

## 16. PALYNOLOGY OF SITES 280-284, DSDP LEG 29, OFF SOUTHEASTERN AUSTRALIA AND WESTERN NEW ZEALAND

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### ABSTRACT

The palynology of DSDP Sites 280 to 284 from the region adjacent to and south of Tasmania, and to the west of New Zealand is described, and the sequence is discussed in terms of the international stages. The early Cenozoic dinoflagellate assemblages at the sites have characteristic associations like those previously described from Antarctica and southern South America, but not like those from southern Australia or New Zealand. This forms a characteristic high-latitude early Cenozoic biogeographic province, about the time of separation of Australia from Antarctica. The presence in the sequences of reworked non-marine palynofloras of Permian, Triassic, and Cretaceous ages indicate that southeastern Australia contributed extensively to the Cenozoic sediments adjacent to and south of Tasmania.

### INTRODUCTION

This paper deals with the palynology of representative material from the sequences cored at Sites 280 to 284 from Leg 29 of the Deep Sea Drilling Project (Figure 1). The material studied was taken from core catcher and section samples of the following cores:

Site 280, (Hole 280, Core 1); (Hole 280A, Cores 1-22)  
Site 281, (Hole 281, Cores 2, 3, 6, 7, 9-17); (Hole 281A, Core 1)

Site 282, Cores 1, 4-18

Site 283, (Hole 283, Cores 2-17); (Hole 283A, Core 1)

Site 284, (Hole 284, Cores 1, 3, 5, 7, 9-22); (Hole 284A, Cores 2, 3)

The samples yielded variable palynofloras ranging from totally barren to well preserved and diverse, although most samples contain good fossil populations. Marine dinoflagellate cysts usually dominate the assemblages, both in diversity and numbers of specimens. However, angiosperm and gymnosperm pollen grains, as well as pteridophyte spores, are often well represented, and occasionally are dominant. Remanié (recycled) palynomorphs from late Paleozoic and/or Mesozoic strata are a consistent element of assemblages from some sections.

This initial examination and discussion was undertaken primarily to provide a palynostratigraphic breakdown of the sequences drilled at the various sites, using dinoflagellate and miospore data. Additional data

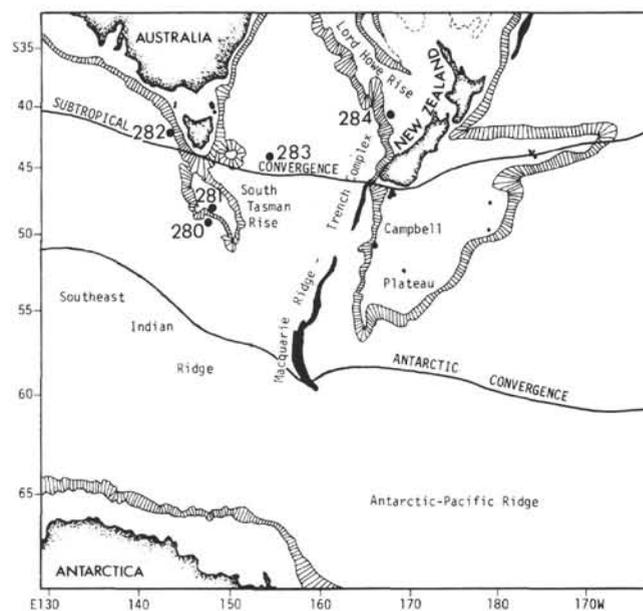


Figure 1. Location of Sites 280-284, DSDP Leg 29.

are included on gross population, variation of the remanié elements of the palynofloras, and comparisons of these palynofloras with those of Australia, New Zealand, South America, and Antarctica. Discussion of new forms and other systematic detail is not undertaken here. The assemblages are described from individual cores or groups of cores depending on the amount and type of variation. Where cores were examined by both authors the discussion represents a synthesis of results.

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## METHODS AND SAMPLE PREPARATION

Palynological preparation of this material was undertaken in the laboratories of the Eastern Petroleum Section of the Geological Survey of Canada, Dartmouth, Nova Scotia, Canada; and at the New Zealand Geological Survey, Lower Hutt, New Zealand. Due to the soft, calcareous nature of the samples little treatment beyond solution of carbonate in dilute HCl was required. However, residues were occasionally treated with hydrofluoric acid or heavy liquid to further separate organic material from remaining, usually siliceous, mineral matter. Oxidation, acetolysis, and staining were used sparingly where necessary. Strew mounts were used exclusively. The mounts, and excess residues are being curated by the two organizations listed. Preparations (on Plates 1-4) prefixed by "L" are lodged in the Palynology Section, New Zealand Geological Survey; those prefixed "P" are held by the Eastern Petroleum Section of the Geological Survey of Canada.

Preparations of sectional samples of the cores listed were examined by T. R. H. Samples from Cores 10-22 of Hole 280A, Cores 13-17 of Site 281, Cores 4-18 of Site 282, and all cores from Site 283 were examined by G. J. W.

## SITE 280

Palynofloras of Core 280-1 are extremely sparse, and samples of Cores 280A-1 to 280A-9 are either devoid of palynomorphs or yielded extremely sparse palynofloras. The only species with stratigraphic significance are single occurrences of *Deflandrea phosphoritica* Eisenack, 1938 in Section 280A-4-4 and *Lejeunia hyalina* Gerlach, 1961 in Section 280A-8-2. The former species has been widely reported from Oligocene and Eocene strata, and the latter is known from middle Eocene and Oligocene strata of Europe (Gerlach, 1961; Bujak, in press). The sequence in Cores 280A-4 to -8 is probably Oligocene, in view of the Eocene age established for the underlying cores. Occasional specimens of spore or pollen species are present in these assemblages of which *Nothofagidites*, usually *N. matauraensis* Couper, 1953, is most commonly encountered. However, though rare, remanié spores and saccate pollen grains predominate over contemporaneous specimens throughout this interval. Of the remanié forms, *Alisporites grandis* (Cookson) Dettmann, 1963, and *A. similis* (Balme) Dettmann, 1963 are more frequently encountered. These species are usually common elements of Australian Lower Cretaceous and Upper Jurassic palynofloras (Dettmann, 1963; Haskell, 1968). Rarer forms include *Stereisporites antiquasporites* (Wilson and Webster) Dettmann, 1963; *Vitreisporites pallidis* (Reissinger) Nilsson, 1958, which has a Permian-Lower Cretaceous range in Australia (Balme, 1957; Haskell, 1968); and *Classopollis classoides* Pflug emend Pocock and Janssonius, 1961, an uppermost Triassic-Lower Cretaceous species (Playford and Dettmann, 1965). Striate saccate grains of a type ranging through the Permian and Triassic (Evans, 1966) are present in Section 280A-7-4.

Core 280A-10 contains somewhat more diverse assemblages. These populations include *Deflandrea*

*macmurdoensis* Wilson, 1967; *D. antarctica* Wilson, 1967; *Turbiosphaera filosa* (Wilson) Archangelsky, 1969; *Spinidinium aperturum* Wilson, 1967; and *S. rotundum* Wilson, 1967. Dinoflagellate populations, including these species, have been reported from Eocene strata of Antarctica (Wilson, 1967a) and South America (Archangelsky, 1968; Archangelsky and Fasola, 1971). Other dinoflagellate forms present include *Deflandrea phosphoritica*; *Cleistosphaeridium* sp.; *Areosphaeridium dictyoplokus* (Klump) Eaton, 1971; and (?) *Chlamydothorella* sp.

These palynofloras also contain several species of podocarp pollen including *Podocarpites exiguus* Harris, 1965, as well as *Nothofagidites matauraensis* and other members of the *Nothofagidites brassi* and *fusca* groups, *Triorites harrisii* Couper, 1953, and occasional trilete spores. Remanié species similar to those from Cores 280A-1 to -9 are present in this core, and include *Zonalapollenites trilobatus* Balme, 1957, of Upper Jurassic to Lower Cretaceous age (Balme, 1957; Dettmann, 1963).

Core 280A-11 yielded palynofloras generally similar to those of Core 280A-10. Additional forms present include *Leiosphaeridia telmatica* Sarjeant and Strachan, 1968; and the Lower Cretaceous remanié grains *Cycadopites nitidus* (Balme) de Jersey, 1963; *Lycopodiumsporites nodosus* Dettmann, 1963; and *Ischiosporites punctatus* Cookson and Dettmann, 1958.

The dinoflagellate assemblage from Core 280A-12 is dominated by two species of *Spinidinium*, and also contains: *Deflandrea antarctica*; *D. distinctum* Wilson, 1967; *Leptodinium victorianum* Cookson and Eisenack, 1965; and *Spiniferites wetzeli* (Deflandre) Sarjeant, 1970. Pollen grains, which are less common than the dinoflagellate cysts, include the species *Nothofagidites flemingii* Couper, 1953, and *Triorites harrisii*. Spore populations are sparse, but *Plicifera delicata* (Bolkhovitina) Bolkhovitina, 1966 is present. The dinoflagellate assemblage, as well as the presence of *N. flemingii*, a New Zealand Bortonian-Runangan (middle-upper Eocene) form (Couper, 1960), indicates that this core is also middle to upper Eocene. Few remanié forms were noted, but include the Lower Cretaceous species *Alisporites grandis* and *Lycopodiumsporites eminulus* Dettmann, 1963.

Palynofloras from Core 280A-13 are relatively rich, and are dominated by the dinoflagellate *Spinidinium rotundum* Wilson, 1967, which locally comprises over 80% of the total palynofloral population. Associated species include *Deflandrea asymmetrica* Wilson, 1967; *Deflandrea phosphoritica phosphoritica*; *D. phosphoritica australis* Cookson and Eisenack, 1961; *D. antarctica*; *D. macmurdoensis*; *Cyclonephelium* cf. *australis* (similar to a species described by Pöthe de Baldi [1966] from the lower Tertiary of southernmost South America); *Spiniferites ramosus* Ehrenberg, 1835; *Leptodinium victorianum*; *L. dispertitum*; *Cleistosphaeridium* sp.; *Palaeoperidinium* sp. 1; *Palaeoperidinium* sp. 2, and *Areosphaeridium dictyoplokus*. Pollen grains and spores are considerably less common with *Nothofagidites matauraensis* being the most abundant species, in association with *N. flemingii*, *Triorites harrisii*, *Proteacidites annularis* Cookson, 1950, *Beaupreaeidites*

*elegansiformis* Cookson, 1956, and *Cicatricosisporites australiensis* (Cookson) Potonié, 1956. A middle to upper Eocene age is indicated for Core 280A-13.

