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PALYNOLOGY OF THE SAND BRANCH MEMBER OF THE CANEY SHALE FORMATION (MISSISSIPPIAN) OF SOUTHERN OKLAHOMA

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PALYNOLOGY OF THE SAND BRANCH MEMBER OF THE CANEY SHALE FORMATION (MISSISSIPPIAN) OF SOUTHERN OKLAHOMA

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PALYNOLOGY OF THE SAND BRANCH MEMBER OF THE CANEY SHALE FORMATION (MISSISSIPPIAN) OF SOUTHERN OKLAHOMA

ABSTRACT

Reginald W. Harris, Jr.

Palynology of the Sand Branch Member of the Caney Shale Formation is described from outcrop samples collected at two measured sections in Johnston County, Oklahoma. At the type locality of the Sand Branch Member, forty-four channel samples were collected; and from exposures of uppermost Sand Branch strata on Sandy Creek south of Wapanucka, Oklahoma, five additional channel samples were collected. The plant palynomorph assemblage contains 72 genera and 154 species, of which 21 genera and 93 species are considered new. The marine acritarch assemblage consists of 10 genera and 39 species, of which 32 species are considered new. A single questionable plant palynomorph type and a questionable acritarch type were recovered. The acritarch assemblage in the Sand Branch is the largest such assemblage reported to date from Mississippian or Pennsylvanian sediments.

Relative percentages of acritarchs and plant spores in the Sand Branch afford a tripartite zonation of this member. The dominance of acritarchs (99.5% to 100%) in Zone I, the basal 35 feet of Sand Branch strata at the type locality, suggests that the site of deposition was at that time effectively isolated from terrigenously derived plant spores. Zone II, the succeeding 65 feet of sediments, contains acritarchs and plant spores that are approximately equal in number, but which alternate in dominance. Zone III consists of the upper 82.5 feet of strata exposed at the Sand Branch type locality and the 24 feet of Sand Branch exposed on Sandy Creek. With the exception of a single

sample that contains predominantly marine palynomorphs, plant spores comprise from 68.5% to 98% of the palynomorphs in Zone III. It is proposed that in southern Oklahoma the dominance in palynomorph assemblages assumed by plant spores in late Sand Branch time (Zone III) was maintained through Goddard and Springer times into the Pennsylvanian.

A minor percentage of Sand Branch palynomorphs were recycled from older stratigraphic units. Acritarchs which were apparently recycled from the Sylvan and Woodford Formations are rare in Zone I, but increase steadily in abundance upward to the middle of Zone III. Their presence suggests that rocks at least as young as Devonian and as old as Ordovician were exposed to erosion during Sand Branch time.

Comparison of the Sand Branch palynomorph assemblage with similar assemblages reported from Mississippian strata of North America, Europe, and Russia suggests an age of Late Mississippian (early to middle Chesterian) for the Sand Branch. On the basis of palynomorph content, upper beds of the Sand Branch (Zone III) and strata comprising the lower part of the Goddard Formation at its type locality are considered time equivalents.

PALYNOLOGY OF THE SAND BRANCH MEMBER OF THE CANEY SHALE FORMATION (MISSISSIPPIAN) OF SOUTHERN OKLAHOMA

INTRODUCTION

Objectives

The purpose of this palynological investigation of the Sand Branch Member of the Caney Shale is essentially four-fold: 1) to present a taxonomic description of the palynomorph assemblage in the Sand Branch; 2) to compare the Sand Branch palynomorph assemblage with assemblages previously described from Mississippian strata of Russia, Europe, and North America; 3) to establish a palynological zonation of the Sand Branch; and 4) to determine, on the basis of palynomorph content, the age relationship of the type sections of the Sand Branch and Goddard shales.

Acknowledgments

The writer expresses his appreciation to Dr. L. R. Wilson, George Lynn Cross Research Professor of Geology and Geophysics, who directed this dissertation and whose advice and suggestions contributed materially to the completion of the investigation.

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THE SAND BRANCH MEMBER OF THE CANEY SHALE FORMATION

Stratigraphic Position

Elias (1956) subdivided the Caney Shale Formation north of the Arbuckle Mountains into three members (ascending): Ahlosa (later emended to Ahloso), Delaware Creek, and Sand Branch. Faunal evidence afforded by invertebrate megafossils induced Elias to assign an age of early Meramecian to the Ahloso Member; late Meramecian or possibly younger to the Delaware Creek Member; and Chesterian to the Sand Branch Member.

In the southern Arbuckles, Elias recognized only the Delaware Creek Member, but did not dismiss the possibility that the Ahloso Member might also be found there. Elias stated (1956, p. 69) that he could find no paleontologic evidence which would indicate correlation of the upper part of the Caney in the southern Arbuckles with the Sand Branch Member north of the mountains. Thus the Caney sediments cropping out in the southern Arbuckles are Meramecian in age.

Elias determined that the Delaware Creek Member was overlain conformably by the Goddard Formation in the southern Arbuckles. The conformable relationship between the Delaware

Creek and the overlying Goddard Formation, and the presence of the goniatite Eumorphoceras in both the Sand Branch Member and the Goddard led Elias to consider the Sand Branch and Goddard as time equivalents, Chesterian in age.

Type Section

Elias and Branson (1959) formally established the Caney Shale Formation for Upper Mississippian shales of the Arbuckle Mountains region. In summarizing their interpretation of the age and stratigraphic relationships of the Caney Shale they state (p. 22):

> Our interpretation of the Caney shale places the typical formation as a Mississippian unit consisting of the Meramecian Ahloso member, the Delaware Creek member (later Meramecian and early Chesterian), and the late Chesterian Sand Branch member. . . The Goddard shale is considered a facies of the Sand Branch member.

The type section of the Sand Branch Member of the Caney Shale Formation is along Delaware Creek and its tributaries, center E½ Sec. 14, T. 2 S., R. 7 E., Johnston County, Oklahoma. According to Elias and Branson (1959, p. 15), the type section consists of 172.75 feet of dark gray to black shales, with several thin (0.2 to 2.0 feet) layers of gray, fossiliferous limestone concretions. Some of the shale beds contain conodonts. Megafossils recovered by Elias and Branson from limestone concretions approximately 45 feet below the top of the Sand Branch include:

Cravenoceras aff. C. malhamense
Cravenoceras cf. C. oklahomense
Eumorphoceras cf. E. girtyi

Orthoceras sp.
Caneyella wapanuckensis

Detailed lithology of the type section is described herein in the discussion of collections.

COLLECTIONS

The Sand Branch Member of the Caney Shale is not exposed in its entirety at any single locality. The composite section studied in this investigation consists of samples collected at four outcrop localities (Figure 1), and totals 206.5 feet in thickness. Collecting localities were assigned Oklahoma Palynological Collection (OPC) numbers as follows:

Locality OPC 856 is the type section of the Sand Branch Member (Elias and Branson 1959), where shales of the lower part of the Sand Branch are well exposed. Localities OPC 912, 913, and 914 are exposures on Sandy Creek south of Wapanucka, Oklahoma, where a continuous sequence of upper Sand Branch shale is exposed (Elias 1956, p. 65). OPC 914 represents the uppermost strata of the Sand Branch Member.

Channel samples were collected from measured sections at each locality, and individual samples received an alphabetical designation, A, B, C, etc., according to their stratigraphic position from the base upward. Detailed descriptions of the 49 channel samples, from the top of the Sand Branch Member to the base, are given by locality in Table 1.

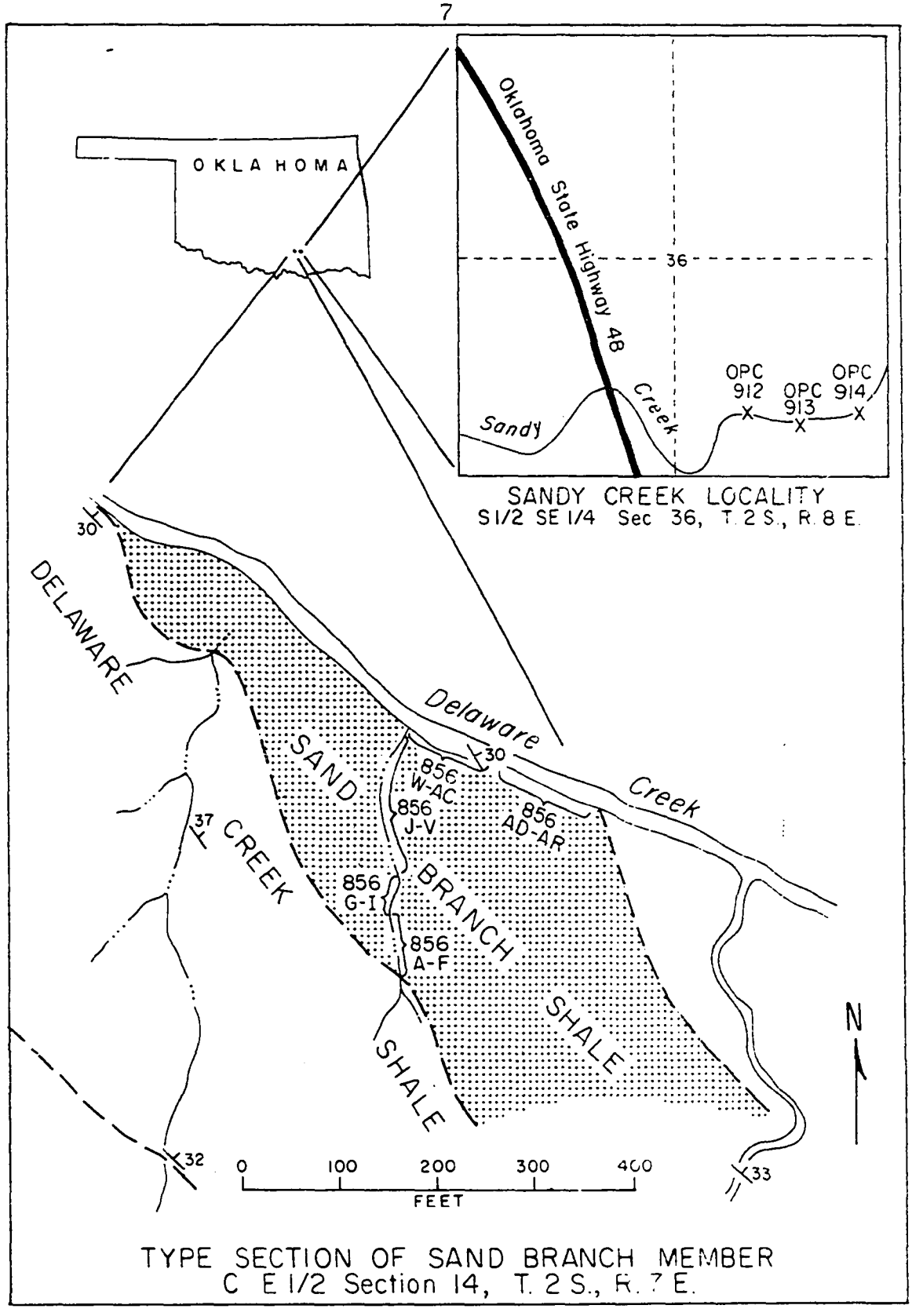


Figure 1. Collecting localities, Johnston County, Oklahoma

TABLE 1

DESCRIPTION OF COLLECTING LOCALITIES
AND CHANNEL SAMPLES

OPC 914: SE¼, SE¼, Sec. 36, T. 2 S., R. 8 E., Johnston County, Oklahoma; south bank of Sandy Creek, 600 yards east of Highway 48, 3 miles south of Wapanucka, Oklahoma.

Sample No.	Description	Thickness (in feet)
OPC 914 A	Shale, black, soft, iron-stained	4.0

OPC 913: C, S½, SE¼, Sec. 36, T. 2 S., R. 8 E., Johnston County, Oklahoma; south bank of Sandy Creek, 300 yards east of Highway 48, 3 miles south of Wapanucka, Oklahoma.

Sample No.	Description	Thickness (in feet)
OPC 913 B	Shale, black, thinly laminated; base of sample includes 3-inch soft, brown shale; top of sample marked by, and includes, 5 inches soft, brown shale	5.0
OPC 913 A	Shale, black, thinly laminated	5.0

OPC 912: SW¼, SE¼, Sec. 36, T. 2 S., R. 8 E., Johnston County, Oklahoma; north bank of Sandy Creek, 150 yards east of Highway 48, 3 miles south of Wapanucka, Oklahoma.

Sample No.	Description	Thickness (in feet)
OPC 912 B	Shale, brown to black, blocky	5.0
OPC 912 A	Shale, black, thinly laminated, half-inch phosphatic concretions	5.0

TABLE 1--Continued

OPC 856: Type section of Sand Branch Member, along Delaware Creek and tributaries, C, E½ Sec. 14, T. 2 S., R. 7 E., Johnston County, Oklahoma.

Sample No.	Description	Thickness (in feet)
OPC 856 AR	Shale, black, laminated; limestone concretions, gray, flattened	2.5
OPC 856 AQ	Shale, black, platy	2.5
OPC 856 AP	Shale, dark gray, platy; 4" limestone concretions, gray, flattened	2.5
OPC 856 AO	Shale, gray, platy to massive	2.5
OPC 856 AN	Shale, dark gray, platy, laminated; 5" limestone concretions, gray, flattened	2.5
OPC 856 AM	Shale, gray, massive, laminated	2.5
OPC 856 AL	Shale, black and brown interbedded, massive	2.5
OPC 856 AK	Shale, black, massive, slightly laminated	2.5
OPC 856 AJ	Shale, black, platy, laminated	2.5
OPC 856 AI	Shale, black, platy, strongly laminated	2.5
OPC 856 AH	Shale, dark gray, platy to massive	2.5
OPC 856 AG	Shale, dark gray, platy	2.5
OPC 856 AF	Shale, black, platy	2.5
OPC 856 AE	Shale, black, platy; 4" limestone concretions, gray, flattened to elliptical	2.5
OPC 856 AD	Shale, black, platy; 8" limestone concretions, gray, flattened, elongate	2.5

TABLE 1--Continued

Sample No.	Description	Thickness (in feet)
OPC 856 AC	Shale, dark gray, platy; 6" limestone concretions, gray, flattened, elongate	5.0
OPC 856 AB	Shale, dark gray, laminated; 5" limestone concretions, gray, elongate	5.0
OPC 856 AA	Shale, dark gray, platy; 3" limestone concretions, gray, elongated along strike	5.0
OPC 856 Z	Shale, dark gray, massive; small phosphatic concretions	5.0
OPC 856 Y	Shale, dark gray, massive; small phosphatic concretions	5.0
OPC 856 X	Shale, dark gray, massive; small phosphatic concretions	5.0
OPC 856 W	Shale, gray, massive	5.0
OPC 856 V	Shale, dark gray, platy to massive	5.0
OPC 856 U	Shale, dark gray, platy to massive, laminated	5.0
OPC 856 T	Shale, gray, platy, laminated	5.0
OPC 856 S	Shale, gray, platy	5.0
OPC 856 R	Shale, gray, platy to massive, laminated	5.0
OPC 856 Q	Shale, gray, platy, laminated; 3" limestone concretion, gray, septarian	5.0
OPC 856 P	Shale, dark gray, massive, slightly laminated	5.0
OPC 856 O	Shale, dark gray, massive, laminated; small phosphatic concretions	5.0

TABLE 1--Continued

Sample No.	Description	Thickness (in feet)
OPC 856 N	Shale, dark gray, platy	5.0
OPC 856 M	Shale, gray, platy, laminated	5.0
OPC 856 L	Shale, gray, platy,	5.0
OPC 856 K	Shale, dark gray, laminated	5.0
OPC 856 J	Shale, dark gray, platy	5.0
OPC 856 I	Shale, dark gray, platy, laminated	5.0
OPC 856 H	Shale, dark gray, platy; 4" limestone concretion, gray, septarian	5.0
OPC 856 G	Shale, dark gray, platy to massive, laminated	5.0
OPC 856 F	Shale, dark gray, platy, slightly laminated	5.0
OPC 856 E	Shale, gray, platy, laminated	5.0
OPC 856 D	Shale, dark gray, platy to massive, laminated	5.0
OPC 856 C	Shale, gray, platy to massive, laminated; small phosphatic concretions	5.0
OPC 856 B	Shale, gray, platy, laminated; small phosphatic concretions	5.0
OPC 856 A	Shale, dark gray, platy to massive, laminated	5.0
	Thickness at type locality:	182.5 feet
	Total thickness of Sand Branch studied:	206.5 feet

SAMPLE PREPARATION AND STUDY PROCEDURE

Preparation

Laboratory techniques and procedure follow closely those outlined by Wilson (1959b). Each rock sample was broken into particles approximately one-eighth inch in diameter, and the fragments were mixed thoroughly. Twenty grams of crushed, mixed sample were separated for palynological preparation and study. The remainder was stored in the palynological collection of the Oklahoma Geological Survey, Norman, Oklahoma. The portion utilized for study was placed in a polyethylene beaker and covered with concentrated hydrochloric acid. After eight to twelve hours, the acid was decanted and the sediment was washed in distilled water until a neutral pH was obtained. The sample was then treated for an equal amount of time with 52% hydrofluoric acid and again neutralized. Residues from the acid treatments were oxidized with Schulze's solution for four to eight hours. Examination of the oxidized residue revealed that further oxidation was required; accordingly, several weak oxidizing agents were tried without success. It was found that satisfactory removal of extraneous organic material could be accomplished

only with potassium hydroxide; consequently, all samples were treated in a 10% solution of this base for 10 to 15 minutes. A heavy liquid, pentahydrous stannic chloride solution, with specific gravity of 1.8 (Davis 1961), was used for separation of the organic and inorganic fractions. A portion of the organic residue was stained with Safranin O to facilitate palynomorph identification and to enhance the quality of subsequent photomicrographs. Stained residue was mounted on a cover slip in Clearcol (Wilson 1959a), and the cover slip was affixed to the microscope slide with Harleco. Six to ten slides were prepared from each sample.

Study Procedure

Microscope slides were studied with the aid of an American Optical Microstar compound binocular microscope equipped with 10X W. F. oculars and 10X, 43X, and 97X (oil immersion) objectives. Each slide was examined by systematic traverses. Microfossils selected to be photographed were ringed with glass-marking ink, and each ring was assigned a number. The indexing system used to designate each specimen employed a sample number, a slide number, and a ring number. For example, OPC 856 W-4-3 refers to the microfossil in ring number three on slide number four of the series of slides prepared from sample OPC 856 W. Microfossils were photographed with a Zeiss Photomicroscope, using 35mm Adox KB-14 film. Prints were made by enlargement on single-weight Kodabromide No. 5 paper.

Microfossils were identified to species, and assemblage counts of 200 specimens per sample were made. Two to three slides per sample were used to insure a representative count of the microfossil assemblage in the sample. Relative percentages of species in each sample were calculated and recorded on the species range charts.

SPORAE DISPERSAE

Anteturma SPORITES H. Potonié, 1893

Turma TRILETES (Reinsch) Potonié and Kremp, 1954

Subturma AZONOTRILETES Luber, 1935

Infraturma LAEVIGATI (Bennie and Kidston) R. Potonie, 1956

Genus LEIOTRILETES (Naumova) Potonié and Kremp, 1954

Type species: L. sphaerotriangulus (Loose) Potonié and Kremp, 1954

Affinity: Spores of this genus have been recovered from the Upper Carboniferous fructification Oligocarpia, the earliest known representative of the Gleicheniaceae. This simple type of spore was probably borne also by members of other families of the Filicales.

LEIOTRILETES SPHAEROTRIANGULUS

(Loose) Potonié and Kremp, 1954

Plate 1, figure 12

This roundly triangular species is a minor but persistent element throughout the section studied. It is represented in many samples by only a single specimen in a 200-grain count, and attains a maximum abundance of only 2 to 3% in the uppermost part of the Sand Branch Member.

Figured specimen: OPC 913 B-1-1
38 X 35 microns

LEIOTRILETES SPORADICUS

(Imgrund) Potonié and Kremp, 1955

Plate 1, figure 13

Specimens of L. sporadicus found in the Sand Branch display the slight lip development that is characteristic of the species. Some specimens when viewed at low magnifications appear punctate. However, when these specimens are examined at higher magnification, the "punctations" appear not as perforations, but as irregularly shaped pits in the outer surface of the wall. These pits may have been caused by the relatively harsh processing.

L. sporadicus occurs in association with L. sphaerotriangulus in most levels of the Sand Branch. L. sporadicus attains its maximum abundance of 2 to 5% in middle Sand Branch strata.

Figured specimen: OPC 856 M-3-1
28 X 25 microns

LEIOTRILETES SP.

Plate 1, figure 14

Spores radial, trilete, 30-37 microns; shape roundly triangular, sides slightly concave or convex; trilete rays equal two-thirds to four-fifths radius, some with slight darkening (thickening ?), but nowhere does this approach a raised labral development; exine laevigate, thin (1.1-1.4

microns), in many specimens irregularly folded or elongated along the axis of one of the trilete rays.

Potonié and Kremp (1955, p. 40) considered the peculiar folding exhibited by some trilete laevigate spores to be a specific character, and erected the species L. gulaferus to accommodate such spores. However, the type of folding found in spores referred to L. gulaferus, and exhibited by the specimen illustrated herein in Plate 1, figure 14, may be caused by factors that are neither inherent nor genetically controlled. It is recognized that the present classification of Sporae Dispersae, which treats spores as form genera, is largely artificial. Nevertheless, the bases of this classification should be, whenever possible, those criteria which most often would be distinguishing characteristics in a natural classification. The type of folding exhibited by spores referred to L. gulaferus is not considered such a characteristic, especially among thin-walled, trilete laevigate spores. Spores assigned to this species should perhaps be reassigned, on the basis of other morphological characteristics, to other species of Leiotriletes.

Leiotriletes sp. is the most abundant representative of the genus in the Sand Branch. It occurs throughout the unit, and attains an abundance of 7.5% in the middle portion.

Figured specimen: OPC 856 AJ-1-1
32 X 28 microns

Genus PUNCTATISPORITES (Ibrahim) Potonié and Kremp, 1954

Type species: P. punctatus (Ibrahim) Potonié and Kremp, 1954

Affinity: Psilopsida, Filicineae, Cycadofilicineae?

PUNCTATISPORITES ATRIFUCATUS Staplin, 1960

Plae 10, figure 10; Plate 11, figure 10

The pronounced labral development and the relatively thick wall characterize this species, first described from the Earlier Chesterian Golata Formation in Alberta, Canada.

This species was present in most samples of Zone III. It was not observed in Zones I and II.

Figures specimens: Plate 10, figure 10 OPC 856 AQ-5-5
50 microns

Plate 11, figure 10 OPC 856 AQ-4-1
61 X 56 microns

PUNCTATISPORITES IRRASUS Hacquebard, 1957

Plate 2, figure 2

Punctatisporites irrasus was described from coals from the Horton Group (Lower Mississippian) of Nova Scotia, Canada.

Although this species does not comprise more than 5.5% of the spore flora, it was found in every sample above level 856 H.

Figured specimen: OPC 856 AR-7-2
86 X 81 microns

Genus PHYLLOTHECOTRILETES Luber, 1955

Type species: P. nigritella (Luber) Luber, 1955

Affinity: Unknown

PHYLLOTHECOTRILETES GOLATENSIS Staplin, 1960

Plate 2, figures 1, 3

This species, described from the Golata Formation of Canada, is found throughout Zones II and III of the Sand Branch. It is most abundant in the upper 40 feet of Zone III.

Figured specimens: Figure 1, OPC 856 AN-4-7
58 X 56 microns

Figure 3, OPC 856 AR-7-3
59 X 54 microns

PHYLLOTHECOTRILETES RIGIDUS Playford, 1962

Plate 2, figure 4

This thick-walled (2.5-4 microns), finely granular species was described from the Tournaisian of Spitzbergen. It is a minor constituent in assemblages from the middle and upper Sand Branch.

Figured specimen: OPC 856 AO-4-2
56 X 51 microns

Genus GULISPORITES Imgrund, 1960

Type species: G. cochlearius (Imgrund) Imgrund, 1960

Affinity: Unknown

GULISPORITES SP. 1

Plate 1, figure 1

Spores radial, trilete, diameter 30-38 microns; shape roundly triangular, sides straight to slightly convex; trilete thin, straight, equal in length to one-half the spore radius, and, in many specimens, is obscured by twisted, raised labra which spread and merge with wall at apices; wall laevigate, thickness not determinable.

This species occurs sporadically in the upper two-thirds of the Sand Branch.

Figured specimen: OPC 912 A-6-1
34 microns

GULISPORITES SP. 2

Plate 1, figures 2, 3

Spores radial, trilete, diameter 34-43 microns; shape roundly triangular, sides of many specimens concave; apices blunt to broadly flattened; trilete rays short, and, in most specimens, obscured by heavy, twisted labra which, upon merging with the wall, cause the radial apices to appear thick and highly contorted; wall laevigate, thickness not determinable.

Lest Gulisporites sp. 2 be considered an immature or "unexpanded" form of G. sp. 1, it should be noted that the average size of G. sp. 2 is greater than that of G. sp. 1. The heavier labra and the broadly flattened, contorted radial apices of G. sp. 2 further serve to differentiate these species.

Gulisporites sp. 2 is most common in middle Sand Branch strata. It attains a maximum abundance of only 2%.

Figured specimens: Figure 2, OPC 856 AJ-5-3
36 microns

Figure 3, OPC 856 AL-3-2
39 microns

Genus RETUSOTRILETES Naumova, 1953

Type species: R. simplex Naumova, 1953

Affinity: Unknown

RETUSOTRILETES SP.

Plate 10, figure 9

Spores radial, trilete, diameter 46-51 microns; amb circular, but interrupted in some specimens by auriculae formed by exoexine at radial position; spore slightly convex distally, highly convex proximally; trilete rays straight, equaling one-half to two-thirds the spore radius, obscured by high, sinuous labra that extend almost to equatorial margin; wall probably thin; proximal surface of spore finely granular, distal surface possesses medium to coarse grana that never approach verrucae; exoexine granulose, close-fitting except at radial position, where it may thicken or loosen to form auriculae.

This species forms a minor percentage of the flora in the lower middle Sand Branch.

Figured specimen: OPC 856 M-2-1
50 microns

Genus CADIOSPORA Kosanke

emend. Bharadwaj and Venkatachala, 1961

Type species: C. magna Kosanke, 1950

Affinity: Unknown

CADIOSPORA SP. 1

Plate 11, figure 4

Spores radial, trilete, 48-54 microns in diameter, slightly convex proximally; crassitude 10 microns wide; exine smooth, but densely infragranular equatorially and distally; trilete straight, simple, extends to inner margin of crassitude; heavy labra widen radially and merge into crassitude.

A single specimen of Cadiospora sp. 1 was recorded in assemblage counts of levels 856 AD and 856 AG. The species is present in level 856 AE, but was not among the first 200 palynomorphs counted.

Figured specimen: OPC 856 AE-1-1
52 microns

CADIOSPORA SP. 2

Plate 11, figure 5

Spores radial, trilete, highly convex proximally and distally, 72-78 microns in diameter; trilete rays simple, equal to two-thirds of spore radius in length; weak labral development extends to crassitude; spore exine laevigate to finely granular; crassitude 6 microns wide.

One specimen of Cadiospora sp. 2 was counted in level 856 AA. C. sp. 2 was present but not counted in level 856 AH.

Figured specimen: OPC 856 AH-2-4
75 microns

Genus AMBITISPORITES Hoffmeister, 1959

Type species: A. avitus Hoffmeister, 1959

Affinity: Unknown

AMBITISPORITES SP.

Plate 9, figure 16

Spores radial, trilete, 36-45 microns in diameter; crassitude 5 microns wide; amb circular to sub-circular; trilete straight, extends to inner margin of crassitude; labra thin, raised; exine densely granular.

Ambitisporites sp. occurs in the upper one-half of Zone III. It attains a maximum abundance of 3.5% in level 856 AM.

Figured specimen: OPC 856 AN-2-8
44 X 37 microns

Infraturma APICULATI (Bennie and Kidston)
R. Potonié, 1956

Subinfraturma GRANULATI Dybová and Jachowicz, 1957

Genus GRANULATISPORITES Ibrahim
emend. Potonié and Kremp, 1954

Type species: G. granulatus Ibrahim, 1933

Affinity: Filicales?, Cycadofilicales?

GRANULATISPORITES PARVUS

(Ibrahim) Potonié and Kremp, 1955

Plate 1, figures 8, 11

This species, with reduced proximal ornamentation, occurs throughout the Sand Branch. In the middle of Zone III it may comprise 4%-8% of the spore assemblage, but elsewhere in the Sand Branch its abundance seldom exceeds 1.5%.

Figured specimens: Figure 8, OPC 856 L-3-2
37 microns

Figure 11, OPC 913 A-1-2
36 microns

Genus CYCLOGRANISPORITES Potonié and Kremp, 1954

Type species: C. leopoldi (Kremp) Potonié and Kremp, 1954

Affinity: Potonié (1960, p. 34) noted the similarity between Cyclogranisporites and spores recovered from Acitheca (Pecopteris) longifolia Brongniart.

CYCLOGRANISPORITES AUREUS

(Loose) Potonié and Kremp, 1955

Plate 2, figure 6

The occurrence of Cyclogranisporites aureus is sporadic in Zone II and in the lower one-half of Zone III. It was recorded from 50% of the samples in the upper one-half of Zone III.

Figured specimen: OPC 913 B-1-2
80 X 69 microns

CYCLOGRANISPORITES COMMODUS Playford, 1963

Plate 2, figure 5

This finely granular species is a minor constituent in approximately 50% of the samples throughout Zones II and III.

Figured specimen: OPC 856 AA-6-2
43 X 41 microns

CYCLOGRANISPORITES cf. C. MINUTUS

Bhardwaj, 1957

Plate 2, figure 9

Sand Branch specimens referred to this species have slightly coarser grana than does the type species of Bhardwaj. Some also exhibit weak lip development.

This species is rare in lower and middle Sand Branch strata. It is present in minor amounts in many of the samples in the upper one-half of Zone III.

Figured specimen: OPC 856 H-1-2
42 microns

CYCLOGRANISPORITES SP.

Plate 2, figures 7, 8

Spores radial, trilete, originally spherical, 57-65 microns in diameter; trilete thin, extends almost to margin; wall 2.5 microns thick, darkened (thickened ?) at ends of trilete rays on some specimens; spore surface ornamented with irregularly spaced grana 0.8 to 1.3 microns in height; distal surface more densely granular than proximal.

This species is most abundant in the upper half of the Sand Branch, where it attains abundances up to 3.5%. Single specimens were recorded from only two levels below sample 856 AA.

Figured specimen: OPC 856 AH-2-1
66 X 56 microns

7. Proximal focus

8. Distal focus

Subinfraturma VERRUCATI Dybová and Jackowicz, 1957

Genus VERRUCOSISPORITES Ibrahim

emend. Smith, Butterworth, Knox, and Love, 1964

Type species: V. verrucosus Ibrahim, 1933

Affinity: Filicales.

VERRUCOSISPORITES GRANDIVERRUCOSUS (Kosanke)

Smith, Butterworth, Knox, and Love, 1964

Plate 12, figure 11; Plate 18, figures 14, 15

Verrucae on this species are closely-spaced and have irregularly-shaped, sub-angular bases and broadly rounded tops. The verrucae seldom exceed 2 microns in height, and range up to 8 microns in breadth. The space between the verrucae appears as a negative reticulum when the focal plane is at the base of the verrucae (Plate 18, figure 15).

The outer portion of the exine on the specimen illustrated on Plate 12, figure 11 did not accept the Safranin O stain; consequently, the ornament appears perisporal in nature in the photomicrograph. However, when

the specimen is examined at high magnification its verrucae can be clearly seen.

Single specimens of this species were found in four samples from the upper one-fourth of the Sand Branch.

Figured specimens: Plate 12, figure 11 OPC 856 AJ-3-1
91 X 76 microns

Plate 18, figures 14, 15
OPC 913 A-2-2
85 X 76 microns

Genus CONVERRUCOSISPORITES

Potonié and Kremp, 1954

Type species: C. triquetrus (Ibrahim) Potonié and Kremp, 1954

Affinity: Unknown

CONVERRUCOSISPORITES SP.

Plate 5, figure 3

Spores radial, trilete, roundly triangular, 37-43 microns in diameter; laesurae straight, extend almost to margin; ornament of laevigate verrucae 3-4 microns in height and 5-12 microns in length; some adjacent verrucae on the distal surface may be united, but never does their morphology approach anastamose muri, as in Convolutispora or Camptotriletes; verrucae on proximal surface reduced in size and number, except along laesurae, where they fuse to form low, but distinct labra.

This species did not occur below the uppermost sample of Zone II. Its abundance does not exceed 2% in Zone III, but it is very persistent in occurrence.

Figured specimen: OPC 856 AJ-2-2
41 X 36 microns

Subinfraturma NODATI Dybova and Jachowicz, 1957

Genus LOPHOTRILETES (Naumova)

Potonié and Kremp, 1954

Type species: L. gibbosus (Ibrahim) Potonié and Kremp, 1954

Affinity: Unknown

LOPHOTRILETES MICROSAETOSUS

(Loose) Potonié and Kremp, 1955

Plate 1, figure 10

This species, with relatively stout, conical spines, occurs sporadically throughout the upper half of the Sand Branch.

Figured specimen: OPC 856 AE-5-1
35 microns

LOPHOTRILETES SP.

Plate 1, figure 9

Spores radial, trilete, 24-27 microns in diameter; angles rounded, sides straight to concave, rarely convex; exine thin; laesurae straight, simple, equal in length to three-fourths of the spore radius; pustulose labral structure is 3-3.5 microns wide; distal surface of spore ornamented with grana and conical spines 1.0-1.5 microns in height; proximal surface granular to subverrucose; proximal verrucae range up to 3 microns in diameter.

This species occurs sporadically and in low relative abundance throughout the Sand Branch.

Figured specimen: OPC 856 V-1-1
25 microns

Genus ANAPICULATISPORITES Potonie and Kremp, 1954

Type species: A. isselburgensis Potonie and Kremp, 1954

Affinity: Filicales ?

ANAPICULATISPORITES SP.

Plate 6, figures 12, 13

Spores radial, trilete, amb circular to subcircular, rarely roundly triangular; original shape probably lenticular with distal hemisphere more convex than proximal; size 45-56 microns; laesurae thin, extend to spore margin; labra absent; exine is thin over central portion of spore, but may thicken to 3.2 microns at equator; surface granular; distal and equatorial surfaces, and outer portion of proximal surface bear pointed spines or blunt pila 1-3.5 microns in height and whose basal diameter is 0.7-1.0 microns.

Anapiculatisporites sp. is rare in the Sand Branch.

Figured specimen: OPC 856 P-4-1
49 microns

12. Distal focus

13. Proximal focus

Genus IBRAHIMISPORES Artüz, 1957

Type species: I. microhorridus Artüz, 1957

Affinity: Unknown

Specimens assigned herein to Ibrahimispores have a flange-like structure that may simulate a saccus or a cingulum (Plate 3, figures 5 and 6), or that may appear to be associated with the trilete rays (Plate 3, figures 4, 8, and 10), depending upon orientation of the spore. Critical examination suggests that this structure is a spine-bearing, post-equatorial flange located on the proximal hemisphere just above the equatorial margin. Further study may warrant the transfer of Ibrahimispores from Subturma Azonotriletes to Subturma Zonotriletes.

IBRAHIMISPORES BREVISPINOSUS Neves, 1961

Plate 3, figures 5, 6

This species is characterized by short, hollow spines that taper to a solid, pointed tip. Even with the spore compressed along the polar axis, the faint trilete mark characteristic of the species is not discernible.

The perfect proximal-distal orientation of the figured specimen causes the post-equatorial flange to appear as an equatorial cingulum.

Single specimens of Ibrahimispores brevispinosus were found in levels OPC 913 A and OPC 914 A.

Figured specimen: OPC 913 A-5-2
overall diameter 80 microns;
spore body 57 microns

IBRAHIMISPORES MAGNIFICUS Neves, 1961

Plate 3, figure 10

This species, described from the Naumurian C of England, is characterized by long (15-20 microns), widely-spaced spines with darkened tips.

A single specimen of Ibrahimispores magnificus was found in level 912 B.

Figured specimen: OPC 912 B-5-3
overall diameter 72 X 76 microns
spore body 60 X 58 microns

IBRAHIMISPORES MICROHORRIDUS Artüz, 1957

Plate 3, figures 7, 9

The spines of Ibrahimispores microhorridus are longer and heavier than those of I. brevispinosus, and more closely set than those of I. magnificus.

Ibrahimispores microhorridus was recorded in assemblage counts of levels 913 B and 856 X. It is present, but was not recorded in assemblage counts, in two other samples from the upper one-fourth of the Sand Branch. The occurrence of I. microhorridus in level 856 X is 52.5 feet below other occurrences of this genus in the Sand Branch.

Figured specimens: Figure 7 OPC 856 AQ-5-3
overall diameter 96 X 85 microns; spore body 64 microns

Figure 9 OPC 912 B-5-1
overall diameter 76 X 91 microns; spore body 66 microns

IBRAHIMISPORES SP. 1

Plate 3, figure 4

Spores radial, trilete, originally spherical, overall diameter 69-85 microns, spore body 67 microns; laesurae faint, rarely discernible; exine granular, beset with stout conical spines 4-8 microns in length and 3-5 microns in basal diameter; spines on proximal surface shorter and fewer in number than those on distal surface; post-equatorial flange on proximal surface is 12-16 microns high and 2-3 microns thick; flat spines 5-7.5 microns in length arise from outer margin of post-equatorial flange.

