IODP Expedition 390C: South Atlantic Transect Reentry Systems

Site U1559 Summary

Background and Objectives

International Ocean Discovery Program (IODP) Site U1559 (proposed site SATL-13A) is in the central South Atlantic Ocean, ~130 km west of the Mid-Atlantic Ridge. The objective for Expedition 390C was to core one hole with the advanced piston corer/extended core barrel (APC/XCB) system to basement for gas safety monitoring, and to install a reentry system with casing through the sediment to ~5 m above basement in a second hole, to expedite basement drilling during South Atlantic Transect Expeditions 390 and 393.

Site U1559 is located on seismic line CREST01 at position CDP 11923 between the CREST06 and CREST1E/F crossing lines. A reflector at ~4.15 s two-way traveltime (TWT) is interpreted as the top of basement and was estimated at 50 m below seafloor (mbsf). Basement is predicted to be approximately 6.6 Ma and formed at a half spreading rate of ~17.0 mm/y. This site was selected as the young crustal endmember of the South Atlantic Transect and will be compared to older crustal material cored at sites further west. The site is similar in age to Hole 504B in the eastern equatorial Pacific (6.9 Ma) that formed at an intermediate rate (36 mm/y half spreading rate) and is covered by 275 m of sediment. As such, material from Site U1559 will allow comparison of how alteration progresses at different spreading centers and with different thicknesses of overlying sediment and sedimentation histories. Overlying sediment from Site U1559 is expected to be primarily carbonate ooze, and will be used in palaeoceanographic and microbiological studies.

Operations

Hole U1559A

The *JOIDES Resolution* completed the 508 nmi transit to Site U1559 from Site U1558 at an average speed of 12.3 kt. We arrived on site at 1715 h on 25 November 2020, lowered the thrusters, and were in dynamic positioning (DP) mode ready to begin operations by 1740 h. An acoustic beacon was not deployed. The APC/XCB bottom-hole assembly (BHA) was made up and deployed, and we began tripping pipe towards the seafloor. Hole U1559A was spudded at 0140 h on 26 November with the bit positioned at 3049.7 m below sea level (mbsl), and Core 1H recovered 3.54 m of sediment. The mudline core established the water depth as 3055.7 m. APC coring continued through Core 4H, advancing to 32 mbsf and recovering 32.9 m of sediment (103%). After Core 4H, we transitioned to the XCB coring system as basement was estimated to be at 50 mbsf. No magnetic orientation or temperature measurements were conducted with the APC cores because of time constraints and not wanting to damage tools if we encountered basement at a shallower depth than expected. XCB Cores 5X to 8X advanced from 32 to 64.7

mbsf. We encountered a hard layer at 64.0 mbsf that dramatically decreased the rate of penetration to <1 m/h. Recovery of this layer was poor: ~11% of the 0.7 m advance and ~8 cm of small, rubbly pieces of basalt. The XCB polycrystalline diamond compact (PDC) cutting shoe lost several cutters during coring of Core 8X. It is unclear whether the lost cutters were due to cumulative use during the entire expedition or difficulty in cutting this younger basalt material. Core 9X was drilled by time (140 min) rather than by advance as the penetration rate was extremely low, and we wanted to avoid damaging the bit by exposing it to elevated temperatures. Ultimately, Core 9X advanced 1.5 m at a rate of 0.64 m/h. Only 0.39 m of material was recovered (26%), consisting of indurated sediment and altered glass. Excluding hard rock material, Cores 5X to 8X advanced 32 m and recovered 24.64 m (77%). In total, Hole U1559A penetrated to 66.2 mbsf with a recovery of 58.01 m (88%). We began pulling out of the hole after Core 9X to have time to install a reentry system with casing. The bit cleared the rig floor at 2200 h, ending Hole U1559A. Overall, coring in Hole U1559A used 1.2 d of operational time.

Hole U1559B

To prepare for installation of the reentry system at Hole U1559B, the upper guide horn (UGH) was removed and the reentry cone was positioned above the moonpool doors underneath the rig floor. The casing shoe was found to be damaged and a new one was prepared. Four joints of 13⅜ inch casing were made up followed by a crossover and the 16 inch casing hanger needed to latch into the reentry cone. One joint of casing was found to have a bent coupling and was replaced. Once the casing string was made up, the Dril-Quip running tool was used to lower it through the reentry cone and latch it into place. Next, the BHA with the bit, underreamer, and mud motor was made up and lowered through the casing, and the running tool engaged with the reentry system. The moonpool doors were opened and the reentry system was lowered through the splash zone at 1645 h on 27 November. The reentry system was lowered at a controlled rate of descent, pausing to fill the drill pipe with water every 10 stands to ensure equalized pressure. The subsea camera was deployed at 2345 h to observe the casing drill-in process and release. The conductivity-temperature-depth (CTD) sensor was attached to the frame of the subsea camera system and logged water column data during the camera deployment.

