

Geophysics and Physical Properties Studies for CRP-2/2A

Introduction

The ten papers in this section present the results of investigations of the regional seismic context of CRP-2/2A, petrophysical measurements and their geological implications, and patterns of fracturing and tilting.

The first two papers in this section extend the CRP-2/2A results into a three-dimensional regional seismic stratigraphic framework. Henrys et al. use whole-core velocity data to link CRP-2/2A depths to the seismic data across the site in two ways: the derivation of a time-depth relation from the measured seismic velocities permits conversion of seismic two-way times to depth, and the computation of a synthetic seismogram permits the correlation of geological units in the core with individual seismic reflectors. In this way, Henrys et al. are able to correlate most of the seismic units at CRP-2/2A with core-based sequence boundaries. Davey et al. correlate seismic events at CRP-2/2A with two previously derived regional seismic stratigraphies - V series and RSS series - based on multiple independent connections among seismic profiles. They demonstrate that two widespread seismic events, V3/V4 and V4/V5, intersect the CRP-2/2A drillhole at ~90 mbsf and ~440 mbsf, respectively. The V4/V5 event is thereby dated as 28-29 Ma, much younger than had previously been thought.

The relationships between geological variables and geophysical responses are examined at a variety of scales: core-plug measurements by Brink & Jarrard, whole-core measurements by Niessen et al., and well logs by Bückler, Wonik, & Jarrard and by Bückler, Jarrard, Wonik & Brink.

Brink & Jarrard use petrophysical measurements of core plugs to provide transforms for determination of porosity from well log and whole-core datasets. They find that cementation has affected many petrophysical responses within CRP-2. An effect of cementation on the velocity/porosity relationship is suggested by Brink & Jarrard and examined in detail by Niessen et al., who use whole-core measurements to demonstrate a systematic downhole increase in the velocity/porosity relationship associated with increasing cementation. Compared to cementation, the effect of grain size on the velocity/porosity relationship is relatively subtle, but detectable. Both cementation and mechanical compaction affect porosity/depth patterns at CRP-2. Niessen et al. and Brink & Jarrard find in independent datasets that sand and mud compaction patterns are similar at CRP-2. In contrast, diamicts are shown by Niessen et al. to be systematically lower in porosity than sands and muds. Brink & Jarrard use sand and mud compaction patterns to infer that the site has experienced 250 ± 150 m of exhumation.

Two papers in this section by Bückler et al. focus on well-log analysis; a related paper, by Brink et al., is in the Sedimentary and Post-depositional Environments section of this volume. Bückler, Wonik, and Jarrard analyze CRP-2/2A temperature logs and determine an average thermal gradient of $24^\circ\text{C}/\text{km}$; equilibrium thermal gradient may be slightly larger than that observed. Superimposed on this overall thermal gradient are temperature anomalies at 150 and 580 mbsf, indicative of cold water influxes. Bückler, Jarrard, Wonik, & Brink use factor analysis and cluster analysis to isolate covariant responses among the extensive suite of well logs from CRP-2/2A. They find that more than 80% of the variance within 11 well logs can be accounted for by three factors. These three factors are in turn related to three dominating geological processes: porosity, grain size, and source-rock provenance. Cluster analysis provides an objective means of subdividing the logged interval into electrofacies, based on similar log responses. Electrofacies, or clusters, corresponding to diamicts and provenance fluctuations are clearly delineated.

Evidence for the structural evolution of CRP-2/2A is provided both by the regional studies of Davey et al. and Henrys et al. and by several analyses of CRP-2/2A cores and logs. Moos et al. identify fracture patterns in the borehole televiewer log; Jarrard et al. determine bedding dips using core images and a dipmeter log; Wilson & Paulsen document the nature

and orientation of natural and induced fracture patterns in cores; and Paulsen et al. orient these fracture patterns using the borehole televiewer log.

Bedding dips within CRP-2/2A are generally shallow and eastward, based on the seismic results of Davey et al. and Henrys et al., the borehole televiewer analysis of Moos et al., and the core and dipmeter results of Jarrard et al.. The gradual downhole increase in structural dip, from 5° to 15°, is most clearly evident in the seismic profile across the site. Core and dipmeter results confirm this pattern, but both also show abundant local dip heterogeneity due to depositional and post-depositional processes. Dipmeter results for sands and muds indicate an average downdip azimuth of N75°E, closely matching that based on a seismically determined structure contour map. Downdip azimuths of diamicts are subtly different, possibly reflecting ESE glacial advance of ancient Mackay glaciers.

The borehole televiewer results of Moos et al. and the core analysis of Wilson & Paulsen indicate both present and former stress directions. Drilling-induced petal-centerline fractures are evident in both cores and the borehole televiewer log. The log, which is azimuthally oriented, demonstrates that these fractures have a strong preferred strike of N10°W, indicating that the contemporary maximum horizontal stress direction is N10°W, parallel to the trend of the Transantarctic Mountains. The current stress state is inferred to be normal to strike-slip and may indicate extension normal to the Transantarctic Mountains. The televiewer-based petal-centerline orientation is used by Paulsen et al. to provide azimuthal orientation for 39% of the CRP-2/2A cores, thereby also orienting other fractures mapped by Wilson & Paulsen within those cores. Wilson & Paulsen and Paulsen et al. conclude that veins and natural fractures, inferred to have been formed in the Oligocene, have a preferred strike of about N30°E, indicating a change in stress direction to the present. Both Paulsen et al. and Moos et al. observe abundant steeply dipping faults, but the dominant WNW core-based strike only approximately agrees with NNW strikes within the televiewer logs.

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