IODP Expedition 392: Agulhas Plateau Cretaceous Climate

Week 4 Report (27 February–5 March 2022)

The fourth week of the International Ocean Discovery Program (IODP) Expedition 392, Agulhas Plateau Cretaceous Climate, included rotary core barrel (RCB) coring and downhole logging of Site U1580 (proposed primary Site AP-09B). All times in this report are in ship local time (UTC + 2 h).

Operations

Week 4 of the expedition began on 27 February 2022 with continued RCB coring in Hole U1580A, from Core U1580A-13R to 42R at 407.4 meters below seafloor (mbsf) on 1 March. Basalt was expected at ~340 mbsf, but based on the coring at Site U1579, was presumed to be deeper. At ~1700 h on 1 March the rate of penetration (ROP) on Core 43R slowed to almost zero and no noticeable progress was being made. The core was pulled at the 2 h mark with an advance of only 0.2 m, with the recovery of only a few cobbles (0.15 m). Core 44R was also cut by time (2 h) and the 1.0 m advance resulted in no recovery. The bit deplugger (a core barrel with a pointed metal tip) was dropped twice in an attempt to clear any material blocking the bit. Core 45R then advanced 3.2 m and recovered 3.25 m. It was determined from recovered pieces that the bit was previously on a chert layer of loosened rock that was preventing recovery.

The sediment/basement contact was very difficult to determine during coring, likely due to multiple chert/silicified horizons in the sediments immediately overlying the basalts. Although core recovery was low, pieces of basalt were recovered in Cores 43R and 45R. A good basalt contact was cored at ~419–420 mbsf on Core 47R on 2 March. The ROP was 1.0 m/h in Cores 47R–49R. Coring continued until 5 March with Core 68R at the final Hole U1580A depth of 533.9 mbsf, and coring in Hole U1580A was terminated at 1630 h on 5 March. The basalt below ~495 mbsf cored at a penetration rate of 3–5 m/h, which is very fast for hard rock, and with good recovery. The overall ROP for RCB in Hole U1580A was 4.4 m/h.

At 1630 h on 5 March, the driller pumped a final sweep to clean the hole, flushing the mud completely out of the hole. The mechanical bit release tool was run down, and the bit dropped at 1715 h. The bit had 120.3 h overall, with ~58.8 m of that in hard rock. The drill string was tripped up to 80.7 mbsf in preparation for downhole logging. At 2145 h the first logging string, the Schlumberger triple combo, was assembled and the tools were run into Hole U1580A starting at 2330 h.

Science Results

Site U1580

Science activities during the week included the processing and measurement of core sections and shipboard samples for Site U1580. The science party gave Site Summary presentations and continued to edit reports for Site U1579.

Lithostratigraphy

Core recovered from Hole U1580A includes ~407 m of sediments atop ~126 m of basalt with interlayered sediments. The top 3 m of Hole U1580A consist of Late Pleistocene light gray foraminiferal ooze with abundant sand-sized pyrite and glauconite grains (Lithostratigraphic Unit I). Below that unit downhole to 293 mbsf consists of early Eocene-Maastrichtian nannofossil ooze and chalk (Lithostratigraphic Unit II) with varying amounts of clay, with the ooze to chalk transition occurring at around 16 mbsf. From 293 to 407 mbsf, sediments consist of Campanian-Coniacian green zeolitic sandstone, siltstone, and claystone (Lithostratigraphic Unit III) lying atop basalt. Between subsequent basalt units, at least 4 intervals of highly altered sediment occur, ranging in thickness from 0.5 to 5 m, and consisting of chert, limestone, claystone, and siltstone.

Igneous Petrology

Igneous rocks in Hole U1580A were recovered in Cores 43R through 68R. Ten igneous units were recovered and identified. All are massive and many show chilled margins. The bottom unit (Igneous Unit 10) is nearly 40 m thick and becomes coarser grained downsection, such that it is categorized as a dolerite; this unit contains three dominant textures within, including a nice example of subophitic texture. All other units are basalts, some of which contain plagioclase phenocrysts, and all are moderately to highly altered. Sedimentary rocks were encountered at least four intervals between the igneous units. Portable X-ray fluorescence spectrometer (pXRF) measurements indicate that all igneous samples analyzed are tholeiitic and are similar to those recovered in Hole U1579D. All cores from Hole U1580A were described. Thin section descriptions continue as there were technical difficulties in the generation of thin sections due to the unique composition of the samples.

