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PALYNOLOGY OF THE RED BRANCH MEMBER OF THE WOODBINE FORMATION (UPPER CRETACEOUS) IN BRYAN COUNTY, OKLAHOMA

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BY

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PALYNOLOGY OF THE RED BRANCH MEMBER OF THE WOODBINE FORMATION (UPPER CRETACEOUS) IN BRYAN COUNTY, OKLAHOMA

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DISSERTATION COMMITTEE

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PALYNOLOGY OF THE RED BRANCH MEMBER OF THE WOODBINE FORMATION (UPPER CRETACEOUS) IN BRYAN COUNTY, OKLAHOMA*

INTRODUCTION

A palynological investigation of the sediments of the Red Branch Member, a stratigraphic unit of Upper Cretaceous (Cenomanian) age was begun during the summer of 1961 with the following objectives: (1) to identify previously described taxa and describe any new taxa that might be encountered; (2) to establish biological affinities of the fossils wherever possible; (3) to examine the possible ecological implications by comparisons with recent environments; (4) to compare the spore and pollen flora recovered from the Red Branch sediments with other similar contemporaneous floras; and (5) to determine whether individual coals and shales within the Red Branch Member are traceable across Eastern Bryan County. The preservation of microfossils in the Red Branch sediments is generally fair to excellent.

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*The National Science Foundation gave financial aid in the form of a summer teaching fellowship.

These sediments have a restricted lateral extent in Bryan County, but the depositional sites were sufficiently different to permit study of geographical variation.

Published palynological studies dealing with strata of Cenomanian age in the United States include the works of Groot and Penny (1960), Groot, Penny and Groot (1961), and Pierce (1961). The assemblages described in these papers are somewhat similar to the Red Branch assemblage, even though the environmental conditions were quite dissimilar.

Acknowledgments

Dr. L. R. Wilson, Research Professor of Geology at the University of Oklahoma, directed this dissertation.

Dr. B. S. Venkatachala, Birbal Sahni Institute of Paleobotany, Lucknow, India, gave suggestions.

The following persons served on the doctoral committee: Dr. C. C. Branson, Dr. P. K. Sutherland, Dr. C. A. Merritt, School of Geology, and Dr. G. Goodman, Department of Botany.

My wife, Donita Hedlund, helped type the original manuscript.

STRATIGRAPHY

The Upper Cretaceous Woodbine Formation was named after the village of Woodbine, Cooke County, Texas, by R. T. Hill in 1901 (Murray, 1961). He originally subdivided the formation into two divisions, an upper fossiliferous division which was called the "Lewisville beds", and a lower unfossiliferous portion which was designated the "Dexter beds".

A detailed map of the Woodbine Formation in Grayson and Cooke Counties, north Texas, which is the type area, was subsequently prepared by Bergquist (1949). He subdivided the Woodbine Formation as follows:

Templeton (argillaceous) Member

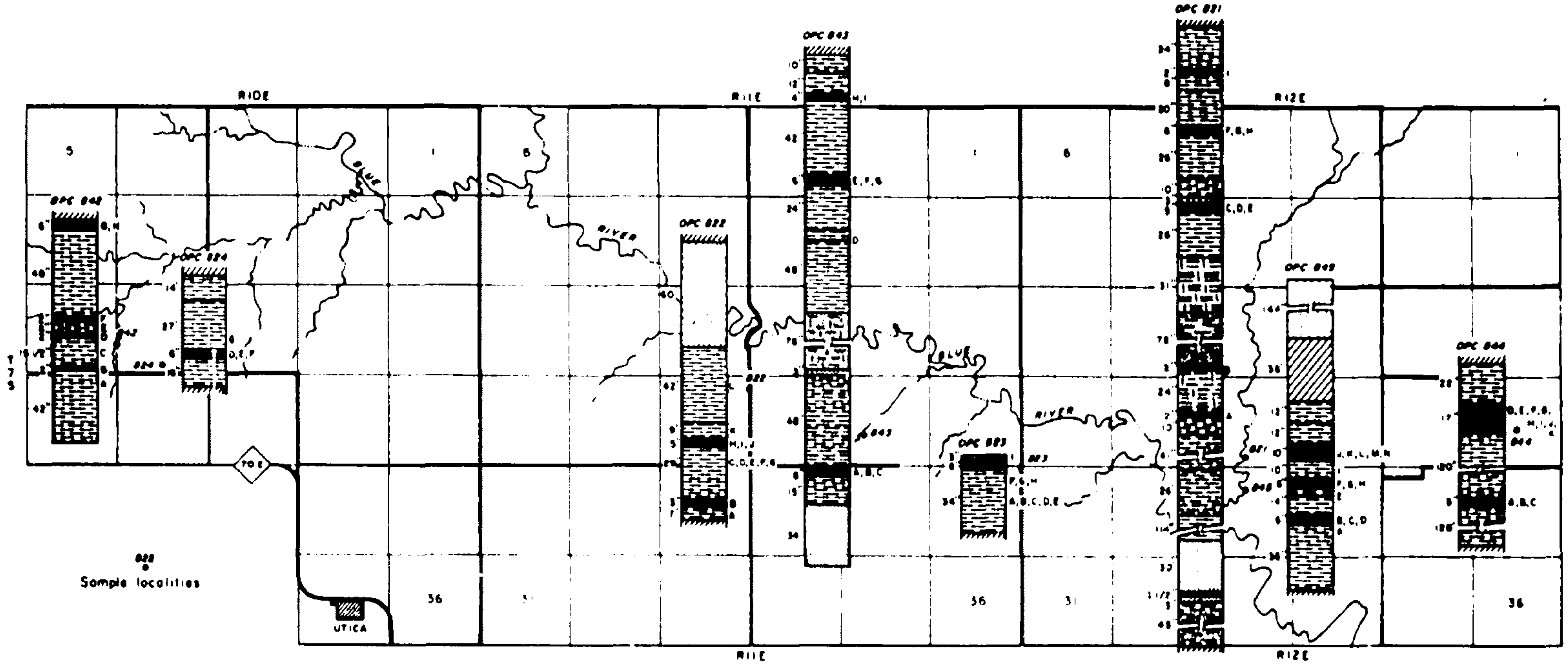
Lewisville (arenaceous glauconitic) Member

Red Branch (argillaceous) Member

Dexter (arenaceous) Member

Bergquist (1949) described the Red Branch Member as follows:

> "At its type locality near the Red Branch community in northwestern Grayson County, the Red Branch member consists of distinctive tuffaceous sandstone, carbonaceous shale, and lignite. Elsewhere the Red Branch member also includes sandy shale and ferruginous sandstone, the entire sequence being from 50 to 80 feet thick. ....Downdip the beds become increasingly marine.......The Red Branch member is thus probably recognizable only in the Red River area."

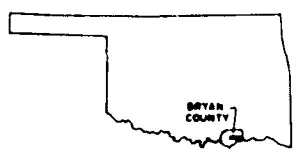


MAP SHOWING LOCATIONS OF RED BRANCH MEASURED SECTIONS AND LOCATIONS OF SAMPLES

by

Richard W. Hedlund

1962



INDEX MAP OF OKLAHOMA SHOWING LOCATION OF MAP AREA

Figure 1

He also noted the presence of leaf imprints in the ferruginous sandstones of the Red Branch Member, a type of fossil not found in the Bryan County outcrops.

The sediments here assigned to the Red Branch Member have been found in Bryan County as far east as sec. 29, T. 7 S., R. 13 E., and exposures of this member were located as far west as sec. 16, T. 7 S., R. 10 E. (fig. 1). Outcrops of the Red Branch sediments are not traceable on available aerial photographs.

Bergquist (1949) and Curtis (1960) thought that the complete section showing the entire sequence of tuffaceous sandstone, ferruginous sandstone, carbonaceous shale and coal does not occur anywhere in a single locality, an opinion here concurred with. In Bryan County, Oklahoma, no tuffaceous sandstone was encountered in the sections chosen for this study. Further, the ferruginous sandstone is not traceable across the eastern part of the county. When the measured sections of the Red Branch Member in this area are compared, it can be seen that none of the individual beds is traceable even short distances. The palynological evidence indicates that the individual coals and carbonaceous shales cannot be correlated from one section to the next. It is assumed, therefore, that the sedimentary units within the Red Branch Member are not continuous throughout the area studied, but occur in lenticular patches.

No outcrops of the Red Branch Member were located west of section No. OPC 842, NW$\frac{1}{4}$ SW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 16, T. 7 S, R. 10 E. Curtis discovered coal float on the west side of Coal Creek in the SE$\frac{1}{4}$ sec. 2, T. 8 S., R. 8 E., and in a stream bed in the NE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 27, T. 7 S., R. 8 E. He also found black carbonaceous shale and purplish brown shale cropping out in the NE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 13, T. 7 S., R. 9 E. On the basis of this evidence it cannot be assumed that the coals do not extend into the western part of Bryan County.

There are few other known occurrences of Cretaceous coals in Oklahoma. Stephenson (1919) reported a coal exposed on the south bank of the Red River in the Woodbine Formation. At the time that collections for the present study were made, this exposure was under water and consequently this coal was not available for study. This unit may be a part of the Red Branch Member. Davis (1960) reported the presence of coal in the Upper Cretaceous of southern McCurtain County. A palynological investigation of brown coal in the Dakota Formation of Cimarron County, Oklahoma, is presently being conducted by D. E. Potter.

Bullard (1925, 1926) did not report coal beds from the Cretaceous of Love and Marshall Counties, Oklahoma. No coal was recorded by Gibbs (1950) from eastern Choctaw County.

COLLECTIONS

Eight sections of the Red Branch Member in the Woodbine Formation were measured and collected during the summer of 1961. Segment samples, generally two inches in length, were collected vertically through the coal seams. No definite underclays or roof shales were found in any of the sections. Samples were also collected of the shales where they appeared carbonaceous or sufficiently fresh for palynological investigations. Most of the coal seams encountered were six inches thick. Each section was assigned an Oklahoma Palynological Collection (OPC) number, and each sample was designated A, B, C, etc., from the bottom of the section upward. Table I describes these 8 measured stratigraphic sections. The unused portion of each sample is stored in the Palynological Collection of the Oklahoma Geological Survey, Norman, Oklahoma.

TABLE 1

MEASURED OUTCROP SECTIONS OF THE RED BRANCH MEMBER AND POSITION OF SEGMENT SAMPLES

OPC 842: Exposed in west bank of creek, approximately 360 feet north of the southwest corner of section 16, and approximately 50 feet east of section line. On west line of the NW¼ SW¼ SW¼ sec. 16, T. 7 S., R. 19 E.

Lithology	Thickness (inches)
Coal, brown, oxidized (OPC 842 H)	2.0
Shale, white, chalky	1.0
Coal, brown, stratified, soft, weathered (OPC 842 G)	4.0
Shale, purple, carbonaceous	48.0
Coal, black, blocky, weathered (OPC 842 F)	2.0
Shale, black, carbonaceous, with ½-inch coal 3 inches from base (OPC 842 E)	6.0
Coal, black, blocky (OPC 842 D)	2.0
Shale, purplish-gray, carbonaceous, selenite crystals (OPC 842 C)	15.5
Coal, black, blocky, selenite crystals (OPC 842 B)	2.0
Shale, black, carbonaceous (OPC 842 A from upper 2 inches)	41.0
Total	123.5

TABLE 1--Continued

Sample No.	Lithology	Thickness (inches)
OPC 842 H	coal	2.0
OPC 842 G	coal	4.0
OPC 842 F	coal	2.0
OPC 842 E	shale with ½" coal	6.0
OPC 842 D	coal	2.0
OPC 842 C	shale	15.5
OPC 842 B	coal	2.0
OPC 842 A	shale (upper 2")	2.0

OPC 842: Exposed in west bank of creek, 0.2 miles north of east-west section line road and 200 feet west of north-south section line road. SE¼ SE¼ sec. 16, T. 7 S., R. 10 E.

Lithology	Thickness (inches)
Shale, brown, carbonaceous, weathered (OPC 824 M, N, O)	14.0
Shale, purple, carbonaceous with one-half-inch coal 10.0 inches from base (OPC 824 G, H, I, J, K, L)	27.0
Coal, black, shaley, oxidized (OPC 824 D, E, F)	6.0
Shale, purple-gray, carbonaceous (OPC 824 A, B, C)	16.0
Total	63.0

TABLE 1--Continued

Sample No.	Lithology	Thickness (inches)
OPC 824 O	shale	5.0
OPC 824 N	shale	5.0
OPC 824 M	shale	4.0
OPC 824 L	shale	5.0
OPC 824 K	shale	6.0
OPC 824 J	shale	6.0
*OPC 824 I	coal	0.5
OPC 824 H	shale	5.0
*OPC 824 G	shale	5.0
*OPC 824 F	coal	2.0
*OPC 824 E	coal	2.0
*OPC 824 D	coal	2.0
*OPC 824 C	shale	6.0
OPC 824 B	shale	5.0
OPC 824 A	shale	5.0

* samples processed

OPC 822: Roadcut approximately 100 feet north of hilltop, facing east, in SW¼ NW¼ NW¼ sec. 22, T. 7 S., R. 11 E.

Lithology	Thickness (inches)
Sandstone, brown, massive, resistant, with ferruginous nodules and stains	60.0
Shale, brown, weathered, and sandstone, brown, interlayered (OPC 822 L)	42.0
Shale, purple, blocky, irregularly layered, some carbonaceous material. (OPC 822 K)	9.0
Coal, black, dull, yellow oxidized spotting (OPC 822 H, I, J)	5.0
Shale, purple, carbonaceous, yellow oxidized lenses, selenite crystals (OPC 822 C, D, E, F, G)	29.0

TABLE 1--Continued

Lithology	Thickness (inches)
Coal, black, dull (OPC 822 B)	3.0
Shale, purple, carbonaceous, yellow oxidized lenses selenite crystals (OPC 822 A)	7.0
Total	155.0

Sample No.	Lithology	Thickness (inches)
OPC 822 L	shale and sandstone	1.0
OPC 822 K	shale	9.0
*OPC 822 J	coal	1.0
*OPC 822 I	coal	2.0
*OPC 822 H	coal	2.0
*OPC 822 G	shale	5.0
OPC 822 F	shale	6.0
OPC 822 E	shale	6.0
OPC 822 D	shale	6.0
OPC 822 C	shale	6.0
*OPC 822 B	coal	3.0
OPC 822 A	shale	7.0

* samples processed

OPC 843: Exposed on east bank of creek, approximately 0.25 miles east of west edge of section 23. NW¼ NE¼ SW¼ sec. 23, T. 7 S., R. 11 E.

Lithology	Thickness (inches)
Shale, purple, interbedded with yellow silt	10.0
Siltstone, yellow, resistant	12.0
Coal, black, blocky (OPC 843 H, I)	4.0

TABLE 1--Continued

Lithology	Thickness (inches)
Shale, purple, carbonaceous	42.0
Coal, black, blocky (OPC 843 E, F, G)	6.0
Clay, blue at base to white	24.0
Shale, purple at base, grading upward to black, carbonaceous shale with carbonized plant fragments. Coal (¼ inch) about one foot from top of unit. (OPC 843 D)	48.0
Clay, blue, sand, red, and silt, buff interbedded with local iron stains and ferruginous concretions	76.0
Sandstone, brown, massive, resistant, ferruginous	3.0
Clay, blue-gray and buff silt interbedded	48.0
Coal, black, layered with numerous plant fibers (OPC 843 A, B, C)	6.0
Clay, blue green at base grading upward to purple	15.0
Sandstone, gray-green with Ostrea soleniscus scattered in lower 24 inches and abundant in a 2-inch zone 24 inches from base of unit	34.0
Total	330.0

Sample No.	Lithology	Thickness (inches)
OPC 843 I	coal	2.0
OPC 843 H	coal	2.0
OPC 843 G	coal	2.0
OPC 843 F	coal	2.0
OPC 843 E	coal	2.0
OPC 843 D	shale with ¼" coal	2.0
OPC 843 C	coal	2.0
OPC 843 B	coal	2.0
OPC 843 A	coal	2.0

TABLE 1--Continued

OPC 823:	West side of roadcut at section corner. NE¼ NE¼ NE¼ sec. 25, T. 7 S., R. 11 E.

Lithology	Thickness (inches)
Shale, blue-gray, weathered, with yellow silt lenses (OPC 823 I)	3.0
Coal, black, weathered (OPC 823 F, G, H)	6.0
Shale, purple, carbonaceous, clayey, 1/8-inch yellow silt lenses (OPC 823 A, B, C, D, E)	34.0
Total	43.0

Sample No.	Lithology	Thickness (inches)
*OPC 823 I	shale	3.0
*OPC 823 H	coal	2.0
*OPC 823 G	coal	2.0
*OPC 823 F	coal	2.0
*OPC 823 E	shale	8.0
OPC 823 D	shale	6.0
OPC 823 C	shale	6.0
OPC 823 B	shale	6.0
OPC 823 A	shale	8.0

* samples processed

TABLE 1--Continued

OPC 821: East bank of Sulphur Creek, cliff exposed along creek and extending north to south; SW¼ SW¼ SE¼ sec. 21, T. 7 S., R. 12 E.

Lithology	Thickness (inches)
Shale, blue, clayey, yellow siltstone lenses	24.0
Coal, black, blocky, selenite crystals (OPC 821 I)	2.0
Shale, purple, carbonaceous, yellow siltstone lenses	8.0
Shale, blue, grading downward into purple shale	20.0
Coal, black, yellow silt spots (OPC 821 F, G, H)	6.0
Shale, purple, carbonaceous, yellow siltstone lenses and resin	26.0
Siltstone, yellow, carbonaceous	10.0
Shale, blue, clayey, grading downward to purple	3.0
Coal, black, blocky (OPC 821 C, D, E)	5.0
Shale, purple, carbonaceous with layers of selenite crystals	26.0
Siltstone, yellow, ferruginous, interbedded with blue clayey shale and bands of selenite crystals	31.0
Shale, purple, clayey, with interbedded lenses of sandstone, siltstone and selenite crystals. Mostly covered.	78.0
Sandstone, brown, massive, and siltstone, yellow, interbedded, jointed with selenite crystals	2.0
Coal, black, blocky, in brown mudstone (OPC 821 B)	0.75
Mudstone, brown	24.0
Coal, black, blocky (OPC 821 A)	2.0
Shale, bluish-gray, clayey	10.0
Siltstone, yellow, ferruginous, selenite crystals	41.0
Siltstone, yellow, fine-grained, resistant, black iron stains and selenite crystals in joints	26.0
Shale, gray, silty, iron stains in joints	114.0

TABLE 1--Continued

Lithology	Thickness (inches)
Sandstone, yellow, blocky, resistant	30.0
Siltstone, blue	1.5
Sandstone, yellow, resistant	3.0
Siltstone, blue, shale, blue, and sandstone, yellow, interbedded with ½-inch pyrite concretions	45.0
Total	538.25

Sample No.	Lithology	Thickness (inches)
OPC 821 I	coal	2.0
OPC 821 H	coal	2.0
OPC 821 G	coal	2.0
OPC 821 F	coal	2.0
OPC 821 E	coal	2.0
OPC 821 D	coal	1.0
OPC 821 C	coal	2.0
OPC 821 B	coal	0.75
OPC 821 A	coal	2.0

OPC 845: Exposed in cliff on east bank of Sulphur Creek approximately 0.5 miles east of section line road. NW¼ NW¼ NE¼ sec. 28, T. 7 S., R. 12 E.

Lithology	Thickness (inches)
Sandstone, brownish-red	144.0
Covered interval	36.0
Shale, blue-gray, silty, carbonaceous, yellow oxidation spots	12.0

TABLE 1--Continued

Lithology	Thickness (inches)
Shale, purple, carbonaceous, yellow oxidation spots, contains thin coal lenses	12.0
Coal, black, blocky, yellow oxidation spots, selenite crystals (OPC 845 J-N)	10.0
Shale, black, carbonaceous, yellow oxidation spots (OPC 845 I)	10.0
Coal, black, blocky, (OPC 845 F, G, H)	6.0
Shale, black, carbonaceous in upper part with ¼ inch coal, grades downward into blue-gray shale (OPC 845 E)	14.0
Coal, black, blocky (OPC 845 B, C, D)	6.0
Shale, black, carbonaceous in upper part, grading downward into blue, silty shale (OPC 845 A)	36.0
Total	286.0

Sample No.	Lithology	Thickness (inches)
OPC 845 N	coal	2.0
OPC 845 M	coal	2.0
OPC 845 L	coal	2.0
OPC 845 K	coal	2.0
OPC 845 J	coal	2.0
OPC 845 I	shale, lower 4 inches	4.0
OPC 845 H	coal	2.0
OPC 845 G	coal	2.0
OPC 845 F	coal	2.0
OPC 845 E	shale, upper 4 inches with ¼ inch coal	4.0
OPC 845 D	coal	2.0
OPC 845 C	coal	2.0
OPC 845 B	coal	2.0
OPC 845 A	shale, upper 4 inches	4.0

TABLE 1-- Continued

OPC 844:	Exposed in a bluff facing east, about thirty feet high. NW¼ SE¼ sec. 24, T. 7 S., R. 12 E.

Lithology	Thickness (inches)
Shale, black, carbonaceous	22.0
Coal, black, blocky, layered (OPC 844 D-K)	17.0
Shale, black, carbonaceous, with selenite crystals	120.0
Coal, black and carbonaceous shale (OPC 844 A, B, C)	5.0
Shale, gray, carbonaceous	128.0
Total	292.0

Sample No.	Lithology	Thickness (inches)
OPC 844 K	coal	2.0
OPC 844 J	coal	2.0
OPC 844 I	coal	2.0
OPC 844 H	coal	2.0
OPC 844 G	coal	2.0
OPC 844 F	coal	2.0
OPC 844 E	coal	2.0
OPC 844 D	coal	3.0
OPC 844 C	coal	1.0
OPC 844 B	coal	2.0
OPC 844 A	coal	2.0

SAMPLE PREPARATION AND STUDY

The sample preparation methods used in this study are essentially those outlined by Wilson (1959 b). Each sample was first crushed and mixed. Ten grams of each sample was placed in polyethylene beakers and covered with 52 per-cent hydrofluoric acid for twenty-four hours. These samples were washed in distilled water and decanted several times to remove the excess acid. The damp residues were mixed with an equal volume of dry powdered potassium chlorate and covered with concentrated nitric acid. Each sample was allowed to stand for four to six hours and the residues were again washed and decanted until free of acid. They were then treated with a saturated solution of potassium carbonate for five to ten minutes, and the maceration progress of each sample was checked carefully during this time. The potassium carbonate was neu-tralized and eventually removed by washing with distilled water.