The remanié palynofloras include *Deflandrea* cf. *D. diebeli* Alberti, 1959, an Upper Cretaceous form; *Alisporites grandis*; *A. similis*; *Lycopodiumsporites eminulus*; *L. circolumenus* Dettmann, 1963, Lower Cretaceous; and the Lower Jurassic pollen grain *Classopollis simplex* (Danzé-Corsin and Lavine) Reiser and Williams, 1969.

Core 280A-14 is very similar to Core 13, with *Spinidinium* still the dominant genus, although in Section 2, *Deflandrea antarctica* and *Areosphaeridium dictyoplokus* are common. Other dinoflagellate species present include *Thalassiphora pelagica* (Eisenack) Eisenack and Gocht, 1960; *Aiora fenestrata* (Deflandre and Cookson) Cookson and Eisenack, 1960; *Hystrichosphaeridium tubiferum* (Ehrenberg) Davey and Williams, 1966; *Deflandrea phosphoritica phosphoritica*; *Spiniferites ramosus*; and *S. cingulatus*. The spore, pollen, and remanié specimens in the samples are rarer, but essentially similar to those in Core 280A-13. An upper or middle Eocene age is indicated by palynomorphs common to Cores 13 and 14.

Samples from Core 280A-15 are usually dominated either by *Areosphaeridium dictyoplokus*, which locally approaches 75% of the total palynoflora, or *Deflandrea phosphoritica*. *D. cf. D. antarctica* is also common. Representatives of the genus *Spinidinium* are rare. Other species include *Aiora fenestrata* and *Thalassiphora pelagica*. *Nothofagidites matauraensis* is common, and the bisaccate pollen grain *Phyllocladites mawsonii* Cookson, 1947, is present together with the acritarch *Leiofusa*. A middle Eocene age is assigned to this core. *Alisporites similis* and *A. grandis* are both remanié elements of palynofloras from Core 15.

Palynoflora of Core 280A-16 are similar to Core 15 and are dominated either by *Areosphaeridium dictyoplokus* or *Deflandrea* cf. *D. phosphoritica*. An additional form present in Core 16 is *Lejeunia hyalina*, a European middle to upper Eocene and Oligocene form. This core is considered to be middle Eocene. Remanié forms were not noted in this core.

Core 280A-17, shows a remarkable fluctuation in the dominant dinoflagellate species throughout the various sections. The top section (17-1) is dominated by *Spinidinium rotundum* (60%), with *Areosphaeridium dictyoplokus* also abundant (30%). In the next section (17-2), the codominants are *Deflandrea* cf. *D. phosphoritica* and *S. rotundum* (~45%). In Section 17-3, the dominant species is *D. cf. D. phosphoritica* (~35%), while *Thalassiphora pelagica* and *Spinidinium* are also abundant. Section 17-4 is similar. In Section 17-5, *S. rotundum* is again dominant (~50%), whereas in Section 17-6 *D. phosphoritica* et var. are dominant (over 75%). The fluctuation in dominant species is probably related both to environmental variation and particle-size differences, since *Spinidinium* is somewhat smaller than the other dominant forms. In all sections, the qualitative species list is similar, and it is only in the quantitative sense that marked differences occur. Pollen, spores, and remanié material are very rare in this core.

The core 280A-18 palynoflora is dominated by *Deflandrea* cf. *D. antarctica*, although *Spinidinium rotundum*, *Areosphaeridium dictyoplokus*, *Palaeoperidinium* sp., and *Thalassiphora pelagica* are abundant. *Aiora fenestrata*, *Deflandrea phosphoritica*, *Deflandrea* cf. *D. phosphoritica*, *Cleistosphaeridium* sp., and *Turbiosphaera funiculata* (Morgenroth) Archangelsky, 1969 are common. The latter form is restricted to the middle and upper Eocene of Europe (Morgenroth, 1966), and middle Eocene is indicated for this core. *Nothofagidites matauraensis* predominates in an otherwise sparse microflora and rare occurrences of *Alisporites similis* and *A. grandis* constitute the remanié miospore assemblage palynoflora.

The samples from Core 280A-19 show the same kind of variation in the dominant species as Core 17. Sections 1 and 2 have no particularly dominant forms, with *Deflandrea* cf. *D. antarctica*, *Peridinium* sp., *Areosphaeridium dictyoplokus*, *Spinidinium rotundum*, and *Deflandrea asymmetrica* all being fairly abundant. Section 3 is dominated by *D. cf. D. antarctica*, while in Section 4 the codominants are *D. cf. D. antarctica* and *A. dictyoplokus*. In Section 5, *D. cf. D. antarctica*, *A. dictyoplokus*, and *Spinidinium rotundum* are all abundant, while in Section 6, the dominant species is *Areosphaeridium dictyoplokus*. Other marine palynomorphs present in Core 19 include *Aiora fenestrata*; *Turbiosphaera filosa*; *T. funiculata*; *Deflandrea asymmetrica*; *D. phosphoritica*; *D. cf. D. phosphoritica*; *Cleistosphaeridium* sp.; "*Dictyosphaeridium deflandrei*" Wetzell, 1952; *Palaeoperidinium* spp.; *Spiniferites ramosus*; *Hystrichosphaeridium tubiferum*; *Leiofusa* sp.; *Veryhachium* sp.; and *Micrhystridium* sp. Pollen grains are rare, with *Nothofagidites matauraensis* and *Triorites harrisii* predominating. The assemblages indicate that lower middle Eocene strata were cored. The remanié forms *Alisporites grandis* and *A. similis* are once again present.

Core 280A-20 assemblages are dominated by *Deflandrea* cf. *D. antarctica*, with *Areosphaeridium dictyoplokus*, *Leiofusa* sp., and *Spinidinium* sp. abundant. Core 21 assemblages are dominated by *Areosphaeridium dictyoplokus* and *Spinidinium* sp. Additional species listed in Core 19 are also present in similar proportions in Cores 20 and 21, and lower middle Eocene is indicated down to the level of Core 21.

Core 280A-22 (1 sample) is dominated by *Spinidinium* cf. *S. aperturum*, with *D. cf. D. phosphoritica* and *D. cf. D. antarctica* also abundant. Qualitatively the core resembles the overlying cores, and the presence of cysts of the *D. phosphoritica* type indicates that the bottom core is no older than Paleocene. One probable specimen of *Deflandrea denticulata* Alberti, 1959 may confirm lower Eocene for the bottom core.

#### Location Summary

The sequence at Site 280 consists of five lithologic units, underlain by basaltic rocks. The four youngest sedimentary units are Oligocene to Pleistocene in age, and are composed of nannoplankton ooze and siliceous nannoplankton ooze. The remaining sedimentary unit, comprising Cores 280A-1 to -22 is composed

predominantly of Oligocene diatom ooze, clays, and silts, underlain by Eocene clay. The clay is locally glauconitic, cherty, and manganese micronodule-bearing.

The palynofloras from Core 280-1 and the probable Oligocene (Cores 280A-1 to -9) covering those parts of the sequence in which oozes are developed, yielded a few contemporaneous specimens, mostly pollen grains, and a significant number of remanié specimens of species which have ranges terminating in the Lower Cretaceous or earlier. This situation appears to reflect a severe reduction in, or lack of precipitation and preservation of, marine microplankton under open oceanic conditions generally indicated by the development of oozes. However, it also shows that the terrigenous material is a component of the sediments involved, and was derived at least partially from Lower Cretaceous beds. The underlying beds are all of Eocene age, and are here subdivided into upper Eocene (Cores 10-14), middle Eocene (Cores 15-21), and lower Eocene (Core 22). Nonmarine taxa, though never prolific, become progressively less important downwards through this sequence; both the remanié and contemporaneous terrestrial palynomorphs being increasingly overwhelmed by the dinoflagellate population. The general lack of terrestrially derived material indicates that the location remained remote from terrigenous sources of sediment. In the authors' opinion, the microplankton sequence reflects a steady increase in water depths and establishment of open oceanic conditions through the sequence from the early Eocene, the greatest diversity of marine palynomorphs occurring in shallow, restricted conditions. Remanié and contemporaneous terrestrial specimens are present, but are less dominant than the dinoflagellates which are produced under more optimum conditions. The predominance of Lower Cretaceous or older nonmarine palynomorphs in the remanié assemblages indicates that terrigenous material was derived from sediments of that age. This material is an important component of the sediments of this section.

#### SITE 281

Preparations from Core 281-2 are barren.

Core 281-3 yielded common *Deflandrea* cf. *D. leptodermata* and, less frequently, (?)*Samlandia* and the pollen grains *Podocarpidites ellipticus* Cookson, 1947, and *Triorites harrisii*, the last named form having an Upper Cretaceous to Pliocene range.

Cores 281-4,-5 and -8 were not studied.

Core 281-6 yielded a single specimen of the acritarch *Leiosphaeridia telmatica*; Core 7, a single *Deflandrea* sp.; and Core 10 several specimens of (?)*Samlandia*; none of which are stratigraphically significant.

The palynofloras from Core 281-11 are dominated by pollen grains with *Nothofagidites cranwellae* Couper, 1960 and *Triorites harrisii* being most common. *Liliacidites* sp. and *Myrtaceidites parvus* Cookson and Pike, 1954 are also present. The spores *Laevigatosporites ovatus* Wilson and Webster, 1946 (possibly remanié); *Dicksonia* sp.; and *Cyathidites minor* Couper, 1953 occur in small numbers, as does *Deflandrea* cf. *D. leptodermata*.

