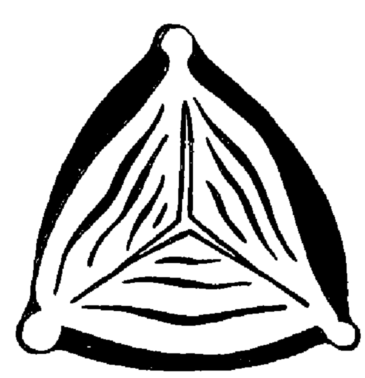
OKLAHOMA GEOLOGICAL SURVEY

CARL C. BRANSON, *Director*

BULLETIN 112

PALYNOLOGY OF THE RED BRANCH MEMBER OF THE WOODBINE FORMATION (CENOMANIAN), BRYAN COUNTY, OKLAHOMA

RICHARD W. HEDLUND



The University of Oklahoma

Norman

1966

CONTENTS

ILLUSTRATIONS

Plates

Text-Figure

Palynology of the Red Branch Member of the Woodbine Formation (Cenomanian), Bryan County, Oklahoma

Richard W. Hedlund*

ABSTRACT

The Red Branch palynological assemblage includes 74 forms of spores and pollen grains and 1 probable gymnospermous ovule, assigned to 45 genera and 71 species; 4 forms are unassigned. Twenty-one species and one genus are described as new. The palynomorph flora can be subdivided into five natural assemblages:

1. Bryophyte-psilopsid-lycopsid-filicinean assemblage
2. Cycadalean-ginkgoalean assemblage
3. Coniferalean assemblage
4. Ephedralean assemblage
5. Angiosperm assemblage

The absence of marine palynomorphs in the Red Branch shales indicates a non-marine depositional environment. The assemblage suggests a warm-temperate to tropical climate during which the Red Branch sediments were deposited in numerous, local, swampy basins along the Cenomanian coastal plain. Upland floristic elements, such as the conifers, were probably derived from cooler elevated areas to the north. The closest palynologic correlation appears to be with the Cenomanian of Minnesota.

INTRODUCTION

The Woodbine Formation of Late Cre-[illegible]us age has been the subject of numerous paleontological studies, among which the works of Berry (1922), Adkins and Lozo (1951), Stephenson (1952), and MacNeal (1958) are perhaps the more notable. Their detailed investigations of megafossils have added much to our knowledge of Woodbine biostratigraphy and paleoecology, but to date, no palynological studies dealing with the Woodbine Formation have been published.

In 1960, Curtis reported the occurrence of a coal-clay sequence in Bryan County, Oklahoma, which he assigned to Bergquist's (1949) Red Branch Member of the Woodbine Formation. A preliminary palynological investigation of some of Curtis' samples revealed an abundant and well-preserved assemblage of spores and pollen which, together with additional collections made by the author from eight measured outcrop sections, constitute the materials for this report.

A palynological investigation of the coals and clays of the Red Branch Member was begun during the summer of 1961. A total of 74 forms of palynomorphs, of which 21 are described as new species, is presented in this report. The probable biological affinities of these fossils have been established wherever possible in order to examine the ecological implications by comparisons with modern environments. In addition, the relationships of this assemblage to other palynological and paleobotanical assemblages of the same relative age are discussed.

The writer is indebted to L. R. Wilson, Research Professor of Geology at The University of Oklahoma, who directed the doctoral dissertation which is the foundation of this report. Thanks are due Carl C. Branson,

*Pan American Petroleum Corporation, Tulsa, Okla.

Director of the Oklahoma Geological Survey, and B. S. Venkatachala, Birbal Sahni Institute of Palaeobotany, for their valuable advice during the progress of the work; to Karl R. Newman and Donald W. Engelhardt, Pan American Petroleum Corporation, for advice and critical reading of the manuscript; and to Charles L. Rowett, University of Alaska, for assistance in the field. Acknowledgment is also extended to the many specialists and authorities who have assisted in various phases of this work. The Oklahoma Geological Survey and the National Science Foundation provided financial assistance, and the National Science Foundation (Grant 6589) made available necessary equipment and supplies.

GEOLOGY

The Cenomanian Woodbine Formation is the oldest Upper Cretaceous unit in the Gulf Coastal Plain. It was named by Hill (1901) for the village of Woodbine, Cooke County, Texas. 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, Texas, 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 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.

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

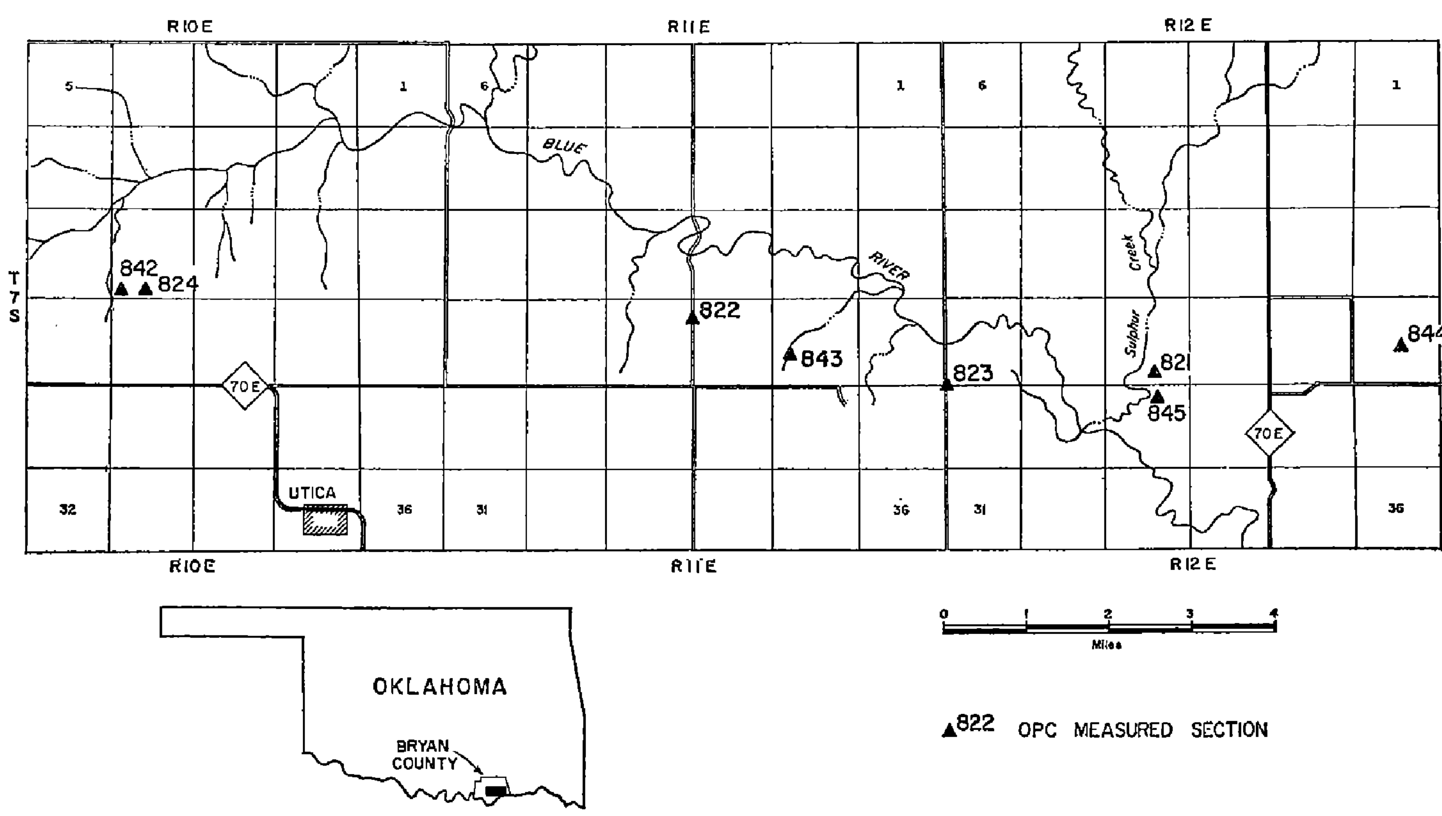
The sediments here assigned to the Red Branch Member have been found in Bryan County as far east as sec. 29, T. 7 S., R. 13 E., and as far west as sec. 16, T. 7 S., R. 10 E. (text-fig. 1). No outcrops of the Red Branch Member were located west of section OPC 842, SW¼ SW¼ SW¼ sec. 16, T. 7 S., R. 10 E. Curtis (1960) discovered coal float on the west side of Coal Creek in SE¼ sec. 2, T. 8 S., R. 8 E., and in a stream bed in NE¼ NE¼ NE¼ sec. 27, T. 7 S., R. 8 E. He also found black carbonaceous shale and purplish-brown shale cropping out in NE¼ NE¼ NE¼ NE¼ sec. 13, T. 7 S., R. 9 E. This evidence suggests that the coals may extend into the western part of Bryan County.

Bergquist (1949) and Curtis (1960) reported that 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, no tuffaceous sandstone was found 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 for even a short distance. It is probable, therefore, that the sedimentary units within the Red Branch Member are not continuous throughout the area studied, but occur in lenticular patches.

Few other occurrences of Cretaceous coals are known in Oklahoma. Stephenson (1918) 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 inaccessible for study. This unit may be part of the Red Branch Member. Davis (1960) reported the presence of coal in the Upper Cretaceous of southern McCurtain County. Potter (1963) published an emendation of the spore genus *Arcellites* from a coal in the Lower Cretaceous Omadi Formation of Cimarron County, Oklahoma.

COLLECTIONS

Eight sections of the Red Branch Member of the Woodbine Formation were measured and collected with the assistance of C. L. Rowett during the summer of 1961 (text-fig. 1). Segment samples, generally 2 inches long, 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 shales where they appeared carbonaceous or sufficiently fresh for palynological investigations. 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. Lithologic descriptions of the sections are given in the appendix. The unused portion of each sample is stored in the palynological collections of the Oklahoma Geological Survey, Norman, Oklahoma.



Text-figure 1. Map of a part of Bryan County, Oklahoma, showing locations of sections measured and sampled for this study. Descriptions of the sections and stratigraphic locations of the samples are given in the appendix.

SAMPLE PREPARATION AND STUDY

The sample-preparation methods employed in this study are essentially those used by the Oklahoma Geological Survey. Ten grams of each sample were placed in polyethylene beakers and covered with 52-percent hydrofluoric acid for 24 hours. These samples were washed in distilled water 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 4 to 6 hours and the residues were again washed until free of acid. They were then treated with a saturated solution of potassium carbonate for 5 to 10 minutes, and the maceration progress of each sample was checked carefully during this time. The potassium carbonate was neutralized and eventually removed by washing with distilled water. Fossil palynomorphs were stained with Safranin O. Approximately twenty slides of each sample were prepared from a mechanically concentrated fossil preparation 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. 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 Oklahoma palynological collection (OPC) section, sample, slide, and ring numbers. The selected specimens were photographed with a Leitz Ortholux microscope and Orthomat camera using 35-mm Adox KB-14 film. All specimens illustrated in this report and the samples from which they were obtained are in the palynological collection of the Oklahoma Geological Survey.

DESCRIPTIVE PALYNOLOGY

The taxonomic system used in this paper employs as a guide the works of R. Potonié (1956, 1958, 1960). 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 relative abundance of each fossil species, expressed in the text as rare, uncommon, common, and abundant, is based upon a count of 200 specimens from each sample. The following scale is an approximate indication of the percentages indicated by the above terms.

Rare	less than 2.6 percent
Uncommon	2.6-5.5 percent
Common	5.6-9.8 percent
Abundant	more than 9.9 percent

SPORAE DISPERSAE

Anteturma SPORITES H. Potonié, 1893

Fungus Spore Type A
Pl. 1, fig. 1

Description. Spores inaperturate, occurring in clusters or as individuals; cell wall 0.5 micron thick, smooth, ovoid; over-all dimensions 15.0 to 21.0 microns.

Occurrence. Uncommon. Fungus spore type A occurs in most levels of the Red Branch sediments.

Illustration. Specimen OPC 843 F-5-2.

Fungus Spore Type B
Pl. 1, fig. 2

Description. Spore chain two or more septate, bilateral; spores inaperturate, 3 to 4 in number; over-all length of chain 27.5 to 30.0 microns; average spore diameter approximately 15.0 microns; spore walls 1.0 to 1.25 microns thick, smooth.

Occurrence. Rare. This spore type was recovered from several levels in section OPC 843.

Affinity. This spore chain closely resembles that of modern *Brachysporium* (Fungi imperfecti). *Brachysporium* is saprophytic on wood and bark.

Illustration. Specimen OPC 843 H-6-1.

Fungus Spore Type C
Pl. 1, fig. 3

Description. Spores circular to ovoid in polar view; exine 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.

Occurrence. Spores referred to fungus spore type C were not counted in the assemblage counts of the Red Branch sediments.

Affinity. Unknown.

Illustration. Specimen OPC 845 I-2-1.

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

Subturma AZONOTRILETES Luber, 1935

Infraturma LAEVIGATI (Bennie and Kidston, 1886) emend. R. Potonié and Kremp, 1954.

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

Type species: *Deltoidospora hallii* Miner, 1935 (p. 618; pl. 24, figs. 7-8).

Deltoidospora hallii Miner, 1935
Pl. 1, figs. 4a,b

Occurrence. Abundant. In levels A, C, K, and D of section OPC 842 this species amounts to less than 2.0 percent of the total assemblage count. In all other levels it is well represented, occurring in greatest abundance in sections OPC 822 and OPC 845. This species is an important element of the Red Branch flora.

Distribution. Deltoidospora hallii was described from the Cretaceous Kootenai Formation of Montana by Miner (1935). Brenner (1963) reported it from the Cretaceous Potomac Group of Maryland. *Deltoidospora hallii* was recovered from the Lower Cretaceous of Canada by Singh (1964) and from the Upper Cretaceous Vermejo Formation of Colorado by Clarke (1963). It has been reported from the pre-Selma Cretaceous of Alabama by Leopold and Pakiser (1964).

Affinity. Miner (1935) reported *Deltoidospora hallii* to be closely related to the Mesozoic fern genera *Gleichenites, Gleicheniopsis,* and *Laccopteris.* The spore is treated here as a member of the family Gleicheniaceae.

Illustrations. Specimens OPC 845 F-3-3, OPC 845 F-5-1.

Genus **SPHAGNUMSPORITES** Raatz, 1937

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

1934 *Sporites stereoides* R. Potonié and Venitz (p. 11; pl. 1, fig. 4).
1956 *Sphagnumsporites stereoides* (R. Potonié and Venitz, 1934) R. Potonié (p. 17).

Sphagnumsporites psilatus (Ross, 1949) Couper, 1958
Pl. 1, fig. 5

1949 *Trilites psilatus* Ross (p. 32; pl. 1, fig. 12).
1958 *Sphagnumsporites psilatus* (Ross, 1949) Couper (p. 131; pl. 15, figs. 1-2).

Occurrence. Uncommon. Specimens referred to *Sphagnumsporites 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.

Distribution. Ross (1949) described this fossil species from the Upper Cretaceous of Sweden. Couper (1958) recovered specimens of *S. psilatus* from the Jurassic and Lower Cretaceous of Britain. In 1961, Groot, Penny, and Groot reported this species from the Upper Cretaceous Magothy Formation of Maryland. *Sphagnumsporites psilatus* was recovered from the Lower Cretaceous of Canada by Singh (1964). Clarke (1963) reported *S.* cf. *S. psilatus* from the Upper Cretaceous Vermejo Formation of Colorado.

Affinity. Sphagnumsporites psilatus is undoubtedly the spore of a Mesozoic *Sphagnum.*

Illustration. Specimen OPC 844 J-28-1.

Genus **CYATHIDITES** Couper, 1953

Type species: *Cyathidites australis* Couper, 1953 (p. 27; pl. 2, figs. 11-12).

Cyathidites australis Couper, 1953
Pl. 1, fig. 12

Occurrence. Uncommon. *Cyathidites australis* has a restricted occurrence throughout the Red Branch sediments, appearing in 25 of the 56 productive samples as a minor element of the palynological assemblage. In these samples it nowhere occurs in excess of 5.5 percent of the total assemblage count.

Distribution. Couper (1953, 1958) reported *Cyathidites australis* from the Jurassic and Lower Cretaceous of Britain and Australasia. Dettmann (1963) recovered this species from the Upper Mesozoic of southeastern Australia. It was reported from the Lower Cretaceous Mannville Group of Canada by Singh (1964).

Affinity. The spores referred to here as *Cyathidites australis* were reported by Couper (1953) as having both cyatheaceous and dicksoniaceous affinities.

Illustration. Specimen OPC 843 E-2-3.

Cyathidites punctatus (Delcourt and Sprumont, 1955) Delcourt, Dettmann, and Hughes, 1963
Pl. 2, figs. 3a,b

1955 *Concavisporites punctatus* Delcourt and Sprumont (p. 25; pl. 1, fig. 8; pl. 2, fig. 2).
1955 *Concavisporites baldurnensis* Delcourt and Sprumont (p. 24; pl. 1, fig. 7).
1955 *Cingulatisporites cavus* Delcourt and Sprumont (p. 38; fig. 8).
1963 *Cyathidites punctatus* (Delcourt and Sprumont, 1955) Delcourt, Dettmann, and Hughes (p. 283; pl. 42, figs. 1-4).

Occurrence. Uncommon. *Cyathidites punctatus* 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.

Distribution. This species was described from the Wealden of Belgium (Delcourt and Sprumont, 1955). Couper (1958) reported it as *Concavisporites punctatus* from the British Wealden and Aptain. Dettmann (1963) recovered this species from the Upper Mesozoic of southeastern Australia. *Cyathidites punctatus* was reported by Brenner (1963) from the Potomac Group of Maryland and by Leopold and Pakiser (1964) from the pre-Selma of Alabama. This species has been reported from the Lower Cretaceous of Canada by Pocock (1962) and by Singh (1964).

Affinity. Delcourt and Sprumont (1955) suggested a gleicheniaceous affinity for this species, but Couper (1958) believed *Concavisporites punctatus* to be more closely related to the families Cyatheaceae and Dicksoniaceae. Bolkhovitina (1961) described a closely similar form, *Lygodium asper*. Spores referred to *Cyathidites punctatus* are most likely related to the schizaeaceous genus *Lygodium*, and are here treated as such.

Illustrations. Specimens OPC 843 H-4-1 and OPC 843 H-6-2b.

Cyathidites minor Couper, 1953
Pl. 2, fig. 2

Occurrence. Common. Fossil spores referred to *Cyathidites minor* were recovered from most Red Branch samples. This species is represented by 21.0 percent of the total assemblage in sample OPC 842 E.

Distribution. Couper (1953, 1958) has reported this species from the Jurassic and Lower Cretaceous of New Zealand and England. Balme (1957) and Dettmann (1963) recovered *Cyathidites minor* from the Upper Mesozoic of Australia. In Canada, this species has been reported from the Lower Cretaceous by Singh (1964) and from the Jurassic through Upper Cretaceous by Pocock (1962). Brenner (1963) recovered *C. minor* from the Cretaceous Potomac Group of Maryland. It has been reported from the Upper Cretaceous Tuscaloosa Formation of the Atlantic Coast by Groot, Penny, and Groot (1961).

Affinity. Cyathidites minor was probably derived from a Mesozoic *Lygodium,* being similar in shape and possessing a trilete ray character similar to that of *C. punctatus.*

Illustration. Specimen OPC 845 I-14-1.

Genus **CONCAVISPORITES** Pflug, 1953

Type species: *Concavisporites rugulatus* Pflug, 1953 (p. 49; pl. 1, figs. 22-23).

Concavisporites subgranulosus Couper, 1958
Pl. 1, fig. 10

Remarks. The Red Branch specimens of this species are somewhat larger than those reported by Couper (1958), the size range being 42.5 to 50.0 microns. This difference in size may be due in part to the fact that Couper's specimens were not well preserved.

Occurrence. Rare. Specimens of *Concavisporites subgranulosus* are restricted to four levels of Red Branch shales and nowhere amount to more than 1.5 percent of the total assemblage count.

Distribution. Concavisporites subgranulosus was described by Couper (1958) from the lower Liassic and Middle Jurassic of Britain.

Affinity. Fossil spores referred to this species closely resemble the spores of the modern tree fern *Cyathea dealbata,* which occurs in forests from sea level to 2,500 feet in New Zealand (Harris, 1955).

Illustration. Specimen OPC 845 A-13-1.

Concavisporites cf. **C. jurienensis** Balme, 1957
Pl. 1, figs. 11a,b

Occurrence. Uncommon. Specimens of *Concavisporites* cf. *C. jurienensis* are well preserved and occur in five sections of the Red Branch sediments. They nowhere make up more than 5.0 percent of the total assemblage count of any level.

Distribution. Balme (1957) described this species from the Lower Jurassic of western Australia. Pflug (1953) described a similar form, *Concavisporites rugulatus*, from the Paleocene of Hannover which differs from Balme's species in having strongly concave sides. *Concavisporites* cf. *C. jurienensis* has been reported as *Concavisporites* type E by Saad (1963) from the Jurassic of the Sinai region.

Affinity. Probably related to the Gleicheniaceae.

Illustrations. Specimens OPC 821 A-5-1 and OPC 821 A-1-1.

Concavisporites sp.
Pl. 1, fig. 9

Description. Spores trilete, radial; laesurae long, extending to equator, bordered by arcuate thickenings; equatorial contour trilobate, sides strongly concave; spore wall approximately 1.0 micron thick, smooth; diameter ranges from 15.0 to 17.5 microns.

Occurrence. Rare. Five specimens of *Concavisporites* sp. were observed during assemblage counts, and only one specimen was properly oriented for study. For this reason, *Concavisporites* sp. is not named in this report.

Affinity. Not known.

Illustration. Specimen OPC 844 K-21-6.

Genus **MATONISPORITES** Couper, 1958

Type species: *Matonisporites phlebopteroides* Couper, 1958 (p. 140; pl. 20, figs. 15-17).

Matonisporites cf. **M. equiexinus** Couper, 1958
Pl. 2, fig. 4

Occurrence. Uncommon. This species was recovered from 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.

Distribution. Couper (1958) described the species from the Jurassic and Lower Cretaceous of Britain.

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

Illustration. Specimen OPC 844 I-10-4.

Matonisporites impensus, new species
Pl. 2, figs. 1a,b

Description. Spores trilete, laesurae 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 spores 4.5 to 5.0 microns thick, smooth. Diameter ranges from 57.5 to 76.0 microns.

Holotype. Specimen OPC 845 I-14-2. Over-all dimensions 75.0 by 71.5 by 69.5 microns.

