IODP Expedition 392: Agulhas Plateau Cretaceous Climate

Week 3 Report (20 – 26 February 2022)

The third 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 U1579 (proposed primary Site AP-10A), and RCB coring of Site U1580 (proposed primary Site AP-09B). All times in this report are in ship local time (UTC + 2 h).

Operations

Week 3 of the expedition began on 20 February 2022 with continued coring in Hole U1579D, from Core U1579D-30R at 397.4 meters below seafloor (mbsf) to Core 65R and a final hole depth of 727.2 mbsf at 0230 h on 24 February. Sepiolite mud sweeps of 30 bbl (42 US gallons/barrel) were pumped every third core from Core 31R to 57R and in Cores 59R, 62R, 64R, and 65R. RCB coring averaged just under 20 m/h in the upper sediment section to 2.0 m/h in basalt, with an average rate of penetration (ROP) of 8.2 m/h.

On 24 February, the bit was released in the bottom of Hole U1579D at 0310 h and the hole was displaced with heavy mud. The pipe was tripped back to 70.7 mbsf and the Schlumberger Quad Combo tool was prepared. The 48 m long tool consisted of the Hostile Environment Litho-Density Sonde (HLDS), Dipole Shear Sonic Imager (DSI), Hostile Environment Natural Gamma Ray Sonde (HNGS), and Magnetic Susceptibility Sonde (MSS). At 0830 h the pipe was flushed to make sure it was all clear for logging, the scaffolding was rigged up, and a safety meeting was held. The Quad Combo logging tool was made-up and run into the hole starting at 1130 h. The logging tool string was run in the hole, pausing every 500 m to allow the new logging line to "season" (i.e., detorque). The downlog was paused to conduct a high resolution uplog from 450 to 250 mbsf. After resuming the downlog, the tool tagged 727.7 mbsf, and an uplog was done. We began pulling up the logging tools at 2040 h and the Quad Combo was back at the rig floor by the end of the day.

On 25 February the drill string was pulled up from logging depth, clearing the seafloor at 0110 h. We continued tripping pipe back to the rig floor and Hole U1579D ended at 0735 h. The rig floor was secured for transit, the thrusters were raised, and at 0740 h we began our sea passage to proposed Site AP-09B (Site U1580). The sea passage ended at 1306 h after a 53 nmi transit (5.4 h at an average speed of 9.8 kt). The thrusters were lowered at 1306 h and the vessel switched from cruise mode to dynamic positioning (DP) mode at 1326 h. The bottom-hole assembly (BHA) was assembled and the pipe was tripped to the seafloor, tagging at 2560.3 m below sea level (mbsl). Hole U1580A was spudded with Core U1580A-1R at 2015 h, recovering 6.82 m. Coring in Hole U1580A continued through Core 12R for the remainder of the week.

Science Results

Site U1579

Science activities during the week included the processing and measurement of core sections and shipboard samples. The science party received a presentation from the Co-Chief Scientists on the scientific objectives of proposed Site AP-09B (Site U1580) and prepared reports for Site U1579.

Lithostratigraphy

The core description team described Cores U1579D-29R to 60R. Sections 29R-1 through 46R-3 are assigned to Lithostratigraphic Subunit IIb (149–556 mbsf), which consists of white nannofossil chalk. Below that interval (Subunit IIc, Sections 46R-3 through 54R-CC; 556–635 mbsf) is clayey calcareous chalk and calcareous chalk with clay that is characterized by prominent color changes that cycle between white, green, and red. Subunit IIc also differs from overlying sediments by having common silicified limestone nodules/layers. Sections 54R-CC through 60R-7 are assigned to Lithostratigraphic Unit III and are characterized by green siltstones and sandstones. This subunit includes intervals with common soft sediment deformation and both normal and reverse grading. Preliminary analysis from an X-ray diffraction (XRD) sample suggests the main mineral constituents include analcime, siderite, glauconite, and montmorillonite. Basalts were recovered in Sections 60R-7 through 64R-3 (697–721 mbsf, Unit IV). Another green sandstone interval was encountered in Sections 64R-4 through 65R-3 (721–725 mbsf, Unit V) that has similar sedimentological characteristics as Unit III. There is a baked contact at the bottom of Unit V where it overlies another layer of basalt (Unit VI, Sections 65R-3 to 65R-5, 725–727 mbsf). A draft of the Site U1579 report was written.

