Dinoflagellate cyst stratigraphy of the Barremian to Albian, Lower Cretaceous, North-East Greenland

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Stratigraphical ranges, geographical distribution and taxonomy of 176 dinoflagellate cyst species are described based on analysis of 192 samples from 40 sections of Early Cretaceous age in North-East Greenland (72°–76°N). The sections make up an approximately 1500 m thick sandy shale sequence previously referred to as the Aptian–Albian series because of scattered ammonite and *Inoceramus* occurrences.

The dinoflagellate cysts indicate the presence of approximately 140 m of Barremian sediments, not previously identified in North-East Greenland, 220 m of Aptian sediments and approximately 1120 m of Albian sediments.

The stratigraphical ranges of 40 sections are documented by range-charts for each section. The previously published ages, based on macrofossils from the area, are discussed in the light of the present results.

Five new species are erected: *Batioladinium shaftesburiense*, *Pseudoceratium iveri*, *P. toveae*, *Hapsocysta? benteae* and *Subtilisphaera kalaalliti*. The definition of the genus *Bourkidinium* and its type species *B. granulatum* is emended. The relationship between the species *Vesperopsis mayi* and *Muderongia asymmetrica* is discussed.The size, shape and ornamentation of 12 species of the genus *Pseudoceratium* are described in detail.

The stratigraphical ranges and frequency of the dinoflagellate cysts recorded in the present study are evaluated on the basis of published literature. Selected papers are discussed in detail, mainly those dealing with the stratigraphical range of Early Cretaceous dinoflagellate cysts in north-western Europe and the Arctic.

Five new dinoflagellate cyst zones and 13 new subzones are proposed for the studied sequence. The zonation is compared with previously established Early Cretaceous dinoflagellate cyst zonations from north-western Europe and Canada.

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Cover picture

Pseudoceratium iveri sp. nov. from Stratumbjerg, Wollaston Forland. Drawn by B. Sikker Hansen.

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Geological Survey of Greenland

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Contents

Dansk sammendrag

Indholdet af dinoflagellat-cyster er undersøgt i 192 prøver fra 40 Nedre Kridt profiler i Østgrønland (72°–76°N). Stratigrafisk og geografisk udbredelse samt taxonomi er beskrevet for 176 dinoflagellat-arter. De undersøgte profiler udgør en ca. 1500 m mægtig akkumuleret, sandet skiferlagfølge. Denne lagfølge er tidligere blevet beskrevet som Aptian–Albian serien på baggrund af dens indhold af få daterbare ammoniter og *Inoceramus*-arter.

Denne undersøgelse af dinoflagellat-cyster indikerer tilstedeværelsen af ca. 140 m aflejringer af barremian alder. Barremian aflejringer er ikke tidligere identificeret i Østgrønland. Ca. 220 m aflejringer er af aptian alder og ca. 1120 m er af albian alder.

Alderen af hver af de 40 undersøgte profiler er dokumenteret ved hjælp af udbredelsesdiagrammer ('range charts') og er sammenlignet med tidligere dateringer af makrofossiler fra området.

Fem nye arter er defineret: *Batioladinium shaftesburiense, Pseudoceratium iveri, P. toveae, Hapsocysta? benteae* og *Subtilisphaera kalaalliti*. Emenderinger af slægten *Bourkidinium* og dens type-art, *B. granulatum*, er foreslået. Mulige relationer mellem arterne *Vesperopsis mayi* og *Muderongia asymmetrica* diskuteres. Inden for slægten *Pseudoceratium* er størrelse, form og ornamentering af 12 arter detaljeret beskrevet.

Stratigrafisk udbredelse af dinoflagellat-arter rapporteret i denne undersøgelse er evalueret på baggrund af publiceret litteratur. Udvalgte afhandlinger, der beskriver udbredelsen af dinoflagellat-cyster fra Nedre Kridt i Nordvesteuropa og de arktiske områder, er kommenteret.

Fem nye dinoflagellat-zoner og 13 subzoner foreslås for lagserien. Den østgrønlandske zonering er sammenlignet med tidligere opstillede Nedre Kridt zoneringer fra Nordvesteuropa og Canada.

Imaqarnersiuineq

Tunumi (allorniusat 72°–76°N akornanni) uumasuaqqat ujaranngorsimasut dinoflagellat-cystit qanoq amerlatiginerat ujaqqani 192-ni ujaqqani qaleriiani 40-suni nedre Kridtimeersuni misissorneqarsimavoq. Dinoflagellatit 176 assigiinngitsut ujaqqani qaleriiaani nunami qanoq isorartutigisumi siaruarsimatiginerat kiisalu ilaqutariissusaat allaatigineqarsimavoq. Ujaqqat ikialasut sioqqanik akullit qaleriiutaartut katillutik 1500 m-it missanik issussuseqarput. Kaleriiaat taakku ikittunnguanik amikunik uilunillu ujaranngorsimasunik nassaarfiusarneri tunngavigalugit siornatigut Aptian–Albian seriamut atasutut allaatigineqartarsimavoq.

Dinoflagellat-cystinik misissuinerup ersersippaa ujaqqanik barremian nalaani pinngorsimasunik 140 m-it missaanni issutigisunik peqartoq. Tunumilu tamakku siornatigut siumorneqanngisaannarsimapput. Ujaqqat qaleriiutaartut 220 m-it missaanni issussusillit aptian nalaani kiviorarsimapput 1120 m-illu missaanni issussusillit albian nalaani kiviorarsimallutik.

Ujaqqat qaleriiutaartut 40-t qanoq pisoqaassusiisa paasiniarat uumasuaqqat ujaranngorsimasut qanoq siaruarsimatiginerat tunngavigalugu uppernarsarneqarsimavoq aammalu tamaani uumasut anginerusut ujaranngorsimasut siornatigut qanga pinngorsimanerinik misissuinerit tunngaviusimallutik.

Ilaqutariit nutaat tallimaat aalajangerneqarsimapput: *Batioladinium shaftesburiense, Pseudoceratium iveri, P. toveae, Hapsocysta? benteae* aamma *Subtilisphaera kalaalliti*. Ilaqutariillu *Bourkidinium* kiisalu *B. granulatum* pisoqaassusiisa naqqinneqarnissaat siunnersuutigineqarsimavoq. Ilaqutariit *Vesperopsis mayi* aamma *Muderongia asymmetrica* imminnut ilaqutariissinnaanerat misissorneqarpoq. Ilaqutariiusullu arqaneq marluusut *Pseudoceratium* taaguutillit akornanni angissusaat, ilusaat qaleruaallu sukumiisumik allaaserineqarsimavoq.

Dinoflagellatit assigiinngitsut qanoq siaruarsimatiginerinik naliliineq allaatigisat saqqummersittareernikut tunngavigalugit ingerlanneqarsimavoq. Allaaserisat immikkut toqqakkat, Europap avannaata kitaani nunanilu issittuni nedre Kridtip nalaani dinoflagellat-cystit qanoq siaruarsimatiginerannik allaaserinnittut uparuarneqarsimapput.

Ujaqqani qaleriiutaartuni dinoflagellatinik akoqartut nutaat tallimat taakkualu ataanni immikkoortut 13-nit siunnersuutigineqarput. Tunumi taama immikkoortiterneqarsinnaanerat Europap avannaata kitaani Canadamilu nedre Kridtimi pisoqaassusilinnut siornatigut immikkoortiterinernut assersuunneqarsimapput.

Introduction and geological setting

The present study describes the biostratigraphy of the Lower Cretaceous sandy shale sequence in East Greenland (72°–76°N, Fig. 1). Dinoflagellate cysts recorded from 40 sections throughout the region dated the sequence as Barremian to Albian (Fig. 2). The project is part of the 'Studies of the onshore hydrocarbon potential in East Greenland' led by the Geological Survey of Greenland (GGU) and described by Marcussen *et al.* (1987, 1988).

Mesozoic sediments in East Greenland have been studied since 1870. A detailed historic review of the expeditions in the area between 1870 and 1956 has been given by Donovan (1957) and updated by Surlyk (1978a).

The Aptian and Albian succession has been treated in detail by Maync (1949) and Donovan (1949, 1953, 1955, 1957, 1972) and subsequently, in less detail, by Surlyk (1978a, 1978b, 1990), Marcussen *et al.* (1987, 1988) and Stemmerik *et al.* (1993).

The sequence has been dated as Aptian to Albian (Spath, 1946; Maync, 1949; Donovan, 1953, 1955, 1957) based on the rather sporadic occurrence of macrofossils. Maync (1949, pp. 195–211, 280–281) termed the shale sequence the 'Aptian–Albian series' or '*Inoceramus* Beds' (Fig. 3). Maync (1949, pp. 211–212, 280–281) questionably correlated the 'Home Foreland Beds' from the north-eastern part of Hold with Hope with the 'Aptian–Albian series' (Fig. 3). According to Maync (1949), the exposed total thickness of the 'Aptian–Albian series' amounts to more than 2000 m. Donovan (in Callomon *et al.*, 1972, pp. 21–24) reported that Hauterivian and Barremian sediments are unknown in East Greenland. Surlyk (1990) mentioned that the Lower Cretaceous shale sequence reaches a cumulative thickness of 1000 m.

The present study indicates a cumulative thickness of approximately 1500 m for Maync's 'Aptian–Albian series', which according to the present study also includes Barremian sediments (Figs 3, 4). The Barremian deposits are represented by approximately 140 m of poorly laminated, silty shales with abundant kidney shaped calcareous concretions. These shales are erosively overlain by a thin calcareous sandstone of early Aptian age, followed by 80 m to 220 m of sandy shale sediments of Aptian age. Following a presumed depositional break, in the upper Aptian – lower Albian, depositional rates increased considerably and approximately 1120 m of shales and fine-grained sandstones were deposited during the Albian. A hiatus between the lower and middle Albian and a second hiatus between the middle and upper Albian are suggested by the fact that several dinoflagellate cyst species have their last or first occurrences at these levels (Fig. 8). The Albian succession comprises several coarsening-upward cycles (Fig. 4).

The overall depositional environment during the Barremian–Albian was apparently a muddy inner shelf with abundant sedimentation of sand beds (Stemmerik *et al.*, 1993). The coarsening-upward cycles recorded in the Albian succession may be a sedimentary response to changes in sea-level and repeated syn-tectonic activity along the western, north–south trending border faults (Surlyk *et al.*, 1981). The tectonic activity was presumably caused by extensional faulting (Surlyk, 1990).

The Barremian–Albian succession rests unconformably on sediments of Late Permian to Early Cretaceous age (Stemmerik *et al.*, 1993). During deposition of the shales an increase in subsidence rate took place, possibly associated with an overall sea-level rise initiated during the latest Hauterivian? – early Barremian and culminating in the Albian (Figs 2, 4, Enclosure 1; Stemmerik *et al.*, 1993).

It is notable that the oldest part of the succession (Barremian to upper Aptian – lower Albian) is best developed in the northern region (from north of Haystack to the northern part of Wollaston Forland) whereas the youngest part of the succession (lower Albian to upper Albian) is mainly dominated in the southern region (southern Wollaston Forland to Traill Ø; Fig. 5).

North of the studied area, Lower Cretaceous (Valanginian and Aptian) outcrops are reported only from Store Koldewey by Ravn (1911), Koch (1929a, 1929b), Frebold (1935), Maync (1949), Donovan (1957) and Stemmerik & Piasecki (1990). Examination, by the present author, of dinoflagellate cysts from this material only indicates the presence of upper Barremian sediments on Store Koldewey, whereas no dinoflagellate cysts of Valanginian or Aptian age have been recorded.

From Germania Land, north of Store Koldewey, macrofossils from loose boulders of Aptian age have been reported by Ravn (1911) and Rosenkrantz (1934, p. 24), but no outcrops have been recorded.

From the Wandel Sea Basin in North Greenland ammonites of late Volgian to early Valanginian and early to middle Albian ages have been reported by Birkelund & Håkansson (1983). Dinoflagellate cysts from the same area indicate ages from middle Oxfordian to early Valanginian (Håkansson *et al.*, 1981). Dinoflagellate cysts of early Albian age have also been recorded from the area by Århus (1991).

From southern Jameson Land, south of the studied

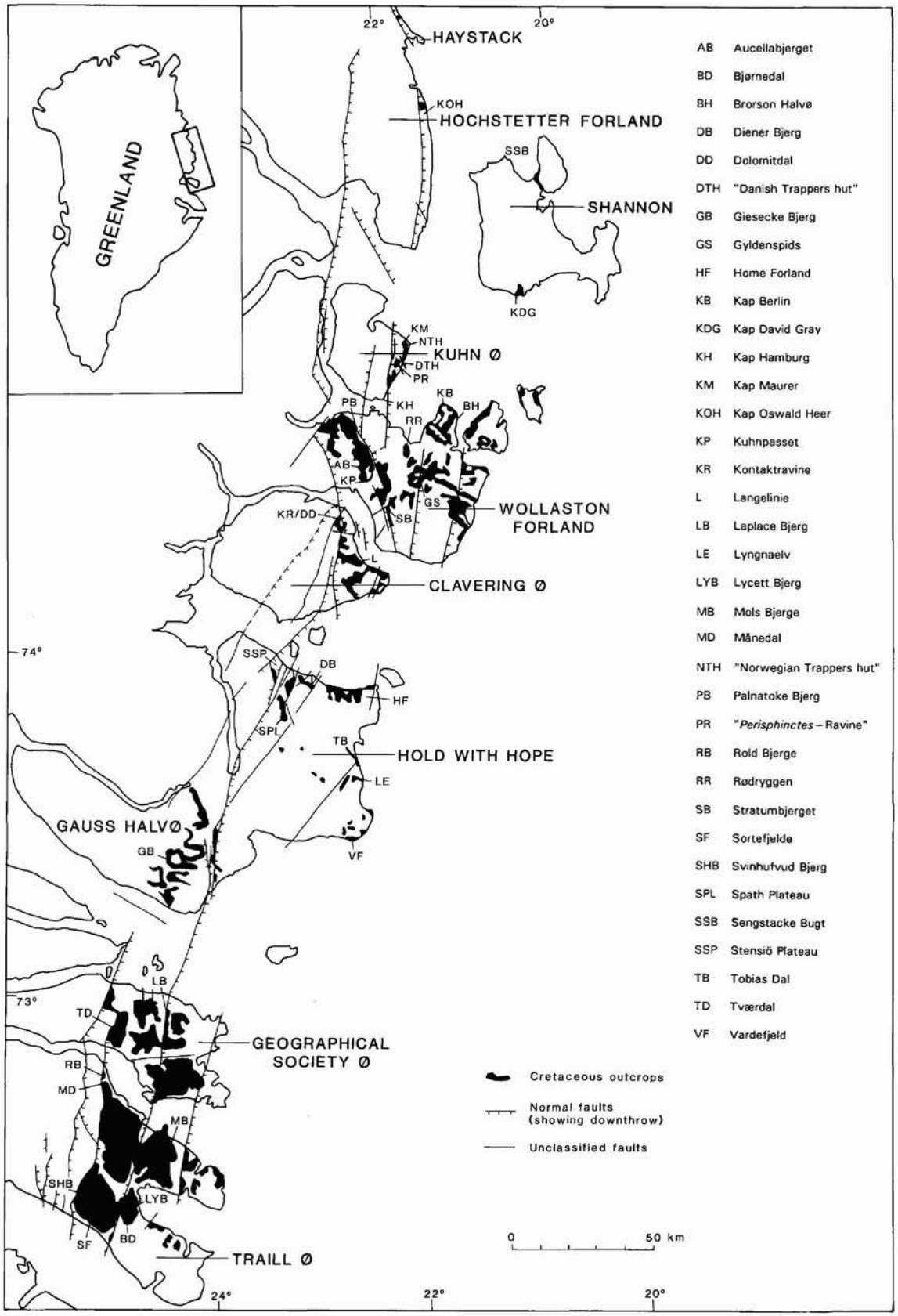


Fig. 1. Map of localities mentioned in the text, Cretaceous outcrops and faults in the studied area in East Greenland (72°–76°N), based on Koch & Haller (1971) and Surlyk (1977b, 1978b).

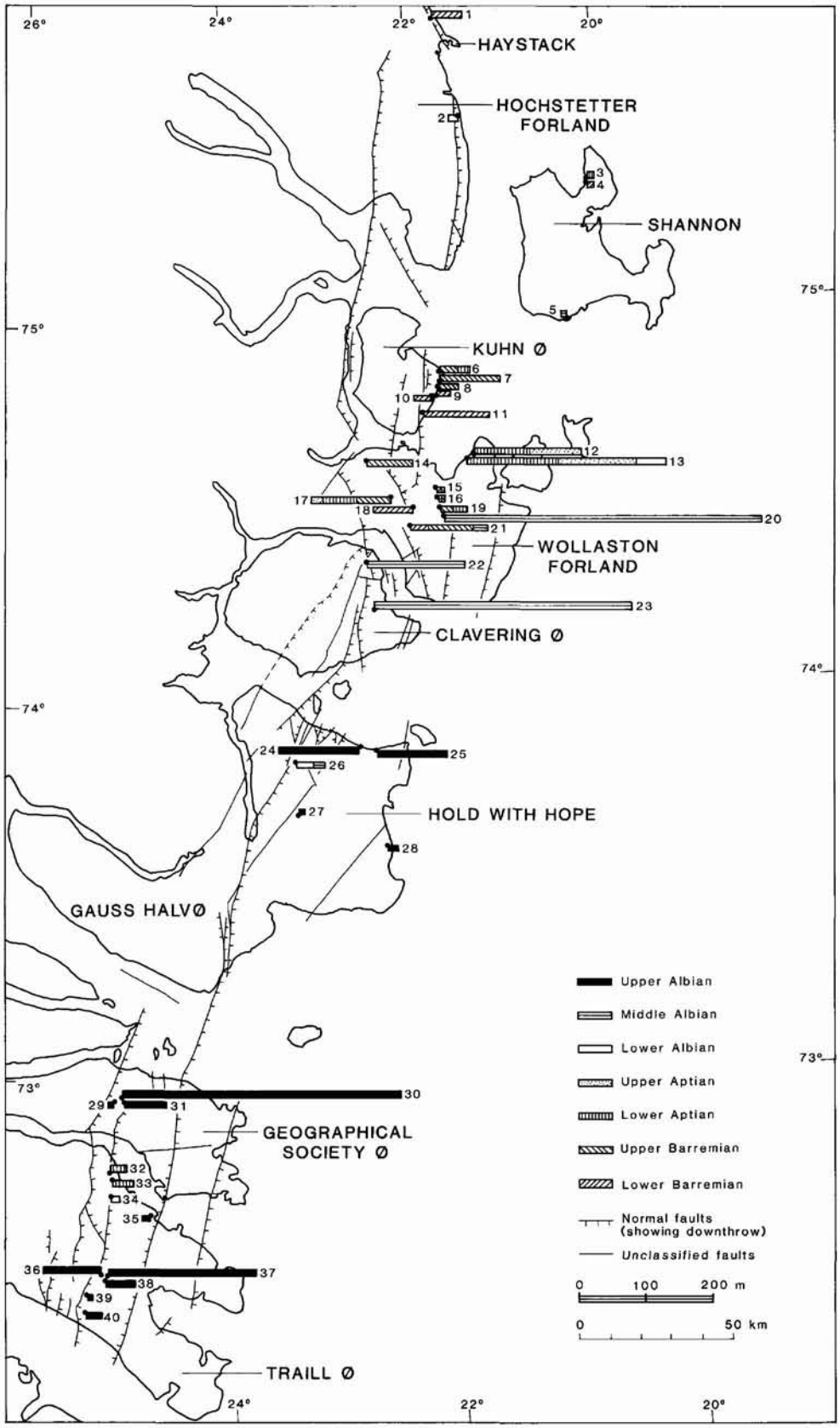


Fig. 2. Distribution of the 40 examined sections that yielded dinoflagellate cysts. The length of the bars represent the thicknesses of the sections and the hatching illustrates the stages represented in each section, as determined on the basis of the dinoflagellate cyst assemblages. The numbers of the sections are the same as those used throughout the paper. The latitudinal/longitudinal position of each section is given in the appendix.

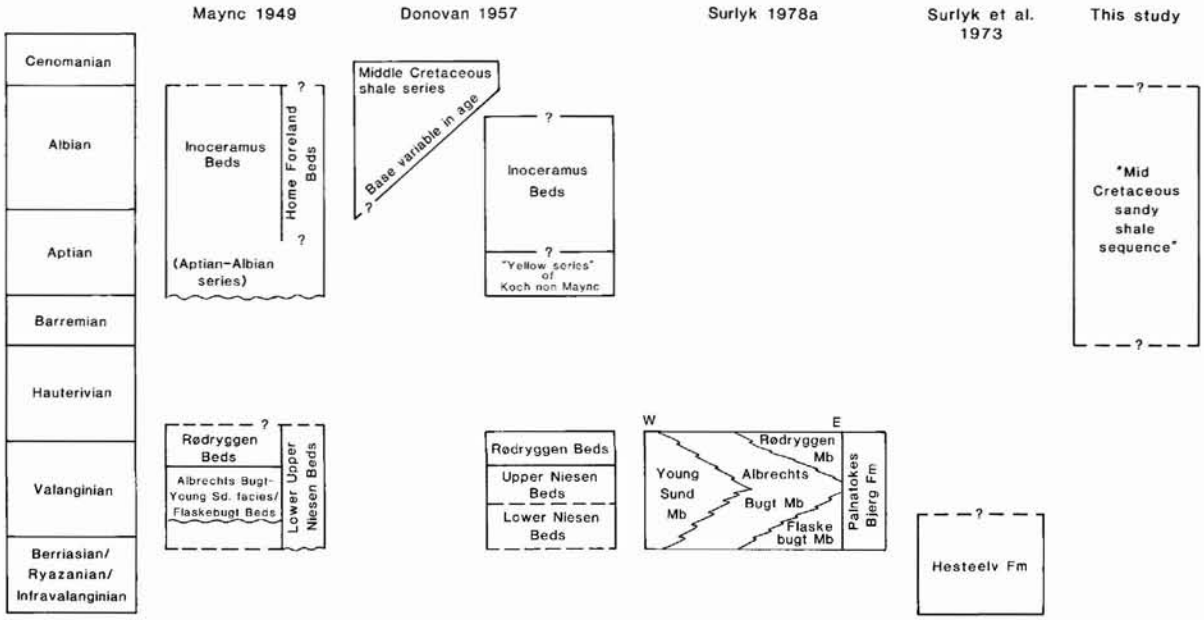


Fig. 3. Stratigraphical subdivision of the Lower Cretaceous beds of East Greenland.

area, the youngest Lower Cretaceous formation described is the Ryazanian – lower Valanginian Hesteelv Formation (Surlyk *et al.*, 1973; Surlyk *et al.*, 1986, fig. 2; Fig. 3).

According to C. Marcussen (personal communication, 1991) seismic data from Scoresby Sund, south of Jameson Land, indicate that the Jameson Land basin continues to the south beneath the Lower Tertiary basalts on the southern shore of the fjord. Probable Lower Cretaceous sediments attain a total thickness here of up to 500 m.

On Milne Land, dinoflagellate cysts indicating middle Volgian to late Ryazanian – early Valanginian ages have been reported by Piasecki (1979). Further south, in the Kangerdlugssuaq area (68°N) dinoflagellate cysts indicating middle Albian to Cenomanian and late Turonian ages have been recorded by Schiøler (in Hoch *et al.* in press).

Comparison with previous macrofossil ages

Previous biostratigraphic studies of Aptian and Albian deposits from East Greenland are compared with the results obtained in the present study (Fig. 2, Enclosure 1). The localities are discussed in geographical order beginning from the north. Localities are illustrated in Fig. 1.

Surlyk (1978b, p. 80, loc. 4, fig. 1) reported uppermost Ryazanian to Valanginian strata north of Haystack which might belong to the sandy parts of the Albrechts Bugt Member or to the transition to the Young Sund Member (Surlyk, 1978a; Fig. 3). However Surlyk (1978b) mentioned that an Aptian–Albian age cannot be totally excluded. Section 1 in the present study is represented by an unconsolidated interbedded silt and sand sequence, corresponding to Surlyk's (1978b) deposits. Dinoflagellate cysts from this section strongly indicate a latest Barremian age.

Surlyk (1978b, p. 80, loc. 7, fig. 1) reported an ammonite fragment from north of Kap Oswald Heer, on the east coast of Hochstetter Forland, and mentioned that the ammonite fragment was identified with some hesitation as an early Aptian species. Section 2, is supposed to correlate with Surlyk's (1978b) location 7, and contains dinoflagellate cysts indicating an early Albian age.

Bøgvad & Rosenkrantz (1934) reported an *Inoceramus* specimen indicating an late Aptian age for shales exposed near Kap David Gray on the south coast of Shannon (section 5 in the present study). Dinoflagellate cysts from one sample in this section are of middle Albian age.

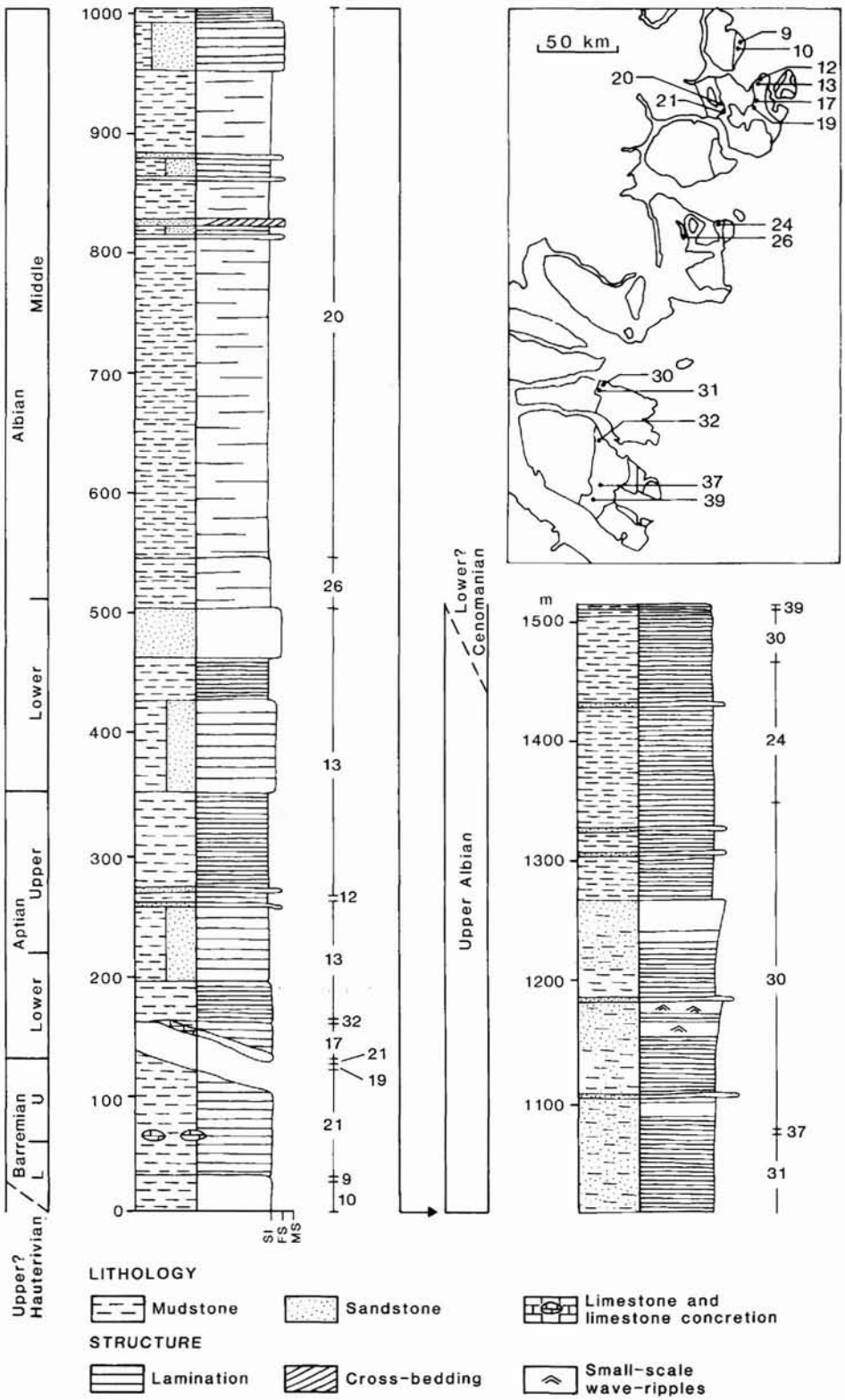


Fig. 4. Cumulated stratigraphic log of the studied deposits. The geographical distribution of the 15 sections that makes up the log are illustrated on the insert map. The 15 sections are correlated by the dinoflagellate cyst content and are the same as used for the composite range charts (Fig. 7, Enclosure 2).

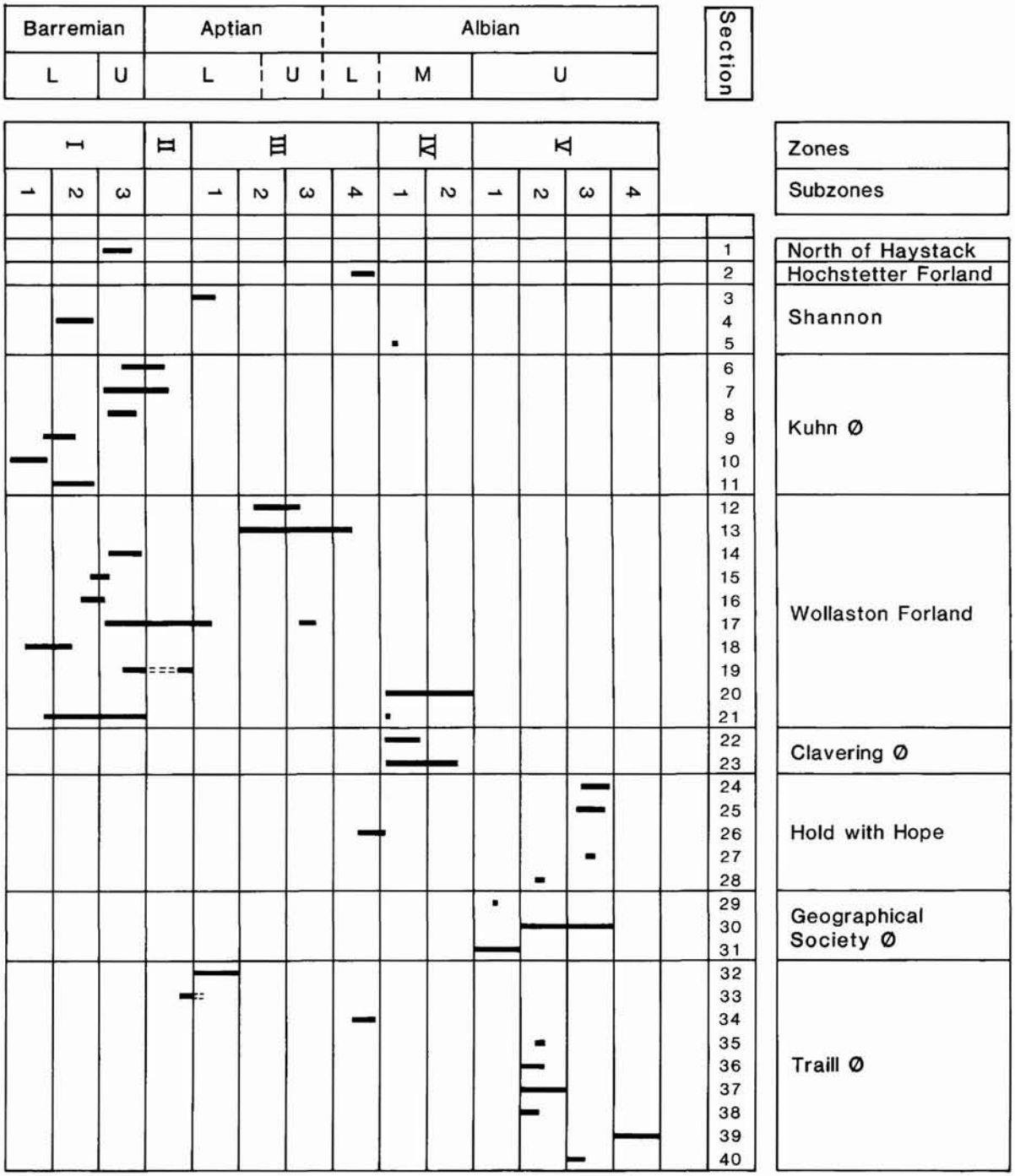


Fig. 5. Correlation and geographical distribution of the 40 sections that yielded dinoflagellate cysts.

Several Jurassic and Lower Cretaceous sections from Kuhn Ø were described by Maync (1949). The southernmost section (section S) is situated approximately 7 km north-east of Kap Hamburg and was referred to the Aptian series based on lithological features. Section 11 is located close to Maync's section S and is dated as late early Barremian, based on dinoflagellate cysts.

Neither Maync (1949) nor Surlyk (1977a, 1978a) men-

tioned the approximately 26 m, thick very weathered shale unit above the Rødryggen Member in their description of the section at '*Perisphinctes*-Ravine', Kuhn Ø. The shale unit (section 10 in the present study) is dated as latest Hauterivian – earliest early Barremian based on dinoflagellate cysts.

Maync (1949) recorded six exposures (A-F) situated between Kap Maurer in the north of Kuhn Ø, and the 'Danish Trappers hut' north of '*Perisphinctes*-Ravine', on the east coast of Kuhn Ø. The sediments were dated as early and late Aptian, based on ammonites, belemnites and *Inoceramus* species. Maync mentioned that the exposures (A-F) cover almost the same stratigraphical interval, illustrated by a 220 m combined section (Maync, 1949, p. 27, fig. 4). Four sections (6–9), from the same area, have been analysed for dinoflagellate cysts. Section 6 (43 m, Enclosure 1) was collected at the first exposed black shale south of Kap Maurer and is comparable with exposure A of Maync. Section 6 represent at least 23 m upper Barremian sediments, whereas the uppermost sample is lower Aptian. Section 7 (90 m, Enclosure 1) is situated approximately halfway between the two hunting cabins (the 'Norwegian Trappers hut' in the north and the 'Danish Trappers hut' north of '*Perisphinctes*-Ravine') and is comparable with Maync's exposure E. The lower 70 m of the section are of upper Barremian age according to the dinoflagellate cysts, whereas the uppermost sample is dated as early Aptian.

Section 8 on eastern Kuhn Ø consists of 32 m of sediments (Enclosure 1) dated as late Barremian based on dinoflagellate cysts. The section is situated approximately 1 km south of section 7 and might be comparable with exposure F of Maync.

Section 9 is situated approximately half way between section 8 and the 'Danish Trappers hut' on eastern Kuhn Ø. This section is dated as late early Barremian based on dinoflagellate cysts. The section may be situated close to Maync's (1949, pl. 1) section 3. However correlation of the sections is questionable. Maync recorded the *Aucella* limestone (according to Surlyk, 1978a, now Albrechts Bugt Member; Fig. 3) and the red sandstone (according to Surlyk, 1978a, now Rødryggen Member; Fig. 3) below the black shale of Aptian age in his section 3 whereas only 25 m of black shale is recognised in section 9 (Enclosure 1) from the present study.

A section from Kap Berlin, Brorson Halvø, Wollaston Forland was dated as Albian, based on ammonites and species of *Inoceramus* (Maync, 1949). East of Kap Berlin Maync (1949) recorded a doubtfully identified Aptian ammonite specimen. Dinoflagellate cysts from section 12, situated south-west of Kap Berlin, indicate an early and late Aptian age whereas section 13, located south of section 12, is dated as early Aptian, late Aptian and early Albian ages. The presence of sediments of Aptian age in the two sections is thus in accordance with Maync's assumed Aptian ammonite from east of Kap Berlin.

At Rødryggen, Wollaston Forland, Maync (1949) recorded an Aptian ammonite in the black sandy shale above the Valanginian Rødryggen Member (Surlyk, 1978a; Fig. 3), although Spath (1946) remarked that the species is also known from the upper Barremian. Dinoflagellate cysts from the two sections 15 and 16 strongly indicate a latest early and earliest late Barremian age for the black shale unconformably resting on the Rødryggen Member which support Spath's remarks.

From the northern flank of Gyldenspids, Wollaston Forland, Maync (1949) described a 618 m thick undifferentiated Aptian–Albian sequence. Here he recorded poorly preserved ammonites, of presumed Aptian age. According to Donovan (1957), these ammonites were not among the specimens identified by Spath (1946). The *Inoceramus* specimens recorded from Gyldenspids (Donovan, 1957) suggest that the greater part, if not the whole section, is of Albian age. Dinoflagellate cysts indicate a middle Albian age for section 20 (470 m, Enclosure 1) from the northern flank of Gyldenspids.

Maync (1949) described a section from Stratumbjerget, Wollaston Forland where he mentioned that black shale with marl bands of indubitable Aptian–Albian age unconformably rest on the Valanginian Rødryggen Member. Section 21 correlates with Maync's black shale. The dinoflagellate cyst assemblages indicate that the lower 30 m is of early Barremian age, followed by approximately 70 m of late Barremian age and one uppermost sample, situated 105 m above the Rødryggen Member, yielded dinoflagellate cysts of middle Albian age. This indicates the presence of a significant hiatus between the upper Barremian and the middle Albian (Enclosure 1) in the section though it is not visible in the outcrop.

A 433 m Valanginian to Aptian sequence from Kuhnpasset to Aucellabjerget, Wollaston Forland, has been described by Maync (1949). According to Maync the Aptian part of the section constitutes at least 140 m but another 150 m below may also be Aptian (Maync, 1949, fig. 27). The Aptian age was based on Spath's (1946) identification of ammonites from two levels in Maync's section. The ammonites were recorded from 130 m and 145 m below the basalts which rest on Maync's Aptian section. Section 17 in the present study consists of 130 m of sediments (Enclosure 1) situated immediately below the basalts at Aucellabjerget. The dinoflagellate cysts indicate that the lower 60 m of section 17 is of late Barremian age whereas the upper 70 m is of early and late Aptian age.

Several sections were measured near Kontaktravine, Dolomitdal, north-eastern Clavering Ø by Maync (1949)

who suggested an Aptian–Albian age. The thickest section is 105 m. Donovan (1957) mentioned that all the exposures on Clavering Ø dated by macrofossils are of Albian age and suggested that the sections from the Kontaktravine region may also belong to this stage. Dinoflagellate cysts from section 22 (147 m, Enclosure 1) at Kontaktravine indicate a early middle Albian age.

Maync (1949) described *Inoceramus* dated Albian strata from the Langelinie, eastern Clavering Ø. Section 23 (386 m, Enclosure 1) from the western part of Langelinie Bjerg is dated as middle Albian based on dinoflagellate cysts.

Maync (1949) proposed the lithological unit 'Home Foreland Beds' (Fig. 3) for the ferruginous sandstones and black shales with ironstone concretions situated below the plateau basalts on the north side of Home Forland on Hold with Hope. A 385 m section through the beds had previously been published by Frebold (1934) who dated the beds as Senonian based on a bivalve found by E. Nielsen. However, Maync (1949) rejected a Senonian age, based on lithological similarity between the 'Home Foreland Beds' and the '*Inoceramus* Beds' (Maync, 1949; Fig. 3) of Aptian and Albian age. Additionally Maync (1949) reported the discovery of an Aptian–Albian *Inoceramus* from the 'Home Foreland Beds'. Donovan (1953, 1957) stressed the danger of correlations based primarily on lithology but mentioned that Maync had extensive experience in the Mesozoic of this part of East Greenland. Donovan (1957) further mentioned that Maync's records of the Aptian–Albian *Inoceramus* species presumably have been based on field identification as the species did not appear in the macrofossil collection that Donovan received from Dr. J. Sornay who studied Maync's material. Sections 24 and 25 in this study from the northern part of Home Forland consist of more than 100 m of shale sediments (Enclosure 1). Section 24 covers the interval 330–452 m, whereas section 25 covers the interval 5–110 m. Both sections are below the basalts and are here interpreted as representing parts of the 'Home Foreland Beds'. The study of dinoflagellate cysts from these sections strongly indicates a middle to latest Albian age.

The published information of the Lower Cretaceous on Geographical Society Ø is sparse. Donovan (1955) reported *Inoceramus* species of Albian? and Cenomanian ages from sediments in Tværdal. Dinoflagellate cysts from three sections (29–31) in Tværdal suggest a middle late Albian age.

A few belemnites from Donovan's (1953) localities 78–80 on the coast north of the Rold Bjerge, north-eastern Traill Ø, indicate an 'Infra-Valanginian' age (Fig. 3). The dinoflagellate cyst content from the same localities (section 33) and from a nearby shallow core (section 32) indicate an early Aptian age.

Donovan (1953) recorded early Albian ammonites in baked shales at Rold Bjerge, Traill Ø. No palynomorphs have been obtained from these shales whereas dinoflagellate cysts from section 35, south-east of Rold Bjerge, indicate a late Albian age.

At Månedal, south of Rold Bjerge, Traill Ø, Donovan (1953) recorded bivalves from his locality 66 and suggested that the macrofossils indicated an Albian age. The dinoflagellate cyst content from section 34 (10 m, Enclosure 1) at the northern slope of Månedal indicates an early Albian age.

Dinoflagellate cysts have not been recorded from Donovan's (1953) Albian – Cenomanian localities in the area of Sortefjelde, Traill Ø, whereas dinoflagellate cysts from sections 36 to 40 from Svinhufvud Bjerg, Traill Ø, indicate a late Albian – early? Cenomanian age.

Dinoflagellate cyst distribution and zonation in the Lower Cretaceous

The literature on Lower Cretaceous dinoflagellate stratigraphy from East Greenland is very sparse and in order to establish the present dinoflagellate stratigraphy it has been necessary to consult papers describing Lower Cretaceous dinoflagellate cysts from Central Europe, Norway, Canada, Africa, Papua New Guinea, Australia, and USA. The stratigraphical coverage of 45 of these papers has been summarised in Figure 6. Some of these papers require explanatory comments with respect to the dating and stratigraphical position of the sections and samples studied. These papers are commented below.

Of European studies, only those papers containing a Lower Cretaceous dinoflagellate cyst zonation or those published after 1987 are commented upon. Most biostratigraphical dinoflagellate studies published on material from north-west Europe (before 1987) were recently compiled and reviewed by Heilmann-Clausen (1987, figs 3–4; p 11–18).

Several of the published papers used as reference for the present stratigraphy are of older date or based on information from well or outcrop sediments with very limited or no stratigraphical information from macrofossils. Not all of the references are equally well located stratigraphically or relevant to East Greenland. The rank-

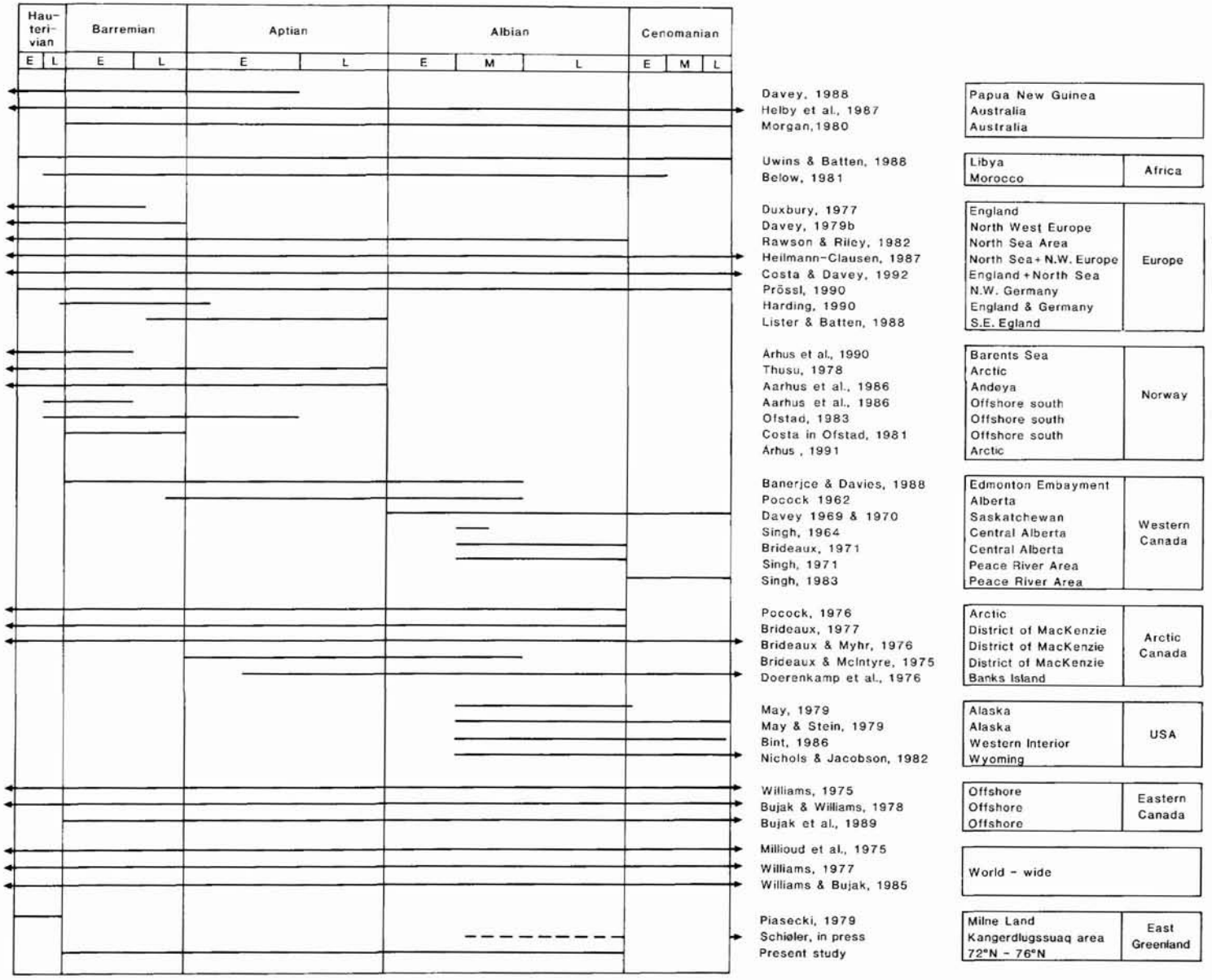


Fig. 6. Approximate stratigraphical coverage of most published dinoflagellate cyst studies of the Hauterivian to Cenomanian in north-west Europe, Arctic Norway, Canada, Greenland and selected studies from Australia, Papua New Guinea, Africa and USA.

ing used below is therefore arranged so that the publication with the best documented age evidence is placed first followed by decreasing reliability with respect to precise dating. This ranking is also used for discussions of ages and correlation in the sections on 'Dinoflagellate cyst zonation in East Greenland' and on 'Systematic palynology'.

Speeton, England; Duxbury, 1977

Duxbury described the dinoflagellate cyst content for the ammonite-dated Berriasian to early 'middle' Barremian deposits of the Speeton Clay of Speeton (for Great Britain, a threefold division is used for the Barremian). Five zones (A to E) was erected for the Berriasian to upper Hauterivian (*variabilis* Zone) whereas the eight younger samples were dated as late Hauterivian to early 'middle' Barremian. The two youngest samples represent the Cement Beds (MB) of early 'middle' Barremian age, the underlying samples represent the Lower B1 Bed (early Barremian) to which *Pseudoceratium anaphrissum* (as *Aptea anaphrissa*) was confined (Duxbury, 1977, p. 60).

Duxbury's Zone E represents the *variabilis* ammonite zone which Rawson *et al.* (1978) placed in the uppermost Hauterivian. Following Kemper *et al.* (1981) the Hauterivian – Barremian stage boundary is now placed below the *variabilis* Zone.

England and North Sea wells; Costa and Davey, 1992

Costa and Davey published the stratigraphical range of numerous index Cretaceous dinoflagellate cysts obtained from 'accurately' ammonite-dated sediments, representing the Cretaceous stages in England and the North Sea.

North-west Europe; Davey, 1979b

Davey erected an interval dinoflagellate cyst zonation for the Portlandian (Jurassic) to Barremian of north-west Europe. Based on his observations from the Speeton Clay section (Davey, 1974), he assigned the *Pseudoceratium anaphrissum* Subzone (as *Doidyx anaphrissa*) a late early Barremian to late 'middle' Barremian age, based on the last occurrence of *P. anaphrissum* in the 'middle' Barremian Cement Beds. Duxbury (1980) and Harding (1990b) questioned Davey's (1974; 1979b) recording of this species from the Cement Beds. According to these authors the last occurrence of this species is in the older Lower B Beds at Speeton and the age of the *P. anaphrissum* Subzone should therefore be early Barremian.

England & Germany; Harding, 1990b

Harding correlated the European boreal Barremian based on dinoflagellate cyst data from one cephalopod dated German section (Gott claypit, Sarstedt) and four English sections (Speeton (ammonite dated), Alford, Hunstanton and Warlingham). Rawson & Mutterlose (1983, p 137) and Harding (1990b, p. 8–9) mentioned that the organic rich lower Barremian Bed LB1 at Speeton may be equivalent to the organic rich German Hauptblätterton. The latter was dated by Mutterlose (1983; 1984) as early Barremian based on cephalopods. The Middle B Beds and the Upper B Beds, which at Speeton overlie the Early Barremian Lower B Beds, have been assigned a late Barremian age.

North-west Germany; Prössl, 1990

Prössl established a zonation for the lower Hauterivian to upper Turonian sediments from the well Konrad 101 in north-west Germany. Prössl used the British threefold division of the Barremian in his range-chart (table 5) but elsewhere (p. 95) follows the twofold division, defined by Mutterlose (1983), where the bitumen rich 'Blatterton' constitutes the major part of the lower Barremian. The 'middle' Barremian is included in the upper Barremian. The lower–upper Barremian boundary in the Konrad 101 well is defined (Mutterlose, 1983; Mutterlose & Harding, 1987a) by the presence of the belemnite *Oxyteuthis brunsvicencis*.

North Sea wells and north-west Europe; Heilmann-Clausen, 1987

Heilmann-Clausen described the dinoflagellate cyst distribution from the uppermost Jurassic (Volgian) to upper Albian – Upper Cretaceous in wells from the North Sea. Most of the data are from ditch cuttings but sidewall cores and a few cores form part of the investigated material. Core samples are from the Tuxen Formation (upper Hauterivian? to 'middle' Barremian), Sola Formation ('middle' Barremian? to lower to upper Albian) and the Rødby Formation (Albian). Only rare upper Hauterivian ammonites were recorded from the cores.

As a reference for the dinoflagellate data from the investigated wells, Heilmann-Clausen compiled a very useful range-chart (fig. 4) for 116 stratigraphical important dinoflagellate cyst species. This range-chart was based on information from most (43 papers) published dinoflagellate studies of the Lower Cretaceous in north-west Europe (before 1987), of which 27 papers described ammonite-dated sections.

It should be noted that Heilmann-Clausen, to facilitate

comparison with the Speeton section in eastern England, used the British three-fold division of the Barremian stage, where the 'middle' Barremian is typified by the Cement Beds (MB Beds).

South-east England; Lister & Batten, 1988

Stratigraphical information on dinoflagellate cysts from the Weald Clay (uppermost Barremian) and Lower Greensand (Aptian) deposits was presented by Lister & Batten (1988) from a borehole section in southern England. The zonation established by Lister & Batten was correlated with the ammonite zonation from the area. It has been difficult to correlate Lister & Batten's (1988) zonation with the zonation from East Greenland due to the dominance of brackish water dinoflagellate cysts, especially in the Weald Clay.

North Sea area; Rawson & Riley, 1982

Rawson & Riley's (1982) zonation scheme covering the Oxfordian (Jurassic) to the Albian was modified from unpublished data from Robertson Research Ltd (1978). Rawson & Riley only published the names of the zones and the zonation may be perceived as informal due to the lack of definitions. The *Pseudoceratium anaphrissum* (as *Doidyx anaphrissa*) Subzone is, as in Davey (1979b), described as 'middle' Barremian, but should, for the reasons mentioned above, be of an early Barremian age.

Western Canada; Pocock, 1962

This early work on material from the Lower and Upper Mannville Group of Alberta and Saskatchewan (according to Pocock, 1962, p. 29, Berriasian to Aptian or slightly younger) only includes stratigraphical information on a few dinoflagellate species. Pocock (p. 29) gave the 'quartz sand' member from the Lower Mannville Group a Barremian age whereas Mellon & Wall (1963) and Mellon (1967) indicate an early to middle? Albian age for this member. Pocock (p. 29) referred the 'calcareous' member of the Lower Mannville Group to the upper Barremian. However Mellon & Wall (1963) and Mellon (1967) assigned a middle Albian age. Data from Brideaux & McIntyre (1975) and Brideaux (1977) indicate that the 'calcareous' member could be as old as late Aptian and as young as early Albian. The more recent studies therefore suggests that the ages of these members are younger than given by Pocock (1962).

Western Canada; Brideaux, 1971

The middle and upper Albian sections described from Alberta (Brideaux, 1971) are all subsurface sections penetrating the Upper Mannville Group (same middle Albian interval as Singh (1964) studied for spores and pollen) and the Lower Colorado Group (upper Albian). Reference to species ranges has been obtained from the systematic chapter of Brideaux's paper. His composite range-chart (text-figure 6) also includes data from previous work.

Western Canada; Davey, 1969, 1970

In Davey's (1969, 1970) papers on Cenomanian non-calcareous microplankton, six Albian–Cenomanian samples, representing the Lower and Upper Colorado Group from a borehole in Saskatchewan, were examined for dinoflagellate cysts. Davey (1970, p. 394) placed the Albian–Cenomanian boundary just below sample Sas 890 which dated the samples Sas 1084, Sas 1023 and Sas 967 as Albian, sample Sas 890 as early Cenomanian, and samples Sas 835 and Sas 805 as middle to late Cenomanian. According to Singh (1983, table 7) recent research indicates that Davey's ages (1970, p. 394) are in error. Singh reassigned them to the following ages: Sas 1084 and Sas 1023 late Albian, Sas 967 and Sas 890 Cenomanian, Sas 835 and Sas 805 early Turonian. It should be noted that the older ranges of some of these species interpreted by Singh (1983) are incorrect as they are based on caved specimens (Davey, personal communication 1992).

Western Canada; Banerjce & Davies, 1988

Banerjce & Davies (1988) studied the Barremian – lower? Aptian Ellerslie Formation and Ostracode Zone of the Manville Group located in the Edmonton Embayment, Alberta. The restricted marine to brackish conditions strongly influence the dinoflagellate cysts distribution in the deposits.

Arctic Canada; Brideaux & McIntyre, 1975

Brideaux & McIntyre (1975) discussed the dinoflagellate cyst stratigraphy from a composite surface section along the Horton River, District of MacKenzie. The section includes the Langton Bay Formation, composed of the older Gilmore Lake Member (Apian), the younger Crossley Lakes Member (Aptian to middle Albian) and the Horton River Formation (middle Albian).

Brideaux & McIntyre (1975, p. 9) mention that the basal part of the Crossley Lakes Member could be as old

as Hauterivian and as young as Aptian based on the presence of the dinoflagellate cyst species *Tenua hystrix*, *Muderongia asymmetrica*, *M. tetracantha* and *Circulodinium brevispinosum*. However, they conclude that the lower part of the Crossley Lakes Member must be assigned to the Aptian because the spore and pollen data from the underlying Gilmore Lake Member indicate an Aptian age.

The Upper part of the Crossley Lakes Member is, according to Brideaux & McIntyre (1975), no older than early Albian and no younger than middle Albian, because they consider the dinoflagellate cyst and spore assemblages from the younger Horton River Formation to be of middle Albian age.

The few ammonites recorded from the section along the Horton River are fragmented but suggest an Albian age (Brideaux & McIntyre, 1975, p. 7).

Offshore Eastern Canada; Williams, 1975

Based on the stratigraphic ranges of dinoflagellate cysts, Williams erected a zonation for Mesozoic and Cenozoic strata in wells on the Scotian Shelf and on the Grand Banks. All the data presented in this paper are from subsurface sections, without macrofossil control, and therefore tentatively dated, according to Williams & Bujak (1985, p. 869).

Offshore Eastern Canada; Bujak & Williams, 1978

This paper slightly modified the zonation of Williams (1975) and is based on data from wells on the Scotian Shelf and Grand Banks. The ages were based on comparison with dinoflagellate assemblages primarily from European outcrops, and with ostracod and foraminiferal datings from the wells offshore eastern Canada.

According to Williams & Bujak (1985, p. 869) the "Lower Cretaceous dinoflagellate assemblages from the Scotian Shelf are most similar to coeval assemblages from southern England, whereas those from northeastern Grand Banks are more similar to those from the Speeton Clay of north-east England. The Albian and Upper Cretaceous assemblages are generally similar to those from France and England."

Australia; Morgan, 1980

Morgan described the dinoflagellate cyst content from the Lower and 'Middle' Cretaceous from conventional cores taken all over Australia. Morgan divided the Aptian to Cenomanian into three microplankton zones and nine subzones.

Australia; Helby *et al.*, 1987

This paper described the stratigraphic range of Mesozoic dinoflagellate cysts from more than 300 wells (mainly core and side-wall core samples) from Australia and Papua New Guinea. The Barremian to Albian stages have been divided into seven dinoflagellate zones, which are parts of the *Muderongia* and *Heterosphaeridium* superzones.

Papua New Guinea; Davey, 1988

Davey established a palynological zonation of the uppermost Middle Jurassic to the Lower Cretaceous of Papua New Guinea. Two zones were proposed for the upper Hauterivian to the lower Aptian and correlated with the work of Helby *et al.* (1987).

'World-wide'; Millioud *et al.*, 1975

This paper includes stratigraphic range charts of selected Cretaceous (Berriasian to Maastrichtian) dinoflagellate cysts, without other comments. The ranges probably represent world-wide ranges. According to the introduction given by Evitt (1975, p. 1) the paper focuses on ranges of important dinoflagellate cysts in space and time.

'World-wide'; Williams & Bujak, 1985

Williams & Bujak (1985) discussed all previously published dinoflagellate zonations for the global Mesozoic and Cenozoic. Additionally they present the 'world-wide' (excluding the Tethyan Realm) total ranges of 385 Mesozoic and Cenozoic species on fig. 19, whereas the ranges of selected species (representing the same time-span) from the Tethyan Realm were presented on fig. 20.

Williams & Bujak (p. 850) mention that they are aware of provincialism in dinoflagellates, but that the "lack of detail at the present time prevents delineation of most provincially or latitudinally restricted taxa. This results in part from the scarcity of detailed paleoecological studies on dinoflagellates".

Remarks

The comments given to the papers above illustrate that very few palynological stratigraphic works outside central Europe have been 'accurately' dated by macrofossils. The present tentative dating of the sequence from East Greenland has therefore, where possible, been dated using correlations with these ammonite-dated works.

The Barremian sequence in this study is mainly dated by correlation with the dinoflagellate assemblages described from the ammonite-dated Speeton section, England (Davey, 1974, 1979b; Duxbury, 1977, 1980; Harding, 1990b; Costa & Davey, 1992) whereas dinoflagellate species not reported from Speeton are correlated with cephalopod dated sections in north-west Germany (Harding, 1990b; Prössl, 1990) and with sections with no or almost no macrofossil control in Norway (Aarhus *et al.*, 1986; Århus *et al.*, 1990;), Africa (Uwins & Batten, 1988), Canada (Brideaux, 1977; Brideaux & Myhr, 1976) and Australia/Papua New Guinea (Morgan, 1980; Helby *et al.*, 1987; Davey, 1988).

The Aptian sequence in this study is mainly dated by correlation with the dinoflagellate assemblages described from macrofossil-dated sections in England (Duxbury, 1983; Lister & Batten, 1988; Costa & Davey, 1992), north-west Germany (Davey, 1982a; Prössl, 1990) and France (Davey & Verdier, 1974) but other sections (with no or almost no macrofossil control) in Norway (Aarhus *et al.*, 1986; Århus, 1991), Canada (Brideaux, 1977; Brideaux & McIntyre, 1975; Brideaux & Myhr, 1976; Doerenkamp *et al.*, 1976), Africa (Uwins & Batten, 1988) and Australia/Papua New Guinea (Morgon, 1980; Helby *et al.*, 1987; Davey, 1988) contain stratigraphically important dinoflagellate species with almost the same range as in East Greenland.

The Albian sequence in this study is mainly dated by correlation with the dinoflagellate assemblages described from macrofossil-dated sections in north-west Germany (Prössl, 1990), France (Davey & Verdier, 1971; 1973) and England (Costa & Davey, 1992) but sections with no or almost no macrofossil control in Canada (Brideaux, 1971, 1977; Singh, 1971; Brideaux & McIntyre, 1975; Brideaux & Myhr, 1976; Doerenkamp *et al.*, 1976), Alaska (May, 1979; May & Stein, 1979), Norway (Århus, 1991) and Australia/Papua New Guinea (Morgan, 1980; Helby *et al.*, 1987) all contain stratigraphically important species with almost the same range as in East Greenland.

Samples and methods

Samples

The Lower Cretaceous samples analysed in the present biostratigraphic study were collected during field work carried out by the Geological Survey of Greenland (GGU) in the summers of 1986 and 1987 in the search for hydrocarbons, in onshore areas of East Greenland (72°–76°N) (Marcussen *et al.*, 1987, 1988).

Several examined sections or samples were thermally affected beyond the level of palynomorph preservation. Dinoflagellate cysts are recorded from 192 Lower Cretaceous samples, representing 40 sections of 1 to 470 metres thickness. The sections are situated on Hochstetter Forland in the north, to Traill Ø in the south (Fig. 2; Table 1, the sections are numbered 1 to 40). Most (37) of the sections are surface outcrops whereas 3 sections are subsurface represented by slim cores from shallow wells drilled by GGU helicopter transportable drilling equipment.

Preparation

Palynological preparation and studies were carried out at GGU. Palynomorphs were extracted from 20 g of sample by modified standard preparation techniques. The bulk of the minerals was dissolved by hydrochloric and hydrofluoric acids. A first slide was made after this treatment. A second slide was made of the organic residue after sieving using a 20 micron nylon mesh. A third slide was made after oxidation (3 to 5 minutes) with fuming nitric acid, followed by washing with a weak potassium hydroxide solution. The oxidation was carried out in order to clean the sample of minor amorphous kerogen particles and pyrite. Finally palynomorphs were separated in most samples from coal particles and woody material using the method described by Hansen & Gudmundsson (1978).

After each of the steps mentioned above the organic residues were mounted in a permanent medium Eukitt R (produced by O. Kindler, Germany).

Depository of material and analyses

The palynological slides were studied with transmitted light using an Olympus BH-2 microscope (BHT 202120). All the coordinates in the plate text refer to this microscope. England finder index corners: Z 75 4 = 2.2–174.9; Z 1 3 = 1.4–102.0; A 1 1 = 25.7–101.9; A 65 2 = 26.2–164.8, center: O 38 = 12.9–138.4. The S.E.M. observations were carried out on oxidised organic material, sieved, strew mounted and Au-coated using a Phillips

Scanning Electron Microscope at the Geological Institute, University of Copenhagen.

The illustrated dinoflagellate cysts with MGUH numbers are kept in the type collection of the Geological Museum of the University of Copenhagen. The additional palynological preparations from the East Greenland samples are housed at the Geological Survey of Greenland where they are accessible for examination.

At least 300 dinoflagellate cysts or cyst fragments, were counted from the sieved, oxidised or gravitation-separated slides in order to obtain the relative percentage of the species content. Rare species recovered after the counting are shown as very rare (less than 0.5%). Unidentifiable dinoflagellate cysts often constituted 5 to 10 percent.

The TAI (Thermal Alteration Index) evaluation was determined from the sieved slide before oxidation.

Due to the very sparse macrofossil content and the rather homogeneous lithology, the stratigraphical correlation of the geographically widespread 40 sections is based solely on the first and the last occurrences and acme of stratigraphically important dinoflagellate species.

Reworked dinoflagellate cysts species are seldom recorded by their different state of preservation but rather on their Jurassic and/or lowermost Lower Cretaceous origin. Reworked species constitute a minor percentage of the examined material, but are included in the counting.

Additional to the material from East Greenland two Lower Cretaceous sections from Arctic Canada were studied. Dinoflagellates from 5 samples from the South Sabine section on Melville Island and from 15 samples from the Lost Hammer section on Axel Heiberg Island were examined for comparison. The Canadian material was palynologically prepared for and kindly placed at my disposal by the Geological Survey of Canada (GSC), Institute of Sedimentary Petroleum Geology (ISPG), Calgary, Canada.

Palynology of the Barremian to Albian sequence

Composition of the organic material, reworking and maturity

Well preserved dinoflagellate cysts dominate the palynomorph assemblages throughout the sequence and in the present study 176 dinoflagellate cyst species were recorded. Saccate pollen and other miospores occur consistently in low numbers. A slightly higher content of miospores was recorded only in section 30. Acritarchs, other algae and miscellaneous palynomorphs are rare.

Reworked specimens of Jurassic and lowermost Cretaceous dinoflagellate cysts constitute a minor percentage of the assemblages in the examined material. These specimens were not identified by their divergent state of preservation but rather by their known stratigraphic ranges.

The organic material is dominated by palynomorphs and by brownish to black woody material, amorphous organic material constitutes a minor part. No clear stratigraphical or regional variation in composition of the organic material was observed during the study and no attempt was therefore made to carry out any organic facies analyses.

The organic material is thermally immature to mature with respect to oil generation. The Thermal Alteration Index (TAI) is -2 to +3. Chemical analyses of the organic matter yielded Total Organic Carbon (TOC) values of 0.5 to 5.0 wt. %, whereas the S_2 values (the maximum amounts of hydrocarbon which can be generated if the sediment is submitted to pyrolysis) are too low (0.1 to 1.0 mg HC/g rock) to have potential as source-rock for oil.

Diversity

The diversity of dinoflagellate cyst species as measured by the number of recorded species per sample varies from 9 to 46 (Enclosure 2). The diversity is relatively high (18–30 species) in samples assigned an earliest Barremian age. The highest diversity (more than 40 species) is recorded in samples assigned a latest Barremian to earliest Aptian age. This is followed by a low diversity interval (9–25 species) of late early Aptian to early Albian age. In the middle Albian the diversity increases (30–40 species). Finally in the upper part of the studied succession, assigned a late Albian age, the diversity is again relatively low and stratigraphically uniform (15–25 species; Enclosure 2).

The low diversity interval in sediments assigned a late early Aptian to early Albian age correlates with the low relative sea-level of the same age described by Haq *et al.* (1986). This is in contrast to the relatively low diversity interval of late Albian age (Enclosure 2), which corresponds to a relatively high sea-level (Haq *et al.*, 1986).

Dominant and frequent species

Barremian

Oligosphaeridium? *asterigerum* is common in the lowermost Barremian sediments, whereas *Muderongia australis* dominates a thin zone in the same interval (Enclosure 2). *Pseudoceratium anaphrissum* and *Muderongia* aff. *M. simplex microperforata* are common to very abundant in the higher parts of the lower Barremian. *Pseudoceratium toveae* sp. nov. and *Circulodinium* aff. *C. attadalicum* are common in the upper Barremian, whereas *Cribroperidinium muderongense* is very abundant in a restricted interval in the uppermost Barremian.

Aptian

Circulodinium aff. *C. attadalicum* is very abundant in the lowermost Aptian whereas *Vesperopsis longicornis* and *Chlamydophorella trabeculosa* are common to very abundant in sediments considered to belong to a higher level of the lower Aptian. *Oligosphaeridium complex* is very abundant in the higher parts of the lower Aptian to the lower parts of upper Aptian. *Senoniasphaera microreticulata* is very common in the uppermost Aptian to the lowermost Albian.

Albian

Circulodinium brevispinosum and *Vesperopsis longicornis* are common to abundant in the lower Albian. *Circulodinium* sp. 1 is very abundant in the lowermost parts of the upper Albian. *Rhombodella paucispinosa* and *Subtilisphaera kalaalliti* sp. nov. dominate the assemblages in the middle and the uppermost Albian; *Ovoidinium*? sp. 1 is quite common in the upper part of this interval.

Chlamydophorella trabeculosa, *Oligosphaeridium complex* and *Spiniferites* spp. are common to abundant throughout the major part of the studied sequences. *Odontochitina operculata*, *Palaeoperidinium cretaceum* and *Sentusidinium* sp. 1 are common to abundant in most of the samples tentatively considered to belong to the upper Barremian to upper Albian.

Possible low salinity indicators

Palaeoperidinium cretaceum constitutes 10 to 40% of the dinoflagellate cyst assemblage in the upper Aptian to upper Albian. Abundant *P. cretaceum* may according to Harding (1990a) indicate low-salinity environments. Another possible low-salinity indicator is abundant *Vesperopsis mayi* which constitutes 5 to 25% of the assemblage in the lower and middle Albian. *Vesperopsis mayi* was described from the Western Interior, U.S.A. by Bint (1986), who recorded the species throughout the Kiowa Formation, dated as early late Albian. *Vesperopsis mayi* is most common in the upper part of the Kiowa Formation. According to Scott (1977, fig. 12) this part of the formation was deposited under open sea to shoreface and bay conditions.

The abundance of *P. cretaceum* and *V. mayi* in the lower to middle part of the Albian in East Greenland could therefore indicate restricted marine conditions. However, the corresponding low diversity (approximately 10 species) of the assemblages reported by Harding (1990a) is not found in the East Greenland assemblages.

Provincialism

Published studies of Arctic Canadian and Boreal European dinoflagellate cyst assemblages illustrate that these Lower Cretaceous floras differ slightly. The dinoflagellate cyst assemblages from East Greenland seem to be almost identical to assemblages from offshore Norway and show several similarities with the assemblages previously described from north-west Europe and show several other similarities with Canadian assemblages. However, it is remarkable how some of the assemblage characteristics from East Greenland are comparable with those from Australia and Papua New Guinea in the southern hemisphere.

According to palaeogeographic maps of the Early Cretaceous of the North Atlantic no apparent land barriers existed to have an influence on the mixing of Arctic and Boreal dinoflagellate cyst assemblages. The geographically restricted occurrence of the species may therefore have been controlled by differences in salinity, temperature or current patterns between the regions.

Pseudoceratium anaphrissum, which is an important stratigraphic marker for the lower Barremian black shale facies in north-west Europe, Norway and East Greenland, is apparently absent in Arctic Canada and probably also in Eastern Canada. *Tubotuberella uncinata* (lower Barremian) is only recorded from East Greenland, Arctic Canada and north-west Europe, where it is very rare. *Batioladinium longicornutum*, is common in Hauterivian to Barremian deposits in north-west Europe, Norway and East Greenland but is very rare in Arctic Canada and not reported from Eastern Canada. *Pseudoceratium nudum* (Barremian to lower Aptian), which is common in East Greenland, Norway and Arctic Canada, is very rare in north-west Europe and apparently absent in Eastern Can-

ada. The new species *Pseudoceratium toveae* (Barremian), recorded from East Greenland, offshore Norway and Arctic Canada (unpublished data 1989) has not been reported from north-west Europe, except offshore Norway. However the closely related species *Pseudoceratium weymouthense* Helby, 1987 occurs in the uppermost Late Jurassic and lowermost Early Cretaceous in Australia.

Senoniasphaera microreticulata (upper? Aptian to middle Albian) has not been reported from north-west Europe or from the southern hemisphere, whereas it seems to be a good stratigraphical marker in offshore Norway, Arctic Canada and East Greenland. *Pseudoceratium expolitum* (middle to upper Albian) is also very rare in Europe except offshore Norway, Arctic and Eastern Canada and East Greenland where it is common and stratigraphically useful.

Chichaouadinium vestitum (middle to upper Albian) and *Wigginsiella grandstandica* (lower part of upper Albian) has not been recorded from areas outside North America and East Greenland.

Ovoidinium? sp. 1 has only been recorded from offshore Norway and East Greenland. It is common to very abundant in the uppermost Albian to lowermost Cenomanian.

The combined dominance of *Rhombodella paucispinosa* and *Subtilisphaera kalaalliti* sp. nov. in upper Albian sediments in East Greenland seems to be a local phenomenon.

Dinoflagellate cyst zonation in East Greenland

The composite range chart (Enclosure 2) shows the ranges of species from 74 selected samples from 15 of the studied sections and the zonation based on their distribution.

The age determinations in the present study are almost exclusively based on dinoflagellate cyst ranges described in the present chapter. No other independent dating is available, except from those discussed in the chapter on 'Comparison with previous macrofossil ages'. The ages given should, therefore, be regarded as tentative.

The zonation is based on the ranges and acmes of the stratigraphically important species (Fig. 8, Enclosure 2). Five zones (I–V) are subdivided into 13 subzones (Fig. 7). Every zone and subzone is defined by the two lowest and/or highest occurrences of taxa, and follows the definition for an interval zone proposed in the 'North American Commission on Stratigraphic Nomenclature' (1983). Zones I and V and Subzone I1 are concurrent range zones; Zone II and III and Subzones I2, I3, III2, III4, IV2, IV1, V2 and V3 are interval zones; Zone IV and Subzone III1 and IV1 are partial range zones; Subzones III3 and V4 are taxon range zones. The common to dominant species listed under 'Characteristic species' are those comprising more than ten per cent of the dinoflagellate cyst assemblage. The species listed as very rare to present constitute less than ten per cent of the dinoflagellate cyst assemblage.

The numbers in parentheses following species listed in 'Characteristic species' refer to the species position on the composite range-chart (Enclosure 2). The letters following these numbers are 'F', first occurrence in zone, 'FB', first occurrence at the base and 'FT', a first occurrence at the top of the zone, 'L', last occurrence within the zone, 'LT', last occurrence at the top and 'LB' last occurrence at the base of the zone. Species which are not followed by a parentheses have not been recorded from the sections included in the composite range-charts (Fig. 8, Enclosure 2). Previously published Lower Cretaceous zonations used for comparison are illustrated on Fig. 9.

I. *Batioladinium longicornutum* Zone

Age. Late Hauterivian? to late Barremian.

Definition. *Batioladinium longicornutum* has its last occurrence at the top of the zone. The base of the zone is defined by the first occurrence of *Muderongia australis*.

Subdivision. The *B. longicornutum* Zone is subdivided into three subzones; (1) *Nelchinopsis kostromiensis* Subzone, (2) *Pseudoceratium anaphrissum* Subzone and (3) *Pseudoceratium toveae* Subzone.

Thickness and distribution in East Greenland. The maximum known thickness of the *Batioladinium longicornutum* Zone is 140 m. It is represented in 15 sections situated on Hochstetter Forland, Shannon, Kuhn Ø and Wollaston Forland, in the northern part of the area studied (Fig. 2, Enclosure 1).

I 1. *Nelchinopsis kostromiensis* Subzone

Age. Late Hauterivian? to early Barremian.

Definition. Nelchinopsis kostromiensis has its last occurrence at the top of the subzone. The base of the subzone is defined by the first occurrence of *Muderongia australis* which, according to Århus *et al.* (1990), Helby (1987) and Davey (1988) has a relatively short stratigraphic range from Hauterivian to Barremian in the Barents Sea, and in Australia and Papua New Guinea, respectively. However older exposures of the dark mudstone sequence do not occur on East Greenland. The dark mudstones rest upon the middle to upper Valanginian Rødryggen Member (Surlyk, 1978a).

Characteristic species. The two stratigraphically important species *Muderongia australis* (27, F, L) and *Nelchinopsis kostromiensis* (4, LT) are common to dominant (Fig. 8, Enclosure 2) while *Batioladinium longicornutum* (6), *Gochteodinia villosa multifurcata*, *Gonyaulacysta perforobtusa* (26, F, L), *Hystrichosphaeridium arborispinum* (35, F), *Leptodinium? hyalodermopse* (38, F), *Pseudoceratium anaphrissum* (28, F) and *Tubotuberella uncinata* (44, F, L) are very rare to frequent in the subzone.

Thickness and distribution. The subzone occurs in 26 m of section 10 and 45 m of section 18, and in two samples from the lower part of sections 9 and 21 (Enclosure 1). All four sections are from Kuhn Ø and Wollaston Forland in the northern part of the area studied (Figs 2 & 5).

Geological setting. Sediments belonging in the lower boundary of the *N. kostromiensis* Subzone are not exposed at sections 9 and 18. The dark mudstone sequence of the subzone in sections 10 and 21 rests on the middle to upper Valanginian Rødryggen Member (Surlyk, 1978a).

Lithology. Dark mudstone sequence with scattered yellow calcareous kidney shaped concretions less than 15 cm in diameter.

Discussion. A dinoflagellate cyst assemblage very similar to that of the *N. kostromiensis* Subzone has recently been reported as Hauterivian – lower Barremian from the Barents Sea by Århus *et al.* (1990).

The dominance of the species *Muderongia australis* in the middle part of the subzone may be of stratigraphical importance. A similar acme has been reported from the Hauterivian uppermost part of Rurikfjeldet Member at Spitsbergen and from the Hauterivian – lower Barremian in the Barents Sea by Århus *et al.* (1990). *Muderongia australis* was originally described from Barremian deposits in Australia by Helby (1987) and later recorded from the lowermost Hauterivian to the 'middle' Barremian in Papua New Guinea by Davey (1988).

Duxbury (1977; 1980) and Riley & Fenton (1984) recorded the last occurrence for the subzone index species *N. kostromiensis* in the *variabilis* ammonite zone. The Hauterivian–Barremian boundary was at that time placed above the *variabilis* Zone by Rawson *et al.* 1978. Following Kemper *et al.* (1981) the boundary is now placed below the *variabilis* Zone. Heilmann-Clausen

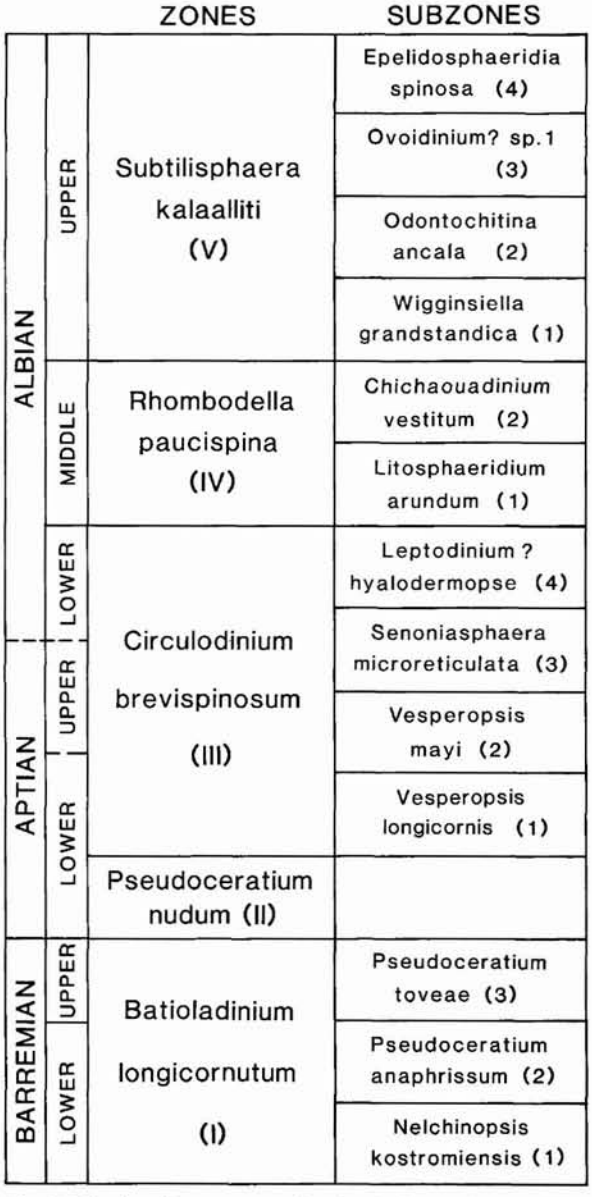
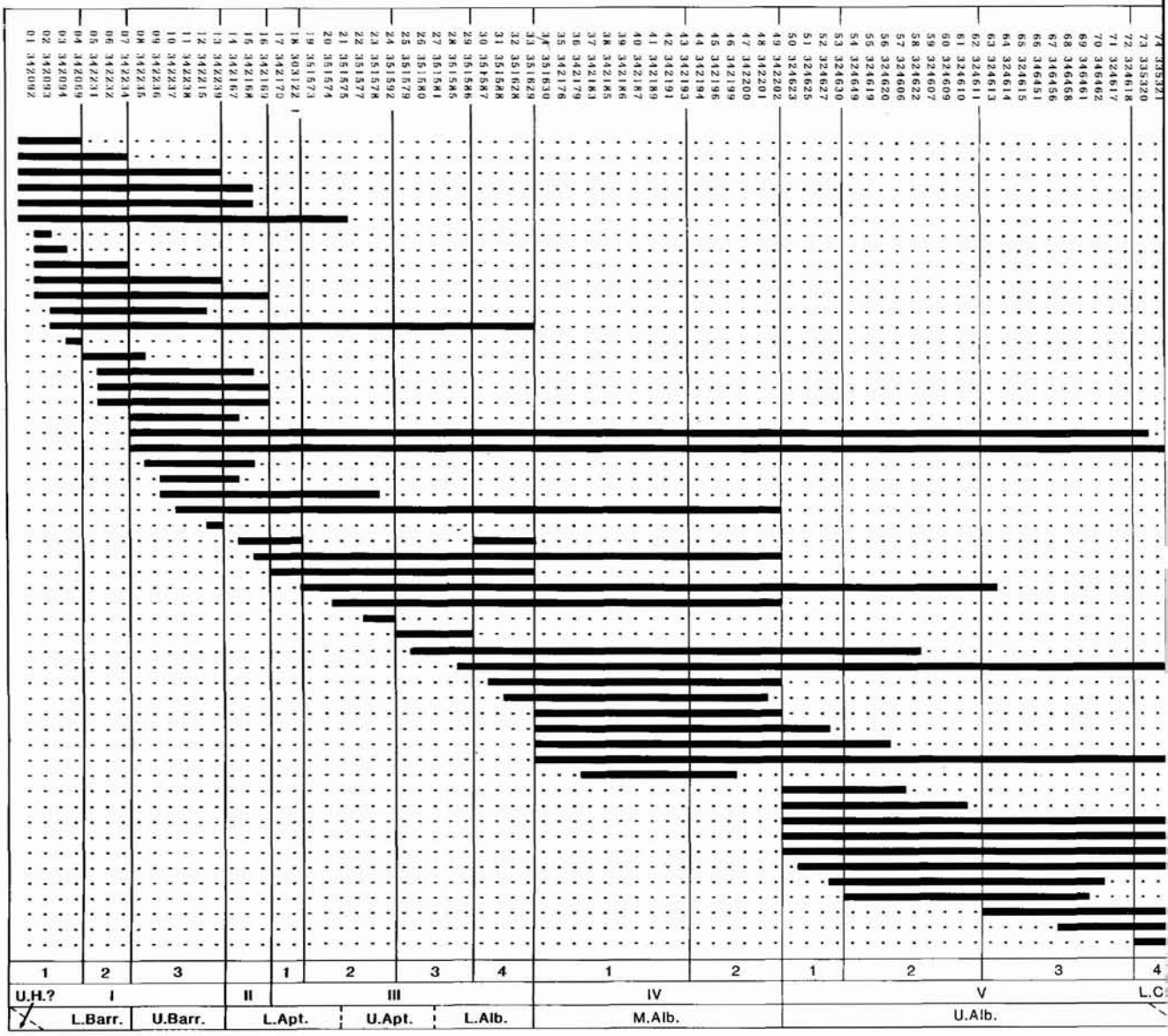


Fig. 7. Dinoflagellate cyst zonation for the Barremian to Albian in East Greenland (72°–76°N).



(1987) and Harding (1990b) report the species as ranging from upper Hauterivian to lower Barremian in north-west Europe and Germany. Århus *et al.* (1990) report the species from the Hauterivian to lower Barremian interval in the Barents Sea. Ofstad (1983) reports this species from Valanginian and upper Hauterivian to lower Barremian offshore southern Norway. McIntyre & Brideaux (1980) recorded *N. kostromiensis* from the middle Valanginian in the District of Mackenzie, Canada, and Wiggins (1972) recorded the species from the upper Valanginian to lower Hauterivian in Alaska.

The few specimens of *Gochteodinia villosa multifurcata* in this subzone in East Greenland may be reworked. This species has previously been reported from lower Hauterivian, as *Pareodinia dasyforma*, by Duxbury (1977) whereas Thusu (1978) recorded the species as *G. villosa* from the Barremian of Arctic Norway. The species was originally recorded from the upper Ryazanian to Valanginian in Denmark by Davey (1982b).

The presence of *Gonyaulacysta perforobtusa* might indicate a Hauterivian age. Duxbury (1977) reported it from the lower to upper Hauterivian (Speeton Clay lithounits D2A to C6) whereas Heilmann-Clausen (1987) indicated a lower Barremian occurrence of the species.

Tubotuberella uncinata has only been reported from the Hauterivian and Barremian from the District of Mack-

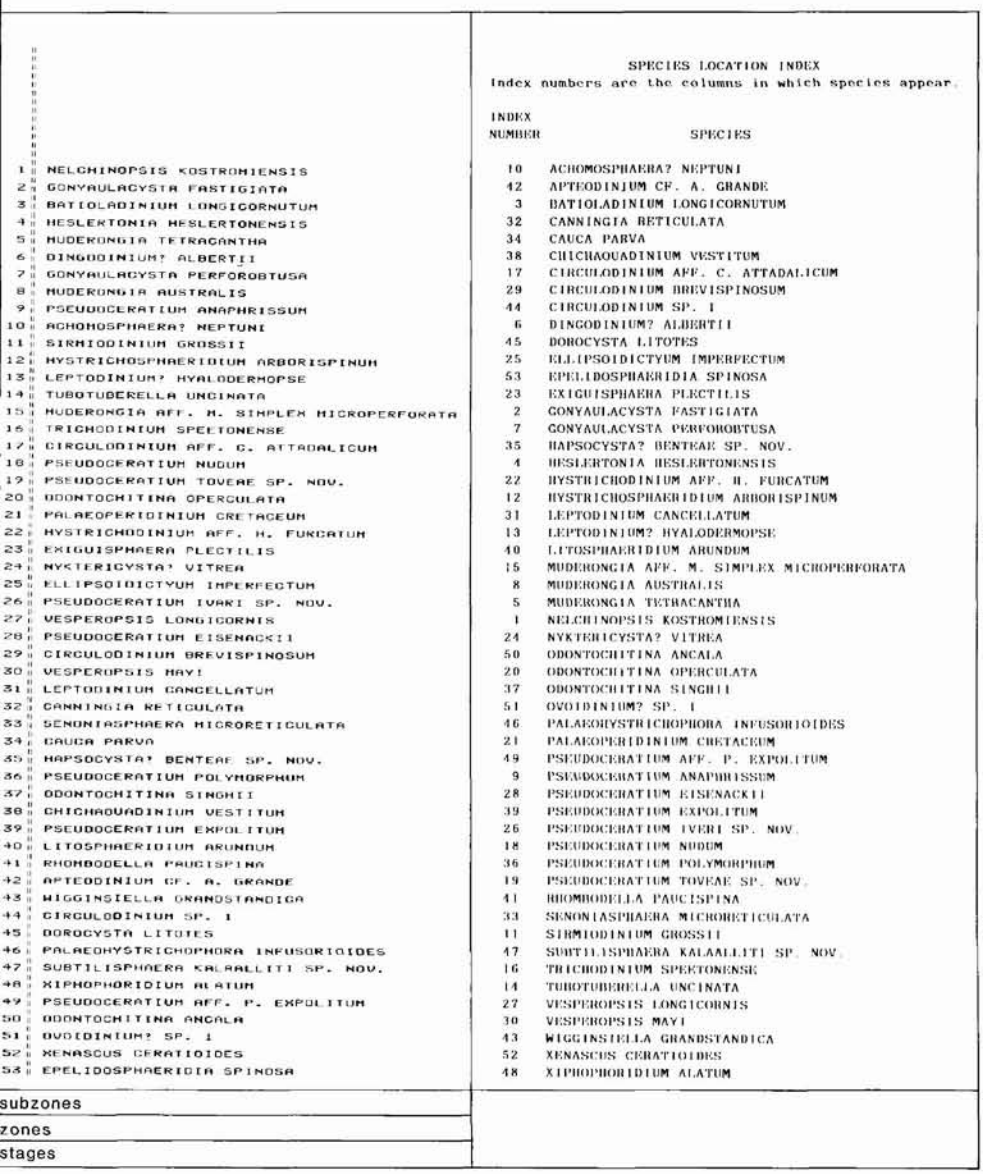


Fig. 8. The total stratigraphical range of 53 age diagnostic dinoflagellate cyst species selected from the composite range chart (Enclosure 2).

enzie, Canada by Brideaux (1977). However, one specimen has recently been recovered from a core including the lower to upper Barremian boundary at the Ahlum-1 well from the Lower Saxony Basin in Northwest Germany (Heilmann-Clausen, personal communication, 1990).

The lowermost occurrences of *Pseudoceratium anaphrissum* and *Hystrichsphaeridium arborispinum* are elsewhere indicative of higher levels of the lower Barremian where they are often abundant. An overlap in the ranges of *N. kostromiensis* and *P. anaphrissum* has only been reported from the Barents Sea (Århus *et al.*, 1990).

The assemblages from the *N. kostromiensis* Subzone contain species characteristic of both the Hauterivian and the lower Barremian. The proposal by Århus *et al.* (1990) that the acme of *M. australis* could be related to an early Barremian transgression would make it a useful lower Barremian marker. In that case the lowermost sample in section 10 could be of Hauterivian age, whereas the two upper samples from that section might be of early Barremian age.

The *M. australis* acme unfortunately seems to be restricted to a very narrow interval in the Arctic which can easily be missed and is recorded only in section 10 from East Greenland.

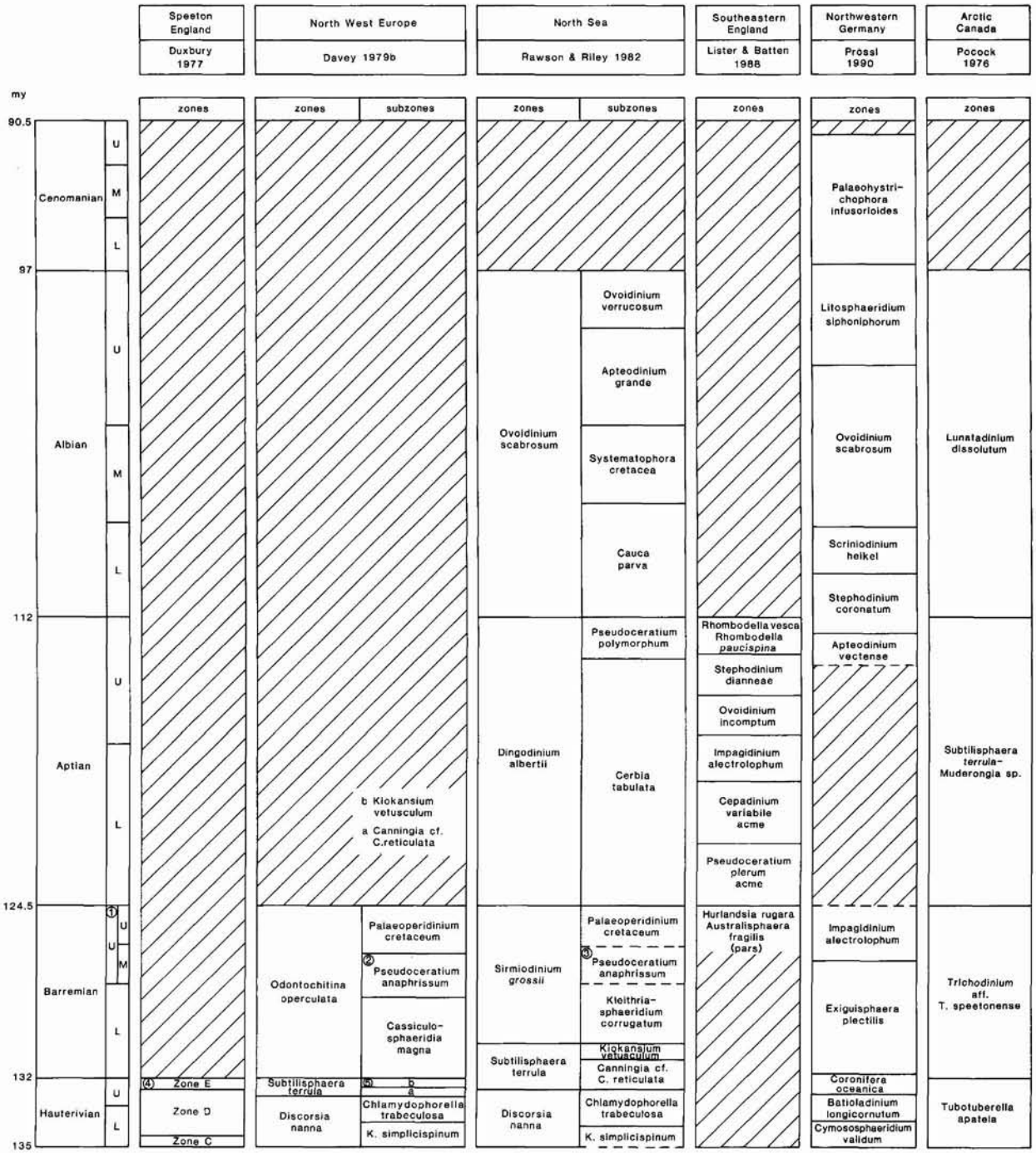
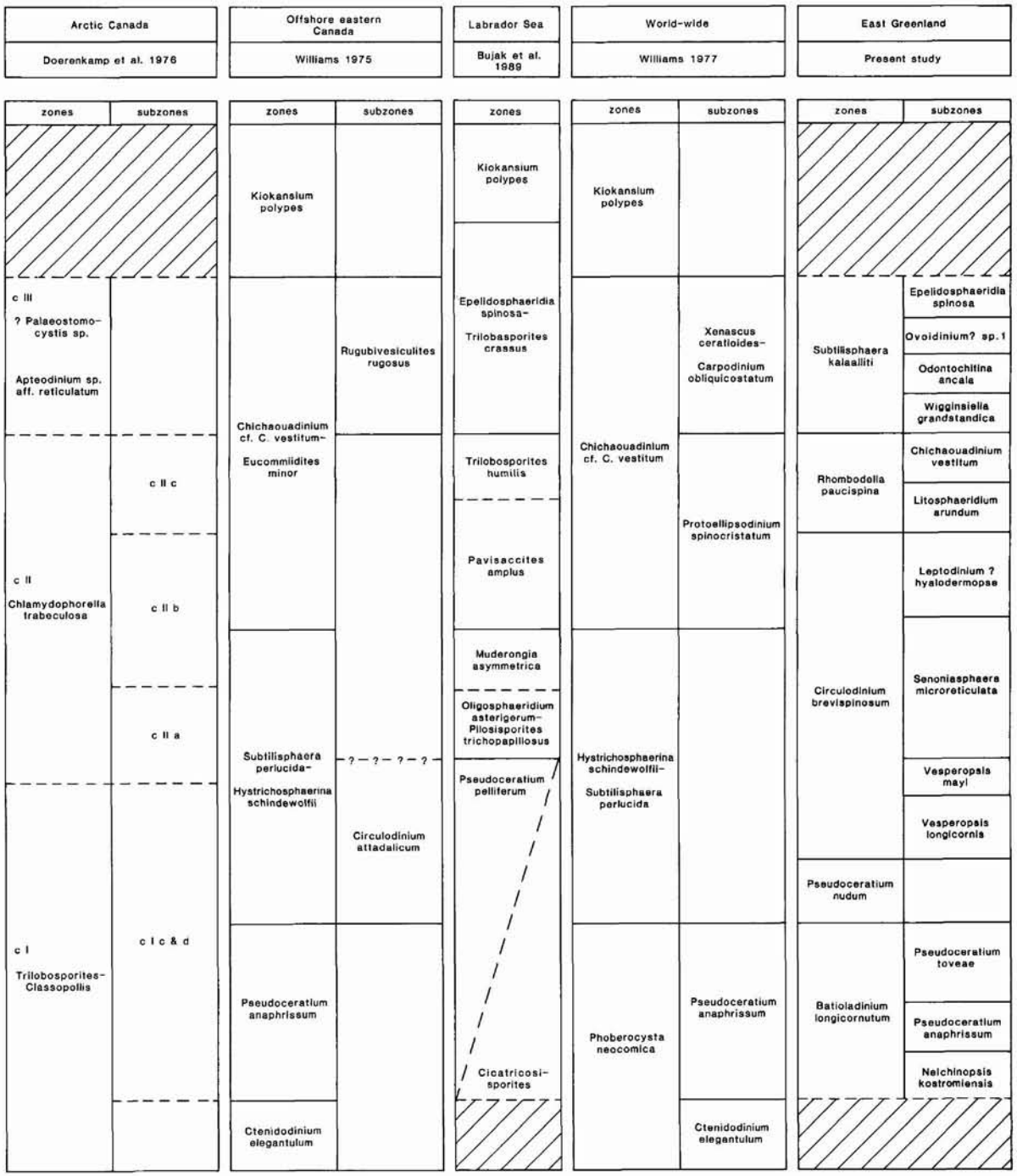


Fig. 9. Comparison of the proposed dinoflagellate cyst zonation from East Greenland and previously established zonations from Europe, Canada and the world. Geological time scale after Harland *et al.* (1990). 1. The 'middle Barremian' typified by the Cement Beds at the Speeton section in England has, according to Rawson & Mutterlose (1983), Mutterlose (1983, 1984), Mutterlose & Harding (1987b) and Harding (1990b) been included in the upper Barremian. 2. and 3. upper lower Barremian according to Duxbury



(1980, p. 137), Harding (1990, pp. 50–51) and Prössl (1990, abb. 4). 4. and 5. Duxbury's (1977) Zone E and Davey's (1979b) *Kiokansium vetusculum* Zone represent the beds C1 and LB6 at Speeton, England. These beds belongs according to Rawson *et al.* (1978) to the uppermost Hauterivian *variabilis* Zone whereas Kemper *et al.* (1981) placed the Hauterivian–Barremian stage boundary, below the *variabilis* Zone.

