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

**Week 4 Report (21–27 January 2018)**

## Operations

Week 4 of Expedition 374 (Ross Sea West Antarctic Ice Sheet History) began while lowering the triple combo logging tool string into the hole. The wireline heave compensator was switched on once the tools reached open hole. A downlog was performed from just above the seafloor to the total hole depth of 648 m below seafloor (mbsf). The hole was then logged up for a 126.5 m calibration pass. The tool string was lowered back to bottom (648 mbsf) and the hole was logged up. Before reaching the end of the drill pipe at 54.4 mbsf, the drill pipe was raised to 38.2 mbsf to provide additional log coverage of the upper part of the borehole before the caliper was closed and the tool string entered the pipe. The tools were pulled from the hole and were back at the rig floor at 0330 h (UTC + 13 h) on 21 January. By 0430 h the triple combo was rigged down and the Formation MicroScanner (FMS)-sonic tool string was assembled with the following tools:

- Formation MicroScanner (FMS);
- Dipole Sonic Imager (DSI);
- Hostile Environment Logging Natural Gamma-ray Spectroscopy Sonde (HNGS);
- Enhanced Digital Telemetry Cartridge (EDTC);
- Logging equipment head-q tension (LEH-QT).

The FMS-sonic tool string was deployed at 0620 h. The tool string was lowered into the drill pipe and a downlog with the FMS calipers closed began at 54.4 mbsf. Natural gamma radiation (NGR) was logged from above the seafloor to depth match the seafloor to the first logging run with the triple combo. The tool string reached the bottom of the hole at 648 mbsf. The hole was logged up from 648 to 103 mbsf with the FMS calipers open. The calipers were then closed and the tool string was lowered back to 648 mbsf. A second uplog was performed and as the tool string approached the end of the drill string, it was again raised to ~38 mbsf to log the upper part of the borehole. The FMS calipers were closed just prior to entering the drill pipe, and the tool string was recovered and disassembled by 1245 h. We then assembled the Versatile Seismic Imager (VSI) tool string for a vertical seismic profile (VSP) experiment. It consisted of the following tools:

- Versatile Seismic Imager (VSI);
- Enhanced Digital Telemetry Cartridge (EDTC);
- Logging equipment head-q tension (LEH-QT).

The VSI tool string was deployed at 1330 h on 21 January. While lowering it into the hole, the protected species watch was initiated. The seismic source was lowered into the water and a “soft start” was initiated according to mandated protocol. The VSI tool string was lowered to 648 mbsf for the first station test. The caliper was opened and data was acquired at 17 different depths in the borehole with good results. After the last station was completed at 1755 h on 21 January, the seismic source and logging tool string was recovered, and by 1930 h, all the logging equipment was rigged down.

The drilling crew then began to secure the drilling equipment for transit. After laying out the knobbies, the drill string was pulled back to the rig floor, clearing the seafloor at 2020 h. The acoustic beacon was released while recovering the drill string and was recovered at 2105 h. The rest of the drill string was recovered, three drill collar stands were racked back in the derrick, and the outer core barrel was disassembled and inspected. The rig floor was secured for transit at 2245 h on 21 January, ending Site U1521. A total of 132.75 h (5.5 d) were spent on Site U1521.

The 88 nmi transit to Site U1522 (proposed Site EBOCS-03C) averaged 10.7 kt. The vessel arrived at Site U1522 at 0629 h on 22 January. The thrusters were lowered and at 0654 h the drill floor started operations at Hole U1522A.

The rotary core barrel (RCB) bottom-hole assembly (BHA) was assembled and lowered toward the seafloor to 143.82 m below rig floor (mbrf) before the top drive was picked up, spaced out, and a core barrel deployed. The calculated precision depth recorder (PDR) depth for the site was 567.5 mbrf; however, the final seafloor depth was measured at 568.5 mbrf (557.6 m below sea level) based on the seafloor tag while starting the hole. Hole U1522A was started at 1115 h on 22 January and the mudline core (1R) recovered 2.89 m of sediment. RCB coring continued through Core 35R (337.6 mbsf). We then switched to cutting half-length cores (4.8 m advance instead of 9.6 m advance) in an attempt to improve core recovery. After poor recovery in Core 36R (9%), this strategy worked for Cores 37R and 38R (70% recovery). However, this was followed by almost no recovery in Cores 39R to 41R. We then switched back to full 9.6 m advances at Core 42R with negligible core recovery until Core 45R. Coring continued to a total depth of 701.8 mbsf (Core 77R) when science objectives were met.

