

## Oligocene and Miocene Marine Palynomorphs from CRP-2/2A, Victoria Land Basin, Antarctica

M.J. HANNAH<sup>1\*</sup>, G.J. WILSON<sup>2</sup>, J.H. WRENN<sup>3</sup>

<sup>1</sup>School of Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington - New Zealand

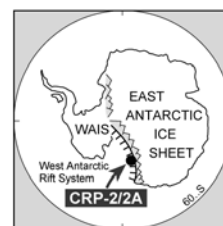
<sup>2</sup>Institute of Geological & Nuclear Sciences Ltd, PO Box 30 368 Lower Hutt - New Zealand

<sup>3</sup>Department of Geology and Geophysics Centre for Excellence in Palynology, Louisiana State University, Baton Rouge, Louisiana 0803 - United States of America

\*Corresponding author (michael.hannah@vuw.ac.nz)

Received 6 September 1999; accepted in revised form 30 May 2000

**Abstract** - A diverse assemblage of marine palynomorphs was recovered from the Oligocene - Miocene section of CRP-2/2A. Most of the assemblage is composed of previously unrecognised species. Three distinct groups of marine palynomorph were recognised: (1) prasinophytes, mainly *Cymatiosphaera*, (2) acritarchs, mainly *Leiosphaeridia* and *Sigmopollis* although *Leiofusa* is an important component of the bottom half of the hole, and (3) dinoflagellate cysts. About 27 species of *in situ* dinoflagellate cysts were recorded, of which seven apparently undescribed species of *Lejeunecysta* form a prominent component. Reworked specimens of several species of the Paleogene Transantarctic Flora occur in CRP-2/2A sediments. Several abundance peaks of reworked taxa from the Transantarctic Flora are recorded. Three marine palynomorph zones were recognised (MP3, MP2, MP1), considered to be early Oligocene, late Oligocene, and late Oligocene /early Miocene in age respectively. Samples from the Quaternary and Pliocene part of CRP-2/2A were also examined. These proved either barren or yielded very sparse low diversity floras.



### INTRODUCTION

CRP-2/2A is the second of three drillholes planned to core strata of late Cretaceous to early Cenozoic age from the western margin of the Victoria Land Basin, Antarctica. Drilling of CRP-2 commenced in October 1998 at a site about 16 km offshore from Cape Roberts, in 178 m of water. CRP-2 was continuously cored from 5 to 57 meters below sea level (mbsf) with core recovery of 91%. Due to technical difficulties drilling was abandoned at this depth and a deviation hole, CRP-2A, was spudded in at the same location. This was cored down to a total depth of 623 mbsf and core recovery was 95%. Drilling was terminated in November 1998. Together the two drillholes are referred to as CRP-2/2A. Unless otherwise stated, all drillhole data is from the Cape Roberts Science Team (1998).

Figure 1 presents a summary lithological column for the combined drillholes. Sediments between 5 and 26 mbsf are considered Pliocene and Quaternary in age on the basis of foraminiferal and diatom assemblages (Webb & Strong, this volume; Scherer et al., this volume). Diatom, nannofossil and foraminiferal analysis date the remainder of the core as Miocene to early Oligocene (Scherer et al., this volume; Watkins & Villa, this volume; Strong & Webb, this volume). The chronology of CRP-2/2A outlined by Wilson et al. (this volume) suggests that the Oligocene - Miocene boundary should fall between 130 and 185 mbsf and that the drillhole terminated within the Oligocene.

The sediments encountered in the Oligocene / Miocene

section consist predominantly of sandstones, mudstones, and diamictites. There is an increase in both the number and thickness of diamictites above about 440 mbsf. All sediments from the core are interpreted to represent glaciomarine environments; detailed depositional settings are listed in figure 1.

The core has been subdivided into twenty-five cyclic packages of facies, each of which commence with an erosional unconformity (Fig. 1). These unconformity-bounded cycles of sediment are probably a result of glacio-eustatic fluctuations (Fielding et al., this volume). Missing section representing a significant amount of unrecorded time probably occurs at each sequence boundary.

### PROCESSING TECHNIQUES

One hundred and sixteen samples from the entire core were processed and examined for this study (Fig. 1). All samples were processed by J. Simes at the Crary Engineering and Science Center, McMurdo Station. Basic steps used in the processing stream were maceration in 50% hydrofluoric acid using a Prolabo M-401 microwave digester, followed by light oxidation (ten minutes in nitric acid). After sieving at 6mm, residues were mounted on slides in glycerine jelly. The presence of thin walled leiospheres in many samples suggests that the processing technique used did not result in the loss of significant numbers of palynomorphs. A detailed discussion of palynology processing used in all

