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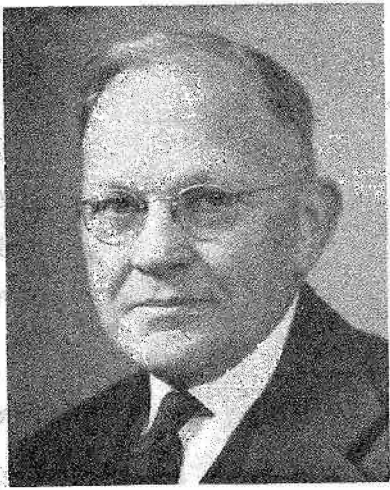

LUTHER CROCKER SNIDER

OKLAHOMA GEOLOGICAL SURVEY • THE UNIVERSITY OF OKLAHOMA • NORMAN, OKLAHOMA

Cover Picture

LUTHER CROCKER SNIDER

L. C. Snider contributed to knowledge of Oklahoma geology over a period of several years. He came to the State as a teacher in chemistry at McAlester High School in 1909. C. N. Gould recognized his abilities and a few months later employed him on the Oklahoma Geological Survey, soon making him assistant director. Gould characterized him as a scientist who could write with a lucid and readable style. His first investigation on the Survey was to collect clay samples which he analyzed and tested in the laboratory of the U. S. Bureau of Mines in Pittsburgh. He wrote a 270-page report on the clays (Bulletin 7, 1911). His 191-page report on road materials appeared as Bulletin 8, in 1911; a report on lead and zinc as Bulletin 9 in 1912; a report on gypsum and salt as Bulletin 11 in 1913; a report on rock asphalts as Circular 5 in 1913; and a report on geology of east-central Oklahoma as Bulletin 17 in 1914.

Snider was offered the directorship of the Survey in 1913, but chose to do graduate work at the University of Chicago. His dissertation, on Mississippian rocks and fossils of northeastern Oklahoma, was published by the Survey (Bulletin 24, 1915). He returned to the Survey briefly in 1915 and wrote *Geography of Oklahoma* (Bulletin 27, 1917). He also contributed much material to the bulletin on oil and natural gas (Bulletin 19, 1915, 1917). During his years in Norman he also published six articles in journals and a book on petroleum and nåtural gas in Oklahoma.

In 1916 he left to begin his career in petroleum geology, first with Pierce Oil Company, then Cosden Oil Company, and then with Empire Oil and Gas Company (Empire Gas and Fuel Company, Cities Service Company, Henry L. Doherty & Co.,). In 1932 he published *Earth History,* an outstanding book of ideas. From 1941 until he died of heart trouble on May 24, 1947, he taught historical geology and petroleum geology at the University of Texas.

Snider was editor of the Bulletin of the American Association of Petroleum Geologists for four years and was president in 1940. He was a charter member of the Association. His contributions to geologic science of Oklahoma were outstanding and pioneering.

The cover picture, taken in 1940, was obtained through the courtesy of Dr. Snider's daughter, Mrs. Hester Schurr, of Austin, Texas.

—C. C. B.

(Photograph by Bachrach)

Ordovician (Richmondian) Foraminifera from Oklahoma, Missouri, Illinois, and Kentucky*

James E. Conkin† and Barbara M. Conkin

INTRODUCTION

During our study of Silurian, Devonian, and Mississippian Foraminifera in the east-central and midcontinental United States, samples were collected also from several Upper Ordovician formations; these Ordovician samples were found to contain Foraminifera which are described in this paper.

Only Moreman (1930, 1933) has published systematic descriptions of Foraminifera from the Ordovician of North America. However, since 1933, a few references have been made to North American Ordovician Foraminifera by Kjellesvig (1934), from the Trentonian of New York; by Moore (1952), from the Trentonian of Virginia; and by Conkin, Conkin, and Pike (1965), from the Richmondian of Oklahoma, Missouri, and Illinois.

Ordovician Foraminifera are described herein for the first time from the following Richmondian formations: Sylvan Shale (Oklahoma), Maquoketa and Orchard Creek Shales (Missouri and Illinois), and Waynesville Formation (Kentucky).

This report includes the first description of *Tolypammina* in the Ordovician and of *Blastammina* in the Ordovician of North America.

Loeblich and Tappan (1964) have proposed a number of generic revisions and reallocations among the arenaceous Foraminifera, some of which concern Paleozoic forms. However, exhaustive restudy of previously described Ordovician, Silurian, and Lower and Middle Devonian Foraminifera must be completed before revision of Paleozoic genera can be undertaken successfully. Thus, we do not follow Loeblich and Tappan (1964) but are continuing our detailed investigations of Paleozoic Foraminifera and are making whatever revisions and reallocations are needful as our studies progress.

METHODS

The shale and silty shale samples were prepared for picking by washing through a 150-mesh sieve. The photomicrographs were taken with a Nikon F 35-mm single-reflex camera through a Bausch and Lomb Stereozoom binocular microscope. Adox KB-14 film was used. The photomicrographs are not retouched.

LIST OF LOCALITIES

Oklahoma

1. Sylvan Shale. Ideal Portland Cement quarry, Lawrence; SE¼ sec. 36, T. 3 N., R. 5 E., Pontotoc County.
2. Sylvan Shale. Outcrop on west bank of Hickory Creek at Rock Crossing, just south of bridge; NE¼ SW¼ sec. 35, T. 5 S., R. 1 E., Criner Hills, Carter County.

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† University of Louisville, Louisville, Kentucky.

Missouri

3. Maquoketa Shale. Roadcut on U. S. Highway 54, northeast of Bowling Green, 1 mile northeast of junction of U. S. Highways 54 and 61; NW¼ NW¼ sec. 24, T. 53 N., R. 3 W., Bowling Green quadrangle.
4. Maquoketa Shale. Roadcut on State Road C, just east of Spencer Creek bridge; SW¼ NW¼ sec. 3, T. 54 N., R. 5 W., Vandalia quadrangle.
5. Maquoketa Shale. Roadcut on secondary road south of Stark Nurseries, southwest of Louisiana; NE¼ SW¼ sec. 25, T. 54 N., R. 2 W., Bowling Green quadrangle.
6. Orchard Creek Shale. Roadcut on southeast side of Lithium, Perry County.

Illinois

7. Orchard Creek Shale. Roadcut at Gale; NE¼ NE¼ NW¼ sec. 4, T. 15 S., R. 3 W., Thebes quadrangle, Alexander County.
8. Maquoketa Shale. Outcrop behind house on northeast side of State Highway 100, north side of Williams Hollow, 0.5 mile north of the creek and 2.1 miles north of the entrance of Père Marquette State Park; NE¼ NW¼ NE¼ sec. 4, T. 6 S., R. 13 W., Brussels quadrangle.
9. Maquoketa Shale. In the south bank of the river, in the town of Custer Park.

Kentucky

10. Waynesville Formation. North of Hillsboro, on State Highway 111, Fleming County.

STRATIGRAPHIC PALEONTOLOGY

Eight genera and nine species of Foraminifera have been described (Moreman, 1930, 1933) from two Ordovician formations in North America (Oklahoma), as follows:

Middle Ordovician (Trentonian) Viola Limestone

Bathysiphon exiguus Moreman, 1930
Kerionammina favus Moreman, 1933
Marsipella aggregata Moreman, 1930
Rhabdammina trifurcata Moreman, 1933
Raibosammina aspera Moreman, 1930
Raibosammina mica Moreman, 1930
Tholosina elongata Moreman, 1930
Webbinella tholus Moreman, 1933

Lower Ordovician Arbuckle limestone

Hyperammina minuta Moreman, 1930

This list is increased to eleven genera and twelve species by the addition of the forms described herein, *Blastammina* sp., *Thurammin-oides sphaeroidalis* Plummer, 1945, and *Tolypammina* sp., from the Upper Ordovician of Oklahoma, Missouri, Illinois, and Kentucky. The distribution of these species is shown in table I.

TABLE I.—OCCURRENCE OF FORAMINIFERA IN UPPER ORDOVICIAN IN OKLAHOMA, MISSOURI, ILLINOIS, AND KENTUCKY

SPECIES	FORMATION AND LOCALITY									
	SYLVAN		MAQUOKETA					ORCHARD CREEK		WAYNESVILLE
	1	2	3	4	5	8	9	6	7	10
Thuramminoides sphaeroidalis	X	X	X	X	X	X	X	X	X	X
Tolypammina sp.	X	X	X	X	X		X		X	
Blastammina sp.	X									

At present little can be said regarding the stratigraphic value of Ordovician Foraminifera in North America; however, we offer some comments on genera previously described. Comments on the presently described forms are given under the systematic paleontology portion of this paper.

Bathysiphon M. Sars, 1872

Lower Paleozoic forms which have been referred to *Bathysiphon* are of doubtful generic position. It seems best to reserve this genus for those forms which are nonbranching tubes, tapering slightly aborally, many displaying some annulations on the exterior surface, and commonly containing sponge spicules in the test wall. Many Recent species incorporate sponge spicules in their test, but none of the Lower Paleozoic forms is reported to contain discernible spicules, perhaps because of alteration of the original material of the test. Sponge spicules are quite prominent in specimens of *Bathysiphon* which we have found in the Bundella Formation in the Permian (Artinskian) of Tasmania.

Recent species may secrete secondary discs closing the aboral end and at intervals along the tube (Loeblich and Tappan, 1964, p. 186).

Bathysiphon ranges from the Ordovician to the Recent. In the Paleozoic, the genus has been reported from the Middle Ordovician, the Lower, Middle, and Upper Silurian, and the Lower Devonian.

Webbinella Rhumbler, 1903

Loeblich and Tappan (1957) erected the genus *Hemisphaerammina* to accommodate single-chambered, arenaceous counterparts of the calcareous genus *Webbinella* Rhumbler, 1903; unfortunately, *Hemisphaerammina* is inadequately defined and the true nature of the genus is unknown.

Loeblich and Tappan (1964, p. 202) placed *Fairliella* Summerson, 1958, in *Hemisphaerammina;* however, we consider *Fairliella* to be a distinct genus.

Loeblich and Tappan gave the range of *Hemisphaerammina* as Devonian to Recent, but *Webbinella tholus* Moreman, 1933, most likely belongs in *Hemisphaerammina* (if *Hemisphaerammina* is a valid genus); thus, the genus probably ranges downward into the Middle Ordovician. The genus is not yet known in the Upper Paleozoic of North America. We consider *Metamorphina* Browne, 1963 (*in* Browne and Schott, 1963), to be invalid inasmuch as *Webbinella tholus* Moreman, 1933, was designated as its type species. In addition, Browne's generic concept of *Metamorphina* is actually that of *Sorosphaera geometrica* Eisenack, 1954, which is generically distinct from *Hemisphaerammina* and *Sorosphaera*.

In connection with our studies of Silurian and Devonian Foraminifera from Ohio, Kentucky, and southern Indiana, we are in the process of investigating *Hemisphaerammina* and *Sorosphaera geometrica*. *Hemisphaerammina* will either have to be revised or the Paleozoic forms seemingly now referable to *Hemisphaerammina* will have to be reallocated, and a new generic name will be needed to replace the name *Metamorphina*.

