

CAMPANIAN-MAESTRICHTIAN AND PALEOCENE DINOFLAGELLATE AND ACRITARCH
ASSEMBLAGES FROM THE MARYLAND-DELAWARE COASTAL PLAIN

by

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INTRODUCTION

General Statement

The present study constitutes a systematic, biostratigraphic and paleoecologic treatment of dinoflagellate and acritarch assemblages from Campanian-Maestrichtian and Paleocene strata of the Maryland-Delaware Coastal Plain. The work of McLean (1969) revealed the presence of diverse, excellently-preserved phytoplankton assemblages in Lower Tertiary strata of the Aquia (Paleocene) and basal Nanjemoy (Eocene) formations of Virginia (Text-fig. 1). The present writer elected to investigate the phytoplankton assemblages of older strata within the region, as part of a concerted effort at VPI & SU to establish a standard dinoflagellate succession for the Atlantic Coastal Plain. The present study provides critical onshore control for the correlation of coastal plain strata with strata of the continental shelf bordering the eastern United States.

Preliminary samples were collected by the writer in April, 1971, from the Upper Cretaceous Monmouth and Mount Laurel formations and the Paleocene Brightseat Formation of the Maryland-Delaware Coastal Plain. Samples used in this study were collected in July, 1971. Samples were collected from scattered outcrops between Ft. Washington, Maryland, and the eastern end of the Chesapeake and Delaware Canal, about 12 miles south of Wilmington, Delaware (Text-fig. 2). Localities for this study were chosen on the basis of the greatest diversity and best preservation of the phytoplankton; good stratigraphic control was also a requisite.

The writer originally intended to investigate the entire Upper Cretaceous marine section of the Maryland-Delaware Coastal Plain. The oldest formation, the Merchantville (Text-fig. 1), was sampled on the north bank of the Chesapeake-Delaware Canal at Summit Bridge and along the Sassafrass River to the Chesapeake Bay (Text-figs. 2, 4). The Merchantville yielded diverse, distinctive assemblages of dinoflagellates; due to time limitations, however, description of these assemblages is postponed to a later date. Samples of the Marshalltown Formation (Text-fig. 1) collected at Summit Bridge were barren. The only accessible samples, however, were from the basal portion of the Marshalltown, and probably represent material reworked from the underlying Englishtown Formation, a fluvial to near-shore deposit (Owens et al., 1970). The Marshalltown, a fine-grained, open-marine shelf deposit (Owens et al., 1970), warrants further sampling for dinoflagellates. The writer processed and examined subsurface samples of the upper Mount Laurel Formation and the overlying Paleocene Hornerstown Formation from the vicinity of Odessa, Delaware, just south of the canal (Text-figs. 1, 2, 4). Few species represented by few, poorly-preserved specimens were recovered; the assemblage was not treated in this study.

Well-preserved, relatively diverse dinoflagellate assemblages were obtained in the vicinity of Annapolis, Maryland, on the Severn River at Round Bay (north shore) and on Long Point (south shore) (Text-fig. 2). At that time, the stratigraphic position of these strata was questionable, and the samples were not investigated in this study. Since then, J. P. Minard (USGS) has established the strata as belonging to the Monmouth

and Brightseat formations, and the Round Bay section has been investigated by Benson (1975).

Scope of this Investigation

The purpose of this investigation is as follows:

1. To clarify and expand the taxonomic concepts of the phytoplankton species, and to describe all new taxa.
2. To record the stratigraphic distribution of each species and to examine the Cretaceous-Tertiary boundary in terms of the last appearance of certain species and the first appearance of other species.
3. To compare the stratigraphically-restricted phytoplankton species with those previously described from other areas, particularly the type locality for the Maestrichtian Stage; to investigate the ages of the units studied; to compare implications of age based on stratigraphically-restricted species with implications based on other criteria, such as Foraminifera, ostracodes, and megafossils.
4. To investigate compositional changes in the assemblages throughout the section as evidence for paleoecological changes through time.

Previous Studies of Upper Cretaceous-Paleocene Phytoplankton

A taxonomic and biostratigraphic study of dinoflagellates of the

Upper Cretaceous Monmouth Group from the coastal plain of New Jersey is being completed by May (1976). A biostratigraphic investigation of Maestrichtian-Danian dinoflagellates near Annapolis, Maryland, has recently been completed by Benson (1975). Drugg (1967) described Maestrichtian-Paleocene assemblages from Fresno County, California; Zaitzeff and Cross (1970) studied Maestrichtian assemblages from the vicinity of Austin, Texas; and Stanley (1965) described a Paleocene assemblage from South Dakota.

Publications of Late Cretaceous-Paleocene phytoplankton assemblages from Europe are far more numerous. Taxonomic information for the present study was obtained from the work of Davey, Downie, Sarjeant, and Williams (1966) on Mesozoic and Cenozoic dinoflagellates from England. Papers on Senonian dinoflagellates by Deflandre (1934-1938, 1940) of France and Lejeune-Carpentier (1938-1940, 1944, 1946) of Belgium were particularly useful. Also useful were the papers of other European palynologists, notably, Gerlach (1961), Górká (1963), De Coninck (1965, 1969), Benedek (1972), Gocht (1968), Eisenack (1954, 1963a, 1963b), and Morgenroth (1966, 1968). A significant contribution is the taxonomic and biostratigraphic study by Wilson (1974) of dinoflagellates from the Maestrichtian type locality.

Upper Cretaceous and Paleocene dinoflagellates of Australia have been treated in the numerous taxonomic papers of Cookson and of Cookson and Eisenack.

GEOLOGY AND STRATIGRAPHY

Regional Geologic Framework

The Maryland-Delaware Coastal Plain is part of the Atlantic Coastal Plain Province, which extends from Massachusetts to Florida, and is flanked on the west by the Piedmont Plateau and on the east by the Atlantic Ocean. The Coastal Plain is a seaward-thickening wedge of marine, marginal marine, and continental strata which lies on igneous and metamorphic basement rocks of Pre-Cambrian and Paleozoic age. In the study-area, pre-Cretaceous warping of the basement created the Salisbury Embayment (Richards, 1948; Mahar, 1965), which is also known as the Chesapeake-Delaware Embayment (Stanley and Richards, 1948; Murray, 1961). Sediments of Early Cretaceous age filled the embayment (Glaser, 1971).

Detailed discussions of the Coastal Plain regional geology appear in Dorf (1942); Spangler and Pederson (1950); Stephenson, King, Monroe, and Imlay (1942); Murray (1961); and Le Grand (1961). For information concerning the Coastal Plain of Maryland and Delaware, see Fox and Olssen (1955); Groot and Gemeroth (1957); Dorf and Fox (1957); Minard, Owens, Sohl, Gill, and Mello (1969); Owens, Minard, Sohl, and Mello (1970). The Maryland Coastal Plain is discussed by Clark, Bagg, and Shattuck (1916); Little (1917); and Glaser (1968, 1971). The Delaware Coastal Plain is treated by Carter (1937); Groot, Organist, and Richards (1954); and Jordan (1962). The tectonic evolution of the Atlantic Coastal Plain is discussed by Owens and Minard (1960); Mahar

(1965, 1970, 1971); Gibson (1970); and Brown, Miller, and Swain (1972).

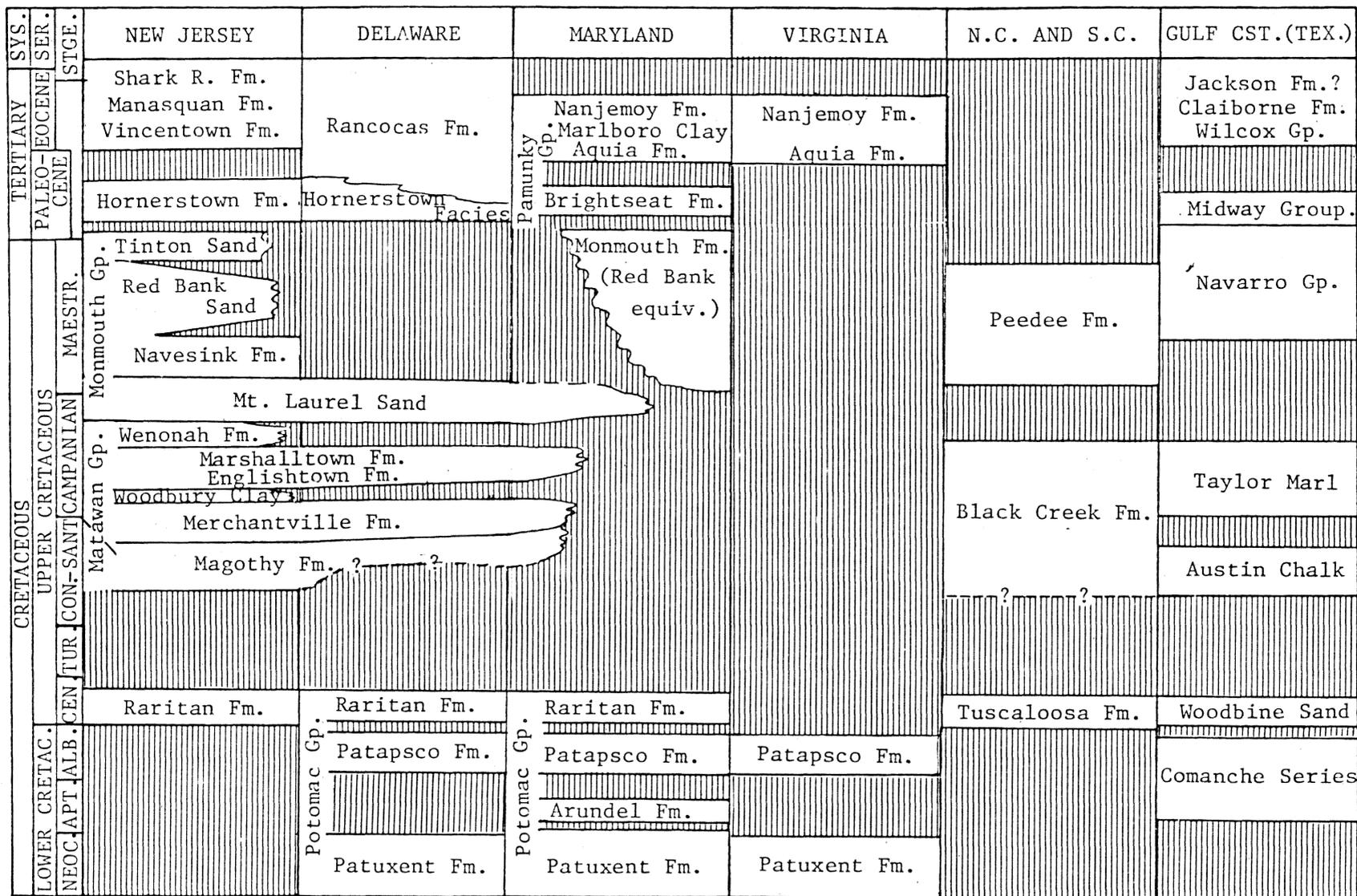
Cretaceous and Tertiary sediments appear in scattered outcrops between Raritan Bay, New Jersey, and the Potomac River in northern Virginia. The Chesapeake Bay and Delaware Bay divide the northeast-southwest trending belt of outcrops into three parts: New Jersey, the Delmarva Peninsula (east of Chesapeake Bay), and southern Maryland (west of Chesapeake Bay). The present study is concerned with the latter two areas.

Regional Stratigraphy

Upper Cretaceous Series

In 1868, Cook subdivided the Upper Cretaceous of New Jersey into the lower Clay Marl Series and the upper Marl Series. In 1897, Clark substituted the term Matawan Group for the Clay Marl Series, and the Monmouth, Rancocas, and Manasquan groups (in ascending order) for the Marl Series; each group was subdivided into several formations (Little, 1917) (Text-fig. 1). From 1894 to 1916, Clark and his associates traced most of the formations from New Jersey toward the southwest. In Maryland, they identified the Matawan, Monmouth, and Rancocas groups but were not able to subdivide them. Hence, the group names there became formation names (Little, 1917).

In 1893, Darton established the name Magothy Formation for the light-colored sands overlying the Potomac Group in northeastern Maryland. The Magothy, Matawan, Monmouth, and Rancocas formations were then considered to constitute the Upper Cretaceous sequence of



Text-fig. 1. Generalized correlation of outcropping Cretaceous - Lower Tertiary strata, Atlantic and Gulf coastal plains.

Maryland. The Raritan Formation was recognized as the base of the sequence when Berry (1908) established its age as Late Cretaceous on the basis of botanical evidence. In 1928 Cooke and Stephenson recognized the age of the Rancocas and Manasquan as Eocene on the basis of both faunal evidence and the transgressive overlap of the Hornerstown Sand on formations of undoubted Upper Cretaceous age. Their stratigraphic revision left the Monmouth the uppermost Cretaceous unit in the region, and established the currently-accepted stratigraphic sequence for New Jersey, Delaware, and eastern Maryland (Owens et al., 1970). Carter, in his investigation of the strata along the Chesapeake and Delaware Canal in 1934-35, applied some of the New Jersey formational names, subdividing the Matawan of this area for the first time; the Monmouth was not subdivided. Spangler and Pederson (1950), Groot et al. (1954), and Jordan (1962) also subdivided the units along the canal, but their identification and correlation of some units differed from Carter's. Owens et al. (1970) agreed with Carter's interpretation of the stratigraphy at the canal.

In New Jersey Owens et al. (1970) subdivided the Upper Cretaceous strata into 11 lithostratigraphic units (Text-fig. 1). There the Upper Cretaceous section is thick and relatively complete; along the strike to the southwest the section becomes thinner and the formations are fewer; particularly affected are the uppermost Cretaceous units. The Paleocene Hornerstown Formation appears to rest from northeast to southwest on successively older formations (Minard et al., 1969).

The Woodbury, Wenonah, and Red Bank formations pinch out from New Jersey toward the canal; the Navesink was removed by pre-Hornerstown erosion (Text-fig. 1), allowing the Hornerstown to be deposited directly upon the Mount Laurel in the vicinity of the canal (Owens et al., 1970). Owens et al. (1970) have traced the stratigraphic units exposed at the canal as far as eastern Maryland (east of the Chesapeake Bay), where good exposures occur along the Sassafrass River (Text-fig. 2). They abandoned the old formational names, Matawan and Monmouth, in this area, and extended the following New Jersey-Chesapeake and Delaware Canal stratigraphic units: the Merchantville, Englishtown, and Marshalltown formations supercede the old term, Matawan Formation, and the Mount Laurel Sand represents the Monmouth Formation (Text-fig. 1); of the 11 Upper Cretaceous stratigraphic units in New Jersey, only these four are traceable into the study-area. In southern Maryland (west of Chesapeake Bay), the Monmouth Formation is considered the equivalent of the Red Bank Sand (Cooke, 1952; Glaser, 1968, 1971).

In the field area, the Delmarva Peninsula and southern Maryland, only the uppermost stratigraphic units, i.e., the Mount Laurel Sand and the Monmouth Formation (Red Bank equivalent) are treated in the present study.

Mount Laurel Sand

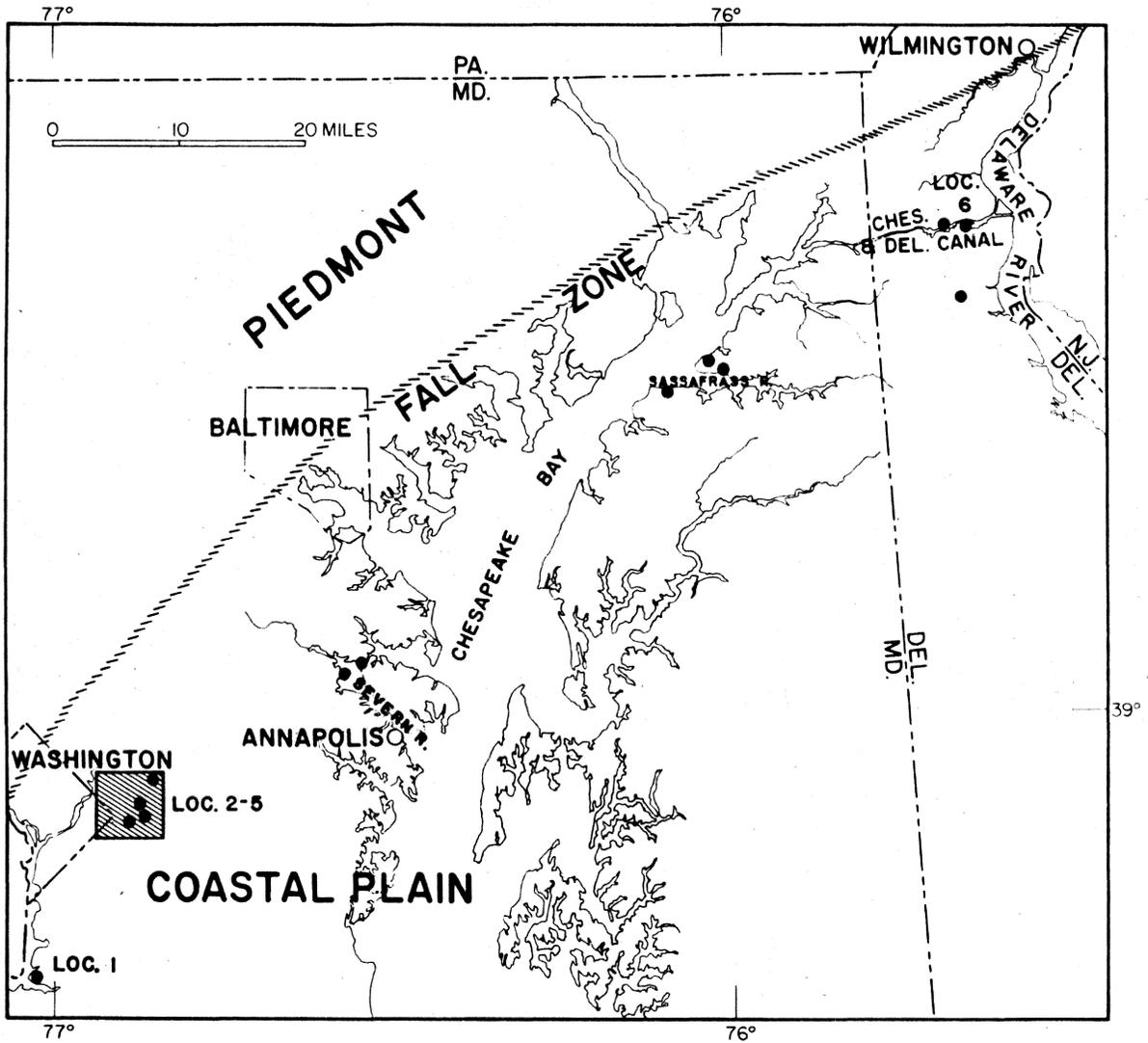
The Mount Laurel is a yellowish- to reddish-brown sand, somewhat clayey and silty. At the Chesapeake and Delaware Canal, the Mount Laurel is about 15 feet thick; the formation may attain a thickness of

up to 170 feet along the eastern shore of the Chesapeake Bay. The strike is northeast-southwest, with a gentle dip to the southeast.

The writer collected samples of the formation at Biggs Farm on the canal (Loc. 6, text-figs. 2, 4); this outcrop is the fossil-collecting site of Groot, Organist and Richards (1954). The lower portion of the outcrop is a calcareous sand, conformably overlain by a reddish-brown sand of the Mount Laurel (Text-fig. 5). The irregular contact between the two units is attributed by Owens et al. (1970) to an uneven leaching of the calcareous unit. The lower, calcareous unit contains small amounts of glauconite, producing a "salt and pepper" appearance (Text-fig. 6, right margin). Only the calcareous unit yielded phytoplankton.

On the basis of megafossils (the Baculites compressus Zone), a Late Campanian age is inferred for the Mount Laurel. On the basis of Foraminifera, the formation is considered Late Campanian- Early Maestrichtian (Owens et al., 1970). Mumby (1962), using Foraminifera, placed the Marshalltown Formation (considered Mount Laurel in her study) immediately below the Campanian-Maestrichtian boundary; the Mount Laurel would then be of earliest Maestrichtian age.

On the basis of the high diversity of Foraminifera and the frequency of occurrence of planktonic specimens, the calcareous unit of the Mount Laurel is thought to have accumulated under open marine conditions (Owens et al., 1970).



Text-fig. 2. Generalized map of study-area. Black dots represent localities sampled; numbered localities are treated in this study.



Text-fig. 3. Detailed map of collection area immediately east of Washington, D. C., showing Localities 2-5.

SW

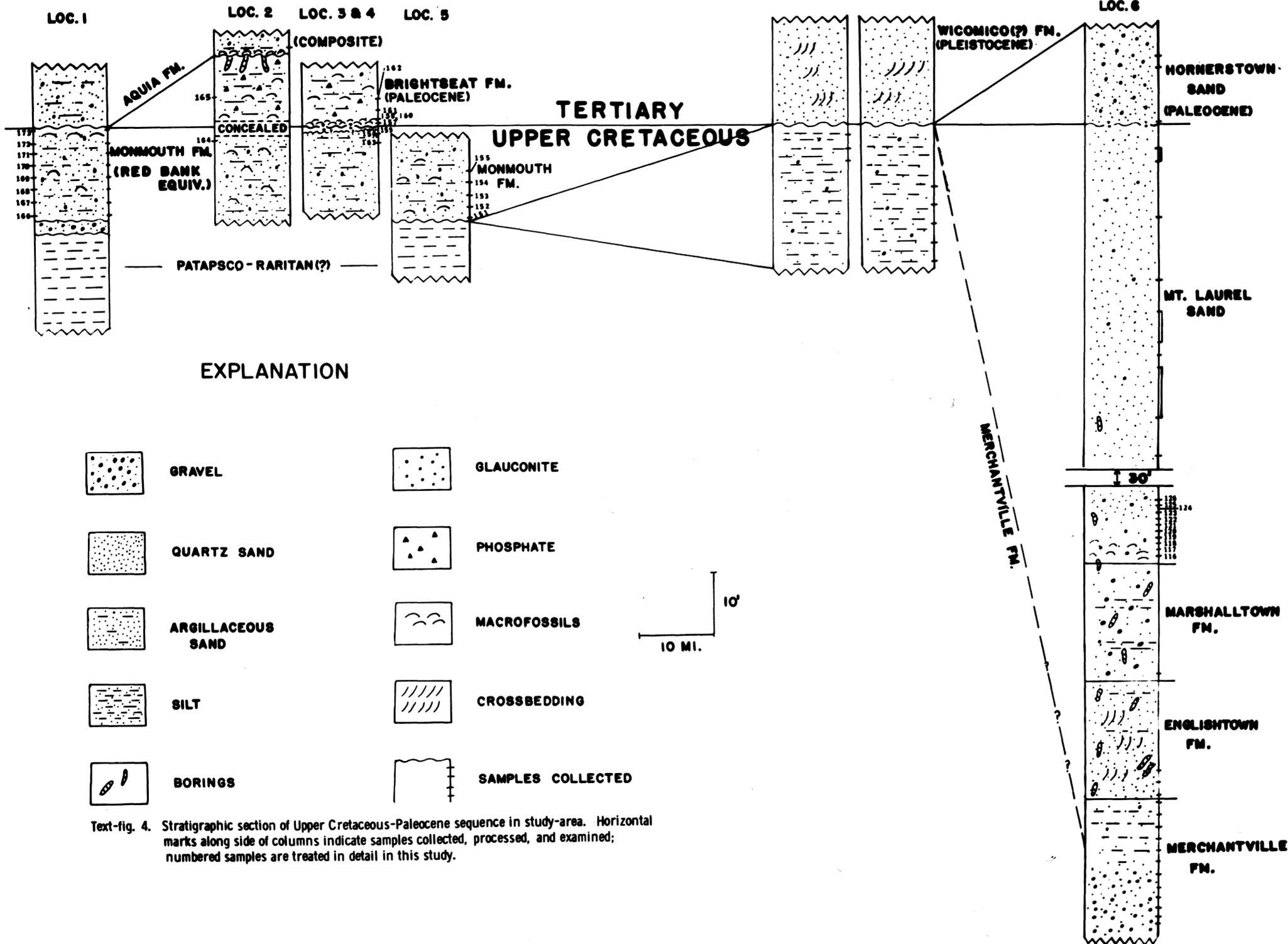
NE

FT. WASH., MD.

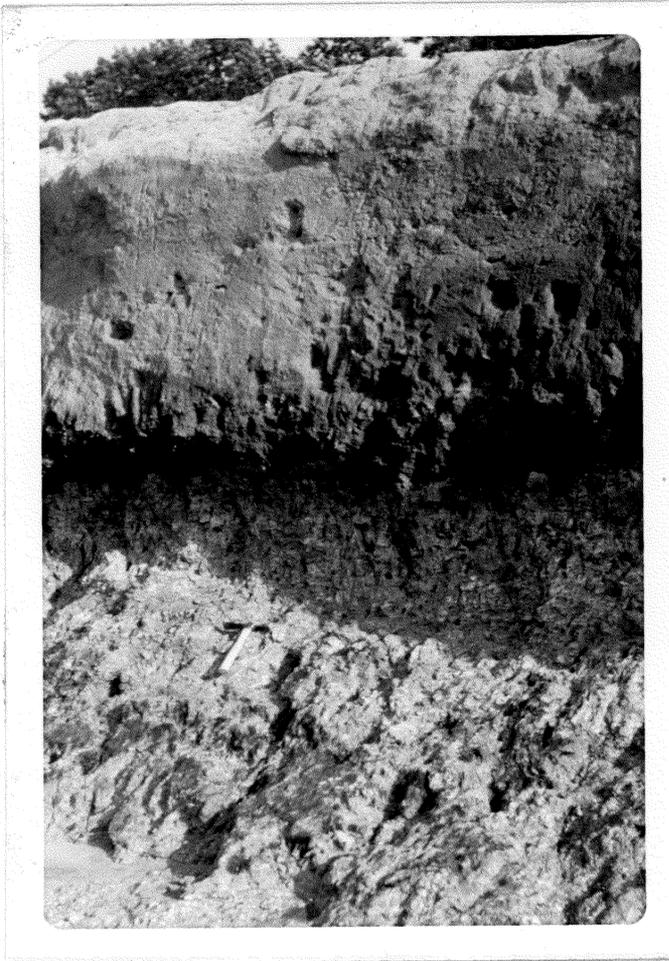
EAST OF D.C.

SASSAFRAS R.

N. DEL. (COMPOSITE)



Text-fig. 4. Stratigraphic section of Upper Cretaceous-Paleocene sequence in study-area. Horizontal marks along side of columns indicate samples collected, processed, and examined; numbered samples are treated in detail in this study.



Text-fig. 5. Basal units of Mount Laurel Formation: a calcareous lower unit conformably overlain by a sandy unit, Biggs Farm, Chesapeake and Delaware Canal; contact with underlying Marshalltown Formation lies just below beach level.



Text-fig. 6. The lower, calcareous unit of the basal Mount Laurel Formation at Biggs Farm. Photo shows glauconite as a "salt and pepper" speckling of the sand.

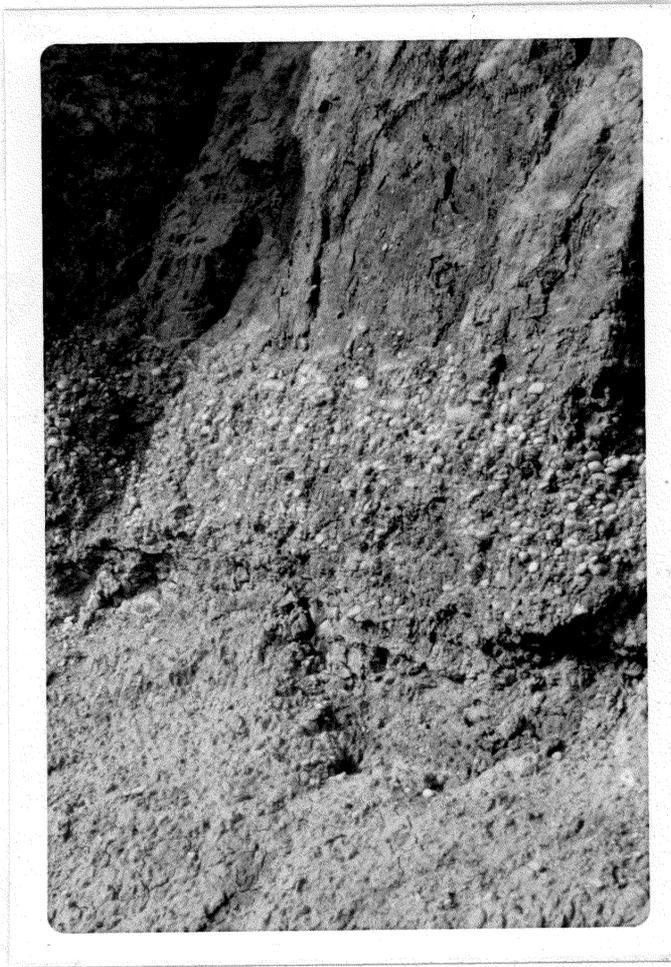
Monmouth Formation

The Monmouth Formation, a dark-gray silt and fine clayey sand, in southern Maryland unconformably overlies the Potomac Group, having overlapped both the Matawan and Magothy formations (Glaser, 1968). The regional strike of the Monmouth is N 46° E; dip is 20 to 25 feet per mile to the southeast, in which direction the formation reaches a thickness of up to 100 feet.

The writer collected samples of the Monmouth at Ft. Washington, south of Washington, D. C. (Loc. 1, text-figs. 2, 4), where the unconformable contact with the Potomac Group is marked by a 12-inch-thick gravel bed, the basal unit of the Monmouth (Text-fig. 7). About 15 feet thick at Ft. Washington, the Monmouth is absent to the west and south of this area (Glaser, 1971). Samples of the Monmouth from outcrops just east of Washington, D. C. (Loc. 2-4, Text-figs. 2-4), were provided for this study by Dr. Joseph Hazel (USGS).

The presence in the Monmouth Formation of Exogyra costata places it in the E. costata Zone of Upper Cretaceous age; the presence of the nautiloid Sphenodiscus lobatus, a widely-recognized guide fossil, indicates a Maestrichtian age (Cooke, 1952; Glaser, 1971).

The Monmouth Formation bears lithologic and faunal similarity to the Peedee Formation of the Carolinas (Glaser, 1971) (Text-fig. 1). Since the Peedee represents open shelf sedimentation, the Monmouth probably does also, according to Glaser (1971).



Text-fig. 7. Basal unit of the Monmouth Formation (Red Bank equivalent), a 12" gravel bed, Ft. Washington; here the Monmouth unconformably overlies the Patapsco Formation of the Potomac Group.

Paleocene Series

Brightseat Formation

The Brightseat type locality is one mile west-southwest of Brightseat, Prince Georges County, Maryland (Text-fig. 3). The formation is a dark gray-brown micaceous sandy clay to fine sand containing occasional megafossils; a four-inch shell bed occurs at the base at Locality 4 of this study (Text-fig. 4). Scattered outcrops of the Brightseat extend from the type locality to Aquia Creek, Stafford County, Virginia. Eight to 11 feet in thickness in outcrop, the Brightseat dips south-southeast about 14 feet per mile and attains a thickness of 50 to 75 feet in the subsurface (Bennett and Collins, 1952).

Sediments of Paleocene age from the subsurface of Maryland were first recognized on the basis of Foraminifera by Cushman (1948) and by Shifflet (1948). On the basis of faunal comparisons with the subsurface strata, Bennett and Collins (1952) proposed the name Brightseat Formation for strata outcropping in Maryland. Exposures of the Brightseat along Aquia Creek were incorporated by Clarke and Martin (1901) into their Zone 1 of the Aquia Formation.

The contact of the Brightseat with the underlying Monmouth Formation was considered to be unconformable by Cooke (1952) on lithologic evidence, and by Glaser (1968), on megafaunal evidence. An unconformity is also indicated by ostracode distribution: species present in the Monmouth Formation do not cross the Cretaceous-Tertiary boundary

into the Brightseat (Hazel, pers. comm.). The contact of the Brightseat with the overlying Aquia Formation is also considered to be unconformable by Hazel (1968, 1969) on the basis of ranges of ostracodes and Foraminifera. He places the Brightseat in the Globoconusca daubjergensis - Globorotalia trinidadensis foraminiferal zone, and assigns it an Early Danian age. Nogan (1964), on the basis of Foraminifera, assigned a Late Danian age to the Brightseat. The environment of deposition was sublittoral; water depth was 300 feet or less (Nogan, 1964; Hazel, 1968).

METHODS OF STUDY

Location and Sampling Procedure

The Upper Cretaceous-Paleocene section under investigation is represented by a belt of scattered outcrops from the Washington, D. C. area to the Chesapeake and Delaware Canal, Delaware. Nowhere in this area does a complete Upper Cretaceous-Paleocene section outcrop. The younger formations, the Brightseat and Monmouth (Red Bank equivalent) were collected from the southwest portion of this belt (Text-figs. 2-3, Localities 1-5); the older material, from the Mount Laurel Formation, was collected in the northeast portion, on the banks of the canal (Text-fig. 2, Loc. 6).

Initially, the outcrop was cleared of weathered debris. Samples were collected at intervals of approximately 6"; tools were cleaned after each sampling to prevent contamination. Samples were sealed in plastic bags and labeled. The author collected a total of 80 samples; Dr. Hazel contributed 10. The stratigraphic position of each sample is shown in Text-fig. 4. All samples were processed, and the resulting slides were examined. Twenty-nine of the samples have been investigated in this study (see p. 13); the following section on Collecting Localities pertains to these samples.

Collecting Localities

The stratigraphic position of each sample collected for this study is shown for each locality in Text-fig. 4.

Locality 1. At Fort Washington National Park, Prince Georges Co., Maryland. References: Mt. Vernon, Md.-Va., quad., 7.5 minute series; geographical coordinates $38^{\circ}42'27''$ N. Lat., $77^{\circ}02'07''$ W. Long. Approximately 15 feet of the Monmouth Formation are exposed at this locality; the Monmouth unconformably overlies the Patapsco Formation of the Potomac Group, and is in turn overlain by the Aquia Formation. The Monmouth outcrops at the end of the road past the old fort ruins, in the bluff overlooking the confluence of the Piscataway Creek with the Potomac River.

Locality 2. Locality 34 of Hazel (1968), approximately two miles southwest of the Brightseat Formation type locality, 0.7 mi. southeast of the intersection of Central Avenue (Md. 214) and Addison Road, Prince Georges Co., Maryland. A Monmouth sample and a Brightseat sample were collected by Hazel along the middle one of three tributaries to Cabin Branch. References: Washington East, Md.-D.C., quad, 7.5 minute series; geographical coordinates: $38^{\circ}52'49''$ N. Lat., $76^{\circ}53'20''$ W. Long.

Locality 3. A composite of two of Hazel's collecting localities: samples of the Brightseat and Monmouth Formations were collected by him at his localities HL 42 and HL 43 on the southwest side of the intersection of I-495 (Capital Beltway) and Central Avenue; a Monmouth sample was collected from the northwest side of the same intersection (Hazel, 1968). Reference: Lanham, Md., quad, 7.5 minute series; geographical coordinates: $38^{\circ}56'45''$ N. Lat., $76^{\circ}49'42''$ W. Long.

Locality 4. Samples were collected by Hazel along the banks of an unnamed creek at the type locality of the Brightseat Formation, one mile west-southwest of Brightseat, Maryland (Hazel's locality 41; Hazel, 1968; Bennett and Collins, 1952). Other samples were collected in another creek 0.2 mi. east of the type locality (HL 12 of Hazel, 1968; locality B of Bennett and Collins, 1952).

Locality 5. The Monmouth Formation (Red Bank equivalent) was collected on the north side of the John Hanson Highway (U.S. 50), one mile east of its intersection with the Palmer Highway (Md. 704), Prince Georges Co., Maryland. Reference: Lanham, Md., quad, 7.5 minute series; geographic coordinates: $38^{\circ}56'45''$ N. Lat., $76^{\circ}49'42''$ W. Long.

Locality 6. On the south bank of the Chesapeake and Delaware Canal, which connects the Chesapeake Bay with the Delaware River, at Biggs Farm (Groot, Organist, and Richards, 1954). This exposure of the Mount Laurel Formation is approximately 900' west of canal light no. 13, and about one mile east of the St. Georges Bridge (Du Pont Parkway). References: Saint Georges, Del., quad, 7.5 minute series; Delaware Geological Survey Geologic Map, Series No. 1, Geology of the Chesapeake and Delaware Canal Area; geographical coordinates: $39^{\circ}33'10''$ N. Lat., $75^{\circ}37'36''$ W. Long.

Laboratory Procedures

Samples were macerated by standard palynological acid-maceration techniques. HCl was used to digest calcareous material and HF, silicate minerals. CloroxTM and NH₄OH oxidized lignin and other unwanted organic matter. Palynomorphs were concentrated by sieving (mesh size 18-22u) and by use of ZnBr (S.G. 2.0). Palynomorphs were darkened for study and photography by acetolization. Palynomorphs were mounted in glycerine jelly on a 22 x 22 mm coverslip, no. 0 thickness, which in turn was mounted on a 25 x 75 mm glass microscope slide. When possible, at least five slides were made of the residue from each sample. Coverslips were sealed with clear fingernail polish. Remaining residues were stored in vials containing distilled water and small amounts of glycerine and ethyl alcohol. All slides are stored in the Virginia Polytechnic Institute and State University Palynology Type Collection (VPISUPTL).

Specimen Location

Slides were examined on a Leitz Dialux Microscope (VPI & SU) and a Nikon Microscope Model L-Ke (University of Washington). Specimens were coordinated by measurement from the lower left corner of the coverslip; the coordinates of a specimen are expressed in millimeters to the right (R) of the corner and above (+) the corner.

Counting Procedure

The relative abundance of each species within a sample was gained from specimen counts on several slides within the sample. To determine what constituted a sufficient count, Wilson (1959) and Waanders (1974) plotted specimens vs. species encountered. In samples of high diversity with little dominance by any one species, they encountered no new species after 200 specimens were counted; they concluded that a count of 250 was adequate. In the present study, however, many samples are dominated by one or two species; other species may be represented by only a few specimens. If only 250 specimens are counted, the presence of the rare species may go undetected. It is desirable in this case, then, to increase the count by at least a factor of two; an increase by a factor of three should reflect the true species composition of a sample. Accordingly, a count of 750 specimens was made when possible. The counts for all samples are tabulated in Chart 1.

Counts were converted into percentages for each species within a sample; each species was then assigned to one of the following categories:

Abundant--greater than 25%

Common--15-25%

Sparse-- 5-15%

Extremely rare--less than 1%

Relative abundances are tabulated in Chart 2. Species not seen during the counting procedure but encountered on other traverses are listed as "extremely rare" in Chart 2, and are designated by a dot in Chart 1.

Photography

Photography was with a Leitz Orthoplan microscope and Orthomat camera (VPI & SU) and a Nikon Microflex camera, model EFM (University of Washington). Kodak Panatomic-X film was exposed at an ASA of 16 and developed at 70° in Agfa Rodinal, at a dilution in distilled water of 1:30 for 10 minutes. Kodak High Contrast Copy film was exposed at an ASA of 6 and developed at 70° in Ethol Tec, at a dilution in distilled water of 1:15 for 5 minutes. Prints were made on Kodak Polycontrast F paper, single weight; polycontrast filters were used for control of contrast.

RESULTS OF PALYNOLOGICAL INVESTIGATION

General Statement

Fifty-one dinoflagellate genera containing 95 species and four subspecies were recovered, of which one genus, nine species and four combinations are described as new. Twelve acritarch genera with 14 species and several informally designated species (spp.) are present in the section, as well as two species of Chlorophyta and one species of Protozoa.

Pollen and spores appear in moderate, variable numbers throughout the section, but no attempt is made in this study to deal with their taxonomy and stratigraphic distribution. A few specimens of calcareous and siliceous microfossils were recovered, but most specimens were destroyed during maceration; ebridians, silicoflagellates, and the cutaneous chamber linings of Microforaminifera were occasionally encountered.

The stratigraphic distribution of each species of dinoflagellate and acritarch in the section is presented in two ways: (1) the occurrence of each species is noted on a sample-by-sample basis for each locality (Text-figs. 8-10), and (2) the overall local range of each species in the section, based on first appearance, is given in a composite section representing all six collecting localities (Text-fig. 11). Since the upper Mount Laurel Formation is not treated in this study, a zonation of the section is not attempted at this time; moreover, it has not been determined how much of the upper Monmouth

Formation has been lost by erosion. The writer feels that only a compilation of information based on numerous samples from a more nearly complete section will make possible an enduring zonation of the Upper Cretaceous-Lower Tertiary strata of the Atlantic Coastal Plain.

Abundances of each species throughout the section are based on a count of 750 specimens per sample, when possible. These abundances are tabulated in Chart 1. From them are drawn relative abundances for the species in a sample; the relative abundances are designated on the following basis: Abundant (greater than 25%), Common (15-25%), Sparse (5-15%), Rare (1-5%), and Extremely Rare (less than 1%) (Chart 2).

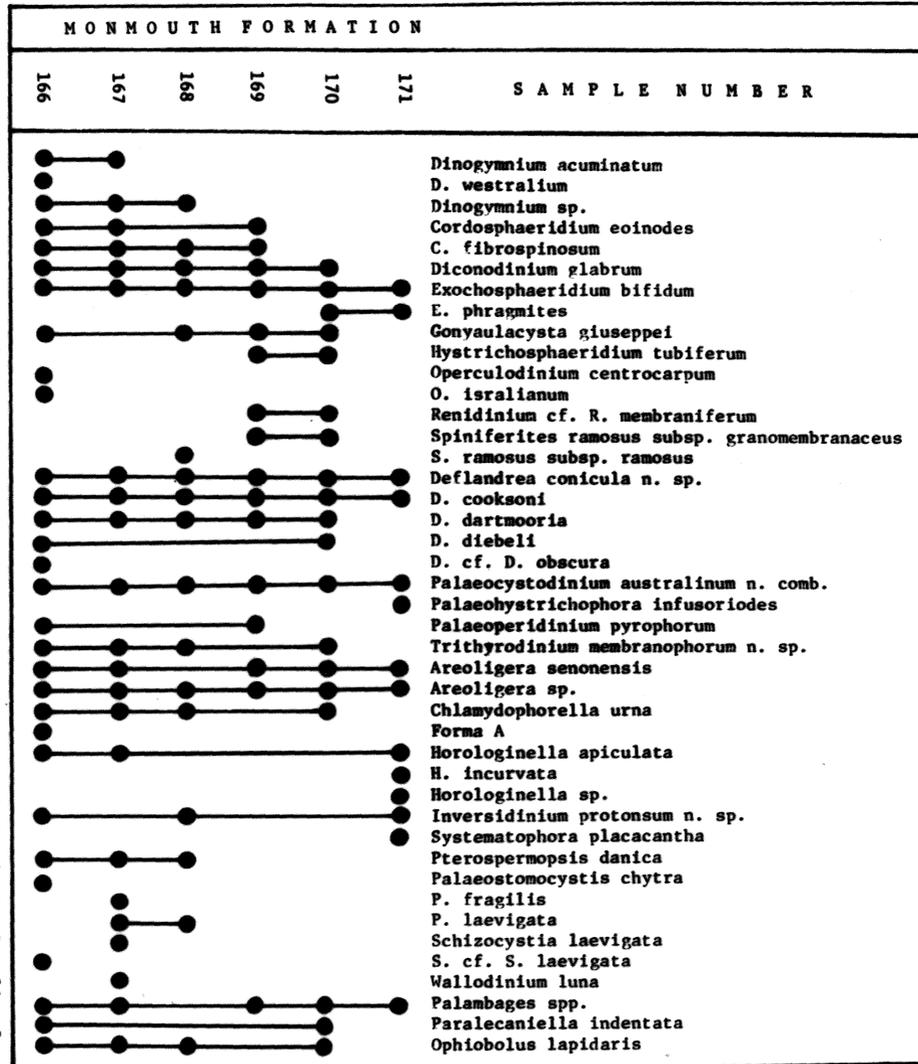
Stratigraphic Palynology

The following table shows the distribution of dinoflagellate and acritarch species among the three formations investigated in this study:

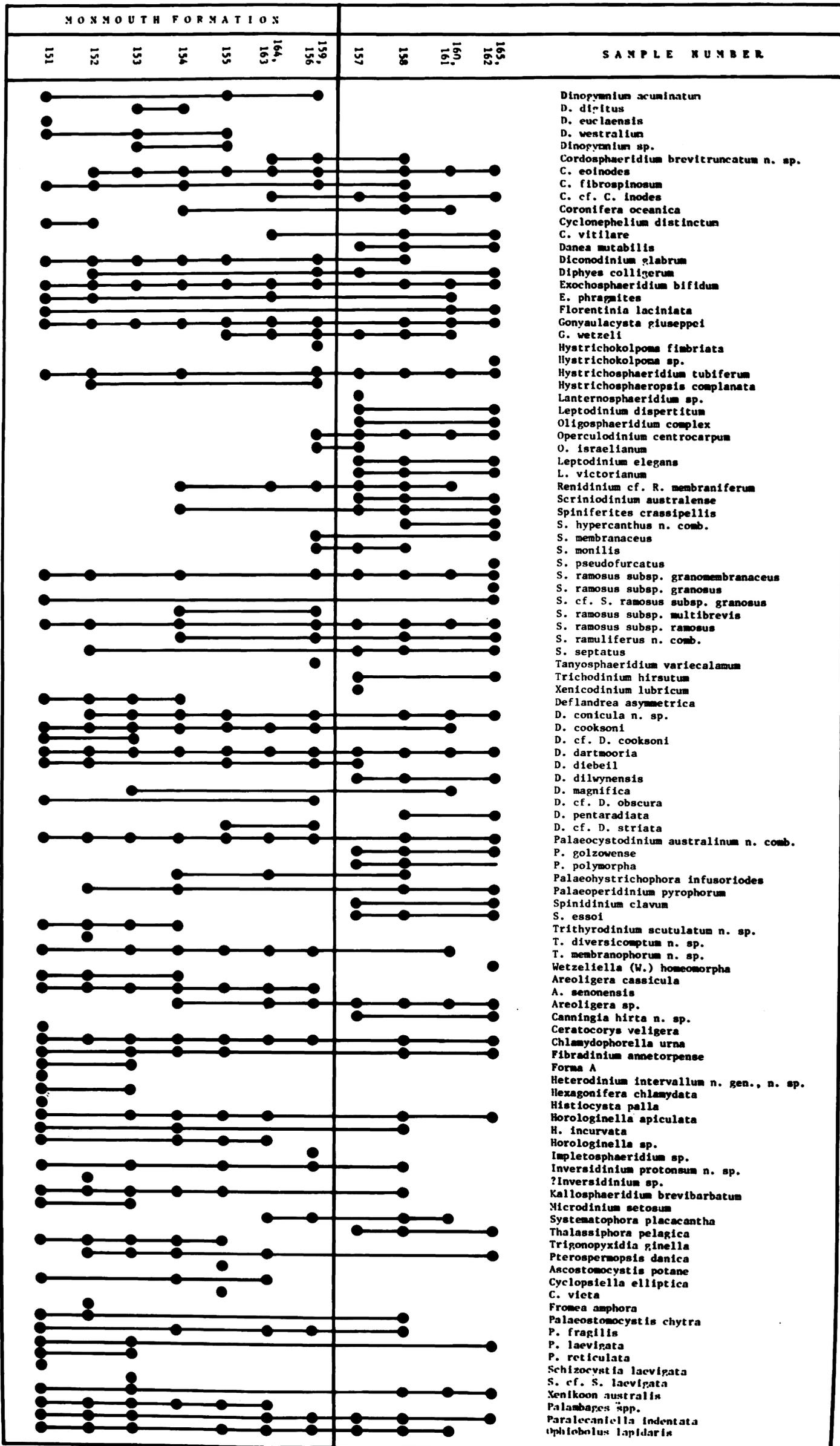
Table 1. Distribution of number of dinoflagellate and acritarch species among the Brightseat, Monmouth, and Mount Laurel formations in this study.

Formation	Number of Dino- flagellate and acritarch species	Dinoflagellate species	Acritarch species	Restricted to formation	
				Dino.	Acrit.
Brightseat	66	62	4	19	0
Monmouth	85	73	12	12	3
Mount Laurel	66	56	10	8	1

Text-fig. 8. Stratigraphic distribution of dinoflagellate and acritarch species at Locality 1.

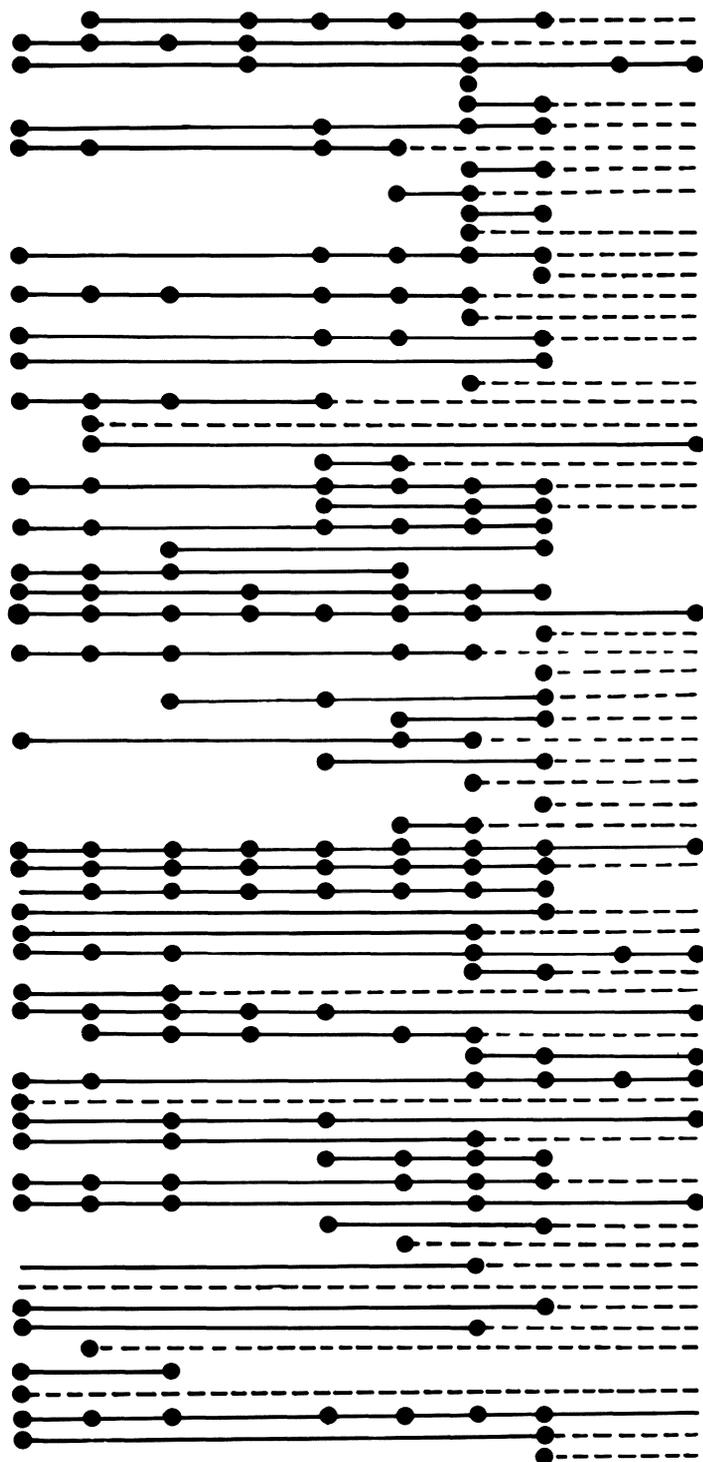


Text-fig. 9. Stratigraphic distribution of dinoflagellate and acritarch species at localities 2-5.



MOUNT LAUREL FORMATION

116 117 118 119 120 121 122 123 125
& 124 126 SAMPLE NUMBER



- Dinogymnium acuminatum
- D. digitus
- D. euclaensis
- Cannosphaeropsis utinensis
- Cordosphaeridium eoinodes
- Coronifera oceanica
- Cyclonephelium distinctum
- Diconodinium glabrum
- Diphyes colligerum
- Exochosphaeridium bifidum
- E. phragmites
- Florentinia laciniata
- Gonyaulacysta guiseppi
- G. wetzeli
- Hystrichokolpoma fimbriata
- Hystrichosphaeridium tubiferum
- Samlandia chlamydochora
- Scriniodinium australense
- Spiniferites crassipellis
- S. membranaceus
- S. ramosus subsp. granomembranaceus
- S. ramosus subsp. multibrevis
- S. ramosus subsp. ramosus
- S. septatus
- Trichodinium castanea
- Ascodinium pontis-mariae
- Deflandrea aspratitidis n. sp.
- D. cf. D. balcattensis
- D. camerata n. sp.
- D. conicula n. sp.
- D. cooksoni
- D. dartmooria
- D. magnifica
- D. cf. D. obscura
- D. cf. D. striata
- Palaeocystodinium australinum n. comb.
- Palaeohystrichophora infusoriodes
- Spinidinium clavum
- S. essoii
- Trithyrodinium scutulatum n. sp.
- T. diversicomptum n. sp.
- T. vermiculatum n. comb.
- Areoligera sp.
- Ceratocorys veligera
- Chlamydochorella urna
- Heterodinium intervallum n. gen., n. sp.
- Hexagonifera chlamydata
- Horologinella apiculata
- H. incurvata
- Horologinella sp.
- Inversidinium protonsum n. sp.
- ?Inversidinium sp.
- Kallosphaeridium brevibarbatum
- Microdinium setosum
- Xenascus ceratiodes
- Trigonopyxidia ginella
- Pterospermopsis danica
- Cyclopsiella elliptica
- C. vieta
- Fromea amphora
- Palaeostomocystis chytra
- P. fragilis
- P. laevigata
- P. reticulata
- Walldodium luna
- Xenikoon australis
- Palambages spp.
- Paralecaniella indentata
- Ophiobolus lapidaris

Text-fig. 10. Stratigraphic distribution of dinoflagellate and acritarch species at locality 6.

CRETACEOUS		TERTIARY	SYSTEM
UPPER CRETACEOUS (MAESTRICHTIAN)		PALEOCENE	SERIES
MOUNT LAUREL FORMATION	MONMOUTH FORMATION (RED BANK EQUIVALENT) (Localities 1 & 5, generalized section)	BRIGHTSEAT FORMATION	FORMATION
126 124 123 122 121 120 119 118 117 116		157 160 161 165 162	SAMPLE NUMBER
			<i>Walloidinium luna</i> <i>Deflandrea aspratitidis</i> n. sp. <i>Samlandia chlamydata</i> <i>Trichodinium castanea</i> <i>Deflandrea</i> cf. <i>D. halcattensis</i> <i>Trithyrodinium varmiculatum</i> n. comb. <i>Deflandrea camerata</i> n. sp. <i>Dinogymnium euclaensis</i> <i>Ceratocorys veligera</i> <i>Cyclonophelium distinctum</i> <i>Trithyrodinium diversicomptum</i> n. sp. <i>?Inversidinium</i> sp. <i>Fromea amphora</i> <i>Hexagonifera chlamydata</i> <i>Microdinium setosum</i> <i>Dinogymnium digitus</i> <i>Trithyrodinium acutulatum</i> n. sp. <i>Trigonopyxidia ginella</i> <i>Deflandrea</i> cf. <i>D. striata</i> <i>Inversidinium protonsum</i> n. sp. <i>Kallosphaeridium brevibarbatum</i> <i>Palaeostomocystis chytra</i> <i>P. fragilis</i> <i>Coronifera oceanica</i> <i>Gonyaulacysta wetzeli</i> <i>Deflandrea cooksoni</i> <i>Xenikoon australis</i> <i>Exochosphaeridium bifidum</i> <i>Florentinia laciniata</i> <i>Hystriochosphaeridium tubiferum</i> <i>Spiniferites crassipellis</i> <i>S. ramosus</i> subsp. <i>ramosus</i> <i>Chlamydata urna</i> <i>Fibradinium amnetorpense</i> <i>Horologinella spiculata</i> <i>Pterospermopsis danica</i> <i>Palaeostomocystis laevigata</i> <i>Palambages</i> spp. <i>Paralecaniella indentata</i> <i>Palaeostomocystis reticulata</i> <i>Dinogymnium acuminatum</i> <i>Horologinella incurvata</i> <i>Spiniferites membranaceus</i> <i>S. ramosus</i> subsp. <i>granomembranaceus</i> <i>Ascodinium pontis-mariae</i> <i>Deflandrea magna</i> <i>Xenascus ceratioides</i> <i>Cyclopsiella elliptica</i> <i>Spiniferites ramosus</i> subsp. <i>multibrevis</i> <i>S. septatus</i> <i>Palaeocystodinium australinum</i> n. comb. <i>Cyclopsiella vieta</i> <i>Deflandrea</i> cf. <i>D. obscura</i> <i>Diphyes colligerum</i> <i>Spinidinium essoi</i> <i>Cannosphaeropsis utinensis</i> <i>Heterosinium intervallum</i> <i>Horologinella</i> sp. <i>Hystriocholpoma fimbriata</i> <i>Diconodinium glabrum</i> <i>Palaeohystriochophora infusorioides</i> <i>Cordosphaeridium acinodes</i> <i>Exochosphaeridium phragmites</i> <i>Scriniodinium australense</i> <i>Ophiobolus lapidaris</i> <i>Gonyaulacysta giuseppi</i> <i>Deflandrea conicula</i> n. sp. <i>D. dartmooria</i> <i>Spinidinium clavum</i> <i>Schizocystia laevigata</i> <i>Histiocysta palla</i> <i>Deflandrea</i> cf. <i>D. cooksoni</i> Forma A <i>Deflandrea asymmetrica</i> <i>Areoligera cassicula</i> <i>Dinogymnium vestralium</i> <i>Areoligera senonensis</i> <i>Cordosphaeridium fibrospinosum</i> <i>Trithyrodinium membranophorum</i> n. sp. <i>Spiniferites</i> cf. <i>S. subsp. granosus</i> <i>Hystriochosphaeropsis complanata</i> <i>Deflandrea diebeli</i> <i>Palaeoperidinium pyrophorum</i> <i>Deflandrea pannucea</i> <i>Schizocystia</i> cf. <i>S. laevigata</i> <i>Walloidinium anglicum</i> <i>Dinogymnium</i> sp. <i>Operculodinium israelianum</i> <i>O. centrocarpum</i> <i>Renidinium</i> cf. <i>R. membraniferum</i> <i>Systematophora placacantha</i> <i>Spiniferites ramuliferum</i> n. comb. <i>Ascotomocystis potane</i> <i>Cordosphaeridium brevitricatum</i> n. sp. <i>C. inodes</i> <i>Cyclonophelium vitilare</i> <i>Areoligera</i> sp. <i>Impletosphaeridium</i> sp. <i>Tanyosphaeridium varicellatum</i> <i>Spiniferites monilis</i> <i>Lanternosphaeridium</i> sp. <i>Xenicodinium lubricum</i> <i>Danea mutabilis</i> <i>Leptodinium dispertitum</i> <i>Oligosphaeridium complex</i> <i>Leptodinium victorianum</i> <i>L. elegans</i> <i>Trichodinium hirsutum</i> <i>Deflandrea dilwynensis</i> <i>Palaeocystodinium golzowense</i> <i>P. polymorpha</i> <i>Canningia hirta</i> n. sp. <i>Ihalassiphora pelagica</i> <i>Spiniferites hypercanthus</i> n. comb. <i>Deflandrea pentaradiata</i> <i>Cordosphaeridium</i> cf. <i>C. inodes</i> <i>Hystriocholpoma</i> sp. <i>Spiniferites pseudofurcatus</i> <i>S. ramosus</i> subsp. <i>granosus</i> <i>Wetzeliella (W.) homomorpha</i>

Text-fig. 11. Ranges of dinoflagellate and acritarch species in the study-area.

CRETACEOUS		TERTIARY		SYSTEM																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Chart 1. Tabulated counts of specimens of each species within a sample.

Species with limited stratigraphic range in the study-area should prove useful in establishing a zonation for the Atlantic Coastal Plain strata. Species restricted to the Mount Laurel Formation in the study-area are the following:

Ascodinium pontis-mariae
Cannosphaeropsis utinensis
Deflandrea aspratitidis, n. sp.
Deflandrea cf. D. balcattensis
Deflandrea camerata n. sp.
Samlandia chlamydophora
Trichodinium castanea
Trithyrodinium vermiculatum n. comb.
Wallodinium luna

Species restricted to the Monmouth Formation in the study-area are the following:

Areoligera cassicula
Areoligera senonensis
Ascostomocystis potane
Deflandrea asymmetrica
Deflandrea cf. D. cooksoni
Deflandrea pannucea
Dinogymnium sp.
Dinogymnium westralium
 Forma A
Histiocysta palla
Hystrichosphaeropsis complanata
Impletosphaeridium sp.
Schizocystia laevigata
Schizocystia cf. S. laevigata
Tanyosphaeridium variecalamum
Wallodinium anglicum

Species restricted to the Brightseat Formation in the study-area are the following:

Canningia hirta n. sp.
Cordosphaeridium cf. C. inodes
Danea mutabilis
Deflandrea dilwynensis
Deflandrea pentaradiata
Hystrichokolpoma sp.

Lanternosphaeridium sp.
Leptodinium dispertitum
Leptodinium elegans
Leptodinium victorianum
Oligosphaeridium complex
Palaeocystodinium golzowense
Palaeocystodinium polymorpha
Spiniferites hypercanthus n. comb.
Spiniferites pseudofurcatus
Spiniferites ramosus subsp. granosus
Thalassiphora pelagica
Trichodinium hirsutum
Wetzeliella (W.) homeomorpha
Xenicodinium lubricum

Evidence Relating to the Cretaceous-Tertiary Boundary

The Cretaceous-Tertiary boundary in the study-area is marked by the last appearance of eight species and one subspecies of dinoflagellates and one acritarch species, and the first appearance of 13 species of dinoflagellates.

Ranges of the following species terminate at the boundary:

Areoligera senonensis
Cyclopsiella elliptica
Deflandrea cf. D. obscura
Deflandrea cf. D. striata
Dinogymnium acuminatum
Hystrichokolpoma fimbriata
Hystrichosphaeropsis complanata
Impletosphaeridium sp.
Spiniferites ramosus subsp. multibrevis
Tanyosphaeridium variecalamum

The following species make their first appearance at the Cretaceous-Tertiary boundary in the Maryland section:

Canningia hirta n. sp.
Danea mutabilis
Deflandrea dilwynensis
Lanternosphaeridium sp.

Leptodinium dispertitum
Leptodinium elegans
Leptodinium victorianum
Oligosphaeridium complex
Palaeocystodinium polymorpha
Palaeocystodinium golzowense
Thalassiphora pelagica
Trichodinium hirsutum
Xenicodinium lubricum

Approximately one foot above the Monmouth-Brightseat contact, Spiniferites hypercanthus n. comb. and Deflandrea pentaradiata make their first appearance in the section.

Forty-four species and two subspecies of dinoflagellates and four species of acritarchs range across the Cretaceous-Tertiary boundary without interruption.

The last appearance of a number of species and the first appearance of others at the boundary implies the presence of an unconformity. The possibility of a marked change in environment of deposition, coupled with continuous sedimentation, cannot be completely discounted; lithologies, however, on either side of the contact are nearly identical. The possibility of the presence of an unconformity seems the more likely alternative. This conclusion substantiates the findings of Benson (1975), that an unconformity representing an undetermined interval of time exists at the Cretaceous-Tertiary boundary in Maryland.

Evidence Relating to the Ages of the Formations

Mount Laurel Formation

In Delaware, the following species of phytoplankton make their first appearance in the basal Mount Laurel:

<u>Species</u>	<u>Previously-reported Stratigraphic Range</u>
<u>Cannosphaeropsis utinensis</u>	Senonian-Maestrichtian
<u>Deflandrea magnifica</u>	Maestrichtian-Paleocene
<u>Dinogymnium acuminatum</u>	Maestrichtian
<u>Palaeocystodinium australinum</u>	Senonian-Oligocene
<u>Palaeostomocystis reticulata</u>	Senonian-Danian

Ranges of the following species terminate in the basal Mount Laurel Formation in Delaware:

<u>Ascodinium pontis-mariae</u>	Albian-?Senonian
<u>Deflandrea aspratitidis</u> n. sp.	Maestrichtian
<u>Deflandrea</u> cf. <u>D. balcattensis</u>	Albian-Senonian
<u>Trithyrodinium vermiculatum</u> n. comb.	?Senonian

Based on the concurrent ranges of the above taxa, a Senonian-Maestrichtian age is indicated. More specific information was gained from a comparison of the basal Mount Laurel assemblages with the assemblages of Wilson (1974), who constructed a composite section of 21 localities of Campanian-Maestrichtian strata from the Maastricht region of Belgium-Netherlands and from northern and eastern Denmark. A general correspondence between ranges of dinoflagellates held in common by Wilson's section and the Delaware section can be ascertained.