Cores 12 and 13 are barren.

Core 281-14 yielded occasional pollen grains, spores, and dinoflagellates. The pollen grains *Nothofagidites matauraensis*, *N. flemingii*, and *Triorites harrisii* are present, as are the saccate pollen grains *Podocarpidites ellipticus* and *Phyllocladites* sp. Dinoflagellates include *Deflandrea phosphoritica*; *Spinidinium aperturum*; *S. rotundum*; *Leptodinium dispertitum*; and *Palmnickia lobifera* Eisenack, 1954. The presence of *N. flemingii* and *Palmnickia lobifera* of middle and upper Eocene and Eocene ages, respectively (Couper, 1953; Eisenack, 1954), indicates that the sample is middle and upper Eocene.

Palynofloras from Core 281-15 include occasional specimens of *Deflandrea phosphoritica* and *Leptodinium victorianum*. Core 16 yielded the dinoflagellates *Achomosphera ramulifera* (Deflandre) Evitt, 1963; *Oligosphaeridium complex* (White) Davey and Williams, 1966; and the spores *Gleicheniidites senonicus* Ross, 1944, and *Cyathidites minor*. None of these forms is of stratigraphic value in this part of the Tertiary.

Core 281-17 yielded more prolific assemblages including the dinoflagellates *Deflandrea phosphoritica*, *D.* cf. *D. leptodermata*, *D. asymmetrica*, *Areosphaeridium dictyoplokus*, and *Lejeunia hyalina*, and acritarch *Leiosphaeridia telmatica*. The pollen grain *Araucariacites australis* Cookson, 1947, and the spore *Cyathidites minor* are also common. A remanié grain of the last named species, as well as a specimen of *Veryhachium reductum* occur in the palynoflora. The presence of *L. hyalina* indicates that the palynofloras are no older than middle Eocene in age.

No deeper material from this site was examined, and the samples from Hole 281A are barren.

#### Location Summary

The sedimentary sequence of Site 281 is composed of four lithological units. The youngest of these is an early Miocene to Pleistocene calcareous ooze and glauconitic sand, which comprises about 60% of the section cored (Cores 1-12). The remaining units are a biogenic-rich glauconitic sand, glauconitic sand, and (?) schist breccia.

Palynofloras from the youngest unit are generally extremely sparse or barren and chronologically indeterminate. The exceptions are Core 3, which yielded a number of dinoflagellate specimens, and Core 11, which included a predominance of terrestrial forms, indicating a temporary influx of terrigenous material.

Core 14 from the sandy section is middle and upper Eocene, and Core 17 from the breccia zone is no older than middle Eocene.

The populations of Cores 14 and 15 are relatively limited with a mixture of dinoflagellates, spores, and pollen grains, indicating marine sedimentation with some terrigenous influence. Palynofloras from the oldest core (Core 17) are similar, though slightly more diverse. The relative lack of remanié material in these assemblages possibly indicates that the sediment source for this sequence was primarily from highly compacted or metamorphic rocks, such as those cored at the base of the hole.

## SITE 282

Core 282-1 yielded occasional specimens of the pollen *Myrtacidites* and the long-ranging spore *Cyathidites australis*. Core 4 palynofloras are locally dominated by the dinoflagellate *Hystrichokolpoma rigaudae* Deflandre and Cookson, 1955. Other dinoflagellates present here included *Operculodinium* sp.; *Spiniferites cingulatus*; and *Cleistosphaeridium polytrichium* (Valensi) Davey, Downie, Sarjeant, and Williams, 1966. Pollen grains noted include *Triorites harrisii*, *Nothofagidites matauraensis*, and *Proteacidites franktonensis* Couper, 1960. *H. rigaudae* was described from Miocene or older strata of Victoria, and *N. matauraensis* tops in the Miocene of New Zealand (Couper, 1960). *P. franktonensis* was described from New Zealand Miocene strata (Couper, 1960). Miocene age is indicated for Core 4. A striate saccate grain was also encountered.

Core 282-5 assemblages include the dinoflagellates *Lingulodinium machaerophorum* (Deflandre and Cookson) Wall, 1967; *Cleistosphaeridium polytrichium*; *Spiniferites ramosus*; *S. cingulatus*; *Deflandrea phosphoritica*; *Hystrichokolpoma rigaudae*; and *Tectatodinium*. Pollen grain microflora are dominated by *Nothofagidites matauraensis*, *N. cranwellae*, *Triorites harrisii*, and *Myrtacidites parvus*. *Proteacidites franktonensis*, *Triorites scabroratus* Couper, 1960, as well as *Plicifera delicata* and other spores, are present. The overlap of Miocene pollen such as *N. cranwellae* and *P. franktonensis* with the Oligocene and older dinoflagellate *D. phosphoritica*, indicates that the core is close to the Oligocene-Miocene boundary.

Samples of Core 282-6 yielded palynofloras similar to those of Core 5.

The palynofloras of Core 282-7 include few dinoflagellates with *Leptodinium victorianum*, *Hystrichokolpoma rigaudae*, and *L. machaerophorum* being represented. An extensive pollen assemblage including *Nothofagidites matauraensis*; *Triorites harrisii*, *Proteacidites annularis* Cookson, 1950; *Myrtacidites parvus*; as well as the saccate grains *Dacrydiamites* sp. and *Microcachrydites antarcticus* Cookson, 1947, is developed in these palynofloras. Of these palynomorphs, *P. annularis* and *M. antarcticus* are known only from lower Oligocene and older strata, indicating that Core 7 is no younger. Numerous remanié taxa including *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann, 1963; *F. dailyi* (Cookson and Dettmann) Dettmann, 1963; *Stereisporites antiquasporites*; and *Zonala-pollenites trilobatus* Balme, 1957, are also represented. These species all terminate their ranges in the Lower Cretaceous of Australia (Dettmann, 1963), the first two being confined to that period.

Cores 282-8 and -9 yielded palynofloras which are as diverse as those of Core 7, and similarly composed. Additional species include the pollen grain *Proteacidites clintonensis* Harris, 1966 and pollen of *Dacrydiamites* cf. *Dacrydium cupressinum*, and the dinoflagellate *Deflandrea* cf. *D. phosphoritica*. Dominance is usually maintained by *N. matauraensis* and/or *M. parvus*, but in

samples of Section 282-9-2, *Hystrichokolpoma rigaudae* is abundant, comprising about 60% of the total palynofloras. Lower Oligocene is indicated for Cores 8 and 9. Similar remanié assemblages occur in these cores, and include monosaccate forms comparable to *Nuskoisporites*, and *Lycopodiumsporites austroclavatidites*, *Coronatispora perforata* Dettmann, 1963, as well as the dinoflagellate *Dingodinium cerviculum* Cookson and Eisenack, 1960. Both *C. perforata* and *D. cerviculum* terminate their ranges in the Lower Cretaceous, the latter form being confined to that interval (Dettmann, 1963; Haskell, 1969).

Cores 282-11 and -12 yielded diverse palynofloras dominated by miospores. Dinoflagellates include *Achomosphaera* cf. *A. triangularis* Gerlach, 1961; *Deflandrea phosphoritica*; *Hystrichokolpoma rigaudae*; *Spiniferites ramosus*; *S. bulloides* (Deflandre and Cookson) Sarjeant, 1970; *Oligosphaeridium complex*; *Leptodinium dispertitum*; and *L. victorianum*. The Eocene-(?)Oligocene dinoflagellate *Deflandrea macmurdoensis* Wilson, 1967 is present in Core 12. The pollen assemblages are once again dominated by *Nothofagidites* cf. *N. spinosus* Couper, 1960; *Haloragacidites* cf. *H. myriophylloides*; *Proteacidites annularis*; *P. crassus* Cookson, 1950; *P. parvus* Cookson, 1950; *P. subscabratus*; *P. clintonensis*; and *Triorites* cf. *T. fragilis*, Couper, 1953. Saccate pollen grains include *Microcachrydites antarcticus* and *Trisaccites microsaccatus* (Couper) Couper, 1960. The joint occurrence of *P. clintonensis*, *D. macmurdoensis*, and *Achomosphaera* cf. *A. triangularis* in Core 12 indicates that the sediments of that core are probably of Oligocene age. Extensively reworked Mesozoic and upper Paleozoic palynofloras similar to those encountered in Cores 8 and 9 are also present in these cores.

Core 282-13 palynofloras are also dominated by terrestrial species. The dinoflagellate population includes *Hystrichokolpoma rigaudae*; *Deflandrea phosphoritica*; *D. leptodermata*; *D. heterophlycta* Deflandre and Cookson, 1955; and *Spiniferites ramosus*. *Nothofagidites matauraensis* is common in all four samples from this core, but predominates only in Section 3. The remaining pollen forms present in Cores 11 and 12 are also present here, with the exception of *Proteacidites clintonensis*, but including *Nothofagidites flemingii*; *Tricolpites asperimarginatus* McIntyre, 1968, usually a Paleocene (Teurian) form (McIntyre, 1968); *Beaupreaeidites elegansiformis* Cookson, 1950 an Oligocene-Miocene form, although Couper (1953) reports a comparable form in the New Zealand Upper Cretaceous; and *Phyllocladites mawsonii* Cookson, 1947. The presence of *D. heterophlycta*, *D. leptodermata*, and *N. flemingii* in this core indicates that the Eocene has been cored at this level. Remanié forms are rare in this sample with *Stereisporites antiquasporites*, *Lycopodiumsporites eminus*, and *Alisporites similis* occurring sporadically.

Palynofloras from Core 282-14 are essentially similar to those of Core 13. Additional forms included *Proteacidites* cf. *P. retiformis* Couper, 1960; *Liliacidites variegatus* Couper, 1953; and the dinoflagellates

*Spiniferites wetzeli* and *Operculodinium centrocarpum* (Deflandre and Cookson) Wall, 1967.

