

## Early Miocene and Quaternary Marine Palynomorphs from Cape Roberts Project CRP-1, McMurdo Sound, Antarctica

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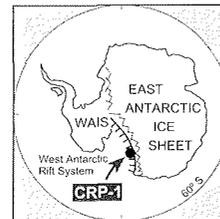
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**Abstract** - A diverse assemblage of marine microplankton was recovered from lower Miocene and Quaternary strata from the Cape Roberts Project drillhole, CRP-1, McMurdo Sound. This is the first diverse assemblage of marine palynomorphs of Miocene age recovered from the Antarctic continent. As well as foraminiferal linings and arthropod/annelid parts, the *in situ* marine palynomorph assemblage can be subdivided into three groups; prasinophyte algae, acritarchs and dinoflagellate cysts (dinocysts). The prasinophyte algae are the most diverse and abundant: nine species are recognised, leiosphaerids and cymatosphaerids dominate. Seven species of acritarchs have been identified and are dominated by *Sigmopollis* sp. and an unknown form referred to here as Acritarch 1.

*In situ* dinocysts make up a sparse but moderately diverse group of nine species. Their greatest abundance and diversity occurs below 39.06 mbsf in the lower Miocene part of the section. It is suspected that most dinocysts recovered from above this level are a result of reworking.

Almost all the *in situ* species are new. The prasinophytes and acritarchs are listed in open nomenclature pending more detailed investigations, whereas most new species of dinocysts are described formally. Several species of reworked dinocysts were recorded dominantly from lower Miocene strata.



### INTRODUCTION

In this paper we describe marine palynomorphs recovered from a suite of samples from CRP-1, the first of a series of planned drillholes to core middle and lower Cenozoic strata on the Antarctic continent. CRP-1 was drilled in October 1997 in about 150 m of water at a site 16 km offshore of Cape Roberts, western McMurdo Sound. The drillhole reached a depth of 148 m below sea floor (mbsf) before drilling was terminated by an unexpected storm and sea-ice breakout (unless otherwise indicated all drillhole data are from Cape Roberts Science Team, 1998). Strata were continuously cored and recovery averaged 77% in the upper 100 m where both soft and brittle strata were encountered. Below 100 m recovery rose to 98% as the drill entered less fractured, more coherent strata.

Figure 1 presents a summary lithological log for the core. The Quaternary section of the core extends to a depth of 43.55 mbsf and comprises poorly consolidated clay, silts, sands and diamictons. An unusual carbonate-dominated interval between 31.70 and 33.82 mbsf yielded a diverse macrofossil assemblage dominated by bryozoans (Taviani et al., this volume).

Between 43.55 mbsf and the total depth of the hole, diatom ages indicate that the sediments are early Miocene in age (Harwood et al., this volume). This is confirmed by numerical ages (McIntosh, this volume; Lavelle, this volume), which suggest that the sediments between the base of the Quaternary section and 124 mbsf are about 17.5 and 18.5 Ma. Palaeomagnetic analysis broadly supports this age determination and suggests that the age of the base

of the drillhole is a little over 20 Ma. Integration of the palaeomagnetic, biostratigraphic, and numerical age data evinces an unconformity at about 124 mbsf (Roberts et al., this volume).

Between 43.55 and about 100 mbsf sandstones are the dominant lithology, with occasional mudstone and diamictite units (Fig. 1). Below 100 mbsf, diamictons become the dominant lithology, although sands and muds are still occasionally present in the section.

### PROCESSING TECHNIQUES

Thirty-six samples were processed and examined from both the Quaternary and Miocene parts of the section and are listed in figure 2. All samples were processed at the Crary Laboratory, McMurdo Station, Antarctica. About 5 g of each sample was crushed and digested in hydrofluoric acid with the assistance of a Prolabo M-401 microwave digester (for a full description see Simes & Wrenn, this volume). The use of this equipment substantially reduced the amount of chemicals necessary, and all noxious vapours could be scrubbed prior to their release into the Antarctic environment. In addition, very little residue remained after digestion, and this could be neutralised easily. After digestion, the samples were oxidized in nitric acid and floated in sodium polytungstate at a specific gravity of 2.4. This high specific gravity was used because during initial trials it was found that some palynomorphs were coated in a thin layer of pyrite that caused them to sink at the lower specific gravity commonly used in palynological preparations.

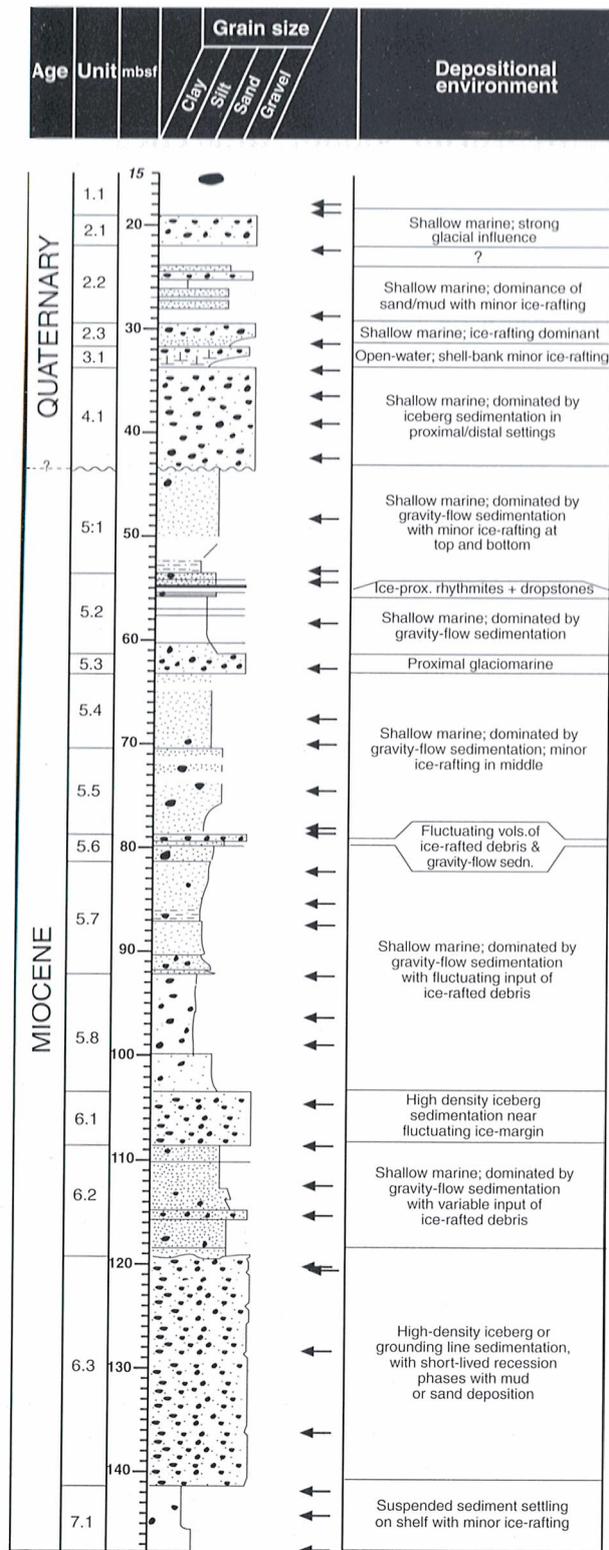


Fig. 1 - Lithological summary of CRP-1. From Cape Roberts Science Team (1998), arrows indicate the position of the samples used in this study.