The basal Mount Laurel may be correlated with Wilson's Zone I, of Late Campanian age. Wilson's Zone II, the base of which coincides with the base of the Maestrichtian Stage, appears to lie within the Mount Laurel Formation, above the basal portion treated in this study. This comparison with ranges of phytoplankton in the Maestrichtian type section indicates a latest Campanian-earliest Maestrichtian age for the Mount Laurel Formation. This conclusion substantiates evidence based on Foraminifera (Owens et al., 1970); a Late Campanian age is assigned on the basis of megafossils (Owens et al., 1970).

Monmouth Formation

A Maestrichtian age for the Monmouth Formation in southern Maryland is indicated by the presence of three species whose previously-reported stratigraphic ranges begin in strata of Maestrichtian age from other localities, and by six species whose ranges terminate in strata of Maestrichtian age from other localities.

In Maryland, the following species make their first appearance in the Monmouth Formation:

<u>Species</u>	<u>Previously-reported Stratigraphic Range</u>
<u>Cordosphaeridium fibrospinus</u>	Maestrichtian-Oligocene
<u>Deflandrea diebeli</u>	Maestrichtian-Paleocene
<u>Deflandrea pannucea</u>	Maestrichtian-Paleocene

In Maryland, ranges of the following species terminate in the Monmouth Formation:

<u>Species</u>	<u>Previously-reported Stratigraphic range</u>
<u>Dinogymnium acuminatum</u>	Maestrichtian
<u>D. digitus</u>	Turonian-Maestrichtian
<u>D. euclaensis</u>	Maestrichtian
<u>D. westralium</u>	Upper Cretaceous, Maestrichtian
<u>Hexagonifera chlamydata</u>	Albian-Maestrichtian
<u>Xenascus ceratiodes</u>	Albian-Maestrichtian

Species held in common between the Monmouth Formation and the Maestrichtian type section were examined in terms of Wilson's zonation; again, a Maestrichtian age is indicated for the Monmouth Formation. This determination substantiates a Maestrichtian age for the Monmouth based on megafossil evidence (Cooke, 1952; Glaser, 1971).

Brightseat Formation

In Maryland, the following species make their first appearance in the Brightseat Formation:

<u>Species</u>	<u>Previously-reported Stratigraphic Range</u>
<u>Danea mutabilis</u>	Danian
<u>Deflandrea dilwynensis</u>	Paleocene
<u>Deflandrea pentaradiata</u>	Middle Paleocene
<u>Trichodinium hirsutum</u>	Paleocene
<u>Wetzeliiella (W.) homeomorpha</u>	Paleocene-Oligocene

Species whose ranges terminate within the Brightseat are the following:

<u>Species</u>	<u>Previously-reported Stratigraphic Range</u>
<u>Coronifera oceanica</u>	Aptian-Danian
<u>Deflandrea diebeli</u>	Maestrichtian-Paleocene
<u>Deflandrea magnifica</u>	Maestrichtian-Paleocene
<u>Palaeostomocystis chytra</u>	Campanian-Danian

The concurrent ranges of the preceding species indicate a Paleocene, possibly a Danian, age for the Brightseat Formation. A Danian age has been assigned on the basis of ostracodes (Hazel, 1968, 1969) and Foraminifera (Nogan, 1964). Dinoflagellate ranges should yield more information when Wilson completes his study of the Danian type section.

Comparison of the Mount Laurel-Monmouth-Brightseat Assemblages with Assemblages of Other Areas

A comparison of the Mount Laurel-Monmouth section was made with the Neylandville-Corsican-Kemp section of Zaitzeff and Cross (1970) from Texas. The basis of comparison consisted of the species held in common between the two sections and the stratigraphic range of each species. Sixteen of the 81 species of Zaitzeff and Cross occur in the Maryland-Delaware section (nomenclatural differences aside). Stratigraphic distributions of the 16 species are similar for the Monmouth and Corsican-Demp sections; little can be said at this time,

however, regarding a comparison of the Mount Laurel and Neylandville assemblages. If the Neylandville is indeed Maestrichtian, as Zaitzeff and Cross contend, the formation may eventually be demonstrated to correlate with the upper part of the Mount Laurel Formation.

Drugg (1967) described 73 species of dinoflagellates and acritarchs from the Upper Mereno Formation (Maestrichtian-Danian) of California; 19 of those species occur in the Monmouth-Brightseat section of the present study. Stanley (1965), in his investigation of the Paleocene Cannonball Formation of South Dakota, recovered 16 species of dinoflagellates, six of which are held in common with the Brightseat Formation in Maryland. Eight of the 19 species of dinoflagellates described by Morgenroth (1968) from Danian strata are present in the Brightseat Formation in Maryland.

Paleoecology

In an attempt to assess various aspects of the paleoenvironment, the writer noted the number of species in each formation and the species dominating each sample; also recorded was the number of species belonging to the Gonyaulacaceae relative to the number of species of the Peridiniaceae. Each of these variables is discussed in the present section and their coordinated implications assessed.

Owens et al. (1970) correlated a high diversity of planktonic Foraminifera with open marine conditions. It appears that environmental stability, particularly with regard to salinity, should

prevail under such conditions. Conversely, a low diversity of planktonic Foraminifera may imply (other factors considered) a relatively near-shore environment, in which turbulence and fluctuations in temperature and salinity prevail. The writer was interested in determining if the correlation between open marine conditions and relatively high diversity might be demonstrated for phytoplankton, and if other factors, in conjunction with high diversity, might also imply open marine conditions. In the present study, the basal Mount Laurel Formation has 56 species of dinoflagellates, the Monmouth, 73, and the Brightseat, 62 species.

Schiller (1937) demonstrated that in the open marine environment, the number of gonyaulacacean dinoflagellate species is relatively higher than the number of peridiniacean dinoflagellate species. This relationship has been borne out by the work of Wall (1967), Wall and Dale (1968a), and Harland (1971). For cysts collected by Wall (1967) from deep-sea cores in the Caribbean, Harland (1971) calculated a gonyaulacacean-peridiniacean (G/P) ratio of 18.0; for near-shore cysts at Woods Hole, Massachusetts, collected by Wall and Dale (1968a), Harland calculated a G/P ratio of 0.44. The G/P ratios for the formations of this study are shown in Table 2 on a sample-by-sample basis. The overall G/P ratio for the basal Mount Laurel Formation is 1.01, that of the Monmouth, 0.91 for Locality 1 and 1.20 for Locality 2, and that of the Brightseat, 2.09.

An interesting and significant aspect of the G/P ratio is that it varies with species diversity on a sample-to-sample basis in the

Table 2. Number of Dinoflagellate Species, Gonyaulacaceae - Peridiniaceae Ratio (G/P), and Dominant Species for each Sample.

MONMOUTH FM. / B' SEAT FM.	Sample no.	No. of species	G/P	Dominant species	Sample no.	No. of species	G/P	Dominant species	Sample no.	No. of species	G/P	Dominant species	
	165	33	2.45	<u>Areoligera sp.</u> - <u>Spinidinium essoi</u>	158	23	1.25	<u>Spinidinium essoi</u> - <u>Deflandrea dilwynensis</u>	162	37	1.75	<u>Areoligera sp.</u> - <u>Spinidinium clavum</u>	
	164	16	1.2	<u>Areoligera senonensis</u> - <u>Deflandrea conicula</u>	157	33	2.75	<u>Trichodinium hirsutum</u> - <u>Areoligera sp.</u>	161	20	1.83	<u>Areoligera sp.</u> - <u>Deflandrea conicula</u>	
					156	31	2.75	<u>Areoligera senonensis</u> - <u>Systematophora placacantha</u>	160	27	4.25	<u>Areoligera sp.</u> - <u>Systematophora placacantha</u>	
					163	14	0.3	<u>Areoligera senonensis</u> - <u>Palaeocystodinium australinum</u>	159	21	1.83	<u>Areoligera senonensis</u> - <u>Areoligera sp.</u>	TERT. CRETAC.
	Locality 2				Locality 3				Locality 4				
	Sample no.	No. of species	G/P	Dominant species	Sample no.	No. of species	G/P	Dominant species	Sample no.	No. of species	G/P	Dominant species	
	171	8	0.5	<u>Deflandrea conicula</u> - <u>Areoligera senonensis</u>	155	21	0.71	<u>Deflandrea conicula</u> - <u>Deflandrea cooksoni</u>					
	170	22	1.33	<u>Areoligera senonensis</u> - <u>Deflandrea conicula</u>	154	32	1.44	<u>Areoligera senonensis</u> sp. - <u>Deflandrea conicula</u>					
	169	13	1.2	<u>Areoligera senonensis</u> - <u>Exochosphaeridium bifidum</u>	153	26	0.44	<u>Deflandrea cooksoni</u> - <u>Deflandrea conicula</u>					
	168	13	0.8	<u>Areoligera sp.</u> - <u>Deflandrea cooksoni</u> - <u>D. conicula</u>	152	26	1.44	<u>Areoligera senonensis</u> - <u>Exochosphaeridium bifidum</u>					
	167	14	0.6	<u>Deflandrea conicula</u> - <u>Palaeocystodinium australinum</u>	151	38	1.22	<u>Deflandrea cooksoni</u> - <u>Trithyrodinium scutulatum</u>					
	166	24	1.0	<u>Areoligera sp.</u> - <u>Exochosphaeridium bifidum</u>									
	Locality 1				Locality 5								
					Sample no.	No. of species	G/P	Dominant species					
					126	11	0.5	<u>Trithyrodinium scutulatum</u>					
					124-5	3	--	-----					
					123	30	1.0	<u>Gonyaulacysta giuseppi</u> - <u>Trithyrodinium diversicomptum</u>					
					122	36	1.56	<u>Dinogymnium digitus</u> - <u>Trithyrodinium diversicomptum</u>					
					121	23	1.0	<u>T. diversicomptum</u> - <u>T. scutulatum</u>					
					120	23	2.17	<u>Spiniferites ramosus</u> - <u>Trithyrodinium diversicomptum</u>					
					119	10	0.20	<u>Dinogymnium digitus</u> - <u>Trithyrodinium scutulatum</u>					
					118	18	0.25	<u>T. scutulatum</u>					
					117	21	1.14	<u>T. diversicomptum</u> - <u>T. scutulatum</u>					
					116	30	1.25	<u>T. diversicomptum</u>					
					Locality 6								

present study (Table 2). The same correspondence between the G/P ratio and species diversity was noted by Harland (1971) for the Campanian Bearpaw Formation of Alberta, Canada.

In documenting his case for correlating high diversity of dinoflagellate species and a high G/P ratio with open marine conditions, Harland (1971) called upon evidence from planktonic Foraminifera: the advent of open marine conditions (in terms of salinity) in the Bearpaw section was reflected by the foraminiferal assemblages and corresponded to relatively high diversity and high G/P ratios of the dinoflagellates.

The high diversity and high G/P ratios of the Basal Mount Laurel, Monmouth, and Brightseat formations in the Maryland-Delaware area, indicate an open marine environment of deposition. Within this context, however, relative differences among the three formations can be assessed. Associations of species through the section were examined for further paleoecological information. After counts of specimens per species were completed for each sample (Chart 1), the species were ranked in order of abundance (Chart 2). The assemblages of each sample were then assigned a hyphenated name for the species ranked one and two in abundance. The Mount Laurel samples are generally dominated by cavate cysts (see Morphological Terms, p. 53), more specifically, by one of two species of Trithyrodinium (T. diversicomptum n. sp. or T. scutulatum n. sp.). In only one Mount Laurel sample does a chorate (p. 53) species (Spiniferites ramosus subsp. ramosus) achieve dominance (Sample

120, Table 2).

In the Monmouth Formation, samples dominated by cavate species alternate with samples dominated by chorate species. Cavate species are Trithyrodinium scutulatum n. sp., Deflandrea conicula n. sp., D. cooksoni, and Palaeocystodinium australinum; chorate species are Areoligera senonensis, Areoligera sp., Systematophora placacantha, and Exochosphaeridium bifidum. The trend from dominance by cavate cysts toward dominance by chorate cysts continues into the Brightseat Formation, in which chorate species (primarily Areoligera sp.) rank first in abundance; position two is occupied by one of two species of Deflandrea (D. conicula n. sp. or D. dilwynensis), or by one of two species of Spinidinium (S. essoii or S. clavum) (Table 2).

Species dominance in terms of cyst type, cavate vs. chorate, appears to be ecologically controlled. Downie, Hussain, and Williams (1971), in an investigation of Eocene strata, considered two associations, one dominated by Spiniferites and the other by Areoligera (both chorate forms), to represent open marine conditions. Vozzhennikova (1967) shared their conviction, in stating that relatively thin-walled chorate cysts with elaborate processes (to facilitate flotation?) live in the open sea, while thick-walled cavate cysts live near shore.

Dominance of the basal Mount Laurel samples by cavate species of dinoflagellates is interpreted in this study to imply, within the open-sea environment, a relatively shallow depth of water (i.e., a nearer-shore environment) than for the Monmouth Formation; the

Brightseat would represent the environment the farthest from shore, in water about 300' deep (according to Nogan, 1964, on foraminiferal evidence).

Dominance by cavate cysts has an alternate explanation which must be considered here. Davey (1970) noted an abundance of the cavate cyst Deflandrea in Cenomanian strata of Saskatchewan and Arctic Canada; in contrast, Deflandrea was absent from the Tethyan assemblages of comparable age from Texas, England, and France, he reported. While the number of dinoflagellate species in the Canadian assemblages is smaller than in the other localities, the number of specimens is approximately the same for all localities. He concluded that Deflandrea may prefer cooler waters and that the Canadian and Arctic Canadian assemblages may constitute a boreal province of phytoplankton.

In the basal Mount Laurel Formation, species of Deflandrea and the cavate cyst Trithyrodinium together comprise 21.4% (nine species, Deflandrea; two species, Trithyrodinium) of the dinoflagellate species; in the Monmouth Formation, they comprise 15.0% (one species, Deflandrea; two species, Trithyrodinium) of the dinoflagellate species. In the Brightseat Formation, cavate cysts, represented by Deflandrea only, comprise 11.2% of the dinoflagellate species.

Although the percentage of Deflandrea-Trithyrodinium species in the basal Mount Laurel Formation is high relative to the Monmouth and Brightseat formations, deposition in cool water is not postulated. It appears that distance from shore is the controlling ecological

factor in the case of the Mount Laurel, and that a substantial influx of clastics has diluted the number of dinoflagellate cysts per unit volume of sediment.

Great numbers of Areoligera cysts appear higher in the section (Chart 1), as noted by McLean (1969) and Witmer (1975) for the Paleocene Aquia Formation of Virginia. "Floods" of Areoligera apparently reflect abnormal (undefined) marine conditions, as inferred by Nogan (1964), on the basis of Foraminifera and lithology. The paleoecological conditions controlling this phenomenon are not yet understood.

SUMMARY AND CONCLUSIONS

Diverse, excellently-preserved assemblages of dinoflagellates and acritarchs have been recovered from the basal Mount Laurel Sand, the Monmouth Formation, and the Brightseat Formation of the Maryland-Delaware Coastal Plain. The six outcrop localities lie along strike, from Ft. Washington, Maryland, about six miles south of the Washington, D.C., city limits, to the eastern end of the Chesapeake and Delaware Canal, about 12 miles south of Wilmington, Delaware. Fifty-one dinoflagellate genera and 95 species and four subspecies are recorded, of which one genus and nine species are described as new; five new combinations are proposed. Twelve acritarch genera containing 12 species and several informally-designated species (spp.), two species of Chlorophyta, and one species of Protozoa have been recovered. The stratigraphic distributions of the species are presented in Text-figures 8, 9, and 10, according to locality; the numerical abundance of each species is tabulated in Text-figure 11; the relative abundance of each species is recorded in Text-figure 12; and the local range of each is given in Text-figure 13.

Within the section, certain species have relatively restricted ranges, indicating the usefulness of dinoflagellates in zoning Atlantic Coastal Plain strata and ultimately, in correlating coastal plain and continental shelf strata. No formal zonation of the coastal plain strata was attempted in this study, however, since only local ranges are presented, and may be modified as new data are recorded.

The stratigraphic distribution of certain dinoflagellate and acritarch species indicates that an unconformity may separate Cretaceous and Tertiary strata in Maryland. Ranges of eight species and one subspecies of dinoflagellates and one acritarch species terminate at the Monmouth-Brightseat boundary, while 13 species of dinoflagellates make their first appearance in the study-area. The presence of an unconformity is supported by the ranges of dinoflagellate species near Annapolis, Maryland (Benson, 1975) and ostracode species (Hazel, pers. comm., 1975), and by lithologic evidence (Bennett and Collins, 1952).

The Mount Laurel and Monmouth phytoplankton assemblages were compared with the assemblages investigated by Wilson (1974) from the Maastricht area (Belgium-Netherlands) and from Denmark. On the basis of ranges of species common to the Maryland-Delaware section and the European section, the basal Mount Laurel Sand correlates with Wilson's Zone I, of Late Campanian age; a Late Campanian-Early Maestrichtian age for the formation as a whole is inferred. Megafossil evidence supports a Late Campanian age and foraminiferal evidence, a Late Campanian-Early Maestrichtian age for the Mount Laurel (Owens et al., 1970). A comparison of the Monmouth Formation with Wilson's Maastricht section confirms a Maestrichtian age based on megafossils (Cooke, 1952; Glaser, 1971).

A Paleocene age is assigned to the Brightseat Formation in this study, based on the concurrent presence of dinoflagellate species whose range either terminates or begins in the Paleocene. Information

based on ranges of ostracode species (Hazel, 1968, 1969) and Foraminifera (Nogan, 1964) indicates a Danian age for the Brightseat Formation; dinoflagellates should provide more information when Wilson completes his study of the Danian type section.

Through the Mount Laurel-Monmouth-Brightseat section, species diversity and the ratio of gonyaulacacean species to peridiniacean species (G/P) ratio were investigated; both may be environmentally controlled. Species diversity and the G/P ratio vary together (Harland, 1971; this study). High diversity and high G/P ratios for the three formations imply the presence of open marine conditions (Harland, 1971).

Differences in the dinoflagellate assemblages through the section may be influenced by minor environmental changes. The work of Vozzhennikova (1967) and Hussein et al. (1971) indicates that cavate cysts (e.g., Deflandrea) occur relatively nearer shore than do chorate cysts (e.g., Areoligera). All but one sample of the basal Mount Laurel Sand are dominated by a cavate species, in terms of rank abundance; in the Monmouth Formation, samples dominated by cavate species alternate with ones dominated by chorate species; in the Brightseat Formation, chorate species dominate each sample. The Mount Laurel is postulated to have been deposited relatively near shore; a shallow water of deposition is supported by lithologic evidence (Owens and Sohl, 1969). The Monmouth may represent deposition farther from shore, and the Brightseat, the farthest from shore of the three formations. The Brightseat was deposited in about 300 feet of water, according to Nogan (1964), on the

basis of foraminiferal evidence.

Dominance of samples near the top of the section by great numbers of Areoligera specimens is also considered to be environmentally-controlled (McLean, 1969; Witmer, 1975). On the basis of foraminiferal evidence (Nogan, 1964), abnormal (undefined) marine conditions are inferred, but the full paleoecologic significance of this phenomenon has yet to be assessed.

SYSTEMATIC PALYNOLOGY

Introduction

In this section, new species and a new genus are named and described, and the taxonomy of previously-described species is critically evaluated. Numerous, well-preserved specimens of most of the species have made possible the study of morphological variations within populations; thus new information and taxonomic clarifications are presented at this time. Probable evolutionary trends, when noted, are discussed.

All dinoflagellates and acritarchs were classified to the species level whenever possible, with the exception of species of Baltisphaeridium, Cymatiosphaera, and Micrhystridium. Due to the taxonomic difficulties of these genera, their questionable stratigraphic significance, and the paucity of specimens, species identification was not attempted.

The relative abundance of each species throughout the section relative to all other phytoplankton species is presented in the following terms:

Abundant - greater than 25%

Common - between 15 and 25%

Sparse - between 5 and 15%

Rare - between 1 and 5%

Extremely rare - less than 1%

All relative abundances are presented in Chart 2 (p. 33); specimen

counts from which the relative abundances are derived are tabulated in Chart 1 (p. 32).

Morphological Terms Employed in this Study

Terms commonly used in this study are defined below. For a more detailed compilation of terms, see Williams, Sarjeant, and Kidston (1973).

Annulate - a series of processes arranged in a closed ring on the outer surface of a cyst; generally one per plate-equivalent.

Antapex - the posterior-most portion of a cyst.

Apex - the anterior-most portion of a cyst.

Cavate - type of cyst characterized by spaces (pericoels) between endophragm and periphragm.

Cingulum - the approximately equatorial furrow; it bears the ribbon-like flagellum in the parent theca.

Chorate - type of cyst with more or less spheroidal main body, of which endophragm and periphragm are in contact; processes, formed from periphragm, radiate out from main body.

Cyst - the resistant-walled body preserved in the fossil state.

Dorsal - the side of a dinoflagellate opposite the side bearing the longitudinal furrow.

Endoblast - in bi-layered cysts, the inner body.

Endophragm - in bi-layered cysts, the inner wall layer.

Epittract - the portion of the cyst anterior to the cingulum.

Gonal process - one originating at the points of intersection of several plate-equivalents, or of a plate-equivalent and the cingulum or sulcus.

Horn - an extension of the wall or outer layer; may be apical, ant-apical, or lateral in position, but commonly apical and antapical.

- Hypotract - the portion of a cyst posterior to the cingulum.
- Left - the portion of a dinoflagellate lying to the left of the longitudinal midline when the dorsal side faces the observer.
- Main body - central portion of a cyst from which processes arise.
- Periblast - the outer body in bilayered cysts.
- Pericoel - the cavity formed by the separation of endophragm and periphragm.
- Periphragm - the outer wall layer in bilayered cysts.
- Peritabular - ornamentation originating immediately interior to plate-equivalent boundaries.
- Simulate - a series of processes forming a closed polygon on the cyst surface, developed within, but parallel to, plate-equivalent boundaries.
- Soleate - a series of processes forming a horseshoe shape on the cyst surface.
- Sulcus - the longitudinal furrow; it bore the whip-like flagellum on the parent theca.
- Suture - the boundary between plate-equivalents.
- Sutural fold - an outwardly-directed fold of the periphragm along plate-equivalent boundaries, producing a separation of periphragm and endophragm directly beneath the fold.
- Sutural ridge - an outwardly-directed projection of either wall along plate-equivalent boundaries; only the outer surface of the wall is involved, rather than the whole wall, as in a sutural fold.
- Tabulation - the pattern by which plate-equivalents in the cyst are arranged. Tabulation is of prime importance in dinoflagellate taxonomy.
- Theca - the "armor" of cellulosic plates enclosing the protoplast in the motile stage of a dinoflagellate life cycle; the thecate stage alternates with the encysted, non-motile stage.
- Ventral - the side of a dinoflagellate bearing the longitudinal furrow, or sulcus.

Classification Employed in this Study

Sarjeant and Downie (1966) devised a strictly morphologic classification system for fossil dinoflagellate genera. Their form genera were grouped into artificial cyst-families, since they could not be accommodated in natural families.

Wall and Dale (1968) criticized the classification of Sarjeant and Downie as being nonevolutionary and nonbiological, because it divorced cysts from thecae. They proposed a comprehensive classification system for fossil and modern dinoflagellates. Modern dinoflagellates and their fossil antecedents would be designated by a single epithet; families would be designated on the basis of tabulation.

Until lineages can be documented and the taxonomic synthesis of cysts and thecae can be accomplished, a generalized scheme for classifying fossil dinoflagellate genera is proposed. Accordingly, the following families are used in this study:

- a. Gonyaulacaceae - for genera which display or presumably have the same basic tabulation as Gonyaulax.
- b. Peridiniaceae - the same as above, for Peridinium.
- c. Family Uncertain - for genera which cannot be assigned to either of the above families.

The acritarchs in this study are classified according to the system of Downie, Evitt, and Sarjeant (1963), with the modification proposed

by Staplin, Jansonius, and Pocock (1965), who restricted the Subgroup Acanthomorphae by erecting the new Subgroup Baltisphaeritae.

Species List

Dinoflagellate and acritarch species recovered in the present study are listed below in alphabetical order within each family, as they are presented in the following section on systematic descriptions.

Division PYRRHOPHYTA Pascher

Class DINOPHYCEAE Fritsch 1935

Order PERIDINIALES Haeckel 1894

Family GYMNODINIALES (Berg) Schutt 1896

Dinogymnium acuminatum Evitt, Clarke, & Verdier 1967

Dinogymnium digitus (Deflandre 1935) Evitt et al. 1967

Dinogymnium euclaensis Cookson & Eisenack 1970

Dinogymnium westralium (Cookson & Eisenack 1958) Evitt et al. 1967

Dinogymnium sp.

Family GONYAULACACEAE Lindemann 1928

Cannosphaeropsis utinensis O. Wetzel 1933

Cordosphaeridium brevitrunctum n. sp.

Cordosphaeridium eoinodes (Eisenack 1958) Eisenack 1963

Cordosphaeridium fibrospinosum Davey & Williams 1966

Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963

Cordosphaeridium cf. C. inodes (Klumpp 1953) Eisenack 1963

Coronifera oceanica Cookson & Eisenack 1958

Cyclonephelium distinctum Deflandre & Cookson 1955

- Cyclonephelium vitilare Cookson 1965
- Danea mutabilis Morgenroth 1968
- Diconodinium glabrum Cookson & Eisenack 1960
- Diphyes colligerum (Deflandre & Cookson 1955) Davey & Williams 1966
- Exochosphaeridium bifidum (Clarke & Verdier 1967) Clarke et al. 1968
- Exochosphaeridium phragmites Davey et al. 1966
- Florentinia laciniata Davey & Verdier 1973
- Gonyaulacysta giuseppeii (Morgenroth 1966) Sarjeant 1969
- Gonyaulacysta wetzeli (Lejeune-Carpentier 1939) Sarjeant 1969
- Hystrichokolpoma fimbriata Morgenroth 1968
- Hystrichokolpoma sp.
- Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
- Hystrichosphaeropsis complanata Eisenack 1965
- Lanternosphaeridium sp.
- Leptodinium dispertitum Cookson & Eisenack 1965
- Leptodinium elegans Cookson & Eisenack 1965
- Leptodinium victorianum Cookson & Eisenack 1965
- Oligosphaeridium complex (White 1842) Davey & Williams 1966
- Operculodinium centropurum (Deflandre & Cookson 1955) Wall 1967
- Operculodinium israelianum (Rossignol 1962) Wall 1967
- Renidinium cf. R. membraniferum Morgenroth 1968
- Samlandia chlamydophora Eisenack 1954

- Scriniodium australiense (Deflandre & Cookson 1955)
Eisenack 1967
- Spiniferites crassipellis (Deflandre & Cookson 1955)
Sarjeant 1970
- Spiniferites hypercanthus (Deflandre & Cookson 1955) n.
comb.
- Spiniferites membranaceus (Rossignol 1964) Sarjeant 1970
- Spiniferites monilis (Davey & Williams 1966) Sarjeant 1970
- Spiniferites pseudofurcatus (Klumpff 1953) Sarjeant 1970
- Spiniferites ramosus subsp. granomembranaceus Davey &
Williams 1966) Lentini & Williams 1973
- Spiniferites ramosus subsp. granosus (Davey & Williams 1966)
Lentini & Williams 1973
- Spiniferites cf. S. ramosus subsp. granosus Davey & Williams
1966) Lentini & Williams 1973
- Spiniferites ramosus subsp. multibrevis (Davey & Williams
1966) Lentini & Williams 1973
- Spiniferites ramosus subsp. ramosus (Ehrenberg 1838) Lentini
& Williams 1937
- Spiniferites ramuliferus (Evitt 1973) n. comb.
- Spiniferites septatus (Cookson & Eisenack 1967) McLean 1971
- Tanyosphaeridium variecalamum Davey & Williams 1966
- Trichodinium castanea (Deflandre 1935) Clarke & Verdier 1967
- Trichodinium hirsutum Cookson 1965
- Xenicodinium lubricum Morgenroth 1968

Family PERIDINIACEAE (Ehrenberg) Engler 1892

- Ascodinium pontis-mariae (Deflandre 1936) Deflandre 1966
- Deflandrea aspratitidis n. sp.

- Deflandrea asymmetrica Wilson 1967
- Deflandrea cf. D. balcattensis Cookson & Eisenack 1969
- Deflandrea camerata n. sp.
- Deflandrea conicula n. sp.
- Deflandrea cooksoni Alberti 1959
- Deflandrea cf. D. cooksoni Alberti 1959
- Deflandrea dartmooria Cookson & Eisenack 1965
- Deflandrea diebeli Alberti 1959
- Deflandrea dilwynensis Cookson & Eisenack 1965
- Deflandrea magnifica Stanley 1965
- Deflandrea cf. D. obscura Drugg 1967
- Deflandrea pannucea Stanley 1965
- Deflandrea pentaradiata Cookson & Eisenack 1965
- Deflandrea cf. D. striata Drugg 1967
- Palaeocystodinium australinum (Cookson 1965) n. comb.
- Palaeocystodinium golzowense Alberti 1961
- Palaeocystodinium polymorphum (Malloy 1972) n. comb.
- Palaeohystrichophora infusorioides Deflandre 1935
- Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
- Spinidinium clavum Harland 1973
- Spinidinium essoi Cookson & Eisenack 1967
- Trithyrodinium scutulatum n. sp.
- Trithyrodinium diversicomptum n. sp.
- Trithyrodinium membranophorum n. sp.
- Trithyrodinium vermiculatum (Cookson & Eisenack 1961)
n. comb.

Wetzeliella (Wetzeliella) homomorpha Deflandre & Cookson
1955

Family UNCERTAIN

Areoligera cassicula Drugg 1970

Areoligera senonensis Lejeune-Carpentier 1938

Areoligera sp.

Canningia hirta n. sp.

Ceratocorys veligera Lejeune-Carpentier 1944

Chlamyphorella urna Cookson & Eisenack 1960

Fibradinium annetorpense Morgenroth 1968

Forma A

Heterodinium intervallum n. gen. n. sp.

Hexagonifera chlamydata Cookson & Eisenack 1962

Histiocysta palla Davey 1969

Horologinella apiculata Cookson & Eisenack 1962

Horologinella incurvata Cookson & Eisenack 1962

Horologinella sp.

Impletosphaeridium sp.

Inversidinium protonsum n. sp.

?Inversidinium sp.

Kallosphaeridium brevibarbatum De Coninck 1969

Microdinium setosum Sarjeant 1966

Systematophora placacantha (Deflandre & Cookson 1955)
Davey et al. 1969

Thalassiphora pelagica (Eisenack 1954) Eisenack & Gocht
1960

Xenascus ceratioides (Deflandre 1937) Lentin & Williams 1973

Group ACRITARCHA Evitt 1963

Subgroup Acanthomorphae (Downie, Evitt, & Sarjeant 1963)
Staplin, Jansonius, and Pocock 1965

Micrhystridium (Deflandre 1937) Downie & Sarjeant 1963
(several species)

Subgroup Baltisphaeritae Staplin et al. 1965

Baltisphaeridium (Eisenack 1958) Downie & Sarjeant 1963

Subgroup Herkomorphae Downie et al. 1963

Cymatiosphaera (O. Wetzel 1933) Deflandre 1954 (several
species)

Subgroup Platymorphae Downie et al. 1963

Trigonopyxidina ginella (Cookson & Eisenack 1960) Cookson &
Eisenack 1961

Subgroup Pteromorphae Downie et al. 1963

Pterospermopsis danica W. Wetzel 1952

Subgroup Uncertain

Ascostomocystis potane Drugg & Loeblich 1967

Cyclopsiella elliptica Drugg & Loeblich 1967

Cyclopsiella vieta Drugg & Loeblich 1967

Fromea amphora Cookson & Eisenack 1958

Palaeostomocystis chytra Drugg 1967

Palaeostomocystis fragilis Cookson & Eisenack 1962

Palaeostomocystis laevigata Drugg 1967

Palaeostomocystis reticulata Deflandre 1937

Schizocystia laevigata Cookson & Eisenack 1962

Schizocystia cf. S. laevigata Cookson & Eisenack 1962

Wallodinium anglicum (Cookson & Hughes 1964) Lentin &
Williams 1973

Wallodinium luna (Cookson & Eisenack 1960) Lentin & Williams
1973

Xenikoon australis Cookson & Eisenack 1960

Division CHLOROPHYTA

Class CHLOROPHYCEAE

Order PROTOCOCCALES?

Family Uncertain

Palambages spp.

Order Volvocales

Family Lecaniella

Paralecaniella indentata (Deflandre & Cookson 1955)
Cookson & Eisenack 1970

Phylum Protozoa

Family incertae sedis Ophiobolidae

Ophiobolus lapidaris O. Wetzel 1933

Systematic Palynology: Descriptions

Division PYRRHOPHYTA Pascher

Class DINOPHYCEAE Fritsch 1935

Order GYMNODINIALES (Poche) Lindemann 1928

Family GYMNODINIACEAE (Berg) Schutt 1896

Genus Dinogymnium Evitt, Clarke & Verdier 1967Dinogymnium acuminatum Evitt, Clarke & Verdier 1967

Plate 1, figs. 1-2

- 1967a Gymnodinium sp. 1 Evitt: pl. 1, figs. A, B, F, G, S-U; text-figs. 1A, J-K.
- 1967 Dinogymnium acuminatum Evitt et al.: 8-16, pls. 1-2; pl. 3, figs. 1-8, 10, 12, 20; text-figs. 11-23.
- 1973 Dinogymnium acuminatum Evitt et al.; Evitt: pl. 1, fig. 1.

Comments: Maryland-Delaware specimens of D. acuminatum closely resemble the California specimens described by Evitt, Clarke and Verdier (1967) in bearing grana scattered over the surface, including the cingulum; all lack grana at the poles, and the costae lack pustules or denticles, but may bear longitudinally-aligned grana.

The Maryland-Delaware specimens vary greatly in size, and are generally smaller than those of Evitt et al.: (mean length x width) 57 x 35u (26 specimens) vs. 82 x 55u (160 specimens), respectively. The Cingulum Index (distance from apex to middle of cingulum, divided by pole-to-pole length, times 100) for the Maryland-Delaware specimens, however, is very close to that of the California specimens: 53.7 vs.

53.5, respectively.

Dimensions: Observed range (26 specimens measured) length 39-91u (mean 57u), width 24-45u (mean 35u); length-to-width ratio 1.5-2.0 (mean 1.7); Cingulum Index 44.2-57.8 (mean 53.7).

Stratigraphic distribution: Loc. 1, extremely rare in sample 166 and rare in sample 167; Loc. 5, extremely rare in samples 151, 155, and 156; Loc. 6, extremely rare to rare throughout the section.

Previously-reported occurrences: Maestrichtian of California, USA (Evitt, 1967b; Evitt, Clarke and Verdier, 1967); Maestrichtian of Texas (Evitt, 1973).

Dinogymnium digitus (Deflandre 1935b)
Evitt, Clarke & Verdier 1967

Plate 1, figs. 5-7

- 1935 Gymnodinium digitus Deflandre: 225-226, text-fig. 7-8.
- 1935b Gymnodinium digitus Deflandre; Deflandre: 12, pl. 2, figs. 4-5.
- 1961 Gymnodinium digitus Deflandre; Eisenack: pl. 33, fig. 3.
- 1967 Gymnodinium sp. 8 Evitt: 358, figs. 1, E-G.
- 1967 Gymnodinium digitus Deflandre; Vozzhennikova: 44, figs. 1a, b; pl. 5, figs. 5, 6, 12; pl. 6, figs. 2-6.
- 1967 Dinogymnium digitus (Deflandre) Evitt, Clarke & Verdier: 18-19.
- 1970 Dinogymnium digitus (Deflandre) Evitt et al.; Zaitzeff & Cross: pl. 4, figs. 35, 44.

Comments: Deflandre's original description of Dinogymnium digitus (Gymnodinium digitus) was based on only one specimen. The presence of numerous, well-preserved specimens in the collection at hand makes possible a re-description of the species.

Description: Cyst narrowly elongate, parallel-sided, with rounded ends; equatorial section ellipsoidal. Archeopyle, apparent on only one specimen, broadly V-shaped; archeopyle illustrated by Evitt (1967) is considerably narrower. Cingulum located anterior to equator of cyst, producing a longer hypotract than epittract. Cingulum, when present, is a shallow indentation at lateral margins of cyst. Cingulum levorotatory, displaced vertically at sulcus 1-1½ times cingulum width. Sulcus shallow but distinct, may extend nearly whole length of cyst; near antapex may be expressed by aligned minute grana; lateral margins may converge at poles. At cingulum, margins of sulcus flare to accommodate pair of thickenings, possibly the site of flagellar attachment on parent theca.

Cyst wall single-layered, ca. 0.5u thick. Surface of cyst laevigate to faintly granulose, with grana less than 0.5u high. Grana may be of two types on a single specimen: uniformly-distributed minute grana, and sparsely-distributed coarse ones. The minute grana may be aligned along epittract, simulating costae. A few specimens bear epittractal costae, which may be attributed to a "collapse" of epittract.

Discussion: The Maryland-Delaware specimens appear to be identical with Deflandre's Gymnodinium digitus and with Evitt's Gymnodinium sp. 8, in that the poles of the cyst are rounded; the sulcus extends onto the epitract; and the minute grana may be longitudinally aligned. Deflandre's holotype, as well as Eisenack's illustrated specimen of G. digitus (1961), appears to have a longer epitract than hypotract; the specimens, however, have been oriented with the antapex directed upward, according to Vozzhennikova (1967) and the present author. The Maryland-Delaware specimens, then, are identical with G. digitus in possessing a small epitract and a relatively long hypotract. The primary difference between the present author's specimens and those of Deflandre and of Vozzhennikova rests with the cingulum: the specimens studied herein display a levorotatory twist to the cingulum, while the cingulum of the specimens of Deflandre and of Vozzhennikova is circular. This difference does not warrant the erection of a new species.

Dimensions: Observed range (48 specimens measured): length 41-76u (mean 58u); width 14-24u (mean 17u). Length-to-width ratio 1.5-2.0 (mean 1.7). CI 32.4-52.1 (mean 40.8), reflecting the small size of epitract relative to hypotract.

Stratigraphic distribution: Loc. 5, extremely rare in sample 154; Loc. 6, rare to common throughout the section.

Previously-reported occurrences: Senonian of France (Deflandre, 1936 and 1937); Upper Cretaceous of Western Australia (Eisenack, 1961);

Senonian and Turonian of the USSR (Vozzhennikova, 1967); Maestrichtian of Texas, USA (Zaitzeff & Cross, 1970).

Dinogymnium euclaensis Cookson & Eisenack 1970

Plate 1, figs. 3-4

1967a Gymnodinium sp. 6 Evitt: 358, fig. 1, H, I; pl. 1, P.

1970a Dinogymnium euclaensis Cookson & Eisenack: 139, pl. 10, figs. 9-12.

Comments: Dinogymnium euclaensis from Maryland and Delaware compares closely in morphology and in size with the material described by Cookson and Eisenack (1970a). Information not included in the original description is added herein.

Description: Epitheca of the Maryland-Delaware forms generally bears up to 10 costae, distal margins of which may be slightly undulatory. "Inflated" specimens lack costae. Archeopyle apical, narrow and V-shaped. Cingulum displaced vertically at sulcus approximately one cingulum width. Sulcus may extend entire length of cyst. At and immediately posterior to cingulum, sulcus has two thickenings which may reflect sites of flagellar attachment on parent theca. Cyst wall up to 1.0 μ thick, surface laevigate to faintly granulose.

Dimensions: Observed range (17 specimens measured): Length 24-42u (mean 32u); width 15-26u (mean 22u). Length-to-width ratio 1.17-1.81 (mean 1.55u); Cingulum Index 47.4-58.9 (mean 56.6).

Stratigraphic distribution: Loc. 5; extremely rare in sample 151; Loc. 6, rare in sample 116, sparse in sample 119, rare in sample 122, and extremely rare in sample 125.

Previously-reported occurrences: Maestrichtian of Alabama and California, USA (Evitt, 1967a); Senonian of Western Australia (Cookson & Eisenack, 1970a).

Dinogymnium westralium (Cookson & Eisenack 1958)
Evitt, Clarke & Verdier 1967

Plate 1, fig. 10

- (?) 1955 Gymnodinium cf. heterocostatum Deflandre; Deflandre & Cookson: 248, pl. 1, fig. 7.
- 1958 Gymnodinium westralium Cookson & Eisenack: 25-26, pl. 1, fig. 9.
- (?) 1967b Gymnodinium sp. 3 Evitt: pl. 1, figs. D, E, L-V.
- 1967 Dinogymnium westralium (Cookson & Eisenack) Evitt, Clarke & Verdier: 23-24.

Comments: The Maryland-Delaware specimens are identical with D. westralium in that the epitheca and hypotheca are approximately equal in length; the antapex may be terminated in a point directed ventrally;

and the costae bear paired longitudinal rows of conspicuous pustulae. While costae are approximately equal in length on a single specimen, they become progressively shorter and converge toward the sulcus on some specimens; this feature was also noted by Evitt et al. (1967). Some specimens are "inflated," as are some of Evitt's (his fig. 1E, 1967). The archeopyle is broadly V-shaped. The cingulum is separated vertically at the sulcus by about one cingulum width. The sulcus is restricted to the hypotract.

Dimensions: Observed range (6 specimens measured): length 46-55u; width 21-29u.

Stratigraphic distribution: Loc. 1, extremely rare in samples 166 and 169; Loc. 5, extremely rare in samples 151, 154, and 155.

Previously-reported occurrences: Upper cretaceous of Western Australia (Deflandre & Cookson, 1955; Cookson & Eisenack, 1958); Maestrichtian of New Jersey and California (Evitt, 1967b).

Dinogymnium sp.

Plate 1, figs. 8-9

1967b Gymnodinium sp. 2 Evitt: pl. 1, C, H-J.

Comments: Two specimens comparable with Evitt's Species 2 were re-covered. Although the species is distinctive, additional specimens are needed to document the range of variation before a new species is erected.

Description: Epitract considerably longer than hypotract. Sulcus, restricted to hypotract, narrows from cingulum toward antapex, which is acuminate terminated. Costae of approximately equal length on a single specimen; grana and longitudinal rows of pustulae lie along costae.

Dimensions: One specimen is 112 x 36u, the other 122 x 38u.

Stratigraphic distribution: Loc. 5, extremely rare in sample 153.

Previously-reported occurrence: Maestrichtian of California, USA (Evitt, 1967b).

Family GONYAULACACEAE Lindemann 1928

Genus Cannosphaeropsis (O. Wetzel 1933) Williams & Downie 1966

Cannosphaeropsis utinensis O. Wetzel 1933

Plate 1, figs. 11-13

1933 Cannosphaeropsis utinensis O. Wetzel: 52, pl. 3, figs. 9-17; text-fig. 12.

- 1935 Cannosphaeropsis utinensis O. Wetzel; Deflandre: 223, pl. 4, fig. 1.
- 1937 Cannosphaeropsis utinensis O. Wetzel; Deflandre: 39, pl. 16, figs. 12-13.
- 1958 Cannosphaeropsis utinensis O. Wetzel filifera nov. subsp.
Cookson & Eisenack: 46, pl. 7, fig. 4.
- 1961 Cannosphaeropsis utinensis O. Wetzel; Alberti: 36, pl. 10, fig. 10.
- 1963 Cannosphaeropsis utinensis O. Wetzel; Eisenack: pl. 1, fig. 10.
- 1971 Cannosphaeropsis utinensis O. Wetzel; Wilson: pl. 3, fig. 1.

Comments: Three damaged specimens appearing identical with O. Wetzel's type specimens of Cannosphaeropsis utinensis were recovered from the Mount Laurel Formation. The surface of the main body bears sparse grana; the wall is ca. 0.5u thick. The primary radial rods, which arise from the main body, and the tangential rods are ca. 2.5u thick.

Stratigraphic distribution: Loc. 6, extremely rare in samples 122 and 123.

Previously-reported occurrences: Senonian of Germany (O. Wetzel, 1933; Alberti, 1961); Senonian of France (Deflandre, 1935 and 1937; Mercier, 1938); Upper Cretaceous of Australia (Cookson & Eisenack, 1958; Eisenack, 1963); Maestrichtian of Denmark (Wilson, 1971).

Genus Cordosphaeridium (Eisenack 1963) Davey 1969c

Cordosphaeridium brevitrunctum n. sp.

Plate 6, figs. 14-16

Derivation of name: brevis, L., short, referring to the numerous short processes; truncus, L., cut off, referring to the distal truncation of the processes.

Description: Spheroidal to ovoidal bi-layered cysts bearing relatively short, parallel-sided, fibrous processes, all of one type, numerous (>30), scattered randomly over surface. Processes, composed of loosely-bound fibers, are flattened; process cross-sections are taeniate to ellipsoidal. Processes bluntly truncated at distal extremity, non-flaring; terminal margin somewhat denser than shaft. Occasionally adjacent processes united by membranous web up to 3/4 the length of the shaft. Only slight variation in process length and width on a single specimen. At process bases, fibers radiate outward onto cyst surface, overlying each other at various angles, imparting micro-reticulate appearance to cyst surface. Fibers originate from delicate periphragm, which is up to 0.5u thick; endophragm dense, ca. 2.0u thick. Pre-cingular archeopyle relatively large (Type P), extends nearly to apex, has gabled anterior margin; operculum simple, free. No indication of cingulum or sulcus.

Discussion: The present author has examined specimens resembling Cordosphaeridium brevitrunctum n. sp. in samples of the Miocene ?Calvert Formation from the Maryland Coastal Plain south of Washington, D. C. The main body of the Virginia specimens is larger and the processes are longer; the fibers comprising the processes are more tightly bound to one another; there is a slight constriction of each process along its shaft. Further investigation may demonstrate an evolutionary lineage uniting the Paleocene and Miocene forms.

Dimensions: Holotype: main body diameter 66u, overall diameter 73u. Observed range (10 specimens measured): main body length 54-71u (mean 64u), width 52-66u (mean 59u); overall length 73-89u (mean 81u), width 70-84u (mean 75u). Processes 5.0-19.0u long, 2.0-9.0u wide.

Comparison with similar species: The relatively short, flattened, fibrous processes, with their parallel sides and bluntly-truncated distal margins, distinguish C. brevitrunctum from other species of Cordosphaeridium.

Holotype: Plate 6, figs. 14-15; VPISUPL sample 160, slide AF 34, coords. R6.8, +6.9.

Stratigraphic distribution: Loc. 2, extremely rare in sample 164; Loc. 3, extremely rare in sample 156; Loc. 4, extremely rare in samples 159 and 160.

Cordosphaeridium eoinodes (Eisenack 1958)
Eisenack 1963b

Plate 7, figs. 1-4

- 1958 Hystrichosphaeridium eoinodes Eisenack: 402, pl. 27, figs. 3-4.
 1959 Hystrichosphaeridium eoinodes Eisenack; Gocht: 69-70, pl. 3,
 figs. 5-6; ?pl. 7, fig. 9.
 1963 Cordosphaeridium eoinodes (Eisenack) Eisenack: 262.

Comments: New information regarding tabulation, archeopyle type, and nature of the processes is given below. This information supplements the descriptions of C. eoinodes of Eisenack (1968) and Gocht (1959). The Maryland-Delaware specimens of C. eoinodes are somewhat larger than Eisenack's type specimens (see Dimensions), but are similar in size to Gocht's specimens.

Description: Cyst bi-layered, main body ovoidal. Three kinds of processes are formed from periphragm: relatively large pre- and post-cingulars with circular bases (ventral) or lunate bases open to cingulum (dorsal); very slender sulcal processes with circular bases; and cingular processes with elliptical bases, their long axes paralleling cingulum. Sulcal processes tubular, remaining ones flattened, may taper slightly in distal direction; distal margins flared, serrate, may be incised up to approximately 1/2 process length; proximal portions of processes may be perforate. Processes only faintly fibrous, are intratabular, one per plate equivalent, outlining tabulation of 4', 6'', 6c, 5''', 10, 1''''', plus an anterior and a posterior sulcal

process and several pairs of small processes flanking sulcus. Archeopyle precingular (Type P), corresponds to 3'', bears gabled anterior margin; operculum simple, free. Cingulum weakly levorotatory, is vertically offset at sulcus by about the height of cingular process bases. Sulcus narrowly elliptical, is delimited by anterior and posterior sulcal processes and by small flanking processes. Endophragm is ca. 0.5u thick, periphragm 1.0-1.5u thick; external surface of periphragm is moderately granulose.

Dimensions: Observed range (14 specimens measured): main body length 56-66u (mean 60u), width 47-61u (mean 54u); overall length 88-115u (mean 103u), width 85-114u (mean 101u). Processes 20-30u long.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 2, extremely rare in sample 164; Loc. 3, extremely rare in sample 156; Loc. 4, extremely rare in samples 160-162; Loc. 5, extremely rare in samples 152, 154-155; Loc. 6, extremely rare in samples 122-123.

Previously-reported occurrences: Upper Aptian of Germany (Eisenack, 1958); Neocomian of Germany (Gocht, 1959).

Cordosphaeridium fibrospinosum Davey & Williams 1966b

Plate 7, figs. 5-6

1965 Hystrichosphaeridium inodes Klumpp; Stanley: 231, pl. 25, figs. 1-6.

- 1966b Cordosphaeridium fibrospinosum Davey & Williams, in Davey et al.: 86, pl. 5, fig. 5.
- 1969 Cordosphaeridium fibrospinosum Davey & Williams; Gocht: 43, pl. 2, figs. 3-4; text-fig. 29.
- 1970 Cordosphaeridium fibrospinosum Davey & Williams; Zaitzeff & Cross: pl. 2, fig. 22.
- 1972 Cordosphaeridium fibrospinosum Davey & Williams; Benedek: 26, pl. 8, fig. 7.

Description: Bi-layered, ovoidal cyst bearing flattened processes composed of loosely-bound fibers; processes approximately equal in length on a single specimen, one per plate-equivalent, outlining tabulation of 3-4', 0a, 6'', ?6c, 5''', 1'''''. Cingulum indicated by aligned processes, sulcus not discernible. Archeopyle pre-cingular (Type P), trapezoidal, corresponds to 3''; operculum free, simple. Endophragm ca. 0.5u thick, periphragm, ca. 1.0u thick.

Dimensions: Observed range (5 specimens measured): main body length 64-90u, width 52-83u; overall length 100-147u, width 81-131u; process length 18-28u.

Stratigraphic distribution: Loc. 1, extremely rare in samples 166, 167, 169, and 170; Loc. 3, rare in sample 156; Loc. 4, extremely rare in sample 160; Loc. 5, extremely rare in samples 151, 152, and 154.

Previously-reported occurrences: Paleocene of South Dakota (Stanley, 1965); Eocene of England (Davey and Williams, 1966b); Lower Eocene,

(Gocht, 1969); Maestrichtian of Texas (Zaitzeff and Cross, 1970);
Oligocene of Germany (Benedek, 1972).

Cordosphaeridium inodes (Klumpp 1953)
Eisenack 1963

Plate 6, figs. 1-11

- 1953 Hystrichosphaeridium truncigerum Cookson: 114, pl. 2, figs. 21-23.
- 1953 Hystrichosphaeridium inodes Klumpp: 391-392, pl. 18, figs. 1-2.
- 1955 Hystrichosphaeridium inodes Klumpp; Deflandre & Cookson: 277, pl. 8, fig. 7.
- 1961 Hystrichosphaeridium inodes Klumpp; Gerlach: 186, pl. 28, figs. 4-6.
- 1963 Cordosphaeridium inodes (Klumpp) Eisenack: 261, pl. 29, fig. 3.
- 1963 Hystrichosphaeridium inodes Klumpp; Brosius: 40, pl. 5, fig. 5.
- 1964 Cordosphaeridium inodes (Klumpp) Eisenack; Rozen: 310, pl. 4, figs. 1, 5.
- 1965 Cordosphaeridium inodes (Klumpp) Eisenack; De Coninck: 31, pl. 8, figs. 1-7; pl. 9, figs. 1, 2, 5.
- 1966 Cordosphaeridium inodes (Klumpp) Eisenack; Davey & Williams, in Davey et al.: 83, pl. 3, figs. 9; text-fig. 18.
- 1966 Cordosphaeridium inodes (Klumpp) Eisenack; Morgenroth: 23, pl. 5, fig. 1.
- ?1967a Cordosphaeridium inodes (Klumpp) Eisenack; Cookson & Eisenack: 134, pl. 19, fig. 12.
- 1967b Cordosphaeridium inodes (Klumpp) Eisenack: 249, pl. 41, fig. 1.
- 1967 Cordosphaeridium inodes (Klumpp) Eisenack; Drugg: 28, pl. 5, figs. 8-9.

- 1968 Cordosphaeridium inodes (Klumpp) Eisenack; Morgenroth: 549-550, pl. 45, fig. 9; pl. 46, figs. 1-8.
- 1969 Cordosphaeridium inodes (Klumpp) Eisenack; De Coninck: 30, pl. 8, figs. 9-10, 15-16, 23-24.
- 1969 Cordosphaeridium inodes (Klumpp) Eisenack; Gocht: 36-41, pl. 1, figs. 1-15; pl. 2, figs. 1-2; pl. 4, fig. 14; pl. 11, figs. 5-6; text-fig. 25-28.
- 1972 Cordosphaeridium inodes (Klumpp) Eisenack; Benedek: 25, pl. 7, figs. 10-11.

Comments: C. inodes occurs frequently in strata of Lower and Middle Tertiary age. For discussions of the morphological variability within the species, see Morgenroth (1968) and Gocht (1969); the Maryland specimens most closely resemble those of Drugg (1967). An account of the variability of the Maryland specimens is provided in the description below.

Description: Cyst ovoidal, bi-layered, Fibrous processes, one per plate-equivalent, outline tabulation of 3-4', 6'', 6c, 5''', 1p, 1'''''. An anterior and a posterior sulcal process are commonly present, plus one or two pairs of small processes flanking sulcus; if two pairs are present, one lies on ventral epitract, the other on ventral hypotract; sulcal processes solid. Processes approximately uniform in length on a single specimen, or may increase in length from apex to antapex. Process tips truncated, but at tip of antapical process axial fibers extend beyond lateral fibers, producing low triangular outline. Apical processes may be fused proximally by web-like fibrous strands. Cingulum, slightly levorotatory, bears flattened processes. Archeopyle

precingular (Type P), trapezoidal, with gabled anterior margin. Cyst surface microreticulate; periphragm is 1.5-2.5u thick, the endophragm 1.0-3.5u.

Discussion: Process length varies from specimen to specimen. Specimens bearing relatively long, slender process approach C. inodes gracilis. Previous workers (De Coninck, 1969; Gocht, 1969; Benedek, 1972), however, have recognized forms intermediate between C. inodes inodes and C. inodes gracilis. Accordingly, considerable variation in process length within C. inodes is tolerated in this study, and no subspecies are designated herein.

Only one specimen displays more than one process per plate-equivalent: the dorsal precingular, cingular, and post-cingular plate-equivalents each bear two processes.

Stratigraphic distribution: Loc. 2, extremely rare in sample 164, sparse in sample 165; Loc. 3, sparse in sample 157, rare in sample 158; Loc. 4, sparse in sample 162.

Previously-reported occurrences: Eocene of Germany (Klumpp, 1953); Oligocene of Australia (Cookson, 1953); Eocene of Australia (Deflandre & Cookson, 1955); Middle Eocene and Middle Miocene of northwestern Germany (Gerlach, 1961); Lower to Middle Eocene of Germany (Eisenack, 1963); Upper Oligocene of Germany (Brosius, 1963); Bartonian of Belgium (Rozen, 1964); Ypresian of Belgium (De Coninck, 1965 and 1969); Eocene of England (Davey and Williams, 1966); Lower Eocene of Germany

(Morgenroth, 1966; Gocht, 1969); Paleocene of western Tasmania and Australia (Cookson & Eisenack, 1967a and 1967b); Danian of California (Drugg, 1967); Danian of Denmark and Germany (Morgenroth, 1968); Oligocene of Germany (Benedek, 1972).

Cordosphaeridium cf. C. inodes (Klumpp 1953)
Eisenack 1963

Plate 6, figs. 11-12

1965 Cordosphaeridium inodes (Klumpp) Eisenack; De Coninck: 31,
pl. 8, figs. 1-7; pl. 9, figs. 1, 2, 5.

Comments: The specimens differ from C. inodes in their spheroidal shape and their thinner walls: the endophragm is 0.5-1.2u thick, the periphragm, ca. 1.0u thick. The processes are composed of very loosely-bound fibers; sulcal processes, however, may be solid, as in the case of C. inodes.

Dimensions: Observed range (7 specimens measured): main body length 78-99u, width 70-96u; overall length 124-163u, width 118-161u; processes up to 44u long.

Stratigraphic distribution: Loc. 2, sparse in sample 165; Loc. 4, rare in sample 162.

Previously-reported occurrence: Ypresian of Belgium (DeConinck, 1965).

Genus Coronifera Cookson & Eisenack 1958Coronifera oceanica Cookson & Eisenack 1958

Plate 3, figs. 9-10

- 1958 Coronifera oceanica Cookson & Eisenack: 45, pl. 12, figs. 5-6.
- 1958 Coronifera oceanica Cookson & Eisenack; Eisenack: 407, pl. 25, fig. 1.
- 1964 Coronifera oceanica Cookson & Eisenack; Cookson & Hughes: 56, pl. 9, figs. 8-9.
- ?1967 Coronifera cf. C. oceanica Cookson & Eisenack; Drugg: 33, pl. 6, fig. 8.
- 1967 Coronifera oceanica Cookson & Eisenack; Clarke & Verdier: 77, pl. 17, fig. 9.
- 1968 Coronifera oceanica Cookson & Eisenack; Cookson & Eisenack: 120, fig. 6K.
- 1969 Coronifera oceanica Cookson & Eisenack; Davey: 162, pl. 8, figs. 8, 11.
- 1969 Coronifera oceanica Cookson & Eisenack; Millioud: 426, pl. 1, figs. 5-6.
- 1969 Coronifera oceanica Cookson & Eisenack; Cookson & Eisenack: 7, fig. 10.
- 1970 Forma F sp. 1 Zaitzeff & Cross: pl. 1, fig. 15.
- 1971 Coronifera oceanica Cookson & Eisenack; Davey & Verdier: 16-17, pl. 2, figs. 7-8.
- 1973 ?Coronifera oceanica Cookson & Eisenack; Harland: 684-685, pl. 85, fig. 13.
- 1974 Coronifera oceanica Cookson & Eisenack; Davey & Verdier: 629.

Comments: The Maryland-Delaware specimens of C. oceanica lack the stiff apical spine observed by Cookson and Eisenack (1958 and 1969) and

by Eisenack (1958). The large, open antapical process is subquadrate to cylindrical, with denticulate to digitate distal margins. The slender, solid processes are numerous (>40), randomly distributed. The processes, formed from the periphragm, are relatively short at the apex and become progressively longer toward the antapex. The processes bear capitate tips; a few circular perforations may be scattered along the shaft. Rarely, adjacent processes are confluent up to 3/4 of their length, or a process may bifurcate at any point along its length. At the base of each process, striations radiate out over the cyst surface. The large precingular archeopyle (Type P) is roundly trapezoidal; the operculum is free, simple. The cyst wall, periphragm plus endophragm, is ca. 0.5u thick. The Maryland-Delaware specimens are similar in size to previously-described specimens.

Dimensions: Observed range (10 specimens measured): main body length 47-60u (mean 54u), width 40-59u (mean 51u); overall length 70-100u (mean 84u), width 62-91u (mean 75u); length of antapical process, 13-27u (mean 21u); length of capitate processes, 12-24u.

Stratigraphic distribution: Loc. 4, extremely rare in samples 160 and 161; Loc. 5, extremely rare in sample 154; Loc. 6, rare in sample 120, and extremely rare in samples 116, 122, and 123.

Previously-reported occurrences: Albian-Cenomanian, Lowest Campanian of Australia (Cookson & Eisenack, 1958, 1968, and 1969); Upper Aptian of northern Germany (Eisenack, 1958); Albian-Lower Coniacian of England

(Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1969);
 Maestrichtian-Danian of California (Drugg, 1967); Upper Hauterivian-
 Lower Aptian of France (Millioud, 1969); Maestrichtian of Texas
 (Zaitzeff & Cross, 1970); Middle and Upper Albian of France (Davey &
 Verdier, 1971 and 1973); Upper Campanian of Alberta, Canada (Harland,
 1973); Aptian of France (Davey & Verdier, 1974).

Cyclonephelium distinctum Deflandre & Cookson 1955

Plate 5, figs. 2-5

- 1955 Cyclonephelium distinctum Deflandre & Cookson: 285-6, pl. 2,
 fig. 14.
- 1959 Cyclonephelium distinctum Deflandre & Cookson; Gocht: 77-8, pl. 4,
 fig. 16-18.
- 1961 Circulodinium deflandrei Alberti: 29, pl. 4, fig. 7-13.
- 1962 Cyclonephelium distinctum Deflandre & Cookson; Cookson & Eisenack:
 494, pl. 5, fig. 4-11.
- 1964 Cyclonephelium distinctum Deflandre & Cookson; Manum & Cookson:
 16, pl. 4, figs. 1-3.
- 1967 Cyclonephelium distinctum Deflandre & Cookson; Drugg: 22-3,
 pl. 3, fig. 7.
- 1967 Cyclonephelium distinctum Deflandre & Cookson; Millioud: pl. 2,
 fig. 13.
- 1967 Cyclonephelium distinctum Deflandre & Cookson; Baltes: pl. 4,
 fig. 13.
- 1967 Cyclonephelium distinctum Deflandre & Cookson; Clarke & Verdier:
 17-8.
- 1968 Cyclonephelium distinctum Deflandre & Cookson; Cookson & Eisenack:
 120, fig. AF.

- 1969 Cyclonephelium distinctum Deflandre & Cookson; Davey: 166-7, pl. 2, figs. 6-8, 10; figs. 16 C, D, F.
- 1969 Cyclonephelium distinctum Deflandre & Cookson; Millioud: 427, pl. 1, fig. 7.
- 1971 Cyclonephelium distinctum Deflandre & Cookson; Davey & Verdier: 17-18.
- 1971 Cyclonephelium distinctum Deflandre & Cookson; Singh: 347-348, pl. 57, figs. 10-12.
- 1971 Cyclonephelium distinctum Deflandre & Cookson; Cookson & Eisenack: 219, pl. 8, fig. 5.
- 1973 Cyclonephelium distinctum Deflandre & Cookson; Davey & Verdier: 178.

Comments: Because of the wide range of variation in the processes of Cyclonephelium distinctum reported by previous authors, a description of the processes of the Maryland-Delaware specimens of this species is given below.

Description: Dorso-ventrally flattened cyst bearing peripheral processes which, to varying degree within the population, encroach upon dorsal and ventral unornamented central areas. Processes discrete, 5-20u in length, 1.0-3.5u in width. The wider processes appear to bear a central canal, as suggested by Alberti (1961). Processes may bear several circular perforations ca. 1.0u in diameter. Process tips flare distally to several times shaft diameter. Archeopyle apical (Type \bar{A}), free, with angular margin bearing sulcal notch. No cingulum, sulcus, or tabulation visible. Cyst outline hemispherical or lobate. If lobate, only right antapical lobe may be present; if two lobes present, the right is more strongly developed. Cyst wall up to ca. 1.75u thick, external surface granulose.

Discussion: C. distinctum closely resembles C. compactum. The latter, however, bears confluent processes: fence-like soleate complexes result if numerous processes are involved, or broad, blade-like processes, if only two adjacent ones are involved.

Dimensions: (Since opercula are only rarely in place, specimen length was measured from the archeopyle margin to the antapex.) Observed range (15 specimens measured): main body length 46-70u (mean 55u), width 53-80u (mean 62u).

Stratigraphic distribution: Loc. 5, extremely rare in sample 151; Loc. 6, extremely rare to sparse throughout the section.

