IODP Expedition 391: Walvis Ridge Hotspot

Week 8 Report (23–29 January 2022)

The eighth week of the International Ocean Discovery Program (IODP) Expedition 391, Walvis Ridge Hotspot, included rotary core barrel (RCB) coring from 37.9 to 422.1 m below seafloor (mbsf) in Hole U1578A (proposed Site CT-05A), involving a bit change and reentry of that hole. All times in this report are in ship local time (UTC + 2 h).

Operations

This week began while RCB coring in Hole U1578A. Cores U1578A-5R to 53R advanced from 37.9 mbsf to 422.1 mbsf and recovered 175.1 m (46%) of sediment and igneous rock. The sediment/basement contact was intersected while cutting Core 20R at a depth of 184.3 mbsf on 23 January. Except for Core 23R, we pumped a high-viscosity mud sweep during every core to keep the hole clean. Forty barrels of mud were circulated during Core 45R while all other coring advances received 20 barrels each. To reach the target penetration depth of ~250 m into igneous basement in Hole U1578A, a change of the coring bit was required. Thus, after recovering Core 45R at 1510 h on 27 January, we secured the coring equipment and began preparing the deployment of a free-fall funnel (FFF) for reentering Hole U1578A after the bit change. The drill string was raised from 373.4 mbsf to 338.9 mbsf with the top drive installed. At 1545 h, we set back the top drive and continued raising the drill string to 105.8 mbsf. Upon pulling the upper guide horn at 1645 h, we rigged up and assembled the FFF. The moonpool doors were then opened, and the FFF was deployed at 1835 h. We then lowered the subsea camera system to the seafloor and observed a cuttings cone around the FFF. While monitoring the funnel, we continued pulling the drill string out of the hole, and the bit cleared the seafloor at 2135 h. The subsea camera system was retrieved, and it arrived in the moonpool at 2315 h on 27 January. After securing the subsea camera system, we continued raising the drill string. The bottom-hole assembly (BHA) reached the surface at 0345 h on 28 January. The bit arrived at the rig floor at 0445 h. A new RCB coring bit was installed, and the outer core barrel assembly was checked. At 0600 h, we began lowering the drill string with the BHA. After deploying the BHA to 110.7 m below sea level (mbsl) and servicing the rig, we continued lowering the drill string with drill pipe. When the drill string reached 3782.7 m below sea level, we filled the drill pipe with seawater. At 1245 h, the subsea camera system was deployed to search for the reentry funnel of Hole U1578A. After we found the cuttings mound and funnel outline, we positioned the bit and maneuvered the vessel to reenter the hole. At 1705 h on 28 January, we reentered Hole U1578A and lowered the bit to a depth of 104.9 mbsf. The subsea camera system was retrieved to the surface, and it was secured at 1915 h. Both deployments of the subsea camera system included successful bottom seawater sampling using a Niskin bottle attached to the frame of the camera system. We then lowered the drill string to 338.9 mbsf. At 2000 h, the knobby drilling joints and the top drive were picked up. With the top drive installed, the bit was lowered to the bottom of

Hole U1578A at 373.4 mbsf. At 2100 h on 28 January, RCB coring resumed in Hole U1578A, cutting Core 46R. It continued through Core 51R, which was retrieved at 1625 h on 29 January. We then repaired a hydraulic hose failure on the top drive service loop. Coring operations resumed at 1800 h, resulting in recovery of Cores 52R and 53R by the end of the day.

Science Results

Scientists described and analyzed cores recovered from Hole U1578A and started writing up the acquired data. The laboratory groups presented their Site U1576 and Site U1577 results at science summary meetings and submitted their Site U1577 reports.

Core Description

The core description team described cores from Site U1578. Hole U1578A recovered a combined 398 m of sediment and underlying igneous basement. The transition to igneous basement occurred at ~184 mbsf. Cores were described using a combination of macroscopic and microscopic (smear slides and thin sections) observations. The core description team took samples for X-ray diffraction analysis. Igneous section halves and selected sample powders were measured using a portable X-ray fluorescence spectrometer (pXRF).

