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Palaeontological Studies for CRP-2/2A

Introduction

Biostratigraphic and other results show that the 624 m of strata cored by the drill holes CRP-2 and 2A comprise Early Oligocene to Early Miocene strata overlain by *c*. 27 m of poorly consolidated Pliocene and Quaternary sediments. Eight papers in this section present amplified results of the biostratigraphic and paleoecological studies carried out at McMurdo Station during the 1998 drilling operation (Cape Roberts Science Team, 1999), and are the result of further laboratory studies on siliceous, calcareous and organic-walled microfossils, and faunal macrofossils undertaken during 1999. An ninth paper considers the palaeoecology and biogeography of ostracod faunas from both CRP-2/2A and the previous Cape Roberts Project drillhole, CRP-1, which was drilled in 1997 (Cape Roberts Science Team 1998; Hambrey & Wise, 1998).

Marine Ostracoda were previously recorded from CRP-1, but are more fully documented from this site and from CRP-2/2A drill-core for the first time in a paper by Dingle. In CRP-2/2A ostracods are sparse, with 8 taxa recovered only from early Miocene and late Oligocene strata. It is suggested that the late Oligocene fauna reflects cold, shelfal waters with temperatures at least as cold as the modern northern Antarctic Peninsula, and with faunal connections to the Antarctic Peninsula and South America. The early Miocene fauna is also of cold-water aspect and has Australasian affinities in addition. Richer ostracod faunas (24 species) were recovered from the biogenic carbonate-rich Quaternary strata of CRP-1 (LSU 2.2 and 3.1). These faunas suggest cold, quiet marine conditions similar to those of the present, at a water depth of *c*. 100-200 m.

Only one paper deals specifically with the post-Miocene section of CRP-2/2A. Webb & Strong examine in detail the benthic foraminiferal content of the 5.6 m thick Pliocene section (LSU 2.2). Initial diatom results from the upper part of this unit (Cape Roberts Science Team, 1999) suggested deposition no earlier than the latest Pliocene or earliest Pleistocene. Basal sands contain traces of Miocene diatoms, but are otherwise barren of biogenic material. Overlying diamicton and sand beds contain near *in situ* foraminiferal assemblages that are interpreted to be of Pliocene age, and have lived in a sea-floor environment influenced by hyposaline waters and nearby ice. An uppermost sand bed contains a sparse, possibly redeposited fauna. The overlying diamicton unit (LSU 2.1) is reported to contain abundant Pleistocene foraminifera. Apart from foraminifera and diatoms (described only in the Initial Report), fossils are extremely sparse in the post-Miocene section, and regarded as mainly or wholly redeposited.

Siliceous microfossils, principally planktic diatoms, proved to be the principal biostratigraphic tool for dating the Oligocene to Miocene section of CRP-2/2A. Based on the distribution of more than 100 diatom taxa, and documented by illustrations of key taxa and taxonomic notes, Scherer et al. present a biostratigraphic zonal framework consisting of ten diatom zones. Although Antarctic neritic forms dominate the assemblages, a number of diatom datums can be correlated to ODP drillholes in lower latitudes, enabling calibration with the magnetostratigraphical, geochronological and conventional geological timescales. These results are in good agreement with geochronological data from argon dating of volcanic materials and strontium dating of calcareous macrofossils, as well as nannofossil datums. In providing a tool for correlation of Antarctic continental shelf mid-Cenozoic strata, the zonation is an important advance. It is applied by the authors to correlation of CRP-2/2A with CIROS-1, with the implication that a considerable part of the Oligocene section present in CRP-2/2A is not represented by correlative strata in CIROS-1. The low relative abundance of benthic diatoms suggests water depths below the photic zone, although relatively high rates of sedimentation may also have suppressed the benthic flora. Intervals of high planktic diatom abundance correspond to finer-grained sedimentary facies, especially the "highstand systems tract" intervals of depositional sequences 19, 11, and 9, and are interpreted to indicate open water and high nutrient availability, as well

as relatively low rates of dilution by clastic sediment. In contrast, low abundances are related to ice cover and high sedimentation rates, and in some sections, notably between c. 412-292 mbsf, and below 565 mbsf, to destruction by diagenesis.

Calcareous nannofossils provide the only other significant biostratigraphic datums in the Oligocene to Miocene section of CRP-2/2A. Watkins & Villa describe very sparse assemblages which indicate that the area was occasionally influenced by oceanic surface waters during the late and late early Oligocene. The c. 449-474 mbsf interval is characterised by the latest Eocene to basal Oligocene form *Reticulofenestra oamaruensis*, redeposited from older sediments.

Foraminiferal assemblages from the Oligocene to Miocene section of CRP-2/2A are divided into four assemblage zones, or "Units", by Strong & Webb. The sparse to moderately abundant assemblages comprise 42 species, which are briefly described and illustrated; they consist exclusively of calcareous benthic forms, and no planktic or agglutinated taxa were observed. The units lack taxa allowing correlation to standard zonal schemes, and the absence of close similarity to the foraminiferal sequences of CIROS-1 and DSDP270 suggests that they most likely reflect local environmental changes. General low faunal diversity and abundance in CRP-2/2A is attributed to high deposition rates and high turbidity resulting from glacial influence. A deepening trend from the base of the section up to c. 194 mbsf, followed by an abrupt return to shallower water is suggested on the basis of diversity gradients and specific faunal preferences.