Cores U1580A-1R to 15R were described. Sections 1R-1 to 1R-3 are foraminiferal ooze with nannofossils, and Section 1R-4 through Core 15R is nannofossil ooze and chalk.

Igneous Petrology

Igneous rocks were recovered in Cores U1579D-60R through 65R. A brief sedimentary interval was encountered between Sections 64R-4 and 65R-3. The igneous rocks were subdivided into two lithostratigraphic units based on the separation by the sediments. The upper unit, Unit IV, consists of a single clinopyroxene-plagioclase phyric massive basalt with chilled margins at both the top and bottom. The second unit, Unit VI, is an almost aphyric massive vesicular basalt with sparse plagioclase phenocrysts and also has a chilled margin at the top. Less than 2 m of the second unit was recovered before drilling in Hole U1579D was terminated. The rest of the week was spent with examination of thin section samples and portable X-ray fluorescence spectrometer (pXRF) measurements of rocks from both units and the writing of reports. Based on our observations and preliminary results from other laboratory groups, both units are interpreted as sill intrusions.

Micropaleontology

The micropaleontology team continued analyzing core catcher samples from Hole U1579D for biostratigraphic age assignments. Across critical intervals, additional core samples were taken. Calcareous nannofossils provide biostratigraphic constraints through Core U1579D-54R; deeper than Core 54R intervals of green sediment (lithostratigraphic Units III and V) are barren of nannofossils. Nannofossils are poorly to moderately preserved in the lower Paleocene. Preservation and abundance improve in the upper Maastrichtian, although both deteriorate downhole, with generally sparse assemblages in the Campanian. The Maastrichtian nannofossil assemblages are similar to those from Maud Rise and other southern high latitude sites, so it is likely that Tethyan ages for some marker taxa do not apply in this region. Biostratigraphically useful planktonic foraminifers were observed in Cores 33R and 46R. Further downhole preservation became poor, so samples were not processed for foraminifers below Core 49R. Diatoms were absent from Core 30R to the bottom of Hole U1579D. Core samples from selected darker, fine-grained intervals within the green siltstone and sandstones sequence of Lithostratigraphic Unit III were taken for palynology. One sample from a gray shale within Core 58R yielded a diverse dinocyst assemblage that provided critical age constraints for Lithostratigraphic Unit III, as well as an assessment of the depositional setting of that unit. Nannofossil biostratigraphy indicates that the section analyzed from Core 28R to Core 55R spans from the lower Paleocene to lower Campanian/upper Santonian. Dinocyst assemblages yielded a Santonian age for Core 58R. The micropaleontology team also prepared the first draft of the Site U1579 report.

Cores U1580A-1R through 12R were analyzed for calcareous nannofossils, foraminifers, and diatoms. These cores yielded abundant calcareous nannofossils of moderate to moderately good preservation, as well as abundant reasonably well-preserved foraminifers. Calcareous nannofossil biostratigraphy indicates that these cores are early Eocene to late Paleocene in age.

Paleomagnetism

The paleomagnetism team completed shipboard measurements of the cores from Holes U1579D and U1580A, which are RCB cored and nonoriented. 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. Within Hole U1579D some clear paleomagnetic reversals are identified, significantly improving the age model, particularly for the Maastrichtian–lowermost Danian part of Site U1579. Data from discrete samples confirm this interpretation. Preliminary paleomagnetic inclination data from Hole U1580A show meaningful swings from normal to reversed magnetic polarity, but a more detailed data inspection is required before correlating the magnetic polarity stratigraphy to the geomagnetic polarity timescale (GPTS). Discrete samples were also measured for their anisotropy of magnetic susceptibility, a parameter sensitive to coring and/or tectonic disturbance of the sediment.

Stratigraphic Correlation

The physical property records of Holes U1579A, U1579B, and U1579C and the upper part of Hole U1579D were compared to establish a common depth scale. Tie points were identified using natural gamma radiation (NGR), magnetic susceptibility (MS) from Whole-Round Multisensor Logger (WRMSL) and Section Half Multisensor Logger (SHMSL), color reflectance data, high-resolution digital core images, and red-green-blue color space (RGB) data extracted from the digital core images. Across all four holes, the most complete and least disturbed intervals of cores were selected, avoiding locations of interstitial water (IW) sampling where possible. A composite record was spliced for the upper 147 m core composite depth below seafloor, method A (CCSF-A) of the recovered stratigraphic succession, with only three small recovery gaps and two uncertain splice tie points. From 147 to 163.87 m CCSF-A, a complete composite record could not be established due to no overlapping cores from parallel holes. From 163.87 to 182.07 m CCSF-A, a composite record was made by stitching cores together from Holes U1579B and U1579D. Below 182.07 m CCSF-A, cores from Hole U1579D do not have parallel drilled sections.