Core 282-15 contains a typical upper Eocene dinoflagellate assemblage including *Deflandrea phosphoritica* and *Wetzeliella glabra* Cookson, 1956. This species of *Wetzeliella* has been recorded from the Eocene of Australia (Cookson, 1956), and upper Eocene of New Zealand (Wilson, 1967b). Other dinoflagellate species include *Hystrichokolpoma* cf. *H. rigaudae*, *Spiniferites ramosus*, *Cyclonephelium* sp., and *Areosphaeridium dictyoplokus*. Pollen is dominated by *Nothofagidites*, representing both the *fusca* and *brassi* types.

Cores 282-16 and -17 contain palynofloras similar to Core 15, and include the additional pollen *Proteacidites subscabatus* Couper, 1960 and *Tricolpites striatus* Couper, 1954, as well as *Turbiosphaera* cf. *T. filosa* and *Nothofagidites flemingii*. These cores are also upper Eocene. Rare specimens of *Alisporites similis* constitute the remanié assemblage in this core.

The oldest core studied (Core 282-18) from this site yielded a palynoflora with almost equal numbers of terrestrial and marine palynomorphs. The dinoflagellates in the sample include *Hystrichosphaeridium recurvatum* Deflandre and Cookson, 1955; *Oligosphaeridium complex*; *Spiniferites ramosus*; *Deflandrea phosphoritica*; *D. cf. D. dartmooria* Cookson and Eisenack, 1965; and *Achomosphaera ramulifera*. Pollen grains include *Triorites harrisii*, which is the most common palynomorph encountered; *Proteacidites* sp.; *Liliacidites variegatus* Couper, 1953; and *Tricolpites sabulosus* Dettmann and Playford, 1968. The spore *Cyathidites minor* is also present. The presence of *T. harrisii* and *D. phosphoritica* in this sample indicate that it is Paleocene or younger (Couper, 1960; Alberti, 1959). The occurrence of a specimen similar to *D. dartmooria*, a form which is typical of Paleocene strata, indicates a possible Paleocene age for the sample, while *Tricolpites sabulosus* has been reported from uppermost Cretaceous strata by Dettmann and Playford (1968). Paleocene is tentatively assigned to this core, the last-named occurrence being either remanié or extending the range of that form.

#### Location Summary

Site 282 is located west of, but relatively close to, the coast of Tasmania. The sequence intersected includes seven sedimentary units. The three youngest units are Miocene to Pleistocene calcareous oozes, which are locally glauconitic. These beds overlie lower and middle Oligocene mixed calcareous ooze and terrigenous silts and clays comprising three other lithologic units. The oldest unit, Eocene, is generally composed of silts and clays.

Based on palynological results the overall sequence is subdivided as follows: Cores 4-6 are Miocene; Cores 7-9, 11, 12 are Oligocene, although Core 12 may be uppermost Eocene; Cores 13-15 are upper Eocene, Cores 16, 17 are lower Eocene, with Core 18 being Paleocene, or possibly Eocene in age.

Pollen grains predominate through much of this sequence, reflecting the continued effect of the presence of

land. The localized domination of floras by *Hystrichokolpoma rigaudae* in parts of Cores 4 and 9 reflects some localized facies change within the marine environment, which is difficult to explain. Monosaccate remanié species representing Permo-Triassic strata, and forms which terminate their ranges in the Lower Cretaceous, indicate that the sediments cored at Site 282 were being provided, in part, by sediments from the erosion of strata of these ages from the adjacent land mass.

#### SITE 283

Core 283-2 yielded diverse palynofloras. Sections 283-2-1 and 2-4 assemblages include the pollen grains *Nothofagidites matauraensis*, *Nothofagidites* spp., and *Triorites annularis*. Specimens of the dinoflagellates *Deflandrea* sp. and *Areosphaeridium dictyoplokus* are also present. Sample 2, CC yielded a moderately rich assemblage of dinoflagellate cysts and miospores. Dinoflagellate cysts are dominated by *Tectatodinium* sp. Other dinoflagellate species include *Hemicystodinium* sp.; *Tuberculodinium* cf. *T. vancampoae* (Rossignol) Wall, 1967; *Hystrichokolpoma rigaudae*; *Deflandrea phosphoritica*; and a distinctive undescribed species of *Palaeoperidinium*. The pollen assemblage is dominated by *Nothofagidites* representing both the *brassi* and *fusca* types. The presence of *Deflandrea phosphoritica* in this core indicates that it is Oligocene or older in age.

Core 283-5 yielded diverse palynofloras. Dinoflagellates present include *Deflandrea phosphoritica*; *D. macmurdoensis*; *D. leptodermata*; *D. asymmetrica*; *Leptodinium aculeatum* Wall, 1967; and *Loptodinium* sp. Pollen species include *Nothofagidites matauraensis*; *Triorites harrisii*; *Proteacidites grandis*; *P. crassus*; *P. parvus*; *Myrtacidites parvus*; *Tricolpites inargutus* McIntyre, 1968; the bisaccate grains *Podocarpidites exiguus* and *Phyllocladidites* sp.; and the trisaccate grain *Microcachrydites antarcticus*. *Cyathidites minor* and *C. australis* are also present. The overlap of the Oligocene form *Tricolpites inargutus*, and the Eocene forms *Deflandrea asymmetrica* and *D. macmurdoensis*, indicates that the sample is located adjacent to the Eocene-Oligocene boundary. The remanié species *Alisporites similis* is also present.

Palynofloras from Core 283-6 are essentially similar to those of Core 5 with the addition of *Spinidinium aper-turum*, *Operculodinium israelianum* (Rossignol) Wall, 1967, and the pollen grains *Proteacidites subscabratus* and *P. pachypolus* Cookson and Pike, 1954. The latter form is known from Australian Paleocene and Eocene strata. Core 6 is considered to be Eocene, probably late Eocene in age. A remanié specimen of the Upper Jurassic and Lower Cretaceous spore *Contignisporites cooksonii* (Balme) Dettmann, 1963, is also present.

The palynofloras of Core 283-7 differ from preceding cores in that pollen grains occur infrequently, with *Nothofagidites matauraensis*, *Myrtacidites parvus*, and *Triorites harrisii* being the most common forms encountered. The dinoflagellate assemblages are diverse and rich, the dominant species being *Deflandrea cygniformis* Pöthe de Baldi, 1966. Other forms present include *Deflandrea phosphoritica phosphoritica*, *D. phosphoritica australis*, *D. leptodermata*, and *D. macmur-*

*doensis*. A middle to upper Eocene age is postulated for this sample. The remanié form *Alisporites similis* is also present in Core 7.

Core 283-8 samples yielded relatively limited palynofloras, usually having *Deflandrea phosphoritica* and/or *D. cygniformis* as the numerical dominant. *Leptodinium victorianum*, *L. aculeatum*, and *Leptodinium* sp. are also present. Occasional specimens of *Triorites harrisii*, *Nothofagidites matauraensis*, *Myrtaceidites parvus*, and *Podocarpidites exiguus* are also encountered.

Sample 283-8, CC contains a typical middle-upper Eocene dinoflagellate assemblage including *Deflandrea phosphoritica* and *Spinidinium aperturum* as codominants. Other dinoflagellate species include *Leptodinium* sp. (an ornate species), *Deflandrea macmurdoensis*, and *Areosphaeridium dictyoplokus*, the latter two species being common in Eocene rocks of Antarctica and South America (Wilson, 1967a; Archangelsky, 1969). Pollen species include *Nothofagidites* and the proteaceous species *Proteacidites* cf. *P. grandis* Cookson, 1950. This core is probably mid-upper Eocene.

The palynofloras from Core 283-9 are also of relatively low species diversity, and number of specimens. *Deflandrea phosphoritica*, *D. cygniformis*, *D. leptodermata*, *D. heterophlycta*, *Leptodinium victorianum*, *L. dispertitum*, *Aiora fenestrata*, and *Areosphaeridium dictyoplokus* are usually common, with the first two species dominant. *Nothofagidites matauraensis*, *N. flemingii*, *Triorites harrisii*, *Proteacidites subscabratus*, and *M. parvus* are all present, but infrequent. A middle and upper Eocene age is indicated for the core by the presence of *N. flemingii*, and the dinoflagellate assemblage in general. Remanié species, including the Lower Cretaceous or older forms *Stereisporites antiquasporites*; *Densoisporites velatus* Weyland and Krieger, 1953; *Alisporites grandis*; and *Neoraistrickia truncata* (Cookson) Potonié, 1956 occur in these samples.

Sample 283-9, CC yielded palynoflora dominated by an undescribed species of *Cladopyxidium*. Other taxa include *Areosphaeridium dictyoplokus*; *Spinidinium aperturum*; *Palaeoperidinium* n. sp.; *Schematophora* sp.; *Operculodinium* sp.; and one probable specimen of *Cassidium fragilis* (Harris) Drugg, 1967. Pollen is relatively rare, and a probable middle Eocene age is indicated.

Core 283-11 yielded excellent palynoflora, all dominated either by *Areosphaeridium dictyoplokus* or *Deflandrea phosphoritica*. Other less common dinoflagellate cysts include *Aiora fenestrata*, *Acanthaulax* sp., *Deflandrea* cf. *D. antarctica*, *Spinidinium aperturum*, and *Thalassiphora pelagica*. Some excellent specimens of the characteristic middle Eocene dinoflagellate *Wetzeliella echinosuturata* Wilson, 1967 were found in Sample 283-11, CC. Pollen is relatively rare, but includes *Nothofagidites matauraensis* and *Proteacidites subscabratus*. A middle Eocene age can be assigned to this core on palynological evidence. Remanié specimens of *Alisporites similis* are present in these palynofloras.

Core 283-12 palynofloras contain a number of lowermost Tertiary types of *Deflandrea*, including *D. cf. D.*

*cooksoni*; *D. asymmetrica*; *D. speciosa* Alberti, 1959; as well as *D. phosphoritica* et var. Pollen species include *Gambierina edwardsii* (Cookson and Pike) Harris, 1972 and *Proteacidites subscabratus*; as well as the bisaccate grain *Podocarpidites exiguus* and the trisaccate grain *Trisaccites microsaccatus*. *D. speciosa* was described from German Paleocene strata and *G. edwardsii* is known from middle Paleocene strata of southern Australia (Harris, 1965). A Paleocene, possibly middle Paleocene, age is indicated for this core. Remanié specimens of *Alisporites grandis*, *A. similis*, and *Stereisporites antiquasporites* are present in these palynofloras.

