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DEEP SEA DRILLING PROJECT
LEG 22, SITE 214
PALYNOLOGY OF PALEOCENE SEDIMENTS

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73/136

DEPARTMENT OF MINES
SOUTH AUSTRALIA

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PALYNOLOGY OF PALEOCENE SEDIMENTS

by

WAYNE K. HARRIS

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ABSTRACT

DSDP Site 214 at about 11°S on the 90E Ridge in the Indian Ocean penetrated below about 340 m to 500 m a sequence of carbonaceous to lignitic clays and sands interbedded with volcaniclastics. Palynolnological evidence, spores, pollen and dinoflagellate cysts, indicates a Paleocene age for this part of the sequence and correlation is within the Australasian region rather than the tropics of Africa, South America, India or south east Asia. Below about 390 m the sequence is entirely non-marine. Above this, marine influence is dominant.

The microflora indicates a temperate climate of high rainfall not dissimilar to present climates of south east Australia or New Zealand. But the assemblage is restricted in that many characteristic species and genera (e.g. *Proteacidites*) of Australasian early Tertiary rocks are absent and the flora must have been oceanic-island in aspect with no direct contact with continental masses.

It is suggested that the northern part of the 90E Ridge was in temperate regions during the Paleocene and moved northwards after the separation of the Australian and Antarctic plates. There is no palynological evidence to support a connection of this part of the Ridge with either India or south east Asia.

INTRODUCTION

Deep sea drilling projects do not often provide the palynologist with a wealth of palynological data but Site 214 in penetrating a sequence of carbonaceous clays and sands interbedded with volcanic flows presented a unique opportunity to not only date biostratigraphically the sequence but also test current theories related to plate tectonics and Southern Hemisphere biogeography.

Site 214 on Deep Sea Drilling Project (D.S.D.P.) Leg 22 was sited (see fig. 1) at Latitude $11^{o}20.2'$S and Longitude $88^{o}43.1'$E in 1665 m of water, on the north-south trending 90E Ridge. The well penetrated 500 m of section and at about 390 m entered a sequence of volcanic rocks and interbedded carbonaceous clays and sands. For about 50 m above this contact the well was in glauconitic and calcareous silts which were, nevertheless, slightly carbonaceous.

This report details the palynology of the lagoonal marine and the non-marine sequence. The distribution and frequency of species are summarised in figure 2 and the samples studied are listed in the Appendix. Large sampling gaps, particularly in the lower part of the sequence, are due mainly to unfavourable lithologies, in particular, volcanics. All samples have been prepared in a similar manner to

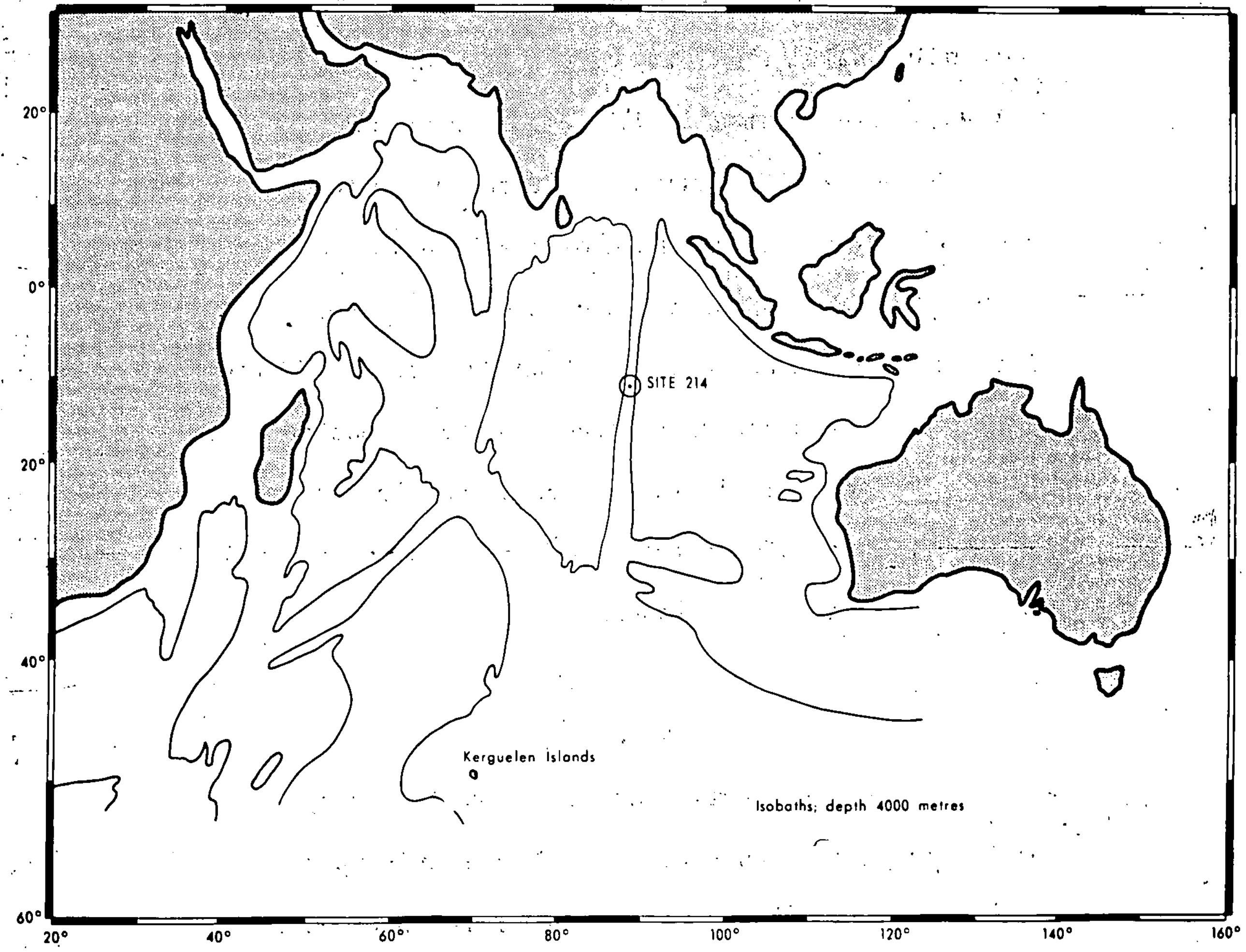

Figure 1 : Location of Site 214, Indian Ocean.

that outlined by Harris (1971). The technique is a standard Hydrofluoric acid digestion followed by oxidation with Schultze Solution and removal of humic acids with potassium carbonate. Calcareous sediments were pretreated with dilute Hydrochloric acid. Slides and residues are housed in the Palynological Collection of the Geological Survey of South Australia. Examination of specimens is by transmitted light with phase contrast and Nomarski differential interference contrast using a Leitz Orthoplan microscope (No. 715494) in the above institution. All co-ordinates of species illustrated in the Plates are from this microscope.

