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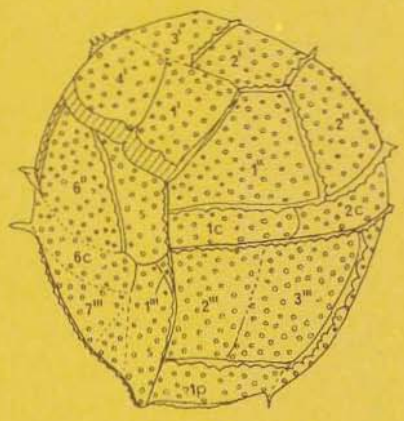
Bulletin No. 132

Dinoflagellate cysts and acritarchs from the Middle and Upper Jurassic of Jameson Land, East Greenland

by

Robert A. Fensome



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Abstract

Twenty-six samples from the Middle and Upper Jurassic strata of Jameson Land were prepared; twenty-one of these were found to contain organic-walled microplankton, of which seventeen yielded assemblages worthy of detailed examination.

A new genus (*Ambonosphaera*) and six new species (*Sentusidinium myriatrichum, Sentusidinium pelionense, Ellipsoidictyum gochtii, Pareodinia brachythelis, Gonyaulacysta birkelundii,* and *Ambonosphaera calloviana*) of dinoflagellates, and two new species of acritarchs (*Veryhachium sortehatense* and *Solisphaeridium ankyleton*) were discovered. One taxon, *Gonyaulacysta pectinigera,* is elevated from subspecific to specific level and its generic reallocation is proposed.

Samples from the Sortehat and Pelion Members of the Vardekløft Formation and from the Olympen formation yielded poor assemblages in terms of the number of taxa present and are therefore not especially biostratigraphically useful. However, previous Bajocian and Lower Oxfordian dates for the Sortehat Member and Olympen Formation respectively are supported.

Moderately rich assemblages from some samples from the Fossilbjerget Member of the Vardekløft Formation and from the Hareelv Formation indicate Bathonian–Callovian and Oxfordian-Kimmeridgian ages respectively. Two samples, one from each of these units, contain organic-walled microplankton assemblages indicative of a date approximately one half stage earlier than that derived from ammonite faunas.

All but one of the samples prepared from the Raukelv Formation contain only carbonized organic remains. One sample, from the Fynselv Member, yielded an assemblage of organic-walled microplankton which, although not conclusive themselves in suggesting a date, do not contradict the latest Jurassic assignation based on ammonite faunas.

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INTRODUCTION

The objective of this work is to describe the dinoflagellate cysts and acritarchs (organic-walled microplankton) from some samples from the Middle and Upper Jurassic of Jameson Land, East Greenland, and to compare ages obtained from these fossils with those obtained from ammonite faunas. This research is intended as a follow-up to Sarjeant's (1972) study of two strewmounts prepared from samples from the Middle Jurassic of Jameson Land.

The location of Jameson Land is shown in text-fig. 1. Text-fig. 2 is a simplified geological map of Jameson Land and also gives the locations of the samples studied. Information pertaining to these samples is given in Table 5. Geological sections through Jameson Land and Liverpool Land are shown in text-fig. 4.

A detailed description of the strata comprising the Middle and Upper Jurassic of Jameson Land was given by Surlyk *et al.* (1973). They formally named the formations and members that are used throughout this work. The ammonite zonation of the Middle and Upper Jurassic of Jameson Land and North-west Europe and the lithological subdivisions of the Jurassic of Jameson Land are shown in Table 1. Details of the history of study of Jurassic strata in Jameson Land can be found in Donovan (1957) and Surlyk *et al.* (1973).

The samples were prepared by standard techniques with minor modifications to suit the equipment present in the palynological laboratory of the University of Saskatchewan.

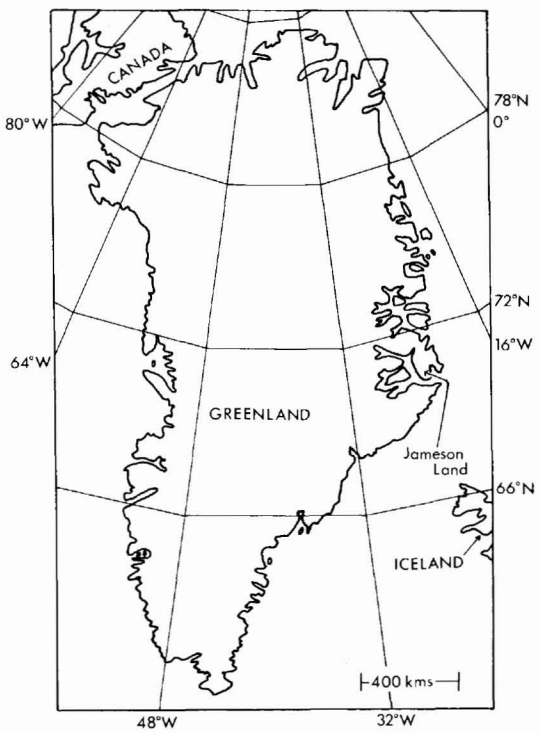
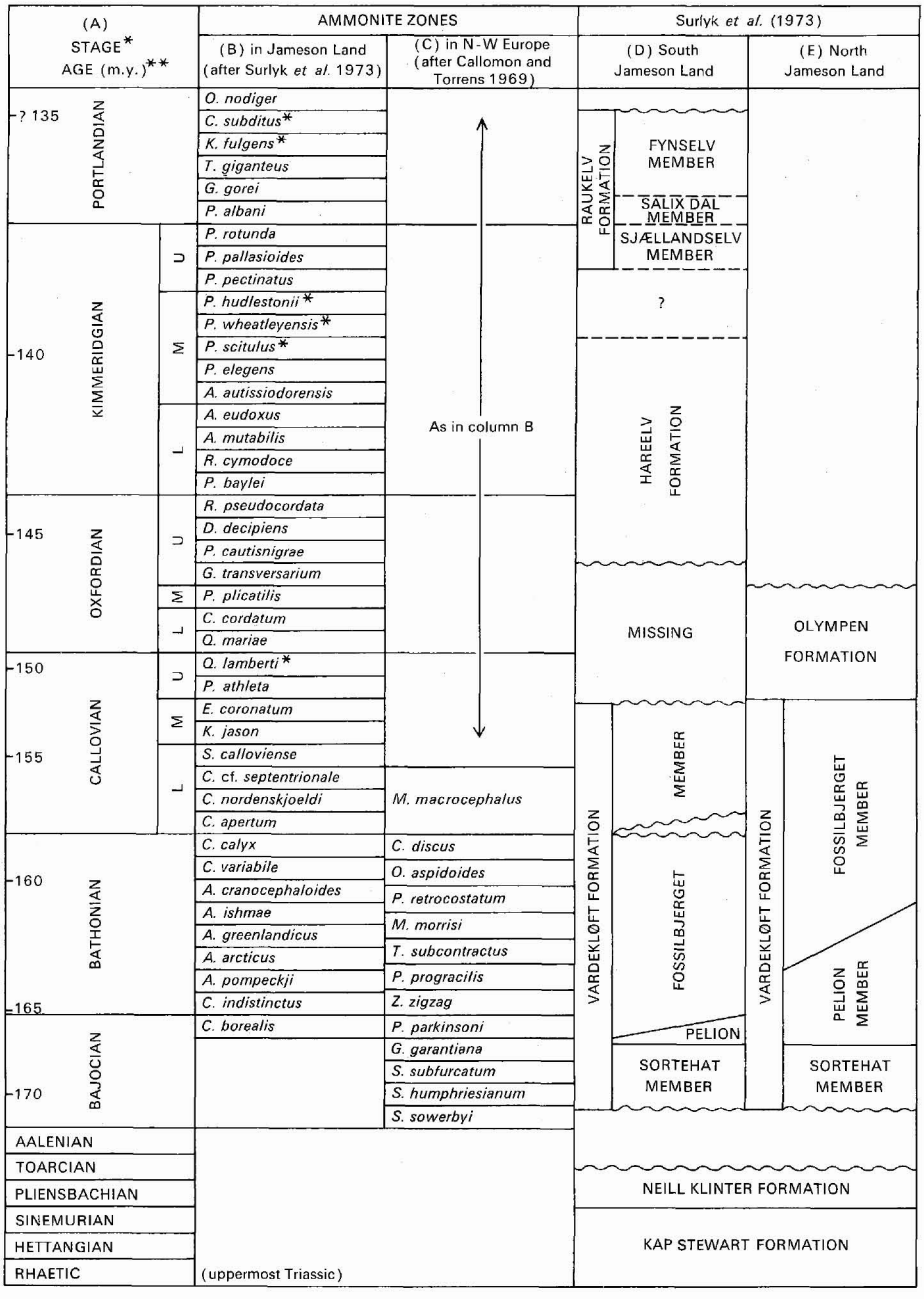


Fig. 1. Map of Greenland, showing the location of Jameson Land.

Table 1. Ammonite zonation of the Middle and Upper Jurassic of Jameson Land and north-western Europe, and the lithological subdivisions of the Jurassic of Jameson Land



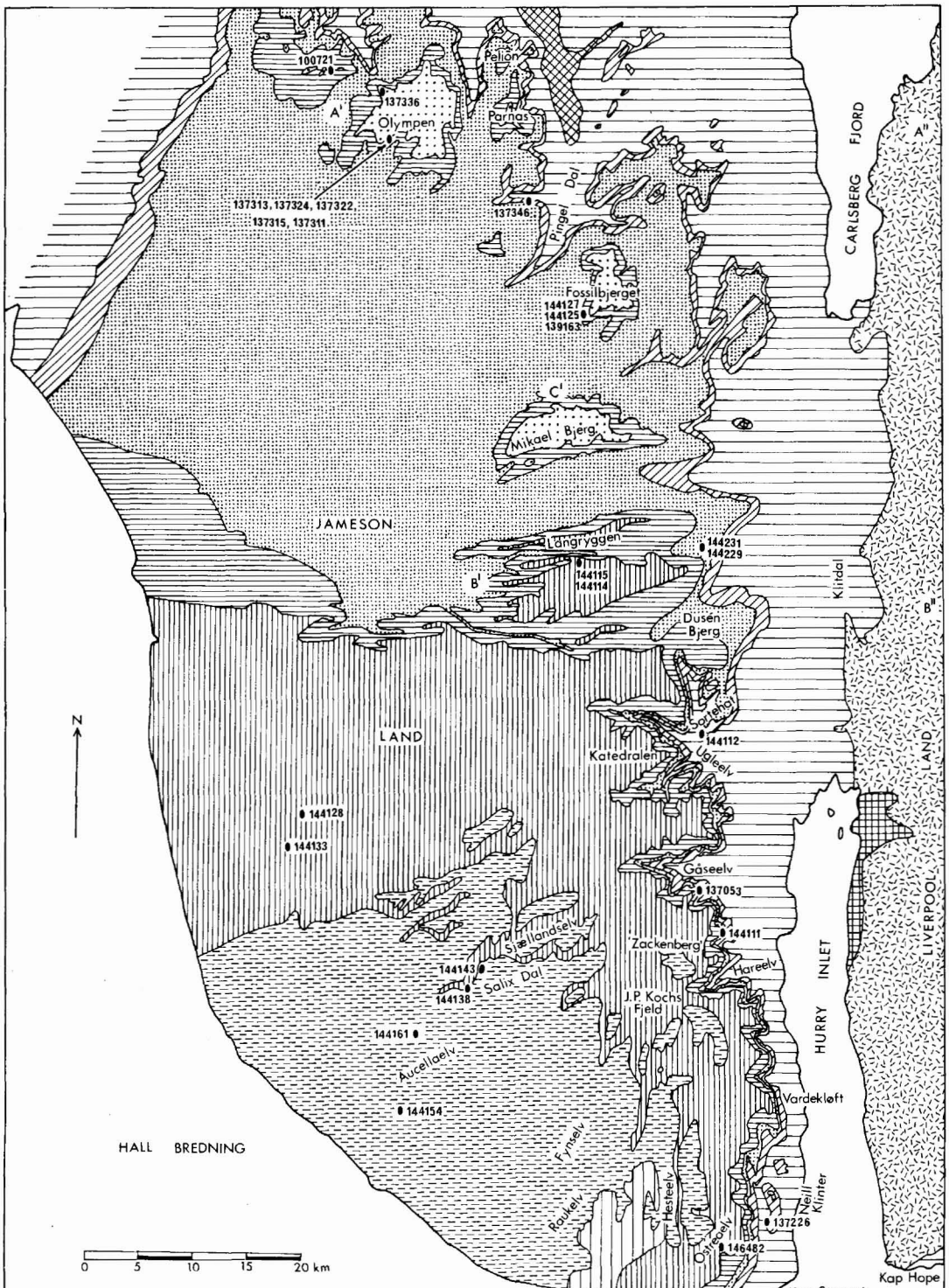


Fig. 2. Simplified geological map of Jameson Land, showing location of samples. (For legend see text-fig. 3).

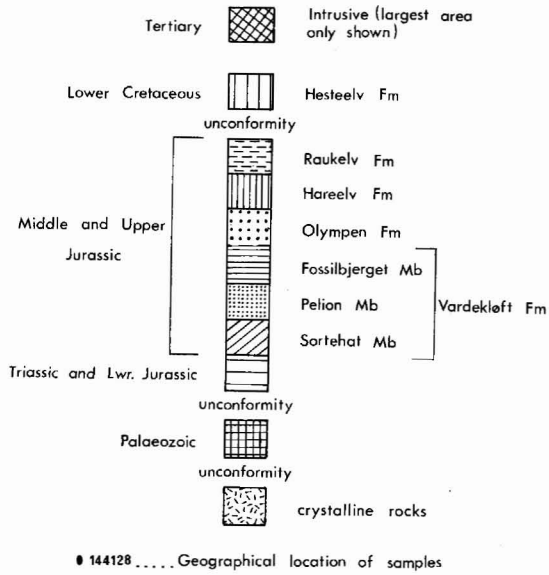


Fig. 3. Legend for text-fig. 2.

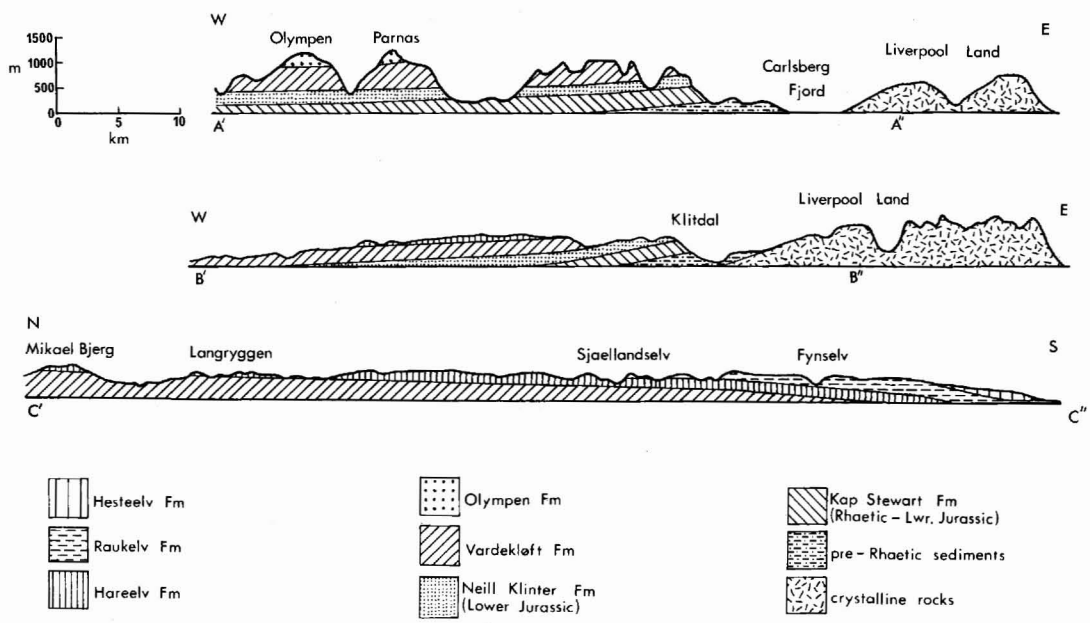


Fig. 4. Geological sections through Jameson Land.

PALAEONTOLOGY

General remarks

The terminology applied to dinoflagellate cysts has been explained in detail by Williams *et al.* (1973) and Evitt *et al.* (1977). The general morphology of acritarchs has been outlined by Evitt (1969).

Where quoting the dimensions of dinoflagellate cysts in the systematic section that follows, the term 'length' specifically refers to the apical-antapical dimension. The term 'breadth' refers to the dimension perpendicular to the length in a plane tangential to the ventral and dorsal surfaces of the cyst; similarly 'depth' indicates the dimension perpendicular to the length in a plane tangential to the lateral surfaces of the cyst.

Where a feature has been measured on more than one specimen, the minimum and maximum dimensions of that feature are given. When a feature is measured on three or more specimens its average dimension is given in parentheses between the maximum and minimum dimensions. For example, the length range of *Chytroeisphaeridia chytroeides* is noted as 35(52)65 μm. This indicates that the minimum and maximum lengths are 35 μm and 65 μm respectively and that the average length of all measured specimens of that species is 52 μm.

All holotypes, paratypes and other figured specimens are lodged in the collections of the Geological Museum, Copenhagen, Denmark. Positions on the microscope slides (in terms of stage readings) of these specimens are given in the text and the captions to plates and text-figures. The stage readings are correct for Zeiss Standard Microscope 4993501, stage 4886971. To facilitate conversion of the stage readings to those of other microscopes, a master slide with reference points has been deposited with the slide collection. With the aid of this, and the stage readings of the reference points taken with the above microscope (deposited with the master slide), conversion factors between stage readings quoted in this work and those from another microscope can be calculated. The author's readings were taken with the slide label to the left; the 'east-west' co-ordinate is given before the 'north-south' co-ordinate.

Wherever possible three hundred microplankton specimens were counted from each sample and additional scanning of at least another one hundred specimens was carried out. However, some samples were barren of microplankton and in some others specimens were so sparse that finding three hundred was impractical.

In samples in which a count of three hundred specimens was possible it was noted that after two hundred had been encountered, only taxa which are rare in these samples were observed for the first time. In the additional scanning only in one case was a specimen of a taxon previously unobserved in an assemblage encountered for the first time.

Systematics

Class DINOPHYCEAE
Order PERIDINIALES
Family CANNINGIACEAE Sarjeant & Downie,1966 emend. Sarjeant & Downie, 1974
Genus *Chytroeisphaeridia* Sarjeant, 1962b emend. Downie & Sarjeant, 1964

Chytroeisphaeridia chytroeides (Sarjeant, 1962b) Downie & Sarjeant, 1964

Plate 1, fig. 1

Leiosphaeridia (Chytroeisphaeridia) chytroeides Sarjeant, 1962b, p. 492; pl. 70, figs 13–16; text-figs 11–12. *Chytroeisphaeridia chytroeides* (Sarjeant); Downie, Evitt & Sarjeant, 1963, p. 9, *nomen nudum* – – Downie & Sarjeant, 1964, p. 103. – Sarjeant, 1965, p. 182; pl. 1, fig. 12. – – Sarjeant, 1968, pl. 3, fig. 10. – – Gitmez, 1970, pp. 242–243; pl. 14, fig. 5. – – Gitmez & Sarjeant, 1972, pp. 185–186; pl. 1, fig. 2. – – Habib, 1972, pl. 4, fig. 4. – – Sarjeant, 1972, p. 40; pl. 2, fig. 5; pl. 3, fig. 1. – – Pocock, 1972, p. 100; pl. 25, fig. 9; pl. 27, figs 21–22; (?). – – Sarjeant, 1976a, p. 25; pl. 3, fig. 3. – – Vigran & Thusu, 1976, pl. 17, fig. 13.

Dimensions: Range; (38 specimens measured) length 35 (52) 65 μm, breadth 36 (55) 74μm.

Remarks: Specimens of *C. chytroeides* vary greatly in size and shape. Such variation is typical for this species; indeed the degree of variability observed in the present study is similar to that illustrated by Sarjeant (1962b, text-fig. 11). The archeopyle is polygonal in shape. There are no other indications of furrows or of a paratabulation.

Davey (1977) has recently cogently argued that *C. chytroeides* has a precingular rather than an apical archeopyle. However, full publication of Davey's findings had not appeared at the time that this paper was in preparation.

Chytroeisphaeridia dictydia Sarjeant, 1972

Plate 1, fig. 10

Chytroeisphaeridia dictydia Sarjeant, 1972, p. 41; pl. 3, fig. 3; pl. 6, fig. 6.

Dimensions: Range; (53 specimens) length 37 (58) 78 μm, breadth 43 (59) 80 μm.

Remarks: The specimens of *C. dictydia* observed in the present study are closely comparable with the type material described by Sarjeant (1972), which was also from Jameson Land. This species is characterized by its consistently finely and irregularly reticulate surface ornamentation. The length of the cyst is typically approximately equal to the breadth. the cyst wall is flexible and therefore tends to be folded. No obvious indication of a paracingulum or a parasulcus was observed, although folding occasionally appears to simulate these structures (Plate 1, fig. 10).

The archeopyle is certainly apical, the operculum usually or always being com-

pletely detached; detached opercula were found. The archeopyle margin is notched by accessory archeopyle sutures; these are usually better developed in *C. dictydia* than in *C. chytroeides* (Sarjeant, 1962b) or *C. pococki* (Sarjeant, 1968).

Chytroeisphaeridia pococki Sarjeant, 1968

Plate 1, fig. 2

Chytroeisphaeridia sp. Sarjeant, 1965, p. 182; pl. 1, fig. 13. *Chytroeisphaeridia pococki* Sarjeant, 1968, p. 230; pl. 3, fig. 9. — Gitmez, 1970, p. 243; pl. 9, figs 7–8; pl. 10, fig. 3. — Gitmez & Sarjeant, 1972, pp. 187–188; pl. 1, fig. 5. — Habib, 1972, pl. 2, fig. 1 — Sarjeant, 1976a, pp. 25–26; pl. 4, fig. 9. — Vigran & Thusu, 1976, pl. 17, fig. 12. *Chytroeisphaeridia chytroeides* (Sarjeant); Gocht, 1970, p. 152; pl. 34, figs 20–24; (?).

Dimensions: Range; (six specimens) length 27 (42) 56 μm, breadth 25 (41) 56 μm.

Remarks: Many of the specimens encountered are poorly preserved or obscured; thus the morphological variation of *C. pococki* in the present study is difficult to observe. The figured specimen is folded, giving it a narrower shape than it would have had originally.

Genus *Sentusidinium* Sarjeant & Stover, 1978

Sentusidinium myriatrichum sp. nov.

Plate 2, fig. 7; text-fig. 5A

Derivation of name: Gr. *myrios,* numberless; *trichos,* hair; in reference to the great abundance of small hairs ornamenting the cysts of this species.

Diagnosis: A species of *Sentusidinium* with a spheroidal to subspheroidal cyst covered with very numerous (about 1000) fine, simple hairs which are approximately one fiftieth of the cyst breadth in length. Distribution of the ornament is continuous, giving no indication of furrows or paratabulation. The cyst wall is thin and often appears to be densely granular, the true nature of the hairs being apparent only at the margin of the cyst.

Holotype: MGUH 14.674, 99.6/12.6 from GGU 144115, Hareelv Formation, south side of Langryggen. Plate 2, fig. 7; text-fig. 5A.

Dimensions: Holotype; length, including attached operculum, 55 μm, length, excluding operculum 42 μm, breadth 48 μm. Range; length, including operculum (two specimens) 55–59 μm, length, without or excluding operculum (four specimens) 42 (48) 49 μm, breadth 45 (51) 59 μm.

Description: S. myriatrichum is characterized by its dense covering of very short, fine hairs. The nature of the ornament can be seen clearly only at the margin of the specimen; in plan view the ornament often resembles a dense granulation. The distal ends of most of the hairs appear to be simple, although some may have

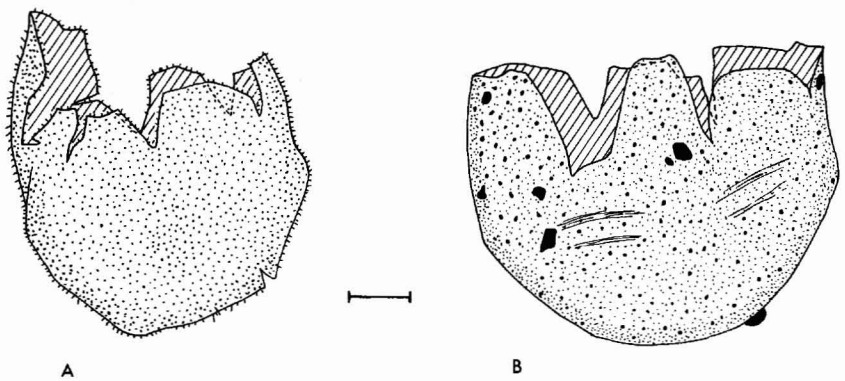


Fig. 5. A; *Sentusidinium myriatrichum* sp. nov., holotype. B; *Sentusidinium pelionense* sp. nov., holotype. (Bar represents 10 microns).

expanded tips; this feature is difficult to discern with the light microscope owing to their small size. The hairs have bulbous bases.

The ornament is continuous and regularly distributed over the cyst surface; there is no indication of furrows or a paratabulation except at the archeopyle margin, which is deeply notched along the parasutures of the parasulcus and six precingular paraplates. The operculum of the holotype remains attached, probably at the parasulcus; however, in the majority of the specimens observed the operculum was completely detached.

The cyst wall is thin and thus tends to be folded. The ambitus is ovoidal to subspheroidal and, when the operculum is detached, the cyst breadth is greater than its length.

Remarks: In its possession of abundant short hairs *S. myriatrichum* is unlike any previously described species of *Sentusidinium*. *Sentusidinium* sp. A. of Fensome, herein, and *Sentusidinium* sp. B of Fensome, herein, also possess numerous very short appendages. *Sentusidinium* sp. A is much smaller, however, and the morphology of its archeopyle is very different from that of *S. myriatrichum*. *Sentusidinium* sp. B is more similar in shape and size, but has a very thick, rigid cyst wall and is thus readily differentiated from *S. myriatrichum*.

Sentusidinium pelionense sp. nov.

Plate 1, figs 5–9; text-fig. 5B

Derivation of name: After the Pelion Member of the Vardekløft Formation, in which this species is most abundantly encountered in the present work.

Diagnosis: A species of dinoflagellate with an ovoidal, thin-walled cyst, of which the breadth is usually or constantly greater than the length. The antapex is gently

rounded. The apex is usually or constantly lost in archeopyle formation. The archeopyle margin is usually, but not consistently deeply notched by accessory archeopyle sutures at the parasulcus and at the parasutures between six precingular paraplates. The paracingulum is weakly to moderately well indicated by slight depressions in the cyst surface, or by lines or clumps of granules which may be coarser than those elsewhere on the cyst wall. There is no other indication of paratabulation on the cyst surface. The general ornamentation of the cyst wall usually consists of a very sparse scatter of tubercles or verrucae of variable size; between verrucae the cyst surface is granular, the granules being variable in size and irregular in distribution. The granules may line up or join to produce low narrow ridges of variable length which, in extreme cases, produce a continuous reticulum. The archeopyle margin tends to have fewer accessory archeopyle sutures in specimens with a reticulate surface ornament.

Holotype: MGUH 14.675, 113.5/10.5 from GGU 144111, Pelion Member, Vardekløft Formation, between Gåseelv and Hareelv. Plate 1, figs 5,7; text-fig. 5B.

Paratypes: (i) MGUH 14.676, 101.0/6.5, Plate 1, fig. 9; (ii) MGUH 14.677, 109.9/19.5, Plate 1, fig. 8; both paratypes from sample GGU 144111, Pelion Member, Vardekløft Formation between Gåseelv and Hareelv.

Dimensions: Holotype; length 48 μm, breadth 60 μm. Paratypes; (i) length 56 μm, breadth 78 μm; (ii) length 49 μm, breadth 69 μm. Range; (24 specimens measured) length 39(51)60 μm, breadth 52(63)78 μm.

Remarks: S. pelionense is distinguished from all other species of *Sentusidinium* by the nature of its ornamentation. Most species of *Sentusidinium* possess spines. *S. verrucosum* (Sarjeant, 1968) is much more densely verrucate and *S? atlanticum* (Habib, 1972) is smaller and minutely granular. In the low relief of its ornamentation *S. pelionense* also resembles species of the genus *Chytroeisphaeridia.* However, no species of *Chytroeisphaeridia* possess verrucae. Because of its possession of verrucae, an often relatively distinct paracingulum and, usually, deep accessory archeopyle sutures, this species was allocated to *Sentusidinium* rather than to *Chytroeisphaeridia.*

The holotype possesses the irregularly granular surface ornamentation which is typical for this species. Paratype (i) has a reticulate pattern on its cyst wall; paratype (ii) possesses an intermediate type of ornamentation. Both paratypes possess fewer accessory archeopyle sutures than is typical for the species.

Apart from the variation of its general surface ornamentation, this species is characterized by a thin, often folded, cyst wall and the consistent occurrence of

sparsely distributed, very coarse granules or verrucae which stand out clearly from the general ornamentation of the cyst wall. A close-up of the cyst surface of the holotype showing several verrucae is shown in Plate 1, fig. 7.

S. pelionense is abundant in one sample from the Pelion Member and was found in the lower part of the Fossilbjerget Member. The ammonite evidence indicates a Bajocian-Bathonian age for these samples. It was surprising, therefore, to find two specimens of *S. pelionense* in a sample from the Fynselv Member of the Raukelv Formation (Upper Kimmeridgian to Portlandian according to Surlyk *et al.*, 1973). These two specimens are probably reworked from Middle Jurassic deposits. This is supported by the presence of other apparently reworked specimens in the same sample (this is discussed more comprehensively in the section dealing with the stratigraphical conclusions for the Raukelv Formation).

Sentusidinium pilosum (Ehrenberg, 1843 emend. Sarjeant, 1968) Sarjeant & Stover, 1978

Plate 1, fig. 3

Xanthidium pilosum Ehrenberg, 1843, pp. 61–63. – Ehrenberg, 1854, pl. 37, fig. 8, no. 4. *Ovum hispidum (Xanthidium) pilosum* (Ehrenberg); Lohmann, 1904, pp. 24–25. *Hystrichosphaeridium pilosum* (Ehrenberg); Deflandre, 1937, p. 79. *Baltisphaeridium pilosum* (Ehrenberg); Sarjeant, 1960b, pl. 13, figs 11–12 – – Sarjeant, 1961a, pp. 101–102; pl. 14, figs 3–5. – – Sarjeant, 1962b, pl. 70, figs 7, 10. *Cleistosphaeridium pilosum* (Ehrenberg); Davey, Downie, Sarjeant & Williams, 1966, p. 170, *nomen nudum. Tenua pilosa* (Ehrenberg); Sarjeant, 1968, p. 231; pl. 2, fig. 7. – – Gitmez, 1970, pp. 244–245; pl. 4, fig. 5. – – Sarjeant, 1975, pl. 3, fig. 7. *Sentusidinium pilosum* (Ehrenberg); Sarjeant & Stover, 1978, p. 50.

Dimensions: Range; (52 measured specimens) central body: length (excluding operculum) 35 (38) 42 μm, breadth 28 (31) 36 μm; length of processes, on average, one seventh of central body breadth.

Remarks: The Jameson Land specimens of *S. pilosum* possess elongate cysts with numerous, often curved, tapering processes. In length the processes are on average one seventh of the central body breadth. Each specimen possesses a mixture of processes with capitate and acuminate endings. All these features are typical for *S. pilosum.* Some specimens possess a granular surface ornamentation; this is probably within the range of morphological variation for this species.

Sentusidinium cf. *S. rioulti* (Sarjeant, 1968) Sarjeant & Stover, 1978

Plate 1, fig. 4

Dimensions: Range; (23 measured specimens) length of central body (operculum detached) 30 (33) 37 μm, breadth of central body 29 (36) 43 μm, length of spines 3–7 μm. Range of type material of *S. rioulti* (after Sarjeant, 1968); length of central body 45–57 μm, breadth of central body 44.5–57 μm.

Remarks: The specimens resemble *S. rioulti* in shape and possession of numerous variable processes with a length between one fifth and one twelfth of the cyst breadth. On both these specimens and on *S. rioulti* the processes have swollen bases, giving the cyst surface a verrucate appearance in plan view. However, the specimens recorded here differ from typical specimens of *S. rioulti* in their significantly smaller size, their lack of granulation on the cyst surface between process bases, and their lesser degree of variation of the process endings. Indeed, in the variation of its process endings *S.* cf. *S. rioulti* more closely resembles *S. villersense* Sarjeant, 1968; *S. villersense,* however, differs from *S.* cf. *S. rioulti* in its almost spherical ambitus and its lack of swollen process bases.

Thus *S.* cf. *S. rioulti* appears in some respects to be intermediate between *S. rioulti* and *S. villersense;* it has, however, more features in common with *S. rioulti.*

Sentusidinium verrucosum (Sarjeant, 1968) Sarjeant & Stover, 1978

Plate 1, fig. 11

Tenua verrucosa Sarjeant, 1968, p. 232; pl. 1, fig. 17; pl. 2, figs 3,6. – – Habib, 1972, pl. 4, fig. 3; pl. 5, fig. 5; (?). *Sentusidinium verrucosum* (Sarjeant); Sarjeant & Stover, 1978, p. 50.

Dimensions: Range; (32 specimens measured) length 32 (42) 49 μm, breadth 35 (44) 50 μm.

Remarks: In all respects the specimens encountered in the present study appear to be typical for this species.