Cores 283-13 to -15 (14 samples) contain fairly similar rich palynoflora and are probably all Paleocene, in age, based on palynological evidence. Dinoflagellate species include *Svalbardella australina* Cookson, 1965; *Turbiosphaera filosa*; *Deflandrea denticulata* Alberti, 1959; *Eisenackia crassitabulata* Deflandre and Cookson, 1955; *Acanthaulax* spp.; a characteristic ornate species of *Leptodinium*; *Palaeoperidinium* cf. *P. pyrophorum* (Ehrenberg) Sargeant, 1967; *Membranilarnacia* sp.; *Cleistosphaeridium* sp.; *Cassidium fragilis*; and *Areosphaeridium dictyoplokus*. The Upper Cretaceous/basal Tertiary colonial alga, *Palambages morulosa* Wetzel, 1933 is a rare element of these assemblages. Miospores are also rare and include the reworked Mesozoic forms *Classopollis classoides*; *Alisporites similis*; and *Ceratosporites equalis* Cookson and Dettmann, 1958.

Core 283-16 (4 samples) appears to be slightly older and may be lower Paleocene. Similar assemblages to those of Cores 13-15 occur with the addition of the characteristic dinoflagellates *Systematophora* sp. and *Glyphanodinium* cf. *G. facetum* Drugg, 1964, the latter species being previously recorded from the Paleocene of California (Drugg, 1964). Pollen includes *Gambierina edwardsii*, a middle Paleocene and Upper Cretaceous form (Harris, 1965; Dettmann and Playford, 1968).

Core 283-17 (6 samples) contains a mixture of uppermost Cretaceous and lower Tertiary palynomorphs, and is therefore tentatively assigned to the "Cretaceous-Tertiary boundary". Species include the dinoflagellates *Deflandrea cretacea* Cookson, 1956; *D. cf. D. bakeri* Deflandre and Cookson, 1955; *Cribroperidinium* cf. *C. orthoceras* (Eisenack) Davey, 1967; *Glyphanodinium* cf. *G. facetum*; *Cleistosphaeridium* sp.; *Eisenackia* sp.; *Areoligera* cf. *A. senonensis* Lejeune-Carpentier, 1938; *Deflandrea denticulata*; and *Exochosphaeridium* cf. *E. striolatum* (Deflandre) Davey, 1969. *Palambages morulosa* is fairly common; pollen is rare.

Samples from Hole 283A were either barren or yielded extremely sparse assemblages.

#### Location Summary

Four sedimentary units were cored at Site 283, the youngest being a zeolitic claystone of unknown age. This unit is underlain by a siliceous ooze at Cores 283-2 to -6. The remainder of the sequence is composed of silty or clayey material. Core 2 is of Oligocene age, while Core 5 is basal Oligocene or latest Eocene in age. Cores 6-9 are of upper Eocene age, and Cores 10 and 11 are

middle Eocene. Cores 12-15 are middle or upper Paleocene, and Core 16 appears to be lower Paleocene. Core 17 is either lowermost Paleocene or uppermost Cretaceous in age.

Dinoflagellate cysts dominate the assemblages and are consistently rich both in individuals and diversity. Terrestrial pollen grains are present throughout, although these are more relatively common in younger cores, due mainly to a decrease in dinoflagellates. The continued presence of these grains probably reflects a relative "down-stream" effect of the site location with respect to the palaeocurrents developed during the time of sedimentation. The persistence of remanié Lower Cretaceous forms in this sequence is probably due to the same effects.

The diversity and dominance of palynofloras by dinoflagellates in the Eocene of this hole is not as prevalent as those of similar age cored at Site 280. Water depths at Site 283 apparently remained at or below calcium carbonate solution level throughout the deposition of the sequence. The continued diverse dinoflagellate spectra may reflect "down-stream" effects, the plankton being derived from the Australian shelf region.

#### SITE 284

Site 284 is some distance from the sites discussed previously, and based on shipboard micropalaeontology, has a generally younger sediment sequence of late Miocene to Pleistocene age. Palynofloras from this sequence are different to those from the other sites examined. The species diversity of these assemblages is consistently low, and spores and pollen grains are generally very rare. The microplankton assemblages are usually composed of a small number of species which have a persistent occurrence through parts of the sequence. Few of the forms present have stratigraphic significance.

Core 284-3 to Section 284-5-1 are characterized by the occurrence of *Spiniferites mirabilis* (Rossignol) Sarjeant, 1970 in variable, occasionally dominant, numbers. *Leptodinium dispertitum*, *L. aculeatum*, and *Spiniferites ramosus* are also present in this interval. Occasional specimens of *Nothofagidites* sp., *Triorites* sp., *Myrtaceidites eugenioides*, *Podocarpidites exiguus*, and *Cyathidites australis* are also encountered.

The samples of Cores 284-5 (Sections 2-6) to 9 are virtually barren, with only occasional specimens of angiosperm pollen grains, and dinoflagellates present. These include *Oligosphaeridium* cf. *O. complex*, *Triorites* cf. *T. harrisii*, *Myrtaceidites parvus*, and *Cyathidites minor*.

Samples from Core 284-10 yielded a few spores and pollen grains including *Triorites harrisii*, *Myrtaceidites parvus*, *Proteacidites* sp., *Podocarpidites* cf. *P. ellipticus*, *P. exiguus*, *Cyathidites minor*, and *Plicifera delicata*.

Cores 284-11 to -13 yielded limited assemblages with rarely more than 10 forms each. *Leptodinium dispertitum* and *L. aculeatum* are the dominant palynomorph species. Other microplankton include *Spiniferites ramosus*, *Operculodinium israelianum* (one occurrence), *Michrystidium* spp., and *Leiosphaeridia telmatica*.

Pollen grains again vary in occurrence, and include those mentioned in Core 10 as well as *Nothofagidites cranwellae*; *N. cf. F. canaliculatus* Dettmann, 1963; and *Palambages* sp. is also represented. The Cretaceous spore *Ceratospirites equalis* Cookson and Dettmann, 1958, is present in Core 12.

Palynofloras of Cores 284-14 to -16 are essentially similar to those of the previous interval, although *Operculodinium israelianum* is common, dominating the relatively limited assemblages.

Samples of Cores 284-17 to 19 are similar to Cores 14-16 above, but lack *Operculodinium israelianum*. A single specimen of *Systematophora placacantha* (Deflandre and Cookson) Davey, Downie, Sarjeant, and Williams, 1966, is present in Core 17. This form was described from the middle Miocene of Victoria, Australia.

Palynofloras from the remaining cores are similar to those above and are dominated by *Leptodinium victorianum* and *L. dispertitum*, these species occasionally being the only forms present. *L. aculeatum* is absent or rare.

#### Location Summary

The low but consistent species diversity in palynofloras from this site is related to the open-ocean conditions in this area during the deposition of the sequence. The continued occurrence of species of *Leptodinium* through the sequence is extremely rare, although a similar occurrence was reported by Wall (1967) from a deep-sea core in the Caribbean Sea. The general lack of nonmarine palynomorphs from this locality, which is relatively close to the New Zealand coast, is probably due to the site location being "up-stream" with respect to paleocurrent directions during the late Miocene and Pliocene. Miospores present in the microflora were derived from the Australia region, and were carried to these locations by a westward-moving current.

Little stratigraphic information is available from the palynofloras of this site.

#### GENERAL CONCLUSIONS

At all but Site 284 the use of palynology provides a satisfactory Tertiary biostratigraphic subdivision for each sequence. Such a subdivision involves both dinoflagellates and pollen grains, which tend to complement each other, providing useful stratigraphic results.

Palynofloras from the five sites studied show considerable variation in both miospore and dinoflagellate populations, as well as in the relative numerical balance between the two groups. The presence of large numbers of pollen grains throughout the sequence cored at Site 282 indicates that the locale, though marine, remained under the influence of nonmarine waters during the Cenozoic. The sequence at Site 284 reflects remote oceanic conditions and consistently yielded small, predominantly dinoflagellate palynofloras. At the remaining sites, dinoflagellates are usually more common than nonmarine palynomorphs. The number of specimens and the species diversity varies considerably, especially within the dinoflagellates of the Paleocene of Site 283, and lower to lower-middle Eocene of Sites 280,

281, and 282. In comparison with consistently small oceanic dinoflagellate palynoflora of Site 284, this change may reflect the penetration of oceanic waters into the region during the lower to lower-middle Eocene at Sites 280, 281, and 282, and Paleocene at Site 283.

The constituent species of Eocene and Oligocene dinoflagellate assemblages from Sites 280-283 can be divided into two groups: species such as *Lejeunia hyalina*, *Deflandrea phosphorifica*, *Palmnickia lobifera*, and *Thalassiphora pelagica* which are widely known in lower Tertiary deposits in various parts of the world; and a group including *Turbiosphaera filosa*, *Spinidinium aperturum*, *Deflandrea distinctum*, *D. macmurdoensis*, *D. asymmetrica*, *D. antarctica*, *D. cygniformis*, and *Wetzeliella echinosuturata*, which are present, along with some or all of the above forms, in palynofloras from the Ross Sea area of Antarctica (Wilson 1967a, b), and South America (Archangelsky, 1968; Archangelsky and Fasola, 1971; Pöthe de Baldis, 1966). The abundance of *Aiora fenestrata* and *Areosphaeridium dictyoplokus* appears to be a feature of palynofloras both from the lower Tertiary of the localities studied here, and from the Ross Sea.