Spines of this species are shorter, more numerous, and more closely-spaced than are those of other species of Ibrahimispores.

Single specimens were recorded in assemblage counts from levels 856 AP and 913 B. The species is present in level 856 AR, but it did not appear in the assemblage count for that level.

Figured specimen: OPC 856 AR-8-2
overall diameter 84 microns;
spore body 67 microns

IBRAHIMISPORES SP. 2

Plate 3, figure 8

Spore radial, trilete, originally spherical or slightly flattened proximally; overall diameter 76 X 89 microns, spore body 66 microns; laesurae faint, equal in length to three-fourths of the spore radius; exine granular,

beset with spines 12-16 microns in length; spines are slender, curved, and taper to solid point that is darkened for one-half the length of the spine; proximal spines rare; granular post-equatorial flange 6-10 microns high bears spines 8-12 microns in length along its margin.

The spines of Ibrahimispores sp. 2 are longer and more slender than those of I. brevispinosus, I. microhorridus, and I. sp. 1, and are more closely-spaced than those of I. magnificus.

The single specimen found in level 856 AN did not appear in the assemblage count.

Figured specimen: OPC 856 AN-3-2
overall diameter 76 X 89 microns
spore body 66 microns

Subinfraturma BACULATI

Dybová and Jachowicz, 1957

Genus RAISTRICKIA

(S., W., and B.) Potonié and Kremp, 1954

Type species: R. grovensis Schopf, in S., W., and B., 1944

Affinity: Probably Filicineae

RAISTRICKIA SAETOSA

(Loose), S., W., and B., 1944

Plate 6, figures 1, 2, 7, 8

Single specimens of Raistrickia saetosa were recovered from levels 856 AA, AE, and AN in the upper one-third of the Sand Branch.

Raistrickia sp. 2 of Wiggins (1962) and R. spp. of Sullivan (1964) may be R. saetosa.

Figured specimens: Figure 1 OPC 856 AA-4-2
spore body 51 X 41 microns
processes 5-13 X 2-4 microns

Figure 2 OPC 856 AO-2-1
spore body 54 X 45 microns
processes 4-14 X 3-4 microns

Figure 7 OPC 856 AE-3-1
spore body 41 microns
processes 4-10 X 2-4 microns

Figure 8 Processes of figure 7 photographed through oil immersion objective

RAISTRICKIA SP. 1

Plate 6, figures 3, 4

Spore trilete, amb subcircular, spore body 50 X 38 microns in diameter; wall 1-2 microns thick; surface finely granular, beset with processes varying from sharply pointed to bluntly conical, flat-topped, bifurcated, or combinations of these; processes 4-8 microns in length, basal diameter 2-8 microns; trilete thin, equal in length to one-half spore radius.

The single specimen referred to Raistrickia sp. 1 may be a variant of R. sp. 2, but it is tentatively separated on the basis of its coarser processes. The processes on R. sp. 1 are smaller than those of R.? gibberosa Hacquebard (1957), and they are not restricted to the distal side.

The single specimen of R. sp. 1 found in level 856 N was the only noted occurrence of Raistrickia below Zone III.

Figured specimen: OPC 856 N-2-2
body 50 X 38 microns
overall size 58 X 44 microns

3. Equatorial focus 4. Proximal focus

RAISTRICKIA SP. 2

Plate 6, figure 5

Spores radial, trilete, amb circular; body 41-49 microns in diameter; processes vary from simple to bifurcate or trifurcate pila 2-8 microns in length and 2-5 microns in basal diameter; processes fewer and smaller proximally; trilete thin, equal in length to one-half spore radius.

Raistrickia sp. 2 is smaller than R. irregularis Kosanke, 1950, and has smaller processes than R.? gibberosa Hacquebard, 1957.

Raistrickia sp. 2 was found in three samples near the middle of the upper half of the Sand Branch.

Figured specimen: OPC 856 AH-1-2
body 48 X 43 microns
overall size 56 X 50 microns

RAISTRICKIA SP. 3

Plate 6, figure 9

Spores radial, trilete, probably originally spherical; body 35-40 microns in diameter; proximal surface laevigate and unornamented; distal and equatorial regions bear irregularly-shaped pila 1-3 microns long; surface otherwise laevigate; distinct trilete almost equal in length to spore radius.

Smaller size and coarser, more irregularly-shaped spines distinguish Raistrickia sp. 3 from R. obtrusa Playford, 1963.

Raistrickia sp. 3 was found in three levels near the middle of Zone III.

Figured specimen: OPC 856 AN-1-5
body 39 X 35 microns
overall size 42 X 36 microns

RAISTRICKIA SP. 4

Plate 6, figures 14, 15

Spore radial, trilete, 86 X 70 microns; wall 1.2 microns thick; proximal surface contains six gemmae 2.5 microns in diameter; distal and equatorial regions ornamented with three thin, muri-like ridges 8 microns high, and more or less evenly distributed baculae 6-8 microns high and 2-5 microns in diameter; surface otherwise finely granular; trilete thin, equal in length to four-fifths radius.

The muri-like ridges distinguish Raistrickia sp. 4 from R. nigra Love, 1960.

The single specimen referred to Raistrickia sp. 4 was found in level 913 A.

Figured specimen: OPC 913 A-3-1
spore body 86 X 70 microns
overall size 91 X 74 microns

14. Low focus 15. High focus

Infraturma MURORNATI Potonié and Kremp, 1954

Genus CAMPTOTRILETES

(Naumova) Potonié and Kremp, 1954

Type species: C. corrugatus (Ibrahim) Potonié and Kremp, 1954

Affinity: Unknown

CAMPTOTRILETES SP.

Plate 5, figures 1, 6

Spores radial, trilete, subcircular, 32-37 microns in diameter; proximal surface unornamented; equatorial and distal portions possess anastamose, reniform muri 3-5 microns high and 3-5 microns wide; muri end blindly and rarely intersect; distal surface also characterized by two to five irregularly-spaced verrucae up to 5 microns in diameter; spore surface laevigate; trilete simple, distinct, equal in length to four-fifths radius.

Camptotriletes sp. comprises no more than 0.5 per cent of the assemblages in which it was found in the upper half of Zone III.

Figured specimens: Figure 1 OPC 856 AE-2-1
35 X 33 microns

Figure 6 OPC 856 AR-2-7 tetrad;
individual spores 33 microns

Genus CONVOLUTISPORA H., S., and M., 1955

Type species: C. florida H., S., and M., 1955

Affinity: Unknown

CONVOLUTISPORA FLEXUOSA forma MINOR

Hacquebard, 1957

Plate 4, figure 16

Convolutispora flexuosa forma minor was first reported from the Lower Kinderhookian Horton Group of Nova Scotia. In the Sand Branch, a single specimen occurred in the assemblage

count for level 856 AO. A single specimen was observed also in level 856 AH, but it was not included in the spores counted.

Figured specimen: OPC 856 AH-3-4
58 X 53 microns

CONVOLUTISPORA cf. C. LAMINOSA Neves, 1961

Plate 5, figure 5

Convolutispora laminosa is characterized by comparatively heavy, anastamose ridges separated by areas of thin exine. The few specimens observed in the Sand Branch are characterized by fewer and more discontinuous ridges. However, discovery and study of more specimens in the Sand Branch may reveal that the Sand Branch specimens fall within the range of variability of C. laminosa.

This species was found in three samples in the upper half of Zone III.

Figured specimen: OPC 856 AR-2-6
61 X 58 microns

CONVOLUTISPORA SP.

Plate 11, figure 9

Spores radial, trilete, probably originally spherical; size ranges from 68-90 microns; laesurae equal in length to two-thirds radius, in many specimens obscured by heavy, raised labra up to 8 microns wide; proximal and distal hemispheres bear heavy, closely-spaced, anastamose ridges; ridges round-topped, 4-7 microns high and 3-9 microns wide; surface laevigate.

This species of Convolutispora is characterized by heavy labral development.

Although it never comprised more than 1.5 per cent of the flora in any level in which it was found, Convolutispora sp. was the most abundant representative of the genus in the Sand Branch. As with other members of the genus, it was not observed below the upper half of Zone III.

Figured specimen: OPC 856 AR-4-5
87 X 71 microns

Genus MICRORETICULATISPORITES

(Knox) Potonié and Kremp, 1954

Type species: M. lacunosus (Ibrahim) Potonié and Kremp, 1954

Affinity: Noeggerathiales?

MICRORETICULATISPORITES PARVIRUGOSUS Staplin, 1960

Plate 7, figure 1

This species was first described from the Golata Formation of Canada. In the Sand Branch, its range was found to include all of Zone III and the upper twenty feet of Zone II.

Figured specimen: OPC 856 AQ-3-1
33 microns

Genus DICTYOTRILETES

(Naumova) Potonié and Kremp, 1954

Type species: D. bireticulatus (Ibrahim) Potonié and Kremp, 1954

Affinity: Filicales?

DICTYOTRILETES FALSUS Potonié and Kremp, 1955

Plate 4, figure 9

This small species occurs throughout Zone III and in the uppermost level of Zone II, level 856 T.

Figured specimen: OPC 856 AQ-6-1
45 microns

DICTYOTRILETES SUBALVEOLARIS

(Luber) Potonié and Kremp, 1955

Plate 4, figure 10

Dictyotriletes subalveolaris was found in only two levels in Zone III, levels 856 Z and 856 AQ.

Figured specimen: OPC 856 AQ-6-3
71 microns

Genus CORBULISPORA

Bharadwaj and Venkatachala, 1961

Type species: C. retiformis Bharadwaj and Venkatachala, 1961

Affinity: Unknown

CORBULISPORA SP. 1

Plate 4, figure 14

Spores radial, trilete, 70-84 microns in diameter; trilete thin, equal in length to one-half radius, marked by narrow, slightly elevated labra; anastamose ridges up to 5 microns high and 5-9 microns wide occur on distal and equatorial portions and may extend slightly onto proximal surface in inter-radial positions; ridges may end blindly or merge gently into exine; ridges rarely intersect, and no

lumen are formed; spore surface smooth, except for crenulate ridges.

Corbulispora sp. 1 resembles Reticulatisporites ornatus (Ibrahim) Potonie and Kremp, 1955, but lacks the lumen and cingulum of Reticulatisporites. The relatively long and narrow ridges distinguish it from other species of Corbulispora.

A single specimen of Corbulispora sp. 1 occurred in assemblage counts of levels 856 Q, 856 AC, and 856 AR.

Figured specimen: OPC 856 AC-1-2
79 X 72 microns

CORBULISPORA SP. 2

Plate 5, figure 2

Spores radial, trilete, sub-circular in outline, 48-51 microns in diameter (two specimens); thin trilete equal in length to two-thirds radius; laesurae covered by narrow, sinuous labra up to 2 microns in height; ornamentation varied from baculae and verrucae 5 microns high and 3-8 microns in diameter to sinuous muri up to 5 microns high and 10 microns wide; surface of spore and ornamentation laevigate.

The varies ornamental elements distinguish Corbulispora sp. 2 from other species of Corbulispora.

Single specimens of this form were observed in levels 856 AC, 856 AM, and 912 B.

Figured specimen: OPC 856 AC-5-2
51 microns

Genus FOVEOSPORITES Balme, 1957

Type species: F. canalis Balme, 1957

Affinity: Unknown

FOVEOSPORITES INSCULPTUS Playford, 1962

Plate 7, figure 2

Foveosporites insculptus, characterized by small, irregularly-shaped foveolae, was not observed below level 856 M.

Figured specimen: OPC 856 AJ-6-2
69 X 66 microns

FOVEOSPORITES SP.

Plate 7, figures 10, 11

Spores radial, trilete, roundly triangular, 43-48 microns in diameter; wall 3 microns thick, perforated by circular to vermicular-shaped foveolae to 1.5 microns in width; surface otherwise laevigate; sinuous laesurae extend almost to equator; no labral development.

The sinuous laesurae distinguish Foveosporites sp. from other species of the genus.

Foveosporites sp. occurs sparingly in the middle portion of the Sand Branch.

Figured specimen: OPC 856 AA-5-2
47 microns

10. Proximal focus 11. Distal focus

Infraturma PSEUDOCINGULATI Neves, 1961

Genus SECARISPORITES Neves, 1961

Type species: S. lobatus Neves, 1961

Affinity: Unknown

SECARISPORITES SP. 1

Plate 5, figure 7

Spores radial, trilete, 39-49 microns in diameter; amb rounded, but made irregular by lobes up to 7 microns high on and near equatorial zone; proximal and distal surfaces bear low, narrow, convolute ridges, those on distal side being the larger; distal surface of many specimens has round verrucae up to 8 microns in diameter; laesurae thin, equal in length to two-thirds radius; no labra; equatorial lobes granular, remainder of surface smooth.

The granular zonal lobes distinguish Secarisporites sp. 1 from S. remotus Neves, 1961.

Secarisporites sp. 1 occurs in most samples above level 856 R. It is most abundant in the upper one-third of Zone III.

Figured specimen: OPC 856 A0-4-3
45 X 43 microns

SECARISPORITES SP. 2

Plate 5, figure 8

Spores radial, trilete, 50-61 microns in diameter; laesurae straight, extend almost to margin; no labra; equatorial zone bears three laevigate lobes up to 8 microns

high and 16 microns wide in inter-radial positions; one to three similar lobes occur on distal surface; distal surface also bears irregularly-shaped verrucae up to 3 microns high which may coalesce to form coarse, obervermiculate ridges; proximal ornament similarly obervermiculate, but much reduced.

The nature and location of the ornamental elements distinguish this species from other species of Secarisporites. Genus F of Wiggins (1962) may be conspecific with Secarisporites sp. 2.

Secarisporites sp. 2 was not found below level 856 T, the uppermost sample of Zone II. Its maximum abundance of 4.5 per cent was in level 856 AR in the upper one-third of Zone III.

Figured specimen: OPC 856 Y-1-1
56 X 52 microns

Equatorial view

Subturma PERINOTRILETES Erdtman, 1947

Genus PEROTRILITES (Erdtman) ex Couper, 1953

Type species: P. granulatus Couper, 1953

Affinity: Some species of Perotrilites appear referable to various extant species of Selaginella.

PEROTRILITES MAGNUS Hughes and Playford, 1961

Plate 17, figure 11

A single specimen of this large form with thin, finely granular "perine" was observed in level 856 AO.

Figured specimen: OPC 856 AO-2-4
116 X 98 microns

PEROTRILITES SP. 1

Plate 7, figures 3-6, 9; Plate 8, figure 4

Spores radial, trilete, 35-62 microns in diameter, amb circular, exoexine perisporal in nature; spore wall laevigate, 1.8-2.4 microns in thickness; trilete thin, distinct, equal in length to one-half to two-thirds radius of spore; weak to moderate labral development up to 12 microns in width formed by thickening and folding of exosporium; pad-like thickenings of exosporium may be present at ends of laesurae; exosporium laevigate to minutely granular, appears closely appressed even though raised into low-irregularly-shaped folds which impart a rugulate to subverrucose character to proximal and distal surfaces.

Perotrilites sp. 1 appears to be conspecific with Punctatisporites cerosus H., S., and M., 1955. In an unpublished master's thesis, Wiggins (1962) assigned P. cerosus to the genus Perotrilites as Perotrilites cerosus n. comb. The writer is in accord with Wiggins' interpretation, but Perotrilites cerosus has yet to be validly published. Accordingly, Sand Branch specimens belonging to this species are herein assigned to the informal taxon Perotrilites sp. 1.

Perotrilites sp. 1 was the second most abundant palynomorph in the Sand Branch. It occurred in all levels of Zones II and III, and attained a maximum relative abundance of 28.5 per cent in level 856 AH.

Figured specimen: Plate 7, figures 3,4 OPC 856 AI-2-2
57 microns
3. Proximal 4. Distal

figures 5,6 OPC 856 AI-4-2
60 microns
5. Proximal 6. Distal

figure 9 OPC 856 N-1-4
46 microns

Plate 8, figure 4 OPC 856 P-3-1
35 microns,
immature specimen

PEROTRILITES SP. 2

Plate 7, figures 12, 15-17

Spores radial, trilete, amb roundly triangular; trilete thin, distinct, equal in length to two-thirds to four-fifths spore radius, tecta slightly raised; wall of spore body finely granular, 0.9-1.4 microns in thickness; exosporium more coarsely granular than spore body, extends 3-5 microns beyond margin of spore body, often thickened and raised over laesurae; overall size 38-48 microns, spore body 31-53 microns.

The granular body and exosporium distinguish Perotrilites sp. 2 from other species of the genus.

Perotrilites sp. 2 occurred in most levels of the Sand Branch but was most abundant in the middle portion of Zone II.

Figured specimens: Figure 12 OPC 856 AB-2-2
overall diameter 46
microns; spore body
37 microns

Figure 15 OPC 856 AK-3-2
overall diameter 47
microns; spore body
42 microns

Figures 16,17 OPC 856 L-1-1
overall diameter 44
microns; spore body
33 microns
16. Distal 17. Proximal

PEROTRILITES SP. 3

Plate 12, figures 9, 10

Spores radial, trilete, amb roundly triangular; trilete simple, distinct, laesurae extend almost to margin of spore body; labrum absent; spore body and exosporium laevigate; exosporium raised into coarse, rugulate folds up to 6 microns high; overall size 49-58 microns, spore body 44-50 microns.

Perotrilites sp. 3 and Spore type E of Wiggins (1962) from the Goddard Formation may be conspecific.

Perotrilites sp. 3 occurred most frequently in the upper half of the Sand Branch. Single specimens in levels 856 J and 856 K, 75 feet below the next highest occurrence, mark the only appearance of this species in the lower half of the Sand Branch.

Figured specimen: OPC 856 K-1-1
overall diameter 55 microns;
spore body 49 microns

9. Proximal 10. Distal

PEROTRILITES? SP. 4

Plate 10, figure 11

Spores radial, trilete, sub-rounded, 42-48 microns in diameter; laesurae equal in length to two-thirds spore radius, covered by rounded labral development up to 3 microns

wide; wall of spore body laevigate, 4 microns in thickness; exosporium granular, raised into small folds seldom over 2 microns in height.

Perotrilites? sp. 4 was found in most levels of Zones II and III.

Figured specimen: OPC 856 M-1-1
47 X 40 microns

PEROTRILITES? SP. 5

Plate 12, figure 12

Spores radial, trilete, amb circular; trilete distinct, laesurae equal in length to three-fourths body radius; spore body highly convex proximally; wall 3 microns thick, laevigate except for finely granular contact area; thin, finely granular exosporium attached near trilete; line of attachment marked by short, radially disposed folds of exosporium; overall diameter 54-65 microns, spore body 51-56 microns.

Were it not for the distinct trilete and the absence from the central body of large scattered grana, Perotrilites? sp. 5 would be included in the genus Endoculeospora Staplin, 1960.

The dominant occurrence of Perotrilites? sp. 5 in the Sand Branch, within the 25-foot interval 856 AF to 856 AP, approximates that of Endoculeospora rarigranulata var. densigranulata Staplin, 1960, to which it is morphologically similar. The occurrence of the single specimen of Perotrilites? sp. 5 in level 856 I near the base of Zone II is seemingly anomalous.

Figured specimen: OPC 856 1-1-1
overall diameter 61 microns;
spore body 54 microns

PEROTRILITES? SP. 6

Plate 12, figure 15

Spores radial, trilete, amb roundly triangular to circular; trilete thin, simple, laesurae equal in length to three-fourths radius of spore body; wall of spore body sparsely and finely granular, approximately 2 microns in thickness; exosporium laevigate, less than 1 micron in thickness, highly folded, easily torn, extends up to 7 microns beyond spore body; overall size 56-63 microns, spore body 44-51 microns.

Perotrilites? sp. 6 occurred in two levels. It comprised 2.5 per cent of the flora in the topmost sample from the Sand Branch, level 914 A. The single specimen observed in level 856 AD did not occur in the assemblage count.

Figured specimen: OPC 856 AD-1-1
overall size 61 X 54 microns;
spore body 50 X 44 microns

Genus VELAMISPORITES Bharadwaj and Venkatachala, 1961

Type species: V. rugosus Bharadwaj and Venkatachala, 1961

Affinity: Unknown

VELAMISPORITES RUGOSUS Bharadwaj and Venkatachala, 1961

Plate 13, figures 11, 12

Velamisporites rugosus, described from the Lower Carboniferous of Spitzbergen, is characterized by its

wrinkled, granular perine. In the Sand Branch, this species occurred throughout Zone III and was found no lower than level 856 S, ten feet below the base of that zone.

Figured specimens: Figure 11, OPC 856 AQ-3-2 overall size 133 X 119 microns; central body 91 X 76 microns

Figure 12, OPC 856 Z-1-1 overall size 103 X 80 microns; central body missing

Genus ENDOCULEOSPORA Staplin, 1960

Type species: E. rarigranulata Staplin, 1960

Affinity: Unknown

ENDOCULEOSPORA RARIGRANULATA var. DENSIGRANULATA Staplin, 1960

Plate 13, figure 8

The large central body and the densely granular bladder or exosporium characterize this species, first described from the Golata Formation of Alberta, Canada. Close examination of Sand Branch specimens reveals that the bladder is attached proximally only.

Endoculeospora rarigranulata var. densigranulata occurred only in the upper half of Zone III. It was recorded by Wiggins (1962) from the Goddard Formation as Perotrilites sp. 2.

Figured specimen: OPC 856 AL-4-3 overall size 91 X 65 microns; spore body 72 X 49 microns

Turma ZONALES (Bennie and Kidston) R. Potonié, 1956

Subturma AURITOTRILETES Potonié and Kremp, 1954

Infraturma AURICULATI (Schopf) Potonié and Kremp, 1954

Genus TRIPARTITES Schemel, 1950

Type species: T. vestustus Schemel, 1950

Affinity: Unknown

TRIPARTITES cf. T. VESTUSTUS Schemel, 1950

Plate 10, figures 4, 5, 6

Sand Branch specimens are designated Tripartites cf. T. vestustus because their auriculae are neither so wide nor so flared as those on the specimens illustrated by Schemel (1950). T. cf. T. vestustus appears to be conspecific with specimens in the Goddard Formation described by Wiggins (1962) as Tripartites sp. 2.

Tripartites cf. T. vestustus was the only species of this genus found in the Sand Branch, and it was extremely rare. Single specimens occurred in levels 856 W and 856 AA. In contrast, Wiggins (1962) recorded ten species of Tripartites from the Goddard Formation.

Figured specimens: Figure 4 OPC 856 AA-3-1
46 X 40 microns

Figures 5,6 OPC W-4-2
37 microns

5. Proximal 6. Distal

Genus MOOREISPORITES Neves, 1958

Type species: M. fustis Neves, 1958

Affinity: Unknown

MOOREISPORITES SP.

Plate 10, figures 2, 3

Spore radial, trilete, sides concave, apices rounded; trilete simple, laesurae equal in length to one-third to one-half body radius; labra absent; proximal surface laevigate; scattered grana and verrucae of distal surface become more numerous toward apices; apical ornamental elements range from individual processes to auriculate-like structures up to 8 microns in length with ragged distal ends; apical elements essentially equatorial but may extend slightly onto distal surface; overall size 65 X 60 microns, spore body 54 X 51 microns.

Ornamentation of the single specimen of Mooreisporites sp. is intermediate between that of M. fustis and M. inusitatus. The specimen was found near the top of the Sand Branch in level 913 A.

Figured specimen: OPC 913 A-6-1
overall size 65 X 60 microns;
spore body 54 X 51 microns

2. Proximal 3. Apical process

Genus AHRENSISPORITES Potonié and Kremp, 1954

Type species: A. guerickei (Horst) Potonié and Kremp, 1954

Affinity: Unknown

AHRENSISPORITES cf. A. ANGULATUS (Kosanke)

Neves, 1958

Plate 10, figure 1

Ahrensisporites angulatus is characterized by a well-developed distal kyrtome on an otherwise laevigate spore body.

The single specimen from the Sand Branch designated A. cf. A. angulatus is similar to A. angulata but has a poorly developed, incomplete kyrtome and possesses scattered, small, distal verrucae.

A single specimen of Ahrensisporites cf. A. angulatus occurred near the top of the Sand Branch in level 912 B.

Figured specimen: OPC 912 B-1-1
54 microns

AHRENSISPORITES SP.

Plate 10, figure 7

Spore radial, trilete, with distal kyrtome; trilete simple, laesurae extend almost to body margin; labra absent; spore body roundly triangular, sides approximately straight, proximal and distal surfaces granular; exine at apices thickened into auriculate lobes from which rugulate kyrtomes extend across distal hemisphere; kyrtomes approximately parallel laesurae; overall size 61 microns, spore body 49 microns.

Rugulate kyrtomes and an irregular, granular surface characterize the single specimen of Ahrensisporites sp. The specimen was found in level 856 AN.

Figured specimen: OPC 856 AN-5-4
overall size 61 microns;
spore body 49 microns

Subturma ZONOTRILETES Waltz, 1935

Infraturma CINGULATI Potonié and Klaus, 1954

Genus STENOZONOTRILETES (Naumova) Potonié, 1958

Type species: S. conformis Naumova, 1953

Affinity: Unknown

STENOZONOTRILETES SP. 1

Plate 10, figures 12, 15, 16; Plate 11, figures 1, 3

Spores radial, trilete, roundly triangular, 37-50 microns in diameter; trilete simple, extends to margin of spore body; laesurae occasionally bifurcated terminally; no labral development; spore body distinct, highly convex proximally; proximal surface laevigate except for finely granular area surrounding apex; distal surface bears scattered grana 0.5-1.5 microns in diameter; cingulum laevigate, 3-6 microns wide.

This species is characterized by its highly convex, apically granular proximal surface.

Stenozonotriletes sp. 1 occurs in most samples from the upper half of the Sand Branch. Its greatest relative abundance is in the middle one-third of the Sand Branch.

Figured specimens:

Plate 10, figure 12 OPC 856 Q-3-1
46 X 41 microns

figures 15,16 OPC 856 R-2-2
39 X 37 microns

15. Distal focus 16. Proximal focus

Plate 11, figures 1,3 OPC 856 R-2-1
42 X 39 microns

1. Distal focus 3. Proximal focus

STENOZONOTRILETES SP. 2

Plate 10, figure 13

Spores radial, trilete, roundly triangular, 57-66 microns in diameter; spore body distinct, laevigate; trilete laesurae bifurcate at body margin; labra weak but always discernible; cingulum laevigate, 4-6 microns wide interradially, up to 8 microns wide at apices.

Its bifurcated laesurae and smaller size distinguish Stenozonotriletes sp. 2 from S. deltoides Hacquebard, 1957.

Stenozonotriletes sp. 2 is a minor constituent of the flora in the upper 40 feet of strata from the type section of the Sand Branch.

Figured specimen: OPC 856 AR-2-3
71 X 64 microns

Genus MUROSPORA Somers, 1952

Type species: M. kosankei Somers, 1952

Affinity: Unknown

MUROSPORA cf. M. MINIMA Somers, 1952

Plate 11, figure 17

Were it not for its larger size, the Sand Branch specimen would be assigned to Murospora minima. The average size of M. minima is 20 microns; the size of the single specimen of M. cf. M. minima, from level 856 AJ, is 46 X 38 microns.

Figured specimen: OPC 856 AJ-5-2
46 X 38 microns

Genus SAVITRISPORITES Bhardwaj, 1955

Type species: S. triangulus Bhardwaj, 1955

Affinity: Unknown

SAVITRISPORITES cf. S. NUX

(Butterworth and Williams) Sullivan, 1964

Plate 1, figures 15, 16, 17

On most specimens of Savitrisporites nux the only proximal ornamentation is a single heavy ridge on either side of the trilete laesurae. In contrast, certain Sand Branch palynomorphs which otherwise conform to the description of S. nux exhibit proximal ridges other than the heavy ridge paralleling the laesurae. For this reason the Sand Branch specimens are not directly assigned to S. nux.

Savitrisporites cf. S. nux was found in most samples in the upper half of the Sand Branch. It increases in relative abundance and frequency of occurrence toward the top of the Sand Branch. Callisporites (Savitrisporites) nux is abundant in the Goddard Formation (Wiggins, 1962).

Figured specimens: Figure 15 OPC 856 AO-1-10
43 microns

Figure 16 OPC 856 Y-5-3
54 X 51 microns

Figure 17 OPC 856 AN-1-6
34 microns

Genus ROTASPORA Schemel, 1950

Type species: R. fracta Schemel, 1950

Affinity: Unknown

ROTASPORA FRACTA Schemel, 1950

Plate 11, figure 14

Single specimens of this Upper Mississippian species were found in each of two consecutive samples, 856 W and 856 X, near the middle of the Sand Branch.

Figured specimen: OPC 856 X-5-1
40 microns

Genus ANGUISPORITES Potonié and Klaus, 1954

Type species: A. anguinus Potonié and Klaus, 1954

Affinity: Unknown

ANGUISPORITES SP.

Plate 11, figure 7

Spores radial, trilete, biconvex, amb subtriangular; spore body demarcated from cingulum by a light-colored zone caused by thinning of exine at juncture of cingulum and proximal surface of spore body; spore body and cingulum laevigate; simple trilete laesurae extend to cingulum; raised, sinuous labra merge into cingulum; diameter of two specimens, 41 and 43 microns.

Anguisporites sp. lacks the granular exine and cingulum of A. anguinus Potonié and Klaus, 1954.

Single specimens of Anguisporites sp. were found in levels 856 AG and 856 AL in Zone III.

Figured specimen: OPC 856 AL-3-1
43 microns

Genus RETICULATISPORITES Ibrahim

emend. Neves, 1964

Type species: R. reticulatus Ibrahim, 1933

Affinity: Unknown

RETICULATISPORITES CORPOREUS (Loose) Neves, 1964

Plate 5, figures 15, 16

Reticulatisporites corporeus was found throughout Zones II and III of the Sand Branch. It appeared in most samples from the upper half of Zone III, but its occurrence below that level was sporadic. Wiggins (1962) reported R. corporeus from the Goddard Formation.

Figured specimens: Figure 15 OPC 856 AO-1-2
64 X 59 microns

Figure 16 OPC 856 AH-4-2
51 X 46 microns

RETICULATISPORITES CRASSIRETICULATUS Artüz, 1957

Plate 3, figure 17

Reticulatisporites crassireticulatus was found in level 856 AG near the middle of Zone III, and in level 914 A, the uppermost sample from the Sand Branch.

Figured specimen: OPC 856 AG-3-2
40 microns

RETICULATISPORITES EXIGUUS var. A Staplin, 1960

Plate 3, figure 12

Short, discontinuous muri characterize this species described from the Golata Formation of Alberta, Canada.

One specimen of Reticulatisporites exiguus var. A was found in level 856 J near the base of Zone II. Its three remaining occurrences were in the upper two-thirds of Zone III.

Figured specimen: OPC 856 J-2-1
50 X 49 microns

RETICULATISPORITES? cf. R. EXIGUUS var. A

Staplin, 1960

Plate 6, figure 6

Although the majority of the ornamental elements on the specimen illustrated on Plate 6, figure 6 are discontinuous muri similar to those of Reticulatisporites exiguus var. A, there are also a number of baculae suggestive of the genus Raistrickia. For this reason, this specimen from level 856 AN is classified as Reticulatisporites? cf. R. exiguus var. A.

Figured specimen: OPC 856 AN-3-8
35 microns

RETICULATISPORITES KARADENIZENSIS Artüz, 1957

Plate 4, figure 7

Single specimens of this species with sub-angular muri were found in levels 856 Z and 913 B in Zone III.

Figured specimen: OPC 856 Z-2-2
67 X 59 microns

RETICULATISPORITES PELTATUS Playford, 1962

Plate 4, figure 8

Mushroom-like processes typically developed at the intersection of muri characterize this species described by

Playford (1962) from the Viséan, possibly to Namurian A, of Spitzbergen.

Reticulatisporites peltatus was found in the sample from the uppermost 2.5 feet of the Sand Branch type section, and in two samples from uppermost Sand Branch strata along Sandy Creek. R. peltatus was recorded from the Goddard Formation by Wiggins (1962) as Spore type K.

Figured specimen: OPC 856 AR-2-5
79 X 74 microns

RETICULATISPORITES cf. R.? FIMBRIATUS Winslow, 1962

Plate 3, figure 13

Spores radial, trilete, sub-spherical in shape; trilete thin, extends almost to margin of spore body; no labral development; muri tapered, serrate, occasionally fimbriate, 6-9 microns high and 2 microns wide at base; lumen irregularly shaped, 9-15 microns in diameter; muri and lumen extend onto interareas of proximal surface; surface of spore body psilate; overall diameter (two specimens) 60-63 microns, spore body 56-57 microns.

Reticulatisporites cf. R.? fimbriatus lacks the infragranular exine of R. sp. 1.

R. cf. R.? fimbriatus was found in levels 856 T and 856 X just below the middle of the Sand Branch.

Figured specimen: OPC 856 T-2-1
60 microns

RETICULATISPORITES SP. 1

Plate 3, figure 11

Spores radial, trilete, circular in equatorial outline; trilete indistinct, laesurae equal in length to one-third to one-half diameter of spore body; no labral development; outer surface of spore body laevigate, inner surface granular; incomplete reticulum formed by thin, diaphanous muri up to 7 microns high covers all of spore except immediate area of laesurae; diameter of spore body (two specimens) 59 and 56 microns, overall size 64 and 62 microns.

The combination of an infragranular exine and diaphanous muri distinguish this species from other species of Reticulatisporites.

One of the two specimens observed occurred in level 856 T; the other was in level 856 AF.

Figured specimen: OPC 856 T-3-1
64 X 61 microns

RETICULATISPORITES SP. 2

Plate 3, figure 14; Plate 4, figure 1

Spores radial, trilete, approximately circular in outline; trilete thin, equal in length to two-thirds radius of spore body; labrum absent; overall diameter of spore 38-50 microns, diameter of spore body 26-35 microns; muri sparsely granular, 3-8 microns high, 2 microns wide at base, tapered to smooth but irregular margin; lumen 9-12 microns wide, 4- to 6-sided; some lumen contain 1 to 3 grana up to

4 microns in diameter; surface of spore body otherwise smooth.

Larger muri and large grana within some of the lumen distinguish Reticulatisporites sp. 2 from R. sp. 3.

The few observed specimens of Reticulatisporites sp. 2 were found in the upper 60 feet of the Sand Branch.

Figured specimens: Plate 3, figure 14 OPC 856 AO-2-7
50 X 45 microns

Plate 4, figure 1 OPC 856 AN-1-7
48 X 45 microns

RETICULATISPORITES SP. 3

Plate 3, figure 15

Spores radial, trilete, approximately circular in outline; trilete thin, equal or greater in length than two-thirds radius of spore body; labral development up to 3 microns high and 5 microns wide; overall spore diameter 43-50 microns, spore body 36-45 microns; muri smooth, tapered, up to 6 microns high; lumen irregularly shaped, 9-15 microns in diameter; surface of spore body smooth to faintly granular.

Single specimens of Reticulatisporites sp. 3 were found in levels 856 AQ and 912 A near the top of the Sand Branch.

Figured specimen: OPC 912 A-5-1
48 X 45 microns

RETICULATISPORITES SP. 4

Plate 4, figure 2

Spores radial, trilete, approximately circular in outline; trilete extends to margin of spore body; slight thickening of exine along commissure forms a weak labrum; overall spore diameter 42-47 microns, spore body 36-40 microns; muri granular, 3-5 microns high, 0.5-2 microns wide, extend only slightly onto proximal surface; lumen irregularly-shaped, 14-18 microns in diameter; some contain scattered grana and baculae up to 2 microns in diameter.

Reticulatisporites sp. 4 occurred in low abundance in the upper one-third of the Sand Branch.

Figured specimen: OPC 856 AE-3-2
43 microns

RETICULATISPORITES SP. 5

Plate 4, figure 3

Spore radial, trilete, sub-spherical in shape; trilete not discernible; overall size 51 X 46 microns, spore body 40 X 35 microns; muri smooth, 6-9.5 microns high, 2-5 microns wide, extend only slightly onto proximal surface; lumen irregularly-shaped, 14-20 microns in diameter; within lumen are grana, baculae, and pila up to 3.5 microns in height; proximal surface of spore body bears grana up to 1.5 microns in diameter.

The single specimen of Reticulatisporites sp. 5, found in level 856 AC, may belong to R. sp. 4, but is

temporarily separated from the latter on the basis of its larger size, heavier muri, coarser secondary ornamentation, and faint (not discernible) trilete mark.

Figured specimen: OPC 856 AC-2-2
51 X 46 microns

RETICULATISPORITES SP. 6

Plate 4, figure 5

Spores radial, trilete, approximately circular in polar view, trapezoidal in equatorial view; trilete thin, equal in length to two-thirds spore radius; no labrum; overall dimensions 55-67 microns X 40-48 microns, spore body 49-54 microns X 38-44 microns; muri thin, tapered, psilate, 3-5 microns high, extend well onto proximal surface in interareas; lumen large, 3-5 per spore diameter; some lumen contain sparse grana 1 micron in diameter; surface otherwise smooth.

Reticulatisporites sp. 6 is larger in size and has shorter laesurae than does R. sp. 4; also, its muri are psilate and extend well onto the proximal surface.

Single specimens of Reticulatisporites sp. 6 were observed in levels 856 Z and 856 AN.

