

ABSTRACT

Eight species of algae; seven new genera and fifteen species, fourteen new, of acritarchs; and one new genus and two new species of other microfossils incertae sedis are described from the Saudi Arabian Lower Carboniferous.

Algae, acritarchs and other microfossils incertae sedis from the Lower Carboniferous of Saudi Arabia

DARWIN O. HEMER AND
Arabian American Oil Company
Dhahran, Saudi Arabia

PAUL W. NYGREEN
Chevron Oil Company
Oklahoma City, Oklahoma

INTRODUCTION

Fossil microplankton are receiving increased attention from paleontologists. Some of the younger fossil microplankton, *i.e.*, Tertiary and upper Mesozoic types, are readily assignable to biological groups by reason of their morphological similarities to extant organisms. The systematic relationship of most fossil microplankton, other than these younger fossils, and of most Paleozoic microplankton is obscure. The resultant speculations have culminated in the proposal by Evitt (1963) that small microfossils of uncertain and varied biologic affinities be treated under the International Code of Botanical Nomenclature and be grouped within an informal category called "acritarchs" until they can be more precisely identified and properly assigned. A classification of the acritarchs was proposed by Downie, Evitt and Sarjeant (1963).

MATERIAL AND AGE

The microfossils described in this paper were extracted from core chips between 4970 and 4980 feet from the borehole ST-8, Arabian American Oil Company's Stratigraphic Test No. 8 in Saudi Arabia, coordinates 29° 53' N. lat. and 41° 55' E. long. (text-figure 1). The fossils were limited to a 10-foot cored interval of dark gray, micaceous, carbonaceous shale encountered within a section of 250 feet of Lower Carboniferous sandstone. The age is determined by the included dominant rich and varied microfloral assemblage of vascular plant spores with species of *Densosporites*, *Vallatisporites*, *Cristatisporites*, *Reticulatisporites* and *Diatomozonotrites* (Hemer, 1965). No other Lower Carboniferous section has been found in Saudi Arabia.

The acid-resistant microfossils were recovered from the rocks by the use of standard palynological maceration techniques.

Slides containing the type specimens will be deposited in the Department of Micropaleontology of the American Museum of Natural History, New York.

ACKNOWLEDGEMENTS

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SYSTEMATIC DESCRIPTIONS

Subphylum ALGAE
Division CHRYSOPHYTA
Class XANTHOPHYCEAE
Order HETEROCOCCALES
Genus *BOTRYOCOCCUS* Kützing (1849)

Botryococcus sp.
Plate 1, figures 1-4

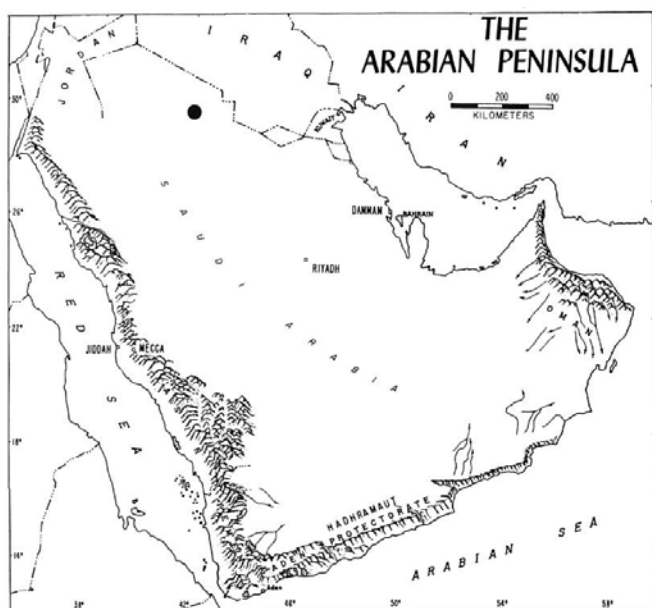
Remarks: Rare occurrences of *Botryococcus* sp. were fragmentary in nature, mostly as single colonies composed of several cuticular thimbles. Cookson (1953) gives the range of the genus as Ordovician to Recent.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimens, slides M-1, MT-1 and MT-4.

Division CHLOROPHYTA
Class CHLOROPHYCEAE
Order CHLOROCOCCALES

Genus *Tetraporina* Naumova (1939) ex Naumova (1950)

Discussion: The genus was originally assigned to the angiosperms by Naumova (1939, 1950) and has been so attributed by subsequent Russian investigators, Teteriuk (1956, 1958) and Kondratyev (1963). This assignment was questioned by Scott, Barghoorn and Leopold (1960), Staplin (1960), and Hughes (1961). Churchill (1960) considered similar Recent forms to be aplanospores of a member of the order Chlorococcales of the Cyanophyceae. The Chlorococcales are at present assigned to the Chlorophyta. The genus has been reviewed recently by Playford (1963). Published accounts of Kondratyev, Playford, Teteriuk and Naumova re-



TEXT-FIGURE 1

Map showing location of borehole ST-8.

port the occurrence of the genus from the Early Carboniferous through the Permian, while Balme (1963) reported it in Lower Triassic rocks of Western Australia and gave the range in Australia as Permian to (?) Recent.

Tetraporina sp. cf. *T. bulligera* Kondratyev
Plate 1, figure 5

Cf. *Tetraporina bulligera* KONDRATYEV, 1963, p. 65, pl. 1, fig. 1.

Description: Rhombohedral form with straight sides; wall thickness uniform, 2 microns; surface smooth.

Dimensions: Length of major axis 65 microns, of minor axis 36 microns.