Remarks. Matonisporites impensus, new species, differs from *Matonisporites equiexinus* Couper, 1958, in its larger size and thicker spore wall. The specific name refers to the large size of this form.

Occurrence. Rare. This fossil species was observed in sections OPC 824 and OPC 845.

Affinity. Matonisporites impensus, new species, is similar to spores of the modern fern genus *Lygodium.*

Illustrations. Specimens OPC 845 I-14-2 and OPC 845 F-1, 54.5 x 113.4.

Genus **CALAMOSPORA** Schopf, Wilson, and Bentall, 1944

Type species: *Calamospora hartungiana* Schopf, 1944, *in* Schopf, Wilson, and Bentall (p. 51-52; fig. 1).

Calamospora cf. **C. mesozoica** Couper, 1958
Pl. 2, fig. 5

Occurrence. Rare. Spores referred to *Calamospora* cf. *C. mesozoica* occur in most levels. This form is persistent, but in no case amounts to more than 4.0 percent of the total assemblage count of any level.

Distribution. Couper (1958) described this species from the Lower and Middle Jurassic of Great Britain. Clarke (1963) reported *C. mesozoica* from the Upper Cretaceous Vermejo Formation of Colorado.

Affinity. *Calamospora* is a Paleozoic genus in which is placed spores of probable calamarian affinities (Schopf, Wilson, and Bentall, 1944). Couper (1958) related *Calamospora mesozoica* to *Neocalamites nathorsti* Erdtman.

Illustration. Specimen OPC 844 H-25-9.

Genus **TODISPORITES** Couper, 1958

Type species: *Todisporites major* Couper, 1958 (p. 134; pl. 16, fig. 6).

Todisporites minor Couper, 1958
Pl. 2, fig. 6

Occurrence. Rare. Fossil spores referred to *Todisporites minor* were recovered from most Red Branch samples, but in no case exceeded 1.0 percent of the total assemblage count.

Distribution. Couper (1958) described *Todisporites minor* from the Jurassic of Great Britain. Pocock (1962) and Singh (1964) reported it from the Jurassic and Lower Cretaceous of Canada. Brenner (1963) found this species in the Cretaceous Potomac Group of Maryland. Clarke (1963) recovered *T. minor* from the Upper Cretaceous Vermejo Formation of Colorado.

Affinity. *Todisporites* minor is comparable to the spores of the osmundaceous fern, *Todea*.

Illustration. Specimen OPC 844 K-21-3.

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

Genus **TRILITES** (Cookson, 1947) Couper, 1953

Type species: *Trilites tuberculiformis* Cookson, 1947 (p. 136; pl. 16, figs. 61, 62).

Trilites sp.
Pl. 2, fig. 8

Description. Spores trilete, laesurae 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 ranges from 23.0 to 25.0 microns.

Occurrence. Rare. Only three specimens of this fossil spore were observed and, although it is a distinctive type, it is not named here.

Affinity. Probably filicalean.

Illustration. Specimen OPC 845 H-12-3.

Genus **OSMUNDACIDITES** Couper, 1953

Type species: *Osmundacidites wellmanii* Couper, 1953 (p. 20, pl. 1, fig. 5).

Osmundacidites wellmanii Couper, 1953
Pl. 2, fig. 7

Occurrence. Uncommon. Fossil spores referred to *Osmundacidites 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 count. It is most abundant in sections OPC 842, OPC 843, and OPC 844.

Distribution. Couper (1953) reported this species as ranging from the Jurassic to the Lower Cretaceous. Dettmann (1963) recovered *O. wellmanii* from the Upper Mesozoic of southeastern Australia. This species was reported from the Lower Cretaceous of Canada by Singh (1964) and from the Upper Cretaceous Vermejo Formation of Colorado by Clarke (1963). *Osmundacidites wellmanii* Couper, 1953, is strikingly similar to *Conosmundasporites* Klaus, 1960, from the Alpine Triassic.

Affinity. Spores referred to *Osmundacidites wellmanii* Couper, 1953, closely resemble those of two modern osmundaceous ferns, *Todea* and *Leptopteris*. The papillae of *Todea* are longer than those of *Leptopteris*, but otherwise these two modern spore genera are morphologically similar. The ornamentation of *Osmundacidites wellmanii* is gradational between large granules and true papillae, the papillate forms being the more common.

Illustration. Specimen OPC 844 J-2-2.

Osmundacidites cf. **O. comaumensis** (Cookson, 1953) Cookson and Dettmann, 1958
Pl. 2, fig. 9

1953 *Trilites comaumensis* Cookson (p. 470; pl. 2, figs. 27, 28).
1956 *Baculatisporites comaumensis* (Cookson, 1953) R. Potonié (p. 33).
1958 *Osmundacidites comaumensis* (Cookson, 1953) Cookson and Dettmann, (p. 100-101).

Occurrence. Rare. Specimens of *Osmundacidites* cf. *O. comaumensis* occur only in three levels of the Red Branch sediments in insignificant amounts.

Distribution. Cookson (1953) described this species from the "Pre-tertiary" Comaum clays of Australia. Cookson and Dettmann (1958) recovered it from the Lower Cretaceous of Australia. Dettmann (1963) reported *O. comaumensis* from the Upper Mesozoic of Australia.

Affinity. Fossil spores referred to *Osmundacidites* cf. *O. comaumensis* resemble those of the modern Osmundaceae.

Illustration. Specimen OPC 844 D-1-3.

Subturma PYROBOLOTRILETES R. Potonié, 1956

Genus **BALMEISPORITES** Cookson and Dettmann, 1958

Type species: *Balmeisporites holodictyus* Cookson and Dettmann, 1958 (p. 42; pl. 2, fig. 1).

Balmeisporites glenelgensis Cookson and Dettmann, 1958
Pl. 5, figs. 1a,b

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

Distribution. Cookson and Dettmann (1958) reported *Balmeisporites glenelgensis* from the Upper Cretaceous sediments of Victoria, Australia.

Affinity. Not known.

Illustrations. Specimens OPC 844 J-20-1 and OPC 843 I-4-1.

Turma ZONALES (Bennie and Kidston, 1886) R. Potonié, 1956

Subturma AURITOTRILETES R. Potonié and Kremp, 1954

Infraturma AURICULATI R. Potonié and Kremp, 1954

Genus **APPENDICISPORITES** Weyland and Krieger, 1953

Type species: *Appendicisporites tricuspidatus* Weyland and Greifeld; 1953 (p. 42; pl. 11, fig. 54).

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

Appendicisporites tricornitatus Weyland and Greifeld, 1953
Pl. 4, figs. 4a,b

Occurrence. Uncommon. Fossil spores referred to *Appendicisporites tricornitatus* occur in percentages ranging from 0.5 to 12.5 percent of the total assemblage count.

Distribution. Weyland and Greifeld (1953) described this species from the lower Senonian of Germany. Delcourt and Sprumont (1955) reported *A. tricornitatus* from the Wealden of Belgium. In 1958, Couper recorded the fossil spore from the Wealden and Aptian sediments of Britain. Singh (1964) reported it from the Lower Cretaceous Mannville Formation of Canada. Groot and Penny (1960) and Brenner (1963) recovered this species from the Lower Cretaceous sediments of the Atlantic Coastal Plain. Groot, Penny, and Groot (1961) extended the range of *A. tricornitatus* to the Upper Cretaceous in the same area. The species has been reported from the Upper Cretaceous Vermejo Formation of Colorado (Clarke, 1963).

Affinity. These fossil spores are similar to the spores of *Anemia tomentosa.*

Illustrations. Specimens OPC 843 H-6-2a and OPC 844 K-6-2.

Appendicisporites undosus, new species
Pl. 4, figs. 2a,b

Description. Spores trilete, laesurae approximately three-fourths radius of spore, commissures indistinct; equatorial contour rounded-triangular, sides convex; ornamentation consists of undulose ribs parallel to equator on proximal and distal faces; ribs extend beyond equator in apical areas forming tapering appendages with rounded ends approximately 6.0 microns wide and 6.0 to 10.0 microns long; ribs 4.0 microns to 6.0 microns wide, approximately 2.0 microns apart. Dimensions range from 45.0 to 62.0 microns.

Holotype. Specimen OPC 843 H-1-2. Over-all dimensions 60.0 microns.

Occurrence. Uncommon. This species was recovered from most Red Branch samples.

Affinity. This species is similar to the spores of modern *Anemia.*

Illustrations. Specimens OPC 843 H-1-2 and OPC 843 I-1, 56.6 x 120.

Spore Type A
Pl. 4, fig. 3

Description. Spore trilete, radial; laesurae approximately three-fourths radius of spore, simple, bordered by thin area where sexine is absent; equatorial contour rounded-triangular, sides convex; spore wall smooth, 1.0 micron thick; apical areas with rounded appendages approximately 8.0 microns long. Diameter of spore 46.0 microns including appendages.

Occurrence. Rare. One specimen of spore type A was recovered from sample OPC 843 A.

Affinity. Spore type A is probably related to the family Schizaeaceae.

Illustration. Specimen OPC 843 A-2, 50.5 x 114.8.

Subturma ZONOTRILETES Waltz, 1935

Infraturma CINGULATI R. Potonié and Klaus, 1954

Genus **CINGULATISPORITES** Thomson, in Thomson and Pflug, 1953

Type species: *Cingulatisporites levispeciosus* Pflug, 1953, *in* Thomson and Pflug, 1953 (p. 58; pl. 1, fig. 16).

Cingulatisporites cf. **C. levispeciosus** Pflug, 1953
Pl. 1, fig. 6

Occurrence. Rare. *Cingulatisporites* cf. *C. levispeciosus* in no case amounts to more than 2.3 percent of the total assemblage count of the seven levels in which it is found.

Distribution. Thomson and Pflug (1953) reported this species from Hannover, ranging from the Danian (?) to the Paleocene. Clarke (1963) recorded an occurrence of *Cingulatisporites* cf. *C. levispeciosus* in the Vermejo Formation of Colorado. In 1961, Pierce described a similar form from the Upper Cretaceous of Minnesota, which he named *Cingutriletes densocingulatus.*

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

Illustration. Specimen OPC 845 I-17-2.

Genus **GLEICHENIIDITES** (Ross, 1949) Delcourt and Sprumont, 1955

Type species: *Gleicheniidites senonicus* (Ross, 1949) Delcourt and Sprumont, 1955.

1949 *Gleicheniidites senonicus* Ross (p. 31; pl. 1, figs. 3, 4).
1955 *Gleicheniidites senonicus* (Ross, 1949) Delcourt and Sprumont (p. 26).

Gleicheniidites senonicus (Ross, 1949) Delcourt and Sprumont, 1955
Pl. 1, fig. 7

Occurrence. Uncommon. This species was recovered from all samples of Red Branch sediments.

Distribution. Ross (1949) described *G. senonicus* from the Cretaceous of Scania. It has been reported from the Wealden by Delcourt and Sprumont (1955). Singh (1964) recovered this species from the Lower Cretaceous Mannville Group of Canada. *Glei-*

cheniidites senonicus was reported from the Cretaceous Potomac Group of Maryland by Brenner (1963). Pierce (1961) described a similar form, *Cingutriletes interruptus,* from the Upper Cretaceous of Minnesota.

Affinity. Fossil spores referred to *Gleicheniidites senonicus* are similar to spores of the family Gleicheniaceae.

Illustration. Specimen OPC 845 J-20, 60.9 x 114.9.

Gleicheniidites confossus, new species
Pl. 1, figs. 8a-c

Description. Spores trilete, laesurae long, reaching to equator; kyrtome distinct, equatorial contour triangular, sides straight to concave; spore wall 1.0 to 1.5 microns thick, pitted; pits less than 1.0 micron wide. Diameter ranges from 25.0 to 42.0 microns.

Holotype. Specimen OPC 843 E-2-4. Over-all dimensions 32.4 by 33.5 microns.

Remarks. This species differs from *G. senonicus* (Ross, 1949) Delcourt and Sprumont, 1955, in its typical pitted ornamentation. The specific name refers to the pitted spore wall.

Occurrence. Abundant. *Gleicheniidites confossus,* new species, is a persistently abundant fossil in the population counts of the Red Branch sediments. 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 confossus* are smaller than those of most living species of *Gleichenia* but otherwise resemble them closely.

Illustrations. Specimens OPC 843 E-2-4, OPC 843 H-7-1, and OPC 845 J-3, 44.1 x 113.1.

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 (p. 12; pl. 3, fig. 27).

1956 *Camarozonosporites* (*Rotaspora*) *cretaceus* (Weyland and Krieger, 1953) R. Potonié (p. 65).

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

Camarozonosporites rudis (Leschik, 1955) Klaus, 1960
Pl. 3, figs. 3a,b

1955 *Verrucosisporites rudis* Leschik (p. 15; pl. 1, fig. 15).

1960 *Camarozonosporites rudis* (Leschik, 1955) Klaus (p. 136; pl. 29, figs. 12, 14).

Occurrence. Uncommon. Spores referred to *Camarozonosporites rudis* have restricted occurrences in the Red Branch sediments. This species is most abundant in levels A, B, and C of section OPC 844, where it amounts to 11.8 percent of the total assemblage. In all other levels in which this species occurs, it amounts to less than 5.0 percent of the total assemblage.

Distribution. Leschik (1955) described this species from the Keuper of Switzerland. Klaus (1960) has recorded *C. rudis* from the Middle Keuper of the same area. It was reported from the Upper Cretaceous of Colorado by Clarke (1963). In 1961, Pierce described a similar species as *Rugutriletes rugosus* from the Upper Cretaceous of Minnesota.

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

Illustrations. Specimens OPC 824 E-1-1 and OPC 844 H-12-2.

Infraturma Murornati R. Potonié and Kremp, 1954

Genus **LYCOPODIACIDITES** Couper, 1953

Type species: *Lycopodiacidites bullerensis* Couper, 1953 (p. 26; pl. 1, fig. 9).

Lycopodiacidites cf. L. kuepperi Klaus, 1960
Pl. 3, figs. 4a,b

Occurrence. Rare. *Lycopodiacidites* cf. *L. keupperi* amounts to less than 1.0 percent of the total assemblage count of five levels and is present as a trace element in four other levels.

Distribution. Klaus (1960) described this species from the Alpine Triassic sediments. Clarke (1963) reported *L.* cf. *L. kuepperi* from the Upper Cretaceous Vermejo Formation of Colorado. Pierce (1961) described a similar form, *Rugutriletes regularis,* from the Upper Cretaceous of Minnesota.

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. kuepperi* is similar to the spores of *Lycopodium cernuum* in sculpture pattern.

Illustration. Specimen OPC 844 K-12-1.

Lycopodiacidites arcuatus, new species
Pl. 3, figs. 2a,b

Description. Spores trilete, laesurae long, approximately three-fourths radius of spore, commissures raised; equatorial contour rounded to rounded-triangular, sides convex; spore wall 1.5 to 2.0 microns thick; proximal face smooth, distal face rugulate with rugulae extending proximally at the ends of the trilete laesurae in an arcuate manner. Diameter ranges from 42.5 to 52.5 microns.

Holotype. Specimen OPC 844 K-21-4. Over-all dimensions 43.2 by 45.4 microns.

Remarks. The specific name is in reference to the arcuate proximal extension of the rugulate ornamentation at the ends of the trilete laesurae.

Occurrence. Rare. Fossil spores referred to *L. arcuatus* are restricted to five levels of Red Branch sediments. They are nowhere represented by more than 1.0 percent of the total assemblage count of the five levels in which they occur.

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

Illustrations. Specimens OPC 844 K-11-5 and OPC 844 K-21-4.

Genus **CICATRICOSISPORITES** R. Potonié and Gelletich, 1933

Type species: *Cicatricosisporites dorogensis* R. Potonié and Gelletich, 1933 (p. 522; pl. 1, figs. 1-5).

1951b *Mohriosporites dorogensis* R. Potonié (p. 114; pl. 20, fig. 14).
1953 *Mohriosporites australiensis* Cookson (p. 470: pl. 2. figs. 31-34).
1956 *Cicatricosisporites australiensis* (Cookson, 1953) R. Potonié (p. 48).

Cicatricosisporites dorogensis R. Potonié and Gelletich, 1933
Pl. 3, figs. 5a,b

Occurrence. Common. Spores referred to *Cicatricosisporites dorogensis* 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 count. The absence of this spore type in section OPC 822 is perhaps a result of weathering.

Distribution. Potonié and Gelletich (1933) described *C. dorogensis* from the Upper Paleocene through the Eocene in the Dorog basin of Hungary. R. Potonié (1934b) found this form in the Eocene sediments of Geiseltal and in 1951 established its range 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 Britain. It has been reported from the Upper Jurassic and Lower Cretaceous of Canada by Pocock (1962) and Singh (1964). Groot and Penny (1960) and Brenner (1963) found this form in the Lower Cretaceous of the Atlantic Coastal Plain, and in 1961, Groot, Penny, and Groot recovered it from Upper Cretaceous sediments in the same area. Clarke (1963) recorded the presence of this species in the Upper Cretaceous Vermejo Formation of Colorado. Leopold and Pakiser (1964) reported *C. dorogensis* from the pre-Selma of Alabama.

Affinity. *Cicatricosisporites dorogensis* is a fossil spore with definite schizaeaceous affinities. It closely resembles several species of *Mohria* as illustrated by Bolkhovitina (1959). Couper (1958) noted the similarity of *C. dorogensis* to the Wealden species *Ruffordia goepperti* (Dunk.) Seward and to the Eocene species *Anemia colwellensis* Chandler.

Illustrations. Specimens OPC 843 H-6-1 and OPC 843 H-2-1.

Cicatricosisporites crassiterminatus, new species
Pl. 4, figs. 1a-c

Description. Spores trilete, laesurae 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 at places, from 2.5 to 3.0 microns wide and spaced from 1.0 to 2.0 microns apart, forming an irregularly ribbed pattern. Diameter ranges from 37.5 to 60.0 microns.

Holotype. Specimen OPC 843 A-5-2. Over-all dimensions 56.2 microns.

Remarks. The specific name refers to the thickened exine at the trilete apices.

Occurrence. Rare. Fossil spores referred to *Cicatricosisporites crassiterminatus*, new species, nowhere amount to more than 2.0 percent of the total assemblage count of any level.

Affinity. This fossil spore has schizaeaceous affinities, somewhat resembling the spores of modern *Anemia.*

Illustrations. Specimens OPC 843 A-5-2, OPC 843 A-3-2, and OPC 843 A-2-1.

Genus **LYCOPODIUMSPORITES** Thiergart, 1938

Type species: *Lycopodiumsporites agathoecus* (R. Potonié, 1934) Thiergart, 1938.

1934 *Sporites agathoecus* R. Potonié (p. 43; pl. 1, fig. 25).
1938 *Lycopodiumsporites agathoecus* (R. Potonié, 1934) Thiergart (p. 293; pl. 22, figs. 9, 10).

Lycopodiumsporites crassimacerius, new species
Pl. 3, figs. 1a-c

Description. Spores trilete, radial; laesurae approximately three-fourths radius of spore; commissures slightly raised and bordered by a small margo which is not always present; equatorial contour rounded-triangular, sides convex; spore wall 2.0 to 4.0 microns thick; proximal surface smooth; distal surface sculptured with a polygonal reticulum which extends onto proximal surface at ends of trilete laesurae; muri of reticulum 4.0 to 5.0 microns high, 2.0 to 3.0 microns wide, simple; lumina of reticulum 6.0 to 7.0 microns wide. Diameter of spore ranges from 45.0 to 67.5 microns.

Holotype. Specimen OPC 842 E-4-2. Diameter 62.6 by 63.7 microns.

Remarks. The specific name *crassimacerius* refers to the thick spore wall.

Occurrence. Uncommon. Spores referred to *Lycopodiumsporites crassimacerius*, new species, have been observed in 4 of the 61 productive Red Branch samples in amounts less than 2.0 percent of the total assemblage count. In two other levels, D and E of section OPC 842, it amounts to more than 5.0 percent of the total assemblage count.

Distribution. Singh (1964) reported a somewhat similar form, *Lycopodiumsporites* sp. A, from the Aptian to middle Albian of Alberta.

Affinity. This species probably has lycopodiaceous affinities, even though the author knows of no modern lycopods with such a thick spore wall and coarse reticulum.

Illustrations. Specimens OPC 842 E-4-2 and OPC 842 D-1-2.

Turma MONOLETES Ibrahim, 1933

Subturma AZONOMONOLETES Luber, 1935

Genus **LAEVIGATOSPORITES** (Ibrahim, 1933) emend. Schopf, Wilson, and Bentall, 1944

Type species: *Laevigatosporites vulgaris* (Ibrahim, 1932) Ibrahim, 1933.

1932 *Sporonites vulgaris* Ibrahim *in* R. Potonié, Ibrahim, and Loose (p. 448; pl. 15, fig. 16).
1933 *Laevigatosporites vulgaris* (Ibrahim, 1932) Ibrahim (p. 39-40; pl. 2, fig. 16; pl. 5, figs. 37, 39).
1944 *Laevigatosporites* (Ibrahim, 1933) Schopf, Wilson, and Bentall (p. 36-37; pl. 1, figs. 5-5b).

Laevigatosporites ovatus Wilson and Webster, 1946
Pl. 5, figs. 2a,b

Occurrence. Uncommon. *Laevigatosporites 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.

Distribution. Wilson and Webster (1946) described this species from the Paleocene Fort Union coal of Montana. It has been reported from the Upper Mesozoic of Australia by Dettmann (1963) and from the Lower Cretaceous of Canada by Singh (1964). Clarke (1963) recorded *L. ovatus* from the Upper Cretaceous Vermejo Formation of Colorado.

Affinity. Laevigatosporites ovatus is probably the spore of a fossil schizaeaceous fern. It resembles the spores of the extant genus *Schizaea.*

Illustrations. Specimens OPC 843 E-9-1 and OPC 845 F-1-3.

Laevigatosporites irroratus, new species
Pl. 5, figs. 4a,b

Description. Spores bilateral, monolete; normally bean-shaped in profile, oval in equatorial view; monolete mark simple, approximately one-half the diameter; spore wall thin, 1.0 to 1.5 microns, surface finely granulose. The length ranges from 45.0 to 50.0 microns and the width from 20.0 to 30.0 microns.

Holotype. Specimen OPC 842 E-10-2. Over-all dimensions 47.5 by 22.5 microns.

Remarks. The specific name *irroratus* refers to the granulose spore wall.

Occurrence. Rare. *Laevigatosporites irroratus* in no case amounts to more than 1.5 percent of the total assemblage count of any level.

Affinity. Fossil spores referred to *Laevigatosporites irroratus,* new species, are similar to the spores of the modern genus *Psilotum.*

Illustrations. Specimens OPC 842 E-10-2 and OPC 845 I-14, 48.4 x 117.6.