Sentusidinium? sp. A

Plate 2, fig. 2; text-fig. 6b

Description: A form of dinoflagellate with a small ovoidal cyst, elongate in an apical-antapical direction. The cyst wall is folded; it has an overall ornament of very short, regularly spaced spinelets 0.3 to 0.5 μm long. The archeopyle is apical. The operculum appears to be compound, two opercular pieces remaining attached at the archeopyle margin. However, the nature of the archeopyle is not perfectly clear on the single specimen encountered. There is no indication of furrows or paratabulation.

Dimensions: Figured specimen: length 28 μm, breadth 23 μm.

Remarks: This form closely resembles *S? atlanticum* (Habib, 1972) in its possession of a small ovoidal cyst (the angularity of Habib's figured specimens appears to be due to the folding of the cyst wall), and in the granular appearance of the autophragm. However, at the margin of the cyst it can be seen that the ornamentation of *Sentusidinium?* sp. A. consists of short spines rather than granules. The nature of the operculum was not noted by Habib; his illustration (Habib, 1972, pl. 4, fig. 2)

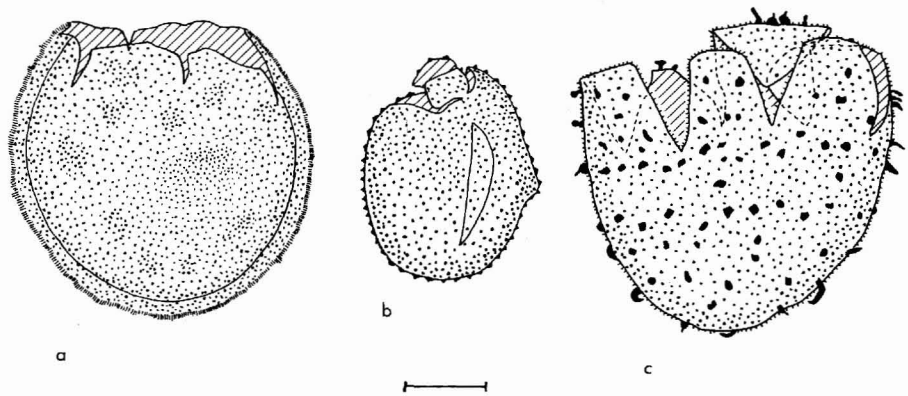


Fig. 6. a; *Sentusidinium* sp. B (MGUH 14.683, 97.9/12.7: from sample GGU 144161, Fynselv Mb). b; *Sentusidinium?* sp. A (MGUH 14.682, 114.6/22.4; from sample GGU 144114, Hareelv Fm). c; *Sentusidinium* sp. C (MGUH 14.684, 99.5/14.6; from sample GGU 144161, Fynselv Mb). (Bar represents 10 microns).

shows a small, partly attached opercular piece, but whether this constitutes the complete operculum or whether it is one of several pieces is not clear to the present author.

In the morphology of its archeopyle and operculum *Sentusidinium?* sp. A is not typical of *Sentusidinium;* indeed these features put its affinity with that genus in question, but no genus has yet been erected that will better accommodate it.

Sentusidinium sp. B

Plate 2, fig. 5,6; text-fig. 6a

Description: A form of dinoflagellate with a spheroidal cyst, possessing a rigid cyst wall 2–3 μm thick. The cyst wall is densely covered with short hairlike spines about 0.5 μm long. In plan view the spines impart a very regular, densely granular appearance. The archeopyle is apical and, in the single specimen encountered, the operculum is detached. The archeopyle margin is deeply notched by accessory archeopyle sutures at the parasulcus and at the parasutures of the precingular paraplates; otherwise there is no indication of furrows or paratabulation.

Dimensions: Figured specimen; length 39 μm, breath 40μm.

Remarks: In its shape and lack of a paracingulum *Sentusidinium* sp. B resembles species of *Chytroeisphaeridia;* however, its possession of spines and parasutural notches along the archeopyle margin clearly identify it as a form of *Sentusidinium. Sentusidinium* sp. B resembles *Chytroeisphaeridia euteiches* Davey, 1969 in shape and thickness of wall, but *C. euteiches* has a dense granulation rather than a cover-

ing of spines. *S. myriatrichum* Fensome, herein, has a much thinner wall and slightly longer spines. *Sentusidinium* sp. A of Fensome, herein, is much smaller, has a thinner wall, and a very different archeopyle morphology.

Sentusidinium sp. C

Plate 2, fig. 1; text-fig. 6c

Description: A form of *Sentusidinium* with an ovoidal ambitus, characterized by the occurrence, on its cyst wall, of two distinctly different types of projections. There is a general cover of very regularly distributed short hairs about 0.5 μm long. There is also a sparse scatter of verrucae, irregularly distributed, which may be surmounted by short, flexible, curved or irregularly shaped spines, 2–4 μm long. Two indistinct rows of verrucae indicate the position of the paracingulum. There is no obvious indication of a paratabulation except along the margin of the apical archeopyle which is notched by accessory archeopyle sutures along the parasutures between six precingular paraplates and at the parasulcus. The operculum is attached in two of the three specimens encountered. The cyst wall is about 1 μm thick.

Dimensions: Range; (two specimens measured) length 30–40 μm, breadth 35–40 μm.

Remarks: In its possession of two types of projections *Sentusidinium* sp. C differs from all previously described species of *Sentusidinium*. *S. myriatrichum* Fensome, herein, possesses a similar cover of short hairs but does not possess any other type of projection. *S. verrucosum* (Sarjeant, 1968) possesses verrucae, but these are not surmounted by spines, nor does *S. verrucosum* possess a dense covering of hairs. *Sentusidinium pelionense* Fensome, herein, has an ornamentation comprising granules and verrucae which are similarly distributed to the hairs and spine-bearing verrucae of *Sentusidinium* sp. C. It is possible that *Sentusidinium* sp. C evolved from an ancestral form morphologically similar to *S. pelionense;* indeed these two species may be closely related.

Specimens very similar to *Sentusidinium* sp. C have been observed by Sarjeant (personal communication) from Bed 2 (*athleta* Zone, Callovian) of the Hackness Rock at Hackness Quarry, Yorkshire (Wright, 1968).

Sentusidinium sp. D

Plate 2, fig. 3; text-fig. 7a,c

Description: A form of *Sentusidinium* with an approximately spheroidal cyst, characterized by its great variety of processes which, in length, are less than one twentieth of the cyst breadth. About 65 processes were counted around the ambitus of the cyst posterior to the archeopyle margin; these vary from verrucae and tuberculae to spines with acuminate, capitate, buccinate, flared or briefly bifurcate

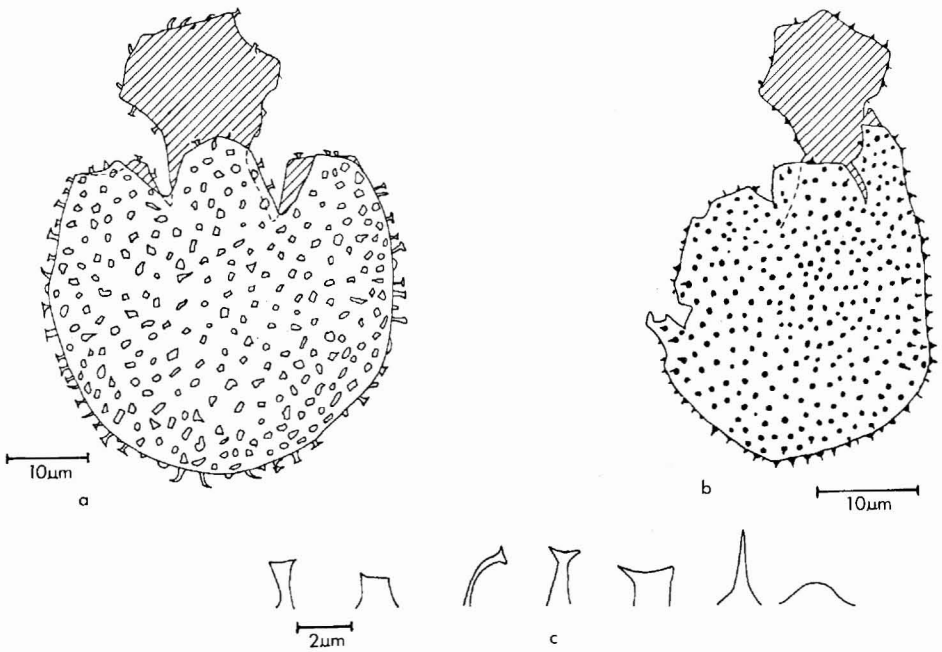


Fig. 7. a; *Sentusidinium* sp. D (MGUH 14.685, 106.4/10.5; from sample GGU 144114, Hareelv Fm). b; *Sentusidinium* sp. E (MGUH 14.686, 100.5/16.4; from sample GGU 144115, Hareelv Fm). c; variation of spine morphology in *Sentusidinium* sp. D.

distal endings. They are more or less regularly distributed over the cyst surface; their distribution gives no obvious indication of furrows or paratabulation. The archeopyle is apical. The archeopyle margin is notched by accessory archeopyle sutures, indicating parasutures between six precingular paraplates. In the single well preserved specimen encountered the polygonal operculum was attached, apparently, to one of the precingular paraplates. The cyst wall is thin; it is unornamented between projections.

Dimensions: Figured specimen; length (including operculum) 58 µm, length (excluding operculum) 41 µm, breadth 45 µm, length of spines up to 2 µm.

Remarks: In the variability of its spines, their shortness, and in the lack of ornamentation of the cyst wall between spines, this form is distinguished from all previously described forms of *Sentusidinium*. Most similar are *S. rioulti* (Sarjeant, 1968) and *S.* cf. *S. rioulti* of Fensome, herein. However, both these forms have an ovoidal rather than a spheroidal cyst and possess significantly longer spines than those of *Sentusidinium* sp. D. The bases of the spines of *S. rioulti* and *S.* cf. *S. rioulti* are swollen; the spine bases of *Sentusidinium* sp. D are not swollen. *Sentusidinium*

sp. D can also be distinguished from typical specimens of *S. rioulti* by the lack of granulation between its spine bases.

Sentusidinium sp. E

Plate 2, fig. 4; text-fig. 7b

Description: A form of *Sentusidinium* having an ovoidal cyst with numerous baculae and short conical, tapering and cylindrical spines; these projections usually or constantly possess swollen bases. The nature of the projections can be clearly perceived only at the margin of the cyst; in plan view the ornamentation resembles a coarse granulation. The paracingulum in one of the specimens observed is marked by parallel rows of spines; this was not observed, however, in the other two specimens. There is no other indication of furrows or paratabulation except along the margin of the apical archeopyle, which is notched by accessory archeopyle sutures to indicate the parasutures between six precingular paraplates. The operculum, in all specimens observed, was attached.

Dimensions: Range; (two specimens) length (with operculum) 41–47 μm, length (without operculum) 35 μm (both), breadth 28–35 μm.

Remarks: This form differs from *Sentusidinium* sp. D of Fensome, herein, in the shape of its cyst and the absence of spines with enlarged distal endings. It also differs from *S. myriatrichum* Fensome, herein, and *Sentusidinium* sp. B of Fensome, herein, by the sparser distribution of its spines and their more complex and varied nature. *S. echinatum* (Gitmez & Sarjeant, 1972) has spines of similar length and distribution; however, the spines of *S. echinatum* are uniformly conical.

Genus *Ellipsoidictyum* Klement, 1960

Ellipsoidictyum gochtii sp. nov.

Plate 2, figs 8–9, 11–12; text-fig. 8

Gen. et sp. indet. 2 of Gocht, 1970, p. 152, pl. 34, figs 18–19; text-fig. 21.

Derivation of name: After Dr. Hans Gocht, micropalaeontologist at the University of Tübingen, West Germany.

Diagnosis: A species of *Ellipsoidictyum* with an ovoidal central body, from which arise numerous regularly distributed buccinate, capitate or bifurcate processes; these have a length equalling about one seventh of the breadth of the central body. The processes arise from low discontinuous crests which appear to represent the rudiments of a reticulum, although no enclosed fields are present. A laevorotatory paracingulum is clearly marked by parallel, almost continuous, crests. The parasulcus is marked on the ventral surface of the cyst by a zone almost free of crests. The cyst wall is single layered; the surface is regularly and densely pitted. The ar-

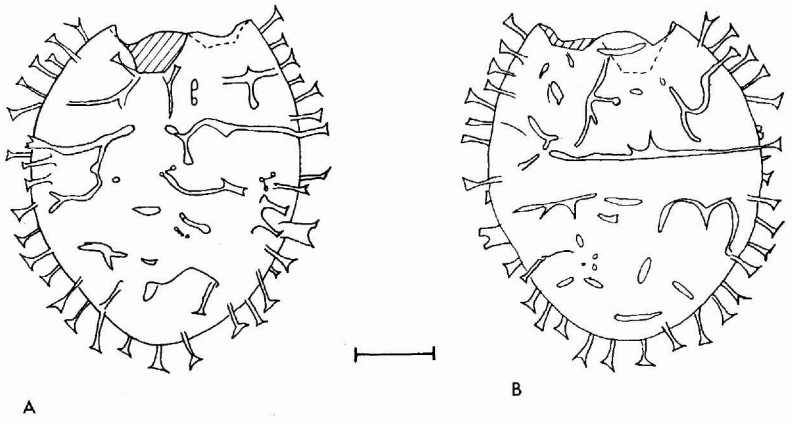


Fig. 8. *Ellipsoidictyum gochtii* sp. nov., holotype. A; ventral view. B; dorsal view. (Bar represents 10 microns).

cheopyle is apical, polygonal and characterized by a moderately deep, broad parasulcal notch on its ventral margin.

Holotype: MGUH 14.687, 115.4/18.0; from GGU 100721, Fossilbjerget Member, Vardekløft Formation, west of Olympen. Plate 2, figs 8–9, 11–12; text-fig. 8.

Dimensions: Holotype; length of central body 42 μm, breadth of central body 35 μm, length of spines 4–6 μm. Range; (eight specimens) length of central body 42 (44) 48 μm, breadth of central body 35 (40) 49 μm, length of spines 3 (4.5) 6 μm.

Description: Ellipsoidictyum gochtii possesses an ovoidal, dorso-ventrally compressed cyst. The cyst wall is single layered. It is ornamented by a fine honeycomb-like pattern of pits. More or less regularly distributed processes arise from a discontinuous network of low crests on the cyst surface. These processes are buccinate, capitate or symmetrically or asymmetrically bifurcate at their distal ends. They are usually solid, though small cavities may be present at their base, or elsewhere along their length; they are distally closed. The processes vary in length by about 2 μm on a single specimen and also vary in thickness. One process on the holotype is exceptionally broad and hollow, but such processes are rare (Gocht [1970, text-fig. 21] also illustrates one exceptionally broad process in his figured specimen).

The paracingulum is clearly defined by two parallel crests which are partly disrupted but more continuous than any crests elsewhere on the cyst. In all of the specimens encountered, crests occurred only rarely within the paracingulum. The paracingulum is laevorotatory, its two ends being offset at the parasulcus by a distance equal to one paracingulum width. The parasulcus is also readily perceived; it is indicated by a broad parasulcal notch on the archeopyle margin, displacement

of the paracingulum and a relative absence of crests within or crossing it. However, its margins are not delineated by crests for most of their length. The crests on the cyst surface appear to give some indication of a gonyaulacoid paratabulation.

The archeopyle is apical, the operculum being detached in all specimens encountered. It is polygonal in outline but not deeply notched except at the parasulcus.

Remarks: This species is clearly attributable to the genus *Ellipsoidictyum* because of its apical archeopyle, its pattern of crests and processes, its clearly defined furrows, the indistinct indication of a paratabulation, and its ovoidal shape. It differs from *E. cinctum* Klement, 1960 and *E. reticulatum* (Valensi, 1953) in the discontinuous nature of its crests, and from *E. cinctum* additionally in its possession of numerous processes arising from its crests. Its finely pitted surface ornament is also characteristic.

Gocht (1970) described a very similar form which he called Gen. et sp. indet. 2. Apart from the presence of some simple processes and, at least in his figured specimen, slightly less well defined furrows, Gocht's specimens and those from Jameson Land are morphologically very similar; indeed they are almost certainly representatives of the same species.

Family AREOLIGERACEAE Evitt, 1963 emend. Sarjeant & Downie, 1966.

Genus *Cyclonephelium* Deflandre & Cookson, 1955 emend. Sarjeant & Stover, 1978.

Cyclonephelium hystrix (Eisenack, 1958) Sarjeant & Stover, 1978

Plate 2, fig. 10

Tenua hystrix Eisenack, 1958, p. 410; pl. 23, figs 1–4; text-fig. 10. – – Gitmez, 1970, p. 244; pl. 5, fig. 8; pl. 10, fig. 7; (?). *Tenua hystricella* Eisenack, 1958, p. 411; pl. 23, figs 5–7. *Cyclonephelium hystrix* (Eisenack); Sarjeant & Stover, 1978, p. 52.

Dimensions: Range; (seven measured specimens) length (operculum lost or excluded) 47 (55) 62 μm, breadth 46 (55) 63 μm, length of spines 2–4 μm.

Remarks: Spines on the specimens encountered in the present study are more densely distributed marginally, thus supporting the transfer of this species from *Tenua* by Sarjeant & Stover (1978). The spines on the ventral and dorsal surfaces of these specimens are arranged so as to crudely simulate a paratabulation.

Family MEMBRANILARNACEAE Eisenack, 1963 emend. Sarjeant & Downie, 1966

Genus *Valensiella* Eisenack, 1963

Valensiella ovulum (Deflandre, 1947) Eisenack, 1963

Plate 3, figs 2, 3

Membranilarnax ovulum Deflandre, 1947, p. 9; figs 22–23. – – Valensi, 1953, p. 62; pl. 9, figs 6, 12. – – Sarjeant, 1961a, p. 109; text-fig. 9c. *Valensiella ovula* (Deflandre); Eisenack, 1963, p. 101. *Favilarnax ovulum* (Deflandre); Sarjeant, 1963, p. 720, *nomen nudum*. *Valensiella ovulum* (Deflandre); Gocht, 1970, pp. 148–149; pl. 34, figs 1–6; text-figs 19b-c. – – Sarjeant, 1976a, p. 26; pl. 5, figs 3, 6. *Valensiella ovalum (sic)* (Deflandre); Vigran & Thusu, 1976, pl. 17, figs 4–10.

Dimensions: Range; (seven specimens measured) overall size: length 65 (75) 85 μm, breadth 56 (69) 84 μm; autocyst: length 53 (61) 70 μm, breadth 47 (57) 68 μm.

Remarks: The specimens of *V. ovulum* from Jameson Land are, on average, significantly larger than Deflandre's type material for this species; furthermore some specimens are spheroidal rather than ovoidal, although this is probably due to their oblique orientation on the slide. A paracingulum was often, though not consistently, perceived on the dorsal surface, but there was no indication of a paratabulation. In the latter feature and in all other respects the specimens of *V. ovulum* from Jameson Land are typical for the species.

Valensiella sp.

Plate 3, figs 10, 11; text-fig. 9A

Description: A form of *Valensiella* with an ovoidal, dorso-ventrally compressed cyst. The archeopyle is apical, polygonal and possesses an entire margin except for a deep, broad parasulcal notch. The autophragm is thick and densely granular and possesses crests which link it to the thin ectophragm.

The crests form a vermiculate pattern, not as densely distributed or as irregularly arranged as the crests of *V. ampulla* Gocht, 1970 and forming a much more regular pattern than the crests of *V. vermiculata* Gocht, 1970. On the ventral surface the crests produce some closed fields; indeed, in ventral view *Valensiella* sp. more closely resembles *V. ovulum* (Deflandre, 1947). A comparison of the crest patterns formed by *Valensiella* sp. with those of other species of *Valensiella* is made in text-fig. 9.

The paracingulum is not clearly indicated, but it may be represented by an indistinct zone almost free of crests on the dorsal surface, and several aligned, elongate enclosed fields on the ventral surface. The parasulcus is indicated by the parasulcal notch on the ventral side of the archeopyle margin and, in the single well preserved specimen encountered, by two apertures (Plate 3, fig. 10). These apertures may reflect the flagellar pores of the motile dinoflagellate, although they are considerably larger than typical flagellar pores; they are elongate in an antero-posterior direction, in line with the sulcal notch of the archeopyle margin and

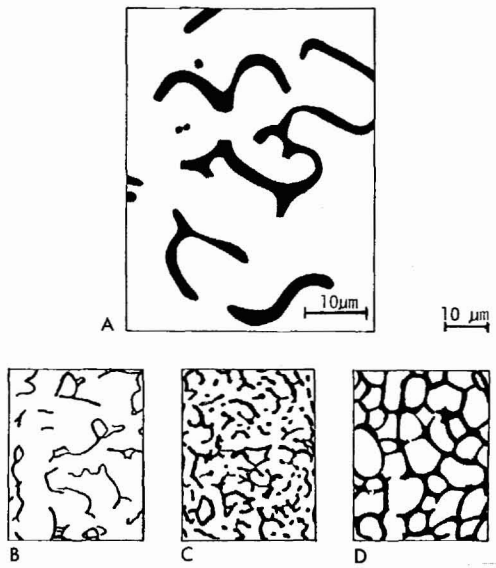


Fig. 9. Surface ornamentation of forms of *Valensiella.* A; dorsal surface of *Valensiella* sp. of Fensome, herein. B; *V. vermiculata* Gocht. C; *V. ampulla* Gocht. D; *V. ovulum* (Deflandre). (B, C and D after Gocht, 1970, text-fig. 19).

are separated from each other by a strip of cyst wall 1 µm or less wide. The anterior aperture measures 8 µm by 5 µm and the posterior aperture, which is immediately adjacent to an elongate crest enclosed field, which may represent part of the paracingulum, measures 7 µm by 4 µm.

Dimensions: Figured specimen; overall size: length 79 µm, breadth 65 µm, size of autocyst: length 65 µm, breadth 53 µm.

Remarks: In the pattern of its crests this species appears to be intermediate between *V. ovulum* on one side and *V. ampulla* and *V. vermiculata* on the other. *Valensiella* sp. is larger than is usual for specimens of *Valensiella.*

Family STEPHANELYTRACEAE Stover, Sarjeant & Drugg, 1977.

Genus *Stephanelytron* Sarjeant, 1961a emend. Stover, Sarjeant & Drugg, 1977

Stephanelytron cf. *S. redcliffense* Sarjeant, 1961a emend. Stover, Sarjeant & Drugg, 1977

Plate 3, fig. 6

Dimensions: Figured specimen; central body: length 42 µm, breadth 28 µm; length of processes to 6 µm.

Remarks: This specimen has processes which are typical for *S. redcliffense* in mor-

phology and distribution. The exact nature of the corona, however, is uncertain because of distortion of the specimen in the region of the antapex. Because the shape of the corona is an important factor in the identification of *S. redcliffense* this specimen is compared with, rather than allocated to, that species.

Stephanelytron caytonense Sarjeant, 1961a emend. Stover, Sarjeant & Drugg, 1977
Plate 3, fig. 5

Stephanelytron caytonense Sarjeant, 1961a, p. 110; pl. 15, fig. 16; text-fig. 11. – – Sarjeant, 1968, p. 225; pl. 1, fig. 19. – – emend. Stover, Sarjeant & Drugg, 1977, pp. 332–333; pl. 1, figs 7–8.

Dimensions: Range; (ten specimens measured) central body: length 42 (52) 65 μm, breadth 27 (37) 58 μm; average depth of corona 13 μm, length of processes 4 (6.5) 10 μm.

Remarks: Stover, Sarjeant & Drugg (1977) remark that *Stephanelytron caytonense* seems to be intergradational with *S. redcliffense.* However, they advocate the retention of both species because specimens of them do not always occur together in the same samples; moreover, the total ranges of the two species differ.

Of the specimens of *Stephanelytron* encountered in the present study, all but one are assigned to *S. caytonense;* this is because of their possession of flaring coronas (ratio between the distal and proximal diameters of the corona is usually about 3:2) and other '*caytonense*-like' features, notably porate processes and a central body approaching a subspheroidal shape. However, several specimens possess some '*redcliffense*-like' features; for instance a few specimens have distally flaring and occasionally fused processes which clearly indicate a paratabulation.

Processes are invariably porate. The corona, however, is less consistently porate, sometimes being smooth or faintly granular. The shape of the central body is also variable; usually it is subspheroidal to slightly ovoidal, but some specimens have a distinctly elongate shape. A well preserved ectophragm was displayed by several specimens.

Thus, although most specimens attributed to this species in the present study can be clearly regarded as typical of *S. caytonense,* some appear to be intermediate with *S. redcliffense* in certain features, supporting the premise of Stover, Sarjeant & Drugg (1977) that the two species may intergrade.

Family MICRODINIACEAE Eisenack, 1964 emend. Sarjeant & Downie, 1974
Genus *Egmontodinium* Gitmez & Sarjeant, 1972
Egmontodinium sp.
Plate 3, fig. 1

Description: A species of *Egmontodinium* with a small elongate ovoidal cyst. The parasutures are marked by rows of coarse granules to baculae. Because of the locally indistinct nature of the parasutures and the compression of the cyst bringing

dorsal and ventral surfaces close together, the complex paratabulation was exceedingly difficult to interpret on the specimen found. However, both posterior and anterior circle paraplate series appear to be present. The paracingulum is narrow (3 μm). The archeopyle is apical, the archeopyle margin possessing shallow accessory archeopyle sutures at the parasulcus and at the parasutures between the anterior circle paraplates. The surface of the cyst is irregularly and discontinuously reticulate.

Dimensions: Figured specimen; length 29 μm, breadth 23 μm.

Remarks: Egmontodinium sp. differs from *E. polyplacophorum* Gitmez & Sarjeant, 1972 in its small size and the nature of the ornamentation of its surface and parasutural crests; the details of the paratabulation of the two species will probably also be found to be at variance when the paratabulation of *Egmontodinium* sp. is known in detail.

Genus *Lithodinia* Eisenack, 1935

Lithodinia cf. *L. jurassica* Eisenack, 1935 emend. Gocht, 1975b

Plate 3, figs 8, 9; text-fig. 10

Description: A form of *Lithodinia* which is very similar to *L. jurassica* in its shape and size (although it is slightly smaller than is typical for *L. jurassica.*) These two forms also possess very similar surface and parasutural ornament (described in detail by Gocht, 1975b) and have similarly shaped archeopyles. The paratabulation of *L.* cf. *L. jurassica* is in general comparable with that of *L. jurassica;* however, *L.* cf. *L. jurassica* appears to possess seven postcingular paraplates. Paraplate 1''' is small and is situated within the parasulcus, immediately adjacent to 2'''; in size and position it is therefore analagous to paraplate 1''' of many species of *Gonyaulacysta.* The parasuture between paraplates 2''' and 3''' is faintly indicated for most of its length. Indeed, whether this poorly defined ridge actually marks a parasuture or not is uncertain; because only one specimen was found, however, the consistent presence of this feature was not ascertained. The parasulcus of *L.* cf. *L. jurassica* is relatively narrow compared with that of *L. jurassica.*

Dimensions: Figured specimen; length 50 μm, breadth 48 μm, height of crests (with spines) 0.2–3.5 μm.

Remarks: This form differs from *L. jurassica* principally in its possession of 6 or 7 postcingular paraplates compared with five in typical specimens of *L. jurassica.* The previously recorded stratigraphical range of *L. jurassica* is Bathonian–Callovian; this specimen of *L.* cf. *L. jurassica* was encountered from the Fynselv Member, of Late Kimmeridgian–Portlandian age (based on ammonite faunas). The author considers that this specimen is probably reworked, in spite of its excellent preser-

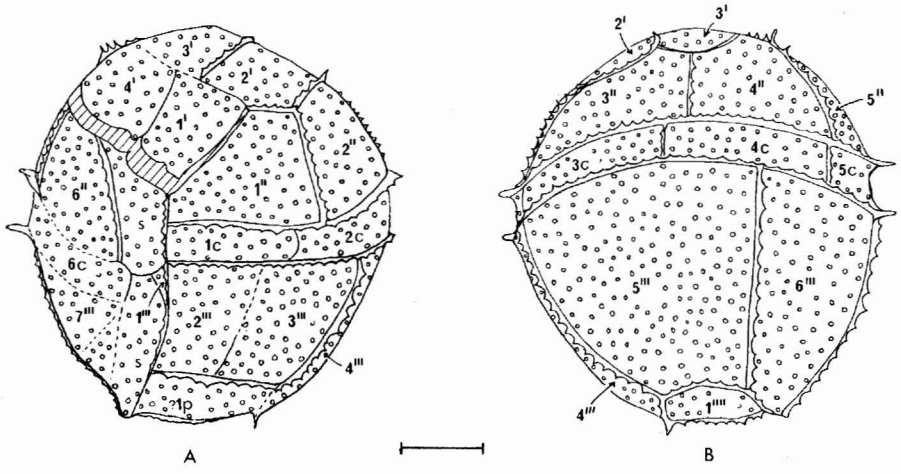


Fig. 10. *Lithodinia* cf. *L. jurassica* Eisenack (MGUH 14.694, 90.5/15.9; from sample GGU 144161, Fynselv Mb). A; ventral view. B; dorsal view. (Bar represents 10 microns).

vation. In support of this conclusion it may be noted that the assemblage from which *L.* cf. *L. jurassica* is found contains other forms which appear to be reworked from Middle Jurassic or lowermost Upper Jurassic strata (see Stratigraphical considerations).

Family Pareodiniaceae Gocht, 1957 emend. Sarjeant & Downie, 1974 emend. Wiggins, 1975

Genus *Pareodinia* Deflandre, 1947 emend. Gocht, 1970 emend. Johnson & Hills, 1973 emend. Wiggins, 1975

Pareodinia ceratophora Deflandre, 1947

Plate 4, fig. 8

Pareodinia ceratophora Deflandre, 1947, p. 4; figs 1–3. – – Valensi, 1953, pp. 29–30; pl. 13, fig. 4. – – Sarjeant, 1960b, pl. 12, fig. 11. – – Sarjeant, 1961a, p. 99; pl. 13, fig. 16. – – Alberti, 1961, p. 23; pl. 2, fig. 14. – – Sarjeant, 1962a, p. 263; pl. 1, fig. 13. – – Sarjeant, 1962b, p. 483; pl. 69, fig. 8; text-fig. 5. – – Vozzhennikova, 1965, fig. 32e. (English translation in Vozzhennikova, 1967b.) – – Sarjeant, 1966b, pp. 211–212; pl. 23, fig. 2. – – Sarjeant, 1968, p. 4; pl. 1, fig. 13. – – Gitmez 1970, p. 281; pl. 6, figs 5–6; pl. 14, fig. 6. – – Gocht, 1970, pp. 154–156; pl. 35, figs 1–8; text-figs 22–25. – – Sarjeant, 1972, pp. 23–25; pl. 4, fig. 8. – – Pocock, 1972, p. 96; pl. 24, figs 3, 5; text-fig. 13. – Habib, 1972 pl. 6, fig. 2. – – Johnson & Hills, 1973, pl. 1, fig. 9; pl. 13, fig. 5; text-fig. 6 – – Wiggins, 1975, p. 103; pl. 1, figs 1–7. – – Filatoff, 1975, p. 90; pl. 29, fig. 15. – – Sarjeant, 1976a, p. 21; pl. 4, fig. 2. – – Vigran & Thusu, 1976, pl. 17, figs 1, 3. – – Bjaerke, Edwards & Thusu, 1976, pl. 1, fig. 6. Peridinien indeterminé Valensi, 1953, pl. 3, figs 4, 7. *Pareodinia aphelia* Cookson & Eisenack, 1958, p. 60; pl. 12, fig. 9; (?). *Cryptomeriapollenites coralliensis* Lantz, 1958, p. 927, pl. 5, figs 55–56; pl. 6, fig. 57. *Kalyptea monoceras* Cookson & Eisenack, 1960b, p. 257; pl. 39, figs 2–3. *Pareodinia cerathophora (sic)* De-

flandre; Balteş, 1963, p. 584; pl. 4, fig. 7; (?). *Pareodinia* cf. *ceratophora* Deflandre; Evitt, 1967, p. 3; pl. 4, fig. 7.

Dimensions: Range; (52 specimens measured) length 61 (74) 96 μm, breadth 31 (44) 63 μm, length of apical horn 10 (23) 33 μm.

Remarks: The size and shape of the archeopyle tends to vary. It appears consistently to involve three anterior intercalary paraplates; the relative sizes of these paraplates, which form separate opercular pieces, also appear to be significantly variable. Similar observations were reported by Wiggins (1975). The variation exhibited by the archeopyle and opercular pieces may have taxonomic significance. However, differentiation of taxa on such a basis would probably be difficult to apply because, when the opercular pieces are completely detached, their individual shapes are not evident from the morphology of the archeopyle. Alternatively and more likely, the variation described above may be a characteristic of a single species (i.e. *P. ceratophora*).

Several of the Jameson Land specimens possess kalyptras or apicular structures, or both. In the present study these features appear to have no stratigraphical or taxonomic significance. However, in some samples, specimens of *P. ceratophora* consistently lacked kalyptras (for example those in sample GGU 144133) whereas in other samples specimens of this species usually or constantly possess kalyptras (or remnants of kalyptras). Since all samples underwent similar preparation procedures, some primary factor, probably ecological, controlling the presence or absence of this feature is suggested.

Pareodinia ceratophora Deflandre 1947b subsp. *scopaeus* (Sarjeant, 1972) Lentin & Williams, 1973

Plate 3, figs 4, 7

Pareodinia ceratophora var. *scopaeus* Sarjeant, 1972, p. 26; pl. 2, fig. 4. *Pareodinia ceratophora* subsp. *scopaeus* (Sarjeant); Lentin & Williams, 1973, p. 108.

Dimensions: Range; (eight specimens measured) length 37 (49) 58 μm, breadth 31 (40) 48 μm, length of apical horn 6 (9) 12 μm.

Remarks: In two specimens of *P. ceratophora* subsp. *scopaeus* from Jameson Land folding of the cyst wall produced a structure comparable to the 'pseudo-endoblasts' described by Wiggins (1975).