Fossils were stained with Safranin O. Approximately twenty slides were prepared for each level, using Clearcol as a mounting medium.

The unused portions of sample residues are stored in an aqueous medium with a few drops of acetic acid added as a preservative. These samples are in the Oklahoma Palynological Collection.

The fossils were examined with the aid of an American Optical Microstar compound binocular microscope. Each slide was studied by horizontal traverses and the microfossils selected for photographing were ringed with black glass-marking ink.

Specimen notations used here refer to section, sample, slide and ring numbers. The selected specimens were photographed with a Zeiss Photomicroscope using 35 mm. Adox KB-14 film.

After identifications were completed, assemblage counts were made by systematic traverses of the slides. Two hundred fossils were counted from each level, using four slides from each level to give random sampling. The relative percentages of species in each level have been calculated and the results plotted in chart form. Whenever possible, each species has been assigned to a natural biological group. The group percentages for each sample were calculated and the results have been plotted as histograms.

PALEONTOLOGY

Introduction

The spores and pollen grains found in the coals and shales of the Red Branch Member of the Woodbine Formation consist of 73 species which are assigned to 43 previously described genera. Of the total assemblage, 35 species and 6 genera are considered new. New names are not assigned in order to avoid misunderstanding as to what constitutes valid publication.

The preservation of the fossil spores and pollen grains is fair to excellent in the Red Branch sediments, depending perhaps upon the degree of weathering of the samples. The shales are, for the most part, deeply weathered, whereas only those coals near the tops of the measured sections show signs of intense oxidation. Fossils recovered from the coal beds normally show good to excellent preservation. One section consisting of coals and shales proved to be barren throughout, perhaps due to deep weathering. In all other sections, minor weathering effects are noticed.

The taxonomic system used in this paper employs as a guide the works of Potonié and Kremp (1954) and Potonié

(1956, 1958 and 1960). The systematic arrangement of taxa is intended to be conservative and for the most part, morphographic, i.e., artificial. The taxonomy used here employs only those emendations which appear to be sufficiently well-defined. An artificial system of classification attempts to assign morphographically similar forms to form-generic groups regardless of their natural affinities. The probable natural affinities of most of the palynomorphs described in this paper are discussed in an attempt to arrive at a near-natural grouping.

The genera are here defined on the basis of such useful features as shape, wall structure, germinal structure and distinctive ornamentation. Variations in size and exine ornamentation are considered to be important in most cases only at the specific level. Further, gradational features are not considered to be valid characteristics for specific differentiations.

SPORAE DISPERSAE

Anteturma Sporites H. Potonié 1893

Genus BRACHYSPORIUM Saccardo

BRACHYSPORIUM SP.

Plate 1, figure 2

Septate spore chain bilateral, spores 3 to 4 in number, non-aperaturate; overall length 27.5 to 30.0 microns; average cell diameter approximately 15.0 by 15.0 microns; cell walls approximately 1.0 micron thick, smooth.

Typical specimen: OPC 843 H-6-1. Overall dimensions 27.5 microns long by 15.0 microns wide.

This spore type was recovered from several levels in section OPC 843. It everywhere occurs sparsely.

Affinity: Brachysporium is an imperfectae fungus, saprophytic on wood and bark.

Figured specimen: OPC 843 H-6-1

FUNGUS SPORE SP. A

Plate 1, figure 1

Spores without apertures, occurring in clusters or as individuals; cell wall 0.5 micron thick, smooth, oval; overall dimensions 15.0 to 21.0 microns.

Typical specimen: OPC 843 F-5-2. Overall dimensions 20.5 microns, 18.4 microns, 16.2 microns.

Fungus spore sp. A is a common form in most levels of the Red Branch sediments.

Figured specimen: OPC 843 F-5-2

Anteturma Sporites H. Potonié, 1893

Turma TRILETES (Reinsch, 1881) emend. Potonié and Kremp, 1954

Subturma Azonotriletes Luber, 1935

Infraturma Laevigati (Bennie and Kidston, 1886) emend. R. Potonié, 1956

Genus DELTOIDOSPORA (Miner, 1935) R. Potonié, 1956

Type Species: *Deltoidospora halli* Miner, 1935, American Midland Naturalist, vol. 16, p. 618, pl. 24, figs., 7, 8.

DELTOIDOSPORA cf. D. HALLI Miner, 1935

Plate 4, figures 7, 9

Specimens referred to *Deltoidospora* cf. *D. halli* are most abundant in the assemblage counts of the Red Branch sediments. In four levels, OPC 842A, 842C, 842K and 842D, this species amounts to less than 2.0 percent of the total assemblage counts. In all other levels it is well represented, occurring in greatest abundance in sections OPC 822 and OPC 845.

This fossil spore was described from the Cretaceous Kootenai Formation of Montana by Miner (1935). It is an important element of the Red Branch flora.

Affinity: Miner (1935) believed this spore type to be closely related to the Mesozoic ferns Gleichenites, Gleicheniopsis and Laccopteris. The spore is treated here as a member of the family Gleicheniaceae. Its great abundance may indicate a near-shore or swamp environment.

Figured specimens: OPC 845 F-3-3, OPC 845 F-5-1

Genus CYATHIDITES Couper 1953

Type Species: Cyathidites australis Couper, 1953, New Zealand Geological Survey Paleontological Bulletin 22, p. 27, pl. 2, figs. 11, 12.

CYATHIDITES cf. C. AUSTRALIS Couper, 1953

Plate 4, figure 4

Cyathidites cf. C. australis has a restricted occurrence throughout the Red Branch sediments, appearing in 25 of the 56 productive samples as a minor element of the microflora. In these samples it nowhere occurs in excess of 5.5 percent of the total assemblage counts.

Couper (1953, 1958) reported this species from the Jurassic and Lower Cretaceous of New Zealand. The presence of this species in the Woodbine Formation extends its range to the Upper Cretaceous.

Affinity: The spores referred to *C.* cf. *C. australis* are reported by Couper (1953) as having both cyatheaceous and dicksoniaceous affinities. The tree ferns today are tropical and subtropical in distribution.

Figured specimen: OPC 843 E-2-3

CYATHIDITES cf. C. MINOR Couper, 1953

Plate 4, figure 2

Specimens of *Cyathidites* cf. *C. minor* occur more consistently than those of *C.* cf. *C. australis*, although they nowhere appear in excess of 8.5 percent of the total assemblage counts.

Couper (1953) has reported this species from the Jurassic and Lower Cretaceous of New Zealand. Groot, Penny and Groot (1961) have recorded the occurrences of *C. minor* from the Upper Cretaceous Tuscaloosa Formation of the Atlantic Coast.

Affinity: Fossil spores referred to *Cyathidites* cf. *C. minor* are somewhat similar to the spores of recent New Zealand Cyatheaceae.

Figured specimen: OPC 844 J-18-6

Genus GLEICHENIIDITES (Ross, 1949)

Delcourt and Sprumont, 1955

Type Species: *Gleicheniidites senonicus* (Ross, 1949) Delcourt & Sprumont, 1955.

1949 *Gleicheniidites senonicus* Ross, Geological Institution of the University of Upsala Bulletin, vol. 34, p. 31, pl. 1, figs. 3, 4.

1955 *Gleicheniidites senonicus* (Ross, 1949) Delcourt and Sprumont, Société Belge de Paléontologie et d'Hydrologie, Mémoires, nouvelles séries 4, Brussels, no. 5, p. 26.

GLEICHENIIDITES SP. A

Plate 1, figure 10

Trilete, lasurae long, reaching to equator, kyrtome distinct, equatorial contour triangular, sides straight to concave; spore wall 1.0 to 1.5 microns thick, pitted. Diameter varies between 25.0 and 37.5 microns.

Typical specimen: OPC 843 E-2-4. Overall dimensions 32.4 by 33.5 microns.

This species is similar to *Gleicheniidites senonicus* (Ross 1949) Delcourt and Sprumont 1955 but differs from it in the typical pitted ornamentation.

Gleicheniidites sp. A is a persistently abundant fossil in the population counts of both the coals and the shales. It is most abundant in section OPC 845 where it exceeds 66.0 percent of the total assemblage count of one level.

Affinity: Fossil spores referred to Gleicheniidites sp. A are smaller than those of most living species of Gleichenia but otherwise resemble them closely. Gleichenia is typically a subtropical to warm-temperate fern and is ecologically associated with near-shore environments.

Figured specimen: OPC 843 E-2-4

Genus CONCAVISPORITES Pflug, 1953

Type Species: Concavisporites rugulatus Pflug, 1953, Palaeontographica, Abt. B, vol. 95, p. 49, pl. 1, figs. 22, 23.

CONCAVISPORITES cf. C. PUNCTATUS Delcourt and Sprumont, 1955

Plate 4, figure 3

Specimens of Concavisporites cf. C. punctatus are rare in the 29 levels of Red Branch sediments in which this species occurs. It nowhere exceeds 3.5 percent of the total population count of any level. Generally, the species is most common and persistent in measured sections OPC 842, OPC 843 and OPC 844.

This species has been reported from the Wealden

(Lower Cretaceous) of Belgium (Delcourt and Sprumont 1955) and from the New Zealand Wealden and Aptian (Couper 1958).

Affinity: Delcourt and Sprumont (1955) have suggested a gleicheniaceous affinity for this species, but Couper (1958) believes it to be more closely related to the families Cyatheaceae and Dicksoniaceae. Spores referred to C. cf. C. punctatus are undoubtedly related to the schizaeaceous genus Lygodium, and are here treated as such. This genus is tropical to warm temperate in distribution.

Figured specimen: OPC 843 H-4-2

CONCAVISPORITES cf. C. SUBGRANULOSUS Couper, 1958

Plate 4, figure 1

Specimens of Concavisporites cf. C. subgranulosus are restricted to four levels of shales and nowhere amount to more than 1.5 percent of the total assemblage counts. The Red Branch specimens are larger than those reported by Couper (1958), the size range being 42.5 to 50.0 microns. This difference in size may be due to the fact that Couper's specimens were not well preserved.

C. subgranulosus has been reported previously from the Lower Liassic and Middle Jurassic of New Zealand by Couper (1958).

Affinity: Fossil spores referred to this species closely resemble the spores of the recent tree fern Cyathea *dealbata* which occurs in lowland forests from sea level to 2,500 feet in New Zealand (Harris 1955). A habitat distant from the depositional site would explain the rare occurrences of this fossil species in the Red Branch sediments.

Figured specimen: OPC 845 A-13-1

CONCAVISPORITES SP. A

Plate 4, figure 5

Trilete, lasurae long, about three-fourths radius of spore, margo narrows at the ends of the commissures, but not as distinct as in *Concavisporites* cf. *C. punctatus*; equatorial contour rounded triangular, sides in all specimens distinctly concave; spore wall 1.0 to 1.5 microns thick, smooth, in many cases folded at ends of trilete lasurae. Diameter varies between 27.5 and 37.5 microns.

Typical specimen: OPC 845 I-14-1. Overall dimensions 37.4 by 37.4 by 37.4 microns.

Concavisporites sp. A differs from *Concavisporites* cf. *C. punctatus* in its smaller size, indistinct margo and lack of ornamentation.

Fossil spores referred to *Concavisporites sp. A* are common to abundant in most samples, in few cases exceeding 10.0 percent of the total assemblage count at any level. This species is represented by 21.0 percent of the total assemblage in sample OPC 842 E.

Affinity: Concavisporites sp. A was probably derived from a Mesozoic Lygodium, being similar in shape and possessing a trilete ray character similar to that of C. punctatus. The abundance of this spore type in most levels may indicate that its parent plants were growing close to the site of deposition.

Figured specimen: OPC 845 I-14-1

Genus SPHAGNUMSPORITES Raatz, 1937

Type Species: Sphagnumsporites stereoides (R. Potonié and Venitz, 1934) R. Potonié, 1956

1934 Sporites stereoides R. Potonié and Venitz, Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, Berlin, vol. 5, p. 11 pl. 1, fig. 4.

1956 Sphagnumsporites stereoides (R. Potonié and Venitz) R. Potonié, Amt für Bodenforschung, Beihefte Geologischen Jahrbuch, Hannover, vol. 23, p. 17.

SPHAGNUMSPORITES cf. S. PSILATUS (Ross, 1949) Couper, 1958

Plate 1, figure 3

1949 Trilites psilatus Ross, Geological Institution of the University of Upsala, Bulletin, vol. 34, p. 32, pl. 1, fig. 12.

1958 *Sphagnumsporites psilatus* (Ross, 1949) Couper, Palaeontographica, Abt. B, vol. 103, p. 131, pl. 15, figs. 1, 2.

Specimens referred to *Sphagnumsporites* cf. *S. psilatus* occur in varying abundance throughout most sections of the Red Branch sediments. They are most abundant in section OPC 844, where they reach a maximum of 21.5 percent of the total assemblage count of the lowermost coal.

Ross (1949) reported the occurrence of this fossil species in the Upper Cretaceous (not later than Senonian) of Sweden. Couper (1958) recovered specimens of *S. psilatus* from the Jurassic and Lower Cretaceous of New Zealand. In 1961 Groot, Penny and Groot reported this species from the Upper Cretaceous Magothy Formation of Maryland.

Affinity: *Sphagnumsporites* cf. *S. psilatus* is undoubtedly the spore of a Mesozoic *Sphagnum*. The modern representatives of this genus occur in swamps and peat bogs and indicate low pH conditions.

Figured specimen: OPC 844 J-28-1

Genus MATONISPORITES Couper, 1958

Type Species: *Matonisporites phlebopteroides* Couper, 1958. Palaeontographica, Abt. B, vol. 103, p. 140, pl. 20, figs. 15-17.

MATONISPORITES cf. M. EQUIEXINUS Couper, 1958

Plate 4, figure 6

This species is a common form in both the coals and shales of the Red Branch Member. It occurs in greatest abundance in section OPC 844 and is present in all other sections except OPC 822.

Couper (1958) has reported the occurrence of *Matonisporites equiexinus* from the Jurassic and Lower Cretaceous of New Zealand.

Affinity: Couper has compared fossil spores referred to *M. equiexinus* to the spores of the modern fern *Matonia pectinata*. This interpretation is not followed in this paper, because the fossil species more closely resembles the spores of the recent schizaeaceous ferns *Anemia* and *Lygodium*.

Figured specimen: OPC 843 E-2-1

MATONISPORITES SP. A

Plate 4, figure 8

Trilete, lasurae reaching almost to the equator, commissures raised and flanked by a distinct margo; equatorial contour rounded triangular, sides in all cases distinctly convex; wall of spore 4.5 to 5.0 microns thick, smooth. Diameter varies between 57.5 and 75.0 microns.

Typical specimen: OPC 845 I-14-2. Overall dimensions 75.0 by 71.5 by 69.5 microns.

Matonisporites sp. A differs from *Matonisporites* cf. *M. equiexinus* in its larger size and thicker spore wall.

This fossil species is rare in all sections of the Red Branch sediments and for this reason does not appear in the assemblage counts. Only five specimens of *Matonisporites* sp. A were encountered in sections OPC 824 and OPC 845.

Affinity: This fossil spore is perhaps related to the recent tropical and warm temperate genus *Lygodium*.

Figured specimen: OPC 845 I-14-2

Infraturma Apiculati (Bennie and Kidston, 1886) emend. R. Potonié, 1956

Genus TRILITES (Cookson, 1947) Couper, 1953

Type Species: *Trilites tuberculiformis* Cookson, 1947, British-Australian-New Zealand Antarctic Research Expedition 1929-1931, Science Reports-Series A, vol. 2, part 8, p. 136, pl. 16, figs. 61, 62.

TRILITES SP. A

Plate 1, figure 6

Trilete, lasurae long, reaching to equator; equatorial contour rounded triangular, sides straight to concave; spore wall 1.0 micron thick; proximal face smooth and folded; distal face with granules projecting 1.0 micron above the surface and about 1.0 micron apart forming a negative reticulum. Diameter varies between 23.0 and 25.0 microns.

Typical specimen: OPC 845 H-12-3. Overall dimensions 23.0 microns.

This fossil spore is rare in all sections of the Red Branch Member. It in no case amounts to more than 1.0 percent of the total assemblage count of any level.

Affinity: Not known.

Figured specimen: OPC 845 H-12-3

Genus OSMUNDACIDITES Couper, 1953

Type Species: *Osmundacidites wellmanii* Couper, 1953, New Zealand Geological Survey Paleontological Bulletin 22, p. 20, pl. 1, fig. 5.

OSMUNDACIDITES cf. O. WELLMANII Couper, 1953

Plate 1, figure 5

Fossil spores referred to *Osmundacidites* cf. *O. wellmanii* are restricted to certain sections of the Red

Branch sediments. They do not occur in sections OPC 821 and OPC 822 and are rare in section OPC 845. In section OPC 824 this species makes up between 1.0 and 3.0 percent of the total assemblage counts. This fossil spore is most abundant in sections OPC 842, OPC 843 and OPC 844 where it amounts to 19.5 percent of the total assemblage count of level OPC 844 D.

Couper (1953) has reported this fossil species as ranging from the Jurassic to the Lower Cretaceous. Conosmundasporites Klaus (1960) is strikingly similar to Osmundacidites wellmanii.

Affinity: Spores referred to Osmundacidites cf. O. wellmanii closely resemble those of two recent osmundaceous ferns, Todea and Leptopteris. The papillae of Todea are longer than those of Leptopteris, but otherwise these two recent spore genera are morphologically similar. The ornamentation of Osmundacidites cf. O. wellmanii is gradational between large granules and true papillae, the papillate forms being the more common. The recent representatives of the above mentioned genera are tropical to subtropical in distribution. Many species of Osmunda are also present in the swamps of Florida.

Figured specimen: OPC 844 J-2-2

Genus BACULATISPORITES Thomson and Pflug, 1953

Type Species: *Baculatisporites* (*Sporites*) *primarius* (Wolff, 1934) Thomson and Pflug, 1953.

1934 *Sporites primarius* Wolff, Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, Berlin, vol. 5, p. 66, pl. 5, fig. 8.

1953 *Baculatisporites* (*Sporites*) *primarius* (Wolff) Thomson and Pflug, Palaeontographica, Abt. B., vol. 94, p. 56, pl. 2, fig. 49.

BACULATISPORITES cf. B. COMAUMENSIS (Cookson, 1953) R. Potonié, 1956

Plate 1, figure 7

1953 *Trilites comaumensis* Cookson, Australian Journal of Botany, vol. 1, p. 470, pl. 2, figs. 27, 28.

1956 *Baculatisporites comaumensis* (Cookson, 1953) R. Potonié, Beihefte zum Geologischen Jahrbuch, vol. 23, p. 33.

Specimens of *Baculatisporites* cf. *B. comaumensis* are extremely rare in the sediments of the Red Branch Member. They occur only in three levels and are insignificant in these levels.

Cookson (1953) reported this species from the

Comaum clays (Pretertiary) of Australia.

Affinity: Fossil spores referred to *Baculatisporites* cf. *B. comaumensis* resemble those of the modern Osmundaceae.

Figured specimen: OPC 844 D-1-3

Infraturma Murornati R. Potonié and Kremp, 1954

NEW GENUS A

Plate 2, figures 4, 5

Trilete, lasurae long, about three-fourths radius of spore, commissure raised; equatorial contour rounded to rounded triangular, sides convex; spore wall 1.5 to 2.0 microns thick; proximal face smooth, distal face rugulate and extending proximally at the ends of the trilete lasurae in an arcuate fashion. Diameter varies between 42.5 and 52.5 microns.

Typical specimen: OPC 844 K-21-4. Overall dimensions 43.2 by 45.4 microns.

This form is characterized by its rounded shape, slightly raised commissures and rugae extending proximally at the ends of the trilete lasurae.

Fossil spores referred to New Genus A are restricted to some levels and rare in the Red Branch sediments. They are nowhere represented by more than 1.0 percent of the total assemblage counts of the five levels in which they occur.

Affinity: The spores referred to this genus are probably the spores of fossil lycopods. The ornamentation resembles that of the spore of the modern Lycopodium drummondii.

Figured specimens: OPC 844 K-21-4, OPC 844 K-11-5

Genus LYCOPODIACIDITES Couper, 1953

Type Species: Lycopodiacidites bullerensis Couper, 1953, New Zealand Geological Survey Paleontological Bulletin 22, p. 26, pl. 1, fig. 9.

LYCOPODIACIDITES cf. L. KEUPPERI Klaus, 1960

Plate 2, figures 3, 6

Lycopodiacidites cf. L. keupperi is a rare spore type in the Red Branch sediments. It amounts to less than 1.0 percent of the total assemblage counts of five levels and is present as a trace element in four other levels.

Klaus (1960) described this species from the Alpine Triassic sediments. A similar form, Lycopodiacidites bullerensis Couper, 1953, is a common form in the Jurassic sediments of New Zealand.

Affinity: Couper (1953) proposed this spore genus for the reception of fossil spores with probable lycopodiaceous affinities which cannot be more accurately placed. *Lycopodiacidites* cf. *L. keupperi* is similar to the spores of *Lycopodium cernuum* in sculpture pattern. The small number of spores of this genus and other lycopodiaceous spores described in this paper is probably due to the distance of the parent plants from the basins of deposition.

Figured specimen: OPC 844 K-12-1

Genus CICATRICOSISPORITES R. Potonié and Gelletich, 1933

Type Species: *Cicatricosisporites dorogensis* R. Potonié and Gelletich, 1933, Gesellschaft Naturforschender Freunde zu Berlin, Sitzungsberichte, vol. 33, p. 522, pl. 1, figs. 1-5.

CICATRICOSISPORITES cf. C. DOROGENSIS R. Potonié and Gelletich, 1933

Plate, figures 4, 5

1933 (see above)

1951 *Mohriosporites dorogensis* R. Potonié, Palaeontographica, Abt. B, vol. 91, pl. 20, fig. 14.

Spores referred to *Cicatricosisporites* cf. *C. dorogensis* are common to abundant in all the sediments studied. They are most abundant in sections OPC 843 and OPC 844 and occur in all other sections except OPC 822 in amounts between 0.5 and 14.5 percent of the total population counts. The absence of this common spore type in section OPC 822 is perhaps a result of weathering.

Potonié and Gelletich (1933) described C. *dorogensis* from the Upper Paleocene through the Eocene in the Dorog Basin of Hungary. R. Potonié (1934) found this form in the Eocene sediments of Geiseltal and in 1951 established the range of this species in Europe as being Upper Paleocene to Upper Oligocene. In 1953, Thomson and Pflug reported the spore type from the Paleocene through the Oligocene. Delcourt and Sprumont (1955) recorded a Wealden occurrence of *C. dorogensis* in Belgium. Couper (1958) reported the species from the Purbeck, Wealden and Aptian sediments of New Zealand. In 1960 Groot and Penny found this form in the Lower Cretaceous of the Atlantic Coastal Plain, and in 1961, Groot, Penny and Groot recovered the species from Upper Cretaceous sediments in the same area.

