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MIDDLE EOCENE DINOFLAGELLATE CYSTS FROM THE ROGOŹNIK SECTION, FLYSCH CARPATHIANS, POLAND

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ABSTRACT. 47 dinoflagellate cyst genera 80 species and 1 subspecies are reported from a section of flysch deposits in the Rogoźnik village, Flysch Carpathians, Poland. The age of studied deposits established on the basis of dinocysts is Eocene, presumably Middle Eocene (*Rhombodinium draco* Zone). The morphological variety within the complex *Homotryblium abbreviatum-H. tenuispinosum* is reported. Three new species are established. These are *Dracodinium laszczynskii* sp. nov., *Homotryblium conicum* sp. nov., and *Cordosphaeridium? solidospinosum* sp. nov.

KEY WORDS: Eocene, Dinoflagellate cysts, biostratigraphy, Flysch Carpathians

INTRODUCTION

This report is intented to document the palynological content and the age of the flysch deposits from an outcrop at Rogoźnik village near Nowy Targ, Polish Carpathians (Fig. 1B).

The studied section (Fig. 2) represents flysch deposits of the Magura Nappe, the southernmost unit of the Outer (Flysch) Carpathians in Poland. It consists of alternating greenish shales and sandstones layers. The section is situated close to tectonic border of the Magura Nappe in the north, and the Pieniny Klippen Belt in the south (Fig. 1A). According to Watycha (1978), the age of these deposits is Paleocene-Lower Eocene, according to Cieszkowski et al. (1991) is Miocene.

MATERIAL AND METHODS

6 samples for palynological studies have been taken from the outcrop at the Rogoźnik village (Fig. 2). One additional sample supplied by Dr. M. Cieszkowski from the same locality has been studied; its exact stratigraphic position is not clear.

Cleaned and crushed samples (15–20 grams each) were processed using standard palynological maceration techniques with both hydrochloric and hydrofluoric acid. Dissolved samples were sieved with 15 μm nylon sieve and separated with heavy liquid $ZnCl_2$ (s. g.: 2.00 g/cm^3). Two permanent slides were made for each sample using glycerine jelly as a mounting medium. The number per slide of dinocyst species and other palynomorphs was calculated. Both the slides and residues are stored in the collection of the Institute of Geological Sciences, Polish Academy of Sciences, Kraków, Poland.

SYSTEMATIC PALEONTOLOGY

Systematic division after Fensome et al. (1993).

Division DINOFLAGELLATA (Bütschli 1885) Fensome et al. 1993

Class DINOPHYCEAE Pascher 1914
Subclass PERIDINIPHYCIDAE Fensome et al. 1993
Order GONYAULACALES Taylor 1980
Suborder GONYAULACINEAE (Autonym)

Family Gonyaulacaceae Lindermann 1928
Subfamily Leptodinioideae Fensome et al. 1993

Genus ***Rhynchodiniopsis*** Deflandre 1938 emended Jan du Chne et al. 1985

Rhynchodiniopsis cladophora (Deflandre) Below 1981

Pl. 8, fig. 2

Remarks. One specimen was found. It shows subcircular shape without apical or antapical protrusions. Parasutural ridges very

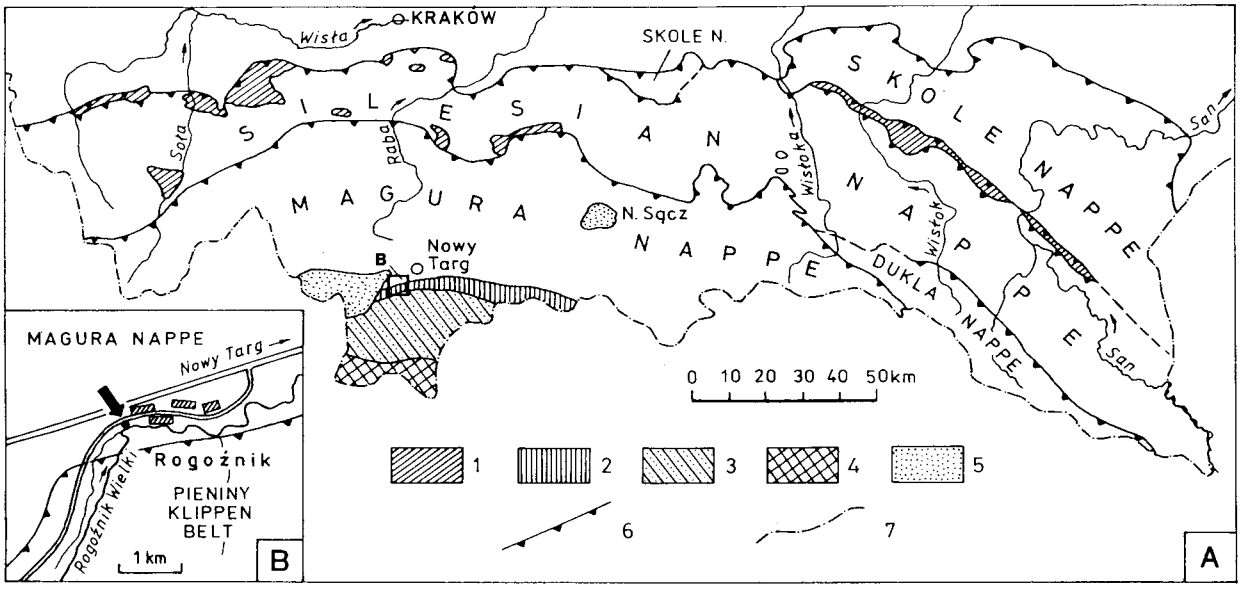

Fig. 1. A – Tectonic units of the Polish Carpathians (after Książkiewicz (1972); simplified); B – Position of ivestigated section; 1. Subsilesian nappe; 2. Pieniny Klippen Belt; 3. Podhale Flysch; 4. Tatra Mountains; 5. Freshwater Miocene; 6. overthrusts; 7. state boundary.

low, giving rise to short (3–4 μm), solid and distally capitating spines. These spines do not appear on all ridges.

Subfamily Cribroperidinioideae Fensome et al. 1993

Genus ***Apteodinium*** Eisenack 1958

Apteodinium sp.

Description. Cyst subspherical, with short apical horn. Autophragm devoid of parasutural features except for two distinct ridges limiting the paracingular area. Cyst wall thick, covered by numerous low-relief forms (granulae and linear structures) giving rise of "wooly" structure of the wall. Dimensions of the central body 86 × 90 μm, length of the apical horn 7 μm. Only one specimen found.

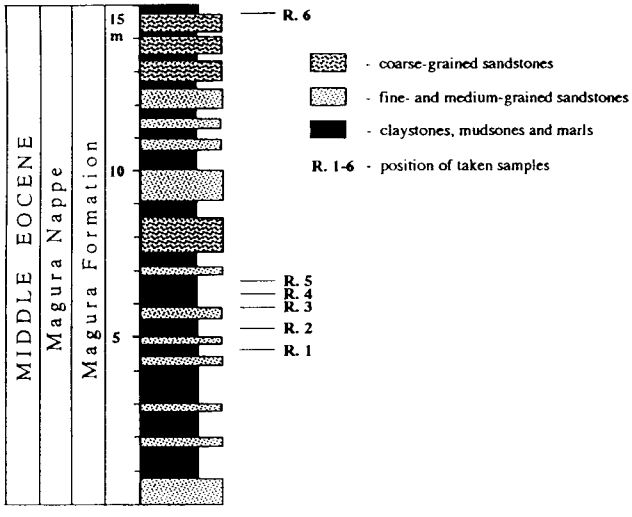

Fig. 2. Lithological section of studied deposits at Rogoźnik village (after Cieszkowski (1992); simplified).

Genus ***Cordosphaeridium*** Eisenack 1963

Cordosphaeridium fibrospinosum Davey & Williams 1966

Pl. 5, fig. 4

Remarks. Specimens with fibrous processes, some broader (6–24 μm) than long (12–20 μm). Diameter of central body 44–70 μm.

Cordosphaeridium gracile (Eisenack) Davey & Williams 1966

Pl. 4, fig. 1; Pl. 9, fig. 9; Pl. 10, fig. 3

Remarks. This species differs from *C. inodes* by generally thinner and smoother processes that are also branched (Y-shaped). Some specimens possess very thin, solid, not fibrous, distally bifurcate or trifurcate processes. Diameter of central body 60–54 μm, length of processes 44 μm.

Cordosphaeridium inodes (Klumpp) Eisenack 1963

Pl. 5, figs 1–2; Pl. 9, fig. 10

Remarks. This is the most frequent representative of the genus *Cordosphaeridium* in the studied material. Several specimens show some features similar to that of *C. gracile* (thiner and smoother processes); presumably they represent transitional forms between

these two species (Pl. 5, fig. 3). Archeopyle precingular (3").

Cordosphaeridium multispinosum
Davey & Williams 1966
Pl. 5, fig. 6

Remarks. Diameter of central body 50 μm, length of processes 16–18 μm.

Cordosphaeridium? solidospinosum sp. nov.
Pl. 4, fig. 2; Pl. 5, figs 7–8

1977. *Cordosphaeridium* aff. *inodes gracilis* (Eisenack 1954); De Coninck, J., p. 40, pl. 5, fig. 1.

Description. Cyst chorate, subspherical. Cyst wall thick, faintly to strongly ornamented. Processes solid, nonfibrous, slender and relatively thin, bifurcate or trifurcate, often complexly branched distally. Archeopyle precingular (3"); operculum free.

Holotype. Slide R.IV-2, England Finder coordinates [K 42.2]

Paratype. Slide R.I-1, England Finder coordinates [C 30.3]

Type locality. Magura Formation, lower part (Magura Nappe, Polish Flysch Carpathians). Left bank of Rogoźnik Wielki stream at Rogoźnik village, 10 km west of Nowy Targ.

Derivation of name. Latin, *solidus*, solid; *spinosus*, thorny – referring to the appearance of the processes.

Dimensions. Diameter of central body 50–60 μm × 70–80 μm, length of processes 40 μm.

Occurrence. Ypresian-Lutetian of the Woensdrechts boring (S Netherlands), as *Cordosphaeridium* aff. *inodes gracilis* of De Coninck (1977); Middle Eocene of the Polish Flysch Carpathians (Magura Nappe), this study.

Comparision. The character of the processes distinguishes *Cordosphaeridum? solidospinosum* from all previously described forms. *C.? cracenospinosum* which also has slender, nonfibrous processes, possess hollow, distally expanded ones which are lacking in *C.? solidospinosum*. Processes do not arise from periphragm ridges in *C.? solidospinosum* contrary to those of *C.? carcenospinosum*.

C.? solidospinosum differs from *Operculodinium microtriainum* which has also solid processes by the nontabular character of the processes of the latter. Also the terminations of the processes of *O. microtriainum* are different.

Discussion. These forms are tentatively assigned to the genus *Cordosphaeridium*: their prcesses are nonfibrous, atypical for the genus. There are however several forms of *Cordosphaeridium gracile* observed in the Rogoznik samples showing some processes of the same character as *C.? solidospinosum*. This may indicate a close affinity of these two species. These forms were also assigned to the genus *Cordosphaeridium* (as *C.* aff. *inodes gracilis*) by De Coninck (1977).

Genus ***Cyclapophysis*** Benson 1976

Cyclapophysis monmouthensis
Benson 1976
Pl. 1, fig. 3

Remarks. One damaged specimen was found. Dimensions of the central body 56 × 72 μm, maximum length of the precingular processes 38 μm. Archeopyle precingular.

Genus ***Diphyes*** Cookson 1965

Diphyes colligerum
(Deflandre & Cookson) Cookson 1965
Pl. 3, fig. 11

Remarks. Three specimens were attributed to this species. Forms small, spherical to subspherical (diameter of central body 27–38 μm), covered by numerous, nontabular hollow processes, distally opened. Length of processes does not exceed 13 μm. Antapical process large (up to 20 μm), cylindrical (11 μm wide at the base), distally narrowing. Archeopyle apical, zigzag margin hardly visible.

Genus ***Hystrichokolpoma*** Klumpp 1953

Hystrichokolpoma rigaudiae
Deflandre & Cookson 1955

Remarks. Only one specimen of this species has been found. Diameter of the central body (without operculum) 34–38 μm, length of the processes 12–14 μm.

Hystrichokolpoma salacium Eaton 1976
Pl. 3, fig. 13

Remarks. One specimen of this species has been found. Diameter of the central body (without operculum) 50 μm, length of the processes 20 μm.

Genus ***Kallosphaeridium*** De Coninck 1969

Kallosphaeridium brevibarbatum
De Coninck 1969
Pl. 2, fig. 7

Remarks. Autophragm thick, granulate, without parasutural features (except of archeopyle). Operculum attached. Dimensions of the cyst 60–64 μm.

Genus ***Lingulodinium***
(Wall) Wall & Dale 1973

Lingulodinium machaerophorum
(Deflandre & Cookson) Wall 1967
Pl. 4, figs 5 & 9; Pl. 9, fig. 6

Remarks. Spherical cysts covered by nontabular hollow processes. Processes characteristic of *Lingulodinium*, distally closed (acuminate or, more seldom, bluntly rounded), blade-like, sometimes covered by short spines. Archeopyle combined: A1P or 2P. Central body diameter 45–63 μm, length and width of processes 11–15 μm and 2–3 μm respectively.

Genus ***Millioudodinium***
Stover & Evitt 1978

Millioudodinium sp.
Pl. 2, fig. 6

Remarks. One specimen has been assigned to this genus. Autophragm thick, covered by distinct granules up to 1 high. Smooth parasutural ridges of not uniform height (0.5–2 μm). No accessory ridges present on paraplates. Archeopyle precingular (3"), operculum free. Distinct apical horn, 10 μm high. Dimensions of cyst 40 × 58 μm.

Genus ***Operculodinium*** Wall 1967

Operculodinium centrocarpum
(Deflandre & Cookson) Wall 1967
Pl. 3, fig. 1; Pl. 9, fig. 3; Pl. 10, figs 10–11

Remarks. Forms spherical to subspherical, with precingular archeopyle (3"), covered by numerous nontabular and distally closed processes. Specimens from the Rogoźnik section assigned to this species show a large variability of central body dimension and length of processes which may vary from 40 to 65 μm, and from 12 to 25 μm respectively.

Operculodinium divergens
(Eisenack) Stover & Evitt 1978
Pl. 5, fig. 5

Remarks. Diameter of cyst body 52–64 μm, length of processes 20 μm.

Operculodinium microtriainum
(Klumpp) Islam 1983
Pl. 3, figs 2–3; Pl. 10, figs 7–8

Remarks. Forms relatively large, with diameter of central body encreasing 90 μm. Surface of cyst smoooth; cyst wall thick (3–4 μm). Numerous processes nontabular, solid, capitate, distally branching into three small hooks. Length of processes up to 60 μm.

Genus ***Thalassiphora***
(Eisenack & Gocht) Gocht 1968

Thalassiphora patula
(Williams & Downie) Stover & Evitt 1978
Pl. 2, figs 1 & 3; Pl. 9, fig. 5

Remarks. This is the most frequent dinocyst in the Rogoźnik section. Endocyst subspherical up to 80 μm in diameter, pericyst lenticular, up to 120 μm.

Thalassiphora pelagica
(Eisenack) Eisenack & Gocht 1960
Pl. 2, fig. 14

Remarks. Only one specimen was found. Endocyst diameter 70 μm, pericyst diameter 140 μm.

Subfamily Gonyaulacoideae (Autonym)

Genus ***Achomosphaera*** Evitt 1963

Achomosphaera alcicornu
(Eisenack) Davey & Williams 1966
Pl. 3, fig. 9

Remarks. Two specimens assigned to this species were found. Length of relatively thin (up to 3–4 μm) processes does not exceed half of the diameter of the central body (68 μm). Periphragm smooth, faint suture lines may be noticed on both periphragm and the processes. Distal termination of hollow processes typicaly bifurcate and trifurcate.

