IODP Expedition 382: Iceberg Alley and Subantarctic Ice and Ocean Dynamics

Week 6 Report (21–27 April 2019)

Week 6 of the International Ocean Discovery Program (IODP) Expedition 382, Iceberg Alley and Subantarctic Ice and Ocean Dynamics, was spent coring and drilling at Holes U1536E (559.0–645.4 mbsf; 15.4 m recovered, 18%) and U1537A (seafloor to 154.5 mbsf; 160.0 m recovered, 104%). Hole U1536E reached middle Miocene strata, and we deployed downhole geophysical logging tools in it. Site U1537 is 20 nmi north of Site U1536, and the stratigraphy down to 160 mbsf at Hole U1537A is similar to that at Site U1536, but does not contain the short slumped intervals present at the former site. During the week, drilling operations stopped for ~50 h because of icebergs and ~7 h because of bad weather conditions. All times in this report are in ship local time (UTC – 3 h).

Operations

At the beginning of the week we were standing by with the drill string at ~50 mbsf in Hole U1536E, waiting for icebergs to clear the area. Icebergs continued to stay close enough to prevent drilling through most of the day, with projected closest points of approach within 3 nmi of the ship. At 2145 h an iceberg moved to within 1.6 nmi of the ship on a trajectory to move closer, so we had to raise the drill string out of the hole and move aside 0.5 nmi to the west–northwest to let the iceberg pass.

By 0730 h on 22 April, the iceberg had moved clear of Site U1536, and we were able to move back to the site. However, sea conditions were rough and vessel heave was up to 4.3 m, which was too high to safely prepare the subsea camera to guide reentry into Hole U1536E. By 1100 h the seas had calmed enough and the subsea camera was deployed at 1245 h. Although the free-fall funnel had sunk into the soft seafloor sediments and/or had been covered by cuttings, the caved space above the funnel was clearly visible.

We reentered Hole U1536E at 1415 h and washed down to 559 mbsf, the current depth of the hole, after removing 22 m of fill. From 2145 h to midnight we waited with the drill string near the base of the hole while tracking two icebergs with a projected closest point of approach of less than 5 nmi, but they did not move closer than that, allowing us to resume coring. Cores U1536E-25R to 26R penetrated from 559.0 to 578.2 mbsf and recovered 5.1 m (27%). At 0800 h on 23 April, an iceberg entered the red zone and continued on a path towards the ship. We raised the drill string clear of the seafloor at 1035 h and moved ~0.5 nmi to the east.

By 1315 h the iceberg had moved clear of the site, so we repositioned and reentered Hole U1536E at 1605 h. After clearing 16 m of soft fill and 4 m of hard fill from the bottom of the hole, we resumed coring again at 0010 h on 24 April. Cores 27R to 33R penetrated from 578.2 to

645.4 mbsf and recovered 10.3 m (15%). At 1715 h, after recovering Core 33R, we decided to stop coring and log the hole to fill stratigraphic gaps in core recovery. The weather forecast predicted relatively calm seas until noon on 25 April, and although there were icebergs on the radar, they were not close or moving in our direction. This rare combination of conditions would permit a long enough time window for downhole logging.

In preparation for logging, we pumped cuttings out of the hole with a 30 bbl mud sweep, released the bit at the bottom of the hole, filled the hole with barite-weighted mud, and raised the drill pipe to the logging depth of 84 mbsf. The "quad combo" logging tool string was assembled by 0400 h on 25 April. It consisted of tools to measure the magnetic susceptibility, natural gamma radiation, electrical resistivity, sonic velocity, and density of the formation. We waited until 0630 h for an iceberg to pass the ship; its closest point of approach was ~5 nmi. We then started to lower the logging tool string down to the seafloor. At 0830 h we started logging Hole U1536E while lowering the tool string down at 550 m/h, reaching 643 mbsf (~3 m above the bottom of the hole). At 1000 h we made a second logging pass while raising the tool string back up, also at 550 m/hr. The wireline heave compensator would not start correctly, and given the time constraints, we decided to log without using it. Ship heave was ~2.5 m during logging, which was enough to cause depth discrepancies of a similar magnitude in the logging data. The borehole diameter was wider than 17 inch from 84 to 420 mbsf. The logging tools were recovered and had been disassembled by 1515 h. The drill string was raised to the ship, which completed operations at Hole U1536E.

At 0145 h on 26 April we started the 20 nmi transit to Site U1537 (proposed Site SCO-18A), arriving 3.5 h later. We selected Site SCO-18A because the top ~150 m of the stratigraphy appears to be uninterrupted by thin slumped intervals compared to the other possible sites, as seen in the seismic and echo sounder profiles. We started to make up the bottom-hole assembly, but high heave and roll forced us to pause operations for ~7 h. Additionally, we had to move ~1 nmi to the northwest to allow an iceberg to pass over the site location. Operations resumed at 1430 h and we lowered the drill string to the seafloor.