## OVERVIEW OF ASSEMBLAGES

Well-preserved marine palynomorphs are present, and occasionally common, in all samples examined. Yields are lower in the Quaternary section than in the underlying Miocene strata, the greatest abundance occurring near the base of the drillhole.

A range chart listing all marine palynomorph species recovered is provided in figure 2. The assemblage can be divided into three parts; prasinophyte algae, acritarchs and dinoflagellate cysts (dinocysts).

Dominant forms throughout the drill hole, but particularly below 99.10 mbsf, are prasinophyte algae, in particular leiospherids, which are represented by three species. Most of the rest of the prasinophyte assemblage consists of several species of *Cymatiosphaera*.

Acritarchs are common in many samples. The non-spinose Acritarch I is found in most Miocene samples but is less common below 99.01 mbsf. Sporadic occurrences of spinose acritarchs in the Quaternary section may result from reworking. *Sigmopollis* sp. occurs consistently in Miocene samples and along with the leiospherids is very common below 99.10 mbsf. Although included here with the acritarchs, the morphology of *Sigmopollis* sp. suggests a closer link with the leiospherids and the prasinophyte algae. This linkage is further supported by similar distributions of *Sigmopollis* sp. and the *Leiospheridia*.

Two peaks in numbers of spinose acritarchs (Acanthomorpha) can be discerned in the range chart (Fig. 2). One peak is focussed on the Miocene/Quaternary boundary, the other occurs between Samples 99.10 and 85.36 mbsf. Spinose acritarchs are very rare to absent below 99.10 mbsf.

A low diversity *in situ* dinocyst assemblage was recovered, primarily from the Miocene section of the drillhole. Some species range up into the lower Quaternary, but these occurrences are possibly a result of reworking. Diversity increases downhole, reaching a maximum below 99.10 mbsf.

*Lejeunecysta fallax* is the most common dinoflagellate species in the drillhole. It occurs in significant numbers between 99.10 and 48.4 mbsf. There are only sporadic occurrences of this species below 99.10 mbsf and none above 48.4 mbsf. For a full discussion of the significance of the distribution of marine palynomorphs in CRP-1 see Wrenn et al. (this volume).

## OTHER ANTARCTIC MARINE PALYNO-MORPH OCCURENCES

The assemblage reported here is the first description of common Miocene marine palynomorphs from Antarctica, and most of the species are described here for the first time. Paleogene (mainly Eocene and early Oligocene) assemblages are now well documented from southern high latitudes (e.g. Wilson, 1967, 1989; Goodman & Ford, 1983; Truswell, 1986; Wrenn & Hart, 1988; Hannah, 1997). Many species from these Paleogene assemblages are recognised as part of the Transantarctic Flora (Wrenn & Hart, 1988). However, there have been no previous reports of any significant assemblages of *in situ* dinocysts, or any other palynomorphs, from Antarctic sediments that are unequivocally of Neogene age.

McMinn (1995) reviewed the distribution of ancient and modern dinocysts from Antarctica and the surrounding Southern Ocean. He suggested that the lack of Neogene dinocysts was a result of the increasing thermal and geographic

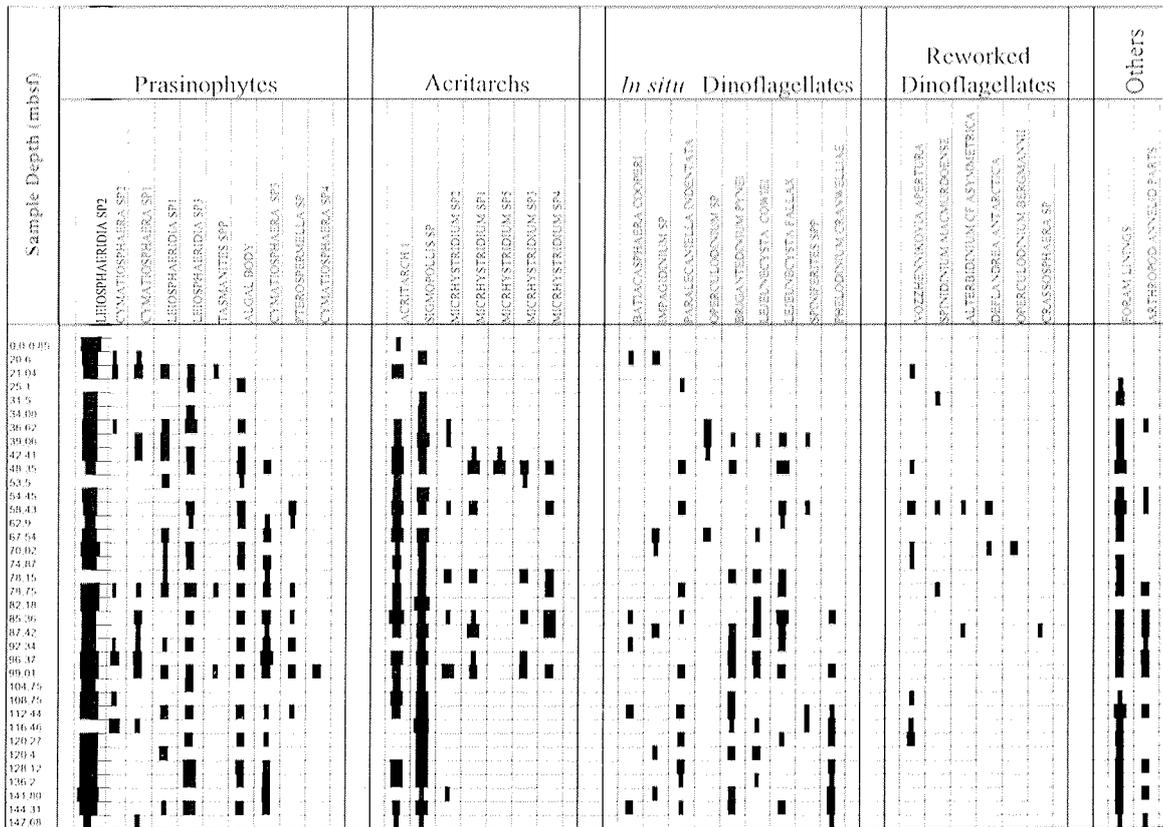


Fig. 2 - Range chart of marine microplankton recovered from CRP-1.

isolation of the continent preventing the pole-ward migration of cyst producing forms. The data from CRP-1 suggests that the dearth of dinocysts from Neogene strata may result from a previous lack of sampling from sections of appropriate age.

Marine palynomorphs were recovered from the Miocene sediments of the MSSTS-1 drillhole (Truswell, 1986). *Leiosphaeridia* spp. were the most prevalent form found in the drillhole. A single occurrence of a species of *Pterospermopsis* was the only other prasinophyte identified. All the dinocysts that Truswell reported, except *Spiniferites* sp., are clearly reworked from sediments of Eocene/Oligocene age.

In a review of the stratigraphy and sedimentology of the Hobbs Glacier Formation, James Ross Island, Pirrie et al. (1997) reported the presence of rare dinocysts, which they suggested were late Miocene in age. A single sample yielded rare specimens of *Lingulodinium* and *Operculodinium*. Slightly more common were specimens of *Spinidinium* and *Bitectatodinium tepikiense*, which were recovered from four samples.

