**IODP Expedition 369: Australia Cretaceous Climate and Tectonics**

**Week 8 Report (12–18 November 2017)**

Week 8 consisted of coring operations in Hole U1515A, the transit to Site U1516 (proposed Site MBAS-10C), and coring operations in Holes U1516A, U1516B, and U1516C.

## Operations

Week 8 began with the recovery of Core U1515A-41R. Conditions in Hole U1515A were generally poor and core recovery overall was low as a result of intermittent chert layers and unconsolidated sand. Coring continued through Core 55R to a total depth of 517.1 m at 0400 h on 13 November. In total, 93.62 m was recovered from 517.1 m cored (18%). Cores 3R, 16R to 21R, 25R, 27R to 28R, and 51R to 52R had no recovery. Logging was not attempted. The drill string was brought back up to the rig floor by 1350 h, officially ending Hole U1515A and Site U1515. We then prepared to get underway to Site U1516. After multiple attempts to release the acoustic positioning beacon, it was abandoned. Similar to Site U1513, the beacon recognized the command to release, but the release mechanism malfunctioned. We began our transit at 1354 h on 13 November. The total time spent at Site U1515 was 3.6 d.

After a 100 nmi transit lasting 11.9 h, we arrived at Site U1516 at 0148 h on 14 November. We prepared to core with the advanced piston corer (APC)/extended core barrel (XCB) system and started Hole U1516A at 1220 h on 14 November. All APC cores were oriented. The mudline core (Core 1H) recovered 4.68 m, which indicated a water depth of 2676.5 m. We then recovered Cores 2H to 20H to 181.3 m, at which point APC refusal was reached. Successful in situ formation temperature measurements were taken while coring 3H, 5H, 7H, and 17H. We switched to coring with the half-length APC (HLAPC) and recovered Cores 21F through Core 29F to 223.6 m. At this depth, piston coring refusal was reached and Hole U1516A ended at 1725 h on 15 November. We recovered 189.76 m from 181.3 m cored (105%) with the APC and 43.55 m recovered from 42.3 m cored (103%) with the HLAPC. In total, we spent 1.7 d at Hole U1516A.

The ship was offset 20 m east and Hole U1516B was started at 1905 h on 15 November. Two APC cores were recovered (1H and 2H) to 16.2 m (104% core recovery). The cores were immediately cut into 30 cm whole rounds on the catwalk and placed in opaque bags; they will be analyzed for optically stimulated luminescence postexpedition. Hole U1516B ended at 0345 h on 16 November, with 10.33 h spent here.

The drill string was brought back up to the rig floor and the ship was offset 20 m south. We then prepared for rotary core barrel (RCB) coring in Hole U1516C, which was started at 1240 h on 16 November. We drilled without coring to 196 m, removed the center bit, and began coring. We

recovered Cores 2R through 41R to 541.6 m, the final depth of the hole, at 1715 h on 18 November. Overall, 208.32 m was recovered from 345.6 m cored (60%). The drill string was brought up out of the hole, clearing the seafloor at 1950 h on 18 November and ending Hole U1516C. In total, 2.7 d were spent at Hole U1516C.

The vessel was offset 20 m west and Hole U1516D was started at 2115 h on 18 November. By the end of the week, we had drilled without coring to 123 m. The target for this hole is to recover another copy of the Cenomanian/Turonian boundary (~460 m).

**Science Results**

The science party activities for the week included the completion of analyses of Hole U1515A, the finalization of the Site U1515 reports, and initial analyses of Site U1516.