Micropaleontology

The micropaleontology team analyzed core catcher samples and additional samples from split core sections of critical intervals from Cores U1580A-13R to the bottom of the sediment recovered in Core 61R. Calcareous nannofossils are abundant and moderately preserved in Paleocene sediments, whereas preservation is poor to moderate and relative abundance varies significantly in the Cretaceous. Despite this, calcareous nannofossils are present in much of the sediment down to Core 60R and indicate that the Cretaceous succession spans from the upper Cenomanian to Maastrichtian, with at least two hiatuses present. Planktonic foraminifers are present in most core catcher samples. Preservation degrades with depth, but key species

identifying the Maastrichtian are present in Core 22R. Benthic foraminifers are also present and show a good record of biconvex trochospiral forms. Below Core 32R, foraminifers can still be extracted from the more indurated sediment but identification is not always possible. Diatoms and other siliceous microfossils were not observed in any samples from Hole U1580A. Dinocysts are present between Cores 34R and 42R and indicate a Coniacian to Santonian age, consistent with calcareous nannofossil biostratigraphy.

Paleomagnetism

The paleomagnetism team completed shipboard measurements of all cores from Hole U1580A, which were RCB cored and therefore unoriented. Shipboard measurements included low-field alternating field (AF) demagnetization of archive section halves up to a peak field of 15 or 20 mT, depending on the quality of the paleomagnetic signal. Stepwise AF demagnetization of one or two representative discrete samples per core was also performed. Measurements were performed on both sedimentary and igneous samples. Within Hole U1580A, numerous clear magnetic reversals were identified from archive half measurements. Results from discrete samples were consistent with those from the archive halves. From both the continuous archive half and discrete measurements, we were able to construct a magnetostratigraphy and correlate it to the geomagnetic polarity timescale (GPTS). In collaboration with the Micropaleontology team, we determined that Hole U1580A spans chrons C24r to C34n. Some temporal gaps in the magnetostratigraphy exist, which correspond with unconformities and intervals of poor core recovery. Experiments for anisotropy of magnetic susceptibility, bulk susceptibility, and isothermal remanent magnetization (IRM) were also performed on discrete samples to improve our understanding of the magnetic mineralogy. The team also began writing the report for Site U1580.

Stratigraphic Correlation

The spliced records of Holes U1579A, U1579B, U1579C, and U1579D were refined and offset (affine) and splice interval tables were constructed. At Site U1580 no parallel holes were drilled by the end of the week. Four sediment cores had more than 100% reported recovery, likely due to core expansion. Eight basalt cores had more than 100% recovery, up to 139% for Core U1580-48R, causing overlap on the core depth below seafloor (CSF-A) depth scale. Basalt cores may have incorporated drilled material that was not dislodged from the substrate during recovery of the previous core. An adjusted depth scale is in preparation for Hole U1580A, which provides core composite depths.

Geochemistry

Headspace samples were taken at the base of each core of Hole U1580A for monitoring hydrocarbons. Methane concentrations remained at or below the detection limit to the bottom of the hole. Solid phase carbonate and total carbon measurements are complete, except for a few carbonate samples from the sediments interlayered between basalt units and outliers from

previous runs. Based on coulometry data, carbonate content remains high for most of the stratigraphic sequence (60% to 95%), with a marked drop to below ~20% at ~290 mbsf. Total organic carbon (TOC) remains below 0.5% throughout the hole. Several samples with elevated TOC concentrations are most likely the result of calculation artifacts between the coulometry and elemental analyzer. A small set of samples has been prepared for decalcification to directly determine TOC on the elemental analyzer. Following initial inconsistent results, maintenance is currently underway for the source rock analyzer.

Sampling for interstitial waters (IW), which was suspended after Core 22R due to a lack of extractable water, resumed in Cores U1580A-31R to 37R. IW pH and alkalinity were measured in near-real time, and the remaining pore water was subsampled and preserved for additional shipboard and shore-based analyses. Alkalinity values were consistently less than 0.5 mM. IW samples from Hole U1580A were analyzed for anions and cations (ion chromatography [IC]) and elemental geochemistry (inductively coupled plasma–atomic emission spectrometry). Sulfate, potassium, and magnesium all decrease downhole with minimum values of 21.90, 1.43, and 2.45 mM, respectively, while chloride and calcium both broadly increase downhole with maximum values of 610.1.3 and 92.8 mM, respectively.

Petrophysics

Physical properties of cores from Hole U1580A were measured on whole-round sections, half-core sections, and discrete samples. Magnetic susceptibility (MS) values range several orders of magnitude among the different lithologies of Hole U1580A between 50 instrument units (IU) and 5000 IU. Natural gamma radiation (NGR) in Hole U1580A gradually increases downhole, with an average of 6.5 counts/s in the upper 130 m and 8.0 counts/s between 270 and 485 mbsf. Bulk density increases with depth from 1.8 to 2.2 g/cm^3 with a distinct decrease in Lithostratigraphic Unit III. Basalt units have average density values of about 2.8 g/cm^3.

In addition to standard track and caliper measurements of *P*-wave velocity on all cores, discrete basalt samples were analyzed (1 per core) for directional information. *P*-wave velocity increases with depth from 1600 m/s at seafloor to about 2500 m/s at 207 mbsf (Lithostratigraphic Unit I–Subunit IIb), while Lithostratigraphic Subunit IIc (207–294 mbsf) has an average velocity of 2600 ± 100 m/s. Seismic velocities are lower in the green zeolitic sediments in Lithostratigraphic Unit III. The *P*-wave velocity in basalts (from 407 mbsf to the bottom of the hole) ranges from 4000–5000 m/s.