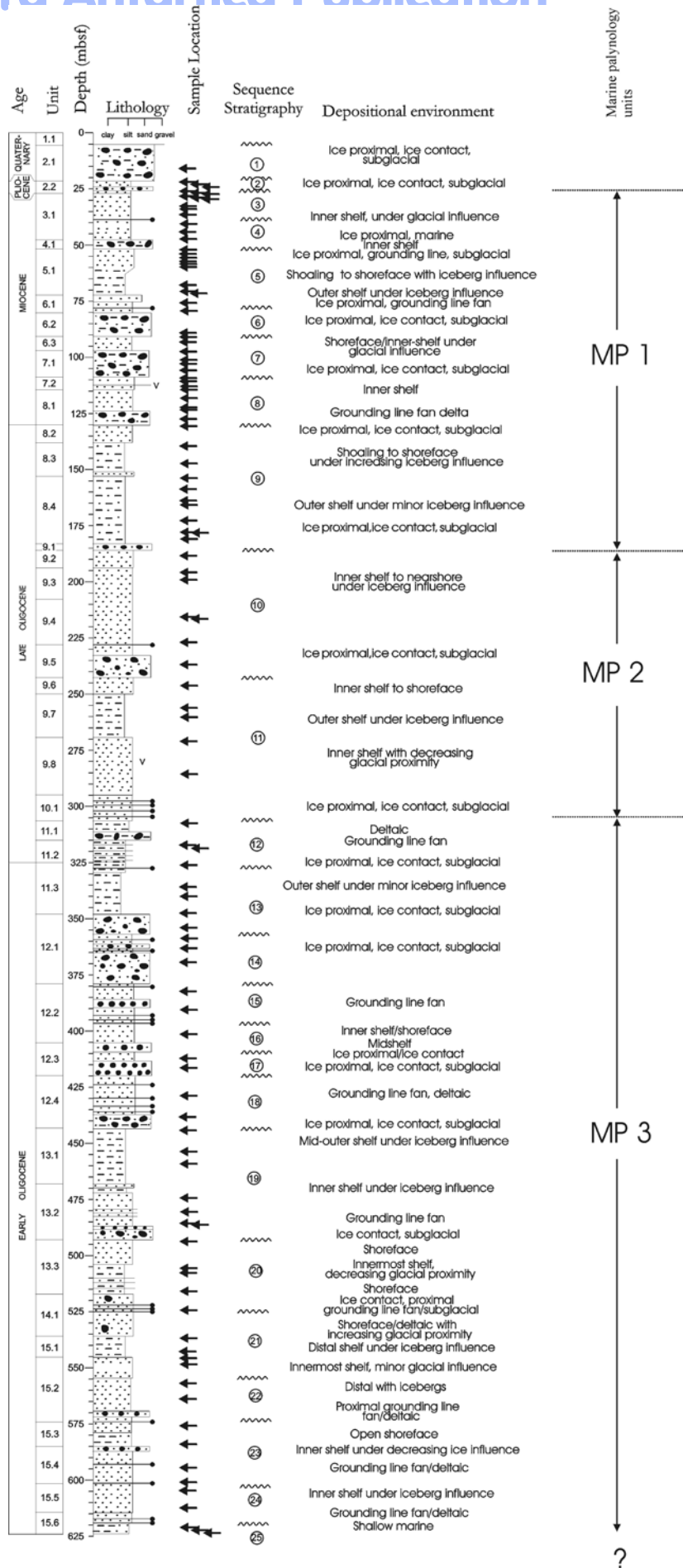


Fig. 1 - Lithological summary for CRP-2/2A. (Cape Roberts Science Team, 1999). Arrows mark the position of samples used in this study.

drilling seasons of the Cape Roberts Project in the Antarctic is provided in Simes & Wrenn (1998).

## BIOSTRATIGRAPHY

A range chart of the palynomorphs recovered from the drill hole is presented in figure 2a & b. Species are grouped into prasinophyte algae, acritarchs, dinoflagellate cysts (dinocysts), both *in situ* and reworked, and "other", which consists mainly of foraminiferal linings and scolecodonts. Most species are new and the open nomenclature used in the initial report (Cape Roberts Science Team, 1999) is retained in this study. A full taxonomic treatment of the flora is being prepared. Key species are illustrated in figures 3-5.

The palynomorphs listed in figure 2 are considered to be overwhelmingly of marine origin. This is unambiguous in the case of the dinocysts. The prasinophyte genera listed have not been reported from fresh water settings, although they are clearly tolerant of a wide range of salinities. (Tappan, 1980; Tyson, 1995; Guy-Ohlsen, 1996). Amongst the acritarchs *Micrhystridium* and *Leiofusa* are also considered to be of marine origin. The remaining acritarchs, dominantly species of *Leiosphaeridia* and *Sigmopollis*, may be fresh water forms present as a result of river inflow. However, sedimentological analysis of the cores suggests no or very little river derived material was being deposited at the time (Cape Roberts Science Team, 1999). In addition, throughout the core numbers of terrestrial palynomorphs are very low (Raine & Askin, this volume). Numbers would be expected to be higher if a significant amount of runoff from the land was occurring. This suggests that on the balance of probability all the palynomorphs listed in figure 2 are likely to be marine.

In a taxonomic study of the marine palynomorph assemblages recovered from CRP-1 Hannah et al. (1998) followed the suggestion of Guy-Ohlsen (1996) and placed *Leiosphaeridia* in the prasinophyte algae. Tyson (1995) noted that the position of *Leiosphaeridia* amongst the prasinophytes is problematic. Leiospheres are smooth walled (Lindgren, 1981, 1982), and lack the morphologic features (pits, pores, ridges, laminated or layered walls) that allow *Tasmanites*, *Cymatiosphaera*, *Pterospermella* and other genera to be classified with confidence as prasinophytes (Tappan, 1980). Because of the uncertainty in their taxonomic position leiospheres are here retained in the Acritarcha.