The presence of *Bitectatodinium tepikiense* suggests that the Hobbs Glacier Formation can be no older than Miocene. The age of the formation was restricted to the late Miocene based on the maximum numeric age (7.13 ± 0.49 Ma, Pirrie et al., 1997) obtained from the overlying James Ross Island Volcanic Group. Elsewhere much younger ages have been reported for the James Ross Island Volcanic Group, some as young as about 3 Ma. (Pirrie et al., 1997), so a Pliocene age cannot be discounted.

SYSTEMATIC PALYNOLOGY

Palynological analysis was carried out on a Leica DMRB microscope at both the Cray Laboratory, McMurdo Station, Antarctica and the School of Earth Sciences, Victoria University of Wellington. All slides used in this project are lodged with the Institute of Geological and Nuclear Sciences, Gracefield, New Zealand.

Division PRASINOPHYTA Round, 1971

The authors hold differing opinions as whether or not the genus *Leiosphaeridia* should be included in the prasinophyte algae. Here the senior author has followed the systematic approach of Guy-Ohlson, (1996) and included *Leiosphaeridia* within the prasinophytes but for a different treatment see Wrenn et al. (this volume).

Order PYRAMIMONADALES Chadeffaud, 1950  
 Family Leiosphaeridiaceae Mädlar, 1963  
 Genus *Leiosphaeridia* Eisenack, 1958

***Leiosphaeridia* sp. 1**  
 (*Leiosphaeridia* sp. 1, Initial Report on CRP-1)(Fig. 3a)

Description: small spherical phycoma. Wall smooth, hyaline and colourless, rarely folded and less than 1 µm thick. No obvious aperture noted.  
 Distinguishing features: phycoma size and lack of colouring.

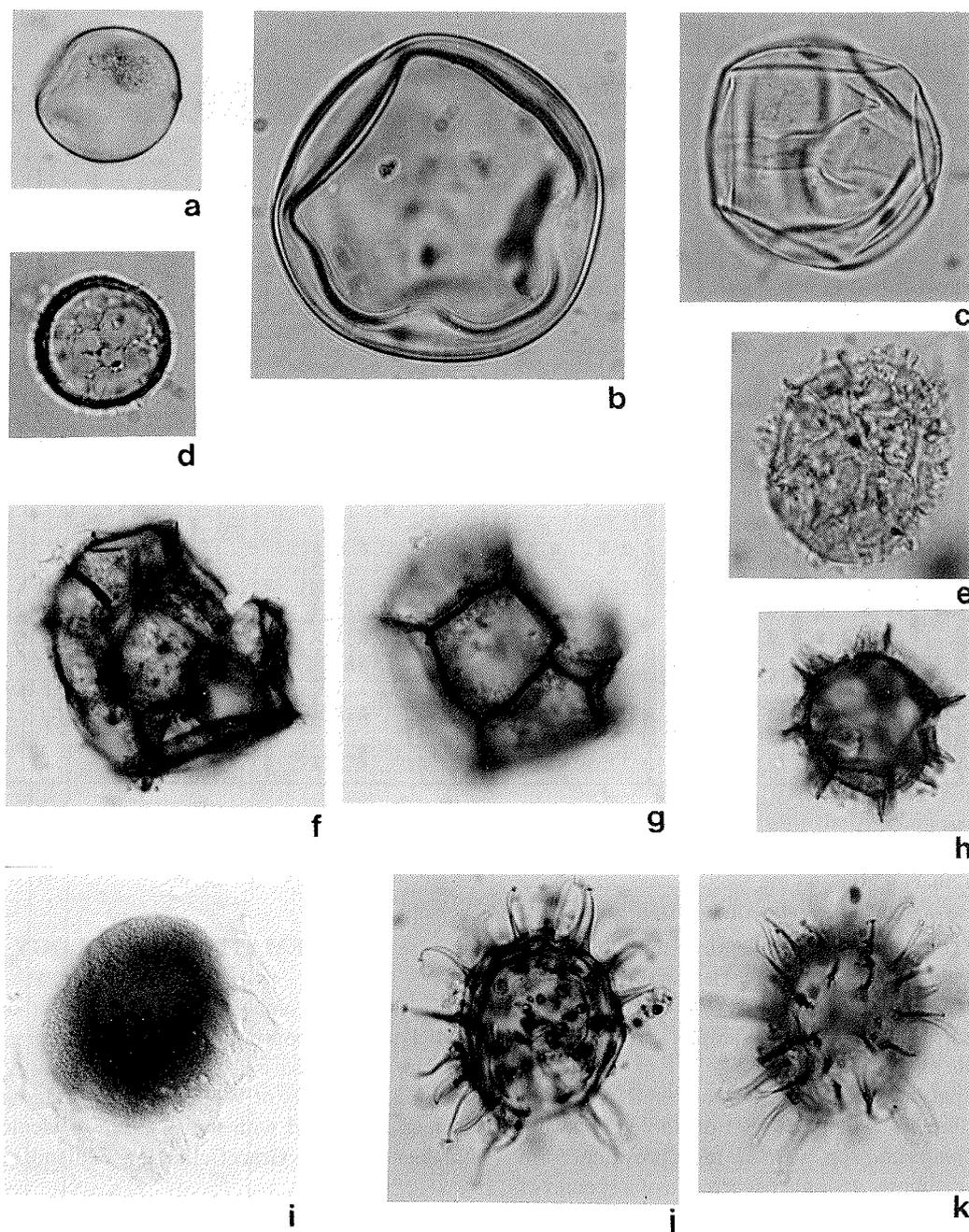


Fig. 3 - Selected palynomorphs from CRP-1. Figures are at different magnifications. *a*) *Leiosphaeridia* sp. 1 (diameter of central body = 11  $\mu$ m, depth = 20.04 mbsf, slide number = P4/2, England co-ordinates = N49/1); *b*) *Leiosphaeridia* sp. 2 (38  $\mu$ m, 144.32 mbsf, P44/1, Q49/2); *c*) *Leiosphaeridia* sp. 3 (28  $\mu$ m, 136.2 mbsf, P40/1, D31/2); *d*) *Cymatiosphaera* sp. 1 (10  $\mu$ m, 20.04 mbsf, P4/2, O42/3); *e*) *Cymatiosphaera* sp. 2 (23  $\mu$ m, 20.04 mbsf, P4/2, Z45/2); *f* & *g*) *Cymatiosphaera* sp. 3 (30  $\mu$ m, 99.10 mbsf, P12/4, G49/1); *h*) *Cymatiosphaera* sp. 4 (15  $\mu$ m, 99.01 mbsf, P12/4, G49/1); *i*) *Pterospermella* sp. (interference contrast, 38  $\mu$ m, 58.40 mbsf, P18/1, D44); *j* & *k*) *Michhystridium* sp. 1 (18  $\mu$ m, 48.35 mbsf, P13/2, Q52/2).

Size: width = 11(13)14  $\mu$ m, based on five specimens.

Distribution: sporadic occurrences throughout the drillhole, lower Miocene and Quaternary.