Figured specimen: OPC 856 AN-4-2
63 X 44 microns

RETICULATISPORITES SP. 7

Plate 4, figure 6

Spore radial, trilete, subcircular in equatorial outline; trilete not discernible; overall size 40 X 32

microns, spore body 28 X 22 microns; muri smooth, not tapered, 4-7 microns high, 1.8-2.2 microns wide, edge rounded; lumen 9-13 microns in diameter; muri and lumen encompass entire spore surface except for area immediately adjacent laesurae; surface of spore body smooth.

The smooth spore body and untapered muri distinguish Reticulatisporites sp. 7 from R. sp. 2 and R. sp. 3. R. type A of H., S., and M., 1955 is larger and has coarser muri than R. sp. 7.

Reticulatisporites sp. 7 was represented by a single specimen found in level 856 AN.

Figured specimen: OPC 856 AN-4-1
40 X 32 microns

RETICULATISPORITES SP. 8

Plate 4, figure 15

Spores radial, trilete, circular in polar view, trapezoidal in equatorial view; trilete thin, equal or greater in length than two-thirds spore radius; no labral development; equatorial diameter 60-73 microns, polar diameter 43-50 microns; muri slightly rounded, smooth to faintly granular, 4-6 microns high, 3.5-6 microns wide; majority of lumen 15-23 microns in diameter, others 8-12 microns; muri and lumen extend slightly onto proximal surface; psilate spore body appears mottled due to differential thickening of exine.

Reticulatisporites sp. 8 occurred in less than half of the samples collected from the upper half of the Sand Branch.

Figured specimen: OPC 856 AQ-1-2
68 X 60 microns

RETICULATISPORITES SP. 9

Plate 5, figure 4

Spores radial, trilete, roundly triangular in equatorial outline; trilete distinct, extends almost to margin of spore body; labra slightly raised; overall diameter 26-37 microns, spore body 21-30 microns; muri 2-2.7 microns high, slightly crenulate, edge rounded; 5 to 9 relatively large muri distributed asymmetrically over distal and equatorial surfaces; surface of spore body smooth.

Except for a single occurrence in level 856 T, Reticulatisporites sp. 9 was found only in the upper one-third of the Sand Branch.

Figured specimen: OPC 912 B-3-1
31 X 28 microns

Genus KNOXISPORITES

Potonié and Kremp emend. Neves, 1964

Type species: K. hageni Potonié and Kremp, 1954

Affinity: Unknown

KNOXISPORITES DISSIDIUS Neves, 1961

Plate 5, figure 17

Specimens of Knoxisporites dissidius, described from the Namurian A of England, were recovered from levels 856 AL and 856 AN in the upper one-fourth of the Sand Branch.

Figured specimen: OPC 856 AN-5-3
45 X 42 microns

KNOXISPORITES ROTATUS H., S., and M., 1955

Plate 5, figures 9, 11

Knoxisporites rotatus possesses a complete, circular, distal annulus and a minor thickening, if any at all, of the exine at the distal pole. The species has been reported from many Upper Mississippian assemblages from North America and Europe. It is the most abundant species of Knoxisporites in the Sand Branch, and occurs in nearly all levels of Zones II and III. It attains its maximum abundance in the upper 35 feet of Sand Branch strata.

Figured specimens: Figure 9 OPC 856 AR-4-2
64 microns

Figure 11 OPC 913 A-5-1
56 microns

KNOXISPORITES STEPHANEPHORUS Love, 1960

Plate 5, figures 10, 12

Pronounced thickening of the exine at the distal pole and an irregularly circular to reniform distal annulus characterize Knoxisporites stephanephorus, which was originally described from the Viséan of Scotland. Like K. rotatus, it occurs throughout Zones II and III of the Sand Branch, but it is not so abundant as K. rotatus.

Figured specimens: Figure 10 OPC 912 A-4-1
38 X 35 microns

Figure 12 OPC 913 A-2-3
40 X 38 microns

KNOXISPORITES TRIRADIATUS H., S., and M., 1955

Plate 5, figures 13, 14

Knoxisporites triradiatus was described from the Middle Chesterian Hardinsburg Formation of Illinois and Kentucky, U.S.A. A triradiate darkening (thickening) of the exine in an inter-radial position on the distal hemisphere characterizes this species.

In the Sand Branch K. triradiatus occurred in the upper 20 feet of Zone II and throughout Zone III.

Figured specimens: Figure 13 OPC 856 AC-4-1
55 microns

Figure 14 OPC 912 B-2-1
59 microns

KNOXISPORITES? SP. 1

Plate 5, figure 18

Spore radial, cingulate, trilete, amb roundly triangular; thin trilete extends almost to margin of spore body; labra sinuous, slightly raised at vertex; overall size 51 X 44 microns, spore body 35 X 31 microns; muri 3 microns high form a distal fovea approximately 17 microns in diameter; from fovea a double row of muri extend to and merge into cingulum so that a single lumina is formed in each distal inter-radial area; surface of spore body otherwise smooth; cingulum slightly crenulate, 4-7.5 microns wide, extends onto proximal surface at apices to cover outer portion of laesurae and merge with labra.

The assignment of this species to Knoxisporites is questionable because of the distal fovea.

The single specimen of Knoxisporites? sp. 1 occurred in level 856 W.

Figured specimen: OPC 856 W-3-2
51 X 44 microns

KNOXISPORITES? SP. 2

Plate 5, figures 19, 20

Spore radial, cingulate, trilete, amb roundly triangular; trilete simple, extends to margin of spore body; labra thin, sinuous, slightly raised at vertex; overall size of spore 46 X 41 microns, spore body 32 X 28 microns; cingulum crenulate, 4.5-6 microns wide, thickened at ends of laesurae where it merges with labra; surface of spore body smooth; muri 3-4 microns high form a central distal fovea; from inter-radial position on fovea a single mura extends to and merges with cingulum.

The assignment of this species to Knoxisporites is questionable because of the central distal fovea. The monotypic taxa K.? sp. 1 and K.? sp. 2 occur within the same level, level 856 W, and may be conspecific. They are provisionally separated because K.? sp. 1 has two muri extending from the fovea in each inter-radial position, whereas K.? sp. 2 has but a single mura in each inter-radial area.

Figured specimen: OPC 856 W-2-3
46 X 41 microns

KNOXISPORITES? SP. 3

Plate 11, figure 2

Spores radial, cingulate, trilete, amb circular; trilete distinct, extends almost to margin of spore body; low labra 2 microns wide near equator become narrower and slightly raised at vertex; cingulum heavy, coarsely granular, 4-6 microns wide inter-radially, greatly restricted to absent at ends of laesurae; spore body roundly triangular in equatorial outline; proximal surface psilate; distal surface sparsely granular and has a central annular ring 3-7 microns wide and 18-20 microns in diameter; beneath ends of laesurae on distal surface, where cingulum is narrowed or absent, are verrucae 5-7 microns in diameter; elsewhere between annular ring and cingulum on distal surface are smaller verrucae 1-3 microns in diameter; overall diameter of spore (two specimens) 36-38 microns, spore body 33-36 microns.

The assignment of this species to Knoxisporites is questionable because of the similarity of its interrupted cingulum to the equatorial thickenings of some species of Secarisporites.

Single specimens of Knoxisporites? sp. 3 were found in levels 856 AN and 912 B in the upper one-fourth of the Sand Branch.

Figured specimen: OPC 856 AN-2-9
36 microns

Genus LYCOSPORA (S., W., and B.) Potonié and Kremp, 1954

Type species: L. micropapillate (Wilson and Coe) S., W., and B., 1944

Affinity: Lepidodendraceae

LYCOSPORA NOCTUINA Butterworth and Williams, 1958

Plate 8, figure 3

Sand Branch specimens of Lycospora noctuina exhibit the coarsely ornamented central body and prominent tecta which characterize this species described from the Namurian of Scotland. L. noctuina was found to occur throughout Zones II and III of the Sand Branch, but it was most abundant in the upper half of Zone III.

Figured specimen: OPC 856 AR-1-1
38 microns

LYCOSPORA PUNCTATA Kosanke, 1950

Plate 7, figure 14

This Carboniferous species was found in most samples from the upper half of Zone III, but it occurred only sporadically in the lower half of Zone III and in the underlying Zone II.

Figured specimen: OPC 856 AH-2-5
48 microns

LYCOSPORA TENEBRICOSA Staplin, 1960

Plate 7, figure 19

L. tenebricosa occurred in nearly all samples of Zone III, attaining maximum abundance of 6 per cent at the

top of the Sand Branch. Single specimens were recorded in three levels near the base of Zone II.

Figured specimen: OPC 856 H-3-1
31 microns

LYCOSPORA TENUIRETICULATA Artuz, 1957

Plate 8, figures 1, 2

L. tenuireticulata, characterized by a granular, sometimes reticulate-appearing exine, occurred in low to moderate abundance in most samples from Zone III. Single specimens occurred in three levels (in the lower half) of Zone I.

Figured specimens: Figure 1 OPC 856 W-2-2
40 microns

Figure 2 OPC 856 N-1-2
40 microns

LYCOSPORA TORULOSA Hacquebard, 1957

Plate 7, figure 13

Variable, coarsely granular to sub-verrucose ornamentation characterizes this species of Lycospora described from the Lower Mississippian Horton Group of Nova Scotia. L. torulosa occurred sporadically in Zones II and III of the Sand Branch.

Figured specimen: OPC 856 AA-2-3
38 X 36 microns

LYCOSPORA SP.

Plate 7, figure 18

Spores radial, cingulate, trilete, amb roundly triangular; trilete extends to margin of spore body; labra

2 microns wide, 1.5-2.5 microns high; spore body rugose; cingulum perfero-reticulate, 4-6 microns wide, radially folded; overall spore diameter 43-48 microns, spore body 34-37 microns.

Rugose ornamentation of the spore body and the radially folded cingulum distinguish Lycospora sp. from previously described species of the genus.

Lycospora sp. appeared in most samples from the middle of Zone III. In the remainder of Zone III and in Zone II its occurrence was sporadic.

Figured specimen: OPC 856 K-2-1
46 microns

Genus DENSOSPORITES Berry

emend. Bharadwaj and Venkatachala, 1961

Type species: D. covensis Berry, 1937

Affinity: Dispersed spores referable to Densosporites have been reported from lycopod cones by Chaloner (1958) and Bharadwaj (1959).

DENSOSPORITES COVENSIS Berry, 1937

Plate 9, figures 1, 2, 3, 4

Densosporites covensis was recovered from level 856 T, the uppermost level of Zone II, and from levels 856 V and 856 AA in the lower one-fourth of Zone III.

Figured specimens: Figures 1,2 OPC 856 AA-2-4
50 X 45 microns

Figures 3,4 OPC 856 AA-6-1
46 X 40 microns

DENSOSPORITES TENUIS H. S., and M., 1955

Plate 9, figure 7

Single specimens of D. tenuis were recovered from levels 856 AC and 856 AR.

Figured specimen: OPC 856 AC-1-1
55 microns

DENSOSPORITES cf. D. DOMINATORIS Schemel, 1950

Plate 9, figure 8

Except for their larger size, 59 and 62 microns, the two Sand Branch specimens would be considered conspecific with the typically granulose to rugulose species D. dominatoris (30-45 microns), described by Schemel in 1950 from the Mississippian of Utah, U.S.A.

Single specimens of Densosporites cf. D. dominatoris were found in levels 856 Q and 856 R near the top of Zone II.

Figured specimen: OPC 856 Q-1-1
59 microns

DENSOSPORITES cf. D. LOBATUS Kosanke, 1950

Plate 9, figures 5, 6

The single specimen classified as Densosporites cf. D. lobatus appeared in level 912 B near the top of the Sand Branch. The rugose to lobate cingulum of D. cf. D. lobatus compares favorably with that of D. lobatus; however, its size of 75 X 60 microns is well above the size range of 34-55 microns given by Kosanke (1950) for D. lobatus.

Figured specimens: OPC 912 B-6-3
75 X 60 microns

Genus CRISTATISPORITES Potonié and Kremp emend. Bharadwaj and Venkatachala, 1961

Type species: C. indignabundus (Loose) Potonié and Kremp, 1954.

Affinity: Spores referable to Cristatisporites were recovered by Chaloner (1962) from the lycopod cone Sporangiostrobus ohioensis from the Pennsylvanian of Ohio, U.S.A. Spores described from Porostrobus zeilleri (Nathorst) by Bharadwaj (1959) as Cristatisporites probably belong to the genus Densosporites.

CRISTATISPORITES cf. C. ELEGANS Bhardwaj, 1957

Plate 9, figure 14

The Sand Branch species Cristatisporites cf. C. elegans conforms to the diagnosis of C. elegans given by Bhardwaj (1957) except that the periphery of the large equatorial spines on the Sand Branch specimens is minutely serrate.

C. cf. C. elegans occurred in levels 856 V and 856 AA near the base of Zone III.

Figured specimen: OPC 856 AA-1-2
55 X 50 microns

CRISTATISPORITES SP. 1

Plate 9, figure 9

Spores radial, cingulate, trilete, amb triangular, trilete mark extends to margin of spore body; labra raised, twisted, prominent on spore body, but merge into outer portion

of cingulum; proximal surface of spore body usually smooth but may bear a few small grana; distal surface bears scattered spines 2-4 microns in length; cingulum 8-13 microns wide, smooth except for spinose periphery; overall size of spore 40-49 microns, spore body 18-25 microns.

The psilate to sparsely granular proximal surface and the small number of spines on the distal surface typify this species.

Cristatisporites sp. 1 is a minor component of the flora in Zone III.

Figured specimen: OPC 912 B-4-1
45 microns

CRISTATISPORITES SP. 2

Plate 9, figure 10

Spore radial, cingulate, trilete, amb triangular; trilete extends to margin of spore body; labra raised, sinuous, extend full length of trilete rays and onto cingulum; proximal surface of spore body bears numerous short spines up to 1.5 microns in length; distal surface has scattered heavy spines 2-4 microns in length; width of cingulum 6-12 microns including peripheral spines 3-5 microns long; shorter spines ranging up to 3 microns in length are concentrically arranged on distal surface of cingulum; overall size of spore 41 microns, spore body 20 microns.

Short spines on the proximal surface distinguish Cristatisporites sp. 2 from C. sp. 1.

The lone specimen of Cristatisporites sp. 2 appeared in level 856 AG.

Figured specimen: OPC 856 AG-7-2
41 microns

CRISTATISPORITES SP. 3

Plate 9, figures 11, 12

Spores radial, cingulate, trilete, amb triangular; trilete extends to margin of spore body; low labra 2 microns wide extend onto cingulum; proximal surface of spore body bears scattered short spines to 1.5 microns in length; distal surface has heavy, commonly bifurcated spines up to 7 microns in length; cingulum thin, 4-12 microns wide including peripheral spines which impart to it a dentate to palmate margin; overall size of spore (two specimens) 56-58 microns, spore body 25 microns.

The strongly incised, dentate to palmate appearance of the cingulum characterizes this species.

Single specimens of Cristatisporites sp. 3 occurred in levels 856 AA and 912 A.

Figured specimen: OPC 856 AA-1-4
56 X 50 microns

CRISTATISPORITES SP. 4

Plate 9, figure 13

Spores radial, cingulate, trilete, amb triangular; trilete extends to margin of spore body; thin labral development up to 3 microns high extends to and merges into periphery

of cingulum; each interarea of proximal surface bears 2-4 short, thick spines whose basal diameter of 1-1.5 microns approximates their length; distal surface has many coarse, sometimes bifurcate spines 6-10 microns in length and up to 3.5 microns in basal diameter; cingulum coarsely spinose, 3-15 microns in width including wide, often bifurcate spines up to 12 microns in length; overall size of spore (two specimens): equatorial diameter 57-60 microns, polar diameter 44-45 microns, spore body 32-33 microns.

The combination of short, stout proximal spines and large, coarse distal and equatorial spines characterizes this species.

Single specimens of Cristatisporites sp. 4 were found in levels 856 Y and 856 Z.

Figured specimen: OPC 856 Y-4-1
60 X 44 microns

Infraturma ZONATI Potonié and Kremp, 1954

Genus CIRRATRIRADITES Wilson and Coe, 1940

Type species: C. maculatus Wilson and Co, 1940

Affinity: Lycopodiales.

CIRRATRIRADITES SP.

Plate 8, figures 18, 19

Spores radial, zonate, trilete, possess distal fovea, amb roundly triangular; trilete extends to margin of spore body; labra raised, sinuous, extend onto zona; proximal surface of spore body granular and with short, serrate

ridges less than 1 micron high; ridges coarser and more dense on distal surface; distal fovea 18 microns in diameter; zona thin, 7-10 microns wide, bears concentric ridges similar to those on proximal surface of spore body; overall spore diameter (two specimens) 76 microns, spore body 61-64 microns.

Short, serrate ridges on the spore body and zona characterize this species.

Single specimens of Cirratriradites sp. were found in levels 912 A and 913 B.

Figured specimen: OPC 912 A-1-1
76 X 64 microns

Infraturma MEMBRANATI Neves, 1961

Genus PROPRISPORITES Neves, 1958

Type species: P. rugosus Neves, 1958

Affinity: Unknown

PROPRISPORITES LAEVIGATUS Neves, 1961

Plate 6, figures 16, 17, 18

As the specific epithet suggests, this species of Proprisporites described from the Namurian of England is typified by its laevigate exine and muri. Sand Branch specimens of Proprisporites which possess these characteristics bear, in addition, scattered small grana. It is felt, however, that these grana are not of sufficient size or number to warrant establishment of a new species.

Accordingly, these Sand Branch specimens are assigned to P. laevigatus.

Representatives of P. laevigatus occurred only in the uppermost 14 feet of Sand Branch strata.

Figured specimens: Figures 16, 17 OPC 913 A-2-1
74 X 69 microns

Figure 18 OPC 913 A-5-3
86 X 70 microns

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Infraturma LAEVIGATIMONOLETI Dybová and Jachowicz, 1951

Genus LAEVIGATOSPORITES Ibrahim, 1933

Type species: L. vulgaris Ibrahim, 1933

Affinity: Equisetales, Sigillariaceae

LAEVIGATOSPORITES VULGARIS Ibrahim, 1933

Plate 14, figure 13

A single specimen of this large, laevigate, sparsely-punctate spore appeared in level 856 D. This was the lowest stratigraphic occurrence of any plant spore within the Sand Branch.

Figured specimen: OPC 856 D-4-1
76 X 48 microns

LAEVIGATOSPORITES SP. 1

Plate 14, figure 12

Spores bilateral, monolete, amb oval; monolete suture equal to or greater in length than four-fifths

longitudinal dimension of spore; exine 1 micron thick, ornamented with low grana of varied size; spore dimensions (two specimens), 53 X 39 microns and 49 X 40 microns.

The relatively long suture and granular exine characterize this species.

Laevigatosporites sp. 1 occurred in two samples from the uppermost 19 feet of Sand Branch strata.

Figured specimen: OPC 913 B-1-3
53 X 39 microns

LAEVIGATOSPORITES SP. 2

Plate 14, figure 14

Spore bilateral, monolete; amb oval, longest sides approximately parallel for most of length, ends of spore roundly flattened; monolete suture approximately equal in length to two-thirds longitudinal dimension of spore; exine faintly granular, differentially thickened resulting in a sub-verrucose appearance; spore dimensions 61 X 33 microns.

The differentially thickened, sub-verrucose appearing exine, and approximately parallel sides characterize this monotypic species.

The only specimen of Laevigatosporites sp. 2 discovered occurred in level 914 A, the uppermost 4.0 feet of the Sand Branch.

Figured specimen: OPC 914 A-3-1
61 X 33 microns

Anteturma POLLENITES R. Potonié, 1931

Turma SACCITES Erdtman, 1947

Subturma MONOSACCITES (Chitaley) Potonié and Kremp, 1954

Infraturma TRILETISACCATI Leschik, 1955

Subinfraturma INTRORNATI Butterworth and Williams, 1958

Genus ENDOSPORITES Wilson and Coe, 1940

Type species: E. ornatus Wilson and Coe, 1940

Affinity: Lycopsida

ENDOSPORITES MICROMANIFESTUS Hacquebard, 1957

Plate 8, figure 7

Representatives of this species, which is characterized by a distinctly infragranular bladder, are common throughout the upper one-fourth of the Sand Branch.

Figured specimen: OPC 913 B-5-2
98 microns

ENDOSPORITES PALLIDUS Schemel, 1950

Plate 8, figures 8, 9, 12

Endosporites pallidus was described by Schemel (1950) from a Utah coal of Meramecian to Chesterian age, and was subsequently reported from the Middle Chesterian Hardinsburg Formation of Kentucky and Illinois by H., S., and M. (1955). A spore illustrated by Love (1960, Plate 2, figure 5) as Auroraspora type A appears to be conspecific with Endosporites pallidus.

Endosporites pallidus occurred throughout Zone III of the Sand Branch.

Figured specimens: Figure 8 OPC 912 A-6-3
82 X 68 microns

Figure 9 OPC 856 AN-1-8
82 X 80 microns

Figure 12 OPC 912 A-4-2
56 microns

ENDOSPORITES SP. 1

Plate 8, figures 5, 6

Spores radial, trilete, amb roundly triangular; trilete thin, equal in length to two-thirds radius of central body, often obscured by commissural folds of bladder; central body dense, margin distinct, conformable to equatorial outline of bladder; diameter of central body slightly greater than two-thirds that of bladder, bladder thin but not highly folded, extends 5-9 microns beyond margin of central body; central body granular, bladder prominently infragranular; overall diameter of spore 45-62 microns, central body 34-43 microns.

The granular central body and its large size relative to the bladder distinguish Endosporites sp. 1 from E. micromanifestus.

Except for single specimens in level 856 L near the base of Zone II and in level 856 Z near the base of Zone III, occurrences of Endosporites sp. 1 in the Sand Branch were restricted to the upper one-third of Zone III.

Figured specimens: Figure 5 OPC 914 A-4-1
46 microns

Figure 6 OPC 856 L-2-1
58 X 54 microns

ENDOSPORITES? SP. 2

Plate 8, figures 13, 14

Spores radial, trilete, amb roundly triangular; position of trilete indicated by commissural folds on bladder; trilete extends almost to margin of central body; central body dense, outline conformable to equatorial outline of bladder; diameter of central body three-fourths to four-fifths that of bladder; bladder thin, flange-like in appearance, extends 3-9 microns past central body; central body granular; bladder infragranular; overall diameter of spore 57-66 microns, central body 46-53 microns.

The flange-like nature of the bladder on some specimens imparts to them a similarity to Leiozonotriletes. Therefore, this species is questionably referred to Endosporites.

Single specimens of Endosporites? sp. 2 were found in levels 856 K and 856 N in Zone II. Otherwise, occurrences of this species were restricted to the upper one-fourth of Zone III.

Figured specimens: Figure 13 OPC 856 K-1-3
60 microns

Figure 14 OPC 912 B-3-2
63 microns

Genus AURORASPORA H., S., and M., 1955

Type species: A. solisortus H., S., and M., 1955

Affinity: Unknown

AURORASPORA SOLISORTUS H., S., and M., 1955

Plate 12, figures 1, 5

Auroraspora solisortus was common to abundant throughout Zones II and III. Relative abundances of 10.5 percent and 11 percent were attained near the middle of Zone III.

Figured specimens: Figure 1 OPC 914 A-1-4
76 microns

Figure 5 OPC 912 A-6-5
69 X 45 microns

AURORASPORA SP. 1

Plate 12, figures 2, 3, 4

Spores radial, trilete, circular to subcircular in equatorial outline; trilete thin, distinct, extends to margin of central body; no labral development; central body thin centrally, thickens to 3.5 microns peripherally, outline approximates that of bladder; bladder thin, extends as much as 20 microns past body margin, commonly bears 3 to 5 prominent radial folds across flange; central body faintly granular, bladder infra-reticulate; overall diameter of spore 93-99 microns, central body 57-60 microns.

Auroraspora sp. 1 is larger than A. solisortus, and the proportion of the central body to the bladder is greater. The size range of A. sp. 1 is within that given by Sullivan (1964a) for A. balteola, but the central body to bladder ratio is significantly less than that of A. balteola.

Auroraspora sp. 1 is common throughout Zone III and attains maximum abundance near the top of the zone.

Figured specimen: OPC 913 A-1-1
95 microns

AURORASPORA SP. 2

Plate 12, figures 6, 7, 8

Spores radial, trilete, circular to subcircular in equatorial outline; trilete extends to margin of central body, tecta slightly raised; central body subcircular, thin, thickened to 1.5-2 microns at margin; bladder thin, possesses many radial folds; bladder often differentially folded distally so that central body appears to be eccentrically placed; central body finely granular, bladder infra-reticulate; overall diameter of unfolded spore 62-67 microns, central body 50-53 microns.

The relatively large, very thin central body distinguishes Auroraspora sp. 2 from A. sp. 1 and A. solisortus. The central body to bladder ratio is less than that of A. balteola.

Like Auroraspora sp. 1, A. sp. 2 is common to abundant throughout Zones II and III. A. sp. 2 attains a maximum relative abundance of 12 percent in the uppermost sample from the Sand Branch, level 914 A.

Figured specimens: Figure 6 OPC 914 A-6-4
74 X 64 microns

Figure 7 OPC 914 A-4-2
79 X 64 microns

Figure 8 OPC 914 A-6-3
66 X 62 microns

Genus SCHULZOSPORA Kosanke, 1950

Type species: S. rara Kosanke, 1950

Affinity: Unknown

SCHULZOSPORA CAMPYLOPTERA (Waltz) H., S., and M., 1955

Plate 14, figures 1, 2

This elliptical-shaped species occurred in most samples from Zone III and increased in relative abundance toward the top of the zone.

Figured specimen: OPC 914 A-1-2
71 X 46 microns

SCHULZOSPORA ELONGATA H., S., and M., 1955

Plate 14, figure 7

This species is characterized by its elongate, sub-rectangular shape. It occurred most frequently in the middle of Zone III. Single specimens were recorded from level 856 T, the upper level of Zone II, and from level 913 A near the top of Zone III.

Figured specimen: OPC 913 A-1-3
78 X 42 microns

SCHULZOSPORA OCELLATA (Horst) Potonié and Kremp, 1956

Plate 14, figures 3, 4

The oblique position of the central body is typical of Schulzospora ocellata. The rare occurrences of S. ocellata were restricted to Zone III.

Figured specimen: OPC 914 A-6-5
87 X 57 microns

SCHULZOSPORA SP.

Plate 14, figure 5

Spores radial, trilete, broadly oval in equatorial outline; trilete faint, rays short, equal in length to one-third to one-half radius of central body; no labral development; central body distinct, faintly granular, subcircular to slightly elliptical, occupies most of saccus; saccus approximately 2 microns thick, reticulate, extends 8-12 microns beyond central body longitudinally and 2-6 microns transversely; overall size of spore 65-72 microns longitudinally and 49-55 microns transversely; central body 47-54 microns longitudinally and 42-47 microns transversely.

The relatively large size of the central body and the resulting narrow extension of the saccus beyond the central body distinguishes Schulzospora sp. from previously described species of the genus.

Schulzospora sp. occurred sporadically throughout Zones II and III.

Figured specimen: OPC 856 K-1-2
69 X 51 microns

Genus REMYSPORITES Butterworth and Williams, 1958

Type species: R. magnificus (Horst) Butterworth and Williams, 1958

Affinity: Cycadofilicales?

REMYSPORITES SP.

Plate 13, figure 2

Spores radial, trilete, subcircular to oval in equatorial outline; trilete extends almost to margin of central body; central body round to oval, wall 2-2.5 microns thick, laevigate; saccus 1.5 microns thick, finely reticulate, attached to proximal surface of central body, otherwise free; overall size of spore 70-85 microns, central body 48-58 microns.

Specimens of Remysporites sp. 2 are consistently less than one-half the size of R. magnificus.

Remysporites sp. was rare in the lower half of Zone III but it occurred with increasing frequency toward the top of the zone. A single specimen was observed in level 856 H at the base of Zone II.

Figured specimen: OPC 856 W-8-1
74 X 66 microns

Subturma EXTRORNATI Butterworth and Williams, 1958

Genus GRANDISPORA H., S., and M., 1955

Type species: G. spinosa H., S., and M., 1955

Affinity: Unknown

GRANDISPORA SPINOSA H., S., and M., 1955

Plate 3, figures 1, 2

Single specimens of this Upper Mississippian species were recorded from levels 856 AJ and 856 AN.

Figured specimen: OPC 856 AN-1-3
82 X 74 microns

GRANDISPORA SP.

Plate 3, figure 3

Spore radial, trilete, roundly triangular to subcircular in equatorial outline; trilete extends almost to margin of central body, is covered by raised, sinuous, commissural folds of saccus which extend almost to spore margin; central body faint, probably psilate; entire saccus granular, distal surface also bears bulbous-based, blunt spines 7-13 microns in length; overall size of spore (single specimen) 84 X 80 microns, central body not discernible.

Grandispora sp. is smaller than G. spinosa and has a much greater number of spines.

The single specimen of Grandispora sp. appeared in level 856 AN.

Figured specimen: OPC 856 AN-1-1
84 X 80 microns

Genus DISCERNISPORITES Neves, 1958

Type species: D. irregularis Neves, 1958

Affinity: Unknown

DISCERNISPORITES CONCENTRICUS Neves, 1958

Plate 8, figure 10

This distally granulose species was found only in levels 856 W, 856 AB, and 912 A.

Figured specimen: OPC 856 W-3-1
69 microns

DISCERNISPORITES SP.

Plate 8, figure 11

Spore radial, trilete, subtriangular in equatorial outline; trilete not seen, but position marked by raised, sinuous tecta which extend to margin of saccus; central body thin, location indicated by darkened area; margin of central body indistinct, outline convexly triangular, conforms to equatorial outline of spore; saccus attached proximally and distally, extends 15-20 microns beyond central body; where saccus contacts central body it bears many coarse, short, branched folds up to 9 microns in length and 2-3 microns wide which may coalesce to form a rugose to coarsely reticulate pattern over the entire distal side of central body and the peripheral one-fourth of the proximal side; some folds extend beyond margin of central body onto equatorial portion of saccus which is otherwise differentially thickened resulting in a mottled appearance; periphery of saccus is a limbus-like thickening 5 microns in width; overall size of spore (one specimen) 104 X 84 microns, central body 68 X 59 microns.

The coarsely rugose-reticulate folding and the limbus-like peripheral thickening of the saccus distinguish Discernisporites sp. from other species of the genus.

The single specimen of D. sp. occurred in level 913 A, 14 feet below the top of the Sand Branch.

Figured specimen: OPC 913 A-4-1
104 X 84 microns

Infraturma VESICULOMONORADITI

Pant emend. Bhardwaj, 1956

Genus POTONIEISPORITES Bhardwaj, 1954

Type species: P. novicus Bhardwaj, 1954

Affinity: Unknown

POTONIEISPORITES SP. 1

Plate 13, figures 14, 15

Spores radial, trilete, subcircular to slightly elongate in equatorial outline; trilete mark faint, often not discernible; central body distinct, finely granular, long axis coincides with short axis of saccus; saccus finely infra-reticulate, often bears crescent-shaped transverse folds parallel to long axis of central body; overall size of spore: long axis 87-165 microns, short axis 81-150 microns, average size 98 X 91 microns; long axis of central body 53-109 microns, short axis 42-88 microns, average size 59 X 47 microns.

Potonieisporites sp. 1 occurred in low relative abundance in most samples from the upper half of Zone III. The single specimen found in level 856 Q of Zone II, illustrated in Plate 13, figure 14, is much larger than other representatives of the species and should perhaps be assigned to another species.

Figured specimens: Figure 14 OPC 856 Q-2-1
165 X 150 microns

Figure 15 OPC 856 AO-2-8
89 X 83 microns

POTONIEISPORITES SP. 2

Plate 14, figures 8, 9

Spores radial, trilete, amb oval to sub-rectangular; trilete mark faint; central body oval, long axis parallel to transverse axis of saccus; wall of central body 0.9-1.2 microns thick, smooth to faintly granular; saccus 0.7-1.0 microns thick, reticulate; overall size of spore 126-157 microns X 80-91 microns, central body 51-64 microns X 59-73 microns.

Potonieisporites sp. 2 is more elongate than P. sp. 1, and the wall of its central body is much thinner than that of P. sp. 3.

Single specimens of Potonieisporites sp. 2 were recorded from levels 856 X, 856 AN, and 856 AQ in Zone III.

Figured specimens: Figure 8 OPC 856 AQ-5-1
148 X 82 microns

Figure 9 OPC 856 AN-5-5
130 X 86 microns

POTONIEISPORITES SP. 3

Plate 14, figures 10, 11

Spores radial, trilete, amb oval; trilete mark faint or not discernible; central body subcircular, may be slightly elongate in direction of either longitudinal or

transverse axis of saccus; wall of central body 1.9-2.4 microns thick, laevigate; saccus 0.9-1.2 microns thick, laevigate to faintly granular, often highly wrinkled; overall size of spore 168-180 microns X 110-119 microns, central body 83-103 microns.

The relatively thick-walled central body, which may be either subcircular or elongate along either the longitudinal or transverse axis of the saccus, characterizes this species.

Occurrences of Potonieisporites sp. 3 were restricted to the upper half of Zone III.

Figured specimens: Figure 10 OPC 912 B-3-4
175 X 116 microns

Figure 11 OPC 856 AC-5-1
175 X 110 microns

Subturma POLYSACCITES Cookson, 1947

Genus ALATISPORITES Ibrahim, 1933

Type species: A. pustulatus Ibrahim, 1933

Affinity: Unknown

ALATISPORITES SP.

Plate 13, figure 13

Spores radial, trilete, trisaccate, amb subcircular; trilete distinct, extends almost to margin of central body; labral development absent; central body circular, wall 1.6-2 microns thick, granular; sacci three in number, granular, thin, easily folded, attached to central body along tecta of trilete proximally, and in a corresponding

position distally, overall size of spore 67-78 microns, central body 45-59 microns.

A granular central body and three granular sacci distinguish Alatisporites sp. from other members of the genus.

Alatisporites sp. was observed in three samples from the upper half of Zone III.

Figured specimen: OPC 914 A-1-3
71 microns

Turma ALETES Ibrahim, 1933

Subturma AZONALETES (Luber) Potonié and Kremp, 1954

Infraturma RETICULONAPITI (Erdtman) Vimal, 1952

Genus RADIALETES Playford, 1962

Type species: R. costatus Playford, 1962

Affinity: Unknown

RADIALETES SP.

Plate 17, figure 15

Spore radial, alete, outline subcircular, shape probably spherical; curved, radially disposed ridges originate from two "poles"; exine, including ridges, reticulate; size (single specimen) 31 X 28 microns.

Smaller size and a reticulate exine distinguish Radialetes sp. from the laevigate species R. costatus.

The only specimen of Radialetes sp. observed occurred in level 856 F of Zone I where marine acritarchs comprise more than 99 percent of the palynomorph assemblages.

Figured specimen: OPC 856 F-1-1
31 X 28 microns

Turma PLICATES (Naumova) Potonié and Kremp, 1960

Subturma PRAECOLPATES Potonié and Kremp, 1954

Genus SCHOPFIPOLLENITES Potonié and Kremp, 1954

Type species: S. ellipsoides (Ibrahim) Potonié and Kremp, 1954

Affinity: Medulloseae

SCHOPFIPOLLENITES ELLIPSOIDES

(Ibrahim) Potonié and Kremp, 1954

Plate 14, figures 15, 16, 17

Two or more specimens of this large, laevigate to infra-granular monocolpate grain were recovered from each of the four samples representing the uppermost 19 feet of the Sand Branch. Single specimens were observed in levels 856 AF and 856 AN.

Figured specimens: Figure 15 OPC 913 A-5-4
144 X 108 microns

Figures 16, 17 OPC 913 A-2-1
160 X 103 microns

NEW SPORE TYPES

SPORE TYPE A

Plate 11, figures 15, 16

Spore radial, trilete, amb triangular, sides slightly convex to slightly concave; trilete distinct, thin, equal in length to one-half to two-thirds spore radius; labra prominent, coarsely obermiculate to rugulate; exine 2.5 microns thick, strongly folded distally, surface undulatory but laevigate; size (one specimen) 59 X 54 microns.

Coarsely obervermiculate to rugulate labra characterize Spore type A.

The lone specimen of Spore type A occurred in level 856 AH.

Figured specimen: OPC 856 AH-2-3
59 X 54 microns

SPORE TYPE B

Plate 11, figure 13

Spore radial, trilete, amb roundly triangular, sides slightly concave to slightly convex; trilete open, extends three-fourths distance to spore margin; margin of trilete marked by darkening (thickening ?) of exine; exine 2.5 microns thick, finely granular to echinate; distal hemisphere possesses heavy arcuate folds extending between vertices; size (one specimen) 56 X 48 microns.

One specimen of Spore type B was observed in level 912 A near the top of the Sand Branch.

Figured specimen: OPC 912 A-5-3
56 X 48 microns

SPORE TYPE C

Plate 1, figures 6, 7

Spores radial, trilete, amb convexly triangular; trilete thin, extends almost to margin, may be obscured by thick labral development which is 6-10 microns wide and extends to margin of spore; grana and coni to 0.9 microns in height cover spore surface; thickness of exine indeterminate owing to close spacing of ornamental elements; observed size range 40-57 microns.

Spore type C of the Sand Branch and Genus A sp. 2 of Wiggins (1962) appear to be conspecific with Lophotriletes labiatus Sullivan, 1964. It is felt, however, that the heavy labral development consistently present on representatives of these three species precludes their assignment to the genus Lophotriletes as presently defined.

Spore type C was recovered from the upper sample of Zone II and from most samples of Zone III.