RESULTS

The distribution and relative frequency of species is plotted on Figure 2. Counts on samples below the marine horizon are based on 200 specimens and because of low yields in the marine section, counts, where possible, were based on only 100 specimens. These low counts, nevertheless, show important trends.

Most species are illustrated in the accompanying plates and the detailed systematics of these will be treated elsewhere. Thus an "open" nomenclature has been adopted for the majority.

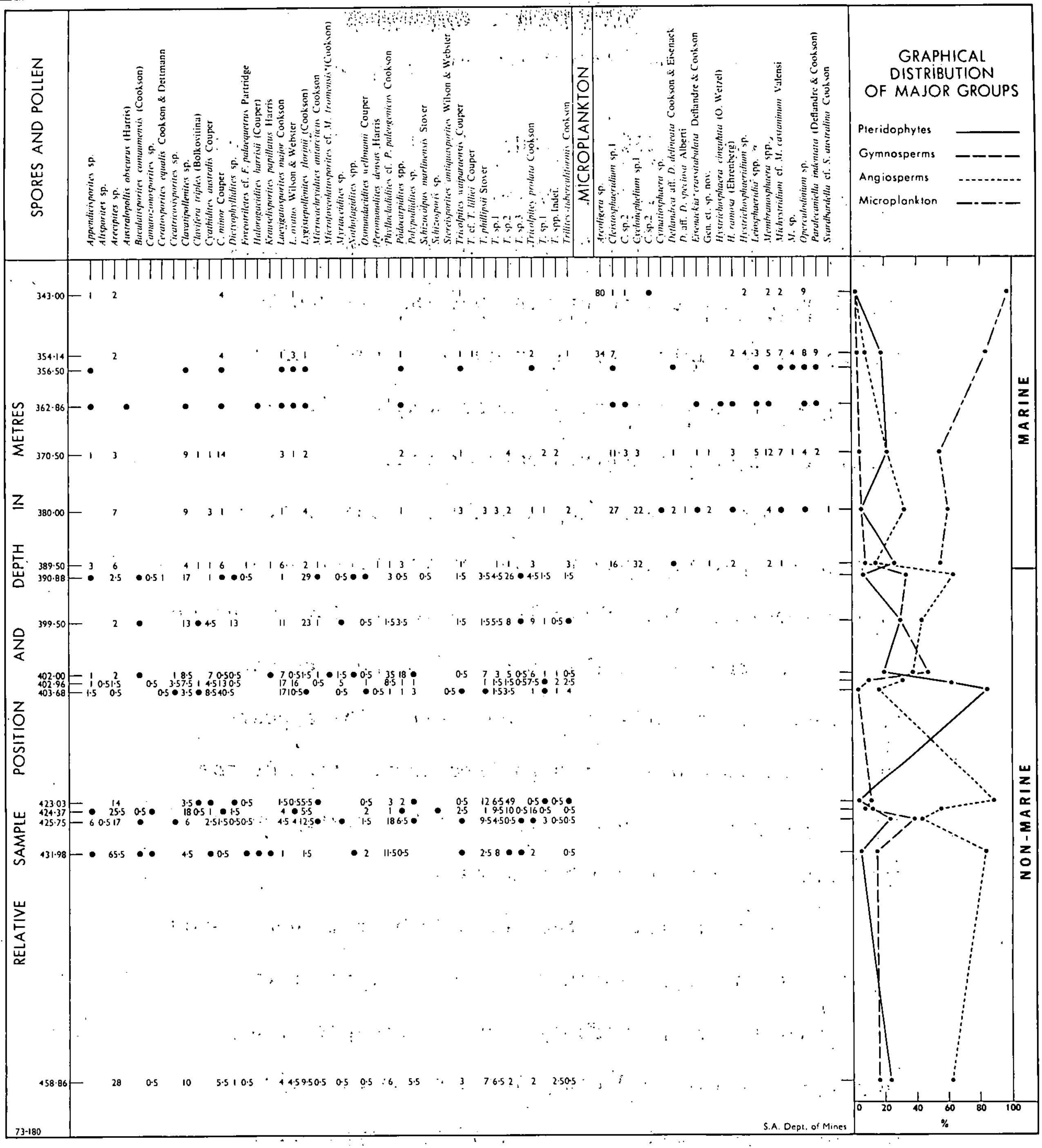

Figure 2 ; Species distribution chart and graphic representation of frequency changes of major plant groups. Species are recorded as percentages on individual counts of 200 specimens on samples from the volcaniclastic sequence and 100 specimens from samples within the marine sequence. ● denotes species observed in the sample but not in the actual count.

S2506 /

O/

Samples S2506, S2507, S2499 and S2495 from Barrel Nos. 52 and 53 were barren, probably due to baking by volcanic flows. The topmost sample, S2504, from Barrel 36 was also barren, but this is due to either unfavourable conditions during deposition or post-depositional oxidation. Most samples yielded abundant and well preserved palynomorphs.

Qualitatively the assemblages show little or no change upsection apart from the introduction of marine species. Thus there is no evidence for any major microfloral changes in the assemblages and they can be treated as essentially the one unit. The appearance of *Areoligera* sp. in high frequencies towards the top of the section studied may be of biostratigraphic significance or merely a biofacies.