*Hole U1515A*

Sediment recovered from Hole U1515A is divided into two main lithostratigraphic units (Units I and II), which are further divided into five subunits. Unit I (Cores U1515A-1R to 15R, 0–128.84 m CSF-A) is a sequence of calcareous ooze/chalk with sponge spicules, silicified limestone, bioclastic limestone, chert, sandy limestone, and sandstone that is Pleistocene–Upper Campanian in age. Unit I is subdivided into Subunits IA and IB at 67.83 m CSF-A. Subunit IB, Miocene–Upper Campanian in age, differs from IA in that it is more lithified and commonly contains chert beds. Due to poor recovery in this interval, the contact between Units I and II was not recovered. Unit II (Cores U1515A-24R to 55R, 209.90–512.98 m CSF-A) is a sequence of gray to black silty sand and glauconitic sandstones/silty sandstones and black claystone. Unit II is subdivided into Subunits IIA (Cores U1515A-24R to 36R, 209.90–325.18 m CSF-A), IIB (Cores U1515A-37R to 41R, 334.70–375.87 m CSF-A) and IIC (Cores U1515A-44R to 55R, 402.00–512.98 m CSF-A). Subunit IIA is characterized by abundant glauconite whereas Subunit IIB contains more abundant pyrite nodules. Subunit IIC is a sequence of silty sandstone with black claystone rich in coal and plant debris, which are characteristic components.

The micropaleontology team analyzed core catchers from Cores U1515A-16R to 48R, all of which were barren of calcareous microfossils. Core 15R, the last in which calcareous plankton age control was available, is Campanian in age. Paleontological sampling was halted after Core 48R and no further core catcher samples were taken.

The natural remanent magnetization (NRM) of archive-half sections of Cores U1515A-40R through 55R and 19 discrete samples collected from the working halves was determined. The archive halves were stepwise treated with up to 20 mT for alternating field (AF) demagnetization and measured with the pass-through superconducting rock magnetometer (SRM) at 5 cm intervals. Discrete samples were progressively demagnetized up to 60 mT and measured with the SRM. Although the magnetic record is noisy and the core recovery poor, intervals of

predominantly normal and reversed polarity can be discerned in the measured section. However, a correlation to the geomagnetic polarity timescale is not possible below 19 m CSF-A mainly because of the poor core recovery and the lack of biostratigraphic age control.

All geochemical sampling and measurements for Hole U1515A were completed. There was no gas present in any of the headspace samples. Both ion chromatography (IC) and inductively coupled plasma–atomic emission spectrometry (ICP-AES) analyses of interstitial water (IW) samples were performed, but poor core recovery resulted in limited data, and therefore limits conclusions about processes affecting IW composition. Several organic carbon-rich layers were recognized (coal) and total organic carbon (TOC) reached 25%–50%. Source rock analysis of 14 samples indicates a predominantly terrestrial source for the kerogen.

The Petrophysics group continued the data acquisition of material recovered from Hole U1515A (Cores 41R to 55R). Bulk density, *P*-wave velocity, and thermal conductivity rapidly increase from 364 to 373 m CSF-A, while the porosity decreases. This change in the physical properties marks the Valanginian unconformity and supports interpretations of seismic reflection profiles. Below this boundary, the RGB and L* signals increase slightly, while magnetic susceptibility (MS) and natural gamma ray (NGR) values remain stable on average.

*Site U1516 (Holes U1516A and U1516C)*

Sediments recovered from Holes U1516A and U1516C are divided into four main lithostratigraphic units. Unit I (Cores U1516A-1H to 29F, 0–223.72 m CSF-A; U1516C-2R to 26R, 0–431.56 m CSF-A) spans the Pleistocene–Eocene and consists of white, light greenish gray, pinkish white, and pinkish gray calcareous ooze with sponge spicules, and sponge spicule-rich calcareous chalk. Unit I is split into two subunits, with Subunit IA characterized by calcareous ooze and Subunit IB characterized by calcareous chalk. The Unit I/Unit II contact coincides with an unconformity between the Eocene and Turonian in Core U1516C-26R (431.53 m CSF-A). Unit II spans the Turonian (Sections U1516A-26R-4 to 31R-4, 431.53–469.85 m CSF-A) and consists of mottled light grayish green calcareous chalk and claystone. This interval is distinctive in that it contains regularly occurring 10–20 cm intervals that are a slightly darker greenish gray, which are similar to those observed at Site U1513. The bottom of Unit II is placed at the Cenomanian/Turonian Boundary, which is a sharp contact between the overlying Turonian grayish green chalks and black laminated claystone (U1516C-31R-4, 119 cm; 469.85 m CSF-A). The top of Unit III is Cenomanian in age and is characterized by interbedded light greenish gray to greenish gray clayey nannofossil chalk and black claystone. This sequence gradually transitions to a lighter alternating sequence between light grayish green and grayish green calcareous chalk that are mottled from bioturbation. Unit IV ranges from the Cenomanian to the Albian and is characterized by massive to mottled black and dark greenish gray claystone and nannofossil-rich claystone (Section U1516C-34R-4, 24 cm to 41R-CC, 483.34–540.10 m CSF-A).