Achomosphaera sagena
Davey & Williams 1966
Pl. 3, fig. 5

Remarks. Thick periphrgam covered by numerous granulae, up to 1 μm high, causing the dark colouration of the cyst wall. Processes T-shaped, hollow (18 μm long and 3 μm thick), distally closed; diameter of central body 50–68 μm. Archeopyle precingular.

Achomosphaera sp. A
Pl. 10, fig. 6

Remarks. Processes very similar to those of *S. ramosus*, thin, hollow, distally bifurcate and trifurcate. Some processes are connected by high septa. Cyst surface devoid of any traces of paratabulation, smooth. Processes not connected proximally. Diameter of central body 40 μm, length of processes 14 μm.

Achomosphaera sp. B
Pl. 3, fig. 12

Remarks. This species is characterized by relatively large dimensions of the central body (90 μm) and short (25 μm), broad (9 μm), and hollow processes. Both processes and periphragm are smooth, without any marks of paratabulation. Two specimens were found.

Achomosphaera sp. C
Pl. 10, fig. 14

Remarks. A species of *Achomosphaera* distinguished by coarsely granular periphragm.

Genus ***Impagidinium*** Stover & Evitt 1978

Impagidinium spp.
Pl. 2, fig. 8

Remarks. Two representatives of this genus have been found. Poor state of preservation does not allow more precise assignment. A smaller form (26 μm), which is granulated, with low and smooth crests, resembles in outline *Impagidinium dispertitum*. A larger form (71 μm), with smooth surface and up to 4 μm high smooth septa, resembles *I. patulum*.

Impagidinium? sp. D
Head & Norris (1989)
Pl. 2, figs 10–11

Remarks. Cyst with small spherical central body ornamented with high parasutural(?) septa. Archeopyle, identified in one case only, seems to be apical. Diameter of central body 16 μm, height of septa 8–12 μm.

Genus ***Nematosphaeropsis***
Cookson & Eisenack 1955

Nematosphaeropsis reticulensis
(Pastiels) Sarjeant 1986
Pl. 2, fig. 9

Remarks. Dimensions of the central body 22–27 × 34 μm, length of the processes up to 15 μm.

Genus ***Pentadinium*** (Gerlach 1961)
Benedek, Gocht & Sarjeant 1982

Pentadinium sp. cf. ***P.? circumsutum***
(Morgenroth) Stover & Evitt 1978
Pl. 2, fig. 12

Remarks. Form with granular periphragm and broad, membranous parasutural crests (up to 22 μm). These features suggest its close affinity with *P.? circumsutum*, however poor state of preservation and scarcity of occurrence (2 specimens) do not allow a closer determination. Diameter of the cyst 90 × 106 μm.

Genus ***Pterodinium*** Eisenack 1958

Pterodinium cingulatum
(O. Wetzel) Below 1981
Pl. 3, fig. 6

Remarks. Specimens assigned to this species are characterized by very thick wall and smooth, thick crests. Broad "processes" are observed at gonal junctions of the crests. The "processes" are 14 μm high and 16 μm wide. Height of the septa does not exceed 4 μm. Both periphragm and crests are smooth. Archeopyle precingular (3"). Dimensions of central body 60 × 84–94 μm.

Genus ***Rottnestia*** Coookson & Eisenack 1961

Rottnestia borussica
(Eisenack) Cookson & Eisenack 1961
Pl. 1, fig. 5

Remarks. Only one specimen was found. Length of the cyst 75 μm, width 22 μm; length of the endocyst 45 μm.

Genus ***Spiniferites*** Mantell 1850

Spiniferites ramosus
(Ehrenberg) Loeblich & Loeblich 1966
Pl. 3, figs 4 & 8; Pl. 10, figs 4 & 12–13

Remarks. Several morphotypes have been assigned to this species without more detailed subdivision. *S. ramosus* from the Rogoźnik section is characterized by small dimensions (diameter of the central body 24–40 μm), thin cyst wall, and numerous, solid, distally bifurcate and trifurcate processes which are proximally connected by parasutural ridges.

Spiniferites sp. A
Pl. 3, fig. 7

Description. This is a species of the genus *Spiniferites* characterized by very high septa, equal in height with processes (10–12 μm), gonal in position. Trifurcate termination of processes exceeds height of membranous septa. Central body ellipsoidal, diameter 32–52 μm.

Remarks. *Spiniferites* sp. A differs from *S. membranaceous* by having septa of equal length which entirley cover the cyst and do not concentrate on the hypocyst only as in *S. membranaceous*.

Subfamily Uncertain

Genus ***Fibrocysta*** Stover & Evitt 1978

Fibrocysta axialis
(Eisenack) Stover & Evitt 1978
Pl. 4, figs 8 & 10

Remarks. *F. axialis* is distinguished from *F. vectensis* by slender processes, smaller cyst body and smoother cyst surface. Apical horn often not prominent. Cyst dimensions: diameter 40 × 60 μm, length of processes 20 μm.

Fibrocysta vectensis
(Eaton) Stover & Evitt 1978
Pl. 4, figs 11–12; Pl. 9, fig. 7

Remarks. Prominent apical process distally branching into three branches. Diameter of the central body 50 × 80 μm, length of processes 20 μm.

Genus ***Melitasphaeridium***
Harland & Hill 1979

Melitasphaeridium pseudorecurvatum
(Morgenroth) Bujak et al. 1980
Pl. 4, figs 6–7

Remarks. Number of processes exceeds 20, reaching maximal number of 35. This confirms observations of Morgenroth (1968) and Eaton (1976) that more than one process occurs on some paraplates. Shape of archeopyle (2P) of one specimen (Pl. 4, fig. 6) indicates on loss of two precingular paraplates instead of one (3"), contrary to the original diagnosis by Harland and Hill (1979). Dimensions of cyst body 27–38 μm, length of processes 11–16 μm.

Genus ***Scriniodinium*** Klement 1957
emended Prauss 1989

Scriniodinium crystallinum
(Deflandre) Klement 1960
Pl. 8, fig. 5

Remarks. One specimen was found.

Family Areoligeraceae Evitt 1963

Genus ***Adnatosphaeridium***
Williams & Downie 1966

Adnatosphaeridium multispinosum
Williams & Downie 1966
Pl. 1, fig. 4; Pl. 9, fig. 1 & 14; Pl. 10, fig. 9

Remarks. Central body diameter ranges between 49–63 μm and 40–56 μm whereas the length and width of processes remain the same, 25–27 μm and 1–4 μm, respectively. Some specimens resemble very closely *Glaphyrocysta intricata*.

Adnatosphaeridium vittatum
Williams & Downie 1966
Pl. 1, fig. 10

Remarks. The form differs from *A. multispinosum* by presence of broad processes, up to 9 μm thick. Only one specimen was found.

Genus ***Areoligera*** Lejeune-Carpentier 1938

Remarks. This genus is represented by three closely related species: *A. senonensis*, *A. medusettiformis* and *A. coronata* grouped in an informal *Areoligera senonensis* complex. Morphologically similar forms (process complexes are developed on the dorsal and ventral sur-

faces, and not only on the dorsal one) described by Williams & Downie (1966) as *A.* cf. *senonensis*, *A.* cf. *medusettiformis* and *A.* cf. *coronata* are also present in the studied material, although they are not distinguished as separate forms.

Areoligera senonensis
Lejeune-Carpentier 1938
Pl. 10, fig. 2

Remarks. Forms lenticular with frequent single antapical lobation. Proccesses arise from low ridges, not connected distally. Apical archeopyle suture zigzag clearly determinable. Separate apical plates often occurr. Observed ranges of central body diameter (without operculum) 72 × 65 μm to 45 × 38 μm; diameter of process complexes 11–18 μm, length of processes up to 16–18 μm.

Areoligera medusettiformis
(O. Wetzel) Lejeune-Carpentier 1938
Pl. 1, fig. 7

and

Areoligera coronata
(O. Wetzel) Lejeune-Carpentier 1938
Pl. 1, fig. 9

Remarks. These two species are distinguished from one another by the shape of process complexes which are more branched in case of *A. coronata*. In the material from Rogoźnik, there a continous transition is observed between these two species. It is very likely that they are conspecific as it was suggested by Morgenroth (1968) and Stover & Evitt (1978). Central body diameter (without operculum) 67 × 61 μm to 49 × 65 μm, length of processes does not exceed 16–18 μm.

Genus ***Chiropteridium*** Gocht 1960

Chiropteridium sp. cf. ***Ch. dispersum***
Gocht 1960
Pl. 1, fig. 11

Remarks. Only one specimen was found. Lenticular body with apical archeopyle (operculum free), covered by membranous processes arranged in rows and grouped on peripheral zone of the cyst body. No processes occurr on mid-ventral and mid-dorsal areas. The processes show various distal terminations, similar to those of *Ch. dispersum*. Antapical processes slightly longer than the others. This form differs from those described by Gocht (1960) by its smaller dimensions: diameter of the central body does not exceed 40 × 45 μm, whereas the holotype measures 80 × 80 μm.

Genus ***Glaphyrocysta*** Stover & Evitt 1978

Glaphyrocysta exuberans
(Deflandre & Cookson) Stover & Evitt 1978
Pl. 1, fig. 12

Remarks. Processes arise from the peripheral zone of the cyst body. They are thin, smooth, relatively long, distally connected by broad and granulated trabeculae.

Glaphyrocysta intricatum
(Eaton) Stover & Evitt 1978
Pl. 1, fig. 1

Remarks. This is the most common species of *Glaphyrocysta* in studied material. Usually one antapical lobation present. Processes smooth and faint, connected distally by trabeculae of approximately the same size, with acculate margins.

Glaphyrocysta laciniiforme
(Gerlach) Stover & Evitt 1978

Remarks. Specimens covered by relatively short (in relation to the central body) processes connected distally by broad trabeculae. Mid-ventral and mid-dorsal areas free of processes. Periphragm smooth or slightly granulated.

Glaphyrocysta ordinata
(Williams & Downie) Stover & Evitt 1978
Pl. 1, fig. 2

Remarks. Processes restricted to the peripheral zone of the cyst. Processes thin, proximately connected by trabeculae with highly acculated margins. In shape of process complexes, the form resembles *Areoligera medusettiformi* the latter differing by shorter processes not restricted to the peripheral zone.

Glaphyrocysta pastielsii
(Deflandre & Cookson) Stover & Evitt 1978
Pl. 1, fig. 13

Remarks. Form similar to *G. exuberans*, characterized by shorter and more proximately interconnections of the processes.

Genus ***Membranophoridium*** (Gerlach) Stover & Evitt 1978

Membranophoridium aspinatum
Gerlach 1961
Pl. 1, fig. 14

Remarks. One specimen of *M. aspinatum* has been found. Mid-dorsal and mid-ventral areas free of processes. Cyst dimensions (without operculum) 56 × 79 μm, height of the membranous processes up to 20 μm.

Suborder GONIODOMINEAE
Fensome et al. 1933
Family Goniodomaceae Lindemann 1928
Subfamily Goniodomoideae (Autonym)

Genus ***Heteraulacacysta***
Drugg & Loeblich Jr. 1967

Heteraulacacysta? leptalea
Eaton 1976
Pl. 2, fig. 5

Remarks. Cyst elliptical with very thin wall. One specimen has been assigned to this species on the basis of the following features: punctate surface, faint and low parasutural crests, and broad (up to 9 μm) membranous crests delimiting the paracingular area. Dimensions of the whole cyst (in apical-antapical view) 47 × 56 μm. The specimen of *H.? leptalea* described from Rogoźnik is much smaller than forms described by Eaton (1976) from the Bracklesham Beds.

Subfamily Pyrodinioideae
Fensome et al. 1993

Genus ***Homotryblium*** Davey & Williams 1966

Homotryblium abbreviatum
Eaton 1976
Pl. 6, figs 5–8

Remarks. Diameter of the cyst body of *H. abbreviatum* from Rogoźnik ranges between 36 and 48 μm, whereas the length of processes ranges between 10 and 14 μm, not exceeding one third of the central body diameter, according to original diagnosis by Eaton (1976). Breadth of processes is not constant on single specimens, and besides the slender processes on sulcal area, it may range fron 4 to 8 μm. Periphragm granular.

H. abbreviatum seems to be closely related to *H. tenuispinosum* from which it differs by shorter process. Transitional forms between these two species are often observed in the studied material (Pl. 6, fig. 10; Pl. 9, figs 4 & 8). They are characterized by granular cyst surface and hollow, tubiform processes, opened distally, with serrate or aculeate margin; their length is approximately one third of central body diameter.

Homotryblium caliculum
Bujak 1980
Pl. 6, fig. 14

Remarks. Diameter of central body 40 μm, length of processes 10–12 μm, breadth: 2–6 μm at the base and 10–12 μm at the distal termination.

Homotryblium conicum sp. nov.
Pl. 6, figs 1–4

Description. Cyst subspherical, chorate with wall composed of two layers: inner – endophragm, thin and smooth, outer – periphragm, covered with medium to coarse granulae (up to 1 μm). Processes intratabular, one per paraplate. Shape of processes conical, distally opened, in some cases distal margin faintly serrate. Width of processes variable, always broader at the base, getting narrower at the distal termination. Processes generally short, their length do not exceed one fourth of central body diameter. Archeopyle epicystal.

Holotype. Slide R.III-1, England Finder coordinates [F 43]

Paratype. Slide R.I-2, England Finder coordinates [S 33.1]

Type locality. Magura Formation, lower part (Magura Nappe, Polish Flysch Carpathians). Left bank of the Rogoźnik Wielki stream at Rogoźnik village, 10 km on west from Nowy Targ.

Derivation of name. Latin *conicum*, conical, in reference to the shape of processes.

Dimensions. Diameter of central body 36–40 × 40–50 μm. Width of processes: 8 μm at the base, and 2–4 μm at the top; length 8–12 μm.

Occurrence. Identified in the Rogoźnik section only. Middle Eocene.

Comparision. The shape of the processes differs *H. conicum* from all previously de-

scribed species of *Homotryblium*. Granular periphragm and short processes of *H. conicum* resemble *H. abbreviatum*, although the processes of the latter are usually tubiform and distally expanding and not narrowing as in *H. conicum*.

Homotryblium oceanicum
Eaton 1976
Pl. 6, fig. 15

Remarks. One specimen of *H. oceanicum* has been found. It differs from the original diagnosis by the character of periphragm which is rather not granular. Processes cylindrical, constant in breadth. Some specimens attributed to *H. pallidum* are very similar to *H. oceanicum*, differing by the shape of processes which, although also long and broad, are cylindrical and not constant in breadth. Diameter of central body 50 μm, length of processes 34 μm, breadth 10 μm.

Homotryblium pallidum
Davey & Williams 1966
Pl. 6, figs 11–12 & 16

Remarks. This form distinguishes by smooth periphragm, some small acuminate processes, and cylindrical tubiform processes. A few slender processes are present in sulcal area. Diameter of central body 36–50 μm, length of processes 24–28 μm, breadth 4–6 μm.

Homotryblium tenuispinosum
Davey & Williams 1966
Pl. 6, figs 9, 13 & 17

Remarks. Diameter of central body 36–56 μm, length of processes 14–20 μm. See also remarks under *H. abbreviatum*.

Genus ***Polysphaeridium***
(Davey & Williams 1966) Bujak et al. 1980

Remarks. Two morphotypes assigned to this genus have been found in the studied material: the first one is covered by numerous (app. 60), relatively thin (1 μm) and slender, hollow, distally opening processes; the second one with less numerous (30–40), shorter and thicker (2–3 μm) processes. The first morphotype has been determined as *P. subtile*, and the second one as *P. zoharyi*, although the difference between them is not very clear in many cases, especially when the epicystal archeopyle is missing. Some specimens may be transitional forms or these two species could be conspecific.

Polysphaeridium subtile
(Davey & Williams 1966) Bujak et al. 1980
Pl. 4, fig. 4

Remarks. Dimensions of central body 56–61 μm, length of processes 11–15 μm.

Polysphaeridium zoharyi
(Rossignol 1962) Bujak et al. 1980
Pl. 4, fig. 3; Pl. 9, fig. 2; Pl. 10, fig. 1

Remarks. Dimension of central body 57 μm, length of processes 9–11 μm.

