IODP Expedition 391: Walvis Ridge Hotspot

Week 7 Report (16–22 January 2022)

The seventh week of the International Ocean Discovery Program (IODP) Expedition 391, Walvis Ridge Hotspot, included rotary core barrel (RCB) coring from the seafloor to a final depth of 193.9 m below seafloor (mbsf) in Hole U1577A (proposed Site VB-13A), the transit to Site U1578 (proposed Site CT-05A), and RCB coring from the seafloor to 37.9 mbsf in Hole U1578A. All times in this report are in ship local time (UTC + 2 h).

Operations

This week began while RCB coring in Hole U1577A. Cores U1577A-7R to 26R advanced from 56.6 mbsf to a final depth of 193.9 mbsf and recovered 111.8 m (81%) of sediment and igneous rock. The sediment/basement contact was intersected while cutting Core 18R at a depth of 154.8 mbsf on 16 January. When we attempted to recover subsequent Core 19R at 0400 h on 17 January, we retrieved only the latch assembly for the upper section of the inner core barrel that was still in place at the end of the drill string. It was discovered that the inner core barrel parted in the upper section at the swivel assembly, which is a single coherent piece that broke at the base of its bearing shaft. We then deployed a second RCB core barrel and attempted to catch the remaining lower section of the inner core barrel to no avail. A new fishing catcher insert was built and deployed successfully. After the inner core barrel was recovered at 0800 h, Core 19R was retrieved and the inner core barrel was repaired. RCB coring resumed with Core 20R at 1030 h on 17 January. Coring continued with half-length (~4.8 m) advances through Core 25R. While cutting Core 26R on 19 January, we were unable to keep the bit on the bottom of the hole due to inclement weather with up to 5 m of ship heave. Thus, at 0215 h on 19 January, the cutting of Core 26R was terminated early. We then raised the drill string to 148.6 mbsf and inserted an extra knobby drilling joint on top of the drill string and waited for the weather to improve enough to resume operations. After we had spent 10.25 h waiting on the weather to improve, it was decided to terminate operations at Site U1577 given the persistent ship heave and the remaining scientific priorities of the expedition. At 1330 h on 19 January, we started pulling the drill string out of Hole U1577A. When the drill string reached 104.6 mbsf at 1400 h, we set back the top drive and continued raising the drill string. The bit cleared the seafloor at 1450 h and arrived at the rig floor at 2125 h. The rig floor was secured at 2150 h on 19 January, ending Hole U1577A and Site U1577. A total of 109.5 h (4.6 days) were spent on Hole U1577A. The final depth of Hole U1577A was 193.9 mbsf.

After receiving notification from the rig floor, the hydrophones and thrusters were raised, and we switched the vessel from dynamic positioning (DP) to cruise mode at 2240 h on 19 January. The vessel was then secured for transit to proposed Site CT-05A (Site U1578). We began our

605 nmi sea passage to the next drill site at 2300 h. The transit ended at 0630 h on 22 January. The average speed of the vessel over the passage was 10.9 kt.

When all thrusters were down and secured at 0655 h on 22 January, we switched the vessel from cruise mode to DP mode. At 0702 h, the rig floor was cleared for operations. The RCB bottom-hole assembly was made up. The outer core barrel had already been assembled during the transit to Site U1578. We began lowering the drill string to the seafloor at 0800 h. The pipe trip to the seafloor was routine and the pipe was filled with seawater twice while being lowered to 3764.0 m below sea level (mbsl). Upon implementing a routine slip and cut of 115 ft of the drilling line, we picked up the top drive at 1630 h and the drill bit was positioned at the seafloor depth of 3790.4 mbsl as indicated by the precision depth recorder (PDR). A dressed nonmagnetic RCB core barrel was dropped and pumped down to land in the outer core barrel. The first attempt to spud Hole U1578A returned a water core. The second attempt to spud Hole U1578A also returned a water core. On the third attempt, Hole U1578A was spudded at 1935 h on 22 January. The seafloor depth was calculated to be 3793.8 mbsl based on the core recovery. The difference between the PDR and the estimated seafloor depth was 15.3 m. RCB Cores U1578A-1R to 4R advanced from the seafloor to 37.9 mbsf and recovered 31.3 m (82%) of sediment by the end of the day.

Science Results

Scientists described and analyzed cores recovered from Hole U1577A and started writing up the acquired data. The laboratory groups submitted their Site U1576 reports.

Core Description

The core description team described cores from Sites U1577 and U1578. Cores were described using a combination of macroscopic and microscopic (smear slides, thin sections, and scanning electron microscopy) observations, supplemented by measurements with the portable X-ray fluorescence spectrometer analysis on igneous archive half sections and selected sample powders for Hole U1577A.