Affinity: *Cicatricosisporites* cf. *C. dorogensis* is a fossil spore with definite schizaeaceous affinities. This species closely resembles several species of *Mohria* as illustrated by Bolchovitina (1959). Couper (1958) has noted the similarity of *C. dorogensis* to the Wealden species *Ruffordia goepperti* (Dunk.) Seward and to the Eocene species *Anemia colwellensis* Chandler. The common occurrence and excellent preservation of this species in the Red Branch sediments may indicate that its parent plants were growing near or in the basins of deposition.

Figured specimens: OPC 843 H-6-1, OPC 843 H-2-1

CICATRICOSISPORITES SP. A

Plate 3, figures 7, 8

Trilete, lasurae long, reaching almost to equator, commissures slightly raised; equatorial contour rounded triangular, sides straight to somewhat concave; spore wall 2.0 to 3.0 microns thick, thicker at the trilete apices; both proximal and distal faces sculptured with slightly raised ribs, branching occasionally, from 2.5 to 3.0 microns wide and spaced from 1.0 to 2.C microns apart, forming an irregularly ribbed pattern. Diameter varies between 37.5 and 60.0 microns.

Typical specimen: OPC 843 A-5-2. Overall dimensions 56.2 microns.

Fossil spores referred to *Cicatricosisporites* sp. A are rare and restricted in the Red Branch sediments, nowhere amounting to more than 2.0 percent of the total assemblage count of any level.

Affinity: This fossil spore has schizaeaceous affinities. It resembles the spores of the modern *Anemia*. The restricted occurrences of this rare spore type indicate either that there were few parent plants growing near the basins of deposition or that the parent plants were growing in an environment distant from the depositional sites.

Figured specimens: OPC 843 A-5-2, OPC 844 K-21-2

Genus KLUKISPORITES Couper, 1958

Type Species: Klukisporites variegatus Couper, 1958, Palaeontographica Abt. B, vol. 103, p. 137, pl. 19, figs. 6, 7.

This genus was erected for the reception of fossil spores with schizaeaceous affinities and with the following characteristics: Trilete, lasurae long, about three-fourths radius of spore, commissures raised, bordered by a margo; equatorial contour rounded-triangular distal surface with foveolate or foveo-reticulate sculpture; contact area of proximal surface has greatly reduced sculpture; exine thick.

KLUKISPORITES SP. A

Plate 2, figures 7, 8

Trilete, lasurae long, about three-fourths radius of spore, commissures somewhat raised and bordered by a small margo; equatorial contour rounded-triangular, sides convex; spore wall 3.0 to 5.0 microns thick; proximal face smooth; distal surface sculptured with a polygonal reticulum which extends onto proximal face at ends of trilete lasurae; ribs of reticulum 4.0 to 5.0 microns high, 2.0 to 3.0 microns wide, lumen of reticulum 6.0 to 7.0 microns wide. Diameter varies between 45.0 and 67.5 microns.

Typical specimen: OPC 842 E-4-2. Overall dimensions 62.6 by 63.7 microns.

Klukisporites sp. A has a restricted occurrence throughout the Red Branch sediments. It appears in 4 of the 61 samples in amounts less than 2.0 percent of the total assemblage counts. In three other levels, OPC 842 E, OPC 842 D and OPC 842 E it amounts to more than 5.0 percent of the total assemblage counts.

Affinity: Spores referred to Klukisporites sp. A probably have schizaeaceous affinities and are here treated as such. Couper (1958) erected this genus for the reception of fossil spores of the type met with in the Jurassic ferns Klukia and Stachypteris.

Figured specimen: OPC 842 E-4-2

Subturma Pyrobolotriletes R. Potonié, 1956

Genus BALMEISPORITES Cookson and Dettmann, 1958

Type Species: Balmeisporites holodictus Cookson and Dettmann, 1958, Micropaleontology, vol. 4, p. 42, pl. 2, fig. 1.

BALMEISPORITES cf. B. GLENELGENSIS Cookson and Dettmann, 1958

Plate 1, figures 12, 13

This "large spore" rarely occurs in the total assemblage counts of any level. Undoubtedly many specimens of this species were lost during the gravitational separation methods used in this study.

Cookson and Dettmann (1958) have reported B. glenelgensis from the Upper Cretaceous sediments of Victoria, Australia.

Affinity: Not known.

Figured specimens: OPC 844 J-20-1, OPC 843 I-4-1

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

Subturma Auritotriletes R. Potonié and Kremp, 1954

Infraturma Auriculati R. Potonié and Kremp, 1954

NEW GENUS D

Plate 1, figure 11

Trilete, lasurae long, extending to equator; equatorial contour trilobate, sides strongly concave; wall of spore thin, smooth; kyrtome strongly developed. Diameter varies between 15.0 and 17.5 microns.

Typical specimen: OPC 844 K-21-6. Overall dimensions 16.2 by 17.3 by 17.3 microns.

New Genus D is a rare form in the Red Branch sediments. It nowhere amounts to more than 2.5 percent of the total assemblage count of any level in which it occurs.

Affinity: Not known.

Figured specimen: OPC 844 K-21-6

NEW GENUS F

Plate 1, figures 8, 9

Trilete, lasurae long, extending to equator, commissures raised; equatorial contour trilobate, sides convex; wall of spore thin, about 1.0 micron, smooth; proximal kyrtome strongly developed with line of weakness about 7.C microns from extremities of trilete lobes; distal face rounded triangular. Diameter varies between 20.0 and 27.0 microns.

Typical specimen: OPC 821 A-5-1. Overall dimensions 22.5 by 22.5 by 25.0 microns.

Spores referred to New Genus F occur in only 5 sections of the Red Branch coals. They nowhere make up more than 5.0 percent of the total assemblage counts of these levels.

Affinity: Not known.

Figured specimens: OPC 821 A-5-1, OPC 821 A-1-1

Genus APPENDICISPORITES Weyland and Krieger, 1953

Type Species: Appendicisporites tricuspidatus Weyland and

Greifeld, 1953, Palaeontographica, Abt. B, vol. 95, p. 42, pl. 11, fig. 54.

The generic name was proposed by Weyland and Kreiger who designated Weyland and Greifeld's species, A. tricuspidatus, described in the same publication, as the type species.

APPENDICISPORITES cf. A. TRICORNITATUS Weyland and Greifeld, 1953

Plate 3, figures 1, 2, 3

Fossil spores referred to Appendicisporites cf. A. tricornitatus are common elements of the Red Branch flora. Percentages vary from 0.5 to 12.5 percent of the total assemblage counts.

Weyland and Greifeld (1953) reported this species from the Lower Senonian of Germany. Delcourt and Sprumont (1953) have recorded A. tricornitatus from the Wealden of Belgium. Couper (1958) reported the fossil spore from the Wealden and Aptian sediments of New Zealand. In 1960, Groot and Penny recovered this species from the Lower Cretaceous sediments of the Atlantic Coast. Groot, Penny and Groot (1961) found A. tricornitatus in the Upper Cretaceous sediments of the same area.

Affinity: These fossil spores are indistinguishable from spores of Anemia tomentosa. The common occurrence of this schizaeaceous species in the Red Branch sediments indicates that the parent plants of *Appendicisporites* cf. *A. tricornitatus* were growing in or near the swamp basins.

Figured specimens: OPC 843 H-1-2, OPC 824 E-14-2
OPC 843 H-6-5

Subturma Zonotriletes Waltz, 1935

Infraturma Cingulati R. Potonié and Klaus, 1954

Genus CINGULATISPORITES Thomson in Thomson and Pflug, 1953

Type Species: *Cingulatisporites levispeciosus* Pflug, in Thomson and Pflug, 1953, Palaeontographica, Abt. B, vol. 94, p. 58, pl. 1, fig. 16.

CINGULATISPORITES cf. C. LEVISPECIOSUS Pflug, 1953

Plate 1, figure 4

This species occurs rarely in the Red Branch sediments. It in no case amounts to more than 2.3 percent of the total assemblage counts of the seven levels in which it is found.

Thomson and Pflug (1953) have reported this species from Hanover, ranging from the Danian (?) to the Paleocene.

Affinity: Fossil spores referred to *Cingulatisporites* cf. *C. levispeciosus* resemble the spores of modern *Sphagnum*.

Figured specimen: OPC 845 I-17-2

Genus CAMAROZONOSPORITES (R. Potonié, 1956) Klaus, 1960

Type Species: Camarozonosporites (Rotaspora) cretaceus (Weyland and Krieger, 1953) R. Potonié, 1956.

1953 Rotaspora cretacea Weyland and Krieger, Palaeontographica, Abt. B, vol. 95, p. 12, pl. 3, fig. 27.

1956 Camarozonosporites cretaceus R. Potonié, Amt für Bodenforschung, Beihefte Geologischen Jahrbuch, Hannover, vol. 23, p. 65.

An important generic characteristic of Camarozonosporites is the thinning of the distal exine at the ends of the trilete lasurae along the equator.

CAMAROZONOSPORITES cf. C. RUDIS (Leschik, 1955) Klaus, 1960

Plate 2, figures 1, 2

1955 Verrucosisporites rudis Leschik, Schweizerischen Paläontologischen Abhandlungen, vol. 72, p. 15, pl. 1, fig. 15.

1960 Camarozonosporites rudis (Leschik, 1955) Klaus, Austria, Geologischen Bundesanstalt, Jahrbuch, vol. 5, p. 136, pl. 29, figs. 12, 14.

Spores referred to Camarozonosporites cf. C. rudis have restricted occurrences in the Red Branch sediments. They are most abundant in levels OPC 844 A, OPC 844 B, and OPC 844 C, amounting to 17.0 percent of the total assemblage count of level OPC 844 C. In all other levels in which this form occurs it amounts to less than 5.0 percent of the total assemblage.

Leschik (1955) has reported the occurrence of C. rudis in the Keuper of Switzerland. Klaus (1960) has recorded this species from the Middle Keuper of the same area.

Affinity: Fossil spores assigned to C. rudis resemble the spores of recent Lycopodium, in particular L. cernuum and L. carolinianum.

Figured specimen: OPC 824 E-1-1

Turma MONOLETES Ibrahim, 1933

Subturma Azonomonoletes Luber, 1935

Genus LAEVIGATOSPORITES (Ibrahim, 1935) emend. Schopf, Wilson and Bentall, 1944

Type Species: Laevigatosporites vulgaris (Ibrahim, 1932) Ibrahim, 1933.

1932 Sporonites vulgaris Ibrahim, in R. Potonié, Ibrahim and Loose, Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Beilage, Abt. B, vol. 67, p. 448, pl. 15, fig. 16.

1933 Laevigato-sporites vulgaris (Ibrahim, 1932) Ibrahim, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Dissertation, Konrad Triltsch, Würzburg, p. 39-40, pl. 2, fig. 16, pl. 5, figs. 37, 39.

The type species, L. vulgaris was redescribed by Ibrahim (1933) as being oval to elliptical, smooth to punctate with a simple monolete dehissence mark ranging in length from 40 microns to 100 microns. Schopf, Wilson and Bentall (1944) extended this diagnosis to include other types of exine ornamentation. They considered shape, thickness of wall and dehissence structure to be generic characters. The type of ornamentation was considered to be of specific rank. The emendation and extension of the generic diagnosis of this form by Schopf, Wilson and Bentall is used in this paper.

LAEVIGATOSPORITES cf. L. OVATUS Wilson and Webster, 1946

Plate 5, figure 2

Laevigatosporites cf. L. ovatus is consistently distributed in all levels of the Red Branch sediments. It has a maximum relative abundance of 4.5 percent in level G of OPC 824.

Wilson and Webster (1946) originally described this species from the Paleocene Fort Union coal of Montana.

Affinity: Laevigatosporites cf. L. ovatus is probably the spore of a fossil schizaeaceous fern. It resembles spores of the extant genus Schizaea. The consistent occurrence of this fossil spore type would seem to indicate that the plant was adapted to a near shore terrestrial environment.

Figured specimen: OPC 843 E-9-1

LAEVIGATOSPORITES SP. A

Plate 5, figure 1

Spores bilateral; monolete; normally bean-shaped in profile, oval in equatorial view; monolete simple, approximately one-half the diameter; wall thin, 1.0 to 1.5 microns, surface finely granulose. Diameter varies between 45.0 to 50.0 microns by 20.0 to 30.0 microns.

Typical specimen: OPC 842 E-10-2. Overall dimensions 47.5 by 22.5 microns.

This species is rare and restricted in the Red Branch sediments. It in no case amounts to more than 1.5 percent of the total assemblage counts of any level.

Affinity: Fossil spores referred to Laevigatosporites sp. A are similar to the spores of the modern genus Psilotum.

Figured specimen: OPC 842 E-10-2

LAEVIGATOSPORITES SP. B

Plate 5, figure 4

Spores bilateral, monolete; spherical to oval in profile and equatorial views; monolete simple, approximately one-half the diameter; spore wall thin, less than 1.0 micron, surface smooth except in area surrounding monolete mark where it is granulose. Diameter varies between 20.0 and 34.6 microns.

Typical specimens: OPC 843 H-1-1. Three spores illustrated. Overall dimensions 32.4 microns, 32.4 microns, 34.6 by 27.0 microns.

Specimens of Laevigatosporites sp. B. are rare in the 33 levels in which they occur. This species in no case amounts to more than 3.0 percent of the total assemblage count of any level.

Affinity: Not known.

Figured specimen: OPC 843 H-1-1

LAEVIGATOSPORITES SP. C

Plate 4, figure 11

Spores bilateral; monolete; spherical in profile and equatorial views; monolete simple, approximately two-thirds the diameter; wall of spore opaque, 1.5 to 1.6 microns thick, smooth to finely granulose. Diameter varies between 35.0 and 77.5 microns.

Typical specimen: OPC 845 F-2-2. Overall dimensions 72.4 by 63.7 microns.

Laevigatosporites sp. C. was found in 10 levels of the Red Branch sediments. It in no case amounts to more than 5.0 percent of the total assemblage count of any level.

Affinity: Not known.

Figured specimen: OPC 845 F-2-2

LAEVIGATOSPORITES SP. D

Plate 5, figure 3

Spores bilateral, monolete; bean-shaped in profile, oval in equatorial view (?); monolete mark simple, approximately one-half the diameter; wall thin, 0.75 to 1.0 micron thick, surface smooth. Diameter varies between 20.0 to 25.0 microns by 15.0 to 20.0 microns.

Typical specimen: OPC 844 B-2-1. Overall dimensions 20.0 by 15.0 microns.

Laevigatosporites sp. D is a rare fossil in the Red Branch sediments. It was not encountered in the assemblage counts of any level, but several specimens were observed in level OPC 844 B.

Affinity: This fossil spore is perhaps related to the family Polypodiaceae.

Figured specimen: OPC 844 B-2-1

Genus VERRUCATOSPORITES Pflug, 1952
in Thomson and Pflug, 1953

Type Species: Verrucatosporites alienus (R. Potonié, 1931) Thomson and Pflug, 1953.

1931 Sporonites alienus R. Potonié, Zeitschrift Braunkohle, vol. 30, p. 556, fig. 1.

1953 Verrucatosporites alienus Thomson and Pflug, Palaeontographica, Abt. B, vol. 94, p. 59.

VERRUCATOSPORITES SP. A

Plate 4, figure 12

Spores bilateral; monolete; bean-shaped in profile; monolete simple, approximately two-thirds the diameter; spore wall 1.5 to 2.0 microns thick, covered with 1.0 microns high and 1.0 to 3.0 microns wide warts forming a weakly developed negative reticulum. Diameter of figured specimen 60.0 by 30.0 microns.

Typical specimen: OPC 824 D-7-2. Overall dimensions 60.0 by 30.0 microns.

Spores referred to Verrucatosporites sp. A are extremely rare in the Red Branch sediments. Only two specimens were encountered.

Affinity: These fossil spores resemble the spores of recent polypodiaceous genera. The spores of Anarthopteris are similar to this fossil species.

Figured specimen: OPC 824 D-7-2

VERRUCATOSPORITES SP. B

Plate 4, figure 10

Spores bilateral; monolete; bean-shaped in profile, elongate in equatorial view; monolete simple, more than two-thirds the diameter; spore wall 1.0 to 1.5 microns thick with small, irregular verrucae forming a pseudo-reticulum. Diameter varies between 50.0 to 60.0 microns by 22.5 to 30.0 microns.

Typical specimen: OPC 844 H-24-1. Overall dimensions 55.1 by 27.0 microns.

This species occurs in 14 levels. It is a rare form, occurring in both coals and shales in amounts in no case exceeding 2.0 percent of the total assemblage counts.

Affinity: Verrucatosporites sp. B is probably the spore of a Mesozoic Tmesipteris. It closely resembles the spore of the modern Tmesipteris tannensis in size, shape and ornamentation. This modern species is a pendulous epiphyte in tropical to warm temperate forests.

Figured specimen: OPC 844 H-24-1

Genus SCHIZAEOISPORITES R. Potonie, 1951

Type Species: Schizaeoisporites (Sporites) dorogensis R. Potonié (1934) eocaenicus (Selling, 1944) R. Potonié, 1956.

1934 *Sporites dorogensis* R. Potonié, Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, Berlin, vol. 4, pl. 1, fig. 22.

1944 *Schizaeoisporites pseudodorogensis* Selling, Göteborgs botaniska Trädgard, Meddelanden, vol. 16, p. 66, pl. 4, fig. 44.

1956 *Schizaeoisporites eocaenicus* R. Potonié, Amt für Bodenforschung, Beihefte Geologischen Jahrbuch, Hannover, vol. 23, p. 81.

SCHIZAEOISPORITES cf. S. PHASEOLUS Delcourt and Sprumont, 1955

Plate 3, figure 6

This species occurs in only two levels of the Red Branch sediments, OPC 844 A and OPC 844 K. It amounts to 1.0 percent of the total assemblage counts in OPC 844 A and is present as a single specimen in OPC 844 K.

Delcourt and Sprumont (1955) recorded this species from sediments of Wealden age.

Affinity: Fossil spores referred to *Schizaeoisporites* cf. *S. phaseolus* have schizaeaceous affinities.

Figured specimen: OPC 844 K-14-1

Anteturma POLLENITES R. Potonié, 1951

Turma SACCITES Erdtman, 1947

Subturma Monosaccites (Chitaley, 1951) Potonié and Kremp, 1954

Infraturma Aletesacciti Leschik, 1955

Genus ARATRISPORITES (Leschik, 1955) Klaus, 1960

Type Species: Aratrisporites parvispinosus Leschik, 1955, Schweizerischen Paläontologischen Abhandlungen, vol. 72, p. 38, pl. 5, fig. 4.

ARATRISPORITES SP. A

Plate 6, figures 1, 3

Grains monosaccate; body and bladder of grains longer than broad; body oval in polar and equatorial views; bladder oval in equatorial view and boat-shaped in polar view; dehissence mark shaped like a flattened figure 8, passing through the central body as a thin suture bifurcating near the ends of the central body blending in a loop-like manner with the outer contour of the bladder. Bladder attached both proximally and distally, apparently free at the ends; typical boat-shaped form caused by the bladder's being pulled against the central body at the ends of the dehissence apparatus; central body smooth to granulose; bladder rugulate and infrareticulate, about 1.0 micron thick;

diameter of central body varies between 12.5 to 17.5 microns by 22.5 to 27.5 microns; diameter of bladder varies between 17.5 to 37.5 microns by 30.0 to 42.5 microns.

Typical specimen: OPC 842 C-7-3. Central body 23.7 by 12.9 microns; bladder 29.2 by 18.4 microns.

This species is abundant in levels OPC 824 F, 824 G, 842 A, 842 C and 845 A. These levels are shales with the exception of OPC 824 F. It is a rare form in 11 other levels, in no case amounting to more than 4.0 percent of the total assemblage counts of these levels.

Affinity: Leschik (1955) referred to the genus as an alete spore. Klaus (1960) emended the original diagnosis and described the unusual loop-like dehissence mark. He defined specimens of Aratrisporites as zonate monolete microspores. In view of the infrareticulate nature of the bladder, Aratrisporites sp. A is treated here as a monosaccate gymnospermous pollen grain of uncertain affinity. The abundance of this species in the shales of section OPC 824, OPC 842, and OPC 845 suggests local occurrences of this form.

Figured specimen: OPC 842 C-7-3

Genus TSUGAEPOLLENITES R. Potonié and Venitz, 1934

Type Species: Tsugaepollenites (Sporonites) igniculus (R. Potonié, 1931) R. Potonié and Venitz, 1934.

1931 Sporonites igniculus R. Potonié, Zeitschrift Braunkohle, vol. 30, p. 556, fig. 2.

1934 Tsugaepollenites igniculus R. Potonié and Venitz, Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, Berlin, vol. 5, p. 17, pl. 1, fig. 8.

TSUGAEPOLLENITES SP. A

Plate 8, figures 1, 2

Grains monosaccate; equatorial contour circular; exine of distal surface thin and granulose over a more or less central circular area (sulcus of bisaccate grains); surrounding this circular area is a well-developed equatorial fringe or tectum composed of twisted tectate frills 2.0 to 2.5 microns high, 2.5 to 3.0 microns wide and less than 0.5 microns between. Diameter varies between 50.0 and 50.8 microns.

Typical specimen: OPC 843 E-8-6. Diameter 50.8 microns.

Pollen grains referred to Tsugaepollenites sp. A are rare, occurring as 0.5 percent of the total assemblage counts of only two levels, OPC 843 A and OPC 843 C. Both levels are within the same coal.

Affinity: Tsugaepollenites sp. A is morphologically comparable to the pollen grains of recent *Tsuga*.

Figured specimens: OPC 843 E-8-6, OPC 843 E-8-5

Subturma Disaccites Cookson, 1947

Genus PARVISACCITES Couper, 1958

Type Species: *Parvisaccites radiatus* Couper, 1958. Palaeontographica, Abt. B, vol. 103, p. 154, pl. 29, figs. 5-8, pl. 30, figs. 1, 2.

PARVISACCITES SP. A

Plate 7, figure 5

Pollen grains bisaccate; body of grain sub-spherical; bladders small in comparison to size of body; body and bladders granular to finely micro-reticulate; exine 1.0 to 1.5 microns thick; distal furrow prominent. Diameter of body from 32.5 to 65.0 microns; length of bladders 15.0 to 30.0 microns; width of bladders 2.5 to 10.0 microns.

