IODP Expedition 374: Ross Sea West Antarctic Ice Sheet History

Week 6 Report (4–10 February 2018)

Operations

Week 6 of Expedition 374 (Ross Sea West Antarctic Ice Sheet History) began while preparing to pull the drill string out of Hole U1523E to complete operations at Site U1523. After pumping a 30-barrel mud sweep, we left the top drive installed while pulling the drill string out of the hole due to unstable hole conditions causing excessive torque and overpull. After clearing the seafloor at 0150 h (UTC + 13 h) on 4 February, the top drive was set back and the drill string retrieved to the vessel. The acoustic beacon was released and recovered at 0450 h and the rig floor was secured at 0547 h, ending operations in Hole U1523E and Site U1523. A total of 147.50 h (6.15 d) was spent on Site U1523.

We departed for Site U1524 (proposed Site RSCR-10A), which is an alternate site for the original primary proposed Site RSCR-02B. We decided to occupy the alternate site because the highest priority target is shallower, the seismic facies show less evidence of transported sediment, and the sea-ice edge is further away. After a 52 nmi transit averaging 11.1 kt, the vessel arrived at Site U1524 at 1027 h on 4 February. The thrusters were lowered and secured and the drill floor was cleared for operations at 1044 h, beginning Hole U1524A. The acoustic beacon was deployed at 1100 h.

We picked up the advanced piston corer (APC)/extended core barrel (XCB) bottom-hole assembly (BHA) and began to lower it toward the seafloor. Since this site is in deeper water than the previous site, some of the drill pipe was drifted (checked to ensure that the interior was clear) and strapped (measured) while being deployed. After positioning the drill string with the bit at 2400 m below rig floor (mbrf) based on the precision depth recorder (PDR) depth for the site, we installed the Icefield orientation tool with the sinker bars. We then deployed a nonmagnetic APC core barrel and started Hole U1524A at 2025 h on 4 February. Core U1524A-1H recovered 4.02 m of core, indicating a seafloor depth of 2394 m below sea level (mbsl). Oriented APC coring continued through Core U1524A-30H (270.3 m). After Core 30H recorded a partial stroke indicating piston core refusal, we removed the Icefield orientation tool and switched to the half-length APC (HLAPC) to collect Core 31F. This core also recorded a partial stroke and recovered only 0.4 m of sediment. We then switched to the XCB coring system and cut Cores 32X to 34X to 299.5 m; all XCB core liners were shattered upon recovery resulting in highly disturbed sediment. At that point we had to terminate coring and pull out of the hole due to approaching sea ice. After pulling the bit up to 249.5 m, we set back the top drive and continued to pull out of the hole, clearing the seafloor at 0950 h on 6 February ending Hole U1524A. Overall recovery in Hole U1524A was 282.35 m (94%). We attempted to retrieve the acoustic beacon while pulling out of the hole, but it would not release.

With ~1.5 h of time left before arrival of sea ice, we decided to collect a single mudline core for high resolution interstitial water and microbiological studies. We moved the vessel 20 m east of Hole U1524A and started Hole U1524B at 1155 h. Core U1524B-1H collected 7.76 m of sediment, establishing a seafloor depth of 2394 m. We then terminated Hole U1524B as the sea ice continued to approach and began to retrieve the drill string back to the ship. The dynamic positioning system was engaged at 1215 h to move away from the ice. The drill collar stands were secured in the derrick and the BHA components were disassembled and inspected. After the bit cleared the rig floor, the remaining rig floor equipment was secured at 2030 h on 6 February, ending Hole U1524B. A total of 57.75 h (2.4 d) was spent at Site U1524B.

