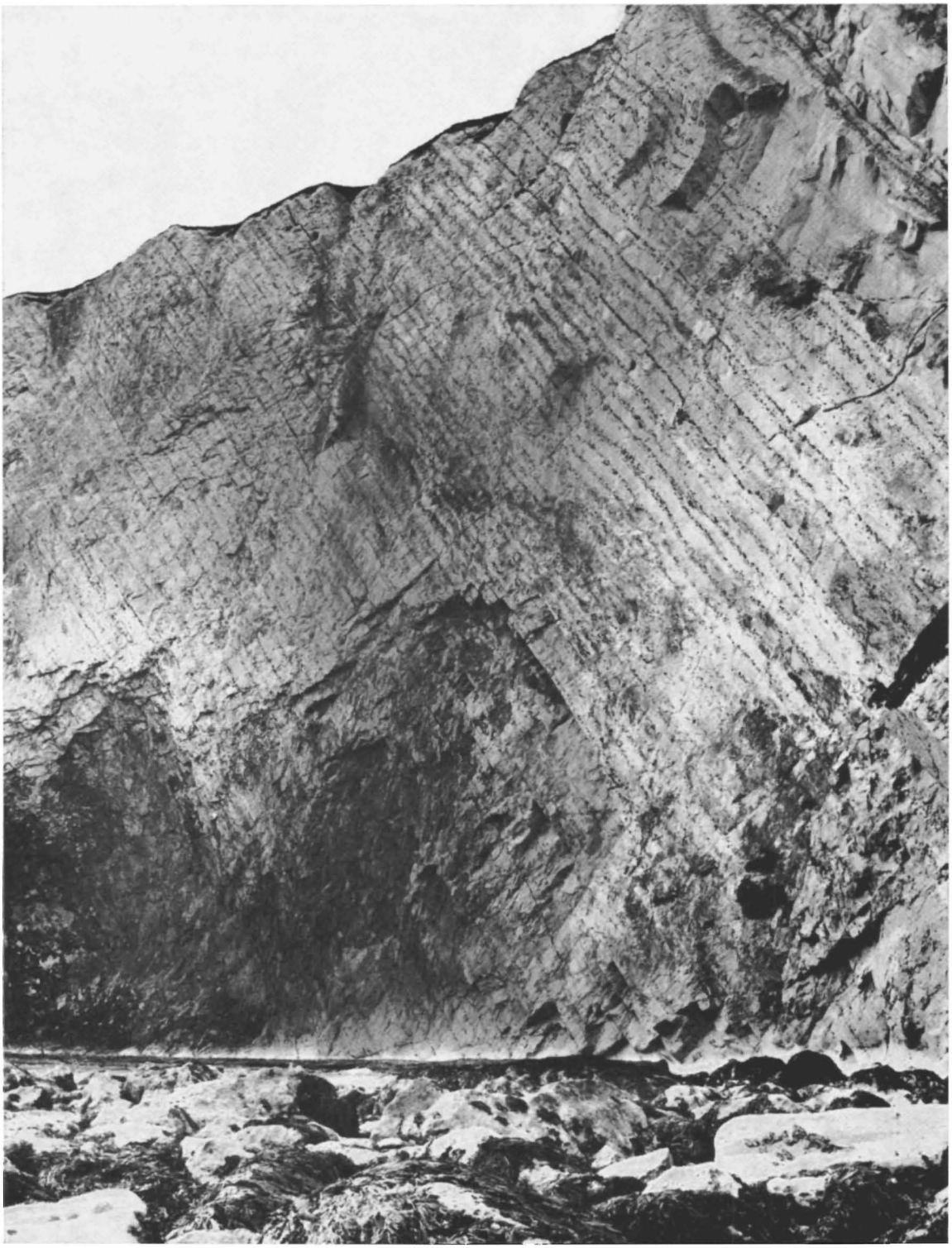

Culver Cliff, Isle of Wight

VERHANDELINGEN DER KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN, AFD. NATUURKUNDE
EERSTE REEKS – DEEL XXIV – No. 3

AN INVESTIGATION OF MICROPLANKTON ASSEMBLAGES FROM THE CHALK OF THE ISLE OF WIGHT, ENGLAND

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CONTENTS

ABSTRACT

Microplankton assemblages are recorded and described from chalk surface samples of Cenomanian to Senonian age from the Isle of Wight, England. The samples have been collected from two sections which are well-dated upon independent palaeontological evidence. The location and stratigraphy of these sampled sections are discussed with reference to maps and columnar sections. The maceration technique required for these chalk samples is also discussed.

The various taxa constituting the microplankton assemblages are described and illustrated in a systematic section which includes four new genera (*Ellipsodinium*, *Hexasphaera*, *Pyramidium*, *Senoniasphaera*) and twenty-one new species.

The recorded microplankton species have been tabulated quantitatively in the form of a distribution chart for the combined sections. The data from this chart have been used to compile a range chart which incorporates a proposed microplankton subdivision for this Cenomanian to Senonian interval. This subdivision is expressed in two ways; one giving five zones and five sub-zones based on conventional stratigraphical methods, the other comprising seven 'intervals' using 'top occurrences' (extinction points) of certain species. This latter form of subdivision is especially valuable to oil company palynologists whose material often consists of cutting samples.

Although the above subdivisions are based virtually upon one section, the observations and results presented have been substantiated by work currently being undertaken at B.I.P.M. on the Upper Cretaceous of France. It is concluded that the use of microplankton will provide a reliable time-stratigraphical control in marine sediments of Upper Cretaceous age.

INTRODUCTION

There are many papers published on the subject of Upper Cretaceous microplankton. However, most of these are primarily interested in descriptive morphology giving little or no stratigraphic data. The majority of the studies previously undertaken in North-West Europe in the Upper Cretaceous have been concentrated on the investigation of microplankton from flint with little or no observations of microplankton occurrences from the surrounding sediment. This paper is an effort to extend these studies in two respects. Firstly we have subjected the sediment to normal palynological maceration technique and obtained generally rich and well preserved microfloras. Secondly we have used the data from these assemblages in an attempt to build up a palynological stratigraphic subdivision for the Cenomanian-Senonian interval in the Isle of Wight.

Acknowledgements

We should like to express our appreciation to the Bataafse Internationale Petroleum Maatschappij N.V. for permission to publish this report and in particular to Dr. R. Lagaaij and Mr. C. A. Hopping for constant help and the critical reading of the manuscript. Very special thanks are accorded to Professor G. Deflandre for his interest in our study and for permitting us to examine holotypes and other material in his collection.

SAMPLE LOCALITIES

The samples for the present study have been collected from two principal sections; Culver Cliff and Watcombe Bay (text-fig. 1).

Culver Cliff Section (Text-figs. 2 and 3)

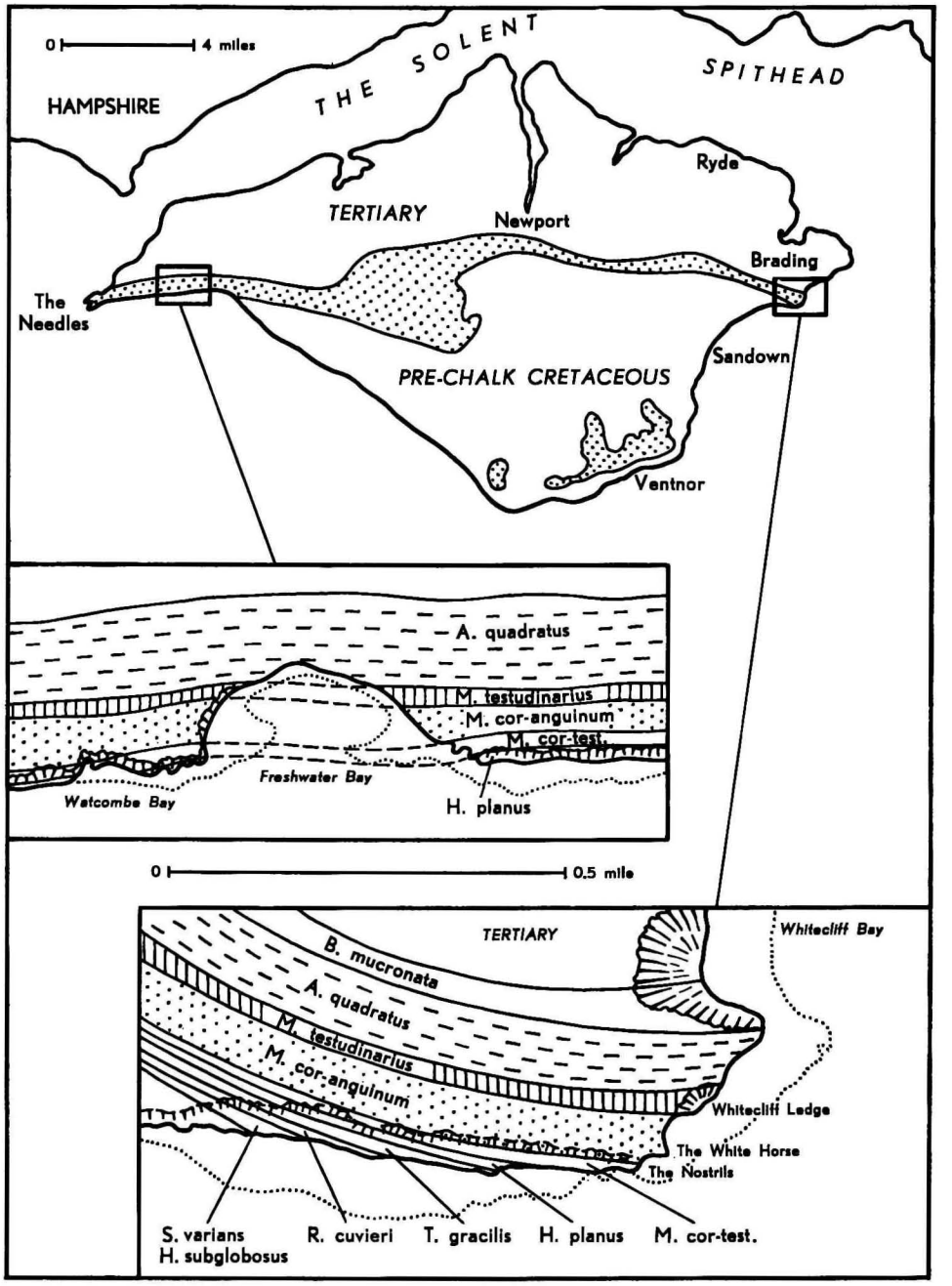
Culver Cliff is situated some 2 miles east of Brading and 2 miles south of Bembridge in the eastern part of the Isle of Wight (text-fig. 1). For purposes of description it is convenient to separate the section west of The Nostrils (The Southern Cliff), from that immediately to the north, and located south of Whitecliff Bay (The Eastern and White Cliffs).

The older zones of the Chalk are exposed in the Southern Cliff for a distance of some 800 yards immediately west of The Nostrils and are best approached from Sandown either by walking along the beach or by taking the cliff path which descends to the beach some 200 yards west of the Greensand/Chalk junction. This section in the Southern Cliff only allows collection of material to be made in the zones of *Schloenbachia varians*, *Holaster subglobosus* and the very base of *Rhynchonella cuvieri*. Above this the section is badly slumped and it becomes impossible to determine the junctions between the zones. Thus it is not possible here to collect satisfactorily from the upper part of the *R. cuvieri*, *Terebratulina gracilis*, *Holaster planus* and *Micraster cor-testudinarium* zones.

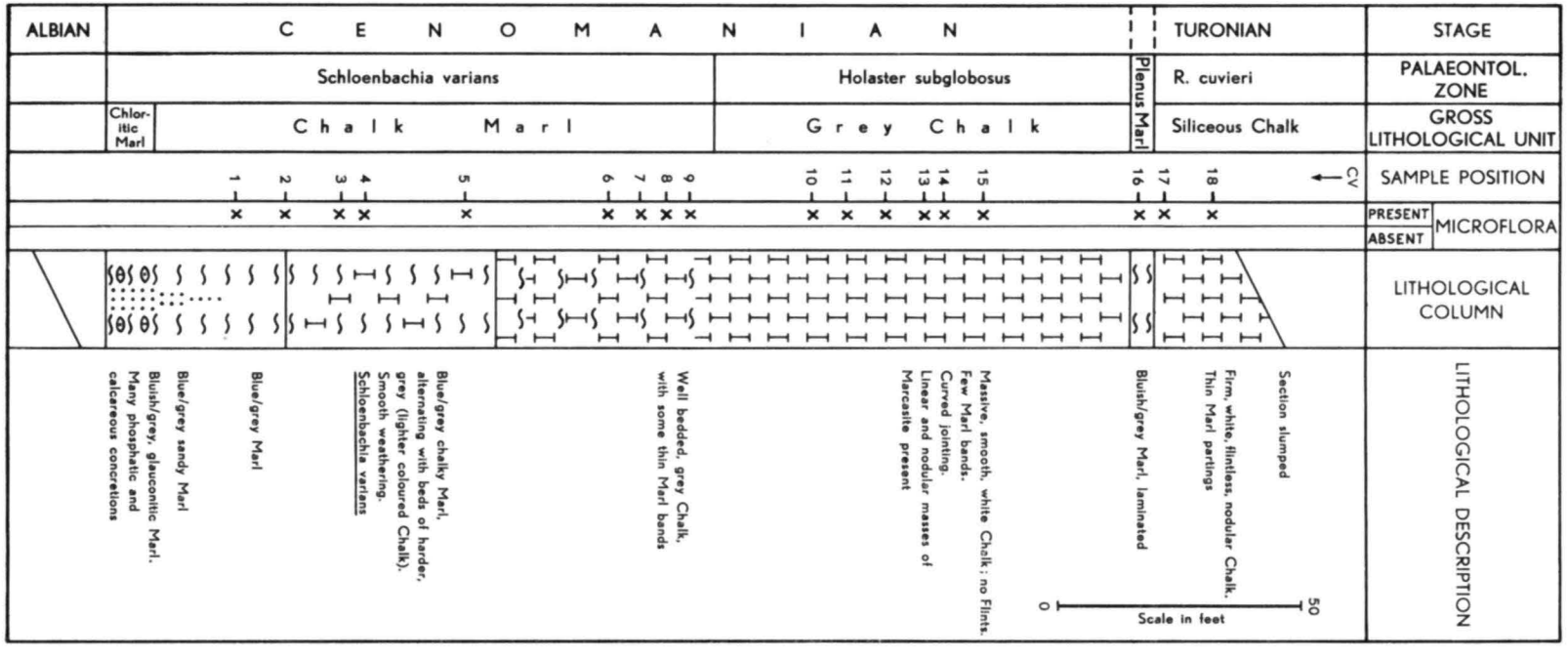
The younger zones, exposed in the cliffs south of Whitecliff Bay, are best approached from the north as only at exceptionally low tide is it possible to approach Whitecliff Bay, along the beach, from the south. This section furnished samples of the *Micraster cor-anguinum*, *Marsupites testudinarius*, *Actinocamax quadratus* and *Belemnitella mucronata* zones. The zone of *M. cor-testudinarium* cannot be worked from this side and the tide generally prohibits an examination of this zone in the Southern Cliff. Further details of the Culver Cliff section can be found in Rowe (1908, p. 237), Brydone (1914, p. 209) and Barr (1962, p. 556).

Watcombe Bay Section (Text-fig. 4)

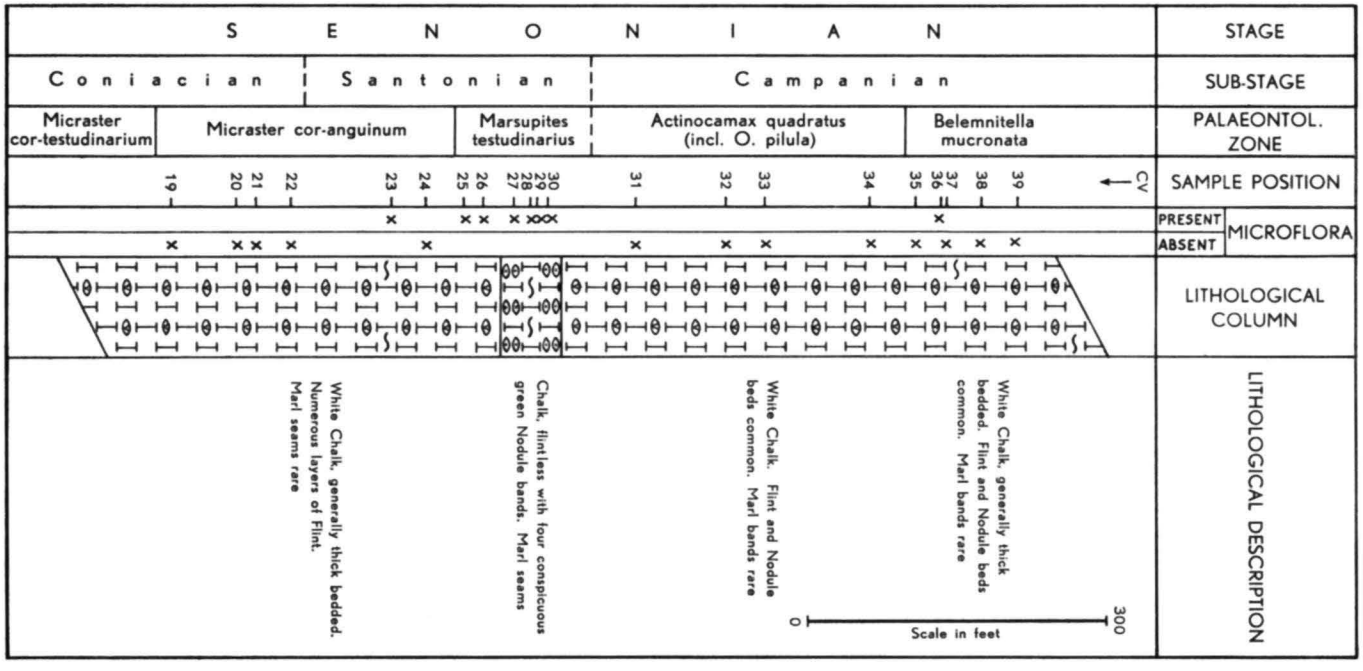
Watcombe Bay is located immediately west of Freshwater but cannot generally be approached from Freshwater Bay. It is possible to reach the beach by way of the cliff path leading across East High Down to Tennyson's Beacon, but this can be rather dangerous on return, due to its steepness, especially if a lot of samples are to be carried. It is no longer possible to reach the beach by way of the tunnel from the cliff-top house. The most satisfactory way to enter the bay, which gives a complete exposure of the *M. cor-testudinarium* zone, is by boat. From this section it is possible to collect from the top of the *H. planus* zone, the complete *M. cor-testudinarium* and the very base of the *M. cor-anguinum* zones.



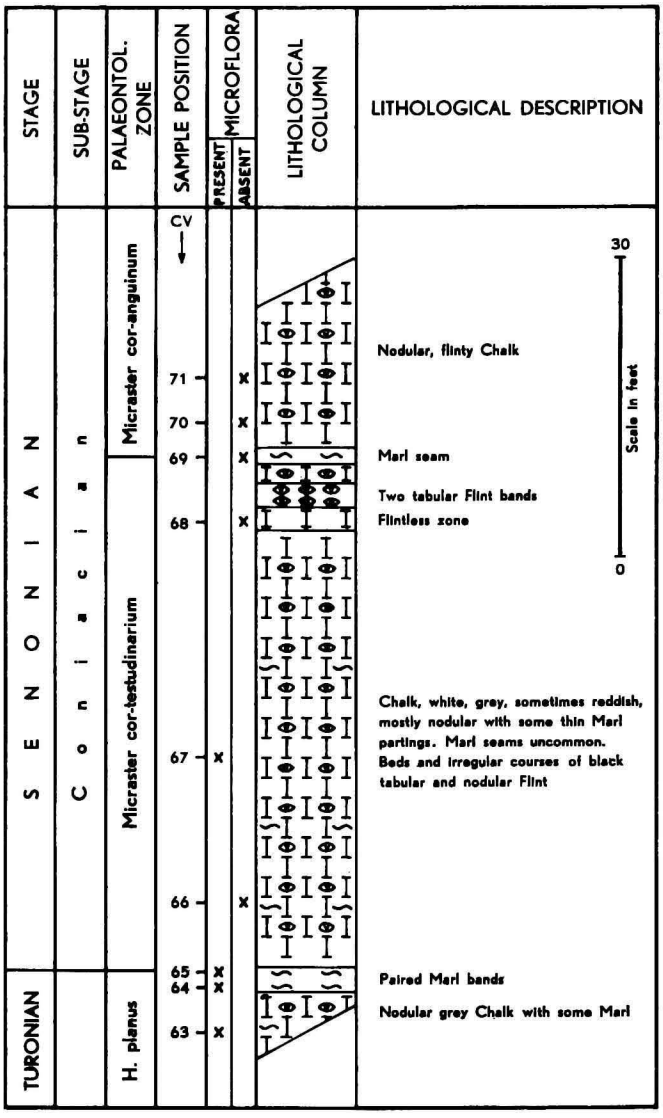
Text-fig. 1. Indicating the location and general geological setting of the two principal sections used in this study.



Text-fig. 2. Culver Section — The Southern Cliff, showing the lithology and stratigraphic position of the samples collected.



Text-fig. 3. Culver Section — The Eastern and White Cliffs, showing the lithology, and stratigraphic position of the samples collected. (Position of the upper limit of the *M. testudinarius* Zone after Barr 1962).



Text-fig. 4. Watcombe Bay Section, showing the lithology and stratigraphic position of the samples collected.

This exposure has previously been described by ROWE (1908, p. 225) and WHITE (1921, p. 75 and 77).

By collecting from these two sections one is able to obtain a sample coverage for most of the Chalk as exposed on the Isle of Wight. However there remains a deficiency of collected material for the zones of *R. cuvieri*, *T. gracilis*, and *Holaster planus*. To obviate this lack of material for the *T. gracilis* and *H. planus* zones a visit was made to a small quarry west of Yarbridge on Brading Down (Map Ref. 599866). This quarry is largely overgrown but at the western end the junction between the *T. gracilis*

and *H. planus* zones can be observed (see WHITE 1921, p. 68). However, the microfloras obtained from these samples are rather poor and restricted to a small number of mainly Acritarch species. They are only briefly discussed at the end of this paper.

STRATIGRAPHIC SECTION

The first serious endeavour to subdivide the British Chalk into bio-stratigraphical units, as opposed to pure litho-stratigraphical divisions, was made by BARROIS (1875, 1876). Barrois grouped his palaeontological zones into the Cretaceous stages Cenomanian, Turonian and Senonian (names that had already been proposed by D'ORBIGNY 1842, 1847) and found that they accorded closely with those zones already elucidated in France.

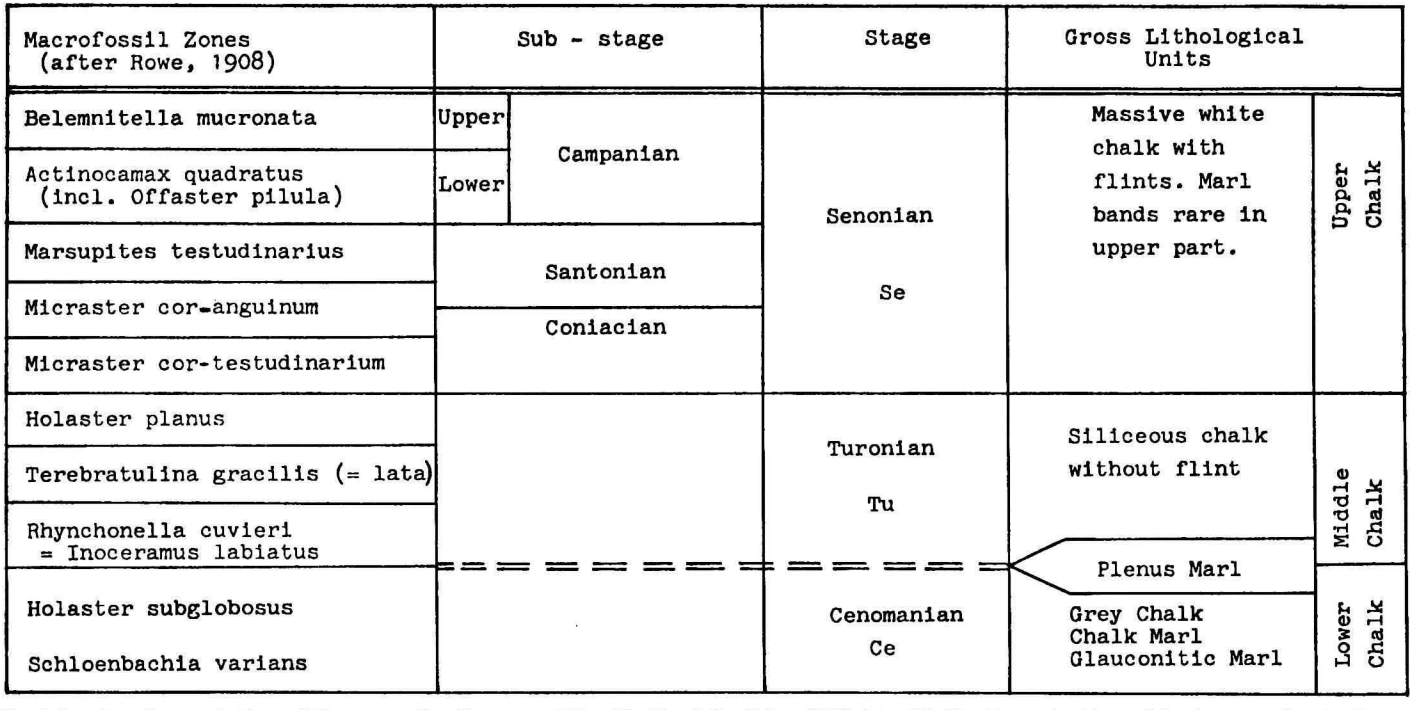
The zonation given by Barrois was later modified (e.g. his zones of *Pecten asper* and *Ammonites inflatus* being placed in the Albian). This formed the basis of the zonation adopted by ROWE (1908) who defined the zones in terms of mappable horizons and established their extent in his study of the White Chalk of the Isle of Wight. The nomenclature established by Rowe for these zones is used in the present paper and the criteria used for separating them in the field have been followed, with one exception. We are inclined to agree with BARR (1962, p. 557) in his discussion of the upper boundary of the *M. testudinarius* zone (see also text-fig. 3).

While it is probably true that the Lower Chalk, Middle Chalk and Upper Chalk in the Isle of Wight, as elsewhere, most nearly correspond to the time-stratigraphic stages Cenomanian, Turonian and Senonian respectively, there has always existed arguments as to the position of some of the lithological and palaeontological units.

The *Plenus*-Marl and the *Actinocamax plenus* sub-zone are variously placed in the Upper Cenomanian and Lower Turonian. The case for its emplacement in the Turonian is clearly stated in JEFFERIES (1963), although the evidence upon which his argument is based does not find universal favour (see HANCOCK in JEFFERIES 1963). The position is made more difficult as it appears that there is a stratigraphic gap between the top of the type Cenomanian and the base of the type Turonian (see HANCOCK in SIGAL et al. 1959, p. 860). It would thus seem possible that the *Plenus*-Marl was deposited, at least in part, during the time represented by this gap. Such a position has been given for the *Plenus*-Marl in our text-fig. 5.

BARROIS (1876) placed the *Holaster planus* zone in the Turonian; this zone is subsequently located in the Upper Chalk by JUKES-BROWNE (1903, p. 1–10). We, following many of the continental stratigraphers (HÉBERT 1874, LAMBERT 1879–82), have retained its position in the Turonian.

The relative positions of the palaeontological zones, stages and sub-



Text-fig. 5. A correlation of the macrofossil zones of the Chalk of the Isle of Wight with the time-stratigraphic stages and sub-stages.

stages are given following the opinions expressed in the Lexique Stratigraphique (SORNAY ed. 1957) and in SIGAL et al. (1959).

The necessary stratigraphic information for the Isle of Wight is tabulated as text-fig. 5.

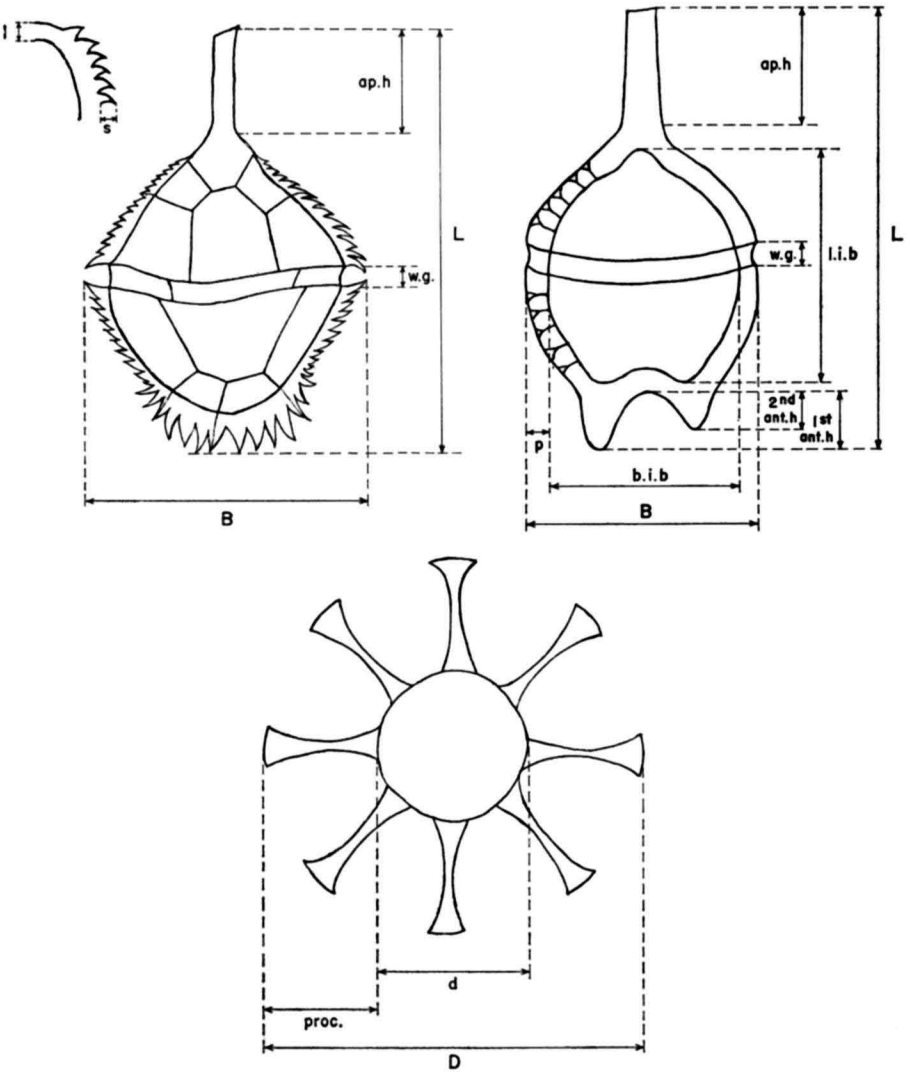
MACERATION PROCEDURE

The lithologies of the samples here studied are chalk, marly chalk, marl and flint. The best microfloras both in preservation and number of species have been obtained from the marly chalk. Good microfloras, but more restricted in absolute number have also been obtained from some marl and chalk samples. However, many of the chalk samples and all the flint samples produced no microflora at all. In the case of the flint the absence of a microflora can be explained if the micro-organisms had been replaced by silica; they would then have been destroyed during the hydrofluoric acid treatment. In general the greater the marl content of the chalk the better the microflora, however some chalk with an extremely low marl content gave satisfactory results (e.g. samples 18, 25, 36). The quantity of marl also determined the amount of material necessary to produce a sufficient residue for examination. It is found that 150 grams for the marly chalk and 350 grams for the non-marly chalk is sufficient quantity to use for the preparation.

The preparation proceeds as follows:

1. The required amount of sample is crushed to about 1 millimeter particle size.
2. The sample is allowed to stand in cold concentrated hydrochloric acid and is then slowly brought to the boil and allowed to stand. When the reaction is complete the sample is washed, centrifuged and decanted.
3. Sample is transfered to a nickel crucible and placed in 40 % commercial hydrofluoric acid and allowed to stand for 24 hours, after which it is centrifuged and the liquid decanted.
4. The silica 'gel' is rejected by adding hot concentrated HCl to the material, which is stirred, centrifuged and decanted. This process sometimes needs to be repeated several times.
5. The sample is washed several times with alcohol.
6. Bromoform (specific gravity 2.2) is added to the sample which is agitated to aid dispersion. Having centrifuged the sample (3,500 r.p.m., for 5 minutes) the upper, lighter fraction is retained. This is then washed several times with alcohol.
7. The residue is placed in a small tube with a little glycerine, labelled and sealed.