Laevigatosporites granaperturus, new species
Pl. 5, fig. 5

Description. 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 ranges from 20.0 to 34.6 microns.

Syntypes. Specimens OPC 843 H-1-1. Three spores illustrated. Over-all dimensions 32.4 microns, 34.6 microns by 27.0 microns.

Remarks. The specific name refers to the granulose ornamentation around the monolete structure.

Occurrence. Rare. Specimens of *Laevigatosporites granaperturus,* new species, occur in 33 levels of Red Branch sediments. This species in no case amounts to more than 3.0 percent of the total assemblage count of any level.

Affinity. Not known.

Illustration. Specimen OPC 843 H-1-1.

Laevigatosporites sp.
Pl. 5, fig. 3

Description. 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. The length ranges from 20.0 to 25.0 microns and the width from 15.0 to 20.0 microns.

Occurrence. Rare. *Laevigatosporites* sp. was not encountered in the assemblage count of any level, but several specimens were observed in level OPC 844 B.

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

Illustration. 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.

1931d *Sporonites alienus* R. Potonié (p. 556, fig. 1).
1953 *Verrucatosporites alienus* (R. Potonié, 1931) Thomson and Pflug (p. 59; pl. 3, fig. 47).

Verrucatosporites pseudoreticulatus, new species
Pl. 5, figs. 7a,b

Description. 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 pseudoreticulum. The length ranges from 50.0 to 60.0 microns and the width from 22.5 to 30.0 microns.

Holotype. Specimen OPC 844 H-24-1. Over-all dimensions 55.1 by 27.0 microns.

Occurrence. Rare. This species occurs in 14 levels in amounts in no case exceeding 2.0 percent of the total assemblage count.

Affinity. Verrucatosporites pseudoreticulatus, new species, is probably the spore of a Mesozoic *Tmesipteris.* It closely resembles the spore of the modern *Tmesipteris tannensis* in size, shape, and ornamentation.

Illustrations. Specimens OPC 844 H-24-1 and OPC 844 H-25-2.

Verrucatosporites sp.
Pl. 5, fig. 8

Description. 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 warts, 1.0 micron high and 1.0 to 3.0 microns wide, forming a weakly developed negative reticulum. Diameter of illustrated specimen 60.0 by 30.0 microns.

Occurrence. Rare. Only two specimens of *Verrucatosporites* sp. were encountered in the Red Branch sediments.

Affinity. These fossil spores resemble the spores of modern polypodiaceous genera, such as *Anarthopteris.*

Illustration. Specimen OPC 824 D-7-2.

Genus **SCHIZAEOISPORITES** R. Potonié, 1951

Type species: *Schizaeoisporites eocaenicus* (Selling, 1944) R. Potonié, 1956.

1934 *Sporites dorogensis* R. Potonié (pl. 1, fig. 22).
1944 *Schizaea eocaenica* Selling (p. 66; pl. 4, fig. 44).
1956 *Schizaeoisporites eocaenicus* R. Potonié (p. 81; pl. 11, fig. 108).

Schizaeoisporites cf. **S. phaseolus** Delcourt and Sprumont, 1955
Pl. 5, fig. 6

Occurrence. Rare. This species occurs in the Red Branch sediments only in levels A and K at section OPC 844. It amounts to 1.0 percent of the total assemblage count in level A. Level K yielded only one specimen.

Distribution. Delcourt and Sprumont (1955) described this species from sediments of Wealden age. Pocock (1962) and Singh (1964) recovered *S. phaseolus* from the Lower Cretaceous Mannville Group of Canada.

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

Illustration. Specimen OPC 844 K-14-1.

Anteturma Pollenites R. Potonié, 1951

Turma Saccites Erdtman, 1947

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

Genus **ARATRISPORITES** Leschik, 1955

Type species: *Aratrisporites parvispinosus* Leschik, 1955 (p. 38; pl. 5, fig. 4).

Aratrisporites monosaccatus, new species
Pl. 6, figs. 4a-c

Description. Pollen grains monosaccate; body and bladder of grains longer than broad; body oval in polar and equatorial views; bladder oval in polar view and boat-shaped in equatorial view; dehiscence mark shaped like a flattened figure eight, passing through the central body as a thin suture, bifurcating near the ends of the central body and blending in a looplike manner with the outer contour of the bladder. Bladder attached both proximally and distally, apparently free at the ends; typical boat-shaped form perhaps caused by the bladder's being pulled against the central body at the ends of the dehiscence apparatus; central body smooth to granulose; bladder rugulose and infrareticulate, about 1.0 micron thick; the width of the central body ranges from 12.5 to 17.5 microns and the length from 22.5 to 27.5 microns; the width of the bladder ranges from 17.5 to 37.5 microns and the length from 30.0 to 42.5 microns.

Holotype. Specimen OPC 842 C-7-3. Central body 23.7 by 12.9 microns; bladder 29.2 by 18.4 microns.

Remarks. Leschik (1955) referred to the genus as an alete spore. Klaus (1960) emended the original diagnosis and described the unusual looplike dehiscence mark, referring to *Aratrisporites* as a zonate monolete microspore. In view of the infrareticulate nature of the "zona," *Aratrisporites monosaccatus,* new species, is here treated as a monosaccate pollen grain.

Occurrence. Common to abundant. *Aratrisporites monosaccatus,* new species, is most abundant in sections OPC 824, OPC 842, and OPC 845.

Affinity. Aratrisporites monosaccatus, new species, is treated here as a gymnospermous pollen grain of uncertain affinities.

Illustrations. Specimens OPC 842 C-7-3 and OPC 842 C-7, 54 x 114.

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 (p. 556; fig. 2).
1934 *Tsugaepollenites* (*Sporonites*) *igniculus* (R. Potonié, 1931) R. Potonié and Venitz (p. 17; pl. 1, fig. 8).

Tsugaepollenites nexosus, new species
Pl. 6, figs. 5a,b

Description. Pollen 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 micron between. Diameter ranges from 50.0 to 50.8 microns.

Holotype. Specimen OPC 843 E-8-6. Diameter 50.8 microns.

Occurrence. Rare. Pollen grains referred to *Tsugaepollenites nexosus,* new species, occur as 0.5 percent of the total assemblage count of only levels A and C of OPC 843. Both levels are within the same coal.

Affinity. Tsugaepollenites nexosus, new species, is morphologically similar to the pollen grains of modern *Tsuga.*

Illustrations. Specimens OPC 843 E-8-6 and OPC 843 E-8-5.

Subturma DISACCITES Cookson, 1947

Genus **PARVISACCITES** Couper, 1958

Type species: *Parvisaccites radiatus* Couper, 1958 (p. 154; pl. 29, figs. 5-8; pl. 30, figs. 1, 2).

Parvisaccites granisaccus, new species
Pl. 6, figs. 6a,b

Description. Pollen grains bisaccate; body of grain subspherical; bladders small in comparison to size of body; body and bladders granular to finely microreticulate; exine 1.0 to 1.5 microns thick; distal furrow prominent. Diameter of body ranges 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.

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

Occurrence. Rare. Specimens referred to *Parvisaccites granisaccus,* new species, occur in three levels of coals and amount to 0.5 percent of the total assemblage count. This species was recovered as a trace element in other levels.

Affinity. Fossil pollen grains assigned to *Parvisaccites granisaccus,* new species, somewhat resemble the grains of the gymnosperm *Phyllocladus.*

Illustrations. Specimens OPC 821 D-14-1 and OPC 824 F-10, 51.9 x 119.1.

Parvisaccites sp.
Pl. 6, fig. 7

Description. 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.

Occurrence. Rare. A single specimen of this pollen type was encountered in level OPC 824 E.

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

Illustration. 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, 1931b (p. 28; pl. 2).

Piceaepollenites cf. **P. alatus** R. Potonié, 1931
Pl. 7, figs. 1a,b

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

Distribution. R. Potonié (1931b, 1951a) 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.*

Illustrations. Specimens OPC 843 H-1-3 and OPC 844 K-21-1.

Genus **ALISPORITES** Daugherty, 1941

Type species: *Alisporites opii* Daugherty, 1941 (p. 98; pl. 34, fig. 2).

Alisporites bilateralis Rouse, 1959
Pl. 7, fig. 3

Occurrence. Rare. This species does not amount to more than 0.5 percent of the total assemblage count of any level.

Distribution. *Alisporites bilateralis* was described from the Lower Cretaceous Kootenai Formation of British Columbia by Rouse (1959). A similar form, *Pteruchipollenites thomasii,* was described by Couper (1958) from the Liassic of Europe. In 1963, Brenner recorded *Alisporites bilateralis* from the Potomac Group of Maryland.

Affinity. *Alisporites bilateralis* is probably related to the family Pinaceae.

Illustration. Specimen OPC 843 A-1-6.

Subturma Podocarpoiditi R. Potonié, Thomson, and Thiergart, 1950

Genus **RUGUBIVESICULITES** Pierce, 1961

Type species: *Rugubivesiculites convolutus* Pierce, 1961 (p. 39-40; pl. 2, fig. 57).

Rugubivesiculites woodbinensis, new species
Pl. 7, figs. 2a,b

Description. Pollen grains bisaccate; body of grain normally spherical; exine of body and proximal cap coarsely reticulate to rugulate; bladders ornamented with a finer reticulation than the body; bladders attached distally as in *Podocarpus,* but generally equal to or not so 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.

Holotype. Specimen OPC 844 J-26-1.

Diameter of body 43.2 microns; length of bladders 44.3 microns, width 29.2 microns.

Occurrence. Rare. Specimens referred to *Rugubivesiculites woodbinensis,* new species, in no case amount to more than 3.0 percent of the total assemblage count of any of the 24 levels in which they occur.

Affinity. Rugubivesiculites woodbinensis, new species, resembles the pollen of the modern tropical to subtropical genus *Dacrydium.* The character of the central body and attachment of the bladders is similar to *Podocarpus,* even though the bladders of this fossil form are not so large as those of the modern genus. These characters suggest that *Rugubivesiculites woodbinensis,* new species, is more closely related to the Podocarpaceae than the Pinaceae.

Illustrations. Specimens OPC 844 J-26-1 and OPC 843 I-1-1.

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 (p. 17; pl. 2, fig. 21).
1953 *Inaperturopollenites (Pollenites magnus dubius) dubius* (R. Potonié and Venitz, 1934) Thomson and Pflug (p. 65; pl. 4, fig. 89; pl. 5, figs. 1-3).

Inaperturopollenites cf. **I. magnus** (R. Potonié, 1934) Thomson and Pflug, 1953

Pl. 7, fig. 4

1931d *Sporonites magnus* R. Potonié (p. 556; fig. 1).
1934b *Pollenites (Sporonites) magnus* (R. Potonié, 1931) R. Potonié (p. 48; pl. 6, fig. 5).
1953 *Inaperturopollenites magnus* (R. Potonié, 1934) Thomson and Pflug (p. 64, 65; pl. 4, figs. 83-88).

Occurrence. Rare. This species occurs in 11 levels of the Red Branch sediments. It in no case amounts to more than 2.0 percent of the total assemblage count in any of these levels.

Distribution. R. Potonié (1931d, 1934b) and Thomson and Pflug (1953) have reported this species from the Tertiary of Germany.

Affinity. The fossil pollen grains reported as *Inaperturopollenites* cf. *I. magnus* are similar to grains of the modern tropical to subtropical Araucariaceae.

Illustration. Specimen OPC 845 F-1-5.

Genus **FOVEOINAPERTURITES** Pierce, 1961

Type species: *Foveoinaperturites foramenif-erus* Pierce, 1961 (p. 43; pl. 3, fig. 71).

Foveoinaperturites cf. **F. forameniferus** Pierce, 1961

Pl. 7, figs. 5a,b

Remarks. Pierce (1961) stated that no difference is discernible between *Foveoinaperturites forameniferus* Pierce and *Punctatisporites quaesitus* Kosanke, 1950. Kosanke's species is most likely the detached operculum from *Vestispora* as described by Wilson and Venkatachala (1963). The author has observed some of these opercula and they differ from the Woodbine specimens here assigned to *Foveoinaperturites* cf. *F. forameniferus.* It is believed that Pierce's illustrated specimen is closely similar to the Woodbine form and not related to *Vestispora.*

Occurrence. Rare. Fossil pollen grains referred to *Foveoinaperturites* cf. *F. foramenif-erus* occur in five coal levels in amounts in no case greater than 1.5 percent of the total assemblage count.

Distribution. Pierce (1961) described this species from the lower Upper Cretaceous of Minnesota.

Affinity. Not known.

Illustrations. Specimens OPC 821 G-10-1 and OPC 822 B-18-1.

Genus **TAXODIACEAEPOLLENITES** Kremp, 1949

Type species: *Taxodiaceaepollenites (Pol-*

lenites) *hiatus* (R. Potonié, 1931) Kremp, 1949.

1931c *Pollenites hiatus* R. Potonié (p. 5; fig. 27).
1933 *Taxodium hiatipites* Wodehouse (p. 493; fig. 17).
1949 *Taxodiaceaepollenites* (*Pollenites*) *hiatus* (R. Potonié, 1931) Kremp (p. 59).

Taxodiaceaepollenites hiatus (R. Potonié, 1931) Kremp, 1949
Pl. 7, fig. 6

Occurrence. Uncommon. This species 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.

Distribution. R. Potonié (1931c, 1934b, 1951a) reported *Taxodiaceaepollenites hiatus* from the Eocene, Oligocene, and Miocene of Germany. Wodehouse (1933) described *Taxodium hiatipites* from the Eocene Green River Formation of Utah and Colorado. In 1960, Kedves recorded it as *Inaperturopollenites hiatus* from the Eocene of the Dorog basin, Hungary. Leopold and Pakiser (1964) reported this species from the pre-Selma of Alabama.

Affinity. *Taxodiaceaepollenites hiatus* is the pollen of *Taxodium.*

Illustration. Specimen OPC 844 H-12-4.

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

Genus **SIMPLICESPORITES** Leschik, 1955

Type species: *Simplicesporites virgatus* Leschik, 1955 (p. 34; pl. 4, fig. 16).

Simplicesporites cf. **S. virgatus** Leschik, 1955
Pl. 8, fig. 1

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

Distribution. Leschik (1955) described this species from the Upper Triassic of Switzerland.

Affinity. Gymnospermous?

Illustration. Specimen OPC 844 E-23-1.

Genus **PERINOPOLLENITES** Couper, 1958

Type species: *Perinopollenites elatoides* Couper, 1958 (p. 152; pl. 27, figs. 9-11).

Perinopollenites cf. **P. elatoides** Couper, 1958
Pl. 9, fig. 5

Occurrence. Uncommon. This fossil species occurs in only eight levels of Red Branch sediments. It in no case amounts to more than 6.5 percent of the total assemblage count of these levels.

Distribution. Couper (1958) described this species from the Jurassic and Lower Cretaceous of England. It has been reported from the Jurassic and Lower Cretaceous of Canada by Pocock (1962) and Singh (1964). Brenner (1963) recorded its occurrence in the Cretaceous Potomac Group of Maryland. Leopold and Pakiser (1964) reported this species from the pre-Selma of Alabama.

Affinity. Couper (1958) stated that this form probably belongs to the taxodiaceous species *Elatides williamsonii.*

Illustration. Specimen OPC 844 D-1-4.

Turma Eupollenites Klaus, 1960

Subturma Operculati Venkatachala and Góczán, 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 (p. 91; pl. 16, figs. 29-31).
1961 *Classopollis classoides* (Pflug, 1953) Pocock and Jansonius (p. 443-444; pl. 1, figs. 1-9).

Remarks. This genus was erected by Pflug (1953) to accommodate "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 nonfunctional reduced trilete scar and the distal pole bears a circular line of weakness (see also Venkatachala and Góczán, 1964). This emendation is regarded as valid in this paper.

Classopollis cf. **C. obidosensis** Groot and Groot, 1962
Pl. 6, figs. 1a,b

Occurrence. Rare. *Classopollis* cf. *C. obidosensis* occurs in 18 levels and in no case exceeds 1.0 percent of the total assemblage count.

Distribution. Groot and Groot (1962) described this species from the Aptian, Albian, and Cenomanian sediments of Portugal.

Affinity. *Classopollis* has been assigned to a number of genera of fossil plants. Hoerhammer (1933) referred *Classopollis* to the Cheirolepidae, 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*. Reissinger (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) 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*. Because 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.

Illustrations. Specimens OPC 844 H-11-1 and OPC 844 J-24-1.

Turma Plicates (Plicata Naumova, 1937, 1939) emend. R. Potonié, 1960

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

Type species: *Eucommiidites troedssonii* Erdtman, 1948 (p. 267-268; text-figs. 5-10, 13-15).

Eucommiidites troedssonii Erdtman, 1948
Pl. 6, fig. 2

Occurrence. Rare. This species was recovered from 14 levels of the Red Branch sediments, occurring as 0.5 percent of the total assemblage counts of 12 levels. In levels A and B of section OPC 845 it amounts to 3.5 and 4.5 percent of the total assemblage count respectively.

Distribution. Erdtman (1948) described *E. troedssonii* from the Jurassic of Scania. It has since been reported from the Wealden (Delcourt and Sprumont, 1956, 1957, 1959), the Lower Liassic (Pons, 1956), the Upper Triassic (Scott, 1960), the Jurassic (Oszast, 1957), the Middle Jurassic (Hughes, 1961; Couper, 1958), the Cretaceous (Rouse, 1959), the Middle and Upper Jurassic and Wealden (Couper, 1958), and the Jurassic and Cretaceous (Pocock, 1962; Singh, 1964). Pierce (1961) reported a similar form (*Psilatricolpites psilatus*) from the Cenomanian of Minnesota. Brenner (1963) recorded this species from the Potomac Group of Maryland.

Affinity. A monosulcate pollen grain related to the Chlamydospermales (?).

Illustration. Specimen OPC 845 I-3-7.

Eucommiidites sp.
Pl. 6, fig. 3

Description. 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 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.

Occurrence. Rare. 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 pollen grain of possible gymnospermous affinity.

Illustration. Specimen OPC 843 H-2-1.

Genus **EPHEDRIPITES** Bolkhovitina, 1953

Type species: *Ephedripites mediolobatus* Bolkhovitina, 1953 (p. 60; pl. 9, fig. 15).

Ephedripites multicostatus Brenner, 1963
Pl. 8, figs. 2a,b

Occurrence. Rare. *Ephedripites multicostatus* is a rare form, occurring in only six levels of the Red Branch sediments. It in no case amounts to more than 1.5 percent of the total assemblage count.

Distribution. Brenner (1963) reported this species from the Cretaceous Potomac Group of Maryland. Leopold and Pakiser (1964) recovered a closely similar form, *Ephedripites* sp., from the pre-Selma of Alabama.

Affinity. This species is probably the pollen grain of *Ephedra.*

Illustrations. Specimens OPC 842 C-7-4 and OPC 821 B-2-1.

Ephedripites ambiguus, new species
Pl. 8, figs. 3a,b

Description. Pollen grains polyplicate; inner body (endexine) ovoid 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.

Holotype. OPC 824 D-7-1. Exine 20.0 by 37.5 microns; central body 15.0 by 20.0 microns.

Occurrence. Rare. Fossil pollen grains referred to *Ephedripites ambiguus,* new species, occur in eight levels of the Red Branch sediments. This species in no case amounts to more than 1.5 percent of the total assemblage count.

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."

Illustrations. Specimens OPC 824 D-7-1 and OPC 824 D-3-1.

Turma Monocolpates Iversen and Troels-Smith, 1950

Genus **PUSTULIPOLLIS,** new genus

Type species: *Pustulipollis ellipticus,* new species.

Diagnosis. Pollen grains prolate, ovate to subspherical; monocolpate; distal colpus narrow (ca. 2.0 microns), expanded slightly at polar ends, more than two-thirds the length of the grain; exine thin, about 0.5 micron, ornamented with irregularly spaced pustules 1.0 to 1.5 microns high and approximately 1.0 micron wide; exine commonly folded and in some cases simulates more than one colpus.

Remarks. Pustulipollis is somewhat similar to *Pistillipollenites* Rouse, but differs by its ovate shape, single colpus, and shape of ornamental elements. *Pistillipollenites* is "circular to broadly triangular, triporate (tricolpate?)" and possesses club-shaped elements of ornamentation (Rouse, 1962).

Affinity. The botanical affinity of *Pustulipollis,* new genus, is uncertain, but it is more than likely angiospermous.

Pustulipollis ellipticus, new species
Pl. 8, figs. 8a,b

Description. Same as for the genus, the length ranges from 15.0 to 18.4 microns and the width from 8.6 to 14.0 microns. The exine of this pollen grain is commonly folded in such a manner as to appear tricolpate.

Holotype. Specimen OPC 844 J-22-1. Total dimensions, 16.2 by 13.0 microns.

Occurrence. Rare. *Pustulipollis ellipticus,* new species, was recovered from five sections of Red Branch sediments. In section OPC 844 this form ranges from 0.5 to 5.5 percent of the total assemblage count of all levels.

Illustrations. Specimens OPC 844 J-22-1 and OPC 844 J-13-3.

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

Genus **MONOSULCITES** Cookson, 1947, ex Couper, 1953

Type species: *Monosulcites minimus* Cookson, 1947 (p. 135; pl. 15, figs. 47-50).

Monosulcites minimus Cookson, 1947
Pl. 8, fig. 5

Occurrence. Rare. *Monosulcites minimus* occurs in only six levels of Red Branch sediments. It in no case amounts to more than 2.0 percent of the total assemblage count.

Distribution. Cookson (1947) described this species from Tertiary lignites of the Kerguelen archipelago. Groot, Penny, and Groot (1961) reported it from the Upper Cretaceous of the Atlantic Coastal Plain. In 1963, Clarke recovered this species from the Upper Cretaceous Vermejo Formation of Colorado.

Affinity. Monosulcites minimus is similar to the pollen of *Ginkgo biloba.*

Illustration. Specimen OPC 821 D-15-1.

Monosulcites cf. **M. carpentieri** Delcourt and Sprumont, 1955
Pl. 8, fig. 4

Occurrence. Rare. Fossil pollen grains referred to *Monosulcites* cf. *M. carpentieri* occur in 17 levels of the Red Branch sediments. They in no case exceed 2.0 percent of the total assemblage count.

Distribution. Delcourt and Sprumont (1955) described this species from the Wealden of Belgium. Clarke (1963) reported it as a rare element in the Upper Cretaceous Vermejo Formation of Colorado.

Affinity. This species is similar to the pollen of *Cycas,* although it is larger than that of most modern species. Couper (1958) compared a closely similar species, *Monosulcites subgranulosus* Couper, 1958, with the pollen of the Bennettitales.

Illustration. Specimen OPC 844 K-7-6.