In Hole U1577A, a combined ~194 m of sediment and underlying igneous basement was recovered. The transition to igneous basement occurred at ~155 mbsf. The sedimentary succession was subdivided into three lithostratigraphic units (I, II, and III) that were recognized with the Unit I/II boundary at 46.90 mbsf (Section 6R-1) and the Unit II/III boundary at 70.72 mbsf (Section 8R-3). Unit III is further subdivided into three subunits based on redox changes of the sediments and facies differences. Divisions between units were supplemented with changes in natural gamma radiation (NGR) and biostratigraphic data. Unit I is an unconsolidated pale brown to white nannofossil ooze of Paleocene age, locally with clay, irregularly interbedded with altered volcanic ash layers with sparse feldspar, biotite, and amphibole crystals. There is significant drilling disturbance in the least consolidated layers. Unit

II consists of an unconsolidated to consolidated brown to pale brown clayey-nannofossil ooze/chalk of late Cretaceous (Maastrichtian) age, interbedded with increasingly prominent brown to gray volcanic ash/tuff layers. There is abundant bioturbation throughout. The more consolidated nature of the sediment results in only moderate drilling disturbance at some levels. Unit III is a pinkish-brown to pale brown bioturbated clayey-nannofossil chalk of Late Cretaceous (Campanian) age, which is interbedded with brown to gray volcanic ash/tuff layers and occasional inoceramid shell fragments. The lower 70 m of the unit shows a faint cyclicity, partially masked by increasing frequency of gray volcanic ash/tuff layers. Prominent black vitric tuff layers occur in the lowermost 20 m above the volcanic basement. The succession changes to a deep green (reduced) color between 92.23 mbsf (Section 10R-5) and 133.53 mbsf (Section 14R-6).

The Hole U1577A igneous sequence, which consists of three rapidly erupted massive lava units (4 m, 12 m, and 19 m in thickness), is devoid of sedimentary intercalation or infillings. Igneous basement began in Section U1577A-18R-1 and continued to the bottom of the hole in Section 26R-1. The volcanic sequence consists of a single igneous lithologic unit of highly phyric massive basalt that was divided into three subunits (1a–c) based on identified flow boundaries and small changes in mineralogy. All subunits are porphyritic holocrystalline, though the matrix texture grades to aphanitic near flow boundaries. Subunit 1a consists of a single massive lava flow with ~22% phenocrysts of plagioclase (15%), pyroxene (5%), and olivine (2%). The top of this massive lava of the uppermost subunit is marked by a thin glassy selvage at the top of a "chilled margin" partially altered to palagonite where it has been in contact with the overlying pelagic sediment (chalk). The second (middle) massive basalt Subunit 1b also is highly phyric but contains mostly plagioclase (7%–22%) and pyroxene (2%–5%). The lowest massive basalt, Subunit 1c, shows the return of olivine (~3%) within the plagioclase (12%–15%) and pyroxene (1%–3%) mineral assemblage. The lavas are dominantly sparsely vesicular and contain round vesicles that are filled with at least one secondary mineral (e.g., clay, calcite, and/or zeolite). Vesicle sizes are, on average, 1–2 mm in diameter. A short interval (~20 cm) in Section 22R-3 contains a pipe vesicle channel, and those calcite-filled vesicles are up to 1 cm in diameter.

In Hole U1578A, Core 1R was described. It consists of nannofossil-foraminifera ooze with clay.

Biostratigraphy

The micropaleontologists processed and analyzed samples from Hole U1577A and worked on the reports and presentations of results from Sites U1576 and U1577. Nannofossil and foraminifera ages in Hole U1577A are in good agreement. Preliminary data place the sedimentary sequence in this hole from the Upper Pleistocene at the seafloor to the Campanian at the sediment/basement contact. A major unconformity is observed between the Pleistocene top (mudline sample) and Paleocene bottom of Core U1577A-1R. Late Cretaceous (late Maastrichtian to early Campanian) taxa are observed from Core 6R through Core 17R. Within that depth interval, an unconformity exists between Cores 7R and 8R between the Maastrichtian

and Campanian. Lastly, operations began in Hole U1578A and calcareous biostratigraphic markers indicate a middle Pleistocene age (<0.43 Ma) at the base of Core U1578A-1R.

