary deposit). There are 160 fibers in a length of 1 mm. in both outer lamella and diaphanotheca. The granules of the inner layer are much smaller. The wall is from 0.03 to 0.04 mm. thick in the last whorl. The wall shows no indication of being arenaceous.

The axial sections of two microspheric specimens show prolocula 0.07 mm. in diameter and the following chambers are symmetrically ar-

ranged; the septa are folded slightly in the median region and the amount of folding increases to the ends of the test; the chomata are prominent, reaching or not reaching the upper wall, depending on the accident of where the section is cut; the tunnel angle is normally 25° to 27°, although in the last whorl of large individuals the tunnel widens greatly, and may subtend an angle of 40°; in very thin sections the outer, fibrous lamella, the median, dark line (tectum), the fibrous, light-colored keriotheca, and the granular chomata are well shown. Common.

This species is very similar to *Fusulinella bocki* Moller in size, wall structure, number of whorls, chambers per whorl, chomata, tunnel, and slightly folded septa, but differs in being relatively longer, the ratio of median to axial diameter in *F. bocki* being less than 1:2, whereas in *F. enthusepta* it is from 1:3 to 1:4.

Faunal list.

SPECIES	MISSISSIPPIAN		PENNSYLVANIAN			PERMIAN	
	Lower	Upper	Lower	Middle	Upper	Lower	Upper
Spirillina radiata n. sp.			X				
Spirillina concavoconvexa n. sp.			X				
Spirillina sp.			X	X			
Agathammina magnatuba n. sp.			X	X	X	X	X
Ammonema filum (Schmid)			X				
Ammovertella undulata Galloway and Harlton			X	X	X		
Ammovertella adherens (Cushman and Waters)			X	X	X		
Ammovertella laterimerensis Galloway and Harlton			X	X			
Ammovertella elongata (Cushman and Waters)			X	X	X		
Tolypammina inclusa (Cushman and Waters)			X	X			
Toylpammina confusa (Galloway and Harlton)			X	X	X		
Endothyra rothrocki Harlton			X				
Endothyra whitesidei n.sp.			X				
Endothyranella minuta (Waters)			X				
Orobias radiata (Brady)		X	X	X	X	X	
Orobias ciscoensis (Harlton)			X	X	X	X	
Orobias waageni (Schwager)			X	X	X	?	
Globivalvulina bulloides (Brady)			X				
Globivalvulina biserialis Cushman and Waters			X	X	X		
Tetrataxis lata Spandel			X	X	X		
Tetrataxis corona Cushman and Waters			X				
Tetrataxis concava n. sp.			X				
Nodosinella cf. cylindrica Brady		X	X				
Nodosinella cf. concinna Brady		X	X				
Bullopora wapanuckaensis Galloway and Harlton			X				
Bullopora redoakensis Galloway and Harlton			X				
Bullopora modesta n. sp.			X				
Tuberitina bulbacea Galloway and Harlton			X	X	X		
Palaeotextularia grahamensis (Cushman and Waters)			X	X	X		
Deckerella clavata Cushman and Waters			X	X	X		
Staffella molleri Ozawa			X	X	X	X	
Schubertella transitoria Staff and Wedekind			X				
Fusulinella euthusepta Henbest			X	X	X		
Species found in different horizons		4	33	17	15	4	1

EXPLANATION OF PLATE I

FIGURE

1.—*Spirillina radiata* n. sp. ×70. *a*, dorsal side; *b*, apertural view; *c*, ventral side.

2.—*Spirillina concavoconvexa* n. sp. ×70. *a*, dorsal side; *b*, apertural view; *c*, ventral side.

3.—*Spirillina* sp. ×70.

4.—*Agathammina magnatuba* n. sp. ×35. *a*, right side; *b*, obverse; *c*, left side; *d*, reverse.

5.—*Ammonema filum* (Schmid). ×70.

6.—*Ammovertrella undulata* Galloway and Hralton. ×70.