The three samples examined from the Quaternary part of the core contained few specimens. The low diversity assemblages recovered were dominated by *Leiosphaeridia* species together with scattered occurrences of the prasinophytes *Pterospermella* and *Cymatiosphaera*. Specimens of only two dinocyst species were recovered, both species of *Batiacasphaera*, one of which (*Batiacasphaera cooperi*) was first recorded from CRP-1 (Hannah et al., 1998, fig. 4). The second appears to be new. It is probable that specimens of both these forms are reworked. Five samples from the Pliocene interval are almost barren, yielding only a few acritarchs (*Leiosphaeridia* and *Sigmopollis*). A single specimen of *Enneadocysta*

*partridgei*, reworked from Eocene sediments, was recovered from the base of this interval.

Except for two barren samples (at 494.10-494.11 and 601.34-601.35 mbsf) all samples from the Oligocene/Miocene interval yielded common to abundant marine palynomorphs. Preservation is generally good.

The palynomorph assemblages recovered from CRP-1 (Hannah et al., 1998; Wrenn et al., 1998) were the first from unequivocal Miocene strata in the Antarctic region. The palynomorph assemblages reported herein from the Oligocene help fill in the gap between the CRP-1 sequence and the Transantarctic dinocyst flora of Eocene to earliest Oligocene age (Hannah, 1997; Wilson, 1967, 1989; Wrenn & Hart, 1988). The Transantarctic flora was not encountered as an *in situ* assemblage in CRP-2/2A (see below for discussion of reworking in CRP-2/2A). Comparison of the Cape Roberts fossil floras with modern assemblages is difficult due to the lack of extensive detailed studies in the region. Much of our understanding of the distribution of modern high latitude palynofloras is based on studies carried out in the Arctic region (see for example Mudie, 1992). The Arctic environment is dominated by river runoff which results in large polar estuaries (Mudie, 1992), a strikingly different environment from that suggested for the Cape Roberts region (Cape Roberts Science Team, 1999) which makes useful assemblage comparisons impossible.

Analysis of modern Antarctic palynofloras are limited to two studies. Marret & de Vernal (1997) analysed dinocyst distribution in the seas to the south of Australia, and Harland et al. (1998) described recent dinocysts from a transect from the Falkland Trough to the Weddell Sea. Neither study yielded assemblages similar to those reported here. In all the samples reported by Marret & de Vernal (1997), and in samples from north of 60° S documented by Harland et al. (1998), the diversity and abundance of dinocysts are much higher than in assemblages from the Cape Roberts cores.

In the Weddell Sea south of 60° S dinoflagellate numbers and diversity drop below that recorded in the Cape Roberts cores. The Weddell Sea assemblages are dominated by *Selenopemphix antarctica* and several species of *Protoperidinium*, all considered heterotrophic forms (Harland et al., 1998, table 3). Although the same species were not present in CRP-2/2A, a significant component of the dinocyst flora were several species of *Lejunecysta*, also a heterotrophic form.

## MARINE PALYNOMORPH UNITS

On the basis of distinctive last occurrences (LOs) and first occurrences (FOs) the interval can be subdivided into three informal marine palynomorph units (MP3, MP2, MP1). The *in situ* dinocyst assemblage is notable for the presence of several species of the genus *Lejunecysta*, some of which are used to define these three units. Once formally described, these species may provide good datums for age control elsewhere in the Ross Sea region. The ages for these three marine palynomorph units are from the age model for the drillhole presented by Wilson, Bohaty et al. (this volume).

