IODP Expedition 391: Walvis Ridge Hotspot

Week 6 Report (9–15 January 2022)

The sixth week of the International Ocean Discovery Program (IODP) Expedition 391, Walvis Ridge Hotspot, included rotary core barrel (RCB) coring from 75.4 m below seafloor (mbsf) to a final depth of 398.1 mbsf in Hole U1576A (proposed Site VB-14A), operations in Hole U1576B with (1) drilling without core recovery from the seafloor to 365.0 mbsf and (2) RCB coring from 365.0 mbsf to a final depth of 450.3 mbsf, and the onset of operations at Site U1577 (proposed Site VB-13A). All times in this report are in ship local time (UTC + 2 h).

Operations

This week began while RCB coring in Hole U1576A. Cores U1576A-9R to 42R advanced from 75.4 mbsf to a final depth of 398.1 mbsf and recovered 248.6 m (77%) of sediment and igneous rock. The sediment/basement contact was intersected while cutting Core 40R at a depth of 380.2 mbsf on 10 January 2022. While cutting the subsequent Core 41R, unusual, highly variable standpipe and pump pressures were observed. The core barrel was retrieved at 1635 h on 10 January. An investigation revealed that the latch that keeps the core barrel in place inside the outer core barrel was sheared. The core barrel was completely jammed with core and was disassembled and the plastic liner that contains the core was pumped out of the core barrel. The recovery was 5.7 m for Core 41R. It was suspected that the outer core barrel was plugged and a bit deplugger was deployed to attempt to unblock the bit. The deplugger was run multiple times without confirmation of a clear outer core barrel. Another dressed core barrel was lowered to the base of the bottom-hole assembly (BHA), and we attempted to cut Core 42R. We advanced 1.5 m but experienced the same erratic standpipe pressures. The attempt to continue coring with Core 42R proved unsuccessful when we recovered an empty core barrel from a depth of 398.1 mbsf at 2305 h. Subsequently, more deployments of the bit deplugger were completed. At 0500 h on 11 January, the decision was made to abandon Hole U1576A, and we started pulling the drill bit out of the hole. The top drive was set back at 0615 h, and the bit cleared the seafloor at 0730 h. While we were retrieving the drill string, the vessel was moved 400 m at 95° to establish a second borehole at Site U1576. The bit arrived at the rig floor at 1230 h, ending Hole U1576A. The bit was removed from the outer core barrel, revealing a completely plugged outer core barrel. Approximately 1.2 m of core was removed from the outer core barrel. The bit float and bearing were removed, cleaned out, and reassembled. We then made up the RCB BHA again and started lowering the bit back to the seafloor. When the drill string was lowered to 3000.8 m below sea level (mbsl), we picked up the top drive at 1930 h. The bit was then positioned at the seafloor depth of 3027.2 mbsl as obtained from the precision depth recorder (PDR). At 2050 h on 11 January, we spudded Hole U1576B and began drilling without core recovery. The hole was advanced to the target depth of 365 mbsf with a core barrel in place. At 0655 h on 12 January, we retrieved the core barrel. It contained some sediment unintentionally recovered at an

indeterminable depth while drilling and was recorded as wash Core U1576B-1W. Cores U1576B-2R to 17R penetrated from 365.0 mbsf to a final depth of 450.3 mbsf and recovered 60.8 m (71%) of sediment and igneous rock. The first contact with igneous rock occurred in Core 5R at a depth of 385.4 mbsf. Half-length (~4.8 m) RCB coring was implemented through Core 14R to a depth of 430.8 mbsf with varying penetration rates. While Core 15R was advancing at a high penetration rate of 8.95 m/h, we switched to full-length (~9.6 m) coring. This core proved to contain entirely sediment. Half-length Cores 16R and 17R returned to slow penetration rates (1.47 and 1.18 m/h, respectively). After Core 17R arrived on deck at 1040 h on 14 January, it was decided to terminate coring in Hole U1576B at a final depth of 450.3 mbsf. In total, 140 barrels of high-viscosity mud were pumped for hole cleaning while coring Hole U1576B. After securing the coring equipment, we started pulling the drill string out of the hole at 1100 h. When the drill string was pulled to a hole depth of 381.6 mbsf, we set back the top drive at 1200 h and continued pulling the drill string up to the surface. The bit cleared the seafloor at 1305 h and arrived at the rig floor at 1820 h, ending Hole U1576B. The outer core barrel was disassembled and inspected, and a new bit was installed. The assembly was spaced out in preparation for the next drill site. The rig floor was secured at 1915 h on 14 January 2022, ending Site U1576. The total time spent on Site U1576 was 155 h or 6.46 days.