Quantitatively the terrestrial components show regression and progression of paludal environments in that dominance of pteridophyte over gymnosperm and angiosperm species indicates local swamp conditions. The most significant assemblage of this type occurs at 403.68 m. At or about 389.50 m the onset of marine influence is strongly marked by abundant dinoflagellate cysts (54% of the palynomorph assemblage) and these continue to increase in dominance to the almost exclusion of terrestrial components (3% at 343.00m.).

The position of the core catcher sample from Barrel 41 is placed at the bottom of the 9 m barrel section but it could have come from higher in that section. Similarly other core catcher samples are taken as being from the bottom of their respective sections. Thus there would be a maximum of about 10 m between the core catcher sample from Barrel 41 and the best located sample from Barrel 42 Section 1.

BIOSTRATIGRAPHY, CORRELATION & AGE

The assemblages are distinctly Australasian and although they are not as diverse as early Tertiary microfloras from either southern Australia or New Zealand they can be compared and correlated with these. Couper (1960), Dettmann & Playford (1969), Harris (1965a, 1971), Stover & Evans (1973) and Stover & Partridge (1973) have provided biostratigraphic schemes for the Late Cretaceous and Early Tertiary in these regions. The species that are of correlative value and their stratigraphic ranges in Australian and New Zealand are: *Australopollis obscurus* (Harris) - *Appendicisporites distocarinatus* Zone (Cenomanian - Turonian) (Dettmann & Playford, 1969) to *Gambierina edwardsii* Zone (Middle to Late Paleocene) (Harris, 1971; Stover & Partridge, 1973);

Clavatipollenites sp. - Paleocene, Australia (author's unpublished data) and as *Ascarina* sp. Paleocene to Recent, New Zealand (Couper, 1960); *Haloragacidites harrisii* (Couper) - *Lygistepollenites balmei* Zone (Middle Paleocene) through late Tertiary (Stover & Partridge, 1973); *Krauselisporites papillatus* Harris - *Gambierina edwardsii* Zone (Middle Paleocene) through Middle Eocene (author's unpublished data);

Microfoveolatosporites fromensis (Cookson) - *Gambierina edwardsii* Zone (Harris, 1965a and unpublished data);

Nothofagidites spp. - *Nothofagidites* Microflora (Dettmann & Playford, 1968, 1969) and *Nothofagidites senectus* Zone (Stover & Partridge, 1973), Late Cretaceous through Tertiary;

Peromonolites densus Harris - *Lygistepollenites balmei* Zone (Middle Paleocene) through Miocene (Stover & Partridge, 1973);

Schizocolpus marlinensis Stover - *Gambierina edwardsii* Zone (author's unpublished data) through *Nothofagidites asperus* Zone (Late Eocene) (Stover & Partridge, 1973);

Tricolpites waiparaensis Couper - ?Late Senonian to Maestrichtian in New Zealand (Couper, 1960) and *Gambierina edwardsii* Zone in southern Australia (author's unpublished data) *Tricolpites longus* to *lygistepollenites blamei* Zone, Paleocene Gippsland Basin (Stover & Evans, 1973);

Tricolpites phillipsii Stover - *Lygistepollenites balmei* Zone (Middle Paleocene) through *Nothofagidites asperus* Zone (Late Eocene) (Stover & Partridge, 1973);

Eisenackia crassitabulata Deflandre & Cookson - Pebble Point Formation *(Gambierina edwardsii* Zone, Middle Paleocene), Deflandre & Cookson (1955), Cookson & Eisenack (1965). Deflandre & Cookson's record of the species ("very rare") from the Late Paleocene to Early Eocene Princetown Member of the Dilwyn Clay, may be due to reworking.

Svardbardella australina Cookson - Haumurian (Maestrichtian), Campbell Island, (Wilson 1967, 1972) to Middle Paleocene, Pebble Point Formation (Cookson, 1965) *(Gambierina edwardsii* Zone, Harris 1965a, 1971), Cookson & Eisenack (1965).

With exception of *T. waiparaensis* and *T. phillipsii* the other species are very rare in this sequence and apart from the microplankton are derived from long distance wind transport.

Other species recorded from this sequence are either long ranging or endemic and insufficient studies have been done on the remaining microplankton assemblage.

The evidence available, and despite the absence of characteristic index species of the southern Australian region, indicates a correlation with the *Gambierina edwardsii* Zone of Harris (1971) (= *Lygistepollenites balmei* Zone of Stover & Partridge in the Gippsland Basin). The type locality for this zone is in the Pebble Point Formation in the Otway Basin and McGowran (1965) correlates a foraminiferal fauna with the *Globorotalia pusilla pusilla* Zone of Bolli (1957) and the unit is therefore of Middle Paleocene age (see also McGowran, 1968 & Mc Gowran *et al* 1971).

ENVIRONMENTS OF DEPOSITION

Carbonaceous sediments from Barrel 42 and below are derived from entirely non-marine environments that range in part from paludal to lacustrine. The most significant change occurs in Barrel 41 with the sudden introduction of marine microplankton. In transgressive sequences elsewhere and in particular in southern Australia, a transitional phase (marginal marine) is represented by low (less than 5%) percentages of dinoflagellate cysts. The abundance increases with increasing marine influence (Harris, 1973).

There are two possible explanations for the sudden appearance of, and domination by dinoflagellate cysts in this sequence. The first is that the core-catcher sample comes from higher in the sequence which would mean that approximately 10 m of section was missing and therefore not sampled. The other and most likely explanation is that the environment was rapidly inundated by the sea without a complex of marginal marine conditions developing. The dominance in the microplankton assemblage of *Areoligera, Cleistosphaeridium Cyclonephelium* and *Operculodinium* species suggests free access to the open marine environment although not necessarily deep water. The rapid decline in frequency of terrestrially derived palynomorphs supports this hypothesis and indicates a rapidly shrinking environment for the colonization of land plants.