Suborder UNCERTAIN
Family Uncertain

Genus ***Batiacasphaera*** Drugg 1970

Batiacasphaera sp.
Pl. 2, fig. 4

Remarks. Autocyst spherical to ovoidal. Autophragm thick, densely covered by granulae and other forms of low relief. Paratabulation absent, except in zone near the apical archeopyle suture which delimits the margins of precingular paraplates. Operculum free. Dimensions: 57 × 58 μm.

Genus ***Cleistosphaeridium*** Davey et al. 1966

Cleistosphaeridium microcysta
(Bujak 1980) Lentin & Williams 1981
Pl. 1, fig. 6

Remarks. Ovoidal cyst covered by numerous, nontabular, hollow, distally closed processes. Each specimen similar in size and shape; they may vary in length from 2 to 6 μm. Apical archeopyle margin hardly visible in several cases. Central body dimensions 36–41 × 45–54 μm.

Cleistosphaeridium sp.
Pl. 1, fig. 8

Remarks. Small spherical forms with granular autophragm covered by numerous, nontabular, short and distally closed (tips acuminate) processes. Archeopyle apical. Diameter of the central body 44 μm, length of the processes 8–10 μm.

Genus ***Dapsilidinium*** Bujak et al. 1980

Dapsilidinium sp.
Pl. 3, fig. 10; Pl. 9, fig. 12

Remarks. One damaged specimen has been found. State of preservation makes more detailed study difficult.

Genus ***Impletosphaeridium*** Morgenroth 1966

Impletosphaeridium kroemmelbeini
Morgenroth 1966

Remarks. Foems circular to subcircular covered by numerous, nontabular processes. Two types of processes have been observed: membranous, distally branching and aculeate, and slender, solid, distally bifurcating or multifurcating. In several cases, an opening was visible; its character is difficult to determine. Diameter of central body 40–60 μm, length of processes 18–22 μm.

Order PERIDINIALES Haeckel 1894
Suborder PERIDINIINEAE (Autonym)

Family Peridiniaceae Ehrenberg 1831
Subfamily Deflandreoideae Bujak & Davies 1983

Genus ***Deflandrea*** Eisenack 1938

Deflandrea denticulata
Alberti 1959
Pl. 2, fig. 2

Remarks. The spesies shows one apical and two antapical, well developed horns. Periphragm smooth, covered by numerous, nontabular spines. Length of the pericyst 96 μm, breadth 56 μm; length of the spines 2 μm.

Deflandrea phosphoritica? Eisenack 1938

Remarks. Two damaged specimens have been found. General shape of the cysts suggests their assignment as *D. phosphoritica*.

Genus ***Isabelidinium*** Lentin & Williams 1977

Isabelidinium sp.

Remarks. One specimen assigned to this genus has been found. Pericyst with one apical horn and two rounded, weakly developed antapical ones. A thickening of the pericyst in the pericingular area is remarkable. Periphragm granular. Endocyst circular, poorly visible occupies central part of the pericyst.

Genus ***Palaeocystodinium*** Alberti 1961

Palaeocystodinium golzowense?
Alberti 1961
Pl. 2, fig. 13; Pl. 5, fig. 9

Remarks. Periphragm smooth covered by small folds only – lack of parasutural features. Small roots on the periphragm in the central part have been recognized on one specimen. Length 120–130 μm, width 36–40 μm. General outline of the cyst resembles *P. benjaminii* Drugg 1967, which is characterized by small spines at the horns, and by the presence of rudimentary second antapical horn. These features, however, are lacking in case of Rogoźnik specimens. Therefore, they are assigned as *P. golzowense*?.

Subfamily Wetzelielloideae (Vozzhennikova)
Bujak & Davies 1983

Genus ***Apectodinium*** (Costa & Downie)
Lentin & Williams 1977

Apectodinium homomorphum
(Deflandre & Cookson) Lentin & Williams 1977
Pl. 10, fig. 5

Remarks. This is the most common species of the genus *Apectodinium* in the studied material. It is distinguished by its oval or subpentagonal outline, lack of prominent horns, and relatively long and thick nontabular processes. Endocyst is not observable. Diameter of the central body 45 × 40 μm, length of the processes 11–22 μm.

Apectodinium quinquelatum
(Williams & Downie) Costa & Downie 1979
Pl. 9, fig. 11

Remarks. Specimens assigned to this species differ from *A. homomorphum* by much shorter, thiner and less numerous nontabular processes. The general outline of *A. quinquelatum* is similar to that of subpentagonal *A. homomorphum*. No prominent horns have been observed. Some specimens presumably represent forms transitional to *A. homomorphum*. Cyst dimensions 49x38 μm , and length of processes 4–7 μm.

Apectodinium summissum
Harland 1979

Remarks. Prominent apical horn distinguishes this species from *A. quinquelatum*. Nature of nontabular processes (short and thin), similar to *A. quinquelatum*, suggests its affinity to that species and to *A. homomorphum* as proposed by Jan du Chene & Adediran (1984). Central body dimensions 56–68 × 45–54 μm, length of processes up to 7–9 μm.

Genus ***Charlesdowniea*** Lentin & Vozzhennikova 1989

Charlesdowniea clathrata
(Eisenack) Lentin & Vozzhennikova 1989

Remarks. Only one specimen was found. Dimensions: height 151 μm, width 102 μm; length of processes 8 μm.

Charlesdowniea coleothrypta
(Williams & Downie) Lentin & Vozzhennikova 1989
Pl. 8, figs 6–9

Remarks. This is the most common species within the genus. It shows a great variability in shape, from almost quadrate (height 104 μm, width 101 μm) to more elongated (120 μm × 103 μm respectively). All horns are well developed, although the apical one may be slightly rounded in several cases. Length of processes 10–12 μm.

Charlesdowniea coleothrypta subsp. ***rotundata***
(Chateauneuf & Gruas-Cavagnetto) Lentin & Vozzhennikova 1989
Pl. 8, figs 1 & 3

Remarks. This subspecies is distinguished by the lack of antapical horns; its antapex is completely rounded. Height of the cyst usually equals its width (100 × 100 μm). Processes are from 6 to 10 μm long.

Charlesdowniea tenuivirgula
(Williams & Downie) Lentin & Vozzhennikova 1989
Pl. 8, fig. 4

Remarks. Only one specimen was found. Processes distally connected by thin secae. Dimensions: height 158 μm, width 112 μm; length of processes 6–10 μm (processes of the central area longer than those from peripheral one).

Genus ***Dracodinium*** Gocht 1955

Dracodinium laszczynskii sp. nov.
Pl. 7, figs 11 & 13

1980. *Dracodinium* sp. 1; Helmann-Clausen, C., and Costa, L. I., p. 465, pl. 1, figs. 1–2.
1980. *Rhombodinium*? sp. B; Head, M. J., and Norris, G., p. 532, pl. 1, fig. 9.

Description. Cyst circumcavate with strongly rounded apex and well developed paracingular horns. Antapical horns not developed or visible as two sinusoid lobations. Endocyst subcircular. Pericoel continuous, well developed. Endophragm and periphragm smooth. No marks of paratabulation is visible except for intercalary archeopyle (2a) and small paracingular folds on paracingular horns. Operculum detached.

Holotype. Slide R.III-2, England Finder coordinates [R 43.4].

Isotype. Slide R.I-2, England Finder coordinates [H 45].

Type locality. Magura Formation, lower part (Magura Nappe, Polish Flysch Carpathians). Left bank of the Rogoźnik Wielki stream at Rogoźnik village, 10 km west of Nowy Targ.

Derivation of name. In honour of Dr Andrzej Łaszczyński, who introduced the author to the geology.

Dimensions. Length of the pericyst 80–96 μm, height 64–98 μm; endocyst 50 × 80 μm.

Occurrence. Lower Eocene (Ypresian) of German Lowlands (Wursterheide research well), as *Dracodinium* sp. 1 of Heilmann-Clausen and Costa (1980); Lower Eocene (NP11) of North Atlantic (Labrador Sea, DSDP Hole 647A), as *Rhombodinium*? sp. B of Head and Norris (1989); Middle Eocene of Polish Flysch Carpathians (Magura Nappe), this study.

Comparision. *D. laszczynskii* is distinguishable by very weakly developed antapical horns causing its circular shape. It differs from *Dracodinium condylos* by smooth periphragm.

Genus ***Rhombodinium*** Gocht 1955

Rhombodinium draco
Gocht 1955
Pl. 7, figs 1, 5, 7 & 12

Remarks. Periphragm thick and smooth in most cases, although some specimens posses very short, single spines or tubercles (m)

grouped in peripheral areas of the cysts; they may represent the forms transitional to *Gochtodinium spinula* Bujak 1979 as it was suggested by Bujak (1979). *G. spinula* is not present in Rogoźnik material. It is known from the Oligocene deposits of neighbouring Podhale Basin (Gedl 1995) (Fig. 1). Length 130 mm, height 110–130 μm; diameter of endocyst 70–90 μm.

Genus ***Wetzeliella*** Eisenack 1938

Wetzeliella unicaudalis
Caro 1973
Pl. 7, fig. 3

Remarks. Paracingulum indicated by a broad fold. Small spines gathered in peripheral areas of the cyst. Length 100 μm; height 80 μm. Only one specimen was found.

Wetzeliella sp. cf. ***W. meckelfeldensis***
Gocht 1969
Pl. 7, fig. 8

Remarks. One damaged specimen has been found. It shows prominent apical and one antapical horn, the latter one strongly reduced. Processes (10–14 μm long), distally terminated with two or three small hooks. Height of the cyst 130 μm, length 90 μm.

Family Congruentidiaceae
Schiller 1935
Subfamily Congruentidioideae (Autonym)

Genus ***Lejeunecysta*** Artzner & Dörhöfer 1978

Remarks. The present author retains the concept of this species as acavate forms, whereas the cavate forms are assigned to *Phelodinium* according to Stover and Evitt (1978).

Lejeunecysta hyalina
Gerlach 1961
Pl. 7, fig. 4

Remarks. Forma acavate, typically brown pigmented, with smooth autophragm, and paracingulum indicated by transverse folds.

Genus ***Phelodinium*** Stover & Evitt 1978

Phelodinium spp.
Pl. 7, figs 9–10

Remarks. All cavate forms similar to *Lejeunecysta* which differ by concave sides and more prominent horns, have been assigned to the genus *Phelodinium*. Periphragm smooth and pale, densely folded.

Family Uncertain

Genus ***Bellattudinium*** Yu et al. 1981

Remarks. The original paper of Yu Jingxian et al. (1981) is unknown up to now to the author. The assignment of the Rogoźnik specimens to this species was based on the description by Kurita and Matsuoka (1994).

Bellatudinium hokkaidoanum
Kurita & Matsuoka 1994
Pl. 7, figs 2 & 6; Pl. 9, fig. 13

Remarks. Cyst of peridinioid outline, acavate, rounded, pentagonal, with one apical horn and two antapical horns, one of which may be slightly reduced. Horns capitate or blunt. Autophragm thin, smooth, devoid of any parasutural features, densly folded. Paracingulum indicated by two equatorial, parallel folds. Archeopyle hardly visible (only in some cases), intercalary, presumably created by the lost of 2a paraplate.

Subclass DINOPHYSIPHYCIDAE
Möhn 1984
Order NANNOCERATOPSIALES
Piel & Evitt 1980
Family Nannoceratopsiaceae
Gocht 1970

Genus ***Nannoceratopsis*** Deflandre 1939

Nannoceratopsis sp.
Pl. 8, fig. 10

Remarks. One damaged specimen was found.

BIOSTRATIGRAPHY

Distribution of dinocysts in the studied samples is not uniform: they are much more abundant in older samples, becoming rare in the youngest ones (Fig. 3).

The whole dinocyst assemblage includes 47 genera, 80 species and 1 subspecies, the majority representing the Eocene taxa. The exact dating of the Rogoźnik samples is difficult due to the lack of comparable biostratigraphical

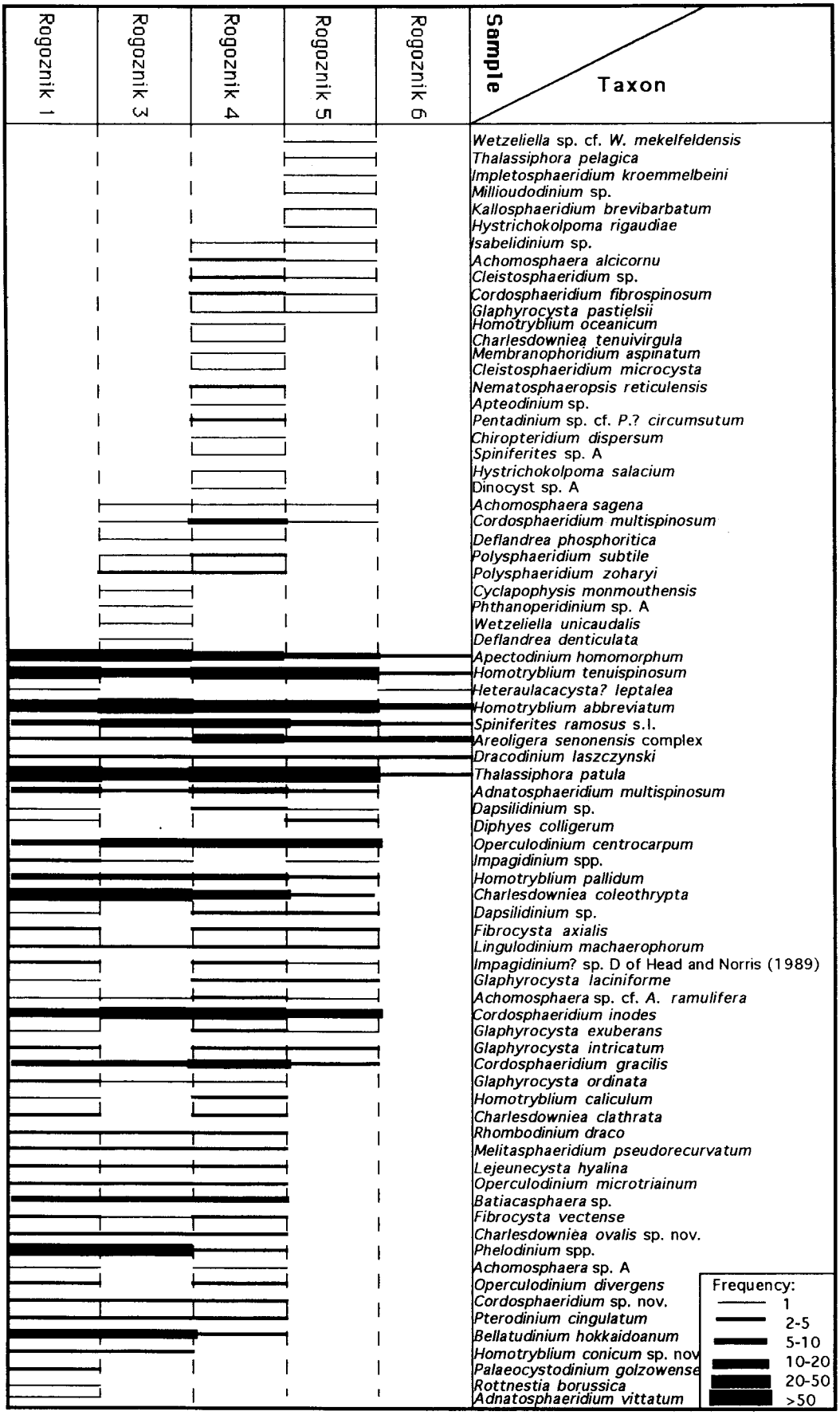

Fig. 3. Distribution of dinocysts in the Rogoźnik section. Sample ROGOŹNIK 2 was devoid of dinocysts.

data from the Eocene of Polish Flysch Carpathians. The only paper concerning Eocene dinocyst in the Polish Carpathians (Bujak in Van Couvering et al. 1981) concerns the Eocene/Oligocene transitional dinocysts from the Silesian Nappe.