After the thrusters were raised and the vessel was switched from dynamic positioning (DP) to cruise mode, we secured the vessel for transit to proposed Site VB-13A (Site U1577). We began our sea passage to the next drill site at 1942 h on 14 January. Upon completing the 134 nmi transit at an average speed of 11.0 kt, the vessel arrived at Site U1577 at 0754 h on 15 January. After lowering the thrusters and switching from cruise mode to DP mode, the rig floor was released to begin operations at 0817 h.

The outer core barrel was picked up and we started assembling the RCB BHA. Once the BHA was made up, we began lowering it to the seafloor while offsetting the ship 90 m eastward from the proposed site coordinates to a new location for Hole U1577A. After installing the crossover at the top of the BHA, 70 stands of pipe were deployed. Once this step was completed, the circulating head to fill the drill pipe with surface seawater was hooked up. After filling the drill pipe, we continued lowering the drill string until the bit reached 3910.0 mbsl at 1630 h. The top drive was picked up and the drill bit was positioned just above the seafloor depth of 3940.2 mbsl as obtained from the PDR. After a nonmagnetic core barrel was deployed, we spudded Hole U1577A at 1710 h 15 January and began RCB coring. Cores U1577A-1R to 6R advanced from the seafloor to 56.6 mbsf and recovered 41.1 m (73%) of sediment by the end of the day.

Routine COVID-19 antigen testing was implemented for all personnel on 10 and 12 January. All results were negative. Following 14 days of shipboard COVID-19 mitigation protocols at sea, the safety measures were lifted at 1354 h on 12 January.

Science Results

Scientists described and analyzed cores recovered from Holes U1576A, U1576B, and U1577A. The laboratory groups submitted their Site U1575 reports.

Core Description

The core description team described cores from Holes U1576A, U1576B, and U1577A. Site U1576 recovered a combined 398 m of sediment and underlying igneous basement. The transition to igneous basement occurred at ~380 mbsf. Only basal sediments and the igneous basement were recovered from Hole U1576B. It consisted of 85.3 m of sediment and igneous basement, and the transition to igneous basement occurred at ~385 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 (XRD) analysis. Igneous section halves and select sample powders were measured using a portable X-ray fluorescence device.

The sediments recovered at Hole U1576A are dominated by biogenic components (i.e., nannofossil-foraminifera ooze and chalk), but with increasing, albeit minor, allochthonous content in the lowermost cores consisting of silt- to sand-sized particles in thin turbiditic layers. The uppermost part of the succession (Lithostratigraphic Unit I) consists of typically unlithified nannofossil-foraminifera ooze with minor radiolarians and thin, diffuse laminae and patches of pyrite. The base of Unit I corresponds to a sharp contact with underlying brown-pink to white bioturbated foraminifera-nannofossil ooze with clay (Unit II). This sharp contact corresponds to a major, ~38-million-year hiatus in the upper part of Hole U1576A and indicates a major unconformity in the succession between middle Miocene and lower Paleocene sediments. The top of Unit III is marked by an Fe-Mn crust and is characterized by 10–50 cm thick cycles of brown-red and pale brown ooze/chalk with slight to heavy bioturbation and rare calcareous to volcanic sand and altered volcanic ash. The lowermost sedimentary succession (Unit IV) is also characterized by faint cycles of gray to green to very faint brown-red chalk and, downward with increasing frequency, interbedded with the distal edges of turbidity currents depositing silt- and sand-sized volcanic and calcareous grains. An unusual 1 m thick sedimentary layer, interpreted as a hyperconcentrated mass flow deposit, provides a useful marker horizon in the lower part of Unit IV. This layer is readily identified in the lower section of the 58 m thick sediments cored in Hole U1576B, allowing robust correlation of the lower sedimentary cover in both holes. In Hole U1576B, the igneous basement alternates with thick (5–12 m) sediment interbeds. These are consistent with those at the base of the overlying continuous sedimentary succession, indicating the depositional environment of Unit V to be coeval with the later stages of local volcanic eruptions and emplacement of pillow and massive lava flows.