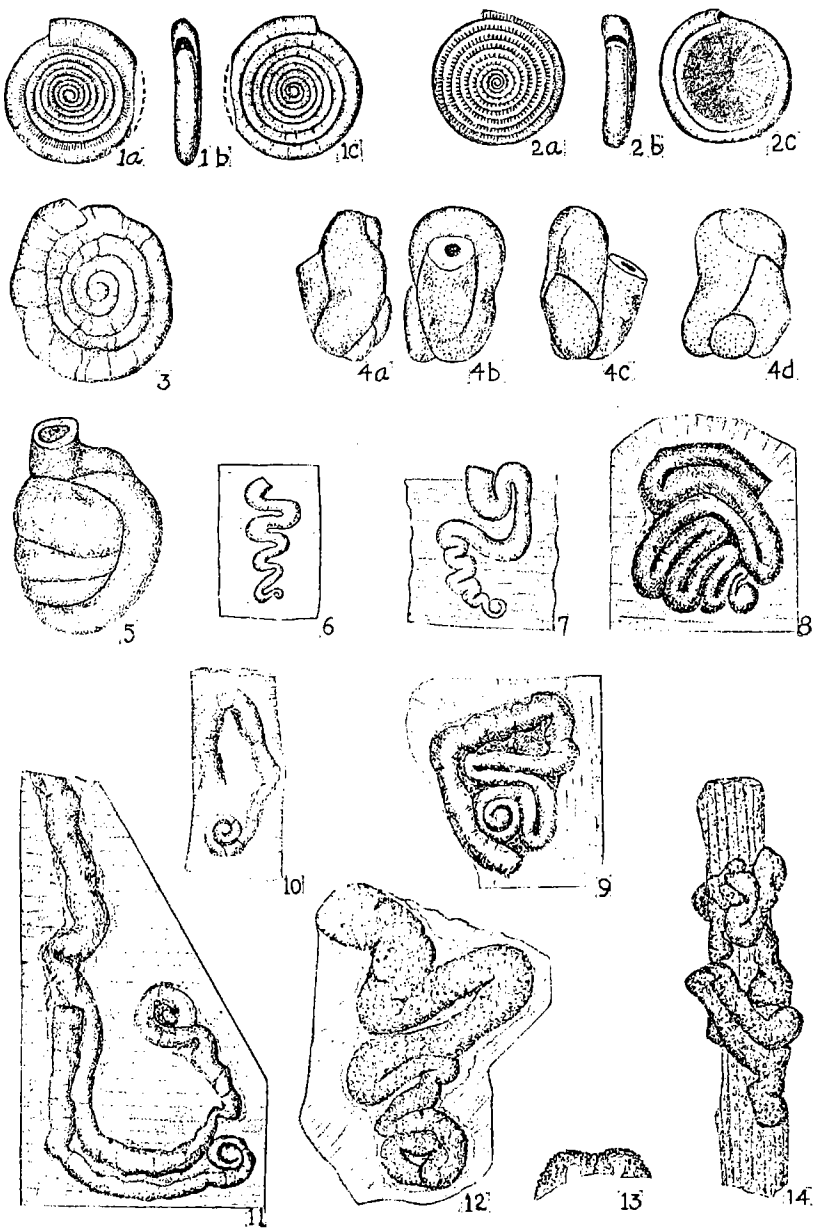
7.—*Ammovertella adherens* (Cushman and Waters). ×70.

8, 9.—*Ammovertella latimerensis* Galloway and Harlton. ×70.

10, 11.—*Ammovertella elongata* (Cushman and Waters). ×35.

12, 13.—*Tolypammina inclusa* (Cushman and Waters). ×35. Fig. 13, cross-section of specimen with host dissolved away by acid.

14.—*Tolypammina confusa* (Galloway and Harlton). ×35.



EXPLANATION OF PLATE II

FIGURE 1-3.—*Endothyra rothrocki* Harlton. Figs. 1 *a-c*, three views of the exterior. ×55. Fig. 2, part of longitudinal section, to show fibrous wall structure. ×110. Fig. 3, part of transverse section, to show fibrous wall structure, and change in the plane of coiling as the whorls are added. ×110.

4.—*Endothyra whitesidei* n. sp. ×55. Three views of the exterior.

5, 6.—*Endothyranella minuta* (Waters). ×55. *a*, side view showing spire; *c*, opposite side; *b*, apertural view.