Approximate dating of the samples was possible by comparison of the Rogoźnik dinocyst assemblage with those described from Eocene deposits of the NW Europe and the North Sea areas. The presence of *Rhombodinium draco* and the lack of *R. porosum* and *Gochtodinium simplex* allows to assign the studied deposits to the D10 Zone of Costa and Manum (1988) which is correlatable with calcareous nannofosil zone NP14? (pars)-NP16. Appearance of *Rhombodinium draco* indicates the presence of the *R. draco* Interval Biozone of Powell (1992), although neither *Areosphaeridium fenestratum* nor *Homotryblium floripes* are present at Rogoźnik. The Rogoźnik samples may also correlate with the *Rhombodinium draco* Biozone of Costa and Downie (1976), and to the equivalent *Heterolaucacysta porosa* (BAR-1) Assemblage Biozone of Bujak et al. (1980). These three biozones are correlatable with the calcarous nannofosil zone NP16.

There is however a number of dinocysts present in the Rogoźnik samples which become extinct just before the NP16 Zone. These are *Deflandrea denticulata*, *Cordosphaeridium fibrospinosum*, complex *Areoligera senonensis sensu* Gocht 1969, *Glaphyrocysta ordinata*, *Adnatosphaeridium vittatum*, *Charlesdowniea tenuivirgula* and *Hystrichokolpoma salacia*. These species are characteristic for older zones than the NP16 Zone such as *Areosphaeridium arcuatum* Interval Biozone and *Glaphyrocysta intricatum* Interval Biozone of Powell (1992). This may indicate either recycling of older taxa, or be an indication that *Rhombodinium draco* appeared in the Polish Flysch Carpathians already before NP16. The first possibility seems more probable as the older dinocysts appear as single specimens, except for more numerous representatives of *Areoligera senonensis* complex *sensu* Gocht 1969.

The presence in the investigated deposits of rare or single specimens of recycled dinocysts, such as *Cyclapophysis monmouthensis*, *Apectodinium quinquelatum*, *A. summisum*, *Wetzeliella unicaudalis* and *Wetzeliella* sp. cf. *W. meckelfeldensis*, indicates simultaneous erosion of Lower Eocene and Paleocene strata nearby. Three Jurassic taxa, *Scriniodinium crystallinum*, *Rhynchodiniopsis cladophora* and *Nannoceratopsis* sp. indicate that even pre-Tertiary rocks were subject to erosion, presumably in the Pieniny Klippen Belt.

PALAEOECOLOGY

The palynomorph content in the studied deposits consists of dominating terrestrial elements, such as higher plant tissues and more oxidized pieces of wood. Marine palynomorphs, mainly the dinocysts, are much less numerous. Such palynofacies is typical for flysch deposits, e. g. from Oligocene flysch deposits of Podhale Basin (Gedl 1995).

Dinocyst assemblage is relatively rich and diversified. It indicates normal marine environment. Other marine palynomorphs that occur subordinately in studied material are fungi (Pl. 8, fig. 11) and foraminiferal linings (Pl. 8, fig. 12).

CONCLUSIONS

The above mentioned data suggest the Middle Eocene age of the studied deposits. The Rogoźnik deposits seem to correlate with *Rhombodinium draco* Zone which is correlatable with NP 16 Zone. This locates the Rogoźnik section within a lower part of the Magura Formation (Magura Nappe, Polish Flysch Carpathians) according to the stratigraphical division of the southern part of this nappe (Birkenmajer & Oszczypko 1989).

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APPENDIX

Index of Rogoźnik dinocysts.

Achomosphaera alcicornu (Eisenack) Davey & Williams 1966 (Pl. 3, fig. 9)

Achomosphaera sagena Davey & Williams 1966 (Pl. 3, fig. 5)

Achomosphaera sp. A (Pl. 10, fig. 6)

Achomosphaera sp. B (Pl. 3, fig. 12)

Achomosphaera sp. C (Pl. 10, fig. 14)

Adnatosphaeridium multispinosum Williams & Downie 1966 (Pl. 1, fig. 4; Pl. 9, fig. 1 & 14; Pl. 10, fig. 9)

Adnatosphaeridium vittatum Williams & Downie 1966 (Pl. 1, fig. 10)
Apectodinium homomorphum (Deflandre & Cookson) Lentin & Williams 1977 (Pl. 10, fig. 5)
Apectodinium quinquelatum (Williams & Downie) Costa & Downie 1979 (Pl. 9, fig. 11)
Apectodinium summissum Harland 1979
Apteodinium sp.
Areoligera coronata (O. Wetzel) Lejeune-Carpentier 1938 (Pl. 1, fig. 9)
Areoligera senonensis Lejeune-Carpentier 1938 (Pl. 10, fig. 2)
Areoligera medusettiformis (O. Wetzel) Lejeune-Carpentier 1938 (Pl. 1, fig. 7)
Batiacasphaera sp. (Pl. 2, fig. 4)
Bellatudinium hokkaidoanum Kurita & Matsuoka 1994 (Pl. 7, figs 2 & 6; Pl. 9, fig. 13)
Charlesdowniea clathrata (Eisenack) Lentin & Vozzhennikova 1989
Charlesdowniea coleothrypta (Williams & Downie) Lentin & Vozzhennikova 1989 (Pl. 8, figs 6–9)
Charlesdowniea coleothrypta subsp. *rotundata* (Chateauneuf & Gruas-Cavagnetto) Lentin & Vozzhennikova 1989 (Pl. 8, figs 1 & 3)
Charlesdowniea tenuivirgula (Williams & Downie) Lentin & Vozzhennikova 1989 (Pl. 8, fig. 4)
Chiropteridium sp. cf. *Ch. dispersum* Gocht 1960 (Pl. 1, fig. 11)
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Cyclapophysis monmouthensis Benson 1976 (Pl. 1, fig. 3)
Dapsilidinium sp. (Pl. 3, fig. 10; Pl. 9, fig. 12)
Deflandrea denticulata Alberti 1959 (Pl. 2, fig. 2)
Deflandrea phosphoritica? Eisenack 1938
Diphyes colligerum (Deflandre & Cookson) Cookson 1965 (Pl. 3, fig. 11)
Dracodinium laszczynskii sp. nov. (Pl. 7, figs 11 & 13)
Fibrocysta vectensis (Eaton) Stover & Evitt 1978 (Pl. 4, figs 11–12; Pl. 9, fig. 7)
Fibrocysta axialis (Eisenack) Stover & Evitt 1978 (Pl. 4, figs 8 & 10)
Glaphyrocysta exuberans (Deflandre & Cookson) Stover & Evitt 1978 (Pl. 1, fig. 12)
Glaphyrocysta intricatum (Eaton) Stover & Evitt 1978 (Pl. 1, fig. 1)
Glaphyrocysta laciniiforme (Gerlach) Stover & Evitt 1978
Glaphyrocysta ordinata (Williams & Downie) Stover & Evitt 1978 (Pl. 1, fig. 2)
Glaphyrocysta pastielsii (Deflandre & Cookson) Stover & Evitt 1978 (Pl. 1, fig. 13)
Heteraulacacysta? leptalea Eaton 1976 (Pl. 2, fig. 5)
Homotryblium abbreviatum Eaton 1976 (Pl. 6, figs 5–8)
Homotryblium caliculum Bujak 1980 (Pl. 6, fig. 14)
Homotryblium conicum sp. nov. (Pl. 6, figs 1–4)
Homotryblium oceanicum Eaton 1976 (Pl. 6, fig. 15)
Homotryblium pallidum Davey & Williams 1966 (Pl. 6, figs 11–12 & 16)
Homotryblium tenuispinosum Davey & Williams 1966 (Pl. 6, figs 9, 13 & 17)
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Hystrichokolpoma salacium Eaton 1976 (Pl. 3, fig. 13)
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Impagidinium? sp. D of Head & Norris (1989) (Pl. 2, figs 10–11)
Impletosphaeridium kroemmelbeini Morgenroth 1966
Isabelidinium sp.
Lejeunecysta hyalina Gerlach 1961 (Pl. 7, fig. 4)
Lingulodinium machaerophorum (Deflandre & Cookson) Wall 1967 (Pl. 4, figs 5 & 9; Pl. 9, fig. 6)
Kallosphaeridium brevibarbatum De Coninck 1969 (Pl. 2, fig. 7)
Melitasphaeridium pseudorecurvatum (Morgenroth) Bujak et al. 1980 (Pl. 4, figs 6–7)
Membranophoridium aspinatum Gerlach 1961 (Pl. 1, fig. 14)
Millioudodinium sp. (Pl. 2, fig. 6)
Nannoceratopsis sp. (Pl. 8, fig. 10)
Nematosphaeropsis reticulensis (Pastiels) Sarjeant 1986 (Pl. 2, fig. 9)
Operculodinium centrocarpum (Deflandre & Cookson) Wall 1967 (Pl. 3, fig. 1; Pl. 9, fig. 3; Pl. 10, figs 10–11)

Operculodinium divergens (Eisenack) Stover & Evitt 1978 (Pl. 5, fig. 5)

Operculodinium microtriainum (Klumpp) Islam 1983 (Pl. 3, figs 2–3; Pl. 10, figs 7–8)

Palaeocystodinium golzowense? Alberti 1961 (Pl. 2, fig. 13; Pl. 5, fig. 9)

Pentadinium sp. cf. *P.? circumsutum* (Morgenroth) Stover & Evitt 1978 (Pl. 2, fig. 12)

Phelodinium spp. (Pl. 7, figs 9–10)

Polysphaeridium subtile (Davey & Williams 1966) Bujak et al. 1980 (Pl. 4, fig. 4)

Polysphaeridium zoharyi (Rossignol 1962) Bujak et al. 1980 (Pl. 4, fig. 3; Pl. 9, fig. 2; Pl. 10, fig. 1)

Pterodinium cingulatum (O. Wetzel) Below 1981 (Pl. 3, fig. 6)

Rhombodinium draco Gocht 1955 (Pl. 7, figs 1, 5, 7 & 12)

Rhynchodiniopsis cladophora (Deflandre) Below 1981 (Pl. 8, fig. 2)

Rottnestia borussica (Eisenack) Cookson & Eisenack 1961 (Pl. 1, fig. 5)

Scriniodinium crystallinum (Deflandre) Klement 1960 (Pl. 8, fig. 5)

Spiniferites ramosus (Ehrenberg) Loeblich & Loeblich 1966 (Pl. 3, figs 4 & 8; Pl. 10, figs 4 & 12–13)

Spiniferites sp. A (Pl. 3, fig. 7)

Thalassiphora patula (Williams & Downie) Stover & Evitt 1978 (Pl. 2, figs 1 & 3; Pl. 9, fig. 5)

Thalassiphora pelagica (Eisenack) Eisenack & Gocht 1960 (Pl. 2, fig. 14)

Wetzeliella unicaudalis Caro 1973 (Pl. 7, fig. 3)

Wetzeliella sp. cf. *W. meckelfeldensis* Gocht 1969 (Pl. 7, fig. 8)

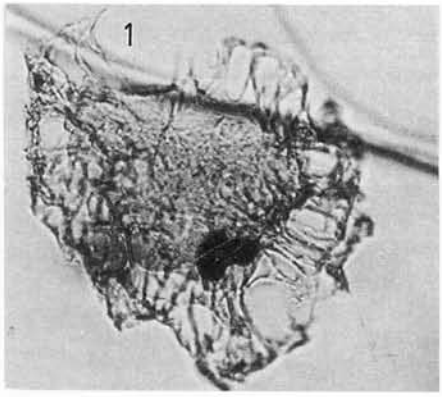
PLATES

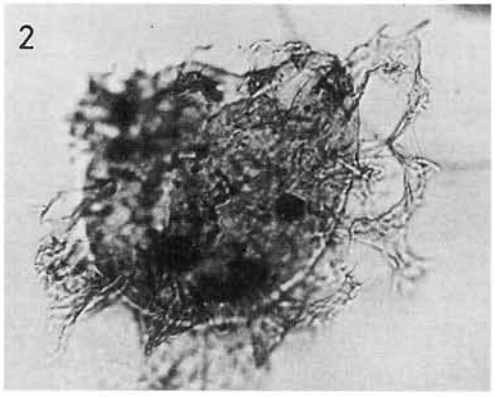
Plate 1

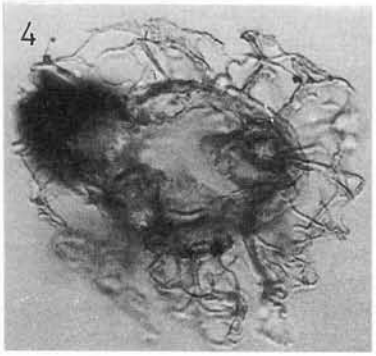
All figures × 540. England Finder coordinates between brackets on the plates 1–8.

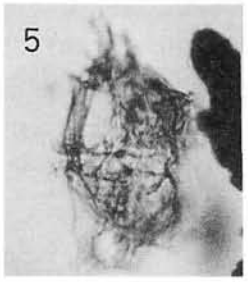
1. *Glaphyrocysta intricatum* (Eaton) Stover & Evitt 1978, slide R.IV.1, [J 29.2]
2. *Glaphyrocysta ordinata* (Williams & Downie) Stover & Evitt 1978, slide R.IV.1, [E 40.4]
3. *Cyclapophysis monmouthensis* Benson 1976, slide R.IV.2, [D 39]
4. *Adnatosphaeridium multispinosum* Williams & Downie 1966, slide R.V, [P 38.3]
5. *Rottnestia borussica* (Eisenack) Cookson & Eisenack 1961, slide R.I.2, [O 37];
6. *Cleistosphaeridium microcysta* (Bujak) Lentin & Williams 1981, slide R.IV.1, [U 30.3]
7. *Areoligera medusettiformis* (O. Wetzel) Lejeune-Carpentier 1938, slide R.IV.1, [Q 41.4]
8. *Cleistosphaeridium* sp., slide R.IV.1, [P 47.2]
9. *Areoligera coronata* (O. Wetzel) Lejeune-Carpentier 1938, slide R.IV.2, [R 50.1]
10. *Adnatosphaeridium vittatum* Williams & Downie 1966, slide R.I.2, [M 39.2]
11. *Chiropteridium* sp. cf. *Ch. dispersum* Gocht 1960, slide R.IV.1, [E 45]
12. *Glaphyrocysta exuberans* (Deflandre & Cookson) Stover & Evitt 1978, slide R.IV.1, [V 39.2]
13. *Glaphyrocysta pastielsii* (Deflandre & Cookson) Stover & Evitt 1978, slide R.IV.1, [G 45.2]
14. *Membranophoridium aspinatum* Gerlach 1961, slide R.IV.1, [V 30.1]