We started Hole U1537A at 0140 h on 27 April, at 3712.9 m below sea level as calculated from the mudline. Cores U1537A-1H to 17H penetrated from the seafloor to 154.5 mbsf and recovered 160.0 m (104%). The seas were relatively calm, and no icebergs were projected to pass within 5 nmi of the ship, allowing uninterrupted coring operations for the rest of the day.

Science Results

Lithostratigraphy

Cores from Holes U1536C and U1536E were described visually and imaged with the X-ray scanner. Three major lithologic units were identified. Unit I, from the seafloor to ~250 mbsf,

consists of interbedded diatom oozes and silty clays. Diatom ooze dominated the sediment until about 120 mbsf. The terrigenous component in the oozes was generally below 25% and the biogenic component (mainly diatoms) in the silty clays typically exceeded 25% of the sediment. Unit II, ~250–550 mbsf, is almost exclusively silty clay with varying amounts of biosilica. Lithification increased downcore. Unit III, from ~550 mbsf to the base of Hole U1536E at 643 mbsf, consists of semi- to fully-lithified mudstone, some with biosilica, and beds of limestone, some of which were nannofossil bearing to nannofossil rich. Throughout, gravel to pebble-sized ice-rafted debris was rare to common and was clearly visible in the X-radiographs. Many intervals in Hole U1536E are characterized by a noticeably higher abundance of visible dropstones, many of which are fine-grained sedimentary rocks.

Biostratigraphy

Diatoms and radiolarians were found in most core-catcher samples. The deepest sample, U1536E-33R-CC, revealed that sediments recovered at this site date back to the mid-Miocene. Two samples (U1536E-28R-1A, 40 cm, and U1536E-28R-CC) were barren of diatoms, but we were able to identify a biostratigraphically significant calcareous nannofossil, which occurred in relatively high abundance, dating these sediments at 8.6–10.8 Ma. There is a possible hiatus between Samples U1536E-30R-CC and 31R-CC. Diatom and radiolarian preservation and abundance generally declined downhole. Palynomorphs (dinocyst, acritarch, prasinopytes, pollen, spores, copepod, and fungi remains) were identified within many samples. Two palynomorphs confirm a late Miocene age for Sample U1536E-26R-CC and a middle Miocene age for Sample 31R-CC. Biostratigraphic age models from the different microfossil groups agree with each other and suggest that we reached the mid-Miocene climate optimum in the lowermost core.

Paleomagnetism

Paleomagnetic investigations focused on completing measurements of natural remanent magnetization (NRM) and alternating field (AF) demagnetization of discrete samples from Hole U1536E. All samples were subjected to AF demagnetization at 5, 10, and 15 mT to verify the archive-half measurements. Despite discontinuous recovery in the rotary core barrel (RCB) cores, we could make tentative ties to the 2012 geomagnetic polarity timescale (GPTS) for intervals between Chrons C2Ar and C3An (3.60 to 6.03 Ma), based on the initial biostratigraphic data. Below this range we observe intervals of normal and reverse polarity that may potentially be correlated to the GPTS postcruise, pending further collaboration with the biostratigraphy group.

Geochemistry

Headspace gas, interstitial water (IW) chemistry, and bulk sediment geochemistry were analyzed at Holes U1536A and U1536E. Headspace gas analyses were performed at a resolution of one sample per core (9.6 m advance) at Hole U1536E (Cores 4R through 33R) and Hole U1537A

(Cores 1H through 17H) as part of the routine environmental protection and safety monitoring program. Methane (CH_4) is the dominant hydrocarbon present in low concentrations (2–4.6 ppmv) throughout the sedimentary sequence. Ethane (C_2H_6) concentration is below the detection limit throughout the cored sequence. Geochemical data continued to be generated on 20 IW samples from Hole U1536A (Cores 1F through 53F) to a depth of 350 mbsf and seven samples from Hole U1536E (Cores 6R through 24R) to a depth of 550 mbsf. Site U1536 is characterized by generally reducing sedimentary conditions, as indicated by the disappearance of dissolved sulfate concentrations at ~100 mbsf. The reducing conditions associated with this microbially mediated sulfate reduction in the upper section exert strong control over the IW profiles of alkalinity, Ca, PO_4 and Fe.

The shipboard solid phase analysis at Site U1536 consisted of measurements of inorganic carbon, total nitrogen (TN), and total carbon. Bulk sediment total organic carbon (TOC) and TN contents are generally low with concentrations ranging from 0.1 to 0.8 wt% and from 0.02 to 0.09 wt%, respectively. Calcium carbonate ($CaCO_3$) contents are also low (<1 wt%), except in a few narrow horizons where an enrichment of $CaCO_3$ takes place along with an increase of TOC/TN ratios.

