IODP Expedition 379: Amundsen Sea West Antarctic Ice Sheet History

Week 5 Report (10–16 February 2019)

This week was spent conducting operations in Holes U1532D, U1532E, U1532F, and U1532G. In Hole U1532D, we drilled without coring to 362.7 m and then rotary core barrel (RCB) cored 19.2 m (17.4 m recovered; 91%) before ice forced us to pull out of the hole. Holes U1532E and U1532F were drilled without coring to 101.6 and 321.4 m, respectively, but had to be abandoned due to ice before RCB coring could begin. In Hole U1532G, we drilled without coring to 372.3 m, below which RCB Cores 2R to 14R penetrated to 497.1 m and recovered 114.89 m (92%). Drifting ice, occasionally combined with adverse weather, caused multiple interruptions to coring operations that totaled 4.3 d and forced us to abandon Holes U1532D, U1532E, and U1532F. All times in this report are in ship local time (UTC – 3 h).

Operations

After penetrating to 362.7 m in Hole U1532D and then waiting for ice at the end of last week, we deployed an RCB core barrel at 0000 h on 10 February and started coring. Cores U1532D-2R to 3R penetrated 19.2 m (362.7–381.9 m) and recovered 17.42 m (91%). At 0415 h on 10 February, approaching ice forced us to raise the bit back up to just below the seafloor. The ice kept converging, so we pulled the bit completely out of Hole U1532D at 0605 h on 10 February. Instead of waiting for the ice to pass and allow us to resume operations, we decided to move ~0.4 nmi to the northwest along the seismic reflection profile and start a new hole. After waiting until 1145 h for ice to clear the area, we started drilling without coring in Hole U1532E, and the bit reached 101.6 m at 1445 h on 10 February. Increasing winds, snow, and swell that made it difficult to visually track smaller pieces of ice (which do not show up on radar) combined with larger ice in the area made us pause operations and raise the bit up to just below the seafloor (48.6 m). Unfortunately, at 1830 h on 10 February approaching ice forced us to pull the bit completely out of Hole U1532E. We raised the bit to 105 m above the seafloor to wait for the ice to move out of the area. We took advantage of this downtime to conduct routine servicing of the drill line (slip and cut). We moved back near the location of Holes U1532A–U1532D and started drilling without coring in Hole U1532F at 2315 h on 10 February. Our plan was to start RCB coring at ~378 m, just above the maximum coring depth in Hole U1532D. We drilled without coring from the seafloor to 105.1 m, at which point we had to stop to fix a hydraulic hose in the top drive. When the bit had reached 321.4 m (at 1630 h on 11 February), approaching ice forced us to stop drilling, recover the RCB core barrel with center bit, and raise the bit back up to just below the seafloor (45.5 m). We wanted to deploy a free-fall funnel (FFF), but the ice was converging on our position too quickly and there was not enough time to deploy it. We pulled the bit out of the seafloor at 1921 h on 11 February and waited for ice to clear the area with the bit just above the seafloor. At 0900 h on 12 February, we decided that due to the frequency of ice

interruptions, a reentry system more substantial than a FFF would be required for the multiple reentries needed to core deeply. So, we removed the top drive and recovered the drill string with the bit arriving back on the rig floor at 1845 h on 12 February. While the drill string was being recovered, we started preparing the parts of a free-fall reentry system (a casing shoe, one joint of casing, the mud skirt, the outer structural parts of the hydraulic release tool, and the FFF cone). As soon as the bit was back on board, we spent the rest of the day assembling the reentry system in the center of the moonpool beneath the rig floor.

We completed assembling the free-fall reentry system at 0115 h on 13 February, and then started lowering the RCB drilling assembly through the middle of the reentry system and to the seafloor. After starting Hole U1532G at 0920 h and penetrating to 51.9 m, we dropped the reentry system at 1100 h on 13 February. We continued drilling without coring to 161.5 m but had to pause operations due to approaching ice from 1730 to 1815 h. After spending ~1 h clearing ice from the wireline seal in the top drive, we resumed drilling. When the bit had reached 171.2 m at 1945 h on 13 February, approaching ice forced us to pause operations again and raise the bit back up to 54 m.

At 0345 h on 14 February, we had to pull completely out of Hole U1532G. At 0700 h on 14 February, we adjusted the bit depth for reentry, deployed the subsea camera system, and reentered Hole U1532G at 1005 h. We recovered the camera system and started lowering the drill string. When the bit reached 201.5 m at 1345 h, we had to raise the bit back up to 45.5 m due to approaching ice. After the rig floor was cleared to resume operations at 1630 h on 14 February, we lowered the bit back down to the bottom of the hole and resumed drilling without coring.