Thermal conductivity increases from 1.2 W/(m·K) to 1.65 W/(m·K) between Lithostratigraphic Unit I to Subunit IIb. Lithostratigraphic Subunit IIc has substantially higher thermal conductivity (1.85–2.2 W/[m·K]) associated with relatively low porosity values (about 30%). In the uppermost interval of Unit III, thermal conductivity drops downhole from 1.1–1.2 W/(m·K). The interbedded sequence of basalt and chert/limestone/claystone/siltstone lithologies has thermal conductivity values of 1.6 ± 0.2 W/(m·K), with higher values typical for basalts and lower values for sedimentary layers.

No new downhole measurements were performed this week. Additional processing of downhole MS sonde data from Hole U1579D was performed.

Education and Outreach

The following outreach activities took place during Week 4.

- Posted two blogs with photos on the Expedition 392 page on the *JOIDES Resolution* (JR) website (one written by the Outreach Officer, and one written by Co-Chief Scientist Gabriele Uenzelmann-Neben).
- Posts on Facebook: 7
- Posts on Twitter: 7, plus retweets of scientist posts.
- Stories posted on Instagram: 3
- Worked with two scientists on an upcoming newsletter: Thomas Wagner and Odysseus Archontikis (UK-IODP Newsletter).
- Wrote haiku for *3-9-2 haiku* (a proposed postexpedition book) and collected haiku from the science party. Held a haiku workshop.
- Completed 4 ship-to-shore live tours; scheduled several events for the coming weeks.
- Conducted interviews with various members of the science party and JRSO technicians.

Technical Support and HSE Activities

The following technical support activities took place during Week 4.

Laboratory Activities

- Underway Geophysics and Downhole Logging
    - Set up heave, roll, and pitch data to send from the IRIS cRIO to the Echo Control software, which allows us to correct water depth for ship's motion.
- Imaging
    - Previous issue with the Section Half Imaging Logger (SHIL) writing files when an image was discarded has been fixed.
- Physical Properties
    - Restored the gamma ray attenuation (GRA) Digi-base preamplifier back to the original unit, which previously failed. Currently, we believe the operating system was dropping the USB connection and that this was not a hardware issue.
    - We experience another dropped USB connection on the AR700 displacement laser.
    - When measuring *P*-wave logger (PWL) data on RCB cores, it is necessary to compress the liner into the core. To prevent damage to the "Pusher" standard, acrylic internal supports were added into the core liner to prevent collapse.

- Paleomagnetism
    - Troubleshooting continued on the superconducting rock magnetometer (SRM) in relation to data noise issues.
    - IM10-30 high-field pulse magnetizer saw was used this week.
    - There were issues with KappaBridge data uploads. An extra space is being inserted at the end of scanned section cube labels, resulting in a MUT uploader problem; however, no error notification is provided. This issue has been passed to the developers.
- Microscopy
    - Zeiss Technical Support has identified a faulty internal power supply for the newest Zeiss Axio Imager.A2. A replacement part has been ordered.
- RigWATCH
    - Top drive and torque signals in RigWATCH are currently having issues, and it is suspected that the signal cable has water in it. When drilling operations permit, this cable will be bypassed with a temporary cable to continue troubleshooting the issue.
    - The RigWATCH junction box behind the driller shack has completely deteriorated, allowing water into the box (possibly related to above issue). Materials are being ordered to replace the box and cabling in the next tie-up.
- Other
    - IRIS (rig instrumentation system): The general user interface was tested and completed. Work continues on the driller's interface and logic control for pipe counting, depth, "on bottom" status, and "in slips" status.

Application Support Activities

- Fixed the display flag for several line scan images and Whole-Round Multisensor Logger (WRMSL) tests for plotting in LIVE.
- Fixed the values of several MadMax test results.
- Scanning electron microscope images were failing to upload; issue resolved.
- Held a meeting with shore developers to finish the IRIS Data Collector.
- Worked with shore IT to resolve issues with the Lamont-Doherty Earth Observatory (LDEO) connection to the ship for downhole logging data transfer.

IT Support Activities

- There were some issues with the NaviPac setup for the remote Helmsman display. Troubleshooting continues.
- Monthly operating system updates and vulnerability patching will continue throughout the expedition.

- Several instrument hosts have randomly shut down while in use and the issue does not appear to be related to rebooting associated with system updates. Troubleshooting is ongoing.
- Network connection issues between the Yellowstone server and LDEO prevented the sending/receiving of logging data (see Application Support Activities). The issue was related to a TAMU firewall, which was has since been reopened.

HSE Activities

- Conducted Sunday safety checks (showers and eye wash).
- Conducted life boat drill.