Intensive laboratory treatment of foraminiferal samples from two CRP-2/2A intervals enabled Galeotti et al. to recover slightly more diverse assemblages than were obtained at McMurdo by Strong and Webb. The upper interval, *c*. 122-140 mbsf , spans the Oligocene/ Miocene boundary interpreted from other data. Foraminifera recovered include rare planktic and agglutinated forms, but no taxa enabling close correlation with the global stratotypes were seen. A shallow-water (*c*. 50 m) and unstable seafloor paleoenvironment is suggested. The lower interval, *c*. 582-624 mbsf, provided a more impoverished assemblage regarded by the authors as intermediate in taxonomic composition between Assemblage C (late Eocene-early Oligocene) and Assemblage D (early Oligocene) of CIROS-1 drillhole. This lends support to the idea that the lower part of CRP-2/2A corresponds to a time interval not represented by strata in CIROS-1 core. Deeper-water (100-200 m) and more stable seafloor conditions are considered to have prevailed in this interval.

Marine palynomorphs were recovered in considerable abundance and diversity from throughout the Oligocene to Miocene section of CRP-2/2A, and include prasinophytes, acritarchs, and dinoflagellate cysts. Their stratigraphic distribution is documented by Hannah et al., although most taxa are considered to be previously undescribed and are so far named informally. Sixteen species of dinoflagellates are considered to be redeposited from Eocene to basal Oligocene strata. These are most abundant in the 122-128 mbsf and 437-480 mbsf intervals, the lower coinciding with the peak in redeposited calcareous nannofossils noted by Watkins & Villa. Dinoflagellate taxa also form the most diverse group (27 species) of taxa considered to be *in situ*. Three biozones, based on the ranges of selected taxa, correspond to the early Oligocene, late Oligocene, and late Oligocene/ early Miocene intervals. While the uppermost assemblage closely resembles that of the early Miocene in CRP-1, the Oligocene assemblages are the first significant ones of this age to be recovered from the Antarctic region and comprise a distinctly Antarctic flora, different from known Oligocene floras of lower latitudes. This limits their current utility for correlation outside the region. On the other hand, the limited stratigraphic range of many of the dinoflagellate taxa indicates considerable potential for precise correlation of inshore Antarctic sediments, if their distribution can be confirmed in other drillholes.

Macroscopic fossils of benthic marine invertebrates were recovered widely from the CRP-2/2A core, with only a few significantly barren intervals. Taviani et al. note that Mollusca are the dominant group, with a least 13 species of bivalves, 6 of gastropods, and one scaphopod species recognized; annelids (3 species of serpulid polychaetes) are also abundant, with scattered occurrences of Bryozoa, Cnidaria, Brachiopoda, Echinodermata, Porifera, and Vertebrata. Despite frequently poor preservation (due to various diagenetic effects), the Oligocene macrofauna is the most diverse so far recovered from East Antarctica, although many taxa are comparable to species previously recovered from coeval sediments drilled in the Ross Sea region. The early Miocene and late Oligocene assemblages are consistent with sub-polar conditions and normal sea-floor circulation, but those of the early Oligocene are suggestive of conditions significantly warmer than at the site at present, and a sea-floor with reduced oxygenation and high H_2S production.

The record of life on land is distorted and diminished by transport of its remains to a marine site of deposition. Askin & Raine suggest that the rarity of Cenozoic pollen and spores in the CRP-2/2A core results from sparse periglacial vegetation, as well as dilution from rapid sediment accumulation. The late Oligocene and early Miocene assemblage is similar to that seen already in the early Miocene of CRP-1, interpreted as derived from a mossy tundra with *Nothofagus* and podocarp shrubs. Early Oligocene assemblages are richer, and are thought to represent *Nothofagus*-podocarp woodland growing in cold but somewhat milder conditions. CRP-2 results highlight the long persistence of vegetation adapted to periglacial conditions, through the Oligocene and early Miocene, and perhaps until the Pliocene, as seen in the Sirius Group of the Transantarctic Mountains. New records of *Phormium* (New Zealand flax) and possible Ranunculaceae and Stylidiaceae pollen shed light on the biogeographic history of these now typically alpine and cool temperate plants. As well as noting that the restricted ranges of some taxa may be of value in dating Antarctic terrestrial deposits, the authors also mention redeposited Eocene taxa, and emphasise an abundance of redeposited Permian to Jurassic palynomorphs and coal derived from erosion of Ferrar and Beacon strata.

As noted above, siliceous microfossils and calcareous nannofossils have provided the key biostratigraphic datums for CRP-2/2A. However age information from other fossil groups is consistent with those results. The various fossil groups have also variously provided insights into factors such as land and sea temperatures, sea ice cover, salinity, turbidity, water depth bottom conditions, sediment provenance, and diagenesis. Although there are differences in emphasis, papers agree in ascribing cold temperate to subpolar conditions to the South Victoria Land coast throughout deposition of the Oligocene to early Miocene sequence of CRP-2/2A.The distinctive fauna and flora, in a large part, remains to be systematically described in further works.

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