No oxidation or ultrasonic vibration treatment was needed in the



Text-fig. 6. Generalized Microplankton to illustrate the dimensions used in this investigation. L = length or overall length; B = breadth or overall breadth; ap.h.= length of apical horn; w.g. = width of girdle; l = height of ledge; s = height of spines; l.i.b. = length of inner body; b.i.b. = breadth of inner body; 1st, 2nd ant. h. = length of antapical horns; p = height of pillars; D = overall diameter; d = diameter of body or main body; proc. = length of processes.

preparation of the present samples. We are of the opinion that this latter treatment can cause undue fracturing of Dinoflagellates, especially of large forms, with apical archaeopyles, e.g. *Odontochitina*, *Pseudoceratium*.

The Slide Collection

All the illustrated specimens are from single preparations mounted in glycerine jelly, unstained, and made permanent with a bees-wax surround.

All slides including one set of assemblage slides, used for counting, are housed in Le Laboratoire de Micropaléontologie de l'Ecole Pratique des Hautes Etudes, Paris, 5.

CLASSIFICATION AND SYSTEMATICS

Within recent years much has been written concerning the classification and affinities of fossil microplankton and as yet no stabilized system has been formulated. Some measure of agreement, however, has followed the proposal of DOWNIE, WILLIAMS and SARJEANT (1961) to consider fossil microplankton under the Botanical Code of Nomenclature. This theme is reiterated and enlarged upon in DOWNIE, EVITT and SARJEANT (1963) where it is further proposed that the Acritarcha (see EVITT 1963) be classified 'artificially' (i.e. into form genera in much the same way as POTONIÉ's 1954 etc., classification of miospores), while the Dinoflagellates be grouped under 'natural' botanical units (Family, Order) as Dinoflagellates are allied to the Algae. The reasons and justifications for these proposals are given in DOWNIE, EVITT and SARJEANT (1963). Despite the recent findings of EVITT and DAVIDSON (1964) which pose further nomenclatural and classification problems we prefer, if only for expediency, to follow DOWNIE, EVITT and SARJEANT (1963) in their grouping of the Acritarcha and to use the family names proposed by EISENACK (1961 and 1963a), but with botanical endings, plus those families set up by EVITT (1963), for the Dinoflagellates.

Class DINOPHYCEAE Pascher
Subclass DINOFEROPHYCIDAE Bergh
Order NORMODINALES Chatton
Family APTEODINIACEAE Eisenack
Genus TRICHODINIUM Eisenack and Cookson 1960 emend.

Type Species, *T. pellitum* Eis. and Cook. 1960

1935 *Palaeoperidinium* Defl., in Deflandre (pars)
1959 *Apteodinium* Eis., in Gocht (pars)

Emended Diagnosis,

Shell spherical to oval with longitudinal and transverse furrows more or less distinct. A short apical horn may be present; there may also be some differentiation antapically. Archaeopyle precingular. Sculpture of generally short hairs, spines or small flat-topped processes. No definite tabulation observed.

Remarks,

The emendation is proposed to group under the same generic name those forms which have a precingular archaeopyle, this distinctive form

of sculpture and a small apical horn. This latter feature is commonly formed by the coalescence of several hairs or bristles in the apical region and is thus different from the horn formation in many other dinoflagellate genera e.g. *Apteodinium*.

Comparison,

Trichodinium emend. differs from *Apteodinium* Eisenack 1958 in the horn formation and type of sculpture, from *Cometodinium* Deflandre and Courteville 1939 in the presence of an apical horn and absence of tabulation and from *Xenicodinium* Klement 1960b in the presence of a girdle and small apical horn.

Within the genus *Trichodinium* emend. are accepted the following species,

T. castanea (Deflandre 1935) comb. nov.

T. hirsutum Cookson 1965b

T. paucispinum Eisenack and Cookson 1960

T. pellitum Eisenack and Cookson 1960

Trichodinium castanea (Deflandre 1935) comb. nov.
Plate 1, figs. 1–2

Holotype,

Palaeoperidinium castanea Defl. 1935, pl. 6, fig. 8

1935 *P. castanea* Deflandre, p. 229, pl. 6, fig. 8

1936a *P. castanea* Defl., in Deflandre, p. 58, fig. 99

1936b *P. castanea* Defl., in Deflandre, p. 177, pl. 6, figs. 1–4

1957 ?Dinoflagellaten gen. and sp. ind., in Gocht, p. 171, pl. 20, figs. 9–10

1959 *Apteodinium ciliatum* Gocht, p. 65, pl. 8, figs. 5–6

1960 *Trichodinium intermedium* Eisenack and Cookson, p. 6, pl. 2, figs. 5–6

1961 *Apteodinium ciliatum* Gocht, in Alberti, p. 24, pl. 4, figs. 1–3, 14–15

1962b *Palaeoperidinium castanea* Deflandre, in Cookson and Eisenack, p. 489, pl. 3, figs. 9–11

1964 *P. castanea* Defl., in Cookson and Hughes, p. 49, pl. 5, fig. 14

1964 *Trichodinium ciliatum* (Gocht) Eisenack and Klement, p. 811

Remarks,

Gocht (1959, p. 65) compares his specimens of *Apteodinium ciliatum* with *Palaeoperidinium castanea* Defl. and states that the two species are very close, differing essentially only in the absence of a girdle in *A. ciliatum*. However, *A. ciliatum* is again illustrated by Alberti (1961) and it is possible to recognize a girdle on some of his specimens (figs. 1, 3, 15). These specimens are inappropriately placed in *Apteodinium* due to the particular type of apical horn formation. For this reason it seems better to assign them generically to *Trichodinium* and as there now appears to be no difference between them and *T. castanea* we accordingly place them in this species.

Previously known Occurrences

Upper Hauterivian to Upper Barremian, Germany (GOCHT 1957, 1959, ALBERTI 1961). Aptian to Lower Albian, Australia (EISENACK and COOKSON 1960). ?Aptian to Cenomanian, Australia (COOKSON and EISENACK 1962b). Upper Albian to Lower Cenomanian, England (COOKSON and HUGHES 1964). Turonian and Senonian, France (DEFLANDRE 1935, 1936a, 1936b, MERCIER 1938).

Family AREOLIGERACEAE Evitt

Genus CANNINGIA Cookson and Eisenack 1960

Type Species, C. reticulata Cook. and Eis. 1960

Canningia colliveri Cookson and Eisenack 1960

Plate 1, figs. 3–4

Holotype,

C. colliveri Cook. and Eis. 1960, pl. 38, fig. 4

1960b *C. colliveri* Cook. and Eis., p. 251, pl. 38, figs. 3–4

Remarks,

A feature of this species is the variability in the shape of the antapex being either rounded or bearing two antapical horns in the extreme cases. MANUM and COOKSON (1964) erect a species *C. ringnesii* which would accommodate only those forms with a rounded antapex. As there appears, however, in our material to be a complete and uninterrupted morphological gradation between the extremes given above we have placed all our specimens in *C. colliveri.*

Previously known Occurrences

Aptian, Australia (COOKSON and EISENACK 1960b, EISENACK and COOKSON 1960).

Canningia reticulata Cookson and Eisenack 1960

Plate 1, fig. 8

Holotype,

C. reticulata Cook. and Eis. 1960, pl. 38, fig. 1

1960b *C. reticulata* Cook. and Eis., p. 251, pl. 38, figs. 1–2

Remarks

This species, previously recorded from the Upper Jurassic, occurs in small numbers in the Cenomanian of the I.O.W.

Canningia senonica sp. nov.

Plate 1, figs. 12–14. Text-fig. 7

Holotype,

Plate 1, fig. 12. Slide Number 643. Sample Number CV 27. Culver Cliff, I.O.W. Senonian.

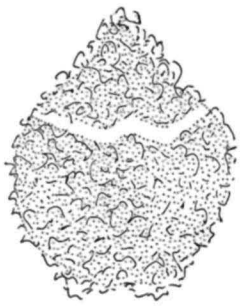
Diagnosis,

A species of *Canningia* with a small apical and frequently two small antapical protrusions. The sculpture consists of a fine, irregular reticulum.

Description,

Shape of body rounded with small apical and sometimes antapical protrusions. The apical archaeopyle is well displayed on most specimens which are incomplete having lost their apical part. Sculpture of thin irregular processes up to 12 μ long which join distally to form an incomplete and irregular reticulum; the sculpture completely covers the body.

Measurements:	Holotype	Range
Overall length	69 μ	60–85 μ
Overall breadth	57 μ	50–70 μ
Process length (max.)	8 μ	6–12 μ



Text-fig. 7. *Canningia senonica* sp. nov., diagrammatic reconstruction. × 800

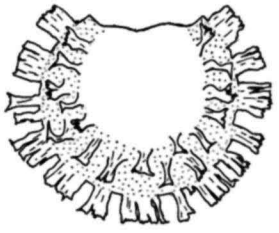
Comparison,

C. senonica sp. nov. differs from *C. reticulata* Cook. and Eis. in the possession of a higher reticulum, from *C. colliveri* Cook. and Eis., and *C. ringnesii* Manum and Cook. in the presence of a reticulum, from *C. rotundata* Cook. and Eis. in the absence of vermiculae and from *C. hirtellum* Eis. in the absence of discrete processes.

Genus CYCLONEPHELIUM Deflandre and Cookson 1955

Type Species, C. compactum Defl. and Cook. 1955

Cyclonephelium hughesii sp. nov.
Plate 2, fig. 6. Text-fig. 8



Text-fig. 8. *Cyclonephelium hughesii* sp. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 2, fig. 6. Slide Number 33. Sample Number CV 3. Southern Cliff, I.O.W. Cenomanian.

1960b *C. densebarbatum* Cook. and Eis., p. 253, p.l 38, fig. 9 (non fig. 10)
1964 *C.* cf. *densebarbatum* Cook. and Eis., in Cookson and Hughes, p. 44, pl. 10, fig. 10

Diagnosis,

A species of *Cyclonephelium* with broad, short processes.

Description,

Main body more or less rounded and showing a distinctly indented apical archaeopyle. Nearly all specimens are found with their apical part detached. Unornamented areas dorsally and ventrally are clearly observable although these vary in areal extent from one specimen to another. Sculpture consists of broad short appendages, closely spaced and with the distal part slightly expanded and indented.

Measurements:	Holotype	Range
Overall length	66 μ	66–110 μ
Overall breadth	63 μ	60–102 μ
Length of processes (max.)	7 μ	7– 12 μ

Remarks,

Cookson and Hughes (1964, pl. 10, fig. 10) illustrate a form *C.* cf. *densebarbatum* which we consider is within the diagnosis of *C. hughesii* sp. nov. Cookson and Hughes maintain a similarity between their specimen and some of those forms recorded by Cookson and Eisenack (1960) from the Upper Jurassic of Western Australia and designated *C. densebarbatum* (see Cook. and Eis. 1960b, p. 253, and Cook. and Hugh. 1964, p. 44).

Comparison,

C. hughesii sp. nov. is distinguished from *C. distinctum* and *C. densebarbatum* in having much broader processes.

Cyclonephelium distinctum Deflandre and Cookson 1955
Plate 1, figs. 6–7

Holotype,

C. distinctum Defl. and Cook. 1955, pl. 2, fig. 14
1955 *C. distinctum* Defl. and Cook., p. 285–286, pl. 2, fig. 14, text-figs. 47–48.
1959 *C. distinctum* Defl. and Cook., in Gocht, p. 77, pl. 14, figs. 16–18
1961 *Circulodinium deflandrei* Alberti, p. 293, pl. 4, figs. 7–13
1962b *Cyclonephelium distinctum* Defl. and Cook., in Cookson and Eisenack, p. 494, pl. 5, figs. 4–11
1964 *C. distinctum* Defl. and Cook., in Manum and Cookson, p. 16, pl. 4, figs. 1–3

Previously known Occurrences

Upper Valanginian to Hauterivian, Germany (GOCHT 1959). Upper Hauterivian to Aptian, ?Lower Albian, Germany (ALBERTI 1961). Albian to Senonian, Australia (COOKSON and EISENACK 1962b, DEFLANDRE and COOKSON 1955). Upper Cretaceous, Canada (MANUM and COOKSON 1964).

Cyclonephelium membraniphorum Cookson and Eisenack 1962
Plate 2, figs. 1–2

Holotype,

C. membraniphorum Cook. and Eis. 1962, pl. 6, fig. 9
1962b *C. membraniphorum* Cook. and Eis., p. 495, pl. 6, figs. 8–14
1964 *C. membraniphorum* Cook. and Eis., in Cookson and Hughes, p. 44, pl. 10, figs. 5–6

Remarks,

Our specimens are referred to *C. membraniphorum* as they appear to fit within the specific diagnosis. However our specimens must also be compared with *C. vitilare* Cookson 1965b from the Paleocene of Australia. Cookson does not compare *C. vitilare* with other species of the genus but it is evident that *C. vitilare* and some specimens of *C. membraniphorum* are morphologically very similar (see COOKSON and HUGHES 1964, pl. 10, figs. 5 and 6).

Previously known Occurrences

Albian to Cenomanian, Australia (COOKSON and EISENACK 1962b). Lower Cenomanian, England (COOKSON and HUGHES 1964).

Family DEFLANDREACEAE Eisenack
Genus CARPODINIUM Cookson and Eisenack 1962

Type Species, *C. granulatum* Cookson and Eisenack 1962

Carpodinium obliquicostatum Cookson and Hughes 1964
Plate 2, figs. 4–5

Holotype,

C. obliquicostatum Cookson and Hughes 1964, pl. 6, fig. 1
1964 *C. obliquicostatum* Cookson and Hughes, p. 48, pl. 6, figs. 1–6

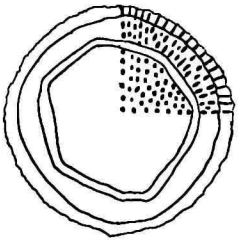
Previously known Occurrences

Upper Albian to Lower Cenomanian, England (COOKSON and HUGHES 1964).

Genus CHLAMYDOPHORELLA Cookson and Eisenack 1958

Type Species, C. nyei Cook. and Eis. 1958

Chlamydophorella discreta sp. nov.
Plate 2, figs. 9–10. Text-fig. 9



Text-fig. 9. *Chlamydophorella discreta* sp. nov., diagrammatic reconstruction, apical view. × 1000

Holotype,

Plate 2, fig. 10. Slide Number 31. Sample Number CV 3. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A species of *Chlamydophorella* with pillars of small length and without obvious sign of a girdle.

Description,

Inner body circular and thin walled. Apical archaeopyle present on some specimens. No apical protrusion has been observed on the inner body. Outer wall is a thin transparent membrane supported from the inner body by discrete pillars which are rod-like and whose tops are flat or only slightly expanded. The height of the pillars is 1–2 μ and the distance between the inner body and outer wall is uniform. No girdle or suggestion of this feature has been observed.

Measurements:	Holotype	Range
Overall diameter	33 μ	29–35 μ

Remarks,

The majority of the specimens are observed in apical, antapical or oblique orientations and are frequently folded.

Comparison,

C. discreta sp. nov. differs from *C. nyei* Cook. and Eis. in the smaller size of the pillars, the less obviously expanded or bifid distal extremities and the absence of a girdle. *C. urna* Cook. and Eis. is distinguished from *C. discreta* sp. nov. by the presence of a girdle, while *C. grossa* Manum and Cookson is obviously much larger.

Genus DEFLANDREA Eisenack 1938

Type Species, D. phosphoritica Eis. 1938

Deflandrea acuminata Cookson and Eisenack 1958
Plate 2, figs. 11–12

Holotype,

D. acuminata Cook. and Eis. 1958, pl. 4, fig. 5

1958 *D. acuminata* Cook. and Eis., p. 27, pl. 4, figs. 5–7 (non fig. 8 – see Cook. and Eis. 1960a, p. 5)

1960 *D. acuminata* Cook. and Eis., in Douglas, p. 19–20, pl. 4, figs. 21a–21b

1964 *D. acuminata* Cook. and Eis., in Manum and Cookson, p. 7–8, pl. 1, fig. 4

Remarks,

We observe, as do MANUM and COOKSON (1964, p. 7), that many specimens of this species lack the small apical protrusion of the inner body. However, in all other respects, e.g. shape of outer wall, relationship of outer wall to inner body etc., the morphology agrees with that diagnosed for *D. acuminata.*

Previously known Occurrences

Cenomanian to Lower Turonian, Australia (COOKSON and EISENACK 1958). Upper Cretaceous, Canada (MANUM and COOKSON 1964). No precise age can be given for the records of DOUGLAS (1960) and THORSTEINSSON and TOZER (1962).

Deflandrea cf. *cooksoni* Alberti 1959
Plate 3, figs. 1–3

Holotype,

D. cooksoni Alb. 1959, pl. 9, fig. 2

1959 *D. cooksoni* Alberti, p. 97, pl. 9, figs. 1–6

1964 *D.* cf. *cooksoni* Alberti, in Manum and Cookson, p. 8, pl. 1, figs. 2–3

Remarks,

It is with some diffidence that we compare the present specimens to *D. cooksoni* for the same reasons given by MANUM and COOKSON (1964, p. 8). Similarity with *D. cooksoni* is evident from the rather indistinct girdle and the granular sculpture. The differences lie in the frequent absence of the epithecal shoulders and a less prominent apical horn clearly displayed in the specimens of Alberti.

Previously known Occurrences

Senonian, Germany (ALBERTI 1959). Upper Cretaceous, Canada (MANUM and COOKSON 1964).

Deflandrea echinoidea Cookson and Eisenack 1960
Plate 3, figs. 4–5

Holotype,

D. echinoidea Cook. and Eis. 1960, pl. 1, fig. 5

1960a *D. echinoidea* Cook. and Eis., p. 2, pl. 1, figs. 5–6

Previously known Occurrences

Senonian, Australia (Cookson and Eisenack 1960a).

Deflandrea victoriensis Cookson and Manum 1964
Plate 3, figs. 8–9

Holotype,

D. victoriensis Cook. and Man. 1964, pl. 76, figs. 3–4

1961a *D. tripartita* Cook. and Eis., in Cookson and Eisenack, p. 70, text-fig. 1

1964 *D. victoriensis* Cookson and Manum, p. 522, pl. 76, figs. 3–8

Remarks,

The specimens attributed to *D.* cf. *cooksoni* Alberti, by BROSIUS (1963, p. 36, pl. 7, figs. 6–8) from the Upper Oligocene of Germany seem very close morphologically to *D. victoriensis*.

Previously known Occurrences

Senonian, Australia (COOKSON and EISENACK 1961a, COOKSON and MANUM 1964).

Genus GARDODINIUM Alberti 1961

Type Species, *G. eisenacki* Alberti 1961

Gardodinium deflandrei sp. nov.
Plate 3, figs. 10–12. Text-fig. 10

Holotype,

Plate 3, fig. 10. Slide Number 226. Sample Number CV 29. Culver Cliff, I.O.W. Senonian.

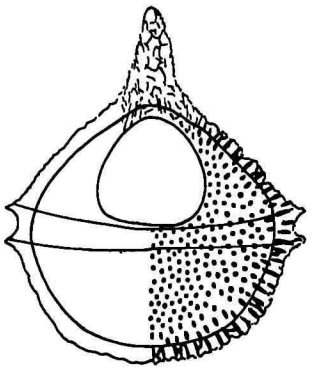
Diagnosis,

A species of *Gardodinium* without an apical protrusion of the inner body, with closely spaced pillars supporting the outer wall, and a precingular archaeopyle.

Description,

Inner body round, connected with a thin outer wall by means of pillars. Pillars more or less equal in length, joining distally or more proximally to give a rugulate pattern (text-fig. 10). This pillar-pattern is present over the whole of the inner body and is extended apically to form a horn. At this point the pillars are not in contact with the apical part of the inner body. A distinct arch-shaped archaeopyle is present and is pre-cingular in position; such a feature is observed on about 90 % of the specimens. A girdle is present and can best be seen when viewed on edge at the outline; ventrally the displacement equals two girdle widths. In many specimens a longitudinal furrow, extended equally on both epitheca and hypotheca, can be observed. There is no tabulation.

Measurements:	Holotype	Range
Overall length	52 μ	52–56 μ
Overall breadth	40 μ	40–48 μ
Length of inner body	36 μ	36–43 μ
Breadth of inner body	34 μ	34–41 μ
Length of apical horn	8 μ	8–10 μ
Length of pillars	1.5–4 μ	1.5–4.5 μ



Text-fig. 10. *Gardodinium deflandrei* sp. nov., diagrammatic reconstruction. × 1000

Remarks,

The above description may be said to be inconsistent with a generic assignation to *Gardodinium* Alberti. However we feel that the absence of tabulation in our species should not exclude it from *Gardodinium* as although the presence of plates is mentioned in the generic diagnosis this feature is not very clearly displayed on *G. eisenacki*. No mention is made of an archaeopyle by Alberti but specimens examined by us from the Lower Cretaceous of the Netherlands also have a pre-cingular archaeopyle (unpublished data, B.I.P.M.). For these reasons we prefer to include our species in *Gardodinium*.

Comparison,

G. deflandrei differs from *G. eisenacki* Alberti in the absence of an apical protrusion on the inner body and from *G. trabeculosum* Alberti

1961 and *G. alberti* Neale and Sarjeant 1962 in the more closely spaced pillars.

Genus PALAEOHYSTRICHOPHORA Deflandre 1935, emend. Deflandre and Cookson 1955

Type Species, P. infusorioides Deflandre 1935

Palaeohystrichophora infusorioides Defl. 1934, ex Deflandre 1935

Plate 4, fig. 10

Holotype,

P. infusorioides Defl. 1934, p. 967, fig. 8

1934 *P. infusorioides* Deflandre, p. 967, fig. 8 nom. nud.

1935 *P. infusorioides* Defl., in Deflandre, p. 230–231, pl. 8, fig. 4

1936b *P. infusorioides* Defl., in Deflandre, p. 186–187, pl. 9, figs. 5–10

1939 *P. infusorioides* Defl., in Deflandre and Courteville, p. 98, pl. 2, fig. 2

1940 *P. infusorioides* Defl., in Deflandre, p. 156–157, text-fig. 3

1955b *P. infusorioides* Defl., in Valensi, p. 591–592, pl. 3, figs. 9, 12 and 14

1958 *P. infusorioides* Defl., in Cookson and Eisenack, p. 37–38, pl. 10, fig. 10

1961 *P. infusorioides* Defl., in Alberti, p. 19, pl. 3, fig. 24

1964 *P. infusorioides* Defl., in Cookson and Hughes, p. 43, pl. 5, fig. 8

1964 *P. infusorioides* Defl., in Manum and Cookson, p. 19–20, pl. 6, fig. 5

Previously known Occurrences

Middle Albian (1 specimen) to Senonian, Germany (Alberti 1961). Cenomanian to Senonian, France (Deflandre 1934, 1935, 1936b, 1940, Deflandre and Courteville 1939, Valensi 1955b). Lower Cenomanian, England (Cookson and Hughes 1964). Cenomanian to Lower Turonian, Australia (Cookson and Eisenack 1958). Upper Cretaceous, Canada (Manum and Cookson 1964).

Genus SCRINIODINIUM Klement 1957
Sub-genus ENDOSCRINIUM Klement 1960

Type Species, Scriniodinium galeritum (Defl. 1938) Klement 1960

Scriniodinium campanula Gocht 1959

Plate 3, figs. 6–7

Holotype,

S. campanula Gocht 1959, pl. 5, fig. 1

1959 *S. campanula* Gocht, p. 61–62, pl. 4, fig. 6, pl. 5, fig. 1

1961 *S. campanula* Gocht, in Alberti, p. 17, pl. 3, fig. 6
1964 *S. campanula* Gocht, in Cookson and Hughes, p. 41–42, pl. 7, figs. 5–9

Previously known Occurrences

Valanginian to Aptian, Germany (Gocht 1959, Alberti 1961). Upper Albian to Lower Cenomanian, England (Cookson and Hughes 1964).

Family GONYAULACACEAE Schiller

Genus GONYAULACYSTA Deflandre 1964, ex Norris and Sarjeant 1965

Type Species, G. (al. *Gonyaulax*) *jurassica*
(Deflandre 1938) Norris and Sarjeant 1965

Gonyaulacysta cassidata (Cookson and Eisenack 1962) nov. comb. and restr.
Plate 4, figs. 4–6

Holotype,

Gonyaulax helicoïdea subsp. *cassidata* Eis. and Cook. 1960, pl. 1, fig. 5.
1960 *G. helicoïdea* subsp. *cassidata* Eis. and Cook., p. 3, pl. 1, figs. 5–6
1962b *G. cassidata* Cook. and Eis., p. 486–487, pl. 2, figs. 1–2
1964 *G. cassidata* Cook. and Eis., in Cookson and Hughes, p. 42, pl. 5, fig. 10 (non fig. 11)

Restricted Description,

Tabulation with 6 precingular plates and an archaeopyle formed by the loss of plate 3″; cingular plates present. Sutures are marked by ledges of varying height having smooth or more generally a denticulate sculpture. The antapical plate is bordered by high ledges bearing well developed denticles; the ledges are sustained at each angle by a support which does not protrude above the top of the ledge. The girdle is displaced generally more than two girdle widths. An inner body is present which is in contact with the outer wall everywhere except at the apex. Verrucae are often present on the plates but their number and distribution is variable. An apical horn is present on which septa are visible.

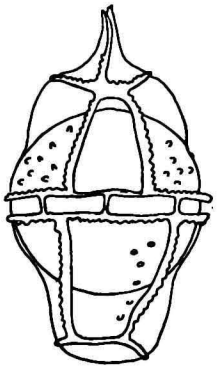
Remarks,

We have been able to distinguish within *G. cassidata* (sensu Cook. and Eis.) two forms which appear to have different stratigraphic ranges. From studies made by B.I.P.M. (unpublished) *G. cassidata* (restr. sense) has a base in the Lower Albian while G. *extensa* sp. nov. (see below) makes its first appearance in the Upper Albian.

Previously known Occurrences

Aptian to Cenomanian, Australia (EISENACK and COOKSON 1960, COOKSON and EISENACK 1962b). Upper Albian to Lower Cenomanian from England (COOKSON and HUGHES 1964).

Gonyaulacysta extensa sp. nov.
Plate 4, figs. 7–9. Text-fig. 11



Text-fig. 11. *Gonyaulacysta extensa* sp. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 4, fig. 9. Slide Number 448. Sample Number CV 12. Southern Cliff, I.O.W. Cenomanian.

1964 *G. cassidata* Cook. and Eis., in Cookson and Hughes, pl. 5, fig. 11

Diagnosis,

A species of *Gonyaulacysta* showing an antapical extension of the outer membrane to form a cavity between the inner body and the outer wall at the antapex.

Description,

Tabulation with 6 precingular plates and an archaeopyle formed by the loss of plate 3″; cingular plates present. Girdle strongly displaced more than two girdle widths. Ledges vary in height and are generally denticulate. Plates may possess verrucae whose number and distribution is variable. An apical horn is present on which septa are visible and often a "lid" is observed at the extremity. An inner body is present which is only in contact with the outer wall around the girdle area.

Measurements:	Holotype	Range
Overall length	82 μ	60–84 μ
Overall breadth	50 μ	36–60 μ
Length inner body	46 μ	33–46 μ
Breadth inner body	44 μ	36–60 μ
Width of girdle	4 μ	3– 8 μ
Height of ledges	3 μ	1– 4 μ
Height of apical horn	10 μ	4–11 μ

Comparison,

G. extensa sp. nov. differs from *G. cassidata* (here restr.) in the presence of a cavity situated antapically and formed by an extension of the outer wall. Therefore the inner body and the outer wall are not in contact in the antapical region. Such a feature is absent in *G. cassidata* (here restr.) where the inner body and outer wall are in contact at the antapex and where the antapical plate is bordered by a high denticulate ledge (pl. 4, fig. 6).

Gonyaulacysta edwardsi (Cookson and Eisenack 1958) comb. nov.
Plate 5, figs. 1

Holotype,

Gonyaulax edwardsi Cook. and Eis., 1958, pl. 3, fig. 6

1958 *G. edwardsi* Cook. and Eis., p. 32–33, pl. 3, figs. 5–6, text-fig. 7

1964 *G. edwardsi* Cook. and Eis., in Cookson and Hughes, p. 43, pl. 5, fig. 9

Previously known Occurrences

Albian to Lower Turonian, Australia (COOKSON and EISENACK 1958). Upper Albian to Lower Cenomanian, England (COOKSON and HUGHES 1964).

Gonyaulacysta microceras (Eisenack 1958) comb. nov.
Plate 4, figs. 1–3

Holotype,

Gonyaulax microceras Eisenack, 1958, pl. 21, fig. 13

1958 *G. microceras* Eisenack, p. 391, pl. 21, figs. 12–13

Remarks,

This rather rare form found in the Senonian of the Isle of Wight appears to be conspecific with *Gonyaulax microceras* Eisenack.

Previously known Occurrences

Upper Aptian, Germany (Eisenack 1958).

Gonyaulacysta striata sp. nov.
Plate 4, figs. 11–13. Text-fig. 12
Plate 5, fig. 15

Holotype,

Plate 4, fig. 11. Slide Number 642. Sample Number CV 26. Culver Cliff, I.O.W. Senonian.

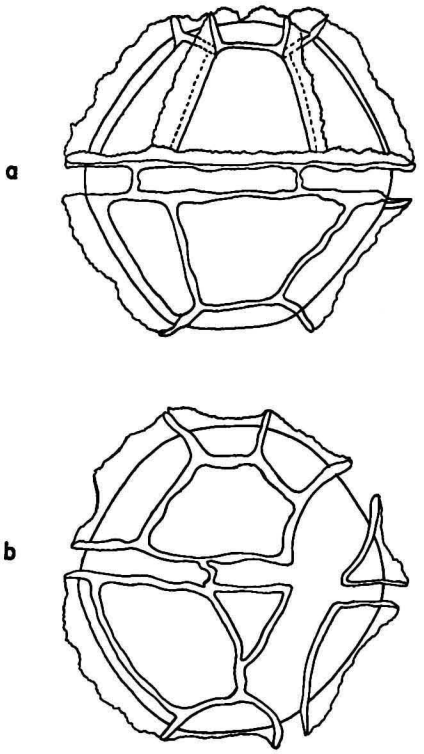
Diagnosis,

A species of *Gonyaulacysta* having no apical horn but possessing thin, often striate ledges.

Description,

Outline circular or oval without an apical horn. Tabulation is distinct and conforms to the *Gonyaulacysta* pattern. Girdle strongly displaced, sometimes more than two girdle widths. Cingular plates present. Longitudinal furrow straight. Plates smooth, bordered by ledges up to 5 μ high with a non-protruding support at their junctions. These ledges are thin, often transparent and generally vertically striate. The precingular archaeopyle is not an obvious feature of most specimens.

Measurements:	Holotype	Range
Overall length	66 μ	40–66 μ
Overall breadth	55 μ	40–55 μ
Height of ledges (max.)	11 μ	4–11 μ
Width of girdle	5 μ	4– 6 μ



Text-fig. 12. *Gonyaulacysta striata* sp. nov., diagrammatic reconstruction. a, dorsal view. b, ventral view. × 1000

Comparison,

G. striata sp. nov. differs from *G. tenuiceras* Eisenack (1958) in the absence of an apical horn and sculpture on the plates. *Gonyaulax freaki* Sarjeant (1963b) differs in having only five post-cingular plates and smooth or perforate ledges. *G. striata* sp. nov. differs from *G. ambigua* (Defl. 1939b) comb. nov. in having higher ledges and from *G. pachyderma* (Defl. 1938d) comb. nov. in the absence of denticulate ledges.

Family GYMNODINIACEAE Bergh

Genus DINOGYMNIUM Evitt, Clarke and Verdier 1967

Type Species, See Evitt, Clarke and Verdier 1967

Dinogymnium albertii sp. nov.
Plate 17, figs. 3–4. Text-fig. 13

Text-fig. 13. *Dinogymnium albertii* sp. nov., diagrammatic reconstruction showing apical archaeopyle and sculpture. × 800

Holotype,

Plate 17, fig. 4. Slide Number 199. Sample Number CV 25. Culver Cliff, I.O.W. Senonian.

Diagnosis,

A species of *Dinogymnium* possessing a micronegative sculpture (perforations) on the ridges and grooves on both epitheca and hypotheca.

Description,

Outline rounded, elongate with longitudinal ridges, bordered by thickenings on each side, present on both hypotheca and epitheca. Hypotheca and epitheca more or less equal. Girdle obvious, fairly wide but not very deep. Longitudinal furrow present. A micronegative sculpture (perforations) is present on the grooves and ridges but is absent from the girdle area.

Measurements:	Holotype	Range
Length	66 μ	60–70 μ
Breadth	44 μ	40–50 μ
Width of girdle (max.)	10 μ	7–12 μ

Comparison,

D. albertii sp. nov. differs from *D. digitum* (Defl.) E., C., and V. in overall shape and the more prominent ridges, from *D. westralium* (Cook. and Eis.) E., C., and V. in the presence of a longitudinal furrow and from all other species in the presence of a micronegative sculpture.

Dinogymnium denticulatum (Alberti 1961)
Evitt, Clarke and Verdier 1967
Plate 5, figs. 2–3

Holotype,

Gymnodinium denticulatum Alb. 1961, pl. 3, fig. 2

1961 *G. denticulatum* Alberti, p. 5, pl. 3, figs. 2–3

Previously known Occurrences

Senonian, Germany (ALBERTI 1961).