#### ***Leiosphaeridia* sp. 2**

(*Leiosphaeridia* sp. 2, Initial Report on CRP-1, Fig. 25j) (Fig. 3b)

Description: pale yellow phycoma, moderate in size, spherical. Wall unornamented, smooth and rarely folded,

about 1  $\mu$ m thick. On compression, the two sides of the phycoma often touch around the circumference making the wall look thicker and more irregular than it actually is. A pylome is present on some specimens.

Distinguishing features: the size, colour and the presence of pylomes are diagnostic of this species. The lack of a sigmoidal suture separates this species from the acritarch *Sigmopollis*.

Size: width = 25(32)39  $\mu$ m based on twelve specimens. Distribution: common throughout the drillhole but especially below 99.10 mbsf.

***Leiosphaeridia* sp. 3**

(*Leiosphaeridia* sp. 3, Initial Report on CRP-1) (Fig. 3c)

Description: moderate-sized phycoma, spherical. Smooth walled hyaline, clear, rarely pale yellow, often folded.

Wall very thin, <1 µm. No obvious apertures.

Distinguishing features: phycoma size, folding of wall and general lack of colour.

Size: width = 25(30)35 µm, based on ten specimens.

Distribution: common throughout the drillhole, particularly below 99.10 mbsf.

**Algal bodies**

Description: compressed spheres, pale yellow to dark brown in colour with a range of sizes. Wall smooth and thin (<1 µm). Usually strongly folded. No obvious apertures present.

Comment: this is a highly variable group that with additional work may be subdivisible. Morphologically specimens resemble the leiospheres and thus tentatively placed in the prasinophytes.

Order PTEROSPERMATALES Schiller 1925

Family Tasmanitaceae Tappan, 1980

Genus *Tasmanites* Newton, 1875

***Tasmanites* spp.**

Comments: several fragments of *Tasmanites* were recovered from the drillhole. Because of the fragmentary nature of the material, it is impossible to ascertain how many species are involved. The fragmentary style of preservation also suggests that the presence of *Tasmanites* in CRP-1 may be a result of reworking.

Family Cymatiosphaeraceae Mädlar, 1963

Genus *Cymatiosphaera* O. Wetzel, 1933 *ex* Deflandre, 1954

***Cymatiosphaera* sp. 1**

(*Cymatiosphaera* sp. 1, Initial Report on CRP-1, Fig. 25d & g) (Fig. 3d)

Description: small spherical central body. Wall smooth, colourless to pale yellow, hyaline, about 1 µm thick.

Phycoma rarely folded. A fine membrane about 1-2 µm high anastomoses over the entire surface, delineating up to 18 distinct fields. No obvious aperture.

Distinguishing features: small size and fine membranes.

Size: width of central body = 10(15)22 µm, based on eight specimens. Membrane height between 1 and 5 µm high.

Distribution: rare occurrences between 99.10 and 78.75 mbsf (lower Miocene), two rare occurrences in the Quaternary section may be due to reworking.

***Cymatiosphaera* sp. 2 (Fig. 3e)**

Description: spherical, moderate sized central body,

hyaline, colourless to pale yellow, about 1 µm thick. Membrane anastomosing over the entire surface delineating an indistinct number of fields. Membrane height generally about 2-3 µm. The free edge of the membrane is wrinkled into a series of very tight folds. No aperture visible.

Distinguishing features: size and the crenulated edge to the membranes.

Size: width of central body = 22(25)27 µm based on thirteen specimens. Membrane height between 3 and 5 µm.

Distribution: rare occurrences in both the lower Miocene (above 99.10 mbsf) and Quaternary part of the section.

***Cymatiosphaera* sp. 3**

(*Cymatiosphaera* sp. 3, Initial Report on CRP-1, Fig. 26k) (Fig. 3f & g)

Description: large phycoma, rarely folded. Usually dark brown in colour but tends to lose its colour in deeper parts of the section. Wall thin, about 1 µm. Robust membranes cover entire surface of central body, delineating more than 10 fields. No aperture evident.

Distinguishing features: phycoma size and wall colour.

Size: width of central body = 34(45)56 µm based on twelve specimens. Membrane height between 1.0 and 7.0 µm high.

Distribution: common in the lower Miocene section below 74.87 mbsf, single occurrence at 48.4 mbsf.

***Cymatiosphaera* sp. 4**

(*Cymatiosphaera* sp. 4, Initial Report on CRP-1, Fig. 25a) (Fig. 3h)

Description: moderate size, rarely folded, dark brown in colour. Wall thin, about 1 µm with a granulate texture. Membranes divide the entire surface of central body into more than 9 fields. No aperture evident.

Distinguishing features: granulate wall, and overall size. Size: width of central body = 15(18)20 µm based on four specimens, membranes about 4 µm high.

Distribution: single occurrence at 99.10 mbsf where it is common.

Family Pterospermellaceae Eisenack, 1972

Genus *Pterospermella* Eisenack, 1972

***Pterospermella* sp.**

(*Pterospermella* sp., Initial Report on CRP-1) (Fig. 3i)

Description: large phycoma with yellow/brown central body. Strongly compressed and surrounded by a wide equatorial flange (ala). Ala colourless, hyaline and solid with a very ragged edge. Wall of central body granulate. No aperture visible.

Distinguishing features: orange central body and broad ala. Size: Width of central body = 29(36)48 µm based on seven specimens. Ala extremely variable in size.

Distribution: common between 58.43 and 112.44 mbsf, lower Miocene.