Comparison with other zones. The *N. kostromiensis* Subzone differs from the zones established by Duxbury (1977), Davey (1979b), Prössl (1990), Pocock (1976) and Williams (1975) for the Hauterivian – lower Barremian (Fig. 9). The most pronounced difference is the overlap of the species *N. kostromiensis* and *P. anaphrissum* in samples from East Greenland and the dominance of *M. australis*. *Muderongia australis* has been reported from north-west Germany by Prössl (1990), where it has its last occurrence in the lower Hauterivian to the middle upper Hauterivian *Cymososphaeridium validum* Zone (Prössl, 1990). The species *Canningia* cf. *C. reticulata* (Davey, 1979b) and *Cassiculosphaeridia magna*, which are common in the upper Hauterivian – lower Barremian *C. magna* Subzone in north-west Europe (Davey, 1979b), are rare or absent in the *N. kostromiensis* Subzone.

I 2. *Pseudoceratium anaphrissum* Subzone

Age. Early Barremian.

Definition. Interval from above the uppermost occurrence of *Nelchinopsis kostromiensis* to the uppermost occurrence of *Pseudoceratium anaphrissum*.

Acmes of the two species *P. anaphrissum* and *Hystrichosphaeridium arborispinum* occur in this interval immediately above the uppermost occurrence of *N. kostromiensis*.

Characteristic species. The three stratigraphically important species *Hystrichosphaeridium arborispinum* (35), *Muderongia* aff. *M. simplex microperforata* (49, F) and *Pseudoceratium anaphrissum* (28, LT) are common to dominant (Fig. 8, Enclosure 2) while *Batioladinium jaegeri* (67, F), *B. longicornutum* (6), *Cassiculosphaeridia magna*, *Gochteodinia villosa multifurcata*, *Gonyaulacysta fastigiata* (3, LT), *Hystrichosphaerina schindewolfii* (73, F), *Hystrichodinium* aff. *H. furcatum* (72, F), *Pseudoceratium nudum* (54, F) and *Trichodinium speetonense* (52, F) are very rare to frequent in the subzone.

Thickness and distribution. The thickness of the subzone is 30–80 m. It constitutes 30 m at section 21 where the entire subzone is exposed. Part of the subzone is present in sections 4, 9, 11, 15, 16 and 18, all from the northern part of the area on Shannon, Kuhn Ø and Wollaston Forland (Figs 2, 5, Enclosure 1).

Geological setting. Sediments belonging in the lower boundary of the *P. anaprissum* Subzone are exposed in sections 9, 18 and 21 where they rest on sediments of the *N. kostromiensis* Subzone. The lower boundary of the *P. anaphrissum* Subzone is not exposed in sections 4, 11, 15 and 17. In section 17 sediments of the *P. anaphrissum* Subzone rest unconformably on the Jurassic Bernberg Formation, an organic rich black mudstone sequence (Surlyk, 1977a).

Lithology. Dark mudstone sequence with scattered yellow to orange calcareous kidney shaped concretions up to 15 cm in diameter.

Discussion. According to Sarjeant (1966b), Davey (1974, 1979b), Duxbury (1980) and Heilmann-Clausen (1987) *Pseudoceratium anaphrissum* is a good marker for 'middle' Barremian in north-west Europe. Mutterlose & Harding (1987b) and Harding (1990b) reported the species only from lower Barremian in North Germany and England. The species has also been reported from the Barremian of Arctic Norway by Thusu (1978), Aarhus *et al.* (1986) and Århus *et al.* (1990).

Århus *et al.* (1990, p. 174) reported that "since *P. anaphrissum* often has an acme occurrence in the lowermost part of its range (e.g. in the commercial Tromsøyflaket wells) this may be the best practical palynological criterion for distinguishing Hauterivian and Barremian strata, although the acme occurrence is probably situated in the 'middle' Barremain *H. rude-fissicostatum* ammonite Zone according to the literature".

The picture differs in East Greenland where *P. anaphrissum* occurs in low numbers in the lower part of its range together with *Nelchinopsis kostromienses* and *Muderongia australis* and the acme of *P. anaphrissum* occurs in the upper part of its range immediately above the last occurrence of *N. kostromiensis*. Several observations indicate that the lowermost occurrence of *P. anaphrissum* is diachronous between East Greenland and the Barents Sea; i.e. the species was present in East Greenland before its appearance in the Barents Sea. This is supported by the observation that *P. anaphrissum* first occurs above the last occurrence of *Muderongia australis* in the Barents Sea, whereas the two species occur together in East Greenland. The species *M.* cf. *M. asymmetrica* (Århus *et al.*, 1990) looks very similar to the species described here as *M.* aff. *M. simplex microperforata*. Both species have their first occurrence in the lowermost part of the *P. anaphrissum* acme in the Barents Sea and in East Greenland it is therefore suggested that the acme of *P. anaphrissum* in the middle-upper part of its range in East Greenland is the same acme as the one observed in the lowermost part of the range in the Barents Sea.

Muderongia simplex microperforata mainly occurs in the Ryazanian–Valanginian (Davey, 1982b; Heilmann-Clausen, 1987), although the species has also been recorded from the Hauterivian (Davey, 1982b; Harding,

1986). The illustrations of latest Hauterivian *M. simplex microperforata* specimens (Harding, 1986, plate 17, figs 3, 5, 8) indicate similarities with the Greenland material. Harding also notes that Davey has recorded the subspecies from the lower Barremian offshore Holland (R. J. Davey, personal communication in Harding, 1986, p. 107), which agrees with the present observation.

The upper Hauterivian – lower Barremian *Muderongia* sp. reported from Libya (Uwins & Batten, 1988, plate 34, figs 18, 19) also resembles *M.* aff. *M. simplex microperforata* from East Greenland.

The species *Gonyaulacysta fastigiata* has its last occurrence in the 'middle' Barremian at Speeton (Duxbury, 1980) and in the lower Barremian of offshore South Norway (Aarhus *et al.*, 1986). This is in agreement with the present observations.

Comparison with other zones. The top of the *P. anaphrissum* Subzone, here erected for East Greenland, seems to be similar to the top of the *P. anaphrissum* Subzone (Fig. 9) erected by Davey (1979b) for north-west Europe. The tops of both subzones are defined by the uppermost occurrence of *P. anaphrissum* and occur immediately below the lowermost occurrence of *Palaeoperidinium cretaceum*. However, the base of Davey's (1979b) subzone differs slightly by being defined by the first occurrence of *P. anaphrissum.*

The *Exiguisphaera plectilis* Zone erected by Prössl (1990) for north-west Germany differs from the present subzone by having the first and last occurrence of *P. anaphrissum* (as *Aptea anaphrissa*) within the zone and by being defined by the total range of *E. plectilis*.

The *P. anaphrissum* Subzone occurs in the interval covering the upper part of the lower Barremian and differs in that way from the lower to the middle part of the upper Barremian *E. plectilis* Zone (Prössl, 1990). The *Trichodinium* aff. *T. speetonense* Zone of Arctic Canada (Pocock, 1976), the *P. anaphrissum* Peak Zone of Eastern Canada and the world-wide *P. anaphrissum* Subzone (Williams, 1975; 1977) all cover the entire Barremian and differ in that way from the present *P. anaphrissum* Subzone.

I 3. *Pseudoceratium toveae* Subzone

Age. Late Barremian.

Definition. The interval from immediately above the last occurrence of *Pseudoceratium anaphrissum* to the last occurrence of *Batioladinium longicornutum*. The interval contains the acme of the species *Pseudoceratium toveae* sp. nov.

Characteristic species. The four stratigraphically important species *Hystrichosphaeridium arborispinum* (35, L), *Odontochitina operculata* (70, F), *Pseudoceratium toveae* sp. nov. (68, FB) and *Pseudoceratium nudum* (54) are common to dominant in the *Pseudoceratium anaphrissum* Subzone (Fig. 8, Enclosure 2) while *Acomosphaera? neptuni* (29, LT), *Batioladinium longicornutum* (6, LT), *Desmocysta plekta* (86, F), *Ellipsoidictyum imperfectum* (81, F), *Exiguisphaera plectilis* (77, F), *Hystrichodinium* aff. *H. furcatum* (72, F), *Hystrichodinium ramoides*, *Hystrichosphaeridium arborispinum* (35, L), *Atopodinium haromense* (76, F), *Nyktericysta? vitrea* (78, F), *Palaeoperidinium cretaceum* (71, FB) and *Pseudoceratium iveri* sp. nov. (85, FT, LT) are very rare to frequent in the subzone.

Thickness and distribution. The subzone is up to 65 m thick in sections 7, 14, 17 and 21 and up to 30 m of thick in sections 1, 6, 8, 15, 16 and 19. All ten sections are from the northern part of the area: Haystack, Kuhn Ø and Wollaston Forland (Figs 2, 5, Enclosure 1).

Geological setting. Sediments belonging in the lower boundary of the *P. toveae* Subzone are exposed only in sections 15, 16 and 21 where they rest upon sediments of the *Pseudoceratium anaphrissum* Subzone. The lower boundary of the *P. toveae* Subzone is not exposed in sections 1, 6, 7, 8 and 17. Strata of the subzone rest unconformably on the uppermost Ryazanian – Valanginian Young Sund Member (Surlyk, 1978a) in section 14 and rest unconformably on the uppermost Ryazanian – Valanginian Albrechts Bugt Member (Surlyk, 1978a) in section 19.

Lithology. The subzone consist of a dark mudstone sequence with scattered yellow, eroded, calcareous, kidney shaped concretions. The lower part of the subzone contains scattered, 5–20 cm thick, calcareous bands.

Discussion. Pseudoceratium toveae sp. nov. has previously been recorded (as *P. gochtii*) from the Barremian in northern Canada (Brideaux, 1976, 1977). For further discussion on the relationship of *P. toveae* sp. nov. to *P. gochtii* see the systematic chapter.

Palaeoperidinium cretaceum has its first occurrence in the 'middle' Barremian at Speeton, England (Davey, 1979b; Duxbury, 1980). *Batioladinium longicornutum*, according to Davey (1979b), has its last occurrence in the top of the 'middle' Barremian. Duxbury (1980) reports the species from lowermost upper Barremian at Speeton. The species has never been recorded from the uppermost Barremian in accurately dated sediments in England whereas according to Harding (1990b) and Prössl (1990)

it has a last occurrence very close to the top of the upper Barremian in Germany. Heilmann-Clausen (1987, fig. 4)) regards *B. longicornutum* as a reliable top Barremian marker. The last occurrence of *Hystrichosphaerindium arborispinum* and *H. ramoides* supports the interpretation of Heilmann-Clausen (1987) that the subzone interval is of Late Barremian age.

Atopodinium haromense has its first occurrence in East Greenland in the *P. toveae* Subzone where it seems to be a good marker. The species was originally described (as *Maduradinium* sp. A) from Turonian to lower Maastrichtian offshore south-west Africa by Davey (1978). Davey (1982a) has also reported the species from the upper Aptian to the lower Albian in north-west Germany. Later the species was recorded from the upper Ryazanian to the upper Barremian in the North Sea well Adda-1 and from Ryazanian to Aptian in the North Sea well I-1, by Heilmann-Clausen (1987). Lister & Batten (1988) reported the species from the lower to upper Aptian deposits in south-east England. In 1988 the species was formally described from the upper Oxfordian to the lower Kimmeridgian (Jurassic) in England by Thomas & Cox (1988).

Nyktericysta? vitrea has its first occurrence in the upper Barremian in East Greenland which is earlier than the record of the species from the lower Aptian in south-east England by Duxbury (1983) and Lister & Batten (1988). Lister & Batten (1988) divided Duxbury's (1983) *Nyktericysta? vitrea* species into the two species, *N.? vitrea* and *Australisphaera pseudovitrea*. They recorded *A. pseudovitrea* from the upper Barremian in southern England, whereas they only recorded *N.? vitrea* from the lower Aptian. Both forms occur together in the upper Barremian and in the lower Aptian in East Greenland where the two species seem to grade into each other and no attempt is made to follow the taxonomic changes of Lister & Batten (1988).

The new species *Pseudoceratium iveri* has its first and last occurrence in the uppermost part of the *P. toveae* Subzone where it is a good marker species. It has not been recorded above the last occurrence of *Batioladinium longicornutum.*

Comparison with other upper Barremian zones. The *P. toveae* Subzone resembles the *Palaeoperidinium cretaceum* Subzone (Fig. 9) established for the upper Barremian in eastern England by Davey (1979b).

The major differences between the two subzones are the presence of *Pseudoceratium toveae* sp. nov., only in Greenland, and *B. longicornutum* which ranges to the top of the interval in Greenland but not in England.

The *Hurlandsia rugarum – Australisphaera fragilis* (pars) Zone established for the low salinity environment deposits of the upper Barremian in southern England by Lister & Batten (1988) cannot be correlated entirely to the *P. toveae* Subzone. The two species *P. cretaceum* and *A. pseudovitrea* have their first occurrence in both the *P. toveae* Subzone and in the *H. rugarum – A. fragilis* (pars) Zone. *Batioladinium longicornutum* has not been recorded from the interval in southern England. *Pseudoceratium toveae* sp. nov. might be present in England, as *P. pelliferum* with rather long horns (Lister & Batten, 1988, plate 2, fig. 4). The precise stratigraphic position of their specimen in the *H. rugarum – A. fragilis* (pars) Zone was not specified. The upper part of the *P. toveae* Subzone may be correlated with the upper part of the *Impagidinium alectrolophum* Zone (Fig. 9) erected by Prössl (1990) for the uppermost Barremian in north-west Germany, based on the dominance and extinction of *Hystrichosphaeridium arborispinum* in both zones and on the extinction of *Batioladinium longicornutum* at the top of both zones.

II. *Pseudoceratium nudum* Zone

Age. Earliest Aptian.

Definition. Interval from immediately above the last occurrence of *Batioladinium longicornutum* to the last occurrence of *Psedouceratium nudum.* The zone is not subdivided into subzones.

Characteristic species. The stratigraphically important species *Circulodinium* aff. *C. attadalicum* (53, LT) is common to dominant (Fig. 8, Enclosure 2) while *Exiguisphaera plectilis* (77, L), *Heslertonia heslertonensis* (11, L), *Hystrichodinium* aff. *H. furcatum* (72, L), *Atopodinium haromense* (76, L), *Muderongia tetracantha* (8, L), *Nyktericysta? vitrea* (78), *Pseudoceratium pelliferum* (5, L), *P. nudum* (54, LT), *P.* cf. *P. retusum* (88, F), *Subtilisphaera perlucida* (65), *Trichodinium speetonense* (52, L) and *Vesperopsis longicornis* (89, F) are very rare to frequent in the zone.

Thickness and distribution. The *Pseudoceratium nudum* Zone (or part of the zone) is present in sections 6, 7, 17, 19 and 33 from Kuhn Ø, Wollaston Forland and Traill Ø. The maximum thickness of the zone, 20 m, is in section 17 (Figs 2, 5, Enclosure 1).

Geological setting. Sediments of the lower boundary of the zone are present in sections 6, 7 and 17 where they rest on dark mudstone of the *Pseudoceratium toveae* Subzone.

Lithology. In section 17, the sample GGU 324167 from

the lowermost part of the *P. nudum* Zone is a dark mudstone overlain by a 0.1 to 0.5 m thick calcareous horizon. The calcareous layer (sample GGU 324268) forms a plateau, with eroded calcareous nodules (0.2–0.5 m), to the east of the section. Sample GGU 324269 is from a dark sandy mudstone at the top of the zone.

Discussion. Pseudoceratium nudum has previously been reported from the upper Hauterivian in Europe (Gocht, 1957) and from the Hauterivian to Barremian in the District of Mackenzie, Canada (Brideaux, 1977). It was not reported from the lower Aptian in France and England (Davey & Verdier, 1974; Duxbury, 1983; Lister & Batten, 1988).

Circulodinium aff. *C. attadalicum* is abundant and has its last occurrence at the top of the *P. nudum* Zone. *Circulodinium attadalicum* was previously reported from the Aptian stratotype in south-east France (Williams, 1977) and from the Hauterivian to the lower Aptian offshore eastern Canada (Williams, 1975). *Circulodinium attadalicum* is also abundant in the lower Aptian offshore eastern Canada which, according to Williams (1975), is indicative of marine transgression.

Aarhus *et al.* (1986) reported *Canninginopsis* cf. *C. colliveri* to be common, together with the first occurrence of *Muderongia asymmetrica*, in an Aptian assemblage from Andøya, Norway. *Circulodinium* cf. *C. colliveri* of Aarhus *et al.* (1986) is similar in size and shape to *Circulodinium* aff. *C. attadalicum* of this study and their *M. asymmetrica* looks very similar to *Vesperopsis longicornis* (Batten & Lister, 1988) Harding, 1990. The assemblage from Andøya occurs above the last occurrence of *Muderongia tetracantha* and may probably be correlated with the upper part of the *P. nudum* Zone of East Greenland.

In north-west Europe *Exiguisphaera plectilis* and *Heslertonia heslertonensis* have their last occurrences in the lower Aptian (Heilmann-Clausen, 1987) which correlate with their extinctions in the *P. nudum* Zone. *Pseudoceratium retusum* was originally reported from the Barremian and Aptian in Canada (Brideaux, 1977), whereas Lister & Batten (1988) only reported this species from the lower Aptian, which corresponds with the present observation of the occurrence of *P.* cf. *P. retusum* in East Greenland.

In Europe *Muderongia tetracantha* has only been reported above the upper Barremian from Germany by Below (1982b) but he did not illustrate the forms recorded from the upper Aptian. Outside Europe the species has been reported from Neocomian to Aptian in Canada (Brideaux & McIntyre, 1975; Poocock, 1976) and from Neocomian to lower Albian in Australia (Cookson & Eisenack, 1958; Morgan, 1980; Helby *et al.*, 1987). Davey recorded the species (as *M. tetracantha sensu* Morgan 1980) from the upper Aptian and lower Albian in Papua New Guinea. *Muderongia tetracantha* seems to range into the lower Aptian in East Greenland where is has its last occurrence in the *P. nudum* Zone. *Vesperopsis longicornis* has its first occurrence in the top of the zone immediately above the last occurrence of *M. tetracantha.*

The calcareous layer in the middle part of the zone might represent the 'medium condensed section' described from the lower Aptian by Haq *et al.* (1987). The present study shows no significant change in the dinoflagellate cyst assemblage of the zone except for *M. tetracantha* that occurs below and in the calcareous limestone and the incoming of *Vesperopsis longicornis* above the calcareous layer.

Comparison with other lower Aptian zones. The *P. nudum* Zone may be correlated with the lowermost Aptian *Aptea plera* acme Zone (now *Pseudoceratium plerum* acme Zone, Fig. 9) from southern England (Lister & Batten, 1988) on the basis of the first occurrence of *P. retusum*, the last occurrence of *Heslertonia heslertonensis* and the presence of *Nyktericysta? vitrea* in both zones. The *P. nudum* Zone shows some similarities with the lower part of Pocock's (1976) *Subtilisphaera terrula – Muderongia* sp. Zone but a more precise correlation is not possible. The lower Aptian *Circulodinium attadalicum* Subzone, established by Williams (1975) for offshore eastern Canada, corresponds to the *P. nudum* Zone. *Circulodinium* aff. *C. attadalicum* is abundant and has its last occurrence in the present zone, and *C. attadalicum* is abundant and becomes extinct in the Canadian subzone. Williams (1975) also reports *Pseudoceratium anaphrissum* from the *C. attadalicum* Subzone but the illustration (Williams, plate 7, fig. 9) suggests that it may be *Pseudoceratium retusum* which has its first occurrence in the *P. nudum* Zone.

III. *Circulodinium brevispinosum* Zone

Age. Early Aptian to early Albian?

Definition. Interval from immediately above the uppermost occurrence of *Pseudoceratium nudum* to the uppermost occurrence of *Circulodinium brevispinosum.*

Subdivision. The *Circulodinium brevispinosum* Zone is subdivided into the four subzones: (1) *Vesperopsis longicornis* Subzone, (2) *Vesperopsis mayi* Subzone, (3) *Senoniasphaera microreticulata* Subzone and (4) *Leptodinium? hyalodermopse* Subzone (Fig. 7).

Thickness and distribution in East Greenland. The maximum thickness of the zone is 330 m. It is represented in 9 sections situated on Hochstetter Forland, Shannon, Wollaston Forland, Hold with Hope and Traill Ø (Figs 2, 5, Enclosure 1).

III 1. *Vesperopsis longicornis* Subzone

Age. 'Late' early Aptian.

Definition. Interval from immediately above the uppermost occurrence of *Pseudoceratium nudum* to immediately below the local lowermost occurrence of *Vesperopsis mayi.*

Characteristic species. The important stratigraphical species *Vesperopsis longicornis* (89, LT1) is common to dominant (Fig. 8, Enclosure 2) while *Circulodinium brevispinosum* (95, FB), *Dingodinium*? *albertii* (9), *Nyktericysta*? *vitrea* (78), *Ovoidinium cinctum* (94, FB; L) and *Pseudoceratium* cf. *P. retusum* (88) are very rare to frequent in the subzone.

Thickness and distribution. The *Vesperopsis longicornis* Subzone is represented by 18 m of sediment in section 32 and by single samples in sections 3 and 17. The three sections are from Shannon, Wollaston Forland and Traill Ø (Figs 2, 5, Enclosure 1).

Geological setting. Sediments containing the subzone rest upon dark sandy mudstone sediments containing the *P. nudum* Subzone at sections 17 and 37.

Lithology. Dark sandy mudstone, often with 2–20 cm thick sandy layers.

Discussion. The *Vesporopsis longicornis* Subzone is characterised by the abundance of *Vesperopsis longicornis* and the first occurrence of *Circulodinium brevispinosum. Circulodinium brevispinosum* was originally described by Pocock (1962) from the Garbutt Formation in western Canada considered by him to be Barremian to Aptian. Brideaux (1977, p. 16) discussed the age of the Garbutt Formation and assigned it to the lower and middle Albian and possibly Aptian. Brideaux & McIntyre (1975) reported the species as *Tenua* sp. A. from Aptian to middle Albian in the District of Mackenzie, Canada. Brideaux (1977) recorded the species in Aptian and Albian sediments from the same area.

Brideaux (1977, p. 16) also mentioned that one specimen of *C. attadalicum*, figured by Williams (1975, plate 2, fig. 3) from the Aptian of offshore eastern Canada, is *C. brevispinosum*. The distinction between *C. attadalicum* and *C. brevispinosum* is mainly based on ornamentation (see chapter on systematics).

Circulodinium aff. *C. attadalicum* is quite abundant in the upper part of its range in East Greenland and does not occur above the last occurrence of *P. nudum. Circulodinium brevispinosum* is not very abundant in the lower part of its range and has not been recorded together with *P. nudum.* In Arctic Norway, the first occurrence of *C. brevispinosum* has been reported from the Aptian (Thusu, 1978). In spite of the different opinions on the two species and their apparent grading into each other it is generally agreed that *C. brevispinosum* has its first occurrence in the lower Aptian.

The first occurrence of *Ovoidinium cinctum* in the *Vesperopsis longicornis* Subzone correlates with other lower to upper Aptian records of this species by Cookson & Eisenack (1958) and Lister & Batten (1988) whereas Helby *et al.* (1987) recorded the species from the upper Barremian to the lower Aptian in their Australian zonation.

Comparison with other lower Aptian zones. The *V. longicornis* Subzone may be correlated with the upper part of the lower Aptian *Aptea plera* acme Zone and the lower part of the *Cepadinium variabile* acme Zone (Fig. 9) from southern England (Lister & Batten, 1988) on the basis of the presence of *Dingodinium*? *albertii, Nyktericysta*? *vitrea* and the absence of *Heslertonia heslertonensis* in both intervals. *Ovoidinium cinctum*, present in this subzone, first occurs in England in the younger early Aptian – late Aptian *Impagidinium alectrolophum* Zone (Lister & Batten, 1988).

The *Vesperopsis longicornis* Subzone can be correlated with the part of the Aptian *Subtilisphaera perlucida – Systematophora schindewolfii* Zone (Williams, 1975) that is situated immediately above the *Circulodinium attadalicum* Subzone (Williams, 1975) (see also the discussion of the *P. nudum* Subzone above).

III 2. *Vesperopsis mayi* Subzone

Age. Latest early Aptian – early late Aptian?

Definition. Interval from the lowermost occurrence of *Vesperopsis mayi* to immediately below the lowermost occurrence of *Senoniasphaera microreticulata.*

Characteristic species. The two stratigraphically important species *Canningia reticulata* (103, F, LT) and *Odontochitina operculata* (70) are common to dominant (Fig. 8, Enclosure 2) while *Carpodinium granulatum* (102, F),

Circulodinium brevispinosum (95), *Dingodinium*? *albertii* (9, L), *Leptodinium cancellatum* (101, F), *Nyktericysta*? *vitrea* (78, L) and *Vesperopsis mayi* (98, FB) are very rare to frequent in the subzone.

Thickness and distribution. The subzone is represented by 85 m in section 12 and approximately 100 m in section 13, both from the northern part of Wollaston Forland (Figs 2, 5, Enclosure 1).

Geological setting. Sediments of the subzone rest at section 13 on the Bernbjerg Formation (Surlyk, 1977a), a Jurassic black mudstone sequence.

Lithology. The subzone is represented by a dark sandy mudstone sequence with occasional 2–20 cm thick sandy layers.

Discussion. *Vesperopsis mayi* has previously been reported from the Albian in the Western Interior, USA (Bint, 1986) and the very similar species *Muderongia asymmetrica* (see the discussion *V. mayi* in the systematic chapter) has been reported from the Aptian, Arctic Norway (Thusu, 1978; Aarhus *et al.*, 1986). Duxbury (1983) recorded *M. asymmetrica* from the lowermost part of the Aptian in south-east England. *M. asymmetrica* has also been reported from the Aptian to lower Albian, Arctic Canada (Brideaux, 1977). The first occurrence of *V. mayi* in the upper part of the lower Aptian in East Greenland correlates reasonably well with previous observations.

Leptodinium cancellatum was originally described from the middle Albian from Canada (Brideaux & McIntyre, 1975) but the first occurrence in the lower to upper Aptian of East Greenland agrees with the upper Aptian first occurrence reported from north-west Germany (Davey, 1982a).

Canningia reticulata has only been recorded from the upper part of the *V. mayi* Subzone. The specimens from East Greenland are almost identical to the specimens of *Canningia reticulata* which Below (1981) reported to be abundant in upper Barremian, upper Aptian and lower Albian deposits from Morocco.

The presence of *Carpodinium granulatum* may indicate upper Aptian (Prössl, 1990). The presence of *Nyktericysta*? *vitrea* indicates lower Aptian (Duxbury, 1983; Lister & Batten, 1988). As discussed above, the *Vesperopsis mayi* Subzone may cover part of the lower Aptian as well as part of the upper Aptian.

Comparison with other Zones. The *V. mayi* Subzone is possibly a correlative with the uppermost part of the lower Aptian – upper Aptian *Impagidinium alectrolophum* Zone (Lister & Batten, 1988) from southern England (Fig. 9). This correlation is based on the last occurrence of *N.*? *vitrea* in both zones.

III 3. *Senoniasphaera microreticulata* Subzone

Age. Late Aptian to early Albian.

Definition. Interval from the lowermost occurrence of *Senoniasphaera microreticulata* to the uppermost occurrence of *S. microreticulata*.

Characteristic species. There are three stratigraphically important species *Ellipsoidictyum imperfectum* (81), *Palaeoperidinium cretaceum* (71) and *Senoniasphaera microreticulata* (105, FB, LT) all common to dominant (Fig 8, Enclosure 2) while *Cauca parva* (107, F), *Circulodinium brevispinosum* (95), *Dingodinium*? *albertii* (9, L), *Gonyaulacysta* aff. *G. cassidata* (106, F), *Leptodinium cancellatum* (101), *Hapsocysta*? *benteae* sp. nov. (109, FT) and *Vesperopsis mayi* (98) are very rare to frequent in the subzone.

Thickness and distribution. The complete subzone measures approximately 175 m in section 13, whereas part of it is present in sections 12 and 17. The subzone is only recorded from Wollaston Forland (Figs 2, 5, Enclosure 1).

Geological setting. Sediments of the subzone rest upon dark sandy mudstone belonging in the *Vesperopsis mayi* Subzone at sections 12 and 13. In section 17 sediments of the subzone probably rest unconformably on dark sandy mudstone of the *Vesperopsis longicornis* Subzone.

Lithology. Dark sandy mudstones with increasing abundance of sandstone layers (20–60 cm thick) in the upper part of sections 13 and 17.

Discussion. *Senoniasphaera microreticulata* has previously been reported from presumed middle Albian in the Barents Sea (Århus, 1991), from presumed middle Albian in the District of Mackenzie, Canada (Brideaux & McIntyre, 1975) and from presumed lower to upper Albian offshore eastern Canada (Bujak & Williams, 1978). The middle Albian range for *S. microreticulata* and *Luxadinium primulum* Brideaux & McIntyre, 1975 proposed by Brideaux & McIntyre (1975) has been questioned by Duxbury (1983, p. 71). Duxbury found a short range of *Luxadinium primulum* in the lower Albian in England, and on this basis he interpreted Brideaux and McIntyre's presumed middle Albian strata to be lower Albian. Århus

(1991) also suggested a middle Albian age for *S. microreticulata*, but Århus mentioned some conflicting data. Århus (1991, p. 13) suggested that the last occurrence of the *Circulodinium colliveri – brevispinosum* group is a stratigraphical marker for the lower Albian in core 7231/4-U-1 from the Barents Sea and in Peary Land, North Greenland. However, Århus recorded a specimen of the *C. colliveri – brevispinosum* group in the upper part of the range of *S. microreticulata*, from core 7231/4-U-1. The fact that *C. brevispinosum* specimens are recorded together with *S. microreticulata* specimens in Canada (Brideaux & McIntyre, 1975) and in the present study from East Greenland provides further support that *S. microreticulata* may indicate lower Albian.

Cauca parva has its first occurrence in the *S. microreticulata* Subzone. Davey & Verdier (1971, 1974) recorded the species from upper part of upper Aptian to upper middle Albian in south-east France. According to Heilmann-Clausen (1987) the species is rare in upper Barremian and in the lower Aptian but quite common in the middle Albian.

Hapsocysta? benteae sp. nov. (= *Hapsocysta* sp. (Davey, 1982a)) has its first occurrence in the uppermost Aptian in north-west Germany according to Davey (1982a). *Hapsocysta? benteae* has its first occurrence in the uppermost part of the *S. microreticulata* Subzone which may indicate that the subzone has an late Aptian to early Albian age.

The last occurrence of *Dingodinium? albertii* in the subzone also indicates a late Aptian – early Albian age. The species is known to range up into the lowermost Albian in north-west Germany (Davey, 1982a) and uppermost Aptian in south-east France (Davey & Verdier, 1974).

Comparison with previous zones. The *S. microreticulata* Subzone is difficult to compare with Lister & Batten's (1988) upper Aptian zones. *Senoniasphaera microreticulata* has not been reported from north-west Europe. The present subzone may correlate with part of the *H. schindewolfii – S. perlucida* Zone (Fig. 9) for eastern Canada and world-wide (Williams, 1975; 1977).

III 4. *Leptodinium? hyalodermopse* Subzone

Age. Early Albian.

Definition. Interval from immediately above the last occurrence of *Senoniasphaera microreticulata* to the last occurrence of *Circulodinium brevispinosum*.

Characteristic species. The two stratigraphically important species *Circulodinium brevispinosum* (95, LT) and *Vesperopsis longicornis* (89, FB2, LT) are common to dominant (Fig. 8, Enclosure 2) while *Batioladinium micropodum* (57, L), *Cauca parva* (107), *Hystrichosphaerina schindewolfii* (73, L), *Leptodinium? hyalodermopse* (38, LT), *Odontochitina singhii* (112, F), *Pseudoceratium polymorphum* (110, F) and *Subtilisphaera perlucida* (65, L) are very rare to frequent in the subzone.

Thickness and distribution. The lower part of the subzone is 20 m thick in section 13 and the upper part reaches a maximum thickness of 16 m in sections 2, 26 and 34. The sections are situated on Hochstetter Forland, Wollaston Forland, Hold with Hope and Traill Ø (Figs 2, 5, Enclosure 1).

Geological setting. Sediments of the subzone rest upon dark sandy mudstones with sandy layers belonging in the *Senoniasphaera microreticulata* Subzone in section 13. The *L.? hyalodermopse* Subzone is overlain by basalts.

Lithology. Dark mudstones with occasional sands.

Discussion. Circulodinium brevispinosum has previously been reported from the Aptian in Arctic Norway (Thusu, 1978), lower Albian in Peary Land, North Greenland and upper Aptian to lower Albian, with a single recording from middle Albian as *Circulodininum colliveri – brevispinosum*, from the Barents Sea (Århus, 1991). The species apparently ranges into the lower Albian in the District of Mackenzie and Edmonton Embayment, Canada (Brideaux, 1977; Banerjee & Davies, 1988).

Vesperopsis longicornis is quite abundant in the upper part of the *L.? hyalodermopse* Subzone, but *V. longicornis*, absent from the *Vesperopsis mayi* and the *Senoniasphaera microreticulata* Subzones, apparently has two acmes. The first occurs in the lower Aptian *Vesperopsis longicornis* Subzone, and the second in the lower Albian *L.? hyalodermopse* Subzone, where it also has its last occurrence.

A few specimens of *Subtilisphaera perlucida* and *Hystrichosphaerina schindewolffi* have been recorded in the upper part of the subzone. In north-west Europe the two species have their last occurrences in the lower Albian (Heilmann-Clausen, 1987).

Leptodinium? hyalodermopse (as *Rhynchodiniopsis hyalodermopsis*) has its last occurrence in the mid lower Albian in north-west Germany (Prössl, 1990) just below the first occurrence of *Litosphaeridium arundum* and above the first occurrence of *Rhombodella paucispina*. *Leptodinium? hyalodermopse* also has its last occurrence immediately below the first occurrence of *L. arundum* in

East Greenland. This level has been determined as the lower–middle Albian boundary based on the coinciding first occurrences of *L. arundum*, *Rhombodella paucispina* and *Chichaouadinium vestitum*. The inconsistency of the age determination from East Greenland with the age determination from Germany might be explained by a hiatus in the upper part of lower Albian in East Greenland. *Leptodinium? hyalodermopse* ranges, according to Brideaux & McIntyre (1975), into the middle Albian in Canada where the last occurrence of the species is in the middle of the range of *Senoniasphaera microreticulata*. Århus (1991) observed the same in the Barents Sea, whereas *L.? hyalodermopse* last occurs in East Greenland above the last occurrence of *S. microreticulata*.

Odontochitina singhii has its first occurrence in East Greenland in the *L.? hyalodermopse* Subzone. Århus (1991) recorded the species from Aptian – lower Albian to middle Albian, Spitsbergen, Norway. It has its first occurrence in the upper Albian in western Canada (Singh, 1983). Dixon *et al.* (1989) discuss their record of the species in assemblages from the Northwest Territories, Canada and propose a late middle to late Albian age for the first occurrence. The species also has been recorded from the lower to upper Albian in Australia (Morgan, 1980).

Pseudoceratium polymorphum has its first occurrence in the lower part of the subzone and ranges up to the uppermost middle Albian. The species is restricted to the Aptian and lower Albian in north-west Europe (Heilmann-Clausen, 1987). The last occurrences of *Circulodinium brevispinosum* and *Subtilisphaera perlucida*, the presence of *Odontochitina singhii* and the absence of the Albian species *Litosphaeridium arundum* and *Chichaouadinium vestitum* indicate a late Aptian? to early Albian age for the subzone.

Comparison with other zones. Correlation with the upper Aptian zones established by Lister & Batten (1988) for southern England is difficult. Part of the *L.? hyalodermopse* Subzone may be correlated with the mid to uppermost lower Albian *Scriniodinium heikei* Zone (Fig. 9) established by Prössl (1990) for north-west Germany based on the extinction of *L.? hyalodermopse* in both zones. The *L.? hyalodermopse* Subzone may possibly correlate with the upper part of the Aptian *S. perlucida* – *H. schindewolfii* Zone (Williams, 1977).

IV. *Rhombodella paucispina* Zone

Age. Early? to middle Albian.

Definition. Interval from immediately above the uppermost occurrence of *Circulodinium brevispinosum* to immediately below the lowermost occurrence of *Subtilisphaera kalaalliti* sp. nov.

Subdivision. The *Rhombodella paucispina* Zone is subdivided into the two subzones. (1) *Litosphaeridium arundum* Subzone and (2) *Chichaouadinium vestitum* Subzone (Fig. 7).

Thickness and distribution in East Greenland. The maximum thickness of the zone is 500 m. It is present in 6 sections situated on Shannon, Wollaston Forland, Clavering Ø and Hold with Hope (Figs 2, 5, Enclosure 1).

IV 1. *Litosphaeridium arundum* Subzone

Age. Early? to middle Albian.

Definition. Interval from immediately above the uppermost occurrence of *Circulodinium brevispinosum* to immediately below the acme of *Chichaouadinium vestitum*.

Characteristic species. The three stratigraphically important species *Oligosphaeridium* sp. 1 (108), *Palaeoperidinium cretaceum* (71) and *Vesperopsis mayi* (98) are common to dominant (Fig. 8, Enclosure 2) while *Apteodinium* cf. *A. grande* (121, F), *Batioladinium shaftesburiense* sp. nov. (113, FB), *Bourkidinium granulatum* (119, F), *Chichaouadinium vestitum* (114, FB), *Discorsia nanna* (74), *Kleithriasphaeridium eoinodes* (13, L), *Leptodinium cancellatum* (101), *Litosphaeridium arundum* (116,FB), *Odontochitina singhii* (112), *Pseudoceratium expolitum* (115, FB) and *Rhombodella paucispina* (118, FB) are very rare to frequent in the subzone.

Thickness and distribution. The subzone is 300 m thick in section 20, approximately 355 m in section 23 and 150 m in section 22. It is only represented by a few samples in sections 5, 21 and 26. The sections are distributed on Shannon, Wollaston Forland, Clavering Ø and Hold with Hope (Figs 2, 5, Enclosure 1).

Geological setting. Sediments containing the base of the subzone are only recorded at section 26 where they rest upon dark mudstones assigned to the *Leptodinium? hyalodermopse* Subzone. Sediments assigned to the *L. arundum* subzone rest unconformably upon sediments containing the upper Barremian *Pseudoceratium toveae* Subzone in section 21 and unconformably overlie a grey coarse-grained Jurassic sandstone in section 22.

Lithology. Dark mudstones with light brown calcareous concretions and cone in cone structures which contain occasional sandstone beds with small ripples and flute-marks. The subzone is overlain by Tertiary basalts in section 22.

Discussion. The coincidence that several species have their last or first occurrences at the base of the present subzone (Fig. 8) might indicate the presence of a hiatus between the *Leptodinium*? *hyalodermopse* and *Leptodinium arundum* Subzones.

Litosphaeridium arundum ranges from lower to upper Albian in north-west Europe and world-wide (Heilmann-Clausen, 1987; Williams & Bujak, 1985). *Pseudoceratium expolitum*, which has its first occurrence at the base of the *L. arundum* Subzone, has previously been recorded from middle to upper Albian of western Canada (Brideaux, 1971; Singh, 1971).

Singh (1983) reported *Bourkidinium granulatum* from the upper Aptian to lower Cenomanian of western Canada. The species was originally recorded from the upper Aptian and Albian in Australia (Morgan, 1975). It is rare in East Greenland, where it has its first occurrence in the *L. arundum* Subzone.

Rhombodella paucispina also has its first occurrence in the *L. arundum* Subzone and is almost always present, but rare. The species has previously been recorded from the Albian in Germany (Alberti, 1961), from the upper Aptian and lower Albian in north-west Germany (Davey, 1982a), from the uppermost Aptian to lowermost upper Cenomanian in north-west Germany (Prössl, 1990), from the middle to upper Albian in France (Davey & Verdier, 1971), middle Albian, Barents Sea (Århus, 1991), the upper Albian to lower Cenomanian (as *R. natans*) from Bathurst Island, Australia by Norvick & Burger (1976) and from the Aptian to Albian as *R. natans* (jr. syn. of *R. paucispina*) in Australia (Cookson & Eisenack, 1962b). There is no published record of the species from Canada, but I have recognized the first occurrence of *R. paucispina* in samples also yielding the first occurrence of *C. vestitum* and *P. expolitum* in samples from Axel Heiberg Island, Arctic Canada (kindly provided to me by ISPG, Calgary, Canada).

Oligosphaeridium sp. 1 dominates the dinoflagellate cyst assemblage in the upper part of the subzone. Århus (1991) recorded the same species from the middle Albian at Spitsbergen, Norway. The species *Chichaouadinium vestitum* (see also discussion in the systematic part) has previously been recorded from middle Albian from Spitsbergen by Århus (1991), lower to upper Albian offshore eastern Canada by Williams (1975) and from the middle and upper Albian from Alaska by May & Stein (1979) and Arctic Canada by Doerenkamp *et al.* (1976). Singh (1971) reported the species from the upper part of middle Albian and upper Albian in western Canada.

Only a few specimens of *Apteodinium* cf. *C. grande* were observed in the subzone. Heilmann-Clausen (1987) reported *A. grande* from uppermost middle Albian and upper Albian in north-west Europe.

The subzone has been dated as Albian based on the presence of the species *Litosphaeridium arundum* and *Chichaouadinium vestitum*. The first occurrence of *Pseudoceratium expolitum* indicates that part or perhaps the entire subzone is of middle Albian age.

Comparison with other Albian zones. The *L. arundum* Subzone may be correlated with part of the *Protoellipsodinium spinocristatum* Subzone which belongs to the lower half of the world-wide Albian *Chichaouadinium* cf. *C. vestitum* Zone (Fig. 9) established by Williams (1977).

IV 2. *Chichaouadinium vestitum* Subzone

Age. Middle Albian.

Definition. Interval from the acme of *Chichaouadinium vestitum* to immediately below the lowermost occurrence of *Subtilisphaera kalaalliti* sp. nov.

Characteristic species. The two species *Odontochitina operculata* (70) and *Palaeoperidinium cretaceum* (71) are common to dominant (Fig. 8, Enclosure 2) while *Apteodinium* cf. *A. grande* (121, L), *Batioladinium shaftesburiense* sp. nov. (113, L), *Chichaouadinium vestitum* (114, LT), *Ellipsoidictyum imperfectum* (81, LT), *Leptodinium cancellatum* (101, LT) *Odontochitina singhii* (112, L), *Protoellipsodinium spinocristatum* (125, F, LT), *Pseudoceratium eisenackii* (92, LT) and *Rhombodella paucispina* (118) are very rare to frequent in the subzone.

Thickness and distribution. The subzone is only present in section 20 (approximately 170 m thick) and in section 23 where it is less than 100 m thick. The subzone is recorded from Wollaston Forland and Clavering Ø (Figs 2, 5, Enclosure 1).

Geological setting. Sediments assigned to the subzone rest upon dark mudstones of the *Litosphaeridium arundum* Subzone and are overlain by Tertiary basalts.

Lithology. Sandy streaked mudstones with incipient ripples concentrated in bands of 0.2–1.0 m thickness.

Discussion. The *C. vestitum* Subzone is characterised by the last occurrence of many species, especially at the very

top of the exposed part of the subzone. The many last occurrences and the fact that the sediments assigned to the subzone are cut off by basalts indicate a hiatus between the strata dated as middle and late Albian.

Protoellipsodinium spinocristatum is the only species with a first occurrence in the subzone, but it is rare. The species range from the lower Aptian to upper Albian in south-east France (Davey & Verdier, 1971, 1974). *Chichaouadinium vestitum* has also previously been reported to have its last occurrence in the upper Albian (see discussion of the *C. vestitum* in the systematic chapter). *Leptodinium cancellatum* is reported as having its last occurrence in lower Albian in north-west Europe (Heilmann-Clausen, 1987) whereas Costa & Davey (1992) reported it from the base of the upper Aptian to the lower part of the upper Albian in England and in the North Sea. Brideaux & McIntyre (1975) reported the species to range up to the middle Albian in the District of Mackenzie, Canada. They also recorded the last occurrence of *Ellipsoidictyum imperfectum* in the uppermost middle Albian of the same area whereas Costa & Davey (1992) reported the last occurrence of the species in the upper Albian in England an the North Sea. *Ellipsoidictyum imperfectum* has not been recorded above the *C. vestitum* Subzone in East Greenland.

Apteodinium cf. *A. grande* has not been recorded above the present subzone. The species is very rare in the material studied from East Greenland and no stratigraphic conclusion has been based on this last occurrence.

The last occurrences of *E. imperfectum* and *L. cancellatum* may indicate a middle Albian age for the subzone.

Comparison with other Albian zones. The *C. vestitum* Subzone might be correlated with the lower part of the uppermost lower Albian to mid upper Albian *Ascodinium scabrosum* Zone (Fig. 9) erected for north-west Germany by Prössl (1990) based on the extinction of *Odontochitina singhii* in both zones. The *C. vestitum* Subzone may be correlated with the world-wide lower to middle Albian *Protoellipsedinium spinocristatum* Subzone (Williams, 1977) which is defined as the interval from the first appearance of *P. spinocristatum* to the first appearance of *Xenascus ceratioides*.

V. *Subtilisphaera kalaalliti* Zone

Age. Late Albian to ?early Cenomanian.

Definition. The base of the zone is defined on the first occurrence of *Subtilisphaera kalaalliti* sp. nov. The upper boundary is defined on the last local occurrence of *Epelidosphaeridia spinosa*.

Subdivision. The *Subtilisphaera kalaalliti* Zone is divided into four subzones; (1) *Wigginsiella grandstandica* Subzone, (2) *Odontochitina ancala* Subzone, (3) *Ovoidinium*? sp. 1 Subzone and (4) *Epelidosphaeridia spinosa* Subzone (Fig. 7).

Thickness and distribution. The maximum thickness of the zone is 485 m. It is present in 13 sections in the southern part of the area studied on Hold with Hope, Geographical Society Ø and Traill Ø (Figs 2, 5, Enclosure 1).

V 1. *Wigginsiella grandstandica* Subzone

Age. Early late Albian.

Definition. Interval from the first occurrence of *Subtilisphaera kalaalliti* sp. nov. to immediately below the first occurrence of *Odontochitina ancala*.

Characteristic species. The three stratigraphically important species *Circulodinium* sp. 1 (128, FB), *Rhombodella paucispina* (118), *Subtilisphaera kalaalliti* sp. nov. (132, FB) are common to dominant (Fig. 8, Enclosure 2) while *Dorocysta litotes* (130, FB), *Palaeohystrichophora infusorioides* (131, FB), *Wigginsiella grandstandica* (127, FB) and *Xiphophoridium alatum* (134, FB) are very rare to frequent in the subzone.

Thickness and distribution. The subzone is 65 m thick in section 31 and occurs in one sample in section 29, both from Geographical Society Ø (Figs 2, 5, Enclosure 1).

Geological setting. The base of sediments belonging in the subzone has been recorded in section 31 where it rests unconformably upon middle Jurassic sandstones.

Lithology. Dark sandy mudstones with scattered sandstone layers.

Discussion. The coincidence that several species have their last or first occurrences at the base of the present subzone (Fig. 8) may indicate the presence of a hiatus between the strata here dated as middle and late Albian.

Wigginsiella grandstandica, which has its first occurrence at the base of the *W. grandstandica* Subzone, has previously only been reported from Alaska (as Genus A, May & Stein, 1979; May, 1979). Lucas-Clark (1987) refers to oral communications with J. Bennett, H. Haga, F. E. May and V. D. Wiggins (1982–1984), who have used the species as an upper Albian marker in Alaska. The species is also recorded from Axel Heiberg Island,

Arctic Canada in samples kindly provided by the ISPG, Calgary, Canada. There *W. grandstandica* occurs together with *Chichaouadinium vestitum, Luxadinium propatalum* and *Rhombodella paucispina*. The first occurrence of the *W. grandstandica* in Canada occurs immediately above the last occurrence of *Odontochitina singhii*. The ranges of *Leptodinium cancellatum* and *W. grandstandica* overlap in the Canadian material.

Dorocysta litotes was originally described from the Cenomanian of England and France by Davey (1970). Williams & Bujak (1985) assign a lower Cenomanian range to the species whereas Brideaux & Myhr (1976) reported the species from unspecified Albian and Cenomanian in the District of Mackenzie, Canada. *Dorocysta litotes* is rare but consistent in the *W. grandstandica* Subzone.

The new species *Subtilisphaera kalaalliti* occurs for the first time in the *W. grandstandica* Subzone.

The species *Circulodinium* sp. 1 is abundant throughout the subzone. *Rhombodella pausispina*, which is rare in the two previous subzones, becomes common in the uppermost part of the *W. grandstandica* Subzone. *Palaeohystrichora infusorioides* and *Xiphophoridium alatum* have their first occurrences in this subzone. These species have not previously been recorded below the upper Albian according to Davey & Verdier (1971; 1973) and Williams & Bujak (1985), indicating a late Albian age for the subzone. Prössl (1990) recorded *X. alatum* from uppermost middle Albian to upper Turonian in north-west Germany.

Comparison with other upper Albian zones. The uppermost part of the *Ascodinium scabrosum* Zone (uppermost lower Albian to upper Albian; Fig. 9), erected for north-west Germany by Prössl (1990), may be correlated with the present subzone based on the first occurrence of *X. alatum* in both zones. However the *A. scabrosum* Zone differs by the absence of *P. infusorioides* and *D. litotes*. The *W. grandstandica* Subzone may be correlated with the lower part of the world-wide *Xenascus ceratioides – Carpodinium obliquicostatum* Subzone (Williams, 1977) based on the first occurrence of *P. infusorioides* and *X. alatum* within both subzones.

V 2. *Odontochitina ancala* Subzone

Age. Mid late Albian.

Definition. Interval from the first occurrence of *Odontochitina ancala* to immediately below the first occurrence of *Ovoidinium*? sp. 1.

Characteristic species. The three stratigraphically important species *Circulodinium* sp. 1 (128, L), *Rhombodella paucispina* (118) and *Subtilisphaera kalaalliti* sp. nov. (132) are common to dominant (Fig. 8, Enclosure 2) while *Cauca parva* (107, L), *Dorocysta litotes* (130), *Epelidosphaeridia* sp. 1 (138, FB), *Litosphaeridium arundum* (116, L), *Odontochitina ancala* (126, FB), *Odontochitina costata*, *Palaeohystrichophora infusorioides* (131), *Wigginsiella grandstandica* (127, L) and *Xiphophoridium alatum* (134) are very rare to frequent in the subzone.

Thickness and distribution. The subzone is represented by 160 m in section 30 and approximately 220 m in section 37. Part of the subzone is present in sections 28, 35, 36 and 38. The subzone was only observed in the southern part of the area at Hold with Hope, Geographical Society Ø and Traill Ø (Figs 2, 5, Enclosure 1).

Geological setting. The lower part of the sections of the *O. ancala* Subzone are the basal sediments in these sections.

Lithology. Dark sandy mudstones containing scattered sandstone intervals with small scale ripples and cross bedding. Section 30 seems to represent 2 or 3 upwards-coarsening sequences.

Discussion. Odontochitina ancala has previously been recorded from the middle and upper Albian from Western Interior, USA (Bint, 1986) and from the middle and upper Albian, Alaska where May & Stein (1979) recorded the species as *O.* cf. *O. operculata.*

Cauca parva, which has its last occurrence within the *O. ancala* Subzone, last occurs in the middle Albian strata in north-west Europe but specimens, probably reworked, have been observed in the upper Albian and lower Cenomanian (Heilmann-Clausen, 1987). *Cauca parva* ranges world-wide up to the top of the upper Albian according to Williams & Bujak (1985).

The last occurrence of *Litosphaeridium arundum* within the subzone, correlates with the last occurrence of the species in the lower part of upper Albian in the Paris Basin in France (Davey & Verdier, 1971). *Rhombodella paucispina* is very abundant in the subzone. This species has not previously been reported from sediments younger than late Albian in Europe and Canada, whereas the species seems to range into the Cenomanian in Australia (see discussion at the *L. arundum* Subzone). The *O. ancala* Subzone is dominated by *Rhombodella paucispina* and *Subtilisphaera kalaalliti* sp. nov.

The first occurrence of *Odontochitina costata* occurs within the subzone. The species has previously been

recorded from the upper Albian in France (Davey & Verdier, 1973) and from the middle and upper Albian of western Canada (Singh, 1971).

The presence of *O. costata, P. infusorioides, R. paucispina, Xiphophoridinium alatum* and the last occurrence of *L. arundum* indicate a mid late Albian age for the subzone.

Comparison with other upper Albian zones. The middle part of the *O. ancala* Subzone may possibly be correlated with the base of the middle part of the upper Albian to lowermost Cenomanian *Litosphaeridium siphoniphorum* Zone (Fig. 9) erected for north-west Germany by Prössl (1990). The correlation is based on the extinction of *Litosphaeridium arundum* and presence of *Xiphophoridium alatum* in both zones. The *O. ancala* Subzone may be correlated with the world-wide *Xenascus ceratioides – Carpodinium obliquicostatum* Subzone (Williams, 1977; Fig. 9) based on the presence of *P. infusorioides* and *X. alatum* in both subzones.

V 3. *Ovoidinium*? sp. 1 Subzone

Age. Mid to late Albian.

Definition. Interval from the lowermost occurrence of *Ovoidinium*? sp. 1 to immediately below the lowermost occurrence of *Epelidosphaeridia spinosa.*

Characteristic species. The three stratigraphically important species *Rhombodella paucispina* (118), *Ovoidinium*? sp. 1 (140, FB) and *Subtilisphaera kalaalliti* sp. nov. (132) are common to dominant (Fig. 8, Enclosure 2) while *Dorocysta litotes* (130), *Epelidosphaeridia* sp. 1 (138, L), *Fromea* aff. *F. expolita* (143, F, LT), *Odontochitina ancala* (126, L), *Ovoidinium* sp. 2 (141, F, LT), *Palaeohystrichophora infusorioides* (131), *Vesperopsis mayi* (98, LB), *Xenascus ceratioides* (144, F) and *Xiphophoridium alatum* (134) are very rare to frequent in the subzone.

Thickness and distribution. The complete subzone is represented by approximately 255 m of sediments at section 30 whereas only part of the subzone is present in sections 24, 25, 27 and 40. All five sections are situated in the southern part of the area on Hold with Hope, Geographical Society Ø and Traill Ø (Figs 2, 5, Enclosure 1).

Geological setting. Sediments belonging in the lower part of the subzone rest upon dark sandy mudstones of the *Odontochitina ancala* Subzone in sections 30 and 40. The age of the underlying sediments in the remaining sections has not been determinated.

Lithology. Dark sandy mudstones with several lenticular and crossbedded sandstone layers up to 12 m thick. The upper part of section 24 is covered by Tertiary basalts.

Discussion. Ovoidinium? sp. 1 is quite abundant in the lower part of the *Ovoidinium*? sp. 1 Subzone. The species is, according to L. I. Costa (personal communication, 1989) very abundant in the upper Albian to lowermost Cenomanian in the Troms and Hammerfest basins, offshore north-west Norway.

Fromea aff. *F. expolita* in East Greenland is restricted to the *Ovoidinium*? sp. 1 Subzone. The species has certain similarities to *F. expolita*, which previously has only been described from the Hauterivian and Barremian in the District of Mackenzie, Canada, by Brideaux (1977).

Vesperopsis mayi, which in East Greenland seems to range up into the middle part of the upper Albian, has previously been recorded from the Albian (Bint, 1986). *Xenascus ceratioides* first occurs in the middle part of the *Ovoidinium*? sp. 1 Subzone. The species has previously been recorded from the middle and upper Albian in France (Davey & Verdier, 1971). The world-wide range of *X. ceratioides* is, according to Williams & Bujak (1985), middle Albian to lowermost Maastrichtian.

Few specimens of *Odontochitina ancala* occur in the subzone. The species has not been recorded from post late Albian strata in this study or previously (Bint, 1986).

The abundance of *R. paucispina* indicates a late Albian age for the subzone.

Comparison with other upper Albian zones. The *Ovoidinium*? sp. 1 Subzone may possibly be correlated with the middle part of the upper Albian to lowermost Cenomanian *Litosphaeridium siphoniphorum* Zone (Fig. 9) erected for north-west Germany by Prössl (1990). The correlation is based on the first occurrence of *Xenascus ceratioides* in both zones. The *Ovoidinium*? sp. 1 Subzone may be correlated with the upper part of the world-wide middle to upper Albian *Xenascus ceratioides – Carpodinium obliquicostatum* Subzone (Williams, 1977) based on the first occurrence of *X. ceratioides* in both subzones.

V 4. *Epelidosphaeridia spinosa* Subzone

Age. Late Albian – middle? Cenomanian.

Definition. The lower boundary of the subzone is defined by the lowermost occurrence of *Epelidosphaeridia spi-*

nosa. The upper boundary is defined by the local last occurrence of *Epelidosphaeridia spinosa*.

Characteristic species. The two stratigraphical important species *Rhombodella paucispina* (118) and *Subtilisphaera kalaalliti* sp. nov. (132) are common to dominant (Fig. 8, Enclosure 2) while *Batioladinium jaegeri* (67), *Desmocysta plekta* (86), *Dorocysta litotes* (130), *Epelidosphaeridia spinosa* (145, FB), *Palaeohystricophora infusorioides* (131), *Palaeoperidinium cretaceum* (71), *Ovoidinium*? sp. 1 (140), *Xenascus ceratioides* (144) and *Xiphophoridium alatum* (134) are very rare to frequent in the subzone.

Thickness and distribution. The subzone has only been recorded in 5 m of thick dark mudstone at section 39 on Traill Ø (Figs 2, 5, Enclosure 1).

Discussion. *Epelidosphaeridia spinosa* was originally described from the lower Cenomanian in England by Cookson & Hughes (1964). Davey (1969) recorded the species from lower and middle horizons of the Cenomanian in England and France and from one Albian sample (Sas. 1023) from Saskatchewan, Canada. The Albian age of the sample was confirmed by Singh (1983, table 7). Davey & Verdier (1971; 1973) reported the species from the upper Albian in France and Foucher (1979) reported a uppermost Cenomanian extinction of *E. spinona* in France and Europe. *Dorocysta litotes* is, according to Williams & Bujak (1985), a lower Cenomanian species and it has previously only been reported from Albian strata in a well from the District of Mackenzie, Canada (Brideaux & Myhr, 1976).

Batioladinium jaegeri, Palaeoperidinium cretaceum and *Rhombodella paucispinosa* (as *R. natans*) all have their last occurrences at the top of the upper Albian (lower Vraconian) *Stoliczkaia blancheti* ammonite zone in the Vraconian type section in France (Davey & Verdier, 1973). In the same area the first occurrence of *Epelidosphaeridia spinosa* is reported from the top of the underlying upper Albian, pre-Vraconian, *Mortoniceras inflatum* ammonite zone (Davey & Verdier, 1973). The fact that the four species also occur together in East Greenland indicates that the *Epelidosphaeridia spinosa* Subzone may be of late Albian age.

Comparison with other zones. The *E. spinosa* Subzone possibly correlates with the upper Albian to lowermost Cenomanian *Litosphaeridium siphoniphorum* Zone (Fig. 9) erected for north-west Germany by Prössl (1990). The correlation is based on the first occurrence of *E. spinosa* in both zones. The *E. spinosa* Subzone might correlate with the very top of the world-wide middle to upper Albian *Xenascus ceratioides – Carpodinium obliquicostatum* Subzone and the world-wide lowermost *Kiokansium polypes polypes* (originally *Cleistosphaeridium polypes*) Zone established by Williams (1977).

Systematic palynology

The present systematic chapter includes all the dinoflagellate cyst species included in the range-charts (Fig. 8, Enclosure 2; Appendix, Tables 2–41) in alphabetic order according to genus. It should be noted that the age of the range given for each cyst species in East Greenland is tentative (see also the 'Dinoflagellate cyst zonation in East Greenland' chapter). References to species not discussed below and not listed in the 'References' are to be found in Lentin & Williams (1989). Species described after 1989 are discussed in the text. Previous records are mentioned in the same order as in the section 'Dinoflagellate cyst distribution and zonation in the Lower Cretaceous'. References to miospores and other palynomorphs encountered in the study are also included in the present reference list. The tabulation formulae given for dinoflagellate cysts in the systematic section follows Kofoid (1907, 1909).

Division Pyrrhophyta Pascher 1914
Class Dinophyceae Fritsch 1929
Order Peridinales Haeckel 1894

Genus *Achomosphaera* Evitt, 1963

Achomosphaera? *neptuni* (Eisenack, 1958) Davey & Williams, 1966a

Plate 1, Figs 1–3

Comments. The specimens recorded are similar to Eisenack's (1958) holotype in size and have the same characteristic trifurcate processes although the length of the processes on the specimens from Greenland tend to be slightly longer than on the type material. The fibrous nature of the processes, sometimes radiating from the base, mentioned by Davey & Williams (1966a) has also

been recognised in the present material (Plate 1, Fig. 3). The archaeopyle is precingular (Plate 1, Fig. 1).

Occurrence in East Greenland. Barremian to Aptian. Sections 2, 3, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 21, 32 and 33. Five specimens, probably reworked, were observed in the lower to middle Albian in sections 3 and 32.

Previous occurrences. Davey & Verdier (1974) reported the last occurrence of *A.*? *neptuni* from the upper Aptian ammonite dated Aptian type area in south-east France. In north-west Germany Prössl (1990) recorded the range of the species from the lower Hauterivian to the upper Barremian. In north-west Europe and in North Sea wells this species has been reported from the upper Ryazanian to upper Aptian (Heilmann-Clausen, 1987) and from the lower Barremian of the Barents Sea (Århus *et al.*, 1990). Singh (1964) reported *A.* sp. cf. *A. neptuni* from the middle Albian, central Alberta, Canada. Brideaux & Myhr (1976) and Brideaux (1977) recorded the species from the Hauterivian to Aptian, District of Mackenzie, Canada. The type material was described as *Baltisphaeridium neptuni* from the Lower Cretaceous in Germany by Eisenack (1958).

Achomosphaera? *neptuni* seems to have its last occurrence in the uppermost Aptian in Europe, Greenland and Canada, which agrees with the observation by Davey & Verdier (1974).

Genus *Apteodinium* Eisenack, 1958; emend. Lucas-Clark, 1987

Apteodinium cf. *A. grande* Cookson & Hughes, 1964

Plate 1, Figs 4–5

Comments. The very few specimens recorded from East Greenland differ from the type species by being smaller, less circular in outline and occasionally the wall appears to be granular or reticulate (Plate 1, Fig. 5). These differences and the first occurrence in middle Albian may indicate that the specimens from East Greenland belong to another species.

Occurrence in East Greenland. Middle Albian. Sections 2, 5, 20 and 23. The species is very rare.

Previous occurrences. Apteodinium grande was previously recorded from the upper Albian to upper Cenomanian, north-west Germany (Prössl, 1990), from the middle? and upper Albian, north-west Europe and North Sea wells (Heilmann-Clausen, 1987) and from Albian to Cenomanian, offshore eastern Canada (Bujak & Williams, 1978). The type material was described from the upper Albian to the lower Cenomanian in England by Cookson & Hughes (1964).

Apteodinium grande is never recorded in ammonite dated strata older than late Albian (Davey & Verdier, 1971; 1973). According to Davey & Verdier the species is a marker species within the upper Albian.

Apteodinium reticulatum Singh, 1971

Plate 1, Fig. 6

Occurrence in East Greenland. Upper Barremian, middle and upper Albian. Sections 7, 13, 14, 15, 17, 19, 20, 21, 23, 30, 31 and 32.

Previous occurrences. Apteodinium reticulatum was previously recorded from the lower Barremian in a core offshore south Norway (Aarhus *et al.*, 1986). The type material was described from the upper Albian in the Peace River area, Canada, by Singh (1971) and later recorded from the middle Albian, Banks Island, Arctic Canada, by Doerenkamp *et al.*, (1976). No 'accurately' dated ages exist for *A. reticulatum.*

Genus *Atopodinium* Drugg, 1978

Atopodinium haromense Thomas & Cox, 1988

Plate 12, Figs 6–8

1978 Dinoflagellate type 4; Thusu, p. 86, pl. 7, fig. 13.
1978 ?*Maduradinium* sp. A; Davey, p. 894–895, pl. 5, figs 5–6.
1982b ?*Maduradinium* sp. A Davey, 1978; Davey, p. 9, pl. 10, fig. 13.
1988 *Atopodinium haromense*; Thomas & Cox, p. 319–320, fig. 4, pl. I, figs 1–6.
1988 *Maduradinium*? sp. A Davey, 1978; Lister & Batten, p. 46–47, pl. 4, figs 18–19.

Comments. The specimens recorded in the present study have an archeopyle breakage in the apical region and pronounced sutural splitting between the precingular plates as described for ?*Maduradinium* sp. A by Davey (1978, p. 894–895). The archeopyle appears to be apical type (tA) as described for *A. haromense* by Thomas & Cox (1988) or a combination apical/precingular type with an adnate apical portion (tA) a + Pa, as proposed for ?*Maduradinium* sp. A Davey, 1978 by Lister & Batten (1988, p. 46–47). The specimens are similar to those illustrated by Thusu (1978), Davey (1978, 1982b), Lister & Batten (1988) and Thomas & Cox (1988).

The Jurassic forms of *A. haromense* (Thusu, 1978; Thomas & Cox, 1988) seem to have slightly less pronounced ornamentation on the autophragm than the Cretaceous forms (Davey, 1978, 1982b; Lister & Batten, 1988; the present study).

Prössl (1990, p. 107–108; plate 5, figs 4–5; plate 6, fig. 9) described and illustrated the species *Atopodinium cretaceum* from the lower Hauterivian to lower Barremian in Germany. *Atopodinium cretaceum* differs from *A. haromense* by having an apical archeopyle where plate 1' is lost.

Occurrence in East Greenland. Uppermost Barremian, lowermost Aptian. Sections 14, 15, 17 and 21.

Previous occurrences. Atopodinium haromense was described from the upper Oxfordian to lower Kimmeridgian (Jurassic), England by Thomas & Cox (1988). The species was previously recorded (as *?Maduradinium* sp. A) from the lower to upper Aptian, south-east England (Lister & Batten, 1988), upper Ryazanian – lower Valanginian to lower–upper? Hauterivian, onshore Denmark (Davey, 1982b), upper Ryazanian to lower Barremian – Aptian, in North Sea wells (Heilman-Clausen, 1987) and Turonian to lower Maastrichtian, offshore south-western Africa (Davey, 1978). The species is also recorded (as Dinoflagellate type 4) from the Callovian and Oxfordian (Jurassic), Arctic Norway (Thusu, 1978).

Genus *Balmula* Bint, 1986
Balmula pentaradiata (Singh, 1983) Bint, 1986

Plate 1, Fig. 7

Comments. Only one specimen was recorded from Greenland. It has, as described by Singh, 5 horns of almost equal length with a circlet of spinules at the horn terminations. The species is very thin walled and hyaline and therefore easily overlooked; this could be the reason for only one specimen having been recorded in the present study.

Occurrence in East Greenland. Uppermost middle Albian. Section 20.

Previous occurrence. Balmula pentaradiata was described from the lower Cenomanian, Upper Shaftesbury Formation, Peace River area, Canada, by Singh (1983).

Genus *Baticasphaera* Drugg, 1970b
Baticasphaera spumosa (Brideaux, 1977) Below, 1981a

Plate 1, Figs 8–9

Comments. The few recorded specimens from Greenland are similar to Brideaux's (1977) holotype in size and shape whereas the fibrous structure on the periphragm is less pronounced than on the type material.

Occurrence in East Greenland. Upper Barremian – lower Aptian. Section 7.

Previous occurrences. The type material was described from the Aptian, District of Mackenzie, Canada, by Brideaux (1977).

Genus *Batioladinium* Brideaux, 1975; emend. Pourtoy, 1988
Batioladinium? exiguum (Alberti, 1961) Brideaux, 1975

Plate 2, Figs 1–2

Comments. The specimens from East Greenland included in *B.? exiguum* have a psilate to shagreenate surface, rarely with few scattered granulae or echinae. The antapical horns are short, usually unequal and blunt although

Plate 1

Fig. 1. *Achomosphaera? neptuni* × 500, section 10; GGU 342093–8; 6.4–144.0 MGUH 21678.

Fig. 2. *Achomosphaera? neptuni* × 585, section 17; GGU 342162, MGUH 21679.

Fig. 3. *Achomosphaera? neptuni* × 2350, close-up illustrating the fibrous nature of the cyst surface and the basal part of the processes.

Fig. 4. *Apteodinium* cf. *A. grande* × 500, section 20; GGU 342199–5, 6.0–140.1; MGUH 21680.

Fig. 5. *Apteodinium* cf. *A. grande* × 500, section 20; GGU 342194–5, 19.8–148.0; MGUH 21681.

Fig. 6. *Apteodinium reticulatum* × 500, section 17; GGU 342161–4, 8.5–150.8; MGUH 21682.

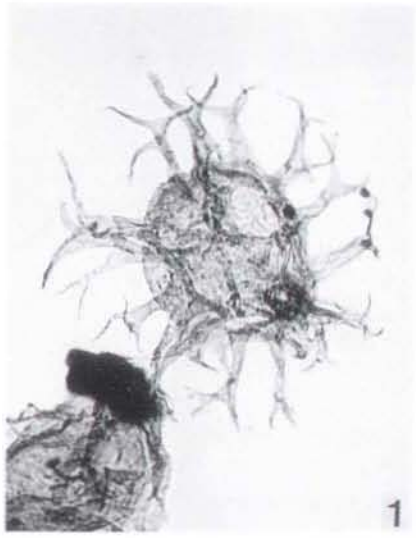
Fig. 7. *Balmula pentaradiata* × 500, section 20; GGU 342196–4, 4.3–153.2; MGUH 21683.

Figs. 8 & 9. *Batiacasphaera spumosa* × 750, section 7; GGU 342087–4, 6.0–119.0; MGUH 21684.

Fig. 10. *Levisphaera* cf. *L. crassicingulata* × 500, section 29; GGU 342599–4, 11.0–126.0; MGUH 21685.

Fig. 11. *Levisphaera* cf. *L. crassicingulata* × 500, section 18; GGU 342222–4, 3.9–134.1; MGUH 21686.

Fig. 12. *Levisphaera* cf. *L. crassicingulata* × 750, section 17; GGU 342169–4, 5.2–130.2; MGUH 21687.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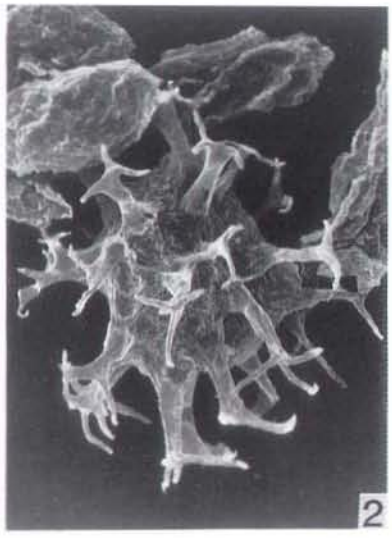
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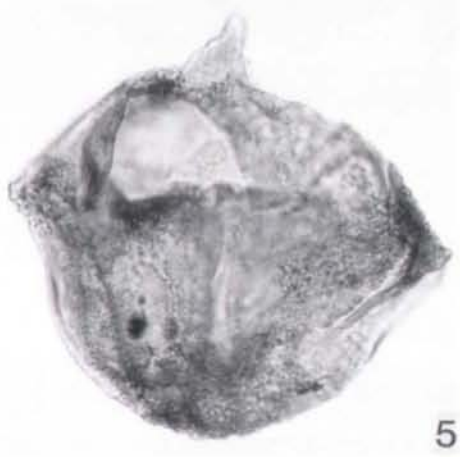
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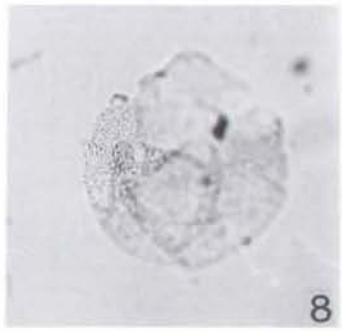
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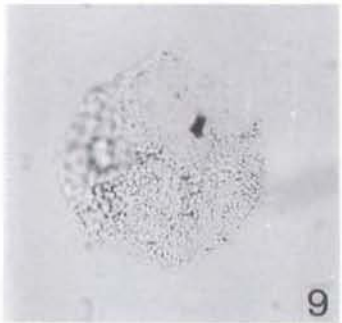
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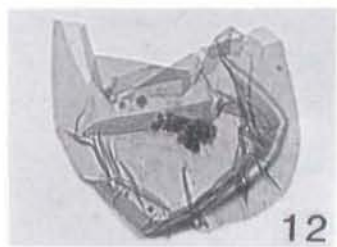
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some are weakly pointed at their free ends. Alberti (1961) did not report granulae or echinae on the wall of the holotype, but otherwise the material from Greenland is very similar to the type specimens. *Batioladinium*? *exiguum* is distinguished from *B. pomum* Davey, 1982b by its reduced ornamentation and by its shorter apical horn.

Occurrence in East Greenland. Upper Barremian to Aptian. Sections 6, 7, 8, 11, 17, 19 and 21.

Previous occurrences. Batioladinium? *exiguum* was described as *Broomea exigua* from the lower Hauterivian to the upper Barremian in Germany by Alberti (1961) and from the Hauterivian, offshore eastern Canada (Bujak & Williams, 1978).

Batioladinium jaegeri (Alberti, 1961) Brideaux, 1975

Plate 2, Figs 3–4

Comments. The specimens observed from East Greenland are similar to the specimens illustrated by Alberti (1961). Specimens with short and long apical horns are present.

Occurrence in East Greenland. Lower Barremian to upper Albian. A few specimens are present in almost all samples but the species never dominates the assemblage.

Previous occurrences. Batioladinium jaegeri was previously recorded from the upper Hauterivian, Speeton, England (Duxbury, 1977) to the upper Albian, Switzerland (Davey & Verdier, 1973) and the upper Hauterivian to the upper Albian, north-west Germany (Prössl, 1990). Costa & Davey (1992) recorded the last occurrence of the species in the lower middle Cenomanian in England. The type material was described as *Broomea jaegeri* from the upper Barremian in Germany by Alberti (1961).

Batioladinium longicornutum (Alberti, 1961) Brideaux, 1975

Plate 2, Fig. 6

Occurrence in East Greenland. Barremian. Sections 1, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19 and 21. Rare in the lower Barremian, always present in the upper Barremian.

Previous occurrences. Duxbury (1977) and Davey (1979b) recorded *B. longicornutum* (as *Necorbroomea longicornuta*) at Speeton, England to range from the lower Hauterivian (Speeton Clay litho-unit C11, *Endemoceras* ammonite zone) to the top of the 'middle' Barremian (Speeton Clay litho-unit Cement Beds). Harding (1990b) recorded approximately the same range for *B. longicornutum* in the Speeton section. In contrast, Harding records the range of this species in the Gott section, Germany (table 2, 3, text-fig 2) from the upper Hauterivian (lower part of the *Simbirskites (Craspedodiscus) discofalcatus* ammonite zone) to the middle part of the uppermost upper Barremian *Oxyteuthis depressa* belemnite zone, i.e. very close to the top of the Barremian. *Batioladinium longicornutum* is recorded from the Hauterivian to Barremian, north-west Europe (Heilmann-Clausen, 1987) and the upper Hauterivian to the uppermost Barremian, north-west Germany (Prössl, 1990). Piasecki (1979, fig. 10) illustrated a form, which he referred to *B. longicornutum* (as *Necrobromea longicornuta*) from the Hauterivian, Milne Land, East Greenland. This species has relatively short antapical horns and might be a specimen of *Batioladinium radiculatum*, Davey, 1982b. *Batioladinium longicornutum* has also been recorded from the lower Barremian, Barents Sea (Århus *et al.*, 1990) and the Hauterivian and Barremian, Arctic Norway (Thusu, 1978). Doerenkamp *et al.* (1976) il-

Plate 2

Fig. 1. *Batioladinium*? *exiguum* × 500, section 7; GGU 342087–4, 12.3–128.5; MGUH 21688.

Fig. 2. *Batioladinium*? *exiguum* × 500, section 17; GGU 342162–6, 7.4–143.4; MGUH 21689.

Fig. 3. *Batioladinium jaegeri* Specimen with relatively short apical horn × 500, section 7; GGU 342081–4, 21.2–139.6; MGUH 21690.

Fig. 4. *Batioladinium jaegeri* Specimen with long apical horn × 500, section 20; GGU 342183–4, 9.6–134.0; MGUH 21691.

Fig. 5. *Batioladinium shaftesburiense* sp. nov. holotype. × 500, section 26; GGU 351630, 22.0–143.6; MGUH 21692.

Fig. 6. *Batioladinium longicornutum* × 500, section 21; GGU 342239–4, 14.1–141.6; MGUH 21693.

Fig. 7. *Batioladinium micropodum* × 750, section 21; GGU 342238–3, 16.4–126.0; MGUH 21694.

Fig. 8. *Batioladinium micropodum* × 500, section 17; GGU 324169–4, 6.3–155.0; MGUH 21695.

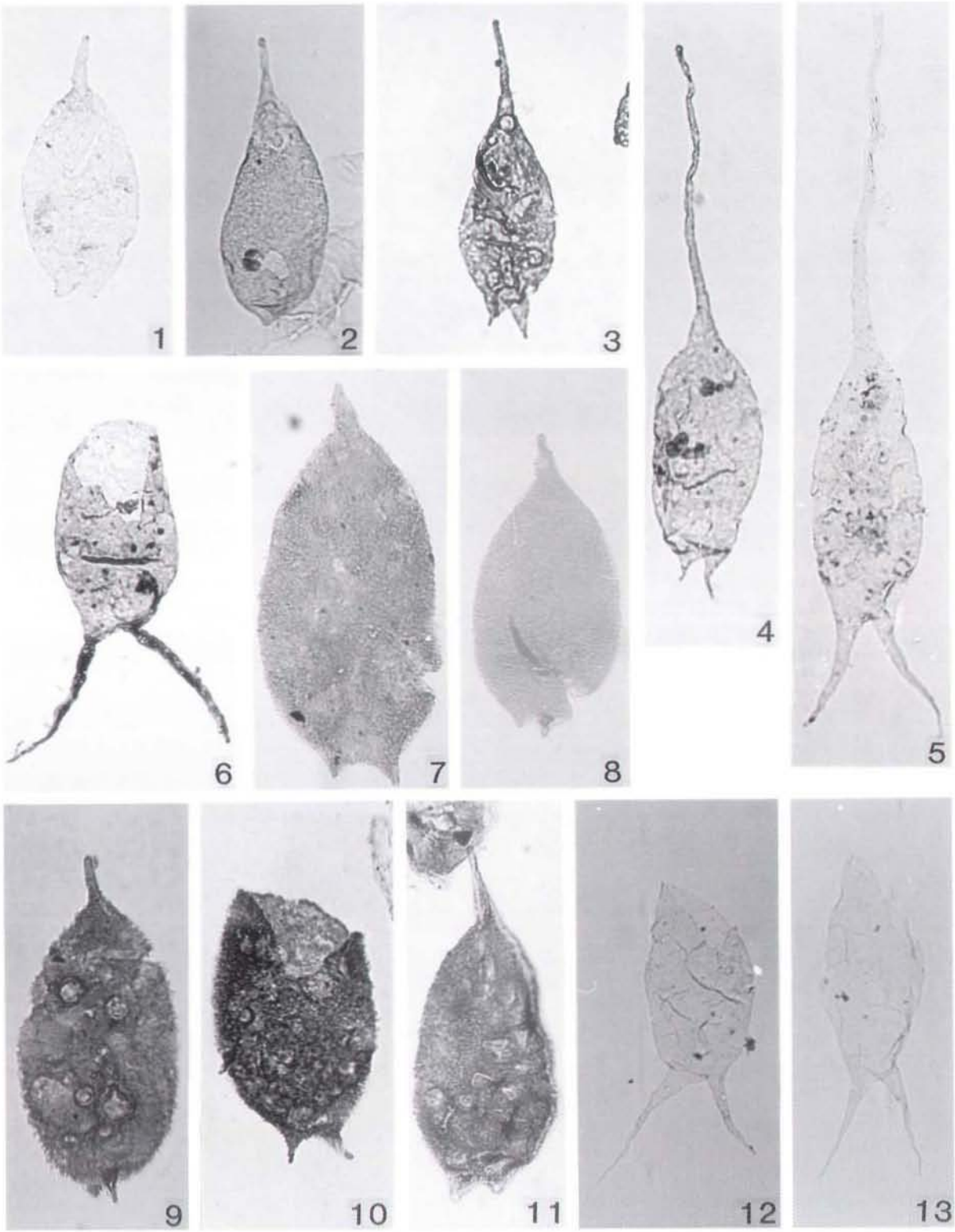
Fig. 9. *Batioladinium*? *pelliferum* × 750, section 17; GGU 342161–4, 14.2–132.0; MGUH 21696.

Fig. 10. *Batioladinium*? *pelliferum* × 750, section 17; GGU 342162–4, 15.5–147.2; MGUH 21697.

Fig. 11. *Batioladinium micropodum/pelliferum* transition form × 750, section 7; GGU 342235–4, 22.0–139.0; MGUH 21698.

Fig. 12. *Batioladinium shaftesburiense* sp. nov. × 500, section 20; GGU 342200–4, 5.0–126.0; MGUH 21699.

Fig. 13. *Batioladinium shaftesburiense* sp. nov. × 500, section 20; GGU 342200–4, 14.2–139.8; MGUH 21700.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lustrated a form referred to *B. longicornutum* from the middle Albian, Banks Island, Arctic Canada. The illustrated specimen is considered to be *B. shaftesburiense* sp. nov. (see below). *Batioladinium longicornutum* has not previously been reported from Arctic Canada but examination of the South Sabine section from Melville Island (kindly provided for me by I.S.P.G., Calgary) yielded a few specimens in samples of supposedly late Barremian age. The species has never been reported from strata younger than late Barremian excluding the above mentioned record by Doerenkamp *et al.* (1976). *Batioladinium longicornutum* was described (as *Broomea longicornuta*) from the upper Hauterivian to the upper Barremian in Germany by Alberti (1961).

According to Harding's (1990b) belemnite-controlled Gott section, *B. longicornutum* occurs from the upper Hauterivian to very close to the top of the Barremian.

Batioladinium micropodum (Eisenack & Cookson, 1960) Brideaux, 1975

Plate 2, Figs 7–8

Comments. In the material from East Greenland, the specimens are coarsely and closely granular, as in the type material described by Eisenack & Cookson (1960).

Occurrence in East Greenland. Upper Barremian to lower Aptian and lower middle Albian. Sections 1, 2, 6, 7, 8, 9, 11, 12, 14, 15, 17, 18, 19, 21, 26, 32 and 33.

Previous occurrences. Batioladinium micropodum was previously recorded from the lower Aptian and lower part of the upper Aptian in the Aptian type area in southern France by Davey & Verdier (1974), the lower Hauterivian in North Sea wells (Heilmann-Clausen, 1987), the lower Barremian, Barents Sea (Århus *et al.*, 1990), the lowermost Barremian, offshore south Norway (Aarhus *et al.*, 1986), the Hauterivian to uppermost Barremian, Arctic Norway (Thusu, 1978), the Hauterivian to uppermost Aptian, Andøya, Norway (Aarhus *et al.*, 1986), the Hauterivian to Aptian, District of Mackenzie, Canada (Brideaux, 1977) and the Barremian to lowermost Albian, Arctic Canada (Pocock, 1976). Eisenack & Cookson (1960) described the type material (as *Broomea micropoda*) from the Aptian and Albian in Australia. The uppermost occurrence of *B. micropodum* in the upper Aptian ammonite dated Aptian type section in France (Davey & Verdier, 1974) advocates for an upper Aptian last occurrence. However Costa & Davey (1992) recorded the last occurrence of the species in the lower upper Albian in ammonite-dated sediments in England.

Batioladinium? *pelliferum* (Alberti, 1961) Brideaux, 1975

Plate 2, Figs 9–10

Discussion. The cyst wall of the specimens recorded from East Greenland is densely covered by 1–2 μ long echinae and resembles Alberti's holotype. The material often differs from the specimen illustrated by Dörhöfer & Davies (1980, figs 33A-D) by having longer and more pronounced echinae.

Batioladinium? *pelliferum* with an echinate surface is normally easily distinguished from *B. micropodum* with a granulate surface, but transitional forms with both echinae and granulae do occur (Plate 2, Fig. 11). Wiggins (1975) treated *B.*? *pelliferum* as a jr syn. of *B. micropodum*, without any reason given. The present author proposes that the two species be retained, like Dörhöfer & Davies (1980), with the remark that intermediate forms exist. The two species occur together and have the same stratigraphic distribution in East Greenland.

Occurrence in East Greenland. Upper Barremian to Aptian and middle Albian. Sections 6, 7, 8, 17, 19 and 26.

Previous occurrences. Previously recorded from the uppermost Barremian to lower Aptian, Germany (Alberti, 1961, type material), the Hauterivian, Germany (Dörhöfer & Davies, 1980) and the Hauterivian and the 'middle' Barremian in North Sea wells (Heilmann-Clausen, 1987).

Batioladinium shaftesburiense sp. nov.

Plate 2, Figs 5 & 12–13

1971 *Broomea* sp.; Singh, p. 321, plate 49, fig. 5.
1976 *Broomea longicornuta*; Doerenkamp *et al.*, plate 5, fig. 26.
1990 *Batioladinium shaftesburiensis* sensu Nøhr-Hansen; Århus *et al.* figs 11 G, H.

Origin of name. After Shaftesbury Formation, Peace River area, north-west Alberta, Canada, where Singh (1971) first recorded the species.

Diagnosis. The cysts are proximate, elongate with slightly convex sides, a long (approximately 1/2 the overall length), slender apical horn and two medium-sized (approximately 1/2 the length of the main body), wide-based, gradually tapering antapical horns. The cysts are frequently dorso-ventrally flattened with slightly convex margin. The wall is thin and hyaline with a psilate surface. The archeopyle is apical (type $\overline{tA}$) with a distinct

ventral sulcal notch. The operculum is simple and usually free.

Description

Cyst type. The cyst is proximate.

Shape. The cyst is elongate with slightly convex sides and one long slender apical horn and two medium-sized antapically horns, of which the right is slightly longer than the left. These horns have wide bases, taper gently and are almost parallel. The cyst is often dorso-ventrally compressed.

Wall relationships. The wall is apparently composed of one layer, the autophragm. The wall is thin, less than 1 μ, and hyaline with a psilate surface.

Paratabulation. This is only indicated by the archeopyle sutures and the presence of a sulcal notch. Two weak sutures are recognised on the holotype below the sulcal notch (Plate 2, Fig. 5) indicating a sulcal plate. The archeopyle suture is located near the apex on the dorsal side.

Archeopyle. The archeopyle is apical (type $\overline{\text{tA}}$), with a distinct sulcal notch. The operculum is simple and lost on all examined specimens except the holotype.

Holotype. Plate 2, Fig. 5, MGUH 21692 from GGU 351530–4, 22.0–143.6.

Type locality. Section 27, Hold with Hope, East Greenland (Fig. 2).

Dimensions. The total length of the holotype is 247 μ, the maximum width is 39 μ. The length of the apical horn is 119 μ, and the length of the antapical horns are 43 μ and 46 μ.

Size range. Total length of the cyst, 247 μ (1 specimen). Length of the apical horn, 119 μ (1 specimen). Length of cyst, excluding the operculum, 102 (113) 128 μ (5 specimens). Width of cyst, 34 (37) 39 μ (5 specimens). Length of the left antapical horn, 25 (33) 43 μ (7 specimens). Length of the right antapical horn, 29 (39) 47 μ (7 specimens).

Discussion. Species of *Batioladinium* with a psilate surface like *B. jaegeri, B.? longicornutum, B. radiculatum* (Davey, 1982b) and *Batioladinium? exiguum* are distinguished by the length and form of their apical and antapical horns. The same criterion is used in defining the new species *B. shaftesburiense*. *Batioladinium shaftesburiense* is distinguished from *B. longicornutum* by the antapical horns being only half as long as in *B. longicornutum*. Additionally the antapical horns of *B. longicornutum* are slender, seldom parallel to one another and characterized by their perforations. The wall of *B. shaftesburiense* differs by its thin and hyaline appearance from the often brownish and thicker cyst wall on *B. longicornutum*. *Batioladinium shaftesburiense* is distinguished from *B. jaegeri* by the length of the antapical horns which are approximately twice the length of the horns of *B. jaegeri*. The antapical horns of *B. radiculatum* (Davey, 1982b) are approximately of the same length as on *B. shaftesburiense* but *B. radiculatum* is distinguished from the new species in having internal vacuoles in the distal part of the cyst and on the antapical horns.

Occurrence in East Greenland. Middle Albian. Sections 20, 23, 29 and 34.

Previous occurrences. Singh (1971) recorded the species as *Broomea* sp from the upper Albian, Shaftesbury Formation, Peace River area, Alberta, Canada, Doerenkamp *et al.* (1976) recorded the species as *Broomea longicornuta* from the lower to middle Albian, Christopher Formation, Banks Island, Arctic Canada and the species was recorded from the lower to middle Albian, Lost Hammer section, Axel Heiberg Island, Arctic Canada (the present author). Århus *et al.* (1990, figs 11G, H) illustrate two specimens of *B. shaftesburiensis* sensu Nøhr-Hansen from lower Barremian cores in the Barents Sea.

Apart from the lower Barremian occurrence in the Barents Sea, the species seems to be restricted to the Albian deposits.

Genus *Bourkidinium* Morgan, 1975; emend.

Type species. *Bourkidinium granulatum* Morgan, 1975, p. 160, plate 2, figs 2a-c.

Discussion. Morgan (1975, p. 160) described and compared the genus *Bourkidinium* as follows. "*Description*. Cysts are chorate, elongate ellipsoidal, and bear long, hollow, tubular processes which are restricted to the apex and antapex (probably associated with only the apical and antapical series of reflected plates). The low relief surface ornament shows no evidence of a cingulum or tabulation. The archeopyle is apical, type A".

Comparison. This genus differs from *Tanyosphaeridium*

Davey & Williams, 1966b by having processes present only at the apex and antapex.

The type species for the genus is *B. granulatum* Morgan, 1975. The only other species so far placed in the genus is *Bourkidinium psilatum* Singh, 1983.

The characteristic feature for the genus is that it has "tubular processes which are restricted to the apex and antapex (probably associated with only the apical and antapical series of reflected plates)" (Morgan, 1975, p. 160). In the description of the type species for the genus *Bourkidinium* Morgan (1975) mentioned that one or two processes may not belong to the apical group. Morgan's (1975) observation together with the precingular processes reported in the present study requires an emendation of the genus *Bourkidinium*.

The following emendation is proposed. "Chorate cysts with an elongate, ellipsoidal main body that bears long, hollow, tubular processes which are restricted to the apex (reflecting apical, or apical and precingular plate-series) and antapex (reflecting antapical, or maybe antapical, postcingular and sulcal plate-series). The equatorial zone is wide and devoid of processes. The low relief surface ornament shows no evidence of a cingulum or tabulation. The archeopyle is apical (type tA)".

Bourkidinium granulatum Morgan, 1975; emend.

Plate 3, Figs 1–9

1975 *Bourkidinium granulatum*; Morgan, p. 160, plate 2, figs 2a-c.
1980 *Bourkidinium granulatum*; Morgan, plate 2, figs 15–16.
1983 *Bourkidinium granulatum* (Morgan, 1975); Singh, p. 124, plate 42, figs 6 & 7.
1987 aff. *Bourkidinium granulatum* (Morgan, 1975); Heilmann-Clausen, p. 47, plate 13, figs 22–24.
1988 *Tanyosphaeridium boletum*; Backhouse, Plate 41, Fig. 15, only Plate 3, Figs 1–9.