Monosulcites inspissatus, new species
Pl. 8, figs. 6a,b

Description. Pollen grains monocolpate; bilaterally symmetrical; grains elongate 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 range from 12.5 to 15.0 microns in length and from 7.5 to 12.5 microns in width.

Holotype. Specimen OPC 844 G-6-2. Over-all dimensions 15.0 by 8.6 microns.

Occurrence. Uncommon. *Monosulcites inspissatus,* new species, is a persistent form in the Red Branch sediments. It occurs in amounts as great as 9.0 percent of the total assemblage count.

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

Illustrations. Specimens OPC 844 G-6-2 and OPC 844 G-6, 45.5 x 121.2.

Monosulcites sp.
Pl. 8, fig. 7

Description. Pollen grain monocolpate; bilaterally symmetrical; grain elongate elliptical; colpus extends almost entire length of grain, bordered by two folds approximately 6.0 microns wide; exine about 0.5 micron wide, punctate. Dimensions of single specimen 22.0 by 36.0 microns.

Occurrence. Rare. A single specimen of *Monosulcites* sp. was recovered from section OPC 824.

Affinity. This fossil pollen grain is probably monocotyledonous.

Illustration. Specimen OPC 824 F-4, 46.8 x 127.

Genus **LILIACIDITES** Couper, 1953

Type species: *Liliacidites kaitangensis* Couper, 1953 (p. 56; pl. 7, fig. 97).

Liliacidites cf. **L. variegatus** Couper, 1953
Pl. 8, fig. 9

Occurrence. Uncommon. Fossil pollen grains referred to *Liliacidites* cf. *L. variegatus* were recovered from six sections of Red Branch sediments. This species in no case amounts to more than 6.0 percent of the total assemblage count of any level.

Distribution. Couper (1953) described

this species from the Upper Cretaceous to the Lower Oligocene in New Zealand. Groot, Penny, and Groot (1961) found *L. variegatus* in the Turonian and Lower Senonian sediments of the Atlantic Coastal Plain. In 1961, Pierce reported a similar form, *Retimonocolpites fragilis* Pierce from the Cenomanian of Minnesota.

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

Illustration. Specimen OPC 824 F-10-2.

Liliacidites dividuus (Pierce, 1961) Brenner, 1963
Pl. 8, fig. 10

1961 *Retimonocolpites dividuus* Pierce (p. 47; pl. 3, fig. 87).
1963 *Liliacidites dividuus* (Pierce, 1961) Brenner (p. 93-94; pl. 40, figs. 7-10).

Remarks. This species is commonly encountered partly or entirely without the tectate sexine.

Occurrence. Rare. *Liliacidites dividuus* occurs in most levels, but in none exceeds 3.5 percent of the total assemblage count.

Distribution. Pierce (1961) described this species from the lower Upper Cretaceous of Minnesota. In 1963 Brenner reported it from the Cretaceous Potomac Group of Maryland.

Affinity. Probably monocotyledonous.

Illustration. Specimen OPC 845 J-3-1.

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

Genus **PALMAEPOLLENITES** R. Potonié, 1951

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

1934b *Pollenites tranquillus* R. Potonié (p. 51; pl. 1, figs. 3, 8).
1951b *Palmaepollenites tranquillus* (R. Potonié, 1934) R. Potonié (pl. 20; figs. 31, 31a).

Palmaepollenites cf. **P. tranquillus** (R. Potonié, 1934) R. Potonié, 1951
Pl. 8, figs. 11a,b

Occurrence. Uncommon. Specimens of *Palmaepollenites* cf. *P. tranquillus* were recovered from all levels of the Red Branch sediments. The percentage of this form ranges from 0.5 to 8.0 percent of the total assemblage count.

Distribution. Potonié (1934b) described 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 pollen grains of modern palms.

Illustrations. Specimens OPC 845 F-1-7 and OPC 845 F-18-3.

Palmaepollenites minusculus, new species
Pl. 9, figs. 1a,b

Description. Pollen grains monocolpate; bilaterally symmetrical; grains ovate; colpus extending entire length of grain; exine thin, 0.5 to 1.0 micron, infragranular; width ranges from 10.0 to 15.0 microns and length from 12.0 to 17.5 microns.

Holotype. Specimen OPC 844 K-7-1a. Diameter 12.0 by 15.0 microns.

Occurrence. Uncommon. *Palmaepollenites minusculus,* new species, occurs in most samples in percentages ranging from 0.5 to 9.0 percent.

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

Illustrations. Specimens OPC 844 K-7-1a and OPC 844 K-7-1b.

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

Genus **TRICOLPITES** Cookson, 1947 ex Couper, 1953

Type species: *Tricolpites reticulatus* Cookson, 1947 (p. 134; pl. 15, fig. 45).

Tricolpites cf. **T. reticulatus** Cookson, 1947
Pl. 9, figs. 3a-d

Occurrence. Common. Specimens of *Tricolpites* cf. *T. reticulatus* amount to as much as 38.5 percent of the total assemblage count of level OPC 821 F. In all other levels the percentages range from 0.5 to 35.0 percent.

Distribution. Cookson (1947) described this species from the Tertiary of Kerguelen. Pierce (1961) described a closely similar form, *Retitricolpites minutus* from the Cenomanian of Minnesota. Clarke (1963) recorded this species from the Upper Cretaceous Vermejo Formation of Colorado.

Affinity. This form genus was proposed to accommodate tricolpate angiospermous pollen grains of uncertain affinities. *Tricolpites* cf. *T. reticulatus* probably was derived from a plant with salicaceous affinities.

Illustrations. Specimens OPC 844 J-13-1, OPC 844 K-11-4, OPC 844 J-22-2, and OPC 845 D-19-3.

Tricolpites erugatus, new species
Pl. 9, figs. 2a,b

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

Holotype. Specimen OPC 845 F-1-4. Over-all dimensions 13.0 by 17.3 microns.

Occurrence. Uncommon. Pollen grains referred to *Tricolpites erugatus,* new species, occur in most levels of the Red Branch sediments. They amount to 0.5 to 33.5 percent of the total assemblage count. This species is most abundant in sections OPC 821, OPC 844, and OPC 845.

Affinity. Angiospermous pollen grains.

Illustrations. Specimens OPC 845 F-1-4 and OPC 845 D-19, 29.5 x 118.6.

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 (p. 92; pl. 7).

Stephanocolpites tectorius, new species
Pl. 9, figs. 8a,b

Description. Pollen grains polycolpate; prolate; 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 microreticulate on the surface. Over-all dimensions 65.0 to 82.5 microns long, 25.0 to 43.2 microns wide.

Holotype. Specimen OPC 843 I-1-5. Over-all dimensions 81.0 by 42.0 microns.

Occurrence. Rare. Fossil pollen grains referred to *Stephanocolpites tectorius,* new species, occur in only six levels of Red Branch sediments. They in no case amount to more than 2.0 percent of the total assemblage count.

Affinity. Angiospermous pollen grains.

Illustrations. Specimens OPC 843 I-1-5 and OPC 843 I-1-4.

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

Infraturma Prolati Erdtman, 1943

Genus **TRICOLPOROPOLLENITES** Pflug, 1952, ex Thomson and Pflug, 1953

Type species: *Tricolporopollenites dolium* (R. Potonié, 1931) Thomson and Pflug, 1953.

1931b *Pollenites dolium* R. Potonié (p. 25; pl. 1).
1953 *Tricolporopollenites dolium* (R. Potonié, 1931) Thomson and Pflug (p. 98; pl. 12, figs. 114-117).

Remarks. R. Potonié (1960, p. 101) stated that *Tricolporopollenites* is synonymous with *Rhoipites* Wodehouse, 1933. This transfer would leave no valid form genus for fossil tricolporate pollen grains of unknown affinities, and therefore the transfer is not recognized by the author.

Tricolporopollenites aliquantulus, new species
Pl. 9, figs. 4a,b

Description. Pollen grains tricolporate; prolate; colpi long, extending almost the entire length of the grain; ora round, approximately 1.0 micron; exine thin, 0.5 to 1.0 micron, smooth to infragranular. Over-all dimensions 10.0 to 11.5 microns wide by 12.0 to 15.5 microns long.

Holotype. Specimen OPC 844 H-25-11. Over-all dimensions 10.8 by 15.1 microns.

Occurrence. Uncommon. Pollen grains referred to *Tricolporopollenites aliquantulus*, new species, are consistent 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 count.

Affinity. Angiospermous pollen grains.

Illustrations. Specimens OPC 844 H-25-11 and OPC 824 D-10-1.

Turma Poroses (Porosa Naumova, 1937, 1939) emend. R. Potonié, 1960

Subturma Triporines (Triporina Naumova, 1937) emend. R. Potonié, 1960

Genus **PISTILLIPOLLENITES** Rouse, 1962

Type species: *Pistillipollenites mcgregorii* Rouse, 1962 (p. 206; pl. 1, figs. 8-12).

Pistillipollenites mcgregorii Rouse, 1962
Pl. 9, fig. 6

Occurrence. Rare. This species is represented only in the assemblage count of levels A, B, and C of section OPC 844.

Distribution. Rouse (1962) described this form from the Eocene (?) of British Columbia.

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.

Illustration. Specimen OPC 844 G-17-1.

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 (p. 329; pl. 2, fig. 1).
1937 *Liquidambarpollenites stigmosus major* Raatz (p. 17; pl. 1, fig. 26).

Liquidambarpollenites sp.
Pl. 9, fig. 7

Description. 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.

Occurrence. Rare. Pollen grains referred to *Liquidambarpollenites* sp. are scarce in the flora of the Red Branch. Only four specimens were encountered and may possibly be laboratory or field contaminants.

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

Illustration. Specimen OPC 845 I-3-1.

SPORAE INCERTAE SEDIS

Genus **SCHIZOSPORIS** Cookson and Dettmann, 1959

Type species: *Schizosporis reticulatus* Cookson and Dettmann, 1959 (p. 213-214; pl. 1, figs. 1-4).

Remarks. 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.

Schizosporis reticulatus Cookson and Dettmann, 1959
Pl. 10, fig. 3

Occurrence. Rare. This species occurs in only two levels, OPC 844 K, a coal, and OPC 845 A, a shale. It amounts to 0.5 percent of the total assemblage count of these two levels.

Distribution. Cookson and Dettmann (1959) described this species from the Lower to Upper Cretaceous (Neocomian-Aptian to ?Cenomanian) of Australia. Pocock (1962) and Singh (1964) reported it from the Lower Cretaceous of Canada. Brenner (1963) recorded its occurrence in the Cretaceous Potomac Group of Maryland.

Affinity. Not known.

Illustration. Specimen OPC 844 K-13-1.

Schizosporis spriggi Cookson and Dettmann, 1959
Pl. 10, fig. 5

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

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

Affinity. Not known.

Illustration. Specimen OPC 821 H-1-1.

Schizosporis parvus Cookson and Dettmann, 1959
Pl. 10, fig. 2

Occurrence. Rare. *Schizosporis parvus* makes up 0.5 to 5.0 percent of the total assemblage count of most levels.

Distribution. Cookson and Dettmann (1959) described this species from the Albian and ?Cenomanian sediments of Australia. Singh (1964) reported it from the Lower Cretaceous Mannville Group of Canada. Clarke (1963) recovered this species from the Upper Cretaceous Vermejo Formation of Colorado.

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

Illustration. Specimen OPC 844 J-2-3.

Schizosporis majusculus, new species
Pl. 10, figs. 1a,b

Description. Palynomorph 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 47.5 to 130.0 microns; polar diameter 142.5 to 207.5 microns.

Holotype. Specimen OPC 844 G-9-1. Over-all dimensions 147.5 by 48.6 microns.

Occurrence. Rare. Palynomorphs referred to *Schizosporis majusculus,* new species, in no case exceed 2.5 percent of the total assemblage count.

Affinity. Probably related to the Magnoliaceae.

Illustrations. Specimens OPC 844 G-9-1 and OPC 842 D-3-1.

PLANTAE INCERTAE SEDIS

Genus **SPERMATITES** Miner, 1935

Remarks. 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, or Coniferales upon the basis of the absence of any megaspore cuticle in *Eucommiidites.* The Chlamydospermales have a conspicuous pollen chamber formed just prior to pollination, 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
Pl. 10, fig. 4

Occurrence. Rare. "Seeds" referred to this species occur in seven levels of Red Branch sediments. At no level do they amount to more than 0.5 percent of the total assemblage.

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

Affinity. Gymnospermous ovule.

Illustration. Specimen OPC 845 A-4-1.

PALEOECOLOGICAL CONSIDERATIONS

The probable environmental conditions existing in Bryan County during the time of deposition of the Red Branch sediments can be reconstructed from an ecological study of the modern plants to which the Cenomanian palynomorphs have been related. In order to arrive at a logical environmental interpretation it is assumed that the fossil species identified and described in this paper represent the total microfossil assemblage of the Red Branch coals and clays. Good preservation of the spores and pollen together with the large numbers recovered from relatively small amounts of sediment help substantiate this view. Comparisons of these fossil palynomorphs with modern taxa are based solely upon morphologic similarities. It is assumed that the plants from which the fossil palynomorphs were derived occupied the same ecological niches as their modern equivalents. A phylogenetic grouping of taxa represented in the Red Branch palynologic assemblage and the ecology of these groups is discussed below.

Fungi Imperfecti

Fungus spores types A, B, and C.

These fungal spores occur in most levels of the Red Branch sediments and are considered to have been saprophytic on angiospermous plants.

Bryophyta

SPHAGNALES

Sphagnumsporites psilatus

Cingulatisporites cf. *C. levispeciosus*

The Sphagnales are a cosmopolitan group, associated with bogs or ponds which have low pH conditions.

Pteridophyta

PSILOPSIDA

PSILOTALES

Laevigatosporites irroratus

Verrucatosporites pseudoreticulatus

The Psilotales, today represented by *Psilotum* and *Tmesipteris,* are erect or pendulous herbaceous epiphytes. *Psilotum* extends from the tropics northward to South Carolina and is also found in Hawaii. *Tmesipteris* is found in tropical to warm-temperate forests in Australia, New Zealand, and Polynesia as a pendulous epiphyte.

LYCOPSIDA

LYCOPODIALES

Lycopodiacidites arcuatus

Lycopodiacidites cf. *L. kuepperi*

Lycopodiumsporites crassimacerius

Camarozonosporites rudis

The Lycopodiales are a cosmopolitan group occurring everywhere except in most arid areas. They are abundant in tropical and subtropical forests as epiphytes and occur as terrestrial inhabitants in temperate and arctic regions.

SPHENOPSIDA

EQUISETALES

Calamospora cf. *C. mesozoica*

The Equisetales are represented by one living genus, *Equisetum,* which occurs throughout the world except Australia and New Zealand. Most species of *Equisetum* occur in the tropics and subtropics, but some are found in the temperate regions of North America.

PTEROPSIDA

FILICALES

OSMUNDACEAE

Osmundacidites wellmanii

Osmundacidites cf. *O. comaumensis*

Todisporites minor

The Osmundaceae are terrestrial to subaquatic plants consisting of three genera. *Osmunda* is a swamp plant of cosmopolitan distribution. *Todea* and *Leptopteris* are found in Australia.

SCHIZAEACEAE

Matonisporites impensus

Matonisporites cf. *M. equiexinus*

Cyathidites punctatus

Cyathidites minor

Cicatricosisporites dorogensis
Cicatricosisporites crassiterminatus
Appendicisporites undosus
Appendicisporites tricornitatus
Schizaeoisporites cf. *S. phaseolus*
Spore type A

The family Schizaeaceae is represented by four genera of terrestrial ferns of diverse habit. *Lygodium* is a twining fern found mainly in tropical and subtropical regions. *Mohria* occurs in the tropics and in southern Africa. *Anemia* consists of approximately 80 species which are mostly restricted to tropical and subtropical regions, but two species are indigenous to the southern United States. *Schizaea* is mostly tropical and subtropical, but *S. pusilla* occurs from New Jersey northward to Ontario.

GLEICHENIACEAE

Gleicheniidites confossus
Gleicheniidites senonicus
Deltoidospora hallii

This family is mostly tropical but extends into warm-temperate regions along the coast of the southern United States.

CYATHEACEAE

Cyathidites australis
Concavisporites subgranulosus

The Cyatheaceae are tree-ferns restricted in distribution to tropical and subtropical montane forests. Some forms extend into warm-temperate regions.

POLYPODIACEAE

Laevigatosporites ovatus
Laevigatosporites sp.
Verrucatosporites sp.

The Polypodiaceae is the largest family of ferns, consisting of approximately 7,000 species. It has a cosmopolitan distribution occurring from the tropics to the arctic and antarctic. This family is most abundant in forests and humid areas.

Sporae Incertae Sedis

Concavisporites cf. *C. jurienensis*
Concavisporites sp.
Balmeisporites glenelgensis
Laevigatosporites granaperturus
Trilites sp.

Spermatophyta

GYMNOSPERMAE

CYCADALES

Monosulcites cf. *M. carpentieri*
Monosulcites inspissatus

This family of nine genera is confined to tropical and subtropical regions. *Cycas* occurs today from Australia to southern Japan and Madagascar. *Zamia* is distributed from Chile to Florida.

GINKGOALES

Monosulcites minimus

The Ginkgoales consist of one living species, *Ginkgo biloba,* which once had a wide global distribution. Today it is a relict group restricted to cultivated areas.

CONIFERALES

PINACEAE

Piceaepollenites cf. *P. alatus*
Alisporites bilateralis
Tsugaepollenites nexosus

A family of woody plants, the Pinaceae consists of nine genera which are most common in temperate regions of the northern hemisphere. *Picea* is found in high altitudes in Eurasia and North America. *Tsuga* is endemic to alpine and north-temperate regions as far south as North Carolina.

PODOCARPACEAE

Rugubivesiculites woodbinensis
Parvisaccites granisaccus
Parvisaccites sp.

The podocarps are large trees restricted to the southern hemisphere. *Podocarpus* occurs in eastern Asia and southern hemisphere temperate and tropical regions. *Dacrydium* is restricted to Malaya, Tasmania, New Zealand, and South America.

ARAUCARIACEAE

Inaperturopollenites cf. *I. magnus*

Araucaria is found today in South America, Australia, New Zealand, and other portions of Australasia.

TAXODIACEAE

Taxodiaceaepollenites hiatus

Perinopollenites cf. *P. elatoides*

Taxodium occurs in North America from Delaware to Mexico, and extends westward to Texas. It is primarily a temperate to subtropical genus which grows in or near water.

GNETALES

EPHEDRACEAE

Ephedripites ambiguus

Ephedripites multicostatus

A monogeneric family represented by the genus *Ephedra* has cosmopolitan distribution in arid regions of tropical and subtropical areas in both the northern and southern hemispheres.

GYMNOSPERMAE INCERTAE SEDIS

Aratrisporites monosaccatus

Simplicesporites cf. *S. virgatus*

Eucommiidites troedssonii

Eucommiidites sp.

Classopollis cf. *C. obidosensis*

Spermatites cf. *S. nanus* (seed)

ANGIOSPERMAE

DICOTYLEDONAE

MAGNOLIACEAE

Schizosporis parvus

Schizosporis majusculus

This family consists of ten genera found in temperate regions of eastern Asia, eastern North America, and as far south as Brazil. *Magnolia* is mostly Asiatic in distribution and lives in humid areas of the southern United States.

HAMAMELIDACEAE

Liquidambarpollenites sp.

Liquidambar is native to the Mediterranean region, Asia, and North America. It is found in swamps of the southeastern United States.

RHIZOPHORACEAE

Tricolporopollenites aliquantulus

The Rhizophoraceae are shrubs and trees, mostly found on tropical shores. *Rhizophora* in the United States is restricted to muddy shores and the Florida everglades.

SALICACEAE

Tricolpites cf. *T. reticulatus*

This family contains plants which exhibit a cosmopolitan distribution.

DICOTYLEDONAE INCERTAE SEDIS

Stephanocolpites tectorius

Tricolpites erugatus

Pistillipollenites mcgregorii

MONOCOTYLEDONAE

LILIACEAE

Liliacidites cf. *L. variegatus*

Liliacidites dividuus

This family has cosmopolitan distribution. The fossil pollen referred to this family are liliaceous, but cannot be more closely assigned.

PALMAE

Palmaepollenites minusculus

Palmaepollenites cf. *P. tranquillus*

The Palmae are a large family of tropical and subtropical woody plants. *Sabal* occurs in the United States from the coast of North Carolina southwestward along the Gulf Coastal Plain into southeastern Texas.

MONOCOTYLEDONAE INCERTAE SEDIS

Pustulipollis ellipticus

Monosulcites sp.

Palynomorphs Incertae Sedis

Schizosporis spriggi

Schizosporis reticulatus

Foveoinaperturites cf. *F. foraminiferus*

Spores referred to the Bryophyta are present throughout all samples, although they are not well represented. Modern *Sphagnum* is endemic to swamps and bogs and normally indicates acidic soil and water conditions.

The Psilopsida, Lycopsida, and Sphenopsida are rare spore types in the Red Branch sediments. These three groups are most common in tropical to temperate forests.

Fossil filicinean spores belonging to the families Gleicheniaceae and Schizaeaceae were recovered in great abundance both from the coals and the shales. Some recent representatives of these families are found today living in or near swamps and marshes. The Osmundaceae are rare to uncommon, but indicate swampy environmental conditions. The Cyatheaceae are primarily tropical montane inhabitants. The rare occurrences of cyatheaceous spores are perhaps a result of the great distances of the parent plants from the sites of Red Branch deposition. The presence of polypodiaceous fern spores apparently has no ecological significance because this group is cosmopolitan in distribution.

The gymnospermous grains, with the exception of *Aratrisporites monosaccatus,* are not well represented in the total assemblage count of any level. Representatives of the Coniferales are basically temperate upland plants, a fact that indicates dispersion and transportation over long distances. *Taxodium* has a temperate to subtropical distribution and lives in or near water. The Cycadales and Gnetales are restricted to tropical and 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 in the flora.

An abundant angiosperm flora was recovered from the Red Branch sediments. *Magnolia* is distributed throughout humid areas of warm-temperate regions. The Palmae and Liliaceae are known to occur today near or in swamp communities in warm-temperate or subtropical to tropical regions. *Rhizophora* (mangrove) and *Liquidambar* are found in coastal swamps and along the shores of the southeastern United States. Angiospermous form genera described in this paper, such as *Tricolpites* and *Stephanocolpites,* are locally abundant, but cannot be assigned with certainty to modern genera. Their abundance, however, suggests that they were not transported long distances before deposition but were nearshore vegetational representatives.

