MICROPLANKTON FROM THE CAMBRIDGE GREENSAND (MID-CRETACEOUS)

by I. C. COOKSON and N. F. HUGHES

ABSTRACT. Thirty-eight species of dinoflagellates (including hystrichospheres) and of acritarchs of uncertain systematic position are recorded from the Cambridge Greensand; eight of these are new, and several others are recorded for the first time in Europe. Rock samples studied include six from the Gault immediately below, and five from the lowest Chalk Marl which continues above the 'greensand'. Evidence for the early Cenomanian (Varians Zone) age of the Cambridge Greensand is discussed.

ALTHOUGH during the last century the Cambridge Greensand was exposed in phosphate diggings over an outcrop length of about 50 miles from West Bedfordshire through Cambridge to north of Soham, there are now few available exposures; the material here studied was collected in 1959 and 1960 in the south-west corner of the then Eastwood's Cement Pit (Nat. Grid Ref. TL 393507), near Barrington. A general map of the location is given in Sparks (1952, p. 164); the pit is now owned by the Rugby Portland Cement Co.

The samples used come from a suite of twenty-eight collected on separate visits by Dr. Mary Dettmann (MD 1), by Mr. G. Norris, and by N. F. H. (CG 1–10); their stratigraphical position is given on text-fig. 1. The samples were taken from a freshly excavated face, and measurements were taken up and down from the clear unconformity at the base of the Cambridge Greensand. At this locality, the Cambridge Greensand is a grey calcareous clay or marl with prominent glauconite grains and dark phosphatic nodules up to about 2 inches in diameter; the sand fraction is composed of the glauconite grains. The bed is from 1 to 2 feet thick, and grades off upward into the Chalk Marl above, which is much paler and in which the glauconite grains finally disappear at about 4 to 5 feet above the unconformity; below the unconformity there is undisturbed stiff blue Gault Clay, without diagnostic macrofossils at this locality.

Stratigraphy. The Cambridge Greensand was described by Cowper Reed (1897) as lying within the Varians Zone (now basal Cenomanian), although this appears to have been determined on the convenience of the unconformity rather than on the presence of any cephalopods. Spath (1943, p. 749) concluded that the formation of the bed occurred in Dispar Subzone times of the uppermost Albian; he described the large *derived* ammonite fauna as being principally from the two preceding subzones (of *substuderi* and *aequatorialis*) with only comparatively rare forms from the Dispar Sub-zone.

There are in the Sedgwick Museum three specimens of *Schloenbachia* which are probably from the Cambridge Greensand. Two of these were mentioned by Spath (1928, p. 245); B1679 is a fragment of a large specimen preserved in dark phosphate as are most of the derived fossils, but B10965 is a small and more complete specimen preserved in relatively light coloured phosphate. The third, B80557, is a mould of a small specimen, identified as *Schloenbachia* indet. cf. *subplana* (Mantell) by Mr. A. G. Brighton, it was found at Barrington Cement Works in 1954 by N. F. H., weathered out loose and lying about a foot above the phosphatic part of the Cambridge Greensand outcrop; the

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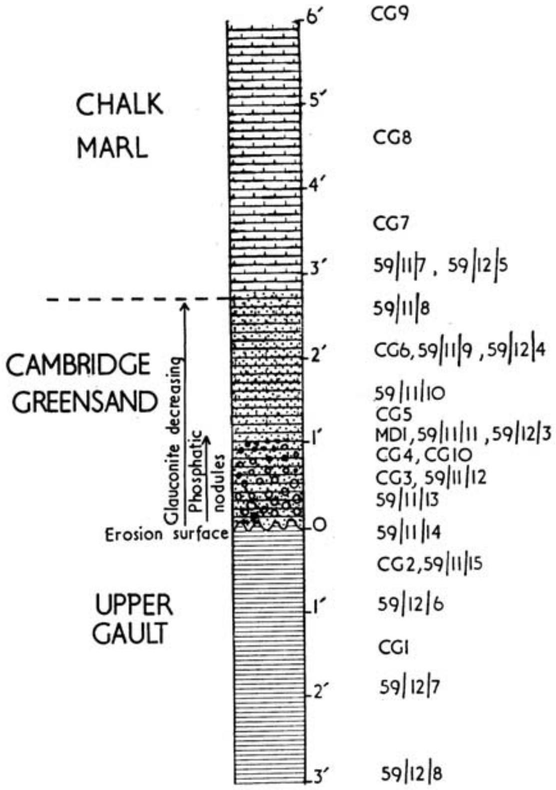
matrix of the specimen contains prominent glauconite grains similar to those seen in the 'greensand' and in the first 3 feet above the unconformity.

It thus seems slightly more likely that the Cambridge Greensand should be considered as of basal Cenomanian age (Varians Zone), than of uppermost Albian (Dispar Zone) for which there is as yet no positive faunal evidence.



TEXT-FIG. 1. Collection levels of samples from the Cement Works Pit, north of Barrington, Cambridgeshire.

Distribution of microfossils. Most of the figured specimens are mounted and ringed on separate slides, the numbers of which in the Sedgwick Museum, Cambridge (prefaced by the letter K), are given in the Plate explanations; these numbers are accompanied by stage readings for Leitz Ortholux microscope No. 491249.

Selected strew preparations from the three samples CG1, CG3, and CG8, have been counted to 200 specimens (+rare forms ex-count) to give a preliminary idea of distribution in the section studied; it is important, however, to record that the flora is not complete in that a few small forms have been omitted. Table 1 gives the distribution of

TABLE 1. Records of counts from three selected samples, CG 1, CG3, and CG8, with occurrences of the species in microplankton floras from other Cretaceous stages. Legend: ×, recorded in literature; —, not recorded; +, record of < 1 per cent; (+), record from uncounted slides; numerals above the column total are percentages.

	Hauterivian/Barremian (Gocht, Alberti)	Aptian (Eisenack)	Aptian/Albian (Australian)	CG 1, Upper Gault	CG 3, Greensand	CG 8, Chalk Marl	Cenomanian (Australia/Europe)	Senonian
Ascodinium scabrosum sp. nov.	—	—	—	+	2	—	—	—
,, *verrucosum* sp. nov.	—	—	—	—	2	5	—	—
Scriniodinium campanula	×	×	—	2	1	+	—	—
Gonyaulax cassidata	—	—	×	—	3	1	×	—
,, *edwardsi*	—	—	×	1	1	2	×	—
Hystrichodinium alatum	—	—	×	2	1	+	×	—
Palaeohystrichophora infusorioides	cf.	—	—	—	(+)	(+)	×	×
Canningia minor sp. nov.	—	—	—	+	1	—	—	—
Cyclonephelium membraniphorum	—	—	×	—	(+)	(+)	×	—
Hystrichosphaera furcata	×	×	—	10	6	2	—	×
,, *ramosa*	—	—	—	4	7	10	—	×
Achomosphaera ramulifera	×	—	—	2	1	1	×	×
Hystrichosphaeridium ancoriferum	—	—	×	+	1	(+)	×	—
,, *arundum*	—	—	×	+	—	—	—	—
,, *complex*	×	×	×	4	—	1	×	×
,, *recurvatum polypes*	—	—	×	+	+	—	×	—
,, *siphoniphorum*	—	—	×	3	4	6	×	—
,, *stellatum* (Tertiary species)	—	—	×	(+)	1	+	×	—
Carpodinium obliquicostatum sp. nov.	—	—	—	+	(+)	1	—	—
Palaeoperidinium castanea	—	—	×	—	+	+	×	×
,, *spinosum* sp. nov.	—	—	—	—	×	—	—	—
Stephodinium europaicum sp. nov.	—	—	—	1	+	2	—	—
Pseudoceratium dettmannae sp. nov.	—	—	—	2	+	—	—	—
,, *turneri*	—	—	×	—	(+)	—	—	—
Apteodinium grande sp. nov.	—	—	—	—	(+)	(+)	—	—
Odontochitina spp.	×	×	×	8	+	2	×	×
cf. *Rottnestia borussica* (Tertiary species)	—	—	—	1	+	2	—	—
Hexagonifera chlamydata	—	—	?	(+)	+	—	×	—
Chlamydophorella nyei	—	—	×	56	56	57	×	—
Fromea amphora	×	×	×	(+)	—	—	×	—
Baltisphaeridium ferox	×	×	×	—	+	(+)	×	×
,, *hirsutum*	—	—	×	+	3	1	—	×
Coronifera oceanica	—	×	×	+	—	—	—	—
Veryhachium reductum (Long range species)	—	—	×	+	1	+	×	—
Diplotesta anglica sp. nov.	—	—	—	+	1	3	—	—
Object 'A'	—	—	—	(+)	+	1	—	—
Micrhystridium spp.	—	—	—	+	4	1	×	×
Total %				100	100	100		
Numbers identified and counted				240	267	200		
Microplankton unidentified				60	37	27		
Spores and pollen not identified				36	40	32		

the more important elements of the flora together with records of their occurrence in floras so far described from two or three stratigraphical stages above and below. It must be emphasized that none of the floras concerned can be regarded as complete in the literature.

Some specimens in the Greensand will have been derived from the Upper Gault; this could have occurred without appreciable damage. It is unlikely that the time break represented by the unconformity was very long, but it does coincide with a general facies change to more calcareous deposits in Britain.

SYSTEMATIC DESCRIPTIONS

As a temporary measure while changes are being made to bring the nomenclature of these fossils under the Botanical Code (see Downie, Evitt, and Sarjeant 1963), certain family names will be left with zoological endings; we do not wish to undertake the emendation or redescription of these families here.

Class DINOPHYCEAE
Family DEFLANDREIDAE
Genus ASCODINIUM Cookson and Eisenack 1960

Comment. The genus *Ascodinium* was originally established for certain small, untabulated dinoflagellates which occur in Western Australian Albian–Cenomanian deposits. The main characters of this genus are, (1) the presence of an internal body or capsule which lies either freely in the cavity of the shell (*A. acrophorum* and *A. serratum* Cookson and Eisenack 1960*a*) or in partial contact with the shell-membrane laterally (*A. parvum* Cookson and Eisenack 1960*a*); (2) the opening of the shell by the removal of the apical region of both shell and capsule (apical archaeopyle). Two species occur in the Cambridge deposits which, although differing in detail from the above-mentioned species, seem best placed with them, at least for the present, as additional species of *Ascodinium*. Their mode of opening is similar but the wall of the capsule is in contact with the shell-membrane to a far greater extent, in fact to such a degree as to suggest that this layer may not mark the limit of an inner body or capsule but represent the inner layer of a two-layered shell-membrane.

Ascodinium scabrosum sp. nov.

Plate 5, figs. 1–3

EXPLANATION OF PLATE 5

Figs. 1–3. *Ascodinium scabrosum* sp. nov. 1, Holotype, CG3; K5151, OR57 121.1, ×500. 2, CG1; K5152, OR36 123.6, ×*c*. 500. 3, CG1; K5153, OR35.4 116.4, ×*c*. 500.

Figs. 4–7. *A. verrucosum* sp. nov. 4, Holotype, 59/11/12; K5154, OR30.1 121.1, ×*c*. 500. 5, 59/11/11; K5155, OR46.7 122.8, ×500. 6, MD1; K5156 ,OR41.4 119.7, ×*c*. 500. 7, CG8; K5157, OR49.3 127.8, ×500.

Fig. 8. *Palaeohystrichophora infusorioides* Defl., 59/12/5; K5162, OR44.6 118.5, ×560.