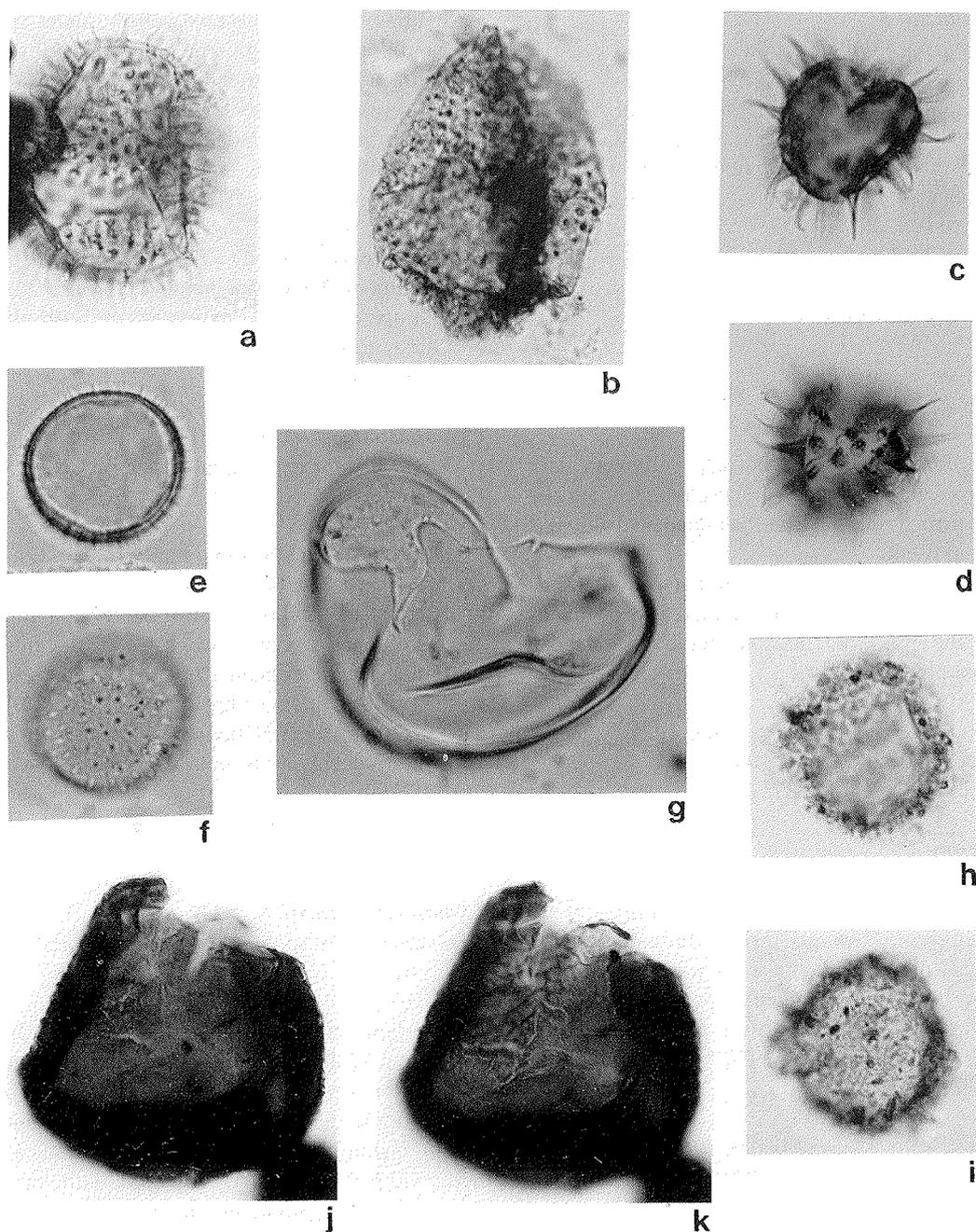


Fig. 4 - Selected palynomorphs from CRP-1. Figures are at different magnifications. a) *Micrhystridium* sp. 2 (diameter of central body = 29  $\mu\text{m}$ , depth = 99.01 mbsf, slide number = P12/1, England co-ordinates = V53); b) *Micrhystridium* sp. 3 (35  $\mu\text{m}$ , 99.01 mbsf, P12/1, P45/1); c & d) *Micrhystridium* sp. 4 (17  $\mu\text{m}$ , 48.35 mbsf, P13/2, E42/4); e & f) *Micrhystridium* sp. 5 (17  $\mu\text{m}$ , 42.4 mbsf, P46/1, N39); g) *Sigmopollis* sp. (36  $\mu\text{m}$ , 136.2 mbsf, P40/1, P36/1); h & i) Acritarch 1 (19  $\mu\text{m}$ , 147.69 mbsf, P45/1, D47/3); j & k) *Batiacasphaera cooperi* n. sp. - holotype (80  $\mu\text{m}$ , 112.44 mbsf, P33/1, M42/4).

#### Informal Group ACRITARCHA Evitt, 1963

Taxonomic treatment of the acritarchs based on Strother (1996). The acritarchs are the most diverse group of palynomorphs recovered from CRP-1 drillhole, the species listed below represent only the most common types. Many new forms have been encountered as either single or very limited occurrences, and these have not been included. A further detailed taxonomic study of these forms is planned and for this reason, open nomenclature has been used for this group.

#### Subgroup Acanthomorphae Downie, Evitt & Sarjeant, 1963

Genus *Micrhystridium* Deflandre 1937, *emend* Sarjeant & Stancliffe, 1994

#### *Micrhystridium* sp. 1

(Acritarch 1, Initial Report on CRP-1, Fig. 25b) (Fig. 3j & k)

Description: subspherical central body with a hyaline, smooth wall about 1  $\mu\text{m}$  thick. Usually pale brown in colour. Entire central body evenly covered with fine

capitate processes. No aperture visible.

Distinguishing features: long, capitate spines.

Size: width = 18(24)30  $\mu\text{m}$  based on seven specimens.

Processes; basal width approx. 1  $\mu\text{m}$ , length between 7-9  $\mu\text{m}$ .

Distribution: sporadic occurrences through the upper part of the lower Miocene section (above 99.10 mbsf).

Single occurrence in Quaternary strata probably due to reworking.

#### *Micrhystridium* sp. 2

(Acritarch 3, Initial Report on CRP-1, Fig. 25f) (Fig. 4a)

Description: subspherical central body, with a smooth, hyaline wall, pale brown in colour thickness <1  $\mu\text{m}$ .

Vesicle covered by a dense, uniform distribution of short, conical processes. No aperture visible.

Distinguishing features: uniform coverage of short conical spines.

Size: width = 22(26)28  $\mu\text{m}$ , based on six specimens. Wall thin, about 1  $\mu\text{m}$ . Processes; basal width approximately 1  $\mu\text{m}$ , length = 2-3  $\mu\text{m}$ .

Distribution: sporadic occurrences throughout the Miocene - this is the only species of spinose acritarch to extend below 99.10 mbsf. Single occurrence in Quaternary strata probably due to reworking.

#### *Micrhystridium* sp. 3

(Acritarch 5, Initial Report on CRP-1, Fig. 25h) (Fig. 4b)

Description: large subspherical central body, with a smooth hyaline wall, pale brown in colour. About 1  $\mu\text{m}$  thick. Short, conical processes cover the vesicle, coverage uniform. No aperture visible.

Distinguishing features: uniform coverage of short, fine conical spines. Separated from *Micrhystridium* sp. 2 by being larger and possessing finer processes, which are not as densely distributed over the vesicle.

Size: width = 25(31)36  $\mu\text{m}$ , based on five specimens. Processes; basal width <1  $\mu\text{m}$ , length = 1-2  $\mu\text{m}$ .

Distribution: restricted to the Miocene part of the section above 99.10 mbsf.

#### *Micrhystridium* sp. 4

(Acritarch 7, Initial Report on CRP-1, Fig. 25i & m) (Fig. 4c & d)

Description: subspherical, central body of variable size, with a smooth, hyaline wall. Wall thickness about 1  $\mu\text{m}$ , pale brown in colour. Central body covered with large rigid conical processes, which can occasionally be capitate. These blade-like processes appear to be hollow suggesting a double wall layer. No aperture visible.

Distinguishing features: the large rigid conical processes make this the most distinctive form here attributed to *Micrhystridium*.

Size: width = 17(21)28  $\mu\text{m}$ , based on seven specimens. Processes; basal width between 2-3  $\mu\text{m}$ , length 5-7  $\mu\text{m}$ .

Distribution: common between 99.10 and 48.4 mbsf, lower Miocene.

#### *Micrhystridium* sp. 5 (Fig. 4e & f)

Description: small spherical central body, with a smooth, hyaline wall. Wall thickness about 1  $\mu\text{m}$ , colourless.

Central body sparsely covered with small hair-like processes. No aperture visible.

Distinguishing features: size and sparse hair-like processes.

Size: width = 15(18)20  $\mu\text{m}$  based on four specimens, wall = 1  $\mu\text{m}$  thick, processes length approx. 1-2  $\mu\text{m}$ .

Distribution: rare between 42.41 and 48.35 mbsf, Miocene.