Previously-reported occurrences: Senonian of Western Australia (Deflandre & Cookson, 1955; Cookson & Eisenack, 1968); Upper Valanginian to Hauterivian of Germany (Gocht, 1959); Upper Hauterivian to Aptian, ?Lower Albian of Germany (Alberti, 1969); Albian to Senonian of Western Australia (Cookson & Eisenack, 1962); Campanian-Cenomanian of Arctic Canada (Manum and Cookson, 1964); Danian of California (Drugg, 1967); Berriasian-Hauterivian of France and Switzerland (Millioud, 1967); Albian of Roumania (Baltes, 1967); Cenomanian to Upper Campanian of England (Clarke & Verdier, 1967); Cenomanian of England, France, and Canada (Saskatchewan) (Davey, 1969); Lower Hauterivian of Switzerland, Upper Hauterivian-Aptian of France (Millioud, 1969); Albian of France (Davey & Verdier, 1971); Valanginian-Danian of Canada (Alberta) (Singh, 1971); Albian-Cenomanian of Western Australia (Cookson & Eisenack, 1971);

Upper Campanian-Upper Maestrichtian of Belgium (Wilson, 1971); Upper Albian (Vracomian) of France; Upper Albian-Lower Cenomanian of Switzerland (Davey & Verdier, 1973); Upper Campanian of Alberta, Canada (Harland, 1973); Campanian-Maestrichtian of NWT, Canada (McIntyre, 1974).

Cyclonephelium vitilare Cookson 1965

Plate 5, figs. 6-7

1965b Cyclonephelium vitilare Cookson: 138, pl. 24, figs. 1-7.

Comments: Three specimens, appearing identical with Cookson's type specimens, were recovered from the Brightseat Formation. The morphological information below supplements Cookson's original description.

Description: Accessory archeopyle sutures delimit six precingular plate-equivalents; a sulcal notch is present. Within and parallel to anterior margins of 1''-5'', periphragm forms single or double fillets ca. 1.0u wide; posteriorly they curve to run parallel to cyst long axis, and are elevated by sparsely-distributed pillars ca. 2.0u high. The fillets spread out distally and are fused into patchy meridional belts along lateral portions of both dorsal and ventral surfaces. The periphragm forms two antapical projections; the left is more strongly-developed.

Dimensions: Observed range (3 specimens measured): Main body length 64-67u, width 66-73u; overall length 73-78u, width 72-80u. (Opercula missing, length measured from archeopyle margin to antapex.)

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 4, extremely rare in samples 160, 162, and 163.

Previously-reported occurrence: Paleocene of Australia (Cookson, 1965c).

Danea mutabilis Morgenroth 1968

Plate 3, figs. 3-8

1968 Danea mutabilis Morgenroth: 542-543, pl. 43, figs. 5-9; pl. 44, figs. 1-3.

1970 Danea mutabilis Morgenroth; Drugg: 816, fig. 9F, fig. 10 A-F.

Comments: The Maryland specimens of Danea mutabilis appear identical in morphology and in size with Drugg's specimens (1970). The following description gives new information concerning tabulation and nature of the processes.

Description: Bi-layered ovoidal cyst bearing fibrous processes formed from the periphragm; pre- and post-cingular processes are grouped into annulate to simulate complexes lying well within plate-equivalent boundaries. Apical process forms quill-like extension of the cyst; antapical process may encircle a narrow, rounded protrusion formed from

the endophragm. Cingular processes flattened. Processes, except apical one, of approximately equal length. Processes outline tabulation of 4', 0a, 6'', 6c, 5''', 1p, 1''''', plus several pairs of sulcal processes varying in number from specimen to specimen; an anterior and a posterior sulcal process may be present. 1'' triangular. Archeopyle (Type P) relatively large, trapezoidal, bears gabled anterior margin, corresponds to 3''; operculum free, simple. Cingulum weakly levorotatory, vertically offset at sulcus by about 1-1½ times height of cingular process bases. Sulcus elongate, ellipsoidal, bordered by anterior and posterior sulcal processes and by flanking sulcal processes. Endophragm and periphragm each ca. 2.0-4.5u thick; external surface of periphragm microreticulate.

Discussion: The Maryland specimens resemble Morgenroth's holotype (his pl. 43, figs. 5-6), which he termed the "typical" form of the species. His "typical" forms grade into others displaying progressively reduced processes (his pl. 43, figs. 7-9); at the extreme, processes are completely suppressed and the cyst wall is greatly thickened (his pl. 44, figs. 1-3). Only his "typical" form, with well-developed processes, appears in the present study. The Maryland specimens are larger than those of Morgenroth.

Dimensions: Observed range (14 specimens measured): main body length 85-115u (mean 107u); width 76-99u (mean 89u); overall length 160-227u (mean 182u), width 117-180u (mean 143u); apical process 38-64u long (mean 50u). Morgenroth's specimens: main body length x width, 80 x 68u (mean).

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in sample 157 and rare in sample 158; Loc. 4, extremely rare in sample 162.

Previously-reported occurrences: Danian of Denmark and northern Germany (Morgenroth, 1968); Danian of Alabama (Drugg, 1960).

Genus Diconodinium Eisenack & Cookson 1960

Diconodinium glabrum Eisenack & Cookson 1960

Plate 5, fig. 12

- 1960 Diconodinium glabrum Eisenack & Cookson: 3, pl. 1, fig. 11.
 1961 Diconodinium glabrum Eisenack & Cookson; Eisenack: 294, text-fig. 6.
 1969 Diconodinium glabrum Eisenack & Cookson; Davey: 13-14, pl. 3, figs. 7-8.

Comments: The Maryland-Delaware specimens, morphologically identical with the specimens of Cookson & Eisenack (1960) and of Davey (1969), are similar in size to the South African specimens; the Australian specimens are considerably larger.

Dimensions: Observed range (15 specimens measured): length 36-54u (mean 47u), width 26-36u (mean 31u). (South African specimens: length 32-38u, width 22-30u; Australian specimens: length 62-142u, width 41-72u).

Stratigraphic distribution: Loc. 1, extremely rare in sample 166, rare in samples 168 and 169, extremely rare in sample 170; Loc. 4, extremely rare in sample 160; Loc. 5, rare in samples 151, 153 and 155, extremely rare in sample 156; Loc. 6, rare in samples 122 and 123.

Previously-reported occurrences: Albian-Cenomanian of Australia (Cookson & Eisenack, 1960); Upper Cretaceous of Natal, South Africa (Davey, 1969b).

Genus Diphyes (Cookson 1965a) Davey & Williams 1966

Diphyes colligerum (Deflandre & Cookson 1955)
Davey & Williams 1966b

Plate 3, fig. 11

- 1953 non Hystrichosphaeridium sp. C Cookson: 115, pl. 2, figs. 29-30.
- 1955 Hystrichosphaeridium colligerum Deflandre & Cookson: 278, pl. 7, fig. 3.
- 1961b Hystrichosphaeridium colligerum Deflandre & Cookson; Cookson & Eisenack: 44, pl. 2, fig. 9.
- 1963 Baltisphaeridium colligerum (Deflandre & Cookson) Downie & Sarjeant: 91.
- 196 Hystrichosphaeridium colligerum Deflandre & Cookson; Rozen: 301-302, pl. 1, figs. 7-8; text-figs. 9-10.
- 1965 Diphyes colligerum (Deflandre & Cookson) Cookson: 86, pl. 9, figs. 1-12.
- 1965 Hystrichosphaeridium colligerum Deflandre & Cookson; Stanley: 231, pl. 24, figs. 7-8.

- 1966 Hystrichosphaeridium colligerum Deflandre & Cookson; Morgenroth: 29-30, pl. 8, figs. 1-2.
- 1966 Diphyes colligerum (Deflandre & Cookson) Davey & Williams, in Davey et al.: 96, pl. 4, figs. 2-3.
- 1967a Diphyes colligerum (Deflandre & Cookson) Davey & Williams; Cookson & Eisenack: 134, pl. 17, fig. 7.
- 1967b Diphyes colligerum (Deflandre & Cookson) Davey & Williams; Cookson & Eisenack: 251, pl. 41, fig. 3.
- 1969 Diphyes colligerum (Deflandre & Cookson) Davey & Williams; De Coninck: 33-34, pl. 9, figs. 13-18.
- 1970 Diphyes colligerum (Deflandre & Cookson) Davey & Williams; Heisecke: 242, pl. 4, fig. 1; pl. 7, fig. 3.
- 1974 Diphyes colligerum (Deflandre & Cookson) Davey & Williams; Matsuoka: 328-329, pl. 44, fig. 7.

Comments: Diphyes colligerum displays two kinds of processes formed from the periphragm: relatively small processes randomly distributed over the cyst surface, and one large antapical process, variable in outline. The specimen illustrated by Deflandre and Cookson (pl. 7, fig. 3; 1955) was oriented with the antapex directed upward, so that they considered the antapical process an apical one. The identity of the antapical process was again overlooked when Cookson (1965) erected the genus Diphyes for bipartite forms bearing an anterior and a posterior portion of the main body, both globose; the posterior portion, however, is actually an "inflated" antapical process. The specimens of Rozen (1964) and of Morgenroth (1966) also have an "inflated" antapical process; a tapering antapical process occurs on the specimens of Deflandre and Cookson (1955) and of Cookson and Eisenack (1967a).

The distal margin of the process may flare to the diameter of the process base (Stanley, 1965; Cookson & Eisenack, 1967a; this study). The antapical process may bear several accessory spinules directed posteriorly (Davey and Williams, 1966; this study). The process may be open or closed distally; in the present study, it is open.

The remaining processes are slender, distally-tapering, and of approximately equal length on a single specimen. Adjacent processes may be fused along nearly their entire length. The processes, at least 44 in number, appear to be distributed in four to five series paralleling the cingulum; the number of processes in each series varies from specimen to specimen.

In the Maryland-Delaware collection two morphotypes may be distinguished on the basis of the distal terminations of the slender processes: one morphotype has acuminate process tips; the other has furcate, aculeate tips. Both types of processes, which appear to be open along their entire lengths, may be up to 7.5u wide at the base. The acuminate-tipped processes are 0.5-0.75u wide at the tip; the furcate ones taper to ca. 1.0u in width before flaring to a width of ca. 3.5u. The two morphotypes are otherwise identical; they occur in approximately equal numbers in this study and show no stratigraphic separation. The emendation of D. colligerum by Davey & Williams (1966) accommodates both morphotypes; accordingly, the morphotypes are considered herein as variants of D. colligerum rather than as subspecies.

The archeopyle is apical, with an angular margin; an operculum was not observed. The cyst surface is laevigate to faintly granulose.

The endophragm and periphragm together are ca. 0.5u thick. The Maryland-Delaware specimens are similar in size to previously-described specimens.

Dimensions: Observed range (9 specimens measured): diameter of main body 34-38u; smaller processes 13-20u in length; antapical process 15-20u in length.

Stratigraphic distribution: Loc. 3, extremely rare in samples 156 and 157; Loc. 4, extremely rare in sample 162; Loc. 5, extremely rare in samples 152 and 154; Loc. 6, extremely rare in samples 121 and 122.

Previously-reported occurrences: Lower Eocene of Australia (Deflandre & Cookson, 1955); Paleocene-Eocene of Australia (Cookson & Eisenack, 1961, and 1967a, 1967b); Bartonian of Belgium (Rozen, 1965); Senonian-Upper Eocene of Australia (Cookson, 1965); Paleocene of South Dakota (Stanley, 1965); Paleocene of Australia (Harris, 1965); Lower Eocene of Germany and Belgium (Morgenroth, 1966); Lower Eocene of England (Davey & Williams, 1966); Ypresian of Belgium (De Coninck, 1969); ?Danian of Argentina (Heisecke, 1970); Miocene of Japan (Matsuoka, 1974).

Genus Exochosphaeridium Davey, Sarjeant, Downie & Williams 1966

Exochosphaeridium bifidum (Clarke & Verdier 1967)
Clarke, Davey, Sarjeant, & Verdier 1968

Plate 2, figs. 13-15

1967 Baltisphaeridium bifidum Clarke & Verdier: 72-73, pl. 17, figs. 5-6; text-fig. 30.

1968 Exochosphaeridium bifidum (Clarke & Verdier) Clarke et al.: 17.

Comments: The Maryland-Delaware specimens closely resemble, in morphology and in size, the specimens of Clarke & Verdier (1967); the treatment of several features in the description below supplements their original description.

Description: Processes, approximately uniform in length on a single specimen, are up to 3.0u wide; among them are interspersed a few processes only 1.0u wide. Adjacent processes may be confluent up to 3/4 of their length. A foliate cluster of loosely-bound fibers occurs at apex. Archeopyle precingular (Type P), trapezoidal, with gabled anterior margin. Endophragm is ca. 0.5u thick, periphragm, 1.5-2.0u thick; external surface of periphragm is microreticulate.

Dimensions: Observed range (39 measured): main body length 54-78u (mean 64u), width 47-81u (mean 59u); overall length 76-119u (mean 93u), width 64-117u (mean 86u); process length 10-31u.

Stratigraphic distribution: Loc. 1, extremely rare to sparse throughout the section; Loc. 2, rare in sample 164 and extremely rare in sample 165; Loc. 3, extremely rare in sample 156; Loc. 4, sparse in sample 159 and extremely rare in samples 160-162; Loc. 5, extremely rare to common throughout the section; Loc. 6, extremely rare to rare throughout the section.

Previously-reported occurrence: Cenomanian-Campanian of England
(Clarke & Verdier, 1967).

Exochosphaeridium phragmites Davey et al. 1966

Plate 3, figs. 1-2

- 1966 Exochosphaeridium phragmites Davey et al.: 165, pl. 2, figs. 8-10.
- 1969 Exochosphaeridium phragmites Davey et al.; Davey: 163, pl. 7, fig. 5.
- ?1967a Exochosphaeridium phragmites Davey et al.; Clarke & Verdier: 149-150, pl. 14, fig. 4.

Comments: The specimens investigated resemble those of Davey et al. in that process lengths are comparable; however, the main body of Davey's specimens is considerably smaller. E. phragmites differs from E. bifidum in its greater number of processes, all bearing acuminate tips, and its slightly greater size; specimens of E. phragmites commonly bear, in addition to the distinctive apical process, a relatively long antapical process. The endophragm is ca. 0.5u thick, the periphragm, 2.0-3.0u thick.

Dimensions: Observed range (13 specimens): main body length 64-100u (mean 85u), width 62-90u (mean 78u); overall length 92-114u (mean 118u), width 93-128u (mean 108u); maximum length of processes, 22u.

Stratigraphic distribution: Loc. 1, rare in samples 170-171; Loc. 2, rare in sample 164; Loc. 4, extremely rare in sample 161; Loc. 5, rare in samples 151-152; Loc. 6, extremely rare in sample 122.

Previously-reported occurrence: Cenomanian of England (Davey et al., 1966); Senonian, Albian-Cenomanian of Australia (Cookson & Eisenack, 1970a).

Genus Florentinia Davey & Verdier 1973

Florentinia laciniata Davey & Verdier 1973

Plate 3, fig. 16; Plate 4, figs. 1-3

- 1937 Hystrichosphaeridium ferox Deflandre: 16-17, pl. 14, figs. 3-4.
- 1939 Hystrichosphaeridium ferox Deflandre; Deflandre & Courteville: 7, pl. 3, fig. 3.
- 1952 Hystrichosphaeridium ferox Deflandre; W. Wetzel: 402, pl. A, fig. 13; text-fig. 20.
- 1955 Hystrichosphaeridium ferox Deflandre; W. Wetzel: 39, text-figs. 15, 20.
- 1958 Hystrichosphaeridium ferox Deflandre; Eisenack: 401, pl. 27, figs. 1-2.
- 1959 Hystrichosphaeridium ferox Deflandre; Gocht: 71, pl. 4, fig. 1.
- 1961 Hystrichokolpoma sp. A Alberti: 39, pl. 9, fig. 12.
- 1962 Hystrichosphaeridium ferox Deflandre; Cookson & Eisenack: 491, pl. 4, fig. 15.
- 1963 Baltisphaeridium ferox (Deflandre) Downie & Sarjeant: 91.
- 1964 Baltisphaeridium ferox (Deflandre) Downie & Sarjeant; Cookson & Hughes: 55, pl. 10, fig. 11.

- 1966 Hystrichokolpoma ferox (Deflandre) Williams & Downie: 181.
- 1967 Baltisphaeridium cf. B. ferox (Deflandre) Downie & Sarjeant; Drugg: 32, pl. 5, fig. 16.
- 1967 "Hystrichosphaeridium" ferox Deflandre; Evitt: 19, pl. 8, figs. 1-5.
- 1967 Baltisphaeridium ferox (Deflandre) Downie & Sarjeant; Clarke & Verdier: 73, pl. 15, fig. 4.
- 1968 Hystrichosphaeridium ferox Deflandre; Cookson & Eisenack: 119, figs. 3M-3N.
- 1969 Hystrichokolpoma ferox (Deflandre) Williams & Downie; De Coninck: 34-35, pl. 10, figs. 5-6.
- 1969 Hystrichokolpoma ferox (Deflandre) Williams & Downie; Davey: 159, pl. 9, figs. 5-7.
- 1970 "Hystrichosphaeridium" ferox Deflandre; Heisecke: 246-248, pl. 7, fig. 2; pl. 8, figs. 1-2.
- 1971 Hystrichokolpoma ferox (Deflandre) Davey; Singh: 326, pl. 51, figs. 1-5.
- 1973 Florentinia laciniata Davey & Verdier: 186-187, pl. 2, figs. 1, 3, 4, 6, 7, 9.

Comments: Previous descriptions of Florentinia laciniata indicate considerable process variation from population to population; moreover, there are several kinds of processes on a single specimen. Hence, a full description of the processes of the Maryland-Delaware specimens is given below.

Description: Cyst bi-layered, spheroidal to ovoidal. Archeopyle combination apical and precingular (Type $\bar{A}a + P$). Apical opercular piece remains attached ventrally; precingular piece, equivalent to 3'', is free. Endophragm 0.5-1.0 μ thick, periphragm, 0.5-1.5 μ thick;

external surface of periphragm is densely granulose.

Processes intratabular, one per plate-equivalent, formed from the periphragm, outline tabulation of 4', 0a, 6'', 6c, 5''', 1p, 1''''.

Processes are of three different types on a single specimen:

1. 1''-5'' and 2'''-5''' have round to sub-angular bases; processes flatten distally and give rise to several prong-like extensions; the area between prongs is deeply concave and closed. Prongs taper to ca. 1.0u in width, are truncated, appear to be open distally.
2. 6'' and 1''', 1p and posterior sulcal process, and apical and antapical processes all simple, slender; they taper distally, are truncated, appear to be open distally. Sulcal processes, commonly two in number, are even more slender.
3. Cingular processes have narrow bases elongate parallel to cingulum and bear a slender subsidiary process at either end.

Discussion: Davey & Verdier erected the genus Florentinia for Hystrichokolpoma-like cysts having a precingular or combination-type archeopyle and processes open distally; the genus Hystrichokolpoma contains forms having an apical archeopyle and distally-closed processes. The present writer feels that the concept of Florentinia is too restrictive because of the difficulty in determining whether

small processes are distally closed or open. In the synonymy for Florentinia presented in this study, cysts previously described as Hystrihokolpoma ferox are included whether the processes are distally open or closed.

Dimensions: Observed range (7 specimens measured): main body length 46-70u, width 41-64u; overall length 64-113u, width 70-106u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 4, extremely rare in samples 161 and 162; Loc. 6, extremely rare in sample 116, rare in sample 120, and extremely rare in samples 121-123.

Previously-reported occurrences: ?Senonian of France (Deflandre, 1937; Deflandre & Courteville, 1939); Upper Aptian of Germany (Eisenack, 1958); Lower Hauterivian of Germany (Gocht, 1959); Cenomanian of Germany (Alberti, 1961); Albian-Cenomanian of Western Australia (Cookson & Eisenack, 1962); Upper Albian and Lower Cenomanian of England (Cookson & Hughes, 1964); Danian of California (Drugg, 1967); Cenomanian to Santonian of England (Clarke & Verdier, 1967); Mid-Cretaceous of Australia (Cookson & Eisenack, 1968); Ypresian of Belgium (De Coninck, 1969); Cenomanian and Turonian of England (Davey, 1969); ?Danian of Argentina (Heisecke, 1970); Upper Aptian to Danian of Alberta, Canada (Singh, 1971); Upper Albian of France (Davey & Verdier, 1973).

Genus Gonyaulacysta (Deflandre 1964) Sarjeant 1969

Gonyaulacysta giuseppei (Morgenroth 1966) Sarjeant 1969

Plate 4, fig. 16; Plate 5, fig. 1

1966 Gonyaulax giuseppei subsp. major Morgenroth: 6, pl. 2, figs. 5-6.

1969 Gonyaulacysta giuseppei (Morgenroth) Sarjeant: 9.

Comments: Specimens of G. giuseppei from Maryland and Delaware display more variation in wall-layer thickness than those described by Morgenroth from Denmark: his specimens are "thin-walled" (no dimensions given), while the periphragm of the Maryland-Delaware specimens is 1.0-5.0u thick. Tabulation is 4', 6'', ?c, 6''', lp, 1'''''. 1'''' laps over somewhat onto the sulcus, is elongate, and lies directly over the larger, also elongate, lp. 2'''' has the shape of an inverted triangle. The sulcus, flask-shaped, contains at least two platelets, also flask-shaped, lying side-by-side across the width of the sulcus, reaching as far as 3/4 the sulcal length. The cingulum is weakly indented, 5-8u in width, vertically offset at the sulcus 1-1½ times the cingulum width; Morgenroth reports an offset of twice the cingulum width for his specimens. The Maryland-Delaware specimens are slightly larger than those of Morgenroth.

Dimensions: Observed range (40 specimens measured): endoblast length 73-119u (mean 91u), width 73-99u (mean 84u); periblast length 87-131u (mean 111u), width 77-109u (mean 96u). Endophragm 0.5-1.0u thick, periphragm, 1.0-5.0u thick. Apical horn 6-20u long; gonally-distributed spines, up to 3u high.

Stratigraphic distribution: Loc. 1, extremely rare in samples 166 and 169, and rare in sample 170; Loc. 2, extremely rare in sample 165; Loc. 3, rare in sample 163 and extremely rare in sample 156; Loc. 4, extremely rare in sample 160 and rare in sample 161; Loc. 5, extremely rare to sparse throughout the section; Loc. 6, common in sample 123.

Previously-reported occurrence: Lower Eocene (?) of Denmark (Morgenroth, 1966).

Gonyaulacysta wetzeli (Lejeune-Carpentier 1939)
Sarjeant 1969

Plate 4, figs. 13-15

- 1939 Gonyaulax wetzeli Lejeune-Carpentier: B526-B529, text-figs. 1-2.
- 1946 Gonyaulax wetzeli Lejeune-Carpentier; Lejeune-Carpentier: B189, text-fig. 1.
- 1968 Gonyaulax wetzeli Lejeune-Carpentier; Morgenroth: 534-535, pl. 41, figs. 1-3.
- 1969 Gonyaulacysta wetzeli (Lejeune-Carpentier) Sarjeant: 11.

Comments: The Maryland-Delaware specimens compare morphologically and in tabulation with the specimens of Lejeune-Carpentier (1939; 1946); tabulation of 4', 6'', 6c, 6''', 1p and 1'''' is confirmed. The small spines she observed on the cyst outer surface are absent, however, from the specimens of the present study.

Morgenroth's specimens compare in size and morphology with those of Lejeune-Carpentier; the Maryland-Delaware specimens are larger (see Dimensions).

Dimensions: Observed range (25 specimens measured): endoblast length 81-116u (mean 95u), width 84-112u (mean 85u); periblast length 90-148u (mean 121u), width 75-102u (mean 95u); (Morgenroth's specimens: periblast mean 71 x 66u, 150 measured). Length of apical horn 12-38u; spines at junction of sutural ridges, up to 7u high. Endophragm ca. 1.0u thick; periphragm, 1.0-3.5u thick.

Stratigraphic distribution: Loc. 2, sparse in sample 164; Loc. 3, extremely rare in samples 156, 157, and 163; Loc. 4, extremely rare in sample 158 and rare in sample 161; Loc. 5, extremely rare in sample 155; Loc. 6, extremely rare to sparse throughout the section.

Previously-reported occurrences: Senonian (?) of Belgium (Lejeune-Carpentier, 1939 and 1946); Danian of Germany (Morgenroth, 1968).

Hystrichokolpoma Klumpp emend. Williams & Downie 1966a

Hystrichokolpoma fimbriata Morgenroth 1968

Plate 3, figs. 12-13

1968 ?Hystrichokolpoma fimbriata Morgenroth: 547-548, pl. 45, figs. 7-8.

Comments: Two specimens of H. fimbriata were recovered from the Maryland-Delaware samples. Because of its precingular archeopyle, the species is only temporarily assigned to Hystrichokolpoma; Morgenroth followed the same procedure. When more specimens are available, a new genus should be erected to accommodate the species.

Description: Cyst bi-layered, ellipsoidal. Plate-equivalents indicated by intratabular, simulate, sub-quadrate complexes of low ridges bearing flexuous spines at the corners; spines interconnected by a membrane extending nearly the entire length of spines, producing a fence-like structure, open distally; distal margins entire. On each plate-equivalent, fine transverse striae extend along cyst surface from suture to spine complex; cyst surface granulose within a complex. Spine complexes outline tabulation of 4', 0a, 6'', ?p, 1p?, 5''', 1'''''. 2''''-5'''' approximately equal in size, 1'''' relatively small, in shape of inverted triangle. Antapical process cylindrical, open, resembling that of Coronifera oceanica; cyst surface coarsely granulose within antapical process. Archeopyle precingular (Type P), roundly trapezoidal, reduced, corresponds to plate-equivalent 3''; operculum simple, free. Cingulum marked by median, linear ridge similar to that of simulate complexes; ridge bears flexuous spines. Cingulum levorotatory, vertically offset at sulcus about $\frac{1}{2}$ cingulum width. Sulcus poorly-defined; a roundly-triangular extension of sulcus onto epitract may mark site of anterior sulcal plate-equivalent. Endophragm ca. 0.5u thick, periphragm, 0.5-1.0u thick.

Dimensions: Observed range (2 specimens measured): main body length 51-52u, width 38-49u; overall length 79-86u, width 68-81u.

Stratigraphic distribution: Loc. 3, extremely rare in sample 156; Loc. 6, extremely rare in sample 122.

Previously-reported occurrence: Danian of Denmark (Morgenroth, 1968).

Hystrichokolpoma sp.

Plate 3, figs. 14-15

Comments: One specimen was recovered. The short, box-like processes resemble those of Hystrichokolpoma poculum Maier 1959; her single specimen, however, also displays several very slender (sulcal?) processes, which are absent from the Brightseat specimen.

Description: Cyst bi-layered, ellipsoidal. Hollow, box-like processes formed from the periphragm, one per plate equivalent, outline tabulation of 4', 0a, 5'', 6c, 5''', 1p, 1'''''. A process lies at each end of sulcus and 2 pairs of small processes flank sulcus. Pre-cingular and post-cingular processes have quadrate bases. Cingular processes are elongate parallel to cingulum. All processes open distally; distal margins entire. Archeopyle apical (Type \bar{A}), with markedly angular margin; operculum simple, free. Cingulum levorotatory, vertically offset at sulcus by about one cingulum width. Endophragm ca. 0.5u thick, periphragm, ca. 1.0u thick; wall layers appressed except under processes.

Surface of periphragm faintly granulose.

Dimensions: Main body length x width, 88 x 76u; overall length x width, 106 x 109u (one specimen observed).

Stratigraphic distribution: Extremely rare (one specimen) in sample 165.

Hystrichosphaeridium Deflandre 1937b
emend. Davey & Williams 1966b

Hystrichosphaeridium tubiferum (Ehrenberg 1834)
Deflandre 1937b emend. Davey & Williams 1966b

Plate 5, figs. 13-19

- 1838 Xanthidium tubiferum Ehrenberg: 1, fig. 16.
- 1948 Xanthidium tubiferum Ehrenberg; Bronn: 1375, pl. 1, fig. 16.
- 1854 Xanthidium tubiferum Ehrenberg; Ehrenberg: pl. 7, fig. 48;
pl. 37, fig. 7, no. 11.
- 1904 Ovum hispidum (Xanthidium) tubiferum (Ehrenberg) Lohmann: 21-25.
- 1933 Hystrichosphaera tubiferum (Ehrenberg) O. Wetzell: 40, pl. 4,
fig. 16.
- 1940 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre: 157,
fig. 2.
- 1940 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Lejeune-
Carpentier: B218, figs. 1-5.
- 1941 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Conrad:
2, pl. 1F, fig. 2F.
- 1952 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Gocht:
pl. 1, fig. 4; text-fig. 4.

- 1952 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; W. Wetzel: 398, text-fig. 10.
- ?1953 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Cookson: 113-114, pl. 2, fig. 24.
- 1955 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Valensi: 592, pl. 4, fig. 2; pl. 5, fig. 8.
- 1956 Hystrichosphaeridium cf. tubiferum (Ehrenberg) Deflandre; Weiler: 139-140, pl. 12, figs. 4-6; text-figs. 9-11.
- ?1958 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Eisenack: 401, pl. 25, fig. 16.
- 1961 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Gerlach: 184-185, pl. 28, fig. 2.
- 1963 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Brosius: 38-39, pl. 8, fig. 4; text-fig. 2 (69-C).
- 1963 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Górká: 55, pl. 8, figs. 1-2; text-fig. 6, 1-2.
- 1964 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Rossignol: 88-89, text-fig. 4.
- 1965 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Stanley: 232, pl. 25, figs. 7-12.
- 1966b Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Davey & Williams, in Davey et al.: 56, pl. 6, figs. 1-2; pl. 8, fig. 5; pl. 10, fig. 2; text-fig. 13.
- 1967 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Drugg: 27, pl. 5, figs. 1-2.
- 1967 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Wilson: 67, fig. 40.
- 1968 Hystrichokolpoma bulbosa (Ehrenberg) Morgenroth: 544, 546, pl. 45, figs. 4-6.
- 1969 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Davey: 143, pl. 5, figs. 5, 8.
- 1969 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; De Coninck: 36, pl. 10, figs. 24, 28-29, 32-40.

- 1969 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre;
Archangelsky: 199, pl. 3, figs. 11-13.
- 1970 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Gocht:
pl. 1, fig. 8.
- 1970a Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Cookson &
Eisenack: 147-148, pl. 14, fig. 2.
- 1970 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Heisecke:
248-250, pl. 9, fig. 5; pl. 10, figs. 4-5.
- 1971 Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre; Davey &
Verdier: 24-25.

Comments: Pedestal-like polygonal fields on the specimens of Lejeune-Carpentier (1940) give rise to each process; such fields are lacking on the Maryland-Delaware specimens.

Considerable process variability has been reported from H. tubiferum; hence, a full description of the processes of the Maryland-Delaware specimens is given below. The main body is comparable in size to that of previously-described specimens of H. tubiferum, whereas the processes are somewhat longer.

Description: Cyst spheroidal to ellipsoidal, bearing at least 23 radially-disposed, tubular processes. Archeopyle apical (Type \bar{A}) with angular margin. Processes plate-centered, one per plate-equivalent; length less than or equal to diameter of main body, of approximately equal length on a single specimen. Processes widen proximally and distally; distal ends trumpet-like; distal margins ragged but entire, or more commonly, aculeate, with aculei 2-7 μ long. Processes of two types: cingular ones somewhat flattened along long axis of cyst, each

producing an oval trace at point of insertion on cyst surface; other processes have circular to subquadrate bases, also producing trace on cyst surface; trace may bear hachure-like marks. Process arrangement indicates tabulation of 4', 6'', 6c, 5''', 1p, 1'''''. In addition, an anterior and a posterior sulcal process, each similar in size and shape to non-cingular processes, are commonly present; two smaller pairs of processes with circular bases typically flank sulcus. Processes formed from periphragm, floored by endophragm, do not communicate with interior of cyst. Periphragm ca. 0.5u thick, outer surface finely granulose; endophragm 0.75-1.0u thick, appears externally laevigate.

Dimensions: Observed range (11 specimens measured; all lack opercula): main body length 41-58u (mean 46u), width 38-53u (mean 46u); overall length 62-110u (mean 89u), width 82-122u (mean 99u). Processes 20-40u long.

Stratigraphic distribution: Loc. 1, extremely rare in samples 169 and 170; Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in sample 156 and rare in sample 157; Loc. 4, extremely rare in samples 160-162; Loc. 5, extremely rare in samples 151, 152, and 154; Loc. 6, extremely rare in samples 116 and 120, and rare in sample 121.

Previously-reported occurrences: Senonian of Germany (O. Wetzel, 1933); Turonian of France (Mercier, 1938); Upper Cretaceous of France (Deflandre, 1940); Upper Cretaceous of Belgium (Lejeune-Carpentier,

1940); Maestrichtian of Belgium (Conrad, 1941); Lower Oligocene of northern and central Germany (Gocht, 1952); Danian of the Baltic region (W. Wetzel, 1952); ?Tertiary of Australia (Cookson, 1953); Middle Oligocene of southwestern Germany (Weiler, 1956); Aptian of northern Germany (Eisenack, 1958); Middle and Upper Oligocene, Middle Miocene of northwestern Germany (Gerlach, 1961); Upper Oligocene of Germany (Brosius, 1963); Turonian, Campanian-Maestrichtian of Poland (Górka, 1963); Pleistocene of Israel (Rossignol, 1964); Paleocene of South Dakota (Stanley, 1965); Cenomanian and Eocene of England (Davey & Williams, 1966b); Lower Tertiary of Antarctica and New Zealand (Wilson, 1967a, 1968a); Danian of Germany (Morgenroth, 1966); Maestrichtian-Danian of California (Drugg, 1967); Eocene of Germany (Morgenroth, 1968); Albian-Turonian of England (Davey, 1969a); Ypresian of Belgium (De Coninck, 1969); Upper Cretaceous of Germany (Gocht, 1970); Senonian of Western Australia (Cookson & Eisenack, 1970); ?Danian of Argentina (Heisecke, 1970); Albian of France (Davey & Verdier, 1971); Middle and Upper Oligocene of Germany (Benedek, 1972); Upper or Middle Miocene of southeastern Australia (Haskell and Wilson, 1975).

Genus Hystrichosphaeropsis (Deflandre 1935)
Sarjeant 1966

Hystrichosphaeropsis complanata Eisenack 1965

Plate 4, figs. 11-12

1954 Hystrichosphaera (Hystrichosphaeropsis) cf. ovum Deflandre;
Eisenack: 63, pl. 12, fig. 14.

1965 Hystrichosphaeropsis complanata Eisenack: 153-154, pl. 14, figs. 5-7; pl. 15, fig. 5; text-figs. 2-3.

Comments: Two specimens of H. complanata were recovered from the Monmouth Formation. The periblast is roughly rectangular in shape, tapering slightly anterior and posterior of the spheroidal endoblast; large pericoels are present. The cyst is process-free. The apex bears a small but well-delineated horn; the antapex is truncated. Low folds of periphragm outline a tabulation of 4', 0a, ?c, ?5''', ?p, 1'''. The precingular archeopyle (Type P) corresponds to plate-equivalent 3''; the operculum is free. The cingulum is ca. 11u wide; cingulum ends and the sulcus are not discernible. The endophragm and periphragm are each ca. 0.5u thick.

Dimensions: Two specimens measured: endoblast length x width, 61 x 58u, 46 x 46u; periblast, 110 x 67u, 88 x 46u.

Stratigraphic distribution: Loc. 3, extremely rare (one specimen) in sample 156; Loc. 5, extremely rare (one specimen) in sample 152.

Previously-reported occurrences: Lower Oligocene of Germany (Eisenack, 1954 and 1965).

Genus Lanternosphaeridium Morgenroth 1966

Lanternosphaeridium sp.

Plate 7, figs. 7-8

Comments: One specimen assigned to Lanternosphaeridium sp. was recovered from the Brightseat Formation. The elongate-ellipsoidal cyst bears fibrous, discrete processes, one per plate-equivalent, reminiscent of Cordosphaeridium inodes. At the apex and antapex are prominent, narrow protrusions involving both endophragm and periphragm. A ramose apical process is present; at the antapex is a relatively dense, tapering process. Cingular processes are broad, flattened. While resembling L. bipolare in bearing narrow polar protrusions, Lanternosphaeridium sp. has broader, less massive processes. The endophragm and periphragm are each ca. 1.0u thick.

Dimensions: Main body length x width, 126u x 73u; overall, 165u x 128u; processes up to 29u long (one specimen measured).

Stratigraphic distribution: Loc. 3, extremely rare (one specimen) in sample 157.

Genus Leptodinium Klement 1960

Leptodinium dispertitum Cookson & Eisenack 1965b

Plate 8, figs. 1-4

1965b Leptodinium dispertitum Cookson & Eisenack: 122-123, pl. 12, figs. 5-7.

Comments: Four specimens were recovered from the Brightseat Formation. They conform to the description of Cookson and Eisenack. The ovoidal

cyst bears sutural folds 2-6u high intergonally; at gonal sites, the folds are expressed by pointed, hollow projections up to 8u high. The folds outline a tabulation of 4', 6'', 6c, 5''', 1p, 1'''''. The endophragm is 0.5-0.75u thick, the periphragm, ca. 0.5u thick; the external surface of the periphragm is finely granulose.

Dimensions: Observed range (4 specimens measured): main body length 67-81u, width 64-73u; overall length 70-87u, width 70-87u.

Stratigraphic distribution: Loc. 3, extremely rare in sample 157; Loc. 4, extremely rare in sample 162.

Previously-reported occurrence: Upper Eocene of Australia (Cookson & Eisenack, 1965b).

Leptodinium elegans Cookson 1965

Plate 8, figs. 5-8

1965 Leptodinium elegans Cookson: 123-124, pl. 12, figs. 10-13.

Comments: Maryland specimens of L. elegans are ellipsoidal, whereas Cookson's specimens are spheroidal. The Maryland specimens lie within the size range of the Australian specimens.

The Maryland specimens resemble Hystrichosphaera cingulata var. cingulata Clarke & Verdier, 1967, in bearing high sutural folds of the periphragm and a granulose endophragm. The specimens of Clarke &

Verdier, however, have rib-like gonal processes, lacked by Leptodinium elegans, and are only half the size of specimens of L. elegans (see Dimensions).

Information supplementing Cookson's original description of L. elegans is given below.

Description: Cyst bi-layered, ovoidal, with circular equatorial section. High sutural folds of periphragm outline tabulation of 4', ?5''', ?5c, 5''', 1p, 1'''''. 1' and 1'''' pentagonal, pre- and post-cingular plate-equivalents trapezoidal; 2''-4'' and 2''''-4'''' relatively large; 1'' and 5'', 1'''' and 5'''' all somewhat smaller. Archeopyle precingular (Type P) corresponds to plate-equivalent 3''; operculum simple, free. Cingulum margins marked by faint folds of periphragm. At sulcus anterior margins of cingulum curve around to merge with lateral margins of 1' and 4''; posterior margins curve around to delimit polygonal field between level of cingulum and plate-equivalent 1''''.

Dimensions: Observed range (4 specimens measured): main body length 70-84u, width 60-73u; overall length 90-116u, width 75-104u. Overall length of Australian specimens of Hystrichosphaera cingulata var. cingulata, 48-56u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in samples 157-158.

Previously-reported occurrence: Upper Eocene of Australia (Cookson, 1965).

Leptodinium victorianum Cookson 1965

Plate 8, figs. 9-11

1965 Leptodinium victorianum Cookson: 123, pl. 12, figs. 8-9.

Comments: Maryland specimens of L. victorianum are ovoidal, while Cookson's specimens are nearly spheroidal. The Maryland specimens fall within the size range of the Australian specimens.

Description: Same as for L. elegans, with the following differences: endophragm surface of L. victorianum microreticulate rather than granulate; cingulum well-defined by sharp anterior and posterior fold of periphragm. Endophragm 0.5-1.0u thick, periphragm, ca. 1.0u thick, with faintly granulate exterior surface.

Dimensions: Observed range (3 specimens measured): main body length 64-76u, width 60-70u; overall length 84-102u, width 84-93u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in samples 157 and 158.

Previously-reported occurrence: Upper Eocene of Australia (Cookson, 1965).

Genus Oligosphaeridium Davey & Williams 1966bOligosphaeridium complex (White 1842)
Davey & Williams 1966b

Plate 5, figs. 20

- 1842 Xanthidium tubiferum complex White: 39, pl. 4, div. 3, fig. 11.
- 1848 Xanthidium complexum (White) Bronn: 1375.
- 1940 Hystrichosphaeridium elegantulum Lejeune-Carpentier: 22, text-figs. 11-12.
- 1946 Hystrichosphaeridium complex (White) Deflandre: 11.
- 1966b Oligosphaeridium complex (White) Davey & Williams, in Davey et al.: 71-74, pl. 7, figs. 1-2; pl. 10, fig. 3; text-fig. 14.

Comments: For the complete synonymy of Oligosphaeridium complex and an account of its taxonomic history, see Davey & Williams (1966b).

Two specimens were recovered from the Brightseat Formation; they resemble the specimens of Davey & Williams (1966b). The tubular processes, one per plate-equivalent, are formed from the periphragm. The processes, 3.5-4.0u wide along the shaft, flare distally, forming recurved, unbranched aculei up to 9.0u long. The distal one-third of each process bears elliptical perforations of varying sizes; the perforations are not numerous enough, however, to warrant the assignment of the specimens to O. pulcherrimum Davey & Williams. The processes outline a tabulation of '?', 6'', 0c, 5''', 1p, 1''''; two processes, not reduced in size, flank the sulcus. The archeopyle is apical with a free operculum; the archeopyle margin is angular, with no sulcal notch. The cyst surface is faintly granulose; the cyst wall, periphragm plus endophragm, is ca. 0.5u thick.

Dimensions: Observed range (2 specimens measured): main body length 44-45u, width 4lu; overall length 8lu, width 81-107u; processes 25-38u long.

Stratigraphic distribution: Loc. 2, extremely rare (one specimen) in sample 165; Loc. 3 extremely rare (one specimen) in sample 157.

Previously-reported occurrences: See Verdier (1970, p. 10).

Genus Operculodinium Wall 1967

Operculodinium centrocarpum (Deflandre & Cookson 1955)
Wall 1967

Plate 7, figs. 12-13

- 1952 Hystrichosphaeridium sp. ind. Gocht: 310, fig. 8.
- 1953 Hystrichosphaeridium sp. a Cookson: 115, pl. 2, figs. 26-27.
- 1953 Hystrichosphaeridium sp. b Cookson: 115, pl. 2, fig. 28.
- 1959 Hystrichosphaeridium centrocarpum Deflandre & Cookson; Maier: 314-315, pl. 31, fig. 7.
- 1961 Baltisphaeridium centrocarpum (Deflandre & Cookson) Gerlach: 192-193, pl. 28, fig. 9.
- 1963 Baltisphaeridium centrocarpum (Deflandre & Cookson) Gerlach; Brosius: 44, pl. 6, fig. 6; text-fig. 2, 8a, b.
- 1963 Baltisphaeridium centrocarpum (Deflandre & Cookson) Gerlach; Downie & Sarjeant: 91.
- 1965 cf. Cordosphaeridium centrocarpum (Deflandre & Cookson) De Coninck: 33-34, pl. 9, figs. 9-11; pl. 11, figs. 45-46.
- 1966 Cordosphaeridium tiara subsp. centrocarpum (Deflandre & Cookson) Morgenroth: 26, pl. 5, fig. 12; pl. 6, fig. 1.

- 1967 Baltisphaeridium centrocarpum (Deflandre & Cookson) Gerlach; Drugg: 31-32, pl. 5, fig. 18.
- 1967 Operculodinium centrocarpum (Deflandre & Cookson) Wall: 111, pl. 16, figs. 1, 2, 5.
- 1969 Cordosphaeridium microtriaina subsp. centrocarpum (Deflandre & Cookson) De Coninck: 32, pl. 8, fig. 25; pl. 9, fig. 5.
- 1969 Operculodinium centrocarpum (Deflandre & Cookson) Wall: 7-8, pl. 2, fig. 6; pl. 3, fig. 4; pl. 4, fig. 5.
- 1971 Operculodinium centrocarpum (Deflandre & Cookson) Wall; Shimakura et al.: pl. 1, fig. 11.
- 1973 Operculodinium centrocarpum (Deflandre & Cookson) Wall; Harland: 36-38.
- 1974 Operculodinium centrocarpum (Deflandre & Cookson) Wall; Wall: 336-337, pl. 45, fig. 9.

Comments: Maryland-Delaware specimens of O. centrocarpum present little morphologic variation, and they display no significant variance from previously described material. The numerous fibrous processes terminate in hooklets or aculei. The large precingular (Type P) archeopyle is roundly trapezoidal in outline. The endophragm is 0.5-1.0 μ thick, the periphragm, 1.0-3.0 μ thick; the external surface of the periphragm is microreticulate.

Previous descriptions of O. centrocarpum indicate that Miocene specimens have large main bodies and long processes, relative to Lower Tertiary and Quaternary specimens. Dimensions of the main body of the Monmouth-Brightseat specimens conform to this observation; the processes, however, are comparable in length to processes of Miocene specimens.

Dimensions: Observed range (30 specimens measured): main body length 47-67u (mean 55u); width 41-79u (mean 54u); overall length 61-99u (mean 79u), width 45-99u (mean 77u). Process length 14-23u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 2, rare in sample 165; Loc. 3, rare in sample 157; Loc. 4, extremely rare in samples 159-161 and rare in sample 162.

Previously-reported occurrences: Oligocene of Germany (Gocht, 1952); Balcombian of Australia (Cookson, 1953; Deflandre and Cookson, 1955); Middle Oligocene-Upper Miocene of northwestern Germany (Maier, 1955; Gerlach, 1961; Brosius, 1963); Lower Eocene of northern Germany (Morgenroth, 1966); Pleistocene, Caribbean Sea (Wall, 1967); Ypresian of Belgium (De Coninck, 1969); Upper Cretaceous of Natal, South Africa (Davey, 1969b); Miocene, Sea of Japan (Shimakura et al., 1971); Quaternary of Scotland (Harland, 1973); Quaternary, Black Sea (Wall & Dale, 1973 and 1974); Miocene of Japan (Matsuoka, 1974).

Operculodinium israelianum (Rossignol 1962) Wall 1967

Plate 7, figs. 14-15

- 1962 Hystrichosphaeridium israelianum Rossignol: 132, pl. 2, fig. 3.
 1964 Baltisphaeridium israelianum Rossignol; Rossignol: 91, pl. 2, fig. 12; pl. 3, figs. 13-14.
 1967 Operculodinium israelianum (Rossignol) Wall: 111, pl. 16, figs. 3-4.

1975 Operculodinium israelianum (Rossignol) Wall; Haskell & Wilson:
pl. 3, fig. 7.

Comments: Three specimens of O. israelianum were recovered from the Monmouth Formation. The very short processes bear furcate tips with entire margins. The processes of Rossignol's specimens have acuminate tips, and of Wall's specimens, capitate tips. The Monmouth specimens are comparable in size with the specimens of Rossignol and of Wall. O. israelianum differs from O. centrocarpum in the length of processes and their distal terminations: the longer processes of O. centrocarpum terminate in hooklets.

Dimensions: Observed range (3 specimens measured): main body diameter 54-65 μ ; processes up to 6 μ long.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 3, extremely rare in sample 157; Loc. 4, extremely rare in sample 159.

Previously-reported occurrences: Quaternary of Israel (Rossignol, 1962 and 1964); Quaternary, Caribbean Sea (Wall, 1967); Quaternary, Black Sea (Wall & Dale, 1974); Upper Miocene-Pleistocene of southeastern Australia (Haskell and Wilson, 1975).

Renidinium Morgenroth 1968Renidinium cf. R. membraniferum Morgenroth 1968

Plate 5, figs. 8-11

?1968 Renidinium membraniferum Morgenroth: 552, pl. 46, fig. 9;
pl. 47, figs. 1-3.

Comments: The Maryland specimens of this species differ from Renidinium membraniferum Morgenroth in several ways: the ventral side of Morgenroth's specimens is weakly indented, whereas the ventral side of the Maryland specimens is planar. Moreover, the dorsal pre- and post-cingular plate-equivalents of Morgenroth's specimens are contiguous, but on the Maryland specimens are separated by linear patches of periphragm which represent the cingulum.

Description: Dorsal pre-cingular, cingular, and post-cingular plate-equivalents each three in number. One antapical plate-equivalent present, reniform in outline, concave to cyst ventral surface. A discrete portion of periphragm covers each dorsal plate-equivalent; a central sub-circular to ellipsoidal area is bare, exposing endophragm; periphragm is thickened around each open central area. Ventral surface bears periphragm as two meridional areas along lateral portions of cyst, leaving an unornamented zone between the areas of periphragm. Archeopyle apical, with angular margin and deeply incised notch. One apical and two antapical lobes present, involving both wall layers; left antapical lobe more strongly-developed than the right. Periphragm,

ca. 0.5u thick, is perforate, discontinuous, externally granulose; endophragm, 0.5-1.0u thick, is continuous except at archeopyle, is externally granulose.

Discussion: The ventral surface of Renidinium cf. R. membraniferum resembles that of Cyclonephelium vitilare Cookson, in bearing on the ventral surface a central unornamented zone flanked by meridional areas of periphragm. Morgenroth considered the entire unornamented zone to be the sulcus. The Maryland specimens are comparable in size with those of Morgenroth.

Dimensions: Observed range (9 specimens measured) (opercula missing; length measured from archeopyle margin to antapex): main body length 49-64u (mean 56u), width 55-67u (mean 65u); overall length 55-73u (mean 65u), width 61-86u (mean 68u). Two complete specimens: main body length 61-84u, width 55-77u; overall length 73-97u, width 61-86u.

Stratigraphic distribution: Loc. 1, extremely rare in samples 170 and 171; Loc. 3, extremely rare in samples 156 and 157 and sparse in sample 163; Loc. 4, extremely rare in samples 159 and 160, and rare in sample 161; Loc. 5, extremely rare in sample 154.

Previously-reported occurrence: Danian of Denmark (Morgenroth, 1968).

Genus Samlandia Eisenack 1954Samlandia chlamydophora Eisenack 1954

Plate 4, figs. 4-7

- 1954 Samlandia chlamydophora Eisenack: 76, pl. 11, figs. 12-15.
- 1954 Palmnickia lobifera Eisenack: 70, pl. 11, figs. 10-11.
- 1961 Palmnickia lobifera Eisenack; Gerlach: 207, pl. 29, fig. 10.
- 1961 Palmnickia lobifera Eisenack; Evitt: 395, pl. 6, figs. 10-13;
pl. 7, fig. 3.
- 1963 Samlandia chlamydophora Eisenack; Eisenack: 112, pl. 2, fig. 14.
- 1966 Samlandia chlamydophora Eisenack; Morgenroth: 39, pl. 10, fig.
12; pl. 11, fig. 1.
- 1969 Samlandia chlamydophora Eisenack; Eisenack: pl. 18, figs. 6-7.
- 1972 Samlandia chlamydophora Eisenack; Benedek: 36, pl. 5, figs. 1-2.

Comments: New information regarding the tabulation of Samlandia chlamydophora and the shapes and relative sizes of various plate-equivalents is included in the description below.

Description: Bi-layered cyst, spheroidal to ellipsoidal. Robust main body bears complex system of low ridges supporting numerous, pillar-like processes; ridges and processes composed of endophragm. Processes may be relatively long at apex and cingulum; processes flare proximally and distally, producing spheroidal cavity between adjacent processes. Low ridges on cyst surface random in distribution or may lie along plate-equivalent boundaries, indicating tabulation of ?3, 6'', 6c, 5''', 1p, 1'''''. Archeopyle precingular (Type P), trapezoidal,

corresponds to plate-equivalent 3''; operculum free, simple. Plate-equivalents 1' and 3' elongate, rectangular; 1' lies directly above sulcus, 3' lies directly above the relatively small 6'''. Plate-equivalent 1''' small, has shape of inverted triangle; 2'''-5''' relatively large. Cingulum levorotatory, displaced vertically at sulcus about one cingulum width. Sulcus non-inclined, poorly-defined. Both endophragm and periphragm are 0.5-1.0u thick, continuous except at archeopyle, externally granulose.

Discussion: Morphologically, the Mount Laurel specimens most closely resemble those of Benedek (1972). The specimens of Morgenroth (1966) are similar, but bear somewhat longer processes. The periphragm of his specimens is continuous at one morphological extreme, but has only patchy distribution at the other extreme; on all the Mount Laurel specimens, however, the periphragm is continuous (except at the archeopyle).

The Mount Laurel specimens are comparable in size with those of Gerlach (1961); other previously-described specimens are somewhat smaller, averaging approximately 20u less in overall length and width.

Dimensions: Observed range (19 specimens measured): main body length 61-90u (mean 74u), width 58-84u (mean 69u); overall length 82-122u (mean 100u), width 76-116u (mean 93u). Apical and cingular processes up to 17u long, remaining ones, 10-12u; processes commonly ca. 1.0u wide, may be up to 3.0u wide.

Stratigraphic distribution: Loc. 6, rare in sample 116, sparse in samples 120-121, rare in sample 122, and sparse in sample 123.

Previously-reported occurrences: Lower Oligocene of Germany (Eisenack, 1954; Evitt, 1961); Middle Miocene of Germany (Gerlach, 1961); Lower Eocene of Germany and Belgium (Morgenroth, 1966); Middle Oligocene of Germany (Benedek, 1972).

Genus Scriniodinium Klement 1957

Scriniodinium australiense (Deflandre & Cookson 1955)
Gerlach 1961

Plate 4, figs. 8-10

- 1955 Gymnodinium australiense Deflandre & Cookson: 248-249, pl. 5, fig. 1.
- 1961 Scriniodinium australiense (Deflandre & Cookson) Gerlach: 173.
- 1965 Emslandia australensis (Gerlach) Nagy: 202, pl. 1, fig. 6; pl. 2, fig. 7.
- 1965a Scriniodinium australiense (Deflandre & Cookson) Gerlach; Cookson & Eisenack: 122, pl. 13, fig. 15.

Comments: Most previously-described specimens of Scriniodinium australiense lack tabulation. The Maryland-Delaware specimens, however, display tabulation, an account of which appears in the following description.

Description: Bi-layered, ovoidal cyst bearing fibrous thickenings of periphragm, intratabular in distribution, outlining tabulation of 4', 0a, 6'', 6c, 5''', 1p?, 1''''; an anterior and a posterior sulcal process are also present. Pre- and post-cingular plate-equivalents large, quadrate, with following exceptions: 1'' triangular, 6'' and 1''' small narrow, 2''' resembles an inverted triangle. Cingular plate-equivalents rectangular, long axis parallels cingulum. Cingulum strongly levorotatory, vertically separated at sulcus one to two times cingulum width. Sulcus poorly-defined, limited by anterior and posterior sulcal processes. Archeopyle precingular (Type P), corresponds to plate-equivalent 3''; margin trapezoidal, with rounded corners at anterior margin; operculum simple, free. Periphragm forms elongate, foliate apical process with relatively dense axis, like that of Danea mutabilis; antapical process is broader and shorter. Inter-tabular periphragm is ca. 2.0u thick, intratabular periphragm, up to 10.0u thick; external surface is microreticulate. Endophragm is 1.0-3.5u thick.

Dimensions: Observed range (11 specimens measured): endoblast length 68-115u, width 60-88u; periblast length 81-130u, width 72-106u. Apical process up to 18u long.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in samples 157 and 158; Loc. 4, extremely rare in sample 162; Loc. 6, extremely rare in sample 122.

Previously-reported occurrences: Balcombian of Australia (Deflandre & Cookson, 1955); Middle Miocene of Hungary (Nagy, 1965); Upper Eocene of Australia (Cookson & Eisenack, 1965a).

Genus Spiniferites Mantell 1854 ex Loeblich
& Loeblich 1966

Spiniferites crassipellis (Deflandre & Cookson 1955)
Sarjeant 1970

Plate 8, figs. 12-13

- 1955 Hystrichosphaera crassipellis Deflandre & Cookson: 265, pl. 6, figs. 2-3.
- ?1959 Hystrichosphaera crassipellis Deflandre & Cookson; Maier: 302-303, pl. 28, fig. 7.
- 1961 Hystrichosphaera crassipellis Deflandre & Cookson; Gerlach: 177-178, pl. 27, fig. 5; text-figs. 16, 17, 23.
- 1963 Hystrichosphaera crassipellis Deflandre & Cookson; Gorka: 52, pl. 7, fig. 1-2; text-pl. 5, fig. 3.
- 1966 Achomosphaera sagena Davey & Williams, in Davey et al.: 51, pl. 2, figs. 1, 2.
- 1966 Hystrichosphaera crassipellis Deflandre & Cookson; Morgenroth: 13-14, pl. 7, figs. 3-4.
- 1967 Hystrichosphaera crassipellis Deflandre & Cookson; Clarke & Verdier: 48, pl. 8, fig. 11; pl. 9, fig. 1.
- 1967 Hystrichosphaera crassipellis Deflandre & Cookson; Drugg: 23, pl. 4, fig. 1.
- 1969 Hystrichosphaera crassipellis Deflandre & Cookson; De Coninck: 27-28, pl. 7, figs. 1-4.
- 1969 Hystrichosphaera cf. crassipellis Deflandre & Cookson; Gocht: 33, pl. 7, fig. 3.

- 1970 Spiniferites crassipellis (Deflandre & Cookson) Sarjeant: 76.
- 1971 Spiniferites crassipellis (Deflandre & Cookson) Sarjeant; Davey & Verdier: 33.
- 1972 Spiniferites crassipellis (Deflandre & Cookson) Sarjeant; Habib: pl. 22, fig. 3.

Comments: The Maryland-Delaware specimens are similar in size to the specimens of Gerlach (1961), of Davey & Williams (1966), and of Drugg (1967); the specimens of Deflandre & Cookson (1955) are somewhat larger (see Dimensions).

Description: Cyst spheroidal to ovoidal, bearing non-septate, furcate processes distributed gonally and intergonally. Processes commonly bear circular perforations in serial arrangement; processes open at base, but appear to be closed distally. Cingulum strongly levorotatory, is displaced vertically at sulcus by $1\frac{1}{2}$ -2 times cingulum width. Endophragm homogenous, 0.75-1.25u thick; periphragm, 1.0-4.5u thick, is composed of densely-packed fibrils of varying lengths, all oriented normal to cyst surface, imparting microreticulate texture to exterior surface of cyst.

Discussion: Spiniferites crassipellis superficially resembles S. septatus. The latter, however, bears septate processes; moreover, the periphragm is composed of bubble-like elements rather than fibrils.

Achomosphaera sagena, according to Davey & Williams (1955) differs from Spiniferites crassipellis in lacking sutural folds. The present author, however, contends that a morphological continuum unites forms

lacking sutural folds with those bearing well-developed sutural folds; hence, Achomosphaera sagena is herein considered synonymous with Spiniferites crassipellis.

Dimensions: Observed range (9 specimens measured): main body diameter 37-58u; overall diameter 60-87u; processes 10-16u long. Specimens of Deflandre & Cookson (1955): overall diameter 105-117u; processes 23-26u long.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in sample 157 and rare in sample 158; Loc. 4, extremely rare in sample 160; Loc. 5, extremely rare in sample 154; Loc. 6, extremely rare in samples 116-118, rare in sample 120.

Previously-reported occurrences: Eocene of Australia (Deflandre & Cookson, 1955); Middle Miocene of Germany (Maier, 1959); Middle Oligocene, Middle Miocene of Germany (Gerlach, 1961); Coniacian-Campanian of Germany (Górka, 1963); Cenomanian-Santonian of England (Davey & Williams, 1966a; Clarke and Verdier, 1967); Lower Eocene of Germany (Morgenroth, 1966; Gocht, 1969); Miocene of Roumania (Baltes, 1967); Danian of California (Drugg, 1967); Ypresian of Belgium (De Coninck, 1969); Albian of France (Davey & Verdier, 1971).

Spiniferites hypercanthus (Deflandre & Cookson 1955) n. comb.

Plate 8, figs. 14-15

- 1955 Hystrichosphaera hypercantha Deflandre & Cookson: 264, pl. 6, fig. 7
- 1966a Achomosphaera hypercantha (Deflandre & Cookson) Davey & Williams: 52.
- 1967 Hystrichosphaera hypercantha Deflandre & Cookson; Wall: 100, pl. 14, fig. 3; text-fig. 2.

Comments: Brightseat specimens bear relatively delicate processes; two commonly occur between adjacent gonial processes. Sutural folds are weakly-developed. The cyst surface is laevigate; the endophragm and periphragm are each ca. 1.0 μ thick.

Discussion: In accord with Sarjeant's 1970 resolution of the Hystrichosphaera-Spiniferites problem, Hystrichosphaera hypercantha is herein transferred to Spiniferites.

Davey & Williams (1966a) transferred Hystrichosphaera hypercantha to Achomosphaera, a genus erected by Evitt (1963) for forms lacking sutural folds. The Brightseat specimens, however, display sutural folds. There appears to exist a morphological continuum uniting specimens lacking sutural folds and specimens bearing well-developed folds, and all such specimens should be contained in a single genus. Hence in this study, Achomosphaera hypercantha is considered synonymous with Spiniferites hypercanthus.

Dimensions: Observed range (4 specimens measured): main body length 41-51u, width 38-46u; overall length 67-81u, width 64-78u; process length 12-17u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 4, extremely rare in samples 160 and 162.

Previously-reported occurrences: Miocene of Australia (Deflandre & Cookson, 1955); Quaternary of the Caribbean Sea (Wall, 1967).

Spiniferites membranaceus (Rossignol 1964)
Lentin & Williams 1973

Plate 8, figs. 16-18

- 1964 Hystrichosphaera furcata var. membranacea Rossignol: 86, pl. 1, figs. 4, 9-10; pl. 3, figs. 7, 12.
- 1966a Hystrichosphaera furcata var. membranacea (Rossignol) Davey & Williams: 37, pl. 4, figs. 8, 12.
- 1967 Hystrichosphaera membranacea (Rossignol) Wall: 102-103, pl. 14, figs. 14-15; text-fig. 2.
- 1973 Spiniferites membranaceus (Rossignol) Lentin & Williams: 128.

Comments: The Maryland-Delaware specimens are similar to the specimens of Davey & Williams; the processes are more robust than those described by Rossignol (1964) and by Wall (1967). Only one specimen in the present study bears the two large, dorsal antapical processes Rossignol observed; it lacks, however, the high sutural fold between the antapical processes displayed by Rossignol's specimens.

Dimensions: Observed range (11 specimens measured): main body length 44-64u, width 39-55u; overall length 81-100u, width 70-100u. Process length 17-31u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in sample 156; Loc. 4, extremely rare in sample 162; Loc. 6, rare in sample 117.

Previously-reported occurrences: Quaternary of Israel (Rossignol, 1964); Quaternary of the Caribbean Sea (Wall, 1967).

Spiniferites monilis (Davey & Williams 1966a)
Sarjeant 1970

Plate 8, fig. 19

1966a Hystrichosphaera monilis Davey & Williams: 45, pl. 5, fig. 2.

1970 Spiniferites monilis (Davey & Williams) Sarjeant: 76.

Comments: Like the British specimens, the Maryland specimens bear open, bubble-like structures along sutural folds, resembling beads on a string. The processes, in bearing circular perforations in serial arrangement, are similar to those of Spiniferites crassipellis; commonly one process lies between adjacent gonal processes. The surface of the main body is finely and densely granulose. The endophragm and periphragm are each 0.5-1.0u thick.

Dimensions: Observed range (7 specimens measured): main body length 40-48u, width 38-42u; overall length 58-75u, width 58-70u; process length 9-14u.

Stratigraphic distribution: Loc. 3, rare in sample 156 and extremely rare in sample 157; Loc. 4, rare in sample 159 and extremely rare in sample 160.

Previously-reported occurrence: Lower Eocene of England (Davey & Williams, 1966a).

Spiniferites pseudofurcatus (Klumpp 1953)
Sarjeant 1970

Plate 8, fig. 20

- 1838 Xanthidium furcatum Ehrenberg: 14, pl. 1, fig. 12.
- 1933 Hystrichosphaera furcata (Ehrenberg) O. Wetzel: 387, pl. 16, fig. 11.
- 1953 Hystrichokibotium pseudofurcatum Klumpp: 388, pl. 16, figs. 12-14.
- 1953 Areoligera incerta Klumpp: 389, pl. 17, figs. 1, 2.
- 1954 Hystrichosphaera cf. furcata (Ehrenberg) O. Wetzel; Eisenack: 61-62, pl. 9, figs. 1-4; text-fig. 3.
- 1954 Hystrichosphaeridium alcicornu Eisenack: 65-66, pl. 10, figs. 1-2, text-fig. 5.
- 1955 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Valensi: 592, pl. 5, figs. 4, 9. Non pl. 4, fig. 4; pl. 5, fig. 12.
- 1960 Hystrichosphaera tertiaria Eisenack & Gocht: 515, text-fig. 4.

