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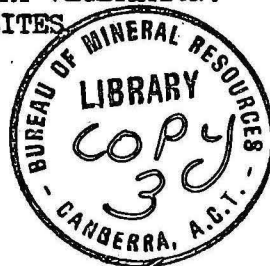
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RECORD 1975/82

ANTARCTIC GLACIATION AND EARLY TERTIARY VEGETATION:
EVIDENCE FROM ROSS SEA DRILLSITES

by



E.M. KEMP and P.J. BARRETT

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Antarctic glaciation and Early Tertiary vegetation: evidence from
Ross Sea Drillsites.

The presence of vegetation in Antarctica in the Early Tertiary has been known since 1908, when Dusen¹ and Gothan² described leaf fossils and wood fragments collected from Seymour Island, at the tip of the Antarctic Peninsula. Dusen identified a diversity of angiosperm taxa, including representatives of Fagaceae, Proteaceae, Monomiaceae, Cunoniaceae, Myricaceae, Cyperaceae, and Winteraceae, and a coniferous element represented by Podocarpaceae and Araucariaceae. The age of the Seymour Island sequences remains uncertain; Dusen referred to them as Oligocene-Miocene, but they have subsequently been referred to the Eocene on the basis of their plant microfossil content³.

Of even greater palaeoclimatic and botanical interest are pollens indicating the former presence of forests in the Ross Sea region, in still higher Tertiary latitudes. Pollen and spore assemblages described from erratic siltstone boulders at Minna Bluff⁴ and Black Island⁵, close to McMurdo Sound, indicate that Southern Beech forest existed nearby in the Eocene. This vegetation is further reflected in abundant recycled pollen, indistinguishable from that of the erratics, which has been recovered in grab samples from the Ross Sea floor^{6,7}. Similar recycled pollen in modern sea-floor sediments near the West Ice Shelf suggests that vegetation cover was also present in that area until at least the mid-Eocene⁸.

Palynological evidence obtained from recent drilling in the Ross Sea by the Glomar Challenger, and documented here, suggests that vegetation persisted in the area until the late Oligocene. Results of the same drilling program suggest that ice-rafting of clastic debris also commenced in the late Oligocene⁹; the vegetation reflected in the pollen spectrum thus appears to have been contemporaneous with the early phases of

glaciation.

Pollen and spores were recovered from Site 270, which was drilled offshore from the edge of the present Ross Ice Shelf (Fig. 1). The sequence at Site 270 is shown in Figure 2. Sediments of probable preglacial origin at the site are thin: one metre of quartz sand overlain by a further metre of glauconitic sandstone overlies a basal breccia and gneisse. Overlying these is a thick pebbly silty claystone of glacial marine origin. Subunits are identified within this thick unit by the presence or absence of stratification. The preglacial glauconitic sandstone is dated as 26 ± 0.4 m.y. by the K-Ar method¹⁰, an age which accords with that suggested by rare dinoflagellates in the unit¹¹. The change from preglacial to glacial marine conditions occurred over a short time interval, since the lower subunits of the glacial marine sequence have also been dated as late Oligocene by their contained foraminifera¹².

Samples of preglacial and glacial marine units were macerated for pollen and spores. Preglacial units were barren of these microfossils. All samples from the glacial marine unit were productive, though in varying degree; yield was highest in the basal subunit, 2J, a laminated, burrowed siltstone with rare dropped pebbles. Degraded tissues, leaf cuticles, and vascular fragments were also common in this subunit, suggesting deposition at no great distance from a vegetation source.

As in all glacial sequences, it is difficult to ascertain whether the plant microfossils in subunit 2J are derived from a parent vegetation which flourished during deposition of the unit, or whether they are recycled from older deposits. Modern glacial marine sediments on the Antarctic continental shelf contain recycled pollen and spores ranging in age from Palaeozoic to Early Tertiary^{6,7,8}. However, in the assemblages from subunit 2J, no forms are obviously recycled: there are none derived from Palaeozoic and Mesozoic sequences in the Transantarctic Mountains, nor are there any of the dinoflagellate cysts which are abundant in the Black Island and Minna

Bluff erratics. All of these older forms do, however, occur as a clearly recycled element in the upper parts of the glacial marine sequence at Site 270. Their absence from the basal part of the sequence suggests that little recycling occurred during deposition of the lower subunits, and that the pollen present reflects a parent vegetation that coexisted with the earliest glaciers.

