IODP Expedition 374: Ross Sea West Antarctic Ice Sheet History

Week 3 Report (14–20 January 2018)

Operations

Week 3 of Expedition 374 (Ross Sea West Antarctic Ice Sheet History) began while underway to Site U1521 (proposed Site EBOCS-01D), having completed 1371 nmi out of our 2014 nmi voyage. The *JOIDES Resolution* met the RVIB *Nathanial B. Palmer* at 1930 h (UTC + 13 h) on 14 January. The *Palmer* acted as an escort through the sea ice into the Ross Sea polynya (ice free area). At 1220 h on 15 January, the *JOIDES Resolution* cleared the southern edge of the sea ice and the *Palmer* was released from escort duty at 1300 h. The vessel arrived at Site U1521 at 0954 h on 16 January after the 2014 nmi transit from Lyttelton, New Zealand, averaging 10.8 kt. The vessel switched to dynamic positioning at 0938 h, and the thrusters were lowered and secured. At 0957 h the drill floor was cleared for operations, beginning Hole U1521A. At 1019 h an acoustic beacon was deployed.

Initial operations consisted of picking up and assembling the rotary core barrel (RCB) bottom-hole assembly (BHA), then deploying the drill string to 143.81 m below rig floor (mbrf). During deployment, the drill pipe was drifted (checked to ensure that the interior was clear) and strapped (measured). The nonmagnetic core barrels were spaced out after assembling the outer core barrel. The top drive was picked up, spaced out, and a wiper pig was inserted into the drill string. The wiper pig was pumped through the drill string with twice the annular volume of the drill string to clean any loose rust or debris from the inside of the drill string before starting to core. The calculated precision depth recorder (PDR) depth for the site was 573.4 mbrf. The core barrels were dressed with liners and a core barrel was deployed.

The drill string was lowered slowly to tag the seafloor. Hole U1521A was started at 1845 h on 16 January. The mudline core recovered 4.28 m of sediment and the seafloor tag was measured at 573.0 mbrf (562.2 m below sea level). RCB coring continued through Core U1521A-37R (352.5 m below seafloor [mbsf]). Due to reduced recovery over the previous cores, we then proceeded to cut half cores (4.8 m advance instead of 9.6 m advance) from Core 38R to 43R (352.5–381.3 mbsf) to improve core recovery. Coring with full 9.6 m advances continued from Core 44R to 71R (381.3–650.1 mbsf), at which point coring was terminated when the science objectives had been met. High viscosity mud sweeps (30 barrels) were pumped every two to four cores from Core 13R (113.0 mbsf) to 68R (611.7 mbsf).

To prepare for downhole logging after coring, the hole was cleaned with a 40-barrel high viscosity mud sweep. The rotary shifting tool (RST) was deployed and the RCB bit released in the bottom of the hole at 1505 h on 20 January. The RST was then run to reposition the bit shifting sleeve back to the circulating position. The hole was filled with 217 barrels of 10.5 ppg mud from 650.1 mbsf to the seafloor. The top drive was set back and the drill string was raised

up to 54.4 mbsf. The circulating head was then attached and the uppermost part of the hole was displaced with 20 barrels of 10.5 ppg mud. The rig floor was then prepared for logging.

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

- Magnetic susceptibility sonde (MSS);
- High-Resolution Laterolog Array (resistivity) (HRLA);
- Hostile Environment Litho-Density Sonde (with source) (HLDS);
- Hostile Environment Logging Natural Gamma-ray Spectroscopy Sonde (HNGS);
- Enhanced Digital Telemetry Cartridge (EDTC);
- Logging equipment head-q tension (LEH-QT);
- Mechanical caliper device (MCD) centralizer (2) for centralizing the Dipole Sonic Imager (DSI) and the HRLA.

The tools were assembled and tested, then lowered into the hole at 2325 h on 20 January. At the end of Week 3, we were running in the hole with the triple combo logging tool string.

Science Results

The scientists continued preparing for the initiation of coring operations by describing and making nondestructive measurements on the Antarctic legacy cores. They also received training on the scanning electron microscope and inputting samples into SampleMaster. We finalized the shipboard sampling plan for Site U1521. The Co-Chief Scientists gave an introduction to the site-specific scientific objectives and an overview of the lithologic and seismic stratigraphic framework of the Ross Sea region. Coring at Site U1521 commenced on 16 January, and by the end of the week Cores U1521A-1R through 60R (0–543.94 mbsf) had been split, described, and sampled for shipboard analyses.