Discussion: Compares closely with *T. bulligera* Kondratyev in size and in shape. The swellings on opposite corners (ends) mentioned in the type description we interpret to be due to compressional distortion.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimen, slide MT-4.

Tetraporina compressa Kondratyev
Plate 1, figure 6

Tetraporina compressa KONDRATYEV, 1963, pp. 70-71, pl. 2, fig. 5.

Description: Rectangular forms with broadly rounded corners. Long sides sharply concave, short sides straight to slightly convex. Wall thickness uniform, 2 microns thick. Surface smooth, sometimes with scattered small

circular perforations 1-3 microns in diameter. Some specimens split parallel to the long axis at approximately mid-width.

Dimensions: Figured specimen length 54 microns, width 47 microns, diagonal length 58 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimen, slide MT-4.

Tetraporina horologia (Staplin)
Plate 1, figure 7

Azonotetraporina? horologia STAPLIN, 1960, p. 6, pl. 1, figs. 4-6.
Tetraporina horologia (Staplin). - PLAYFORD, 1963, p. 659, pl. 95, figs. 14-15.

Description: Quadrangular forms with rounded corners and concave to nearly straight sides. Thin-walled, often folded. Surface finely granulate.

Dimensions: Diagonal length 48-60 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimen, slide MT-5.

Tetraporina incrassata Naumova
Plate 1, figure 8

Tetraporina incrassata NAUMOVA, 1950, pp. 103-113.

Description: Quadrangular forms with rounded corners and distinctly concave sides. Wall thickness 2 microns, slightly greater at corners. Surface smooth to slightly roughened.

Dimensions: Diagonal length 46-58 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimen, slide MT-7.

Tetraporina sibirica Kondratyev
Plate 1, figures 9-10

Tetraporina sibirica KONDRATYEV, 1963, p. 72, pl. 2, figs. 13-14.

Description: Rectangular forms with broadly rounded corners. Long sides straight to slightly concave, short sides uniformly convex. Wall thickness uniform, 2-3 microns. Surface smooth to slightly roughened.

Dimensions: Diagonal length 50-67 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimens, slide MT-7.

Genus *DIPORINA* Naumova, (1937?, 1939)

Diporina? sp.
Plate 1, figure 11

Description: Ellipsoidal form with elongated dark thickening at each end of major axis. Body surface

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smooth, auriculate thickenings granulate. Wall thickness a uniform 1.5 microns. Terminal thickenings 8 microns long, 10 microns in diameter, with rounded ends and sloping sides.

Dimensions: Length 46 microns, width 16 microns (maximum).

Discussion: Tentative assignment of this form to *Diporina* is based on the two auriculate thickenings. Affinity with the algae is inferred by reason of close comparison of many features in common with the genus *Tetraporina*.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimen, slide MT-2.

Genus TRIPORINA Naumova (1937)

Triporina? sp. Plate 1, figure 12

Description: Roundly triangular form with convex sides (reconstructed) and with a radially extended auriculate thickening at each angle. Surface smooth with numerous circular perforations. Thin-walled. Auriculate extended thickenings 3.5 to 8 microns in height.

Dimensions: Length 45 microns (maximum).

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimen, slide MT-5.

INCERTAE SEDIS

Genus *Laterilites* Hemer and Nygreen, new genus

Type species: *Laterilites laterculus* Hemer and Nygreen, n.sp.

Description: Body subrectangular, biconvex in cross section, with a circular opening near one end.

Laterilites laterculus Hemer and Nygreen, new species

Plate 1, figures 13-14

Description: Body subrectangular to subelliptic, biconvex in cross section. Circular opening near one end, partially or fully covered with a membrane. Opening 5-25 microns in diameter. Distal end usually truncate normal to long axis but may be rounded or pointed. Center opaque, margins darkly translucent. Surface smooth but often exhibiting corrosional pits.

Dimensions: Length 80-100 microns, width 32-56 microns.

Discussion: Superficially resembles *Clistrocytis graptolithophilus* Kozłowski (1959), a chitinous appendix on rhabdosomes of the graptolites *Mastigograptus* and *Gymnograptus* and on other fossil animals, but differs in being smaller and in lacking a distal tube.

Holotype: Plate 1, figure 13. The holotype is 32 microns wide and 95 microns long, and has an opening 24 microns in diameter.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-7; figured specimen, slide MT-3.

Genus *Tetrapterites* Sullivan and Hibbert (1964)

Discussion: This genus was instituted for a spore tetrad structure of unusual organization from the Lower Carboniferous of Great Britain. It consists of a tetrahedral non-cellular membrane with flaring modifications (skiadions) at the apices. The skiadions are often found separate. Each consists of a cupule, which originally contained a single spore, and a wing, which flares distally from the cupule.

Tetrapterites? ceterus Hemer and Nygreen, new species Plate 1, figures 15-16, 19

Description: A skiadion-like structure consisting of a pulvinus (cushion) centered on a pendent wing. The pulvinus is quadrangular to hexagonal in outline with sides straight to decidedly cusped. The wing is finely corrugated radially.

Dimensions: Size of pulvinus 27-46 microns, size of wing 46-80 microns.

Discussion: Differs from *T. visensis* Sullivan and Hibbert (1964) in its smaller size and radially corrugated wing. The pulvinus is somewhat different from the cupule of the type species, and assignment to the genus is regarded as tentative.

Holotype: Plate 1, figure 19. The holotype measures 50 × 68 microns; its pulvinus, 34 × 46 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-1; figured specimens, slides MT-3 and MT-5.

Form A Plate 2, figures 15-16

Description: Sheetlike non-cellular tissue consisting of a lobed portion opposed to a crenulated zone of attachment (?). Lobate zone composed of single or multiple projections.