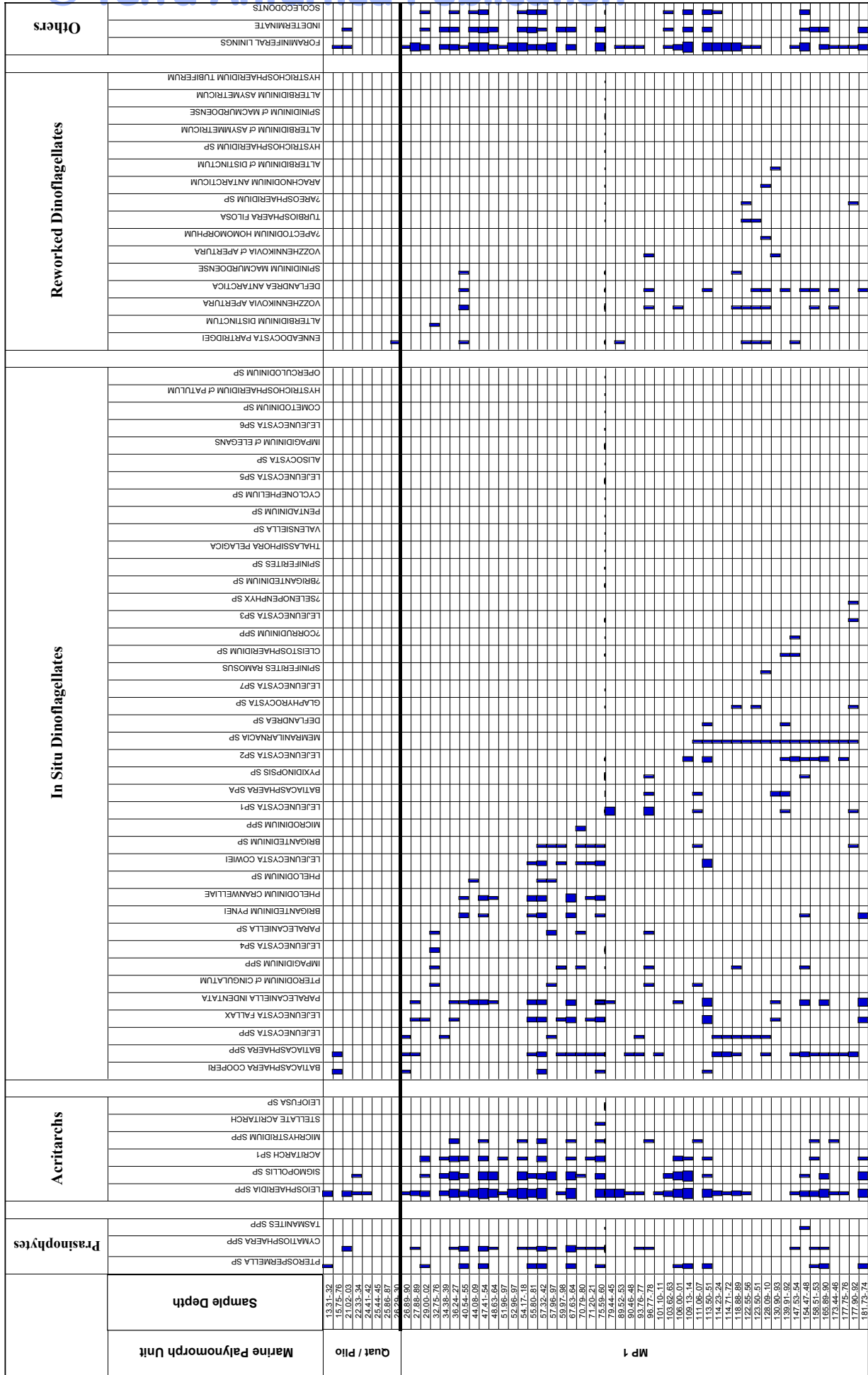


Fig. 2a - Range chart of marine microplankton recovered from the upper part of CRP-2/2A. (MP1 -Pliocene / Quaternary).



