

IODP Expedition 383: Dynamics of Pacific Antarctic Circumpolar Current (DYNAPACC)

Week 3 Report (3–9 June 2019)

Week 3 of the International Ocean Discovery Program (IODP) Expedition 383, Dynamics of the Pacific Antarctic Circumpolar Current (DYNAPACC), was spent coring at Sites U1539 and U1540. At Site U1539 we cored Holes U1539B (0–28.2 m below seafloor [mbsf]; 21.92 m recovered, 78% recovery), U1539C (0–268.1 mbsf; 247.5 m recovered, 92% recovery), and U1539D (47.5–198 mbsf; 128.18 m recovered, 85% recovery). At Site U1540 we cored Hole U1540A from the seafloor to 150.0 mbsf (155.1 m recovered, 103% recovery). During the week, coring operations stopped three times (for a total of ~18 h), because of high seas and bad weather conditions. All times in this report are in ship local time (UTC – 3 h).

Operations

At the beginning of the week, the seas had calmed enough to attempt spudding Hole U1539B. The vessel was offset 20 m to the east of Hole U1539A, and the bit was set at 4081 m below the rig floor (mbrf). Once the sinker bars and orientation tool were installed, Hole U1539B was spudded at 0540 h on 3 June 2019. The seafloor was calculated at 4070.5 m below sea level (mbsl) based on the Core U1539B-1H recovery of 9.21 m. Coring continued to 28.2 mbsf with Cores 2H and 3H being misfires. It was decided to terminate the hole and wait for seas to improve before continuing operations. The bit was pulled to 4060 mbrf, clearing the seafloor at 1000 h on 3 June and ending Hole U1539B. By 1245 h, heave had fallen to 3.0 m and it was decided to attempt coring again.

The vessel was moved 20 m south of Hole U1539B and the bit was spaced out to 4081 mbrf for spudding. Core U1539C-1H returned a full core barrel. This allowed us to determine a seafloor depth of 4070.2 mbsl. Full-length advanced piston corer (APC) coring continued to refusal at a depth of 240.1 mbsf (Core 26H). Half-length APC (HLAPC) coring was then used to deepen the hole, with coring terminated after Core 32F at 268.1 mbsf. The bit was pulled back to 4050 mbrf, clearing the seafloor at 1230 h and ending Hole U1539C. A total of 32 cores were taken using the APC and HLAPC coring tools. Advanced piston corer temperature tool (APCT-3) formation temperature measurements were taken with Cores U1539C-4H, 13H, and 16H. Partial strokes were recorded on Cores 24H through 27F, with high overpull on Cores 17H through 26H. A misfire was recorded on Core 31F.

Hole U1539D was spot cored to fill in coring gaps from the previous holes. The vessel was moved 20 m to the west of Hole U1539C and a wash barrel was dropped. Hole U1539D was spudded at 1405 h on 5 June and drilled ahead without recovery to 47.5 mbsf. The wash barrel was pulled and coring began. The hole was advanced to 198 mbsf with seven drilled intervals

totaling 68.7 m. A total of 14 APC cores were taken over the 129.3 m cored interval with a recovery of 128.15 m (99%). The hole reached its total depth of 198 mbsf at 1500 h on 6 June, and the drill string was recovered with the bit clearing the rotary table at 0115 h, ending Hole U1539D and Site U1539. Misfires were recorded on Cores U1539D-2H, 3H, 6H, 8H, and 9H, and a partial stroke was recorded on Core 18H. No temperature or orientation measurements were taken in this hole.

After recovering the drill string, the rig floor was secured for transit at 0130 h. The thrusters were raised and the sea voyage to Site U1540 (proposed Site CSP-7A) began at 0224 h. After a 61 nmi transit at an average speed of 10 kt, we arrived on site at 0830 h on 7 June. The thrusters were lowered and the vessel switched to dynamic positioning mode over the site coordinates at 0929 h on 7 June.