Dimensions: Length 112-198 microns, height 50-80 microns. Projections up to 40 microns in length and 10 microns in width.

Discussion: Rare in the recovered assemblage. Biological affinity unknown.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimens, slides MT-6 and MT-7.

Group ACRTARCHA Evitt (1963)

Subgroup SPHAEROMORPHITAE Downie, Evitt and Sarjeant (1963)

Genus *Arabisphaera* Hemer and Nygreen, new genus

Type species: Arabisphaera bellula Hemer and Nygreen, n. sp.

Description: Globose tests, circular in outline, with one or more pores. Surface smooth. Wall two-layered; inner wall much thinner than outer wall. Corrosion commonly exposes structural rods, resulting in a baculate-punctate appearance. Wall often irregularly ruptured upon compression.

Discussion: Porate bodies are rare in Paleozoic sediments. The biological affinities are presumed to be with algae, as several algal groups are known to form porate cysts.

Arabisphaera bellula Hemer and Nygreen, new species
Plate 3, figures 7-11

Description: Spherical tests, circular in outline, porate, usually with one pore but sometimes with a few scattered additional pores. Surface smooth, usually corroded, the corrosion exposing structural rods and producing a crowded baculate appearance. Wall two-layered, its thickness 2-5 microns.

Dimensions: Diameter 28-40 microns (mean 38 microns).

Holotype: Plate 3, figure 7. Holotype diameter 28 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-5; figured specimens, slides M-1, MT-5 and MT-7.

Arabisphaera fossilis Hemer and Nygreen, new species
Plate 2, figures 5-6

Description: Spherical tests with one or a few circular pores. Surface smooth. Corrosion produces a crowded baculate-appearing pseudo ornamentation. Wall thickness 3-5 microns.

Dimensions: Diameter 60-68 microns.

Discussion: Differs from *Arabisphaera bellula* in its distinctly larger size.

Holotype: Plate 2, figure 5. Holotype diameter 62 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-2; figured specimen slide M-3.

Genus *Hemisphaerium* Hemer and Nygreen, new genus

Type species: Hemisphaerium inominatum Hemer and Nygreen, n. sp.

Description: Spherical, circular in outline. Grooved. Surface smooth to granular. Test often split along and beyond the groove.

Discussion: Forms with definite grooves that split either naturally or upon compression occur in many portions of the geologic column and have been assigned to various biologic groups. Most pre-Cretaceous forms and many of the Cretaceous and younger forms are likely of algal origin.

Hemisphaerium germanum Hemer and Nygreen,
new species
Plate 2, figure 12

Description: Spherical, circular in outline. Groove nearly equal to test diameter. Surface minutely granulate. Wall thickness 2-3 microns.

Dimensions: Diameter 70-78 microns.

Holotype: Plate 2, figure 12. Holotype measures 70 × 78 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-7.

Hemisphaerium inominatum Hemer and Nygreen,
new species
Plate 2, figures 7-8

Description: Spherical, circular in outline. Groove straight, one-half to four-fifths of test diameter. Surface matte to minutely granular, often with pigmented area near groove. Wall thickness 1-3 microns. Wall slightly folded.

Dimensions: Diameter 38-56 microns.

Holotype: Plate 2, figure 7. Holotype diameter 50 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-3; figured specimen, slide MT-6.

Hemisphaerium signum Hemer and Nygreen,
new species
Plate 2, figures 4, 11

Description: Spherical, circular in outline. Length of groove nearly equal to test diameter. Surface minutely granulate. Thin-walled; wall thickness 1-2 microns. Wall frequently with tapered folds.

Dimensions: Diameter 58-68 microns.

Holotype: Plate 2, figure 4. Holotype diameter 58 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-6; figured specimen, slide MT-6.

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Genus *Lacunalites* Hemer and Nygreen, new genus

Type species: Lacunalites sphaericus Hemer and Nygreen, n. sp.

Description: Spherical, foveate, grooved, often folded along the groove or split into connected hemispheres.

Discussion: Forms which split into hemispheres are known from the Mesozoic. The genus *Retialetes* Staplin (1960), described from the Golata Formation (Mississippian) of Canada, is ellipsoidal and is reticulate. *Perforosporites* Scott and Rouse (1961) is similar to *Lacunalites* but is trilete, and the pores have a decided lip.

Lacunalites is remarkably similar to the extant algal genus *Exuviaella*, assigned to the Desmodontae of the Pyrrophyta. The test of *Exuviaella* consists of two apposed valves with irregularly distributed pores on all except the marginal area apposed to the other valve. A marginal zone of fewer foveae is suggested in some specimens of *L. sphaericus*.

The possible relationship of *Lacunalites* to *Exuviaella* suggests the possible extension of the known lower limit of the Desmodontae to the Lower Carboniferous.

Lacunalites sphaericus Hemer and Nygreen, new species Plate 3, figures 1-4

Description: Spherical. Grooved, often folded or split along the groove into hemispheres, which remain connected by a narrow ungrooved portion of the wall. Foveate; diameter of foveae 1-3 microns. Wall thickness 1-3 microns.

Dimensions: Diameter 48-66 microns.

Holotype: Plate 3, figure 1. Holotype diameter 48 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-2; figured specimens, slides MT-1, and M-5.

Genus *Leiosphaeridia* Eisenack (1958), emend. Downie and Sarjeant (1963)

Leiosphaeridia orbiculata (Staplin) Plate 3, figures 5-6

Protoleiosphaeridium orbiculatum STAPLIN, 1961, p. 405, pl. 48, fig. 12.