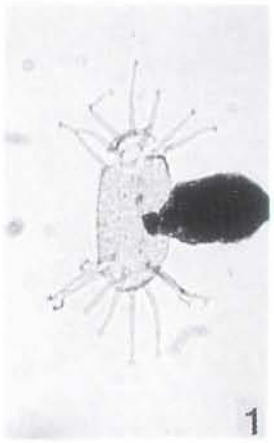
Discussion. The holotype of *B. granulatum* illustrates (Morgan, 1975, figs 2a-c) that all the apical processes are connected to the free operculum whereas Morgan (1975, p. 161) under the description of the type species (*B. granulatum*) mentioned that: "all, or all but one or two of the apical group of processes are on the free operculum". From the original description it can be concluded that a certain number of processes belonging to the precingular plate series is acceptable for the species and additionally for the genus *Bourkidinium*. The illustration of the holotype of the other *Bourkidinium* species, *B. psilatum* Singh, 1983 (p. 125, plate 42, fig. 8) indicates that most, if not all, of the apex processes are of a precingular nature.

Twelve specimens of *B. granulatum* have been recorded in the material from East Greenland. Three of these are without precingular processes (Plate 3, Figs 7–9) and nine with 1–6 precingular processes (Plate 3, Figs 1–6). Six to fifteen processes occur at the antapex but is has not been possible to distinguish the plate series. The processes are 23–30 μ long, 1.0–2.5 μ in diameter. The body is about 45 μ long and 25 μ in diameter.

This discussion advocates an extension of Morgan's (1975, p. 161) description and the following emendation is proposed for *B. granulatum*: "Chorate cysts with elongate ellipsoidal main body that bears long, hollow, distally flared processes arranged in two groups, one in the apical region and the other in the antapical region. The number of processes is variable but there are always more at the antapex than at the apex. The group at the antapex consist of 6–15 processes which, apart from the antapical processes, may include the postcingular and sulcal processes. The group at the apex consists of 4–10 processes including the apical, or the apical and precingular processes. The processes are cylindrical or slightly tapering

Plate 3

Fig. 1. *Bourkidinium granulatum* × 500, section 29; GGU 324599–4, 2.8–120.7; MGUH 21701.
Fig. 2. *Bourkidinium granulatum* × 750, section 25; GGU 346442–3, 5.5–123.0; MGUH 21702 .
Fig. 3. *Bourkidinium granulatum* × 750, section 20; GGU 342199–4, 8.7–118.8; MGUH 21703.
Fig. 4. *Bourkidinium granulatum* × 750, section 20; GGU 342194–4, 10.6–126.0; MGUH 21704.
Fig. 5. *Bourkidinium granulatum* × 750, section 30; GGU 324617–8, 15.5–144.4; MGUH 21705.
Fig. 6. *Bourkidinium granulatum* × 750, section 28; GGU 351636–4, 22.3–120.0; MGUH 21706.
Fig. 7. *Bourkidinium granulatum* × 750, section 28; GGU 351638–4, 10.7–131.0; MGUH 21707.
Fig. 8. *Bourkidinium granulatum* × 750, section 20; GGU 342179–4, 8.2–149.1; MGUH 21708.
Fig. 9. *Bourkidinium granulatum* × 750, section 36; GGU 324090–7, 5.9–131.6; MGUH 21709.
Fig. 10. *Bourkidinium* sp. 1 × 750, section 20; GGU 342199–4, 6.3–139.0; MGUH 21710.
Fig. 11. *Bourkidinium*? sp. 2 × 500, section 10; GGU 342092–4, 18.3–137.1; MGUH 21711.
Fig. 12. *Bourkidinium*? sp. 2 × 500, section 10; GGU 342092–4, 16.4–124.1; MGUH 21712.
Fig. 13. *Callaiosphaeridium asymmetricum* × 500, section 23; GGU 351676, 17.6–123.5; MGUH 21713.
Fig. 14. *Callaiosphaeridium asymmetricum* × 500, specimen with vacuolar parasutural ridges. Section 31; GGU 324623–8, 17.4–131.6; MGUH 21714.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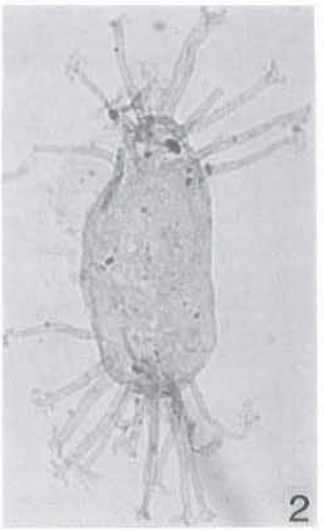
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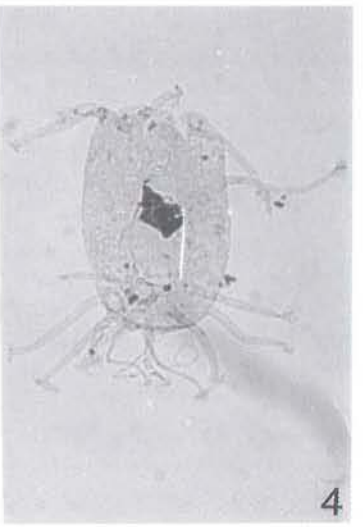
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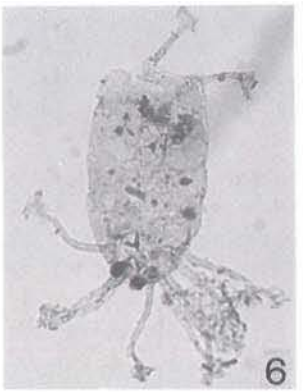
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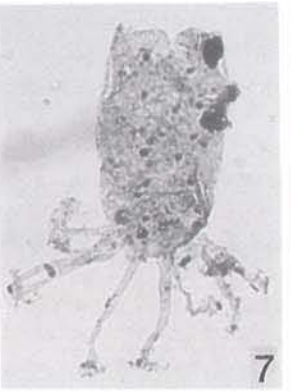
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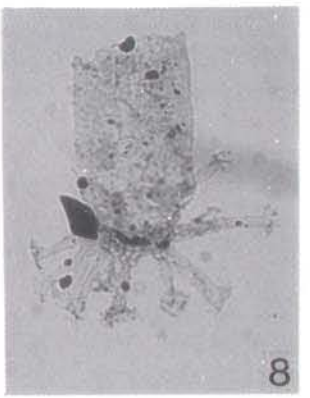
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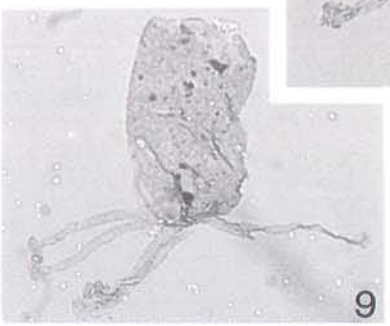
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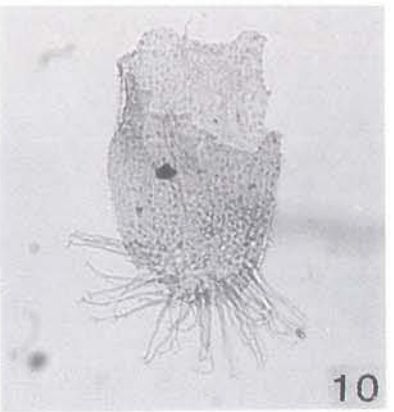
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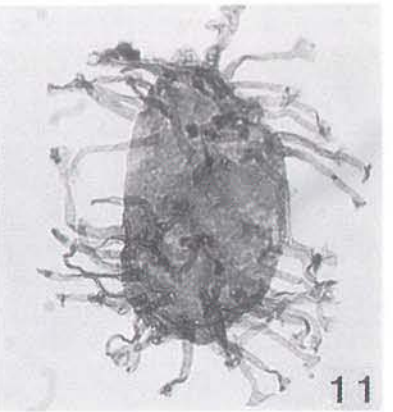
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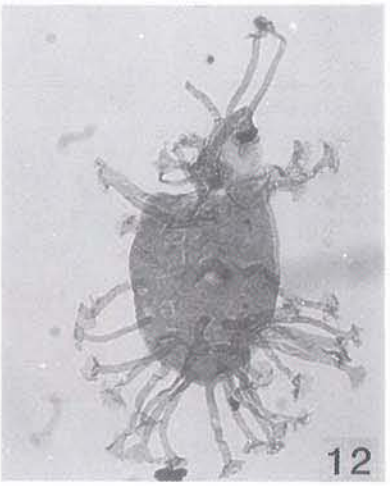
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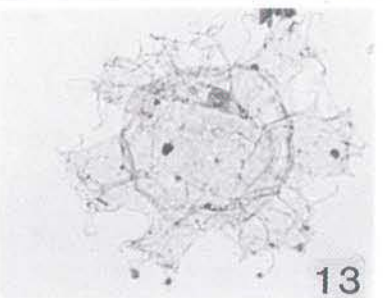
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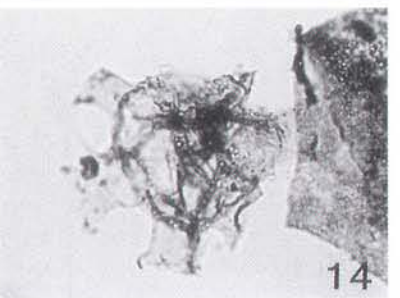
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towards the distal end which is strongly flared and slightly recurved with serrate margins. The body is densely granulate and lacks indications of a cingulum or tabulation. The archeopyle is apical (type tA). The processes at apex are generally concentrated on the free, composite operculum but up to 6 processes may occur on the uppermost part of the precingular plate series leaving a wide equatorial zone devoided of processes".

Occurrence in East Greenland. Upper Barremian, section 1 and middle to upper Albian, sections 20, 23, 24, 25, 28, 29, 30 and 36.

Previous occurrences. Bourkidinium granulatum was previously recorded from the lower Hauterivian, north-west Germany (Prössl, 1990), the Valanginian to the upper Hauterivian as aff. *B. granulatum* in North Sea wells (Heilmann-Clausen, 1987), the upper Aptian to the lower Cenomanian, Peace River area, Canada (Singh, 1983) and the upper Aptian and Albian, Australia (Morgan, 1975, 1980).

Bourkidinium sp. 1

Plate 3, Fig. 10

Description. Elongate to ellipsoidal chorate cyst with approximately 30 long (14–17 μ), slender (1–1.5 μ), distally recurved, serrate processes concentrated in the antapical region. The cingular area is devoid of processes. Processes have not been observed on the apical region of the single specimen observed due to damage. The body is 49 μ long and 31 μ wide and densely covered by granulae. The species differs from the previously described *B. granulatum* and *B. psilatum* by having more antapical processes and by its surface ornamentation.

Occurrence in East Greenland. Only one specimen has been recorded from the middle Albian, section 20.

Bourkidinium? sp. 2

Plate 3, Figs 11–12

Discussion. The specimens questionably assigned to the genus *Bourkidinium* have more than 15 apical/precingular and more than 20 'antapical' processes, a broad cingular area almost devoid of processes, except for 1 to 6 cingular widely spaced, processes. All processes are long, slender, distally trumpet-shaped with a serrate margin.

Occurrence in East Greenland. Lower Barremian, section 10, from where only few specimens have been recorded.

Genus *Callaiosphaeridium* Davey & Williams, 1966b; emend. Below, 1981a

Callaiosphaeridium asymmetricum (Deflandre & Courteville, 1939) Davey & Williams, 1966b

Plate 3, Figs 13–14

Comments. The species occasionally has vacuolar sutural crests as illustrated by Duxbury (1980, plate 8, fig. 11). *Callaiosphaeridium asymmetricum* is always rare in the studied material.

Occurrence in East Greenland. Upper Barremian to upper Albian. Sections 6, 7, 8, 14, 15, 19, 20, 21, 23 and 31.

Previous occurrences. Callaiosphaeridium asymmetricum was previously recorded from Cenomanian to Santonian, southern England (Clarke & Verdier, 1967), lower Hauterivian to lower Campanian, England and the North Sea (Costa & Davey, 1992), Cenomanian to Campanian, France (Foucher, 1979), lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990), Barremian to Aptian – lower Albian in North Sea wells (Heilmann-Clausen, 1987), Aptian Andøya, Norway (Aarhus *et al.*, 1986), middle to upper Albian, Alaska (May & Stein, 1979), upper Albian, central Alberta, Canada (Brideaux, 1971), Barremian, District of Mackenzie, Canada (Brideaux, 1977) and Hauterivian to Cenomanian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978). The type material was recorded as *Hystrichosphaeridium asymmetricum* from the Senonian in France by Deflandre & Courteville (1939).

Genus *Canningia* Cookson & Eisenack, 1960b; emend. Helby, 1987

Canningia palliata Brideaux, 1977

Plate 4, Figs 1–2

Comments. The few specimens observed in this study are similar to Brideaux's (1977, plate 3, figs 1–8) type material in size and shape. No tabulation is observed. The consideration of Helby (1987) that *C. palliata* should be a junior synonym of *C. reticulata* is questioned by the present author. Cookson & Eisenack (1960b, plate 38, fig. 1) clearly show the presence of a cingulum on the holotype of *C. reticulata* whereas a cingulum was not observed on the holotype of *C. palliata* (Brideaux, 1977, plate 3, figs 1–4).

Occurrence in East Greenland. Lower Aptian. Section 7.

Previous occurrence. Canningia palliata was previously

recorded from Barremian, District of Mackenzie, Canada (Brideaux, 1977).

Canningia reticulata Cookson & Eisenack, 1960b; emend. Helby, 1987

Plate 4, Figs 3–6

Comments. The specimens recorded from East Greenland are very similar to the forms of the species described and illustrated from Morocco by Below (1981) but are slightly larger (up to 100 μ wide) in contrast to the width measured by Below (69 μ (73 μ) 84 μ).

Occurrence in East Greenland. In a narrow interval in uppermost lower Aptian, sections 12 and 13, where it is abundant.

Previous occurrences. Canningia reticulata was previously recorded from Barremian to Albian, Morocco, where it is abundant in the uppermost Barremian, middle Aptian and lowermost Albian (Below, 1981; abb. 89), Tithonian, Upper Jurassic, Australia (Cookson & Eisenack, 1960b, type material), Berriasian to Hauterivian, Australia (Helby *et al.*, 1987) and upper Valanginian to 'middle' Barremian, Papua New Guinea (Davey, 1988).

Genus *Canninginopsis* Cookson & Eisenack, 1962b

Canninginopsis cf. *C. colliveri* (Cookson & Eisenack, 1960b) Backhouse, 1988

Plate 4, Fig. 11

Discussion. Cookson & Eisenack (1960b) described the wall of the species as thin, granular or closely to sparsely spinulate. Very few specimens with granulae have been observed in the present study. Most specimens from East Greenland with the same size and shape have 2–7 μ long spines and have been assigned to *Circulodinium brevispinosum* (Pocock, 1962) Jansonius, 1986.

Occurrence in East Greenland. Lower–upper Aptian, section 13.

Previous occurrences. Canninginopsis colliveri was previously recorded from upper Hauterivian to upper Aptian, Andøya (Aarhus *et al.*, 1986), lower middle Albian, central Alberta, Canada (Singh, 1964), middle to upper Albian, Peace River, Canada (Singh, 1971), Hauterivian to lower Albian, District of Mackenzie, Canada (Brideaux, 1977), upper Barremian to upper Albian, Arctic Canada (Pocook, 1976), middle to upper Albian, Alaska (May & Stein, 1979), Hauterivian to Aptian, offshore eastern Canada (Williams, 1975), Hauterivian to Cenomanian, Grand Banks (Bujak & Williams, 1978), uppermost Neocomian to lower Cenomanian, Australia (Morgan, 1980) and uppermost Neocomian to lower Albian in Australia (as *Circulodinium colliveri*) (Helby *et al.*, 1987). The type material was described from the Aptian in Australia by Cookson & Eisenack (1960b).

Genus *Carpodinium* Cookson & Eisenack, 1962b; emend. Leffingwell & Morgan, 1977

Carpodinium granulatum Cookson & Eisenack, 1962b; emend. Leffingwell & Morgan 1977

Plate 4, Fig. 12

Occurrence in East Greenland. Upper part of lower Aptian or lower part of upper Aptian, section 13 and lower part of middle Albian, sections 20 and 21. Only few specimens were recorded.

Previous occurrences. Carpodinium granulatum was previously recorded from the upper Barremian and upper Aptian to upper Albian, north-west Europe and in North Sea wells (Heilmann-Clausen, 1987), upper Aptian to lower part of the upper Albian, north-west Germany (Prössl, 1990), Cenomanian, Peace River area, Canada (Singh, 1983), middle to upper Albian, Alaska (May & Stein, 1979) and upper Aptian, Papua New Guinea (Davey, 1988). The type material was described from the Aptian to Albian in Australia by Cookson & Eisenack (1962a).

Genus *Cassiculosphaeridia* Davey, 1969a

Cassiculosphaeridia magna Davey, 1974

Plate 4, Fig. 13

Occurrence in East Greenland. Upper Barremian. Sections 8 and 18. Only a few specimens have been observed during this study.

Previous occurrences. The type material was recorded from the lower to upper Barremian at Speeton, England by Davey (1974). *Cassiculosphaeridia magna* is also recorded from Ryazanian to Barremian in North Sea wells and Hauterivian to Barremian, north-west Europe (Heilmann-Clausen, 1987) where the species is often a dominant feature of the dinoflagellate cyst assemblages (Davey, 1979b), lower Hauterivian to 'middle' Barremian, north-west Germany (Prössl, 1990). The species

was not recorded above the lower Barremian in Germany and England by Harding (1990b). *Cassiculosphaeridia magna* was also recorded from the lower Barremian, Barents Sea (Århus *et al.*, 1990) and the upper Hauterivian to Aptian, Andøya, Norway (Aarhus *et al.*, 1986). Based on 'accurately' dated material from Speeton, *C. magna* has its last occurrence in the upper Barremian (Davey, 1974).

Cassiculosphaeridia reticulata Davey, 1969a

Plate 4, Fig. 14

Occurrence in East Greenland. Upper Barremian, middle Albian? Sections 1, 11, 15, 16, 17, 18 and 21. The species is rare in the studied material.

Previous occurrences. The type material was recorded from the lower to upper Cenomanian in south-east England and north-west France by Davey (1969). *Cassiculosphaeridia reticulata* was also recorded from the Cenomanian to Santonian, France (Foucher, 1979), lower Cretaceous to upper Santonian, England and the North Sea (Costa & Davey, 1992), lower Hauterivian to middle Albian, north-west Germany (Prössl, 1990), Ryazanian to Late Cretaceous in North Sea wells by Heilmann-Clausen (1987) who mentioned that his ranges might be unreliable due to difficulties in distinguishing between *C. reticulata* and *Ellipsoidictyum imperfectum*. From Norway *C. reticulata* was recorded from the lower Barremian, Barents Sea (Århus *et al.*, 1990), uppermost Hauterivian to Aptian, Andøya (Aarhus *et al.*, 1986) and upper Hauterivian to lower Barremian, south-west offshore Norway (Aarhus *et al.*, 1986).

Genus *Catastomocystis* Singh, 1983
Catastomocystis microreticulata Singh, 1983

Plate 5, Fig. 1

Occurrence in East Greenland. Only three specimens were recorded, one specimen from the lower part of the middle Albian and two specimens from the uppermost Albian – lower Cenomanian?. Sections 26 and 39.

Previous occurrence. The type material was recorded from lower Cenomanian, Peace River area, Canada (Singh, 1983).

Genus *Cauca* Davey and Verdier, 1971
Cauca parva (Alberti, 1961) Davey & Verdier, 1971

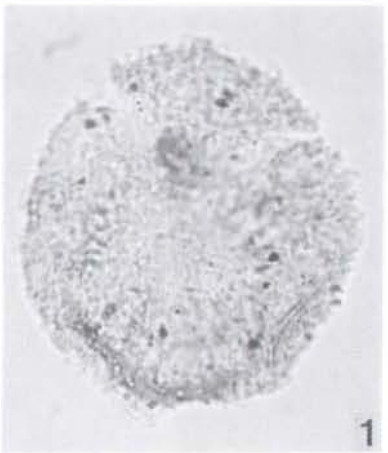
Plate 5, Fig. 2

Occurrence in East Greenland. Upper Aptian to upper Albian. Only two specimens were observed from the uppermost Albian. Sections 12, 13, 20, 21, 22, 23, 26, 27, 30, 31, 33 and 37. Where present, the species always occurs in low numbers.

Previous occurrences. Cauca parva was previously recorded from the 'middle' to upper Barremian from Speeton, England (Duxbury, 1980), upper part of the upper Aptian to upper part of the middle Albian in the Aptian and Albian type sections in south-east France (Davey & Verdier, 1971, 1974), lower Aptian to lower Albian, south England (Duxbury, 1983), the lower Barremian to upper Cenomanian, north-west Germany (Prössl, 1990) upper Barremian to lower Cenomanian, north-west Europe and North Sea wells, being rare in the upper Albian and lower Cenomanian (Heilmann-Clausen, 1987). Doerenkamp *et al.* (1976) recorded the species from middle Albian to upper Albian and from Santonian?, Banks Island, Arctic Canada. The type material was described

Plate 4

Figs. 1 & 2. *Canningia palliata* × 750, section 7; GGU 342087–4, 7.3–125.1; MGUH 21715.
Fig. 3. *Canningia reticulata* × 500, section 37; GGU 351592–4, 20.3–126.5; MGUH 21716.
Fig. 4. *Canningia reticulata* × 500, section 37; GGU 351592–4, 8.5–128.2; MGUH 21717.
Fig. 5. *Canningia reticulata* × 490, section 37; GGU 351592; MGUH 21718.
Fig. 6. *Canningia reticulata* × 1000, same specimen as above close-up of hypocyst.
Fig. 7. *Circulodinium*? sp. 2 × 500, section 10; GGU 342094–4, 11.1–124.9; MGUH 21719.
Fig. 8. *Circulodinium*? sp. 3 × 500, section 9; GGU 342070–4, 15.4–120.0; MGUH 21720.
Fig. 9. *Circulodinium*? sp. 4 × 500, section 7; GGU 342079–4, 19.2–132.3; MGUH 21721.
Fig. 10. *Circulodinium*? sp. 4 × 500, section 7; GGU 342079–3, 16.4–127.1; MGUH 21722 .
Fig. 11. *Canninginopsis* cf. *C. colliveri* × 500, section 13; GGU 351579–4, 19.0–132.0; MGUH 21723.
Fig. 12. *Carpodinium granulatum* × 750, section 20; GGU 342179–4, 6.4–127.6; MGUH 21724.
Fig. 13. *Cassiculosphaeridia magna* × 500, section 18; GGU 342221–4, 9.0–126.0; MGUH 21725.
Fig. 14. *Cassiculosphaeridia reticulata* 500x section 17; GGU 342166–4, 7.5–135.1; MGUH 21726.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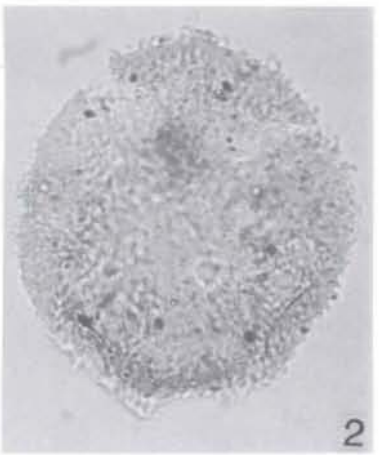
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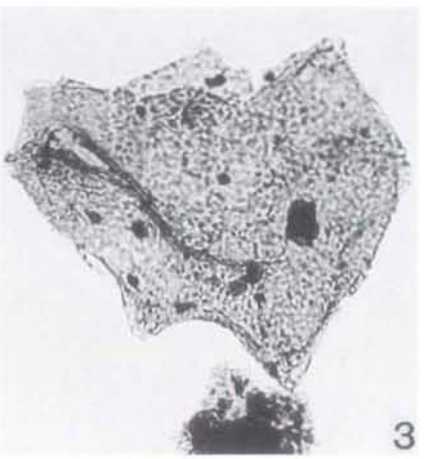
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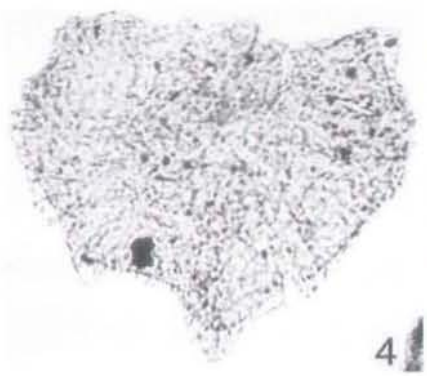
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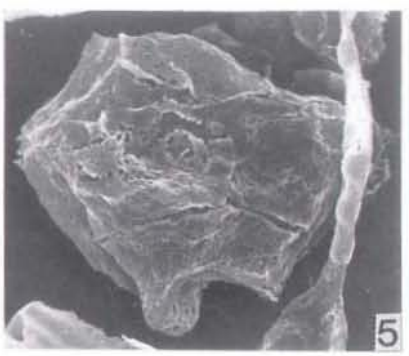
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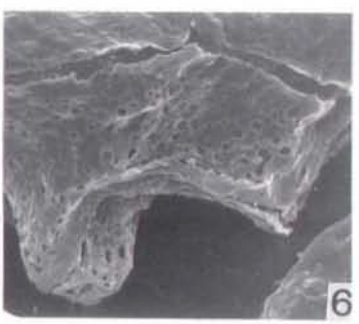
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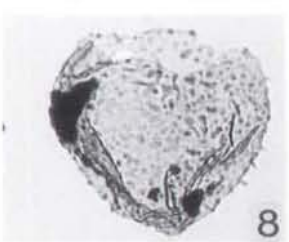
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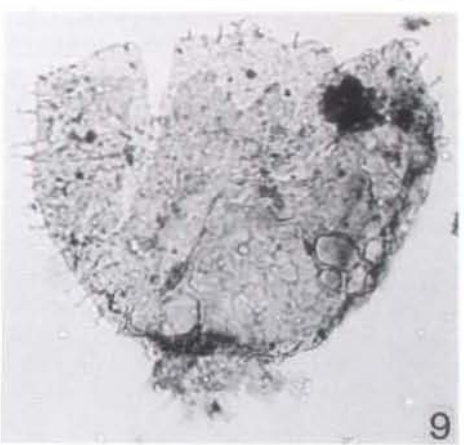
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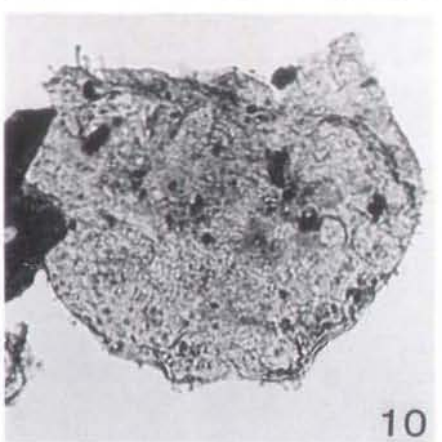
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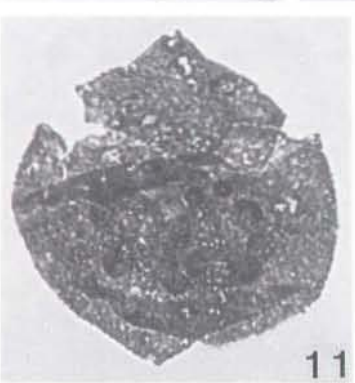
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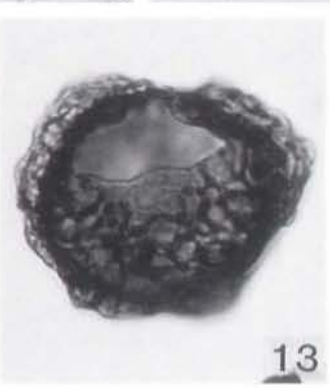
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from the lower Aptian to lower Albian in Germany by Alberti (1961). *Cauca parva* has never been reported 'accurately' below the 'middle' Barremian.

Genus *Chichaouadinium* Below, 1981a
Chichaouadinium vestitum (Brideaux, 1971) Bujak & Davies, 1983

Plate 5, Figs 3–5

Discussion. The specimens recorded from East Greenland are similar to Brideaux's (1971) type material in size and shape. The archeopyle is intercalary often with a free plate 2a. Accessory breaks between the plates 2", 3" and 4" are often observed.

A weakly recognisable, spherical, hyaline inner body is often present. The inner body was not mentioned by Brideaux but the central shadows on the illustrations of Brideaux (1971, plate 29, figs 99–103) may indicate such a body. The species '*Deflandrea*' *limpida* Singh, 1971 which according to Lentin & Williams (1973) is a jr syn. of *C. vestitum,* also has a smooth hyaline, spherical inner body (Singh, 1971, p. 359, plate 61, figs 1–12).

Isabelidinium gallium (Davey & Verdier, 1973) Stover & Evitt, 1978 is very similar to *C. vestitum* but differs according to Davey & Verdier (1973, p. 197), by being smaller and less spinous, has an inner body but (as mentioned) an inner body may also occur in *C. vestitum.*

Accepting an inner body for *C. vestitum* reduces the differences between *C. vestitum* and *I. gallium.* The archeopyle on *I. gallium* was described as intercalary type (2a) (Davey & Verdier, 1973, p. 197) but further details have been difficult to see on their illustrations of the species (plate 3, figs 1–4).

The two species *C. vestitum* and *I. gallium* have been maintained as separate species but further investigation of the archeopyle of *I. gallium* may justify including *I. gallium* as a jr syn. of *C. vestitum.*

Occurrence in East Greenland. Chichaouadinium vestitum occurs in a few horizons from the lower part of the middle Albian; it is nearly always frequent (up to 7%) in the upper part of the middle Albian. Only one questionable specimen has been observed from the upper Albian. Sections 20, 22, 23, 26 and 36.

Previous occurrences. Chichaouadinium vestitum was previously recorded from middle Albian, Spitsbergen (Århus, 1991), upper Albian, central Alberta, Canada (Brideaux, 1971), upper middle Albian and upper Albian, Peace River area, Canada (Singh, 1971), Aptian, Edmonton Embayment, Canada (Banerjee & Davies, 1988), middle and upper Albian, Banks Island, Arctic Canada (Doerenkamp *et al.,* 1976), lower Aptian to upper Albian, Arctic Canada (Pocock, 1976), upper Albian, Utah, USA (Nichols & Jacobsen, 1982), middle and upper Albian, Alaska (May & Stein, 1979), middle Albian, Alaska (May, 1979) and Albian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978).

The species has not, to the author's knowledge, been reported from north-west Europe except for one specimen, described as *Spinidinium* cf. *S. echinoideum* (Cookson & Eisenack, 1960a) Lentin & Williams, 1976, by Davey, 1970. Brideaux (1971, p. 101) mentioned that Davey's *S.* cf. *S. echinoideum* is similar to *C. vestitum.* Brideaux additionally noted that Davey's species is from Cenomanian of Saskatchewan. Davey & Verdier (1973, p. 197) corrected Brideaux's statement mentioning that *S.* cf. *S. echinoideum* (*sensu* Davey, 1970) has been recorded from the Upper Greensand (Albian), Fetcham Mill Borehole, England.

Plate 5

Fig. 1. *Catastomocystis microreticulata* × 500, section 26; GGU 351630–4, 3.0–134.2; MGUH 21727.

Fig. 2. *Cauca parva* × 500, section 30; GGU 342620–7, 6.6–121.0; MGUH 21728.

Fig. 3. *Chichaouadinium vestitum* × 750, section 20; GGU 342202–4, 7.2–123.9; MGUH 21729.

Fig. 4. *Chichaouadinium vestitum* × 500, section 20; GGU 342194–4, 6.0–125.0; MGUH 21730.

Fig. 5. *Chichaouadinium vestitum* × 750, section 20; GGU 342183–4, 17.7–131.2; MGUH 21731.

Fig. 6. *Lagenadinium? membranoidium* × 750, with a very pronounced antapical corona, section 7; GGU 342085–4, 10.1–129.0; MGUH 21732.

Fig. 7. *Chlamydophorella nyei* × 750, section 30; GGU 342620–7, 1.8–131.0; MGUH 21733.

Fig. 8. *Chlamydophorella trabeculosa* × 500, specimen with a relatively short apical horn, section 21; GGU 342320–7, 3.0–121.8; MGUH 21734.

Fig. 9. *Chlamydophorella trabeculosa* × 750, specimen with a relatively short apical horn, section 16; GGU 351512–4, 15.2–148.3; MGUH 21735.

Fig. 10. *Chlamydophorella trabeculosa* × 530, specimen with a relatively short apical horn, section 16; GGU 351512; MGUH 21736.

Fig. 11. *Chlamydophorella trabeculosa* × 750, section 31; GGU 351574–4, 8.3–146.2; MGUH 21737.

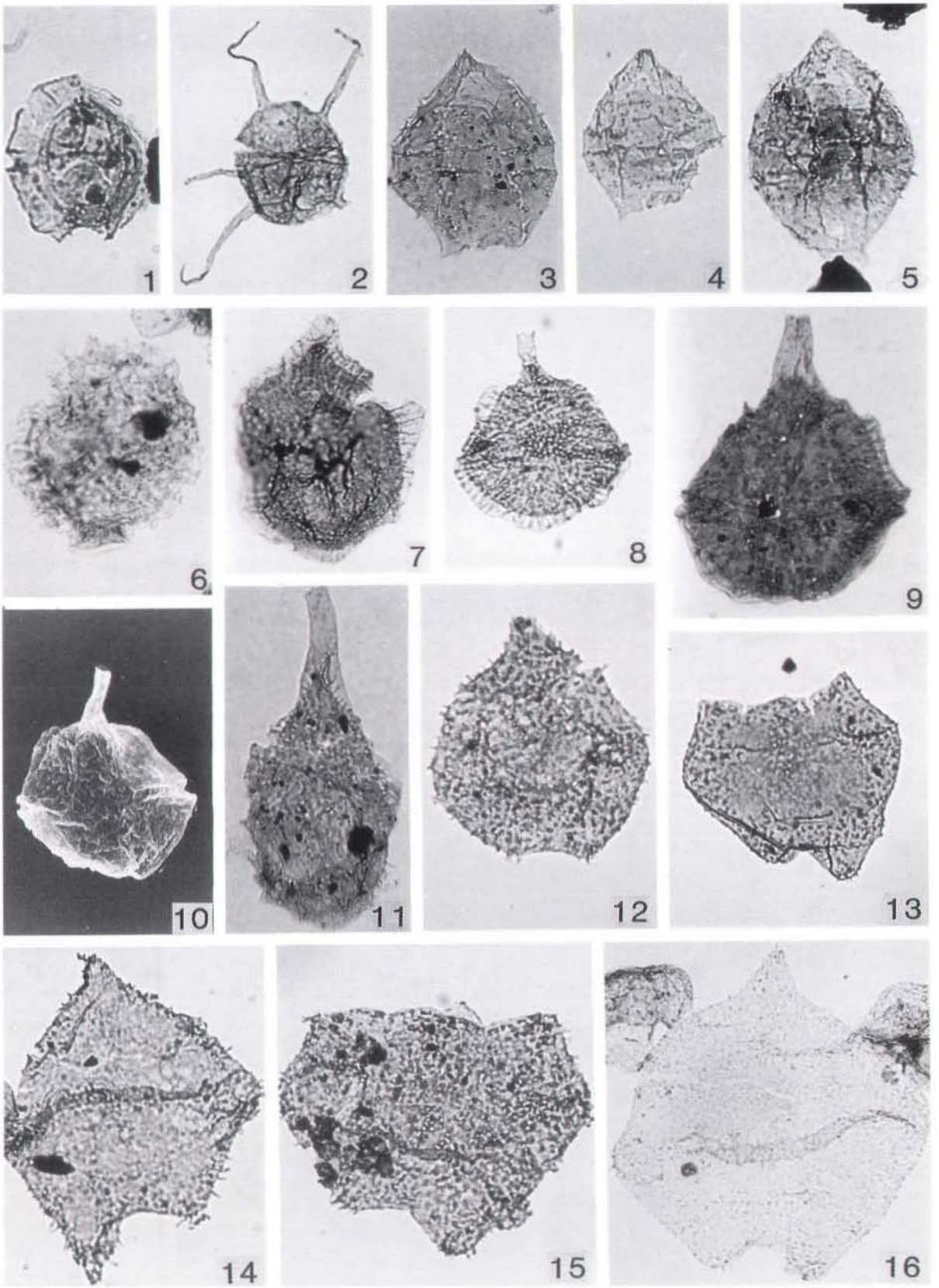
Fig. 12. *Circulodinium* aff. *C. attadalicum* × 500, section 17; GGU 342161–4, 6.3–149.8; MGUH 21738.

Fig. 13. *Circulodinium* aff. *C. attadalicum* × 500, section 17; GGU 342169–4, 8.2–144.2; MGUH 21739.

Fig. 14. *Circulodinium brevispinosum* × 500, section 13; GGU 351587–4, 13.3–153.8; MGUH 21740.

Fig. 15. *Circulodinium brevispinosum* × 500, section 34; GGU 324556–4, 20.9–144.7; MGUH 21741.

Fig. 16. *Circulodinium brevispinosum* × 500, section 17; GGU 342174–7, 2.7–141.7; MGUH 21742.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Remarks. Chichaouadinium vestitum seems to be a good marker species for the upper part of the middle Albian in East Greenland, whereas it has been recorded from both Aptian and Albian deposits in North America.

The morphologically very similar species *I. gallium* is, according to Heilmann-Clausen (1987), a good marker species in north-west Europe for the uppermost Albian.

Genus *Chlamydophorella* Cookson & Eisenack, 1958; emend. Duxbury, 1983

Chlamydophorella nyei Cookson & Eisenack, 1958

Plate 5, Fig. 7

Comments. The specimens referred to *C. nyei* in this study are very similar to Cookson & Eisenack's holotype with a short apical projection. The short slender processes which support the outer membrane are also present on the short apical horn.

Occurrence in East Greenland. Lower Barremian to upper Albian. Only a few specimens were recorded from the Aptian, lower and middle Albian. Sections 6, 8, 9, 11, 17, 18, 20, 21, 24, 26, 30, 37 and 38.

Previous occurrences. Chlamydophorella nyei was previously recorded from the upper Aptian in north-west Europe whereas it ranges up to upper Albian in North Sea wells (Heilmann-Clausen, 1987), lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990), lower Barremian, Barents Sea (Århus *et al.,* 1990), upper Albian, central Alberta, Canada (Brideaux, 1971), middle and upper Albian, Peace River area, Canada (Singh, 1971), upper Albian to Cenomanian, Saskatchewan, Canada (Davey, 1969), lower Aptian to middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), lower Hauterivian to upper Albian, District of Mackenzie, Canada (Brideaux, 1977), lower Aptian to lower Cenomanian, District of Mackenzie, Canada (Brideaux & Myhr, 1976), lower Albian to Cenomanian, Arctic Canada (Doerenkamp *et al.,* 1976) and middle to upper Albian, Alaska (May & Stein, 1979). The type material was described from the Aptian to Turonian in Australia by Cookson & Eisenack (1958).

Chlamydophorella trabeculosa (Gocht, 1959) Davey, 1978

Plate 5, Figs 8–11

Remarks. Davey (1978) has been followed concerning the systematic position of the species.

The specimens observed in the present study all have a pronounced apical horn. The length of the horn is twice (or more) the thickness of the membrane that covers the rest of the cyst. The horn is open-ended with an abrupt angular termination. The contrast to *C. nyei*, no processes are present on the distal part of the horn.

Occurrence in East Greenland. Lower Barremian to upper Albian. The species occurs in 34 sections and is common (more than 10%) in the Aptian.

Previous occurrences. Chlamydophorella trabeculosa was previously recorded from lower Valanginian? – Hauterivian to upper Aptian, north-west Europe (Heilmann-Clausen, 1987), lower–upper? Hauterivian, Denmark (Davey, 1982b), lower Hauterivian to the lower part of the upper Aptian, north-west Germany (Prössl, 1990), Valanginian to upper Aptian, Arctic Norway (Thusu, 1978), lower Barremian, Barents Sea (Århus *et al.,* 1990), Hauterivian to upper Aptian, Andøya, Norway (Aarhus *et al.,* 1986), lower Barremian, offshore south Norway (Ofstad, 1983), upper Hauterivian to lower Albian, Arctic Canada (Pocock, 1976), lower Hauterivian to middle Albian, District of Mackenzie, Canada (Brideaux, 1977), lower Aptian to middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), lower Hauterivian to upper Aptian, District of Mackenzie, Canada (Brideaux & Myhr, 1976), middle and upper Albian, Peace River area, Canada (Singh, 1971), lower Aptian to middle Albian, Arctic Canada (Doerenkamp *et al.,* 1976), Cenomanian, Alaska (May, 1979) and lower Hauterivian to upper Aptian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978). The type material was described from upper Hauterivian in Germany by Gocht (1959).

Summarizing the observations, the species occurs from Valanginian?–Hauterivian to upper Albian – Cenomanian. The presence of the species throughout the Barremian to Albian in the present study thus seems to be of little stratigraphic importance.

Genus *Circulodinium* Alberti, 1961

Circulodinium aff. *C. attadalicum* (Cookson & Eisenack, 1962b) Helby, 1987

Plate 5, Figs 12–13

Discussion. The outline of *C.* aff. *C. attadalicum* is polygonal, with two antapical projections of unequal size, as in *C. attadalicum.* The width of the present specimens ranges from 65–82 μ. *Circulodinium attadalicum* has a width ranging from 72–82 μ.

The midventral and middorsal areas are relatively free

from appendages and the girdle-like equatorial zone, described by (Cookson & Eisenack, 1962b) has also been recognised in the present material.

Circulodinium aff. *C. attadalicum* seems to be quite similar to *C. attadalicum* except from its slightly smaller spines (1–4 μ) compared to the spines on the holotype (2–6 μ). The grouped intervals of spines around the cyst, especially in the antapical region on the holotype of *C. attadalicum* is not observed on *C.* aff. *C. attadalicum*.

Circulodinium aff. *C. attadalicum* differs mainly from *C. brevispinosum* by its ornamentation and smaller size. The similar shape and relatively small size difference between *C. attadalicum* and *C. brevispinosum* seems to have caused problems in the identification of both species. The surface of *C. brevispinosum*, however, is covered by rather densely, somewhat irregularly distributed verucae (1–2 μ) that near the periphery grade into spines or even short muri or membranes up to 5 μ high (Jansonius, 1986, p. 204). *Circulodinium attadalicum* has a width ranging from 72–82 μ (Cookson & Eisenack, 1962b) whereas the width of *C. brevispinosum* ranges from 69 to 110 μ (Pocock, 1962) and from 77–115 μ (Brideaux, 1977).

In the present study, specimens with a width less than 82 μ, a polygonal outline and covered by short spines (1–4 μ), except for the equatorial region, are assigned to *C.* aff. *C. attadalicum*, whereas specimens with a width over 82 μ, a polygonal outline and short spines (2–6 μ), irregularly distributed, are assigned to *C. brevispinosum*.

Occurrence in East Greenland. Barremian to lower Aptian. Sections 1, 3, 6, 7, 9, 11, 14, 15, 16, 17, 18, 19, 21, 32 and 33. The species is very abundant in the upper part of its range.

Previous occurrences. Circulodinium attadalicum was previously recorded from the Aptian stratotype in France (Williams, 1977), the Hauterivian to lower Aptian, offshore eastern Canada, where the species also is very abundant in the lower Aptian (Williams, 1975), Aptian–Albian?, Australia (Cookson & Eisenack, 1962b, type material) and Valanginian and upper Aptian, Papua New Guinea (Davey, 1988).

Circulodinium brevispinosum (Pocock, 1962) Jansonius, 1986

Plate 5, Figs 14–16

Comments. The specimens recorded in the present study are more than 100 μ wide and have the characteristic shape illustrated on the holotype. The length of the spines is variable (2–7 μ) as described by Pocock. The species has been distinguished from *C.* aff. *C. attadalicum* by its regular ornamentation and by being larger. *Canninginopsis colliveri* (Cookson & Eisenack, 1960b) Backhouse, 1988, differs from *C. brevispinosum* by having granulae or smaller spines.

Occurrence in East Greenland. Lower to upper Aptian – lower? Albian. Sections 2, 4, 12, 13, 17, 26 and 34. The species, which becomes more abundant in its upper range, has not been observed together with *C.* aff. *C. attadalicum*.

Previous occurrences. Circulodinium brevispinosum was previously recorded from lower? Albian, Peary Land, North Greenland and upper Aptian to middle Albian Barents Sea as the *Circulodinium colliveri – brevispinosum* group (Århus, 1991), Aptian, Arctic Norway (Thusu, 1978), upper Barremian and Aptian, Canada (Pocock, 1962, holotype). Brideaux (1977, p. 15) discussed the range given by Pocock and suggested a lower and middle Albian, possibly Aptian range, as most likely in the western Canadian plains. Brideaux (1977) reported the species from the Aptian and lower Albian, District of Mackenzie, Canada, Brideaux & McIntyre (1975) gave an Aptian to middle Albian age for the species (as *Tenua* sp. A) in the same area. Brideaux & Myhr (1976) reported the species from the Hauterivian to upper Aptian also from the District of Mackenzie, Canada. *Circulodinium brevispinosum* has also been reported from the upper Aptian and lower Albian, Edmonton Embayment, Canada (Banerjee & Davies, 1988).

The species has only been reported from the pre-Aptian by Brideaux & Myhr (1976) and an Aptian first appearance seems to fit with most of the previous observations. The reported last occurrence for the species seems to range from the upper Aptian to middle Albian.

Circulodinium distinctum (Deflandre & Cookson, 1955) Jansonius, 1986

Plate 6, Fig. 1

Occurrence in East Greenland. Lower Barremian to upper Albian. The species occurs in 34 sequences and is often common (more than 10%).

Previous occurrences. The type material was described from the Senonian in Australia by Deflandre & Cookson (1955). According to Williams & Bujak (1985) *C. distinctum* range from Kimmeridgian (Jurassic) to post Maastrichtian (uppermost Cretaceous).

Circulodinium sp. 1

Plate 6, Figs 2–4

Description. Proximate to proximochorate asymmetric cyst with a short blunt apical horn and two antapical lobes, one of which may be reduced. Cyst dorso-ventrally compressed. Surface of cyst covered by spines which become short or are absent on the central part of the dorsal and ventral sides.

Dimensions. Length with operculum 70–80 μ, width 60–70 μ, length of spines 5–8 μ.

Discussion. Circulodinium aff. *C. attadalicum* differs from *Circulodinium* sp. 1 by its ornamentation of shorter spines and by its more pronounced antapical lobes. *Circulodinium* sp. 1 differs from *C. distinctum* by having an apical horn and two antapical lobes.

Occurrence in East Greenland. Lower part of the upper Albian. Sections 29, 30 and 31.

Circulodinium? sp. 2

Plate 4, Fig. 7

Description. Small cysts (40–45 μ in diameter), spherical to subspherical cyst occasionally with antapical lobes. Archeopyle apical, operculum free. Surface densely reticulate to granulate. Granulae less than 1 μ.

Discussion. Circulodinium? sp. 2 differs from previous described *Circulodinium* species by its smaller size and by its low spines. The species are almost identical to *Canningia? turrita* Brideaux, 1977 in size, shape and ornamentation, but differs by having an apical archeopyle in contrast to the apical/intercalary combination archeopyle described by Brideaux (1977, p. 13).

Occurrence in East Greenland. Barremian and Aptian. Sections 5, 9, 10, 13, 15, 17 and 33.

Circulodinium? sp. 3

Plate 4, Fig. 8

Description. Spherical to subspherical cysts (55–65 μ in diameter) often with antapical lobes. Archeopyle apical, operculum free. Surface ornamentation consists of scattered 1–2.5 μ granulae to short spines.

Discussion. Circulodinium? sp. 3 differs from *Circulodinium*? sp. 2 by being larger and by its fewer but longer granulae/spines. *Circulodinium*? sp. 3 differs from previous described *Circulodinium* species by its smaller size and smaller granulae/spines. *Circulodinium*? sp. 3 has some similarity to *Canningia torulosa* Davey & Verdier, 1973, although the, cingulum on *C. torulosa* is usually devoid of ornamentation.

Occurrence in East Greenland. Barremian and lower Aptian. Sections 9, 13, 15 and 18.

Circulodinium? sp. 4

Plate 4, Figs 9–10

Description. Relatively large (90–115 μ in diameter) subspherical to angular cyst with two antapical lobes. Archeopyle apical, operculum free. Scattered spines (4–5 μ long) with expanded to bifurcate distal termination.

Discussion. Circulodinium? sp. 4 differs from *Circulodinium*? sp. 2 and 3 by its larger size. The two antapical lobes on *Circulodinium*? sp. 4 are less pronounced than the blunt antapical lobes or horns of *Circulodinium brevispinosum* and of *C. attadalicum. Circulodinium*? sp. 4 differs from *Canningia reticulata* by having less pronounced antapical lobes and by its ornamentation.

Occurrence in East Greenland. Upper Barremian. Sections 1, 7 and 14.

Plate 6

Fig. 1. *Circulodinium distinctum* × 500, section 18; GGU 342220–4, 9.6–155.0; MGUH 21743.

Fig. 2. *Circulodinium* sp. 1 × 500, section 30; GGU 324619–3, 18.3–153.0; MGUH 21744.

Fig. 3. *Circulodinium* sp. 1 × 500, section 29; GGU 324599–4, 11.0–126.0; MGUH 21745.

Fig. 4. *Circulodinium* sp. 1 × 500, section 29; GGU 324599–4, 2.3–122.0; MGUH 21746.

Fig. 5. *Cleistosphaeridium? aciculare* × 500, section 10; GGU 342092–7, 13.1–129.0; MGUH 21747.

Fig. 6. *Cleistosphaeridium? aciculare* × 500, section 17; GGU 342161–4, 7.1–151.4; MGUH 21748.

Fig. 7. *Cleistosphaeridium huguoniotii* × 500, section 30; GGU 324617–8, 6.5–126.0; MGUH 21749.

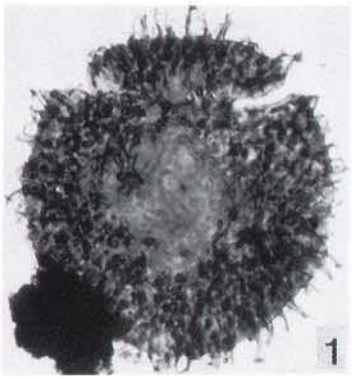
Fig. 8. *Coronifera oceanica* × 500, section 5; GGU 351565–4, 6.4–129.3; MGUH 21750.

Figs 9 & 10. *Cribroperidinium*? aff. *C. cornutum* × 500, section 15; GGU 351512–5, 7.8–127.6; MGUH 21751.

Fig. 11. *Cribroperidinium*? aff. *C. cornutum* × 500, section 11; GGU 342103–4, 12.3–141.0; MGUH 21752.

Figs 12 & 13. *Cribroperidinium edwardsii* × 500, section 8; GGU 342078–9, 13.2–151.4; MGUH 21753.

Fig. 14. *Cribroperidinium edwardsii* × 500, section 30; GGU 324617–8, 14.0–150.5; MGUH 21754.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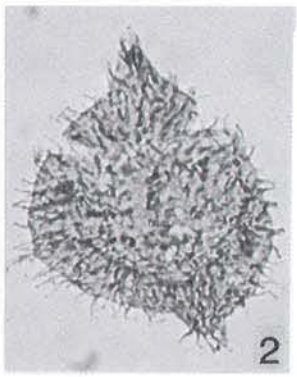
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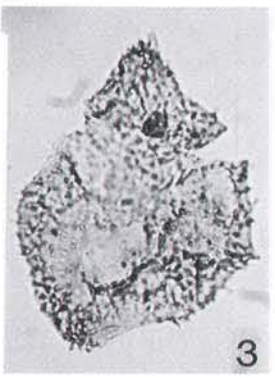
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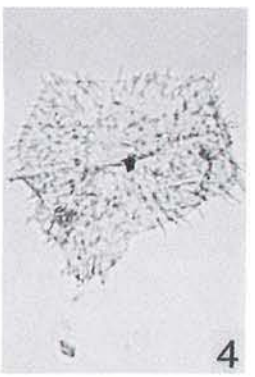
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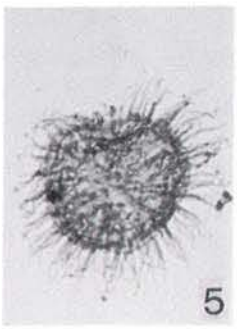
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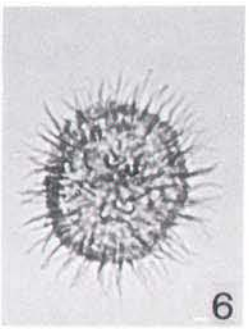
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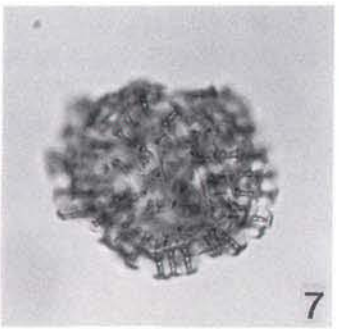
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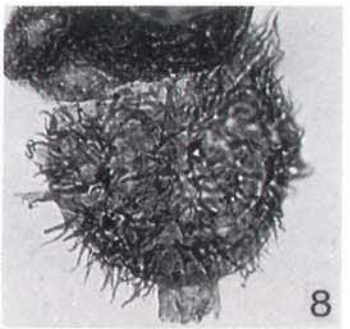
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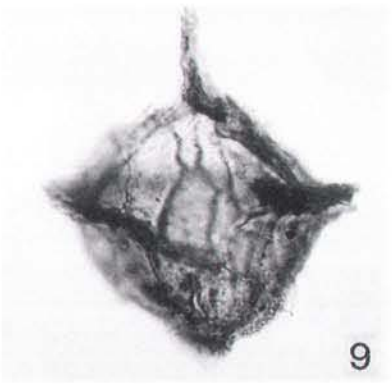
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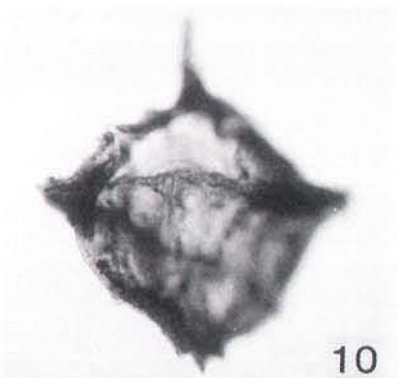
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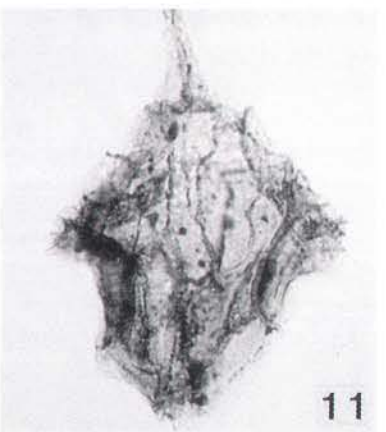
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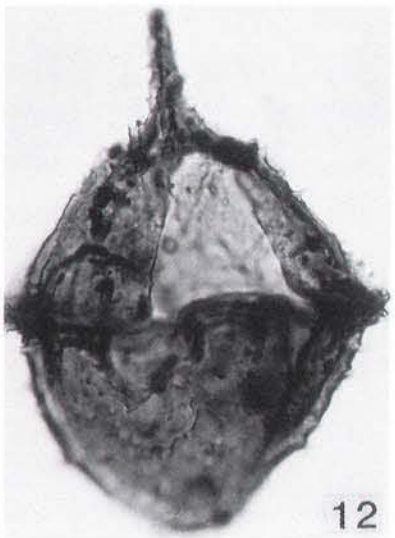
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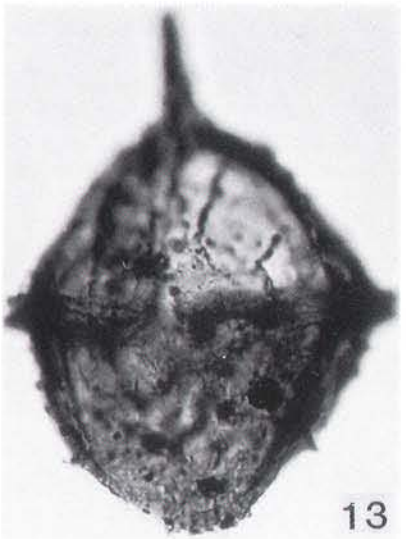
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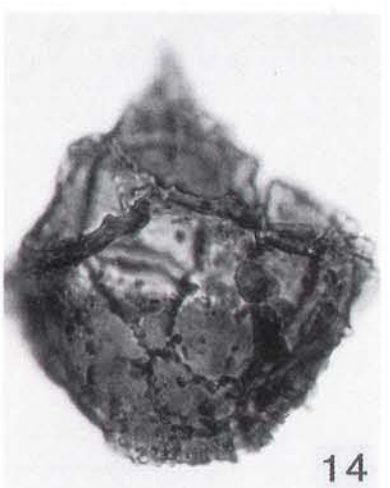
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Genus *Cleistosphaeridium* Davey *et al.*, 1966

Cleistosphaeridium? *aciculare* Davey, 1969a / *Cleistosphaeridium*? *multispinosum* (Singh, 1964) Brideaux, 1971 complex

Plate 6, Figs 5–6

Comments. The specimens included in this complex have numerous short or long slender processes or numerous short or long broader processes. The processes occasionally bifurcate distally. Brideaux (1971) included the *C.*? *aciculare* figured specimen of Davey (1969, plate 6, fig. 11) as a partial synonym of *C.*? *multispinosum.* The processes of *C.*? *multispinosum* are slightly shorter (10–15 μ) than on Davey's specimen (up to 21 μ), but apart from the length of the processes the two species are very similar. The holotype of *C.*? *aciculare,* which has broad acuminate processes, was not included in *C.*? *multispinosum* by Brideaux. In the present study both forms have been included in the *C.*? *aciculare – C.*? *multispinosum* complex.

Occurrence in East Greenland. Lower Barremian to upper Albian; it is present in 35 of the examined sections. The complex has been named *Cleistosphaeridia*? *aciculare* in the range charts (Tables 1–40 and Scheme 2).

Previous occurrences. Previously recorded as *C. aciculare*, upper Hauterivian to upper Cenomanian and as *C. multispinosum*, lower Albian to lowermost Cenomanian, north-west Germany (Prössl, 1990), middle to upper Albian, central Alberta, Canada (Singh, 1964), upper Albian to lower Cenomanian, Saskatchewan, Canada, Davey (1969), lower Barremian to upper Aptian, District of Mackenzie, Canada (Brideaux, 1977), lower Aptian to middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), lower Hauterivian to lower Cenomanian, District of Mackenzie, Canada (Brideaux & Myhr, 1976) and middle to lower Cenomanian, Alaska (May, 1979; May & Stein, 1979).

Cleistosphaeridium huguoniotii (Valensi, 1955a) Davey, 1969a

Plate 6, Fig. 7

Occurrence in East Greenland. Lower Barremian to upper Albian. The species occurs in 27 sections and constitutes often more than 5% of the Barremian dinoflagellate cyst assemblage; however it occurs more sporadically in the Aptian and Albian material.

Previous occurrences. Cleistosphaeridium huguoniottii was previously recorded from the lower Cretaceous to upper Cenomanian, England and the North Sea (Costa & Davey, 1992), the lower Hauterivian, Andøya (Aarhus *et al.,* 1986), Hauterivian, offshore south Norway (Aarhus *et al.,* 1986), middle and upper Albian, Alaska (May & Stein, 1979) and Albian and Cenomanian, offshore eastern Canada (Bujak & Williams, 1978). The type material was described from the Upper Cretaceous by Valensi (1955).

Genus *Coronifera* Cookson & Eisenack, 1958; emend. Mao Shaozhi & Norris, 1988

Coronifera oceanica Cookson & Eisenack, 1958; emend. May, 1980

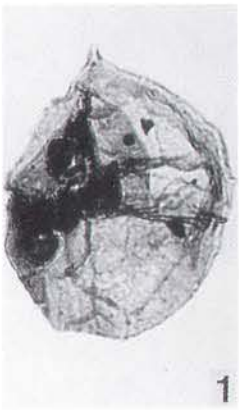
Plate 6, Fig. 8

Occurrence in East Greenland. Barremian to middle Albian. Sections 1, 5, 7, 8, 11, 12, 15, 17, 18, 19, 20, 21 and 23, where it only occurs sporadically and in low numbers.

Previous occurrences. Coronifera oceanica was previously recorded from the upper Hauterivian to the upper Turonian, north-west Germany (Prössl, 1990), Hauterivian to Barremian in North Sea wells (Heilmann-Clausen, 1987), lower Albian, Saskatchewan, Canada (Davey,

Plate 7

Fig. 1. *Cribroperidinium exilicristatum* × 500, section 21; GGU 342232–4, 17.7–125.3; MGUH 21755.
Fig. 2. *Cribroperidinium exilicristatum* × 500, section 21; GGU 342232–4, 10.3–126.0; MGUH 21756.
Fig. 3. *Cribroperidinium intricatum* × 500, section 24; GGU 346458–4, 17.5–136.0; MGUH 21757.
Fig. 4. *Cribroperidinium intricatum* × 500, section 24; GGU 346458–4, 9.8–139.7; MGUH 21758.
Fig. 5. *Cribroperidinium muderongense* × 500, section 19; GGU 342215–3, 13.7–140.3; MGUH 21759.
Fig. 6. *Cribroperidinium muderongense* × 500, section 19; GGU 342215–3, 4.1–138.2; MGUH 21760.
Fig. 7. *Cribroperidinium tensiftense* × 500, section 30; GGU 342610–3, 12.3–137.2; MGUH 21761.
Fig. 8. *Ctenidodinium elegantulum* × 500, section 18; GGU 342222–7, 12.7–127.8; MGUH 21762.
Fig. 9. *Desmocysta plekta* × 500, specimen with precingular archeopyle, section 1; GGU 360380–4, 14.1–136.4; MGUH 21763.
Fig. 10. *Desmocysta plekta* × 500, specimen with precingular archeopyle, section 21; GGU 342240–4, 18.9–122.2; MGUH 21764.
Fig. 11. *Desmocysta plekta* × 525, specimen with apical archeopyle, section 31; GGU 324623–4, 10.9–140.0; MGUH 21765.
Fig. 12. *Desmocysta plekta* × 750, specimen with apical archeopyle, section 31; GGU 324623–4, 1.7–128.9; MGUH 21766.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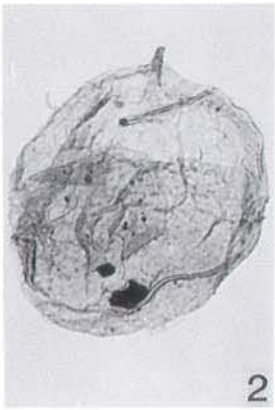
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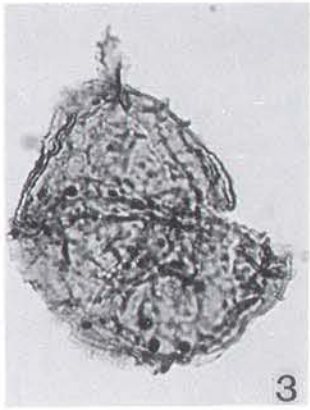
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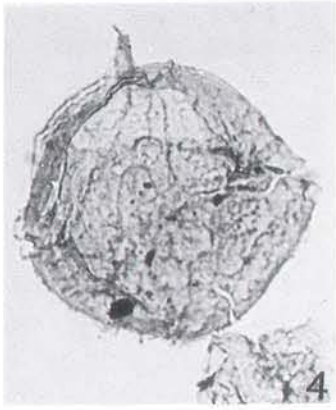
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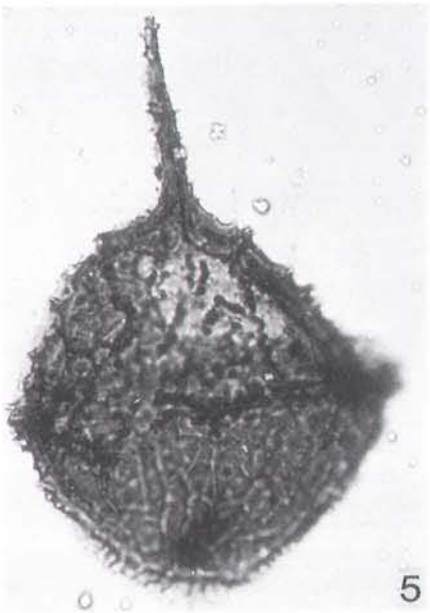
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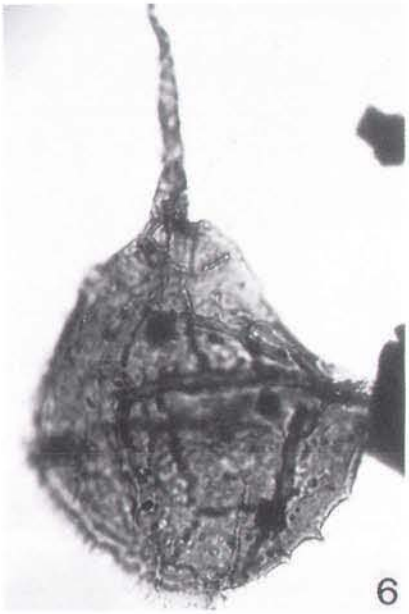
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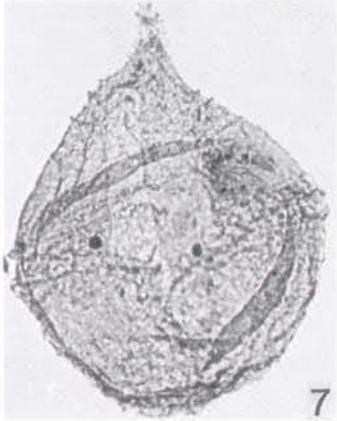
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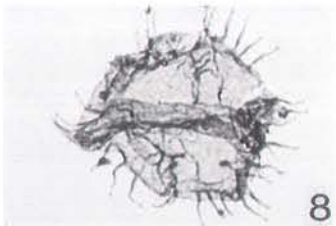
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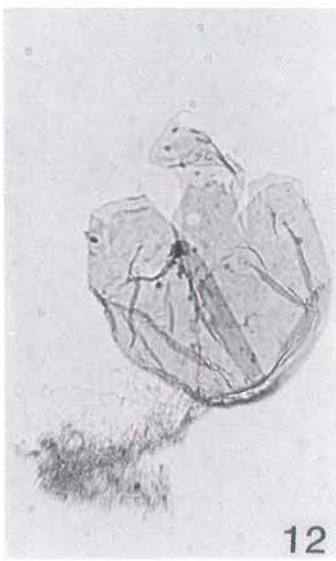
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1969), lower to upper Albian, Arctic Canada (Pocock, 1976), middle Albian, Arctic Canada (Doerenkamp *et al.*, 1976), lower Hauterivian to upper Barremian, District of Mackenzie, Canada (Brideaux & Myhr, 1976), lower Cenomanian, Peace River Area, Canada (Singh, 1983) and lower Hauterivian to lower Cenomanian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978). The type material was described from the Albian of Australia by Cookson & Eisenack (1958).

Genus *Cribroperidinium* Neale & Sarjeant, 1962; emend. Helenes, 1984

Cribroperidinium? aff. *cornutum* Davey, 1974

Plate 6, Figs 9–11

Comments. The cingular and antapical extensions of the pericoels are not as pronounced as on the holotype (Davey, 1974; Plate 2, Figs 2, 3).

Occurrence in East Greenland. Upper part of lower Barremian and upper Barremian. Sections 8, 11, 15, 16 and 19?. The species is rare in the present material.

Previous occurrences. Cribroperidinium? *cornutum* was previously recorded from the 'middle' and upper Barremian, Speeton, England (Davey, 1974, type material; Duxbury, 1980), upper Barremian, Speeton, England, and Gott, Germany (Harding, 1990b), Santonian, north-west Germany (Yun, 1981) and Barremian in North Sea wells (Heilmann-Clausen, 1987).

Cribroperidinium edwardsii (Cookson & Eisenack, 1958) Davey, 1969a

Plate 6, Figs 12–14

Comments. The cysts from East Greenland assigned to *Cribroperidinium edwardsii* are thick walled with scattered coarse spines on the plates. Tabular ridges with few broad based spines have been observed.

Occurrence in East Greenland lower Barremian to upper Albian. Sections 2, 5, 7, 8, 9, 11, 15, 16, 17, 18, 19, 21, 23, 26, 29, 30, 32 and 33.

Previous occurrences. Cribroperidinium edwardsii was previously recorded from the lower Hauterivian to upper Cenomanian, north-west Germany (Prössl, 1990) and Berriasian to Maastrichtian, world-wide (Helenes, 1984). The type material was described from the Albian to lower Turonian in Australia by Cookson & Eisenack (1958).

Cribroperidinium exilicristatum (Davey, 1969a) Stover & Evitt, 1978

Plate 7, Figs 1–2

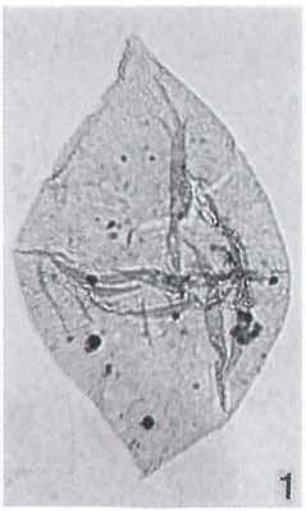
Comments. The cysts from East Greenland included in *Cribroperidinium exilicristatum* are similar in size and shape and have the same poorly defined sutural crests as described by Davey (1969).

Dimensions. Length (77–80 μ), width (60–80 μ), 4 specimens.

Occurrence in East Greenland. Only recorded from the lower Barremian, section 21, where it is common in a restricted interval.

Plate 8

Fig. 1. *Diconodinium articum* × 750, section 22; GGU 346584–4, 18.9–153.3; MGUH 21767.
Fig. 2. *Dingodinium*? *albertii* × 500, section 17; GGU 342169–4, 15.1–121.5; MGUH 21768.
Fig. 3. *Dingodinium*? *albertii* × 580, section 17; GGU 342162; MGUH 21769.
Fig. 4. *Dingodinium*? *albertii* × 2300, same specimen as above close-up of sulcal region, section 17; GGU 342162.
Fig. 5. *Discorsia nanna* × 500, section 17; GGU 342161–4, 6.1–126.2; MGUH 21770.
Fig. 6. *Dorocysta litotes* × 500, section 30; GGU 324613–8, 12.3–136.0; MGUH 21771.
Fig. 7. *Ellipsoidictyum imperfectum* × 500, section 21; GGU 342240–4, 5.0–120.8; MGUH 21772.
Fig. 8. *Endoscrinium campanula* × 500, section 22; 346584–4, 12.1–144.0; MGUH 21773.
Fig. 9. *Endoscrinium* cf. *E. rostratum* × 500, section 32; 303122–5–4, 6.7–127.0; MGUH 21774.
Fig. 10. *Epelidosphaeridia spinosa* × 500, section 39; 355321–4, 2.5–135.0; MGUH 21775.
Fig. 11. *Epelidosphaeridia* sp. 1 × 500, section 37; 324648–4, 20.5–132.0; MGUH 21776.
Fig. 12. *Epelidosphaeridia* sp. 1 × 500, section 37; 324650–4, 8.5–121.0; MGUH 21777.
Fig. 13. *Exiguisphaera plectilis* × 500, section 7; 342081–4, 3.1–139.6; MGUH 21778.
Fig. 14. *Exiguisphaera plectilis* × 800, section 17; 342166; MGUH 21779.
Figs 15 & 16. *Exiguisphaera plectilis* × 1000, same specimen as above, close-up of ornamentation.
Fig. 17. *Exochosphaeridium phragmites* × 500, section 19; GGU 342215–3, 21.9–126.0; MGUH 21780.
Fig. 18. *Florentinia mantellii cooksoniae* complex × 500, section 21; GGU 342237–4, 8.9–138.0; MGUH 21781.
Fig. 19. *Fromea amphora* × 500, section 17; GGU 342167–4, 8.6–141.0; MGUH 21782.
Fig. 20. *Fromea fragilis* × 500, section 17; GGU 342161–4, 11.9–150.0; MGUH 21783.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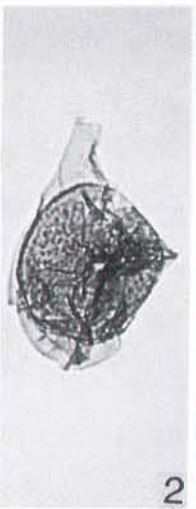
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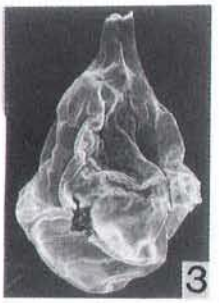
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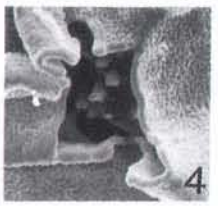
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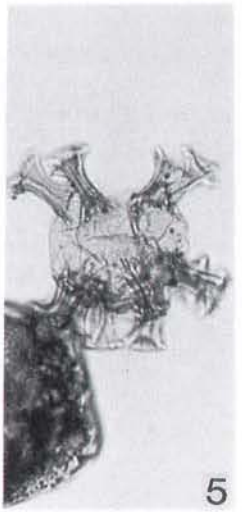
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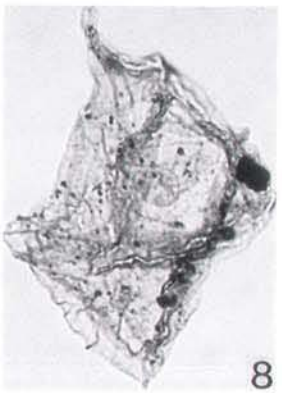
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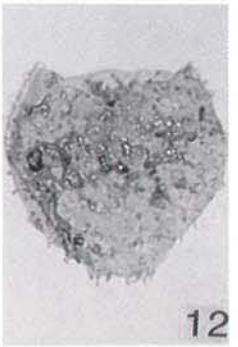
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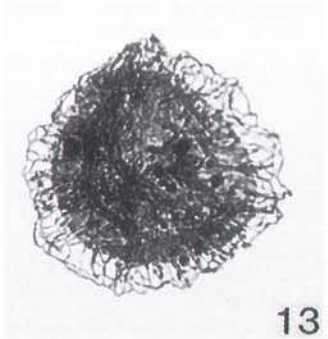
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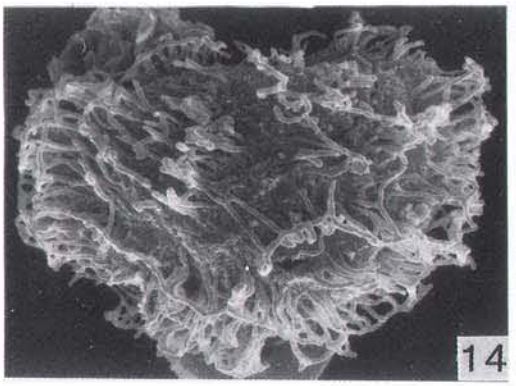
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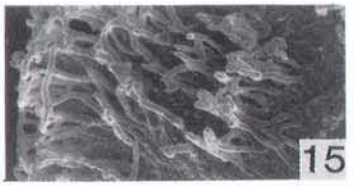
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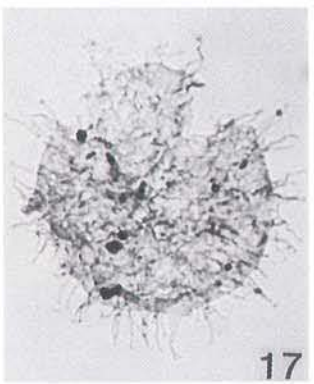
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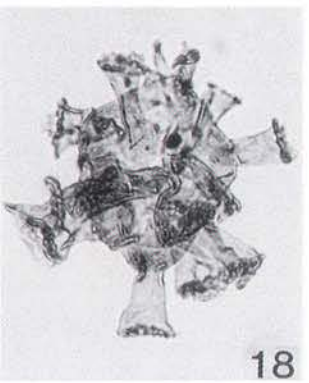
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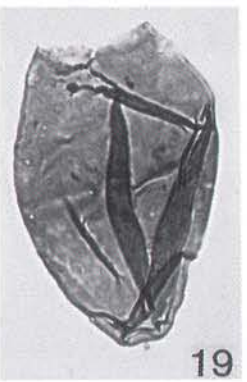
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Previous occurrences. Cribroperidinium exilicristatum was previously recorded from the lower Cenomanian, north-west Germany (Prössl, 1990), lower to upper Albian, France (Davey & Verdier, 1973) Cenomanian, England and upper Albian, Saskachewan, Canada (Davey, 1969, type material), Albian to lower Santonian, Peace River area (Singh, 1983) and upper Albian to lower Cenomanian, Libya (Uwins & Batten, 1988). The lower Barremian specimens recorded from East Greenland seem to be the oldest record of the species, which has never previously been reported from stages older than Albian.

Cribroperidinium intricatum Davey, 1969a

Plate 7, Figs 3–4

Comments. The sutural crests, intratabular ornamentation and shape of the material from East Greenland is very similar to Davey's (1969) description, whereas the overall length (83–94 μ), overall width (68–83 μ) and length of the horn (11–14 μ) on three measured specimens are slightly smaller than Davey's (1969) type material.

Occurrence in East Greenland. Only recorded from the upper Albian. Sections 24 and 31.

Previous occurrence. The type material was recorded from Albian and Cenomanian, England and upper Albian Saskatchewan by Davey (1969).

Cribroperidinium muderongense (Cookson & Eisenack, 1958) Davey, 1969a

Plate 7, Figs 5–6

Comments. The specimens from East Greenland assigned to *Cribroperidinium muderongense* have a rather long, slender apical horn (up to 50 μ). The sutural ridges are spiny. Spines also occur on the intratabular areas as single spines or as spiny ridges.

Occurrence in East Greenland. Upper Barremian. Sections 1, 8 and 19. The species is abundant in a restricted interval in section 19.

Previous occurrences. Cribroperidinium muderongense was previously recorded from the lower Hauterivian to upper Aptian, north-west Germany (Prössl, 1990) and Barremian to Santonian world-wide (Helenes, 1984). The type material was described from the Aptian in Australia by Cookson & Eisenack (1958).

Cribroperidinium tensiftense Below, 1981a

Plate 7, Fig. 7

Occurrence in East Greenland. Middle upper Albian. Section 30.

Previous occurrences. Cribroperidinium tensiftense was previously recorded from the lower and upper Barremian England and Germany (Harding, 1990b), lower Barremian to upper Aptian, north-west Germany (Prössl, 1990) and Hauterivian to Albian, Morocco (Below, 1981, type material).

Genus *Ctenidodinium* Deflandre, 1938b, emend. Benson, 1985
Ctenidodinium elegantulum Millioud, 1969; emend. Below, 1981a

Plate 7, Fig. 8

Occurrence in East Greenland. A few specimens were recorded from the lower and upper Barremian. Sections 9, 11, 14, 15, 16 and 18.

Previous occurrences. Ctenidodinium elegantulum was previously recorded from ammonite dated lower Aptain strata, south England (Duxbury, 1983; Lister & Batten, 1988), the lower Hauterivian to upper Barremian, north-west Germany (Prössl, 1990), the lower Valanginian to lower Aptian, north-west Europe (Heilmann-Clausen, 1987), lower Barremian, offshore south Norway (Aarhus *et al.*, 1986), late Hauterivian to lower Barremian offshore south Norway (Costa, 1981; Ofstad, 1983) and Hauterivian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978). The type material was described from the upper Hauterivian to Barremian in France by Millioud (1969).

Genus *Desmocysta* Duxbury, 1983
Desmocysta plekta Duxbury, 1983

Plate 7, Figs 9–12

Discussion. Out of 94 specimens examined from East Greenland, 73 specimens display the same characteristic features including a two-plate, precingular archeopyle, as Duxbury (1983) described for the holotype. In additional 9 damaged specimens were observed, on which it was impossible to recognise the two-plate precingular archeopyle. The species occurs in 23 sections of late early Barremian to late Albian age. Whereas 12 specimens of another form, very similar in size and appearance to *D. plekta,* have been recognised in the upper Albian section

31. The species differs from *D. plekta* by having an apical archeopyle. In the present study they are included in *D. plekta* but the different archeopyle may advocate the erection of a new species and maybe also a new genus.

Previous occurrence. The type material was recorded from the Aptian in England by Duxbury (1983).

Genus *Diconodinium* Eisenack & Cookson, 1960; emend. Morgan, 1977
Diconodinium arcticum Manum & Cookson, 1964

Plate 8, Fig. 1

Comments. Only two specimens have been recorded. They occur in the middle Albian sections 22 and 23. The specimens are approximately 75 μ long and 49 μ wide. The cyst is smooth to weakly granulate and fusiform in shape.

Previous occurrences. Diconodinium arcticum was previously recorded from the Upper Cretaceous, Canada (Manum & Cookson, 1964, type material; McIntyre, 1974) and Aptian in Senegal (Jain & Millepied, 1973). The present record seems to be the first specimens observed from Albian sediments.

Genus *Dingodinium* Cookson & Eisenack, 1958; emend. Mehrotra & Sarjeant, 1984b
Dingodinium? *albertii* Sarjeant 1966c

Plate 8, Figs 2–4

Comments. The size of the recorded specimens falls within the size range of the type material (overall lengths 50–66 μ, overall widths 37.5–52 μ) described by Sarjeant (1966b).

Occurrence in East Greenland. Lower Barremian to lower Aptian. The species is nearly always present in the lower Barremian, upper Barremian and lower Aptian. Sections 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 21, 32 and 33.

Previous occurrences. Dingodinium? *albertii* was previously recorded from the lower Barremian in Speeton, England (Sarjeant, 1966b, type material), Berriasian to Barremian, Speeton, England (Duxbury, 1977), upper Jurassic to lower Albian, England and the North Sea (Costa & Davey, 1992), upper Hauterivian to upper Barremian, Speeton, England and Gott, Germany (Harding, 1990b), lower Aptian to lowermost Albian, south England (Duxbury, 1983), Aptian, south England (Lister & Batten, 1988), Aptian, south-east France (Davey & Verdier, 1974) and upper Aptian to lower Albian, Germany (Davey, 1982a). The last occurrence of the species tends to be a good marker for the uppermost Aptian – lowermost Albian.

Remarks. Davey (1978) mentioned that the Europeans have tended to use *D.*? *albertii* (overall size 50–66 μ) for their specimens and the Australians and Canadians use *D. cerviculum* (overall size 81–109 μ). The difference between the two species is one of size rather than morphology.

Genus *Discorsia* Duxbury, 1977; emend. Khowaja-Ateequzzaman *et al.*, 1985
Discorsia nanna (Davey, 1974) Duxbury, 1977; emend. Khowaja-Ateequzzaman *et al.*, 1985

Plate 8, Fig. 5

Occurrence in East Greenland. Upper Barremian to lower part of the upper Albian. Sections 1, 2, 6, 7, 8, 9, 14, 17, 18, 19, 20, 21, 22, 23, 26, 31, 33 and 37.

Previous occurrences. Discorsia nanna was previously recorded from the lower Barremian at Speeton, England (Davey, 1974, type material), upper Aptian, south-east France (Davey & Verdier, 1974), lower Valanginian to lower Albian, England and the North Sea (Costa & Davey, 1992), upper Aptian to lower Albian, Germany (Davey, 1982a), the lower Hauterivian to lower part of the upper Aptian, north-west Germany (Prössl, 1990), upper Valanginian to lower Albian, north-west Europe (Heilmann-Clausen, 1987) lower Barremian, Barents Sea (Århus *et al.*, 1990), lower and upper Barremian, District of Mackenzie, Canada (Brideaux, 1977), lower and upper Barremian, District of Mackenzie, Canada (Brideaux & Myhr, 1976) and lower Cenomanian, Peace River area, Canada (Singh, 1983).

Genus *Dorocysta* Davey, 1970
Dorocysta litotes Davey, 1970

Plate 8, Fig. 6

Occurrence in East Greenland. Upper Albian. Sections 24, 25, 27, 28, 29, 30, 31, 35, 36, 37, 38, 39 and 40.

Previous occurrences. Dorocysta litotes was previously recorded from top middle to lowermost upper Cenomanian, north-west Germany (Prössl, 1990), Cenoma-

nian, England and France (Davey, 1970, type material), and Albian to lower Cenomanian, District of Mackenzie, Canada (Brideaux & Myhr, 1976).

Ellipsoidictyum Klement, 1960
Ellipsoidictyum imperfectum (Brideaux & McIntyre, 1975) Lentin & Williams, 1977b

Plate 8, Fig. 7

Occurrence in East Greenland. From upper Barremian to middle Albian. The species is present but never abundant in 18 sections.

Previous occurrences. Ellipsoidictyum imperfectum was previously recorded from the upper part of upper Aptian to the lower–uppermost? part of the upper Albian, England and the North Sea (Costa & Davey, 1992), upper Hauterivian to middle Barremian, Andøya, Norway (Aarhus *et al.*, 1986), lower Aptian to middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975, type material), lower to upper Albian, Arctic Canada (Doerenkamp *et al.*, 1976), lower Hauterivian to middle Albian, District of Mackenzie, Canada (Brideaux, 1977) and lower Aptian to middle Albian, District of Mackenzie, Canada (Brideaux & Myhr, 1976).

Genus *Endoscrinium* (Klement, 1960) Vozzhennikova, 1967
Endoscrinium campanula (Gocht, 1959) Vozzhennikova, 1967

Plate 8, Fig. 8

Occurrence in East Greenland. From lower Barremian to upper Albian, the species is seldom represented by more than two specimens in each sample. Sections 1, 7, 8, 9, 10, 11, 15, 16, 17, 19, 20, 21, 22, 23, 30, 32, 33 and 39.

Previous occurrences. Endoscrinium campanula was previously recorded from the lower Hauterivian, north-west Germany (Gocht, 1959, type material), the lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990), Ryazanian to Aptian – lower Albian in North Sea wells (Heilmann-Clausen, 1987), upper Hauterivian to middle Barremian, offshore south Norway (Ofstad, 1983), lower Barremian to middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), middle to upper Albian Peace River area, Canada (Singh, 1971), middle Albian to Cenomanian, Arctic Canada (Doerenkamp *et al.*, 1976), lower Aptian to upper Albian, Arctic Canada (Pocock, 1976), middle Albian, Alaska (May, 1979) and lower Hauterivian to Cenomanian, offshore eastern Canada (Bujak & Williams, 1978).

Endoscrinium cf. *E. rostratum* (Brideaux & McIntyre, 1975) Below, 1981a

Plate 8, Fig. 9

Comments. The few specimens observed in the present study are poorly preserved but in general similar to the holotype in size and shape with the characteristic beak-like apical prominence.

Occurrence in East Greenland. Lower Aptian, section 32.

Previous occurrences. Endoscrinium rostratum was previously recorded from the uppermost Aptian to the upper part of the lower Albian, north-west Germany (Prössl, 1990), middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975, type material) and Albian, Morocco (Below, 1981).

Genus *Epelidosphaeridia* Davey, 1969a
Epelidosphaeridia spinosa (Cookson & Hughes, 1964) Davey, 1969a

Plate 8, Fig. 10

Occurrence in East Greenland. Only in a few samples of uppermost Albian age. Section 39.

Previous occurrences. Epelidosphaeridia spinosa was previously recorded from the lower Cenomanian, England (Cookson & Hughes, 1964, type material), the uppermost Albian to lower upper Cenomanian, north-west Germany (Prössl, 1990), the upper part of the middle Albian to upper part of the middle Cenomanian, France and Europe (Foucher, 1981), Albian, Saskatchewan, Canada (Davey, 1969), lower Aptian to upper Albian, Arctic Canada (Pocock, 1976) and lower Albian to Cenomanian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978).

Epelidosphaeridia sp. 1

Plate 8, Figs 11–12

Comments. Epelidosphaeridia sp. 1 closely resembles *Epelidosphaeridia spinosa* in size and shape, but differs from it by only having developed a weak cingular girdle and by its slightly shorter spines.

Occurrence in East Greenland. The middle part of the upper Albian, below the first occurrence of *E. spinosa*. Sections 24, 25, 27, 28, 35, 36, 37, 38 and 40.

Genus *Exiguisphaera* Duxbury, 1979a; emend. Jan du Chêne *et al.*, 1986b
Exiguisphaera plectilis Duxbury, 1980; emend. Jan du Chêne *et al.*, 1986b

Plate 8, Figs 13–16

Comments. Although an archeopyle (type 2P) has only been recognised on a few specimens, the species is easily recognised by its characteristic sutural crests.

Occurrence in East Greenland. Primarily upper Barremian but one specimen was recorded from the uppermost part of the lower Barremian and another specimen, from the lowermost Aptian. Sections 1, 7, 14, 15, 17, 18, 19 and 21.

Previous occurrences. Exiguisphaera plectilis was previously recorded from 'middle' Barremian, Speeton, England (Duxbury, 1980, type material, lower and 'middle' Barremian, north-west Germany (Prössl, 1990). Harding (1990b) recorded the first occurrence of the species at the base of the upper Barremian at Speeton, England and at Gott, Germany. Heilmann-Clausen (1987) reported the species from the upper Barremian and lower Aptian in north-west Europe and Aarhus *et al.* (1986) reported the species from the Aptian at Andøya, Norway.

Genus *Exochosphaeridium* Davey *et al.*, 1966
Exochosphaeridium phragmites Davey *et al.*, 1966

Plate 8, Fig. 17

Occurrence in East Greenland. Lower Barremian to upper Albian. The species has been recorded in 35 of the 40 sections.

Previous occurrences. Selected records for *E. phragmites*, upper Hauterivian to lower Aptian, England and Germany (Harding, 1990b), lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990), Cenomanian, England (Davey *et al.*, 1966, type material), lower to upper Albian, France (Davey & Verdier, 1971), Albian to Santonian, France (Foucher, 1979) and upper Barremian to upper Aptian, south-east England (Lister & Batten, 1988).

Genus *Florentinia* Davey & Verdier, 1973; emend. Duxbury, 1980
Florentinia cooksoniae (Singh, 1971) Duxbury, 1980 / *Florentinia mantellii* (Davey & Williams, 1966b) Davey & Verdier, 1973

Plate 8, Fig. 18

Comments. The presence of secondary tubules towards, but not at, the distal process margins described for *F. cooksoniae* by Duxbury (1980, p. 120) seems to be the most pronounced difference between *F. cooksoniae* and *F. mantellii*. As the presence of those tubules is often difficult to recognise, these two species have been treated together as a complex in the present study.

Occurrence in East Greenland. Upper part of lower Barremian to upper Albian. The complex has been recorded from 29 sections.

Previous occurrences. Florentinia cooksoniae was previously recorded from the upper Albian, Peace River area, Alberta, Canada (Singh, 1971, type material), the upper Hauterivian to upper Albian, north-west Germany (Prössl, 1990) and from lower Albian to upper Cenomanian, world-wide (Williams & Bujak, 1985). *Florentinia mantellii* was previously recorded from the lower Cenomanian, England (Davey & Williams, 1966b, type material), the upper Aptian to the lower part of the upper Turonian, north-west Germany (Prössl, 1990) and from lower Aptian to lower Cenomanian, world-wide (Williams & Bujak, 1985). Both species are recorded from the Turonian in France by Foucher (1982).

Genus *Fromea* Cookson & Eisenack, 1958; emend. Yun, 1981
Fromea amphora Cookson & Eisenack, 1958

Plate 8, Fig. 19

Occurrence in East Greenland. Lower Barremian to upper Albian. The species has been recorded from 20 sections.

Previous occurrences. Fromea amphora was previously recorded from the Barremian and Aptian, England (Duxbury, 1980, 1983), Ryazanian to Aptian? in North Sea wells (Heilmann-Clausen, 1987) and Albian and Cenomanian, Australia (Cookson & Eisenack, 1958, type material). According to Costa & Davey (1992) the species has a last occurrence at the top of the Cenomanian in England and the North Sea.

Fromea aff. *F. expolita* (Brideaux, 1977) Lentin & Williams, 1981

Plate 9, Figs 1–4

Comments. The specimens recorded in the present study resemble *Fromea expolita* (Brideaux, 1977) Lentin & Williams, 1981 in their pear-shaped to triangular outline and in their smooth to scabrate surface, but differ by a smaller length (50–60 μ) and width (50–60 μ) compared to the length (65–100 μ) and width (70–86 μ) for the type material.

Occurrence in East Greenland. Restricted to the uppermost Albian. Sections 24, 25, 30 and 37.

Previous occurrence. Fromea expolita was previously only recorded from the Hauterivian and Barremian in the District of Mackenzie, Canada (Brideaux, 1977).

Fromea fragilis (Cookson & Eisenack, 1962b) Stover & Evitt, 1978

Plate 8, Fig. 20

Occurrence in East Greenland. Barremian to Albian. The species has been recorded in 22 of the 40 examined sections.

Previous occurrence. Fromea fragilis was previously recorded from the Aptian to Cenomanian, Australia (Cookson & Eisenack, 1962b, type material), middle and upper Albian, central Alberta, Canada (Brideaux, 1971; Singh, 1971) and Aptian and middle Albian in the District of Mackenzie, Canada (Brideaux & McIntyre, 1975).

Fromea cf. *F. glabella* (Singh, 1971) Lentin & Williams, 1981

Plate 9, Fig. 5

Comments. Only one specimen was recorded in the present study and differs from *F. glabella* by a slightly larger antapical width.

Occurrence in East Greenland. Lower Aptian. Section 17.

Previous occurrence. The type material was described from the upper Albian, Peace River area, Canada (Singh, 1971).

Fromea sp. 1

Plate 9, Figs 6–7

Description. The cysts described as *Fromea* sp. 1 include long (approximately 150 μ) slender (width approximately 60 μ), conical cysts, which are narrow antapically and wider apically at the archeopyle. The operculum is always detached. Accessory archeopyle sutures have not been observed. The cyst surface is shagreenate. Two longitudinal folds often occur (Plate 9, Fig. 6). The folds start at the antapex and continue as a long V-shape along the cyst to the archeopyle margin. The species differs from *F. nicosia* Jansonius, 1989, by its conical shape, smaller size and two folds.

Occurrence in East Greenland. Barremian to Albian. Sections 6, 7, 10, 17, 21, 22, 24, 25, 35, 36, 39 and 40.

Plate 9

Fig. 1. *Fromea* aff. *F. expolita* × 500, section 24; GGU 346461–4, 21.1–121.3; MGUH 21784.

Fig. 2. *Fromea* aff. *F. expolita* × 500, section 24; GGU 346461–4, 7.7–119.1; MGUH 21785.