This similarity and the unique nature of the dinoflagellate assemblages noted here and those of similar age in Antarctica and South America indicate that some provincial controls were exerted on the distribution of these forms. If this control was only latitudinal and climatically based, it would appear that the province should include parts of Southern Australia and New Zealand. However, these characteristic dinoflagellate associations have not been recorded in these two countries. The distribution encompassing the Leg 29 sites, south of Australia and New Zealand, in addition to Antarctica, suggests a common high latitude, lower Tertiary biogeographic province about the time of, or soon after, the separation of the Antarctic and Australian continents. The presence of the same assemblages in South America, including Tierra del Fuego, indicate that the same province extended to the southernmost South American area, and may have been related to early stages in the development of the Circum-Antarctic current.

Remanié assemblages from the sites studied include a distinctive Permian and Triassic suite consisting of monosaccate and striate bisaccate grains and a Lower Cretaceous suite of saccate pollen grains, spores, and a single dinoflagellate species. These types of remanié palynofloras are well known in Antarctic and Australian Tertiary palynofloras (Wilson, 1968; Harris, 1965). Permian and Triassic sediments are widespread in Antarctica, Australia, and New Zealand, although in the last case the metamorphic grades of such strata is usually, though not invariably, too high for preservation of microfossils. The presence of Permian and Triassic remanié microfossils in the sequences studied reflects a contribution of Permian and Triassic age to the sediments from the Australian and Antarctic continents in the initial stages of separation, and probably from Australia as separation increased.

The presence of a Lower Cretaceous remanié palynoflora indicates that the Australian continental

mass had a strong influence on sedimentation. Cretaceous sediments are now uncommon on the Antarctic continent, and were possibly never extensively developed there. In Australia, on the other hand, very large areas are underlain by Lower Cretaceous strata (Dettmann, 1963; Whitehouse, 1955). In southeastern Australia these strata are predominantly nonmarine (Dettmann, 1963; Haskell, 1972) although late Aptian and Albian marine sediments in the Great Artesian Basin are widespread north and west of the areas of non-marine beds.

The nonmarine nature of the Lower Cretaceous remanié assemblages, shows that southeastern Australia clearly contributed extensively to the sediments of the sequences at Sites 280-283, although the occurrence of a single marine Lower Cretaceous specimen suggests that the Great Artesian Basin was also a source of terrigenous sediment.

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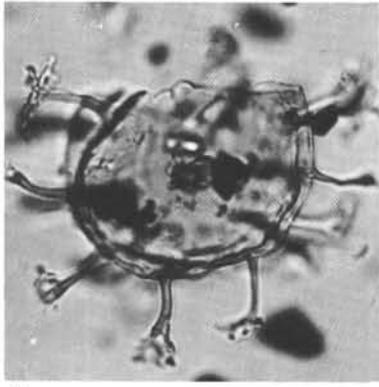


PLATE 1

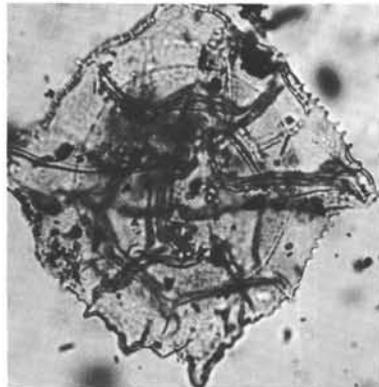
Selected Palynomorphs from Sites 280-284  
(Magnification values only approximate)

- Figure 1 *Areosphaeridium dictyoplokus* (Klumpp). Sample 283-11A, CC; L6422;  $\times 640$
- Figure 2 *Wetziella (Wetziella) echinosuturata* Wilson. Sample 283-11, CC; L6422/1;  $\times 400$ .
- Figure 3 *Deflandrea cretacea* Cookson. Sample 283-17-4, 14 cm; L6462/1;  $\times 640$ .
- Figure 4 *Deflandrea phosphoritica* Eisenack. Sample 283-7, CC; L6439/1;  $\times 500$ .
- Figure 5 *Deflandrea* aff. *bakeri* Deflandre and Cookson. Sample 283-17-1, 40 cm; L6359/4;  $\times 400$ .
- Figure 6 *Spinidinium aperturum* Wilson. Sample 280A-14-2, 57 cm; L6389/1;  $\times 800$ .
- Figure 7 *Deflandrea asymmetrica* Wilson. Sample 281-14-1, 120 cm; L6458/2;  $\times 500$ .
- Figure 8 *Nothofagidites matauraensis* (Couper). Sample 283-4, CC; L6353/2;  $\times 800$ .
- Figure 9 *Triorites harrisii* Couper. Sample 283-2, CC; L6436/2;  $\times 800$ .
- Figure 10 *Proteacidites* sp. Sample 283-13-5, 64 cm; L6447/2;  $\times 800$ .
- Figure 11 *Gambierina edwardsii* (Cookson and Pike). Sample 281-14-1, 120 cm; L6458/2;  $\times 800$ .
- Figure 12 *Deflandrea antarctica* Wilson. Sample 280A-20-3, 38 cm; L6370/2;  $\times 640$ .
- Figure 13 *Deflandrea macmurdoensis* Wilson. Sample 280A-10-5, 66 cm; L6399/1;  $\times 640$ .
- Figure 14 *Deflandrea cygniformis* Pöthe de Baldi. Sample 283-7, CC; L6439/1;  $\times 320$ .
- Figure 15 *Svalbardella australina* Cookson. Sample 283-13-4, 38 cm; L6446/1;  $\times 300$ .

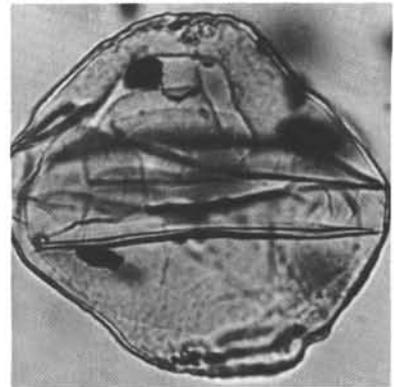
PLATE 1



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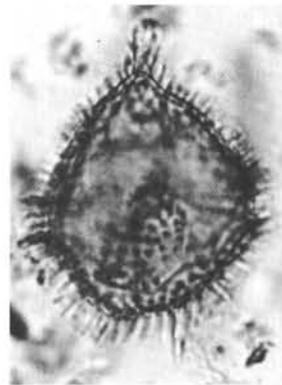
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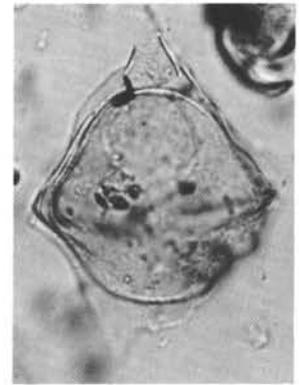
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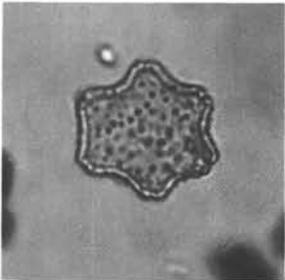
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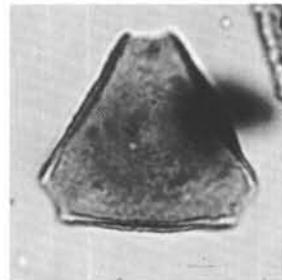
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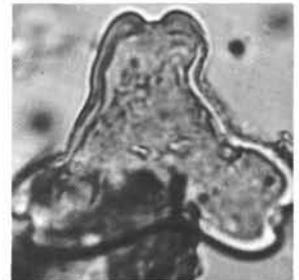
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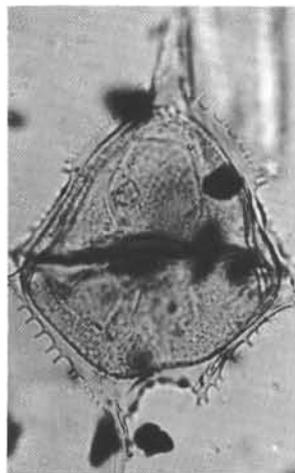
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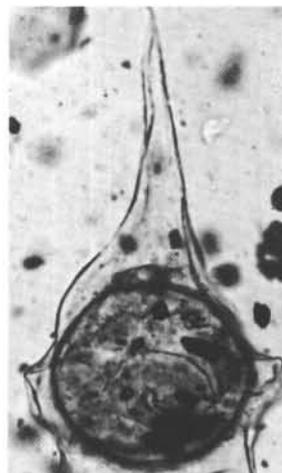
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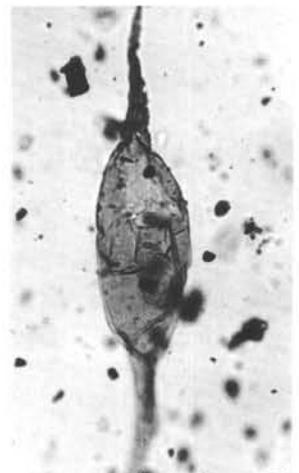
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PLATE 2

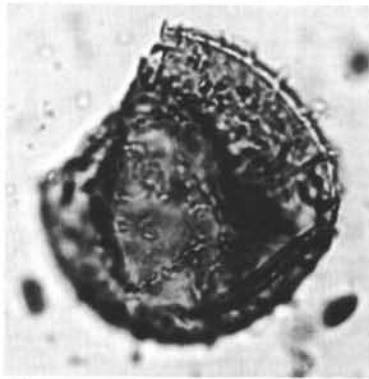
Selected Palynomorphs from DSDP Sites 280-284  
(Magnification values only approximate)

- Figures 1, 2, 7 *Leptodinium* sp.  $\times 640$ .  
1. Sample 283-15-2, 38 cm; L6490/1.  
2. Sample 283-13-2, 15 cm; L6444/2.  
7. Sample 283-7, CC; L6439/1.
- Figure 3 *Dictyosphaeridium deflandrei* W. Wetzel. Sample 283-13-2, 15 cm; L6444/2;  $\times 800$ .
- Figure 4 *Aiora fenestrata* (Deflandre and Cookson). Sample 283-11, CC; L6422;  $\times 500$ .
- Figure 5 *Thalassiphora pelagica* (Eisenack). Sample 280A-18-1, 117 cm; L6380/1;  $\times 300$ .
- Figure 6 *Tectatodinium* sp. Sample 283-2, CC; L6436/1;  $\times 800$ .
- Figure 8 *Palaeoperidinium* sp. Sample 283-2, CC; L6436/2;  $\times 800$ .
- Figure 9 *Palambages morulosa* O. Wetzel. Sample 283-17-1, 40 cm; L6359/4;  $\times 640$ .
- Figure 10 *Turbiosphaera* sp. cf. *T. filosa* (Wilson). Sample 280A,-17, CC; L6380/1;  $\times 640$ .
- Figure 11 *Palaeoperidinium pyrophorum* (Ehrenberg). Sample 283-14-4, 70 cm; L6489/1;  $\times 500$ .
- Figure 12 *Hystrichokolpoma rigaudae* Deflandre and Cookson. Sample 283-8, CC; L6354/2;  $\times 640$ .