Fig. 9. *Gonyaulax edwardsi* Cooks. and Eisenack, CG3; K5163, OR39.3 120, ×500.

Figs. 10, 11. *G. cassidata* Cooks. and Eisenack. 10, CG8; K5164, OR42.2 124.1, ×800. 11, CG3; K5161, OR36.9 121.9, ×875.

Figs. 12, 13. *Hystrichodinium alatum* Cooks. and Eisenack, CG8, ×500. 12, K5159, OR31.3 123.7. 13, K5160, OR25.7 115.3.

Fig. 14. *Palaeoperidinium castanea* Deflandre, 59/11/7; K5158, OR34.8 124, ×500.

Diagnosis. Shell longer than broad with convex sides which curve inwards towards a bluntly pointed apex and slant slightly towards a somewhat truncate antapex. A circular girdle is faintly indicated in the equatorial region. The shell-membrane is very thin, not more than *c*. 0·5 μ and densely covered with minute granules. The capsule wall, which is also 0·5 μ thick, is unpatterned and closely opposed to the shell-membrane laterally. Opening is effected by the complete removal of the apical region of the shell and capsule.

Holotype. Plate 5, fig. 1; K5151, lowest 6 in. Cambridge Greensand (CG3).

Dimensions. Holotype 80 μ long, 64 μ broad. Range 52–80 μ long, 42–64 μ broad.

Occurrence. Upper Gault CG1, CG2, 59/11/14; Greensand, 59/11/12, CG3.

Ascodinium verrucosum sp. nov.

Plate 5, figs. 4–7

Diagnosis. Shell slightly longer than broad with strongly convex sides, a circular girdle and a short longitudinal furrow in the hypotheca. Shell-membrane completely adherent to the thicker wall of the capsule except at the extreme apex where it narrows towards a small, pointed, cap-like projection and antapically where it forms a prominent projection with a slanting asymmetrical base. The surface of the shell-membrane is ornamented with more or less densely arranged hollow verrucae; the wall of the capsule is unornamented, the two membranes together measure about 2–3 μ. Opening is effected by the complete detachment of the apical portion of the shell and capsule.

Holotype. Plate 5, fig. 4; K5154, 6 in. above base of Greensand (59/11/12).

Dimensions. Holotype 52 μ long, 32 μ broad. Range 55–80 μ long, 40–59 μ broad, the exceptionally large specimen (98 × 73 μ) shown on Plate 5, fig. 5 omitted.

Occurrence. Greensand, 59/11/12, CG3, CG4, CG10, 59/11/11, MD1; Chalk Marl, 59/12/5, 59/11/7, CG8.

Comment. Considerable variation both in size of shell and density of ornament has been observed amongst the individuals included in *A. verrucosum*, the larger shells having fewer and more widely spaced verrucae than the smaller ones. *A. verrucosum* is one of the commoner types in the Cambridge Greensand and Chalk Marl. It is particularly abundant in sample CG10.

Genus SCRINIODINIUM Klement 1957
Scriniodinium? *campanula* Gocht 1959

Plate 7, figs. 5–9

1959 *Scriniodinium campanula* Gocht, pl. 4, fig. 6, pl. 5, fig. 1.
1961 *Scriniodinium campanula* Gocht; Alberti, pl. 3, fig. 6.

Dimensions. Overall length 73–135 μ, width 60–100 μ, horn 9–15 μ long, longest diameter of ventral opening 8–15 μ.

Occurrence. Upper Gault, CG1, CG2, 59/11/14; Greensand 59/11/12, CG3, CG4, CG10, MD1; Chalk Marl, 59/12/5, 59/11/7, CG8.

Comment. This species, whilst readily recognizable, is extremely difficult to interpret morphologically from surface views. It is therefore not at all surprising that both Gocht's description and consequent association of it with *Scriniodinium* are open to doubt.

In the Cambridge examples, which undoubtedly are specifically identical with the German forms, the dorsal surface of the shell is strongly convex and the ventral surface flat or slightly concave. The circular girdle which is usually deeply folded, crosses the dorsal surface somewhat above the equatorial line to end on the ventral surface a short distance within the margin of the shell. A fold in the middle of the dorsal convexity extends from the girdle to the antapex.

Our main disagreement with Gocht's description concerns the suggested presence of an inner body or capsule which is said to be separated from the shell-membrane by a wide space. One or more lines running parallel to and at some distance from the edge of the shell are clearly seen, but instead of regarding these lines as indicating the limit of an internal capsule of approximately the same shape as the shell we suggest that this appearance is due to the steepness of the gradient of the dorsal convexity. This idea is supported by transverse and longitudinal sections cut, at a thickness of 2 μ, through two shells. In these sections there is no sign of a central body. Of course it may be argued that in reality an internal capsule is differentiated and that its wall is in direct contact with the shell-membrane. As far as our work has gone this seems unlikely since the shell-membrane is so thin that, as our photographs show, even in sections 2 μ thick no indication of a second layer can be seen. These sections were kindly prepared for us by Dr. Mary Dettmann.

As in most of the German specimens indications of surface markings suggestive of tabulation have been rarely seen in the Cambridge examples. On the other hand one feature, invariably present in them, which has not been mentioned in connexion with the German forms is a small round or oval opening on one side of the ventral wall towards the antapex. The significance of this feature is unknown.

The present record has extended the geological range of *S.*? *campanula* from Lower and Upper Hauterivian (Gocht and Alberti) to Cenomanian.

Family GONYAULACEAE Lindemann

Genus GONYAULAX Diesing 1866

Gonyaulax cassidata Cookson and Eisenack 1962

Plate 5, figs. 10, 11

1960 *Gonyaulax helicoidea* subsp. *cassidata* Eisenack and Cookson, p. 3, pl. 1, figs. 5, 6.
1962 *Gonyaulax cassidata* Cookson and Eisenack, p. 486, pl. 2, figs. 11, 12.

Comment. Specimens indistinguishable from the Australian Aptian–Cenomanian species *G. cassidata* occur regularly but infrequently. All have the small size, strongly helicoid girdle, oblique longitudinal furrow, and dome-shaped apex of this species. In addition the girdle and plates have the high ledges with serrate edges of *G. cassidata* and the plates are similarly ornamented with small tubercles.

Occurrence. Upper Gault, 59/11/14; Greensand, 59/11/12, CG3, CG4, 59/11/11, 59/11/9; Chalk Marl, 59/11/7, CG8.

Gonyaulax edwardsi Cookson and Eisenack 1958

Plate 5, fig. 9

Comment. Specimens which agree in general characters and in tabulation with those of *G. edwardsi* from Australian Albian to Cenomanian deposits occur in the Cambridge Greensand.

Occurrence. Greensand, 59/11/12, CG3, CG4, CG10, 59/11/11; Chalk Marl, CG8.

Family HYSTRICHODINIDAE

Genus HYSTRICHODINIUM Deflandre 1936

Hystrichodinium alatum Cookson and Eisenack 1962

Plate 5, figs. 12, 13

Comment. Specimens which agree in all respects with *H. alatum* from Western Australian ?Albian–Cenomanian deposits occur sparsely in most of the Cambridge deposits of comparable age. They have the tabulated shells of *H. alatum*, the whorls of hollow, pointed processes around the apex, antapex and girdle, the wing-like development of the outer membrane from which the processes arise, and the small tubercles with fine points which ornament the plates.

Occurrence. Upper Gault, 59/11/14; Greensand, 59/11/12, CG3, 59/11/9; Chalk Marl, 59/12/5, CG8.

Genus PALAEOHYSTRICHOPHORA Deflandre 1934 emend. Defl. and Cookson 1955

Palaeohystrichophora infusorioides Deflandre

Plate 5, fig. 8

1934 *Palaeohystrichophora infusorioides* Deflandre, *C.R. Acad. Sci.* **149**, 967, fig. 8.
1936 *Palaeohystrichophora infusorioides* Defl.; Deflandre, *Ann. Paléont.* **25**, 38, pl. 9, fig. 8.
1958 *Palaeohystrichophora infusorioides* Defl.; Cookson and Eisenack, p. 37, pl. 10, fig. 10.

Comment. In recording *P. infusorioides* from the Cambridge Greensand it must be noted that the short surface hairs characteristic of this species seem to be less numerous and prominent than those of the French Cenomanian and ?Senonian examples or the example from the German Senonian Alberti (1961; plate 3, fig. 24).

Occurrence. Greensand, CG3, CG4, CG10, 59/11/11; Chalk Marl, 59/12/7, CG8.

Family AREOLIGERACEAE Evitt 1963

Genus CANNINGIA Cookson and Eisenack (1960) 1961b

Canningia minor sp. nov.

Plate 8, figs. 1–3, 5

Diagnosis. Shell almost circular in outline, in well-preserved examples slightly longer than broad, opening by the removal of an apical segment along a zigzag line, the freed edge of the shell showing notches at intervals; apex with or without a short prominence, antapex usually unindented. Girdle absent; wall *c*. 1 μ thick, surface scabrate.

Holotype. Plate 8, fig. 1; K5184, Cambridge Greensand (CG10).

Dimensions. Holotype $70 \times 73\ \mu$. Range 42–73 μ long, 36–73 μ broad.

Occurrence. Upper Gault, CG1, CG2; Greensand, CG4, CG10.

Comment. Of the three described species of *Canningia*, *C. minor* most closely resembles the Australian Aptian species *C. colliveri* Cookson and Eisenack 1960*b*. However, it can be distinguished from this species by the less frequent occurrence of an apical prominence and indented antapex, its consistently smaller size (average dimensions of 19 specimens $56 \times 52\ \mu$), and the finer ornamentation of the shell-membrane.

In the majority of specimens the apex is partially detached and crumpled so that a more accurate ratio of length to breadth has not been possible. Plate 8, fig. 4 shows a specimen with a girdle developed; in spite of several similarities to *C. minor*, we prefer to record this as *Canningia*? *sp*.

Genus CYCLONEPHELIUM Deflandre and Cookson 1955
Cyclonephelium membraniphorum Cookson and Eisenack 1962

Plate 10, figs. 5, 6

Comment. A number of specimens which can safely be identified with *C. membraniphorum* from Western Australian ?Albian–Cenomanian deposits have been recovered. However, in them the membranes of the circumferential border-zone are proportionally more strongly developed and the radial supporting fibres less conspicuous than are those of the Australian examples.

Occurrence. Greensand, 59/11/12, CG3, CG4; Chalk Marl, 59/11/7, CG8.

Cyclonephelium cf. *densebarbatum* Cookson and Eisenack 1960

Plate 10, fig. 10

1960*b* *Cyclonephelium densebarbatum* Cookson and Eisenack, 253, pl. 38, figs. 9, 10.

Comment. A few specimens from one sample, although distinct from the type of *C densebarbatum* in having longer and stouter appendages, are comparable with specimens from the Upper Jurassic deposits at Wallal in north-west Western Australia which were included by Cookson and Eisenack in *C. densebarbatum*. As in the latter the periphery of the shell is ornamented with short, rather densely arranged, free appendages with relatively broad apices.

Occurrence. Greensand, 59/11/9.

EXPLANATION OF PLATE 6

Figs. 1–6. *Carpodinium obliquicostatum* sp. nov. 1, Holotype, CG1; K5165, OR42 118, $\times c$. 900. 2, CG8; K5166, OR38.5 114.3, $\times 750$. 3, 59/11/12; K5167, OR37 122.8, $\times 750$. 4, Dorsal surface, 59/11/12; K5168, OR37.4 117, $\times 625$. 5, As last—ventral surface (low focus). 6, Detail, CG3; K5169, OR36.1 117, $\times c$. 1500.