Fig. 3. *Fromea* aff. *F. expolita* × 500, section 37; GGU 324655–3, 2.4–156.4; MGUH 21786.

Fig. 4. *Fromea* aff. *F. expolita* × 500, section 30; GGU 342618–4, 19.8–123.1; MGUH 21787.

Fig. 5. *Fromea* cf. *F. glabella* × 500, section 17; GGU 342169–4, 21.9–135.0; MGUH 21788.

Fig. 6. *Fromea* sp. 1 × 500, section 24; GGU 346458–4, 19.0–123.0; MGUH 21789.

Fig. 7. *Fromea* sp. 1 × 500, section 25; GGU 346440–4, 16.1–157.1; MGUH 21790.

Fig. 8. *Gochteodinia villosa multifurcata* × 500, section 18, GGU 342218–4, 11.6–143.0; MGUH 21791.

Fig. 9. *Gonyaulacysta* aff. *G. cassidata* × 500, section 1; GGU 360375–3, 17.6–129.5; MGUH 21792.

Fig. 10. *Gonyaulacysta* aff. *G. cassidata* × 500, section 1; GGU 360380–3, 22.5–145.0; MGUH 21793.

Fig. 11. *Gonyaulacysta fastigiata* × 500, section 10; GGU 342093–8, 17.3–132.3; MGUH 21794.

Fig. 12. *Gonyaulacysta fastigiata* × 500, section 11; GGU 342105–4, 14.5–127.0; MGUH 21795.

Figs 13 & 14. *Gonyaulacysta helicoidea helicoidea* × 500, section 9, GGU 342071–4, 6.8–120.7; MGUH 21796 .

Fig. 15. *Gonyaulacysta perforobtusa* × 500, section 18; GGU 342219–4, 12.2–127.9; MGUH 21797.

Fig. 16. *Heslertonia heslertonensis* × 500, section 14; GGU 342133–4, 10.7–131.2; MGUH 21798.

Fig. 17. *Hystrichodinium* aff. *H. furcatum* × 500, section 7; GGU 342081–4, 17.2–129.0; MGUH 21799.

Fig. 18. *Hystrichodinium* aff. *H. furcatum* × 500, section 1; GGU 360375–3, 11.5–128.5; MGUH 21800.


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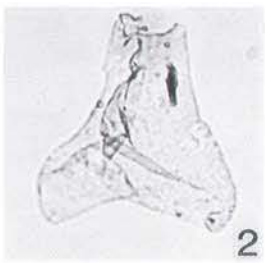
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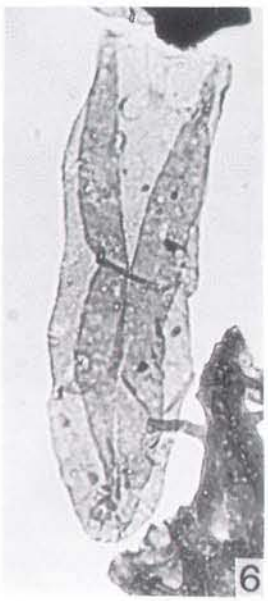
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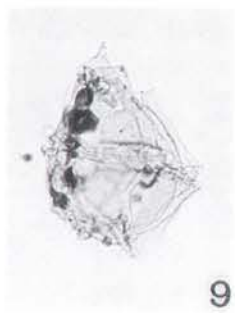
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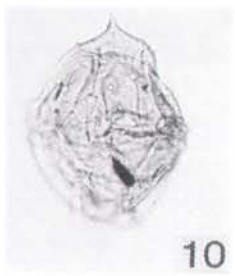
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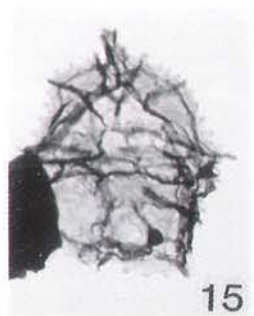
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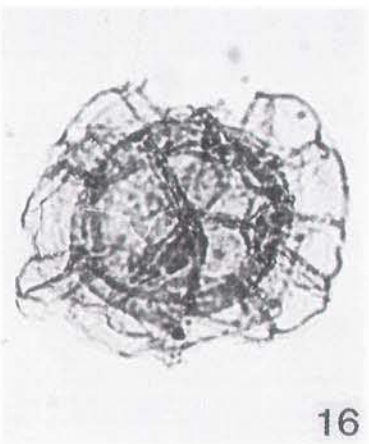
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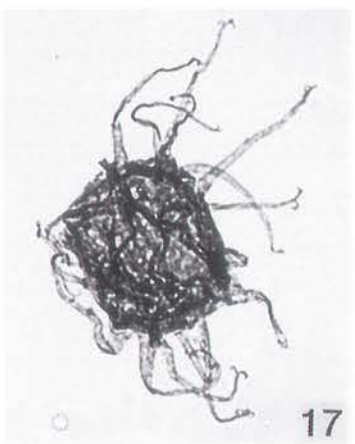
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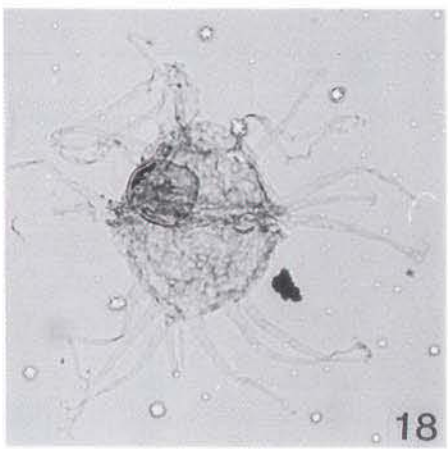
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Genus *Gochteodinia* Norris, 1978
Gochteodinia villosa (Vozzhennikova, 1967) Norris, 1978
Gochteodinia villosa subsp. *multifurcata* Davey, 1982b

Plate 9, Fig. 8

Occurrence in East Greenland. Only a few specimens have been observed in three samples from sections 9, 18, and 21, where the subspecies occurs in the lower part of the range of *Pseudoceratium anaphrissum* together with *Nelchinopsis kostromiensis*. The three samples have been dated as upper Hauterivian? – lower Barremian.

Previous occurrences. Gochteodinia villosa subsp. *multifurcata* was previously recorded from upper Ryazanian and lower Valanginian in the Haldager No. 1 borehole, Denmark, by Davey (1982b, type material). Duxbury (1977) reported the species (as *Pareodinia dasyforma*) from the lower Hauterivian at Speeton, England. Heilmann-Clausen (1987) reported the species from the lower Valanginian and lower Hauterivian in north-west Europe. Thusu (1978) illustrated several specimens of *Gochteodinia villosa* (as *Imbatodinium villosum*) from Arctic Norway. Three of Thusu's illustrations (plate 4, figs 6,7,10) show specimens of *G. villosa multifurcata.* Thusu (1978) showed on his range-chart that *G. villosa* (as *I. villosum*) occurs from Ryazanian through to Barremian in Arctic Norway which indicates that *G. villosa villosa* and *G. villosa multifucata* might range up to the Barremian in the Arctic. Aarhus *et al.* (1986; Århus *et al.*, 1990) have also recorded *G. villosa* from the lower Barremian offshore south Norway and from the Barents Sea but consider the specimens as reworked.

The possibility that *G. villosa multifurcata* could range up into Barremian in the Arctic is not excluded but previous stratigraphic observations point to the fact that the present specimens have been reworked.

Genus *Gonyaulacysta* Deflandre, 1964; emend. Sarjeant, 1982b
Gonyaulacysta aff. *G. cassidata* (Eisenack & Cookson, 1960) Sarjeant, 1966b

Plate 9, Figs 9–10

Comments. The few specimens hereby assigned to *G.* aff. *G. cassidata* have less pronounced tubercles and are slightly shorter than the type material of *G. cassidata.*

Occurrence in East Greenland. The species has only been recorded from the upper Barremian section 1, and the Aptian section 13.

Previous occurrences. Gonyaulacysta cassidata was previously recorded from the Cenomanian, England (Sarjeant, 1966a), the lower Aptian to upper Cenomanian, England and the North Sea (Costa & Davey, 1992), the lower Barremian to upper Cenomanian, north-west Germany (Prössl, 1990) and world-wide from the upper Hauterivian to lower Turonian (Williams & Bujak, 1985). The type material was described from the Aptian to Cenomanian in Australia by Eisenack & Cookson (1960).

Gonyaulacysta fastigiata Duxbury, 1977

Plate 9, Figs 11–12

Comments. The specimens recorded in the present study often have very pronounced denticles on the tabular crests.

Occurrence in East Greenland. Lower to lower part of the upper Barremian. Sections 4, 9, 10, 11, 16, 18 and 21.

Previous occurrences. Gonyaulacysta fastigiata was previously recorded from the lower Hauterivian to lowermost Barremian, north-west Germany (Prössl, 1990), 'middle' Barremian, Speeton, England (Duxbury, 1980, type material), whereas Harding (1990b) reported a last occurrence at the top of the lower Barremian at Speeton, England and at Gott, Germany, lower Hauterivian to top lower Barremian, England and the North Sea (Costa & Davey, 1992), Ryazanian to upper? Hauterivian in North Sea wells (Heilmann-Clausen, 1987), lower Hauterivian, Andøya, Norway (Aarhus *et al.*, 1986), Hauterivian to lower Barremian, Barents Sea (Århus *et al.*, 1990), Hauterivian and lower Barremian, offshore south Norway (Aarhus *et al.*, 1986) and Ryazanian and Valanginian from Arctic Norway (Thusu, 1978).

Gonyaulacysta fastigiata has its last occurrence in the 'middle' Barremian (now upper Barremian) according to Duxbury's (1980) ammonite dated material from Speeton, England.

Gonyaulacysta helicoidea (Eisenack & Cookson, 1960) Sarjeant, 1966b subsp. *helicoidea* Lentin & Williams (1973).

Plate 9, Figs 13–14

Occurrence in East Greenland. Lower Barremian to lower Aptian. Sections 1, 6, 7, 8, 9, 10, 11, 14, 15, 17, 18, 19, 21 and 33.

Previous occurrences. Previously recorded from the Hauterivian and Barremian, Speeton, England (Duxbury, 1977; 1980), Aptian, south England (Lister & Batten,

1988), Albian, south-east France (Davey & Verdier, 1971), the upper Hauterivian to lower Cenomanian in north-west Germany (Prössl, 1990), Ryazanian to Aptian, offshore south-east Norway (Aarhus *et al.*, 1986), the lower Barremian, Barents Sea, Norway (Århus *et al.*, 1986), the middle Albian, Peace River area, central Alberta, Canada (Singh, 1971), the middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), the Neocomian to Aptian, Australia (Eisenack & Cookson, 1960, type material) and lower Hauterivian to lower Cenomanian, world-wide (Williams & Bujak, 1985).

Gonyaulacysta jurassica (Deflandre, 1938b) emend. Sarjeant, 1982b

Comments. The species is rare and considered reworked as, according to the literature, it has never been reported *in situ* from above the Upper Jurassic.

Occurrence in East Greenland. Barremian. Sections 9, 10, 11, 15, 17, 18 and 21.

Gonyaulacysta perforobtusa Duxbury, 1977

Plate 9, Fig. 15

Occurrence in East Greenland. Lowermost Barremian. Sections 10 and 18, where it is very rare.

Previous occurrences. Gonyaulacysta perforobtusa was previously recorded from the Hauterivian, Speeton, England (Duxbury, 1977, type material), the lower and upper Hauterivian, north-west Germany (Prössl, 1990), the Hauterivian and possible lower Barremian in north-west Europe (Heilmann-Clausen, 1987) and lower Barremian, offshore south-east Norway (Aarhus *et al.*, 1986).

Genus *Hapsocysta* Davey 1979b

Hapsocysta? *benteae* sp. nov.

Plate 25, Figs 11–12, Text Figs 10–11

?1962b *Stephodinium australicum*; Cookson & Eisenack, plate 2, figs 5 & 10 only.
1982a ?*Hapsocysta* sp.; Davey, p. 377, taf. 6.3–3, fig. 1.
1983 *Stephodinium australicum*; Singh, plate 57, figs 5 & 6.
1991 ?*Hapsocysta* sp. of Davey 1982a; Århus, fig. 7.
1992 *Hapsocysta*? sp. of Davey 1982a; Costa & Davey, plate 3.5, fig. 6.

Origin of name. After my wife Bente Meldgaard Clausen.

Diagnosis. The species is represented by camocavate, lenticular cysts with a circular equatorial outline in polar view. The cysts are thin-walled, hyaline and apical/antapically compressed with a smaller, spherical, dorsally attached endocyst with a smooth surface. The surface of the periphragm is also smooth but ornamented by low sutural ribs reflecting a gonyaulacoid tabulation pattern. A precingular archeopyle (type P) may be distinguished on the dorsal side, whereas a sulcal opening (an opisthopyle) is always present on the ventral surface of the pericyst.

Description

Cyst type. Camocavate with a large ventral pericoel.

Shape. The cyst is lenticular with a circular equatorial outline in polar view.

Wall relationships. The cyst is composed of a thin-walled (less than 1μ), hyaline, tabulate pericyst, and a smaller endocyst approximately half the diameter of the pericyst. The endocyst is smooth thin walled, hyaline, lenticular with a circular equatorial outline in polar view and often folded probably due to the apical/antapical compression of the cyst. Periphragm and endophragm are dorsally appressed.

Tabulation. Low sutural ribs on the periphragm indicate tabulation, which is gonyaulacoid with an S-type ventral pattern (Evitt, 1985). Formula ?4', 6", 6c, 1p, 6‴, 1⁗ (Figs 10–11). Five sulcal plates have been distinguished: the posterior sulcal plate (ps), the right sulcal plate (rs), the left sulcal plate (ls), the right accessory plate (ras) and the anterior sulcal plate (as). An almost circular opening in the sulcal area (an opisthopyle) is always present on the pericyst. The opening is demarcated by the plates: as, ras, rs, ls and 1‴ (Figs 10–11).

Archeopyle. A precingular archeopyle may be distinguished on the dorsal side.

Holotype. Plate 25, Fig. 11; Text Fig. 10, MGUH 21988 from GGU 342240–4, 10,0–140,0.

Type locality. Section 21, Stratumbjerg, Wollaston Forland, East Greenland (Fig. 2).

Dimensions. Holotype: diameter of pericyst 78 μ, diameter of endocyst 44 μ.

Size range. Diameter of pericyst 60 (71) 85 μ (10 specimens), diameter of endocyst 36 (40) 45 μ (10 specimens).

Discussion. The species has been assigned to the genus

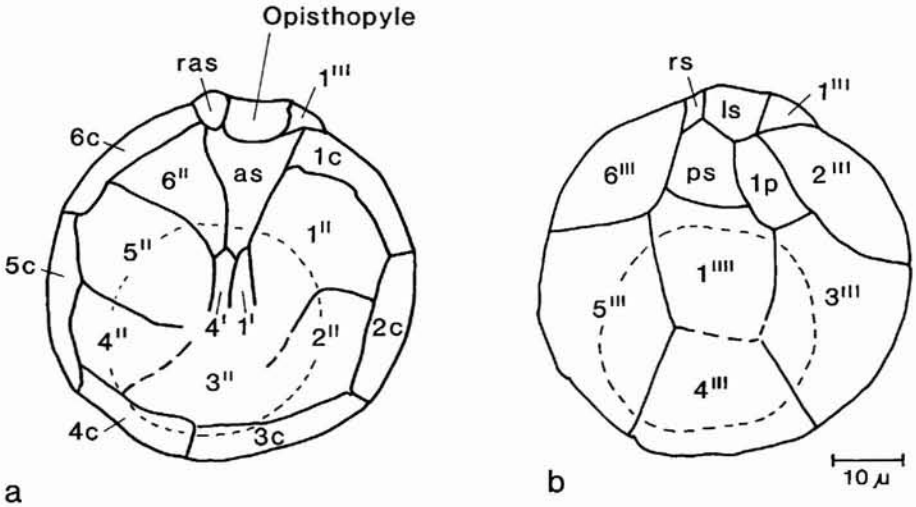


Fig. 10. *Hapsocysta*? *benteae* sp. nov., the holotype, also shown in Plate 25, Fig. 11 from section 21; GGU 342240–4, 10.0–140.0. The tabulation, opisthopyle and outline of inner body (stippled) are shown. (a) internal apical view. (b) external antapical view.

Hapsocysta with a question mark, due to the presence of a thin walled periphragm. In the diagnosis of the genus *Hapsocysta* Davey (1979a) described the periphragm to have a net-like structure, where the areas between the strands may be filled with a subsidiary network.

Hapsocysta? *benteae* sp. nov. differs from *Stephodinium australicum* by the smaller diameter of the pericyst, by being apical/antapically compressed, by being tabulate and by having the endocyst situated dorsally. The equatorial, wing-like outgrowth described and illustrated by Cookson & Eisenack (1962b, p. 491, plate 2, figs 6–9) has not been observed in the present material.

Occurrence in East Greenland. Lower to upper Albian. Sections 13, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 35, 36, 37, 38, 39 and 40. The species never dominates the dinoflagellate cyst assemblages but seems to be a good marker species for the Albian in East Greenland.

Previous occurrences. Hapsocysta? *benteae* sp. nov. was previously recorded from the upper Aptian and lower Albian, north-west Germany, as ?*Hapsocysta* sp. (Davey, 1982a), upper Aptian to Upper Cretaceous, North Sea area, as *Hapsocysta*? sp. of Davey 1982a (Costa & Davey, 1992), middle Albian, Barents Sea (Århus, 1991), upper? Albian and Cenomanian, Peace River area, Canada as *S. australicum* (Singh, 1983) and upper Albian to Cenomanian in Australia as *S. australicum* (Cookson & Eisenack, 1962b, plate 2, figs 5 & 10 only). The present author has also recorded the species from the lower and middle Albian, Axel Heiberg Island, Arctic Canada.

Genus *Heslertonia* Sarjeant, 1966b; emend. Duxbury, 1980

Heslertonia heslertonensis (Neale & Sarjeant, 1962) Sarjeant 1966b; emend. Duxbury, 1980

Plate 9, Fig. 16

Occurrence in East Greenland. Lower Barremian to lower Aptian. Sections 1, 3, 6, 7, 8, 9, 10, 11, 14, 15, 17,

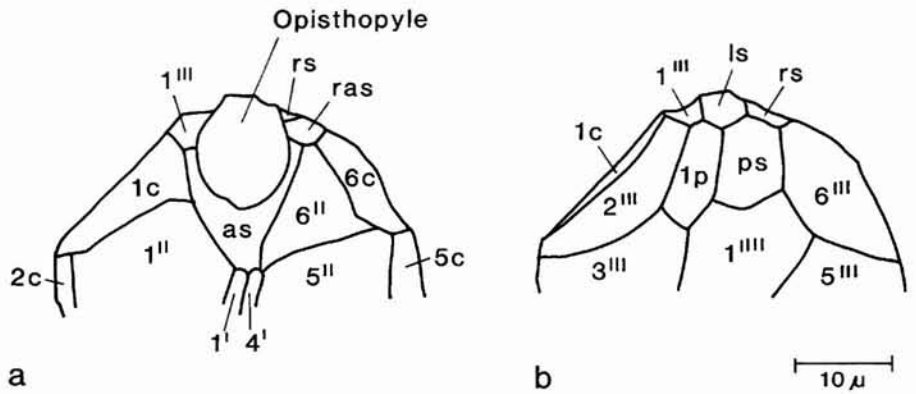


Fig. 11. *Hapsocysta*? *benteae* sp. nov., same specimen as Plate 25, Fig. 12 from section 30; GGU 342619–3, 10.2–131.0. The opisthopyle and tabulation, with emphasis on the sulcal plates are shown. (a) external apical view. (b) internal antapical view.

18, 19, 21, 26, 32 and 33. One questionable specimen was recorded from the lower Albian section 26.

Previous occurrences. Heslertonia heslertonensis was previously recorded from the Hauterivian and Barremian, Speeton, England (Neale & Sarjeant, 1962, type material), the upper Ryazanian to lower Aptian, England and the North Sea (Costa & Davey, 1992), the lower Hauterivian to middle Albian, north-west Germany (Prössl, 1990), upper Ryazanian to lower, or possibly upper Aptian in north-west Europe (Heilmann-Clausen, 1987), and world-wide (Williams & Bujak, 1985).

Genus *Hystrichodinium* Deflandre, 1935b; emend. Sarjeant, 1966b
Hystrichodinium aff. *H. furcatum* Alberti, 1961

Plate 9, Figs 17–18

Comments. The relatively few specimens recorded in the present study differ slightly in body shape from the type material described by Alberti (1961) and the processes are significantly longer than on the holotype. Also the distal furcation of the processes have shorter branches.

Occurrence in East Greenland. Upper part of lower Barremian? to lowermost Aptian. *Hystrichodinium* aff. *H. furcatum* is very rare in the uppermost lower Barremian. Only a few specimens were recorded in the *Pseudoceratium anaphrissum* Subzone in sections 9 and 11. The species is more common in the upper Barremian *Pseudoceratium toveae* Subzone in sections 1, 6, 7, 8, 14, 17, 19, and 21. Only two specimens were recorded from the lower Aptian *Pseudoceratium nudum* Zone in section 17, GGU 342168.

Previous occurrences. Hystrichodinium furcatum was previously recorded from the lower Hauterivian to lower Barremian, England and the North Sea (Costa & Davey, 1992), lower Hauterivian to the lower part of the 'middle' Barremian in north-west Europe where, according to Heilmann-Clausen (1987), it has its last occurrence in the lower part of the range of *P. anaphrissum*, lower Hauterivian to the middle part of the upper Barremian, north-west Germany (Prössl, 1990).

Harding (1990b) indicated that the species has a very short stratigraphic range restricted to lowermost Barremian in Germany and England. Harding (1990b) mentioned that Alberti's (1961) Hauterivian recording of the type material might be wrongly dated due to unreliable borehole material. Århus *et al.* (1990) have observed the species from Valanginian–Hauterivian? in the Barents Sea. Williams & Bujak (1985) indicate that the species has a world-wide range from the middle part of the upper Valanginian to the top of the lower Aptian.

In conclusion, the information given above indicates that *H. furcatum* is a lower Barremian marker in north-west Europe where it occurs below and in the lower part of the range of *P. anaphrissum* in contrast to *H.* aff. *H. furcatum* which tends to be an upper Barremian marker in East Greenland, where it has only been recorded in the upper part of and above the range of the species *P. anaphrissum*.

Hystrichodinium pulchrum Deflandre, 1935 subsp. *pulchrum* Lentin & Williams 1973

Plate 10, Figs 1–2

Comments. In the present study, the subspecies has been distinguished from *Hystrichodinium voigtii* by the presence of tubercles, its lower sutural crests and by having more processes.

Occurrence in East Greenland. Middle Albian. Sections 20 and 23.

Previous occurrences. The type material was described from Senonian in France by Deflandre (1935). Costa & Davey (1992) recorded *H. pulchrum* from the upper Bathonian (Jurassic) to upper Maastrichtian, England and the North Sea. Williams & Bujak (1985) recorded the species from all Cretaceous stages, world-wide.

Hystrichodinium ramoides Alberti, 1961

Plate 10, Fig. 3

Comments. The species, rare in the material from East Greenland, is characterised by processes that distally furcate more than once.

Occurrence in East Greenland. In the upper Barremian *Pseudoceratium toveae* Subzone, where it occurs together with *H.* aff. *H. furcatum* and *P. toveae* sp. nov., and above the last occurrence of *Pseudoceratium anaphrissum* in sections 7, 14 and 19.

Previous occurrences. Hystrichodinium ramoides was previously recorded from the 'middle' and upper Barremian, Speeton, England (Duxbury, 1980), lower and upper Barremian, England and the North Sea (Costa & Davey, 1992), the Hauterivian to uppermost Barremian, north-west Germany (Prössl, 1990). Harding (1990b, p. 52) mentions that "This species has an extremely short vertical range within the latest Barremian time" in Ger-

many and England. The type material was described from the upper Barremian in Germany by Alberti (1961) and Heilmann-Clausen (1987) recorded the species from the upper part of the lower Barremian, 'middle' Barremian and upper Barremian in north-west Europe.

Remarks. According to Harding (1990b) *H. ramoides* has no overlap with the lower Barremian species *H. furcatum.* The occurrence of *H. ramoides* in East Greenland correlates with Harding's (1990b) latest Barremian range for the species, but differs by not being present above the last occurrence of *H.* aff. *H. furcatum.*

Hystrichodinium voigtii (Alberti, 1961; emend. Sarjeant, 1966b) Davey, 1974

Plate 10, Figs 4–5

Occurrence in East Greenland. Lower Barremian to lower Aptian. Sections 1, 7, 8, 9, 10, 11, 14, 16, 17, 18, 19, 21 and 33.

Previous occurrences. Hystrichodinium voigtii was previously recorded from the lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990), Barremian to lower Aptian, Germany (Alberti, 1961, type material) and from the Jurassic to upper Albian in North Sea wells (Heilmann-Clausen, 1987).

Genus *Hystrichosphaeridium* Deflandre, 1937b; emend. Davey & Williams, 1966b *Hystrichosphaeridium arborispinum* Davey & Williams, 1966b

Plate 10, Figs 6–9

Occurrence in East Greenland. Upper part of lower and upper Barremian. Sections 1, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19 and 21. The species is common to dominant in the uppermost part of the lower Barremian and in the lowermost part of the upper Barremian (see section 21).

Previous occurrences. Hystrichosphaeridium arborispinum was previously recorded from the lower and 'middle' Barremian, Speeton, England (Davey and Williams, 1966b, type material), the uppermost lower, 'middle' and lowermost upper Barremian, Speeton, England (Duxbury, 1980), the lower Hauterivian to upper Barremian, England and the North Sea (Costa & Davey, 1992), the 'middle' and upper Barremian, north-west Europe (Heilmann-Clausen, 1987) and the middle part of the lower to the middle part of the upper Barremian, north-west Germany (Prössl, 1990). Harding (1990b) mentioned that the species is extremely common in the middle? to upper part of lower Barremian but becomes rare in the upper Barremian of Germany and England. Harding's observation seems consistent with the present study. Outside of Europe the species has been recorded from the lower Barremian to the lowermost Aptian in Arctic Canada by Pocock (1976).

Genus *Hystrichosphaerina* Alberti, 1961 *Hystrichosphaerina schindewolfii* Alberti, 1961

Plate 10, Figs 10–13

Comments. Alberti (1961) mentioned in his description of the species that a few long thin processes are arranged in the equatorial zone. Davey (1982b) likewise indicates that the genus *Hystrichosphaerina* has solid cingular processes, but mentioned also that they sometimes may be absent. In the present material, both forms with (Plate 10,

Plate 10

Fig. 1. *Hystrichodinium pulchrum* × 500, section 20; GGU 342189–4, 13.9–145.1; MGUH 21801.

Fig. 2. *Hystrichodinium pulchrum* × 500, section 23; GGU 351686–4, 12.0–137.0; MGUH 21802.

Fig. 3. *Hystrichodinium ramoides* × 500, section 7; GGU 342081–4, 3.5–135.2; MGUH 21803.

Fig. 4. *Hystrichodinium voigtii* × 500, section 10; GGU 342094–4, 13.2–127.0; MGUH 21804.

Fig. 5. *Hystrichodinium voigtii* × 580, section 21; GGU 342232; MGUH 21805.

Fig. 6. *Hystrichosphaeridium arborispinum* × 500, section 14; GGU 342216–4, 3.3–127.0; MGUH 21806.

Fig. 7. *Hystrichosphaeridium arborispinum* × 500, section 7; GGU 342081–4, 17.4–157.1; MGUH 21807.

Fig. 8. *Hystrichosphaeridium arborispinum* × 850, section 18; GGU 342222; MGUH 21808.

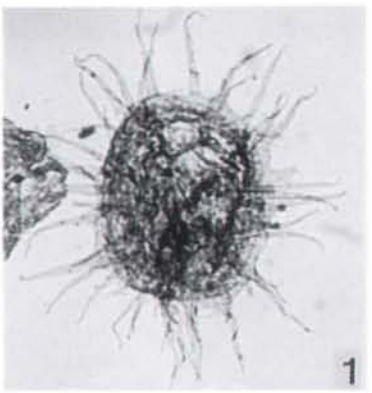
Fig. 9. *Hystrichosphaeridium arborispinum* × 1600, same specimen as above close-up of processes, section 18; GGU 342222.

Fig. 10. *Hystrichosphaerina schindewolfii* × 500, specimen with cingular processes, section 7; GGU 342081–4, 7.6–137.0; MGUH 21809.

Fig. 11. *Hystrichosphaerina schindewolfii* × 550, specimen with cingular processes, section 7; GGU 342081; MGUH 21810.

Fig. 12. *Hystrichosphaerina schindewolfii* × 500, specimen without (?) cingular processes, section 21; GGU 342237–4, 17.4–155.0; MGUH 21811.

Fig. 13. *Hystrichosphaerina schindewolfii* × 550, specimen without cingular processes, section 7; GGU 342081; MGUH 21812.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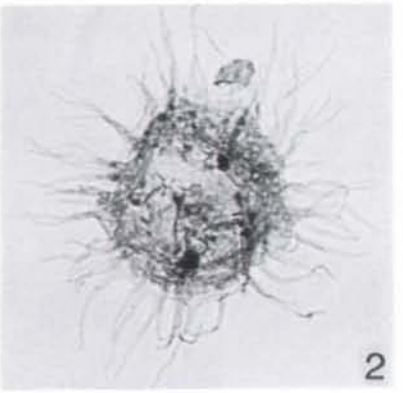
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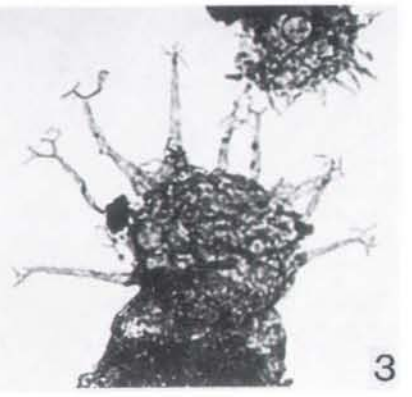
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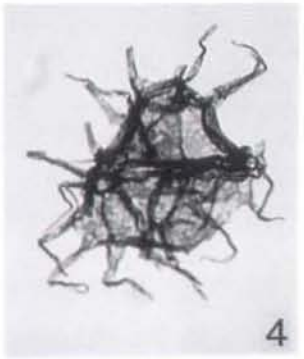
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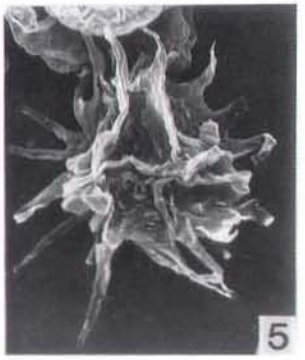
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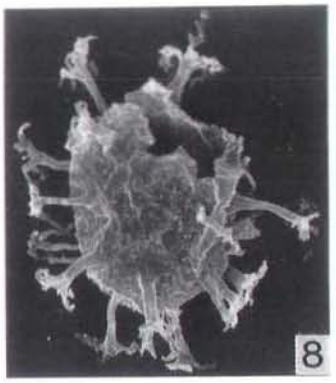
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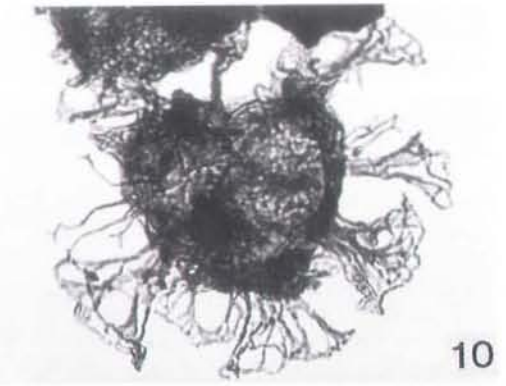
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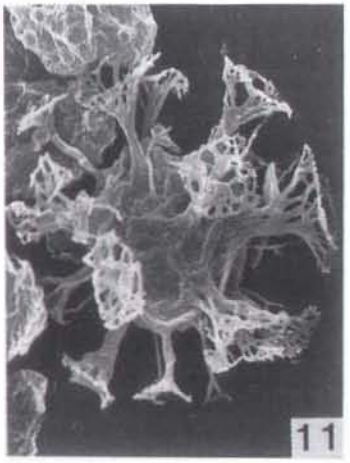
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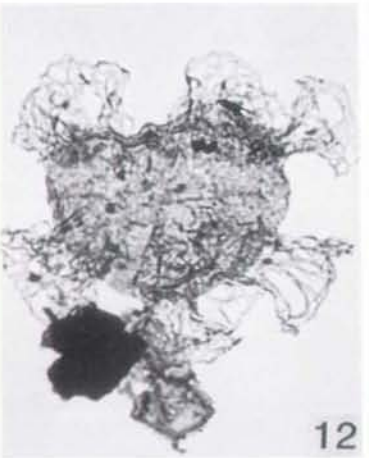
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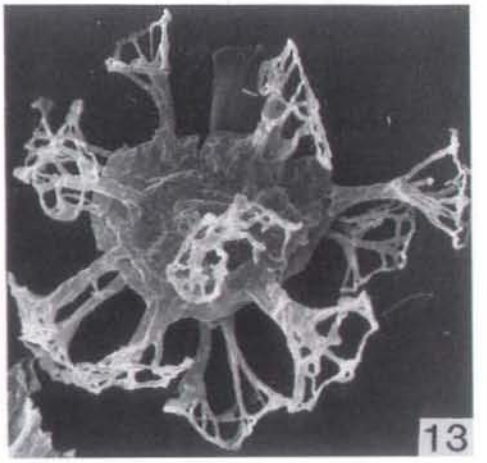
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Figs 10–11) and without (Plate 10, Figs 12–13) cingular processes have been recorded and referred to the species.

Occurrence in East Greenland. The upper part of the lower Barremian to lower Aptian. Sections 1, 6, 7, 8, 9, 11, 14, 15, 17, 18, 19, 21 and 33. One specimen has been observed from the lower Albian. Section 26.

Previous occurrences. Hystrichosphaerina schindewolfii was previously recorded from the upper Barremian, Turonian and Senonian, Germany (Alberti, 1961, type material), the uppermost lower, 'middle' and lowermost upper Barremian, Speeton, England (Duxbury,1980), the lower Valanginian to lower Albian, England and the North Sea (Costa & Davey, 1992), the upper Barremian to upper Aptian, south England (Lister & Batten, 1988), the lower Hauterivian to the upper part of the lower Albian, north-west Germany (Prössl, 1990), lower Barremian to lower Aptian, and upper Aptian to lower Albian in north-west Europe (Heilmann-Clausen, 1987), Valanginian in Denmark, Davey (1982b), lower Hauterivian to upper Aptian, District of Mackenzie, Canada (Brideaux, 1977) and upper Hauterivian to upper Albian, world-wide (Williams & Bujak, 1985).

Genus *Kiokansium* Stover & Evitt, 1978; emend. Duxbury, 1983
Kiokansium polypes (Cookson & Eisenack, 1962b) Below, 1982c subsp. *polypes* Lentin & Williams (1986)

Plate 11, Figs 2–8

Comments. The specimens herein referred to *Kiokansium polypes polypes* have a spheroidal cyst with forty, or often more, slender processes that distally are fringed with short, straight to recurved tips.

Occurrence in East Greenland. Lower Barremian to upper Albian. The subspecies has been recorded from 30 sections. The abundance varies throughout the examined stages but the species often constitutes 5% or more of the assemblage.

Previous occurrences. Kiokansium polypes polypes was previously recorded from Hauterivian to Cenomanian, Speeton, England (Duxbury, 1977), lower Hauterivian to upper Albian, north-west Germany (Prössl, 1990) and upper Hauterivian to lowermost? Albian in a North Sea well (Heilmann-Clausen, 1987). The type material was described from the Albian to Cenomanian in Australia by Cookson & Eisenack (1962b).

Genus *Kleithriasphaeridium* Davey, 1974
Kleithriasphaeridium corrugatum Davey, 1974

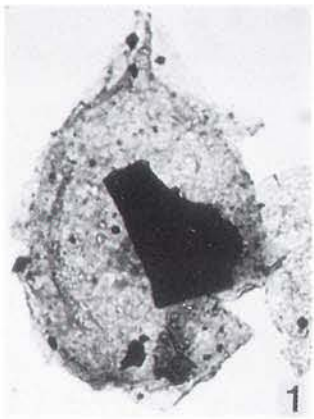
Plate 11, Fig. 10

Occurrence in East Greenland. Lower Barremian and lowermost part of the upper Barremian; sections 9, 15, 16, 18 and 21. The species is very rare to rare in the studied material.

Previous occurrences. Kleithriasphaeridium corrugatum was previously recorded from the lower Barremian, Speeton, England (Davey, 1974, type material), the lowermost part of the 'middle' Barremian, Speeton, England (Duxbury, 1980), the upper Ryazanian to upper Barremian, England and the North Sea (Costa & Davey, 1992), the uppermost lower Hauterivian to the middle 'middle' Barremian, north-west Germany (Prössl, 1990). Harding (1990b, p. 52) mentions that the species "becomes extinct at the end of the lower Barremian". The species has been

Plate 11

Fig. 1. *Pareodinia* sp. × 500, section 21; GGU 342240–4, 20.1–140.2; MGUH 21813.
Fig. 2. *Kiokansium polypes polypes* × 500, section 10; GGU 342094–4, 11.8–128.7; MGUH 21814.
Fig. 3. *Kiokansium polypes polypes* × 500, section 20; GGU 342186–4, 7.7–133.9; MGUH 21815.
Fig. 4. *Kiokansium polypes polypes* × 500, section 17; GGU 342167–4, 7.1–140.1; MGUH 21816.
Fig. 5. *Kiokansium polypes polypes* × 500, section 10; GGU 342092–4, 20.8–142.3; MGUH 21817.
Fig. 6. *Kiokansium polypes polypes* × 800, section 17; GGU 342161; MGUH 21818.
Fig. 7. *Kiokansium polypes polypes* × 550, section 17; GGU 342161; MGUH 21819.
Fig. 8. *Kiokansium polypes polypes* × 750, section 17; GGU 342161; MGUH 21820.
Fig. 9. *Leiofusa* sp. × 500, section 31; GGU 324627–4, 16.5–129.5; MGUH 21821.
Fig. 10. *Kleithriasphaeridium corrugatum* × 500, section 15; GGU 351526–4, 13.9–127.0; MGUH 21822.
Fig. 11. *Kleithriasphaeridium eoinodes* × 500, section 19; GGU 342214–4, 13.4–143.0; MGUH 21823.
Fig. 12. *Leptodinium cancellatum* × 500, section 12; GGU 351589–4, 12.2–135.0; MGUH 21824.
Fig. 13. *Leptodinium cancellatum* × 500, section 20; GGU 342176–4, 11.3–150.2; MGUH 21825.
Fig. 14. *Leptodinium*? cf. *L. delicatum* × 500, section 23; GGU 351676–4, 21.8–136.0; MGUH 21826.
Fig. 15. *Leptodinium*? *hyalodermopse* × 500, section 17; GGU 342167–4, 9.7–124.0; MGUH 21827.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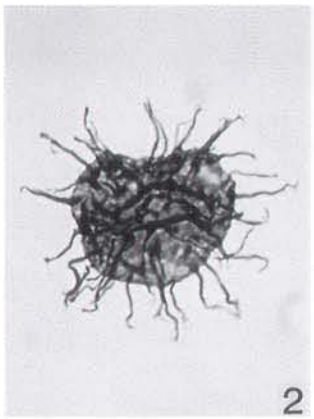
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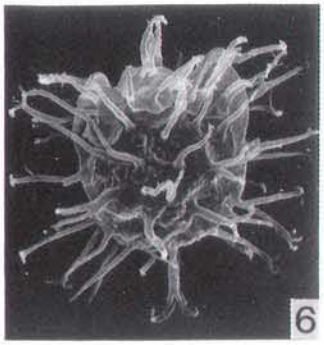
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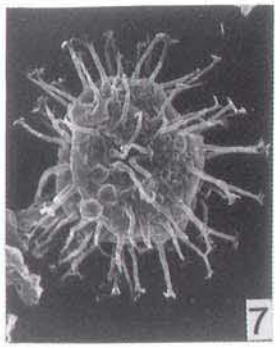
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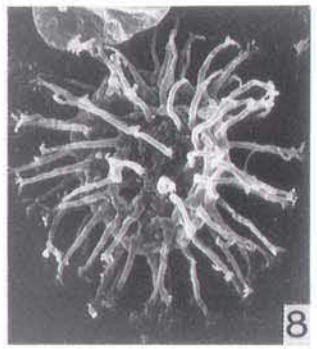
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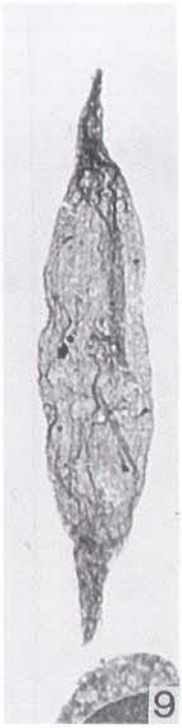
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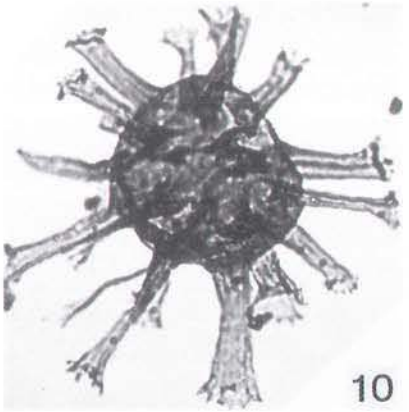
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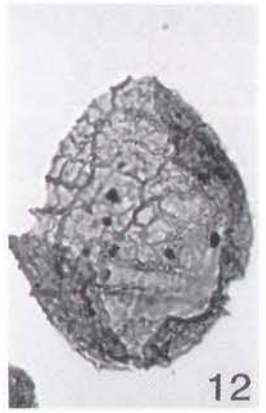
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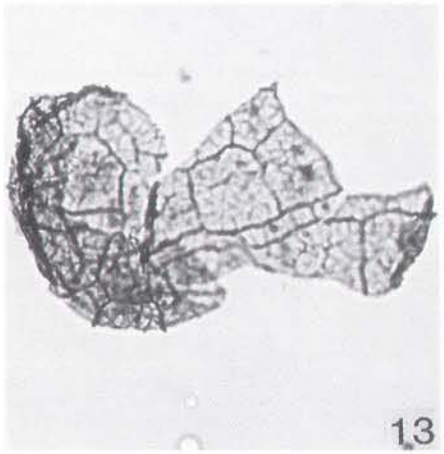
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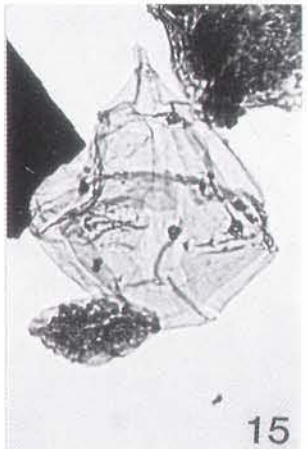
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recorded from the upper Ryazanian to the 'middle' Barremian in north-west Europe (Heilmann-Clausen, 1987). Williams & Bujak (1985) have an lower Barremian last occurrence for the species, world-wide.

Remarks. The last occurrence of the species in the lowermost 'middle' Barremian (now lowermost upper Barremian) recorded by Duxbury (1980; Costa & Davey, 1992), in the 'accurate' dated Speeton section, correlates with the observations from East Greenland.

Kleithriasphaeridium eoinodes (Eisenack, 1958) Davey, 1974; emend. Sarjeant, 1985a

Plate 11, Fig. 11

Remarks. The present study follow Below's (1982a) consideration that *K. simplicispinum* is a jr syn. of *K. eoinodes*.

Occurrence in East Greenland. Lower Barremian to middle Albian. Sections 1, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 26, 32 and 33.

Previous occurrences. Kleithriasphaeridium eoinodes was previously recorded from the upper Barremian to the uppermost Albian in north-west Germany, Prössl (1990), whereas Heilmann-Clausen (1987) reported the species from upper Ryazanian to middle Albian in north-west Europe and Williams & Bujak (1985) reported a lower Valanginian to 'middle' Barremian world-wide range. The type material was described from the upper Aptian in Germany by Eisenack (1958). The European range correlates with the present observations.

Genus *Lagenadinium* Piel, 1985
Lagenadinium? membranoidium (Vozzhennikova, 1967); emend. Lentin & Vozzhennikova, 1990

Plate 5, Fig. 6

Comments. One specimen with a pronounced corona was observed. On the other observed specimens the corona is usually indistinct.

Occurrence in East Greenland. Lower Barremian to middle Albian and rare specimens from the upper Albian. Sections 1, 6, 7, 9, 10, 11, 13, 14, 16, 17, 18, 19, 20, 25 and 30.

Previous occurrences. Lagenadinium? membranoidium was previously recorded as *Chlamydophorella membranoidea* from the Hauterivian, upper Barremian and upper Aptian, north-west Europe and North Sea wells (Heilmann-Clausen, 1987). The type material was described from Upper Jurassic, Russia by Vozzhennikova (1967).

Genus *Leptodinium* Klement, 1960; emend. Sarjeant, 1982b
Leptodinium cancellatum Brideaux & McIntyre, 1975

Plate 11, Figs 12–13

Comments. The species is easily distinguished, even in fragments, due to the intratabular apiculate to vermiculate sculpture.

Occurrence in East Greenland. Upper part of the lower Aptian to uppermost part of the middle Albian. Sections 12, 13, 17, 20, 21, 22 and 23. The species seems to be a good stratigraphic marker although it seldom constitutes more than 1% of the dinoflagellate cyst assemblages.

Previous occurrences. Leptodinium cancellatum was previously recorded from the uppermost Aptian to lower Albian, Germany (Davey, 1982a), upper Aptian to lower upper Albian in England and the North Sea (Costa & Davey, 1992), the uppermost Aptian to lowermost Albian, north-west Europe (Heilmann-Clausen, 1987), lower? Albian, Peary Land, North Greenland and upper Aptian to middle Albian, Barents Sea (Århus, 1991) and the middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975).

Leptodinium? cf. *L. delicatum* (Davey, 1969a) Sarjeant *in* Davey *et al.*, 1969

Plate 11, Fig. 14

Comments. The few recorded specimens are often fragmented. They have a thin smooth hyaline wall, with tabulation defined by crests. The crests may be a little higher than on the type material described by Davey (1969).

Occurrence in East Greenland. Uppermost lower Aptian to lowermost upper Albian. Sections 13, 23 and 29.

Previous occurrences. Leptodinium? delicatum was previously recorded from the middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), Barremian, District of Mackenzie, Canada (Brideaux, 1977) and Cenomanian, Saskatchewan, Canada (Davey, 1969, type material).

Leptodinium? *hadrum* (Sarjeant, 1966b) Helenes, 1984

Plate 12, Fig. 1

Occurrence in East Greenland. Uppermost Barremian. Sections 7, 14 and 17.

Previous occurrence. Leptodinium? *hadrum* was previously recorded (as *Gonyaulacysta hadra)* from the upper Barremian, England (Sarjeant, 1966a, type material).

Leptodinium? *hyalodermopse* (Cookson & Eisenack, 1958) Stover & Evitt, 1978

Plate 11, Fig. 15

Occurrence in East Greenland. Lower Barremian to top lower Albian. Sections 1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 21, 26, 32, 33 and 34.

Previous occurrences. Leptodinium? *hyalodermopse* was previously recorded from the Hauterivian to the middle part of the lower Albian (as *Rhynchodinium hyalodermopse*) north-west Germany (Prössl, 1990), lower? Albian, Peary Land, North Greenland and uppermost lower Albian to lowermost middle Albian, Barents Sea, as *Gonyaulacysta hyalodermopsis* (Århus, 1991), middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), Barremian, District of Mackenzie, Canada (Brideaux, 1977), and upper Neocomian to Aptian, Australia (Cookson & Eisenack, 1958, type material).

Genus *Levisphaera* Davey, 1988

Levisphaera cf. *L. crassicingulata* (Burger, 1980) Davey, 1988

Plate 1, Figs 10–12

Comments. Ovoidal cyst with a psilate surface. The wall is apparently composed of one layer, the autophragm. The wall is thin, less than 1 μ, and hyaline. The archeopyle is apical occasionally with the operculum attached. The length of the cyst, excluding the operculum is 40–45 μ. The width of the cyst is 36–43 μ.

Remarks. Levisphaera cf. *L. crassicingulata* differs from the type material (Burger, 1980), by being smaller. *L.* cf. *L. crassicingulata* differs from *Batiacasphaera euteiches* (Davey, 1969a) Davey, 1979d by having a thin, hyaline and psilate wall. The size, shape and wall features of *L.* cf. *L. crassicingulata* are similar to *Chytroeisphaeridia chytroeides* (Sarjeant, 1962a) Downie & Sarjeant, 1965; emend. Davey, 1979b. However *L.* cf. *L. crassicingulata* differs by having an apical archeopyle in contrast to the precingular archeopyle characteristic for *C. chytroeides.*

Occurrence in East Greenland. Lower Barremian to upper Albian. The species occurs in 31 of the 40 examined sections and is often common.

Previous occurrences. Burger (1980) described the species as *Canningia crassicingulata* from the Neocomian in Australia and Davey (1988) recorded the species as *L. crassicingulata* from the Kimmeridgian (Jurassic), Papua New Guinea.

Genus *Litosphaeridium* Davey & Williams, 1966b; emend. Lucas-Clark, 1984

Litosphaeridium arundum (Eisenack & Cookson, 1960) Davey, 1979b; emend. Lucas-Clark, 1984

Plate 12, Figs 2–3

Occurrence in East Greenland. From top lower Albian? – base middle Albian to the middle part of the upper Albian. Sections 5, 20, 22, 23, 26, 29, 30, 31 and 40.

Previous occurrences. Litosphaeridium arundum was previously recorded from the upper Aptian to upper Albian, France (Davey & Verdier, 1971, 1974), the lower to upper Albian, England and the North Sea (Costa & Davey, 1992), the uppermost lower Albian to middle part of the late Albian, north-west Germany (Prössl, 1990), lower Albian to lowermost upper Albian, north-west Europe (Heilmann-Clausen, 1987), Aptian – lower Albian to middle Albian, Spitsbergen and middle Albian, Barents Sea (Århus, 1991), middle to upper Albian, western Canada (Brideaux, 1971; Singh, 1971) and uppermost lower Albian to lowermost Cenomanian, world-wide (Williams & Bujak, 1985). The type material was described from the Albian in Australia by Eisenack & Cookson (1960).

Litosphaeridium siphoniphorum (Cookson & Eisenack, 1958) Davey & Williams, 1966b

Plate 12, Fig. 4

Occurrence in East Greenland. Only two specimens have been recorded from the upper Albian. Sections 24 and 35.

Previous occurrences. Litosphaeridium siphoniphorum was previously recorded from the upper Albian in south-east France (Davey & Verdier, 1973), the upper Albian to

lower Turonian, England and the North Sea (Costa & Davey, 1992) and the upper Albian to lower Cenomanian, north-west Europe (Heilmann-Clausen, 1987). The species is a marker for uppermost Albian to the top Cenomanian in Europe (Foucher, 1981). The type material was described from the Albian to Cenomanian in Australia by Cookson & Eisenack (1958).

Genus *Luxadinium* Brideaux & McIntyre, 1975

Luxadinium sp.

Plate 12, Fig. 5

Comments. A few thin-walled, almost hyaline, cavate specimens with a large acheopyle (tI?,3P) have been recorded from the lower part of the upper Albian. Sections 30 and 31.

Genus *Meiourogonyaulax* Sarjeant, 1966b

Meiourogonyaulax stoveri Millioud, 1969

Plate 12, Figs 9–10

Occurrence in East Greenland lower Barremian. Sections 9, 10, where the species is rare.

Previous occurrences. Meiourogonyaulax stoveri was previously recorded from the lower Hauterivian to lowermost Albian, England and the North Sea (Costa & Davey, 1992), the uppermost Hauterivian to uppermost 'middle' Barremian, north-west Germany (Prössl, 1990), Hauterivian to Aptian, western Europe (Millioud, 1969, type material), lower and upper Aptian, south England (Lister & Batten, 1988), Hauterivian and older to upper Albian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978), upper Hauterivian to lower Aptian, Arctic Canada (Pocock, 1976) and upper Hauterivian to lowermost Albian, world-wide (Williams & Bujak, 1985).

Genus *Muderongia* (Cookson & Eisenack, 1958)

Remarks. The emendation and the new morphographic approach proposed for the genus and species of *Muderongia* by Monteil (1991) is not followed due to the relative sparse occurrence of specimens of the genus *Muderongia* in the present study.

Muderongia australis Helby, 1987

Plate 12, Fig. 12

Comments. The specimens recorded in the present study have cingular horns projecting laterally from the cingulum. The horns are slightly longer than the stout lateral bosses described by Helby (1987, p. 300), but are shorter than the cingular horns on *Muderongia macwhaei* Cookson & Eisenack, 1958; emend. Helby, 1987.

Occurrence in East Greenland. Lower Barremian. Sections 9, 10 and 15. The species dominates the assemblages in a restricted interval in section 10.

Previous occurrences. Muderongia australis was previously recorded from lowermost Hauterivian, north-west Germany (Prössl, 1990). The species has also been reported in large numbers from a restricted interval in the Hauterivian, the uppermost part of the Rurikfjeldet Member at Spitsbergen and from Hauterivian – lower Barremian in the Barents Sea (Århus *et al.*, 1990), Barremian in Australia (Helby, 1987, type material) and lowermost Hauterivian to 'middle' Barremian, Papua New Guniea (Davey, 1988).

Plate 12

Fig 1. *Leptodinium? hadrum* × 500, section 14; GGU 342132–6, 11.2–138.2; MGUH 21828.

Fig. 2. *Litosphaeridium arundum* × 500, section 23; GGU 351670–4, 19.6–134.2; MGUH 21829.

Fig. 3. *Litosphaeridium arundum* × 800, section 20; GGU 342191; MGUH 21830.

Fig. 4. *Litosphaeridium siphoniphorum* × 750, section 14; GGU 346451–4, 19.9–119.1; MGUH 21831.

Fig. 5. *Luxadinium* sp. × 500, section 20; GGU 342176–4, 7.0–122.2; MGUH 21832.

Fig. 6. *Atopodinium haromense* × 500, section 14; GGU 342134–4, 6.3–135.5; MGUH 21833.

Fig. 7. *Atopodinium haromense* × 500, section 17; GGU 342161–4, 11.0–141.1; MGUH 21834.

Fig. 8. *Atopodinium haromense* × 500, section 17; GGU 342162–4, 6.7–143.1; MGUH 21835.

Fig. 9. *Meiourogonyaulax stoveri* × 500, external dorsal view illustrating attached apical operculum, vacuolar surface and crests, section 17; 9; GGU 342094–4, 10.4–154.4; MGUH 21836.

Figs 10 & 11. *Meiourogonyaulax stoveri* × 500, antapical/apical view illustrating apical archeopyle, vacuolar surface and crests, section 9; GGU 342094–4, 8.1–129.9; MGUH 21837.

Fig. 12. *Muderongia australis* × 500, section 10; GGU 342093–4, 23.2–137.9; MGUH 21838.

Fig. 13. *Muderongia extensiva* × 500, section 9; GGU 342070–7, 2.2–130.4; MGUH 21839.


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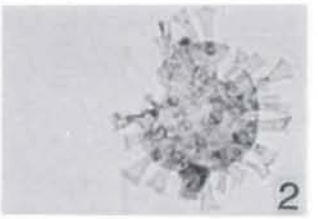
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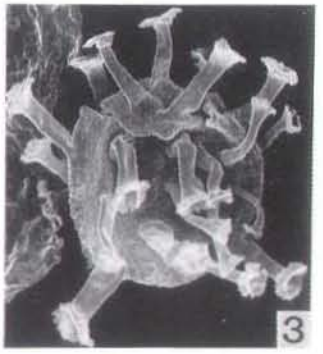
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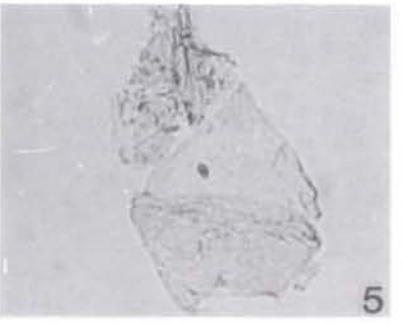
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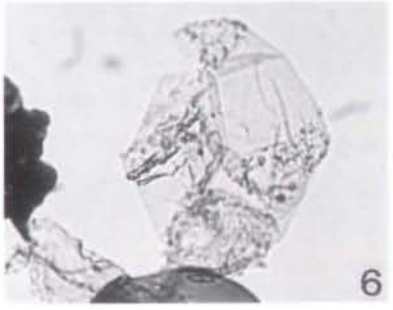
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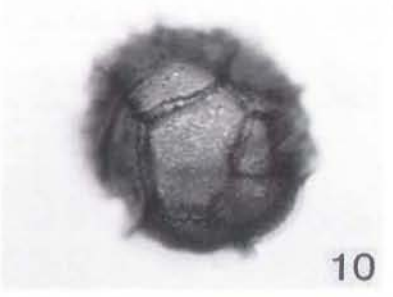
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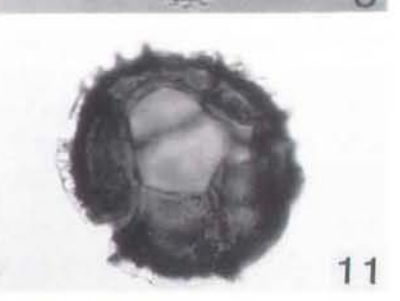
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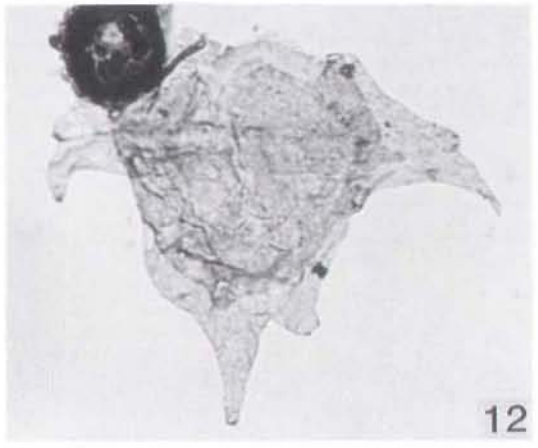
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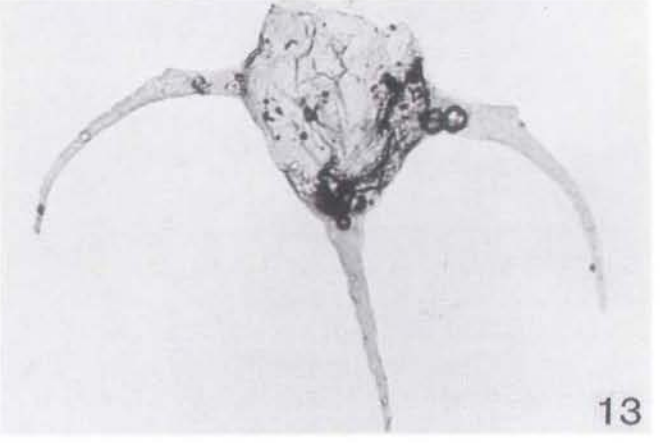
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Muderongia extensiva Duxbury, 1977

Plate 12, Fig. 13

Comments. A few, possible reworked, specimens are recorded from the lower Barremian, section 9. They have rather long lateral horns extending almost at right angles from the body. The horns are distally notched as originally described by Duxbury (1977, p. 54).

Previous occurrences. Muderongia extensiva was previously recorded from the lower Valanginian to lower Hauterivian, Speeton, England (Duxbury, 1977, type material) and Valanginian to Aptian, Arctic Norway, (Thusu, 1978, plate 2, fig. 7) but Thusu's specimen is not very typical of the species.

Muderongia cf. *M. pariata* Duxbury, 1983

Plate 13, Fig. 1

Comments. Only one specimen was recorded in the present study. The specimen has the characteristic short lateral horns which are distally blunt, open, and notched. The specimen has also, like *M. pariata*, only one antapical horn but it has not been possible to recognise the distal open part of this horn due to a shadowing particle which covers the tip.

Occurrence in East Greenland. Lower Aptian. Section 33.

Previous occurrences. Muderongia pariata was previously recorded from the lower Aptian to lower Albian, southern England (Duxbury, 1983, type material), 'middle' Barremian and lower Aptian to lower Albian, northwest Europe (Heilmann-Clausen, 1987) and lower to upper Aptian, southern England (Lister & Batten, 1988).

The species is reported from the Barremian in the Barents Sea as *Muderongia perforata* Alberti, 1961 by Århus *et al.* (1990) who proposed the transfer of *M. pariata* into *M. perforata.*

Muderongia simplex Alberti, 1961 *Muderongia* aff. *M. simplex* subsp. *microperforata* Davey, 1982b

Plate 13, Figs 2, 3 & 6

Comments. The ends of the lateral horns in the present specimens differs from the type material (Davey, 1982b; plate 9, figs 4–6) by being more pronounced, in contrast to the holotype which only has shorter bulges. The pointed horn terminations on the lateral horns have also been observed by Harding (1986, plate 17, figs 3, 8). Harding referred his specimens to *M. simplex microperforata.* Uwins & Batten (1988, plate 34, figs 18, 19) reported specimens from Libya, as *Muderongia* sp., which also look very similar to the present material. Århus *et al.* (1990, figs 12D, F) illustrated two specimens which they named *Muderongia* cf. *M. asymmetrica* with lateral horn terminations similar to the present material.

The marked difference of the morphology in specimens from East Greenland, southern England (Harding, 1986), Libya (Uwins & Batten, 1988) and Barents Sea (Århus *et al.*, 1990) from the type material of *M. simplex microperforata* (Davey, 1982b) may indicate that we are dealing with a new subspecies or maybe, more likely, a new species.

Occurrence in East Greenland. The upper part of the lower Barremian to the lower part of the upper Barremian. Sections 9, 11, 16, 18 and 21.

Previous occurrences. Muderongia simplex microperforata was previously recorded from the lower Barremian at Alford, England (Harding, 1990b), upper Ryazanian to

Plate 13

Fig. 1. *Muderongia* cf. *M. pariata* × 500, section 33; GGU 324029–4, 10.0–143.4; MGUH 21840.

Fig. 2. *Muderongia* aff. *M. simplex microperforata* × 500, section 16; GGU 351512–4, 11.0–138.3; MGUH 21841.

Fig. 3. *Muderongia* aff. *M. simplex microperforata* × 500, section 21; GGU 342231–7, 5.5–138.9; MGUH 21842 .

Fig. 4. *Nelchinopsis kostromiensis* × 500, section 10; GGU 342092–4, 21.9–114.8; MGUH 21843.

Fig. 5. *Nelchinopsis kostromiensis* × 500, section 21; GGU 342320–7, 22.2–141.0; MGUH 21844.

Fig. 6. *Muderongia* aff. *M. simplex microperforata* × 500, section 21; GGU 342231–7, 14.2–135.7; MGUH 21845.

Fig. 7. *Muderongia staurota* × 500, section 9; GGU 342071–4, 20.3–143.6; MGUH 21846.

Fig. 8. *Muderongia tetracantha* × 500, section 21; GGU 342230–8, 13.0–128.7; MGUH 21847.

Fig. 9. *Muderongia* cf. *M. tomaszowensis* × 500, section 9; GGU 342071–4, 9.1–132.0; MGUH 21848.

Fig. 10. *Muderongia* cf. *M. tomaszowensis* × 500, section 9; GGU 342071–4, 7.2– 130.0; MGUH 21849.

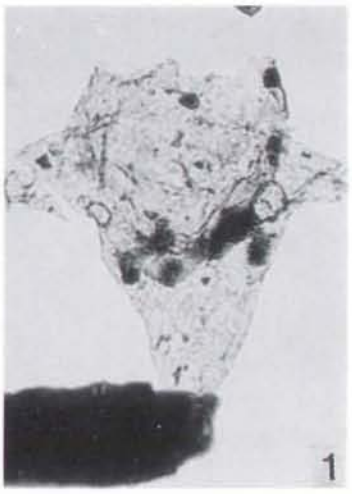
Fig. 11. *Nyktericysta? vitrea* × 500, section 17; GGU 342169–4, 17.1–153.2; MGUH 21850.

Fig. 12. *Nyktericysta? vitrea* × 500, section 17; GGU 342169; MGUH 21851.

Fig. 13. *Nyktericysta? vitrea* × 500, section 7; GGU 342087–10, 22.6–130.4; MGUH 21852.

Fig. 14. *Nyktericysta? vitrea* × 500, section 7; GGU 342087–11, 15.9–153.0; MGUH 21853.

Fig. 15. *Odontochitina ancala* × 500, section 36; GGU 324092–7, 16.4–155.2; MGUH 21854.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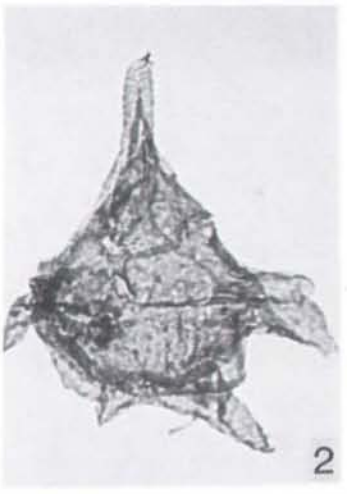
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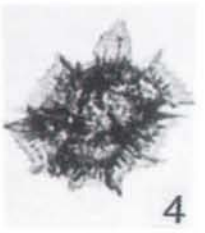
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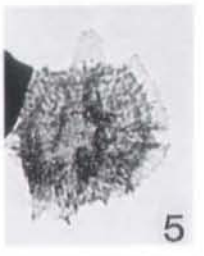
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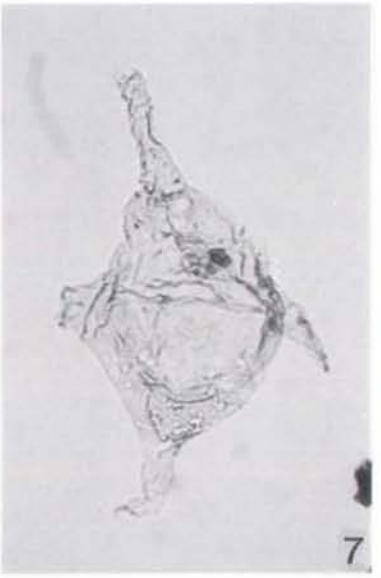
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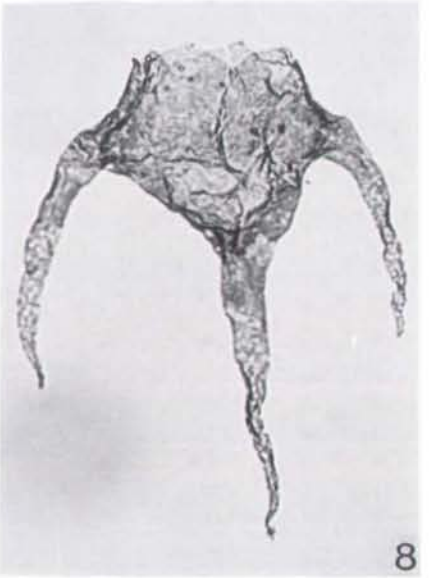
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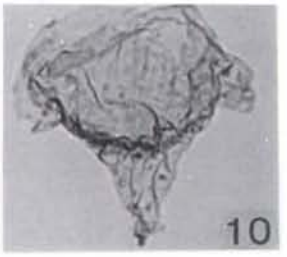
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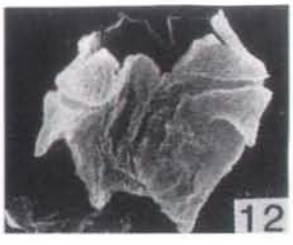
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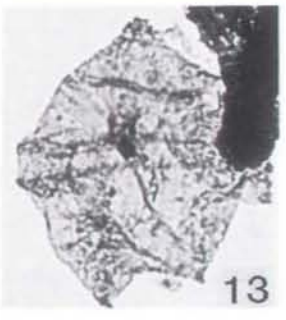
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upper Barremian, England and the North Sea (Costa & Davey, 1992), upper Ryazanian to lower Valanginian, north-west Europe, Ryazanian to upper Valanginian or lower Hauterivian in North Sea wells (Heilmann-Clausen, 1987), upper Ryazanian to lower Valanginian, Denmark (Davey, 1982b, type material), Hauterivian, southern, England (Harding, 1986) and lowermost Barremian, offshore Holland (R. J. Davey, personal communication in Harding, 1986 p. 107). The very similar species *M.* cf. *M. asymmetrica* Århus *et al.*, 1990 has been observed from the lower Barremian in the Barents Sea, whereas another similar species, *Muderongia* sp. Uwins & Batten, 1988, has been reported from the upper Hauterivian to lower Barremian, Libya.

Muderongia staurota Sarjeant, 1966c

Plate 13, Fig. 7

Occurrence in East Greenland. Lower to upper Barremian. Sections 9, 10 and 21, where only a few specimens have been recorded.

Previous occurrences. Muderongia staurota was previously recorded from the lower Barremian, Speeton, England (Sarjeant, 1966b, type material), the upper Hauterivian to lower Aptian, England and the North Sea (Costa & Davey, 1992), the uppermost lower Hauterivian to 'middle' Barremian, north-west Germany (Prössl, 1990), upper Hauterivian to uppermost Barremian, north-west Europe (Heilmann-Clausen, 1987) and upper Hauterivian to lower Barremian, Andøya, Norway (Aarhus *et al.*, 1986). The species seems not to have been recorded from above the Barremian.

Muderongia tetracantha (Gocht, 1957) Alberti, 1961

Plate 13, Fig. 8

Occurrence in East Greenland. Lower Barremian to lowermost Aptian. Sections 1, 4, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19 and 21.

Previous occurrences. Muderongia tetracantha was previously recorded from the lower Valanginian to lower Barremian, England and the North Sea (Costa & Davey, 1992), the lower Valanginian?, lower Hauterivian to upper Barremian and upper Aptian, north-west Europe (Heilmann-Clausen, 1987). Heilmann-Clausen (1987, p. 19) mentioned that the species has only been recorded above the lower Barremian by Below (1982b) from northern Germany, and considered the species as more typical for the Hauterivian and lower Barremian.

Aarhus *et al.* (1986) reported the species from the upper Hauterivian to lower Barremian, Andøya, Norway and Århus *et al.* (1990) reported it from the Hauterivian to lower Barremian, Barents Sea. Thusu (1978) reported a lower Valanginian to upper Aptian occurrence, Arctic Norway. Pocock (1976) and Brideaux (1977) have recorded the species from Hauterivian to lower Barremian, Arctic Canada and District of Mackenzie, Canada. Brideaux & McIntyre (1975) have recorded the species in the upper Aptian, also from the District of Mackenzie, Canada. Brideaux & Myhr (1976) similarly recorded the species from the District of Mackenzie, Canada, but only from the Barremian. Morgan (1980) recorded it from the uppermost Neocomian to top of the lower Albian in Australia. Helby *et al.* (1987) recorded *M. teracantha* from the uppermost Valanginian to lower Albian in Australia. Davey (1988) recorded the species (as *M. tetracantha sensu* Morgan 1980) from the upper Aptian and lower Albian in Papua New Guniea. Williams & Bujak (1985) reported the world-wide range as upper Hauterivian to lower Barremian.

Previous observations indicate that the species is rather common in the Hauterivian and lower Barremian but rare in the Aptian of Europe, whereas Aptian occurrence in Arctic Norway, Canada and Australia seems to be more common. The presumed lowermost Aptian record from East Greenland supports the suggestion that it has a longer range in the Arctic.

Muderongia cf. *M. tomaszowensis* Alberti, 1961

Plate 13, Figs 9–10

Comments. The few lower to upper Barremian specimens recorded from East Greenland, sections 9, 11 and 21, have slightly shorter lateral horns than the type material illustrated by Alberti. The present material has lateral horns similar to those of *M. pariata*, but the antapical horns of *M.* cf. *M. tomaszowensis* differ by not being open ended, blunt and notched.

Previous occurrences. Muderongia tomaszowensis was previously recorded from the Valanginian, Poland (Alberti, 1961, type material), Berriasian to upper Barremian (Millioud *et al.*, 1975) and Barremian, offshore eastern Canada (Bujak & Williams, 1978).

Genus *Nelchinopsis* Wiggins, 1972

Nelchinopsis kostromiensis (Vozzhennikova, 1967) Wiggins, 1972

Plate 13, Figs 4–5

Comments. In the present study no attempt has been made

to deal with the systematic discussion on this species (Wiggins, 1972, p. 299; Duxbury, 1977, p. 37; Stover & Williams, 1987, p. 11; Lentin & Vozzhennikova, 1990, p. 108–110; Harding, 1990b, p. 52).

Occurrence in East Greenland. The species here referred to as *N. kostromiensis* occurs in the upper Hauterivian? – lower Barremian, sections 9, 10, 18 and 21, but a few specimens were also found in the lowermost upper Barremian sample GGU 342235 from section 21.

Previous occurrences. Nelchinopsis kostromiensis was previously recorded from the lower Valanginian to upper Hauterivian, England and the North Sea (Costa & Davey, 1992), the lower Hauterivian to lower Barremian (as *Gonyaulacysta kostromiensis)* from north-west Europe by Heilmann-Clausen (1987) and lower Hauterivian to uppermost Hauterivian (as *G. kostromiensis)*, north-west Germany (Prössl, 1990). Harding (1990b) observed that the species (as *Alaskadinium wigginsi*) ranges into the lowermost Barremian in England and Germany. This is consistent with observations of the species (as *N. kostromiensis*) from the Barents Sea (Århus *et al.*, 1990) and the present records from East Greenland. The species also has been recorded from Valanginian and upper Hauterivian to lower Barremian (as *Gonyaulacysta kostromiensis*), offshore south Norway (Ofstad, 1983) and from upper Valanginian to lower Hauterivian, Alaska (Wiggins, 1972). The type material was described from the Valanginian in the Kostroma region, Russia by Vozzhennikova (1967).

Genus *Nyktericysta* Bint 1986
Nyktericysta? *vitrea* (Duxbury, 1983) Bint, 1986

Plate 13, Figs 11–14

Comments. The cysts from East Greenland described as *Nyktericysta*? *vitrea* have two closely adpressed wall layers, an autophragm covered by a microreticulate ectophragm (Plate 13, Fig. 12).

Discussion. Lister & Batten (1988) divided *Australisphaera vitrea* Duxbury, 1983 into *A. vitrea* and *A. pseudovitrea* Lister & Batten, 1988, without making any comments on Bint's (1986, p. 149) provisional assignment of the species to *Nyktericysta*? *vitrea. Australisphaera pseudovitrea* might very well be a species of *Nyktericysta.* and is distinguished from *A. vitrea* by the lack of sharply digitate projections at its lateral horns (Lister & Batten, 1988, p. 27). Lister & Batten (1988; table 1, A-B) indicated that *A. vitrea* and *A. pseudovitrea* never occur together in their material from southern England. In the present study forms similar to the two species distinguished by Lister & Batten (1988) have been recorded from the same sample (Plate 13, Figs 13–14).

In the studied material from East Greenland the two species *N.*? *vitrea* and *A. pseudovitrea* seem to be two end members of the same species and no attempt has been made to follow the division by Lister & Batten (1988).

Occurrence in East Greenland. Upper Barremian to upper Aptian. Sections 1, 6, 7, 8, 13, 15, 17, 19, 21, 32 and 33.

Previous occurrences. Nyktericysta? *vitrea* was previously recorded from the lower Aptian, southern England as *A. vitrea* (Duxbury, 1983, type material), upper Barremian as *A. pseudovitrea* and from the lower Aptian as *A. vitrea*, southern England (Lister & Batten, 1988).

Genus *Odontochitina* Deflandre, 1935; emend. Bint, 1986
Odontochitina ancala Bint, 1986

Plate 13, Fig. 15

Occurrence in East Greenland. Except for a few questionable specimens from the middle Albian sections 20, 23, all the recorded specimens are of late Albian age (sections 24, 25, 27, 30, 31, 35, 36, 37 and 38).

Previous occurrences. Odontochitina ancala was previously recorded from the upper Barremian to middle Albian, north-west Germany (Prössl, 1990), lower Aptian to middle Albian, Portugal (Berthou & Leereveld, 1990), middle and upper Albian in Western Interior, USA (Bint, 1986, type material) and from the same interval in Alaska (as *O.* cf. *O. operculala)* by May & Stein (1979).

Odontochitina costata Alberti, 1961; emend. Clarke & Verdier, 1967

Plate 14, Fig. 1

Occurrence in East Greenland. Middle part of the upper Albian. Sections 36, 37 and 38.

Previous occurrences. Odontochitina costata was previously recorded from the Cenomanian and Turonian, Germany (Alberti, 1961, type material), the upper Aptian to upper Turonian, north-west Germany (Prössl, 1990), middle to upper Albian, Peace River area, western Canada (Singh, 1971), upper Albian to lower Cenomanian, Saskatchewan, Canada (Davey, 1969), lower Cenomanian, Alaska (May, 1979), upper Albian to Cenomanian, off-

shore eastern Canada (Williams, 1975; Bujak & Williams, 1978) and upper Albian to top Campanian, worldwide (Williams & Bujak, 1985).

Odontochitina imparilis (Duxbury, 1980) Jain & Khowaja-Ateequzzaman, 1984

Plate 14, Fig. 2

Comments. Two specimens have been recorded from the lower Aptian section 33. On both specimens the cingulum is reflected by a distinct double line on the long lateral horn (Plate 14, Fig. 2).

Previous occurrence. Odontochitina imparilis was previously recorded from the 'middle' and upper Barremian, Speeton, England (Duxbury, 1980, type material).

Odontochitina cf. *O. imparilis* (Duxbury, 1980) Jain & Khowaja-Ateequzzaman, 1984

Plate 14, Fig. 3

Comments. Two specimens recorded from the lower Aptian part of section 7 have a very elongate endoblast exhibiting projections into the apical and antapical horns, as described by Duxbury (1980, p. 128), whereas the reflection of the cingulum on the lateral horn is absent or very weak (Plate 14, Fig. 3). These specimens could be atypical forms of *Odontochitina operculata* but are here assigned to *O.* cf. *O. imparilis.*

Odontochitina operculata (O. Wetzel, 1933a) Deflandre & Cookson, 1955

Plate 14, Figs 4–6

Comments. Apart from specimens very similar to the holotype, several specimens with a swollen basal part on the antapical horn (Plate 14, Figs 4 & 6) have been observed and treated as *O. operculata* in the present study.

Occurrence in East Greenland. Upper Barremian to upper Albian. The species is rather common from the uppermost Barremian to the uppermost middle Albian. It has been recorded in 33 of the 40 examined sections.

Previous occurrences. Odontochitina operculata was previously recorded from the lowermost to uppermost Barremian, Speeton, England (Davey, 1979b), whereas Duxbury (1980) recorded the first occurrence of the species in the lower part of the 'middle' Barremian (now upper Barremian) at Speeton, England. Costa & Davey (1992) recorded the species from the lower Barremian to upper Maastrichtian, England and the North Sea. Heilmann-Clausen (1987) recorded the species from the lower Barremian to Cenomanian, north-west Europe, whereas (Prössl, 1990) recorded it questionably in the upper Hauterivian to lower Barremian but present from the uppermost lower Barremian to upper Turonian, northwest Germany. According to Duxbury (1980) pre-Barremian records of *O. operculata* may be disregarded. Harding (1990b) recorded the first occurrence of the species as upper Barremian, England and Germany and mentioned that the previously reported pre-upper Barremian occurrences of the species may be misidentifications of, for example, operculae from *Muderongia* species. Harding's suggestion corroborates the observations from East Greenland.

Odontochitina singhii Morgan, 1980

Plate 14, Fig. 7

Occurrence in East Greenland. Lower Albian to top middle Albian. Sections 5, 20, 22, 23 and 26. Two specimens have also been recorded from the presumed lowermost upper Albian section 29.

Previous occurrences. Odontochitina singhii was previously recorded from the upper Barremian to middle Al-

Plate 14

Fig. 1. *Odontochitina costata* × 500, section 36; GGU 324093–5, 18.3–135.7; MGUH 21855.

Fig. 2. *Odontochitina imparilis* × 500, section 33; GGU 324029–5, 9.0–156.3; MGUH 21856.

Fig. 3. *Odontochitina* cf. *O. imparilis* × 500, section 7; GGU 342087–4, 13.2–126.6; MGUH 21857.

Fig. 4. *Odontochitina operculata* × 500, section 20; GGU 342194–4, 9.7–127.0; MGUH 21858.

Fig. 5. *Odontochitina operculata* × 500, section 17; GGU 342169–4, 16.8–122.2; MGUH 21859.

Fig. 6. *Odontochitina operculata* × 500, section 20; GGU 342199–4, 15.9–127.8; MGUH 21860.

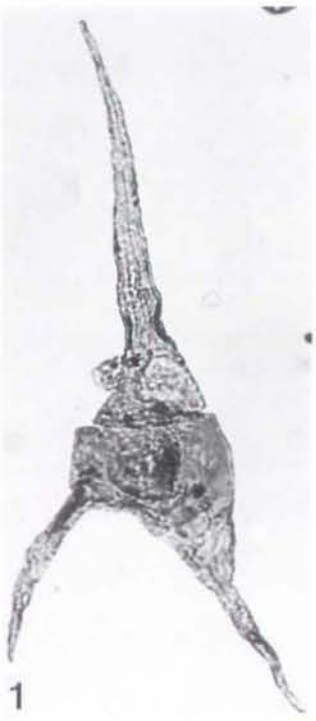
Fig. 7. *Odontochitina singhii* × 250, section 20; GGU 342183–4, 13.2–134.0; MGUH 21861.

Fig. 8. *Oligosphaeridium* cf. *O. albertense* × 500, section 11; GGU 342102–8, 16.7–154.0; MGUH 21862.

Fig. 9. *Oligosphaeridium*? *asterigerum* × 500, section 19; GGU 342214–4, 7.0–135.8; MGUH 21863.

Fig. 10. *Oligosphaeridium*? *asterigerum* × 500, section 7; GGU 342081–5, 18.5–136.0; MGUH 21864.

Fig. 11. *Oligosphaeridium complex* × 500, section 17; GGU 342169–4, 8.8–120.0; MGUH 21865.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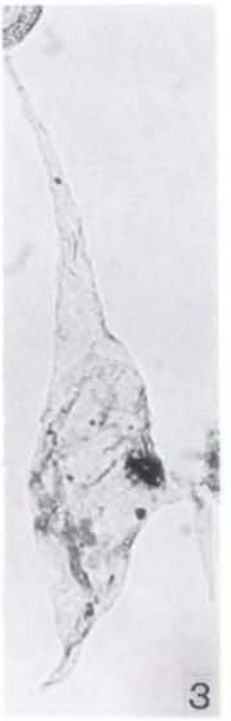
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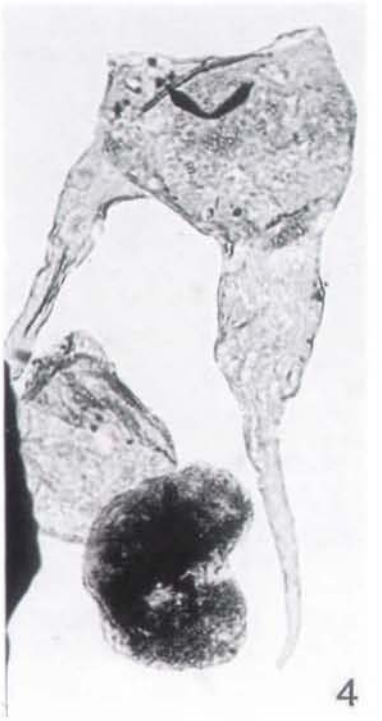
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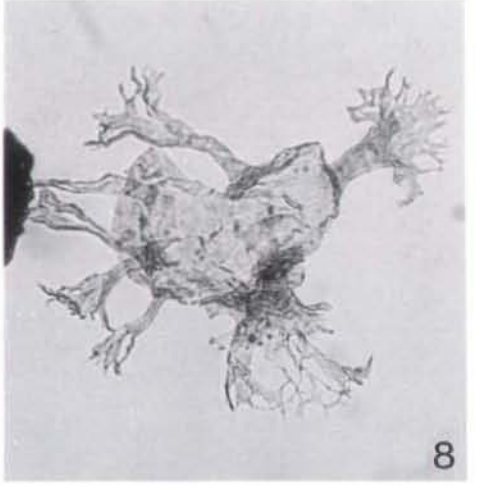
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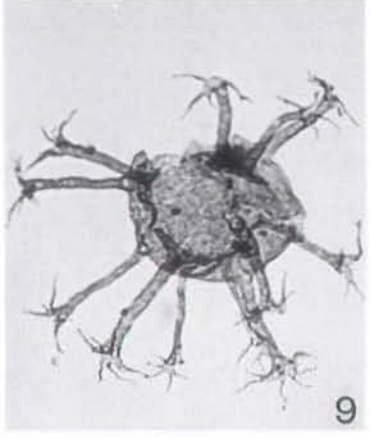
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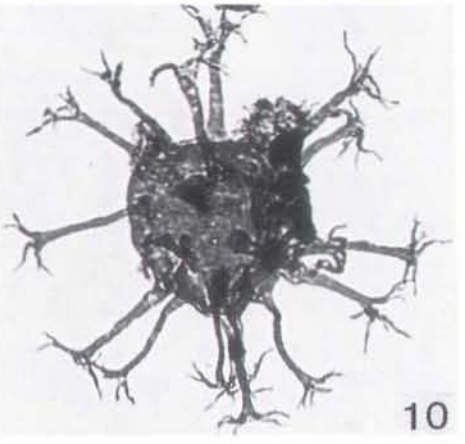
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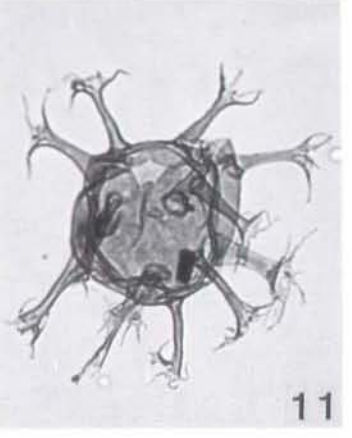
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bian, north-west Germany (Prössl, 1990), Aptian – lower Albian to middle Albian, Spitsbergen (Århus, 1991) whereas it has its first occurrence in the upper Albian, western Canada (Singh, 1983). Dixon *et al.* (1989) discuss the age of their recording of the species from the Northwest Territories, Canada and propose a late middle to late Albian age. From Australia the species has been recorded from the lower to upper Albian (Morgan, 1980, type material).

Genus *Oligosphaeridium* Davey & Williams, 1966b; emend. Davey, 1982b

Oligosphaeridium cf. *O. albertense* (Pocock, 1962) Davey & Williams, 1969

Plate 14, Fig. 8

Comments. The recorded specimens are thin walled and often damaged.

Occurrence in East Greenland. Lower and upper Barremian. Sections 10, 11, 16, 18 and 19.

Previous occurrences. Oligosphaeridium albertense was previously recorded from the uppermost Hauterivian to uppermost lower Albian, north-west Germany (Prössl, 1990), upper Barremian, western Canada (Pocock, 1962, type material), Hauterivian to lower Albian, District of Mackenzie, Canada (Brideaux, 1977) and middle and upper Albian (as *O. irregulare*) Alaska (May & Stein, 1979). Costa & Davey (1992) recorded the last occurrence of the species in the top lower Cenomanian in England and the North Sea.

Oligosphaeridium? *asterigerum* (Gocht, 1959) Davey & Williams, 1969

Plate 14, Figs 9–10

Occurrence in East Greenland. Lower Barremian to lower Aptian. Sections 1, 4, 7, 8, 9, 10, 11, 13, 14, 16, 17, 18, 19, 21 and 33.

Comments. The processes on *Oligosphaeridium*? *asterigerum* are slender cylindrical with secate process tips in contrast to the processes on *O. complex* which are funnel shaped with aculeate process tips.

Previous occurrences. Oligosphaeridium? *asterigerum* was previously recorded from the lower Hauterivian, Germany (Gocht, 1959, type material), the lower Hauterivian to lowermost upper Turonian, north-west Germany (Prössl, 1990) and Valanginian to upper Barremian and from the upper Aptian in north-west Europe (Heilmann-Clausen, 1987).

Oligosphaeridium complex (White, 1842) Davey & Williams, 1966b

Plate 14, Fig. 11 & Plate 15, Fig. 1

Occurrence in East Greenland. Lower Barremian to upper Albian, the species has been observed in all the 40 examined sections where it is often quite common.

Previous occurrences. Oligosphaeridium complex was previously recorded from the lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990). Davey & Williams (1966b) described the neotype from the Cenomanian in England and mentioned that they, also in England, have recorded similar specimens from the Barremian and Ypresian (Tertiary).

Oligosphaeridium cf. *O. fenestratum* Duxbury, 1980

Plate 15, Fig. 2

Comments. The few specimens recorded are often fragmented.

Plate 15

Fig. 1. *Oligosphaeridium complex* × 500, section 17; GGU 342161–4, 8.5–153.0; MGUH 21866.

Fig. 2. *Oligosphaeridium* cf. *O. fenestratum* × 500, section 9; GGU 342069–8, 7.2–132.2; MGUH 21867.

Fig. 3. *Oligosphaeridium preforatum perforatum* × 500, section 14; GGU 342132–4, 21.0–150.1; MGUH 21868.

Fig. 4. *Oligosphaeridium perforatum perforatum* × 500, fragment of specimen illustrating the characteristically distal part of the processes, section 13; GGU 351585–4, 4.0–140.5; MGUH 21869.

Fig. 5. *Oligosphaeridium perforatum colum* × 500, fragment illustrating the processes, section 18; GGU 342218–4, 7.8–144.3; MGUH 21870.

Fig. 6. *Oligosphaeridium perforatum colum* × 500, section 21; GGU 342238–3, 13.8–121.0; MGUH 21871.

Fig. 7. *Oligosphaeridium poculum* × 500, section 17; GGU 342162–4, 14.8–153.2; MGUH 21872.

Fig. 8. *Oligosphaeridium poculum* × 500, section 17; GGU 342167–4, 8.1–148.6; MGUH 21873.

Fig. 9. *Oligosphaeridium poculum* × 500, section 30; GGU 324617–8, 21.2–153.1; MGUH 21874.

Fig. 10. *Oligosphaeridium prolixispinosum* × 500, section 17; GGU 342169–4, 12.4–128.8; MGUH 21875.

Fig. 11. *Oligosphaeridium prolixispinosum* × 500, section 17; GGU 342169; MGUH 21876.

Fig. 12. *Oligosphaeridium* cf. *O. pulcherrimum* × 500, section 21; GGU 342238–3, 6.5–131.1; MGUH 21877.

Fig. 13. *Oligosphaeridium* cf. *O. pulcherrimum* × 540, section 17; GGU 342164: MGUH 21878.


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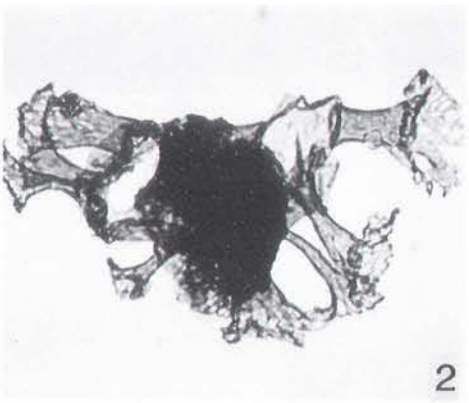
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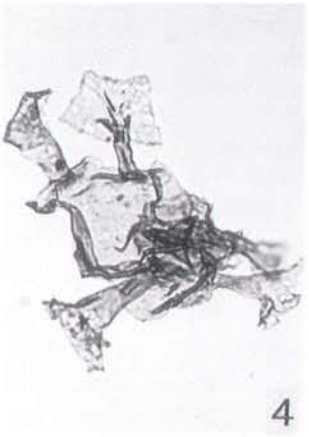
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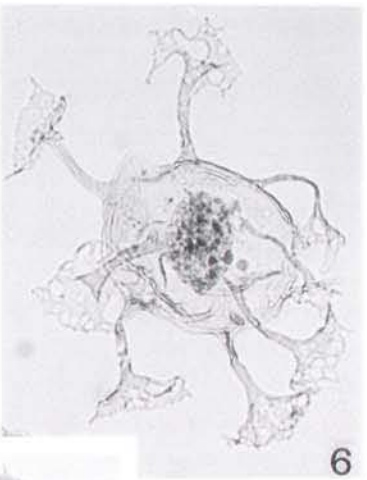
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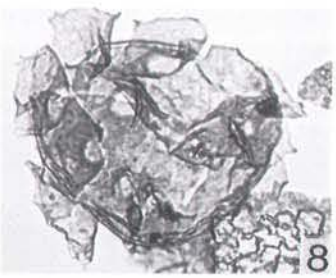
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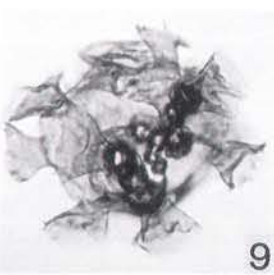
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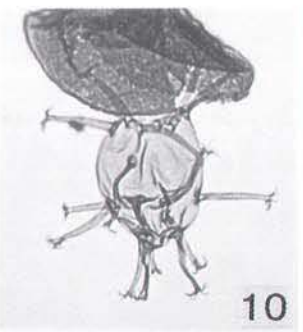
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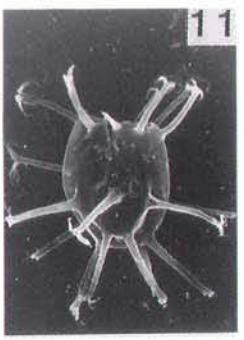
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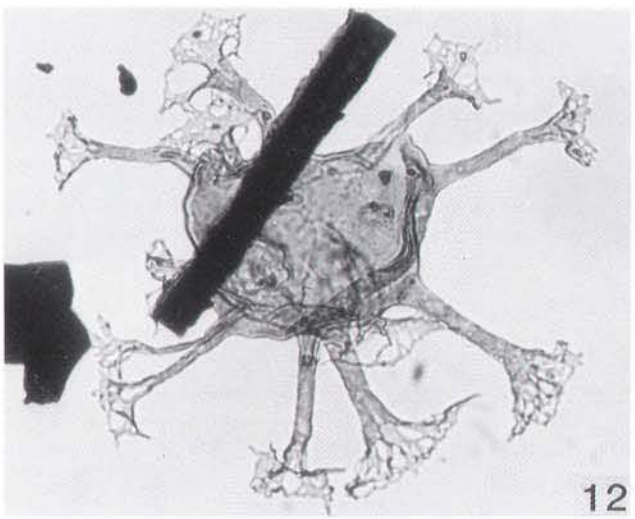
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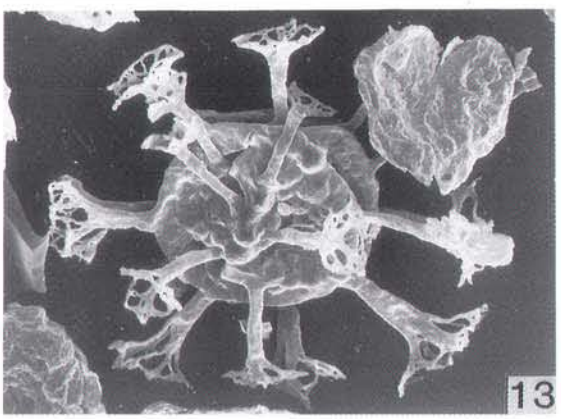

13

Occurrence in East Greenland. Barremian. Sections 6, 9, 11, 14, 16, and 18.