We departed for Site U1525 (alternate proposed Site RSCR-03A) at 2030 h on 6 February. We decided to go to Site RSCR-03A because it is close to Site U1524 (47 nmi) but outside the sea ice edge, and the Ross Sea unconformity RSU3 (primary objective at our previous Site U1524) is located at a shallower depth. After a 50 nmi transit (including a small deviation in course to navigate around sea ice) that averaged 8.9 kt, we arrived at Site U1525 at 0200 h on 7 February. The thrusters were lowered and secured and the drill floor was cleared for operations at 0215 h, beginning Hole U1525A. We did not deploy an acoustic beacon at this site. After preparing the APC/XCB BHA, we lowered the drill string toward the seafloor. The calculated PDR depth for the site was 1790.8 mbrf. We picked up the top drive and lowered the drill bit to tag the seafloor. Since the tag indicated the seafloor was soft, we prepared a nonmagnetic APC core barrel and positioned the drill bit at 1786 mbrf. Hole U1525A was started at 1000 h on 7 February. Core U1525A-1H recovered 8.62 m of sediment, establishing a seafloor depth of 1776 mbsl. We continued to APC core with nonmagnetic core barrels through Core 4H (28.9 m), which was a partial stroke. We switched to the half-length APC (HLAPC) coring system to collect Cores 5F through 8F (28.9–43.0 m). Since Core 8F was a partial stroke with no recovery, we switched to the XCB to cut Cores 9X and 10X (43.0–55.7 m) to get through an indurated zone. We then switched back to the HLAPC system for Cores 11F to 15F (55.7–79.2 m). With continued success piston coring, we switched back to full length APC core barrels and collected Cores 16H through 19H, which penetrated to 111.8 m. Since Core 19H recorded a partial stroke, we advanced 4.1 m based on recovery and switched to the half-length APC (HLAPC) coring system, collecting Cores 20F to 24F (111.8–131.2 m). Core 24F also recorded a partial stroke, indicating HLAPC refusal, so then we switched to the XCB coring system. The remainder of the hole was cored with the XCB system, cutting Cores 25X to 33X to a total depth of 213.2 m. We experienced multiple shattered core liners using the XCB system, which we suspect resulted from a combination of very cold seawater (−1.7°C) circulating through the hole and the small space between the core liner and the core barrel, which allows vibration. Since ice conditions at Site U1524 were forecast to improve over the next 24 h, we opted to terminate coring after Core U1525A-33X. We pulled the drill string out of the hole, clearing the seafloor at 2150 h on 8 February. After conducting routine rig maintenance (slip and cut of 115 ft of drill line), the remainder of the drill string was retrieved and the rig floor was secured at 0535 h on 9 February, ending operations at Site U1525. The total time spent at Site U1525 was 51.25 h (2.1 d).

The transit back to Site U1524 covered 47 nmi at an average speed of 10.7 kt. We arrived at Site U1524 at 1006 h on 9 February and the vessel was positioned over the acoustic positioning beacon that we had left there. We prepared a rotary core barrel (RCB) BHA and lowered the drill string towards the seafloor. After the drill bit reached 1766 mbrf, we deployed the subsea camera to recover the seafloor beacon since its release had failed when we had previously abandoned the site due to approaching sea ice. We lowered the drill string to near the seafloor, maneuvered the vessel to the beacon, and captured it with a grapple hanging from the camera frame. We recovered the subsea camera to the ship, with the beacon arriving on deck at 1915 h on 9 February. After securing the subsea camera we continued to prepare for drilling operations. We dropped an RCB core barrel with center bit and started Hole U1524C at 2110 h on 9 February. The hole was advanced by drilling without coring to 260.5 m. A 30-barrel high viscosity mud sweep was pumped at the end of the drilled interval and the RCB core barrel with the center bit was retrieved. We started RCB coring and cut Cores U1524C-2R through 14 (260.5–384.3 mbsf) by the end of Week 6.

Science Results

The sedimentologists described cores from Holes U1524A (Cores 1H through 34X) and U1525A (Cores 1H through 33X) using a combination of visual core description, microscopic inspection of smear slides, core imaging, spectral color scanning, point magnetic susceptibility, and X-ray diffraction (XRD). Hole U1524A consists of interbedded massive to laminated diatom-bearing/rich mud and mud-bearing diatom ooze. The sequence is characterized by centimeter- to meter-scale color alternations between brown/light brown and greenish gray sediment near the top of the hole, changing downhole to alternations between olive gray and greenish gray sediment. The olive gray beds are usually thicker (decimeter to meter scale) with sharp basal contacts. Sand/silt stringers and lenses are common, particularly in laminated intervals of the olive gray mud. The greenish gray beds are usually burrowed and show gradational lower contacts. Pyrite stains, mottling, and occasional clasts are also present throughout the sequence.