Kerionammina Moreman, 1933

This genus may be restricted to the Ordovician; however, inasmuch as it is monotypic, known from only one formation, and its generic status is uncertain, its usefulness is quite limited.

Marsipella Norman, 1878

The range of *Marsipella* is Ordovician to Recent. In the Paleozoic, it has been reported from the Middle Ordovician, and the Middle Silurian (Stewart and Priddy, 1941).

Rhabdammina M. Sars, 1860

The validity of some species of Paleozoic *Rhabdammina* is questionable inasmuch as specimens of other genera (such as *Tolypammina*) can be distorted and broken so that they resemble *Rhabdammina*, as demonstrated in the systematic paleontology portion of this paper. The range of *Rhabdammina* is Ordovician to Recent; in the Paleozoic, the genus has been reported from the Middle Ordovician, Middle Silurian, and Middle Devonian.

Tholosina Rhumbler, 1895

We are not certain of the relationship between Paleozoic forms which have been placed in *Tholosina*, *Colonammina* Moreman, 1930, and *Hemisphaerammina*. We are considering these generic concepts in our continuing work on the Silurian and Devonian Foraminifera. The range of *Tholosina* is from the Ordovican to the Recent; Paleozoic representatives are recorded from the Middle Ordovician, Lower and Middle Silurian, and questionably from the Middle Devonian.

Raibosammina Moreman, 1930

Raibosammina was reallocated to *Stegnammina* by Loeblich and Tappan (1964, p. 196). Although we have not yet made a detailed study of *Stegnammina*, we prefer at this time to recognize *Raibosammina* as distinct from *Stegnammina*. *Raibosammina* has been reported from the Middle Ordovician and the Middle Silurian; its range is Ordovician to Recent.

Hyperammina Brady, 1878, emended Conkin, 1961

We cannot agree with Loeblich and Tappan (1964, p. 190) in restricting the generic definition of *Hyperammina* to forms with a relatively large bulbous proloculus and a tube generally of lesser diameter than the proloculus. If this extremely narrow view of the genus were accepted, a large number of Paleozoic species of *Hyperammina* would have to be reallocated, and indeed the microspheric and megalospheric forms of several species of *Hyperammina* would belong to different genera. The second chamber of many Paleozoic species of *Hyperammina* has a diameter greater than that of the proloculus, especially in the microspheric forms, and many species do not possess a relatively large proloculus even in the megalospheric form. The morphological nature of various species of *Hyperammina* in the Lower and Middle Paleozoic is imperfectly known, but the genus deserves particular attention inasmuch as *Hyperammina* is one of the genera of Paleozoic arenaceous Foraminifera which has been proven to exhibit evolutionary lineages useful for age determination and correlation (Conkin, 1961; Conkin, Conkin, and McDonald, 1963; and Conkin and Conkin, 1964a).

Hyperammina is known from the Lower Ordovician to the Recent. The genus has not been reported from the Upper Silurian and Lower Devonian.

SYSTEMATIC PALEONTOLOGY

Family ASTRORHIZIDAE

Genus *Thuramminoides* Plummer, 1945, emended Conkin, 1961

Thuramminoides sphaeroidalis Plummer, 1945, emended Conkin, 1961

Plate I, figures 1-17

Thuramminoides sphaeroidalis Plummer, 1945, Univ. of Texas, Pub. 4401, p. 218, 219, pl. 15, figs. 4-10. Crespin, 1958, Australia, Bur. Min. Res., Geol. and Geophys., Bull. 48, p. 40, 41, pl. 3, figs. 9-11; pl. 31, figs. 1, 2. Conkin, 1961, Bull. Amer. Paleont., vol. 43, no. 196, p. 243-247, pl. 17, figs. 1-10; pl. 18, figs. 1-4; pl. 16, figs. 1-3; text-fig. 1. Conkin, Conkin, and McDonald, 1963, Micropaleont., vol. 9, p. 221, pl. 1, figs. 16, 17. Conkin and Conkin, 1964, Micropaleont., vol. 10, p. 32, pl. 1, figs. 51-54. Conkin and Conkin, 1964, Bull. Amer. Paleont., vol. 47, no. 213, p. 71, 72, pl. 12, figs. 36-38. Conkin, Conkin, and Pike, 1965, Micropaleont., vol. 11, p. 344-345, pl. 1, figs. 4-7.

Thuramminoides teicherti (Parr). Crespin, 1958, Australia, Bur. Min. Res., Geol. and Geophys., Bull. 48, p. 41, 42, pl. 3, figs. 12, 13.

Description.—Test, free, originally spheroidal or nearly so, secondarily compressed, generally assuming a discoidal form, many having the shape of a red blood corpuscle; present specimens are small to rather large, ranging from 0.17 to 1.46 mm in diameter; central interior structure destroyed in all present specimens so that the thin to rather thick wall surrounds an interior cavity with little or no trace of any original material, and filled with sediment in instances where the test is broken open; apertures show up on the exterior and interior of the test wall of thick-walled forms; in many thin-walled specimens the apertures are poorly developed, or are absent in extremely thin-walled forms; texture of the wall is smooth to rather smooth, in many cases shiny, composed of fine siliceous grains in much siliceous cement; color of test ranges from light gray in thinner walled forms to buff-white in the thicker walled forms.

Measurements.—The ranges in maximum diameter of the tests of all specimens of *Thuramminoides sphaeroidalis* from the various Ordovician formations are as follows:

FORMATION	DIAMETER (MM)
Sylvan	0.17-1.43
Orchard Creek	0.25-1.46
Maquoketa	0.21-1.18
Waynesville	0.25-0.37

Measurements of the figured specimens are given in table II.

Comparison and affinities.—The specimens here reported from the Upper Ordovician agree with descriptions of previously reported forms of the species. Many thin-walled forms are present among the specimens.

Stratigraphic occurrence.—*Thuramminoides sphaeroidalis* is known from the Upper Ordovician to the Pennsylvanian in the United States. In Australia, including Tasmania, it is known from the Permian, in which it is common. Recently, we have examined the type of *Trochammina bursaria* from the Silurian of Victoria (Chapman, 1933) and have found that it is probably conspecific with *T. sphaeroidalis*. *T. sphaeroidalis* is listed by Loeblich and Tappan (1964, p. 208) as occurring in the Mesozoic of the U. S. S. R.

TABLE II.—MEASUREMENTS OF *Thuramminoides sphaeroidalis*

OU SPECIMEN	MAXIMUM DIAMETER (MM)	MINIMUM DIAMETER (MM)	LOCALITY AND (FIGURE)*
4917	0.32	0.05	1 (1)
4918	0.44	0.08	1 (2)
4919	0.37	0.07	1 (3)
4920	0.47	0.05	7 (4)
4921	0.49	0.07	1 (5)
4922	0.59	0.10	1 (6)
4923	0.69	0.19	1 (7)
4924	0.66	0.19	7 (8)
4925	0.67	0.15	3 (9)
4926	0.82	0.15	1 (10)
4927	0.88	0.24	1 (11)
4928	0.79	- - -	3 (12)
4929	0.96	0.62	1 (13)
4930	0.86	0.17	1 (14)
4931	0.96	0.21	1 (15)
4932†	1.38	0.17	3 (16)
4933	1.21	0.24	1 (17)

* Figure number given in parentheses refers to plate I.
† "Twinned" specimen.

Remarks.—Loeblich and Tappan (1964, p. 208, 210) have discussed the genus *Thuramminoides* in some detail and expressed several opinions regarding its status; we have pertinent information regarding the genus. Loeblich and Tappan's discussion is quoted here, followed by our comments.

> This genus was defined as having a labyrinthic or spongy interior, and in the type-species varying from a smooth surface to a papillate one. Examination of the original types strongly suggests that these include more than one species and possibly more than one genus. The holotype and one paratype have a compressed circular form, with smoothly finished surface; another paratype shows large protuberances bearing small rounded openings. Other specimens with irregular surfaces show roughened internal walls which suggest a labyrinthic structure. However, the globular paratype Plummer figured as an internal cast, showing the spongy interior, we believe to be a complete specimen, as it shows an agglutinated wall and is not a secondarily formed internal cast. It is a globular specimen with exterior labyrinthic wall and seems quite distinct from the smooth-walled, compressed holotype. The interior of a large number of smooth forms must be examined in order to determine if they do represent a single species, and if the genus does include all specimens here included by Plummer.

We have examined the interiors of a great number of specimens, including topotypes, from the Ordovician to the Pennsylvanian of the United States.

The holotype chosen by Plummer (1945, pl. 15, fig. 4), although typical of the ordinarily encountered specimen of this species, does not display the apertures piercing the test wall, nor a papillate texture of the exterior, and of course it is not possible to determine whether the internal tubular structure is present inasmuch as the specimen is complete and unbroken; nevertheless, the holotype is without doubt a *Thuramminoides sphaeroidalis*, as are, we believe, all of the other specimens figured by Plummer (1945, pl. 15, figs. 4-10).

Plummer did not describe *Thuramminoides sphaeroidalis* as having a papillate surface, but stressed that the test may be smooth, without protuberances, or may have one or many protuberances which may bear apertures. Protuberances occur in the specimens shown by Plummer in figures 5 and 8 (1945, pl. 15). It is true that some tests of *T. sphaeroidalis* do have a subdued to moderately papillate exterior surface texture (Conkin and Conkin, 1964b, pl. 12, figs. 36-38; pl. I, figs. 1, 2, 5, 9, and 16, of this paper) which may be the outward expression of pores in the test wall which do not completely pierce the outer surface of the test.

Most specimens of *Thuramminoides sphaeroidalis* are distorted and characteristically assume a compressed circular form (discoidal or commonly resembling a red blood corpuscle). Collapse is due to destruction of the material of the interior portion of the test, along with compaction of the surrounding sediment. The species characteristically is smoothly finished as a result of much siliceous cement and the fineness of the incorporated quartz silt particles.