Previous occurrence. The type material was recorded from the Barremian in England by Duxbury (1980).

Oligosphaeridium perforatum (Gocht, 1959) Davey & Williams, 1969 subsp. *colum* Duxbury, 1983

Plate 15, Figs 5–6

Comments. A very few specimens of the subspecies have been recorded from the lower and upper Barremian, sections 18 and 21. The distal parts of the processes have less angularity and more fenestration than the other subspecies *O. perforatum perforatum.*

Previous occurrence. The type material was described from the upper Aptian to lower Albian in England by Duxbury (1983).

Oligosphaeridium perforatum (Gocht, 1959) Davey & Williams, 1969 subsp. *perforatum* Duxbury (1983)

Plate 15, Figs 3–4

Occurrence in East Greenland. Lower Barremian to middle Albian. Sections 1, 6, 7, 9, 12, 13, 14, 17, 18, 20, 22 and 23.

Previous occurrences. Oligosphaeridium perforatum was previously recorded from the lower to upper Aptian, England (Duxbury, 1983), Hauterivian to Barremian, Germany (Gocht, 1959, type material), upper Hauterivian to top lower Aptian, Andøya, Norway (Aarhus *et al.*, 1986) and upper Hauterivian in a North Sea well (Heilmann-Clausen, 1987).

Oligosphaeridium poculum Jain, 1977b

Plate 15, Figs 7–9

Occurrence in East Greenland. Lower Barremian to middle part of upper Albian. Sections 5, 7, 8, 9, 10, 13, 14, 15, 17, 18, 19, 20, 21, 23, 30, 31, 32, 34 and 36. The species always occurs in low numbers.

Previous occurrences. Oligosphaeridium poculum was previously recorded from the lower Hauterivian to lowermost upper Albian, north-west Germany (Prössl, 1990). The German distribution, like the present observations documents that the species has a rather long range. It has also been reported from the uppermost Barremian to upper Aptian, south-east England by Lister & Batten (1988). The species was described from the lower Albian in India by Jain (1977) who mentioned (1977, p. 181) that *Polystephanephorus* sp. cf. *P. urnaformis* (Cookson, 1953), described from the Albian of western Canada by Singh (1971) and Pocook (1976), appears to be synonymous with *O. poculum.*

Oligosphaeridium prolixispinosum Davey & Williams, 1966b

Plate 15, Figs 10–11

Occurrence in East Greenland. Barremian to middle Albian. Sections 7, 17, 19, 20, 21 and 22.

Previous occurrences. Oligosphaeridium prolixispinosum was previously recorded from the Cenomanian, England (Davey & Williams, 1966b, type material), the upper part of the lower Albian to the lowermost part of the middle Albian, north-west Germany (Prössl, 1990), upper Barremian from north-west Europe, Heilmann-Clausen (1987) and upper Barremian to top Coniacian, worldwide (Williams & Bujak, 1985).

Oligosphaeridium cf. *O. pulcherrimum* (Deflandre & Cookson, 1955) Davey & Williams, 1966b

Plate 15, Figs 12–13

Comments. The specimens here referred to *O.* cf. *O. pulcherrimum* differ slightly from the type material described by Deflandre & Cookson (1955) by the shape of the processes. The processes of *O. pulcherrimum* gradually widen into deep strongly perforated almost reticulate funnels from about half their length, the rims of the funnels are fringed with numerous spines. The processes on the *O.* cf. *O. pulcerrimum* gradually widen into perforated almost reticulate funnels from about two thirds of their length and have fewer spines distally. The processes of *O.* cf. *O. pulcherrimum* are morphological close to the processes of *Stiphrosphaeridium anthophorum* but the processes of *S. anthophorum* widen into reticulate funnels almost from their base, have more extensive reticulation and fewer or no spines on the continuous smooth distal edges.

Occurrence in East Greenland. Lower Barremian to upper Albian. The species has been recorded from 32 of the 40 examined sections.

Previous occurrences. Oligosphaeridium pulcherrimum was previously recorded from the upper Hauterivian and

the Barremian, Speeton, England (Duxbury, 1977; 1980), the Lower Cretaceous, Australia (Eisenack & Cookson, 1955, type material) and upper Hauterivian to upper Turonian, north-west Germany (Prössl, 1990). The species range according to Davey & Verdier (1974) from pre-Barremian to post-Cenomanian in Europe.

Oligosphaeridium cf. *O. totum* Brideaux, 1971

Plate 16, Fig. 1

Occurrence in East Greenland. Uppermost lower Aptian to upper Albian. Sections 12, 13, 20, 21, 22, 23, 24, 25, 26, 28, 29, 31, 35, 36 and 37.

Previous occurrences. Oligosphaeridium totum was previously recorded from the Aptian, Arctic Norway (Thusu, 1978) lower? Albian, Peary Land, North Greenland and upper Aptian to lower Albian, Barents Sea (Århus, 1991), middle and upper Albian, western Canada (Singh, 1971; Brideaux, 1971, type material), Aptian to upper Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975), Hauterivian to lower Albian, District of Mackenzie, Canada (Brideaux, 1977), Hauterivian to top Barremian, District of Mackenzie, Canada (Brideaux & Myhr, 1976), upper Aptian to lowermost middle Albian, Edmonton Embayment, western Canada (Banerjee & Davies, 1988) and lower Albian to above the lower Cenomanian, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978).

Oligosphaeridium sp. 1

Plate 16, Fig. 2

Description. The specimens here described as *Oligosphaeridium* sp. 1 have some similarities with *Oligosphaeridium albertense* (Pocock, 1962) Davey & Williams, 1969, but the processes differ by being slightly larger (up to 52 μ), less trumpet-shaped and almost cylindrical, except for a distal expansion, slightly fenestrate with an aculate to secate margin. The fenestration is much less pronounced than on *O. fenestratum* and *O. pulcherrimum.*

Occurrence in East Greenland. Upper Aptian to upper Albian. Sections 5, 12, 13, 20, 23, 26, 29 and 30. The species is abundant to dominant in a rather narrow interval in the middle Albian. Sections 5, 20 and 23.

Previous occurrence. Oligosphaeridium sp. 1 was previously recorded from the middle Albian, Spitsbergen as *Oligosphaeridium* sp. *sensu* Nøhr-Hansen (Århus, 1991).

Genus *Ovoidinium* Davey 1970; emend. Duxbury, 1983

Ovoidinium cinctum (Cookson & Eisenack, 1958) Davey, 1970

Plate 16, Figs 3–4

Comments. The few recorded specimens from the lower Aptian part of section 17 have the typical shape, an apical horn with a small central projection, and a granular epicyst as originally described by Cookson & Eisenack, 1958.

Previous occurrences. Ovoidinium cinctum was previously recorded from the upper Neocomian to lower Aptian, Papua New Guinea (Cookson & Eisenack, 1958, type material) and uppermost lower Aptian to upper Aptian (as *Ascodinium cinctum*) from southern England (Lister & Batten, 1988).

Ovoidinium? sp. 1

Plate 24, Figs 5–14

Description. Ovoidinium? sp 1 is represented by two morphological very similar forms that always occur together. The first morphotype has an ovoidal outline and the wall is probably composed of two closely appressed layers (Plate 24, Figs 5, 6, 11, 12?, 14). The second morphotype is hypocavate. The pericyst is ovoidal to slightly pentagonal in outline whereas the endocyst is smaller and almost circular (Plate 24, Figs 7, 8, 9, 10, 13).

Both forms are dorsoventral compressed. Both endophragm and ectophragm are smooth without any ornamentation. The archeopyle is type ?tAtI and the operculum is free or adherent. Tabulation pattern is only observed at the archeopyle margin; cingulum and sulcus are not indicated. The length of five complete specimens ranges from 50 to 65 μ and the width ranges from 45 to 55 μ.

Remarks. The species is placed in the genus *Ovoidinium* with a question mark due to the absence of cingulum and sulcus, which are usually present on *Ovoidinium* species.

Occurrence in East Greenland. Uppermost Albian where it is quite common. Sections 24, 25, 27, 30, 39 and 40. The species seems to be a good stratigraphical marker.

Previous occurrence. The species was previously observed from the upper Albian to lowermost Cenomanian, Troms and Hammerfest basins, offshore north-west Norway (L. I. Costa, personal communication 1989).

Ovoidinium sp. 2

Plate 16, Figs 5–8

Description. The few observed specimens are bicavate with a smooth, thin-walled pericyst of pentagonal outline and a smooth, thin-walled spherical endocyst, a short apical horn and two reduced antapical horns. A combination archeopyle (type tAtI) is indicated by fractures on the observed specimens. The cingulum is indicated by a flange. A small dark circular spot is present inside the epicyst on the observed specimens.

Remarks. Ovoidinium sp. 2 differs from *O.* sp. 3 by having a cingular flange, a circular spot inside the epicyst and by its smooth periphragm and endophragm.

Occurrence in East Greenland. Uppermost Albian. Sections 30 and 40.

Ovoidinium sp. 3

Plate 16, Figs 9–11

Description. The few observed specimens have a thin-walled periphragm and a shagreenate to granulate spherical inner-body. The cyst is bicavate with a broad based, gently narrowing apical projection, an even broader based antapical projection with almost parallel sides, and an almost right-angled to slightly rounded posterior closure. The cingulum is indicated by folds or ridges on the periphragm. No tabulation has been observed.

The combination archeopyle (type tAtI) is indicated by a fracture on three specimens, whereas the operculum is detached on a fourth and slightly larger specimen (width 51 μ; Plate 16, Fig. 11). This larger specimen differs slightly in the shape of the endophragm which has an antapical bulge extending into the antapical projection.

Dimensions. Complete specimens (3) length 62 (67) 71 μ, width 35 (40) 43 μ, apical projection 14 (16) 20 μ, antapical projection 14 (16) 20 μ.

Remarks. Ovoidinium sp. 3 resembles *O. incorporeum* Duxbury, 1983, but differs by its size and shape of the apical and antapical projections. The specimens differ from *O. verrucosum* (Cookson & Hughes 1964) Davey, 1970 by having a relatively large apical projection and grana instead of verrucae on the endophragm.

Occurrence in East Greenland. Middle Albian. Sections 21 and 22.

Ovoidinium sp. 4

Plate 16, Figs 12–13

Description. The few specimens observed from the upper Barremian, section 17, are cavate with a thin walled periphragm and a shagreenate to scabrate, spherical endophragm. The apical horn has a small projection leaving a very narrow anterior cavation. The posterior cavation is larger and the antapical projection is asymmetrical with a prominent pointed left horn. The cingulum is developed by folds on the periphragm. The combination archeopyle (type tAtI) is indicated by fractures in the endophragm, the operculum being attached on one of the two observed specimens (Plate 16, Fig. 13). Tabulation is only indicated by fractures between the dorsal precingular plates on the endophragm.

Dimensions. Dimension of the complete specimen. Length 59 μ, width 42 μ. Specimen without operculum, length 36 μ.

Remarks. The specimens differ from *O. scabrosum* (Cookson & Hughes, 1964) Davey, 1970 by its smaller anterior cavation and by its pronounced fracturing between the precingular plates. The specimens are almost comparable to *O. verrucosum* (Cookson & Hughes, 1964) Davey, 1970 in size and shape, but the ornamentation on the endophragm is less distinctive than the verrucae on *O. verrusosum.*

Genus *Palaeohystrichophora* Deflandre, 1935

Palaeohystrichophora infusorioides Deflandre, 1935

Plate 16, Fig. 14

Occurrence in East Greenland. Upper Albian. Sections 24, 25, 28, 30, 31, 37, 39 and 40.

Previous occurrences. Palaeohystrichophora infusorioides was previously recorded from the Vraconian (uppermost Albian) to Cenomanian, France (Davey & Verdier, 1973), middle Cenomanian, Peace River area, western Canada (Singh, 1983), Cenomanian, Saskatchewan, Canada (Davey, 1970; samples 890, 835, 805), but according to Singh (1983, table 7) sample 890 is of late Albian age, lower Cenomanian, Western Interior, USA (Nichols & Jacobsen, 1982), middle? – upper Albian and upward, offshore eastern Canada (Williams, 1975; Bujak & Williams, 1978), upper Albian to top Campanian, world-wide (Williams & Bujak, 1985) and Albian and younger, Australia (Cookson & Eisenack, 1960a; Ingram,

1968; Morgan, 1980). Other reported first occurrences of the species are of younger age (for full references see Singh, 1983, p. 158–159). The species appears in the upper Albian in Australia, north-west Europe and East Greenland and has also been reported from the upper Albian, offshore eastern Canada and Saskatchewan, Canada. The species first occurs in the Cenomanian or younger strata in the Western Interior, western Canada and Arctic Canada.

Genus *Palaeoperidinium* Deflandre, 1935; emend. Sarjeant, 1967b
Palaeoperidinium cretaceum Pocock, 1962, emend. Davey, 1970

Plate 16, Fig. 15

Occurrence in East Greenland. Upper Barremian to upper Albian. The species is quite common in the upper Aptian to mid upper Albian. It was recorded in 34 of the 40 examined sections.

Previous occurrences. Palaeoperidinium cretaceum has never been reported from sediments older than late Barremian (including the 'middle' Barremian in England, Davey, 1979b; Duxbury, 1980; Harding, 1990b). Thusu (1978) reported the species from unspecified Barremian strata, Arctic Norway, and Århus *et al.* (1990) recorded the species from the lower Barremian of the Barents Sea. Prössl (1990) reported it from the uppermost lower Barremian to upper Turonian, north-west Germany. Brideaux (1977) recorded the species from the Hauterivian to middle Albian, District of Mackenzie, Canada and Williams & Bujak (1985) recorded it from the upper Barremian to the mid middle Albian, world-wide. Harding (1990a, b) concluded, from his observations of the species in the upper Barremian that the species was restricted to nearshore environments and also mentioned (1990b, p. 52) that the species may be used as a palaeoenvironmental indicator but that it does not satisfy the requirements of a zonal index species.

Palaeoperidinium? sp. 1

Plate 16, Figs 16–17

Description. A relatively small cyst (length 46 μ, width 37 μ), spherical to slightly pentagonal in outline, a small apical and left antapical horn, whereas the right antapical horn is absent or reduced to a bulge. The broad cingulum divides the cyst into a slightly longer epicyst than hypocyst. The surface is scabrate to granulate, no archeopyle has been observed.

Remarks. Palaeoperidinium? sp. 1 is smaller and has less pronounced antapical horns than *P. cretaceum*.

Occurrence in East Greenland. Upper Albian. Sections 24, 25, 27, 28, 29, 30, 31, 35, 36, 37, 38, 39 and 40. The first occurrence of the species seems to be a good marker for the base of the upper Albian.

Genus *Pareodinia* Deflandre 1947; emend. Stover & Evitt, 1978
Pareodinia spp.

Plate 11, Fig. 1, Plate 17, Figs 1–5

Comments. In the present study no attempt has been made to identify species of the genus.

Occurrence in East Greenland. Barremian to upper Albian. Sections 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 18, 19, 20, 21, 22, 30, 32 and 36.

Genus *Phoberocysta* Millioud, 1969; emend. Helby, 1987
Phoberocysta neocomica (Gocht, 1957) Millioud, 1969; emend. Helby, 1987 subsp. *neocomica* Lentin & Williams (1973)

Plate 17, Figs 6–8

Occurrence in East Greenland. Barremian. Sections 8, 9, 11, 15, 16, 18, 19 and 21.

Previous occurrences. Phoberocysta neocomica neocomica was previously recorded from the Hauterivian, Germany (Gocht, 1957, type material), the upper Ryazanian to lower Aptian, England and the North Sea (Costa & Davey, 1992), the upper Ryazanian to lowermost Aptian, north-west Europe (Heilmann-Clausen, 1987) and upper Berriasian to lowermost Aptian, world-wide (Williams & Bujak, 1985).

Genus *Prolixosphaeridium* Davey *et al.*, 1966; emend. Davey, 1969a
Prolixosphaeridium parvispinum (Deflandre, 1937b) Davey *et al.*, 1966

Plate 17, Fig. 9

Occurrence in East Greenland. Barremian and middle Albian. Sections 7, 10, 17 and 20.

Previous occurrences. Prolixosphaeridium parvispinum was previously recorded from the 'middle' Barremian to

upper Albian, north-west Europe (Heilmann-Clausen, 1987) and the uppermost 'middle' Barremian to lowermost upper Albian, north-west Germany (Prössl, 1990).

Genus *Protoellipsodinium* Davey & Verdier, 1971

Protoellipsodinium clavulum Davey & Verdier, 1974; emend. Duxbury, 1983

Plate 17, Figs 10–11

Comments. Only three specimens have been recorded from the lower Aptian, section 17. One of the specimens (Plate 17, Fig. 10) has capitate to slightly bifurcate process tips, as mentioned by Davey & Verdier (1974), whereas another (Plate 17, Fig. 11) has bi- to multifurcate process tips as described by Duxbury (1983) in his emendation of the species.

Previous occurrences. Protoellipsodinium clavulum was previously recorded from the Aptian, France (Davey & Verdier, 1974, type material), lower Aptian to lower Albian, southern England (Duxbury, 1983), Aptian or lower Albian in a North Sea well (Heilmann-Clausen, 1987), lower Barremian to lower Albian, north-west Germany (Prössl, 1990) and (as *Operculodinium? spinigerum*) from Hauterivian? to Barremian, District of Mackenzie, Canada (Brideaux, 1977).

Protoellipsodinium spinocristatum Davey & Verdier, 1971

Plate 17, Figs 12–13

Occurrence in East Greenland. The species is very rare and has only been recorded from the middle Albian. Sections 20 and 23.

Previous occurrences. Protoellipsodinium spinocristatum was previously recorded from the Aptian, south-east France (Davey & Verdier, 1974), Albian, south-east France (Davey & Verdier, 1971, type material), Aptian, south-east England (Duxbury, 1983; Lister & Batten, 1988), lower Aptian to upper Albian, England and the North Sea (Costa & Davey, 1992) and upper Aptian to mid upper Albian, north-west Germany (Prössl, 1990).

Genus *Pseudoceratium* Gocht, 1957; emend. Bint, 1986

Comments. The genus *Pseudoceratium* is well represented in the present study and some of the species are quite abundant. Several specimens of the most abundant species have been measured in order to best define the species. The method of measurement has partly been adapted from Helby (1987, plate 18) and is illustrated on Fig. 12.

Pseudoceratium anaphrissum (Sarjeant, 1966b) Bint, 1986

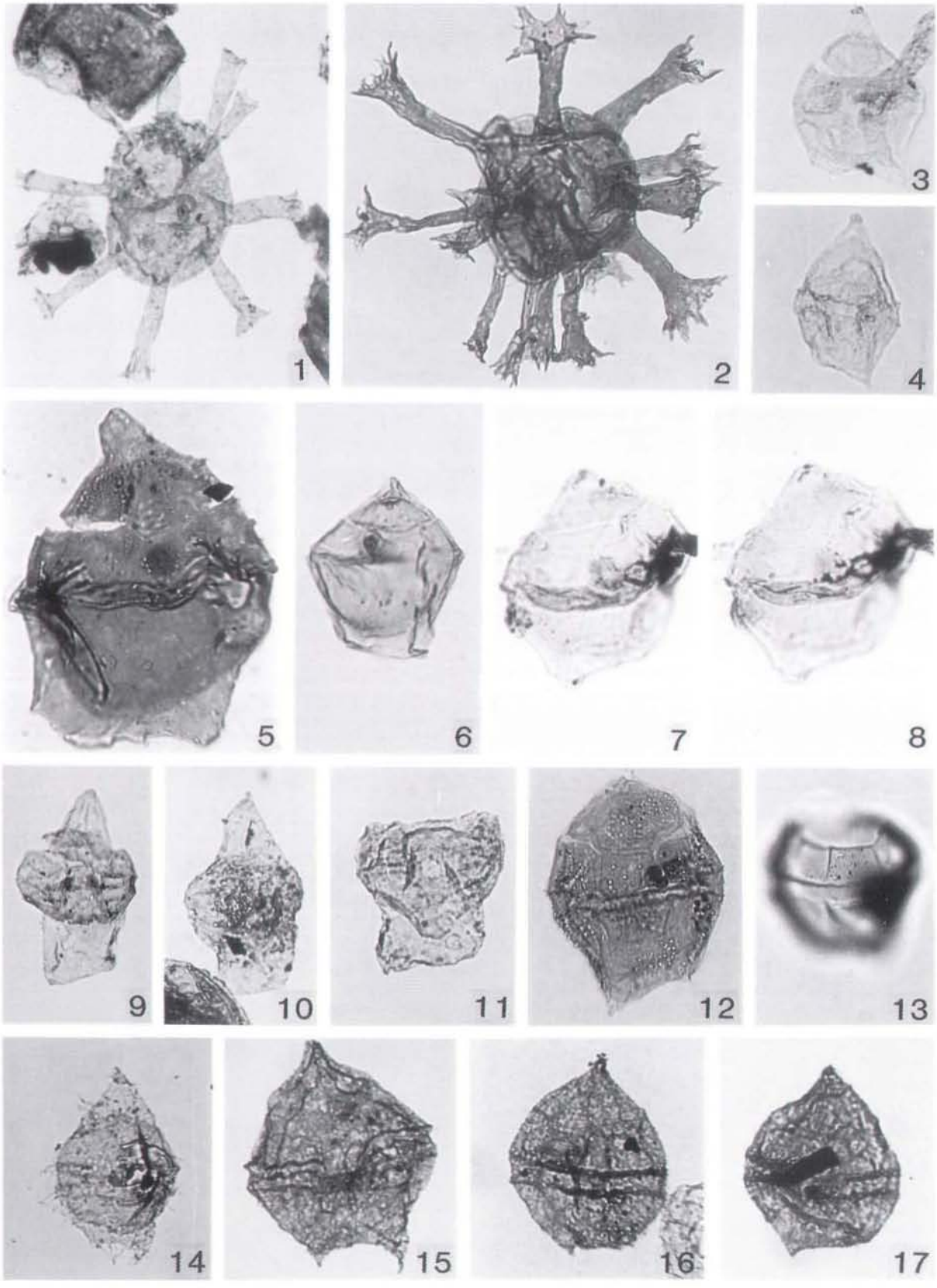
Plate 17, Figs 14–16; Plate 18, Figs 1–3

Comments. The frequent specimens observed in the present material are similar to the holotype but slightly larger, differing especially in the length of the spines. The specimens from East Greenland are, on the other hand, almost identical to the one illustrated by Thusu (1978, plate 2, fig. 3) from Arctic Norway.

Dimensions. (Measurements in μ.)

Plate 16

Fig. 1. *Oligosphaeridium* cf. *O. totum* × 500, section 12; GGU 324651–4, 5.4–150.4; MGUH 21879.
Fig. 2. *Oligosphaeridium* sp. 1 × 500, section 5; GGU 351565–4, 3.2–125.6; MGUH 21880.
Fig. 3. *Ovoidinium cinctum* × 500, section 17; GGU 342170–4, 20.1–126.1; MGUH 21881.
Fig. 4. *Ovoidinium cinctum* × 500, section 17; GGU 342170–4, 20.0–144.6; MGUH 21882.
Fig. 5. *Ovoidinium* sp. 2 × 700, section 30; GGU 324615–3, 10.9–137.2; MGUH 21883.
Fig. 6. *Ovoidinium* sp. 2 × 500, section 30; GGU 324617–8, 16.1–125.0; MGUH 21884.
Figs 7 & 8. *Ovoidinium* sp. 2 × 500, section 30; GGU 324615–7, 21.7–154.0; MGUH 21885.
Fig. 9. *Ovoidinium* sp. 3 × 500, section 21; GGU 342240–4, 22.0–145.7; MGUH 21886.
Fig. 10. *Ovoidinium* sp. 3 × 500, section 22; GGU 346588–4, 7.3–132.0; MGUH 21887.
Fig. 11. *Ovoidinium* sp. 3 × 500, section 22; GGU 346588–4, 17.8–122.0; MGUH 21888.
Fig. 12. *Ovoidinium* sp. 4 × 500, section 17; GGU 342169–4, 17.2–143.2; MGUH 21889.
Fig. 13. *Ovoidinium* sp. 4 × 500, section 17; GGU 342169–4, 4.5–124.9; MGUH 21890.
Fig. 14. *Palaeohystrichophora infusorioides* × 500, section 30, GGU 324613–8, 12.0–150.9; MGUH 21891.
Fig. 15. *Palaeoperidinium cretaceum* × 500, section 31; GGU 324623–4, 20.8–134.8; MGUH 21892.
Fig. 16. *Palaeoperidinium*? sp. 1 × 500, section 37; GGU 324648–4, 11.2–140.4; MGUH 21893.
Fig. 17. *Palaeoperidinium*? sp. 1 × 500, section 37; GGU 324648–4, 3.1–146.7; MGUH 21894.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		Range			Specimens
	A:	60	(71)	82	10
A_1 =	A incl. spines:	65	(79)	102	10
	B:	71	(89)	105	10
B_1 =	B incl. spines:	82	(106)	122	10
	C:	97	(106)	122	4
C_1 =	C incl. spines:	108	(120)	136	4
S =	max. spine length:	9	(13)	23	10

Holotype. (Sarjeant, 1966b, plate 22, fig. 8).
B = 102 μ B_1 = 118 μ C_1 = 105 μ D = 7 μ.

Occurrence in East Greenland. Lower Barremian, sections 4, 9, 10, 11, 18 and 21. The species is very abundant (up to 35%) in a narrow interval in the middle part of its range. A few questionable specimens are recorded from the lowermost upper Barremian in section 16.

Previous occurrences. Pseudoceratium anaphrissum was previously recorded from the lower Barremian at Speeton, England (Sarjeant, 1966b, type material; Duxbury, 1980 Harding, 1990b). Davey (1974; 1979b) recorded the species from the lower Barremian LB1 Beds and from the 'middle' Barremian established for the Middle B Beds or Cement Beds at Speeton, England. Costa & Davey (1992) recorded the species from the lower Barremian to the lowermost upper Barremian, England and the North Sea.

Harding (1990b, text fig. 3, following Rawson & Mutterlose (1983) and Mutterlose (1983, 1984)) divided the Speeton section into lower and upper Barremian, based on belemnite zonation and lithostratigraphic correlation with Germany, and placed the lower–upper Barremian boundary at the base of the Middle B Beds (Cement Beds). According to this new division of the Speeton section, *P. anaphrissum* was recorded from the lower Barremian at Speeton by Sarjeant (1966b), Duxbury (1980) and Harding (1990b) whereas Duxbury (1980) and Harding (1990b) questioned Davey's (1974; 1979b) record of the species from the Middle B Beds (now upper Barremian) of Speeton, England. Besides the lower Barremian records from the Speeton section, Harding (1990b) also recorded the species from other lower Barremian sediments in south-eastern England and northern Germany. Heilmann-Clausen (1987, fig. 4) has used Davey's (1974; 1979b) 'middle' Barremian range for the species in his record of selected dinoflagellate cysts from north-west Europe. Prössl (1990) recorded the species (as *Aptea anaphrissa*) from the lower Barremian, north-west Germany.

Thusu (1978) reported the species from the Barremian, Arctic Norway. Aarhus *et al.* (1986) recorded the species (as *Aptea anaphrissa*) from the upper Hauterivian to lower Barremian, Andøya, Norway, Århus *et al.* (1990) recorded the species from the lower Barremian, Barents Sea, Costa (1981) recorded the species (as *Aptea anaphrissum*) from the Barremian, offshore south Norway.

According to Harding (1990b, p. 51), the illustrated Canadian records of the species (Williams, 1975; Pocock, 1976) are not of conspecific specimens. The previous records from north-west Europe indicate that the species is probably restricted to the lower Barremian.

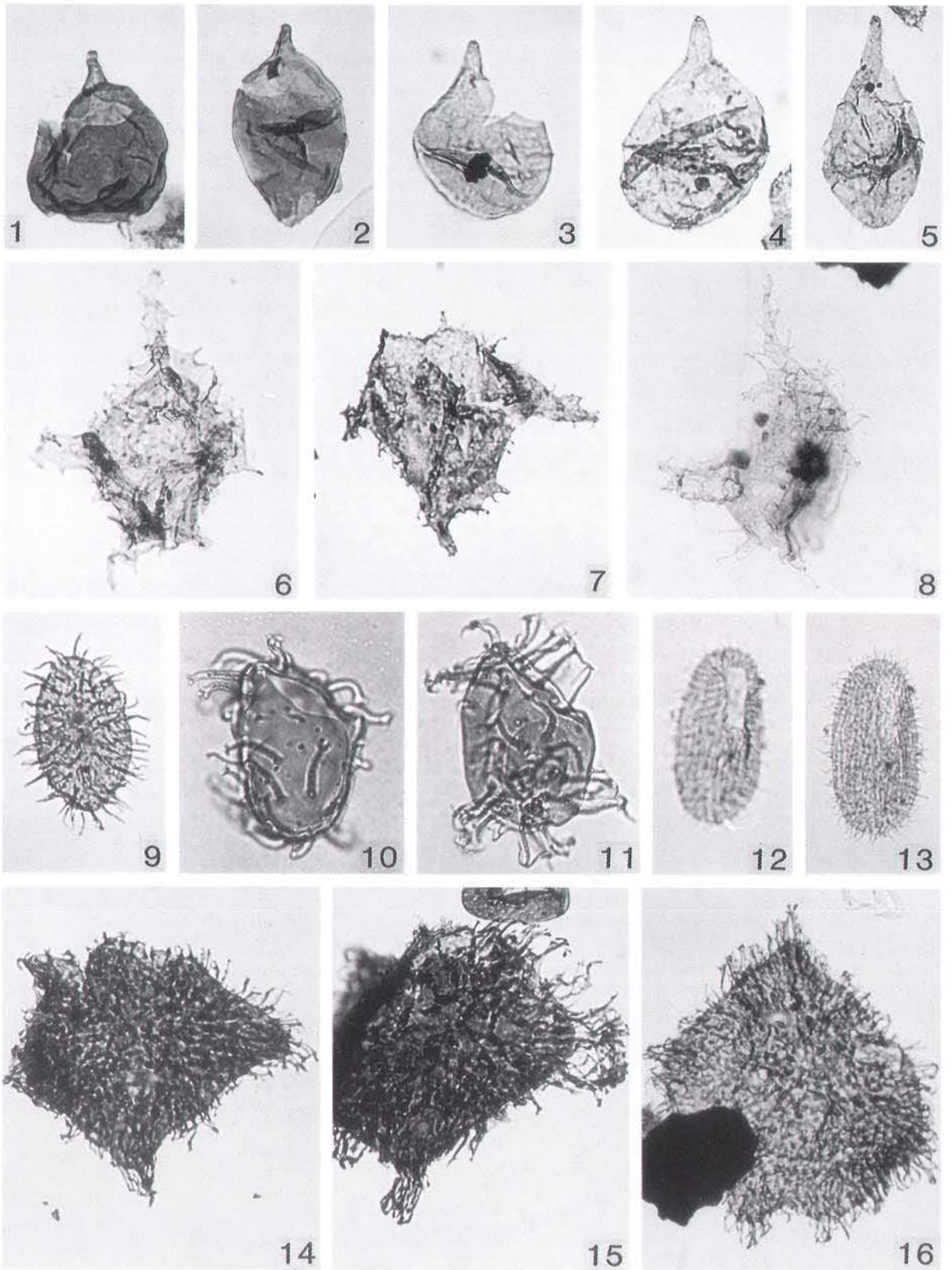
Pseudoceratium eisenackii (Davey, 1969a) Bint, 1986

Plate 18, Figs 4–9

Comments. The specimens assigned to *Pseudoceratium eisenackii* in the present material are subtriangular to pentagonal in shape, with a well developed apical horn. A weak lateral projection is present in a postcingular position. Two antapical projections may exist, one often only

Plate 17

Fig. 1. *Pareodinia* sp. × 500, section 10; GGU 342092–7, 4.3–155.4; MGUH 21895.
Fig. 2. *Pareodinia* sp. × 500, section 10; GGU 342092–7, 13.2–140.1; MGUH 21896.
Fig. 3. *Pareodinia* sp. × 500, section 14; GGU 342134–4, 10.0–137.2; MGUH 21897.
Fig. 4. *Pareodinia* sp. × 500, section 21; GGU 342237–4, 4.1–132.4; MGUH 21898.
Fig. 5. *Pareodinia* sp. × 500, section 19; GGU 342214–4, 10.4–127.2; MGUH 21899.
Fig. 6. *Phoberocysta neocomica neocomica* × 500, section 11; GGU 342104–7, 3.3–153.7; MGUH 21900.
Fig. 7. *Phoberocysta neocomica neocomica* × 500, section 21; GGU 342320–4, 7.7–126.0; MGUH 21901.
Fig. 8. *Phoberocysta neocomica neocomica* × 500, section 9; GGU 342071–8, 17.2–144.0; MGUH 21902.
Fig. 9. *Prolixosphaeridium parvispinum* × 500, section 17; GGU 342169–4, 21.2–146.7; MGUH 21903.
Fig. 10. *Protoellipsodinium clavulum* × 750, specimen with capitate to bifurcate process termination, section 17; GGU 342167–4, 19.0–144.0; MGUH 21904.
Fig. 11. *Protoellipsodinium clavulum* × 750, specimen with bi- to multifurcate process termination and operculum inside the cyst, section 17; GGU 342167–4, 11.4–121.4; MGUH 21905.
Figs 12 & 13. *Protoellipsodinium spinocristatum* × 500, section 23, GGU 351670–4, 12.4–124.9; MGUH 21906.
Fig. 14. *Pseudoceratium anaphrissum* × 500, section 16, GGU 351512–4, 16.0–140.2; MGUH 21907.
Fig. 15. *Pseudoceratium anaphrissum* × 500, section 16; GGU 351512–4, 10.3–127.9; MGUH 21908.
Fig. 16. *Pseudoceratium anaphrissum* × 500, section 10; GGU 342094–4, 7.0–147.0; MGUH 21909.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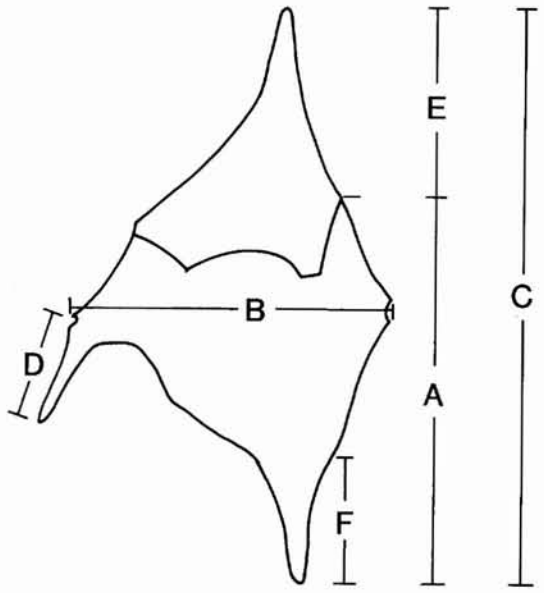


Fig. 12. Key used for measurements of *Pseudoceratium* species (partly after Helby, 1987, fig. 18).

represented by a weak bulge or is practically absent, the other being always a bulge which usually forms a prominent horn.

The ornamentation is a network of low crests and short spines covering most of the surface. A circular area on the ventral and/or dorsal side may be devoid of ornamentation. The ornamentation on one specimen (Plate 18, Fig. 7), examined by SEM, illustrates that the network ornamentation is intratabular on the pre- and postcingular plates and that the cingular area is distinguished by one partly broken crest.

Dimensions. (Measurements in μ.)

	Range			*Specimens*
Total length:	100	(120)	139	2
Cyst length without operculum:	57	(73)	88	19
Cyst width:	65	(80)	94	19
Height of crests:	1	(4)	9	18

Remarks. The specimens from East Greenland are slightly larger and, occasionally, have larger projections than the type material described from Saskatchewan, Canada by Davey (1969), although the ornamentation pattern and height of the crests resemble Davey's (1969) material.

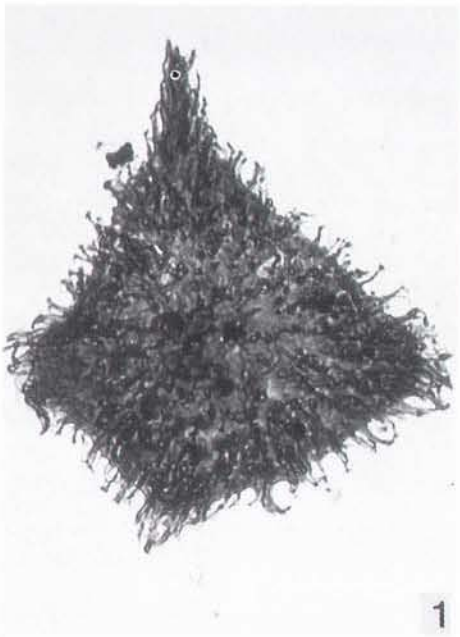
The species has been distinguished from *Pseudoceratium polymorphum* (Eisenack, 1958; emend. Dörhöfer & Davies, 1980) Bint, 1986 by its smaller overall size and by its lower crests. *Pseudoceratium eisenackii* differs from *P. retusum* Brideaux, 1977 by its smaller lateral and antapical horns, and by its ornamentation. *Pseudoceratium securigerum* (Davey & Verdier, 1974) Bint, 1986 is very similar to the present material of *P. eisenackii* in size and shape but differs by its ornamentation which is composed of discrete processes that seldom make up crests.

Occurrence in East Greenland. Uppermost Barremian to the mid upper Albian. Sections 13, 14, 17, 20, 22, 23, 26, 29, 32, 33, 35 and 36.

Previous occurrences. Pseudoceratium eisenackii was previously recorded from the upper Aptian to uppermost Albian (as *Aptea eisenackii*), north-west Germany (Prössl, 1990), upper Albian, Saskatshewan, Canada (Davey, 1969, type material), middle to upper Albian (as *Cyclonephelium eisenackii*), Alaska (May & Stein, 1979), upper Albian, Western Interior, USA (Bint, 1986), lower to upper Aptian, Libya (Uwins & Batten, 1988) and Albian and Cenomanian (Millioud *et al.*, 1975).

Plate 18

Fig. 1. *Pseudoceratium anaphrissum* × 500, section 16; GGU 351512–4, 19.3–123.5; MGUH 21910.
Fig. 2. *Pseudoceratium anaphrissum* × 530, operculum, section 16; GGU 351512; MGUH 21911 .
Fig. 3. *Pseudoceratium anaphrissum* × 530, section 16; GGU 351512; MGUH 21912.
Fig. 4. *Pseudoceratium eisenackii* × 500, section 17; GGU 342169–4, 9.2–151.6; MGUH 21913.
Fig. 5. *Pseudoceratium eisenackii* × 500, section 17; GGU 342169–4, 14.0–128.3; MGUH 21914.
Fig. 6. *Pseudoceratium eisenackii* × 500, section 17; GGU 342169–4, 15.2–140.2; MGUH 21915.
Fig. 7. *Pseudoceratium eisenackii* × 500, section 17; GGU 342169; MGUH 21916.
Fig. 8. *Pseudoceratium eisenackii* × 500, section 20; GGU 342196–4, 10.5–134.0; MGUH 21917.
Fig. 9. *Pseudoceratium eisenackii* × 500, section 20; GGU 342174–7, 13.1–134.4,; MGUH 21918.
Fig. 10. *Pseudoceratium expolitum* × 500, section 20; GGU 342194–4, 9.8–125.3; MGUH 21919.
Fig. 11. *Pseudoceratium* aff. *P. expolitum* × 500, section 37; GGU 324651–4, 6.4–128.7; MGUH 21920.
Fig. 12. *Pseudoceratium* aff. *P. expolitum* × 500, section 24; GGU 346456–4, 19.5–117.8; MGUH 21921.
Fig. 13. *Pseudoceratium expolitum* × 500, section 20; GGU 342201–4, 4.9–145.8; MGUH 21922.
Fig. 14. *Pseudoceratium* cf. *P. interiorense* × 500, section 22; GGU 346584–4, 4.8–127.6; MGUH 21923.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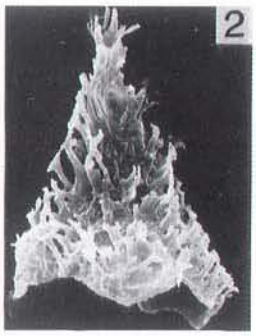
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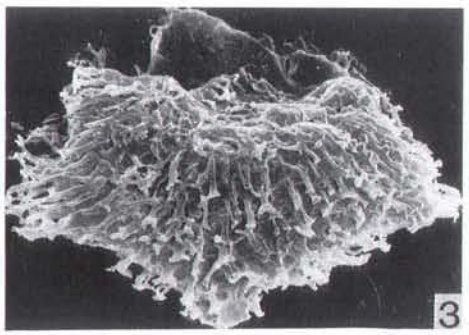
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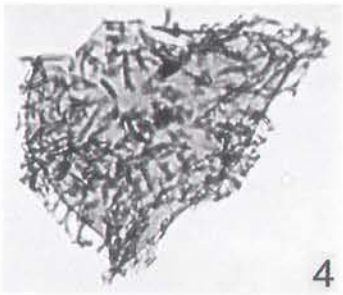
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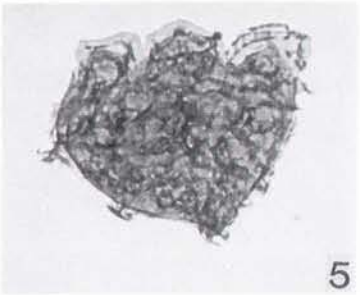
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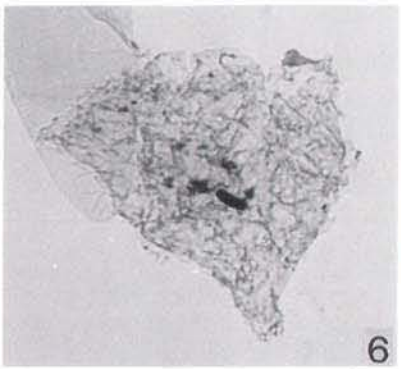
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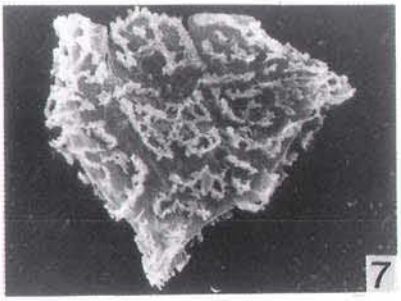
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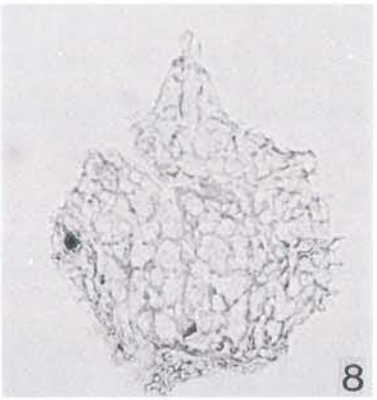
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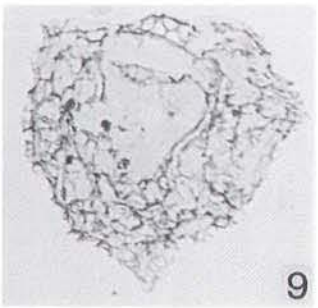
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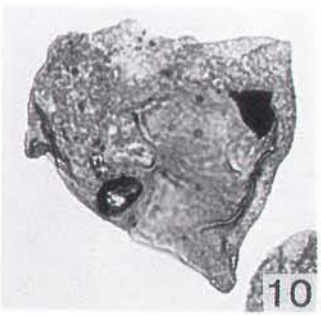
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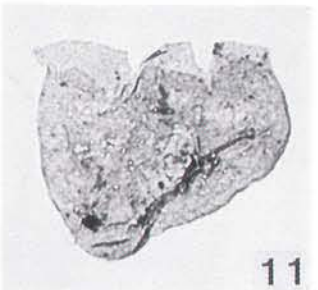
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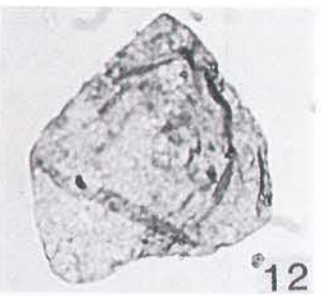
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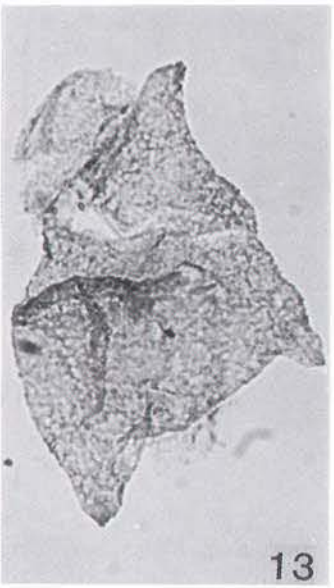
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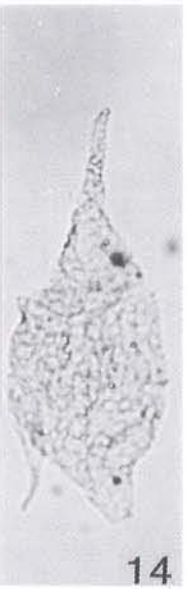
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Pseudoceratium expolitum Brideaux, 1971

Plate 18, Figs 10, 13

Comments. The material from East Greenland is very similar to the type material described and illustrated by Brideaux (1971).

Dimensions. (Measurements in μ.)

	Range			Specimens
Total length:	117	(125)	133	2
Length without operculum:	57	(73)	88	14
Width:	60	(79)	91	14

Occurrence in East Greenland. Base of middle Albian to lowermost part of the upper Albian. Sections 5, 20, 22, 23, 26, 29 and 31.

Previous occurrences. Pseudoceratium expolitum was previously recorded from the Aptian to lower Albian, Spitsbergen (Århus, 1991), middle to upper Albian, Alberta, Canada (Brideaux, 1971, type material and Singh, 1971, as *Pseudoceratium regium*), lower Hauterivian to upper Albian (as *P. regium*), Arctic Canada (Pocock, 1976), base middle to mid upper Albian, Arctic Canada (Doerenkamp *et al.,* 1976), upper Barremian to lower Albian, Edmonton Embayment, western Canada (Banerjee & Davies, 1988), middle and upper Albian, Alaska (May & Stein, 1979; May 1979) and middle Albian to upper Cenomanian (Millioud *et al.,* 1975), lower Barremian to upper Aptian (as *P. regium*) and lower to mid middle Albian (as *P. expolitum*), offshore eastern Canada (Bujak & Williams, 1978). Only one specimen has been recorded from Europe where Davey (1982a) reported the species (as *P. regium*) from the upper Aptian, north-west Germany.

Remarks. The present observation seems to be the first outside North America, except for Davey's (1982a) and Århus' (1991) few recorded specimens. The middle Albian first occurrence is consistent with the recordings by Brideaux (1971), Singh (1971), Doerenkamp *et al.* (1976), May & Stein (1979) and May (1979) from Alberta, Arctic Canada and Alaska.

Pseudoceratium aff. *P. expolitum* Brideaux, 1971

Plate 18, Figs 11–12

Comments. These specimens differ from *P. expolitum* by being smaller and by having broad based bulges, or broad-based short projections, apically, laterally and antapically, instead of well developed horns as described and illustrated by Brideaux (1971).

Dimensions. (Measurements in μ.)

	Range			Specimens
Total length:	63	(73)	85	4
Length without operculum:	42	(48)	59	12
Width:	63	(73)	85	12

Occurrence in East Greenland. Middle upper Albian. Sections 24, 25, 28, 30, 31, 35, 36, 37 and 40. The species seems to be a reasonably good marker for the middle upper Albian. *Pseudoceratium* aff. *P. expolitum* always occurs in younger sediments than *P. expolitum.*

Pseudoceratium cf. *P. interiorense* Bint, 1986

Plate 18, Fig. 14

Description. The specimen is hyaline and very thin walled. The position of the right lateral horn close to the antapical horn and the reticulation, are very similar to *P. interiorense.*

Occurrence in East Greenland. Only one specimen has been recorded from the middle Albian in East Greenland. Section 22.

Previous occurrence. The type material was described from the lower upper Albian, Western Interior, USA (Bint, 1986).

Pseudoceratium iveri sp. nov.

Plate 19, Figs 1–8; Text Figs 13–15

Origin of name. After Iver Iversen who fatefully followed the explorer Ejnar Mikkelsen on his East Greenland expedition.

Diagnosis. The species is a large, dorso-ventrally compressed ceratioid cyst, with long, pointed apical, right lateral and left antapical horns. The species has two wall layers. The ectophragm consists of a complicated network, supported by processes. The network extends the horn terminations and is concentrated on the plates, leaving the pandasutural areas free of ornamentation. Tabulation is ceratioid. Cingulum is characterised by a narrow broken flange and sulcal plates have low ornamentation. The archeopyle is apical (type $\overline{\text{tA}}$).

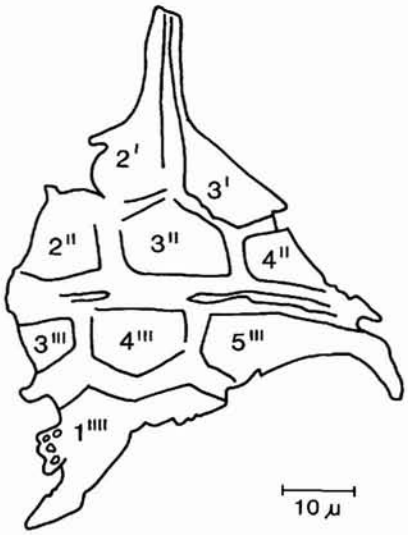


Fig. 13. *Pseudoceratium iveri* sp. nov., the holotype, also shown in Plate 19, Fig. 1, from section 17; GGU 342166–5, 16.7–146.0. External dorsal view illustrating the tabulation and the archeopyle sutures.

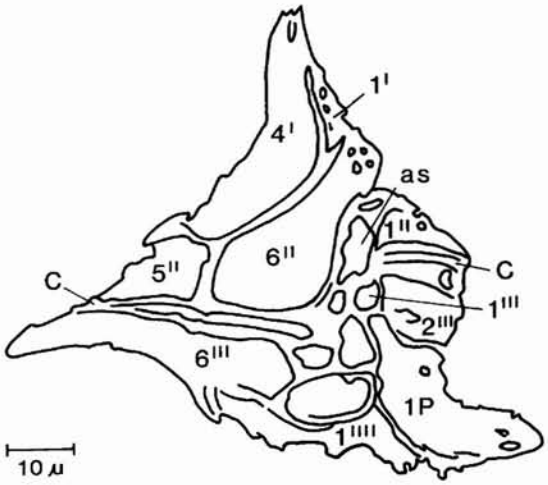


Fig. 14. *Pseudoceratium iveri* sp. nov., same specimen as Plate 19, Fig. 3, from section 21; GGU 342239. External ventral view illustrating the tabulation, including five weakly developed ventral plates.

Description

Cyst type. Proximate, ceratioid.

Shape. Dorso-ventrally compressed cyst with three moderately long horns, an apical, a right lateral (cingular/post-cingular) and an antapical horn. The three horns are situated with approximately 120° spacing.

Wall relationship. The cyst-wall is two-layered and composed of autophragm and ectophragm.

Wall features. The autophragm has a shagreenate to microperforate outer surface in the pandasuture areas (Plate 19, Fig. 4) whereas the plates are covered with processes. The processes supports the ectophragm which consist of an irregular intratabular network. The ectophragm extends the horn terminations up to 15 μ. Ectophragm and autophragm are close in the sulcal area and on plate 6' (Plate 19, Fig. 5) whereas elsewhere the ectophragm is elevated up to 7 μ by processes and pillars on the plates (Plate 19, Figs 3–5).

Tabulation. The tabulation is difficult to observe in transmitted light. In SEM the tabulation is seen to be ceratioid 4', 6", ?6c, 6''', 1p, 1'''' with probably 5 small sulcal plates (as, ras, rs, ls and ps). The tabulation is expressed by the pandasutures which are devoid of the reticulate ectophragm. The antapical plate 1'''' is rather large, sexiform, and together with plate 1p, composes the antapical horn. The small plate 1''' is situated above plate 1p, and extends slightly into the sulcal area. Cingulum appears to be composed of a broken flange. The plate 6" is large and a distinct sulcal notch is formed between 6" and 1". The length-axis of the sulcal area is twisted from the right side of the hypocyst to the left side of the epicyst. Five sulcal plates of very low relief have been distinguished (Plate 19, Figs 3 & 5, text Figs 14 & 15).

Archeopyle. Apical (type $\overline{\text{tA}}$).

Holotype. Plate 19, Fig. 1 Text Fig. 11, MGUH 21924 from GGU 342166–5, 16.7–146.O.

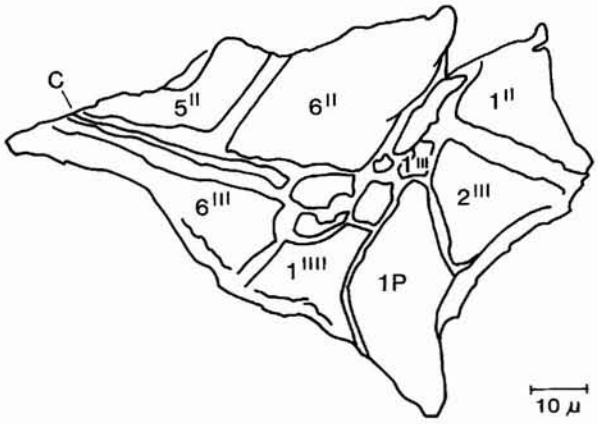


Fig. 15. *Pseudoceratium iveri* sp. nov., same specimen as Plate 19, Fig. 5, from section 21; GGU 342239. External ventral view illustrating paratabulation, including five weakly developed ventral plates and the archeopyle sutures.

Type locality. Section 17, Aucella Bjerg, Wollaston Forland, East Greenland (Fig. 2).

Dimensions. (Measurements in μ.) See Fig. 12 for definitions of A-F.

	Holotype	*Range*	*Specimens*
A	106	74 (100) 116	9
B	85	71 (81) 94	9
C	170	142 (176) 216	9
D	42	28 (43) 57	9
E		65 (74) 85	5
F	43	31 (37) 51	9

Discussion. *Pseudoceratium plerum* (Duxbury, 1983) Bint, 1986 from the lower Aptian (Duxbury, 1983) and lower and upper Aptian (Lister & Batten, 1988) in southern England, differs from *P. iveri* sp. nov. by being smaller, having shorter, distally rounded horns and by a less complex ectophragm. *Pseudoceratium iveri* and *P. plerum* have approximately the same tabulation formula although they are interpreted slightly differently (Duxbury, 1983, text fig. 5; present study, text Figs 13–15.

Pseudoceratium polymorphum differs from *P. iveri* by being smaller, having shorter horns and by its ornamentation of processes that frequently fusion at their distal tips.

Occurrence in East Greenland. The species seems to be a good marker species restricted to a very narrow interval in the uppermost Barremian. Sections 7, 17 and 21.

Pseudoceratium nudum Gocht, 1957

Plate 20, Figs 1–2

1957 *Pseudoceratium*? *nudum*; Gocht, p. 168, plate 18, figs 3, 4, 6.
1962 *Pseudoceratium* (*Pseud.*)? *nudum*; Neale & Sarjeant, p. 448.
1975 *Pseudoceratium*?; Wall & Evitt, plate 1, figs 10 & 11.
1977 *Pseudoceratium nudum*; Brideaux, p. 14, plate 5, fig. 3.
1980 *Odontochitina nuda*; Dörhöfer & Davies, p. 39.
1986 *Pseudoceratium nudum*; Bint, p. 145.

Comments. The species has been referred to the genus *Pseudoceratium* until Dörhöfer & Davies (1980, p. 39) transferred it to the genus *Odontochitina*, because, as they state, of its smooth periphragm and cavate nature. Bint (1986) emended the description of the genus *Pseudoceratium* (1986, p. 144) and included *P. nudum* without any comments (1986, p. 145).

Bint's transfer of the species may have been overlooked by Lentin & Williams (1989, p. 261 and 306) who do not comment on the transfer. Helby (1987) also emended the genus *Pseudoceratium* but did not mention the species *P. nudum*.

The cavate (cornucavate) nature of *P. nudum* suggested by Dörhöfer & Davies (1980, p. 39) is not distinctly observable on the specimens from East Greenland. A cavate appearance may possibly be recognisable on Wall & Evitt's (1975) plate 1, fig. 11, but is not visible on the type material (Gocht's, 1957, plate 8, figs 3, 4, and 6, or on the specimen of Brideaux (1977) plate 5, fig. 3.

The poor documentation of a cavate nature is, according to the present author, too weak as evidence to keep the species in the genus *Odontochitina* and thus it is retained in *Pseudoceratium*.

Dimensions. (Measurements in μ.) See Fig. 12 for definitions of A-F.

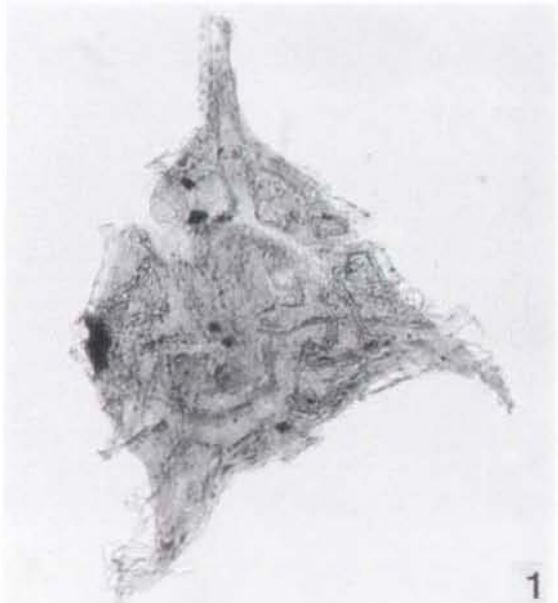
	Holotype (Gocht)	*Paratypes* (Gocht)	*Range*	*Specimens*
A			91 (114) 135	10
B	45–70	50	43 (57) 65	10
C	190–228	216	215	1
D			37 (55) 77	10
E	75		80	1
F	57		51 (66) 99	10

Occurrence in East Greenland. Uppermost lower Barremian to lowermost Aptian. Sections 1, 7, 9, 11, 14, 15, 16, 17, 18, 19, 21, and 33.

Previous occurrences. *Pseudoceratium nudum* was previously recorded from the upper Hauterivian in Germany (Gocht, 1957, type material), lower Cretaceous, Speeton,

Plate 19

Fig. 1. *Pseudoceratium iveri* sp. nov. holotype × 500, section 17; GGU 342166–5, 16.7–146.0; MGUH 21924.
Fig. 2. *Pseudoceratium iveri* sp. nov. × 500, section 7; GGU 342086–5, 20.0–135.8; MGUH 21925.
Fig. 3. *Pseudoceratium iveri* sp. nov. × 475, section 21; GGU 342239; MGUH 21926.
Fig. 4. *Pseudoceratium iveri* sp. nov. × 1100, same specimen as above, close-up of plates near the sulcal area.
Fig. 5. *Pseudoceratium iveri* sp. nov. × 610, section 21; GGU 342239; MGUH 21927.
Fig. 6. *Pseudoceratium iveri* sp. nov. × 950, same specimen as above, close-up of surfaces on ectophragm and autophragm in the sulcal notch area.
Fig. 7. *Pseudoceratium iveri* sp. nov. × 850, same specimen as above, close-up of sulcal area.
Fig. 8. *Pseudoceratium iveri* sp. nov. × 500, section 7; GGU 342086–5, 11.1–142.2; MGUH 21928.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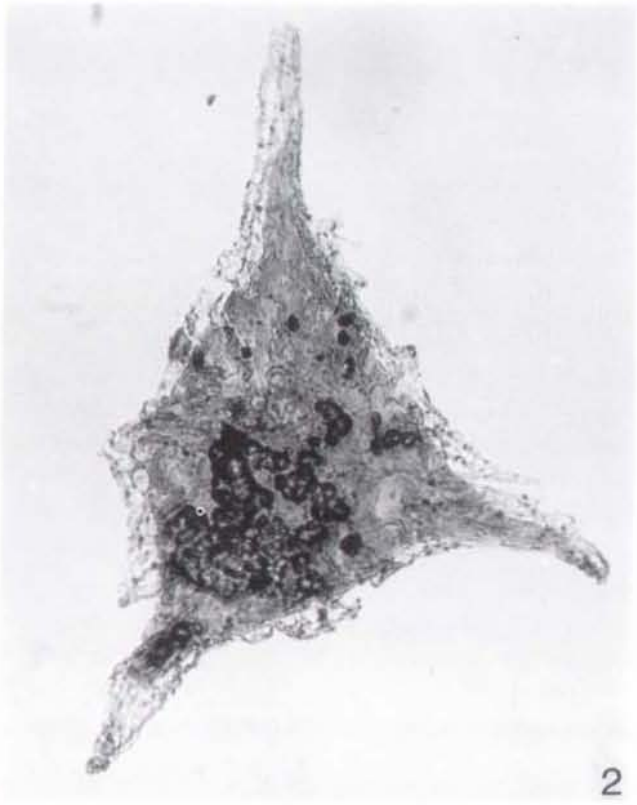
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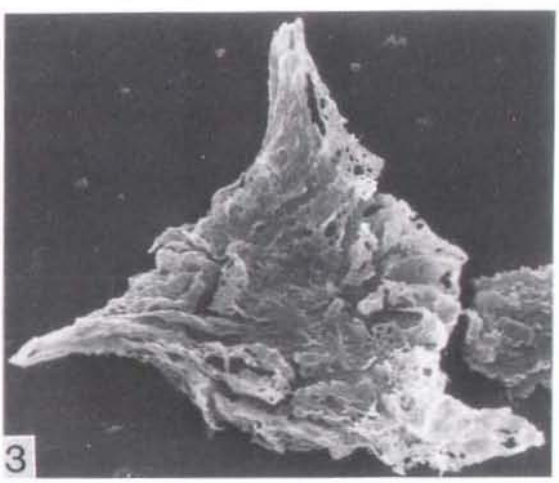
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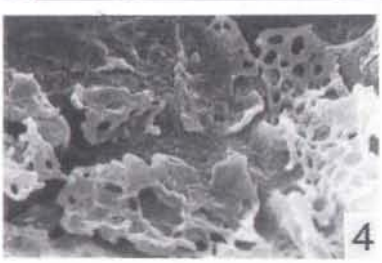
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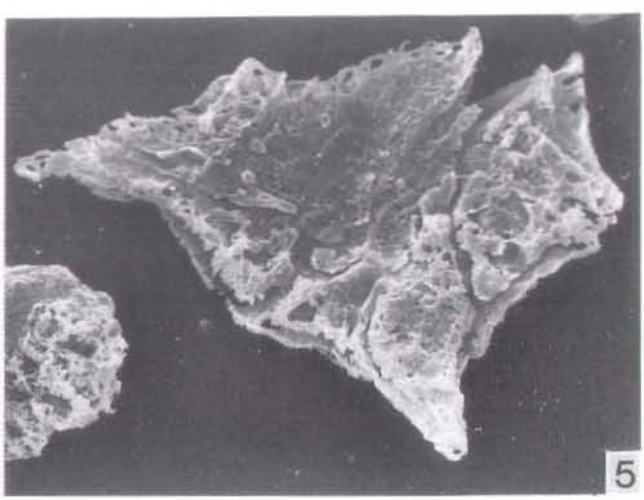
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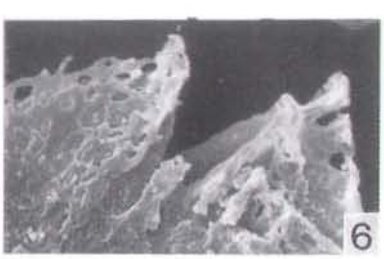
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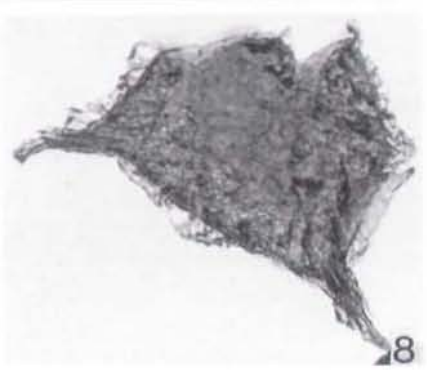
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England (Wall & Evitt, 1975), Hauterivian and Barremian, (Millioud *et al.*, 1975) and Hauterivian to Barremian, District of Mackenzie, Canada (Brideaux, 1977).

Pseudoceratium pelliferum Gocht, 1957

Plate 20, Figs 3–6

Comments. The lengths of the apical, lateral and antapical horns are very variable in the present material but within the range of Gocht's (1957) type material, as illustrated below. Mutterlose & Harding (1987a, b) discussed the length of the horns and suggested that the variation could be related to changing water temperatures. The spines vary in length from very small to 4 μ. Their distribution occasionally shows a tabulation pattern. The density of the spines is very variable. The spines on one specimen (Plate 20, Fig. 5) show an anastomosing network and are occasionally joined distally by trabeculae.

Dimensions. (Measurements in μ.) See Fig. 12 for definitions of A-F.

	Holotype (Gocht)	*Paratypes* (Gocht)	*Range*	*Specimens*
A	59		71 (94) 131	32
B	132	52 (57) 70	45 (57) 68	32
C	12	92 (132) 173	119 (142) 173	8
D	35		10 (26) 56	32
E	25		17 (35) 56	8
F			17 (35) 57	32
S	2		1-4	

Remarks. The size of the horns and the length – width ratio of the cyst on some of the specimens recorded from the lower to lowermost upper Barremian (Plate 20, Fig. 6) are similar to *Pseudoceratium solocispinum* (Davey, 1974) Lentin & Williams, 1975; stat. nov. et emend. Harding (1990b). However, these specimens do not have the robust nature of the processes which, according to Harding (1990b), distinguishes *P. solocispinum* from *P. pelliferum*.

Occurrence in East Greenland. Lower and the lowermost upper Barremian. Sections 4, 7, 9, 10, 11, 14, 15, 16, 18 and 21.

A few specimens are recorded from the uppermost Barremian and the lower Aptian part of sections 7 and 33 and if they are *in situ* the species ranges up into the lower Aptian in East Greenland.

Previous occurrences. Pseudoceratium pelliferum was previously recorded from the lower and 'middle' Barremian, Speeton, England (Davey, 1974), the upper Ryazanian to upper Barremian, England and the North Sea (Costa & Davey, 1992), the Valanginian to Hauterivian, Germany (Gocht, 1957, type material), the lower Hauterivian to upper Aptian, north-west Germany (Prössl, 1990), upper Ryazanian to lower Aptian, north-west Europe (Heilmann-Clausen, 1987), upper Barremian to lower Aptian, south-east England (Lister & Batten, 1988), Barremian, offshore southern Norway (Costa 1981), Hauterivian, Barremian and Aptian, Arctic Norway (Thusu, 1978), lower Barremian offshore southern Norway (Aarhus *et al.*, 1986), lower Aptian, Arctic Canada (Doerenkamp *et al.*, 1976) and upper Berriasian to lower Aptian, world-wide (Williams & Bujak, 1985). Harding (1990b) reported the last occurrence of the species in England and Germany in the lower upper Barremian and mentioned that *P. pelliferum* or *P. solocispinum* reported from post-Barremian strata should be treated with caution as they are likely to be reworked or to be misidentifications.

Pseudoceratium polymorphum (Eisenack, 1958; emend. Dörhöfer & Davies, 1980) Bint, 1986

Plate 21, Figs 1–5

Comments. The ornamentation on the studied material is composed of complex process crests concentrated on the sutural areas. In the centre of both the dorsal and ventral surfaces there is an almost circular area devoid of ornamentation. The processes are broad based, often interconnected, and distally becoming digitate or multifurcate and occasionally joined by trabeculae.

Plate 20

Fig. 1. *Pseudoceratium nudum* × 500, section 11; GGU 342106–4, 12.3–141.0; MGUH 21929.

Fig. 2. *Pseudoceratium nudum* × 500, section 7; GGU 342087–4, 13.6–126.9; MGUH 21930.

Fig. 3. *Pseudoceratium pelliferum* × 500, section 10; GGU 342092–4, 11.8–134.8; MGUH 21931.

Fig. 4. *Pseudoceratium pelliferum* × 500, section 16; GGU 351512–4, 9.4–141.1; MGUH 21932.

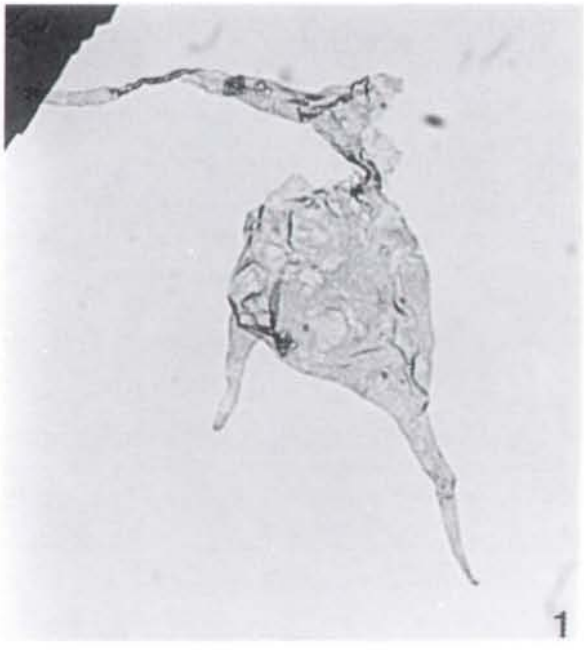
Fig. 5. *Pseudoceratium pelliferum* × 500, section 18; GGU 342221–4, 9.9–148.6; MGUH 21933.

Fig. 6. *Pseudoceratium pelliferum* × 500, section 10; GGU 342092–4, 13.2–124.9; MGUH 21934.

Fig. 7. *Pseudoceratium* cf. *P. solocispinum* × 500, section 19; GGU 342214–4, 20.5–132.0; MGUH 21935.

Fig. 8. *Pseudoceratium* cf. *P. solocispinum* × 500, section 11; GGU 342105–4, 19.0–122.0; MGUH 21936.

Fig. 9. *Pseudoceratium* cf. *P. solocispinum* × 500, section 8; GGU 342076–4, 5.5–125.3; MGUH 21937.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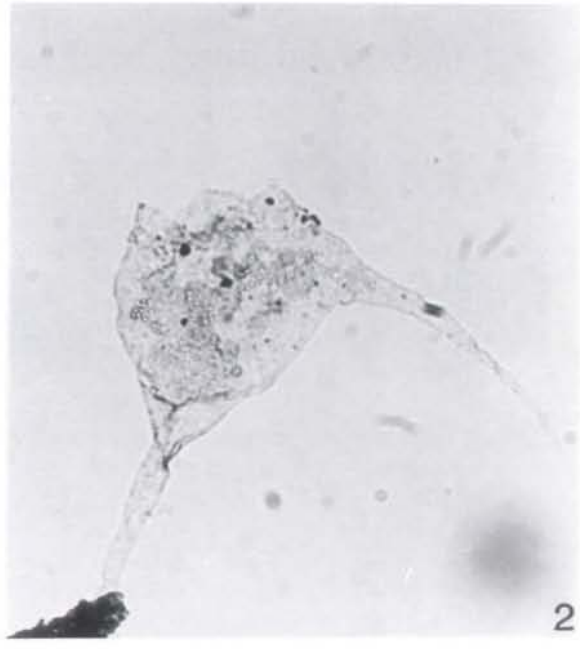
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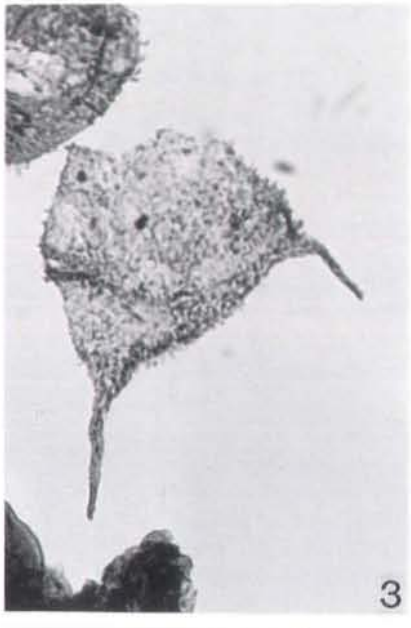
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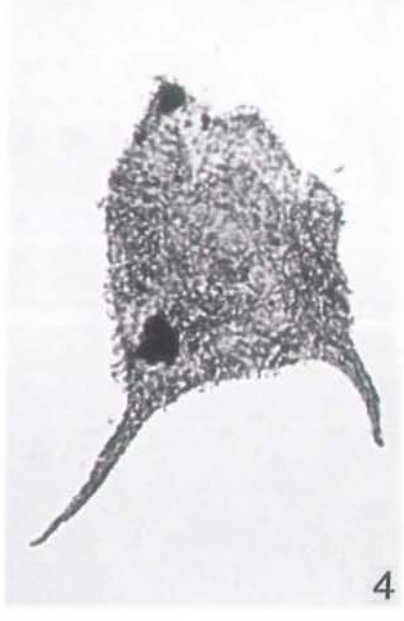
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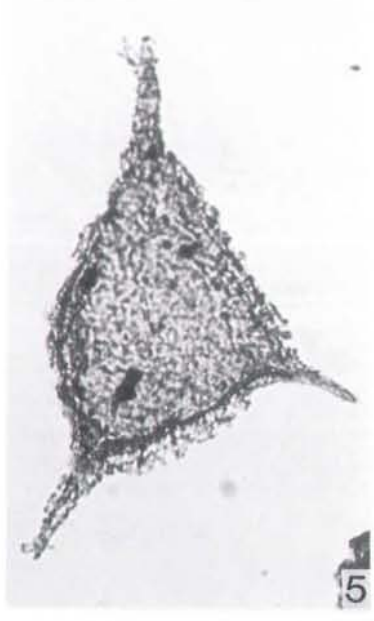
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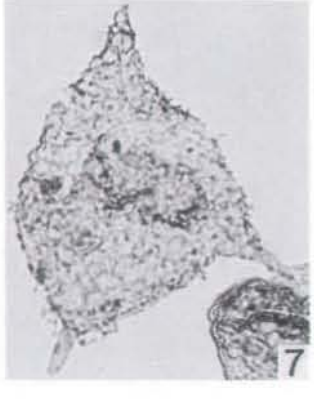
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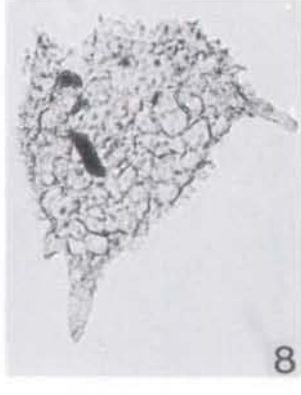
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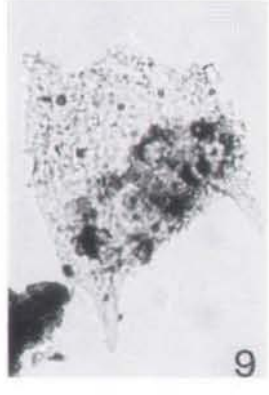
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Dimensions. (Measurements in μ.) See Fig. 12 for definitions of A-B.

	Range	*Specimens*
A	65 (89) 102	8
B	83 (102) 122	8
Process crests	3 (7) 14	8

Occurrence in East Greenland. Lower to lowermost upper Albian. Sections 5, 13, 20, 21, 22, 23, 26 and 29.

Previous occurrences. *Pseudoceratium polymorphum* was previously recorded from the upper Aptian, Germany (Eisenack, 1958, type material), the uppermost lower and upper Aptian, France (Davey & Verdier, 1974), the lower and upper Aptian in England and the North Sea (Costa & Davey, 1992), the uppermost lower and upper Aptian, south-east England (Lister & Batten, 1988), the Aptian – lower Albian to middle Albian, Spitsbergen and middle Albian, Barents Sea, as the *Aptea polymorpha – Cyclonephelium compactum* group (Århus, 1991), lower Aptian to lower Albian in north-west Europe (Heilmann-Clausen, 1987), upper Aptian, as *Aptea polymorpha*, north-west Germany (Prössl, 1990), Aptian to upper Albian, Peace River area, western Canada (Singh, 1971) and lower and upper Aptian, world-wide (Williams & Bujak, 1985).

Pseudoceratium cf. *P. retusum* Brideaux, 1977

Plate 21, Figs 6–10

Comments. In the material from East Greenland, the specimens assigned to *Pseudoceratium* cf. *P. retusum* have slightly longer lateral and antapical horns than those described and illustrated by Brideaux (1977), whereas the spines are shorter, 1–3 μ, compared to 3–8 μ on Brideaux's type material.

Dimensions. (Measurements in μ.) See Fig. 12 for definitions of A-F.

	Holotype (Brideaux)	*Paratypes* (Brideaux)	*Specimens*	*Range*	*Specimens*
A		63-93	46	51 (74) 88	9
B				48 (68) 79	9
C	100	93-120	17	93 (98) 102	2
D	10			5 (22) 34	9
E	25	14-25	17	20	1
F				8 (23) 38	9

Occurrence in East Greenland. Lower Aptian. Sections 7, 13, 17, 19 and 33.

Previous occurrences. *Pseudoceratium retusum* was previously recorded from the lower Aptian, south-east England (Lister & Batten, 1988), Barremian to Aptian, District of Mackenzie, Canada (Brideaux, 1977, type material), Barremian and Aptian, Libya (Uwins & Batten, 1988).

The forms illustrated as *Pseudoceratium pelliferum* by Pocock (1962) and Singh (1971) from Aptian? and lower to middle Albian, Alberta, western Canada are, according to Brideaux (1977 p. 14), similar to *P. retusum*.

Pseudoceratium cf. *P. solocispinum* (Davey, 1974) Lentin & Williams, 1975; stat. nov. et. emend. Harding (1990b)

Plate 20, Figs 7–9

Comments. The specimens from East Greenland are similar in shape and size to the type material described by Harding (1990b), whereas the spines on *P.* cf. *P. solocispinum* are slightly smaller and do not have all the characteristic features described from the holotype.

Dimensions. (Measurements in μ.) See Fig. 12 for definitions of A-F.

Plate 21

Fig. 1. *Pseudoceratium polymorphum* × 500, section 20; GGU 342191–5 6.8–130.8; MGUH 21938.

Fig. 2. *Pseudoceratium polymorphum* × 540, section 20; GGU 342191; MGUH 21939 .

Fig. 3. *Pseudoceratium polymorphum* × 750, same specimen as above, close-up of antapical horn, section 20; GGU 342191.

Fig. 4. *Pseudoceratium polymorphum* × 500, section 20; GGU 342201–4, 6.5–121.7; MGUH 21940.

Fig. 5. *Pseudoceratium polymorphum* × 500, section 22; GGU 346584–4, 10.4–122.9; MGUH 21941.

Fig. 6. *Pseudoceratium* cf. *P. retusum* × 500, section 7; GGU 342087–11, 7.1–152.4; MGUH 21942.

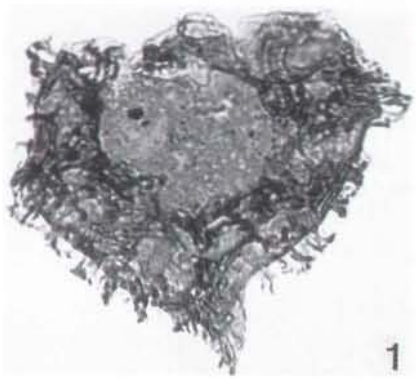
Fig. 7. *Pseudoceratium* cf. *P. retusum* × 500, section 7; GGU 342087–10, 18.5–132.0; MGUH 21943.

Fig. 8. *Pseudoceratium* cf. *P. retusum* × 500, section 7; GGU 342087–4, 12.6–154.1; MGUH 21944.

Fig. 9. *Pseudoceratium* cf. *P. retusum* × 500, section 7; GGU 342087–4, 13.2–122.8; MGUH 21945.

Fig. 10. *Pseudoceratium* cf. *P. retusum* × 500, section 7; GGU 342087–4, 21.1–120.9; MGUH 21946 .

Fig. 11. *Pseudoceratium toveae* sp. nov. × 500, section 14; GGU 342132–4, 11.9–125.0; MGUH 21947.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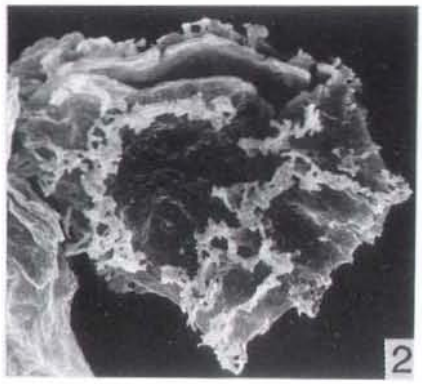
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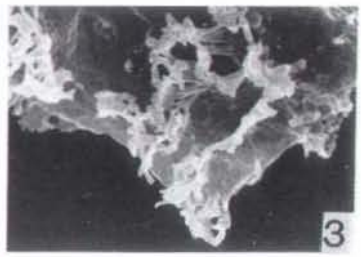
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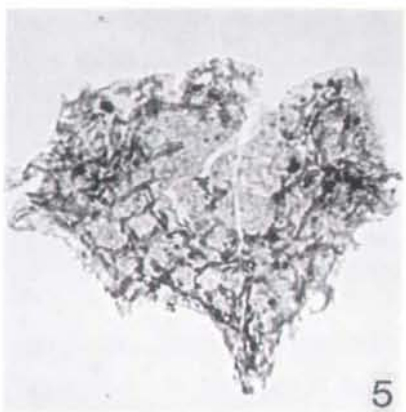
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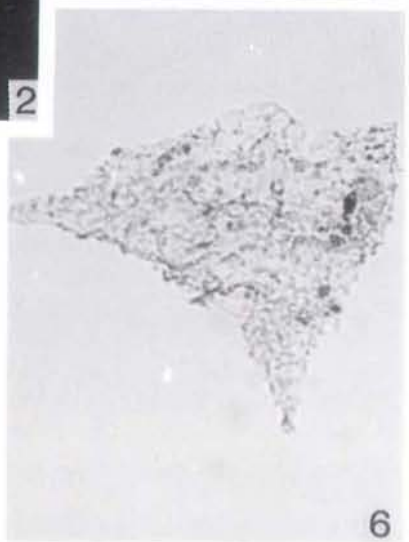
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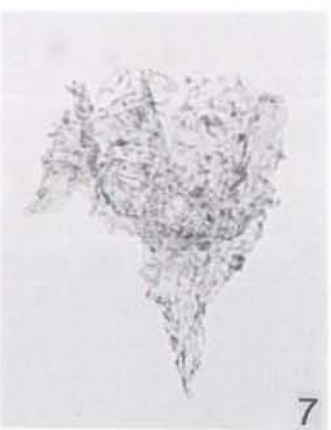
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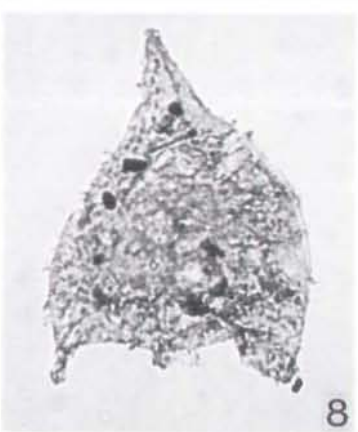
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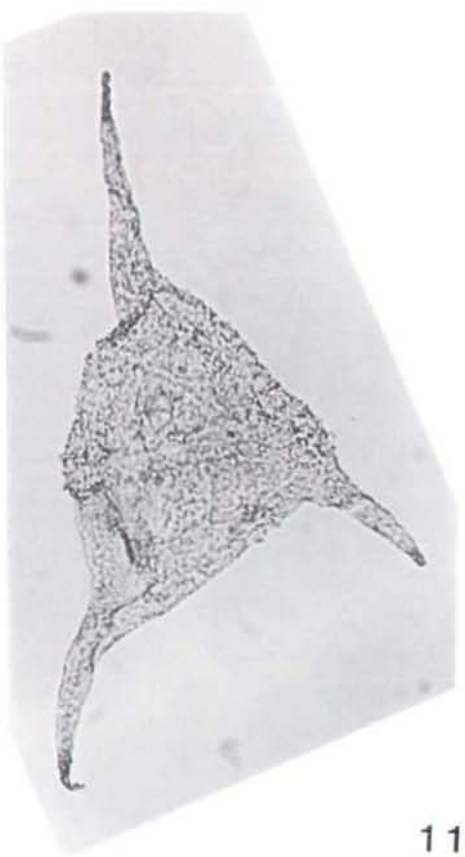
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	Harding (1990b)			*Specimens*	*Range*			*Specimens*
A	66	(85)	73	26	60	(74)	85	7
B	48	(58)	62	26	50	(56)	63	7
C	108	(122.6)	130	11	100	(107)	120	3
D					9	(13)	17	7
E					17	(21)	28	3
F					14	(19)	23	7

Occurrence in East Greenland. Uppermost Barremian. Sections 8, 11 and 19.

Previous occurrences. Pseudoceratium solocispinum was previously recorded from the upper Barremian at Speeton, England (Davey, 1974; Duxbury, 1980). Harding (1990b) recorded the species from the uppermost Barremian in England and Germany where *P. solocispinum* is only observed stratigraphically above *P. pelliferum*.

Pseudoceratium toveae sp. nov.

Plate 21, Fig. 11; Plate 22, Figs 1–7

Origin of name. After Professor Tove Birkelund who, with her detailed studies of ammonites from Greenland, provided a major biostratigraphic framework for future work.

Diagnosis. Large, dorso-ventrally compressed ceratioid, proximate cyst, with three large horns. The cyst is two-layered with a smooth to microgranulate autophragm and an intratabular reticulate ectophragm, the autophragm and ectophragm are closely adpressed. Tabulation is indicated by bold pandasutural areas. Archeopyle apical (type $\overline{\text{tA}}$).

Description

Cyst type. The cyst is proximate ceratioid.

Shape. The cyst has three long horns: one apical, one right lateral and one antapical. The angle between the horn is approximately 120°.

Wall relationship. The cyst wall is two-layered, composed of closely adpressed autophragm and ectophragm.

Wall features. The autophragm, which is only visible on the pandasutural areas, has a smooth to microgranulate outer surface (Plate 22, Fig. 5). The ectophragm forming the ornamentation is restricted to the intratabular areas and is composed of low processes (less than 1 μ). The surface of the ectophragm is reticulate (Plate 22, Figs 5 & 7). The processes are of variable size often making it difficult to distinguish the two layers, especially on the horns.

Tabulation. The tabulation is expressed by the pandasutural areas which are devoid of the reticulate ectophragm, and by the archeopyle sutures. The cingular plates are occasionally distinguishable (Plate 22, Fig. 5) but no sulcal area has been observed. Tabulation formula: ?4', ?6", ?6S, ?6‴, ?1P, 1⁗.

Archeopyle. The archeopyle is apical (type $\overline{\text{tA}}$).

Holotype. Plate 22, Fig 1, MGUH 21948 from GGU 360371–3, 15,3–132,0.

Type locality. Section 1 north of Haystack, East Greenland (Fig. 2).

Dimensions. (Measurement in μ.) See Fig. 12 for definitions of A-F.

	Holotype	*Range*			*Specimens*
A	119	99	(130)	165	15
B	73	63	(68)	74	15
C	190	193	(219)	250	4
D	68	54	(65)	85	15
E	56	68	(88)	119	4
F	57	54	(70)	99	15

Discussion. Pseudoceratium toveae sp. nov. resembles *Pseudoceratium weymouthense* in size and shape, described from the upper Tithonian to lower Berriasian of Australia by Helby (1987). However, *P. weymouthense* differs by its weak tabulation, indicated by larger processes in the pandasutural areas which, according to

Plate 22

Fig. 1. *Pseudoceratium toveae* sp. nov. holotype × 500, section 1; GGU 360371–3, 15.3–132.0; MGUH 21948.

Fig. 2. *Pseudoceratium toveae* sp. nov. × 500, section 8; GGU 342072–4, 12.1–127.6; MGUH 21949.

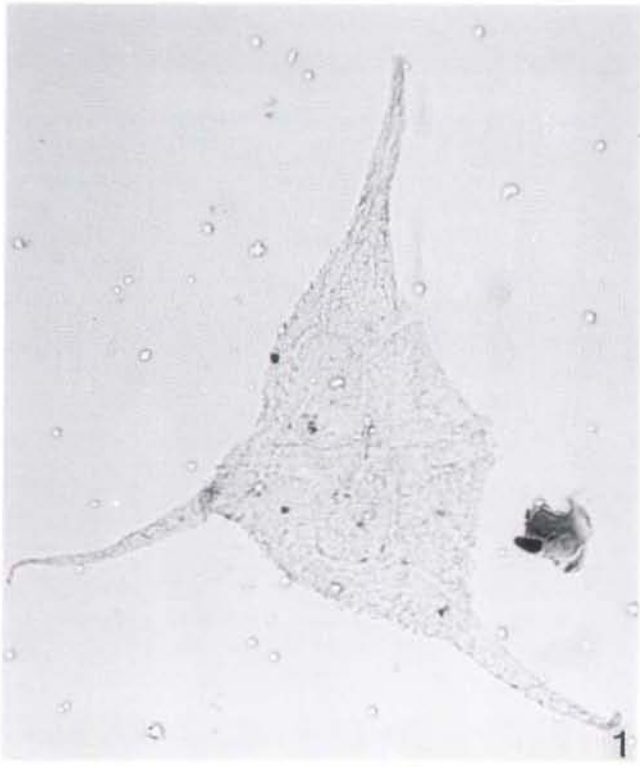
Fig. 3. *Pseudoceratium toveae* sp. nov. × 500, section 17; GGU 342161–5, 11.1–149.4; MGUH 21950.

Fig. 4. *Pseudoceratium toveae* sp. nov. × 540, section 17; GGU 342164; MGUH 21951.

Fig. 5. *Pseudoceratium toveae* sp. nov. × 1400, same specimen as above, close-up of surface ornamentation on the ectophragm and autophragm, which make up the pandasutures. Cingular plates are seen in the lower part of the figure.

Fig. 6. *Pseudoceratium toveae* sp. nov. × 540, section 21; GGU 342238; MGUH 21952.

Fig. 7. *Pseudoceratium toveae* sp. nov. × 2300, same specimen as above, close-up of plates close to the cingulum.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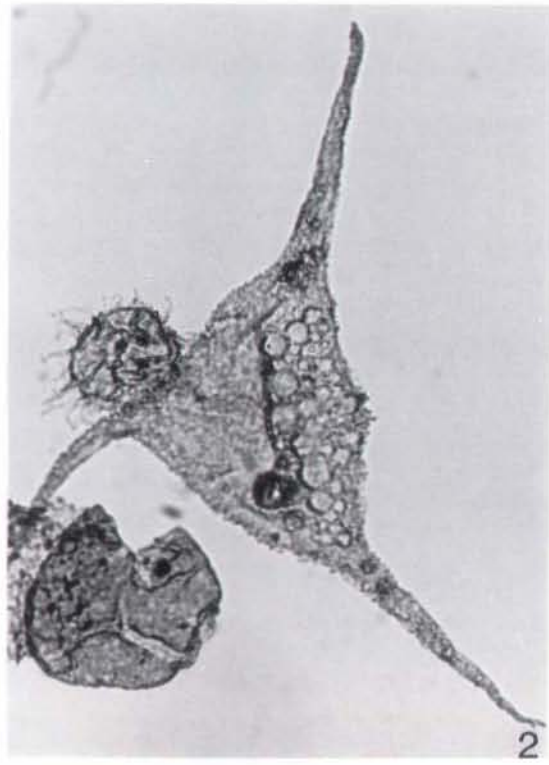
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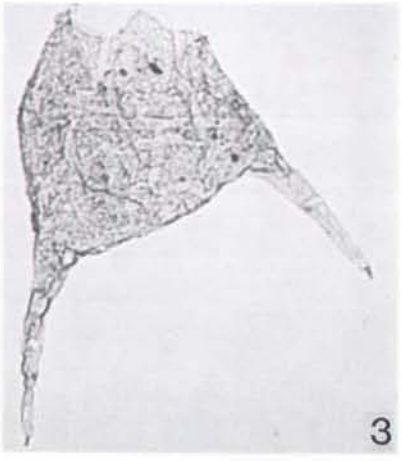
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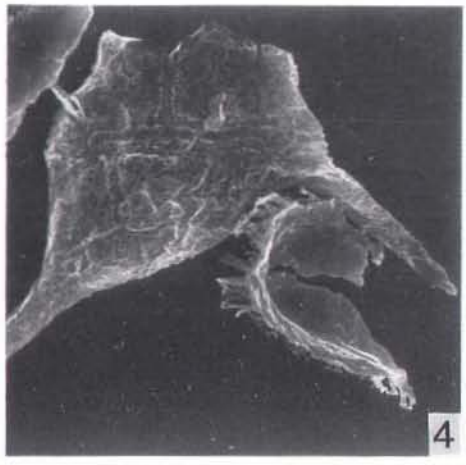
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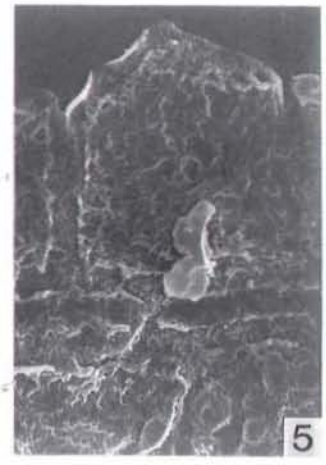
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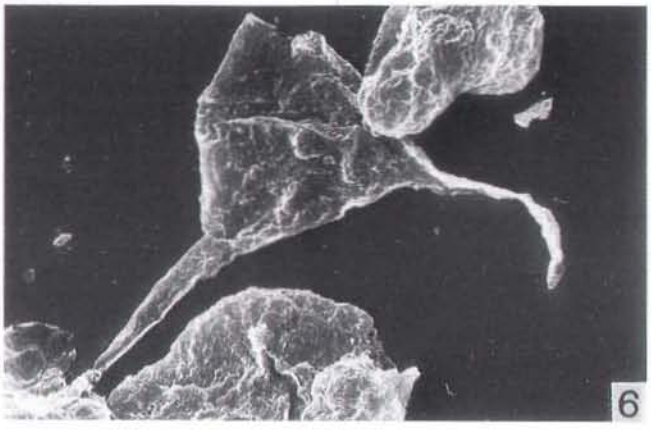
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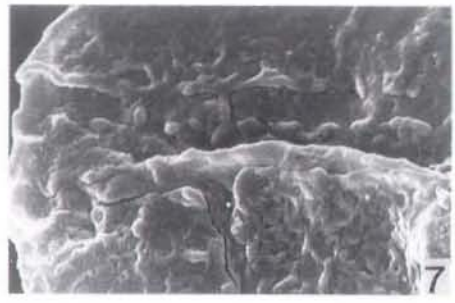
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Helby (1987 p. 317), are apparently covered by a continuous ectophragm, and by its rather pronounced extension of the cingulum onto the anterior part of the post-cingular horn.