- 1961 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Gerlach: 174, pl. 27, fig. 1.
- 1961 Hystrichokibotium pseudofurcatum Klumpp; Gerlach: 182, pl. 27, fig. 2; text-fig. 14-15.
- 1961 Hystrichosphaeridium alcicornu Eisenack; Gerlach: 188-189, pl. 28, fig. 7.
- 1963 Hystrichosphaera tertiaria Eisenack & Gocht; Brosius: 49, pl. 6, fig. 2.
- 1965 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Rozen: pl. 3, figs. 6-7; text-fig. 15.
- 1965 "Hystrichokibotium pseudofurcatum Klumpp" and "Areoligera incerta Klumpp"; Eisenack: 155-156, pl. 15, figs. 9-10.
- 1966a Achomosphaera alcicornu (Eisenack) Davey & Williams, in Davey et al.: 50, pl. 5, fig. 3.
- 1966 Hystrichosphaera buccina Davey & Williams, in Davey et al.: 42-43, pl. 4, fig. 1; text-figs. 10-11.
- 1966 Hystrichosphaera incerta (Klumpp) Morgenroth: 15, pl. 7, figs. 7-8.
- 1967 Hystrichosphaera buccina Davey & Williams; Archangelsky: 407-408, figs. 5-6.
- 1969 Hystrichosphaera pseudofurcata (Klumpp) Gocht: 32-33, pl. 4, figs. 12-13; text-fig. 22.
- 1972 Achomosphaera alcicornu (Eisenack) Davey & Williams; Benedek: 21, pl. 8, fig. 4.
- 1972 Hystrichosphaera pseudofurcata (Klumpp) Gocht; Benedek: 24, pl. 7, fig. 7.

Comments: The Brightseat specimens appear identical with the specimens of Gocht (1969); both smooth-walled and granulose forms are present.

Dimensions: Observed range (4 specimens measured): main body length 41-50u, width 38-44u; overall length 71-88u, width 65-79u; process length 15-23u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165.

Previously-reported occurrences: Senonian of Germany (O. Wetzel, 1933); Eocene of Germany (Klumpp, 1953; Eisenack and Gocht, both 1960; Morgenroth, 1966); Lower Oligocene of Germany (Eisenack, 1954); Upper Cretaceous of France (Valensi, 1955); Middle-Upper Oligocene of Germany (Gerlach, 1961; Benedek, 1972); Upper Oligocene of Germany (Brosius, 1963); Bartonian of Belgium (Rozen, 1965); Eocene of England (Davey & Williams, 1966a); Lower Eocene, ?Upper Eocene, Middle Oligocene of Germany (Gocht, 1969).

Spiniferites ramosus subsp. granomembranaceus
(Davey & Williams 1966a) Lentin & Williams 1973

Plate 9, figs. 1-2

1966a Hystrichosphaera ramosa var. granomembranacea Davey & Williams:
37-38, pl. 4, fig. 4.

1973 Spiniferites ramosus subsp. granomembranaceus (Davey & Williams)
Lentin & Williams: 130.

Comments: Maryland-Delaware specimens of S. ramosus subsp. granomembranaceus range from thick-walled forms with a densely granulose or even pebbled surface to thin-walled forms with a sparsely granulose surface. High sutural folds commonly occur at the poles and cingulum; lower folds may extend from process to process around the cyst. Up to two intergonal processes lie along a plate-equivalent boundary. The endophragm is 1.0-2.0 μ thick, the periphragm, 0.5-1.5 μ thick.

Dimensions: Observed range (8 specimens measured): main body length 36-49u, width 35-46u; overall length 61-87u, width 58-84u; process length 9-18u.

Stratigraphic distribution: Loc. 3, extremely rare in sample 157; Loc. 4, extremely rare in sample 160 and 162; Loc. 6, extremely rare in sample 117.

Previously-reported occurrence: Lower Eocene of England (Davey & Williams, 1966a).

Spiniferites ramosus subsp. granosus
(Davey & Williams 1966a) Lentin & Williams 1973

Plate 9, figs. 3-6

1966a Hystrichosphaera ramosa var. granosa Davey & Williams, in Davey et al.: 35, pl. 4, fig. 9.

1973 Spiniferites ramosus subsp. granosus (Davey & Williams) Lentin & Williams: 130.

Comments: One specimen of S. ramosus subsp. granosus was recovered from the Brightseat Formation; it appears identical with the specimens of Davey & Williams (1966a). One or two processes occur between adjacent gonal processes. The endophragm is ca. 1.5u thick, the periphragm, ca. 0.5u thick.

Dimensions: One specimen measured: main body diameter 40.5u; overall length x width, 84 x 81u; process length 18-20u.

Stratigraphic distribution: Loc. 2, extremely rare (one specimen) in sample 165.

Previously-reported occurrence: Eocene of England (Davey & Williams, 1966a).

Spiniferites cf. S. ramosus subsp. granosus
(Davey & Williams 1966a) Lentin & Williams 1973

Plate 9, figs. 7-8

Comments: Two specimens of S. cf. S. ramosus subsp. granosus were recovered from the Monmouth and Brightseat formations. The specimens resemble those of Davey & Williams in bearing slender processes and a granulose main body surface; the Maryland specimens, however, bear up to three processes between adjacent gonal processes. Sutural folds are weakly developed. The endophragm is ca. 1.0u thick, the periphragm ca. 0.5u thick.

Dimensions: Two specimens measured: main body length 48-51u, width 44-52u; overall length 64-87u, width 64-81u; process length 12-17u.

Stratigraphic distribution: Loc. 4, extremely rare in sample 162; Loc. 5, extremely rare in sample 151.

Spiniferites ramosus subsp. multibrevis
(Davey & Williams 1966a) Lentin & Williams 1973

Plate 9, fig. 9

- 1955 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Valensi: 586, pl. 4, fig. 4; pl. 5, fig. 12.
- 1958 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Eisenack: 406, pl. 25, figs. 4-8.
- 1966a Hystrichosphaera ramosa var. multibrevis Davey & Williams: 35-36, pl. 1, fig. 4; pl. 4, fig. 6; text-fig. 9.
- 1969 Hystrichosphaera ramosa var. multibrevis Davey & Williams: Davey: 173, pl. 10, figs. 3-4.
- 1971 Spiniferites ramosus var. multibrevis (Davey & Williams) Davey & Verdier: 33.
- 1973 Spiniferites ramosus subsp. multibrevis (Davey & Williams) Lentin & Williams: 130.

Comments: Maryland-Delaware specimens of S. ramosus subsp. multibrevis differ from those of Valensi and of Davey & Williams in having fewer processes: there is only one process, if any, between adjacent gonal processes.

Description: Cyst main body spheroidal to ellipsoidal. Processes delicate to robust from specimen to specimen. Cingulum, 5-7u wide, is levorotatory; vertical offset at sulcus is about 1-1½ times cingulum width. Endophragm is 0.5-1.0u thick, periphragm, ca. 0.5u thick; exterior surface of periphragm is laevigate, occasionally micro-reticulate.

Dimensions: Observed range (11 specimens measured): main body length 41-54u, width 33-45u; overall length 58-78u, width 55-70u; process length 9-15u.

Stratigraphic distribution: Loc. 3, extremely rare in sample 156; Loc. 4, extremely rare in sample 159; Loc. 5, extremely rare in sample 154; Loc. 6, extremely rare in samples 120 and 121.

Previously-reported occurrences: Upper Cretaceous of France (Valensi, 1955); Aptian of Germany (Eisenack, 1958); Hauterivian to Ypresian of England (Davey & Williams, 1966a); Cenomanian of England and France, Albian of Saskatchewan, Canada (Davey, 1969); Albian of France (Davey & Verdier, 1971).

Spiniferites ramosus (Ehrenberg 1838) Loeblich & Loeblich 1966
subsp. ramosus (Ehrenberg 1838) Lentini & Williams 1973

Plate 9, figs. 10-13

- 1838 Xanthidium furcatum Ehrenberg: pl. 1, fig. 14.
- 1838 Xanthidium ramosum Ehrenberg: pl. 1, fig. 15.
- 1933 Hystrichosphaera furcata (Ehrenberg) O. Wetzel: 34-35, pl. 2, figs. 35a, b; pl. 5, figs. 1, 5, 9, 15, 16.
- 1933 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel: pl. 5, figs. 7, 8, 10-12, 18, 19.
- 1937 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Deflandre: 8, pl. 11, figs. 1, 3, 4.
- 1937 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel; Deflandre: 10, pl. 11, figs. 5, 7.
- 1938 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Deflandre: 186.

- 1940 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Deflandre: 156, fig. 4.
- 1948 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Pastiels: 36-37, pl. 3, fig. 11.
- 1952 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Gocht: 306, pl. 1, fig. 10; pl. 2, fig. 21.
- 1952 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; W. Wetzel: 393-394, text-fig. 1; pl. A, fig. 1.
- 1953 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Cookson: 113, pl. 1, figs. 13-17.
- 1953 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; O. Wetzel: 41, pl. 2, fig. 5.
- 1954 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Deflandre-Rigaud: 58.
- 1955 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Deflandre & Cookson: 263, pl. 8, fig. 9.
- 1955 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; W. Wetzel: 34, text-figs. 2-3.
- 1958 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Eisenack & Cookson: 406, pl. 25, figs. 4-8.
- 1959 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Gocht: 74, pl. 4, fig. 4; pl. 5, fig. 11.
- 1960 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Sarjeant: pl. 14, fig. 17.
- 1961 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel; Gerlach: 175, pl. 27, fig. 3.
- 1963 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Gorka: 45, pl. 6, figs. 1-2; text-pl. 5, figs. 1-2.
- 1966 Hystrichosphaera furcata (Ehrenberg) O. Wetzel; Morgenroth: 14, pl. 7, figs. 5-6.
- 1966a Hystrichosphaera ramosa (Ehrenberg) O. Wetzel var. ramosa (Ehrenberg) Davey & Williams, in Davey et al.: 29-34, pl. 1, figs. 1, 6; pl. 3, fig. 1; text-fig. 8.

- 1966 Spiniferites ramosus (Ehrenberg) Mantell; Loeblich & Loeblich: 56-57; SD.
- 1969 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel; Gocht: 30-31, pl. 4, figs. 10-11; text-fig. 21.
- 1969 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel; Millioud: 428-429.
- 1969 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel; Archangelsky: 196-197, pl. 3, figs. 7-8.
- 1970 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel; Zaitzeff & Cross: pl. 3, fig. 26.
- 1971 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel; Shimakura et al.: pl. 1, fig. 3.
- 1972 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel var. ramosa Davey & Williams; Benedek: 23, pl. 7, fig. 8.
- 1973 Spiniferites ramosus (Ehrenberg) Loeblich & Loeblich subsp. ramosus (Ehrenberg) Lentin & Williams: 130.
- 1973 Hystrichosphaera ramosa (Ehrenberg) O. Wetzel var. ramosa Davey & Williams; Harland: 689, pl. 87, fig. 7.
- 1974 Hystrichosphaera ramosus (Ehrenberg) Loeblich & Loeblich; McIntyre: pl. 9, figs. 7, 9.

Comments: Maryland-Delaware specimens of S. ramosus ramosus appear identical in morphology with the specimens of Davey & Williams (1966a), and in size, with the specimens of Gerlach (1961).

Dimensions: Observed range (24 specimens measured): main body length 41-58u (mean 49u), width 33-55u (mean 43u); overall length 73-104u (mean 85u), width 60-90u (mean 78u). Process length 14-26u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 169; Loc. 2, rare in sample 165; Loc. 3, rare in sample 156 and extremely

rare in sample 157; Loc. 4, extremely rare in samples 159-162; Loc. 6, extremely rare in samples 116-117, abundant in sample 120, sparse in sample 121, and rare in samples 122-123.

Previously-reported occurrences: Spiniferites ramosus subsp. ramosus ranges from Middle Barremian to Ypresian; Spiniferites ramosus, Oxfordian to Recent, with world-wide distribution.

Spiniferites ramuliferus (Evitt 1973) n. comb.

Plate 9, figs. 14-15

- 1935 Hystrichosphaera cf. ramosa Deflandre: 232, pl. 5, fig. 11.
- 1937 Hystrichosphaeridium ramuliferum Deflandre: 188-189, pl. 14, figs. 5-6; pl. 17, fig. 10.
- 1941 Hystrichosphaeridium ramuliferum Deflandre; Conrad: 2, pl. 1, fig. J.
- 1948 Hystrichosphaeridium ramuliferum Deflandre; Pastiels: 39, pl. 3, figs. 17-19.
- 1952 Hystrichosphaeridium ramuliferum Deflandre; W. Wetzel: 398, pl. A, fig. 9; text-fig. 9.
- 1955 Hystrichosphaeridium ramuliferum Deflandre; Valensi: 394, pl. 4, fig. 6.
- 1959 Hystrichosphaeridium ramuliferum Deflandre; Gocht: 71, pl. 3, fig. 9.
- 1961 Hystrichosphaeridium ramuliferum Deflandre; Gerlach: 185, pl. 28, fig. 3.
- 1963 Hystrichosphaeridium ramuliferum Deflandre; Baltes: 586, pl. 7, figs. 13, 17, 18.

- 1963 Hystrichosphaeridium ramuliferum Deflandre; Górka: 59, pl. 8, fig. 3; text-fig. 6, figs. 3-4.
- 1963 Hystrichosphaeridium ramuliferum Deflandre; Downie & Sarjeant: 92.
- 1963 Achomosphaera ramulifera (Deflandre) Evitt: 163.
- 1964 Achomosphaera ramulifera (Deflandre) Evitt; Cookson & Hughes: 45, pl. 9, fig. 10.
- 1966a Achomosphaera ramulifera (Deflandre) Evitt; Davey & Williams: 49, pl. 2, fig. 3.
- 1967 Achomosphaera ramulifera (Deflandre) Evitt; Cookson & Eisenack: 249, pl. 41, fig. 2.
- 1967 Achomosphaera ramulifera (Deflandre) Evitt; Clarke & Verdier: 40, pl. 8, fig. 1.
- 1969 Achomosphaera ramulifera (Deflandre) Evitt; Davey: 174-175, pl. 10, fig. 7.
- 1971 Achomosphaera ramulifera (Deflandre) Evitt; Davey & Verdier: 10-12.
- 1972 Achomosphaera ramulifera (Deflandre) Evitt; Benedek: 21, pl. 8, fig. 5.

Description: Main body ovoidal, bears robust, gonally-distributed processes. Most processes on single specimen bifurcate, then trifurcate; each branch bears small bifurcation at tip. An occasional process merely trifurcates; each branch bears small distal bifurcation. Cingular processes wide, antapical processes also wide, divergent. Archeopyle precingular (Type P); operculum free, simple. Sutural folds variously developed (see Discussion below). Endophragm and periphragm each 0.5-0.75u thick; external surface of periphragm laevigate to faintly granulose.

Discussion: Wide cingular and antapical processes are also present on the specimens of Gerlach (1961) and of Davey & Williams (1966a). The furcate processes of the Maryland-Delaware specimens resemble those of the Eocene specimens of Pastiels (1948) and of Davey & Williams (1966a).

Individual specimens may bear periphragmal folds along some or all sutures; these specimens may be assigned to Spiniferites Mantell 1854. Other specimens, which lack sutures, may be assigned to Achomosphaera Evitt 1963. In the present study, however, the specimens all belong to a single, variable population; accordingly, Achomosphaera is herein considered a junior synonym of Spiniferites (see Discussion under Spiniferites hypercanthus n. comb., p. 130).

Dimensions: Observed range (8 specimens measured): main body length 45-73u, width 44-67u; overall length 82-126u, width 64-117u. Process length 18-35u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in samples 156-158; Loc. 5, extremely rare in sample 154.

Previously-reported occurrences: Senonian of France (Deflandre, 1935, 1937; Deflandre & Courteville, 1939; Deflandre-Rigaud, 1955; Valensi, 1955); Maestrichtian of Belgium (Conrad, 1941); Eocene of Belgium (Pastiels, 1948); Danian of Germany (W. Wetzel, 1952); Neocomian of northwestern Germany (Gocht, 1959); Upper Oligocene, Middle Miocene of Germany (Gerlach, 1961); Cenomanian of Roumania (Baltes, 1963);

Turonian, Upper Campanian of Poland (Górka, 1963); Cenomanian to Ypresian of England (Cookson & Hughes, 1964; Davey & Williams, 1966a); Cenomanian of England and France (Davey, 1969); Albian of France (Davey & Verdier, 1971); Middle Oligocene-Upper Oligocene of Germany (Benedek, 1972).

Spiniferites septatus (Cookson & Eisenack 1967)
McLean 1971

Plate 9, figs. 16-19

- 1961 Hystriosphera crassipellis Deflandre & Cookson; Gerlach: 177, pl. 27, fig. 5; text-figs. 16, 17, 23.
- 1967b Baltisphaeridium septatum Cookson & Eisenack: 253-254, pl. 42, figs. 6-10.
- 1971 Spiniferites septatus (Cookson & Eisenack) McLean: 729-730, pl. 88, figs. 1-9.

Comments: The Maryland-Delaware specimens of S. septatus are morphologically identical with the specimens of McLean (1971); the dimensions of the main body, processes, and periphragm of the former, however, exceed the dimensions of McLean's specimens. The endophragm is ca. 1.0u thick, the periphragm, 3.5-6.0u thick.

Dimensions: Observed range (12 specimens measured): main body length 47-70u, width 44-64u; overall diameter 70-118u; process length 9-25u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in samples 157 and 158; Loc. 4, extremely rare in samples 160 and 162; Loc. 5, extremely rare in sample 152; Loc. 6, rare in sample 120 and extremely rare in samples 122 and 123.

Previously-reported occurrences: Upper Paleocene of Australia (Cookson & Eisenack, 1967); Upper Paleocene of Maryland and Virginia (McLean, 1971).

Tanyosphaeridium variecalamum Davey & Williams 1966b

Plate 9, fig. 20

- 1966b Tanyosphaeridium variecalamum Davey & Williams: 98-99, pl. 6, fig. 7; text-fig. 20.
- 1969 Tanyosphaeridium variecalamum Davey & Williams; Davey: 151, pl. 6, figs. 2, 5.
- 1973 Tanyosphaeridium variecalamum Davey & Williams; Harland: 687, pl. 86, figs. 13-14.

Comments: Two specimens of T. variecalamum were recovered from the Monmouth Formation. They resemble the specimens of Davey & Williams (1966b) in that the ellipsoidal main body bears tubular processes formed from the periphragm; the processes form oval traces on the main body, with the trace long axis paralleling the cyst long axis; process tips are aculeate, recurved.

New information regarding the tabulation of Tanyosphaeridium variecalamum is included in the description below.

Description: Process distribution indicates tabulation of ?', 6'', 6c, 5''', 6'''''. Three pairs of processes flank sulcus, and an anterior sulcal process is present; all are equal in size to non-sulcal processes. Archeopyle apical (Type \bar{A}), with free operculum. Endophragm and periphragm together are ca. 0.75u thick; external surface of periphragm bears sparse grana.

Dimensions: Two specimens measured: main body length 35-38u, width 19-23u; overall length 51-63u, width 47-56u; process length 13-19u.

Stratigraphic distribution: Loc. 3, extremely rare (one specimen) in sample 156; Loc. 4, extremely rare (one specimen) in sample 159.

Previously-reported occurrences: Cenomanian of England (Davey & Williams, 1966b); Albian-Turonian of England, Cenomanian of France, Albian of Saskatchewan, Canada (Davey, 1969); Upper Campanian of Alberta, Canada (Harland, 1973).

Genus Trichodinium (Eisenack & Cookson 1960)
Clarke & Verdier 1967

Trichodinium castanea (Deflandre 1935) Clarke & Verdier 1967

Plate 2, figs. 10-12

1935 Palaeoperidinium castanea Deflandre: 229, pl. 6, fig. 8.

- 1936a Palaeoperidinium castanea Deflandre; Deflandre: 57, text-fig. 99.
- 1936b Palaeoperidinium castanea Deflandre; Deflandre: 20-21, pl. 6, figs. 1-4.
- 1957 ?Dinoflagellaten gen. and sp. ind.; Gocht: 171, pl. 20, figs. 9-10.
- 1959 Apteodinium ciliatum Gocht: 65, pl. 8, figs. 5-6.
- 1960 Trichodinium intermedium Eisenack & Cookson: 6, pl. 2, figs. 5-6.
- 1961 Apteodinium ciliatum Gocht; Alberti: 24, pl. 4, figs. 1-3, 14-15.
- 1962b Palaeoperidinium castanea Deflandre; Cookson & Eisenack: 489, pl. 3, figs. 9-11.
- 1964 Palaeoperidinium castanea Deflandre; Cookson & Hughes: 49, pl. 5, fig. 14.
- 1964 Trichodinium ciliatum (Gocht) Eisenack & Klement: 811.
- 1967 Trichodinium castanea (Deflandre) Clarke & Verdier: 19, pl. 1, figs. 1-2.
- 1967 Palaeoperidinium castanea Deflandre; Vozzhennikova: 102, pl. 41, figs. 4a, 4b.
- 1969 Trichodinium castanea (Deflandre) Clarke & Verdier; Davey: 131-132, pl. 11, figs. 1-3.
- 1971 Trichodinium castanea (Deflandre) Clarke & Verdier; Davey & Verdier: 37.
- 1974 Trichodinium castanea (Deflandre) Clarke & Verdier; McIntyre: pl. 12, fig. 3.

Comments: The Delaware specimens of Trichodinium castanea are similar in morphology and in size to previously-described specimens.

Description: Bristle-like, furcate spines formed from periphragm cover cyst surface, may be aligned along boundaries of cingulum and sulcus.

Spines form apical tuft-like projection 5-7u long; remaining spines are 3-5u long. Cingulum is 5-6u wide, levorotatory; vertical offset at sulcus is 1-1½ times cingulum width. Sulcal margins are slightly bowed toward cyst lateral margins; sulcus parallels cyst long axis and extends onto hypotract by about one cingulum width. Endophragm is ca. 0.5u thick, periphragm, ca. 1.0u thick; external surface of periphragm is microreticulate.

Dimensions: Observed range (4 specimens measured): main body length 55-74u, width 55-65u; overall length 64-85u, width 64-74u.

Stratigraphic distribution: Loc. 6, extremely rare in sample 116, sparse in sample 120, rare in sample 121, extremely rare in sample 122, and rare in sample 123.

Previously-reported occurrences: Turonian-Senonian of France (Deflandre, 1935, 1936a, 1936b; Mercier, 1938; Davey, 1969); Upper Hauterivian-Upper Barremian of Germany (Gocht, 1957, 1959; Alberti, 1961); Aptian-Lower Albian of Australia (Eisenack & Cookson, 1960); ?Aptian-Cenomanian of Australia (Cookson & Eisenack, 1962b); Upper Albian-Lower Cenomanian of England (Cookson & Hughes, 1964; Clarke & Verdier, 1967); Upper Jurassic of the USSR (Vozzhennikova, 1967); Cenomanian of England and France (Davey, 1969); Albian of France (Davey & Verdier, 1971); Campanian-?Senonian of NWT, Canada (McIntyre, 1974).

Trichodinium hirsutum Cookson 1965b

Plate 2, figs. 1-9

1965b Trichodinium hirsutum: 139, pl. 25, figs. 5-13.

Comments: Brightseat specimens display more variability in process construction and distribution than Cookson (1965) indicated; an account of this variability within the study-area population of T. hirsutum is included in the following description.

Description: Cyst bi-layered, spheroidal to ellipsoidal. Periplasm forms fibrous processes loosely-bound at base, more tightly bound distally. Processes may be randomly-distributed, slender, acuminate-tipped, several per plate-equivalent (Pl. 2, figs. 1-4). Specimens bearing such processes appear to be related by morphological gradation to specimens bearing loosely-bound bundles of the slender processes, intratabular in distribution (Pl. 2, figs. 5-9). In the extreme case, intratabular bundles are tightly-bound into processes resembling those of Cordosphaeridium inodes. Processes may vary considerably in length within a population of T. hirsutum, though are of approximately equal length on a single specimen, with following exceptions: apical, antapical, and cingular processes usually somewhat longer, and remaining processes may be slightly longer toward apex. Apical process is often foliate. Cingulum marked by linear complexes of processes conspicuous at lateral margins of cyst. Cingulum strongly levorotatory; sulcus poorly-defined, may be delineated by

anterior and posterior sulcal processes. Archeopyle relatively large, precingular (Type P), corresponds to 3''; archeopyle outline trapezoidal, anterior margin gabled; operculum simple, free. Endophragm 1.0-2.5u thick, amy form rounded protrusion at apex; periphragm ca. 1.0u thick, external surface microreticulate.

Dimensions: Observed range (32 specimens measured): main body length 70-97u (mean 83u), width 63-79u (mean 72u); overall length 86-130u (mean 109u), width 85-111u (mean 99u).

Stratigraphic distribution: Loc. 3, abundant in sample 157; Loc. 4, extremely rare in sample 162.

Previously-reported occurrence: Paleocene of Australia (Cookson, 1965b).

Xenicodinium lubricum Morgenroth 1968

Plate 7, figs. 9-11

1968 Xenicodinium lubricum Morgenroth: 554, pl. 47, fig. 9; pl. 48, fig. 1.

Comments: The one Brightseat specimen of X. lubricum resembles Morgenroth's (1968) specimens in that tabulation and a sulcus are lacking. His specimens also lack a cingulum, but one is indicated on the Brightseat specimen by aligned processes.

The processes are blunt-tipped spines, ranged along low ridges randomly distributed over the cyst surface. Adjacent spines of a single ridge are joined by a membrane running the entire length of the spines. The Brightseat specimen falls at the upper limit on size for Morgenroth's 50 specimens.

Dimensions: Main body diameter 44u, overall diameter 55u.

Stratigraphic distribution: Loc. 3, extremely rare (one specimen) in sample 157.

Previously-reported occurrence: Danian of northern Germany (Morgenroth, 1968).

Family PERIDINIACEAE (Ehrenberg) Engler 1892

Genus Ascodinium Cookson & Eisenack 1960a

Ascodinium pontis-mariae (Deflandre 1936b)
Deflandre 1966

Plate 10, fig. 1

Comments: The Mount Laurel specimens appear identical with Deflandre's holotype. The cyst outline is fusiform; the cyst bears a bluntly-rounded terminus (apex?) and a more constricted, pointed one (antapex?); a cingulum, suggested by a slight indentation of the periphragm, is

displaced somewhat toward the pointed end of the cyst. On the Mount Laurel specimens the wall layers are ca. 0.5u thick; the external surface of the periphragm is finely and faintly granulose, of the periphragm, laevigate. Vozzhennikova (1967) reported the presence of a hoof-shaped archeopyle on her specimens, but the French and German specimens and those of the present study lack this feature. The dimensions of the Delaware specimens surpass those previously recorded for A. pontis-mariae.

Dimensions: Observed range (4 specimens measured): endoblast length 46-50u, width 24-43u; periblast length 86-98u, width 40-58u.

Alberti's 2 specimens: periblast, length x width 68 x 40u and 55 x 35u; Vozzhennikova's specimens: periblast length 49-59u, width 30-35u; Deflandre's specimens: periblast length 42-52u, width 24-26u.

Stratigraphic distribution: Loc. 6, extremely rare in sample 118, rare in sample 123.

Previously-reported occurrences: ?Senonian of France (Deflandre, 1936, 1966); Turonian of Germany (Alberti, 1959); Upper Cretaceous of the USSR (Vozzhennikova, 1967); Albian-Cenomanian of Saskatchewan, Canada (Davey, 1970).

Genus Deflandrea Eisenack 1938

Deflandrea aspratitidis n. sp.

Plate 10, fig. 2

1970 Deflandrea sp. 4 Zaitzeff & Cross: pl. 6, figs. 59, 59a.

Derivation of name: aspratitidis, L., rough, referring to texture of cyst surface.

Description: Cyst bi-layered, fusiform in dorso-ventral outline, dorso-ventrally flattened, with ellipsoidal equatorial cross-section. No evidence of tabulation. Periblast tapers anteriorly to apical horn, which bears rounded tip; posteriorly, periblast tapers to two antapical horns, also with rounded tips. Right horn strongly reduced relative to left horn; bases of antapical horns close together. Endoblast ellipsoidal, laterally may be tightly appressed to periblast, or lateral pericoels several microns in width may separate wall layers. Archeopyle intercalary (Type I/I), with free operculum; archeopyle outlined hexagonal with alternating long and short sides. Cingulum, 6-9 μ wide, scarcely indented, offset vertically at sulcus by about one-half cingulum width. Cingulum margins marked by low folds of periphragm and/or aligned fine grana. Sulcus shallow, margins delineated by low folds of periphragm; sulcus may be parallel-sided or may widen posteriorly. Reniform thickening slightly left of sulcal midline may mark site of flagellar attachment in parent theca. Endophragm and periphragm each ca. 0.5 μ thick; external surface of periphragm scabrate to densely granulose, with fine to coarse grana present on a single specimen.

Dimensions: Observed range (6 specimens measured): endoblast length 84-124u, width 64-108u; periblast length 125-188u, width 67-116u.

Discussion: The fusiform shape of D. aspratitidis n. sp., the proximity of the antapical horns to one another, the reduction of the right antapical horn, and the ornamentation all serve to distinguish this species from the previously-described species of Deflandrea.

Holotype: Plate 10, fig. 2; VPISUPL sample 117, slide AD 54, coords. R 21.5, +15.8.

Stratigraphic distribution: Loc. 6, extremely rare in samples 116-118 and 121.

Previously-reported occurrence: Maestrichtian of Texas, USA (Zaitzeff & Cross, 1971).

Deflandrea asymmetrica Wilson 1967a

Plate 10, figs. 3-8

1967a Deflandrea asymmetrica Wilson: 62-63, figs. 17-21.

1967b Deflandrea acutula Wilson: 225, figs. 11-12.

1971 Deflandrea aff. asymmetrica Wilson; Wilson: pl. 1, fig. 14.

Comments: Specimens assignable to Deflandrea asymmetrica and ones assignable to D. acutula all appear to belong to one morphologically

variable population in the Monmouth samples. Hence, a full description of the population is given below.

Description: Bi-layered cyst, peridinioid in outline, dorso-ventrally flattened, bilaterally asymmetrical to varying degrees within the population. Right antapical horn strongly-developed, acuminate-tipped; left antapical horn weakly-developed, occurring as broadly-rounded protuberance, or as only an inflection of periphragm. Apical horn tapers to bluntly-rounded tip. Archeopyle intercalary (Type I/I), linguloid in overall shape, roundly hexagonal; operculum attached at posterior margin. Tabulation not apparent. Endoblast roundly pentagonal, asymmetrical, may follow overall outline of periblast, extending into right antapical horn. Endoblast not appressed to periblast laterally; at cingulum, pericoels are up to 4μ in width. Endophragm ca. 0.5μ thick, externally laevigate; periphragm ca. 0.5μ thick, outer surface may be ornamented with closely-spaced fine grana (ca. 0.25μ in height). An occasional specimen displays the longitudinal keels and serrate lateral margins noted by Wilson (1967a) in his original description of D. asymmetrica. Cingulum formed by folds of periphragm or by one or two rows of aligned grana; cingulum levorotatory, displaced vertically at sulcus by about one-half cingulum width; ends separated laterally up to three times cingulum width, accommodating a broad sulcus. Sulcal margins, marked by folds of periphragm, extend to tips of antapical horns.

Discussion: Deflandrea acutula accommodates forms similar to D. asymmetrica, but which have a more strongly-developed right antapical horn. Gradational development of this horn, however, is present within the population of the present study. The relative development of the horn is reflected in the length-to-width ratio of the periblast. Text-fig. 12 shows D. acutula near one end of the continuum, displaying a high length-to-width ratio; D. asymmetrica, with a relatively short right antapical horn, lies near the other extreme. The two species appear to belong to one population which displays considerable variation in the development of the right antapical horn. Accordingly, D. acutula is herein regarded as a junior synonym of D. asymmetrica.

Dimensions: Observed range (30 specimens measured): endophragm length 35-60u (mean 48u); width 34-49u (mean 40u). Periblast length 60-93u (mean 77u); width 39-57u (mean 46u).

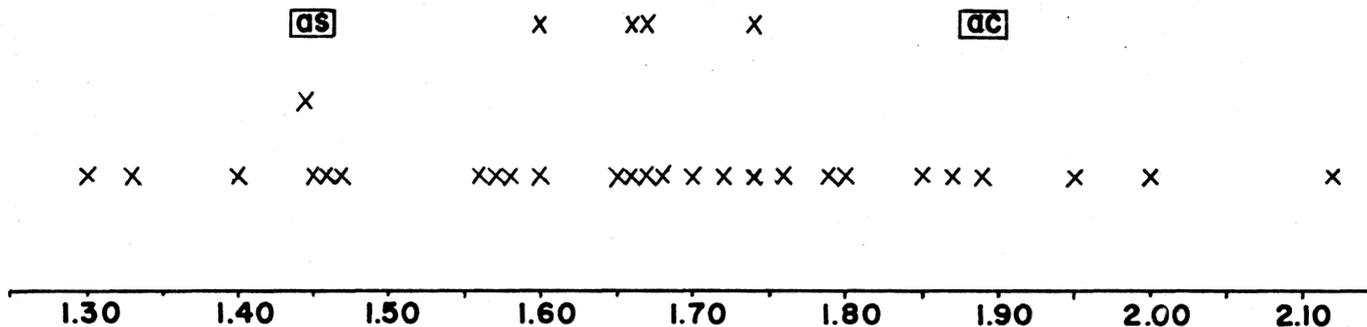
Stratigraphic distribution: Loc. 5, sparse in sample 151, rare in sample 152, rare in sample 153, and extremely rare in sample 154.

Previously-reported occurrences: Paleocene, ?Eocene of New Zealand (Wilson, 1967a and b); Upper Cretaceous of New Zealand (Wilson, 1975).

Deflandrea cf. D. balcattensis Cookson & Eisenack 1969

Plate 10, figs. 15-16

(?) 1969 Deflandrea balcattensis Cookson & Eisenack: 3, fig. 1, B-F.



Text-fig. 12. Length-to-width ratios of randomly-selected specimens of Deflandrea asymmetrica - Deflandrea acutula. as marks the L/W ratio of the holotype of D. asymmetrica, ac of D. acutula. The two holotypes lie near the ends of a morphological continuum, representing variation within a population (see Discussion).

(?) 1970a Deflandrea balcattensis Cookson & Eisenack; Cookson & Eisenack: 142, pl. 11, fig. 13.

Comments: Cookson's type specimens of Deflandrea balcattensis bear a right antapical horn. Strongly-reduced, the horn is represented by a convex-outward inflection of the periblast. The Delaware specimens, however, lack any indication of a right antapical horn.

The Delaware specimens are comparable in size with the Australian specimens.

Description: Cyst bi-layered, dorso-ventrally flattened; epitract slightly longer than hypotract. Periblast fusiform is dorso-ventral outline, bears roundly convex margins; endoblast spheroidal. Wall layers in contact dorsally and ventrally. Apex and antapex formed by necking and subsequent truncation of periblast beyond endoblast. Apex aligned with longitudinal axis of cyst; antapex offset slightly to left of axis, represents left antapical horn. No archeopyle or tabulation observed. Cingulum 3-6u wide, indented, non-levorotatory; on dorsal surface anterior and posterior margins of cingulum bear aligned grana. Sulcus, restricted to hypotract, widens posteriorly. Endophragm, ca. 1.0u thick, is externally laevigate; periphragm, ca. 0.5u thick, externally bears fine grana.

Dimensions: Observed range (10 specimens measured): endoblast length 30-46u (mean 37u), width 30-42u (mean 36u); periblast length 42-63u (mean 54u), width 35-44u (mean 41u). Dorso-ventral thickness 18u (one specimen measured).

Stratigraphic distribution: Loc. 6, extremely rare to rare throughout the section.

Previously-reported occurrences: Albian-Cenomanian and Senonian of Western Australia (Cookson and Eisenack, 1969 and 1970a).

Deflandrea camerata n. sp.

Plate 11, figs. 1-2

Derivation of name: camera, L., chamber or vault with arched roof, referring to the prominent apical pericoel.

Description: Peridinoid cyst with parallel lateral margins. Endoblast oblatelately spheroidal, laterally appressed to periblast. Archeopyle intercalary (Type I/I), hexagonal, with sides approximately equal in length; operculum simple, free, corresponds to plate-equivalent 2a; accessory sutures may occur between 3'' and 4'', between 4'' and 5'', and may intersect cingulum. Other evidence of tabulation not apparent. Apical horn bluntly-rounded, bears central pore-like opening at tip. Left antapical horn strongly-developed, acuminate-tipped; right antapical horn much reduced, tip broadly-rounded. Large apical and antapical pericoels present. Apical pericoel formed by convexities of periphragm at cyst lateral margins; antapical one formed by webbing of periphragm between antapical horns. Margins of cingulum and sulcus marked by low, sharp folds of periphragm. Cingulum up to 9u wide, shallow, bears denticulate margins. Weakly-levorotatory, cingulum is

offset vertically at sulcus up to one-half cingulum width. Sulcus widens posteriorly, margins extend to tips of antapical horns. Reniform thickening to left of sulcal midline may represent flagellar pore in original theca. Endophragm and periphragm each ca. 0.5u thick. Periphragm externally bears longitudinal folds imparting striate appearance to cyst and may bear densely-distributed grana ca. 0.25u high.

Discussion: The unique combination of the longitudinally striate periphragm, the prominent apical and antapical pericoels, the consistent polar flattening of the endoblast, and the strong reduction of the right antapical horn, distinguishes Deflandrea camerata from all other species of Deflandrea.

Dimensions: Observed range (23 specimens measured): endoblast length 33-47u (mean 39u), width 37-55u (mean 48u); periblast length 66-97u (mean 80u), width 42-61u (mean 52u).

Holotype: Plate 11, figs. 1-2. VPISUPL sample 118, slide AD 55, coords. R10.0, +7.8.

Stratigraphic distribution: Loc. 6, rare to common throughout the section; restricted to the Mount Laurel Formation in the study-area.

Deflandrea conicula n. sp.

Plate 11, figs. 7-10

Derivation of name: coniculus, L., cone, referring to the coni on periphragm outer surface.

Description: Peridinoid cyst with lateral margins straight to convex outward. Cyst slightly longer than broad, with epitract somewhat longer than hypotract. Enoblast spheroidal to rhomboidal, appressed to periblast except in region of horns, may bulge into bases of antapical horns. Apical and antapical horns short, slender, constrict just beyond endoblast. Apical horn blunt-tipped, may bear central pore-like indentation; antapical horns divergent, acuminate-tipped, left horn commonly somewhat reduced. Archeopyle intercalary (Type I/I) with rounded hexagonal outline in both wall layers, corresponds to plate-equivalent 2a; operculum simple, free. Cingulum and sulcus shallow but well-defined, are bordered by sharp folds of periphragm. Cingulum ca. 4-8u wide, levorotatory, offset vertically at sulcus by one-half to one cingulum width. Margins of sulcus may extend to tips of antapical horns; reniform thickening to left of sulcal midline may represent flagellar pore in parent theca. Outer surface of cyst bears coni 0.5-1.0u high, randomly distributed or aggregated into fields, partially indicating tabulation; plate-equivalent 1'' bears lozenge-shaped field of coni, 1'' and 7'' bear triangular fields, and 1''' and 5''', inverted triangular fields. Coni, when well-developed, give serrate appearance to cyst lateral margins. Endophragm less than 0.5u thick; periphragm, ca. 0.5u thick.

Dimensions: Observed range (30 specimens measured): endoblast length

41-67u (mean 56u), width 44-70u (mean 58u); periblast length 67-107u (mean 84u), width 53-75u (mean 65u).

Comparison with similar species: Deflandrea conicula resembles D. ventriosa Alberti 1959 in having a similar overall outline; both have a large endoblast nearly filling the periblast. The left antapical horn of D. ventriosa, however, is only weakly-developed, and coni are absent.

D. conicula also resembles D. wetzeli Morgenroth 1966: both have coni, a large endoblast, and antapical horns nearly equal in size. The overall outline of D. wetzeli, however, is somewhat different: epitracial lateral margins are strongly convex and the bases of the antapical horns are farther apart than those of D. conicula.

Holotype: Plate 11, fig. 8. VPISUPL sample 166, slide AF 73, coords. R11.1, +16.1.

Stratigraphic distribution: Loc. 1, rare to abundant throughout the section; Loc. 3, common in sample 164 and extremely rare in sample 165; Loc. 3, extremely rare in sample 156 and rare in sample 163; Loc. 4, rare in sample 160 and extremely rare in sample 162; Loc. 5, sparse to abundant throughout the section; Loc. 6, sparse in sample 123.

Deflandrea cooksoni Alberti 1959

Plate 10, figs. 10-13.

- 1959 Deflandrea cooksoni Alberti: 97, pl. 9, figs. 1-6.
- 1960a Deflandrea tripartita Cookson & Eisenack: 2, pl. 1, fig. 10.
- 1964 Deflandrea tripartita (Cookson & Eisenack) emend. Cookson & Manum: 521-522, pl. 76, figs. 1-2.
- 1967 Australiella cooksoni (Alberti) Vozzhennikova: 132, pl. 61, figs. 2-5.
- 1967 Australiella tripartita (Cookson & Eisenack) Vozzhennikova: 134-135, pl. 61, fig. 1; pl. 64, figs. 1-4.

Comments: In the original description of Deflandrea tripartita, Cookson and Eisenack (1960a) stated that the species differs from D. cooksoni in possessing a cingulum. The Maryland-Delaware specimens, however, display a considerable range of variation; the cingulum is clearly expressed to completely absent.

On the holotype of D. tripartita the periblast constricts strongly just anterior and posterior to the endoblast; the holotype of D. cooksoni, however, lacks this constriction. Again, the Maryland-Delaware specimens display a continuum of morphological variation between the two holotypes, which are herein considered end members of an intergradational series. Accordingly, the two species are considered synonymous in this study; the older epithet, D. cooksoni, has priority over D. tripartita.

Dimensions: Observed range (32 specimens measured): endoblast length 35-65u (mean 48u), width 41-60u (mean 52u); periblast length 73-134u (mean 110u), width 44-62u (mean 55u).

Stratigraphic distribution: Loc. 1, rare to common throughout the

section; Loc. 2, rare in sample 164; Loc. 3, extremely rare in sample 156, rare in sample 163; Loc. 4, rare in sample 161; Loc. 5, rare to abundant throughout the section; Loc. 6, extremely rare to rare throughout the section.

Previously-reported occurrences: Upper Senonian of Germany (Alberti, 1959); ?Upper Turonian to Middle Senonian of Western Australia (Cookson and Eisenack, 1960 and 1964); Senonian of USSR (Vozzhennikova, 1967).

Deflandrea cf. D. cooksoni Alberti 1959

Plate 10, fig. 14

Comments: The Monmouth specimens differ from Deflandrea cooksoni in bearing coarse grana, up to 1.0u high, on the outer surface of the periphragm; the grana may coalesce into rod-like or vermiculate thickenings.

Dimensions: Observed range (13 specimens measured): endoblast length 35-54u (mean 44u), width 42-62u (mean 55u); periblast length 77-118u (mean 99u), width 44-68u (mean 58u).

Stratigraphic distribution: Loc. 5, extremely rare in samples 151 and 153.

Deflandrea dartmooria Cookson & Eisenack 1965b

Plate 12, figs. 2-11

1965b Deflandrea dartmooria Cookson & Eisenack: 133, pl. 16, figs. 1-2; text-fig. 1.

1973 Deflandrea dartmooria Cookson & Eisenack; Stover: 176, pl. 3, figs. 4a-b; pl. 4, figs. 1a-d, 2.

Comments: Maryland-Delaware specimens of Deflandrea dartmooria display a wider range of morphological variation than the original description of Cookson and Eisenack (1965b) indicated; therefore, a full description of the species is presented below.

Description: Peridinoid cyst bearing strongly-developed horns. Apical horn tapers to blunt tip, often containing plug-like thickening extending ca. 1.0u beyond tip of horn. Antapical horns broad-based, widely separated at base, diverging to varying degree from specimen to specimen and tapering to acuminate or rounded tips. Epittract slightly longer than hypottract. Cyst lateral margins straight or more commonly, weakly concave. Archeopyle intercalary (Type I/I), trapezoidal-hexagonal in both wall layers, with relatively broad posterior margin. Endoblast ovoidal to weakly pentagonal, often slightly broader than long, occasionally bulges into bases of antapical horns. Endoblast appressed to periblast along lateral margins of epittract; between antapical horns, wall layers appressed or separated to varying degree from specimen to specimen. Endoblast ca. 0.5-1.0u thick, externally laevigate; periphragm less than 0.5u thick, outer surface bears coni

0.5-1.0u high; coni may be randomly scattered over cyst surface, but more commonly are aggregated into intratabular fields outlining a tabulation of 4', 3a, 7'', ?c, 5''', 2'''. Triangular fields of coni outline 1'' and 7''. Coni lie along cingulum margins. On Brightseat specimens, coarse coni (ca. 1.0u in height and basal diameter) may be developed; distally-rounded to acuminate on a single specimen, these coarse coni may be aligned in longitudinal rows. Cingulum weakly indented, circular to slightly levorotatory, separated at sulcus about one-half cingulum width; ends of cingulum may be deflected downward at sulcus. Sulcus extends onto epitheca one-half to one cingulum width; sulcal margins nearly parallel, extend to posterior margin of periblast between antapical horns. Reniform thickening to left of sulcal mid-line may represent flagellar pore of original theca.

Discussion: Deflandrea dartmooria is rare in the Mount Laurel Formation. Typical specimens have few, delicate coni, and the apical horn is robust and broad-based. Specimens of D. dartmooria are relatively abundant in the Brightseat Formation, in which typical specimens have numerous, coarse coni, often aligned in longitudinal rows; the apical horn is slender, with the periblast constricting abruptly just anterior to the endoblast.

Dimensions: Observed range (38 specimens measured): endoblast length 57-83u (mean 69u), width 60-86u (mean 71u); periblast length 119-175u (mean 139u), width 63-100u (mean 79u).

Stratigraphic distribution: Loc. 1, rare to sparse throughout the section; Loc. 2, rare in sample 164 and sparse in sample 165; Loc. 3, extremely rare in samples 157 and 158, sparse in sample 163; Loc. 4, rare in samples 160-162; Loc. 5, extremely rare to sparse throughout the section; Loc. 6, rare in sample 123.

Previously-reported occurrences: Lower Eocene of Australia (Cookson and Eisenack, 1965b; Stover, 1973).

Deflandrea diebeli Alberti 1959

Plate 11, figs. 5-6.

1959 Deflandrea diebeli Alberti: 99, pl. 9, figs. 18-21.

1963 Deflandrea diebeli Alberti; Gorka: 29, pl. 4, figs. 6-8.

1967 Ceratiopsis diebeli (Alberti) Vozzhennikova: 159-160, pl. 119, fig. 4.

Comments: Maryland specimens of Deflandrea diebeli are closely similar in morphology to previously-described specimens; there appears to be little intraspecific variation. The Maryland specimens are somewhat larger than those of Alberti (1959) (see Dimensions).

Dimensions: Observed range (13 specimens measured): endoblast length 60-90u (mean 78u), width 41-88u (mean 71u); periblast length 131-262u (mean 220u), width 48-96u (mean 78u). Alberti's specimens: periblast length 110-210u, width 40-50u.

Stratigraphic distribution: Loc. 1, extremely rare in samples 166 and 170; Loc. 3, extremely rare in sample 156; Loc. 5, rare in samples 151 and 152, extremely rare in samples 153 and 155.

Previously-reported occurrences: Upper Senonian of Germany (Alberti, 1959); Lower and Upper Maestrichtian of Poland (Gorka, 1963); Paleocene of western Siberia (Vozzhennikova, 1967); Maestrichtian of Denmark (Wilson, 1971).

Deflandrea dilwynensis Cookson & Eisenack 1965

Plate 11, figs. 12-14

1965c Deflandrea dilwynensis Cookson & Eisenack: 141, pl. 18, figs. 6-9.

Comments: The excellently-preserved, numerous specimens of Deflandrea dilwynensis in the Brightseat Formation provide information supplemental to the original description of Cookson and Eisenack (1965c). Moreover, the range of morphological variation within a population of D. dilwynensis can be documented. Hence, a full description of the species is given below.

Description: Peridinioid cyst, epitheca longer than hypotheca. Lateral margins of periblast more or less straight-sided, may be slightly convex on epitheca, pulling away from endoblast. Apical horn distally rounded, bears small distal pore appearing as depression

in dorso-ventral view. Antapical horns relatively close-set, moderately divergent posteriorly; right antapical horn usually reduced. Archeopyle intercalary (Type I/I), formed by release of 2a, is hexagonal in outline; operculum free. Typically, accessory archeopyle sutures extend between plate-equivalents 3'' and 4'', between 4'' and 5'', and may transect cingulum. Low, delicate folds of periphragm or sparse grana mark cingulum margins; cingulum slightly levorotatory, offset vertically at sulcus by about one-half cingulum width. Plate-equivalents outlined by low folds of periphragm on some specimens, by coarse, sparsely-distributed grana on others. Endoblast variable in outline, spheroidal to ovoidal to roundly-pentagonal; in the last case, posterior margins of endoblast may bulge slightly into bases of antapical horns. Endophragm and periphragm each ca. 0.5u thick; periphragm bears sparse to numerous longitudinal striae on exterior surface.

Discussion: The Brightseat specimens differ from those of Cookson and Eisenack (1965c) in several minor respects: the archeopyle is trapezoidal on their specimens, but hexagonal on the Brightseat specimens. The apical horn of the Pebble Point specimens is relatively short, so that the overall lengths are considerably less than for the Brightseat specimens; the endoblast dimensions, however, are comparable.

The accessory archeopyle sutures noted in this study also appear on the Pebble Point specimens (pl. 18, fig. 9 of Cookson and Eisenack, 1965c).

Dimensions: Observed range (20 specimens measured): endoblast length

44-59u (mean 54u); width 46-60u (mean 53u); periblast length 66-103u (mean 82u), width 50-72u (mean 60u). Specimens of Cookson and Eisenack (1965c): periblast length 56-76u, width 48-60u.

Stratigraphic distribution: Loc. 2, rare in sample 165; Loc. 3, rare in sample 157 and common in sample 158; Loc. 4, extremely rare in sample 162.

Previously-reported occurrence: Paleocene of Australia (Cookson and Eisenack, 1965c).

Deflandrea magnifica Stanley 1965

Plate 11, fig. 3

1965 Deflandrea magnifica Stanley: 218-219, pl. 20, figs. 1-6.

1967 Deflandrea magnifica Stanley; Drugg: 17, pl. 1, fig. 18.

Comments: Five specimens of D. magnifica were recovered in this investigation. They resemble the specimens of Stanley (1965) and of Drugg (1967): all have a broadly pentagonal outline in dorso-ventral view, short horns, a large endoblast, and a large hexagonal archeopyle (Type I/I) with a broad posterior margin. The apical horn is square-tipped; the antapical horns are acuminate, nearly equal in size, and divergent. The cingulum is shallow, 4.5-8.0u wide, and weakly levo-rotatory; vertical offset at the sulcus is about one-half cingulum width. The sulcus, poorly-defined, widens posteriorly. The periphragm

bears faint longitudinal folds; the endophragm and periphragm are each ca. 0.3-0.5u thick. The Mount Laurel-Monmouth specimens are, on the average, 30u shorter than the specimens of Stanley (1965) and of Drugg (1967).

Dimensions: Observed range (5 specimens measured): endoblast length 77-93u, width 62-99u; periblast length 96-113u, width 64-103u.

Stratigraphic distribution: Loc. 5, extremely rare in sample 153; Loc. 6, extremely rare in samples 118 and 120, rare in sample 123.

Previously-reported occurrences: Paleocene of South Dakota (Stanley, 1965); Maestrichtian-Danian of California (Drugg, 1967).

Deflandrea cf. D. obscura Drugg 1967

Plate 11, fig. 4

(?) 1967 Deflandrea obscura Drugg: 17, pl. 2, figs. 8-9, fig. 5.

Comments: Monmouth specimens of Deflandrea cf. D. obscura resemble Drugg's specimens in having weakly-developed horns, a reduced left antapical horn, and sparse grana scattered over the cyst surface. They differ in that the endoblast and periblast are appressed on Drugg's specimens, whereas lateral pericoels several microns in width are developed on the Monmouth specimens; Drugg's specimens bear faint traces of tabulation, whereas the study-area specimens do not; moreover

the latter are larger (see Dimensions).

The archeopyle is intercalary (Type I/I); its outline is hexagonal, with rounded corners and a broad posterior margin; the operculum is simple and free. The cingulum and sulcus are delimited by low folds of the periphragm. The cingulum, 5-7u wide, is weakly levorotatory; it is offset vertically at the sulcus a maximum of one-half cingulum width. The sulcus widens slightly toward the antapex. The endophragm and periphragm are each ca. 0.5u thick.

Dimensions: Observed range (7 specimens measured): endoblast length 42-55u, width 49-58u; periblast length 55-78u, width 52-61u. Drugg's specimens: periblast length 45-60u, width 40-54u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 3, extremely rare in sample 156; Loc. 4, extremely rare in sample 159; Loc. 5, extremely rare in sample 151; Loc. 6, extremely rare in samples 121 and 123.

Previously-reported occurrence: Maestrichtian-Danian of California (Drugg, 1967).

Deflandrea pannucea Stanley 1965

Plate 12, fig. 1

1965 Deflandrea pannucea Stanley: 220, pl. 22, figs. 1-4, 8-10.

1970 Deflandrea pannucea Stanley; Zaitzeff & Cross: pl. 6, figs. 55-56.

Comments: The four specimens of Deflandrea pannucea recovered from the Monmouth Formation appear identical, in both morphology and size, with the specimens of Stanley (1965).

Dimensions: Observed range (4 specimens measured): endoblast length 49-61u, width 51-62u; periblast length 81-96u, width 55-71u.

Stratigraphic distribution: Loc. 5, extremely rare in sample 153.

Previously-reported occurrences: Paleocene of South Dakota (Stanley, 1965); Maestrichtian of Texas (Zaitzeff and Cross, 1971).

Deflandrea pentaradiata Cookson & Eisenack 1965

Plate 12, figs. 12-15

1965c Deflandrea pentaradiata Cookson & Eisenack: 139, pl. 18, figs. 1-2.

Comments: Several Brightseat specimens of Deflandrea pentaradiata resemble the type specimens of Cookson and Eisenack (1965c) in having a pentagonal overall outline with concave lateral margins, a roughly pentagonal endoblast, antapical horns approximately equal in length, and a trapezoidal intercalary archeopyle (Type I/I) bearing rounded corners. Other Brightseat specimens of D. pentaradiata, however, display a broader range of morphological variation than the original description indicates. The lateral margins of these specimens are only slightly concave to straight; lateral extensions of the cingulum

are expressed to varying degree from specimen to specimen; the endoblast is ovoidal to spheroidal.

The cingulum and sulcus of the Pebble Point specimens are delimited by narrow ridges, which the Brightseat specimens lack; instead, the cingulum is discernible only near the lateral margins of the cyst, where broad convexities of the periblast form cingulum boundaries: sulcal boundaries are not visible. Tabulation is lacking, except for the occasional alignment of relatively coarse grana along boundaries of antapical plate-equivalents. The endophragm and periphragm are each ca. 0.5u thick. The external surface of the endophragm bears densely-distributed hair-like bacula ca. 0.5u high at the apex, up to 2.0u high at the antapex; the external surface of the periphragm bears scattered grana up to 0.5u high.

Dimensions: Observed range (15 specimens measured): endoblast length 82-106u (mean 86u); width 78-106u (mean 82u); periblast length 120-172u (mean 138u), width 85-125u (mean 109u).

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in sample 158; Loc. 4, extremely rare in sample 162.

Previously-reported occurrences: Middle Paleocene of Australia (Cookson & Eisenack, 1965c; Stover, 1973).

Deflandrea cf. D. striata Drugg 1967

Plate 11, fig. 11

? Deflandrea striata Drugg: 18, pl. 2, figs. 13-14.

Comments: Three specimens of D. cf. D. striata were recovered in this investigation. They resemble the specimens of Drugg (1967) of Deflandrea striata in bearing grana and longitudinal folds of the periphragm. The grana of the Maryland-Delaware specimens, however, are sparsely scattered over the outer surface of the periphragm, while the grana of Drugg's specimens are aligned in longitudinal rows or low ridges.

Dimensions: Observed range (3 specimens measured): endoblast length 60-87u, width 58-87u; periblast length 113-150u, width 67-99u.

Stratigraphic distribution: Loc. 3, extremely rare in sample 156; Loc. 5, extremely rare in sample 155; Loc. 6, extremely rare in samples 116, 121, and 122.

Previously-reported occurrence: Danian of California (Drugg, 1967).

Genus Palaeocystodinium Alberti 1961

Palaeocystodinium australinum (Cookson 1965) n. comb.

Plate 13, fig. 1

- ?1936 Ceratium cf. fusus (Ehrenberg) forma incerta Deflandre: 40, pl. 10, Figs. 8-9.
- ?1955 Ceratium cf. fusus forma incerta Deflandre; Deflandre & Cookson: 293, pl. 8, fig. 1.
- 1965b Svalbardella australina Cookson: 140, pl. 25, figs. 1-4.
- 1967 Svalbardella aff. australina Cookson; Wilson: 227, fig. 10.
- 1972 Svalbardella australina Cookson; Malloy: 63, pl. 1, figs. 17, 20.
- 1975 Svalbardella australina Cookson; Haskell & Wilson: pl. 1, fig. 15.

Comments: The Maryland-Delaware specimens of P. australinum appear morphologically identical with those of Malloy (1972); the apical and antapical horns are approximately equal in length, whereas the apical horn of Cookson's type specimens is slightly longer. The Maryland-Delaware specimens are larger than those of Malloy and smaller than those of Cookson (see Dimensions).

Palaeostomocystis australinum n. comb. differs from P. golzowense, the type species, only in the possession of an accessory projection on the antapical horn.

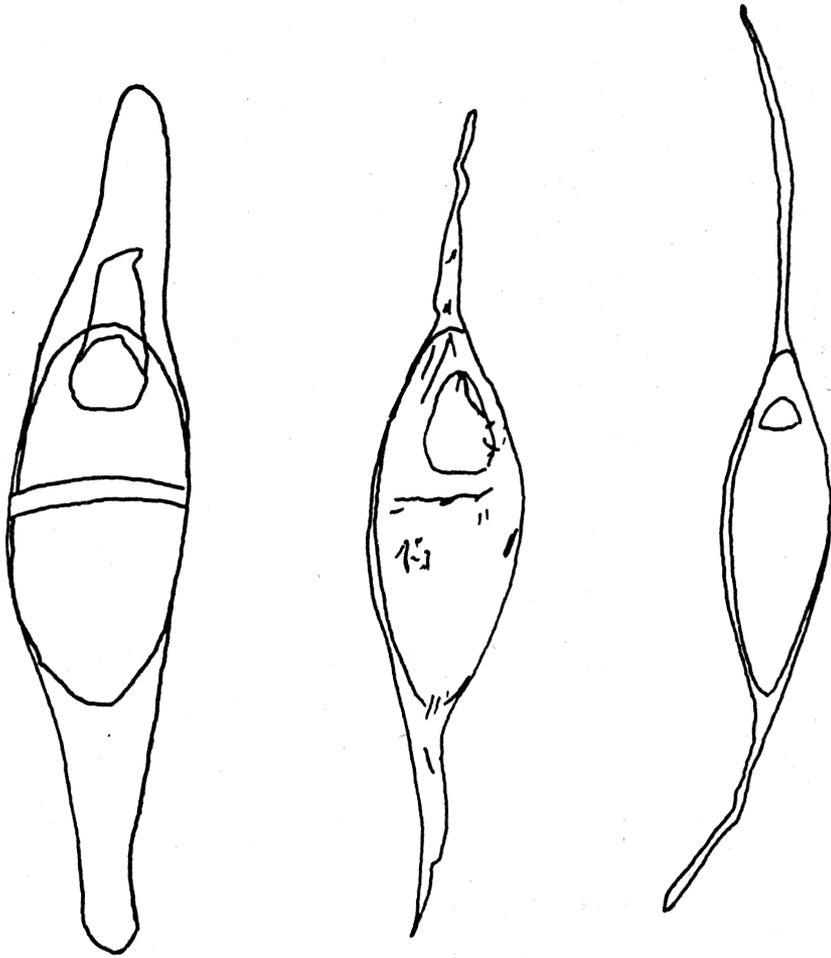
Description: Accessory spur-like projection is 2-10 μ long. "Spur" originates on antapical horn about 1/3 to 1/2 distance from endoblast to tip of horn, diverges from cyst mid-line, is acuminate-tipped. Antapical horn acuminate, apical horn tapers to several microns in width, is truncated normal to cyst long axis. Horn length ranges from approximately 1/3 to 1/2 length of endoblast. Archeopyle intercalary

(Type I/I), outline hexagonal, with alternating long and short sides; posterior margin broad. Endophragm and periphragm, each ca. 0.5u thick, are externally laevigate.

Discussion: The original descriptions of Svalbardella and Palaeocystodinium do not sufficiently distinguish the two genera, but the type species convey the concept of each genus. In Svalbardella cooksoniae Manum, the periblast constricts only slightly beyond the endoblast, so that the cyst lateral margins taper gradually to bluntly-rounded tips. In Palaeocystodinium golzowense Alberti, the periblast constricts strongly immediately beyond the endoblast; the long, slender horns bear acuminate tips. In no instances have a thick horn with a bluntly-rounded tip and a slender horn with an acuminate tip been observed on a single specimen. It appears, then, that the two morphotypes should be taxonomically separated. Accordingly, Svalbardella australinum is herein transferred to Palaeocystodinium.

In fig. 13, the overall shape of Svalbardella cooksoniae (a.) is contrasted with that of Palaeocystodinium australinum n. comb. (b.), and with P. golzowense (c.), also treated in this study.

Dimensions: Observed range (42 specimens measured): endoblast length 86-170u (mean 115u), width 44-97u (mean 57u); periblast length 164-272u (mean 200u), width 44-98u (mean 58u). Malloy's specimens range in overall length from 110-175u, those of Cookson, 239-302u.



Text-fig. 13. a. Svalbardella cooksoniae Manum 1960
b. Palaeocystodinium australinum (Cookson 1965) n. comb.
c. Palaeocystodinium golzowense Alberti 1961

Stratigraphic distribution: Loc. 1, rare to sparse throughout the section; Loc. 2, rare in sample 164; Loc. 3, rare in samples 156-158 and common in sample 163; Loc. 4, extremely rare in sample 160, sparse in sample 161, and extremely rare in sample 162; Loc. 5, extremely rare to sparse throughout the section; Loc. 6, extremely rare in sample 120 and sparse in sample 123.

Previously-reported occurrences: Senonian of France (Deflandre, 1936); Paleocene to Lower Eocene of Australia (Deflandre and Cookson, 1955); Upper Oligocene of Germany (Brosius, 1962); Paleocene of Australia (Cookson, 1962b; Haskell & Wilson, 1975); Senonian-Maestrichtian of Gabon, West Africa (Malloy, 1972).

Palaeocystodinium golzowense Alberti 1961

Plate 13, fig. 2

- 1961 Palaeocystodinium golzowense Alberti: 20, pl. 7, figs. 10-12; pl. 12, fig. 16.
- ?1962 Netrelytron n. sp. Brosius: 38, pl. 3, fig. 2; pl. 4, fig. 2; pl. 5, fig. 2.
- ?1965 Palaeocystodinium golzowense Alberti; Stanley: 225, pl. 23, figs. 1-2.
- 1969 Palaeocystodinium golzowense Alberti; De Coninck: 46-47, pl. 14, figs. 10-11, 15-16.
- 1972 Palaeocystodinium golzowense Alberti; Benedek: 13-14, pl. 2, figs. 4, 6, 7; pl. 14, figs. 11-13.
- 1972 Palaeocystodinium golzowense Alberti; Malloy: 64, pl. 1, figs. 18-19.

Comments: The Maryland specimens of P. golzowense appear identical with those of Alberti (1961). He illustrated two morphotypes within the species, however: his holotype (pl. 7, fig. 12) displays horns whose lengths are approximately $\frac{1}{2}$ that of the endoblast, while his other specimens (such as fig. 11 of his pl. 7) have horns that equal or exceed the length of the endoblast. Benedek (1972) also reported the presence of both morphotypes. The specimens of Malloy (1972) are only the shorter-horned form. The Maryland specimens are only the longer-horned form; they are larger than previously-described specimens of Palaeocystodinium golzowense.