Leiosphaeridia orbiculata (Staplin). - DOWNIE and SARJEANT, 1963, p. 95.

Discussion: Downie and Sarjeant (1963) expressed doubt of the distinctness of this species from *L. wenlockia* Downie. All specimens in the Saudi Arabian assemblage have wall thickness greater than 2 microns and are minutely granulate, the granulation being much finer than that illustrated on *P. microgranifer* Staplin or on *P. cryptogranulosum* Staplin, both of which are described as microgranulose.

Depository: American Museum of Natural History, Department of Micropaleontology; figured specimens, slide MT-7.

Genus *Portalites* Hemer and Nygreen, new genus

Type species: Portalites confertus Hemer and Nygreen, n. sp.

Description: Amb circular to oval. Thick-walled, with a portion of the wall thickened and containing a simple circular pore, from which a canal extends to the interior.

Discussion: Porate forms of this description have heretofore not been noted in the Paleozoic. The possibility of contamination cannot be ruled out but is thought to be unlikely. The authors know of no aplanospore of algae containing porate-canalicular structure of the type exhibited by this form, but a possible relationship with the algae can not be eliminated.

Portalites confertus Hemer and Nygreen, new species Plate 1, figures 17-18

Description: Test with near-circular amb. Surface microgranulate with occasional larger granules. Wall two-layered with inner layer approximately one-quarter of thickness of outer layer. Combined thickness 2 microns, a portion of the wall thickening to 4-6 microns. Thickened area contains a single canal 2-4 microns in diameter.

Dimensions: Diameter 22-28 microns.

Holotype: Plate 1, figure 17. Holotype diameter 22 microns.

Deposition: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-4; figured specimen, slide MT-7.

Genus *Sphaeroporolites* Hemer and Nygreen, new genus

Type species: Sphaeroporolites solus Hemer and Nygreen, n. sp.

Description: Spherical tests circular in outline. Porate; pores simple, circular, singular or multiple. Surface microgranulate. Wall thickness 1-2 microns.

Sphaeroporolites multiplex Hemer and Nygreen, new species Plate 2, figure 3

Description: Spherical, with circular outline, multiporate; pores circular, approximately 1 micron in diameter, confined to slightly more than one hemisphere. Surface microgranulate. Wall single-layered, 2 microns thick.

Dimensions: Diameter 23-26 microns.

Holotype: Plate 2, figure 3. Holotype diameter 26 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-7.

Sphaeroporites solus Hemer and Nygreen, new species
Plate 2, figures 1-2

Description: Spherical, with circular outline, monoporate; pore diameter one micron. Pore area often pigmented. Surface psilate. Wall single-layered, its thickness 1-2 microns.

Dimensions: Diameter 18-26 microns.

Holotype: Plate 2, figure 1. Holotype diameter 18 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-4; figured specimen, slide MT-2.

Subgroup NETROMORPHITAE Downie, Evitt and Sargeant (1963)

Genus **Deusilites** Hemer and Nygreen, new genus

Type species: *Deusilites tentus* Hemer and Nygreen, n. sp.

Description: Test elongate, fusiform or terete, circular in cross section, grooved. Wall 2 microns thick. Pigmentosae sometimes present at one end. Grooves multiple longitudinal or oblique, some wedge-shaped with point at or near one end and with low angle of separation. Surface matte to minutely granulate.

Discussion: Differs from *Leiofusa* Eisenack (1938) in being ornamented and grooved. *Quisquilites* Wilson and Urban (1963) is multilayered, bilateral, and lacks the multiple grooves.

Deusilites tentus Hemer and Nygreen, new species
Plate 2, figures 17-18; plate 3, figure 19

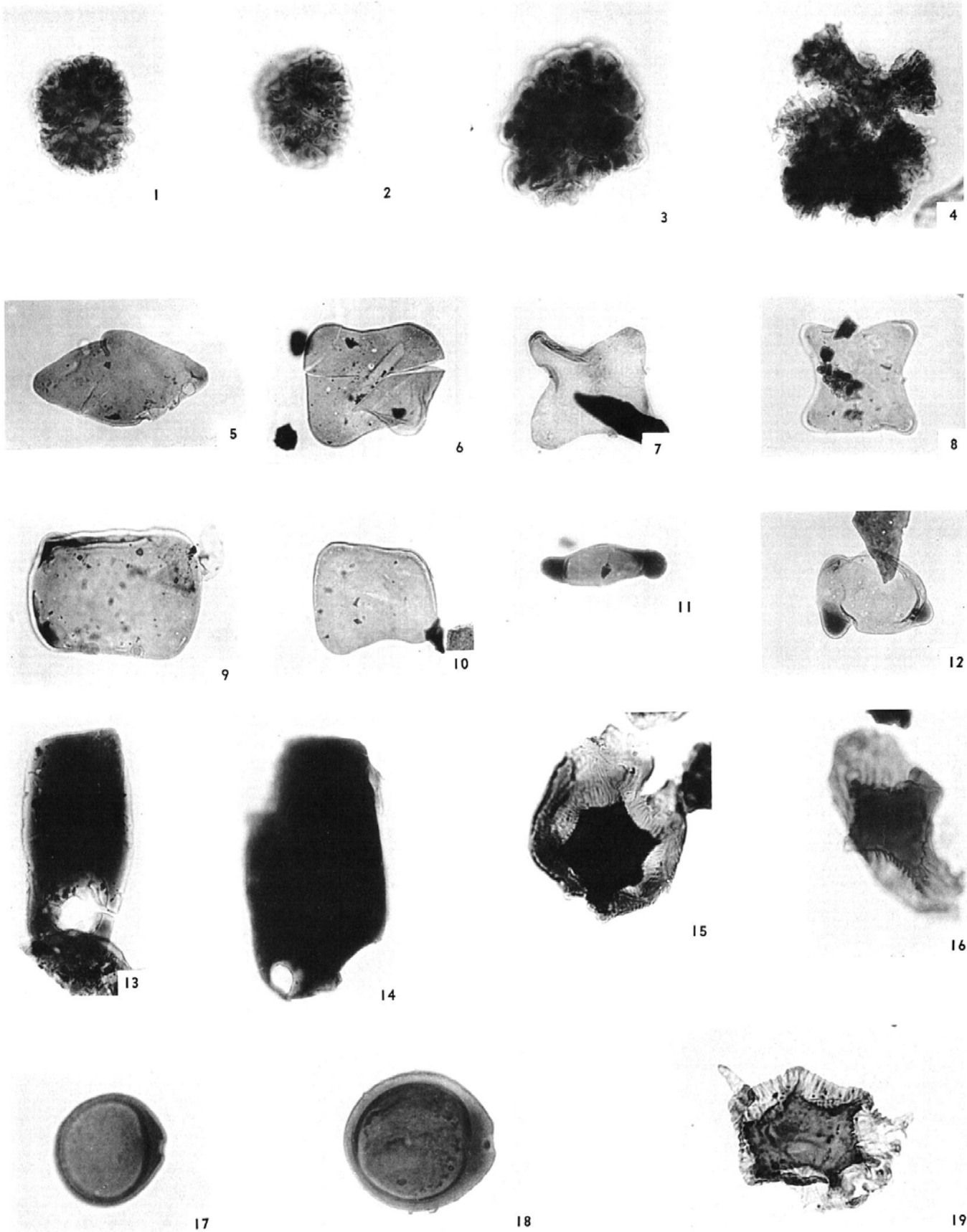
Description: Same as for the genus.