Typical specimen: OPC 821 D-14-1. Diameter of body 39.0 by 43.2 microns; distal furrow 15.1 by 9.7 microns; length of bladders 30.0 microns; width of bladders 10.0 microns.

Specimens referred to *Parvisaccites* sp. A occur in three levels of the coals and amount to 0.5 percent of the total assemblage counts. This species was recovered as a trace element in other levels.

Affinity: Fossil pollen grains assigned to *Parvisaccites* sp. A do not resemble the grains of any living gymnosperm, although they appear to be coniferous.

Figured specimen: OPC 821 D-14-1

PARVISACCITES SP. B

Plate 7, figure 6

Pollen grains bisaccate; body of grain spherical; bladders small in comparison to size of body; body and bladders granular-verrucose, verrucae 1.0 to 1.5 microns wide; exine 2.5 microns thick; distal furrow long, more than two-thirds the diameter of the grain. Diameter of body 43.2 microns; length of bladders 30.2 microns; width of bladders 6.5 to 7.6 microns; distal furrow 37.8 microns long.

Typical specimen: OPC 824 E-6-2. Overall dimensions same as above.

A single specimen of this characteristic pollen was encountered in level OPC 824 E.

Affinity: Pollen grains assigned to *Parvisaccites* sp. B are probably coniferous.

Figured specimen: OPC 824 E-6-2

Subturma Abietosacci (Erdtman, 1945) emend. R. Potonié, 1958

Genus PICEAEPOLLENITES R. Potonié, 1931

Type Species: *Piceaepollenites alatus* R. Potonié, 1931, Gesellschaft Naturforschender Freunde zu Berlin, Sitzungsberichte, no. 1-3, p. 28, pl. 2.

PICEAEPOLLENITES cf. P. ALATUS R. Potonié, 1931

Plate 7, figures 1, 3

Pollen grains referred to this species occur in small percentages in the Red Branch coals and shales. They are present in 33 levels in amounts nowhere greater than 2.0 percent of the total assemblage counts.

Potonié (1931, 1951) reported this fossil species from the Oligocene and Miocene of Germany.

Affinity: *Piceaepollenites* cf. *P. alatus* resembles the pollen grains of the modern genus *Picea*. This genus is restricted to alpine regions and it is conceivable that the fossil pollen grains originated in such an area.

Figured specimen: OPC K-21-1

Subturma Podocarpoiditi R. Potonié, Thomson and Thiergart, 1950

Genus PODOCARPIDITES Cookson, 1947

Type Species: *Podocarpidites ellipticus* Cookson, 1947, British-Australian-New Zealand Antarctic Research Expedition 1929-1931, Science Reports-Series A, vol. 2, pt. 8, p. 131, pl. 13, fig. 6.

The name *Podocarpidites* was proposed for fossil bisaccate pollen grains of the *Podocarpus* type derived from *Podocarpus*, *Dacrydium*, or an extinct member of the Podocarpaceae.

PODOCARPIDITES SP. A

Plate 7, figures 2, 4

Grains bisaccate; body of grain normally spherical; exine of body and proximal cap coarsely reticulate to vermiculate; bladders ornamented with a finer reticulation than the body; bladders attached distally as in *Podocarpus*, but generally equal to or not as long as the central body; no significant germinal apparatus has been observed. Diameter of body 29.2 to 47.5 microns; length of bladders 32.4 to 44.3 microns; width of bladders 18.4 to 29.2 microns.

Typical specimen: OPC 844 H-1-2. Diameter of body 43.2 microns; length of bladders 44.3 microns; width of bladders 29.2 microns.

Specimens referred to Podocarpidites sp. A are rare in the Red Branch sediments, in no case amounting to more than 3.0 percent of the total assemblage count of any of the 24 levels in which they occur.

Affinity: Podocarpidites sp. A resembles the pollen grains of the modern tropical-subtropical genus Dacrydium. The character of the central body and the attachment of the bladders is similar to Podocarpus, even though the bladders of this fossil form are not as long as those of the recent genus. This fossil pollen grain was perhaps transported long distances before deposition.

Figured specimens: OPC 844 H-1-2, OPC 844 J-26-1

Turma ALETES Ibrahim, 1933

Subturma Azonaletes (Luber, 1935) R. Potonié and Kremp, 1954

Infraturma Psilonapiti Erdtman, 1947

Genus INAPERTUROPOLLENITES (Pflug, 1952 ex Thomson and Pflug, 1953) emend. R. Potonié, 1958

Type Species: Inaperturopollenites (Pollenites magnus dubius) dubius (R. Potonié and Venitz, 1934)

Thomson and Pflug, 1953.

1934 Pollenites magnus dubius R. Potonié and Venitz, Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, Berlin, vol. 5, p. 17, pl. 2, fig. 21.

1953 Inaperturopollenites (Pollenites magnus dubius) dubius (R. Potonié and Venitz, 1934) Thomson and Pflug, Palaeontographica, Abt. B, vol. 94, p. 65, pl. 4, fig. 89, pl. 5, figs. 1-3.

INAPERTUROPOLLENITES cf. I. MAGNUS (R. Potonié, 1934)
Thomson and Pflug, 1953
Plate 8, figure 4

1931 Sporonites magnus R. Potonié, Zeitschrift Braunkohle, vol. 30, p. 556, fig. 1.

1934 Pollenites (Sporonites) magnus (R. Potonié, 1931) R. Potonié, Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, Berlin, vol. 4, p. 48, pl. 6, fig. 5.

1953 Inaperturopollenites magnus (R. Potonié, 1934) Thomson and Pflug, Palaeontographica, Abt. B, vol. 94, p. 64, 65, pl. 4, figs. 83-88.

This species occurs in eleven levels of the Red Branch sediments. It in no case amounts to more than 2.0 percent of the total assemblage of any of these levels.

Affinity: The fossil pollen grains reported as Inaperturopollenites cf. I. magnus are similar to recent grains of the Araucariaceae. Living representatives of this tropical-subtropical family have similar pollen grains.

Figured specimen: OPC 845 F-1-5

INAPERTUROPOLLENITES SP. A

Plate 8, figure 8

No germinal aperture; grains originally spherical but folded in fossil state; exine less than 1.0 micron thick, smooth. Overall diameter 35.0 to 57.5 microns.

Typical specimen: OPC 844 H-25-9. Diameter 43.2 microns ("trilete mark" is a fold).

Pollen grains referred to Inaperturopollenites sp. A occur in most levels. The form is persistent, but rare, in no case amounting to more than 4.0 percent of the total assemblage count of any level.

Affinity: Inaperturopollenites sp. A is similar to the pollen of recent representatives of the family Araucariaceae.

Figured specimen: OPC H-25-9

NEW GENUS E

Plate 8, figures 3, 5

No germinal aperture; pollen grain originally spherical but commonly folded in the fossil state; exine about 1.0 micron thick, covered with small, shallow pits giving the wall a pseudo-reticulate appearance. Overall diameter 27.5 to 55.0 microns.

Typical specimen: OPC 821-10-1. Diameter 46.4 by 43.2 microns.

Fossil pollen grains referred to New Genus E are extremely rare in the Red Branch sediments, occurring in 5 coal levels in amounts in no case greater than 1.5 percent of the total assemblage counts.

Affinity: Not known.

Figured specimens: OPC 821 G-10-1, OPC 822 B-18-1

Genus TAXODIACEAEPOLLENITES Kremp, 1949

Type Species: Taxodiaceaepollenites (Pollenites) hiatus (R. Potonié, 1931) Kremp, 1949.

1931 Pollenites hiatus R. Potonié, Preussischen Geologischen Landesanstalt, Jahrbuch, vol. 53, p. 5, fig. 27.

1933 Taxodium hiatipites Wodehouse, Torrey Botanical Club Bulletin, vol. 60, p. 493, fig. 17.

1949 Taxodiaceaepollenites (Pollenites) hiatus (R. Potonié, 1931) Kremp, Palaeontographica, Abt. B, vol. 90, p. 59.

TAXODIACEAEPOLLENITES cf. T. HIATUS (R. Potonié, 1931) Kremp, 1949

Plate 8, figure 6

This species is rare to common in the Red Branch sediments. It normally amounts to less than 5.0 percent of the total assemblage count of any level, but is represented by 10.0 percent of level OPC 821 C.

R. Potonié (1931, 1934, 1950, 1951) reported this pollen grain from the Eocene, Oligocene and Miocene of Germany. Kevdes (1960) recorded Inaperturopollenites hiatus from the Eocene of the Dorog Basin, Hungary.

Affinity: Taxodiaceaepollenites cf. T. hiatus is the pollen of Taxodium. Although not abundant, this fossil pollen is present in almost every level, indicating its presence in or near the depositional sites.

Figured specimen: OPC 844 H-12-4

Subturma Zonaletes (Luber, 1935) emend. R. Potonié, 1958

Genus SIMPLICESPORITES Leschik, 1955

Type Species: Simplicesporites virgatus Leschik, 1955, Schweizerischen Paläontologischen Abhandlungen, vol. 72, p. 34, pl. 4, fig. 16.

SIMPLICESPORITES cf. S. VIRGATUS Leschik, 1955

Plate 6, figure 2

Pollen grains referred to this species are rare in all but two measured sections, OPC 844 and OPC 824. In level OPC 844 G Simplicesporites cf. S. virgatus makes up 9.0 percent of the total assemblage count.

Leschik (1955) recorded the type species from the Upper Triassic of Switzerland.

Affinity: Gymnospermous?

SIMPLICESPORITES SP. A

Plate 6, figures 5, 6

No germinal aperture; grains originally oval, but in some cases folded in fossil state; central body oval to subspherical with a smooth wall, about 0.5 microns thick; exospore (?) oval to subspherical, smooth to finely granular, thin and commonly folded. Diameter of central body varies between 18.3 and 28.0 microns; total diameter varies between 22.7 and 37.8 microns.

Typical specimen: OPC 844 D-1-4. Diameter of central body 22.7 by 27.0 microns; diameter of total grain 32.4 by 37.8 microns.

This fossil species occurs in only 8 levels. It in no case amounts to more than 6.5 percent of the total assemblage counts of these levels.

Affinity: Gymnospermous?

Figured specimens: OPC 844 D-1-4, OPC 843 H-4-2

Turma EUPOLLENITES Klaus, 1960

Subturma Operculati Venkatachala and Goczan, 1962

Genus CLASSOPOLLIS (Pflug, 1953) emend.
Pocock and Jansonius, 1961

Type Species: Classopollis classoides (Pflug, 1953) emend. Pocock and Jansonius, 1961.

1953 Classopollis classoides Pflug, Palaeontographica, Abt. B, vol. 95, p. 91, pl. 16, figs. 29-31.

1961 Classopollis classoides (Pflug, 1953) Pocock and Jansonius, Micropaleontology, vol. 7, no. 4, p. 443-444, pl. 1, figs. 1-9.

This genus was erected by Pflug to accomodate "tricolporate or tetracolporate pollen grains with a distinct rimula, germinal aperture gaping".

Pocock and Jansonius (1961) emended this original and misleading diagnosis to include spherical or ovoid distally monoporate pollen grains. The grains are equatorially striated. These striations can be seen clearly in obliquely or equatorially flattened grains, but appear as broad punctae on the equator in polar view. The proximal pole bears a non-functional reduced trilete scar. (See also Venkatachala and Goczan, 1962). This emendation is regarded valid in this paper.

Pocock and Jansonius (1961) noted the presence of a circular distal line of weakness but failed to recognize it as an operculum.

CLASSOPOLLIS SP. A

Plate 6, figures 8, 9

Pollen grains; more or less circular in polar view; exine apparently two-layered; intexine thin, slightly granular; exoexine thicker, 1.6 to 2.1 microns, enveloping the central body; at the distal pole is a pore surrounded by a ring of weakness 15.0 to 20.0 microns in diameter interpreted as an operculum; exoexine thickened in the equatorial area forming parallel equatorial ridges and grooves. Polar diameter of grains 23.0 to 25.0 microns; diameter of operculum 15.0 to 20.0 microns; diameter of pore about 5.0 microns.

Typical specimen: OPC 844 H-11-1. Polar diameter 23.7 to 25.0 microns; diameter of operculum 15.1 by 18.4 microns; diameter of pore 5.0 microns.

Classopollis sp. A is rare in the Red Branch sediments, occurring in 18 levels and in no case exceeding 1.0 percent of the total assemblage counts.

Affinity: *Classopollis* has been assigned to a number of genera of fossil plants. Hoerhammer (1933) referred *Classopollis* to the Cheirclepidae, having recovered this palynomorph from unattached male cones believed to be related to this family. Kendall (1949) assigned *Classopollis* to the genus *Brachyphyllum*. Couper (1958) found grains of *Classopollis* closely associated with grains referred to *Pagiophyllum convivens*. Reissenger (1950) and Rogalska (1954) have also assigned *Classopollis* to *Pagiophyllum*, although they have cited no supporting evidence for their conclusions (Pocock and Jansonius, 1961).

Pocock and Jansonius (1961) have stated that *Classopollis* pollen was produced by an extinct plant of gymnospermous affinities. Further, this plant may have belonged to the genera *Cheirolepis*, *Brachyphyllum* or *Pagiophyllum*. Since the genera *Cheirolepis* and *Brachyphyllum* are probably related and some species of *Pagiophyllum* are difficult to distinguish from *Brachyphyllum*, it is possible that some species of all three genera produced *Classopollis*-type pollen grains.

Figured specimens: OPC 844 H-11-1, OPC 844 J-24-1

NEW GENUS G

Plate 6, figures 4, 7

Pollen grains; circular to ovoid in polar view; exine appears two-layered; intexine thick, smooth, exoexine thick, dark, smooth, enveloping intexine much as a cup; in equatorial view, exine cup-shaped and covered by an operculum. Polar diameter of grain 25.0 to 32.5 microns; diameter of operculum 20.0 to 30.0 microns.

Typical specimen: OPC 845 I-2-1. Diameter 25.0 by 20.0 microns; diameter of operculum 20.0 microns; depression 20.0 microns wide, 12.5 microns deep.

Pollen grains referred to New Genus G were not counted in the assemblage counts of the Red Branch sediments.

Affinity: Unknown.

Figured specimens: OPC 845 I-2-1, OPC 824 G-5-1

Turma PLICATES (PLICATA Naumova 1937, 1939) emend. R. Potonié, 1960

Genus EUCOMMIIDITES (Erdtman, 1948) emend. Couper, 1958

Erdtman (1948) originally described Eucommiidites as a tricolpate pollen grain, thus postulating a Jurassic origin for the modern angiosperms. In 1961 Hughes emended the genus as a zonisulcate form.

Couper (1958) emended the genus as follows:

Pollen grains, with one colpus generally better developed than the other two and similar to the single sulcus of some gymnospermous pollen grains; grains elongated-elliptical in equatorial contour, not symmetrical about their long axis, the surface carrying the main colpus being more flattened; exine smooth to scabrate.

It is here considered that Couper's emended diagnosis is justified and that Eucommiidites is not an angiospermous pollen grain. Couper (1958) pointed out the following major differences between Eucommiidites and the grains of dicotyledonous pollen:

1. The radial symmetry of tricolpate pollen grains is in all cases radial in polar view. Eucommiidites is symmetrical about its long axis and is therefore similar to gymnospermous monosulcate grains.

2. Most specimens of E. troedssonii show a broad invaginated main colpus with rounded ends. This colpus is similar in nature to the single sulcus of monosulcate gymnospermous grains and is unlike the colpi of dicotyledonous pollen grains.

3. Studies of the orientation of E. troedssonii show that it behaves in exactly the same way as monosulcate gymnospermous grains but in a markedly different fashion from tricolpate, dicotyledonous grains.

Type Species: Eucommiidites troedsonii Erdtman, 1948, Geologiska Föreningens i Stockholm, Förhandlingar, vol. 70, no. 2, p. 267-268, text figs. 5-10, 13-15.

EUCOMMIIDITES cf. E. TROEDSSONII Erdtman, 1948

Plate 6, figure 11

This species was recovered from 14 levels of the Red Branch sediments. It is a rare form, occurring as 0.5 percent of the total assemblage counts of 12 levels. In OPC 845 A and OPC 845 B it amounts to 3.5 and 4.5 percent of the total assemblage counts respectively.

Erdtman originally described E. troedssonii from the Jurassic of Scania. It has since been reported (Hughes, 1961) from the Wealden (Delcourt and Sprumont 1956, 1957, 1958) the Lower Liassic (Pons 1956), Upper Triassic (Scott 1960), Jurassic (Oszast 1957), Middle Jurassic (Hughes and Couper 1958), Cretaceous (Rouse 1959) and the Middle and Upper Jurassic and Wealden (Couper 1958).

Affinity: Fundamentally a monosulcate pollen grain of possible gymnospermous affinity.

Figured specimen: OPC 845 I-3-7

EUCOMMIIDITES SP.

Plate 6, figure 12

Pollen grain monosulcate, sulcus extending almost the entire length of grain, somewhat invaginated and bordered by a ring furrow; ring furrow well developed and tends to parallel equatorial contour of the grain; grain apparently symmetrical about its long axis; exine 2.0 microns thick, tectate and somewhat folded. Diameter of single specimen 39.0 by 50.0 microns.

Typical specimen: OPC 843 H-2-1. Overall dimensions 39.0 by 50.0 microns.

A single specimen of Eucommiidites sp. was recovered from level OPC 843 H and for this reason no attempt is made to erect a species.

Affinity: Monosulcate grain of possible gymnospermous affinity.

Figured specimen: OPC 843 H-2-1

Turma POLYPLICATES Erdtman, 1952

Genus EPHEDRIPITES Bolchovitina, 1953

Type Species: Ephedripites mediolobatus Bolchovitina, 1953, Academy of Science of the USSR, Institute of Geological Sciences, Trudy, Geological series 61, vol. 145, p. 60, pl. 9, fig. 15.

EPHEDRIPITES SP. A

Plate 8, figure 9

No definite germinal apparatus; grains fusiform; provided with numerous (20?) longitudinal ribs separated by well-defined grooves which disappear in the extreme polar ends of the grain; ribs about 0.5 microns wide and spaced 0.5 microns apart; exine 0.5 microns thick. Dimensions vary between 35.1 to 42.5 microns by 10.0 to 22.5 microns.

Typical specimen: OPC 842 C-7-4. Overall dimensions 35.1 by 14.0 microns.

Ephedripites sp. A is a rare form, occurring in only 6 levels of the Red Branch sediments. It in no case amounts to more than 1.5 percent of the total assemblage counts.

Affinity: This species is probably the pollen grain of Ephedra. The pollen production of modern Ephedra is low, and even if the fossil plants were growing near the depositional basins they would be expected to be poorly represented.

Figured specimen: OPC 842 C-7-4

EPHEDRIPITES SP. B

Plate 8, figure 10

No definite germinal apparatus; inner body ovoid (endexine) and 1.0 to 1.5 microns thick, surrounded by a thin fusiform exine provided with numerous longitudinal ribs 1.0 to 1.5 microns wide and 1.5 microns apart; ribs disappear in extreme polar regions of pollen grains. Dimensions of exine 15.0 to 21.6 microns by 32.5 to 37.5 microns; dimensions of central body (endexine) 15.0 to 21.6 microns by 20.0 microns.

Typical specimen: OPC 824 D-7-2. Exine 20.0 by 37.5 microns; central body (endexine) 15.0 by 20.0 microns.

Fossil pollen grains referred to *Ephedripites* sp. B occur in 8 levels of the Red Branch sediments. These forms are rare, in no sample amounting to more than 1.5 percent of the total assemblage counts.

Affinity: This pollen grain probably has affinities with *Ephedra*, although the pollen grains of this modern genus in no case show such a prominent "inner body".

Figured specimen: OPC 824 D-7-2

Turma MONOCOLPATES Iversen and Troels-Smith, 1950

Genus CLAVATIPOLLENITES Couper, 1958

Type Species: *Clavatipollenites hughesii* Couper, 1958, Palaeontographica, Abt. B, vol. 103, p. 159, pl. 31, figs. 19-22.

CLAVATIPOLLENITES SP. A

Plate 9, figure 1

Pollen grains monosulcate; sulcus narrow, extending almost the entire length of the grain; grains circular to subcircular in equatorial contour; exine consists of an inner unsculptured nexinous layer less than 1.0 micron thick, and an outer sexinous layer consisting of clavate projections about 1.0 micron long; the clavae are fused at their tips to form a tectum; in surface view the clavate pattern forms a micro-reticulum. Overall dimensions 30.0 to 42.5 microns.

Typical specimen: OPC 845 J-3-1. Overall dimensions 33.5 by 36.7 microns.

Clavatipollenites sp. A is a rare pollen type. It occurs in many levels, but in none exceeds 3.5 percent of the total assemblage counts. This species is commonly encountered without the tectate sexine.

Affinity: Probably angiospermous. Couper (1958) reported a striking similarity between *Clavatipollenites* and the grains of the modern *Ascarina lucida*. The fossil pollen grains described here as *Clavatipollenites* sp. A are much larger than Couper's species, *C. hughesii*, and do not resemble the pollen of *Ascarina*.

Figured specimen: OPC 845 J-3-1

NEW GENUS C

Plate 9, figures 7, 8

Pollen grains monocolpate (?); distal colpus narrow, expanding somewhat at the polar ends, more than two-thirds the length of the grain; grains oblong; exine thin, about 0.5 microns, ornamented with 1.0 to 1.5 microns high and 1.0 micron wide irregularly spaced pustules; exine commonly folded and in some cases appears like one or more colpi. Dimensions vary from 15.0 to 18.4 microns by 8.6 to 14.0 microns.

Typical specimen: OPC 844 J-22-1. Overall dimensions 16.2 by 13.0 microns.

This pollen grain is commonly folded in such a manner as to appear tricolpate.

Fossil pollen grains referred to New Genus C are rare in most levels of the Red Branch sediments. In section OPC 844 this form varies between 0.5 and 5.5 percent of the total assemblage counts of all levels.

Affinity: This pollen grain is probably angiospermous.

Figured specimens: OPC 844 J-22-1, OPC 844 J-13-3

Subturma Retectines (Malavkina, 1949) emend R. Potonié, 1958

Genus MONOSULCITES (Cookson, 1947)
Couper, 1953

Type Species: Monosulcites minimus Cookson, 1947, British-Australian-New Zealand Antarctic Research Expedition 1929-1931, Science Reports-Series A, vol. 2, part 8, p. 135, pl. 15, figs. 47-50.

MONOSULCITES cf. M. MINIMUS Cookson, 1947
Plate 8, figure 11

Specimens referred to this species resemble closely the grains of Monosulcites minimus but are more elongate and have thin exines.