Dimensions: Observed range (11 specimens measured): endoblast length 75-120u (mean 98u), width 44-57u (mean 50u); periblast length 218-293u (mean 257u), width 49-57u (mean 53u). Alberti's specimens: length 125-180u, width 25-34u.

Stratigraphic distribution: Loc. 2, rare in sample 165; Loc. 3, rare in samples 157 and 158; Loc. 4, extremely rare in sample 162.

Previously-reported occurrences: Paleocene-Lower Eocene of Australia (Cookson & Deflandre, 1955); Upper Eocene-Upper Oligocene of Germany (Alberti, 1961); Upper Oligocene of Germany (Brosius, 1962); Paleocene of South Dakota (Stanley, 1965); Oligocene of Germany (Benedek, 1972); Maestrichtian-Paleocene? of Gabon, West Africa (Malloy, 1972).

Palaeocystodinium polymorphum (Malloy 1972) n. comb.

Plate 13, fig. 3

1972 Svalbardella polymorpha Malloy: 63-64, pl. 1, fig. 8-16,
21.

Comments: Brightseat specimens of Palaeocystodinium polymorphum n. comb. have antapical horns of approximately equal length, with contiguous bases. On Malloy's specimens, however, the antapical horns are commonly unequal in length to varying degree from specimen to specimen, and are separated at the base. Moreover, the Brightseat specimens are considerably longer than those of Malloy (see Dimensions).

Description: Cyst fusiform in overall outline; endoblast elongate, ellipsoidal, laterally appressed to periblast. Periblast constricts abruptly just beyond endoblast, tapers to acuminate-tipped apical horn, and gives rise to two acuminate-tipped antapical horns. Equal in length on all but one specimen, antapical horns are shorter than apical horn. Archeopyle intercalary (Type I/I), trapezoidal; operculum simple, free. No indication of tabulation. Endophragm ca. 0.3 μ thick, periphragm, ca. 0.5 μ thick, both externally laevigate.

Discussion: On the basis of its slender, acuminate-tipped horns, Svalbardella polymorpha Malloy is herein transferred to Palaeocystodinium, in accord with the taxonomic treatment afforded Svalbardella australina in this study (see Discussion, p. 178).

Dimensions: Observed range (16 specimens measured): endoblast length 96-139u (mean 117u), width 44-74u (mean 60u); periblast length 174-264u (mean 227u), width 47-74u (mean 61u). Malloy's specimens: periblast length 90-170u, width 38-77u.

Stratigraphic distribution: Loc. 3, extremely rare in samples 157 and 158; Loc. 4, extremely rare in sample 162.

Previously-reported occurrence: Maestrichtian of Gabon, West Africa (Malloy, 1972).

Genus Palaeohystrichophora Deflandre 1935, emend. Deflandre
and Cookson 1955

Palaeohystrichophora infusorioides Deflandre 1935

Plate 13, figs. 4-5

- 1935 Palaeohystrichophora infusorioides Deflandre: 230-231, pl. 8, fig. 4.
- 1936 Palaeohystrichophora infusorioides Deflandre; Deflandre: 186, pl. 9, fig. 7.
- 1937 P. infusorioides Deflandre; Deflandre: 27-28, pl. 9, figs. 5-10.
- 1939 P. infusorioides Deflandre; Deflandre & Courteville: 98, pl. 2, fig. 2.
- 1940 P. infusorioides Deflandre; Deflandre: 156-157, text-fig. 3.
- 1955 P. infusorioides Deflandre; Valensi: 591-592, pl. 3, figs. 9, 12, 14.
- 1958 P. infusorioides Deflandre; Cookson & Eisenack: 37-38, pl. 10, fig. 10.

- 1961 P. infusorioides Deflandre; Alberti: 19, pl. 3, fig. 24.
- 1964 P. infusorioides Deflandre; Cookson & Hughes: 43, pl. 5, fig. 8.
- 1964 P. infusorioides Deflandre; Manum & Cookson: 19-20, pl. 6, fig. 5.
- 1966 P. infusorioides Deflandre; Baltes:
- 1967 P. infusorioides Deflandre; Vozzhennikova: 173, pl. 99, figs. 1-5.
- ?1967 P. infusorioides Deflandre; Clarke & Verdier: 28, pl. 4, fig. 10.
- 1968 P. infusorioides Deflandre; Ingram: 66.
- 1970 P. infusorioides Deflandre; Cookson & Eisenack: 144, pl. 12, figs. 12-13.
- 1970 P. infusorioides Deflandre; Davey: 346-347, pl. 3, figs. 3, 6.
- 1970 P. infusorioides Deflandre; Habib: 345-379, pl. 8, fig. 11; pl. 9, fig. 5.
- 1973 P. infusorioides Deflandre; Davey & Verdier: 199.

Description: Cyst outline peridinioid to broadly fusiform; apical horn moderately long; antapical horns strongly convergent, with left horn longer of the two. Cyst dorso-ventrally flattened. Periplasm bears short, solid spines, delicate and flexible, 4-7 μ long, with basal diameter of ca. 0.5 μ . Spines intratabular in distribution, indicating tabulation of 4', 3a, 7'', ?c, 5''', 2'''''. Endoblast ovoidal; endoblast and periblast appressed except at apex and antapex.

Archeopyle possibly transapical (see Discussion). Cingulum approximately circular, ends deflected posteriorly, merging into sulcus to form a "Y"; area within fork of "Y" may be site of anterior sulcal platelet. Cingulum margins elevated, each bearing row of

closely-set spines. Sulcus non-inclined, about one cingulum in width, slightly indented; margins essentially parallel, each bearing row of closely-set spines.

Discussion: Some specimens exhibit faint sutural thickenings on the dorsal epitract in addition to the intratabular spines. These thickenings, not a constant feature, may be displayed by only variant specimens. A transapical archeopyle is suspected: rupture of the endoblast is observed in some specimens; examination, however, of numerous specimens shows no consistent rupture in the periphragm. The specimens in this study resemble those originally described by Deflandre, but have shorter spines and show tabulation on some specimens. These differences do not appear great enough, however, to warrant the establishment of a new species.

Dimensions: Observed range (11 specimens measured): endoblast length 50-61u (mean 58u), width 50-60u (mean 54u); periblast length 80-110u (mean 96u), width 52-70u (mean 59u). These dimensions exceed all others previously reported for P. infusorioides.

Stratigraphic distribution: Loc. 1, sparse in sample 171; Loc. 3, rare in sample 158 and extremely rare in sample 163; Loc. 5, extremely rare in sample 154; Loc. 6, extremely rare in sample 122.

Previously-reported occurrences: Cenomanian-Senonian of France (Deflandre, 1934, 1935, 1936, 1937, 1940; Deflandre & Courteville, 1939; Valensi, 1955; Davey, 1970); Cenomanian-Lower Turonian of

Australia (Cookson & Eisenack, 1958); Middle Albian (one specimen)-
 Senonian of Germany (Alberti, 1961); Lower Cenomanian-Santonian of
 England (Cookson & Hughes, 1964; Clarke & Verdier, 1967; Davey, 1970);
 Lower Campanian-Upper Cenomanian of Arctic Canada (Manum & Cookson,
 1964); Cenomanian-Turonian of Roumania (Baltes, 1966); Senonian of
 Australia (Ingram, 1968); Cenomanian of England, France and
 Saskatchewan, Canada (Davey, 1970); Maestrichtian of Texas, USA
 (Zaitzeff & Cross, 1970); Albian-Cenomanian of the Bahamas (Habib,
 1970); Albian of France (Davey & Verdier, 1973).

Genus Palaeoperidinium Deflandre 1934
 ex Sarjeant 1967

Palaeoperidinium pyrophorum (Ehrenberg 1838)
 Sarjeant 1967

Plate 12, fig. 16

- 1838 Peridinium? (Glenodinium?) pyrophorum Ehrenberg: 110, pl. 1,
 figs. 2, 4.
- 1854 Peridinium pyrophorum Ehrenberg: pl. 37, sect. 7, figs. b1-
 b2.
- ?1933 ?Peridinium cf. conicum (Gran) Ostenfeld & Schmidt; O. Wetzel:
 164, pl. 2, fig. 11.
- 1934 Palaeoperidinium pyrophorum (Ehrenberg) Deflandre: 967,
 text-fig. 1.
- 1935 Palaeoperidinium pyrophorum (Ehrenberg) Deflandre; Deflandre:
 27, pl. 6, figs. 5-7.
- 1936a Peridinium conicum (Gran) Ostenfeld & Schmidt; Deflandre: 57,
 text-fig. 96.

- 1936b Peridinium conicum (Gran) Ostenfeld & Schmidt; Deflandre: pl. 4, figs. 4-6.
- 1936b Palaeoperidinium pyrophorum (Ehrenberg) Deflandre; Deflandre: 175.
- 1938 Peridinium pyrophorum (Ehrenberg) Lejeune-Carpentier: 1-9, figs. 1-10.
- 1952 Peridinium pyrophorum (Ehrenberg) Lejeune-Carpentier; W. Wetzel: 407-408, pl. A, fig. 10.
- 1955 Palaeoperidinium pyrophorum (Ehrenberg) Deflandre; W. Wetzel: 39, text-fig. 16.
- 1967 Palaeoperidinium pyrophorum (Ehrenberg) Deflandre; Drugg: 13, pl. 1, figs. 9-11; pl. 9, fig. 1a-1b.
- 1967 Palaeoperidinium pyrophorum (Ehrenberg) Deflandre; Sarjeant: 246-247, text-figs. 1-6.
- 1971 Palaeoperidinium pyrophorum (Ehrenberg) Sarjeant; Wilson: pl. 2, fig. 12.
- ?1972 Palaeoperidinium cf. P. pyrophorum (Ehrenberg) Sarjeant; Benedek: 37-38, pl. 11, fig. 1.
- 1974 Palaeoperidinium pyrophorum (Ehrenberg) Sarjeant; McIntyre: pl. 6, figs. 1-3.
- 1975 Palaeoperidinium pyrophorum (Ehrenberg) Sarjeant; Haskell & Wilson:

Comments: Maryland specimens of Palaeoperidinium pyrophorum appear morphologically identical with Ehrenberg's type specimens as re-described by Lejeune-Carpentier (1938), but are considerably larger (see Dimensions).

Description: Cyst peridinioid in overall outline, dorso-ventrally flattened. Apical horn bluntly terminated, bears plug-like thickening at tip; antapical horns weakly divergent, moderately rounded at tip;

left horn often slightly reduced. No evidence of endoblast. Dorsal plate-equivalents symmetrical about cyst longitudinal axis; ventral plate-equivalents not symmetrical: 1''' smaller and more nearly isodiametric than 5'''. No unequivocal evidence of an archeopyle (see Discussion). Cingulum 4-6u wide, indented, and weakly levorotatory, is vertically offset at sulcus by about one-half cingulum width; margins of cingulum are crenate. Sulcus extends onto epitract, is terminated by convergence of growth zones flanking sulcus; mid-line parallels long axis of cyst. Sulcus widens posteriorly as flanking growth zones diverge. Small longitudinal thickenings are present within sulcus on hypotract. Intratabular polygonal thickenings up to 5u wide form mosaic pattern of areoles.

Discussion: Occasional specimens of Palaeoperidinium pyrophorum exhibit a rupture just anterior to the cingulum. Sarjeant (1967) interpreted this type of rupture as evidence of an epittractal archeopyle; Brideaux (1971) and the present author, however, consider such breaks accidental. Evitt (1975) contends that the archeopyle is transapical. Many Maryland specimens display a thickened line just beyond the anterior and lateral margins of plate-equivalent 2a, within the growth zone; the bounded area, however, is always in place. Davey (1970) noted this possible suture, and also observed the 2a consistently in place. If the archeopyle is indeed intercalary, the 2a must snap back into place following excystment. Many more specimens of P. pyrophorum must be examined before archeopyle formation can be demonstrated conclusively.

Lejeune-Carpentier (1938) stated that P. pyrophorum differs from P. conicum by the pronounced asymmetry of the hypotheca, and by its greater size. W. Wetzel (1952), however, considered specimens of P. conicum to be only somewhat smaller forms of P. pyrophorum; the present author, in concurring with Wetzel, treats P. conicum herein as a junior synonym of P. pyrophorum.

P. basilium was erected by Drugg (1967) for forms displaying tabulation and bearing antapical horns approximately equal in length; P. basilium is also treated herein as a junior synonym of P. pyrophorum.

Dimensions: Observed range (25 specimens measured): length 136-270u (mean 186u), width 104-196u (mean 151u). Ehrenberg's specimens: length 100-138u, width 69-88u.

Stratigraphic distribution: Loc. 1, extremely rare in samples 166 and 168; Loc. 2, extremely rare in sample 165; Loc. 3, extremely rare in sample 156; Loc. 4, extremely rare in samples 159, 160, rare in sample 162; Loc. 5, extremely rare in sample 152 and 153, and rare in sample 154.

Previously-reported occurrences: Senonian of Germany (Ehrenberg, 1838, 1854; Lejeune-Carpentier, 1938; Sarjeant, 1967); Danian and Senonian, Baltic region, Denmark (O. Wetzel, 1933); Senonian of France (Deflandre, 1934, 1935, 1936); Danian of Germany (W. Wetzel, 1952, 1955); Upper Maestrichtian-Lower Danian of California (Drugg, 1967); Upper Maestrichtian-Lower Danian of Denmark (Wilson, 1971); Middle

Oligocene of Germany (Benedek, 1972); Campanian-Maestrichtian of NWT, Canada (McIntyre, 1974).

Genus Spinidinium Cookson & Eisenack 1962b

Spinidinium clavum Harland 1973

Plate 13, figs. 6-9

1973 Spinidinium clavum Harland: 674-675, pl. 84, figs. 5, 6, 10.

Comments: Maryland-Delaware specimens of Spinidinium clavum are similar in size and in morphology to the specimens of Harland (1973). He noted the presence, however, of sutural ridges rather than sutural folds. Moreover, the tabulation he recorded is ?4, 1a, 7'', ?4c, 5-6''', ?2''''; tabulation of the Maryland-Delaware specimens is included in the description below, which adds new information to Harland's description of S. clavum.

Description: Fusiform, bi-layered cyst; epittract longer than hypottract; equatorial section approximately circular. Apical horn square-tipped, bears central pore-like indentation; left antapical horn acuminate-tipped; right antapical horn strongly reduced to absent. Periphragm expands at base of apical horn to form pericoel. Endoblast ovoidal to sub-pentagonal, appressed at periblast except under horns and sutural folds of periphragm. Folds, up to 3u high, outline tabulation of 4', 3a, 7'', ?5c, 5''', 2''''; 1' lozenge-shaped. Distal

edge of a fold may be entire or denticulate; if denticulate, tooth-like expansions are shallow to deeply-incised, up to 1u high. Sutures along cingulum and sulcus may bear coni, up to 1.0u in height and basal diameter, instead of folds. Archeopyle not observed, but occasional ruptures around plate-equivalent 2a indicate that 2a functions as operculum. Cingulum width variable, up to 7u; cingulum levorotatory, vertically separated at sulcus $\frac{1}{2}$ - $1\frac{1}{2}$ cingulum widths. Margins of sulcus, when parallel, extend to posterior margins of cyst between antapical horns; when margins divergent, extend to tip(s) of antapical horn(s). Endophragm and periphragm each ca. 0.5u thick, each laevigate on internal and external surface.

Dimensions: Observed range (35 specimens measured): endoblast length 28-45u (mean 37u), width 26-41u (mean 35u); periblast length 38-67u (mean 53u), width 31-45u (mean 38u).

Stratigraphic distribution: Loc. 2, rare in sample 165; Loc. 4, sparse in sample 162; Loc. 5, rare in sample 151; Loc. 6, extremely rare in sample 123.

Previously-reported occurrence: Upper Campanian of Alberta, Canada (Harland, 1973).

Spinidinium essoii Cookson & Eisenack 1967a

Plate 13, figs. 10-13

1967a Spinidinium essoi Cookson & Eisenack: 135, pl. 19, figs. 1-8.

Comments: Maryland-Delaware specimens of Spinidinium essoi appear identical, in morphology and in size, with the type specimens of Cookson & Eisenack (1967a). Further morphological details, however, can be added at this time.

Description: Bi-layered, dorso-ventrally flattened cyst bearing square-tipped apical horn and acuminate-tipped left antapical horn; right antapical horn expressed by slight inflection of periphragm, or is absent. Overall cyst outline roughly pentagonal to globose. Endoblast not laterally appressed to periblast; wall layers separated by pericoels several microns wide. Endoblast follows outline of periblast, may bulge slightly into bases of horns. Cyst surface bears discrete, tapering spines with either capitate or furcate tips less than 0.5u wide; small size hinders clarification of this point. Spines 1.5-4.0u long, of approximately equal length on a single specimen, may be somewhat longer at site of right antapical horn. Spines peritabular, outlining tabulation of 4', 3a, 7'', ?c, 5''', 2''''; intratabular areas relatively free of spines. Archeopyle intercalary (Type Ia/Ia), corresponds to plate-equivalent 2a, is hexagonal, with alternating long and short margins; operculum remains attached along its broad posterior margin. Cingulum indented, 5.0-8.5u wide, levorotatory, vertically offset at sulcus by about one cingulum width. Sulcus not indented, widens posteriorly. Endophragm and periphragm each ca. 0.5u thick.

Dimensions: Observed range (40 specimens measured): endoblast length 45-76u (mean 64u), width 41-70u (mean 59u); periblast length 60-112u (mean 84u), width 50-79u (mean 69u).

Stratigraphic distribution: Loc. 2, common in sample 165; Loc. 3, sparse in sample 157 and abundant in sample 158; Loc. 4, rare in sample 162; Loc. 6, rare in sample 121 and extremely rare in sample 122.

Previously-reported occurrence: Paleocene of Tasmania (Cookson & Eisenack, 1967a).

Genus Trithyrodinium Drugg 1967

Comments: Trithyrodinium was erected by Drugg (1967) for Deflandrea-like specimens bearing a tripartite operculum in which the three intercalary plate-equivalents function as a unit. Davey (1969) emended Trithyrodinium to include those Deflandrea-like forms in which the archeopyle is formed by the loss of three plate-equivalents, as a unit or separately, from the endophragm, and the loss of the 2a from the periphragm.

Emended description: The same as for Deflandrea Eisenack 1938, except for archeopyle formation: archeopyle formed by loss of plate-equivalent 2a from periphragm and of the three intercalary plate-equivalents from endophragm (Type I/3I), or by loss of the three intercalary plate-equivalents from periphragm and endophragm

(Type 3I/3I). Opercular pieces may be lost as a unit or separately.

Discussion: In this study, several new species of Trithyrodinium are erected and a species of Hexagonifera is transferred to Trithyrodinium.

Trithyrodinium scutulatum n. sp.

Plate 14, figs. 5-6

Derivation of name: scutulatus, L., diamond-shaped, referring to the overall outline of the cyst.

Description: Bi-layered cyst with diamond-shaped overall outline. Apical horn blunt-tipped; left antapical horn acuminate-tipped, right horn, bluntly-rounded, reduced. Epitheca and hypotheca approximately equal in length. Lateral margins of cyst straight to slightly convex. Endoblast spheroidal, ellipsoidal, or ovoidal, is laterally appressed to periblast. Archeopyle intercalary (Type 3I/3I); opercular pieces of endophragm free, approximately similar to one another in size and shape. Plate-equivalents 1a and 3a of periphragm are free; 2a often remains attached along posterior margin. 2a elongate-hexagonal, with alternating long and short sides; anterior corners may be rounded. 1a and 3a, pentagonal to hexagonal, are about $\frac{1}{2}$ as long as 2a. Cingulum marked by low folds of periphragm which may bear aligned grana; cingulum vertically offset at sulcus by about one cingulum length. Sulcus, bordered by aligned grana, is restricted to .

hypotract; sulcus may widen slightly in posterior direction, terminating between antapical horns. A reniform thickening, possibly representing flagellar pore in parent theca, lies slightly to left of sulcal mid-line. External surface of endophragm bears densely-distributed grana up to ca. 0.5u high; in addition, coarse grana, up to ca. 1.0u high, may be present as intratabular fields, outlining tabulation identical with that of Deflandrea. Periphragm and endophragm each ca. 0.5u thick; external surface of endophragm appears laevigate.

Dimensions: Observed range (25 specimens measured): endoblast length 57-82u (mean 65u), width 52-79u (mean 63u); periblast length 106-162u (mean 139u), width 54-90u (mean 69u).

Comparison with similar species: T. scutulatum n. sp. differs from the two pre-existing species of Trithyrodinium by its distinctive overall outline, its relatively great size, and its relatively robust periphragm.

Holotype: Plate 14, fig. 5. VPISUPL sample 117, slide AD 54, coordinates R 4.3, +13.4.

Stratigraphic distribution: Loc. 5, common in sample 151, rare in samples 152 and 153, and extremely rare in sample 154; Loc. 6, extremely rare to abundant throughout the section.

Trithyrodinium diversicomptum n. sp.

Plate 14, figs. 8-10

Derivation of name: diversus, L., different, diverse; comptus, L., ornamented. Refers to the diversity of ornamentation from specimen to specimen.

Description: Bi-layered cyst with rhomboidal overall outline. Endoblast and periblast appressed except at apex and antapex. Apical horn bluntly-rounded at tip, left antapical horn acuminate to bluntly-rounded; right antapical horn, broadly-rounded at tip, is strongly reduced. Archeopyle intercalary (Type 3I/3I), similar in both wall layers. Plate-equivalent 2a is largest of the three, is hexagonal, with alternating long and short sides; 1a and 3a are similar to one another, pentagonal, nearly equilateral. Double rows of coarse grana or low folds of periphragm visible only at cyst lateral margins, may lie along margins of cingulum. Cingulum is 6-8u wide, levorotatory, separated vertically at sulcus by 1-1½ cingulum widths. Sulcus is weakly-indented, may bear aligned grana. Exterior surface of endophragm bears densely-distributed fine grana; also present may be coarser grana up to 0.5u high and pustular thickenings up to 1.5u in diameter, or filmy strands up to 3.0u long. Periphragm may bear a few fine grana scattered over exterior surface; rarely, intratabular field of grana outlines plate-equivalent 1'. Endophragm is 1.0-2.0u thick; periphragm, ca. 0.5u thick, is often completely ripped away.

Dimensions: Observed range (13 intact specimens measured): endoblast length 52-68u (mean 60u), width 49-68u (mean 58u); periblast length 81-106u (mean 95u), width 55-74u (mean 62u).

Comparison with similar species: T. diversicomptum n. sp. most closely resembles T. vermiculatum n. comb. in size, in the shape of the endoblast and periblast, and in the hyaline nature of the periphragm; T. vermiculatum, however, bears vermiculate thickenings on the external surface of the endophragm, rather than the type of ornamentation just described for T. diversicomptum.

Holotype: Plate 14, fig. 8. VPISUPL sample 120, slide AD 59, coords. R 4.7, +3.8.

Stratigraphic distribution: Loc. 5, extremely rare in sample 152; Loc. 6, rare in sample 116, extremely rare in samples 117-119, common in sample 120, sparse in sample 121, common in sample 122, and sparse in sample 123.

Trithyrodinium membranophorum n. sp.

Plate 14, figs. 11-12

Derivation of name: membranophorum, L., membrane-bearing, referring to the delicate, filmy periphragm.

Description: Bi-layered cyst, dorso-ventrally flattened, with rhomboidal outline. Apical horn square-tipped, corners rounded; antapical horns have rounded tips; right antapical horn greatly reduced. Archeopyle intercalary (Type 3I/3I). Plate-equivalent 2a hexagonal with alternating long and short sides: 1a and 3a are parallel-sided polygons with gabled anterior margins. Both wall layers appear to be involved in archeopyle formation. Cingulum and sulcus, when present, are expressed by broad folds of periphragm; sulcus weakly indented, margins parallel. Endophragm ca. 0.5u thick, external surface finely granulose; periphragm delicate, membranous, less than 0.5u thick. Periphragm usually ripped completely away from endophragm; when present, is appressed to endophragm except at tips of horns.

Dimensions: Periblast length 73-77u, width 51-54u (3 intact specimens measured). Endoblast length 56-87u (mean 70u), width 51-64u (mean 56u) (30 specimens measured).

Comparison with similar species: The membranous periphragm and its appression to the endophragm distinguish T. membranophorum from previously-described species of Trithyrodinium.

Holotype: Plate 14, fig. 11. VPISUPL sample 151, slide AE 52, coords. R 9.0, +10.2.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166, sparse in sample 167, and extremely rare in sample 170; Loc. 2,

extremely rare in sample 164; Loc. 3, extremely rare in samples 156 and 163; Loc. 4, extremely rare in sample 161; Loc. 5, extremely rare in sample 151, rare in sample 153, and extremely rare in samples 154 and 155.

Trithyrodinium vermiculatum
(Cookson & Eisenack 1961a) n. comb.

Plate 14, fig. 7

1961a Hexagonifera vermiculata Cookson & Eisenack: 74, pl. 12, figs. 6-8.

Description: Bi-layered cyst, rhomboidal in dorso-ventral outline, bearing hyaline periphragm drawn into apical horn and convergent antapical horns. Apical horn and left antapical horn bluntly-rounded at tip; right antapical horn strongly rounded at tip, reduced. Archeopyle intercalary (Type ?3I/3I); opercular pieces of endophragm and periphragm appear similar in size and shape. Plate-equivalent 2a hexagonal with alternating long and short sides; 1a and 3a pentagonal, with two short sides forming posterior margin. Opercular pieces lost separately. Cingulum may be indicated at lateral margins of cyst by low folds of periphragm; sulcus not expressed. Periphragm ca. 0.25u thick, often partially or completely ripped away. External surface laevigate or finely granulose. Endoblast robust, spheroidal, laterally appressed to periblast; endophragm 2.5-4.5u thick, external surface covered with coarse vermiculate thickenings.

Dimensions: Observed range (6 entire specimens measured): endoblast length 49-80u, width 49-63u; periblast length 75-99u, width 57-68u.

Stratigraphic distribution: Loc. 6, rare in samples 116-121, extremely rare in samples 122, 123.

Previously-reported occurrence: ?Senonian of Victoria, Australia (Cookson & Eisenack, 1961a).

Genus Wetzeliella Eisenack 1938

Subgenus Wetzeliella Alberti 1961

Wetzeliella (Wetzeliella) homomorpha
Deflandre & Cookson 1955

Plate 14, figs. 1-4

- 1948 Hystrichosphaeridium geometricum Pastiels (pars): 41, pl. 4, fig. 8; non H. geometricum Deflandre 1942.
- 1953 Hystrichosphaeridium geometricum Pastiels; Cookson: 116-117, pl. 2, fig. 25.
- 1955 Wetzeliella homomorpha Deflandre & Cookson: 254, pl. 5, fig. 7; text-figs. 17-18.
- 1965 Wetzeliella homomorpha Deflandre & Cookson; De Coninck: 14-15, pl. 2, figs. 1-2, 5-6, 8-9, 14; text-fig. 2.
- 1966 Wetzeliella (Wetzeliella) homomorpha Deflandre & Cookson; Morgenroth: 10, pl. 1, figs. 8-9.
- 1966a Wetzeliella (Wetzeliella) ovalis Eisenack; Williams & Downie in Davey et al.: 192-193, pl. 18, fig. 10.
- 1967a Wetzeliella homomorpha Deflandre & Cookson; Cookson & Eisenack: 133, pl. 17, figs. 5-6.

- 1967b Wetzeliella homomorpha Deflandre & Cookson; Wilson: 479,
figs. 26-28.
- 1969 Wetzeliella homomorpha Deflandre & Cookson; De Coninck: 20,
pl. 3, figs. 3-6.

Comments: The variability of W. (W.) homomorpha in overall shape and process type has been noted by previous workers. The overall outline may be ovoidal, rhomboidal, or distinctly pentagonal. Williams & Downie (1966a), in an attempt to deal with the great intraspecific variation, grouped the pentagonal forms into W. (W.) homomorpha var. quinquelata; their oval forms were assigned to W. (W.) ovalis Eisenack 1954. Since all intermediate forms exist between pentagonal forms and round ones, however, one species name should encompass all forms; an attempt to allocate such variants to separate varieties or even separate species constitutes a strictly artificial taxonomic treatment.

Description: On sub-pentagonal forms, apical horn prominent, square-tipped, bears small process at each distal corner. Left antapical horn stocky, square-tipped, bearing several processes, or slender and acuminate-tipped, bearing one long process directed posteriorly. Right antapical horn greatly reduced, acuminate-tipped. Endoblast bulges into bases of horns. Lateral horns, only rarely present, expressed as slight expansions of periphragm at cingulum. On more rounded, intermediate forms, only apical and left antapical horns consistently present; right antapical horn may be present. Ovoidal forms closely resemble Eisenack's W. (W.) ovalis (his pl. 8, fig. 6),

in bearing apical horn and left antapical horn. On spheroidal forms, all horns suppressed.

Archeopyle intercalary (Type I/I), trapezoidal with rounded corners, corresponds to plate-equivalent 2a; operculum simple, free. Endoblast not appressed to periblast laterally; pericoels a few microns wide separate wall layers. Processes 3-10u long; 1.0-2.5u wide along shaft, broader at base, they taper slightly before terminating distally; process tips aculeate. Processes open proximally; broader ones open along entire length, narrow ones closed distally. Processes, concentrated around periphery of cyst, commonly united into linear complexes, with bases of adjacent processes confluent. Linear complexes also lie along margins of cingulum and along plate-equivalent boundaries. Intratabular processes solitary. Intratabular areas of plate-equivalents 3'' and 4'' relatively process-free. Endophragm and periphragm each ca. 0.5u thick.

Dimensions: Observed range (26 specimens measured): endoblast length 42-73u (mean 57u), width 42-66u (mean 53u); periblast length 64-94u (mean 78u), width 55-76u (mean 68u).

Stratigraphic distribution: Loc. 2, rare in sample 165; Loc. 4, rare in sample 162.

Previously-reported occurrences: Ypresian of Belgium (Pastiels, 1948; De Coninck, 1965, 1969); ?Oligocene of Victoria, Australia (Cookson, 1953); Upper Paleocene or Lower Eocene of Victoria, Australia

(Deflandre & Cookson, 1955); Lower Eocene of Germany and Belgium (Morgenroth, 1966); Eocene of England (Williams & Downie, 1966a); Upper Paleocene of Tasmania (Cookson & Eisenack, 1967a); Paleocene of New Zealand (Wilson, 1967b).

Family UNCERTAIN

Genus Areoligera Lejeune-Carpentier 1938
emend. Williams & Downie 1966c

Areoligera cassicula Drugg 1970

Plate 15, fig. 1

1970 Areoligera cassicula Drugg: 811, figs. 2B, 3A-B.

Comments: Monmouth specimens of Areoligera cassicula appear identical with those of Drugg (1970). Accessory archeopyle sutures are commonly present, as well as a prominent sulcal notch. The left antapical lobe is more strongly-developed than the right.

Dimensions: Observed range (5 specimens measured): main body length (archeopyle margin to antapex) 58-67u, width 60-70u; overall length (measured from archeopyle margin) 67-93u, width 74-104u.

Stratigraphic distribution: Loc. 5, extremely rare in samples 151, 152, and 154.

Previously-reported occurrence: Lower Eocene of Alabama (Drugg, 1970).

Areoligera senonensis Lejeune-Carpentier 1938

Plate 15, fig. 2

- 1938 Areoligera senonensis Lejeune-Carpentier: B164-B166, figs. 1-3.
- ?1965 Areoligera cf. senonensis Lejeune-Carpentier; Stanley: 228, pl. 26, figs. 1-8.
- 1969 Areoligera senonensis Lejeune-Carpentier; Gocht: 56-58, pl. 8, figs. 4-9; text-figs. 40-41.

Comments: Because of the variability within Areoligera senonensis reported by previous authors, a description of the Maryland specimens is given below.

Description: Maryland specimens of A. senonensis bear hemispherical to lobed dorso-ventral outline; when two lobes present, left one is more strongly developed. Low, annulate ridges on cyst surface bear slender, discrete processes; process tips bifid. Neighboring processes may be connected by trabeculae, but more frequently, fuse into perforate, blade-like structures, leaving process tips free. Processes and ridges outline tabulation of 4', 0a, 6'', 6c?, 5''', 1p, 1''''; a posterior sulcal process may also be present. Ventral processes weakly-expressed to absent. Archeopyle apical (Type \bar{A}), with simple, free operculum. Archeopyle margin strongly angular,

bearing accessory archeopyle sutures and deeply-incised sulcal notch. Cyst apparently bi-layered, with endophragm and periphragm each ca. 0.5u thick; external surface of periphragm microreticulate.

Discussion: While the Maryland specimens bear only annulate ridges, the specimens of Lejeune-Carpentier and of Gocht bear annulate to soleate ridges. Process tips of the Maryland specimens are bifid, like those of Gocht's specimens; process tips of Lejeune-Carpentier's specimens are acuminate. Ventral processes are weakly-expressed to absent, like those of Lejeune-Carpentier's specimens; these processes are well-developed on Gocht's specimens.

An occasional Maryland specimen which displays relatively short processes appears identical with a specimen illustrated by Lejeune-Carpentier (1938, fig. 1); Gocht made no mention of such a variant among his specimens.

Dimensions: Observed range (30 specimens measured) (opercula are missing; length is measured from archeopyle margin to antapex): main body length 49-67u (mean 58u), width 54-74u (mean 62u); overall length 64-91u (mean 76u), width 80-113u (mean 94u).

Stratigraphic distribution: Loc. 1, extremely rare in samples 166 and 168, abundant in samples 169-171; Loc. 2, abundant in sample 164; Loc. 3, abundant in sample 163; Loc. 4, extremely rare in sample 159; Loc. 5, rare in sample 151, abundant in sample 152, extremely rare in sample 153, abundant in sample 154, and rare in sample 155.

Previously-reported occurrences: Senonian of Belgium (Lejeune-Carpentier, 1938); Paleocene of South Dakota (Stanley, 1965); Paleocene, Lower Eocene, and Middle Oligocene of Germany (Gocht, 1969).

Areoligera sp.

Plate 15, figs. 3-6

Comments: Specimens of Areoligera in this study not assignable to A. cassicula or A. senonensis belong to a morphologically variable complex to which no specific name can be assigned at this time.

Description: Cyst main body hemispherical or bilobed in dorso-ventral outline; when two lobes present, left one more strongly-developed. Dorsal surface convex outward, ventral surface, planar. Cyst surface bears soleate process complexes: a low curved ridge bearing slender processes comprises each complex; pre- and post-cingular complexes open toward cingulum. Processes of approximately equal length on single specimen. Complexes developed to varying degree from specimen to specimen. On some specimens ridges well-developed on dorsal surface and on plate-equivalent 6''; processes discrete; occasionally adjacent processes are joined distally by trabeculae. Other specimens bear weakly-developed ridges on dorsal surface and none on central area of ventral surface; processes commonly joined distally by elaborate network of trabeculae. Soleate process complexes outline tabulation of 4', 0a, 6'', 6c?, 5''', 1p, 1''''; posterior sulcal process may be present.

Archeopyle margin strongly angular; sulcal notch deeply-incised. Accessory archeopyle sutures may be developed between post-cingular plate-equivalents. Cingulum may be marked by discontinuous linear ridge sections bearing discrete processes. Sulcus marked by sulcal notch and posterior sulcal process. Cyst wall apparently single-layered, ca. 1.0 μ thick, with microreticulate exterior surface.

Discussion: McLean (1969) and Witmer (1975) concluded that morphological variants of Areoligera sp. appear to be restricted to particular environments. In strata believed by Nogan (1964) to represent conditions of less-than-normal marine salinity, McLean and Witmer encountered variants with large process-free areas on the ventral surface; trabeculae are present. Higher in their sections, under what Nogan postulates are more nearly normal marine conditions, most specimens have relatively small process-free areas on the ventral surface, and they lack trabeculae.

Monmouth specimens of Areoligera sp. typically have large process-free areas on the ventral surface, and the dorsal processes may be weakly-developed; trabeculae are commonly present. Typical Brightseat specimens of Areoligera sp. bear well-developed soleate process complexes, with a 6'' process complex commonly present; trabeculae are rare. According to the findings of McLean (1969) and Witmer (1975), the Monmouth would represent conditions of less-than-normal marine salinity, whereas the Brightseat would represent conditions of normal marine salinity.

Dimensions: Observed range (30 specimens measured): main body length 58-110u (opercula missing; length measured from archeopyle margin to antapex); width 64-117u (mean 83u). Overall length 75-142u (mean 101u); width 83-156 (mean 117u).

Stratigraphic distribution: Loc. 2, abundant in sample 165; Loc. 3, sparse in sample 157 and rare in sample 158; Loc. 4, abundant in samples 161-162.

Genus Canningia Cookson & Eisenack 1960b

Canningia hirta n. sp.

Plate 16, figs. 19-20

Derivation of name: Hirtus, L., hairy, shaggy; refers to the numerous long, slender processes.

Description: Cyst main body hemispherical in dorso-ventral outline, may bear bluntly-rounded antapical lobes developed to varying degree from specimen to specimen; when lobes present, left one is the larger. Apical lobe present, is more nearly pointed than antapical lobes. Cyst strongly flattened dorso-ventrally. Numerous slender, tapering processes are randomly distributed over cyst surface, but sulcal area relatively process-free. Processes slightly fibrous, solid, discrete; rarely, adjacent processes coalesce at bases. Occasionally, processes in antapical region bear distal trabeculae. Process tips are bifid;

terminations are normal to shaft or slightly oblique. No trace of cingulum or tabulation. Archeopyle apical (Type \bar{A}), with simple, free operculum; dorsal margin of archeopyle nearly straight, ventral margin is incised by sulcal notch. Cyst wall apparently single-layered, 0.5-1.0u thick; external surface microreticulate.

Dimensions: Observed range (30 specimens measured): main body length (archeopyle margin to antapex) 58-110u, width 64-113u; process length 14-23u. Two complete specimens: main body length 116u, 122u; width 104u, 106u. Overall length 142u, 157u; width 131u.

Comparison with similar species: C. hirta most closely resembles C. hirtella in the overall cyst outline and in the numerous, slender processes; the processes of C. hirtella, however, are only 3-4u long.

Holotype: Plate 16, fig. 19. VPISUPL sample 157, slide AF 16, coords. R19.7, 12.3.

Stratigraphic distribution: Loc. 3, sparse in sample 157; Loc. 4, rare in sample 162.

Genus Ceratocorys Stein 1883

Ceratocorys veligera Lejeune-Carpentier 1944

Plate 15, fig. 15-17

1937 Microhystridium veligerum Deflandre: 24, pl. 12, fig. 9.

- 1944 Ceratocorys veligera (Deflandre) Lejeune-Carpentier: 22, text-figs. 1-6.
- 1952a Ceratocorys veligera (Deflandre) Lejeune-Carpentier; Deflandre: 120, text-fig. 102.
- 1952b Ceratocorys veligera (Deflandre) Lejeune-Carpentier; Deflandre: text-figs. 304 A-C.
- 1967 Eisenackia crassitabulata Deflandre & Cookson; Clarke & Verdier: 64, pl. 8, figs. 4-6.
- 1967 Ceratocorys veligera (Deflandre) Lejeune-Carpentier; Vozzhennikova: 92, pl. 35, figs. 1-5; pl. 36, fig. 3.

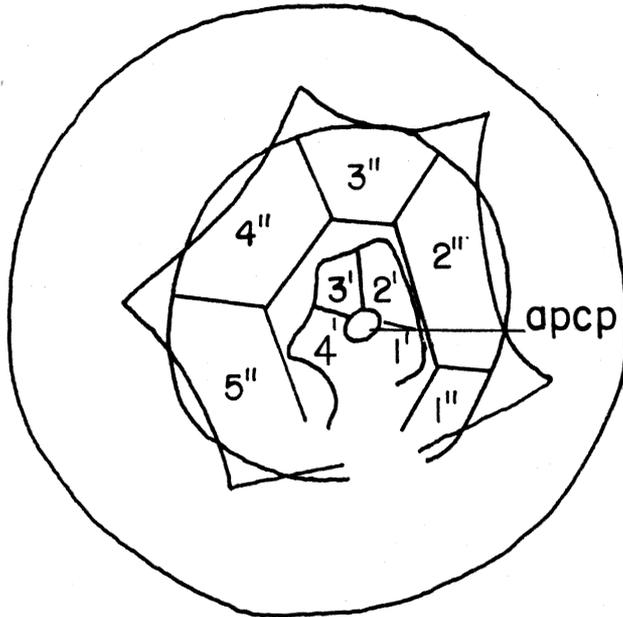
Description: On Ceratocorys veligera the alary projections, or sutural lists, alternate with the post-cingular plate-equivalents. On Maryland-Delaware specimens, adjacent lists may curve around distally toward one another, but do not meet. Archeopyle is apical, attached ventrally (Type Aa). Anterior margins of precingular plate-equivalents are straight, not gabled. Sutures between pre-cingulars lie in line with peaked expansions of cingular list. Tabulation is 4', 0a, 5'', 6c?, 6''', 1p, 1'''' (see Discussion). Endophragm is ca. 0.3u thick, periphragm, ca. 0.5u; wall layers are appressed except under sutural lists. External surface of periphragm between lists bears isolated bacula up to 0.5u high. Lists are externally laevigate; their distal margins may be denticulate.

Discussion: On Lejeune-Carpentier's specimens also, the lists alternating with the post-cingular plate-equivalents curve around distally, but adjacent lists meet. Consequently, these plate-equivalents are bordered on three sides by lists. (The posterior margin of the

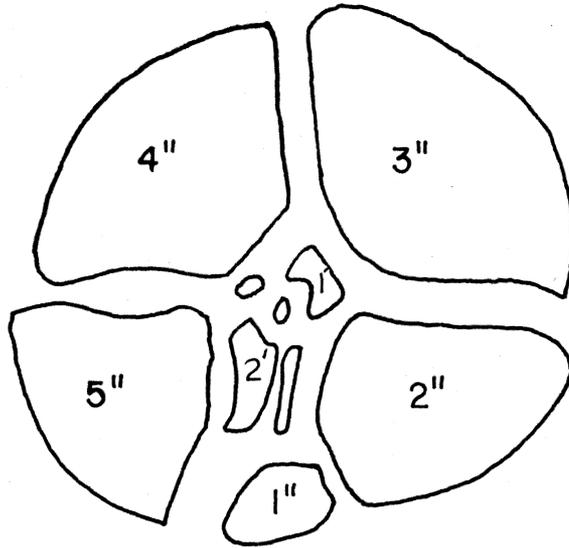
cingulum lacks a list.) The Belgian specimens bear a variety of ornamentation, including areoles and dense spines.

While apical details of the Maryland-Delaware specimens are not completely clear, there appear to be four apical plate-equivalents and an apical pore closing platlet (apcp), centrally located; each apical plate-equivalent is in contact with the apcp. The apex of the modern Ceratocorys, as described by Graham (1942), is somewhat different: four plate-equivalents surround the apcp, but only two are in contact with it (Text-fig. 15, p. 213); these two plate-equivalents are considered the 1' and 2' by Graham. He designates the two plate-equivalents not in contact with the apcp the 1a and 2a. Further comparisons should be made of the apices of fossil and modern cysts of Ceratocorys. It may be that the separation of two opposing epittractal plate-equivalents from the apcp occurs on only variant specimens. If the separation is a constant feature, it may represent an evolutionary modification of forms on which all four epittractal plate-equivalents are in contact with the apcp, and all four are designated apical plate-equivalents. If such an evolutionary modification is indeed the case, the four plate-equivalents of the modern Ceratocorys should likewise be considered apical plate-equivalents. Studies of Tertiary specimens of Ceratocorys should aid in resolving this problem.

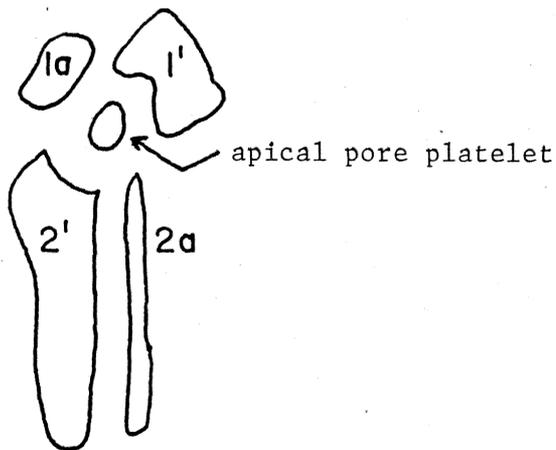
Davey's transfer of C. veligera to Microdinium is herein rejected because of considerable differences in tabulation between the two genera.



Text-fig. 14. Apical view of *Ceratocorys veligera*, showing plate-equivalents 1' - 4' surrounding, and in contact with, the circular, centrally-located apical pore closing plate (apcp).



Text-fig. 15. a. Expanded apical view of the modern Ceratocorys horrida Stein (after Graham, 1942).



b. Enlarged view of apex of C. horrida; plate-equivalents 1' - 2' and 1a - 2a surround circular, centrally-located plate-equivalent, which is in contact with only 1' and 2', according to Graham (1942). (See Discussion.)

Dimensions: Observed range (11 specimens measured): main body length 27-44u (mean 33u), width 24-38u (mean 29u); overall length 32-54u (mean 39u); width 29-44u (mean 36u).

Stratigraphic distribution: Loc. 5, extremely rare in sample 151; Loc. 6, rare in samples 116 and 122.

Previously-reported occurrences: Senonian of France (Deflandre, 1937 and 1952); Senonian of Belgium (Lejeune-Carpentier, 1944); Upper Cretaceous of England (Clarke & Verdier, 1967); Upper Cretaceous of the USSR (Vozzhennikova, 1967); Cenomanian of England and France (Davey, 1969).

Genus Chlamydophorella Cookson & Eisenack 1958

Chlamydophorella urna Cookson & Eisenack 1960a

Plate 15, figs. 18-20; Plate 16, fig. 1

1960 Chlamydophorella urna Cookson & Eisenack: 10, pl. 3, fig. 7.

1961 Chlamydophorella urna Cookson & Eisenack; Eisenack: pl. 36, fig. 12.

Comments: The following description of Chlamydophorella urna offers information supplemental to the original description of Cookson & Eisenack (1960).

Description: Cyst bi-layered, spheroidal to ovoidal. Epittract considerably smaller than hypottract. Bacula extend outward radially from base of endophragm, extending beyond endophragm by ca. 1.0u; distal tips of bacula support membranous periphragm. Bacula in plan view are circular, elliptical, or occasionally vermiform; all types may be present on a single specimen. Cingulum may be expressed by low, distally rounded folds of periphragm, may be apparent only at lateral margins of cyst; bacula may be longer under folds. No indication of sulcus. Archeopyle apical, attached ventrally (Type $\bar{A}a$); operculum is lid-like, sub-circular to sub-hexagonal. Accessory archeopyle sutures may lie between pre-cingular plate-equivalents, indicating possible total of six; no direct evidence of tabulation apparent. Endophragm relatively thick, ca. 0.75u; periphragm ca. 0.5u thick.

Discussion: The specimens of Cookson & Eisenack (1968) range from "oval to slightly angular in outline." The Maryland-Delaware specimens are almost exclusively oval (spheroidal to ovoidal); only one specimen is angular, with epittractal lateral margins straight rather than convex outward. Such variation in overall cyst shape, however, is considered herein to be well within acceptable limits for the species.

Dimensions: Observed range (30 specimens measured): endoblast length 23-35u (mean 30u), width 23-35u (mean 28u); periblast length 26-39u (mean 33u), width 26-38u (mean 31u).

Stratigraphic distribution: Loc. 1, extremely rare in samples 166 and 167, rare in sample 168, and extremely rare in sample 170; Loc. 2,

extremely rare in samples 164 and 165; Loc. 3, rare in sample 158; Loc. 4, extremely rare in sample 160, rare in sample 162; Loc. 5, rare in sample 151, extremely rare in sample 152, rare in samples 153 and 155, extremely rare in sample 156; Loc. 6, extremely rare in samples 116 and 117, rare in samples 118 and 122, and extremely rare in sample 124.

Previously-reported occurrences: Albian-Cenomanian of Western Australia (Cookson & Eisenack, 1960); Upper Cretaceous of Western Australia (Eisenack, 1961).

Fibradinium annetorpense Morgenroth 1968

Plate 16, figs. 2-6

1968 Fibradinium annetorpense Morgenroth: 538-539, pl. 42, figs. 4-7.

Comments: Fibradinium annetorpense is being formally redescribed by McLean (VPI & SU) as a species of Microdinium; in the meantime, the epithet Fibradinium is used in this study for convenience.

The Maryland-Delaware specimens are somewhat larger than the specimens of Morgenroth (see Dimensions).

Description: Cyst ellipsoidal, bi-layered; hypotract longer than epittract. Sutural folds of periphragm, 1.5-4.0 μ high, outline tabulation of 4', 4a, 7'', 6c + tr., 6''', 1p, 1''''; in addition, anterior sulcal plate (AS) and sulcal platelet present. Plate-equivalent 7''

and AS lie above transitional plate (tr.) and sulcal platelet (see Text-fig. 18, p. 236 of this study for interpretation of these plate-equivalents in Microdinium setosum). Archeopyle apical with operculum attached ventrally (Type A1a); apical and anterior intercalary plate-equivalents lie on operculum. Cingulum approximately circular; sulcus narrow at cingulum but widens markedly in posterior direction. Endophragm ca. 1.0u thick; periphragm, ca. 0.5u thick, externally granulose.

Dimensions: Observed range (25 specimens measured): main body length (without sutural folds) 29-40u (mean 33u), width 26-35u (mean 30u); overall length 33-46u (mean 38u), width 28-44u (mean 35u). Morgenroth's specimens: overall length 28-34u, width 22-31u.

Stratigraphic distribution: Loc. 2, extremely rare in sample 165; Loc. 3, rare in sample 158; Loc. 4, extremely rare in sample 162; Loc. 5, extremely rare in samples 151, 153-155; Loc. 6, extremely rare in samples 116, 118, 122, 124, and 126.

Previously-reported occurrence: Danian of Germany (Morgenroth, 1968).

Forma A

Plate 16, figs. 7-9

Description: Cyst bi-layered, ellipsoidal, with hypotract longer than epittract. Sutural ridges of the endophragm outline tabulation of '?',

?a, ?'', 6c, 5''', 1p, 1'''''. Ridges ca. 0.75-1.5u wide, up to 5u high; they flare distally, support periphragm. Ridges most prominent in gonal positions. Single pillars or a ridge section occupy center of each plate-equivalent, producing circular or straight to curved trace, respectively, on surface of periphragm. Archeopyle apical with operculum attached ventrally (Type Aa or $\overline{A}1a$, if intercalaries present); construction details of operculum unclear. Cingulum 9-10u wide, approximately circular; sulcus poorly-defined. Endophragm ca. 1.0u thick, periphragm, ca. 0.5u; each wall layer continuous except at archeopyle, and each appears externally laevigate.

Dimensions: Observed range (12 specimens measured): endoblast length 29-41u, width 28-43u; periblast length 32-44u, width 33-38u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 5, rare in sample 151, extremely rare in samples 153 and 154.

Genus Heterodinium n. gen.

Derivation of name: Heteros, Gr., different, referring to the disparity in size between epitract and hypotract.

Description: Cyst bi-layered, ellipsoidal to spheroidal, lacking horns or processes. Epitract much smaller than hypotract. Tabulation reflected by low peritabular folds of endophragm; gonal pillars support periphragm; periblast envelops endoblast as membrane which is continuous

except at archeopyle. Archeopyle apical (Type $\bar{A}a$), with operculum attached ventrally by narrow isthmus. Cingulum is weakly levorotatory; sulcus widens posteriorly.

Type species: Heterodinium intervallum, n. sp.

Other species: None.

Discussion and comparison with similar genera: In size, overall shape, and in the possession of an apical, attached operculum, Heterodinium resembles Microdinium, Histiocysta, and Chlamydothorella. The tabulation of Microdinium and Histiocysta, however, is outlined by sutural, rather than peritabular, structures: sutural folds of the periphragm in Microdinium, and sutural ridges of the endophragm in Histiocysta. Chlamydothorella possesses bacula, whereas Heterodinium has none.

Heterodinium intervallum, n. sp.

Plate 16, figs. 10-13

Derivation of name: intervallum, L., open space between palisades, referring to the sutural areas between peritabular ridges.

Description: Ellipsoidal to spheroidal bi-layered cyst lacking horns or processes. Low, peritabular ridges formed from endophragm indicate tabulation of 1', 5', 6c, 6'', 1p, 1'''. Plate-equivalents 2''-5'' trapezoidal, 1'' triangular; cingular plate-equivalents are rectangular, post-cingulars elongate, quadrilateral. Gonal pillars,

1.0-2.5u high, support periphragm. Archeopyle apical with operculum attached ventrally (Type $\bar{A}a$); margin irregularly angular to rounded. Cingulum weakly levorotatory. Sulcus delineated by ellipsoidal, ridge-bordered areas aligned end-to-end (Pl. 16, fig. 12); platelet at top of sulcus at level of cingulum may be anterior sulcal platelet. Sulcus widens posteriorly; posterior margin broadly V-shaped. Left posterior margin of sulcus lies adjacent to plate-equivalent l''', right margin, adjacent to lp. Endophragm and periphragm each ca. 0.5u thick, externally laevigate, and continuous except at archeopyle.

Dimensions: Observed range (16 specimens measured): main body (without ridges) length 22-38u (mean 30u), width 25-32u (mean 28u); overall length 26-42u (mean 35u), width 26-38u (mean 32u).

Discussion and comparison with similar species: Occasionally a peritabular ridge is breached by perforations, so that isolated rods simulate a string of beads in plan view; the same occurrence has been reported for Microdinium ornatum (Cookson & Eisenack, 1960a, p. 7).

The combination of endophragmal ridges and their peritabular disposition distinguish H. intervallum from all other previously-described species.

Holotype: Plate 16, fig. 10; VPISUPL sample 122, slide AD 69, coords. R15.7, +6.4.

Stratigraphic distribution: Loc. 5, extremely rare in sample 151; Loc. 6, rare in sample 122, extremely rare in sample 123.

Genus Hexagonifera Cookson & Eisenack 1961
emend. Cookson & Eisenack 1962b

Hexagonifera chlamydata Cookson & Eisenack 1962b

Plate 16, figs. 17-18

- 1962b Hexagonifera chlamydata Cookson & Eisenack: 496, pl. 7,
figs. 1-3, 5-8.
- 1964 Hexagonifera chlamydata Cookson & Eisenack; Cookson & Hughes:
53-54, pl. 10, figs. 7-9.
- 1967 Hexagonifera chlamydata Cookson & Eisenack; Baltes: 332,
pl. 1, figs. 28-36.
- 1967 Hexagonifera chlamydata Cookson & Eisenack; Clarke & Verdier:
69-70, pl. 11, figs. 6-8.
- 1970 Hexagonifera chlamydata Cookson & Eisenack; Davey: 349, pl. 3,
figs. 3, 9, 10.
- 1971 Hexagonifera chlamydata Cookson & Eisenack; Wilson: pl. 4,
fig. 8.
- 1974 Hexagonifera chlamydata Cookson & Eisenack; McIntyre: pl. 11,
figs. 7-9.

Description: Main body thick-walled, elongate-ovoidal, enveloped by hyaline periblast; no point of attachment between wall layers observed. Archeopyle apical with simple, attached operculum (Type $\bar{A}a$), operculum, similar in both wall layers, attached ventrally by narrow isthmus, is ellipsoidal to sub-hexagonal. Tabulation not expressed, though weak folds of periphragm may lie along cingulum margins. Endophragm 2.0-2.5u thick, externally bears coarse grana; periphragm, ca. 0.5u thick, may externally bear a few coarse grana.

Discussion: Previous workers have reported a variety of ornamentation for Hexagonifera chlamydata, from granulose to verrucose, to even reticulate. Clarke & Verdier (1967), as well as Davey (1970), noted the presence of an apical prominence formed from the periphragm, but this prominence is lacking on the Maryland-Delaware specimens.

The Maryland-Delaware specimens are considerably smaller than the Australian ones. (see Dimensions), but at the upper end of their size range, overlap the lower end for Davey's specimens.

Dimensions: Observed range (16 specimens measured): main body length 32-44u (mean 37u), width 26-40u (mean 31u); overall length 35-52u (mean 42u), width 31-46u (mean 37u). Australian specimens: overall length 68-75u, width 42-64u.

Stratigraphic distribution: Loc. 5, rare in sample 151 and extremely rare in sample 153; Loc. 6, extremely rare in samples 116 and 118.

Previously-reported occurrences: ?Upper Albian-Cenomanian of Australia (Cookson & Eisenack, 1962); Lower Cenomanian of England (Cookson & Hughes, 1964); Turonian and Senonian of England (Clarke & Verdier, 1967); Cenomanian of England and France, Lower Cenomanian of Saskatchewan, Canada (Davey, 1969); Lower Cenomanian of Roumania (Baltes, 1967); Maestrichtian of Denmark (Wilson, 1971); Santonian-Maestrichtian of NWT, Canada (McIntyre, 1974).

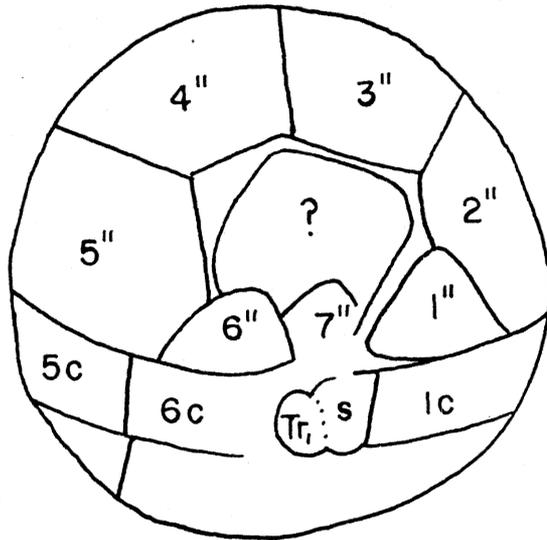
Genus Histiocysta Davey 1969a

Histiocysta palla Davey 1969a

Plate 16, figs. 14-16

- 1939 Microhystridium sp.? Deflandre & Courteville: pl. 3, fig. 4.
 1969a Histiocysta palla Davey: 138-140, pl. 1, figs. 5-6; text-
 figs. 14A, B.
 1971 Histiocysta palla Davey; Davey & Verdier: 21, pl. 3, figs. 7, 9.

Description: Cyst bi-layered, ellipsoidal. Sutural ridges of endophragm support periphragm; ridges outline tabulation of ?', ?a, 7'', 6c + transition plate (tr.), 6''', lp, ''''; sulcal platelet (s) is also present. Plate-equivalents 2''-5''' trapezoidal, with straight, not gabled, anterior margins; 1'', 6'', and 7'' relatively smaller, triangular; 7'' lies in line with sulcus, above transition plate and the sulcal platelet (text-fig. 16). Post-cingular plate-equivalents quadrilateral, larger than pre-cingulars; 1'''' hexagonal. Ridges formed from endophragm also extend intratabularly as vermiculae. Archeopyle apical with attached operculum (Type $\bar{A}a$), essentially hexagonal in outline. Cingulum weakly levorotatory, separated vertically at sulcus by about one-half cingulum width. Sulcus widens posteriorly, bears broadly V-shaped posterior margin; left posterior margin borders 1''''', right margin borders lp. Endophragm and periphragm each ca. 0.5u thick, sutural and ornamental folds of endophragm, ca. 1.0u high.



Text-fig. 16. Oblique apical view of Histiocysta palla, displaying a postulated seven pre-cingular plate-equivalents, with a transitional plate-equivalent (Tr.) and a sulcal platelet (s) lying below the 7'.

Dimensions: Observed range (2 specimens measured): main body length 29u, width 23u, 26u; overall length 32u, 40u, width 26u, 31u.

Stratigraphic distribution: Loc. 5, extremely rare in sample 151.

Previously-reported occurrences: Senonian of France (Deflandre & Courteville, 1939); Cenomanian of England and France (Davey, 1969a); Albian of France (Davey & Verdier, 1971).

Genus Horologinella Cookson & Eisenack 1962a

Horologinella apiculata Cookson & Eisenack 1962a

Plate 17, fig. 9

- 1962 Horologinella apiculata Cookson & Eisenack: 272, pl. 37, fig. 4.
 1967 Horologinella apiculata Cookson & Eisenack; Wilson: 229, fig. 17.
 1974 Horologinella apiculata Cookson & Eisenack; McIntyre: pl. 8, fig. 12.

Comments: Cookson & Eisenack (1962) made no mention of the presence of a second wall layer; endamaged Maryland-Delaware specimens have a membranous periphragm which follows the general outline of the endophragm. The wall layers are appressed along the lateral margins of the cyst, which are weakly to strongly concave.

Dimensions: Observed range (30 specimens measured): Endoblast length 17-26u (mean 21u), width 16-24u (mean 20u); endophragm ca. 0.5u thick. 10 specimens with periphragm intact: length 18-27u, width 18-27u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166, sparse in sample 167, and extremely rare in sample 170; Loc. 2, extremely rare in sample 164; Loc. 3, rare in sample 158; Loc. 4, extremely rare in sample 162; Loc. 5, extremely rare in samples 151 and 153, rare in sample 154, and extremely rare in sample 155; Loc. 6, extremely rare to abundant throughout the section.

Previously-reported occurrences: Campanian of Western Australia (Cookson & Eisenack, 1962a); ?Paleocene of New Zealand (Wilson, 1967); Campanian and Maestrichtian of NWT, Canada (McIntyre, 1974).

Horologinella incurvata Cookson & Eisenack 1962a

Plate 17, fig. 10

- 1962a Horologinella incurvata Cookson & Eisenack: 272, pl. 27, fig. 5.
- 1969 Horologinella incurvata Cookson & Eisenack; De Coninck: 44, pl. 13, figs. 16-18.

Comments: Maryland-Delaware specimens of Horologinella incurvata appear identical with the specimens of De Coninck, in displaying lateral margins less deeply concave than those of the holotype. As in H. apiculata, a membranous periphragm is present on undamaged specimens. The periblast follows the outline of the endoblast, or may be drawn out laterally into acuminate-tipped projections at the four "corners" of the cyst. H. incurvata lacks the apical projection characteristic of H. apiculata.

Dimensions: Approximately the same as for H. apiculata.

Stratigraphic distribution: Loc. 1, extremely rare in sample 170; Loc. 4, extremely rare in sample 160; Loc. 5, extremely rare in samples 151 and 154; Loc. 6, common in sample 118, sparse in sample 119, extremely rare in sample 121, and rare in samples 122 and 126.

Previously-reported occurrences: ?Lower Eocene of Western Australia (Cookson & Eisenack, 1962a); Lower Ypresian of Belgium (De Coninck, 1969).

Horologinella sp.

Plate 17, fig. 11

Comments: Maryland-Delaware specimens resembling H. apiculata but bearing randomly-distributed verrucae, commonly five in number, are herein assigned to Horologinella sp. The verrucae are up to 2u in basal diameter and in height. A periphragm has not been observed.

Dimensions: Length x width, up to 19 x 17u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 170; Loc. 2, extremely rare in sample 164; Loc. 5, extremely rare in samples 151, 155, and 156; Loc. 6, rare in sample 122, extremely rare in sample 123, and sparse in sample 124.

Genus Impletosphaeridium Morgenroth 1966aImpletosphaeridium sp.

Plate 17, figs. 1-2

Description: Cyst bi-layered, spheroidal, bears numerous slender processes ca. 0.5-1.0u wide, 7-9u long. Processes widen slightly proximally and distally; process tips interconnected by delicate, perforate trabeculae, forming complex network enveloping main body of cyst. Archeopyle apical (Type \bar{A}), with strongly-angular margin; operculum simple, free. Endophragm ca. 0.5u thick, periphragm, 0.5-1.5u thick.

Dimensions: Observed range (3 specimens measured) (opercula missing, length measured from archeopyle margin to antapex): main body length 49-55u, width 50-57u.

Stratigraphic distribution: Loc. 4, extremely rare in sample 159.

Genus Inversidinium McLean 1973Inversidinium protonsum n. sp.

Plate 17, figs. 5-6

Derivation of name: protonsus, L., extended, stretched out, referring to the elongation of the apex and antapex.

