

Geophysics and Tectonic Studies for CRP-3

Introduction

Eight papers in this section present the results of investigations of both local and regional seismic context of CRP-3, downhole geothermal and petrophysical measurements and their geological implications, and patterns of subsidence, fracturing, tilting and stress inferred from core and logging data.

In the first paper in this section, Henrys et al. identify nine reflection events in the seismic reflection data across the CRP-3 drill site. They use whole-core velocity data to link CRP-3 depths to the seismic line across the site in two ways:

- i) a time-depth relation that permits conversion of seismic two-way times to depth, and
- ii) a synthetic seismogram and vertical seismic profiling data (VSP) permit identification of depths and causes of individual seismic reflectors.

In this way, Henrys et al. are able to correlate most of the seismic units at CRP-3 with core-based sequence boundaries.

Based on the physical properties and ages of the sedimentary units in CRP-2/2A and CRP-3, De Santis et al. de-compact the sedimentary units and compensate for thermal subsidence and isostatic loading to deduce the tectonic subsidence history for the Cape Roberts margin of the Victoria Land basin. A major change in subsidence rate, from about 230 m/m.y. below about 100 m beneath the seafloor (32.5 Ma) to 23 m/m.y. above, is derived.

Jarrard presents results of laboratory measurements of velocity, resistivity, bulk density, porosity and matrix density on core plugs from CRP-3 core. These are used for calibration of whole core and downhole logging data. Core plug and whole-core seismic velocity measurements show a very close agreement. The velocity-porosity relationship for CRP-3 core is similar to that for the lower part of CRP-2A and is consistent with data for sandstone. However, the sensitivity of velocity to pressure is higher than for the earlier drillcore, reaching up to 9% for the difference between in-situ velocities and those measured at atmospheric pressure; rebound or microcracks may be responsible for this difference.

Temperature and salinity measurements downhole are presented and discussed by Bückler et al., who determine an average thermal gradient of 28.5°C/km, significantly lower than other thermal gradient measurements in the region around the CRP drillsites. Repeat measurements allowed the opportunity to observe transient effects in temperature and salinity. Superimposed on this overall thermal gradient are negative temperature anomalies that are interpreted to be caused by inflow of cold fluid, probably drilling mud returning from permeable layers after drilling ceased. Thermal conductivity measurements on core were used to derive an average heat flow of 60 mW/m². Radiogenic heatflow is estimated, from logging results, to be less than 1% of the total heat flow.

Jarrard, Paulsen and Wilson examine the problem of orientation of the core, as there was no means of determining core orientation during the drilling. A borehole televiewer was used to log oriented images of the borehole wall, which were subsequently used with the digitally imaged outer surface of the cores to orient 25% of the core. Core sections were rotated to match the shapes of their adjoining surfaces and the gaps closed. Features such as fractures, bedding and clasts, were used to correlate the core to the borehole televiewer images and orient these sections of the core to an accuracy

of about 10° – 15° . These studies provide the constraints for deducing the bedding dips of the sequences by Jarrard, Bucker, Wilson and Paulsen, and the fault and fracture patterns by Wilson and Paulsen.

Bedding dips within CRP-3 are generally shallow and eastward and become steeper with depth, based on the seismic results of Henrys et al., the borehole televiwer analysis and the core and dipmeter results of Jarrard, Bucker, Wilson and Paulsen. The latter shows a downhole increase in structural dip, from about 10° – 15° above about 100 mbsf to 21° below this and in the Beacon strata cored below 823 mbsf. Local dip varies up to 20° in the Beacon strata due to Tertiary fracturing and brecciation. The change in dip at c. 100 mbsf corresponds closely in depth with the change in subsidence rates noted by De Santis et al. Dipmeter results for sedimentary section indicate an average downdip azimuth of $N65^{\circ}E$, closely matching that ($N71^{\circ}E$) for the base of seismic unit V4 based on the seismically determined dip direction (Henrys et al.).

Studies of fractures in core and in the borehole walls by Wilson and Paulsen show a remarkable similarity to the orientations of both onshore and onshore mapped faults. A north-northeast-striking normal displacement set is dominant, and indicates a north-northeast trending dominant maximum horizontal stress direction. Detailed analysis of the faults indicates an Oligocene age, inferred by the authors to be associated with the further development of the Transantarctic Mountains. Two large-scale brittle fracture zones in the core are inferred to have a normal displacement. Breakouts in the walls of the borehole are used to infer the present day minimum horizontal stress direction of east-northeast. This is not compatible with the oblique stress orientations derived from the natural fracture sets. These interpretations are complemented by the borehole televiwer results of Jarrard, Moos, Wilson and Bucker, which also indicate present day stress directions within CRP-3, and which they conclude is strike-slip. Drilling-induced fractures observed on the borehole televiwer log indicate that the minimum horizontal stress direction is now $N75^{\circ}E \pm 6^{\circ}$, similar to the direction of $N77^{\circ}E$ at the CRP-2A drillsite, and suggests that topography can be excluded as a possible control on local horizontal stresses.

Christian J. Bucker
Frederick J. Davey