Dinogymnium heterocostatum (Deflandre 1935)
Evitt, Clarke and Verdier 1967
Plate 5, figs. 4–6

Holotype,

Gymnodinium heterocostatum Defl. 1935, text-fig. 6

1935 *G. heterocostatum* Deflandre, p. 225, text-fig. 6

1936b *G. heterocostatum* Defl., in Deflandre, p. 165–166, pl. 2, fig. 6

1943 *G. heterocostatum* Defl., in Deflandre, p. 503, text-fig. 10

1951 *G. heterocostatum* Defl., in Lejeune-Carpentier, p. B. 308–309, text-fig. 2

Remarks,

The specimens referred to *Gymnodinium* cf. *heterocostatum* by DEFL. and COOK. (1955, p. 248, pl. 1, fig. 7) have been placed in *Gymnodinium westralium* (*Dinogymnium westralium* E., C., and V.), by COOKSON and EISENACK (1958, p. 26).

Previously known Occurrences

Senonian, France (DEFLANDRE 1935, 1936b, 1943), Maastrichtian, Belgium (LEJEUNE-CARPENTIER 1951).

Dinogymnium microgranulosum sp. nov.
Plate 5, figs. 7–10. Text-fig. 14

Holotype,

Plate 5, fig. 9. Slide Number 484. Sample Number CV 25. Culver Cliff, I.O.W. Senonian.

Diagnosis,

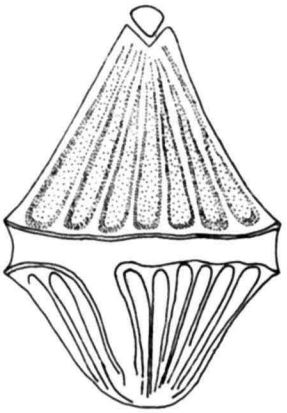
A species of *Dinogymnium* having the epitheca longer than the hypotheca. Ribs sculptured with scabrae.

Description,

Overall outline elongate oval. Epitheca longer and more pointed than hypotheca. Apical archaeopyle present (pl. 5, fig. 10). Girdle present,

distinct, showing only slight interruption ventrally. Longitudinal furrow present on both epi- and hypotheca. Sculpture of numerous broad ridges separated by narrow striae. Scabrae are present, densely packed, on the ridges but appear to be generally absent from the striae and the girdle area. The ridges are more or less equal on each side of the hypotheca but appear to be more numerous dorsally than ventrally on the epitheca.

Measurements:	Holotype	Range
Length	84 μ	51–85 μ
Breadth	54 μ	29–54 μ
Width of girdle (max.)	13 μ	5–13 μ



Text-fig. 14. *Dinogymnium microgranulosum* sp. nov., diagrammatic reconstruction showing apical archaeopyle and sculpture. × 800

Comparison,

D. microgranulosum sp. nov. differs from *D. albertii* sp. nov., *D. digitum* (Defl.) E., C., and V. and *D. westralium* (Cook. and Eis.) E., C. and V. in the presence of a micropositive sculpture and from *D. denticulatum* (Alberti) E., C., and V. in the absence of undulating ribs. Although no micropositive sculpture is mentioned in the original description of *D. cretaceum* (Defl.) E., C., and V., an examination of the holotype reveals the presence of this type of sculpture. However, *D. cretaceum* differs from *D. microgranulosum* in having the sculpture completely covering the body and its overall size is much smaller. *D. microgranulosum* differs from *D. nelsonense* (Cookson) E., C. and V. in the stronger ribs and more pronounced girdle.

Family HYSTRICHODINIACEAE Deflandre

Genus COMETODINIUM Deflandre and Courteville 1939

Type Species, C. obscurum Defl. and Court. 1939

Cometodinium obscurum Deflandre and Courteville 1939

Plate 10, fig. 3. Plate 11, fig. 9

Holotype,

C. obscurum Defl. and Court. 1939, pl. 2, fig. 1

1939 *C. obscurum* Defl. and Court., p. 99, pl. 2, fig. 1

Previously known Occurrences

Turonian, France (DEFLANDRE and COURTEVILLE 1939).

Genus DINOPTERYGIUM Deflandre 1935

Type Species, D. cladoides Deflandre 1935

Dinopterygium cladoides Deflandre 1935
Plate 6, fig. 4

Holotype,

D. cladoides Defl., 1935, pl. 8, fig. 6

1935 *D. cladoides* Defl., p. 231, pl. 8, fig. 6

1936b *D. cladoides* Defl., in Deflandre, p. 181–182, pl. 8, figs. 1–2

1950 Incertae sedis, in Reissinger, p. 119, pl. 19, fig. 11

1955 *D. cladoides* Defl., in Deflandre and Cookson, p. 261, pl. 1, fig. 2

1960 *Oodnadattia tuberculata* Eis. and Cook., p. 6–7, pl. 2, figs. 10–14

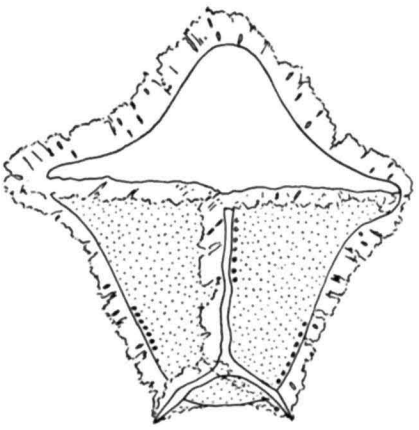
Remarks,

Our specimens have been compared with the holotype.

Previously known Occurrences

Albian, Australia (DEFLANDRE and COOKSON 1955, EISENACK and COOKSON 1960). Senonian, France (DEFLANDRE 1935, VALENSI 1955a). Ypresian, Belgium (REISSINGER 1950).

Dinopterygium perforatum sp. nov.
Plate 6, figs. 1–3. Text-fig. 15



Text-fig. 15. *Dinopterygium perforatum* sp. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 6, fig. 2. Slide Number 680. Sample Number CV 5. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A species of *Dinopterygium* with an indistinct girdle marked on the outline by two protrusions, and ledges which are perforate.

Description,

The epitheca is smaller than the hypotheca. Sides of epitheca straight; a small horn is sometimes observed at the apex. Sides of hypotheca straight; antapex rounded. Girdle indicated on outline only by the presence of two protrusions (pl. 6, fig. 2). Tabulation present, distinct and similar in arrangement to that of *Scriniodinium*. Plates bordered by high ledges 6–12 μ high, sculptured by perforations of various sizes. The form of the ledges is irregular, sometimes being high and entire, but often there is a development of processes of irregular width and height, generally perforated and with expanded tops. In this latter case the processes join at their bases to form low perforate ledges. The plates are mostly smooth except for a small perforated area adjacent to the ledges. No definite archaeopyle has so far been observed.

Measurements:	Holotype	Range
Length	66 μ	60–90 μ
Breadth	71 μ	60–84 μ
Height of ledges (max.)	11 μ	6–12 μ

Comparison,

D. perforatum sp. nov. differs from *D. cladoides* in the presence of perforated ledges, and the absence of verrucae on the plates.

Genus HYSTRICHODINIUM Deflandre 1935 emend.

Type Species, H. pulchrum Deflandre 1935

1961 *Heliodinium* Alberti

Emended Diagnosis,

Dinoflagellate cysts with a helicoid girdle, tabulation, a pre-cingular archaeopyle and the possession of numerous hollow processes.

Discussion,

The genus *Hystrichodinium* Deflandre is originally diagnosed as having a helicoid girdle, hollow processes, a sculpture of areolate punctations and without tabulation. From an examination of a great number of

specimens it cannot any longer be said that *Hystrichodinium* is non-tabulate although this feature is not always clearly displayed (see also VALENSI 1955b, pl. 3, fig. 11). Furthermore it is evident that *Hystrichodinium* has a precingular archaeopyle. Such a feature is already apparent on the original illustration of the type species (see DEFLANDRE 1935, p. 230, text-fig. 10).

Accepting that *Hystrichodinium* possesses tabulation and a precingular archaeopyle its morphological similarity with *Heliodinium* Alberti becomes readily apparent. In fact the only useful criterion Alberti uses to distinguish his genus from *Hystrichodinium* is the presence of tabulation in *Heliodinium*. The evidence obtained from the present study indicates therefore that *Heliodinium* is, in reality, a synonym of *Hystrichodinium* emend.

Comparison,

The inability to elucidate accurately the tabulation pattern makes effective comparison with *Hystrichosphaera* (Wetzel) Deflandre, and *Gonyaulacysta* Deflandre ex Norris and Sarjeant difficult although the clarity of tabulation on these latter two genera could be said to differentiate them from *Hystrichodinium* emend.

The following species are accepted within *Hystrichodinium* emend.

H. compactum Alberti 1961
H. furcatum Alberti 1961
H. oligacanthum Deflandre and Cookson 1955
H. ramoides Alberti 1961
H. patriciae (Neale and Sarjeant 1962) comb. nov.
H. voigti (Alberti 1961) comb. nov.

Hystrichodinium pulchrum Deflandre 1935
Plate 7, fig. 4

Holotype,

H. pulchrum Defl. 1935, text-figs. 9–10, pl. 5, fig. 1

1935 *H. pulchrum* Defl., p. 229–230, text-figs. 9–11, pl. 5, fig. 1
1936a *H. pulchrum* Defl., in Deflandre, p. 58, text-fig. 101
1936b *H. pulchrum* Defl., in Deflandre, p. 182–184, pl. 8, figs. 3–8, pl. 9, figs. 1–4
1941 Dinoflagellate, in Wetzel, W., Wetzel, O., and Deflandre, text-fig. 7
1943 *H. pulchrum* Defl., in De Wit, p. 385, text-fig. 13
1944 *H. pulchrum* Defl., in De Wit
1952a *H. pulchrum* Defl., in Deflandre, text-fig. 103
1952b *H. pulchrum* Defl., in Deflandre, text-fig. 300B
1955b *H. pulchrum* Defl., in Valensi, p. 591, pl. 3, fig. 1
1959 *H. pulchrum* Defl., in Gocht, p. 58, pl. 3, fig. 11, pl. 5, fig. 7

1961 *H. pulchrum* Defl., in Alberti, p. 14–15, pl. 8, figs. 6–10
1963 *H. pulchrum* Defl., in Górka, p. 32–34, pl. 5, fig. 5
1964 *H. pulchrum* Defl., in Manum and Cookson, p. 17, pl. 2, fig. 11

Description,

Outline oval, epitheca and hypotheca more or less equal. Girdle distinct and displaced one or two girdle widths. Archaeopyle rounded, arch-shaped and precingular in position. Body bears numerous, apparently randomly disposed, long, flattened, ribbonlike processes which are generally pointed at their extremities. The bases of the processes may join to form low, unornamented, often discontinuous ledges outlining the tabulation. The ledges are most pronounced in the girdle area where it also appears that the concentration of the processes is greater on the hypothecal girdle ledge than on the epithecal side. Sculpture, where present, is tabular and consists of a series of verrucae which are surrounded by a shallow groove (similar to that seen in *Pyramidium alatum* comb. nov. and *Dinopterygium cladoides* Deflandre).

Remarks,

The distinct form of the sculpture is not seen on all the specimens; we assume that its absence is a preservational phenomenon.

Deflandre (1936a) proposes a split of *H. pulchrum* into three varieties based on overall shape and the size and disposition of the processes. We have been unable to maintain these varieties in the present material and think that they probably represent normal specific morphographic variability combined with differential preservation.

Previously known Occurrences

Valanginian to Senonian, Germany (Gocht 1959, Alberti 1961). Lower Hauterivian, Switzerland (Alberti 1961). Hauterivian and Upper Campanian, Poland (Alberti 1961, Górka 1963). Senonian, France (Deflandre 1935, 1936a, 1936b, 1940, 1952a, 1952b, Deflandre-Rigaud 1954, 1955, Valensi 1955b). Senonian, Belgium (Deflandre 1936b). Maastrichtian, Holland (De Wit 1943, 1944). Upper Cretaceous, Canada (Manum and Cookson 1964).

Genus PYRAMIDIUM gen. nov.

Type Species, P. alatum (Cookson and Eisenack 1962) comb. nov.

Diagnosis,

Overall shape pyramidal. Tabulation present. Girdle present and displaced ventrally. Plates bordered by ledges bearing processes of which those at the junction of the septa are the longest. Wall smooth or ornamented with tubercles or verrucae. Archaeopyle apical.

Comparison,

Pyramidium gen. nov. differs from *Hystrichodinium* Deflandre 1935 here emended, in the position of the archaeopyle.

Pyramidium alatum (Cookson and Eisenack 1962) comb. nov.
Plate 6, figs. 5–6

Holotype,

Hystrichodinium alatum Cook. and Eis. 1962, pl. 2, fig. 1

1962b *H. alatum* Cook. and Eis., p. 487–488, pl. 2, figs. 1–4

1964 *H. alatum* Cook. and Eis., in Cookson and Hughes, p. 43, pl. 5, figs. 12–13

Remarks,

It is necessary to compare *P. alatum* with *Hystrichosphaeridium pterophorum* Deflandre and Courteville. The holotype of the latter species is in apical view and thus it is not clear if an archaeopyle is present. However, plesiotype material has been examined in lateral view and there exists close similarity between these specimens and those observed in the present study. As we have not been able to examine the holotype of *H. pterophorum* and as the plesiotype material has not been illustrated we prefer to leave open, for the present, the question of synonymy of these two species (i.e. *H. pterophorum* and *P. alatum*).

Previously known Occurrences

Albian to Cenomanian, Australia (Cookson and Eisenack 1962b). Upper Albian to Lower Cenomanian, England (Cookson and Hughes 1964).

Family HYSTRICHOSPHAERACEAE Evitt

Genus ACHOMOSPHAERA Evitt 1963

Type Species, A. (al. *Hystrichosphaeridium*) *ramulifera* (Deflandre 1937) Evitt 1963

Achomosphaera ramulifera (Deflandre 1937) Evitt 1963
Plate 8, fig. 1

Holotype,

Hystrichosphaeridium ramuliferum Deflandre 1937, pl. 14, fig. 5

1935 *Hystrichosphaera* cf. *ramosa* Ehr., in Deflandre, pl. 5, fig. 11

1937c *Hystrichosphaeridium ramuliferum* Deflandre, p. 74–75, pl. 14, figs. 5–6, pl. 17, fig. 10

1941 *H. ramuliferum* Defl., in Conrad, p. 2, pl. 1, fig. J

1948 *H. ramuliferum* Defl., in Pastiels, p. 39, pl. 3, figs. 17–19

1952a *H. ramuliferum* Defl., in Deflandre, fig. 4

1955 *H. ramuliferum* Defl., in Deflandre-Rigaud, p. 19

1955b *H. ramuliferum* Defl., in Valensi, p. 594, pl. 4, fig. 6
1961 *H. ramuliferum* Defl., in Gerlach, p. 185–186, pl. 28, fig. 3
1963 *H. ramuliferum* Defl., in Baltes, p. 586, pl. 7, figs. 13, 17–18
1963 *H. ramuliferum* Defl., in Górka, p. 59–60, pl. 8, fig. 3, text-fig. 6, figs. 3–4
1963 *Baltisphaeridium ramuliferum* (Defl.) Downie and Sarjeant, p. 92
1963 *Achomosphaera ramulifera* (Defl.) Evitt, p. 163
1964 *A. ramulifera* (Defl.) Evitt, in Cookson and Hughes, p. 45–46, pl. 9, fig. 10
1964 *Hystrichosphaeridium ramuliferum* Defl., in Rozen, p. 299–300, pl. 3, fig. 4, text-fig. 8

Remarks,

The specimen illustrated by Gocht (1959, pl. 3, fig. 9) as *Hystrichosphaeridium ramuliferum* Defl. appears to show an apical archaeopyle and is therefore considered as only a doubtful synonym of *A. ramulifera* Evitt 1963.

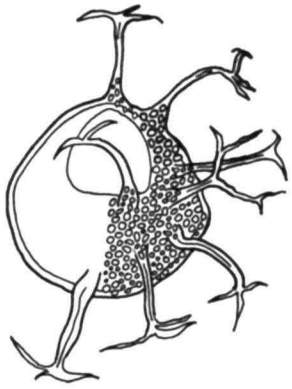
Previously known Occurrences

Lower Cenomanian, England (Cookson and Hughes 1964—see text only). Cenomanian, Rumania (Baltes 1963). Turonian, Poland (Górka 1963). Senonian, France (Deflandre 1937c, Deflandre and Courteville 1939, Deflandre-Rigaud 1955, Valensi 1955b). Upper Campanian, Poland (Górka 1963). Maastrichtian, Holland (De Wit 1943), Belgium (Conrad 1941). Danian, Germany (Wetzel 1955). Eocene, Belgium (Pastiels 1948, Rozen 1964). Upper Oligocene, Germany (Gerlach 1961, Brosius 1963). Middle Miocene, Germany (Gerlach 1961).

Achomosphaera reticulata sp. nov.
Plate 8, figs. 2–3. Text-fig. 16

Holotype,

Plate 8, fig. 2. Slide Number 89. Sample Number CV 5. Southern Cliff. I.O.W. Cenomanian.



Text-fig. 16. *Achomosphaera reticulata* sp. nov., diagrammatic reconstruction. × 800

Diagnosis,

Body reticulate, processes solid.

Description,

Outline of body circular. Wall upto 3 microns thick. Sculpture of body reticulate, uniformally distributed. Muri thin, luminae rounded or polygonal. Numerous processes arise from the body without obvious symmetry. These are long, being approximately half the body diameter in length, solid or with a narrow canal which terminates at the point of division distally. The initial division is a bifurcation or trifurcation becoming polyfid towards the distal extremity. The processes are smooth except for a general encroachment of the body sculpture proximally. A precingular archaeopyle is an obvious feature of most specimens; other than this the specimens show no obvious orientation.

Measurements:	Holotype	Range
Diameter of body	48 μ	38–53 μ
Length of processes	21–26 μ	15–28 μ

Comparison,

A. reticulata sp. nov. differs from the type species in the sculpture of the main body.

Remarks,

We have placed our specimens in *Achomosphaera* Evitt, based on the presence of an angular arched opening which is considered to be precingular in position. The disposition of the processes observed and remarked upon by Evitt (1963, p. 163) is not an obvious feature of our species. The sculpture on the body of *A. reticulata* sp. nov. is similar to that of the plate sculpture of *Hystrichosphaera crassipellis* Deflandre and Cookson.

Genus HEXASPHAERA gen. nov.

Type Species, Hexasphaera (al. *Hystrichosphaeridium*) *asymmetrica* (Deflandre and Courteville 1939) comb. nov.

Diagnosis,

Dinoflagellate cyst with tabulation consisting of one six-sided apical plate, one six-sided antapical plate joined by three large plates which are both pre- and post-cingular in position. Archaeopyle apical. Two types of processes present, one series of which is large and hollow while the other consists of smaller, solid appendages. Both types have expanded or bifurcating tops.

Comparison,

Hexasphaera gen. nov. differs from *Hystrichosphaera* (Wetzel) Deflandre and *Achomosphaera* Evitt in the form of the tabulation, the apical archaeopyle and the possession of two types of processes. Two types of processes and an apical archaeopyle are features of *Hystrichokolpoma* Klumpp but this genus does not have the type of tabulation characterizing *Hexasphaera* gen. nov.

Hexasphaera asymmetrica (Deflandre and Courteville 1939) comb. nov. and emend.

Plate 7, figs. 1–3. Text-fig. 17

Holotype,

H. (al. *Hystrichosphaeridium*) asymmetrica (Defl. and Court. 1939) comb. nov., p. 100–101, pl. 4, fig. 1.

1939 *Hystrichosphaeridium asymmetricum* Defl. and Court., p. 100–101, pl. 4, figs. 1–2

Emended Description,

Main body more or less circular in outline, probably originally spherical. Tabulation distinct. The apical and antapical plates bear at each corner a solid slender process which is openly bifurcate at the extremity. A ledge connects each process; the ledge is smooth at the top but may contain perforations, especially at the base. Six large, hollow, tubular appendages are present around the equator (reflecting perhaps a girdle). These are long and expanded distally from which recurved filaments project (see text-fig. 17). The disposition of these large processes with regard to the three large plates is such that each plate has one process in the centre and half a process at its junction with the next plate, i.e. three processes are situated on the sutures and three are centra-tabular (see pl. 7, figs. 1–2). The sutures separating the large plates are frequently perforate giving a 'beaded' appearance and can often be seen to extend onto three of the large processes. Archaeopyle formed by the loss of the apical plate. Generally the amount of buckling seen in most specimens precludes a clear observation of this feature.

Discussion,

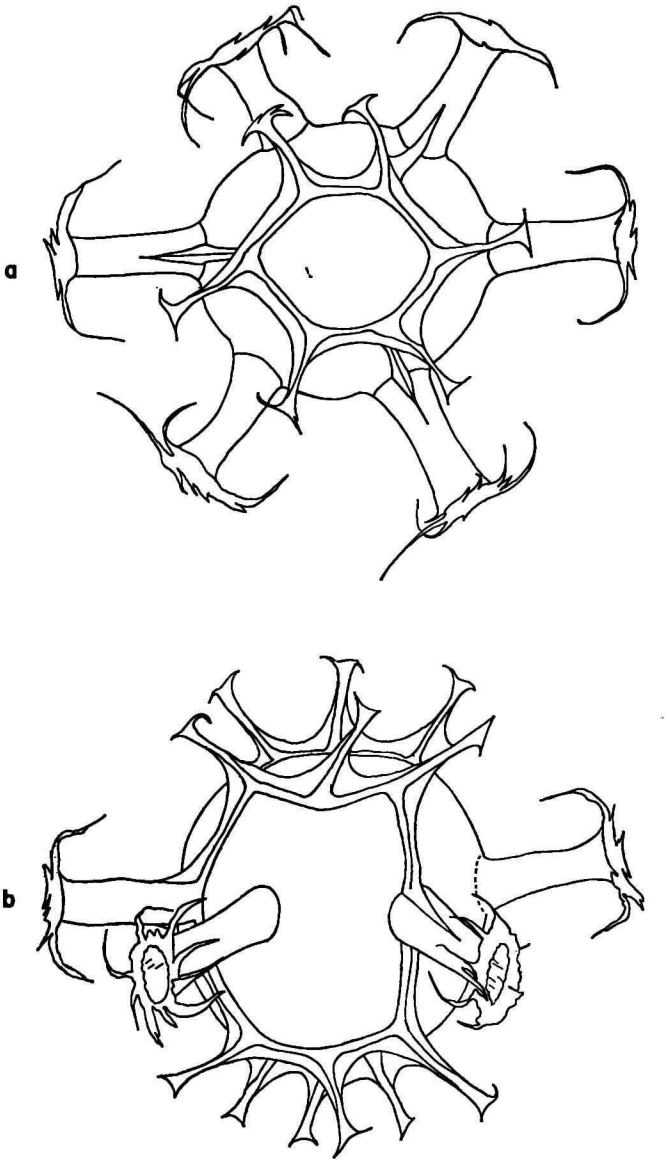
The changes made here in the emended description of *Hexasphaera asymmetrica* comb. nov. from the original diagnosis given by Deflandre and Courteville for *Hystrichosphaeridium asymmetricum* include firstly the observation of an apical and antapical plate with six sides bearing a process at each corner (in contrast to the pentameral symmetry given by Deflandre and Courteville), and secondly the elucidation of the position of the large processes (compare our text-fig. 17 with that of DEFLANDRE and COURTEVILLE 1939, pl. 4, figs. 1–2).

The presence of an apical archaeopyle is not mentioned in the original description.

We have had the opportunity to examine paratype material of *Hystrichosphaeridium asymmetricum* and find it to possess identical morphology to material found throughout the Upper Cretaceous in the I.O.W.

Previously known Occurrences

Turonian and Senonian, France (DEFLANDRE and COURTEVILLE 1939).



Text-fig. 17. *Hexasphaera asymmetrica* comb. nov., diagrammatic reconstruction. a, apical view. b, lateral view. × 800

Genus HYSTRICHOSPHAERA Wetzel 1933, emend Deflandre 1937

Type Species, *H.* (al. *Xanthidium*) *furcata* (Ehrenberg 1838) Wetzel 1933

Hystrichosphaera cingulata (Wetzel 1933) Deflandre and Cookson 1955

Holotype,

H. (al. *Cymatiosphaera*) *cingulata* (Wetzel) Deflandre and Cookson 1955 in WETZEL (1933), pl. 4, fig. 10.

Remarks,

This common species shows considerable morphological variability and can conveniently be described as a series of varieties. This treatment becomes pertinent as some of these varieties have stratigraphic significance, e.g. *H. cingulata* var. *granulata* var. nov. and *H. cingulata* var. *polygonalis* var. nov.

Hystrichosphaera cingulata var. *cingulata* var. nov.
Plate 8, figs. 9–10

Holotype,

Same as species *cingulata*.

1933 *Cymatiosphaera cingulata* Wetzel, p. 28, pl. 4, fig. 10
1955 *Hystrichosphaera cingulata* (Wetzel) Defl. and Cook., p. 267, pl. 6, figs. 4–5
1955 *H. cingulata* Defl. and Cook., in Defl.-Rigaud, p. 19
1963 *H. cingulata* Defl. and Cook., in Górka, p. 51, pl. 6, figs. 8–10
1963 *H. cingulata* Defl. and Cook., in Baltes, p. 587, pl. 4, figs. 12–17
1964 *H. cingulata* Defl. and Cook., in Rossignol, p. 87, text-fig. G
1965 *H. cingulata* Defl. and Cook., in Baltes, p. 14, pl. 4, figs. 116–119

Diagnosis,

A variety of *H. cingulata* possessing a smooth wall, plates and ledges.

Previously known Occurrences

Albian to Cenomanian, Rumania (BALTES 1963, 1965). Cenomanian and Maastrichtian, Poland (GÓRKA 1963). Senonian, France (DEFLANDRE-RIGAUD 1955). Senonian, Germany (WETZEL 1933). Lower Eocene to Middle Miocene, Australia (DEFLANDRE and COOKSON 1955).

Hystrichosphaera cingulata var. *granulata* var. nov.
Plate 9, figs. 5–6. Text-fig. 18

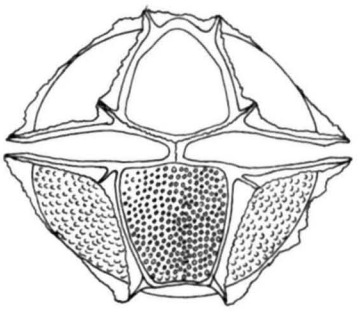
Holotype,

Plate 9, fig. 5. Slide No. 532. Sample Number CV 6. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A variety of *H. cingulata* having distinct, densely packed granules or low verrucae on the plates; the ledges are smooth.

Measurements:	Holotype	Range
Overall length	51 μ	48–56 μ
Overall breadth	49 μ	43–50 μ
Height of ledges	8 μ	5– 8 μ

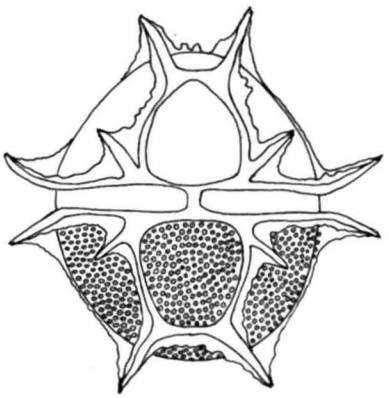


Text-fig. 18. *Hystrichosphaera cingulata* var. *granulata* var. nov., diagrammatic reconstruction. × 800

Comparison,

H. cingulata var. *granulata* var. nov. differs from *H. cingulata* var. *cingulata* in the presence of granules or verrucae on the plates.

Hystrichosphaera cingulata var. *perforata* var. nov.
Plate 9, figs. 2–4. Text-fig. 19



Text-fig. 19. *Hystrichosphaera cingulata* var. *perforata* var. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 9, fig. 2. Slide Number 337. Sample Number CV 10. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A variety of *H. cingulata* having a finely perforate sculpture on the plates and which may or may not be present on the ledges. The ledges

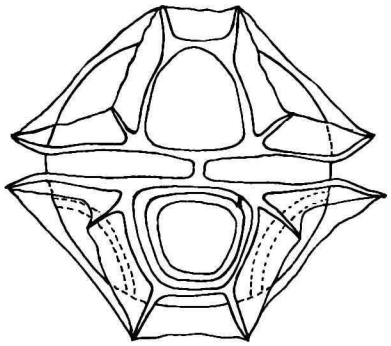
are higher at the junction of the plates but the supporting process, although occasionally bifurcate, never protrudes beyong the edge of the ledge.

Measurements:	Holotype	Range
Overall length	81 μ	75–82 μ
Overall breadth	66 μ	55–66 μ
Height of ledges	14 μ	5–15 μ

Comparison,

H. cingulata var. *perforata* var. nov. differs from all other varieties of *H. cingulata* in the presence of a micronegative sculpture.

Hystrichosphaera cingulata var. *polygonalis* var. nov.
Plate 8, figs. 7–8. Text-fig. 20



Text-fig. 20. *Hystrichosphaera cingulata* var. *polygonalis* var. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 8, fig. 7. Slide Number 90. Sample Number CV 16. Southern Cliff, I.O.W. *Plenus*-Marl.

Diagnosis,

A variety of *H. cingulata* having a linear depressed area on each side of the ledges thereby separating a more elevated central plate area from the ledges. Both the plates and ledges are smooth.

Measurements:	Holotype	Range
Overall length	60 μ	55–65 μ
Overall breadth	50 μ	50–58 μ
Height of ledges	8 μ	8–11 μ

Comparison,

H. cingulata var. *polygonalis* var. nov. differs from *H. cingulata* var. *cingulata* var. nov. in the presence of the striae around the plate margins.

Hystrichosphaera crassipellis Defl. and Cooks. 1954,
ex Deflandre and Cookson 1955
Plate 8, fig. 11. Plate 9, fig. 1

Holotype,

H. crassipellis Defl. and Cook. 1954, text-fig. 5

1954 *H. crassipellis* Defl. and Cook., text-fig. 5, nom. nud.

1955 *H. crassipellis* Defl. and Cook., in Deflandre and Cookson, p. 265, pl. 6, figs. 2–3, text-fig. 20

1961 *H. crassipellis* Defl. and Cook., in Gerlach, p. 177–178, pl. 27, fig. 5, text-figs. 16–18

Remarks,

Professor Deflandre has seen our specimens and agrees with their specific determination.

Previously known Occurrences

Lower Eocene, Australia (Deflandre and Cookson 1954, 1955), Middle Oligocene and Middle Miocene, Germany (Gerlach 1961).

Hystrichosphaera furcata (Ehrenberg 1838) Wetzel 1933
Plate 8, figs. 12–13

1838 *Xanthidium furcatum* Ehr., p. 109–136, pl. 1, fig. 14

1854 *X. furcatum* Ehr., in Ehrenberg, pl. 37, No. 7, fig. 7

1933 *Hystrichosphaera furcata* (Ehr.) Wetzel, p.l 34–35, pl. 2, figs. 35a, 35b, pl. 5, figs. 1, 5, 9, 15, 16

For "Remarks" see below under *H. ramosa*.

Hystrichosphaera ramosa (Ehrenberg 1838) Wetzel 1933
Plate 16, figs. 6–7

1838 *Xanthidium ramosum* Ehr., p. 109–136, pl. 1, fig. 15, nos. 1–5

1854 *X. ramosum* Ehr., in Ehrenberg, pl. 37, no. 7, figs. 9–10, pl. 29, fig. 49, pl. 30, figs. 3–4

1933 *Hystrichosphaera ramosa* (Ehr.) Wetzel, p. 35–36, pl. 5, figs. 7–8, 10–12, 18–19

Remarks,

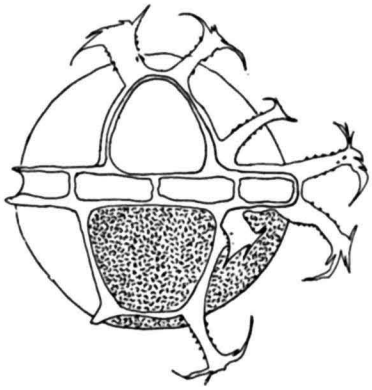
Many authors previously have remarked upon the difficulty of effectively separating *H. furcata* from *H. ramosa* (see Deflandre 1937c, Lejeune 1937a, Cookson and Hughes 1964). While it is not difficult to separate the extreme forms, the majority of the specimens are morphologically between these extremes and we have been unable to establish any useful criteria for separating these specimens into one or other of the two species

H. ramosa, and *H. furcata*. Therefore for the present study we have combined the two species into a *H. furcata/ramosa* group (see text-figs. 32 and 33).

Previously known Occurrences

Both *H. furcata* and *H. ramosa* make their first appearance in the Oxfordian and appear to become extinct in the Pleistocene, although there is some evidence that they may still be present today (see EVITT and DAVIDSON 1964).