Figured specimens: Figure 6 OPC 856 AQ-5-2
55 microns

Figure 7 OPC 912 A-3-1
45 X 40 microns

SPORE TYPE D

Spores radial, trilete, amb subcircular; trilete distinct, except on very dense specimens, extends almost to margin, location may or may not be indicated by labra;

labral development ranges from a tectum-like thickening to true labra 2-5.7 microns wide; exine 1.7-2.2 microns thick, commonly folded around equatorial margin to simulate a cingulum; ornamental elements consist of grana or pila and baculae up to 5 microns high and 4 microns in diameter, moderately to closely spaced, always more dense on distal surface than proximal; observed size range 36-71 microns.

SPORE TYPE D, Sp. 1

Plate 1, figures 4, 5; Plate 2, figures 10-14;
Plate 6, figure 10

Spores radial, trilete, amb subcircular; trilete extends almost to margin of spore; labral development ranges from labra-like thickenings to true labra up to 5.7 microns wide; exine commonly folded near equator to simulate a cingulum; thickness of exine indeterminate due to numerous closely spaced pila and baculae up to 4 microns long and 2 microns in diameter; ornamental elements reduced in size and number of proximal surface; observed size range 37-55 microns, average size 46 microns.

Spore type D sp. 1 and Spore type D sp. 2 possess similar ornament, but the size of species 1 is less than that of species 2.

Spore type D sp. 1 occurred in all samples of Zones II and III and was the most abundant spore species in the Sand Branch. It was most numerous in the lower 30 feet of Zone III, and in level 856 W of that interval attained a maximum relative abundance of 40.5 percent.

Figured specimens: Plate 1, figures 4,5 OPC 856 AN-3-7
47 X 42 microns

Plate 2, figure 10 OPC 856 AJ-7-1
48 X 43 microns

figure 11 OPC 856 J-2-2
47 X 43 microns

figure 12 OPC 856 AR-1-6
56 X 53 microns

figure 13 OPC 856 H-4-3
40 X 37 microns

figure 14 OPC 856 J-4-1
40 microns

Plate 6, figure 10 OPC 856 AN-3-6
46 microns

SPORE TYPE D, SP. 2

Plate 2, figure 16

Spores radial, trilete, amb subcircular; trilete extends almost to margin, tecta slightly raised; labra rarely present, 2-3.8 microns wide at apex, narrower toward margin; pseudo-cingulum formed by peripheral folding is occasionally present; ornament consists of pila and baculae ranging up to 5 microns in height and 4 microns in diameter; ornamentation reduced proximally; observed size range 67-78 microns, average size 75 microns.

Spore type D sp. 2 is consistently larger than Spore type D sp. 1. Forms of intermediate size were not observed. Species 2 seldom possess the wide labra common to many specimens of Species 1.

Occurrences of Spore type D sp. 2 were limited to the lower half of the Sand Branch.

Figured specimen: OPC 856 J-1-2
75 X 52 microns

SPORE TYPE D, SP. 3

Plate 10, figure 8

Spores radial, trilete, amb subcircular; trilete extends one-half to two-thirds distance to margin; tecta raised, coalesced into labra up to 3 microns wide; exine 1.7-2.2 microns thick, folded equatorially to form a pseudocingulum; widely spaced grana up to 0.8 microns in diameter cover proximal and distal surfaces; in addition, distal surface possesses widely scattered pila ranging up to 3 microns in height and 1.8 microns in diameter; observed size range 51-65 microns, average size 57 microns.

Ornamental elements on Spore type D sp. 3 are much fewer in number than on Spore type D species 1 and 2. As can best be determined, this characteristic appears to be inherent and not a result of corrosion or abrasion.

Spore type D sp. 3 occurred in most levels of Zone III and in two levels near the base of Zone II.

Figured specimen: OPC 856 Z-2-3
59 X 54 microns

SPORE TYPE E

Plate 6, figure 11

Spores radial, trilete, equatorial outline subcircular, distal hemisphere highly convex; trilete thin, equal in length to approximately two-thirds spore radius; labra absent; exine 0.9-1.4 microns thick, proximal surface

finely rugulate, equatorial and distal surfaces possess moderately spaced clavae up to 6.4 microns in height and 4.3 microns in diameter; several adjacent clavae often unite at tips to form discrete ornamental elements that simulate an open reticulum; observed size range 48-59 microns.

Discrete ornamental elements composed of clavae united at their tips characterize Spore type E.

Spore type E is probably generically equivalent to Spore type 'A' of Hacquebard and Barss, 1957.

Single specimens of Spore type E were recorded from three samples in the upper half of Zone III.

Figured specimen: OPC 914 A-5-1
55 X 49 microns

SPORE TYPE F

Plate 7, figures 7, 8; Plate 9, figures 17, 18

Spores radial, trilete, perisporate, amb subcircular to roundly triangular; trilete distinct, equal to or greater in length than two-thirds radius of spore body; labra slightly raised, up to 3.2 microns wide at apex, become narrower and lower toward spore margin; proximal surface finely granular; distal surface coarsely and densely granular, adjacent grana sometimes coalesce; perispore finely granular, normally tightly appressed, often wrinkled to vermiculate about distal pole; observed size range 38-54 microns.

Spore type F occurred throughout Zones II and III of the Sand Branch. It was most abundant in the middle third of Zone III.

Figured specimens: Plate 7, figure 7 OPC 856 T-1-1 46 X 39 microns

figure 8 OPC 856 H-4-1 46 X 38 microns

Plate 9, figures 17,18 OPC 856 AI-4-1 55 microns

SPORE TYPE G

Plate 2, figure 15

Spores radial, cingulate, trilete, equatorial outline subcircular, distal hemisphere highly convex; trilete extends to cingulum; labra 4-6 microns high, 3-5 microns wide, sub-spinose, extend to and join cingulum; cingulum 4-7 microns wide, spinose; interareas of proximal surface bear 2 to 3 radially disposed ridges with spines up to 1.7 microns long; distal surface bears more-or-less concentrically arranged short ridges 3 microns high and 1.5-2 microns wide, possessing spines up to 2.8 microns in length; ridges never united to form a complete pattern parallel to equator; observed overall size range 47-53 microns, spore body 42-46 microns.

Short, highly spinose distal ridges distinguish Spore type G from the genus Savitrisporites whose distal ornamental elements most often form a closed pattern parallel to the equator.

Spore type G was recovered only from upper Sand Branch sediments at the Sandy Creek localities.

Figured specimen: OPC 912 B-6-1
52 X 45 microns

SPORE TYPE H

Plate 11, figures 11, 12

Spores cingulate, radial, trilete, amb subcircular; trilete thin, extends almost to margin of spore body; tecta slightly raised, labra absent; spore body laevigate, triangular, sides concave; cingulum laevigate, thinner than spore body; observed overall size range 47-51 microns, spore body 35-38 microns.

The labra-like appearance of the dense spore body distinguishes Spore type H from the genus Rotaspora. Spore type H may be equivalent to Spore type E of H., S., and M. (1955), and to Spore type C of Neves (1958).

Single specimens of Spore type H occurred in levels 856 X, 856 AH, and 856 AR from the type section of the Sand Branch.

Figured specimen: OPC 856 AH-4-1
48 X 46 microns

SPORE TYPE I

Plate 11, figure 6

Spore radial, cingulate, trilete, amb roundly triangular, proximal surface slightly convex; trilete extends to margin of spore body; labra raised and narrow at apex, lower and broader where merged into cingulum;

spore body distinct, roundly triangular, proximal surface laevigate, distal surface bears scattered grana to 1.5 microns in diameter; margin of spore body clearly visible through cingulum so that spore appears bicingulate; total width of cingulum 7-10 microns, amount of overlap of cingulum onto spore body approximates extension of cingulum beyond spore body; surface of cingulum irregular but laevigate, flange intrapunctate; overall size (single specimen) 43 microns, spore body 34 microns.

A bicingulate appearance and an intrapunctate cingulum characterize Spore type I.

The single occurrence of Spore type I was in level 856 R of Zone II.

Figured specimen: OPC 856 R-3-1
43 microns

SPORE TYPE J

Spores radial, cingulate, trilete, subcircular in proximal-distal view, trapezoidal in equatorial view; trilete simple, distinct, extends almost to margin of spore body; labra heavy, often merge into cingulum; spore body bears heavy ridges (muri ?) which may intersect but seldom form closed lumen; ridges reduced in size and number on proximal surface; area between ridges laevigate or with sparse grana or verrucae; cingulum a single ridge thicker than broad, similar to but larger than other ridges; cingulum separates spore into small proximal and large distal hemispheres; size range 60-108 microns.

Were the spores comprising Spore type J present in sufficient numbers for adequate interpretation, they could perhaps be satisfactorily placed within either Reticulatisporites, Corbulispora, or Secarisporites.

SPORE TYPE J, SP. 1

Plate 4, figures 11, 12

Spores radial, cingulate, trilete, subcircular in proximal-distal orientation, trapezoidal in equatorial view; trilete extends almost to margin of spore body; labra rounded, sinuous, 3-5 microns wide, 2.7 microns high, merge into cingulum; cingulum laevigate, lobate, 2.8-4 microns wide, 3-12 microns thick; spore body bears anastamose, rounded, lobate ridges (muri ?) to 6 microns wide and 3 microns high; ridges end blindly, occasionally intersect, seldom form closed lumen; area between ridges granular and with sparse verrucae 1.7-3.1 microns in diameter; proximal ornament similar but reduced; observed size range (five specimens) 81-108 microns, average size 97 microns.

The rare occurrences of Spore type J sp. 1 were restricted to the upper one-half of Zone III.

Figured specimens: Figure 11, OPC 856 AH-3-3
103 X 80 microns

Figure 12, OPC 856 AO-3-4
86 X 65 microns

SPORE TYPE J, SP. 2

Plate 4, figure 13

Spore radial, cingulate, trilete, trapezoidal in equatorial view, amb subcircular; location of trilete

indicated by labra; trilete not visible due to orientation of specimen; labra laevigate, rounded, 3 microns wide, 9 microns high at apical knob, but reduced to 3 microns at juncture with cingulum; cingulum laevigate, rounded, 4.4-5 microns wide, 5-6.2 microns thick; proximal surface of spore without ornamentation; distal hemisphere possesses rounded, finely crenulate muri to 2.8 microns high and 3.4 microns wide; muri merge into cingulum, often intersect to form large, occasionally closed lumen; area between muri laevigate; size (single specimen) 64 X 46 microns.

Spore type J sp. 2 differs from Spore type J sp. 1 in that its cingulum and muri are not lobate, but of more-or-less constant diameter. Also, the area between the muri of species 2 is laevigate, whereas on species 1 it is granular to verrucate.

The single specimen of Spore type J sp. 2 was recorded from level 856 AC.

Figured specimen: OPC 856 AC-6-3
64 X 46 microns

SPORE TYPE K

Plate 10, figure 14

Spores radial, cingulate, trilete, amb roundly triangular; trilete extends almost to margin of spore body; labra thin, sinuous, merge into cingulum; spore body sharply convex proximally, roundly convex distally, equatorial outline convexly triangular; surface of spore

body undulatory but laevigate; cingulum 3-13 microns wide, periphery irregular and thickened, inner portion thin, granular to sub-verrucose where joined to spore body; observed overall size (five specimens) 56-69 microns, spore body 39-43 microns.

The undulatory, laevigate, highly convex spore body typifies Spore type K.

Spore type K was found in three levels in the lower two-thirds of Zone III.

Figured specimen: OPC 856 V-1-2
69 X 56 microns

SPORE TYPE L

Plate 9, figure 15

Spores radial, cingulate, trilete, amb subcircular; trilete equal to or greater in length than two-thirds radius of spore body; labra absent; spore body subcircular, laevigate, possesses circular distal fovea 17-20 microns in diameter; exine differentially thickened; cingulum laevigate, narrow, 2-3.4 microns wide, rim-like in nature, very thin where attached to spore body and hence often folded onto spore body; observed size range (four specimens) 47-54 microns.

Spore type L is characterized by its very narrow, rim-like cingulum and the distal fovea.

Single specimens of Spore type L occurred in four levels of the lower two-thirds of Zone III.

Figured specimen: OPC 856 AG-2-2
53 X 45 microns

SPORE TYPE M

Plate 11, figure 8

Spores radial, cingulate ?, trilete, amb subcircular; trilete extends to margin of spore body; labra absent; spore body 29-31 microns, laevigate, convexly triangular with angular apices; spore body covered equatorially and distally by closely-spaced, lobate, convolute muri 4-6 microns high which may coalesce, especially equatorially, to form a rugulate surface; rugulate middle layer encompassed by an intragranulose outer layer which extends 4-7 microns beyond middle layer equatorially; outer layer approximately 3.5 microns thick equatorially, 2 microns thick distally; overall effect of these layers is a spore that appears bicingulate in proximal-distal orientation; size range (four specimens) 48-57 microns.

Single specimens of Spore type M occurred in the upper level of Zone II and in three levels in the middle third of Zone III. It was not recorded from uppermost Sand Branch strata at the Sandy Creek localities.

Figured specimen: OPC 856 AQ-6-5
56 X 48 microns

SPORE TYPE N

Plate 8, figures 16, 17

Spores radial, monosaccate, trilete, amb roundly triangular; trilete extends to margin of central body; labra

absent; position of trilete reflected on saccus by raised, twisted commissural folds which extend to margin of spore; central body laevigate, occupies most of saccus; saccus laevigate, with many concentric folds about periphery; saccus not appressed to central body, but of similar size and shape; overall size (three specimens) 75-79 microns.

Similarity in size and shape of the central body and its loosely appressed saccus characterizes Spore type N.

Single specimens of Spore type N occurred in three samples in the upper half of Zone III.

Figured specimen: OPC 914 A-1-1
75 microns

SPORE TYPE O

Plate 12, figures 13, 14

Spores radial, monosaccate, trilete, amb subcircular; trilete greater in length than one-half radius of central body; labra absent; central body distinct, laevigate to finely granular, roundly triangular in outline, highly convex proximally, saccus thin, infra-reticulate, attached equatorially so that approximately one-half of proximal surface of central body and three-fourths of distal surface are free of saccus; observed size range of spore 66-75 microns, central body 48-58 microns.

Spore type O was found to be moderately abundant in the upper half of the Sand Branch.

Figured specimens: Figure 13 OPC 856 W-6-1
75 X 62 microns

Figure 14 OPC 856 W-2-1
71 X 66 microns

SPORE TYPE P

Spores radial, monosaccate, trilete, original shape probably subspherical; trilete faint, equal to or greater in length than three-fourths radius of central body; labra weak to absent; central body laevigate to granular, subcircular in outline, probably originally spherical; saccus infra-reticulate, attached proximally; wall of saccus thinner than that of central body; observed size range 68-114 microns.

The faint trilete mark and the relatively thick wall of the central body distinguish Spore type P from Remysporites.

SPORE TYPE P. SP. 1

Plate 13, figures 1, 3, 4, 5

Spores radial, monosaccate, trilete; central body flattened, subcircular, laevigate to granular; trilete faint, equal to or greater in length than three-fourths radius of spore body; labra absent; saccus infra-reticulate, attached proximally, central body wall 1.9-2.4 microns thick, saccus 0.8-1.2 microns thick; overall size of spore 86-113 microns, central body 63-77 microns.

Spore type P sp. 1 is separated from Spore type P sp. 2 by virtue of its larger size.

Spore type P sp. 1 was found only in Zone III. Its greatest abundance and frequency of occurrence were attained in the upper 36.5 feet of the Sand Branch.

Figured specimens: Figure 1 OPC 912 B-6-4
90 X 82 microns

Figure 3 OPC 913 B-1-5
91 X 82 microns

Figure 4 OPC 856 AC-6-2
93 X 84 microns

Figure 5 OPC 856 AN-2-10
107 X 87 microns

SPORE TYPE P. SP. 2

Plate 13, figures 6, 10

Spores radial, monosaccate, trilete; original shape probably subspherical; central body distinct, subcircular, granular; trilete faint, extends almost to margin of central body; labra weak to absent; saccus infra-reticulate, attached proximally; wall of central body 1.5-1.8 microns thick, saccus 0.8-1.0 microns thick; overall size of spore 67-78 microns, central body 49-58 microns.

Spore type P sp. 2 is smaller than Spore type P sp. 1, and its central body is always granular.

Spore type P sp. 2 occurred in level 856 L and in all levels above level 856 P.

Figured specimens: Figure 6 OPC 856 AA-2-2
76 X 61 microns

Figure 10 OPC 856 AA-5-1
75 microns

SPORE TYPE Q

Plate 12, figures 16, 18

Spores radial, monosaccate, trilete, probably originally spherical; central body subcircular, wall 1.1-1.4

microns thick, laevigate; trilete faint, equal in length to one-third to one-half radius of spore body, location often indicated by heavy commissural folds on saccus; saccus slightly thicker than central body, attached proximally, densely rugulate to corrugate; overall size of spore 71-98 microns, central body 44-63 microns.

The ratio of the central body to the saccus is much less for Spore type Q than for Velamisporites.

Spore type Q occurred throughout Zone III but was most abundant in the upper 37 feet of that zone.

Figured specimens: Figure 16 OPC 856 AC-3-1
74 microns

Figure 18 OPC AQ-5-2
95 microns

SPORE TYPE R

Plate 14, figure 6

Spores radial, monosaccate, trilete, probably originally spherical; central body subcircular to oval, wall 1 micron thick, laevigate; trilete faint, short, length of laesurae equal to or less than one-half radius of central body; labra absent; saccus thin, approximately 0.4 microns thick, infragranular, frequently radially folded, attached proximally; ratio of saccus to central body approximately 2:1; observed overall size range 138 X 111 microns-153 microns, central body 66 X 52 microns-71 microns.

The very thin, radially folded, infragranular saccus typifies Spore type R.

Spore type R occurred only in the uppermost level of the Sand Branch, level 914 A, where its relative abundance was comparatively high (7.0 percent).

Figured specimen: OPC 914 A-6-1
147 X 119 microns

SPORE TYPE S

Plate 13, figure 7

Spores radial, monosaccate, trilete, probably originally spherical; central body subcircular, wall 1.8-2.1 microns thick, laevigate; trilete distinct, laesurae extend almost to margin of central body; labra absent; saccus attached proximally, 1.9-2.1 microns thick, perfero-reticulate; closely-spaces sub-hexagonal lumen perforate wall of saccus imparting a coarse appearance; observed overall size range 61-76 microns, central body 50-58 microns.

The coarsely-textured, perfero-reticulate saccus characterizes Spore type S.

Spore type S occurred sporadically throughout Zone III, but attained a relative abundance of 2.5 percent in level 856 X near the base of the zone.

Figured specimen: OPC 856 AB-2-1
75 X 65 microns

SPORE TYPE T

Plate 8, figure 15

Spores radial, monosaccate, trilete, amb roundly triangular; central body laevigate, outline conforms to

that of saccus, wall 1.2 microns thick; trilete distinct, extends almost to margin of central body; labra absent on central body, but position of trilete indicated by raised, slightly sinuous commissural folds on saccus; saccus approximately 1.1 microns thick, coarsely granular to sub-verrucose equatorially and distally, faintly granular over proximal surface of central body; observed size range 53-61 microns, central body 36-40 microns.

Distinct commissural folds on the saccus and its coarsely granular to sub-verrucose equatorial and distal surfaces distinguish Spore type T from Endosporites.

Single specimens of Spore type T appeared in levels 856 N and 856 Z. Otherwise, occurrences of this spore type were limited to the upper 26.5 feet of the Sand Branch type section.

Figured specimen: OPC 856 N-1-3
55 microns

SPORE TYPE U

Plate 12, figure 17

Spore radial, monosaccate, trilete ?, amb subcircular, central body eccentrically located in saccus; central body roundly triangular, dense, finely granular with scattered larger grana to 1 micron; trilete not discernible; saccus 1.8 microns thick, finely granular with scattered larger grana and gemmae to 2.7 microns; overall size (one specimen) 66 X 63 microns, central body 30 X 24 microns.

The eccentrically placed central body and the nature of the ornament typify Spore type U.

A single specimen was found in level 912 A.

Figured specimen: OPC 912 A-5-2
66 X 63 microns

Group ACRITARCHA Evitt, 1963

Subgroup ACANTHOMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus BALTISPHAERIDIUM Eisenack

emend. Downie and Sarjeant, 1963

Type species: B. longispinosum (Eisenack) Eisenack, 1958

Affinity: Unknown

BALTISPHAERIDIUM LONGISPINOSUM

(Eisenack) Eisenack, 1958

Plate 15, figure 1

The single specimen of Baltisphaeridium longispinosum recorded from level 856 AN was probably recycled from either the Sylvan or Woodford Formations.

Figured specimen: OPC 856 AN-2-6
body 57 microns;
processes 30-37 microns

BALTISPHAERIDIUM BREVISPINOSUM

(Eisenack) Eisenack, 1958

Plate 15, figures 2, 5

The three specimens assigned to Baltisphaeridium brevispinosum were recorded from levels 856 O, 856 AJ, and 856 AO. Like B. longispinosum, they are believed to be recycled from older sediments.

Figured specimens: Figure 2 OPC 856 AO-1-12
body 58 X 51 microns;
processes 14-17 microns

Figure 5 OPC 856 O-2-1
body 50 X 44 microns;
processes 18-23 microns

BALTISPHAERIDIUM? cf. B. DILATISPINOSUM Downie, 1963

Plate 15, figure 20

Some processes on the Sand Branch specimen assigned to Baltisphaeridium? cf. B. dilatispinosum are not closed at their tips, and for this reason the form is questionably assigned to the genus Baltisphaeridium. In overall appearance the Sand Branch specimen resembles the Silurian species B. dilatispinosum, the only difference being the lack of short spinelets at the tips of the processes on the Sand Branch specimen. However, specimens of B. dilatispinosum with the spinelets missing from some of the processes have been observed in other material.

The single specimen of Baltisphaeridium? cf. B. dilatispinosum was recorded from level 856 E. Although level 856 E is in Zone I, the zone dominated by acritarchs and considered not likely to contain many recycled forms, this single specimen is believed to have been recycled from the Sylvan Shale Formation.

Figured specimen: OPC 856 E-3-1
33 microns

BALTISPHAERIDIUM? cf. B. TRAUMATICUM Cramer, 1964

Plate 18, figures 1, 3, 4

Organization and sculpture of the Sand Branch forms is similar to that of Baltisphaeridium traumaticum described by Cramer (1964) from the Ludlovian of Spain. However, processes of the Sand Branch specimens are smooth, not striate as are those of B. traumaticum.

Three specimens of B.? cf. B. traumaticum were recovered from level 856 F in Zone I.

Figured specimens: Figure 1 OPC 856 F-4-1
body 23 microns;
processes 9-11 microns

Figure 3 OPC 856 F-3-6
body 20 microns;
processes 8 microns

Figure 4 OPC 856 F-3-7
body 23 X 18 microns;
processes 5-6 microns

BALTISPHAERIDIUM SP. 1

Plate 15, figures 3, 4

Vesicle spherical, 49-60 microns in diameter; wall 0.9-1.3 microns in thickness, laevigate to sparsely and finely granular; processes laevigate, thin, curved, easily bent, commonly appressed to vesicle, pointed at tips; length of processes 20-23 microns, basal diameter 2.3-2.6 microns; overall size range (2 specimens) 89-101 microns, vesicle 49-63 microns.

Thin, easily bent processes typify Baltisphaeridium sp. 1.

A single specimen of Baltisphaeridium sp. 1 was recovered from each of levels 856 AN and 912 B. B. sp. 1 is believed to have been recycled from older sediments.

Figured specimens: Figure 3 OPC 856 AN-4-5
body 49 microns;
processes 20-22 microns

Figure 4 OPC 912 B-5-4
body 63 X 55 microns;
processes 20-23 microns

BALTISPHAERIDIUM? SP. 2

Plate 16, figure 12

Vesicle spherical, wall laevigate, less than 1 micron in thickness; processes thin, filmy, tapered to point, length 5-8 microns, basal diameter 2.4-3.3 microns; occasional suggestion of connecting membrane between processes; overall diameter (two specimens) 36 and 38 microns; vesicle 24-29 microns.

Processes of the genus Baltisphaeridium are not joined together by a loculum nor by a membrane. Because there are indications of a membrane between some of the processes on B.? sp. 2, this species is questionably assigned to the genus Baltisphaeridium.

Single specimens of Baltisphaeridium? sp. 2 occurred in levels 856 D and 856 G in Zone I.

Figured specimen: OPC 856 D-1-4
38 microns

BALTISPHAERIDIUM? SP. 3

Plate 18, figure 2

Vesicle flattened, folded, probably originally spherical; wall laevigate, less than 1.0 micron in thickness; processes located approximately 90° apart, four in number, laevigate, tips closed; three processes 8 microns in length, 2.2-3 microns in diameter, ends blunt; one larger process 10 microns in length, 4 microns in diameter, center constricted, tip concave; overall size 43 X 37 microns, vesicle 25 X 18 microns.

Baltisphaeridium? sp. 3 lacks the rugulate surface of B.? cf. B. traumaticum.

The single specimen of Baltisphaeridium? sp. 3 appeared in level 856 E of Zone I.

Figured specimen: OPC 856 E-1-1
body 25 X 18 microns;
processes 8-10 microns

Genus MICHRYSTRIDIUM Deflandre

emend. Downie and Sarjeant, 1963

Type species: M. inconspicuum (Deflandre) Deflandre, 1937

Affinity: Unknown

MICHRYSTRIDIUM STELLATUM Deflandre, 1945

Plate 17, figures 1, 2, 3, 4

Michrystridium stellatum occurred throughout Zone I and in all samples through Acritarch Interval 2 in Zone II. It was most abundant in levels 856 M and 856 N the lower 10 feet of Acritarch Interval 2.

Figured specimens: Figure 1, OPC 856 F-1-3
35 X 32 microns

Figure 2, OPC 856 E-5-1
53 microns

Figure 3, OPC 856 E-4-3
38 X 25 microns

Figure 4, OPC 856 E-3-3
38 microns

MICHRYSTRIDIUM SP. 1

Plate 15, figures 7, 8

Vesicle spherical, wall less than 1 micron in thickness; processes spinose, closely spaced, slightly curved,

tapered to closed point; length of processes 2.5-7 microns, basal diameter 1.0-1.6 microns; most processes on a given individual are of similar size; overall size range 21-35 microns, vesicle 16-23 microns.

Michrystridium sp. 1 occurred in all samples from Zone I. It also occurred in Acritarch Intervals 1 and 2 of Zone II.

Figured specimens: Figure 7 OPC 856 F-2-2
24 X 19 microns

Figure 8 OPC 856 E-3-2
34 microns

MICHRYSTRIDIUM SP. 2

Plate 16, figure 1

Vesicle spherical, wall thickness less than 1 micron; processes filamentous, 4.5-7 microns in length, less than 1.0 micron in diameter, occur in groups of 2-5; overall size range 18-23 microns, vesicle 13-17 microns.

Relatively long, filamentous processes characterize Michrystridium sp. 2.

Michrystridium sp. 2 did not occur above Acritarch Interval 2 of Zone II.

Figured specimen: OPC 856 D-1-1
21 microns

Subgroup POLYGONOMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus VERYHACHIUM Deunff

emend. Downie and Sarjeant, 1963

Type species: V. trisulcum (Deunff) Deunff, 1958

Affinity: Unknown

VERYHACHIUM SP.

Plate 16, figures 17-20

Vesicle triangular, sides slightly concave to convex, each angle extended into hollow, pointed, closed-tip spine; wall faintly granular, less than 1.0 in thickness; overall size range 34-44 microns, vesicle 19-22 microns, spines 8-15 microns.

With the exception of a single specimen in level 856 F near the top of Zone I, occurrences of Veryhachium sp. were restricted to Zone II, where the species attained maximum abundance in Acritarch Interval 2.

Figured specimens:

Figure 17	OPC 856 H-2-1 34 microns
Figure 18	OPC 856 H-5-1 38 microns
Figure 19	OPC 856 H-4-2 39 microns
Figure 20	OPC 856 H-7-1 39 microns

Subgroup SPHAEROMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus LEIOSPHAERIDIA Eisenack

emend. Downie and Sarjeant, 1963

Type species: L. baltica Eisenack, 1958

Affinity: Algal?

LEIOSPHAERIDIA SP. 1

Plate 17, figures 5, 7, 14

Vesicle small, spherical, laevigate, no trace of germinal apparatus; wall less than 0.5 microns in thickness, commonly folded; observed size range 20-45 microns, average size 37 microns.

Leiosphaeridia sp. 1 occurred in all levels of Zones I and II and in most levels of Zone III. In Zone I, relative abundance of L. sp. 1 ranged from 22-26 percent.

Figured specimens: Figure 5 OPC 856 P-1-1
34-37 microns

Figure 7 OPC 856 B-3-3
41 microns

Figure 14 OPC 856 H-5-2
43 X 15 microns

LEIOSPHAERIDIA SP. 2

Plate 17, figure 6

Vesicle small, spherical, no trace of germinal apparatus; wall less than 0.5 microns in thickness, granular, commonly folded; observed size range 18-30 microns, average size 22 microns.

Smaller size and a granular surface distinguish Leiosphaeridia sp. 2 from L. sp. 1.

Leiosphaeridia sp. 2 was the most abundant acritarch in the Sand Branch. It occurred in all samples from Zones

I and II and in most samples in the middle of Zone III. L. sp. 2 comprised from 25-48.5 percent of the palynomorphs present in individual samples from Zone I.

Figured specimen: OPC 856 O-1-4
21-24 microns

LEIOSPHAERIDIA SP. 3

Plate 17, figures 8, 9

Vesicle large, originally spherical, no trace of germinal apparatus; wall relatively thin, less than 1 micron in thickness, commonly finely wrinkled and with long folds; outer surface laevigate, inner surface reticulate; observed size range 120-142 microns, average size 134 microns.

The relatively thin, infra-reticulate wall typifies Leiosphaeridia sp. 3.

L. sp. 3 was recorded from levels 856 H and 856 P in Zone II, and from several levels in the middle one-third of Zone III. It did not occur in the predominantly marine assemblages of Zone I. L. sp. 3 is believed to be recycled from older sediments, probably from the Woodford Shale Formation.

Figured specimens: Figure 8 OPC 856 P-1-3
122 microns

Figure 9 OPC 856 H-7-2
134 microns

LEIOSPHAERIDIA SP. 4

Plate 17, figures 10, 12

Vesicle large, originally spherical, no traces of germinal apparatus; wall relatively thin, approximately 1 micron in thickness, outer surface laevigate, inner surface sparsely pitted (corroded ?); observed size range 170-300 microns, average size 260 microns.

Leiosphaeridia sp. 4 can be differentiated from L. sp. 3 by its larger size and laevigate wall.

Leiosphaeridia sp. 4 was rare in the upper part of Zone II and near the middle of Zone III. Single specimens were recorded from the oldest and youngest Sand Branch samples levels 856 A and 914 A, respectively. L. sp. 4 is believed to be recycled from older sediments, probably from the Woodford Shale Formation.

Figured specimens: Figure 10 OPC 856 0-1-2
193 X 146 microns

Figure 12 OPC 856 P-2-2
264 X 172 microns

LEIOSPHAERIDIA SP. 5

Plate 17, figures 13, 17

Vesicle large, originally spherical, no trace of germinal apparatus; wall approximately 1.0 micron thick, finely granular, commonly folded; observed size range 70-95 microns, average size 81 microns.

Leiosphaeridia sp. 5 is larger than L. sp. 2, the other granular leiosphere species found in the Sand Branch.

Leiosphaeridia sp. 5 was present in all samples from Zones I and II and in most samples from Zone III.

Figured specimens: Figure 13 OPC 856 H-1-3
89 X 40 microns

Figure 17 OPC 856 L-3-1
76 X 61 microns

LEIOSPHAERIDIA SP. 6

Plate 17, figures 16, 18

Vesicle of medium size, originally spherical, frequently bears a single slit that resembles a monolete germinal scar; wall relatively thick, 0.9-1.3 microns in thickness, laevigate to sparsely granular; observed size range 24-40 microns, average size 32 microns.

Leiosphaeridia sp. 6 is distinguished from other species of Leiosphaeridia of similar size by its relatively thick wall.

Leiosphaeridia sp. 6 was found in all samples of Zone I, but it occurred only sporadically in Zones II and III.

Figured specimens: Figure 16 OPC 856 B-2-1
36 X 32 microns

Figure 18 OPC 856 C-3-1
28 X 26 microns

Genus TASMANITES (Newton) S., W., and B., 1944

Type species: T. punctatus Newton, 1875

Affinity: Algal, Class Chlorophyceae. In 1962, Wall pointed out the close resemblance between the Tasmanaceae and the green algae, Class Chlorophyceae. The conclusions of Wall

concerning the affinity of Tasmanites are accepted, and the genus is treated herein within the group Acritarcha solely upon the basis of prior usage.

TASMANITES SP. 1

Plate 18, figure 5

Vesicle large, thick-walled originally spherical, no trace of germinal apparatus; wall 15-18 microns thick, laevigate, with moderately-spaced punctae; observed size range 274-339 microns, average size 294 microns.

Moderately-spaced punctae through the thick, laevigate wall characterize Tasmanites sp. 1.

Rare specimens of Tasmanites sp. 1 were observed in the upper half of the Sand Branch. These differentially stained forms are considered to be recycled from the Woodford Shale Formation.

Figured specimen: OPC 856 W-5-1
329 microns

TASMANITES SP. 2

Plate 18, figures 6, 7

Vesicle large, thick-walled, originally spherical, no indication of germinal apparatus; wall 3-5 microns thick, laevigate with rare punctae; observed size range 70-160 microns, average size 128 microns.

Rare, widely-spaced punctae typify Tasmanites sp. 2.

Tasmanites sp. 2 occurred in nearly all samples of the Sand Branch above Acritarch Interval 1. Its greatest

relative abundance was a high 26.5 percent in level 856 AK of Zone III. Although T. sp. 2 was not found in the totally marine assemblages of Zone I, this species is believed to be *in situ* in the Sand Branch.

Figured specimens: Figure 6 OPC 856 0-1-3
84 microns

Figure 7 OPC 856 S-1-1
143 microns

TASMANITES SP. 3

Plate 18, figures 8-11

Vesicle large, thick-walled, spherical, no indication of germinal apparatus; wall 6-9 microns thick, outer surface laevigate; inner surface with striations and grooves that intersect in a dendritic to subpolygonal pattern; punctae not discernible; observed size range 70-98 microns, average size 89 microns.

The dendritic to sub-polygonal pattern on the inner surface of the wall characterizes Tasmanites sp. 3.

Tasmanites sp. 3 occurred rarely in the upper part of Zone II and in the middle of Zone III. The species may be recycled from the Woodford Formation.

Figured specimens: Figures 8, 9 OPC 856 P-1-2
92 X 80 microns

Figures 10, 11 OPC 856 0-3-1
82 X 69 microns

TASMANITES SP. 4

Plate 18, figures 12, 13

Vesicle large, thick-walled, spherical, no indication of germinal apparatus; wall 3.5-5 microns thick, densely

perforate and hence with irregular surface; observed size range 74-87 microns, average size 82 microns.

The densely perforate wall characterized Tasmanites sp. 4.

Tasmanites sp. 4 occurred in only four levels, two in Zone II and two in Zone III, and is considered to be recycled from the Woodford Shale Formation.

Figured specimen: OPC 856 O-4-1
82 X 74 microns

TASMANITES SP. 5

Plate 18, figure 16

Vesicle large, relatively thin-walled, originally spherical, no suggestion of germinal apparatus; wall 1-1.4 microns thick, coarsely infragranular, outer surface laevigate; observed size range 70-81 microns, average size 74 microns.

Tasmanites sp. 5 can be recognized by virtue of its coarsely infragranular wall.

Tasmanites sp. 5 occurred throughout Zone II and in four samples above the middle of Zone III.

Figured specimen: OPC 856 AK-1-3
73 microns

Genus LOPHOSPHAERIDIUM Timofeev, 1959

Type species: L. rarum Timofeev, 1959

Affinity: Unknown

All representatives of Lophosphaeridium found in the Sand Branch are considered in situ.

LOPHOSPHAERIDIUM SP. 1

Plate 15, figure 6

Vesicle spinose, originally spherical, 33-39 microns in diameter, no trace of germinal apparatus; wall 0.7-0.9 microns thick, bears stout, curved, closed-tip spines 2.3-3.5 microns in length, 1.5 microns in basal diameter; surface between spines laevigate; observed size range 38-46 microns, average size 41 microns.

Moderately-spaced, stout, curved spines typify Lophosphaeridium sp. 1.

Lophosphaeridium sp. 1 occurred throughout Zone I and in all three Acritarch Levels of Zone II. A single specimen appeared in level 856 AG near the middle of Zone III.

Figured specimen: OPC 856 F-3-5
40 X 34 microns

LOPHOSPHAERIDIUM SP. 2

Plate 15, figures 9, 10, 12

Vesicle spinose, originally spherical, no trace of germinal apparatus; wall less than 1.0 micron thick, bears curved, close-tipped, pointed spines, 2-5 microns in length; spine tips occasionally ramiform; surface laevigate between spines; overall size 41-52 microns, vesicle size 38-42 microns.

Lophosphaeridium sp. 2 occurred in moderate abundance throughout Zones I and II, but was rare in Zone III.

Figured specimens: Figure 9 OPC 856 H-3-2
46 microns

Figure 10 OPC 856 D-2-4
40 X 36 microns

Figure 12 OPC 856 N-1-1
44 X 39 microns

LOPHOSPHAERIDIUM SP. 3

Plate 15, figure 11

Vesicle spinose, originally spherical, no trace of germinal apparatus; wall less than 1 micron in thickness, laevigate between spines; spines 5-7 microns in length, 1 micron in diameter; tips usually ramiform, occasionally pointed; overall size 40-53 microns, vesicle size 36-42 microns.