At 0345 h on 15 February, we reached the depth where we wanted to start coring (372.3 m). After clearing ice from the wireline seal in the top drive and sinker bars, we recovered the RCB core barrel with the attached center bit and started RCB coring. Once Core U1532G-3R arrived on deck, approaching ice forced us to pause operations at 1100 h on 15 February. We resumed coring at 1330 h on 15 February. After Core 14R (487.5–497.1 m) arrived on the rig floor at 1315 h, approaching ice forced us to stop coring. We raised bit up to 65 m and spent the rest of 16 February waiting for the ice to clear the area.

Science Results

Lithostratigraphy

Cores U1532D-2R and 3R and Cores U1532G-2R through 7R were X-rayed and images were examined. Cores U1532D-2R and 3R, and Cores U1532G-2R through 4R were split and described. The RCB cores were of good quality with generally only slight to moderate core disturbance. The sediments consist of dark gray thinly laminated silty clay with one interbed of

greenish gray silty clay with dispersed sand and granules. Cores U1532D-2R and 3R comprise a correlative sequence with the lowermost sediments recovered in Hole U1532C.

For the sediments described from Holes U1532A–U1532D, six facies and two subfacies were defined based on lithologic descriptions. Also, petrological and mineralogical characterization of the silt- to pebble-sized fractions was carried out, clay mineralogy data were acquired and analyzed, and thin sections were prepared and analyzed. Sediment appears highly bioturbated with discrete zones of variable grain size present throughout the matrix.

The lithologic facies include (1) color banded silty clay/clay, (2) thinly laminated silty clay/clay, (3) massive, bioturbated silty clay, (4) sandy mud to clast-poor diamict, (5) mud with biosiliceous microfossil fragments, and (6) foraminfer-bearing to foraminifer-rich mud. Subordinate facies include thinly laminated to very thin beds of silt and sandy silt.

The most prominent lithofacies transition is at 92 m in Hole U1532A, where horizontally laminated and color banded brown and gray silty clays change over to a relatively uniform succession of dark gray laminated silty clays interbedded with greenish gray silty clay. The clay mineralogical composition also significantly changes at this same depth. Below 92 m, there is a strong correlation between lithofacies, magnetic susceptibility, color reflectance, and clay mineral composition.

Biostratigraphy

Micropaleontology samples were analyzed from core catcher and selected split core samples from Cores U1532C-28X to 33X (~330–392 m), Cores U1532D-2R and 3R (368.36–381.23 m), and Cores U1532G-2R to 5R (~372–410 m). Samples were generally barren of diatoms and other siliceous fossils, calcareous nannofossils, and foraminifers. Exceptions include a sample at 377.2 m and samples from within a low-density, bioturbated horizon at ~406 m, which contain trace-to-rare occurrences of diatoms. Rare in situ dinoflagellate cysts were present in all samples examined, and reworked marine and terrestrial palynomorphs of Cretaceous–Paleogene age were common.

Few age-diagnostic microfossils were identified in the interval between ~330 and 410 m, but diatoms present within Section U1352G-5R-4 (~406 m) indicate an early Pliocene age (<4.85 Ma). We compared radiolarian assemblages recovered from Holes U1532A–U1532C to Pliocene assemblages recovered from Kerguelen Plateau (Legs 120 and 183) and the Weddell Sea (Leg 113), and the assemblages documented at Site U1532 are consistent with our interpreted Pliocene age based on the diatom data.

Paleomagnetism

All archive-half sections from Hole U1532D were measured on the pass-through superconducting rock magnetometer. Three oriented discrete samples were collected from working-half sections. Natural remanent magnetization (NRM) intensity ranges from ~10^{-2} to

~10^{-1} A/m. Both NRM intensity and magnetic susceptibility (MS) values decrease by ~75% from ~364 to ~370 m. All archive-half data show normal polarity at the 20 mT demagnetization level, indicating that the base of Hole U1532D must be younger than the beginning of the Nunivak subchron (C3n.2n; 4.6 Ma). Results from alternating field demagnetization of the discrete samples confirm these findings.

Petrophysics

Density and MS measurements were collected from Cores U1532D-2R and 3R using the Whole-Round Multisensor Loggers at a 2 cm interval. *P*-wave velocity of whole-round core sections was not measured due to incomplete filling of the core liner. Natural gamma radiation was also measured on whole-round cores at an interval of 10 cm. Additionally, one thermal conductivity measurement was conducted on a split core section. Moisture and density (MAD) measurements were made on six discrete samples, and 43 *P*-wave caliper velocity measurements were made on split core sections. Continuous and distinctive variations in MS provided clear correlation tie points between Holes U1532C and U1532D.