Because no intermediate forms have yet been recorded between *P. ceratophora* and *P. ceratophora* subsp. *scopaeus,* the status of subspecies is here preferred.

Pareodinia brachythelis sp.nov.

Plate 4, figs 3,5–7; text-fig. 11

Pareodinia sp. B of Wiggins, 1975, p. 108; pl. 2, fig. 6;(?).

Derivation of name: Gr. *brachy,* small: *thelis,* nipple; in reference to the short apical horn of this species.

Diagnosis: A species of *Pareodinia* having a thick cyst wall densely ornamented by coarse granules or verrucae. The cyst is ovoidal with a smoothly rounded outline, and surmounted by a distinct, short mamelon-like apical horn which is often itself surmounted by a rod-like or irregularly shaped solid apicular structure; similar structures may occur elsewhere on the cyst wall, notably at the antapex. The archeopyle is intercalary, involving the loss of three (occasionally possibly four or more) paraplates. The operculum is compound. The paracingulum is usually only weakly indicated or absent. There is no other indication of a paratabulation.

Holotype: MGUH 14.697, 101.2/6.2; from GGU 144125, Fossilbjerget Member, Vardekløft Formation, west side of Fossilbjerget. Plate 4, fig. 5; text-fig. 11E.

Paratype: MGUH 14.698, 108.7/11.5; from GGU 144125, Fossilbjerget Member, Vardekløft Formation, west side of Fossilbjerget. Plate 4, fig. 3; text-fig. 11C.

Dimensions: Holotype; length 52 μm, breadth 37 μm, length of apical horn 5 μm, length of apicular structure 2 μm. Paratype; length 54 μm, breadth 32 μm, length of apical horn 4 μm, length of apicular structure 2 μm. Range; (36 specimens measured) length 45 (54) 66 μm, breadth 31 (36) 42 μm, length of apical horn 3 (6) 8 μm, length of apicular structure (where present) 2 (3.5) 5 μm.

Description: The apical horn is of characteristic shape, with a broad base and a usually well rounded distal extremity (exclusive of any apicular structure). The horn is usually distinct from the rest of the cyst; it is variable in length but, in the type material, this does not exceed one sixth of the overall length of the cyst. Rarely the horn may be very short; indeed one specimen superficially resembles a form of *Chytroeisphaeridia.* The presence of a rod-like or irregularly shaped apicular structure at the distal tip of the apical horn often gives the apex a more pointed or irregular shape. Solid protuberances of irregular outline may rarely occur elsewhere on the cyst surface, especially at the antapex.

The paratype appears to possess a pre-apical paraplate on its apical horn differentiated from the rest of the cyst by a more lightly stained portion of the cyst wall; this is ornamented by a scatter of coarse, wart-like verrucae. A pre-apical paraplate was not observed on any other specimen from Jameson Land (although see Remarks below).

The archeopyle is large. The operculum is compound; it is formed by three or perhaps occasionally four or more anterior intercalary paraplates. Each opercular piece may be attached to or detached from the archeopyle margin; detached opercular pieces often occur within the cavity of the cyst.

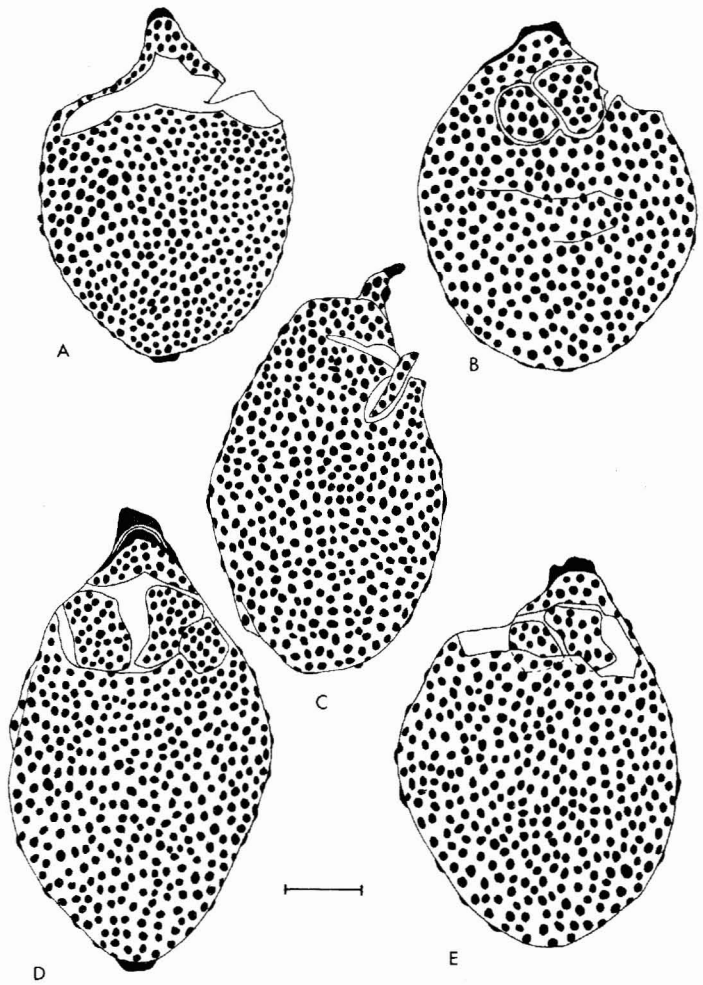


Fig. 11. *Pareodinia brachythelis* sp. nov., showing morphological variation. A; (MGUH 14.700, 92.5/12.3; from sample GGU 144125, Fossilbjerget Mb). B; (MGUH 14.702, 95.3/16.4; from sample GGU 144125, Fossilbjerget Mb). C; Paratype. D; (MGUH 14.701, 104.7/18.2; from sample GGU 144125, Fossilbjerget Mb). E; Holotype. (Bar represents 10 microns).

The paracingulum may be faintly indicated by a slight depression in the cyst wall or by folding; similarly a slight depression may indicate the position of the parasulcus. Otherwise, there is no indication of furrows or of a paratabulation on the cyst surface except at the archeopyle and rarely at the apex, as mentioned above. None of the specimens observed possesses a kalyptra.

Remarks: P. brachythelis resembles *P. alaskensis* Wiggins, 1975 in its possession of

a coarse surface ornamentation, a thick cyst wall, a short apical horn and usually a type 3I archeopyle. However *P. alaskensis* is larger, more elongate and more spindle-shaped than *P. brachythelis,* which has an inflated, regularly rounded appearance.

P. minuta Wiggins, 1975 is of similar size to *P. brachythelis* and also possesses a coarse surface ornamentation and probably a three-paraplate intercalary archeopyle. However, like *P. alaskensis, P. minuta* is spindle shaped and not rounded in outline; it also differs from *P. brachythelis* in the morphology of its apical horn.

The ornamentation of *P. verrucosa* (Vozzhennikova, 1967a) and of *P.* cf. *P. verrucosa* of Fensome, herein, is distinctly coarser than that of *P. brachythelis. P. verrucosa* and *P. kondratjevi* (Vozzhennikova, 1967) have much longer apical horns than *P. brachythelis. P. robusta* Wiggins, 1975 differs from *P. brachythelis* in its unevenly distributed ornamentation, its elongate shape and its type 2I archeopyle.

P. brachythelis is closely similar in shape, surface ornamentation, the nature of its archeopyle and apical morphology to *Pareodinia* sp. B of Wiggins, 1975; indeed Wiggins' specimen is probably attributable to *P. brachythelis.* Wiggins (1975, p. 108) notes that a pre-apical series occurs at the apex of his specimen. This appears to be analagous to the pre-apical paraplate observed on the paratype of *P. brachythelis.*

Pareodinia evittii (Pocock, 1972), Wiggins, 1975

Plate 4, fig. 4

Tenua evittii Pocock, 1972, pp. 94–95; pl. 24, figs 6–8; text-fig. 11. *Pareodinia tripartitus,* Johnson & Hills, 1973, p. 208; text-fig. 12a. *Pareodinia evittii* (Pocock); Wiggins, 1975, p. 105; pl. 3, fig. 9.

Dimensions: Figured specimen; length 64 μm, breadth 49 μm, length of apical horn 19 μm.

Remarks: This species is differentiated from *Pareodinia ceratophora* Deflandre, 1947 by the jagged shape of its archeopyle margin. It has probably often been overlooked in the past and included in *P. ceratophora.* Indeed *P. ceratophora,* as that species is now defined, is known to have a variable archeopyle morphology; it is therefore possible that *P. evittii* is within the morphological variation of *P. ceratophora* and thus a junior synonym of it.

Pareodinia cf. *verrucosa* (Vozzhennikova, 1967a) Wiggins, 1975

Plate 3, fig. 12; text-fig. 12

Description: A form of *Pareodinia* having an ovoidal cyst with a short but usually distinct, rounded apical horn. The apical horn may possess a very short rod-like

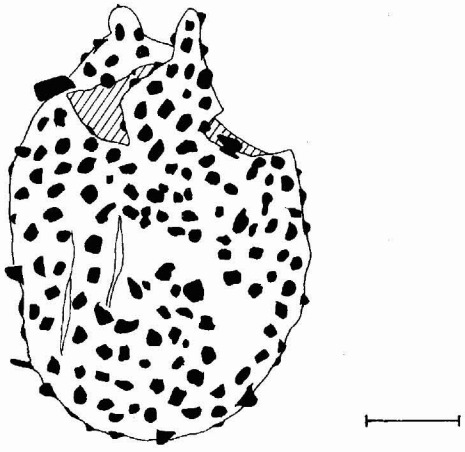


Fig. 12. *Pareodinia* cf. *P. verrucosa* (Vozzhennikova) MGUH 14.704, 106.1/10.0; from sample GGU 144125, Fossilbjerget Mb. (Bar represents 10 microns).

apicular structure or irregular thickening at its distal tip, or it may lack such a structure. The cyst wall is ornamented by usually well-spaced verrucae, variable in size but not exceeding a height of 3 μm. The antapex is broadly rounded. The paracingulum is usually faintly indicated or absent, although folding (and in one specimen, tearing) of the cyst wall appears occasionally to simulate it. The archeopyle is intercalary, involving almost certainly three paraplates. The operculum is compound and usually at least partly attached. There is no other indication of a paratabulation. A kalyptra was not observed.

Dimensions: Range; (five specimens measured) length 37 (41) 47 μm, breadth 23 (30) 34 μm, length of apical horn 2.5 (3) 4.5 μm.

Remarks: P. verrucosa has only previously been recorded from the Upper Kimmeridgian-Portlandian of Siberia by Vozzhennikova (1967a); the dimensions of only one specimen were given and no variation was described in her original diagnosis of this species. The specimens encountered in the present study have a very similar type of ornamentation to that of the holotype of *P. verrucosa,* but they possess a much shorter apical horn (a maximum of 4.5 μm long as compared with 13 μm. for *P. verrucosa*). Vozzhennikova notes that an annular furrow (i.e. paracingulum) is present and that the cyst possesses two antapical processes (i.e. horns). Neither of these features are evident from her illustration (1967a, pl. 12, fig. 6). Indeed, she says, in the same description, that the cyst possesses a broadly rounded antapex.

Because of the confusion surrounding the original diagnosis and because of the significant difference in the length of the apical horn between the Jameson Land specimens and the holotype, the author prefers to compare the present specimens with, rather than attribute them to, *P. verrucosa.*

Genus *Kalyptea* Cookson & Eisenack, 1960b emend. Wiggins, 1975

Kalyptea diceras Cookson & Eisenack, 1960b

Plate 4, figs 1–2; Plate 5, fig. 4

Pareodinia cf. *ceratophora* Deflandre; Valensi, 1953, p. 30; pl. 3, fig. 11. *Kalyptea diceras* Cookson & Eisenack, 1960b, pp. 256–257; pl. 39, fig. 1. – – Wiggins, 1975, p. 110; pl. 5, figs 6–9.

Dimensions: Range; (eight specimens measured) length 79 (100) 148 μm, breadth (or depth) 39 (44) 48 μm, length of apical horn 10 (24) 43 μm, length of antapical horn 6 (13) 38 μm.

Remarks: The development of horns, both apical and antapical, is variable. The apicalhorn is always longer than the antapical horn, but on some specimens it is much longer and on others the length of the antapical horn approaches that of the apical horn more closely (compare the specimens illustrated in Plate 4, fig. 1 and Plate 5, fig. 4). The development of apicular and 'antapicular' structures is also variable; they may be short or long solid rods surmounting a horn or they may consist of solid infillings of the horn tips. A kalyptra is sometimes, but not consistently, present.

The archeopyle involves at least two and almost certainly three intercalary paraplates, which vary in size and shape (compare the archeopyles of specimens illustrated in Plate 4, fig. 2, and Plate 5, fig. 4). The operculum is compound, the opercular pieces being detached or remaining attached. In its mode of archeopyle formation and in the nature of the variability of its archeopyle morphology, *K. diceras* appears to parallel *Pareodinia ceratophora* Deflandre, 1947. It is clear, therefore, that these two species are very closely related.

Kalyptea glabra (Cookson & Eisenack, 1960b) Wiggins, 1975

Plate 4, fig. 9

Komewuia glabra Cookson & Eisenack, 1960 b, p. 257; pl. 39, figs 7–8. *Kalyptea jurassica,* Alberti, 1961, p. 27; pl. 7, fig. 8. *Kalyptea stegasta* (Sarjeant); Wiggins, 1975, (pars), p. 110; pl. 5, figs 10–11. *Kalyptea glabra* (Cookson & Eisenack); Wiggins, 1975, p. 110.

Dimensions: Figured specimen; length 72 μm, length of apical horn 20 μm, length of antapical horn 10 μm, breadth 47 μm.

Remarks: K. jurassica Alberti, 1961 is here considered to be a junior synonym of *K. glabra.* The original descriptions of these two taxa appear to be mutually inclusive; both have an apical horn and an invariably shorter antapical horn, an inflated central body, and an intercalary archeopyle. The illustrations of Cookson & Eisenack (pl. 39, figs 7–8) show that the archeopyle of *K. glabra* is large, though the exact number of plates involved is not clear. The specimens observed in the present study do not clarify this feature.

The inclusion by Wiggins (1975) of *K. jurassica* with *Netrelytron stegastum* Sarjeant, 1961a is here rejected because *N. stegastum* has a true endocyst (see Sarjeant, 1976c).

Solid, irregular apicular and 'antapicular' structures occurred on one of the Jameson Land specimens. A kalyptra was similarly only present on one of the specimens encountered.

Family Uncertain

Genus *Paragonyaulacysta* Johnson & Hills, 1973

Paragonyaulacysta sp.

Plate 5, figs 1–3; text-fig. 13

Description: A form of dinoflagellate with a small elongate, polygonal (approximately pentagonal) cyst, slightly dorso-ventrally compressed. The parasutures are usually marked by beaded crests up to 2 μm high. Occasionally, however, they are low and indistinct against the overall surface ornament, especially on the ventral surface. The parasutures indicate a paratabulation of 3′, ?2a, 6″, 6c, 6‴, 1p, 1⁗, 4+s. The cyst wall is composed of a single layer. The general surface ornamentation consists of a system of irregular and discontinuous nodular ridges about 1 μm high. At the margin of the cyst these ridges are seen to be perforate, and give the outer surface of the cyst wall a spongy appearance. In plan view the ornamentation gives the appearance of an irregular discontinuous reticulum or pseudoreticulum. There is a distinct, short apical horn surmounted by an irregularly shaped apicular structure.

The parasutures towards the apex are indistinct and, together with the presence of the archeopyle in that region, make the paratabulation there difficult to discern. There appear to be three apical paraplates, two on the ventral surface (1′ and 3′), which extend from the horn for some distance onto the main body of the cyst, and one (2′) restricted to the dorsal surface of the horn. Paraplate 3′ is relatively very large.

On the dorsal surface there is an intercalary archeopyle. Because the operculum is detached and because the archeopyle margin gives little clue as to the number of

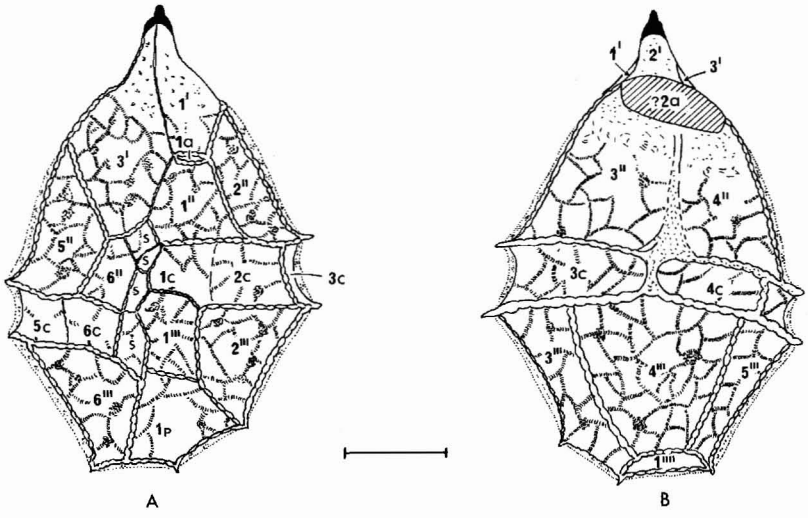


Fig. 13. *Paragonyaulacysta* sp. (MGUH 14.709, 92.7/14.0; from sample GGU 100721, Fossilbjerget Mb). A; ventral view. B; dorsal view. (Bar represents 10 microns).

paraplates involved, the exact number of missing paraplates is not clear; however, since the archeopyle is small it is assumed that probably one or two paraplates are absent. A small anterior intercalary paraplate is present on the ventral surface, inserted between paraplates 1′ and 1″.

There are six precingular paraplates, of which 1″ and 6″ are relatively small owing to the elongation of apical paraplates 1′ and 3′ respectively and, in the case of 1″, also to the configuration of the paracingulum.

The paracingulum is broad and laevorotatory; its two ends are displaced at the parasulcus by a distance equal to one paracingulum width. It is divided into six paraplates of which those at the ends are relatively short. The paracingulum divides the cyst into a conical epicyst and a slightly smaller roughly trapezoidal hypocyst. The parasulcus is narrow and short, extending for only a small distance beyond either end of the paracingulum. It is divided into at least four small paraplates.

There are six postcingular paraplates, of which 1‴ is reduced in size to make room for a posterior intercalary paraplate. The orientation of the cyst makes the detail of the antapex difficult to perceive, but there appears to be a single antapical paraplate present.

Dimensions: Figured specimen; length 47 μm, breadth 33 μm.

Remarks: This specimen is comparable with *P. calloviense* Johnson & Hills (1973), the only species yet attributed to *Paragonyaulacysta.* These two forms are similar in their shape, size and especially in their combination of a gonyaulacoid paratabulation and a dorsally situated intercalary archeopyle. The most obvious difference between *Paragonyaulacysta* sp. and *P. calloviense* is in the nature of their surface ornamentation. *P. calloviense* has a smooth surface whereas *Paragonyaulacysta* sp. has an intricate pattern of ridges. Because Johnson & Hills gave the specific description of *P. calloviense* as the description for the genus, the present specimen does not fit readily into the extant diagnosis for *Paragonyaulacysta.* However, these two taxa are almost certainly attributable to the same genus; therefore, when better known, the genus *Paragonyaulacysta* should be redefined more broadly.

Paragonyaulacysta combines features which have hitherto been considered characteristic of the two principal lineages of Jurassic dinoflagellate cysts. It displays a paratabulation which is quite typical for cysts of the gonyaulacoid lineage, other than its possession of large anterior intercalary paraplates on the dorsal surface, which are lost in archeopyle formation; in the latter feature it is quite typical of pareodinioid cysts. Furthermore, *Paragonyaulacysta* sp., and possibly also *P. calloviense* (see Johnson & Hills, 1973, pl. 2, fig. 16), possesses an apicular structure, a feature common among pareodinioid cysts but very rare among gonyaulacoid cysts. (The specimen of *Wanaea digitata* Cookson & Eisenack, 1958 encountered in the present study possesses a wall thickening at the distal tip of its antapical horn).

Two explanations may be suggested for this unusual combination of pareodinioid and gonyaulacoid features. Firstly, *Paragonyaulacysta* may be a gonyaulacoid form which has developed a dorsal intercalary archeopyle. The development of this type of archeopyle in *Paragonyaulacysta* and in pareodinioid forms might thus be an example of convergent evolution. This hypothesis is even more plausible because of the recent discovery, by W. R. Evitt of a small dorsal anterior intercalary paraplate in *Gonyaulacysta jurassica* (Deflandre, 1938b) (see Sarjeant, 1978). The presence of a dorsal anterior intercalary paraplate is therefore not unique to *Paragonyaulacysta* among forms with a gonyaulacoid paratabulation.

The converse situation to the first explanation provides the second hypothesis; *Paragonyaulacysta* may be a pareodinioid form with a modified paratabulation coinciding with that of gonyaulacoid forms. This seems to be a more complex and less likely evolutionary development than that suggested in the first hypothesis, but supporting it is the presence of an apicular structure at least on *Paragonyaulacysta* sp.

Family GONYAULACYSTACEAE Sarjeant & Downie, 1966 emend. Sarjeant & Downie, 1974

Genus *Gonyaulacysta* Deflandre, 1964 ex Norris & Sarjeant, 1965 emend. Sarjeant, *in* Davey, Downie, Sarjeant & Williams, 1969

Gonyaulacysta jurassica (Deflandre, 1938b) Norris & Sarjeant, 1965

Plate 4, fig. 10

Gonyaulax jurassica Deflandre, 1938a, p. 688; text-fig. 2, *nomen nudum.* – – Deflandre, 1938b, pp. 168–170; pl. 6, figs 2–5; text-figs 1–2. – – Valensi, 1953, p. 25; pl. 1, fig. 7; (?). – – Downie, 1957, p. 420; text-fig. 3 b. – – Cookson & Eisenack, 1958, pp. 29–30; pl. 2, figs 9–10. – – Klement, 1960, pp. 27–28; pl. 2, figs 3–5; text-fig. 6. – – Sarjeant, 1960b, pp. 393–394; pl. 13, figs 1, 14; text-fig. 6. – – Sarjeant, 1961a, p. 91; pl. 13, figs 9–12; text-figs 1–15. – – Evitt, 1961b, p. 390; pl. 1, fig. 5; pl. 2, fig. 5. – – Sarjeant, 1962a, pp. 257–258; pl. 1, figs 1–2. – – Vozzhennikova, 1965, text-figs 33H–I. (English translation in Vozzhennikova, 1967b.) *Gonyaulacysta jurassica* (Deflandre); Deflandre, 1964, p. 5, *nomen nudum.* – – Sarjeant, 1965, text-fig. 2b, *nomen nudum.* – – Norris & Sarjeant, 1965, p. 65. – – Gorka, 1965, pp. 298–299; pl. 1, figs 4a-b. – – Dodekova, 1967, pp. 16–17; pl. 2, fig. 1. – – Sarjeant, 1968, pl. 1, fig. 14. – – Gorka, 1970, pp. 482–483; pl. 1, figs 3a–b; text fig. 1. – – Sarjeant, 1972, pp. 10–11; pl. 1, figs 2–4. – – Pocock, 1972, p. 88; pl. 22, fig. 9. – – Johnson & Hills, 1973, pl. 1, figs 1–2. – – Sarjeant, 1974a, pl. 13, fig. 7; text-fig. 20b. – – Williams, 1974, pl. 5, fig. 1. – – Felix, 1975, pl. 1, fig. 2. – – Vigran & Thusu, 1976, pl. 19, fig. 1. – – Muir & Sarjeant, 1978, pl. 2, fig. 4. *Gonyaulacysta* cf. *jurassica* (Deflandre); Sarjeant 1976a, pp. 16, 18; pl. 6, fig. 8; (?).

Dimensions: Range; (32 specimens measured) overall length 65 (78) 94 μm, breadth 33 (44) 60 μm, length of apical horn 10 (17) 22 μm.

Remarks: In the present material a variation in the ornamentation of the parasutural crests similar to that illustrated by Sarjeant (1961a) was observed. One specimen (Plate 4, fig. 10) possesses both apical and antapical pericoels; it also possesses an unusually broad apical horn. Sarjeant (1972, plate 1, fig. 2) illustrated a similar specimen.

Gonyaulacysta jurassica (Deflandre, 1938b), Norris & Sarjeant, 1965 var. *longicornis* Deflandre, 1938b

Plate 5, fig. 7

Gonyaulax jurassica var. *longicornis* Deflandre, 1938b, p. 171; pl. 6, fig. 6. – – Sarjeant, 1961a, pp. 92–94; text-figs 2–3, 15. – – Sarjeant, 1962a, p. 258; pl. 1, fig. 3. – – Vozzhennikova, 1967a, p. 85; pl. 19, fig. 5. (English translation in Vozzhennikova, 1971). Peridinien Lantz, 1958, pl. 7, fig. 74. *Gonyaulax jurassica longicornis* Deflandre; Klement, 1960, pl. 2. figs 6–8. *Gonyaulacysta jurassica* var. *longicornis* Deflandre; Gitmez, 1970, pp. 260–261; pl. 5, fig. 11. – – Sarjeant, 1972, pp. 11–12; pl. 2, fig. 3. – – Johnson & Hills, 1973, pl. 1, figs 3–4. – – Felix, 1975, pl. 1, fig. 1. *Gonyaulacysta jurassica* subsp. *longicornis* (Deflandre); Lentin & Williams, 1973, p. 62.

Dimensions: Range: (three specimens measured) length 93 (100) 107 μm, breadth 51 (54) 59 μm, length of apical horn 29 (32) 37 μm.

Remarks: The parasutural crests of the specimens encountered are low and unornamented or only weakly denticulate; this is a characteristic typical of this varietas. Lentin & Williams (1973) elevated this taxon to the status of subspecies. However, because it represents merely an extreme in the continuous variation of *G. jurassica,* the status of varietas is here preferred.

Gonyaulacysta birkelundii sp. nov.

Plate 5, figs 5, 8, 11; text-fig. 14

Derivation of name: After Professor Tove Birkelund, palaeontologist at the Institute of Historical Geology and Palaeontology, Copenhagen, Denmark.

Diagnosis: A species of *Gonyaulacysta* with an ovoidal ambitus. The apical horn is distinctly differentiated from the rest of the cyst; it is usually narrow and of variable length. The cyst wall is composed of two layers closely appressed over the whole surface. It is granular and possesses numerous irregularly distributed short spines.

Parasutures are marked by spinose thickenings of the cyst wall or by ragged, irregularly shaped crests. They mark a paratabulation of 4′, ?1a, 6″, ?c, 7‴, 1p, 1⁗, 6+s. The paracingulum is weakly laevorotatory. The parasulcus is broad and straight, situated principally on the hypocyst; it is sparsely ornamented and is subdivided into several small paraplates. The archeopyle is precingular, formed by the loss of paraplate 3″, the operculum typically being detached.

Holotype: MGUH 14.712, 109.5/11.6; from GGU 144161, Fynselv Member, Raukelv Formation, north side of Aucellaelv, Plate 5, figs 5, 8, 11; text-figs 14 A, B.

Dimensions: Holotype; length 91 μm, breadth 69 μm, length of apical horn 14 μm. Range; (five specimens measured) length 74 (83) 91 μm, breadth 51 (63) 69 μm, length of apical horn 14 (19) 33 μm.

Description: A species of dinoflagellate with a usually subovoidal, dorso-ventrally compressed cyst, surmounted by a distinct apical horn which varies from one seventh to one third of the overall cyst length (see fig. 14 c). The spine cover appears to be less dense on the ventral surface than on the dorsal surface, and is almost totally absent from the parasulcus. The parasutures are less clearly marked on the ventral surface; they are especially difficult to perceive towards the margins of the cyst because of the combined effects of spine cover and oblique orientation of the wall as presented to the viewer. In plan view the spines, because of their broad bases, often resemble verrucae.

The parasutures are marked by thickenings of the cyst wall surmounted by low ragged crests, by rows of spines slightly longer than those of the general ornament or by linear zones of such spines.

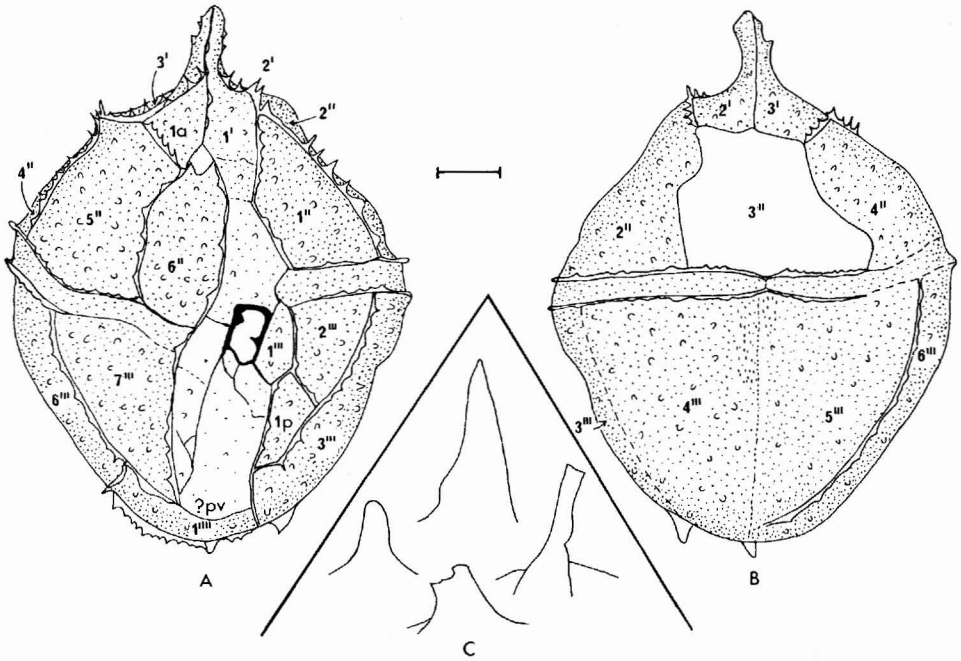


Fig. 14. *Gonyaulacysta birkelundii* sp. nov. A; holotype, ventral view. B; holotype, dorsal view. C; variation in the morphology of the apical horn. (Bar represents 10 microns).

There are four apical paraplates of which 1′ is elongate, extending from the horn towards the parasulcus. Paraplates 2′ and 3′ also extend to the distal tip of the horn but 4′ impinges only onto the base of the horn. A possible small anterior intercalary paraplate at the anterior end of 6″ was present on the holotype, but was not seen with certainty on any other specimen. There are six precingular paraplates, of which 6″ is slightly smaller than the others. Paraplate 3″ is usually lost in archeopyle formation.

The paracingulum is narrow, laevorotatory, its ends being displaced at the parasulcus by approximately one paracingulum width. Parasutures within the paracingulum are rarely clearly visible, especially on the dorsal surface, but there appear to be at least five paraplates present.

The parasulcus is depressed; it is subdivided into at least five paraplates, including one large paraplate on the epicyst. The central part of the parasulcus is depressed relative to the rest of the parasulcus; this area usually possesses two flagellar markings which may develop into grooves.

There are seven postcingular paraplates, paraplate 1‴ being small and projecting into the parasulcus beyond the end of the paracingulum. Paraplate 2‴ is also

small, but larger than 1‴.Parasutures on the dorsal surface of the hypocyst are indistinct, but there appear to be four large postcingular paraplates (3‴ to 6‴) on the dorsal and lateral surfaces. Ventrally situated paraplate 7‴ is smaller than these but significantly larger than 1‴ and 2‴.

There is a single, pentagonal, elongate posterior intercalary paraplate inserted between 1‴, 2‴,3‴ and the parasulcus. The structure of the antapex is not clear, but it appears that at least one antapical paraplate is present.

Remarks: Although *G. birkelundii* possesses a general spine cover, the presence of a strong apical horn and the nature of its parasutures indicate that it is more allied with the genus *Gonyaulacysta* than with *Acanthaulax* Sarjeant, 1968. A combination of a distinct apical horn, a general spine cover and a characteristic paratabulation distinguishes *G. birkelundii* from most other forms of *Gonyaulacysta* and *Acanthaulax*. Most similar is *Gonyaulacysta* sp. A of Gitmez & Sarjeant, 1972; this form has a similar shape and paratabulation, especially in the shape of paraplates 1‴, 2‴, 1p and 4′ (1a of Gitmez & Sarjeant). However, the spines of the general ornament of *Gonyaulacysta* sp. A are much sparser than those of *G. birkelundii*. Nevertheless, these two taxa appear to be closely related.

Gonyaulacysta cladophora (Deflandre, 1938b) Dodekova, 1967

Plate 5, fig. 6

Gonyaulax cladophora Deflandre, 1938a, p. 688; fig. 4; *nomen nudum*. – – Deflandre, 1938b, pp. 173–176; pl. 17, figs 1–5; text-figs 5–6. – – Deflandre, 1941, p. 9; pl. 3, figs 4–5. – – Valensi, 1953, pp. 25–27; pl. 1, figs 3, 6; pl. 13, figs 2–3; text-figs 2b-c. – – Klement, 1960, pp. 33–38; pl. 3, figs 1–12; pl. 4, figs 1–9; text-figs 11–17. – – Sarjeant, 1961a, p. 93; pl. 13. fig. 2; pl. 14, figs 1–2. – – W. Wetzel, 1966, pl. 15, figs 1a-b. – – Vozzhennikova, 1967a, pp. 78–79; pl. 19, figs 1–4. (English translation in Vozzhennikova, 1971). *Gonyaulacysta cladophora* (Deflandre); Sarjeant, 1966a, p. 130, *nomen nudum*. – – Dodekova, 1967, pp. 17–18; pl. 2, figs 2–8. – – Sarjeant, 1968, pl. 1, fig. 6. – – Gorka, 1970, pp. 483–484; pl. 1, fig. 4; pl. 2, figs 1a-c; text-figs 2a-b. – – Pocock, 1972, pp. 86–87; pl. 22, figs 3–4; text-fig. 1. – – Johnson & Hills, 1973, pl. 1, fig. 5. – – Williams, 1974, pl. 4, fig. 16. – – Felix, 1975, pl. 1, fig. 6. – – Vigran & Thusu, 1976, pl. 19, fig. 4. – – Bjaerke, Edwards & Thusu, 1976, pl. 1, fig. 8.