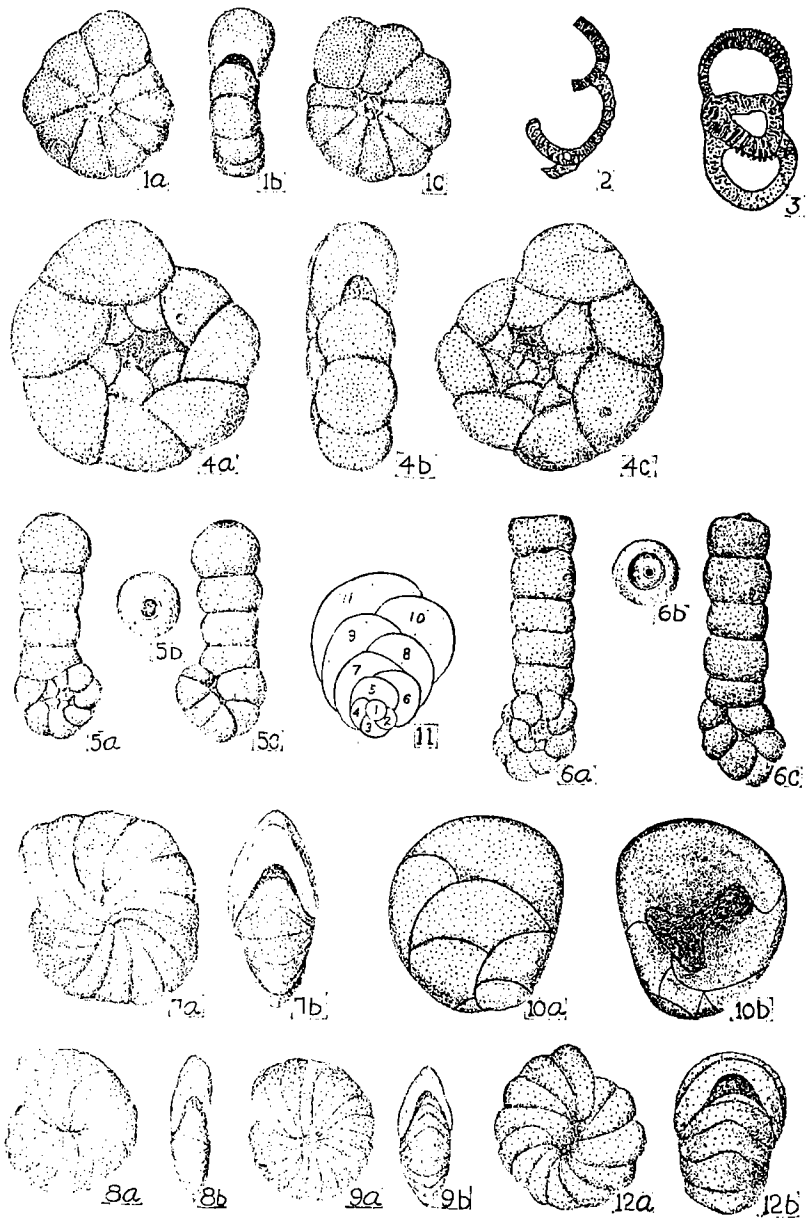
7.—*Orobias waageni* (Schwager). ×55. Side and apertural views.

8.—*Orobias radiata* (Brady). ×55. Side and apertural views.

9.—*Orobias ciscoensis* (Harlton). ×55. Side and apertural views.

10, 11.—*Globivalvulina biserialis* Cushman and Waters. ×55. *a*, dorsal side; *b*, ventral side. Fig. 11, diagram of dorsal surface flattened out, to show coil and succeeding biserial chambers.

12.—*Staffella mölleri* Ozawa. ×55. Side and apertural views.