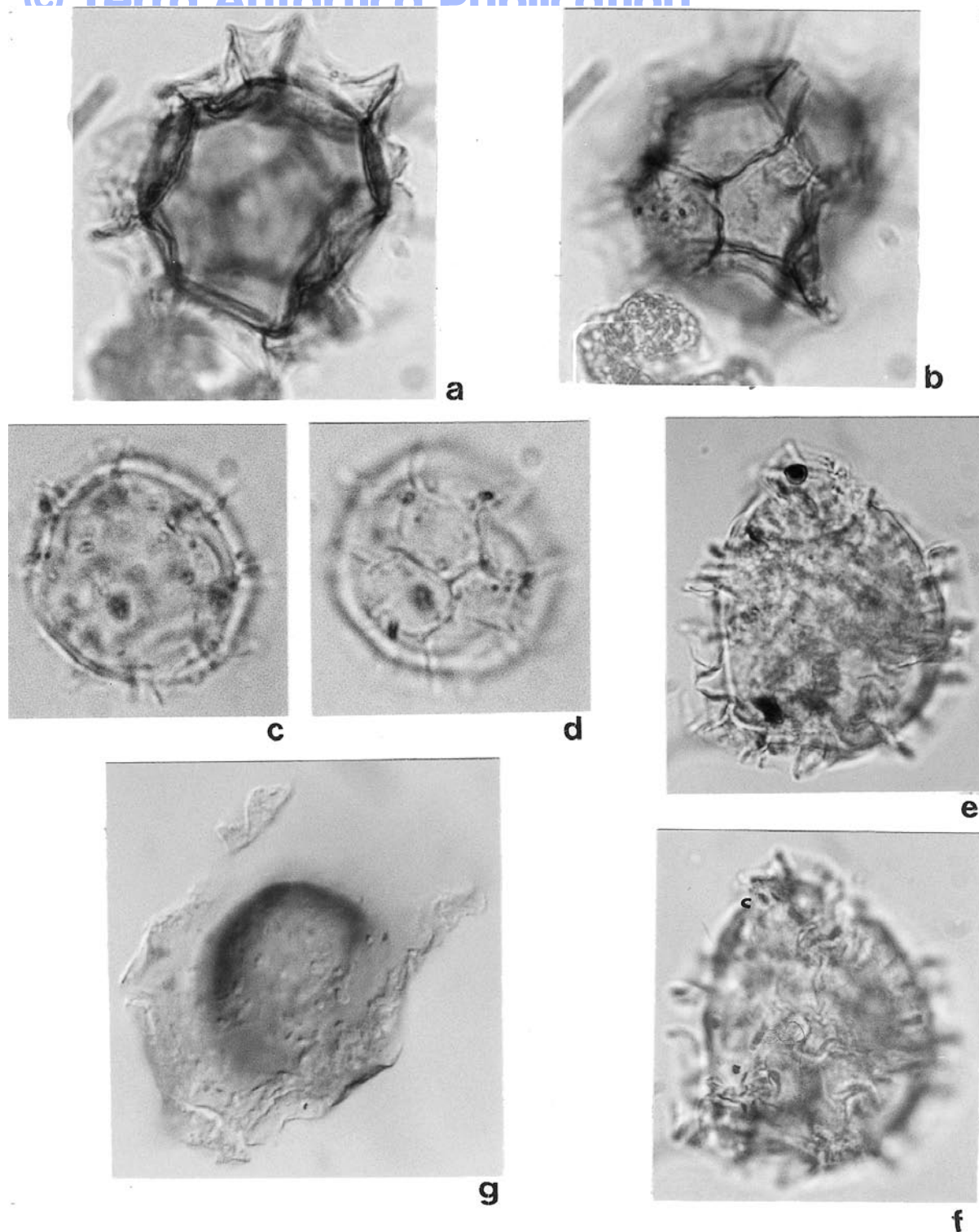


Fig. 3 - Selected palynomorphs from CRP-2/2A. Figures are at various magnifications. a & b) *Cymatiosphaera* sp. (diameter of central body = 25  $\mu\text{m}$ , depth = 57.82-57.84 mbsf, slide number = P85/1, England Finder coordinates = W46/4); c & d) *Cymatiosphaera* sp. 1 of Hannah et al., 1998 (10  $\mu\text{m}$ , 548.46-548.47 mbsf, P172/1, M55); e & f) *Cymatiosphaera* cf. *invaginata* (10  $\mu\text{m}$ , 67.63-67.64, P89/1, N47/2); g) *Pterospermella* sp. (21  $\mu\text{m}$ , 40.45-40.55 mbsf, P66/1, Q48/2).

#### MARINE PALYNOFORM UNIT 3 (MP3)

##### 624.14-624.15 – 307.12-307.13 mbsf. Early Oligocene

This is the thickest of the three marine palynomorph units, occupying almost the entire lower half of the drill hole. The base of MP3 is the bottom of the hole, the top

is marked by the LO of the dinocysts *Lejeunecysta* sp. 1 and *Lejeunecysta* sp. 5, and of the fusiform acritarch *Leiofusa*. Assemblages recovered from this interval are characterised by high numbers of *Leiofusa*.

Other dinocysts which are common throughout MP3 are *?Pyxidinospis* sp. and a distinctive robust form, *Impagidinium* cf. *elegans*. *?Pyxidinospis* sp. makes its last