Processes of Lophosphaeridium sp. 3 are longer, more closely-spaced, and more often with ramiform tips than those of L. sp. 2. They are longer but not so closely-spaced as those of L. sp. 5.

Lophosphaeridium sp. 3 occurred in Acritarch Levels 1 and 2 of Zone II and in all samples from Zone I.

Figured specimen: OPC 856 A-3-1
47 X 41 microns

LOPHOSPHAERIDIUM SP. 4

Plate 15, figures 13-16

Vesicle spherical, spinose, no trace of germinal apparatus; wall 1.0-1.3 microns in thickness, laevigate between spines; spines short, 1.8-4 microns in length, 1.5 microns in basal diameter, tapered to closed, pointed,

rarely bifurcate tips; overall size 44-57 microns, vesicle 39-50 microns.

Lophosphaeridium sp. 4 is larger than other species of Lophosphaeridium in the Sand Branch.

Lophosphaeridium sp. 4 occurred in all levels of Zones I and II and in most levels of Zone III. It was particularly abundant in the lower 20 feet of the Sand Branch.

Figured specimens: Figures 13, 14 OPC 856 B-3-4
54 microns

Figure 15 OPC 856 D-2-3
49 X 42 microns

Figure 16 OPC 856 F 3-1
45 X 39 microns

LOPHOSPHAERIDIUM SP. 5

Plate 15, figure 17

Vesicle spherical, spinose, no trace of germinal apparatus; wall thickness indeterminate; processes closely-spaced, 1.4-2.3 microns in length, approximately 1 micron in basal diameter, tips closed, ramiform; overall size 34-39 microns, vesicle 32-36 microns.

Short, closely-spaced processes with ramiform tips characterize Lophosphaeridium sp. 5.

L. sp. 5 was found in all samples from Zone I, but its occurrence was sporadic throughout the remainder of the Sand Branch.

Figured specimen: OPC 856 H-1-1
38 X 33 microns

Subgroup NETROMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus QUISQUILITES Wilson and Urban, 1963

Type species: Q. buckhornensis Wilson and Urban, 1963

Affinity: Algal, Chlorophyceae? Results obtained from an electron microscope study of the wall structure of the genera Tasmanites and Quisquilites led Wilson and Skvarla (1967) to conclude that the general are probably phylogenetically related.

QUISQUILITES BUCKHORNENSIS Wilson and Urban, 1963

Plate 18, figure 18

A single specimen of this reniform, laevigate to minutely granular species was recovered from sample 856 AR, the topmost sample from the type section of the Sand Branch. This specimen is considered to be recycled from the Woodford Shale Formation.

Figured specimen: OPC 856 AR-7-3
101 X 55 microns

Subgroup HERKOMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus CYMATIOSPHAERA O. Wetzel

emend. Deflandre, 1954

Type species: C. radiata O. Wetzel, 1933

Affinity: Unknown

CYMATIOSPHAERA PAVIMENTUM (Deflandre) Downie, 1959

Plate 16, figures 3, 4

This small species of Cymatiosphaera was originally described by Deflandre (1945) from the Silurian of France as Michrystridium pavimentum. Cymatiosphaera pavimentum occurred throughout Zones I and II and in level 856 AK in Zone III.

Figured specimens: Figure 3 OPC 856 F-3-4
20 microns

Figure 4 OPC 856 H-3-3
25 microns

CYMATIOSPHAERA SP. 1

Plate 3, figure 16; Plate 15, figures 18, 19;
Plate 16, figures 9, 10, 11

Vesicle originally spherical, bears upright intersecting membranes, no trace of germinal apparatus; wall approximately 0.8 microns thick, surface laevigate between membranes; membranes thin, upright, intersect to form a reticulum with sub-polygonal lumen 8-12 microns in diameter; overall size 38-56 microns, vesicle 25-52 microns, membrane 2.5-5.0 microns in height.

Cymatiosphaera sp. 1 occurred abundantly throughout Zones I and II and as single specimens in three samples in Zone III.

Figured specimens: Plate 3, figure 16 OPC 856 AK-1-1
56 X 48 microns

Plate 15, figure 18 OPC 856 P-2-1

figure 19 OPC 856 O-1-1

Plate 16, figure 9 OPC 856 D-1-3
47 X 43 microns

figure 10 OPC 856 H-4-4
39 microns

figure 11 OPC 856 E-5-2
42 X 36 microns

CYMATIOSPHAERA SP. 2

Plate 16, figure 2

Vesicle small, spherical, bears upright intersecting membranes, no trace of germinal apparatus; wall less than 0.5 micron in thickness, minutely granular between membranes; membranes very thin, intersect to form a reticulum of 3- to 6-sided, irregularly-shaped, small lumen 1.2-3.4 microns in diameter; overall size 28-34 microns vesicle 20-24 microns, membranes 3-5.5 microns in height.

Numerous small lumen formed by very thin intersecting membranes characterize Cymatiosphaera sp. 2.

Cymatiosphaera sp. 2 occurred in the upper half of Zone I and in Acritarch Interval 2 of Zone II.

Figured specimen: OPC 856 F-3-2
30 microns

CYMATIOSPHAERA SP. 3

Plate 16, figure 6

Vesicle spherical, bears upright intersecting membranes, no trace of germinal apparatus; wall less than 1.0 microns in thickness, laevigate between membranes;

membranes 1-2 microns high, up to 4 microns at junctions; membranes intersect to form reticulum of sub-polygonal lumen 9-14 microns in diameter; overall size 36-42 microns, vesicle 33-38 microns.

Cymatiosphaera sp. 3 is similar in size to C. sp. 1 but has lower membranes and slightly larger lumen.

Cymatiosphaera sp. 3 was found in the upper half of Zone I, in the three Acritarch Intervals of Zone II, and in three samples just above the middle of Zone III.

Figured specimen: OPC 856 D-3-4
41 microns

CYMATIOSPHAERA SP. 4

Plate 16, figure 7

Vesicle spherical, bears upright intersecting membranes, no trace of germinal apparatus; wall approximately 1 micron in thickness, laevigate between membranes except for 3 to 5 low verrucae 2.5-4.5 microns in diameter; membranes slightly sinuous, relatively heavy, 1.8-2.6 microns high, approximately 2 microns wide at base, intersect to form 5- to 6-sided lumen 10-16 microns in diameter; overall size range 48-57 microns, vesicle 45-50 microns.

Cymatiosphaera sp. 4 is larger than C. sp. 1 or C. sp. 3, and is characterized by relatively heavy membranes.

Single specimens of Cymatiosphaera sp. 4 appeared in three levels in the lower part of Zone I.

Figured specimen: OPC 856 D-3-3
50 microns

CYMATIOSPHAERA SP. 5

Plate 16, figures 13, 14

Vesicle spherical, bears upright intersecting membranes, no trace of germinal apparatus; wall laevigate, extremely thin except around one circumference (equator?) which has a darkened band approximately 3.7 microns wide that appears to be an equatorial thickening on inside of vesicle; membranes highly sinuous, intersect to form hexagonal lumen 15-18 microns in diameter; overall size 38-48 microns, vesicle 32-43 microns, membranes 5-7.5 microns in height.

The highly sinuous membranes, extremely thin-walled vesicle, and the darkened (thickened?) equatorial band distinguish Cymatiosphaera sp. 5 from other species of Cymatiosphaera.

Cymatiosphaera sp. 5 was found only in level 914 A, the topmost level of the Sand Branch, where it comprised 2 percent of the total assemblage.

Figured specimens: Figure 13 OPC 914 A-2-3
48 microns

Figure 14 OPC 914 A-3-2
38 microns

CYMATIOSPHAERA SP. 6

Plate 16, figures 15, 16

Vesicle spherical, bears upright intersecting membranes, no trace of germinal apparatus; wall less than 1 micron in thickness, laevigate between membranes; membranes finely

granular, 6-9 microns in height, 2-2.7 microns wide at base, tapered to feather edge, intersect to form reticulum with lumen 7-10 microns in diameter; overall size 37-44 microns, vesicle 25-29 microns.

Relatively high, tapered, granular membranes typify Cymatiosphaera sp. 6.

Cymatiosphaera sp. 6 occurred in two samples in Zone I and in one sample from both Acritarch Intervals 1 and 2 in Zone II.

Figured specimens: Figure 15 OPC 856 E-2-1
43 X 40 microns

Figure 16 OPC 856 F-2-1
39 microns

CYMATIOSPHAERA SP. 7

Plate 4, figure 4

Vesicle spherical, bears upright intersecting membranes; wall 2.3-2.5 microns in thickness, laevigate between membranes; membranes thin, laevigate, intersect in a reticulate pattern resulting in polygonal lumen 7-13 microns in diameter; on either side of base of membrane is a row of solid rodlets which extend through vesicle wall; double row of rodlets emphasized polygonal pattern formed by membranes and imparts a tectate appearance to wall around periphery; overall size (one specimen) 51 X 44 microns, vesicle 48 X 43 microns, membranes to 4 microns in height.

The double row of rodlets that penetrate the vesicle wall at the base of the membranes characterizes Cymatiosphaera sp. 7.

The single specimen of Cymatiosphaera sp. 7 was found in level 856 AK.

Figured specimen: OPC 856 AK-1-4
51 X 44 microns

Genus DICTYOTIDIUM Eisenack emend. Staplin, 1961

Type species: D. dictyotum (Eisenack) Eisenack, 1955

Affinity: Unknown

DICTYOTIDIUM SP. 1

Plate 16, figure 5

Vesicle spherical, bears intersecting low ridges, no indication of germinal apparatus; wall less than 1.0 micron in thickness, laevigate between ridges; ridges laevigate, approximately 1.0 micron in height, width equal to or greater than height; ridges intersect in a reticulate pattern with resulting irregularly-shaped lumen 3-6 microns in diameter; overall size range 30-38 microns, body 27-34 microns.

Dictyotidium sp. 1 is less than one-half the size of D. dictyotum Eisenack, 1955.

Dictyotidium sp. 1 occurred rarely and sporadically throughout Zones I and II.

Figured specimen: OPC 856 F-3-3
32 X 28 microns

DICTYOTIDIUM SP. 2

Plate 16, figure 8

Vesicle spherical, bears low intersecting ridges, no indication of germinal apparatus; wall less than 1.0

micron in thickness, laevigate between ridges; ridges up to 1.0 micron in height, crenulate, intersect in reticulate pattern resulting in 4- to 6-sided lumen 5-8 microns in diameter; on inner surface of vesicle wall, in position corresponding to ridges, are grana approximately 0.8 micron in diameter; overall size (one specimen) 54 microns, vesicle 52 microns.

The single row of grana on the inner surface of the vesicle wall, arranged in a pattern corresponding to ridges of outer surface, typifies Dictyotidium sp. 2.

The single specimen of D. sp. 2 occurred in level 856 AK.

Figured specimen: OPC 856 AK-3-1
54 microns

Subgroup PTEROMORPHITAE

Downie, Evitt, and Sarjeant, 1963

Genus PTEROSPERMOPSIS W. Wetzel, 1952

Type species: P. danica W. Wetzel, 1952

Affinity: Unknown

PTEROSPERMOPSIS SP.

Plate 13, figure 9

Central capsule spherical, wall 2 microns thick, surface rugulate; circular equatorial flange approximately 1 micron thick, 30 microns wide, surface laevigate but with weak radial undulations; overall diameter (one specimen) 50 microns, central capsule 20 microns.

The single specimen of Pterospermopsis sp., possibly recycled from older sediments, was found in level 856 AE.

Figured specimen: OPC 856 AE-3-3
50 microns

FOSSILIS INCERTAE SEDIS

INCERTAE SEDIS A

Plate 14, figures 18, 19, 20

Shape irregular; object composed of variously compacted, coiled, anastamose, lobate muri; muri 4-11 microns in diameter, intragranular, externally laevigate; darkened central area formed by densely coiled muri is suggestive of central body; loosely coiled, occasionally branched muri emanate from and encircle central area; overall size range 55 X 46 microns to 97 X 61 microns, central area 22-32 microns.

Incertae sedis A occurred in approximately half of the samples from Zone III and in the topmost sample of Zone II.

Figured specimens: Figure 18 OPC 856 AA-1-3
97 X 61 microns

Figure 19 OPC 856 AC-6-4
59 X 46 microns

Figure 20 OPC 856 AA-2-5
55 X 46 microns

INCERTAE SEDIS B

Plate 18, figure 17

Outline subcircular, original shape probably spherical, surface irregular but laevigate, germinal apparatus not discernible; wall 4.5-6 microns in thickness, composed of three entities; inner layer undulatory, mat-like in nature, 1-1.5 microns in thickness; from inner layer arise irregularly-shaped gemmae 5-7 microns in diameter and 3.5-4 microns in height; area between gemmae only partially occupied by third wall element so that resulting outer surface is undulatory but laevigate; observed size range 86-97 microns.

Incertae sedis B undoubtedly has affinity with Tasmanites or Leiosphaeridia, but because of its unique wall structure it was not assigned to an existing genus.

Incertae sedis B occurred in five widely-separated levels from all zones of the Sand Branch. Its greatest relative abundance was 3.5 percent in level 856 S, Acritarch Interval 3 in Zone II. The distribution of this form suggests that it may be recycled.

Figured specimen: OPC 856 A-2-1
89 microns

DISCUSSION

Ecological Zonation

Based upon the ratio of marine to non-marine palynomorphs, the Sand Branch Member of the Caney Shale can be subdivided into three zones (Figure 4). Palynomorph assemblages of Zone I, the basal 35 feet, are dominated by marine palynomorphs (acritarchs). Zone II, the succeeding 65 feet, contains marine and non-marine palynomorphs that are approximately equal in number, but alternate in dominance. Assemblages of Zone III, the uppermost 106.5 feet, are dominated by non-marine palynomorphs (plant spores).

Zone I consists of levels 856 A through 856 G, and may continue downward into the underlying Delaware Creek Member. Marine palynomorphs constitute at least 95% of the assemblage in Zone I. Although plant spores occur in this zone, none were observed in 200-specimen assemblage counts in levels 856 A through 856 F. In level 856 G a single specimen of Lycospora tenebricosa was among the 200 palynomorphs counted. Dominant acritarch genera in Zone I are Leiosphaeridia (60.5% to 76.5%), Lophosphaeridium (3.5% to 19.5%), Cymatiosphaera (9.5% to 17.5%), and Michrystridium

(2.5% to 8.5%). Dictyotidium, Baltisphaeridium, and Veryhachium are rare. Tasmanites was not found in Zone 1, but it may be present.

Zone II, levels 856 H through 856 T, represents the cyclic transition from Zone I to Zone III. Zones I and III are dominated by acritarchs and plant spores, respectively, whereas in Zone II these forms are equally represented, but each is alternately dominant in three intervals. The three intervals dominated by acritarchs in Zone II are designated as acritarch intervals. In the lower acritarch interval of Zone II, levels 856 H and 856 I, dominant genera are Leiosphaeridia (56%), Cymatiosphaera (8% to 12%), Lophosphaeridium (5.5% to 12%), Veryhachium (5.5% to 9%), and Michrystridium (3% to 4%). Tasmanites is absent from this lower interval. The middle acritarch interval, levels 856 M through 856 P, is dominated by Leiosphaeridia (40.5% to 69%), Veryhachium (2.5% to 16.5%), Cymatiosphaera (6% to 11%), Lophosphaeridium (4% to 9%), and Michrystridium (3% to 8.5%). Tasmanites varies in abundance from 2% to 4%. The single sample 856 S represents the upper acritarch interval. Dominant genera are Leiosphaeridia (26.5%), Lophosphaeridium (25%), and Tasmanites (15.5%). Incertae sedis B forms 3.5% of the assemblage. Cymatiosphaera and Veryhachium comprise 1.5% and 2% of the assemblage, respectively. The top of Zone II is marked by the final continuous occurrence in the Sand Branch Member of abundant marine palynomorphs.

Zone III includes the upper 82.5 feet of Sand Branch strata exposed at the type locality (levels 856 U through 856 AR), and the 24 feet of uppermost Sand Branch exposed on Sandy Creek (OPC 912, 913, and 914). Plant spores are the dominant palynomorphs in assemblages from Zone III. Except for a low of 20.5% in level 856 AK, plant spores comprise 68.5% to 98% of the palynomorphs in assemblages from Zone III.

It is proposed herein that the 100 feet of sediments that comprise Zones I and II of the Sand Branch Member represent the final Mississippian environment in the Ardmore and southern Anadarko basins that was conducive to growth of abundant marine palynomorphs for a prolonged period of time. This environment may have migrated to another part of the basin during late Sand Branch or early Goddard time, but, if so, it apparently disappeared shortly thereafter. Wiggins (1962) reported only a few acritarchs from the lower portion of the type section of the Goddard Shale, but some or all of these may be recycled from the Sylvan and Woodford Formations. It is possible, then, that the environment which supported abundant acritarchs in early Sand Branch time was destroyed before late Sand Branch-early Goddard time. The dominant role in palynomorph assemblages assumed by plant spores in late Sand Branch time (Zone III) appears to have continued through Goddard and Springer times into the Pennsylvanian. Additional palynological studies of Mississippian and Pennsylvanian

clastics in southern Oklahoma are needed to test this theory.

All samples collected at the Sand Branch type locality, with the exception of samples 856 AD through 856 AR, were 5-foot channel samples. Samples 856 AD through 856 AR were 2.5-foot channel samples. In order to establish a control interval of five feet through the interval 856 AD through 856 AR, the percentages of acritarchs in adjacent 2.5-foot channel samples in this interval were averaged. The percentage figures thus obtained are assumed to represent the percentage of acritarchs in consecutive 5-foot intervals between samples 856 AD and 856 AR, and are connected by the dashed line on Figure 4. The solid line on Figure 4 represents the percentage of acritarchs in the channel samples actually collected. The latter percentage was determined from counts of 200 palynomorphs per slide. In interval 856 AD through 856 AR the percentage curve for the actual 2.5-foot channel samples possesses the greater maximum variation, as well as the greater sample to sample variation. Conversely, the peaks (high and low extremes) of the percentage curve for the calculated 5-foot samples are reduced, and the configuration of this curve is in closer agreement with that of the curve for the actual 5-foot channel samples throughout the remainder of the section studied.

The subdued nature of the percentage curve for the 5-foot samples from 856 AD through 856 AR is obviously the

result of reducing extremes by averaging. Not so obvious, however, is the inference that should be made from the difference between the 2.5-foot and 5-foot percentage curves. That is, samples of different thickness, although from the same interval and locality, may yield significantly different palynomorph percentages. Appreciation of this simple principle is of utmost importance to the petroleum palynologist who must at times correlate sidewall or conventional cores varying in thickness from one inch to several feet with drill stem cuttings that are commonly composited in intervals of thirty feet or more.

Recycled Palynomorphs

Recycled palynomorphs comprise only a small percentage of the palynomorphs recovered from the Sand Branch Member of the Caney Shale. Palynomorph assemblages from Zone I samples contained few palynomorphs known to be recycled. This should not be surprising, however, in view of the limited number (0% to .5%) of plant spores in assemblages from Zone I. Such a low percentage of plant palynomorphs suggests that the site of deposition of Zone I sediments was effectively isolated from terrigenously derived palynomorphs, including recycled forms. The abundance (99.5% to 100%) and perfect preservation of acritarchs in Zone I suggest that these forms were not recycled.

Palynomorph assemblages of Zones II and III of the Sand Branch Member contain recycled acritarchs that appear to have been derived from the Sylvan and Woodford Formations. These recycled forms are rare in Zone II but become increasingly abundant upward through Zone III. Tasmanites sp. 1 is considered to be a recycled Woodford species, as is the single specimen of Quisquilites buckhornensis from sample 856 AR. Leiosphaeridia sp. 3 and L. sp. 4 are similar to species in the Woodford and Sylvan Formations and are apparently recycled. Tasmanites sp. 3, T. sp. 4, and related form Incertae Sedis B may be recycled. Baltisphaeridium brevispinosum, B. longispinosum, and B. sp. 1, all rare in upper Sand Branch strata, are considered to be recycled. Species with similar morphology have been reported by Hedlund (1960) from the Sylvan Shale, and by Urban (1960) from the Woodford Shale. Dictyotidium sp. 2 may be recycled, but its parent formation is unknown.

The appearance in the Sand Branch of recycled Woodford and Sylvan acritarchs indicates that rocks at least as old as the Sylvan (Late Ordovocian) and as young as the Woodford (Late Devonian) were being eroded and were contributing sediments to the Sand Branch sea.

All plant palynomorphs described herein are considered to be in situ. However, future palynological investigations of pre-Sand Branch sediments may prove the Sand Branch palynomorph assemblage to contain a minor percentage of recycled Woodford (and possibly Sylvan) plant palynomorphs.

Comparison and Age of Sand Branch Palynomorph Assemblage

Comparison of the Sand Branch palynomorph assemblage with similar assemblages reported from North America, Russia, and Europe indicates for the Sand Branch Member of the Caney Shale Formation an age of Late Mississippian (Early to Middle Chesterian); or, in terms of the European classification, Late Viséan to earliest Namurian. Occurrences in the Sand Branch of genera and species considered to be most pertinent to this assemblage comparison are discussed below (taxa are considered in approximate order of decreasing age):

The genus Retusotriletes (Naumova, 1953) appears to have attained maximum speciation and geographic distribution in Middle to Late Devonian time. The genus has been reported from Canada, Europe, and Russia. Species of this genus are characterized by strong depression of the areas separating the trilete rays. Sand Branch specimens assigned to Retusotriletes possess weak proximal depressions, and thus may represent a species near the end of the lineage of this genus. Sand Branch specimens are referred to a single species, Retusotriletes sp., which occurs no higher than ten feet above Zone II....the form may be recycled.

Punctatisporites irrasus Hacquebard, 1957, was described from beds of probable Tournaisian age in Nova Scotia, Canada. In the Sand Branch, P. irrasus was found

in all samples of Zones II and III, excepting sample 856 H, the basal sample of Zone II.

Spore type C appears to be conspecific with Spore type 1 Love, 1960 (Viséan, Scotland); Genus A sp. 2 Wiggins 1962 (Goddard Formation); and Lophotriletes labiatus Sullivan, 1964 (probable Westphalian A, England). Spore type C appeared in many samples in the interval 856 X through 912 A of Zone III.

Playford (1962) described Foveosporites insculptis and Reticulatisporites peltatus from a Late Viséan to earliest Namurian Murospora aurita assemblage of Spitzbergen. Foveosporites insculptis occurs sporadically throughout the Sand Branch, but attains maximum abundance above and below the boundary separating Zones II and III. Reticulatisporites peltatus appeared in three samples in the upper one-fourth of Zone III.

Other than the assemblage from the Goddard Formation, the assemblage most closely approximating in age that of the Sand Branch was described by Staplin (1960) from the Lower Chesterian Golata Formation of Alberta, Canada. Among the Golata species found in the Sand Branch are Phyllothecotriletes golatensis, Punctatisporites atrifucatus, Reticulatisporites exiguus var. A., and Endoculeospora rarigranulata var. densigranulata, all established by Staplin, 1960. In the Sand Branch, Phyllothecotriletes golatensis is one of the most persistent species in Zones

II and III; Punctatisporites atrifucatus occurs in the upper two-thirds of Zone III; single specimens of Endoculeospora rarigranulata var. densigranulata were observed in four samples in the upper one-half of Zone III; and Reticulatisporites exiguus var. A occurs in the upper one-half of Zone III, and is represented by a single specimen in sample 856 J, near the base of Zone II.

The genus Secarisporites was described by Neves (1961) from Namurian A strata of England. Species of the genus have been reported subsequently from beds as old as Viséan (Sullivan and Marshall, 1962). Secarisporites is represented in the Sand Branch by two species, both considered as new. Each occurs in the upper one-fourth of Zone II and throughout Zone III, and attains maximum abundance in the uppermost twenty feet of the Sand Branch sequence at the type locality.

Neves (1958) described the genus Proprisporites from the Namurian A Gastrioceras subcrenatus horizon of North Staffordshire, England. One of Neves' species, P. laevigatus, was found in each of the four youngest Sand Branch samples collected.

Hoffmeister, Staplin, and Malloy (1955) described, among other species, Auroraspora solisortus and Grandispora spinosa from the Chesterian Hardinsburg Formation in Illinois and Kentucky. Both species were discovered in the Goddard Formation by Wiggins (1962), who considered

Grandispora to be the most reliable stratigraphic marker palynomorph in the Goddard. Grandispora was found in only two samples in the Sand Branch, samples 856 AJ and 856 AN, directly above the middle of Zone III. Auroraspora solisortus occurs throughout Zones II and III, and in samples near the middle of Zone III may comprise up to 11% of the assemblage.

Rotaspora fracta and Tripartites vestustus, described by Schemel (1950) from a coal of probable Meramecian to Chesterian age in Utah, are also present in the Hardinsburg and Goddard assemblages. Wiggins (1962) noted that these two species occurred throughout the Goddard Shale and that their abundance varied proportionately with that of Densosporites. Rotaspora fracta was found in levels 856 W (0.5%) and 856 X (present) in the Sand Branch. Tripartites cf. T. vestustus was observed in levels 856 W and 856 AA, but the species did not occur therein in assemblage counts.

Correlation of the Sand Branch Member of the Caney Shale with the Goddard Formation

Comparison of Sand Branch and Goddard palynomorph assemblages suggests that the upper part of the Sand Branch (most of Zone III) as presently defined, is coeval with the lower part of the type section of the Goddard. Precise correlation is hindered by the lack of a palynomorph range chart for the Goddard Formation, and by the fact that the

Sand Branch represents a more marine facies than does the Goddard.

Ensuing remarks concerning the palynomorphs of the Goddard Formation have reference to the palynological study of the Goddard type section made by Wiggins (1962).

Perotrilites sp. 1 in the Sand Branch is conspecific Punctatisporites cerosus Hoffmeister, Staplin, and Malloy, 1955 and Perotrilites cerosus in Wiggins, 1962. According to Wiggins, Perotrilites cerosus is abundant throughout the Goddard. Its Sand Branch equivalent, P. sp. 1, occurs in all samples in Zones II and III, and is the second most abundant species in the Sand Branch sequence. P. sp. 1 may prove to be an index palynomorph for Lower and Middle Chesterian strata of the Mid-Continent region.

Ibrahimispores spp. are characteristic of the upper one-third of Zone III of the Sand Branch, although a single specimen was found in level 856 X, near the base of Zone III. Wiggins (1962, Pl. 7, figs. 4-6) illustrated four similar species from the lower 40 feet of the Goddard sequence as Hymenozonotriletes (possibly recycled from the Devonian).

Reticulatisporites peltatus occurs in three samples in the upper one-fourth of the Sand Branch. The specimen illustrated by Wiggins (1962, Pl. 11, figs. 3-4) from approximately the middle of the Goddard as Spore type K sp. 1 is conspecific.

Wiggins (1962, Pl. 14, fig. 5,) illustrated Genus F from a horizon approximately 200 feet above the base of the

Goddard. This Goddard form closely resembles Secarisporites sp. 2 from the upper part of Zone III in the Sand Branch; the two forms may be conspecific.

The specimen designated by Wiggins (1962, Pl. 3, figs. 3-4) as Genus A sp. 2 from a horizon approximately in the middle of the Goddard is conspecific with Spore type C from Zone III of the Sand Branch.

Of three species of Rotaspora that Wiggins reported as ranging throughout the Goddard, only one of these, Rotaspora fracta, was present in the Sand Branch, and it was found in only two samples, 856 W (0.5%) and 856 X (present, but not included in assemblage count).

CONCLUSIONS

1. The Sand Branch Member of the Caney Shale Formation contains an abundant palynomorph assemblage of marine acritarchs and nonmarine plant spores. The acritarch assemblage in the Sand Branch may be the largest reported to date from rocks of Mississippian or Pennsylvanian age.

2. Relative percentages of marine acritarchs and nonmarine plant spores afford a tripartite zonation of the Sand Branch Member of the Caney Shale Formation. The palynomorph assemblage in the lower zone, Zone I, consists of 99.5% to 100% acritarchs, and suggests that sediments of Zone I represent a continuation of the underlying Delaware Creek Member. The top of Zone I forms a practical subdivision, for the palynologist, between the Sand Branch and Delaware Creek Members of the Caney Shale Formation.

3. Recycled palynomorphs, similar to *in situ* species in the Woodford and Sylvan Formations, comprise a minor percentage of the Sand Branch palynomorph assemblage. They are rare in the lower part of the Sand Branch, and become increasingly abundant through upper Sand Branch strata. Their presence in the Sand Branch Member of the

Caney Shale Formation indicates that rocks at least as old as Late Ordovician and as young as Late Devonian contributed sediments to the Sand Branch sea.

4. Comparison of the Sand Branch palynomorph assemblage with similar assemblages reported from North America, Russia, and Europe indicates for the Sand Branch Member of the Caney Shale Formation an age of Late Mississippian (early to middle Chesterian); or, in terms of the European classification, Late Viséan to earliest Namurian.

5. Comparison of the palynomorph assemblage from the Sand Branch Member, as currently defined, with that of the Goddard Formation suggests that the upper part of the Sand Branch (most of Zone III), is coeval with strata comprising the lower part of the Goddard type section.

TYPE SECTION OF SAND BRANCH M
(182.5 FEET)

		Michrystridium stellatum	M. sp. 1	M. sp. 2	Lophosphaeridium sp. 1	L. sp. 2	L. sp. 3	L. sp. 4	L. sp. 5	Baltisphaeridium longispinosum	B. brevispinosum	B.? cf. B. dilatispinosum	B.? cf. B. traumaticum	B. sp. 1	B.? sp. 2	B.? sp. 3	Veryhachium sp.	Leiosphaeridia sp. 1	L. sp. 2	L. sp. 3	L. sp. 4	L. sp. 5	L. sp. 6	Tasmanites sp. 1	T. sp. 2	T. sp. 3	T. sp. 4	T. sp. 5	Quisquilites buckhornensis	Incertae sedis B	Cymatiosphaera pavimentum	C. sp. 1	C. sp. 2	C. sp. 3	C. sp. 4
	U																	3.5							3.5							.5			
	T					1.5		1.5	3								1.5	3	17			2.5			4.5										
	S				1	6		10	8								2	11	10			4	1.5	1	12	1		1.5		3.5	1			.5		
	R							4									1	2	8		.5	.5	.5		1.5	4.5						.5			
	Q							1.5										6	3			P													
	P	.5	1.5	1	1.5	5.5		2									2.5	22.5	43.5	P	P	3			.5	P		3.5			.5	8.5			
	O	1.5	1.5			4		4			P						8.5	18	42		P	1.5			2.5	P	P	1.5			1	8	.5	.5	
	N	6	2.5			1.5	.5	2									9.5	15.5	18			6.5	.5		2.5		.5				.5	7			
	M	4	4			1	1.5	3.5									16.5	16.5	23			2			1.5			.5			.5	5	.5		
	L	2.5				.5		1									2	11.5	13			2			2.5						1	7.5			
	K	1				3.5		4									1.5	7	10.5			6			1.5						2				
	J	.5		.5		3.5		2									1.5	8	6.5			3						1.5		.5	8.5				
	I	1.5	2.5		1.5	1.5	.5	2									9	18	34.5			1.5	.5									7.5		.5	
	H	.5	2.5		.5	2	1.5	8	P								5.5	18.5	32	P		2.5	4								P	11			
	G	1	3.5	1	P	3	.5	3						.5				22.5	38.5			4	1.5								1	8.5	.5	.5	
	F	.5	5	.5		.5	1	1.5	.5				P				.5	22.5	38.5			8	2.5								2	14.5	.5	.5	
	E	2	6	.5		2	.5	3.5	.5			P			P			22	40.5			7	4.5									5.5	1.5	2	
	D		7	P	.5	4	.5	10	.5					P				26	30.5			4.5	3								1.5	12		P	P
	C		5		1	7.5	1	8.5	1.5									25.5	28			4	3								.5	14.5			
	B	.5	3.5		.5	4.5	1.5	10.5	1.5									23.5	25.5			7.5	6									14			.5
OPC 856	A*		1.5	1	.5	1.5	2.5	14	1									24	25		.5	6	5.5							P	1	15.5			.5
	ACRITARCH SPECIES																																		

* *Channel sample thickness:*
OPC 914A, 4 feet, OPC 912 and 913, 5 feet each
OPC 856 AR to 856 AD, 2.5 feet each, OPC 856 AC to 856 A, 5 feet each

'P'=*Present in sample but not in 200 specimens counted*

FIGURE 3. DISTRIBUTION OF ACRITARCHS IN SAND BRANCH MEMBER OF THE CA
DISTRIBUTION RECORDED AS PERCENTAGES OF 200-PALYNOMORPH PER SAMPLE COUNT

SAMPLE LOCALITIES AND DESIGNATION			RELATIVE PERCENTAGE OF SPECIES																														
SANDY CREEK (24 FEET)	914	A							1							1.5		.5	1	.5												2	
	OPC 913	B							1.5	.5									.5														
		A							3						2				1.5			2											
	OPC 912	B							.5				P						.5		1	1					.5						
		A																				2.5											
TYPE SECTION OF SAND BRANCH MEMBER (182.5 FEET)	OPC 856	AR																			.5	2				P							
		AQ																			.5	1			.5								
		AP													.5							2											
		AO										P					.5		.5			2											
		AN									P		P		.5		1		4.5			2.5											
		AM																1.5	2		.5	4											
		AL							1.5						1.5	2	.5		1.5	1		8.5					1				1		
		AK					1		13	8					5.5	8		1.5	8	1	1.5	26.5	1.5	1	2			.5	.5				
		AJ							.5			.5			2	.5				.5		2			.5								
		AI					1		4.5						6	9	.5	.5	3			6									1		
		AH				5									1	.5						1											
		AG				.5									2				1.5			1.5	.5						.5		.5		
		AF																.5				1	.5		.5								
		AE														.5						2											
		AD													.5	1.5						2	1.5										
		AC							1.5						1.5	1			2			7.5	.5										
		AB							6						6		.5		.5			4.5											
		AA							.5	.5					2.5				.5			2.5											
		Z																				2.5											
		Y							4	3.5					2.5	5.5						6.5	1.5										
		X					.5		2	3						.5			1.5			5.5											
		W							.5	.5									.5		P	.5											
		V							1.5	6.5										.5	1.5	3		1					.5				
		U													3.5							3.5											
		T					1.5		1.5	3				1.5	3	17			2.5			4.5											
		S				1	6		10	8				2	11	10			4	1.5	1	12	1		1.5		3.5	1			.5		
		R							4					1	2	8		.5	.5	.5		1.5	4.5						.5				
		Q							1.5						6	3			P														
		P	.5	1.5	1	1.5	5.5		2					2.5	22.5	43.5	P	P	3			.5	P		3.5			.5	8.5				
		O	1.5	1.5			4		4			P		8.5	18	42		P	1.5			2.5	P	P	1.5			1	8	.5	.5		1
		N	6	2.5			1.5	.5	2					9.5	15.5	18			6.5	.5		2.5		.5				.5	7				

Lophosphaeridium sp. 1	*L. sp. 2*	*L. sp. 3*	*L. sp. 4*	*L. sp. 5*	*Baltisphaeridium longispinosum*	*B. brevispinosum*	*B.? cf. B. dilatispinosum*	*B.? cf. B. traumaticum*	*B. sp. 1*	*B.? sp. 2*	*B.? sp. 3*	*Verythachium sp.*	*Leiosphaeridia sp. 1*	*L. sp. 2*	*L. sp. 3*	*L. sp. 4*	*L. sp. 5*	*L. sp. 6*	*Tasmanites sp. 1*	*T. sp. 2*	*T sp. 3*	*T. sp. 4*	*T. sp. 5*	*Quisquilites buckhornensis*	*Incertae sedis B*	*Cymatiosphaera pavimentum*	*C. sp. 1*	*C. sp. 2*	*C. sp. 3*	*C. sp. 4*	*C. sp. 5*	*C. sp. 6*	*C. sp. 7*	*Dictyotidium sp. 1*	*D. sp. 2*	*Pterospermopsis sp.*	
			1.5	6.5													.5		1.5	3																	
													3.5						3.5																		
	1.5		1.5	3								1.5	3	17			2.5		4.5																		
1	6		10	8								2	11	10			4	1.5	1	12	1		1.5		3.5	1		.5								ACRITARCH INTERVAL 3
			4									1	2	8		.5	.5	.5		1.5	4.5						.5									
			1.5										6	3			P																			
1.5	5.5		2									2.5	22.5	43.5	P	P	3			.5	P		3.5			.5	8.5					.5				ACRITARCH INTERVAL 2
	4		4			P						8.5	18	42		P	1.5			2.5	P	P	1.5			1	8	.5	.5		1					
	1.5	.5	2									9.5	15.5	18			6.5	.5		2.5		.5				.5	7									ZONE II
	1	1.5	3.5									16.5	16.5	23			2			1.5			.5			.5	5	.5					.5		
	.5		1									2	11.5	13			2			2.5						1	7.5						.5		
	3.5		4									1.5	7	10.5			6			1.5						2									
	3.5		2									1.5	8	6.5			3						1.5		.5	8.5									
1.5	1.5	.5	2									9	18	34.5			1.5	.5									7.5		.5						ACRITARCH INTERVAL 1
.5	2	1.5	8	P								5.5	18.5	32	P		2.5	4								P	11				1		1.5		
P	3	.5	3						.5				22.5	48.5			4	1.5								1	8.5	.5	.5							
	.5	1	1.5	.5			P					.5	22.5	38.5			8	2.5								2	14.5	.5	.5			P		1		
	2	.5	3.5	.5		P				P			22	40.5			7	4.5									5.5	1.5	2			.5		1.5		ZONE I
.5	4	.5	10	.5					P				26	30.5			4.5	3								1.5	12		P	P					
1	7.5	1	8.5	1.5									25.5	28			4	3								.5	14.5								
.5	4.5	1.5	10.5	1.5									23.5	25.5			7.5	6									14			.5				.5	
.5	1.5	2.5	14	1									24	25		.5	6	5.5							P	1	15.5			.5					

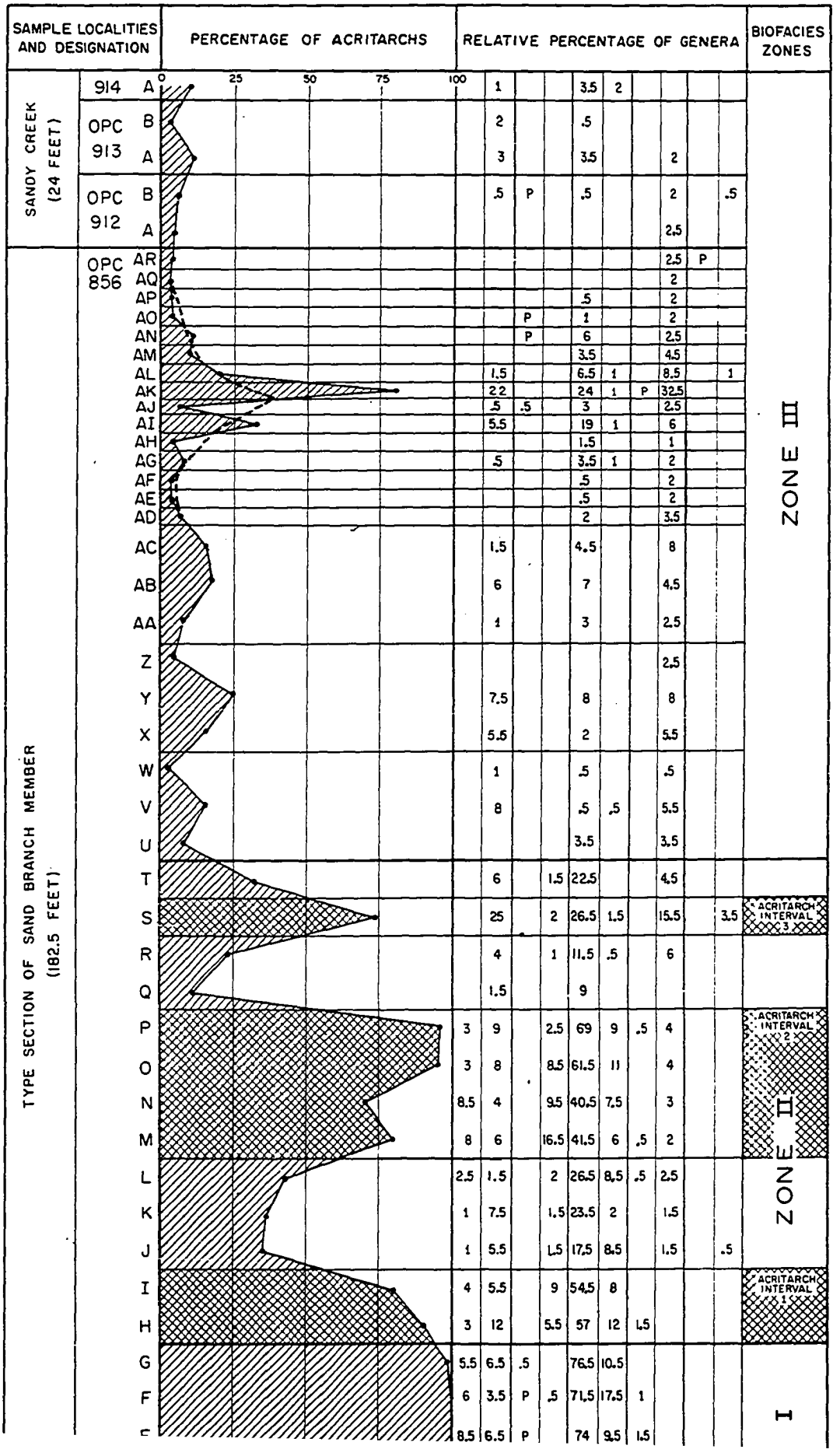
by R. W. Harris, Jr.