Fig. 7. *Pseudoceratium turneri* Cooks. and Eisenack, 59/11/12; K5172, OR25.5 115, $\times 500$.

Figs. 8–9. *Apteodinium grande* sp. nov. 8, 59/11/12; K 5171, OR37 117.5, $\times 500$. 9, Holotype, 59/11/11; K5170, OR31 120, $\times 375$.

Family HYSTRICHOSPHAERACEAE O. Wetzel 1933 emend. Evitt 1963
Genus HYSTRICHOSPHAERA O. Wetzel 1933
Hystrichosphaera furcata (Ehr.) O. Wetzel

Plate 9, fig. 1, 2

1838 *Xanthidium furcatum* Ehrenberg, *Abh. K. Akad. Wiss. Berlin*, 109–36, pl. 1, fig. 14.
1933 *Hystrichosphaera furcata* (Ehrenberg) O. Wetzel, *Palaeontographica*, **77A**, 34, pl. 5, figs. 1, 5, 9, 15, 16.
1935 *Hystrichosphaera furcata* (Ehr.); Deflandre, *Bull. Biolog.*, **232**, pl. 5, fig. 9; 1937, *Ann. Pal.* **26**, 13, pl. 11, figs. 1, 3, 4.

Comment. Specimens agreeing with the description and illustrations of European forms attributed to *H. furcata* are regular components of the Cambridge Upper Gault, Greensand, and Chalk Marl deposits.

Hystrichosphaera ramosa (Ehr.) O. Wetzel 1933

Plate 9, figs. 4, 5

1838 *Xanthidium ramosum* Ehrenberg, *Abh. K. Akad. Wiss. Berlin* (1836–8), pl. 1, fig. 14.
1933 *Hystrichosphaera ramosa* (Ehrenberg) O. Wetzel, *Palaeontographica*, **77**, 35, 78: pl. 5, figs. 7, 8, 10, 10–12, 18, and 19.
1937 *Hystrichosphaera ramosa* (Ehr.); Deflandre, p. 16, pl. 11, figs. 5, 7.
1937 *Hystrichosphaera ramosa* (Ehr.); Lejeune, *Ann. Soc. Geol. Belg.* **60,** B239–B260, pl. 1, figs. 1–4; pl. 2, figs. 5–10.
1955 *Hystrichosphaera ramosa* (Ehr.); Deflandre and Cookson, pp. 263–4, pl. 2, fig. 1; pl. 5, fig. 6; pl. 6, fig. 1.
1961 *Hystrichosphaera ramosa* (Ehr.); Gerlach, *N. Jb. Geol. Pal.* **112,** 175, pl. 27, fig. 3.

Comment. Since writers such as Deflandre and Lejeune have stressed the difficulty of distinguishing *H. ramosa* from *H. furcata* it is with some diffidence that we record the occurrence of *H. ramosa* in the Cambridge deposits. The form so designated is consistently larger, has thicker-walled appendages, more strongly outlined fields, and wider membranes subtending the appendages than those referred to *H. furcata*. In these features the Cambridge specimens tend towards *H. wetzeli* Deflandre but differ from this species in that the appendages of the posterior part are radially arranged and not parallel to the long axis of the shell as Deflandre (1937) described them to be in *H. wetzeli*.

Occurrence. In Upper Gault, Greensand, and Chalk Marl.

Genus ACHOMOSPHAERA Evitt 1963
Achomosphaera ramulifera (Deflandre)

Plate 9, fig. 10

1935 *Hystrichosphaera* cf. *ramosa* Deflandre, *Bull. Biol.* **49,** pl. 5, fig. 11.
1937 *Hystrichosphaeridium ramuliferum* Deflandre, p. 26, pl. 14, figs. 5, 6; pl. 17, fig. 10.
1952 *Hystrichosphaeridium ramuliferum* Deflandre; W. Wetzel, *Geol. Jb.* **66,** 398, pl. A, fig. 9.
1959 *Hystrichosphaeridium ramuliferum* Deflandre; Gocht, p. 71, pl. 3, fig. 9.
1961 *Hystrichosphaeridium ramuliferum* Deflandre; Gerlach, *N. Jb. Geol. Palëont.* **112,** 185, pl. 28, fig. 3.
1963 *Achomosphaera ramulifera* (Defl.) Evitt.

Comment. Three specimens that appear to be referable to *A. ramulifera* have been recorded. Their appendages, although possibly somewhat shorter than those of the French types, are similarly branched and the shape of both shell and pylome is identical.

The sculpture of the shell-membrane, unfortunately not mentioned in the original description of *H. ramuliferum*, appears to be identical with that of the specimen illustrated by Deflandre on plate 14, fig. 6. Gocht (1959) in recording *H. ramuliferum* from German Neocomian deposits makes no mention of the development of surface sculpture whilst Gerlach (1961) indicates that in her Tertiary specimens the membrane is finely reticulate or unpatterned. Such an inclusion of smooth and sculptured shells in one species at once raises the question as to whether surface sculpture, evident in the one specimen of Deflandre's referred to above and indicated by dotting in his two other figures, should be regarded as a specific character. In the Cambridge specimens the pattern which has been constant and strongly developed and may even extend to the undivided portion of the appendages seems to be composed of small thickened areas of varying sizes and shapes separated by shallow grooves.

Occurrence. Greensand, CG3, CG4.

Genus CANNOSPHAEROPSIS O. Wetzel 1933
cf. *Cannosphaeropsis densa* Cookson and Eisenack 1962

Plate 10, fig. 4

Comment. The incomplete figured specimen was the only one of this type recovered from the Cambridge samples. The shell is somewhat smaller and the investing network less dense and prominent than in *C. densa* from ?Albian–Cenomanian of the Perth Basin, Western Australia. The straight or curved peripheral spine-like branches agree with those of *C. densa*.

Occurrence. Chalk Marl, CG8.

Family HYSTRICHOSPHAERIDIACEAE Evitt 1963
Genus HYSTRICHOSPHAERIDIUM Deflandre 1937
Hystrichosphaeridium complex (White)

Plate 9, fig. 6

1842 *Xanthidium tubiferum complex* White, *Micr. J.* **2**, pl. 14, fig. 11; 1844, *Trans. Micr. Soc.* **1**, 83, pl. 8, fig. 10.

1940 *Hystrichosphaeridium elegantulum* Lejeune-Carpentier, *Ann. Soc. Geol. Belg.* **63**, B222, figs. 11–12.

1946 *Hystrichosphaeridium complex* (White); Deflandre, *C.R. Soc. Géol. Fr.* 111.

1953 *Hystrichosphaeridium tubiferum*; Cookson, *Mem. Nat. Mus. Victoria*, **18**, 113, pl. 2, fig. 24.

EXPLANATION OF PLATE 7

Figs. 1–4. *Pseudoceratium dettmannae* sp. nov. 1, Holotype, CG8; K5173, OR39.7 118.8, × 500. 2, CG3; K5176, OR34.4 119, × *c*. 500. 3, 59/11/12; K5175, OR52.6 120.2, × *c*. 500. 4, Oblique scetion, CG3; K5177, OR40.5 125.5, × 625.

Fig. 5–9. *Scriniodinium campanula* Gocht, CG3. 5, K5181, OR36.7 117.5, × 500. 6, K5180, OR40.3 116, × 500. 7, K5178, OR36.5 119.2, × *c*. 500. 8, Longitudinal section; K5179, OR27.9 124.9, × 850. 9, Transverse section; K5182, OR35 115.5, × 500.

1955 *Hystrichosphaeridium complex* (White); Deflandre and Cookson, p. 270, pl. 1, figs. 9, 10
1956 *Hystrichosphaeridium* cf. *elegantulum* Lejeune-Carpentier; Weiler, *N. Jb. Geol. Paläont.* **104,** 140, pl. 12, figs. 7, 8; pl. 13, fig. 1.
1958 *Hystrichosphaeridium complex* (White); Cookson and Eisenack, p. 42, pl. 12, fig. 10.
1959 *Hystrichosphaeridium complex* (White); Gocht, p. 66, pl. 3, figs. 2, 3.

Comment. Since *H. complex* was first described from English Upper Cretaceous deposits it is not surprising that examples of it have been recovered from most of the Cambridge Albian and Cenomanian samples examined. In addition to the European occurrences referred to above, *H. complex* is widely distributed in Australian Aptian and Albian deposits.

Occurrence. Upper Gault, CG1, 59/11/14; Greensand, 59/11/11, MD1; Chalk Marl, 59/12/5, CG8.

Hystrichosphaeridium recurvatum (White) subsp. *polypes* Cooks. and Eisenack 1962

Plate 9, fig. 14

Comment. A few specimens have been observed in the Cambridge Greensand which agree with those occurring in Australian Cretaceous deposits upon which the subspecies *polypes* at present stands. All have many more appendages than typical examples of *H. recurvatum* and the 'hair-like' branches of the apical processes noted for the Australian examples have been seen. The wide geographical distribution of this subspecies demonstrated by the present record suggests that when better known this form will prove to be specifically distinct from *H. recurvatum*.

Occurrence. Upper Gault, CG2; Greensand, 59/11/12, 59/11/11, 59/11/9; Chalk Marl, 59/12/5.

Hystrichosphaeridium ancoriferum Cookson and Eisenack 1960*a*

Plate 9, fig. 7

Comment. Specimens which agree with *H. ancoriferum* from ?Upper Albian–Cenomanian deposits in Western Australia are common in the Cambridge deposits. Sometimes they are rather difficult to distinguish from the larger of the specimens of *Chlamydophorella nyei* Cookson and Eisenack 1958 with which they are frequently associated but usually their appendages are distinctly coarser than those of *C. nyei*, and they lack the outer membrane of this form.

Occurrence. Upper Gault, CG2, 59/11/14; Greensand, 59/11/12, CG3, CG4, CG10; Chalk Marl 59/12/5, 59/11/7, CG8.

Hystrichosphaeridium arundum Eisenack and Cookson 1960

Plate 9, fig. 16

Comment. Several specimens which approximate closely to the Australian Albian species *H. arundum* have been observed in preparations of one sample. The features in which they are in agreement with the Australian examples are the size and granular surface of the shell, the tubular form of the appendages, and the variability of their shape and size in one and the same example. The appendages of the Cambridge forms have either straight or slanting sides and some of the smaller ones are sharply conical. The presence of the latter type was not noted in the description of *H. arundum* but in the present state of our knowledge this feature scarcely seems to be of diagnostic significance. The average diameter of six of the Cambridge shells is 33 μ and their overall diameter 51 μ.

Occurrence. Upper Gault, CG2.

Hystrichosphaeridium siphoniphorum Cookson and Eisenack 1958

Plate 9, fig. 15

Comment. The Cambridge specimens agree closely with the type and other examples of *H. siphoniphorum* from ?Albian–Cenomanian deposits in the Perth Basin and deposits of approximately the same age in north-west Western Australia.

Occurrence. Upper Gault, CG2, 59/11/14; Greensand, 59/11/12, CG3, CG4, CG10, 59/11/11, MD1; Chalk Marl, 59/12/5, 59/11/7, CG8.

Hystrichosphaeridium stellatum Maier 1959

Plate 9, fig. 11

Comment. A few specimens conform to Maier's species and compare well with specimens from Western Australian Albian to Cenomanian deposits, recently referred to it by Cookson and Eisenack (1962).

Occurrence. Upper Gault, CG1, CG2; Greensand, CG3, 59/11/12; Chalk Marl, CG8.