The nature of the structure of the test wall is shown in thin sections in Mississippian examples by Conkin (1961, pl. 26, figs. 1, 2) and in examples from the Permian of Australia by Crespin (1958, pl. 31, fig. 2). In addition, Conkin (1961, pl. 26, fig. 3) presented a thin section of an undoubted specimen of *Thuramminoides sphaeroidalis* in which the tubular structure of the test wall has been destroy-

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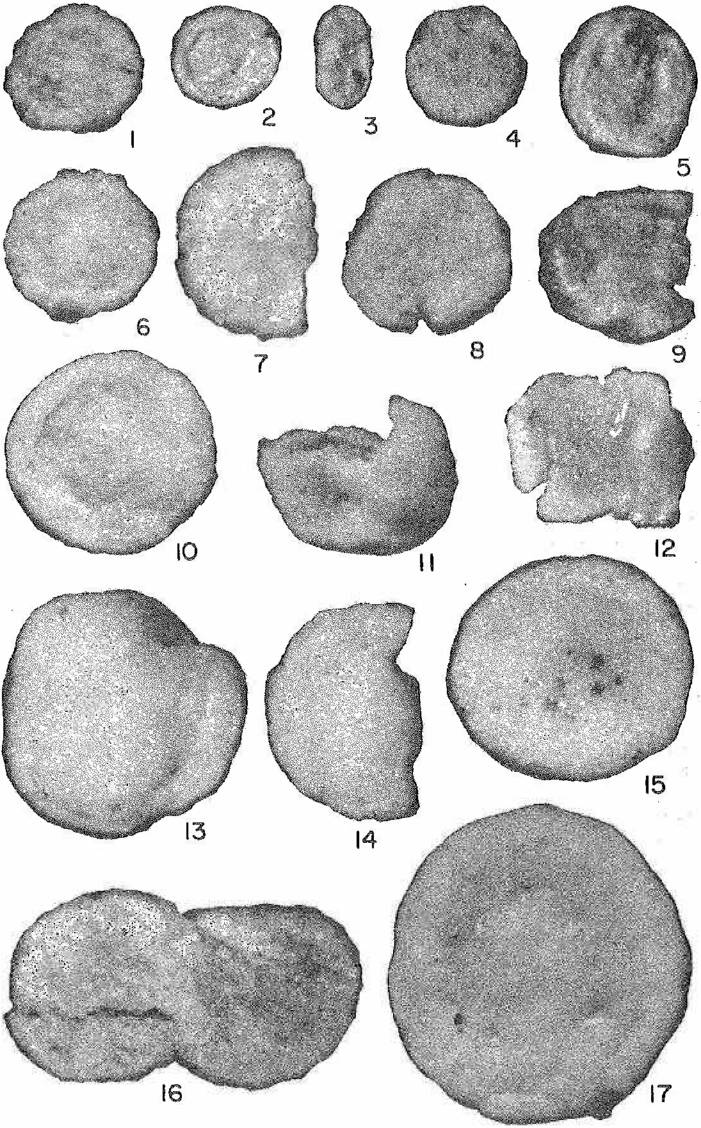
Explanation of Plate I

(All figures approximately x40)

Figures 1-17. Thuramminoides sphaeroidalis **Plummer, 1945, emend. Conkin, 1961**

1. **Medium-sized, thick-walled test with papillate texture, OU 4917. Locality 1.**
2. **Small-sized, thin-walled test with papillate texture, OU 4918. Locality 1.**
3. **Small and distorted specimen not showing apertures, OU 4919. Locality 1.**
4. **Medium-sized, thick-walled specimen showing apertures piercing exterior of test wall, OU 4920. Locality 7.**
5. **Medium-sized test showing fine papillae and wrinkling of test wall, OU 4921. Locality 5.**
6. **Medium-sized, thick-walled specimen with apertures, OU 4922. Locality 1.**
7. **Large-sized, thick-walled, broken specimen showing papillae on exterior of test wall and small portion of interior surface of the test wall with an aperture (seen as a round dot in upper right quadrant), OU 4923. Locality 1.**
8. **Medium-sized, thick-walled specimen with apertures, OU 4924. Locality 7.**
9. **Medium-sized, thin-walled, broken specimen with fine papillae, OU 4925. Locality 3.**
10. **Medium-sized, thick-walled specimen with apertures; cracks in test due to collapse of test wall, OU 4926. Locality 1.**
11. **Medium-sized, thick-walled, broken specimen showing interior cavity and large apertures, OU 4927. Locality 1.**
12. **Fragment of large, thick-walled, broken specimen showing interior wall with faintly visible apertures, OU 4928. Locality 3.**
13. **Large, thick-walled, rather smashed, semiglobular specimen, OU 4929. Locality 1.**
14. **Fragment of large, thick-walled specimen showing apertures faintly, OU 4930. Locality 1.**
15. **Large, thick-walled, strongly compressed specimen, with apertures, OU 4931. Locality 1.**
16. **Abnormally "twinned" specimens with fairly thick walls with fine papillae, moderately large papillae, and a few apertures in the left-hand specimen, OU 4932. Locality 3.**
17. **Large, thick-walled specimen with large apertures, OU 4933. Locality 1.**

Plate I



ed, the usual condition of preservation of specimens of this species, apparently including the holotype.

The exact nature of Plummer's globular paratype (1945, pl. 15, fig. 9), referred to by Loeblich and Tappan as having been called an internal cast by Plummer, will not be known until a thin section is made of it. Plummer did not describe this specimen as a cast, but as the interior mass of the test itself, devoid of its outer wall. In most specimens the interior mass is destroyed and a hollow space is left surrounded by a wall of varying thickness. The figures of this paratype given by Plummer and by Loeblich and Tappan (1964, fig. 121-4) differ considerably. The figure given by Loeblich and Tappan emphasizes a labyrinthic aspect; *Thuramminoides sphaerodalis* is not labyrinthic (Conkin, 1961, p. 241); the figure as shown by Plummer portrays the pitted appearance of the ends of the partially destroyed radiating tubular structure (Conkin, 1961, p. 241). The interior structure of this species, when preserved, is as described by Conkin. Recently, we have again broken open a few uncompressed topotypes collected by us and have found (in particularly well-preserved forms) tubular structure radiating out equally and regularly in all directions on a definite geometric plan from a small central space; this is the first time that we have observed the tubular structure preserved from nearly the center of the test to the outer wall.

In some instances, as well shown by certain specimens from the Lower Mississippian, the interior of the test is filled with small waxy-appearing spheres which leave their impression on the interior of the test wall. The pattern thus produced is that which Plummer called reticulate, and which Conkin (1961) called pitted polygonal structure and which he thought represented the traces of the ends of the destroyed internal tubular structure. We do not know the origin or function of these spherical bodies, which may be secondary in nature.

Regarding the number of taxa represented in Plummer's material in the Cushman Foraminiferal Collection at the U. S. National Museum, several unfigured paratypes evoke doubts as to their identity. In many instances, it is quite difficult to be certain whether a specimen should be referred to *Thurammina texana* Plummer, 1945, or to *Thuramminoides sphaeroidalis* without one of the following features of *Thuramminoides* being present: apertures piercing the test wall, tubular structure internally, reticulate pattern on the interior of the test wall, or papillate texture on the exterior. In cases where these features are not developed, or are destroyed, differentiation between *T. sphaeroidalis* and *T. texana* is, in a strict sense, not possible. In such cases, Plummer relied upon the smoother nature and finer grained texture and greater amount of siliceous cement in the wall of *T. sphaeroidalis*, as well as the greater prominence of the protuberances in *T. texana* for differentiation between the two species; however, Plummer realized that these criteria were not precise nor consistent enough for complete accuracy. Thus, we suspect that *T. texana* may be conspecific with *T. sphaeroidalis*, or if not, then at least some specimens in the Cushman Foraminiferal Collection which have been referred to *T. texana* may well belong in *T. sphaeroidalis*.

If complete alteration of the original chemical makeup of the test of *Thuramminoides sphaeroidalis* has occurred (that is, if the test was not originally siliceous arenaceous), it is possible that this species may have been a pelagic organism, which would indeed be more consistent with its wide geographic distribution, and it may belong to a group of organisms other than the Foraminifera. Inasmuch as the true biologic nature of the species is unknown, we do not follow Loeblich and Tappan (1964) in placing the genus in the family Saccamminidae, but retain it in the Astrorhizidae as reallocated by Conkin (1961).

Family SACCAMMINIDAE

Genus *Blastammina* Eisenack, 1932

Blastammina sp.

Plate II, figures 12a,b

Description.—Test free, subglobular, originally nearly spherical; no wrinkling to test, but with two shallow furrows on one side; test of fine quartz grains embedded in siliceous and tectinous cement; surface of test, smooth, with grains lying with their flat surfaces parallel to test surface; no apertures noted; color of test, light yellowish tan.

Measurements.—The solitary specimen of this species, found at locality 1, yielded the following measurements:

	MM
Maximum diameter	0.57
Median diameter	0.52
Minimum diameter	0.37
Maximum diameter of grains (Avg. 0.02 mm or less)	0.02-0.04

Comparison and affinities.—*Blastammina* sp. has its closest affinities to *B. eisenacki* Conkin, Conkin, and Pike, 1965, from the Upper Devonian and Lower Mississippian of Missouri and Illinois, in having (1) rather globular test, (2) thick test wall, (3) abundance of quartz grains in smaller amount of organic cement; however, it differs from *B. eisenacki* in having (1) somewhat larger size, (2) smaller sized quartz grains (0.03-0.04 mm in *B. eisenacki*), and (3) a less spherical shape to the test.

Stratigraphic occurrence.—*Blastammina* occurs in North America in the Upper Devonian and Lower Mississippian (Conkin, Conkin, and Pike, 1965) as well as in the Middle Devonian (Hamiltonian) Cedar Valley Limestone of Illinois and Sellersburg Formation of Kentucky and southern Indiana. The genus is herein recorded from the Ordovician of North America.

Remarks.—Only one specimen was found; thus, no attempt is made at specific determination, or to erect a new species. In addition, the test is poorly preserved.

Family TOLYPAMMINIDAE

Genus *Tolypammina* Rhumbler, 1895

Tolypammina sp.

Plate II, figures 1-11

Description.—Test consists of a gradually enlarging and irregularly winding, hemitubular to partially tubular second chamber; proloculus not preserved in present material; test attached throughout

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Explanation of Plate II

(All figures approximately x40)

Figures 1-11. Tolypammina **sp.**

1a. Oblique view of portion of second chamber, showing open tube at base where attached to foreign body, OU 4934. Locality 3.

1b. Top view of same specimen.

2, 3. Portions of second chamber of two sinuously curved specimens; proloculi not preserved, OU 4935 and OU 4936. Locality 1.

4. Portion of second chamber; proloculus not preserved, OU 4937. Locality 3.

5. Portion of second chamber of slender specimen; proloculus not preserved, OU 4938. Locality 3.

6. Portion of second chamber of a large and rather flattened specimen, OU 4939. Locality 3.

7. Basal view of fragment of second chamber showing surface of attachment partially covered by a basal floor wall, OU 4940. Locality 5.

8. Portion of second chamber; proloculus not preserved, OU 4941. Locality 9.

9. Portion of second chamber of large specimen, OU 4942. Locality 9.

10, 11. Fragments of distorted specimens of Tolypammina **sp. which superficially resemble** Rhabdammina.

10a. View showing somewhat hairpin-curved portion of part of second chamber of specimen; two openings (broken parts of the test) are present, OU 4943. Locality 9.

10b. Side view of same specimen.

11. Fragment of distorted specimen which is curved and bent to resemble a Rhabdammina**; two openings are present (representing broken parts of the test), OU 4944. Locality 9.**

Figure 12. Blastammina sp.

12a. Nearly spherical specimen showing residual traces of tectinous cement in central portion of the test, OU 4945. Locality 1.

12b. Opposite side of the same specimen showing tectinous cement between quartz grains, particularly just right of the center.

its length or may be attached at places along its course; attached side of second chamber generally covered by a rather thin floor, or the floor may be absent, with a slitlike, longitudinal opening running partly, or in some instances entirely, along the length of the chamber (pl. II, fig. 1a); apertural end broken in all specimens; test composed of siliceous grains in siliceous cement; color of test, whitish gray with a greasy luster; grain size, medium to fine.