The crew made up an APC/XCB (extended core barrel) bottom-hole assembly (BHA), and the bit was lowered to a depth of 2171 mbrf by 1645 h. The vessel began experiencing heave above 7.0 m with a roll of approximately 5° at that time, and it was decided to wait for the seas to calm before continuing operations. By 0415 h on 8 June, the seas had calmed sufficiently to continue operations. With an estimated seafloor depth of 3600.6 mbrf based on calculation from the precision depth recorder (PDR), the bit was lowered to 3595.0 mbrf to spud Hole U1540A. Core U1540A-1H recovered 9.0 m of sediment and the seafloor was calculated at 3595.5 mbrf (3584.6 mbsl). The hole was cored to 150 mbsf by 0815 h on 9 June. The top drive was set back and the bit pulled to 3561 mbrf, clearing the seafloor at 0900 h on 9 June and ending Hole U1540A. A total of 16 cores were taken with the APC coring system with a recovery of 155.09 m (103%). APCT-3 formation temperature measurements were taken with Cores 4H, 7H, 10H, 13H, and 16H. A misfire on Core 7H caused a noisy temperature reading. Orientation measurements were taken on all cores. Misfires were recorded on Cores 1H, 7H, and 16H.

Science Results

Lithostratigraphy

The sedimentology team spent much of the week describing Hole U1539C and U1539D cores, reviewing and finalizing the visual core description sheets (VCDs), and preparing the site summary presentation and the first draft of the site report.

The sediment in the lower section of Hole U1539C is dominated by light greenish gray to greenish gray, wavy bedded diatom ooze with varying contributions of carbonate, most likely originating from partly fragmented foraminifers and nannofossils, interbedded with intervals of massive stacked diatom mats. Core quality of Hole U1539D cores was generally low due to frequent drilling disturbance caused by deteriorating weather conditions, but a lithostratigraphic correlation with Hole U1539C cores was possible in most cases.

The first cores of Hole U1540A were split and described at the end of the week. Carbonate-dominated lithologies recovered in Hole U1540A required slight adjustments to the lithologic core description template. The upper ~70 m of Hole U1540A comprise predominantly whitish to light gray, strongly bioturbated carbonate-rich ooze interbedded on a meter-scale with greenish gray diatom ooze. Diatom mats become more frequent in the lower part of this interval. Lithologic changes are well reflected by variations in downhole RGB, color reflectance, and physical properties measurements.

Biostratigraphy

Core catcher (CC) samples from Holes U1539A and U1539C were analyzed for diatoms, silicoflagellates, radiolarians, calcareous nannofossils, planktonic and benthic foraminifers, and ostracods. Additional selected samples from the cores were analyzed for diatoms, silicoflagellates, and calcareous nannofossils to refine the site's biostratigraphy. Diatoms, radiolarian, planktonic foraminifers, and calcareous nannofossils provided useful bioevents. Diatoms and radiolarians are abundant. Silicoflagellates are rare to common throughout the hole and show a high intraspecific variability, but do not provide any relevant bioevent. Calcareous nannofossils abundance varies markedly throughout the sequence, becoming dominant in particular layers, which usually corresponds to interglacial intervals. Planktonic foraminifers are present in all samples but are generally less abundant than radiolarians in the washed and sieved fraction. *Neogloboquadrina pachyderma* dominates the assemblage in all samples, and *G. bulloides*, *G. puncticulata puncticuloides*, and *T. crassaformis* occur regularly but in lower numbers. Benthic foraminifers are few to rare in most of the samples, and absent in Sample U1539C-18H-CC. The most common species at Site U1539 are *Cibicidoides mundulus*, *Epistominella exigua*, *Globocassidulina subglobosa*, *Melonis barleeaanum*, *Oridorsalis umbonatus*, and *Pullenia bulloides*. Ostracods are very rare or absent. Overall, the combined biostratigraphy suggests a maximum age of ~1.2–1.3 Ma at the base of Core U1539C-31F. The estimated sedimentation rates are 16.6 cm/ky for the upper 150 m of the hole, and ~31.4 cm/ky for the lower interval to 268 mbsf. The lower interval is characterized by mats of *Thalassiothrix antarctica*.