Dimensions: Length 90-246 microns, diameter of cross section 24-56 microns.

Holotype: Plate 2, figure 17. Holotype dimensions 24 × 90 microns.

PLATE 1

- 1-2 *Botryococcus* sp.
1, low focus; 2, high focus; COC-6, 38 × 46 microns, × 500, location 31.6-115.7 (Ref. 60.4-107.2).
- 3 *Botryococcus* sp.
COC-2, 58 × 68 microns, × 500, location 43.3-124.5 (Ref. 59.9-106.8).
- 4 *Botryococcus* sp.
COC-5, 65 × 78 microns, × 500, location 38.7-127.3 (ref. 59.1-107.9).
- 5 *Tetraporina* sp. cf. *T. bulligera* Kondratyev
COC-5, 36 × 65 microns, × 500, location 34.0-118.8 (Ref. 59.1-107.9).
- 6 *Tetraporina compressa* Kondratyev
COC-5, 47 × 54 microns, × 500, location 40.6-120.8 (Ref. 59.1-107.9).
- 7 *Tetraporina horologia* (Staplin)
COC-9, diagonal length 57 microns, × 500, location 30.7-113.8 (Ref. 61.5-107.4).
- 8 *Tetraporina incrassata* Naumova
COC-11, diagonal length 58 microns, × 500, location 33.2-126.9 (Ref. 61.5-107.9).
- 9 *Tetraporina sibirica* Kondratyev
COC-11, diagonal length 67 microns, × 500, location 49.0-117.7 (Ref. 61.5-107.9).
- 10 *Tetraporina sibirica* Kondratyev
COC-11, diagonal lengths 50, 54 microns, × 500, location 31.7-126.9 (Ref. 61.5-107.9).
- 11 *Diporina?* sp.
COC-3, 46 × 16 microns, × 500, location 54.7-121.0 (Ref. 61.5-106.5).
- 12 *Tripolina?* sp.
COC-9, max. length 45 microns, × 500, location 41.8-110.9 (Ref. 61.5-107.4).
- 13 *Laterilites laterculus* Hemer and Nygreen, n. sp.
Holotype, COC-11, 32 × 95 microns, opening 24 microns, × 500, location 35.5-125.7 (Ref. 61.5-107.9).
- 14 *Laterilites laterculus* Hemer and Nygreen, n. sp.
COC-4, 52 × 100 microns, × 500, location 44.0-121.8 (Ref. 58.4-106.7).
- 15 *Tetrapterites?* *ceterus* Hemer and Nygreen, n. sp.
COC-9, 58 × 76 microns, × 500, location 45.6-114.2 (Ref. 61.5-107.4).
- 16 *Tetrapterites?* *ceterus* Hemer and Nygreen, n. sp.
COC-4, 80 microns, × 500, location 44.0-121.8 (Ref. 58.4-106.7).
- 17 *Portalites confertus* Hemer and Nygreen, n. sp.
Holotype, COC-5, 22 microns, × 1000, location 27.6-124.0 (Ref. 59.1-107.9).
- 18 *Portalites confertus* Hemer and Nygreen, n. sp.
COC-11, 28 microns, × 1000, location 44.9-121.1 (Ref. 61.5-107.9).
- 19 *Tetrapterites?* *ceterus* Hemer and Nygreen, n. sp.
Holotype, COC-2, 50 × 68 microns, × 500, location 46.7-123.9 (Ref. 59.9-106.8).



Depository: American Museum of Natural History; Department of Micropaleontology; holotype, slide MT-1; figured specimens, slides M-1 and M-4.

Genus *Fusilites* Hemer and Nygreen, new genus

Type species: *Fusilites lucis* Hemer and Nygreen, n. sp.

Description: Test longitudinally ellipsoidal to fusiform, biconvex in cross section. Wall single-layered, often containing pigmentosae of irregular area.