In Hole U1576A, the top of igneous basement is in Section 40R-3 and continues to the bottom of the hole in Section 42R-4. The volcanic sequence is divided into two units based on distinctive eruptive styles and petrographic observations. The upper unit is composed of sheet flows with

9%–12% phenocrysts of plagioclase and pyroxene with sparse (<3%) vesicles often filled with secondary minerals. The lower unit consists of an aphyric pillow basalt package with intermittent glassy margins. The lavas range from sparse to moderately vesicular and contain round vesicles that are filled with at least one secondary mineral (e.g., clay, calcite, zeolite, and/or pyrite). Vesicle sizes are 1–2 mm in diameter on average, but can amount up to 10 mm.

Hole U1576B revealed volcanic sequences interlayered with foraminifera-nannofossil chalk. Some chalk layers are up to 11.7 m thick. The igneous basement extends from Sections 5R-3 to 17R-5 at the bottom of the hole. The volcanic succession is divided into 11 units based on volcanological observations, eruptive style, and petrography. The igneous units mostly consist of pillow lava flows (18.2 m total) and massive lava flows (20.2 m total) with a small sheet flow (2.56 m) at the bottom of the hole. The top portion of the hole (Igneous lithologic Units 1 to 5) is aphyric, and microphenocrysts of plagioclase are visible in some samples. The bottom sequence of the hole (Units 6–11) is sparsely plagioclase ± pyroxene phyric (2%–4% total phenocrysts) with the centers of massive flows containing higher phenocrysts abundances (<8%). The lavas are dominantly nonvesicular to sparsely vesicular, though one unit was moderately to highly vesicular, and most of the vesicles were completely filled with secondary minerals.

In Hole U1577A, Core 1R was described. It consists of an alternation of nannofossil ooze with clay and foraminifera-nannofossil ooze, including occasional intercalations of calcareous clayey sand with volcaniclasts.

Biostratigraphy

The micropaleontologists continued processing and analyzing samples from both Hole U1576A and Hole U1576B and began working on the site report and presentation for that material. Nannofossil and foraminifera ages in Hole U1576A are in good agreement. Preliminary data place the sedimentary sequence in this hole from the middle Pleistocene (<0.43 Ma) to the early Campanian stage of the Upper Cretaceous. A major unconformity was observed between Cores U1576A-10R and 11R. Finally, operations commenced in Hole U1577A and calcareous biostratigraphic markers indicate a lower Paleocene age (<59.2 Ma) at the base of Core 1R.

Paleomagnetism

The paleomagnetism team completed shipboard measurements of the cores from Hole U1576A and partially completed shipboard measurements of the cores from Hole U1576B. This work included partial alternating field (AF) demagnetization of archive section halves, as well as stepwise AF and thermal demagnetization of about 80 discrete samples. Cores U1576A-1R to 10R are primarily composed of calcareous nannofossil ooze that was disturbed and showed magnetization intensities too weak to confidently interpret regarding magnetostratigraphy. Cores 11R to 41R reveal stronger magnetizations and allowed for the construction of a magnetostratigraphy that is interpreted to span from the base of Chron C26r to the top of Chron C33r. AF demagnetization of discrete sediment samples collected from Cores 11R through 40R was successful after the removal of a drill string-related magnetic overprint by AF levels of