Description: Cyst bi-layered, peridinoid in dorso-ventral outline, but lacking antapical horns. Apex and antapex are truncated obliquely

or normal to cyst long axis. Lateral margins of cyst are concave, particularly in hypotract. Endoblast roundly triangular in dorso-ventral view, inverted, with a vertex extending toward antapex. Endoblast appressed to periblast except at apex, antapex, and cingulum. Cingulum and sulcus may be indicated by transverse and longitudinal folds, respectively, of periphragm. Folds are convex outward, distal margins sharp. Two vertices of endoblast lie along transverse fold. Longitudinal fold may extend entire length of cyst. No evidence of tabulation observed, nor any definite excystment apparatus in either wall layer; excystment presumably occurs at antapex, as postulated by McLean (1973) for Inversidinium exilimurum. Endophragm and periphragm hyaline, unornamented, each ca. 0.3-0.5u thick.

Dimensions: Observed range (13 specimens measured): endoblast length 20-44u, width 26-41u; periblast length 46-78u, width 38-75u.

Comparison with similar species: I. protonsum most closely resembles I. exilimurum McLean (1973); in I. protonsum, however, the periphragm is drawn out and narrowly-constricted at the antapex, while in I. exilimurum the antapex is relatively broad.

Both species of Inversidinium superficially resemble Wetzeliella (Rhombodinium?) miniscula Alberti 1961, but the latter has two antapical protrusions separated by a longitudinal cleft; moreover, the endoblast of W. (R?) miniscula is rhombohedral in dorso-ventral outline and more nearly fills the periblast (McLean, 1973).

Both species of Inversidinium also resemble Palaeotetradinium silicorum Deflandre 1936b; but whereas the periphragmal extensions of Inversidinium occur in one plane, those of Palaeotetradinium silicorum occur in a tetrahedral configuration.

Holotype: Plate 17, fig. 5. VPISUPL sample 151, slide AE 52, coords. R2.8, +3.0.

Stratigraphic distribution: Loc. 1, extremely rare in samples 166, 168, and 170; Loc. 5, extremely rare in samples 151, 153, and 156; Loc. 6, rare in sample 116, extremely rare in samples 117, 122, 123, and 124.

?Inversidinium sp.

Plate 17, figs. 7-8

Description: Cyst peridinoid as in I. protonsum, but bears broadly-truncate antapex; large circular opening (archeopyle?) occurs at antapex. Endoblast rhombohedral, oriented to follow outline of periblast, not appressed to periblast; each corner of endoblast bears nipple-like protrusion. Longitudinal keel-like fold (sulcus?) present, transverse fold absent. Wall layers each ca. 0.3-0.5 μ thick.

Discussion: The two specimens are tentatively assigned to Inversidinium on the basis of the overall shape of the bi-layered cyst, and the opening at what is presumably the antapex. The specimens

resemble I. exilimurum McLean 1973 in having a pointed apex and a broadly-truncate antapex; the opening in the latter, however, is triangular rather than circular. ?Inversidinium sp. differs from both I. exilimurum and I. protonsum in possessing a rhombohedral endoblast rather than a triangular one.

Dimensions: (Two specimens measured): endoblast length 34u, 31u; endoblast width 29u, 35u. Periblast length 60u, 70u; periblast width 62u, 70u.

Stratigraphic distribution: Loc. 5, extremely rare (one specimen) in sample 152; Loc. 6, extremely rare (one specimen) in sample 116.

Genus Kallosphaeridium De Coninck 1969

Kallosphaeridium brevibarbatum De Coninck 1969

Plate 15, figs. 13-14

1969 Kallosphaeridium brevibarbatum De Coninck: 43-44, pl. 13, figs. 14-15.

Description: Bi-layered cyst, spheroidal to ovoidal. Endophragm relatively thick, 1.0-1.5u; closely-spaced bacula arise from base of endophragm, extend outward radially ca. 0.5u beyond endophragm and comprise outer wall layer. Cingulum and sulcus are not expressed. Archeopyle is apical (Type $\bar{A}a$); operculum is attached ventrally by a narrow isthmus; four apical plate-equivalents and two anterior

intercalaries lie within operculum (Text-fig. 17, p. 233). Accessory archeopyle sutures may be developed, delimiting six pre-cingular plate-equivalents.

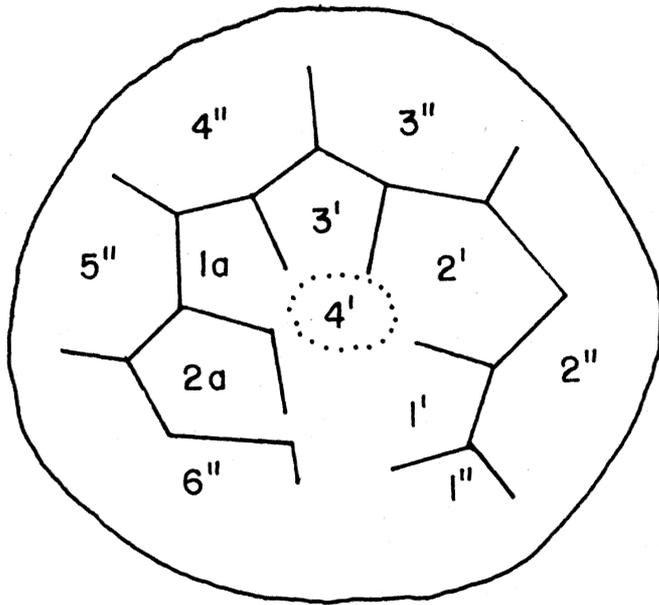
Discussion: One well-preserved specimen clearly displays the construction of the operculum: plate-equivalents 1' and 2' are relatively large; 3' is smaller, similar in size to the two intercalaries; 4' occupies a poorly-defined central area. Sutures separating opercular plate-equivalents extend to approximately the center of the anterior margin of each precingular plate-equivalent lying directly below. Anterior margins of plate-equivalents 4'' and 5'' are distinctly gabled (Text-fig. 17, p. 233).

Kallosphaeridium brevibarbatum resembles Chlamydophorella urna in bearing closely-spaced bacula, but the bacula of the latter extend farther beyond the endophragm, and their distal tips support a membranous periphragm.

Dimensions: Observed range (25 specimens measured): endoblast length 26-38u (mean 31u), width 24-37u (mean 28u); overall length 28-40u (mean 33u), width 26-39u (mean 31u).

Stratigraphic distribution: Loc. 4, extremely rare in sample 160; Loc. 5, rare in sample 151, extremely rare in sample 152, rare in sample 153, and extremely rare in sample 154; Loc. 6, extremely rare in samples 116, 118, 120, and 126.

Previously-reported occurrence: Ypresian of Belgium (De Coninck, 1969).



Text-fig. 17. Apical view of Kallosphaeridium breviparbatum, displaying plate-equivalents 1' - 3' and 1a - 2a surrounding the 4'.

Genus Microdinium Cookson & Eisenack 1960a

Microdinium setosum Sarjeant 1966b

Plate 15, figs. 10-12

- 1966b Microdinium setosum Sarjeant, in Davey et al.: 151, pl. 16, figs. 9-10; text-fig. 39.
- 1967 Microdinium echinatum Clarke & Verdier: 64-65, pl. 1, figs. 9-10.
- 1969 Microdinium setosum Sarjeant; Davey: 133, pl. 2, fig. 4; text-fig. 13 H.
- 1973 Microdinium setosum Sarjeant; Davey & Verdier: pl. 5, fig. 6.

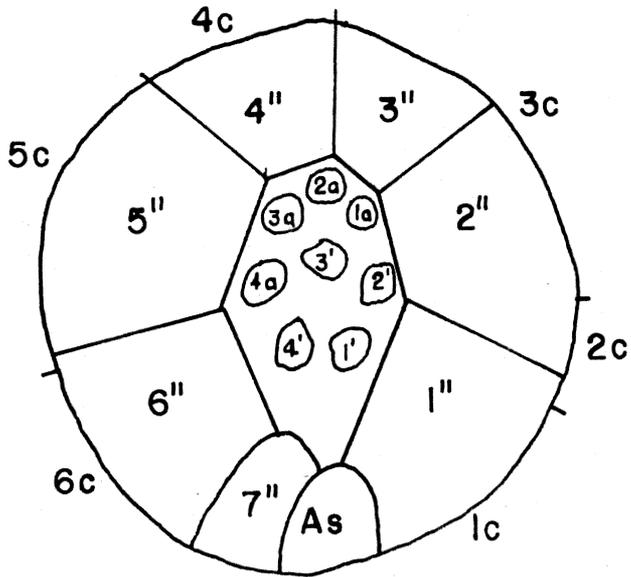
Description: Ovoidal bi-layered cyst bears sutural folds outlining plate-equivalents; distal edges of folds drawn out into numerous, regularly-spaced spines of uniform length, with acuminate tips; bases of adjacent spines are confluent, producing scalloped effect. Folds and spines together up to 5.5u high. Epitract considerably smaller than hypotract. Cingulum 4-5u wide, not indented, nearly circular. Sulcus widens posteriorly, abuts against 1'''. Ventral side of cyst somewhat flattened. Archeopyle apical (Type $\bar{A}a$); operculum essentially hexagonal, attached ventrally by narrow connection; four apical plate-equivalents and four anterior intercalaries lie on operculum. Basic tabulation is 4', 4a, 7'', 6c, 6''', 1p, 1'''' (see Discussion). Endophragm and periphragm each ca. 0.5u thick; surface of periphragm faintly granulose.

Discussion: The four apical plate-equivalents are of equal size; the anterior intercalaries, lying along the dorsal margins of the operculum, are smaller. The anterior margins of the precingular plate-equivalents are straight, not gabled. Seven precingular plate-equivalents are present: 1''-6'' are relatively large, of equal size; 7'' is smaller, lies directly posterior to the 4''; an anterior sulcal plate (AS), equal in size to the 7'', lies directly posterior to the 1''. In line with the cingulum at the sulcus are two smaller plate-equivalents, a transitional plate-equivalent (tr.) lying beneath the 7'', and a sulcal plate-equivalent (s), beneath the AS; these plate-equivalents are apparent in fig. 39 of Sarjeant (1966b, p. 150). The post-cingular plate-equivalents are considerably larger than the pre-cingulars; the lp is nearly equal in size to the hexagonal 1'''''. The complete tabulation is 4', 4a, 7''', 6c + tr., 6''', lp, 1'''' (plus sulcal platelet) (Text-fig. 18).

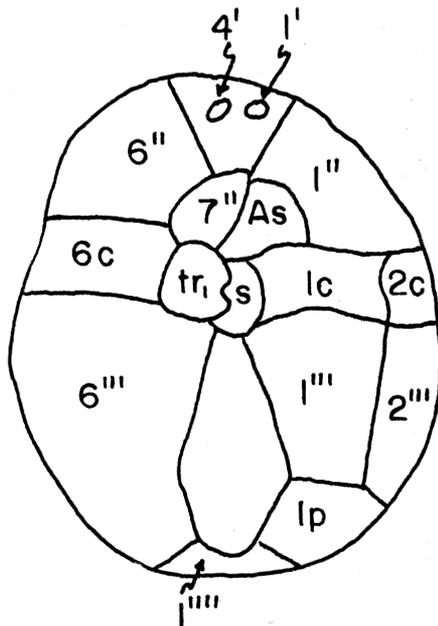
Dimensions: Observed range (9 specimens measured): main body length 28-37u, width 27-34u.

Stratigraphic distribution: Loc. 5, extremely rare in samples 151 and 153; Loc. 6, extremely rare in samples 116, 118, and 122.

Previously-reported occurrences: Cenomanian of England (Sarjeant, 1966b; Clarke & Verdier, 1967; Davey, 1969); Cenomanian of France (Davey, 1969); Vraconian of France (Davey & Verdier, 1973).



Text-fig. 18. a. Apical view of *Microdinium setosum*, displaying plate-equivalents 1' - 4' and 1a - 4a lying within the operculum.



b. Ventral view of *M. setosum*. (See text for discussion of tabulation.)

Genus Systematophora Klement 1960

Systematophora placacantha (Deflandre & Cookson 1955)
Davey et al. 1969

Plate 15, figs. 7-9

- 1955 Hystrichosphaeridium placacanthum Deflandre & Cookson: 276-277, pl. 9, figs. 1-3.
- 1963 Baltisphaeridium placacanthum (Deflandre & Cookson) Downie & Sarjeant: 72, pl. 7, fig. 12.
- 1966 Impletosphaeridium placacanthum (Deflandre & Cookson) Morgenroth: 35-36, pl. 9, figs. 10-11.
- 1967 Systematophora spp.; Evitt: pl. 1, figs. 1-6.
- 1969 Systematophora placacantha (Deflandre & Cookson) Davey et al.: 17.

Comments: The numerous, well-preserved specimens of Systematophora placacantha from the Monmouth and Brightseat Formations allow new morphological information, particularly concerning tabulation, to be introduced at this time; hence, a full description is given below.

Description: Bi-layered cyst, hemispherical in outline, with circular equatorial section. Plate-equivalents outlined by processes complexes: annular to simulate low ridges bear slender, evenly-spaced processes, commonly 7-13 per complex. Processes taper distally to ca. 1.0 μ in width; tips are bifid. Adjacent processes may be joined by oblique trabeculae at any point along shaft, but processes tips free. Process complexes outline tabulation of 4', 0a, 6'', 6c, 5''', 1p, 1''''; posterior sulcal process (ps) may be present, and small

processes may flank sulcus. Plate-equivalent 2' triangular, 3', elongate; both are larger than plate-equivalents 1' and 4'. Pre- and post-cingular complexes large relative to lp and ps. Plate-equivalent 1'''' reniform, its concave margin opposes lp and base of sulcus. Cingulum consists of discontinuous, straight ridge sections, each bearing several processes; cingulum vertically offset at sulcus by about three cingulum widths. Sulcus narrow at anterior margin, widens posteriorly. Archeopyle apical (Type \bar{A}) with simple, free operculum; archeopyle margin strongly angular; sulcal notch present. Accessory archeopyle sutures may be present, separating pre-cingular process complexes. Endophragm ca. 1.5u thick; periphragm ca. 1.0u thick, exterior surface microreticulate.

Dimensions: Observed range (30 specimens measured) (opercula missing; length measured from archeopyle margin to antapex): main body length 46-67u (mean 57u), width 55-92u (mean 65u); overall length 67-97u (mean 81u), width 87-112u (mean 99u).

Stratigraphic distribution: Loc. 1, extremely rare in sample 171; Loc. 3, rare in samples 163 and sparse in sample 156; Loc. 4, rare in sample 159 and sparse in samples 160 and 161.

Previously-reported occurrences: Miocene of Australia (Deflandre & Cookson, 1955); Lower Eocene of Germany and Belgium (Morgenroth, 1966).

Genus Thalassiphora (Eisenack & Gocht 1960)
Williams & Downie 1966

Thalassiphora pelagica (Eisenack 1954)
Eisenack & Gocht 1960

Plate 14, figs. 13-16

- 1954 Pterospermopsis pelagica Eisenack: 71, pl. 12, figs. 17-18.
- 1955 ?Pterocystidiopsis velata Deflandre & Cookson: 291, pl. 8, fig. 8.
- 1956 Pterospermopsis cf. P. danica Weiler: 136, pl. 11, figs. 7-8; pl. 13, fig. 4, text-fig. 7.
- 1960 Thalassiphora pelagica (Eisenack) Eisenack & Gocht: 513, text-figs. 1-3.
- 1961 Dinoflagellata; Hacquaert: 78, pl. 4, fig. 17; pl. 7, fig. 26.
- 1961 Pterospermopsis pelagica Eisenack; Gerlach: 209, pl. 28, fig. 15.
- 1961 Pterospermopsis cf. P. pelagica Eisenack; Alberti: 40, pl. 11, fig. 11.
- 1961b Thalassiphora velata Cookson & Eisenack: 44, pl. 2, figs. 13-14.
- 1963 Thalassiphora pelagica (Eisenack) Eisenack & Gocht; Brosius: 50, pl. 3, fig. 3.
- 1966b Thalassiphora pelagica (Eisenack) Eisenack & Gocht; Williams & Downie, in Davey et al.: 234, pl. 26, fig. 7.
- 1966 Thalassiphora pelagica (Eisenack) Eisenack & Gocht: Morgenroth: 40, pl. 11, figs. 3-4.
- 1967 Thalassiphora pelagica (Eisenack) Eisenack & Gocht: Cookson & Cranwell: 206-207, pl. 2, figs. 4-5.
- 1968 Thalassiphora pelagica (Eisenack) Eisenack & Gocht; Gocht: 149-156, pls. 25-27; text-figs. 1-2.
- 1969 Thalassiphora pelagica (Eisenack) Eisenack & Gocht; Gocht: 66-68, pl. 5, figs. 4-10, text-figs. 46-47.

- 1969 Thalassiphora pelagica (Eisenack) Eisenack & Gocht; Archangelsky: 412, pl. 2, figs. 9-10.
- 1972 Thalassiphora pelagica (Eisenack) Eisenack & Gocht; Benedek: 38, pl. 11, fig. 14; text-fig. 15.
- 1975 Thalassiphora pelagica (Eisenack) Eisenack & Gocht; Haskell & Wilson: pl. 2, fig. 5.

Comments: Maryland specimens of Thalassiphora pelagica belong to the "Endstadium" of Gocht's ontogenetic series (1968, 1969); no representatives of the intermediate stages or of the tabulated "Anfangstadium" were observed. In the "Endstadium," the outer, fibrous membrane is completely expanded; no trace of tabulation remains. The outer membrane of an occasional specimen is irregularly-contracted around the main body, but this appears to be the result of mechanical deformation. Undamaged specimens bear the antapical pointed extension ("Zipfel") of the outer membrane, characteristic of the later ontogenetic stages. A nipple-like protrusion of the endophragm may be present at the apex and/or antapex. The endophragm is 1.0-2.5u thick, the periphragm, ca. 0.5u thick. The Maryland specimens are comparable in size with the specimens of Gocht (1968).

Dimensions: Observed range (11 specimens measured): main body length 94-119u (mean 104u), width 79-85u (mean 80u); overall length 171-234u (mean 192u), width 118-199u (mean 169u).

Stratigraphic distribution: Loc. 3, sparse in samples 157 and 158; Loc. 4, extremely rare in sample 162.

Previously-reported occurrences: Lower Oligocene of Germany (Eisenack, 1954); Eocene of Australia (Deflandre & Cookson, 1955); Middle Oligocene of Germany (Weiler, 1956; Gocht, 1968 and 1969); Upper Eocene of Germany (Eisenack, 1938; Eisenack & Gocht, 1960); Middle Oligocene to Middle Miocene of Germany (Gerlach, 1961); Upper Hauterivian to Upper Barremian of northern Germany (Alberti, 1961); Eocene of Australia (Cookson & Eisenack, 1961); Upper Oligocene of Germany (Brosius, 1963); Lower Eocene of Germany and Belgium (Morgenroth, 1966); Eocene of England (Williams & Downie, 1966b); Middle and Upper Oligocene of Germany (Benedek, 1972); Middle Eocene of southeastern Australia (Haskell & Wilson, 1975).

Genus Xenascus Cookson & Eisenack 1969

Xenascus ceratioides (Deflandre 1937) Lentin & Williams 1973

Plate 17, figs. 3-4

- 1937 Hystrichosphaera ceratioides Deflandre: 12, pl. 12, figs. 7-8.
- ?1950 Ceratium operculatum O. Wetzel: 170-171, pl. 13, fig. 6.
- 1961 Forma H; Evitt: 400, pl. 6, fig. 9.
- 1966 Pseudoceratium ceratioides (Deflandre) Deflandre: 6.
- 1967 Pseudoceratium ceratioides (Deflandre) Deflandre; Clarke & Verdier: 60, pl. 13, fig. 8; pl. 15, figs. 1-2.
- 1967 Endoceratium perforatum Vozzhennikova: 188-189, pl. 112, figs. 1-3; pl. 13, fig. 1.
- 1969 Xenascus australense Cookson & Eisenack: 7, figs. 1 I-K.

- 1970 Forma C sp. 1 Zaitzeff & Cross: pl. 5, figs. 48, 51.
- 1970 Odontochitina blastema Davey: 356-357, pl. 5, figs. 4-5.
- 1971 Phoberocysta ceratioides (Deflandre) Millioud; Davey & Verdier: 26-27, pl. 5, fig. 12.
- 1971 Pseudoceratium ceratioides (Deflandre) Deflandre; Wilson: pl. 2, fig. 5.
- 1973 Xenascus ceratioides (Deflandre) Lentin & Williams: 144.

Comments: Mount Laurel specimens of Xenascus ceratioides differ from Deflandre's type specimens in lacking aligned cingular processes. The following description adds information concerning the shape of the horns and processes.

Description: Cyst bi-layered; ellipsoidal main body bears an apical, a post-cingular, and an antapical horn. Apical horn broad at base, narrows mid-way along its length, flares slightly, is open distally; at distal margin, wall of horn may be delicate, perforate. Other horns similar to apical horn, but taper less strongly. Archeopyle apical (Type \bar{A}), with nearly straight margin. Tabulation not discernible, but trace of cingulum can be observed. Tubular processes present on horns and main body, are distributed at random; processes given off by main body longer and wider than those of horns. Processes may flare distally or may bifurcate or trifurcate; secondary process may be borne at any point along shaft. Endophragm ca. 1.0 μ thick, the periphragm, ca. 0.5 μ thick; external surface of periphragm faintly granulose.

Dimensions: One complete specimen measured: main body length x width, 81 x 73u; overall, 185 x 122u. Processes on horns up to 17u long and 4u wide; processes on main body up to 30u long and 16u wide.

Stratigraphic distribution: Loc. 6, extremely rare in samples 120-123.

Previously-reported occurrences: Senonian of France (Deflandre, 1937); Senonian of Germany (O. Wetzel, 1950); Senonian of West Pakistan (Evitt, 1961); Cenomanian-Campanian of England (Clarke & Verdier, 1967); Upper Cretaceous of the USSR (Vozzhennikova, 1967); Albian-Cenomanian of Australia (Cookson & Eisenack, 1969); Maestrichtian of Texas (Zaitzeff & Cross, 1970); Upper Cenomanian of England and France (Davey, 1970); Albian of France (Davey & Verdier, 1971); Maestrichtian of Belgium (Wilson, 1971).

Group Acritarcha Evitt 1963

Subgroup Acanthomorpha (Downie, Evitt & Sarjeant 1963)
Staplin et al. 1965

Genus Micrhystridium (Deflandre 1937)
Downie & Sarjeant 1963

Micrhystridium spp.

Plate 17, fig. 12

Comments: Because of their small size, their taxonomic difficulties, and their questionable stratigraphic usefulness, species of Micrhystridium are only mentioned as being present in the studied section, and individual species are not discussed herein.

Subgroup Baltisphaeritae Staplin et al. 1965

Genus Baltisphaeridium (Eisenack 1958)
Downie & Sarjeant 1963

Baltisphaeridium spp.

Plate 17, figs. 13-15

Comments: Small numbers of Baltisphaeridium spp. occur throughout the section; since their stratigraphic significance appears limited, no formal species names are designated herein.

Subgroup Herkomorphitae Downie, Evitt, & Sarjeant 1963

Genus Cymatiosphaera (O. Wetzel 1933) Deflandre 1954

Cymatiosphaera spp.

Plate 17, fig. 16

Comments: Because of their questionable stratigraphic value, the several species of Cymatiosphaera recovered are not discussed; a typical form is illustrated in this study.

Subgroup Platymorphitae Downie, Evitt, & Sarjeant 1963

Genus Trigonopyxidia (Cookson & Eisenack 1960)
Cookson & Eisenack 1961b

Trigonopyxidia ginella (Cookson & Eisenack 1960)
Cookson & Eisenack 1961b

Plate 17, fig. 17

- 1960 Trigonopyxis ginella Cookson & Eisenack: 11, pl. 3, figs. 18-20.
- 1961b Trigonopyxidia ginella (Cookson & Eisenack) Cookson & Eisenack: 75.
- 1964 Trigonopyxidia ginella (Cookson & Eisenack) Cookson & Eisenack; Cookson & Hughes: 57, pl. 11, fig. 6.
- 1964 Trigonopyxidia ginella (Cookson & Eisenack) Cookson & Eisenack; Manum & Cookson: 26-27, pl. 6, fig. 6.
- 1967 Trigonopyxidia ginella (Cookson & Eisenack) Cookson & Eisenack; Vozzhennikova: 124.

Comments: Maryland-Delaware specimens of Trigonopyxidia ginella appear identical with the specimens of Cookson & Eisenack (1960), but morphological information can be added herein.

Description: Bi-layered cyst with triangular overall outline; vertices are bluntly-rounded, lateral margins, concave to varying degree from specimen to specimen. Inner body, triangular with broadly-rounded vertices, has straight to slightly convex lateral margins; inner body oriented to follow outline of outer body. Tip of one vertex of outer body is truncated, leaving circular opening which may function in excystment; vertex of inner body opposing circular opening

is also truncated. "Operculum" of outer body is lost; that of inner body may remain as a cap, nearly in place. Other vertices may be incidentally ruptured. Inner body not centric, is displaced toward outer wall opposite circular opening. Each wall layer ca. 0.5u thick; external surface of inner body laevigate; external surface of outer body laevigate to finely granulose.

Dimensions: Observed range (12 specimens measured): diameter of inner body 29-46u (mean 36u); diameter of outer body 46-62u (mean 55u).

Stratigraphic distribution: Loc. 5, extremely rare in samples 151 and 153; Loc. 6, extremely rare in samples 116, 118, and 122.

Previously-reported occurrences: (?)Upper Albian to Cenomanian of Western Australia (Cookson & Eisenack, 1960 and 1961b); Cenomanian of England (Cookson & Hughes, 1964); Campanian-Cenomanian of Arctic Canada (Manum & Cookson, 1964); Paleocene of the USSR (Vozzhennikova, 1967).

Subgroup Pteromorphitae Downie, Evitt, & Sarjeant 1963

Genus Pterospermopsis W. Wetzel 1952

Pterospermopsis danica W. Wetzel 1952

Plate 17, figs. 18-19

- 1952 Pterospermopsis danica W. Wetzel: 412, pl. A, fig. 16;
text-fig. 34.
- 1967 Pterospermopsis danica W. Wetzel; Drugg: 34, pl. 6, fig. 10.

Comments: The Maryland specimens of Pterospermopsis danica display a considerable variation in size, as do the specimens of Drugg (1967).

Dimensions: Observed range (5 specimens measured): central body diameter 35-90u, overall diameter 70-136u; wall thickness of central body 2.0-2.5u, of outer lamella, ca. 0.5u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 2, extremely rare in sample 165; Loc. 4, extremely rare in sample 162.

Previously-reported occurrences: Danian of northern Germany (W. Wetzel, 1952); Maestrichtian, Danian of California (Drugg, 1957).

Subgroup Uncertain

Genus Ascostomocystis Drugg & Loeblich 1967

Ascostomocystis potane Drugg & Loeblich 1967

Plate 18, fig. 1

- 1967 Ascostomocystis potane Drugg & Loeblich: 187-188, pl. 3, figs. 10-12; text-fig. 6.

Comments: One specimen of Ascostomocystis potane was recovered from the Monmouth Formation. It resembles the specimens of Drugg and Loeblich (1967) in morphology and in size. Their specimens, however, have a cingulum, while the Monmouth specimen does not.

Dimensions: Inner body length x width, 98 x 56u; overall length x width, 105 x 88u.

Stratigraphic distribution: Loc. 5, extremely rare (one specimen) in sample 155.

Previously-reported occurrence: Oligocene of Mississippi (Drugg & Loeblich, 1967).

Genus Cyclopsiella Drugg & Loeblich 1967

Cyclopsiella elliptica Drugg & Loeblich 1967

Plate 18, fig. 2

1967 Cyclopsiella elliptica Drugg & Loeblich: 190, pl. 3, figs. 1-6; text-fig. 7.

Comments: Two specimens of Cyclopsiella elliptica were recovered from the Monmouth Formation. The inner wall is ca. 0.5u thick; the outer wall, thin and filmy, forms a flange up to 6u wide around the periphery of the cyst. The cingulum is indicated by a discontinuous fold. Acuminate processes, commonly present on the specimens of

Drugg & Loeblich (1967), were not observed on the Monmouth specimens.

Dimensions: Two specimens measured: (1) length x width 64 x 55u, apertural rim ca. 1.5u in thickness, aperture ca. 8.0u in diameter; (2) length x width 55 x 52u, no apertural rim, aperture ca. 7.5u in diameter.

Stratigraphic distribution: Loc. 3, extremely rare (one specimen) in sample 163; Loc. 5, extremely rare (one specimen) in sample 151.

Previously-reported occurrence: Oligocene of Mississippi (Drugg & Loeblich, 1967).

Cyclopsiella vieta Drugg & Loeblich 1967

Plate 18, fig. 3

1967 Cyclopsiella vieta Drugg & Loeblich: 192-194, pl. 3, figs. 7-9; text-fig. 8.

Comments: One specimen of Cyclopsiella vieta was recovered from the Monmouth Formation. It resembles the specimens of Drugg and Loeblich (1967) in possessing a wrinkled outer surface and a rimmed aperture. The transverse fold present on the Mississippi specimens is absent. The inner wall is ca. 0.75u thick; the outer wall is filmy, wrinkled, and externally granulose.

Dimensions: One specimen: length x width 74 x 60u; thickness of apertural rim, 5u; diameter of aperture, 7u.

Stratigraphic distribution: Loc. 5, extremely rare (one specimen) in sample 155.

Previously-reported occurrence: Oligocene of Mississippi (Drugg & Loeblich, 1967).

Genus Fromea Cookson & Eisenack 1958

Fromea amphora Cookson & Eisenack 1958

Plate 17, fig. 17

- 1958 Fromea amphora Cookson & Eisenack: 56, pl. 5, figs. 10-11.
- 1961 Fromea amphora Cookson & Eisenack; Alberti: 23, pl. 12, fig. 13.
- 1964 Fromea amphora Cookson & Eisenack; Cookson & Hughes: 54-55, pl. 10, fig. 2.
- 1964 Fromea amphora Cookson & Eisenack; Cookson & Manum:
- 1966 Fromea amphora Cookson & Eisenack; Sarjeant: 209, pl. 22, fig. 4; pl. 23, fig. 3.
- 1967 Fromea amphora Cookson & Eisenack; Vozzhennikova: 128.
- 1967 Fromea amphora Cookson & Eisenack; Baltés:
- 1971 Fromea amphora Cookson & Eisenack; Brideaux: 80, pl. 22, fig. 33.

Comments: Four intact specimens of Fromea amphora were recovered from the Mount Laurel and Monmouth Formations. The cingulum is marked by

a slight indentation in the cyst wall and/or by a diffuse band of somewhat darker color up to 30u wide. The cyst exterior is finely granulose. The specimens are morphologically identical with ones previously described; they are comparable in size with the specimens of Vozzhennikova (1967) and of Brideaux (1971).

Dimensions: Observed range (4 specimens measured): length 103-120u, width 76-86u; width of aperture, 26-35u.

Stratigraphic distribution: Loc. 5, extremely rare in sample 152; Loc. 6, extremely rare in samples 117, 121, and 122.

Previously-reported occurrences: Aptian-Cenomanian of Australia (Cookson & Eisenack, 1958); Barremian of Germany (Alberti, 1961); Upper Albian and Lower Cenomanian of England (Cookson & Hughes, 1964); Lower Upper Cretaceous of Arctic Canada (Manum & Cookson, 1964); Upper Barremian of England (Sarjeant, 1966); Upper Cretaceous of the USSR (Vozzhennikova, 1967); Albian of Roumania (Baltes, 1967); Upper Albian of Alberta, Canada (Brideaux, 1971); Campanian-?Santonian of NWT, Canada (McIntyre, 1974).

Genus Palaeostomocystis Deflandre 1937b

Palaeostomocystis chytra Drugg 1967

Plate 18, figs. 4-5

- 1967 Palaeostomocystis chytra Drugg: 35, pl. 6, fig. 12.
 1974 Palaeostomocystis chytra Drugg; McIntyre: pl. 8, figs. 4-6.

Comments: Monmouth-Mount Laurel specimens of Palaeostomocystis chytra appear identical with the specimens of Drugg (1967).

Dimensions: Observed range (6 specimens measured): length 29-38u, width 16-32u. Width of aperture 5-10u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 2, extremely rare in sample 164; Loc. 5, extremely rare in samples 151 and 152; Loc. 6, extremely rare in sample 116.

Previously-reported occurrences: Maestrichtian, Danian of California (Drugg, 1967); Campanian, Maestrichtian of NWT, Canada (McIntyre, 1974).

Palaeostomocystis fragilis Cookson & Eisenack 1962

Plate 18, fig. 6

- 1962b Palaeostomocystis fragilis Cookson & Eisenack: 496-497, pl. 7, figs. 10-11.
 1964 Palaeostomocystis fragilis Cookson & Eisenack; Manum & Cookson: 28-29, pl. 4, fig. 10.
 1971 Palaeostomocystis fragilis Cookson & Eisenack; Brideaux: 80-81, pl. 23, fig. 35.

Comments: Maryland-Delaware specimens of Palaeostomocystis fragilis are similar to the Australian and Canadian specimens in possessing a longitudinal keel-like fold; in addition, an equatorial transverse fold or a shallow indentation, indicating a cingulum, may be present. The cyst wall, ca. 0.5u thick, is externally finely granulose.

The Maryland-Delaware specimens are smaller than those of Cookson & Eisenack (1964), but fall within the broad size range reported by Brideaux (1971).

Dimensions: Observed range (16 specimens measured): length 60-96u (mean 75u); width 44-72u (mean 57u). Specimens of Cookson & Eisenack: length 82-157u, width 70-105u.

Stratigraphic distribution: Loc. 1, rare in sample 167; Loc. 2, rare in sample 164; Loc. 4, extremely rare in samples 159 and 160; Loc. 5, rare in sample 151 and extremely rare in sample 154; Loc. 6, rare in samples 117 and 121, extremely rare in sample 123.

Previously-reported occurrences: Aptian-Cenomanian of Australia (Cookson & Eisenack, 1962b); Upper Cretaceous of the Canadian Arctic (Manum & Cookson, 1964); Upper Albian of Alberta, Canada (Brideaux, 1971); Campanian-Maestrichtian of NWT, Canada (McIntyre, 1974).

Palaeostomocystis laevigata Drugg 1967

Plate 18, fig. 7

1967 Palaeostomocystis laevigata Drugg: 35, pl. 6, fig. 14-15.

Comments: Maryland-Delaware specimens of Palaeostomocystis laevigata differ from Drugg's specimens only in that some specimens bear rimmed pores at either pole; Drugg's specimens bear rimmed pores only at the anaperturate pole. In addition to the pores, coarse grana may be present at both poles. Some of the Maryland-Delaware specimens are more elongate than Drugg's specimens, displaying a higher upper limit to the length/width ratios than he recorded.

Dimensions: Observed range (25 specimens measured): length 54-74u (mean 62u), width 19-31u (mean 25u); length/width ratio 1.5-3.1 (mean 2.5); terminal aperture 5-11u wide. Drugg's specimens: length 27-69u, width 22-35u; length/width ratio 1.6-2.5.

Stratigraphic distribution: Loc. 1, rare in samples 167 and 168; Loc. 4, extremely rare in sample 162; Loc. 5, extremely rare in sample 151 and rare in sample 153; Loc. 6, rare to sparse throughout the section.

Previously-reported occurrences: Maestrichtian, Danian of California (Drugg, 1967); Santonian-Maestrichtian of NWT, Canada (McIntyre, 1974).

Palaeostomocystis reticulata Deflandre 1937

Plate 18, figs. 8-10

- 1935 Palaeostomocystis reticulata Deflandre: 234, pl. 9, fig. 13.
- 1936 Palaeostomocystis reticulata Deflandre: 77, fig. 133.
- 1937 Palaeostomocystis reticulata Deflandre; Deflandre: 53, pl. 12, fig. 4.
- 1967 Palaeostomocystis reticulata Deflandre; Drugg: 35, pl. 6, fig. 13.

Comments: Maryland-Delaware specimens of Palaeostomocystis reticulata appear identical with those of Drugg (1967). The apertural rim is thickened and a short neck is present, unlike Deflandre's specimens (1935). The Maryland-Delaware specimens bear pillars of uniform height, whereas the pillars of some of Deflandre's specimens are relatively long at the antapex, becoming progressively shorter toward the apex.

Dimensions: Observed range (11 specimens measured): length of main body without reticulum, 22-32u (mean 27u); width of main body without reticulum, 19-27u (mean 23u). Overall length 24-36u (mean 30u); overall width 22-32u (mean 27u).

Stratigraphic distribution: Loc. 5, extremely rare in samples 151 and 153; Loc. 6, rare in sample 117.

Previously-reported occurrences: ?Senonian of France (Deflandre, 1935, 1936, and 1937); Senonian of France (Deflandre-Rigaud, 1954); Danian of California (Drugg, 1957).

Genus Schizocystia Cookson & Eisenack 1962a

Schizocystia laevigata Cookson & Eisenack 1962a

Plate 18, fig. 11

- 1962a Schizocystia laevigata Cookson & Eisenack: 270-271, pl. 37, figs. 13-14.
- 1964 Schizocystia laevigata Cookson & Eisenack; Manum & Cookson: 29, pl. 7, figs. 1-2.
- 1971 Schizocystia laevigata Cookson & Eisenack; Singh: 430, pl. 80, figs. 7-9.

Comments: Two specimens of Schizocystia laevigata were recovered from the base of the Monmouth Formation. They appear identical with the type specimens of Cookson & Eisenack (1962a). The cyst wall is ca. 1.0u thick.

Dimensions: One specimen 6l x 6lu, the other 55 x 55u, both intact.

Stratigraphic distribution: Loc. 5, extremely rare in sample 151.

Previously-reported occurrences: ?Upper Albian and Cenomanian of Western Australia (Cookson & Eisenack, 1962a); Lower Campanian-Upper Cenomanian of the Canadian Arctic (Manum and Cookson, 1964); Upper Albian and Cenomanian of Alberta, Canada (Singh, 1971).

Schizocystia cf. S. laevigata Cookson & Eisenack 1962a

Plate 18, fig. 12

?1962a Schizocystia laevigata Cookson & Eisenack: 270-271, pl. 37, figs. 13-14.

Comments: Two specimens of Schizocystia cf. S. laevigata were recovered from the Monmouth Formation. They are considerably smaller than the type specimens of Cookson & Eisenack (1962a) (see Dimensions).

Dimensions: One specimen, 20 x 23u, the other 20 x 20u, both intact; cyst wall is ca. 0.5u thick. Holotype of Cookson & Eisenack (1962a): 42 x 56u.

Stratigraphic distribution: Loc. 1, extremely rare in sample 166; Loc. 5, extremely rare in sample 153.

Genus Walloodinium Loeblich & Loeblich 1968

Walloodinium anglicum (Cookson & Hughes 1964)
Lentin & Williams 1973

Plate 18, fig. 13

1964 Diploresta anglica Cookson & Hughes: 56-57, pl. 11, figs. 1-5.

1964 Diploresta anglica Cookson & Hughes; Manum & Cookson: 25, pl. 5, fig. 7.

1973 Walloodinium anglicum (Cookson & Hughes) Lentin & Williams: 140.

1974 Walloodinium anglicum (Cookson & Hughes) Lentin & Williams; McIntyre:

Comments: One specimen of Wallodinium anglicum was recovered from the Monmouth Formation. It resembles the specimens of Manum & Cookson (1964) in having a large inner body, relative to the outer body; in the British specimens the inner body is relatively small. The Monmouth specimen is considerably smaller overall than previously-described specimens (see Dimensions).

Dimensions: (one specimen): Outer body length x width 58 x 58u; inner body length x width 50 x 20u (holotype of Cookson & Hughes: outer body 126 x 44u; inner body 52 x 24u).

Stratigraphic distribution: Loc. 1, extremely rare (one specimen) in sample 168.

Previously-reported occurrences: Middle Cretaceous of England (Cookson & Hughes, 1964); Lower Upper Cretaceous of Arctic Canada (Manum & Cookson, 1964); Campanian-?Santonian of NWT, Canada (McIntyre, 1974).

Wallodinium luna (Cookson & Eisenack 1960)
Lentin & Williams 1973

Plate 18, fig. 14

- 1960a Diplo-testa luna Cookson & Eisenack: 10-11, pl. 3, fig. 21.
 1962a Diplo-testa luna Cookson & Eisenack; Cookson & Eisenack: 497, pl. 4, figs. 18-19.
 1964 Diplo-testa luna Cookson & Eisenack; Manum & Cookson: 26, pl. 5, fig. 9.

1967 Diplotesta luna Cookson & Eisenack; Vozzhennikova: 123, pl. 98, figs. 4-5.

1973 Wallodinium luna (Cookson & Eisenack) Lentin & Williams: 140.

Comments: One specimen was recovered from the Mount Laurel Formation; it appears identical, in both morphology and size, with the holotype of Cookson & Eisenack (1960a).

Dimensions: (one specimen): outer body length x width, 70 x 26u; inner body length x width, 49 x 20u.

Stratigraphic distribution: Loc. 6, extremely rare (one specimen) in sample 116.

Previously-reported occurrences: ?Upper Albian to Cenomanian of Australia (Cookson & Eisenack, 1960a and 1962a); Lower Upper Cretaceous of Arctic Canada (Manum & Cookson, 1964); Upper Cretaceous of western Siberia (Vozzhennikova, 1967).

Genus Xenikoon Cookson & Eisenack 1960

Xenikoon australis Cookson & Eisenack 1960

Plate 18, fig. 15

1960 Xenikoon australis Cookson & Eisenack: 14-16, pl. 3, figs. 16-17.

1961 Xenikoon australis Cookson & Eisenack; Eisenack: pl. 33, fig. 9-10; text-fig. 4.

Comments: Cookson & Eisenack (1960) reported that their specimens of Xenikoon australis bear a "semicircular to nearly square pylome."

Of the eight specimens recovered in the present study, only one has a nearly square opening; two have an irregular, sub-apical rupture in the outer wall layer, and five have no opening at all.

The wall layers of the Maryland-Delaware specimens may be loosely or tightly appressed below the prominent apical pericoel. The outer wall layer, 0.5-1.0u thick, is externally finely granulose; the inner wall layer is 1.0-2.0u thick.

Dimensions: Observed range (8 specimens measured): length of outer body 62-95u, width 54-72u; length of inner body 50-70u, width 53-67u.

Stratigraphic distribution: Loc. 3, extremely rare in samples 156 and 158; Loc. 4, extremely rare in samples 159 and 161; Loc. 5, extremely rare in samples 151 and 154; Loc. 6, extremely rare in sample 116.

Previously-reported occurrences: ?Upper Turonian-Middle Senonian of Western Australia (Cookson & Eisenack, 1960): Lower Cretaceous of Western Australia (Eisenack, 1961).

Division CHLOROPHYTA

Class CHLOROPHYCEAE

Order PROTOCOCCALES?

Family UNCERTAIN

Genus Palambages O. Wetzel 1961Palambages spp.

Plate 18, figs. 18-19

Comments: Maryland-Delaware specimens of Palambages fall into two informally-defined categories: one group consists of eight-celled colonies: the cells are relatively large (up to 50 μ in diameter); the external surface of each cell is scabrate (pl. 18, fig. 19). These colonies can be assigned to Form C. of Manum & Cookson (1964). Specimens of the other group bear smaller cells (ca. 20 μ in diameter); there are from 16 to at least 40 cells per colony; the external surface of each cell is laevigate to sparsely granulose (pl. 18, fig. 18). These colonies can be assigned to Form A of Manum & Cookson.

It is not yet established which features of Palambages are significant at the species level. Rather than following the procedure of O. Wetzel (1961) and Górká (1963) in employing specific names, the present author follows Manum & Cookson in using temporary, non-specific designations.

Stratigraphic distribution: Loc. 1, extremely rare to rare throughout the section; Loc. 2, extremely rare in sample 164; Loc. 3, extremely rare in sample 157, rare in sample 158; Loc. 5, extremely rare to rare throughout the section; Loc. 6, extremely rare to rare throughout the section..

Previously-reported occurrences of Palambages: Cretaceous of the Baltic region (O. Wetzel, 1933, 1947, 1953a, 1961); Maestrichtian of Poland (Górka, 1963); Campanian-Genomanian of Arctic Canada (Manum & Cookson, 1964); Maestrichtian of Texas (Zaitzeff & Cross, 1970); Campanian-Maestrichtian of NWT, Canada (McIntyre, 1974).

Order Volvocales

Family Lecaniella

Genus Paralecaniella Cookson & Eisenack 1970

Paralecaniella indentata (Deflandre & Cookson 1955)
Cookson & Eisenack 1970

Plate 18, figs. 16-17

- 1955 Epicephalopyxis indentata Deflandre & Cookson: 292-293, pl. 9, figs. 5-7; text-fig. 56.
- 1965 Epicephalopyxis indentata Deflandre & Cookson; Cookson & Eisenack: 145.
- 1967 Epicephalopyxis indentata Deflandre & Cookson; Cookson & Eisenack: 136-137.
- ?1967 Epicephalopyxis indentata Deflandre & Cookson; Clarke & Verdier: 78, pl. 1, fig. 5.
- 1970 Paralecaniella indentata (Deflandre & Cookson) Cookson & Eisenack: 321-323, text-fig. 1.

Comments: Maryland-Delaware specimens of Paralecaniella indentata appear identical, in both morphology and size, with the type specimens of Deflandre & Cookson (1955).

Dimensions: Observed range (25 specimens measured): 58-96u in diameter.

Stratigraphic distribution: Loc. 1, extremely rare in samples 166 and 170; Loc. 2, extremely rare in samples 164 and 165; Loc. 4, extremely rare in samples 159; Loc. 5, extremely rare in samples 151-154; Loc. 6, extremely rare to sparse throughout the section.

Previously-reported occurrences: Paleocene to Upper Eocene(?), Miocene(?) of Australia (Deflandre & Cookson, 1955); Middle to Upper Paleocene of Australia (Cookson & Eisenack, 1965, 1967); Cenomanian to Senonian (Santonian) of England (Clarke & Verdier, 1967); Vraconian of France (Davey & Verdier, 1973).

Phylum PROTOZOA

Family incertae sedis Ophiobolidae Deflandre 1952

Genus Ophiobolus O. Wetzel 1933 Emend. Evitt 1967

Ophiobolus lapidaris O. Wetzel 1933

Plate 18, fig. 20

- 1933 Ophiobolus lapidaris O. Wetzel: 167-179, pl. 2, figs. 30-34; text-figs. 5-7.
- 1935 Ophiobolus lapidaris O. Wetzel; Deflandre: pl. 5, fig. 4; text-fig. 2.
- 1936a Ophiobolus lapidaris O. Wetzel; Deflandre: text-figs. 85-89.
- 1936b Ophiobolus lapidaris O. Wetzel; Deflandre: 7 (Multicop.), pl. 1, figs. 1-5.

- 1952 Ophiobolus lapidaris O. Wetzel; Deflandre in Piveteau: 130, figs. 144-150.
- 1952 Ophiobolus lapidaris O. Wetzel; Deflandre in Grasse: text-figs. 434 A, 435 A-E.
- 1961 Ophiobolus lapidaris O. Wetzel; Alberti: 34.
- 1966 Ophiobolus lapidaris O. Wetzel; Deflandre: 2.
- 1967 Scuticabolus lapidaris (O. Wetzel) Loeblich: 68-69.
- 1968 Ophiobolus lapidaris O. Wetzel; Evitt: 1-9, pl. 1, figs. 1-12; text-figs. 1-6.
- 1968 Ophiobolus lapidaris O. Wetzel; Morgenroth: 557, pl. 48, fig. 7.
- 1974 Ophiobolus lapidaris O. Wetzel; McIntyre: pl. 13, fig. 7.

Comments: Maryland specimens of Ophiobolus lapidaris are ellipsoidal, bearing one to three flagella at one pole. The external surface of the cyst is laevigate or faintly to distinctly granulose; as noted by Evitt (1968), the grana may coalesce into low vermiform ridges.

The two specimens recovered from the Brightseat Formation, unless reworked, represent the first-reported occurrence of O. lapidaris from Tertiary strata of North America.

Dimensions: Observed range (12 specimens measured): length 36-53u (mean 44u), width 16-26 (mean 21u).

Stratigraphic distribution: Loc. 1, extremely rare in sample 166, rare in sample 167, and extremely rare in sample 170; Loc. 2, extremely rare in sample 164; Loc. 3, extremely rare in sample 156; Loc. 4, extremely rare in samples 160-161; Loc. 5, extremely rare to rare throughout the section.

Previously-reported occurrences: Senonian-Danian of northern Germany (O. Wetzel, 1933); ?Senonian of France (Deflandre, 1935, 1936, 1953, 1966); Turonian of Germany (Alberti, 1961); Campanian-Maestrichtian of New Jersey, Alabama, Texas, and Kansas (Evitt, 1968); Danian of Denmark (Morgenroth, 1968); Campanian-Santonian of NWT, Canada (McIntyre, 1973).

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ILLUSTRATIONS OF FOSSILS

Explanation of Plates

VPISUPL denotes samples deposited in the Palynology Laboratory of Virginia Polytechnic Institute and State University, Blacksburg, Virginia. For elongate, unornamented specimens, the length and width are given by L x W, and are recorded in microns, represented by the symbol "u." For ornamented specimens, the length and width (L x W) of the main body of the cyst are given first, followed by the overall length and width. For spherical, unornamented specimens, the diameter is given; for spherical specimens with ornamentation, the diameter of the main body is given, followed by the overall diameter. Coordinates of a specimen on a slide are given in millimeters measured from the lower left-hand corner of the coverslip; the number preceded by "R" indicates millimeters to the right of the corner of the coverslip, whereas the number preceded by "+" indicates millimeters toward the top of the coverslip. For example, R10.3, +7.4 indicates 10.3mm to the right of the lower left-hand corner of the coverslip, and 7.4mm toward the top of the coverslip.

Plate 1

- FIGS. 1-2. Dinogymnium acuminatum Evitt, Clarke & Verdier 1967. Several views of one specimen. Fig. 1, dorsal view; Fig. 2, ventral view (focused through specimen). L x W: 94 x 72u. VPISUPL sample 121, slide AD 62, coords. R1.9, +2.8.
- FIGS. 3-4. Dinogymnium euclaensis Cookson & Eisenack 1970. Fig. 3, dorsal view. Specimen L x W: 32 x 24u. VPISUPL sample 116, slide AD 45, coords. R19.2, +10.4. Fig. 4, ventral view of another specimen. Specimen L x W: 34 x 30u. VPISUPL sample 122, slide AD 73, coords. R1.9, +11.1.
- FIGS. 5-7. Dinogymnium digitus (Deflandre 1935) Evitt, Clarke & Verdier 1967. All are ventral views. Specimen array shows morphological variation from a laevigate to a granulose external surface. Fig. 5, specimen L x W: 65 x 17u. VPISUPL sample 122, slide AD 64, coords. R10.4, +1.4. Fig. 6, specimen L x W: 60 x 22u. VPISUPL sample 122, slide AD 63, coords. R5.6, +6.1. Fig. 7, specimen L x W: 61 x 23u. VPISUPL sample 122, slide AD 73, coords. R15.0, +12.1.
- FIGS. 8-9. Dinogymnium sp. Dorsal view of two specimens. Note relatively long epittract, distally-acuminate hypottract, denticulate costae. Fig. 8, specimen L x W: 80 x 32u. VPISUPL sample 155, slide AE 97, coords. R5.1, +7.4. Fig. 9, specimen L x W: 114 x 37u. VPISUPL sample 153, slide AE 75, coords. R10.6, +19.6.
- FIG. 10. Dinogymnium westralium (Cookson & Eisenack 1958) Evitt, Clarke & Verdier 1967. Fig. 10, lateral view, displays broadly-rounded apex and acuminate antapex. L x W: 51 x 29u. VPISUPL sample 151, slide AE 52, coords. R16.1, +15.6.
- FIGS. 11-13. Cannosphaeropsis utinensis O. Wetzel 1933. Fig. 11, lateral view of complete specimen. Main body L x W: 70 x 50u; overall L x W: 140 x 81u. VPISUPL sample 122, slide AD 65, coords. R13.5, +17.7. Fig. 12, detail view of tangential rods of Fig. 11. Length of viewed portion of specimen, 48u. Fig. 13, detail view of tangential rod of another specimen. Length of viewed portion of specimen, 50u. VPISUPL sample 122, slide AD 76, coords. R13.0, +8.0.

PLATE I

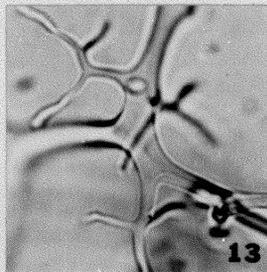
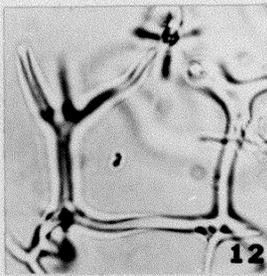
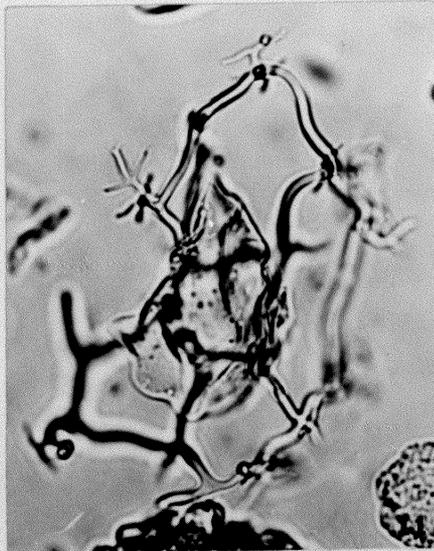
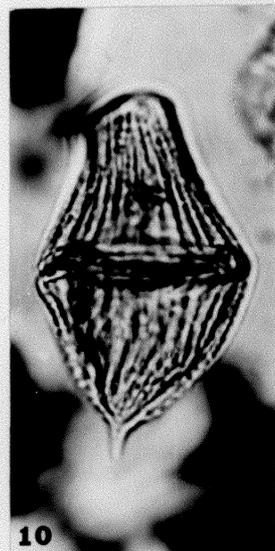
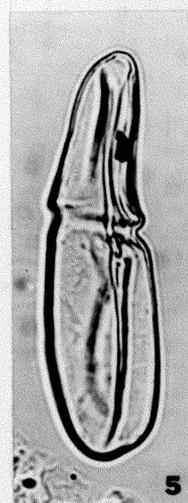
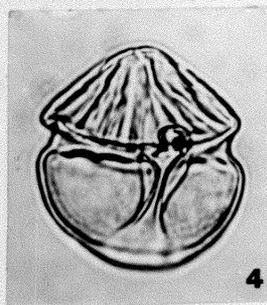
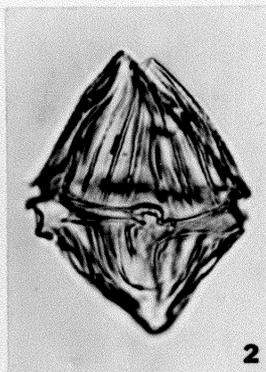
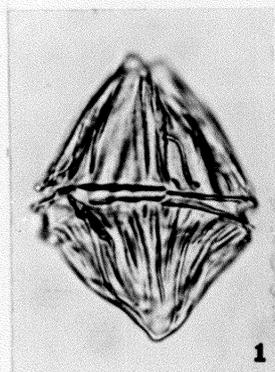


Plate 2

- FIGS. 1-9. Trichodinium hirsutum Cookson 1965. Array of members of a population shows range of morphological variation. Fig. 1, cross-sectional view, displays apical tuft of processes and random distribution of remaining processes. Main body L x W: 134 x 114u. VPISUPL sample 157, slide AF 15, coords. R3.7, +5.9. Fig. 2 and Fig. 3, cross-sectional and ventral view, respectively, of one specimen. Note discrete processes, randomly distributed. Main body L x W: 106 x 88u; overall L x W: 130 x 114u. VPISUPL sample 157, slide AF 15, coords. R3.6, +4.8. Fig. 4, dorsal view. Discrete processes are aggregated into fields outlining plate-equivalents. Main body diameter, 85u; overall L x W: 121 x 117u. VPISUPL sample 157, slide AF 18, coords. R18.4, +3.4. Fig. 5, ventral view, and Fig. 8, cross-sectional view of one specimen. Note fusion of processes and their aggregation into fields outlining plate-equivalents. Main body L x W: 87 x 78u; overall diameter, 123u. VPISUPL sample 157, slide AF 17, coords. R10.0, +9.0. Fig. 6, dorsal view showing outline of archeopyle, and Fig. 7, cross-sectional view of one specimen. Main body L x W: 90 x 82u; overall L x W: 122 x 121u. VPISUPL sample 157, slide AF 17, coords. R13.2, +13.0. Fig. 9, lateral view. Note delineation of pre-cingular, cingular, and post-cingular plate-equivalents. Main body L x W: 85 x 76u; overall L x W: 116 x 101u. VPISUPL sample 157, slide AF 17, coords. R6.0, +11.0.
- FIGS. 10-12. Trichodinium castanea (Deflandre 1935) Clarke & Verdier 1967. Fig. 10, dorsal view, shows archeopyle outline (slightly distorted) and alignment of processes along margins of cingulum. Main body diameter, 60u; overall L x W: 72 x 66u. VPISUPL sample 123, slide AD 79, coords. R4.8, +7.5. Fig. 11, cross-sectional view of same specimen. Note tuft of slightly longer processes at apex. Fig. 12, ventral view (focused through specimen) displaying levorotatory displacement of ends of cingulum. Main body L x W: 92 x 78u; overall L x W: 102 x 88u. VPISUPL sample 122, slide AD 76, coords. R9.2, +8.7.
- FIGS. 13-16. Exochosphaeridium bifidum (Clarke & Verdier 1967) Clarke et al. 1968. Fig. 13, dorsal view showing outline of archeopyle; Fig. 14, cross-sectional view displaying apical cluster of processes. Main body L x W: 76 x 69u; overall L x W: 108 x 100u. VPISUPL sample 160, slide

AF 33, coords. R19.8, +6.7. Fig. 15, cross-sectional view of specimen bearing relatively numerous processes. Main body L x W: 79 x 60u; overall L x W: 90 x 91u. VPISUPL sample 159, slide AF 31, coords. R3.6, +6.0. Fig. 16, dorsal view of specimen with relatively thick periphragm and endophragm, and relatively robust processes. Main body L x W: 84 x 82u; overall L x W: 146 x 142u. VPISUPL sample 122, slide AD 76, coords. R7.7, +11.2.

PLATE 2

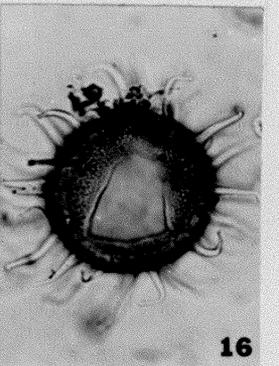
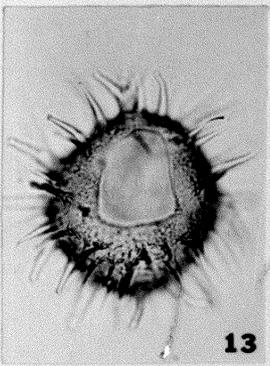
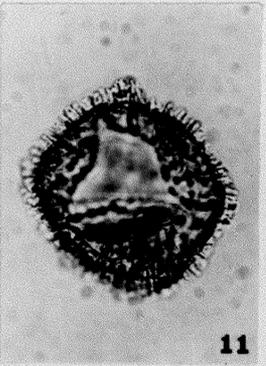
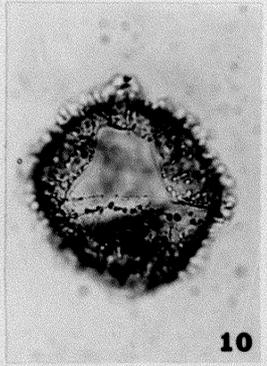
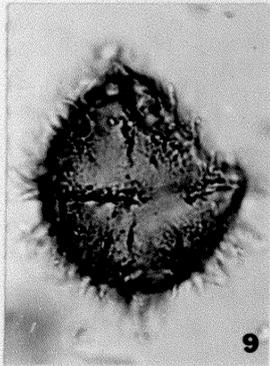
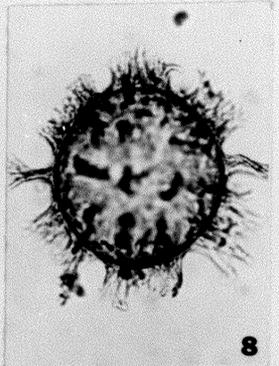
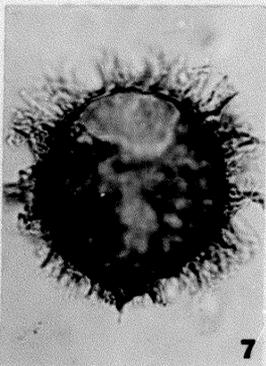
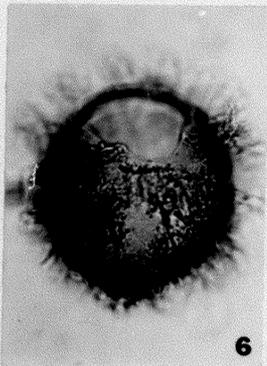
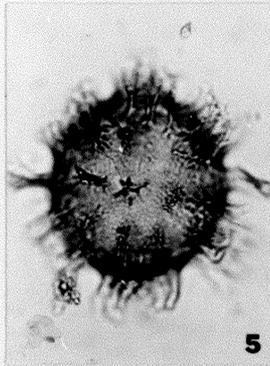
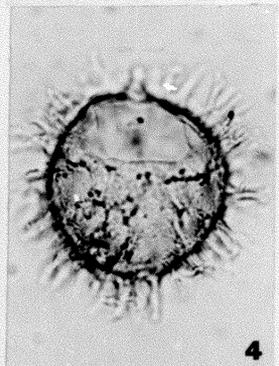
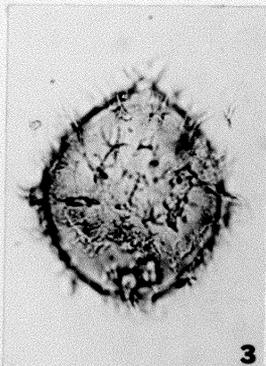
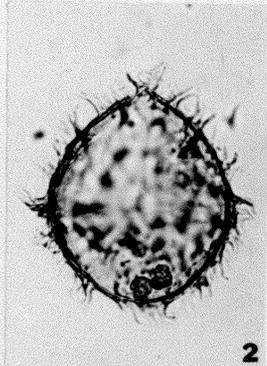
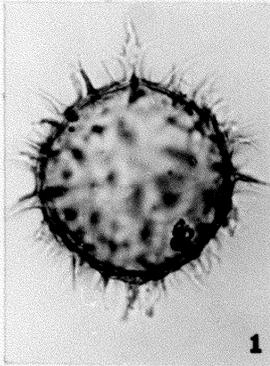


Plate 3

- FIGS. 1-2. Exochosphaeridium phragmites Davey et al. 1966. Fig. 1, ventral view (focused through specimen). Note apical cluster of processes; Fig. 2, dorsal view. Main body L x W: 88 x 86u; overall L x W: x 111u. VPISUPL sample 152, slide AE 68, coords. R3.0, +3.2.
- FIGS. 3-8. Danea mutabilis Morgenroth 1968. Fig. 3, dorsal view showing archeopyle outline and quill-like extension of periphragm at apex. Main body L x W: 106 x 91u; overall L x W: 193 x 160u. VPISUPL sample 157, slide AF 16, coords. R9.5, +7.0. Fig. 4, lateral view of hypotract, showing annulate post-cingular process (3'''); Fig. 5, detail view of 3''' process. Note microreticulate external surface of periphragm. Main body L x W: 124 x 110u; overall L x W: 210 x 201u. VPISUPL sample 157, slide AF16, coords. R2.3, +9.9. Figs. 6 and 7, lateral (high focus level) and cross-sectional view, respectively, of one specimen. Main body L x W: 124 x 94u; overall L x W: 185 x 135u. VPISUPL sample 157, slide AF 17, coords. R8.6, +11.9. Fig. 8, dorsal view. Main body L x W: 110 x 94u; overall L x W: 206 x 172u. VPISUPL sample 157, slide AF 16, coords. R7.8, +5.5.
- FIGS. 9-10. Coronifera oceanica Cookson & Eisenack 1958. Both are ventral views displaying numerous, slender processes and a relatively large antapical process. Fig. 10 displays striations radiating out from base of each process.
 Fig. 9, main body L x W: 58 x 47u; overall L x W: 88 x 68u. VPISUPL sample 154, slide AE 94, coords. R9.0, +5.3. Fig. 10, main body L x W: 60 x 56u; overall L x W: 84 x 66u. VPISUPL sample 152, slide AE 68, coords. R7.3, +19.2.
- FIG. 11. Diphyes colligerum (Deflandre & Cookson 1955) Davey & Williams 1966. Ventral view displays numerous, distally-tapering processes and a relatively large antapical process. Main body diameter, 38u; overall diameter, 70u. VPISUPL sample 157, slide AF 18, coords. R3.0, +15.3.
- FIGS. 12-13. Hystrichokolpoma fimbriata Morgenroth 1968. Fig. 12, lateral view showing intratabular complexes of low ridges outlining plate-equivalents. Main body L x W: 48 x 44u; overall L x W: 69 x 70u. VPISUPL sample 159, slide AF 30, coords. R5.7, +15.9. Fig. 13, lateral view displaying slender processes situated at corners of

intratabular ridges and linked by a membrane. Main body L x W: 74 x 57u; overall L x W: 112 x 92u. VPISUPL sample 120, slide AD 60, coords. R13.5, +1.0.

