IODP Expedition 395E: Complete South Atlantic Transect Reentry Systems

Site U1560 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1560 (proposed site SATL-25A) is at 30.4°S in the central South Atlantic Ocean, ~315 km west of the Mid-Atlantic Ridge. The objective for Site U1560 during Expedition 395E was to core one hole with the advanced piston corer/extended core barrel (APC/XCB) system to basement for gas safety monitoring and to confirm the depth to basement, and to install a reentry system with casing through the sediment into basement in a second hole. These operations will expedite basement drilling during South Atlantic Transect Expeditions 390 and 393.

Site U1560 is located on seismic line CREST02 at CDP 12770, ~400 m south of the CREST1E crossing line. A reflector at ~5.08 s two-way traveltime (TWT) was interpreted to be the top of basement and was estimated to be 104 m below seafloor (mbsf) (Coggon et al., 2020). Based on the deeper-than-expected basement depths we found during Expedition 390C, we expected basement to be similarly deeper at Site U1560. The ocean crust at Site U1560 was estimated to have formed at 15.2 Ma at a half spreading rate of 25.5 mm/y. This site targets the second-youngest crust of the South Atlantic Transect sites. The mineralogy and alteration extent of the basement rocks at Site U1560, changes in physical properties such as porosity, and the composition of the microbial communities will be compared to the same characteristics at the other sites along the transect to investigate the development of hydrothermal circulation and crustal aging. Overlying sediment at Site U1560 is primarily carbonate ooze and will be used in paleoceanographic and microbiological studies.

Operations

Hole U1560A

The *JOIDES Resolution* completed the 1817 nmi transit to Site U1560 from Cape Town in 6.7 d at an average speed of 11.3 kt. We arrived at Site U1560 at 0108 h on 22 April 2021, lowered the thrusters, and switched to dynamic positioning (DP) mode at 0215 h, marking the start of operations at Site U1560. The APC/XCB bottom-hole assembly (BHA) was made up and we started lowering the drill bit to the seafloor at 0945 h. During the descent, the brakes on the drawworks unit were found to be slipping, and tripping was paused several times for adjustments. The drill string deployment was stopped at 1900 h to inspect the brakes. Everything appeared normal, except the bands appeared to be dusty. The bands were washed off and the covers were reinstalled. The brakes operated normally after this. Tripping resumed at 2250 h to 3708 m below sea level (mbsl). Because this was the first site of the expedition, we pumped two pigs (pipe cleaning devices) through the drill string to remove rust. The first APC core was shot

from 3714 mbsl but returned empty, missing the mudline, so the drill bit was lowered 5 m for the next attempt.

We spudded Hole U1560A (30°24.2064′S, 16°55.3718′W) at 0405 h on 23 April. Mudline Core U1560A-1H arrived on deck at 0430 h and recovered 4.7 m, establishing a seafloor depth of 3723.7 mbsl. Cores U1560A-2H to 11H advanced from 4.6 to 99.7 mbsf. All APC cores were oriented with the Icefield MI-5 core orientation tool. Formation temperature measurements were taken on Cores 4H and 7H with the advanced piston corer temperature (APCT-3) tool.

At 1730 h we changed to the XCB coring system because we were approaching the anticipated basement depth. We used the polycrystalline diamond compact (PDC) XCB cutting shoe that had proven successful at recovering basement material during Expedition 390C. Cores U1560A-12X to 14X advanced from 99.7 to 120.1 mbsf. During Core U1560A-15X, a slowing in the drilling rate indicated that the basement contact was reached at 120.2 mbsf. Cores U1560A-15X and 16X advanced from 120.1 to 122.5 mbsf and recovered 0.44 m (18%). Upon recovery, these two cores were confirmed to be basalt. The rate of penetration in this solid formation was slow (~0.6 m/h), so we stopped coring at this point. We raised the drill bit up to the ship, and it cleared the rig floor at 1520 h on 24 April, ending Hole U1560A. Cores U1560A-1H to 16X recovered 119.08 m (97%). The total depth for Hole U1560A was 122.5 mbsf and total time was 61.05 h (2.5 d).

Hole U1560B

We then prepared to install the reentry system in Hole U1560B. At 1745 h on 24 April we started making up the hydraulic release tool (HRT) BHA followed by the 10¾ inch casing string. We picked up the casing with the running tool, and landed it on the base of the reentry cone in the moonpool. Then we rigged up the drill pipe stinger, including a drill bit, underreamer, and mud motor, and tested it in the moonpool. By 1300 h on 25 April we had lowered the stinger through the casing and secured it to the base. We assembled the reentry cone and welded it to the base, and at 1545 h we started lowering the assembly to the seafloor, reaching 3675 mbsl at 0130 h on 26 April. We installed the top drive and deployed the subsea camera and conductivity-temperature-depth (CTD) instrument.