~20 mT. Thermal demagnetization of discrete specimens was also successful with magnetizations that regularly lasted to thermal steps of more than 650°C, indicative of the presence of hematite among the magnetic carriers, which is consistent with the very high coercivities observed in AF demagnetizations. Basalts recovered from Section 40R-4 through Core 41R were often heavily altered but good directions were obtained for three of five discrete samples. These samples have reversed polarity, in agreement with the basal sediments overlying them. In Hole U1576B, the basal sediments have a magnetic behavior similar to that of the bottommost sediments from Hole U1576A and show a similar magnetostratigraphy, containing the same reversal that is observed just above basement in Hole U1576A. The basalts in Hole U1576B are mostly heavily altered and interbedded with sediment. The interbedded sediments are generally like the basal sediments and appear to contain hematite as a magnetic carrier. The fresher basalts exhibit ideal demagnetization behavior, whether in AF or thermal demagnetization, while the more altered basalts show much weaker magnetizations. Therefore, it was more difficult to obtain reliable directions from them. Overall, reliable directions were obtained from about half of the discrete samples from Hole U1576B, all of which are in close agreement with the 20 mT step measurement from the superconducting rock magnetometer. Additional experiments including measurements of bulk magnetic susceptibility (MS), anisotropy of magnetic susceptibility, and thermal demagnetization of isothermal remanent magnetization (Lowrie test) were conducted on a subset of discrete specimens to ascertain contextual information about rock magnetic properties. The team also worked on summarizing the reported magnetic results in a report on Site U1576.

Geochemistry

The interstitial water (IW) and organic geochemistry team worked on gas, liquid, and solid samples collected from Site U1576. A total of 39 headspace gas samples were prepared by oven-heating (50°C) sediment in serum vials, and C1–C6 gases in these samples were monitored. Methane concentrations of these samples were below 2.0 µL/L and no other hydrocarbon gases higher than C1 were detected. We collected 46 IW samples from 5–10 cm long whole-round sediment core pieces obtained at Site U1576. We measured pH and alkalinity using titrator, phosphate, and ammonium of IW using a UV spectrometer, and chloride, sulfate, bromide, chloride, calcium, magnesium, potassium, and sodium of IW using ion chromatography. We also measured major and trace elements (Na, Ca, Mg, Sr, K, Li, Si, Mn, Fe, B, and Ba) of IW samples on the inductively coupled plasma–atomic emission spectrometry (ICP-AES) instrument. The pH varies from 7.5 to 7.8, and alkalinity from 2.6 to 5.0 mM. Compared to Site U1575, a broad Mn(IV) and Fe(III) reduction zone appears at Site U1576. Released mass of calcium to IW and consumed mass of magnesium by sediment are about 10× higher here than Site U1575, indicating that mineral and redox reactions are more intense at Site U1576. We also measured inorganic and organic carbon concentrations in 45 sediment samples. Calcium carbonate concentrations are higher than 90% from Cores U1576A-1R to 9R. Below Core 9R, it declined toward the minimum value (55%) at Core 40R. The geochemistry team also prepared for sampling and measurements at the next drill site (Site U1577).

This week, the igneous geochemistry team performed sample preparation and ICP-AES measurements: 33 samples taken from Hole U1575A were beaded and measured. However, the results had significant problems. The total values of major elements in some samples were significantly lower than 100 wt% (minimum value 82 wt%), while in some other samples, the total values were higher than 100 wt% (maximum value 105 wt%). SiO_2 content and other major element oxide concentrations correlate with the total values, probably due to a sample preparation issue. It is suspected that the bead sampler causes the problem. There was a technical issue with the bead sampler, which required the temperature to be raised from the normal 1050°C to 1300°C. However, some of the beads (3 out of 33) have black microcrystalline matter inside the beads, and these samples have significantly lower totals. After discussing this with other shipboard scientists, the beads will be made with more flux material to enable a more thorough digestion of the powdered rock samples. Preliminary measurements using 10 standard materials and 4 samples from Hole U1575A are currently in preparation.