Form-species identified in subunit 2J, and their probable botanical affinities, are listed in Table 1. Numerically, the assemblages are dominated by pollens of the Nothofagus type, with fossil forms similar to pollen of the extant fusca group present in slightly greater abundance than those of the brassi group. Pollen of Proteaceae is also well represented, but the forms are not diverse; small smooth-walled pollens referable to Proteacidites minimus are the most common. Small myrtaceous pollens, not identifiable below family level, occur rarely, as do tricolpate and triporate pollens that could be derived from a variety of parent families. Among gymnosperm pollens, podocarpaceous types predominate; the long-ranging Microcachrydites antarcticus and Podosporites microsaccatus are most common. Lygistipollenites florinii, of mid-Paleocene to Miocene range in southeastern Australia¹³, is a rare component. Cycadophyte pollens were not identified. Fern spores are rare, and chiefly suggest Cyathaceae, but include rare polypodiaceous types.

The assemblage is much less diverse than those of Early Tertiary sequences in Australia and New Zealand; it is less diverse than the Seymour Island fossil assemblages too. It is almost identical with that from the Black Island erratics, which on dinoflagellate evidence is probably late Eocene. The microflora from the erratics was interpreted as reflecting Southern Beech forest of the kind presently growing in cool temperate South America and New Zealand⁵; temperatures cooler than those of Eocene New Zealand were suggested, as pollen types indicative of warmth in the New Zealand Eocene are absent.

Data presented here for the Ross Sea region are interpreted as reflecting a late Oligocene parent vegetation which was essentially similar to that of the erratics. Nothofagus-dominated vegetation, with subordinate podocarps, Proteaceae, and Myrtaceae, appears to be represented by the pollen spectrum. Little change in floristic composition seems to have occurred with increasing deterioration of the Antarctic climate from the Eocene through the Oligocene. Possibly, the addition of new groups by dispersal and migration was impeded by the growing isolation of Antarctica, and by the intensification of circulation patterns outward, away from the continent. Transformation of the original forests into a tundra-like cover may have occurred, possibly with morphological and physiological adaptations, such as dwarfism and increased periods of dormancy, which would be undocumented in the fossil record. The pollen record gives no indication of taxa which are important elements of the modern sub-antarctic vegetation, such as Graminae, Cyperaceae, Umbelliferae, and Compositae; these groups may never have reached the Antarctic landmass beyond the Antarctic Peninsula. There is thus no evidence that there ever existed in the Ross Sea region a vegetation similar to that of present high southern latitudes, such as the Magellanic moorlands of southern Chile¹⁴ and the herbfields and tussock grasslands of the sub-Antarctic islands¹⁵. There is little evidence either, aside from rare Sphagnum type spores, of a vegetation phase dominated by a moss flora. It is not possible to determine precisely when adverse environmental conditions eliminated the Ross Sea vegetation entirely: the Miocene part of the drilled sequence in the region does contain pollen, but in low frequencies only, and with evidence of extensive reworking from older deposits.

The relationship between vegetation cover and the extent of glaciation in Antarctica in the Early Cainozoic remains problematical. The persistence of some form of vegetation around the Ross Sea until at least the late Oligocene is not at odds with geological evidence bearing on the earliest stages of glaciation. Sedimentation rates have been used in this context to

give a broad guide to the extent of ice-cover¹⁶. High rates of sedimentation are believed to reflect an environment with wet-base 'temperate' glaciers calving bergs into a relatively open sea; by contrast, periods of intense cold, with major ice-shelf development, are distinguished by slow sedimentation and erosion by sub-ice currents. High sedimentation rates (41 metres/million years) prevailed through the Oligocene and early Miocene sequence at Site 270¹⁷. This, and the observation that pebbles in this part of the sequence are derived from Marie Byrd Land, suggest that the Ross Ice Shelf was not in existence during this interval, but that glaciers from Marie Byrd Land calved directly into an open Ross embayment. Such a situation appears compatible with limited vegetation cover, which was perhaps confined to coastal zones and interglacier elevations.