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

Osmunda
Lygodium
Polypodiaceae
Taxodium
Magnolia
Liquidambar
Rhizophora
Sabal (referred to here as *Palmaepollenites minusculus,* new species)

Fossil spores referred to the Lycopodiaceae, Gleicheniaceae, Schizaeaceae, Cyatheaceae, Psilotales, and Equisetales are known to occur today near or in swamp communities in warm-temperate or subtropical to tropical regions. The cycads and some representatives of the palms are restricted to tropical and subtropical forests and swamps.

The spore-pollen flora in all the studied outcrop sections appears to be the same without any major fluctuations. This flora can be subdivided into five palynomorph assemblages:

1. The bryophyte - psilopsid - lycopsid - filicinean assemblage, with the fern families Gleicheniaceae and Schizaeaceae dominant.

2. The cycadalean-ginkgoalean assemblage, containing representatives of *Cycas, Zamia,* and *Ginkgo.*

3. The coniferalean assemblage, represented by pollen related to the Pinaceae, Podocarpaceae, Araucariaceae, and Taxodiaceae.

4. The ephedralean assemblage, represented by two species of *Ephedra.*

5. The angiosperm assemblage, including both monocotyledons and dicotyledons.

The Red Branch palynomorph flora is basically a pteridophyte-angiosperm assemblage. The same species occur throughout all the measured sections with variations in the percentages of each species. This fact suggests that the Red Branch sediments in Bryan County were deposited within a relatively short span of time. No marine palynomorphs (such as hystrichosphaerids or dinoflagellate cysts) were recovered from the shales, the entire microfossil assemblage consisting of spores and pollen. This evidence indicates a nonmarine depositional environment.

The palynological assemblage, together with the evidence of known plant community ecology, would indicate a warm-temperate to tropical climate in Bryan County during the time of Red Branch deposition. The predominance of ferns and angiosperms in coals and clays which are not mappable from one outcrop section to the next further suggests that there were numerous, local, swampy depositional basins which supported their own local floras. These basins were most likely along the coastal plain or on major drainage flood plains.

The cycads and conifers are rare elements in the assemblage. With the possible exception of *Taxodium,* the parent plants were probably living in the more elevated areas to the north, including the Arbuckle and the Ouachita Mountains. The rare occurrences of these forms suggests relatively long distances of transportation.

Ephedra occurs sparsely in the Red Branch flora. At present this genus is restricted to arid regions and probably was derived from outside the coastal plain environment in Red Branch time.

PALYNOLOGICAL COMPARISONS

Studies dealing with the palynology of lowermost Upper Cretaceous deposits in the Western Hemisphere are few and show only generalized relationships to the Red Branch materials. These studies include the works of Groot and Penny (1960), Groot, Penny, and Groot (1961), Pierce (1961), and Leopold and Pakiser (1964). Palynological literature on the younger Upper Cretaceous includes papers by Ames (1950), Radforth and Rouse (1954), Rouse (1959), Anderson (1960), and Clarke (1963). These latter works describe palynological assemblages consisting of large numbers of morphologically advanced pollen types, such as tricolpate and triporate grains. Some of the spores and gymnospermous pollen types described in these works, however, were recovered from the Red Branch materials.

Groot and Penny (1960) and Groot, Penny, and Groot (1961) have described the palynology of the 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
Tsugaepollenites (different species)
Monosulcites minimus
Liliacidites variegatus
Taxodiaceaepollenites hiatus
tricolpate grains
tricolporate grains

Little similarity between the assemblages described by Groot and Penny (1960) and Groot, Penny, and Groot (1961) and the palynomorph association recovered from the Red Branch sediments is apparent. Groot, Penny, and Groot (1961) reported an abundant variety of tricolpate and tricolporate grains and a large number of triporate taxa referrable to *Turonipollis, Plicapollis, Latipollis, Sporopollis, Vacuopollis,* and *Trudopollis,* all of which are significantly absent in the Red Branch materials.

Leopold and Pakiser's (1964) work on pre-Selma Upper Cretaceous sediments in western Alabama recorded spores and pollen similar to those recovered by Groot and Penny (1960) and Groot, Penny, and Groot (1961) from the eastern Atlantic Coast. They reported a large number of triporate pollen species, such as *Basopollis, Sporopollis, Triatriopollenites, Triorites, Minorpollis, Conclavipollis,* and *Latipollis.* Also reported was a number of oblate tricolporate species, none of which is present in the Red Branch assemblage. Common elements to both the Alabama and Oklahoma materials include:

Deltoidospora hallii
Cyathidites punctatus
Cicatricosisporites dorogensis
Schizaeoisporites
Taxodiaceaepollenites hiatus
Ephedripites
Classopollis (different species)
Liliacidites
Parvisaccites
Perinopollenites elatoides

Little other similarity is apparent between Leopold and Pakiser's assemblage and the Red Branch palynomorph assemblage. The triporate grains mentioned above have, in part, been listed as characteristic genera of Cenomanian deposits in Europe by Krutzsch (1957) and are present both in Alabama and on the Atlantic Coastal Plain. It is possible that the parent plants of these grains were not ecologically suited for climatic conditions existing during Red Branch time, or that the Red Branch is older than the strata studied.

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

Deltoidospora
Cingulatisporites cf. *C. levispeciosus*
Gleicheniidites senonicus
Camarozonosporites rudis
Lycopodiacidites cf. *L. kuepperi*
Cicatricosisporites
Appendicisporites
Eucommiidites
Foveoinaperturites foramenifer us
Tsugaepollenites
Piceaepollenites
Rugubivesiculites
Parvisaccites
Monosulcites spp.
Liliacidites variegatus
Liliacidites dividuus
Tricolpites cf. *T. reticulatus*
Ephedripites
Tricolporopollenites

It should be noted that neither the Minnesota nor the Red Branch assemblages contain triporate pollen grains. The triporate types were common elements in the Upper Cretaceous sediments studied by Groot, Penny, and Groot (1961) and Leopold and Pakiser (1964). Pierce (1961) also reported a large number of bisaccate pollen species from the Minnesota Cenomanian. These forms are rare in all levels of the Red Branch sediments, which are interpreted as having been deposited along a tropical to warm-temperate coastal plain. Pierce's materials were perhaps derived from several climax communities living in or near the site of deposition, among which was undoubtedly a temperate coniferous forest.

Published works on Lower Cretaceous palynological assemblages in North America include papers by Pocock (1962), Singh (1964) and Brenner (1963). Spores and gymnospermous pollen grains with long stratigraphic ranges are common to the Red Branch materials and the Canadian Lower Cretaceous Mannville Group materials studied by Pocock (1962) and Singh (1964). Angiospermous pollen grains are absent in the Canadian assemblages. Brenner (1963) described the palynomorphs from uppermost Lower (?) Cretaceous (Albian) sediments of the Maryland coastal plain. Many of his species were also recovered from the Red Branch sediments. He also reported eight species of angiospermous tricolpate pollen grains. The angiospermous pollen would suggest that this assemblage represents a flora which appeared before Cenomanian time because of optimum environmental conditions. Other authors have reported undisputed angiospermous pollen grains from sediments as old as Albian (Bolkhovitina, 1953; Couper, 1960).

COMPARISON OF PLANT MEGAFOSSILS AND MICROFOSSILS

The spore and pollen flora recovered from the Red Branch Member of the Woodbine Formation is basically a pteridophyte-angiosperm assemblage consisting of 75 taxa. Of these, 3 are fungal spores, 2 are bryophytes, 28 are pteridophytes, 5 are spores of uncertain affinity, 20 are gymnosperms, 8 are dicotyledonous angiosperms, and 6 are monocotyledonous angiosperms. Palynomorphs of uncertain affinities are represented by 3 taxa.

Berry (1922) described a collection of plant megafossils from the Woodbine Formation at Arthurs Bluff, Lamar County, Texas, as consisting of 43 species, of which 41 were angiosperms and 2 were gymnosperms. This flora was recovered from the "Dexter beds" of Hill (1901), which is the equivalent of the Lewisville Member of the Woodbine Formation. The Lewisville Member immediately overlies the Red Branch Member in north-central Texas. No fungal material, bryophytes, or pteridophytes were present in Berry's assemblage, most likely owing to the depositional environment of the "Dexter beds." Of Berry's 32 genera, only 4 appear in common with the microfloral elements of the Red Branch sediments.

1. *Podozamites,* a cycad, is possibly the parent plant of such pollen grains as *Monosulcites inspissatus,* new species, which is here interpreted as being the pollen of a Mesozoic *Zamia.*

2. *Brachyphyllum* has been interpreted by Pocock and Jansonius (1961) as an organ of one of the possible parent plants which produced *Classopollis*-type pollen.

3. *Magnolia* is probably represented by *Schizosporis parvus* and *Schizosporis majusculus.*

4. *Salix,* or a plant producing similar pollen grains, may be represented by *Tricolpites* cf. *T. reticulatus.*

Berry (1922) recorded five species common to the Woodbine and the European Cenomanian, with three species "tentatively recognized at this horizon." He also recorded two species which occur in the European Turonian. In comparing the character of his flora to the floras described from the Tuscaloosa and Magothy Formations of the Coastal Plain, he considered the Woodbine assemblage to be Turonian rather than Cenomanian in age. Berry's Turonian age determination of the Woodbine is based upon three species common to Texas and Europe.

MacNeal (1958) studied the plant megafossils from the Woodbine Formation of Denton County, Texas, and recorded a total of 82 species. In addition to the four genera reported by Berry (1922), MacNeal recovered representatives from three other families, spores and pollen of which are represented in the Red Branch assemblage. His total flora consists of temperate to subtropical elements which were deposited in fresh or brackish water along the seacoast.

1. Osmundaceae—This family is represented by the spore genera *Osmundacidites* and *Todites.*

2. Polypodiaceae—Spores referred to *Laevigatosporites* and *Verrucatosporites* have affinities with this fern family.

3. Araucariaceae—*Inaperturopollenites* cf. *I. magnus* may have affinities with this family.

MacNeal concluded that the Woodbine flora is definitely Cenomanian, being closely related to that of the Dakota Group and showing some relationships to the Raritan and Magothy Formations of the east coast of the United States.

STRATIGRAPHIC CONSIDERATIONS

The Red Branch Member of the Woodbine Formation in Bryan County, Oklahoma, contains spores and pollen grains similar to those recovered by Pierce (1961) from the "Dakota formation" of Minnesota. Both of these assemblages contain morphologically similar palynomorph types, but Pierce reported a larger number of coniferous species. R. W. Brown (*in* Stephenson, 1952, p. 35) studied fossil leaf collections from two Red Branch localities in Grayson and Cooke Counties, Texas, and found no coniferous remains. He noted the similarity of the other plant fossils to those of the so-called "Dakota sandstone" in Kansas.

Little similarity exists between the Red Branch palynomorph assemblage and those described by Groot, Penny, and Groot (1961) and Leopold and Pakiser (1964). Their assemblages from Cenomanian sediments contained large numbers of tricolporate and triporate grains not found in the Red Branch material.

Woodbine plant magafossils were described in detail by Berry (1922) from the Lewisville Member at Arthurs Bluff, Lamar County, Texas, and by MacNeal (1958) from Denton County, Texas. Berry advocated the correlation of the Texas Woodbine with the European Turonian and Atlantic Coastal Plain Magothy Formation upon the basis of three species of plant remains. MacNeal doubted the significance of these three long-ranging forms and interpreted his assemblage of 82 species as being definitely Cenomanian in age.

Paleozoological evidence further substantiates a Cenomanian age for the Woodbine Formation in Texas. Adkins and Lozo (1951) presented a provisional revised zonation of the Woodbine and overlying Eagle Ford "groups." In this work they subdivided the Woodbine into five zones based upon ammonites and stated that the "Woodbine covers only the equivalents of about two western European Cenomanian zones." The overlying Eagle Ford "group" was considered by them to be in part Cenomanian, and in part Turonian.

In 1952, Stephenson described and illustrated invertebrate fossils from 230 Woodbine localities in Texas. His fauna consisted of 281 species, among which was *Ostrea solenisca* Meek, the only invertebrate megafossil recovered by the author from the Red Branch sediments of Bryan County, Oklahoma. Adkins and Lozo (1951) have also reported this species from the Texas Woodbine. Stephenson compared his assemblage with faunas reported from equivalent units in areas within and outside the United States and accepted the "traditional" assignment of this formation to the Cenomanian.

The assignment of coal-clay sequences in Bryan County, Oklahoma, to the Red Branch Member of the Woodbine Formation was made by N. M. Curtis, Jr., in 1960. The assignment was made upon the basis of stratigraphic position and lithologic characteristics. The author is in agreement with this assignment as it is compared with Bergquist's (1949) description of the Red Branch Member. Fossil leaves were not found in the measured sections described in this paper, but carbonaceous plant fragments were abundant in many of the clays. It was, therefore, impossible to compare the palynomorphs with identifiable megascopic plant remains. It is probable that the palynologic assemblage recovered from the Red Branch sediments represents but a small fraction of the flora which was living during Woodbine time. Silts and clays from other members of the Woodbine Formation in Oklahoma might yield angiospermous palynomorph assemblages which could be more closely related to the assemblages of MacNeal (1958), Groot, Penny, and Groot (1961), and Leopold and Pakiser (1964).

REFERENCES

Adkins, W. S., and **Lozo, F. E., Jr.**, 1951, Stratigraphy of the Woodbine and Eagle Ford, Waco area, Texas: Dallas, Southern Methodist Univ. Press, Fondren Science Series, no. 4, p. 101-164.

Ames, H. T., 1950, Plant microfossils in a Colorado Cretaceous coal: Mass., Univ., unpublished Master of Science thesis.

Anderson, R. Y., 1960, Cretaceous-Tertiary palynology, eastern side of the San Juan basin, New Mexico: N. Mex. Bur. Mines Mineral Resources, Mem. 6, 58 p.

Balme, B. E., 1957, Spores and pollen grains from the Mesozoic of Western Australia, **in** Fuel research, Physical and chemical survey of the national coal resources: Australia, Commonwealth Science Indus. Res. Organization (Ref. T.C. 25), Coal Research Section, 50 p., 11 pls., 1 fig., 4 tables.

Bergquist, H. R., 1949, Geology of the Woodbine formation of Cooke, Grayson, and Fannin Counties, Texas: U. S. Geol. Survey, Oil and Gas Inv., Prelim. Map 98, 2 sheets.

Berry, E. W., 1922, The flora of the Woodbine sand at Arthurs Bluff, Texas, **in** Shorter contributions to general geology: U. S. Geol. Survey, Prof. Paper 129-G, p. 153-180, 5 pls., 1 fig.

Bolkhovitina, N. A., 1953, Sporovo-pyl'tsevaya kharakteristika melovykh otlozheniy tsentral'nykh oblastey SSSR: Akad. Nauk SSSR, Instituta Geologicheskikh Nauk, Trudy, vol. 145, Geologicheskai Seriya (no. 61), 184 p., 16 pls., 10 text-figs., 10 tables.

—— 1959, Sporovo-pyl'tsevye kompleksy mezozoyskikh otlozheniy Vilyuyskoy vpadiny i ikh znachenie dlya stratigrafii: Akad. Nauk SSSR, Geologicheskogo Instituta, Trudy, vol. 24, 185 p.

—— 1961, Iskopaemye i sovremennye spory semeystva Skhizeynykh: Akad. Nauk SSSR, Geologicheskogo Instituta, Trudy, vol. 40, 176 p., 10 fig., 41 pls., 9 tables.

Brenner, G. J., 1963, The spores and pollen of the Potomac Group of Maryland: Md. Dept. Geology, Mines and Water Resources Bull. 27, 215 p., 43 pls., 7 text-figs., 7 tables.

Clarke, R. T., 1963, Palynology of Vermejo Formation coals (Upper Cretaceous) in the Canon City coal field, Fremont County, Colorado: Okla., Univ., unpublished doctoral dissertation, 161 p., 2 figs., 2 tables.

Cookson, I. C., 1947, Plant microfossils from the lignites of the Kerguelen archipelago: British-Australian-New Zealand Antarctic Research Expedition 1929-1931, Science Repts., Ser. A, vol. 2, pt. 8, p. 127-142, 5 pls.

—— 1953, Difference in microspore composition of some samples from a bore at Comaum, South Australia: Australian Jour. Botany, vol. 1, p. 462-473, 2 pls.

Cookson, I. C., and **Dettmann, M. E.**, 1958, Cretaceous "megaspores" and a closely associated microspore from the Australian region: Micropaleontology, vol. 4, p. 39-49, 2 pls., 3 text-figs., 1 table.

—— 1959, On **Schizosporis**, a new form genus from Australian Cretaceous deposits: Micropaleontology, vol. 5, p. 213-216, 1 pl.

Couper, R. A., 1953, Upper Mesozoic and Cainozoic spores and pollen grains from New Zealand: New Zealand Geol. Survey, Paleont. Bull. 22, 77 p., 9 pls., 3 figs., 3 tables.

—— 1958, British Mesozoic microspores and pollen grains; a systematic and stratigraphic study: Palaeontographica, Abt. B, vol. 103, p. 75-179, 17 pls., 11 figs., 12 tables.

—— 1960, New Zealand Mesozoic and Cainozoic plant microfossils: New Zealand Geol. Survey, Paleont. Bull. 32, 88 p., 12 pls., 4 figs., 3 tables.

Curtis, N. M., Jr., 1960, Lignite in the Red

Branch Member, Woodbine Formation, Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, vol. 20, p. 240-244, 1 fig.

Daugherty, L. H., 1941, The Upper Triassic flora of Arizona, with a discussion of geologic occurrence by H. R. Stagner: Carnegie Inst. Washington, Pub. 526, Contr. Paleontology, 108 p.

Davis, L. V., 1960, Geology and ground-water resources of southern McCurtain County, Oklahoma: Okla. Geol. Survey, Bull. 86, 108 p., 1 pl., 19 figs., 8 tables.

Delcourt, A. F., Dettmann, M. E., and **Hughes, N. F.**, 1963, Revision of some Lower Cretaceous microspores from Belgium: Palaeontology, vol. 6, p. 282-292, 4 pls., 1 text-fig.

Delcourt, A. F., and **Sprumont, G.**, 1955, Les spores et grains de pollen du Wealdien du Hainaut: Société Belge de Géologie, de Paléontologie et d'Hydrologie, Mém., nouvelles séries 4, no. 5, 73 p., 4 pls., 15 text-figs., 3 tables.

—— 1956, Présence d'**Eucommiidites** dans une coupe du Wealdien de Baudour: Société Belge de Géologie, de Paléontologie et d'Hydrologie, Bull., vol. 65, p. 375-380.

—— 1957, Quelques microfossiles du Wealdien de Féron Glageon: Société Belge de Géologie, de Paléontologie et d'Hydrologie, Bull., vol. 66, p. 57-70.

Dettmann, M. E., 1963, Upper Mesozoic microfloras from southeastern Australia: Roy. Soc. Victoria, Proc., New Ser., vol. 77, pt. 1, 148 p., 27 pls., 6 figs., 10 tables.

Erdtman, G., 1948, Did dicotyledonous plants exist in Jurassic times?: Geologiska Föreningens i Stockholm, Förhandlingar, vol. 70, p. 265-271, 1 fig.

Groot, J. J., and **Groot, C. R.**, 1962, Plant microfossils from Aptian, Albian, and Cenomanian deposits of Portugal: Comunicações dos Serviços Geológicos de Portugal, vol. 46, p. 133-171, 10 pls.

Groot, J. J., and **Penny, J. S.**, 1960, Plant microfossils and age of nonmarine Cretaceous sediments of Maryland and Delaware: Micropaleontology, vol. 6, p. 225-236, 2 pls., 1 fig., 3 tables.

Groot, J. J., Penny, J. S., and **Groot, C. R.**, 1961, Plant microfossils and age of the Raritan, Tuscaloosa, and Magothy formations of the eastern United States: Palaeontographica, Abt. B, vol. 108, p. 121-140, 3 pls., 1 fig., 2 tables.

Hammen, Th. van der, 1954, El desarrollo de la flora colombiana en los periodos geologicos: Bogotá, Boletin Geológico, vol. 2, p. 49-106, 21 pls., 7 figs.

—— 1956, Description of some genera and species of fossil pollen and spores: Bogotá, Boletin Geológico, vol. 4, p. 111-117.

Harper, R. M., 1910, Preliminary report on the peat deposits of Florida: Fla. State Geol. Survey, 3rd Ann. Rept., p. 197-375, 13 pls., 19 text-figs.

—— 1914, Geography and vegetation of northern Florida: Fla. State Geol. Survey, 6th Ann. Rept., p. 163-437, 50 figs.

Harris, W. F., 1955, A manual of the spores of New Zealand Pteridophyta: New Zealand Dept. Sci. Indus. Research, Bull. 116, 186 p.

Hill, R. T., 1901, Geography and geology of the Black and Grand Prairies, Texas: U. S. Geol. Survey, 21st Ann. Rept., 1899-1900, pt. 7, 666 p.

Hoerhammer, L., 1933, Über die Coniferen-Gattungen **Cheirolepis** Schimper und **Hirmeriella** nov. gen. aus dem Rhät-Lias von Franken: Stuttgart, Bibliotheca Botanica, vol. 107, p. 1-34.

Hughes, N. F., 1961, Further interpretation of **Eucommiidites** Erdtman, 1948: Palaeontology, vol. 4, p. 292-299, 2 pls. 1 fig.

Ibrahim, A. C., 1933, Sporenformen des Aegirhorizonts des Ruhr-Reviers: Würzburg, Konrad Triltsch, 48 p., 8 pls., 1 fig.

Kedves, Miklós, 1960, Études palynologiques dans le bassin de Dorog, I: Pollen et Spores, vol. 2, p. 89-118, 10 pls., 5 figs.

Kendall, M. W., 1949, On a new conifer from the Scottish Lias: Annals Magazine Nat. History, ser. 12, vol. 2, p. 299-308.

Klaus, Wilhelm, 1960, Sporen der karnischen Stufe der ostalpinen Trias: Austria, Geologischen Bundesanstalt, Jahrbuch, Sonderband 5, p. 107-184, 11 pls., 14 figs.

Kremp, G. O. W., 1949, Pollenanalytische Untersuchung des miozänen Braunkohlenlagers von Konin an der Warthe: Palaeontographica, Abt. B., vol. 90, p. 53-93, 7 pls.

Krutzsch, Wilfried, 1957, Sporen- und Pollengruppen aus der Oberkreide und dem Tertiär Mitteleuropas und ihre stratigraphische Verteilung: Zeitschrift für Angewandte Geologie, vol. 3, p. 509-548, 16 pls., 1 fig., 2 tables.

Leopold, E. B., and **Pakiser, H. M.**, 1964, A preliminary report on the pollen and spores of the pre-Selma Upper Cretaceous strata of western Alabama, **in** Studies of pre-Selma Cretaceous core samples from the outcrop area in western Alabama: U. S. Geol. Survey, Bull. 1160-E, p. 71-95, 7 pls., 5 tables.