A ~184 m thick succession of calcareous pelagic sediment interbedded with volcaniclastic layers lies on top of the volcanic basement in Section U1578A-20R-1. Two main lithostratigraphic units, with the second one further subdivided into two subunits, were recognized based on macroscopic and microscopic (smear slide, thin section, and scanning electron microscopy) lithological observations together with changes in magnetic susceptibility (MS), natural gamma radiation (NGR), and biostratigraphic data. Lithostratigraphic Unit I forms the uppermost 27 m of the sedimentary cover. It consists of white to pale brown foraminifera-nannofossil ooze with clay. Significant drilling disturbance occurs throughout due to poor consolidation of this pelagic sediment, but almost complete (99%) recovery was achieved. Preliminary biostratigraphic and lithological observations suggest the occurrence of possible slumps close to the boundary with underlying Unit II in Section 3R-6. This boundary is marked by the appearance of tephra and a gradual clay increase in the calcareous ooze/chalk downhole, which correlates with an increase in MS and NGR values. Lithostratigraphic Unit II is a ~157 m thick succession of calcareous pelagic sediment with rare volcaniclastic deposits, becoming progressively more consolidated with depth. Relatively limited (<40%) recovery in this unit probably occurred due to significant heave motion during drilling. Two subunits (Subunits IIA and IIB) were defined in Unit II based on changes in clay content and NGR values. Subunit IIA occurs from 27.00 to 135.20 mbsf (base in Section 15R-1). It consists of white to pale pinkish-brown nannofossil ooze to chalk with clay and rare radiolarians, siliceous sponge spicules, and foraminifera. The unit also includes minor (commonly disturbed) interbeds of light to dark gray tephra. Subunit IIB occurs from 135.20 to 184.26 mbsf and consists of light gray to greenish-gray clayey-nannofossil chalk with rare radiolarians, siliceous sponge spicules, and foraminifera. The unit also includes minor

(commonly disturbed) interbeds of dark greenish-gray to black vitric sandstone/tuff. The boundary between the sedimentary cover and the volcanic basement is marked by altered volcaniclastic deposits on top of a volcanic succession of variable nature. At least six sedimentary intervals intercalate with lava flows of the basement. These sedimentary interbeds primarily consist of layered to laminated volcaniclastic deposits with subordinate bioturbated clayey-nannofossil chalk.

In Hole U1578A, the recovered volcanic succession (from Section 20R-1 downhole) consists of sheet and massive lava flows, as well as thick stacks of pillow and lobate lava flows, occasionally showing interbedded pelagic and volcaniclastic sediment. Glassy remnants are preserved on some pillow margins. The top 110 m of the volcanic sequence consists of highly phyric (~15% plagioclase and 2%–3% pyroxene) basalt making up pillow and lobate lava flows. In highly phyric lavas, plagioclase phenocrysts and glomerocrysts are blocky to tabular and can be up to 1.5 cm in diameter. After a sedimentary interbed, the pillow and massive flows change to sparsely plagioclase phyric to aphyric basalts with small (2–3 mm), slender plagioclase laths. Lavas return to a highly phyric texture with plagioclase (12%–18%) and pyroxene (1%–5%) phenocrysts below a pelagic sedimentary interbed in Core 26R. Some of the lava flow units are quite large: one massive basalt unit is 23 m thick, and one pillow unit is >100 m thick. Phenocryst-bearing units are fine-grained and holocrystalline while aphanitic units have more microcrystalline, equigranular groundmass. The lavas range from moderately vesicular with both 2–4 mm and <1 mm round to subround vesicles to sparsely and nonvesicular, where the vesicles are 1 mm or less in size. Pipe vesicles (up to 1 cm in length) are sporadically present in some flow interiors. Sedimentary interbeds separate major eruptive packages that represent distinct volcanic episodes. Lavas range from dominantly unaltered massive flows with sparse pyrite-lining vesicles to highly altered pillow flows and contain one or more of a variety of alteration minerals (e.g., calcite, goethite, clay minerals, and epidote). The vesicular and fractured nature of pillow lava stacks makes them susceptible to hydrothermal alteration in the form of vesicle infilling and veins in fractures. The nature of this secondary alteration changes downward through the succession with carbonate and calcite, together with Fe-oxyhydroxide dominating the upper igneous units, and pyrite (marcasite) together with Cu-bearing coatings and zeolites infillings becoming more common downhole.

