

IODP Expedition 393: South Atlantic Transect 2

Week 4 Report (26 June–2 July 2022)

In Week 4 of International Ocean Discovery Program (IODP) Expedition 393, South Atlantic Transect 2, we cored three holes at Site U1558 (proposed Site SATL-43A). Hole U1558E consisted of one core which missed the mudline. The sedimentary succession was cored to the basement contact in Hole U1558F. Basement rocks were cored in Hole U1558D, where a reentry cone and casing had previously been set during Expedition 390C.

Operations

Hole U1558E

The week began with the bit above seafloor at 4319 meters below sea level (mbsl), but weather and sea conditions had deteriorated. This delayed the start of Hole U1558E, and we waited on weather until ship heave started to subside. The ship was positioned 20 m to the south of Hole U1558D, and at 0440 h on 26 June 2022, Core U1558E-1H penetrated 9.5 m and recovered 9.97 m (105%); however, there was no mudline, and at 0515 h Hole U1558E was terminated.

Hole U1558F

The ship was offset 10 m to the east and at 0610 h on 26 June we started Hole U1558F. Coring started with the full-length advanced piston corer (APC), and a seafloor depth of 4337.3 mbsl was established based on the mudline in Core U1558F-1H. After Core U1558F-3H we drilled ahead by 3 m in an effort to offset gaps in recovered stratigraphy within Hole U1558A, which had also been APC-cored during Expedition 390C. APC coring continued to Core U1558F-10H at a depth of 86.9 meters below sea floor (mbsf), where 80,000 lb of overpull was required to free the barrel, marking APC refusal depth. All full-length APC cores were oriented and the advanced piston corer temperature (APCT-3) tool was deployed on Cores U1558F-3H, 6H and 10H. The half-length advanced piston corer (HLAPC) was deployed for Cores U1558F-11F to 19F. Core U1558F-19F at 124.5 mbsf needed to be freed by drilling over the core barrel, marking HLAPC refusal depth. The extended core barrel (XCB) coring system was deployed from Cores U1558F-20X to 24X. The driller noted basement contact at 176.0 mbsf, and drilling was terminated at 177.2 mbsf, approximately 1.2 m into basement. Cores U1558F-1H to 24X penetrated from 0 to 177.2 mbsf and recovered 164.3 m (93%). The drill string was recovered to the ship, and the drill bit cleared the rotary table at 0035 h on 28 June, ending Hole U1558F.

Hole U1558D

We then made up the rotary core barrel (RCB) bottom-hole assembly (BHA) and lowered it down to Hole U1559D, where a reentry system had been installed during Expedition 390C in November 2020. Guided by the subsea camera video feed, the ship maneuvered over the hole. At

first the bit could not reenter, but the second attempt was successful and the bit reentered Hole U1558D at 1505 h. We lowered the bit to the depth of the existing hole, 150 mbsf, and started coring at 1845 h. The existing hole is designated as drilled Interval U1558D-1-1. Cores U1558D-2R to 3R penetrated from 150 to 166.5 mbsf and recovered 3.27 m (20%) of sediment. The sediment/basement contact was determined to be at 166.5 mbsf, based on an abrupt slowing of the rate of penetration at that depth while starting to core Core U1558D-4R. Coring continued through the remainder of the week, at first alternating between full and half cores based on the rate of penetration and core recovery, and from Core U1558D-16R switching exclusively to half-length cores. Perfluorocarbon tracer (PFT) was run on all cores. By the end of the week we had reached Core U1558D-30R. Cores U1558D-4R to 30R penetrated from 166.5 to 326.6 mbsf and recovered 78.1 m (50.3%).

Science Results

During Week 4, the science party processed and described sediment cores from Holes U1558E and U1558F and Cores U1559D-2R to 3R, and basalt Cores U1558D-4R to 30R.