Family INCERTA
Genus CARPODINIUM Cookson and Eisenack 1962
Carpodinium obliquicostatum sp. nov.

Plate 6, figs. 1–6

Diagnosis. Shell elongate-oval, divided almost equally by a circular girdle evident as lateral indentations 2–3 μ deep. Epitheca with a short tapering horn which arises from the outer membrane. Plates elongate, bordered by relatively high sutures with serrate edges; indications of an antapical plate have been seen and a large quadrangular pylome (pre-cingular archaeopyle) and longitudinal furrow are clearly evident in one specimen (Pl. 6, figs. 4, 5). The surface pattern of the plates provides the most distinctive specific feature; it consists of roughly triangular areas of variable size and shape which lie more

EXPLANATION OF PLATE 8

Figs. 1–3, 5. *Canningia minor* sp. nov., $\times 500$. 1, Holotype, CG10; K5184, OR37.9 119.2. 2, CG10; K5187, OR55.5 120. 3, CG10; K5183, OR 35.4 111.4. 5, CG10; K5185, OR43.8 109.8.

Fig. 4. *Canningia? sp.*, $\times 500$. CG2; K5186, OR29 116.

Figs. 6–8. *Palaeoperidinium spinosum* sp. nov. 6, CG3; K5189, OR42.9 125, $\times 500$. 7, CG3; K5193, OR42.4. 118.6, $\times$ *c*. 500. 8, Holotype, 59/11/9; K5188, OR48 122.5, $\times 875$.

Figs. 9–17. *Stephodinium europaicum* sp. nov., 59/11/12. 9–12, Holotype rotated to various positions but mounted as in 12; K5190, OR41.5 115.4, $\times$ *c*. 500. 13, K5192, OR30 120, $\times 750$. 14, K5191, OR32 129, $\times$ *c*. 500. 15–17, Specimens rotated; K 5235, $\times$ *c*. 500. 15, Antapical view, high focus. 16, Low focus. 17, Oblique view.

or less obliquely to the long axis of the shell and are delimited by narrow anastomosing grooves.

Holotype. Plate 6, fig. 1; K5165, Upper Gault (CG1).

Dimensions. Holotype 73 μ long, 50 μ broad. Range 59–80 μ long, 36–50 μ broad.

Occurrence. Upper Gault, CG1, 59/11/14; Greensand, 59/11/12, CG3, CG4, 59/11/11, MD1, 59/11/9; Chalk Marl, 59/12/5, 59/11/7, CG8.

Comment. The general form and size of *C. obliquicostatum* is similar to that of the type species *C. granulatum* Cooks. and Eisenack 1962 from Australian Aptian and Albian deposits, but the two species are readily distinguishable by their surface patterns. *C. granulatum* has not, as yet, been recovered from Cenomanian deposits.

Genus PALAEOPERIDINIUM Deflandre 1935
Palaeoperidinium castanea Deflandre 1935

Plate 5, fig. 14

1935 *Palaeoperidinium castanea* Deflandre, *Bull. Biologique*, **49**, 228, pl. 5, fig. 8; *Ann. Paléont.* **25**, 29, pl. 6, figs. 1–4.

1962 *Palaeoperidinium castanea* Deflandre; Cookson and Eisenack, pl. 3, figs. 9–11.

Comment. Specimens agreeing closely with Deflandre's description of *P. castanea* from the French Senonian or Turonian have been recovered in small numbers. They have a helicoid girdle, the shell is ornamented with short spines and, as in the French specimens, the pylome extends from just beneath the apex to the girdle. Similar forms have recently been recorded by Cookson and Eisenack (1962) from Western Australian deposits of ?Aptian–Albian to Cenomanian age.

Occurrence. Upper Gault, 59/11/14; Greensand, 59/11/12, CG3; Chalk Marl, 59/11/7, CG8.

Palaeoperidinium spinosum sp. nov.

Plate 8, figs. 6–8

Diagnosis. Shell with convex sides, an arched apex with a slight central prominence, a slanting antapex, a shallow, circular, equatorial girdle, and a short, rather ill-defined longitudinal furrow. A capsule is not developed. Shell-membrane thin, covered with short, blunt, hollow outgrowths *c.* 2 μ long which usually give the wall a scalloped appearance. The shell opens by the detachment of the distal portion of the epitheca.

Holotype. Plate 8, fig. 8; K5188, Cambridge Greensand, 2 ft. above base (59/11/9).

Dimensions. Holotype; overall length 55 μ, overall breadth 46 μ. Range 55–67 μ long, 38–50 μ broad.

Occurrence. Greensand, CG4, MD1, 59/11/9; Chalk Marl, 59/11/7.

Comment. The genus *Palaeoperidinium* has been used for this species in the general sense in which it was created by Deflandre. *P. spinosum* resembles *P. caulleryi* Deflandre (1934) in its small size, the type of ornament, the scalloped shell outline, and the development of a slight projection on one side of the antapex. It differs, however, in having a denser ornamentation, a circular instead of helicoid girdle, and a less pronounced apical prominence. The mode of opening of the shell in *P. caulleryi* was not specified by Deflandre.

Palaeoperidinium spinosum has not been generically associated with *Spinidinium* Cookson and Eisenack 1962, to the description of which it conforms in several respects, on account of its different mode of opening. In the type species *S. styloniferum* a pylome is present in the epitheca, in contrast to the detachment of the apex in *P. spinosum*.

Genus STEPHODINIUM Deflandre 1936

Stephodinium europaicum sp. nov.

Plate 8, figs. 9–17

Diagnosis. Shell broadly oval with a definite surface tabulation composed of plates of varying sizes delimited by low, narrow ledges. An equatorial girdle incompletely encircles the shell leaving an untabulated area on the ventral surface which appears to represent a longitudinal furrow (Pl. 8, fig. 10). The girdle is bounded by two conspicuous flanges which extend from the shell in a plane at right angles to the longitudinal axis; the ledges of the pre- and post-equatorial plates adjacent to the girdle run radially across the flanges to their margins.

The exact tabulation has not been determined. Almost certainly there is a single four- or ?five-sided antapical plate (Pl. 8, fig. 13) and probably one four or ?five-sided apical plate from which a short horn projects (Pl. 8, fig. 14). A large and strongly outlined plate, comparable in position with plate 3″ of many other dinoflagellates, extends on the dorsal surface from the apical plate to the margin of the pre-equatorial flange (Pl. 8, figs. 11, 12, 15). This plate, which marks the position of the pylome, widens considerably towards the girdle.

The shell-membrane is thin and smooth, except at the margins of the girdle-flanges which are minutely serrated.

Holotype. Plate 8, figs. 9–12; K5190, Cambridge Greensand (59/11/12).

Dimensions. Holotype body 59 μ long, horn 5 μ, body breadth 75 μ, overall breadth 46 μ. Range, body 52–60 μ long, 42–52 μ broad, overall breadth 67–78 μ.

EXPLANATION OF PLATE 9

Figs. 1–5. *Hystrichosphaera spp.* 1, *H. furcata* (Ehr.) O. Wetzel, CG4; K5194, OR46 112.6, ×500. 2, *H. furcata*, CG3; K5195, OR50.6 123.8, ×500. 3, *H.* cf. *furcata*, CG4; K5233, OR47.8 118, ×500. 4–5, *H. ramosa* (Ehr.) O. Wetzel, CG3, ×500. 4, K5197, OR46 121. 5, K5196, OR37.2 118.4.

Fig. 6. *Hystrichosphaeridium complex* (White), CG8; K5202, OR42.8 117, ×400.

Fig. 7. *H. ancoriferum* Cooks. and Eisenack, 59/11/14; K5212, OR29.8 114.4, ×*c*. 500.

Figs. 8–9. *Coronifera oceanica* Cooks. and Eisenack, ×500. 8, CG1; K5200, OR4 5117.8. 9, 59/11/12; K5201, OR47.7 121.

Fig. 10. *Achomosphaera ramulifera* (Defl.), CG3; K5213, OR34.4. 115.8, ×500.

Fig. 11. *Hystrichosphaeridium stellatum* Maier, CG3; K5204, OR38.1 119.3, ×500.

Figs. 12, 13. cf. *Rottnestia borussica* (Eisenack), ×*c*. 700. 12, Dorsal aspect, CG4; K5208, OR54 111.5. 13, Ventral aspect, CG3; K5195, OR47.6 127.

Fig. 14. *Hystrichosphaeridium recurvatum* subsp. *polypes* Cooks. and Eisenack, 59/11/9; K5211, OR30.1 122.4, ×*c*. 500.

Fig. 15. *H. siphoniphorum* Eisenack and Cookson, 59/11/7; K5207, OR37.3 116.4, ×500.

Fig. 16. *H. arundum* Eisenack and Cookson, CG2; K5206, OR 33.7 113.6, ×*c*. 500.

Occurrence. Upper Gault, CG1, 59/11/14; Greensand, 59/11/12, CG3, CG4, 59/11/11, MD1; Chalk Marl, 59/11/7, CG8.

Comment. In its general form and size *Stephodinium europaicum* conforms to Deflandre's species *S. coronatum*. However, as the description of this species was based on a single specimen preserved in a flint (?Senonian) it is not possible to compare the Cambridge forms with it.

Another species *S. australicum*, of comparable geological range, was recently described by Cookson and Eisenack (1962). All the available specimens of *S. australicum* were considerably flattened and in consequence difficult to interpret. However, in spite of some still existing uncertainties regarding the morphology of *S. australicum* there is no doubt that it is specifically distinct from *S. europaicum*.

S. europaicum is of special interest in that it completely confirms the dinoflagellate affinities of *Stephodinium* originally suggested by Deflandre, and gives a more accurate idea of the orientation of the shell than was previously possible. Furthermore, it provides the first clear evidence of the existence of a system of tabulation in a member of the genus as well as the presence of a transverse girdle previously postulated by Deflandre.

Unfortunately gaps in our knowledge still remain owing to the delicate nature of the shells and their consequent distortion and preferred orientation in permanent mounts. Most of the details and photographs had to be obtained from a few fully expanded examples that were removed for examination to hollow slides containing 50 per cent. glycerine solution, and later mounted in glycerine jelly.

Genus PSEUDOCERATIUM Gocht 1957

Pseudoceratium turneri Cookson and Eisenack 1958

Plate 6, fig. 7

Comment. Several examples referable to *P. turneri* have been recovered from the lowest part of the Cambridge Greensand. All agree in size, shape, and surface ornament with the Australian Aptian–Albian species. In this species the external processes usually unite forming lamella-like membranes which coalesce to form a net-like pattern, the meshes of which are of variable size and shape. In the German Neocomian species *P. pelliferum* Gocht 1957 the processes comprising the ornament are free from one another.

Occurrence. Greensand, 59/11/12.

Pseudoceratium dettmannae sp. nov.

Plate 7, figs. 1–4

Diagnosis. Shell approximately four-sided with a longish straight-sided apical horn and a short projection at each of the three angles. Indications of a $\pm$circular girdle occur in most specimens. The shell opens by the detachment of an apical segment along a straight or slightly oblique line. The surface of the shell is scabrate except for a relatively wide finely pitted band that encircles both dorsal and ventral surfaces. Transverse sections (cut by Dr. Mary Dettmann) have shown that the shell-membrane is two-layered, the two layers being in contact and traversed by elongated pits in the region of the pitted band mentioned above and widely separated from one another in the unpitted portions of the membrane.

Holotype. Plate 7, fig. 1; K5173, Cambridge Greensand (CG3).