Biostratigraphy

The micropaleontologists analyzed samples from Hole U1578A which recovered sediments ranging from Pleistocene to early Paleocene. A large unconformity was observed between the uppermost sediments from Sections 1R-CC and 2R-CC that have a maximum age of early Pleistocene, Piacenzian stage, and Section 3R-CC, where early Eocene to late Paleocene ages are observed through microfossil analysis. The oldest age in the sedimentary succession, just above the basement contact, is ~62.00 Ma, which agrees with preliminary chronostratigraphic data provided by the paleomagnetists. Calcareous nannofossil samples taken from sedimentary interbeds within the volcanic succession revealed a slightly older age of ~63.25–64.81 Ma. Closer evaluation of these samples will be performed postexpedition in an attempt to distinguish

lava flows temporally and determine the oldest possible age where sedimentation is preserved in the stratigraphy.

Paleomagnetism

The paleomagnetism team conducted shipboard measurements of the cores from Hole U1578A. This work included partial alternating field (AF) demagnetization of archive section halves, as well as stepwise AF and thermal demagnetization of discrete samples from both sediments and igneous rocks. All sediment cores had magnetizations strong enough to be measured. Characteristic remanent magnetization components were successfully identified in 16 out of 17 discrete sediment specimens subjected to AF demagnetization and two out of three discrete sediment specimens subjected to thermal demagnetization. Demagnetization behavior and measurement of isothermal remanent magnetization acquisition as well as backfield curves point to titanomagnetite with various Ti contents and hematite as the dominant magnetization carriers. From both archive half and discrete sample measurements of sediments, we were able to construct a magnetostratigraphy for Cores U1578A-4R through 19R that we interpret to span from the base of Chron 24r into Chron 27n. After removal of a drill string-related overprint by AF levels of 20 mT, basalts and interbedded sediments from Cores 20R through 32R measured from archive section halves exhibit negative magnetic inclinations, except for a small interval in a volcaniclastic interbed. Cores 33R to 37R are mostly pillow basalts with only a few small, oriented pieces. Thus, archive half measurements were done more sparsely and led to less reliable results with a large variation in magnetic inclinations. About 50 basalt and interbedded sediment discrete specimens were collected and demagnetized. Samples from Cores 20R through 32R had ideal thermal and AF demagnetization behaviors, and most of them yielded successful principal component analysis fits, showing inclinations consistent with those given by the archive half measurements. The magnetic remanence carriers seem to be mostly single-domain to pseudosingle-domain titanomagnetite. In contrast, demagnetization experiments of discrete samples from Cores 33R to 37R were mostly unsuccessful and we could only retrieve reliable inclinations from a few of them.

Geochemistry

The interstitial water (IW)/organic geochemistry team worked on samples from Site U1578. We took 17 headspace gas samples and monitored C1–C6 gases. Methane concentrations of these samples are all below 2 µL/L, i.e., at the atmospheric background level, and no other hydrocarbon gases higher than C1 were detected. Twenty IW samples from 5 cm long whole-round sediment samples were collected, consistently yielding enough volume for both shipboard and postexpedition personal analyses. We finished all shipboard analyses on these IW samples. Specifically, we measured pH/alkalinity and concentrations of phosphate, ammonium, chloride, sulfate, and bromine. We also measured routine major and trace element concentrations (Na, Ca, Mg, Sr, K, Li, Si, Mn, Fe, B, and Ba) of these samples by inductively coupled plasma–atomic emission spectroscopy (ICP-AES). The IW concentrations of calcium, magnesium, and strontium are affected by diagenesis of biogenic carbonates. The IW manganese concentration is

elevated near both the top and bottom of the sediment succession, indicating chemically reducing environments. IW silicon concentration increases from 200 µM at the top depth to ~700 µM at ~50 mbsf, and retains this high concentration below this depth, suggesting intense dissolution of biogenic silica and/or volcanic sands. Additionally, we measured inorganic and organic carbon concentrations in 17 sediment samples. Carbonate concentration varies between 42 and 95 wt%. Carbonate content is high (88 wt%) in the top part of the sediments where the sediment is predominantly foraminifera-nannofossil ooze, and declines toward the bottom of the sediment succession, where clay and volcanic sand become more prevalent in the sediment.

This week, the igneous geochemistry team measured seven samples from Site U1577 for their major and minor elements composition using ICP-AES. The modified glass bead sample preparation method worked well, and the total weight percentages of major elements ranged from 96.95 to 100.71 wt%. All samples from Site U1577 are classified as basalts and have a tholeiitic composition. On bivariate diagrams of Mg# versus the other major and trace elements, the Site U1577 samples form tight clusters that overlap with previous dredge and Deep Sea Drilling Project core samples from the Walvis Ridge. The three igneous lithologic subunits (1a to 1c) of Site U1577 show very limited geochemical variations downhole. Consistent with the absence of olivine in Subunit 1b, MgO, Mg#, and Ni, as well as Cr, are slightly higher in olivine-bearing basalts of Subunits 1a and 1c. We also completed the drafts of the reports for Sites U1575, U1576, and U1577. Samples from Site U1578 were selected for ICP-AES measurements. Powdering and glass bead-making preparation process for those samples is ongoing.