Hole U1525A consists of diatom-bearing massive sandy mud with dispersed clasts and clast-poor/rich muddy diamict in the upper ~100 m. The sequence below is similar to that cored at Site U1524 and consists of interbedded diatom-bearing/rich mud, diatom-rich sandy mud, diatom ooze, and diatom-rich sandy diamict. The sandy diamict typically coarsens upward and is interbedded at decimeter scale with the sandy mud. Color alternations also characterize the sediment at this site, with color alternating between greenish gray and dark greenish gray. Greenish gray sediment typically exhibits gradational lower contacts, whereas dark greenish gray beds typically have sharp basal contacts. Laminae occur as mud and fine sand couplets and sand stringers and lenses are common within laminated mud beds. Pyrite stains, mottling, and occasional (dominantly mudstone) clasts are also present throughout the sequence.

The paleontologists examined core catcher samples from Holes U1524A and U1525A for diatoms, radiolarians, foraminifers, and palynomorphs (including dinocysts, pollen, and spores). A few samples were also examined for calcareous nannofossils. At Site U1525, the uppermost ~80 mbsf contains a mix of reworked and in situ diatom assemblages that hamper age assignment; however, a series of last appearance datums suggest a Pleistocene age for this interval. Poorly preserved radiolarians are also present, but only in trace numbers. Between ~100 and 150 m, radiolarians are more abundant and better preserved, dinoflagellates are present in rare numbers, and foraminifers are also present. Diatom and radiolarian assemblages suggest an early Pleistocene age for this interval, although the location of the Pliocene/Pleistocene boundary is difficult to place. Several samples within this interval yield particularly diverse dinocyst and foraminifer assemblages, and calcareous nannofossils consistent with a Neogene age assignment were also found in one sample. Below ~150 m, radiolarians, dinocysts, and foraminifers are absent or present only in trace numbers. Diatoms are somewhat more abundant and suggest a Pliocene age for the base of the hole. The sequence is very similar at Hole U1524A. The uppermost core contains a late Pleistocene diatom assemblage, but below that there are significant proportions of reworked taxa down to ~80 m. Below the reworked interval, diatom assemblages indicate a Pliocene to lower Pleistocene sequence for the remainder of the hole.

The paleomagnetists measured the natural remanent magnetization of all archive-half sections from Holes U1524A and U1525A. The alternating field (AF) demagnetization and measurement sequence was reduced to 0, 10, and 20 mT peak AF demagnetization to keep up with core flow, but is still detailed enough to evaluate potential variations in coercivity at these sites. Oriented discrete samples (up to 3–4 samples/core) were collected to test the fidelity of the magnetostratigraphy and to determine the magnetic fabric. The magnetostratigraphies of Holes U1524A and U1525A are correlated to the geomagnetic polarity timescale, aided by biostratigraphic datums, which indicate an upper Pliocene to Pleistocene sequence. Most of the cores from Sites U1524 and U1525 have an oblate anisotropy of magnetic susceptibility fabric with a vertical minimum axis that indicates compaction, which is common in sedimentary settings.

The physical properties team collected physical property data on whole-round cores, section halves, and discrete samples for Holes U1524A and U1525A. The *P*-wave logger (PWL) was used for whole-round core sections collected with the APC and HLAPC coring systems. Thermal conductivity and shear strength measurements were carried out successfully on cores from both sites. At Site U1524, bulk density and natural gamma radiation (NGR) show a downhole increase over the upper ~50 m. Porosity decreases from ~80% near the seafloor to ~60% at 50 m, indicating compaction of this interval. Below this, there is a general downhole trend of decreasing magnetic susceptibility (MS), NGR, bulk density, and *P*-wave velocity, and a small increase in porosity. This change could be related to increased diatom content in the sediment. At Site U1525, there is a distinct change in physical properties at ~50 m. Above this depth, bulk and grain densities are higher and porosity is low (~40%). NGR shows a general increase over this interval, which corresponds to dominantly diamict lithologies. Within the diamict there is an overcompacted interval a few meters thick with high bulk density, MS, NGR, and *P*-wave velocity. Below ~50 m, NGR shows an overall downhole decrease and bulk density, MS, and NGR exhibit cyclicity that is likely related to downhole lithological variations of mud, sandy mud, and diatom ooze.