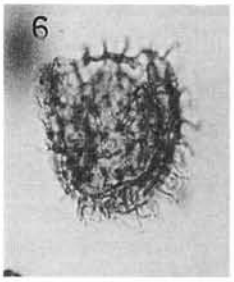
Plate 1

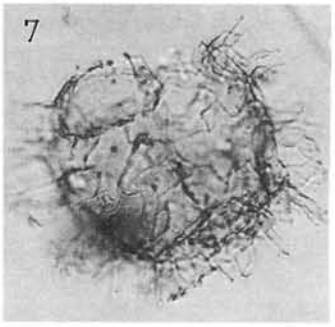


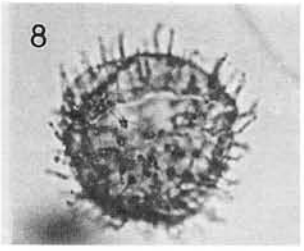


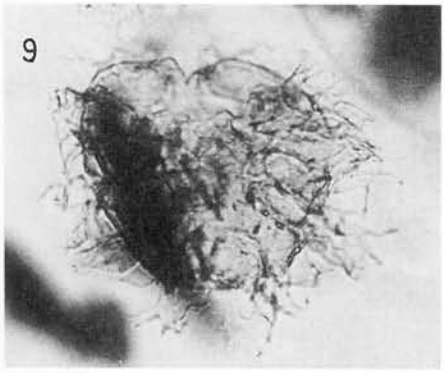


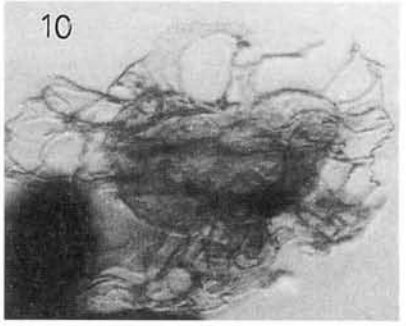


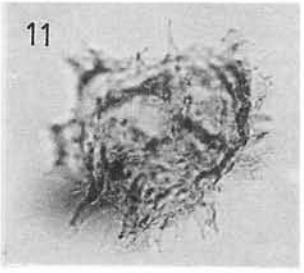


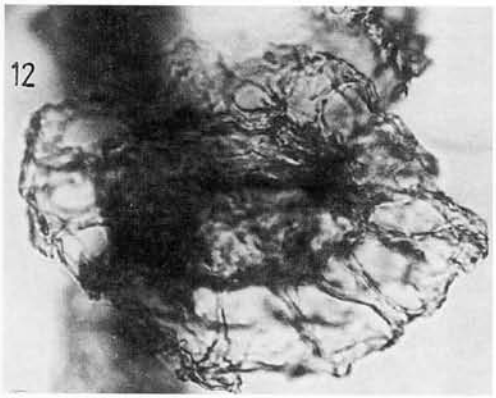












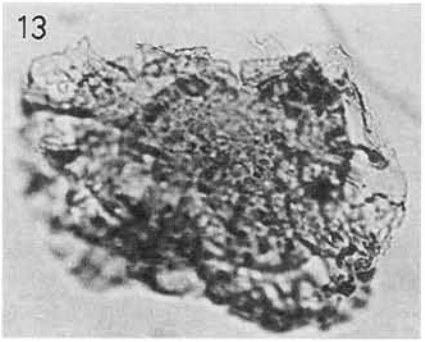


Plate 2

1, 3. *Thalassiphora patula* (Williams & Downie) Stover & Evitt 1978, 1: slide R.I.1, [G 40.2]; 3: slide R.I.1, [Q 36.2]

2. *Deflandrea denticulata* Alberti 1959, slide R.III.2, [H 38.3]

4. *Batiacasphaera* sp., slide R.I.2, [S 45]

5. *Heteraulacacysta? leptalea* Eaton 1976, slide R.I.2, [S 38]

6. *Millioudodinium* sp., slide R.V.A, [N 43]

7. *Kallosphaeridium brevibarbatum* De Coninck 1969, slide R.V.A, [H 48.2]

8. *Impagidinium* spp., slide R.III.1, [K 30.3]

9. *Nematosphaeropsis reticulensis* (Pastiels) Sarjeant 1986, slide R.IV.1, [Q 40.3]

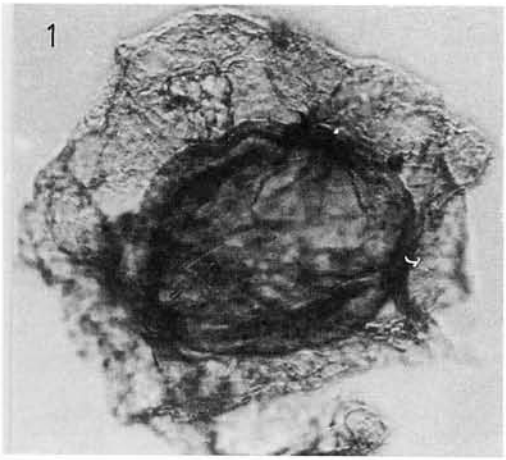
10, 11. *Impagidinium*? sp. D of Head & Norris (1989), 10: slide R.I.1, [Q 36]; 11: slide R.I.2, [R 46.3]

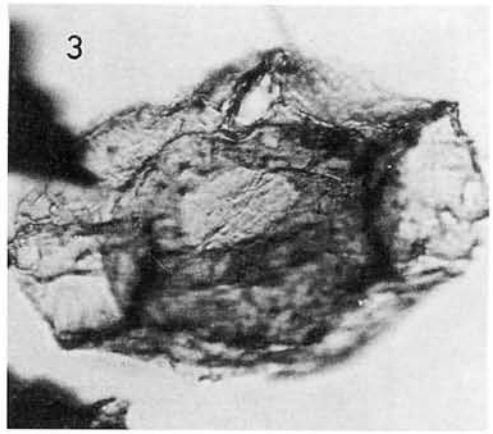
12. *Pentadinium* sp. cf. *P.? circumsutum* (Morgenroth) Stover & Evitt 1978, slide R.IV.1, [Q 38.4]

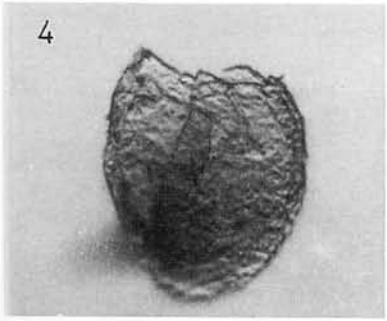
13. *Palaeocystodinium golzowense*? Alberti 1961, slide R.I.1, [E 34]

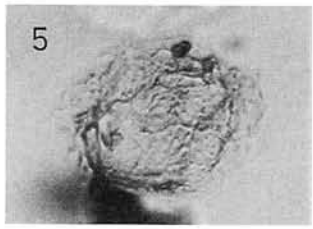
14. *Thalassiphora pelagica* (Eisenack) Eisenack & Gocht 1960, slide R.V, [V 46.4]

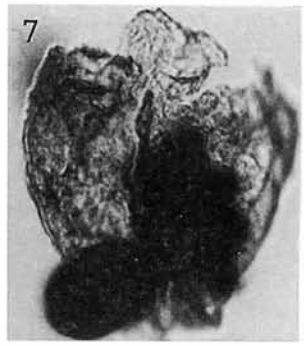
Plate 2

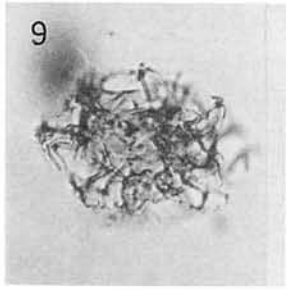


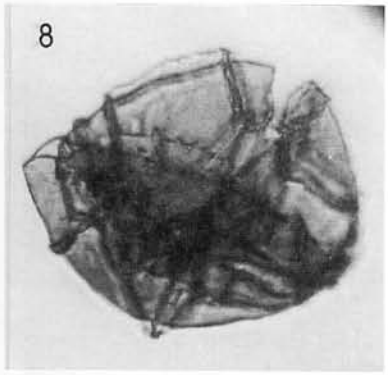


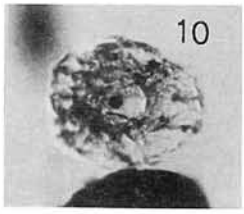


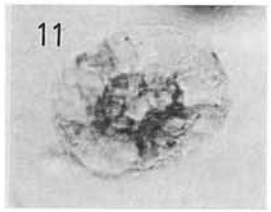


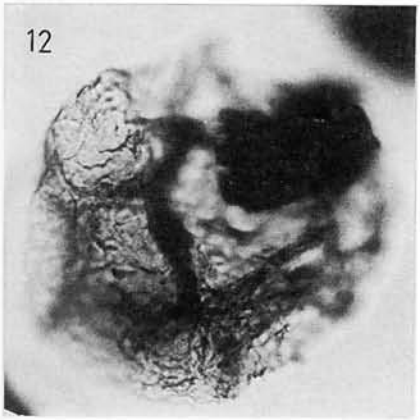


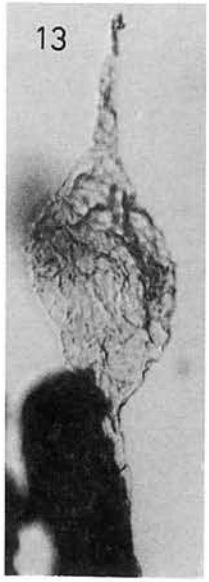












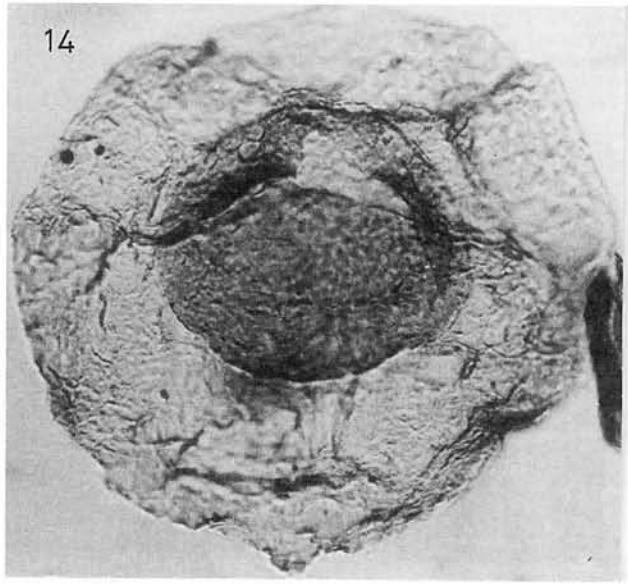
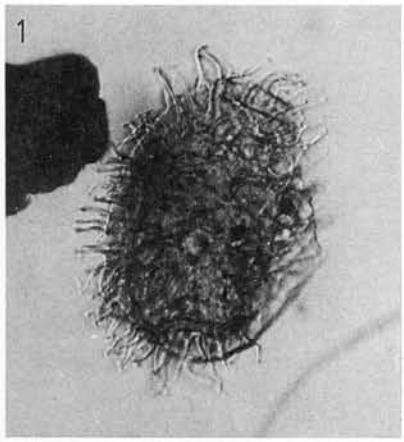
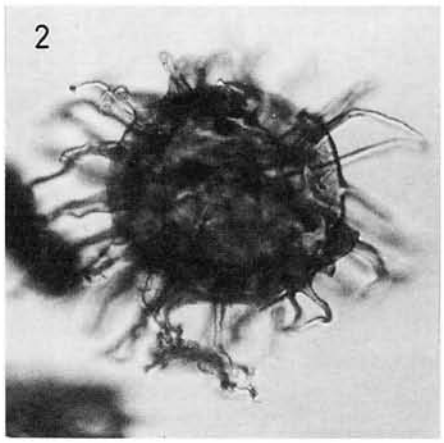


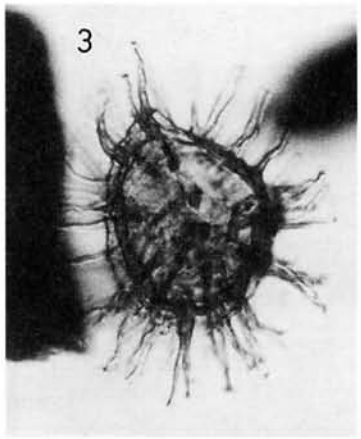
Plate 3

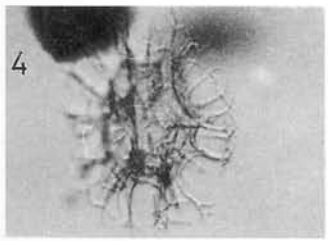
1. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, slide R.IV.2, [F 44]
2, 3. *Operculodinium microtriainum* (Klumpp) Islam 1983, 2: slide R.IV.2, [P 37.1]; 3: slide R.III.1, [J 40]
4, 8. *Spiniferites ramosus* (Ehrenberg) Loeblich & Loeblich 1966, 4: slide R.V.A, [U 47.2]; 8: slide R.III.1, [P 38.4]
5. *Achomosphaera sagena* Davey & Williams 1966, slide R.V; [D 38.1]
6. *Pterodinium cingulatum* (O. Wetzel) Below 1981, slide R.IV.2, [D 42]
7. *Spiniferites* sp. A, slide R.IV.2, [G 49]
9. *Achomosphaera alcicornu* (Eisenack) Davey & Williams 1966, slide R.V.A, [H 43.2]
10. *Dapsilidinium* sp., slide R.V.A, [O 41]
11. *Diphyes colligerum* (Deflandre & Cookson) Cookson 1965, slide R.I.1, [S 37.2]
12. *Achomosphaera* sp. B, slide R.I.2, [P 48.2]
13. *Hystrichokolpoma salacium* Eaton 1976, slide R.IV.2, [R 33.1]

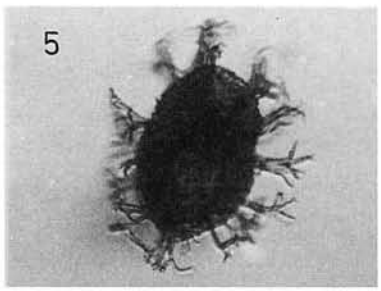
Plate 3

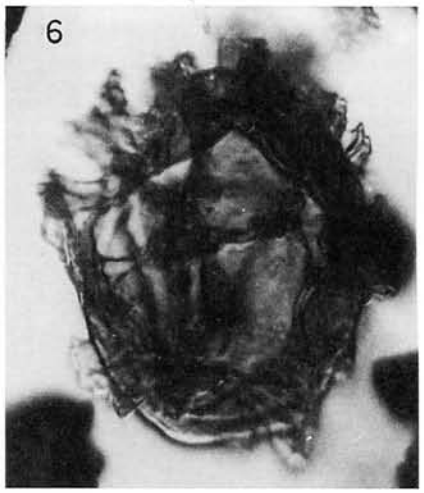


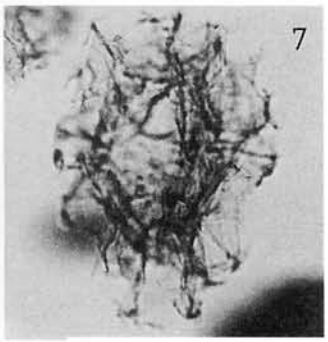


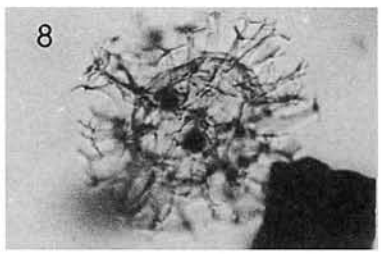


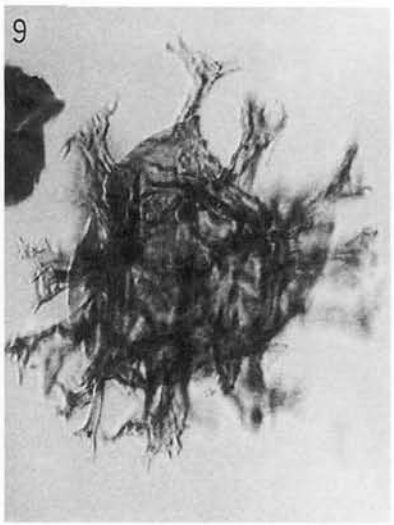


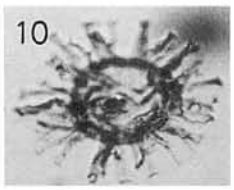


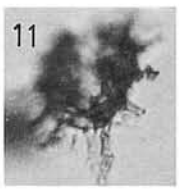


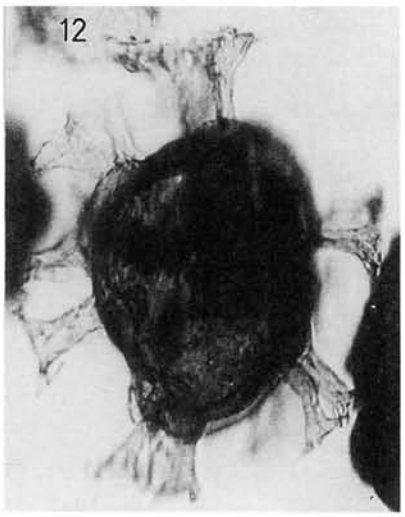












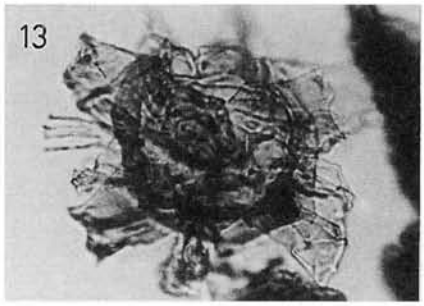
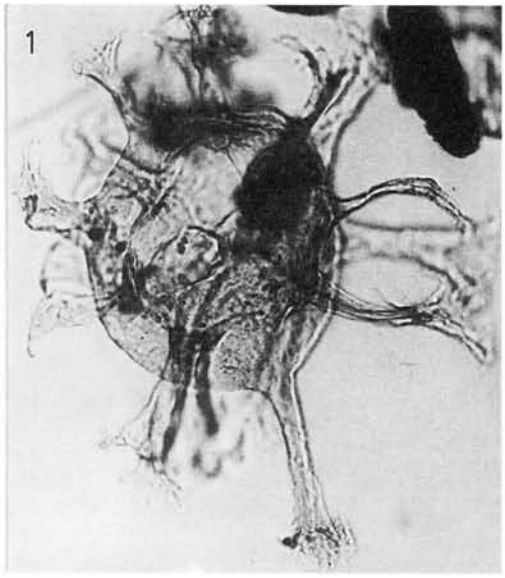
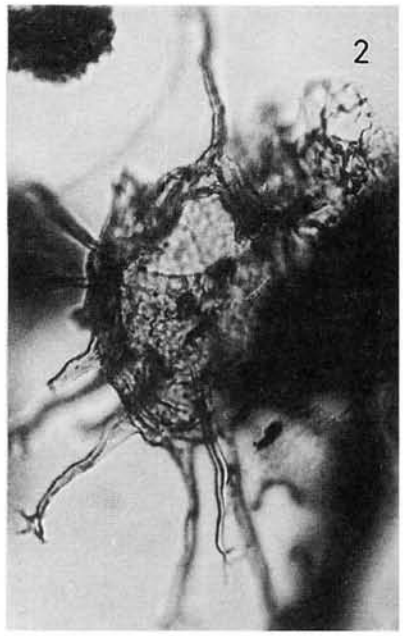