Discussion: The frequent occurrence of pigmented areas (pimentosae) and the lenticular cross section make this palynomorph distinctive.

Fusilites dulcis Hemer and Nygreen, new species

Plate 2, figures 9-10, 13-14

Description: Test ellipsoidal, biconvex in cross section, grooved. Groove straight, longitudinal, centrally located, length one-fifth to four-fifths of the length of the major axis. Wall uniformly 2 microns thick, pigmentosae sometimes present. Surface minutely granulate.

Dimensions: Length 48-64 microns, width 38-50 microns.

Holotype: Plate 2, figure 9. Holotype dimensions 48 × 64 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-1; figured specimens, slides MT-2 and M-2.

Fusilites lucis Hemer and Nygreen, new species

Plate 3, figures 12-13

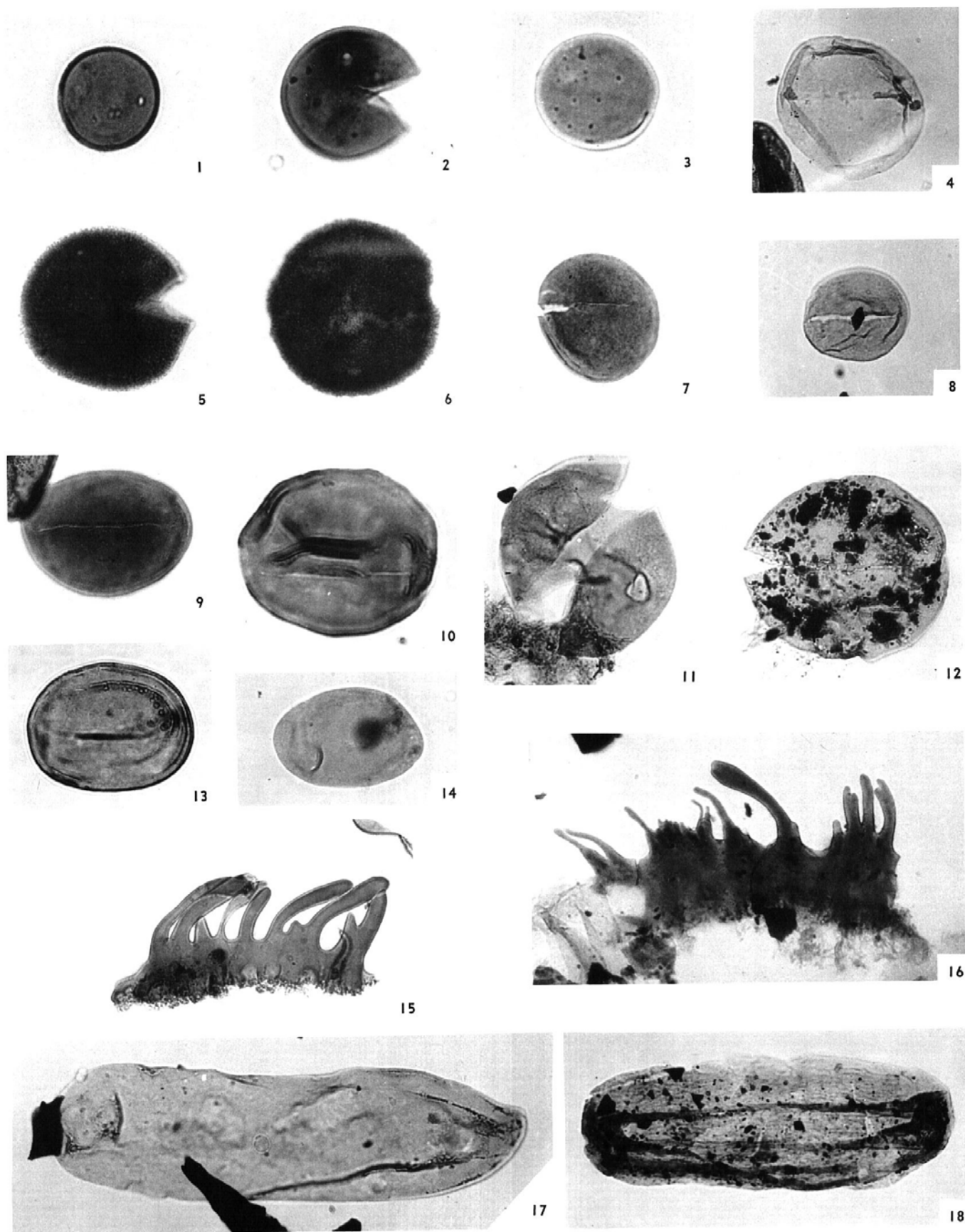
Description: Test elongate, inflated fusiform in outline, biconvex in cross section, grooved. Groove straight, extending from one end a distance of one-quarter to one-half of the length of the test. Wall uniformly 2 microns thick. Pigmentosae often present near the interior end of the groove. Surface matte to minutely granulate.

Dimensions: Length 51-76 microns, width 33-40 microns.

Holotype: Plate 3, figure 13. Holotype dimensions 40 × 76 microns.