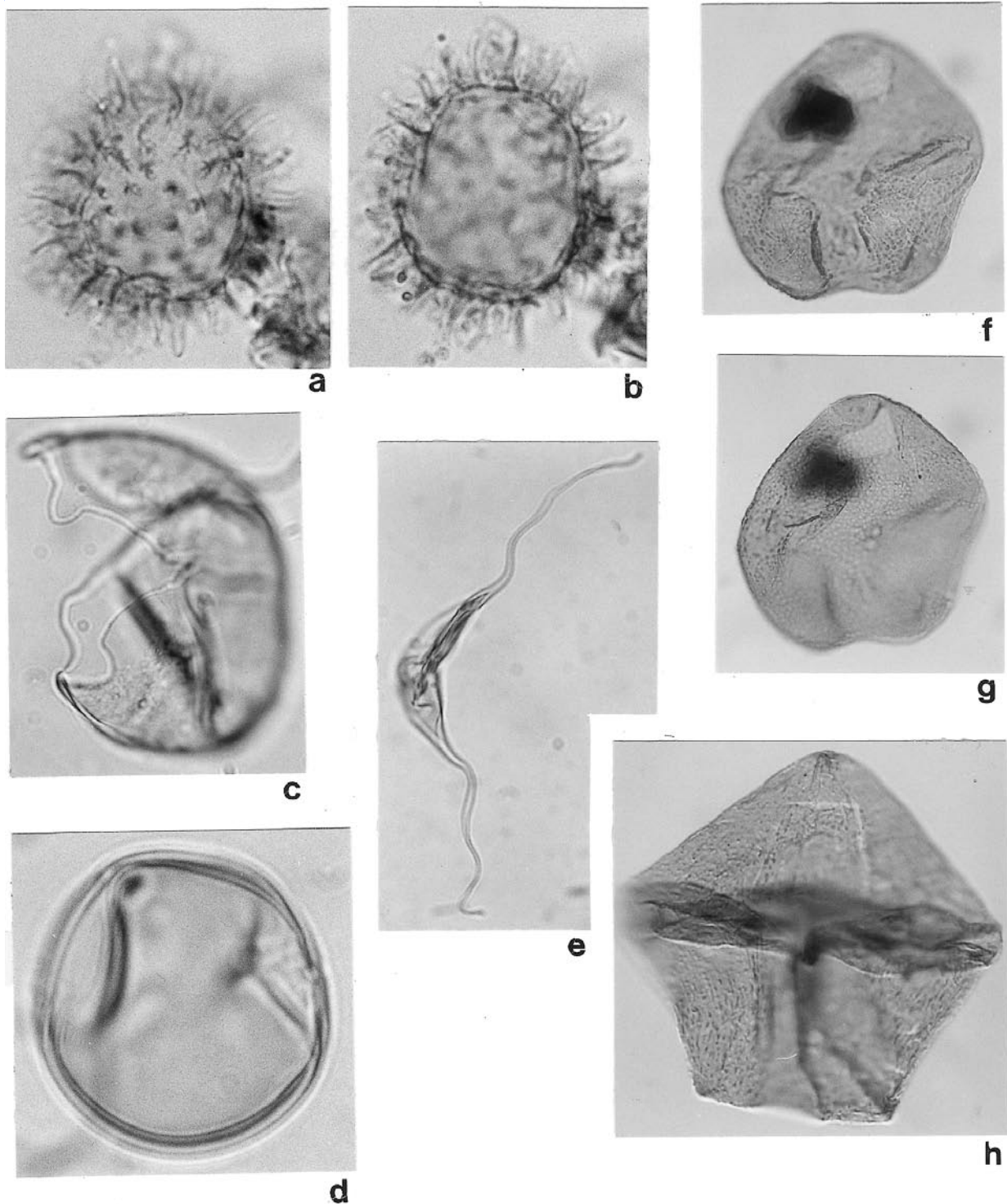


Fig. 4 - Selected palynomorphs from CRP-2/2A. Figures are at various magnifications. a & b) *Micrhystridium* sp.2 of Hannah et al., 1998 (width =16  $\mu$ m, depth = 67.63-67.64 mbsf, slide number = P89/1, England Finder coordinates = N47/2); c) *Sigmopollis* sp. (32 $\mu$ m, 36.24-36.27 mbsf, P56/1, D44/1); d) *Leiosphaeridia* sp 2. of Hannah et al., 1998 (23 $\mu$ m, 36.24-36.27 mbsf, P56/1, U45); e) *Leiofusa* sp. ( length = 63  $\mu$ m, 548.46-548.47, P172/1, U53/4); f & g) *Lejeunecysta* sp. 5 ( 99  $\mu$ m, 251.49-.52 mbsf, P113/1, Q42/1); h) *Lejeunecysta* sp. 1 (27  $\mu$ m, 25.59 -25.60 mbsf, P81/1, U38/4).

consistent appearance in the drill hole at 316.50-316.52 mbsf, just below the top of MP3, however it is recorded sporadically up to 96.77-96.78 mbsf. *Impagidinium* cf. *elegans* is restricted to the lower part of MP3.

Individuals assignable to *Cymatiosphaera* are the only prasinophyte algae present in MP3. They are common and are listed in the range chart as *Cymatiosphaera* spp. Several

species are present, some of which were not recorded in CRP-1 (Hannah et al., 1998). Rare acanthomorph acritarchs are present. Individuals of *Leiosphaeridia* are recorded sporadically throughout this interval, although both their numbers and diversity are low.

