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Sedimentary Environments for CRP-2/2A

Introduction

The CRP-2/2A drill hole reached a depth of 624 mbsf and cored strata of Quaternary to early Oligocene age. A wide range of studies have been undertaken to determine the nature of the depositional processes, the provenance of the sediments, and the palaeoclimates. The core records primarily marine sedimentation under a glacial regime that was subject to substantial oscillations. Sedimentary environments range from ice marginal/subglacial to outer shelf with minor iceberg influence.

Two papers in this section examine the sedimentary facies in the core, but from different perspectives. The first by Powell et al. develops conceptual models, based on an understanding of modern processes in glacimarine environments. These authors define 12 lithofacies that commonly occur in associations repeated throughout the core. Several 'depositional systems' are defined, including: outer shelf with minor iceberg influence, outer shelf-inner shelf-nearshore to shoreface under iceberg influence, deltaic or grounding-line fan, and ice proximal-ice marginal to subglacial. These interpretations are used to evaluate changing glacier proximity through time. Comparisons with the global eustatic sea-level and ^{18}O curves indicate reasonable matching, but with key divergences that need further investigation.

The second of these papers, by Fielding et al., also recognises the same 12 recurrent lithofacies, and interprets them in a similar way. These authors define a cyclical vertical arrangement of lithofacies, which is then used as a basis for sequence stratigraphic analysis. There are 24 sequences, each beginning with a sequence boundary or *Glacial Surface of Erosion*. Reinterpretation of the seismic reflection data indicates that the major reflectors match with the sequence boundaries defined by lithofacies variations. Tectonic controls, particularly active subsidence are also recognised in the core. Possible controls on cyclicity are considered, and this allows separation of tectonic from climatic signals.

Critical to understanding the ice sheet evolution in this region is establishing whether diamictites were formed subglacially as till or proglacially as glacimarine sediment. Using newly developed techniques of thin-section analysis, van der Meer has examined 26 samples for signs of deformation in the upper half of the core. Particular types of fabric and microstructure are characteristic of subglacially deformed and deposited till, and at least two (and possibly a further ten) are indicative of ice-grounding events. There is strong correlation between these samples and sequence stratigraphic boundaries.

Downhole logging to record changes in the physical properties of the core, information which bears on sedimentological changes induced by glacimarine processes, have been undertaken by Brink et al. They describe a suite of well logs recording the following parameters: density, resistivity, neutron, microresistivity, spectral gamma-ray logs, and magnetic susceptibility. Parallel measurements were made of lonestone abundance in the core. On the basis of these parameters, provenance changes can be identified, and eight log-based units defined. The authors interpret these provenance changes as indicative of glaciation intensity and relative sea-level changes. Highstand sedimentation (muds) represents erosion of highland Ferrar Dolerite, whereas lowstand sedimentation (diamictites) is associated with erosion of lowland Granite Harbour Intrusive rocks. These data can also be used to define sequence boundaries within CRP-2 independently of those defined on the basis of lithology.

Other indications of provenance come from analyses of bitumen and whole-rock elemental composition, as undertaken by Kettler and Papastavros. Overall, the core contains relatively little organic matter (average TOC = 0.28%). Values are higher for early Oligocene sediments than in younger rocks because they include significant amounts of coal detritus. TOC values are also highest in the fine-grained rocks deposited as part of highland system tracts, probably as a result of the presence of aquatic organic matter, as well as coal detritus. The bitumen in these sediments thus comes from two sources: autochthonous bitumen from aquatic organic matter, and allochthonous bitumen from deeper sedimentary rocks of the Beacon Supergroup.

As a further development of the sequence stratigraphy, Woolfe et al. examine the gravel-free, high-resolution particle-size data. Textural dislocations, which occur at most sequence boundaries, are taken to provide independent corroboration of these boundaries. They conclude that most of the diamictites were probably deposited from floating ice.

Grain-size data have been acquired for over 100 samples from CRP-2/2A by Barrett and Anderson, using sieving and Sedigraph techniques. These data, using well-established methods, provide a reference point with which to compare with the faster techniques described by Woolfe et al., and allow refinement of the lithofacies descriptions.

Claps et al. performed a high-frequency analysis of physical properties, *i.e.* low-field magnetic susceptibility and wet bulk density. Based on selected fine-grained intervals, they conclude that three main sets of periodicities are present, which are in tune with those associated with Milankovitch orbital perturbations. These periodicities allow a refinement of the sedimentation rates in the fine-grained intervals.

The carbonate content in CRP-2/2A has been studied by Dietrich et al. They demonstrate that carbonate content is low at most intervals. Only samples in the lower part of the core are marginally higher, with a peak of 12.9%. They infer (i) that carbonates are present in cemented clasts in the Quaternary and Pliocene part of the core, (ii) that cemented patches and horizons, as well as fossil fragments occur in Miocene and Upper Oligocene strata, and (iii) that below 320 mbsf cementation is more or less continuous.

Aghib et al. deal with the main diagenetic features of the Oligocene strata from the core. Authigenic low-Mg calcite is the most common precipitate throughout the core. Early stages of diagenesis appear to be represented by fringing cements, drusy cement with cavities, and as vein-infills, as well as by associated zeolites. Late-stage diagenesis is represented by blocky calcite crystals below 500 mbsf.

Finally, Passchier examines soft-sediment defomation and brecciation as recorded during logging procedures and in the core-scan. Structures range from soft-sediment folding, through micro-faulting, clastic dykes and shear zones to intraformational breccias, and are ascribed to hydrofracturing, subglacial shearing, slumping and gas-hydrate formation. These features have a stratigraphic distribution related to major unconformities and sequence boundaries.

From the sedimentological studies presented in this volume, a picture is emerging of primary marine sedimentation under the strong influence of glacial fluctuations. Sequence definitions established during logging are supported by the results of diverse analytical techniques. Sequence boundaries appear to be related to grounding events or ice marginal processes, while the preserved sediments relate to receding ice and ice-distal processes. Frequency-analysis points to the presence of cyclicity, both of a Milankovitch and a sub-Milankovitch origin. In general, most analyses do not seem to contradict each other, nor to support each other. Seemingly contradictory interpretations that deposition of diamictites was from floating ice, in contrast to van der Meer's evidence for grounded ice, are less problematic if we accept that the diamictites are largely reworked glacimarine deposits.

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