PLATE 2

- 1 *Sphaeroporolites solus* Hemer and Nygreen, n. sp.
Holotype, COC-5, 18 microns, × 1000, location 44.6-127.1 (Ref. 59.1-107.9).
- 2 *Sphaeroporolites solus* Hemer and Nygreen, n. sp.
COC-3, 26 microns, × 1000, location 55.7-125.1 (Ref. 61.5-106.5).
- 3 *Sphaeroporolites multiplex* Hemer and Nygreen, n. sp.
Holotype, COC-11, 26 microns, × 1000, location 46.8-124.3 (Ref. 61.5-107.9).
- 4 *Hemisphaerium signum* Hemer and Nygreen, n. sp.
Holotype, COC-10, 58 microns, × 500, location 42.4-120.9 (Ref. 61.4-107.2).
- 5 *Arabisphaera fossilis* Hemer and Nygreen, n. sp.
Holotype, COC-3, 62 microns, × 500, location 56.0-125.2 (Ref. 61.5-106.5).
- 6 *Arabisphaera fossilis* Hemer and Nygreen, n. sp.
COC-8, 68 microns, × 500, location 33.7-120.2 (Ref. 59.7-107.2).
- 7 *Hemisphaerium inominatum* Hemer and Nygreen, n. sp.
Holotype, COC-4, 50 microns, × 500, location 36.5-114.1 (Ref. 58.4-106.7).
- 8 *Hemisphaerium inominatum* Hemer and Nygreen, n. sp.
COC-10, 40 microns, × 500, location 35.4-126.3 (Ref. 61.4-107.2).
- 9 *Fusilites dulcis* Hemer and Nygreen, n. sp.
Holotype, COC-2, 48 × 64 microns, × 500, location 42.0-118.6 (Ref. 59.9-106.8).
- 10 *Fusilites dulcis* Hemer and Nygreen, n. sp.
COC-3, 40 × 48 microns, × 775, location 43.6-126.9 (Ref. 61.5-106.5).
- 11 *Hemisphaerium signum* Hemer and Nygreen, n. sp.
COC-10, 66 microns, × 500, location 48.8-117.5 (Ref. 61.4-107.2).
- 12 *Hemisphaerium germanum* Hemer and Nygreen, n. sp.
Holotype, COC-11, 70 × 78 microns, × 500, location 48.2-122.0 (Ref. 61.5-107.9).
- 13 *Fusilites dulcis* Hemer and Nygreen, n. sp.
COC-3, 49 × 62 microns, × 500, location 37.0-128.3 (Ref. 61.5-106.5).
- 14 *Fusilites dulcis* Hemer and Nygreen, n. sp.
COC-7, 38 × 56 microns, × 500, location 20.5-119.4 (Ref. 48.9-106.9).
- 15 Form A
COC-11, 50 × 198 microns, × 500, location 38.5-120.7 (Ref. 61.5-107.9).
- 16 Form A
COC-10, 80 × 112 microns, × 500, location 57.5-112.1 (Ref. 61.4-107.2).
- 17 *Deusilites tentus* Hemer and Nygreen, n. sp.
Holotype, COC-2, 24 × 90 microns, × 500, location 43.1-124.1 (Ref. 59.9-106.8).
- 18 *Deusilites tentus* Hemer and Nygreen, n. sp.
COC-13, 50 × 140 microns, × 500, location 54.4-113.6 (Ref. 60.5-107.0).



Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-2; figured specimen, slide MT-7.

Genus *QUISQUILITES* Wilson and Urban (1963)

Quisquilites? ornatus Hemer and Nygreen, new species
Plate 3, figures 15–16

Description: Bilaterally symmetrical, elliptical in outline, round to oval in cross section. Wall thickness 2 microns. Surface granulate to extravermiculate, sometimes with scattered perforations.

Dimensions: Length 72–84 microns, width 34–50 microns.

Discussion: Differs from *Q. ? pluralis* in its pronounced ornamentation and lack of the apertural area. Multilayering of the wall was not positively observed.

Holotype: Plate 3, figure 15. Holotype dimensions 44 × 84 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-5; figured specimen, slide MT-6.

Quisquilites? pluralis Hemer and Nygreen, new species
Plate 3, figures 14, 17–18

Description: Bilaterally symmetrical, longitudinally tere, round to oval in cross section. Wall thickness 1–4 microns. Surface smooth, matte or minutely granulate, often with scattered perforations. Sometimes split longitudinally. May contain indefinite to definite oval areas which may be apertural.

Dimensions: Length 58–76 microns, width 26–38 microns.