PLATE 2



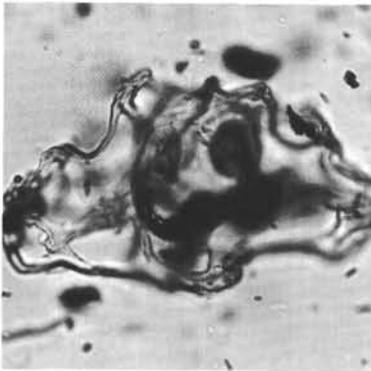
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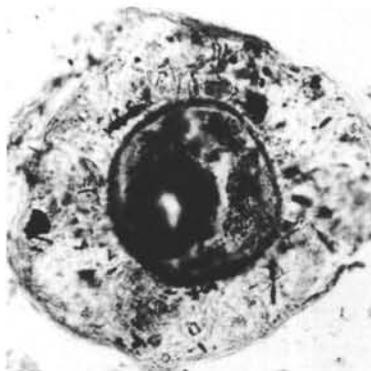
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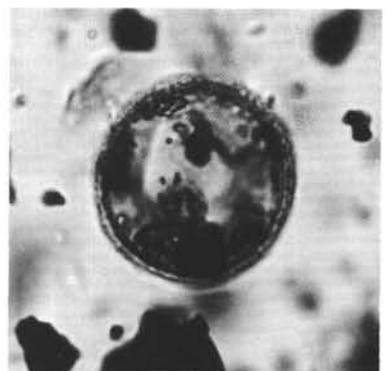
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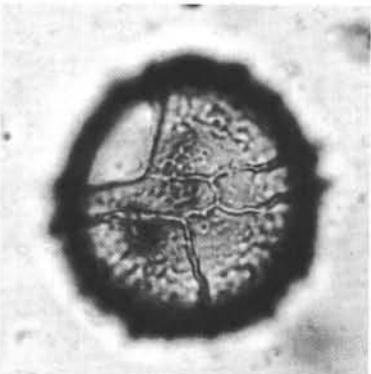
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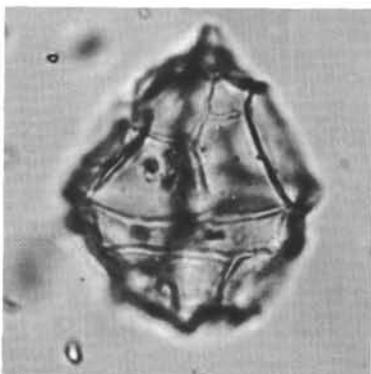
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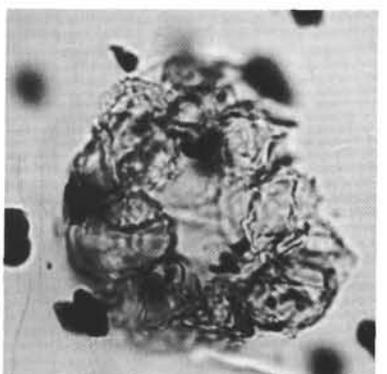
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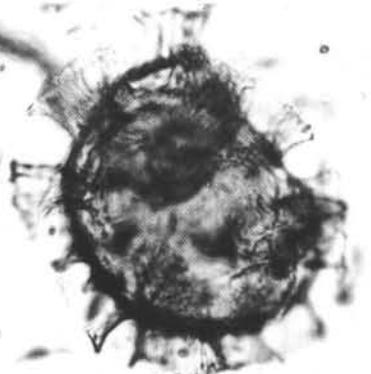
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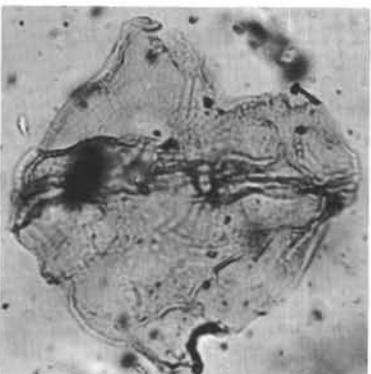
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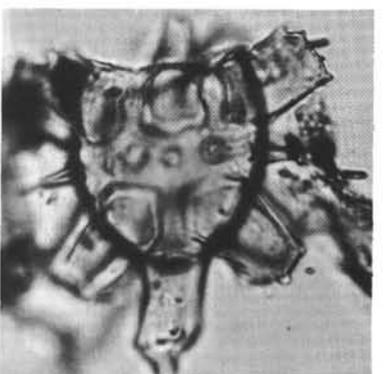
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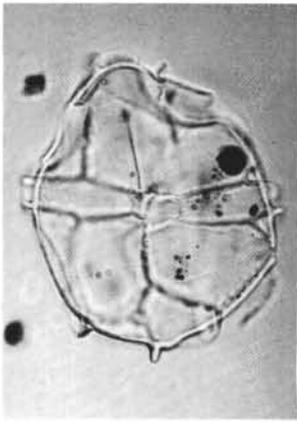
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PLATE 3

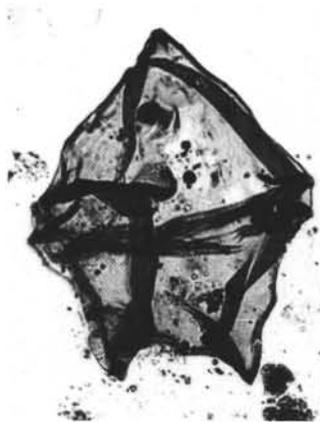
Selected Palynomorphs from DSDP Sites 280-284  
(Figures 1-9,  $\times 500$ ; Figures 10-15,  $\times 750$ )

- Figure 1 *Leptodinium victorianum* Cookson and Eisenack. Sample 284-19-2, 80 cm; P3460-01.
- Figure 2 *Lejeunia hyalina* Gerlach. Sample 282-16-1, 90 cm; P3321-01.
- Figure 3 *Cassidium fragilis* (Harris). Sample 282-14-3, 70 cm; P3320-01.
- Figure 4 *Operculodinium israelianum* (Rossignol). Sample 284-15-3, 80 cm; P3439-01.
- Figure 5 *Eisenackia crassitabulata* Deflandre and Cookson. Sample 283-14-2, 70 cm; P3356-01.
- Figure 6 *Leptodinium dispertitum* Cookson and Eisenack. Sample 283-14-2, 81 cm; P3356-01.
- Figure 7 *Systematophora placacantha* Deflandre and Cookson. Sample 284-17-2, 92 cm; P3449-01.
- Figure 8 *Deflandrea heterophlycta* Deflandre and Cookson. Sample 282-9-3, 60 cm; P3307-01.
- Figure 9 *Dingodinium cerviculum* Cookson and Eisenack. Sample 282-8-2, 87 cm; P3302-01.
- Figure 10 *Phyllocladidites mawsonii* Cookson. Sample 282-13-3, 70 cm; P3316-01.
- Figure 11 *Cicatricosisporites australiensis* (Cookson). Sample 283-9-5, 90 cm; P3347-01.
- Figure 12 *Cyathidites minor* Couper. Sample 282-13-3; P3316-02.
- Figure 13 *Dacrydiumites*. Sample 282A-13-3, 70 cm; P3316-01.
- Figure 14 *Podocarpidites exiguus* Harris. Sample 284-19-1, 95 cm; P3459-01.
- Figure 15 *Podocarpidites ellipticus* Cookson. Sample 284-20-6, 80 cm; P3470-01.

