IODP Expedition 376: Brothers Arc Flux

Week 3 Report (20–26 May 2018)

The third week of the International Ocean Discovery Program (IODP) Brothers Arc Flux Expedition (376) consisted of (a) terminating rotary core barrel (RCB) coring in Hole U1527C, (b) RCB coring in Hole U1528A, (c) installation of casing in Hole U1528B, and (d) the first ever seafloor coring with the CDEX turbine-driven coring system (TDCS) in Hole U1528C. All times in this report are in ship local time (UTC + 12 h).

Operations

This week began while we were continuing to work the stuck drill string from 116 m to the seafloor in cased Hole U1527C. Finally, the drill string cleared the seafloor at 0155 h on 20 May; unfortunately, the reentry system and casing returned to the ship with the drill string. We secured the reentry system in the moonpool and removed the hard rock landing frame. Upon removal of the reentry funnel, we continued to work on releasing the drill string from the 94 m long 10¾ inch casing assembly. We broke the flange connection and cleaned out cuttings made of lapilli-sized tephra that clogged up the hydraulic release tool (HRT) and upper casing sub. We worked the drill string up and down and eventually freed it from the casing. The bit was finally back on the rig floor at 1725 h, ending Hole U1527C on 20 May. We laid out the casing—all eight joints were bent during the effort to pull out of hole. We moved the ship ~1.1 nmi to Site U1528 (proposed Site UC-1A) in dynamic positioning mode and started preparations for RCB coring a pilot hole at Site U1528. While we were running the RCB bottom-hole assembly (BHA) to the seafloor, we began a camera survey of the seafloor to identify four possible hole locations for Site U1528, tagging the seafloor at each location. After retrieving the subsea camera system and reassembling the rig floor, we picked up the top drive, dropped a core barrel, and started coring Hole U1528A at 0825 h on 21 May. Cores 1R to 15R penetrated from the seafloor to a final total depth of 84.4 m and recovered 22.2 m (26%). We switched to half-length advances (4.8 m) on Core 7R. We noticed a substantial change to hard formation at 12.7 m. We pumped 30 barrels of mud sweeps at 35, 45, 49, and 54 m, as well as at various depths thereafter to keep the hole clean. Once Core 15R was cut, we had to work a stuck drill string that was finally freed after 3 h. While we were pulling it out of the hole, we had to work through poor hole conditions with high torque from 83 to 66 m, likely due to unconsolidated volcanic debris from the uppermost ~13 m of the hole. After the drill string cleared the seafloor, we offset the vessel 10 m southward to the surveyed location of Hole U1528B. We were able then to retrieve Core 15R, ending Hole U1528A at 1945 h on 22 May. Our initial objective for the subsequent Hole U1528B was to determine the length of casing we wanted to use to stabilize the uppermost unconsolidated formation so that we could core deeply. At 2040 h on 22 May, we started RCB

drilling without coring using a center bit in Hole U1528B. After reaching a total depth of 13 m, we started pulling the drill string out of the hole, and once the bit had cleared the rig floor at 0150 h on the following day, we started our casing operations for Hole U1528B. After assembling the 24 m long 10¾ inch casing string, we lowered it to the moonpool and latched it to the mud skirt. We then prepared the drilling assembly (mud motor, underreamer, 9⅞ inch tri-cone bit) to drill in the reentry system. Following a successful test of the mud motor and underreamer in the moonpool, we lowered the drilling assembly through the casing and attached it with the HRT to the casing flange on the mud skirt. After assembling the reentry funnel and welding it to the casing hanger, we spent the next 20 h waiting for the weather to improve enough so that we could safely deploy the reentry system, due to the high surge in the moonpool as well as the need to precisely position Hole U1528B in the extremely limited areas of flat seafloor in the center of a steep-walled pit crater. At 1100 h on 24 May, we finally picked up the reentry system and started it lowering through the open moonpool doors to the seafloor. We then deployed the subsea camera and sonar system and continued lowering the drill string to the seafloor. The position of Hole U1528B was located by sonar and it was reentered at 1645 h. We then drilled from 13.0 to 25.6 m. After dropping the go-devil to release the reentry system, we observed the HRT inside the throat of the reentry cone, but initially we could not pull out the drill string further. The underreamer arms were apparently not completely closed and able to pass up inside the casing. After working the drill string with varying pump strokes, we were able to retract the drilling stinger (mud motor, underreamer, drill bit) from the reentry system. We retrieved the subsea camera system and pulled the drill string out of the reentry system with the drilling stinger sliding through the casing with drag, clearing the top of the reentry cone at 2330 h on 24 May. We then lowered the subsea camera system back to the seafloor with a changed running sleeve for being able to pass the HRT to verify the landing position of the reentry cone. After observing the barely visible reentry cone at the seafloor, we recovered the subsea camera system and pulled the drill string out of Hole U1528B. Once the drilling assembly had reached the moonpool, we flushed the mud motor and underreamer with fresh water. The bit returned to the rig floor at 0450 h on 25 May, ending Hole U1528B. We reassembled the rig floor and carried out a routine cut and slip of 115 ft of drilling line. Then we started assembling the CDEX TDCS. Upon completing the assembly, we successfully tested the function of the TDCS core barrel on the rig floor. At 1800 h, we started lowering the TDCS BHA, including a polycrystalline diamond compact (PDC) bit. Then we deployed the subsea camera system to assist in an effort to reenter Hole U1528B and continued lowering the drill string. We picked up the top drive and attempted to reenter Hole U1528B at 2245 h on 25 May. While we were attempting the reentry of the hole, the PDC bit hung up in the reentry funnel throat, possibly due to the base of the reentry system not sitting flat on the seafloor. After we had made several unsuccessful attempts to reenter Hole U1528B, we offset the vessel and tagged the seafloor to establish a depth for Hole U1528C. The subsea camera system was recovered and we started drilling Hole U1528C at 0230 h on 26 May, and drilled down from the seafloor to 22 m by 0630 h. We then installed the TDCS core barrel and began TDCS coring in the seafloor for the

