**IODP Expedition 374: Ross Sea West Antarctic Ice Sheet History**

**Week 5 Report (28 January–3 February 2018)**

## Operations

Week 5 of the Ross Sea West Antarctic Ice Sheet History Expedition (374) began while retrieving the Versatile Seismic Imager (VSI) logging tool string from Hole U1522A after encountering a bridge at 203.5 m. After reaching the rig floor at 0025 h on 28 January, we added a Hostile Environment Natural Gamma Ray Sonde (HNGS) to the tool string to increase the weight. The VSI tool string was lowered in the hole at 0055 h and again encountered the bridge at 203.5 m; however, after working the tool string with the added weight up and down for 30 min, the tool string passed the bridge and reached 297.5 m before encountering another bridge that could not be passed. Protected species observation started while lowering the tool string in the hole, and the seismic source was deployed and a soft start was initiated. Eight stations were selected and tested, with each yielding good results. Several shut downs occurred during the logging run when marine mammals (whales and seals) entered the exclusion zone during the vertical seismic profile (VSP) experiment. At 0600 h on 28 January the last station was completed and the seismic source was secured. The VSI tool string returned to the rig floor at 0630 h and was secured by 0700 h.

The third logging tool string used at Hole U1522A was the Formation MicroScanner (FMS), which contained the following tools:

- Formation MicroScanner (FMS);
- Hostile Environment Natural Gamma Ray Sonde (HNGS);
- Enhanced Digital Telemetry Cartridge (EDTC);
- Logging equipment head-q tension (LEH-QT).

The FMS tool string was lowered into the hole at 0730 h. Natural gamma radiation (NGR) was logged from just above the seafloor while lowering the tool to depth match the seafloor to the triple combo run. The FMS tool string reached to 193.5 m, and the first upward pass collected data with the FMS calipers open from 193.5–101.5 m. The tool string was lowered back to 193.5 m and a second upward pass was collected. The end of the pipe was raised to 86.5 m as the FMS tool approached to increase log coverage of the borehole. After completing the uplog, the calipers were closed and the tool string returned to the rig floor. All logging equipment was disassembled by 1030 h on 28 January.

We then began to pull the drill string back to the rig floor. The acoustic beacon was released while raising the drill string and recovered to the deck at 1213 h. Three drill collar stands were racked in the derrick and the outer core barrel was disassembled and inspected. The rig floor was

secured for transit at 1311 h on 28 January, ending Hole U1522A and Site U1522. A total of 149.25 h (6.2 d) was spent on Site U1522.

The 147 nmi transit to Site U1523 (proposed Site RSCR-14A) averaged 11.5 kt. The vessel arrived at Site U1523 at 0158 h on 29 January. The thrusters were lowered and secured at 0218 h and the drill floor was cleared for operations, beginning Hole U1523A. We made up an advanced piston corer (APC)/extended core barrel (XCB) bottom-hole assembly (BHA), then we began to lower the drill string toward the seafloor. Due to uncertain seafloor conditions, we decided to survey the seafloor prior to starting the first hole. After the drill string reached 599.1 m below rig floor (mbrf), we pulled the upper guide horn to deploy the subsea camera for the seafloor survey to look for large rocks in the vicinity of the potential hole locations. While lowering the subsea camera, we also continued to lower the drill string. Since this site is in deeper water than the two previous sites (the precision depth recorder indicated a depth of 837 mbrf), some additional drill pipe had to be drifted (checked that it was clear of internal obstructions) and strapped (measured) as it was deployed. We picked up the top drive and prepared a nonmagnetic APC core barrel before conducting the seafloor survey, which included tagging the seafloor at four potential hole positions. All tag depths were 839 mbrf (828 m below sea level). An acoustic positioning beacon was deployed at 1000 h after completing the survey. The vessel was moved back to the first tag location, and we left the subsea camera down to observe the core barrel being shot into the seafloor to start Hole U1523A.