13, 5 feet each
ach, OPC 856 AC to 856 A, 5 feet each

pecimens counted

3. DISTRIBUTION OF ACRITARCHS IN SAND BRANCH MEMBER OF THE CANEY SHALE
DISTRIBUTION RECORDED AS PERCENTAGES OF 200-PALYNOMORPH PER SAMPLE COUNT

RELATIVE PERCENTAGE OF SPECIES																																BIOFACIES ZONES
			1							1.5		.5	1	.5												2						ZONE III
			1.5	.5									.5																			
			3						2				1.5			2																
			.5				P						.5		1	1					.5											
																2.5																
															.5	2				P												
															.5	1			.5													
									.5							2																
						P					.5		.5			2																
					P		P		.5		1		4.5			2.5																
												1.5	2		.5	4																
			1.5						1.5	2	.5		1.5	1		8.5					1				1							
	1		13	8					5.5	8		1.5	8	1	1.5	26.5	1.5	1	2			.5	.5					P		P		
			.5			.5			2	.5				.5		2			.5													
	1		4.5						6	9	.5	.5	3			6									1							
5									1	.5						1																
.5									2				1.5			1.5	.5						.5		.5							
												.5				1	.5		.5													
										.5						2															P	
									.5	1.5						2	1.5															
			1.5						1.5	1			2			7.5	.5															
			6						6		.5		.5			4.5																
			.5	.5					2.5				.5			2.5																
																2.5																
			4	3.5					2.5	5.5						6.5	1.5															
	.5		2	3						.5			1.5			5.5																
			.5	.5									.5		P	.5																
			1.5	6.5										.5	1.5	3		1					.5									
									3.5							3.5																
	1.5		1.5	3				1.5	3	17			2.5			4.5																
1	6		10	8				2	11	10			4	1.5	1	12	1		1.5		3.5	1			.5							ACRITARCH INTERVAL 3
			4					1	2	8		.5	.5	.5		1.5	4.5						.5									
			1.5						6	3			P																			
1.5	5.5		2					2.5	22.5	43.5	P	P	3			.5	P		3.5			.5	8.5						.5			ACRITARCH INTERVAL 2
	4		4			P		8.5	18	42		P	1.5			2.5	P	P	1.5			1	8	.5	.5		1					
	1.5	.5	2					9.5	15.5	18			6.5	.5		2.5	[illegible]					[illegible]	[illegible]									II


SAMPLE LOCALITIES AND DESIGNATION
PERCENTAGE OF ACRITARCHS
RELATIVE PERCENTAGE OF GENERA
BIOFACIES ZONES
0
25
50
75
100
SANDY CREEK (24 FEET)
914 A
OPC 913 B
OPC 913 A
OPC 912 B
OPC 912 A
TYPE SECTION OF SAND BRANCH MEMBER (182.5 FEET)
OPC 856 AR
AQ
AP
AO
AN
AM
AL
AK
AJ
AI
AH
AG
AF
AE
AD
AC
AB
AA
Z
Y
X
W
V
U
T
S
R
Q
P
O
N
M
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ZONE III
ACRITARCH INTERVAL 3
ACRITARCH INTERVAL 2
ZONE II
ZONE I
ACRITARCH INTERVAL 1

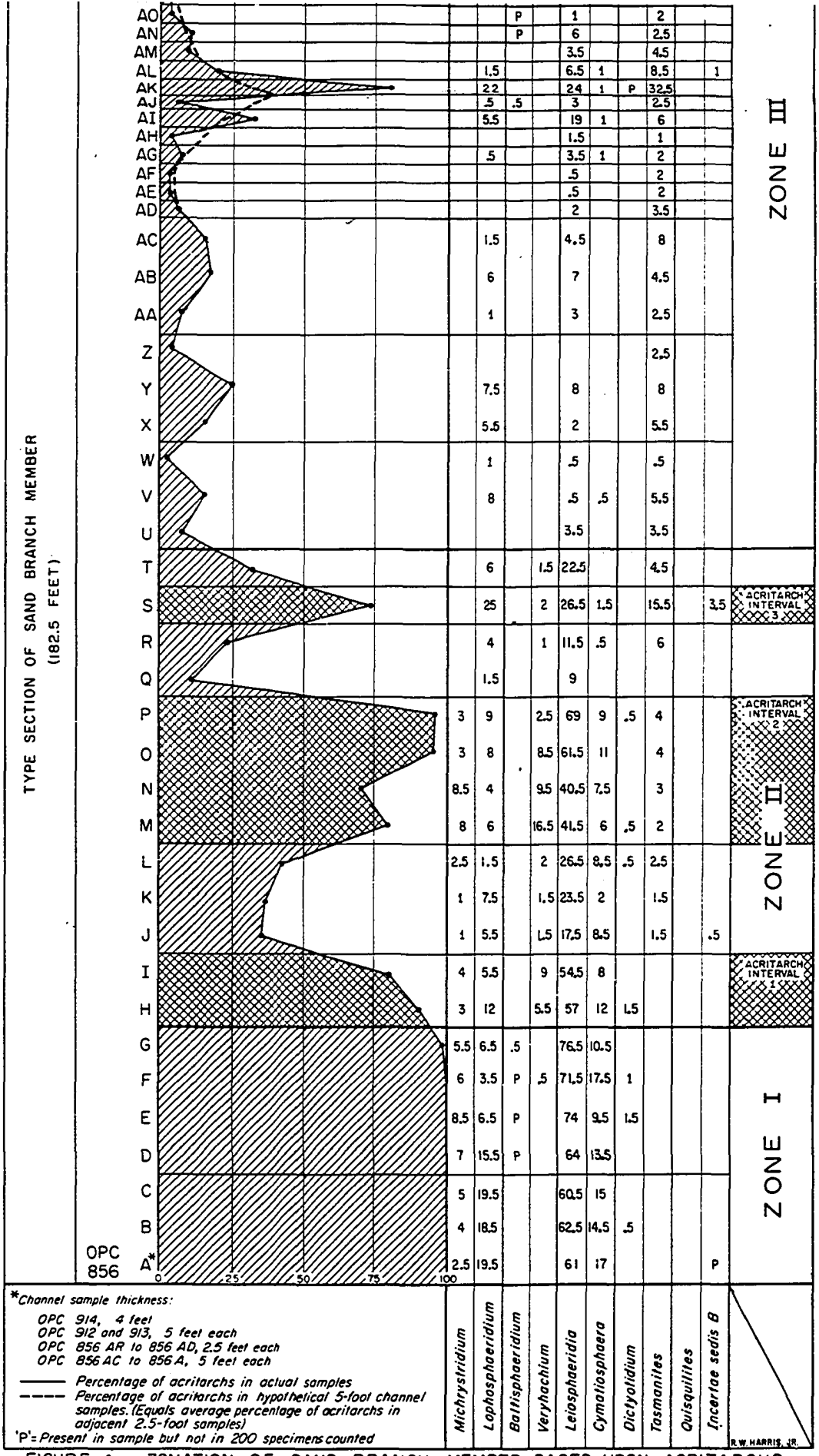

FIGURE 4. ZONATION OF SAND BRANCH MEMBER BASED UPON ACRITARCHS

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APPENDIX

PLATE 1

PLATE I

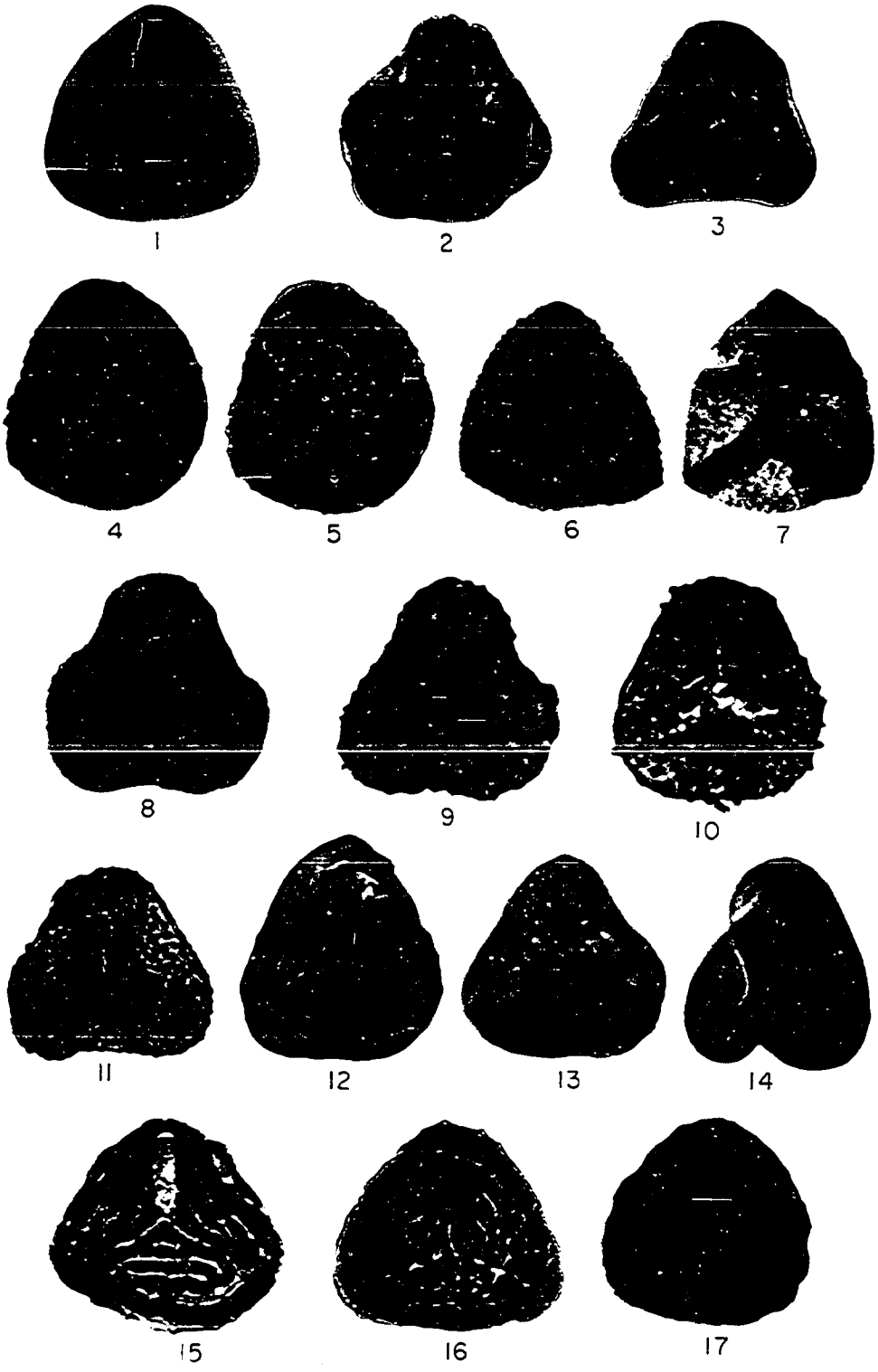

PLATE 2

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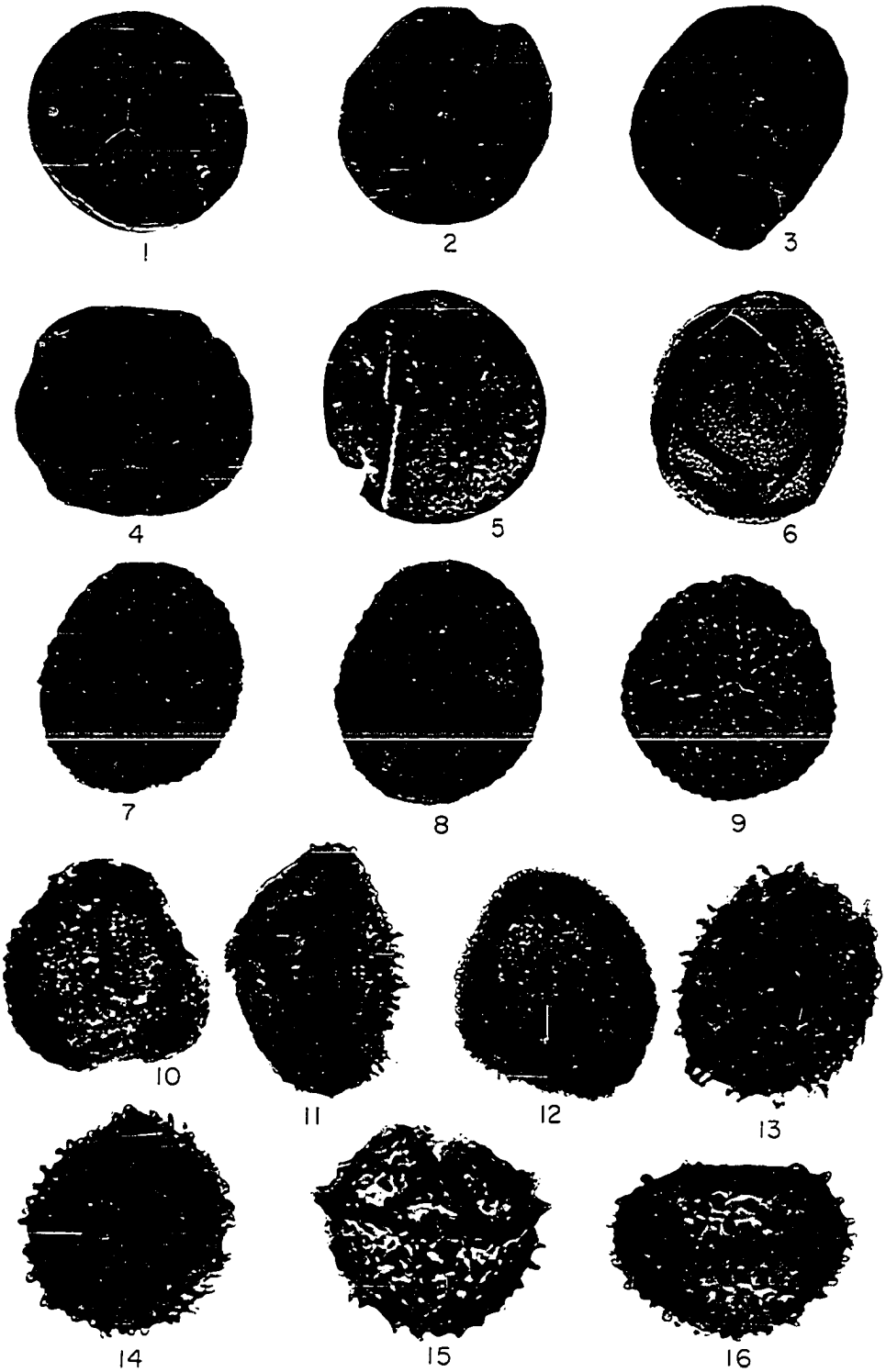


PLATE 3

Figure — Page

1,2. Grandispora spinosa H., S., and M., 1955. . . . 89
82 X 74 microns overall, central body 51 microns OPC 856 AN-1-3
(1) proximal focus (2) equatorial focus

3. Grandispora sp. 90
84 X 80 microns OPC 856 AN-1-1

4. Ibrahimispores sp. 1 32
84 X 78 microns overall, spore body 67 microns OPC 856 AR-8-2

5,6. Ibrahimispores brevispinosus Neves, 1961 . . . 30
80 microns overall, spore body 57 microns OPC 913 A-5-2

7,9. Ibrahimispores microhorridus Artüz, 1957 . . . 31
(7) 96 X 85 microns overall, spore body 64 microns; polar view OPC 856 AQ-5-3
(9) 91 X 76 microns overall, spore body 66 microns; semi-equatorial view OPC 912 B-5-1

8. Ibrahimispores sp. 2 32
89 X 76 microns overall, spore body 66 microns; equatorial view OPC 856 AN-3-2

10. Ibrahimispores magnificus Neves, 1961 31
76 X 72 microns overall, spore body 60 X 58 microns; equatorial view OPC 912 B-5-3

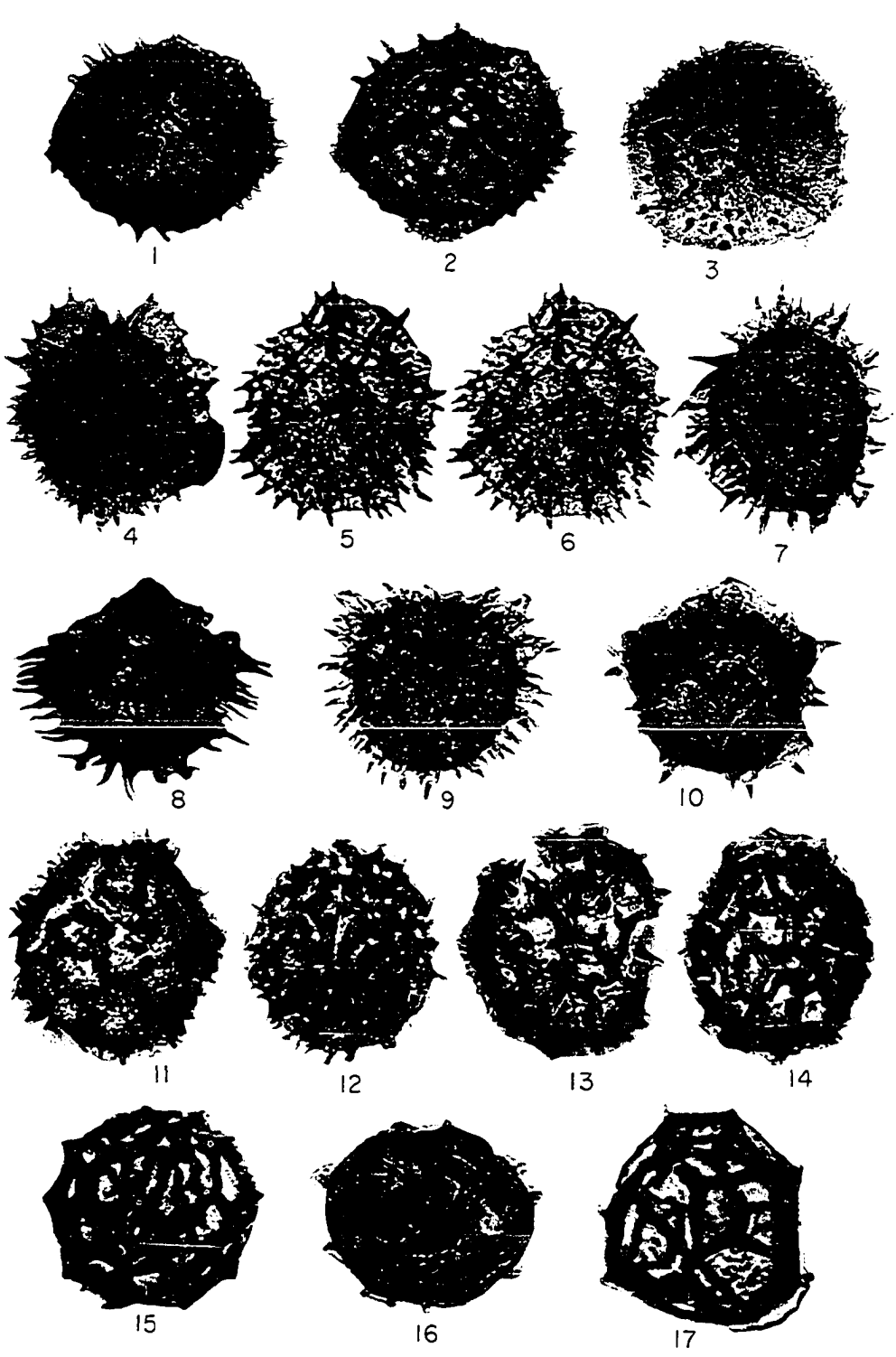
11. Reticulatisporites sp. 1 61
64 X 61 microns overall, spore body 59 X 54 microns OPC 856 T-3-1

12. Reticulatisporites exiguus var. A Staplin, 1960 58
50 X 49 microns overall, spore body 46 X 44 microns OPC 856 J-2-1

13. Reticulatisporites cf. F? fimbriatus Winslow, 1962 60
60 microns overall, spore body 56 microns OPC 856 T-2-1

PLATE 3--Continued.

PLATE 3



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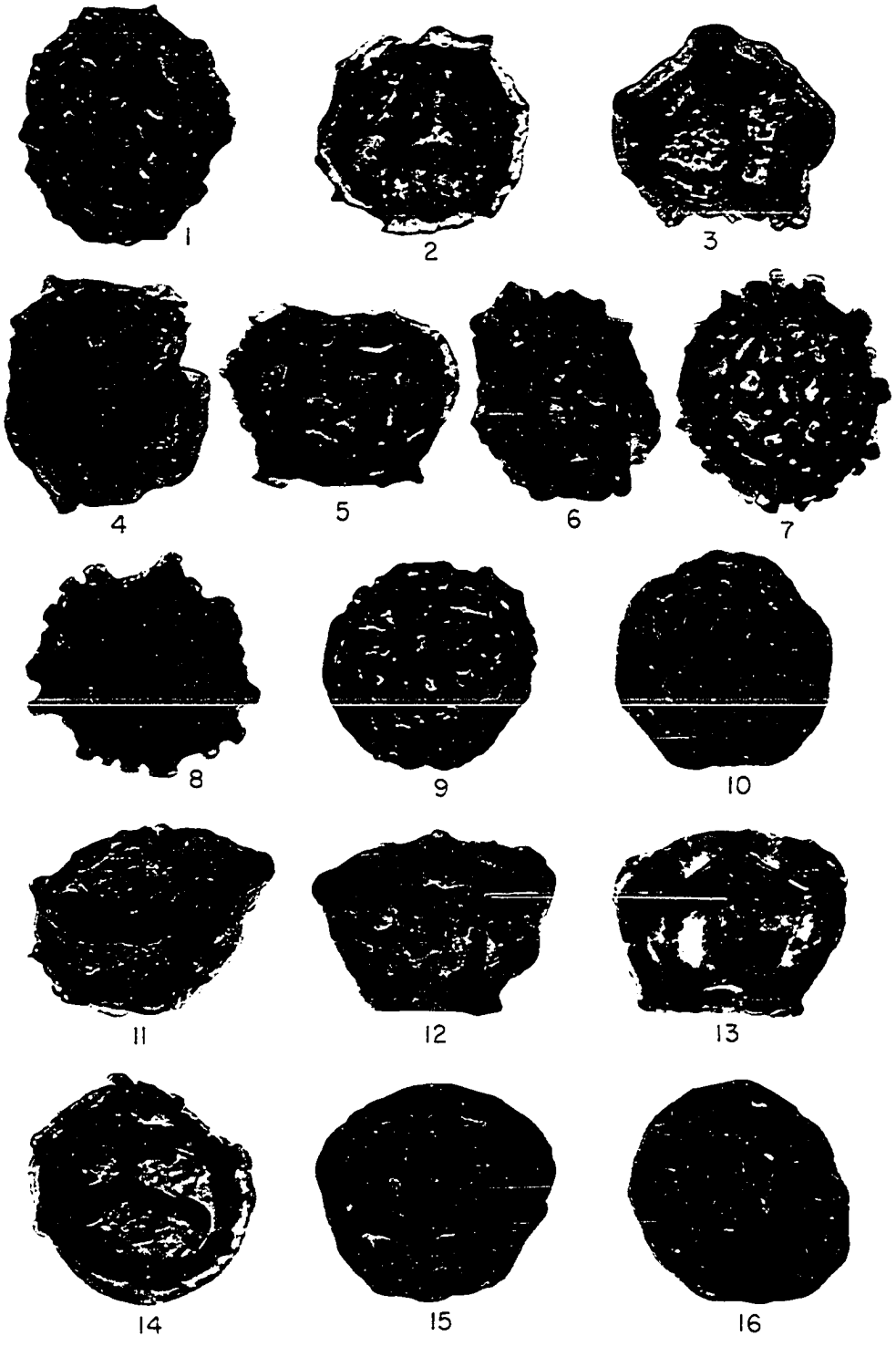

PLATE 5

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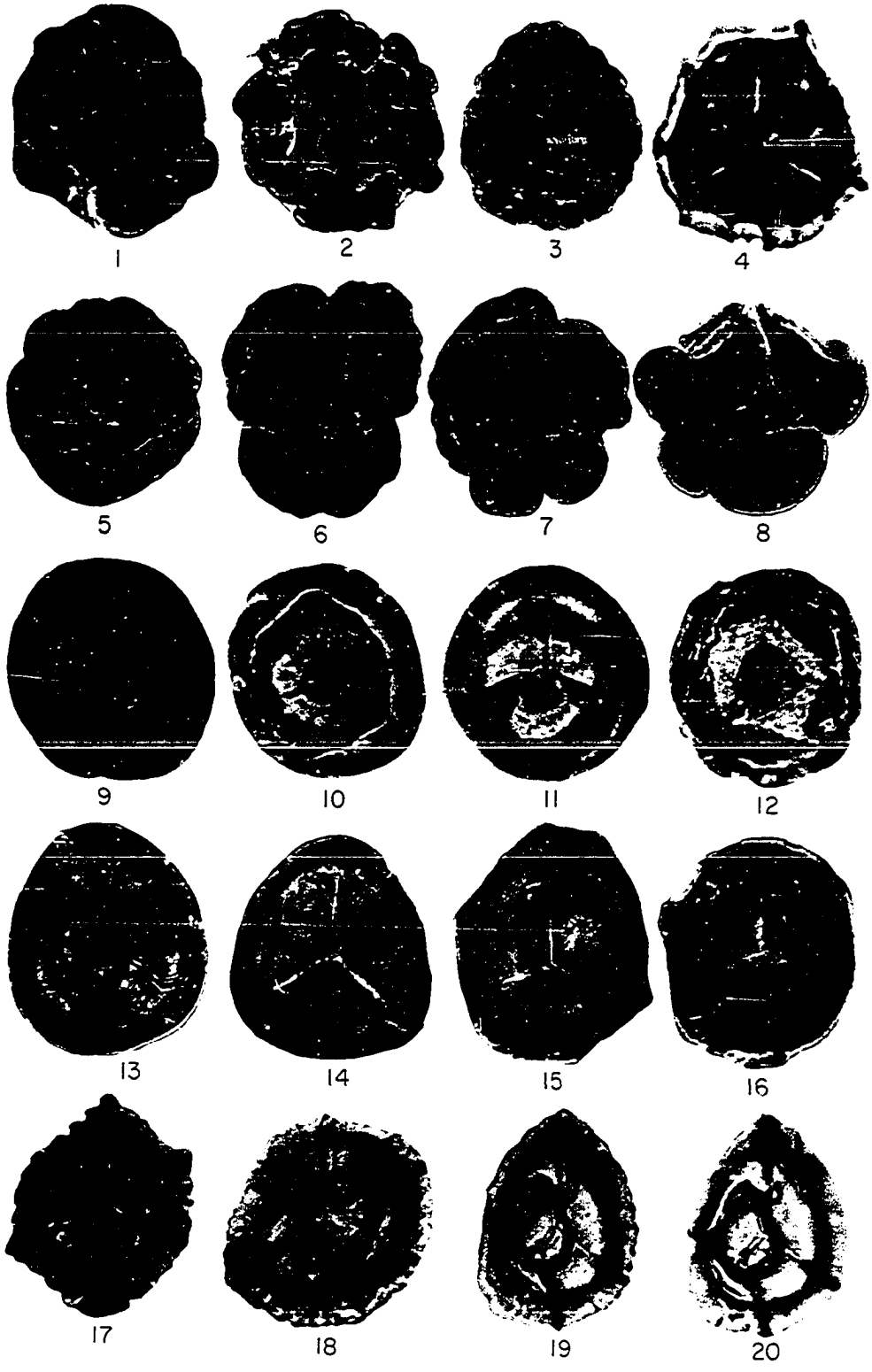

PLATE 6

PLATE 6--Continued.

Figure		Page
16-18.	Proprisporites laevigatus Neves, 1961 . . . . (16,17) 74 X 69 microns overall, spore body 69 X 64 microns OPC 913 A-2-1 (16) high focus (17) low focus (18) 86 X 70 microns overall, spore body 75 X 66 microns OPC 913 A-5-3	79

PLATE 6

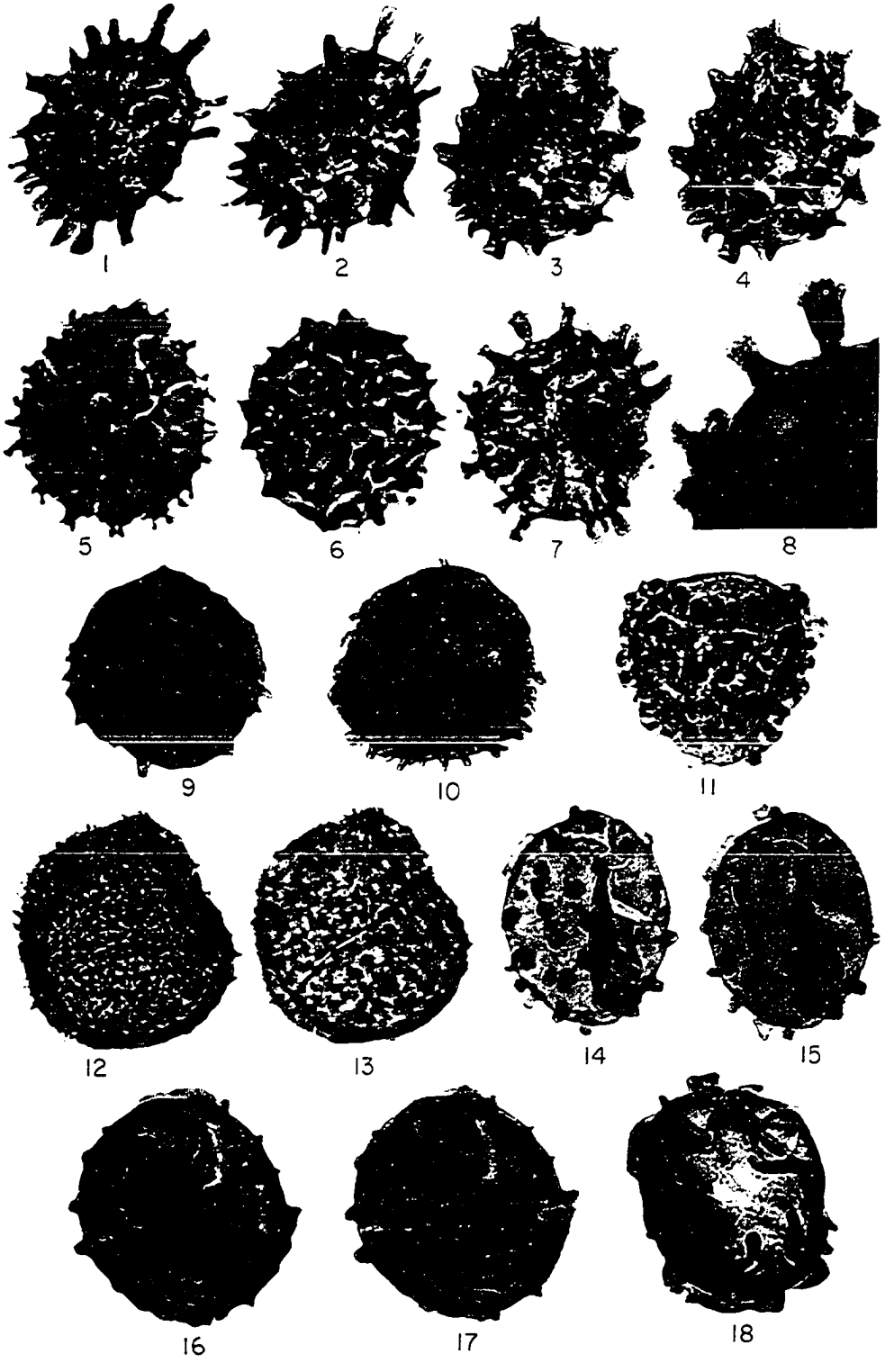

PLATE 7

PLATE 7

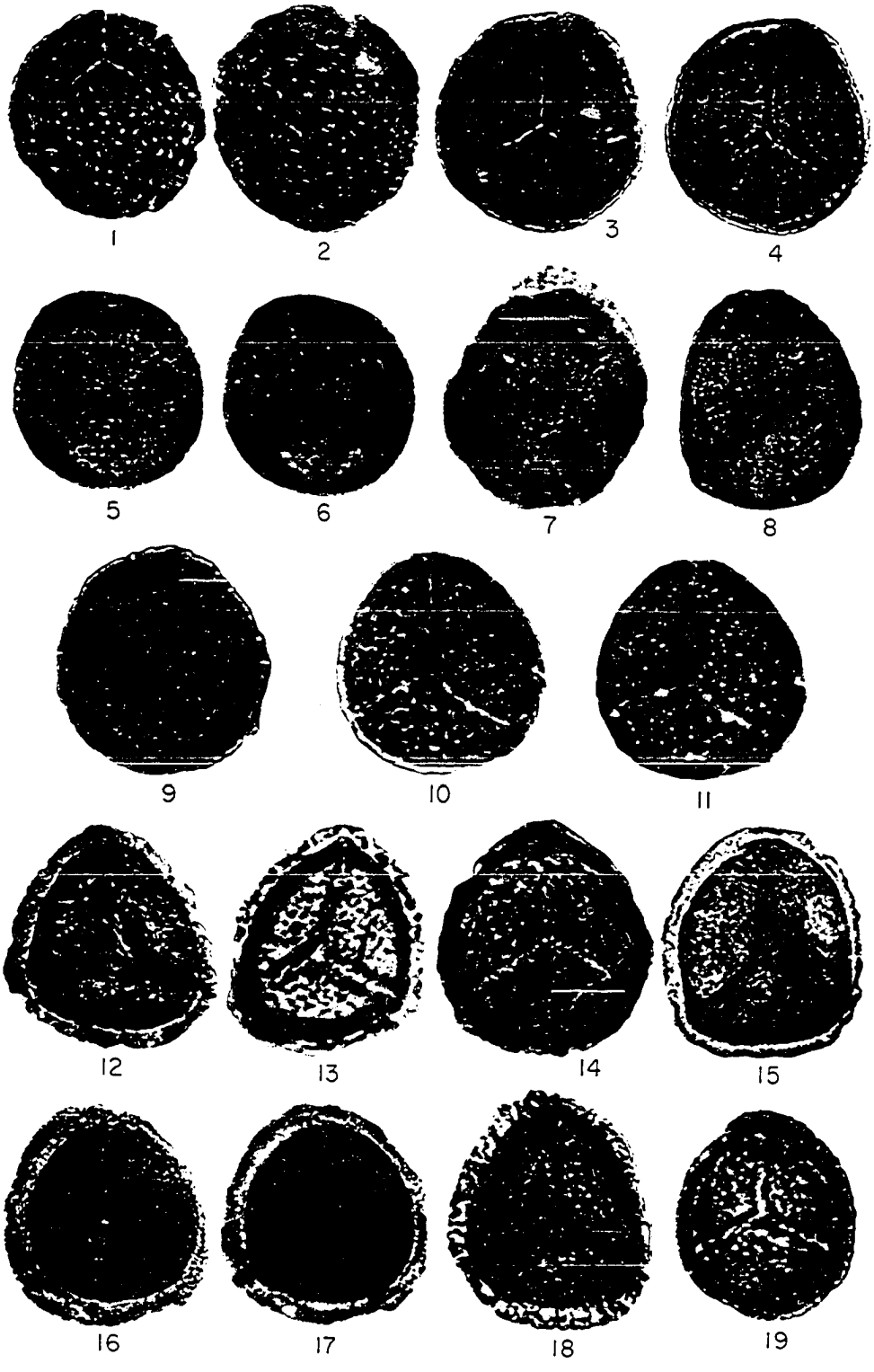

PLATE 8

Figure		Page
1,2.	Lycospora tenuireticulata Artüz, 1957 . . . . (1) 40 microns overall, spore body 32 microns OPC 856 W-2-2 (2) 40 microns overall, spore body 31 microns OPC 856 N-1-2	72
3.	Lycospora noctuina Butterworth and Williams, 1958 . . . . . 38 microns overall, spore body 29 microns OPC 856 AR-1-1	71
4.	Perotrilites sp. 1 . . . . . 35 microns, immature specimen OPC 856 P-3-1	45
5,6.	Endosporites sp. 1 . . . . . (5) 46 microns overall, central body 34 microns OPC 914 A-4-1 (6) 58 X 54 microns overall, central body 41 microns OPC 856 L-2-1	83
7.	Endosporites micromanifestus Hacquebard, 1957 . . . . . 98 microns overall, central body 59 microns OPC 912 B-5-2	82
8,9, 12.	Endosporites pallidus Schemel, 1950 . . . . . (8) 82 X 68 microns overall, central body 49 microns OPC 912 A-6-3 (9) 82 X 80 microns overall, central body 51 microns OPC 856 AN-1-8 (12) 56 microns overall, central body 38 microns OPC 912 A-4-2	82
10.	Discernisporites concentricus Neves, 1958 . . 69 microns overall, central body 41 microns OPC 856 W-3-1	90
11.	Discernisporites sp. . . . . 104 X 84 microns overall, central body 68 X 59 microns OPC 913 A-4-1	91

PLATE 8--Continued.