Leschik, Georg, 1955, Die Keuperflora von Neuewelt bei Basel, II, Die Iso- und Mikrosporen: Schweizerischen Paläontologischen Abhandlungen, Mém. Suisses Paläont., vol. 72, 70 p., 10 pls., 1 text-fig.

MacNeal, D. L., 1958, The flora of the Upper Cretaceous Woodbine sand in Denton County, Texas: Acad. Nat. Sciences Philadelphia, Mon. 10, 152 p., 36 pls., 8 text-figs., 2 tables.

Miner, E. L., 1935, Paleobotanical examinations of Cretaceous and Tertiary coals: Amer. Midland Naturalist, vol. 16, p. 585-625, 7 pls., 6 figs., 1 table, 1 map.

Mürriger, Friedrich, and **Pflug, Hans**, 1951, Über die Altersstellung der Braunkohle von Burghasungen, Bezirk Kassel, auf Grund pollenanalytischer Untersuchungen und Vergleiche mit anderen Braunkohlenvorkommen: Hessischen Landesamtes für Bodenforschung zu Wiesbaden, Notizblatt, vol. 6, p. 87-97.

Oszast, J., 1957, **Tricolpites (Eucommiidites) troedssonii** Erdtman in refractory Jurassic clays from Grojec near Krakow: Polish Academy Science, Bull., Biol. Ser., vol. 5, no. 3, p. 103-105.

Pflug, Hans, 1952, Palynologie und stratigraphie der eozänen Braunkohlen von Helmstedt: Paläontologische Zeitschrift, vol. 26, p. 112-137, 3 pls., 8 figs.

—— 1953, Zur Entstehung und Entwicklung des angiospermiden Pollens in der Erdgeschichte: Palaeontographica, Abt. B, vol. 95, p. 60-171, 11 tables.

Pierce, R. L., 1961, Lower Upper Cretaceous plant microfossils from Minnesota: Minn. Geol. Survey, Bull. 42, 86 p., 3 pls., 1 fig., 3 tables.

Pocock, S. A. J., 1962, Microfloral analysis and age determinations of strata at the Jurassic-Cretaceous boundary in the western Canada plains: Palaeontographica, Abt. B, vol. 111, p. 1-95.

Pocock, S. A. J., and **Jansonius, Jan**, 1961, The pollen genus **Classopollis** Pflug, 1953: Micropaleontology, vol. 7, p. 439-449, 1 pl., 6 text-figs.

Pons, Armand, 1956, Sur un pollen du Lias inférieur: Academie Sciences Paris, Comptes Rendus, vol. 243, p. 1547-1549.

Potonié, Robert, 1931a, Zur Mikroskopie der Braunkohlen. I: Zeitschrift **Braunkohle**, vol. 30, p. 325-333, 2 pls.

—— 1931b, Pollenformen der miozänen Braunkohle. II: Gesellschaft Naturforschender Freunde zu Berlin, Sitzungsberichte, no. 1-3, p. 24-28, 1 pl.

—— 1931c, Pollenformen aus tertiären Braunkohlen. III: Preussischen Geologischen Landesanstalt, Jahrbuch, vol. 52, p. 1-7, 34 text-figs.

—— 1931d, Zur Mikroskopie der Braunkohlen. IV: Zeitschrift Braunkohle, vol. 30, p. 554-556.

—— 1934a, Zur Morphologie der fossilen Pollen und Sporen: Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, vol. 4, p. 5-24.

—— 1934b, Zur Mikrobotanik des eozänen Humodils des Geiseltals: Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, vol. 4, p. 25-125, 6 pls.

—— 1951a, Pollen- und Sporenformen als Leitfossilien des Tertiärs: Mikroskopie, vol. 6, p. 272-383, 2 pls.

—— 1951b, Revision stratigraphisch wichtiger Sporomorphen des mitteleuropäischen Tertiärs: Palaeontographica, Abt. B, vol. 91, p. 131-151, 2 pls., 1 table.

—— 1956, Synopsis der Gattungen der Sporae dispersae. Teil I. Sporites: Amt für Bodenforschung, Hannover, Geologischen Jahrbuch, Beihefte, vol. 23, 103 p., 11 pls.

—— 1958, Synopsis der Gattungen der Sporae dispersae. Teil II. Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates: Amt für Bodenforschung, Hannover, Geologischen Jahrbuch, Beihefte, vol. 31, 114 p., 11 pls.

—— 1960, Synopsis der Gattungen der Sporae dispersae. Teil III. Nachträge Sporites, Fortsetzung Pollenites mit Generalregister: Amt für Bodenforschung, Hannover, Geologischen Jahrbuch, Beihefte, vol. 39, 189 p., 9 pls.

Potonié, Robert, and **Gelletich, Johann**, 1933, Ueber Pteridophyten-Sporen einer eozänen Braunkohle aus Dorog in Ungarn: Gesellschaft Naturforschender Freunde zu Berlin, Sitzungsberichte, vol. 33, p. 517-528, 2 pls.

Potonié, Robert, **Ibrahim, A. C.**, and **Loose, F.**, 1932, Sporenformen aus dem Flözen Aegir und Bismarck des Ruhrgebietes: Neues Jahrbuch Mineralogie Geologie Paläontologie, Beilage, Abt. B, vol. 67, p. 438-454, 7 pls., 1 fig.

Potonié, Robert, and **Venitz, Herbert**, 1934, Zur Mikrobotanik des miozänen Humodils der niederrheinischen Bucht: Preussischen Geologischen Landesanstalt, Institut für Paläobotanik und Petrographie der Brennsteine, Arbeiten, vol. 5, p. 1-54, 4 pls.

Potter, D. E. (as D. R. Potter), 1963, An emendation of the sporomorph **Arcellites** Miner, 1935: Okla. Geol. Survey, Okla. Geology Notes, vol. 23, p. 227-230.

Raatz, G. V., 1937, Mikrobotanisch-stratigraphische Untersuchung der Braunkohle des muskauger Bogens: Preussischen Geologischen Landesanstalt, Abhandlungen, Neue Folge, vol. 183, p. 1-48, 1 pl. 5 figs.

Radforth, N. W., and **Rouse, G. E.**, 1954, The classification of recently discovered Cretaceous plant microfossils of potential importance to the stratigraphy of western Canadian coals: Canadian Jour. Botany, vol. 32, p. 187-201.

Reissinger, A., 1950, Die "Pollenanalyse" ausgedehnt auf alle Sedimentgesteine der geologischen Vergangenheit: Palaeontographica, Abt. B, vol. 90, p. 99-126.

Rogalska, Maria, 1954, Analiza sporowopylkowa Liasowego węgla Blanowickiego z Górnego Śląska: Instytut Geologiczny, Bull. 89, 46 p., 12 pls.

Ross, N. E., 1949, On a Cretaceous pollen and spore bearing clay deposit of Scania: Upsala, Univ., Geol. Institution, Bull., vol. 34, p. 25-43, 3 pls., 4 figs.

Rouse, G. E., 1959, Plant microfossils from Kootenay coal-measures strata of British Columbia: Micropaleontology, vol. 5, p. 303-324, 2 pls.

—— 1962, Plant microfossils from the Burrard Formation of western British Columbia: Micropaleontology, vol. 8, p. 187-218, 5 pls.

Saad, S. I., 1963, Pollen and spores recently discovered in the coals of Sinai region. Part I. Euone Moussa: Palaeontographica, Abt. B, vol. 113, p. 117-125.

Schopf, J. M., **Wilson, L. R.** and **Bentall, Ray**, 1944, An annotated synopsis of Paleozoic spores and the definition of generic groups: Ill. State Geol. Survey, Rept. Inv. 91, 72 p., 3 pls., 5 figs.

Scott, R. A., 1960, Pollen of **Ephedra** from the Chinle Formation (Upper Triassic) and the genus **Equisetosporites:** Micropaleontology, vol. 6, p. 271-276.

Selling, O. H., 1944, Studies in the recent and fossil species of **Schizaea,** with particular reference to their spore characters: Göteborgs Botaniska Trädgard, Mededelingen, vol. 16, p. 1-112.

Singh, C., 1964, Microflora of the Lower Cretaceous Mannville Group, east-central Alberta: Research Council Alberta, Bull. 15, 238 p., 29 pls., 13 figs., 6 tables.

Stephenson, L. W., 1918, A contribution to the geology of northeastern Texas and southern Oklahoma, **in** Shorter contributions to general geology, 1918: U. S. Geol. Survey, Prof. Paper 120, p. 129-163, 14 pls.

—— 1952, Larger invertebrate fossils of the Woodbine Formation (Cenomanian) of Texas: U. S. Geol. Survey, Prof. Paper 242, 211 p., 54 pls., 5 figs.

Teichmüller, Marlies, and **Thomson, P. W.**, 1958, Vergleichende mikroskopische und chemische Untersuchungen der wichstigen Fazies-Typen im Hauptflöz der niederrheinischen Braunkohle: Fortschritte in der Geologie von Rheinland und Westfalen, vol. 2, p. 573-598, 4 pls., 3 figs., 5 tables.

Thiergart, F., 1938, Die Pollenflora der Niederlausitzer Braunkohle: Preussischen Geologischen Landesanstalt, Jahrbuch, vol. 58, p. 282-351, 9 pls.

Thomson, P. W., and **Pflug, Hans**, 1953, Pollen und Sporen des mitteleuropäischen Tertiärs: Palaeontographica, Abt. B, vol. 94, 138 p., 15 pls., 20 figs.

Venkatachala, B. S., and **Baltes, N.**, 1962a, Studii palinologice asupra depozitelor terţiare din Depresiunea precarpatică romînă —Depresiunea getică: Petrol şi Gaze, vol. 13, p. 244-258.

—— 1962b, Studii palinologice asupra depozitelor terţiare din Depresiunea precarpatică romînă Depresiunea getică. Consideraţii stratigrafice: Petrol şi Gaze, vol. 13, p. 295-303.

Venkatachala, B. S., and **Góczán, F.**, 1964, The spore-pollen flora of the Hungarian "Kössen facies": **Academiae Scientiarum** Hungaricae, Acta Geologica, vol. 8, p. 203-228.

Weyland, Hermann, and **Greifeld, G.**, 1953, Über strukturbietende Blätter und pflanzliche Mikrofossilien aus den untersenonen Tonen der Gegend von Quedlinburg: Palaeontographica, Abt. B, vol. 95, p. 30-52, 8 pls., 4 figs.

Weyland, Hermann, and **Krieger, Wilhelm**, 1953, Die Sporen und Pollen der Aachener Kreide und ihre Bedeutung für die Charakterisierung des mittleren Senons: Palaeontographica, Abt. B, vol. 95, p. 6-29, 5 pls.

Wilson, L. R., and **Venkatachala, B. S.**, 1963, An emendation of **Vestispora** Wilson and Hoffmeister, 1956: Okla. Geol. Survey, Okla. Geology Notes, vol. 23, p. 94-100.

Wilson, L. R., and **Webster, R. M.**, 1946, Plant microfossils from a Fort Union coal of Montana (abs.): Amer. Jour. Botany, vol. 33, p. 271-278, 2 pls.

Wodehouse, R. P., 1933, Tertiary pollen, II, The oil shales of the Eocene Green River formation: Torrey Bot. Club, Bull., vol. 60, p. 479-524, 54 figs., 1 table.

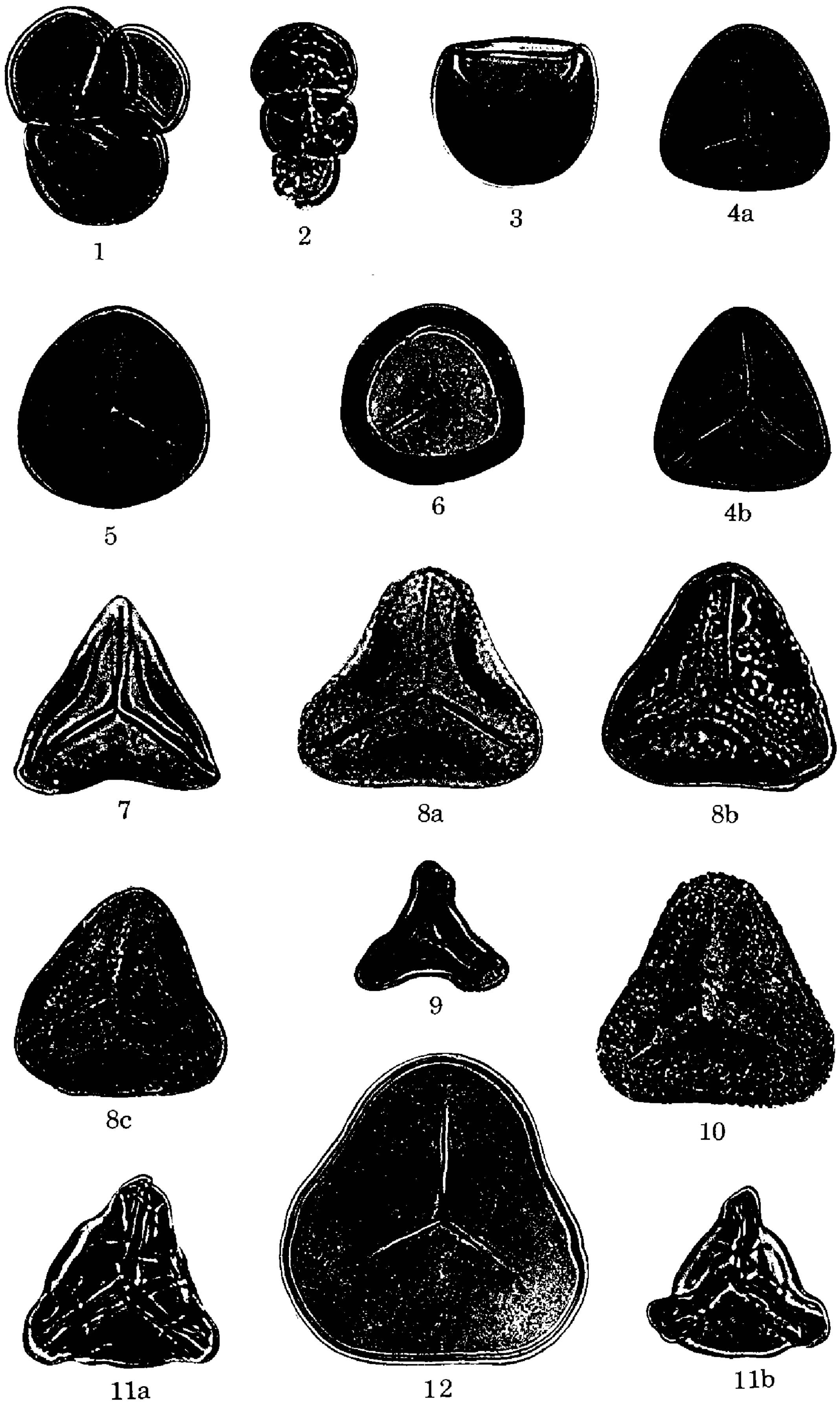
RED BRANCH PALYNOMORPHS

PLATES 1-10

Species	Plate
Alisporites bilateralis	7
Appendicisporites tricornitatus	4
Appendicisporites undosus	4
Aratrisporites monosaccatus	6
Balmeisporites glenelgensis	5
Calamospora cf. *C. mesozoica*	2
Camarozonosporites rudis	3
Cicatricosisporites crassiterminatus	4
Cicatricosisporites dorogensis	3
Cingulatisporites cf. *C. levispeciosus*	1
Classopollis cf. *C. obidosensis*	6
Concavisporites cf. *C. jurienensis*	1
Concavisporites subgranulosus	1
Concavisporites sp.	1
Cyathidites australis	1
Cyathidites minor	2
Cyathidites punctatus	2
Deltoidospora hallii	1
Ephedripites ambiguus	8
Ephedripites multicostatus	8
Eucommiidites troedssonii	6
Eucommiidites sp.	6
Foveoinaperturites cf. *F. forameniferus*	7
Fungus spore type A	1
Fungus spore type B	1
Fungus spore type C	1
Gleicheniidites confossus	1
Gleicheniidites senonicus	1
Inaperturopollenites cf. *I. magnus*	7
Laevigatosporites granaperturus	5
Laevigatosporites irroratus	5
Laevigatosporites ovatus	5
Laevigatosporites sp.	5
Liliacidites dividuus	8
Liliacidites cf. *L. variegatus*	8
Liquidambarpollenites sp.	9
Lycopodiacidites arcuatus	3
Lycopodiacidites cf. *L. kuepperi*	3
Lycopodiumsporites crassimacerius	3
Matonisporites cf. *M. equiexinus*	2
Matonisporites impensus	2
Monosulcites cf. *M. carpentieri*	8
Monosulcites inspissatus	8
Monosulcites minimus	8
Monosulcites sp.	8
Osmundacidites cf. *O. comaumensis*	2
Osmundacidites wellmanii	2
Palmaepollenites minusculus	9
Palmaepollenites cf. *P. tranquillus*	8
Parvisaccites granisaccus	6
Parvisaccites sp.	6
Perinopollenites cf. *P. elatoides*	9
Piceaepollenites cf. *P. alatus*	7
Pistillipollenites mcgregorii	9
Pustulipollis ellipticus	8
Rugubivesiculites woodbinensis	7
Schizaeoisporites cf. *S. phaseolus*	5
Schizosporis majusculus	10
Schizosporis parvus	10
Schizosporis reticulatus	10
Schizosporis spriggi	10
Simplicesporites cf. *S. virgatus*	8
Spermatites cf. *S. nanus*	10
Sphagnumsporites psilatus	1
Spore type A	4
Stephanocolpites tectorius	9
Taxodiaceaepollenites hiatus	7
Todisporites minor	2
Tricolpites erugatus	9
Tricolpites cf. *T. reticulatus*	9
Tricolporopollenites aliquantulus	9
Trilites sp.	2
Tsugaepollenites nexosus	6
Verrucatosporites pseudoreticulatus	5
Verrucatosporites sp.	5

Plate 1

		Page
1.	**Fungus spore type A** **OPC 843 F-5-2; 20.5 microns, 18.4 microns, 16.2 microns**	**10**
2.	**Fungus spore type B** **OPC 843 H-6-1; 27.5 microns by 15 microns**	**10**
3.	**Fungus spore type C** **OPC 845 I-2-1; 20 microns by 25 microns**	**10**
4.	Deltoidospora hallii **Miner, 1935** **a. OPC 845 F-5-1; 31.3 microns by 32.4 microns** **b. OPC 845 F-3-3; 32.4 microns by 34.6 microns**	**10**
5.	Sphagnumsporites psilatus **(Ross, 1949) Couper, 1958** **OPC 844 J-28-1; 28.1 microns**	**11**
6.	Cingulatisporites **cf.** C. levispeciosus **Pflug, 1953** **OPC 845 I-17-2; 35 microns**	**16**
7.	Gleicheniidites senonicus **(Ross, 1949) Delcourt and Sprumont, 1955** **OPC 845 J-20, 60.9 x 114.9; 29 microns**	**16**
8.	Gleicheniidites confossus, **new species** **a. OPC 843 H-7-1; 35 microns** **b. Holotype OPC 843 E-2-4; 32.4 microns by 33.5 microns** **c. OPC 845 J-3, 44.1 x 113.1; 42 microns**	**17**
9.	Concavisporites sp. **OPC 844 K-21-6; 16.2 microns by 17.3 microns**	**13**
10.	Concavisporites subgranulosus **Couper, 1958** **OPC 845 A-13-1; 42.5 microns by 45 microns**	**12**
11.	Concavisporites **cf.** C. jurienensis **Balme, 1957** **a. OPC 821 A-1-1; 26 microns by 27 microns** **b. OPC 821 A-5-1; 22.5 microns by 27 microns**	**12**
12.	Cyathidites australis **Couper, 1953** **OPC 843 E-2-3; 55.1 microns by 59.4 microns**	**11**