The Micropaleontology team analyzed all of the core catchers and, where necessary, samples from split core sections. An integrated calcareous nannofossil and planktonic foraminiferal age model is available for both holes. Hole U1516A spans the Pleistocene through middle Eocene, and Hole U1516C spans the middle Eocene through Albian. The intervals spanning ocean anoxic events (OAE) 2 and 1d are in Cores U1516C-31R to 32R and U1516C-39R to 40R, respectively. The mid-Cenomanian event likely falls in Cores U1516C-33R to 34R. Benthic foraminifera indicate bathyal paleowater depths throughout.

All archive-half sections of Hole U1516A and Cores U1516C-1R through 37R were stepwise treated with up to 20 mT for AF demagnetization and measured with the SRM at 5 cm intervals. The results show that inclinations after the 20 mT demagnetization step exhibit intervals dominated by positive and negative inclination values, defining a magnetic polarity sequence from Chron C1n (Brunhes Chron) to C34n, the long Cretaceous Normal Superchron, with at least one major hiatus present. Currently, paleomagnetic measurements of Cores U1516C-38R through 41R are in progress.

Geochemical sampling of Holes U1516A and U1516C was completed. There was no gas present in any of the headspace samples. IW samples were collected from Cores U1516A-1H to 29F, and starting at 224.8 m CSF-A (Core 5R) in Hole U1516C to the bottom (Core 41R, 537.76 m CSF-A). Salinity was measured in all IW samples; alkalinity and pH were only analyzed when sufficient IW (~10 mL) could be retrieved and is generally restricted to above 383.37 m CSF-A. Analysis of IW samples on the IC and ICP-AES is in progress, as are the bulk sediment geochemistry analyses.

The physical properties data reflect the uniform lithology of Hole U1516A (calcareous nannofossil ooze with some clay-rich layers). NGR and MS values rapidly decrease in the uppermost 10 m and stabilize to low values below that interval in Hole U1516A (5 counts/s for NGR, 0 IU for MS). Occasional spikes in NGR occur within the clay-rich layers, whereas spikes in MS occur within the calcareous and nannofossil ooze, suggesting the occurrence of iron oxides. Caliper *P*-wave readings spike in Hole U1516C by 200–300 m/s at ~390 m CSF-A, approaching the Turonian–Eocene unconformity; there is a coincident increase in MS. NGR values spike through the Cenomanian/Turonian boundary interval, and continue to increase downhole through the Cenomanian and Upper Albian mudstones, similar to the NGR signal from Site U1513. NGR values peak near the Cenomanian/Albian boundary. Bulk density values increase downhole from 1.6 to 1.85 g/cm$^3$ in the upper 180 m of Hole U1516A. Density continues to increase downhole to a maximum value of ~2.0 g/cm$^3$ near 430 m CSF-A, below which values decrease to ~1.7 g/cm$^3$ in the Turonian to Albian age sediments. Porosity decreases steadily downhole from 67% near the seafloor to 40% at ~400 m CSF-A. Thermal conductivity progressively increases with depth from 1.1 W/(m·K) near the seafloor to ~1.8 W/(m·K) at ~420 m CSF-A near the Turonian–Eocene unconformity, then decreases to ~1.3 W/(m·K) in the Cenomanian to Albian sediments. Additionally, four downhole formation temperatures were

acquired from Cores 3H, 5H, 7H, and 17H, which will allow for a heat flow calculation when combined with thermal conductivity values.