After installing the sinker bars and orientation tool, the first APC core barrel was lowered into the drill string with the drill bit at 838.0 mbrf (1 m above the seafloor tag depth). Hole U1523A was started at 1050 h on 22 January. The mud line core recovered 8.51 m of sediment. We continued to APC core with nonmagnetic core barrels and orientation through Core U1523A-3H (0–25.2 m). Since Core 3H was a partial stroke, we switched to the half-length APC (HLAPC) and continued coring through Core 7F (46.3 m). While drilling out the cored interval, backflow of sand/gravel/stones into the BHA blocked the drill string. Since we were unable to land a core barrel or circulate, we abandoned Hole U1523A. We pulled the drill string out of the hole and attempted to clear the BHA while it was above the seafloor. We then dropped an XCB core barrel with a deplugger; however, this attempt to clear the BHA also failed. After the XCB core barrel was retrieved, the drill string was pulled up to the rig floor and the BHA was disassembled and cleaned of debris. The lockable float valve (LFV) was damaged either by debris or the XCB core barrel. The bit cleared the rotary table at 0450 h, ending Hole U1523A. We recovered 23.22 m of core over 27.5 m of coring (84%) with the APC coring system, and 10.29 m of core over 18.8 m of coring (55%) with the HLAPC system. Total core recovered for the hole was 33.51 m (72%). Total time spent on Hole U1523A was 26.5 h (1.1 d).

After clearing out the BHA, the outer core barrel was reassembled, then the drill string was lowered toward the seafloor. The vessel was positioned 20 m east of Hole U1523A. After picking up the top drive, the drill bit was positioned at 838 mbrf (1 m above the seafloor) to start Hole U1523B. A nonmagnetic APC core barrel was deployed and Hole U1523B was started at

1100 h on 30 January 2018. Core U1523B-1H recovered 8.49 m. We then dropped an XCB center bit and advanced the hole without coring to 46.7 m with a hard layer observed at 45.9 m. After recovering the XCB center bit, we deployed a HLAPC core barrel. Coring continued from Core U1523B-3F through 13F (46.7–93.8 m). We pumped 20- or 30-barrel mud sweeps every few cores to maintain good hole conditions. Core 13H was a partial stroke, so we switched to the XCB coring system. Cores 14X through 16X penetrated from 93.8 to 103.3 m, with almost no recovery. Since Core 16X only advanced 0.1 m, we dropped a center bit and drilled ahead without coring for 5.0 m to try to advance past a very hard layer. We then resumed XCB coring and cut Cores 18X and 19X (108.3–127.5 m), again with minimal recovery (3%). Since drilling parameters suggested we had successfully passed the hard layers, we switched back to the HLAPC coring system for Cores 20F and 21F (127.5–135.6 m). We had to drill over Core 21F to release it from the formation due to excessive overpull, so we switched back to the XCB coring system. We cut cores 22X through 24X (135.6–164.4 m) with minimal recovery (9%). We terminated coring at 164.4 m in Hole U1523B due to unstable hole conditions causing excessive torque. We pumped a 30-barrel mud sweep and pulled the drill string clear of the seafloor, ending Hole U1523B at 2120 h on 31 January. A single APC core recovered 8.49 m over an 8.5 m advance (100%). The HLAPC recovered 33.48 m over 55.2 m of coring (61%). The XCB recovered 3.16 m over 57.5 m of coring (5%). Total time spent on Hole U1523B was 37.0 h (1.5 d).

After clearing the seafloor, the vessel was repositioned 20 m south of Hole U1523B. Hole U1523C was planned to selectively core intervals of poor recovery with the HLAPC while avoiding hard layers encountered in previous holes. We dropped a center bit in preparation to start Hole U1523C and noticed high pump pressures indicating clogged jets in the drill bit. After attempting to clear the jets, we started Hole U1523C at 1915 h on 31 January and drilled ahead without coring to 43.3 m when we lost circulation through the drill string, forcing us to abandon Hole U1523C. The bit cleared the seafloor at 2120 h and was back on the rig floor at 0130 h on 1 February, ending Hole U1523C. Total time spent on Hole U1523C was 7.75 h (0.3 d).