PHYTOGEOGRAPHIC NOTES

The most striking attribute of this assemblage in comparison with other Early Tertiary assemblages from the Southern Hemisphere is the complete lack of *Proteacidites* spp. But nevertheless the assemblages **does have** strong affinities with Late Cretaceous and Early Tertiary microfloras from southern Australia (Dettmann & Playford, 1969, Harris, 1965a, 1971;

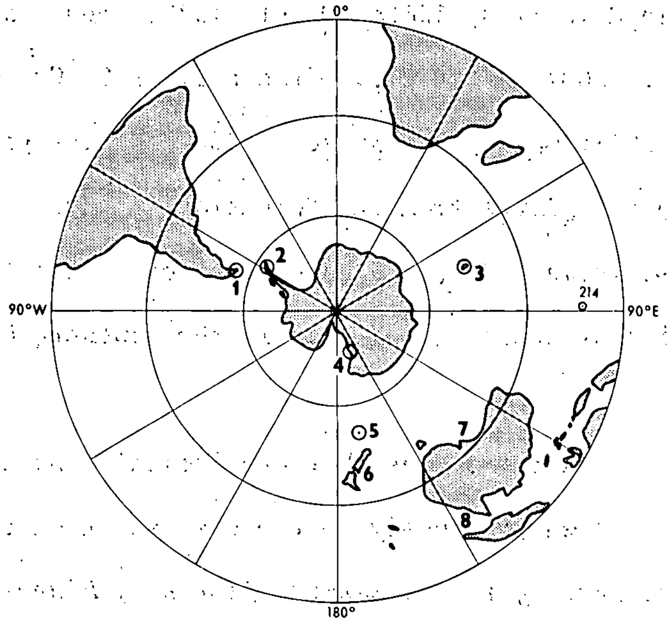

Figure 3 : Distribution of known late Cretaceous and early Tertiary microfloras in the Southern Hemisphere. Numbered localities refer to : 1, Southern Chile and Patagonia; 2, Seymour Island; 3, Kerguelen Islands; 4, McMurdo Sound; 5, Campbell Island; 6, New Zealand; 7, southern Australian basins; 8, Queensland basins.

Stover & Evans, 1973; Stover & Partridge, 1973), Queensland (Harris, 1965b; Hekel, 1972), New Zealand (Couper, 1960), Antarctica (Cranwell, 1959; Cranwell *et al*, 1960; McIntyre & Wilson, 1966) and the younger (Miocene) lignites from the Kerguelan Islands (Cookson, 1947, Mechkova, 1969). Figure 3 indicates the distribution of these microfloras in the Southern Hemisphere.

Apart from the characteristically Australasian species listed previously in the discussion on biostratigraphy, *Lygistepollenites florinii*, *Microcachryidites antarcticus*, *Myrtaceidites* sp. *Phyllocladidites* cf. *P. paleogenicus* and *Podocarpidites* spp. are very strong southern Hemisphere indicators at least within the Late Cretaceous and Early Tertiary. Although representatives of some of these may be found today in the pollen of species inhabiting the tropic zone and extending into the Northern Hemisphere, the meagre fossil evidence suggests that genera such as *Phyllocladus* and *Podlocarpus* arrived in these regions late in the Tertiary (Muller, 1966). In contrast the gymnosperm representatives in Early Tertiary sediments from Sarawak, Malaysia are *Pinus*, *Picea* and *Tsuga* which are typically Asian and Northern Hemisphere genera (Muller, 1966; 1968).

Assemblages from tropical areas (Germeraad *et al.*, 1968) and in Africa (Hoekenklinkenberg, 1964, 1966) central America (Hammen, 1957; Hammen & Wymstra, 1964; Hammen & Garcia de Mutis, 1965; Leidelmeyer, 1966) India (Baksi, 1962, 1965; Ramanujam, 1966; Sah & Dutta, 1966) and south east Asia (Muller, 1968) bear little or no resemblance to the microfloras described here. U.S.S.R., Northern Asia and North American microfloras are distinct also.

The flora at Site 214 is the result of colonisation by plants capable of migration across oceanic waters (e.g. wind dispersed seeds) to a mid oceanic island system. Although the elements of the flora indicate close relationships with those from Australasia this does not imply contact or even closeness to the southern polar continents at this time. The obvious lack of *Proteacidites* spp. indicates that it is one group which evidently was not suited to this type of dispersal mechanism. The genus is widely distributed in the Early Tertiary sediments of Australia, New Zealand and southernmost South America. The Miocene microflora from Kerguelen is similar in having certain gymnosperms *Phyllocladus*, *Podocarpus* and *Microcachrys* in common but otherwise has a distinctly younger aspect.

Climatic interpretation of palynological data is a dangerous procedure in early Tertiary sediments. Nevertheless the presence of a microflora at Site 214 with abundant gymnosperm pollen of *Dacrydium*, *Microcachrys*, *Phyllocladus* and *Podocarpus* together with elements similar to or identical with those from southern Australia and New Zealand coevel sediments points to a cool to warm temperate climate with a high rainfall. The genus *Ascarina*, with pollen of two species indistinguishable from that of *Clavatipollenites* sp. (Plate 2 Fig. 12-14), for example is represented in New Zealand and the Kermadec Islands by *A. lucida* Hook. f. and *A. lonceolata* Hook. f. and is rare to common in New Zealand Paleocene to Recent sediments (Couper, 1960). No pollen descriptions of the other nine species of *Ascarina*, distributed through the Pacific Islands of New Caledonia, The Philippines, the Society, Soloman and Bismarck Islands, are available. Kemp (1968) has discussed the affinities of *Clavatipollenites* and is cautious about its relationships with angiosperm pollen.

CONCLUSIONS

The microfloras from Site 214 have distinct Australasian affinities but are derived from a restricted phytogeographic province with no land connections to any of the present continents.

Nevertheless the assemblages correlate well with Paleocene (late Cretaceous at the most) assemblages particularly from southern Australia. There is no evidence for similarity with other tropical early Tertiary microfloras from Africa, central America or Asia. Recent reconstructions involving part of southeast Asia with Gondwanaland (Ridd, 1971; Audley-Charles *et al.*,1972) are neither supported by the palynological data presented here nor that from the Australia. McKenzie & Sclater's (1971, Fig. 45) reconstruction at 75 m.y.B.P. places eastern India adjacent to the northern end of the 90E ridge (i.e. near Site 214) and this is difficult to reconcile with the available palynological evidence which suggests that Site 214 was in higher latitudes during the Paleocene and moved northwards after the separation of the Australian and Antarctic plates.