Dimensions: Range: (55 measured specimens) overall length 87 (102) 119 μm, breadth 65 (95) 108 μm, length of apical horn 11 (14) 20 μm.

Remarks: Specimens of *G. cladophora* were found to be generally poorly preserved, as often appears to be the case with this species (for example see Sarjeant, 1961a). The surface texture of most specimens is rough and irregular, obviously resulting from poor preservation; occasional specimens, however, showed a more regularly punctate surface ornamentation. One specimen possesses, in its antapical region, a remnant of what appears to be a crest composed of fused spines; this is

unusual for this species. This specimen is also unusual in the sparsity and shortness of its parasutural spines. This is probably in part preservational, and its general shape, surface texture and occurrence in a sample with numerous other specimens of this species are consistent with its allocation to *G. cladophora.*

Gonyaulacysta eisenacki (Deflandre, 1938b) Dodekova, 1967

Plate 6, fig. 3

Gonyaulax eisenacki Deflandre, 1938b, pp. 171–173; pl. 6, figs 7–10; text-figs 3–4. – – Valensi, 1953, p. 25; pl. 1, fig. 5; pl. 13, fig. 1. – Klement, 1960, pp. 29–30; pl. 2, figs 9–10. – – Sarjeant, 1962a, p. 258, pl. 1, fig. 4. – – Gorka, 1965, pp. 299–300; pl. 1, figs 5a-c. – – Vozzhennikova, 1967a, p. 81; pl. 21, figs 3a-b. (English translation in Vozzhennikova, 1971). *Gonyaulacysta eisenacki* (Deflandre); Sarjeant, 1966, p. 131, *nomen nudum.* – – Dodekova, 1967, pp. 18–19; pl. 2, figs 9–11. – – Sarjeant, 1968, p. 227; pl. 3, fig. 14. – – Sarjeant, 1974a, pl. 8, fig. 3. – – Muir & Sarjeant, 1978, pl. 3, fig. 1. *Endoscrinium eisenacki* (Deflandre); Gocht, 1970, pp. 146–147; pl. 33, figs 9–12; text-fig. 15f. – – Johnson & Hills, 1973, pl. 2, fig. 4.

Dimensions: Range: (eight specimens measured) overall length 64 (78) 85 μm, overall breadth 43 (54) 60 μm.

Remarks: One specimen of *G. eisenacki* possesses an ancillary aperture on its dorsal surface between the archeopyle and the apex. (Plate 6, fig. 3). This is formed apparently by the removal of a whole, or part, of an apical paraplate. It seems unlikely that this aperture is a result of random tearing because of its regular shape; furthermore, Sarjeant (1972) described a similar aperture from a specimen of *G. eisenacki* subsp. *oligodentata* Cookson & Eisenack, 1958. A second specimen of *G. eisenacki* from the present study, although poorly preserved, appears to possess a similar aperture.

One specimen possesses an opisthopyle in its periphragm, opening into the antapical pericoel. This feature is more characteristic of *G. eisenacki* subsp. *oligodentata* and is discussed more fully in the entry for that taxon, and also in the Palaeoecological considerations.

Gonyaulacysta eisenacki (Deflandre, 1938b) Dodekova, 1967 subsp. *oligodentata* Cookson & Eisenack, 1958

Plate 6, fig. 1

Gonyaulax eisenacki subsp. *oligodentata* Cookson & Eisenack, 1958, p. 30; pl. 2, fig. 11. *Endoscrinium eisenacki* subsp. *oligodentata* Cookson & Eisenack; Gocht, 1970, pp. 146–147; pl. 33, figs 10–12. *Gonyaulacysta eisenacki* subsp. *oligodentata* Cookson & Eisenack; Sarjeant, 1972, pp. 17–19; pl. 2, fig. 1; text-fig. 3.

Dimensions: Figured specimen: overall length 94 μm, breadth 55 μm, length of apical horn 6 μm, length of endocyst 62 μm.

Remarks: As is typical for this subspecies, the parasutural crests are almost entire. Both specimens possess an oval opisthopyle (an aperture opening into the antapical pericoel) on the ventral surface of the cyst; a similar opening was reported from this subspecies by Sarjeant (1972, pp. 18–19; text-fig. 3). Such apertures could have been involved with pressure release from the internal cavities of the cyst during excystment; however, this explanation seems less likely since the opisthopyle connects only with the antapical pericoel, from which there is no direct connection to the main cavity of the cyst. Alternatively such apertures may have been involved in controlling the buoyancy of the cyst (see Palaeoecological considerations).

Gonyaulacysta granuligera (Klement, 1960) Sarjeant, *in* Davey, Downie, Sarjeant & Williams, 1969

Plate 5, fig. 10

Gonyaulax granuligera, Klement, 1960, pp. 41–42; pl. 5, figs 4–5. *Gonyaulacysta granuligera* (Klement); Sarjeant, 1966a, p. 131, *nomen nudum.* – – Sarjeant, *in* Davey, Downie, Sarjeant & Williams, 1969, p. 10. – – Gitmez, 1970, pp. 256–257; pl. 1, figs 10–11; text-fig. 10.

Dimensions: Figured specimen; length 105 μm, breadth 91 μm, length of apical horn 9 μm.

Remarks: The two specimens encountered are slightly larger than is usual for this species; in all other respects, however, they appear to be typical.

Gonyaulacysta nuciformis (Deflandre, 1938b) Sarjeant, 1968

Plate 5, fig. 13

Palaeoperidinium nuciforme Deflandre, 1938b, p. 180; pl. 8, figs 4–6. – – Sarjeant, 1962a, pl. 1, fig. 8. *Gonyaulax nuciformis* (Deflandre); Sarjeant, 1962b, pp. 482–483; pl. 69, fig. 6; text-fig. 4. *Palaeoperidinium nuciformoides* Gorka, 1965, pp. 300–301; pl. 2, figs 1–2. *?Gonyaulacysta nuciformis* (Deflandre); Sarjeant, 1966, p. 132, *nomen nudum. Gonyaulacysta nuciformis* (Deflandre); Sarjeant, 1968, p. 227; pl. 3, fig. 4. – – Gitmez, 1970, p. 3; pl. 6, fig. 1. – – Gitmez & Sarjeant, 1972, pp. 200–202; pl. 3, fig. 5; text-fig. 8. – – Habib, 1972, pl. 3, fig. 4.

Dimensions: Figured specimen; length 74 μm, breadth 67 μm, length of apical horn 9 μm.

Remarks: This specimen is slightly squashed. In its possession of a thick, densely granular cyst wall, a small apical horn readily distinguished from the main body of the cyst and low parasutural ridges, this specimen appears to be typical of *G. nuciformis.*

Gonyaulacysta pectinigera (Gocht, 1970) comb. nov., stat. nov., emend.
Plate 6, figs 2, 4, 10; text-fig. 15

Leptodinium subtile subsp. *pectinigerum* Gocht, 1970, pp. 138–139; pl. 33, figs 1–4; text-fig. 11.

Emended diagnosis: Proximate dinoflagellate cysts with a subpolygonal (roughly pentagonal) outline, polygonality being accentuated by the presence of high denticulate parasutural crests which occur dorsally and laterally. Ventrally crests are low and usually spinose. Paratabulation: 1 pr, 4′, 6″, 7c, 6‴, 1p, 1⁗. The cyst wall consists of two layers which separate only at the apex, where the periphragm is drawn out into a short rectangular to irregularly polygonal horn and the endophragm produces a mamelon-like structure. The cyst wall and parasutural crests are foveolate; pandasutural zones with more densely foveolate ornamentation often occur on many of the larger dorsal and lateral paraplates. The archeopyle is precingular, formed by the loss of paraplate 3″; the operculum is usually detached.

Holotype: Prap. Pr. 1375/Ph. 46/14/4 (plate 33, fig. 1 of Gocht); Borehole Aldorf 12 (Kreis Grafsch. Diepholz, N. W. Germany), Kern 1109–1112, 2m; Kiste 3. Lower Dogger, epsilon Sandstone (Lower Bathonian). (Gocht, 1970).

Dimensions: Range; (eight specimens measured) length 58 (77) 96 μm, breadth 56 (74) 83 μm, depth (in one specimen only) 38 μm, length of apical horn 5 (10) 15 μm, height of crests 5 (7) 9 μm.

Description: The cyst is slightly dorso-ventrally flattened. In ventral or dorsal view it is approximately pentagonal, the corners of the central body being more or less rounded. Polygonality is imparted by the presence of high sutural crests. Many of the lateral and dorsal precingular and postcingular paraplates possess a pandasutural zone of variable breadth in which the foveolate ornament of the cyst wall is denser than elsewhere. The boundary of this zone, where present, is usually or constantly sharp. The cyst wall also appears to be slightly thicker in the pandasutural zones.

The dorsal paraplates of *G. pectinigera* are well delineated by high parasutural crests which have strongly and more or less regularly denticulate distal margins. The denticles are usually pointed, but they may occasionally bifurcate distally and more rarely they may be blunt. The parasutural crests on the ventral surface are usually much lower and give rise to short, narrow, pointed spinelets.

The apical horn is produced by apical paraplates 1′, 2′ and 3′, none of which extend greatly below the base of the horn. The other apical paraplate, 4′, is not involved in the formation of the apical horn. There appears to be a small preapical paraplate at the distal tip of the horn, at least on some of the specimens encountered.

The apical horn is variable in shape. In some specimens it was short and rectangular in outline, as in the specimen illustrated by Gocht (1970, text-fig. 11) and in

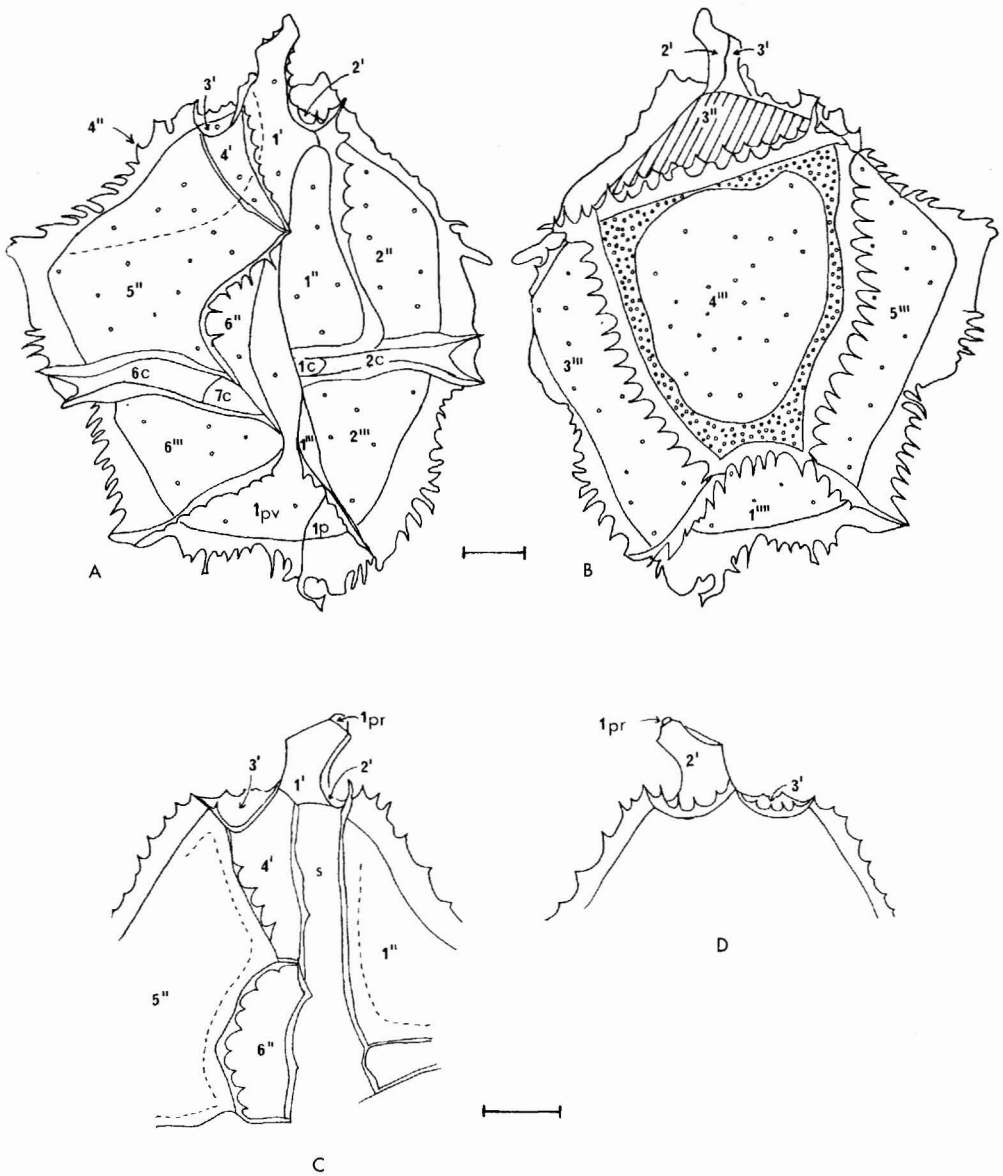


Fig. 15. *Gonyaulacysta pectinigera* (Gocht) comb. nov., stat. nov., emend. A, B; (MGUH 14.719, 102.3/18.5; from sample GGU 100721, Fossilbjerget Mb). A; ventral view. B; dorsal view. C, D; (MGUH 14.720, 99.2/14.5; from sample GGU 100721, Fossilbjerget Mb). C; ventral view of epicyst. D; anterior dorsal morphology. (Bars represent 10 microns).

one specimen illustrated in this work (Plate 6, fig. 4). In other specimens it tends to be more irregular in shape (Plate 6, fig. 2 and text-fig. 15).

There are six precingular paraplates, of which 6'' is relatively small owing to the presence of paraplate 4'. In all of the specimens encountered paraplate 3'' is lost in archeopyle formation.

The paracingulum is laevorotatory, its ends being displaced at the parasulcus by about one paracingulum width. Parasutures within the paracingulum indicate seven paraplates; six of these are elongate, but 1c is very short. The paracingular paraplates were often difficult to perceive.

The parasulcus extends from the posterior end of apical paraplate 1' to the antapical paraplate. It is straight, broadening slightly on the hypocyst. The specimen illustrated in text-fig. 15A, B has a parasulcus which has collapsed inwards; its morphology in this region is therefore difficult to study in detail. However, other specimens show faint ridges within this region, indicating possible parasutures. One specimen exhibits a faint flagellar marking.

There are six postcingular paraplates, 1''' being narrow and generally poorly indicated. It is not shown by Gocht (1970, text-figure 11) but may be discerned on at least one of his photographs (ibid, pl. 33, fig. 1b). Also present is a small, triangular posterior intercalary paraplate, inserted between paraplates 1''', 1'''' and the parasulcus. There is a single rectangular antapical paraplate (1'''').

Remarks: This taxon was originally described by Gocht (1970) as *Leptodinium subtile* Klement, 1960 subsp. *pectinigerum.* Although its paratabulation does resemble that of *L. subtile,* its crests are very distinctive and quite unlike those of *L. subtile.* Moreover, its possession of an apical horn merits its inclusion in the genus *Gonyaulacysta,* rather than *Leptodinium.*

G. pectinigera is similar to *G. jurassica* (Deflandre, 1938b) Norris & Sarjeant, 1965, but it has a distinctive pentagonal shape and is not as elongate as *G. jurassica;* the overall breadth of *G. pectinigera* approaches and may occassionally equal or even slightly exceed the overall length.

G. pectinigera also resembles *G. crassicornuta* (Klement, 1960), but has a much shorter apical horn and denticulate and spinose rather than consistently spinose crests. From Klement's photographs, *G. crassicornuta* appears to have a much rougher surface ornamentation than *G. pectinigera* (although Klement comments that *G. crassicornuta* possesses a smooth to unclearly punctate membrane).

G. eisenacki (Deflandre, 1938b) has an antapical pericoel and because of this, its more elongate shape and subconical apex, it is easily distinguished from *G. pectinigera. G.* cf. *G. eisenacki* of Valensi (1953, pl. 1, fig. 5) is more similar to *G. pectinigera* but appears to lack an apical horn; Valensi did not describe its paratabulation.

G. aff. *G. jurassica* of Sarjeant (1972) is also similar to *G. pectinigera* in general appearance but has only five postcingular paraplates and lower, more irregularly denticulate parasutural crests.

Gonyaulacysta scarburghensis Sarjeant, 1964

Plate 5, fig. 9

Gonyaulax areolata Sarjeant, 1961a, pp. 95–97; pl. 13, fig. 13; text-fig. 5 (*non* Kofoid & Mitchener, 1911). *Gonyaulacysta scarburghensis* Sarjeant, 1964, pp. 472–473. – Habib, 1972, pl. 5, fig. 6; (?).

Dimensions: Range; (13 specimens measured) overall length 106 (115) 126 μm, breadth 77 (91) 103 μm, length of apical horn 20 (23) 25 μm.

Remarks: Specimens of *G. scarburghensis* from Jameson Land were mostly poorly preserved and fragmentary. However, they were readily identified because of their very characteristic surface ornamentation.

Genus *Leptodinium* Klement, 1960 emend. Sarjeant, *in* Davey, Downie, Sarjeant & Williams, 1969

Leptodinium subtile Klement, 1960

Plate 6, fig. 11

Leptodinium subtile Klement, 1960, pp. 46–47; pl. 6, figs 1–4; text-figs 23–24. – – Vozzhennikova, 1967a, pp. 90–91; text-fig. 16. (English translation in Vozzhennikova, 1971).

Dimensions: Range: (two specimens measured) length 80–89 μm, breadth 68 μm.

Remarks: In its shape, the nature of its crests, and in its paratabulation, the single well-preserved specimen observed is typical of the species. However, it is slightly larger than the largest specimen observed by Klement (1960). It has a granular surface ornamentation.

Leptodinium aceras (Eisenack, 1958) Sarjeant, *in* Davey, Downie, Sarjeant & Williams, 1969 emend. Gitmez & Sarjeant, 1972

plate 5, fig. 12

Gonyaulax aceras Eisenack, 1958b, p. 391; pl. 2, figs 1–2. *Gonyaulacysta aceras* (Eisenack); Sarjeant, 1966a, p. 131, *nomen nudum. Leptodinium aceras* (Eisenack); Sarjeant *in* Davey, Downie, Sarjeant & Williams, 1969, p. 12. – – emend. Gitmez & Sarjeant, 1972, pp. 215–216; pl. 5, figs 1–3; text-fig. 17.

Dimensions: Figured specimen: length 96 μm, breadth 93 μm.

Remarks: Because of folding of the cyst wall and crushing together of the dorsal and ventral surfaces it was difficult to verify whether the paratabulation corres-

ponds to that illustrated by Gitmez & Sarjeant (1972). However, the narrow paracingulum, small elongate paraplates 1''' and 1p and reduced 6'' are clearly recognizable. The cyst surface is very coarsely granular.

Family APTEODINIACEAE Eisenack, 1961 emend. Sarjeant & Downie, 1974
Genus *Trichodinium* Eisenack & Cookson, 1960 emend. Clarke & Verdier, 1967

Remarks: The genera *Trichodinium* and *Xenicodinium* Klement, 1960 are very similar. The principal (and possibly the only) difference between the two genera is the presence in *Trichodinium* of an apical horn. It is therefore questionable whether the retention of two genera is justifiable. However, a restudy of the type material of *Xenicodinium* is necessary before *Trichodinium* can be considered to be a junior synonym of it.

Trichodinium castanea (Deflandre, 1935) Clarke & Verdier, 1967
Plate 7, figs 1, 4

Palaeoperidinium castanea Deflandre, 1935, p. 229; pl. 6, fig. 8. – – Deflandre, 1936, pp. 29–30; pl. 6, figs 1–4. – – Deflandre, 1936b, fig. 99. – – Cookson & Eisenack, 1962, p. 489; pl. 3, figs 9–11. – – Cookson & Hughes, 1964, p. 49; pl. 5, fig. 14. – – Vozzhennikova, 1967a, pp. 155–156; pl. 41, figs 4a-b. (English translation in Vozzhennikova, 1971.) *Trichodinium castanea* (Deflandre); Clarke & Verdier, 1967, p. 19; pl. 1, figs 1–2. – – Foucher, 1974, p. 19; pl. 4, figs 2, 3. *Trichodinium castaneum* (Deflandre); Davey, 1969, pp. 131–132; pl. 11, figs 1–3. – – McIntyre, 1974, pl. 12, fig. 3.

Dimensions: Figured specimen; overall length 59 μm, overall breadth 54 μm, length of apical horn 4 μm, length of spines (average) 2 μm.

Remarks: The specimen of *T. castanea* observed in the present study is similar to *T.* cf. *T. ciliatum* of Fensome, herein, in its ornamentation. It possesses a general cover of thornlike or conical, solid spines and a secondary ornament consisting of punctae and a low irregular reticulum. However, it differs from *T.* cf. *T. ciliatum* in its possession of a small apical horn about 4 μm long, and 5 μm wide at its base, a distinct laevorotatory paracingulum on both dorsal and ventral surfaces and a distinctive parasulcus; the furrows are outlined by spinose ridges. The spines which comprise the general ornament of the cyst are often joined or in lines; indeed they appear locally to simulate a paratabulation. All of these features are in accordance with the original description of *T. castanea.*

The relationship between the two taxa observed in the present study, *T. castanea* and *T.* cf. *T. ciliatum,* is not clear. However, they appear to be members of a group of closely related, possibly gradational, forms which also includes *T. ciliatum* (Gocht, 1959) (considered by Clarke & Verdier, 1967, to be a junior synonym of

T. castanea, but reinstated by Davey, 1974), *T. speetonensis,* Davey, 1974 and *Xenicodinium densispinosum* Klement, 1960.

T. castanea was described from the Jurassic of Siberia by Vozzhennikova (1967a); this constitutes the only previous record of this species from the Jurassic. Vozzhennikova's specimens, however, are very fragmentary and can not be ascribed to this species with any confidence.

Trichodinium cf. *T. ciliatum* (Gocht, 1959) Eisenack, 1964

Plate 6, figs 9, 12; Plate 7, fig. 2

Trichodinium ciliatum (Gocht); Davey, 1974, pp. 62–63; pl. 7, fig. 1; (?).

Dimensions: Figured specimen; overall length 51 μm, overall breadth 46 μm, length of spines (average) 2 μm.

Remarks: This specimen accords very closely with the description given by Davey (1974) of the specimens he attributed to *T. ciliatum.* The Jameson Land specimen possesses a paracingulum marked by two lines of spines immediately beneath the archeopyle, but nowhere else is the paracingulum apparent. A secondary ornament of dark lines (probably resulting from slight thickenings of the cyst wall) and punctae is present and probably corresponds to the 'fibro-pitted' ornament of Davey's specimens.

In his diagnosis of *T. ciliatum* Gocht stated that no furrows are present. Both the Jameson Land specimen and those described by Davey possess a definite parasulcus; furthermore, as already noted, the Jameson Land specimen possesses some indication of a paracingulum. In consequence the attribution of these forms to *T. ciliatum* is questionable. Gocht's illustrations indicate that his specimens also had thinner spines than those of *T.* cf. *T. ciliatum.* It is likely that the relationship between *T. ciliatum* and *T.* cf. *T. ciliatum* will only be resolved by restudy of the type material of *T. ciliatum.*

Further observations regarding the relationships of *T.* cf. *T. ciliatum* are made in the entry for *T. castanea.*

Family Ctenidodiniaceae Sarjeant & Downie, 1966 emend. Sarjeant & Downie, 1974

Genus *Ctenidodinium* Deflandre, 1938b emend. Sarjeant, 1974

Ctenidodinium ornatum (Eisenack, 1935) Deflandre, 1938b

Plate 6, fig. 8

Lithodinia jurassica var. *ornata* Eisenack, 1935, pp. 175–177; pl. 4, figs 9–10. *Ctenidodinium ornatum* (Eisenack); Deflandre, 1938b, pp. 181–182; pl. 9, figs 1–7. – – Gocht, 1970, pp. 140–141; pl. 26, figs 1–2, 5; pl. 28, figs 1–2; pl. 29, figs 3–4; pl. 32, figs 5–11; text-fig. 6. – – Williams, 1974, pl. 2, fig. 11.

Gonyaulax ornata (Eisenack); Klement, 1960, pp. 30–33; pl. 2, figs 11–15; text-figs 7–10. *Gonyaulacysta ornata* (Eisenack); Pocock, 1972, pp. 87–88; pl. 22, figs 5–6; text-fig. 3; (?).

Dimensions: Figured specimen; length 83 μm, breadth 68 μm. Range; (37 half cysts were measured): longest diameter 49 (63) 83 μm, shortest diameter 33 (46) 53 μm, height of crests 4 (6) 8 μm.

Remarks: Only one whole specimen was observed. The remainder were half cysts. Although simpler and less densely denticulate than those of *C.* cf. *C. continuum* of Fensome, herein, the parasutural crests of specimens of *C. ornatum* encountered in the present study are variable; they vary primarily in the density of denticles and in their overall length.

Ctenidodinium cf. *C. continuum* Gocht, 1970

Plate 6, fig. 5; Plate 8, fig. 1

Dimensions: Complete cyst; (one measured) length (partly squashed) 62 μm, breadth 65 μm. Half cysts; range; (five specimens measured) longest overall diameter 56 (69) 89 μm, shortest overall diameter 39 (53) 64 μm.

Remarks: One complete specimen and several half cysts were observed with perforate parasutural crests ornamented by a variety of closely spaced denticles. The perforations appear to be larger on the posterior parasuture of the paracingulum. The crests were of more irregular appearance than is typical of *C. continuum.* Poor preservation and folding of all the specimens seen prevented a further, more detailed, morphological analysis of this species.

Genus *Wanaea* Cookson & Eisenack, 1958

Wanaea digitata Cookson & Eisenack, 1958

Plate 6, fig. 7

Wanaea digitata Cookson & Eisenack, 1958, p. 58; pl. 9, figs 2–5. – – Sarjeant, 1968, p. 233; pl. 1, fig. 2. – – Sarjeant, 1972, p. 46; pl. 7, fig. 5. – – Johnson & Hills, 1973, pl. 2, fig. 6; (?). – – Muir & Sarjeant, 1978, pl. 2, fig. 1. *Wanaea fimbriata* Sarjeant; Johnson & Hills 1973, pl. 1, figs 18–19; (?).

Dimensions: Figured specimen; overall length 90 μm, overall breadth 114 μm, length of epicyst 19 μm, length of hypocyst 68 μm, width of fringe 20 μm, length of apical horn 9 μm.

Remarks: The antapical horn of the specimen encountered possesses a wall thickening at its distal extremity to about 2 μm. This structure is reminiscent of the apicular and 'antapicular' structures of many pareodinioid cysts.

A small lid-like epicyst is retained. A fuller consideration of this feature and of the genus *Wanaea* is in preparation.

Wanaea fimbriata Sarjeant, 1961

Plate 7, fig. 10

Wanaea fimbriata Sarjeant, 1961, pp. 112–113; pl. 15, fig. 14; text-fig. 13. – – Sarjeant, 1968, p. 233; pl. 3, fig. 1. – – Sarjeant, 1976c p. 10; pl. 4, fig. 4; pl. 5, fig. 6.

Dimensions: Range; (two specimens measured) overall breadth 106–112 μm, length (excluding fringe) 59–69 μm, width of fringe 16–21 μm.

Remarks: The specimen encountered in the Hareelv Formation (sample GGU 144115) is atypical of the species in its possession of a fused block of processes and also probably in its lesser degree of linkage in parts of the fringe other than the fused section (Plate 7, fig. 10). The ammonite-derived age for sample GGU 144115 is Late Oxfordian – Early Kimmeridgian (see Table 2). *W. fimbriata* has been previously recorded only from the Early Oxfordian. It is therefore possible that the single specimen found in this sample is reworked.

Family Uncertain

Genus *Ambonosphaera* gen. nov.

Derivation of name: Gr. *ambon,* ridge or crest, in reference to the presence of distinctive parasutures; Gr. *sphaira,* ball.

Type species: A. calloviana Fensome, herein; Plate 7, figs 3, 5–6, 8–9; text-figs 16–17.

Diagnosis: A genus of dinoflagellate possessing a subspherical, subovoidal or subpolygonal cavate cyst on which there is no development of antapical or lateral horns, though weakly developed apical prominences may or may not occur. A paratabulation is more or less well-developed on the periphragm. It is gonyaulacoid; 4′ 5–6″, 6–7c, 6–7‴, 1 p, 0–1 pv, 1 (–2?)⁗, ns. Paratabulation is usually weakly represented on, or absent from the relatively thicker walled endophragm. The archeopyle is formed by loss of the apical paraplate series (type $4\overline{A}$).

Remarks: Ambonosphaera is distinguished from all other dinoflagellate cyst genera by the following combination of features: the presence of pericoels, a gonyaulacoid paratabulation, the development of an apical archeopyle, and its lack of pronounced horns.

Lithodinia Eisenack, 1935 emend. Gocht, 1975b is similar in its possession of a gonyaulacoid paratabulation and a type 4A archeopyle, but is not cavate. *Meiourogonyaulax* Sarjeant, 1966a may be similarly distinguished from *Ambonosphaera.* (*Meiourogonyaulax* has been considered a junior synonym of *Lithodinia* by Gocht [1975b], but Sarjeant [1978] has expressed some reservations about this.)

Ovoidinium Davey, 1970 emend. Lentin & Williams, 1975, *Ascodinium* Cook-

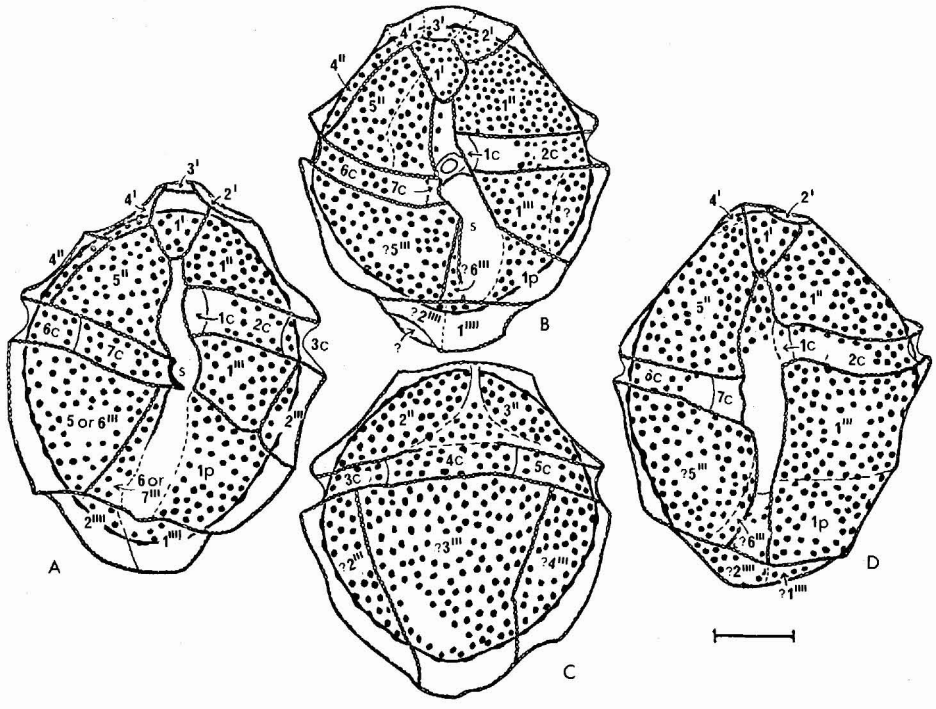


Fig. 16. *Ambonosphaera calloviana* gen. et sp. nov. A; paratype (ii), ventral view. B; holotype, ventral view. C; holotype, dorsal view. D; paratype (iii), ventral view. Ornament of endophragm idealized; ornament of periphragm omitted. (Bar represents 10 microns).

son & Eisenack, 1960a, and *Hexagonifera* Cookson & Eisenack, 1961 are all peridinioid rather than gonyaulacoid, and all possess combination type archeopyles. *Ambonosphaera* differs from *Senoniasphaera* Clarke & Verdier, 1967 in its lack of horns.

Other species of Ambonosphaera:
jurassica (Gitmez & Sarjeant, 1972) comb. nov. = *Hexagonifera jurassica* Gitmez & Sarjeant, 1972, pp. 240–241; pl. 14, figs 5, 8. *Senoniasphaera jurassica* (Gitmez & Sarjeant); Lentin & Williams, 1977, p. 144.

Ambonosphaera calloviana sp. nov.

Plate 7, figs 3, 5–6, 8–9; text-figs 16, 17

Derivation of name: After the Callovian stage of the Jurassic system, from which this species is recorded for the first time.