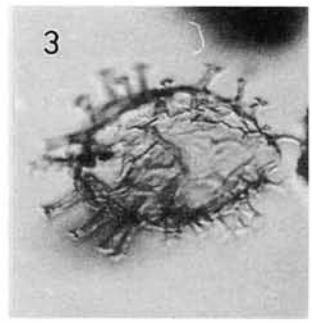
Plate 4

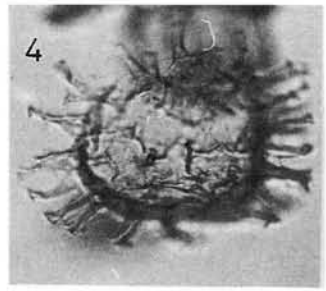
1. *Cordosphaeridium gracile* (Eisenack) Davey & Williams 1966, slide R.IV.1, [T 39.1]
2. *Cordosphaeridium? solidospinosum* sp. nov., paratype, slide R.I.1, [C 29.2]
3. *Polysphaeridium zoharyi* (Rossignol) Bujak et al. 1980, slide R.III.2, [T 46.4]
4. *Polysphaeridium subtile* (Davey & Williams) Bujak et al. 1980, slide R.IV.1, [T 31]
5, 9. *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall 1967, 5: slide R.IV.1, [N 45.3]; 9: slide R.IV.1, [J 46]
6, 7. *Melitasphaeridium pseudorecurvatum* (Morgenroth) Bujak *et al.* 1980, 6: slide R.III.2, [F 42]; 7: slide R.I.1, [V 30.1]
8, 10. *Fibrocysta axialis* (Eisenack) Stover & Evitt 1978, 8: slide R.III.1, [K 38.3]; 10: slide R.I.1, [F 32.1]
11, 12. *Fibrocysta vectensis* (Eaton) Stover & Evitt 1978, 11: slide R.IV.1, [K 43]; 12: slide R.III.2, [V 45]

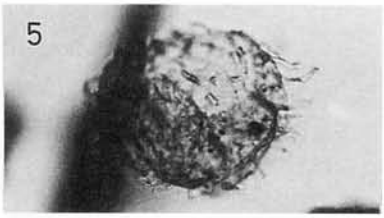
Plate 4

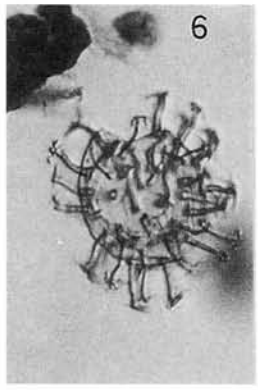


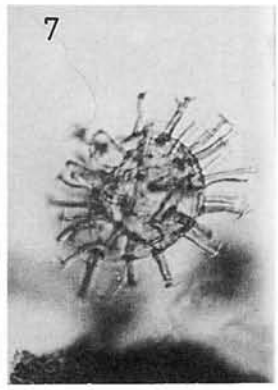


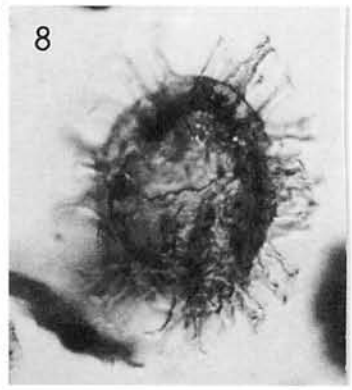


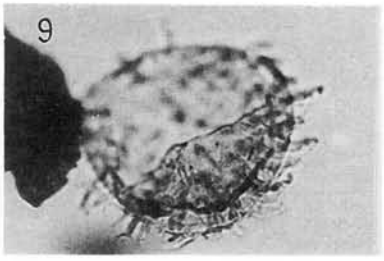


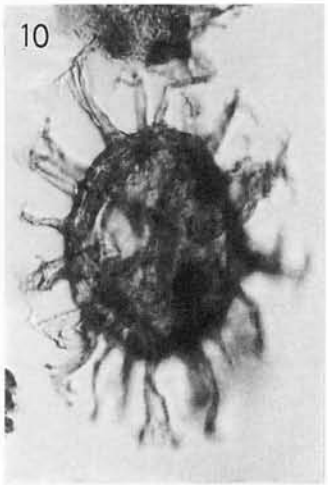


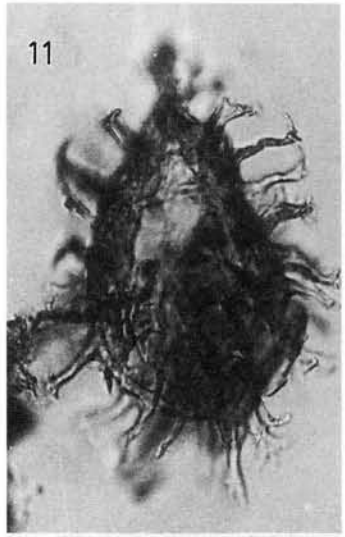












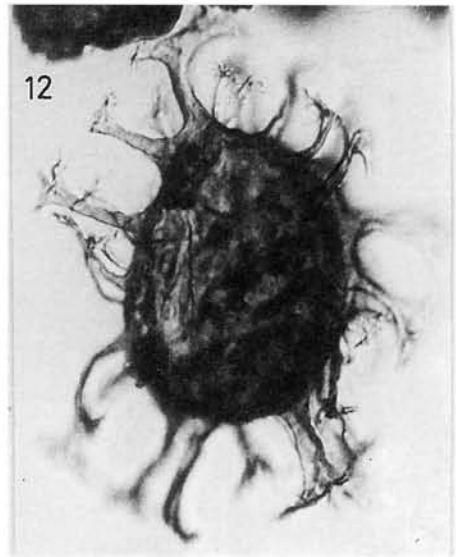
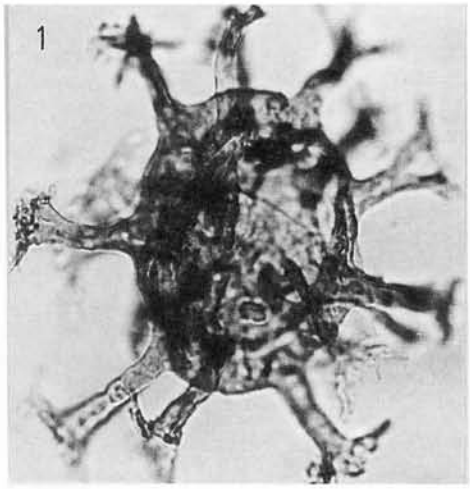
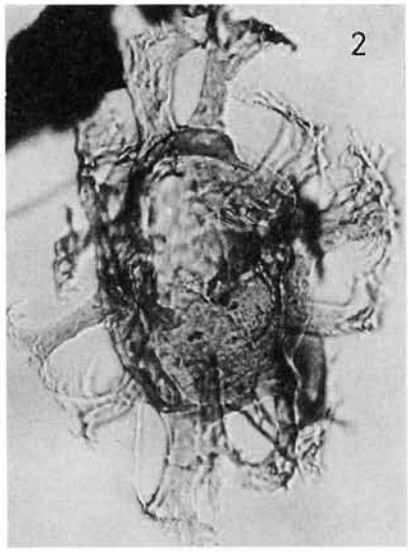


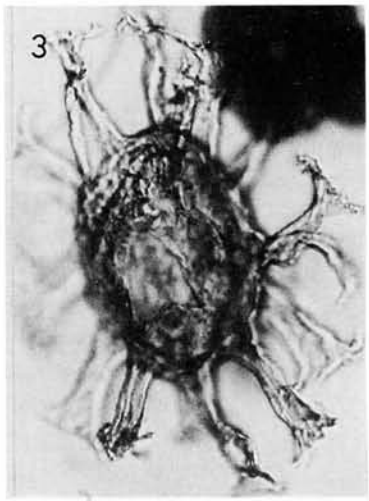
Plate 5

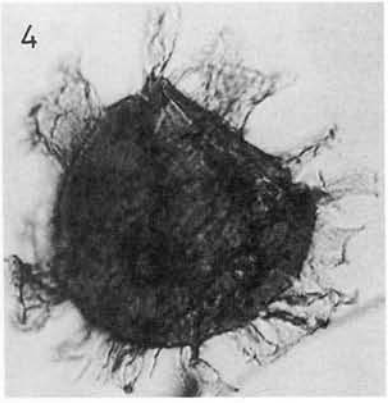
1, 2. *Cordosphaeridium inodes* (Klumpp) Eisenack 1963, 1: slide R.IV.1, [G 46.1]; 2: slide R.IV.1, [J 30]
3. Transitional form between *C. inodes* and *C. gracilis*, slide R.IV.1, [E 34]
4. *Cordosphaeridium fibrospinosum* Davey & Williams 1966, slide R.V.A, [T 37.4]
5. *Operculodinium divergens* (Eisenack) Stover & Evitt 1978, slide R.IV.1, [V 39.3]
6. *Cordosphaeridium multispinosum* Davey & Williams 1966, slide R.IV.1, [J 28]
7, 8. *Cordosphaeridium? solidospinosum* sp. nov., holotype, slide R.IV.2, [K 42.1]; 7: high focus; 8: low focus
9. *Palaeocystodinium golzowense*? Alberti 1961, slide R.I.2, [J 34]

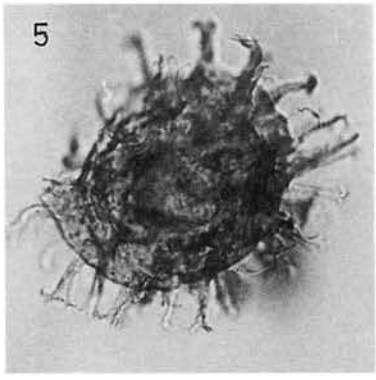
Plate 5

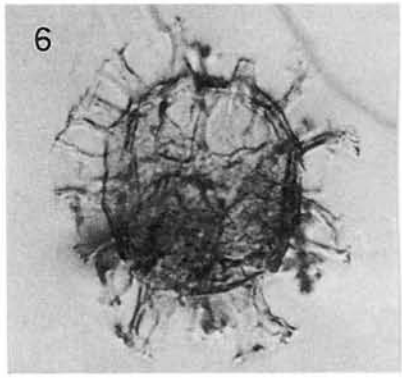


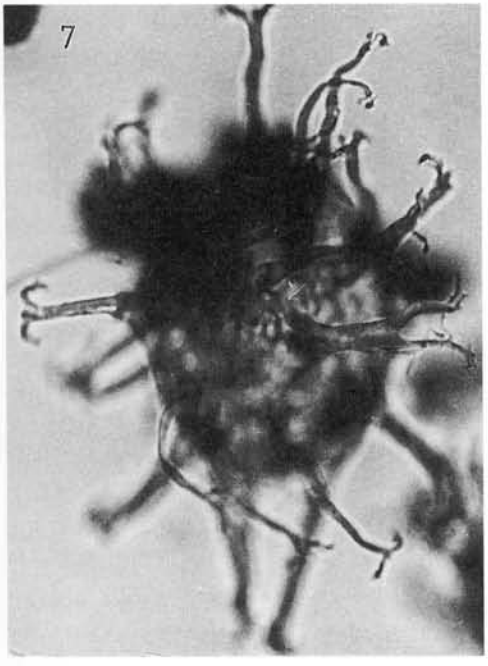












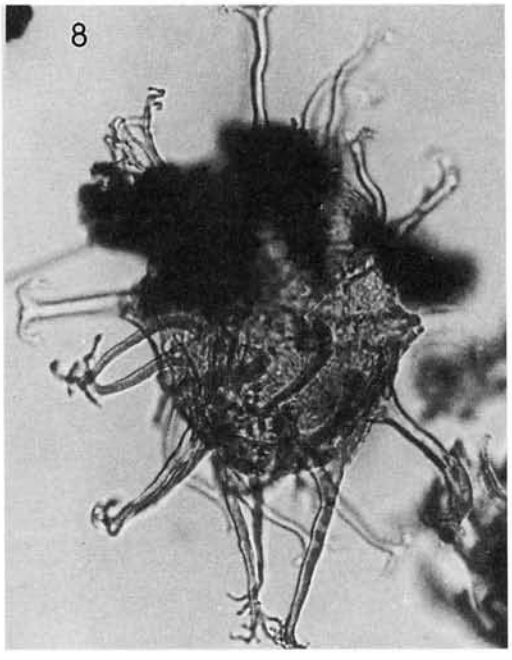


Plate 6

1–4. *Homotryblium conicum* sp. nov.