Paleomagnetism

The paleomagnetism team completed shipboard measurements of the cores from Hole U1577A. This work included partial alternating field (AF) demagnetization of archive half sections, as well as stepwise AF and thermal demagnetization of 48 discrete samples from both sediments and igneous rocks. Sediments from Core U1577A-1R through the uppermost portion of Core 18R primarily consist of partially to fully consolidated ooze and chalk with clay. Characteristic remanent magnetization (ChRM) components were successfully identified in 13 out of 15 discrete sediment specimens subjected to AF demagnetization and all four discrete sediment specimens subjected to thermal demagnetization. Thermal demagnetization spectra of sediments show slow magnetization loss at temperatures between 200°C and 400°C, followed by a sharp drop at ~580°C, consistent with a mixture of titanomagnetite and varying Ti contents and magnetite as the dominant magnetization carriers. Isothermal remanent magnetization (IRM) acquisition curves also reveal the presence of hematite in the sediment samples. From both archive half and discrete sample measurements of sediments, we were able to construct a magnetostratigraphy that was interpreted to span the base of Chron 26r to Chron 34n. There are some temporal gaps within the magnetostratigraphy that resulted from unconformities or reduced core recovery. After removal of a drill string-related overprint by AF levels of 20 mT, basalts recovered from Cores 18R through 26R exhibited negative magnetic inclinations that are consistent with formation in the Southern Hemisphere during Chron 34n. Among discrete basalt specimens, 15 were subjected to AF demagnetization, while 14 were thermally demagnetized. AF demagnetization was more successful than thermal demagnetization in terms of enabling identification of ChRM components and retrieving paleoinclination values. Thermal demagnetization specimens had widely varying demagnetization behavior with some being substantially demagnetized at temperatures as low as 200°C, whereas other specimens had magnetizations that persisted to the 580°C magnetite Curie temperature, suggesting the presence of magnetite with widely ranging Ti contents. Less than half of thermal demagnetization specimens contained stable magnetizations that could be successfully fit using principal component analysis. Coercivity distributions from partial anhysteretic remanent magnetization and IRM acquisition experiments provide further evidence that coarse-grained titanomagnetite and magnetite are likely the dominant remanence carriers in the basalts. The team also began drafting a summary of the magnetic results in the Site U1577 report.

Geochemistry

The interstitial water (IW)/organic geochemistry team worked on samples from Site U1577, taking 16 IW samples from 5 cm whole-round (WR) sediment cores as well as 16 headspace gas samples. Monitoring C1–C6 gases in the latter samples revealed methane concentrations to be all below 2 µL/L, i.e., at the atmospheric background level, and no other hydrocarbon gases higher than C1 were detected. All the WR samples collected for IW extraction yielded enough volume

for both shipboard and postexpedition personal analyses. All shipboard analyses on these IW samples were completed. Specifically, pH/alkalinity and concentrations of phosphate, ammonium, chloride, sulfate, and bromine were measured. Also, routine major and trace element concentrations (Na, Ca, Mg, Sr, K, Li, Si, Mn, Fe, B, and Ba) were determined using inductively coupled plasma–atomic emission spectroscopy (ICP-AES). The IW concentrations of alkalinity, calcium, and magnesium are affected by diagenesis of biogenic carbonates. The IW boron and silicon concentrations are affected by interactions with clays and volcanic sands. In Lithostratigraphic Subunits IIIB and IIIC, increased IW manganese concentrations indicate a chemically reducing environment. Additionally, inorganic and organic carbon concentrations were measured in 16 sediment samples. Carbonate concentration varies between 37 and 80 wt%. A decline in carbonate content coincides with the transition between Lithostratigraphic Subunits IIIB and IIIC, where clay and volcanic sand become more prevalent in the sediment.

This week, the igneous geochemistry team mainly focused on revising our sample preparation methodology for ICP-AES analysis. To fix the low total issue, we performed a preliminary measurement of standard materials and four unknown samples using 125 mg of sample and 800 mg of flux material that is used for digestion of the sample beads. This change in ICP-AES sample preparation yielded much better results for Site U1577 igneous rocks than the first round of measurements, and the total sum amounted to around 100 wt%. Therefore, we measured all samples from Sites U1575 and U1576 again after applying the modified sample preparation method. However, we still have a low total value in 7 out of 42 samples ranging from 90.4–95.4 wt%, which affects interpreting major element compositions, while all other samples have good totals ranging from 96.7–102.9 wt%. We decided to separate results of samples with low totals sums and continue to use the modified method during the remainder of Expedition 391. ICP-AES results from Hole U1575A confirm basaltic chemical composition with mostly tholeiitic character. Downhole geochemical variations display an overall increase in MgO. The most striking geochemical variability is observed at ~274 mbsf. In the upper portions of the recovered interval, the TiO_2 content is relatively constant and sharply drops at 274 mbsf at the bottom of Igneous Lithologic Unit 5. Thereafter, the TiO_2 value remains constant throughout Unit 5 to Unit 8 and slowly increases from Unit 9 to 10 again to a concentration similar to the upper part of the volcanic sequence (Units 1–5). This Ti evolution correlates with a similar pattern for Sr, Y, and Zr. After implementing the analysis, we drafted the igneous geochemistry data report for Site U1575.

