

IODP Expedition 369: Australia Cretaceous Climate and Tectonics

Week 7 Report (5–11 November 2017)

Week 7 consisted of coring and logging operations in Hole U1514C, the transit to Site U1515 (proposed Site MBAS-9A), and coring operations in Hole U1515A.

Operations

We started Week 7 recovering the drill string after coring was completed in Hole U1514B, which was finished at 0925 h on 5 November. The ship was offset 20 m south and preparations were then made for coring with the rotary core barrel (RCB) system. Hole U1514C was started at 1940 h on 5 November. The water depth was calculated as 3838.8 m. We drilled without coring to 195.6 m by 0115 h on 6 November. We pulled the center bit at 0200 h and coring commenced with Core 2R. We then recovered Cores 3R through 35R to 516.8 m by 1605 h on 8 November. In total, we recovered 247.47 m from 321.2 m cored (77%).

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 end of the pipe was pulled up to 82.2 m for downhole logging. The modified triple combination tool string was assembled. Specifically, the tools included 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 0015 h on 9 November. A full logging run was conducted to 514.0 m. The logging tools were recovered at 0630 h on 9 November and disassembled by 0815 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 by 1735 h on 9 November, which ended Hole U1514C. A total of 4.3 d were spent at Hole U1514C.

After a 62.5 nmi transit to Site U1515 at an average speed of 9.9 kt, we arrived on site at 0000 h on 10 November. We started RCB coring in Hole U1515A at 0650 h at a water depth of 849.7 m. By the end of the week, we had recovered Cores 1R to 40R to 373.1 m. Recovery is poor overall (<20%) because of intervals of sand and chert.

Science Results

The science party activities for the week included the completion of analyses of Hole U1514C, the finalization of the Site U1514 reports, and initial analyses of Hole U1515A.

Hole U1514C

The Core Description team described the lithology of each core recovered from Hole U1514C (Cores 2R to 35R, 195.60–515.64 m CSF-A). Sediments recovered from Hole U1514C comprised two lithostratigraphic units (Unit II through Unit III). Overall for Site U1514, there are three main lithostratigraphic units with Units I and III subdivided into two subunits. Unit I is a 81.20 m thick sequence of very pale brown to pale yellow nannofossil ooze, foraminiferal ooze, and sponge spicule-rich nannofossil ooze that is Pleistocene–Eocene in age. Unit I is subdivided into Subunits IA and IB with their boundary at 30.38 m CSF-A in Hole U1514A. Subunit IB (Miocene–Eocene) is characterized by an increased abundance of biosiliceous material, especially sponge spicules. This subunit is mainly yellow/brown and is distinctively darker than Subunit IA. Unit II is a 308.01 m thick sequence of Eocene–Paleocene light greenish gray clayey nannofossil ooze, sponge spicule-rich clay, and nannofossil-rich clay that gradationally transitions into clayey nannofossil chalk and nannofossil-rich claystone. Unit III is a 126.43 m thick sequence of greenish gray, brown, and black claystone that is Paleocene–Albian in age. Unit III is subdivided into Subunits IIIA and IIIB (boundary at 454.33 m CSF-A in Hole U1514C). Subunit IIIA contains soft sediment deformation (Cores 25R to 28R; 411.2–449.11 m CSF-A), including convoluted and overturned bedding. Subunit IIIB is Cenomanian/Albian–Albian and distinguished from the overlying Subunit IIIA (Paleocene–Cenomanian/Albian) because it is a much darker greenish gray and even black claystone.

The age model for Hole U1514C is based on integrated calcareous nannofossil and planktonic foraminiferal assemblages analyzed from all core catchers and selected split core sections. It spans the middle Eocene through upper Albian. Sedimentation rates were relatively high (~15 m/My) throughout the early Paleogene, but fell in the upper Cretaceous (to ~4 m/My). The Cretaceous/Paleogene boundary is present in Section U1514C-23R-2. Benthic foraminifera, where present, indicate bathyal paleowater depths.

The natural remanent magnetization (NRM) of all archive-half core sections and 82 discrete samples collected from the working halves of Holes U1514A and U1514C was determined. The archive halves were stepwise treated with up to 20 or 30 mT 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. The NRM intensity of the recovered cores is in the order of 10^{-6} to 1 A/m. The demagnetization results show that inclinations after the 20 or 30 mT demagnetization step exhibit intervals dominated by positive and negative inclination values, defining an almost complete magnetic polarity sequence from Chron C1n (Brunhes Chron) to C34n, the long Cretaceous Normal Superchron; in total, 74 identified and dated reversals were found.

