IODP Expedition 371: Tasman Frontier Subduction Initiation and Paleogene Climate

Site U1509 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1509 (34.65°S, 165.83°E, 2924 m water depth; proposed Site NCTS-2A) is ~640 km west of the northern tip of New Zealand, ~300 km south of DSDP Site 206, and ~200 km north of DSDP Site 592. The location is on the western margin of New Caledonia Trough at the base of the Lord Howe Rise slope, near the mouth of a canyon that drains around the end of a small submerged spur. This spur, inferred to have been created by deformation, is underlain by the northeast-dipping limb of a west-verging fold that exposes strata that can be traced beneath the axis of the New Caledonia Trough. Site U1509 was chosen to determine the timing of Cenozoic folding in the southern New Caledonia Trough, and to obtain stratigraphic constraints on the timing of vertical tectonic movements and volcanism.

Operations

Hole U1509A (34°39.1312'S, 165°49.6599'E, water depth 2913 m)

We arrived at Site U1509 at 1030 h on 2 September, completing the 273 nmi transit from Site U1508. Rotary core barrel (RCB) coring in Hole U1509A was initiated at 2145 h on 2 September. Coring continued until 2345 h on 6 September and reached 690.7 m (Core U1509A-74R). Total recovery in Hole U1509A was 462.86 m (67%).

Planned wireline logging in Hole U1509A was cancelled due to ship heave exceeding 3.0 m. Hole U1509A was ended at 1434 h, after a total of 127.5 h or 5.3 d. At 1630 h on 7 September the ship began a ~200 nmi transit to the north to avoid severe weather forecast for 9–10 September. This weather also impacted other remaining proposed drilling sites.

Principal Results

Lithostratigraphy

The sedimentary sequence at Site U1509 consists of ~415 m thick calcareous ooze, chalk, and limestone (Unit I), overlying ~275 m thick claystone (Unit II).

Lithostratigraphic Unit I is divided into three subunits. Subunit IA (0–99.6 m) consists of calcareous ooze and chalk with rare tuffaceous beds. RCB coring led to soupy and mousse-like drilling disturbances in the soft sediments of the upper ~50 m of this subunit, followed by biscuiting, horizontal cracking, fracturing, and pulverization in the more indurated lower sediment of the unit. The ooze to chalk transition was observed at ~55 m. Subunit IB (99.6–139.28 m) comprises calcareous chalk showing significant soft-sediment deformation (i.e., slumps). Subunit IC (139.28–414.57 m) consists of calcareous chalk and limestone with biosilica

and several silicified (chert) intervals. Subunit IC is characterized distinctively by tilted bedding (apparent dip ~20°). From Subunit IC downhole, preferential fracturing of cores was seen along primary deformation structures such as shear zones, microfaults, and tilted bedding. The chalk-to-limestone transition occurs within Subunit IC around 385 m.

Lithostratigraphic Unit II is divided into two subunits. Subunit IIA (414.57–614.2 m) consists of claystone with nannofossils and silt. Subunit IIB (614.2–689.68 m) consists of massive brown claystone with minor bioturbation and agglutinated benthic foraminifera. Similar to Subunit IC, tilted bedding is observed throughout Unit II.

Nannofossil and planktic foraminifera preservation and abundance generally decrease downhole, with these groups absent below 617.6 m and 536 m, respectively. Radiolaria are abundant and well preserved in the upper 393 m, but are rare and poorly preserved farther downhole. Benthic foraminifera abundance is low, and preservation decreases downhole in the upper 249 m, and remains poor below. Only agglutinated taxa are found in sediments below 617.6 m. Ostracods are common to rare with moderate to poor preservation in the upper 178 m, and are rare to barren below. A palynological reconnaissance study focused on Unit II recovered rich and well-preserved assemblages.

Nannofossil and foraminifera datums yielded Miocene (22.41–82.47 m), Oligocene (90.13–248.63 m), Eocene (259.98–407.07 m) and Paleocene (418.53–609.27 m) ages for the sequence at Hole U1509A. The interval 617.6 to 689.6 m is barren of age diagnostic nannofossils and planktic foraminifera taxa, but contains Late Cretaceous dinocysts and agglutinated benthic foraminifera.

The intensity of natural remanent magnetization of most sediment cores from Hole U1509A is weak, mostly around 10^{-4} A/m. This results in generally noisy paleomagnetic data from the pass-through magnetometer. However, stepwise alternating field (AF) demagnetization of some discrete samples gives reliable paleomagnetic data. Integrating these data with biostratigraphy, the observed magnetic polarities at 110 m to ~260 m are tentatively correlated to chrons C9 through C13 of the geomagnetic polarity timescale (GPTS2012). The claystone interval of Subunit IIB produces higher quality pass-through data compared to intervals above. Cores from Subunit IIB have a normal polarity.

Physical property measurements in Hole U1509A exhibit gradual changes in bulk density and *P*-wave velocity with depth, except across a layer of limestone between ~390 and 415 m. Through the ooze and chalk, above the limestone, *P*-wave velocity and bulk density increase with depth from 1500 to 1900 m/s and from 1.55 to 1.90 g/cm^3, respectively. The transition from ooze to chalk is shallow (~60 m) and correlates with a *P*-wave velocity increase of ~100 m/s. The limestone of Unit IC represents a discrete interval where *P*-wave velocity and density increase by ~40% and porosity decreases sharply. *P*-wave velocity, bulk density, and magnetic susceptibility are approximately constant in the Unit II claystone below the limestone. A gradual decrease in

porosity with depth is also observed. Natural gamma radiation values show high variance in Unit II (from 8 to 30 counts/s), reflecting changes in clay composition and abundance.

A total of 23 interstitial water (IW) samples were collected from Hole U1509A. Profiles of some species show trends similar to those at Site U1508. For example, sulfate concentrations decrease and ammonium concentrations increase downhole, suggesting sulfate reduction of particulate organic matter and release of nitrogen to pore waters. Furthermore, at ~370 m, sulfate concentrations drop below 1.0 mM and methane concentrations start to rise. This suggests further sulfate consumption by anaerobic oxidation of methane (AOM) at a deep sulfate methane transition (SMT). Reduction of sulfate leads to production of hydrogen sulfide, which reacts with iron to form pyrite, which is present in most cores from this hole. Below the SMT, methane concentrations rise to 15,000 ppmv and dissolved Ba concentrations increase to 0.4 mM. Such values are common to slope environments of many continental margins.

Bulk sediment chemistry corresponds with lithostratigraphic units. Unit I is characterized by carbonate contents that decrease downhole from ~94% at 20 m to ~65% between 360 and 380 m. Carbonate content varies little in the uppermost 200 m, and by more than 10% in the lower part. Carbonate content drops drastically across the transition from Unit I to II (415 m), to average values of 18% and 0.5% in Subunits IIA and IIB, respectively. Organic carbon contents are ~0.3% in Unit I and Subunit IIA and ~1.0% in upper Cretaceous Subunit IIB.