Hystrichosphaera scabrosa sp. nov.
Plate 9, figs. 7–10. Text-fig. 21



Text-fig. 21. *Hystrichosphaera scabrosa* sp. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 9, fig. 10. Slide Number 566. Sample Number CV 12. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A species of *Hystrichosphaera* with scabrae on the ledges and processes; the plates are generally rugulate.

Description,

Body more or less circular, wall 1–2 μ thick. Processes arise from the junction of the plates. These are long, up to half the body diameter in length, of varying width and which bifurcate or trifurcate at their distal extremity; there may be more than one branching. The very wide angle of the bifurcations shows similarity with that observed in *Achomosphaera ramulifera* Evitt 1963. The processes are joined by low ledges outlining the girdle and the plate system. The sculpture on the plates consists of a fine rugulation while the ledges and especially the processes possess irregularly spaced scabrae. The precingular archaeopyle is sometimes visible.

Measurements:	Holotype	Range
Body diameter	44 μ	42–48 μ
Length of processes	16 μ	16–24 μ

Comparison,

H. scabrosa sp. nov. differs from *H. cingulata* Deflandre and Cookson 1955 in the presence of processes which project above the top of the ledges, and from *H. crassipellis* Deflandre and Cookson 1955 in the presence of scabrae on the ledges and processes.

Genus HYSTRICHOSPHAEROPSIS Deflandre 1935

Type Species, H. ovum Defl. 1935

Remarks,

DEFLANDRE (1937c, p. 61) reduced his genus *Hystrichosphaeropsis* to subgeneric status as a subordinate of *Hystrichosphaera.* EISENACK (1963a, p. 118) re-erects *Hystrichosphaeropsis* to generic rank and gives (1965, p. 153–155) a pertinent comparison between this genus and *Rottnestia* Cookson and Eisenack 1961b. We accept the generic status of *Hystrichosphaeropsis* and agree upon the differentiation of the two genera (i.e. *Hystrichosphaeropsis* and *Rottnestia*) set up by EISENACK (1965).

Hystrichosphaeropsis ovum Deflandre 1935
Plate 10, figs. 6–9

Holotype,

H. ovum Defl. 1935, pl. 8, fig. 11

1935 *H. ovum* Defl., p. 232, pl. 8, fig. 11

1937c *Hystrichosphaera ovum* (Defl.) Deflandre, p. 67–68, pl. 12, figs. 1–3

1961 *Hystrichosphaeropsis ovum* Defl., in Gerlach, p. 176–177, pl. 27, fig. 4

Remarks,

From the great number of specimens which we have examined from the Senonian of the I.O.W. it is evident that there exists a considerable variation in the disposition of the body and outer wall sculpture. The extremes of this are between specimens showing a sculptured inner body and outer wall (pl. 10, fig. 7) to completely smooth forms. An intermediate form with a smooth outer wall but with a sculptured inner body is shown on pl. 10, fig. 9. No attempt has been made to elucidate criteria for the separation of these potential varieties, all of which make their first appearance in the Senonian (sample CV 25).

Previously known Occurrences

Senonian, France (DEFLANDRE 1935, 1937c). Upper Oligocene?, Middle Miocene, Germany (GERLACH 1961).

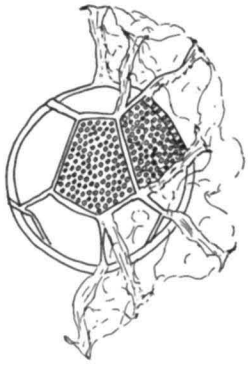
Genus NEMATOSPHAEROPSIS Deflandre and Cookson 1955

Type Species, N. balcombiana Defl. and Cook. 1955

Discussion,

There exists some confusion as to which are the diagnostic characters of the genera *Nematosphaeropsis* Defl. and Cook., *Hystrichokibotium* Klump 1953 and *Cannosphaeropsis* Wetzel 1933. As originally diagnosed *Nematosphaeropsis* possesses tabulation, a girdle and connected processes. *Hystrichokibotium* has tabulation but lacks a girdle or a connection between the processes, while *Cannosphaeropsis* is characterized by the presence of process connections and the absence of plates or girdle. Recently, however, it has been suggested that the type species of *Hystrichokibotium* is in fact a specimen of *Hystrichosphaera* in an unusual orientation (see EVITT 1963, and EISENACK and GOCHT quoted in NORRIS and SARJEANT 1965). Thus the genus *Hystrichokibotium* can be abandoned. However, *Hystrichokibotium trabeculiferum* Defl. and Cook. 1955 shows tabulation, and connected processes which would exclude it from *Hystrichokibotium*, *Hystrichosphaera* and *Cannosphaeropsis* but not necessarily from *Nematosphaeropsis* if the orientation is such that the girdle cannot be seen. The present specimens attributed by us to *N. velata* sp. nov. do not show a distinct girdle; this also appears to be the case in the type species *N. balcombiana*. In all other respects our specimens are very close to the diagnosis of *Nematosphaeropsis* and we prefer to place them in this genus, which differs most obviously from *Hystrichosphaera* in having connected processes and from *Cannosphaeropsis* in the possession of a tabulation.

Nematosphaeropsis velata sp. nov.
Plate 10, figs. 1–2. Text-fig. 22



Text-fig. 22. *Nematosphaeropsis velata* sp. nov., diagrammatic reconstruction, × 800

Holotype,

Plate 10, fig. 2. Slide Number 344. Sample Number CV 25. Culver Cliff, I.O.W. Senonian.

Diagnosis,

A species of *Nematosphaeropsis* having a thick wall to the main body, an apical archaeopyle and a distinct plate system.

Description,

Main body round or oval, wall thick (up to 4 μ) showing fine, evenly distributed perforations (pl. 10, fig. 2). Tabulation distinct but there is no obvious girdle present. Plates bordered by very high, almost transparent ledges with a support at each junction which protrudes slightly above the top of the ledge. The distal extremity of the supports (processes) are bifid or trifid and these are connected in a similar manner to those in *Cannosphaeropsis*.

Measurements:	Holotype	Range
Overall diameter	105 μ	90–120 μ
Diam. main body	55 μ	45– 65 μ
Length of processes + ledge	max. 32 μ	24– 36 μ
Height of ledges	max. 20 μ	17– 26 μ

Remarks,

No mention is made of an archaeopyle in the original diagnosis of *Nematosphaeropsis* but from the present material it is clear that an indented opening is present (pl. 10, fig. 1).

Comparison,

N. velata sp. nov. differs from the type species in overall size and the height of the ledges.

Family HYSTRICHOSPHAERIDIACEAE Evitt

Genus CANNOSPHAEROPSIS Wetzel 1933

Type Species, C. utinensis Wetzel 1933

Cannosphaeropsis caulleryi (Defl. 1938) Deflandre 1947

Plate 11, fig. 3

Holotype,

Hystrichosphaeridium caulleryi Defl. 1938, pl. 11, figs. 2–3

1938d *H. caulleryi* Deflandre, p. 189, pl. 11, figs. 2–3
1947a *Cannosphaeropsis caulleryi* (Defl.) Deflandre, p. 1575
1955b *C. caulleryi* Defl., in Valensi, p. 588, pl. 2, fig. 13
1955b *C.* cf. *caulleryi* Defl., in Valensi, p. 588, pl. 2, fig. 10
1957 *C. caulleryi* Defl., in Downie, p. 428, pl. 20, fig. 1
1959 *C. caulleryi* Defl., in Gocht, p. 74, pl. 4, fig. 3
1960 *C. caulleryi* Defl., in Sarjeant, pl. 12, fig. 6, pl. 14, fig. 5

1961 *C. caulleryi* Defl., in Alberti, p. 35, pl. 9, figs. 9–11, pl. 10, fig. 11
1961a *C. caulleryi* Defl., in Sarjeant, p. 103, pl. 13, fig. 8, pl. 15, fig. 4
1962a *C. caulleryi* Defl., in Sarjeant, pl. 2, fig. 4
1962b *C. caulleryi* Defl., in Sarjeant, pl. 70, fig. 3

Remarks,

All the Tertiary records of *C. caulleryi* have recently been transferred by Cookson (1956b) to *Cyclonephelium retiintextum* Cookson.

Previously known Occurrences

Upper Dogger (probably Callovian), Germany (ALBERTI 1961). Lower Callovian to Oxfordian, England (SARJEANT 1960, 1961a, 1962a). Lower Oxfordian, France (DEFLANDRE 1938d). Lusitanian, England (SARJEANT 1962b). Kimmeridgian, England (DOWNIE 1957). Jurassic, France (VALENSI 1955b). Berriasian, Germany (GOCHT 1959). Valanginian to Lower Hauterivian, Germany (ALBERTI 1961).

Genus HYSTRICHOSPHAERIDIUM (Deflandre 1937) Eisenack 1958

Type Species, H. (al. *Xanthidium*) *tubiferum* (Ehr.) Deflandre 1937
Hystrichosphaeridium complex (White 1842) Deflandre 1946
Plate 11, figs. 10–11

Holotype,

H. (al. *Xanthidium*) *complex* in White 1842, pl. 4, fig. 11
1842 *Xanthidium tubiferum complex* White, p. 39, pl. 4, div. 3, fig. 11
1844a *X. tubiferum complex* White, in White, p. 83, pl. 8, fig. 10
1940 *Hystrichosphaeridium elegantulum* Lejeune-Carpentier, p. 222, figs. 11–12
1952 *H. complex* Defl., in Firtion, p. 156, pl. 9, figs. 2, 4, 5, text-pl. 1, figs. A–F
1955 *H. complex* Defl., in Deflandre and Cookson, p. 270, pl. 1, figs. 9–10
1955b *H. complex* Defl., in Valensi, p. 592, pl. 4, fig. 3
1958 *H. complex* Defl., in Cookson and Eisenack, p. 42, pl. 12, fig. 10
1959 *H. complex* Defl., in Gocht, p. 66–67, pl. 3, figs. 2–3, pl. 7, figs. 5–6
1964 *H. complex* Defl., in Varma and Dangwal, p. 65, pl. 2, figs. 2–3
1964 *H. complex* Defl., in Cookson and Hughes, p. 46–47, pl. 9, fig. 6
1965 *H. complex* Defl., in Baltes, p. 14, pl. 4, figs. 109–111

Previously known Occurrences

Upper Valanginian to Aptian, Germany (EISENACK 1958, GOCHT 1959). Hauterivian to Albian(?), Rumania (BALTES 1965). Lower and Upper Cretaceous, Australia (DEFLANDRE and COOKSON 1955, COOKSON and EISENACK 1958, 1961a). Albian, Ivory Coast (VACHEY and JARDINÉ 1962).

Upper Albian to Senonian, England (WHITE 1842, 1844a, COOKSON and HUGHES 1964). Cenomanian, France (FIRTION 1952). Cretaceous, France (VALENSI 1955b). Lower Tertiary, India (VARMA and DANGWAL 1964).

Hystrichosphaeridium huguonioti Valensi 1955
Plate 11, figs. 4–5

Holotype,

H. huguonioti Valensi 1955, fig. 2A

1955a *H. huguonioti* Valensi, p. 38–39, fig. 2A

1960a *H. ancoriferum* Cookson and Eisenack, p. 8, pl. 2, fig. 11

1964 *H. ancoriferum* Cook. and Eis., in Cookson and Hughes, p. 47. pl. 9, fig. 7

Remarks,

We do not agree with the recommendation of Downie and Sarjeant 1963 concerning the transfer of *H. huguonioti* Valensi to *Baltisphaeridium* emend. Downie and Sarjeant 1963. It is by no means certain that *H. huguonioti*, which is extremely abundant in the Cenomanian, has processes with their ends closed. It is clear, however, that there exists in many specimens processes with a thin central canal which extends distally at least as far as the bifurcation and may even continue to give an open process. Until it can be conclusively proved otherwise we prefer to keep *H. huguonioti* as originally assigned and consider that it most probably has open-ended processes. Furthermore some specimens show an indented opening which is probably an apical archaeopyle (pl. 11, fig. 5). Such a feature would also exclude its generic assignation to *Baltisphaeridium*.

COOKSON and EISENACK 1960a erect a new species *H. ancoriferum* which is not compared with *H. huguonioti*. From the descriptions of *H. ancoriferum* and *H. huguonioti* we feel that there are insufficient criteria to maintain their specific separation.

Previously known Occurrences

Albian to Cenomanian from Australia (COOKSON and EISENACK 1960a). Upper Albian to Lower Cenomanian from England (COOKSON and HUGHES 1964). Cretaceous from France (VALENSI 1955a).

Hystrichosphaeridium pulcherrimum Defl. and Cook. 1954, ex Deflandre and Cookson 1955
Plate 10, figs. 4–5

Holotype,

H. pulcherrimum Defl. and Cook. 1954, text-fig. 6

1954 *H. pulcherrimum* Defl. and Cook., text-fig. 6, nom. nud.

1955 *H. pulcherrimum* Defl. and Cook., in Deflandre and Cookson, p. 270–271, pl. 1, fig. 8, text-figs. 21–22

1955b *H. pulcherrimum* Defl. and Cook., in Valensi, p. 592–593, pl. 4, fig. 1

1957 *H. pulcherrimum* Defl. and Cook., in Delcourt and Sprumont. p. 59, pl. 1, figs. 4 (A, B, C), pl. 2, fig. 12

Remarks,

This rare species in the British Upper Cretaceous is well circumscribed in the publication of DEFLANDRE and COOKSON (1955).

Previously known Occurrences

Wealden from Belgium (DELCOURT and SPRUMONT 1957, 1959a, 1959b). Cretaceous from France (VALENSI 1955b). Lower Cretaceous from Australia (DEFLANDRE and COOKSON 1954, 1955).

Hystrichosphaeridium siphoniphorum Cookson and Eisenack 1958
Plate 11, figs. 1–2

Holotype,

H. siphoniphorum Cook. and Eis. 1958, pl. 11, fig. 8

1958 *H. siphoniphorum* Cook. and Eis., p. 44, pl. 11, figs. 8–10

1963 *Hystrichokolpoma* sp. B, in Baltes, p. 587–588, pl. 6, figs. 6–8

1963 *H.* sp. A, in Baltes, p. 587, pl. 6, figs. 1–5

1964 *Hystrichosphaeridium siphoniphorum* Cook. and Eis., in Cookson and Hughes, p. 48, pl. 9, fig. 15

1965 *H. siphoniphorum* Cook. and Eis., in Baltes, p. 14, pl. 4, figs. 120–121

Remarks,

This species is very common throughout the Cenomanian of the present material.

Previously known Occurrences

Albian from Rumania (BALTES 1963, 1965). Upper Albian to Lower Cenomanian from England (COOKSON and HUGHES 1964). Albian to Cenomanian from Australia (COOKSON and EISENACK 1958).

Hystrichosphaeridium stellatum Maier 1959
Plate 12, figs. 1–2

Holotype,

H. stellatum Maier 1959, pl. 33, fig. 3

1959 *H. stellatum* Maier, p. 320–321, pl. 33, figs. 3–4

1962b *H. stellatum* Maier, in Cookson and Eisenack, p. 492, pl. 4, fig. 14

1964 *H. stellatum* Maier, in Cookson and Hughes, p. 48, pl. 9, fig. 11
1964 *H. stellatum* Maier, in Manum and Cookson, p. 14–15, pl. 3, fig. 4
1965 *H. stellatum* Maier, in Baltes, p. 14, pl. 4, figs. 114–115

Remarks,

This species is present throughout the investigated interval but is most abundant in the Cenomanian.

Previously known Occurrences

Hauterivian, Germany (Gocht 1959, – see Cookson and Eisenack 1962b, p. 492). Albian, Rumania (Baltes 1965). Albian to Cenomanian, Australia (Cookson and Eisenack 1962b). Upper Albian to Lower Cenomanian, England (Cookson and Hughes 1964). Upper Cretaceous, Canada (Manum and Cookson 1964). Middle Oligocene and Middle Miocene, Germany (Maier 1959).

Hystrichosphaeridium truncigerum Deflandre 1937
Plate 12, figs. 3–4

Holotype,

H. truncigerum Defl. 1937, pl. 13, fig. 6
1937c *H. truncigerum* Defl., p. 71–72, pl. 13, figs. 6–7
1941 *H. crassipes* (Reade) Lejeune-Carpentier, p. B79, fig. 9
1953 *H. truncigerum* Defl., in Cookson, p. 114, pl. 2, figs. 21–23
1959 *H. truncigerum* Defl., in Gocht, p. 70, pl. 4, fig. 15, pl. 7, figs. 7–8
1963 *H. truncigerum* Defl., in Górka, p. 64–65, pl. 9, fig. 7, text-pl. 7, fig. 4

Remarks,

The validity of the use of *truncigerum* as the specific epithet for this species as against the use of *crassipes* is fully discussed in Deflandre (1946b); we accept his argument and follow his recommendation.

Previously known Occurrences

Oxfordian, Poland (Górka 1965). Upper Valanginian to Lower Hauterivian, Germany (Gocht 1959). Turonian to Maastrichtian, Poland (Górka 1963). Senonian, France (Deflandre 1937c, Deflandre-Rigaud 1954). Maastrichtian, Belgium (Lejeune-Carpentier 1941). Oligocene, Australia (Cookson 1953).

The following records have not been incorporated due to insufficient illustration, description, etc.;

1839 *Xanthidium crassipes* Reade, Senonian, England
1842 *X. crassipes* White, Senonian, England
1844 *X. crassipes* White, Senonian, England

1941 ?*Hystrichosphaeridium truncigerum*, in Conrad, Maastrichtian, Belgium
1959 *H.* cf. *truncigerum*, in Maier, Upper Oligocene, Germany
1961a *H.* cf. *truncigerum*, in Sarjeant, Oxfordian, England

Family MEMBRANILARNACACEAE Eisenack

Genus VALENSIELLA Eisenack 1963

Type Species, Membranilarnax ovulum Deflandre 1947

Valensiella ovula (Deflandre 1947) Eisenack 1963
Plate 2, figs. 7–8

Holotype,

Membranilarnax ovulum Defl 1947, text-fig 22
1947b *M. ovulum* Defl., p. 9–10, text-figs. 22–23
1953 *M. ovulum* Defl. in Valensi, p. 62, pl. 9, figs. 6 and 12
1955b *M. ovulum* Defl. in Valensi, p. 590, pl. 2, fig. 4, pl. 5, fig. 6
1961a *M. ovulum* Defl. in Sarjeant, p. 109, text-fig. 9c
1962a *M. ovulum* Defl. in Sarjeant, pl. 2, figs. 8–9
1963a *Favilarnax ovulum* (Deflandre) Sarjeant, p. 720
1963b *Valensiella ovula* (Deflandre) Eisenack, p. 100–101

Previously known Occurrences

Bajocian to Bathonian, France (DEFLANDRE 1947b, VALENSI 1953). Callovian to Lower Oxfordian, England (SARJEANT 1961a, 1962a). Jurassic, France (VALENSI 1955b).

Family PSEUDOCERATIACEAE Eisenack

Genus APTEA Eisenack 1958

Type Species, A. polymorpha Eisenack 1958

Aptea rugulosa sp. nov.
Plate 12, figs. 5–6. Text-fig. 23

Text-fig. 23. *Aptea rugulosa* sp. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 12, fig. 6. Slide Number 559. Sample Number CV 28. Culver Cliff, I.O.W. Senonian.

Diagnosis,

Inner body protruding into the apical and antapical horns. Sculpture finely rugulate to reticulate.

Description,

Inner body oval. Outer wall thin and differentiated into an apical and two antapical horns. The inner body is attached to the outer membrane except at the apex and antapex into which it may protrude. The antapical horns are generally equal and symmetrically placed. The outer membrane is wavy in outline, and gives the appearance of a rugulation or an irregular reticulum. An apical archaeopyle is generally visible.

Measurements:	Holotype	Range
Overall length	74 μ	65–82 μ
Overall breadth	50 μ	50–53 μ
Length inner body	59 μ	50–62 μ
Breadth inner body	38 μ	38–50 μ
Length apical horn	8 μ	6– 8 μ
Length antapical horns	8, 9 μ	6–12 μ

Comparison,

A. rugulosa sp. nov. differs from *A. polymorpha* Eisenack 1958 in the position of the antapical horns, the finer sculpture and the considerably smaller overall size.

Genus ODONTOCHITINA Deflandre 1935

Type Species, O. operculata (Wetzel 1933) Defl. and Cook. 1955

Odontochitina costata Alberti 1961 emend

Plate 13, figs 4–6

Holotype,

O. costata Alb. 1961, pl. 6, fig. 12

1961 *O. costata* Alb., p. 31, pl. 6, figs. 10–13

1962b *O. striatoperforata* Cook. and Eis., p. 490, pl. 3, figs. 14–19

1964 *O.* cf. *striatoperforata* Cook. and Eis., in Cookson and Hughes, p. 52–53, pl. 11, fig. 9

1964 *O. striatoperforata* Cook. and Eis., in Manum and Cookson, p. 10–11, pl. 2, fig. 6

Emended Diagnosis,

A species of *Odontochitina* having an inner body generally circular in outline, with long apical and antapical horns which bear a sculptural pattern of striae and perforations.

Remarks,

Having observed several hundred specimens which are representative of *O. costata* and *O. striatoperforata* we find that it is difficult to differentiate these two species, based on the presence of perforations. The development of perforations is extremely varied and irregular, in some cases confined to the distal extremity of the horns or in other cases more randomly disposed over the general length of the horns; so far no perforation development has been observed on the main body. We consider, for the above reasons, that *O. striatoperforata* is a synonym of *O. costata*, and also because of the presence of perforations in the original illustrations of *O. costata* (see Alberti 1961, pl. 6, figs. 10 and 12).

Previously known Occurrences

Albian to Cenomanian, Australia (Cookson and Eisenack 1962b). Lower Cenomanian, England (Cookson and Hughes 1964). Cenomanian to Turonian, Germany (Alberti 1961). Upper Cretaceous, Canada (Manum and Cookson 1964).

Odontochitina operculata (Wetzel 1933) Defl. and Cook. 1955
Plate 13, figs. 1 and 7

Holotype,

Ceratium operculatum Wetzel 1933, pl. 2, fig. 21

1933 *C.* (*Euceratium*) *operculatum* Wetzel, vol. 77, p. 170–171, vol. 78, pl. 2, figs. 21–22
1935 *Odontochitina silicorum* Deflandre, p. 234, pl. 9, figs. 8–10
1936 *Ceratium* sp., in Wiesner, pl. 7, figs. 6–7
1937c *Odontochitina silicorum* Defl., in Deflandre, p. 95, pl. 18, figs. 8–13
1950 Dreihörnige Hüllen mit Stachelkleid?, in Wetzel, p. 170, pl. 13, fig. 6
1952 *Odontochitina operculatum* (Wetzel) Defl., in Firtion, p. 160–161, pl. 9, fig. 9
1955 *O. operculata* (Wetzel) Defl., in Deflandre and Cookson, p. 291–292, pl. 3, figs. 5–6
1958 *O. operculata* (Wetzel) Defl., in Eisenack, p. 393, p. 27, figs. 7–8
1959 *O. operculata* (Wetzel) Defl., in Gocht, p. 64, pl. 6, fig. 12
1961 *O. operculata* (Wetzel) Defl., in Alberti, p. 30–31, pl. 6, figs. 6–9
1961 *O. operculata* (Wetzel) Defl., in Eisenack, pl. 36, fig. 3
1962 *O. silicorum* Defl., in Pocock, p. 78, pl. 14, figs. 211–212
1963 *O. operculata* (Wetzel) Defl., in Baltes, p. 584, pl. 5, figs. 1–4
1963 *O. operculata* (Wetzel) Defl., in Górka, p. 35–37, pl. 4, figs. 1–5

Previously known Occurrences

Barremian to Senonian (doubtful occurrence in Hauterivian and Paleocene), Germany (WETZEL 1933, 1950, EISENACK 1958, 1961, GOCHT 1959, ALBERTI 1961). Barremian to possibly Senonian, Canada (POCOCK 1962). Albian, Rumania (BALTES 1963). Albian to Turonian, Australia (DEFLANDRE and COOKSON 1955, COOKSON and EISENACK 1958). Cenomanian to Senonian, Poland (GÓRKA 1963, ALBERTI 1961). Lower Cenomanian, Senonian, France (DEFLANDRE 1935, 1937c, DEFLANDRE and COURTEVILLE 1939, FIRTION 1952, DEFLANDRE-RIGAUD 1955). Turonian, Czechoslovakia (WIESNER 1936).

Genus PSEUDOCERATIUM Gocht 1957

Type Species, P. pelliferum Gocht 1957

Pseudoceratium ceratioides (Defl. 1937) Deflandre 1966
Plate 13, fig. 8. Plate 15, figs. 1–2

Holotype,

Hystrichosphaera ceratioides Defl. 1937, pl. 12, fig. 7

1937c *H. ceratioides* Defl., p. 66–67, pl. 12, figs. 7–8
1950 *Ceratium operculatum* Wetzel, in Wetzel, p. 169–171, pl. 13, fig. 6
1966 *Pseudoceratium ceratioides* (Defl.) Deflandre, p. 6

Remarks,

It is clear that *H. ceratioides* lacks several of the characters necessary for its proper inclusion in *Hystrichosphaera.* With the Isle of Wight material many well preserved specimens made possible a re-appraisal of *H. ceratioides* and it is felt that these specimens can be satisfactorily included within the genus *Pseudoceratium.* Our specimens were shown to Professor Deflandre, who agreed to the new generic assignation proposed by us (see Deflandre 1966, p. 6).

Previously known Occurrences

Senonian, France (DEFLANDRE 1937c). Senonian, Germany (WETZEL 1950).

Pseudoceratium dettmannae Cookson and Hughes 1964
Plate 15, fig. 3

Holotype,

P. dettmannae Cook. and Hugh. 1964, pl. 7, fig. 1

1964 *P. dettmannae* Cook. and Hugh., p. 51–52, pl. 7, figs. 1–4

Previously known Occurrences

This very rare species in the present material has only been previously recorded from the Albian and Cenomanian of England (see COOKSON and HUGHES 1964, p. 39).

Genus SENONIASPHAERA gen. nov.

Type Species, Senoniasphaera protrusa sp. nov.

Diagnosis,

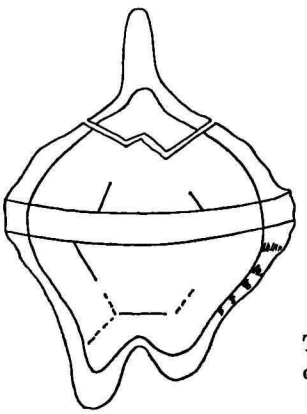
Inner body round or oval. Outer membrane is extended from the inner body to form one apical, two antapical and often two lateral horns. The inner body frequently protrudes into the apical and antapical horns. Tabulation present. Girdle and longitudinal furrow present. Archaeopyle apical.

Comparison,

Senoniasphaera gen. nov. differs from *Aptea* Eisenack 1958 in the presence of tabulation and from *Pseudoceratium* Gocht 1957 by the length and position of the antapical horns in relation to the long axis.

Senoniasphaera gen. nov. would appear to bear more than a superficial resemblance to specimens recently described by Cookson (1965b, p. 138, pl. 24, figs. 1–7) and named *Cyclonephelium vitilare.* However, the unornamented areas present on *C. vitilare* are absent from *Senoniasphaera* gen. nov.

Senoniasphaera protrusa sp. nov.
Plate 14, figs. 7–9. Text-fig. 24



Text-fig. 24. *Senoniasphaera protrusa* gen. et sp. nov., diagrammatic reconstruction showing tabulation and apical archaeopyle. × 800

Holotype,

Plate 14, fig. 8. Slide Number 183. Sample Number CV 25. Culver Cliff, I.O.W. Senonian.

Diagnosis,

A species of *Senoniasphaera* in which the inner body protrudes into the apical and antapical horns.

Description,

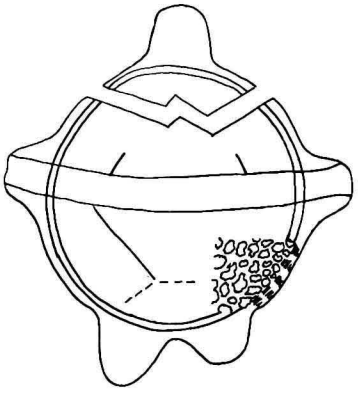
Inner body round or oval, protruding into the apical and antapical horns. Outer membrane is extended to form a distinct, long apical horn and two generally unequal antapical horns; these latter are, however, symmetrically disposed on either side of the long axis. The outer membrane is attached to the inner body mostly on the dorsal and ventral sides by a series of perforated pillars which may be so short as to be hardly visible. The transverse girdle is distinct and its edge can be seen at the margin of the outer membrane. In this species, however, the outer membrane is seldom developed into lateral horns. A longitudinal furrow is present although not clearly differentiated while the transverse girdle, although interrupted, appears to show only slight displacement. Tabulation is present but to resolve accurately the number and location of plates is difficult. In the majority of specimens the apical part has been lost leaving an indented archaeopyle with a sulcal notch. Sculpture of the inner body and outer wall is either psilate or scabrate.

Measurements:	Holotype	Range
Overall length	100 μ	80–110 μ
Overall breadth	71 μ	55– 82 μ
Length of inner body	66 μ	50– 69 μ
Breadth of inner body	60 μ	44– 66 μ
Length of apical horn	18 μ	15– 20 μ
Length of antapical horns	12 μ	8– 18 μ
Width of transverse furrow	6 μ	6– 7 μ

Remarks,

The specimen named by Deflandre *Podolampas* spec. (1935, p. 229, pl. 7, fig. 1) is probably conspecific with *S. protrusa* sp. nov.

Senoniasphaera rotundata sp. nov.
Plate 14, figs. 1–3. Text-fig. 25



Text-fig. 25. *Senoniasphaera rotundata* sp. nov. diagrammatic reconstruction showing tabulation and apical archaeopyle. × 800

Holotype,

Plate 14, fig. 2. Slide Number 162. Sample Number CV 25. Culver Cliff, I.O.W. Senonian.

Diagnosis,

A species of *Senoniasphaera* in which the outer membrane is detached from the inner body to form one apical, two antapical and frequently two lateral horns.

Description,

Inner body rounded which seldom protrudes into the horns. Wall thickness 1–2 μ. In the ideal case the outer membrane is closely attached to the inner body by short perforated pillars except where the membrane is detached and expanded to form the horns. In atypical forms (pl. 14, fig. 3) the outer membrane is detached over a larger and more irregular area and the attachment pillars become more visible. The position of the antapical horns is not always symmetrical with respect to the long axis and they are generally of unequal size; the same applies to the lateral horns. A girdle is present and its edge can be seen on the lateral horns; its displacement ventrally is slight although the interruption may be considerable. The plate system is not always clearly displayed and even in the most clear cases it is not possible to resolve the actual position of the tabulation. The longitudinal furrow is obscure. A well defined apical archaeopyle is present which can also be observed in complete specimens (pl. 14, figs. 1–2). The sculpture is a combination of perforations and an irregular reticulum, the muri being fairly thick.

Measurements:	Holotype	Range
Overall length	92 μ	78–100 μ
Overall breadth	67 μ	58– 81 μ
Length of inner body	71 μ	56– 85 μ
Breadth of inner body	60 μ	50– 77 μ
Length of apical horn	14 μ	10– 14 μ
Length of antapical horns	8, 2 μ	2– 11 μ
Width of transverse furrow	3 μ	3– 5 μ

Comparison,

S. rotundata sp. nov. differs from *S. protrusa* sp. nov. in the absence of inner body protrusions into the horns, and in the presence of a reticulum.

Family MICRODINIACEAE Eisenack
Genus EISENACKIA Defl. and Cook. 1954, ex Deflandre and Cookson 1955

Type Species, *E. crassitabulata* Defl. and Cook. 1954, ex Deflandre and Cookson 1955

Eisenackia crassitabulata Defl. and Cook. 1954,
ex Deflandre and Cookson 1955
Plate 8, figs. 4–6

Holotype,

E. crassitabulata Defl. and Cook. 1954, text-fig. 8–9

1954 *E. crassitabulata* Defl. and Cook., p. 1237, figs. 8–11, nom. nud.

1955 *E. crassitabulata* Defl. and Cook., p. 258–261, pl. 5, fig. 2, text-figs. 6–16

1961 *E. crassitabulata* Defl. and Cook., in Alberti, p. 32, fig. 19

Remarks,

The holotype has been examined and the identity of the present specimens confirmed by Professor Deflandre.

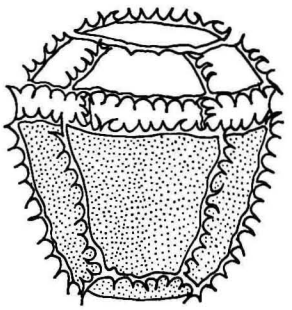
Previously known Occurrences

Paleocene to Lower Eocene, Australia (Deflandre and Cookson 1954, 1955). Upper Paleocene, Germany (Alberti, 1961). Upper Paleocene to Lowermost Eocene, Russia (Alberti 1961).