Sub Group Sphaeromorphitiae Downie, Evitt & Sarjeant, 1963

Genus *Sigmopollis* Hedlund, 1965

#### *Sigmopollis* sp.

(*Sigmopollis* sp. 1, Initial Report on CRP-1) (Fig. 4g)

Description: central body smooth walled, pale yellow to colourless, and hyaline. Subspherical to ovate in shape.

Excystment a sigmoidal suture around the periphery, often with a prominent tab arising from one margin of the aperture and matching notch on the opposite margin of the aperture.

Distinguishing features: sigmoidal aperture.

Size: width, measured parallel to excystment feature = 35(38)40  $\mu\text{m}$  (based on twelve specimens).

Distribution: common below 21.04 mbsf very common below 99.10 mbsf.

#### Acritarch 1

(Acritarchs 9 & 11, Initial Report on CRP-1, Fig. 25k & l) (Fig. 4h & i)

Description: a simple spherical central body with inclusions of opaque organic matter in the wall. Often the wall is very thin and colourless. However, some specimens are surrounded by amorphous organic matter, making the wall seem thick and indistinct. In these cases the central body appears to be dark grey in colour. Very variable in size.

Distinguishing features: the inclusion of organic material in the vesicle wall is the most distinctive feature of this form. The extreme variability suggests that further study may cause the form to be subdivided.

Size: width = 11(27)44  $\mu\text{m}$ , (based on 18 specimens).

Distribution: common throughout the drillhole.

Division PYRRHOPHYTA Pascher, 1914

Class DINOPHYCEAE Fritsch, 1929

Order PERIDINIALES Haekel, 1894

Several new species are recorded here for the first time, most are given formal descriptions. However, in cases where there is only very limited material available, open nomenclature is retained. Species known to be reworked are listed at the end of this section.

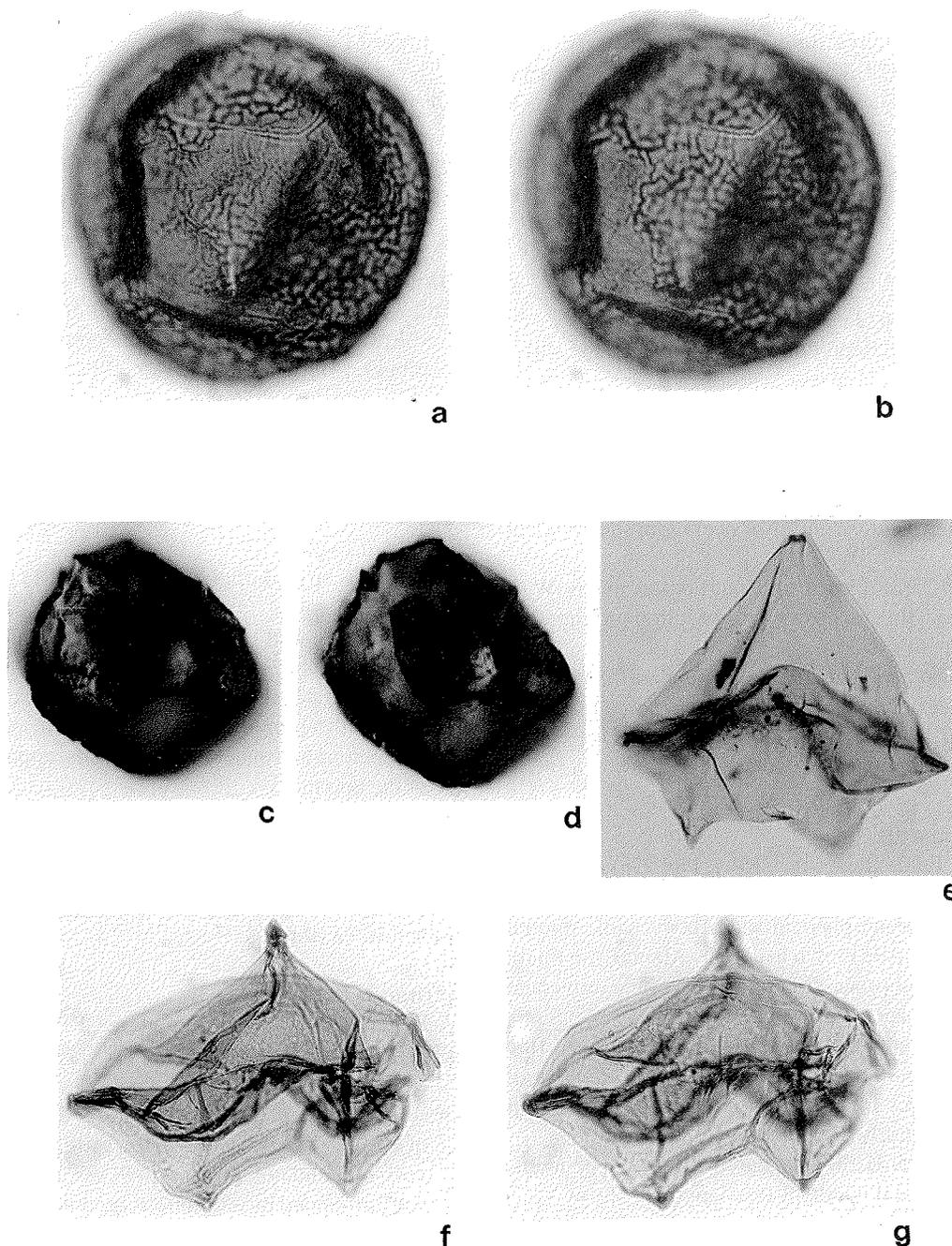


Fig. 5 - Selected palynomorphs from CRP-1. Figures are at different magnifications. A & b) *Brigantedinium pynei* n. sp. - holotype (diameter of central body = 73  $\mu$ m, depth = 145.65 mbsf, slide number = P45/1, England co-ordinates = D31/3); c & d) *Impagidinium* sp. (73  $\mu$ m, 92.34 mbsf, P28/1, J36), note operculum within cyst; e) *Lejeunecysta fallax* (Morgenroth) (length = 55  $\mu$ m, 85.30 mbsf, P25/1, H33/1); f & g) *Lejeunecysta cowiei* n. sp. - holotype (length = 70  $\mu$ m, width = 95  $\mu$ m, 120.40 mbsf, P14/1, F36/4).

Genus *Batiacasphaera* Drugg, 1970

Type species; *Batiacasphaera compta* Drugg, 1970

*Batiacasphaera cooperi* n. sp. (Fig. 4j & k)

1998, *Batiacasphaera* sp., Initial Report on CRP-1.

Name: for Pat Cooper, Drilling Manager CRP.

Holotype: slide P33/1, 112.44 mbsf, England finder co-ordinates, M42/4, diameter = 84  $\mu$ m, figure 5a & b.

Shape: large, subspherical.

Phragma: autophragm covered with a dense reticulum.

Muri thick but lumen variable in width. No paratabulation indicated by wall features.

Archaeopyle: large apical archaeopyle, operculum detached. Margins of the archaeopyle often indistinct due to cyst damage. No detached opercula found.

Size: diameter = 63(73)84  $\mu$ m, based on six specimens.

Note: species differs from *Batiacasphaera cassicula* Wilson (1988) by having a coarser more variable reticulum.