first time in the history of scientific ocean drilling. Cores U1528C-2N to 8N penetrated from 22.0 m to a final total depth of 53.5 m at full 4.5 m advancements and recovered 3.6 m (11.5%). We pumped 30 barrels of mud sweeps at 31, 35.5, 40, 44.5, and 49 m. When Core 8N was pulled, we observed that only the top third of the core barrel was recovered. The core barrel had parted in the reduction gear, so that the lower core barrel remained in the BHA. We started pulling the drill string out of the hole with the bit clearing the seafloor at 2330 h on 26 May. At the end of the week we had set back the top drive and were preparing to recover the drill string.

Science Results

Scientists spent the first half of the week continuing to acquire, analyze, and write up Hole U1527C data, as well as preparing the corresponding presentations and reports for Site U1527. Later in the week, they described and analyzed the cores recovered from Hole U1528A and U1528C, submitted their Site U1527 laboratory group reports, and held the first of two Site U1527 science summary meetings.

Core Description

The Igneous Petrology/Volcanology team completed their data collection and analysis of Site U1527. This included descriptions of the last cores of Hole U1527C, analysis of 22 thin sections, scanning electron microscope (SEM) imaging, and portable X-ray fluorescence spectrometer (pXRF) analyses. Visual core description (VCD) and thin section summary templates were drafted together with the IODP JRSO technical staff. The site report for Site U1527 was completed and turned in for evaluation.

Two Igneous Units were defined at Site U1527. Unit 1 consists of fresh, plagioclase-pyroxene phyric dacite, recovered in both Hole U1527A (29.10–67.81 m) and Hole U1527C (108.4–176.16 m). Unit 2 consists of altered volcaniclastic rocks from Hole U1527C between 185.20 and 234.38 m. Unit 2 was subdivided into four subunits. Igneous Subunit 2a (185.20–185.44 m) is a breccia consisting of fresh dacitic clasts surrounded by a brown fine-grained matrix, probably representing altered tuff. Subunits 2b–2d consist of lapilli-tuffs and tuff-breccias with variable matrix/clast ratios but generally pervasive alteration. Less altered clasts and matrix in Subunits 2b–2d are similar in petrography and composition to the fresh dacite of Unit 1. Plagioclase phenocrysts are common throughout, while clinopyroxene disappears in the lower part of Hole U1527C below 215.36 m.

At Site U1528 (pit crater on top of the resurgent cone), 6 m of unconsolidated polymict volcanic material were recovered in Hole U1528A (0–6.03 m) and the top of Hole U1528C. These unaltered volcaniclastics are underlain by highly altered, cemented volcaniclastic rocks, mostly lapillistones and pyroclastic breccias down to the total final depths of Holes U1528A (83.00 m) and U1528C (46.00 m). The cores were described macroscopically and the microscopic

description is underway (Hole U1528A). We have started working on the site report for Site U1528.