Monosulcites cf. M. minimus is a rare pollen type in the Red Branch sediments, occurring in only 6 levels. It in no case amounts to more than 2.0 percent of the total assemblage counts.

Groot, Penny and Groot (1961) reported this species from the Upper Cretaceous of the Atlantic Coastal Plain.

Affinity: Monosulcites cf. M. minimus is similar to the pollen grain of Ginkgo biloba.

Figured specimen: OPC 821 D-15-1

MONOSULCITES SP. A

Plate 8, figure 7

Pollen grains monocolpate; symmetry bilateral; grain elongate and fusiform; colpus extends entire length of the grain; exine thin and subgranular. Dimensions vary from 37.5 to 66.0 microns long by 17.5 to 29.2 microns wide.

Typical specimen: OPC 844 K-7-6. Overall dimensions 66.0 by 29.2 microns.

Fossil pollen grains referred to Monosulcites sp. A occur in 17 levels of the Red Branch sediments. They in no case exceed 2.0 percent of the total assemblage counts.

Affinity: This species is similar to the pollen of Cycas, although it is larger than that of most modern species. The cycads today are a comparatively small group confined to isolated areas in subtropical and tropical regions.

Figured specimen: OPC 844 K-7-6

MONOSULCITES SP. B

Plate 8, figure 12

Pollen grains monocolpate; bilaterally symmetrical; grains elongated and oval; colpus extends almost the entire length of the grain, bordered by two folds about 2.0 microns wide; exine thin, less than 1.0 micron, smooth. Dimensions vary from 12.5 to 15.0 microns long by 7.5 to 12.5 microns wide.

Typical specimen: OPC 844 G-6-2. Overall dimensions 15.0 by 8.6 microns.

Monosulcites sp. B is a persistent form in the Red Branch sediments and is rare to common. It occurs in amounts as great as 9.0 percent of the total assemblage counts.

Affinity: This fossil grain is questionably bennettitalean or cycadalean with closer resemblance to the pollen of Zamia.

Figured specimen: OPC 844 G-6-2

Genus LILIACIDITES Couper, 1953

Type Species: Liliacidites kaitangatensis Couper, 1953, New Zealand Geological Survey Paleontological Bulletin 22, p. 56, pl. 7, fig. 97.

LILIACIDITES cf. L. VARIEGATUS Couper, 1953

Plate 9, figure 6

Fossil pollen grains referred to Liliacidites cf. L. variegatus are rarely encountered in the Red Branch sediments. This species in no case amounts to more than 6.0 percent of the total assemblage counts of any level.

Couper (1953) reported this species from the Upper Cretaceous to the Eocene in New Zealand. Groot, Penny and Groot (1961) found L. variegatus in the Turonian and Lower

Senonian sediments of the Atlantic Coastal Plain.

Affinity: Couper (1953) proposed this genus for the reception of fossil pollen grains of liliaceous affinities that cannot be more accurately placed.

Figured specimen: OPC 824 F-10-2

Subturma Monoptyches (Naumova, 1937) emend R. Potonié, 1958

Genus PALMAEPOLLENITES R. Potonié, 1951

Type Species: Palmaepollenites tranquillus (R. Potonié, 1934) R. Potonié, 1951.

1934 Pollenites tranquillus R. Potonié, Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, Berlin, vol. 4, p. 51, pl. 1, figs. 3, 8.

1951 Palmaepollenites tranquillus R. Potonié, Palaeontographica Abt. B, vol. 91, pl. 20, figs. 31, 31a.

PALMAEPOLLENITES cf. P. TRANQUILLUS (R. Potonié, 1934) R. Potonié, 1951

Plate 9, figures 3, 4

Specimens of Palmaepollenites cf. P. tranquillus are rare to common in all levels. The percentage of this form ranges from 0.5 to 8.0 percent of the total assemblage counts.

Potonié (1934) recorded this species from the Eocene of Germany. It has been reported from the early Tertiary by Mürriger and Pflug (1951) and from the middle Eocene by Thomson and Pflug (1953).

Affinity: Fossil pollen grains referred to *Palmaepollenites* cf. *P*. *tranquillus* resemble the grains of modern palms. These modern trees inhabit near-shore swamp environments of warm-temperate, tropical to subtropical regions.

Figured specimens: OPC 845 F-1-7, OPC 845 F-18-3

PALMAEPOLLENITES SP. A

Plate 9, figure 2

Pollen grains monocolpate; bilaterally symmetrical; grains ovoid; colpus extending entire length of grain; exine thin, 0.5 to 1.0 micron, infragranular; diameter varies between 10.0 to 15.0 microns by 12.0 to 17.5 microns.

Typical specimen: OPC 844 K-7-1. Diameter 12.0 by 15.0 microns.

Palmaepollenites sp. A is rare to common in the Red Branch sediments. Percentages vary between 0.5 and 9.0 percent of most samples.

Affinity: Pollen grains assigned to this species closely resemble the grains of living representatives of *Sabal*, a modern swamp plant.

Figured specimen: OPC 844 K-7-1

Subturma Triptyches (Triptycha Naumova, 1937?, 1939) R. Potonié, 1960

Genus TRICOLPITES Cookson, 1947 ex Couper, 1953

Type Species: *Tricolpites reticulatus* Cookson, 1947, British-Australian-New Zealand Antarctic Research Expedition 1929-1931, Science Reports-Series A, vol. 2, part 8, p. 134, pl. 15, fig. 45.

TRICOLPITES cf. T. RETICULATUS Cookson, 1947

Plate 9, figure 5

This form genus has been proposed to accommodate tricolpate angiospermous pollen grains of uncertain affinities.

Specimens of *Tricolpites* cf. *T. reticulatus* are common to abundant in the Red Branch coals and shales. They amount to as much as 38.5 percent of the total assemblage count of level OPC 821 F. In other levels the percentages vary between 0.5 and 35.0 percent.

Cookson (1947) described this species from the Tertiary of Kerguelen.

Affinity: Angiospermous pollen grains.

Figured specimen: OPC 844 J-13-1

TRICOLPITES SP. A

Plate 9, figure 10

Pollen grains tricolpate; prolate; colpi extending the entire length of the grain; exine 0.5 to 0.75 micron thick, smooth to microgranulose. Overall dimensions 15.0 to 17.5 microns by 9.0 to 15.0 microns.

Typical specimen: OPC 845 F-1-4. Overall dimensions 13.0 by 17.3 microns.

Pollen grains referred to Tricolpites sp. A are abundant in most levels of the Red Branch sediments. They amount to 0.5 to 33.5 percent of the total assemblage counts. This species is most abundant in sections OPC 821, OPC 844 and OPC 845.

Affinity: Angiospermous. The parent plants of this species were probably growing near the basins of deposition.

Figured specimen: OPC 845 F-1-4

TRICOLPITES SP. B

Plate 9, figures 9, 13

Pollen grains tricolpate; grains prolate; colpi long, broad, exine 1.0 to 1.5 microns thick, granular. Dimensions 15.1 to 31.3 microns by 10.0 to 21.6 microns.

Typical specimen: OPC 844 J-22-2. Overall dimensions 23.8 by 20.5 microns.

Fossil pollen referred Tricolpites sp. B is rare in all levels of the Red Branch sediments but one shale, OPC 845 E, where it makes up 17.0 percent of the total assemblage count. It is absent in section OPC 845.

Affinity: Angiospermous pollen grains of unknown affinity.

Figured specimens: OPC 844 J-22-2, OPC 824 E-13-2

Subturma Polyptyches (Polyptycha, Naumova, 1937, 1939) R. Potonié, 1958

Genus STEPHANOCOLPITES (van der Hammen, 1954, 1956) R. Potonié, 1956

Type Species: Stephanocolpites costatus van der Hammen, 1954, Bogotá, Boletin Geológico, vol. 2, no. 1, p. 92, pl. 7.

STEPHANOCOLPITES SP. A

Plate 9, figures 14, 16

Pollen grains hexacolpate to polycolpate; colpi broad, long, but not reaching the polar ends of the grains; grains elongate; exine thin, 2.0 to 2.5 microns thick, tectate, appearing micro-reticulate on the surface. Overall dimensions 65.0 to 82.5 microns long; 25.0 to 43.2 microns wide.

Typical specimen: OPC 843 I-1-5. Overall dimensions 81.0 by 42.0 microns.

Fossil pollen grains referred to Stephanocolpites sp. A are rare in the Red Branch sediments, occurring only in six levels of coals. They in no case amount to more than 2.0 percent of the total assemblage counts.

Affinity: Angiospermous pollen of uncertain affinity.

Figured specimens: OPC 843 I-1-5, OPC 843 I-1-4

Subturma Ptychotriporines (Ptychotriporina Naumova, 1937 ?, 1939) R. Potonié, 1960

Infraturma Prolati Erdtman, 1943

Genus ARALIACEOIPOLLENITES R. Potonié, 1951

Type Species: Araliaceoipollenites (Pollenites) euphorii (R. Potonié, 1931) R. Potonié, 1951.

1931 <u>Pollenites euphorii</u> R. Potonié, Zeitschrift Braunkohle, vol. 30, p. 332, pl. 1, fig. 12.

1951 <u>Araliaceoipollenites</u> (<u>Pollenites</u>) <u>euphorii</u> (R. Potonié, 1931) R. Potonié, Palaeontographica Abt. B, vol. 91, pl. 21, figs. 139, 140.

ARALIACEOIPOLLENITES cf. A. EUPHORII (R. Potonié, 1931)
R. Potonié, 1951

Plate 9, figure 15

This species is rare in the Red Branch sediments, occurring in only 4 coal levels. It in no case amounts to more than 0.5 percent of the total assemblage counts.

R. Potonié (1931) described the type species from the Eocene of Germany. Thomson and Pflug (1953) have recorded this pollen grain from the Upper Eocene to the Lower Oligocene.

Affinity: This species is closely related to the pollen of modern Araliaceae.

Figured specimen: OPC 821 C-1-1

Infraturma Sphaeroidati Erdtman, 1943

Genus NYSSAPOLLENITES Thiergart, 1937

Type Species: <u>Nyssapollenites</u> (<u>Pollenites</u>) <u>pseudocruciatus</u>

(R. Potonié, 1931) Thiergart, 1937.

1931 *Pollenites pseudocruciatus* R. Potonié, Zeitschrift Braunkohle, vol. 30, p. 328, pl. 1, fig. 10.

1937 *Nyssapollenites* (*Pollenites*) *pseudocruciatus* (R. Potonié, 1931) Thiergart, Preussischen Geologischen Landesanstalt, Jahrbuch, vol. 58, p. 322, pl. 25, figs. 32,34.

NYSSAPOLLENITES SP. A

Plate 9, figures 11, 12

Pollen grains tricolporate; grains small, prolate; colpi long, extending almost the entire length of the grain; pores small and round; exine thin, 0.5 to 1.0 micron, smooth to infragranular. Overall dimensions 10.0 to 11.5 microns wide by 12.0 to 15.5 microns long.

Typical specimen: OPC 844 H-25-11. Overall dimensions 10.8 by 15.1 microns.

Pollen grains referred to *Nyssapollenites* sp. A are consistently rare in the Red Branch sediments, occurring in both the coals and shales. This species in no case amounts to more than 8.0 percent of the total assemblage counts.

Affinity: This fossil species resembles the pollen grains of modern *Nyssa*, which is a typical swamp plant in warm temperate regions.

Figured specimens: OPC 824 D-10-1, OPC 844 H-25-11

Genus PISTILLIPOLLENITES Rouse, 1962

Type Species: Pistillipollenites mcgregorii Rouse, 1962, Micropaleontology, vol. 8, no. 2, p. 206, pl. 1, figs. 8-12.

PISTILLIPOLLENITES cf. P. MCGREGORII Rouse, 1962

Plate 9, figure 17

This species is rare in all sections of the Red Branch sediments. It is represented only in the assemblage counts of levels OPC 844 A, OPC 844 B and OPC 844 C.

Rouse described this form from the Middle Eocene of British Columbia. Wilson (personal communication) has recovered specimens of P. mcgregorii from the Middle Eocene Green River Formation.

Affinity: Rouse (1962) reported the similarity of this species with the pollen grains of the modern monotypic genus Rusbyanthus, a member of the family Gentianaceae.

Figured specimen: OPC 844 G-17-1

Turma POROSES (POROSA Naumova, 1937, 1939) emend. R. Potonié, 1960

Subturma Polyporines (Polyporina Naumova, 1937, 1939) emend. R. Potonié, 1960

Infraturma Periporiti (Periporites van der Hammen, 1956) emend. R. Potonié, 1960

Genus LIQUIDAMBARPOLLENITES Raatz, 1937

Type Species: Liquidambarpollenites (Pollenites) stigmosus (R. Potonié, 1931) Raatz, 1937.

1931 Pollenites stigmosus R. Potonié, Zeitschrift Braunkohle, vol. 30, p. 329, pl. 2, fig. 1.

1937 Liquidambarpollenites stigmosus major Raatz, Preussischen Geologischen Landesanstalt, Abhandlungen, neue Folge, vol. 183, p. 17, pl. 1, fig. 26.

LIQUIDAMBARPOLLENITES SP. A

Plate 9, figures 18, 19

Pollen grains polyporate; outline circular; exine smooth, 1.5 microns thick;pores 29 to 30 in number, round, 2.0 microns in diameter; grains about 25.0 microns in diameter.

Typical specimen: OPC 845 I-3-1. Diameter 25.0 microns.

Pollen grains referred to Liquidambarpollenites sp. A are trace elements in the flora of the Red Branch. Only four specimens were encountered.

Affinity: These grains are similar to the pollen of *Liquidambar*.

Figured specimen: OPC 845 I-3-1

INCERTAE SEDIS

Genus SCHIZOSPORIS Cookson and Dettmann, 1959

Cookson and Dettmann (1959) erected the genus *Schizosporis* to accommodate medium to large microspores with an equatorial line or furrow along which a separation into two approximately equal parts takes place.

Type Species: *Schizosporis reticulatus* Cookson and Dettmann, 1959, Micropaleontology, vol. 5, p. 213-214, pl. 1, figs. 1-4.

SCHIZOSPORIS cf. S. RETICULATUS Cookson and Dettmann, 1959

Plate 5, figures 8, 9

This is a rare type in the Red Branch sediments. It occurs in only two levels, OPC 844 K, a coal, and OPC 845 A, a shale. It amounts to only 0.5 percent of the total assemblage counts of these two levels.

Cookson and Dettmann (1959) reported this species from the Lower to the Upper Cretaceous (Neocomian-Aptian to ? Cenomanian) of Australia.

Affinity: Not known.

Figured specimens: OPC 844 K-13-1, OPC 845 A-6-1

SCHIZOSPORIS cf. S. SPRIGGI Cookson and Dettmann, 1959

Plate 5, figure 6

Fossils referred to Schizosporis cf. S. spriggi are rare, occurring in two levels of the Red Branch sediments in minor percentages of the total assemblage counts. They occur in three other levels as trace elements.

The known stratigraphic distribution of this form is Albian and ? Cenomanian (Cookson and Dettmann 1959).

Affinity: Not known.

Figured specimen: OPC 821 H-1-1

SCHIZOSPORIS cf. S. PARVUS Cookson and Dettmann, 1959

Plate 5, figure 7

This is a rare to common palynomorph in the Red Branch sediments making up 0.5 to 5.0 percent of the total assemblage counts of most levels.

Cookson and Dettmann (1959) reported this species from the Albian and ? Cenomanian sediments of Australia.

Affinity: Venkatachala and Baltes (1962) have referred similar pollen to the Magnoliaceae. Some of their specimens show a distinct monosulcate furrow on the proximal side.

Figured specimen: OPC 844 H-12-5

SCHIZOSPORIS SP. A

Plate 5, figure 5

Polospore (?) large; elliptical in equatorial view; splitting equatorially into two narrow, elongate boat-shaped sections; exine 3.0 to 4.0 microns thick, smooth. Equatorial diameter 142.5 to 207.5 microns; polar diameter 47.5 to 130.0 microns.

Typical specimen: OPC 844 G-9-1. Overall dimensions 147.5 by 48.6 microns.

Palynomorphs referred to Schizosporis sp. A are rare in the Red Branch sediments. This species in no case exceeds 2.5 percent of the total assemblage count.

Affinity: Probably related to the Magnoliaceae.

Figured specimen: OPC 844 G-9-1

DISPERSED SEEDS

Genus SPERMATITES Miner, 1935

Miner (1935) who designated no type species for this genus, stated that, although no spores were found associated with Spermatites, they resembled sporangia. He further postulated that this genus might be a primitive seed, with the orifice situated in the micropyle and the thickened basal portion representing the chalaza.

Hughes (1961) referred to Spermatites as a gymnospermous ovule and found pollen grains of Eucommiidites delcourtii in the micropylar canal. He eliminated the possibility of Spermatites being related to the Cycadales, Ginkgoales and Coniferales on the basis of the absence of any megaspore cuticle in Eucommiidites. The Chlamydospermales have a conspicuous pollen chamber formed just prior to pollenation, and a single true integument greatly elongated as a micropylar tube. The genus Spermatites is therefore treated as a gymnospermous ovule belonging to a Mesozoic Chlamydospermae.

SPERMATITES cf. S. NANUS Miner, 1935

Plate 6, figure 10

'Seeds' referred to this species are rare in the Red Branch sediment, occurring in seven levels. They never amount to more than 0.5 percent of the total assemblage counts of any level.

Miner (1935) described this form from Cretaceous coals of Greenland.

Affinity: Gymnospermous ovule.

Figured specimen: OPC 845 A-4-1

PALYNOLOGICAL ASSOCIATIONS

The Red Branch Member of the Woodbine Formation has a limited lateral distribution with outcrops in the easternmost part of Bryan County. It is here assumed that the lithologic units making up the Red Branch Member are discontinuous because 1) the individual coals and shales are not traceable from one locality to the next and 2) the palynological evidence shows no correlation on a species or group percentage basis. The same genera and species, however, are present throughout all the examined lithologic units.

Table 3 illustrates the relative abundances in percentage of spore and pollen species in each processed level of the Red Branch sediments. Histograms have been plotted (Fig. 2), using as a basis the relative abundances of spore and pollen groups in each coal and shale. These graphic representations of the Red Branch spore and pollen assemblages show that the relative abundances of the different floral groups differs from one area to the next.

The relative abundances plotted in histogram form signify a definite percentage and show the relative abundances of the 20 floral groups listed below. In the histograms and Table 3 the index numbers refer to palynomorphs assigned to the following classes or groups:

1. Fungi imperfectae
2. Bryophyta
3. Psilopsida
4. Lycopsida
5. Osmundaceae
6. Cyatheaceae
7. Gleicheniaceae
8. Schizaeaceae
9. Polypodiaceae
10. Sporae incertae sedis
11. Cycadales and Ginkgoales
12. Coniferales
13. Gnetales
14. Gymnospermae incertae sedis
15. Magnoliaceae
    - Schizosporis cf. S. parvus
    - Schizosporis sp. A
16. Tricolporate and Porate Pollen grains
    - Liquidambarpollenites sp. A
    - Pistillipollenites cf. P. mcgregorii
    - Nyssapollenites sp. A
    - Araliaceoipollenites cf. A. euphorii
17. Tricolpate and polycolpate pollen grains
    - Tricolpites cf. T. reticulatus
    - Tricolpites sp. A
    - Tricolpites sp. B
    - Stephanocolpites sp. A
18. Monocolpate pollen grains
    - Liliacidites cf. L. variegatus
    - Palmaepollenites cf. P. tranquillus
    - Palmaepollenites sp. A
    - Clavatipollenites sp. A
    - New Genus C
19. Incertae sedis
20. Indeterminable types

The histograms of the measured stratigraphic sections are arranged from east to west in the following order: OPC 842, OPC 824, OPC 822, OPC 843, OPC 821, OPC 845, OPC 844 (Fig. 1). Measured section number OPC 823 has been eliminated, insofar as all collected samples proved to be barren.

The compilation of data in Table II is taken from the histograms (Fig. 2) and shows in table form the more abundant forms found in each coal or shale. Each stratigraphic unit is listed from the base of the measured sections upward.

FIGURE 2A. HISTOGRAMS ILLUSTRATING RELATIVE PERCENTAGES OF 20 SPORE AND POLLEN GROUPS IN EACH REPORTED LITHOLOGIC UNIT OF THE RED BRANCH SEDIMENTS.

FIGURE 2B. HISTOGRAMS ILLUSTRATING RELATIVE PERCENTAGES OF 20 SPORE AND POLLEN GROUPS IN EACH REPORTED LITHOLOGIC UNIT OF THE RED BRANCH SEDIMENTS.