At the end of the week, core catcher samples from Hole U1540A were being analyzed for diatoms, silicoflagellates, radiolarians, calcareous nannofossils, planktonic and benthic foraminifers, and ostracods. Planktonic foraminifer analyses show assemblages similar to those observed at Site U1539, while benthic foraminifers appear to be different. The preliminary combined biostratigraphy suggests a maximum age of ~2.5 Ma at the base of Core U1540A-16H (150 mbsf).

Paleomagnetism

The natural remanent magnetization (NRM) of all archive-half sections was measured and demagnetized at 10 and 15 mT using the shipboard 2G superconducting rock magnetometer (SRM). The intensities of NRM from the four holes are weak, with a typical range lower than

10^{-3} A/m. NRM is found to be affected by a drill string overprint that can be effectively removed by AF demagnetization at 10 mT. After removal of the drilling overprint, the downhole variation of NRM intensities shows a good correlation with lithology. Hole U1539A is characterized with negative inclination (at 107.6 mbsf) that is close to the value predicted by a geocentric axial dipole (GAD) at this site, suggesting that the retrieved cores from Hole U1539A are younger than the last geomagnetic reversal around 780 ky ago. Intervals with positive inclinations were found in the two deeper holes, U1539C and U1539D. However, these intervals are just a few core sections long and the inclination of the adjacent core sections often oscillates between the GAD inclination value and 0. This feature is interpreted as a result of at least two NRM components that have opposite inclinations and indicates that the last geomagnetic reversal is within this interval, even though the exact boundary could not be resolved from the magnetic records at this time.

Geochemistry

Sixty-three whole-round (WR) core samples collected from Holes U1539A and U1539C were squeezed and processed. The interstitial water (IW) and squeeze cake samples were split for shipboard analysis and shore-based research requests. Samples from both holes are in preparation for bulk sediment inductively coupled plasma–atomic emission spectrometry (ICP-AES) analysis. The IW samples were analyzed for salinity, alkalinity, pH, chlorinity (in triplicate), phosphate, ammonium, silica, and major and minor cations and anions on the ion chromatography (IC) and ICP-AES instruments. Alkalinity and pH increase in the uppermost 10 m and remain roughly constant with depth thereafter. Salinity is stable at 35 throughout the record, but chlorinity shows a small increase in the upper 50 m from 556 to 565 mM. Fe is not measurable, but Mn and Ca show distinct peaks in the upper 10–30 m followed by removal at depth. Sr remains constant until 200 mbsf, where it increases above the seawater value. Phosphate shows significant variability in concentrations downhole, sulfate decreases with depth, and ammonium increases. These trends are likely due to a combination of anaerobic microbial activity (e.g., sulfate reduction) and inorganic geochemical interactions (e.g., adsorption of phosphate to carbonate minerals).

Ninety split core samples from Hole U1539 have been measured for calcium carbonate, total organic carbon (TOC), and total nitrogen (TN). Calcium carbonate content varies between 3 and 92 wt%. TOC varies between 0.7 and 0.2 wt%. TN shows a small variability downhole and is generally below 0.12 wt%. TOC/TN ratios increase at ~130 mbsf from an average of 4.9 to an average of 10.4, suggesting an increased terrigenous contribution to the organic material found in the hole.

Twenty-five WR samples have been taken from Hole U1540A for analysis. A mudline water sample was collected from Hole U1540B. About 20 samples collected from Hole U1540A are undergoing freeze drying and will be ready to be analyzed over the course of next week. Eleven

headspace samples for hydrocarbon analyses have been collected and measured from Hole U1540A to a depth of 148 m, and hydrocarbon concentrations remained below 5 ppmv.