Petrology

Two major volcanic sequences were intersected in Cores U1558D-4R to 22R, which we divided into four units. Units 1 and 2, in Cores 4R to 12R, form the upper sequence. They are moderately to highly plagioclase-olivine-clinopyroxene-phyric, cryptocrystalline pillow basalts with distinctive green (chromian?) clinopyroxene phenocrysts. The second sequence starts with Unit 3 in Section 13R-1, which consists of an 80 cm interval of volcanoclastic breccia with a limestone matrix, marking what is interpreted to be a paleo seafloor horizon and a hiatus in volcanism. Beneath Unit 3, Unit 4 (Section 13R-2 to Core 22R) lavas are aphyric to sparsely plagioclase-olivine phyric crypto- to microcrystalline pillow lava basalts that lack the distinctive green clinopyroxenes of the first sequence (Units 1–2). Interpillow sediments and breccias are common in Unit 4A (Cores 14R and 15R), but cease in Unit 4B. Unit 4B continues from its upper contact in Section 15R-1 to the base of Core 22R. Three to four portable X-ray fluorescence spectrometer (pXRF) measurements per section were taken on cut core surfaces on Cores 2R to 22R. The lavas have a constant Zr/Ti composition downhole and are consistent with mid-ocean-ridge basalt (MORB). All of the core exhibits evidence of hydrothermal alteration, manifested as background alteration, alteration halos, and secondary minerals filling vesicles and veins. This alteration is variable but is particularly high in the breccia-containing sequences of Unit 4A. Examples of prismatic phillipsite-Na lining vugs and mixed calcite-phillipsite-Na veins have been confirmed by X-ray diffraction (XRD). The Deutsche Montan Technologie (DMT) scanner was used to make 360° scans of the cylindrical core pieces.

Lithostratigraphy

The sedimentology group described lithology, ichnology, and mineralogy of Holes U1558E and U1558F, Cores U1558D-2R and 3R, and intercalated sediments deeper in Hole U1558D; analyzed smear slides; and estimated clay and CaCO₃ content. Cores U1558F-1H to 5H are clayey nannofossil ooze, Cores 6H to 20X are nannofossil ooze with clay in some layers, and Cores 21X to 24X are mostly nannofossil chalk with clay. XRD data for Hole U1558F was partially analyzed. After core description was complete, the data was checked for consistency and lack of errors, and the scientists proceeded to preparing the site report and figures.

Geochemistry

The geochemistry group sampled and started analysis of pore waters, sediments, and igneous rocks from Holes U1558F and U1558D. In total, 36 pore water samples were extracted from 24 Hole U1558F sediment cores, along with 90 Rhizon fluid samples. These fluid samples and their associated squeeze cakes were aliquoted for shipboard analyses and to meet postexpedition research requests from Expedition 390/393 scientists. Hole U1558F pore waters were measured for salinity, alkalinity, for major cations and anions (K, Na, Ca, Mg, Cl, Br, SO₄) via ion chromatography, and for phosphate and ammonia by UV-visible light spectrophotometry. Pore fluid salinity (36–37 psu) was similar to bottom seawater (36 psu), pH varied between 7.46 and 7.64, and alkalinity showed some variation downhole, ranging from up to 2.9 mM at ~8 mbsf to 2.1 at ~150 mbsf. Ion chromatographic results showed small variations in pore water Ca (9.8–10.7 mM) and Mg (51.6–54.0 mM) contents, and no strong trends with depth. Overall, Na/Cl and Br/Cl ratios remained within error of the seawater values (0.86 and 1.5×10^{-3} , respectively), while K concentrations rose sharply across the sediment/water interface, reaching 12.5 mM at Section U1558F-1H-1 and decreasing somewhat steadily for the uppermost 100 m. SO₄ concentrations decreased from the seawater value (28.9 mM) down to 26.6 mM for the first ~63 m, and then increased back to 28.5 mM between ~63 and ~174 mbsf. Results for phosphate and ammonia point to low values at or near instrument detection limits, so these are also being analyzed using the plate reader instrument brought aboard during Expedition 390. Inductively coupled plasma–atomic emission spectroscopy (ICP-AES) analyses were conducted on basaltic rock samples from Hole U1559D and from XCB cores recovered during Expeditions 390C and 395E. We also reanalyzed a number of samples from Expedition 390 Sites U1556 and U1557. The Hole U1559B basalts are typical, Mg-rich (≈ 8 wt%), depleted MORBs (TiO₂: ≈ 1.0 wt%) with relatively low K₂O (0.09–0.18 wt%), suggesting a comparatively modest degree of seawater alteration.