Genus MICRODINIUM Cookson and Eisenack 1960

Type Species, M. ornatum Cook. and Eis. 1960

Microdinium echinatum sp. nov.
Plate 1, figs. 9–10. Text-fig. 26



Text-fig. 26. *Microdinium echinatum* sp. nov., diagrammatic reconstruction. × 1500

Holotype,

Plate 1, fig. 9. Slide Number 442. Sample Number CV 12. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A species of *Microdinium* possessing relatively high ledges ornamented with echinae of regular height. Plates sculptured with granae or rugulae.

Description,

Outline rounded polygonal. A distinct transverse girdle divides the body into two unequal parts; the epitheca being smaller than the hypotheca.

The girdle is interrupted ventrally and slightly displaced. Tabulation is well displayed and appears to have the same number and pattern reported in the generic diagnosis of *Microdinium* except for the addition of cingular plates. The plates are bordered by well developed denticulate ledges. The denticles are in the form of sharp spines of equal height and spacing. Sculpture of the plates consists of granae or rugulae. An apical archaeopyle is visible on nearly all specimens and often the apical portion is still attached although displaced.

Measurements:	Holotype	Range
Overall length	33 μ	28–34 μ
Overall breadth	30 μ	26–32 μ
Width of girdle	5 μ	4– 5 μ
Height of ledges	3 μ	2– 3 μ
Height of spines	2 μ	1– 2 μ

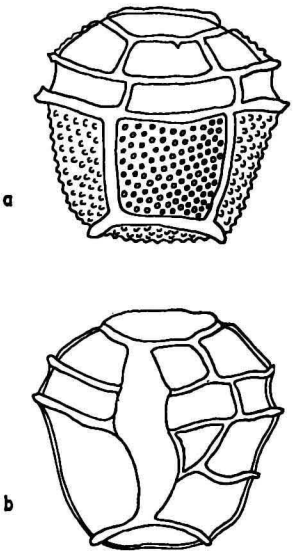
Comparison,

M. echinatum differs from *M. irregulare* and *M. ornatum* in the possession of denticulate (echinate) ledges.

Remarks,

No mention is made in the generic diagnosis of cingular plates. Such plates are present in *M. echinatum* sp. nov., and *M. irregulare* sp. nov. Our species are not excluded from *Microdinium* based on this feature as cingular plates are very clearly seen on the illustrations of the type species (Cookson and Eisenack 1960a, pl. 2, figs. 3–6, text-fig. 2).

Microdinium irregulare sp. nov.
Plate 7, figs. 5–8. Text-fig. 27



Text-fig. 27. *Microdinium irregulare* sp. nov., diagrammatic reconstruction. a, dorsal view. b, ventral view. × 1500

Holotype,

Plate 7, fig. 5. Slide Number 91. Sample Number CV 16. Southern Cliff, I.O.W. *Plenus*-Marl.

Diagnosis,

This species is characterized by the possession of granae on the plates and well developed smooth ledges.

Description,

Outline rounded with a flattened apex. A distinct, broad girdle divides the body into two very unequal parts, the epitheca being much smaller than the hypotheca. The girdle is interrupted but hardly displaced. Longitudinal furrow is well developed. Tabulation distinct, plates bordered by smooth, undulating ledges. Sculpture of the plates consists of granae or verrucae, often densely packed to form a rugulate pattern. However, the spacing of the granae may differ from one plate to another. An archaeopyle is nearly always visible and formed by the loss of the apical plate (or plates).

Measurements:	Holotype	Range
Overall length	34 μ	30–38 μ
Overall breadth	36 μ	32–39 μ
Width of girdle	4 μ	4– 6 μ
Height of ledges (max.)	5 μ	4– 5 μ

Comparison,

M. irregulare sp. nov. differs from *M. ornatum* Cook. and Eis. in the possession of smooth ledges.

Microdinium ornatum Cookson and Eisenack 1960
Plate 5, figs. 11–14

Holotype,

M. ornatum Cook. and Eis. 1960, pl. 2, figs. 3–4

1960a *M. ornatum* Cook. and Eis., p. 6–7, pl. 2, figs. 3–8, text-figs. 2–4

1964 *M. ornatum* Cook. and Eis., in Manum and Cookson, p. 19, pl. 3, figs. 8–10

Remarks,

The specimens which we have assigned to this species all have smooth (occasionally scabrate) plates, and ledges which are low and consist of small flat-topped verrucae or baculae. This differs slightly from the description given by Cookson and Eisenack (1960a, p. 6–7) who stress the perforate character of the ledges and the occasional development of tubercles on the plates. However, it is evident that our specimens are extremely close to the holotype (clearly figured in Cookson and Eisenack)

and our specimens are thus assigned. The specimen illustrated by COOKSON and EISENACK (1960a, pl. 2, fig. 7) with tubercles on the plates appears, in this respect, similar to our species *M. irregulare* sp. nov.

Previously known Occurrences

Albian to Lower Turonian, Australia (COOKSON and EISENACK 1960a). Upper Cretaceous, Canada (MANUM and COOKSON 1964).

Family STEPHODINIACEAE Eisenack

Genus STEPHODINIUM Deflandre 1936

Type Species, S. coronatum Deflandre 1936

Stephodinium coronatum Deflandre 1936

Plate 12, figs. 10–11

Holotype,

S. coronatum Defl. 1936, p. 59, text-fig. 104

1936a *S. coronatum* Deflandre, p. 58–59, text-fig. 104

1936b *S. coronatum* Defl., in Deflandre, p. 171, pl. 2, figs. 10–11

1962b *S. australicum* Cookson and Eisenack, p. 491, pl. 2, figs. 5–10

1964 *S. europaicum* Cookson and Hughes, p. 50–51, pl. 8, figs. 9–17

Remarks,

Having examined the holotype and having discussed this with Professor Deflandre, we have reached the conclusion that there is no difference between the holotype specimen of *S. coronatum* and our specimens of *Stephodinium* (which fall within the description given by COOKSON and HUGHES 1964 for *S. europaicum*); therefore all these specimens should now be referred to *S. coronatum*. Furthermore the criteria for distinguishing between *S. coronatum* and *S. australicum* are not sufficient to justify the specific status of the latter.

Previously known Occurrences

Upper Albian to Lower Cenomanian, England (COOKSON and HUGHES 1964). ?Upper Albian to Cenomanian, Australia (COOKSON and EISENACK 1962b). Turonian and ?Senonian, France (DEFLANDRE 1936a, 1936b, MERCIER 1938). Upper Cretaceous, Canada (MANUM and COOKSON 1964).

Family "INCERTAE-SEDIS"

Genus DICTYOPYXIDIA Eisenack 1961

Type Species, D. (al. *Dictyopyxis*) *areolata* Cookson and Eisenack 1960

Dictyopyxidia circulata sp. nov.

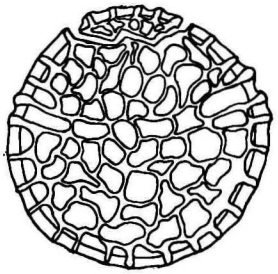
Plate 1, fig. 11. Plate 2, fig. 3. Text-fig. 28

Holotype,

Plate 1, fig. 11. Slide Number 453. Sample Number CV 12. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A species of *Dictyopyxidia* with an inner body and outer wall connected by a reticulum; the overall shape is circular.



Text-fig. 28. *Dictyopyxidia circulata* sp. nov., diagrammatic reconstruction. × 1000

Description,

Inner body and outer wall circular, connected by means of a low reticulum 1–1.5 μ high. The muri are 1.0 μ thick and enclose irregular and polygonal shaped luminae. An elongation of the reticulum parallel to the equator suggests the presence of a girdle in many specimens. Archaeopyle is apical and indented; there are no apical or antapical horns.

Measurements:	Holotype	Range
Length	40 μ	39–45 μ
Breadth	39 μ	35–40 μ

Remarks,

The I.O.W. specimens are interpreted as having an inner body and outer wall separated by a reticulum, i.e. the reticulum supports the outer wall. We are not sure if this is the case for *D. areolata* as Eisenack does not mention an inner body, although his illustrations suggest that one is present. Therefore we have assigned our forms to *Dictyopyxidia.*

We exclude consideration of a generic assignation to *Ellipsoidictyum* Klement 1960 in view of the presence of a 'median seam' in that genus.

Genus ELLIPSODINIUM gen. nov.

Type Species, E. rugulosum sp. nov.

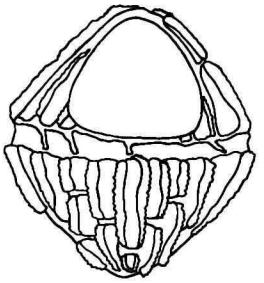
Diagnosis,

Main body oval, elliptical or rounded in outline. Girdle present. Archaeopyle precingular. Reticulate sculpture. No tabulation, apical or antapical protrusions, or inner body.

Comparison,

Ellipsodinium gen. nov. differs from *Ellipsoidictyum* Klement 1960 and *Dictyopyxidia* Eisenack 1961 in the presence of a precingular archaeopyle.

Ellipsodinium rugulosum sp. nov.
Plate 14, figs. 4–6. Text-fig. 29



Text-fig. 29. *Ellipsodinium rugulosum* gen. et sp. nov., diagrammatic reconstruction showing precingular archaeopyle and sculpture. × 1000

Holotype,

Plate 14, fig. 6. Slide Number 587. Sample Number CV 15. Southern Cliff, I.O.W. Cenomanian.

Diagnosis,

A species of *Ellipsodinium* having the luminae of the reticulum elongated parallel to the long axis of the body (i.e. parallel to the apical/antapical axis) and with muri which narrow noticeably distally.

Description,

Overall shape oval, ellipsoidal. A girdle is present, formed by the horizontal interruption of the longitudinally disposed reticulum. The sculpture consists of coarse, distinct, rectangular luminae, which are elongated and disposed generally parallel with the apical/antapical axis. Muri 1–3 μ thick at base, narrowing to become transparent distally. Distal margin irregular. Some thickening is sometimes apparent at the junction of the muri. Archaeopyle nearly always present as a rounded arch-shaped opening.

Measurements:	Holotype	Range
Length	40 μ	35–45 μ
Breadth	39 μ	33–40 μ
Height of ledges	upto 1.5 μ	1– 3 μ

Genus HEXAGONIFERA Cook. and Eis. 1961
emend. Cookson and Eisenack 1962

Type Species, H. glabra Cook. and Eis. 1961

Hexagonifera chlamydata Cookson and Eisenack 1962
Plate 11, figs. 6–8

Holotype,

H. chlamydata Cookson and Eisenack 1962, pl. 7, fig. 2

1962b *H. chlamydata* Cook. and Eis., p. 496, pl. 7, figs. 1–3, 5–8

1964 *H. chlamydata* Cook. and Eis., in Cookson and Hughes, p. 53–54, pl. 10, figs. 7–9

Remarks,

This common species in the British Upper Cretaceous has afforded many well preserved specimens and it is possible now to describe some additional features. The basic morphology consists of an inner body with an apical archaeopyle enveloped completely by a thin transparent outer membrane. The relationship between the body and the membrane is not always clear but it seems most likely that the attachment is in a median zone close to the archaeopyle leaving the remainder of the body and membrane detached, i.e. a space or cavity is present between them (pl. 11, fig. 8). Furthermore a cavity exists apically over that position of the body released by the rupture of the archaeopyle and a small apical horn is sometimes present, formed by the outer membrane (pl. 11, fig. 6).

We endorse the statement of Cookson and Eisenack (1962b, p. 496) that there is variability in the sculptural pattern. In fact we find that the two extremes are from practically smooth to coarsely verrucate.

Previously known Occurrences

Albian to Cenomanian, Australia (Cookson and Eisenack 1962b). Upper Albian to Lower Cenomanian, England (Cookson and Hughes 1964).

Genus PALAEOPERIDINIUM Deflandre 1934

Palaeoperidinium spinosum Cookson and Hughes 1964

Plate 14, figs. 10–12

Holotype,

P. spinosum Cook. and Hugh., 1964, pl. 8, fig. 8

1964 *P. spinosum* Cook. and Hugh., p. 49–50, pl. 8, figs. 6–8

Previously known Occurrences

Lower Cenomanian, England (Cookson and Hughes 1964).

Genus THALASSIPHORA Eisenack and Gocht 1960

Type Species, Pterospermopsis pelagica Eisenack 1954

Thalassiphora velata (Defl. and Cook. 1955)

Eisenack and Gocht 1960

Plate 15, fig. 5

Holotype,

T. velata (Defl. and Cook.) Eis. and Gocht, in Defl. and Cook., 1955, pl. 8, fig. 8

1955 *Pterocystidiopsis velata* Deflandre and Cookson, p. 291, pl. 8, fig. 8

1960 *Thalassiphora velata* (Defl. and Cook.) Eisenack and Gocht, p. 514–515

1961b *T. velata* (Defl. and Cook.) Eisenack and Gocht, in Cookson and Eisenack, p. 44, pl. 2, figs. 13–14

Previously known Occurrences

Lower Tertiary, Australia (DEFLANDRE and COOKSON 1955, COOKSON and EISENACK 1961b).

Group ACRITARCHA Evitt

Subgroup ACANTHOMORPHITAE Downie, Evitt and Sarjeant

Genus BALTISPHAERIDIUM Eisenack 1958, emend. Downie and Sarjeant 1963

Type Species, *B. longispinosum* Eisenack 1931

Baltisphaeridium armatum (Deflandre 1937) Downie and Sarjeant 1963

Plate 13, fig. 3

Holotype,

Hystrichosphaeridium armatum Defl. 1937, pl. 16, fig. 6

1937c *H. armatum* Defl., p. 76–77, pl. 16, figs. 6–7

1963 *Baltisphaeridium armatum* (Defl.), Downie and Sarjeant, p. 91

Remarks,

Deflandre in the original diagnosis mentions the presence of punctations at a low magnification which are resolved as short thin hairs when viewed under higher power. Our specimens indeed possess positive sculptural elements on the body but it is impossible to individualize these as hairs. Rather the sculpture imparts a diffuse zone around the body outline without being able to give any further precision. On other grounds there is no difference between the present specimens and those examined in Professor Deflandre's collection and the difference in the aspect of the body sculpture can probably be attributed to the mode of preservation (flint and chalk).

It seems most probable that many of the specimens assigned to *Hystrichosphaeridium hirsutum* forma *minor* should be included in *B. armatum* Downie and Sarjeant (see DE WIT 1943, p. 381, text-fig. 9A, non 9B and PASTIELS 1948, p. 45, pl. 5, figs. 4–6). Furthermore those

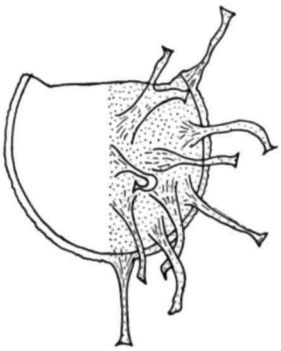
forms assigned by WETZEL (1932, 1933) as "forma *minor*" and "forma *varians*" are probably encompassed within the definition of *B. armatum* (Professor DEFLANDRE – personal communication).

Previously known Occurrences

Cenomanian and Senonian, France (Deflandre 1937c).

Baltisphaeridium bifidum sp. nov.

Plate 17, figs. 5–6. Text-fig. 30



Text-fig. 30. *Baltisphaeridium bifidum* sp. nov., diagrammatic reconstruction. × 800

Holotype,

Plate 17, fig. 5. Slide Number 149. Sample Number CV 25. Culver Cliff, I.O.W. Senonian.

Diagnosis,

A species of *Baltisphaeridium* diagnosed by the thick wall and long processes which have slightly bifid or expanded tops. The base of the processes and the body generally exhibit a striate appearance.

Description,

Main body circular, wall 2–3 microns thick, bearing long distinct processes. Processes generally discrete, only occasionally being joined at their bases. Each process widens at its base and possesses a short bifurcation or expansion distally. The sculpture of the body, which extends in some cases onto the base of the processes, consists of elongated perforations which imparts a striate appearance to the wall and especially to the proximal part of the processes. An apical opening is present on some specimens.

Measurements:	Holotype	Range
Diameter of body	66 μ	44–72 μ
Length of processes	22 μ	13–34 μ

Remarks,

This new species is assigned to *Baltisphaeridium* because of the presence of solid, closed processes. However, the apical opening referred to above is frequently indented and thus takes the form of an archaeopyle rather than a pylome. As the opening is not always visible we prefer, at this stage, to place our species in *Baltisphaeridium* as this represents the natural generic placing of those specimens which do not show the opening. A few specimens have been observed in which the opening, from its shape, appears to be precingular: this position is enhanced by the position of a larger process which is developed apically.

Comparison,

It is evident that *B. bifidum* sp. nov. must be compared with *B. striolatum* (Defl. 1937) Downie and Sarjeant 1963. From an examination of the holotype of *B. striolatum* it is concluded that *B. bifidum* differs from it in the more constant form of the processes, the presence of bifid or expanded tops, and the absence of low sutures connecting the bases of the processes.

Baltisphaeridium erectum (Manum and Cookson 1964) comb. nov.
Plate 16, figs. 3–5

Holotype,

Hystrichosphaeridium erectum Manum and Cookson 1964, pl. 3, fig. 5

1964 *H. erectum* Manum and Cookson, p. 14, pl. 3, figs. 5–6

Remarks,

The present specimens have solid processes and as this appears to be the case also for the specimens described by MANUM and COOKSON (1964) we feel the transfer to *Baltisphaeridium* is justified.

Previously known Occurrences.

Upper Cretaceous, Canada (MANUM and COOKSON, 1964).

Baltisphaeridium ferox (Defl. 1937) Downie and Sarjeant 1963
Plate 15, fig. 4

Holotype,

Hystrichosphaeridium ferox Defl. 1937, pl. 14, figs. 3–4

1937c *H. ferox* Deflandre, p. 72, pl. 14, figs. 3–4
1939 *H. ferox* Defl., in Deflandre et Courteville, p. 7, pl. 3, fig. 3
1952 *H. ferox* Defl., in Wetzel, p. 402, pl. A, fig. 13, text-fig. 20
1958 *H. ferox* Defl., in Eisenack, p. 401, pl. 27, figs. 1–2
1959 *H. ferox* Defl., in Gocht, p. 71, pl. 4, fig. 1

1962b *H. ferox* Defl., in Cookson and Eisenack, p. 491, pl. 4, fig. 15
1963 *Baltisphaeridium ferox* (Defl.) Downie and Sarjeant, p. 91
1964 *B. ferox* Downie and Sarj., in Cookson and Hughes, p. 55, pl. 10, fig. 11

Remarks,

The present specimens have been compared with the holotype and their identify confirmed. The specimen figured and described by Alberti (1961, p. 39–40, pl. 9, fig. 12) as *Hystrichokolpoma* sp. A from the Cenomanian of Germany is probably synonymous with *B. ferox.*

Previously known Occurrences

Lower Hauterivian, Germany (Gocht 1959). Upper Aptian, Germany (Eisenack 1959). Albian to Cenomanian, Australia (Cookson and Eisenack 1962b). Albian to Cenomanian, England (Cookson and Hughes 1964). Senonian, France (Deflandre 1937c, Deflandre and Courteville 1939). Danian, Germany (Wetzel 1952).

Baltisphaeridium granulosum (Deflandre 1937) Sarjeant 1962
Plate 12, figs. 7–9

Holotype,

Hystrichosphaeridium xanthiopyxides var. *granulosum* Defl. 1937, pl. 16, fig. 4
1935 *Hystrichosphaera xanthiopyxides* Wetzel, in Deflandre, p. 233, pl. 9, fig. 7
1937c *Hystrichosphaeridium xanthiopyxides* (Wetzel) var. *granulosum* Deflandre, p. 29, pl. 16, fig. 4
1955b *H. xanthiopyxides* var. *granulosum* Defl., in Valensi, p. 594, pl. 3, fig. 16, pl. 5, fig. 7
1957 *H. xanthiopyxides* var. *granulosum* Defl., in Downie, p. 426–427, text-fig. 46
1962a *Baltisphaeridium granulosum* (Defl.), Sarjeant, p. 264, pl. 2, fig. 14, text-fig. 8c

Remarks,

The comparison between this species and *Baltisphaeridium mixtispinosum* Klement 1960 is made in Klement (1960, p. 59). *B. granulosum* differs from *B. parvispinum* (Cook. and Eis. 1958) Klement 1960 in the longer and less pointed processes.

Previously known Occurrences

Corallian (Lusitanian), England (Sarjeant 1962a). Kimmeridgian, England (Downie 1957). Senonian, France (Deflandre 1935, 1937c, Valensi 1955b).

Baltisphaeridium pseudohystrichodinium (Defl. 1937)
Downie and Sarjeant 1963
Plate 15, fig. 7

Holotype,

Hystrichosphaeridium pseudohystrichodinium Defl. 1937, pl. 15, fig. 3

1937c *H. pseudohystrichodinium* Deflandre, p. 73, pl. 15, figs. 3–4
1941 *H. pseudohystrichodinium* Defl., in Conrad, p. 2, pl. 1, fig. E
1941 *H. pseudohystrichodinium* Defl., in Lejeune-Carpentier, p. B76–77, fig. 8
1943 *H. pseudohystrichodinium* Defl., in De Wit, p. 379, text-fig. 6
1948 *H. pseudohystrichodinium* Defl., in Pastiels, p. 43–44, pl. 3, figs. 12–15
1952 *H. pseudohystrichodinium* Defl., in Wetzel, p. 400, text-fig. 15
1963 *H. pseudohystrichodinium* Defl., in Górka, p. 61–62, pl. 8, figs. 4–6, text-pl. 7, figs. 1–3
1963 *Baltisphaeridium pseudohystrichodinium* (Defl.) Downie and Sarjeant, p. 92

Remarks,

Our specimens have been compared with the holotype.

Previously known Occurrences

Lusitanian, Poland (Górka 1965). Senonian, France (Deflandre 1937c). Campanian to Maastrichtian, Poland (Górka 1963). Maastrichtian, Holland (De Wit, 1943, 1944). Maastrichtian, Belgium (Conrad 1941, Lejeune-Carpentier 1941). Danian, Germany (Wetzel 1952). Eocene, Belgium (Pastiels 1948).

Baltisphaeridium striolatum (Defl. 1937) Downie and Sarjeant 1963
Plate 15, fig. 6

Holotype,

Hystrichosphaeridium striolatum Defl. 1937, pl. 15, fig. 1

1838a *Xanthidium hirsutum* (?) Ehrenberg, pl. 1, fig. 13
1854 *X. hirsutum* Ehr., in Ehrenberg, pl. 37, figs. 7–8
1937c *Hystrichosphaeridium striolatum* Defl., p. 72–73, pl. 15, figs. 1–2
1939 *H. striolatum* Defl., in Deflandre et Courteville, pl. 3, fig. 2
1941 *H. hirsutum* (Ehr.) Lejeune-Carpentier, p. B72–76, text-figs. 1–4
1955b *H. striolatum* Defl., in Valensi, p. 593, pl. 4, fig. 10, pl. 5, fig. 3
1958 *H.* cf. *hirsutum* (Ehr.), in Cookson and Eisenack, p. 44–45, pl. 11, figs. 5–6 and not fig. 13

1963 *H.* cf. *striolatum* Defl., in Górka, p. 68–70, pl. 10, figs. 6–7, text-pl. 8, figs. 5–6
1963 *Baltisphaeridium hirsutum* (Ehr.) Downie and Sarjeant, p. 91
1963 *B. striolatum* (Defl.) Downie and Sarjeant, p. 92
1964 *B. hirsutum* (Ehr.) Down. and Sarj., in Cookson and Hughes, p. 55, pl. 10, figs. 1–2

Previously known Occurrences

Aptian to Albian, Australia (Cookson and Eisenack 1958). Upper Albian to Lower Cenomanian, England (Cookson and Hughes 1964). Cenomanian, France (Deflandre 1937c). Cenomanian and Upper Campanian, Poland (Górka 1963). Senonian, England (Ehrenberg 1838a), Denmark (Ehrenberg 1854), France (Deflandre 1937c, Deflandre and Courteville 1939, Deflandre-Rigaud 1954, 1955, Valensi 1955b), Belgium (Lejeune-Carpentier 1941).

Baltisphaeridium whitei (Defl. and Court. 1939) Sarjeant 1959
Plate 16, figs. 1–2

Holotype,

Hystrichosphaeridium whitei Defl. and Court. 1939, pl. 3, fig. 5
1839 *Xanthidium hirsutum* Ehr., in Reade, pl. 9, fig. 3, not fig. 8
1842 *X. hirsutum* Ehr., in White, p. 36–37, pl. 4, fig. 4
1844a *X. hirsutum* Ehr., in White, p. 79–80, pl. 8, fig. 3
1939 *Hystrichosphaeridium whitei* Defl. and Court., p. 103, pl. 3, figs. 5–6
1955b *H. whitei* Defl. and Court., in Valensi, p. 593, pl. 5, fig. 11
1959 *Baltisphaeridium whitei* (Defl. and Court.) Sarjeant, p. 339
1963 *Hystrichosphaeridium whitei* Defl. and Court., in Górka, p. 67–68, pl. 9, fig. 9, text-pl. 8, fig. 2

Remarks,

The I.O.W. specimens have been compared with paratype material of this species. There is a small difference with regard to the processes. In the paratype material the attachment can be observed while in the present specimens such observance is obscured giving a diffuse zone surrounding the body. Furthermore the extremities of the processes are more obviously pointed than in our specimens. However, it is considered that the assignation of these specimens to *B. whitei* is sound and that the difference is in the method of preservation as already indicated for *B. armatum* (see page 71).

Previously known Occurrences

Turonian, Poland (Górka 1963). Senonian, France (Deflandre and Courteville 1939, Valensi 1955b), England (Reade 1839, White 1842, 1844a).

Genus CORONIFERA Cookson and Eisenack 1958

Type Species, C. oceanica Cook. and Eis. 1958

Coronifera oceanica Cookson and Eisenack 1958
Plate 17, fig. 7

Holotype,

C. oceanica Cook. and Eis. 1958, p. 45, pl. 12, fig. 6

1958 *C. oceanica* Cook. and Eis., p. 45, pl. 12, figs. 5–6

1958 *C. oceanica* Cook. and Eis., in Eisenack, p. 407–408, pl. 25, fig. 1

1961 ? Dinoflagellate gen. and sp. indet., in Alberti, p. 40–41, pl. 11, fig. 12

1964 *C. oceanica* Cook. and Eis., in Cookson and Hughes, p. 56, pl. 9, fig. 8–9

Remarks,

This distinctive form has been found in small numbers in some of our Cenomanian samples.

Previously known Occurrences

Aptian, Germany (Eisenack 1958, Alberti 1961). Albian, Australia (Cookson and Eisenack 1958). Upper Albian to Lower Cenomanian, England (Cookson and Hughes 1964).

Subgroup POLYGONOMORPHITAE Downie, Evitt and Sarjeant

Genus VERYHACHIUM Deunff 1954, emend. Downie and Sarjeant 1963

Veryhachium spp.
Plate 13, fig. 2

Remarks,

Specimens of *Veryhachium* occur in small numbers in most of the samples studied being slightly more abundant in the Cenomanian. The most common form has six appendages while forms with three to eight processes also occur. No attempt has been made here to further classify these.

Subgroup PTEROMORPHITAE Downie, Evitt and Sarjeant

Genus PTEROSPERMOPSIS Wetzel 1952

Type Species, P. danica Wetzel 1952

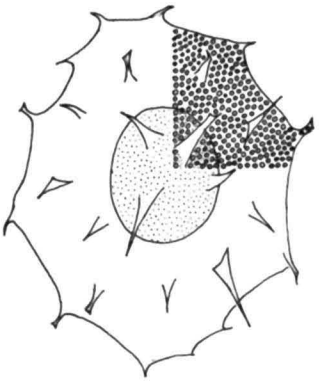
Pterospermopsis spinosa sp. nov.
Plate 17, figs. 1–2. Text-fig. 31

Holotype,

Plate 17, fig. 1. Slide Number 558. Sample Number CV 28. Culver Cliff, I.O.W. Senonian.

Diagnosis,

A species of *Pterospermopsis* with a small rounded main body and an outer membrane bearing both perforations and spines (echinae). No opening has been observed.



Text-fig. 31. *Pterospermopsis spinosa* sp. nov., diagrammatic reconstruction, × 800

Description,

The inner body is in contact with the outer membrane only at the apex and antapex giving an equatorial expansion. The main body is smooth. The outer membrane, however, is uniformly sculptured with small perforations. A positive sculpture is also present in the form of spines and short processes with expanded tops again covering the whole of the outer membrane but unlike the perforations they are well separated. No pylome or archaeopyle has so far been seen.

Measurements:	Holotype	Range
Overall diameter	93 μ	85–100 μ
Inner body diameter	38 μ	35– 50 μ
Length of spines	5–12 μ	3– 18 μ

Comparison,

P. spinosa sp. nov. differs from all previously described species in the presence of spines on the outer membrane.

Subgroup UNCERTAIN

Genus EPICEPHALOPYXIS Deflandre 1935

Type Species, E. adhaerens Deflandre 1935

Epicephalopyxis indentata Deflandre and Cookson 1955

Plate 1, fig. 5

Holotype,

E. indentata Defl. and Cook. 1955, pl. 9, fig. 6

1955 *E. indentata* Defl. and Cook., p. 292–293, pl. 9, figs. 5–7, text-fig. 56

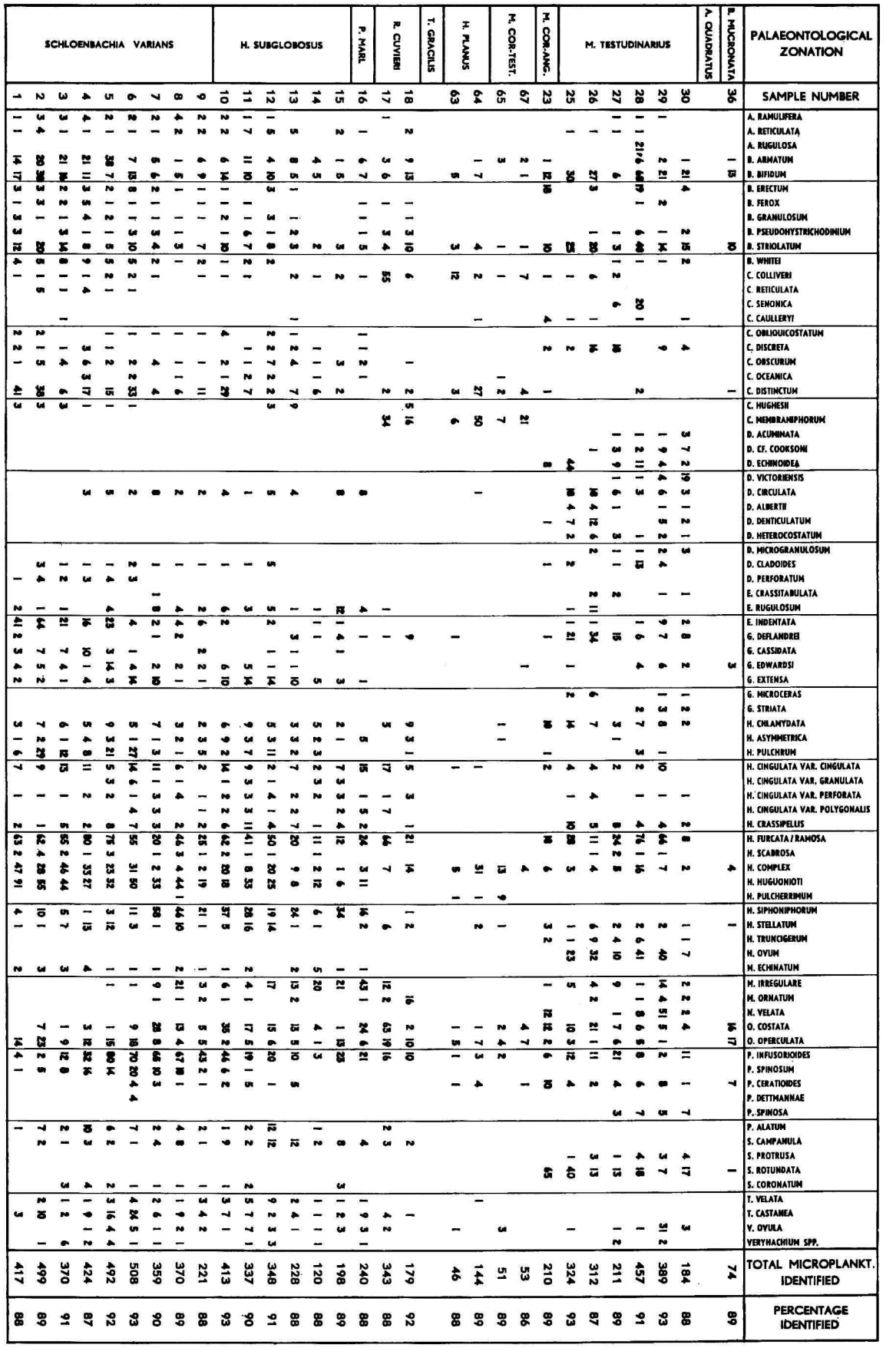
Previously known Occurrences

Paleocene to Upper Eocene (?), Miocene (?), Australia (DEFLANDRE and COOKSON 1955).