Diagnosis: A species of dinoflagellate having a small cavate cyst; the pericyst is subpolygonal and the endocyst is usually ovoidal to spheroidal. Polygonality is

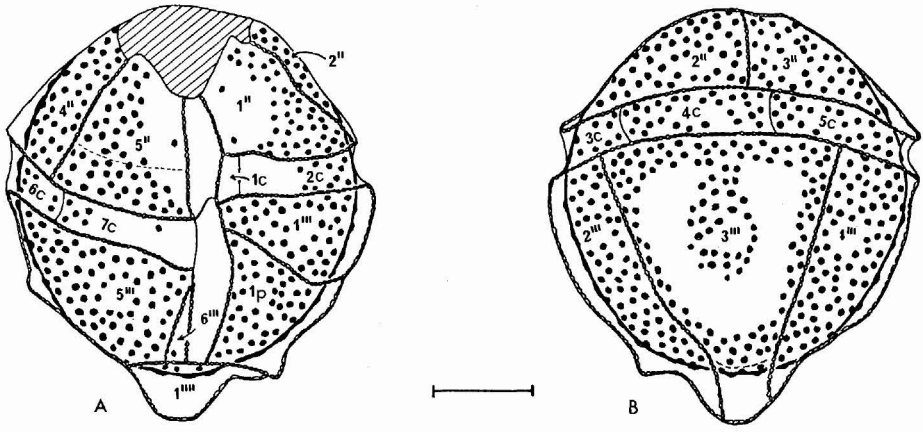


Fig. 17. *Ambonosphaera calloviana* gen. et sp. nov., paratype (i). A; ventral view. B; dorsal view. Ornament of endophragm idealized; ornament of periphragm omitted. (Bar represents 10 microns).

imparted to the pericyst by crest-like bulges bearing parasutural ridges; the paratabulation is 4′, 5 or 6″, 7c, 6 or 7‴, 1p, 1pv, ?2⁗, 3 or 3+s. The endophragm is thick and coarsely and irregularly granular; the periphragm is thin, translucent and less coarsely granular than the endophragm. Usually small apical and antapical pericoels are present; separation of the two wall layers other than at the apex and antapex is variable both within a single specimen and from one specimen to another. Rarely the two wall layers may be closely appressed over almost all of the cyst surface. The archeopyle is apical; the operculum may be attached or detached.

Holotype: MGUH 14.731, 97.5/10.0; from GGU 100721, Fossilbjerget Member, Vardekløft Formation, west of Olympen. Plate 7, figs 3, 6, 9; text-fig. 16B, C.

Paratypes: (i) MGUH 14.733, 117.9/11.7 (Plate 7, fig. 8; text-fig. 17); (ii) MGUH 14.732, 113.2/7.6 (Plate 7, fig. 5; text-fig. 16A); (iii) MGUH 14.734, 108.1/5.6 (text-fig. 16D). All paratypes from sample GGU 100721, Fossilbjerget Member, Vardekløft Formation, west of Olympen.

Dimensions: See Table 2.

Description: A species of *Ambonosphaera* with a subpolygonal pericyst and a usually spheroidal to ovoidal endocyst. The development of pericoels is variable, but nowhere great. Paratype (iii) (text-fig. 16D) is an extreme example in which the two wall layers are closely appressed over most of the surface of the cyst; in this case the shape of the endocyst approximately reflects that of the pericyst. The greatest separation of the wall layers is at the apex and, most notably, at the antapex; in these regions small pericoels occur. Elsewhere the separation is most

Table 2. Dimensions of Ambonosphaera calloviana *gen. et sp. nov.*
(Measurements given in microns)

	Length (Archeopyle formed)		Length (Archeopyle not formed)		Breadth	
	Endocyst	Pericyst	Endocyst	Pericyst	Endocyst	Pericyst
Holotype			38	45	38	42
Paratype (i)	37	42			36	39
Paratype (ii)			34	40	28	33
Paratype (iii)			46	49	38	40
Range (of eight specimens)	37–40	42–45	34(38)46	40(43)49	26(32)38	32(38)42

pronounced along the parasutures where the periphragm tends to form narrow outbulges, producing crest-like structures; these give the pericyst its polygonality.

The endophragm is thick and ornamented by coarse granules; these are irregularly distributed, sometimes in lines or clumps. Ornamentation is absent from parts of the parasulcus and occasionally from small areas elsewhere on the endocyst. The periphragm is thinner and less coarsely granular than the endophragm.

The parasutures are more or less distinct, usually represented by low ridges 0.4 to 4 μm wide, situated along the distal extremity of the outbulges of the pericyst. Some, however, are much less distinct, especially those delineating the smaller paraplates.

There are four small apical paraplates, of which 1′ extends towards the parasulcus. In two specimens the apical series is lost in archeopyle formation. When the archeopyle is developed the position of paraplate 1′ is clearly indicated by an indentation of the archeopyle margin projecting into the parasulcus.

There are 5 or 6 precingular paraplates; 1″ to 4″ are of approximately equal size. The parasuture dividing 5″ and 6″ is at most only faintly marked and is sometimes absent; indeed, it is not possible to be confident about the presence of two plates here.

The paracingulum is laevorotatory, its two ends separated by a distance equal to, or slightly greater than, one paracingulum width. It is divided into seven paraplates of which 1c is small. Paraplate 7c appears to vary in size, sometimes being of approximately equal size to paraplates 2c to 6c, but sometimes it is small. The paracingulum is 7–9 μm broad on the holotype, which is typical.

The parasulcus is straight to slightly sinuous, narrow and depressed. It extends for most of the length of the cyst and tends to be more deeply depressed on the hypocyst. It is subdivided into at least three paraplates (though these are not visible

in all specimens) including a posterior ventral paraplate. In the holotype a small circular plate-like area within the parasulcus and adjacent to the paracingulum may reflect the flagellar pore of the motile stage.

On the hypocyst to the left of the parasulcus the paratabulation is again indistinct. The postcingular series in this area is reduced in size because of the presence of a moderately large posterior intercalary paraplate. However, whether one or two postcingular paraplates are present is not clear. On one specimen a parasuture between the two possible paraplates is clearly indicated (text-fig. 16A), but on others it is faint or absent (text-figs 16B, D, 17A). Paraplates ?2‴, ?3‴ and ?4‴ on the lateral and dorsal surfaces are large, but ?5‴ is smaller owing to the configuration of the paracingulum. Paraplate ?6‴ is usually moderately well marked; it is narrow and elongate, broadening towards the antapex.

The number of antapical paraplates is not clear. At least one is present and ventrally inclined, but low, poorly marked ridges in the region of the antapex may indicate the presence of more paraplates there.

Remarks: Ambonosphaera jurassica (Gitmez & Sarjeant, 1972) Fensome, herein,is distinguished from *A. calloviana* by its more rounded outline, the more consistent width of its pericoels in ambital view and by its less well developed paratabulation.

Dingodinium minutum Dodekova, 1975, recorded from the Upper Bathonian of Bulgaria, appears to be similar to *A. calloviana,* at least superficially. The two species appear to be comparable in size, in the nature of the surface ornament of their endoblasts, in the nature of their parasutural crests, and in the development of their archeopyles.

D. minutum, however, differs from *A. calloviana* in the detail of its paratabulation. *A. calloviana* does not possess any anterior intercalary paraplates and certainly has at least six postcingular paraplates, including a small elongate paraplate immediately to the right of the parasulcus. Dodekova reports two possible anterior intercalary paraplates and five postcingular paraplates from *D. minutum.* If Dodekova's plate 5, fig. 13 is indeed of the ventral surface, *D. minutum* can be further differentiated from *A. calloviana* by its asymmetrically situated endocyst, its circular paracingulum and its relatively indistinct parasulcus. Because of its determinable paratabulation and apparently apical archeopyle, *D. minutum* possibly merits generic reattribution, a conclusion also reached by Sarjeant, (1978). Its paratabulation, as described by Dodekova, however, does not accord with that of *Ambonosphaera.*

Genus *Sirmiodinium* Alberti, 1961 emend. Warren, 1973
Sirmiodinium grossi Alberti, 1961 emend. Warren, 1973

Plate 6, fig. 6; Plate 7, fig. 11

Sirmiodinium grossi Alberti, 1961, p. 22; pl. 7, figs 5–7; pl. 12, fig. 5. – – Sarjeant, 1966b, p. 212; pl. 22, fig. 7. – – emend. Warren, 1973, pp. 104–113; pls 1–3, all figs; text-figs 3–6. – – Bjaerke, Edwards & Thusu, 1976, pl. 1, fig. 1. Brideaux, 1977, pl. 15, fig. 11. *Sirmiodinium* sp. Evitt, 1967, pl. 8, figs 6–9. *Sirmiodinium* sp. Evitt, 1967, pl. 8, figs 10–11.

Dimensions: Range; (twelve specimens measured) pericyst: length 45 (66) 87 μm, breadth 52 (63) 78 μm; endocyst: length 37 (53) 63 μm, breadth 39 (52) 63 μm.

Remarks: The variation of overall shape, the nature of, and variation in, the development of the archeopyle, and the presence and position of accessory apertures in the Jameson Land specimens of this species confirm the observations of Warren (1973). The parasutures are faintly indicated. Pentagonal forms predominate; Warren noted that this was so with his specimens from the Upper Jurassic. However, one approximately triangular form was observed (Plate 7, fig. 11).

Family Endoscriniaceae Vozzhennikova, 1967a emend. Sarjeant & Downie, 1974
Genus *Endoscrinium* Klement, 1960 (Vozzhennikova, 1967a)
Endoscrinium galeritum (Deflandre, 1938b emend. Klement, 1960) Vozzhennikova 1967a

Plate 7, fig. 7

Gymnodinium galeritum Deflandre, 1938b, p. 167; pl. 5, figs 7–9; pl. 6, fig. 1; text-fig. 1. *Scriniodinium (Endoscrinium) galeritum* (Deflandre); emend. Klement, 1960. pp. 22–27; pl. 1, figs 4–12; pl. 2, figs 1–2; text-figs 4–5. – – Habib, 1972, pl. 6, fig. 3; (?). *Scriniodinium galeritum* (Deflandre); Sarjeant, 1961a, pp. 98–99; pl. 14, fig. 6. – – Dodekova, 1967, pp. 13–14; pl. 1, figs 1–5. *Endoscrinium galeritum* (Deflandre); Vozzhennikova, 1967a, p. 176; pl. 98, fig. 7. (English translation in Vozzhennikova, 1971, pp. 273–274). – – Sarjeant, 1968, p. 236; pl. 1, fig. 11. – – Gitmez, 1970, p. 301; pl. 3, figs 7–8; pl. 8, fig. 3. – Johnson & Hills, 1973, pl. 1, fig. 16. *Endoscrinium* cf. *galeritum* (Deflandre); Sarjeant, 1972, p. 50; pl. 3, fig. 6; (?).

Dimensions: Range; (24 specimens measured) pericyst: length 96 (105) 116 μm, breadth 90 (96) 106 μm; endocyst: length 77 (80) 83 μm, breadth 79 (85) 91 μm.

Remarks: The Jameson Land specimens of *E. galeritum* appear to be typical of this species in all respects.

Endoscrinium oxfordianum (Sarjeant, 1962b) Vozzhennikova, 1967a

Plate 8, fig. 2

Scriniodinium sp. A. Sarjeant, 1960b, p. 394; pl. 13, fig. 2. *Scriniodinium (?Endoscrinium)* sp. Sarjeant, 1962a, p. 263, pl. 1, fig. 15. *Scriniodinium (?Endoscrinium) oxfordianum* Sarjeant, 1962b, p. 485; pl. 69, figs 13–14. *Endoscrinium* aff. *oxfordianum* (Sarjeant); Vozzhennikova, 1967a, p. 177; pl. 98, fig. 8; (?). (English translation in Vozzhennikova, 1971). *Endoscrinium oxfordianum* (Sarjeant); Sarjeant, 1975, pl. 3, fig. 4. *Scriniodinium crystallinum* (Deflandre); Felix, 1975, pl. 1, fig. 3. – – Vigran & Thusu, 1976, pl. 18, fig. 4; (?); Brideaux, 1977, pl. 15, fig. 11.

Dimensions: Range; (three specimens measured) pericyst: length 96 (101) 106 μm, breadth 79 (91) 103 μm; endocyst: length 75 (80) 83 μm, breadth 64 (70) 76 μm.

Remarks: This species is often confused with *Scriniodinium crystallinium* (Deflandre, 1938). Both species have a similar shape and a similarly smooth cyst wall; indeed, they may be intergradational. However, *E. oxfordianum* possesses parasutural crests on the endocyst and often a slightly larger antapical pericoel. The Jameson Land specimens appear to possess discontinuous parasutural crests, and because of this the paratabulation is difficult to interpret. In size and shape they are typical of this species.

Endoscrinium subvallare (Sarjeant, 1962a) Lentin & Williams, 1973

Plate 8, fig. 3

Scriniodinium subvallare Sarjeant, 1962a, pp. 262–263; pl. 1, fig. 10; text-fig. 7. *Endoscrinium subvallare* (Sarjeant); Lentin & Williams, 1973, p. 54.

Dimensions: Figured specimen: pericyst: length 116 μm, breadth 92 μm; endocyst: length 92 μm, breadth 73 μm.

Remarks: Unless well preserved, specimens of *E. subvallare* are difficult to distinguish from *E. galeritum* (Deflandre, 1938b).

Endoscrinium sp.

Plate 8, fig. 11; text-fig. 18

Description: A form of *Endoscrinium* with an elongate subovoidal cyst and a short but distinct apical horn. The cyst wall consists of two layers which are separated apically and antapically, producing a small apical pericoel and a larger antapical pericoel. In the single well preserved specimen the two wall layers are also detached laterally for a variable distance from the apex and antapex, most notably along the left side of the hypocyst. The paratabulation is indicated on the periphragm by low parasutural crests ornamented by short, well-spaced denticles;

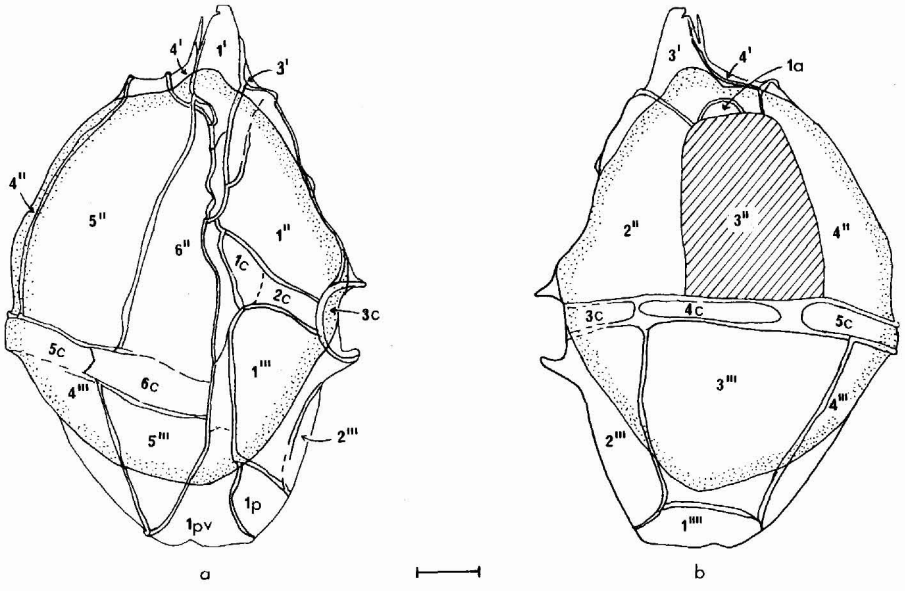


Fig. 18. *Endoscrinium* sp. (MGUH 14.740, 109.7/9.7; from sample GGU 144133, Hareelv Fm). a; ventral view. b; dorsal view (operculum detached and present within endocoel, but not illustrated). (Bar represents 10 microns).

these denticles are difficult to see except at the edges of the specimen. The paratabulation is 4′, 2a, 6‴, 6c, 5‴, 1pv, 1p, 1⁗, 3+s.

There are four apical paraplates of which 1′, 3′ and 4′ form the apical horn and also extend for short distances onto the main body of the cyst. The posterior margins of these three paraplates are irregularly shaped to accommodate the anterior intercalary paraplates. Paraplate 2′ is inserted between the parasulcus and paraplate 1″, immediately at the base and to the left of the apical horn; it is elongate in an antero-posterior direction.

There are two small anterior intercalary paraplates. One of these, 1a, is located on the dorsal surface immediately anterior to paraplate 3″ and projecting into paraplate 3′. Paraplate 2a is situated on the ventral surface; it is a small curved paraplate inserted between 1′, 4′ and 6″.

There are six precingular paraplates, 6″ being narrow relative to the others. Paraplate 3″ is involved in archeopyle formation. In one specimen the operculum is detached but has fallen into the cavity of the cyst. In another the operculum remains attached along the posterior parasuture of 3″.

The paracingulum is narrow and strongly laevorotatory; its free ends are displaced at the parasulcus by a distance equal to about two and a half paracingulum

widths. It broadens immediately to the left of the parasulcus to form paraplate 1c, which is much shorter than the other five paracingular paraplates. The parasutures between the paracingular paraplates on the dorsal surface consist of wall thickenings of variable width. The parasuture separating paraplates 2c and 3c on the figured specimen is very wide and thick; the significance of this feature is not fully understood, and it was not noted on other specimens. The paracingulum divides the cyst into a subconical epicyst and a slightly smaller, approximately trapezoidal hypocyst.

The parasulcus is narrow and essentially straight, although its margins are slightly sinous. It extends for most of the length of the cyst. It is divided into four paraplates, possibly including a relatively large, poorly defined posterior ventral paraplate. The parasulcus broadens towards the antapex.

There are five postcingular paraplates; 1‴ and 5‴ are small relative to the others, paraplate 1‴ because of the insertion of a small posterior intercalary paraplate between it and the antapex, and paraplate 5‴ because of the configuration of the paracingulum. The antapex is flat and possesses a single antapical paraplate.

The endocyst is subspheroidal. At the apex the endophragm is produced into a mamelon-like horn; at the antapex it is rounded. The endophragm is slightly thicker than the periphragm. Both wall layers are shagreenate to sparsely granular.

Dimensions: Figured specimen; overall length 87 μm, breadth 60 μm, length of endocyst 65 μm, length of apical horn 10 μm.

Remarks: This form of *Endoscrinium* most closely resembles *E. klementii* (Pocock, 1972) in its shape, although it does possess a longer apical horn. However, the paratabulation of *Endoscrinium* sp. differs from that of *E. klementii* in its possession of a posterior intercalary paraplate and significantly larger paraplates 6″ and 1‴. Furthermore, *Endoscrinium* sp. has a much narrower parasulcus and lower parasutural crests than are present in *E. klementii.*

E. galeritum (Deflandre, 1938) and *E. subvallare* (Sarjeant, 1962a) both differ in the detail of their paratabulation from *Endoscrinium* sp., but are more readily distinguished from it by shape. *E. galeritum* and *E. subvallare* are more rounded apically and antapically than is *Endoscrinium* sp.; they also possess a broader equatorial region in relation to the rest of the cyst.

Genus *Glabridinium* Brideaux, 1977

Glabridinium apatelum (Cookson & Eisenack, 1960b) Brideaux, 1977

Plate 8, fig. 6

Scriniodinium apatelum Cookson & Eisenack, 1960b, p. 249; pl. 37, figs 12–13. – – Manum & Cookson, 1964, p. 20; pl. 4, fig. 4. *Psaligonyaulax apaletum (sic)* (Cookson & Eisenack); Sarjeant, 1966a, p. 138, *nomen nudum. Psaligonyaulax apaleta (sic)* (Cookson & Eisenack); Sarjeant *in* Davey, Downie, Sarjeant & Williams, 1969, p. 15. – – Gitmez, 1970, pp. 303–304; pl. 6, fig. 8; text-fig. 29. *Psaligonyaulax apatela* (Cookson & Eisenack); Sarjeant, 1975, pl. 1, fig. 3. *Psaligonyaulax apatelum* (Cookson & Eisenack); Bjaerke, Edwards & Thusu, 1976, pl. 1, figs 2–4. *Glabridinium apatelum* (Cookson & Eisenack) : Brideaux, 1977, p. 35–36.

Dimensions: Range; (seven specimens measured) pericyst length 65 (83) 95 μm, pericyst breadth 32 (42) 52 μm, endocyst length 43 (52) 68 μm, endocyst breadth 32 (40) 52 μm, length of apical pericoel 4 (7) 10 μm, length of antapical pericoel 15 (22) 29 μm, length of apical horn 0.5 (3) 5 μm.

Remarks: The Jameson Land specimens of *G. apatelum* are on the small side of the size range of the type material, but only one specimen was outside that range. The apex was often damaged and this factor may have caused the measurements of horn length to be inaccurate.

Family Cleistosphaeridiaceae Sarjeant & Downie, 1974

Genus *Cleistosphaeridium* Davey, Downie, Sarjeant & Williams, 1966

Cleistosphaeridium ehrenbergi (Deflandre, 1947) Davey, Downie, Sarjeant & Williams, 1969

Plate 8, fig. 10

Hystrichosphaeridium cf. *hirsutum* Deflandre, 1938a, pl. 10, fig. 9. *Hystrichosphaeridium ehrenbergi* Deflandre, 1947, fig. 1, no. 5. – – Valensi, 1955, p. 587; pl. 3, fig. 1. *Baltisphaeridium ehrenbergi* (Deflandre); Sarjeant, 1962b, pp. 486–487; pl. 70, fig. 1; text-fig. 6a. *Cleistosphaeridium ehrenbergi* (Deflandre); Davey, Downie, Sarjeant & Williams, 1966, p. 170, *nomen nudum.* – – Davey, Downie, Sarjeant & Williams, 1969, p. 16. – – Gitmez, 1970, p. 284; pl. 4, fig. 7. text-fig. 22a.

Dimensions: Figured specimen; central body: length 25 μm, breadth 36 μm, length of spines (average) 8 μm.

Remarks: This specimen has approximately 70 processes. Sarjeant (1978) notes that *C. ehrenbergi* has typically 80–100 processes. Gitmez (1970) also figured a specimen with fewer processes than is typical for this species.

Family HYSTRICHOSPHAERIDIACEAE Evitt, 1963 emend. Sarjeant & Downie, 1974
Genus *Perisseiasphaeridium* Davey & Williams, 1966
Perisseiasphaeridium cf. *P. pannosum* Davey & Williams 1966

Plate 8, fig. 5

Oligosphaeridium pulcherrimum (Deflandre & Cookson); Gitmez, 1970, p. 290; pl. 7, fig. 7. — Gitmez & Sarjeant, 1972, pp. 235–236; pl. 13, fig. 3; text-fig. 25. Cf. *Perisseiasphaeridium pannosum* Davey & Williams; Vigran & Thusu, 1976, pl. 19, fig. 3.

Dimensions: Range: (14 specimens measured) central body: length 40 (45) 52 μm, breadth 41 (46) 49 μm; length of processes to 31–40 μm.

Remarks: This form was illustrated and described by Gitmez & Sarjeant, 1972. They attributed their specimens to *Oligosphaeridium pulcherrimum* (Deflandre & Cookson, 1955). Although the processes of *Perisseiasphaeridium* cf. *pannosum* do resemble those of *O. pulcherrimum,* they are more ragged and more broadly flaring. Furthermore, *Perisseiasphaeridium* cf. *pannosum* possesses relatively simple, fine parasulcal and paracingular processes (illustrated, but not described or mentioned by Gitmez & Sarjeant); because of these, this species is referable to *Perisseiasphaeridium* rather than to *Oligosphaeridium* Davey & Williams, 1966.

The Jameson Land specimens of *P.* cf. *P. pannosum* are mostly poorly preserved; however, other than the paracingular and parasulcal processes, the paratabulation appears to agree with that interpreted by Gitmez & Sarjeant. There are at least three parasulcal processes, but the number of paracingular processes is unclear.

This form closely resembles *P. pannosum;* however, the allocation of these Jurassic specimens to an Eocene species would be questionable. *P. pannosum* was originally described on the basis of four specimens from the London Clay, a stratum which is known to contain well preserved reworked Jurassic dinoflagellate cysts (Sarjeant, personal communication). Since its original description *P. pannosum* has been reported only from the Eocene sediments of Romania (Balteş, 1969) and from the Middle Eocene to Miocene of Brazil (Regali *et al.,* 1974). The specimen figured by Balteş (pl. 2, fig. 1) does not appear to have fenestrate processes, and the fine parasulcal and paracingular processes of the nature illustrated by Davey & Williams (1966, text-fig. 15, plate 3, fig. 5) are not clearly evident; closer examination of Balteş' figured specimen would be necessary, however, to more confidently assess his assignation. The specimen illustrated by Regali *et al.* (1974) differs from typical specimens of *P. pannosum* in the morphology and probably also in the distribution of its processes; it is therefore probably not attributable to this species.

Thus, it is possible that *P. pannosum* is a Jurassic species, and that the specimens described by Davey & Williams (and possibly also by Balteş) (1969) are reworked

into Tertiary sediments. As well as those described by Gitmez & Sarjeant (1972), specimens which appear to be synonymous with *P.* cf. *P. pannosum* have been reported by Vigran & Thusu (1976, pl. 19, fig. 3) from the Jurassic of Norway.

It is interesting to note that the only other species of *Perisseiasphaeridium* yet described, *P. eisenacki* Davey & Williams *in* Davey *et al.*, 1969, is of Lower Cretaceous age.

Family ADNATOSPHAERIDIACEAE Sarjeant & Downie, 1966
Genus *Adnatosphaeridium* Williams & Downie, 1966
Adnatosphaeridium aemulum (Deflandre, 1938b) Williams & Downie *in* Davey, Downie, Sarjeant & Williams, 1969

Plate 8, fig. 8

Hystrichosphaeridium aemulum Deflandre, 1938b, pp. 187–189; pl. 9, fig. 12; pl. 10, figs 5–8; pl. 11, figs 1–7. *Cannosphaeropsis aemula* (Deflandre); Deflandre, 1947, p. 1574. – – Sarjeant, 1961a, p. 104; pl. 15, fig. 1. – – Alberti, 1961, p. 36; pl. 10, fig. 8. *Adnatosphaeridium aemulum* (Deflandre); Williams & Downie, 1966, p. 218, *nomen nudum*. – – Williams & Downie *in* Davey, Downie, Sarjeant & Williams, 1969, p. 17. – – Sarjeant, 1975, pl. 3, fig. 6. *Adnatosphaeridium paucispinum* (Klement); Gitmez & Sarjeant, 1972, pl. 10, figs 1–2; (?).

Dimensions: Range; (56 specimens measured) central body: longest diameter 45 (53) 65 μm, shortest diameter 39 (45) 51 μm; length of processes 25 (31) 33 μm.

Remarks: The Jameson Land specimens appear to be typical of *A. aemulum* in all respects. The specimens figured by Gitmez & Sarjeant (1972, pl. 10, figs 1–2) as *A. paucispinum* (Klement, 1960) appear more closely comparable with *A. aemulum.* They certainly appear to have too many processes to be attributable to *A. paucispinum.*

Family SYSTEMATOPHORACEAE Sarjeant & Downie, 1974
Genus *Systematophora* Klement 1960
Aff. *Systematophora* sp.

Plate 8, fig. 4

Description: A species of dinoflagellate cyst with a subovoidal central body, possessing numerous processes apparently linked basally and at various points along their length into penitabular groups. The width of the processes and the degree of linkage between them appears to be very variable. The processes may be distally free or they may be linked. All three specimens observed were, however, too poorly preserved for the paratabulation to be interpreted. In one of these specimens a distinct tube-like structure, possibly in an antapical position, is present

(Plate 8, fig. 4). Similar but very poorly preserved appendages appear to be present in the other two specimens encountered. An archeopyle was not clearly perceived in any of the specimens.

Dimensions: Range; (two specimens measured) longest diameter of central body 52 μm, shortest diameter of central body 41–47 μm, length of processes 11–25 μm, length of tube (one measurable) 15 μm.

Remarks: The possession of what appears to be an antapical tube distinguishes this form from all known species of *Systematophora.*

Genus *Polystephanephorus* Sarjeant, 1961b
Polystephanephorus paracalathus (Sarjeant, 1960a) Sarjeant, 1961b

Plate 8, fig. 7

Polystephanosphaera paracalathus Sarjeant, 1960a, pp. 143–144; pl. 6, fig. 4; text-fig. 3b. *Polystephanephorus paracalathus* (Sarjeant) Sarjeant, 1961b, p. 1096. – – Sarjeant, 1968, p. 233, 235; pl. 1, fig. 15. – – Sarjeant, 1976c, pp. 18–19; pl. 6, figs 1–2.

Dimensions: Figured specimen; central body: length 60 μm, breadth 49 μm; length of processes 25–30 μm.

Remarks: This specimen is only moderately well preserved, but the groups of processes and the trabeculae joining them are clearly seen.

Genus *Prolixosphaeridium* Davey, Downie, Sarjeant & Williams, 1966
Prolixosphaeridium cf. *P. deirense* Davey, Downie, Sarjeant & Williams, 1966

Plate 8, fig. 12

Prolixosphaeridium cf. *deirense* Davey, Downie, Sarjeant & Williams; Gitmez, 1970, p. 292; pl. 13, fig. 9; (?).

Dimensions: Figured specimen; length 49 μm, breadth ?30 μm, length of processes to 10 μm. Other specimen (?); length 56 μm, breadth 26 μm, length of process to 16 μm.

Remarks: The single well preserved specimen encountered had a densely granular cyst wall and numerous simple acuminate processes, as is the case with *P. deirense.* However, the enlarged antapical process and the spine rows which characterize *P. deirense* were not observed, and therefore this specimen is compared with, rather than assigned to, that species. Gitmez (1970) encountered similar specimens from the basal Kimmeridgian of Dorset, England.

Family CORDOSPHAERIDIACEAE Sarjeant & Downie, 1974
Genus *Kleithriasphaeridium* Davey, 1974
Kleithriasphaeridium cf. *K. corrugatum* Davey, 1974
Plate 9, fig. 2

Dimensions: Figured specimen; central body diameter 45 μm, length of the two complete processes 20 μm, 26 μm.

Remarks: As far as could be seen this specimen agrees with the diagnosis and description of Davey for *K. corrugatum,* notably in the mode of archeopyle formation, the nature of the processes and the surface ornamentation. (Davey notes that "the type of wall ornamentation present between the processes is difficult to determine; the scanning electron microscope, however, clearly reveals that a complex series of ribs and corrugations are present". The ribs and corrugations on the surface of the Jameson Land specimen were, however, clearly visible without the aid of a scanning electron microscope.)

Because of the only moderate preservation and because the paratabulation could not be fully determined, this specimen is compared with, rather than attributed to, *K. corrugatum.*

Order DINOPHYSIDALES
Family NANNOCERATOPSITACEAE Sarjeant & Downie, 1974
Genus *Nannoceratopsis* Deflandre, 1938b emend. Evitt, 1961a
Nannoceratopsis pellucida Deflandre, 1938b emend. Evitt, 1961a
Plate 9, fig. 13

Nannoceratopsis pellucida Deflandre, 1938a, fig. 5, *nomen nudum.* – – Deflandre, 1938b, pp. 183–184; pl. 8, figs 8–12. – – Cookson & Eisenack, 1958, p. 52; pl. 10, figs 5–6; text-fig. 19. – – Sarjeant, 1960b, pl. 12, figs 7, 10. – – emend. Evitt, 1961a, p. 34; pl. 1, figs 13–18; pl. 2, figs 30–31. – – Sarjeant, 1962b, pl. 69, figs 9–10. – – Vozzhennikova, 1965, figs 32A, 47H. (English translation in Vozzhennikova, 1967b). – – Gocht, 1970, p. 157; pl. 32, figs 19–22; text-fig. 26. – – Gitmez, 1970, p. 282; pl. 7, fig. 4. – – Johnson & Hills, 1973, pl. 2, fig. 1; text-fig. 7. – – Sarjeant, 1974a, pl. 9, fig. 2; text-fig. 30. – – Felix, 1975, pl. 1 fig. 4.

Dimensions: Figured specimen; length 109 μm, depth 41 μm.

Remarks: The specimens observed from Jameson Land are narrower than the type material for this species, and the antapical horns are longer and more divergent. Neither of these specimens possessed a detached or partially detached epicyst, although these have been observed in this species (Sarjeant, 1974, p. 78 and personal communication).

Nannoceratopsis gracilis Alberti, 1961 emend. Evitt, 1962

Plate 9, fig. 1

Nannoceratopsis gracilis Alberti, 1961, p. 30; pl. 7, figs 16–17. – – emend. Evitt, 1962, pp. 1129–1130. – – Gocht, 1964, pp. 115–120; pl. 15, figs 1–8; pl. 16, figs 1–4; text-figs 1–36. – – Wall, 1965, pp. 164–165; pl. 6, figs 12, 13. – – Gocht, 1972, pp. 16–28; figs 1–4, 6A. – – Johnson & Hills, 1973, pp. 207–208; pl. 3, figs 13–19; text-fig. 7–10. – – Felix, 1975, pl. 1 fig. 5. – – emend. Van Helden, 1977, p. 165; pl. 33.1, figs 10–14; pl. 33.2, figs 1–13. *Nannoceratopsis deflandrei* Evitt, 1961a, pp. 308–312; pl. 1, figs 1–14; pl. 2, figs 1–29; text-figs 5, 9–17. *Nannoceratopsis* sp. Chornaya, 1963, pl. 8, figs 1–14. *Nannoceratopsis senex* Van Helden, 1977, pp. 165, 170; pl. 33.1, figs 1–9.

Dimensions: Range; (54 specimens measured) length 63 (72) 87 μm, depth 43 (50) 59 μαm.

Remarks: Extensive morphological studies of *N. gracilis* have been made by Evitt (1961a) and Gocht (1972). They noted especially the great variability in the cyst shape, in the nature of the crests bounding the large lateral areas and in the nature of the ornamentation of the wall; a similar variability is exhibited by the Jameson Land specimens.

Johnson & Hills (1973) encountered numerous specimens of *N. gracilis* from the lower part of the Savik Formation from Axel Heiberg Island in the Canadian Arctic. They also noted considerable morphological variation and observed that 'boat-shaped' forms were replaced gradually by forms with a prominent ventral antapical horn at successively higher levels of their section. Although both morphological extremes, as well as intermediate forms, occur in sample 144229, specimens with distinctive antapical horns predominate. This sample might therefore tentatively correlate with assemblages of *N. gracilis* towards the top of the section studied by Johnson & Hills, indicating a late Bajocian age.