EXPLANATION OF PLATE III

FIGURE

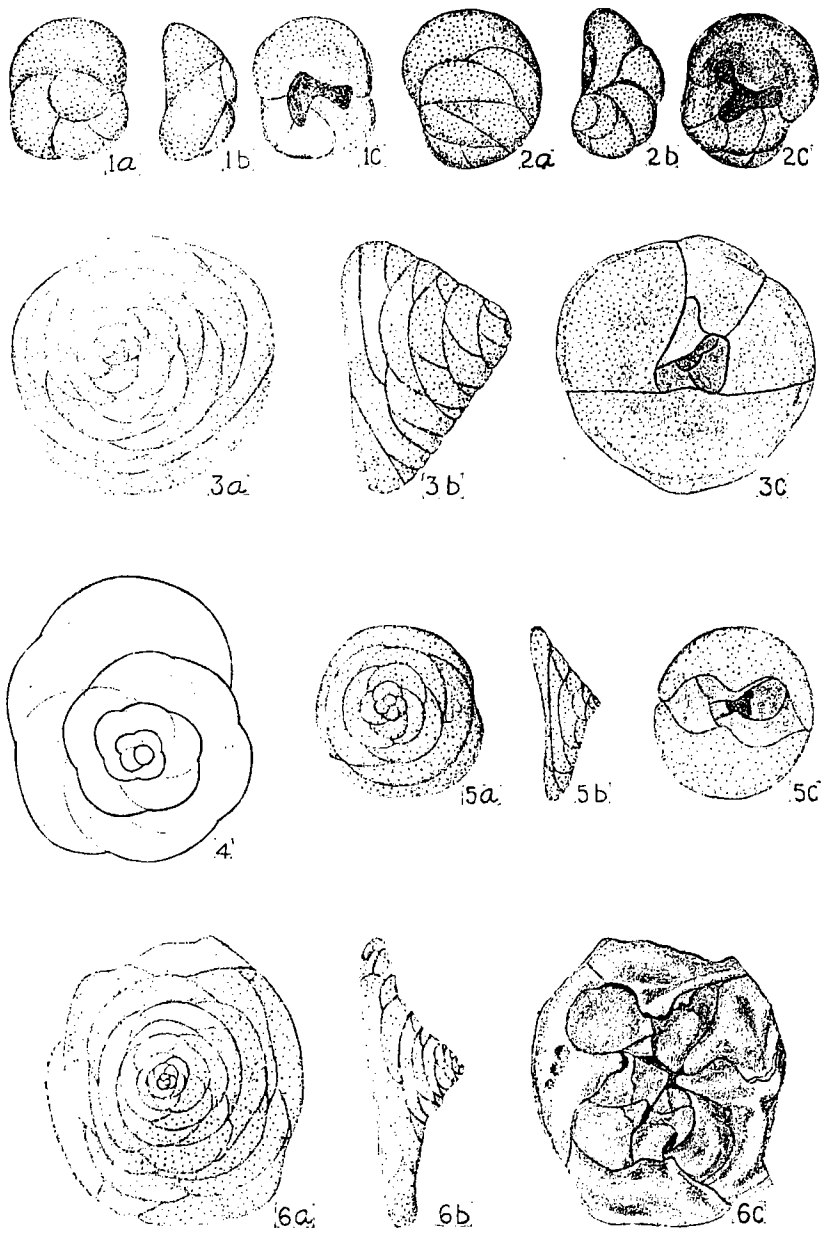
1.—*Globivalvulina bulloides* (Brady). ×55. Dorsal, edge and ventral views.

2.—*Globivalvulina biserialis* Cushman and Waters. ×55. Dorsal, edge and ventral views.

3, 4.—*Tetrataxis lata* Spandel. ×55. Dorsal, side and ventral views. Fig. 4, Camera lucida sketch of the apex of a microspheric specimen, to show the arcuate chambers and their spiral arrangement. ×110.

5.—*Tetrataxis corona* Cushman and Waters. ×35. Dorsal, edge and ventral views.

6.—*Tetrataxis concava* n. sp. ×35. Dorsal, edge and ventral views.



EXPLANATION OF PLATE IV

FIGURE 1, 2.—*Nodosinella* cf. *cylindrica* Brady. ×35. Fig. 1, crushed specimen. Fig. 2, nearly perfect specimen.

3, 4.—*Nodosinella* cf. *concinna* Brady. ×35. Two incomplete specimens.

5, 6.—*Bullopora wapanuckaensis* Galloway and Harlton. ×55. Two specimens, attached to ramose, calcareous algae.

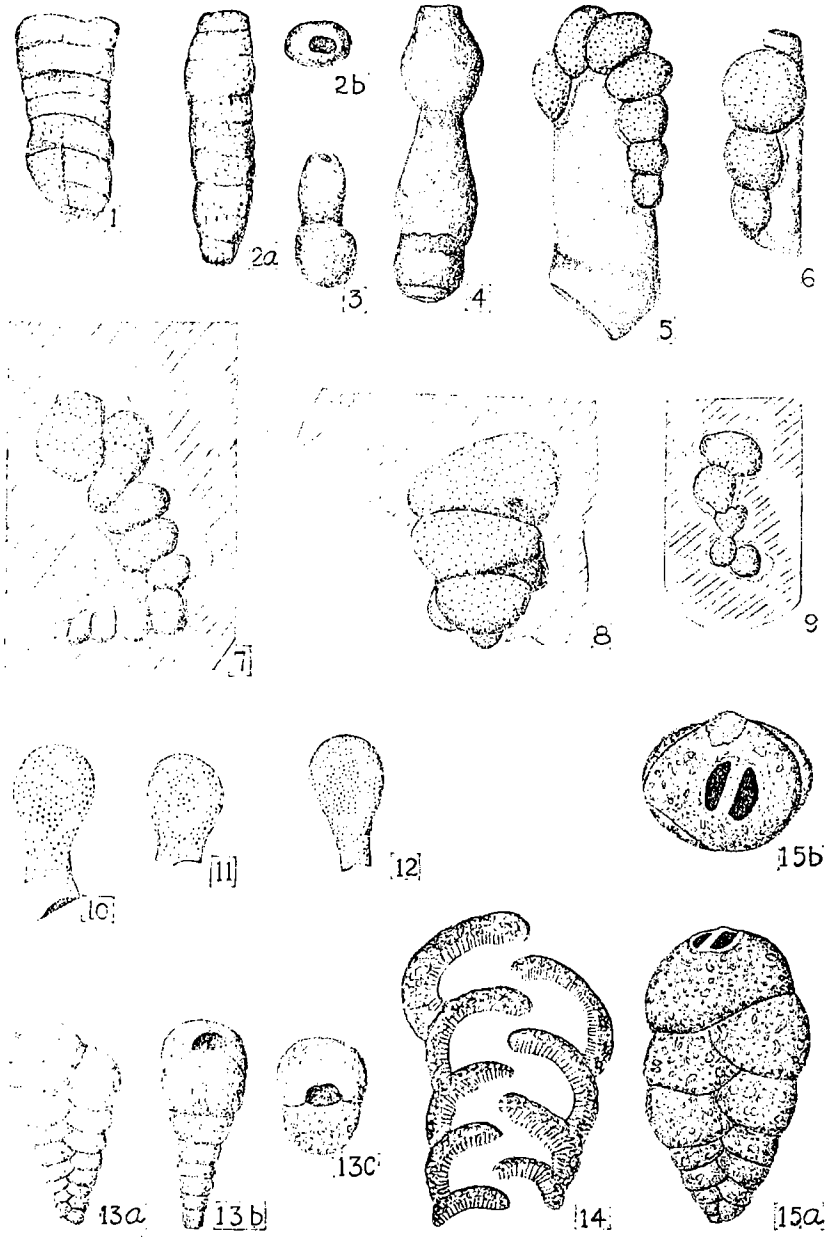
7, 8.—*Bullopora redoakensis* Galloway and Harlton. Fig. 7, ×35. Fig. 8, ×55. Two specimens, attached to complanate, calcareous algae.