ACKNOWLEDGEMENTS

I am indebted to Dr. Brian McGowran who initiated this study and provided much of the necessary background information for Leg 22 and also discussed and criticized the ideas presented here. This paper is published with the permission of the Director of Mines.

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APPENDIX

Sample data

Core Barrel No.	Section	Depth (in cms) in Section	Approximate depth (in metres) below sea floor	Palynological Sample No.
36	3	108-110	337.08	S2504
37	2	top	343.00	S2592
38	2	64-66	354.14	S2591
38	4	top	356.50	S2590
39	1	136-138	362.86	S2589
39	cc	-	370.50	S2588
40	cc	-	380.00	S2587
41	cc	-	389.50	S2496
42	1	88-92	390.88	S2493
42	cc	-	399.50	S2497
43	cc	-	402.00	S2498
44	1	46-48	402.96	S2500
44	1	118-120	403.68	S2501
46	2	103-106	423.03	S2502
46	2	137-140	424.37	S2503
46	3	125-128	425.75	S2492
47	1	98-100	431.98	S2505
51	1	136-138	458.86	S2494
52	1	130-132	477.80	S2506
52	1	135-137	477.85	S2507
53	2	62-63	488.10	S2499
53	2	64-65	488.12	S2495

Note : cc denotes "core catcher" sample.

10 - *Clavifera triplex* (Bolkovitina)

S2053/1, 30.6 : 109.5.

11 - *Stereisporites antiquasporites* Wilson & Webster

S2501/1, 40.3 : 96.9.

12 - *Foveotriletes* cf. *F. palaequetrus* Partridge

S2498/2, 31.9 : 109.9.

13 - *Trilites tuberculiformis* Cookson

S2501/1, 50.7 : 95.7.

14 - *Ceratosporites equalis* Cookson & Dettmann

S2503/1, 39.2 : 105.9.

15 - *Krauselisporites papillatus* Harris

S2498/2, 26.8 : 107.9.

16 - *Camarozonosporites* sp.

S2503/1, 41.1 : 109.3.

17 - *Appendicisporites* sp.

S2498/1, 40.6 : 101.8.

18 - *Cicatricosisporites* sp.

S2498/1, 38.7 : 98.3.

EXPLANATION TO PLATES

All figures x750 and in bright field unless
otherwise specified. NDC refers to
Nomarski Differential Interference Contrast

PLATE 1

Figure : 1 - *Laevigatosporites major* Cookson.

S2053/, 37.5 : 108.5.

Gradational forms between this species and *L. ovatus* Wilson & Webster make separation of the two species difficult.

2 - *Polypodiidites* sp.

S2498/2, 28.1 : 108.8.

3 & 4 - *Microfoveolatosporites* cf. *M. fromensis* (Cookson) Harris

S2498/1, 33.5 : 101.8; 35.5 : 96.5.

5 - *Peromonolites densus* Harris

S2501/1, 42.2 : 109.3.

6 - *Baculatisporites comaumensis* (Cookson) x 500

S2498/2, 28.1 : 110.8.

7 - *Osmundacidites wellmanii* Couper

S2492/1, 34.5 : 103.9.

8 - *Dictyophyllidites* sp.

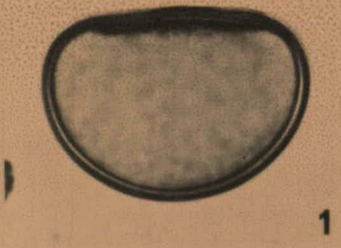
S2502/1, 32.9 : 97.4.

9 - *Cyathidites australis* Couper

S2503/1, 42.9 : 102.8.

This species appear to intergrade with *C. minor* Couper.

PLATE I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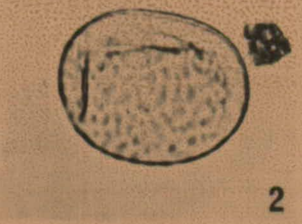
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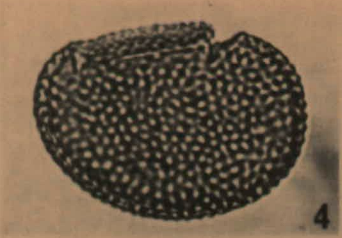
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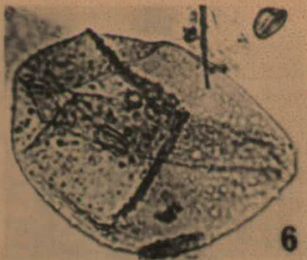
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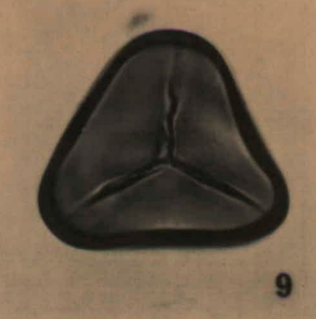
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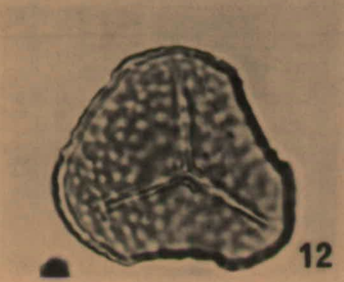
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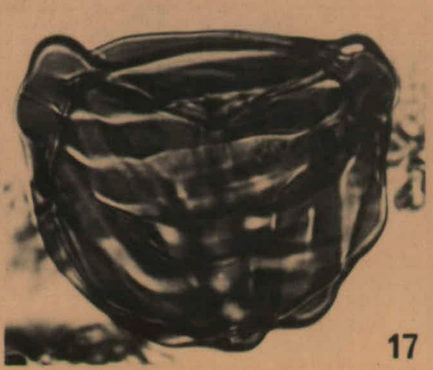
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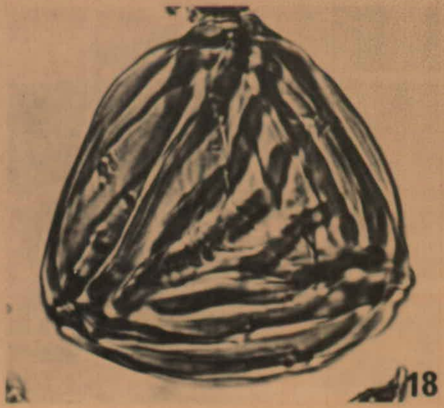
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PLATE 2

Figure 1 & 2 - *Schizosporis* spp.

