IODP Expedition 369: Australia Cretaceous Climate and Tectonics

Week 6 Report (29 October–4 November 2017)

Week 6 consisted of coring and logging operations in Hole U1513D, the transit to Site U1514 (proposed Site MBAS-8D) in the Mentelle Basin, and coring operations in Holes U1514A and U1514B.

Operations

We started Week 6 waiting for the weather to calm in order to resume coring; we experienced swells reaching 9 m. At 1200 h on 29 October, a center bit was dropped, and we lowered the drill string from 139.4 m (where it had hung during the bad weather) to 466 m where we encountered resistance. We washed down past the obstruction as well as another one at 495 m. High viscosity mud was circulated at 495 m to clear the hole of any infill/cuttings. The pipe reached the bottom of the hole (603.8 m) at 2215 h and there was no indication of material at the bottom. A final high viscosity mud sweep was conducted and the center bit was retrieved at midnight. Rotary core barrel (RCB) coring recommenced with Core 57R. Cores 58R to 65R were recovered to 690.2 m. Then, while cutting Core 66R, a hard contact was felt at 692 m, which was the sediment/basalt interface. We recovered Cores 66R through 75R to 757.4 m, all of which contained basalt, by 1700 h on 31 October. This completed coring in Hole U1513D. In total, we recovered 437.05 m material of 662.4 m cored (66%). For the basalt sections, we recovered 54.94 m of material from 67.2 m cored (86%).

After coring was completed, the hole was swept twice with high viscosity mud to clear cuttings and displaced with heavy mud. The RCB bit was then dropped at the bottom of the hole. The drill string was brought up to logging depth (146.3 m) at 0015 h on 1 November. The modified triple combination tool string was assembled with the Hostile Environment Natural Gamma Ray Sonde (HNGS), High-Resolution Laterolog Array (HRLA), Dipole Sonic Imager (DSI), Hostile Environment Litho-Density Sonde (HLDS) (with source), Enhanced Digital Telemetry Cartridge (EDTC), logging equipment head-q tension (model QT) (LEHQT), and the magnetic susceptibility sonde (MSS). The tool string was deployed at 0200 h on 1 November. The tool string encountered an obstruction at 346 m. After several unsuccessful attempts were made to move past the obstruction, we logged up from depth and recovered the tool string. We replaced the MSS with the hole-finder tool. It was deployed again at 0955 h, but encountered another obstruction at 337 m. At this point, logging was terminated, and the tool string was back on the rig floor at 1405 h and disassembled at 1545 h. The drill string was then pulled out of the hole, clearing the seafloor at 1637 h. The drill string was brought up to the rig floor at 0130 h on 2 November, which ended Hole U1513D and Site U1513. While bringing the drill string back up to the rig floor, several attempts were made to release the acoustic positioning beacon. The

beacon responded, recognizing the command to release, but the release mechanism malfunctioned. As a result, the beacon was abandoned. The thrusters were raised and the transit to Site U1514 (proposed Site MBAS-8D) began at 0142 h on 2 November. Overall, 14.4 d (18 October to 2 November) were spent at Site U1513.

After a 51 nmi transit at an average speed of 8.1 kt (6.25 h), the ship arrived at Site U1514. We lowered the thrusters and engaged the dynamic positioning at 0800 h on 2 November. The acoustic positioning beacon was deployed at 0830 h while we assembled the advanced piston corer (APC)/extended core barrel (XCB) bottom-hole assembly. We lowered the drill string to the seafloor and started Hole U1514A at 2220 h. The mudline core (1H) recovered 8.15 m of material and established the seafloor at 3838.2 mbsl. We recovered Cores 2H to 19H to 178.1 m. Successful in situ formation temperature measurements with the advanced piston corer temperature tool (APCT-3) were recorded on Cores 4H, 6H, and 8H. Core 19H recorded a partial stroke, indicating APC refusal. Coring switched to the half-length APC (HLAPC) and we recovered Cores 20F through 24F to 202.1 m, at which depth piston coring refusal was reached. Coring then switched to the XCB system and we recovered Cores 25X to 31X to 255.6 m. When cutting Core 31X, our rate of penetration slowed to less than 5 m/h with pump pressure at 2950 psi; thus, we decided to stop coring with the XCB. The drill string was pulled up, clearing the seafloor and ending Hole U1514A at 2015 h on 4 November. In total, we cored 255.6 m and recovered 255.2 m (99.8%). We recovered 185.96 m from 178.1 m cored (104%) with the APC, 24.88 m from 24.0 m cored (104%) with the HLAPC, and 44.36 m of 53.5 m cored (83%) with the XCB system. We spent 2.5 d at Hole U1514A.