Dimensions. Holotype 180 × 150 μ. Range 104–132 μ long, 78–99 μ broad, horn *c.* 31 μ.

Occurrence. Greensand, 59/11/12, CG3, CG4, MD1; Chalk Marl, 59/12/5.

Comment. Our reason for referring this species to *Pseudoceratium* is its superficial resemblance to *P. ludbrooki* (Cookson and Eisenack 1958) which was removed from *Ceratocystidiopsis* Deflandre by Eisenack (1961). However, at present we do not know whether the structure of the Cambridge species, as revealed by thin sections, is similar to that of either *P. ludbrooki* or the other species of *Pseudoceratium*.

Another important question that arises from the present investigation is whether or not a capsule is present in *P. dettmannae* or even in *P. ludbrooki* as was stated in the description of this species. As far as *P. dettmannae* is concerned the fact that the pits extend without a break through the entire wall of the pitted area rather suggests that the separation and development of 'air-spaces' in the intervening unpitted portions of the wall is not connected with the development of an internal capsule.

Genus APTEODINIUM Eisenack 1958

Apteodinium grande sp. nov.

Plate 6, figs. 8, 9

Diagnosis. Shell large, almost circular in outline with a lightly defined circular girdle; epitheca with a short median solid horn which in perfect specimens narrows towards a small bifureate tip, although sometimes, as in the type, only the basal part of the horn remains. A large hoof-shaped pylome extends from the girdle to a short-distance beneath the horn. Shell-membrane about 2–4 μ thick, minutely pitted, and of spongy texture.

Holotype. Plate 6, fig. 9; K5170, Cambridge Greensand (59/11/11).

Dimensions. Holotype, overall length 153 μ, breadth 138 μ, pylome 52 × 57 μ. Range, overall length 111–153 μ, breadth 99–138 μ, horn 13–17 μ long, wall 2–4 μ thick.

Occurrence. Upper Gault, 59/11/14; Greensand, 59/11/12, MD1, 59/11/11; Chalk Marl, 59/12/5, 59/11/7.

Comment. Apteodinium grande is distinguishable from the German Aptian species *A. granulatum* Eisenack 1958 by its consistently larger size and the pitted character of its wall. It differs from the Australian Aptian–Albian species *A. maculatum* Eisenack and Cookson 1960 both in size and the absence of the small thickened areas with circular outlines that gives *A. maculatum* its characteristic appearance.

Genus ODONTOCHITINA Deflandre 1935

Plate 11, fig. 9

Comment. The genus *Odontochitina* is well represented in the Cambridge deposits, particularly so in the upper portion of the Gault. During this work no attempt has been made to identify specifically the individual types present. However, it is almost certain that these include the European Lower and Upper Cretaceous species *O. operculata*

(O. Wetzel) also recorded from Australia (Deflandre and Cookson 1955) and less certainly *O. striatoperforata* Cookson and Eisenack 1962 from ?Albian to Cenomanian deposits in Western Australia and possibly the closely related German species *O. costata* Alberti 1961.

Genus ROTTNESTIA Cookson and Eisenack 1961*a*
cf. *Rottnestia borussica* (Eisenack) 1954

Plate 9, figs. 12, 13

1954 *Hystrichosphaera borussica* Eisenack, pl. 9, figs. 5–7.
1955 *Hystrichosphaera borussica* Eisenack; Deflandre and Cookson, p. 268, pl. 5, figs. 9, 10.
1961*a* *Rottnestia borussica* (Eisenack); Cookson and Eisenack, pp. 41–42, pl. 2, figs. 1, 2; figs. *a–d*.

Comment. Some specimens resembling the Tertiary species *Rottnestia borussica* occur sparingly in the Cambridge samples. Taken as a whole the fields composing their surface tabulation are not so completely delimited as they are in *R. borussica* but considerably more so than in the apparently related species *Hystrichosphaera ovum* as illustrated by Deflandre (1937). The apical expansion is surmounted by a short median horn and the ledges outlining the fields have serrated edges; short forked appendages occur at the corners of the fields.

Occurrence. Greensand, 59/11/12, CG3, CG4; Chalk Marl, 59/12/5, 59/11/7.

Genus BROOMEA Cookson and Eisenack 1958
Broomea cf. *jaegeri* Alberti 1961

Plate 11, fig. 10

Comment. Three specimens referable to the genus *Broomea*, one complete (Pl. 11, fig. 10) and two represented only by their antapices, have been recovered. This genus was originally established on specimens from Jurassic deposits in north-west Western Australia and New Guinea, and subsequently recorded by Alberti (1961) from German Hauterivian and Lower Aptian sediments. The Cambridge specimens, although not identical with Alberti's figured examples of *B. jaegeri*, have been compared with this species firstly because their antapical horns are more sharply pointed than those of the Australian and New Guinea species *B. simplex* Cookson and Eisenack 1958 which they also resemble, and secondly because of their closer palaeogeographical and stratigraphical proximity.

Occurrence. Upper Gault, 59/11/14; Greensand, CG3.

Genus HEXAGONIFERA Cookson and Eisenack 1961
Hexagonifera chlamydata Cookson and Eisenack 1962

Plate 10, figs. 7–9

Comment. Specimens which are identical in all respects with those recorded from ?Upper Albian–Cenomanian deposits in Western Australia are widely distributed in the Cambridge deposits. As in the Australian examples the shells open by the removal of a six-sided portion of the wall at one end and are completely or partially enclosed in a smooth, transparent outer membrane. The sculpture of the shell itself also varies from finely granular to verrucose.

Occurrence. Upper Gault, CG1, CG2, 59/11/14; Greensand, 59/11/12, CG3, CG4, CG10, 59/11/11, 59/11/9; Chalk Marl, 59/11/7.

Genus CHLAMYDOPHORELLA Cookson and Eisenack 1958
Chlamydophorella nyei Cookson and Eisenack 1958

Plate 6, fig. 12

Comment. C. nyei is one of the commonest types in these Cambridge deposits. Most of the examples, like their Australian counterparts, are seen in apical or antapical views. However, a few have been observed in lateral view (Pl. 6, fig. 12), including occasional shells in course of opening by the detachment of the apical region (Cookson and Eisenack 1962, pl. 7, fig. 16). As far as we know *C. nyei* has not previously been recorded from extra-Australian deposits. Its known geological range in Australia is from Aptian to Cenomanian.

Occurrence. Frequent in all samples examined.

Genus KALYPTEA Cookson and Eisenack 1960*b*
Kalyptea monoceras Cookson and Eisenack 1960

Plate 11, fig. 7

Comment. The figured specimen is one of two specimens that can be referred to *Kalyptea monoceras*. Others which appear to be comparable with them occur in samples CG1, CG4, CG10. However, although each of the latter consists of an approximately oval shell of comparable size which is enclosed in the characteristic kalyptean diaphanous 'veil', none has shown the slender horn of the figured specimen and of the type and paratype of *K. monoceras*. The present record of this Australasian species in Britain is of palaeogeographical interest.

Occurrence. Greensand, 59/11/12.

Genus FROMEA Cookson and Eisenack 1958
Fromea amphora Cookson and Eisenack 1958

Plate 10, fig. 3

EXPLANATION OF PLATE 10

Figs. 1, 2. *Baltisphaeridium hirsutum* (Ehr.), CG8. 1, K5221, OR39.5 126.4, × 500. 2, Sculpture detail × *c.* 1500.

Fig. 3. *Fromea amphora* Cooks. and Eisenack, 59/11/14; K5219, OR42.1 124.2, × *c.* 500.

Fig. 4. cf. *Cannosphaeropsis densa* Cooks. and Eisenack, CG8; K5218, OR32.7 115.6, × 500.

Figs. 5, 6. *Cyclonephelium membraniphorum* Cooks. and Eisenack, × 500. 5, 59/11/7; K5215, OR35.5 119. 6, CG8; K5157, OR48 119.7.

Figs. 7–9. *Hexagonifera chlamydata* Cooks. and Eisenack. 7, CG3; K5216, OR49.7 118.8, × *c.* 500. 8, CG8; K5221, OR36.7 109, × 500. 9, 59/11/9; K5217, OR54.4 126.9, × *c.* 800.

Fig. 10. *Cyclonephelium* cf. *densebarbatum* Cooks. and Eisenack, 59/11/9; K5209, OR59 127.8, × 500.

Fig. 11. *Baltisphaeridium ferox* Deflandre, CG3; K5205, OR40.3 116.3, × 500.

Fig. 12. *Chlamydophorella nyei* Cooks. and Eisenack, CG3; K5220, OR40.5 117, × *c.* 800.

Comment. Typical examples of *Fromea amphora* are sparsely represented in the samples mentioned. All have shown the equatorial 'girdle' so clearly indicated in the holotype and since seen by one of us (I. C. C.) in a relatively large number of Western Australian Albian and Cenomanian examples. The present stratigraphical range of *F. amphora* in Australia is from the Aptian to Cenomanian. Recently the same species was recorded by Alberti (1961) from Barremian deposits in Germany.

Occurrence. Upper Gault, CG1, 59/11/14; Greensand, MD1; Chalk Marl, 59/11/7.

Group INCERTAE SEDIS
Group ACRITARCHA Evitt 1963
Subgroup ACANTHOMORPHITAE Downie, Evitt, and Sarjeant 1963
Genus BALTISPHAERIDIUM Eis. emend. Downie and Sarjeant 1963
Baltisphaeridium hirsutum (Ehr.)

Plate 10, figs. 1, 2

1836 *Xanthidium hirsutum* Ehrenberg, *Abh. Kgl. Akad. Wiss. Berlin* (1838).
1935 *Hystrichosphaera hirsuta* (Ehr.); Deflandre, *Bull. Biol.* **69**, pl. 9, fig. 4.
1936 *Hystrichosphaeridium hirsutum* (Ehr.); Deflandre, *Ann. Paléont.* **26**, 30.
1941 *Hystrichosphaeridium hirsutum* (Ehr.); Lejeune-Carpentier, *Ann. Soc. Geol. Belg.* **64**, B71–92, figs. 1–9.
1963 *Baltisphaeridium hirsutum* (Ehr.); Downie and Sarjeant, p. 91.

Comment. In referring the relatively numerous and conspicuous Cambridge specimens of the *B. hirsutum* type to *B. hirsutum* itself the difficulty of distinguishing this form from the closely related species *B.* cf. *spinosum* (White), *B. spinosum* (White), *B. spinosum* var. *deflandrei* Lejeune-Carpentier, *B. pseudhystrichodinium* Deflandre, as reviewed by Lejeune-Carpentier (1941) has been borne in mind. However, the appendages of the Cambridge examples agree closely with those of *B. hirsutum* and divided ones occur in most specimens. The surface pattern of the shells (Pl. 10, fig. 2) is that of all members of the '*hirsutum*' group.

Occurrence. Upper Gault, CG1, 59/11/14; Greensand, 59/11/12, CG3, CG4, CG10, 59/11/11, MD1, 59/11/9; Chalk Marl, 59/12/5, CG8.

Baltisphaeridium ferox (Deflandre) Downie and Sarjeant 1963

Plate 10, fig. 11

Comment. Specimens referable to *Hystrichosphaeridium ferox* as originally described by Deflandre (1937) from ?Senonian flints of the Paris Basin and subsequently recorded from the German Lower Cretaceous (Eisenack 1958, Gocht 1959) have been recovered from the Cambridge sediments. Comparable forms have also been recently reported from Western Australian ?Albian–Cenomanian deposits (Cookson and Eisenack 1962). In three of the Cambridge examples (e.g. Pl. 6, fig. 11) one of the larger appendages is longer, narrower, and less deeply divided than the others, a feature that is reminiscent of the 'tubular horn' of *Coronifera oceanica* Cookson and Eisenack 1958.