While coring, 30 barrels of high viscosity mud were pumped every 2–4 cores between 145.2 and 501.3 mbsf. Due to deteriorating hole conditions, 90 barrels of high viscosity mud were pumped at 520.5 mbsf. Below 549.3 mbsf, mud was circulated on each core to try to improve hole cleaning and reduce the off-bottom torque. After terminating coring in Hole U1522A, the hole was cleaned with two 50-barrel high viscosity mud sweeps, followed by a third high viscosity sweep in an effort to improve hole conditions for downhole logging. The rotary shifting tool (RST) was lowered into the hole on the coring line to release the RCB bit at 0645 h on 27 January. Several slugs of heavy mud were pumped to offset the high pressure in the annulus. The RST was then run again to reposition the bit shifting sleeve back to the circulating position in the mechanical bit release (MBR). After shifting the sleeve in the MBR, the RST was pulled back to the surface and the sinker bars were removed from the drill string. The end of the drill string was raised up to 583.9 mbsf with the top drive installed because of the poor hole conditions. After a decrease in torque, the hole was displaced with 190 barrels of 10.5 ppg mud from 583.9 mbsf to the seafloor. The top drive was set back and the end of the drill string was pulled up to a logging depth of 91.3 mbsf while monitoring for drag. After positioning the end of pipe, the circulating head was attached and the hole was top displaced to the seafloor with 20 barrels of 10.5 ppg mud. The rig floor then prepared for downhole logging.

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

- Magnetic susceptibility sonde (MSS);
- High-Resolution Laterolog Array (resistivity) (HRLA);
- Dipole Sonic Imager (DSI);
- 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 DSI and the HRLA.

The tools were tested and lowered into the drill string at 1630 h on 27 January. The average heave was estimated to be 0.3 m just prior to logging. The WHC was turned on once the tools reached open hole. A downlog was performed from just above seafloor to 650.3 mbsf (~50 m above the bottom of the hole). The hole was then logged up with a 143 m calibration pass, run back to bottom (650.3 mbsf), and logged up to the end of the drill pipe at 91.3 mbsf. The caliper was closed prior to the tool string being pulled into the end of the drill pipe. The tool string was back on the rig floor at 2035 h on 27 January, and by 2200 h the triple combo was rigged down. The second tool string (VSI) was assembled with the following tools:

- Versatile Seismic Imager (VSI);
- Enhanced Digital Telemetry Cartridge (EDTC);
- Logging equipment head-q tension (LEH-QT).

After the VSI tool string was tested, it was lowered into the pipe at 2245 h and lowered to ~194.5 mbsf, where it was unable to pass a narrow area in the borehole. After spending 30 min attempting to pass the bridge, the week ended with tool string being brought back to the rig floor to add weight.

**Science Results**

The sedimentologists described Cores U1521A-60R through 71R, which consist of interbedded very dark greenish gray mudstone to muddy sandstone with dispersed clasts and clast-poor sandy diamictite, underlain by very dark greenish gray interbedded clast-poor sandy to muddy diamictite with slight stratification and intervals of fine lamination. Shell fragments and carbonate concretions are present. A centimeter-thick carbonate-cemented mudstone is also present in the lowermost part of the hole. The overall stratigraphy at this site is divided into seven lithostratigraphic units. Unit I consists of unconsolidated diatom ooze and mud. Unit II (~7–85 mbsf) is composed of interbedded diatomite and sandy diamictite, which is underlain by diatom-rich to diatom-bearing mudstone (Unit III; ~85–210 mbsf). Unit IV (~210–280 mbsf) comprises diatom-bearing clast-poor sandy diamictite. Unit V (~280–325 mbsf) was poorly recovered, but material that was recovered consists of mudstone and chert. Below this, Unit VI (~325–570 mbsf) consists of diamictite and interbedded mudstone, some of which is bioturbated. Unit VII (~570–648 mbsf) is composed of interbedded muddy to sandy diamictite with faint stratification.

The sedimentologists also described Cores U1522A-1R through 76R. The upper ~290 m of Hole U1522A consists of massive, dark gray clast-rich diamictite with metasedimentary and granitoid clasts. Mudstone clasts become more common in the lower part of this interval. A thin zone of interbedded diamictite and greenish gray mudstone is located near the base of this interval. Below 290 mbsf, the sediment is predominantly gray to dark greenish gray massive diatom-bearing clast-poor to clast-rich sandy to muddy diamictite. There are a few beds of mudstone, sometimes carbonate cemented, interspersed throughout the diamictite. Clasts in the upper part of this interval are dominated by mudstone. Below ~475 mbsf, clast lithology is more diverse and includes chert nodules, metasedimentary and igneous rock types, as well as basalt. Shell fragments are scattered throughout the diamictite. Near the base of the hole, the diamictite is interbedded with greenish gray mudstone and diatomite beds, some with sharp bases.