Headspace samples from Hole U1514C were analyzed for interstitial gas; trace amounts of methane were detected. Whole-round interstitial water (IW) sampling in Hole U1514C started with Core 8R and continued to the bottom of hole (Core 35R, 515.64 m CSF-A). Salinity was

measured in all samples, but the majority of IW samples produced too little fluid (<10 mL) for alkalinity and pH measurements. The salinity of IW samples is generally constant, with the exception of distinctly fresher IW in Subunit IIIB. This low salinity interval is reflected as decreases in concentration for many elemental profiles, particularly the bromide and chloride profiles, and reflects an input of fresher water. IW analyses were also completed with the inductively coupled plasma–atomic emission spectrometer (ICP-AES) for analyzing major and minor elements. The dissolved magnesium, potassium, calcium, lithium, strontium, and sodium concentration profiles reflect alteration of volcanic material from depths below the cored interval for this site. Bulk sediment samples from both Holes U1514A and U1514C were measured with the coulometer, elemental analyzer, and source rock analyzer. Total organic carbon content was generally low (<0.3%), except in the black layers within the possible late Aptian ocean anoxic event (OAE) 1d interval, which contained up to 1.2%. Source rock analysis on eight samples from working-half core sections indicates a predominantly terrestrial source for the kerogen in these samples.

The Petrophysics group collected measurements of magnetic susceptibility (MS) and bulk density for Cores U1514C-2R through 12R, which were used by the Stratigraphic Correlators to correlate Holes U1514A and U1514C. Additional physical property data were collected with the Whole-Round Multisensor Logger (WRMSL), Section Half Multisensor Logger (SHMSL; point MS and color reflectance), Natural Gamma Radiation Logger (NGRL), and discrete samples. The natural gamma radiation (NGR) values in Cores U1514C-2R to 21R show values below 25 counts/s. A spike in the NGR spectra may mark or be very close to the Paleocene/Eocene Thermal Maximum. This spike is accompanied by increased uranium content. The amplitude of the NGR variations increases from Cores 22R to 32R. In this interval, the NGR reaches its highest value (110 counts/s) in Section U1514C-23R-3, ~2 m below the Cretaceous/Paleogene boundary. It corresponds to the highest values of uranium (10 ppm). Another spike in NGR, and uranium concentration, occurs in Core U1514C-28R, potentially corresponding to the Cenomanian/Turonian boundary interval. The NGR fluctuates with low amplitude and a mean value of 25 counts/s from Core U1514-32R to the bottom of Hole U1514C. The MS and b^* show high values from Cores U1514C-6R to 11R and Cores U1514C-23R to 32R, where NGR values are high. In other intervals, the values are low. Bulk density increases from 1.6 to 2.8 g/cm³ from Core U1514C-2R to 4R. It is stable around 1.8 g/cm³ down to Core U1514C-26R, and then decreases with depth to 1.6 g/cm³.

Downhole logging data demonstrated that the borehole deviated less than ~4° from vertical. The downhole tools provided continuous coverage of the borehole and filled several coring gaps. The most striking features identified include peaks in the NGR log at 390–400 and 420–430 m WMSF, which correspond to a decrease in bulk density, sonic velocity, and resistivity. Other peaks in NGR values include a sharp peak of ~190 gAPI at ~396 m WMSF, as well as other peaks between ~422–430, 442–448, and 455–480 m WMSF. The large NGR peak at 396 m WMSF corresponds with a spike in U concentrations (>10 ppm), roughly 10× the mean value for the hole. This horizon occurs near the Cretaceous/Paleogene boundary. However, some of the

sharp changes in the NGR, sonic velocities, resistivity, and density correspond to a noted zone of soft sediment deformation (Unit III, Cores U1514C-25R to 28R), likely associated with a large slump/mass transport complex.

Coring in Hole U1514C resulted in very good recovery in Cores 2R to 8R, the interval that overlapped with Hole U1514A (Cores 24X to 31X). Recognition of matching features between holes, particularly patterns of variations in NGR measurements, provided the observations that underpin a splice for the interval from 196 to 253 m CCSF. Downhole logs corresponded quite well to core-based measurements at the meter scale, and 18 tie points were proposed to correlate between coring depths and wireline matched depths. Efforts to use the logging data to assess specifically where coring breaks and drilling disturbance occur across the Paleocene/Eocene boundary interval (Core U1514C-11R, recovery 6.51 m [68%]) were less successful. Patterns in NGR, MS, and density lacked the resolution and/or consistent excursions needed to correlate confidently at the decimeter or finer length scale. Thus, where stratigraphic breaks occur in Core U1514C-11R remains ambiguous. On the other hand, refined biostratigraphic, lithologic, and paleomagnetic observations did permit identification of the Cretaceous/Paleogene boundary as occurring within a 5 cm interval of bioturbated sediment in Section U1514C-23R-2.

Hole U1515A

Sediments recovered from Hole U1515A (Cores 1R to 39R, 0–363.50 m CSF-A) are currently divided into two lithostratigraphic units (Unit I through Unit II). Unit I is a sequence of light greenish gray calcareous ooze to chalk with sponges spicules that gradationally transitions into chert and sandy limestone. Unit I is subdivided into Subunits IA and IB with the boundary placed at 105.05 m CSF-A. Subunit IA is light greenish gray calcareous ooze/chalk with sponge spicules that is Pleistocene to Miocene in age. Subunit IIB is a Miocene–Campanian light greenish gray chert, pale green to light greenish gray sandy limestone, and olive yellow, dark reddish gray, and light greenish gray sandy floatstone. Unit II is a sequence of greenish black and black sand to sandstone.