The ship was offset 20 m east and Hole U1514B was started at 2200 h on 4 November. Only two APC cores were recovered (Cores 1H and 2H) to 15.1 m. The cores were sectioned into 30 cm whole rounds on the catwalk and immediately placed in opaque bags. They will be analyzed postexpedition for optically stimulated luminescence (OSL). Hole U1514B recovered 15.43 m of 15.1 m cored (102%). The drill string was pulled clear of the seafloor at 2355 h. As of midnight on 4 November, we had started bringing the drill string back to the rig floor to switch to RCB coring operations.

Science Results

The science party activities for the week included the completion of analyses of Hole U1513D, the finalization of the Site U1513 reports, and initial analyses of Hole U1514A.

Hole U1513D

The core description group finished describing the lithology of material from Hole U1513D (Cores 53X to 75R; 565.4 to 755.4 m CSF-A). Once all of the cores were described, the remaining lithostratigraphic units of Site U1513 were defined. In total, recovered sediments and

igneous rocks are divided into six lithostratigraphic units (Unit I through Unit V, and igneous Unit 1) based on macroscopic core description, microscopic examination with smear slides and thin sections, and X-ray diffraction (XRD)/X-ray fluorescence (XRF) analyses. The sediments recovered during Week 6 exclusively belonged to lithostratigraphic Unit V and the igneous rocks recovered constitute Unit 1. Unit V consists of sandstone interbedded with siltstones and claystones that rest unconformably on the basalt sequence of Unit 1. The sandstone is classified as volcanic-rich sandstone (with lithics/clasts/feldspars), lithic sandstone, and glauconitic sandstone in thin sections. Unit 1 consists of four basalt flow sequences intercalated with three volcaniclastic breccia beds and will be further subdivided into discrete flow units.

The Micropaleontology team analyzed the core catchers from Cores 57R through 75R. The core catcher samples became progressively more difficult to process as the material became more lithified and they were mostly barren of all microfossils. The last microfossil (planktonic foraminifer) was identified in Core 40R (~440 m CSF-A) and indicated a maximum age of 112.96 Ma in the early Albian.

Natural remanent magnetization of archive-half sections of Cores 55R through 75R was measured. These sections were subjected to stepwise alternating field (AF) demagnetization up to 30 mT. In addition, a total of 98 discrete samples from Site U1513 were subjected to detailed stepwise AF demagnetization up to 60 mT or 80 mT to aid in discerning magnetic polarities. The measured sections display stable magnetization components, which allows for determination of magnetic polarity. A magnetic polarity sequence was defined below ~450 m, and the magnetic polarity sequence between 450 m and 690 m is tentatively assigned to Chrons M0r to M10N, which corresponds to the time interval from the late Valanginian to the early Aptian. A normal and a reversed polarity chron were identified in the basal basalt unit from ~690 m to 760 m CSF-A. These two polarity chrons cannot be assigned to the geomagnetic polarity timescale because of the lack of numerical age constraints.

An additional 18 samples from Hole U1514D were analyzed for interstitial gas, for routine safety monitoring; all contained only trace amounts of methane. Sixteen additional interstitial water (IW) samples from Hole U1513D (Cores 49R to 65R) were recovered. Salinity and pH have been measured on all IW samples; alkalinity was only analyzed when sufficient IW (~10 mL) could be retrieved. Alkalinity values are very low (<1 mM). IW analyses for Site U1513 were completed by successfully using the new Agilent inductively coupled plasma–atomic emission spectrometer (ICP-AES) to analyze 12 major and minor elements. The dissolved magnesium, potassium, and sodium concentration profiles reflect alteration of volcanic material found in lithostratigraphic Units IV and V. No evidence for significant sulfate reduction was detected; sulfate is present throughout the hole, and barium concentrations are correspondingly low. The dissolved calcium and strontium concentration profiles primarily reflect the release of these elements during the alteration reactions of volcanic material. Lithium appears to have been released in Unit IV, then is incorporated into alteration products in Unit V. The Geochemistry team also completed analyses of all remaining discrete samples on the coulometer and elemental

analyzer, as well as 28 samples on the source rock analyzer. Total organic carbon (TOC) content was generally low (<1.5%), except in the black layers near the Cenomanian/Turonian boundary, which contained up to 10.5% TOC. Source rock analysis indicates a predominantly marine source for the organic matter in the black layers.