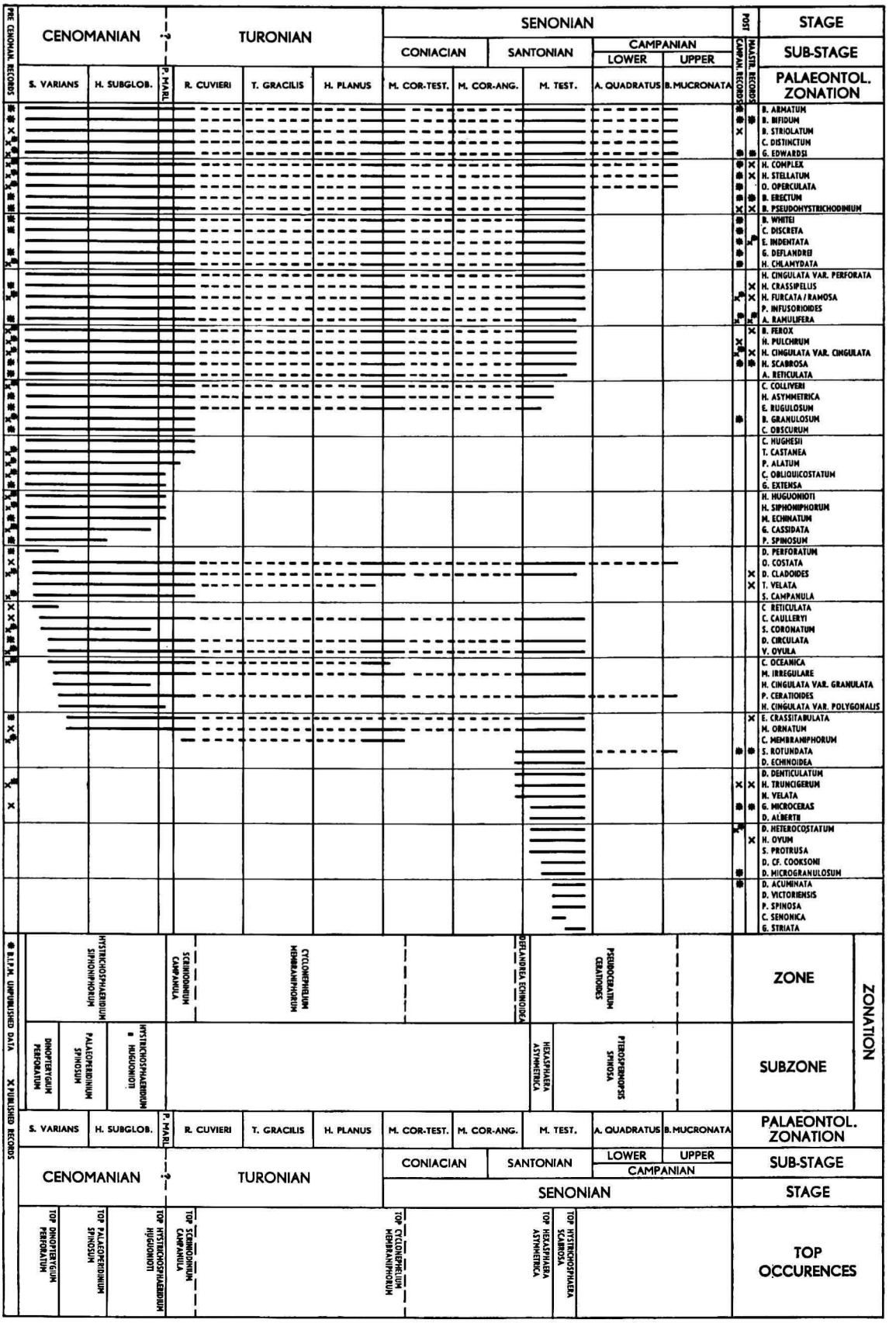
STRATIGRAPHIC DISCUSSION

The distribution and frequency of the various species constituting the microfloras examined in this study are plotted on text-fig. 32. The ranges deduced from this distribution chart are given as text-fig. 33. It is thus appropriate here to remark briefly upon the distribution of some of those types which are already known but which are recorded in the Cenomanian to Senonian interval for the first time.

1. *Eisenackia crassitabulata* Defl. and Cook. 1955 has not previously been recorded from sediments older than Tertiary age. This form occurs only very rarely in the present material and it is not possible to precisely ascertain its base.
2. The present record of *Hystrichosphaera crassipellis* Defl. and Cook. 1955 constitutes its first recovery from Upper Cretaceous sediments; previously having only been known from the Tertiary. This type is present and fairly abundant from the base of the Cenomanian to the top of the present section. However, data furnished by B.I.P.M. reports (unpublished) indicate that *H. crassipellis* is present in Hauterivian/Barremian sediments of Europe. Such findings therefore considerably extend the range of this form.
3. *Gonyaulacysta microceras* (Eisenack) comb. nov. has only one previous record, the Aptian of Germany. This is in marked contrast to the occurrence of our specimens, which we believe to be conspecific with *G. microceras*, in the Senonian of the Isle of Wight. It is possible to invoke reworking of our specimens although such an hypothesis is not supported by any other types which would also be expected to appear if the Senonian samples contained reworked Aptian.
4. COOKSON and HUGHES (1964) record *Cyclonephelium membraniphorum* Cook. and Eis. 1962 from the Albian and Lower Cenomanian of England. At present it is not completely understood why this type in the Isle of Wight does not make its first appearance until the Turonian.
5. COOKSON and EISENACK (1960a) record *Microdinium ornatum* from Albian to Lower Turonian sediments in Australia. This species does not make its first appearance in the Isle of Wight until the sub-zone of *Palaeoperidinium spinosum* (i.e. above the base of the Cenomanian). This first occurrence is confirmed from studies made in the Upper Cretaceous of France (B.I.P.M. data, unpublished).



Text-fig. 32. Distribution chart.



Text-fig. 33. Range chart (N.B. the pre-Cenomanian records given at the bottom of the chart include the Vraconian).

Definition of Microplankton Zones

The present section has been zoned according to the ranges of certain index species. These forms have purposely only been chosen where they are well differentiated taxonomically and occur in sufficient abundance to have confidence in the ranges exhibited. It is appreciated that it may be a little premature to erect a zonation of this sort based on what is virtually only one section. However, the section is fairly complete, well dated and where fossiliferous has generally rich microfloras and on these grounds we feel that at least the attempt is justified. Furthermore, work presently being undertaken at B.I.P.M. on the Upper Cretaceous of France so far substantiates the zonation given in this paper.

The section has been subdivided in two ways. The first is based on the conventional palaeontological method to give assemblage, range and concurrent range zones (see A.A.P.G. Bull., vol. 45, 1961). The second divides the section into intervals based only on the "top occurrence" (evolutionary extinction point) of various forms. This type of subdivision is especially useful to palynologists, generally working for oil companies, whose sample material sometimes consists of ditch-cuttings (see text-fig. 33).

1. *Zone of Hystrichosphaeridium siphoniphorum* (concurrent-range zone)

   Base of Zone,

   First appearance of *P. infusorioides*. Palynologically this can be taken as the base of the Cenomanian as this type does not occur in the Upper Albian.

   Top of Zone,

   Last appearance of *C. obliquicostatum*, *G. extensa*, *H. huguonioti*, *H. siphoniphorum*, *M. echinatum*, *H. cingulata* var. *polygonalis*. *O. costata* makes its first appearance very near the base of this zone.

   Age of Zone,

   Cenomanian – ? Turonian

1a. *Subzone of Dinopterygium perforatum* (concurrent-range sub-zone)

   Base of sub-zone,

   First appearance of *P. infusorioides*.

   Top of sub-zone,

   Last appearance of *D. perforatum* and *C. reticulata*.

   M. irregulare and *H. cingulata* var. *granulata* make their first appearance at the top of this subzone.

1b. *Sub-zone of Palaeoperidinium spinosum* (concurrent-range sub-zone)

   Base of sub-zone,

   First appearance of *P. ceratioides* and *H. cingulata* var. *polygonalis*.

   Top of sub-zone,

   Last appearance of *P. spinosum*.

1c. *Sub-zone of Hystrichosphaeridium huguonioti* (assemblage sub-zone)

Base of sub-zone,

Immediately above the last appearance of *P. spinosum.*

Top of sub-zone,

Last appearance of *C. obliquicostatum, G. extensa, H. huguonioti, H. siphoniphorum, H. cingulata* var. *polygonalis, M. echinatum.*

H. cingulata var. *granulata* makes it last appearance in this sub-zone.

2. *Zone of Scriniodinium campanula* (assemblage zone)

Base of Zone,

Immediately above the last appearance of *C. obliquicostatum, G. extensa, H. huguonioti, H. siphoniphorum, H. cingulata* var. *polygonalis, M. echinatum.*

Top of Zone,

Last appearance of *S. campanula.*

The zone is characterized by the presence of *S. campanula, P. alatum, C. hughesii, C. obscurum.*

Age of Zone,

? Cenomanian – Turonian.

3. *Zone of Cyclonephelium membraniphorum* (assemblage zone)

Base of Zone,

Immediately above the last appearance of *S. campanula.*

Top of Zone,

Last appearance of *C. membraniphorum.*

C. oceanica, probably makes its last appearance in this zone.

Age of Zone,

Turonian – Coniacian/Santonian.

4. *Zone of Deflandrea echinoidea* (assemblage zone)

Base of Zone,

Immediately above the top of *C. membraniphorum.*

Top of Zone,

Immediately below the base of *H. ovum, D. albertii, D. heterocostatum.*

This zone is characterized by the presence of *D. echinoidea, N. velata, D. denticulatum, S. rotundata.*

Age of Zone,

Santonian.

5. *Zone of Pseudoceratium ceratioides* (concurrent-range zone)

Base of Zone,

First appearance of *H. ovum, D. albertii, D. heterocostatum.*

Top of Zone,

Last appearance of *P. ceratioides.*

Age of Zone,

Santonian – Campanian.

5a. *Sub-zone of Hexasphaera asymmetrica* (concurrent-range sub-zone)

Base of sub-zone,

First appearance of *H. ovum*, *D. albertii*, *D. heterocostatum*.

Top of sub-zone,

Last appearance of *H. asymmetrica*.

E. rugulosum makes its last appearance in this sub-zone.

5b. *Sub-zone of Pterospermopsis spinosa* (concurrent-range sub-zone)

Base of sub-zone,

First appearance of *P. spinosa*, *C. senonica*. *G. striata* makes its first appearance in this sub-zone.

Top of sub-zone,

Last appearance of *P. ceratioides*.

Definition of the palynological "intervals"

1. *Interval of Hystrichosphaera scabrosa*
   Based on the "top" of *H. scabrosa*. *A. reticulata* and *C. senonica* have a top occurrence in this interval.
2. *Interval of Hexasphaera asymmetrica*
   Based on the "top" of *H. asymmetrica* and *C. colliveri*. *E. rugulosum* has a top in this interval.
3. *Interval of Cyclonephelium membraniphorum*
   Based on the "top" of *C. membraniphorum*. *C. oceanica* probably has a top in this interval.
4. *Interval of Scriniodinium campanula*
   Based on the "top" of *S. campanula*. *C. obscurum* and *C. hughesii* have top occurrences in this interval.
5. *Interval of Hystrichosphaeridium huguonioti*
   Based on the "top" of *H. huguonioti*, *C. obliquicostatum*, *G. extensa*, *H. siphoniphorum*, *M. echinatum*, *H. cingulata* var. *polygonalis*. *G. cassidata*, *S. coronatum*, *H. cingulata* var. *granulata* have top occurrences in this interval.
6. *Interval of Palaeoperidinium spinosum*
   Based on the "top" of *P. spinosum*.
7. *Interval of Dinopterygium perforatum*
   Based on the "top" of *D. perforatum* and *C. reticulata*.

The top of the Cretaceous (i.e. top Maastrichtian) can probably be based on the top occurrences of *H. pulchrum*, *G. edwardsi*, *O. operculata*, *O. costata*, *H. chlamydata*, *P. infusorioides* and *D. heterocostatum*.

Due to some unsampled intervals in the original collecting and to certain non-microfossiliferous intervals there exists some gaps in the succession of microfloras. Thus the position of some of the zonal boundaries is not precisely known in relation to the macrofossil zones. Those palynological zones which have not been found in contact include the top of the Zone of *Scriniodinium campanula*, the top of the Zone of *Cyclonephelium membraniphorum* and necessarily the top of the Zone of *Pseudoceratium ceratioides*.

General points concerning the microfloras

The general relationship between the microfloras and the lithology is given on page 14. Those samples which produce a microflora give, in general, rich, varied and well preserved assemblages. However, samples CV 63–67 collected from the *Holaster planus* and *Micraster cor-testudinarium* zones are less rich both numerically and in the number of species than those from above and below this interval. It is worth noting this in connection with the distribution of certain forms. From the Distribution Chart (text-fig. 32) it can be seen that *Achomosphaera reticulata, Hystrichosphaera cingulata* var. *perforata, Baltisphaeridium erectum, Chlamydophorella discreta, Gonyaulacysta edwardsi, Microdinium irregulare, M. ornatum, Baltisphaeridium whitei,* and *Gardodinium deflandrei* occur in sediments both younger and older than those represented by samples CV 63–67. It thus becomes necessary to consider that their occurrence above (i.e. in sediments younger than) samples CV 63–67 is due to reworking. However, we consider that such a phenomenon has not taken place, to any great degree, for the following reasons,

a) As mentioned above the samples CV 63–67 are less rich than those above and below this interval and therefore the absence of a type (especially one which is not particularly common elsewhere in the section) may not indicate extinction of a particular form at this point.
b) *B. erectum, G. edwardsi, M. ornatum, B. whitei* have been previously recorded from Senonian sediments.
c) Many other species show a similar distribution to those listed above, but they are also known to have Tertiary occurrences making their appearance in the Senonian, due to reworking, extremely unlikely. Such species include *Hystrichosphaera crassipellis, Epicephalopyxis indentata, Achomosphaera ramulifera, Baltisphaeridium pseudohystrichodinium, B. ferox, Dinopterygium cladoides.*
d) There is no hiatus discernible in the field section.

Thus it is concluded that the absence in samples CV 63–67 of all these forms is monocausal i.e. due to the general paucity of species occurrence within this interval. The Range Chart (text-fig. 33) has been built up on the acceptance of this premise.

Most samples giving a microflora have microplankton as the major constituent; both Acritarcha and Dinoflagellata being well represented. An exception to this, however, are the samples collected from the *Terebratulina gracilis* and *Holaster planus* zones near Yarbridge (see p. 13). In this case the microfloras are very poor and consist entirely of species of *Baltisphaeridium* and *Hystrichosphaeridium.* The overall poorness of these samples precludes any satisfactory deduction being made concerning this "apparently restricted" microflora. Apart from microplankton other microfossils are present in most samples and include spores, pollen and

microforaminifera. The amount of spores and pollen present is small in all samples, always constituting less than eight per cent of the total microflora.

Text-fig. 32 represents the distribution of the complete assemblage (based on the examination of two slides per sample) except for some very small types (e.g. *Micrhystridium*) and a number of irregularly occurring, very transparent, forms of *Ascodinium* which first occur in sample CV 13 and continue to the top of the section.

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INDEX OF SPECIES

PLATES 1–17

PLATE 1

Fig. 1. *Trichodinium castanea* comb. nov., sl. 592, CV 6, 600 ×

Fig. 2. *Trichodinium castanea* comb. nov., sl. 547, CV 6, 600 ×

Fig. 3. *Canningia colliveri* Cook. & Eis., sl. 678, CV 63, 600 ×

Fig. 4. *Canningia colliveri* Cook. & Eis., sl. 677, CV 63, 600 ×

Fig. 5. *Epicephalopyxis indentata* Defl. & Cook., sl. 230, CV 29, phase contrast, 600 ×

Fig. 6. *Cyclonephelium distinctum* Defl. & Cook., sl. 274, CV 11, 600 ×

Fig. 7. *Cyclonephelium distinctum* Defl. & Cook., sl. 270, CV 5, 600 ×

Fig. 8. *Canningia reticulata* Cook. & Eis., sl. 617, CV 2, 600 ×

Fig. 9. *Microdinium echinatum* sp. nov. — holotype, sl. 442, CV 12, 750 ×

Fig. 10. *Microdinium echinatum* sp. nov. — paratype, sl. 517, CV 3, 1000 ×

Fig. 11. *Dictyopyxidia circulata* sp. nov. — holotype, sl. 453, CV 12, 750 ×

Fig. 12. *Canningia senonica* sp. nov. — holotype, sl. 643, CV 27, 600 ×

Fig. 13. *Canningia senonica* sp. nov. — paratype, sl. 653, CV 27, 600 ×

Fig. 14. *Canningia senonica* sp. nov. — paratype, sl. 669, CV 27, 600 ×

PLATE 1

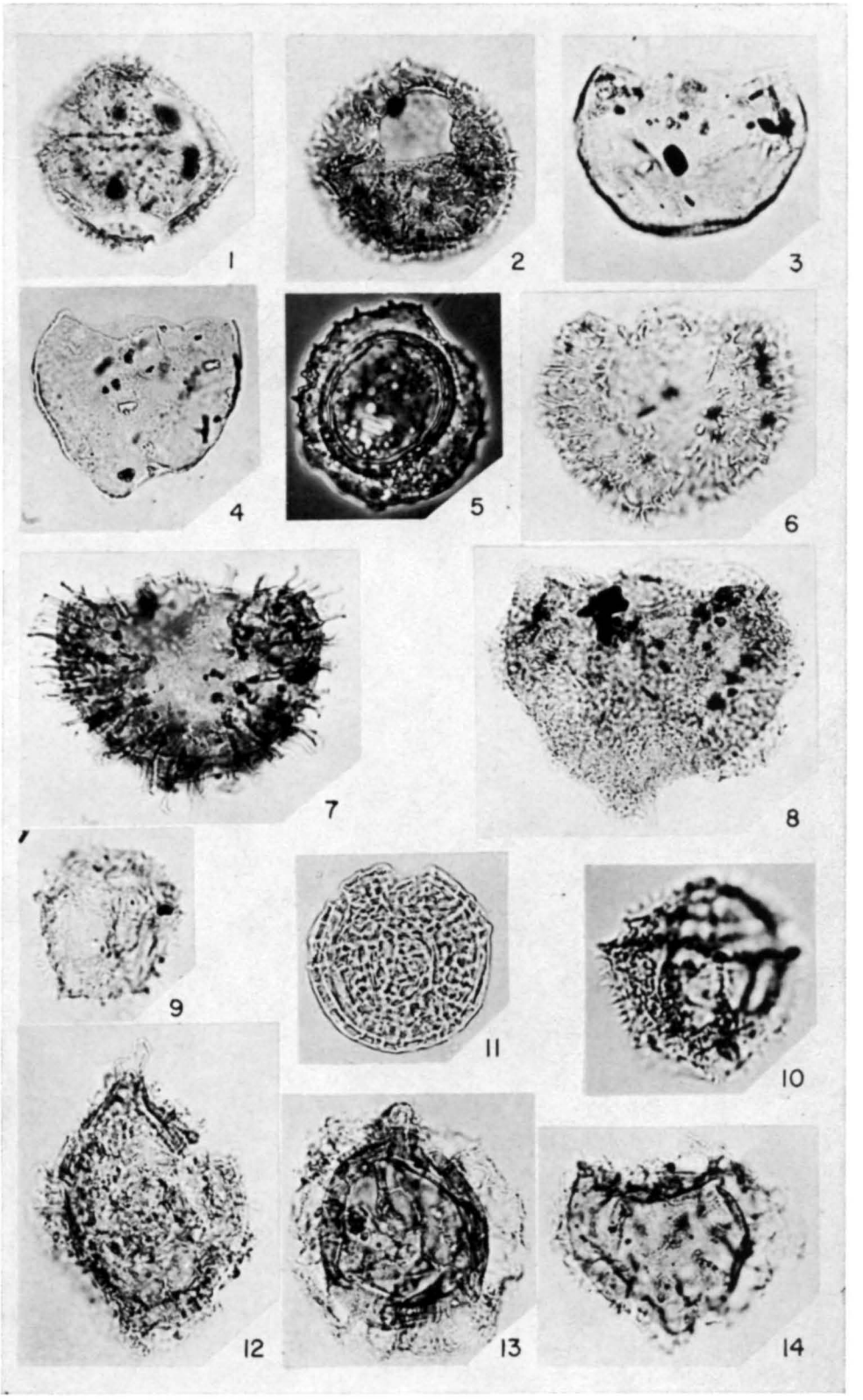


PLATE 2

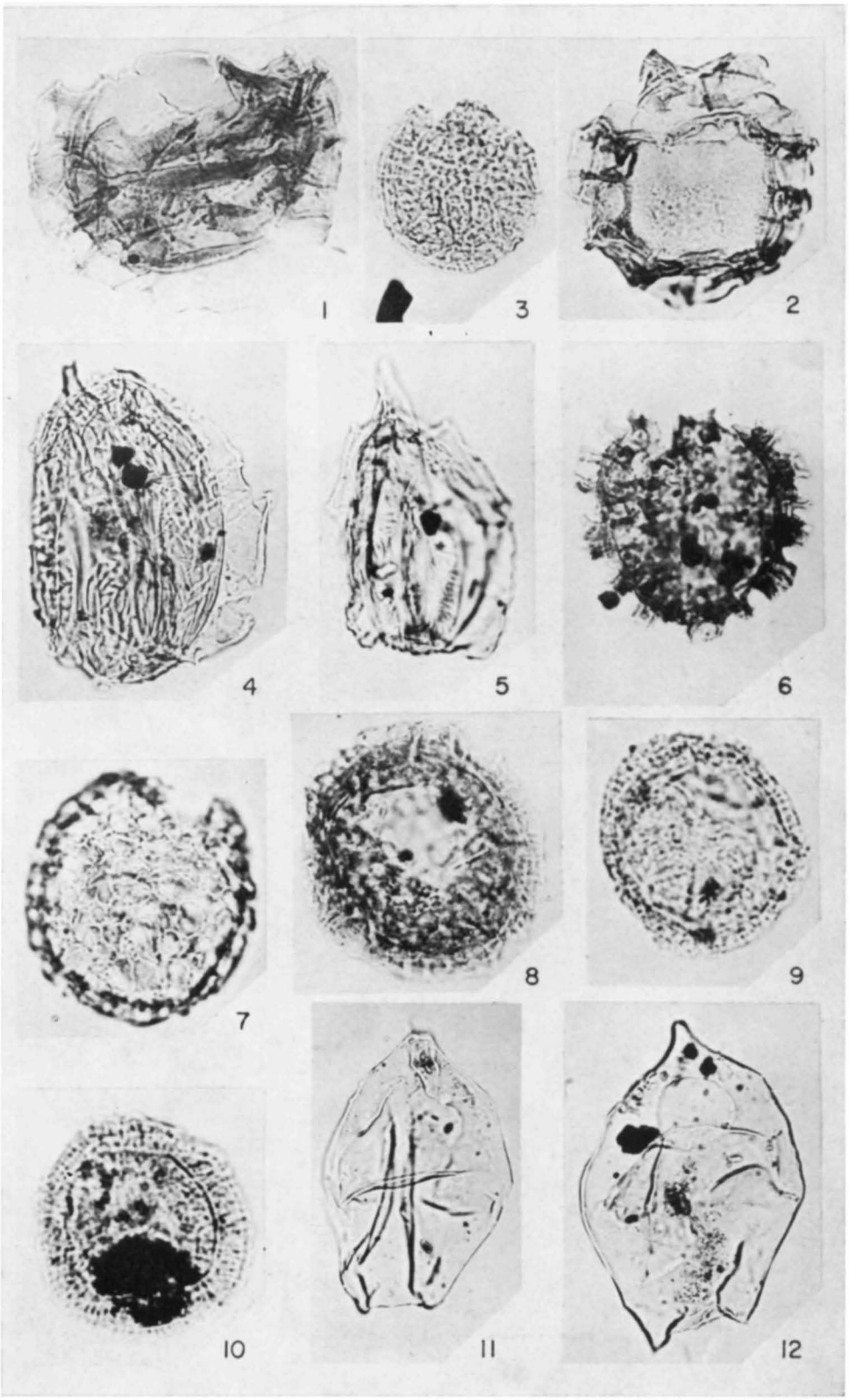


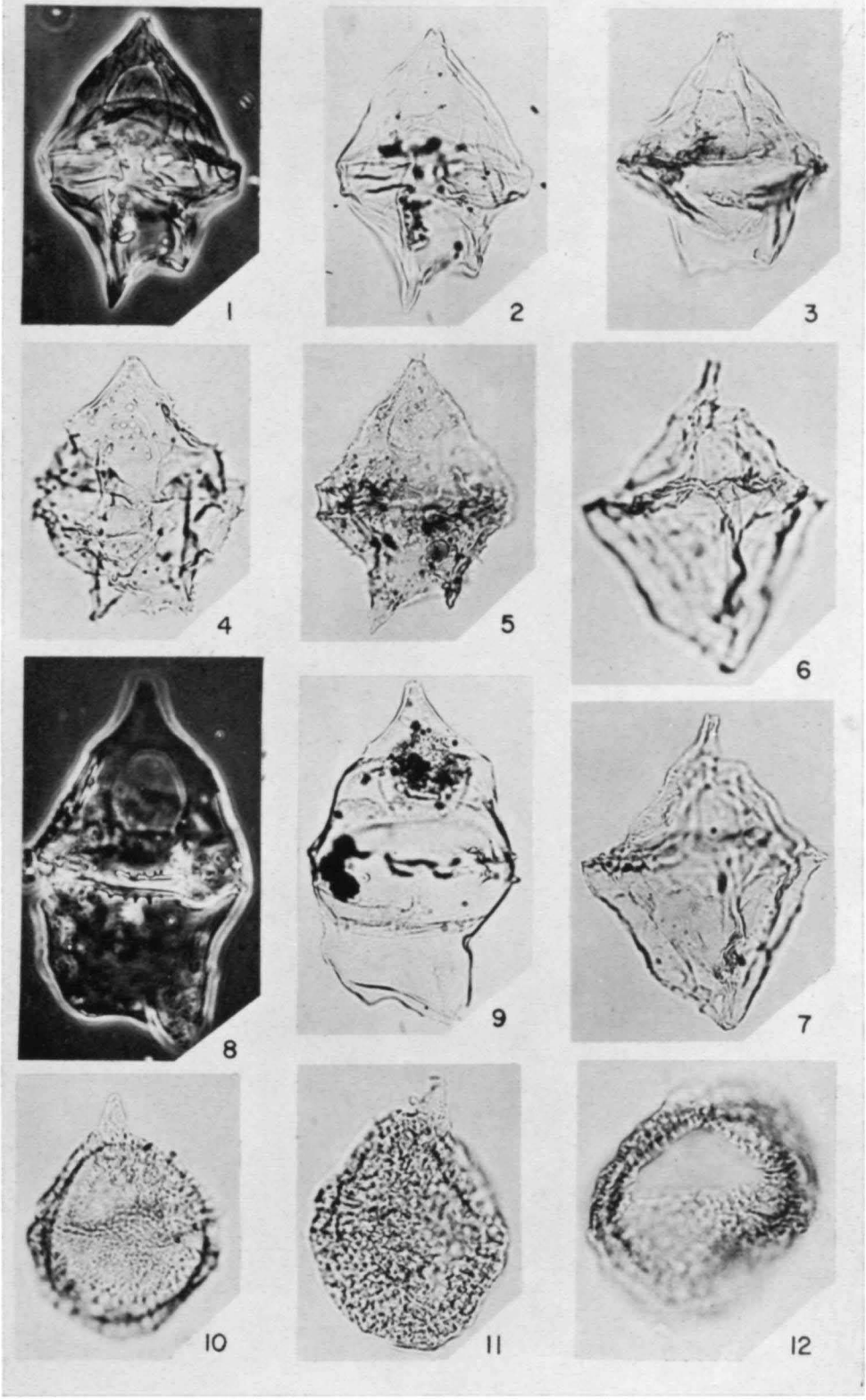
PLATE 2

Fig. 1. *Cyclonephelium membraniphorum* Cook. & Eis., sl. 609, CV 17, 600 ×
Fig. 2. *Cyclonephelium membraniphorum* Cook. & Eis., sl. 636, CV 17, 600 ×
Fig. 3. *Dictyopyxidia circulata* sp. nov. — paratype, sl. 127, CV 16, 750 ×
Fig. 4. *Carpodinium obliquicostatum* Cook. & Hugh., sl. 394, CV 10, 750 ×
Fig. 5. *Carpodinium obliquicostatum* Cook. & Hugh., sl. 100, CV 16, 750 ×
Fig. 6. *Cyclonephelium hughesii* sp. nov. — holotype, sl. 33, CV 3, 600 ×
Fig. 7. *Valensiella ovula* (Defl.) Eis., sl. 182, CV 25, 600 ×
Fig. 8. *Valensiella ovula* (Defl.) Eis., sl. 544, CV 6, 750 ×
Fig. 9. *Chlamydophorella discreta* sp. nov. — paratype, sl. 325, CV 26, 1000 ×
Fig. 10. *Chlamydophorella discreta* sp. nov. — holotype, sl. 31, CV 3, 1000 ×
Fig. 11. *Deflandrea acuminata* Cook. & Eis., sl. 185, CV 25, 600 ×
Fig. 12. *Deflandrea acuminata* Cook. & Eis., sl. 181, CV 25, 600 ×

PLATE 3

Fig. 1. *Deflandrea* cf. *cooksoni* Alb., sl. 214, phase contrast.
Fig. 2. *Deflandrea* cf. *cooksoni* Alb., sl. 214, CV 29, 600 ×
Fig. 3. *Deflandrea* cf. *cooksoni* Alb., sl. 641, CV 27, 600 ×
Fig. 4. *Deflandrea echinoidea* Cook. & Eis., sl. 563, CV 28, 600 ×
Fig. 5. *Deflandrea echinoidea* Cook. & Eis., sl. 562, CV 28, 600 ×
Fig. 6. *Scriniodinium campanula* Gocht, sl. 588, CV 15, 600 ×
Fig. 7. *Scriniodinium campanula* Gocht, sl. 588, CV 15, 600 ×
Fig. 8. *Deflandrea victoriensis* Cook. & Man., sl. 224, CV 29, phase contrast, 600 ×
Fig. 9. *Deflandrea victoriensis* Cook. & Man., sl. 219, CV 29, 600 ×
Fig. 10. *Gardodinium deflandrei* sp. nov. — holotype, sl. 226, CV 29, 750 ×
Fig. 11. *Gardodinium deflandrei* sp. nov. — paratype, sl. 486, CV 25, 750 ×
Fig. 12. *Gardodinium deflandrei* sp. nov. — paratype, sl. 667, CV 27, 1000 ×

PLATE 3



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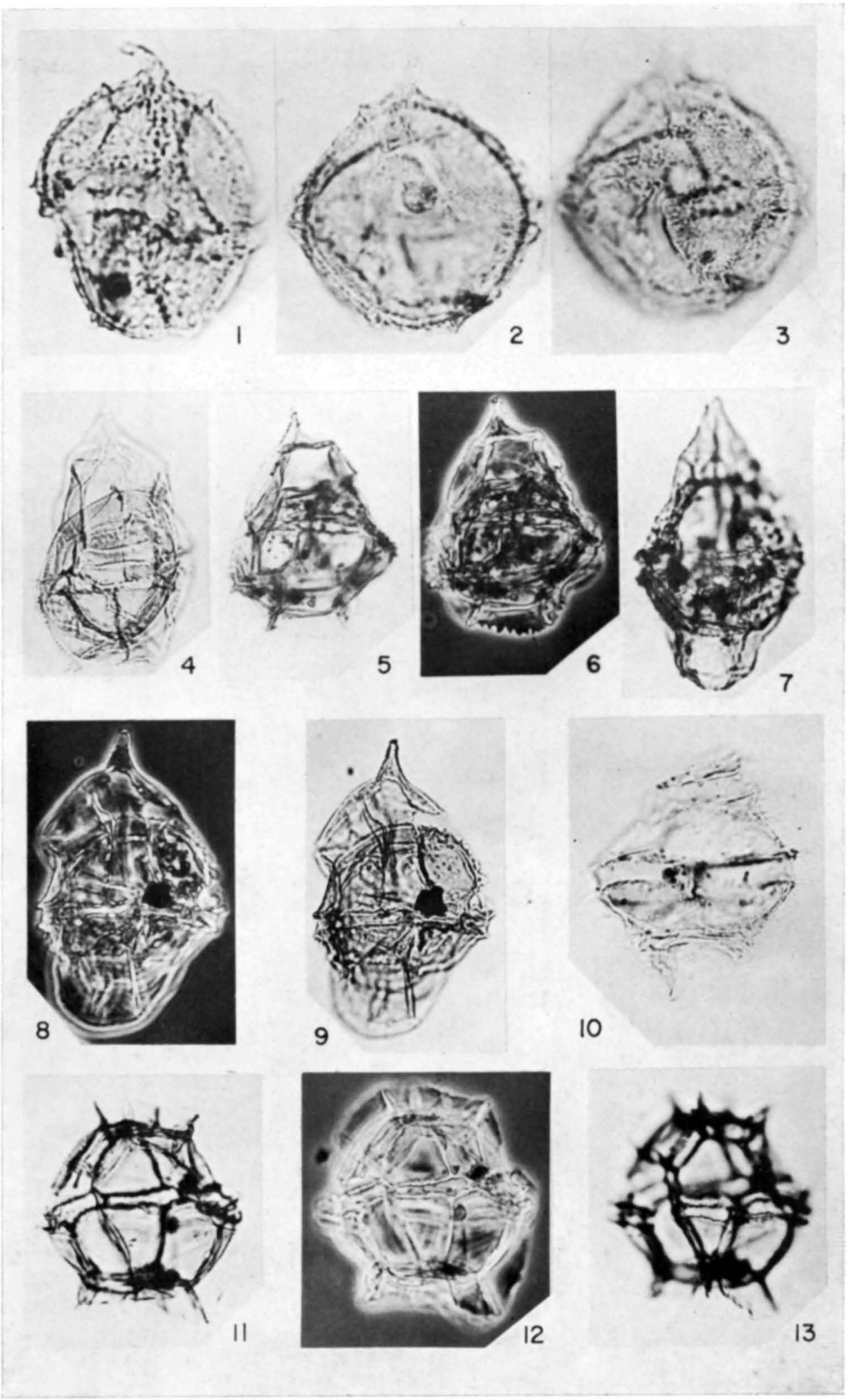


PLATE 4

Fig. 1. *Gonyaulacysta microceras* (Eis.) comb. nov., sl. 281, CV 26, 1000 ×
Fig. 2. *Gonyaulacysta microceras* (Eis.) comb. nov., sl. 491, CV 25, 1000 ×
Fig. 3. *Gonyaulacysta microceras* (Eis.) comb. nov., sl. 491, CV 25, 1000 ×
Fig. 4. *Gonyaulacysta cassidata* (Cook. & Eis.) comb. nov., sl. 522, CV 3, 600 ×
Fig. 5. *Gonyaulacysta cassidata* (Cook. & Eis.) comb. nov., sl. 15, CV 3, 600 ×
Fig. 6. *Gonyaulacysta cassidata* (Cook. & Eis.) comb. nov., sl. 15, phase contrast.
Fig. 7. *Gonyaulacysta extensa* sp. nov. — paratype, sl. 251, CV 5, 600 ×
Fig. 8. *Gonyaulacysta extensa* sp. nov. — holotype, phase contrast.
Fig. 9. *Gonyaulacysta extensa* sp. nov. — holotype, sl. 448, CV 12, 600 ×
Fig. 10. *Palaeohystrichophora infusorioides* Defl., sl. 616, CV 2, 600 ×
Fig. 11. *Gonyaulacysta striata* sp. nov. — holotype, sl. 642, CV 26, 600 ×
Fig. 12. *Gonyaulacysta striata* sp. nov. — holotype, phase contrast.
Fig. 13. *Gonyaulacysta striata* sp. nov. — holotype, sl. 642, CV 26, 600 ×

PLATE 5

Fig. 1. *Gonyaulacysta edwardsi* (Cook. & Eis.) comb. nov., sl. 51, CV 5, 500 ×

Fig. 2. *Dinogymnium denticulatum* (Alb.) E., C., & V., sl. 583, CV 26, 600 ×

Fig. 3. *Dinogymnium denticulatum* (Alb.) E., C., & V., sl. 583, phase contrast.