Microbiology

The microbiology team collected approximately one sample per 10 m advance of sediment and basement in Holes U1558F and U1558D for preservation for shore-based analysis. Before processing the basement whole rounds, they were imaged using the Foldio lightbox/turntable system. All sampling was done within the KOACH system, a portable air filtration unit

that creates a particle-free area for low-contamination sampling. Sample handling was conducted using an ethanol-washed steel rock box and chisels. Subsamples from the microbiology whole rounds from these cores were preserved for cell counts and analysis of community DNA, RNA, and lipids for postexpedition research. Viral production and prophage induction experiments were set up in the anaerobic chamber. To test the contamination of drilling fluid, we collected the inner and outer rock chips containing perfluorocarbon tracer (PFT) (perfluoromethyldecalin [PFMD]) from each whole-round. Furthermore, we collected drilling fluid at Site U1558 on 26–27 June, and 2 July. During postexpedition research, DNA will be extracted from these samples to create a database of potential contaminants for comparison with cored samples.

Micropaleontology

The micropaleontology team focussed on biostratigraphy for Hole U1558F and constructing a robust age-depth model in conjunction with the paleomagnetic team. Both shipboard and shore-based scientists also refined their data from Hole U1558A (cored during Expedition 390C) and prepared sections for the preliminary site reports. In Holes U1558A and U1558F, sedimentation appears to have been continuous from approximately 42 to 22 Ma (middle Eocene to early Miocene).

Paleomagnetism

The paleomagnetism team conducted continuous and discrete magnetic measurements mainly on sediment cores of Hole U1558F and basement cores of Hole U1558D. Remanence magnetization before and after three different alternating field (AF) demagnetization steps (5, 10, and 20 mT) were performed using the superconducting rock magnetometer (SRM) on most of the core intervals. A total of 38 sediment cubes and 15 basalt cubes were sampled and measured from these two holes, which is around 2 samples per core. SRM data reveals frequent changes in polarity throughout the holes. AF demagnetization patterns are relatively unstable in sediments compared to basalt samples, though we were able to derive characteristic remanent magnetization (ChRM) for most of the samples. Anisotropy of magnetic susceptibility (AMS) measurements were conducted on all discrete samples. The samples do not show a consistent fabric orientation. Isothermal remanent magnetization (IRM) acquisition curves and backfield IRM experiments were done on 8 sediment samples and 12 basement samples. The results mainly imply the dominance of low-coercivity minerals such as titanomagnetite, similar to the results from Hole U1559B.

Physical Properties and Stratigraphic Correlation

The physical properties group measured 85 m of basement core material from Hole U1558D and 174 m of sediments from Holes U1558E and U1558F. This included running all whole-round sections through the Natural Gamma Radiation Logger (NGRL), Whole-Round Multisensor Logger (WRMSL), and Special Task Multisensor Logger (STMSL), as well as running discrete measurements of compressional velocity and compressional and shear strength on sediment

section halves. All cylindrical hard rock core pieces were imaged using the Deutsche Montan Technologie (DMT) core scanner (DMT scanning duties are shared between the petrology and physical properties teams). Thermal conductivity was measured on 40 core pieces or section halves that captured the representative lithologies from the holes. Moisture and density (MAD) and *P*-wave velocity measurements were performed on three discrete oriented cubes (sampled to cover a range of fresh and altered basalt lithologies) along with 39 samples from different sedimentary lithological units. In the sediment column, bulk density increased from 1.55 g/cm³ near the seafloor to 1.95 g/cm³ near basement in a compaction trend. Natural gamma ray (NGR) values are higher where there is more clay in the sediment, and reach up to 35 counts/s in the uppermost 10 m. Three formation temperature measurements were made in Hole U1558F, indicating a thermal gradient of ~25°C/km.