Geochemistry

Whole-round (WR) core samples were processed for IW and headspace void gas samples for gas analysis. IW pH and alkalinity, as well as headspace/void gas methane, ethane, and propane concentration were measured in near-real time, and the remaining pore water was subsampled and preserved for additional shipboard and shore-based analyses. IW sampling continued at a resolution of one every other core until samples from three cores (U1579D-42R, 45R, and 47R) yielded no water. IW samples from Site U1579 were analyzed for ammonium concentration, anions and cations (ion chromatograph), and elemental geochemistry (inductively coupled plasma–atomic emission spectrometry). Ammonium concentrations generally increase downcore with values lower than anticipated based on alkalinity measurements. Sulfate and potassium both decrease downcore with minimum values of 22.66 and 6.84 mM, respectively, while chloride and calcium both increase downcore with maximum values of 614.3 and 29.94 mM, respectively. Magnesium decreases to 253 mbsf before increasing again downcore.

Methane concentrations remain at or below detection limit from the seafloor to around 330 mbsf and increase to ~10 ppm below that depth. Downcore methane concentrations remain at or below background (~2 ppm), with the exception of a few samples that reach levels above background ranging from 5 ppm to 21 ppm (maximum in Core U1579D-28R, ~387 mbsf). Solid phase carbonate and total carbon measurements are complete for Site U1579 except for the last carbonate sample. Coulometry data show that carbonate content remains high for most stratigraphic sequences, remaining within the range of 60% to 95% carbonate, with an increase in variability and extended range (20%–95%) around 500 mbsf. A marked decrease in range and variability (lower than 46% carbonate) below 643 mbsf is associated with the green siltstone and sandstone lithology. Total organic carbon (TOC) remains low, ranging from 0% to 0.6% for most samples. Few samples showing higher or lower TOC concentrations are most likely the

result of calculation artifacts between the coulometry and elemental analyzer. Two samples that were suspected to have significant organic carbon relative to the rest of the core based on lithology (i.e., color and laminations) and palynology assessment were subsequently analyzed with the source rock analyzer (SRA) from Core U1579D-58R. SRA data suggest the two samples are substantially thermally altered, likely related to the suspected sill rather than burial depth.

Physical Properties

Physical properties of cores from Hole U1579D were measured on WR sections, half-core sections, and discrete samples. The first several cores from Hole U1580A were also measured for WR track data on the Natural Gamma Radiation Logger (NGRL) and WRMSL.

The basalts from the deepest interval of Hole U1579D have elevated MS values (>1000 IU) and low porosity and NGR values. The green siltstones and sandstones overlying the basalts have negative a* values (greenness indicator) and relatively high potassium content (>1 wt%), as derived from the deconvolution of NGR data. Volcaniclastic sediments have lower grain density data (~2.5 g/cm^3) than the overlying calcareous sediments (~2.7 g/cm^3). Nannofossil chalk and ooze lithologic units exhibit relatively low NGR and WRMSL MS values. Bulk density and thermal conductivity values display an inverse correlation with porosity data throughout the cored interval at Hole U1579D.

P-wave seismic velocity data and bulk density data from WRMSL gamma ray attenuation (GRA) and moisture and density (MAD) analyses are relatively constant in the nannofossil chalk from ~200–550 mbsf. In the underlying chert-rich nannofossil chalk, both bulk density and caliper *P*-wave velocities increase to 2.4 g/cm^3 and ~3500 m/s, respectively. The volcaniclastic sediments exhibit lower bulk density and *P*-wave velocity than the chert-rich unit, and the basalt exhibits very high *P*-wave velocities (>5000 m/s) and density (~2.9 g/cm^3). Physical property data in aggregate facilitated the placement of lithostratigraphic boundaries and the refinement of seismic interpretations at Hole U1579D.

