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OCCURRENCE OF RADIOLARIA IN THE MISSISSIPPIAN OF ARKANSAS

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INTRODUCTION

Radiolaria are present as a part of a fauna consisting mainly of small siliceous fossils occurring in a calcareous concretion in the Fayetteville Shale of northern Arkansas.

The stratigraphy, paleontology, and paleoecology of the Fayetteville Shale will be described elsewhere by Rainer Zangerl and others. This paper reports the first occurrence of radiolarian skeletons from unquestioned Mississippian strata of North America.

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CARBONIFEROUS OCCURRENCES OF RADIOLARIA

North American.—No Radiolaria have been reported from rocks of unquestionably Mississippian age in North America. Previously published accounts list fossils from Pennsylvanian rocks and from formations possibly transgressing the Devonian–Mississippian boundary.

Henbest (1936) recorded radiolarians from the Arkansas Novaculite of Arkansas and from the Caballos Novaculite of Texas. Aberdeen (1940) described a radiolarian fauna from the Santiago Member of the Caballos Formation of Texas. However, Weller *et al.* (1948) pointed out that the Caballos is very similar to the Arkansas Novaculite, and that these two formations possess elements that indicate

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equivalent age. They further indicated that the Arkansas Novaculite in its lower part is Devonian, but the middle and upper portions may be of Mississippian age. They also stated that the age of the Caballos is equally difficult to assign.

Keroher *et al.* (1966) noted that the Santiago Member is also hard to place stratigraphically. Apparently it either overlies the Caballos or constitutes its middle and upper parts.

Goldstein and Hendricks (1953) recorded the presence of radiolarians in Oklahoma in the Arkansas Novaculite, Stanley Shale, Jackfork Sandstone, and Atoka Formation. The Atoka Formation is Pennsylvanian, the Stanley Shale is commonly considered to be Mississippian, and the Jackfork Sandstone is probably Pennsylvanian. Moore (1944), however, placed the latter two formations in the early to middle Pottsville (Pennsylvanian). Weller *et al.* (1948) believed their age to be debatable, although the faunas were considered possibly Upper Mississippian.

Foreman (1959, 1963) described and illustrated a rich radiolarian fauna from Ohio in the Huron member of the Ohio Shale. This member is considered by Cooper (1942) to lie at the top of the Devonian, but some doubt still exists about the age of the uppermost part of the Ohio Shale (Weller *et al.*, 1948).

The radiolarians here illustrated bear a great resemblance to those of the Ohio Shale. The sedimentary regimen, particularly their concretionary occurrence, is also similar.

Orlov (1959) stated that, in North America, Lower Mississippian schists containing radiolarians have been studied near the city of Washington (no state given), and also in Arkansas, Oklahoma, and Texas. The latter three references are apparently to reports by Henbest (1936), Aberdeen (1940), and Goldstein and Hendricks (1953). The present authors were unable to locate the reference to an occurrence "near Washington."

Outside North America.—Well described and illustrated Lower Carboniferous radiolarian faunas occur in Lower Viséan phosphatic nodules (Deflandre, 1946, 1952, 1958, 1960, 1963a, 1963b, 1964; Deflandre and Deflandre-Rigaud, 1958) and in Upper Viséan nodules (Demanet, 1938). Equally well studied fossils are known in Derbyshire, England from Namurian "bullions" (Holdsworth, 1964, 1966a, 1966b).

Undescribed but illustrated Carboniferous occurrences have been reported from the Far East (Olga-Tetyukhinsk area) of the Soviet

Union (Zhamoida, 1958). Rüst (1892) reported Carboniferous Radiolaria in the Pechora River Region of the Soviet Union and Orlov (1959) noted additional occurrences from the North and Main Caucasus and in the Primor'e Territory. Poorly preserved radiolarians have been reported from Novaya Zemlya (Lee, 1909), and Khabakov (1932) described four species from sediments believed to have been deposited in shallow water during the Carboniferous. Radiolaria have been illustrated from the Culm (Lower Carboniferous) of Germany (Schwartz, 1924, 1928). Occurrences of Carboniferous radiolarians have also been cited from England (Hinde and Fox, 1895; Fox, 1896; Pulfrey, 1932; Oakley, 1947), Sicily (Rüst, 1892), Japan (Kawada, 1953), Hungary (Rüst, 1892), and Wales (Dixon and Vaughan, 1911). Carboniferous polycystines have been reported from the Holy Cross Mountains of Southern Poland (Sujkowski, 1933).