Physical Properties

The physical properties team measured a total of 26 cores from Hole U1577A using a suite of instruments designed to measure whole-round cores, section halves, and discrete samples for NGR, gamma ray attenuation (GRA) bulk density, *P*-wave velocity (*x*-, *y*-, and *z*- directions), shear strength, magnetic susceptibility (MS), thermal conductivity, and moisture and density (MAD) porosity and bulk density. For discrete samples, the team measured every representative unit, at least one sample per core. Hole U1577A physical properties measurements are in good agreement and appear to image two distinct lithologic intervals. The sedimentary interval—ooze

and chalk—extends from the seafloor to ~155 mbsf and is characterized by GRA and MAD bulk density of 1.00 to 2.56 g/cm^3, NGR counts between 3.76 and 34.6 counts/s, and MS values ranging from 6.67 to 647 SI × 10^{-5}. The basement interval, consisting of massive and relatively coherent basalt flows, extends from the sediment contact to the bottom of the hole at ~194 mbsf. Basalts in Hole U1577A have relatively uniform values of both GRA/MAD bulk density (1.01 to 2.84 g/cm^3) and NGR (4.76 to 15.8 counts/s), and broader MS range of values (47.0 to 2709 SI × 10^{-5}) compared to the overlying sedimentary succession. The latter displays a notable feature between ~80 and ~90 mbsf, displaying cyclic variations in NGR and MS that correlate to similar trends in reflectance and magnetic properties measured by the Section Half Multisensor Logger (SHMSL) and superconducting rock magnetometer (SRM), respectively. Abrupt increases in NGR, MS, and *P*-wave velocities reliably correspond to tephra layers in the sediment interval in Hole U1577A.

Outreach

This week, Expedition 391 hosted 10 live broadcast events in four countries (Ireland, Japan, UK, and USA). This includes Saint Helena Island, which represents another volcanic hotspot location in the Atlantic Ocean. Exact participation numbers are still pending, but audiences included over 370 people. Fourteen posts were made on Twitter, leading to 40,208 impressions, 1,681 engagements, 536 likes, 97 retweets, and 17 replies. The Twitter account gained 64 new followers. Nine posts were made on Facebook, reaching 20,360 people, and leading to 1,815 engagements, 614 reactions, 32 shares, and 39 comments. Four posts were made to Instagram, which reached a total of 3,113 people, elicited 411 reactions, seven shares, and four comments. One Expedition 391 scientist was featured in the news bulletin of his university (Rice University, USA: https://news.rice.edu/news/2022/data-beneath-south-atlantic-ocean).

Technical Support and HSE Activities

This week, the JRSO technical staff focused on processing cores from Holes U1577A and U1578A.

Laboratory Activities

- Received, processed, and sampled cores from Holes U1577A and U1578A.
- Conducted sampling parties for Sites U1575, U1576, and U1577.
- The right-hand side temperature controller of the lighting system failed on the Section Half Imaging Logger. The high-temperature alarm was triggered, indicating that the heaters were continuously applying heat to the lights. The controller was replaced, and the system is now working.

- Intermittent and inconsistent communication errors between the Integrated Measurement System software and the Exlar electric actuators on the *P*-wave velocity Gantry instrument were experienced, and it has been difficult to diagnose the cause of the issue. The communication errors can be resolved; however, the method to resolve them is also inconsistent. Troubleshooting continues.
- We repaired two microscope light sources that failed, and inspected and repaired additional light sources that were showing wire fatigue.

IT Support Activities

- CorelDRAW GS 2021 graphic design software was installed on selected user room and Publications Office computers.
- The *P*-wave Gantry workstation did not recognize the RS-485 Serial interface module, and the Native Instruments (NI) software stated there was a driver missing. We downloaded and installed the NI-Serial v21.3 driver, which solved the issue.
- Microsoft New Technology File System Paragon software driver v15.9.313 for Mac was installed on several Mac computers (Science Office, Imaging Specialist Office, and Outreach Office).
- We ran a Hewlett-Packard (HP) diagnostic software tool (LTT Tape Tool) on the HP Tape library drive, collected logfiles, and sent them to HP per company's open case request following an ongoing library issue.

Application Support Activities

- Worked on projects for the Paleomagnetics Laboratory: (1) Wrote code for uploading the text files in the Kappabridge instrument uploader and for displaying these files in a report; (2) Helped design a QCViewer SRM template so that the SRM standard data will be visible in the QCViewer.
- Worked on applications related to standard samples: (1) Helped modify standard samples output by adding offsets to them and enabling upload to Laboratory Information Management System (LIMS); (2) Fixed the issue preventing the LIMS application from downloading data files for "Measurements on Standards."
- Assigned QCViewer template permission to all technicians.

HSE Activities

- The safety shower and eye wash stations were tested.
- A lifeboat safety drill was held on 16 January.