1, 2. paratype; slide R.I.2, [S 33.1], 1: low focus, 2: high focus; 3, 4: holotype; slide R.III.1, [F 43], 3: low focus, 4: high focus

5–8. *Homotryblium abbreviatum* Eaton 1976, 5: slide R.IV.1, [E 43]; 6: slide R.IV.2, [D 40.1]; 7: slide R.IV.1, [G 32.2]; 8: slide R.IV.2, [K 39.4]

9, 13, 17. *Homotryblium tenuispinosum* Davey & Williams 1966, 9: slide R.IV.2, [F 42.1]; 13: slide R.IV.1, [L 33.3]; 17: slide R.IV.2, [M 40]

10. Transitional form between *H. abbreviatum* and *H. tenuispinosum*, slide R.IV.2, [K 46.1]

11, 12, 16. *Homotryblium pallidum* Davey & Williams 1966, 11: slide R.IV.1, [P 37.2]; 12: slide R.IV.1, [K 38.3]; 16: slide R.III.1, [L 38]

14. *Homotryblium caliculum* Bujak 1980, slide R.I.1, [P 33]

15. *Homotryblium oceanicum* Eaton 1976, slide R.IV.1, [G 49.4]

Plate 6

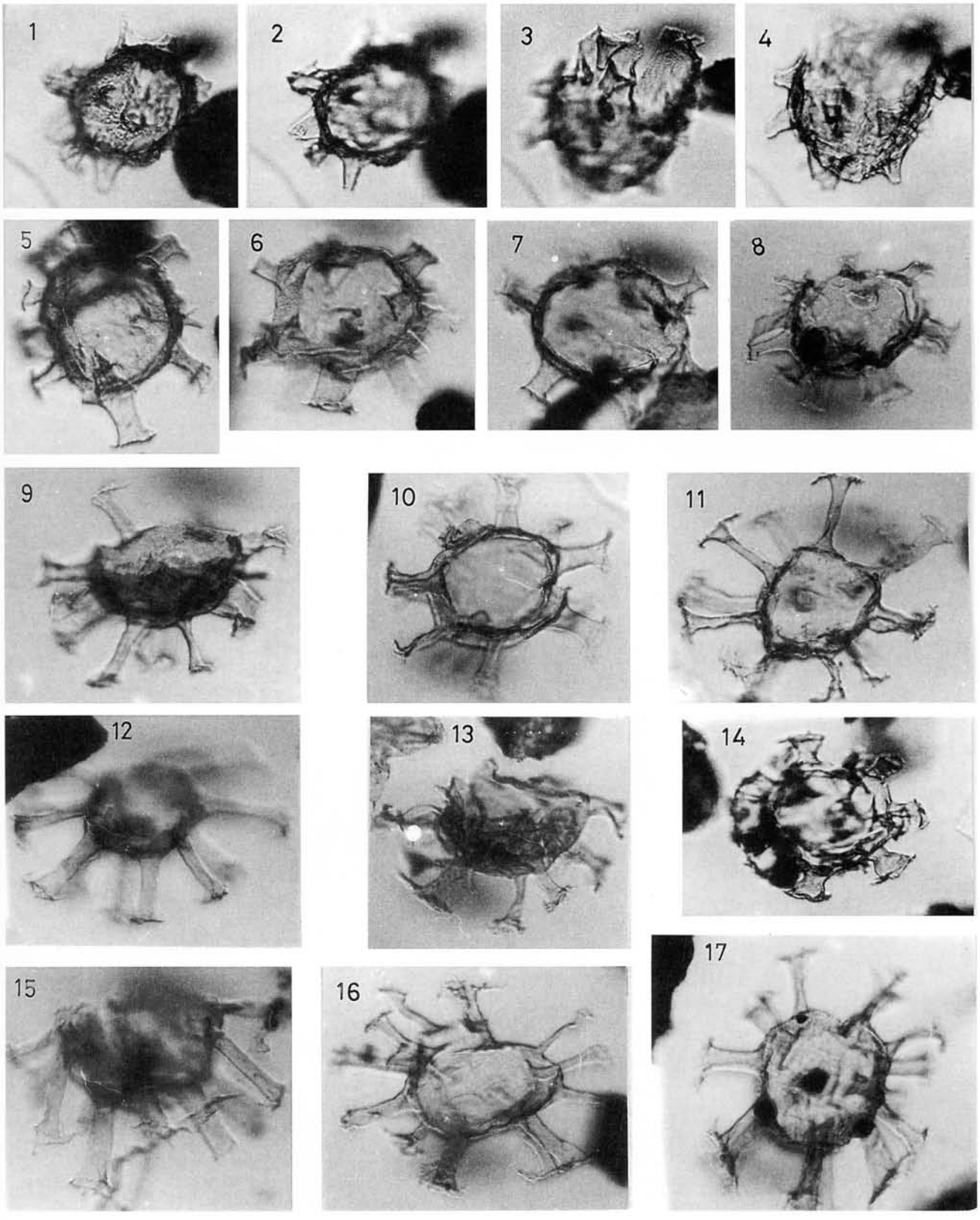


Plate 7

1, 5, 7, 12. *Rhombodinium draco* Gocht 1955, 1: slide R.III.1, [T 46.4]; 5: slide R.III.1, [D 46.2]: 7: slide R.I.2, [M 45] (the specimen is upside-down); 12: slide R.I.2, [E 40.4]

2, 6. *Bellatudinium hokkaidoanum* Kurita & Matsuoka 1994, 2: slide R.I.1, [K 41.4]; 6: slide R.I.1, [P 41.4]

3. *Wetzeliella unicaudalis* Caro 1973, slide R.III.2, [W 39.3]

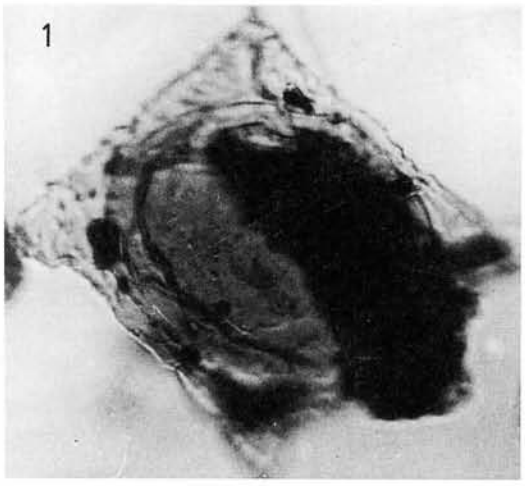
4. *Lejeunecysta hyalina* Gerlach 1961, slide R.III.2, [V 34.2]

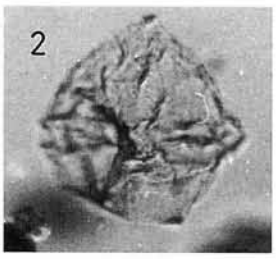
11, 13. *Dracodinium laszczynskii* sp. nov., 11: paratype, slide R.VI, [H 40.3]; 13: holotype, slide R.III.2, [R 43.4]

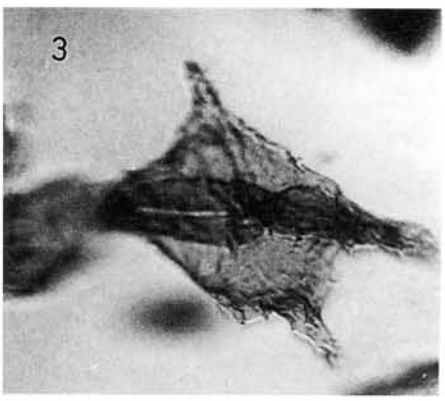
8. *Wetzeliella* sp. cf. *W. meckelfeldensis* Gocht 1969, slide R.V, [T 41]

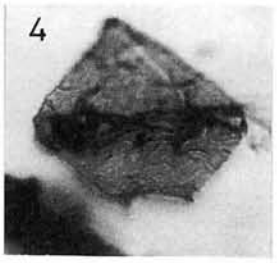
9, 10. *Phelodinium* spp., 9: slide R.I.2, [M 35.4]; 10: slide R.I.2, [P 45.4]

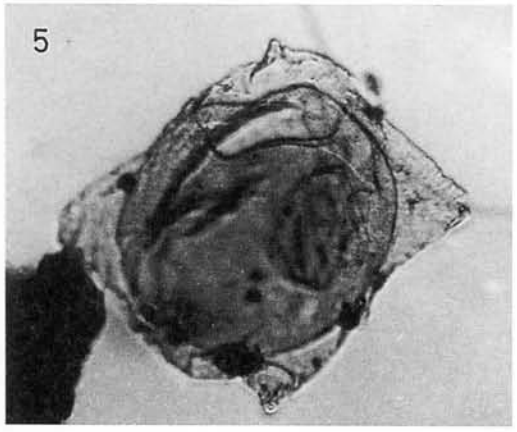
Plate 7

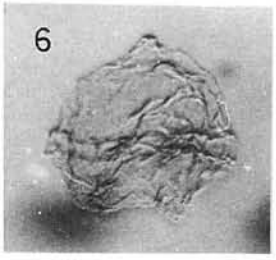


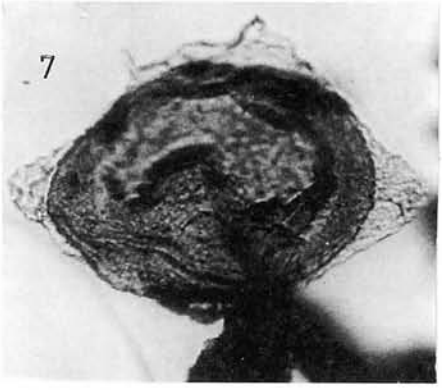


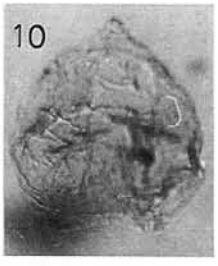


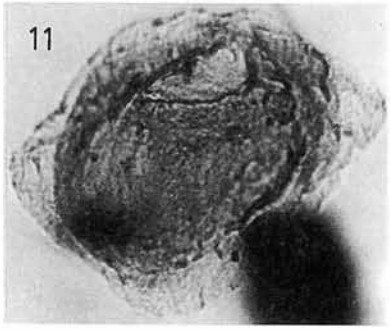


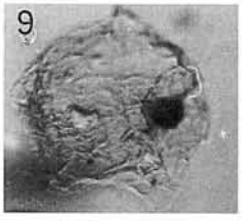


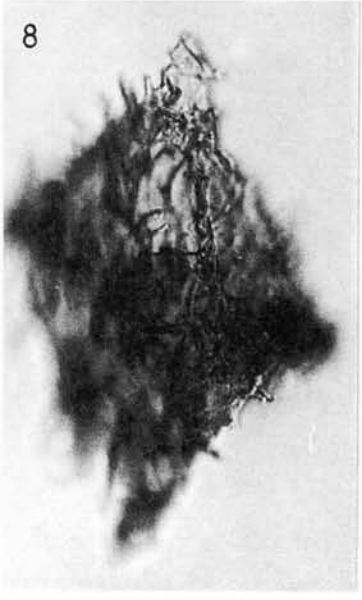


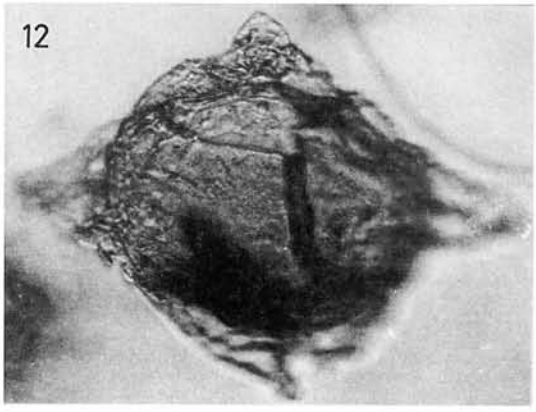












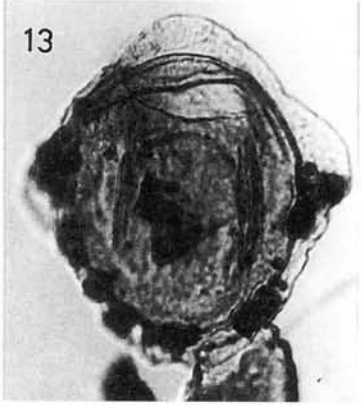


Plate 8

1, 3. *Charlesdowniea coleothrypta* subsp. *rotundata* (Chateauneuf & Gruas-Cavagnetto) Lentin & Vozzhennikova 1989, 1: slide R.I.1, [D 43.1]; 3: slide R.IV.1, [L 29]

2. *Rhynchodiniopsis cladophora* (Deflandre) Below 1981, slide R.III.2, [O 33]

4. *Charlesdowniea tenuivirgula* (Williams & Downie) Lentin & Vozzhennikova 1989, slide R.III.2, [F 38]

5. *Scriniodinium crystallinum* (Deflandre) Klement 1960, slide R.I.2, [H 46.2]

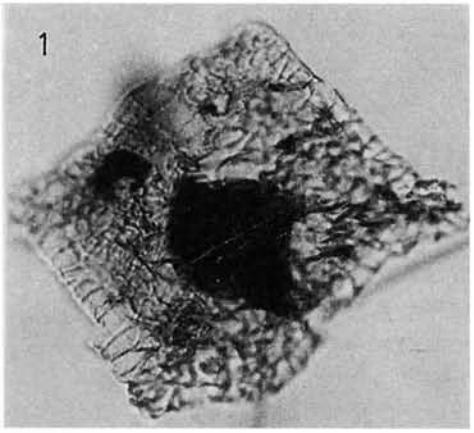
6, 6a, 7, 8, 9. *Charlesdowniea coleothrypta* (Williams & Downie) Lentin & Vozzhennikova 1989, 6: sample R.IV, × 780; 6a: sample R.IV, × 720; 7: slide R.I.2, [J 46.4]; 8: sample R IV, × 660; 9: slide R.IV.1, [L 29]

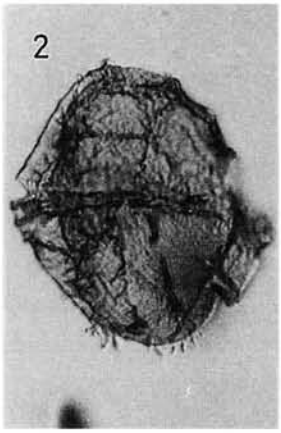
10. *Nannoceratopsis* sp., slide R.III.1, [K 35.1]

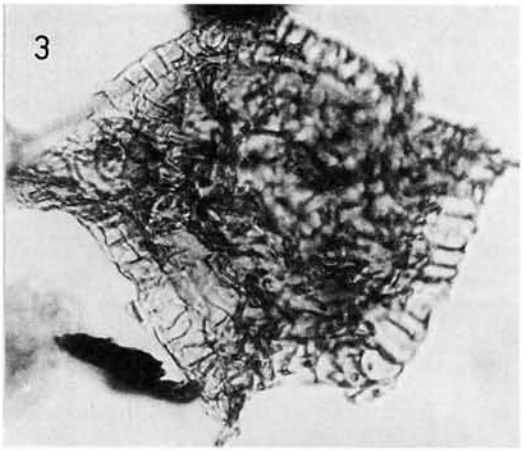
11. Fungi, slide R.III.1, [C 41.3]

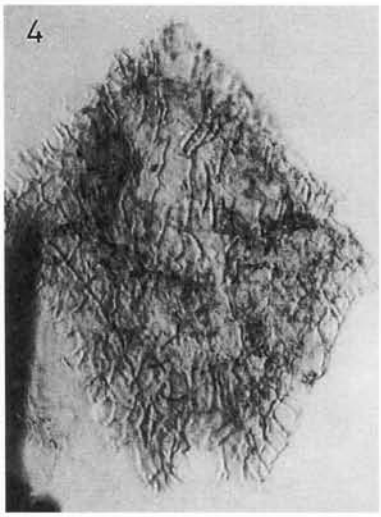
12. Foraminifera lining, slide R.IV.2, [F 37]

