iments (such as core 36–29 in fig. 2) appear at least in part to be transported coarser fractions. Several cores have a coarse, winnowed upper surface. Available sea bottom photographs (Jacobs *et al.,* 1970) and bottom velocity mesurements (Gordon, in press) support this interpretation of the depositional environment.

Since Gilbert epoch sediments exist with fine fractions in the region, it is clear that the bottom current must have increased substantially in velocity since that time, to create the scour zone. We interpret this increase to be from a current system with velocity dominantly less than 10 cm per sec to one with velocity dominantly greater than 10 cm per sec, possibly as a result of substantial changes in the production of Antarctic Bottom Water some time since t = 3.0 million

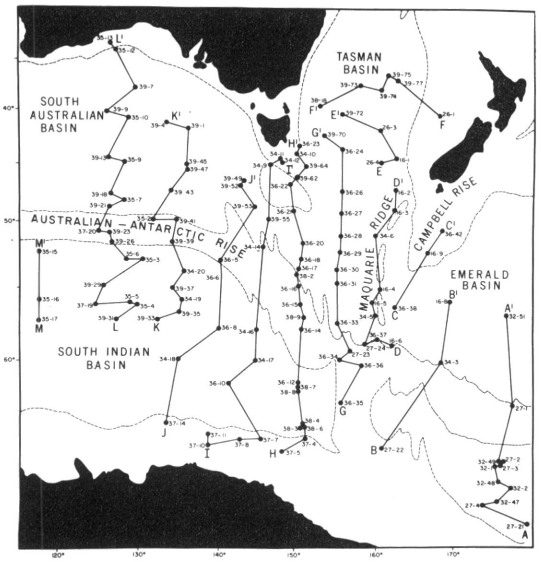

Figure 1. Locations of *Eltanin* deep-sea sedimentary cores between Australia, New Zealand, and Antarctica, Cruises 16 to 39. Traverses A–A' to M–M' are employed in the analyses of Watkins and Kennett (in press). Bathymetric contour is the approximate 2,000-m depth. Core numbers are next to each site: first number is cruise; second number is core.

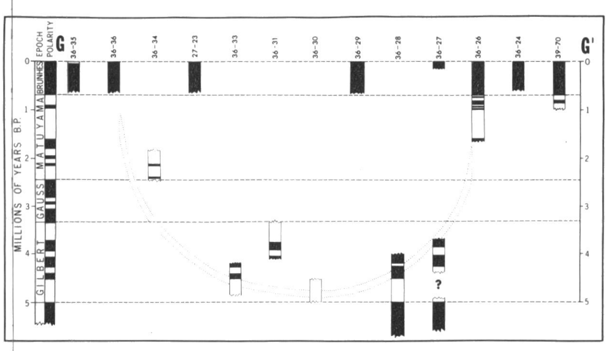

Figure 2. Assigned age ranges and paleomagnetic data for cores in traverse G–G' (from fig. 1). The cores are restricted to an approximate time range micropaleontologically, and by analysis of the paleomagnetic data are isolated into the time range shown. The known polarity time scale is shown at the left (black = normal polarity; clear = reversed polarity). Core numbers as in fig. 1. Concave dotted line is local average age of the sediment surface.

years. Realization of the intimate relation existing between bottom water velocity and sediment particle size in this region leads us to predict that during the early and mid-Tertiary, when Australia was much closer to the Antarctic Continent, the high water velocities required to accommodate the circumantarctic current between the major land masses must have created a unique sedimentary regime. It is highly probable that deep-sea drilling south of Australia will recover cores with dominantly coarse fractions and high manganese nodule content.