Occurrence. Upper Gault, CG2; Greensand, 59/11/12; Chalk Marl, 59/12/5, 59/11/7, CG8.

Genus CORONIFERA Cookson and Eisenack 1958
Coronifera oceanica Cookson and Eisenack 1958

Plate 9, figs. 8, 9

Comment. Several specimens identical in most respects with the holotype of *C. oceanica* Cookson and Eisenack (1958, pl. 12, fig. 6) have been observed. All agree with the type in having a prominent tubular horn with a toothed or fringed apex at one end of the shell, numerous fine, pointed, simple or bifurcate, flacid appendages, and a granular shell-membrane. The stiff spine mentioned in the specific description as occurring at the opposite end of the shell has not been apparent in the Cambridge specimens. One of the latter with fewer appendages than is usual shows clearly that their bases are united forming a net-like pattern (Pl. 9, fig. 8). *Coronifera oceanica* was originally described from two Western Australian Albian deposits. The specimen from the German Upper Aptian deposit (Eisenack 1958) has fewer and apparently larger appendages.

Occurrence. Upper Gault, CG1, 59/11/14; Greensand, 59/11/12, 59/11/9.

Subgroup POLYGONOMORPHITAE Downie, Evitt, and Sarjeant 1963
Genus VERYHACHIUM Deunff 1954 emend. Downie and Sarjeant 1962
Veryhachium reductum (Deunff 1958)

Plate 11, fig. 8

1958 *Veryhachium trisulcum* (Deunff 1952) var. *reductum* Deunff, *Bull. Soc. Geol. et Min. Bretagne*, N.S. **2,** 27, pl. 1, figs. 1, 3, 8, 10, 12, 14, 16, 17, 22, 23.
1961 *Veryhachium reductum* (Deunff 1958) Jekhowsky, *Rev. Micropaléont.* **3,** 210–12, pl. 2, figs. 22–37.
1961 *Veryhachium reductum* (Deunff); Brosius and Bitterli, *Bull. Ver. Schweizer. Petrol-Geol.-Ing.* **28,** 36, pl. 1, figs. 3–6.
1962 *Veryhachium reductum* (Deunff); Cookson and Eisenack, **8,** 492, pl. 4, fig. 16.

Comment. Occasional specimens, similar to the one figured, have been observed in preparations of most of the Cambridge samples.

Subgroup DINETROMORPHITAE Downie, Evitt, and Sarjeant 1963
Genus DIPLOTESTA Cookson and Eisenack 1960
Diplotesta anglica sp. nov.

Plate 11, figs. 1–5

EXPLANATION OF PLATE 11

Figs. 1–5. *Diplotesta anglica* sp. nov. 1, CG3; K5222, OR56.2 111.8, ×*c.* 500. 2, Holotype, CG10; K5224, OR25.9 114.8, ×550. 3, CG10; K5226, OR34 122.7, ×*c.* 500. 4, 59/11/7; K5223, OR44.7 119.5, ×750. 5, CG10, K5225, OR36 122.6, ×500.
Fig. 6. *Trigonopyxidia ginella* Cooks. and Eisenack, MD1; K5227, OR64.6 125.8, ×500.
Fig. 7. *Kalyptea monoceras* Cooks. and Eisenack, 59/11/12; K5228, OR45.4 116, ×*c.* 500.
Fig. 8. *Veryhachium reductum* (Deunff 1958), CG4; K5194, OR24.5 112.2, ×650.
Fig. 9. *Odontochitina* cf. *striatoperforata* Cooks. and Eisenack, CG3; K5231, OR37.6 119.3, ×*c.* 150.
Fig. 10. *Broomea* cf. *jaegeri* Alberti, 59/11/14; K5232, OR53 119.7, ×*c.* 300.
Figs. 11, 12. Object 'A', ×500. 11, CG4; K5230, OR29.9 122.6. 12, MD1; K5229, OR37.6 121.5.

Diagnosis. Shell elongated with, in side view, one side straight or slightly concave, the other strongly convex, narrowing towards bluntly pointed apices one of which is usually open as the result of the partial or complete detachment of the wall along a straight line (Pl. 11, figs. 1, 3, 4). Capsule elongate-oval, strongly biconvex, narrowing somewhat towards both ends. The shell-membrane is scabrate.

Holotype. Plate 11, fig. 2; K5224, Cambridge Greensand (CG10).

Dimensions. Holotype 126 μ long, 44 μ broad; capsule 52×24 μ. Range 34–80 μ long, 29–44 μ broad; capsule 25–54 μ long, 17–23 μ broad.

Occurrence. Upper Gault, 59/11/14, CG2; Greensand, CG3, CG10, 59/11/11, MD1; Chalk Marl, 15/12/5.

Comment. Shells of the *Diplotesta* type have been frequent in the samples studied but the majority have been badly crumpled. However, a few have clearly demonstrated the occurrence of this genus in the Cambridge deposits and permitted comparison with the three previously described species, namely *D. glaessneri* Cookson and Eisenack 1960*b* from Australian Upper Jurassic and Lower Cretaceous deposits, *D. luna* Cookson and Eisenack 1960*a* from ?Upper Albian–Cenomanian deposits in Western Australia, and *D. krutzschi* Alberti 1961 from the German Upper Barremian. *D. anglica* seems to be in closest agreement with *D. luna*, mainly differing in the plano-convex to slightly concavo-convex shell and to some extent in the shape of the capsule. Although Alberti (1961, p. 21) has described the shells of *D. krutzschi* as biconvex and so precluded reference of the Cambridge specimens to this species, his specimen shown on Plate 7, fig. 21 bears a strong resemblance to *D. anglica*.

Genus TRIGONOPYXIDIA (Cookson and Eisenack 1960*a*) C. and E. 1961*b*
Trigonopyxidia ginella Cookson and Eisenack (1960*a*) 1961*b*

Plate 11, fig. 6

Comment. The genus *Trigonopyxidia* was instituted for simple shells of triangular outline with a centrally placed capsule which were recovered from a certain Western Australian ?Upper Albian–Cenomania deposit. The outline of the internal capsule was either circular or triangular but owing to the limited number of examples available both forms were included in the one species, *T. ginella*. Two specimens which can be accommodated in *T. ginella* in its present broad sense have been observed in the Cambridge Greensand. Although poorly preserved their triangular outline is clear and both contain a free internal capsule of sub-triangular outline similar to that of one of the Western Australian specimens (Cookson and Eisenack 1960*a*, pl. 3, fig. 18). *T. ginella* is a rare type; this is the first extra-Australian record.

Occurrence. Greensand, CG4, MD1.

INCERTAE SEDIS
Object 'A'

Plate 11, figs. 11, 12

Description. Spherical body with wall approx. 6–7 μ thick. Sculpture pattern of short irregular ridges 1 μ across, 1 μ high, and up to 10 μ long. Some of these ridges form regular circles or ovals up to 6 μ diameter enclosing a smooth area; the circles and ovals are irregularly distributed. Perforations of the main body are from 12 μ up to 44 μ diameter; each is surrounded by a low ridge (1×1 μ). Irregularities in the outline of the body are due to these perforations.

Dimensions. Diameter 86–153 μ; largest perforation (Plate 11, fig. 11), 44 μ.

Occurrence. Upper Gault, CG1; Greensand, 59/11/12, CG3, CG4, CG10, 59/11/11; Chalk Marl, 59/11/7, CG8.

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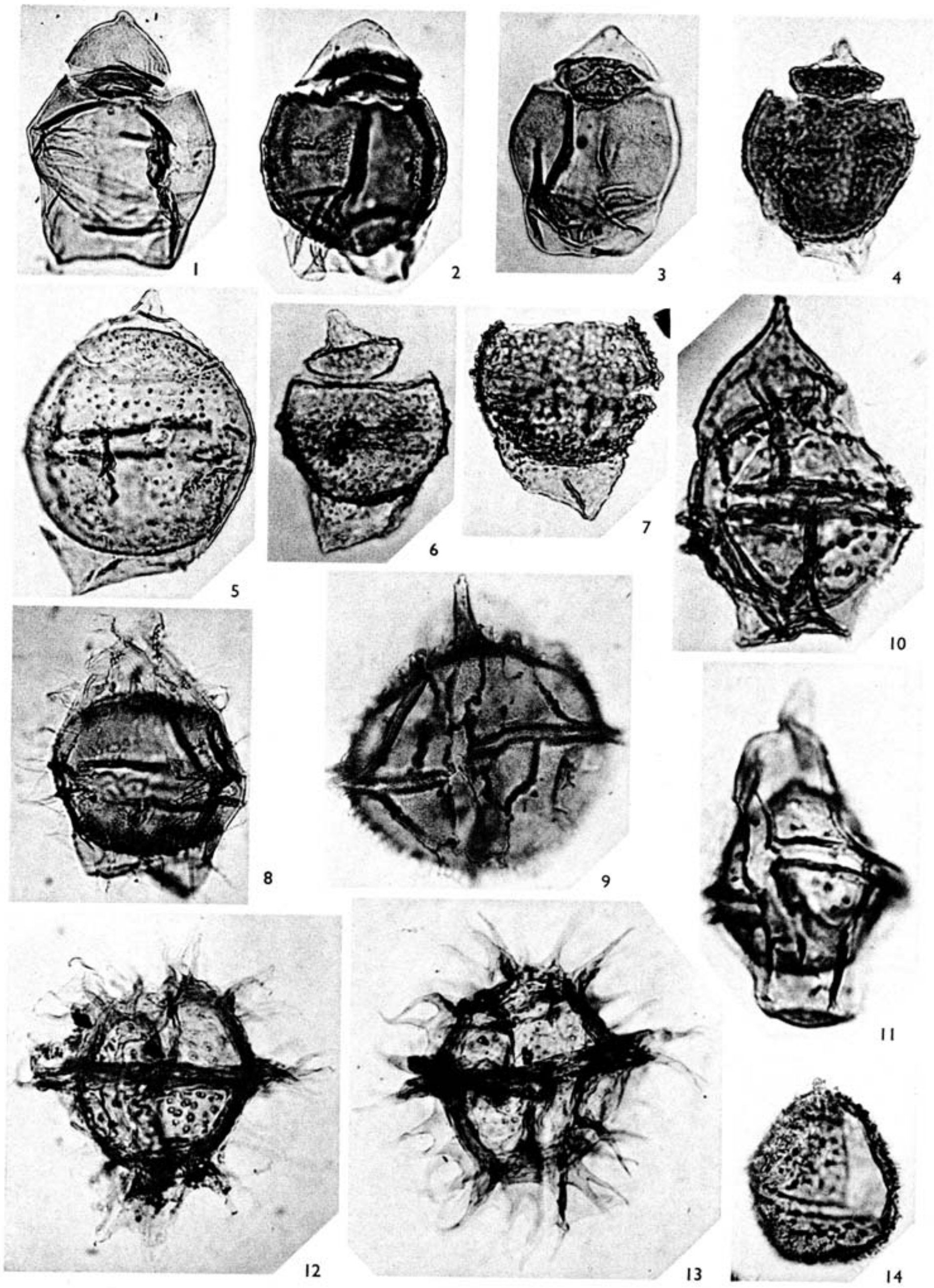
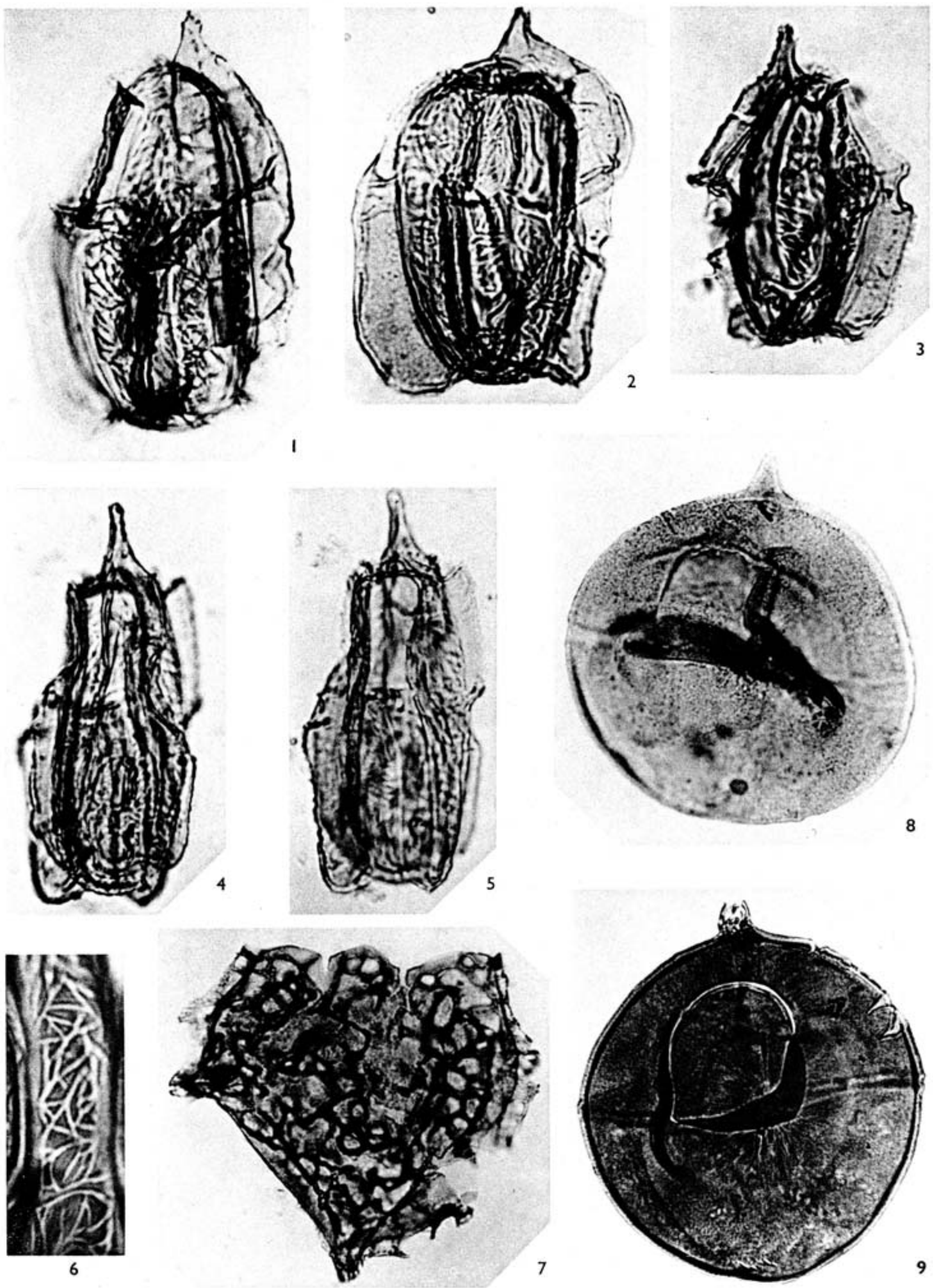