Fig. 4. *Dinogymnium heterocostatum* (Defl.) E., C., & V., sl. 500, phase contrast.

Fig. 5. *Dinogymnium heterocostatum* (Defl.) E., C., & V., sl. 482, CV 25, 600 ×

Fig. 6. *Dinogymnium heterocostatum* (Defl.) E., C., & V., sl. 500, CV 25, 600 ×

Fig. 7. *Dinogymnium microgranulosum* sp. nov., — paratype, sl. 657, CV 27, 600 ×

Fig. 8. *Dinogymnium microgranulosum* sp. nov. — paratype, sl. 187, CV 25, 600 ×

Fig. 9. *Dinogymnium microgranulosum* sp. nov. — holotype, sl. 484, CV 25, 600 ×

Fig. 10. *Dinogymnium microgranulosum* sp. nov. — holotype, phase contrast.

Fig. 11. *Microdinium ornatum* Cook. & Eis., sl. 605, CV 11, 750 ×

Fig. 12. *Microdinium ornatum* Cook. & Eis., sl. 605, CV 11, 750 ×

Fig. 13. *Microdinium ornatum* Cook. & Eis., sl. 568, CV 13, 750 ×

Fig. 14. *Microdinium ornatum* Cook. & Eis., sl. 568, CV 13, 750 ×

Fig. 15. *Gonyaulacysta striata* sp. nov. — paratype, sl. 671, CV 28, 600 ×

PLATE 5

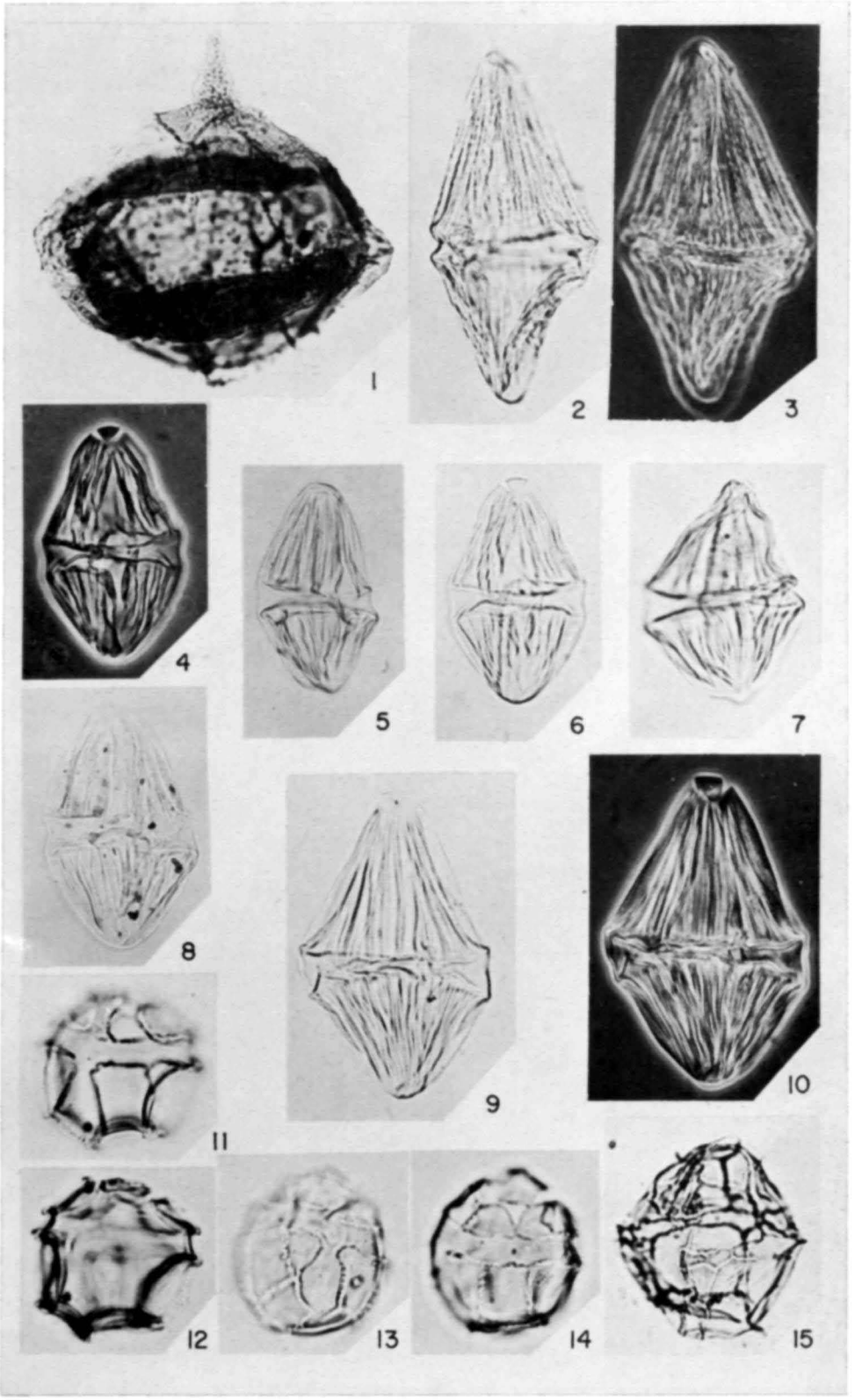


PLATE 6

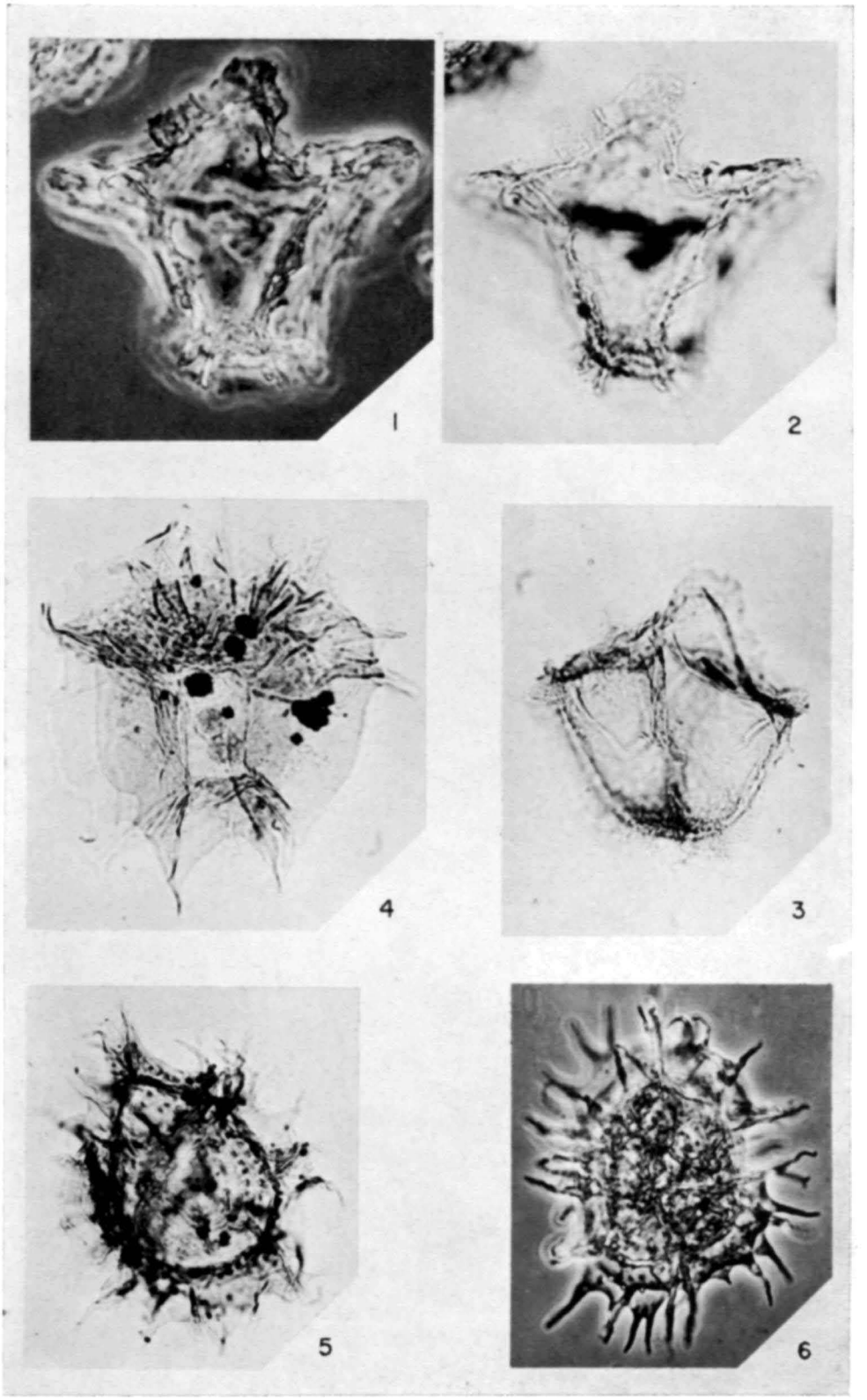


PLATE 6

Fig. 1. *Dinopterygium perforatum* sp. nov. — holotype, phase contrast.

Fig. 2. *Dinopterygium perforatum* sp. nov. — holotype, sl. 680, CV 5, 750 ×

Fig. 3. *Dinopterygium perforatum* sp. nov. — paratype, sl. 529, CV 5, 750 ×

Fig. 4. *Dinopterygium cladoides* Defl., sl. 584, CV 27, 600 ×

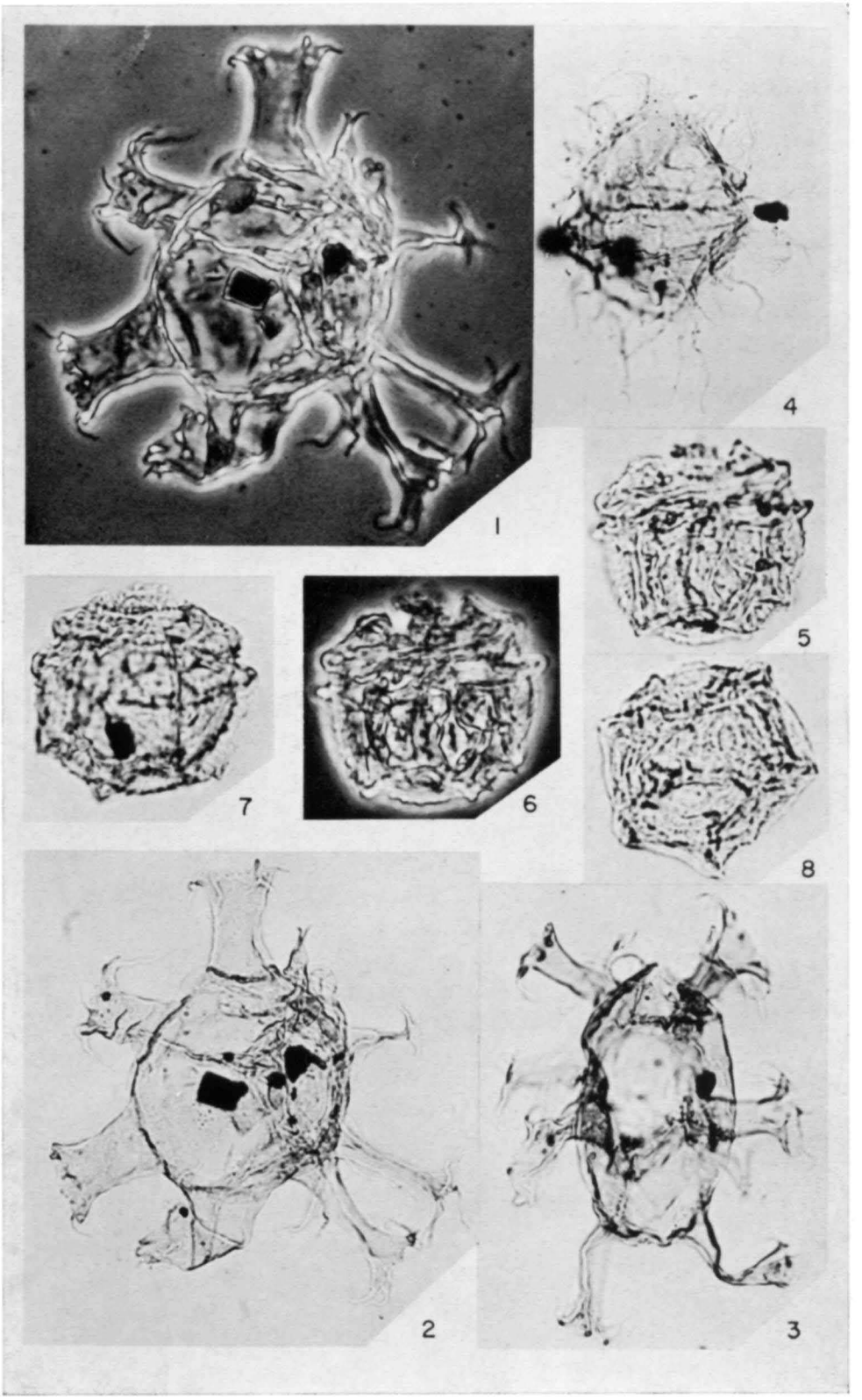
Fig. 5. *Pyramidium alatum* (Cook. & Eis.) comb. nov., sl. 75, CV 5, 600 ×

Fig. 6. *Pyramidium alatum* (Cook. & Eis.) comb. nov., sl. 265, CV 5, phase contrast, 600 ×

PLATE 7

Fig. 1. *Hexasphaera asymmetrica* comb. nov., sl. 299, phase contrast.
Fig. 2. *Hexasphaera asymmetrica* comb., nov., sl. 299, CV 5, 750 ×
Fig. 3. *Hexasphaera asymmetrica* comb. nov., sl. 260, CV 5, 750 ×
Fig. 4. *Hystrichodinium pulchrum* Defl., sl. 356, CV 6, 600 ×
Fig. 5. *Microdinium irregulare* sp. nov. — holotype, sl. 91, CV 16, 1000 ×
Fig. 6. *Microdinium irregulare* sp. nov. — hototype, phase contrast.
Fig. 7. *Microdinium irregulare* sp. nov. — paratype, sl. 125, CV 16, 1000 ×
Fig. 8. *Microdinium irregulare* sp. nov. — paratype, sl. 122, CV 16, 1000 ×

PLATE 7



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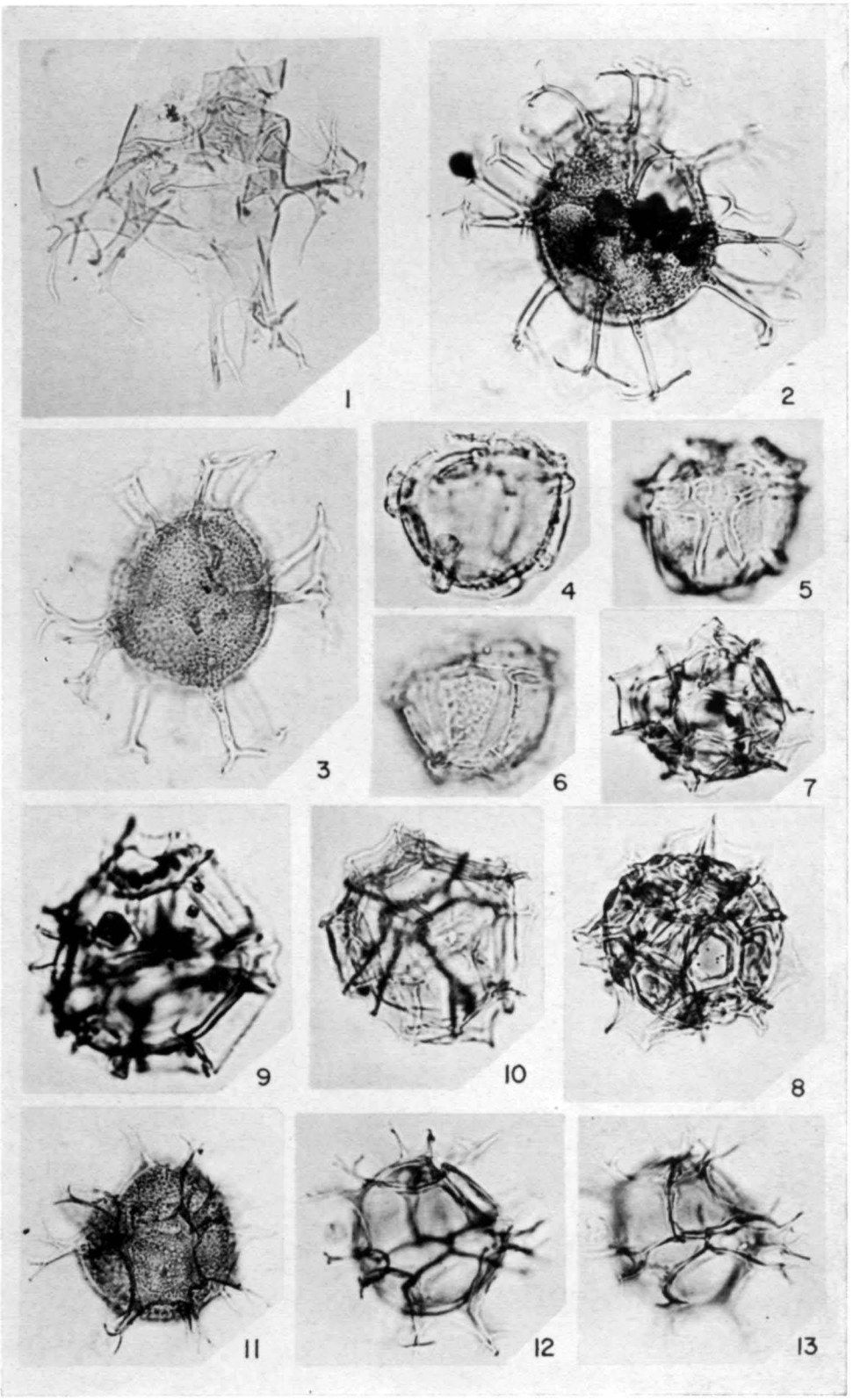


PLATE 8

Fig. 1. *Achomosphaera ramulifera* (Defl.) Evitt, sl. 595, CV 4, 600 ×

Fig. 2. *Achomosphaera reticulata* sp. nov. — holotype, sl. 89, CV 5, 600 ×

Fig. 3. *Achomosphaera reticulata* sp. nov. — paratype, sl. 579, CV 13, 600 ×

Fig. 4. *Eisenackia crassitabulata* Defl. & Cook., sl. 582, CV 26, 750 ×

Fig. 5. *Eisenackia crassitabulata* Defl. & Cook., sl. 582, CV 26, 750 ×

Fig. 6. *Eisenackia crassitabulata* Defl. & Cook., sl. 582, CV 26, 750 ×

Fig. 7. *Hystrichosphaera cingulata* var. *polygonalis* var. nov. — holotype, sl. 90, CV 16, 600 ×

Fig. 8. *Hystrichosphaera cingulata* var. *polygonalis* var. nov. — paratype, sl. 573, CV 13, 600 ×

Fig. 9. *Hystrichosphaera cingulata* var. *cingulata* var. nov., sl. 59, CV 5, 750 ×

Fig. 10. *Hystrichosphaera cingulata* var. *cingulata* var. nov., counting slide, CV 6, 1000 ×

Fig. 11. *Hystrichosphaera crassipellis* Defl. & Cook., sl. 66, CV 5, 600 ×

Fig. 12. *Hystrichosphaera furcata* (Ehr.) Wetz., sl. 655, CV 27, 600 ×

Fig. 13. *Hystrichosphaera furcata* (Ehr.) Wetz., sl. 655, CV 27, 600 ×

PLATE 9

Fig. 1. *Hystrichosphaera crassipellis* Defl. & Cook., sl. 243, CV 5, phase contrast, 600 ×

Fig. 2. *Hystrichosphaera cingulata* var. *perforata* var. nov. — holotype, sl. 337, CV 10, 600 ×

Fig. 3. *Hystrichosphaera cingulata* var. *perforata* var. nov. — holotype, phase contrast.

Fig. 4. *Hystrichosphaera cingulata* var. *perforata* var. nov. — paratype, sl. 457, CV 10, 600 ×

Fig. 5. *Hystrichosphaera cingulata* var. *granulata* var. nov. — holotype, sl. 532, CV 6, 750 ×

Fig. 6. *Hystrichosphaera cingulata* var. *granulata* var. nov. — paratype, sl. 178, CV 11, 750 ×

Fig. 7. *Hystrichosphaera scabrosa* sp. nov. — paratype, sl. 599, CV 8, 600 ×

Fig. 8. *Hystrichosphaera scabrosa* sp. nov. — paratype, sl. 599, CV 8, 600 ×

Fig. 9. *Hystrichosphaera scabrosa* sp. nov. — holotype, phase contrast.

Fig. 10. *Hystrichosphaera scabrosa* sp. nov. — holotype, sl. 566, CV 12, 600 ×

PLATE 9

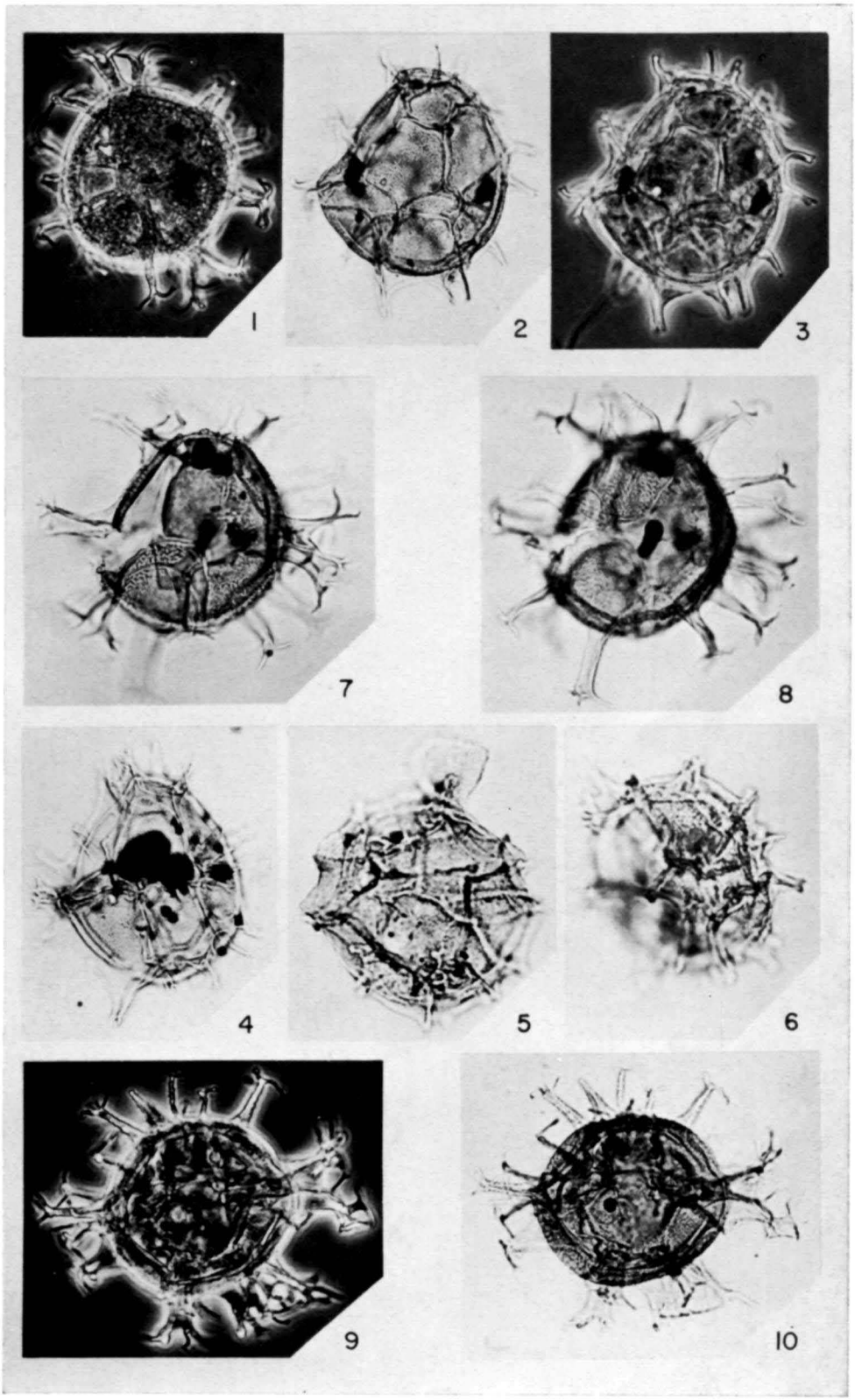


PLATE 10

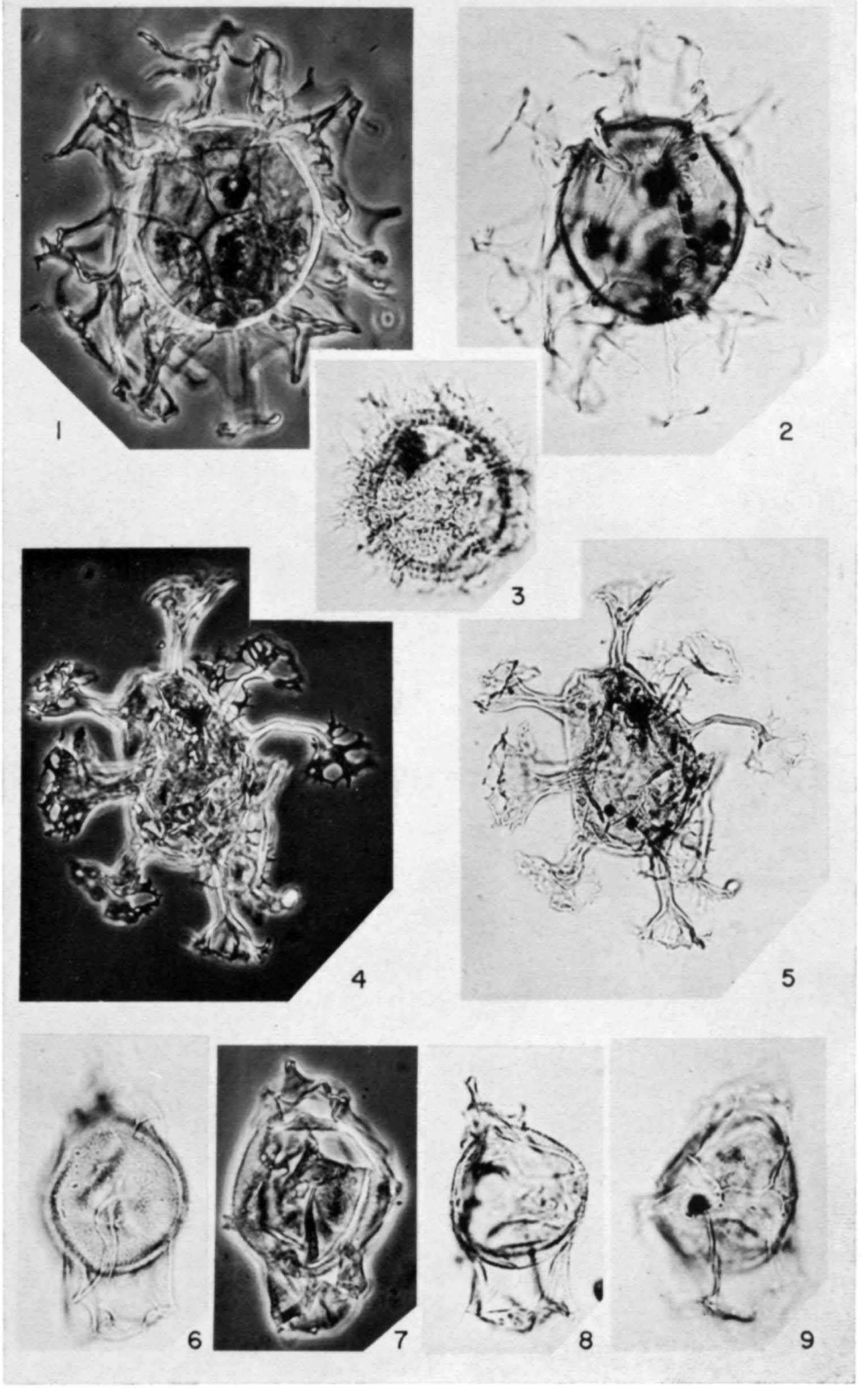


PLATE 10

Fig. 1. *Nematosphaeropsis velata* sp. nov. — holotype, phase contrast.
Fig. 2. *Nematosphaeropsis velata* sp. nov. — holotype, sl. 344, CV 25, 600 ×
Fig. 3. *Cometodinium obscurum* Defl. & Court., sl. 41, CV 5, 750 ×
Fig. 4. *Hystrichosphaeridium pulcherrimum* Defl. & Cook., sl. 423, phase contrast.
Fig. 5. *Hystrichosphaeridium pulcherrimum* Defl. & Cook., sl. 423, CV 8, 500 ×
Fig. 6. *Hystrichosphaeropsis ovum* Defl., sl. 180, CV 25, 600 ×
Fig. 7. *Hystrichosphaeropsis ovum* Defl., sl. 495, CV 25, phase contrast, 600 ×
Fig. 8. *Hystrichosphaeropsis ovum* Defl., sl. 308, CV 26, 600 ×
Fig. 9. *Hystrichosphaeropsis ovum* Defl., sl. 668, CV 27, 600 ×

PLATE 11

Fig. 1. *Hystrichosphaeridium siphoniphorum* Cook. & Eis., sl. 434, CV 12, 600 ×

Fig. 2. *Hystrichosphaeridium siphoniphorum* Cook. & Eis., sl. 464, CV 10, phase contrast, 600 ×