PLATE 8

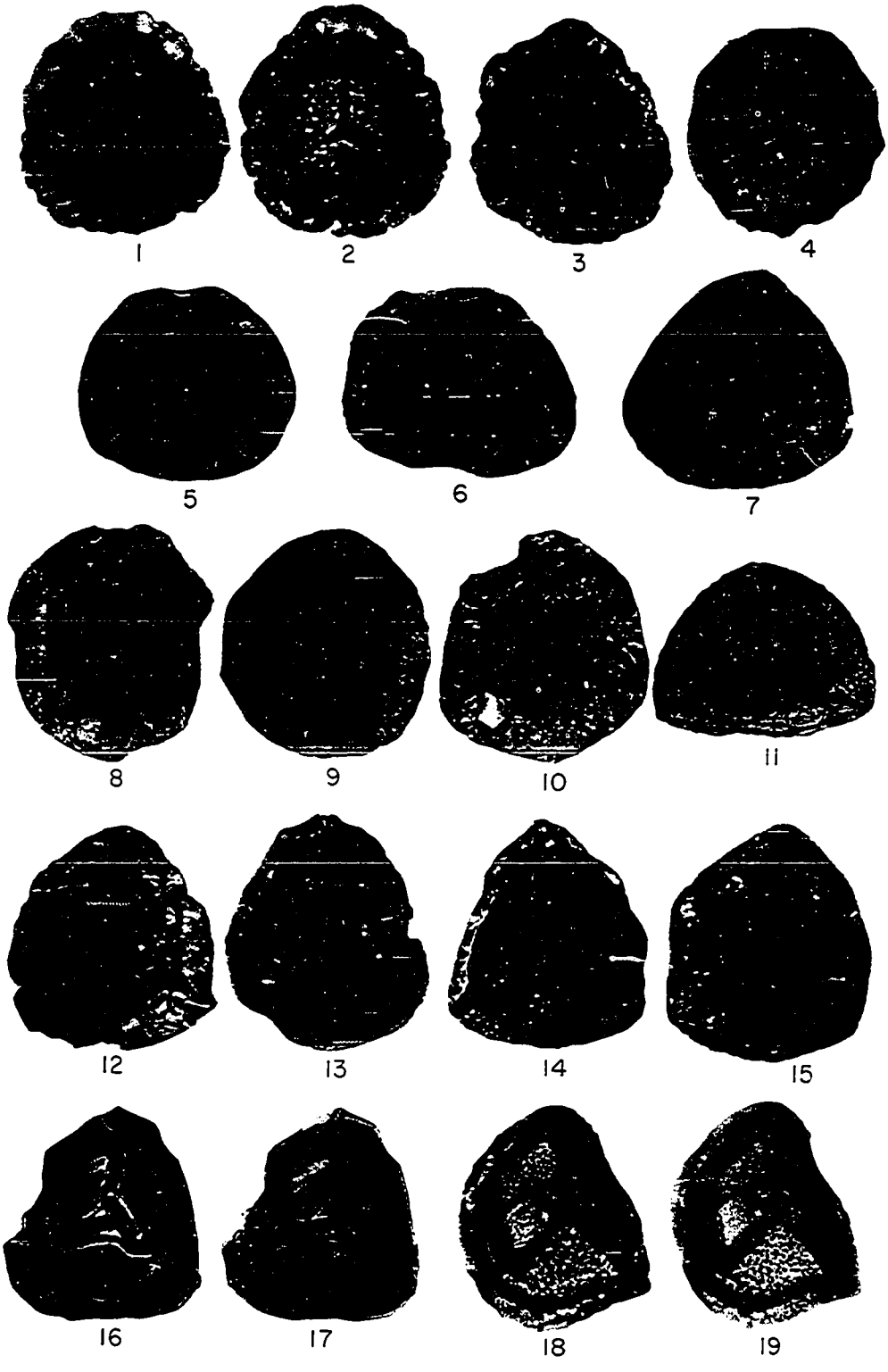

PLATE 9

PLATE 9--Continued.

PLATE 9

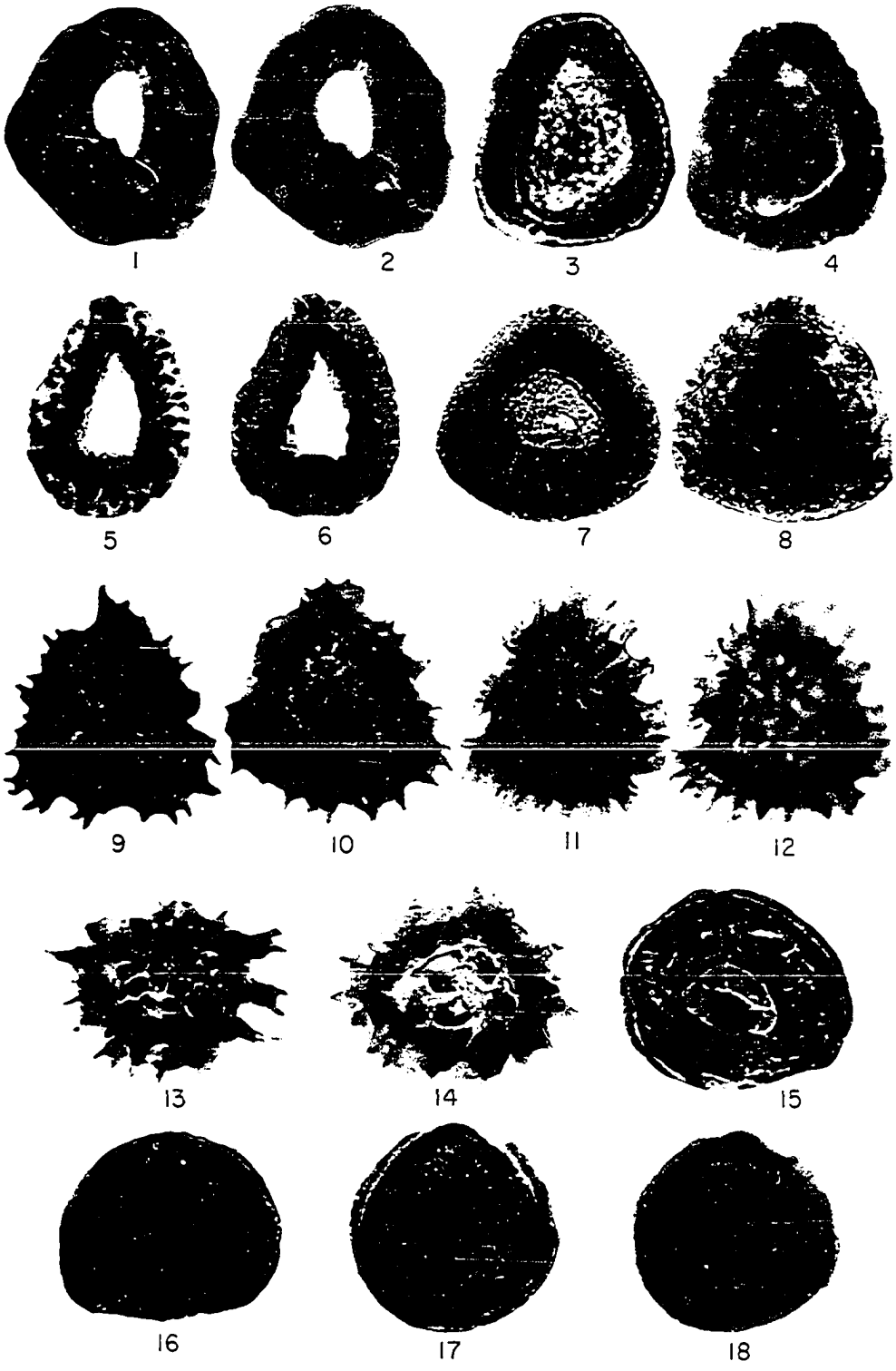

PLATE 10

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14.	Spore type K . . . . . 69 X 56 microns overall, spore body 43 X 41 microns OPC 856 V-1-2	107

PLATE 10

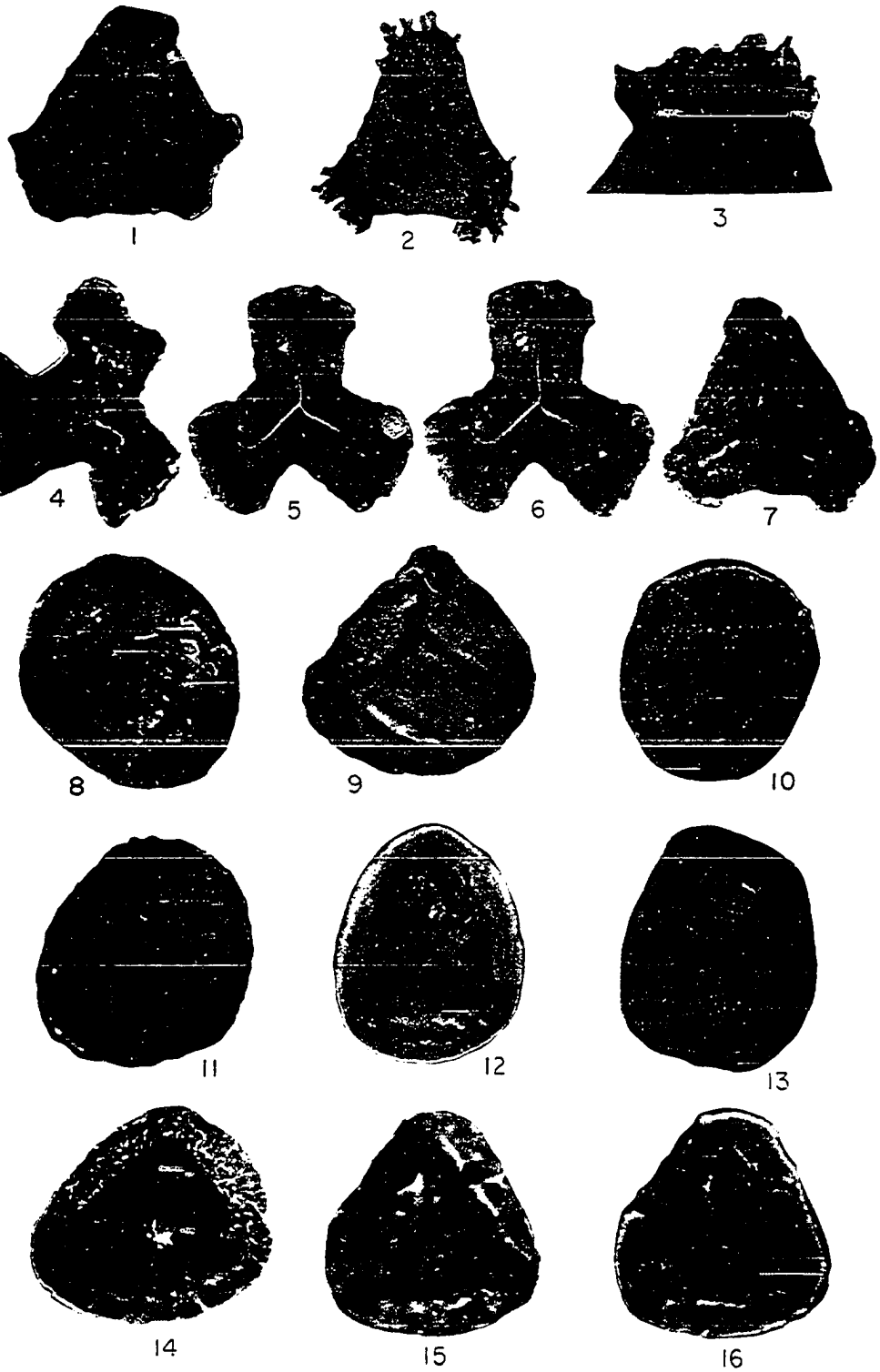

PLATE 11

PLATE II

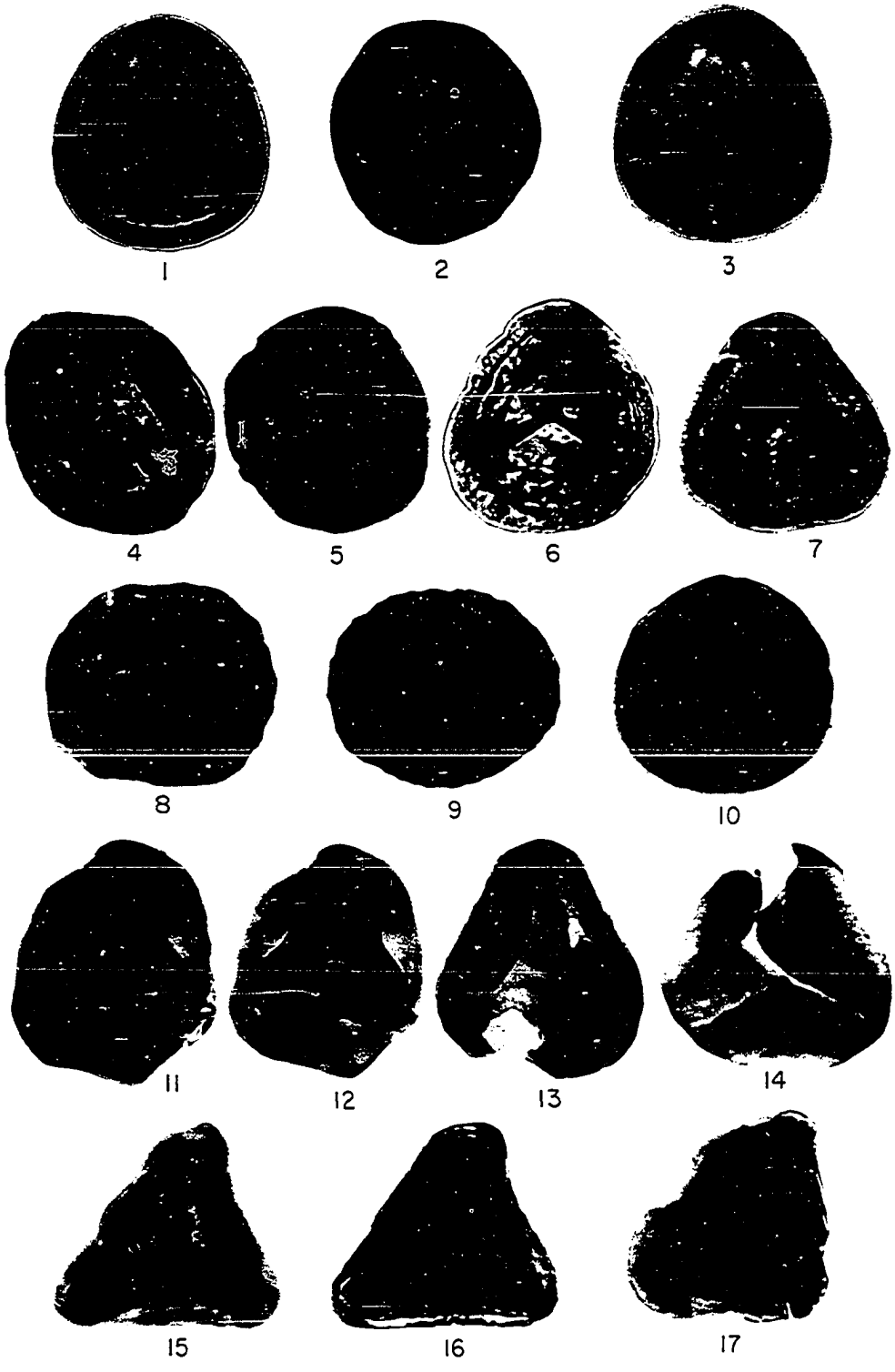

PLATE 12

PLATE 12--Continued.

PLATE 12

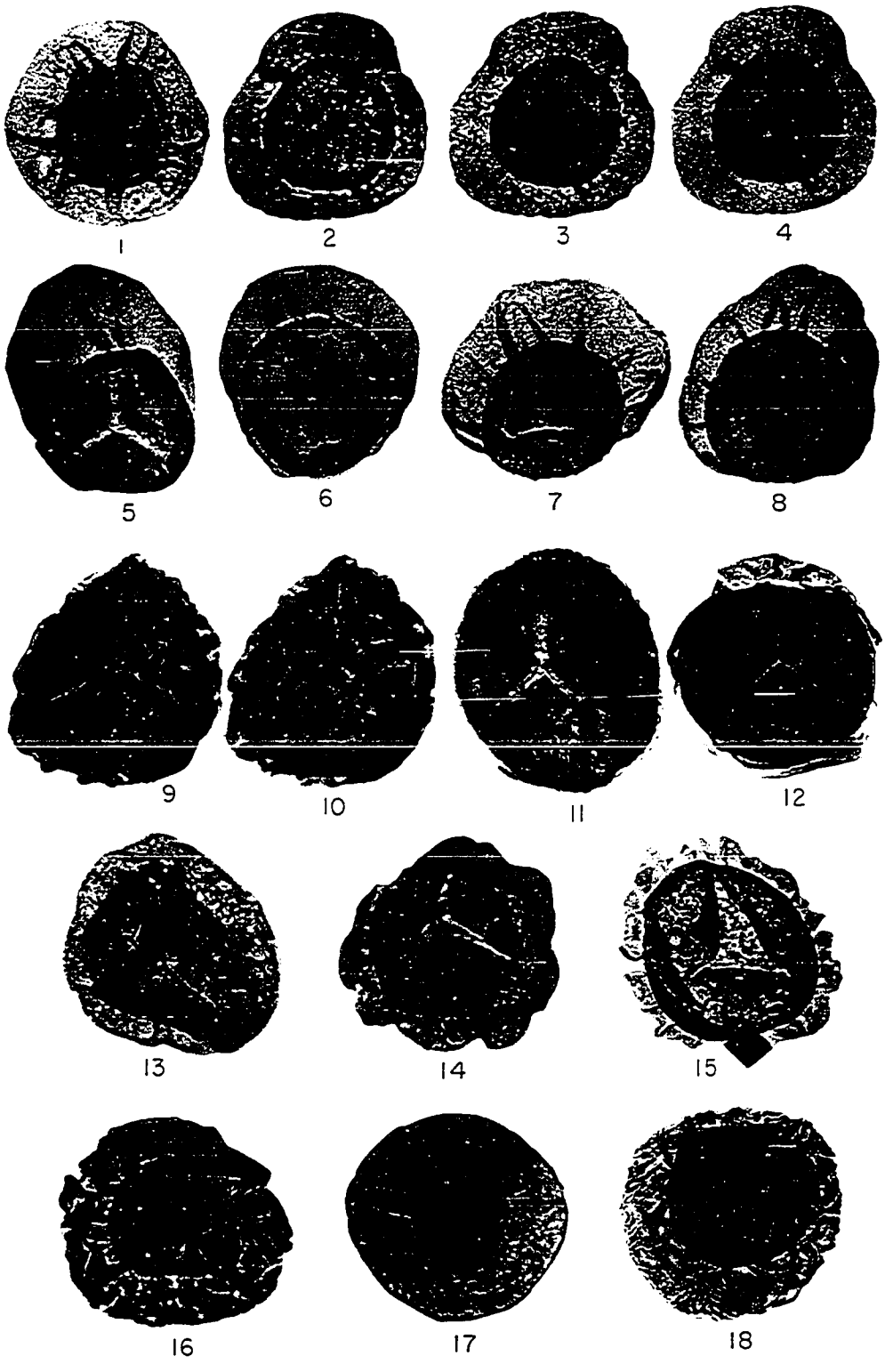

PLATE 13

Figure		Page
1,3, 4,5.	Spore type P sp. 1	111
	(1) 90 X 82 microns overall, central body 68 X 57 microns OPC 912 B-6-4	
	(3) 91 X 82 microns overall, central body 79 X 71 microns OPC 913 B-1-5	
	(4) 93 X 84 microns overall, central body 76 microns OPC 856 AC-6-2	
	(5) 107 X 87 microns overall, central body 71 microns OPC 856 AN-2-10	
2.	Remysporites sp.	89
	74 X 66 microns overall, central body 53 X 40 microns OPC 856 W-8-1	
6,10.	Spore type P sp. 2	112
	(6) 76 X 61 microns overall, central body 59 X 51 microns OPC 856 AA-2-2	
	(10) 75 microns overall, central body 52 microns OPC 856 AA-5-1	
7.	Spore type S	114
	75 X 65 microns overall, central body 57 X 50 microns OPC 856 AB-2-1	
8.	Endoculeospora rarigranulata var. densigranulata Staplin, 1960	50
	91 X 65 microns overall, central body 72 X 49 microns OPC 856 AL-4-3	
9.	Pterospermopsis sp.	141
	50 microns overall, central body 20 microns OPC 856 AE-3-3	
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	(11) 133 X 119 microns overall, central body 91 X 76 microns OPC 856 AQ-3-2	
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13.	Alatisporites sp.	94
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	(14) 165 X 150 microns overall, central body 88 X 109 microns OPC 856 Q-2-1	
	(15) 89 X 83 microns overall, central body 55 X 44 microns OPC 856 AO-2-8	

PLATE 13

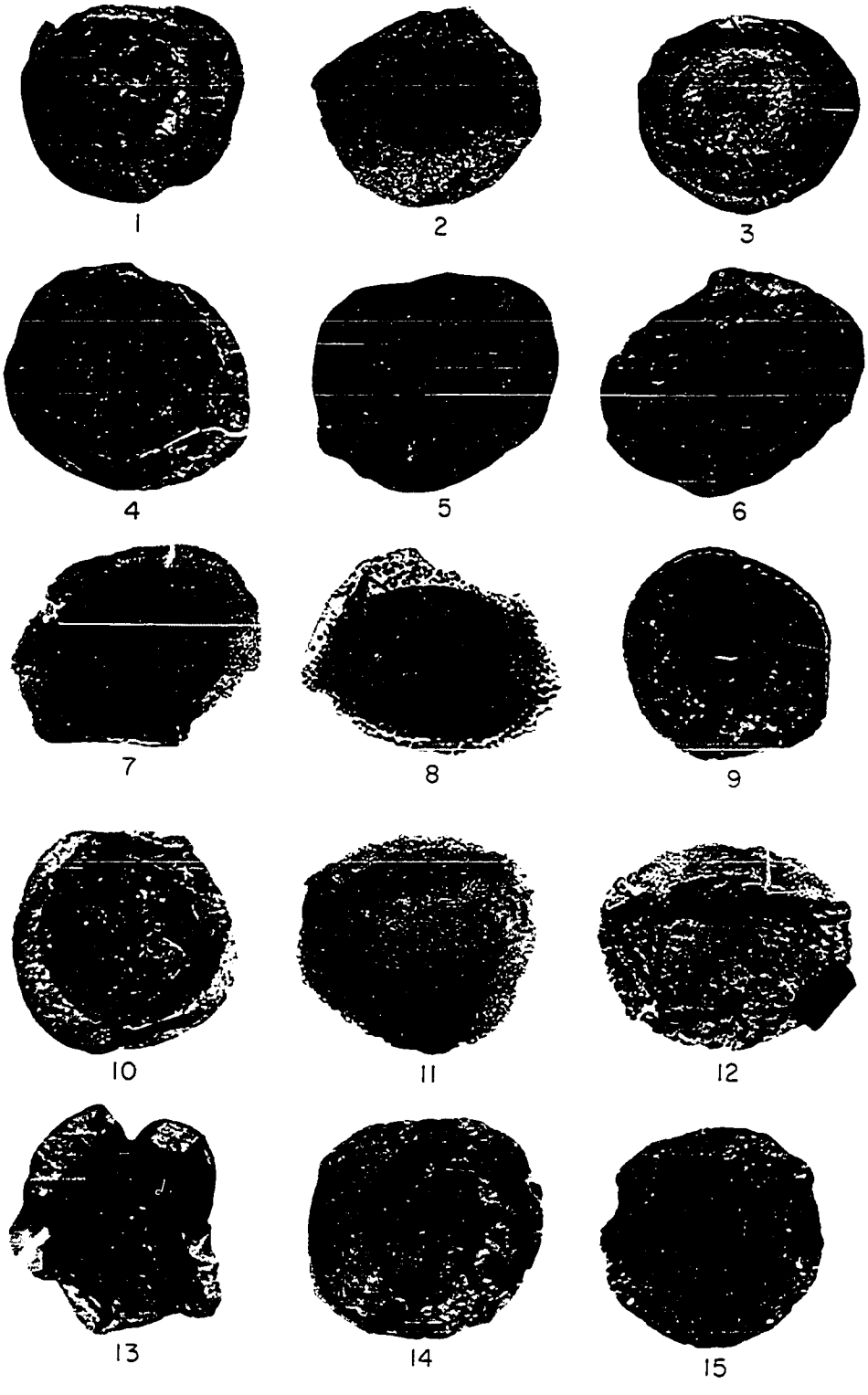

PLATE 14

PLATE 14--Continued.

PLATE 14

PLATE 15

PLATE 15--Continued.

Figure		Page
17.	Lophosphaeridium sp. 5 . . . . . Body 35 X 30 microns, processes 1.5-2.5 microns OPC 856 H-1-1	133
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20.	Baltisphaeridium? cf. B. dilatispinosum Downie, 1963 . . . . . Body 24 microns, processes 3-5 microns long X 3 microns wide OPC 856 E-3-1	118

PLATE 15

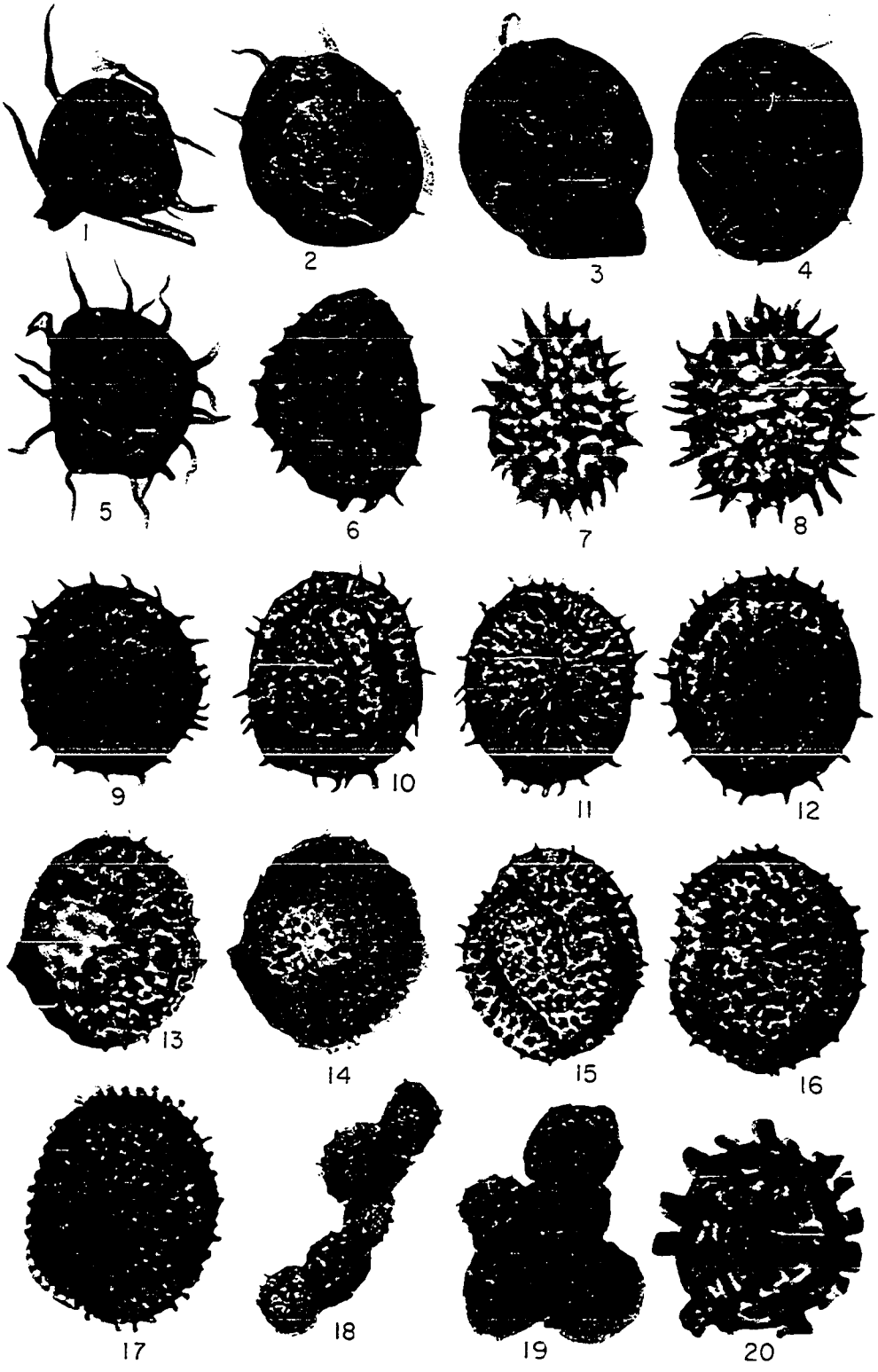


PLATE 16

PLATE 16--Continued.