STRATIGRAPHIC POSITION

The late Mississippian (Chester) Fayetteville Shale in Arkansas is divided by the Wedington Sandstone into upper and lower parts. The Mississippian correlation chart (Weller *et al.*, 1948) places the Wedington Sandstone exactly opposite to the line separating the Upper Viséan from the Lower Namurian. Since the locality of our specimen is in the upper member of the Fayetteville Shale, its stratigraphic position may approximate the European Uppermost Viséan. This locality is along the bank of the Town Branch south of the town of Fayetteville, Washington County, Arkansas.

FAUNAL ASSOCIATION

The specimen (Field Museum no. B56) from which the radiolarians were obtained is a fine-grained, dark gray, calcareous concretion. The concretion is a ring-like mass adhering to the outer wall of the living chamber of a *Rayonnoceras solidoforme* found in a vertical position in the shale.

The organisms associated with the radiolarians consist principally of disarticulated sponge spicules, of which the most plentiful are hexactines. A few fragments of sponges, including an exceptionally well-preserved demosponge (Nitecki and Rigby, 1966) have also been observed. Goniatites, of which *Rayonnoceras* is the most conspicuous, are also present. Arenaceous foraminiferans and supposed worm

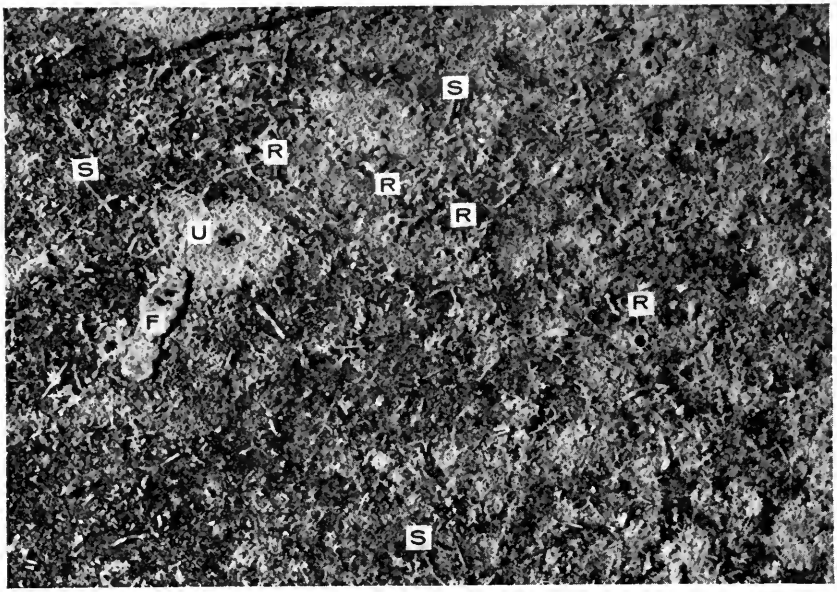

FIG. 1. A photomicrograph of an etched surface showing the relation of radiolarian remains to other organisms. Radiolarians are marked with the letter "R," sponges with "S." Arenaceous foraminiferans with "F" and problematica with "U." Field Museum no. B56.

tubes are present in various stages of preservation. The beaks and arm hooks of nautiloids have been noted, as well as two problematica —one with round perforated mounds, and the other consisting of spindle-shaped bodies.

Parts of this association within the concretion are shown in Figure 1. The specimen photographed is part of the surface of a concretion that was treated with dilute hydrochloric acid.