The sedimentologists described cores from Hole U1521A (Cores 1R–60R) using a combination of visual core description, microscopic inspection of smear slides, core imaging, spectral color scanning, point magnetic susceptibility, and handheld X-ray fluorescence (XRF) measurements. This interval of the hole contains a sequence of interbedded massive clast-poor diatom-bearing muddy diamictite and diatom-rich to diatom-bearing mudstones. The diatom-rich mudstones are heavily bioturbated and contain rare lonestones and bivalve shells. Deeper in the hole, thicker sequences of diatom-rich to diatom-bearing heavily bioturbated mudstones alternate with massive diatom-bearing clast-poor to clast-rich sandy diamictites. The deepest diamictites recovered in this sequence contain intervals of silica cementing, which seem to be associated with more mud-rich intervals. Other diagenetic features present are carbonate cements and nodules, pyrite cements and nodules, and chert. Clast lithologies include both extrusive (basalt) and intrusive (granite and diorite) igneous rocks, mudstone, and chert. The transitions between

the mudstones and diamictites show both soft sediment and postsedimentary microfaulting and fracturing, indicating physical intermixing.

All core catcher samples from Hole U1521A were examined for diatoms, radiolarians, and foraminifers, and select samples were examined for palynomorphs (dinoflagellates, pollen, and spores) and calcareous nannofossils. The upper ~280 m of Hole U1521A yielded rich assemblages of diatoms, silicoflagellates, and ebridians. Below this, siliceous microfossils are altered to opal C/T and cannot be extracted for study. A low-diversity assemblage of poorly-preserved diatoms, some of which may have limited biostratigraphic value, occurs sporadically between ~380 and 580 mbsf. Radiolarians are present in generally low abundance in the upper ~30 m of the hole and continue to be sporadically present in trace numbers to ~260 mbsf. Diatom and radiolarian biostratigraphy indicate that the site includes a thin Pliocene–Pleistocene cover overlying an upper lower to middle Miocene section. Age diagnostic taxa are sparse below 280 mbsf and additional work is needed to develop a preliminary age model.

A total of 30 samples were processed and prepared for microscopic inspection of palynomorph assemblages. The samples yielded rare to common dinoflagellate cysts and sporomorphs. Above ~190 mbsf, dinolagellate cysts (dinocysts) are relatively abundant and diverse, and from ~190 to 320 mbsf their abundance and diversity decreases. Below 320 mbsf, samples are barren of in situ dinocysts. Foraminiferal linings are also present in some samples. Benthic foraminifers are relatively abundant in the upper part of Hole U1521, and assemblages are similar to those found in other sites previously cored in the Ross Sea. Below ~280 mbsf, foraminifers are still sporadically present, but only in trace to rare numbers. Two samples yielded very sparse calcareous nannofossils that are not age diagnostic.

The paleomagnetists measured the natural remanent magnetization of archive-half core sections of Cores U1521A-1R to 55R. The alternating field demagnetization sequence was variable for these cores and strongly depended on changes in core flow and lithology, but always included at least three steps of 0, 10, and 20 mT. In addition, detailed measurements of the demagnetization behavior of selected discrete samples were carried out to confirm magnetic results from the pass-through measurements and to determine the appropriate demagnetization sequences. The palaeomagnetists identified numerous stable normal and reversed polarity zones and work is currently ongoing to correlate these to the geomagnetic polarity timescale, aided by biostratigraphic tie points.

All cores from Hole U1521A were measured at 2.5 cm resolution on the Whole-Round Multisensor Logger (WRMSL) to collect gamma ray attenuation (GRA) bulk density and magnetic susceptibility (MS) after equilibrating to room temperature for 4 h. *P*-wave velocity was also measured on WRMSL for the first two cores of this hole, but measurements were terminated at this point due to poor contact of sediment with the core liner. Each core section was then logged for natural gamma radiation (NGR) at 10 cm intervals. The first two detectors (10 and 20 cm) from the NGR instrument were not connected during background measurements,

thus giving higher values that need to be corrected after new background measurements are complete. Thermal conductivity measurements were performed on whole-round sections prior to splitting for Cores 1R and 2R, and on working-half sections for Cores 3R to 37R. The quality of thermal conductivity measurements decreased with depth due to the presence of more consolidated sediments with irregular surfaces. Thermal conductivity measurements were terminated below Core 37R after numerous attempts to acquire values failed. Discrete *P*-wave (*x*-axis) measurements were made on every working-half section from Core 1R to 60R, except for where fractures were pervasive throughout the section. Moisture and density (MAD) were measured on 10 cm^3 plugs or cut pieces collected from the working halves (adjacent to paleomagnetic samples), at a rate of 2–4 per core; however, only samples from Cores 1R to 47R have been fully processed.

Physical properties display variations that correlate well with lithologies identified by the sedimentologists. Diamictites are commonly characterized by high GRA bulk density, NGR, MS, and thermal conductivity, whereas diatom-bearing mudstones show low MS and thermal conductivity, and lower NGR and GRA bulk density. MAD data show a decrease in porosity and increase in bulk density at ~210 mbsf, which corresponds to increases in *P*-wave velocity, NGR, and MS. Discrete *P*-wave measurements display variations that generally correspond with major reflectors identified in seismic profiles.