S2503/1, 40.7 : 94.0; S2498/1, 34.1 : 95.5

Fig. 1 is similar to a species occurring rarely in south eastern Australian Paleocene sediments and to *Ovoidites ligneolus* Potonié.

3 & 4 - *Lygistepollenites florinii* (Cookson)

S2493/1, 41.6 : 109.5; S2503/1, 40.8 : 110.1.

These specimens demonstrate the range of variability accepted in the species.

5 & 6 - *Podocarpidites* spp.

S2498/2, 25.7 : 105.4; S2492/1, 24.2 : 107.4.

Fig. 5 is closely similar to *P. ellipticus* Cookson.

7 - *Microcachryidites antarcticus* Cookson

S2497/1, 26.5 : 105.6.

8 & 9 - *"Phyllocladidites"* cf. *"P". paleogenicus* Cookson x 1250.

S2498/2, 38.8 : 111.1. Fig. 1 - NDC, 2 - Phase contrast.

10 & 11 - *Arecipites* sp. x 1250.

S2498/2, 43.6 : 93.6. Fig. 11 - Phase contrast.

12, 13 & 14 - *Clavatipollenites* sp. Figs. 12 & 13, x 1250. S2493/1, 44.3 : 96.6; S2497/1, 39.2 : 109.5. Fig. 13 - NDC.Fig. 14 is an uncommon trichotomosulcate form.

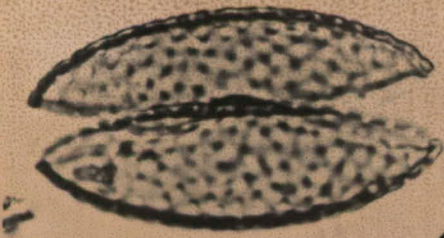
15 - *Haloragacidites harrisii* (Couper) Harris S2589/1, 35.7 : 103.9.

16 - *Tricolpites* sp. 3 S2493/1, 36.0 : 109.3.

17 & 18 - *Tricolpites* sp. 1 x 1250 S2492/1, 38.9 : 106.2; S2498/2, 35.1 : 111.0. Fig. 18 by NDC.

19 - *T. waiparaensis* Couper x 1250. S2503/1, 43.3 : 92.9. Phase contrast. This species is similar to *T. reticulata* Cookson and *T. microreticulata* Belsky, Boltenhagen & Potonié which are regarded as conspecific by Leffingwell (1966). *T. interangulas* Newman (1964) is also similar. With the exception of *T. reticulata* (Miocene, Kerguelen) the other species are characteristic Late Cretaceous species in equatorial Africa (Belsky, Boltenhagen & Potonié, 1965), Alberta, Canada (Srivastava, 1966) and Montana, U.S.A. (Norton & Hall, 1967).

PLATE 2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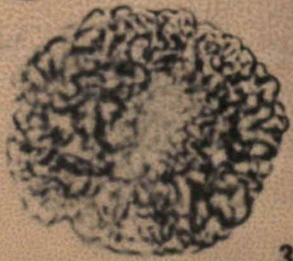
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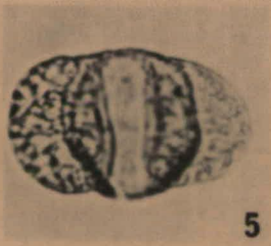
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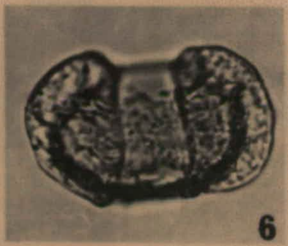
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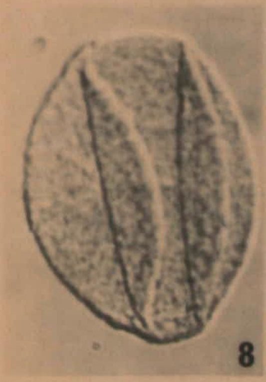
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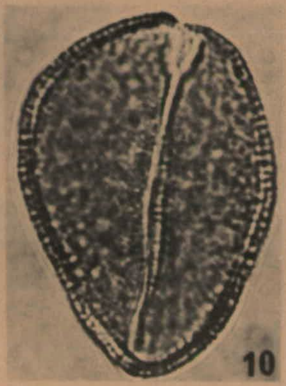
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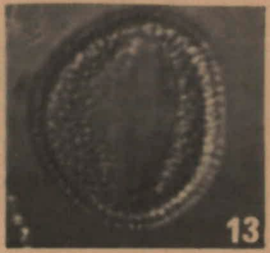
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PLATE 3

Figure 1 - *T. waiparaensis* Couper

2 - *T. phillipsii* Stover x 1250
S2502/1, 35.5 : 102.2. By NDC.

3 - *Tricolpites* sp. 2 x 1250
S2502/2, 38.5 : 96.9. This species may only be a prolate form of *T.*sp. 1.

4 & 5 - *Myrtaceidites* sp. x 1250.
S2498/2, 36.1 : 107.9. Fig. 4 by Phase Contrast.

6 & 7 - *Tricolpites* cf. *T. lilliei* Couper
S2591/1, 31.0 : 96.0. Mid and high focus. The ornament is similar to *T. lilliei* but the apertures appear to be more complex.

8 - *Tricolporites* sp. 1.
S2502/1, 38.6 : 94.9.
The ornament on this species is spinulate.

9 & 10 - *Tricolporites prolata* Cookson x 1250.
S2502/2, 45.6 : 101.6. Mid and high focus.

11 - *Australopollis obscurue* (Harris) Krutzsch.
S2589/2, 36.8 : 111.0. Grain is fractured.

12, 13 & 14 - *Nothofagidites* spp.
S2493/1, 36.6 : 94.4; S2587/4, 41.0 : 101.7; S2505/2, 41.8 : 100.3. Fig. 12 & 13 are of the *N. emarcida* - *N. hetera* complex and fig. 14 is of the *N. brachyspinulosa* type.