The geochemists collected samples from Holes U1524A and U1525A for shipboard analyses of headspace gas, interstitial water (IW) geochemistry, and bulk sediment geochemistry. Samples were also collected from both holes for shore-based microbiological studies. Hole U1524B consisted of a single core sampled for high-resolution IW and microbiological studies. At Site U1524, methane concentration is very low in the upper 80 m, and increases below that depth, concomitant with a decrease in IW sulfate concentration and abrupt increase in barium concentration. Alkalinity shows a linear increase over the upper ~90 m. At Site U1525, methane is very low in the upper 140 m, and increases slightly below that depth. Sulfate decreases to below detection limit below 140 m, whereas alkalinity shows a linear increase over this interval. Magnesium concentration shows a general downhole increase. Bulk sediment total organic carbon (TOC) and calcium carbonate ($CaCO_3$) contents are generally low (<0.6 wt% and <5 wt%, respectively) at both sites. Diatom-bearing/rich mud generally has increased TOC and $CaCO_3$ content in the upper 150 m of Hole U1524A. TOC/total nitrogen ratios at both sites suggest a mixed source (marine and terrigenous) of the organic matter.

The downhole measurements team received the processed logging data for Hole U1523D from shore. Borehole conditions were reasonable in Hole U1523D; however, the caliper data identified a number of minor washouts where measurements such as resistivity may be affected. The gamma ray and resistivity data show clear alternations of high and low measurements throughout the borehole that might correspond to alternating layers of fine and coarse sediments. As core recovery below ~130 m was very poor at this site, the postcruise analyses of the log data are expected to provide critical formation information.

Education and Outreach

This week, the Education and Outreach team conducted 13 live broadcasts with schools in Italy (1), Portugal (1), United Kingdom (2), United States (3), France (4), and New Zealand (2). We also posted five blogs on the *JOIDES Resolution* website (http://joidesresolution.org/): "Tracking the age of the core," "The crucial role of ice shelves," "Calm at Sea," "Celebrating 60 years of Antarctic scientific research and 50 years of scientific ocean drilling," and "360° video: core on deck." All three members of the Education and Outreach team continued to make posts to social media, including Facebook (https://www.facebook.com/joidesresolution), Twitter (https://twitter.com/TheJR), and Instagram (http://instagram.com/joides_resolution).

The New Zealand educator published an article about the expedition titled "Discovering the secret past of Antarctica" on the New Zealand Science Learning Hub. She continued to work on her illustrated booklets for school classrooms and began to add classroom activities to go with each booklet. She also scheduled additional New Zealand radio interviews with shipboard scientists. The French educator continued to work on blogs, including several that will highlight different shipboard laboratories. She is developing activities to go with these blogs in conjunction with the scientists, and our videographer is making a short video to go with each blog and activity.

Our American videographer posted several videos that feature micropaleontology and marine palynology, as well as a 360° tour of the ship. She also put together a video of the science party learning and singing a traditional Maori song to celebrate Waitangi Day (6 February).

Technical Support and HSE Activities

The following technical support activities took place during Week 6.

Laboratory Activities

- Laboratories received cores from Site U1524 (Holes U1524A–U1524B) and Site U1525 (Hole U1525A).
- We reinforced coverage of the catwalk to keep it warmer.
- One detector (for cations) on the Metrohm Ion Chromatograph has been acting up. The anion detector is still working and the ICP–AES also produces cation data. A new detector has been requested.
- The third-party handheld XRF accidentally fell and now displays an error. After contacting vendor, we determined that it requires a service call, so XRF scanning has ceased.
- We conducted “tech for a day” training for two educators.

HSE Activities

- Tested safety showers and eye wash stations.
- An abandon ship and fire drill was conducted on 10 February.