Measurements.—The measurements of *Tolypammina* sp. are given in table III.

Comparison and affinities.—These specimens clearly belong in

Plate II

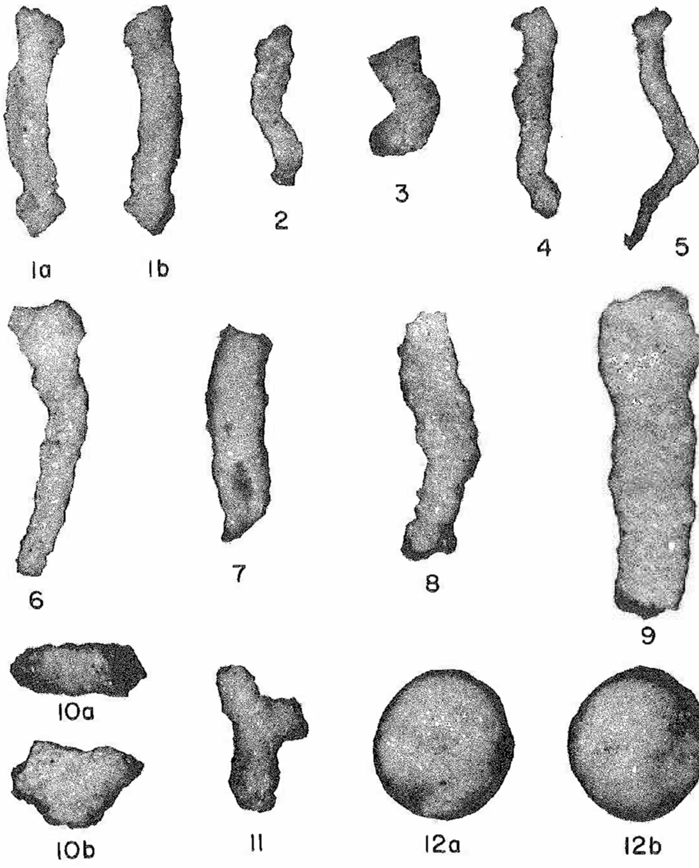

TABLE III.—MEASUREMENTS OF FRAGMENTS OF *Tolypammina* SP.

OU SPECIMEN	LENGTH (MM)	MAXIMUM DIAMETER (MM)	MINIMUM DIAMETER (MM)	LOCALITY AND (FIGURE)*
4934	0.86	0.19	0.13	3 (1)
4935	0.60	0.13	0.08	1 (2)
4936	0.45	0.20	0.13	1 (3)
4937	0.82	0.15	0.09	3 (4)
4938	0.96	0.13	0.03	3 (5)
4939	1.01	0.27	0.10	3 (6)
4940	0.79	0.19	---	5 (7)
4941	0.99	0.25	0.08	9 (8)
4942	1.23	0.39	0.27	9 (9)
4943	0.49	0.25	0.20	9 (10)
4944	0.55	0.20	0.14	9 (11)

* Figure number given in parentheses refers to plate II.

Tolypammina, but inasmuch as the prolocular portion, which is all-important in specific identification in this genus, is not preserved in the present forms, a specific determination is not possible.

Stratigraphic occurrence.—Valid species of *Tolypammina* have been recorded from the Silurian to the Recent. This report constitutes the first description of the genus from the Ordovician.

Remarks.—It is possible that fragments of *Tolypammina* have been observed in the Ordovician by other workers (Kjellesvig, 1934), but the fragmentary nature of the tests and resulting difficulty of generic assignment, have perhaps discouraged attempts at description. In addition, a few specimens which belong in *Tolypammina* were found which resemble *Rhabdammina,* in that they appear to possess Y-shaped branching; however, they are actually sharply bent and broken fragments of *Tolypammina.* Such distortion of specimens of *Tolypammina* can hinder their recognition in Paleozoic sediments; such distorted specimens are shown in this paper (pl. II, figs. 10, 11).

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Ten-Year Volume of Bibliography of North American Geology

The U. S. Geological Survey has just published the 1950-1959 *Bibliography of North American Geology*. It is issued in four thick volumes with a total of 4,025 pages. The bibliography is Bulletin 1195, Part 1, Bibliography (vols. 1, 2) and Part 2, Index (vols. 3, 4). The U. S. Geological Survey deserves the thanks of all geologists for continuing to produce the combined volumes. Geologists can now discard Bulletins 985, 1025, 1035, 1054, 1065, 1075, 1095, 1115, and 1145, the volumes for individual years. Bulletin 1195 is priced at $10.75 and is available from Superintendent of Documents, Washington 25, D. C.

—C. C. B.

Rhodocrinites beanei, New Species, from the Hampton Formation (Mississippian) of Iowa

Harrell L. Strimple* and Richard Boyt

The Iowa State Department of History and Archives in Des Moines, has purchased the huge starfish slab illustrated by Laudon and Beane (1937, fig. 4) and four major crinoid slabs from B. H. Beane of Le Grand, Iowa. These slabs are from the Hampton Formation of Kinderhookian (Mississippian) age at Le Grand. While preparing the material for display at the state museum, the junior author developed a technique for cleaning or extracting specimens in these slabs, using an airdent machine originally designed for dental work by the S. S. White Company. The matrix of the slabs yields easily to this technique and complete specimens may be entirely freed of matrix and details exposed that would otherwise be indistinct or unknown.

In the course of study, two specimens of *Rhodocrinites* were discovered which do not agree with the characters of other described species of the genus. One specimen is part of a display slab in the state museum and is considered as a paratype. The principal specimen has been mainly freed from a small segment of rock and is figured herein as the holotype of *Rhodocrinites beanei,* new species. The specific name is for B. H. Beane, who has studied the Le Grand crinoids for a lifetime and is coauthor of the only comprehensive study of the fauna.

Family Rhodocrinitidae Roemer

Genus *Rhodocrinites* Miller

Although we recognize need for a more comprehensive study of the genus, this report considers only those forms found in the Hampton Formation at Le Grand, Iowa. These may be roughly divided into four groups as follows:

Group A.—*R. watersianus* (Wachsmuth and Springer)
R. wortheni (Hall)

Group B.—*R. douglassi* var. *haploformis* (Laudon and Beane)

Group C.—*R. kirbyi* (Wachsmuth and Springer)
R. octadactylus (Laudon and Beane)
R. sculptus (Miller and Gurley)

Group D.—*R. nanus* (Meek and Worthen)
R. nanus var. *glyptoformis* (Laudon and Beane)
R. caelatus (Miller and Gurley)
R. beanei, new species

Our interest centers in Group D, which is typified by *R. nanus.*

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Factors held in common by forms in the group are the nodose to stellate nature of the cup plates and the light color. Forms in group C, typified by *R. kirbyi,* also have nodose cup plates but are consistently of a dark color and usually have a broader basal plane with less rapid expansion of the cup than is found in Group D. Forms in Group A have smooth cups, and those in Group B have strongly stellate plates and are darker in color.

Rhodocrinites beanei Strimple and Boyt, new species

Figures 1, 2

This species has a relatively large, expanded calyx, tumid and stellate cup plates, small, nodose tegmen plates, and a small protruded area about the anus. The fixed arms bifurcate once, and the free arms have two branchings, both of which are close to the cup, so that 40 arms are formed. The over-all length of the arms is no greater than the height of the calyx, which has a short, broad crown that is distinctive from those of other species of the genus. A decided differentiation between the fixed first secundibrach and the free second and third secundibrachs is also a good specific characteristic.*

The cup is bowl-shaped, as in *R. nanus* var. *glyptoformis,* width at arm bases (distorted by lateral compression) 19.1 mm, height 10.0 mm, on holotype. Infrabasals are small, confined to the bottom of the basal concavity where they form a horizontal platform, the center of which is occupied by the moderate-sized proximal columnal. Five large basals are in contact all around, and proximal areas form the walls of the basal concavity but recurve sharply to participate in forming the lateral walls of the cup. Five radials are separated all around, height and width about equal, 3.8 mm and 3.6 mm respectively, and in contact with PBr_1 above and interbrachials laterally. The second primibrach is axillary (PBr_2ax) and moderately large. First secundibrachs are rather large and fixed in the calyx. They are separated at their summit by a small fixed interbrachial.

The second secundibrach is a part of the free arm and does not nearly fill all of the upper surface of the SBr_1. The third secundibrach is commonly axillary. All arms have two or three uniserial tertibrachs with $TBr_{2-3}ax$. The arms become biserial with the junction of the first and second QBrr.

A large interradial plate separates the radials and rests upon the truncated upper surface of the basal plate. In normal rays it is followed by two interbrachials (iBrr), the next cycle by three iBrr. There may be from two to four iBrr in the next cycle, and usually four iBrr in the cycle above. In the posterior interray the anal plate is slightly larger than the other interradial plates and is followed above by three anal plates. In succeeding cycles the arrangement is irregular and more plates are involved than in normal interrays. Raised ridges mark the rays and dividing pass from each radial plate onto adjoining basal

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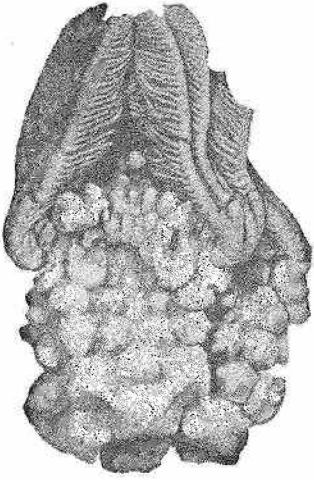
* The term "free" used herein has reference to arms which have some freedom of movement as opposed to those portions of arms that are "fixed" or are a corporate part of the calyx.



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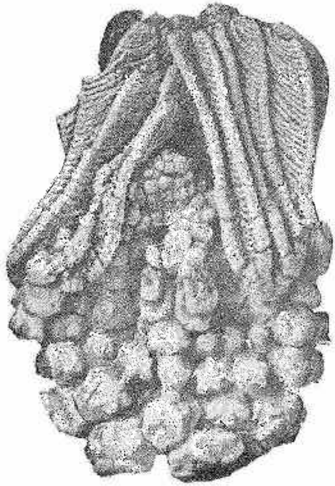

b

Figure 1. Side views of holotype of R. beanei **from posterior (a) and from anterior (b), natural size, unretouched photographs.**

plates and plates in the interrays. A rimlike projection is formed about the basal concavity by a conspicuous ridge that passes from basal to basal.

The 40 arms are delicate, biserial after last bifurcation with each brachial supporting a slender, relatively long pinnule. As previously noted, a sharp reduction in size of arms takes place with SBr_2, which is the first free brachial. The facet on the first secundibrach is exposed in the left half ray of the left anterior, and it is possible to see the unusual system of ridges and fossae (fig. 2). A shallow trough marks the area beyond the actual contact surface, which is itself a low ridge. We are unable to visualize the function of the trough other than to serve as a sort of socket for the SBr_2 as it moved about. The relationship here between SBr_1 and SBr_2 is the same as between the radial and PBr_1 in forms where the arms become free at the radial plate. Ambulacral openings into the body cavity are formed primarily by the SBr_1 with the upper portion of the opening surrounded by small tegmen and ambulacral plates.