METHOD OF EXTRACTION

The following procedure was used to extract Radiolaria from the matrix: first, slices of the concretion were dipped in strong hydrochloric acid for about a minute and then rinsed with water. Radiolarians could then be picked from the surface under a binocular microscope on the follicle end of a recently extracted eyebrow or eyelash. Generally, a drop or two of weak hydrochloric acid helped to free a particular specimen which was transferred to a glass microscope slide and mounted in Canada balsam.

FIG. 2. Form A. × 250.

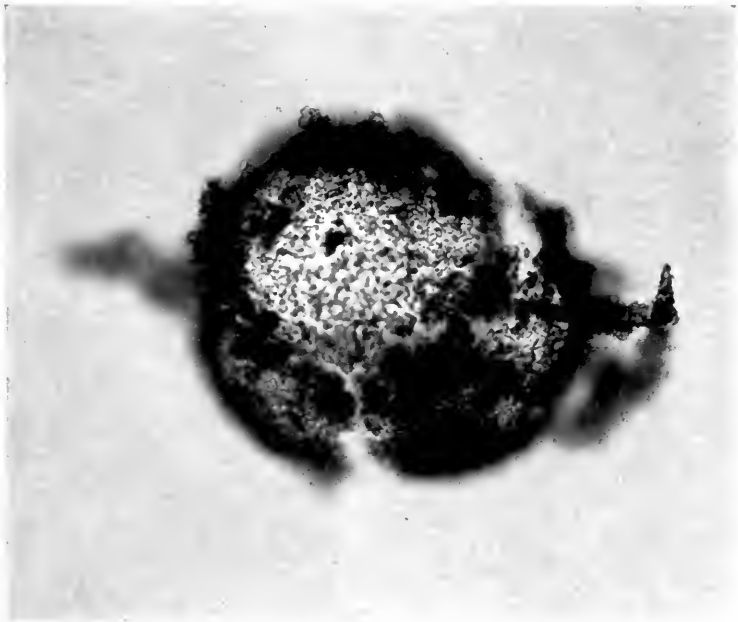

FIG. 3. Form B. × 250.

DESCRIPTION OF RADIOLARIAN FAUNA

Both Spumellaria-like forms and members of the family Albaillellidae Deflandre, 1952, were found, although occurrences of the latter are rare. Since it could not be determined whether an internal spicular structure is present within the spherical forms, it is not possible to place these either with the Devonian species of Foreman (1963), in which there is an internal spicular structure, or with the more familiar Cenozoic species in which there is no such spicular arrangement.

No taxonomic work has been attempted; the present authors wish only to report the occurrence and to give generalized descriptions of the forms encountered during a relatively brief search. Figured specimens have been given Field Museum numbers PE11457 through