FIGS. 14-15. Hystrichokolpoma sp. Figs. 14 and 15, dorsal and cross-sectional view, respectively, of one specimen. Fig. 15 shows apical archeopyle bearing apical processes and one small central process. Main body L x W: 88 x 6u; overall L x W: 106 x 109u. VPISUPL sample 165, slide AF 68, coords. R2.2, +8.7.

FIG. 16. Florentinia laciniata Davey & Verdier 1973. Dorsal view shows combination archeopyle (Type $\bar{A}a + P$) formed by release of apical plate-equivalents and plate-equivalent 3''. Main body diameter, 52u; overall diameter, 82u. VPISUPL sample 158, slide AF 22, coords. R14.3, +5.4.

PLATE 3

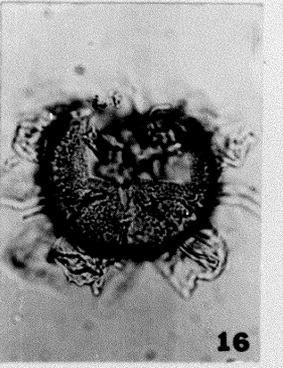
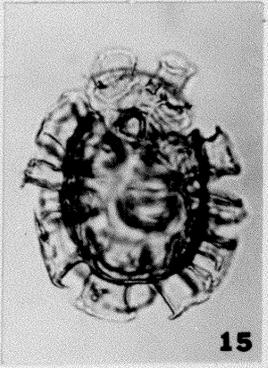
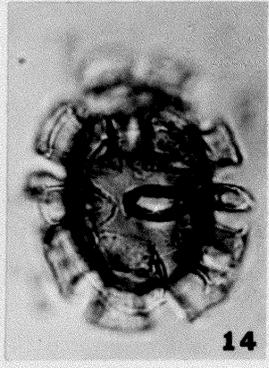
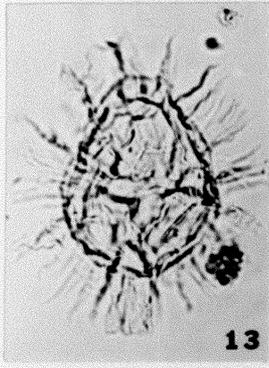
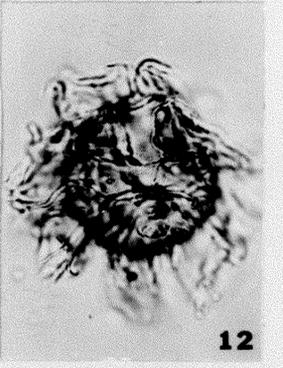
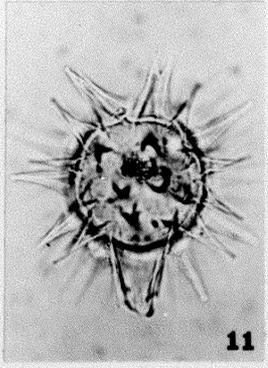
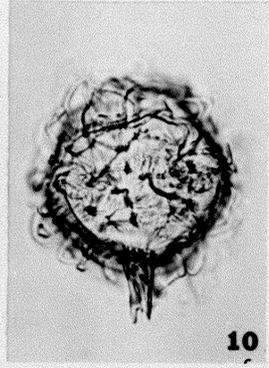
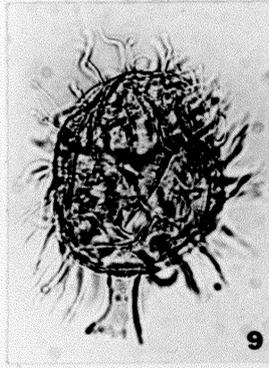
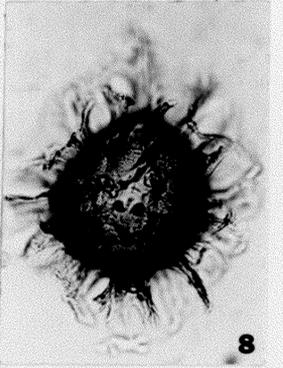
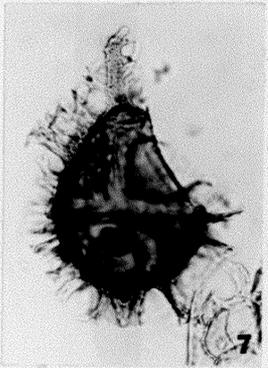
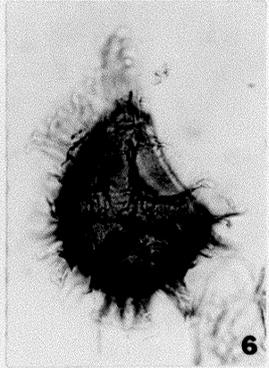
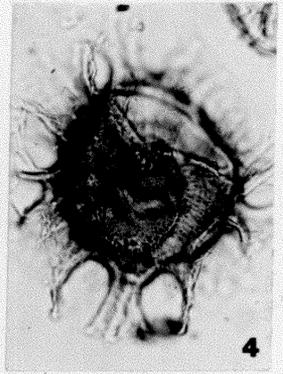
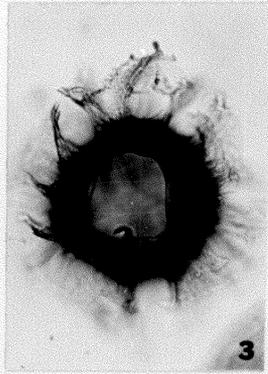
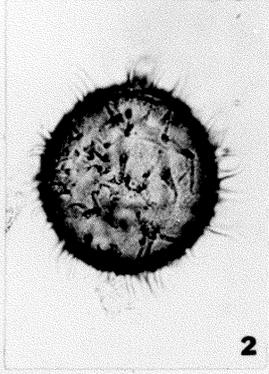
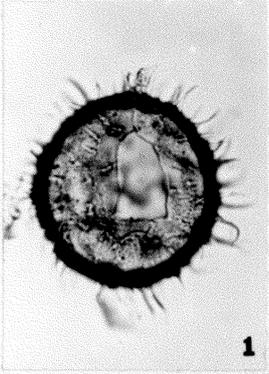


Plate 4

- FIGS. 1-3. Florentinia laciniata Davey & Verdier 1973 (cont. from Plate 3). Fig. 1, lateral hypotractal view displaying large post-cingular processes and elongate cingular processes bearing a subsidiary process at each end. Main body L x W: 60 x 50u; overall L x W: 91 x 88u. VPISUPL sample 157, slide AF 19, coords. R10.7, +7.2. Fig. 2, ventral view showing large 5'' process, small 6'' process, and small sulcal processes with bases joined by low membranous ridge. Main body L x W: 50 x 49u; overall L x W: 71 x 78u. VPISUPL sample 160, slide AF 34, coords. R3.7, +4.3. Fig. 3, ventral hypotractal view displaying posterior sulcal process, lp process, and 1'''' process. Width of main body, 62u; overall width, 102u. VPISUPL sample 122, AD 76, coords. R17.6, +12.4.
- FIGS. 4-7. Samlandia chlamydophora Eisenack 1954. Fig. 4, dorsal view showing archeopyle outline, with gabled anterior margin, and relatively high pillars of endophragm at apex and antapex; Fig. 5, ventral view of same specimen. Main body L x W: 71 x 60u; overall L x W: 83 x 77u. VPISUPL sample 123, AD 79, coords. R9.4, +12.0. Fig. 6, detail of wall displaying pillars up to 8u in height. VPISUPL sample 122, coords. AD 73, R19.1, +15.3. Fig. 7, apical view displaying two elongate apical plate-equivalents. VPISUPL sample 122, slide AD 63, coords. R5.4, +11.3.
- FIGS. 8-10. Scriniodinium australense (Deflandre & Cookson 1955) Eisenack 1967. Fig. 8, dorsal view of spheroidal specimen, showing shape of archeopyle. Note apical and antapical extensions of periphragm. Main body L x W: 89 x 82u; overall L x W: 128 x 97u. VPISUPL sample 157, slide AF 15, coords. R12.3, +10.9. Figs. 9 and 10, ventral and cross-sectional view, respectively, of ovoidal specimen. Patchy thickenings of periphragm outline plate-equivalents. Main body L x W: 108 x 93u; overall L x W: 148 x 112u. VPISUPL sample 157, slide AF 18, coords. R19.4, +11.8.
- FIGS. 11-12. Hystrichosphaeropsis complanata Eisenack 1965. Fig. 11, dorsal view showing archeopyle outline and faintly-expressed cingulum and plate-equivalents 2' and 3'; Fig. 12, ventral view of same specimen, displays faintly-expressed plate-equivalents 1' and 2'. Endoblast L x W: 60 x 68u; overall L x W: 112 x 72u. VPISUPL sample 157, slide AF 18, coords. R15.6, +14.4.

FIGS. 13-15. Gonyaulacysta wetzeli (Lejeune-Carpentier 1939) Sarjeant 1969. Fig. 13, dorsal view; Fig. 15, ventral view of same specimen (focused through specimen), showing levo-rotatory displacement of ends of cingulum. Overall L x W: 128 x 108u. VPISUPL sample 159, slide AF 28, coords. R4.9, +14.8. Fig. 14, ventral view. Note shapes of plate-equivalents 1''' and 6''', and subdivisions of flask-shaped sulcus. Overall L x W: 104 x 100u. VPISUPL sample 164, slide AF 59, coords. R5.8, +5.9.

PLATE 4

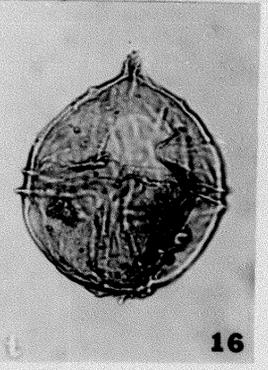
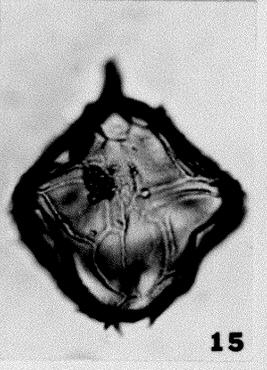
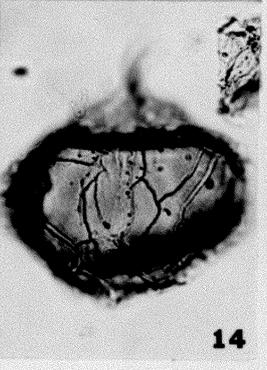
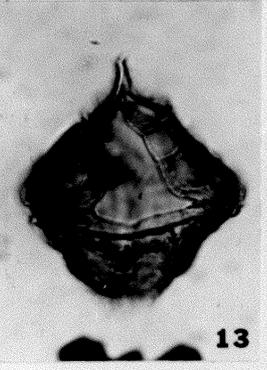
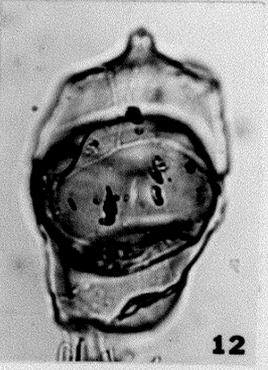
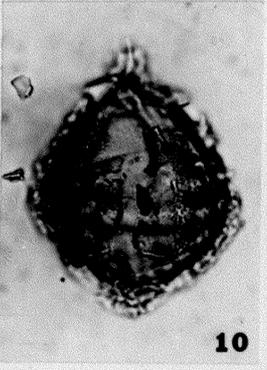
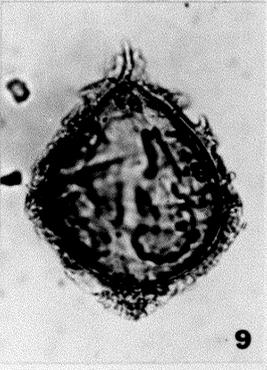
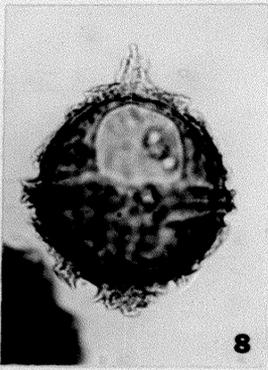
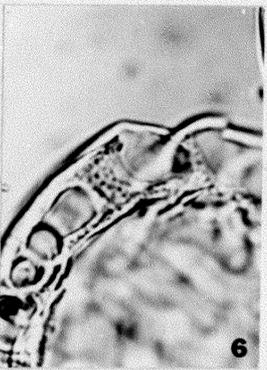
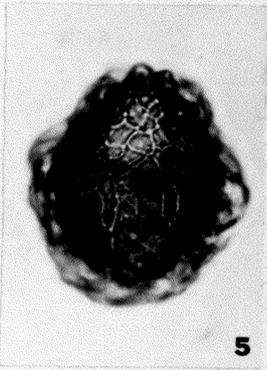
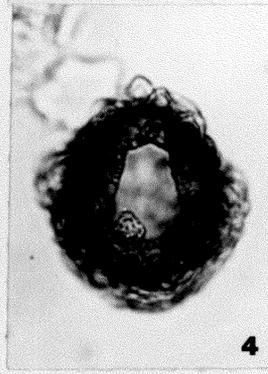
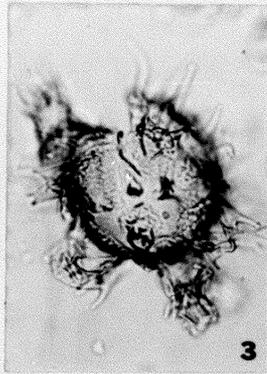
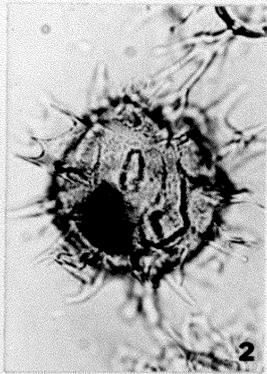
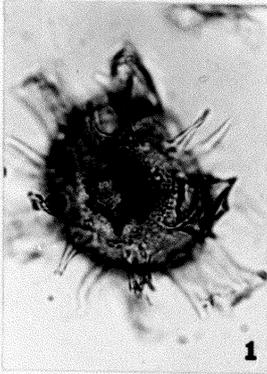


Plate 5

- FIG. 1. Gonyaulacysta giusepei (Morgenroth 1966) Sarjeant 1969 (continued from Plate 4). Ventral view. Overall L x W: 108 x 95u. VPISUPL sample 152, slide AE 64, coords. R3.1, +20.6.
- FIGS. 2-5. Cyclonephelium distinctum Deflandre & Cookson 1955. Morphological variation within a population of C. distinctum is typified by specimens in array. Fig. 2, ventral view displaying relatively short, sparse processes. Main body L x W: 62 x 72u (L measured from archeopyle margin to antapex); overall L x W: 76 x 86u. VPISUPL sample 123, slide AD 79, coords. R10.0, +18.8. Figs. 2 and 3, ventral and dorsal view, respectively, of specimen with relatively long, numerous processes. Main body L x W: 48 x 54u; overall L x W: 62 x 71u. VPISUPL sample 116, slide AD 47, coords. R9.5, +13.2. Fig. 5, dorsal view displaying an occasional relatively broad process, and longer processes at antapex. Main body L x W: 72 x 82u; overall L x W: 102 x 97u. VPISUPL sample 117, slide AD 52, coords. R16.1, +4.6.
- FIGS. 6-7. Cyclonephelium vitilare Cookson 1965. Fig. 6, dorsal hypotractal view displaying reniform l'''' plate-equivalent. Main body width 65u, overall width 70u. VPISUPL sample 160, slide AF 34, coords. R14.1, +11.6. Fig. 7, ventral view, shows meridional belts of periphragm confined to lateral portions of cyst. Main body L x W: 71 x 69u (L measured from archeopyle margin to antapex); overall L x W: 77 x 75u. VPISUPL sample 163, slide AF 55, coords. R5.7, +8.8.
- FIGS. 8-11. Renidinium cf. R. membraniferum Morgenroth 1968. Figs. 8 and 9, dorsal views, display thickened rims of periphragm outlining plate-equivalents. Fig. 8, main body L x W: 51 x 55u (L measured from archeopyle margin to antapex); overall L x W: 55 x 60u. VPISUPL sample 163, slide AF 55, coords. R15.3, +6.2. Fig. 9, main body L x W: 64 x 75u (L measured from archeopyle margin to antapex); overall L x W: 73 x 80u. VPISUPL sample 154, coords. R10.6, +16.8. Fig. 10, ventral view of Fig. 8, focused through specimen. Fig. 11, complete specimen. Note well-developed apical lobe expressed in both endophragm and periphragm. Main body L x W: 62 x 56u; overall L x W: 75 x 64u. VPISUPL sample 159, coords. R13.1, +11.0.

- FIG. 12. Diconodinium glabrum Cookson & Eisenack 1960. Ventral view. Main body L x W: 42 x 30u; overall L x W: 49 x 36u. VPISUPL sample 153, slide AE 75, coords. R14.4, +1.9.
- FIGS. 13-19. Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937. Figs. 13 and 14, lateral views of one specimen (sulcus at left margin of cyst). Fig. 13, focused through specimen, displays hachure-like marks at base of each process. Main body L x W: 46 x 44u; overall L x W: 92 x 98u. VPISUPL sample 157, slide AF 16, coords. R12.0, +11.6. Fig. 15, ventral view, shows small pair of processes flanking sulcus. Main body L x W: 50 x 47u; overall L x W: 102 x 110u. VPISUPL sample 157, slide AF 17, coords. R10.9, +10.3. Fig. 16, dorsal view. Main body L x W: 55 x 49u; overall L x W: 115 x 106u. VPISUPL sample 157, slide AF 19, coords. R10.8, +3.9. Figs. 17-18, apical views showing angular outline of archeopyle. Fig. 17, main body diameter 56u, overall diameter 130u. VPISUPL sample 157, slide AF 19, coords. R20.0, +7.6. Fig. 18, main body diameter 67u, overall diameter 137u. VPISUPL sample 158, slide AF 22, coords. R21.3, +17.6. Fig. 19, cross-sectional view at level of cingulum. Main body diameter 40u, overall diameter 88u. VPISUPL sample 156, slide AF 11, coords. R6.8, +20.2.
- FIG. 20. Oligosphaeridium complex (White 1842) Davey & Williams 1966. Ventral view. Main body L x W: 48 x 46u (L measured from archeopyle margin to antapex); overall L x W: 104 x 114u. VPISUPL sample 157, slide AF 16, Coords. R6.4, +2.0.

PLATE 5

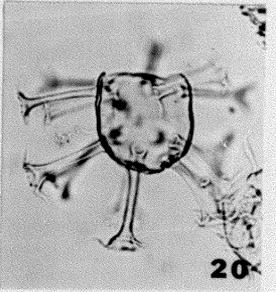
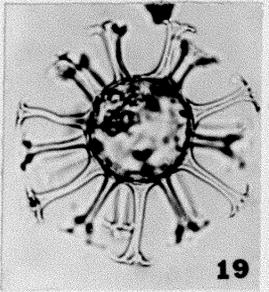
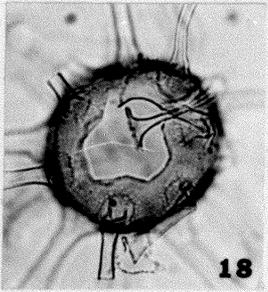
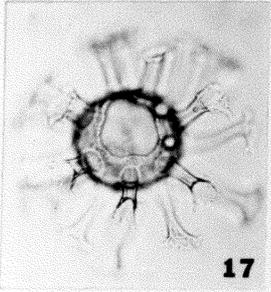
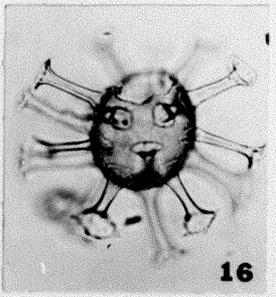
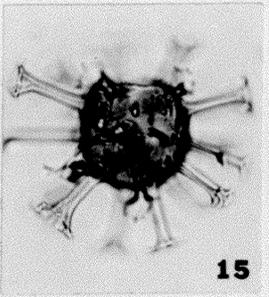
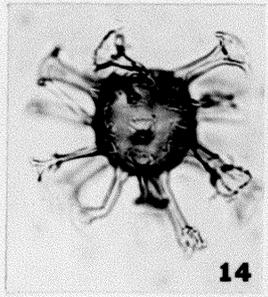
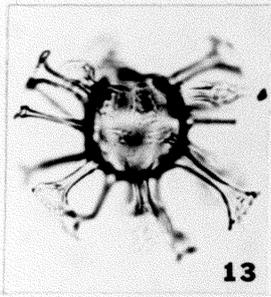
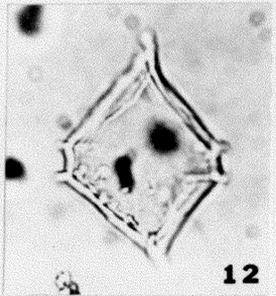
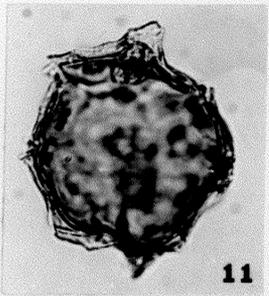
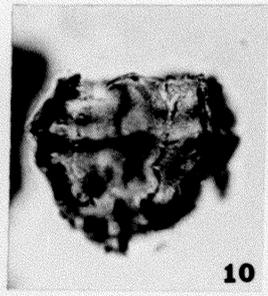
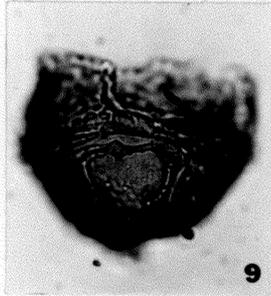
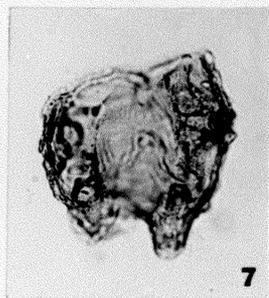
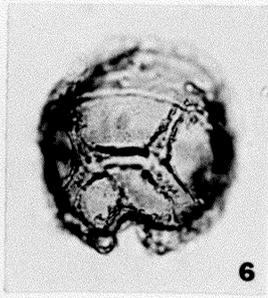
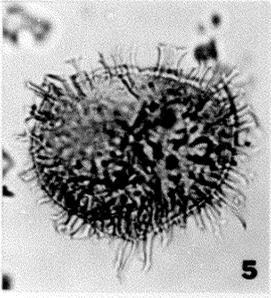
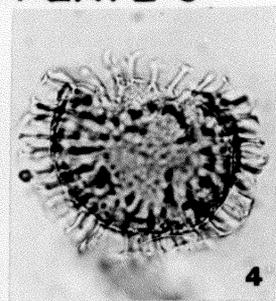
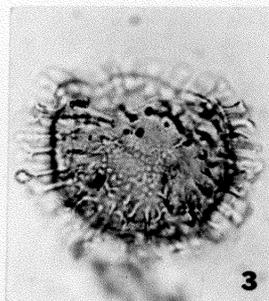
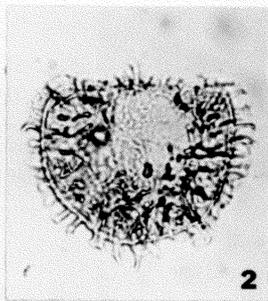
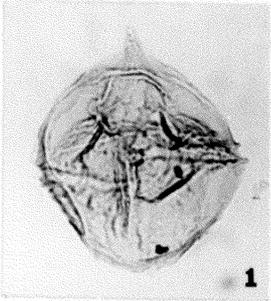


Plate 6

- FIGS. 1-11. Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963. Specimen array displays morphological variation within a population of C. inodes. Figs. 1 and 2, dorsal and cross-sectional view, respectively, of one specimen. Note archeopyle outline and relatively long processes, one per plate-equivalent. Main body L x W: 100 x 92u, overall L x W: 197 x 158u. VPISUPL sample 157, slide AF 16, coords. R9.8, +6.6. Fig. 3, dorsal view. Main body L x W: 96 x 90u; overall L x W: 170 x 150u. VPISUPL sample 157, slide AF 16, coords. R5.0, +5.5. Fig. 4, ventral view. Note anterior and posterior sulcal processes and pair of small processes flanking sulcus. Main body L x W: 102 x 94u; overall L x W: 200 x 170u. VPISUPL sample 165, slide AF 68, coords. R4.8, +6.6. Fig. 5, ventral view of specimen bearing relatively slender processes. Main body L x W: 102 x 92u; overall L x W: 206 x 210u. VPISUPL sample 165, slide AF 67, coords. R15.2, +13.2. Fig. 6, cross-sectional view of specimen bearing a spheroidal main body. Main body diameter 77u, overall diameter 138u. VPISUPL sample 162, slide AF 47, coords. R14.6, +2.9. Fig. 7, lateral epittractal view showing quadrate cross-section of 2'' process. Main body L x W: 89 x 81u; overall L x W: 162 x 136u. VPISUPL sample 157, slide AF 17, coords. R14, +13.5. Figs. 8 and 9, dorsal and cross-sectional view, respectively, of a specimen displaying relatively short processes. Main body diameter 106u; overall L x W: 180 x 148u. VPISUPL sample 157, slide AF 16, coords. R1.8, +9.7. Figs. 10 and 11, dorsal and cross-sectional view, respectively, of a specimen possessing still shorter processes. Main body L x W: 98 x 92u; overall L x W: 153 x 128u. VPISUPL sample 162, slide AF 48, coords. R2.1, +18.9.
- FIGS. 12-13. Cordosphaeridium cf. C. inodes. Figs. 12 and 13, dorsal and cross-sectional view, respectively, of one specimen. Main body L x W: 98 x 107u; overall L x W: 195 x 176u. VPISUPL sample 162, slide AF 49, coords. R14.5, +4.5.
- FIGS. 14-16. Cordosphaeridium brevitrunctum n. sp. Figs. 14 and 15, dorsal and cross-sectional view, respectively, of HOLOTYPE. Main body L x W: 60 x 55u; overall L x W: 78 x 72u. VPISUPL sample 160, slide AF 32, coords. R6.8, +6.9. Fig. 16, cross-sectional view of specimen with relatively short processes. Main body L x W: 72 x 64u;

overall L x W: 86 x 75u. VPISUPL sample 160, slide AF
35, coords. R6.3, +10.7.

PLATE 6

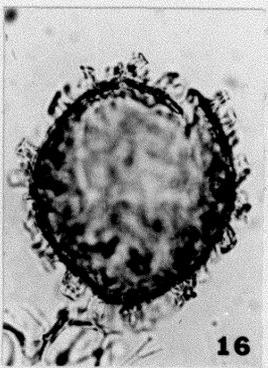
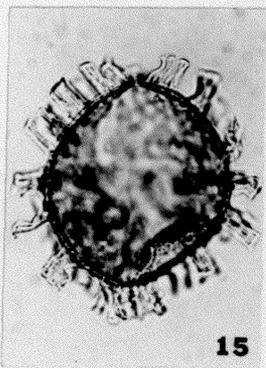
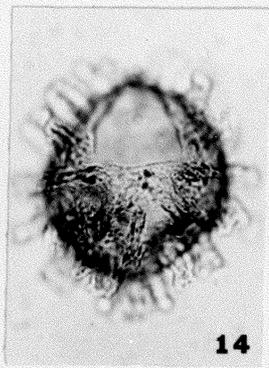
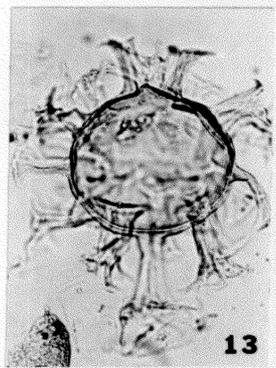
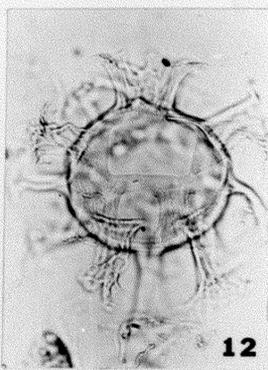
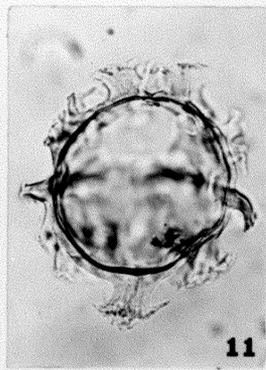
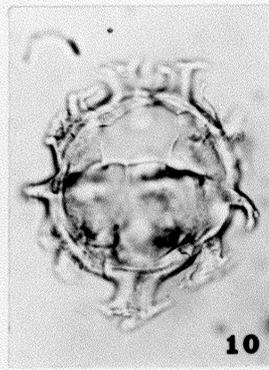
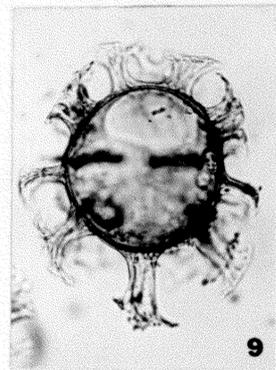
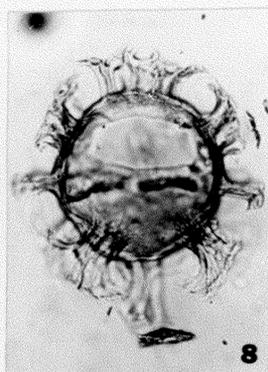
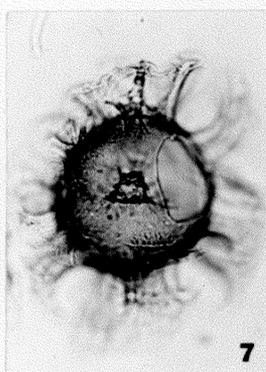
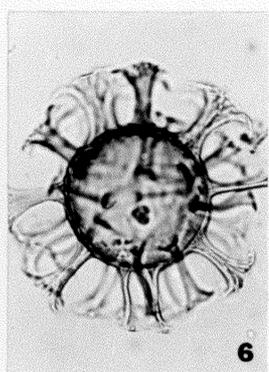
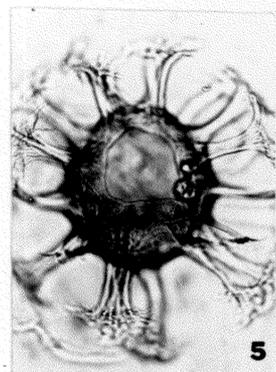
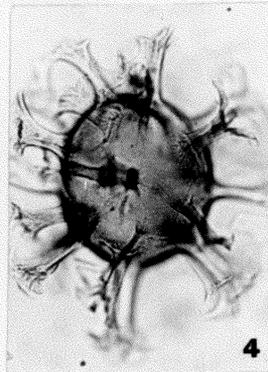
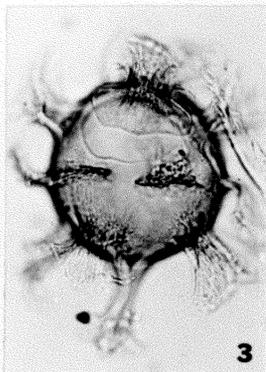
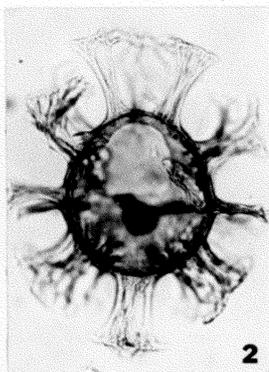
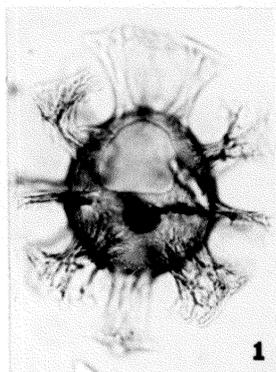


Plate 7

- FIGS. 1-4. Cordosphaeridium eoinodes (Eisenack 1958) Eisenack 1968. Fig. 1, dorsal view displaying archeopyle outline and robust processes, one per plate-equivalent. Main body L x W: 64 x 57u; overall L x W: 105 x 114u. VPISUPL sample 160, slide AF 34, coords. R4.9, +7.8. Fig. 2, ventral view displaying small processes flanking sulcus. Main body L x W: 68 x 66u; overall L x W: 114 x 113u. VPISUPL sample 160, slide AF 35, coords. R3.7, +7.6. Fig. 3, detail view of sulcus showing anterior and posterior sulcal processes, in addition to small pairs of processes flanking sulcus; note process of plate-equivalent lp. Main body L x W: 61 x 58u; overall L x W: 114 x 115u. VPISUPL sample 160, slide AF 33, coords. R18.6, +12.9. Fig. 4, lateral hypotractal view, displays lunate base of 2'' process (focused through specimen). Main body L x W: 57 x 48u; overall L x W: 90 x 86u. VPISUPL sample 154, slide AE 89, coords. R9.9, +9.1.
- FIGS. 5-6. Cordosphaeridium fibrospinosum Davey & Williams 1966. Fig. 5, dorsal view. Main body L x W: 66 x 62u; overall L x W: 114 x 127u. VPISUPL sample 164, slide AF 60, coords. R18.9, +2.3. Fig. 6, lateral view, displays process fibers more loosely-bound than in Fig. 5. Main body L x W: 60 x 48u; overall L x W: 86 x 81u. VPISUPL sample 154, slide AE 94, coords. R5.3, +16.2.
- FIGS. 7-8. Lanternosphaeridium sp. Several views of one specimen. Fig. 7, cross-sectional view, displays apical protrusion involving both endophragm and periphragm. Fig. 8, ventral view (focused through specimen) displays antapical protrusion. Main body L x W: 125 x 80u; overall L x W: 172 x 148u. VPISUPL sample 157, slide AF 17, coords. R10.4, +17.2.
- FIGS. 9-10. Xenicodinium lubricum Morgenroth 1968. Several views of one specimen. Fig. 9, dorsal epittractal view showing archeopyle outline. Fig. 10, dorsal view. Fig. 11, cross-sectional view displaying nature of the densely-distributed spines. Main body diameter 44, overall diameter 55u. VPISUPL sample 157, slide AF 19, coords. R12.4, +9.8.
- FIGS. 12-13. Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967. Several views of one specimen. Fig. 12, dorsal view showing archeopyle outline. Fig. 13, cross-

sectional view displaying the numerous slender processes. Main body diameter 48u, overall diameter 78u. VPISUPL sample 157, slide AF 18, coords. R18.0, +14.3.

FIGS. 14-15. Operculodinium israelianum (Rossignol 1962) Wall 1967. Several views of one specimen. Fig. 14, dorsal view displaying archeopyle outline; Fig. 15, cross-sectional view showing the numerous short, slender processes. Main body diameter 59u, overall diameter 71u. VPISUPL sample 162, slide AF 47, coords. R17.7, +6.3.

PLATE 7

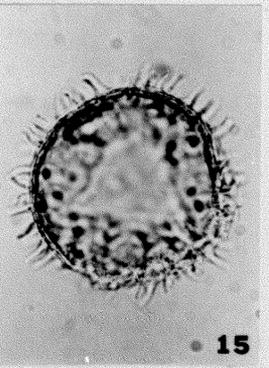
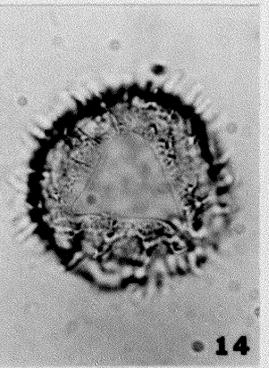
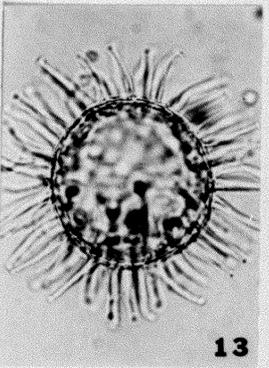
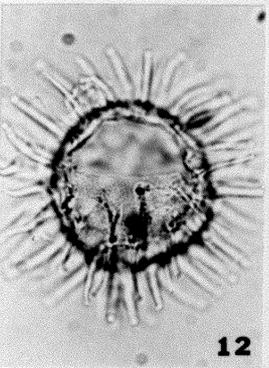
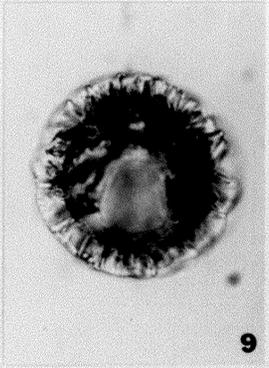
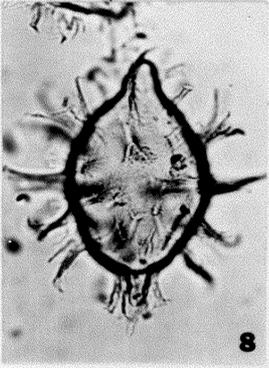
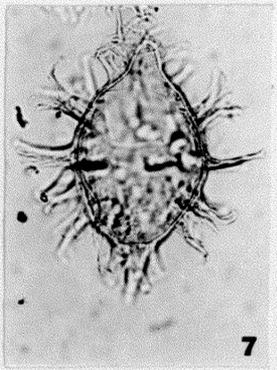
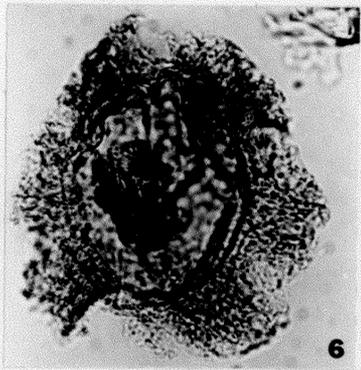
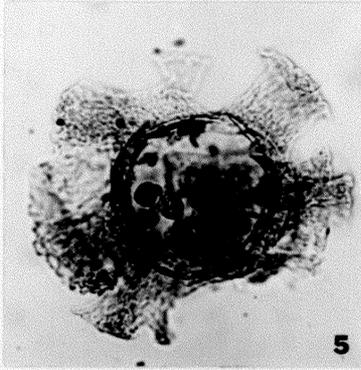
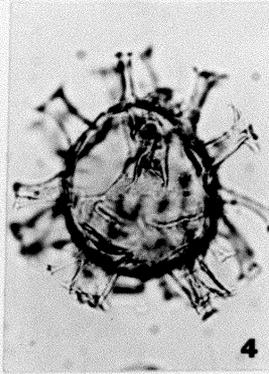
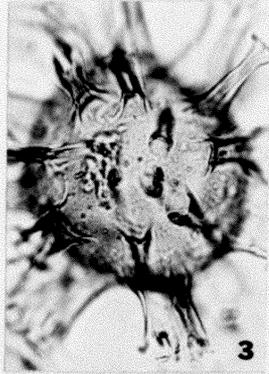
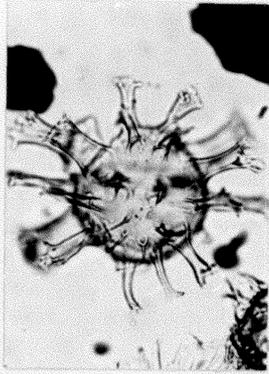
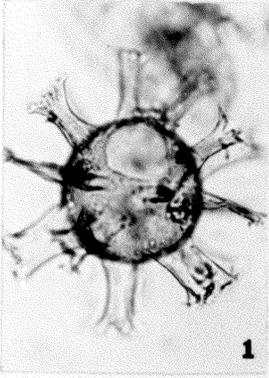
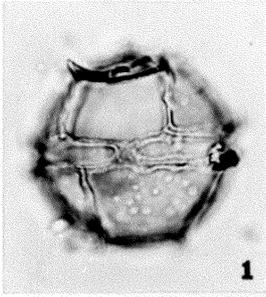


Plate 8

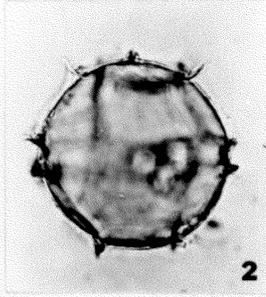
- FIGS. 1-4. Leptodinium dispertitum Cookson & Eisenack 1965. Figs. 1-3, several views of one specimen. Fig. 1, dorsal view; Fig. 2, cross-sectional view; Fig. 3, ventral view. Main body diameter 66u, overall diameter 72u. VPISUPL sample 157, slide AF 18, coords. R8.1, +5.9. Fig. 4, lateral view showing plate-equivalents 6'' and 6''' . Main body diameter 72u, overall diameter 80u. VPISUPL sample 157, slide AF 17, coords. R8.8, +14.0.
- FIGS. 5-8. Leptodinium elegans Cookson & Eisenack 1965. Figs. 5-7, several views of one specimen. Fig. 5, dorsal view; Fig. 6, cross-sectional view; Fig. 7, ventral view (focused through specimen). Main body diameter, 73u; overall L x W: 92 x 82u. VPISUPL sample 157, slide AF 15, coords. R13.2, +17.3. Fig. 8, ventral view. Main body L x W: 81 x 65u; overall L x W: 110 x 102u. VPISUPL sample 165, slide AF 67, coords. R8.6, +7.5.
- FIGS. 9-11. Leptodinium victorianum Cookson & Eisenack 1965. Several views of one specimen. Fig. 9, dorsal view (focused through specimen); Fig. 10, cross-sectional view; Fig. 11, ventral view. Main body L x W: 98 x 80u; overall L x W: 122 x 108u. VPISUPL sample 165, slide AF 70, coords. R11.1, +14.5.
- FIGS. 12-13. Spiniferites crassipellis (Deflandre & Cookson 1955) Sarjeant 1970. Several views of one specimen. Fig. 12, dorsal view; Fig. 13, cross-sectional view: note thickness of periphragm relative to endophragm. Main body diameter, 49u; overall diameter: 68u. VPISUPL sample 121, slide AD 62, coords. R14.1, +9.4.
- FIGS. 14-15. Spiniferites hypercanthus (Deflandre & Cookson 1955) n. comb. Fig. 14, dorsal view. Main body L x W: 54 x 50u; overall L x W: 82 x 80u. VPISUPL sample 165, slide AF 69, coords. R20.1, +4.6. Fig. 15, dorsal view. Note well-developed sutural folds at antapex. Main body L x W: 64 x 51u; overall L x W: 98 x 82u. VPISUPL sample 165, slide AF 67, coords. R19.4, +8.3.
- FIGS. 16-18. Spiniferites membranaceus (Rossignol 1964). Several views of one specimen. Fig. 16, apical view; Fig. 17, dorsal view; Fig. 18, cross-sectional view. Main body L x W: 52 x 48u; overall L x W: 90 x 96u. VPISUPL sample 162, slide AF 48, coords. R6.5, +12.0.

- FIG. 19. Spiniferites monilis (Davey & Williams 1966) Sarjeant 1970. Lateral view. Main body L x W: 46 x 44u; overall L x W: 76 x 72u. VPISUPL sample 160, slide AF 34, coords. R11.5, +7.9.
- FIG. 20. Spiniferites pseudofurcatus (Klumpp 1953) Sarjeant 1970. Later view. Main body L x W: 48 x 43u; overall L x W: 82 x 80u. VPISUPL sample 154, slide AE 94, coords. R20.0, +9.5.

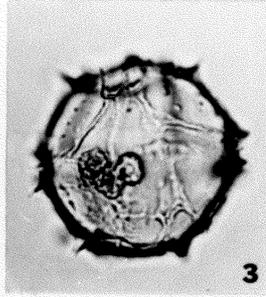
PLATE 8



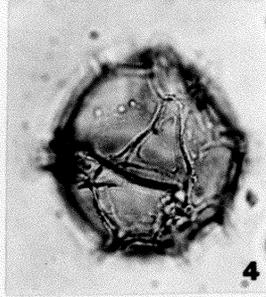
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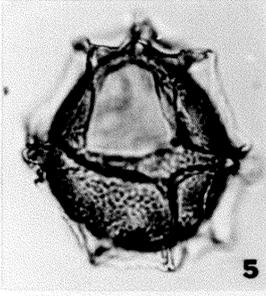
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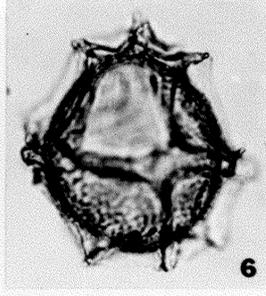
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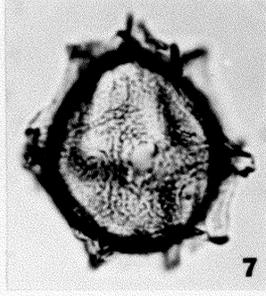
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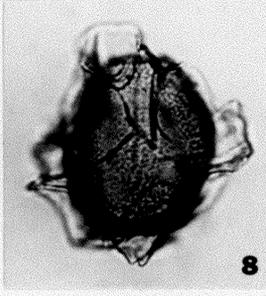
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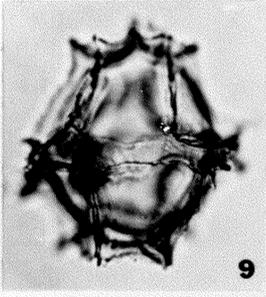
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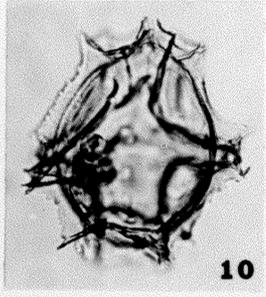
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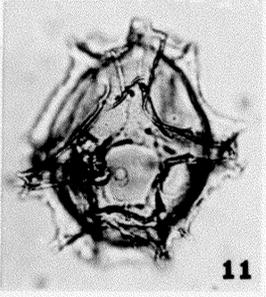
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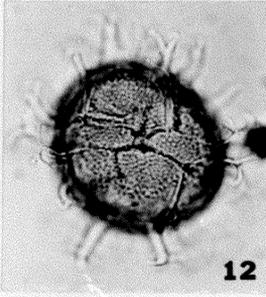
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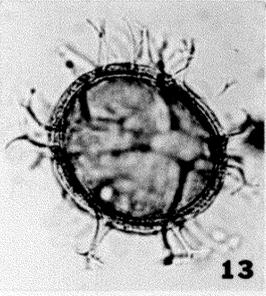
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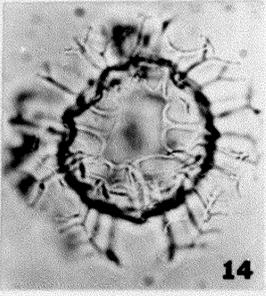
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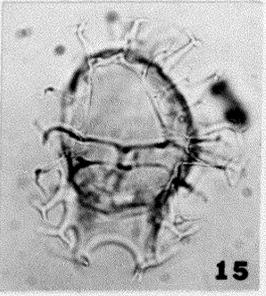
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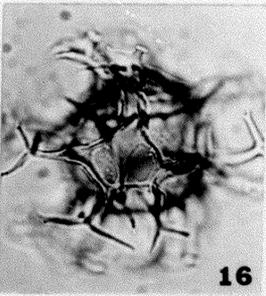
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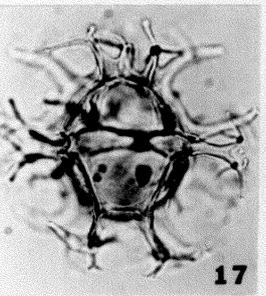
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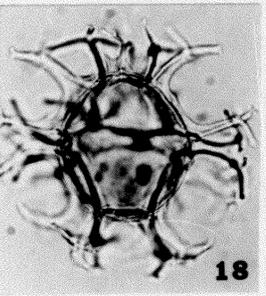
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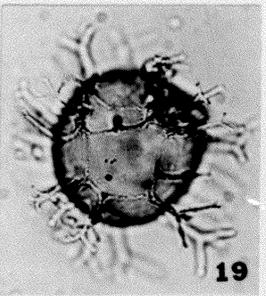
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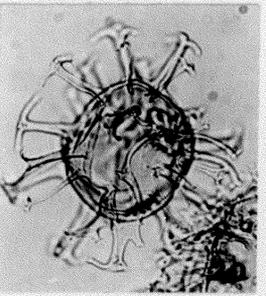


Plate 9

- FIGS. 1-2. Spiniferites ramosus subsp. granomembranaceus (Davey & Williams 1966) Lentin & Williams 1973. Fig. 1, dorsal view; Fig. 2, cross-sectional view. Main body L x W: 53 x 46u; overall L x W: 76 x 74. VPISUPL sample 157, slide AF 19, coords. R9.3, +4.5.
- FIGS. 3-6. Spiniferites ramosus subsp. granosus (Davey & Williams 1966) Lentin & Williams 1973. Fig. 3, view of dorsal epittract. Note reduced archeopyle. Figs. 4-6, several views of one specimen: Fig. 4, dorsal view; Fig. 5, cross-sectional view; Fig. 6, ventral view. Main body L x W: 50 x 46u; overall L x W: 88 x 76u. VPISUPL sample 162, slide AF 47, coords. R16.3, +5.3.
- FIGS. 7-8. Spiniferites cf. S. ramosus subsp. granosus (Davey & Williams 1966) Lentin & Williams 1973. Fig. 7, dorsal view; Fig. 8, cross-sectional view. Main body L x W: 48 x 44u; overall L x W: 64 x 67u. VPISUPL sample 152, slide AE 68, coords. R3.3, +10.2.
- FIG. 9. Spiniferites ramosus subsp. multibrevis (Davey & Williams 1966) Lentin & Williams 1973. Lateral view. Main body L x W: 66 x 56u; overall L x W: 90 x 72u. VPISUPL sample 154, slide AE 94, coords. R11.5, +20.8.
- FIGS. 10-13. Spiniferites ramosus subsp. ramosus (Ehrenberg 1838) Lentin & Williams 1973. Figs. 10-12, several views of one specimen. Fig. 10, dorsal view; Fig. 11, view of dorsal epittract; Fig. 12, cross-sectional view. Main body L x W: 50 x 47u; overall L x W: 99 x 91u. VPISUPL sample 162, slide AF 51, coords. R5.8, +17.5. Fig. 13, ventral view displaying marked displacement of ends of cingulum at sulcus. Main body L x W: 54 x 50u; overall L x W: 102 x 90u. VPISUPL sample 165, slide AF 69, coords. R12.5, +5.0.
- FIGS. 14-15. Spiniferites ramuliferus (Evitt 1973) n. comb. Fig. 14, dorsal view; Fig. 15, ventral view. Main body L x W: 85 x 62u; overall L x W: 142 x 126u. VPISUPL sample 157, slide AF 16, coords. R4.1, +2.0.
- FIGS. 16-19. Spiniferites septatus (Cookson & Eisenack 1967) McLean 1971. Fig. 16, dorsal view; Fig. 17, cross-sectional view. Main body L x W: 64 x 57u; overall L x W: 92 x 80u. VPISUPL sample 167, slide AF 69, coords. R4.2,

+19.8. Figs. 18-19, detail views of the septate rocesses, up to 20u in length. VPISUPL sample 165, slide AF 68, coords. R10.3, +15.1.

FIG. 20. Tanyosphaeridium variecalamum Davey & Williams 1966. Dorsal view. Main body L x W: 38 x 24u (L measured from archeopyle margin to antapex); overall L x W: 53 x 50u. VPISUPL sample 159, slide AF 26, coords. R15.7, +16.0.

PLATE 9

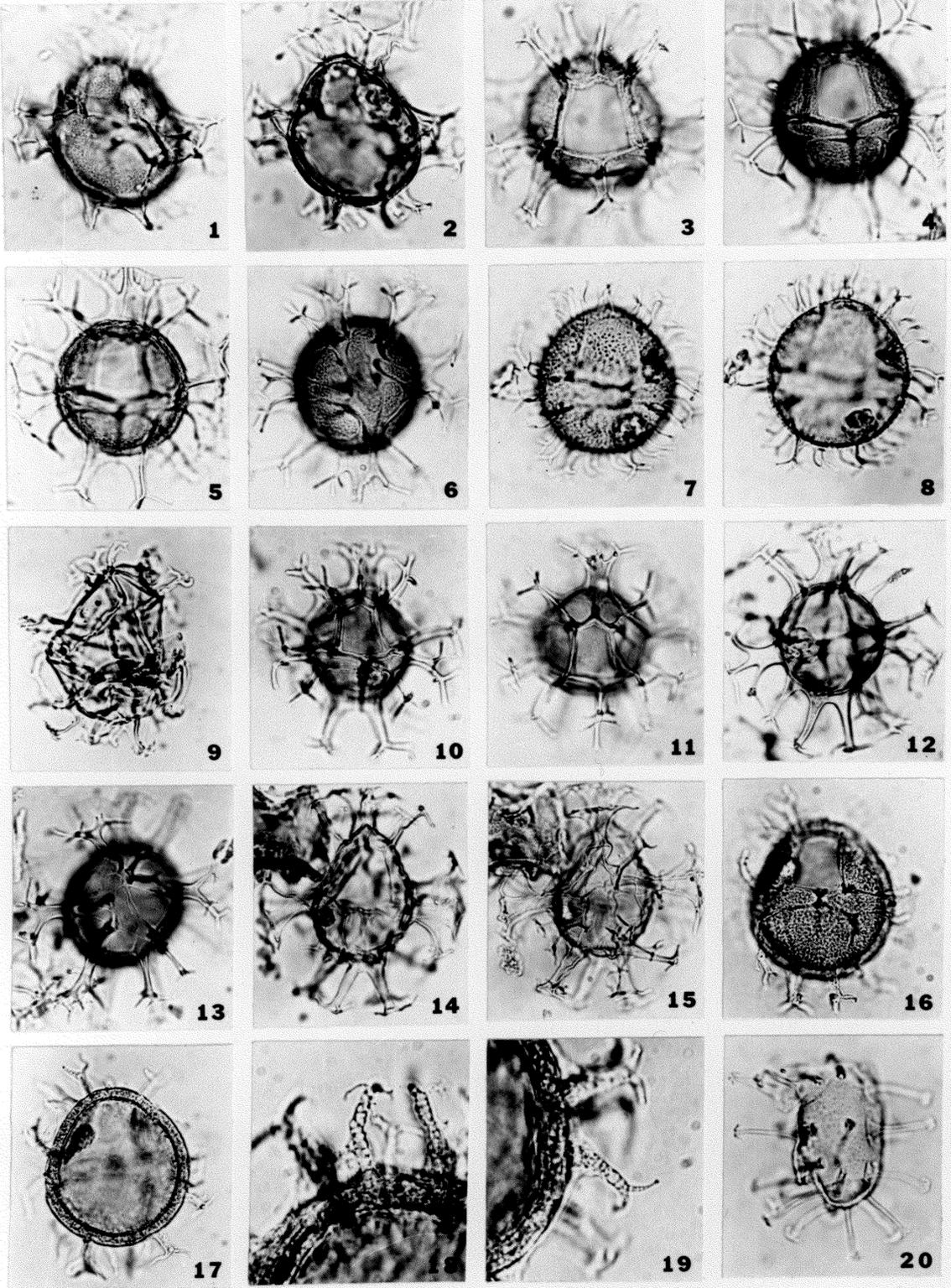


Plate 10

- FIG. 1. Ascodinium pontis-mariae (Deflandre 1936) Deflandre 1966. Dorsal view. Main body L x W: 48 x 33u; overall L x W: 88 x 42u. VPISUPL sample 123, slide AD 79, coords. R16.9, +13.7.
- FIG. 2. Deflandrea aspratitidis n. sp. Dorsal view. Main body L x W: 126 x 110; overall L x W: 192 x 126. VPISUPL sample 117, slide AD 54, coords. R21.5, +15.8.
- FIGS. 3-8. Deflandrea asymmetrica Wilson 1967. Specimens display a range of morphological variation, with Figs. 3 and 8, end members; Fig. 3 displays relatively low L/W ratio, Fig. 8, relatively high ratio. Fig. 3, dorsal view (focused through specimen). Endoblast L x W: 46 x 43u; overall L x W: 76 x 52u; L/W ratio, 1.46. VPISUPL sample 153, slide AE 81, coords. R8.9, +18.1. Fig. 4, dorsal view. Endoblast L x W: 33 x 37u; overall L x W: 64 x 42u; L/W ratio, 1.5. VPISUPL sample 151, slide AE 52, coords. R4.7, +5.0. Fig. 5, ventral view. Endoblast L x W: 46 x 40u; overall L x W: 78 x 46u. L/W ratio, 1.69. VPISUPL sample 151, slide AE 52, coords. R11.5, +17.0. Fig. 6, ventral view. Endoblast L x W: 54 x 46u; overall L x W: 78 x 48u. L/W ratio, 1.6. VPISUPL sample 151, slide AE 55, coords. R10.6, +13.0. Fig. 7, dorsal view. Endoblast L x W: 55 x 42u; overall L x W: 82 x 48u. L/W ratio, 1.71. VPISUPL sample 151, slide AE 55, coords. R7.3, +6.9. Fig. 8, dorsal view. Endoblast L x W: 64 x 38u; overall L x W: 88 x 44u; L/W ratio, 2.0. VPISUPL sample 123, slide AE 78, coords. R10.8, +10.6.
- FIGS. 9-13. Deflandrea cooksoni Alberti 1959. Fig. 9, cross-sectional view. Endoblast L x W: 57 x 54u; overall L x W: 132 x 63u. VPISUPL sample 168, slide AF 83, coords. R15.0, +15.8. Fig. 10, dorsal view. Endoblast L x W: 48 x 51u; overall L x W: 110 x 52u. VPISUPL sample 151, slide AE 6, coords. R14.3, +2.2. Fig. 11, dorsal view (focused through specimen). Endoblast L x W: 36 x 41u; overall L x W: 75 x 44u. VPISUPL sample 152, slide AE 68, coords. R16.3, +8.2. Fig. 12, ventral view. Endoblast L x W: 41 x 53u; overall L x W: 89 x 54u. VPISUPL sample 152, slide AE 68, coords. R20.2, +15.3. Fig. 13, lateral view. Endoblast length, 42u; overall length, 100u. VPISUPL sample 152, slide AE 68, coords. R17.7, +15.2.

- FIG. 14. Deflandrea cf. D. cooksoni Alberti. Ventral view.
Endoblast L x W: 40 x 54u; overall L x W: 73 x 58u.
VPISUPL sample 151, slide AE 55, coords. R10.2, +10.7.
- FIGS. 15-16. Deflandrea cf. D. balcattensis Cookson & Eisenack 1969.
Fig. 15, dorsal view; Fig. 16, cross-sectional view.
L x W: 39 x 38u; overall L x W: 66 x 47u. VPISUPL
sample 123, slide AD 78, coords. R14.6, +12.2.

PLATE 10

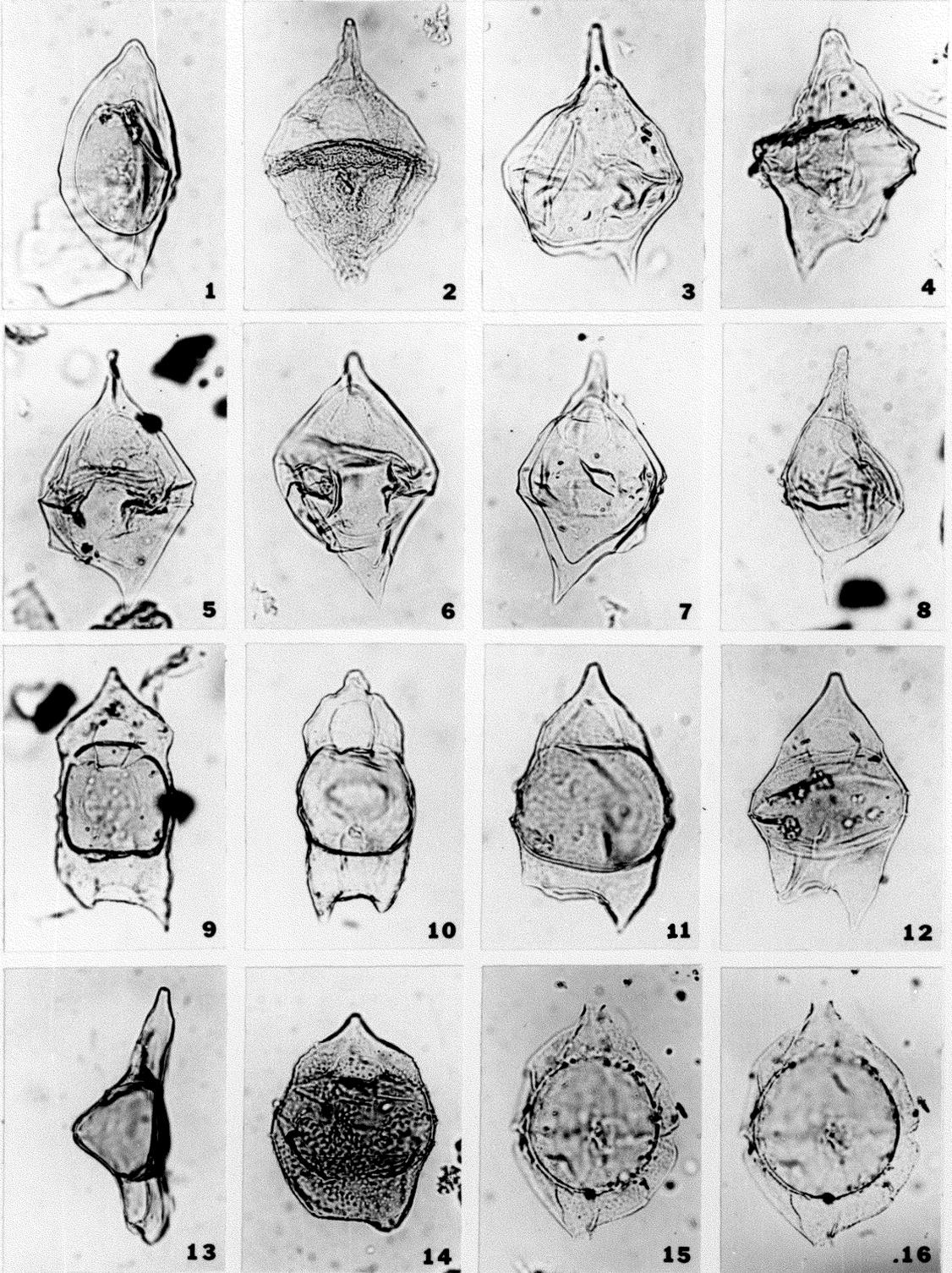


Plate 11

- FIGS. 1-2. Deflandrea camerata n. sp. Several views of HOLOTYPE. Fig. 1, dorsal view (focused through specimen); Fig. 2, ventral view. Endoblast L x W: 40 x 48u; overall L x W: 84 x 56u. VPISUPL sample 118, slide AD 55, coords. R10.0, +7.8.
- FIG. 2. Deflandrea magnifica Stanley 1965. Dorsal view (focused through specimen). Endoblast L x W: 82 x 72u; overall L x W: 106 x 76u. VPISUPL sample 123, slide AD 79, coords. R12.5, +17.1.
- FIG. 4. Deflandrea cf. D. obscura Drugg 1967. Cross-sectional view. Endoblast L x W: 43 x 55u; overall L x W: 57 x 59u. VPISUPL sample 166, slide AF 78, coords. R11.4, +9.7.
- FIGS. 5-6. Deflandrea diebeli Alberti 1959. Fig. 5, dorsal view (focused through specimen); Fig. 6, ventral view. Endoblast L x W: 72 x 74u; overall L x W: 264 x 82u. VPISUPL sample 151, slide AE 55, coords. R10.7, +20.3.
- FIGS. 7-10. Deflandrea conicula n. sp. Fig. 7, dorsal view. Note intratabular fields of con. Endoblast L x W: 56 x 58u; overall L x W: 76 x 66u. Fig. 8, dorsal view of HOLOTYPE. Endoblast L x W: 60 x 58u; overall L x W: 84 x 64u. VPISUPL sample 166, slide AF 73, coords. R11.1, +16.1. Fig. 9, dorsal view. Endoblast L x W: 67 x 63u; overall L x W: 92 x 68u. VPISUPL sample 155, slide AE 100, coords. R9.7, +11.1. Fig. 10, cross-sectional view. Endoblast L x W: 54 x 57u; overall L x W: 72 x 62u. VPISUPL sample 166, slide AF 78, coords. R8.1, +7.6.
- FIG. 11. Deflandrea cf. D. striata Drugg 1967. Dorsal view. Endoblast diameter, 84u; overall L x W: 146 x 90u. VPISUPL sample 116, slide AD 45, coords. R8.4, +12.1.
- FIGS. 12-14. Deflandrea dilwynensis Cookson & Eisenack 1965. Fig. 12, dorsal view. Endoblast L x W: 54 x 52u; overall L x W: 86 x 60u. VPISUPL sample 165, slide AF 70, coords. R14.8, +14.1. Fig. 13, ventral view. Endoblast L x W: 58 x 51u; overall L x W: 80 x 58u. VPISUPL sample 158, slide AF 22, coords. R14.6, +17.3. Fig. 14, ventral view. Endoblast L x W: 50 x 48u; overall L x W: 80 x 54u. VPISUPL sample 158, slide AF 22, coords. R10.4, +4.9.