All core catcher samples from Hole U1522A were examined for diatoms, radiolarians, and foraminifers, and select samples were examined for palynomorphs (dinoflagellates, pollen, and spores) and calcareous nannofossils. Diatom valves are present throughout the hole, including abundant reworked specimens, with preservation mostly ranging from moderate to poor. A few samples contain well preserved diatoms. Radiolarians are mostly absent in the upper ~215 m of Hole U1522A, as well as from ~410 mbsf to the bottom of the hole. Between 215 and 410 mbsf, moderately preserved radiolarians are consistently present in trace to rare numbers, and a few samples contain abundant radiolarians. Despite the strong influence of reworking and fragmentation of diatom valves, several biostratigraphic marker species were identified and, together with radiolarians, provide age constraint for Site U1522. The upper ~210 m are dated to the Pleistocene based on diatoms. The Pliocene extends from ~210–400 mbsf based on both diatoms and radiolarians. The age is uncertain between 400 and 490 mbsf due to significant reworking and poor preservation. From 490 mbsf to the base of the hole at 695 mbsf is an upper Miocene sequence that also contains phytoclasts likely derived from seaweed.

A total of 20 samples from Hole U1522A were analyzed for their palynomorph content. Besides a few leiospheres noted in every sample, the dinoflagellate cysts through the section are either absent or present only in rare numbers, with the occasional appearance of reworked cysts. A single sample from ~400 mbsf contains a diverse heterotrophic and autotrophic dinocyst assemblage, suggesting productive open-water conditions. Samples below ~625 mbsf generally contain increased organic matter content, including foraminifer linings, pollen, and spores. Trace numbers of dinocysts indicate a late Miocene age, with surface water conditions conducive to high productivity. Foraminifers are very sparse through Hole U1522A. When present, calcareous benthic foraminifers are represented by a few specimens of typical late Neogene Ross Sea shelf species, many of which are likely reworked. Agglutinated foraminifers are present in every sample. A single upper Pliocene sample contains a well-preserved assemblage that includes the planktonic foraminifer *Neogloboquadrina pachyderma*.

The paleomagnetic team measured the natural remanent magnetization (NRM) of all archive-half core sections from Site U1521 (Cores 56R–71R), as well as most sections from Hole U1522A. In addition, the anisotropy of magnetic susceptibility was measured on the remaining discrete samples from Site U1521 and all newly collected cubes from Site U1522. Cube sampling resolution was reduced to ~3 per core to keep up with the core flow. At both sites, select discrete samples were chosen for detailed NRM measurements, using a 19-step alternating-field demagnetization sequence to confirm the polarity patterns identified in archive-half core sections. Poor recovery in Hole U1522A hampers development of a magnetostratigraphy; however, reversed polarity mostly characterizes the interval between 500 and 650 mbsf, which is tentatively correlated to a late Miocene interval of the geomagnetic polarity timescale.

The physical properties team collected physical property data on whole-round cores, section halves, and discrete samples for Site U1522. The *P*-wave logger was switched off for whole-round measurements due to the smaller diameter of RCB cores. In addition, thermal conductivity measurements were collected only for Core 1R, as the nature of the sediment gave poor results for the deeper cores. Physical properties for Hole U1522A cores and samples display variations that correlate well with lithologies identified by the sedimentologists. Sandy diamictites are commonly characterized by high gamma ray attenuation (GRA) bulk density, natural gamma radiation (NGR), and magnetic susceptibility (MS), whereas diatom-bearing mud/mudstone and clast-poor muddy diamictite show low MS, and lower NGR and GRA bulk density. In addition, the technical staff ran background measurements on the NGR during the transit from Site U1521 to U1522, as detector 8 was not functioning during the initial background run done prior to coring at Site U1521. Data from Site U1521 have now been calibrated using the new background measurements.