The geochemists collected samples from Cores U1521A-1R through 71R (0–648.17 mbsf) for shipboard routine headspace analysis, and samples from Cores 1R through 60R for organic geochemistry bulk sediment analyses (carbon, nitrogen, and calcium carbonate content). Whole-round samples for interstitial water (IW) were collected from Cores 1R to 38R (353.88 mbsf) at a rate of one sample every 1–3 cores, depending on recovery. Below Core 38R, IW content became too small for analysis. Samples were taken from Core 1R for detailed analyses of metagenomics, cell counts, metabolomics, and cultures. Headspace methane concentrations are below 12 ppmv for the uppermost 38 m and fluctuate between 15,000 and 65,000 ppmv below. The ethane concentration remains low (<20 ppmv) in the upper 300 mbsf of the site and increases up to 264 ppmv between 300 and 620 mbsf. Salinity is high at 35 in the upper 40 mbsf and drops to a constant value of 30 below 100 mbsf. Alkalinity increases over the upper ~80 mbsf, then decreases slightly below that. Sulfate content in IW indicates complete sulfate reduction in the uppermost 100 m of the hole, which is also reflected by an increase in methane below that depth, indicating a change to methanogenesis at the sulfate–methane transition zone. The total organic carbon content of sediment is generally low (<1.2 wt%) throughout the upper 270 mbsf. Except for a single sample taken from a calcite-cemented interval, carbonate content is low (<2.0 wt%) in the upper 200 mbsf and increases slightly with values up to 6.0 wt% from 200 to 380 mbsf. Throughout Hole U1521A, the C_{org}/N_{tot} ratio is in the range of 10 or higher.

The downhole measurement specialists met with the Schlumberger logging engineer, the Operations Superintendent, the Co-Chiefs, and the Staff Scientist to finalize the plan for Hole U1521A downhole logging measurements. Three logging runs are planned: (1) the triple

combination ("triple combo") to measure NGR, density, resistivity, and MS; (2) the Formation MicroScanner-sonic tool string to measure NGR, acoustic velocity, and resistivity images of the borehole; and (3) the Versatile Seismic Imager for a checkshot survey. Preparations for logging began at ~2000 h on 20 January, with the triple combo being lowered down the hole at 2325 h. At the end of the week, the triple combo was being lowered toward the bottom of the hole.

Education and Outreach

This week we hosted seven live broadcasts with classrooms from France, the United Kingdom, and South Korea, and a conference in Italy. We also continued to schedule more broadcasts. We posted four blogs on the *JOIDES Resolution* website (http://joidesresolution.org/), nine posts on Facebook (https://www.facebook.com/joidesresolution), 10 tweets and four retweets on Twitter (https://twitter.com/TheJR), and five posts on Instagram (http://instagram.com/joides_resolution). Our most popular Facebook post was the "beach" photo of the science party at the bow. Our most popular tweet on Twitter and Instagram post was three photos of an iceberg.

In terms of ongoing projects, our videographer made a video profile of one of the sedimentologists and filmed a ship tour with one of the paleontologists. She is nearly finished with the first video ("Reaching the mid-Miocene") and another series of videos. Our New Zealand educator worked on a dinoflagellate flip book with text, photos, and illustrations that can be a future educational tool. She also took a tour of the food stores with the camp boss to learn more about how the catering crew feeds ~120 people during two months at sea. Our French educator conducted many of the live broadcasts, and both educators continued to work on blog posts.

Technical Support and HSE Activities

The following technical support activities took place during Week 3.

Laboratory Activities

- Laboratories were prepared for the start of coring, which began on 16 January. By the end of the week, 71 cores had been received.
- The X-ray diffractometer (XRD) autosampler mechanical grabber is not working (the problem started during Expedition 372). With no spare on board, after contacting the vendor, samples are being loaded manually for the remainder of the expedition.
- HF usage by the palynologist has gone well, with 30 samples processed so far.
- The ship's chill water went down unexpectedly and we received no notification. The cryomagnetometer shut down, but fortunately it was noticed in time and the technical

staff were able to switch the line over to the Haskris before major problems occurred. The chill water line has since been repaired and the Engine Control Room notified to inform the Laboratory Officers and Assistant Laboratory Officers whenever the chill water goes down.

- The seismic source was prepared for the vertical seismic profile experiment, and protected species observation training was provided to all technical staff (and was attended by some scientists).

HSE Activities

- Tested safety showers and eye wash stations.
- Technical staff participated in Marine Emergency Training Squad (METS) HF spill and fire drill in the Chemistry Laboratory, working with the ship's crew emergency teams to familiarize everyone with emergency protocol.