Many specimens of *N. gracilis* from sample GGU 144229 have lost their epicysts and others have partially detached epicysts. Evitt (1961a) and Gocht (1964) have also noted this feature amongst their assemblages. Piel & Evitt (1978) have recently shown that *N. gracilis* has an archeopyle which is formed by the loss of a mid-dorsal paracingular paraplate. The loss of this paraplate mechanically weakens the already narrow paracingulum; this consequently tends to tear beyond the preformed archeopyle, in some cases so far that the epicyst becomes completely detached.

Van Helden (1977) has subdivided *N. gracilis* sensu Alberti into two species, *N. gracilis* and a new taxon, *N. senex*. The latter is intended to include all 'boat-shaped' forms, other specimens remaining in a consequently restricted *N. gracilis*. Although the present author recognizes the possible stratigraphical significance of splitting *N. gracilis*, the method of subdivision apparently used by van Helden is theoretically unsound. In defining *N. gracilis* and *N. senex* he appears to have subdivided variable assemblages in which individuals form a morphological conti-

nuum. Many palaeontologists consider that such continuous variation fields represent natural units (i.e, species) (for example George, 1971). If *N. gracilis* is to be subdivided, the procedure used should leave such natural units intact.

INCERTAE SEDIS

Group ACRITARCHA Evitt, 1963

Subgroup ACANTHOMORPHITAE Downie, Evitt & Sarjeant, 1963

Genus *Micrhystridium* Deflandre, 1937 emend. Sarjeant, 1967

Micrhystridium deflandrei Valensi, 1948

Plate 8, fig. 9

Micrhystridium deflandrei Valensi, 1948, pp. 553–554; fig. 5, nos. 3–5. – – Valensi, 1953, p. 51; pl. 7, figs 19, 21–22. – – Valensi, 1955, p. 589; pl. 3, fig. 18. – – Sarjeant, 1960b, p. 400; text-fig. 1q. – – Sarjeant, 1962b, text-fig. 9e. – – Chornaya, 1963, p. 284; pl. 7, fig. 11. – – Sarjeant, 1965, p. 179; pl. 1, fig. 5. – – Sarjeant 1968, pl. 2, fig. 9. – – Sarjeant, 1973, p. 42; pl. 1, fig. 12 (upper). – – Muir & Sarjeant, 1978, pl. 1, fig. 6.

Dimensions: Range; (39 specimens measured) diameter 13 (16) 19 μm.

Remarks: This species is characterized by its numerous regularly distributed short spines. It is common in one of the samples from the Fossilbjerget Member. These specimens are typical of *M. deflandrei* in all morphological characteristics.

Micrhystridium fragile Deflandre, 1947b

Plate 9, fig. 7

Micrhystridium fragile Deflandre, 1947b, p. 8; figs 13–18. – – Valensi, 1947, fig. 7. – – Valensi, 1953, pp. 41–43; pl. 5, figs 1–14, 17–19; pl. 14, figs 1–2. – – Valensi, 1955, p. 589; pl. 2, fig. 14. – – Delcourt & Sprumont, 1957, p. 60; pl. 2, fig. 7. – – Sarjeant, 1959, p. 340; text–figs 7a,d. – – Sarjeant, 1960b, pp. 398–399; pl. 12, fig. 3; pl. 13, figs 9, 14; pl. 14, fig. 9; text-figs 1m, 1o, 2. – – Sarjeant, 1961a, p. 105; pl. 13, figs 3–4. – – Sarjeant, 1962a, p. 264; pl. 2, figs 11–12; text-fig. 8d. – – Sarjeant, 1962b, p. 489; pl. 70, fig. 6; text-fig. 8a. – – Chornaya, 1963, p. 284; pl. 7, figs 3–4. – – Takahashi, 1964, pp. 205–206; pl. 31, figs 8–10. – – Sarjeant, 1965, p. 177; pl. 1, fig. 10. – – Medd, 1966, p. 252; pl. 59, figs 1–2. – – Sarjeant, 1967, pl. 1, fig. 7; text-fig. 1h. – – Sarjeant, 1968, pl. 1, fig. 5; – – Gitmez, 1970, pp. 316–317; pl. 8, fig. 8; pl. 12, fig. 4. – – Muir & Sarjeant, 1978, pl. 2, fig. 6. *Archaechystrichosphaeridium minimum* Isagulova, 1963, p. 1157; fig. 24; (?).

Dimensions: Range; (29 specimens measured) diameter of central body 10 (13) 17 μm, length of spines 5 (7) 9 μm.

Remarks: The specimens observed from Jameson Land appear to be typical of this species.

Micrhystridium pyramidispinum Dodekova, 1969

Plate 9, fig. 6

Micrhystridium pyramidispinum Dodekova, 1969, pp. 23–24; pl. 5, figs 7–13; text-fig. H.

Dimensions: Figured specimen; diameter of central body 18 μm, length of spines 2 μm. Holotype; diameter of central body 15 μm, length of spines 1.5 μm (from Dodekova, 1969).

Remarks: This is the first record of this species other than its original description by Dodekova from the Tithonian (Upper Kimmeridgian–Portlandian) of north-central Bulgaria. This specimen is closely comparable with Dodekova's figured specimens in its shape and the nature of its spines; it is slightly larger, however, than her two measured specimens.

Micrhystridium recurvatum Valensi, 1953

Plate 9, fig. 5

Micrhystridium recurvatum Valensi, 1953, p. 43; pl. 6, figs 1–4. – – Valensi, 1955, p. 589; pl. 1, fig. 10. – – Sarjeant, 1960b, p. 392, pl. 14, fig. 19; text-fig. 1a. – – Sarjeant, 1962b, p. 489, text-figs 8b,f. Gocht, 1964, p. 123, pl. 16, fig. 13; text-fig. 43. – – Sarjeant, 1965, pp. 177–178; pl. 1, figs 11–18. – – Dodekova, 1967, p. 27; pl. 3, fig. 10. – – Sarjeant, 1967, pl. 1, figs 1, 3–5, 9; text-fig. 1h. – – Gitmez & Sarjeant, 1972, p. 247; pl. 17, figs 1–2.

Dimensions: Range; (22 specimens measured) diameter of central body 10 (14) 20 μm, length of spines 4 (5) 7 μm.

Remarks: Specimens of *M. recurvatum* were encountered in several of the Jameson Land samples. They appear to be typical of this species in all respects.

Genus *Solisphaeridium* Staplin, Jansonius & Pocock, 1965 emend. Sarjeant, 1968

Solisphaeridium stimuliferum (Deflandre, 1938b) Staplin, Jansonius & Pocock, 1965

Plate 9, fig. 3

Hystrichosphaeridium stimuliferum Deflandre, 1938b, p. 192; pl. 10, fig. 10. – – Deflandre, 1947, p. 5; text-fig. 4. – – Valensi, 1953, p. 36; pl. 4, figs 13, 15–16; pl. 13, fig. 17. *Baltisphaeridium stimuliferum* (Deflandre); Sarjeant, 1960b, text-fig. 1. – – Sarjeant, 1961a, pp. 100–101; pl. 15, fig. 5; text-fig. 8a. – – Sarjeant, 1962b, pp. 488–489; pl. 70, figs 5, 17; text-figs 8c, e, g. *Baltisphaeridium* cf. *stimuliferum* (Deflandre); Sarjeant, 1962a, pp.264–265; pl. 2, fig. 10; text-fig. 8a. *Solisphaeridium stimuliferum* (Deflandre); Staplin, Jansonius & Pocock, 1965, p. 183; pl. 18, figs 1–2; text-figs 3, 10. – – Sarjeant, 1968, p. 223; pl. 3, fig. 6; text-fig. 1. – – Deflandre & Sarjeant, 1970, pp. 5–6; pl. 1, fig. 4. – – Gitmez, 1970, pp. 320–321; pl. 13, fig. 6; text-figs 34 a-1.

Dimensions: Range; (five specimens measured) central body: longest diameter 22 (25) 28 μm, shortest diameter 16 (20) 23 μm; length of spines to 12 (14) 19 μm.

Remarks: Several of the specimens observed are obscured or torn and therefore difficult to study. However, in size, shape and nature of their spines, the Jameson Land specimens appear to be typical of this species.

Solisphaeridium ankyleton sp. nov.

Plate 9, figs 10–11, 15; text-fig. 19

Derivation of name: Gr. *ankyleton,* javelin; in reference to the long spines of this species.

Diagnosis: A species of *Solisphaeridium* with an ovoidal or spheroidal central body, with 5–9 long, lanceolate or very rarely briefly bifurcate processes; the ratio of longest process length to longest central body diameter is approximately 3:2. For the greater part of their length the processes are hollow, but there is a short solid section at or near each process base. The wall is smooth to finely granular and opens by means of a cryptosuture.

Holotype: MGUH 14.756, 97.2/18.7; from GGU 144115, Hareelv Formation, south side of Langryggen. Plate 9, figs 10, 15; text-fig. 19B.

Paratype: MGUH 14.757, 107.5/15.1; from GGU 144115, Hareelv Formation, south side of Langryggen. Plate 9, fig. 11; text-fig. 19A.

Dimensions: Holotype; central body 26×23 μm, processes to 33 μm. Paratype; central body 21×17 μm, processes 20–30 μm. Range; (six specimens measured) central body: longest diameter 17 (23) 27 μm, shortest diameter 15 (20) 23 μm; length of longest processes 30 (34) 35 μm.

Description: This species is characterized by its long spines, each with a solid basal section. This may occur immediately at the base of the process, as in the holotype, or it may be located at a short distance above the base, as in most spines on the paratype; in the latter case the base of the processes are hollow for the proximal 2–3 μm of their length, this part of the processes connecting freely with the cavity of the central body. The solid part of each process is usually 4–8 μm long; it is not markedly constricted, if at all. Between the solid section and their closed, somewhat flattened distal extremity, the processes are hollow. All processes seen, with one exception, have a simple, pointed distal tip; in the one exception the process is finely and briefly bifurcate. Unfortunately many processes have been truncated during preservation, so it is difficult to assess the consistency of process length in a given specimen; however, all processes that remain complete are considerably longer than the test diameter.

The wall of both the central body and the processes is thin and thus prone to

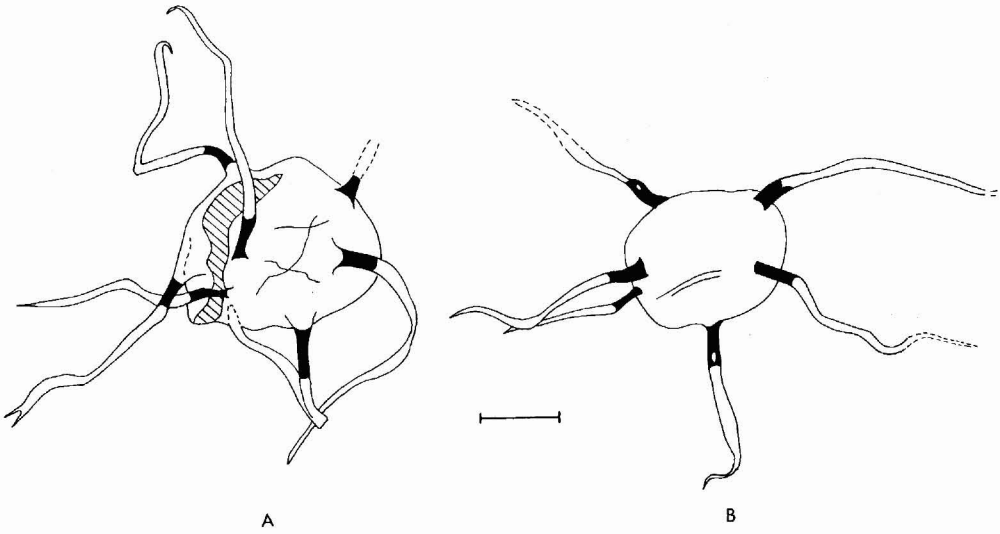


Fig. 19. *Solisphaeridium ankyleton* sp. nov. A; paratype. B; holotype. (Bar represents 10 microns).

folding. Only in the paratype was a cryptosuture observed, but because of folding of the test wall its exact nature is not clear.

Remarks: The only other forms of *Solisphaeridium* in which the process and central body cavities are not freely interconnected are *S. claviculorum* (Deflandre, 1938b) and *S.* cf. *S. claviculorum* of Muir & Sarjeant, 1978. However, *S. ankyleton* is clearly distinguished from these by its fewer and considerably longer processes. Similar forms have been encountered by Sarjeant (personal communication) from Bed 2 of Wright (1968) (*athleta* Zone, Callovian) of the Hackness Rock at Hackness Quarry, Yorkshire.

Solisphaeridium brevispinosum (Sarjeant, 1961a) emend. Sarjeant, 1968

Plate 9, fig. 17

Baltisphaeridium ehrenbergi var. *brevispinosum* Sarjeant, 1961a, p. 103; pl. 15, fig. 8; text-fig. 8a. *Baltisphaeridium debilispinum* var. *brevispinosum* (Sarjeant); Wall, 1965, p. 155; pl. 1, fig. 10; pl. 7, fig.5. *?Solisphaeridium brevispinosum* (Sarjeant); emend. Sarjeant, 1968, pp. 223–224; pl. 1, figs 3, 9. *Solisphaeridium brevispinosum* (Sarjeant); Gitmez, 1970, p. 320; pl. 2, fig. 7. – – Sarjeant, 1973, pp. 55–56; pl. 13, fig. 10. – – Sarjeant, 1976c, pp. 19–20; pl. 3, fig. 6.

Dimensions: Figured specimen; central body; longest diameter 29 μm, shortest diameter 26 μm; length of spines 7–9 μm.

Remarks: There are about 40 spines (slightly fewer than is typical); their length is between one third and one fifth of the test diameter (one quarter to one fifth is typical). The test is ovoidal, almost spheroidal, and the test wall is finely granular.

Subgroup POLYGONOMORPHITAE Downie, Evitt & Sarjeant, 1968
Genus *Veryhachium* Deunff, 1958 emend. Downie & Sarjeant, 1963

Veryhachium sortehatense sp. nov.

Plate 9, figs 4, 8–9; text-fig. 20 B-I

Derivation of name: After the Sortehat Member of the Vardekløft Formation, in which this species is most abundantly encountered in the present work.

Diagnosis: A species of acritarch with a polygonal central body from the angulations of which arise 5–9 broad-based, hollow, horn-like processes; these usually have a length of 50–110 per cent of the greatest diameter of the central body although rarely they may be shorter. They are usually acuminate but may occasionally bifurcate or, rarely, trifurcate distally. The test surface is distinctly granular. Opening is by means of a cryptosuture.

Holotype: See Table 3. From the Sortehat Member, Vardekløft Formation, north of Dusén Bjerg.

Paratypes: See Table 3. All paratypes are from the Vardekløft Formation, Paratypes (i) – (vi) are from the Sortehat Member, north of Dusén Bjerg, and paratype (vii) is from the Fossilbjerget Member, west of Fossilbjerget.

Dimensions: See Table 3.

Table 3. Dimensions of, and information pertaining to the holotype and paratypes of Veryhachium sortehatense *sp. nov.*
(Measurements given in microns)

	Greatest diameter of central body	Length of spines	Slide no.	Slide location	Sample no.	Plate-figure	Text-figure
Holotype	16	to 12	MGUH 14.759	94.4/17.0	GGU 144231	9–8	20B
Paratype (i)	15	to 12	MGUH 14.760	107.3/19.0	GGU 144231	–	20H
Paratype (ii)	16	to 12	MGUH 14.761	106.4/ 9.5	GGU 144231	9–4	20G
Paratype (iii)	23	to 10	MGUH 14.762	90.5/12.0	GGU 144231	–	20E
Paratype (iv)	15	to 10	MGUH 14.763	102.1/14.5	GGU 144231	9–9	20F
Paratype (v)	15	to 13	MGUH 14.764	111.2/17.6	GGU 144231	–	20I
Paratype (vi)	19	to 12	MGUH 14.765	110.6/17.8	GGU 144231	–	20D
Paratype (vii)	16	to 8	MGUH 14.766	105.6/12.0	GGU 139163	–	20C
Range (50 specimens)	11(15)23	to 8(12)16	–	–	–	–	–

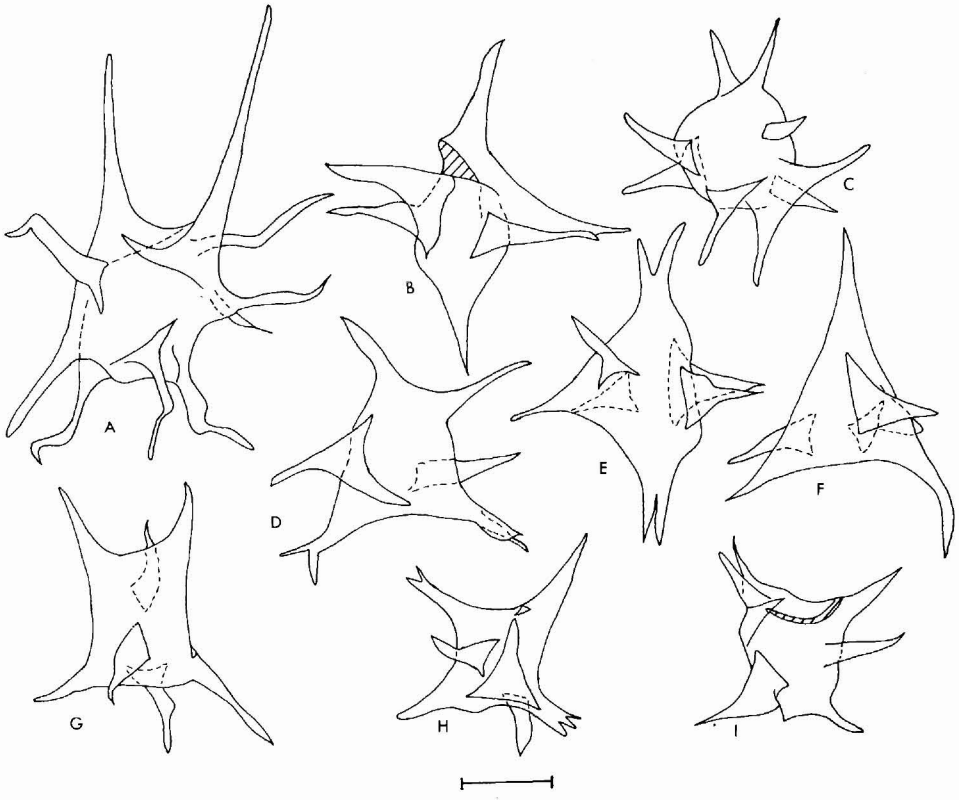


Fig. 20. A; *Veryhachium* cf. *V. sortehatense* sp. nov. Fensome (MGUH 14.767, 109.7/14.5; from sample GGU 144144, Pelion Mb). B–I, *Veryhachium sortehatense* sp. nov. B; holotype. C; paratype (iii). D; paratype (vi). E; paratype (iii). F; paratype (iv). G; paratype (ii). H; paratype (i). I; paratype (v). (For details of these specimens, see Table 4). (Bar represents 10 microns).

Description: This species possesses a test which, in plan view, is subtriangular to subrectangular, rarely fusiform to subspheroidal. Five to nine spines usually merge with the central body; more rarely they may be more or less distinct. The cavities of the spines connect freely with that of the central body. Spine length is rarely shorter than 50 per cent of the greatest diameter of the central body and may occasionally exceed 100 per cent; within that range, however, spine length is variable. Distally most spines are more or less sharply pointed; in some specimens, however, one or two spines bifurcate or, rarely, trifurcate. The test wall is single layered and distinctly granular; granules may develop into short barbs, especially on the spines. The test opens by means of a cryptosuture.

Remarks: Some specimens of *V. sortehatense* resemble *V. collectum* Wall, 1965, but *V. sortehatense* has more variation in the shape of its central body and also more broadly based processes; it never exhibits the whip-like processes that characterize many specimens of *V. collectum.*

V. sortehatense also resembles *V. riburgense* Brosius & Bitterli, 1961. However, the spines of *V. riburgense* are usually significantly shorter than those of *V. sortehatense* and generally possess blunter distal endings. The variation within *V. riburgense,* as described by Brosius & Bitterli, is nevertheless similar to that observed in *V. sortehatense.* The granular surface ornament may be a further point of distinction between *V. sortehatense* and both *V. riburgense* and *V. collectum.*

Similar specimens have been observed by Sarjeant (personal communication) from Bed 2 of Wright (1968) (*athleta* Zone, Callovian) of the Hackness Rock at Hackness Quarry, Yorkshire.

One specimen was observed from the Pelion Member which resembles *V. sortehatense* in its general morphology. However, it possesses ten spines (5–9 is typical for *V. sortehatense*); furthermore, some of these spines are of significantly greater relative length than is typical for this species. This specimen is illustrated in text-fig. 20A.

Subgroup PTEROMORPHITAE Downie, Evitt & Sarjeant, 1963

Genus *Pterospermopsis* W. Wetzel, 1952

Pterospermopsis sp. A.

Plate 9, fig. 12; text-fig. 21 a,c

Description: A form of *Pterospermopsis* having a spheroidal central body with a smooth, thick wall. One specimen (Plate 9, fig. 12) has an irregularly shaped aperture in this wall, possibly resulting from random tearing. The wing is relatively thick for this genus; in width it is about 1/2–2/3 the central body diameter, and is ornamented by several more or less straight, radially arranged wing-folds. Between wing-folds the surface of the wing is smooth.

Dimensions: Range; (five specimens measured) overall diameter 20 (25) 30 μm, diameter of central body 9 (12) 14 μm; ratio of wing breadth to central body diameter usually between 0.5:1 and 0.7:1.

Remarks: This form is superficially similar to *P. helios* Sarjeant, 1959 and *P. australiensis* Deflandre & Cookson, 1955. When compared in detail with *P. helios,* however, it can be seen that whereas the wing of *Pterospermopsis* sp. A is relatively thick, that of *P. helios* is very delicate. Furthermore, the wing folds of *P. helios* are much more pronounced than those of *Pterospermopsis* sp. A, which, in plan view, appear as narrow radial lines.

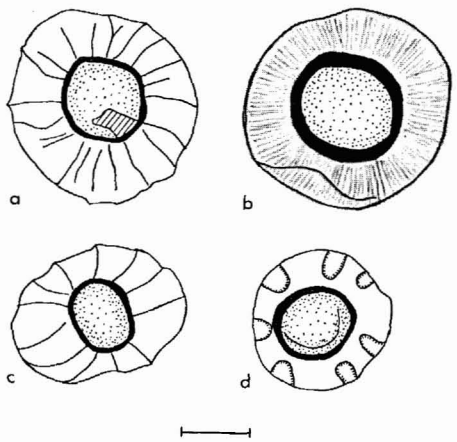


Fig. 21. a; *Pterospermopsis* sp. A (MGUH 14.768, 109.0/12.6; from sample GGU 144161, Fynselv Mb). b; *Pterospermopsis* sp. B (MGUH 14.769, 109.5/12.2; from sample GGU 144161, Fynselv Mb). c; *Pterospermopsis* sp. A (MGUH 14.771, 100.3/3.0; from sample GGU 144111, Pelion Mb). d; *Pterospermopsis* sp. C (MGUH 14.770, 110.2/13.2; from sample GGU 144161, Fynselv Mb). (Bar represents 10 microns).

The wing folds of *P. australiensis,* as shown by the illustrations of Deflandre & Cookson (1955), are much less regularly distributed and less continuous than are those of *Pterospermopsis* sp. A.

Pterospermopsis sp. B.

Plate 9, fig. 16; text-fig. 21b

Description: A form of *Pterospermopsis* in which the wing is unfolded and slightly narrower than the diameter of the central body. The wing is circular in outline and finely granular; it possesses faint striations, densely and radially arranged across its surface. The central body is spheroidal; its wall is about 1.5 μm thick, smooth to finely granular and possesses a fold which is probably a preservational feature.

Dimensions: Figured specimen; overall diameter 31 μm, diameter of central body 17 μm.

Remarks: This form differs from *P. australiensis* Deflandre & Cookson, 1955, *P. helios* Sarjeant, 1959 and *Pterospermopsis* spp. A and C of Fensome, herein, by the lack of distinctive folds on its wing. It is also similar to *P. aureolata,* Cookson & Eisenack, 1958, *P. eurypteris* Cookson & Eisenack, 1958 and *P. pluriparietes* Döring, 1961; however, it is distinguished from these species by its lack of all but very fine ornament on its wing.

Pterospermopsis sp. C

Plate 9, fig. 14; text-fig. 21 d

Description: A form of *Pterospermopsis* similar to *Pterospermopsis* sp. A of Fensome, herein, in its general morphology and size, but with folds on the wing arranged so as to give a regularly scalloped appearance.

Dimensions: Range; (two specimens measured) overall diameter 23–29 μm, diameter of central body 13–15 μm, breadth of wing 5–6 μm, thickness of central body wall 1 μm.

Remarks: Pterospermopsis sp. C differs from all previously described forms of *Pterospermopsis* in the scalloped nature of its wing folds. In general shape and dimensions it is similar to *Pterospermopsis* sp. A of Fensome, herein, *Pterospermopsis* sp. B of Fensome, herein, *P. helios* Sarjeant, 1959 and *P. australiensis* Deflandre & Cookson, 1955.

DISCUSSION AND CONCLUSIONS

Stratigraphical considerations

General Remarks

The distribution of taxa encountered and their previously recorded stratigraphical ranges are given in Tables 4a, b. The stratigraphical ranges of organic-walled microplankton taxa have been compiled from various sources, most notably Riley & Sarjeant (1972), Harker & Sarjeant (1975) and Sarjeant (1975, 1978). It should be noted that the study of Jurassic dinoflagellate cysts is still at a pioneer stage and ranges of individual taxa must inevitably be modified as our knowledge increases. Assignations of the samples to stages or ammonite zones were supplied with the samples by T. Birkelund (Table 5).

Sortehat Member

Of the five samples prepared from the Sortehat Member, two contained palynomorphs too badly carbonized for meaningful study. The other samples yielded organic-walled microplankton assemblages which are poor in terms of the number of taxa represented. Sample GGU 144229 contains a rich assemblage in terms of the absolute number of individuals present. This assemblage is, however, almost totally dominated by *Nannoceratopsis gracilis,* which constitutes 98 per cent of the individuals from that assemblage. The organic-walled microplankton from sample 144112 are well preserved but sparse; in this assemblage *N. gracilis* is again an important constituent. The assemblage of sample 144231 is dominated by the new acritarch species, *Veryhachium sortehatense. N. gracilis* was not encountered in this sample.

Thus, the organic-walled microplankton assemblages obtained from the Sortehat Member of the Vardekløft Formation do not allow for accurate dating. *N. gracilis* has previously been recorded from Early Jurassic to at least Bajocian sediments and possibly ranges into the Bathonian. The overall shape of the majority of specimens of *N. gracilis* encountered in sample 144229 may tentatively indicate a late Bajocian age; this is discussed more fully in the systematic section.

The organic-walled microplankton assemblages obtained from the Sortehat Member therefore only broadly support the Bajocian assignation tentatively established for it by ammonite associations, though they certainly do not contradict such a dating.

Pelion Member

One sample (144111) was prepared from the Pelion Member. The organic-walled microplankton assemblage obtained from this sample is dominated by species

of the family Canningiaceae, notably *Sentusidinium verrucosum* and a new species, *Sentusidinium pelionense*. *S. verrucosum* has previously been recorded from Late Callovian – Middle Oxfordian sediments. However, since the lower part of the overlying Fossilbjerget Member is most probably of Bathonian age (as discussed below) the Pelion Member in southern Jameson Land is almost certainly older than Callovian. By its ammonite associations sample 144111 is dated as Late Bajocian – Early Bathonian. Thus it appears that the stratigraphical ranges of *S. verrucosum,* and also of *Chytroeisphaeridia dictydia* (also present in sample 144111 and previously described only from Late Bathonian – Middle Callovian sediments), must be extended downwards to at least the Early Bathonian. Other taxa encountered in sample 144111 are long-ranging or previously undescribed and therefore of little present stratigraphical use.

Fossilbjerget Member

Of six samples prepared from the Fossilbjerget Member, all except sample 137324 yielded assemblages of organic-walled microplankton worthy of detailed examination. Of these samples, 144127 and 139163 have been assigned to the *apertum* Zone (Callovian) and sample 100721 to the *calloviense* Zone (Callovian) on the basis of their ammonite associations; the other two samples, 137053 and 144125, can be dated as post-*arcticus* Zone, Bathonian – Callovian and Bathonian respectively, again on the basis of associated ammonites.

Sample 144125 yielded a moderately rich assemblage, over 15 taxa being observed. Forms of *Chytroeisphaeridia* and *Pareodinia* predominate and include one new species, *Pareodinia brachythelis,* which is a common constituent of the assemblage. Two forms of *Ctenidodinium, C. ornatum* and *C.* cf. *C. continuum,* are also present; *C. continuum* has been previously recorded only from the early Bathonian (Gocht, 1970). Most surprising is the presence in this sample of *Sirmiodinium grossi* (?Kimmeridgian – Campanian); however, because only one specimen was found, pollution cannot be excluded to explain its occurrence here. Other taxa encountered are long-ranging or new and consequently of little immediate stratigraphical value.

It would appear from the taxa present that this sample is not older than Bathonian. In the combination of *Ctenidodinium ornatum, C.* cf. *C. continuum* and several forms of *Chytroeisphaeridia* and *Pareodinia,* this assemblage is typical of Bathonian assemblages. The organic-walled microplankton thus support the date for this sample based on ammonite faunas.

The assemblage contained in sample 137053 is not as diverse as that of 144125, only eight taxa being recorded. Forms of *Chytroeisphaeridia* and *Pareodinia* are less prominent. The acritarchs are dominated by species of *Micrhystridium, Ctenidodinium ornatum* is an important constituent of this assemblage and *C.* cf. *C.*

Table 4a. The dinoflagellate cysts and acritarchs (*) recovered from the Vardekløft Formation

	Sortehat			Pelion	Fossilbjerget					Previously recorded stratigraphical ranges
	144112	144231	144229	144111	144125	137053	139163	144127	100721	
Micrhystridium deflandrei									C	L. Trias. – Oxf.
Ambonosphaera calloviana									R	
Leptodinium subtile									S	E. Bath. – M. Kim.
Gonyaulacysta pectinigera									I	Bath.
Paragonyaulacysta sp.									S	
Egmontodinium sp.									S	
Valensiella ovulum									I	Baj. – E. Oxf.
Valensiella sp.									R	
Ellipsodictyum gochtii									R	
Solisphaeridium stimuliferum *								R		Baj. – E. Port.
Gonyaulacysta jurassica								R	R	E. Bath. – M. Kim.
Chytroeisphaeridia pococki								R	R	L. Bath. – L. Kim.
Gonyaulacysta cladophora							R			(?E.) M. Baj. – E. Kim.
Gonyaulacysta eisenacki							R		R	M. Cal. – M. Kim.
Pareodinia ceratophora							R	I		E. Jur. – L. Alb.
Sirmiodinium grossi					S					(?Kim.) Port. – Camp.
Nannoceratopsis pellucida					R					?L. Baj. – E. Kim.
Ctenidodinium ornatum					R	F	R			E. Bath. – M. Oxf.
Ctenidodinium cf. *continuum*					R	R				(E. Bath.)**

Pareodinia ceratophora subsp. *scopaeus*					R	R		R	R	M. Cal.
Pareodinia brachythelis					F		R			?L. Jur.
Pterospermopsis sp. *A* *				R						
Micrhystridium fragile *				I	R				R	Het. – L. Kim.
Micrhystridium recurvatum *				R	R			F	R	Baj. – M. Kim.
Pareodinia cf. *verrucosa*				S	R					
Sentusidinium pelionense				C	R					
Sentusidinium verrucosum				F	R					L. Cal. – M. Oxf.
Chytroeisphaeridia dictydia				R	F		A	C	F	L. Bath. – M. Cal.
Veryhachium sortehatense *		D								
Chytroeisphaeridia chytroeides		R		R	R	I	R	I	R	L. Bath. – Port.
Nannoceratopsis gracilis	P		D							Het. – Baj. –?
Indeterminate acritarchs *	R			R	R	R			S	
Indeterminate dinoflagellate cysts	R	R	R	R	R	R	I	R	R	

P Present (impractical to compute percentage because of the sparseness of specimens within the assemblage)
S Single specimen only
R Rare – greater than one specimen but less than 5% of the total assemblage
I Infrequent – » » 5% » » » 15% » » » »
F Frequent – » » 15% » » » 30% » » » »
C Common – » » 30% » » » 50% » » » »
A Abundant – » » 50% » » » 75% » » » »
D Dominant – » » 75%

N. B. Approximate stratigraphical sequence only is implied by the listed order of the specimens in these tables. Taxa groupings indicate the assemblages from each sample, but *no* stratigraphical sequence or zonal scheme is implied by the order of these assemblages in Tables 4 a, b.

* Taxa indicated by a single asterisk are acritarchs.