Pseudoceratium toveae differs by its larger size and less pronounced reticulate ectophragm from *P. aulaeum*, described by Harding (1990b) from a presumed low salinity assemblage of late Barremian age in the Warlingham borehole, England.

Pseudoceratium toveae differs from *P. gochtii* Neale & Sarjeant (1962) by its lack of spines and by its larger horns. Duxbury (1977, p. 60) questioned the species *P. gochtii* and regarded Neale & Sarjeant's specimens as belonging in *P. pelliferum*.

The species *Eopseudoceratium* sp. cf. *E. gochtii* recorded from the Barremian of the District of Mackenzie by Brideaux & Myhr (1976), Brideaux (1976, plate 44.2, fig. 2) and Brideaux (1977, p. 14, plate 5, fig. 4), may belong to *P. toveae* but the available illustrations and description are insufficient for a close comparison.

Occurrence in East Greenland. Upper Barremian to lowermost? Aptian. Sections 1, 6, 7, 8, 11, 14, 15, 16, 17, 19, 21 and 33.

Genus *Pterodinium* Eisenack, 1958; emend. Sarjeant, 1985a

Pterodinium sp.

Plate 25, Fig. 10

Occurrence in East Greenland. Only one specimen has been recorded from the uppermost middle Albian, section 20.

Genus *Rhombodella* Cookson & Eisenack, 1962b; emend. Sung Zhi-chen *et al.* ('Jiabo'), 1978

Rhombodella paucispina (Alberti, 1961) Duxbury, 1980

Plate 23, Figs 1–7

Comments. The majority of the specimens recorded in the present study have 4–5 μ long spines concentrated on the poles and on the flanks of the body as described by Alberti (1961, p. 19–20). However, together with the forms hereby referred to *R. paucispina*, there occurs forms with no or only very small spines (Plate 23, Figs 6 & 7). The specimens without spines might be similar to the Lower Tertiary *Rhombodella baculata* described by Sung Zhi-chen *et al.* ('Jiabo'), 1978, (this paper is cited as Sung Zhi-chen *et al.*, 1978 in Chen Yow-yuh *et al.*, 1988) from China, although comparison has been difficult as the present author only has a poor copy of Sung Zhi-chen *et al.'s* ('Jiabo') illustrations of *R. baculata*.

Among the numerous specimens observed in the present study, several exhibit an angular opening, probably an archeopyle, close to what is interpreted as the apical pole (Plate 23, Figs 3 & 6). Another opening, circular in outline, has been observed (Plate 23, Figs 3 & 6) at the interpreted antapical pole. This circular hole may be an opisthopyle. The presumed archeopyle and opisthopyle have been observed both on forms with and without spines. The two forms might represent environmental adaptions of a single species.

Occurrence in East Greenland. Middle and upper Albian. Sections 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 35, 36, 37, 38, 39 and 40. The species is very rare in the middle Albian but becomes abundant to dominant in the upper Albian.

Previous occurrences. Rhombodella paucispina was previously recorded from the upper Aptian and lower Albian, north-west Germany (as *R. natans*, Davey, 1982a), uppermost Aptian to upper Cenomanian, north-west Ger-

Plate 23

Fig. 1. *Rhombodella paucispina* × 750, section 30; GGU 324615–3, 3.8–120.5; MGUH 21953.

Fig. 2. *Rhombodella paucispina* × 500, section 38, GGU 303127–15–4, 16.3–119.5; MGUH 21954.

Fig. 3. *Rhombodella paucispina* × 750, section 35; GGU 346456; MGUH 21955.

Fig. 4. *Rhombodella paucispina* × 1000, section 30; GGU 324615; MGUH 21956.

Fig. 5. *Rhombodella paucispina* × 825, section 30; GGU 324615; MGUH 21957.

Fig. 6. *Rhombodella paucispina* × 750, specimen without spines, section 30; GGU 324619–6, 18.2–124.3; MGUH 21958.

Fig. 7. *Rhombodella paucispina* × 750, specimen without spines, section 30; GGU 324619–6, 15.2–124.4; MGUH 21959.

Fig. 8. *Rhombodella vesca* × 500, section 1; GGU 360380–4, 13.3–123.8; MGUH 21960.

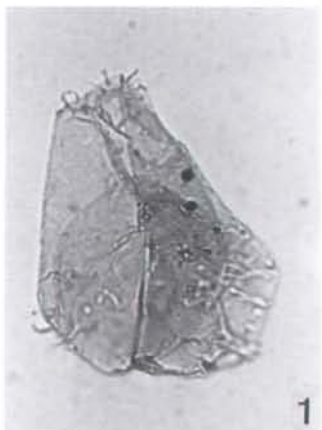
Fig. 9. *Rhynchodiniopsis* cf. *R. aptiana* × 500, section 14; GGU 342072–4, 6.9–126.5; MGUH 21961.

Fig. 10. *Rhynchodiniopsis* cf. *R. aptiana* × 500, section 17; GGU 342161–4, 6.4–129.1; MGUH 21962.

Fig. 11. *Rhynchodiniopsis fimbriata* × 500, section 15; GGU 351527–3, 12.3–135.6; MGUH 21963.

Fig. 12. *Rigaudella* sp. × 500, section 9; GGU 342069–3, 8.9–130.2; MGUH 21964.

Fig. 13. *Rigaudella* sp. × 500, section 9; GGU 342070–7, 9,1–140,3; MGUH 21965.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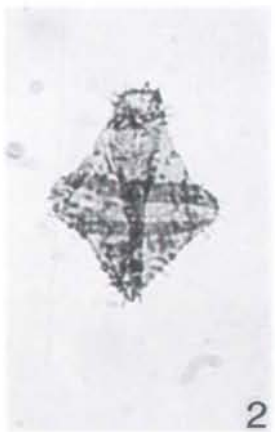
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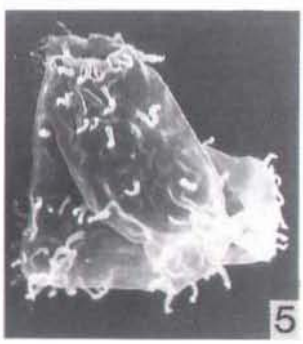
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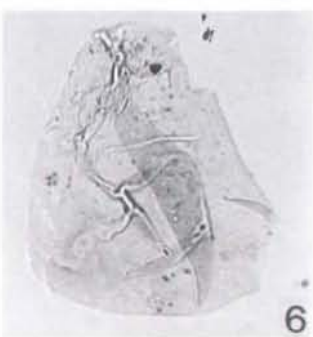
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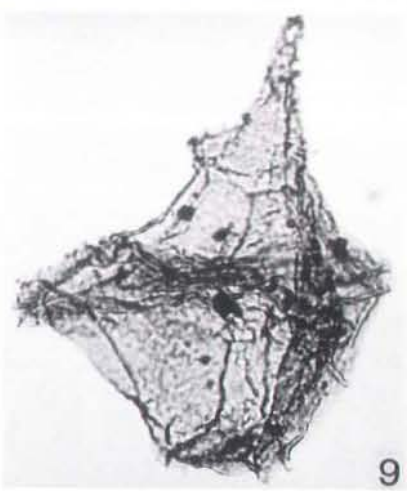
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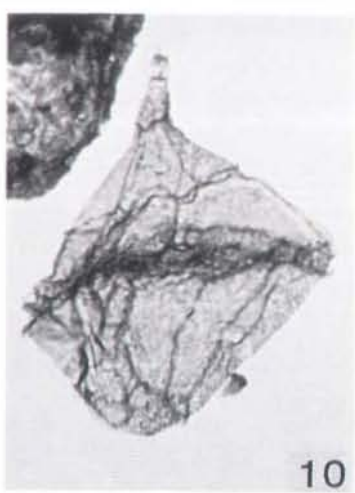
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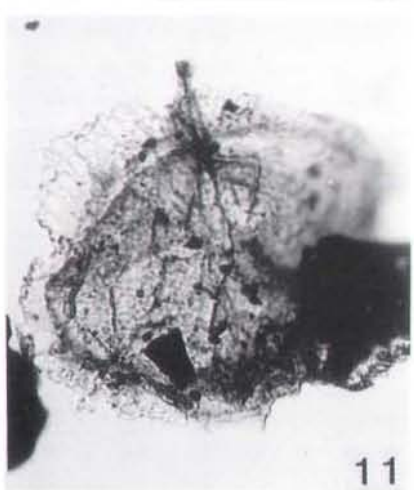
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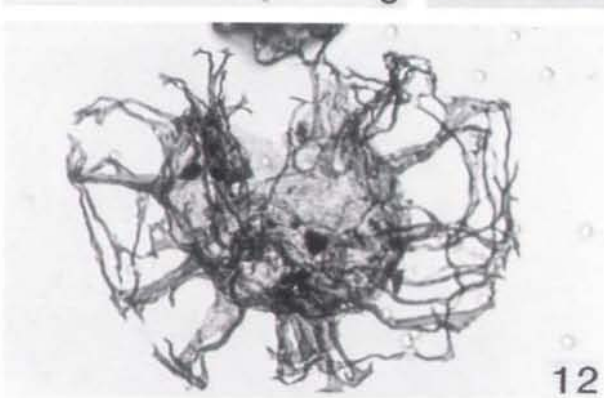
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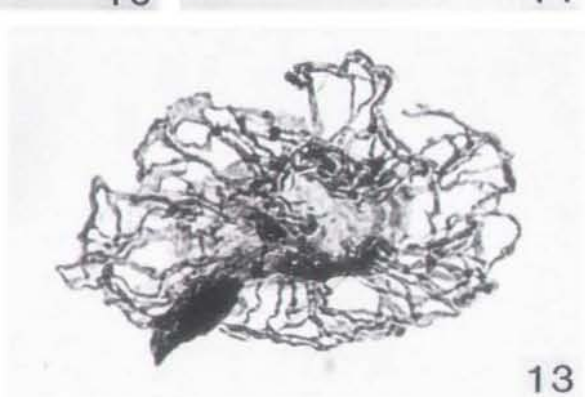
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many (Prössl, 1990), Albian in Germany (as *Palaeohystrichophora paucispina*, Alberti, 1961, type material), middle to upper Albian, France (as *R. natans*, Davey & Verdier, 1971). Present in the middle Albian, Barents Sea (Århus, 1991), recorded from the Aptian to Albian, Australia (as *Rhombodella natans*) by Cookson & Eisenack (1962b) and from the upper Albian to lower Cenomanian, Bathurst Island, Australia (as *R. natans*) by Norvick & Burger (1976). The species has not previously been reported from Canada but examination of middle and upper Albian samples from Axel Heiberg Island, Arctic Canada (kindly provided to me by I.S.P.G., Calgary, Canada) proved its presence in North America.

Rhombodella vesca Duxbury, 1980
Plate 23, Fig. 8

Occurrence in East Greenland. Two specimens have been recorded, one from the upper Barremian section 1 and one from the lower Aptian section 33.

Previous occurrences. Rhombodella vesca was previously recorded from the 'middle' Barremian, Speeton, England (Duxbury, 1980, type material). Harding (1990b) reported the species from the upper Hauterivian to upper Barremian, north Germany and from the lower and upper Barremian, Speeton. The species has also been recorded from a narrow interval in the lowermost upper Aptian, south-east England (Duxbury, 1983) and from the uppermost Hauterivian to the mid lower Albian, north-west Germany (Prössl, 1990).

Genus *Rhynchodiniopsis* Deflandre, 1935; emend. Jan du Chêne *et al.*, 1985b
Rhynchodiniopsis cf. *R. aptiana* Deflandre, 1935; emend. Sarjeant, 1982b
Plate 23, Figs 9–10

Comments. The specimens recorded from East Greenland differ from the type material by having lower and less denticular sutural crests.

Occurrence in East Greenland. Lower to upper Barremian. Sections 1, 10, 14, 17 and 21.

Previous occurrences. Rhynchodiniopsis aptiana was previously recorded from the lower Hauterivian to the lowermost upper Barremian, north-west Germany (Prössl, 1990), 'middle' Barremian to upper Aptian, north-west Europe (Heilmann-Clausen, 1987). The Aptian recording is based on the occurrence of the holotype in a flint of Aptian age, although, the species appears to be more typical for the Barremian according to Heilmann-Clausen (1987). However, Lister & Batten (1988) reported the species from the lower to upper Aptian, south-east England.

Rhynchodiniopsis fimbriata (Duxbury, 1980) Sarjeant 1982b
Plate 23, Fig. 11

Occurrence in East Greenland. Lower and upper Barremian. Sections 8 and 15.

Previous occurrences. Rhynchodiniopsis fimbriata was previously recorded from the 'middle' Barremian, Speeton, England (Duxbury, 1980, type material), uppermost 'middle' Barremian, north-west Germany (Prössl, 1990), upper Hauterivian to upper Barremian, Gott, Germany and upper Hauterivian to lower Aptian, England (Harding, 1990b).

Genus *Rigaudella* Below 1982b
Rigaudella sp.
Plate 23, Figs 12–13

Comments. Specimens of an undetermined species of *Rigaudella* have been recorded from six of the studied sections. The specimens are regarded as reworked from the Jurassic.

Occurrence in East Greenland. Barremian. Sections 9, 10, 11, 18, 19 and 21.

Genus *Senoniasphaera* Clarke & Verdier, 1967
Senoniasphaera microreticulata Brideaux & McIntyre, 1975
Plate 24, Fig. 1

Occurrence in East Greenland. Upper Aptian to lower Albian. Sections 12, 13 and 17. The species is quite common in this interval and seems to be a good stratigraphic marker.

Previous occurrences. Senoniasphaera microreticulata was previously recorded from the middle Albian, Barents Sea, Norway (Århus, 1991), from the middle Albian, District of Mackenzie, Canada (Brideaux & McIntyre, 1975, type material) and from the lower to upper Albian, offshore eastern Canada (Bujak & Williams, 1978). For further discussion, see the *Senoniasphaera microreticulata* Subzone, in the chapter on zonation.

Genus *Sentusidinium* Sarjeant and Stover, 1978

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

Plate 24, Fig. 2

Occurrence in East Greenland. Upper Barremian to upper Albian. Sections 6, 13, 17, 20 and 25. The species is rare and might be reworked.

Previous occurrences. Sentusidinium verrucosum was previously recorded from the upper Jurassic in France and East Greenland by Sarjeant (1968, type material) and Fensome (1979).

Sentusidinium sp. 1

Plate 24, Fig. 3

Description. Ovoidal cyst with numerous baculae and/or echinae. Archeopyle apical, seldom attached. The species has some similarity to *Sentusidinium* sp. E described from the Jurassic of East Greenland by Fensome (1979, p. 20).

Occurrence in East Greenland. Lower Barremian to upper Albian. The species has been recorded from 31 of the examined 40 sections and is quite common.

Sentusidinium sp. 2

Plate 24, Fig. 4

Description. Ovoidal cyst with a setose ornamentation. Archeopyle apical, seldom attached. *Sentusidinium* sp. 2 differs from *Sentusidinium* sp. 1 by having longer and more densely spaced baculae and echinae. The species also differs from *S. echinatum* (Gitmez & Sarjeant, 1972) Sarjeant & Stover, 1978, originally reported from the Jurassic, which is covered by fewer and slightly smaller echinae.

Occurrence in East Greenland. Lower Barremian to upper Albian. The species has been recorded from 22 of the 40 examined sections.

Genus *Sirmiodinium* Alberti, 1961

Sirmiodinium grossii Alberti, 1961; emend. Warren, 1973

Plate 25, Fig. 1

Occurrence in East Greenland. Lower Barremian to lower Aptian. Sections 1, 2, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21 and 32.

Previous selected occurrences. Sirmiodinium grossii was previously recorded from the upper Bathonian (Jurassic) to lower Aptian, England and the North Sea (Costa & Davey, 1992), upper Hauterivian to upper Barremian, Germany (Alberti, 1961) and Jurassic to lowermost Albian, north-west Europe (Heilmann-Clausen, 1987, p. 19 for his comments on the species range).

Genus *Spiniferites* Mantell, 1850; emend. Sarjeant, 1970

Spiniferites spp.

Plate 25, Figs 2–9

Remarks. In the present study no attempt has been made to distinguish between the species of *Spiniferites*.

Occurrence in East Greenland. Barremian to Albian. Species of *Spiniferites* have been recorded in 38 of the 40 examined sections.

Genus *Stiphrosphaeridium* Davey, 1982b

Stiphrosphaeridium cf. *S. anthophorum* (Cookson & Eisenack, 1958) Davey, 1982b

Plate 25, Figs 13–14

Comments. The specimens herein assigned to *S.* cf. *S. anthophorum* include forms with deeply fenestrate processes and entire, finely serrate distal edges (Plate 25, Fig. 14) similar to the type material described by Cookson & Eisenack (1958) but also forms with less fenestrate processes often with an incompletely developed, circular, slightly spinous distal trabecula (Plate 25, Fig. 13).

Occurrence in East Greenland. Lower Barremian to middle Albian. Sections 7, 8, 11, 13, 14, 16, 17, 18, 19, 20, 21, 22 and 23.

Previous selected occurrences. Stiphrosphaeridium anthophorum was previously recorded from the Upper Jurassic to lower Ryazanian, upper Barremian and upper Aptian to lower Albian, north-west Europe (Heilmann-Clausen, 1987) and upper Barremian to lowermost upper Albian, north-west Germany (Prössl, 1990). Costa & Davey (1992) recorded a lowermost upper Albian last occurrence for the species in England and the North Sea. The type material was described from the Upper Jurassic and Aptian to Albian in Australia and Papua New Guniea by Cookson & Eisenack (1958).

Genus *Subtilisphaera* Jain & Millepied, 1973; emend. Lentin & Williams, 1976 *Subtilisphaera kalaalliti* sp. nov.

Plate 26, Figs 1–5

Origin of name. Greenlandic: kalaallit; people.

Diagnosis. The species is represented by thin-walled pentagonal, partly hypocavate cysts. Epicyst long, conical, tapering from the cingulum; hypocyst short with one broad-based antapical horn. A presumed intercalary archeopyle is seldom observed, whereas a secondary opening, an opisthopyle, is almost always present antapically.

Description

Cyst type. Partly hypocavate cyst.

Shape. Dorsoventrally compressed pentagonal cyst. Epicyst long (almost twice the length of the hypocyst), conical, tapering from the cingulum. Hypocyst short, angular, with one broad-based antapical horn.

Wall relationships. Cyst wall two-layered, endophragm and periphragm closely appressed on the epicyst, cingulum and anterior part of the hypocyst, whereas a pericoel is present in the antapical part of the hypocyst (including the horn).

Wall features. Endophragm thin-walled, hyaline, with a psilate to shagreenate surface. Periphragm thin-walled, hyaline, also with an almost smooth surface.

Tabulation. A cingular furrow has been distinguished between two periphragmal folds running almost parallel two thirds down the cysts.

Archeopyle. A presumed intercalary archeopyle may be distinguished on a few specimens, whereas an antapical opening (an ophistopyle) next to the antapical horn, is almost always present.

Holotype. Plate 26, Figs 1 & 2, MGUH 21992 from GGU 324622–3, 23.0–138.4.

Type locality. Section 30, Tværdal, Geographical Society Ø, East Greenland (Fig. 2).

Dimensions. (Measurements in μ.)

	Holotype	*Range*	*Specimens*
Total length	74	60 (70) 85	9
Width	55	42 (47) 61	9
Length antapical horn	13	8 (10) 14	9

Discussion. Subtilisphaera kalaalliti sp. nov. resembles in shape and size *Cepadinium ventriosum* (Alberti, 1959a) Lister & Batten, 1988, but differs from the genus *Cepadinium* by being a double-walled cyst. The new species has been included in the genus *Subtilisphaera*, because of its two wall layers and cavate nature, its weakly discernible archeopyle, and the absence of tabulation except for the low transverse equatorial folds or ridges that most likely indicate a cingulum.

The species *S. pirnaensis* (Alberti, 1959a) Jain & Millepied, 1973 resembles *S. kalaalliti* in shape, but differs by being cavate to bicavate and by its slightly larger size.

Palaeoperidinium cretaceum differs from *S. kalaalliti* by its slightly larger size, by having two conical antapical horns and by having a periphragm of similar shape as the endophragm.

Occurrence in East Greenland. Upper Albian. Sections 24, 25, 26?, 27, 28, 29, 30, 31, 35, 36, 37, 38, 39 and 40 where it is quite abundant.

Plate 24

Fig. 1. *Senoniasphaera microreticulata* × 500, section 17; GGU 342172–4, 12.1–127.1; MGUH 21966.

Fig. 2. *Sentusidinium verrucosum* × 500, section 17; GGU 342169–4, 14.7–138.2; MGUH 21967.

Fig. 3. *Sentusidinium* sp. 1 × 700, section 17; GGU 342169–4, 7.3–130.2; MGUH 21968.

Fig. 4. *Sentusidinium* sp. 2 × 750, section 17; GGU 342169–4, 13.0–153.7; MGUH 21969.

Fig. 5. *Ovoidinium*? sp. 1 × 500, section 30; GGU 324615–7, 19.0–127.8; MGUH 21970.

Fig. 6. *Ovoidinium*? sp. 1 × 500, section 30; GGU 324615–7, 22.5–128.8; MGUH 21971.

Fig. 7. *Ovoidinium*? sp. 1 × 700, section 24; GGU 346451–4, 5.6–143.0; MGUH 21972.

Fig. 8. *Ovoidinium*? sp. 1 × 500, section 15; GGU 351526–4, 2.0–144.9; MGUH 21973.

Fig. 9. *Ovoidinium*? sp. 1 × 800, section 24; GGU 346456; MGUH 21974.

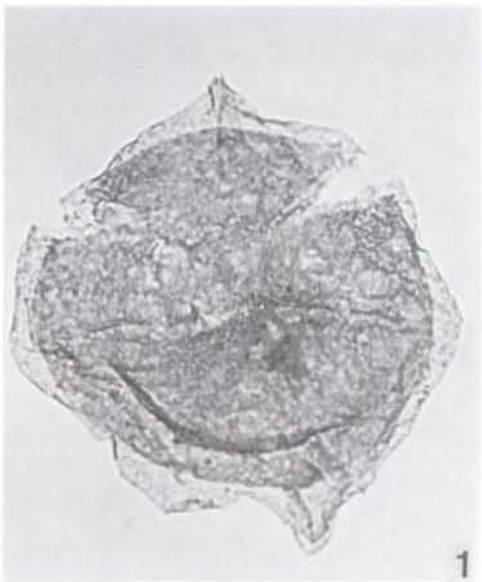
Fig. 10. *Ovoidinium*? sp. 1 × 800, section 25; GGU 346442; MGUH 21975.

Fig. 11. *Ovoidinium*? sp. 1 × 700, section 40; GGU 303125–1; MGUH 21976.

Fig. 12. *Ovoidinium*? sp. 1 × 700, section 24; GGU 346456; MGUH 21977.

Fig. 13. *Ovoidinium*? sp. 1 1 × 500, same specimen as Fig. 10 above, close-up of archeopyle, section 25; GGU 346442.

Fig. 14. *Ovoidinium*? sp. 1 × 2000, same specimen as Fig. 11 above, close-up of archeopyle, section 40; GGU 303125–2.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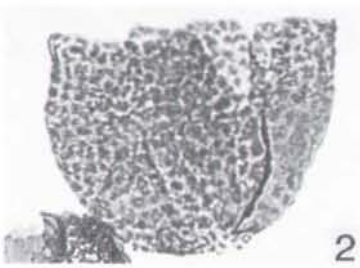
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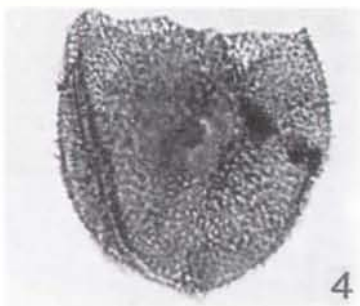
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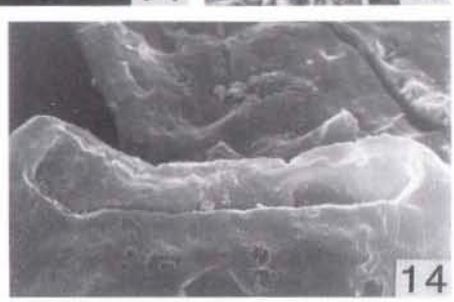
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Subtilisphaera perlucida (Alberti, 1959b) Jain & Millepied, 1973

Plate 26, Fig. 6

Occurrence in East Greenland. Lower Barremian to middle Albian. Sections 7, 11, 12, 13, 14, 17, 19, 21, 23, 32 and 33. One questionable specimen has been recorded from the upper Albian section 36.

Previous selected occurrences. Subtilisphaera perlucida was previously recorded from the upper Barremian, Germany (Alberti, 1959, type material), lower and upper Aptian, Aptian type section, south-east France (Davey & Verdier, 1974), the lower Barremian to lowermost Albian, north-west Europe (Heilmann-Clausen, 1987), upper Hauterivian to upper Barremian, north-west Germany (Prössl, 1990) and from the upper Hauterivian to lower Albian, world-wide (Williams & Bujak, 1985).

Genus *Surculosphaeridium* Davey *et al.*, 1966; emend. Davey, 1982b

Surculosphaeridium aff. *S. phoenix* (Duxbury, 1980) Lentin & Williams, 1981

Plate 26, Figs 7–8

Comments. The specimens herein described as *S.* aff. *S. phoenix* have the characteristic processes illustrated by Duxbury (1980) but the number of processes is greater on the specimens from East Greenland.

Occurrence in East Greenland. Lower Barremian to lower Albian. Sections 1, 2, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18 and 21.

Previous occurrence. The type material was described from the Barremian, England (Duxbury, 1980).

Genus *Systematophora* Klement, 1960

Systematophora aff. *S. cretacea* Davey, 1979b

Plate 26, Figs 9–13

Comments. The specimens are very similar to the type material described by Davey (1979a, p. 560) but differs in its slightly smaller size and by its less densely granular periphragm.

Occurrence in East Greenland. Lower Barremian to lower Albian. Sections 7, 11, 15, 17, 20 and 21.

Previous occurrences. Systematophora cretacea was previously recorded from the lower Albian, southern England (Duxbury, 1983), middle Albian, England and the North Sea (Costa & Davey, 1992), lower and upper Aptian, south-east England, (as *S.* sp. cf. *S. cretacea* by Lister & Batten, 1988), upper Aptian to lower Cenomanian, north-west Germany (Prössl, 1990) and Albian, northern Bay of Biscay, offshore W. France (Davey, 1979a, type material).

Genus *Tanyosphaeridium* Davey & Williams, 1966b

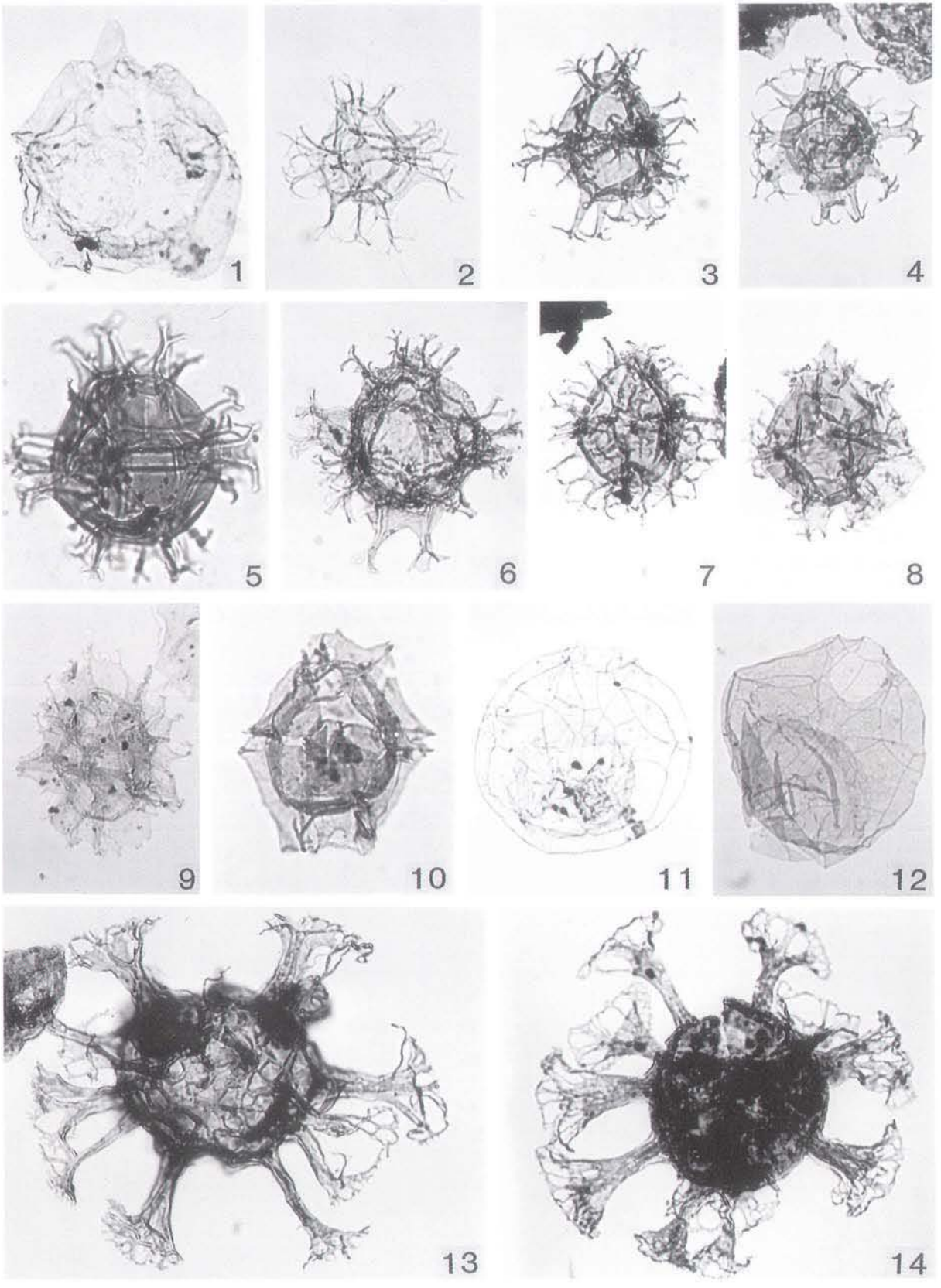
Tanyosphaeridium boletum Davey, 1974

Plate 27, Figs 1–3

Comments. The present specimens of *T. boletum* have more than 30 processes, commonly 40 to 75. The processes show a circular alignment parallel to the central body width. A narrow cingular area devoid of processes has been observed on the majority of the specimens. The surface of the cyst is shagreenate to granulate. The processes are long (17–25 μ), slender (0.5–2 μ) and are distally expanded and often recurved or slightly furcated.

Plate 25

Fig. 1. *Sirmiodinium grossii* × 500, section 21; GGU 342234–7, 4.5–147.4; MGUH 21978.
Fig. 2. *Spiniferites* sp. × 500, section 14; GGU 342134–4, 10.0–137.2; MGUH 21979.
Fig. 3. *Spiniferites* sp. × 500, section 19; GGU 342215–3, 5.5–128.0; MGUH 21980.
Fig. 4. *Spiniferites* sp. × 500, section 20; GGU 342176–4, 2.8–123.8; MGUH 21981.
Fig. 5. *Spiniferites* sp. × 750, section 31; GGU 342623–4, 4.5–123.5; MGUH 21982.
Fig. 6. *Spiniferites* sp. × 500, section 14; GGU 342135–3, 12.0–140.0; MGUH 21983.
Fig. 7. *Spiniferites* sp. × 500, section 21; GGU 342230–7, 13.5–147.4; MGUH 21984.
Fig. 8. *Spiniferites* sp. × 500, section 21; GGU 342235–4, 18.6–131.8; MGUH 21985.
Fig. 9. *Spiniferites* sp. × 500, section 30; GGU 324609–7, 7.4–148.7; MGUH 21986.
Fig. 10. *Pterodinium* sp. × 750, section 20; GGU 342202–4, 18.1–132.2; MGUH 21987.
Fig. 11. *Hapsocysta*? *benteae* sp. nov. holotype, × 500, section 21; GGU 342240–4, 10.0–140.0; MGUH 21988.
Fig. 12. *Hapsocysta*? *benteae* sp. nov. × 500, section 30; GGU 342619–3, 10.2–131.0; MGUH 21989.
Fig. 13. *Stiphrosphaeridium* cf. *S. anthophorum* × 500, section 19; GGU 342216–4, 17.3–129.4; MGUH 21990.
Fig. 14. *Stiphrosphaeridium* cf. *S. anthophorum* × 500, section 20; GGU 342176–5, 19.4–147.0; MGUH 21991.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Occurrence in East Greenland. Lower Barremian to upper Albian. Sections 1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 33 and 34.

Previous occurrences. Tanyosphaeridium boletum was previously recorded from the Barremian at Speeton, England (Davey, 1974, type material), lower and upper Aptian, south-east England (Lister & Batten, 1988) and lower Hauterivian to upper Aptian, north-west Germany (Prössl, 1990).

Tanyosphaeridium cf. *T. isocalamus* (Deflandre & Cookson, 1955) Davey & Williams, 1969

Plate 27, Fig. 4

Comments. Tanyasphaeridium cf. *T. isocalamus* differs slightly from the type material described by Deflandre & Cookson (1955) by its somewhat expanded process tips, which seem to be serrate rather than cleanly truncate.

Occurrence in East Greenland. Only a few specimens are recorded from the lower Barremian in section 21, whereas the majority (approximately 10 specimens) occur in the middle and upper Albian. Sections 20, 23 and 25.

Previous occurrences. Tanyosphaeridium isocalamus was previously recorded from the lower Hauterivian to lowermost Barremian, north-west Germany (Prössl, 1990) and Lower Cretaceous, Australia (Deflandre & Cookson, 1955, type material).

Tanyosphaeridium salpinx Norvick, 1976

Plate 27, Fig. 5–7

Comments. The species has approximately 30 moderately long (10–22 μ), broad (2–3 μ) processes, with trumpet-like terminations.

Occurrence in East Greenland. Barremian. Sections 15 and 18, middle and upper Albian. Sections 23, 25 and 39.

Previous occurrences. Tanyosphaeridium salpinx was previously recorded from the lower Aptian, south-east England (Lister & Batten, 1988), lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990), Aptian to Cenomanian, Peace River area, Canada, as *Tanyosphaeridium* sp. (Singh, 1971) and Cenomanian from the same area (Singh, 1983), Cenomanian, Australia (Norvick, 1976 *in* Norvick & Burger, 1976, type material) and Aptian to Cenomanian, Australia (Morgan, 1980).

Genus *Trichodinium* Eisenack & Cookson, 1960; emend. Clarke & Verdier, 1967

Trichodinium speetonense Davey, 1974

Plate 27, Figs 8–9

Occurrence in East Greenland. Lower Barremian to lowermost Aptian. Sections 1, 6, 7, 8, 11, 14, 15, 16, 17, 18, 19, 21, 32 and 33.

Previous occurrences. Trichodinium speetonense was previously recorded from the lower, 'middle' and upper Barremian, Speeton, England (Davey, 1974, type material), upper Barremian, England and the North Sea (Costa & Davey, 1992), the upper Hauterivian to top of the Barremian, north-west Europe (Heilmann-Clausen, 1987), lower Hauterivian to upper Aptian, north-west Germany (Prössl, 1990). Harding (1990b, p. 53) mentions that the species first occurs in the middle part of the lower Barremian, Speeton, England, and Gott, Germany where the species ranges up to the top of the upper Barremian. Harding (1990b, table 7) also reported the species from the Warlingham borehole, England where it occurred in Aptian strata. The present observations from East Greenland agree with Hardings's (1990b) range.

Plate 26

Figs 1 & 2. *Subtilisphaera kalaalliti* sp. nov. holotype × 730, section 30; GGU 324622–3, 23.0–138.4; MGUH 21992.

Figs 3 & 4. *Subtilisphaera kalaalliti* sp. nov. × 500, section 30; GGU 324622–3, 6.0–123.8; MGUH 21993.

Fig. 5. *Subtilisphaera kalaalliti* sp. nov. × 500, section 12; GGU 324654; MGUH 21994.

Fig. 6. *Subtilisphaera perlucida* × 700, section 17; GGU 342169–4, 9.7–143.0; MGUH 21995.

Fig. 7. *Surculosphaeridium* aff. *S. phoenix* × 500, section 2; GGU 351558–4, 3.7–129.7; MGUH 21996.

Fig. 8. *Surculosphaeridium* aff. *S. phoenix* × 500, section 8; GGU 342076–4, 9.5–129.0; MGUH 21997.

Fig. 9. *Systematophora* aff. *S. cretacea* × 500, section 7; GGU 342085–4, 40.0–129.0; MGUH 21998.

Fig. 10. *Systematophora* aff. *S. cretacea* × 500, section 17; GGU 342161–4, 5.0–130.8; MGUH 21999.

Fig. 11. *Systematophora* aff. *S. cretacea* × 500, fragment showing the annulate complex of processes, section 21; GGU 342237–4, 3.5–139.1; MGUH 22000.

Fig. 12. *Systematophora* aff. *S. cretacea* × 725, section 17, GGU 342166; MGUH 22001.

Fig. 13. *Systematophora* aff. *S. cretacea* × 1200, same specimen as above, close-up of the annulate complex of the processes and the cyst surface.


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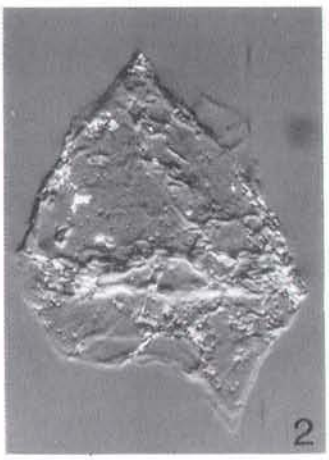
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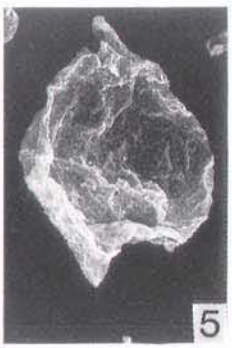
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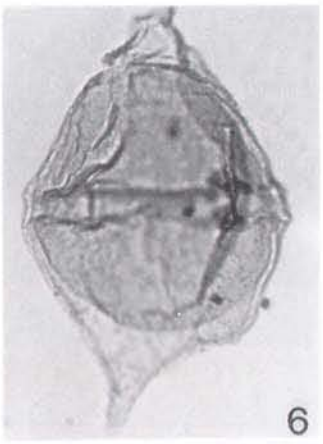
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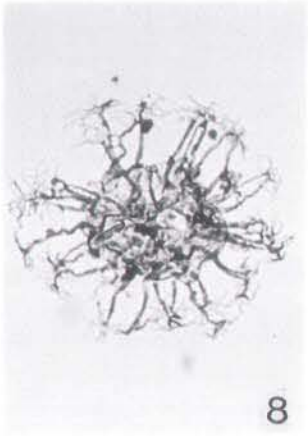
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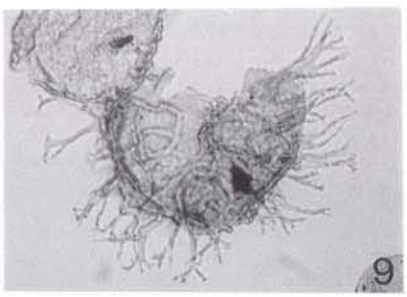
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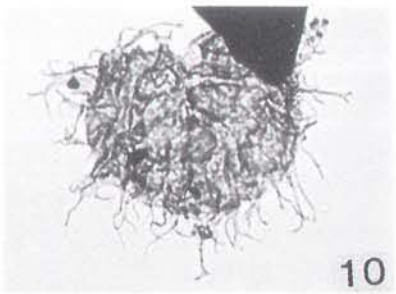
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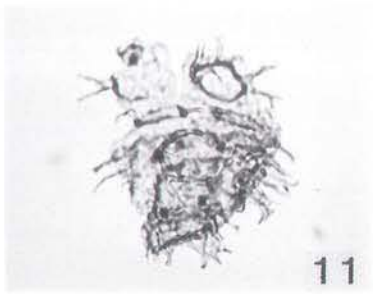
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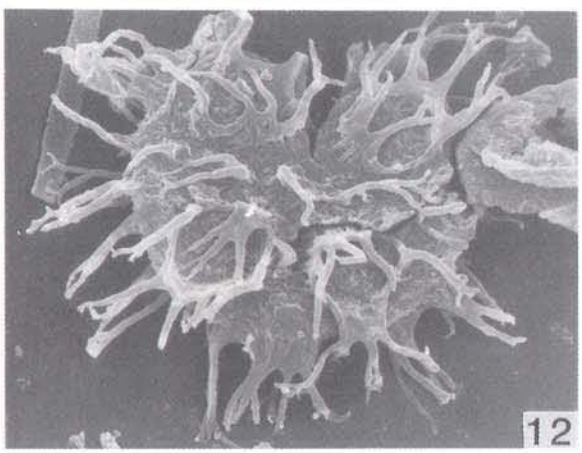
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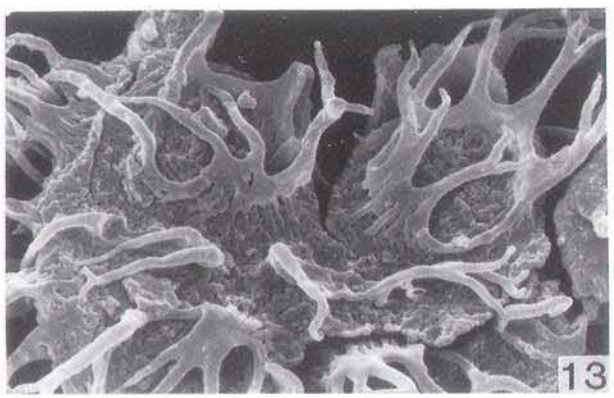
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Genus *Tubotuberella* Vozzhennikova, 1967; emend. Sarjeant, 1982

Tubotuberella uncinata (Brideaux, 1977) Davies, 1983

Plate 27, Fig. 10

Occurrence in East Greenland. Lower Barremian. Sections 9, and 11.

Previous occurrences. Tubotuberella uncinata was previously recorded from the Hauterivian and Barremian, District of Mackenzie, Canada (Brideaux, 1977). The species has not previously been reported outside Canada, but one specimen was recorded by Heilmann-Clausen (personal communication, 1990) from the Barremian in the Ahlum-1 well in the Lower Saxony Basin, Germany. The species is rare, but seems to be a good stratigraphical index species for the Barremian in Canada.

Tubotuberella sp.

Occurrence in East Greenland. Lower Barremian to upper Aptian. Sections 1, 7, 11, 13, 17 and 21.

Remarks. Specimens of *Tubotuberella* are very rare in the present material and are considered as reworked from pre-Hauterivian Cretaceous and Jurassic strata.

Genus *Vesperopsis* Bint, 1986

Vesperopsis? *digitata* (Duxbury, 1983) Bint, 1986

Plate 27, Fig. 11

Occurrence in East Greenland. Five very thin-walled, folded or damaged specimens were recorded from the middle Albian sections 20 and 23. All the specimens have the characteristic pre- and postcingular extensions on the lateral horns.

Previous occurrence. The type material was described from the upper Aptian, southern England by Duxbury (1983).

Vesperopsis aff. *V. fragilis* (Harding, 1986a) Harding, 1990

Plate 27, Figs 12–16

Comments. The specimens referred to *Vesperopsis* aff. *V. fragilis* differ from *V. fragilis* by their slightly longer, sometimes pointed, antapical horns, and by less distinctly developed cingulum and cingular horns (bulge).

Occurrence in East Greenland. Upper Albian. Sections 36, 37 and 39.

Previous occurrences. Vesperopsis fragilis was previously recorded from the upper Hauterivian, England (Harding, 1986a) and from presumed brackish-water deposits in the Barremian of south-east England, (Batten & Lister, 1988; Lister & Batten, 1988).

Remarks. The occurrence in East Greenland diverges remarkably from the previous records. *Vesperopsis* aff. *V. fragilis* may therefore be a new species.

Vesperopsis longicornis Batten & Lister, 1988; comb. nov. et emend. Harding, 1990

Plate 28, Figs 1–4

Comments. The specimens from East Greenland are generally larger than those described by Batten & Lister

Plate 27

Fig. 1. *Tanyosphaeridium boletum* × 750, section 7, GGU 342081–4, 19.5–130.7; MGUH 22002.
Fig. 2. *Tanyosphaeridium boletum* × 750, section 6, GGU 342111–7, 0.5–137.7; MGUH 22003.
Fig. 3. *Tanyosphaeridium boletum* × 750, section 18, GGU 342220–4, 4.5–149.5; MGUH 22004.
Fig. 4. *Tanyosphaeridium* cf. *T. isocalamus* × 750, section 25, GGU 346440–4, 17.4–135.0; MGUH 22005.
Fig. 5. *Tanyosphaeridium salpinx* × 750, section 25, GGU 346440–4, 15.7–127.1; MGUH 22006.
Fig. 6. *Tanyosphaeridium salpinx* × 750, section 25, GGU 346440–8, 12.2–133.7; MGUH 22007.
Fig. 7. *Tanyosphaeridium salpinx* × 750, section 23, GGU 351676–4, 9.6–120.0; MGUH 22008.
Fig. 8. *Trichodinium speetonense* × 500, section 17; GGU 342161–4, 17.8–130.6; MGUH 22009.
Fig. 9. *Trichodinium speetonense* × 500, section 14; GGU 342132–4, 15.0–142.8; MGUH 22010.
Fig. 10. *Tubotuberella uncinata* × 500, section 9; GGU 342069–4, 5.6–147.8; MGUH 22011.
Fig. 11. *Vesperopsis*? *digitata* × 500, section 20; GGU 342189–4, 16.5–126.8; MGUH 22012.
Fig. 12. *Vesperopsis* aff. *V. fragilis* × 500, section 37; GGU 324649–4, 5.8–128.9; MGUH 22013.
Fig. 13. *Vesperopsis* aff. *V. fragilis* × 500, section 37; GGU 324650–4, 5.8–136.2; MGUH 22014.
Fig. 14. *Vesperopsis* aff. *V. fragilis* × 500, section 37; GGU 324655–3, 13.0–125.4; MGUH 22015.
Fig. 15. *Vesperopsis* aff. *V. fragilis* × 500, section 37; GGU 324648–4, 2.8–149.8; MGUH 22016.
Fig. 16. *Vesperopsis* aff. *V. fragilis* × 500, section 37; GGU 324648–4, 7.2–141.0; MGUH 22017.


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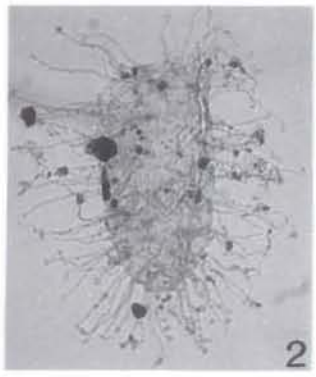
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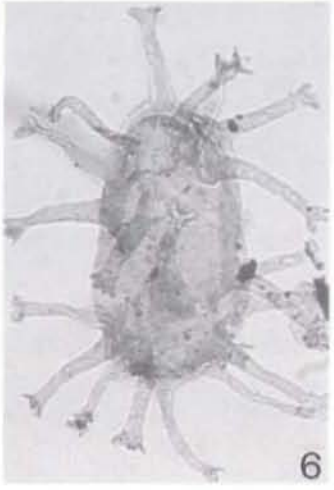
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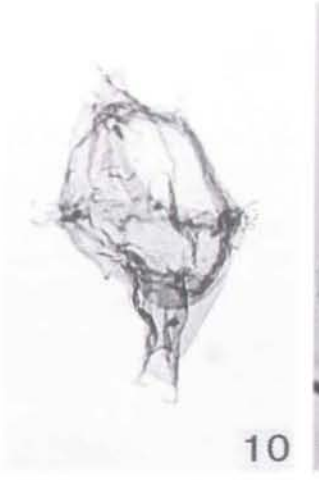
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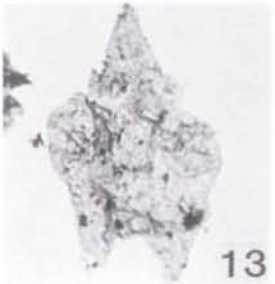
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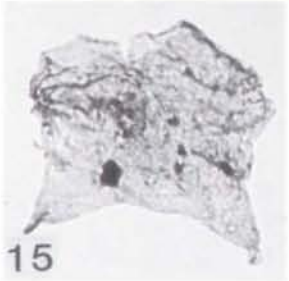
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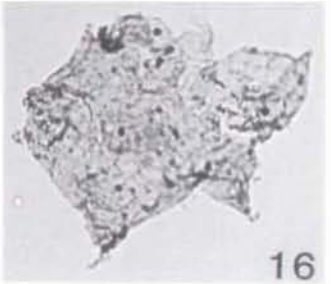
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(1988) and Harding (1990b). The right antapical horn varies from being rather short (Plate 28, figs 1–3) to a length almost as long as the left antapical horn (Plate 28, Fig. 4).

Dimensions. (Measurements in μ.) Length, 9 complete specimens: 85 (141) 193, width 65 (106) 170, 21 specimens, length, 30 excysted specimens 71 (93) 114.

Occurrence in East Greenland. Lower Aptian. Sections 3, 6, 17, 19 and 32, where it has an acme with a rather narrow interval. A second acme occurs in a narrow interval in the upper Aptian – lower? Albian. Sections 2, 13, 26 and 34.

Previous occurrences. Vesperopsis longicornis was previously recorded from the uppermost Barremian, southeast England, as *Australisphaera* sp. *A* (Lister & Batten, 1988), and upper Barremian to lower Aptian at the Warlingham borehole, England (Harding, 1990b).

Vesperopsis mayi Bint, 1986

Plate 28, Figs 5–10

Description. The specimens here identified as *V. mayi* have an apical, two lateral and two antapical horns as described by Bint (1986, p. 157).

The lateral horns on most of the observed specimens differ slightly from those on the holotype by tapering more gradually to the tip. They are almost equal in length but differ slightly in shape. The left lateral horn has a clear cingular indentation, often more pronounced than on the holotype, whereas the cingular indentation is vague on the right lateral horn. The left antapical horn is long and narrow whereas the right antapical horn is short, often less than a third of the length of the left antapical horn, but never absent as mentioned by Bint (1986, p. 157). The archeopyle is apical with the operculum usually in place. The cysts are composed of one wall layer.

Remarks. According to Bint (1986, p. 157) *Muderongia asymmetrica* Brideaux, 1977 is very similar to *V. mayi* but differs by having an inner body, a free apical operculum, and a right postcingular horn which is longer than the left postcingular horn. The same data can be obtained from Brideaux's (1977, p. 40) description of the species and Monteil's (1991) emendation.

The holotype of *M. asymmetrica* has been re-examined by the present author. This and a closer look at Brideaux's illustrations of the holotype (1977, plate 15, fig. 9 and plate 16, fig. 1) reveal that the specimen has folded postcingular horns of almost equal lengths and no free apical operculum. Furthermore the inner body is, according to the present author, very difficult to distinguish.

The most obvious difference between the two species, apart from the questionable presence of an inner body, may be the length of the right antapical horn, which is very small or absent on *V. mayi*, whereas it is more pronounced on the holotype of *M. asymmetrica.*

Occurrence in East Greenland. Lower Aptian to middle upper Albian. The species is common to abundant in the lower and middle Albian. Sections 2, 5, 12, 13, 17, 20, 21, 22, 23, 26, 30, 31, 34 and 40.

Previous occurrences. Vesperopsis mayi was previously recorded from the Albian, Western Interior, USA (Bint, 1986, type material) and middle to upper Albian, Alaska (as *Muderongia* sp. A, May & Stein, 1979).

Genus *Wallodinium* Loeblich & Loeblich, 1968

Wallodinium krutzschii (Alberti, 1961) Habib, 1972

Plate 29, Fig. 1

Occurrence in East Greenland. Lower Barremian to upper Albian. Sections 1, 3, 6, 7, 8, 11, 12, 14, 17, 18, 19, 20, 21, 22, 23, 26, 30, 31, 32, 33, 34 and 40.

Plate 28

Fig. 1. *Vesperopsis longicornis* × 500, section 34; GGU 342556–4, 20.3–132.8; MGUH 22018.
Fig. 2. *Vesperopsis longicornis* × 500, section 34; GGU 324556–4, 12.3–153.4; MGUH 22019.
Fig. 3. *Vesperopsis longicornis* × 500, section 17; GGU 342169–4, 13.8–124.1; MGUH 22020.
Fig. 4. *Vesperopsis longicornis* × 500, section 17; GGU 342169–4, 13.9–149.2; MGUH 22021.
Fig. 5. *Vesperopsis mayi* × 500, section 30; GGU 324613–8, 19.1–139.1; MGUH 22022.
Fig. 6. *Vesperopsis mayi* × 500, section 26; GGU 351630–4, 14.0–122.5; MGUH 22023.
Fig. 7. *Vesperopsis mayi* × 500, section 30; GGU 324619–6, 8.8–126.9; MGUH 22024.
Fig. 8. *Vesperopsis mayi* × 500, section 20; GGU 342189–4, 16.7–126.0; MGUH 22025.
Fig. 9. *Vesperopsis mayi* × 500, section 20; GGU 342179–4, 3.8–122.8; MGUH 22026.
Fig. 10. *Vesperopsis mayi* × 500, section 13; GGU 351587–4, 10.8–135.3; MGUH 22027.


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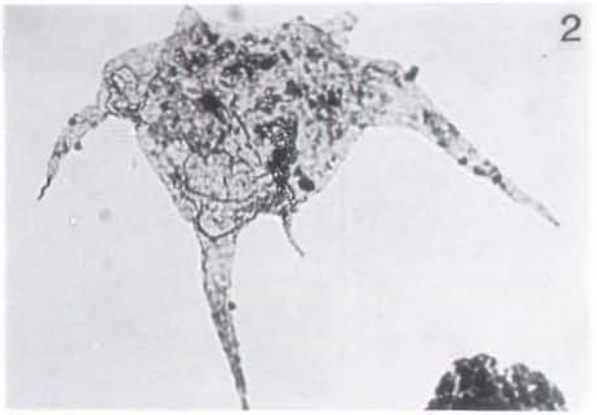
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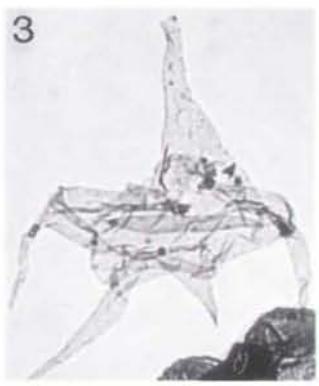
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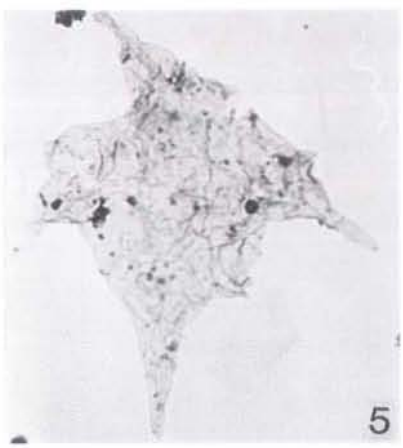
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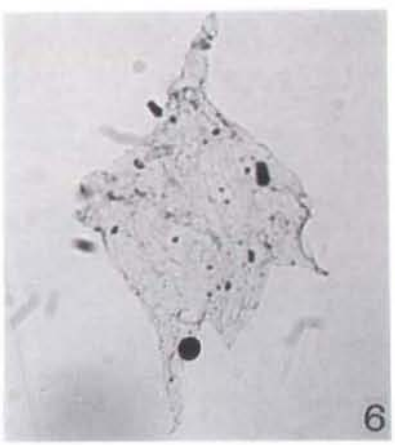
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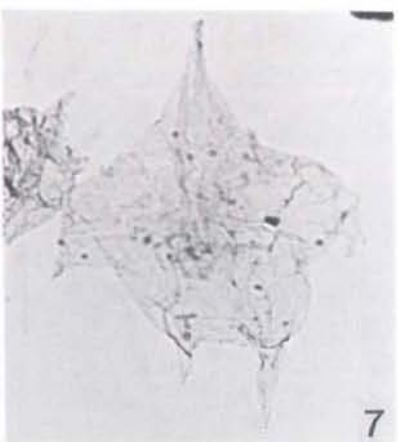
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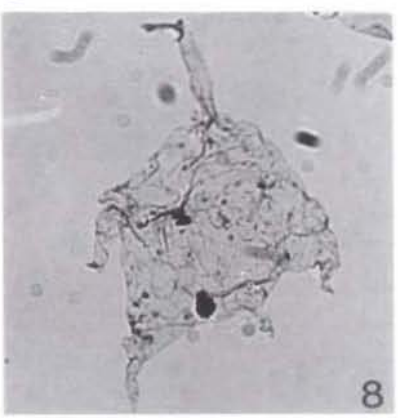
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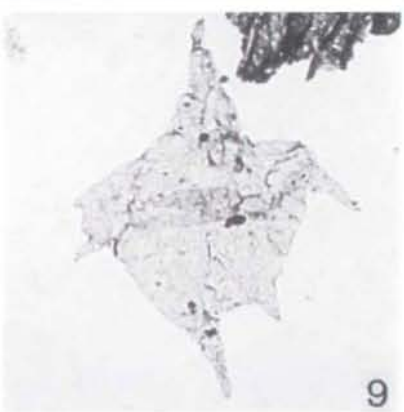
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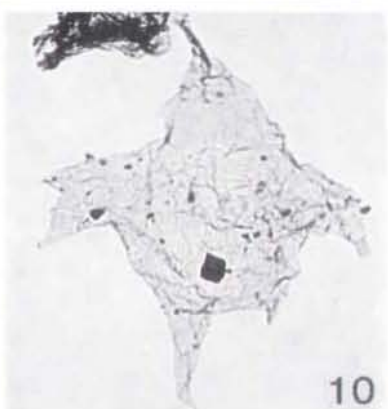
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Previous occurrences. Wallodinium krutzschii was previously recorded from the Hauterivian and Barremian, Germany (Alberti, 1961, type material) and the lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990).

Wallodinium luna (Cookson & Eisenack, 1960a) Lentin & Wiliams, 1973

Plate 29, Fig. 2

Occurrence in East Greenland. Lower Barremian to upper Albian. Sections 9, 10, 15, 25, 28, 31, 34 and 36.

Previous occurrences. Wallodinium luna was previously recorded from the upper? Albian to Cenomanian, Australia (Cookson & Eisenack, 1960a, type material), the lower Hauterivian to upper Turonian, north-west Germany (Prössl, 1990) and from Berriasian to Campanian, world-wide (Williams & Bujak, 1985).

Genus *Wigginsiella* Lucas-Clark, 1987
Wigginsiella grandstandica Lucas-Clark, 1987

Plate 29, Figs 3–5

Occurrence in East Greenland. In a rather narrow interval in the lower upper Albian. Sections 29, 30 and 31.

Previous occurrences. Wigginsiella grandstandica was previously recorded as Genus A from the upper Albian, Alaska (May & Stein, 1979; May, 1979). In the description of the type material Lucas-Clark (1987, p. 162) referred to oral communication with J. Bennett, H. Haga, F. E. May and V. D. Wiggins (1982–1984) who employed the species as an upper Albian marker in Alaska. The present observations from East Greenland agree well with the previous occurrences.

Genus *Xenascus* Cookson & Eisenack, 1969; emend. Stover & Helby, 1987a
Xenascus ceratioides (Deflandre, 1937b) Lentin & Williams, 1973

Plate 29, Figs 6–8

Comments. The few specimens observed in the present study are poorly preserved. No attempt has, therefore been made to distinguish between the different subspecies.

Occurrence in East Greenland. Uppermost Albian. Sections 24, 25, 27, 30, 39 and 40.

Previous occurrences. Xenascus ceratioides was previously recorded from the uppermost Albian to upper Turonian, north-west Germany (Prössl, 1990), lower Albian to Campanian, France (Foucher, 1979; 1981), the lower Albian to upper Maastrichtian, England and the North Sea (Costa & Davey, 1992), uppermost Albian and younger strata, offshore eastern Canada (Bujak & Williams, 1978), offshore eastern Canada (Williams, 1975) and upper middle Albian to lowermost Maastrichtian, worldwide (Williams & Bujak, 1985).

Genus *Xiphophoridium* Sarjeant, 1966b
Xiphophoridium alatum (Cookson & Eisenack, 1962b) Sarjeant, 1966b

Plate 29, Fig. 9

Occurrence in East Greenland. Upper Albian. Sections 24, 25, 27, 28, 30, 31, 36, 37, 38, 39 and 40.

Previous occurrences. Xiphophoridium alatum was previously recorded from the upper Albian to lower Santonian, England and the North Sea (Costa & Davey, 1992), the upper middle Albian to the middle upper Turonian, north-west Germany (Prössl, 1990), middle Albian to upper Santonian, France; Campanian and Maastrichtian, Belgium (Foucher, 1979; 1981), Albian (upper?) and Cenomanian, Australia (Cookson & Eisenack, 1962b,

Plate 29

Fig. 1. *Wallodinium krutzschii* × 500, section 7; GGU 342084–4, 4.4–143.6; MGUH 22028.

Fig. 2. *Wallodinium luna* × 500, section 15; GGU 351526–4, 16.4–138.5; MGUH 22029.

Figs 3 & 4. *Wigginsiella grandstandica* × 500, section 29; GGU 324599–4, 3.5–124.9; MGUH 22030.

Fig. 5. *Wigginsiella grandstandica* × 500, section 31; GGU 324623–8, 2.3–124.4; MGUH 22031 .

Fig. 6. *Xenascus ceratioides* × 500, section 30; GGU 324617–8, 21.9–134.0; MGUH 22032.

Fig. 7. *Xenascus ceratioides* × 500, operculum, section 30; GGU 324617–8; MGUH 22033.

Fig. 8. *Xenascus ceratioides* × 500, section 39; GGU 335320–4, 0.8–150.5; MGUH 22034.

Fig. 9. *Xiphophoridium alatum* × 500, section 30; GGU 324613–8, 13.4–142.0; MGUH 22035.

Fig. 10. *Pterospermella* cf. *P. australiensis* × 500, section 20; GGU 342179–4, 17.1–129.0; MGUH 22036.

Fig. 11. ?Hair from leaf × 500, section 17; GGU 342162–4, 4.7–128.3; MGUH 22037.

Fig. 12. Dinoflagellate cyst 1 × 500, section 31; GGU 324623–4, 23.0–119.6; MGUH 22038.


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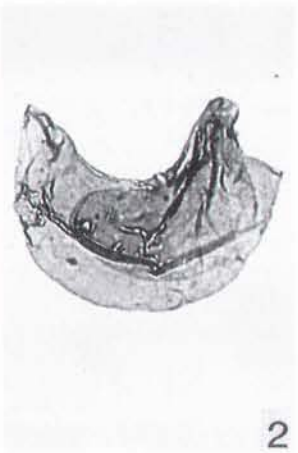
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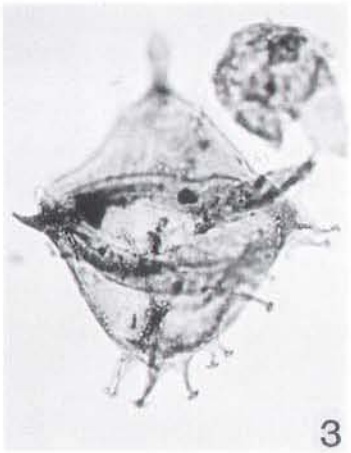
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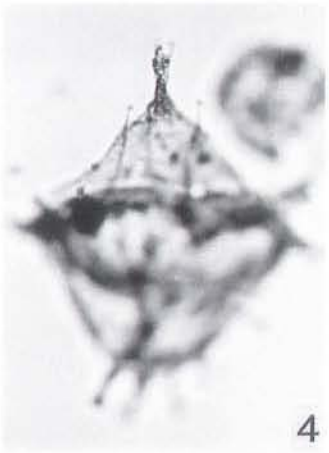
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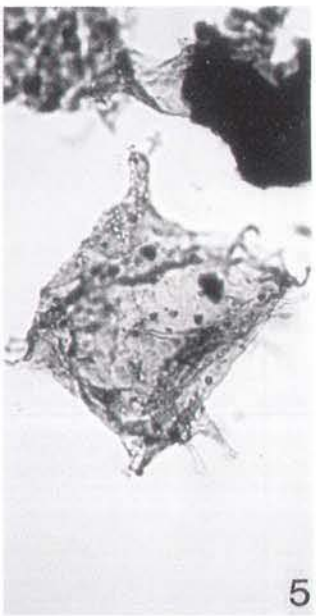
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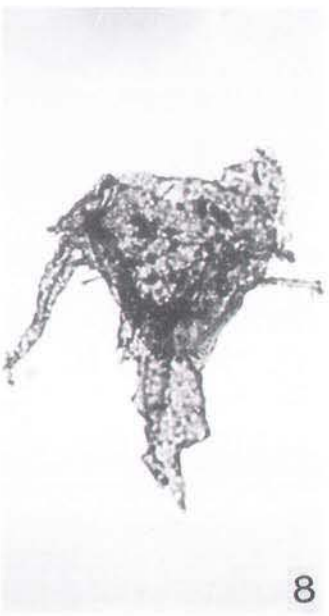
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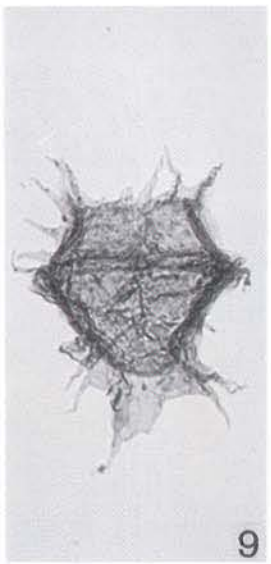
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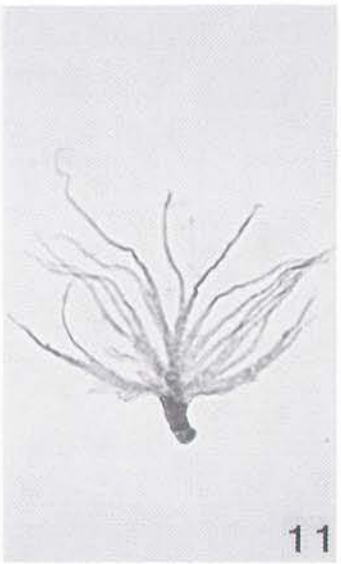
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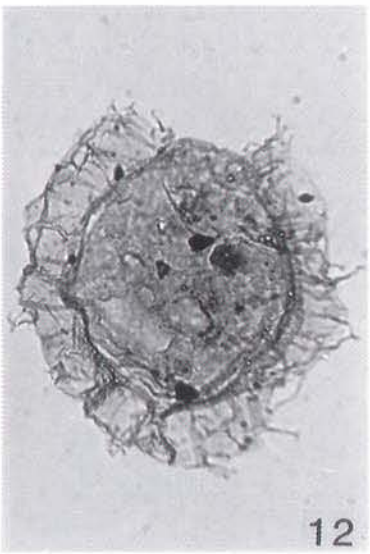
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type material) and upper Albian to upper Santonian, world-wide (Williams & Bujak, 1985).

Dinoflagellate cyst 1

Plate 29, Fig. 12

Description. Dinoflagellate cyst 1 is a relatively small (total length 68 μ, width 64 μ), lenticular to spherical cyst with an apparently cingular flange (width of flange 15–18 μ) with slender spines/processes (length of processes 5–10 μ) that bi- or trifurcate distally. The flange is continuous, except for a narrow interval, which could be a sulcal area. The specimens are observed in a presumed polar view and the main body of the cyst is then ovoidal in outline and without any ornamentation. Fractures along the base of the flange from the dorsal to the one lateral side may indicate a precingular archeopyle (type P?). There is no clear orientation of the cysts except for the flange and the questionable archeopyle.

Occurrence in East Greenland. Only a few specimens have been observed from the upper Albian section 31.

Dinoflagellate cyst 2

Plate 30, Fig. 1

Description. Dinoflagellate cyst 2 is a large (length 213 μ), probably cavate, elongate, thin walled cyst with a smooth ectophragm surface. The epicyst is conical with a cylindric apical horn (35 μ) and a precingular acheopyle (type P?). A cingulum may be distinguished as a equatorial traverse furrow. The hypocyst is slightly folded but gradually tapered and may antapical terminate in a square or round aperture (opisthopyle?) as in the genus *Tubotuberella*.

Occurrence in East Greenland. Only one specimen has been observed from the upper Albian of section 30.

Dinoflagellate cyst 3

Plate 30, Figs 2 & 3

Description. Dinoflagellate cyst 3 is a small chorate cyst (overall size 45 μ, width of body 29 μ) with a densely scabrate to granulate surface. The processes arise from the surface of the main body and are arranged in circles (most probably plate related; intratabular). Each circle is composed of six to eight cylindrical to slightly tapering processes that often join distally like the poles in a teepee. The archeopyle is apical (type tA) and the operculum is attached.

Occurrence in East Greenland. Only one specimen has been observed from the lower Aptian part of section 17.

Dinoflagellate cyst 4

Plate 30, Figs 4 & 5

Description. Dinoflagellate cyst 4 is a relatively small (central body 30 μ) chorate cyst with a rugulate surface. The processes are numerous (more than 50) and occur randomly. They are approximately 15 μ long, slightly tapering and multifurcate distally. The processes are proximally striate and the transition to the surface looks like the attachment of supporting roots. The archeopyle is apical but the precise type is not yet known.

Occurrence in East Greenland. Only one specimen has been observed from the lower Aptian part of section 17.

Plate 30

Fig. 1. Dinoflagellate cyst 2 × 500, section 30; GGU 324617–8, 21.1–130.2; MGUH 22039.

Fig. 2. Dinoflagellate cyst 3 × 800, note that the apparently apical archeopyle is situated to the left on the illustration, section 17; GGU 342169; MGUH 22040.

Fig. 3. Dinoflagellate cyst 3 × 1750, same specimen as above, close-up illustrating the granulate cyst surface and the process complexes that fusionate distally.

Fig. 4. Dinoflagellate cyst 4 × 750, section 17; GGU 342169; 22041 .

Fig. 5. Dinoflagellate cyst 4 × 1950, same specimen as above, close-up illustrating the verrucate cyst surface and the processes that furcate distally.

Fig. 6. *Plicatella insignis* × 500, section 30; GGU 324619–4, 19.8–124.2; MGUH 22042.

Fig. 7. *Costatoperforosporites* sp. × 500, section 30; GGU 324610–3, 8.0–138.3; MGUH 22043.

Fig. 8. Spore ? × 500, section 25; GGU 346440–5, 7.6–138.0; MGUH 22044.

Fig. 9. ?*Acanthotriletes varispinosus* × 500, section 30; GGU 324619–6, 7.2–125.0; MGUH 22045.

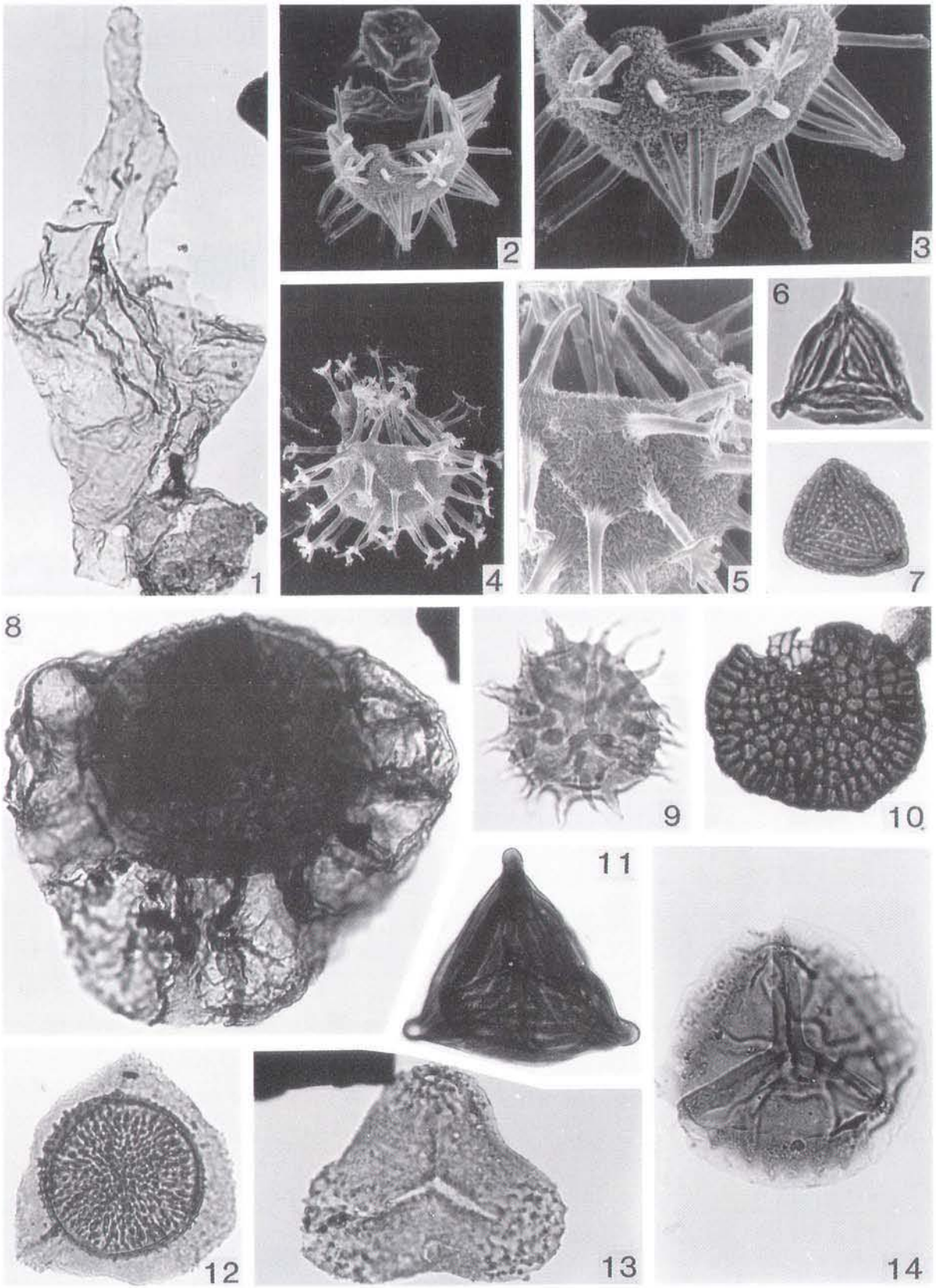
Fig. 10. *Tythodiscus* sp. × 500, section 30; GGU 324620–7, 18.1–152.0; MGUH 22046.

Fig. 11. *Plicatella concentrica* × 500, section 30; GGU 324610–3, 11.5–148.9; MGUH 22047.

Fig. 12. *Aequitriradites ornatus* × 500, section 30; GGU 324619–6, 10.5–154.1; MGUH 22048.

Fig. 13. *Trilobosporites apiverrucatus* × 500, section 30; GGU 324610–3, 11.8–129.0; MGUH 22049.

Fig. 14. Spore × 500, section 30; GGU 324619–6, 7.6–143.7; MGUH 22050.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Group Acritarcha Evitt, 1963

Schizocystia spp. is shown separately on the range charts. The remaining acritarchs have been grouped as Acritarcha (undifferentiated).

Occurrence in East Greenland. Barremian to Albian. Acritarchs have been recorded from 24 of the 40 examined sections.

Genus *Leiofusa* Eisenack, 1938
Leiofusa sp.
Plate 11, Fig. 9

Occurrence in East Greenland. In the middle to upper Albian. Sections 20, 23, 29, 30 and 31. The species often occurs in the lower part of the sections, but not consistently.

Genus *Schizocystia* Cookson & Eisenack, 1962a
Schizocystia spp.

Occurrence in East Greenland. Barremian to Albian. Sections 17, 20, 23, 24, 30, 31 and 38.

Prasinophycean algae

Genus *Pterospermella* (W. Wetzel, 1952)
Pterospermella cf. *P. australiensis* Deflandre & Cookson, 1955
Plate 29, Fig. 10

Occurrence in East Greenland. Barremian to Albian. Recorded from 18 of the 40 examined sections.

Genus *Ulvella* P. L. & H. M. Crouan, 1859
cf. *Ulvella nannae* Hansen, 1980
Plate 30, Fig. 10

Occurrence in East Greenland. Barremian to Albian. Sections 7, 21, 30 and 31 where the species is rare.

Miospores

Saccate pollen and trilete spores occur in very low numbers and have not been included in the range charts (Tables 1–40). Section 30 seems to have a slightly higher content of trilete spores than the rest of the sections. The following spore genera have kindly been identified by Eva B. Koppelhus from the middle upper Albian, section 30:

?*Acanthotriletes varispinosus* Pocock, 1962
Plate 30, Fig. 9

Aequitriradites ornatus Upshaw, 1963
Plate 30, Fig. 12

Genus *Costatoperforosporites* Deák, 1962
Costatoperforosporites sp.
Plate 30, Fig. 7

Plicatella concentrica (Kemp, 1970) Davies, 1985
Plate 30, Fig. 11

Plicatella insignis (Markova, 1961) Davies, 1985
Plate 30, Fig. 6

Trilobosporites apiverrucatus Couper, 1958
Plate 30, Fig. 13

Miscellaneous

?Hair from leaf
Plate 29, Fig. 11

Comments. Small, miscellaneous hair-like elements of antler-like shape.

Occurrence in East Greenland. Upper Barremian to lower Albian. Sections 6, 7, 14, 17 and 26 where it is very rare. This *Incertae sedis* has also been recorded from the upper Barremian, South Sabine section, Melville Island, Arctic Canada (samples kindly provided to me from I.S.P.G., Calgary, Canada).

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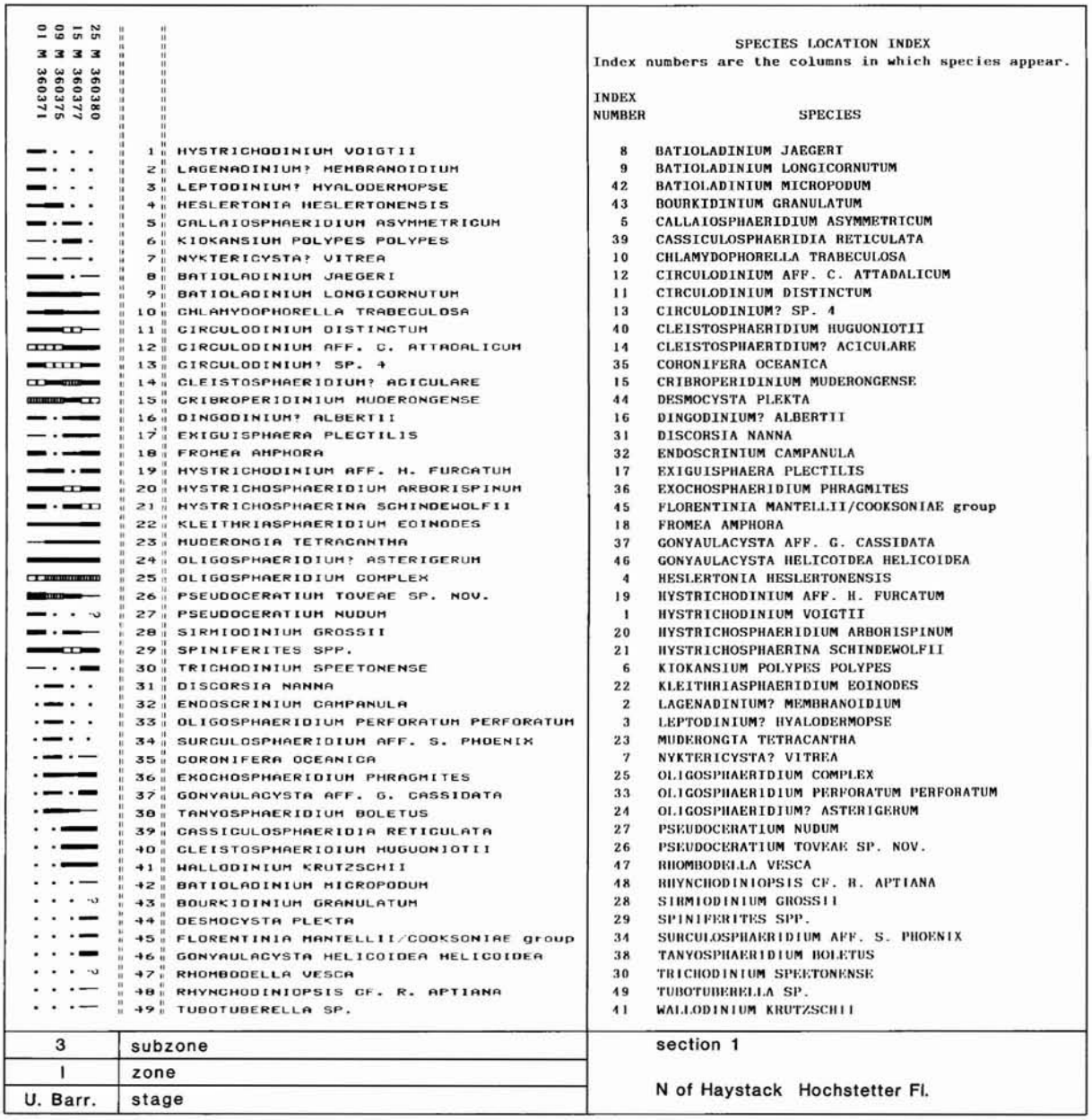
APPENDIX

Table 1. Sections yielding dinoflagellate cysts from North-East Greenland

Section	Location / Region	Latitude	Longitude	Thickness metres	Sample No. (GGU)
1	N of Haystack/ Hochstetter Forland	75°49′	19°40′	25	360371, 75, 77, 80
2	N of Kap Oswald Heer/ Hochstetter Forland	75°33′	19°23′	12	351550, 58
3	Sengstacke Bugt/N Shannon	75°19′	18°12′	1	351559
4	Sengstacke Bugt/N Shannon	75°20′	18°07′	1	279826
5	Kap David Gray/S Shannon	75°00′	18°28′	1	351565
6	Kap Maurer/N Kuhn Ø	74°51′	19°45′	43	342108, 9, 10. 11
7	'East coast'/Kuhn Ø	74°49′	19°47′	90	342079, 80, 81, 82, 83, 84, 85, 86, 87
8	'East coast'/Kuhn Ø	74°49′	19°48′	32	342072, 76, 78
9	'East coast'/Kuhn Ø	74°48′	19°48′	25	342069, 70, 71
10	'Perisphinctes-Ravine'/Kuhn Ø	74°48′	19°52′	26	342092, 93, 94
11	N of Kap Hamburg/S Kuhn Ø	74°45′	20°00′	100	342102, 3, 4, 5, 6, 7
12	SW of Kap Berlin/ Wollaston Forland	74°37′	19°37′	160	351589, 91, 92, 95, 98
13	SW of Kap Berlin/ Wollaston Forland	74°37′	19°37′	296	351573, 74, 75, 77, 78, 79, 80, 81, 85, 86, 87, 88
14	Palnatoke Bjerg/ Wollaston Forland	74°37′	20°38′	65	342131, 32, 33, 34, 35, 36
15	Rødryggen/Wollaston Fl.	74°31′	19°49′	10	351526, 27
16	Rødryggen/Wollaston Fl.	74°31′	19°49′	5	351512, 13
17	Aucellabjerget/ Wollaston Forland	74°31′	20°22′	120	342161, 62, 63, 64, 66, 67, 68, 69, 70, 72, 74
18	SE of Kuhnpasset/ Wollaston Forland	74°31′	20°08′	60	342218, 19, 20, 21, 22
19	N of Gyldenspids/ Wollaston Forland	74°30′	19°45′	40	342214, 15, 16, 17
20	Gyldenspids/Wollaston Fl.	74°29′	19°43′	470	342176, 79, 83, 85, 86, 87, 89, 91, 93, 94, 96, 99, 200, 201, 202
21	Stratumbjerget/ Wollaston Forland	74°27′	20°12′	107	342230, 31, 32, 34, 35, 36, 37, 38, 39, 40
22	Kontaktravine/Clavering Ø	74°35′	20°35′	147	346584, 88, 90, 92, 97
23	Langelinie/Clavering Ø	74°14′	20°35′	386	351669, 70, 71, 73, 76, 77, 80, 81, 82, 83, 84, 85, 86, 88
24	N Home Forland/ Hold with Hope	73°53′	20°40′	122	346451, 56, 58, 61, 62
25	N Home Forland/ Hold with Hope	73°53′	20°40′	105	345440, 42, 45, 50
26	Spaths Plateau	73°50′	21°14′	42	351627, 28, 29, 30
27	Tobias Dal/Hold w. Hope	73°44′	21°13′	1	351626
28	Lyngnaelv/Hold w. Hope	73°38′	20°28′	15	351636, 38
29	Tværdal/Geogr. Soc. Ø	72°57′	23°01′	1	342599
30	Tværdal/Georg. Soc. Ø	72°58′	23°02′	415	324619, 20, 06, 22, 07, 09, 10, 11, 13, 14, 15, 17, 18
31	Tværdal/Geogr. Soc. Ø	72°57′	23°04′	65	324623, 25, 27, 30
32	Shallow bore, Rold Bjerge/ Traill Ø	72°46′	23°05′	23	303122–1, –3, –5
33	Rold Bjerge/Traill Ø	72°45′	23°03′	32	324029, 32
34	Månedal/Traill Ø	72°41′	23°03′	10	324556, 57
35	SE of Rold Bjerge/Traill Ø	72°24′	23°15′	5	324507, 10
36	Svinhufvud Bjerge/Traill Ø	72°26′	23°11′	75	324092, 93, 95, 90, 98
37	Svinhufvud Bjerge/Traill Ø	72°24′	23°10′	220	324648, 49, 50, 51, 52, 53, 54, 55
38	Shallow bore, Svinhuf-vud Bjerge/Traill Ø	72°24′	23°10′	46	303127–1, –9, –15
39	Svinhufvud Bjerge/Traill Ø	72°25′	23°18′	5	335320, 21
40	Shallow bore, Svinhuf-vud Bjerge/Traill Ø	72°24′	23°21′	24	303125–1, –4, –7

Table 2. Range charts of distribution and abundances of dinoflagellate cysts from North-East Greenland

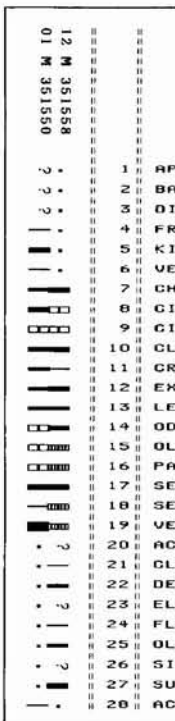
The relative thickness of each section and the sample position is given in metres to the left of each GGU sample number. The thickness for the three sections representing shallow wells are calculated from surface downwards. The abundances are arranged on basis of first occurrences. A question mark indicates that the presence of the species is questionable. The relative abundances of each species is based on counting of more 300 specimens from each sample, except for a few almost barren samples. Percentages are based on the counting. Species not identified normally constitute 5 to 10 percent of the assemblages. This group is not illustrated on the range chart but is included in the counts. Miospores have not been counted or included in the range charts. The occurrence of other palynomorphs, miscellaneous and dinoflagellate cysts considered as reworked are listed last in the range charts.
Key to symbols at end.



SPECIES LOCATION INDEX
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
8	BATIOLADINIUM JAEGERI
9	BATIOLADINIUM LONGICORNUTUM
42	BATIOLADINIUM MICROPODUM
43	BOURKIDINIUM GRANULATUM
5	CALLAIOSPHAERIDIUM ASYMMETRICUM
39	CASSICULOSPHAERIDIA RETICULATA
10	CHLAMYDOPHORELLA TRABECULOSA
12	CIRCULODINIUM AFF. C. ATTADALICUM
11	CIRCULODINIUM DISTINCTUM
13	CIRCULODINIUM? SP. 4
40	CLEISTOSPHAERIDIUM HUGUONIOTII
14	CLEISTOSPHAERIDIUM? ACICULARE
35	CORONIFERA OCEANICA
15	CRIBROPERIDINIUM MUDERONGENSE
44	DESMOCYSTA PLEKTA
16	DINGODINIUM? ALBERTII
31	DISCORSIA NANNA
32	ENDOSCRINIUM CAMPANULA
17	EXIGUISPHAERA PLECTILIS
36	EXOCHOSPHAERIDIUM PHRAGMITES
45	FLORENTINIA MANTELLII/COOKSONIAE group
18	FROMEA AMPHORA
37	GONYAULACYSTA AFF. G. CASSIDATA
46	GONYAULACYSTA HELICOIDEA HELICOIDEA
4	HESLERTONIA HESLERTONENSIS
19	HYSTRICHODINIUM AFF. H. FURCATUM
1	HYSTRICHODINIUM VOIGTII
20	HYSTRICHOSPHAERIDIUM ARBORISPINUM
21	HYSTRICHOSPHAERINA SCHINDEWOLFII
6	KIOKANSIUM POLYPES POLYPES
22	KLEITHRIASPHAERIDIUM EOINODES
2	LAGENADINIUM? MEMBRANOIDIUM
3	LEPTODINIUM? HYALODERMOPSE
23	MUDERONGIA TETRACANTHA
7	NYKTERICYSTA? VITREA
25	OLIGOSPHAERIDIUM COMPLEX
33	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
24	OLIGOSPHAERIDIUM? ASTERIGERUM
27	PSEUDOCERATIUM NUDUM
26	PSEUDOCERATIUM TOVEAE SP. NOV.
47	RHOMBODELLA VESCA
48	RHYNCHODINIOPSIS CF. R. APTIANA
28	SIRMIODINIUM GROSSII
29	SPINIFERITES SPP.
34	SURCULOSPHAERIDIUM AFF. S. PHOENIX
38	TANYOSPHAERIDIUM BOLETUS
30	TRICHODINIUM SPEETONENSE
49	TUBOTUBERELLA SP.
41	WALLODINIUM KRUTZSCHII

3	subzone	section 1
I	zone	N of Haystack Hochstetter Fl.
U. Barr.	stage	



SPECIES LOCATION INDEX

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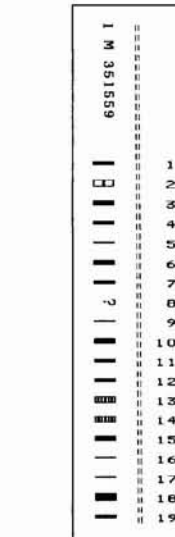
INDEX NUMBER	SPECIES
20	ACHOMOSPHAERA? NEPTUNI
28	ACRITARCH
1	APTEODINIUM CF. A. GRANDE
2	BATIOLADINIUM MICROPODUM
7	CHLAMYDOPHORELLA TRABECULOSA
8	CIRCULODINIUM BREVISPINOSUM
9	CIRCULODINIUM DISTINCTUM
21	CLEISTOSPHAERIDIUM HUGUONIOTII
10	CLEISTOSPHAERIDIUM? ACICULARE
11	CRIBROPERIDINIUM EDWARDSII
22	DESMOCYSTA PLEKTA
3	DISCORSIA NANNA
23	ELLIPSOIDICTYUM IMPERFECTUM
12	EXOCHOSPHAERIDIUM PHRAGMITES
24	FLORENTINIA MANTELLII/COOKSONIAE group
4	FROMEA AMPHORA
5	KIOKANSIUM POLYPES POLYPES
13	LEVISPHAERA CF. L. CRASSICINGULATA
14	ODONTOCHITINA OPERCULATA
25	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
15	OLIGOSPHAERIDIUM COMPLEX
16	PALAEOPERIDINIUM CRETACEUM
17	SENTUSIDINIUM SP. 1
18	SENTUSIDINIUM SP. 2
26	SIRMIODINIUM GROSSII
27	SURCULOSPHAERIDIUM AFF. S. PHOENIX
19	VESPERIOPSIS LONGICORNIS
6	VESPEROPSIS MAYI

4	subzone
III	zone
L.Alb.	stage

section 2

N of Kap Oswald Heer Hochstetter Fl.