The Petrophysics group completed data acquisition from Cores 57R through 75R. Hole U1513D measurements were obtained mainly from the sandstone lithology that contains volcanic clasts (Unit V) and the basalt unit (Unit 1). Natural gamma radiation (NGR) values remained around 10 counts/s in the sandstone, while magnetic susceptibility (MS) was high (~1000 IU). Bulk density also showed increased values compared to the overlying lithologic units, with values around 2 g/cm^3. A distinct peak in NGR values occurs in the basal part of Unit V. It is related to uranium concentration enrichment (up to 6 ppm). This enrichment could be due to the presence of terrestrial organic material, as seen in smear slides. In the basalts (Cores 66R to 75R), the NGR values remained low, while the MS and bulk density values showed a sharp increase. Discrete samples were collected from Hole U1513D to determine moisture and density (MAD) and *P*-wave velocities through the core. The MAD measurements showed that porosity decreases with depth to a mean value of ~50%, while *P*-wave velocities gently increased to a mean value of ~2000 m/s. Three samples showed a sharp decrease in the porosity values at ~550, ~610 and ~650 m CSF-A. The samples at ~550 and ~650 m CSF-A are accompanied by higher values of *P*-wave velocities up to 3000 m/s. The thermal conductivity values in Unit V are nearly constant at around 1.2 W/(m·K). The top of the basalts is marked by a decrease in porosity to 20%–30%, an increase in the *P*-wave velocities to 5000 m/s, and an increase in thermal conductivity to 1.6 W/(m·K).

Downhole logging was attempted after coring in Hole U1513D. However, an obstruction prevented the collection of logging data deeper than ~300 m. The logs that were obtained are most reliable for a ~100 m thick section between ~150 and ~250 m WMSF. Wireline logs from deeper and shallower sections have lower quality due to the caliper failing to make contact with the borehole wall, preventing the tool string from centralizing. However, the interval of good coverage (~150–250 m WMSF) yielded similar downhole data to that obtained in Hole U1513A, which provided a more continuous signal and is a more reliable source of data.

Coring in Hole U1513D continued to a total depth of almost 760 m. The splice of the Cenomanian/Turonian interval (234.0 to 271.6 m CSF-A in Hole U1513A, and 229.4 to 271.8 m CSF-A in Hole U1513D) was refined using tie points drawn principally from NGR measurements, Section Half Imaging Logger-based reflectance data, and lithological features in high resolution core photos. These correlations suggest 97% coverage of the section despite only 54% average recovery (44% in Hole U1513A and 66% in Hole U1513D). The accuracy of the splice is supported by the presence of matching features in NGR records from the cores and wireline logs. Below the splice, recovery was very good to excellent. It averaged 68% across 180 m of clay- and sandstone dated biostratigraphically as early Cenomanian to middle Albian, 75% from 290 m of sandstones tentatively dated using magnetostratigraphy as Aptian to

Valanginian, and 82% for 70 m of basalt and basaltic breccia whose age is predicted to most likely be either 120–122 Ma or ~132 Ma based on the regional geology. The good core recovery in general and age control downhole allowed for the completion of an age-depth plot that does not indicate any large unconformities or hiatuses across the cored intervals.

Hole U1514A

The Core Description team described all of the material recovered so far from Hole U1514A (Cores 1H to 31X, 0 to 253.82 m CSF-A). Sediments recovered from Hole U1514A are currently divided into two lithostratigraphic units (Unit I and Unit II). Unit I is a 90.14 m thick sequence of Pleistocene to late Eocene nannofossil ooze that gradationally transitions into nannofossil rich clay. Clay content in this unit notably increases from Section 10H-5 (84.1 m CSF-A). This unit has medium and thick beds that are massive and structureless with rare bioturburbated intervals. The color progressively changes downhole from very pale brown and pale yellow in the upper interval to light yellowish brown and pale yellow in the lower interval. In smear slides, biogenic grains reveal that dominant nannofossils, abundant sponge spicules, and rare to common foraminifera are the major constituents of this unit. Lithostratigraphic Unit I is further subdivided into Subunits IA (nannofossil ooze) and IB (sponge spicule-rich nannofossil ooze) based on the relative abundance of biosiliceous and calcareous components. Unit II is characterized by increased content of clay minerals with very thick light greenish gray sponge spicule-rich clay. Disseminated brown to black ferromanganese oxides are present throughout the upper parts of Unit II. There is a gradual transition into a more lithified clayey nannofossil chalk by Core 22F, which is the dominant lithology throughout the rest of the described material.

Core catcher samples were analyzed from Hole U1514A. The age model for the hole, based on calcareous nannofossil and planktonic foraminifera, spans a seemingly continuous (at least within the resolution of current sampling) Pleistocene through late Eocene sequence. Benthic foraminiferal assemblages are restricted and indicate lower bathyal paleowater depths throughout the recovered interval. Notably the middle Eocene (Cores 14F to 26X, 122.1–217.35 m CSF-A) is expanded in contrast to the Oligocene (Cores 6H and 7H, 46.1–65.49 m CSF-A).