COOKSON and HUGHES, Mid-Cretaceous microplankton



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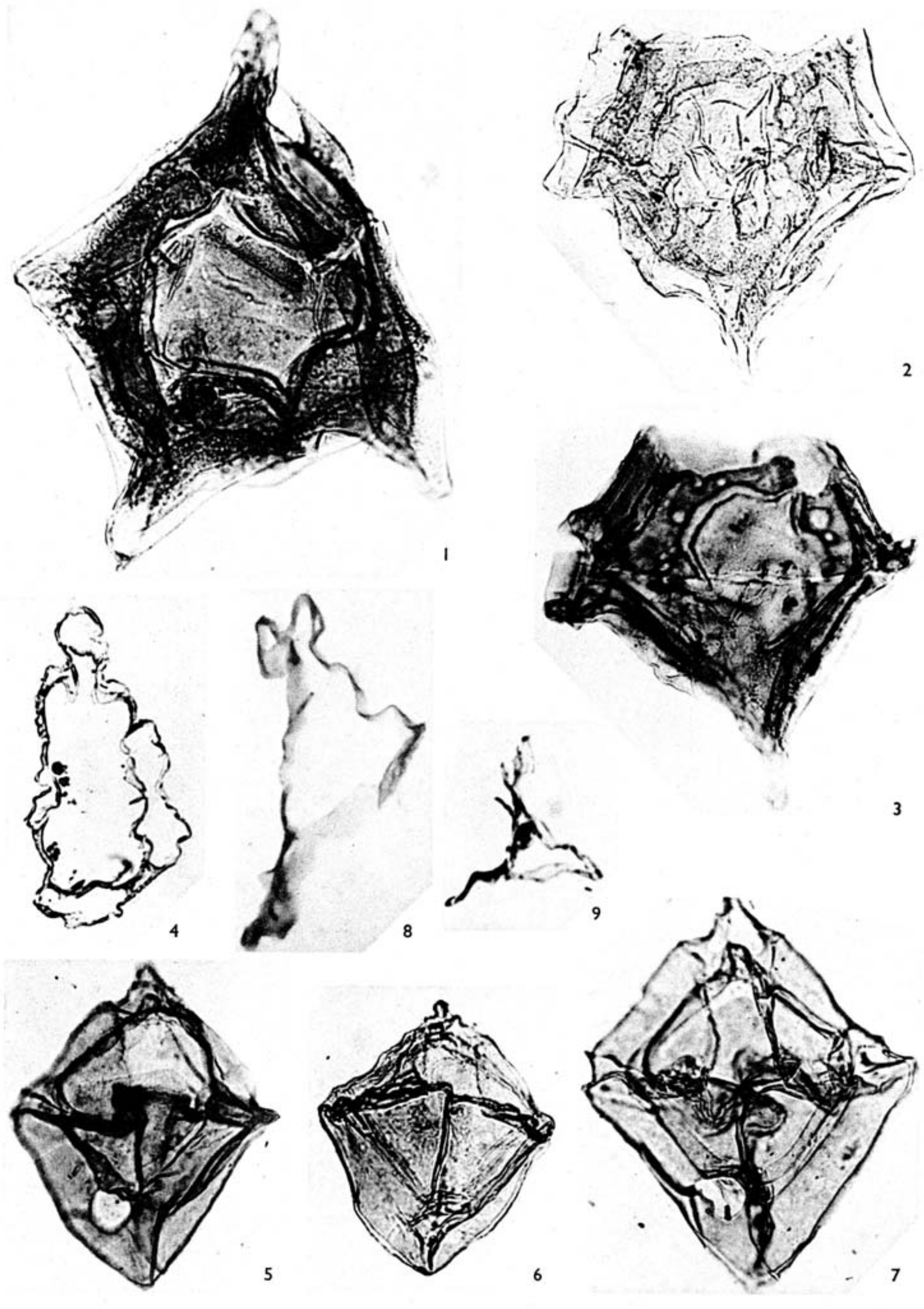

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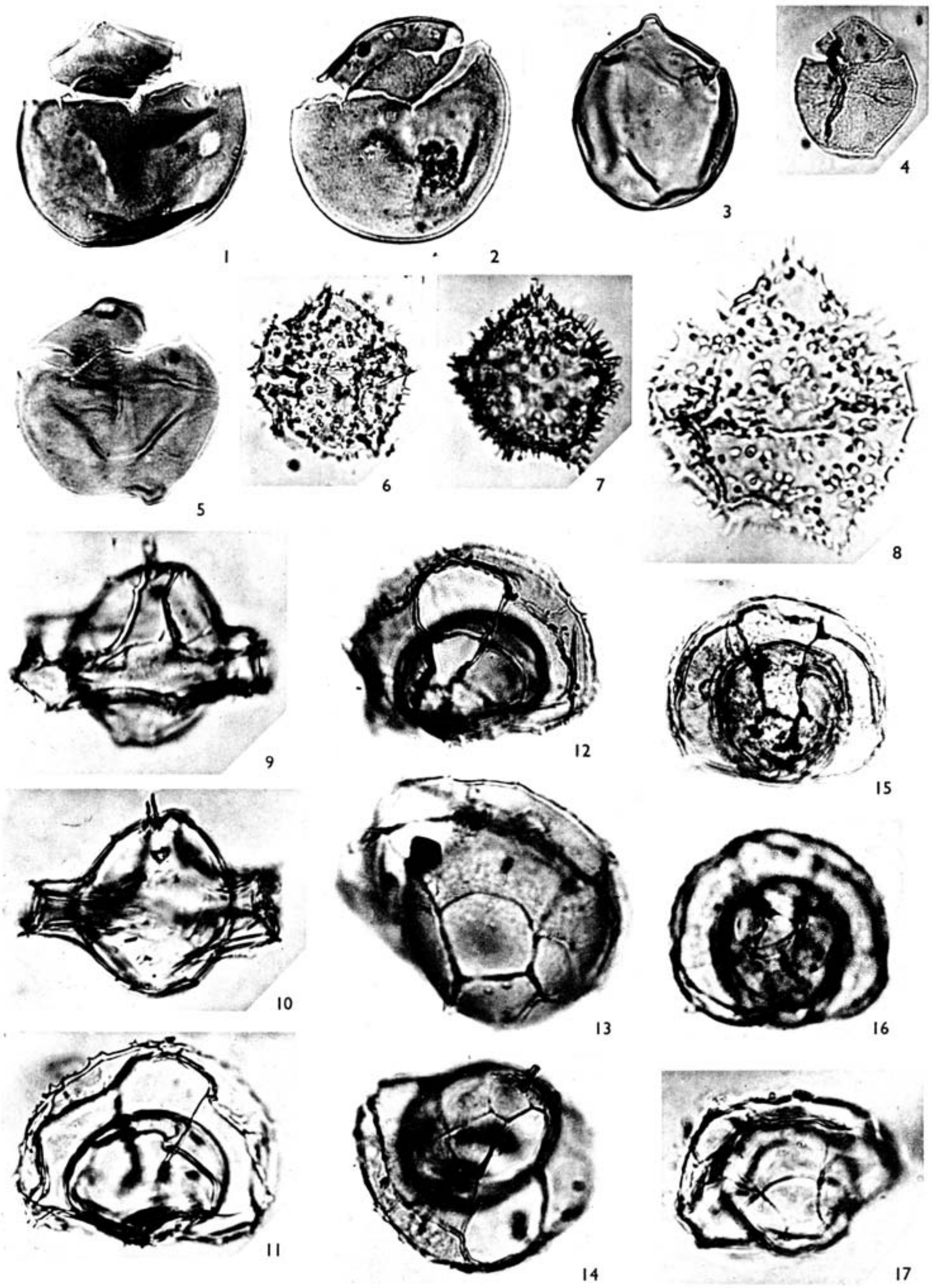