15 - *Schizocolpus marlinensis* Stover x 1250.
S2503/1, 29.8 : 109.0. This species very closely resembles the pollen of the Madagascan genus *Didymeles* (Straka, 1966; Stover & Evans, 1973).

16 - *Leiosphaeridia* sp.
S2589/2, 31.2 : 106.6.

17 & 18 - *Paralecaniella indentata* (Deflandre & Cookson)
S2590/1, 36.2 : 103.2; 41.9 : 99.0. Phase contrast. Note the girdle-like groove in Fig. 18.

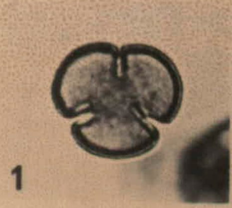
19 & 20 - *Michystridium* sp.
S2590/2, 30.6 : 109.1. Fig. 20 by Phase Contrast. Ornament consists of evenly spaced very short rods.

21 - *Cymatiosphaera* sp. x 1250.
S2587/1, 40.8 : 104.0. Phase contrast. This species is similar to *C. eupelos* (Valensi) Deflandre.

22 - *Michystridium* cf. *M. castaninum* Valensi.
S2588/2, 25.9 : 105.2.

23 - ?*Pterospermopsis* sp.
S2587/4, 42.2 : 106.6.
Only one specimen of this species has been found.

PLATE 3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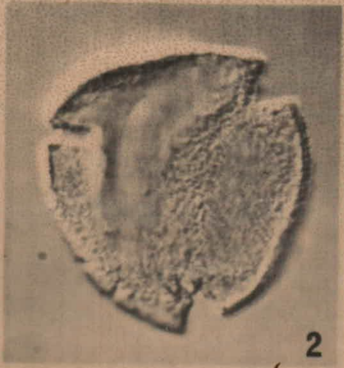
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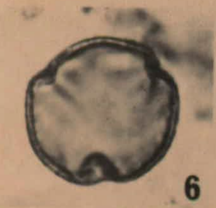
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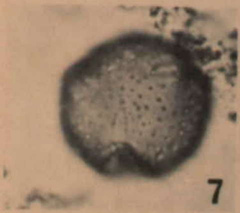
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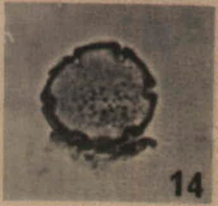
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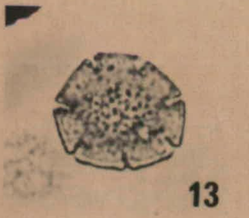
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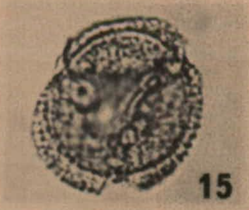
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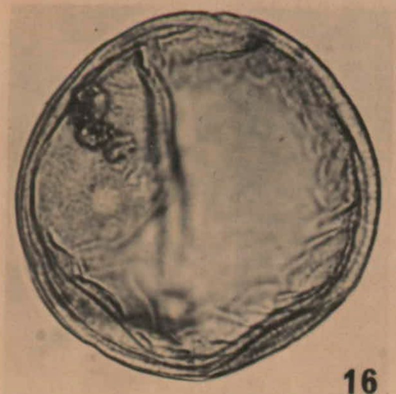
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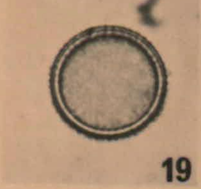
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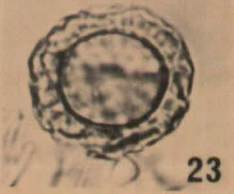
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PLATE 4

Figure 1 & 2 - *Deflandrea* aff *D. delineata* Cookson & Eisenack.
S2590/2, 22.6 : 98.0. Fig. 2 section of capsule in Phase Contrast. Note the foveolute sculpture pattern. This pattern is also present on the periphragm.

3 - *D.* aff. *D. speciosa* Alberti
S2587/4, 24.2 : 109.8.

4 - *Svardbardella* cf. *S. australina* Cookson x 500.
S2587/1, 27.1 : 97.1. Phase contrast.

5 & 6 - *Membranosphaera* sp.
S2587/4, 32.1 : 95.7. Phase contrast.

7 - 11 - Gen. and sp. nov.
Fig. 7-9, S2587/4, 35.5 : 103.8. High mid and low focus. Figs. 10 & 11, S2587/4, 32.1 : 95.7. Fig. 11, phase contrast.

12, 13 & 14 - *Cleistosphaeridium* sp. 2 mid and high focus, Figs. 12, 13, S2590/2, 23.2 : 112.2, Fig. 14, S2588/1, 40.8 : 108.7.

15 - *Hystrichosphaera ramosa* (Ehrenberg) x 500.
S2587/1, 42.6 : 95.1. Phase contrast.

16 - *Cleistosphaeridium* sp. 1. x 500.
S2587/4, 42.2 : 104.7. Phase contrast.