An overall picture of Antarctic Tertiary vegetation can be drawn at present only on evidence from four localities, hence much remains speculative; as most of the available data are from the Ross Sea area, and it would be hazardous to generalize from this region to the whole continent. The Antarctic Peninsula, for instance, may have always lain in lower latitudes, and hence experienced a milder climate³. The coastal areas adjacent to the Ross Sea, however, apparently supported a cool temperate forest dominated by Nothofagus, with subordinate podocarps, through the Eocene. Glaciers of limited extent may have existed alongside this forest cover - early and middle Eocene glaciations have been suggested on evidence from Pacific cores¹⁸. From evidence presented here, this vegetation appears to have persisted with little floristic modification until at least the late Oligocene. There is presently nothing in the pollen record to indicate the introduction of plant groups which are important in the modern sub-Antarctic vegetation. Adaptation to increasingly adverse conditions, if it occurred at all, may have been through morphological and physiological change. The fate of the late Oligocene vegetation is not clear: palynological data are sparse and confused by recycling in Miocene sequences. However, near-complete elimination of vegetation probably occurred during the Miocene well before

the major ice advances of the early Pliocene⁹.

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Table 1: Form species of spores and pollen recovered from subunit 2J, Site 270, and their probable botanical affinities.

Pollen	Affinity
<u>Podocarpidites</u> spp.	Podocarpaceae
<u>Lygistepollenites florinii</u> (Cookson & Pike) Stover & Evans	Podocarpaceae (cf. <u>Dacrydium</u> spp.)
<u>Phyllocladidites mawsonii</u> Cookson	Podocarpaceae (cf. <u>Dacrydium franklinii</u>)
<u>Microcachrydites antarcticus</u> Cookson	Podocarpaceae (cf. <u>Microcachrys</u>)
<u>Podosporites Microsaccatus</u> (Couper) Dettmann	Podocarpaceae
<u>Nothofagidites heterus</u> (Cookson) Stover & Evans	<u>Nothofagus</u> (<u>brassi</u> group)
<u>N. matauraensis</u> Couper	<u>Nothofagus</u> (<u>brassi</u> group)
<u>N. vansteenisi</u> (Cookson) Stover & Evans	<u>Nothofagus</u> (<u>brassi</u> group)
<u>N. flemingi</u> (Couper) Potonie	<u>Nothofagus</u> (<u>fusca</u> group)
<u>N. cf. asperus</u> (Cookson) Stover & Evans	<u>Nothofagus</u> (<u>menziesii</u> group)
<u>Tricolpites</u> cf. <u>matauraensis</u> Couper	unknown
<u>T. cf. fissilis</u> Couper	unknown
<u>Triporopollenites</u> spp.	unknown
<u>Proteacidites minimus</u> Couper	Proteaceae
<u>P. subscabratus</u> Couper	Protaceae
<u>P. cf pseudomoides</u> Stover	Protaceae
<u>P. spp.</u>	Protaceae
<u>Myrtaceidites</u> spp.	Myrtaceae
Spores	
<u>Cyathidites</u> spp.	Cyathaceae
<u>Gleicheniidites cerciniidites</u> (Cookson) Dettman	Gleicheniaceae
<u>Laevigatosporites major</u> (Cookson) Krutzsch	unknown
<u>Polypodiisporites</u> spp.	Polypodiaceae
<u>Lycopodiumsporites</u> spp.	Lycopodiaceae
<u>Stereisporites antiquasporites</u> (Wilson & Webster) Dettman	Sphagnaceae