Site U1516 coring penetrated to a maximum depth of 540.1 m CSF-A. Greater than 100% recovery in Hole U1516A using APC and HLAPC was matched by excellent core quality and resulted in recovery of an effectively complete record from the seafloor to 223.72 m CSF-A. Ages span the present to the late Miocene. Several targets of correlation were identified at 205 and 214 m CSF-A in Hole U1516A, and RCB coring in Hole U1516C started at 196 m to overlap these targets. Unfortunately, poor recovery in Hole U1516C down to 254 m CSF-A precluded precise correlation between holes. Recovery was variable from 254 m to 446 m CSF-A. Intervals of good recovery included the Miocene–Oligocene and late Eocene–Oligocene intervals, as well as an apparently 50-million-year-long, 15 m thick interval spanning the middle Turonian to late Eocene. From 446 m to 498 m CSF-A recovery was again excellent. Cores recovered span from above the Cenomanian/Turonian boundary to below the Albian/Cenomanian boundary and include the OAE 2 interval. Correlative cores from Site U1513 suggested similar lithologic changes are present at the two sites, but sedimentation rates in Hole U1516C are lower over this interval than they are at Site U1513. From 498 m CSF-A to the bottom of the hole, recovery was again variable, and it seems likely the record of OAE 1d falls within a non-recovered interval.

**Education and Outreach**

We conducted 10 live interactive events with schools in Japan, Germany, and the USA, as well as museums in the UK (Natural History Museum, London) and USA (National Museum of Natural History, Washington, D.C). These broadcasts reached approximately 370 people. Additional media coverage included another live interview with BBC World News.

On social media, there were 10 new posts to Facebook (https://www.facebook.com/joidesresolution; total of 955 likes/comments and shares), 11 new posts on Twitter (https://twitter.com/TheJR; 146 total likes and 63 retweets), eight posts on Instagram (http://instagram.com/joides_resolution; 481 total likes and 58 new followers for 867 total followers), and two new blogs for the *JOIDES Resolution* (JR) website (http://joidesresolution.org). One of the posted photos has won a prize from the Australian Geological Council, and the president of the council will visit the JR in Fremantle. The BBC Earth Instagram has featured three posts about the JR, which have reached almost a million people and garnered >20,000 likes.

Individual projects included an embroidery pattern packet available on the JR website, continued work on embroidered images of microfossils, scientist interviews for the *Smithsonian* magazine articles, and filming and transcribing scientist interviews. A new program for the podcast Calling

Brazil was conducted. We also continued writing articles and curricula, including articles for *Jornal da UNICAMP* and Portal CAPES.

**Technical Support and HSE Activities**

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

*Core Handling*

- The cores spanning the OAE 2 (Cores U1516C-31R to 34R) were wrapped with $O_2$ barrier film, flushed with argon, and sealed with $O_2$ absorber packs. End caps were not chemically sealed.
- Helped scientists resample several cores and redistribute sample residues, including IW squeeze cakes and whole-round core catcher samples, from Site U1515.

*Laboratory Activities*

- The PVC tubing for the SRM compressor outflow line cracked and leaked chill water. The tubing has been replaced, but it is recommended to check and replace the tubing on a regular basis.
- Continued work on the new application for the Cahn Balance in the Chemistry Laboratory.
- Modified the LIMS Information Viewer (LIVE) data display to improve the speed of the display frequency.
- Measured the heat coming off the monitors on the Stratigraphic Correlator station and planned for swapping out with new monitors on the next expedition.
- The lapping machine (LP50) in the Thin Section Laboratory is not functioning properly. After several troubleshooting sessions, a loose wire was found and repaired. However, the machine is still behaving erratically so the vendor (Logitech) has been contacted.

*I.T. Activities*

- Provided general help desk support for staff and science party.
- The primary RigWatch server had an unplanned shutdown but was restarted. We suspect RigWatch crashed (then the server) when it lost the logging data feed and the corresponding input on RigWatch was not turned off.
- Windows Update server ran out of space in the update repository. This was addressed and the bandwidth used to download updates has been reduced to 256 kbps.
- Entered all AMS location changes for equipment moved on this expedition.

- Tested the speed and functionality of the new Workday application from Human Resources.

*Miscellaneous*

- End of expedition cleaning assignments have been handed out.
- A Siem Offshore engineer installed a temporary drain line to address the leak in the Core Laboratory. The permanent repair is now a dry dock/tie-up project as the pipe is not accessible.

*HSE Activities*

- Safety showers and eye wash stations were tested.
- The weekly boat drill was held on 15 November.