Thus far, 19 samples from Site U1514 have been analyzed for interstitial gas, although only trace amounts of methane were detected. Twenty-two IW samples from Hole U1514A (Cores 1H to 21F) have been taken for IW analysis. Sufficient IW volumes were squeezed from all Hole U1514A cores, which will allow for the full suite of analyses to be completed. Alkalinity rose to maximum values of 7.2 mM by ~190 m CSF-A, and salinity remains at values slightly higher than seawater. Further IW analyses (IC and ICP-AES) and bulk sediment geochemical analyses ($CaCO_3$, TOC) are pending.

Petrophysical data from Hole U1514A have been collected from Cores 1H–31X (top to bottom of the hole). The NGR values showed a rapid decrease within Core 1H, caused by a decrease in uranium content. In Section 4H-3, the bulk density values decreased from 1.5 to <1.4 g/cm^3. This sharp decrease was accompanied by a decrease in the thermal conductivity values from

~1.1 W/(m·K) to ~0.9 W/(m·K) and also coincided with changes in the color of the sediment (pale brown to pale yellow). Generally, from Cores 1H through 18H, the bulk density and thermal conductivity seem to covary. A second jump in physical property data appeared within Section 11H-2; the MS values sharply decreased from 25 IU to 5 IU, while *P*-wave velocities showed much higher variability. The NGR values also reached their maximum at 30 counts/s. Once again, this change coincided with a sediment color change (pale yellow to greenish gray). At the top of Core 12H (103.1 m CSF-A), MS and NGR values strongly decreased, and deeper than Core 12H, the MS and NGR signals display an obviously cyclical pattern with a thickness of ~40 cm that may reflect changes in the sediment color.

Hole U1514A was cored with the APC/HLAPC and XCB systems. Recovery was >100% in all cores to 202.1 m which indicates fairly complete coverage over this part of the geological record (Pleistocene to middle Eocene), although suck-in disturbance is present in Cores 12H, 13H, and 24F. Below ~200 m when we switched to the XCB system, four primary targets for correlation are present in the interval from 215 to 237 m CSF-A, and their characteristics will be used to decide at what depth to begin RCB coring in Hole U1514C.

Education and Outreach

We conducted six live interactive events this past week with schools and universities in the United Kingdom, USA, Korea, and Brazil. These broadcasts reached approximately 150 students.

On social media, there were eight new posts to Facebook (https://www.facebook.com/joidesresolution; total of 553 likes/comments and shares), 16 new posts on Twitter (https://twitter.com/TheJR; 148 total likes and 92 retweets), nine posts on Instagram (http://instagram.com/joides_resolution; 476 total likes and 9 new followers for 818 total followers), and four new blogs for the *JOIDES Resolution* (JR) website (http://joidesresolution.org). Additional media coverage included a guest blog post by one of the Education Officers on Exhibitricks, which had 20,000 hits last month, and a guest blog post by one of the scientists for the Geological Society of London, which included social media coverage from the Society.

Individual projects included the development of fabric designs, beginning three articles that will be published as features by *Smithsonian* magazine, finishing and posting the first podcast about the JR in Portuguese, finalizing a partnership with the Brazilian Newspaper SBPC, as well as filming and interviewing scientists.

Technical Support and HSE Activities

Activities of the technical team mainly revolved around supporting the science party and laboratories while coring and assisting with core handling afterwards. Specific activities included the following.

Site U1513

- Finished core processing in Hole U1513D; a hard rock sample party for the recovered basalts will be conducted on board in the near future.
- Limited logging was completed in Hole U1514D; the marine mammal/sea bird watch for the seismic experiment was not necessary.

Site U1514

- Two APC cores from Hole U1514B (15.43 m of material; the entire hole) were sectioned in 30 cm whole rounds on the catwalk and placed immediately in opaque bags for storage and transport.

Laboratory Activities

- We discovered an issue with the thin section (TS) image file-naming convention. The capture software (ImageCapture) retains the interval information from close-up images and applies this to the TS images. This problem was fixed and we were able to identify all the affected files and correct them (both on the ASMAN file server and the ship reports [LORE]).
- Deployed new reports (LORE) for Kappabridge measurements in the Paleomagnetism Laboratory.
- Continued work to develop a new application for the Cahn Balance in the Chemistry Laboratory.
- Continued work to modify the application for the coulometer in the Chemistry Laboratory.

I.T. Activities

- Provided general help desk support for staff and science party.
- Finished setting up RigWatch on the new Offshore Installation Manager's PC.
- Identified an issue with files from Expedition 369 being uploaded to a different expedition's folder. This was corrected for future uploads, and any others will be fixed on shore.

Miscellaneous

- The assistant laboratory officers handled logistics for upcoming bulk shipments and inventory.
- We discovered that a case of small-sized Kimwipes (LS0193) had been left out of the shipment for this expedition, despite shipping papers being present.

HSE Activities

- Safety showers and eye wash stations were tested.
- The weekly boat drill was held on 31 October.