Distribution: single appearance at 21.04 mbsf (?reworked), otherwise restricted to the Miocene part of the section below 85.36 mbsf.

Genus *Brigantedinium* Reid, 1977

Type species; *Brigantedinium simplex* (Wall, 1967)  
Reid, 1977

***Brigantedinium pynei* n. sp.** (Fig. 5a & b)

1998 *Brigantedinium* sp., Initial Report on CRP-1,  
figure 26a, b, c & f.

Name: for Alex Pyne, Science Support Manager CRP.

Holotype: slide P43/1, 145.65 mbsf England finder co-ordinates; E36, diameter = 68  $\mu\text{m}$ , figure 5c & d.

Shape: large, spherical.

Phragma: autophragm, orange brown in colour. Surface rugulose with no visible paratabulation.

Archaeopyle: intercalary. Although the archaeopyle is clearly visible on the holotype, it is often difficult to see.

However, the operculum, consisting of a single intercalary paraplate is commonly preserved within the cyst.

Size: width = 63(73)83  $\mu\text{m}$  based on 10 specimens.

Distribution: common in the Miocene part of the section, possibly reworked into the sample at 39.06 mbsf.

Genus *Impagidinium* Stover & Evitt, 1978

Type species; *Impagidinium disperitum* (Cookson & Eisenack, 1965) Stover & Evitt, 1978.

***Impagidinium* sp.** (Fig. 5c & d)

1998, *Impagidinium* sp., Initial Report on CRP-1.

Shape: large subspherical cyst.

Phragma: single wall dark brown in colour, surface rugulose. Paratabulation poorly defined by a series of low ridges. The paracingulum the most obvious feature.

Archaeopyle: precingular, the archaeopyle is often difficult to see due to poor preservation but the holotype contains a single plate operculum which appears to be precingular in form.

Comments: specimens are often damaged and occur as fragments with some paratabulation present.

Size: only three relatively complete specimens found, width = 50, 56, and 43  $\mu\text{m}$  respectively.

Distribution: sporadic occurrences below 67.54 mbsf in the lower Miocene section, and a single occurrence at 39.06 mbsf, which may represent reworking into the Quaternary strata.

Genus *Lejeunecysta* Artzner & Dörhöfer, 1978 *emend.*

Bujak, 1980.

Type species; *Lejeunecysta hyalina* (Gerlach, 1961)

Artzner & Dörhöfer, 1978

***Lejeunecysta cowiei* n. sp.** (Fig. 5f & g)

1998, *Lejeunecysta* sp1, Initial Report on CRP-1, figure 26h & i.

Name: for Jim Cowie, Project Manager CRP.

Holotype: slide P14/1, 120.4 mbsf, England finder co-

ordinates; F36/4, length = 70  $\mu\text{m}$ , width = 95  $\mu\text{m}$ , figure 5g & f.

Shape: large peridinioid cyst, width greater than length.

Prominent quadrate apical horn. Reduced, blunt antapical horns.

Phragma: autophragm brown in colour when not covered with pyrite, no sign of paratabulation. Cyst often folded at the position of the paracingulum occasionally producing a quadrate midline.

Archaeopyle: intercalary.

Size: length = 59(71)78  $\mu\text{m}$ , based on 5 specimens. Width = 69(83)102  $\mu\text{m}$  based on six specimens.

Comments: differs from *Lejeunecysta fallax* in being consistently wider than long, and possessing a prominent quadrate apical horn rather than rounded.

Distribution: common below 67.54 mbsf in the lower Miocene section, a single occurrence at 39.06 mbsf may represent reworking into the Quaternary sediments.

***Lejeunecysta fallax*** (Morgenroth, 1966) Artzner & Dörhöfer, 1978 (Fig. 5e)

1966, *Lejeunia fallax* Morgenroth, p. 2-3, plate 1, figures 6 & 7.

1978, *Lejeunecysta hyalina* (Gerlach), Artzner & Dörhöfer, p. 1381-1382.

1983, *Lejeunecysta hyalina* (Gerlach), Artzner & Dörhöfer, *emend.* Biffi & Grignani, p. 132.

1988, *Lejeunia fallax* (Morgenroth), Wrenn & Hart, p. 358-359, figure 28.3.

1998, *Lejeunia fallax* (Morgenroth), Initial Report on CRP-1, figure 26e.

Comment: the most abundant dinoflagellate species present in CRP-1. The cyst is brown in colour and often distorted. Specimens assigned to this species in CRP-1 have a distinctive rounded apical horn. Antapical horns small and often solid. Commonly folded around the presumed paracingulum, sometimes producing a quadrate midline. Distribution: single occurrence in the lower Quaternary section, common between 48.35 and 99.02 mbsf, sporadic occurrences below this level.

Genus *Operculodinium* Wall, 1967

Type species; *Operculodinium centrocarpum* (Deflandre & Cookson, 1955) Wall, 1967

***Operculodinium* sp.** (Fig. 6a & b)

Shape: subspherical.

Phragma: cyst covered with stout spines, which are cornucavate; elsewhere walls closely appressed, light brown in colour. Spines distinctive, bases broad and fibrous tapering rapidly to a blunt quadrate termination. No paratabulation visible.

Archaeopyle: precingular.

Size: width = 25(28)30  $\mu\text{m}$ . based on four specimens. Spines 4 mm wide at base, 1  $\mu\text{m}$  wide at top, 4  $\mu\text{m}$  long.