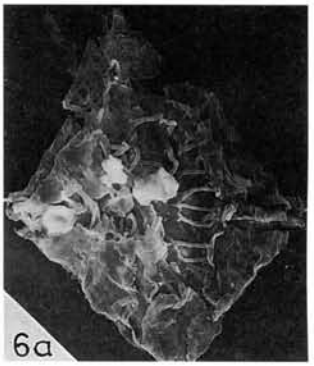
Plate 8

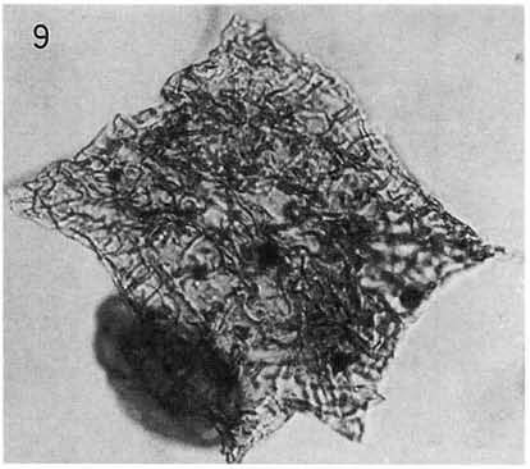


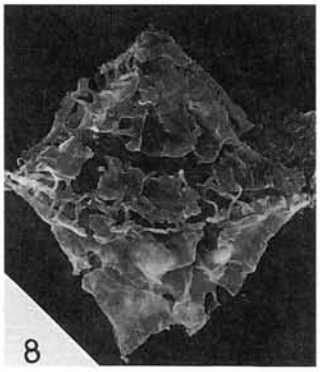


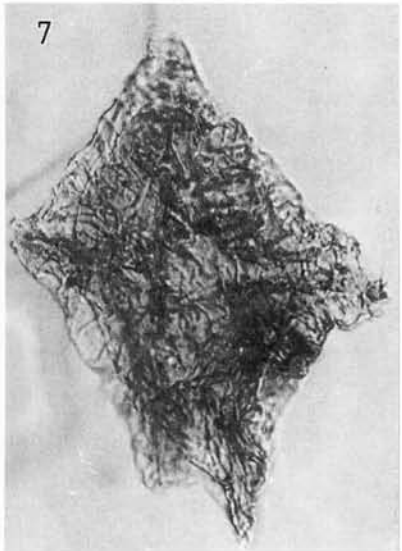


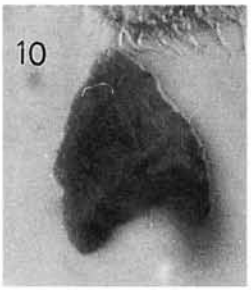


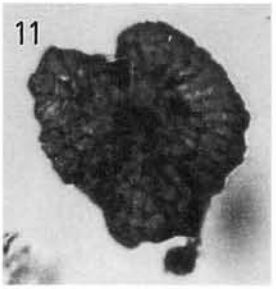












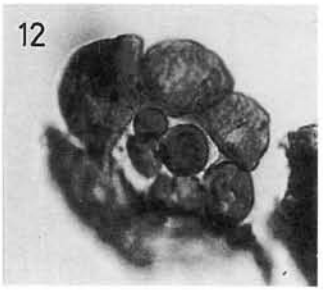


Plate 9

1, 14. *Adnatosphaeridium multispinosum* Williams & Downie 1966, 1: sample R.IV, × 1500; 14: sample R.IV, × 1200

2. *Polysphaeridium zoharyi* (Rossignol) Bujak et al. 1980, sample R.IV, × 1200

3. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, sample R.IV, × 1300

4, 8. Transitional forms between *H. abbreviatum* and *H. tenuispinosum*, 4: sample R.IV, × 1100; 8: sample R.IV, × 1000

5. *Thalassiphora patula* (Williams & Downie) Stover & Evitt 1978, sample R.IV, × 780

6. *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall 1967, sample R.IV, × 1300

7. *Fibrocysta vectensis* (Eaton) Stover & Evitt 1978, sample R.IV, × 1100

9. *Cordosphaeridium gracile* (Eisenack) Davey & Williams 1966, sample R.IV, × 780

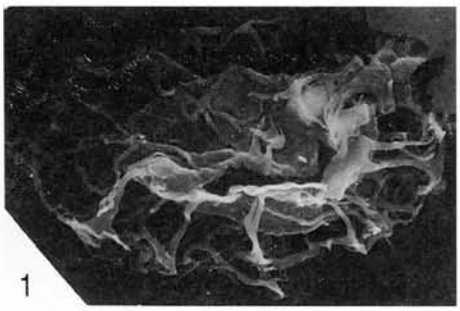
10. *Cordosphaeridium inodes* (Klumpp) Eisenack 1963, sample R.IV, × 780

11. *Apectodinium quinquelatum* (Williams & Downie) Costa & Downie 1979, sample R.IV, × 1300

12. *Dapsilidinium* sp., sample R.IV, × 1300

13. *Bellatudinium hokkaidoanum* Kurita & Matsuoka 1994, sample R.IV, × 1500

Plate 9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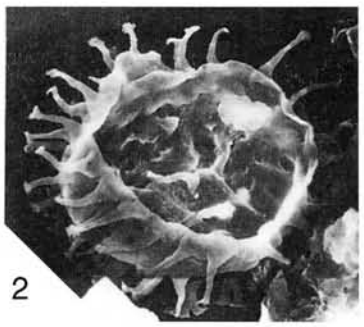
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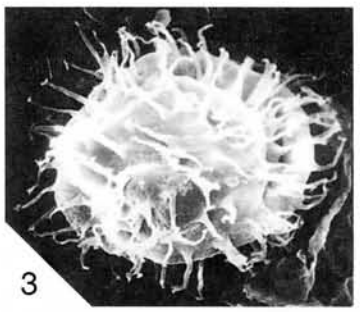
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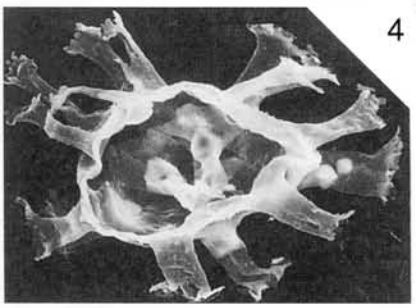
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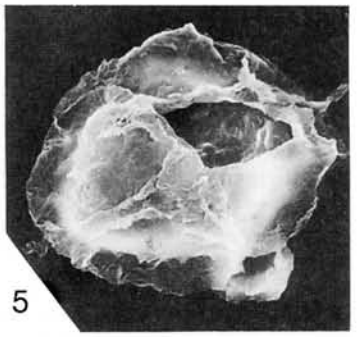
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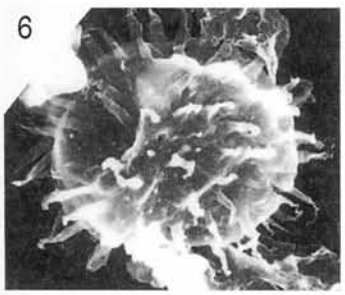
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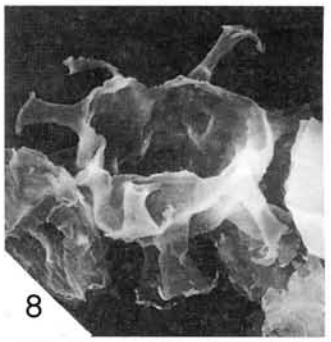
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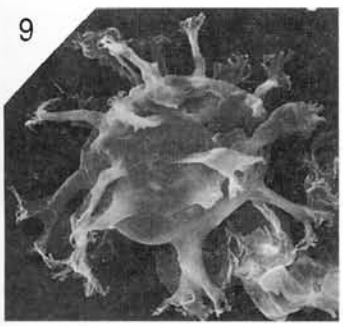
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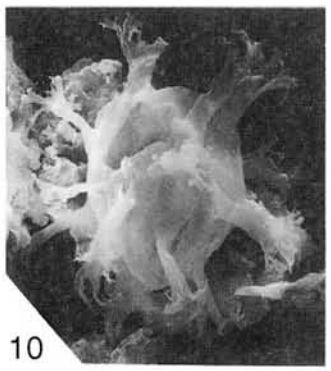
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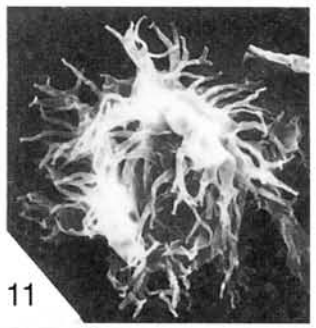
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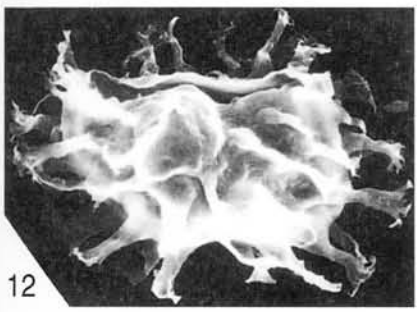
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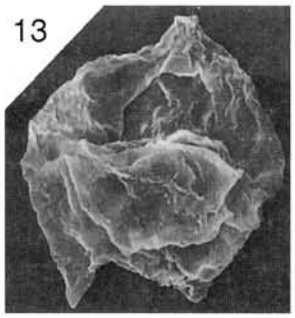
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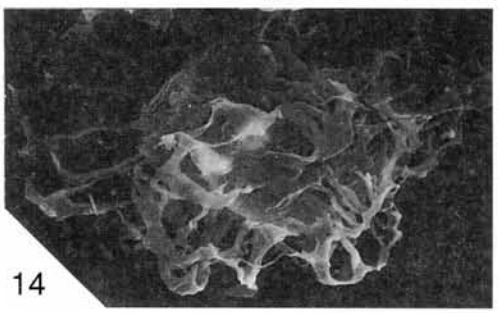
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Plate 10

1. *Polysphaeridium zoharyi* (Rossignol) Bujak et al. 1980, sample R.IV, × 1200

2. *Areoligera senonensis* Lejeune-Carpentier 1938, sample R.IV, × 1200

3. *Cordosphaeridium gracile* (Eisenack) Davey & Williams 1966, sample R.IV, × 780

4, 12, 13. *Spiniferites ramosus* (Ehrenberg) Loeblich & Loeblich 1966), 4: sample R.IV, × 1600; 12: sample R.IV, × 1500; 13: sample R.IV, × 1600

5. *Apectodinium homomorphum* (Deflandre & Cookson) Lentin & Williams 1977, sample R.IV, × 1300

6. *Achomosphaera* sp. A, sample R.IV, × 1600

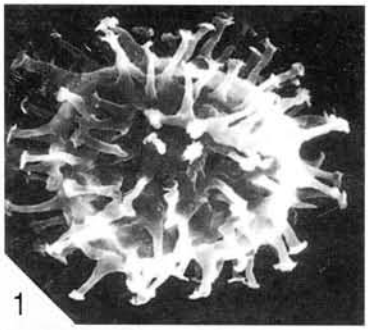
7, 8. *Operculodinium microtriainum* (Klumpp) Islam 1983, sample R.IV, × 860

9. *Adnatosphaeridium multispinosum* Williams & Downie 1966, sample R.IV, × 1000

10, 11. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall 1967, 10: sample R.IV, × 1500; 11: sample R.IV, × 1200

14. *Achomosphaera* sp. C, sample R.IV, × 1800

Plate 10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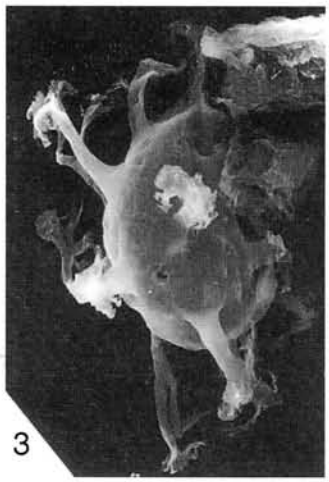
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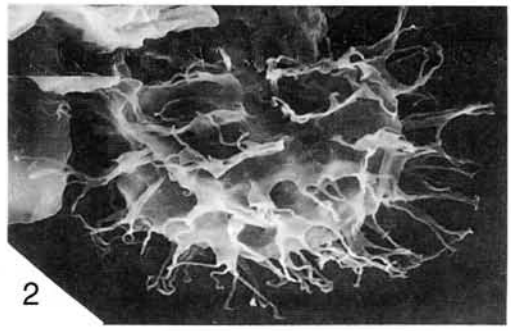
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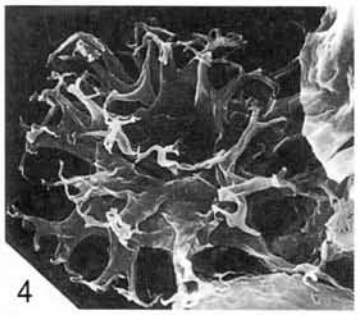
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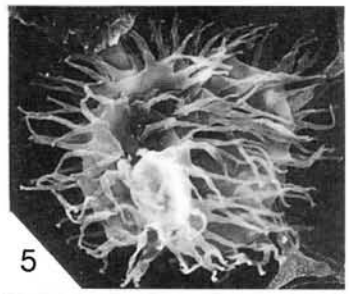
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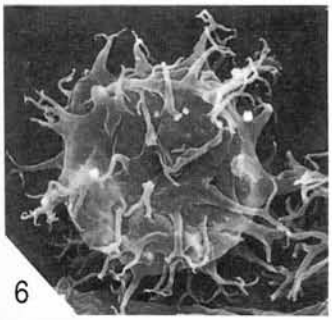
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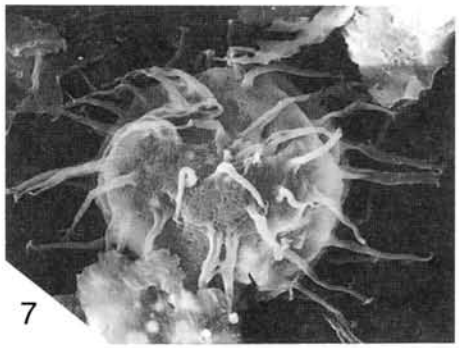
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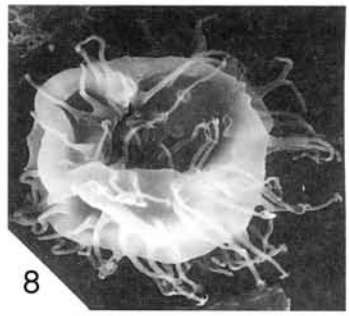
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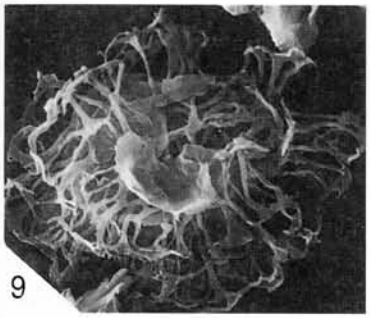
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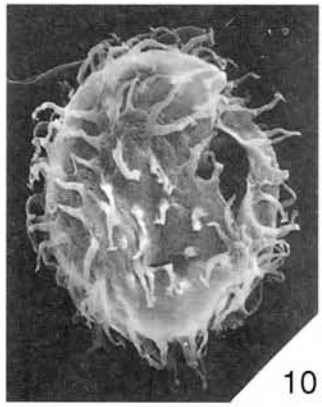
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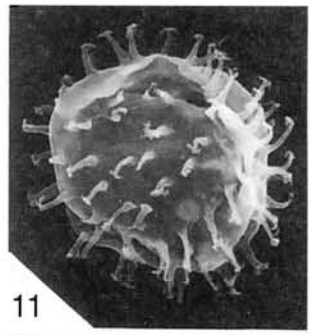
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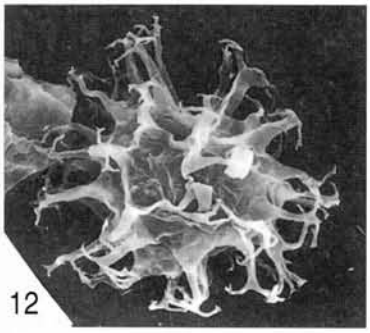
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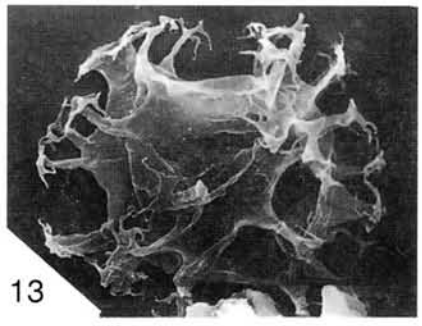
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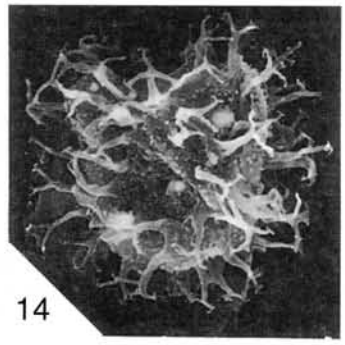
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