1
2
3
4a
5
6
4b
7
8a
8b
8c
9
10
11a
12
11b

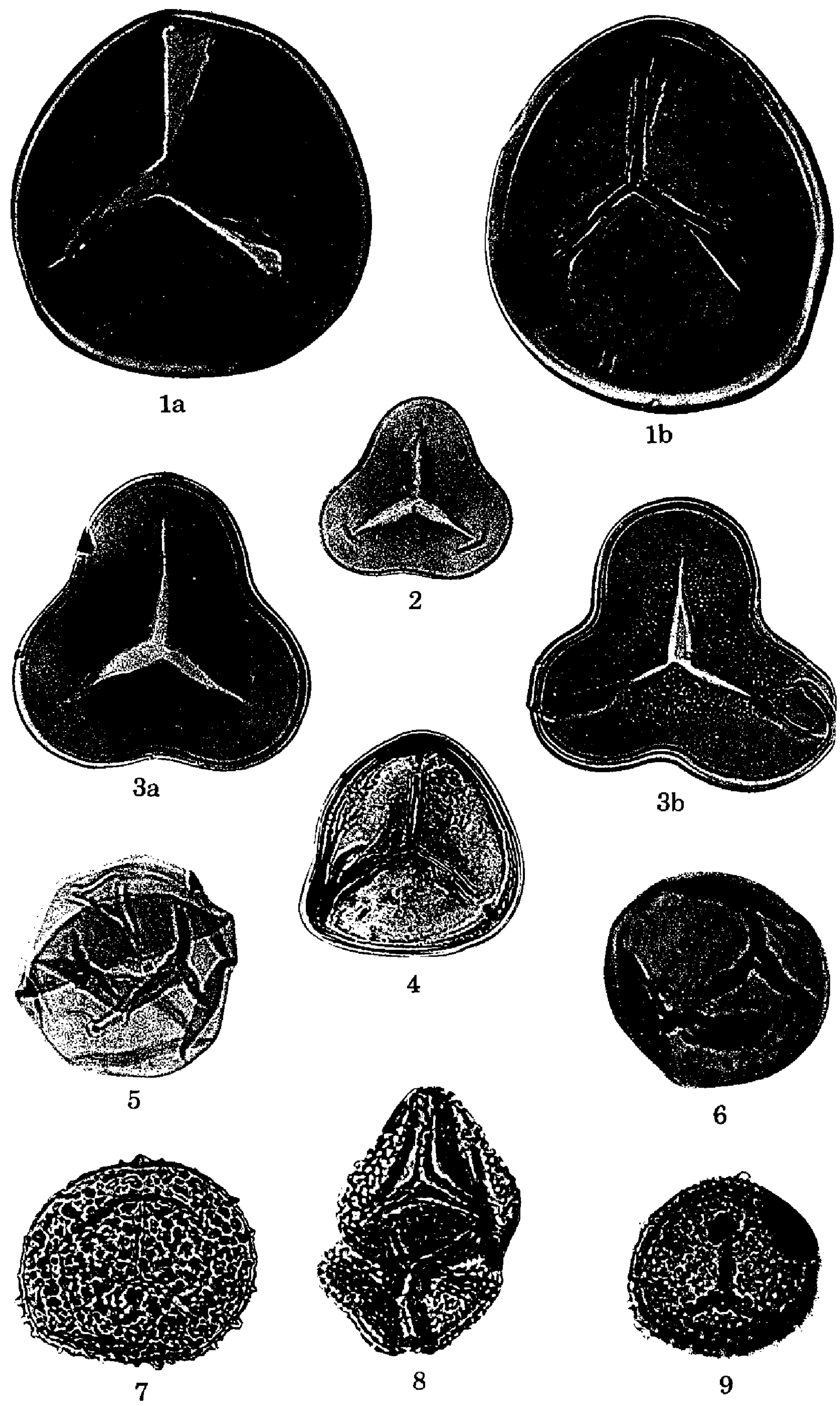
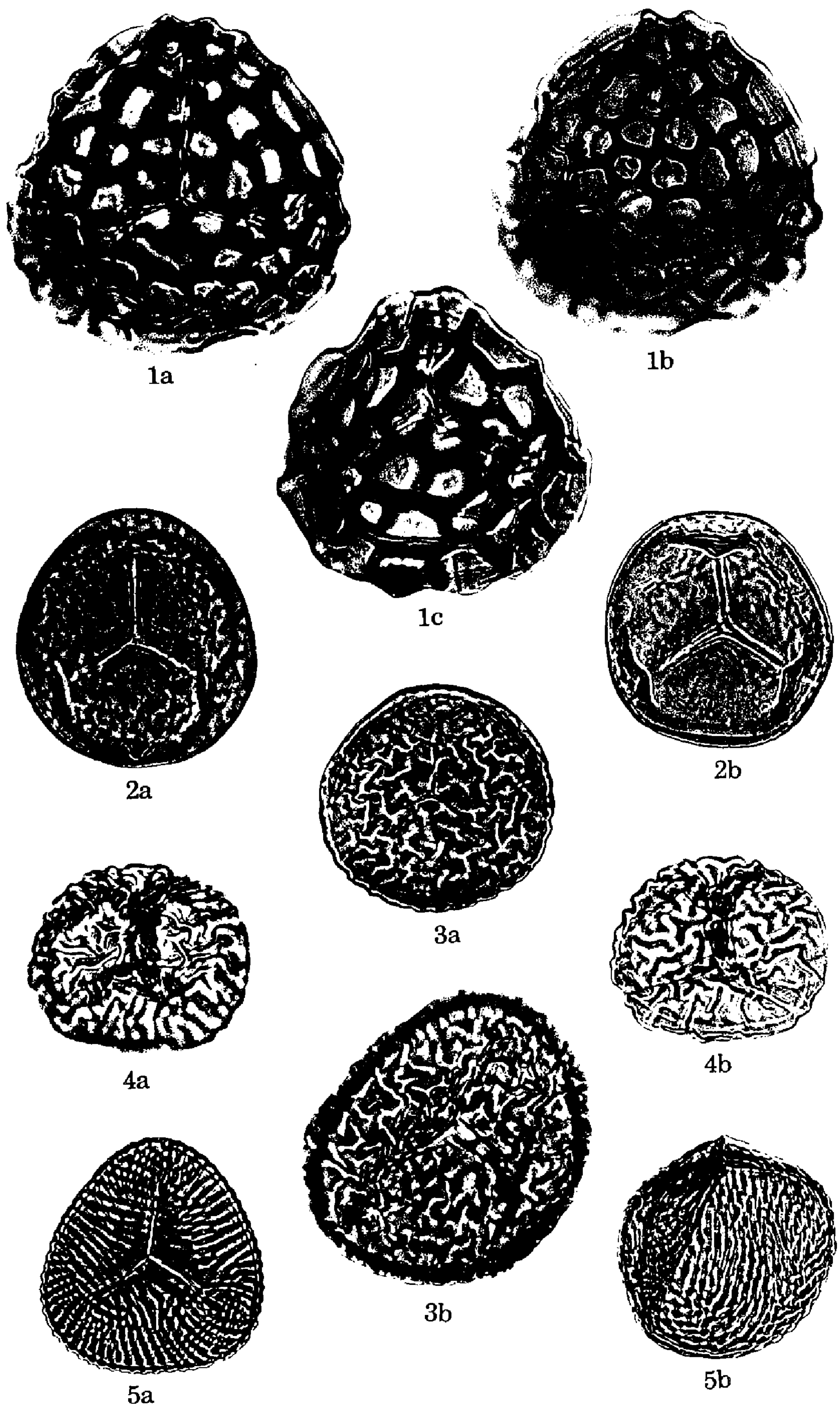

1a
1b
2
3a
3b
4
5
6
7
8
9

Plate 2

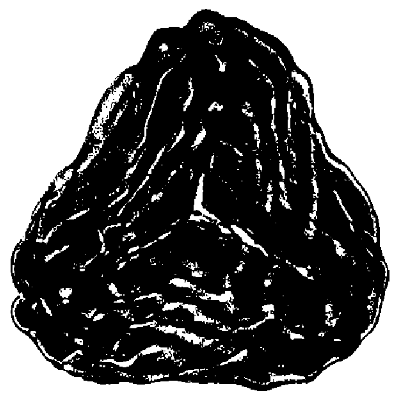
		Page
1.	Matonisporites impensus, **new species**	**13**
	a. OPC 845 F-1, 54.5 x 113.4; 75 microns by 76 microns	
	b. Holotype OPC 845 I-14-2; 69.5 microns by 71.5 microns by 75 microns	
2.	Cyathidites minor **Couper, 1953**	**12**
	OPC 845 I-14-1; 37.4 microns	
3.	Cyathidites punctatus **(Delcourt and Sprumont, 1955) Delcourt, Dettmann, and Hughes, 1963**	**11**
	a. OPC 843 H-4-1; 57.5 microns	
	b. OPC 843 H-6-2b; 51 microns by 52 microns by 56 microns	
4.	Matonisporites **cf.** M. equiexinus **Couper, 1958**	**13**
	OPC 844 I-10-4; 48 microns	
5.	Calamospora **cf.** C. mesozoica **Couper, 1958**	**13**
	OPC 844 H-25-9; 43.2 microns	
6.	Todisporites minor **Couper, 1958**	**14**
	OPC 844 K-21-3; 24 microns by 26 microns	
7.	Osmundacidites wellmanii **Couper, 1953**	**14**
	OPC 844 J-2-2; 46.4 microns	
8.	Trilites **sp.**	**14**
	OPC 845 H-12-3; 25 microns	
9.	Osmundacidites **cf.** O. comaumensis **(Cookson, 1953) Cookson and Dettmann, 1958**	**15**
	OPC 844 D-1-3; 37.8 microns	

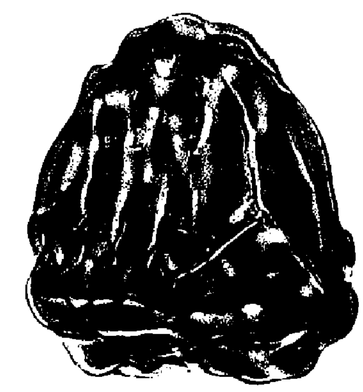
Plate 3

		Page
1.	Lycopodiumsporites crassimacerius, **new species**	**19**
	a, b. Holotype OPC 842 E-4-2; 62.6 microns by 63.7 microns; proximal (a) and distal (b) foci	
	c. OPC 842 D-1-2; 61 microns	
2.	Lycopodiacidites arcuatus, **new species**	**18**
	a. OPC 844 K-11-5; 45.5 microns by 47.5 microns by 48.7 microns	
	b. Holotype OPC 844 K-21-4; 43.2 microns by 45.4 microns	
3.	Camarozonosporites rudis **(Leschik, 1955) Klaus, 1960**	**17**
	a. OPC 824 E-1-1; 43.2 microns	
	b. OPC 844 H-12-2; 40 microns by 47 microns	
4.	Lycopodiacidites **cf.** L. kuepperi **Klaus, 1960**	**18**
	OPC 844 K-12-1; 42.1 microns; distal (a) and proximal (b) foci	
5.	Cicatricosisporites dorogensis **R. Potonié and Gelletich, 1933**	**18**
	a. OPC 843 H-6-1; 43.2 microns by 45.6 microns	
	b. OPC 843 H-2-1; 63.7 microns	

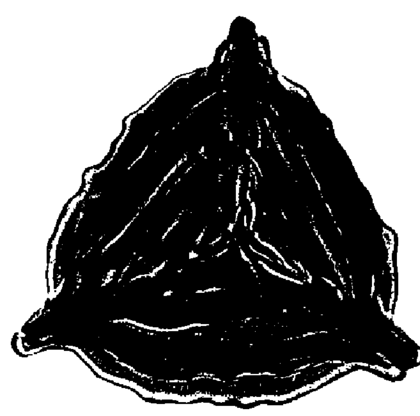


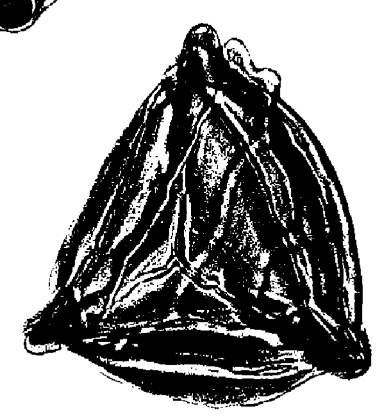
1a
1b
1c
2a
2b
3a
4a
4b
3b
5a
5b


1a

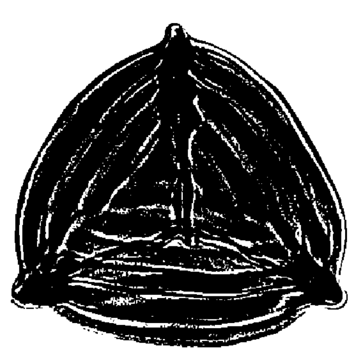

1b


1c


2a


2b


3


4a

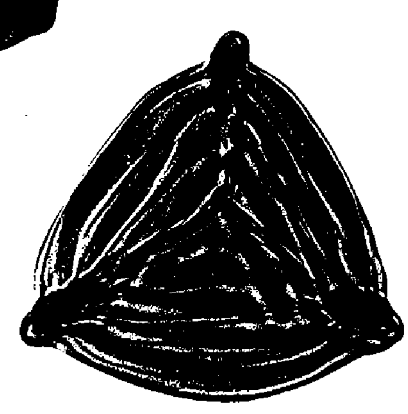
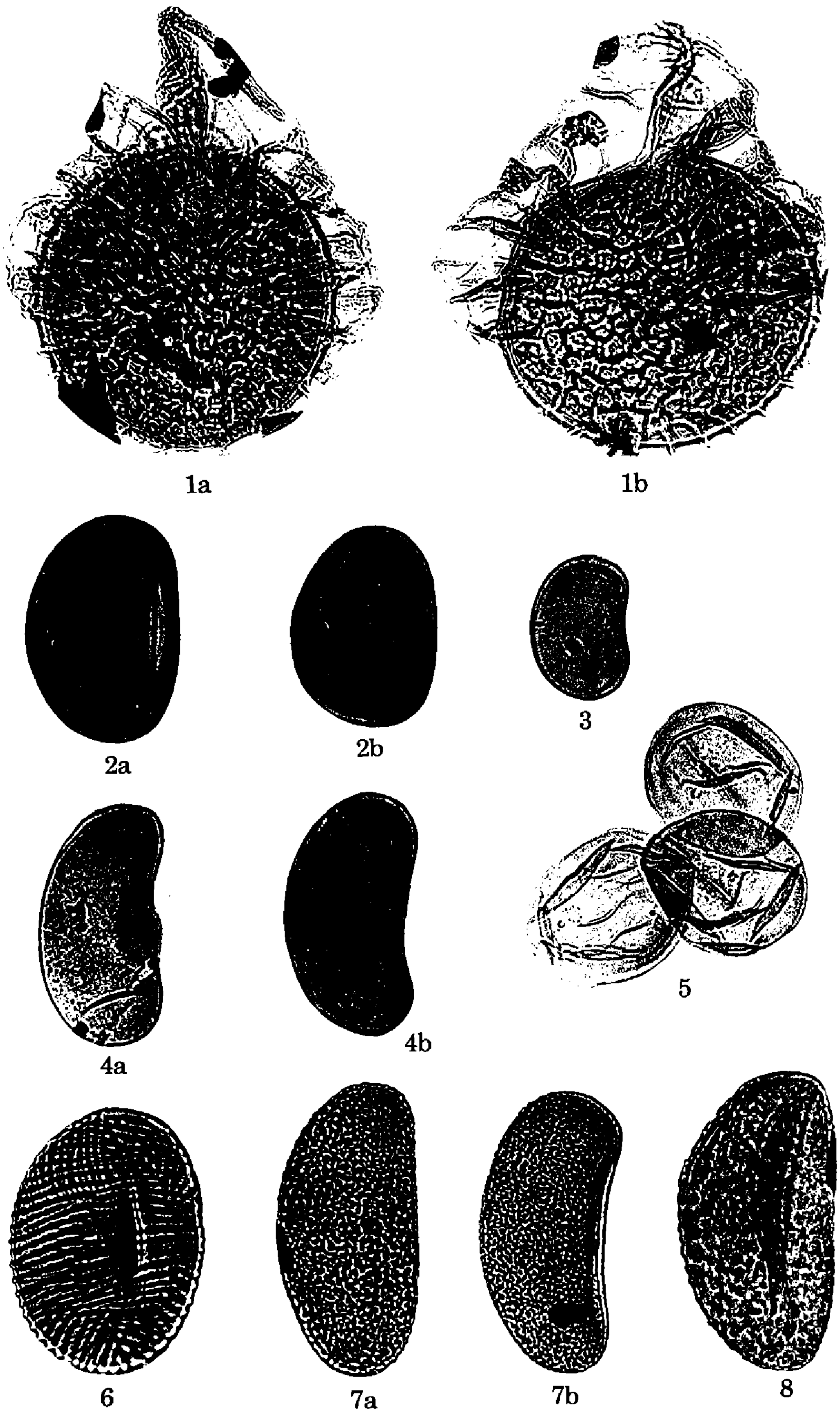

4b

Plate 4

		Page
1.	Cicatricosisporites crassiterminatus, **new species**	**19**
	a. Holotype OPC 843 A-5-2; 56.2 microns	
	b. OPC 843 A-3-2; 54 microns by 59 microns	
	c. OPC 843 A-2-1; 52 microns by 53 microns	
2.	Appendicisporites undosus, **new species**	**16**
	a. Holotype OPC 843 H-1-2; 61.6 microns by 62.6 microns	
	b. OPC 843 I-1, 56.6 x 120; 55 microns by 58 microns by 61 microns	
3.	**Spore type A**	**16**
	OPC 843 A-2, 50.5 x 114.8; 46 microns	
4.	Appendicisporites tricornitatus **Weyland and Greifeld, 1953**	**15**
	a. OPC 843 H-6-2a; 48.6 microns by 50.8 microns	
	b. OPC 844 K-6-2; 60 microns	

Plate 5

		Page
1.	Balmeisporites glenelgensis **Cookson and Dettmann, 1958**	**15**
	a. OPC 843 I-4-1; 187.5 microns	
	b. OPC 844 J-20-1; 187.5 microns	
2.	Laevigatosporites ovatus **Wilson and Webster, 1946**	**20**
	a. OPC 845 F-1-3; 25 microns by 46 microns	
	b. OPC 843 E-9-1; 29.2 microns by 37.8 microns	
3.	Laevigatosporites **sp.**	**20**
	OPC 844 B-2-1; 15 microns by 20 microns	
4.	Laevigatosporites irroratus, **new species**	**20**
	a. Holotype OPC 842 E-10-2; 22.5 microns by 47.5 microns	
	b. OPC 845 I-14, 48.4 x 117.6; 24 microns by 48 microns	
5.	Laevigatosporites granaperturus, **new species**	**20**
	Syntypes OPC 843 H-1-1; 32.4 microns, 27 microns, 34.6 microns	
6.	Schizaeoisporites **cf.** S. phaseolus **Delcourt and Sprumont, 1955**	**21**
	OPC 844 K-14-1; 37.5 microns by 52.4 microns	
7.	Verrucatosporites pseudoreticulatus, **new species**	**21**
	a. Holotype OPC 844 H-24-1; 27 microns by 55.1 microns	
	b. OPC 844 H-25-2; 26 microns by 58.5 microns	
8.	Verrucatosporites **sp.**	**21**
	OPC 824 D-7-2; 30 microns by 60 microns	


1a
1b
2a
2b
3
4a
4b
5
6
7a
7b
8

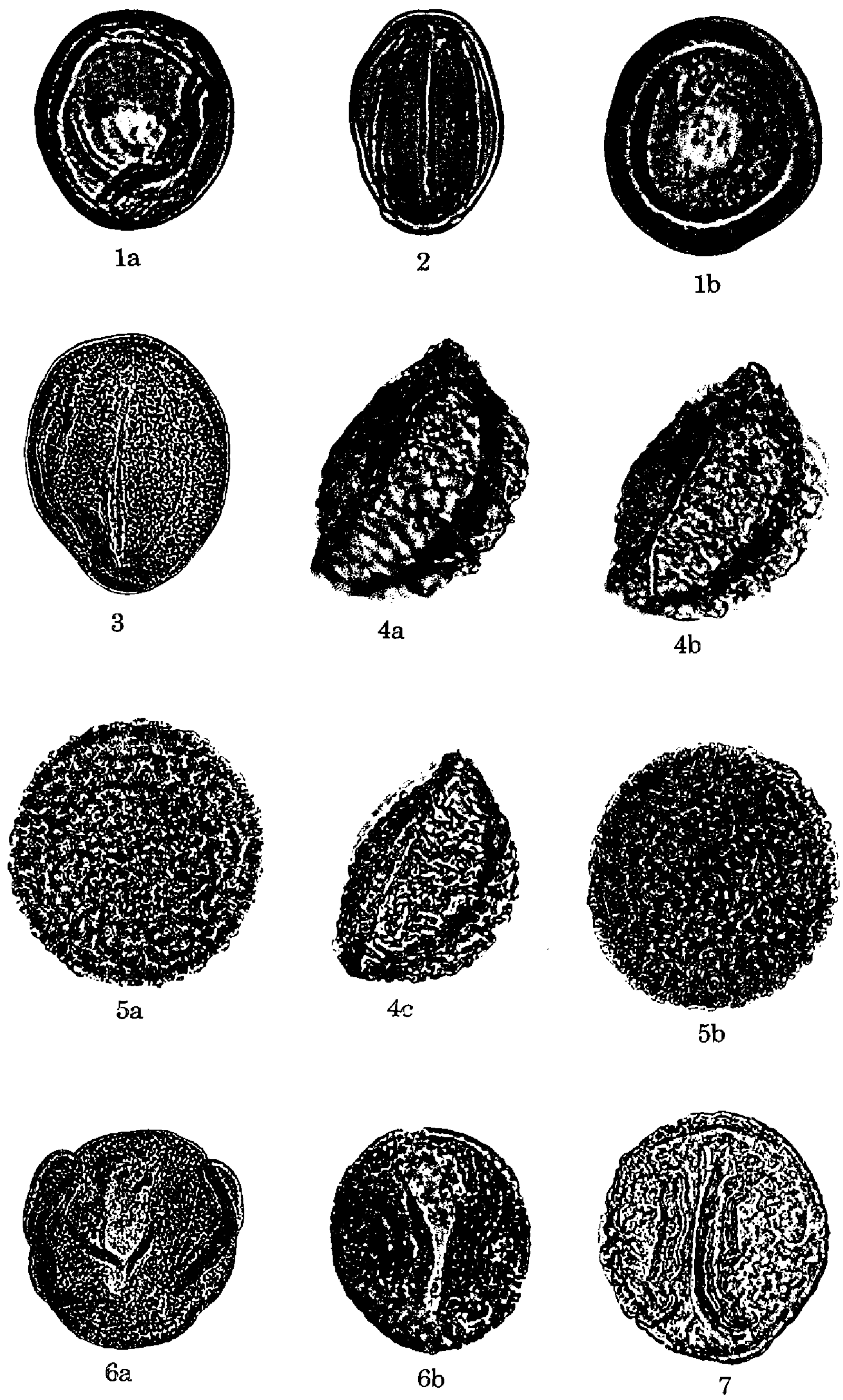
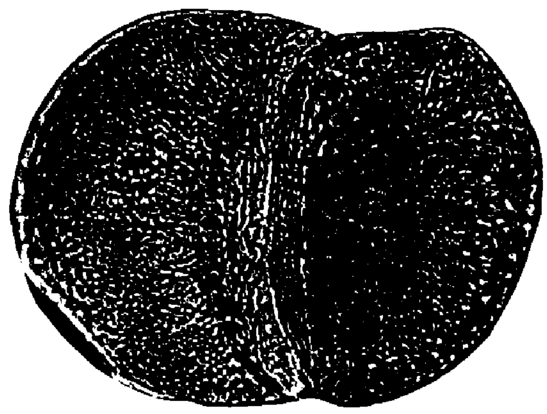

1a
2
1b
3
4a
4b
5a
4c
5b
6a
6b
7

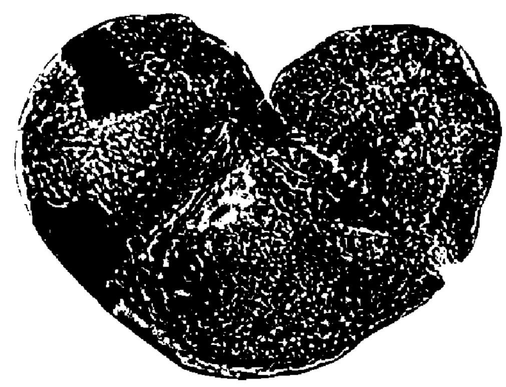
Plate 6

		Page
1.	Classopollis cf. C. obidosensis **Groot and Groot, 1962**	**26**
	a. OPC 844 H-11-1; 23.7 microns by 25 microns	
	b. OPC 844 J-24-1; 25 microns	
2.	Eucommiidites troedssonii **Erdtman, 1948**	**26**
	OPC 845 I-3-7; 17.3 microns by 26 microns	
3.	Eucommiidites **sp.**	**26**
	OPC 843 H-2-1; 39 microns by 50 microns	
4.	Aratrisporites monosaccatus, **new species**	**21**
	a,b. Holotype OPC 842 C-7-3; 29.2 microns	
	c. OPC 842 C-7, 54 x 114; 25 microns by 37 microns	
5.	Tsugaepollenites nexosus, **new species**	**22**
	a. Holotype OPC 843 E-8-6; 50.8 microns	
	b. OPC 843 E-8-5; 50 microns	
6.	Parvisaccites granisaccus, **new species**	**22**
	a. Holotype OPC 821 D-14-1; 39 microns by 43.2 microns	
	b. OPC 824 F-10, 51.9 x 119.1; 34 microns	
7.	Parvisaccites **sp.**	**23**
	OPC 824 E-6-2; 43.2 microns	