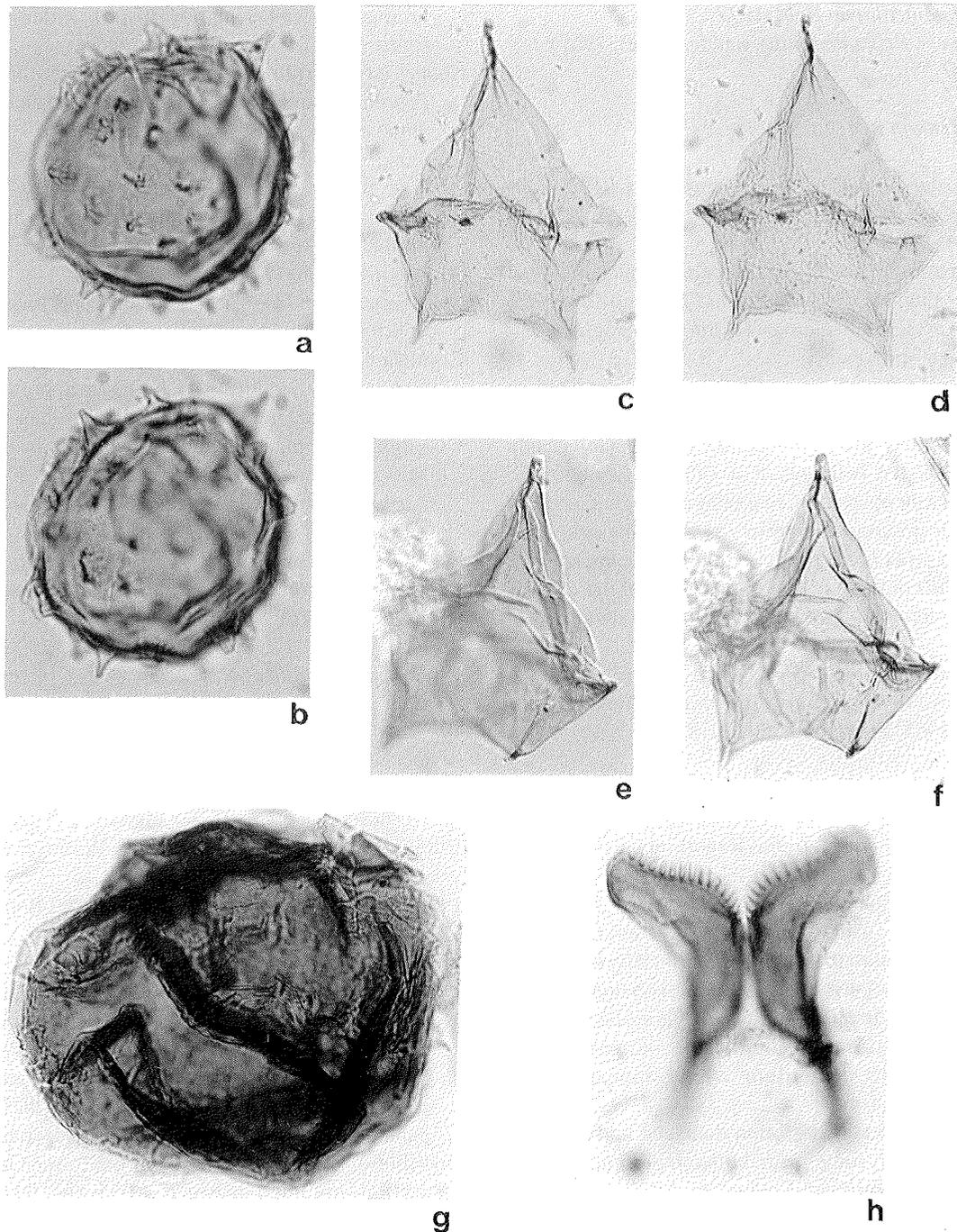


Fig. 6 - Selected palynomorphs from CRP-1. Figures are at different magnifications. *A & b*) *Operculodinium* sp. (diameter of central body = 28  $\mu$ m, depth = 36.60 mbsf, slide number = P48/1, England co-ordinates = P44/2); *c & d*) *Phelodinium cranwelliae* n. sp.- holotype (112  $\mu$ m, 141.80 mbsf, P15/2, U45/4); *e & f*) *Phelodinium cranwelliae* n. sp. (h, interference contrast, 104  $\mu$ m, 144.31 mbsf, P44/1, K49). note pore on apical horn; *g*) *Paralecaniella indentata* (Deflandre & Cookson) (74  $\mu$ m, 112.44 mbsf, P33/1, V34); *h*) Arthropod / Annelid part typical of material found throughout the drillhole (length = 206  $\mu$ m, 78.15 mbsf, P16/2, Y48/2).

Distribution: common at the base of the Quaternary sequence, single appearance in the lower Miocene at 67.54 mbsf.

Genus *Paralecaniella* Cookson & Eisenack, 1970  
*emend.* Elsik, 1977

Type species; *Paralecaniella indentata* (Deflandre & Cookson, 1955) Cookson & Eisenack, 1970, *emend.* Elsik 1977.

*Paralecaniella indentata* (Deflandre & Cookson, 1955) Cookson & Eisenack, 1970, *emend.* Elsik 1977. (Fig. 6g)

1955, *Epicephalopyxis indentata* Deflandre & Cookson, p. 292-293, plate 9, figures 5 to 7, text-figure 56.

1970, *Paralecaniella indentata* (Deflandre & Cookson), Cookson & Eisenack, p. 323.

1977, *Paralecaniella indentata* (Deflandre & Cookson), Cookson & Eisenack, *emend.* Elsik, p. 96, plate 1,

figures 1 to 15, plate 2, figures 1 to 11.

1988, *Paralecaniella indentata* (Deflandre & Cookson) Cookson & Eisenack, *emend.* Elsik, Wrenn & Hart, p. 364–365, figure 31.5.

1998 *Paralecaniella indentata*, Initial Report on CRP-1.

**Comment:** Specimens from CRP-1 are identical to the material described from Seymour Island by Wrenn & Hart (1988). Like the Seymour Island material, endocyst often appears to be cracked and shattered as if it were brittle. This is especially noticeable in damaged specimens that have lost their periphragm. Wrenn & Hart (1988) suggested this was a preservational feature. In the Initial Report on CRP-1 (Cape Roberts Science Team, 1998) this species was considered to be reworked. However, because this study has shown this species to be common throughout the drillhole, the possibility that it is *in situ* cannot be discounted.

**Size:** maximum length of endocyst = 60(70)83 µm based on four specimens.

**Distribution:** sporadic occurrences throughout the lower Miocene section. Single possibly reworked occurrence in the Quaternary section.

Genus *Phelodinium* Stover & Evitt, 1978

Type species: *Phelodinium pentagonale* (Corradini, 1973) Stover & Evitt, 1978

*Phelodinium cranwelliae* n. sp. (Fig. 6c, d, e & f)

1998 *Phelodinium* sp.1, Initial Report on CRP-1, figure 26d & g.

**Name:** for Lucy Cranwell, pioneer Antarctic palynologist.

**Holotype:** slide P15/2, 141.8 mbsf, England finder coordinates; U45/4, figure 6d. Length = 112 µm, width = 76 µm.

**Shape:** large, elongate peridinioid cyst moderately compressed dorso-ventrally. Two prominent, short antapical horns, about equal in size and sharp, often filled. Apical horn can be extremely elongate with a blunt termination, usually folded. Walls semi-rigid and usually straight, except between the two antapical horns where it is concave. Specimens are often folded around the probable paracingular area.

**Phragma:** cornucavate, the two walls are closely appressed elsewhere on the cyst. Brown in colour. One, or occasionally two, small pores are often present near the tip of the apical horn. Ornamentation absent. No paratabulation has been noted, however, a region of strong folding often marks the position of the paracingulum.

**Archaeopyle:** intercalary, operculum remaining attached along the edge nearest the paracingulum.

**Size:** determining the length of this species accurately is difficult as many specimens have a folded apical horn resulting in measurements that are too short. Length = 83(96)112 µm. Width = 59(71)78 µm based on nine specimens.

**Distribution:** common between 83.36 and 147.68 mbsf, lower Miocene.

Genus *Spiniferites* Mantell, 1850, *emend.* Sarjeant, 1970

Type species: *Spiniferites ramosus* (Ehrenberg, 1837), Loeblich & Loeblich, 1966.

*Spiniferites* spp.

**Comment:** several broken specimens are assignable to this genus, but possibly representing more than one species. Although listed on the range chart as *in situ*, largely because of the uncertainty of the species involved, the fragmentary mode of preservation suggests that the presence of this genus may be a result of reworking.

## REWORKED DINOCYSTS

Reworked dinocysts occurred sporadically throughout the drillhole reaching a peak in diversity near the top of the Miocene section (Fig. 2). Most are members of the Paleocene Transantarctic Flora, *Vozzhennikovia apertura* being the most common species. Other species present are: *Alterbidinium* cf. *asymmetricum*, *Deflandrea antarctica*, *Crassosphaera* sp., *Operculodinium bergmannii*, and *Spinidinium macmurdoense*.

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