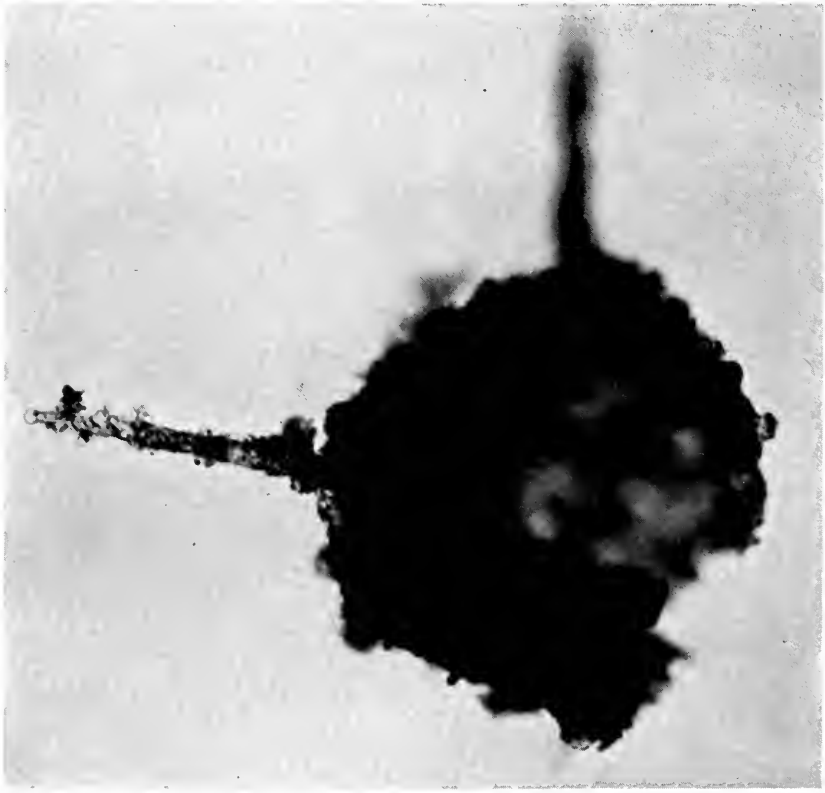

FIG. 4. Form C. × 330.

PE11466 and are located according to England Finder co-ordinates (Riedel and Foreman, 1961). Other specimens are in the collection of the senior author.

FIG. 5. Form D. × 280.

SPUMELLARIA-LIKE FORMS

Representatives of seven Spumellaria-like forms are illustrated. These are designated by letters, A, B, C, D (two specimens illustrated), E, F, and G, and are shown in Figures 2–9.

FORM A (Fig. 2)

Shell spherical with a single, 3-bladed spine about as long as shell diameter. Diameter of shell 88 μ; spine length 72 μ (one specimen, Field Museum no. PE11457, A32/0).

FORM B (Fig. 3)

Shell relatively large, spherical or ellipsoidal. Spines delicate, probably cylindrical, tapered, one at each pole. Diameter of shell approximately 200 μ; longest spine 80 μ (one specimen, Field Museum no. PE11458, U34/4).

FORM C (Fig. 4)

Shell relatively large, spherical. Probably 4 spines—only 2 are preserved—delicate, cylindrical, tapered. Diameter of shell 143 μ; longest spine 119 μ (one specimen, Field Museum no. PE11459, J37/4).

FIG. 6. Form D, note internal spines. × 280.

FIG. 7. Form E. × 180.

FIG. 8. Form F. × 280.

FORM D (Figs. 5, 6)

Shell spherical. Probably 4 spines (possibly more), but generally some of these are broken. Spines delicate, 3-bladed, tapered. One specimen has numerous, short, delicate by-spines arising from the surface of the shell. One specimen (Fig. 6) possesses 2 (at least) internal spines continuous with corresponding external spines, but these are broken before they reach the center of the shell. No internal spicular structure was distinguished in any other specimen. Diameter of shell 64–96 μ; maximum spine length 48–104 μ [5 specimens, Field Museum nos. PE11460, K31/0 (Fig. 5); PE11461, H39/0 (Fig. 6)].

FORM E (Fig. 7)

Shell heavy, spherical. Spines well developed, relatively long, tapered, 3-bladed, 6 of them along mutually perpendicular axes. Most specimens lack one or two spines. None shows any internal

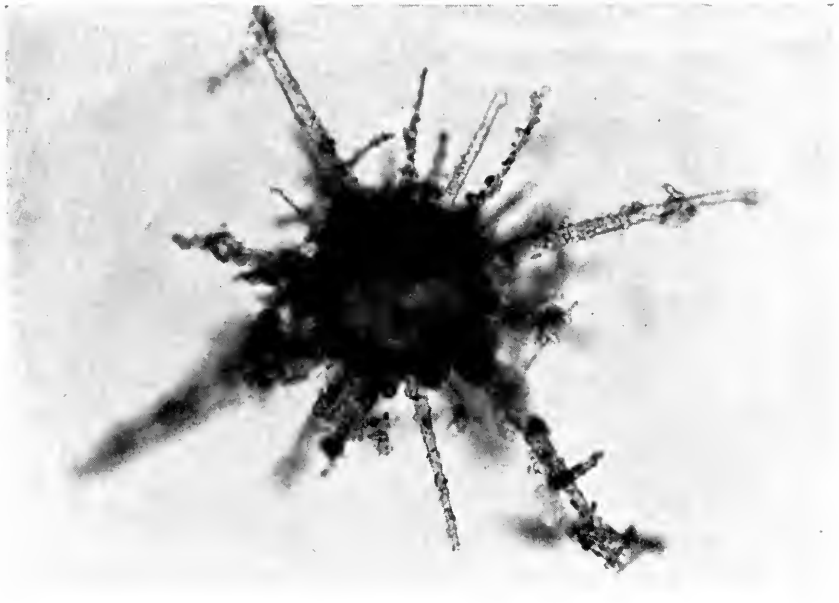

FIG. 9. Form G. × 220.