TABLE II

ABUNDANT SPORE AND POLLEN GROUPS IN EACH STUDIED LITHOLOGIC UNIT

Sample No.	Lithology	Spore-Pollen groups in decreasing abundance
		OPC 842
842 F	coal	Gleicheniaceae, Schizaeaceae, Angiospermae, Fungi, Bryophyta, all other ferns, Lycopsida
842 E	shale	Schizaeaceae, all other ferns, Angiospermae, Fungi, Angiospermae, Psilopsida
842 D	coal	Schizaeaceae, Angiospermae, all other ferns, Fungi, Gymnospermae
842 C	shale	Gymnospermae, Angiospermae, Schizaeaceae, Gleicheniaceae
842 B	coal	Gleicheniaceae, Schizaeaceae, all other ferns, Bryophyta, Angiospermae, Fungi
842 A	shale	Gymnospermae, all other ferns, Schizaeaceae, Angiospermae, Lycopsida
		OPC 824
824 G	shale	Gymnospermae, Angiospermae, Schizaeaceae, all other ferns, Bryophyta
824 D,E,F	coal	Schizaeaceae, Gymnospermae, Gleicheniaceae, Angiospermae, all other ferns, Fungi

TABLE II--Continued

Sample No.	Lithology	Spore-Pollen groups in decreasing abundance
		OPC 822
822 H,I	coal	Gleicheniaceae
822 G	shale	Gleicheniaceae, Coniferales, Angiospermae
822 B	coal	Angiospermae, Coniferales, Fungi
		OPC 843
843 H,I	coal	Gleicheniaceae, Schizaeaceae, Angiospermae, all other ferns, Gymnospermae, Bryophyta
843 E,F,G	coal	Schizaeaceae, Gleicheniaceae, all other ferns, Angiospermae
843 D	shale, $\frac{1}{4}$" coal	Gleicheniaceae, Schizaeaceae, Fungi, all other ferns, Angiospermae, Gymnospermae
843 A,B,C	coal	Gleicheniaceae, Schizaeaceae, Angiospermae, Fungi, Coniferales

TABLE II--Continued

Sample No.	Lithology	Spore-Pollen groups in decreasing abundance
		OPC 821
821 F,G,H	coal	Angiospermae, Gleicheniaceae, Coniferales
821 C,D,E	coal	Angiospermae, Schizaeaceae, Gleicheniaceae, Gymnospermae
821 B	coal	Gleicheniaceae, Angiospermae, Schizaeaceae, Bryophyta, Gymnospermae
821 A	coal	Gleicheniaceae, Angiospermae, all other ferns, Lycopsida, Bryophyta
		OPC 845
845 J-N	coal	Gleicheniaceae, Angiospermae, Coniferales
845 I	shale	Angiospermae, Gleicheniaceae, Schizaeaceae, Bryophyta, all other ferns, Fungi
845 F,G,H	coal	Gleicheniaceae, Angiospermae, all other ferns, Gymnospermae
845 E	shale	Angiospermae, Schizaeaceae, Gleicheniaceae, Gymnospermae, all other ferns, Bryophyta, Fungi
845 B,C,D	coal	Angiospermae, Gleicheniaceae, Fungi, all other ferns
845 A	shale	Gymnospermae, Angiospermae, Gleicheniaceae, all other ferns, Fungi

TABLE II--Continued

Sample No.	Lithology	Spore-Pollen groups in decreasing abundance
		OPC 844
844 D-K	coal	Angiospermae, Schizaeaceae, Gleicheniaceae, all other ferns, Fungi, Gymnospermae, Bryophyta
844 A,B,C	coal	Gleicheniaceae, Bryophyta, Angiospermae, all other ferns

DISCUSSION

The following fossil palynomorphs were recovered from the Red Branch sediments:

Fungi Imperfectae
- *Brachysporium* sp.
- *Fungus spore* sp. A

Bryophyta
- Sphagnales
  - *Sphagnumsporites* cf. *S. psilatus*
  - *Cingulatisporites* cf. *C. levispeciosus*

Psilopsida
- Psilotales
  - *Laevigatosporites* sp. A
  - *Verrucatosporites* sp. B

Lycopsida
- Lycopodiales
  - *Lycopodiacidites* cf. *L. keupperi*
  - *Camarozonosporites* cf. *C. rudis*
  - *New Genus A*

Pteropsida
- Filicales

  - Osmundaceae
    - *Osmundacidites* cf. *O. wellmanii*
    - *Baculatisporites* cf. *B. comaumensis*

  - Cyatheaceae
    - *Concavisporites* cf. *C. subgranulosus*
    - *Cyathidites* cf. *C. australis*
    - *Cyathidites* cf. *C. minor*

  - Gleicheniaceae
    - *Gleicheniidites* sp. A
    - *Deltoidospora* cf. *D. halli*

Schizaeaceae
- _Schizaeoisporites_ cf. _S. phaseolus_
- _Appendicisporites_ cf. _A. tricornitatus_
- _Cicatricosisporites_ cf. _C. dorogensis_
- _Cicatricosisporites_ sp. A
- _Klukisporites_ sp. A
- _Concavisporites_ cf. _C. punctatus_
- _Concavisporites_ sp. A
- _Matonisporites_ cf. _M. equiexinus_
- _Matonisporites_ sp. A

Polypodiaceae
- _Verrucatosporites_ sp. A
- _Laevigatosporites_ cf. _L. ovatus_
- _Laevigatosporites_ sp. D

Sporae incertae sedis
- _Trilites_ sp. A
- _New Genus_ D
- New Genus F
- _Balmeisporites_ cf. _B. glenelgensis_
- _Laevigatosporites_ sp. B
- _Laevigatosporites_ sp. C

Spermatophyta

Gymnospermae

Cyadales
- _Monosulcites_ sp. A
- _Monosulcites_ sp. B

Ginkgoales
- _Monosulcites_ cf. _M. minimus_

Coniferales

Pinaceae
- _Picaeapollenites_ cf. _P. alatus_
- _Tsugaepollenites_ sp. A

Taxodiaceae
- _Taxodiaceaepollenites_ cf. _T. hiatus_

Araucariaceae
- _Inaperturopollenites_ cf. _I. magnus_
- _Inaperturopollenites_ sp. A

Podocarpaceae
- *Podocarpidites* sp. A
- *Parvisaccites* sp. A
- *Parvisaccites* sp. B

Gnetales

Ephedraceae
- *Ephedripites* sp. A
- *Ephedripites* sp. B

Gymnospermae incertae sedis
- *Aratrisporites* sp. A
- *Simplicesporites* cf. *S. virgatus*
- *Simplicesporites* sp. A
- *Eucommiidites* cf. *E. troedssonii*
- *Eucommiidites* sp. A
- *Classopollis* sp. A
- New Genus G
- New Genus E
- *Spermatites* cf. *S. nanus* (seed)

Angiospermae

Dicotyledonae
- *Schizosporis* cf. *S. parvus*
- *Schizosporis* sp. A
- *Liquidambarpollenites* sp. A
- *Nyssapollenites* sp. A
- *Araliaceoipollenites* cf. *A. euphorii*
- *Tricolpites* cf. *T. reticulata*
- *Tricolpites* sp. A
- *Tricolpites* sp. B
- *Stephanocolpites* sp. A
- *Pistillipollenites* cf. *P. mcgregorii*

Monocotyledonae
- *Liliacidites* cf. *L. variegatus*
- *Palmaepollenites* cf. *P. tranquillus*
- *Palmaepollenites* sp. A
- *Clavatipollenites* sp. A
- New Genus C

Incertae sedis
- *Schizosporis* cf. *S. spriggi*
- *Schizosporis* cf. *S. reticulatus*

The Bryophytes are present throughout all samples although they are not well represented. Recent *Sphagnum* is found in swamps and bogs and usually indicates acidic soil and water conditions.

Fossil pteridophytic spores belonging to the families Gleicheniaceae and Schizaeaceae were recovered in great abundance from both the coals and the shales. Some recent representatives of these families are found today living in or near swamps and marshes.

The gymnospermous grains, with the exception of *Aratrisporites*, are not well represented in the total assemblage counts of any level. These grains were probably dispersed and transported long distances, or the parent plants were not abundant in or near the basins of deposition.

The abundance of angiospermous forms such as *Nyssa*, *Aralia*, and forms referrable to the Magnoliaceae and Palmae, also other angiospermous pollen grains such as *Tricolpites*, *Monocolpites*, and others, may indicate that these grains were not transported great distances but were deposited at or near the place in which the parent plants were growing.

The spore and pollen flora in all the studied sections appears to be the same without any major fluctuations. The same species occur throughout all the measured sections with variations in the percentages of each species.

It is suggested, therefore, that the Red Branch sediments in eastern Bryan County were deposited all within a short span of time. The local variations in assemblage percentages and the fact that none of the coals or shale intervals is traceable from one section to the next may suggest that there was more than one basin of deposition and that these basins supported their own local floras. No marine organisms (such as hystrichosphaerids or dinoflagellates) were recovered from either the shales or the coals, the entire microfossil assemblages consisting of the spores and pollen grains of terrestrial plants. This evidence indicates a non-marine depositional environment.

An analysis of the floral components of the Florida coastal swamp communities which have been studied by Harper (1910, 1914) shows common elements between the fossil assemblage studied here and these swamps. Teichmüller's (1958) synopsis of the swamp vegetation also includes a similar discussion. The following genera and families found in the Red Branch sediments are indicative of a warm temperate swampy depositional site:

Fungi imperfectae
Osmunda
Lygodium
Polypodiaceae
Taxodium

Magnolia
Liquidambar
Nyssa
Aralia
Sabal (referred to here as *Palmaepollenites* sp. A)

Fossil palynomorphs referred to the Lycopodiaceae, Gleicheniaceae, Schizaeaceae and Cyatheacae, along with *Palmaepollenites tranquillus* and *Liliacidites variegatus* are known to occur today near or in swamp communities in warm temperate or subtropical to tropical regions. *Palmaepollenites* and *Liliacidites* are here supposed to represent the pollen grains of palms and lilies.

The fossil pollen assignable to the Cycadales Ginkgoales and Coniferales occur today as forest elements of warm temperate, tropical or subtropical forests. Their rare occurrences in the Red Branch sediments may indicate that they were transported some distance before being deposited or that their parent plants grew in the neighborhood of the swamps as rare elements or remnants.

Angiospermous form genera described in this paper, such as *Tricolpites*, *Stephanocolpites* and *Monocolpites* are locally abundant but cannot be assigned with certainty to recent genera. Their abundance, however, suggests that they were not transported long distances before deposition. An abundance of these grains usually indicates that they were near-shore vegetational representatives (Dansereau, 1957). Because of the large number of these and other angiospermous pollen grains, fresh-water lagoonal sites were possible as depositional areas.

Palynological Comparisons

The palynological assemblage of the Red Branch sediments is comparable to the Cenomanian assemblage described by Krutzsch (1957). He did not attempt to put forth an elaborate taxonomic scheme in this paper, and therefore close comparison is impossible. However, as can be seen by his chart and excellent photographs, the Cenomanian assemblage consists of the following elements which are present in the Red Branch material:

Lycopodiaceae
Gleicheniaceae
Appendicisporites
Cicatricosisporites
Schizaeoisporites
Few saccate grains
Inaperturopollenites
Classopollis
Magnolia
Nyssa
Tricolporate grains
Tricolpate grains

He also lists as characteristic of Cenomanian sediments _Glyptostrobus_ and _Latipollis_. These form genera were not found in the Red Branch sediments.

The only two North American Cenomanian (lowermost Upper Cretaceous) assemblages are those studied by Pierce

(1960) and the combined works of Groot and Penny (1960) and Groot, Penny and Groot (1961). The Minnesota assemblage of Pierce (1960) consists of spore and pollen types similar to those recovered from the Red Branch sediments. Unfortunately, Pierce's system of taxonomy makes a valid comparison difficult. For convenience, his genera are converted to suit the taxonomic practice adopted in this paper. The fossil types common to both assemblages are:

<u>Sphagnumsporites</u>
<u>Cingulatisporites</u>
<u>Lycopodiacidites</u>
<u>Deltoidospora</u>
<u>Gleicheniidites</u>
<u>Cicatricosisporites</u>
<u>Monosulcites</u>
<u>Piceaepollenites</u>
<u>Tsugaepollenites</u>
<u>Podocarpidites</u>
<u>Parvisaccites</u>
<u>Nyssapollenites</u>
<u>Tricolpites</u>
<u>Clavatipollenites</u>

He also recorded a large number of bisaccate pollen grains from the Minnesota material. Bisaccate species are rare in all measured sections of the Red Branch sediments. The Cretaceous spore and pollen studied by Pierce (1960) is supposed to represent a vegetation growing in a cooler climate.

Groot and Penny (1960) and Groot, Penny and Groot (1961) have described the palynology of the Lower Cenomanian deposits of the Atlantic Coastal Plain. The palynomorphs common to both the Red Branch and their material include:

- *Sphagnumsporites psilatus*
- *Cyathidites minor*
- *Appendicisporites tricornitatus*
- *Cicatricosisporites dorogensis*
- *Monosulcites minimus*
- *Tsugaepollenites* (different species)
- *Inaperturopollenites* (different species)
- *Nyssa* ?
- Tricolpate grains
- *Liliacidites variegatus*

Little similarity between the assemblage described by Groot and Penny (1960) and the palynomorph association recovered from the Red Branch sediments is apparent. They reported an abundant variety of tricolpate and tricolporate grains. Their assemblage also included a large number of pollen grains referrable to *Turonipollis*, *Plicapollis*, *Latipollis*, *Sporopollis*, *Vacuopollis* and *Trudipollis*, all of which are significantly absent in the Red Branch material.

Plant Megafossil Comparison

The spore and pollen flora recovered from the Red Branch Member of the Woodbine Formation consists of 73 species and is basically a pteridophyte-angiosperm assemblage. Seven of the angiospermous species have been assigned form-generic names insofar as their absolute affinities are not determinable.

Berry (1962) described the Woodbine Sandstone flora as consisting of 43 species, of which 41 were angiospermous types and 2 were gymnosperms. This flora was recovered from the "Dexter beds" of Hill (1901) which is possibly the equivalent of Bergquist's (1949) Dexter Member, immediately underlying the Red Branch Member. No ferns or lower plants were present in this assemblage, most likely due to the environment in which the plants lived. Of Berry's 32 genera, only four appear in common with the microfloral elements of the Red Branch sediments.

1. *Podozamites* is possibly the parent plant of such pollen grains as *Monosulcites* sp. B, which is here interpreted as being the pollen of a Mesozoic *Zamia*.

2. *Brachyphyllum* has been interpreted by Pocock and Jansonius as one of the possible parent plants which produced *Classopollis*-type pollen.

3. *Magnolia* is probably represented by *Schizosporis parvus* and *Schizosporis* sp. A.

4. *Aralia* appears in the Red Branch assemblage as *Araliaceoipollenites* cf. *A. euphorii*.

Stratigraphical Considerations

The Red Branch spore and pollen flora is similar to the Cenomanian assemblages described by Krutzsch (1957), Pierce (1960) and Groot, Penny and Groot (1961). This comparison is suggestive of a Cenomanian age for the Red Branch Member of the Woodbine Formation.

Berry (1922) recorded five species common to the Woodbine and the European Cenomanian sediments, and two species common to the Woodbine and the European Turonian. In comparing his flora to the floras described from the Tuscalcosa and Magothy Formations of the Atlantic Coastal Plain, he considered the Woodbine assemblage as of Turonian age.

Adkins and Lozo (1951) included the Woodbine Formation of the Cretaceous Gulf Coastal area in the Cenomanian zonal stage on the basis of megafossil evidence. The spore and pollen evidence recovered from the Red Branch sediments also suggests a Cenomanian age for the Red Branch Member.

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APPENDIX

PLATE 1

1. Fungus spore sp. A
20.5 microns, 18.4 microns, 16.2 microns OPC 843 F-5-2, Page 22.

2. Brachysporium sp.
27.5 x 15.0 microns OPC 843 H-6-1, Page 22

3. Sphagnumsporites cf. S. psilatus (Ross, 1949) Couper, 1958. 28.1 microns OPC 844 J-28-1, Page 30.

4. Cingulatisporites cf. C. levispeciosus Pflug, 1953
35.0 microns OPC 845 I-17-2, Page 47.

5. Osmundacidites cf. O. wellmanii Couper, 1953
46.4 microns OPC 844 J-2-2, Page 34.

6. Trilites sp. A
25.0 microns OPC 845 H-12-3, Page 34.

7. Baculatisporites cf. B. comaumensis (Cookson, 1953) R. Potonie, 1956. 37.8 microns OPC 844 D-1-3, page 36.

8. New Genus F
22.5 x 22.5 x 27.0 microns OPC 821 A-5-1, Page 45.

9. New Genus F
26.0 x 27.0 x 27.0 microns OPC 821 A-1-1, Page 45.

10. Gleicheniidites sp. A
32.4 x 33.5 microns OPC 843 E-2-4, Page 26.

11. New Genus D
16.2 x 17.3 x 17.3 microns OPC 844 K-21-6, Page 44.

12. Balmeisporites cf. B. glenelgensis Cookson and Dettmann, 1958. 125.0 x 140.0 microns, 187.5 microns including neck OPC 844 J-20-1, Page 44.

13. Balmeisporites cf. B. glenelgensis Cookson and Dettmann, 1958. 130.0 microns, 187.5 microns including neck OPC 843 I-4-1, Page 44.