Although the tegmen is distorted by lateral compression, the slight overhang of tegminal plates at the ambulacral openings of the calyx and the depressed interradial areas demonstrate a broad pentagonal tegmen composed of small, sharply tumid plates. A small pyramid surrounds the anus.

The column is composed of thin, alternately expanded columnals of moderate size and is pierced by a quinquilobate lumen.

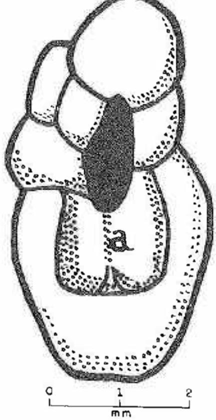

Figure 2. Enlarged camera lucida view of arm attachment facet (a) on the fixed first secundibrach and plates surrounding the ambulacral opening of the left half of the left anterior ray of the holotype of R. beanei. The facet (a) is considerably smaller than the total surface of the fixed secundibrach.

Remarks.- As previously outlined, *R. beanei* belongs to a distinct group (Group D) of the rhodocrinitids. These forms have pronounced basal invagination, a broad cup that is not constricted at its summit, deeply sculptured cup plates, and biserial arms that are laterally directed as they leave the cup. Forms of Group D in the Hampton Formation are light colored. At this time they are known only from the Hampton Formation with the exception of *R. nanus,* which is said to be relatively rare in the Hampton Formation and whose type horizon is the Burlington Limestone.

R. nanus typically has six arms to a ray, and the second bifurcation is an appreciable distance from the cup. The arms are proportionately long. In *R. beanei* the cup is proportionately large and the arms short and thin. Each ray has eight arms, and the second and third bifurcations are near the cup.

R. nanus var. *glyptoformis* is not nearly so light colored and is considered an advanced variety of *R. nanus,* in which the cup expands more rapidly and the interbrachial areas are broader.

R. caelatus is noted by Miller and Gurley (1889) to resemble *R. nanus,* but it has more deeply sculptured plates and, like *R. watersianus,* has only four arms to a ray, with the second bifurcation an appreciable distance from the cup. Some difference also occurs in their relative proportions. Miller and Gurley (1889, p. 361) noted the color factor of crinoids as follows: "Certain species from Le Grand are invariably dark colored, while others are invariably light colored. This is a peculiarity not known to us as prevailing at any other locality." The column of *R. caelatus* is proportionately larger than that of *R. beani,* and the free arms are directed upward in their lower extremities with second bifurcation well away from the summit of the cup (SBr_6ax). In *R. beanei* the arms are laterally directed at the cup and bifurcate close to the cup ($SBr_{2-3}ax$) and again with TBr_3ax.

We believe the increased number of arms is a progressive modification brought about to compensate for the loss of feeding and respiratory area, caused by shortening of the arms.

Occurrence.—Hampton Formation, Kinderhookian, Mississippian; quarry northwest of Le Grand, Iowa.

Types.—The holotype and paratype are in the Historical Building, Department of History and Archives, Des Moines, Iowa. A plastoholotype (SUI 11911) is in the Department of Geology, State University of Iowa, Iowa City, Iowa. Another plastoholotype (OU 3972) is in the invertebrate paleontological collections of The University of Oklahoma. A third specimen of this species is in the collection of B. H. Beane.

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Chemical Quality of Public Water Supplies in Oklahoma A Review

With the increase in population of the United States and a steady growth in per capita consumption of water, the problem of providing suitable public water supplies becomes more acute each year. Along with the increased difficulty in providing adequate quantities, which is the aspect of the problem most widely publicized, is a steadily growing difficulty in providing water of good chemical quality, and this aspect is receiving greater attention in current hydrologic investigations. A recent publication of the U. S. Geological Survey is a 1-sheet chart which summarizes some of the available data concerning the more prominent characteristics of water quality in the United States and Puerto Rico.

Chemical quality of public water supplies of the United States and Puerto Rico, 1962, by Charles N. Durfor and Edith Becker, is the title of U. S. Geological Survey Hydrologic Investigations Atlas HA-200, published in 1964. Chemical quality of untreated and finished public water supplies is shown as statewide averages of constituent contents, mainly in graphic and tabular form. For each state the average is weighted for population served. Eight maps of the United States and Puerto Rico depict the dissolved-solids, sodium, and fluoride concentrations and the hardness of untreated- and finished-water supplies of 1,596 municipal water systems as of 1962. Information shown on the maps is discussed in the text. Maps of nitrate concentration were not prepared, but the text discusses the sources and amount of nitrate present in water and quotes the U. S. Public Health Service recommendation that "in areas in which the nitrate content is known to be in excess of . . . [45 ppm], the public should be warned of the potential dangers of using the water for infant feeding."

In Oklahoma the survey included 17 municipal water systems serving 948,000 people (40.7 percent of the total population, or 64.7 percent of the urban population living in places of 2,500 inhabitants or more).

Maps A and E show that in Oklahoma the average dissolved-solids concentration in untreated- and finished-water supplies is within the range of 251 to 500 ppm (parts per million). In states adjacent to Oklahoma, only in Colorado and Arkansas do both untreated- and finished-water supplies contain lesser concentrations (101 to 250 ppm). The average hardness of untreated-water supplies (map B) is shown as greater than 180 ppm (highest classification), whereas that of finished-water supplies (map F) is between 121 and 180 ppm, indicating the degree to which Oklahoma water supplies are being treated with water softeners. Kansas also treats its water supplies, but, on the average, Texas does not.

Maps C and G, depicting the statewide averages of sodium concentration in untreated- and finished-water supplies, show that both supplies are within range of 41 to 60 ppm. Average fluoride concentration in both types of water (maps D and H) is within the range of 0 to 0.5 ppm in Oklahoma. Only four states exceed this range of fluoride concentration in untreated-water supplies. In 13 other states where the average for untreated-water is the same as that of Oklahoma, the average fluoride concentrations are greater than 0.6 ppm in the finished-water supplies, indicating that many municipalities fluoridate their water supplies. The text states that it has been "proved that fluoride concentrations of about 0.6 to 1.7 ppm reduced incidence of dental caries and that concentrations greater than 1.7 ppm also protected the teeth from cavities but caused an undesirable black stain."

The U. S. Geological Survey has been studying the quality of public water supplies for more than four decades. For this period, table 1 contains the data on hardness of finished water (average weighted for population served) for each state, the District of Columbia, and Puerto Rico. The data for Oklahoma are as follows:

YEAR	HARDNESS (PPM)	POPULATION SERVED
1922	400	194,000
1932	156	554,000
1952	125	896,000
1962	153	948,000

—L. J.

Reevaluation of *Pygmaeoceras*

James Harrison Quinn*

INTRODUCTION

Gastrioceras pygmaeum Mather, 1915, was described from a number of small shells collected from a limestone quarry in the northeastern part of Fayetteville, Arkansas. Because all of the specimens Mather collected are similarly small, he assumed they represent fully developed individuals. The species was referred to *Cravenoceras* by Plummer and Scott (1937, p. 265) and to "*Gastrioceras*" by Miller and Moore (1938, p. 347). Gordon proposed the name *Pygmaeoceras* (1960, p. 147) for the genus and designated *G. pygmaeum* as the type species. Ruzhencev (1962, p. 381) referred *Pygmaeoceras* to *Donetzoceras* Librovitch (1946).

Quinn (1962) reported the occurrence of *Reticuloceras* based upon nearly 1,000 specimens as much as 35 mm in diameter, from a locality on Kessler Mountain about 6 miles southwest of the type locality for *P. pygmaeum*. These goniatites were referred to *Reticuloceras* because of their reticulate ornamentation (fig. 4c) and similarity of appearance to *R. reticulatum*. Subsequently, a nearly unanimous consensus developed among interested paleontologists that the Kessler Mountain form is not referable to *Reticuloceras* because the ventral prongs of the suture are not as narrow as those of *Reticuloceras*, and the ornamentation is not quite the same in that all *Reticuloceras* display umbilical ribs at small diameters and tend to develop a revolving sulcus similar to that of *Eumorphoceras* at large sizes.

Bisat (1964, personal communication) suggested that the Kessler Mountain "*Reticuloceras*" is in reality *Pygmaeoceras pygmaeum*. His observations were based upon small specimens supplied from the Mather locality, as well as upon similar material from Kessler Mountain. The probability of the correctness of Bisat's suggestion has been strengthened by discovery of the Kessler Mountain form at the Mather locality from the presumed level of the type material. The new fossils are as much as 21 mm in diameter and provide unquestionable support for the reference of the Kessler Mountain "*Reticuloceras*" to *Pygmaeoceras pygmaeum*. Nearly all specimens from the Kessler Mountain locality retain the shells. Although the matrix is detrital limestone, the fossils have a black coating and separate readily from the enclosing rock. The shell cannot be chipped or peeled away, but the sutures may be exposed by scraping or by solution of the shell with acid. Living chambers are not preserved. The shells cannot be "broken back." Consequently, only a half dozen specimens in the entire lot retain impressions of the internal portion of the suture preserved on the ventral surface of the next inner whorl (fig. 1A). A number of specimens are crushed to some extent but most appear to be undistorted.

The specimens from the type locality retain the shell in most cases. The containing limestone is more adherent and considerably

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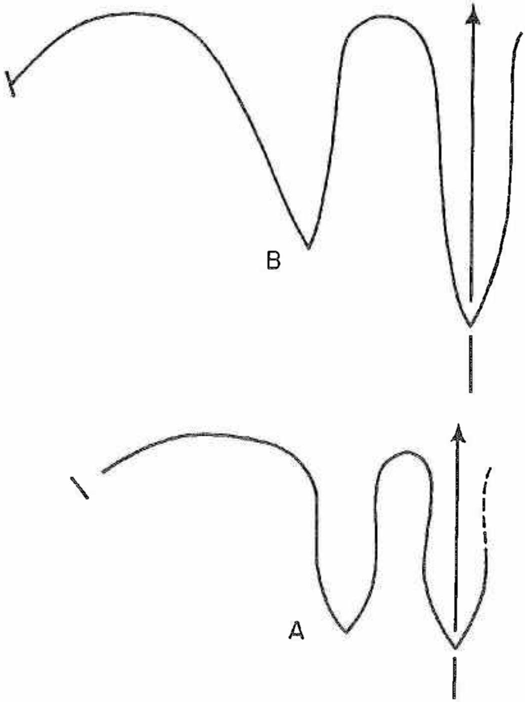


Figure 1. Dorsal, or internal, sutures of Pygmaeoceras **and** Gaitherites, **new genus.**

A. Pygmaeoceras pygmaeum **(Mather), UA L115-10. Dorsal suture, x8, at a diameter of approximately 22.4 mm (diameter of whorl on which suture is impressed, 18 mm).**

B. Gaitherites, **new genus (=** Pygmaeoceras solidum **Gordon), UA L95-58. Dorsal suture, x8, at a diameter of 25 mm (diameter of whorl on which suture is impressed, 18.6 mm).**

(Drawings by W. Bruce Saunders)

more recrystallization seems to have occurred than in the Kessler Mountain material. The shells of specimens from the type locality tend to be recrystallized, thickened, and crumbly. Ornamentation is retained in few places. Also, most specimens are extremely small. For these reasons the remarks that follow are derived mainly from examination of the more abundant, larger, and better preserved Kessler Mountain material.