Plate 7

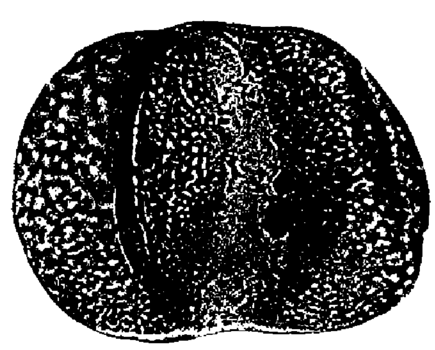
	Page
1. Piceaepollenites cf. P. alatus **R. Potonié, 1931**	**23**
a. **OPC 843 H-1-3; 36.7 microns by 77.8 microns**	
b. **OPC 844 K-21-1; 70.2 microns**	
2. Rugubivesiculites woodbinensis, **new species**	**23**
a. **Holotype OPC 844 J-26-1; 75.6 microns**	
b. **OPC 843 I-1-1; 51 microns by 66 microns**	
3. Alisporites bilateralis **Rouse, 1959**	**23**
OPC 843 A-1-6; 49 microns by 65 microns	
4. Inaperturopollenites cf. I. magnus **(R. Potonié, 1934) Thomson and Pflug, 1953**	**24**
OPC 845 F-1-5; 55 microns by 67 microns	
5. Foveoinaperturites **cf.** F. forameniferus **Pierce, 1961**	**24**
a. **OPC 821 G-10-1; 43.2 microns by 46.4 microns**	
b. **OPC 822 B-18-1; 37.8 microns by 43.2 microns**	
6. Taxodiaceaepollenites hiatus **(R. Potonié, 1931) Kremp, 1949**	**25**
OPC 844 H-12-4; 30 microns	


1a


1b


2a

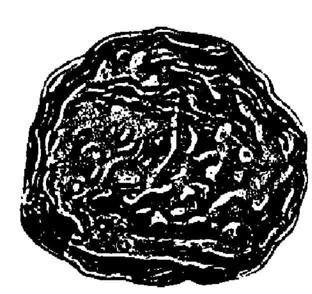

2b


3


4


5a


6


5b

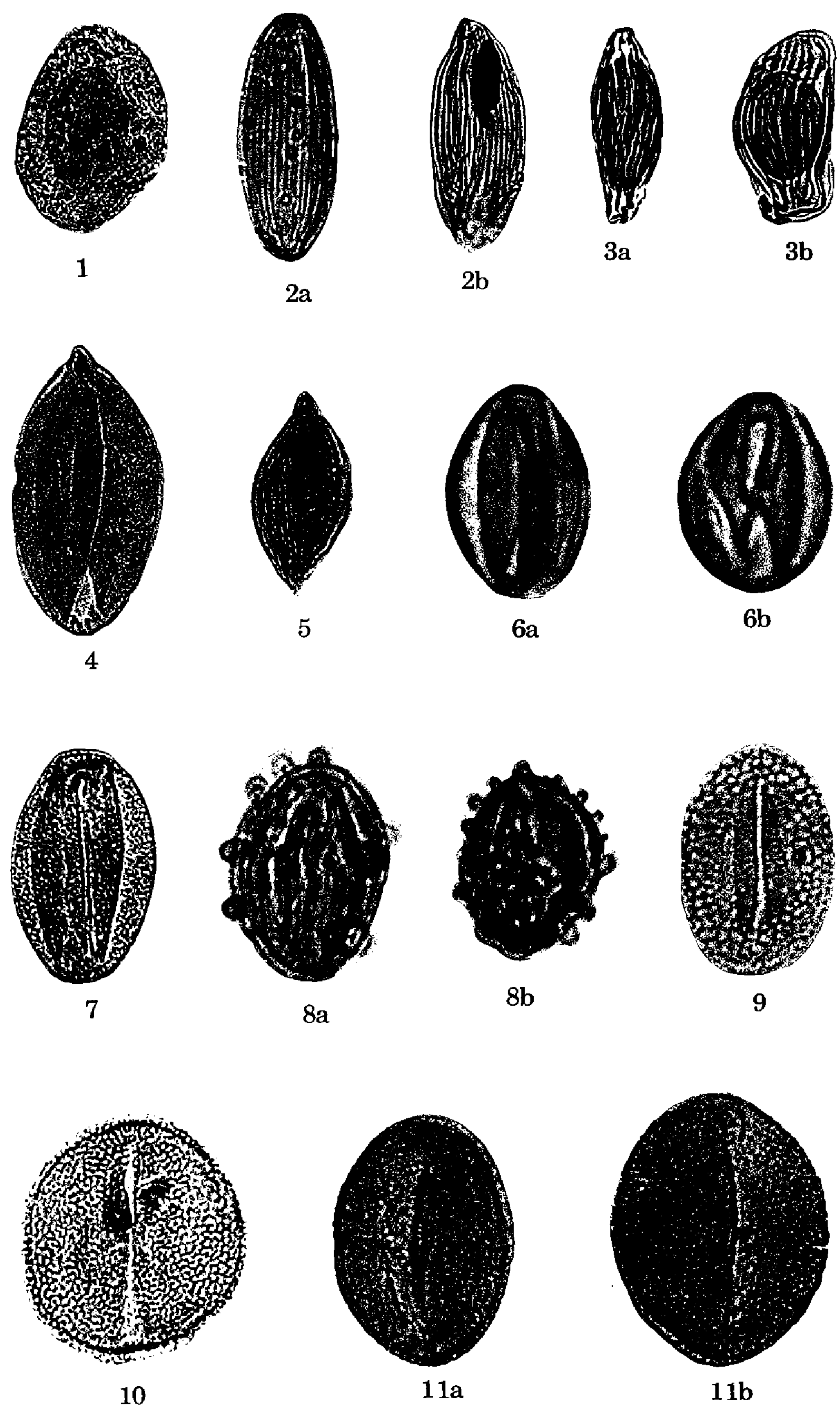

1
2a
2b
3a
3b
4
5
6a
6b
7
8a
8b
9
10
11a
11b

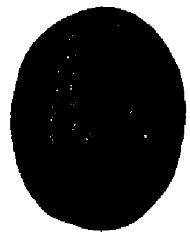
Plate 8

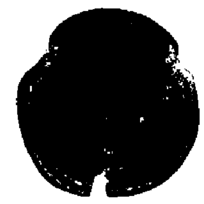
		Page
1.	Simplicesporites cf. S. virgatus **Leschik, 1955** **OPC 844 E-23-1; 29 microns by 38.9 microns**	25
2.	Ephedripites multicostatus **Brenner, 1963** **a. OPC 842 C-7-4; 14 microns by 35.1 microns** **b. OPC 821 B-2-1; 20 microns by 46 microns**	27
3.	Ephedripites ambiguus, **new species** **a. OPC 824 D-3-1; 17 microns by 36 microns** **b. Holotype OPC 824 D-7-1; 20 microns by 37.5 microns**	27
4.	Monosulcites **cf.** M. carpentieri **Delcourt and Sprumont, 1955** **OPC 844 K-7-6; 29.2 microns by 66 microns**	28
5.	Monosulcites minimus **Cookson, 1947** **OPC 821 D-15-1; 18.4 microns by 38 microns**	28
6.	Monosulcites inspissatus, **new species** **a. Holotype OPC 844 G-6-2; 8.6 microns by 15 microns** **b. OPC 844 G-6, 45.5 x 121.2; 11 microns by 14 microns**	28
7.	Monosulcites **sp.** **OPC 824 F-4, 46.8 x 127; 22 microns by 36 microns**	28
8.	Pustulipollis ellipticus, **new genus, new species** **a. OPC 844 J-13-3; 13 microns by 18.4 microns** **b. Holotype OPC 844 J-22-1; 13 microns by 16.2 microns**	27
9.	Liliacidites **cf.** L. variegatus **Couper, 1953** **OPC 824 F-10-2; 17.5 microns by 27.5 microns**	28
10.	Liliacidites dividuus **(Pierce, 1961) Brenner, 1963** **OPC 845 J-3-1; 33.5 microns by 36.7 microns**	29
11.	Palmaepollenites cf. P. tranquillus **(R. Potonié, 1934) R. Potonié, 1951** **a. OPC 845 F-1-7; 21.6 microns by 29.2 microns** **b. OPC 845 F-18-3; 24.8 microns by 31.3 microns**	29

Plate 9

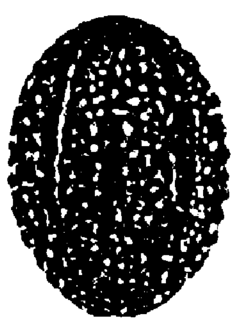
		Page
1.	Palmaepollenites minusculus, **new species**	**29**
	a. Holotype OPC 844 K-7-1a; 12 microns by 15 microns	
	b. OPC 844 K-7-1b; 12 microns by 16 microns	
2.	Tricolpites erugatus, **new species**	**30**
	a. Holotype OPC 845 F-1-4; 13 microns by 17.3 microns	
	b. OPC 845 D-19, 29.5 x 118.6; 15 microns	
3.	Tricolpites **cf.** T. reticulatus **Cookson, 1947**	**29**
	a. OPC 844 J-13-1; 20.5 microns by 27 microns	
	b. OPC 844 K-11-4; 25 microns	
	c. OPC 845 D-19-3; 25 microns by 32.5 microns	
	d. OPC 844 J-22-2; 20.5 microns by 23.8 microns	
4.	Tricolporopollenites aliquantulus, **new species**	**30**
	a. Holotype OPC 844 H-25-11; 10.8 microns by 15.1 microns	
	b. OPC 824 D-10-1; 10.8 microns by 11.1 microns	
5.	Perinopollenites **cf.** P. elatoides **Couper, 1958**	**25**
	OPC 844 D-1-4; 32.4 microns by 37.8 microns	
6.	Pistillipollenites mcgregorii **Rouse, 1962**	**31**
	OPC 844 G-17-1; 17.5 microns	
7.	Liquidambarpollenites **sp.**	**31**
	OPC 845 I-3-1; 27.5 microns	
8.	Stephanocolpites tectorius, **new species**	**30**
	a. OPC 843 I-1-4; 36.7 microns by 70 microns	
	b. Holotype OPC 843 I-1-5; 42 microns by 81 microns	

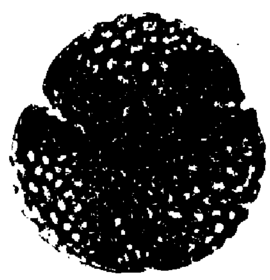

1a


2a


2b


1b


3a


3b

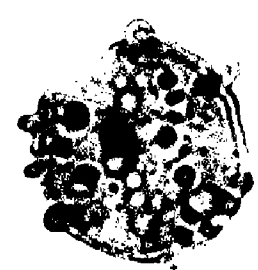

3c

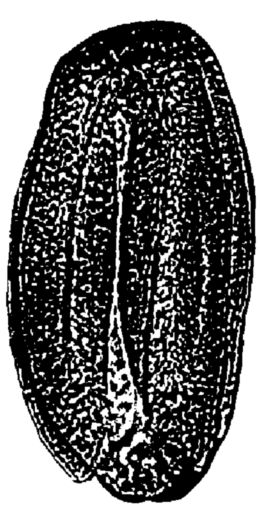

3d

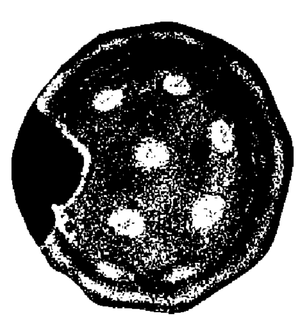

4a

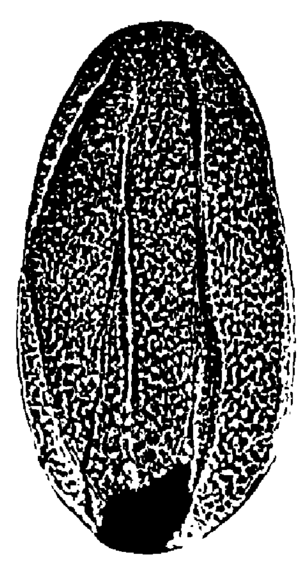

4b


5


6


8a


7


8b

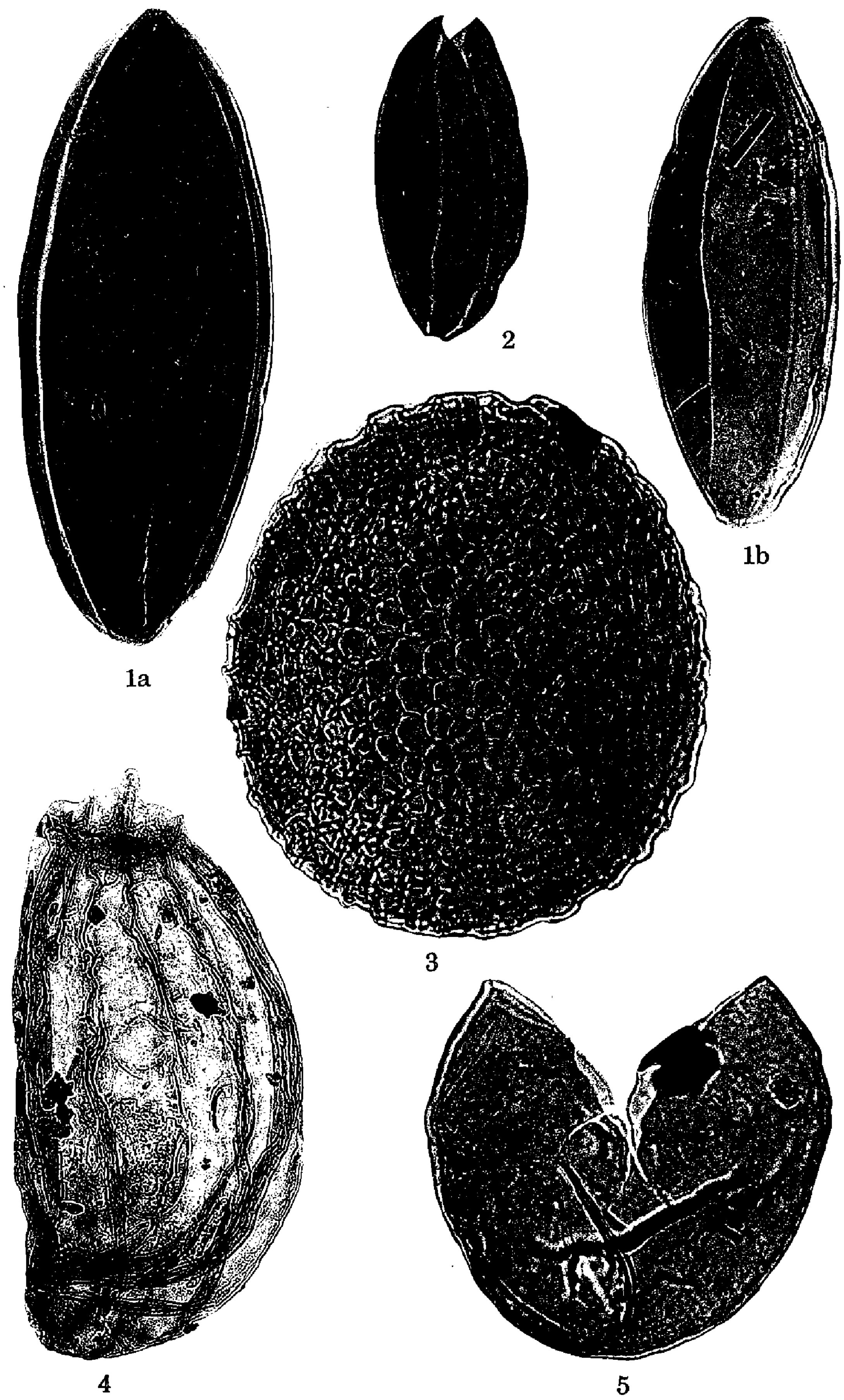

2
1b
1a
3
4
5

Plate 10

		Page
1.	Schizosporis majusculus, **new species**	**32**
	a. Holotype OPC 844 G-9-1; 48.6 microns by 147.5 microns	
	b. OPC 842 D-3-1; 79 microns by 199.5 microns	
2.	Schizosporis parvus **Cookson and Dettmann, 1959**	**32**
	OPC 844 J-2-3; 31 microns by 66 microns	
3.	Schizosporis reticulatus **Cookson and Dettmann, 1959**	**32**
	OPC 844 K-13-1; 120 microns by 130 microns	
4.	Spermatites **cf.** S. nanus **Miner, 1935**	**33**
	OPC 845 A-4-1; 261.6 microns by 501.4 microns	
5.	Schizosporis spriggi **Cookson and Dettmann, 1959**	**32**
	OPC 821 H-1-1; 80 microns	

APPENDIX

Measured Sections and Samples

OPC 821

SW¼ SW¼ SE¼ sec. 21, T. 7 S., R. 12 E.

East bank of Sulphur Creek, cliff exposed along creek and extending north to south.

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
	Shale, blue clayey; yellow siltstone lenses	24.0
I	Coal, black, blocky; selenite crystals	2.0
	Shale, purple, carbonaceous; yellow siltstone lenses	8.0
	Shale, blue; grading downward into purple shale	20.0
F-H	Coal, black; yellow silt spots	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
C-E	Coal, black, blocky	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
B	Coal, black, blocky; in brown mudstone	0.75
	Mudstone, brown	24.0
A	Coal, black, blocky	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
	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

OPC 822

SW¼ NW¼ NW¼ sec. 22, T. 7 S., R. 11 E.

Roadcut approximately 100 feet north of hilltop, facing eastward.

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
	Sandstone, brown, massive, resistant; with ferruginous nodules and stains	60.0
L	Shale, brown, weathered; and sandstone, brown, interlayered	42.0
K	Shale, purple, blocky, irregularly layered; some carbonaceous material	9.0
H-J	Coal, black, dull; yellow oxidized spotting	5.0
C-G	Shale, purple, carbonaceous; yellow oxidized lenses; selenite crystals	29.0
B	Coal, black, dull	3.0
A	Shale, purple, carbonaceous; yellow oxidized lenses; selenite crystals	7.0
	Total	155.0

OPC 823

NE¼ NE¼ NE¼ sec. 25, T. 7 S., R. 11 E.

West side of roadcut at section corner.

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
I	Shale, blue-gray, weathered; with yellow silt lenses	3.0
F-H	Coal, black, weathered	6.0

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
A-E	Shale, purple, carbonaceous, clayey; ⅛-inch yellow silt lenses	34.0
	Total	43.0

OPC 824

SE¼ SW¼ sec. 16, T. 7 S., R. 10 E.

Exposed in west bank of creek, 0.2 mile north of east-west section-line road and 200 feet west of north-south road.

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
M-O	Shale, brown, carbonaceous, weathered	14.0
G-L	Shale, purple, carbonaceous; with ½-inch coal 10.0 inches from base	27.0
D-F	Coal, black, shaley, oxidized	6.0
A-C	Shale, purple-gray, carbonaceous	16.0
	Total	63.0

OPC 842

SW¼ SW¼ SW¼ sec. 16, T. 7 S., R. 10 E.

Exposed in east bank of creek, approximately 360 feet north of the southwest corner of section 16, and approximately 50 feet east of section line.

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
H	Coal, brown, oxidized	2.0
	Shale, white, chalky	1.0
G	Coal, brown, stratified, soft, weathered	4.0
	Shale, purple, carbonaceous	48.0
F	Coal, black, blocky, weathered	2.0
E	Shale, black, carbonaceous; with ½-inch coal 3 inches from base	6.0
D	Coal, black, blocky	2.0
C	Shale, purplish-gray, carbonaceous; selenite crystals	15.5
B	Coal, black, blocky; selenite crystals	2.0
A*	Shale, black, carbonaceous	41.0
	Total	123.5

*From upper 2 inches.

OPC 843

NW¼ NE¼ SW¼ sec. 23, T. 7 S., R. 11 E.

Exposed on east bank of creek, approximately 0.25 mile east of west edge of section 23.

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
	Shale, purple; interbedded with yellow silt	10.0
	Siltstone, yellow, resistant	12.0
H, I	Coal, black, blocky	4.0
	Shale, purple, carbonaceous	42.0
E-G	Coal, black, blocky	6.0
	Clay; blue at base to white	24.0
D	Shale; purple at base, grading upward to black, carbonaceous shale with carbonized plant fragments. Coal (¼-inch) about 1 foot from top of unit	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
A-C	Coal, black, layered; with numerous plant fibers	6.0
	Clay; blue-green at base, grading upward to purple	15.0
	Sandstone, gray-green; with *Ostrea solenisca* scattered in lower 24 inches and abundant in a 2-inch zone 24 inches from base of unit	34.0
	Total	328.0

OPC 844

NW¼ SE¼ sec. 24, T. 7 S., R. 12 E.

Exposed in eastward-facing bluff, about 30 feet high.

SAMPLE (S)	LITHOLOGY	THICKNESS (INCHES)
	Shale, black, carbonaceous	22.0
D-K	Coal, black, blocky, layered	17.0
	Shale, black, carbonaceous; with selenite crystals	120.0
A-C	Coal, black; and carbonaceous shale	5.0
	Shale, gray, carbonaceous	128.0
	Total	292.0

OPC 845

NE¼ sec. 28, T. 7 S., R. 12 E. NW¼ NW¼

Exposed in cliff on east bank of Sulphur Creek approximately 0.5 mile east of section-line road.

SAMPLE(S)	LITHOLOGY	THICKNESS (INCHES)
	Sandstone, brownish-red	144.0
	Covered interval	36.0
	Shale, blue-gray, silty, carbonaceous; yellow oxidation spots	12.0
	Shale, purple, carbonaceous; yellow oxidation spots; contains thin coal lenses	12.0
J-N	Coal, black, blocky; yellow oxidation spots; selenite crystals	10.0
I	Shale, black, carbonaceous; yellow oxidation spots	10.0
F-H	Coal, black, blocky	6.0
E	Shale, black; carbonaceous in upper part with ¼-inch coal; grades downward into blue-gray shale	14.0
B-D	Coal, black, blocky	6.0
A	Shale, black; carbonaceous in upper part; grading downward into blue, silty shale	36.0
	Total	286.0

INDEX

(*Italic number* indicates main reference)