We switched to the rotary core barrel (RCB) coring system to core and log a deeper hole. The RCB BHA was assembled and lowered toward the seafloor. After picking up the top drive, we prepared a core barrel with a center bit. Hole U1523D was started at 0725 h on 1 February. The hole was advanced to 135.0 m without coring. We pumped a 30-barrel high viscosity mud sweep and retrieved the center bit. RCB coring continued from Core U1523D-2R through 19R (135.0–307.8 m) with very poor recovery (0.84 m; 1%). We pumped 30-barrel high viscosity mud sweeps every 2–3 cores to clear cuttings. We terminated coring after reaching our target depth of ~300 m and prepared the hole for downhole logging by circulating two 50-barrel high viscosity mud sweeps to improve hole conditions. The rotary shifting tool (RST) was lowered on the coring line to release the RCB bit in the bottom of the hole at 0800 h on 2 February. After running the RST a second time to shift the sleeve in the mechanical bit release back to the circulating position, we displaced the hole with 94 barrels of 10.5 lb/gal mud from 307.8 m to the seafloor. We then pulled the drill string to 258.5 m, set back the top drive, and continued to pull

the drill string up to a logging depth of 82.3 m. After displacing the upper part of the hole with 20 barrels of 10.5 lb/gal mud, the drill floor was prepared for downhole logging operations at 1130 h on 2 February.

A modified triple combo tool string was assembled with the following tools:

- Magnetic susceptibility sonde (MSS);
- Dipole Sonic Imager (DSI);
- High-Resolution Laterolog Array (HRLA);
- Hostile Environment Litho-Density Sonde (without source) (HLDS);
- Hostile Environment Natural Gamma Ray Sonde (HNGS);
- Enhanced Digital Telemetry Cartridge (EDTC);
- Logging equipment head-q tension (LEH-QT);
- Mechanical caliper device (MCD) centralizer (2) for centralizing the DSI and the HRLA.

The triple combo tool string was lowered into the drill string at 1320 h on 2 February. The average heave was estimated to be 0.3 m just prior to logging. The active heave compensator switched on once the tools reached open hole. A downlog was performed from just above seafloor to 292 m, within 15 m of the bottom of the hole. The hole was then logged up with a 136 m calibration pass, and the tool string was lowered back to the bottom (288 m), then logged up. When the tool string neared the end of the pipe, it was raised to 67 m to provide additional log coverage of the borehole. The tools were back at the surface at 1630 h on 2 February and the triple combo was disassembled by 1745 h.

The second tool string with the FMS was assembled with the following tools:

- Formation MicroScanner (FMS);
- Hostile Environment Natural Gamma Ray Sonde (HNGS);
- Enhanced Digital Telemetry Cartridge (EDTC);
- Logging equipment head-q tension (LEH-QT).

The FMS tool string was lowered into the hole at 1820 h. NGR was logged from above the seafloor as the tool string was lowered to depth match results to the first logging run. The FMS reached a total depth of 289.6 m. Two upward passes were logged with the FMS tool string. During the second uplog, the end of the pipe was raised to 67 m to provide additional coverage of the borehole. The FMS tool string was returned to the rig floor at 2130 h and all logging equipment was disassembled by 2245 h on 2 February. We then began to raise the drill string back toward the rig floor, clearing the seafloor at 2315 h on 2 February. After placing three stands of drill collars in the derrick, the outer core barrel was disassembled and inspected. The end of the drill string cleared the rotary table at 0240 h on 3 February, ending Hole U1523D. A total of 0.90 m of core was recovered over 172.8 m of RCB coring (1%). Total time spent on Hole U1523D was 49.25 h (2.1 d).

We switched back to the APC/XCB coring system to target poorly recovered intervals from Holes U1523A and U1523B. The drill string was lowered toward the seafloor and the bit was set at 830 mbrf for the first core. Hole U1523E was started at 0810 h on 3 February and Core 1H recovered a full barrel (9.86 m). We then drilled ahead 9.5 m without coring, then switched to the HLAPC coring system and proceeded with spot coring. Over the upper ~90 m, this consisted of collecting 1–3 HLAPC cores, followed by a drill ahead interval ranging from 2.8 to 12.3 m in length. Depths were chosen to avoid gravel encountered in Holes U1523A and U1523B. Below ~90 m, the coring plan included dropping a center bit to drill through hard layers encountered between 93–95 m, 104–108 m, and 116–117 m, with HLAPC cores collected in between. This technique proved particularly successful for the interval below 100 m, allowing us to fill in substantial gaps in the stratigraphy. The last core (25F) in Hole U1523E arrived on deck at 2350 h on 3 February. At the end of the week, we were preparing to retrieve the drill string to the rig floor to complete operations at Site U1523.