PLATE 3



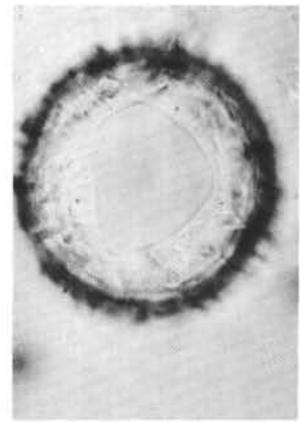
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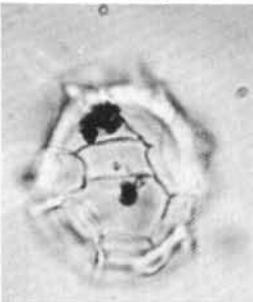
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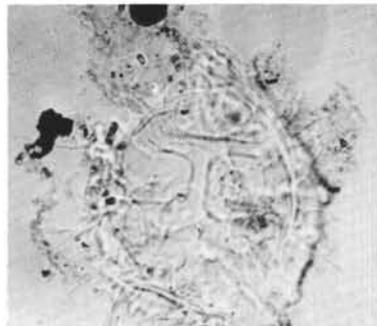
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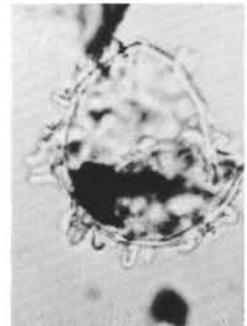
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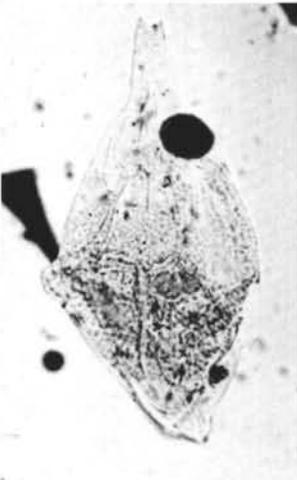
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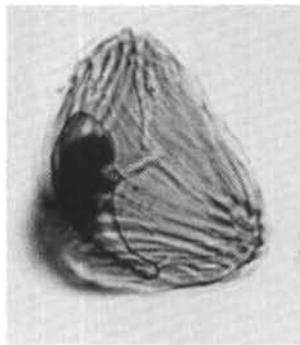
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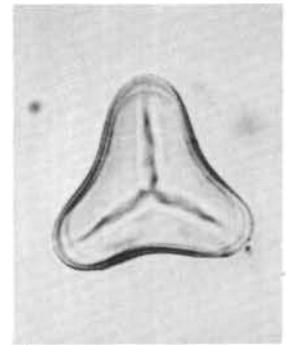
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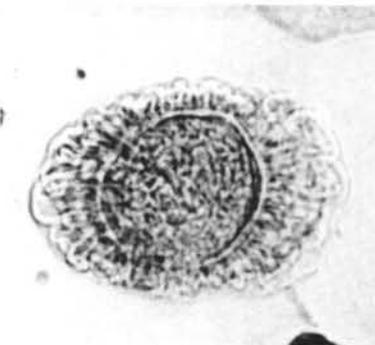
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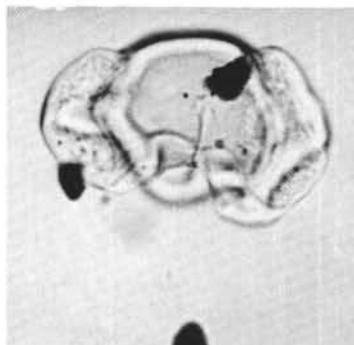
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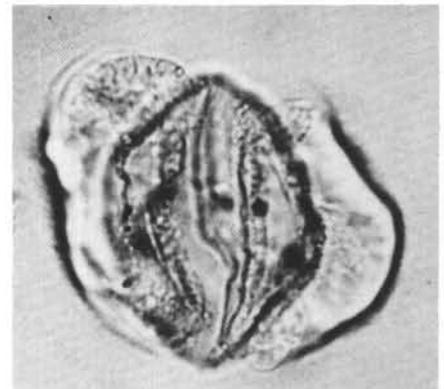
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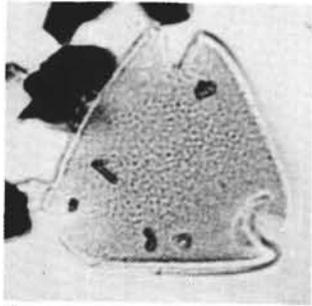
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## PLATE 4

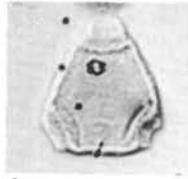
Selected Palynomorphs from DSDP Sites 280-284  
(Figures 1-15,  $\times 750$ ; Figures 16-22,  $\times 500$ )

- Figure 1 *Beaupreaeidites elegansiformis* Cookson, Sample 282-13-3, 70 cm, P3314-02.
- Figures 2,3 *Proteacidites annularis* Cookson.  
2. Sample 282-4-3, 70 cm; P3298-01.  
3. Sample 282-13-3, 67 cm; P3316-02.
- Figures 4, 5 *Tricolpites sabulosus* Dettman and Playford.  
Sample 282-18-1, 85 cm; P3328-01.  
4. General View.  
5. Detail of colpae.
- Figure 6 *Proteacidites incurvatus* Cookson. Sample 283-9-3, 90 cm; P3345-01.
- Figure 7 *Nothofagidites* sp. (*fucsa* group). Sample 282-13-3, 70 cm; P3316-02.
- Figure 8 *Myrtaceidites parvus* Cookson and Pike. Sample 282-12-2, 90 cm; P3312-02.
- Figure 9 *Proteacidites* cf. *scaboratus* Couper. Sample 282-14-3, 70 cm; P3320-01.
- Figure 10 *Proteacidites franktonensis* Couper, Sample 282-8-3, 70 cm; P3303-01.
- Figure 11 *Proteacidites clintonensis*, Harris. Sample 282-9-1, 115 cm; P3305-01.
- Figure 12 *Nothofagidites flemingii* Couper. Sample 282-13-3, 70 cm; P3316-02.
- Figure 13 *Proteacidites* cf. *retiformis* Couper. Sample 282-14-3, 70 cm; P3320-01.
- Figure 14 *Proteacidites pachypolas* Cookson and Pike. Sample 283-9-5, 90 cm; P3347-01.
- Figure 15 *Vitreisporites pallidus* (Reissinger). Sample 280A-11-3, 69 cm; P3245-01.
- Figure 16 *Alisporites grandis* (Cookson). Sample 280-13-3, 37 cm; P3249-01.
- Figures 17, 18 *Striatites* spp.  
17. Sample 282-4-3, 80 cm; P3298-01.  
18. Sample 282-8-2, 87 cm; P3302-01.
- Figure 19 *Zonalapollenites trilobatus* Balme. Sample 282-17-1, 135 cm; P3311-02.
- Figure 20 *Densoisporites velatus* Weyland and Krieger. Sample 283-9-5, 90 cm; P3347-01.
- Figure 21 *Coronatispora perforata* Dettmann. Sample 282-8-3, 70 cm; P3303-01.
- Figure 22 *Lycopodiumsporites austroclavatidites* (Cookson). Sample 282-8-2, 87 cm; P3302-01.

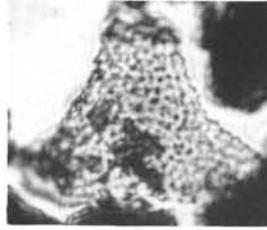
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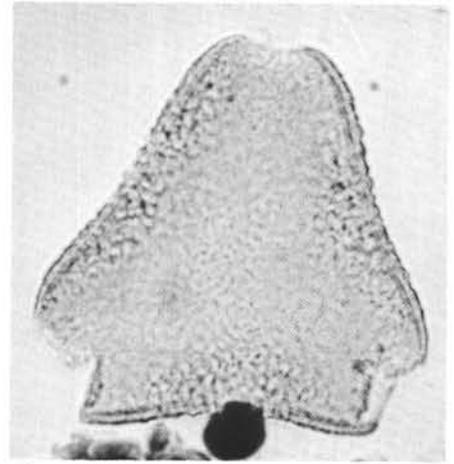
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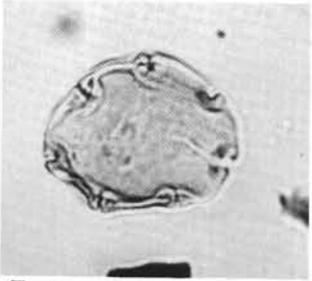
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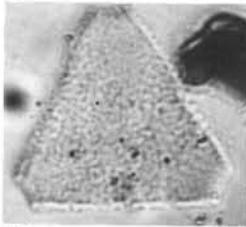
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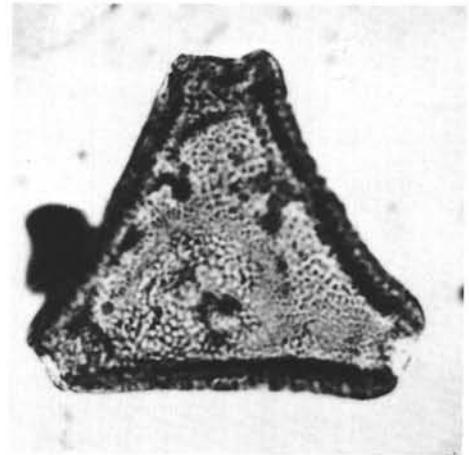
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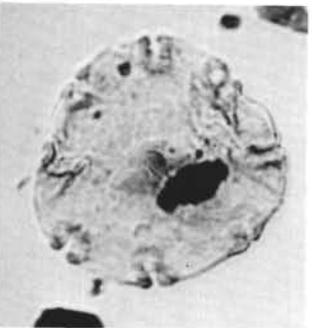
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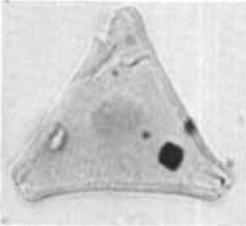
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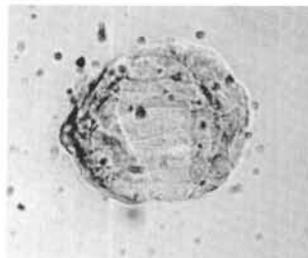
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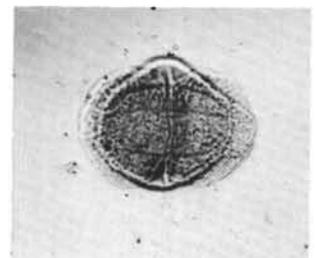
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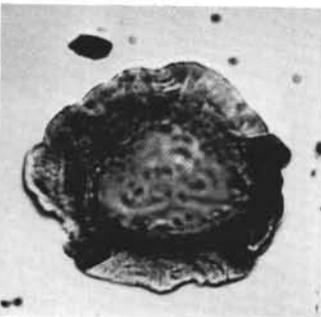
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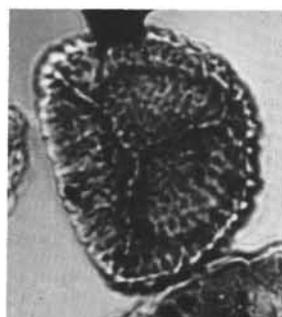
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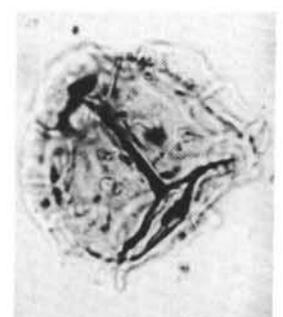
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