Physical Properties

This week, the physical properties team obtained bulk density, MS, NGR, *P*-wave velocity, thermal conductivity, and porosity measurements from 50+ cores recovered from Hole U1578A. Collectively, physical properties datasets record one major lithologic boundary (the contact between calcareous ooze/chalk and basalt at ~184 mbsf), as well as multiple contacts between sediments and basalt flows below ~184 mbsf. The uppermost sediment interval is distinguished by NGR of 1.36 to 29.5 counts/s, MS from 1.75 to 662 SI × 10^{-5}, *P*-wave velocity (*x*- and *y*-directions) from 1464 to 2429 m/s, thermal conductivity of 0.988 to 1.323 W/m·K, and 33.1 to 74.7 vol% porosity. Similarly, high NGR and porosity and low bulk density, MS, *P*-wave velocity, and thermal conductivity values record sediment interbeds below the initial basement contact. As with previous Expedition 391 sites, physical properties datasets reliably correlate to observations from other shipboard science teams. For example, tephra deposits in calcareous ooze and chalk in the uppermost sediment interval are identified by NGR peaks (e.g., 19.5 counts/s in Section 4R-2). Additionally, MS and NGR datasets align with pXRF geochemical measurements and may record compositional shifts and secondary alteration in Hole U1578A basalt flows.

Outreach

This week, Expedition 391 hosted 12 live broadcast events in eight countries (Canada, Germany, Japan, Namibia, Puerto Rico, Singapore, UK, and USA) to more than 500 people. Sixteen posts were made on Twitter, leading to 33,654 impressions, 1,212 engagements, 428 likes, 65 retweets, and 13 replies. The Twitter account gained 47 new followers. Nine posts were made on Facebook, reaching 18,698 people, and leading to 1,281 engagements, 550 reactions, 41 shares, and 15 comments. Seven posts were made to Instagram, which reached a total of 4,415 people, elicited 597 reactions, nine shares, and three comments. One new post was published to the *JOIDES Resolution* website by the onboard Outreach Officer. Fifteen students submitted entries to Expedition 391 Contest #1: "Design Your Dreamboat"; judging is underway.

Technical Support and HSE Activities

This week, the JRSO technical staff focused on processing cores from Hole U1578A.

Laboratory Activities

- Received, processed, and sampled cores from Hole U1578A.
- Conducted first sampling party for Hole U1578A.
- Subsea deployments: We successfully deployed the Conductivity-Temperature-Depth (pressure) instrument and a Niskin bottle water sampler on two runs of the vibration isolated television frame during FFF deployment and reentry operations for Hole U1578A, respectively.
- Manufactured motor clamps for worn-out clamps on the AGICO JR6 MS meters using the 3-D printer. The clamps keep the motor from rotating if the sample holder gets jammed.

IT Support Activities

- The Microsoft computer workstation that contains the digital video recorder of the subsea camera footage encountered hardware issues. One of the dual in-line memory modules intermittently disappeared from the basic input/output system memory, resulting in subsea video camera software failure. Removing the modules did not resolve the issue. The spare computer was installed and is operational. The original computer is being shipped to shore for repair.
- Server inventory was performed per shore request.
- Encountered satellite communication issues during the first half of the day on 26 January, prompting interaction with Marlink that eventually resolved the issue with the satellite provider.

- We continued running a Hewlett-Packard (HP) diagnostic software tool (LTT Tape Tool) on the HP Tape library drive, collecting more logfiles, and sending to HP per company's open case request following an ongoing library issue.
- Started drafting the end-of-expedition report.

Application Support Activities

- Continued writing code for the uploader of the new AGICO Kappabridge instrument in the Paleomagnetics Laboratory.
- Added a timestamp field in the copy/paste field in the QC Viewer project and redeployed it on the ship.
- Removed non-IODP employees' Oracle accounts on the ship, and also removed their accounts in Auther.
- Canceled false Laboratory Information Management System data as requested.

HSE Activities

- The safety shower and eye wash stations were tested.
- A lifeboat safety drill was held on 23 January.