PLATE 4


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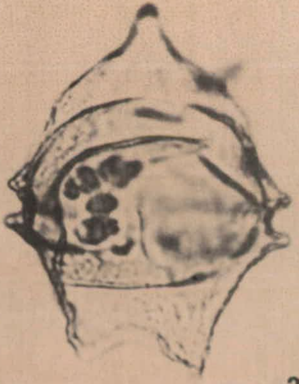
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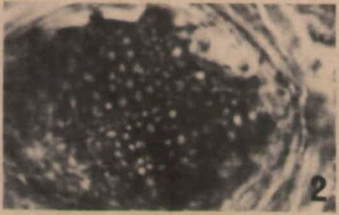
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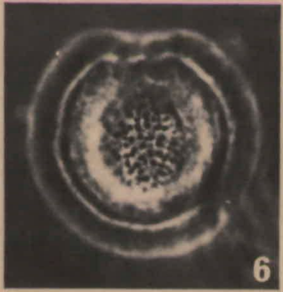
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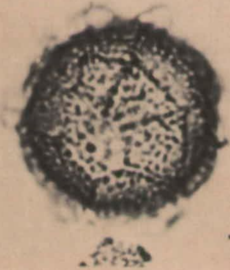
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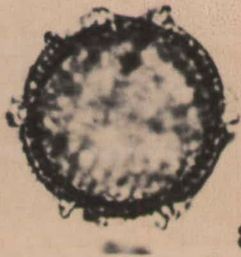
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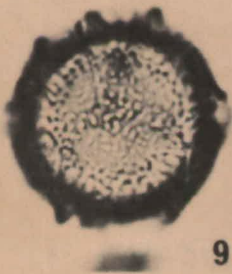
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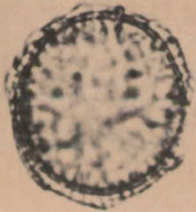
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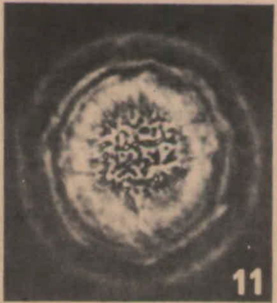
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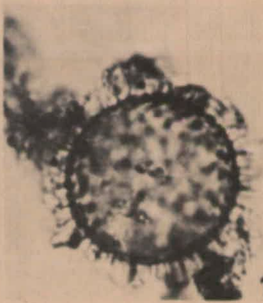
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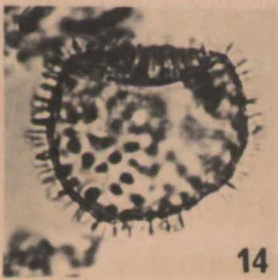
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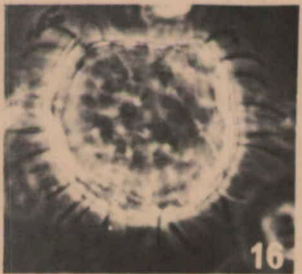
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PLATE 5

Figures 1 & 2 - *Operculodinium* sp.

S2589/1, 32.5 : 108.1. High and mid focus.

3 - *Hystrichosphaeridium* sp.

S2589/1, 29.7 : 112.1.

4 - *Cleistosphaeridium* sp.

5 - *Cyclonephelium* sp. 2

S2592/2, 35.9 : 109.8.

6 - *Cyclonephelium* sp. 1 x 500

S2587/4, 25.7 : 109.8.

7 - *Areoligera* sp.

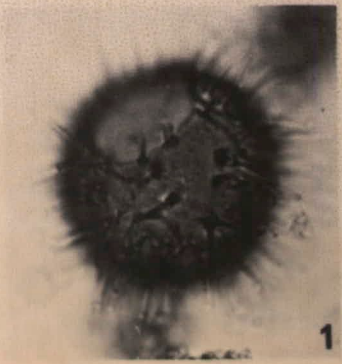
S2592/2, 31.1 : 109.6.

8 & 9 - *Cleistosphaeridium* sp. x 500.

S2587/1, 24.2 : 95.6; 25.6 : 113.1.

Phase contrast.

PLATE 5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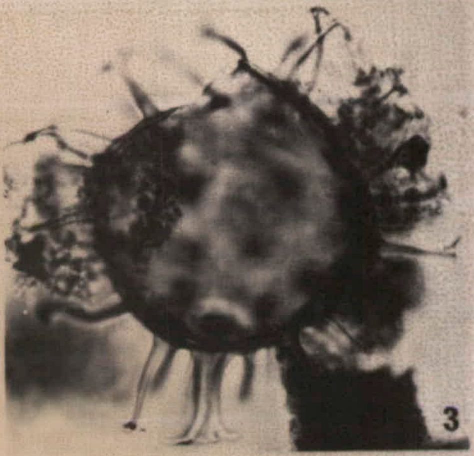
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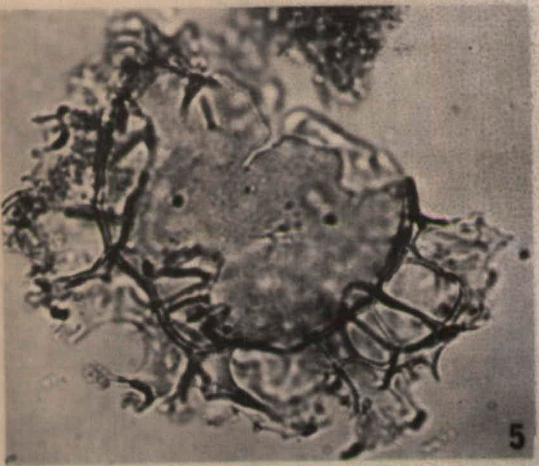
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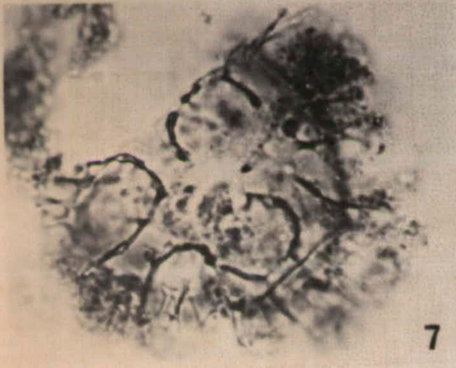
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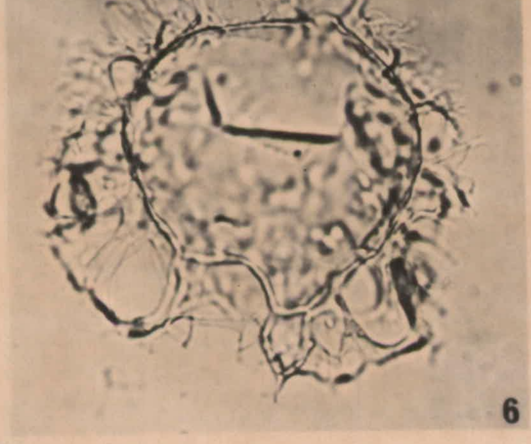
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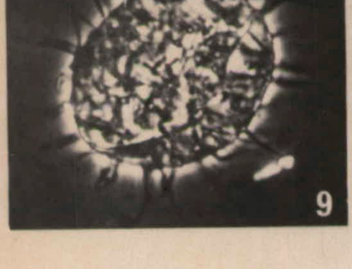
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