** Ranges of the species with Jameson Land specimens are compared and given in parentheses.

Table 4b. The dinoflagellate cysts and acritarchs (*) recovered from the Olympen, Hareelv and Raukelv Formations

	Olympen		Hareelv					Raukelv	previously recorded stratigraphic ranges
G G U sample numbers	137315	137311	144128	144114	144115	146482	144133	144161	
Pterospermopsis sp. A*								R	
Pterospermopsis sp. B*								S	
Pterospermopsis sp. C*								R	
*Michrystridium fragile**								R	Het. – L. Kim.
*Michrystridium pyramidispinosum**								S	L. Kim. – Port.
Kleithriasphaeridium cf. *corrugatum*								S	(Barremian)**
Trichodinium castanea								S	L. Val. – L. San.
Trichodinium cf. *ciliatum*								S	
Gonyaulacysta birkelundii								I	
Lithodinia cf. *jurassica*								S	(?Bath. – Cal.)**
Sentusidinium pelionense								R	
Sentusidinium sp. C								R	
Sentusidinium sp. B								S	
Cyclonephelium hystrix								I	?Kim. – L. Apt.
Perisseiasphaeridium cf. *pannosum*							F		E. Kim.
Endoscrinium sp.							R		
Gonyaulacysta nuciformis							S		L. Cal. – L. Kim.
Gonyaulacysta granuligera							R		E. – M. Kim.
*Solisphaeridium ankyleton**					R				
Polystephanephorus paracalathus					S				E. Cal. – M. Oxf.
Endoscrinium subvallare					R				M. Oxf.
Leptodinium subtile					?S				E. Bath. – M. Kim
Gonyaulacysta eisenacki subsp. *oligodentata*					R				Cal. – Kim.
Gonyaulacysta jurassica var. *longicornis*					R	S	S		Oxf. –? Port.
Pareodinia evittii					R		S		Baj. – L. Cal.
Sentusidinium sp. E					R				
Prolixosphaeridium cf. *deirense*				S			?S		E. Kim.

Adnatosphaeridium aemulum				C	F				(?E.) L. Cal. – M. Kim.
Glabridium apatelum				R	R				M. Oxf. – L. Kim.
Endoscrinium galeritum				I	I				Bath. – E. Kim.
Endoscrinium oxfordianum				S	R				E. Oxf. – L. Kim.
Wanaea digitata				S					E. Cal. – M. Oxf.
Leptodinium aceras				S					E. – M. Kim.
Gonyaulacysta scarburghense				R	R				L. Cal. – M. (L.?) Kim.
Gonyaulacysta eisenacki				R	R				M. Cal. – M. Kim.
Sentusidinium sp. A				S					
Sentusidinium sp. D				R					
*Solisphaeridium stimuliferum**			R	S	R				Baj. – E. Port.
*Solisphaeridium brevispinosum**			S						Trias. – E. Kim.
aff. *Systematophora* sp.			R						
Cleistosphaeridium ehrenbergi			S						M. Cal. – L. Kim.
Sirmiodinium grossi			R		R			S	(?Kim.) Port. – Camp.
Gonyaulacysta jurassica			R	R	R		R		E. Bath. – M. Kim.
Gonyaulacysta cladophora			I	F	I		R		(E.?) M. Baj. – E. Kim.
Kalyptea diceras			R		R		R		L. Kim. – ?E. Cret.
Kalyptea glabra			R						L. Kim. – E. Cret.
Pareodinia ceratophora subsp. *scopaeus*			R						M. Cal.
Stephanelytron cf. *redcliffense*			S						(E. Oxf. – E. Kim.)**
Stephanelytron caytonense			R	R	R				L. Cal. – M. Oxf.
Sentusidinium myriatrichum			R		S				
Sentusidinium pilosum			I	R	F				M. Oxf. – L. Kim.
Sentusidinium cf. *rioulti*			R		R				(L. Bath. – E. Oxf.)**
Chytroeisphaeridia pococki			R	R	R				L. Bath. – L. Kim.
Wanaea fimbriata		S			S				E. Oxf.
Pareodinia ceratophora	P		I	R	R		C		E. Jur. – L. Alb.
Chytroeisphaeridia chytroeides	P	P	R	R	R		R		L. Bath. – Port.
Indeterminate acritarchs*							R	R	
Indeterminate dinoflagellate cysts			R	R	R		R	R	

Table 5. Samples from Jameson Land used in this study

GGU*	Formation or member	AGE (Based on ammonite faunas)	Lithology
		Samples from the Olympelv section (Northern Jameson Land)	
137311	Olympen	E. Oxfordian	micaceous siltstone
137313	Olympen	?E. Oxfordian	micaceous siltstone
137315	Olympen	E. Oxfordian	micaceous silty shale
137322	Olympen	L. Callovian – E. Oxfordian	micaceous silty shale
137324	Fossilbjerget	L. Callovian	argillaceous sandstone
		Samples from other localities in Northern Jameson Land	
137336	Olympen	L. Callovian	calcareous silty sandstone
100721	Fossilbjerget	calloviense Z., Callovian	siltstone
139163	Fossilbjerget	apertum Z., Callovian	fine-grained sandstone
144127	Fossilbjerget	apertum Z., Callovian	argillaceous siltstone
144125	Fossilbjerget	Bathonian	glauconitic sand
137346	Sortehat	?Bajocian	micaceous sandy shale
		Samples from Southern Jameson Land	
144161	Fynselv	L. Kimmeridgian – Portlandian	sandstone
144154	Salix Dal	L. Kimmeridgian – Portlandian	silty micaceous shale
144143	Sjællandselv	?M. – L. Kimmeridgian	sandstone
144138	Hareelv/ Raukelv	?M. Kimmeridgian	sandstone
144133	Hareelv	eudoxus-mutabilis Z. E.Kimmeridgian	shale
144128	Hareelv	?decipia Z., E. Kimmeridgian	shale
144115	Hareelv	L. Oxfordian – E. Kimmeridgian	micaceous silty shale
144114	Hareelv	L. Oxfordian – E. Kimmeridgian	silty shale
146482	Hareelv	L. Oxfordian – E. Kimmeridgian	shale
137053	Fossilbjerget	?post arcticus Z., Bathonian–Callovian	micaceous siltstone
144111	Pelion	?Bajocian	calcareous sandstone
136226	Sortehat	?Bajocian	silty micaceous shale
144231	Sortehat	?Bajocian	silty shale
144112	Sortehat	?Bajocian	argillaceous limestone
144229	Sortehat	? Bajocian	sandy siltstone

* Sample numbers of the Geological Survey of Greenland.

continuum also occurs. Thus the organic-walled microplankton support a Bathonian age, but the amount of evidence is small and a Callovian age cannot be precluded.

Chytroeisphaeridia dictydia is abundant in both sample 139163 and sample 144127. Species of *Pareodinia* also occur, but they are less prominent here than in the samples from the Fossilbjerget Member discussed above. *Gonyaulacysta eisenacki* (Middle Callovian – Middle Kimmeridgian) and *G. cladophora* (Middle Bajocian – Middle Kimmeridgian) occur, their earliest recorded level in Jameson Land. Other taxa encountered in these two samples are of little stratigraphical use. Thus the dinoflagellate cysts from these two samples indicate little more than broad support for the ammonite-derived dating of Callovian.

The dinoflagellate cysts contained in sample 100721 are more helpful, however. This sample yielded a moderately diverse assemblage of over 18 taxa including three new species, *Ellipsoidictyum gochtii* (previously briefly described, but not named, by Gocht [1970] from the Bathonian of Germany), *Gonyaulacysta pectinigera* (again recorded by Gocht [1970] from the Bathonian of Germany, but named as a subspecies of *Leptodinium subtile* by him) and *Ambonosphaera calloviana.* In addition to these, sample 100721 contains three other previously undescribed forms of dinoflagellate cyst, *Egmontodinium* sp. (this genus has previously been recorded from Oxfordian to Portlandian strata), *Paragonyaulacysta* sp. (a genus previously recorded only from the Early Callovian of the Canadian Arctic), and *Valensiella* sp.

No specimens of *Ctenidodinium* were encountered, but *Chytroeisphaeridia dictydia* is still present as an important constituent of the assemblage. *Gonyaulacysta eisenacki* occurs, and one specimen of *Leptodinium subtile* (Early Bathonian – Middle Kimmeridgian) was encountered. Of other taxa represented in sample 100721 only *Valensiella ovulum* (Bajocian – Early Oxfordian) is of stratigraphical significance.

This assemblage thus appears to be of Bathonian or Callovian age. The presence of *Gonyaulacysta pectinigera* and *Ellipsoidictyum gochtii* would favour a Bathonian age; in both cases, however, this work constitutes only the second record of these species, and thus their stratigraphical ranges are as yet only poorly known. The presence of *Gonyaulacysta eisenacki, Egmontodinium* sp. and *Paragonyaulacysta* sp. favour a Callovian age, though in the case of the last two named taxa, only very tentatively. The evidence from dinoflagellate cysts, therefore, suggests a Late Bathonian to Early Callovian age for this sample.

Olympen Formation

Of five samples prepared from the Olympen Formation only two contained organic-walled microplankton. These were, unfortunately, mostly long-ranging

forms. Sample 137311, however, contained one specimen of *Wanaea fimbriata* (Early Oxfordian), thus supporting the Early Oxfordian date for this sample based on its associated ammonite fauna.

Hareelv Formation

Five samples were prepared from the Hareelv Formation of which four yielded diverse assemblages of organic-walled microplankton. The exception was sample 146482 which yielded mainly carbonized organic material. The only recognizable dinoflagellate cyst encountered in this sample was a specimen of *Gonyaulacysta jurassica* var. *longicornis;* this varietas has been previously recorded from Oxfordian to Kimmeridgian, possibly Portlandian strata.

Sample 144128 is dated by its ammonite associations as *decipiens* Zone, Late Oxfordian. Its organic-walled microplankton assemblage included specimens of one new species, *Sentusidinium myriatrichum* and two other hitherto undescribed taxa. Quantitatively important are species of *Sentusidinium, Pareodinia ceratophora* (but no other species of *Pareodinia,* although two species of the closely related genus, *Kalyptea,* are present – their earliest occurrence in Jameson Land) and *Gonyaulacysta cladophora.* All these taxa are well within their known stratigraphical range except the two species of *Kalyptea, K. diceras* and *K. glabra.* However, Wiggins (1975) recorded *K. diceras* and *K. glabra* (as *K. stegasta*) from the Upper Jurassic of Alaska, and Gocht (1970) reported similar forms (which he included as *Pareodinia ceratophora*) from the Bathonian of Germany. Therefore, the occurrence of these two species from the Upper Jurassic of East Greenland is not surprising.

In samples from the Vardekløft and Olympen Formations no chorate cysts were encountered and cavate cysts were rare. In the Hareelv Formation both these cyst types are more important, however, especially in samples 144114, 144115 and 144133. In sample 144128 two chorate species, aff. *Systematophora* sp. and *Cleistosphaeridium ehrenbergi.* (Middle Callovian – Late Kimmeridgian) are present. *Sirmiodinium grossi* is the only cavate species present.

Taxa of greatest stratigraphical use in sample 144128 are *Stephanelytron caytonense* (Late Callovian – Middle Oxfordian) and *S.* cf. *S. redcliffense* (*S. redcliffense* has a recorded range from Early Oxfordian to Early Kimmeridgian). The occurrence of both these forms indicates an Oxfordian age for this sample. The occurrence of *Sentusidinium pilosum* (Middle Oxfordian – Late Kimmeridgian) would likewise suggest a Middle or Late Oxfordian age. Thus the dinoflagellate cysts are in accord with the ammonite faunas in their age determination of this sample.

Samples 144114 and 144115 (both dated as Late Oxfordian – Early Kimmeridgian on the basis of associated ammonites) contain diverse assemblages of organic-walled microplankton, over 19 and 27 taxa respectively being observed. Sam-

Table 6. Previously recorded ranges of selected stratigraphically useful taxa encountered in sample GGU 144115 from the Hareelv Formation

Dashed line indicates tentative extension of range

Sample GGU 144115	Pre Oxf.	Oxfordian			Kimmeridgian			Post Kim.
		E	M	L	E	M	L	
*Pareodinia evittii**	▬							
Wanaea fimbriata		▬						
Stephanelytron caytonense	▬	▬	▬					
Polystephanephorus paracalathus	▬	▬	▬					
Endoscrinium subvallare			▬					
Endoscrinium galeritum	▬	▬	▬	▬	▬			
Gonyaulacysta cladophora	▬	▬	▬	▬	▬			
Adnatosphaeridium aemulum	▬	▬	▬	▬	▬	▬		
Gonyaulacysta eisenacki	▬	▬	▬	▬	▬	▬		
Gonyaulacysta scarburghensis	▬	▬	▬	▬	▬	▬	- - -	
Endoscrinium oxfordianum		▬	▬	▬	▬	▬	▬	
Sentusidinium pilosum			▬	▬	▬	▬	▬	
Glabridinium apatelum			▬	▬	▬	▬	▬	
Gonyaulacysta jurassica var. *longicornis*		▬	▬	▬	▬	▬	▬	▬
*Kalyptea diceras**							▬	▬
*Kalyptea glabra**							▬	▬

* See text for discussion of the ranges of these species.

ple 144115 contains one new species of acritarch, *Solisphaeridium ankyleton.* Both samples contain a variety of forms of *Sentusidinium* and *Gonyaulacysta, Sentusidinium pilosum* (Middle Oxfordian – Late Kimmeridgian) and *Gonyaulacysta cladophora* being prominent in both samples.

In these samples chorate and cavate cysts attain their greatest representation amongst all the Jameson Land assemblages examined. Most prominent amongst chorate cysts is *Adnatosphaeridium aemulum* (Late Callovian – Middle Kimmeridgian). *Endoscrinium galeritum* (Bathonian – Early Kimmeridgian) is the most common cavate form in both assemblages.

Diagrammatic representations of the known stratigraphical ranges of selected taxa from samples 144115 and 114114 are shown in Tables 6 and 7 respectively. They indicate for sample 144115 an Early to Middle Oxfordian date. If the single specimen of *Wanaea fimbriata* found in this sample is reworked, which is possibly the case, a Middle Oxfordian date is indicated for this sample.

The combined presence of *Stephanelytron caytonense, Leptodinium aceras* and

Table 7. Previously recorded ranges of selected stratigraphically useful taxa encountered in sample GGU 144114 from the Hareelv Formation
Dashed line indicates tentative extension of range

Sample GGU 144114	Pre Oxf.	Oxfordian			Kimmeridgian		
		E	M	L	E	M	L
Stephanelytron caytonense							
Wanaea digitata							
Endoscrinium galeritum							
Gonyaulacysta cladophora							
Prolixosphaeridium cf. *deirense*							
Adnatosphaeridium aemulum							
Gonyaulacysta eisenacki							
Leptodinium aceras							
Gonyaulacysta scarburghensis							
Endoscrinium oxfordianum							
Sentusidinium pilosum							
Glabridinium apatelum							

Prolixosphaeridium cf. *P. deirense* indicates a Middle Oxfordian to Early Kimmeridgian date for sample 144114.

Table 8 shows the known stratigraphical ranges of selected taxa from sample 144133 (dated as *eudoxus-mutabilis* Zones, Early Kimmeridgian by its ammonite associations). Quantitatively the most important taxa from this sample are *Perisseiasphaeridium* cf. *P. pannosum* (Early Kimmeridgian) and *Pareodinia ceratophora.* The dinoflagellate cysts from this sample are in accord with an Early Kimmeridgian age.

Raukelv Formation

Samples 144138 (from the Hareelv Formation – Raukelv Formation boundary), 144143 (from the Sjællandselv Member) and 144154 (from the Salix Dal Member) contain no recognizable microplankton, but much carbonized organic material.

Sample 144161 (dated as Late Kimmeridgian – Portlandian by its ammonite associations), however, yielded a sparse assemblage of excellently preserved dinoflagellate cysts and acritarchs. This assemblage included two new species, *Gonyaulacysta birkelundii* and *Sentusidinium pelionense.* Taxa that are more widely recorded from Cretaceous sediments than from Jurassic sediments, or forms comparable with such taxa, are predominant. These are *Cyclonephelium hystrix, Trichodinium castanea, Trichodinium* cf. *T. ciliatum* and *Kleithriasphaeridium* cf. *K.*

Table 8. Previously recorded ranges of selected stratigraphically useful taxa encountered in samples GGU 144128 (upper) and GGU 144133 (lower), both from the Hareelv Formation

Sample GGU 144128	Pre Oxf.	Oxfordian			Kimmeridgian			Post Kim.
		E	M	L	E	M	L	
Stephanelytron caytonense								
Gonyaulacysta cladophora								
Solisphaeridium brevispinosum								
(Stephanelytron redcliffense)								
Cleistosphaeridium ehrenbergi								
Sentusidinium pilosum								
*Kalyptea diceras**								
*Kalyptea glabra**								
Sample GGU 144133								
Perisseiasphaeridium cf. *pannosum*								
Gonyaulacysta granuligera								
Gonyaulacysta nuciformis								
Gonyaulacysta jurassica var. *longicornis*								
*Kalyptea diceras**								

* See text for discussion of the ranges of these species.

corrugatum. The occurrence in sample 144161 of one specimen of *Lithodinia* cf. *L. jurassica* (which is certainly at least closely related to *L. jurassica,* a species previously recorded from ?Bathonian – Callovian strata) is surprising. Also unexpected is the presence of two specimens of *Sentusidinium pelionense,* which is a common constituent of the assemblage obtained from sample 144111. Thus it is possible that these two taxa are reworked into sample 144161 from Middle Jurassic sediments. *Sentusidinium* sp. C was also encountered in sample 144161. Very similar specimens have been observed from Callovian strata by Sarjeant (personal communication); this taxon might also, therefore, be reworked into sample 144161.

Because assemblages of organic-walled microplankton from latest Jurassic strata and at the Jurassic – Cretaceous boundary are as yet only poorly known, it is difficult to derive a firm date for sample 144161 on the basis of these fossils.

Palaeoecological considerations

Because dinoflagellates are planktonic marine organisms, they are much less useful as palaeoecological indicators than benthonic organisms would be. In a study such as this, in which a small number of samples are taken from a moderately large geographical area and represent a range of stratigraphical levels, meaningful palaeoecological interpretations are especially difficult to make.

Since by far the largest proportion of investigations on Jurassic organic-walled microplankton has been concerned with European strata, most of the previously described taxa encountered in this study have inevitably been described from that region. A few taxa, however, have as yet been described only on the western side of the Atlantic, for example the genus *Paragonyaulacysta* and the species *Pareodinia brachythelis*. Nevertheless, any detailed delineation of dinoflagellate floral provinces for the Jurassic at this stage would be premature.

Diverse assemblages of Middle and Upper Jurassic pareodinioid forms have been noted from Greenland (in the present study and by Sarjeant, 1972), Alaska (Wiggins, 1975) and Arctic Canada (Brideaux & Fisher, 1976). Assemblages from Europe or elsewhere do not exhibit a similar diversity of forms from this group. Possibly there is a basis here for the differentiation of floral provinces.

Wall (1965), in a palynological study of the Lias of England and Wales, noted that small spinose species of *Micrhystridium* characterized inshore environments; species with short spines were associated with turbulent conditions whereas species with long spines occurred in more tranquil environments. The new species *Veryhachium sortehatense* is a small long-spined acritarch morphologically similar (and probably closely related) to species of *Micrhystridium*. Surlyk *et al.* (1973) noted that the shales of the Sortehat Member were deposited under low-energy marine conditions. Thus the dominance of *V. sortehatense* in one sample from the Sortehat Member accords with Wall's conclusions.

In one sample, also from the Sortehat Member, the cyst *Nannoceratopsis gracilis* is prolific, constituting 98 per cent of the assemblage. Where it is present at all, this species appears commonly to be represented by large numbers of individuals (see for example Evitt, 1961a). The appearance of *N. gracilis* in such large numbers is almost certainly ecologically controlled, but which environmental factors are involved are as yet uncertain.

The functional morphology of dinoflagellate cysts has so far received little attention from palynologists. Apertures in the cyst wall, other than the archeopyle, have been noted in dinoflagellate cysts, however (see for example Sarjeant, 1972, pp. 17–19). In the present study accessory apertures were noted in *Sirmiodinium grossi* and opisthopyles in *Gonyaulacysta eisenacki* and *G. eisenacki* subsp. *oligodentata;* all of these apertures connect pericoels with the external environment. It is likely that such apertures were in some way involved with gas or liquid exchange

between the pericoels and the immediate external environment of the cyst, thereby regulating the cysts' buoyancy. The subapical aperture of specimens of *G. eisenacki,* in contrast, connects the exterior with the main cavity (endocoel) of the cyst. This aperture may have been involved with the release of pressure from the endocoel during excystment.

Two apertures were also encountered in the parasulcal region of the specimen of *Valensiella* sp. Although these two apertures are large for such a feature, their position strongly suggests that they reflect the flagellar pores of the motile stage. May (1976) suggests that such pores in a fossil dinoflagellate indicate that one is dealing with a fossil motile form; this is certainly not the case with *Valensiella* sp., however, which possesses a definite archeopyle as well as these parasulcal openings. Flagellar markings, consisting of depressions in the parasulcus, were also observed in specimens of *Trichodinium castanea, Trichodinium* cf. *T. ciliatum* and *Gonyaulacysta birkelundii.* Similar markings were observed in specimens of *Wetzeliella* by Gocht (1967).

SUMMARY

Dates of the samples based on organic-walled microplankton assemblages are, for the most part, in agreement with, or at least do not contradict those dates derived from ammonites. In two cases, however, they indicate a date up to one half stage earlier than that derived from ammonite faunas. Sparsity of the ammonite faunas or their distinctness from North-west European assemblages may, at some levels, preclude accurate correlation based on ammonites. Also the ranges of some taxa of organic-walled microplankton are not yet fully known. These factors may explain such discrepancies between the dates derived from ammonites and those derived from organic-walled microplankton.

The organic-walled microplankton assemblages broadly support a Bajocian date for the Sortehat Member of the Vardekløft Formation; a late Bajocian assignation may even be very tentatively suggested for one sample. The assemblage obtained from the Pelion Member is, however, not very helpful for dating purposes. Assemblages from the Fossilbjerget Member support Bathonian to Callovian assignations.

Poor assemblages of organic-walled microplankton were extracted from samples from the Olympelv Formation in terms of both the number of specimens and the number of taxa present. However, an Early Oxfordian date is indicated for one sample.

The samples from the Hareelv Formation yielded moderately rich assemblages indicative of an Oxfordian date except for one sample, for which an Early Kimmeridgian assignation was determined.

Of the samples prepared from the Raukelv Formation only one, from the Fynselv Member, contained an assemblage of organic-walled microplankton worthy of study. This assemblage, although not conclusive in supporting a date, does not contradict the latest Jurassic date derived from ammonite faunas for the Fynselv Member.

As more published accounts of Jurassic dinoflagellate cyst and acritarch assemblages become available, especially of Middle Jurassic and latest Jurassic assemblages, and thus as ranges of individual taxa become better known, the above results may require slight modification.

As noted in the palaeoecological considerations, dinoflagellate cysts appear to be of limited value in deducing palaeoenvironments; acritarchs, though, may be more useful. However, more consideration could be given to the adaptive or functional morphology of dinoflagellate cysts; this may assist the palaeoecological studies of these fossils.

The present work must be regarded as a pilot study of the Middle and Late Jurassic organic-walled microplankton from Jameson Land. Further detailed study

of regularly sampled sequences, especially of the Fossilbjerget Member of the Vardekløft Formation and the Hareelv Formation, would certainly yield valuable supplementary stratigraphical data; for instance, such a study might clarify the age of the lower part of the Hareelv Formation, for which the dates derived from ammonites and those derived from dinoflagellates appear to be at variance. Similarly, the study of additional assemblages from the Fynselv Member of the Raukelv Formation might yield interesting information pertaining to the organic-walled microplankton assemblages which straddle the Jurassic-Cretaceous boundary.

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Plate 1

Photomicrographs 4–11 taken by phase contrast; c.b = central body.

Fig. 1. *Chytroeisphaeridia chytroeides* (Sarjeant). Slide MGUH 14.671, 103.7/8.8; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length 41 μm.

Fig. 2. *Chytroeisphaeridia pococki* Sarjeant. Slide MGUH 14.673, 94.3/13.4; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length 37 μm.

Fig. 3. *Sentusidinium pilosum* (Ehrenberg). Slide MGUH 14.679, 99.5/16.5; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length of c.b. 46 μm.

Fig. 4. *Sentusidinium* cf. *S. rioulti* (Sarjeant). Slide MGUH 14.680, 110.0/11.0; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length of c.b. 33 μm.

Figs 5, 7. *Sentusidinium pelionense* sp. nov., holotype. Slide MGUH 14.675, 113.5/10.5; from sample GGU 144111, Pelion Mb, between Gåseelv and Hareelv. Length 48 μm. Fig. 7, detail showing verrucae on cyst surface.

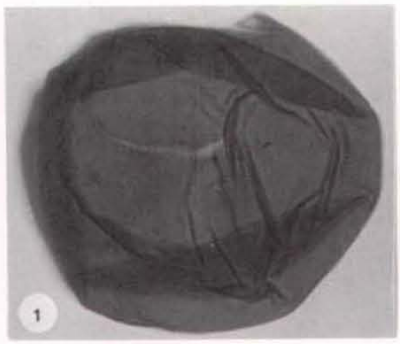
Fig. 6. *Sentusidinium pelionense* sp. nov. Slide MGUH 14.678, 101.3/13.4; from sample GGU 144111, Pelion Mb, between Gåseelv and Hareelv. Length of field of view 36 μm. Detail of surface ornamentation.

Fig. 8. *Sentusidinium pelionense* sp. nov., paratype (ii). Slide MGUH 14.677, 109.9/19.5; from sample GGU 144111, Pelion Mb, between Gåseelv and Hareelv. Length 49 μm.

Fig. 9. *Sentusidinium pelionense* sp. nov., paratype (i). Slide MGUH 14.676, 101.0/6.5; from sample GGU 144111, Pelion Mb, between Gåseelv and Hareelv. Field of veiw 31 μm × 26 μm. Detail of surface ornamentation.

Fig. 10. *Chytroeisphaeridia dictydia* Sarjeant. Slide MGUH 14.672, 100.4/2.5; from sample GGU. 139163, Fossilbjerget Mb, west side of Fossilbjerget. Length 40 μm.

Fig. 11. *Sentusidinium verrucosum* (Sarjeant). Slide MGUH 14.681, 110.8/3.8; from sample GGU 144111, Pelion Mb, between Gåseelv and Hareelv. Length 43 μm.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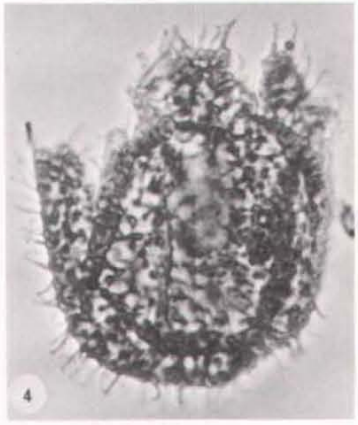
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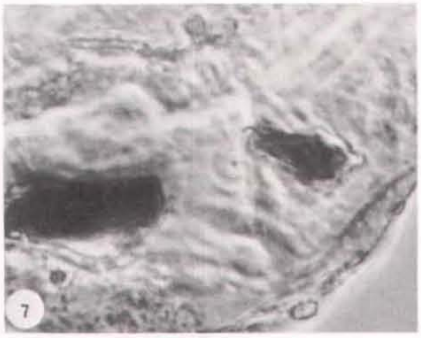
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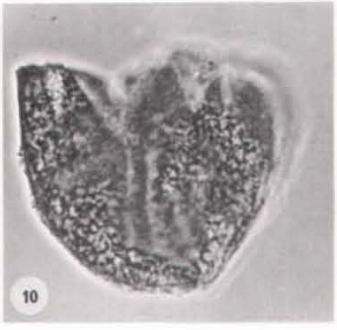
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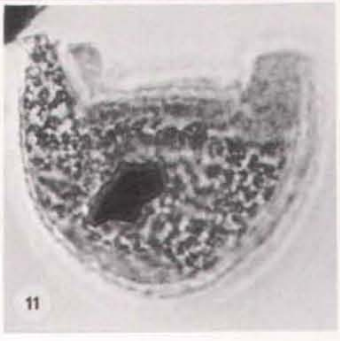
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Plate 2

Photomicrographs 1, 4, 6–7 taken by phase contrast; c.b. = central body.

Fig. 1. *Sentusidinium* sp. C. Slide MGUH 14.684, 99.5/14.6; from sample GGU 144161, Fynselv. Mb, north side of Aucellaelv. Length 40 μm.

Fig. 2. *Sentusidinium?* sp. A. Slide MGUH 14.682, 114.6/22.4; from sample GGU 144114, Hareelv FM, south side of Langryggen. Length 28 μm.

Fig. 3. *Sentusidinium* sp. D. Slide MGUH 14.685, 106.4/10.5; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length 58 μm.

Fig. 4. *Sentusidinium* sp. E. Slide MGUH 14.686, 100.5/16.4; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 41 μm.

Figs 5, 6. *Sentusidinium* sp B. Slide MGUH 14.683, 97.9/12.7; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length 39 μm. Fig. 6, detail of surface ornamentation.

Fig. 7. *Sentusidinium myriatrichum* sp. nov., holotype. Slide MGUH 14.674, 99.6/12.6; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 55 μm.

Figs 8–9, 11–12. *Ellipsoidictyum gochtii* sp. nov., holotype. Slide MGUH 14.687, 115.4/18.0; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length of c.b. 42 μm. Fig 8, dorsal view; fig. 9, optical section; fig. 11, ventral view showing rudimentary paratabulation; fig. 12, ventral view showing parasulcal notch in archeopyle margin.

Fig. 10. *Cyclonephelium hystrix* (Eisenack). Slide MGUH 14.688, 97.1/18.9; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length 49 μm. Ventral view.


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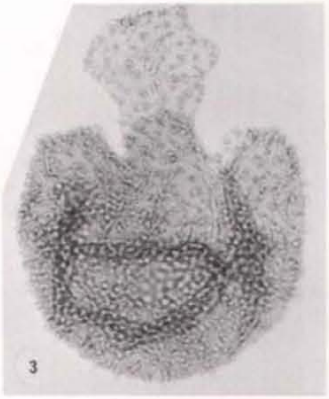
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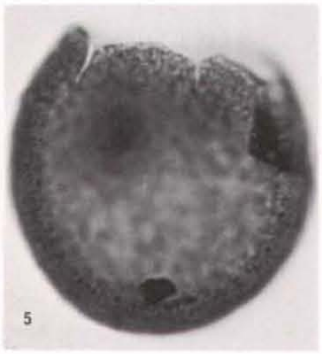
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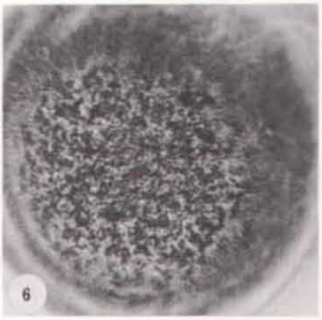
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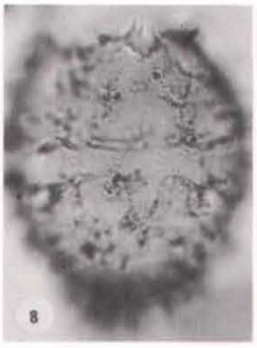
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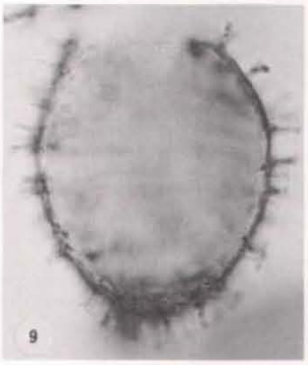
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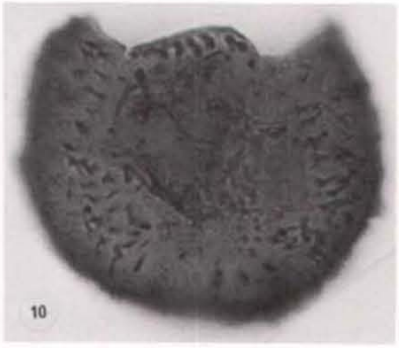
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Plate 3

Photomicrographs 1, 4, 7, 12 taken by phase contrast; c.b. = central body.

Fig. 1. *Egmontodinium* sp. Slide MGUH 14.693, 117.2/15.9; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length 29 μm.

Figs 2, 3. *Valensiella ovulum* (Deflandre). Slide MGUH 14.689, 91.4/14.0; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Overall length 65 μm. Fig. 2, ventral view; fig. 3, optical section showing ectophragm and its supporting spines.

Figs 4, 7. *Pareodinia ceratophora* subsp. *scopaeus* (Sarjeant). Slide MGUH 14.696, 111.6/14.2; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length 53 μm. Fig. 4, dorsal view; fig. 7, dorsal anterior view showing opercular paraplates.

Fig. 5. *Stephanelytron caytonense* Sarjeant. Slide MGUH 14.692, 100.5/4.1; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length of c.b. 47 μm.

Fig. 6. *Stephanelytron* cf. *S. redcliffense* Sarjeant. Slide MGUH 14.691, 109.5/3.1; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length of c.b. 42 μm.

Figs 8, 9. *Lithodinia* cf. *L. jurassica* Eisenack. Slide MGUH 14.694, 90.5/15.9; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length 50 μm. Fig. 8, ventral view; fig. 9, dorsal view.

Figs 10, 11. *Valensiella* sp. Slide MGUH 14.690, 107.1/4.8; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Overall length 79 μm. Fig. 10, dorsal view; fig. 11, detail of ventral surface showing parasulcal apertures (?flagellar pores).

Fig. 12. *Pareodinia* cf. *P. verrucosa* (Vozzhennikova). Slide MGUH 14.704, 106.1/10.0; from sample GGU 144125 Fossilbjerget Mb, west side of Fossilbjerget. Length 44 μm. Lateral view.