The cross-sectional aspect of large *P. pygmaeum* (fig. 2) does not differ materially from that illustrated by Gordon (1960, p. 148, fig.

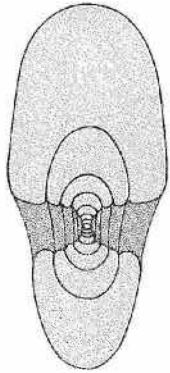


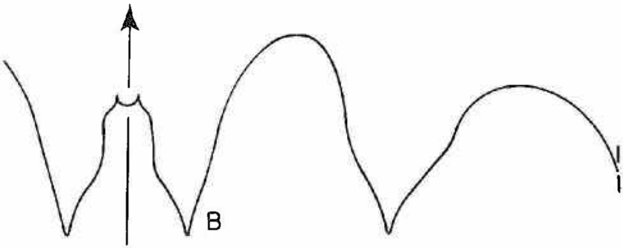
Figure 2. Cross-sectional configuration of Pygmaeoceras pygmaeum (Mather), x2.2, UA L115-11.

(Drawing by J. A. McCaleb)

3A) insofar as the first five whorls (excluding the protoconch) are concerned. Beyond the fifth whorl are strong differences in the rate of shell expansion, seemingly a reflection of some degree of dimorphism in specimens from 5 to 15 mm in diameter. Some specimens tend to have relatively smooth shells, smaller umbilici, and are laterally compressed whereas others have adolescent umbilical ribs and more inflated shells with larger umbilici. These differences seem to disappear in the larger specimens, which are remarkably similar in appearance.

The young shells are ornamented with fine lirae, which are radially directed and nearly straight. At a diameter of 12 to 14 mm the lirae have developed weak ventrolateral salients and a deeper ventral sulcus. At about the same stage revolving lirae develop, imparting a finely reticulate pattern to the shells. Because the ornamentation is delicate, it is readily destroyed. The shells bear weak constrictions which are expressed externally and number no more than four on smaller specimens. They seem to become obsolescent on larger shells.

The suture has rounded lobes as illustrated by Gordon (1960, p. 148, fig. 3C) at diameters of less than 8 mm. At a diameter of about 14 mm, the prongs of the ventral lobe are relatively broad, ventrally inflated, diagonally "truncated," and terminate with a blunt apex. The first lateral lobe is broad, short, and terminated in a small, clearly expressed tip. At a diameter of 25 to 30 mm (fig. 3A) the ventral prongs are relatively longer, less inflated medially, and more inflated laterally. The first lateral saddle is materially deepened. The first lateral lobe has developed a longer and less abruptly terminated tip. The largest sutures have developed longer tips on the prongs of the ventral lobes as well (fig. 3B). The large sutures resemble closely those of *Verneuilites* Librovitch as figured by Ruzhencev (1962, p. 378, fig. 145C). (It was this resemblance of the suture that led Furnish (*in* Furnish, Quinn, and McCaleb, 1964, p. 175) to refer the Kessler Mountain "*Reticuloceras*" of Quinn (1962) to *Verneuilites*.) The illustration of the shell (Ruzhencev, 1962, pl. 22, fig. 7) does not indicate sufficiently the form or dimensions for purposes of comparison.



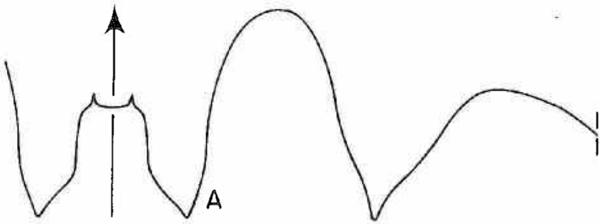


Figure 3. Pygmaeoceras pygmaeum **(Mather), UA L115-12.**
A. External suture at a diameter of about 28 mm.
B. External suture at a diameter of about 33 mm.
(Drawings by J. A. McCaleb)

It does indicate that the umbilicus is considerably larger than that of *Pygmaeoceras.**

The internal, or dorsal, portion of the suture (fig. 1A) can be traced with some assurance on one specimen (UA L115-10). The greatest diameter of the fossil is 22.4 mm. The portion to which the internal suture belonged is missing and would have been somewhat larger. The dorsal lobes are narrow and closely crowded. The dorso-lateral lobes are slightly curved and little inflated. The median lobe is about 3.8 mm long and no more than 1.25 mm wide. The sides are biconvex, providing an inflated appearance. The saddles are correspondingly slightly pinched. In general these lobes and saddles are subuniform in size. A broad second saddle extends across the flank of the whorl to the umbilical seam. Otherwise the lobes are sharply pointed and the saddles are smoothly rounded at the base.

In the configuration of the internal, or dorsal, portion of the su-

* While this paper was in press the author received a personal communication (June 18, 1965) from L. S. Librovitch, to whom he had sent several specimens of **Pygmaeoceras pygmaeum** from the Kessler Mountain locality. Librovitch is of the opinion that the Kessler Mountain forms are referable to the genus **Verneuilites** and probably to the type species, **V. verneuili.**

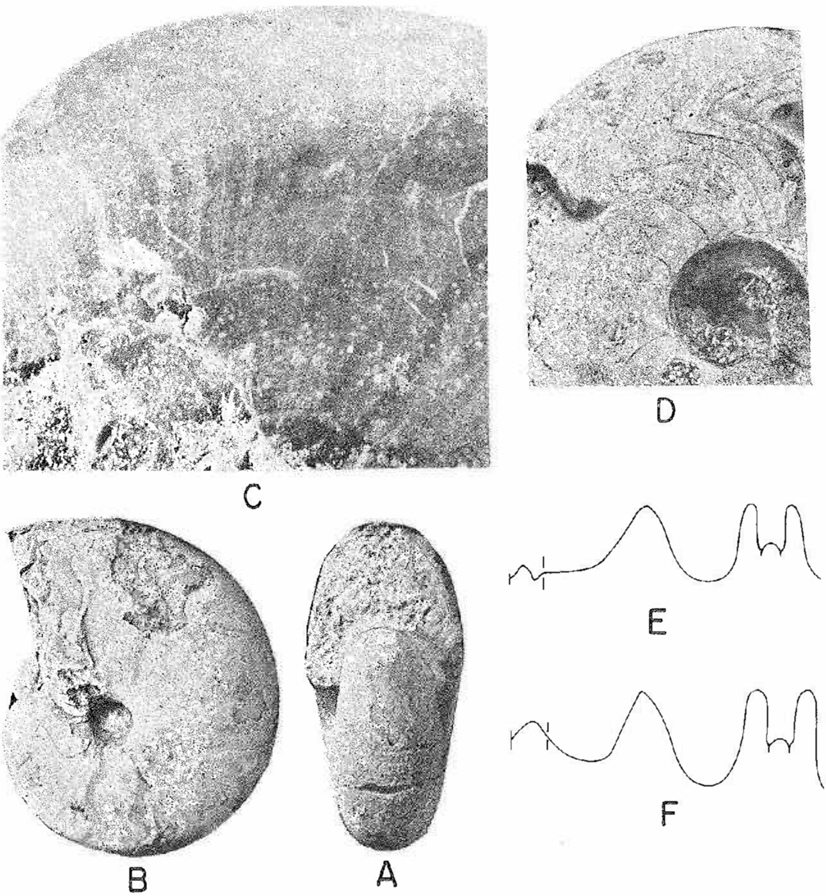


Figure 4. Pygmaeoceras pygmaeum **(Mather) and** Gaitherites solidum **(Gordon).**

A-C. Pygmaeoceras pygmaeum **(Mather). A. Front view of an uncrushed shell, diameter about 32 mm, x1.6, UA L115-13. B. Side view of shell, diameter 33 mm, x1.5, UA L115-14. C. Opposite side of shell shown in B, showing detail of ornamentation.** (Photographs by J. A. McCaleb and J. H. Quinn).

D-F. Gaitherites solidum **(Gordon). D. Side view of shell showing adventitious saddle on umbilical shoulder, diameter about 33 mm, x2, UA L95-59.**
E. Suture of shell shown in D, with adventitious umbilical saddle, at a diameter of 32 mm.
F. A normal suture at a diameter of 35 mm, UA L95-60.
(Photograph and drawings by J. A. McCaleb)

ture, *P. pygmaeum* differs most markedly from *Reticuloceras*. In *Reticuloceras* the internal lobes are short and triangular (Bisat, 1924, pl. 10, fig. 11). In the early stages of ontogeny, the ornamentation of *P. pygmaeum* resembles early ornamentation of *Anthracoceras* cf. *A. discus* from the Peyton Creek beds (Quinn, 1962, p. 220). Both in turn are ornamented quite like *Cravenoceras*. Whether or not the similarity is indicative of some degree of relationship, nothing else in the morphology of the three forms suggests that they are at all closely related.

According to Bisat (1924, p. 114, 120) the transverse striae of *Reticuloceras* are more or less crenulate, and the transverse striae of *Gastrioceras* are crenulate where associated with revolving "striae." In both genera, large shells tend to become smooth except perhaps for umbilical ribs or nodes. More advanced *Gastrioceras* may lose the striations altogether. The reticulate ornamentation of *Pygmaeoceras* is fine (fig. 4c), but the lirae are quite regular and there are no crenulations. This difference between ornamentation of *Pygmaeoceras* and that of *Reticuloceras* adds strength to the view that physical similarities of the two forms are coincidental and not indicative of genetic connections. I can discover no compelling evidence for associating *Pygmaeoceras pygmaeum* with any other known taxon.

OCCURRENCE

Pygmaeoceras pygmaeum appears to be confined to strata at the top of the Hale Formation. Associated goniatites include a primitive *Gastrioceras, Eoasianites* cf. *E. globosus,* and a form resembling *Cymoceras* McCaleb (1964a, p. 236-237), which Gordon (1965, p. 241-242) referred to *Homoceratoides cracens* Gordon. All of these belong to a Hale rather than Bloyd faunal assemblage. The containing rock is limestone in all cases and has generally been included in the Brentwood Member of the Bloyd Formation. A weathered zone above the *Pygmaeoceras* strata is indicative of an unconformity above rather than below this horizon. Still, it may be that the *Pygmaeoceras* horizon is contained in a limited stratigraphic unit between the Hale and Bloyd Formations.