PLATE 16

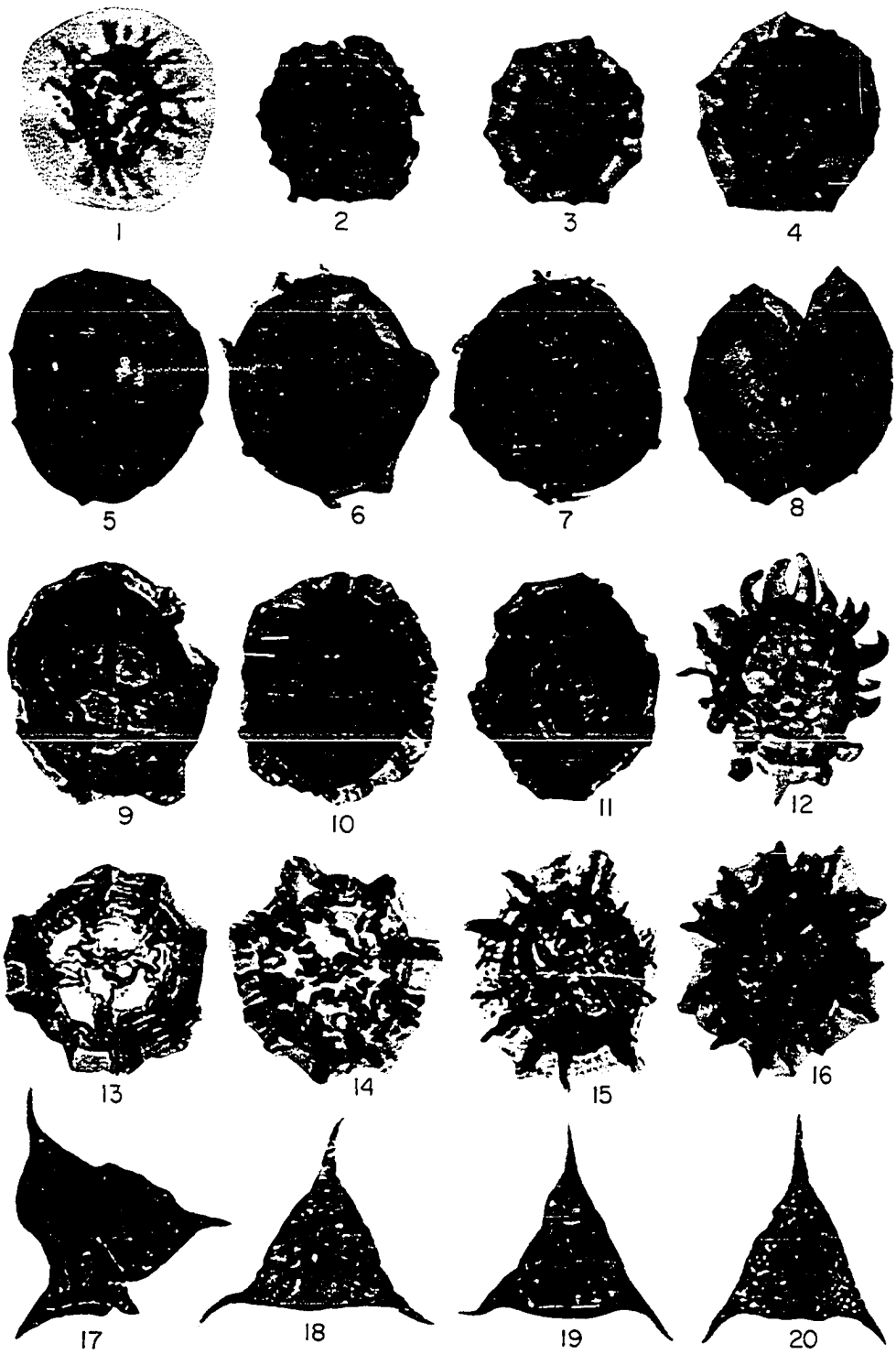


PLATE 17

Figure | Page

1,2, 3,4. *Michrystridium stellatum* Deflandre, 1945 . . . 121
(1) Body 25 X 23 microns, processes 6-8 microns OPC 856 F-1-3
(2) Body 31 X 28 microns, processes 11-13 microns OPC 856 E-5-1
(3) Body 28 X 24 microns, processes 5-7 microns OPC 856 E-4-3
(4) Body 21 X 19 microns, processes 7-10 microns OPC 856 E-3-3

5,7, 14. *Leiosphaeridia* sp. 1 124
(5) Individual: 34-37 microns OPC 856 P-1-1
(7) 41 microns OPC 856 B-3-3
(14) 43 X 15 microns (folded specimen) OPC 856 H-5-2

6. *Leiosphaeridia* sp. 2 124
Individual: 21-24 microns OPC 856 O-1-4

8,9. *Leiosphaeridia* sp. 3 125
(8) 122 microns OPC 856 P-1-3
(9) 134 microns OPC 856 H-7-2

10,12. *Leiosphaeridia* sp. 4 126
(10) 193 X 146 microns OPC 856 O-1-2
(12) 264 X 172 microns OPC 856 P-2-2

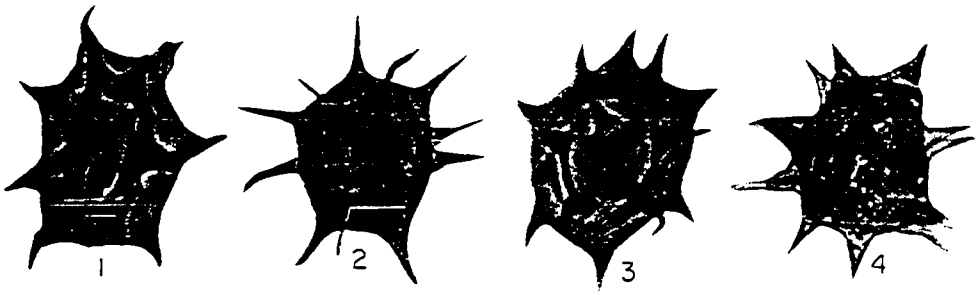
11. *Perotrilites magnus* Hughes and Playford,1961. . 44
116 X 98 microns OPC 856 AO-2-4

13,17. *Leiosphaeridia* sp. 5 126
(13) 89 X 40 microns (folded specimen) 856 H-1-3
(17) 76 X 61 microns (split specimen) OPC 856 L-3-1

15. *Radialetes* sp. 95
31 X 28 microns OPC 856 F-1-1

16,18. *Leiosphaeridia* sp. 6 127
(16) 36 X 32 microns (split specimen) OPC 856 B-2-1
(18) 28 X 26 microns (split specimen) OPC 856 C-3-1

PLATE 17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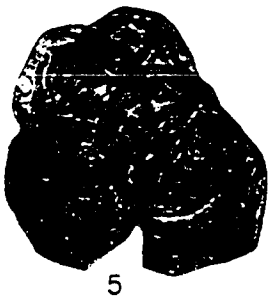
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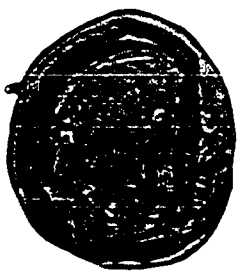
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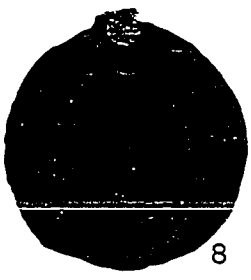
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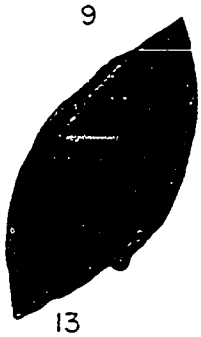
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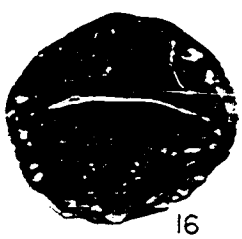
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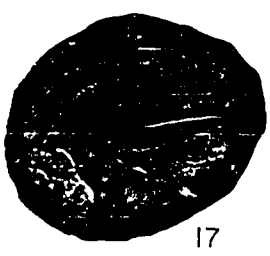
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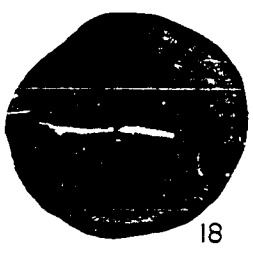
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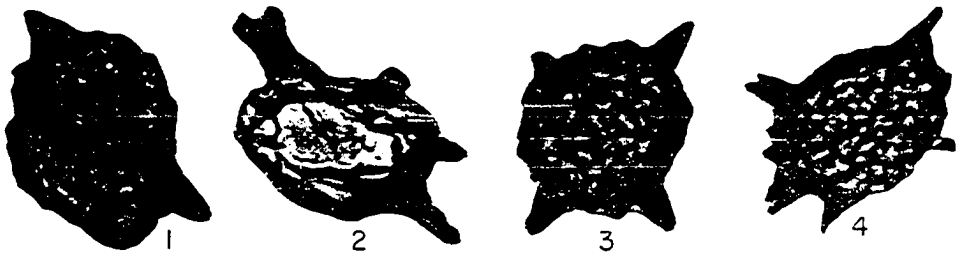
PLATE 18

PLATE 18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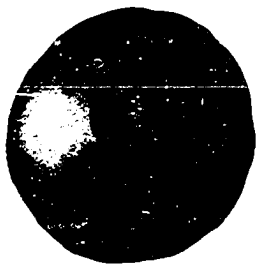
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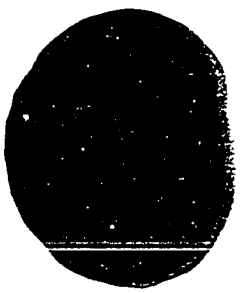
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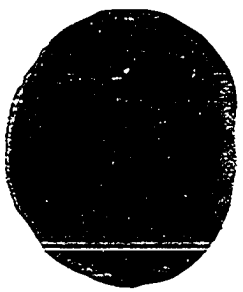
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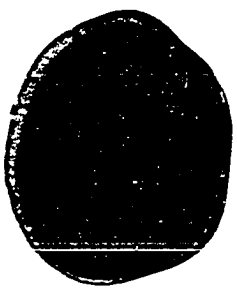
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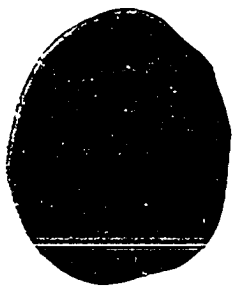
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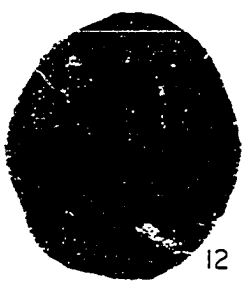
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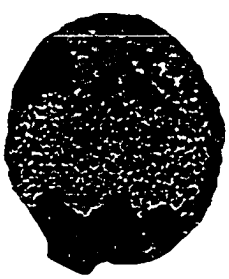
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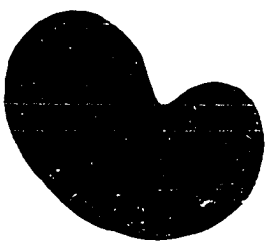

18

TION OF SAND BRANCH MEMBER
(182.5 FEET)

SANDY CREEK
(124 FEET)

SAMPLE LOCALITIES AND DESIGNATION	914 A	OPC 913 B	OPC 913 A	CPC 912 B	OPC 912 A	OPC 856 AR	AQ	AP	AO	AN	AM	AL	AK	AJ	AI	AH	AG	AF	AE	AD	AC	AB	AA	Z	Y	X	W	V	U	T	S	R	Q	D
Radiolaria sp.																																		
Laevigatosporites vulgaris						1.5	.5	.5	.5	1	1.5	1	.5	1	.5	1	2	.5	1.5	1	1.5	2	1.5	1.5	2	.5	1.5	.5	.5	.5	.5	1.5	.5	
L. sp. 1	P			.5		1.5	.5	.5	.5	1.5	1.5	1	.5	1	.5	1.5	2	.5	1.5	1	1.5	2	1.5	1.5	2	.5	1.5	.5	.5	.5	.5	1.5	.5	
L. sp. 2	P	P				.5	.5	.5	.5	1	1.5	1	.5	1	.5	1	2	.5	1.5	1	1.5	2	1.5	1.5	2	.5	1.5	.5	.5	.5	.5	1.5	.5	
Leiotriletes sphaerotriangularis	1.5	2	3	5		1.5	.5	.5	.5	1	1.5	1	.5	1	.5	1	2	.5	1.5	1	1.5	2	1.5	1.5	2	.5	1.5	.5	.5	.5	.5	1.5	.5	
L. sporadicus	1	1.5	.5	1		.5	.5	.5	.5	1	1.5	1	.5	1	.5	1	2	.5	1.5	1	1.5	2	1.5	1.5	2	.5	1.5	.5	.5	.5	.5	1.5	.5	
L. sp.	6	1.5	1	1	1	1.5	.5	.5	.5	1	1.5	1	.5	1	.5	1	2	.5	1.5	1	1.5	2	1.5	1.5	2	.5	1.5	.5	.5	.5	.5	1.5	.5	
Punctatisporites atrifucatus	1	1	1	1	2	3	3	3	3	3	3	2	1	2	1	2	3	1	4	1	4	3	4	4	3	1	4	1	1	1	1	2	1	
P. irrasus	2	2	2	4	3	5.5	5.5	5.5	5.5	5.5	5.5	2	1	3.5	1.5	2.5	2.5	1.5	4	3.5	4.5	5	5	5	1	3.5	1	3.5	3.5	4.5	1	2.5	1.5
Phyllothecotriletes golatensis	3	1	4.5	3	6	6.5	5.5	5.5	5.5	4	4	3.5	1	5.5	1.5	2.5	2	4	4	1.5	4.5	2.5	2.5	4	1.5	1.5	6.5	3.5	2	1	1	1.5	.5
P. rigidus				2.5	.5	5.5	.5	P	.5	.5	3.5	.5		.5			.5			4.5	1	2	.5					.5	1	.5	.5			
Gulisporites sp. 1			1	.5	.5			.5		.5				P						.5	1	2		1	.5	1.5			1					
G. sp. 2		5				.5						.5																						
Retusotriletes sp.																				.5	P													
Cadiospora sp. 1																P	.5			P														
C. sp. 2																																		
Ambilisporites sp.	.5	1	.5	1	.5	.5	1	1.5	.5	.5	3.5	2		2	1	2.5	1.5	1	5.5	1.5	4	8	4											
Granulatisporites parvus		1	.5	1.5	.5	.5	1	1.5	1	2	1						3	2	1.5		1	1												
Cyclogranisporites aureus	P	1	.5	1.5	.5	.5	.5	1	2	.5	.5			.5		P	.5	1.5	.5	.5	1	1.5	5											
C. commodus	1.5	1	.5		1.5	.5	.5	1	2	.5				.5		P	.5	.5	.5	.5	1	.5												
C. cf. C. minulus	1	1.5	1	2.5	.5	1.5	.5	2	1	1.5	1.5	2		.5		P	.5	.5	.5	.5	1	.5												
C. sp.	1	1	.5	.5	1	.5	.5	1	1	1	.5	.5		.5			.5		.5	.5	1	.5												
Verrucosisporites grandiverrucosus		1	.5	.5	.5	.5	.5	.5	.5	.5	1			P	.5				.5	.5	.5			.5										
Converrucosisporites sp.		3	.5		.5	.5	.5	.5	.5	.5	.5			P	.5				.5	.5	.5			.5										
Lophotriletes microsaetosus		1.5	.5		.5	.5	.5	.5	.5	.5	.5		1	.5					.5	.5	.5		1.5	.5										
L. sp.			.5		.5	.5	.5	1	.5	.5	.5											1												
Anapiculatisporites sp.	.5		P																														
Ibrahimispores brevispinosus																																		
I. magnificus		.5	P	P			P																											
I. microhorridus		.5					P																											
I. sp. 1										P																								
I. sp. 2																																		
Raistrickia saetosa																				P			P											
R. sp. 1																																		
R. sp. 2																P							.5											

SPOR

NON-SACCATE

Leiotriletes microadriensis	
L. sp.	
Anapiculatisporites sp.	
Ibrahimispores brevispinosus	
I. magnificus	
I. microhorridus	
I. sp. 1	
I. sp. 2	
Raistrickia saetosa	
R. sp. 1	
R. sp. 2	
R. sp. 3	
R. sp. 4	
Camptotriletes sp.	
Convolutispora flexuosa forma minor	
C. cf. C. laminosa	
Convolutispora sp.	
Microreticulatisporites parvirugosus	
Dictyotriletes falsus	
D. subalveolaris	
Corbulispora sp. 1	
C. sp. 2	
Foveosporites insculptis	
F. sp.	
Secarisporites sp. 1	
S. sp. 2	
Perotrilites magnus	
P. sp. 1	
P. sp. 2	
P. sp. 3	
P.? sp. 4	
P.? sp. 5	
P.? sp. 6	
Velamisporites rugosus	
Endoculeospora rarigranulata var. densigranulata	
Tripartites cf. T. vestustus	
Mooreisporites sp.	
Ahrensisporites cf. A. angulatus	
A. sp.	
Stenozonotriletes sp. 1	
S. sp. 2	
Murospora cf. M. minima	
Savitrisporites cf. S. nux	
Rotaspora fracta	
Anguisporites sp.	
Reticulatisporites corporeus	
R. crassireticulatus	
R. exiguus var. A	

O R I T E S

C A T E

Murospora cf. M. minima	*Savitrisporites cf. S. nux*	*Rolaspora fracta*	*Anguisporites sp.*	*Reticulatisporites corporeus*	*R. crassireticulatus*	*R. exiguus var. A*	*R. karadenizensis*	*R. pellatus*	*R. cf. R.? fimbriatus*	*R. sp. 1*	*R. sp. 2*	*R. sp. 3*	*R. sp. 4*	*R. sp. 5*	*R. sp. 6*	*R. sp. 7*	*R. sp. 8*	*R. sp. 9*	*Knoxisporites dissidius*	*K. rotatus*	*K. stephanephorus*	*K. triradiatus*	*K.? sp. 1*	*K.? sp. 2*	*K.? sp. 3*	*Lycospora noctuina*	*L. punctata*	*L. tenebricosa*	*L. tenuireticulata*	*L. torulosa*	*L. sp.*	*Densosporites covensis*	*D. tenuis*	*D. cf. D. dominatoris*	*D. cf. D. lobatus*	*Cristatisporites cf. C. elegans*	*C. sp. 1*	*C. sp. 2*	*C. sp. 3*	*C. sp. 4*	*Cirratriradites sp*	*Proprisporites laevigatus*	*Spore type A*	*Spore type B*	*Spore type C*	*Spore type D sp. 1*
				.5														.5									6.5 5.5	6		1															1
	1.5		.5			.5							.5						3	.5 .5					2	1.5 1	.5		1												1.5			8
	.5		1				.5			.5			.5						2	.5 .5					5.5	3.5	1														1			7
	1		1		.5													.5	2		1				.5			5 1.5					P	P			.5					6.5
	1.5		1				.5				P								2.5	P .5					1.5		.5	2 1.5						1	.5	P		P	1	11.5
	.5					P												.5	1.5	.5 1					P	1 1	2 1				.5			.5						.5	15.5
											.5						P 1		1.5		.5				.5	1.5 2	2.5		1												1	14.5
			.5														.5		2		1				3	3 2	2		.5													24
	.5		1						P										4	.5					1	1	2														.5	23
	.5		.5						.5						P P			1.5						P .5	2.5 2			1.5												.5	7.5
	P		1														.5 .5	1.5							1.5 4	1		1.5												.5	16
	1		.5 .5		.5												.5 1	.5							5 1	1		.5												.5	16.5
P																									1.5	.5		.5														6
											.5								1						3	1.5 1.5	1		1.5														19.5
	.5		P																						3	3.5 1.5	1															12
	1		.5 1	P													1	1.5							3	1.5 1.5	.5													P	1	28
			.5				.5										.5	.5							1.5	.5 .5	1.5									P					1	16.5
	.5							1	P					.5			1	.5							.5	.5 1		1.5	1.5												.5	18
													.5				1				.5				1		1.5	2 1	1												.5	17
																									.5	1																16
			2											P				1.5	.5		P				1	1.5						P				.5						23.5
																									2	4.5	1.5 1.5															15
	1		.5		.5													1.5	1		1						1 .5		1				P				P				.5	15
						P									.5		.5		2		1.5				1.5													.5			.5	29
	.5																.5		1.5	.5	.5				1.5	.5	.5 .5	.5										P				31
	P								.5										1.5		1.5					.5 1.5										.5						.5	25
	.5																		1				P P		.5		.5	1		1													40.5
	1		.5																1						1	.5 .5				.5				.5								38
	.5																		2		.5					1.5 2.5																	25.5
	.5								P P								.5 .5			1						.5 1.5		3	2 .5												.5	11
																	.5		1.5	.5						1.5																8.5
	1		.5																1.5		.5				2	4					.5											20
			2																1.5	.5 .5					1	1			.5		P											33.5

SACCATE

D. cf. D. dominatoris	D. cf. D. lobatus	Cristatisporites cf. C. elegans	C. sp. 1	C. sp. 2	C. sp. 3	C. sp. 4	Cirratriradites sp	Proprisporites laevigatus	Spore type A	Spore type B	Spore type C	Spore type D sp. 1	Spore type D sp.2	Spore type D sp. 3	Spore type E	Spore type F	Spore type G	Spore type H	Spore type I	Spore type J sp. 1	Spore type J sp. 2	Spore type K	Spore type L	Spore type M	Incertae sedis A	Endosporites micromanifestus	E. pallidus	E. sp. 1	E.? sp. 2	Auroraspora solisortus	A. sp. 1	A. sp. 2	Grandispora spinosa	G. sp.	Discernisporites concentricus	D. sp.	Remysporites sp.	Alatisporites sp.	Spore type N	Spore type O	Spore type P sp. 1	Spore type P sp. 2	Spore type Q	Spore type R	Spore type S	Spore type T
											1			.5 .5											.5		2	.5 3.5	7 12							P	P .5		1.5 2.5	.5 .7		1
								1.5			8			5	.5		.5							.5		.5	.5 3	8 2							.5		2.5	1.5 1	.5		.5
								1			7	1		4	.5											1.5	4.5 1			P	.5		1.5	1.5 .5			
	P		P				.5				6.5			.5 3.5	.5										2		.5	P P	P				3.5 .5	1.5	P 2	.5		1
			1		.5		P			P	1 11.5			0											1	1.5 1.5	.5 3.5	6 2			.5				.5 1.5	1		
			.5								.5 15.5	.5		5.5		.5								1.5	.5		3.5	4 2.5							2.5	2		.5
											1 14.5	.5		8.5									P	1		1 3.5	2.5 1.5				2.5		.5	1 3	1		.5
											24	2		7	.5										.5		4.5	1.5 2.5				1.5		.5	.5 2.5			.5
											.5 23			11					P						1.5	.5	.5 5.5	4 1				.5		.5	2	.5		
											.5 7.5	1		5.5								.5		.5	1.5	.5	5.5	2	.5	P					1 2	.5		.5
											.5 16	3		7.5				1				.5	.5	.5	.5		4	2 3				.5			3			.5
											.5 16.5			10						.5				.5		1	1.5	2				.5		.5	2			
											6			1																							1			
											19.5			5 5											.5		11	3 4	.5				.5			3			.5
											12	1.5		6.5											.5	.5	1.5	2								.5			1
									P		1 28	.5		12	.5		P							.5		.5	2				.5				.5		.5	
			P								1 16.5			17								P				2.5	5	4.5							1			
											.5 18	.5		13.5												.5	10.5	2.5				5	.5		1.5			
											.5 17	4		5.5												.5	5.5	1 11.5							2.5	1		
											16			4									.5	1		.5	5	4.5 9				1			1.5			
P			.5								23.5			3						P				1.5			1	3.5							P	P		
											15			4												.5	1.5	1.5			.5				.5			P
			P		P						.5 16			4										1.5		2	6.5	1.5 1.5							.5 3.5			
					.5						.5 29		P	4.5						1.5				1.5			11	4 2				2		2	.5 1.5	.5	.5	
					P						31		1	2										1			3	1							1	.5		
			.5								.5 25			6.5		.5						5				.5	6.5	.5 2						.5	.5		2.5	
											40.5			6												1	6.5	.5			P	2	3.5		4			
		.5									38	1	.5							P							2.5	1					3.5		.5	1	.5	
											25.5	1		1													4	5.5					1.5		1.5	1		
											.5 11	1.5		2									.5	.5			3	1.5							P			
											8.5	2		5													.5 1.5						.5		1			
.5											20			.5					P								4								2			
P											33.5			3.5													2	1.5							2.5			

POLLENITES

SACCATE

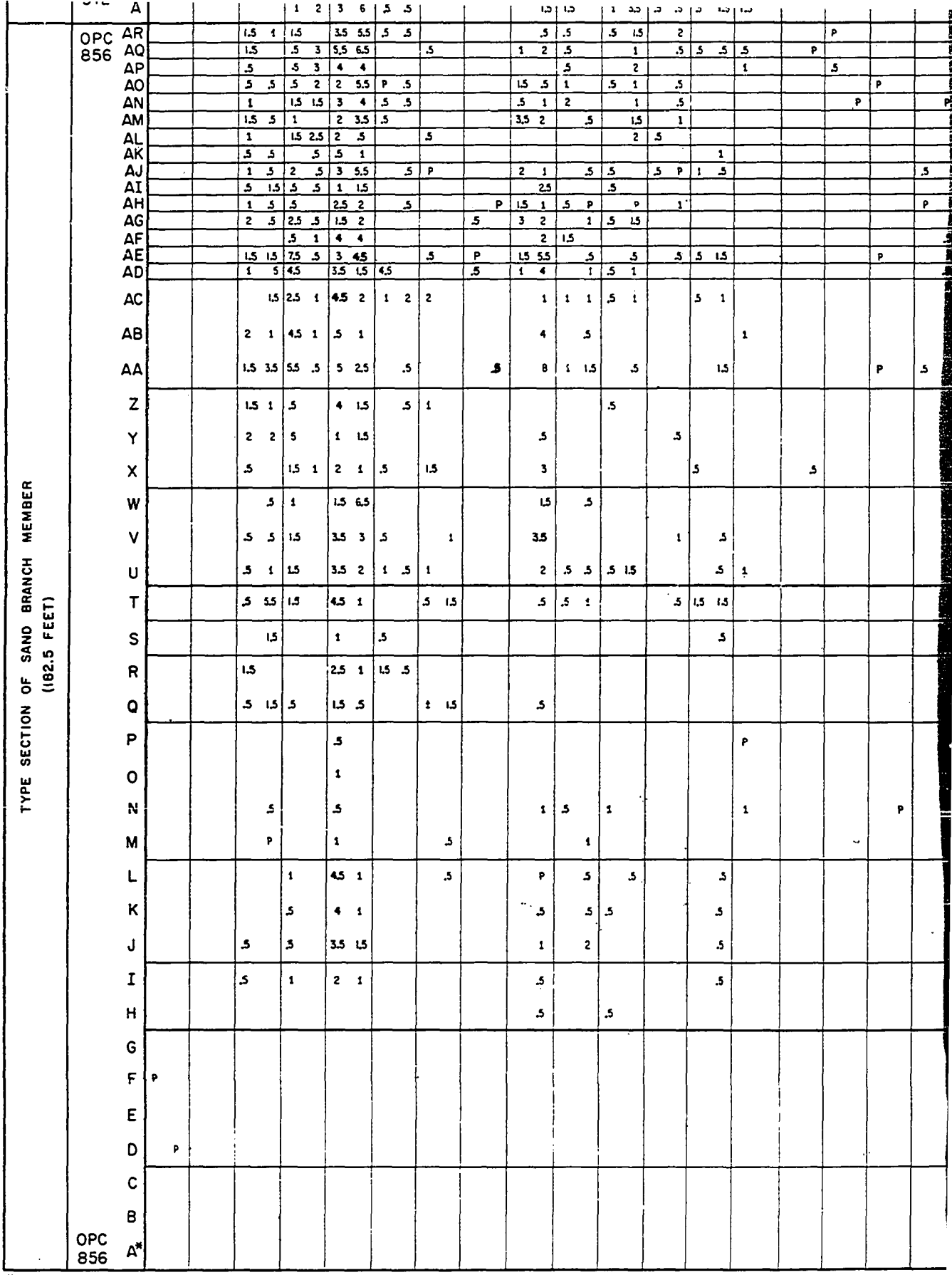
BIOFACIES ZONES	
	Spore type H
	Spore type I
	Spore type J sp. 1
	Spore type J sp. 2
	Spore type K
	Spore type L
	Spore type M
	Incertae sedis A
	Endosporites micromanifestus
	E. pallidus
	E. sp. 1
	E.? sp. 2
	Auroraspora solisortus
	A. sp. 1
	A. sp. 2
	Grandispora spinosa
	G. sp.
	Discernisporites concentricus
	D. sp.
	Remysporites sp.
	Alatisporites sp.
	Spore type N
	Spore type O
	Spore type P sp. 1
	Spore type P sp. 2
	Spore type Q
	Spore type R
	Spore type S
	Spore type T
	Spore type U
	Schulzospora campyloptera
	S. elongata
	S. ocellata
	S. sp.
	Potonieisporites sp. 1
	P. sp. 2
	P. sp. 3
	Schopfipollenites ellipsoides

ZONE III

ACRITARCH INTERVAL

ACRITARCH INTERVAL 3.3

ACRITARCH INTERVAL



*Channel sample thickness:
OPC 914 A, 4 feet, OPC 912 and 913, 5 feet each
OPC 856 AR to 856 AD, 2.5 feet each, OPC 856 AC to 856 A, 5 feet each

'P'- Present in sample but not in 200 specimens counted

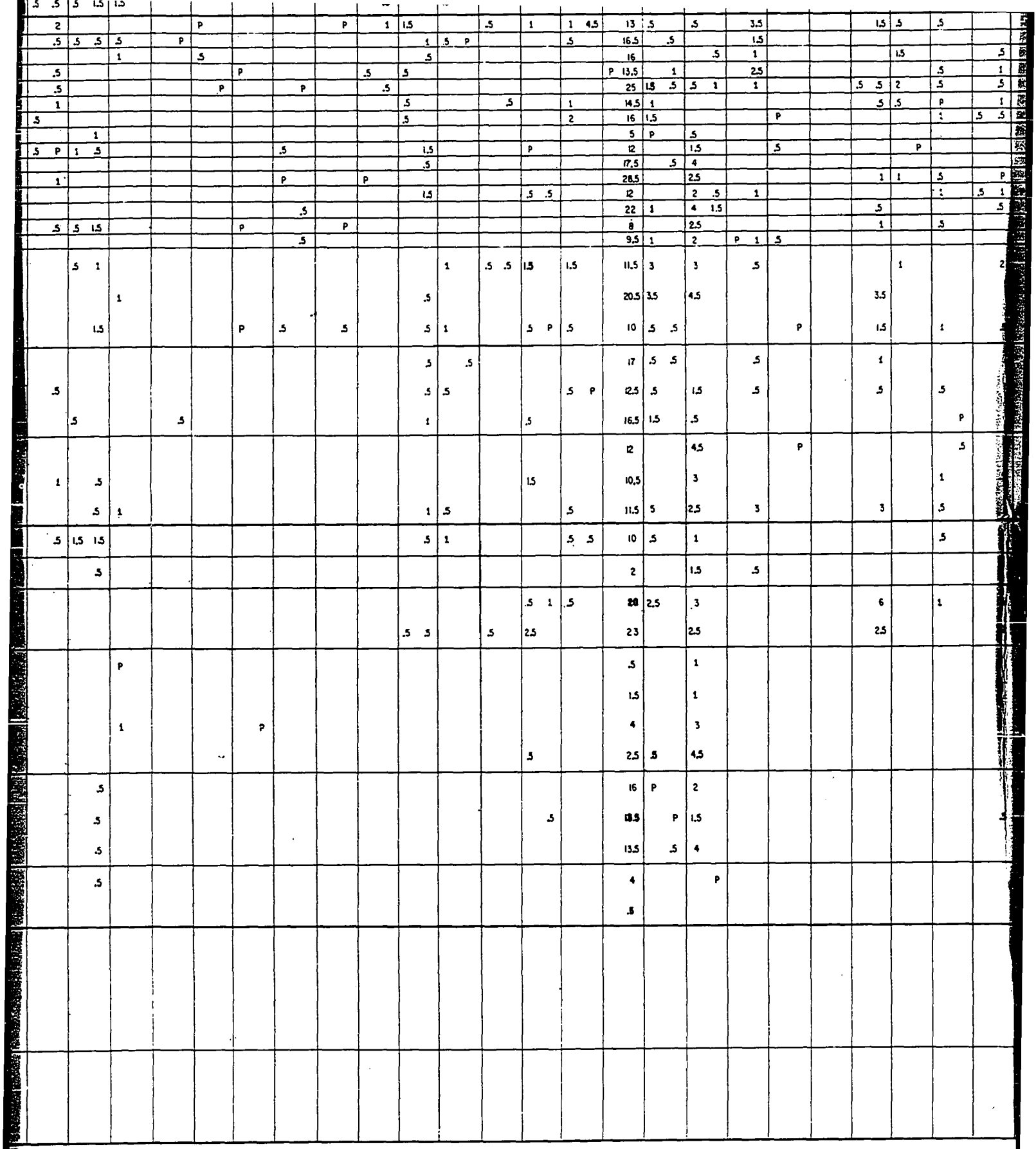


FIGURE 2. DISTRIBUTION OF PLANT PALY

DISTRIBUTION RECORDED

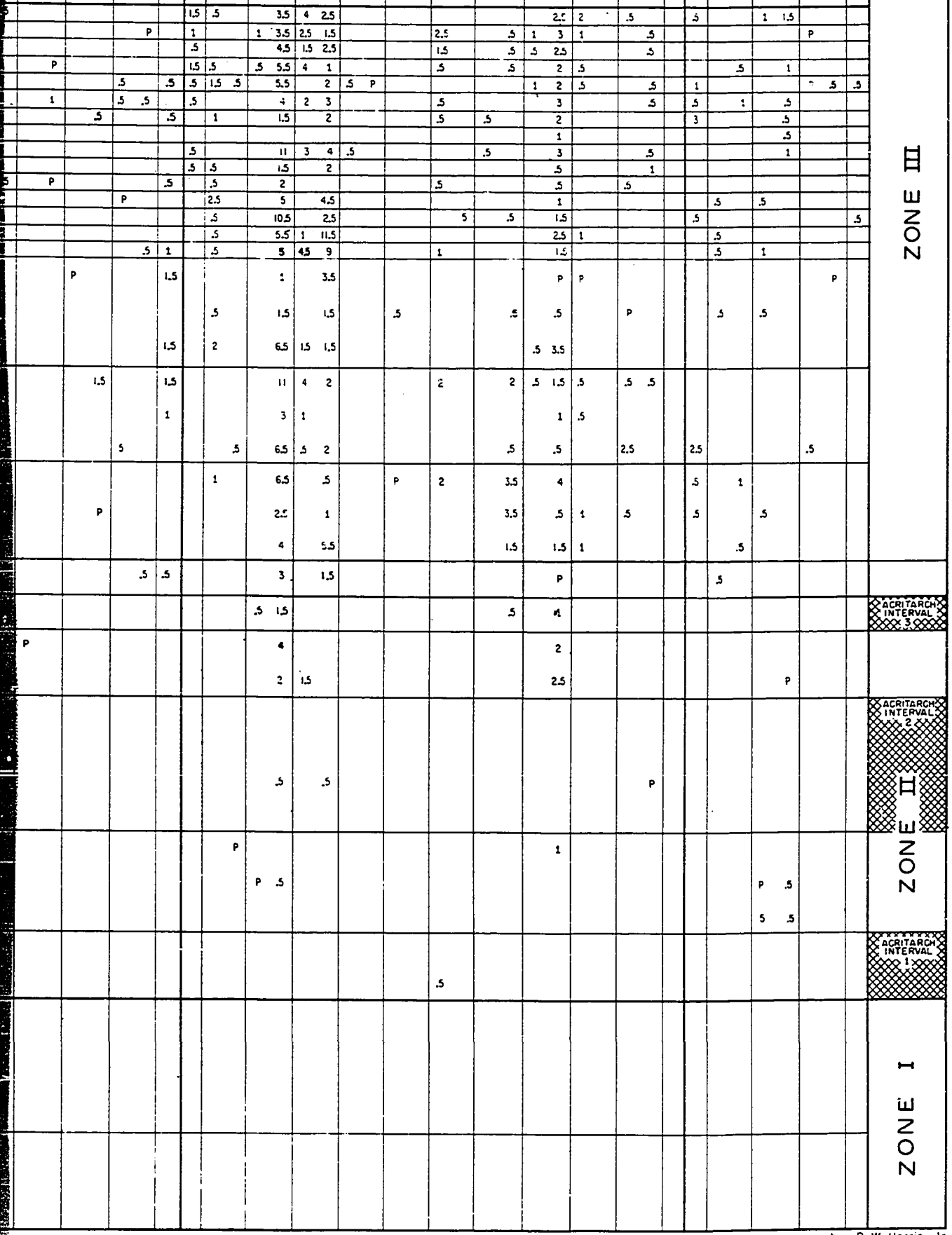
		1.5	.5	.5			P					.5	1.5	.5 1		P	1 1	2 1		.5		.5									
									.5			P 1	1.5	.5		.5	1.5 2	2.5	1												
			1.5		.5							.5	2	1		3	3 2	2	.5												
				.5	1				P				4	.5		1	1	2													
		.5 .5	2	.5	.5				.5			P P	1.5			P .5	2.5 2		1.5												
		.5	.5	P	1							.5 .5	1.5				1.5 4	1	1.5												
				1	.5 .5	.5						.5 1	.5				5 1	1	.5												
																	1.5	.5	.5												
			P										1			3	1.5 1.5	1	1.5												
									.5							3	3.5 1.5	1													
		1	1	.5	P											3	1.5 1.5	.5													
				1	.5 1	P						1	1.5			1.5	.5 .5	1.5				P									
		.5			.5			.5				.5	.5			.5	.5 1		1.5												
		1		.5					1	P		1	.5			1		1.5	1.5												
										.5		1		.5		.5	1	2 1	1												
			1		2					P		1.5	.5	P		1	1.5			P		.5									
		3.5														2	4.5	1.5 1.5													
P		1.5		1	.5	.5						1.5	1	1				1 .5	1		P		P								
		1					P				.5	.5	2	1.5												.5					
		.5		.5								.5	1.5	.5		1.5	.5	.5 .5	.5							P					
				P				.5					1.5	1.5			.5 1.5								.5						
P				.5									1		P P	.5	.5	1	1												
				1	.5								1			1	.5 .5			.5		.5									
		3		.5									2	.5			1.5 2.5														
				.5				P P				.5 .5		1			.5 1.5	3	2 .5												
												.5	1.5	.5			1.5														
		6		1	.5								1.5	.5		2	4			.5											
		2.5			2								1.5	.5 .5		1	1		.5	P											
																	.5 .5														
																	.5														
														.5			.5 3	P	1												
																1	.5 1	.5													
														.5	2		.5 1	1													
					.5											1.5	.5	.5	P												
						.5								.5		1.5	.5														
																	1														
																	1 2		1.5												
																	.5														

N OF PLANT PALYNOMORPHS IN THE SAND BRANCH MEMBER OF THE CANEY SHALE

DISTRIBUTION RECORDED AS PERCENTAGES OF 200-PALYNOMORPH PER SAMPLE COUNT

.5		.5				.5	15.5	.5	5.5	.5					1.5	.5		3.5	4	2.5						2.5	2		.5	
						1	14.5	.5	8.5					P	1		1	3.5	2.5	1.5			2.5		.5	1	3	1		
							24	2	7						.5			4.5	1.5	2.5			1.5		.5	.5	2.5			
						.5	23		11		P				1.5	.5	.5	5.5	4	1			.5		.5		2	.5		
						.5	7.5	1	5.5				.5	.5	.5	1.5	.5	5.5		2	.5	P				1	2	.5		
						.5	16	3	7.5		1		.5	.5	.5			4	2	3			.5				3			
						.5	16.5		10			.5		.5		1		1.5		2			.5	.5			2			
							6		1																		1			
							19.5		5	.5					.5			11	3	4	.5				.5		3			
							12	1.5	8.5						.5	.5		1.5		2							.5			
					P	1	28	.5	12	.5	P			.5		.5		2					.5				.5		.5	
		P				1	16.5		17				P			2.5		5		4.5							1			
						.5	18	.5	13.5							.5		10.5		2.5				5	.5		1.5			
						.5	17	4	5.5							.5		5.5	1	11.5							2.5	1		
							16		4					.5	1	.5		5	4.5	9			1				1.5			
P		.5					23.5		3			P			1.5			1		3.5							P	P		
							15		4							.5		1.5		1.5		.5			.5		.5		P	
	P		P			.5	16		4						1.5	2		6.5	1.5	1.5						.5	3.5			
			.5			.5	29	P	4.5			1.5			1.5			11	4	2			2		2	.5	1.5	.5	.5	
			P				31	1	2						1			3	1								1	.5		
		.5				.5	25		6.5	.5			5			.5		6.5	.5	2					.5		.5		2.5	
							40.5		6							1		6.5		.5		P	2		3.5		4			
	.5						38	1 .5				P						2.5		1					3.5		.5	1	.5	
							25.5	1	1									4		5.5					1.5		1.5	1		
						.5	11	1.5	2					.5	.5			3		1.5							P			
							8.5	2	.5									.5 1.5							.5		1			
.5							20		.5		P							4									2			
P							33.5		3.5									2	1.5								2.5			
							P																							
							P																							
							9.5											.5		.5										
							5.5		.5																					
							18.5		4.5							P											1			
							26	2.5 2	5.5									P .5												
							12.5	1	5																					
							4.5	1.5 2.5																						
							2.5		P														.5							

HE CANEY SHALE



by R. W. Harris, Jr