Education and Outreach

This week the Onboard Outreach Officer made 25 posts (crossposted on each of the social media sites), ran five ship-to-shore video tours, and wrote two posts for the *JOIDES Resolution* Expedition Log.

- [Twitter](#) has an average 82 engagements (minimum is 20 and maximum is 315) per post, and an engagement rate of 3%, with 45 additional followers.
- [Facebook](#) posts reached 7,438 people, with 31 page views, and 10 new followers.
- [Instagram](#) posts reached 2,884 accounts, engaged 419 accounts, and has 16 new followers, 13 unfollows.
- Five ship-to-shore video tours to a total of ~200 people, the largest of which was to the St. Pauls Steam Competition in São Paulo, Brazil (~150 people).
- The [JOIDES Resolution website](#) has three new blog posts.

Technical Support and HSE Activities

Technical staff supported the science laboratories at Site U1558.

Laboratory activities

- Fixed a leak in the sink at the moisture and density station.
- Established that the tape that the Gulf Coast Repository uses also works well on D-tubes on the *JOIDES Resolution*.
- Ran PFT samples on GC2 gas chromatography instrument.
- Set up the COY hard-shell anaerobic chamber for nitrogen in the microbiology cold-room.

- Core describers reported that, as in prior weeks, a DescLogik error message continued to appear sporadically and they lost the ability to copy/paste. The macroscopic template was removed and then reimported which has resolved the issue for the moment.
- The three advanced piston corer temperature (APCT-3) tool runs in Hole U1558F produced data files with raw data but no temperature data. The calibration files were found and this enabled the temperature time series to be calculated.
- Ran both the Conductivity-Temperature-Depth (CTD) instrument and the Niskin water sampler on the subsea camera deployment at Hole U1558D. A 1.6 L water sample was taken from 4327 mbsl for microbiology culture experiments. We are modifying the frame and visual cue for triggering the water sampler so that it is clearer in the monitor display.
- Started Expedition 398 Petrel seismic project and loaded all Society of Exploration Geophysicists (SEG-Y) files from the site survey database.
- Took 65 close-up images for Site U1558.
- Performed microscope cleaning and maintenance.
- Designed and built a holder for pXRF standards and feet for the rock saws to make them easier to clean around.
- Scientists performed an experiment to determine the reproducibility of velocity measurements on the caliper gantry using hard rock sample cubes. They found that the first measurement was always higher than the following ones. The value decreased until it stabilized after approximately five measurements. This may be caused by sample shifting because the faces are not exactly parallel. The same test was performed on the 20 mm and 34.99 mm acrylic standards, yielding an acceptable difference of approximately 1 m/s between the measurements.
- The STMSL magnetic susceptibility (MS) loop correction factor had been set to 1.0 but it should be 1.174, resulting in underestimates of MS. This affected STMSL MS data from Hole U1558F and maybe STMSL MS measurements in previous expeditions.
- Thermal conductivity Minipuck H51033 had intermittent connection problems; checks continue.
- Prepared hard rock thin sections from samples from Hole U1558D.
- Holding daily sample parties for shipboard and pooled hard rock samples from Hole U1558D.

IT Support Activities

- Continued to develop additional deployment images for the upcoming workstation upgrade.
- Continued developing and testing deployment plans for Adobe Creative Cloud for our Windows and macOS machines.
- Created a wireless network (GEN) available only in the User Room area, for those who needed internet on a second device for reauthentication purposes. There have been many

requests for reauthentication so that messaging applications like WhatsApp continue to work on laptops.

- VMware upgrades for ship's vCenter server and ESXi Hosts are still in progress. Work continues on a VMware environment exclusively for testing and maintenance using old vCenter server.
- Preparing for potential Mac computer replacements during this cruise, if not during the Tie-Up/Transit.
- TAMU Division of IT performed routine maintenance on their Windows servers for the ship. An unexpected issue came up that led to us not being able to access emails for an extended amount of time (~3 h).

Health, Safety, and Environment Activities

- Conducted shower and eye wash safety checks.