9.—*Bullopora modesta* n. sp. ×55. A specimen attached to complanate, calcareous alga.

10-12.—*Tuberitina bulbacea* Galloway and Harlton. ×35. Three small specimens. Fig. 10, with two chambers. Figs. 11, 12, unilocular specimens.

13 14.—*Palaeotextularia grahamensis* (Cushman and Waters). Fig. 13, side, edge and apertural views. ×35. Fig. 14, part of longitudinal section, to show inner, fibrous layer and outer, granular layer composing the walls. ×110.

15.—*Deckerella clavata* Cushman and Waters. ×35.



EXPLANATION OF PLATE V

FIGURE 1-5.—*Schubertella transitoria* Staff and Wedekind. ×55.
Fig. 1, nepionic specimen 0.27 mm. long. Fig. 2, neanic specimen 0.54 mm. long. Fig. 3, ephebic specimen, 0.7 mm. long. Fig. 4, axial section of a microspheric specimen 1 mm. long, showing asymmetrical, endothyrine nucleoconch, the thin, fibrous walls, nearly straight septa, and prominent, granular, chomata. Fig. 5, median section of a microspheric specimen, with four whorls, showing asymmetrical, endothyrine nucleoconch, fibrous walls, and prominent chomata.

6-11.—*Fusulinella cuthuscpta* Henbest.
Fig. 6, a nearly perfect, typical specimen. ×15. Fig. 7, a specimen with part of the outer wall removed, showing the tunnel, and upturned, axial ends of the test. ×15. Fig. 8, longitudinal section of a microspheric specimen, showing symmetrical nucleoconch, tunnel, the septa which are much folded at the ends of the test, and the fibrous walls. ×15. Fig. 9, part of the outside wall, taken from the upper, right end of the specimen shown in Fig. 8, showing the wall to be composed of two fibrous layers separated by a dark line; *o*, outer lamella; *t*, tectum; *d*, diaphanotheca. ×110. Fig. 10, part of the wall and chomata, taken from the third from the last and next to last whorls at the lower, right side of the tunnel of the specimen, shown in Fig. 8, showing the tectum, *t*; the fibrous diaphanotheca, *d*; the outer lamella, *o*; and the granular chomata, *c* ×110. Fig. 11, median section of a microspheric specimen, showing the proloculum, seven whorls, and the fibrous structure of the walls. ×35. Fig. 11 *a*, part of a whorl, taken from the northwest quadrant of the next to the last whorl shown in Fig. 11; *o*, outer, fibrous lamella; *t*, tectum; *d*, fibrous diaphanotheca; *s*, granular, secondary deposit. ×110.

12.—*Fusulina ventricosa* Meek.
Part of the wall, showing the tectum, *t*; and the coarse keriotheca, *k*; for comparison with the wall of *Fusulinella*, shown in Figs. 9, 10 and 11*a*, drawn to the same scale. ×110.