Physical Properties

All WR core sections from Site U1539 and some from Hole U1540A were measured with the Natural Gamma Radiation Logger (NGRL) and with the Whole-Round Multisensor Logger (WRMSL) for gamma ray density (GRA), magnetic susceptibility (MS), and *P*-wave velocity.

For Holes U1539B, U1539C, and the upper part of U1539D, core sections were analyzed with the Special Task Multisensor Logger (STMSL) for MS and GRA at 3 cm resolution before temperature equilibration to provide data quickly to the stratigraphic correlators to help determine coring offsets for a complete composite record for the site. After splitting, archive core section halves were X-rayed. Discrete measurements of *P*-wave velocity were made on the working halves at a resolution of one measurement per core on average, resulting in a total of 56 measurements, since disturbed and fluid-rich sediment intervals were not sampled.

For moisture and density measurements (MAD), a total of 157 samples were analyzed, mainly from Holes U1539A and U1539C, to determine bulk and grain density and porosity to calibrate and support the whole-round GRA density data. Comparison between these two data sets provided a high correlation coefficient ($r^2 > 0.89$), leading to the decision to decrease MAD sampling frequency from one sample per section to one every other section and as needed for lithofacies changes at future sites.

Stratigraphic Correlation

We used data from the STMSL, WRMSL, NGR, and RGB blue intensity in Correlator v3.0, together with lithologic data, to build a composite section (splice) for Site U1539 successfully.

Outreach

Three live broadcasts were conducted (one school in Germany, and two in New York State) with a total of ~60 students and their teachers.

Four blogs were posted this week and also several posts on [joidesresolution.org](https://www.joidesresolution.org), Facebook (<https://www.facebook.com/joidesresolution>), Twitter (<https://twitter.com/TheJR>), and Instagram (http://instagram.com/joides_resolution), including a video message to celebrate World Oceans Day (8 June) that already recorded more than 2,100 views.

Technical Support and HSE Activities

Laboratory Activities

- Air conditioners were removed from RadVan.
- We finished processing cores from Site U1539.
- Section Half Imaging Logger (SHIL) high-resolution RGB files are now being generated after Labview code correction.
- The pusher on the STMSL/X-ray track was modified to make it easy to switch between the two systems. A plate added for section halves on Expedition 382 was modified so we can remove it by loosening two screws and replace it by tightening the same screws.
- The aft heater on the catwalk was repaired and now produces minimal noise.

Application Support Activities

- Continued development of Catwalk module (SampleMaster replacement project).
- Corrected an issue with LIVE not showing drilling disturbance data.
- Resolved an issue where labels were not printing at the core entry station.
- Discovered a defect in SampleMaster that caused the driller to be temporarily unable to upload a new core to the database. This issue is ongoing, but the cause is known and we are working on how to resolve it.
- Fixed a defect in the Correlator downloader with regard to drilling disturbance data. A new version was tested and deployed.
- Worked with developers on shore to test different cloud-based project planning tools intended for use with the GEODESC project.
- Corrected a problem with the ImageCapture software on the microscopes. The software was attaching an incorrect scale bar to the images. There was a workaround, which involved reducing the quality of the images slightly. This has been resolved.

I.T. Support Activities

- Worked with Rignet on power levels adjustments for better internet connection.
- Worked with Rignet in preparation to provision satellite transition for Site CSP-1A.
- TAMU I.T. implemented changes to the ship's Exchange server to buffer emails during internet outages. Changes were tested aboard the ship successfully.
- Set up MATLAB R2018b on Downhole Measurements Laboratory PC for TP-Fit scripts to run.

HSE Activities

- Conducted weekly test of safety showers and eyewash stations.
- The weekly fire and abandon ship drills were held on Monday 3 June and Sunday 9 June.