Hole U1515A has an integrated calcareous nannofossil and planktonic foraminiferal age model, determined from analysis of core catcher samples. Cores U1515A-1R to 15R span the Pleistocene through upper Campanian. However, there are multiple hiatuses within the sequence, e.g., the early Eocene through Maastrichtian is missing. In the topmost cores in Hole U1515A (Cores 1R through 10R), assigned to the Neogene, there is severe reworking of older material into younger sediments, complicating precise age assignment. All samples acquired below Core U1515A-16R are barren of microfossils. Benthic foraminifera, where present, indicate bathyal paleowater depths.

The NRM of archive-half sections of RCB Cores U1515A-1R through 39R was measured before and after stepwise AF demagnetization up to 20 mT. In addition, 14 discrete samples were taken for detailed stepwise AF demagnetization. Changes in the magnetic polarity allows for the tentative assignment of Pleistocene Chrons C1n through C1r.2r in the top 20 m of the section.

Several intervals of normal and reverse polarity can be discerned between 20 and 270 m CSF-A, however, they currently cannot be assigned to the geomagnetic polarity timescale because of poor recovery and the lack of biostratigraphic control. Polarity between 250 and 350 m CSF-A is predominantly negative (normal).

Headspace samples from Hole U1515A were analyzed for interstitial gas; trace amounts of methane were detected. As a result of the low recovery, few IW samples have been recovered. Bulk sediment samples were collected when recovery permitted and will be analyzed on the coulometer and elemental analyzer.

Because many of the cores from Hole U1515A have poor recovery, coverage of physical property data is sporadic between 40 to 130 m CSF-A and 286 to 317 m CSF-A. However, where possible, the recovered sections have been run through the WRMSL and NGRL and subjected to thermal conductivity measurements.

Education and Outreach

We conducted eight live interactive events with schools in China, Germany, the USA, and the UK. These broadcasts reached approximately 230 people. One of the broadcasts was to the Intrepid Sea, Air, and Space Museum in New York, NY, USA, for 70 teachers attending a full day professional development workshop. Another one of these broadcasts was to the IODP meeting in Brazil for 50 professors and researchers.

Additional media coverage included a Reddit Ask Me Anything (AMA) session where several of the scientists onboard assisted in fielding questions asked by the public (https://www.reddit.com/r/science/comments/7b4g8u/science_ama_series_were_scientists_on_a_ship_off/). We had over 1,000 views of the session with 190 people voting positively for the session (which was 86% of the vote). In total, over 33 questions were asked and answered.

On social media, there were six new posts to Facebook (<https://www.facebook.com/joidesresolution>; total of 532 likes/comments and shares), seven new posts on Twitter (<https://twitter.com/TheJR>; 166 total likes and 39 retweets), five posts on Instagram (http://instagram.com/joides_resolution; 290 total likes and 11 new followers for 820 total followers), and two new blogs for the *JOIDES Resolution* website (<http://joidesresolution.org>). The content posted received positive feedback through Instagram and Facebook messages.

Individual projects included continued work on embroidered images of microfossils, filming and transcribing scientist interviews, and filming various shots of scientists working. We also continued writing articles and curricula, including articles for *Jornal da UNICAMP*, Portal CAPES, and the Brazilian scientific newspaper *SBPC*.

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

- Assisted with a hard-rock sample party for the recovered basalts from Site U1513.
- Helped scientists resample several cores and redistribute sample residues, including IW squeeze cakes and whole-round core catcher samples, from Site U1514.

Laboratory Activities

- A new version of ImageCapture has been deployed to prevent further errors with assigning interval values.
- Continued work on the new application for the Cahn Balance in the Chemistry Laboratory.
- Deployed the new software application for the coulometer in the Chemistry Laboratory.

I.T. Activities

- Provided general help desk support for staff and science party.
- Prepared to ship unneeded equipment back to shore.

Miscellaneous

- The Assistant Laboratory Officers handled logistics for upcoming bulk shipments.
- Several overhead emergency LED lights had been flickering during coring, which was a result of low batteries. The batteries were replaced and a small transformer was installed.
- A leaking pipe in the ceiling in the Core Laboratory was found. The Siem Offshore crew are waiting for a coring break to perform repairs.
- A general alarm went off inside one of the flammable lockers, which was a result of a bad connection to the drain tray. The space has been treated and dried, and a new drain line was installed. As a precaution, the other hazardous chemical locker will be investigated next week.

HSE Activities

- Safety showers and eye wash stations were tested.
- The weekly boat drill was held on 8 November.