SPECIES LOCATION INDEX

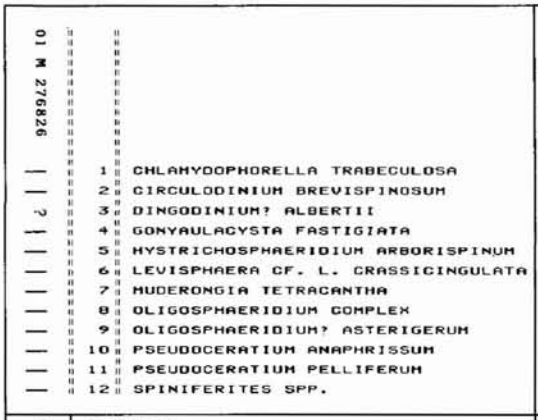
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
1	ACHOMOSPHAERA? NEPTUNI
2	CHLAMYDOPHORELLA TRABECULOSA
3	CIRCULODINIUM AFF. C. ATTADALICUM
4	CIRCULODINIUM DISTINCTUM
5	CLEISTOSPHAERIDIUM HUGUONIOTII
6	CLEISTOSPHAERIDIUM? ACICULARE
7	DINGODINIUM? ALBERTII
8	ELLIPSOIDICTYUM IMPERFECTUM
9	HESLERTONIA HESLERTONENSIS
10	KIOKANSIUM POLYPES POLYPES
11	LEVISPHAERA CF. L. CRASSICINGULATA
12	ODONTOCHITINA OPERCULATA
13	OLIGOSPHAERIDIUM COMPLEX
14	PALAEOPERIDINIUM CRETACEUM
15	SENTUSIDINIUM SP. 1
16	SENTUSIDINIUM SP. 2
17	SPINIFERITES SPP.
18	VESPEROPSIS LONGICORNIS
19	WALLODINIUM KRUTZSCHII

1	subzone
III	zone
L.Apt.	stage

section 3

Sengstacke Bugt N Shannon



SPECIES LOCATION INDEX
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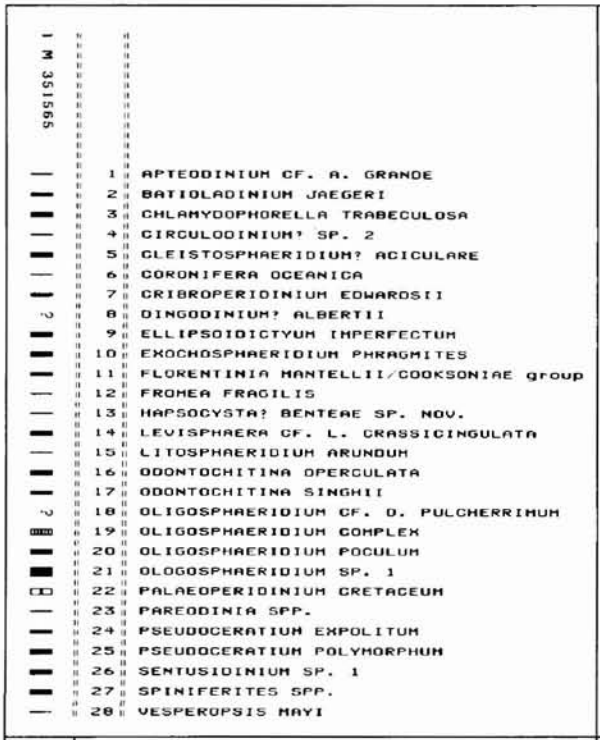
INDEX NUMBER	SPECIES
1	CHLAMYDOPHORELLA TRABECULOSA
2	CIRCULODINIUM BREVISPINOSUM
3	DINGODINIUM? ALBERTII
4	GONYAULACYSTA FASTIGIATA
5	HYSTRICHOSPHAERIDIUM ARBORISPINUM
6	LEVISPHAERA CF. L. CRASSICINGULATA
7	MUDERONGIA TETRACANTHA
8	OLIGOSPHAERIDIUM COMPLEX
9	OLIGOSPHAERIDIUM? ASTERIGERUM
10	PSEUDOCERATIUM ANAPHRISSUM
11	PSEUDOCERATIUM PELLIFERUM
12	SPINIFERITES SPP.

2	subzone
I	zone
L.Bar.	stage

section 4

Sengstacke Bugt N Shannon



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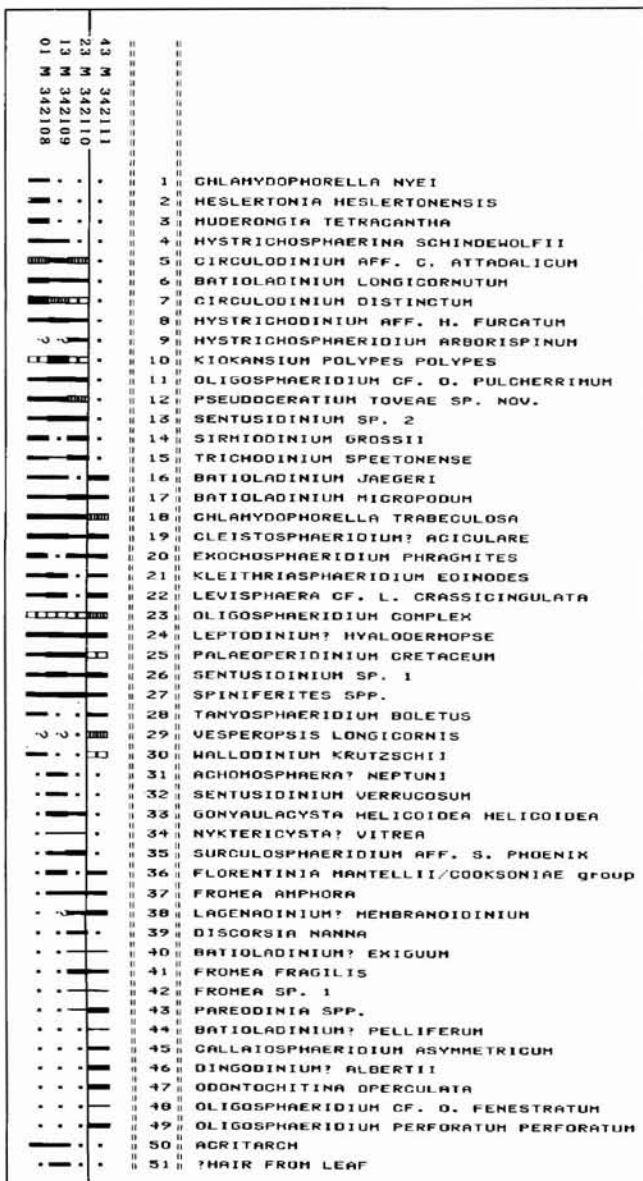
4	CIRCULODINIUM? SP. 2
5	CLEISTOSPHAERIDIUM? ACICULARE
6	CORONIFERA OCEANICA
7	CRIBROPERIDINIUM EDWARDSII
8	DINGODINIUM? ALBERTII
9	ELLIPSOIDICTYUM IMPERFECTUM
10	EXOCHOSPHAERIDIUM PHRAGMITES
11	FLORENTINIA MANTELLII/COOKSONIAE group
12	FROMEA FRAGILIS
13	HAPSOCYSTA? BENTEAE SP. NOV.
14	LEVISPHAERA CF. L. CRASSICINGULATA
15	LITOSPHAERIDIUM ARUNDUM
16	ODONTOCHITINA OPERCULATA
17	ODONTOCHITINA SINGHII
18	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
19	OLIGOSPHAERIDIUM COMPLEX
20	OLIGOSPHAERIDIUM POCULUM
21	OLOGOSPHAERIDIUM SP. 1
22	PALAEOPERIDINIUM CRETACEUM
23	PAREODINIA SPP.
24	PSEUDOCERATIUM EXPOLITUM
25	PSEUDOCERATIUM POLYMORPHUM
26	SENTUSIDINIUM SP. 1
27	SPINIFERITES SPP.
28	VESPEROPSIS MAYI

1	subzone
IV	zone
M.Alb.	stage

section 5

Kap David Gray S. Shannon



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51	?HAIR FROM LEAF
31	ACHOMOSPHAERA? NEPTUNI
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6	BATIOLADINIUM LONGICORNUTUM
17	BATIOLADINIUM MICROPODUM
40	BATIOLADINIUM? EXIGUUM
44	BATIOLADINIUM? PELLIFERUM
45	CALLAIOSPHAERIDIUM ASYMMETRICUM
1	CHLAMYDOPHORELLA NYEI
18	CHLAMYDOPHORELLA TRABECULOSA
5	CIRCULODINIUM AFF. C. ATTADALICUM
7	CIRCULODINIUM DISTINCTUM
19	CLEISTOSPHAERIDIUM? ACICULARE
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41	FROMEA FRAGILIS
42	FROMEA SP. 1
33	GONYAULACYSTA HELICOIDEA HELICOIDEA
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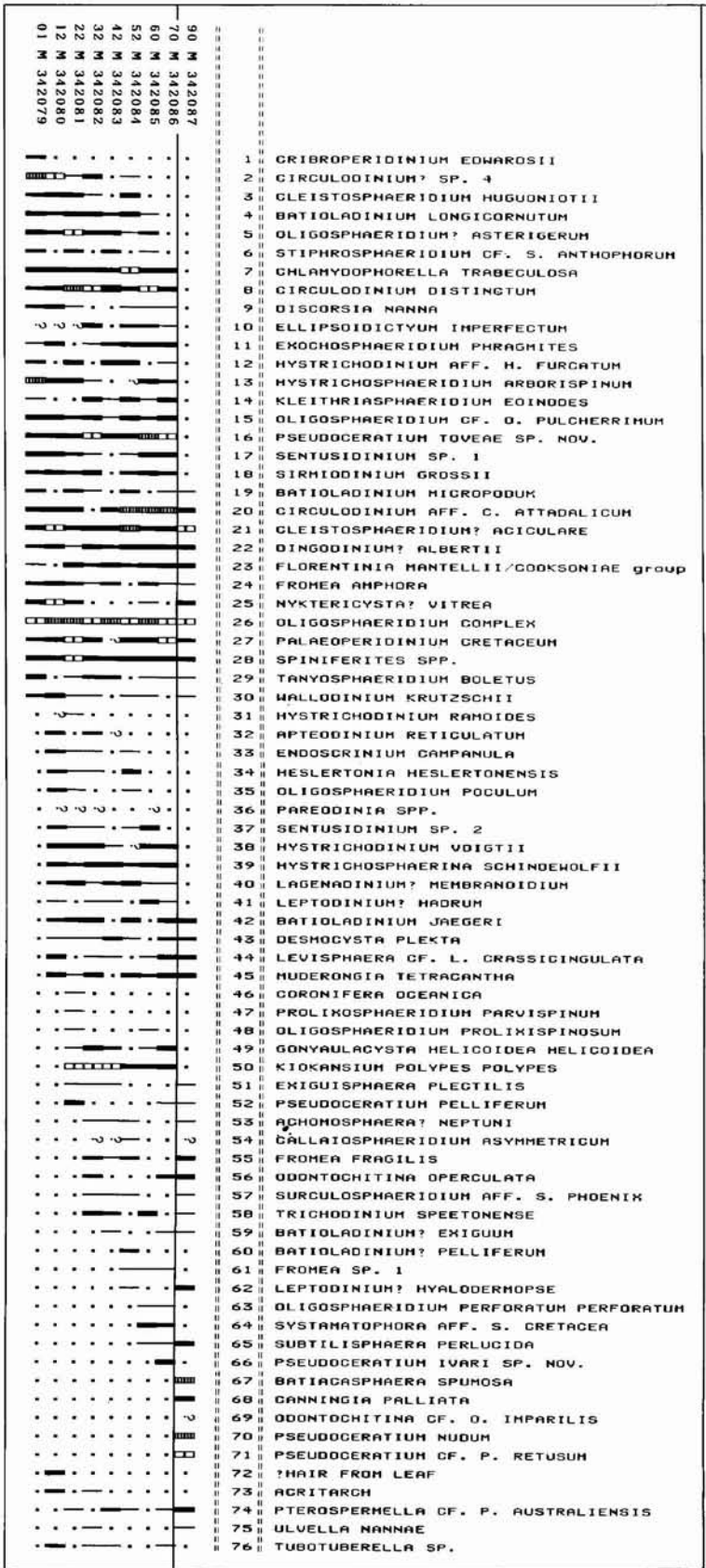
4	HYSTRICHOSPHAERINA SCHINDEWOLFII
10	KIOKANSIUM POLYPES POLYPES
21	KLEITHRIASPHAERIDIUM EOINODES
38	LAGENADINIUM? MEMBRANOIDINIUM
24	LEPTODINIUM? HYALODERMOPSE
22	LEVISPHAERA CF. L. CRASSICINGULATA
3	MUDERONGIA TETRACANTHA
34	NYKTERICYSTA? VITREA
47	ODONTOCHITINA OPERCULATA
48	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
11	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
23	OLIGOSPHAERIDIUM COMPLEX
49	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
25	PALAEOPERIDINIUM CRETACEUM
43	PAREODINIA SPP.
12	PSEUDOCERATIUM TOVEAE SP. NOV.
26	SENTUSIDINIUM SP. 1
13	SENTUSIDINIUM SP. 2
32	SENTUSIDINIUM VERRUCOSUM
14	SIRMIODINIUM GROSSII
27	SPINIFERITES SPP.
35	SURCULOSPHAERIDIUM AFF. S. PHOENIX
28	TANYOSPHAERIDIUM BOLETUS
15	TRICHODINIUM SPEETONENSE
29	*VESPEROPSIS LONGICORNIS*
30	WALLODINIUM KRUTZSCHII

section 6

Kap Maurer N Kuhn Ø



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67	BATIACASPHAERA SPUMOSA
42	BATIOLADINIUM JAEGERI
4	BATIOLADINIUM LONGICORNUTUM
19	BATIOLADINIUM MICROPODUM
59	BATIOLADINIUM? EXIGUUM
60	BATIOLADINIUM? PELLIFERUM
54	CALLAIOSPHAERIDIUM ASYMMETRICUM
68	CANNINGIA PALLIATA
7	CHLAMYDOPHORELLA TRABECULOSA
20	CIRCULODINIUM AFF. C. ATTADALICUM
8	CIRCULODINIUM DISTINCTUM
2	CIRCULODINIUM? SP. 4
3	CLEISTOSPHAERIDIUM HUGUONIOTII
21	CLEISTOSPHAERIDIUM? ACICULARE
46	CORONIFERA OCEANICA
1	CRIBROPERIDINIUM EDWARDSII
43	DESMOCYSTA PLEKTA
22	DINGODINIUM? ALBERTII
9	DISCORSIA NANNA
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49	GONYAULACYSTA HELICOIDEA HELICOIDEA
34	HESLERTONIA HESLERTONENSIS
12	HYSTRICHODINIUM AFF. H. FURCATUM
31	HYSTRICHODINIUM RAMOIDES
38	HYSTRICHODINIUM VOIGTII
13	HYSTRICHOSPHAERIDIUM ARBORISPINUM
39	HYSTRICHOSPHAERINA SCHINDEWOLFII
50	KIOKANSIUM POLYPES POLYPES
14	KLEITHRIASPHAERIDIUM EOINODES
40	LAGENADINIUM? MEMBRANOIDIUM
41	LEPTODINIUM? HADRUM
62	LEPTODINIUM? HYALODERMOPSE
44	LEVISPHAERA CF. L. CRASSICINGULATA
45	MUDERONGIA TETRACANTHA
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69	ODONTOCHITINA CF. O. IMPARILIS
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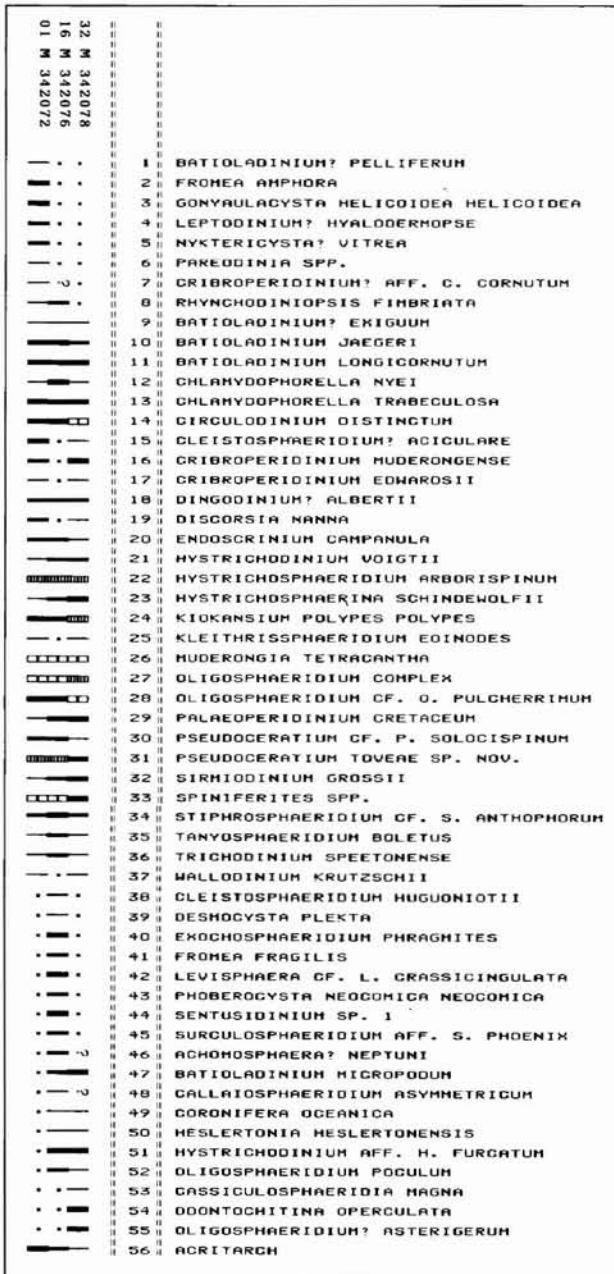
15	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
26	OLIGOSPHAERIDIUM COMPLEX
63	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
35	OLIGOSPHAERIDIUM POCULUM
48	OLIGOSPHAERIDIUM PROLIXISPINOSUM
5	OLIGOSPHAERIDIUM? ASTERIGERUM
27	PALAEOPERIDINIUM CRETACEUM
36	PAREODINIA SPP.
47	PROLIXOSPHAERIDIUM PARVISPINUM
71	PSEUDOCERATIUM CF. P. RETUSUM
66	PSEUDOCERATIUM IVARI SP. NOV.
70	PSEUDOCERATIUM NUDUM
52	PSEUDOCERATIUM PELLIFERUM
16	PSEUDOCERATIUM TOVEAE SP. NOV.
74	PTEROSPERMELLA CF. P. AUSTRALIENSIS
17	SENTUSIDINIUM SP. 1
37	SENTUSIDINIUM SP. 2
18	SIRMIODINIUM GROSSII
28	SPINIFERITES SPP.
6	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
65	SUBTILISPHAERA PERLUCIDA
57	SURCULOSPHAERIDIUM AFF. S. PHOENIX
64	SYSTAMATOPHORA AFF. S. CRETACEA
29	TANYOSPHAERIDIUM BOLETUS
58	TRICHODINIUM SPEETONENSE
76	TUBOTUBERELLA SP.
75	ULVELLA NANNAE
30	WALLODINIUM KRUTZSCHII

3		subzone
I	II	zones
U. Barremian	L.Ap.	stages

section 7

"East coast" Kuhn Ø



SPECIES LOCATION INDEX

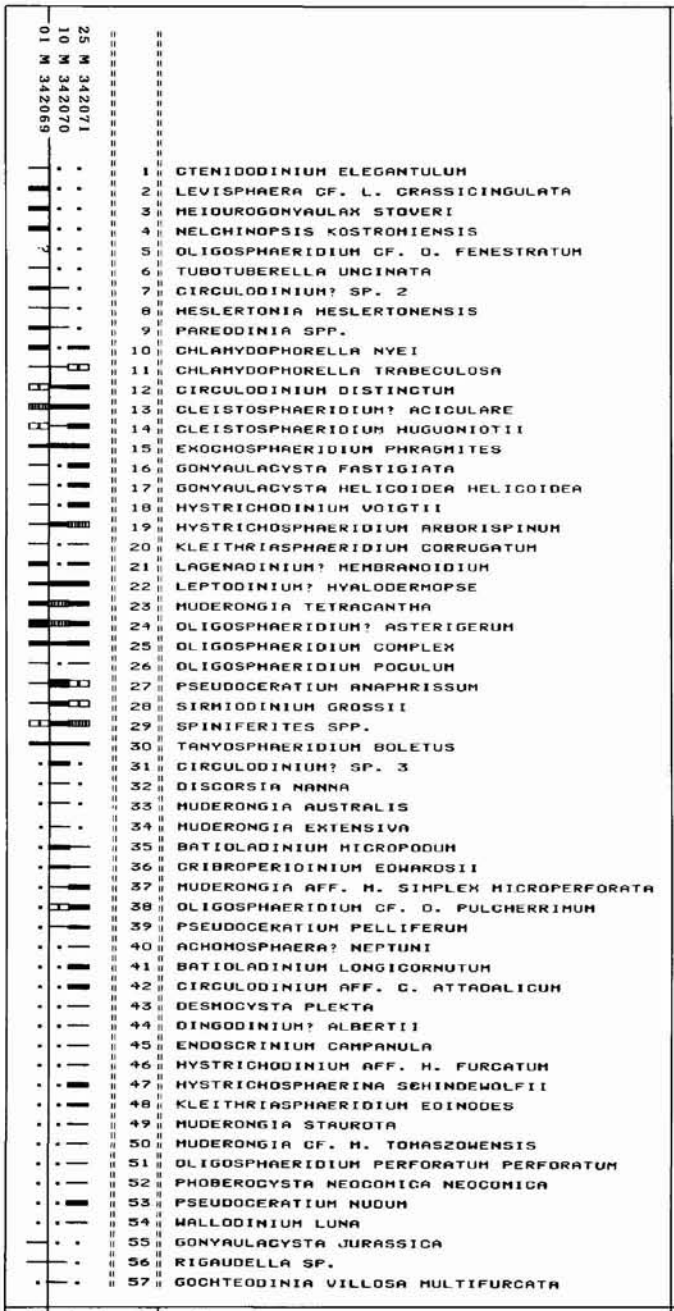
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
46	ACHOMOSPHAERA? NEPTUNI
56	ACRITARCH
10	BATIOLADINIUM JAEGERI
11	BATIOLADINIUM LONGICORNUTUM
47	BATIOLADINIUM MICROPODUM
9	BATIOLADINIUM? EXIGUUM
1	BATIOLADINIUM? PELLIFERUM
48	CALLAIOSPHAERIDIUM ASYMMETRICUM
53	CASSICULOSPHAERIDIA MAGNA
12	CHLAMYDOPHORELLA NYEI
13	CHLAMYDOPHORELLA TRABECULOSA
14	CIRCULODINIUM DISTINCTUM
38	CLEISTOSPHAERIDIUM HUGUONIOTII
15	CLEISTOSPHAERIDIUM? ACICULARE
49	CORONIFERA OCEANICA
17	CRIBROPERIDINIUM EDWARDSII
16	CRIBROPERIDINIUM MUDERONGENSE
7	CRIBROPERIDINIUM? AFF. C. CORNUTUM
39	DESMOCYSTA PLEKTA
18	DINGODINIUM? ALBERTII
19	DISCORSIA NANNA
20	ENDOSCRINIUM CAMPANULA
40	EXOCHOSPHAERIDIUM PHRAGMITES
2	FROMEA AMPHORA
41	FROMEA FRAGILIS
3	GONYAULACYSTA HELICOIDEA HELICOIDEA
50	HESLERTONIA HESLERTONENSIS
51	HYSTRICHODINIUM AFF. H. FURCATUM
21	HYSTRICHODINIUM VOIGTII
22	HYSTRICHOSPHAERIDIUM ARBORISPINUM
23	HYSTRICHOSPHAERINA SCHINDEWOLFII
24	KIOKANSIUM POLYPES POLYPES
25	KLEITHRISSPHAERIDIUM EOINODES
4	LEPTODINIUM? HYALODERMOPSE
42	LEVISPHAERA CF. L. CRASSICINGULATA
26	MUDERONGIA TETRACANTHA
5	NYKTERICYSTA? VITREA
54	ODONTOCHITINA OPERCULATA
28	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
27	OLIGOSPHAERIDIUM COMPLEX
52	OLIGOSPHAERIDIUM POCULUM
55	OLIGOSPHAERIDIUM? ASTERIGERUM
29	PALAEOPERIDINIUM CRETACEUM
6	PAREODINIA SPP.
43	PHOBEROCYSTA NEOCOMICA NEOCOMICA
30	PSEUDOCERATIUM CF. P. SOLOCISPINUM
31	PSEUDOCERATIUM TOVEAE SP. NOV.
8	RHYNCHODINIOPSIS FIMBRIATA
44	SENTUSIDINIUM SP. 1
32	SIRMIODINIUM GROSSII
33	SPINIFERITES SPP.
34	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
45	SURCULOSPHAERIDIUM AFF. S. PHOENIX
35	TANYOSPHAERIDIUM BOLETUS
36	TRICHODINIUM SPEETONENSE
37	WALLODINIUM KRUTZSCHII

3	subzone
I	zone
U.Barr.	stage

section 8

"East coast" Kuhn Ø



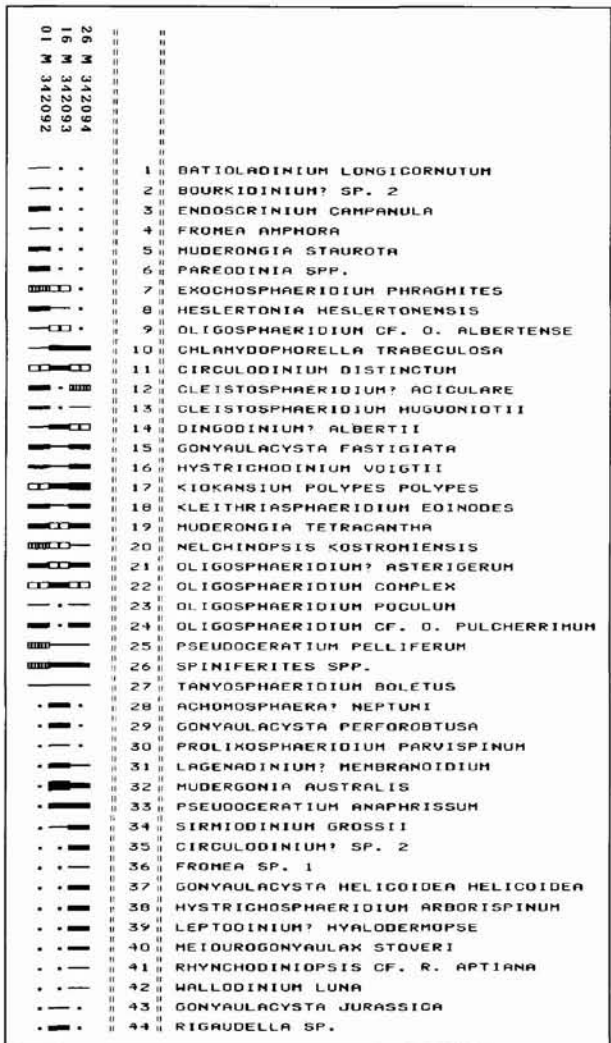
SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
40	ACHOMOSPHAERA? NEPTUNI
41	BATIOLADINIUM LONGICORNUTUM
35	BATIOLADINIUM MICROPODUM
10	CHLAMYDOPHORELLA NYEI
11	CHLAMYDOPHORELLA TRABECULOSA
42	CIRCULODINIUM AFF. C. ATTADALICUM
12	CIRCULODINIUM DISTINCTUM
7	CIRCULODINIUM? SP. 2
31	CIRCULODINIUM? SP. 3
14	CLEISTOSPHAERIDIUM HUGUONIOTII
13	CLEISTOSPHAERIDIUM? ACICULARE
36	CRIBROPERIDINIUM EDWARDSII
1	CTENIDODINIUM ELEGANTULUM
43	DESMOCYSTA PLEKTA
44	DINGODINIUM? ALBERTII
32	DISCORSIA NANNA
45	ENDOSCRINIUM CAMPANULA
15	EXOCHOSPHAERIDIUM PHRAGMITES
57	GOCHTEODINIA VILLOSA MULTIFURCATA
16	GONYAULACYSTA FASTIGIATA
17	GONYAULACYSTA HELICOIDEA HELICOIDEA
55	GONYAULACYSTA JURASSICA
8	HESLERTONIA HESLERTONENSIS
46	HYSTRICHODINIUM AFF. H. FURCATUM
18	HYSTRICHODINIUM VOIGTII
19	HYSTRICHOSPHAERIDIUM ARBORISPINUM
47	HYSTRICHOSPHAERINA SCHINDEWOLFII
20	KLEITHRIASPHAERIDIUM CORRUGATUM
48	KLEITHRIASPHAERIDIUM EOINODES
21	LAGENADINIUM? MEMBRANOIDIUM
22	LEPTODINIUM? HYALODERMOPSE
2	LEVISPHAERA CF. L. CRASSICINGULATA
3	MEIOUROGONYAULAX STOVERI
37	MUDERONGIA AFF. M. SIMPLEX MICROPERFORATA
33	MUDERONGIA AUSTRALIS
50	MUDERONGIA CF. M. TOMASZOWENSIS
34	MUDERONGIA EXTENSIVA
49	MUDERONGIA STAUROTA
23	MUDERONGIA TETRACANTHA
4	NELCHINOPSIS KOSTROMIENSIS
5	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
38	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
25	OLIGOSPHAERIDIUM COMPLEX
51	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
26	OLIGOSPHAERIDIUM POCULUM
24	OLIGOSPHAERIDIUM? ASTERIGERUM
9	PAREODINIA SPP.
52	PHOBEROCYSTA NEOCOMICA NEOCOMICA
27	PSEUDOCERATIUM ANAPHRISSUM
53	PSEUDOCERATIUM NUDUM
39	PSEUDOCERATIUM PELLIFERUM
56	RIGAUDELLA SP.
28	SIRMIODINIUM GROSSII
29	SPINIFERITES SPP.
30	TANYOSPHAERIDIUM BOLETUS
6	TUBOTUBERELLA UNCINATA
54	WALLODINIUM LUNA

section 9

"East coast" Kuhn Ø



SPECIES LOCATION INDEX

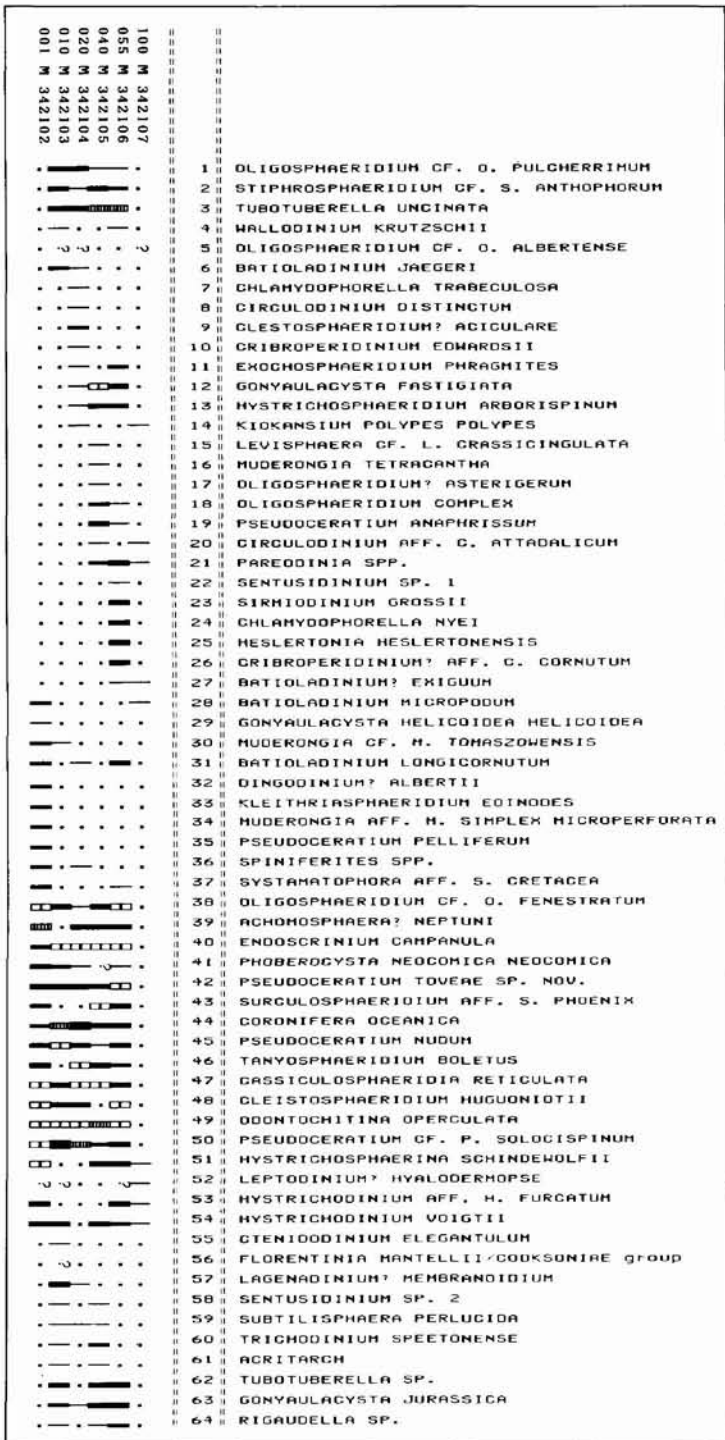
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
28	ACHOMOSPHAERA? NEPTUNI
1	BATIOLADINIUM LONGICORNUTUM
2	BOURKIDINIUM? SP. 2
10	CHLAMYDOPHORELLA TRABECULOSA
11	CIRCULODINIUM DISTINCTUM
35	CIRCULODINIUM? SP. 2
13	CLEISTOSPHAERIDIUM HUGUONIOTII
12	CLEISTOSPHAERIDIUM? ACICULARE
14	DINGODINIUM? ALBERTII
3	ENDOSCRINIUM CAMPANULA
7	EXOCHOSPHAERIDIUM PHRAGMITES
4	FROMEA AMPHORA
36	FROMEA SP. 1
15	GONYAULACYSTA FASTIGIATA
37	GONYAULACYSTA HELICOIDEA HELICOIDEA
43	GONYAULACYSTA JURASSICA
29	GONYAULACYSTA PERFOROBTUSA
8	HESLERTONIA HESLERTONENSIS
16	HYSTRICHODINIUM VOIGTII
38	HYSTRICHOSPHAERIDIUM ARBORISPINUM
17	KIOKANSIUM POLYPES POLYPES
18	KLEITHRIASPHAERIDIUM EOINODES
31	LAGENADINIUM? MEMBRANOIDIUM
39	LEPTODINIUM? HYALODERMOPSE
40	MEIOUROGONYAULAX STOVERI
32	MUDERGONIA AUSTRALIS
5	MUDERONGIA STAUROTA
19	MUDERONGIA TETRACANTHA
20	NELCHINOPSIS KOSTROMIENSIS
9	OLIGOSPHAERIDIUM CF. O. ALBERTENSE
24	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
22	OLIGOSPHAERIDIUM COMPLEX
23	OLIGOSPHAERIDIUM POCULUM
21	OLIGOSPHAERIDIUM? ASTERIGERUM
6	PAREODINIA SPP.
30	PROLIXOSPHAERIDIUM PARVISPINUM
33	PSEUDOCERATIUM ANAPHRISSUM
25	PSEUDOCERATIUM PELLIFERUM
41	RHYNCHODINIOPSIS CF. R. APTIANA
44	RIGAUDELLA SP.
34	SIRMIODINIUM GROSSII
26	SPINIFERITES SPP.
27	TANYOSPHAERIDIUM BOLETUS
42	WALLODINIUM LUNA

1	subzone
I	zone
L.Barr.	stage

section 10

"Perisphinctes-Ravine" Kuhn Ø



SPECIES LOCATION INDEX

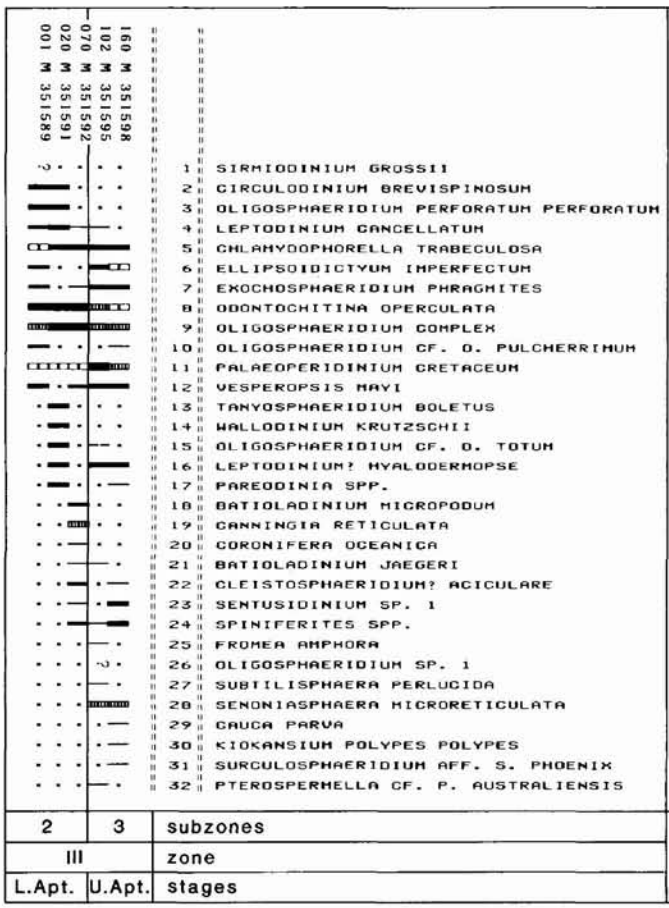
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
39	ACHOMOSPHAERA? NEPTUNI
61	ACRITARCH
6	BATIOLADINIUM JAEGERI
31	BATIOLADINIUM LONGICORNUTUM
28	BATIOLADINIUM MICROPODUM
27	BATIOLADINIUM? EXIGUUM
47	CASSICULOSPHAERIDIA RETICULATA
24	CHLAMYDOPHORELLA NYEI
7	CHLAMYDOPHORELLA TRABECULOSA
20	CIRCULODINIUM AFF. C. ATTADALICUM
8	CIRCULODINIUM DISTINCTUM
48	CLEISTOSPHAERIDIUM HUGUONIOTII
9	CLESTOSPHAERIDIUM? ACICULARE
44	CORONIFERA OCEANICA
10	CRIBROPERIDINIUM EDWARDSII
26	CRIBROPERIDINIUM? AFF. C. CORNUTUM
55	CTENIDODINIUM ELEGANTULUM
32	DINGODINIUM? ALBERTII
40	ENDOSCRINIUM CAMPANULA
11	EXOCHOSPHAERIDIUM PHRAGMITES
56	FLORENTINIA MANTELLII/COOKSONIAE group
12	GONYAULACYSTA FASTIGIATA
29	GONYAULACYSTA HELICOIDEA HELICOIDEA
63	GONYAULACYSTA JURASSICA
25	HESLERTONIA HESLERTONENSIS
53	HYSTRICHODINIUM AFF. H. FURCATUM
54	HYSTRICHODINIUM VOIGTII
13	HYSTRICHOSPHAERIDIUM ARBORISPINUM
51	HYSTRICHOSPHAERINA SCHINDEWOLFII
14	KIOKANSIUM POLYPES POLYPES
33	KLEITHRIASPHAERIDIUM EOINODES
57	LAGENADINIUM? MEMBRANOIDIUM
52	LEPTODINIUM? HYALODERMOPSE
15	LEVISPHAERA CF. L. CRASSICINGULATA
34	MUDERONGIA AFF. M. SIMPLEX MICROPERFORATA
30	MUDERONGIA CF. M. TOMASZOWENSIS
16	MUDERONGIA TETRACANTHA
49	ODONTOCHITINA OPERCULATA
5	OLIGOSPHAERIDIUM CF. O. ALBERTENSE
38	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
1	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
18	OLIGOSPHAERIDIUM COMPLEX
17	OLIGOSPHAERIDIUM? ASTERIGERUM
21	PAREODINIA SPP.
41	PHOBEROCYSTA NEOCOMICA NEOCOMICA
19	PSEUDOCERATIUM ANAPHRISSUM
50	PSEUDOCERATIUM CF. P. SOLOCISPINUM
45	PSEUDOCERATIUM NUDUM
35	PSEUDOCERATIUM PELLIFERUM
42	PSEUDOCERATIUM TOVEAE SP. NOV.
64	RIGAUDELLA SP.
22	SENTUSIDINIUM SP. 1
58	SENTUSIDINIUM SP. 2
23	SIRMIODINIUM GROSSII
36	SPINIFERITES SPP.
2	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
59	SUBTILISPHAERA PERLUCIDA
43	SURCULOSPHAERIDIUM AFF. S. PHOENIX
37	SYSTAMATOPHORA AFF. S. CRETACEA
46	TANYOSPHAERIDIUM BOLETUS
60	TRICHODINIUM SPEETONENSE
62	TUBOTUBERELLA SP.
3	TUBOTUBERELLA UNCINATA
4	WALLODINIUM KRUTZSCHII

2	subzone
I	zone
L.Barremian	stage

section 11

N of Kap Hamburg Kuhn Ø



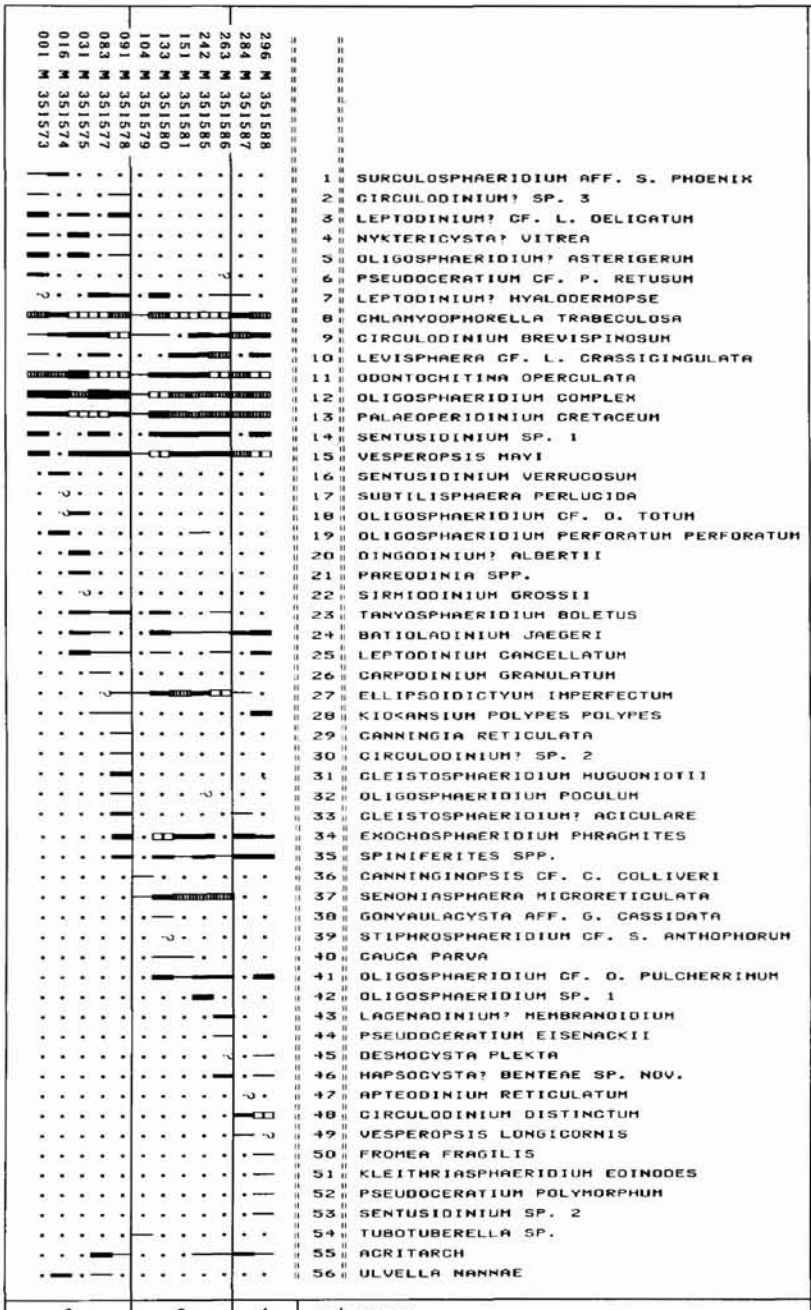
SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
21	BATIOLADINIUM JAEGERI
18	BATIOLADINIUM MICROPODUM
19	CANNINGIA RETICULATA
29	CAUCA PARVA
5	CHLAMYDOPHORELLA TRABECULOSA
2	CIRCULODINIUM BREVISPINOSUM
22	CLEISTOSPHAERIDIUM? ACICULARE
20	CORONIFERA OCEANICA
6	ELLIPSOIDICTYUM IMPERFECTUM
7	EXOCHOSPHAERIDIUM PHRAGMITES
25	FROMEA AMPHORA
30	KIOKANSIUM POLYPES POLYPES
4	LEPTODINIUM CANCELLATUM
16	LEPTODINIUM? HYALODERMOPSE
8	ODONTOCHITINA OPERCULATA
10	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
15	OLIGOSPHAERIDIUM CF. O. TOTUM
9	OLIGOSPHAERIDIUM COMPLEX
3	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
26	OLIGOSPHAERIDIUM SP. 1
11	PALAEOPERIDINIUM CRETACEUM
17	PAREODINIA SPP.
32	PTEROSPERMELLA CF. P. AUSTRALIENSIS
28	SENONIASPHAERA MICRORETICULATA
23	SENTUSIDINIUM SP. 1
1	SIRMIODINIUM GROSSII
24	SPINIFERITES SPP.
27	SUBTILISPHAERA PERLUCIDA
31	SURCULOSPHAERIDIUM AFF. S. PHOENIX
13	TANYOSPHAERIDIUM BOLETUS
12	VESPEROPSIS MAYI
14	WALLODINIUM KRUTZSCHII

section 12

SW of Kap Berlin Wollaston Fl.



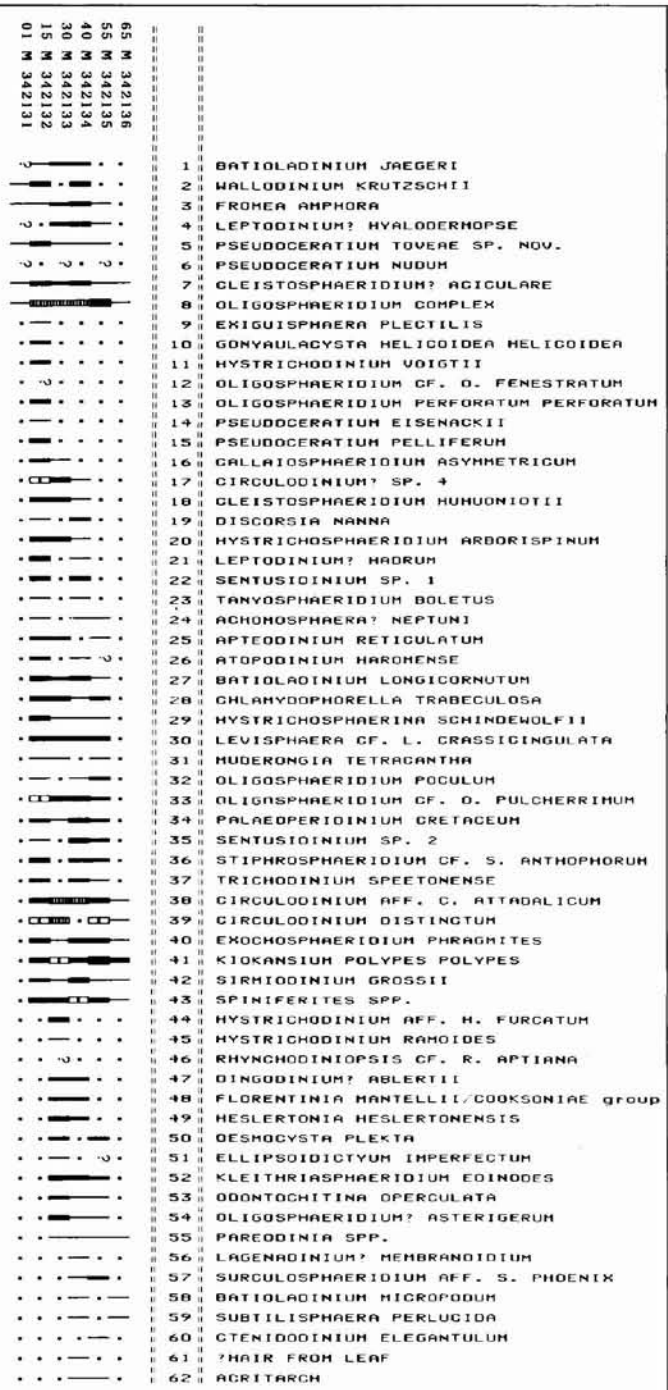
SPECIES LOCATION INDEX

Index numbers are the columns in which species appear

INDEX NUMBER	SPECIES
55	ACRITARCH
47	APTEODINIUM RETICULATUM
24	BATIOLADINIUM JAEGERI
29	CANNINGIA RETICULATA
36	CANNINGINOPSIS CF. C. COLLIVERI
26	CARPODINIUM GRANULATUM
40	CAUCA PARVA
8	CHLAMYDOPHORELLA TRABECULOSA
9	CIRCULODINIUM BREVISPINOSUM
48	CIRCULODINIUM DISTINCTUM
30	CIRCULODINIUM? SP. 2
2	CIRCULODINIUM? SP. 3
31	CLEISTOSPHAERIDIUM HUGUONIOTII
33	CLEISTOSPHAERIDIUM? ACICULARE
45	DESMOCYSTA PLEKTA
20	DINGODINIUM? ALBERTII
27	ELLIPSOIDICTYUM IMPERFECTUM
34	EXOCHOSPHAERIDIUM PHRAGMITES
50	FROMEA FRAGILIS
38	GONYAULACYSTA AFF. G. CASSIDATA
46	HAPSOCYSTA? BENTEAE SP. NOV.
28	KIOKANSIUM POLYPES POLYPES
51	KLEITHRIASPHAERIDIUM EOINODES
43	LAGENADINIUM? MEMBRANOIDIUM
25	LEPTODINIUM CANCELLATUM
3	LEPTODINIUM? CF. L. DELICATUM
7	LEPTODINIUM? HYALODERMOPSE
10	LEVISPHAERA CF. L. CRASSICINGULATA
4	NYKTERICYSTA? VITREA
11	ODONTOCHITINA OPERCULATA
41	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
18	OLIGOSPHAERIDIUM CF. O. TOTUM
12	OLIGOSPHAERIDIUM COMPLEX
19	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
32	OLIGOSPHAERIDIUM POCULUM
42	OLIGOSPHAERIDIUM SP. 1
5	OLIGOSPHAERIDIUM? ASTERIGERUM
13	PALAEOPERIDINIUM CRETACEUM
21	PAREODINIA SPP.
6	PSEUDOCERATIUM CF. P. RETUSUM
44	PSEUDOCERATIUM EISENACKII
52	PSEUDOCERATIUM POLYMORPHUM
37	SENONIASPHAERA MICRORETICULATA
14	SENTUSIDINIUM SP. 1
53	SENTUSIDINIUM SP. 2
16	SENTUSIDINIUM VERRUCOSUM
22	SIRMIODINIUM GROSSII
35	SPINIFERITES SPP.
39	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
17	SUBTILISPHAERA PERLUCIDA
1	SURCULOSPHAERIDIUM AFF. S. PHOENIX
23	TANYOSPHAERIDIUM BOLETUS
54	TUBOTUBERELLA SP.
56	ULVELLA NANNAE
49	VESPEROPSIS LONGICORNIS
15	VESPEROPSIS MAYI

section 13

SW of Kap Berlin Wollaston Fl.



SPECIES LOCATION INDEX

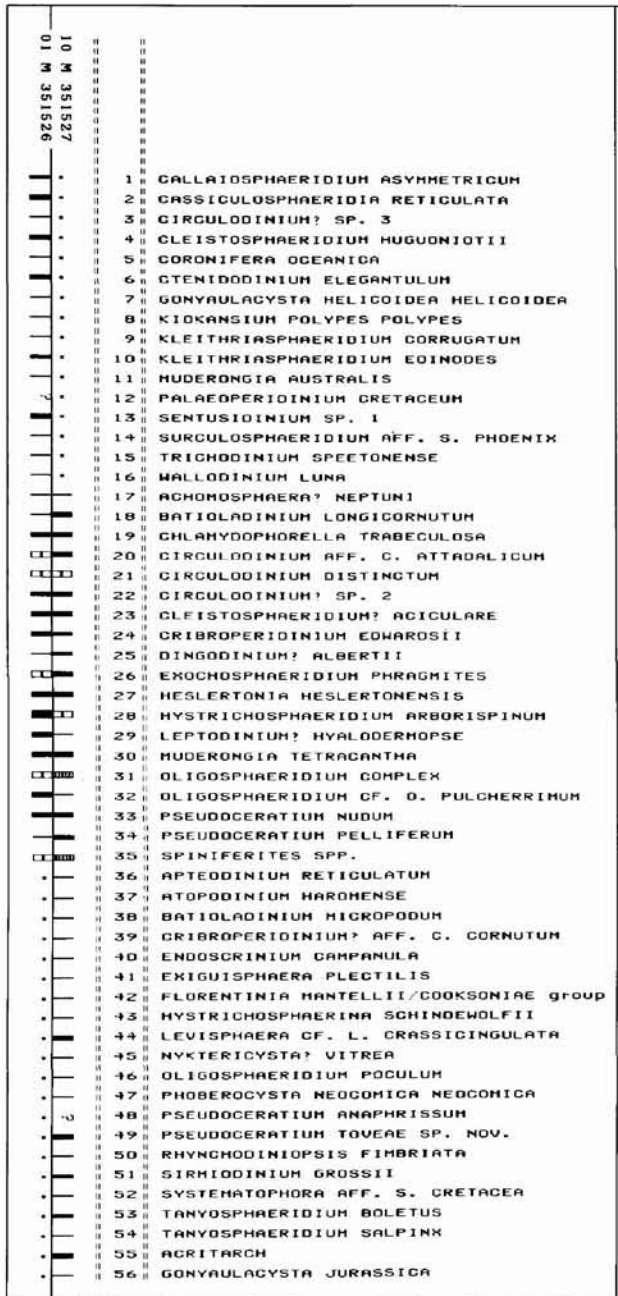
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
61	?HAIR FROM LEAF
24	ACHOMOSPHAERA? NEPTUNI
62	ACRITARCH
25	APTEODINIUM RETICULATUM
26	ATOPODINIUM HAROMENSE
1	BATIOLADINIUM JAEGERI
27	BATIOLADINIUM LONGICORNUTUM
58	BATIOLADINIUM MICROPODUM
16	CALLAIOSPHAERIDIUM ASYMMETRICUM
28	CHLAMYDOPHORELLA TRABECULOSA
38	CIRCULODINIUM AFF. C. ATTADALICUM
39	CIRCULODINIUM DISTINCTUM
17	CIRCULODINIUM? SP. 4
18	CLEISTOSPHAERIDIUM HUHUONIOTII
7	CLEISTOSPHAERIDIUM? ACICULARE
60	CTENIDODINIUM ELEGANTULUM
50	DESMOCYSTA PLEKTA
47	DINGODINIUM? ABLERTII
19	DISCORSIA NANNA
51	ELLIPSOIDICTYUM IMPERFECTUM
9	EXIGUISPHAERA PLECTILIS
40	EXOCHOSPHAERIDIUM PHRAGMITES
48	FLORENTINIA MANTELLII/COOKSONIAE group
3	FROMEA AMPHORA
10	GONYAULACYSTA HELICOIDEA HELICOIDEA
49	HESLERTONIA HESLERTONENSIS
44	HYSTRICHODINIUM AFF. H. FURCATUM
45	HYSTRICHODINIUM RAMOIDES
11	HYSTRICHODINIUM VOIGTII
20	HYSTRICHOSPHAERIDIUM ARBORISPINUM
29	HYSTRICHOSPHAERINA SCHINDEWOLFII
41	KIOKANSIUM POLYPES POLYPES
52	KLEITHRIASPHAERIDIUM EOINODES
56	LAGENADINIUM? MEMBRANOIDIUM
21	LEPTODINIUM? HADRUM
4	LEPTODINIUM? HYALODERMOPSE
30	LEVISPHAERA CF. L. CRASSICINGULATA
31	MUDERONGIA TETRACANTHA
53	ODONTOCHITINA OPERCULATA
12	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
33	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
8	OLIGOSPHAERIDIUM COMPLEX
13	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
32	OLIGOSPHAERIDIUM POCULUM
54	OLIGOSPHAERIDIUM? ASTERIGERUM
34	PALAEOPERIDINIUM CRETACEUM
55	PAREODINIA SPP.
14	PSEUDOCERATIUM EISENACKII
6	PSEUDOCERATIUM NUDUM
15	PSEUDOCERATIUM PELLIFERUM
5	PSEUDOCERATIUM TOVEAE SP. NOV.
46	RHYNCHODINIOPSIS CF. R. APTIANA
22	SENTUSIDINIUM SP. 1
35	SENTUSIDINIUM SP. 2
42	SIRMIODINIUM GROSSII
43	SPINIFERITES SPP.
36	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
59	SUBTILISPHAERA PERLUCIDA
57	SURCULOSPHAERIDIUM AFF. S. PHOENIX
23	TANYOSPHAERIDIUM BOLETUS
37	TRICHODINIUM SPEETONENSE
2	WALLODINIUM KRUTZSCHII

3	subzone
I	zone
U.Barr.	stage

section 14

Palnatokes Bjerg Wollaston Fl.



SPECIES LOCATION INDEX

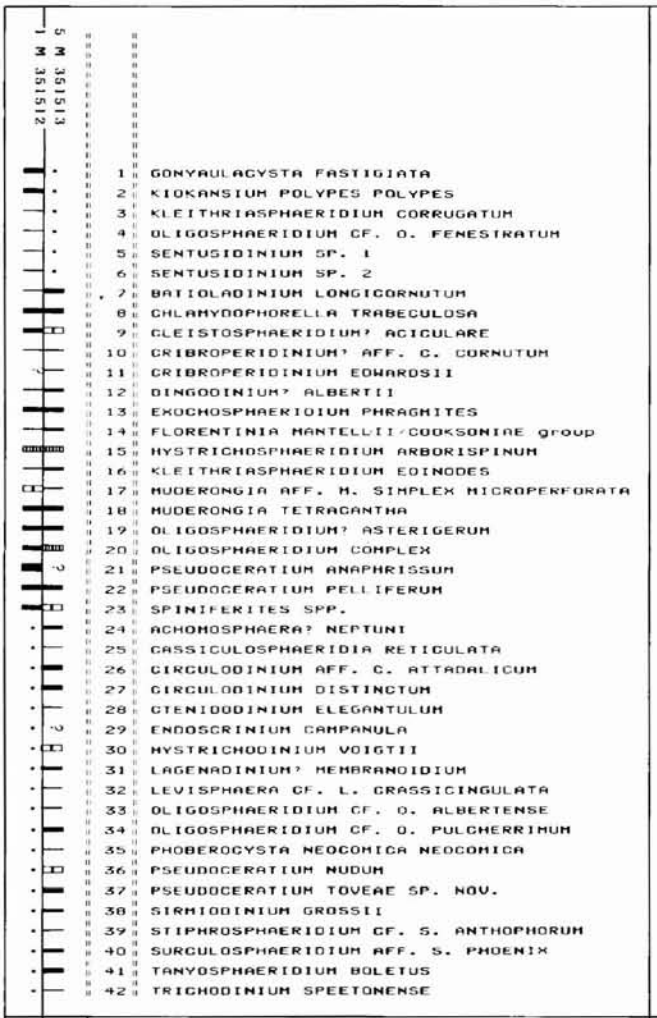
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
17	ACHOMOSPHAERA? NEPTUNI
55	ACRITARCH
36	APTEODINIUM RETICULATUM
37	ATOPODINIUM HAROMENSE
18	BATIOLADINIUM LONGICORNUTUM
38	BATIOLADINIUM MICROPODUM
1	CALLAIOSPHAERIDIUM ASYMMETRICUM
2	CASSICULOSPHAERIDIA RETICULATA
19	CHLAMYDOPHORELLA TRABECULOSA
20	CIRCULODINIUM AFF. C. ATTADALICUM
21	CIRCULODINIUM DISTINCTUM
22	CIRCULODINIUM? SP. 2
3	CIRCULODINIUM? SP. 3
4	CLEISTOSPHAERIDIUM HUGUONIOTII
23	CLEISTOSPHAERIDIUM? ACICULARE
5	CORONIFERA OCEANICA
24	CRIBROPERIDINIUM EDWARDSII
39	CRIBROPERIDINIUM? AFF. C. CORNUTUM
6	CTENIDODINIUM ELEGANTULUM
25	DINGODINIUM? ALBERTII
40	ENDOSCRINIUM CAMPANULA
41	EXIGUISPHAERA PLECTILIS
26	EXOCHOSPHAERIDIUM PHRAGMITES
42	FLORENTINIA MANTELLII/COOKSONIAE group
7	GONYAULACYSTA HELICOIDEA HELICOIDEA
56	GONYAULACYSTA JURASSICA
27	HESLERTONIA HESLERTONENSIS
28	HYSTRICHOSPHAERIDIUM ARBORISPINUM
43	HYSTRICHOSPHAERINA SCHINDEWOLFII
8	KIOKANSIUM POLYPES POLYPES
9	KLEITHRIASPHAERIDIUM CORRUGATUM
10	KLEITHRIASPHAERIDIUM EOINODES
29	LEPTODINIUM? HYALODERMOPSE
44	LEVISPHAERA CF. L. CRASSICINGULATA
11	MUDERONGIA AUSTRALIS
30	MUDERONGIA TETRACANTHA
45	NYKTERICYSTA? VITREA
32	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
31	OLIGOSPHAERIDIUM COMPLEX
46	OLIGOSPHAERIDIUM POCULUM
12	PALAEOPERIDINIUM CRETACEUM
47	PHOBEROCYSTA NEOCOMICA NEOCOMICA
48	PSEUDOCERATIUM ANAPHRISSUM
33	PSEUDOCERATIUM NUDUM
34	PSEUDOCERATIUM PELLIFERUM
49	PSEUDOCERATIUM TOVEAE SP. NOV.
50	RHYNCHODINIOPSIS FIMBRIATA
13	SENTUSIDINIUM SP. 1
51	SIRMIODINIUM GROSSII
35	SPINIFERITES SPP.
14	SURCULOSPHAERIDIUM AFF. S. PHOENIX
52	SYSTEMATOPHORA AFF. S. CRETACEA
53	TANYOSPHAERIDIUM BOLETUS
54	TANYOSPHAERIDIUM SALPINX
15	TRICHODINIUM SPEETONENSE
16	WALLODINIUM LUNA

2	3	subzones
	I	zone
L.B.	U.B.	stages

section 15

Rødryggen Wollaston Fl.



SPECIES LOCATION INDEX

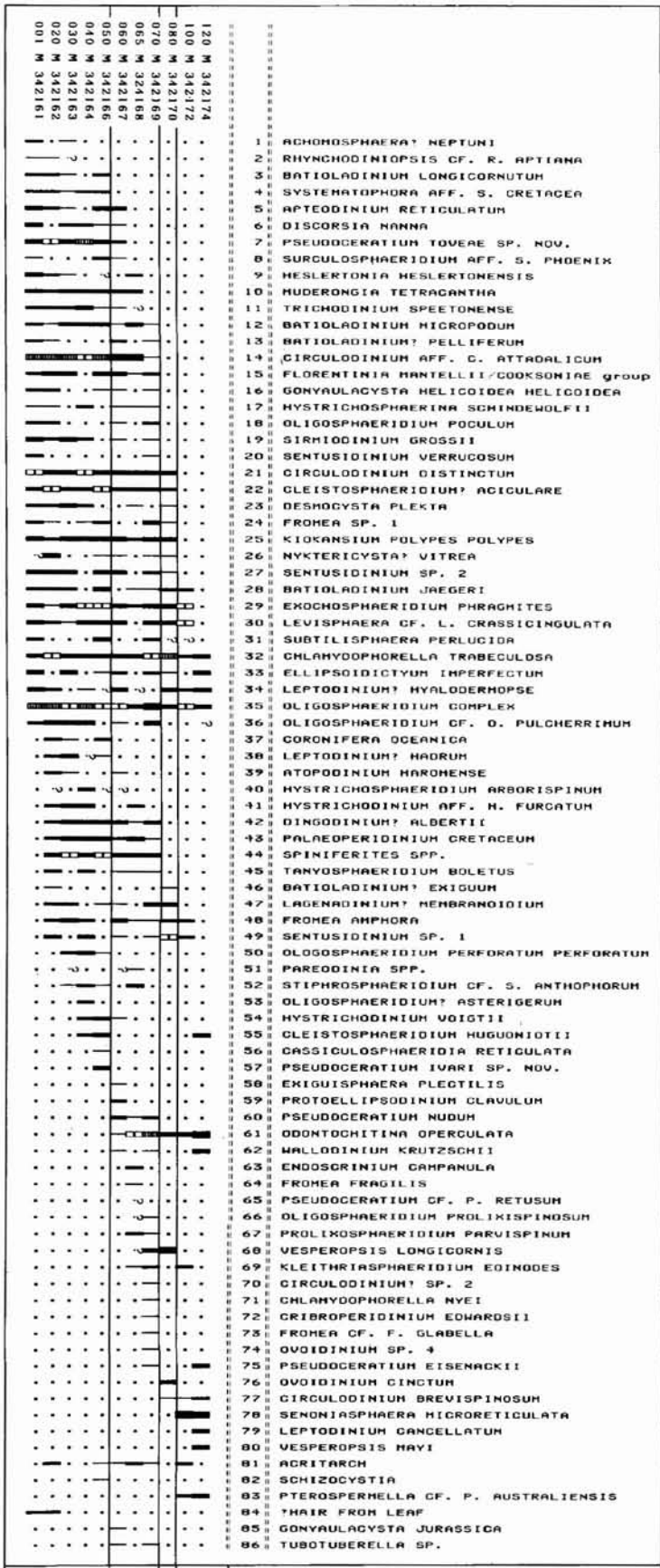
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
24	ACHOMOSPHAERA? NEPTUNI
7	BATIOLADINIUM LONGICORNUTUM
25	CASSICULOSPHAERIDIA RETICULATA
8	CHLAMYDOPHORELLA TRABECULOSA
26	CIRCULODINIUM AFF. C. ATTADALICUM
27	CIRCULODINIUM DISTINCTUM
9	CLEISTOSPHAERIDIUM? ACICULARE
11	CRIBROPERIDINIUM EDWARDSII
10	CRIBROPERIDINIUM? AFF. C. CORNUTUM
28	CTENIDODINIUM ELEGANTULUM
12	DINGODINIUM? ALBERTII
29	ENDOSCRINIUM CAMPANULA
13	EXOCHOSPHAERIDIUM PHRAGMITES
14	FLORENTINIA MANTELLII/COOKSONIAE group
1	GONYAULACYSTA FASTIGIATA
30	HYSTRICHODINIUM VOIGTII
15	HYSTRICHOSPHAERIDIUM ARBORISPINUM
2	KIOKANSIUM POLYPES POLYPES
3	KLEITHRIASPHAERIDIUM CORRUGATUM
16	KLEITHRIASPHAERIDIUM EOINODES
31	LAGENADINIUM? MEMBRANOIDIUM
32	LEVISPHAERA CF. L. CRASSICINGULATA
17	MUDERONGIA AFF. M. SIMPLEX MICROPERFORATA
18	MUDERONGIA TETRACANTHA
33	OLIGOSPHAERIDIUM CF. O. ALBERTENSE
4	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
34	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
20	OLIGOSPHAERIDIUM COMPLEX
19	OLIGOSPHAERIDIUM? ASTERIGERUM
35	PHOBEROCYSTA NEOCOMICA NEOCOMICA
21	PSEUDOCERATIUM ANAPHRISSUM
36	PSEUDOCERATIUM NUDUM
22	PSEUDOCERATIUM PELLIFERUM
37	PSEUDOCERATIUM TOVEAE SP. NOV.
5	SENTUSIDINIUM SP. 1
6	SENTUSIDINIUM SP. 2
38	SIRMIODINIUM GROSSII
23	SPINIFERITES SPP.
39	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
40	SURCULOSPHAERIDIUM AFF. S. PHOENIX
41	TANYOSPHAERIDIUM BOLETUS
42	TRICHODINIUM SPEETONENSE

2	3	subzones
	I	zone
L.B.	U.B.	stages

section 16

Rødryggen Wollaston Fl.



SPECIES LOCATION INDEX

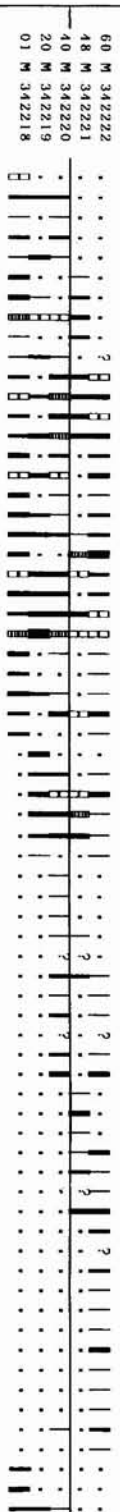
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
84	?HAIR FROM LEAF
1	ACHOMOSPHAERA? NEPTUNI
81	ACRITARCH
5	APTEODINIUM RETICULATUM
39	ATOPODINIUM HAROMENSE
28	BATIOLADINIUM JAEGERI
3	BATIOLADINIUM LONGICORNUTUM
12	BATIOLADINIUM MICROPODUM
46	BATIOLADINIUM? EXIGUUM
13	BATIOLADINIUM? PELLIFERUM
56	CASSICULOSPHAERIDIA RETICULATA
71	CHLAMYDOPHORELLA NYEI
32	CHLAMYDOPHORELLA TRABECULOSA
14	CIRCULODINIUM AFF. C. ATTADALICUM
77	CIRCULODINIUM BREVISPINOSUM
21	CIRCULODINIUM DISTINCTUM
70	CIRCULODINIUM? SP. 2
55	CLEISTOSPHAERIDIUM HUGUONIOTII
22	CLEISTOSPHAERIDIUM? ACICULARE
37	CORONIFERA OCEANICA
72	CRIBROPERIDINIUM EDWARDSII
23	DESMOCYSTA PLEKTA
42	DINGODINIUM? ALBERTII
6	DISCORSIA NANNA
33	ELLIPSOIDICTYUM IMPERFECTUM
63	ENDOSCRINIUM CAMPANULA
58	EXIGUISPHAERA PLECTILIS
29	EXOCHOSPHAERIDIUM PHRAGMITES
15	FLORENTINIA MANTELLII/COOKSONIAE group
48	FROMEA AMPHORA
73	FROMEA CF. F. GLABELLA
64	FROMEA FRAGILIS
24	FROMEA SP. 1
16	GONYAULACYSTA HELICOIDEA HELICOIDEA
85	GONYAULACYSTA JURASSICA
9	HESLERTONIA HESLERTONENSIS
41	HYSTRICHODINIUM AFF. H. FURCATUM
54	HYSTRICHODINIUM VOIGTII
40	HYSTRICHOSPHAERIDIUM ARBORISPINUM
17	HYSTRICHOSPHAERINA SCHINDEWOLFII
25	KIOKANSIUM POLYPES POLYPES
69	KLEITHRIASPHAERIDIUM EOINODES
47	LAGENADINIUM? MEMBRANOIDIUM
79	LEPTODINIUM CANCELLATUM
38	LEPTODINIUM? HADRUM
34	LEPTODINIUM? HYALODERMOPSE
30	LEVISPHAERA CF. L. CRASSICINGULATA
10	MUDERONGIA TETRACANTHA
26	NYKTERICYSTA? VITREA
61	ODONTOCHITINA OPERCULATA
36	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
35	OLIGOSPHAERIDIUM COMPLEX
18	OLIGOSPHAERIDIUM POCULUM
66	OLIGOSPHAERIDIUM PROLIXISPINOSUM
53	OLIGOSPHAERIDIUM? ASTERIGERUM
50	OLOGOSPHAERIDIUM PERFORATUM PERFORATUM
76	OVOIDINIUM CINCTUM
74	OVOIDINTUM SP. 4
43	PALAEOPERIDINIUM CRETACEUM
51	PAREODINIA SPP.
67	PROLIXOSPHAERIDIUM PARVISPINUM
59	PROTOELLIPSODINIUM CLAVULUM
65	PSEUDOCERATIUM CF. P. RETUSUM
75	PSEUDOCERATIUM EISENACKII
57	PSEUDOCERATIUM IVARI SP. NOV.
60	PSEUDOCERATIUM NUDUM
7	PSEUDOCERATIUM TOVEAE SP. NOV.
83	PTEROSPERMELLA CF. P. AUSTRALIENSIS
2	RHYNCHODINIOPSIS CF. R. APTIANA
82	SCHIZOCYSTIA
78	SENONIASPHAERA MICRORETICULATA
49	SENTUSIDINIUM SP. 1
27	SENTUSIDINIUM SP. 2
20	SENTUSIDINIUM VERRUCOSUM
19	SIRMIODINIUM GROSSII
44	SPINIFERITES SPP.
52	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
31	SUBTILISPHAERA PERLUCIDA
8	SURCULOSPHAERIDIUM AFF. S. PHOENIX
4	SYSTEMATOPHORA AFF. S. CRETACEA
45	TANYOSPHAERIDIUM BOLETUS
11	TRICHODINIUM SPEETONENSE
86	TUBOTUBERELLA SP.
68	VESPEROPSIS LONGICORNIS
80	VESPEROPSIS MAYI
62	WALLODINIUM KRUTZSCHII

3		1	3	subzones
I	II	III		zones
U.Barr.	L.Apt.	U.Apt.		stages

section 17

Aucellabjerget Wollaston Fl.



1	OLIGOSPHAERIDIUM CF. O. ALBERTENSE
2	NELCHINOPSIS KOSTROMIENSIS
3	OLIGOSPHAERIDIUM PERFORATUM COLUM
4	SENTUSIDINIUM SP. 1
5	TANYOSPHAERIDIUM BOLETUS
6	KLEITHRIASPHAERIDIUM EOINODES
7	MUDERONGIA AFF. M. SIMPLEX MICROPERFORATA
8	OLIGOSPHAERIDIUM? ASTERIGERUM
9	PHOBEROCYSTA NEOCOMICA NEOCOMICA
10	ACHOMOSPHAERA? NEPTUNI
11	CHLAMYDOPHORELLA TRABECULOSA
12	CIRCULODINIUM DISTINCTUM
13	CIRCULODINIUM? SP. 3
14	CLEISTOSPHAERIDIUM? ACICULARE
15	CLEISTOSPHAERIDIUM HUGUONIOTII
16	EXOCHOSPHAERIDIUM PHRAGMITES
17	GONYAULACYSTA FASTIGIATA
18	HESLERTONIA HESLERTONENSIS
19	HYSTRICHODINIUM VOIGTII
20	HYSTRICHOSPHAERIDIUM ARBORISPINUM
21	KIOKANSIUM POLYPES POLYPES
22	LAGENADINIUM? MEMBRANOIDIUM
23	LEVISPHAERA CF. L. CRASSICINGULATA
24	OLIGOSPHAERIDIUM COMPLEX
25	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
26	SENTUSIDINIUM SP. 2
27	SIRMIODINIUM GROSSII
28	SPINIFERITES SPP.
29	TRICHODINIUM SPEETONENSE
30	GONYAULACYSTA PERFOROBTUSA
31	LEPTODINIUM? HYALODERMOPSE
32	MUDERONGIA TETRACANTHA
33	PSEUDOCERATIUM ANAPHRISSUM
34	PSEUDOCERATIUM PELLIFERUM
35	TANYOSPHAERIDIUM SALPINX
36	CORONIFERA OCEANICA
37	DINGODINIUM? ALBERTII
38	SURCULOSPHAERIDIUM AFF. S. PHOENIX
39	OLIGOSPHAERIDIUM POCULUM
40	PAREODINIA SPP.
41	BATIOLADINIUM LONGICORNUTUM
42	BATIOLADINIUM MICROPODUM
43	CHLAMYDOPHORELLA NYEI
44	ELLIPSOIDICTYUM IMPERFECTUM
45	KLEITHRIASPHAERIDIUM CORRUGATUM
46	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
47	CASSICULOSPHAERIDIA MAGNA
48	CASSICULOSPHAERIDIA RETICULATA
49	WALLODINIUM KRUTZSCHII
50	GONYAULACYSTA HELICOIDEA HELICOIDEA
51	HYSTRICHOSPHAERINA SCHINDEWOLFII
52	PALAEOPERIDINIUM CRETACEUM
53	PSEUDOCERATIUM NUDUM
54	BATIOLADINIUM JAEGERI
55	CIRCULODINIUM AFF. C. ATTADALICUM
56	CRIBROPERIDINIUM EDWARDSII
57	CTENIDODINIUM ELEGANTULUM
58	DISCORSIA NANNA
59	EXIGUISPHAERA PLECTILIS
60	FLORENTINIA MANTELLII/COOKSONIAE group
61	FROMEA AMPHORA
62	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
63	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
64	ACRITARCH
65	PTEROSPERMELLA CF. P. AUSTRALIENSIS
66	GOCHTEODINIA VILLOSA MULTIFURCATA
67	RIGAUDELLA SP.
68	GONYAULACYSTA JURASSICA

SPECIES LOCATION INDEX

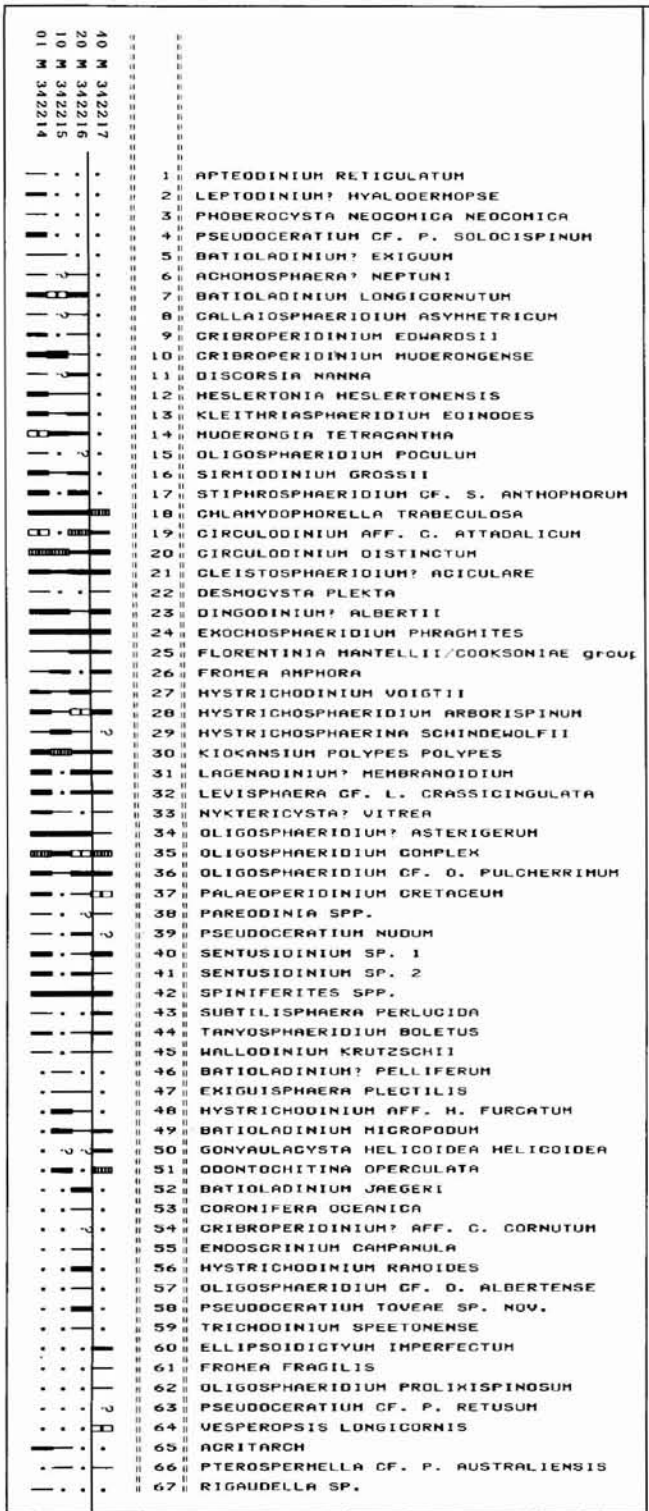
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
10	ACHOMOSPHAERA? NEPTUNI
64	ACRITARCH
54	BATIOLADINIUM JAEGERI
41	BATIOLADINIUM LONGICORNUTUM
42	BATIOLADINIUM MICROPODUM
47	CASSICULOSPHAERIDIA MAGNA
48	CASSICULOSPHAERIDIA RETICULATA
43	CHLAMYDOPHORELLA NYEI
11	CHLAMYDOPHORELLA TRABECULOSA
55	CIRCULODINIUM AFF. C. ATTADALICUM
12	CIRCULODINIUM DISTINCTUM
13	CIRCULODINIUM? SP. 3
15	CLEISTOSPHAERIDIUM HUGUONIOTII
14	CLEISTOSPHAERIDIUM? ACICULARE
36	CORONIFERA OCEANICA
56	CRIBROPERIDINIUM EDWARDSII
57	CTENIDODINIUM ELEGANTULUM
37	DINGODINIUM? ALBERTII
58	DISCORSIA NANNA
44	ELLIPSOIDICTYUM IMPERFECTUM
59	EXIGUISPHAERA PLECTILIS
16	EXOCHOSPHAERIDIUM PHRAGMITES
60	FLORENTINIA MANTELLII/COOKSONIAE group
61	FROMEA AMPHORA
66	GOCHTEODINIA VILLOSA MULTIFURCATA
17	GONYAULACYSTA FASTIGIATA
50	GONYAULACYSTA HELICOIDEA HELICOIDEA
68	GONYAULACYSTA JURASSICA
30	GONYAULACYSTA PERFOROBTUSA
18	HESLERTONIA HESLERTONENSIS
19	HYSTRICHODINIUM VOIGTII
20	HYSTRICHOSPHAERIDIUM ARBORISPINUM
51	HYSTRICHOSPHAERINA SCHINDEWOLFII
21	KIOKANSIUM POLYPES POLYPES
45	KLEITHRIASPHAERIDIUM CORRUGATUM
6	KLEITHRIASPHAERIDIUM EOINODES
22	LAGENADINIUM? MEMBRANOIDIUM
31	LEPTODINIUM? HYALODERMOPSE
23	LEVISPHAERA CF. L. CRASSICINGULATA
7	MUDERONGIA AFF. M. SIMPLEX MICROPERFORATA
32	MUDERONGIA TETRACANTHA
2	NELCHINOPSIS KOSTROMIENSIS
1	OLIGOSPHAERIDIUM CF. O. ALBERTENSE
25	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
46	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
24	OLIGOSPHAERIDIUM COMPLEX
3	OLIGOSPHAERIDIUM PERFORATUM COLUM
62	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
39	OLIGOSPHAERIDIUM POCULUM
8	OLIGOSPHAERIDIUM? ASTERIGERUM
52	PALAEOPERIDINIUM CRETACEUM
40	PAREODINIA SPP.
9	PHOBEROCYSTA NEOCOMICA NEOCOMICA
33	PSEUDOCERATIUM ANAPHRISSUM
53	PSEUDOCERATIUM NUDUM
34	PSEUDOCERATIUM PELLIFERUM
65	PTEROSPERMELLA CF. P. AUSTRALIENSIS
67	RIGAUDELLA SP.
4	SENTUSIDINIUM SP. 1
26	SENTUSIDINIUM SP. 2
27	SIRMIODINIUM GROSSII
28	SPINIFERITES SPP.
63	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
38	SURCULOSPHAERIDIUM AFF. S. PHOENIX
5	TANYOSPHAERIDIUM BOLETUS
35	TANYOSPHAERIDIUM SALPINX
29	TRICHODINIUM SPEETONENSE
49	WALLODINIUM KRUTZSCHII

1	2	subzones
I		zone
L.Barr.		stage

section 18

SE of Kuhnpasset Wollaston Fl.



SPECIES LOCATION INDEX

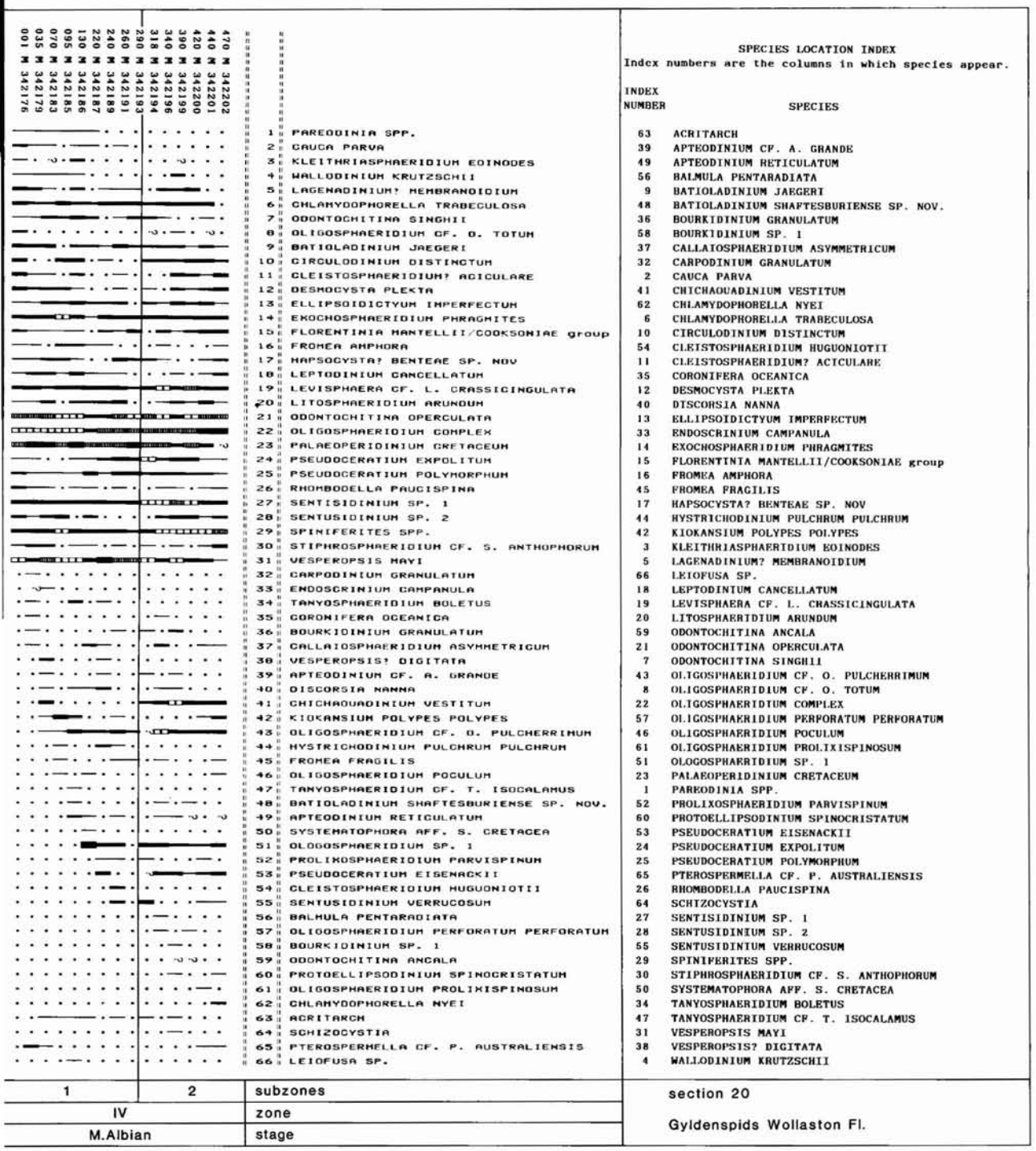
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
6	ACHOMOSPHAERA? NEPTUNI
65	ACRITARCH
1	APTEODINIUM RETICULATUM
52	BATIOLADINIUM JAEGERI
7	BATIOLADINIUM LONGICORNUTUM
49	BATIOLADINIUM MICROPODUM
5	BATIOLADINIUM? EXIGUUM
46	BATIOLADINIUM? PELLIFERUM
8	CALLAIOSPHAERIDIUM ASYMMETRICUM
18	CHLAMYDOPHORELLA TRABECULOSA
19	CIRCULODINIUM AFF. C. ATTADALICUM
20	CIRCULODINIUM DISTINCTUM
21	CLEISTOSPHAERIDIUM? ACICULARE
53	CORONIFERA OCEANICA
9	CRIBROPERIDINIUM EDWARDSII
10	CRIBROPERIDINIUM MUDERONGENSE
54	CRIBROPERIDINIUM? AFF. C. CORNUTUM
22	DESMOCYSTA PLEKTA
23	DINGODINIUM? ALBERTII
11	DISCORSIA NANNA
60	ELLIPSOIDICTYUM IMPERFECTUM
55	ENDOSCRINIUM CAMPANULA
47	EXIGUISPHAERA PLECTILIS
24	EXOCHOSPHAERIDIUM PHRAGMITES
25	FLORENTINIA MANTELLII/COOKSONIAE group
26	FROMEA AMPHORA
61	FROMEA FRAGILIS
50	GONYAULACYSTA HELICOIDEA HELICOIDEA
12	HESLERTONIA HESLERTONENSIS
48	HYSTRICHODINIUM AFF. H. FURCATUM
56	HYSTRICHODINIUM RAMOIDES
27	HYSTRICHODINIUM VOIGTII
28	HYSTRICHOSPHAERIDIUM ARBORISPINUM
29	HYSTRICHOSPHAERINA SCHINDEWOLFII
30	KIOKANSIUM POLYPES POLYPES
13	KLEITHRIASPHAERIDIUM EOINODES
31	LAGENADINIUM? MEMBRANOIDIUM
2	LEPTODINIUM? HYALODERMOPSE
32	LEVISPHAERA CF. L. CRASSICINGULATA
14	MUDERONGIA TETRACANTHA
33	NYKTERICYSTA? VITREA
51	ODONTOCHITINA OPERCULATA
57	OLIGOSPHAERIDIUM CF. O. ALBERTENSE
36	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
35	OLIGOSPHAERIDIUM COMPLEX
15	OLIGOSPHAERIDIUM POCULUM
62	OLIGOSPHAERIDIUM PROLIXISPINOSUM
34	OLIGOSPHAERIDIUM? ASTERIGERUM
37	PALAEOPERIDINIUM CRETACEUM
38	PAREODINIA SPP.
3	PHOBEROCYSTA NEOCOMICA NEOCOMICA
63	PSEUDOCERATIUM CF. P. RETUSUM
4	PSEUDOCERATIUM CF. P. SOLOCISPINUM
39	PSEUDOCERATIUM NUDUM
58	PSEUDOCERATIUM TOVEAE SP. NOV.
66	PTEROSPERMELLA CF. P. AUSTRALIENSIS
67	RIGAUDELLA SP.
40	SENTUSIDINIUM SP. 1
41	SENTUSIDINIUM SP. 2
16	SIRMIODINIUM GROSSII
42	SPINIFERITES SPP.
17	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
43	SUBTILISPHAERA PERLUCIDA
44	TANYOSPHAERIDIUM BOLETUS
59	TRICHODINIUM SPEETONENSE
64	VESPEROPSIS LONGICORNIS
45	WALLODINIUM KRUTZSCHII

3		subzone
I	II	zones
U.Barr.	L.Apt.	stages

section 19

N off Gyldenspids Wollaston Fl.



SPECIES LOCATION INDEX

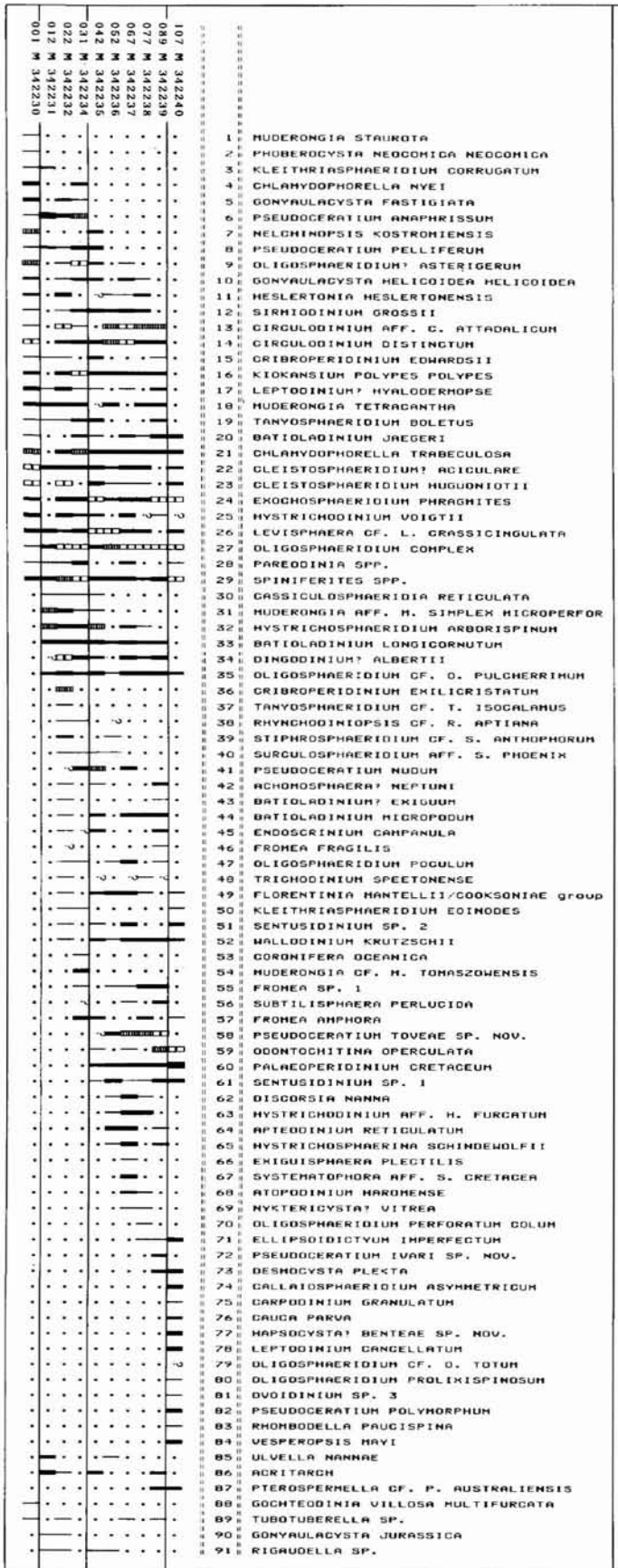
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
63	ACRITARCH
39	APTEODINIUM CF. A. GRANDE
49	APTEODINIUM RETICULATUM
56	BALMULA PENTARADIATA
9	BATIOLADINIUM JAEGERI
48	BATIOLADINIUM SHAFTESBURIENSE SP. NOV.
36	BOURKIDINIUM GRANULATUM
58	BOURKIDINIUM SP. 1
37	CALLAIOSPHAERIDIUM ASYMMETRICUM
32	CARPODINIUM GRANULATUM
2	CAUCA PARVA
41	CHICHAOUADINIUM VESTITUM
62	CHLAMYDOPHORELLA NYEI
6	CHLAMYDOPHORELLA TRABECULOSA
10	CIRCULODINIUM DISTINCTUM
54	CLEISTOSPHAERIDIUM HUGUONIOTII
11	CLEISTOSPHAERIDIUM? ACICULARE
35	CORONIFERA OCEANICA
12	DESMOCYSTA PLEKTA
40	DISCORSIA NANNA
13	ELLIPSOIDICTYUM IMPERFECTUM
33	ENDOSCRINIUM CAMPANULA
14	EXOCHOSPHAERIDIUM PHRAGMITES
15	FLORENTINIA MANTELLII/COOKSONIAE group
16	FROMEA AMPHORA
45	FROMEA FRAGILIS
17	HAPSOCYSTA? BENTEAE SP. NOV
44	HYSTRICHODINIUM PULCHRUM PULCHRUM
42	KIOKANSIUM POLYPES POLYPES
3	KLEITHRIASPHAERIDIUM EOINODES
5	LAGENADINIUM? MEMBRANOIDIUM
66	LEIOFUSA SP.
18	LEPTODINIUM CANCELLATUM
19	LEVISPHAERA CF. L. CRASSICINGULATA
20	LITOSPHAERIDIUM ARUNDUM
59	ODONTOCHITINA ANCALA
21	ODONTOCHITINA OPERCULATA
7	ODONTOCHITINA SINGHII
43	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
8	OLIGOSPHAERIDIUM CF. O. TOTUM
22	OLIGOSPHAERIDIUM COMPLEX
57	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
46	OLIGOSPHAERIDIUM POCULUM
61	OLIGOSPHAERIDIUM PROLIXISPINOSUM
51	OLOGOSPHAERIDIUM SP. 1
23	PALAEOPERIDINIUM CRETACEUM
1	PAREODINIA SPP.
52	PROLIXOSPHAERIDIUM PARVISPINUM
60	PROTOELLIPSODINIUM SPINOCRISTATUM
53	PSEUDOCERATIUM EISENACKII
24	PSEUDOCERATIUM EXPOLITUM
25	PSEUDOCERATIUM POLYMORPHUM
65	PTEROSPERMELLA CF. P. AUSTRALIENSIS
26	RHOMBODELLA PAUCISPINA
64	SCHIZOCYSTIA
27	SENTISIDINIUM SP. 1
28	SENTUSIDINIUM SP. 2
55	SENTUSIDINIUM VERRUCOSUM
29	SPINIFERITES SPP.
30	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
50	SYSTEMATOPHORA AFF. S. CRETACEA
34	TANYOSPHAERIDIUM BOLETUS
47	TANYOSPHAERIDIUM CF. T. ISOCALAMUS
31	VESPEROPSIS MAYI
38	VESPEROPSIS? DIGITATA
4	WALLODINIUM KRUTZSCHII

1	2	subzones
IV		zone
M.Albian		stage

section 20

Gyldenspids Wollaston Fl.



SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
42	ACHOMOSPHAERA? NEPTUNI
86	ACRITARCH
64	APTEODINIUM RETICULATUM
68	ATOPODINIUM HAROMENSE
20	BATIOLADINIUM JAEGERI
33	BATIOLADINIUM LONGICORNUTUM
44	BATIOLADINIUM MICROPODUM
43	BATIOLADINIUM? EXIGUUM
74	CALLAIOSPHAERIDIUM ASYMMETRICUM
75	CARPODINIUM GRANULATUM
30	CASSICULOSPHAERIDIA RETICULATA
76	CAUCA PARVA
4	CHLAMYDOPHORELLA NYEI
21	CHLAMYDOPHORELLA TRABECULOSA
13	CIRCULODINIUM AFF. C. ATTADALICUM
14	CIRCULODINIUM DISTINCTUM
23	CLEISTOSPHAERIDIUM HUGUONIOTII
22	CLEISTOSPHAERIDIUM? ACICULARE
53	CORONIFERA OCEANICA
15	CRIBROPERIDINIUM EDWARDSII
36	CRIBROPERIDINIUM EXILICRISTATUM
73	DESMOCYSTA PLEKTA
34	DINGODINIUM? ALBERTII
62	DISCORSIA NANNA
71	ELLIPSOIDICTYUM IMPERFECTUM
45	ENDOSCRINIUM CAMPANULA
66	EXIGUISPHAERA PLECTILIS
24	EXOCHOSPHAERIDIUM PHRAGMITES
49	FLORENTINIA MANTELLII/COOKSONIAE group
57	FROMEA AMPHORA
46	FROMEA FRAGILIS
55	FROMEA SP. 1
88	GOCHTEODINIA VILLOSA MULTIFURCATA
5	GONYAULACYSTA FASTIGIATA
10	GONYAULACYSTA HELICOIDEA HELICOIDEA
90	GONYAULACYSTA JURASSICA
77	HAPSOCYSTA? BENTEAE SP. NOV.
11	HESLERTONIA HESLERTONENSIS
63	HYSTRICHODINIUM AFF. H. FURCATUM
25	HYSTRICHODINIUM VOIGTII
32	HYSTRICHOSPHAERIDIUM ARBORISPINUM
65	HYSTRICHOSPHAERINA SCHINDEWOLFII
16	KIOKANSIUM POLYPES POLYPES
3	KLEITHRIASPHAERIDIUM CORRUGATUM
50	KLEITHRIASPHAERIDIUM EOINODES
78	LEPTODINIUM CANCELLATUM
17	LEPTODINIUM? HYALODERMOPSE
26	LEVISPHAERA CF. L. CRASSICINGULATA
31	MUDERONGIA AFF. M. SIMPLEX MICROPERFORATA
54	MUDERONGIA CF. M. TOMASZOWENSIS
1	MUDERONGIA STAUROTA
18	MUDERONGIA TETRACANTHA
7	NELCHINOPSIS KOSTROMIENSIS
69	NYKTERICYSTA? VITREA
59	ODONTOCHITINA OPERCULATA
35	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
79	OLIGOSPHAERIDIUM CF. O. TOTUM
27	OLIGOSPHAERIDIUM COMPLEX
70	OLIGOSPHAERIDIUM PERFORATUM COLUM
47	OLIGOSPHAERIDIUM POCULUM
80	OLIGOSPHAERIDIUM PROLIXISPINOSUM
9	OLIGOSPHAERIDIUM? ASTERIGERUM
81	OVOIDINIUM SP. 3
60	PALAEOPERIDINIUM CRETACEUM
28	PAREODINIA SPP.
2	PHOBEROCYSTA NEOCOMICA NEOCOMICA
6	PSEUDOCERATIUM ANAPHRISSUM
72	PSEUDOCERATIUM IVARI SP. NOV.
41	PSEUDOCERATIUM NUDUM
8	PSEUDOCERATIUM PELLIFERUM
82	PSEUDOCERATIUM POLYMORPHUM
58	PSEUDOCERATIUM TOVEAE SP. NOV.
87	PTEROSPERMELLA CF. P. AUSTRALIENSIS
83	RHOMBODELLA PAUCISPINA
38	RHYNCHODINIOPSIS CF. R. APTIANA
91	RIGAUDELLA SP.
61	SENTUSIDINIUM SP. 1
51	SENTUSIDINIUM SP. 2
12	SIRMIODINIUM GROSSII
29	SPINIFERITES SPP.
39	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
56	SUBTILISPHAERA PERLUCIDA
40	SURCULOSPHAERIDIUM AFF. S. PHOENIX
67	SYSTEMATOPHORA AFF. S. CRETACEA
19	TANYOSPHAERIDIUM BOLETUS
37	TANYOSPHAERIDIUM CF. T. ISOCALAMUS
48	TRICHODINIUM SPEETONENSE
89	TUBOTUBERELLA SP.
85	ULVELLA NANNAE
84	VESPEROPSIS MAYI
52	WALLODINIUM KRUTZSCHII

1	2	3	1	subzones	section 21
I			IV	zones	Stratumbjerget Wollaston Fl.
L. Barr.		U. Barr.	M. Alb.	stages	

1	CLEISTOSPHAERIDIUM? ACICULARE	1
2	DESMOCYSTA PLEKTA	2
3	OLIGOSPHAERIDIUM PROLIXISPINOSUM	3
4	PSEUDOCERATIUM CF. P. INTERIORENSE	4
5	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM	5
6	DICONODINIUM ARCTICUM	6
7	ENDOSCRINIUM CAMPANULA	7
8	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM	8
9	SENTUSIDINIUM SP. 2	9
10	CALLAIOSPHAERIDIUM ASYMMETRICUM	10
11	CHLAMYDOPHORELLA TRABECULOSA	11
12	ELLIPSOIDICTYUM IMPERFECTUM	12
13	LEPTODINIUM CANCELLATUM	13
14	LEVISPHAERA CF. L. CRASSICINGULATA	14
15	ODONTOCHITINA SINGHII	15
16	SENTUSIDINIUM SP. 1	16
17	WALLODINIUM KRUTZSCHII	17
18	BATIOLADINIUM JAEGERI	18
19	CIRCULODINIUM DISTINCTUM	19
20	EXOCHOSPHAERIDIUM PHRAGMITES	20
21	FLORENTINIA MANTELLII/COOKSONIAE group	21
22	HAPSOCYSTA? BENTEAE SP. NOV.	22
23	LITOSPHAERIDIUM ARUNDUM	23
24	ODONTOCHITINA OPERCULATA	24
25	OLIGOSPHAERIDIUM COMPLEX	25
26	PALAEOPERIDINIUM CRETACEUM	26
27	PAREODINIA SPP.	27
28	PSEUDOCERATIUM POLYMORPHUM	28
29	RHOMBODELLA PAUCISPINA	29
30	SPINIFERITES SPP.	30
31	VESPEROPSIS MAYI	31
32	OVOIDINIUM SP. 3	32
33	PSEUDOCERATIUM EISENACKII	33
34	TANYOSPHAERIDIUM BOLETUS	34
35	KLEITHRIASPHAERIDIUM EOINODES	35
36	PSEUDOCERATIUM EXPOLITUM	36
37	DISCORSIA NANNA	37
38	FROMEA FRAGILIS	38
39	CHICHAOUADINIUM VESTITUM	39
40	FROMEA SP. 1	40
41	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM	41
42	CAUCA PARVA	42
43	OLIGOSPHAERIDIUM CF. O. TOTUM	43
44	PTEROSPERMELLA CF. P. AUSTRALIENSIS	44

SPECIES LOCATION INDEX

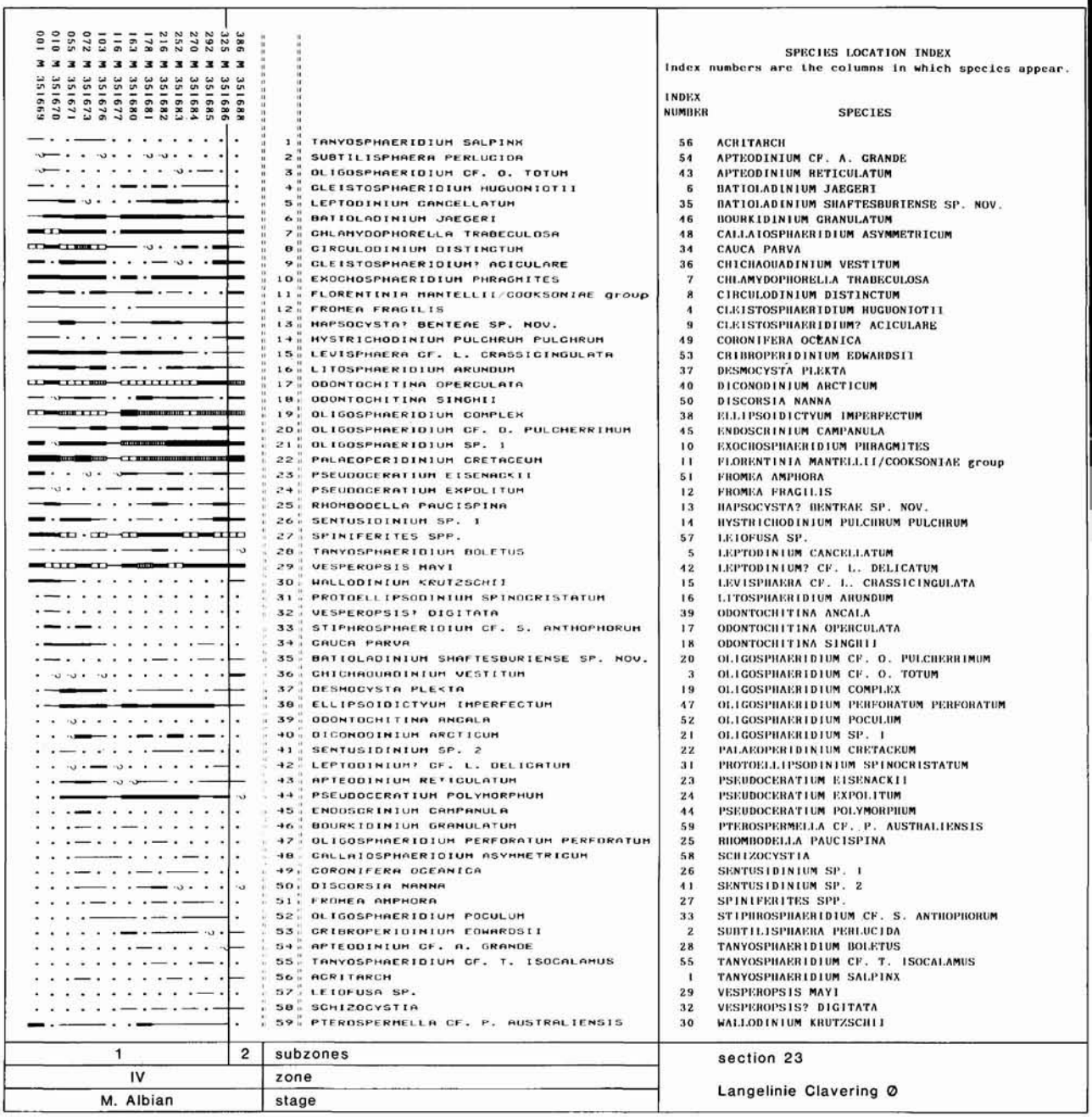
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
18	BATIOLADINIUM JAEGERI
10	CALLAIOSPHAERIDIUM ASYMMETRICUM
42	CAUCA PARVA
39	CHICHAOUADINIUM VESTITUM
11	CHLAMYDOPHORELLA TRABECULOSA
19	CIRCULODINIUM DISTINCTUM
1	CLEISTOSPHAERIDIUM? ACICULARE
2	DESMOCYSTA PLEKTA
6	DICONODINIUM ARCTICUM
37	DISCORSIA NANNA
12	ELLIPSOIDICTYUM IMPERFECTUM
7	ENDOSCRINIUM CAMPANULA
20	EXOCHOSPHAERIDIUM PHRAGMITES
21	FLORENTINIA MANTELLII/COOKSONIAE group
38	FROMEA FRAGILIS
40	FROMEA SP. 1
22	HAPSOCYSTA? BENTEAE SP. NOV.
35	KLEITHRIASPHAERIDIUM EOINODES
13	LEPTODINIUM CANCELLATUM
14	LEVISPHAERA CF. L. CRASSICINGULATA
23	LITOSPHAERIDIUM ARUNDUM
24	ODONTOCHITINA OPERCULATA
15	ODONTOCHITINA SINGHII
8	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
43	OLIGOSPHAERIDIUM CF. O. TOTUM
25	OLIGOSPHAERIDIUM COMPLEX
41	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
3	OLIGOSPHAERIDIUM PROLIXISPINOSUM
32	OVOIDINIUM SP. 3
26	PALAEOPERIDINIUM CRETACEUM
27	PAREODINIA SPP.
4	PSEUDOCERATIUM CF. P. INTERIORENSE
33	PSEUDOCERATIUM EISENACKII
36	PSEUDOCERATIUM EXPOLITUM
28	PSEUDOCERATIUM POLYMORPHUM
44	PTEROSPERMELLA CF. P. AUSTRALIENSIS
29	RHOMBODELLA PAUCISPINA
16	SENTUSIDINIUM SP. 1
9	SENTUSIDINIUM SP. 2
30	SPINIFERITES SPP.
5	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
34	TANYOSPHAERIDIUM BOLETUS
31	VESPEROPSIS MAYI
17	WALLODINIUM KRUTZSCHII

1	subzone
IV	zone
M.Alb.	stage

section 22

Kontaktravine Clavering Ø



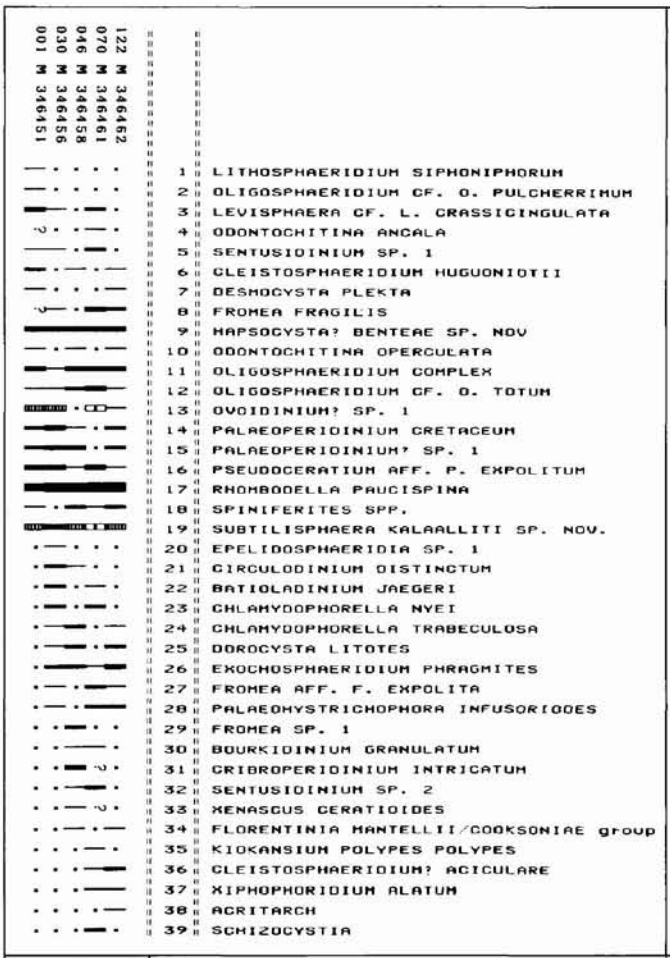
SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
56	ACRITARCH
54	APTEODINIUM CF. A. GRANDE
43	APTEODINIUM RETICULATUM
6	BATIOLADINIUM JAEGERI
35	BATIOLADINIUM SHAFTESBURIENSE SP. NOV.
46	BOURKIDINIUM GRANULATUM
48	CALLAIOSPHAERIDIUM ASYMMETRICUM
34	CAUCA PARVA
36	CHICHAOUADINIUM VESTITUM
7	CHLAMYDOPHORELLA TRABECULOSA
8	CIRCULODINIUM DISTINCTUM
4	CLEISTOSPHAERIDIUM HUGUONIOTII
9	CLEISTOSPHAERIDIUM? ACICULARE
49	CORONIFERA OCEANICA
53	CRIBROPERIDINIUM EDWARDSII
37	DESMOCYSTA PLEKTA
40	DICONODINIUM ARCTICUM
50	DISCORSIA NANNA
38	ELLIPSOIDICTYUM IMPERFECTUM
45	ENDOSCRINIUM CAMPANULA
10	EXOCHOSPHAERIDIUM PHRAGMITES
11	FLORENTINIA MANTELLII/COOKSONIAE group
51	FROMEA AMPHORA
12	FROMEA FRAGILIS
13	HAPSOCYSTA? BENTEAE SP. NOV.
14	HYSTRICHODINIUM PULCHRUM PULCHRUM
57	LEIOFUSA SP.
5	LEPTODINIUM CANCELLATUM
42	LEPTODINIUM? CF. L. DELICATUM
15	LEVISPHAERA CF. L. CRASSICINGULATA
16	LITOSPHAERIDIUM ARUNDUM
39	ODONTOCHITINA ANCALA
17	ODONTOCHITINA OPERCULATA
18	ODONTOCHITINA SINGHII
20	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
3	OLIGOSPHAERIDIUM CF. O. TOTUM
19	OLIGOSPHAERIDIUM COMPLEX
47	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
52	OLIGOSPHAERIDIUM POCULUM
21	OLIGOSPHAERIDIUM SP. 1
22	PALAEOPERIDINIUM CRETACEUM
31	PROTOELLIPSODINIUM SPINOCRISTATUM
23	PSEUDOCERATIUM EISENACKII
24	PSEUDOCERATIUM EXPOLITUM
44	PSEUDOCERATIUM POLYMORPHUM
59	PTEROSPERMELLA CF. P. AUSTRALIENSIS
25	RHOMBODELLA PAUCISPINA
58	SCHIZOCYSTIA
26	SENTUSIDINIUM SP. 1
41	SENTUSIDINIUM SP. 2
27	SPINIFERITES SPP.
33	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
2	SUBTILISPHAERA PERLUCIDA
28	TANYOSPHAERIDIUM BOLETUS
55	TANYOSPHAERIDIUM CF. T. ISOCALAMUS
1	TANYOSPHAERIDIUM SALPINX
29	VESPEROPSIS MAYI
32	VESPEROPSIS? DIGITATA
30	WALLODINIUM KRUTZSCHII

section 23

Langelinie Clavering Ø



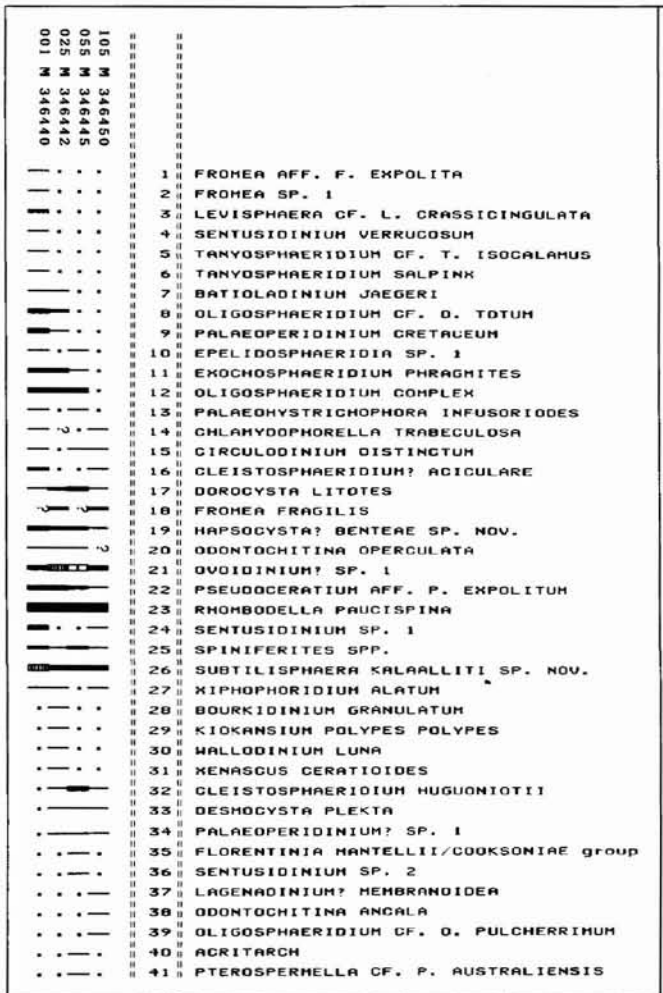
SPECIES LOCATION INDEX
Index numbers are the columns in which species appear

INDEX NUMBER	SPECIES
38	ACRITARCH
22	BATIOLADINIUM JAEGERI
30	BOURKIDINIUM GRANULATUM
23	CHLAMYDOPHORELLA NYEI
24	CHLAMYDOPHORELLA TRABECULOSA
21	CIRCULODINIUM DISTINCTUM
6	CLEISTOSPHAERIDIUM HUGUONIOTII
36	CLEISTOSPHAERIDIUM? ACICULARE
31	CRIBROPERIDINIUM INTRICATUM
7	DESMOCYSTA PLEKTA
25	DOROCYSTA LITOTES
20	EPELIDOSPHAERIDIA SP. 1
26	EXOCHOSPHAERIDIUM PHRAGMITES
34	FLORENTINIA MANTELLII/*COOKSONIAE* group
27	FROMEA AFF. F. EXPOLITA
8	FROMEA FRAGILIS
29	FROMEA SP. 1
9	HAPSOCYSTA? BENTEAE SP. NOV
35	KIOKANSIUM POLYPES POLYPES
3	LEVISPHAERA CF. L. CRASSICINGULATA
1	LITHOSPHAERIDIUM SIPHONIPHORUM
4	ODONTOCHITINA ANCALA
10	ODONTOCHITINA OPERCULATA
2	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
12	OLIGOSPHAERIDIUM CF. O. TOTUM
11	OLIGOSPHAERIDIUM COMPLEX
13	OVOIDINIUM? SP. 1
28	PALAEOHYSTRICHOPHORA INFUSORIOIDES
14	PALAEOPERIDINIUM CRETACEUM
15	PALAEOPERIDINIUM? SP. 1
16	PSEUDOCERATIUM AFF. P. EXPOLITUM
17	RHOMBODELLA PAUCISPINA
39	SCHIZOCYSTIA
5	SENTUSIDINIUM SP. 1
32	SENTUSIDINIUM SP. 2
18	SPINIFERITES SPP.
19	SUBTILISPHAERA KALAALLITI SP. NOV.
33	XENASCUS CERATIOIDES
37	XIPHOPHORIDIUM ALATUM

3	subzone
V	zone
U. Albian	stage

section 24

N Home Forland Hope with Hope



SPECIES LOCATION INDEX

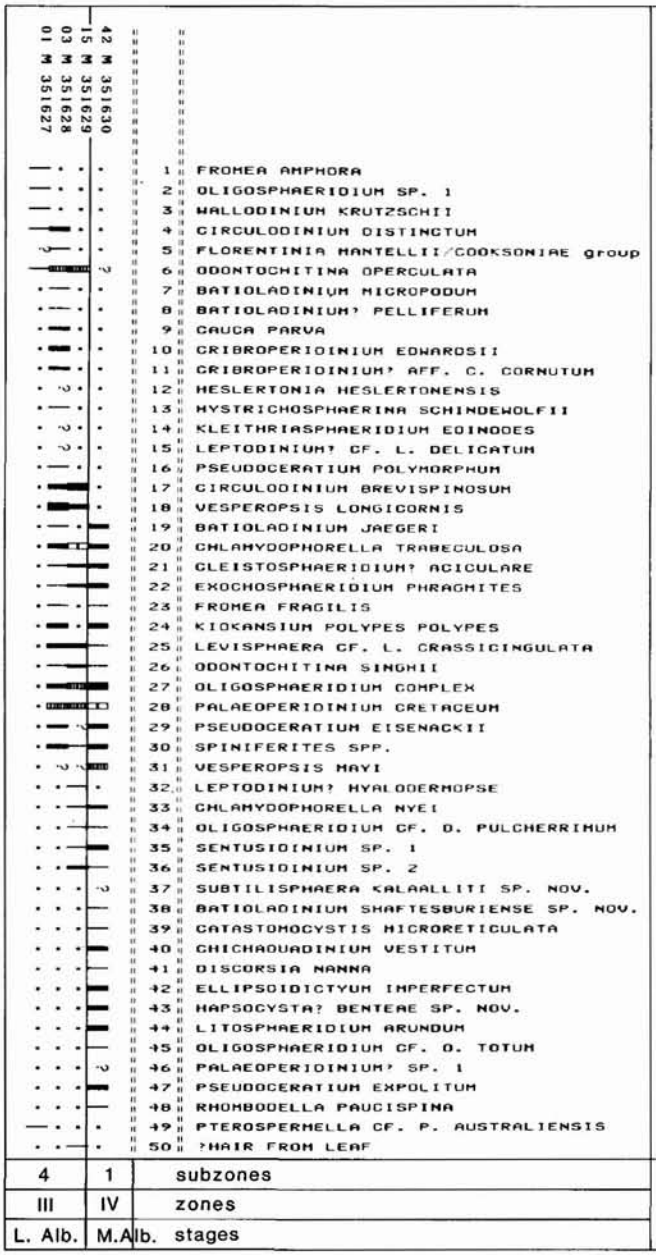
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
40	ACRITARCH
7	BATIOLADINIUM JAEGERI
28	BOURKIDINIUM GRANULATUM
14	CHLAMYDOPHORELLA TRABECULOSA
15	CIRCULODINIUM DISTINCTUM
32	CLEISTOSPHAERIDIUM HUGUONIOTII
16	CLEISTOSPHAERIDIUM? ACICULARE
33	DESMOCYSTA PLEKTA
17	DOROCYSTA LITOTES
10	EPELIDOSPHAERIDIA SP. 1
11	EXOCHOSPHAERIDIUM PHRAGMITES
35	FLORENTINIA MANTELLII/COOKSONIAE group
1	FROMEA AFF. F. EXPOLITA
18	FROMEA FRAGILIS
2	FROMEA SP. 1
19	HAPSOCYSTA? BENTEAE SP. NOV.
29	KIOKANSIUM POLYPES POLYPES
37	LAGENADINIUM? MEMBRANOIDEA
3	LEVISPHAERA CF. L. CRASSICINGULATA
38	ODONTOCHITINA ANCALA
20	ODONTOCHITINA OPERCULATA
39	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
8	OLIGOSPHAERIDIUM CF. O. TOTUM
12	OLIGOSPHAERIDIUM COMPLEX
21	OVOIDINIUM? SP. 1
13	PALAEOHYSTRICHOPHORA INFUSORIODES
9	PALAEOPERIDINIUM CRETACEUM
34	PALAEOPERIDINIUM? SP. 1
22	PSEUDOCERATIUM AFF. P. EXPOLITUM
41	PTEROSPERMELLA CF. P. AUSTRALIENSIS
23	RHOMBODELLA PAUCISPINA
24	SENTUSIDINIUM SP. 1
36	SENTUSIDINIUM SP. 2
4	SENTUSIDINIUM VERRUCOSUM
25	SPINIFERITES SPP.
26	SUBTILISPHAERA KALAALLITI SP. NOV.
5	TANYOSPHAERIDIUM CF. T. ISOCALAMUS
6	TANYOSPHAERIDIUM SALPINX
30	WALLODINIUM LUNA
31	XENASCUS CERATIOIDES
27	XIPHOPHORIDIUM ALATUM

3	subzone
V	zone
U. Albian	stage

section 25

N Home Forland Hold with Hope



SPECIES LOCATION INDEX

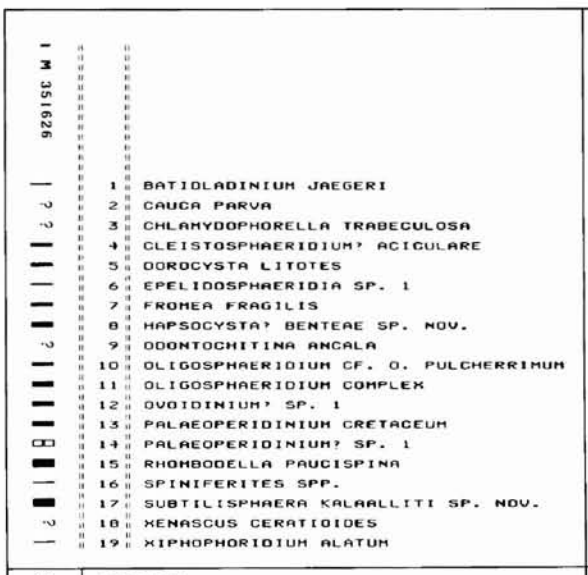
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
50	?HAIR FROM LEAF
19	BATIOLADINIUM JAEGERI
7	BATIOLADINIUM MICROPODUM
38	BATIOLADINIUM SHAFTESBURIENSE SP. NOV.
8	BATIOLADINIUM? PELLIFERUM
39	CATASTOMOCYSTIS MICRORETICULATA
9	CAUCA PARVA
40	CHICHAOUADINIUM VESTITUM
33	CHLAMYDOPHORELLA NYEI
20	CHLAMYDOPHORELLA TRABECULOSA
17	CIRCULODINIUM BREVISPINOSUM
4	CIRCULODINIUM DISTINCTUM
21	CLEISTOSPHAERIDIUM? ACICULARE
10	CRIBROPERIDINIUM EDWARDSII
11	CRIBROPERIDINIUM? AFF. C. CORNUTUM
41	DISCORSIA NANNA
42	ELLIPSOIDICTYUM IMPERFECTUM
22	EXOCHOSPHAERIDIUM PHRAGMITES
5	FLORENTINIA MANTELLII/COOKSONIAE group
1	FROMEA AMPHORA
23	FROMEA FRAGILIS
43	HAPSOCYSTA? BENTEAE SP. NOV.
12	HESLERTONIA HESLERTONENSIS
13	HYSTRICHOSPHAERINA SCHINDEWOLFII
24	KIOKANSIUM POLYPES POLYPES
14	KLEITHRIASPHAERIDIUM EOINODES
15	LEPTODINIUM? CF. L. DELICATUM
32	LEPTODINIUM? HYALODERMOPSE
25	LEVISPHAERA CF. L. CRASSICINGULATA
44	LITOSPHAERIDIUM ARUNDUM
6	ODONTOCHITINA OPERCULATA
26	ODONTOCHITINA SINGHII
34	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
45	OLIGOSPHAERIDIUM CF. O. TOTUM
27	OLIGOSPHAERIDIUM COMPLEX
2	OLIGOSPHAERIDIUM SP. 1
28	PALAEOPERIDINIUM CRETACEUM
46	PALAEOPERIDINIUM? SP. 1
29	PSEUDOCERATIUM EISENACKII
47	PSEUDOCERATIUM EXPOLITUM
16	PSEUDOCERATIUM POLYMORPHUM
49	PTEROSPERMELLA CF. P. AUSTRALIENSIS
48	RHOMBODELLA PAUCISPINA
35	SENTUSIDINIUM SP. 1
36	SENTUSIDINIUM SP. 2
30	SPINIFERITES SPP.
37	SUBTILISPHAERA KALAALLITI SP. NOV.
18	VESPEROPSIS LONGICORNIS
31	VESPEROPSIS MAYI
3	WALLODINIUM KRUTZSCHII

4	1	subzones
III	IV	zones
L. Alb.	M.Alb.	stages

section 26

Spaths Plateau Hold with Hope



SPECIES LOCATION INDEX

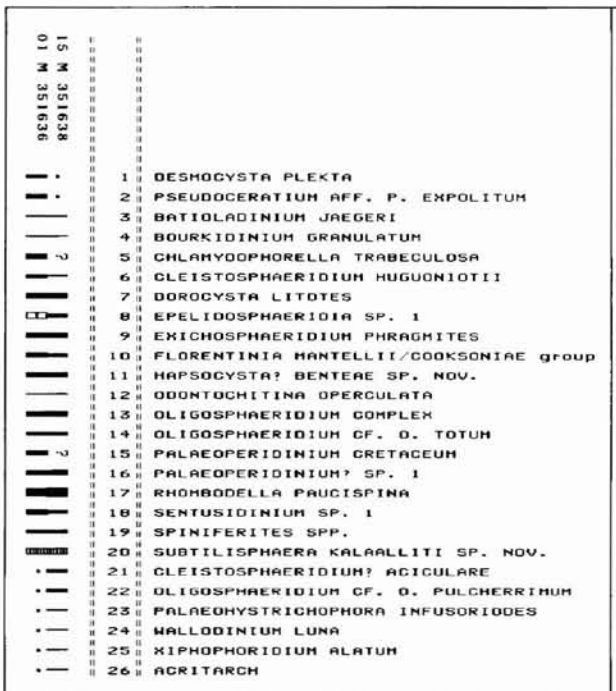
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
1	BATIOLADINIUM JAEGERI
2	CAUCA PARVA
3	CHLAMYDOPHORELLA TRABECULOSA
4	CLEISTOSPHAERIDIUM? ACICULARE
5	DOROCYSTA LITOTES
6	EPELIDOSPHAERIDIA SP. 1
7	FROMEA FRAGILIS
8	HAPSOCYSTA? BENTEAE SP. NOV.
9	ODONTOCHITINA ANCALA
10	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
11	OLIGOSPHAERIDIUM COMPLEX
12	OVOIDINIUM? SP. 1
13	PALAEOPERIDINIUM CRETACEUM
14	PALAEOPERIDINIUM? SP. 1
15	RHOMBODELLA PAUCISPINA
16	SPINIFERITES SPP.
17	SUBTILISPHAERA KALAALLITI SP. NOV.
18	XENASCUS CERATIOIDES
19	XIPHOPHORIDIUM ALATUM

3	subzone
V	zone
U. Alb.	stage

section 27

Tobias Dal Hope with Hope



SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
26	ACRITARCH
3	BATIOLADINIUM JAEGERI
4	BOURKIDINIUM GRANULATUM
5	CHLAMYDOPHORELLA TRABECULOSA
6	CLEISTOSPHAERIDIUM HUGUONIOTII
21	CLEISTOSPHAERIDIUM? ACICULARE
1	DESMOCYSTA PLEKTA
7	DOROCYSTA LITOTES
8	EPELIDOSPHAERIDIA SP. 1
9	EXICHOSPHAERIDIUM PHRAGMITES
10	FLORENTINIA MANTELLII/COOKSONIAE group
11	HAPSOCYSTA? BENTEAE SP. NOV.
12	ODONTOCHITINA OPERCULATA
22	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
14	OLIGOSPHAERIDIUM CF. O. TOTUM
13	OLIGOSPHAERIDIUM COMPLEX
23	PALAEOHYSTRICHOPHORA INFUSORIODES
15	PALAEOPERIDINIUM CRETACEUM
16	PALAEOPERIDINIUM? SP. 1
2	PSEUDOCERATIUM AFF. P. EXPOLITUM
17	RHOMBODELLA PAUCISPINA
18	SENTUSIDINIUM SP. 1
19	SPINIFERITES SPP.
20	SUBTILISPHAERA KALAALLITI SP. NOV.
24	WALLODINIUM LUNA
25	XIPHOPHORIDIUM ALATUM

2	subzone
V	zone
U. Alb.	stage

section 28

Lygnaelv Hold with Hope

	1	BATIOLADINIUM JAEGERI
	2	BATIOLADINIUM SHAFTESBURIENSE SP. NOV.
	3	BOURKIDINIUM GRANULATUM
	4	CHLAMYDOPHORELLA TRABECULOSA
	5	CIRCULODINIUM DISTINCTUM
	6	CIRCULODINIUM SP. 1
	7	CRIBROPERIDINIUM EDWARDSII
	8	DOROCYSTA LITOTES
	9	EXOCHOSPHAERIDIUM PHRAGMITES
	10	FLORENTINIA MANTELLII/COOKSONIAE group
	11	HAPSOCYSTA? BENTEAE SP. NOV.
	12	LEPTODINIUM? CF. L. DELICATUM
	13	LEVISPHAERA CF. L. CRASSICINGULATA
	14	LITOSPHAERIDIUM ARUNDUM
	15	ODONTOCHITINA OPERCULATA
	16	ODONTOCHITINA SINGHII
	17	OLIGOSPHAERIDIUM COMPLEX
	18	OLIGOSPHAERIDIUM PERFORATUM COLUM
	19	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
	20	OLIGOSPHAERIDIUM CF. O. TOTUM
	21	OLIGOSPHAERIDIUM SP. 1
	22	PALAEOPERIDINIUM CRETACEUM
	23	PALAEOPERIDINIUM? SP. 1
	24	PSEUDOCERATIUM EISENACKII
	25	PSEUDOCERATIUM EXPOLITUM
	26	PSEUDOCERATIUM POLYMORPHUM
	27	RHOMBODELLA PAUCISPINA
	28	SPINIFERITES SPP.
	29	SUBTILISPHAERA KALAALLITI SP. NOV.
	30	SENTUSIDINIUM SP. 1
	31	SENTUSIDINIUM SP. 2
	32	WIGGINSIELLA GRANDSTANDICA
	33	ACRITARCH
	34	LEIOFUSA SP.
	35	PTEROSPERMELLA CF. P. AUSTRALIENSIS

SPECIES LOCATION INDEX

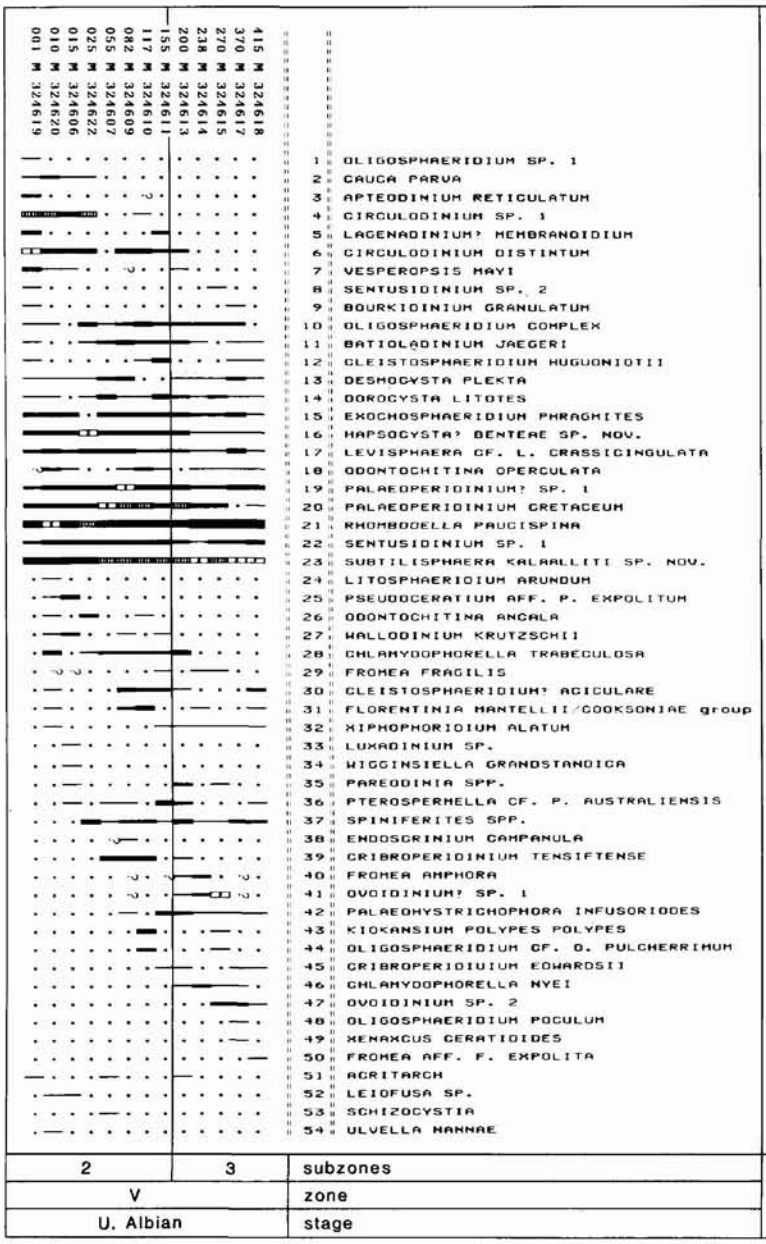
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
33	ACRITARCH
1	BATIOLADINIUM JAEGERI
2	BATIOLADINIUM SHAFTESBURIENSE SP. NOV.
3	BOURKIDINIUM GRANULATUM
4	CHLAMYDOPHORELLA TRABECULOSA
5	CIRCULODINIUM DISTINCTUM
6	CIRCULODINIUM SP. 1
7	CRIBROPERIDINIUM EDWARDSII
8	DOROCYSTA LITOTES
9	EXOCHOSPHAERIDIUM PHRAGMITES
10	FLORENTINIA MANTELLII/COOKSONIAE group
11	HAPSOCYSTA? BENTEAE SP. NOV.
34	LEIOFUSA SP.
12	LEPTODINIUM? CF. L. DELICATUM
13	LEVISPHAERA CF. L. CRASSICINGULATA
14	LITOSPHAERIDIUM ARUNDUM
15	ODONTOCHITINA OPERCULATA
16	ODONTOCHITINA SINGHII
19	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
20	OLIGOSPHAERIDIUM CF. O. TOTUM
17	OLIGOSPHAERIDIUM COMPLEX
18	OLIGOSPHAERIDIUM PERFORATUM COLUM
21	OLIGOSPHAERIDIUM SP. 1
22	PALAEOPERIDINIUM CRETACEUM
23	PALAEOPERIDINIUM? SP. 1
24	PSEUDOCERATIUM EISENACKII
25	PSEUDOCERATIUM EXPOLITUM
26	PSEUDOCERATIUM POLYMORPHUM
35	PTEROSPERMELLA CF. P. AUSTRALIENSIS
27	RHOMBODELLA PAUCISPINA
30	SENTUSIDINIUM SP. 1
31	SENTUSIDINIUM SP. 2
28	SPINIFERITES SPP.
29	SUBTILISPHAERA KALAALLITI SP. NOV.
32	WIGGINSIELLA GRANDSTANDICA

1	subzone
V	zone
U.Alb.	stage

section 29

Tværdal Geographical Society Ø



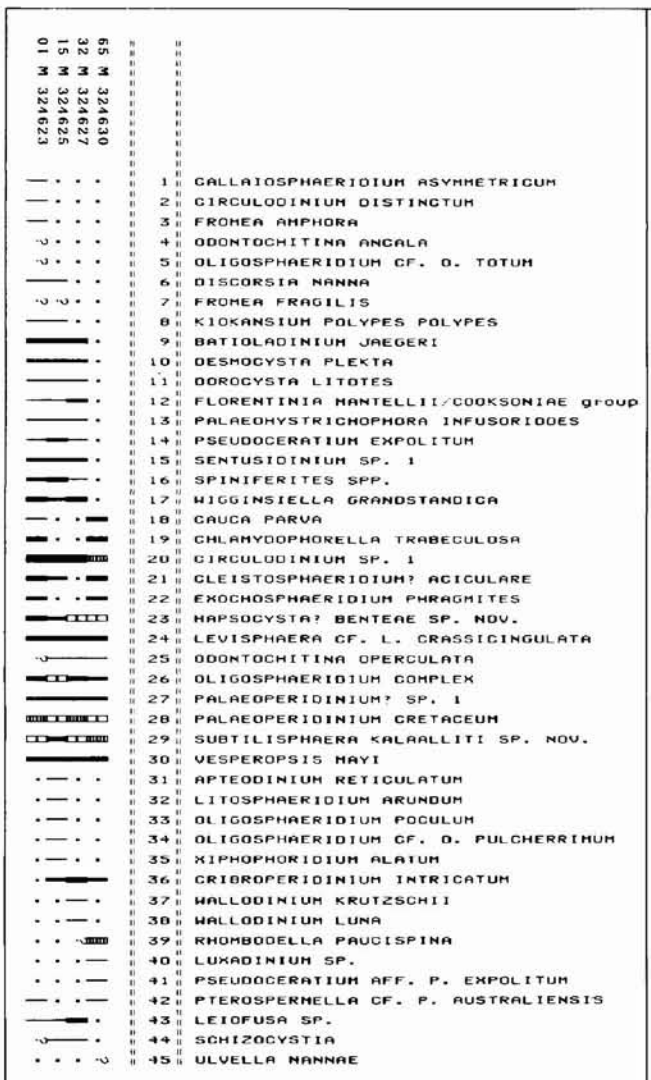
SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
51	ACRITARCH
3	APTEODINIUM RETICULATUM
11	BATIOLADINIUM JAEGERI
9	BOURKIDINIUM GRANULATUM
2	CAUCA PARVA
46	CHLAMYDOPHORELLA NYEI
28	CHLAMYDOPHORELLA TRABECULOSA
6	CIRCULODINIUM DISTINTUM
4	CIRCULODINIUM SP. 1
12	CLEISTOSPHAERIDIUM HUGUONIOTII
30	CLEISTOSPHAERIDIUM? ACICULARE
39	CRIBROPERIDINIUM TENSIFTENSE
45	CRIBROPERIDIUIUM EDWARDSII
13	DESMOCYSTA PLEKTA
14	DOROCYSTA LITOTES
38	ENDOSCRINIUM CAMPANULA
15	EXOCHOSPHAERIDIUM PHRAGMITES
31	FLORENTINIA MANTELLII/COOKSONIAE group
50	FROMEA AFF. F. EXPOLITA
40	FROMEA AMPHORA
29	FROMEA FRAGILIS
16	HAPSOCYSTA? BENTEAE SP. NOV.
43	KIOKANSIUM POLYPES POLYPES
5	LAGENADINIUM? MEMBRANOIDIUM
52	LEIOFUSA SP.
17	LEVISPHAERA CF. L. CRASSICINGULATA
24	LITOSPHAERIDIUM ARUNDUM
33	LUXADINIUM SP.
26	ODONTOCHITINA ANCALA
18	ODONTOCHITINA OPERCULATA
44	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
10	OLIGOSPHAERIDIUM COMPLEX
48	OLIGOSPHAERIDIUM POCULUM
1	OLIGOSPHAERIDIUM SP. 1
47	OVOIDINIUM SP. 2
41	OVOIDINIUM? SP. 1
42	PALAEOHYSTRICHOPHORA INFUSORIODES
20	PALAEOPERIDINIUM CRETACEUM
19	PALAEOPERIDINIUM? SP. 1
35	PAREODINIA SPP.
25	PSEUDOCERATIUM AFF. P. EXPOLITUM
36	PTEROSPERMELLA CF. P. AUSTRALIENSIS
21	RHOMBODELLA PAUCISPINA
53	SCHIZOCYSTIA
22	SENTUSIDINIUM SP. 1
8	SENTUSIDINIUM SP. 2
37	SPINIFERITES SPP.
23	SUBTILISPHAERA KALAALLITI SP. NOV.
54	ULVELLA NANNAE
7	VESPEROPSIS MAYI
27	WALLODINIUM KRUTZSCHII
34	WIGGINSIELLA GRANDSTANDICA
49	XENAXCUS CERATIOIDES
32	XIPHOPHORIDIUM ALATUM

section 30

Tværdal Geographical Society Ø



SPECIES LOCATION INDEX

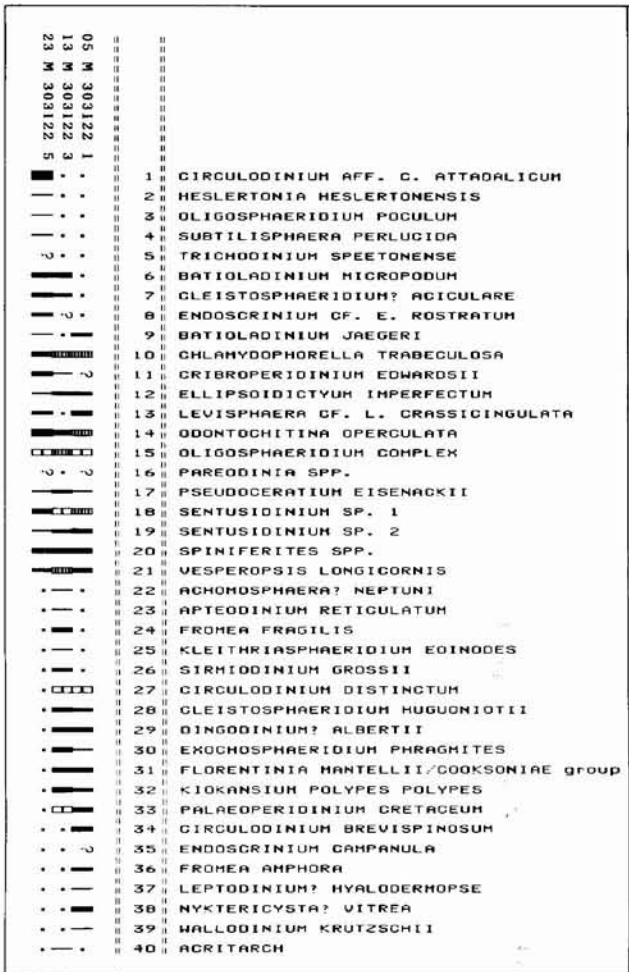
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
31	APTEODINIUM RETICULATUM
9	BATIOLADINIUM JAEGERI
1	CALLAIOSPHAERIDIUM ASYMMETRICUM
18	CAUCA PARVA
19	CHLAMYDOPHORELLA TRABECULOSA
2	CIRCULODINIUM DISTINCTUM
20	CIRCULODINIUM SP. 1
21	CLEISTOSPHAERIDIUM? ACICULARE
36	CRIBROPERIDINIUM INTRICATUM
10	DESMOCYSTA PLEKTA
6	DISCORSIA NANNA
11	DOROCYSTA LITOTES
22	EXOCHOSPHAERIDIUM PHRAGMITES
12	FLORENTINIA MANTELLII/COOKSONIAE group
3	FROMEA AMPHORA
7	FROMEA FRAGILIS
23	HAPSOCYSTA? BENTEAE SP. NOV.
8	KIOKANSIUM POLYPES POLYPES
43	LEIOFUSA SP.
24	LEVISPHAERA CF. L. CRASSICINGULATA
32	LITOSPHAERIDIUM ARUNDUM
40	LUXADINIUM SP.
4	ODONTOCHITINA ANCALA
25	ODONTOCHITINA OPERCULATA
34	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
5	OLIGOSPHAERIDIUM CF. O. TOTUM
26	OLIGOSPHAERIDIUM COMPLEX
33	OLIGOSPHAERIDIUM POCULUM
13	PALAEOHYSTRICHOPHORA INFUSORIODES
28	PALAEOPERIDINIUM CRETACEUM
27	PALAEOPERIDINIUM? SP. 1
41	PSEUDOCERATIUM AFF. P. EXPOLITUM
14	PSEUDOCERATIUM EXPOLITUM
42	PTEROSPERMELLA CF. P. AUSTRALIENSIS
39	RHOMBODELLA PAUCISPINA
44	SCHIZOCYSTIA
15	SENTUSIDINIUM SP. 1
16	SPINIFERITES SPP.
29	SUBTILISPHAERA KALAALLITI SP. NOV.
45	ULVELLA NANNAE
30	VESPEROPSIS MAYI
37	WALLODINIUM KRUTZSCHII
38	WALLODINIUM LUNA
17	WIGGINSIELLA GRANDSTANDICA
35	XIPHOPHORIDIUM ALATUM

1	subzone
V	zone
U. Albian	stage

section 31

Tværdal Geographical Society Ø



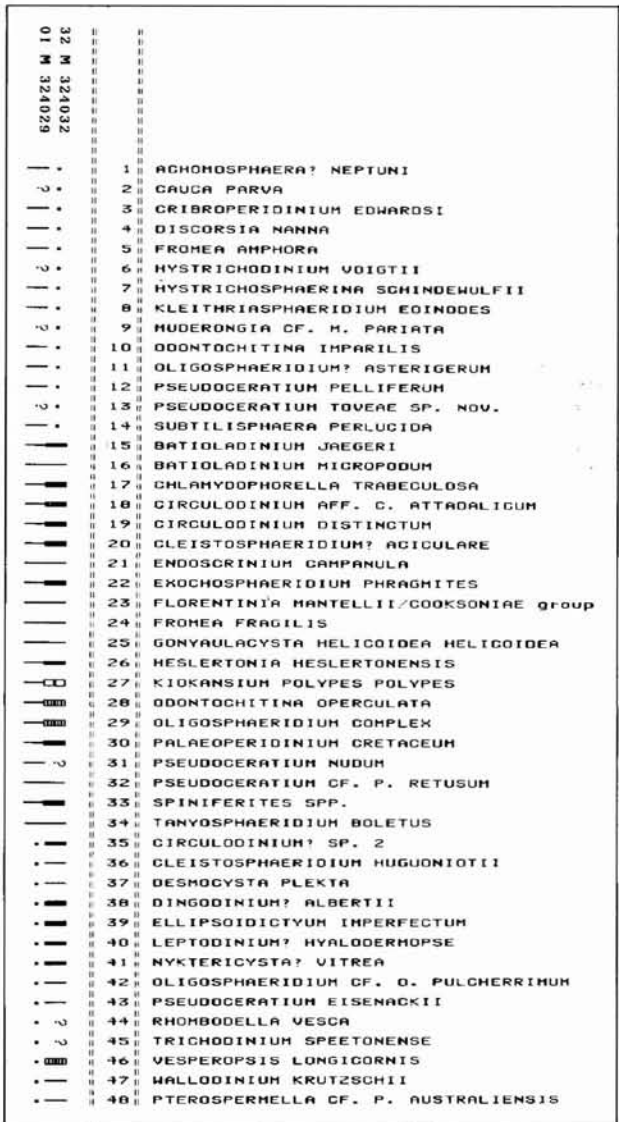
SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
22	ACHOMOSPHAERA? NEPTUNI
40	ACRITARCH
23	APTEODINIUM RETICULATUM
9	BATIOLADINIUM JAEGERI
6	BATIOLADINIUM MICROPODUM
10	CHLAMYDOPHORELLA TRABECULOSA
1	CIRCULODINIUM AFF. C. ATTADALICUM
34	CIRCULODINIUM BREVISPINOSUM
27	CIRCULODINIUM DISTINCTUM
28	CLEISTOSPHAERIDIUM HUGUONIOTII
7	CLEISTOSPHAERIDIUM? ACICULARE
11	CRIBROPERIDINIUM EDWARDSII
29	DINGODINIUM? ALBERTII
12	ELLIPSOIDICTYUM IMPERFECTUM
35	ENDOSCRINIUM CAMPANULA
8	ENDOSCRINIUM CF. E. ROSTRATUM
30	EXOCHOSPHAERIDIUM PHRAGMITES
31	FLORENTINIA MANTELLII/COOKSONIAE group
36	FROMEA AMPHORA
24	FROMEA FRAGILIS
2	HESLERTONIA HESLERTONENSIS
32	KIOKANSIUM POLYPES POLYPES
25	KLEITHRIASPHAERIDIUM EOINODES
37	LEPTODINIUM? HYALODERMOPSE
13	LEVISPHAERA CF. L. CRASSICINGULATA
38	NYKTERICYSTA? VITREA
14	ODONTOCHITINA OPERCULATA
15	OLIGOSPHAERIDIUM COMPLEX
3	OLIGOSPHAERIDIUM POCULUM
33	PALAEOPERIDINIUM CRETACEUM
16	PAREODINIA SPP.
17	PSEUDOCERATIUM EISENACKII
18	SENTUSIDINIUM SP. 1
19	SENTUSIDINIUM SP. 2
26	SIRMIODINIUM GROSSII
20	SPINIFERITES SPP.
4	SUBTILISPHAERA PERLUCIDA
5	TRICHODINIUM SPEETONENSE
21	VESPEROPSIS LONGICORNIS
39	WALLODINIUM KRUTZSCHII

1	subzone
III	zone
L. Apt.	stage

section 32
shallow well
Rold Bjerge Traill Ø



SPECIES LOCATION INDEX

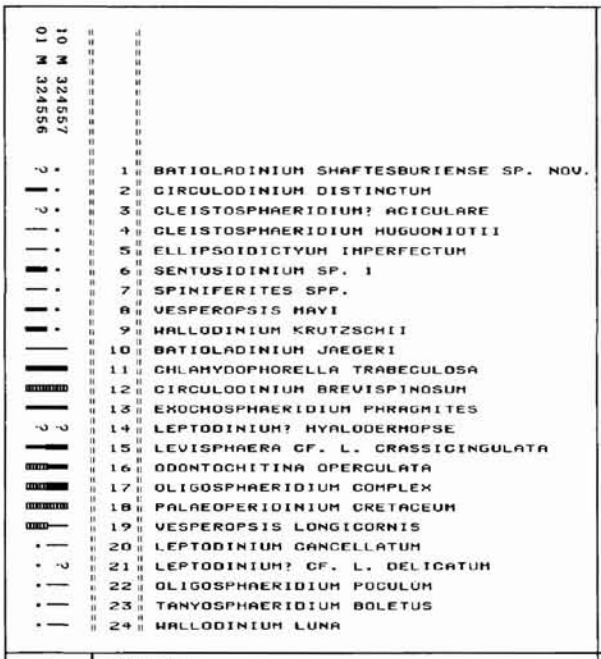
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
1	ACHOMOSPHAERA? NEPTUNI
15	BATIOLADINIUM JAEGERI
16	BATIOLADINIUM MICROPODUM
2	CAUCA PARVA
17	CHLAMYDOPHORELLA TRABECULOSA
18	CIRCULODINIUM AFF. C. ATTADALICUM
19	CIRCULODINIUM DISTINCTUM
35	CIRCULODINIUM? SP. 2
36	CLEISTOSPHAERIDIUM HUGUONIOTII
20	CLEISTOSPHAERIDIUM? ACICULARE
3	CRIBROPERIDINIUM EDWARDSI
37	DESMOCYSTA PLEKTA
38	DINGODINIUM? ALBERTII
4	DISCORSIA NANNA
39	ELLIPSOIDICTYUM IMPERFECTUM
21	ENDOSCRINIUM CAMPANULA
22	EXOCHOSPHAERIDIUM PHRAGMITES
23	FLORENTINIA MANTELLII/COOKSONIAE group
5	FROMEA AMPHORA
24	FROMEA FRAGILIS
25	GONYAULACYSTA HELICOIDEA HELICOIDEA
26	HESLERTONIA HESLERTONENSIS
6	HYSTRICHODINIUM VOIGTII
7	HYSTRICHOSPHAERINA SCHINDEWOLFII
27	KIOKANSIUM POLYPES POLYPES
8	KLEITHRIASPHAERIDIUM EOINODES
40	LEPTODINIUM? HYALODERMOPSE
9	MUDERONGIA CF. M. PARIATA
41	NYKTERICYSTA? VITREA
10	ODONTOCHITINA IMPARILIS
28	ODONTOCHITINA OPERCULATA
42	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
29	OLIGOSPHAERIDIUM COMPLEX
11	OLIGOSPHAERIDIUM? ASTERIGERUM
30	PALAEOPERIDINIUM CRETACEUM
32	PSEUDOCERATIUM CF. P. RETUSUM
43	PSEUDOCERATIUM EISENACKII
31	PSEUDOCERATIUM NUDUM
12	PSEUDOCERATIUM PELLIFERUM
13	PSEUDOCERATIUM TOVEAE SP. NOV.
48	PTEROSPERMELLA CF. P. AUSTRALIENSIS
44	RHOMBODELLA VESCA
33	SPINIFERITES SPP.
14	SUBTILISPHAERA PERLUCIDA
34	TANYOSPHAERIDIUM BOLETUS
45	TRICHODINIUM SPEETONENSE
46	VESPEROPSIS LONGICORNIS
47	WALLODINIUM KRUTZSCHII

	subzone
II	zone
L. Apt.	stage

section 33

Rold Bjerge Traill Ø



SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
10	BATIOLADINIUM JAEGERI
1	BATIOLADINIUM SHAFTESBURIENSE SP. NOV.
11	CHLAMYDOPHORELLA TRABECULOSA
12	CIRCULODINIUM BREVISPINOSUM
2	CIRCULODINIUM DISTINCTUM
4	CLEISTOSPHAERIDIUM HUGUONIOTII
3	CLEISTOSPHAERIDIUM? ACICULARE
5	ELLIPSOIDICTYUM IMPERFECTUM
13	EXOCHOSPHAERIDIUM PHRAGMITES
20	LEPTODINIUM CANCELLATUM
21	LEPTODINIUM? CF. L. DELICATUM
14	LEPTODINIUM? HYALODERMOPSE
15	LEVISPHAERA CF. L. CRASSICINGULATA
16	ODONTOCHITINA OPERCULATA
17	OLIGOSPHAERIDIUM COMPLEX
22	OLIGOSPHAERIDIUM POCULUM
18	PALAEOPERIDINIUM CRETACEUM
6	SENTUSIDINIUM SP. 1
7	SPINIFERITES SPP.
23	TANYOSPHAERIDIUM BOLETUS
19	VESPEROPSIS LONGICORNIS
8	VESPEROPSIS MAYI
9	WALLODINIUM KRUTZSCHII
24	WALLODINIUM LUNA

4	subzone
III	zone
L.Alb.	stage

section 34

Månedal Traill Ø

SPECIES LOCATION INDEX

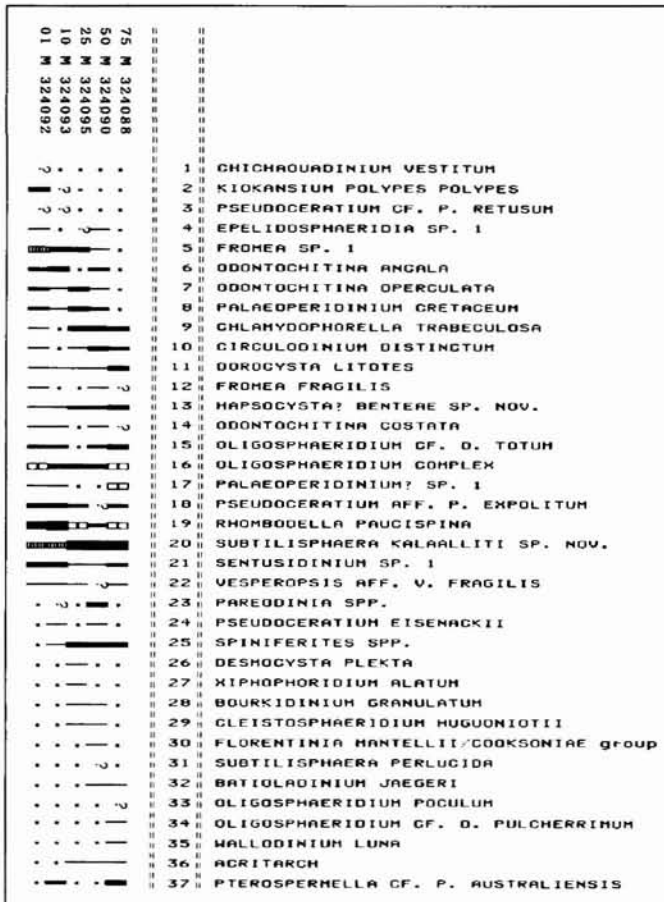
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
1	BATIOLADINIUM JAEGERI
2	CHLAMYDOPHORELLA TRABECULOSA
3	CLEISTOSPHAERIDIUM HUGUONIOTII
18	CLEISTOSPHAERIDIUM? ACICULARE
7	DOROCYSTA LITOTES
4	EPELIDOSPHAERIDIA SP. 1
5	EXOCHOSPHAERIDIUM PHRAGMITES
8	FROMEA SP. 1
9	HAPSOCYSTA? BENTEAE SP. NOV.
10	KIOKANSIUM POLYPES POLYPES
19	LITOSPHAERIDIUM SIPHONIPHORUM
11	ODONTOCHITINA ANCALA
12	ODONTOCHITINA OPERCULATA
6	OLIGOSPHAERIDIUM CF. O. TOTUM
13	OLIGOSPHAERIDIUM COMPLEX
20	PALAEOPERIDINIUM CRETACEUM
14	PALAEOPERIDINIUM? SP. 1
15	PSEUDOCERATIUM AFF. P. EXPOLITUM
21	PSEUDOCERATIUM EISENACKII
16	RHOMBODELLA PAUCISPINA
17	SUBTILISPHAERA KALAALLITI SP. NOV.

2	subzone
V	zone
U. Alb.	stage

section 35

SE of Rold Bjerge Traill Ø



SPECIES LOCATION INDEX

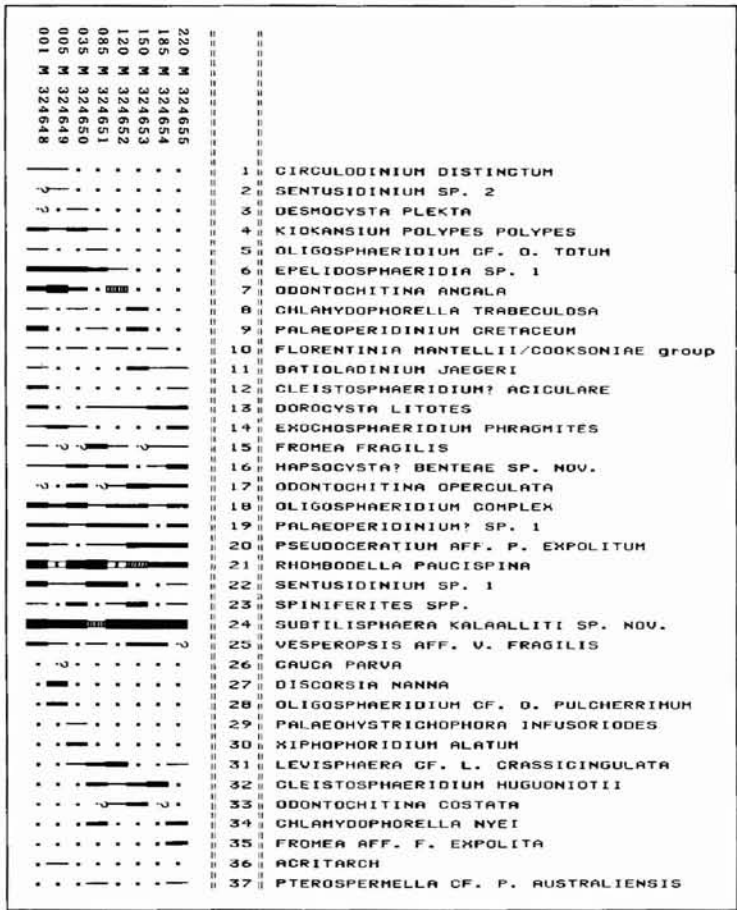
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
36	ACRITARCH
32	BATIOLADINIUM JAEGERI
28	BOURKIDINIUM GRANULATUM
1	CHICHAOUADINIUM VESTITUM
9	CHLAMYDOPHORELLA TRABECULOSA
10	CIRCULODINIUM DISTINCTUM
29	CLEISTOSPHAERIDIUM HUGUONIOTII
26	DESMOCYSTA PLEKTA
11	DOROCYSTA LITOTES
4	EPELIDOSPHAERIDIA SP. 1
30	FLORENTINIA MANTELLII/COOKSONIAE group
12	FROMEA FRAGILIS
5	FROMEA SP. 1
13	HAPSOCYSTA? BENTEAE SP. NOV.
2	KIOKANSIUM POLYPES POLYPES
6	ODONTOCHITINA ANCALA
14	ODONTOCHITINA COSTATA
7	ODONTOCHITINA OPERCULATA
34	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
15	OLIGOSPHAERIDIUM CF. O. TOTUM
16	OLIGOSPHAERIDIUM COMPLEX
33	OLIGOSPHAERIDIUM POCULUM
8	PALAEOPERIDINIUM CRETACEUM
17	PALAEOPERIDINIUM? SP. 1
23	PAREODINIA SPP.
18	PSEUDOCERATIUM AFF. P. EXPOLITUM
3	PSEUDOCERATIUM CF. P. RETUSUM
24	PSEUDOCERATIUM EISENACKII
37	PTEROSPERMELLA CF. P. AUSTRALIENSIS
19	RHOMBODELLA PAUCISPINA
21	SENTUSIDINIUM SP. 1
25	SPINIFERITES SPP.
20	SUBTILISPHAERA KALAALLITI SP. NOV.
31	SUBTILISPHAERA PERLUCIDA
22	VESPEROPSIS AFF. V. FRAGILIS
35	WALLODINIUM LUNA
27	XIPHOPHORIDIUM ALATUM

2	subzone
V	zone
U. Albian	stage

section 36

Svinhufvud Bjerge Traill Ø



SPECIES LOCATION INDEX

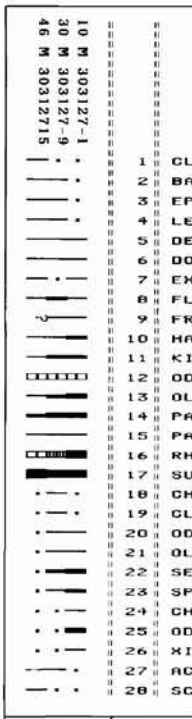
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
36	ACRITARCH
11	BATIOLADINIUM JAEGERI
26	CAUCA PARVA
34	CHLAMYDOPHORELLA NYEI
8	CHLAMYDOPHORELLA TRABECULOSA
1	CIRCULODINIUM DISTINCTUM
32	CLEISTOSPHAERIDIUM HUGUONIOTII
12	CLEISTOSPHAERIDIUM? ACICULARE
3	DESMOCYSTA PLEKTA
27	DISCORSIA NANNA
13	DOROCYSTA LITOTES
6	EPELIDOSPHAERIDIA SP. 1
14	EXOCHOSPHAERIDIUM PHRAGMITES
10	FLORENTINIA MANTELLII/COOKSONIAE group
35	FROMEA AFF. F. EXPOLITA
15	FROMEA FRAGILIS
16	HAPSOCYSTA? BENTEAE SP. NOV.
4	KIOKANSIUM POLYPES POLYPES
31	LEVISPHAERA CF. L. CRASSICINGULATA
7	ODONTOCHITINA ANCALA
33	ODONTOCHITINA COSTATA
17	ODONTOCHITINA OPERCULATA
28	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
5	OLIGOSPHAERIDIUM CF. O. TOTUM
18	OLIGOSPHAERIDIUM COMPLEX
29	PALAEOHYSTRICHOPHORA INFUSORIODES
9	PALAEOPERIDINIUM CRETACEUM
19	PALAEOPERIDINIUM? SP. 1
20	PSEUDOCERATIUM AFF. P. EXPOLITUM
37	PTEROSPERMELLA CF. P. AUSTRALIENSIS
21	RHOMBODELLA PAUCISPINA
22	SENTUSIDINIUM SP. 1
2	SENTUSIDINIUM SP. 2
23	SPINIFERITES SPP.
24	SUBTILISPHAERA KALAALLITI SP. NOV.
25	VESPEROPSIS AFF. V. FRAGILIS
30	XIPHOPHORIDIUM ALATUM

2	subzone
V	zone
U. Albian	stage

section 37

Svinhufvud Bjerge Traill Ø



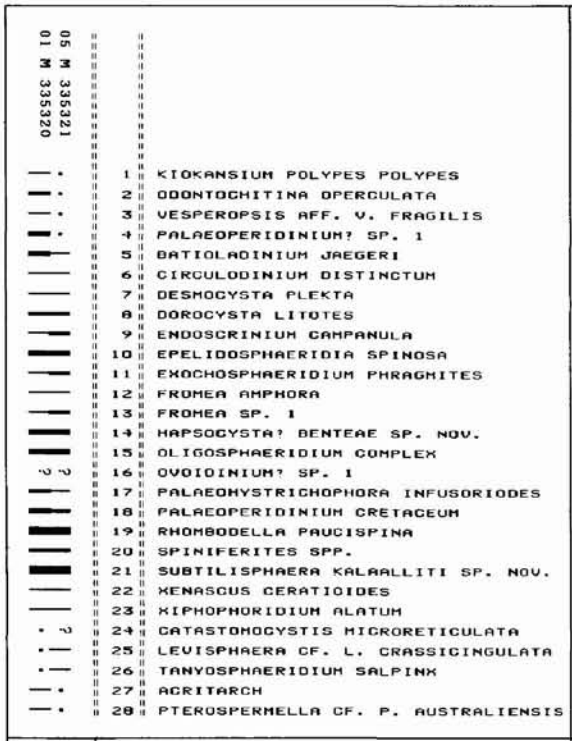
SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
27	ACRITARCH
2	BATIOLADINIUM JAEGERI
18	CHLAMYDOPHORELLA NYEI
24	CHLAMYDOPHORELLA TRABECULOSA
1	CLEISTOSPHAERIDIUM HUGUONIOTII
19	CLEISTOSPHAERIDIUM? ACICULARE
5	DESMOCYSTA PLEKTA
6	DOROCYSTA LITOTES
3	EPELIDOSPHAERIDIA SP. 1
7	EXOCHOSPHAERIDIUM PHRAGMITES
8	FLORENTINIA MANTELLII/COOKSONIAE group
9	FROMEA FRAGILIS
10	HAPSOCYSTA? BENTEAE SP. NOV.
11	KIOKANSIUM POLYPES POLYPES
4	LEVISPHAERA CF. L. CRASSICINGULATA
12	ODONTOCHITINA ANCALA
20	ODONTOCHITINA COSTATA
25	ODONTOCHITINA OPERCULATA
21	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
13	OLIGOSPHAERIDIUM COMPLEX
15	PALAEOPERIDINIUM CRETACEUM
14	PALAEOPERIDINIUM? SP. 1
16	RHOMBODELLA PAUCISPINA
28	SCHIZOCYSTIA
22	SENTUSIDINIUM SP. 1
23	SPINIFERITES SPP.
17	SUBTILISPHAERA KALAALLITI SP. NOV.
26	XIPHOPHORIDIUM ALATUM

2	subzone
V	zone
U. Albian	stage

section 38
shallow well
Svinhufvud Bjerge Traill Ø



SPECIES LOCATION INDEX

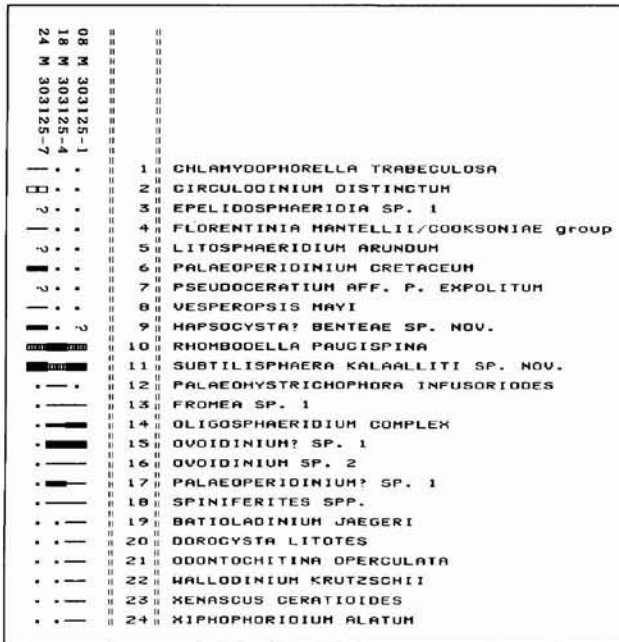
Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
27	ACRITARCH
5	BATIOLADINIUM JAEGERI
24	CATASTOMOCYSTIS MICRORETICULATA
6	CIRCULODINIUM DISTINCTUM
7	DESMOCYSTA PLEKTA
8	DOROCYSTA LITOTES
9	ENDOSCRINIUM CAMPANULA
10	EPELIDOSPHAERIDIA SPINOSA
11	EXOCHOSPHAERIDIUM PHRAGMITES
12	FROMEA AMPHORA
13	FROMEA SP. 1
14	HAPSOCYSTA? BENTEAE SP. NOV.
1	KIOKANSIUM POLYPES POLYPES
25	LEVISPHAERA CF. L. CRASSICINGULATA
2	ODONTOCHITINA OPERCULATA
15	OLIGOSPHAERIDIUM COMPLEX
16	OVOIDINIUM? SP. 1
17	PALAEOHYSTRICHOPHORA INFUSORIODES
18	PALAEOPERIDINIUM CRETACEUM
4	PALAEOPERIDINIUM? SP. 1
28	PTEROSPERMELLA CF. P. AUSTRALIENSIS
19	RHOMBODELLA PAUCISPINA
20	SPINIFERITES SPP.
21	SUBTILISPHAERA KALAALLITI SP. NOV.
26	TANYOSPHAERIDIUM SALPINX
3	VESPEROPSIS AFF. V. FRAGILIS
22	XENASCUS CERATIOIDES
23	XIPHOPHORIDIUM ALATUM

4	subzone
V	zone
U.Albian	stage

section 39

Svinhufvud Bjerge Traill Ø



SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
19	BATIOLADINIUM JAEGERI
1	CHLAMYDOPHORELLA TRABECULOSA
2	CIRCULODINIUM DISTINCTUM
20	DOROCYSTA LITOTES
3	EPELIDOSPHAERIDIA SP. 1
4	FLORENTINIA MANTELLII/COOKSONIAE group
13	FROMEA SP. 1
9	HAPSOCYSTA? BENTEAE SP. NOV.
5	LITOSPHAERIDIUM ARUNDUM
21	ODONTOCHITINA OPERCULATA
14	OLIGOSPHAERIDIUM COMPLEX
16	OVOIDINIUM SP. 2
15	OVOIDINIUM? SP. 1
12	PALAEOHYSTRICHOPHORA INFUSORIODES
6	PALAEOPERIDINIUM CRETACEUM
17	PALAEOPERIDINIUM? SP. 1
7	PSEUDOCERATIUM AFF. P. EXPOLITUM
10	RHOMBODELLA PAUCISPINA
18	SPINIFERITES SPP.
11	SUBTILISPHAERA KALAALLITI SP. NOV.
8	VESPEROPSIS MAYI
22	WALLODINIUM KRUTZSCHII
23	XENASCUS CERATIOIDES
24	XIPHOPHORIDIUM ALATUM

3	subzone
V	zone
U.Albian	stage

section 40

shallow well

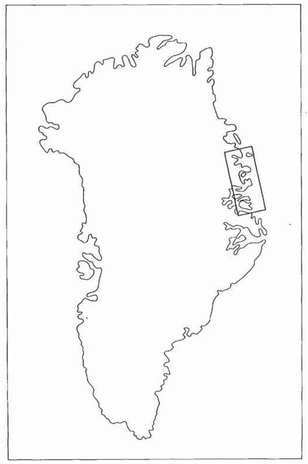
Svinhufvud Bjerge Traill Ø

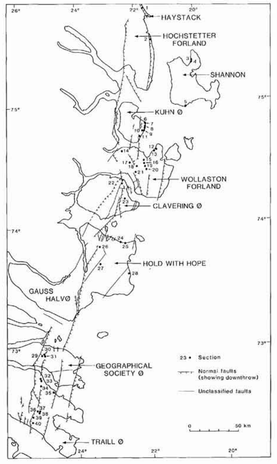
Key to Species Diversity

	= Very Rare	0- 0.49%
	= Rare	0.5- 0.99%
	= Few	1.0- 4.9 %
	= Frequent	5.0- 9.9 %
	= Common	10.0-24.9 %
	= Abundant	25.0-49.9 %
	= Dominant	50.0-100 %
?	= Questionably Present	
.	= Not Present	

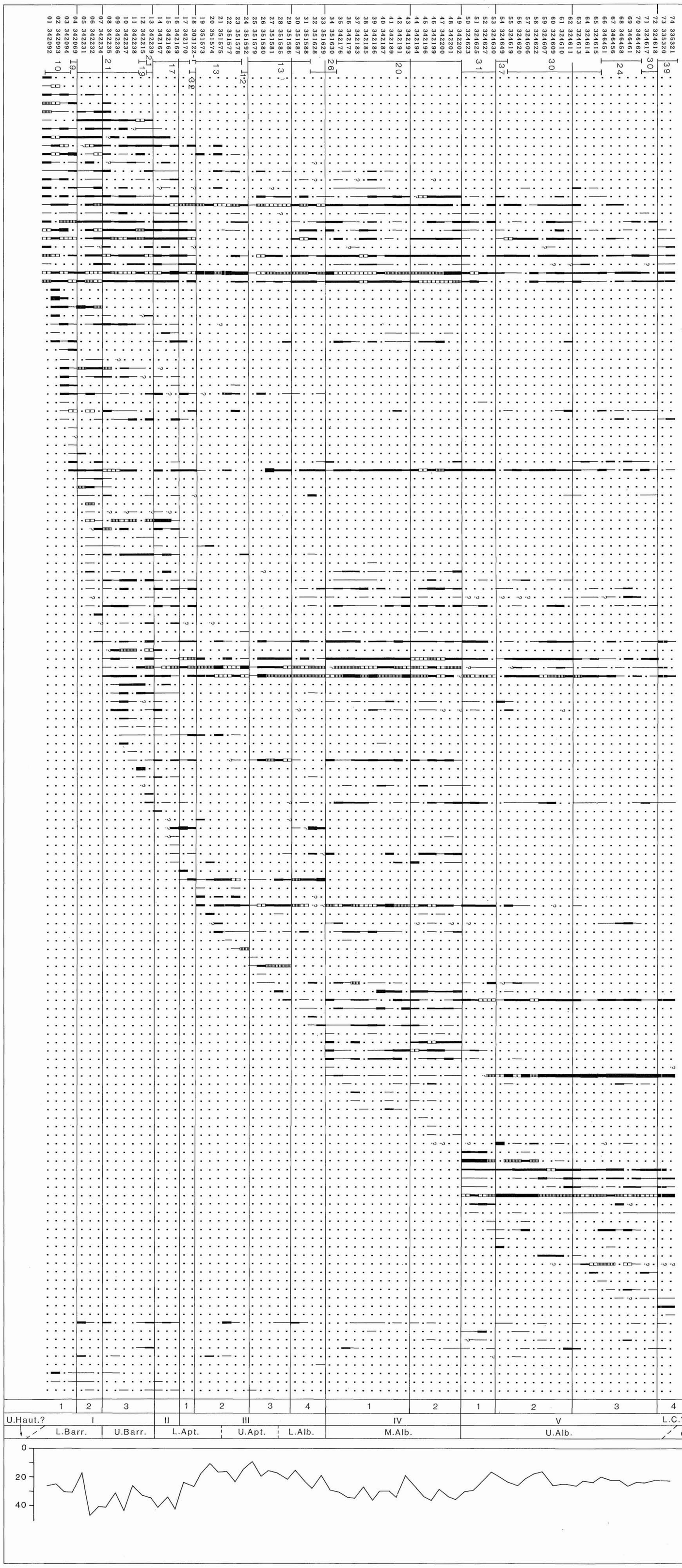
Enclosure 1. Lithologies, thicknesses and biostratigraphical correlation of the 40 sections that yielded dinoflagellate cysts. The section numbers correspond to the numbers used on the insert map. Lines on the left of the lithological columns indicate positions of the studied samples. The thickness of each section is also indicated to the left of each column.

Enclosure 2. Composite rangechart and species diversity. The samples are numbered from 1 to 74 followed by the GGU sample number. The numbers to the right of the GGU numbers refer to the numbered sections. Further explanations to the range-chart are given in the Appendix; the key to the species diversity is given on p. 171.




HAYSTACK
HOCHSTETTER FORLAND
SHANNON
KUHN Ø
WOLLASTON FORLAND
CLAVERING Ø
HOLD WITH HOPE
GAUSS HALVØ
GEOGRAPHICAL SOCIETY Ø
TRAILL Ø
33 • Section
Normal faults (showing downthrow)
Unclassified faults
0 50 km

Upper? Hauterivian
Lower Barremian
Upper Barremian
Lower Aptian
Upper Aptian
Lower Albian
Middle Albian
Lower? Cenomanian
Zones
Subzones
Sections
Regions
North of Haystack
Hoch-stetter Forland
Shannon
Kuhn Ø
Wollaston Forland
Clavering Ø
Hold with Hope
Geographical Society Ø
Traill Ø
Late Albian
LITHOLOGY
Scree covered
Sandstone
Mudstone
Interlaminated sandstone (50 %) and mudstone (50 %)
Palynological sample
Isolated concretions
Horizon of concretions
B Overlying Tertiary basalts
J Underlying Jurassic sediments
V Underlying Valanginian sediments



SPECIES LOCATION INDEX

Index numbers are the columns in which species appear.

INDEX NUMBER	SPECIES
152	?HAIR FROM LEAF
29	ACHOMOSPHAERA? NEPTUNI
147	ACRITARCH
121	APTEODINIUM CF. A. GRANDE
75	APTEODINIUM RETICULATUM
76	ATOPODINIUM HAROMENSE
123	BALMULA PENTARADIATA
67	BATIOLADINIUM JAEGERI
6	BATIOLADINIUM LONGICORNUTUM
57	BATIOLADINIUM MICROPODUM
113	BATIOLADINIUM SHAFTESBURIENSE SP. NOV.
55	BATIOLADINIUM? EXIGUUM
83	BATIOLADINIUM? PELLIFERUM
119	BOURKIDINIUM GRANULATUM
124	BOURKIDINIUM SP. 1
84	CALLAIOSPHAERIDIUM ASYMMETRICUM
103	CANNINGIA RETICULATA
104	CANNINGINOPSIS CF. C. COLLIVERI
102	CARPODINIUM GRANULATUM
48	CASSICULOSPHAERIDIA RETICULATA
117	CATASTOMOCYSTIS MICRORETICULATA
107	CAUCA PARVA
114	CHICHAOUADINIUM VESTITUM
46	CHLAMYDOPHORELLA NYEI
16	CHLAMYDOPHORELLA TRABECULOSA
53	CIRCULODINIUM AFF. C. ATTADALICUM
95	CIRCULODINIUM BREVISPINOSUM
20	CIRCULODINIUM DISTINCTUM
128	CIRCULODINIUM SP. 1
37	CIRCULODINIUM? SP. 2
96	CIRCULODINIUM? SP. 3
40	CLEISTOSPHAERIDIUM HUGUONIOTII
18	CLEISTOSPHAERIDIUM? ACICULARE
66	CORONIFERA OCEANICA
50	CRIBROPERIDINIUM EDWARDSII
51	CRIBROPERIDINIUM EXILICRISTATUM
133	CRIBROPERIDINIUM INTRICATUM
82	CRIBROPERIDINIUM MUDERONGENSE
139	CRIBROPERIDINIUM TENSIFTENSE
111	CRIBROPERIDINIUM? AFF. C. CORNUTUM
42	CTENIDODINIUM ELEGANTULUM
86	DESMOCYSTA PLEKTA
9	DINGODINIUM? ALBERTII
74	DISCORSIA NANNA
130	DOROCYSTA LITOTES
81	ELLIPSOIDICTYUM IMPERFECTUM
21	ENDOSCRINIUM CAMPANULA
138	EPELIDOSPHAERIDIA SP. 1
145	EPELIDOSPHAERIDIA SPINOSA
77	EXIGUISPHAERA PLECTILIS
22	EXOCHOSPHAERIDIUM PHRAGMITES
63	FLORENTINIA MANTELLII/COOKSONIAE group
143	FROMEA AFF. F. EXPOLITA
23	FROMEA AMPHORA
91	FROMEA CF. F. GLABELLA
62	FROMEA FRAGILIS
41	FROMEA SP. 1
106	GONYAULACYSTA AFF. G. CASSIDATA
3	GONYAULACYSTA FASTIGIATA
36	GONYAULACYSTA HELICOIDEA HELICOIDEA
154	GONYAULACYSTA JURASSICA
26	GONYAULACYSTA PERFOROBTUSA
109	HAPSOCYSTA? BENTEAE SP. NOV.
11	HESLERTONIA HESLERTONENSIS
72	HYSTRICHODINIUM AFF. H. FURCATUM
122	HYSTRICHODINIUM PULCHRUM PULCHRUM
7	HYSTRICHODINIUM VOIGTII
35	HYSTRICHOSPHAERIDIUM ARBORISPINUM
73	HYSTRICHOSPHAERINA SCHINDEWOLFII
19	KIOKANSIUM POLYPES POLYPES
45	KLEITHRIASPHAERIDIUM CORRUGATUM
13	KLEITHRIASPHAERIDIUM EOINODES
32	LAGENADINIUM? MEMBRANOIDIUM
148	LEIOFUSA SP.
101	LEPTODINIUM CANCELLATUM
97	LEPTODINIUM? CF. L. DELICATUM
38	LEPTODINIUM? HYALODERMOPSE
47	LEVISPHAERA CF. L. CRASSICINGULATA
116	LITOSPHAERIDIUM ARUNDUM
142	LITOSPHAERIDIUM SIPHONIPHORUM
135	LUXADINIUM SP.
33	MEIOUROGONYAULAX STOVERI
49	MUDERONGIA AFF. M. SIMPLEX MICROPERFORATA
27	MUDERONGIA AUSTRALIS
64	MUDERONGIA CF. M. TOMASZOWENSIS
1	MUDERONGIA STAUROTA
8	MUDERONGIA TETRACANTHA
4	NELCHINOPSIS KOSTROMIENSIS
78	NYKTERICYSTA? VITREA
126	ODONTOCHITINA ANCALA
70	ODONTOCHITINA OPERCULATA
112	ODONTOCHITINA SINGHII
2	OLIGOSPHAERIDIUM CF. O. ALBERTENSE
43	OLIGOSPHAERIDIUM CF. O. FENESTRATUM
15	OLIGOSPHAERIDIUM CF. O. PULCHERRIMUM
100	OLIGOSPHAERIDIUM CF. O. TOTUM
24	OLIGOSPHAERIDIUM COMPLEX
80	OLIGOSPHAERIDIUM PERFORATUM COLUM
99	OLIGOSPHAERIDIUM PERFORATUM PERFORATUM
17	OLIGOSPHAERIDIUM POCULUM
90	OLIGOSPHAERIDIUM PROLIXISPINOSUM
108	OLIGOSPHAERIDIUM SP. 1
10	OLIGOSPHAERIDIUM? ASTERIGERUM
94	OVOIDINIUM CINCTUM
141	OVOIDINIUM SP. 2
140	OVOIDINIUM? SP. 1
131	PALAEOHYSTRICHOPHORA INFUSORIOIDES
71	PALAEOPERIDINIUM CRETACEUM
129	PALAEOPERIDINIUM? SP. 1
14	PAREODINIA SPP.
31	PROLIXOSPHAERIDIUM PARVISPINUM
87	PROTOELLIPSODINIUM CLAVULUM
125	PROTOELLIPSODINIUM SPINOCRISTATUM
136	PSEUDOCERATIUM AFF. P. EXPOLITUM
28	PSEUDOCERATIUM ANAPHRISSUM
88	PSEUDOCERATIUM CF. P. RETUSUM
92	PSEUDOCERATIUM EISENACKII
115	PSEUDOCERATIUM EXPOLITUM
85	PSEUDOCERATIUM IVARI SP. NOV.
54	PSEUDOCERATIUM NUDUM
5	PSEUDOCERATIUM PELLIFERUM
110	PSEUDOCERATIUM POLYMORPHUM
68	PSEUDOCERATIUM TOVEAE SP. NOV.
150	PTEROSPERMELLA CF. P. AUSTRALIENSIS
118	RHOMBODELLA PAUCISPINA
34	RHYNCHODINIOPSIS CF. R. APTIANA
153	RIGAUDELLA SP.
149	SCHIZOCYSTIA
105	SENONIASPHAERA MICRORETICULATA
69	SENTUSIDINIUM SP. 1
61	SENTUSIDINIUM SP. 2
93	SENTUSIDINIUM VERRUCOSUM
30	SIRMIODINIUM GROSSII
25	SPINIFERITES SPP.
59	STIPHROSPHAERIDIUM CF. S. ANTHOPHORUM
132	SUBTILISPHAERA KALAALLITI SP. NOV.
65	SUBTILISPHAERA PERLUCIDA
56	SURCULOSPHAERIDIUM AFF. S. PHOENIX
79	SYSTEMATOPHORA AFF. S. CRETACEA
12	TANYOSPHAERIDIUM BOLETUS
58	TANYOSPHAERIDIUM CF. T. ISOCALAMUS
146	TANYOSPHAERIDIUM SALPINX
52	TRICHODINIUM SPEETONENSE
155	TUBOTUBERELLA SP.
44	TUBOTUBERELLA UNCINATA
151	ULVELLA NANNAE
137	VESPEROPSIS AFF. V. FRAGILIS
89	VESPEROPSIS LONGICORNIS
98	VESPEROPSIS MAYI
120	VESPEROPSIS? DIGITATA
60	WALLODINIUM KRUTZSCHII
39	WALLODINIUM LUNA
127	WIGGINSIELLA GRANDSTANDICA
144	XENASCUS CERATIOIDES
134	XIPHOPHORIDIUM ALATUM