**Science Results**

The sedimentologists described cores from Site U1523 (Cores U1523A-1H to 7F, U1523B-3F to 24X, U1523D-2R to 15R, U1523E-14F to 21F) using a combination of visual core description, microscopic inspection of smear slides, core imaging, spectral color scanning, point magnetic susceptibility, X-ray diffraction (XRD), and handheld X-ray fluorescence (XRF) measurements. The upper ~35 m of the section consists of grayish brown to greenish gray foraminifer-rich/bearing muddy sand, diatom-rich/bearing sandy mud, and muddy diamict. The muddy sand and sandy mud are interbedded at decimeter-scale, with individual beds ranging from laminated to highly bioturbated. Pebble-sized clasts are common and occasional cobble-sized clasts are also present. Below this the sediment consists of interbedded (decimeter-scale) greenish gray to olive gray muddy sand, diatom-bearing/rich mud, and diatom ooze. Pebble-sized clasts, glauconite, and pyrite stains are common throughout this interval. Shell fragments are sporadically present. Downhole individual beds become thicker (up to a meter thick) and diatom abundance decreases. Sand stringers are common in the muddy lithologies throughout the recovered interval. The lithology below ~135 m is poorly known as RCB coring in Hole U1523D only recovered pebble- to cobble-sized gravel with almost no finer grained material. Clasts consist of diorite, chert, and metasedimentary rocks.

The paleontologists examined core catcher samples from all holes at Site U1523. Diatoms and radiolarians are present throughout the samples examined. Radiolarians are moderately to well preserved and present in trace to common abundances. Diatoms are rare and poorly preserved in the uppermost part of the site, becoming more abundant and better preserved below ~30 mbsf. Foraminifers of variable preservation are common to abundant in the upper ~40 m of the site. Moderately to well preserved dinoflagellate cysts (dinocysts) are present throughout the recovered interval, sometimes reaching abundant numbers. Reworking of dinocysts is minimal

but the in situ taxa present are not age diagnostic in the upper ~90 m. The assemblage suggests highly productive surface waters. Diatom and radiolarian biostratigraphy indicate a Pliocene to Pleistocene age for the upper ~90 m and late Miocene age below. Several dinocyst taxa also confirm a late Miocene age and the overall assemblage indicates productive and possibly seasonally stratified surface waters.

The paleomagnetists measured the natural remanent magnetization of all archive-half sections from Site U1523. The alternating field (AF) demagnetization and measurement sequence always included 0, 5, 10, and 20 mT peak AF demagnetization to evaluate potential variations in coercivity at this site. Oriented discrete samples were collected from each core to test the appropriate demagnetization sequences of archive-half sections and to confirm the magnetostratigraphy. In addition, the discrete samples were used for anisotropy of magnetic susceptibility (AMS) measurements. Discontinuous recovery and cores with severe core disturbance hampers the construction of a continuous magnetostratigraphy for Site U1523. Despite this, several normal and reversed polarity zones were identified and should improve the age model through correlation to the geomagnetic polarity timescale when coupled with biostratigraphic tie points.

The physical properties team collected physical property data on whole-round cores, section halves, and discrete samples from Holes U1523A, U1523B, and U1523E. No physical property data were collected for Hole U1523D, which consisted of short (<20 cm) cores of primarily washed gravel. The *P*-wave logger (PWL) was used for APC and HLAPC whole-round sections. Thermal conductivity and shear strength measurements were carried out successfully on the cores from both Holes U1523A and U1523B. Overall, physical properties measured on cores from Site U1523 demonstrate similar trends in magnetic susceptibility (MS), natural gamma radiation (NGR), density, and porosity. MS is highly variable and shows cyclical variations between higher and lower values over tens of meters. NGR shows similar variability, although it is less pronounced in the uppermost part of the site. *P*-wave velocity is relatively constant downhole, with values more variable in the uppermost ~20 m. Bulk density increases slightly downhole, with some intervals of lower density corresponding with more diatom-rich lithologies. Porosity is highly variable, but shows a general decrease downhole that is likely associated with compaction.