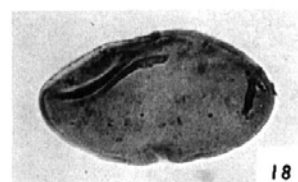
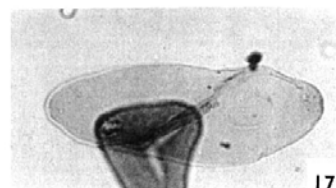
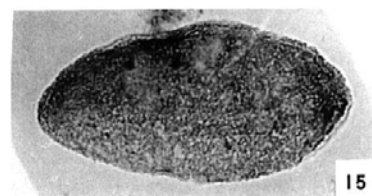
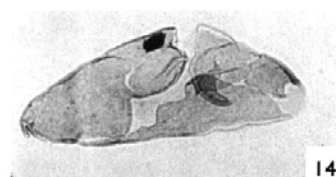
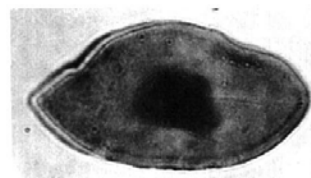
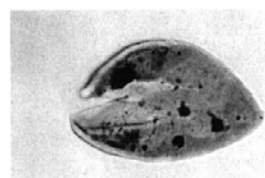
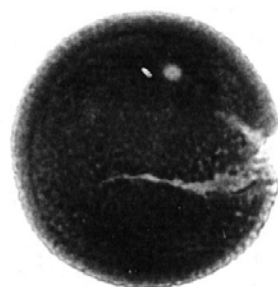
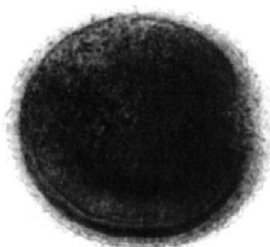
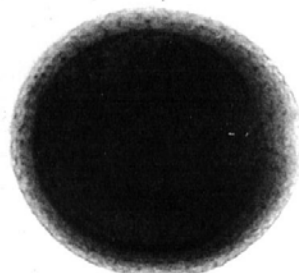
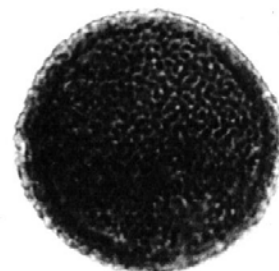
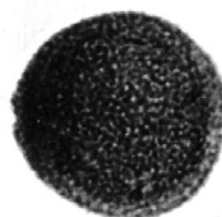
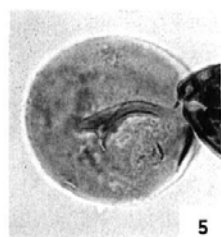
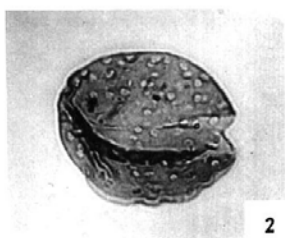
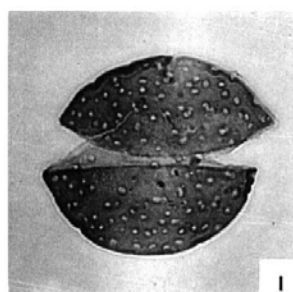
Discussion: Provisional assignment to *Quisquilites* is made on the basis of shape, presence of perforations on some forms, ornamentation and cross section. This species differs from *Q. buckhornensis* in not being reniform and in possessing oval apertural? areas on some specimens. Multilayering of the wall was not positively observed.

Holotype: Plate 3, figure 17. Holotype dimensions 26 × 72 microns.

Depository: American Museum of Natural History, Department of Micropaleontology; holotype, slide MT-5; figured specimens, slides M-3 and MT-5.

PLATE 3

- 1 *Lacunalites sphaericus* Hemer and Nygreen, n. sp.
Holotype, COC-3, 48 microns, × 500, location 41.4–109.0 (Ref. 61.5–106.5).
- 2 *Lacunalites sphaericus* Hemer and Nygreen, n. sp.
COC-2, 48 microns, × 500, location 24.1–121.8 (Ref. 59.9–106.8).
- 3 *Lacunalites sphaericus* Hemer and Nygreen, n. sp.
COC-2, 65 microns, × 500, location 42.5–123.1 (Ref. 59.9–106.8).
- 4 *Lacunalites sphaericus* Hemer and Nygreen, n. sp.
H-3419, 66 microns, × 500, location 50.2–111.1 (Ref. 58.8–130.2).
- 5 *Leiosphaeridia orbiculata* (Staplin)
COC-11, 48 microns, × 500, location 61.4–119.4 (Ref. 61.5–107.9).
- 6 *Leiosphaeridia orbiculata* (Staplin)
COC-11, 46 microns, × 500, location 35.5–125.7 (Ref. 61.5–107.9).
- 7 *Arabisphaera bellula* Hemer and Nygreen, n. sp.
Holotype, COC-9, 28 microns, × 1000, location 32.7–127.9 (Ref. 61.5–107.4).
- 8 *Arabisphaera bellula* Hemer and Nygreen, n. sp.
COC-6, 36 microns, × 1000, location 57.0–123.4 (Ref. 60.4–107.2).
- 9–10 *Arabisphaera bellula* Hemer and Nygreen, n. sp.
9, high focus; 10, low focus; COC-11, 40 microns, × 1000, location 36.2–120.2 (Ref. 61.5–107.9).
- 11 *Arabisphaera bellula* Hemer and Nygreen, n. sp.
COC-9, 37 microns, × 1000, location 56.3–118.6 (Ref. 61.5–107.4).
- 12 *Fusilites lucis* Hemer and Nygreen, n. sp.
COC-11, 33 × 51 microns, × 500, location 60.6–124.3 (Ref. 61.5–107.9).
- 13 *Fusilites lucis* Hemer and Nygreen, n. sp.
Holotype, COC-3, 40 × 76 microns, × 500, location 44.5–126.9 (Ref. 61.5–106.5).
- 14 *Quisquilites? pluralis* Hemer and Nygreen, n. sp.
COC-9, 30 × 76 microns, × 500, location 27.6–109.2 (Ref. 61.5–107.4).
- 15 *Quisquilites? ornatus* Hemer and Nygreen, n. sp.
Holotype, COC-9, 44 × 84 microns, × 500, location 54.4–128.2 (Ref. 61.5–107.4).
- 16 *Quisquilites? ornatus* Hemer and Nygreen, n. sp.
COC-10, 40 × 72 microns, × 500, location 44.6–113.7 (Ref. 61.4–107.2).
- 17 *Quisquilites? pluralis* Hemer and Nygreen, n. sp.
Holotype, COC-9, 26 × 72 microns, × 500, location 48.7–115.9 (Ref. 61.5–107.4).
- 18 *Quisquilites? pluralis* Hemer and Nygreen, n. sp.
COC-8, 38 × 64 microns, × 500, location 31.6–116.3 (Ref. 59.7–107.2).
- 19 *Deusilites tentus* Hemer and Nygreen, n. sp.
COC-6, 56 × 246 microns, × 500, location 47.8–126.9 (Ref. 60.4–107.2).



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