Anomalously low bulk and grain densities were observed from 18 previously measured MAD samples due to high water retention from clay-rich sediments. These samples were placed back in the oven for 48 h of additional drying to remove any remaining interstitial water (IW) and then measured for dry mass and dry volume.

Geochemistry

We measured major cations, anions, and nutrients of IW from Holes U1532B and U1532C. The downhole profiles of SO_4, K, Na, and Mg show a decreasing trend with depth while Ca increases. Principal component analysis (PCA) was carried out for the major cation and trace element data to recognize the dominant factors that control the distribution and behavior of the IW chemical components, and these factors were compared with other data such as clay mineralogy, MS, and diatom abundance. Our analysis shows that Fe and $H_4Si(OH)_4$ correlate to higher diatom abundance in the sediments between 100 and 250 m.

Headspace gas sampling to monitor for light hydrocarbons documented only very low methane concentrations, as observed in the preceding holes. Bulk geochemical analyses of discrete samples from Holes U1532B–U1532D show that total organic carbon, total nitrogen, and total sulphur remain low and show little variability with depth. The total inorganic carbon content continues to be highly variable in Hole U1532B and increases to an average of ~2 wt% in the lower section of Hole U1532C.

Outreach

The Outreach Officers continue to document the expedition with photos, videos, writings, and comics. Translations of comics to Japanese, Spanish, and Hindi have been posted. A French comic is ready to be posted, and Filipino and Mandarin drafts were received. Comics will be translated into a total of ten languages. The second and third in the fruitcake/sedimentology/core description series of #AntarcticLog comics have been posted. Social media (Facebook [https://www.facebook.com/joidesresolution], Twitter [https://twitter.com/TheJR], and Instagram [http://instagram.com/joides_resolution]) continue to be updated as internet connectivity allows. Work is continuing on large-format comics about the Co-Chief Scientists. Photographs and comics are being sent to the Scientific Committee for Antarctic Research (SCAR). Blogs are being submitted to the British Antarctic Survey (BAS) and the Geological Society of London for promotion of the expedition through their channels. Scientists and IODP JRSO technical staff blogs have been sent to shore for posting by shore-based staff. Co-Chief Scientist Karsten Gohl was filmed for the German TV station ZDF and the footage will be sent to shore when connectivity allows. Media interviews are being scheduled for the final section of the trip when we should have more reliable internet. Postcruise videos are being planned and filmed.

Technical Support and HSE Activities

Staff continued supporting science activities at Site U1532.

General Activities

- Caver Hydraulic Jacks: Work continued on the hydraulic jack overhaul.

Laboratory Activities

- Chemistry:
  - IW Squeezer: Replaced leaking hydraulic jack with a newly rebuilt system.
- Physical Properties:
  - Velocity Experiments: Experiments completed and results submitted to shore.
- X-Ray Imaging:
  - Automated X-ray imaging successfully deployed to image Hole U1532G cores using the IMS software to control positioning and image capture.
  - Staff implemented a fiber optic switch to turn on the external “X-ray on” warning light.

Application Support Activities

- Drilling Report: Fixed issue with “end times” not transferring to next shift correctly.
- CorrelationDownloader: Work continued to migrate application to Java 11.

- JAVA Actors: Effort to convert the JAVA Actors from LDAC have stalled. Unable to pull MAVEN code resources from shore repository due to internet outages.

IT Support Activities

- Chemistry: The communication switch that allowed the GC2 computer to switch between instrument's and ship's network failed. Replacement unit was installed, which resolved the matter.
- VSAT: Major outages from 11 through 13 February because of weather and latitude. No issues with equipment.
- CommVault: Encountered two incidents where the CommVault Application Manager hung, stopping routine backups. Currently investigating the matter.
- Outlook Errors:
    - Investigated unusual Outlook error messages; campus IT provided suggested fixes that were unsuccessful.
    - Problems with changing personal password for Outlook are being investigated. Error messages were packaged and sent to shore for research. A ticket has been opened with campus.
- Network Authentication: Users unable to self-authenticate when accessing ship's network for the first time with their personal equipment. Error messages were packaged and sent to vendor for ongoing assistance and resolution.

HSE Activities

- Weekly fire and boat drill postponed due to weather.