The geochemists collected samples from Holes U1523A, U1523B, and U1523E for shipboard routine headspace gas analysis, interstitial water (IW) geochemistry, and organic geochemical bulk sediment analyses (total carbon, nitrogen, and calcium carbonate), as well as low-resolution sampling for shore-based microbiological studies. Additionally, high-resolution sampling for IW and microbiology was conducted on Core U1523B-1H. Methane and ethane concentrations are very low throughout the site (<3 ppmv). Low and high-resolution geochemical analyses of IW show a downhole decrease in sulfate concentration and increase in alkalinity. Silica concentration in the water from the mudline is lower than the concentration in the IW, and it increases downhole. Total organic carbon (TOC) and calcium carbonate contents are generally

low throughout the holes (<0.6 wt% and <3.5 wt%, respectively). Elevated levels of TOC/total nitrogen suggest a mixed source (marine and terrigenous) of organic matter. Results from handheld X-ray fluorescence (XRF) measurements show variations in ratios of lithogenic elements such as Ti/Th. Remaining carbon, nitrogen, and calcium carbonate analyses for Site U1523 are ongoing.

The final upward pass of the VSI logging run for Hole U1522A was completed on 28 January 2018; the Hole U1522A raw log data were sent to shore for processing, and the processed data were received a few days later. Caliper data show that the borehole size varies significantly, with numerous washed out intervals and multiple ledges, which resulted in the FMS tool string being unable to reach the bottom of the hole. Despite the lower quality borehole conditions, downhole data generally match well with results from core measurements. NGR data from downhole logging shows good correspondence with NGR data from whole-round cores, whereas the core-based *P*-wave velocity consistently underestimates the velocity relative to the downhole log data. The FMS resistivity images appear to be of reasonable quality and should help assess lithologies in the poorly recovered upper part of the formation. Data at eight check-shot stations were successfully measured with the VSI (geophone).

We also conducted downhole logging in Hole U1523D this week. The first logging run used a modified triple combo, which included tools to measure NGR, resistivity, sonic velocity, and MS. Due to unstable hole conditions, the density tool was deployed without the source to measure borehole width with the caliper. The tool string reached to ~290 m, 10 m above the total borehole depth. The second logging run used the FMS. Again, the logging run reached approximately 10 m above total depth. Borehole conditions were reasonable; however, the caliper data identified a number of minor washouts. The resistivity data show clear alternations of high and low resistivity throughout the borehole that may correspond to alternating layers of fine and coarse sediments.

**Education and Outreach**

This week, the education and outreach team conducted 10 live broadcasts with schools in the United Kingdom (1), France (4), the United States (4), and New Zealand (1). We posted three blogs on the *JOIDES Resolution* website (http://joidesresolution.org/): "Not all ice sheets are the same," "What's the food like?" and "The Timelords of Expedition 374," which describes the role of micropaleontology aboard the vessel. Future blogs are in development to document how magnetostratigraphy and biostratigraphy are used to develop an age model. All three members of the Education and Outreach team continued to make posts to social media (Facebook [https://www.facebook.com/joidesresolution], Twitter [https://twitter.com/TheJR], and Instagram [http://instagram.com/joides_resolution]). The most popular Facebook posts included the "Timelords" video and the link to the blog about food on the *JOIDES Resolution*.

The New Zealand educator facilitated radio interviews with the New Zealand participants. The four interviews conducted with the Co-Chief Scientist, two scientists, and the Educator will be broadcast on a local Napier, New Zealand, radio station and are also available online from http://onlineradiobox.com/nz/radiokidnappers. She also completed three short illustrated booklets for use in elementary school classrooms covering marine palynology, downhole logging, and paleomagnetism.

The American videographer published three videos that included a 20-min tour of the *JOIDES Resolution*; a laboratory profile of the micropaleontology team to supplement the "Timelords" blog written by the French Educator, and a more in-depth look at marine palynology. She is also working on several other videos, which include science lessons from Ross the penguin and a music video about sedimentology.

**Technical Support and HSE Activities**

The following technical support activities took place during Week 5.

*Laboratory Activities*

- Laboratories received cores from Site U1523, which includes Holes U1523A, U1523B, U1523D, and U1523E.
- Conducted vertical seismic profile experiment (including seismic source deployment and protected species observation) for Hole U1522A.
- The new Gestel autosampler for the GC2 is now working after updating firmware and replacing the USB cable with a serial cable.
- The Labconco freeze drier in the Chemistry Laboratory is working again. It has gone down twice during the expedition. The vacuum pump needs a new gasket.
- Found that Bluetooth technology interferes with the superconducting rock magnetometer (SRM) if used within a short radius (1–2 m) of the instrument.

*HSE Activities*

- Tested safety showers and eye wash stations.
- An abandon ship and fire drill was conducted on 2 February.