PLATE 1

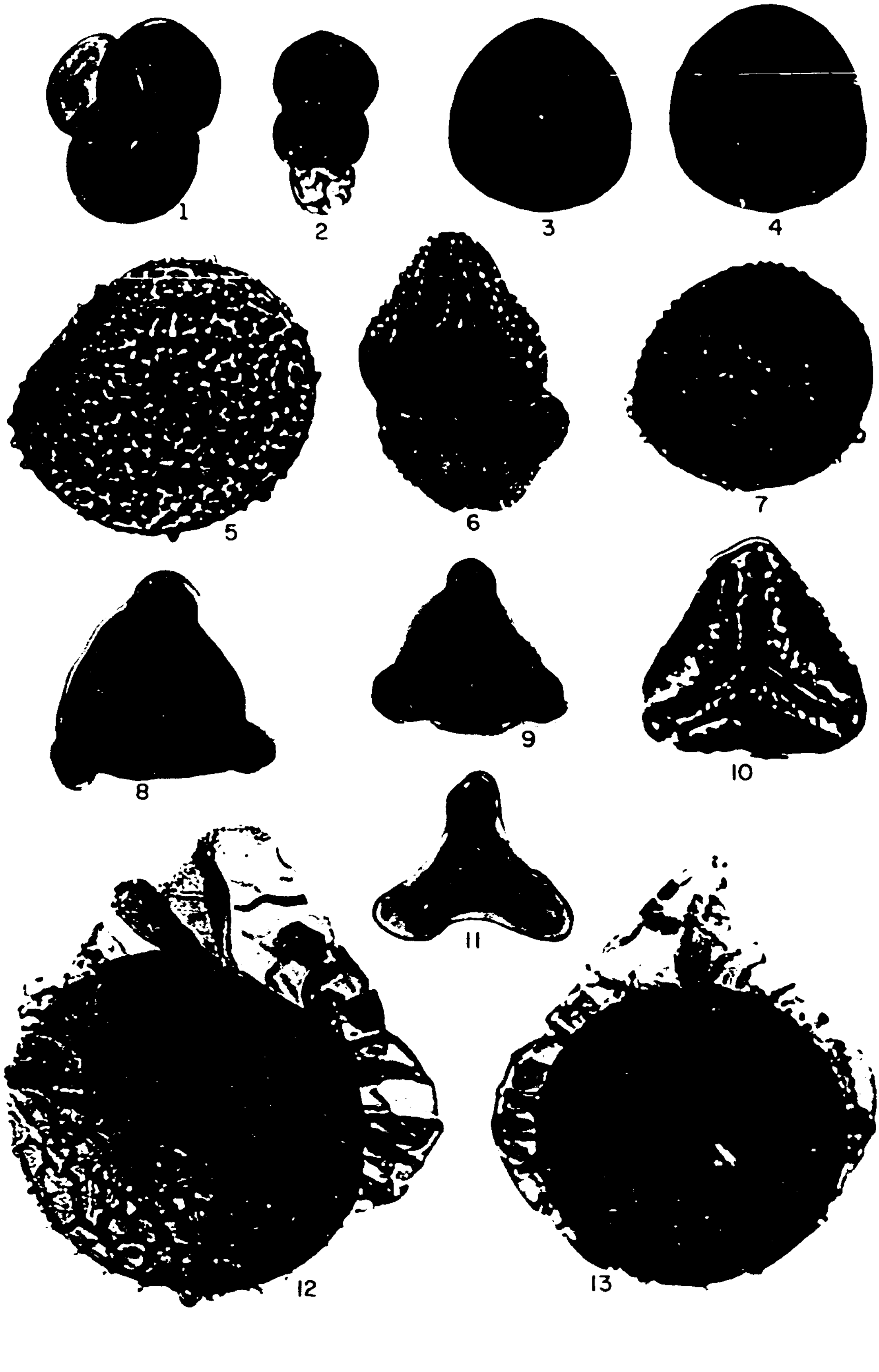

PLATE 2

1. Camarozonosporites cf. C. rudis (Leschik, 1955) Klaus, 1960. Proximal view, 43.2 microns OPC 824 E-1-1, Page 48.

2. Camarozonosporites cf. C. rudis (Leschik, 1955) Klaus, 1960. Distal view, 43.2 microns OPC 824 E-1-1, Page 48.

3. Lycopodiacidites cf. L. keupperi Klaus, 1960 Proximal view, 42.1 microns OPC 844 K-12-1, Page 38.

4. New Genus A
43.2 x 45.4 x 45.4 microns OPC 844 K-21-4, Page 37.

5. New Genus A
45.4 x 47.5 x 48.7 microns OPC 844 K-11-5, Page 37.

6. Lycopodiacidites cf. L. keupperi Klaus, 1960 Distal view, 42.1 microns OPC 844 K-12-1, Page 38.

7. Klukisporites sp. A
Proximal view, 62.6 x 63.7 microns OPC 842 E-4-2, Page 42.

8. Klukisporites sp. A
Distal view, 62.6 x 63.7 microns OPC 842 E-4-2, Page 42.

PLATE 2

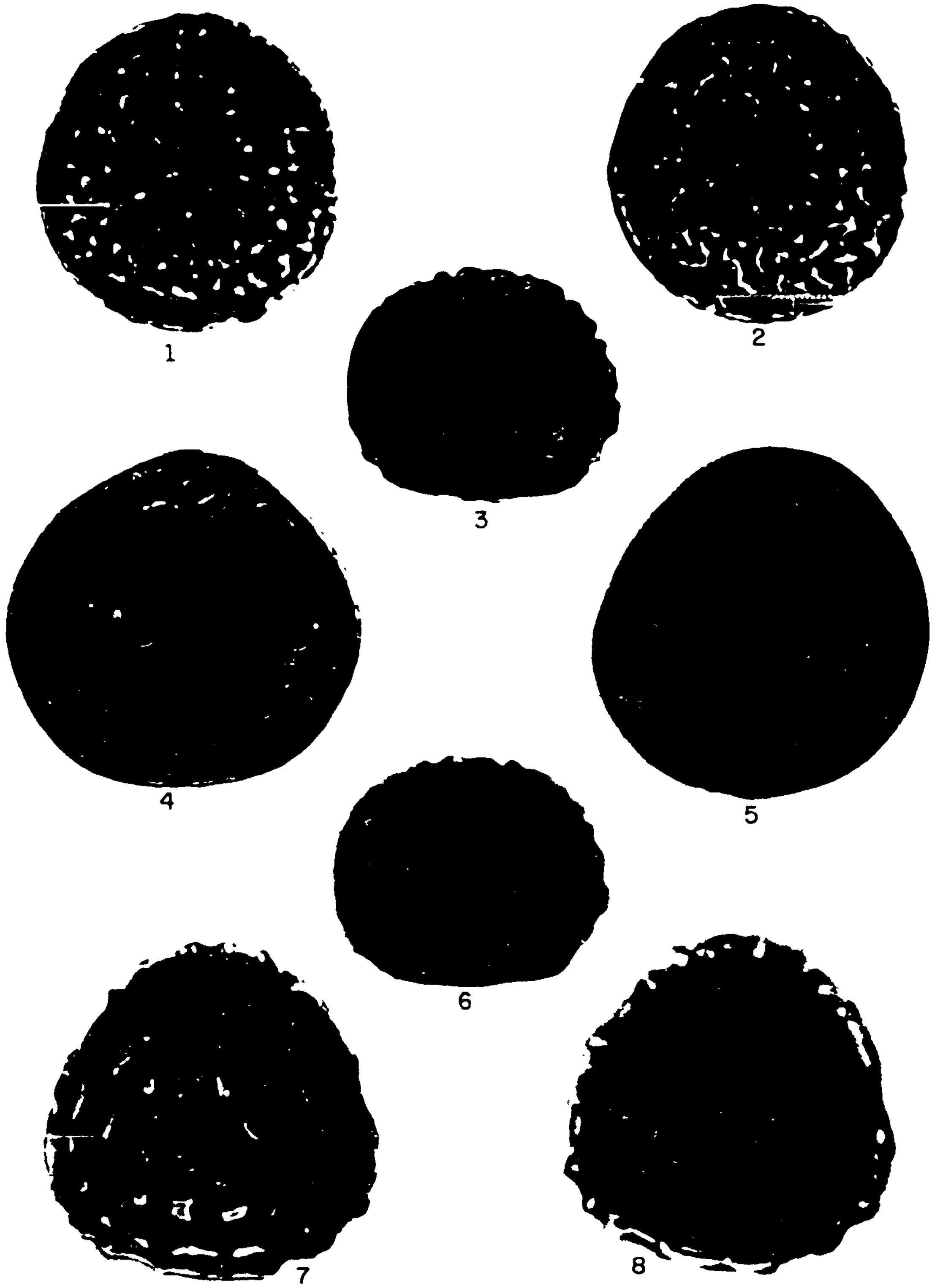

PLATE 3

1. Appendicisporites cf. A. tricornitatus Weyland and Greifeld, 1953. 61.6 x 62.6 microns OPC 843 H-1-2, Page 46.

2. Appendicisporites cf. A. tricornitatus Weyland and Greifeld, 1953. 63.7 microns OPC 824 E-14-2, Page 46.

3. Appendicisporites cf. A. tricornitatus Weyland and Greifeld, 1953. 48.6 x 50.8 microns OPC 843 H-6-5, Page 46.

4. Cicatricosisporites cf. C. dorogensis R. Potonié and Gelletich, 1933. 43.2 x 45.6 microns OPC 843 H-6-1, Page 39.

5. Cicatricosisporites cf. C. dorogensis R. Potonié and Gelletich, 1933. 63.7 microns OPC 843 H-2-1, Page 39.

6. Schizaeoisporites cf. S. phaseolus Delcourt and Sprumont, 1955. 37.5 x 52.5 microns OPC 844 K-14-1, Page 56.

7. Cicatricosisporites sp. A 56.2 microns OPC 843 A-5-2, Page 41.

8. Cicatricosisporites sp. A 58.3 microns OPC 844 K-21-2, Page 41.

PLATE 3

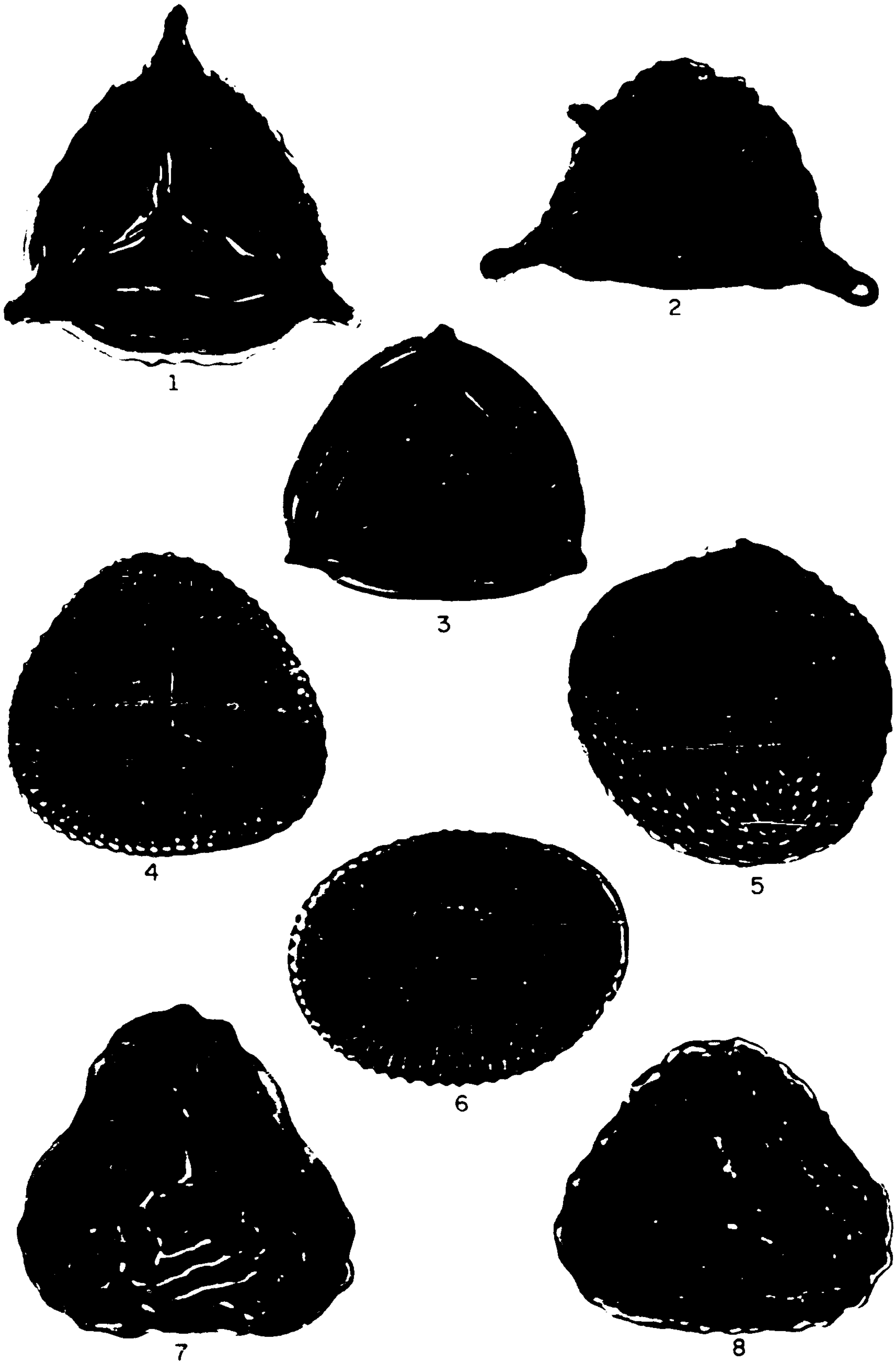

PLATE 4

1. Concavisporites cf. C. subgranulosus Couper, 1958
42.5 x 45.0 microns OPC 845 A-13-1, Page 28.

2. Cyathidites cf. C. minor Couper, 1953
37.8 x 40.0 x 40.0 microns OPC 844 J-18-6, Page 25.

3. Concavisporites cf. C. punctatus Delcourt and Sprumont, 1955. 57.5 microns OPC 843 H-4-2, Page 27.

4. Cyathidites cf. C. australis Couper, 1953
55.1 x 59.4 microns OPC 843 E-2-3, Page 24.

5. Concavisporites sp. A
37.4 microns OPC 845 I-14-1, Page 29.

6. Matonisporites cf. M. equiexinus Couper, 1958
50.1 microns OPC 843 E-2-1, Page 32.

7. Deltoidospora cf. D. halli Miner, 1935
32.4 x 34.6 microns OPC 845 F-3-3, Page 23.

8. Matonisporites sp. A
69.5 x 71.5 x 75.0 microns OPC 845 I-14-2, Page 32.

9. Deltoidospora cf. D. halli Miner, 1935
31.3 x 32.4 microns OPC 845 F-5-1, Page 23.

10. Verrucatosporites sp. B
27.0 x 55.1 microns OPC 844 H-24-1, Page 55.

11. Laevigatosporites sp. C
63.7 x 72.4 microns OPC 845 F-2-2, Page 52.

12. Verrucatosporites sp. A
30.0 x 60.0 microns OPC 824 D-7-2, Page 54.

PLATE 4

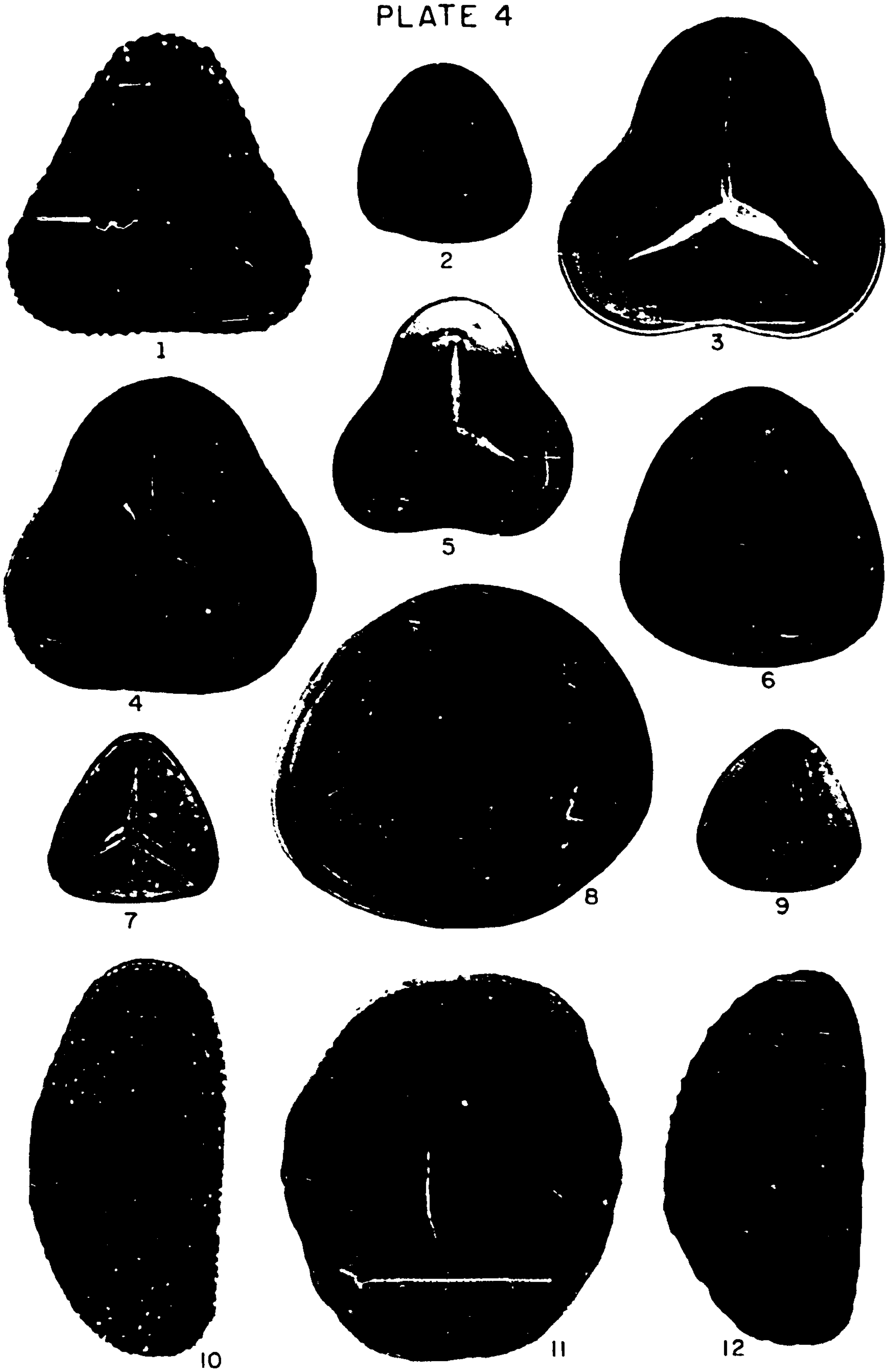

PLATE 5

1. Laevigatosporites sp. A
   22.5 x 47.5 microns OPC 842 E-10-2, Page 51.

2. Laevigatosporites cf. L. ovatus Wilson and Webster, 1946. 29.2 x 37.8 microns OPC 843 E-9-1, Page 50.

3. Laevigatosporites sp. D
   15.0 x 20.0 microns OPC 844 B-2-1, Page 53.

4. Laevigatosporites sp. B
   32.4 microns, 27.0 microns, 34.6 microns OPC 843 H-1-1, Page 51.

5. Schizosporis sp. A
   48.6 x 147.5 microns OPC 844 G-9-1, Page 96.

6. Schizosporis cf. S. spriggi Cookson and Dettmann, 1959. 80.0 microns OPC 821 H-1-1, Page 95.

7. Schizosporis cf. S. parvus Cookson and Dettmann, 1959. 36.7 x 75.6 microns OPC 844 H-12-5, Page 95.

8. Schizosporis cf. S. reticulatus Cookson and Dettmann, 1959. 120.0 x 130.0 microns OPC 844 K-13-1, Page 94.

9. Schizosporis cf. S. reticulatus Cookson and Dettmann, 1959. 122.5 microns OPC 845 A-6-1, Page 94.

PLATE 5

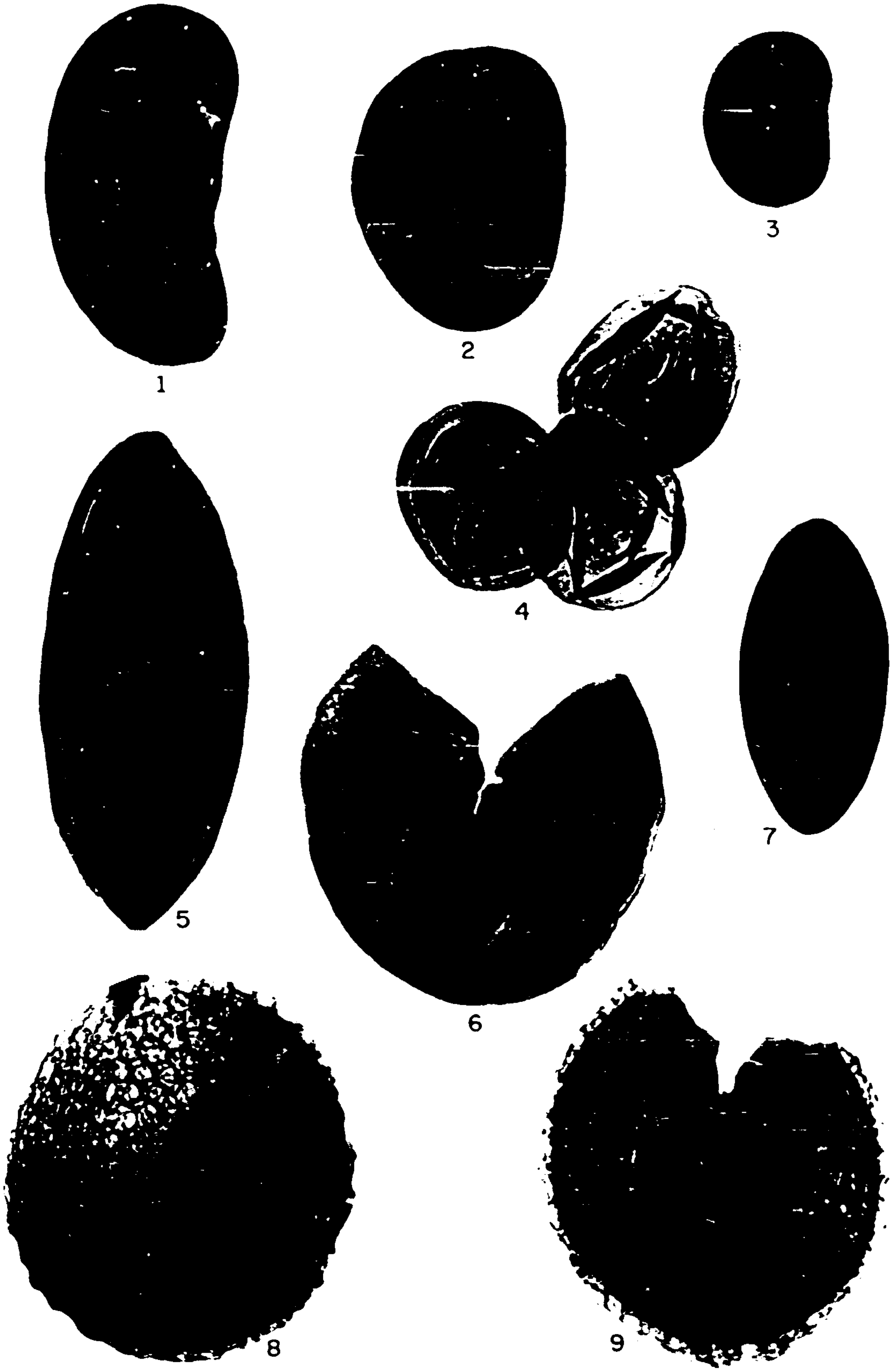

PLATE 6

1. Aratrisporites sp. A
   29.16 microns OPC 842 C-7-3, Page 57.

2. Simplicesporites cf. S. virgatus Leschik, 1955
   29.0 x 38.9 microns OPC 844 E-23-1, Page 69.

3. Aratrisporites sp. A
   OPC 842 C-7-3 Retouched photograph to show germinal apparatus, Page 57.

4. New Genus G
   20.0 x 25.0 microns OPC 845 I-2-1, Page 73.

5. Simplicesporites sp. A
   32.4 x 37.8 microns OPC 844 D-1-4, Page 69.

6. Simplicesporites sp. A
   22.7 x 26.0 microns OPC 843 H-4-2, Page 69.

7. New Genus G
   27.5 x 32.5 microns OPC 824 G-5-1, Page 73.

8. Classopollis sp. A
   25.0 microns OPC 844 J-24-1, Page 71.

9. Classopollis sp. A
   23.7 x 25.0 microns OPC 844 H-11-1, Page 71.

10. Spermatites cf. S. nanus Miner, 1935
    261.6 x 501.4 microns OPC 845 A-4-1, Page 97.

11. Eucommiidites cf. E. troedssonii Erdtman, 1948
    17.3 x 26.0 microns OPC 845 I-3-7, Page 75.

12. Eucommiidites sp.
    39.0 x 50.0 microns OPC 843 H-2-1, Page 76.

PLATE 6

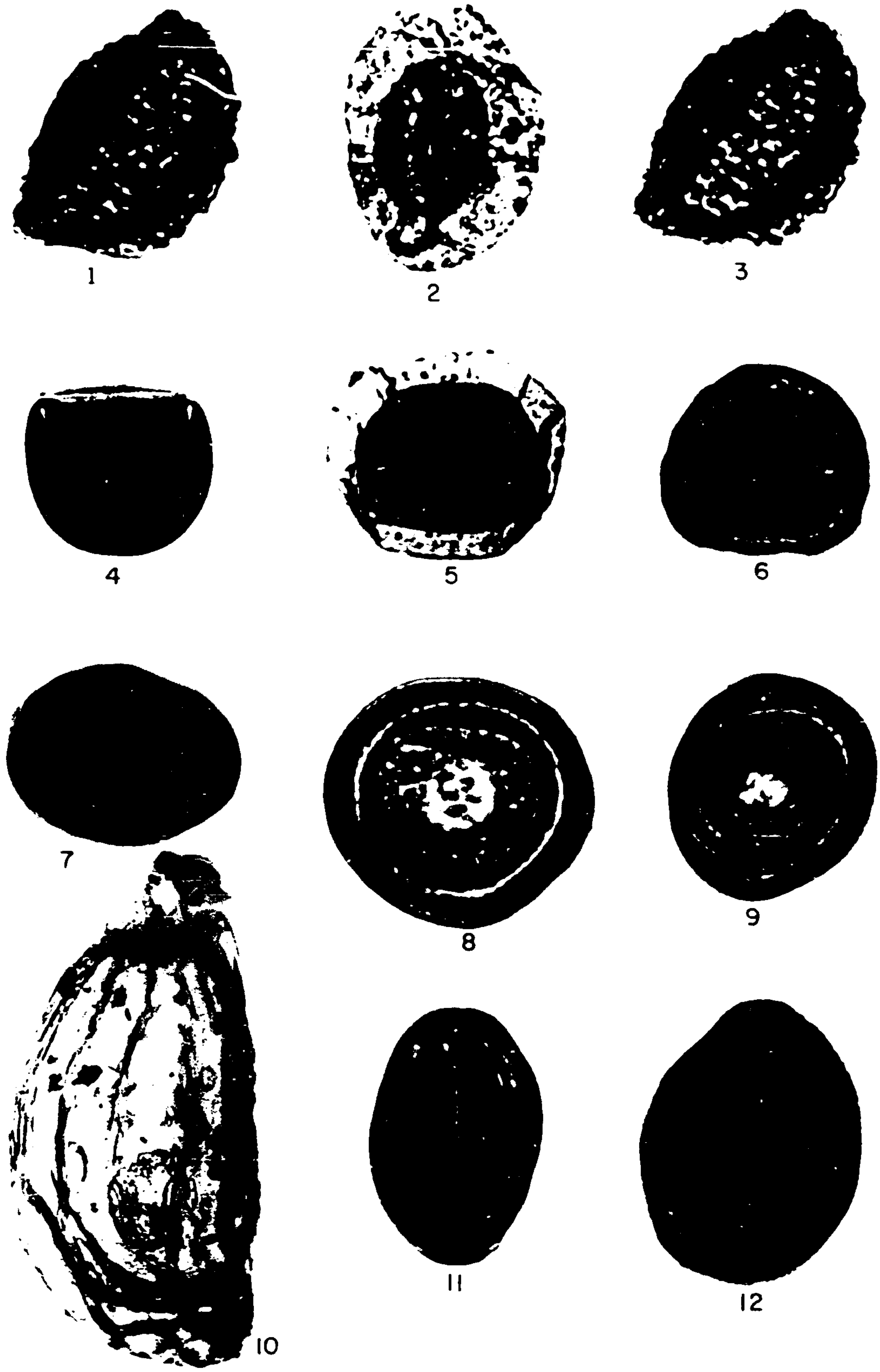

PLATE 7

1. *Piceaepollenites* cf. *P. alatus* R. Potonié, 1931
70.2 microns OPC 844 K-21-1, Page 62.

2. *Podocarpidites* sp. A
75.6 microns OPC 844 J-26-1, Page 63.

3. *Piceaepollenites* cf. *P. alatus* R. Potonié, 1931
36.7 x 77.8 microns OPC 843 H-1-3, Page 62.

4. *Podocarpidites* sp. A
44.3 x 63.7 microns OPC 844 H-1-2, Page 63.