The geochemists finished remaining bulk sediment analyses of discrete samples taken at Site U1521. At Site U1522, sampling for headspace gas analyses and shore-based methane isotope investigations was performed for Cores 1R through 76R. Additional samples for organic geochemical bulk sediment analyses were taken from the main lithologies identified at Site U1522. Methane concentration increases below ~80 mbsf and varies between 1,000 and 65,000 ppmv with no clear trend. Interstitial water (IW) sampling at Site U1522 was limited to a mudline sample and five 10 cm whole-round samples taken from ~1.4, 80, 88, 98, and 215 mbsf. Squeezing of the deepest sample yielded less than 2 mL of IW so sampling was discontinued. The chemical composition of the mudline sample and the first IW sample is very different and indicates that early diagenesis occurs immediately below the mudline. Salinity and sulfate concentration decrease in the upper 100 mbsf and remain low at 215 mbsf. The ammonium concentration increases downhole. Total organic carbon (TOC) and calcium carbonate ($CaCO_3$) contents are generally low in the upper 500 mbsf (<0.8 wt% and <3.4 wt%, respectively). The TOC/total nitrogen decreases downhole from the seafloor to ~520 mbsf, which may suggest a higher contribution of marine-derived organic matter. Remaining sediment carbon, nitrogen, and calcium carbonate analyses for Site U1522 and interpretation of shipboard X-ray fluorescence (XRF) data are ongoing.

Logging of Hole U1521A included runs with three tool strings, all of which reached to the bottom of the hole. The triple combo measured NGR, density, porosity, resistivity, MS, and borehole diameter. The caliper data show that the borehole was in excellent condition, with only one washed out interval. The NGR, bulk density, and porosity data match well with measurements from the cores, whereas the MS data do not correlate as well, possibly due to temperature drift or other issues with the MSS. The second logging run consisted of the FMS-sonic tool string to measure resistivity borehole images and acoustic velocity. The latter shows good correlation to the data measured with the *P*-wave caliper, especially above 300 mbsf. The FMS images are extremely well resolved and clearly show clasts in the diamictite intervals, as well as a poorly recovered layered interval of chert and mudstone. The third logging run was the VSI to conduct a VSP experiment. Raw checkshot data were used in preliminary velocity models for initial seismic-core-log correlation.

Logging with a modified triple combination tool string that included the sonic tool and the density tool without the source was conducted in Hole U1522A. The VSI tool was then prepared and was being lowered into the borehole at the end of week 4.

**Education and Outreach**

This week, the Education and Outreach team held 10 live broadcasts with classrooms in France, the USA, Spain, and Belgium. Two scientists conducted events with the University of Vigo (Spain) and Virginia Tech University (USA). The team also continued to schedule additional broadcasts for the coming weeks, and also continued to post expedition updates to social media, including six blogs on the *JOIDES Resolution* website (http://joidesresolution.org/), 13 posts on Facebook (https://www.facebook.com/joidesresolution), 10 tweets and one retweet on Twitter (https://twitter.com/TheJR), and one post on Instagram (http://instagram.com/joides_resolution).

The New Zealand Educator produced short comic book-style documents about dinoflagellates, downhole logging, and paleomagnetism. The French Educator produced blog posts about ice, micropaleontology, and paleomagnetism. The USA Videographer made four videos: (a) a ship tour, (b) an interview with a graduate student, (c) an episode covering the transit and arrival of core on deck, and (d) an introduction to paleomagnetism. The paleomagnetism video was done in conjunction with a blog as part of an education package that can be used in classrooms.

## Technical Support and HSE Activities

The following technical support activities took place during Week 4.

*Laboratory Activities*

- Laboratories received cores from the remainder of Hole U1521A and all of Hole U1522A.
- Since the NGR background for Site U1521 was collected without detector 8 (due to a loose cable), we repeated collecting the NGR background after finishing Hole U1521A, and new background has been applied to all Hole U1521A data.
- Fume hood (C-7) in the Paleontology Preparation Laboratory stopped working. A broken switch was replaced and resolved the issue.
- Built storage space for paleontologists in the bookshelf area in the hallway across from the Paleomagnetism Laboratory.
- Freezer compressor for the Chemistry Laboratory freeze drier stopped working properly. The temperature only drops to ~3ºC, whereas it should reach −50ºC. The required refrigerant is not available on the ship. Currently continuing to troubleshoot the problem.
- Problem with Bridge Deck sink (leaky hose and problems with plumbing) resolved by replumbing the entire drain line and installing two traps.

*HSE Activities*

- Tested safety showers and eye wash stations.
- Technical staff are working with Chief Mate to finalize Marine Emergency Training Squad (METS) duties.