With the bit spaced out to 3022.7 mbsl, we picked up the top drive and spudded Hole U1559B at 0130 h on 28 November, establishing the seafloor depth as 3055.0 m. The bit reached its maximum depth of 58.9 mbsf by 0315 h with the casing shoe at 55.3 mbsf. Basement was expected to be at 64.0 mbsf. With the reentry system on the seafloor, the driller then applied torque to rotate the running tool 3.5 times, releasing it from the reentry system and casing. We pulled out of the hole, with the bit clearing the reentry cone at 0358 h. The subsea camera was pulled back to the surface and recovered at 0415 h. The top drive was set back, and fluid was circulated through the drill string, displacing seawater with freshwater in the drill pipe. We tripped the rest of the drill pipe back to surface, recovered and laid out the BHA, and detorqued the running tool. The UGH was reinstalled and the moonpool secured. The rig floor was secured for transit at 1815 h, ending Hole U1559B as well as operations for Expedition 390C. Overall, Hole U1559B used 1.8 d of operational time. The ship transitioned out of DP mode and got

underway. The 1723 nmi transit to Cape Town, South Africa, is anticipated to take ~6.5 d with an estimated arrival on 5 December.

Principal results

Basement at Site U1559 was determined to be only slightly deeper than estimated from seismic data, at 64.0 mbsf, relative to the estimated 50 mbsf. Cores U1559A-1H to 7X were measured on the whole-round (WR) and split-core track systems. Sections from Cores 8X and 9X, containing hard rock material, 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 7X 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). No systematic core description took place during Expedition 390C. Sediment lithology consists of carbonate ooze. Sediment color is slightly darker in the first core and then transitions to a lighter white color throughout the rest of the hole. However, even in this upper, darker core, calcium carbonate content is 92.2 wt%. Physical properties generally correlate with lithology. Counts of natural gamma radiation peak in the first section of the first core, decline rapidly through the first core, and then continue to decrease slowly with depth throughout the hole.

Data acquired from analysis of IW in Hole U1559A do not show as clear downhole trends as observed at Sites U1556 and U1557. Alkalinity is relatively low in the mudline sample (2.32 mM), increases to a broad maximum at ~30 mbsf, and then decreases again towards basement. Similar to results from Hole U1558A, the range in alkalinity concentrations (2.24 mM to 2.90 mM) is less than those found at Sites U1556 and U1557. Total dissolved sulfur concentrations, as measured by inductively coupled plasma–atomic emission spectroscopy of IW samples, likewise do not vary substantially downhole, ranging from 29.6 mM in the mudline sample to a minimum of 28.2 mM at a depth of 60.175 mbsf. Total sulfur concentrations are similar in value to sulfate concentrations measured by ion chromatography. There is no indication of significant sulfate reduction in the sediment column at this site. Dissolved manganese (Mn) concentrations do show a subsurface maximum, however, suggesting reduction of oxidized Mn mineral phases. Dissolved iron is below the detection limit, likely because it reoxidized and precipitated during the WR squeezing process. There is no clear trend in ammonium concentrations, which were near the detection limit of the spectrophotometer.

Dissolved calcium (Ca) data do not show a clear trend in the top portion of the hole, though concentrations reach maximum values between ~20 and 40 mbsf and then decrease again towards basement. Strontium (Sr) concentrations more clearly increase to this depth, and then decrease towards basement. As with data from Hole U1558A, Ca and Sr concentrations are lower than at Sites U1556 and U1557. Dissolved magnesium concentrations are variable with depth, whereas potassium increases slightly with a sharp decrease just above the hard rock contact at 64.0 mbsf. Dissolved silicon concentrations are low in the mudline sample, relatively

constant with depth, and then increase above basement. Boron concentrations are low in the mudline sample, increases with depth, and then decreases slightly above basement.

All cores excluding the unsplit basement sections were measured on the superconducting rock magnetometer (SRM) for natural remanent magnetization (NRM) and then at alternating field demagnetization levels of 5, 10, and 20 mT. Vertical drilling overprints were ubiquitous but were generally removed by the 5 mT demagnetization step. Many samples appeared to show a characteristic remanent magnetization (ChRM) after 20 mT demagnetization, although some likely have a higher coercivity component that will need to be examined during postexpedition research. A spike in intensity at the top of Section U1559A-7X-1 was likely caused by a small piece of hard material, possibly basalt, which is observable in the X-ray images.

The CTD sensor was deployed along with the subsea camera system at Hole U1559B. It successfully logged water column data.