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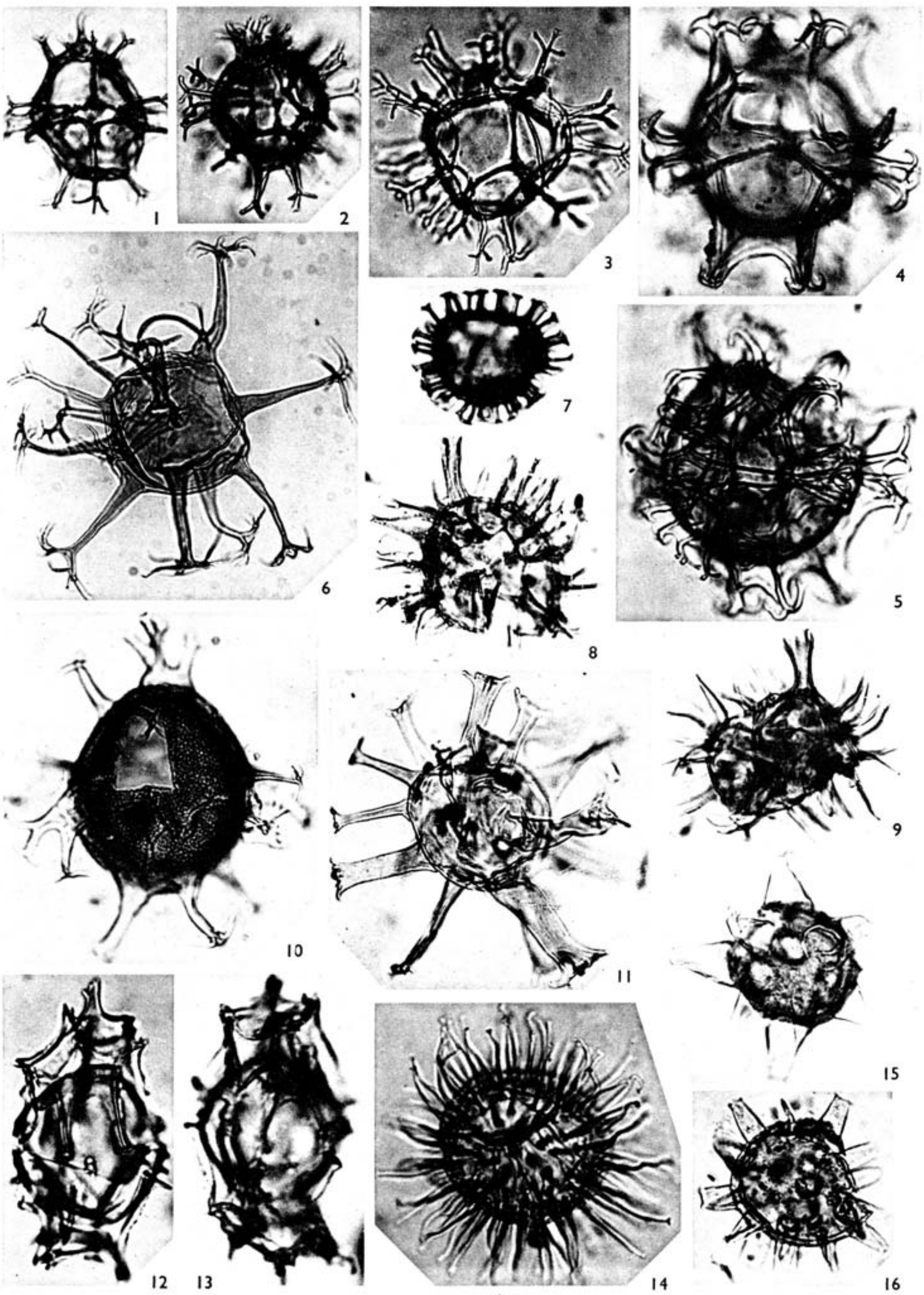

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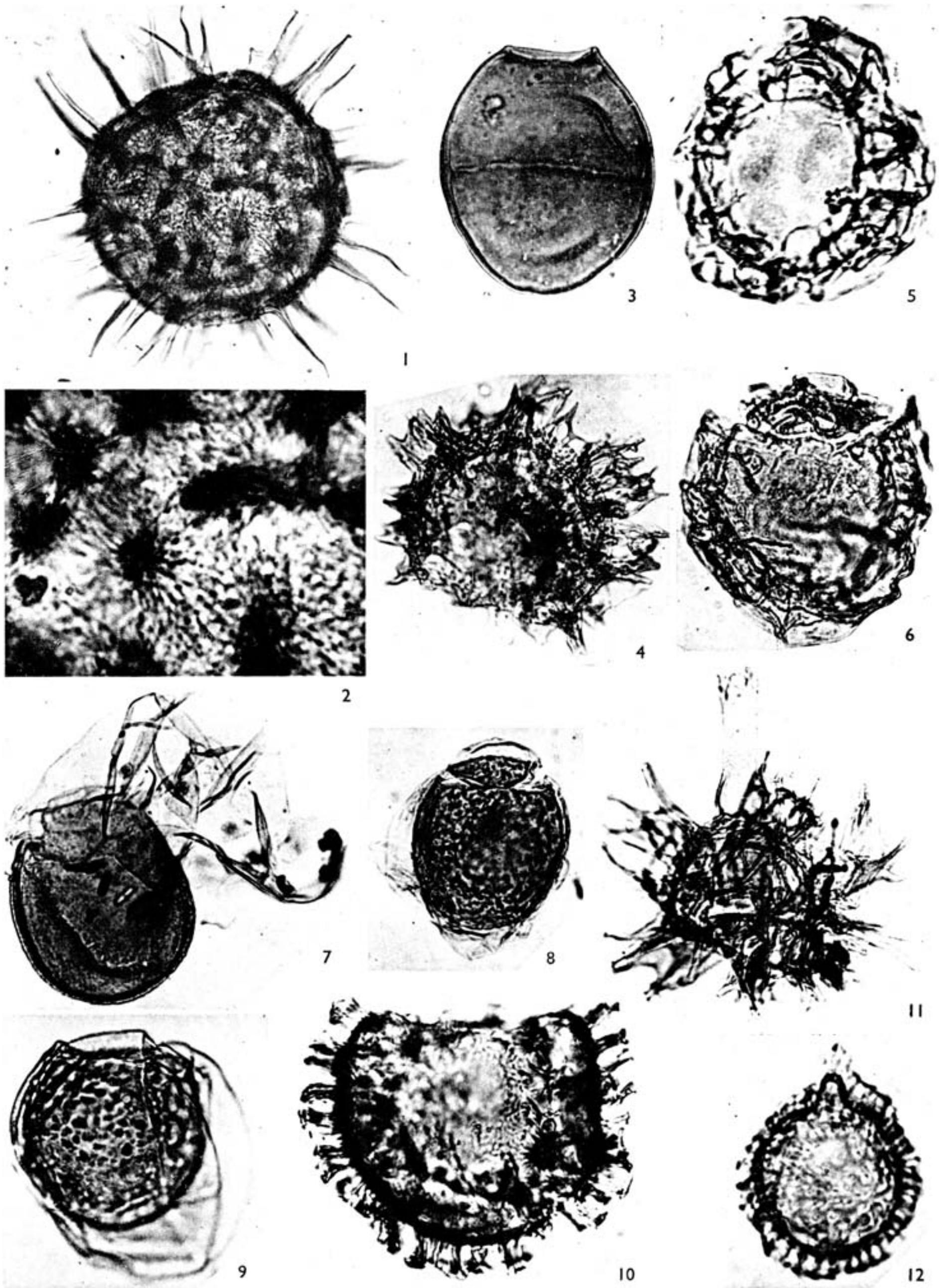

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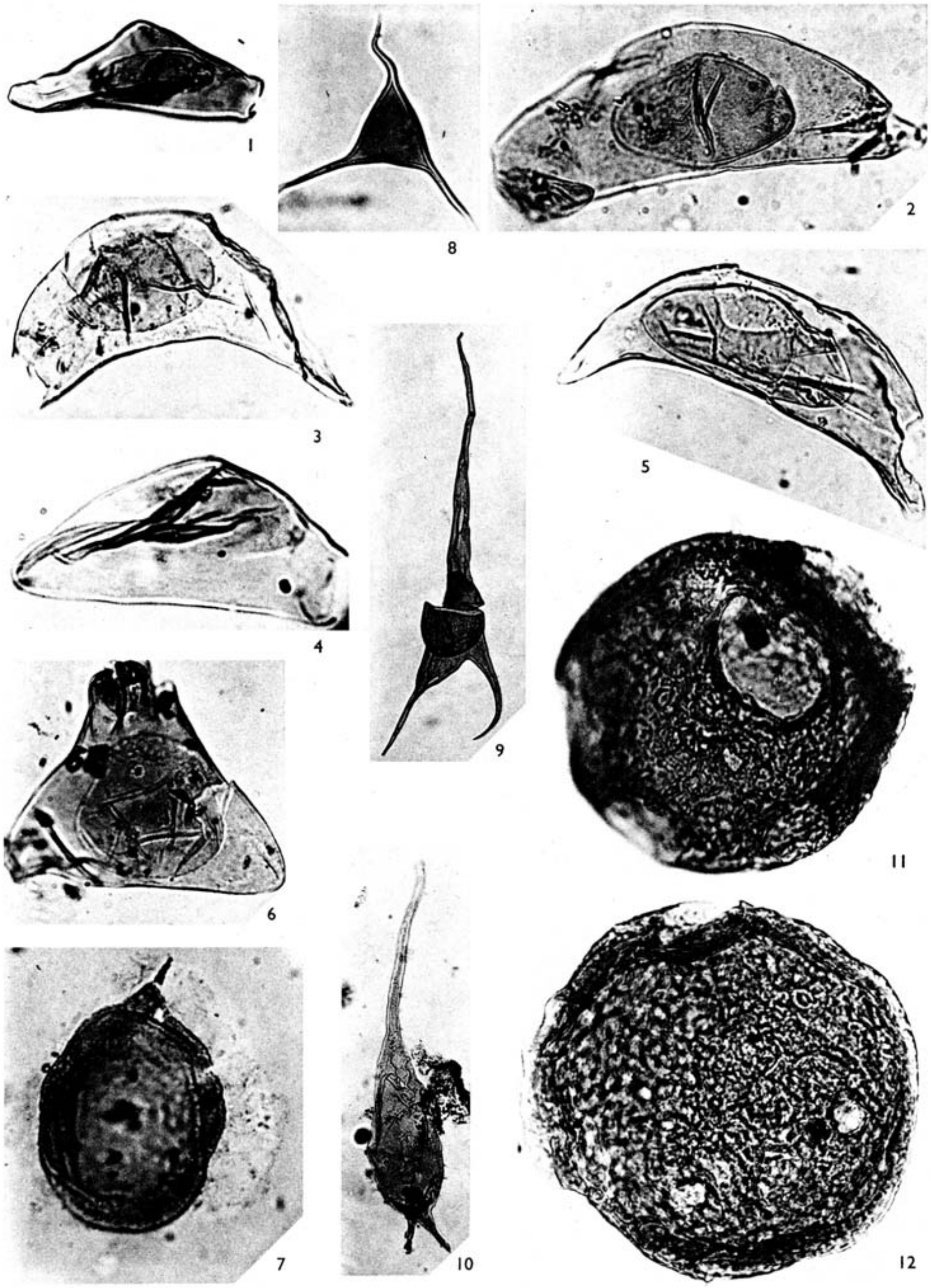

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