Directly below the *Pygmaeoceras* horizon, in the Prairie Grove Member of the Hale Formation, *Arkanites* and *Baschkirites* occur (McCaleb, Quinn, and Furnish, 1964, p. 26; Furnish, Quinn, and McCaleb, 1964, p. 175). The Bloyd goniatites above the *Pygmaeoceras* horizon include *Branneroceras, Gastrioceras, Eoasianites oblatus,* and a number of other forms. The Bloyd assemblage is sharply differentiated from that of the Hale Formation. The difference is almost as great as that between the Late Mississippian fauna and that of the Early Pennsylvanian. *Pygmaeoceras* has no known relatives and has not certainly been encountered beyond the limits of Washington County, Arkansas.

REMARKS

Gordon (1965, p. 244-247) described two new species, which he referred to *Gordonites,* from the type locality of *P. pygmaeum.* The smaller of these, *Gordonites matheri* Gordon, is as much as 19 mm in diameter. A holotype and five paratypes were available. The second form he referred to *Gordonites filifer* Gordon. The largest specimen, his holotype, is 26.3 mm in diameter. A single paratype is 14 mm in diameter. Some shells are more inflated or widely umbilicate than others. Some have more or less strongly expressed ornamentation. All these configurations are matched in the Kessler Mountain sample where the differences are gradational. Thus the described and illustrated materials of these taxa are merely specimens of *P. pygmaeum*.

Furnish and Beghtel (1961, p. 293) suggested that *Gordonites* is a synonym of *Wiedeyoceras* Miller. McCaleb (1963, p. 873) followed this arrangement. I examined the type and paratype of *Wiedeyoceras sanctijohanis*, kindly lent to me by Myra Keene, Stanford University, and found a general resemblance to large *Pygmaeoceras pygmaeum* but no suggestion of close relationship.

Gordon referred a goniatite taxon from Gaither Mountain (U. S. G. S. loc. 8623) to *Pygmaeoceras* as new species *P. solidum* (1965, p. 262, fig. 82; pl. 28, figs. 26-39). This form was previously described by Miller and Moore (1938, p. 346-347, fig. 2A; pl. 43, figs. 2, 3) as a syntype of *Cravenoceras*? *morrowense*. Miller and Moore also figured a large and somewhat atypical specimen of *Eoasianites oblatus* (p. 347, fig. 2B; pl. 43, fig. 1) as a syntype. Gordon (1965, pl. 23, figs. 19, 20, 30, 31, and p. 222, fig. 60D) refigured the smaller specimen (Miller and Moore's figs. 2, 3) under the name *Glaphyrites morrowensis*. With approval of the State University of Iowa, I borrowed all the syntype material from M. K. Elias, who had retained the fossils for a number of years. The lot included both figured specimens and a considerable number of additional small members of Gordon's *P. solidum*. Miller refigured *Cravenoceras*? *morrowense* upon the basis of material from Union Valley, Oklahoma (Miller and Owen, 1944, pl. 65, figs. 3, 4). It is quite clear that the large form was intended to represent the species. It is also equally clear that the second specimen illustrated by Miller and Moore (1938, pl. 43, figs. 2, 3) must be considered a distinct taxon. I therefore propose the new genus *Gaitherites* for reception of the species. The ornamentation of *Gaitherites* lacks the revolving lirae (fig. 4D); the shell has well-defined umbilical ribs at small sizes. The constrictions are internal (internal varices of Gordon, 1965, p. 87), whereas those of *Pygmaeoceras* are expressed externally. The suture differs markedly, both ventrally and dorsally (figs. 1B, 4E,F). The shells of *Gaitherites* are considerably more inflated, and, finally, *Gaitherites* is of considerably later age. The species *Gaitherites solidum* (Gordon) is abundant in the Gaither Mountain assemblage. In Washington County, Arkansas, it occurs in strata about 27 feet below the Baldwin coal (Henbest, 1953) or in the upper part of the Brentwood Member of the Bloyd Formation. Gordon's description of the species may be taken as diagnostic for the genus. No other known species is referable to this genus.

Cravenoceras? *morrowense* was referred to *Glaphyrites* by Gordon (1965, p. 223). He also referred *Eoasianites oblatus* to *Glaphyrites*. Removal of the second "syntype" from *Cravenoceras*? *morrowense* eliminates the characters differentiating the two forms "*Glaphyrites*" *morrowensis* and "*Glaphyrites*" *oblatus*. Because "*G.*" *morrowensis* has page priority, "*G.*" *oblatus* becomes a synonym of "*G.*" *morrowensis*.

McCaleb (1964b) has pointed out that the proper generic designation for "*G.*" *morrowensis* (= *oblatus*) and "*G.*" *globosus* (= *Eoasianites globosus*) is *Syngastrioceras* Librovitch (1938).

ACKNOWLEDGMENTS

I am indebted to the administration of the University of Arkansas for making it possible for me to carry on the long-range investigation of the Arkansas goniatites in which I have been engaged for the past eight years. University research funds have been provided to me from time to time. I am especially indebted to the University for granting me an off-campus duty assignment during the fall semester of 1963, permitting me to visit museums and colleagues in England and on the Continent, where I was able to study and discuss many of the goniatites which appear identical with Arkansas specimens.

The specimens figured herein are at the University of Arkansas (UA). The specimens of *Pygmaeoceras pygmaeum* are from Kessler Mountain, Washington County, Arkansas, those of *Gaitherites solidum* from Gaither Mountain, Carrol County, Arkansas. The photographs and drawings were made by James A. McCaleb, now with Pan American Corporation, and W. Bruce Saunders, of the University of Arkansas.

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PALYNOLOGICAL ASSEMBLAGE FROM THE PERMIAN WELLINGTON FORMATION, NOBLE COUNTY, OKLAHOMA

RICHARD W. HEDLUND*

Palynomorphs from Permian deposits in Oklahoma have been described and illustrated from the Flowerpot Shale, Greer County (Wilson, 1962), and from the Council Grove Group, Osage County (Jizba, 1962). In 1964, Shaffer reported a large and varied palynomorph flora from evaporites in the Wellington Formation in Rice and Reno Counties, Kansas. No accounts of palynological assemblages from the Wellington Formation (Leonardian) of Oklahoma have been published.

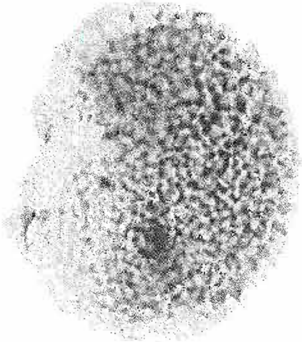
The present paper is a note on a palynological investigation of a productive coaly shale sample from the Wellington Formation in Noble County, Oklahoma. The sample was collected by John Kearns, Jr.,* in July 1963, from a small gully near an abandoned prospect, 8 miles

* Pan American Petroleum Corporation, Tulsa, Oklahoma.

Explanation of Plate I

Figure 1. Clavatasporites irregularis **Wilson, 1962, slide P-18614 A-5, 29.5 x 118.3. Size 80 μ.**
Figure 2. Punctatisporites **sp., slide P-18614 A-2, 30.6 x 117.8. Size 96 μ.**
Figure 3. Acanthotriletes **sp., slide P-18614 A-2, 27.1 x 123.9. Size 63 μ.**
Figure 4. Spore type A, slide P-18614 A-8, 21.7 x 124.9. Size 77 μ.
Figure 5. Punctatisporites **sp., slide P-18614 A-1, 31.2 x 124.1. Size 42 μ.**
Figure 6. Apiculatisporis **sp., slide P-18614 A-2, 21.3 x 126. Size 37 μ.**
Figure 7. Calamospora cf. C. breviradiata **Kosanke, 1950, slide P-18614 A-7, 31.7 x 120.1. Size 80 μ.**

Plate I



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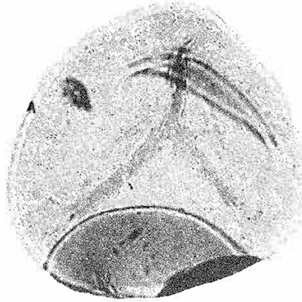

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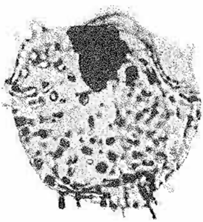

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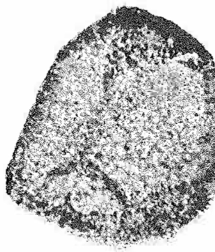

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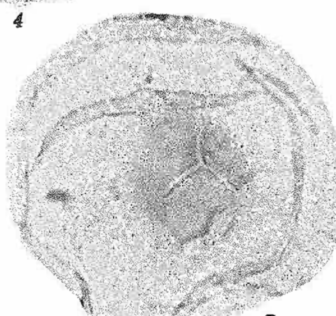

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southeast of Perry, NE¼ sec. 24, T. 20 N., R. 1 W. The 3-inch lens of dark-gray coaly shale in the exposure contains nodules of chalcopyrite, malachite, and azurite. Above the coaly shale lens is a 6-foot bed of poorly indurated, gray sandstone. This, in turn, is overlain by an undetermined thickness of red, cross-bedded sandstone which contains hematitic wood fragments. The base of the section is covered by talus.

A single composite sample of the 3-inch coaly shale lens was processed for palynological study. The residue yielded a small number of well-preserved palynomorphs, which are illustrated on plates I-III. The total assemblage consists of 21 species, of which five have been illustrated by Wilson (1962) from the Upper Permian (Guadalupean) Flowerpot Shale. These are:

Clavatasporites irregularis Wilson, 1962
Calamospora cf. *C. breviradiata* Kosanke, 1950
Lunulasporites vulgaris Wilson, 1962
Potonieisporites simplex Wilson, 1962
Hamiapollenites saccatus Wilson, 1962

Jizba (1962) figured a suite of bisaccate pollen grains from the Upper Pennsylvanian Virgilian Series of Kansas, the Wolfcampian of Kansas and Oklahoma, and the Leonardian of Texas. Of her total assemblage, only two species from the Leonardian of Callahan County, Texas, were also recovered from the Noble County sample. These are:

Alisporites zapfei (Potonié and Klaus, 1954) Jizba, 1962
Hamiapollenites saccatus Wilson, 1962 (*Striatosaccites* Type A of Jizba)

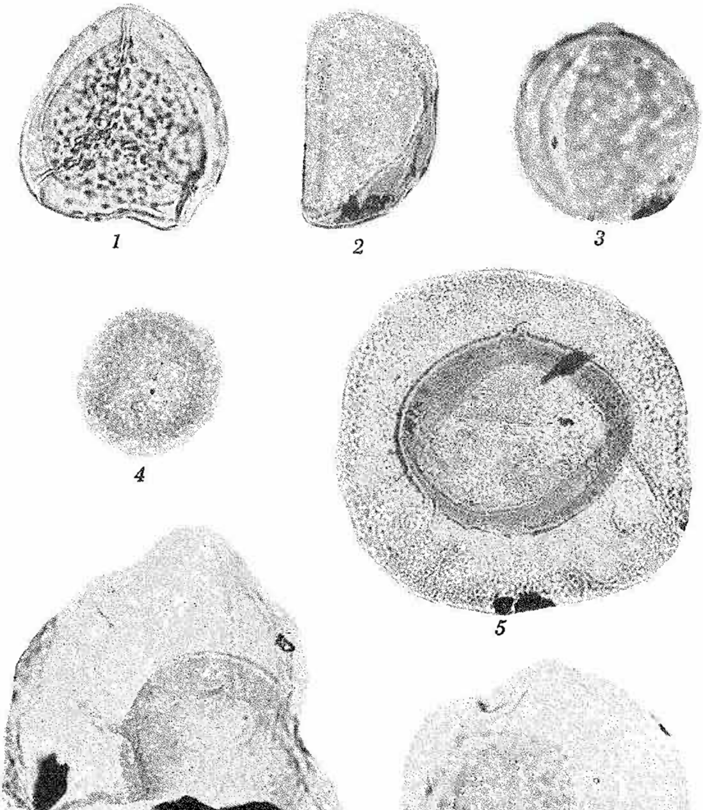
Shaffer (1964) illustrated a large palynomorph assemblage from the Wellington Formation of Kansas, but included no specific epithets. A comparison of our Oklahoma forms with those shown in his photographs shows the following Wellington forms to be common to both areas:

Punctatisporites spp. (*Leiotriletes* spp. of Shaffer)
Lycospora sp.
Thymospora cf. *T. pseudothiessenii* (Kosanke, 1950) Wilson and Venkatachala, 1963

Explanation of Plate II

Figure 1. Hymenozonotriletes **sp., slide P-18614 A-4, 26.3 x 118.5. Size 52 μ.**
Figure 2. Lunulasporites vulgaris **Wilson, 1962, slide P-18614 A-2, 33 x 120.8. Size 71 μ.**
Figure 3. Thymospora **cf.** T. pseudothiessenii **(Kosanke, 1950) Wilson and Venkatachala, 1963, slide P-18614 A-6, 18 x 117.8. Size 27 μ.**
Figure 4. Lycospora **sp., slide P-18614 A-1, 29.8 x 124.2. Size 34 μ.**
Figure 5. Potonieisporites simplex **Wilson, 1962, slide P-18614 A-6, 31.5 x 111.9. Size 183 μ.**
Figure 6. Incertae sedis Type A, slide P-18614 A-1, 25.5 x 121.5. Size 104 μ.
Figure 7. Incertae sedis Type A, slide P-18614 A-8, 26.7 x 111.5. Size 86 μ.

Plate II



Potonieisporites simplex Wilson, 1962
Hamiapollenites saccatus Wilson, 1962

The Wellington Formation sample from Noble County, Oklahoma, contains a typical Permian palynomorph assemblage. Because of the small number of species recovered, no new generic or specific names are here proposed.

The palynomorphs illustrated represent the total assemblage observed in the preparations. Microscope slides containing the specimens are in the palynological collection of Pan American Petroleum Corporation, Tulsa, Oklahoma. Specimen locations are given by coordinates of a Leitz Ortholux microscope equipped with a standard mechanical stage.

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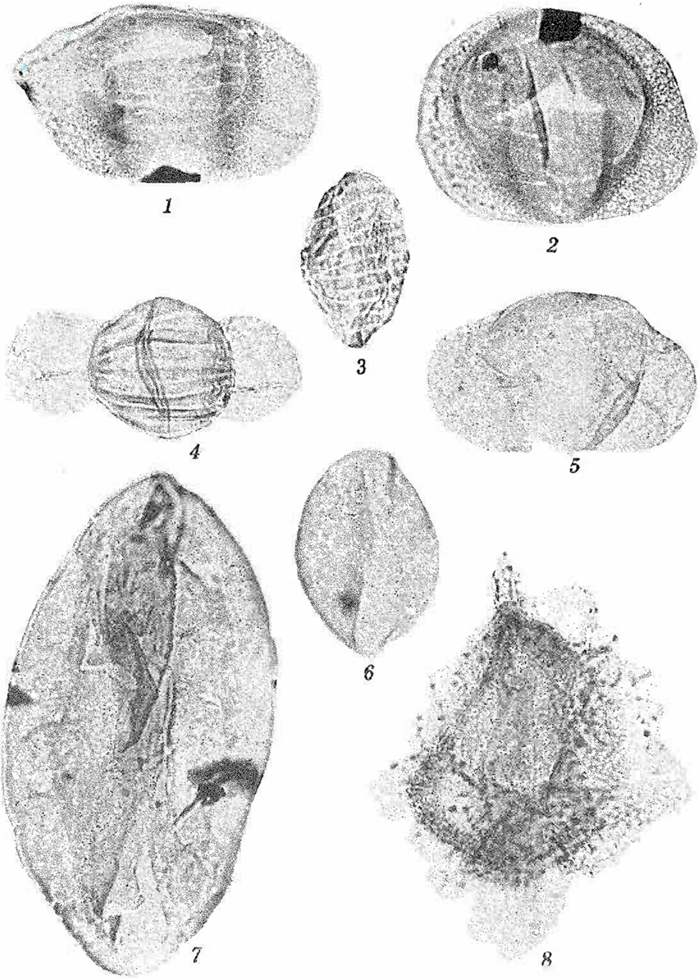
Explanation of Plate III

Figure 1. Striatites sp., **slide P-18614 A-2, 28.2 x 117.1. Size 72 μ.**
Figure 2. Jugasporites **cf.** J. schaubergoides **Klaus, 1963, slide P-18614 A-7, 34.2 x 112.3. Size 67 μ.**
Figure 3. Cf. Vittatina **sp., slide P-18614 A-8, 30 x 113.3. Size 42 μ.**
Figure 4. Hamiapollenites saccatus **Wilson, 1962, slide P-18614 A-1, 29 x 118.2. Size 70 μ.**
Figure 5. Alisporites zapfei **(Potonié and Klaus, 1954) Jizba, 1962, slide P-18614 A-7, 22.1 x 119.6. Size 63 μ.**
Figure 6. Monosulcites **sp., slide P-18614 A-5, 23.8 x 114.8. Size 27 μ.**
Figure 7. Schopfipollenites **sp., slide P-18614 A-8, 29.1 x 121.1. Size 160 μ.**
Figure 8. Incertae sedis Type B, slide P-18614 A-6, 27.9 x 110.6. Size 98 μ.

Plate III



Upper-Mantle Study and Oklahoma

The U. S. Geological Survey has just released Miscellaneous Geologic Investigations Map I-448, entitled *Geologic and crustal cross section of the United States along the 37th parallel, a contribution to the Upper Mantle Project*, by Warren Hamilton and L. C. Pakiser. The cross section shows the rock units in color from the surface to the Mohorovičić discontinuity. Surface distribution of rock units and structures is based largely upon published geologic maps except in western Nevada, where unpublished maps were used. Velocities of crustal and upper-mantle materials and depths to seismic discontinuities are based upon experimental determinations from both published sources and unpublished U. S. Geological Survey data. Subsurface materials and processes indicated on the cross sections and in notes are interpretations based in part upon speculation.

The cross section is divided into west and east halves, one printed above the other. As Oklahoma geologists well know, the midpoint is close to the midpoint of the State's northern border and the part relative to Oklahoma is divided between the two. This cross section is probably the first of the Transcontinental Geophysical Survey which is to be made in the United States by the Federal Survey. The area of the proposed survey is a band approximately four degrees of latitude wide (35 to 39 degrees north). (The 35th parallel passes a short distance south of the towns of Poteau, Holdenville, Purcell, Chickasha, and Hobart; hence more than two-thirds of the area of the State is included in the area of the survey.) This band has a remarkable variety of geologic and tectonic features, starting in California and extending across the Coast Ranges, the Central Valley, the Sierra Nevada, the Basin and Range Province, the Colorado Plateau, the Front Range, the Wichita Mountains, the Arbuckle Mountains, the Ozark Mountains, the Cumberland Plateau, the Valley and Ridge Province, the Blue Ridge, the Piedmont, and finally the Atlantic Coastal Plain.

The Transcontinental Geophysical Survey is only one of the programs of special regional investigations related to the Upper Mantle Project. The project was proposed in 1960 to the international scientific community at the XII General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Helsinki. The proposal was approved by the full assembly and then circulated to national IUGG committees for approval and formulation of national programs as part of the Upper Mantle Project. The Comité International de Géophysique (CIG) accepted the invitation to coordinate the plans for the project. In response to the recommendations of the IUGG and CIG, a number of nations, including Canada, Japan, the Soviet Union, and the United States, indicated their intention to participate in the project.

In the United States, a Panel on Solid Earth Problems was organized under the Geophysics Research Board of the National Academy of Sciences-National Research Council. The proposed United

States program for the International Upper Mantle Project is given by the board in a publication dated November 30, 1962. The publication cites the *Report of the CIG/IUGG Working Group of the Upper Mantle Project* (Paris, January 1961). In this report the following outline of the scope and objectives was given:

> The objective of the project is to stimulate world-wide cooperation in research into the nature of the outer 1,000 km of the earth. The goals are to determine the variation of the physical and chemical properties of the upper mantle and crust, both radially and with latitude and longitude, the present and past movements of material in the mantle and the sources of energy within it. These studies are a necessary basis to the understanding of the causes of tectonic and magnetic processes. To this end the development and application of the following new geophysical techniques will be fostered: magnetotelluric measurements, long waves and free oscillations of the earth, deep seismic soundings, ocean-bottom seismographs, deep drilling, heat-flow determinations, and paleomagnetic methods . . . . data should also be considered from geological records in the various continents recording the evolution of tectonic and magmatic processes through the earth's history.
>
> Some of the unsolved problems which would fall within the scope of this project are: differences in the upper mantle and crust between continents and oceans, and the various tectonic zones; mechanism at the earthquake focus; nature of the M discontinuity; explanation of electric conductivity variations with depth; origin of the low-velocity zones in the upper mantle; extent and significance of intermediate layers; explanation of detection of zones near melting point; evolution of tectonic and magmatic processes over geological time.

The working-group report pointed out that understanding of the physical mechanisms behind tectonic and magmatic processes may be gained by studies of the shields and stable zones, folded and activated zones, and margins of the continents; the deep basins, submarine ridges, and island arcs of the oceans; and inland seas using all the geophysical techniques listed here.

V. V. Beloussov, in his presidential address to the IUGG in 1962, stated:

> The understanding of deep processes which cause tectonic movements, magmatic and thermal phenomena, and rock metamorphism, has not only tremendous theoretical significance, but also considerable practical interest; almost all useful minerals directly or indirectly are connected with deep processes during their formation or accumulation.

Besides the basic research programs in the Upper Mantle Project, special regional investigations, of which the Transcontinental Geophysical Survey is one, are regional geophysical profiles and other international cooperative studies, such as of the Great Lakes, the Gulf of California, and the Andes.

In the United States a large number of research programs relating to the Upper Mantle Project are already underway or being considered by university and private research organizations. Major contributions are expected from the U. S. Geological Survey and U. S. Coast and Geodetic Survey.

—L. J.

New Theses Added to O. U. Geology Library

The following Master of Science thesis was added to The University of Oklahoma Geology Library in July 1965.

Palynology of the Drywood and Bluejacket coals (Pennsylvanian) of Oklahoma, by Logan L. Urban.

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