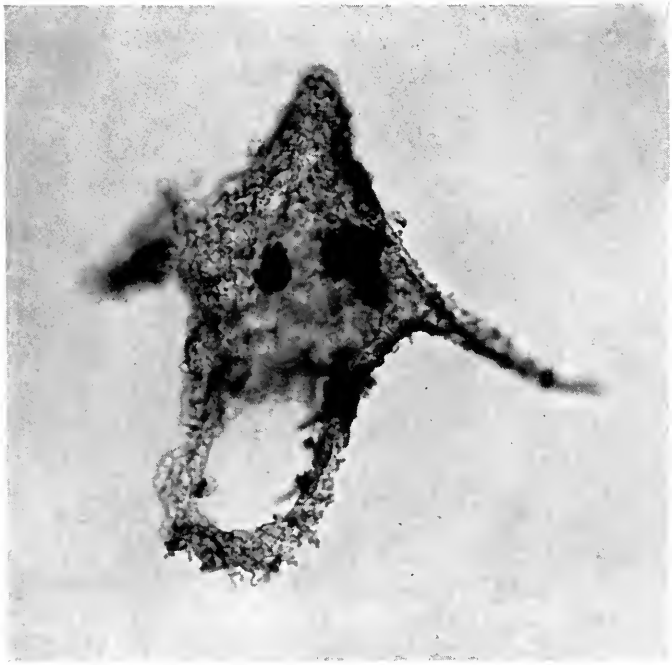

FIG. 10. Albaillellid. × 280.

spicular structure. Diameter of shell 64–80 μ; maximum spine length 114–285 μ (11 specimens, Field Museum no. PE11462, L38/2).

FIG. 11. Albaillellid. × 250.

FORM F (Fig. 8)

Shell spherical, heavy. Single, long, 3-bladed spine, and numerous, shorter, cylindrical by-spines. Diameter of shell 135 μ; length of main spine 159+ μ (one specimen, Field Museum no. PE11463, M36/0).

FORM G (Fig. 9)

Shell heavy, spherical. Four main spines, cylindrical, tapered, and numerous strong, cylindrical, tapered by-spines of varying length. Diameter of shell 80 μ; maximum spine length 119 μ (one specimen, Field Museum no. PE11464, L36/0).

ALBAILLELLIDS

(Figs. 10, 11)

The forms described below probably belong to the genus *Albaillella* Deflandre, 1952, but their preservation is such that neither segmentation nor internal skeletal elements can be seen.

Shell conical above, and cylindrical below the point of emergence of two prominent lateral "wings" lying in a single plane. "Wings" concave apically, tapered. Shell termination ragged. Some specimens have a short, cylindrical, tapered, slightly oblique apical horn.

Two parallel spines (columellae) project beyond the shell and are joined distally by a solid cross-bar. These form the H-frame described by Deflandre (1952) and Holdsworth (1966a).

One specimen has about seven short spines projecting from the shell wall and/or the columellae. Possibly the proximal pair of these spines are homologous with the "wings" described by Deflandre (1952) and Holdsworth (1966a). One columella on this same specimen (which might be a different species) projects beyond the cross-bar of the H-frame.

Dimensions: Length of apical horn 32–48 μ; of shell (excluding columellae and apical horn) 159–199 μ; of columellae beyond shell wall 88–119 μ. Maximum shell breadth 104–135 μ. Maximum distance between columellae 48–80 μ. [Based on 5 specimens, Field Museum nos. PE11465, C44/2 (Fig. 10); PE11466, Q33/0 (Fig. 11).]

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