Physical Properties

The physical properties team performed the standard suite of shipboard measurements on 42 cores from Hole U1576A and 17 cores from Hole U1576B. Whole-round core pieces of sedimentary and igneous rock were measured for *x*- and *y*-axis *P*-wave velocity, gamma ray attenuation (GRA) bulk density, MS, and natural gamma radiation using the Whole-Round Multisensor Logger and the Natural Gamma Radiation Logger. Whole-round core sections of unlithified sediments were tested for thermal conductivity using a temperature probe. Two sets of measurements were collected from representative units in unlithified sediment section halves: shear strength, using the automated vane shear system, and *P*-wave velocity in the *x*-, *y*-, and *z*-directions using the caliper and bayonet gantry system. Representative units in lithified sediment and basalt section halves were measured for thermal conductivity and *x*-axis *P*-wave velocity. Discrete sample cubes of lithified sediment and basalt were collected by the paleomagnetism team for AF magnetization and thermal demagnetization experiments. The same samples were then passed to the physical properties team for bulk moisture and density, bulk porosity, and *x*-, *y*-, and *z*-axis *P*-wave velocity measurements. Physical properties data identify basalt-sediment contacts in both holes and are in general agreement with measurements from other shipboard laboratory teams. Additionally, it is possible to correlate between Holes U1576A and U1576B using characteristic “wiggles” in MS and GRA bulk density logs, amounting to about 5 m of vertical offset between both holes. This correlation suggests that both holes sample a relatively coherent, 450 m package of sedimentation and basalt volcanism at Site U1576.

Outreach

This week, Expedition 391 hosted six live broadcast events in three countries (France, UK, and USA). Exact participation numbers are still pending, but audiences included more than 100 people. Thirteen posts were made on Twitter, leading to 71,165 impressions, 3,702 engagements,

708 likes, 147 retweets, and 26 replies. The Twitter account gained 75 new followers. Eight posts were made on Facebook, reaching 17,363 people, and leading to 1,348 engagements, 522 reactions, 31 shares, and 26 comments. Six posts were made to Instagram, which reached a total of 5,454 people, eliciting 609 reactions, 14 shares, and 10 comments. One new blog post was published to the *JOIDES Resolution* web page, written by the onboard Outreach Officer. The official Expedition 391 press release was revised to include updated information on the successful handling of the COVID-19 outbreak aboard the vessel. The release was shared with media contacts from 14 universities and organizations.

Technical Support and HSE Activities

This week, the JRSO technical staff focused on processing cores from Holes U1576A, U1576B, and U1577A.

Laboratory Activities

- Received, processed, and sampled cores from Holes U1576A, U1576B, and U1577A.
- Coordinated routine COVID-19 testing for IODP JRSO staff and science party through 12 January.
- Replaced the communications transceiver for the towed magnetometer and verified with the manufacturer that the whole system is working correctly. The magnetometer was towed during the transit from Site U1576 to Site U1577. We determined that the other transceiver failed, and it will be returned to the manufacturer for repair.
- Both AGICO JR-6 Spinner magnetometer instruments were broken during use and repaired.
- One of the hang-down loops on the Cahn Microbalance was broken off. The balance was replaced with a spare that was then configured. One of the other spare balances was also not working and was repaired.

IT Support Activities

- Security patch updates were applied to the shipboard Texas A&M University Exchange servers.
- We updated Room Alert environmental monitoring software on a hardware analyzer, the satellite communication network terminal, and the Erebus server.
- The license of the NetCrunch web server monitoring platform was updated through February 2023.
- Acronis business backup and recovery software stopped synchronization with the XRDcloud license server due to an expired license, causing backups to stop. We worked with Acronis support and updated the license. Backup resumed running successfully thereafter.

- We created the Expedition 392 email and server accounts.

Application Support Activities

- Made changes to LIVE data plotting software. Angle information was added to the header for whole-round core quadrant images.
- Changes to QCViewer were implemented, removing its Internet dependencies so that it does not rely on the network and loads faster.
- Made changes to Windows application MegaUploadaTron (MUT) upload so that it saves the different instrument names according to which instrument is being used. For example, on Expedition 391, the Malvern Panalytical AERIS X-ray diffractometer instrument is used for the XRD analysis, so the AERIS is recorded as a test instrument.
- We added wash core type "W" to LIMS and made Sample Master accept this core type.
- Cahn Microbalance hardware was broken, so we worked with Marine Instrumentation Specialist technicians to get a spare balance working with the software.

HSE Activities

- The safety shower and eye wash stations were tested.
- A lifeboat safety drill was held on 9 January.