5. *Parvisaccites* sp. A
39.0 x 43.2 microns OPC 821 D-14-1, Page 60.

6. *Parvisaccites* sp. B
43.2 microns OPC 824 E-6-2, Page 61.

PLATE 7

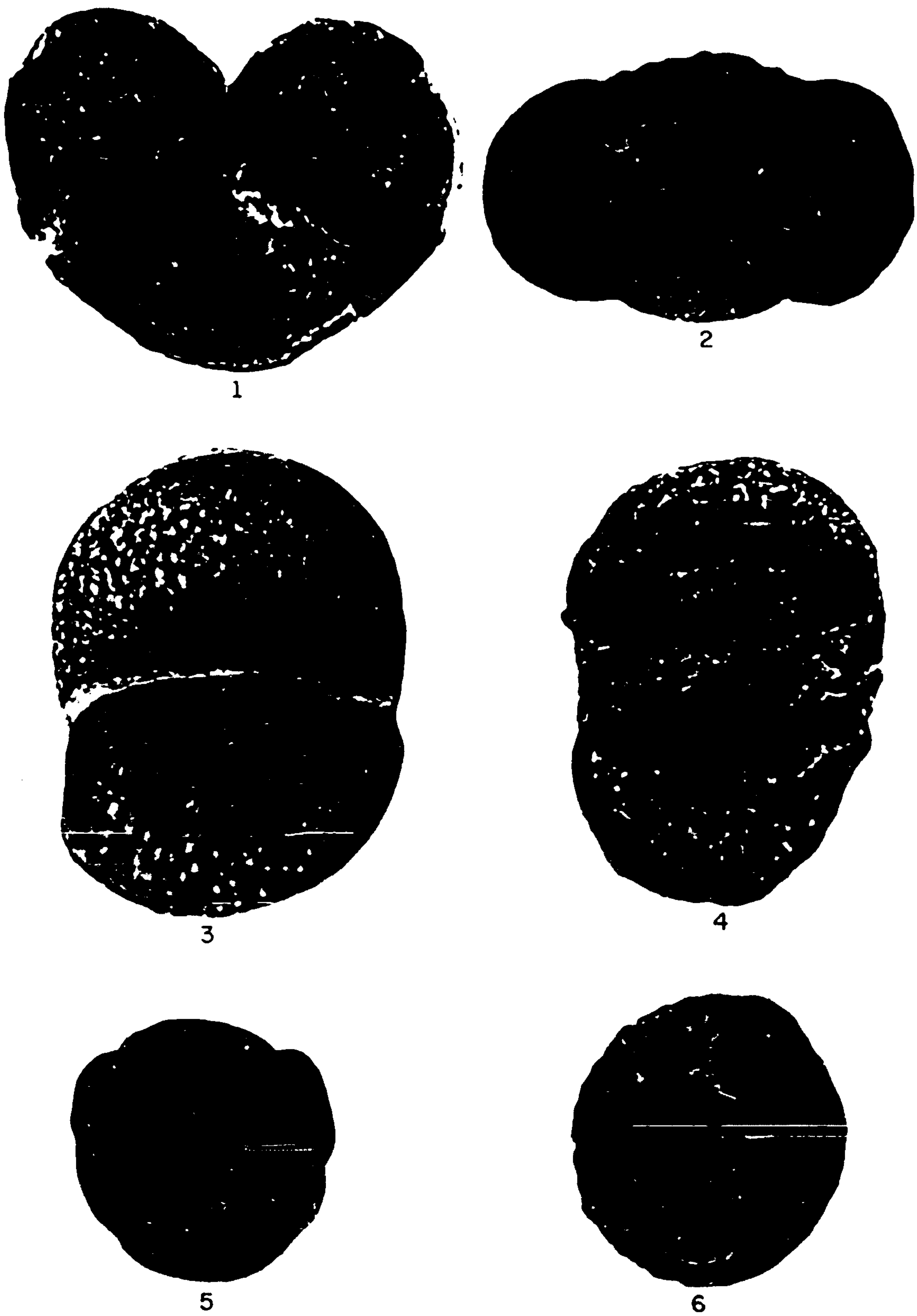

PLATE 8

1. *Tsugaepollenites sp. A*
50.8 microns OPC 843 E-8-6, Page 59.

2. *Tsugaepollenites sp. A*
50.0 microns OPC 843 E-8-5, Page 59.

3. New Genus E
43.2 x 46.4 microns OPC 821 G-10-1, Page 67.

4. *Inaperturopollenites* cf. *I. magnus* (R. Potonié, 1934) Thomson and Pflug, 1953. 55.0 x 67.0 microns OPC 845 F-1-5, Page 65.

5. New Genus E
37.8 x 43.2 microns OPC 822 B-18-1, Page 67.

6. *Taxodiaceaepollenites* cf. *T. hiatus* (R. Potonié, 1931) Kremp, 1949. 30.0 microns OPC 844 H-12-4, Page 68.

7. *Monosulcites sp. A*
29.2 x 66.0 microns OPC 844 K-7-6, Page 82.

8. *Inaperturopollenites sp. A*
43.2 microns OPC 844 H-25-9, Page 66.

9. *Ephedripites sp. A*
14.0 x 35.1 microns OPC 842 C-7-4, Page 77.

10. *Ephedripites sp. B*
20.0 x 37.5 microns OPC 824 D-7-2, Page 77.

11. *Monosulcites* cf. *M. minimus* Cookson, 1947
18.4 x 38.0 microns OPC 821 D-15-1, Page 81.

12. *Monosulcites sp. B*
8.6 x 15.0 microns OPC 844 G-6-2, Page 82.

PLATE 8

PLATE 9

1. Clavatipollenites sp. A
33.5 x 36.7 microns OPC 845 J-3-1, Page 79.

2. Palmaepollenites sp. A
12.0 x 15.0 microns OPC 844 K-7-1, Page 85.

3. Palmaepollenites cf. P. tranquillus (R. Potonié, 1934) R. Potonié, 1951. 21.6 x 29.2 microns OPC 845 F-1-7, Page 84.

4. Palmaepollenites cf. P. tranquillus (R. Potonié, 1934) R. Potonié, 1951. 24.8 x 31.3 microns OPC 845 F-18-3, Page 84.

5. Tricolpites cf. T. reticulatus Cookson, 1947
20.5 x 27.0 microns OPC 844 J-13-1, Page 86.

6. Liliacidites cf. L. variegatus Couper, 1953
17.5 x 27.5 microns OPC 824 F-10-2, Page 83.

7. New Genus C
13.0 x 16.2 microns OPC 844 J-22-1, Page 80.

8. New Genus C
13.0 x 18.4 microns OPC 844 J-13-3, Page 80.

9. Tricolpites sp. B
20.5 x 23.8 microns OPC 844 J-22-2, Page 88.

10. Tricolpites sp. A
13.0 x 17.3 microns OPC 845 F-1-4, Page 87.

11. Nyssapollenites sp. A
10.8 x 11.1 x 11.1 microns OPC 824 D-10-1, Page 91.

12. Nyssapollenites sp. A
10.8 x 15.1 microns OPC 844 H-25-11, Page 91.

13. Tricolpites sp. B
25.0 microns OPC 824 E-13-2, Page 88.

PLATE 9--Continued

14. *Stephanocolpites* sp. A
42.0 x 81.0 microns OPC 843 I-1-5, Page 89.

15. *Araliaceoipollenites* cf. *A. euphorii* (R. Potonié, 1931) R. Potonié, 1951. 30.0 x 40.0 microns OPC 821 C-1-1, Page 90.

16. *Stephanocolpites* sp. A
36.7 x 70.0 microns OPC 843 I-1-4, Page 89.

17. *Pistillipollenites* cf. *P. mcgregorii* Rouse, 1962
17.5 microns OPC 844 G-17-1, Page 92.

18. *Liquidambarpollenites* sp. A
27.5 microns OPC 845 I-3-1, Page 93.

19. *Liquidambarpollenites* sp. A
27.5 microns OPC 845 I-3-1, Page 93.

PLATE 9

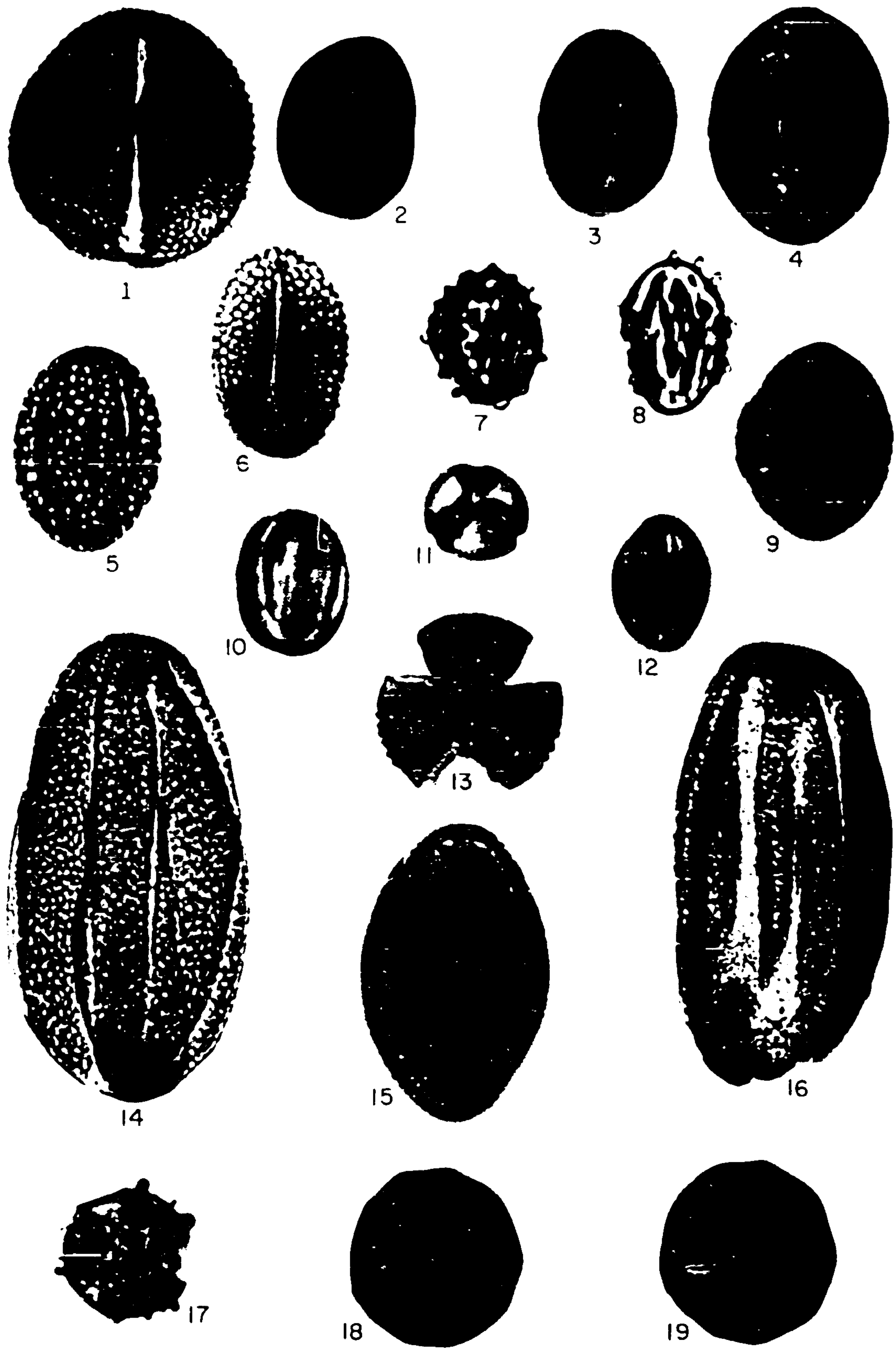

TABLE 3. RELATIVE PERCENTAGES OF SPORE-POLLEN SPECIES IN SEVEN SECTIONS OF THE RED BRANCH MEMBER

(Occurrences of less than 0.1 percent are indicated by tr.)

		OPC 840						OPC 824		OPC 822			OPC 843				OPC 821				OPC 845						OPC 844	
		A	B	C	D	E	F	D&F	G	B	G	HI	ABC	J	EFG	HI	A	b	CDE	FGH	A	BCD	E	FGH	I	J-N	ABC	D-K
1	Brachysporium sp. Fungus spore sp. A	2.0	4.5	1.0	16.0	7.5	11.5	5.3		2.5		0.3	10.0	19.5	4.6	2.0	1.0	1.0	0.2	0.2	9.5	4.8	5.0		9.7	0.8	1.0	6.4
2	Sphagnumsporites cf. S. psilatus Cingulatisporites cf. C. levispeciosus	0.5	5.5	1.0			2.5		2.5	0.5			1.5	1.5	3.5 0.3	5.5	11.0	6.0	0.2		0.5	0.3	5.0		12.3 2.3		20.7 0.8	2.4 tr.
3	Laevigatosporites sp. A Verrucatosporites sp. B					1.5 0.5		0.3 1.2					0.3 0.3			0.6 0.3			0.2	0.2 0.2	1.0				0.3 0.3	tr.	0.2	0.4 0.2
4	Lycopodiacidites cf. L. kuepperi Camarozonosporites cf. C. rudis New Genus A	0.5 0.5					0.5 1.0	tr. 1.0	0.5				0.2 1.0 tr.	0.5	0.5 tr.	tr. tr.	4.0								0.3 2.3 0.7	0.1	0.2 11.8 0.2	tr. 0.4 0.2
5	Osmundacidites cf. O. wellmanii Baculatisporites cf. B. comaumensis		0.5		2.5	5.0	1.0	2.0 0.1	1.0				0.2	0.5	3.2							0.2			0.6 0.3		0.3	4.3 0.2
6	Concavisporites cf. C. subgranulosus Cyathidites cf. C. australis Cyathidites cf. C. minor	0.5	1.5	0.5	0.5 4.0	0.5 3.0 4.5	2.0	2.5 0.8					0.2 1.2	0.5 2.0 1.5	3.5 1.3	2.8 0.5		1.0	0.7 0.7	0.2	1.5 5.5	0.2 2.8	0.5 5.5	0.2	0.3 3.3	0.4	0.7 0.2	1.3 2.2
7	Gleicheniidites sp. A Deltoidospora cf. D. hallii	6.0 1.0	7.0 53.0	1.0	3.5 5.5	4.0 4.0	4.5 45.0	4.8 12.3	2.0 6.5	8.0 78.0	9.0 67.5	22.5 75.3	18.7 15.0	15.0 11.5	19.3 5.3	7.3 33.8	19.5 40.0	6.0 43.0	3.0 5.3	19.8 11.5	5.0 15.5	3.3 11.0	1.5 13.5	11.2 71.0	6.6 13.6	44.4 5.2	8.0 26.5	2.0 13.3
8	Schizaeoisporites cf. S. phaseolus Appendicisporites cf. A. tricornitatus Cicatricosisporites cf. C. doregensis Cicatricosisporites sp. A Klukisporites sp. A Concavisporites cf. C. punctatus Concavisporites sp. A Matonisporites cf. M. equiexinus Matonisporites sp. A	0.5 1.0 0.5 7.0 1.0	7.5 1.0 0.5 4.0	5.0	3.5 4.0 tr. 9.5 1.5 12.5 4.5	3.5 4.0 0.5 6.5 3.0 21.0 4.0	4.5 9.0 3.0 6.0 0.5	1.6 9.3 0.2 2.5 0.5 5.5 6.0 tr.	1.0 2.5 15.5 1.5				4.7 13.8 0.7 1.7 2.8 2.3	5.0 5.5 1.0 4.0 3.5	9.0 20.0 1.0 1.0 1.3 4.0	7.8 7.3 1.3 2.6 3.3	0.5 0.5	3.0 2.0 1.0	6.2 1.0 0.6 0.2 3.0 0.2	0.2 1.2 0.2	2.0 2.5 0.5 2.5 0.5	0.5 0.3	9.0 1.0 0.5 5.5 3.0	0.2 0.2	1.0 4.3 tr. 0.6 4.6 5.3 tr.	0.1 tr. tr. 0.2	0.3 2.7 2.5 0.2	tr. 2.4 6.3 tr. 0.1 1.5 6.5 5.4
9	Verrucatosporites sp. A Laevigatosporites cf. L. ovatus Laevigatosporites sp. D	1.0	3.5	0.5	4.0	4.0	0.5	1.8	4.5	1.0	0.5	0.6	1.7	2.0	3.3	2.0	4.0		1.5	0.2	1.5	0.3	3.5	1.3	2.6	0.4	0.8	1.4
10	Trilites sp. A New Genus D New Genus F Balmeisporites cf. B. glenelgensis Laevigatosporites sp. B Laevigatosporites sp. C	0.5 0.5 1.5		0.5	1.0	1.0	0.5	0.2 0.2 0.2 1.0	2.5	0.5 0.5	0.5 0.5 0.5		1.0 tr. 0.7 0.2	1.5 0.5 3.0 0.5	1.3 0.3	0.3 1.5 0.5 1.8	0.5 5.0 1.0 0.5		1.0	0.2 0.2 0.2 0.2	tr. 0.5	0.2 0.2	0.5 0.5 0.5	0.7 0.2 0.3 3.7	1.6 tr. 1.6 0.3	tr. 0.1 0.2	0.3 0.3 0.3	0.2 0.1 0.1 0.4
11	Monosulcites cf. M. minimus Monosulcites sp. A Monosulcites sp. B	1.0		2.0 1.0	1.0 0.5	1.5		1.0 1.7	2.0 4.0				0.3 0.2	2.0	0.2 0.2	0.3			0.6 1.6	0.2 2.3	0.5 2.0	0.2 1.6	7.0	1.5	0.6	0.2 0.2	0.2 2.3	0.3 0.4 2.4
12	Piceaepollenites cf. P. alatus Tsugaepollenites sp. A Taxodiaceaepollenites cf. T. hiatus Inaperturopollenites cf. I. magnus Inaperturopollenites sp. A Podocarpidites sp. A Parvisaccites sp. A Parvisaccites sp. B	0.5 3.5 2.0 0.5	1.0 1.0	2.0 2.0 tr. 0.5	1.0 2.0 0.5 1.5	1.0 1.5 1.0 2.0	1.0	1.6 0.7 [illegible] tr.	1.5 2.5	0.5 0.5 0.5 1.0 0.5	[illegible]	0.5	0.8 2.0 1.8 0.8 0.3	2.5 1.5	0.3 0.2 1.8 0.7 0.3 1.2	0.8 0.3 2.5 0.3 0.3 0.6	0.5 0.5 0.5	1.0 1.0 1.0	1.2 6.0 0.5 1.3 0.3	0.5 0.7 1.7 0.3	0.5 2.5 1.5 0.5 tr.	0.2 0.8 1.8	0.5 4.5 0.5 0.5	0.2 0.5 0.2 0.3	0.6 0.3	0.4 1.0 1.1 0.5	0.2 0.5	0.3 2.1 tr. 1.4 0.4 tr. tr.
13	Ephedripites sp. A Ephedripites sp. B			1.5		1.0		0.3 0.5	0.5				0.2		0.2			1.0 1.0							0.3			0.1 0.2
14	Aratrisporites sp. A Simplicesporites cf. S. virgatus Simplicesporites sp. A Eucommiidites cf. E. troedssonii Eucommiidites sp. A Classopollis sp. A New Genus D New Genus E Spermatites cf. S. nanus	61.5 1.5		76.0 1.0	1.0 0.5	2.0 tr.	0.5	12.0 3.2 0.3 0.7 0.2	25.0 0.5	0.5 0.5			1.3 tr.	1.0 0.5 0.5	0.2	3.3		1.0	0.3 0.2	0.2 0.2 0.6 0.2	10.5 5.5 3.5 0.5 0.5	0.2 1.7 0.2	0.5		2.6 0.3 tr. tr. 0.3	0.1	0.5 0.3 0.3 0.3	1.1 3.6 0.5 0.2 0.3 tr. tr.
15	Schizosporis cf. S. parvus Schizosporis sp. A			1.0	0.5 2.0	1.5	1.5 1.5	0.7 0.7		0.5			0.3		0.5					1.0 0.3	0.5 1.5	1.3	0.5	0.3	0.3	0.5		3.0 0.8
16	Liquidambarpollenites sp. A Pistillipollenites cf. P. mcgregorii Nyssapollenites sp. A Araliaceoipollenites cf. A. euphorii			0.5	1.5			1.2	2.0						0.5	0.3	0.5		0.5 tr.	0.2	2.0	0.7 0.2	0.5		0.3	0.9	0.5 5.3	1.0 0.1
17	Tricolpites cf. T. reticulatus Tricolpites sp. A Tricolpites sp. B Stephanocolpites sp. A	2.5 2.5 0.5	0.5 3.0	0.5 2.5	3.0 6.5	2.5 3.5 1.0	2.5	2.3 4.3 0.2	1.5 8.0	1.0 3.0		0.5	2.7 6.8 0.7 0.2	2.5 7.5 0.5	1.7 5.7 0.5	7.0 1.8 0.5 1.0	0.5 4.0	1.0 17.0 1.0	22.7 29.7 0.3 0.2	24.2 24.3	5.0 6.5	19.0 28.5 4.0	4.5 17.0	1.5 1.2 1.8	3.3 9.6 0.6	14.6 19.1 1.7	0.2 5.5 0.7	2.9 12.1 1.0 tr.
18	Liliacidites cf. L. variegatus Palmaepollenites cf. P. tranquillus Palmaepollenites sp. A Clavatipollenites sp. A New Genus C	tr. 0.5	1.0 1.0		tr. 2.5	0.5 0.5	0.5 1.0	0.6 1.8 0.5 0.2	6.0 3.5 3.5	0.5	1.0	0.3	1.0 0.8	0.5 1.5	0.6 0.3 0.2	0.6 0.3	0.5 5.0 0.5 0.5	2.0 5.0	1.0 1.0 2.0 0.6 0.2	2.5 1.2 2.5 1.5	1.0 1.5 0.5	2.3 5.3 1.2	2.0 4.5	3.3 0.7 0.3	0.3 tr. 1.0 tr. 3.0	1.2 3.4 1.5	0.2 2.5 2.5 0.3	1.0 1.3 1.4 0.6 2.3
19	Schizosporis cf. S. spriggii Schizosporis cf. S. reticulatus								0.5											0.7	0.5				tr.			tr. tr.
20	Indeterminable types		0.5	0.5	1.0			0.2	0.5				0.3	0.5	0.7	0.3			3.2	1.0	2.5	5.6	3.5	0.2	0.3	1.7		1.3