Downhole Measurements

Following recovery of the deepest core in Hole U1579D at ~727 mbsf, the drill pipe was retracted to ~70 mbsf and heavy mud was added to stabilize the borehole for downhole logging measurements. The Quad Combo logging tool string measured natural gamma ray (HNGS), density (HLDS), resistivity (HRLT), dipole sonic velocity (DSI), and magnetic susceptibility (MSS) profiles of the borehole walls. Based on caliper measurements of the borehole diameter, which were generally 10–12 inch, the condition of the borehole was good to excellent. The interval from approximately 100–720 m wireline log depth below seafloor (WSF) was logged with the caliper deployed, providing datasets that are currently being processed onshore at Lamont-Doherty Earth Observatory, Columbia University. Preliminary results indicate that DSI data will be able to accurately constrain in situ seismic velocities. Unprocessed downhole NGR

profiles follow similar trends to the shipboard NGR logger data from cores and will facilitate correlation of the site to marine records elsewhere, especially for intervals in the nannofossil chalk (475–550 mbsf) with poor to moderate core recovery.

Education and Outreach

The following outreach activities took place during Week 3.

- 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 scientist Peter Davidson).
- Posts on Facebook: 10
- Posts on Twitter: 9, plus retweets of scientist posts
- Stories posted on Instagram: 2
- Worked with two scientists on upcoming news and blog publications: Derya Gürer (Australian National University newsletter); Debadrita Jana (Rice University magazine, https://news.rice.edu/news/2022/voyage-reveals-wonder-and-beauty-long-dead-ocean-dwellers).
- Wrote daily haiku for *3-9-2 haiku* (a proposed postexpedition book) and collected haiku from the science party.
- Completed five ship-to-shore live tours; scheduled four future events, including participation in panel discussion during the Festival of Tomorrow, Swindon, UK.
- 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 3.

Laboratory Activities

- Underway Geophysics and Downhole Logging
  - Collected bathymetric data on transit between Sites U1579 and U1580.
  - Tube finder catalog was updated.
- Imaging
  - There has been an ongoing issue with Section Half Imaging Logger (SHIL) image uploads. This week code was added to the log file write events and user interaction section. It was determined that the rogue ".rgb" and ".roi" files were written after the user chose to discard the image. A fix was applied and is currently being tested.
- Physical Properties
  - Repaired the *P*-wave logger (PWL) water pump on the WRMSL.

    - NGR host computer auto-restarted again. No data was lost (this was not during a measurement); troubleshooting is ongoing.
- Paleomagnetism
    - Troubleshooting continued on the superconducting rock magnetometer (SRM) in relation to data noise issues.
- Microscopy
    - The newest Zeiss Axio Imager.A2 cannot be powered up; troubleshooting is ongoing. It is likely due to the battery in the main board or the main board itself. Awaiting details and advice from Zeiss Customer Support if the unit needs to be sent back for repairs. For now, the similar unit from the Microbiology Laboratory is used to provide both differential interference contrast (DIC) and Phase Contrast capability for nannofossil and diatom microscopy.
    - During an inventory of microscope supplies it was found that all 5 quartz sliders (0-3 lambda) are delaminated and one of the new Axio-scopes has a broken polarizer locking pin.
- RigWATCH
    - RigWATCH went offline. A blown fuse was discovered in the 12V power supply and repaired.
    - Fixed communication issues on the vibration isolated television (VIT) PC. A Windows update had remapped the com ports. A new diagram of instructions has been made on how to configure the com ports in NI MAX if this should happen again. Everything is currently up and running with the exception of control of LED3.
- Other
    - Rig instrumentation system (IRIS): The UI graphical and digital displays were completed with user interface for setting data type and display attributes.

Application Support Activities

- Assisted with SHIL image upload issues.
- An instance of GEODESC (upcoming core description software) is now running on the ship.
- Incorrect recovery depth for no-recovery core of Hole U1579A fixed in the database. However, it was found that depths are not automatically recalculated when cores are updated in Catwalk.

IT Support Activities

- All ESXi VMware Host machines were patched with latest firmware to remediate a security advisory from VMware.
- IODP Ship Vulnerabilities were cut by half over the course of the week per CrowdStrike tenancy. More patching will be done next week.

- Staff installed the latest Window patches to the instrument hosts.

HSE Activities

- Shipboard COVID testing concluded and the ship was declared COVID free.
- Hydrofluoric acid (HF) spill mitigation and safety classes were held for ship's crew.
- Conducted Sunday safety checks (showers and eye wash).
- Conducted life boat drill.