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Paleoglacial history of Antarctica recorded in deep-sea cores

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Micropaleontological and sedimentological studies have been carried out on 18 Early to Late Cenozoic deep-sea cores from the subantarctic Pacific sector of the southern oceans (Margolis and Kennett, 1970, 1971). The ages of the cores on either side of the southern portion of the East Pacific Rise and the Pacific-Antarctic Rise are consistent with the previous maximum ages predicted by crustal spreading for this region (fig. 1). Low planktonic foraminiferal diversity indicates a cool southern ocean throughout much of the Cenozoic. Furthermore, in those cores of Early and Middle Cenozoic age, ice-rafted quartz sand (fig. 2), as determined by scanning electron microscope studies, occurs in all cores older than Lower Miocene. Glacially derived, ice-rafted sands and relatively low diversity are associated with periodic, major cooling of the southern oceans during the Early Eocene, Late

Figure 1. Ages of subantarctic cores used in this investigation and relation to magnetic anomaly patterns of sea-floor crust. Deduced maximum ages for portions of the sea-floor crust are indicated by appropriate patterns on either side of the East Pacific and Pacific-Antarctic Ridges. Note relationship between core ages and crustal age.

Middle Eocene, and Oligocene. The extent of glaciation is still unknown, but it was sufficient to cause considerable ice-rafting of continental sediments to present-day subantarctic regions.

Increased species diversity, presence of reworked sand grains, and reduction or absence of typical ice-rafted sands in Lower and Middle Miocene cores indicate a warming trend that ended in the Late Miocene, after which a cooling trend commenced that led to Antarctica's Pleistocene glaciation. Glaciation on Antarctica appears to have prevailed throughout much of the Cenozoic, and changing glacial conditions must have played an important role in glacio-eustatic sea-level changes during this time. A means of differentiating ice-rafted sands from those of reworked origin has been established by studying sand grain surface feature variability with a scanning electron microscope.

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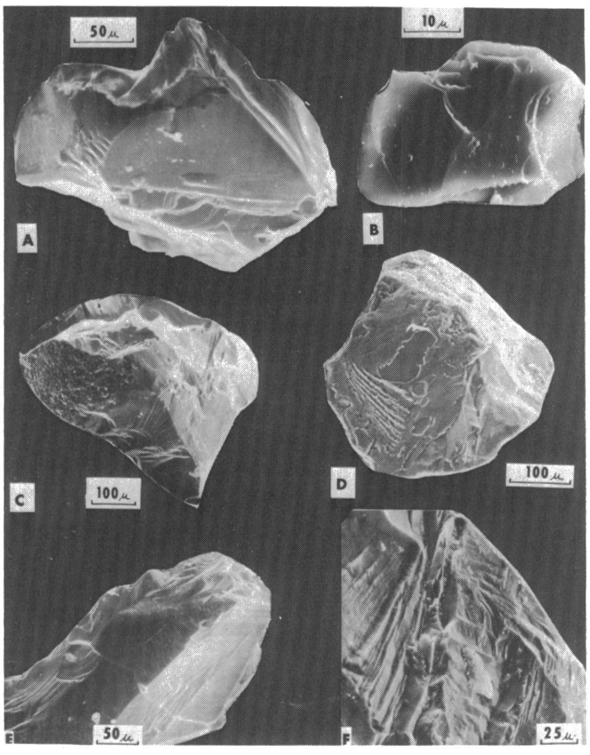

Figure 2. Quartz sand grains of glacial origin photographed by electron microscope. *A:* Grain from 1 m depth in core DWHG–34 (Lower Oligocene) has sharp angular outline, high relief, featureless surfaces (from fracture planes) in center, striations in upper right edge, large breakage blocks and step-like fractures on bottom edge, and oriented etch pits on left side. *B:* Experimentally produced simulated glacial grain (pseudoglacial) shows sharp outline, high relief, large-scale conchoidal fractures, smooth surfaces, and step-like fractures. *C:* Grain from dirt horizon in basal ice of Byrd Station deep drill hole, in addition to most features on grain *A* (3 m above bedrock) exhibits arc-shaped steps in the lower left edge. Finely pitted surface at left may be a remnant of the preglacial surface. *D:* Same sample from Byrd Station drill-hole shows clear example of semi-parallel striations on lower half of grain and thin discontinuous overgrowth which was probably formed prior to glaciation. *E:* Grain from 17 m depth in *Eltanin* core 13–4 (Lower Eocene) shows the following features: sharp outline, high relief, arc-shaped steps and semi-parallel step-like fractures at top and along right and left side of grain, and oriented etch pits on the central portion. *F:* Grain from 520 cm depth in *Eltanin* core 24–8 (Lower Eocene) shows large breakage blocks, semi-parallel step-like fractures, and high relief.