Fig. 3. *Cannosphaeropsis caulleryi* (Defl.) Defl., sl. 169, CV 25, 750 ×

Fig. 4. *Hystrichosphaeridium huguonioti* Val., sl. 302, CV 11, 750 ×

Fig. 5. *Hystrichosphaeridium huguonioti* Val., sl. 105, CV 11, 750 ×

Fig. 6. *Hexagonifera chlamydata* Cook. & Eis., counting slide, CV 6, 600 ×

Fig. 7. *Hexagonifera chlamydata* Cook. & Eis., sl. 525, CV 5, 600 ×

Fig. 8. *Hexagonifera chlamydata* Cook. & Eis., sl. 524, CV 5, 600 ×

Fig. 9. *Cometodinium obscurum* Defl. & Court., sl. 41, CV 5, phase contrast, 750 ×

Fig. 10. *Hystrichosphaeridium complex* (White) Defl., sl. 8, CV 3, 500 ×

Fig. 11. *Hystrichosphaeridium complex* (White) Defl., sl. 549, CV 6, 500 ×

PLATE 11

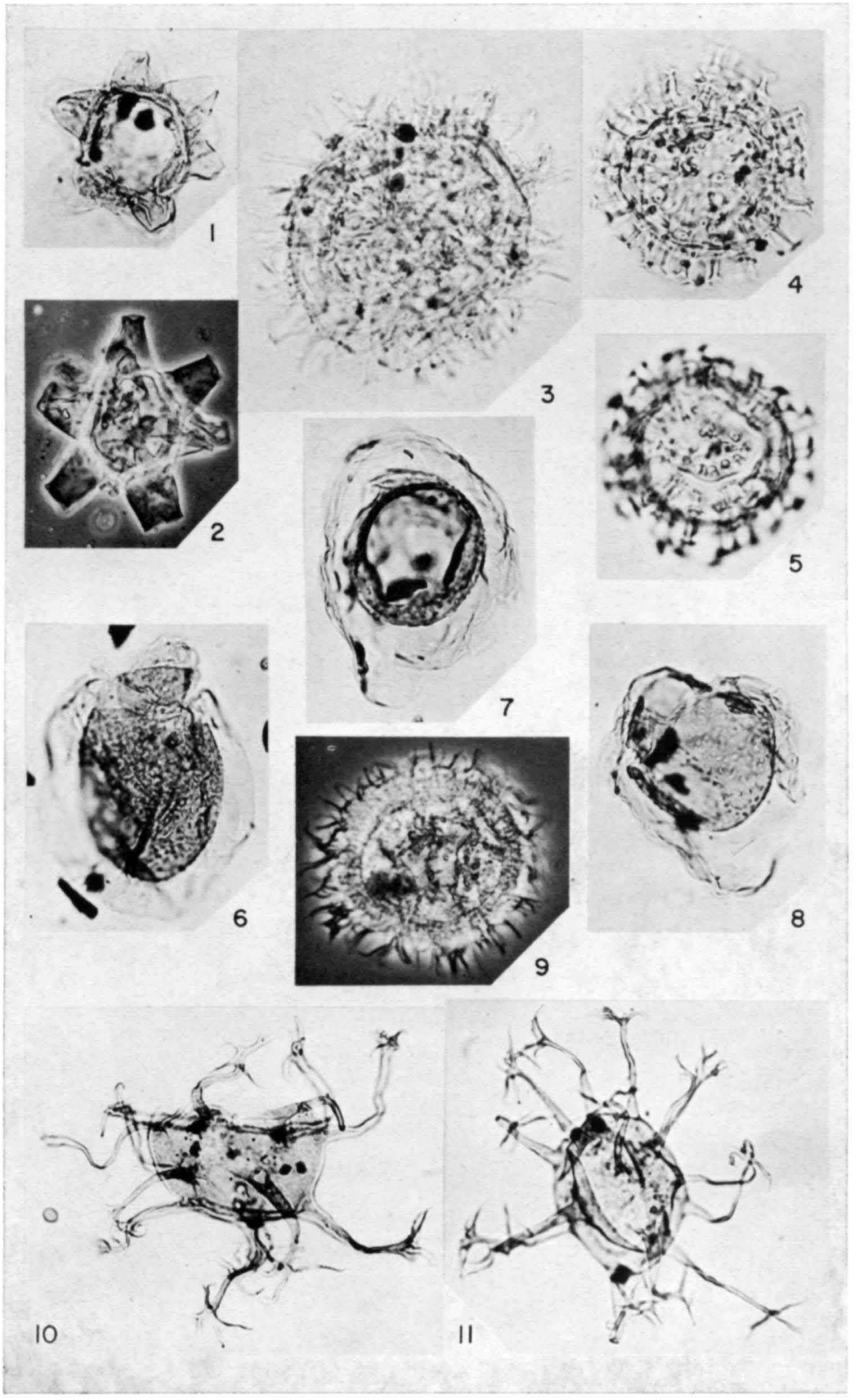


PLATE 12

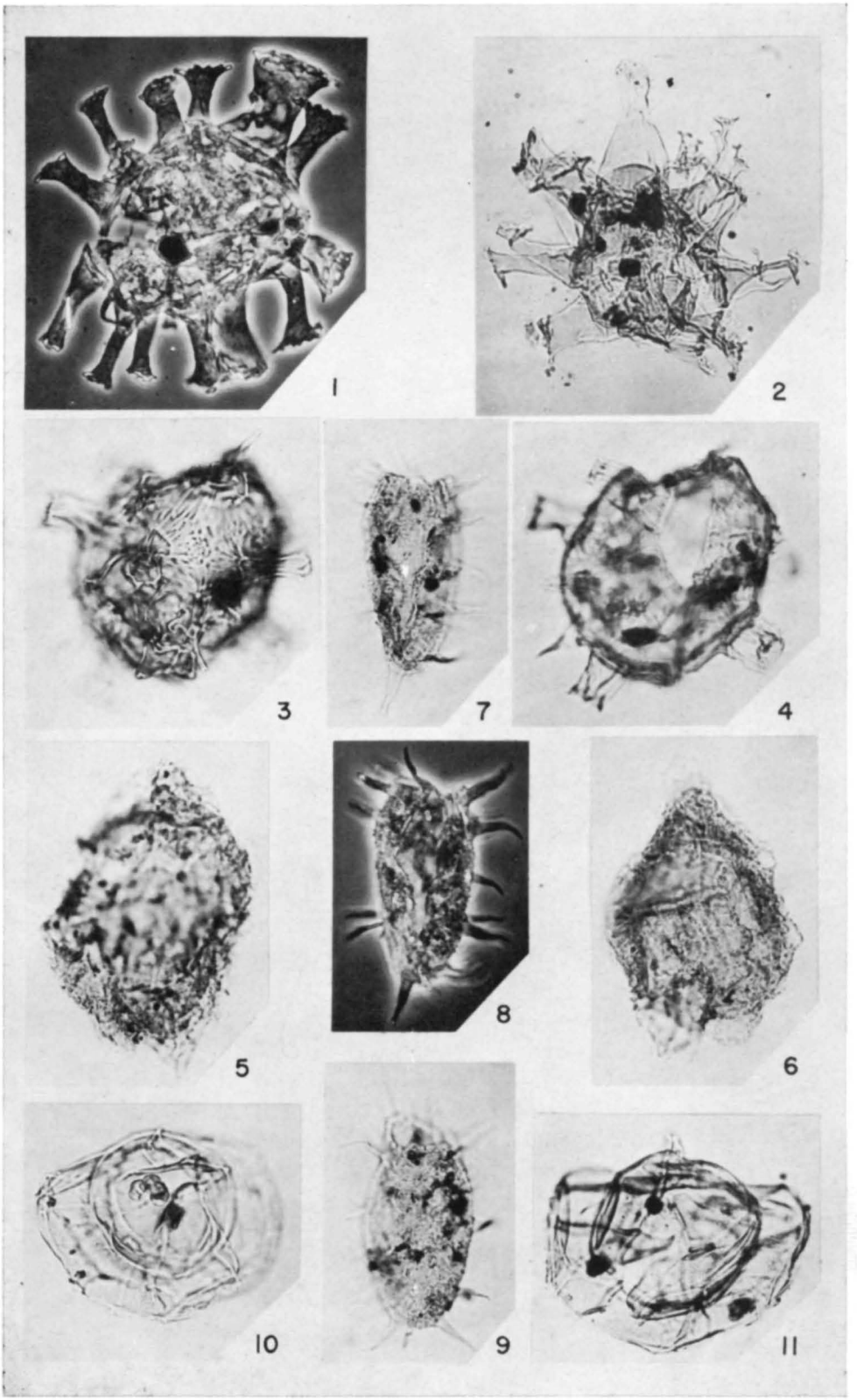


PLATE 12

Fig. 1. *Hystrichosphaeridium stellatum* Maier, sl. 261, CV 5, phase contrast, 500 ×
Fig. 2. *Hystrichosphaeridium stellatum* Maier, sl. 250, CV 5, 500 ×
Fig. 3. *Hystrichosphaeridium truncigerum* Defl., sl. 541, CV 26, 600 ×
Fig. 4. *Hystrichosphaeridium truncigerum* Defl., sl. 541, CV 26, 600 ×
Fig. 5. *Aptea rugulosa* sp. nov. — paratype, sl. 561, CV 28, 600 ×
Fig. 6. *Aptea rugulosa* sp. nov. — holotype, sl. 559, CV 28, 600 ×
Fig. 7. *Baltisphaeridium granulosum* (Defl.) Sarj., sl. 589, CV 4, 600 ×
Fig. 8. *Baltisphaeridium granulosum* (Defl.) Sarj., sl. 589, phase contrast.
Fig. 9. *Baltisphaeridium granulosum* (Defl.) Sarj., sl. 591, CV 2, 600 ×
Fig. 10. *Stephodinium coronatum* Defl., sl. 569, CV 15, 600 ×
Fig. 11. *Stephodinium coronatum* Defl., sl. 372, CV 6, 600 ×

PLATE 13

Fig. 1. *Odontochitina operculata* Defl. & Cook., sl. 401, CV 6, 300 ×

Fig. 2. *Veryhachium* sp., sl. 656, CV 27, 600 ×

Fig. 3. *Baltisphaeridium armatum* (Defl.) Dow. & Sarj., sl. 264, CV 5, 750 ×

Fig. 4. *Odontochitina costata* (Alb.) emend., sl. 311, CV 26, 300 ×

Fig. 5. *Odontochitina costata* (Alb.) emend., sl. 94, CV 16, 300 ×

Fig. 6. *Odontochitina costata* (Alb.) emend., sl. 586, CV 17, 300 ×

Fig. 7. *Odontochitina operculata* Defl. & Cook., sl. 535, CV 6, 600 ×

Fig. 8. *Pseudoceratium ceratioides* (Defl.) Defl., sl. 156, CV 25, 500 ×

PLATE 13

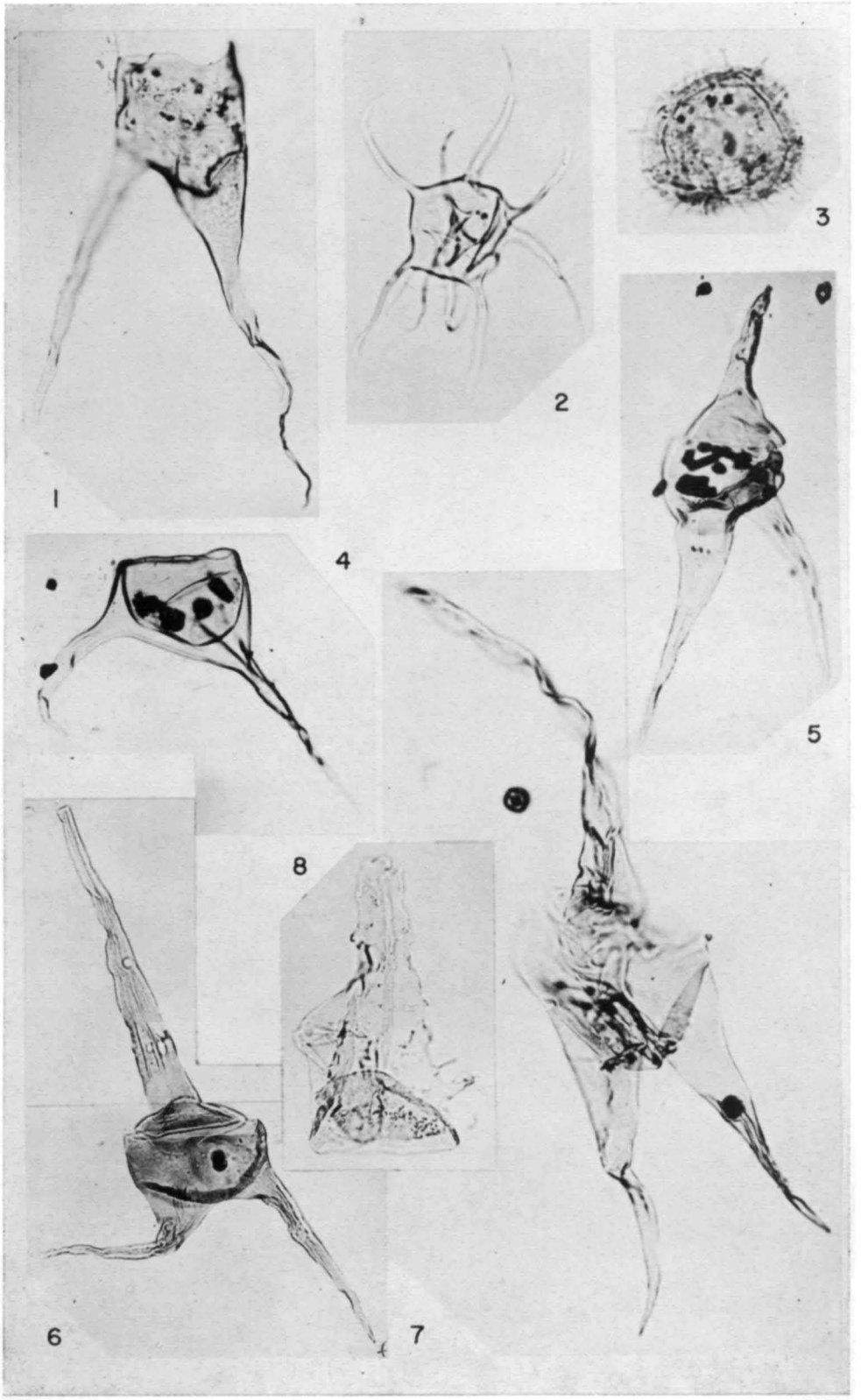


PLATE 14

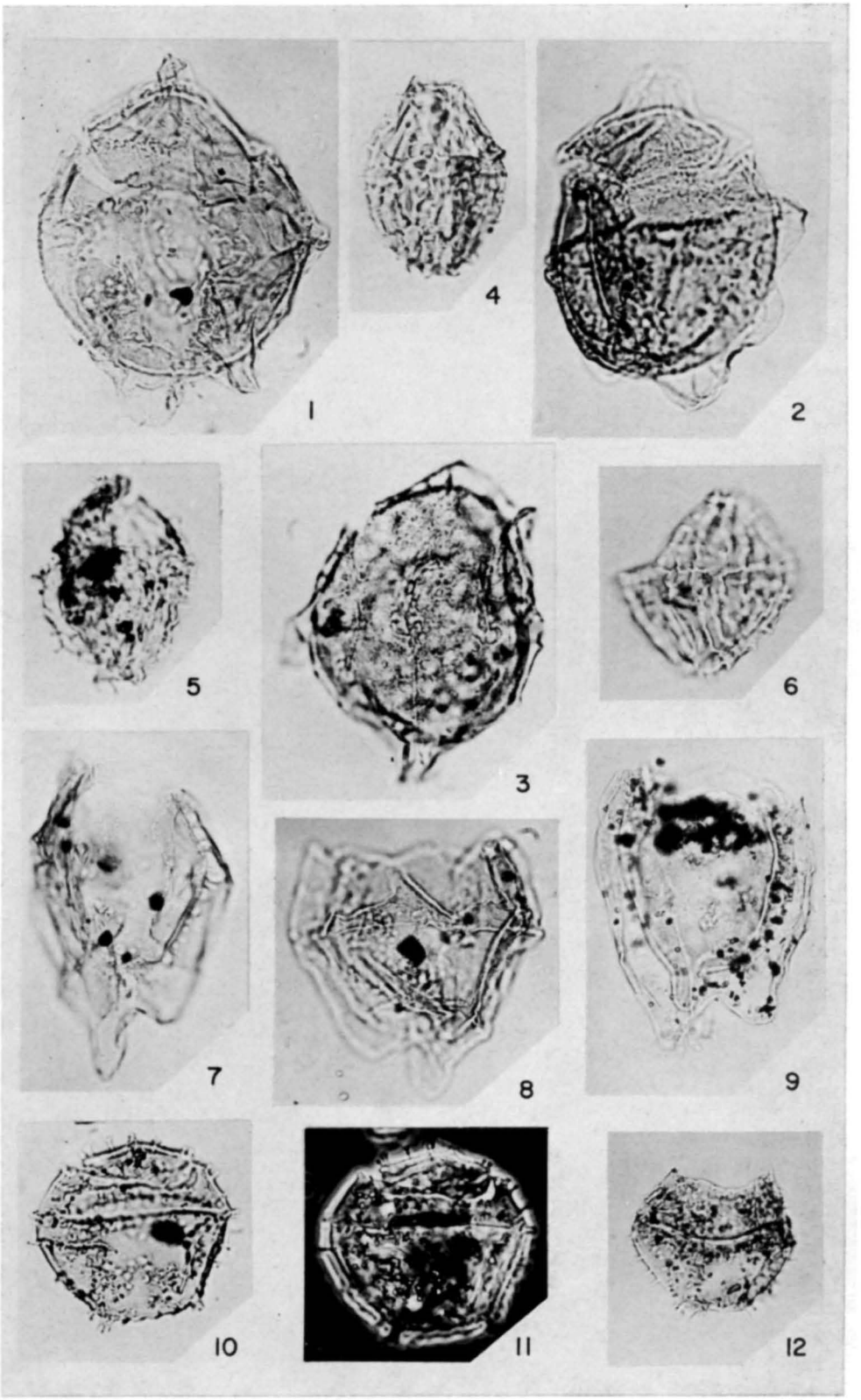


PLATE 14

Fig. 1. *Senoniasphaera rotundata* sp. nov. — paratype, sl. 135, CV 25, 600 ×
Fig. 2. *Senoniasphaera rotundata* sp. nov. — holotype, sl. 162, CV 25, 600 ×
Fig. 3. *Senoniasphaera rotundata* sp. nov. — paratype, sl. 137, CV 25, 600 ×
Fig. 4. *Ellipsodinium rugulosum* sp. nov. — paratype, sl. 570, CV 15, 600 ×
Fig. 5. *Ellipsodinium rugulosum* sp. nov. — paratype, sl. 131, CV 16, 600 ×
Fig. 6. *Ellipsodinium rugulosum* sp. nov. — holotype, sl. 587, CV 15, 600 ×
Fig. 7. *Senoniasphaera protrusa* sp. nov. — paratype, sl. 539, CV 26, 600 ×
Fig. 8. *Senoniasphaera protrusa* sp. nov. — holotype, sl. 183, CV 25, 600 ×
Fig. 9. *Senoniasphaera protrusa* sp. nov. — paratype, sl. 228, CV 29, 600 ×
Fig. 10. *Palaeoperidinium spinosum* Cook. & Hugh., sl. 414, CV 6, 600 ×
Fig. 11. *Palaeoperidinium spinosum* Cook. & Hugh., sl. 414, phase contrast.
Fig. 12. *Palaeoperidinium spinosum* Cook. & Hugh., sl. 626, CV 4, 600 ×

PLATE 15

Fig. 1. *Pseudoceratium ceratioides* (Defl.) Defl., sl. 555, CV 27, 500 ×

Fig. 2. *Pseudoceratium ceratioides* (Defl.) Defl., sl. 555, phase contrast.

Fig. 3. *Pseudoceratium dettmannae* Cook. & Hugh., sl. 550, CV 6, 600 ×

Fig. 4. *Baltisphaeridium ferox* (Defl.) Dow. & Sarj., sl. 259, CV 5, 600 ×

Fig. 5. *Thalassiphora velata* (Defl. & Cook.) Eis. & Gocht., sl. 433, CV 12, 600 ×

Fig. 6. *Baltisphaeridium striolatum* (Defl.) Dow. & Sarj., counting slide, CV 29, 600 ×

Fig. 7. *Baltisphaeridium pseudohystrichodinium* (Defl.) Dow. & Sarj., sl. 83, CV 5, 600 ×

PLATE 15

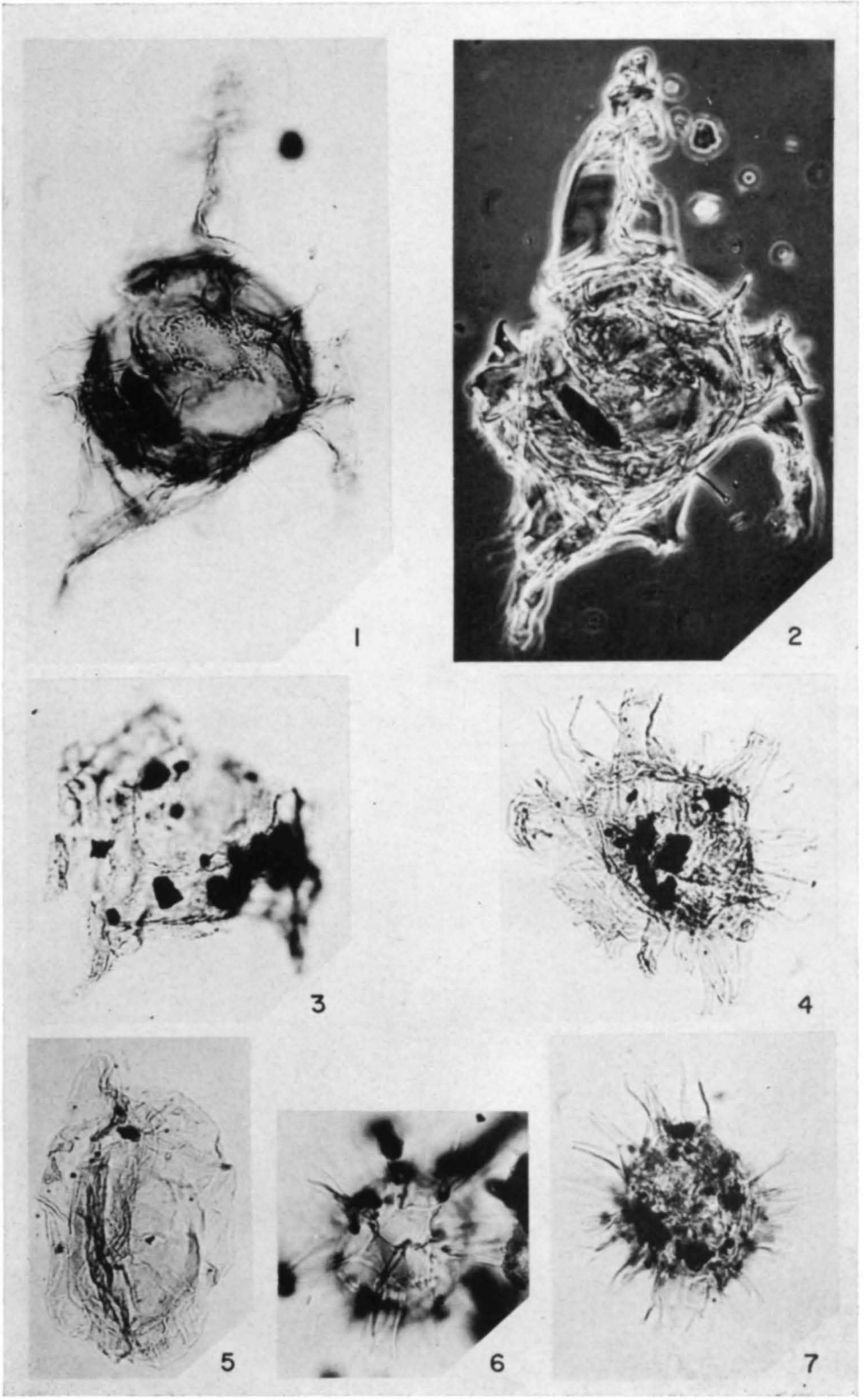


PLATE 16

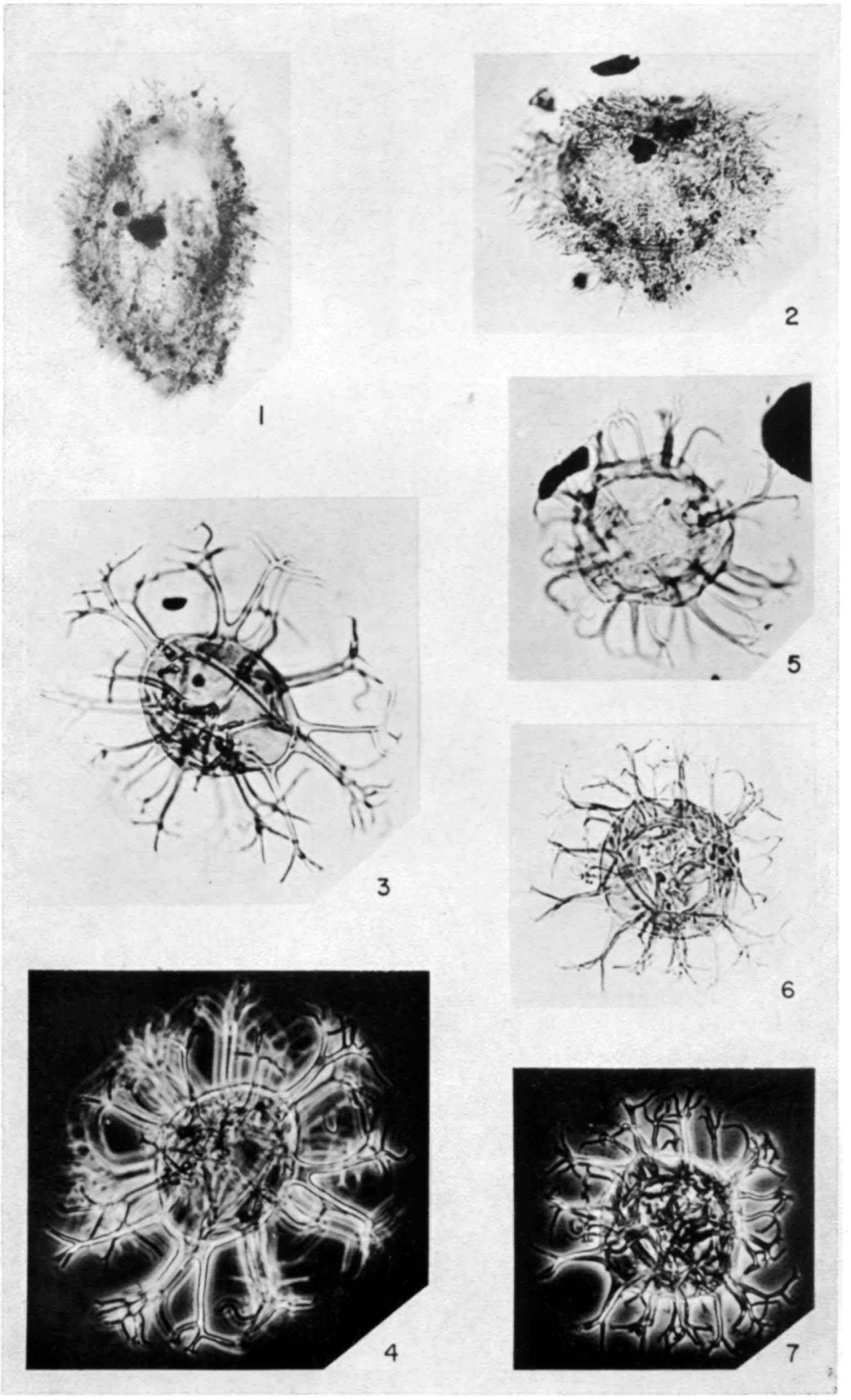


PLATE 16

Fig. 1. *Baltisphaeridium whitei* (Defl. & Court.) Sarj., sl. 246, CV 5, 600 ×

Fig. 2. *Baltisphaeridium whitei* (Defl. & Court.) Sarj., counting slide, CV 6, 750 ×

Fig. 3. *Baltisphaeridium erectum* (Man. & Cook.) comb. nov., sl. 198, CV 4, 750 ×

Fig. 4. *Baltisphaeridium erectum* (Man. & Cook.) comb. nov., sl. 198, phase contrast.

Fig. 5. *Baltisphaeridium erectum* (Man. & Cook.) comb. nov., counting slide, CV 6, 750 ×

Fig. 6. *Hystrichosphaera ramosa* (Ehr.) Wetz., sl. 426, CV 12, 600 ×

Fig. 7. *Hystrichosphaera ramosa* (Ehr.) Wetz., sl. 426, phase contrast.

PLATE 17

Fig. 1. *Pterospermopsis spinosa* sp. nov. — holotype, sl. 558, CV 28, 600 ×

Fig. 2. *Pterospermopsis spinosa* sp. nov. — paratype, sl. 216, CV 29, phase contrast, 600 ×

Fig. 3. *Dinogymnium albertii* sp. nov. — holotype, phase contrast.

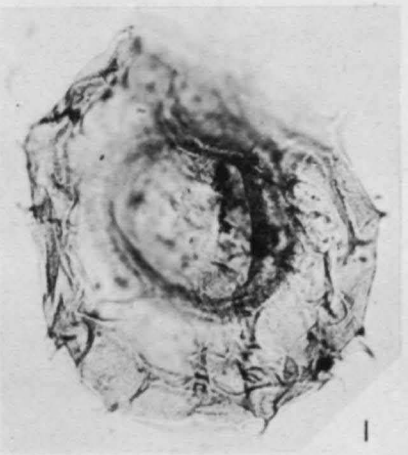
Fig. 4. *Dinogymnium albertii* sp. nov. — holotype, sl. 199, CV 25, 600 ×

Fig. 5. *Baltisphaeridium bifidum* sp. nov. — holotype, sl. 149, CV 25, phase contrast, 600 ×

Fig. 6. *Baltisphaeridium bifidum* sp. nov. — paratype, sl. 165, CV 25, 600 ×

Fig. 7. *Coronifera oceanica* Cook. & Eis., counting slide, CV 4, 750 ×

PLATE 17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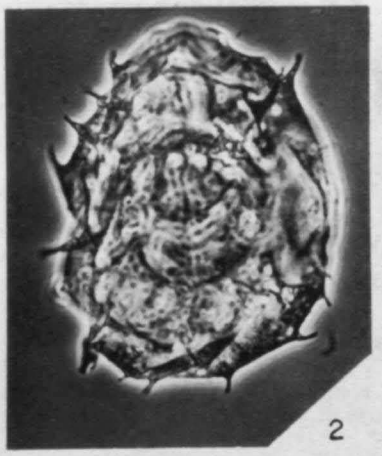
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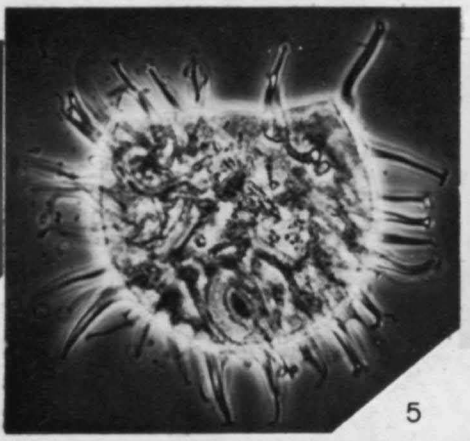
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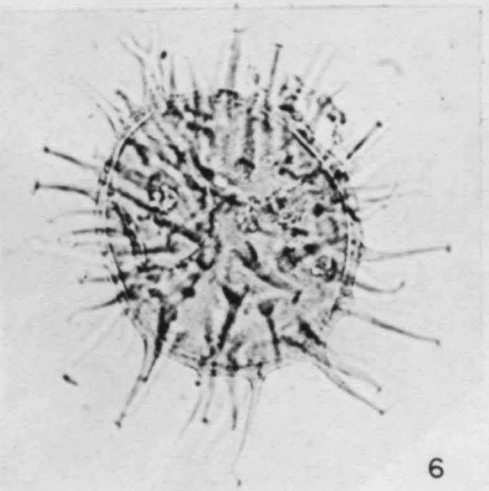
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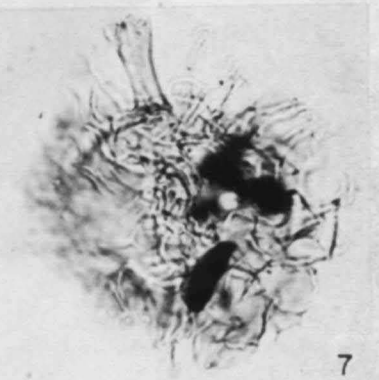
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