PLATE II

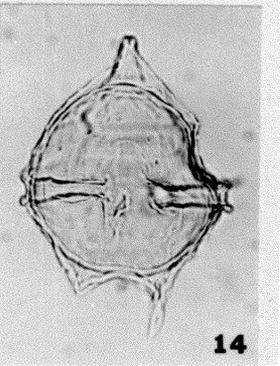
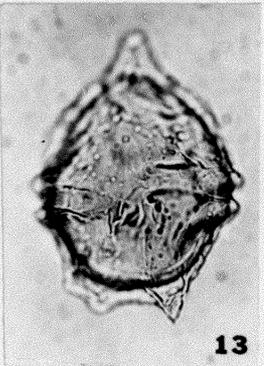
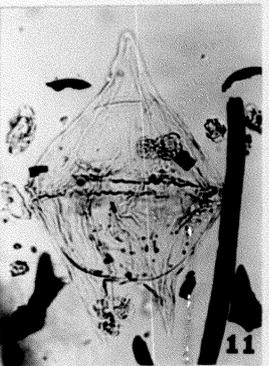
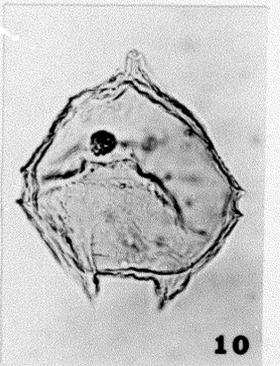
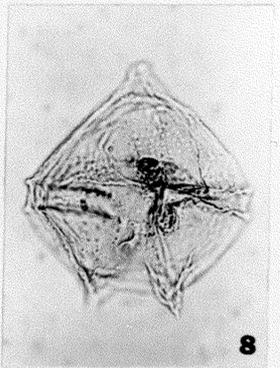
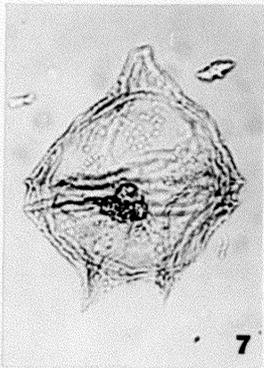
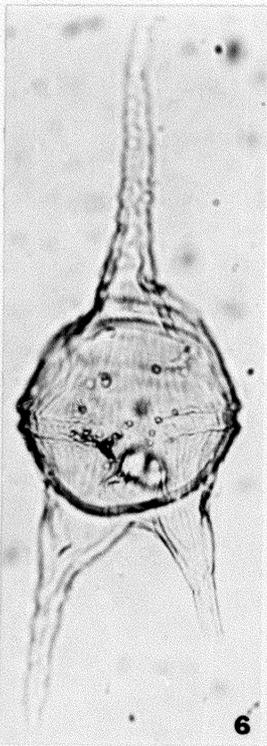
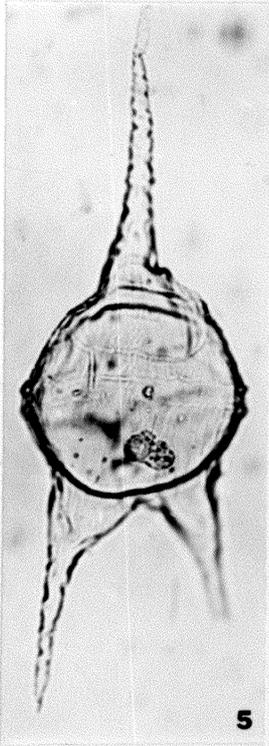
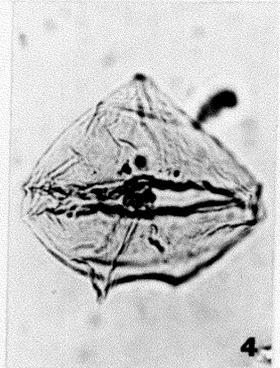
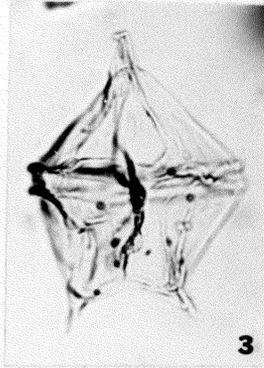
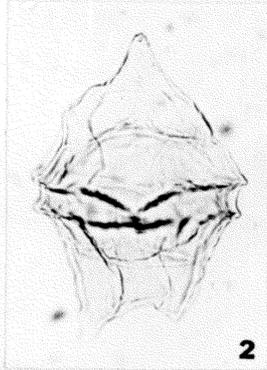
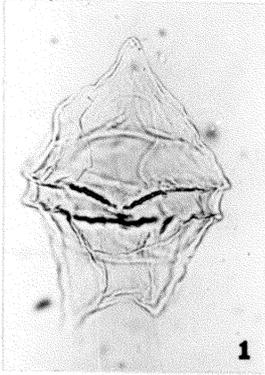


Plate 12

- FIG. 1. Deflandrea pannucea Stanley 1965. Dorsal view. Endoblast diameter, 56u; overall L x W: 84 x 64u. VPISUPL sample 153, slide AE 75, coords. R8.1, +2.7.
- FIGS. 2-11. Deflandrea dartmooria Cookson & Eisenack 1965. Specimen array shows general morphological trends within D. dartmooria from Monmouth specimens to Brightseat ones. Monmouth specimens have broad-based, gently-tapering apical horns and bear few coni. Brightseat specimens bear narrow apical horns and numerous, often coarse coni; coni may be scattered, distributed in intratabular fields, or aligned in longitudinal rows. Fig. 2, cross-sectional view. Endoblast L x W: 77 x 70u; overall L x W: 174 x 77u. VPISUPL sample 160, AF 33, coords. R5.3, +16.7. Fig. 3, ventral view. Endoblast diameter, 72u; overall L x W: 140 x 80u. VPISUPL sample 166, AF 78, coords. R9.2, +9.6. Fig. 4, dorsal view. Endoblast L x W: 66 x 72u; overall L x W: 152 x 88. VPISUPL sample 163, slide AF 55, coords. R3.3, +0.8. Figs. 5 and 6, dorsal and ventral view, respectively, of one specimen. Endoblast L x W: 65 x 77u; overall L x W: 146 x 86u. VPISUPL sample 165, slide AF 70, coords. R10.0, +11.5. Figs. 7 and 8, dorsal and ventral view, respectively, of one specimen. Endoblast L x W: 70 x 76u; overall L x W: 141 x 85u. VPISUPL sample 163, slide AF 55, coords. R11.8, +6.8. Fig. 9, ventral view. Endoblast L x W: 65 x 78u; overall L x W: 153 x 86u. Fig. 10, dorsal view. Main body L x W: 68 x 67u; overall L x W: 124 x 76u. VPISUPL sample 162, slide AF 48, coords. R12.7, +17.5. Fig. 11, dorsal view. Endoblast L x W: 44 x 72u; overall L x W: 146 x 81u. VPISUPL sample 165, slide AF 69, coords. R8.8, +17.0.
- FIGS. 12-15. Deflandrea pentaradiata Cookson & Eisenack 1965. Figs. 12 and 13, dorsal and ventral view, respectively, of specimen resembling holotype, in bearing concave lateral margins, lateral extensions of cingulum, and roughly pentagonal endoblast. Endoblast L x W: 90 x 84u; overall L x W: 144 x 110u. VPISUPL sample 158, slide AF 21, coords. R4.4, +5.3. Figs. 14 and 15 display typical variation within a population of D. pentaradiata. Fig. 14, cross-sectional view. Endoblast L x W: 90 x 84u; overall L x W: 140 x 109u. VPISUPL sample 162, slide AF 48, coords. R6.2, +7.2. Fig. 15, cross-sectional view of specimen with nearly straight lateral margins,

repressed extensions of cingulum, and ovoidal endoblast. Endoblast L x W: 92 x 83u; overall L x W: 137 x 108u. VPISUPL sample 158, slide AF 22, coords. R18.9, +4.4.

FIG. 16. Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967. Dorsal view. Note intertabular growth zones marked by fine striae oriented normal to plate-equivalent margins. VPISUPL sample 157, slide AF 16, coords. R5.7, +11.4.

PLATE 12

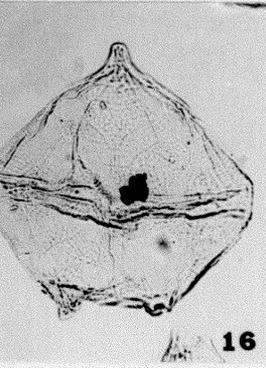
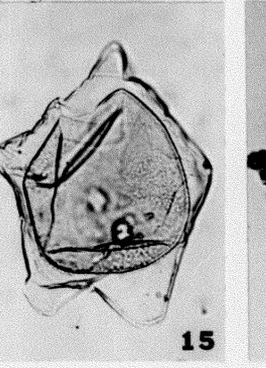
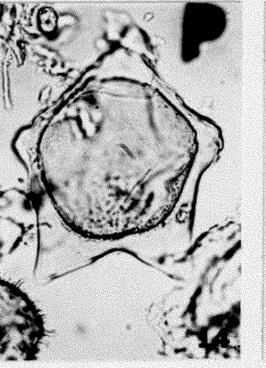
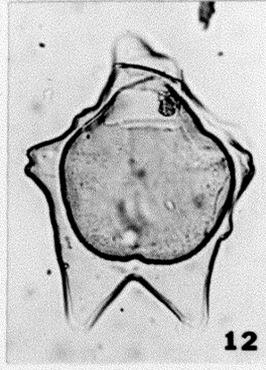
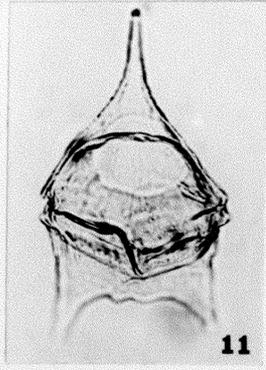
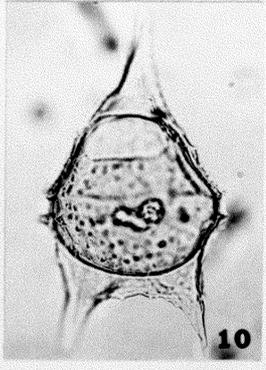
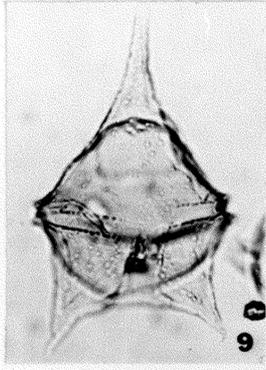
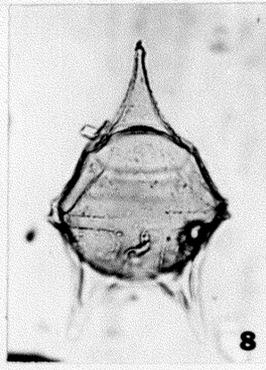
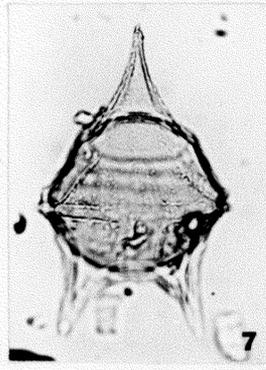
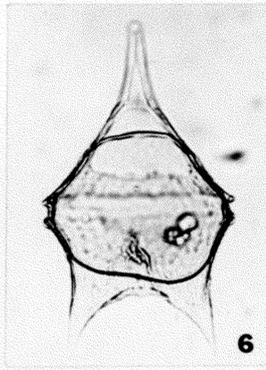
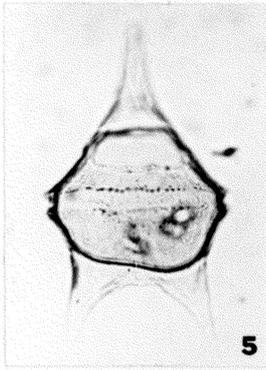
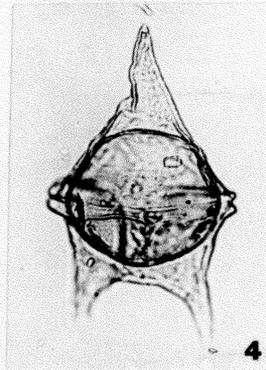
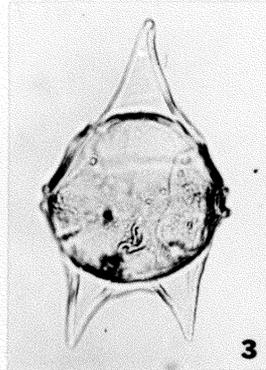
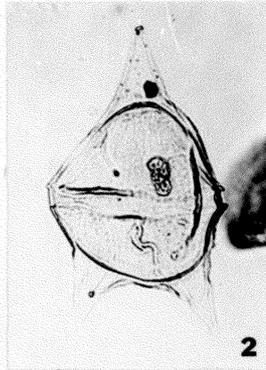
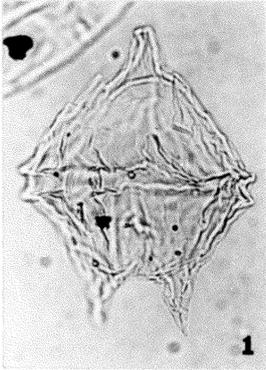


Plate 13

- FIG. 1. Palaeocystodinium australinum (Cookson 1965) n. comb. Dorsal view. Endoblast L x W: 92 x 52u; overall L x W: 92 x 52u; overall L x W: 185 x 57u. VPISUPL sample 161, slide AF 42, coords. R11.1, +5.6.
- FIG. 2. Palaeocystodinium golzowense Alberti 1961. Dorsal view (focused through specimen). Endoblast L x W: 100 x 54u; overall L x W: 286 x 56u. VPISUPL sample 165, slide AF 70, coords. R13.7, +19.5.
- FIG. 3. Palaeocystodinium polymorphum (Malloy 1972) n. comb. Dorsal view. Endoblast L x W: 126 x 66u; overall L x W: 230 x 68u. VPISUPL sample 158, slide AF 21, coords. R6.9, +12.9.
- FIGS. 4-5. Palaeohystrichophora infusoriodes Deflandre 1935. Figs. 4 and 5, dorsal and ventral view, respectively, of one specimen. Endoblast L x W: 58 x 52u; overall L x W: 94 x 60u.
- FIGS. 6-9. Spinidinium clavum Harland 1973. Fig. 6, dorsal view. Endoblast L x W: 38 x 32u; overall L x W: 57 x 37u. VPISUPL sample 151, slide AE 52, coords. R4.1, +4.8. Fig. 7, view of dorsal epitract. Endoblast width 33u, overall width 38u. VPISUPL sample 162, slide AF 45, coords. R9.5, +4.6. Fig. 8, cross-sectional view. Endoblast L x W: 40 x 26u; overall L x W: 60 x 42u. VPISUPL sample 162, slide AF 45, coords. R1.3, +6.5. Fig. 9, ventral view. Endoblast L x W: 24 x 36u; overall L x W: 60 x 43. VPISUPL sample 162, slide AF 48, coords. R19.0, +1.4.
- FIGS. 10-13. Spinidinium essoi Cookson & Eisenack 1967. Fig. 10, dorsal view (focused through specimen). Endoblast L x W: 66 x 58u; overall L x W: 84 x 65u. VPISUPL sample 165, slide AF 67, coords. R12.2, +5.5. Fig. 11, dorsal view. Endoblast L x W: 56 x 54u; overall L x W: 72 x 62u. VPISUPL sample 158, slide AF 21, coords. R15.3, +10.7. Figs. 12 and 13, dorsal and ventral view, respectively, of one specimen. Endoblast L x W: 48 x 56u; overall L x W: 72 x 66u. VPISUPL sample 157, slide AF 15, coords. R6.3, +3.3.

PLATE 13

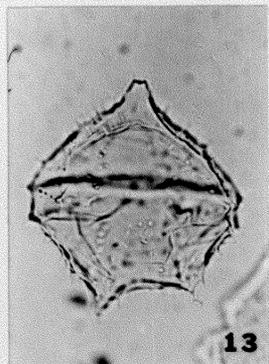
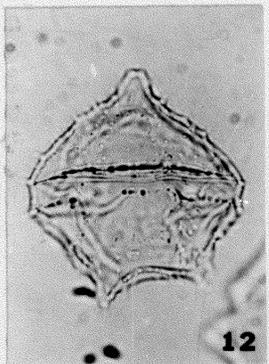
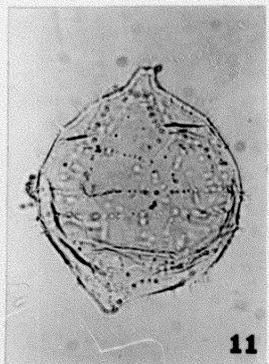
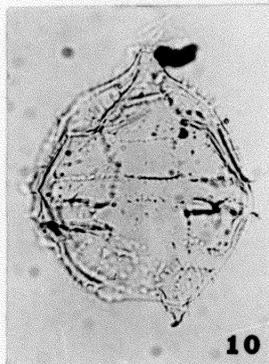
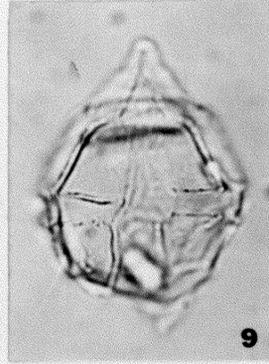
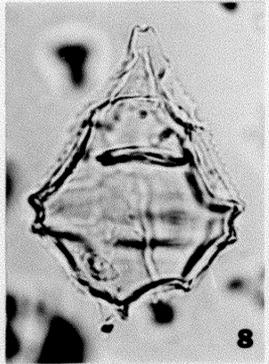
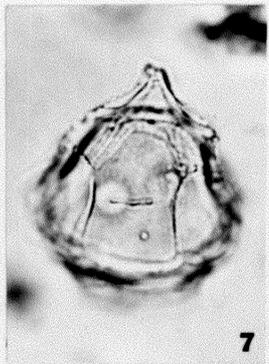
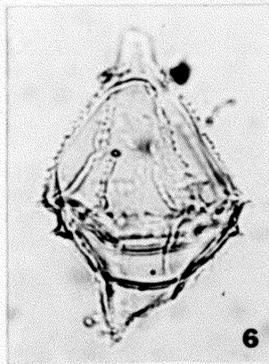
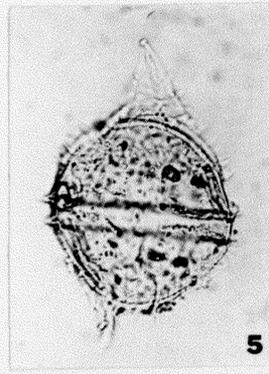
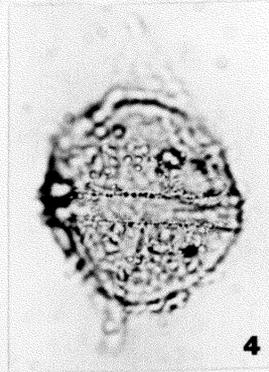
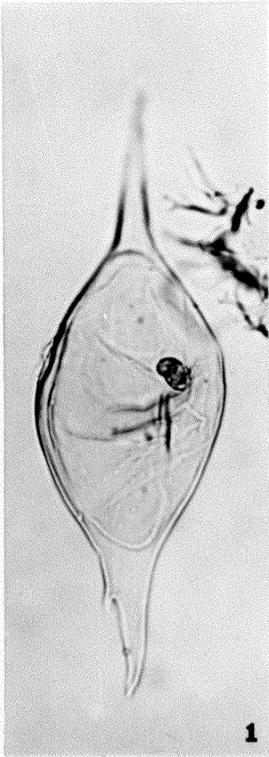


Plate 14

- FIGS. 1-4. Wetzeliella (W.) homeomorpha Deflandre & Cookson 1955. Fig. 1, dorsal view of pentagonal specimen. Endoblast L x W: 66 x 52u; overall L x W: 85 x 70u. VPISUPL sample 162, slide AF 50, coords. R14.6, +12.8. Fig. 2, dorsal view of sub-pentagonal specimen. Endoblast L x W: 56 x 54u; overall L x W: 80 x 68u. VPISUPL sample 165, slide AF 69, coords. R12.6, +10.7. Figs. 3 and 4, ventral and cross-sectional view, respectively, of specimen with nearly circular outline. Endoblast L x W: 60 x 54u; overall L x W: 80 x 72u. VPISUPL sample 165, slide AF 69, coords. R7.7, +5.7.
- FIGS. 5-6. Trithyrodinium scutulatum n. sp. Fig. 5, dorsal view of HOLOTYPE. Endoblast L x W: 68 x 60u; overall L x W: 144 x 67u. VPISUPL sample 117, slide AD 54, coords. R4.3, +13.4. Fig. 6, ventral view of another specimen. Endoblast L x W: 81 x 73u; overall L x W: 156 x 79u. VPISUPL sample 152, slide AE 68, coords. R9.5, +7.5.
- FIG. 7. Trithyrodinium vermiculatum (Cookson & Eisenack 1961) n. comb. Dorsal view. Endoblast L x W: 62 x 57u; overall L x W: 100 x 64u. VPISUPL sample 117, slide AD 54, coords. R4.5, +14.7.
- FIGS. 8-10. Trithyrodinium diversicomptum n. sp. Specimens display variety of ornamentation on exterior surface of endoblast. Fig. 8, dorsal view of HOLOTYPE. Endoblast L x W: 74 x 67u; overall L x W: 118 x 71u. VPISUPL sample 120, AD 59, coords. R4.7, +3.8. Fig. 9, dorsal view. Note tripartite operculum, double rows of grana along margins of cingulum on exterior surface of periphragm. Endoblast L x W: 70 x 63u; overall L x W: 96 x 66u. VPISUPL sample 121, slide AD 61, coords. R8.4, +21.1. Fig. 10, dorsal view. Endoblast diameter 64u; overall L x W: 78 x 65u. VPISUPL sample 123, slide AD 79, coords. R4.5, +6.3.
- FIGS. 11-12. Trithyrodinium membranophorum n. sp. Fig. 11, dorsal view of HOLOTYPE. Note tripartite operculum. Endoblast L x W: 70 x 52u; overall L x W: 74 x 52u. VPISUPL sample 151, slide AE 52, coords. R9.0, +10.2. Fig. 12, ventral view. Endoblast L x W: 67 x 57u; overall L x W: 70 x 57u. VPISUPL sample 151, slide AE 55, coords. R12.2, +10.6.
- FIGS. 13-16. Thalassiphora pelagica (Eisenack 1954) Eisenack & Gocht 1960. Fig. 13, cross-sectional view displaying apical

and antapical protrusions of main body. Main body L x W: 104 x 82u; overall L x W: 206 x 183u. VPISUPL sample 157, slide AF 15, coords. R9.2, +7.0. Fig. 14, detail of fibers of outer membrane shown in Fig. 13. Length of viewed portion of specimen, ca. 90u. Fig. 15, cross-sectional view of specimen lacking protrusions of main body. Main body L x W: 98 x 82u; overall L x W: 186 x 176u. VPISUPL sample 157, slide AF 17, coords. R16.6, +10.1. Fig. 16, detail of fibers of outer membrane of another specimen. Length of viewed portion of specimen, ca. 90u. VPISUPL sample 157, slide AF 17, coords. R18.3, +10.4.

PLATE 14

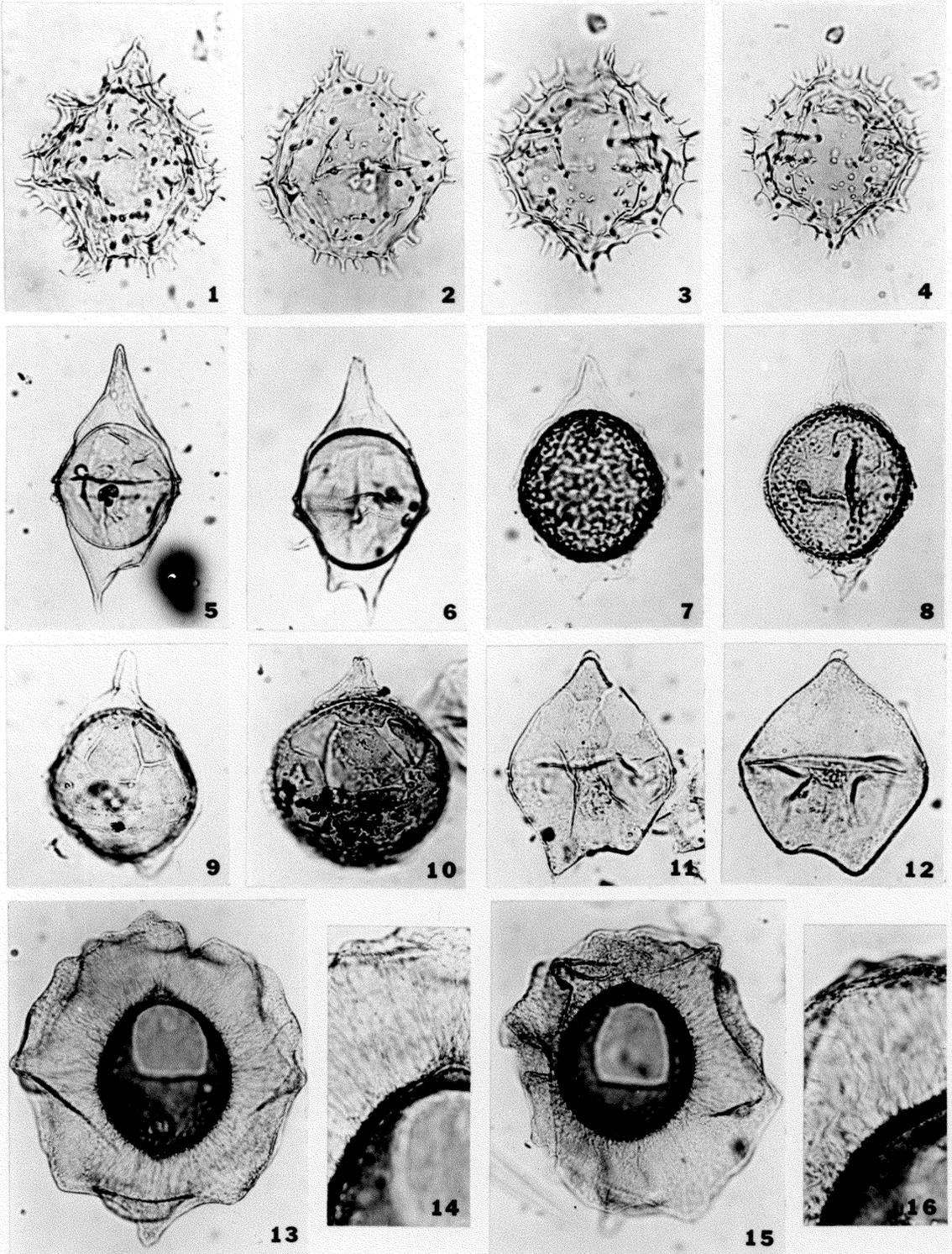


Plate 15

- FIG. 1. Areoligera cassicula Drugg 1970. Dorsal view. Main body L x W: 58 x 62u (length measured from archeopyle margin to antapex); overall L x W: 68 x 74u. VPISUPL sample 154, slide AE 94, coords. R7.2, +6.7.
- FIG. 2 Areoligera senonensis Lejeune-Carpentier 1938. Dorsal view. Main body L x W: 58 x 62u (length measured from archeopyle margin to antapex); overall L x W: 78 x 90u. VPISUPL sample 154, slide AE 95, coords. R4.9, +5.7.
- FIGS. 3-6. Areoligera sp. Fig. 3, dorsal view, shows lack of antapical protrusion(s) of main body. Main body L x W: 90 x 85u (length measured from archeopyle margin to antapex); overall L x W: 150 x 144u. VPISUPL sample 158, slide AF 19, coords. R12.4, +6.4. Fig. 4, ventral view. Note antapical lobes of main body. Main body L x W: 110 x 92u; overall L x W: 160 x 134u. VPISUPL sample 157, slide AF 19, coords. R16.4, +9.0. Fig. 5, dorsal view. Main body L x W: 62 x 68u (length measured from archeopyle margin to antapex); overall L x W: 96 x 104u. VPISUPL sample 162, slide AF 48, coords. R17.0, +9.5. Fig. 6, ventral view. Note restriction of processes to lateral margins of main body, and development of trabeculae near tips of processes. Main body L x W: 56 x 64u (length measured from archeopyle margin to antapex); overall L x W: 90 x 110u. VPISUPL sample 156, slide AF 9, coords. R16.4, +9.9.
- FIGS. 7-9. Systematophora placacantha (Deflandre & Cookson) Davey et al. 1969. Fig. 7, dorsal view. Main body L x W: 54 x 64u (length measured from archeopyle margin to antapex); overall L x W: 95 x 97u. VPISUPL sample 160, slide AF 33, coords. R14.5, +5.8. Fig. 8, ventral view. Main body L x W: 56 x 66u (length measured from archeopyle margin to antapex); overall L x W: 78 x 99u. VPISUPL sample 160, slide AF 33, coords. R13.3, +15.0. Fig. 9, isolated operculum. Main portion, ca. 46u long. VPISUPL sample 160, slide AF 33, coords. R7.4, +8.8.
- FIGS. 10-12. Microdinium setosum Sarjeant 1966. Figs. 10 and 12, dorsal and cross-sectional view, respectively, of one specimen. Main body L x W: 30 x 28u; overall L x W: 34 x 30u. VPISUPL sample 151, slide AE 52, coords. R15.3, +8.7. Fig. 11, ventral view of another specimen. Main body L x W: 32 x 29u; overall L x W: 34 x 30u. VPISUPL sample 118, slide AD 55, coords. R5.0, +14.0.

- FIGS. 13-14. Kallosphaeridium brevibarbatum De Coninck 1969. Fig. 13, cross-sectional view. Main body diameter 29u, overall diameter 32u. VPISUPL sample 153, slide AE 75, coords. R13.1, +15.3. Fig. 14, apical view displaying outline of archeopyle. Main body diameter 28u, overall diameter 31u. VPISUPL sample 151, slide AE 52, coords. R10.3, +15.7.
- FIGS. 15-17. Ceratocorys veligera Lejeune-Carpentier 1944. Several views of one specimen. Fig. 15, dorsal view (focused through specimen); Fig. 16, cross-sectional view; Fig. 17, ventral view. Main body diameter, 32u; overall L x W: 40 x 38u. VPISUPL sample 120, slide AD 60, coords. R11.2, +0.8.
- FIGS. 18-20. Chlamydophorella urna Cookson & Eisenack 1960. Fig. 18, cross-sectional view. Note accessory archeopyle sutures. Main body L x W: 35 x 32u; overall L x W: 39 x 37u. VPISUPL sample 162, slide AF 44, coords. R18.0, +16.9. Fig. 19, cross-sectional view; epittract bears low, dome-like outline. Main body diameter, 32u; overall L x W: 36 x 35u. VPISUPL sample 162, slide AF 46, coords. R15.2, +4.8. Fig. 20, detail of wall of specimen in Fig. 19. Length of viewed portion of specimen, ca. 23u.

PLATE 15

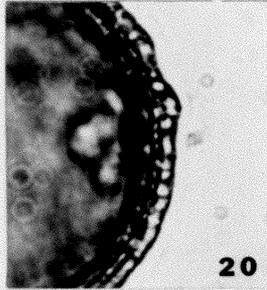
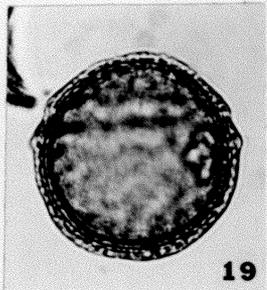
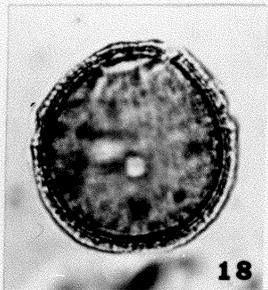
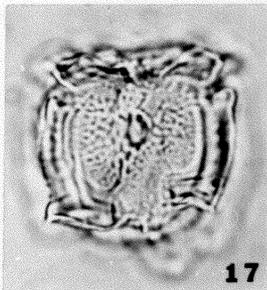
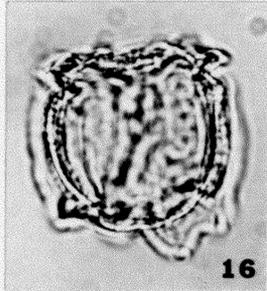
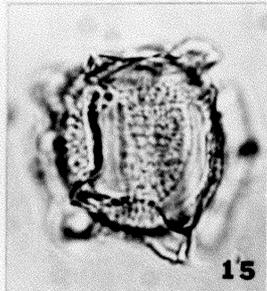
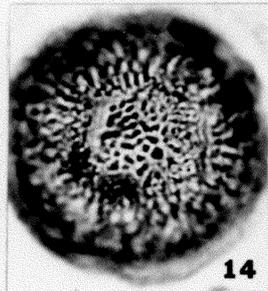
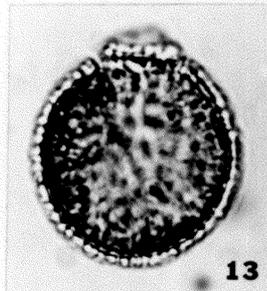
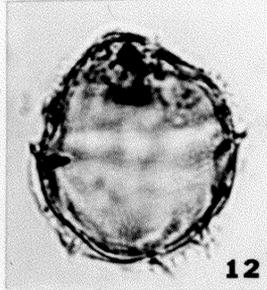
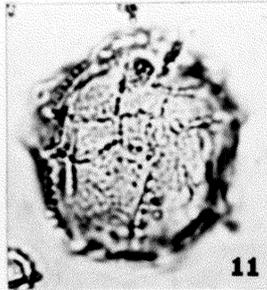
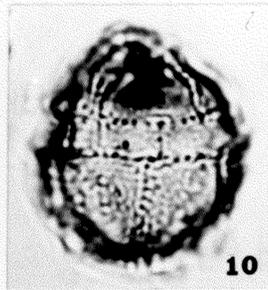
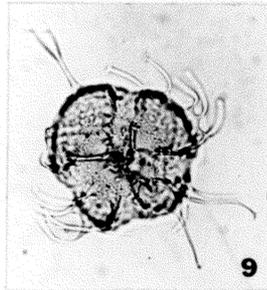
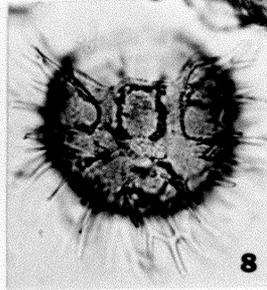
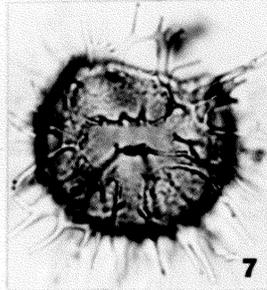
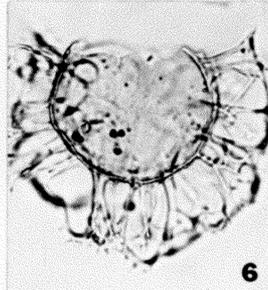
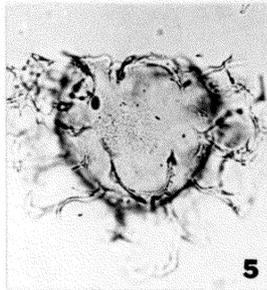
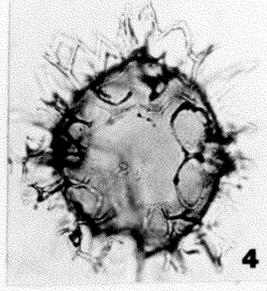
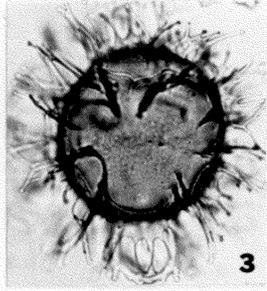
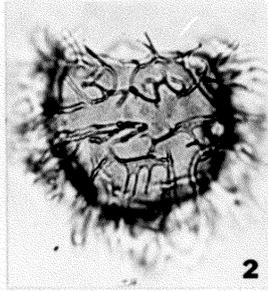
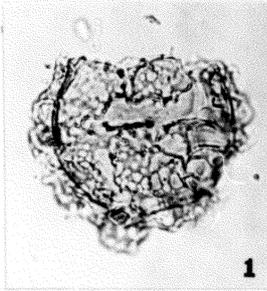


Plate 16

- FIG. 1. Chlamydochorella urna (continued from Plate 15). Cross-sectional view. Main body L x W: 32 x 30u; overall L x W: 35 x 34u. VPISUPL sample 151, slide AE 52, coords. R8.6, +5.6.
- FIGS. 2-6. Fibradinium annetorpense Morgenroth 1968. Figs. 2-4, several views of one specimen: Fig. 2, dorsal view (focused through specimen); Fig. 3, cross-sectional view; Fig. 4, ventral view. Main body L x W: 40 x 37u; overall L x W: 46 x 44u. VPISUPL sample 122, slide AD 76, coords. R14.5, +17.8. Figs. 5 and 6, dorsal and cross-sectional view, respectively, of one specimen. Main body L x W: 44 x 40u; overall L x W: 52 x 50u. VPISUPL sample 158, slide AF 22, coords. R17.3, +2.2.
- FIGS. 7-9. Forma A. Figs. 7 and 8, dorsal and cross-sectional view, respectively, of one specimen. Main body L x W: 35 x 32u; overall L x W: 42 x 38u. VPISUPL sample 151, slide AE 52, coords. R19.9, +9.1. Fig. 9, cross-sectional view of specimen displaying flipped-up operculum at apex. Main body L x W: 34 x 30u; overall L x W: 40 x 39u. VPISUPL sample 153, slide AE 79, coords. R20.0, +1.7.
- FIGS. 10-13. Heterodinium intervallum n. gen. n. sp. Fig. 10, dorsal view of HOLOTYPE. Main body L x W: 32 x 26u; overall L x W: 38 x 30u. VPISUPL sample 122, slide AD 69, coords. R15.7, +6.4. Fig. 11, dorsal view. Note breaching of peritabular ridges by perforations. Main body L x W: 27 x 25u; overall diameter, 30u. VPISUPL sample 116, slide AD 45, coords. R4.2, +7.9. Fig. 12, ventral view. Main body diameter, 30u; overall L x W: 34 x 32u. VPISUPL sample 151, slide AE 52, coords. R2.9, +3.0. Fig. 13, view of ventral hypotract. Note plate-equivalents 1''' and lp. Main body L x W: 22 x 25u. VPISUPL sample 151, slide AE 52, coords. R16.6, +16.9.
- FIGS. 14-16. Histiocysta palla Davey 1960. Several views of one specimen. Fig. 14, dorsal view (focused through specimen); Fig. 15, cross-sectional view; Fig. 16, ventral view. Main body L x W: 34 x 31u; overall L x W: 39 x 35u. VPISUPL sample 153, slide AE 76, coords. R9.3, +7.0.
- FIGS. 17-18. Hexagonifera chlamydata Cookson & Eisenack 1962. Fig. 17, lateral view focused on archeopyle margin. Main body L x W: 32 x 30u; overall L x W: 39 x 36u. VPISUPL sample

153, slide AE 76, coords. R10.4, +7.4. Fig. 18, cross-sectional view. Main body L x W: 34 x 30u; overall diameter 38u. VPISUPL sample 151, slide AE 52, coords. R10.1, +9.9.

FIGS. 19-20. Canningia hirta n. sp. Fig. 19, dorsal view of HOLOTYPE. Note well-developed antapical lobes. Main body L x W: 126 x 112u. Overall L x W: 150 x 138u. VPISUPL sample 157, slide AF 16, coords. R19.7, +12.3. Fig. 20, ventral view. Note strong development of left antapical lobe only. Main body L x W: 97 x 110u (L measured from archeopyle margin to antapex); overall L x W: 128 x 138u. VPISUPL sample 157, slide AF 18, coords. R17.3, +5.0.

PLATE 16

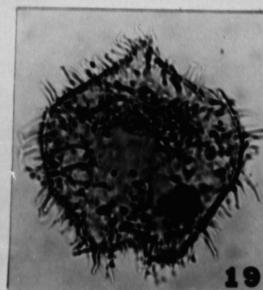
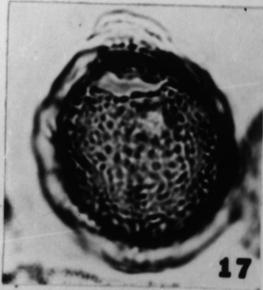
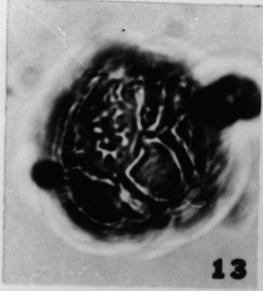
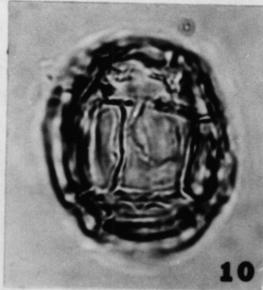
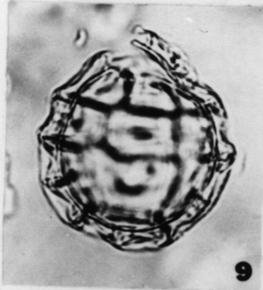
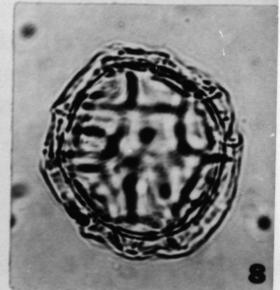
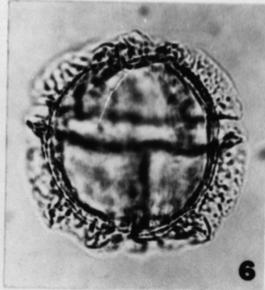
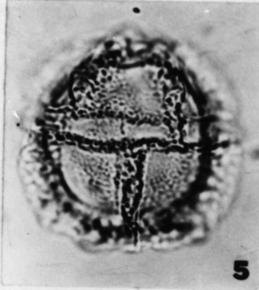
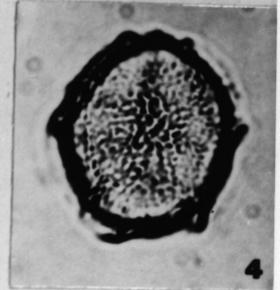
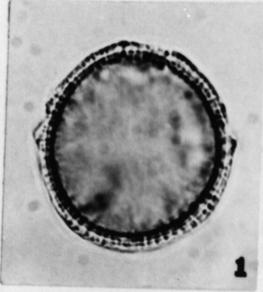


Plate 17

- FIGS. 1-2. Impletosphaeridium sp. Figs. 1 and 2, dorsal and cross-sectional view, respectively, of one specimen. Main body L x W: 48 x 52u (L measured from archeopyle margin to antapex); overall L x W: 60 x 66. VPISUPL sample 159, slide AF 28, coords. R9.5, +7.8.
- FIGS. 3-4. Xenascus ceratiodes (Deflandre 1937) Lentin & Williams 1973. Fig. 3, dorsal view. Main body L x W: 82 x 76u; overall L x W: 204 x 124u. VPISUPL sample 122, slide AD 70, coords. R13.8, +11.4. Fig. 4, isolated operculum. Overall length 92u. VPISUPL sample 123, slide AD 79, coords. R11.2, +14.2.
- FIGS. 5-6. Inversidinium protonsum n. sp. Fig. 5, ventral view of HOLOTYPE. Endoblast L x W: 24 x 34u; overall L x W: 58 x 46u. VPISUPL sample 151, slide AE 52, coords. R2.8, +3.0. Fig. 6, cross-sectional view. Endoblast L x W: 27 x 29u; overall L x W: 60 x 53u. VPISUPL sample 155, slide AE 97, coords. R6.3, +5.2.
- FIGS. 7-8. ?Inversidinium sp. Fig. 7, ventral view at low focus level; Fig. 8, high focus level displaying longitudinal keel-like fold (sulcus?). Endoblast crumpled; overall L x W: 72 x 75u. VPISUPL sample 152, slide AE 68, coords. R3.4, +12.7.
- FIG. 9. Horologinella apiculata Cookson & Eisenack 1962. Cross-sectional view. Endoblast L x W: 19 x 18u; overall L x W: 22 x 26u. VPISUPL sample 117, slide AD 52, coords. R9.4, +16.1.
- FIG. 10. Horologinella incurvata Cookson & Eisenack 1962. Cross-sectional view. Endoblast L x W: 19 x 16u; overall L x W: 24 x 23u. VPISUPL sample 122, slide AD 73, coords. R11.1, +11.2.
- FIG. 11. Horologinella sp. Cross-sectional view. Endoblast L x W: 19 x 12u; overall L x W: 21 x 15u. VPISUPL sample 122, slide AD 73, coords. R13.4, +9.2.
- FIG. 12. Micrhystridium sp. Cross-sectional view. Main body diameter 44u; overall diameter 148u. VPISUPL sample 157, slide AF 16, coords. R9.4, +2.3.

- FIGS. 13-15. Baltisphaeridium spp. All are cross-sectional views. Fig. 13, main body L x W: 38 x 42u. VPISUPL sample 151, slide AE 52, coords. R10.9, +2.5. Fig. 14, main body L x W: 94 x 68u; overall L x W: 121 x 93u. VPISUPL sample 166, slide AF 78, coords. R14.7, +9.8. Fig. 15, main body L x W: 35 x 25u; overall L x W: 44 x 36u. VPISUPL sample 151, slide AE 52, coords. R5.4, +12.1.
- FIG. 16. Cymatiosphaera sp. Main body diameter 40u; overall diameter 45u. VPISUPL sample 154, slide AE 83, coords. R12.4, +1.2.
- FIG. 17. Trigonopyxidina ginella (Cookson & Eisenack 1960) Cookson & Eisenack 1961. Cross-sectional view. Endoblast diameter 44u; overall diameter 70u. VPISUPL sample 151, slide AE 57, coords. R10.2, +19.4.
- FIGS. 18-19. Pterospermopsis danica W. Wetzel 1952. Each is a cross-sectional view. Fig. 18, main body diameter 72u; overall diameter 140u. VPISUPL sample 165, slide AF 69, coords. R13.4, +18.4. Fig. 19, main body diameter 57u; overall diameter 100u. VPISUPL sample 162, slide AF 49, coords. R8.3, +6.9.
- FIG. 20. Fromea amphora Cookson & Eisenack 1958. Cross-sectional view. Specimen L x W: 112 x 88u. VPISUPL sample 122, slide AD 73, coords. R14.0, +14.9.

PLATE 17

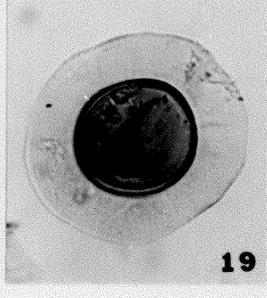
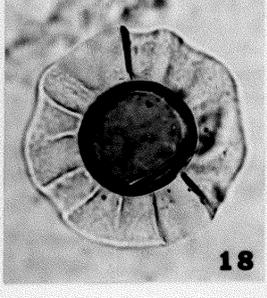
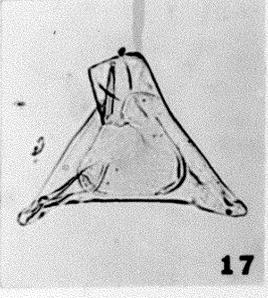
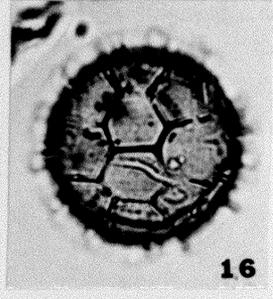
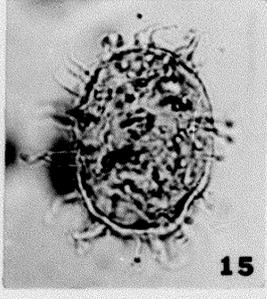
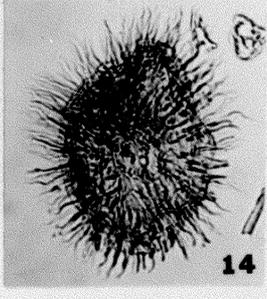
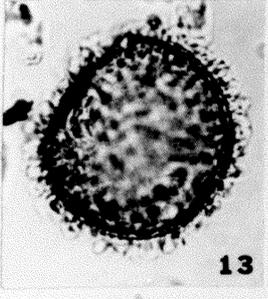
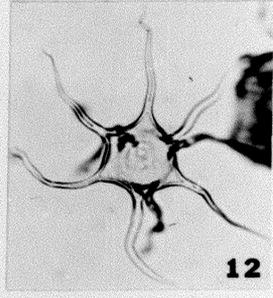
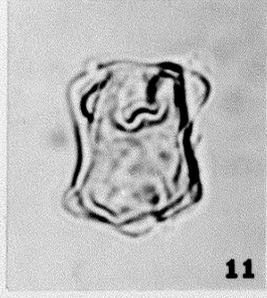
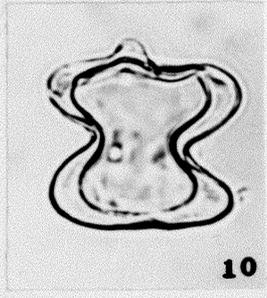
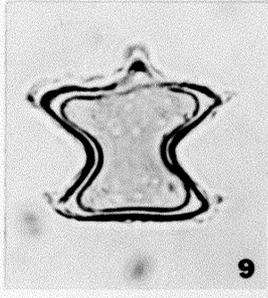
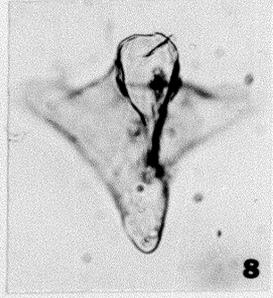
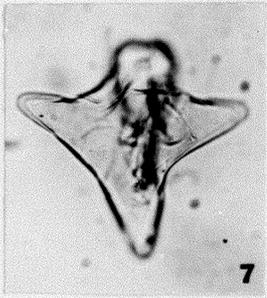
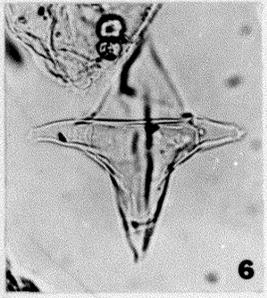
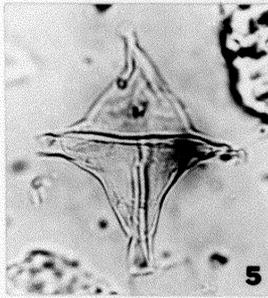
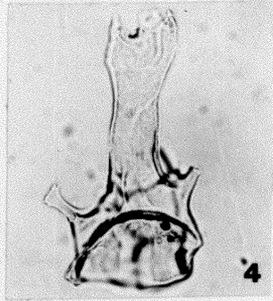
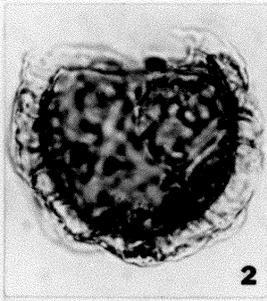
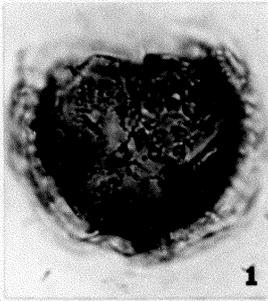
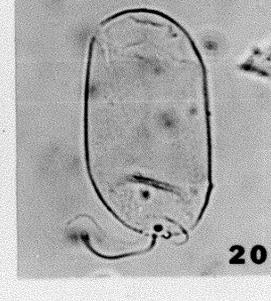
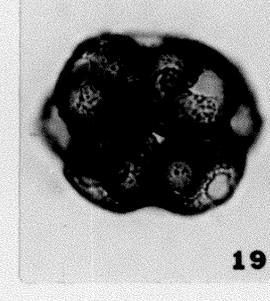
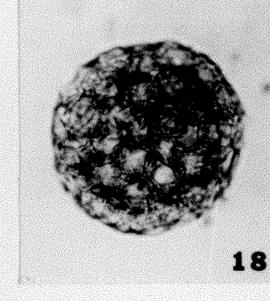
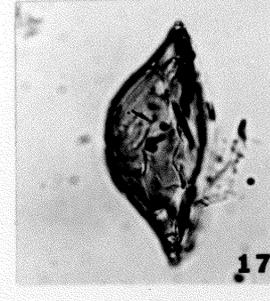
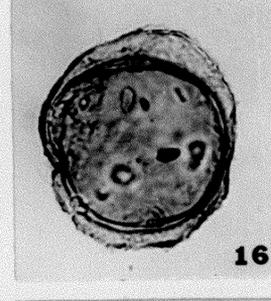
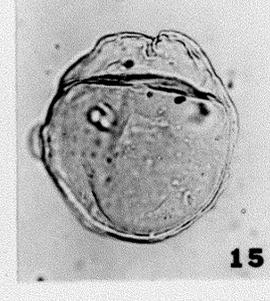
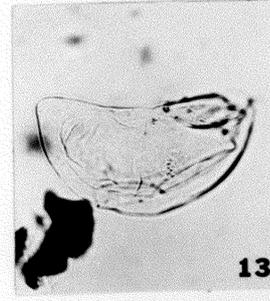
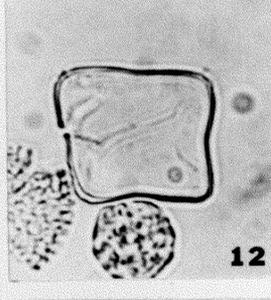
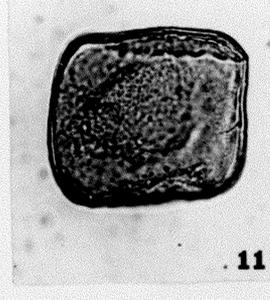
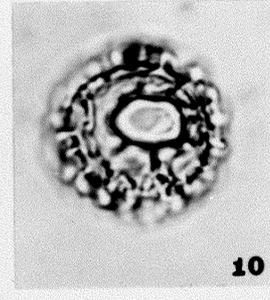
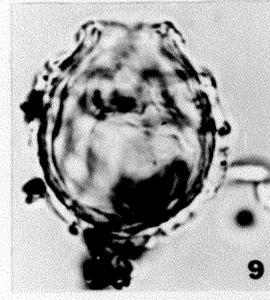
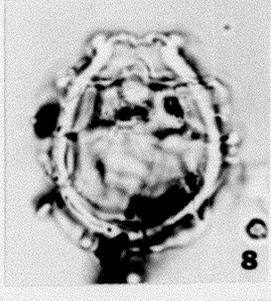
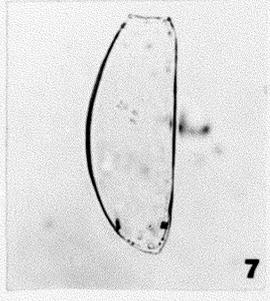
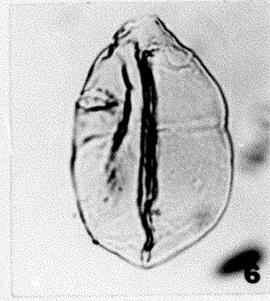
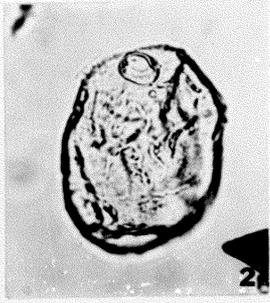
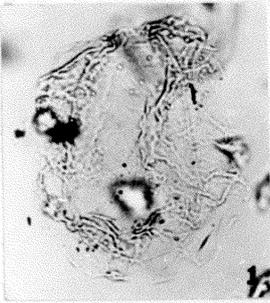


Plate 18

- FIG. 1. Ascostomocystis potane Drugg & Loeblich 1967. Cross-sectional view. Main body L x W (at widest point): 94 x 94u; overall L x W: 112 x 88u. VPISUPL sample 155, slide AE 97, coords. R8.2, +16.8.
- FIG. 2. Cyclopsiella vieta Drugg & Loeblich 1967. High focus level displays rimmed aperture and wrinkled outer wall. Overall L x W: 74 x 60u; diameter of aperture, 7u. VPISUPL sample 155, slide AE 98, coords. R20.2, +18.4.
- FIG. 3. Cyclopsiella elliptica Drugg & Loeblich 1967. Cross-sectional view. Overall diameter 56u. VPISUPL sample 163, slide AF 53, coords. R15.3, +3.9.
- FIGS. 4-5. Palaeostomocystis chytra Drugg 1967. Each is a cross-sectional view. Fig. 4, overall L x W: 46 x 42u. VPISUPL sample 116, slide AE 45, coords. R7.5, +6.1. Fig. 5, overall L x W: 20 x 17u. VPISUPL sample 164, slide AF 56, coords. R14.3, +13.4.
- FIG. 6. Palaeostomocystis fragilis Cookson & Eisenack 1962. Cross-sectional view. Overall L x W: 84 x 54u. VPISUPL sample 151, slide AE 52, coords. R12.3, +17.3.
- FIG. 7. Palaeostomocystis laevigata Drugg 1967. Cross-sectional view. Note rimmed pores at each pole. Overall L x W: 58 x 22u. VPISUPL sample 122, slide AD 73, coords. R12.0, +15.0.
- FIGS. 8-10. Palaeostomocystis reticulata Deflandre 1937. Fig. 8, high focus level in lateral view; Fig. 9, cross-sectional view of same specimen. Main body L x W: 31 x 24u; overall L x W: 34 x 30u. VPISUPL sample 117, slide AD 53, coords. R11.3, +2.5. Fig. 10, polar view showing rimmed aperture. Main body diameter 20u; overall diameter 23u. VPISUPL sample 117, slide AD 53, coords. R16.6, +7.2.
- FIG. 11. Schizocystia laevigata Cookson & Eisenack 1962. Maximum dimension 54u. VPISUPL sample 151, slide AE 55, coords. R5.0, +8.4.
- FIG. 12. Schizocystia cf. S. laevigata Cookson & Eisenack 1962. Maximum dimension 23u. VPISUPL sample 153, slide AE 75, coords. R17.7, +19.6.

- FIG. 13. Wallodinium anglicum (Cookson & Hughes 1964) Lentin & Williams 1973. Main body L x W: 50 x 24u; overall L x W: 60 x 36u. VPISUPL sample 168, slide AF 83, coords. R14.8, +8.6.
- FIG. 14. Wallodinium luna (Cookson & Eisenack 1960) Lentin & Williams 1973. Main body L x W: 52 x 26u; overall L x W: 72 x 50u. VPISUPL sample 116, slide AD 45, coords. R1.9, +14.6.
- FIG. 15. Xenikoon australis Cookson & Eisenack 1960. Specimen L x W: 64 x 60u. VPISUPL sample 116, slide AD 47, coords. R9.2, +13.1.
- FIGS. 16-17. Paralecaniella indentata (Deflandre & Cookson 1955) Cookson & Eisenack 1970. Fig. 16, specimen L x W: 82 x 68u. VPISUPL sample 116, slide AD 47, coords. R13.6, +7.1. Fig. 17, lateral view of another specimen. Specimen height 32u. VPISUPL sample 116, slide AD 47, coords. R12.2, +5.9.
- FIGS. 18-19. Palambages spp. In Fig. 18, specimen bears numerous small cells. Diameter of individual cells, ca. 20u; diameter of colony, 114u. VPISUPL sample 152, slide AE 68, coords. R17.9, +5.5. In Fig. 19, specimen bears relatively few, large cells. Diameter of individual cells, ca. 50u; diameter of colony, 98u. VPISUPL sample 165, slide AF 67, coords. R9.1, +9.5.
- FIG. 20. Ophiobolus lapidaris O. Wetzel 1933. Specimen L x W: 43 x 24u. VPISUPL sample 154, slide AE 83, coords. R5.5, +10.5.

PLATE 18



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CAMPANIAN-MAESTRICHTIAN AND PALEOCENE DINOFLAGELLATES AND ACRITARCHS
FROM THE MARYLAND-DELAWARE COASTAL PLAIN

BY

Barbara Louise Whitney

(Abstract)

The taxonomy and biostratigraphy of Upper Cretaceous and Paleocene dinoflagellate and acritarch assemblages from the Maryland-Delaware Coastal Plain have been investigated from strata outcropping near Washington, D.C., to the eastern end of the Chesapeake and Delaware Canal, Delaware. Samples of the Cretaceous Mount Laurel Sand and Monmouth Formation (Red Bank equivalent) and the Paleocene Brightseat Formation yielded 51 genera containing 95 species and four subspecies, of which one genus and nine species are described as new; five new combinations are proposed. Twelve acritarch genera with 14 species and several informally-designated species, two species of Chlorophyta, and one species of Protozoa also occur in the section.

The Cretaceous-Tertiary boundary in Maryland is marked by the termination of ranges of eight species and one subspecies of dinoflagellates and one acritarch species, and by the first appearance of 13 species of dinoflagellates. An unconformity representing a time interval of unknown duration may separate Cretaceous and Tertiary strata in the study area in Maryland; lithologic evidence (Bennett and Collins, 1952) and evidence based on the ranges of

dinoflagellates near Annapolis, Maryland (Benson, 1975), and the ranges of ostracodes (Hazel, pers. comm., 1975) supports this conclusion. Species with stratigraphic ranges restricted to the Mount Laurel, Monmouth, or Brightseat Formation indicate the potential usefulness of dinoflagellates in zoning Atlantic Coastal Plain strata and in correlating coastal plain and continental shelf strata.

A correlation of the Mount Laurel with Wilson's Zone I of the Maestricht section (Belgium-Netherlands), based on the ranges of species in common, indicates a Late Campanian age; megafossil evidence supports a Late Campanian age, and foraminiferal evidence, a Late Campanian-Early Maestrichtian age for the Mount Laurel (Owens et al., 1970). A correlation of the Monmouth Formation with Wilson's Zone II confirms a Maestrichtian age determination based on megafossils (Cooke, 1952; Glaser, 1971). Concurrent ranges of dinoflagellate species indicate a Paleocene age for the Brightseat Formation, confirming evidence based on ostracodes (Hazel, 1968, 1969) and Foraminifera (Nogan, 1964).

Species diversity and the ratio of gonyaulacacean to peridiniacean species (G/P ratio) are seemingly interrelated. Diversity varies with the G/P ratio from sample to sample through the section. On the basis of an overall high diversity and high G/P ratio, the section as a whole may represent deposition under open marine conditions (Harland, 1971).

Dominance by cavate cysts (e.g., Deflandrea) to dominance by chorate cysts (e.g., Areoligera) occurs progressively from the Mount

Laurel into the Brightseat Formation. Vozzhennikova (1967) and Downie et al. (1971) indicate that chorate cysts occur seaward of cavate cysts. Brightseat samples are dominated by chorate cysts. Water depth during deposition of the Brightseat was about 300 feet, according to Nogan (1964), who based his evidence on foraminiferal paleoecology. In the Monmouth, samples dominated by chorate cysts alternate with samples dominated by cavate cysts; the Monmouth appears to represent an environment of deposition nearer to shore than the Brightseat. The Mount Laurel Sand, dominated by cavate cysts, indicates deposition still nearer shore; this conclusion is supported by lithologic evidence (Owens and Sohl, 1969).