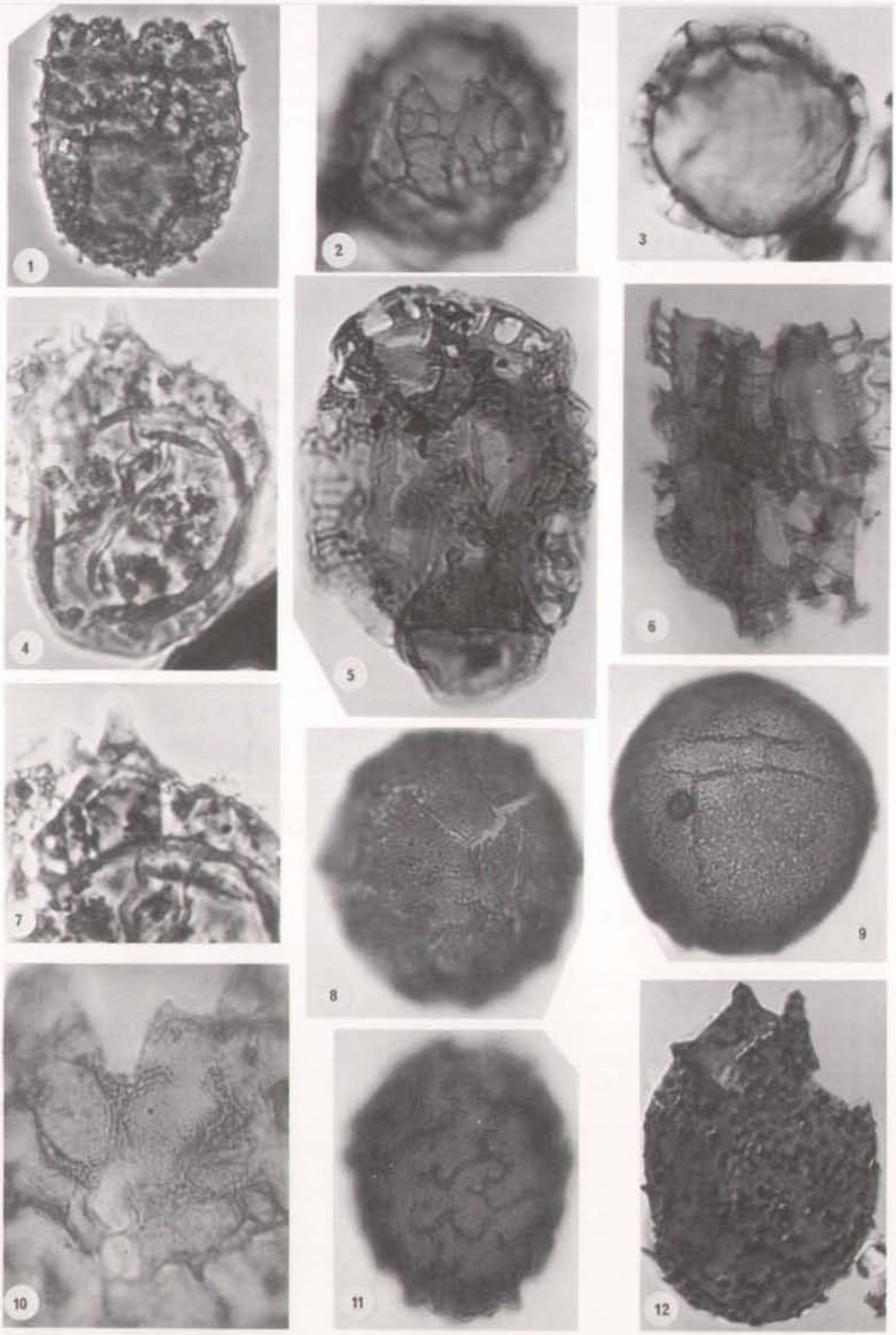
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Plate 4

Fig. 1. *Kalyptea diceras* Cookson & Eisenack. Slide MGUH 14.707, 113.5/9.9; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length 148 µm. Lateral view.

Fig. 2. *Kalyptea diceras* Cookson & Eisenack. Slide MGUH 14.706, 108.5/9.7; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length 98 µm. Lateral view.

Fig. 3. *Pareodinia brachythelis* sp. nov., paratype. Slide MGUH 14.698, 108.7/11.5; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Length 54 µm. Lateral view.

Fig. 4. *Pareodinia evittii* (Pocock). Slide MGUH 14.703, 107.7/11.5; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 64 µm. Oblique lateral-dorsal view.

Fig. 5. *Pareodinia brachythelis* sp. nov. Slide MGUH 14.699, 109.0/5.7; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Length 68 µm. Lateral view.

Fig. 6. *Pareodinia brachythelis* sp. nov., holotype. Slide MGUH 14.697, 101.2/6.2; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Length 52 µm. Dorsal view.

Fig. 7. *Pareodinia brachythelis* sp. nov. Slide MGUH 14.702, 95.3/16.4; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Length 68 µm. Oblique lateral-dorsal view. Phase contrast photomicrograph.

Fig. 8. *Pareodinia ceratophora* Deflandre. Slide MGUH 14.695, 100.6/17.9; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length 96 µm. Lateral view.

Fig. 9. *Kalyptea glabra* (Cookson & Eisenack) Slide MGUH 14.708, 99.5/17.0; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length 72 µm. Lateral view.

Fig. 10. *Gonyaulacysta jurassica* (Deflandre). Slide MGUH 14.710, 105.8/11.3; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length 87 µm. Dorsal view.


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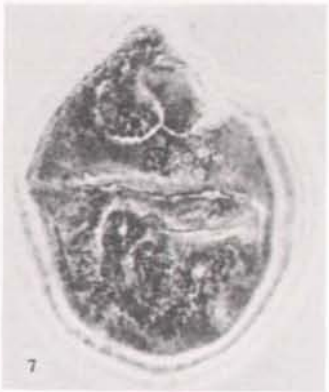
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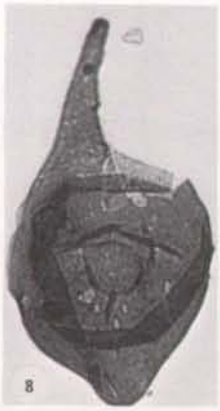
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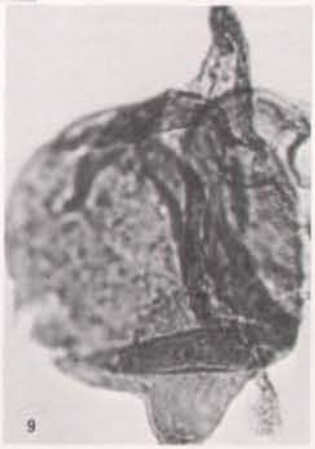
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Plate 5

Photomicrographs 3 and 12 taken by phase contrast.

Figs 1–3. *Paragonyaulacysta* sp. Slide MGUH 14.709, 92.7/14.0; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Fig. 1, ventral view; fig. 2, dorsal view; fig. 3, ventral view. Length 47 µm.
Fig. 4. *Kalyptea diceras* Cookson and Eisenack. Slide MGUH 14.705, 113.2/6.0; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length 89 µm. Lateral view.
Figs 5, 8, 11. *Gonyaulacysta birkelundii* sp. nov., holotype. Slide MGUH 14.712, 109.5/11.6; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length, 91 µm. Fig. 5, ventral view; fig. 8, optical section; fig. 11, dorsal view.
Fig. 6. *Gonyaulacysta cladophora* (Deflandre). Slide MGUH 14.713, 116.5/13.4; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length 103 µm.
Fig. 7. *Gonyaulacysta jurassica* var. *longicornis* (Deflandre). Slide MGUH 14.711, 96.0/3.5; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length 93 µm.
Fig. 9. *Gonyaulacysta scarburghensis* Sarjeant. Slide MGUH 14.721, 114.0/13.2; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length 112 µm. Dorsal view.
Fig. 10. *Gonyaulacysta granuligera* (Klement). Slide MGUH 14.716, 109.1/13.3; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length 105 µm. Lateral view.
Fig. 12. *Leptodinium aceras* (Eisenack). Slide MGUH 14.723, 109.9/14.7; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length 96 µm. Ventral view.
Fig. 13. *Gonyaulacysta nuciformis* (Deflandre). Slide MGUH 14.717, 108.4/14.3; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length 74 µm. Lateral view.

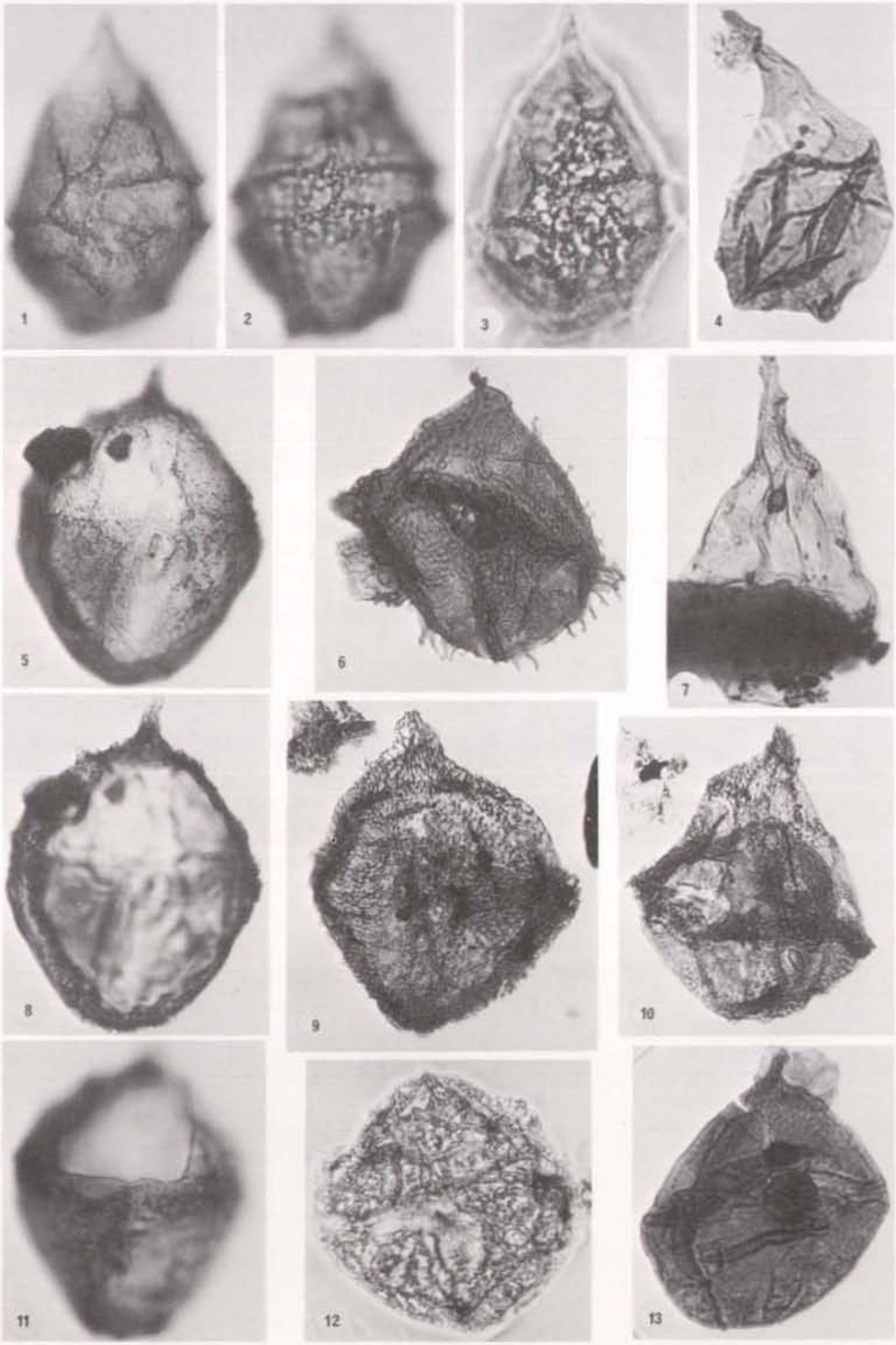
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Plate 6

Photomicrographs 1, 5 and 8 taken by phase contrast.

Fig. 1. *Gonyaulacysta eisenacki* subsp. *oligodentata* Cookson & Eisenack. Slide MGUH 14.715, 106.8/4.4; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 94 µm. Dorsal view.

Figs 2, 10. *Gonyaulacysta pectinigera* (Gocht). Slide MGUH 14.719, 102.3/18.5; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length 96 µm. Fig. 2, ventral view; fig. 10, dorsal view.

Fig. 3. *Gonyaulacysta eisenacki* (Deflandre). Slide MGUH 14,714, 103.9/17.0; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 67 µm. Dorsal view.

Fig. 4. *Gonyaulacysta pectinigera* (Gocht). Slide MGUH 14.718, 94.6/10.7; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Breadth 52 µm. Ventral view.

Fig. 5. *Ctenidodinium* cf. *C. continuum* Gocht. Slide MGUH 14.727, 93.7/10.3; from sample GGU 137053, Fossilbjerget Mb, south side of Gåseelv. Longest overall diameter 84 µm. Half cyst.

Fig. 6. *Sirmiodinium grossi* Alberti. Slide MGUH 14.736, 97.5/13.2; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length 60 µm.

Fig. 7. *Wanaea digitata* Cookson & Eisenack. Slide MGUH 14.729, 103.4/12.5; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length 90 µm.

Fig. 8. *Ctenidodinium ornatum* (Eisenack) Slide MGUH 14.726, 99.4/9.4; from sample GGU 137053, Fossilbjerget Mb, south side of Gåseelv. Length 83 µm.

Figs 9, 12. *Trichodinium* cf. *T. ciliatum* (Gocht). Slide MGUH 14.725, 114.7/16.0; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length 51 µm. Fig. 9, dorsal view; fig. 12, optical section.

Fig. 11. *Leptodinium subtile* Klement. Slide MGUH 14.722, 90.4/16.5; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length 80 µm. Ventral view.


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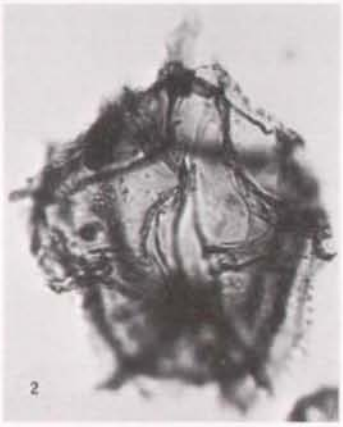
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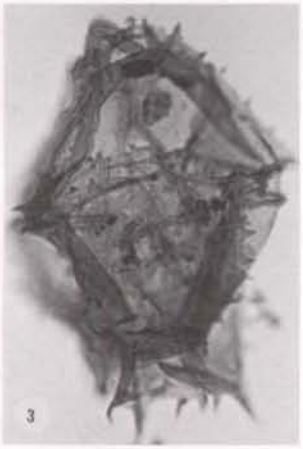
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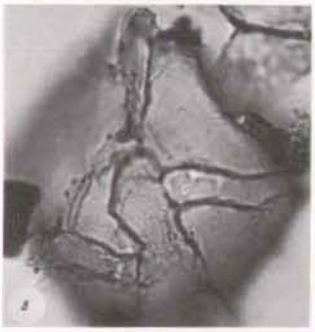
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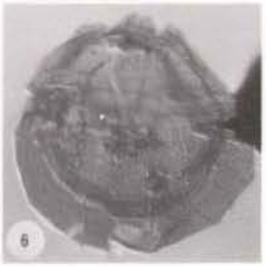
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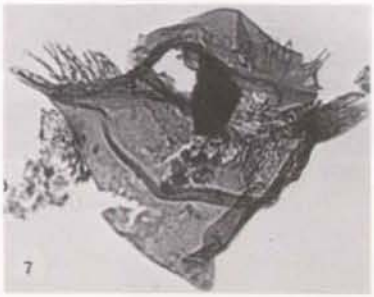
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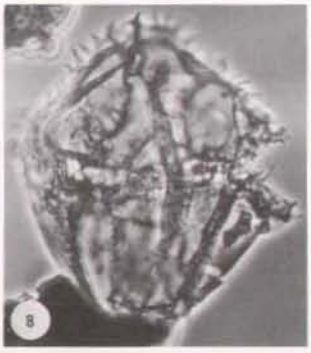
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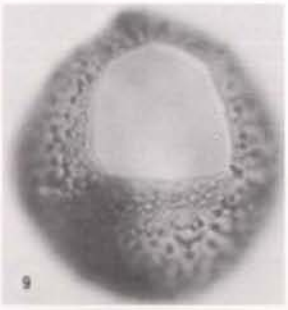
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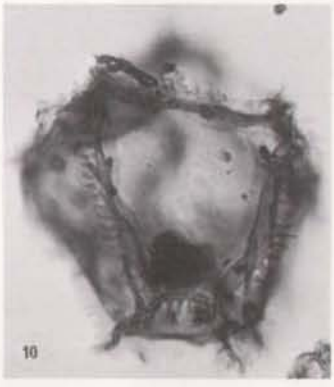
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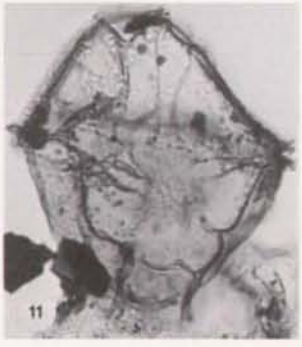
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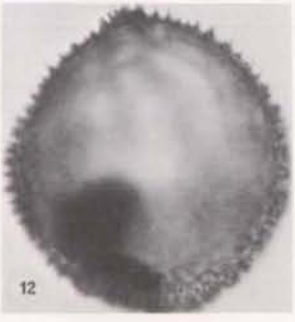
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Plate 7

Figs 1, 4. *Trichodinium castanea* (Deflandre). Slide MGUH 14.724, 100.4/5.8; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length 59 µm. Fig. 1, ventral view; fig. 4, optical section.

Fig. 2. *Trichodinium* cf. *T. ciliatum* (Gocht). Slide MGUH 14.725, 114.7/16.0; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Length of field of view 44 µm. Close up of part of ventral surface. Phase contrast photomicrograph.

Figs 3, 6, 9. *Ambonosphaera calloviana* gen. et sp. nov., holotype. Slide MGUH 14.731, 97.5/10.0; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length 45 µm. Fig. 3, ventral view; fig. 6, optical section; fig. 9, dorsal view.

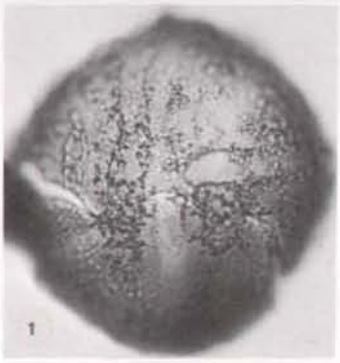
Fig. 5. *Ambonosphaera calloviana* gen et sp. nov. paratype (ii). Slide MGUH 14.732, 113.2/7.6; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length 40µm. Optical section.

Fig. 7. *Endoscrinium galeritum* (Deflandre), Slide MGUH 14.737 116.0/17.0; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 108 µm.

Fig. 8. *Ambonosphaera calloviana* gen et sp. nov. paratype (i). Slide MGUH 14.733, 117.9/11.7; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Length 42 µm. Ventral view.

Fig. 10. *Wanaea fimbriata* Sarjeant. Slide MGUH 14.730, 98.7/15.6; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Breadth 106 µm.

Fig. 11. *Sirmiodinium grossi* Alberti. Slide MGUH 14.735, 99.8/6.7; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Length 45 µm.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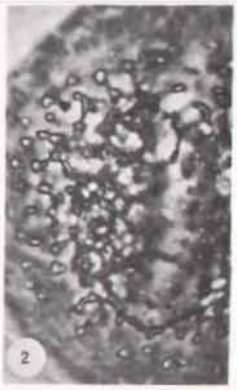
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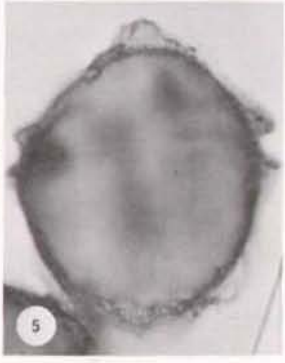
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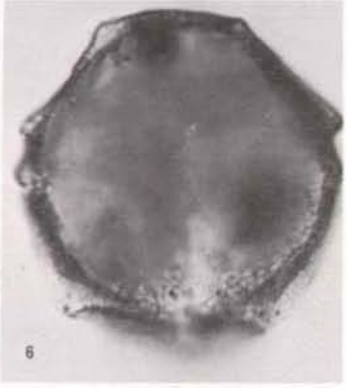
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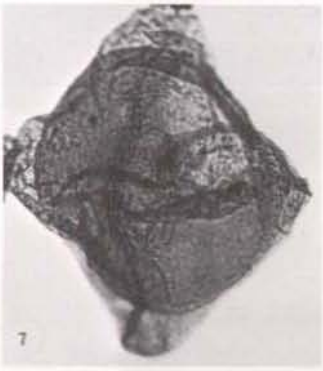
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Plate 8

Photomicrographs 9, 12 taken by phase contrast.; c.b. = central body.

Fig. 1. *Ctenidodinium* cf. *C. continuum* Gocht. Slide MGUH 14.728, 96.1/23.3; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Length 62 µm.

Fig. 2. *Endoscrinium oxfordianum* (Sarjeant). Slide MGUH 14.738, 109.5/20.0; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 102 µm. Ventral view.

Fig. 3. *Endoscrinium subvallare* (Sarjeant). Slide MGUH 14.739, 111.8/16.7; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length 116 µm. Dorsal view.

Fig. 4. Aff. *Systematophora* sp. Slide MGUH 14.745, 107.1/3.0; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Longest diameter of c.b. 52 µm.

Fig. 5. *Perisseiasphaeridium* cf. *P. pannosum* Davey & Williams. Slide MGUH 14.743, 110.7/19.0; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length of c.b. 64 µm.

Fig. 6. *Glabridinium apatelum* (Cookson & Eisenack). Slide MGUH 14.741, 105.4/12.7; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length 95 µm. Ventral view.

Fig. 7. *Polystephanephorus paracalathus* (Sarjeant). Slide MGUH 14.746, 102.1/12.0; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length of c.b. 60 µm.

Fig. 8. *Adnatosphaeridium aemulum* (Deflandre). Slide MGUH 14.744, 113.9/6.7; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Length of c.b. 50 µm.

Fig. 9. *Micrhystridium deflandrei* Valensi. Slide MGUH 14.751, 103.4/11.5; from sample GGU 100721, Fossilbjerget Mb, west of Olympen. Diameter of c.b. 19 µm.

Fig. 10. *Cleistosphaeridium ehrenbergi* (Deflandre). Slide MGUH 14.742, 110.2/2.6; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Length of c.b. 25 µm.

Fig. 11. *Endoscrinium* sp. Slide MGUH 14.740, 109.7/9.7; from sample GGU 144133, Hareelv Fm, west-central Jameson Land. Length 87 µm.

Fig. 12. *Prolixosphaeridium* cf. *P. deirense* Davey et al. Slide MGUH 14.747, 116.7/7.3; from sample GGU 144114, Hareelv Fm, south side of Langryggen. Length 49 µm.

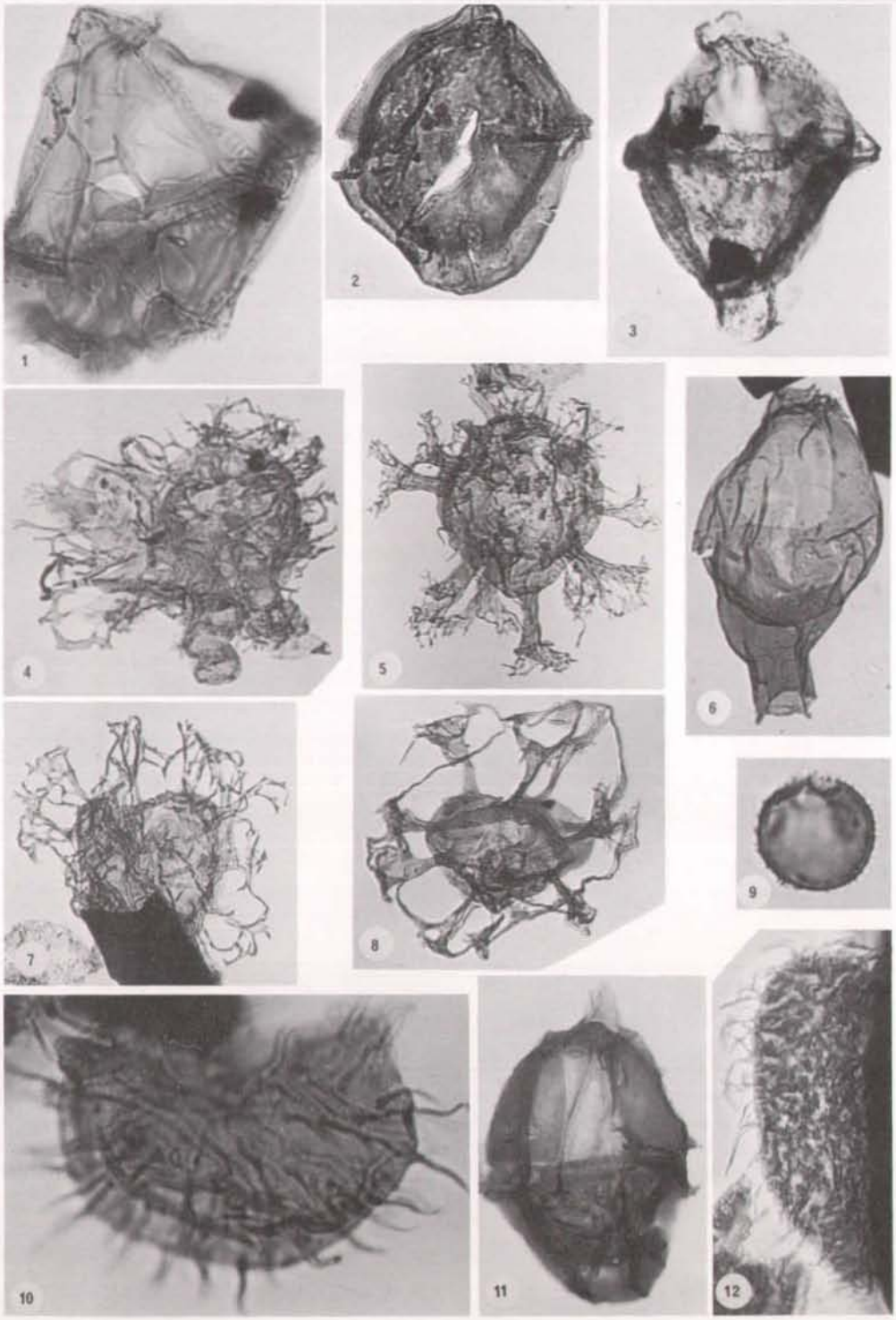
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Plate 9

Photomicrographs 1, 4–9, 12–14, 16 taken by phase contrast; c.b. = central body.

Fig. 1. *Nannoceratopsis gracilis* Alberti. Slide MGUH 14.750, 101.4/2.4; from sample GGU 144112, Sortehat Mb, Sortehat. Length 65 μm. Right lateral view.

Fig. 2. *Kleithriasphaeridium* cf. *K. corrugatum* Davey. Slide MGUH 14.748, 97.5/14.6; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Diameter of c.b. 45 μm. Left lateral view.

Fig. 3. *Solisphaeridium stimuliferum* (Deflandre). Slide MGUH 14.755, 96.2/15.3; from sample GGU 144127, Fossilbjerget Mb, west side of Fossilbjerget. Long diameter of c.b. 25 μm.

Fig. 4. *Veryhachium sortehatense* sp. nov., paratype (ii). Slide MGUH 14.761, 106.4/9.5; from sample GGU 144231, Sortehat Mb, north of Dusén Bjerg. Greatest diameter 39 μm.

Fig. 5. *Micrhystridium recurvatum* Valensi. Slide MGUH 14.754, 99.0/16.5; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Diameter of c.b. 12 μm.

Fig. 6. *Micrhystridium pyramidispinum* Dodekova. Slide MGUH 14.753, 107.2/13.0; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Diameter of c.b. 18 μm.

Fig. 7. *Micrhystridium fragile* Deflandre. Slide MGUH 14.752, 109.2/6.5; GGU 144111, Pelion Mb, between Gåseelv and Hareelv. Diameter of c.b. 17 μm.

Fig. 8. *Veryhachium sortehatense* sp. nov., holotype. Slide MGUH 14.759, 94.4/17.0; from sample GGU 144231, Sortehat Mb, north of Dusén Bjerg. Greatest diameter 40 μm.

Fig. 9. *Veryhachium sortehatense* sp. nov., paratype (iv). Slide MGUH 14.763, 102.1/4.5; from sample GGU 144231, Sortehat Mb, north of Dusén Bjerg. Greatest diameter 37 μm.

Figs 10, 15. *Solisphaeridium ankyleton* sp. nov., holotype. Slide MGUH 14.756, 97.2/18.7; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Diameter of c.b. 23–26 μm. Fig. 15 is close-up of a process base showing solid section.

Fig. 11. *Solisphaeridium ankyleton* sp. nov., paratype. Slide MGUH 14.757, 107.5/15.1; from sample GGU 144115, Hareelv Fm, south side of Langryggen. Diameter of c.b. 17–21 μm.

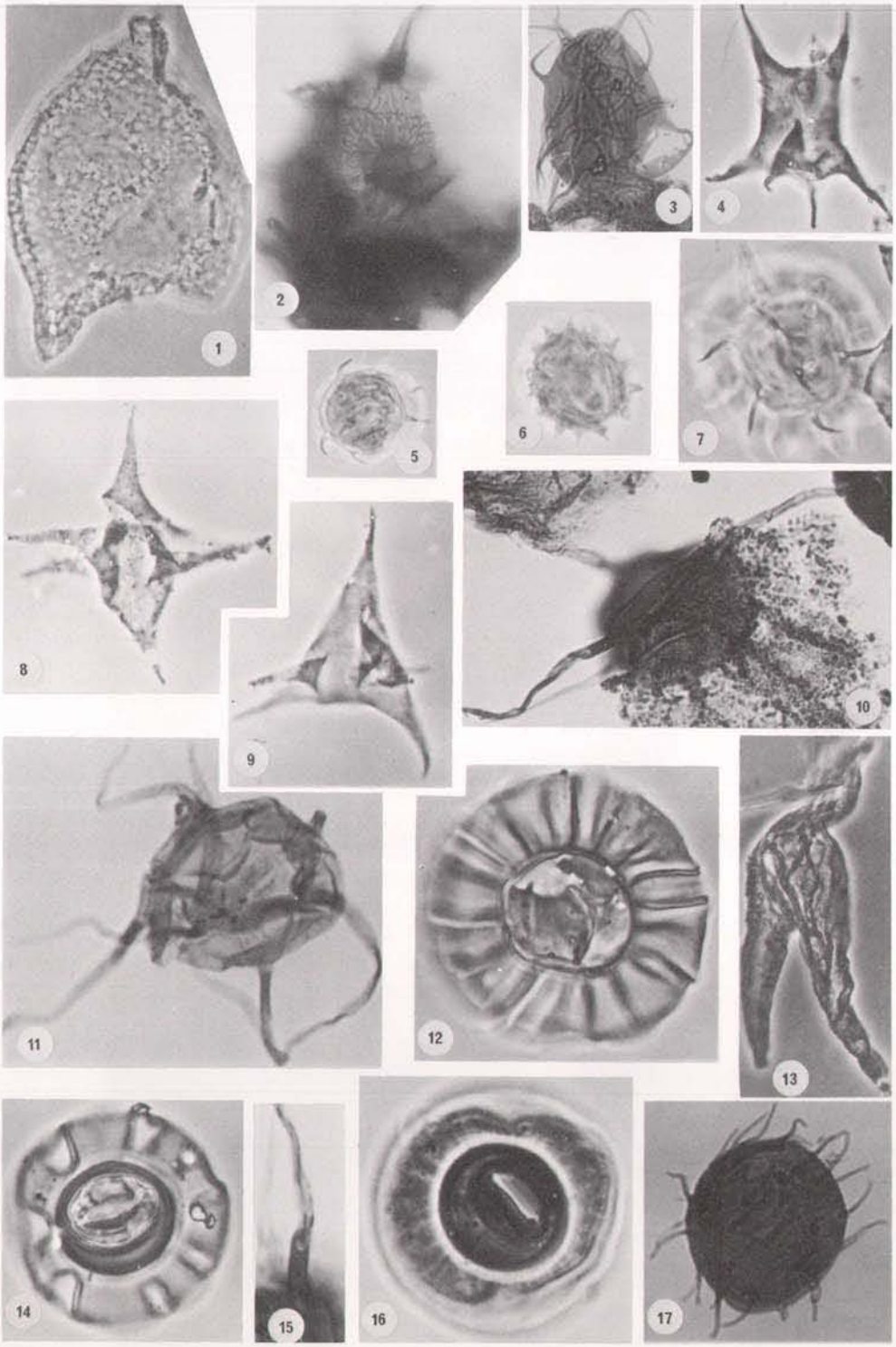
Fig. 12. *Pterospermopsis* sp. A. Slide MGUH 14.768, 109.0/12.6; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Diameter of c.b. 15 μm.

Fig. 13. *Nannoceratopsis pellucida* Deflandre. Slide MGUH 14.749, 106.7/17.0; from sample GGU 144125, Fossilbjerget Mb, west side of Fossilbjerget. Length 109 μm.

Fig. 14. *Pterospermopsis* sp. C. Slide MGUH 14.770, 110.2/13.2; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Diameter of c.b. 13–14 μm.

Fig. 16. *Pterospermopsis* sp. B. Slide MGUH 14.769, 109.5/12.2; from sample GGU 144161, Fynselv Mb, north side of Aucellaelv. Diameter of c.b. 17 μm.

Fig. 17. *Solisphaeridium brevispinosum* (Sarjeant). Slide MGUH 14.758, 100.7/14.1; from sample GGU 144128, Hareelv Fm, west-central Jameson Land. Diameter of c. b. 26–29 μm.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