Petrophysics

Standard measurements were made on whole-round core sections from Holes U1536E and U1537A, including bulk density and magnetic susceptibility (MS) at 2.5 cm intervals, natural gamma radiation (NGR) at 10 cm intervals, and thermal conductivity at one measurement per core. *P*-wave velocity measurements were not made on RCB cores from Hole U1536E because of the air gap between the core and the liner. Light reflectance, color imaging, and MS point measurements were made at 2.5 cm intervals along core section halves, as well as X-ray imaging. Moisture and density measurements were made on 22 discrete samples in Hole U1536E.

In Hole U1536E, density and MS increase from 370 to 490 mbsf and then decrease from 490 to 560 mbsf. *P*-wave velocity increases gradually, except for an abrupt increase at 560 mbsf. Downhole logging in Hole U1536E measured MS, gamma ray spectra, electrical resistivity, *P*- and *S*-wave velocities, and density. These in situ measurements successfully covered data gaps in core recovery and complement the measurements taken in the laboratory. Both core and downhole density and *P*-wave velocity measurements generally increased with depth, reflecting downhole sediment compaction. Step changes in density and *P*-wave velocity correspond to main reflectors in the multichannel seismic profile in this location. For example, an increase in density and velocity at 455 mbsf is associated with the top of a series of reflectors starting at 5000 ms, and a series of steps in velocity below 540 msbf is probably coincident with high amplitude reflectors recorded in the seismic data.

In Hole U1537A, five downhole temperature measurements were made with the advanced piston corer temperature tool (APCT-3) on Cores 4H, 7H, 10H, 13H, and 16H, and yielded

temperatures between 2.7 and 12.1°C. All physical properties measurements, including light reflectance and RGB values, show characteristic orbital scale variations that are useful for stratigraphic correlation.

Outreach

joidesresolution.org: We posted three blogs this week about shrinking cups, diatom DNA, and an interview with Co-Chief Scientist Maureen Raymo.

Twitter (https://twitter.com/TheJR): On Earth Day (22 April) we posted 18 tweets with interesting Antarctic facts from onboard scientists. We posted 13 tweets over the rest of the week, including announcements about blog posts, Ask Me Anything, and Facebook Live.

Facebook (https://www.facebook.com/joidesresolution): Facebook posts included:

- 22 April: CBS This Morning Earth Day content link (4.4K people reached, 263 clicks/actions)
- 23 April: Blog post—A Chat with Mo (4.4K people reached, 277 clicks/actions)
- 23 April: Facebook Live with Maureen Raymo announcement
- 23 April: Shrunken cup photos
- 24 April: Quiet Southern Ocean photo
- 24 April: Facebook Live with Maureen Raymo
- 24 April: Dinoflagellates (4.6K people reached, 454 clicks/actions)
- 25 April: Blog Post—Shrunken Cups
- 28 April: New site update
- 28 April: Blog Post—Squeezing DNA from Mud

Instagram (http://instagram.com/joides_resolution): There were three posts this week, about shrunken cups (132 Likes), Dinoflagellates (134 Likes), and an iceberg photo, and three Instagram Stories about Facebook Live with Maureen Raymo, Sunsets and moonrises (seen by 256), and the Southern Right Whale.

Live Events: with scientist Q&A (Total students reached: ~ 250)

- Universidad Complutense de Madrid—Yasmina Martos
- Santa María de la Capilla—Yasmina Martos, Ivan Hernandez-Almeida
- SST Public School Rashidabad—Ivan Hernandez-Almeida, Thomas Ronge, Stefanie Brachfeld, Frida Hoem
- Bay Point Elementary School—Michelle Guitard, Thomas Ronge, Ivan Hernandez-Almeida

- IES Emilio Ferrari—Ivan Hernandez-Almeida, Thomas Ronge, Stefanie Brachfeld, Frida Hoem
- AMNH Visualizing Ocean Science—Marga García, Yasmina Martos, Ian Bailey, Sidney Hemming
- St. Columba Primary School—Marga García, Linda Armbrecht

Technical Support and HSE Activities

Laboratory Activities

- We continued to troubleshoot the drift of NGR Detector 7, bypassing Detector 7's bias potentiometer with a standalone version made by G. Chubaryan, but this did not solve the problem. Most of the time it is a rightward drift (recording the ^{40}K peak towards higher apparent energies) but we also see leftward drift at times. Very occasionally we see both drift directions contained within a single run (10 min time span). Calibration is performed frequently during coring and we will continue to monitor the issue.

Application Support Activities

- We worked on a bug that causes the superconducting rock magnetometer Integrated Measurement System (IMS) software to write a configuration file every time it launches; this work is still in progress.
- X-Ray image processor: we fixed single-image processing so that it overlays the image with sample information and the scale bar.
- The Batch Download feature on LORE was not working; we worked with shore personnel to correct the issue so technicians can download data to assist in the drift problem on the NGR.

HSE Activities

- We conducted the weekly fire and abandon ship drill.
- Safety showers and eyewash stations were tested.