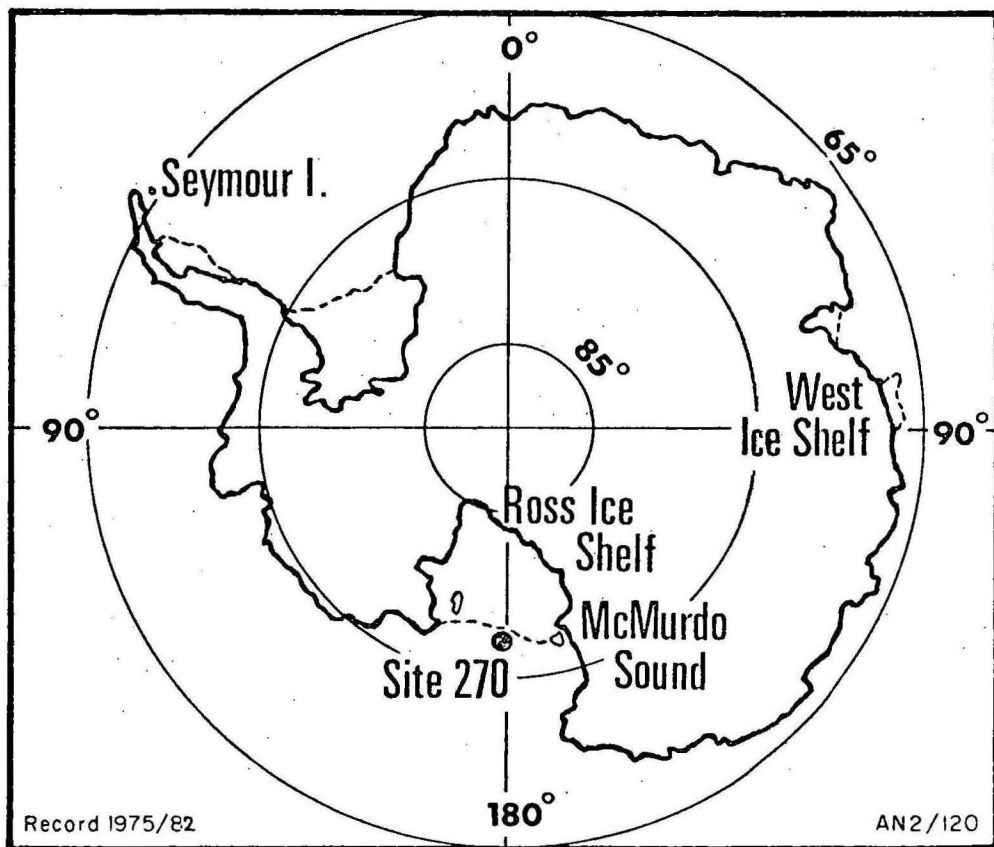


Figure 1. Map showing Antarctic localities from which Tertiary plant microfossils have been recovered.

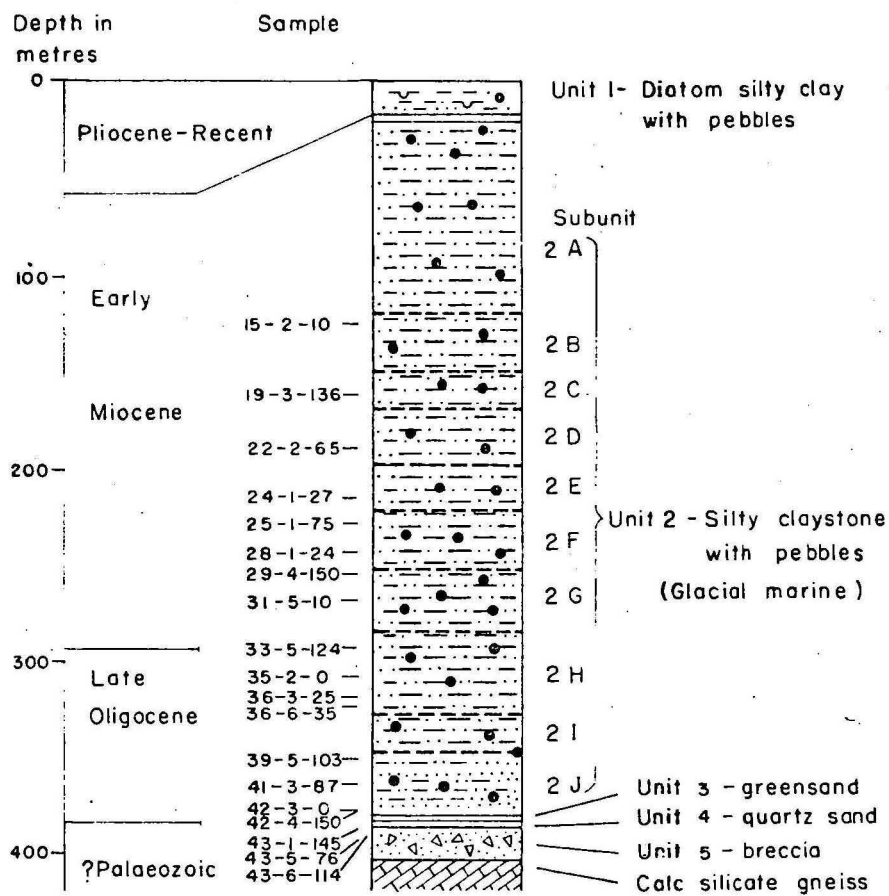


Figure 2. Lithological sequence at site 270. Palynological sample horizons shown on left side of column.