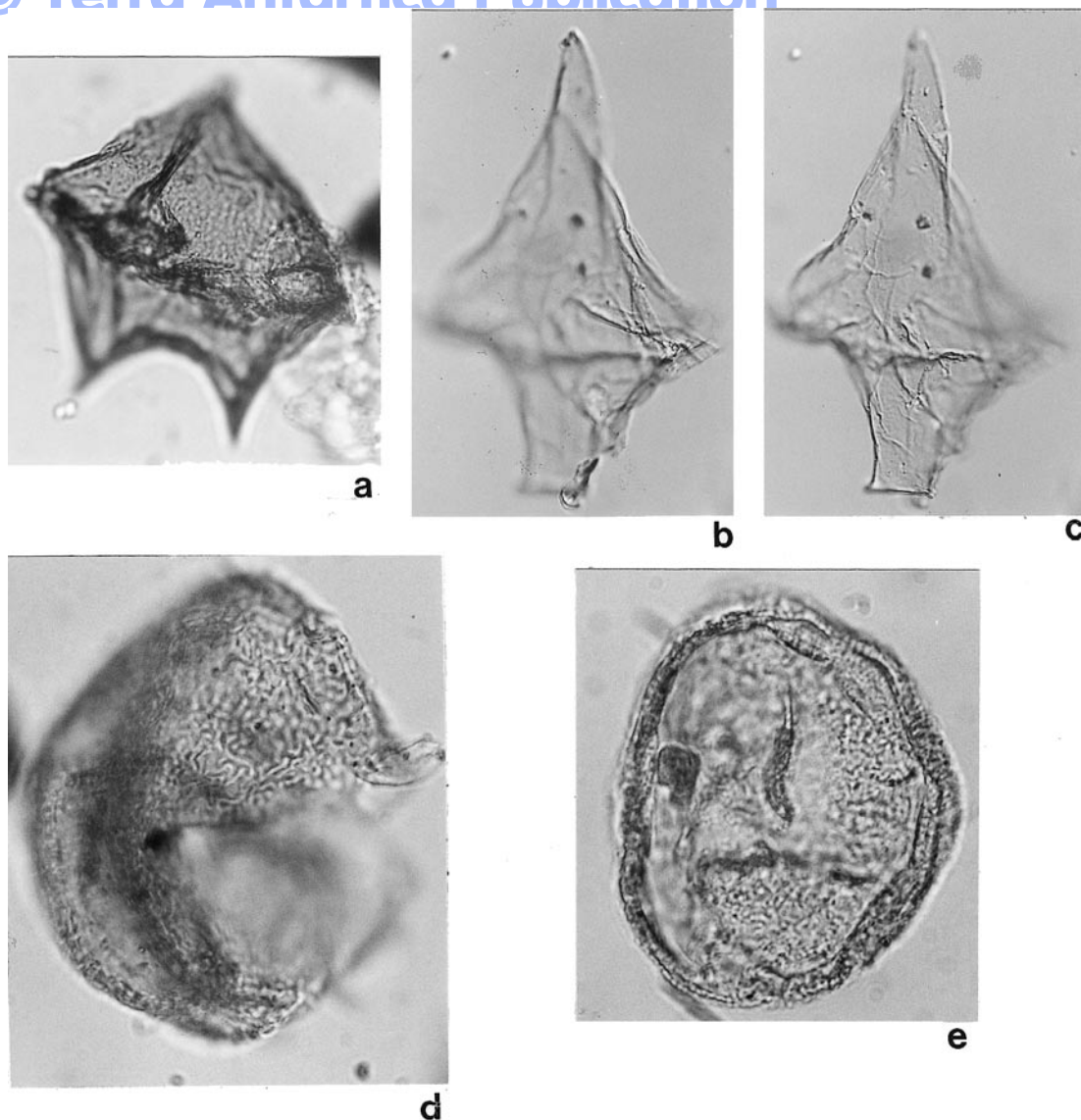


Fig. 5 - Selected palynomorphs from CRP-2/2A. Figures are at various magnifications. a) *Lejeunecysta* sp. 6. (length = 81 $\mu$ m, depth = 444.76-444.78 mbsf, slide number = P140/1, England Finder coordinates = U51); (length = 70  $\mu$ m, depth = 495.02-495.04 mbsf, slide number = P151/2, England Finder coordinates = M38) b & c) *Lejeunecysta* sp. 7 (70  $\mu$ m, 495.02-495.04 mbsf, P151/2, M38); d) *Pyxidinospis* sp., coarsely rugulose form (width= 44  $\mu$ m, 623.77-623.79, P163/1, Y50/1); e) *Pyxidinospis* sp., finely rugulose form (39  $\mu$ m, 623.77-623.79, P163/1, T49).

#### MARINE PALYNOLOGY UNIT 2 (MP2)

##### 296.32-296.33 – 187.45-187.46 mbsf. Late Oligocene.

The base of the unit is placed at the FO of *Lejeunecysta* sp.1 and its top at the FO of the acritarch *Sigmopollis* sp. This, the thinnest of the marine palynomorph units, is marked by assemblages of low diversity and limited numbers. Dinocysts occur sporadically throughout MP2. *Lejeunecysta* sp.1 and *Batiacasphaera* spp. are the most common dinocyst species present.

#### MARINE PALYNOLOGY UNIT 1 (MP1)

##### 181.73-181.74 – 26.89-26.90 mbsf. Late Oligocene – early Miocene.

The base of MP1 is marked by the FO of the acritarch *Sigmopollis* sp. at 181.73-181.74 mbsf. The top, at 26.89-

26.90 mbsf represents the uppermost appearance of numerically significant palynomorph assemblages. This unit yields the most abundant and diverse palynomorph assemblages in the drillhole. The abundance and diversity of *Leiosphaeridia* species is high, specimens numerically dominating many of the samples. All the species of this genus initially identified from CRP-1 were recorded again here, plus additional forms. *Sigmopollis* is also common to abundant in many samples. The numbers of acanthomorph acritarch specimens are very low. In these respects the assemblage is almost identical with that found in the lower part of CRP-1 between 104.75 and 147.68 mbsf (Hannah et al., 1998, figs 2-6). MP1 clearly represents an extension of the Early Miocene *Leiosphaeridia*-dominated assemblage into the late Oligocene

A moderately diverse *in situ* dinocyst assemblage was recovered from MP1, but no single species predominates. Hannah et al. (1998) recorded only nine dinocyst species in CRP-1, whereas a minimum of 27 species have been

recorded from CRP-2/2A (Fig. 2). Distribution of all species is patchy, with no one form dominating the assemblage. Hannah et al. (1998) described four new species from the Miocene part of CRP-1: *Batiacasphaera cooperi*, *Brigantedinium pynei*, *Lejeunecysta cowiei* and *Phelodinium cranwelliae*. All are restricted to the early Miocene portion of CRP-2/2A.