We spudded Hole U1560B (30°56.4546′S, 26°37.7898′W) at 0430 h on 26 April. A water depth of 3723.7 mbsl was assumed, based on the mudline depth at Hole U1560A. In the subsea camera images, Hole U1560B lies about 5 m to the west-southwest of Hole U1560A. We drilled to the target depth of 124 mbsf and disconnected the casing using the HRT at 1025 h. We filled the cased hole with heavy mud to prevent inflow and raised the subsea camera and CTD instrument to the ship. We then raised the stinger assembly to the ship, and the drill bit reached the rig floor at 2355 h and was disassembled. Wear on the bit indicated that basement was contacted, but the excellent condition of the underreamer cutters suggests that it is unlikely that the underreamer and casing reached basement. Therefore, the basement contact at Hole U1560B is a little deeper than at Hole U1560A (120.2 mbsf), as a result of local basement surface topography.

We made up the cementing BHA and lowered it to just above the seabed. The subsea camera was lowered to the BHA to guide reentry, and at 1445 h on 27 April we reentered Hole U1560B. We positioned the base of the BHA at 3 mbsf, which was deep enough for the cup packer in the BHA to seal the top of the casing. We established circulation and pumped down 10 bbl of 15 ppg cement, and then pulled the BHA back out of the hole, clearing the reentry cone at 1545 h. The drill pipe was cleared of any residual cement by pumping down two pigs and flushing it with seawater. The subsea camera was raised back to the ship, followed by the BHA, ending operations at Hole U1560B at 2315 h on 27 April. The rig floor was secured for transit at 0045 h on 28 April. We raised the thrusters and started the sea passage to Site U1557 at 0124 h on 28 April, ending operations at Site U1560.

The next site of Expedition 395E had originally been planned to be Site SATL-33B, the middle site of the South Atlantic Transect on 30.6 Ma crust. Because of the four-day delay in leaving port, there would not have been enough time to complete operations at all four planned sites, so we decided to defer operations at Site SATL-33B until Expedition 390 or 393 in 2022. Instead, the next hole of Expedition 395E was the higher priority Hole U1557D (proposed Site SATL-56A), where Expedition 390C had installed a reentry system consisting of a reentry cone and 60 m of 16 inch casing in November 2020. This site was technically more challenging because the heavy weight of ~5 km of pipe and 573 m of casing meant that the installation could only take place under calm conditions. The weather forecast predicted calm seas at Site U1557, and we decided to take advantage of that.

Principal results

The sediment/basement contact at Hole U1560A is a sharp transition at 120.1 mbsf. The contact was deeper than originally estimated from seismic data (104 mbsf), but similar to what was expected from the basement depths cored during Expedition 390C. The basement depth at cased Hole U1560B is slightly deeper than at Hole U1560A, but the exact depth at Hole U1560B remains to be determined by drilling and logging on Expedition 390 or 393.

Cores U1560A-1H to 14X were measured on the whole-round (WR) and split-core track systems. Cores 15X and 16X were measured on the WR tracks but were not split, and were instead preserved in nitrogen gas-flushed bags for description and analysis during Expeditions 390 and 393. Core catcher samples from Cores 1H to 13X were collected for postexpedition biostratigraphic dating. In addition, we collected one sample per core for headspace gas analysis as well as 1–2 WR samples per core for chemical analysis of interstitial water (IW). The squeezed sediments from the IW samples were measured on the carbonate coulometer and X-ray diffraction instruments. No systematic core description took place during Expedition 395E.

The sediment is predominantly carbonate ooze, ranging from 81 to 95 wt% calcium carbonate. Generally low values of magnetic susceptibility and natural gamma radiation reflect the low terrigenous content of the carbonate ooze, and 10-m to sub-meter-scale variations in these

physical property values likely reflect variations in terrigenous sediment content. Paleomagnetic reversals are evident in the superconducting rock magnetometer (SRM) data, and a preliminary assessment of the reversal stratigraphy suggests that sedimentation is most probably continuous at this site since the crust formed ~15 Ma. It is likely that a robust magnetostratigraphy can be constructed after further holes are cored on Expedition 390 or 393 and a complete splice is available.

Preliminary analysis of the IW chemistry data shows that sulfate has a flat profile, varying between 27.4 and 28.8 mM. Ammonium has more variability, ranging from 3 μM near the top of the hole to 40 μM near its base. Most dissolved element profiles have some downhole structure, but over narrow concentration ranges; for example, magnesium varies between 49.7 and 52.5 mM. Headspace methane measurements were all below the detection limit. These results suggest that diagenetic processes at Site U1560 are slow, consistent with this site's open ocean location and low organic matter input.

Reference

Coggon, R.M., Christeson, G.L., Sylvan, J.B., Teagle, D.A.H., Estes, E., Williams, T., and Alvarez Zarikian, C.A., 2020. *Expedition 390/393 Scientific Prospectus: The South Atlantic Transect*. International Ocean Discovery Program. https://doi.org/10.14379/iodp.sp.390393.2020