## REWORKING

Marine palynomorphs of the Paleogene Transantarctic Flora were recorded in CRP-2/2A but do not appear to be *in situ*. Hannah (1997) documented the final up-hole appearance of the Transantarctic Flora in CIROS-1. He suggested that this assemblage ranges no higher than early Oligocene (Chron 13n). Wilson et al. (this volume) indicate that the base of CRP-2/2A is no older than Chron C12r, suggesting that any appearance of species assigned to the Transantarctic Flora is due to reworking. The patchy distribution and very variable preservation (from well preserved to fragments) of the Transantarctic Flora also suggests reworking. Reworked dinocysts are plotted separately in figure 2. Apart from a small amount of reworking at about 40 mbsf and 97 mbsf, it is below 122 mbsf that persistent reworking occurs. The most abundant reworked species are *Enneadocysta partridgei*, *Vozzhennikovia apertura* and *Deflandrea antarctica*. Below 122 mbsf two intervals of more intense reworking are apparent at about 480-437 mbsf and 128-122 mbsf.

## SUMMARY

The marine palynomorphs recovered from CRP-2/2A were some of the most common microfossils recovered from CRP-2/2A, being found in almost all samples from the Oligocene/Miocene part of the section, often in high numbers. These assemblages extend the marine palynomorph record initially recovered from Miocene sediments of CRP-1, down to the early Oligocene.

The three marine palynomorph zones recognised here are probably environmentally controlled. Because of difficulty in making comparisons with modern assemblages the exact nature of that control is unclear. The greater part of the assemblage is new, hence its biostratigraphic usefulness is at present limited. However, the planned development of a comprehensive age model for the entire Cape Roberts sequence, together with detailed taxonomic work on the marine microplankton floras and comparison with other circum-polar palynofloras should allow a robust biostratigraphy to be developed.

## ACKNOWLEDGEMENTS

Funding for participation in this project comes from; the Internal Grants committee, Victoria University of Wellington (MJH), National Science Foundation (JHW) and the Public Good Science Fund, New Zealand (GJW). The authors would like to thank Andrew McMinn and Peta Mudie for comprehensive reviews.

## REFERENCES

- Cape Roberts Science Team, 1999. Studies from the Cape Roberts Project Ross Sea, Antarctica. Initial Report on CRP-2/2A. *Terra Antarctica* **6**(1/2), 1-173.
- Guy-Ohlsen D., 1996. Chapter 7B. Prasinophyte algae. In: Jansonius J., & McGregor, D. C., (eds.). *Palynology: principles and applications*. American Association of Stratigraphic Palynologists Foundation, **1**, 181-189.
- Hannah M. J., 1997. Climate controlled dinoflagellate distribution in Late Eocene-earliest Oligocene strata from the CIROS-1 Drillhole, McMurdo Sound Antarctica. *Terra Antarctica*, **4**(2), 73-78.
- Hannah M. J., Wrenn J. H., & Wilson G. J., 1998. Early Miocene and Quaternary marine palynomorphs from CRP-1, McMurdo Sound. *Terra Antarctica* **5**(3), 527-538.
- Harland R., Pudsey C. J., Howe J. A. & Fitzpatrick M. E. J., 1998. Recent dinoflagellate cysts in a transect from the Falkland trough to the Weddell Sea Antarctica. *Palaeontology*, **41**, 1093-1131.
- Lindgren S., 1981. Remarks on the taxonomy, botanical affinities, and distribution of leiospheres. *Stockholm Contributions in Geology*, **38**, 1-20.
- Lindgren S., 1982. Taxonomic review of the *Leiosphaeridia*, from the Mesozoic and Tertiary. *Stockholm Contributions in Geology*, **38**, 21-33.
- Marret F. & de Vernal A., 1997. Dinoflagellate cyst distribution in surface sediments of the southern Indian Ocean. *Marine Micropalaeontology*, **29**, 367-392.
- Mudie P. J., 1992. Circum-Arctic Quaternary and Neogene marine palynofloras: paleoecology and statistical analysis. In: Head M.J., & Wrenn, J. H., *Neogene and Quaternary Dinoflagellate Cysts and Acritarchs*. American Association of Stratigraphic Palynologists Foundation, Dallas, 347-390.
- Roberts A.P., Wilson G.S., Florindo F., Sagnotti L., Verosub K.L. & Harwood D. M., 1998. Magnetostratigraphy of Lower Miocene Strata from the CRP-1 core, McMurdo Sound, Ross Sea, Antarctica. *Terra Antarctica*, **5**(3), 703-713.
- Simes J. & Wrenn J.H., 1998. Palynological processing in Antarctica. *Terra Antarctica* **5**(3), 549-552.
- Tappan H., 1980. *The paleobiology of plant protists*. W. H. Freeman & Co., San Francisco, 979 p.
- Tyson R.V., 1995. *Sedimentary Organic Matter, Organic Facies and Palynofacies*. Chapman and Hall, London, 615 p.
- Wilson G. J., 1967. Some new species of Lower Tertiary dinoflagellates from McMurdo Sound Antarctica. *New Zealand Journal of Botany*, **5**, 57-83.
- Wilson G.J., 1989, Marine Palynology. In: Barrett P. J. (ed) Antarctic Cenozoic history from the CIROS -1 drillhole, McMurdo Sound, *DSIR Bulletin*, **245**, 129-134.
- Wrenn J.H. & Hart G.F., 1988, Paleogene dinoflagellate cyst biostratigraphy from Seymour Island, Antarctica. *Bulletin of the Geological Society of America*, **169**, 321-448.