The Alteration Mineralogy group conducted macroscopic and microscopic (thin section) observations of core recovered from Holes U1527C and U1528A. The team also completed image scanning and Section Half Multisensor Logger (SHMSL) measurements of core section halves, and analyzed X-ray diffraction (XRD) data of powders from these sections. Work also accomplished a draft of Site U1527 report and preparation of a presentation that summarizes the alteration of rocks collected at Site U1527.

In summary, at Hole U1527C, we defined three Alteration Types with two subtypes: (1) Type 1a: Fresh dacitic volcanic rock with vesicles partially filled with zeolite, and matrix glasses replaced by palagonite and iron oxyhydroxide; (2) Type 1b: Matrix that is moderately altered and replaced by abundant oxyhydroxide, but clasts are less altered with primary plagioclase and clinopyroxene phenocrysts; (3) Type 2a: Highly and pervasively altered volcanic breccia showing greenish to light greenish color. Primary plagioclase still persists, but is partially replaced by chlorite, illite, and silica minerals (opal and quartz). Matrix has been completely replaced by chlorite, illite, and silica minerals; (4) Type 2b: Highly and pervasively altered volcanic breccia showing dark yellowish to dark orange brown color, which overprints the Alteration Type 2a. The Alteration Type 2b is characterized by more abundant iron oxyhydroxide and (sometimes oxidized) pyrite; and (5) Type 3: Breccia clasts display a range of colors and show various degrees of alteration. The associated matrix is intensely altered and replaced by chlorite, quartz, and illite. Dark gray elongate clasts are mainly composed of silica minerals whose outer rims are often surrounded by fine-grained pyrite.

The alteration type of Hole U1528A is quite different from Hole U1527C. Under the microscope, the samples of Hole U1528A include abundant sulfate minerals such as barite, anhydrite, and gypsum as well as quartz, amorphous silica, and different clay minerals from Hole U1527C. We continue to work on detailed descriptions of the samples from Holes U1528A and U1528C. Preliminary fluid inclusion results from Cores 7R to 14R of Hole U1528A have indicated that the latest drusy vein and vug fillings are dominated by low-temperature hydrous sulfate minerals and that the latest mineral precipitation occurred at <75°C, based on fluid inclusion homogenization/decrepitation temperatures.

The Structural Geology team described and measured structures throughout Hole U1528A, observed all of the thin sections from Hole U1527C, completed the Site U1527 report, and logged all cores of Hole U1528C. Hole U1527C is characterized by moderately to steeply dipping alteration boundaries, fractures, and faults in addition to shallowly dipping shears and relatively few veins. Alteration boundaries are sharp and demarcate the transition from Alteration Type 2a (green) to 2b (brown). Dip of alteration boundaries varies from 0° to 74° ($\bar{x}$ = 48°). Fractures also have a moderate to steep dip with a range from 37° to 90° ($\bar{x}$ = 68°). There is low density of veins and fractures, but it increases slightly downhole. Fractures almost always

have a brown-orange alteration halo overprinting all other types of alteration. Faults also have a steep dip ranging from 45° to 83° ($\bar{x}$ = 66°). Lastly, there are shallowly dipping shears defined by ribbons of white clays.

In Hole U1528A, alteration veins represent the main structure. Veins are irregular, usually 1 mm thick, and typically meander between volcanic clasts, especially in the top part of the hole. In the lower part of the hole, veins form networks and are more siliceous. Vein dip ranges from horizontal to subvertical in the upper part of the hole and is steeper in the bottom part of the hole.

Paleomagnetism

During this week, we measured the natural remanent magnetization (NRM) of 11 archive-half sections from Holes U1528A and U1528C using the superconducting rock magnetometer (SRM), and we carried out alternating field (AF) demagnetization experiments on these archive-half sections. The oriented pieces larger than ~10 cm in these archive-half sections have shown a primary component with very minor drilling overprint and a consistent inclination of the magnetization compatible with the inclination of the geomagnetic field at the latitude of Brothers volcano. AF and thermal demagnetization experiments on 14 discrete samples from Hole U1528A confirm the findings from the experiments carried out using the SRM. The first version of the Site U1527 report was submitted.

Geochemistry

During Week 3, Geochemistry team members analyzed rock samples from Hole U1527C against standards for inorganic carbon content via coulometry; as well as for total carbon, total nitrogen, and total sulfur via elemental analyzer; and for major, minor, and trace elements via inductively coupled plasma–atomic emission spectroscopy (ICP-AES). Geochemistry results from Site U1527 were analyzed and communicated in the site report. These findings were also described to other shipboard scientists in a presentation during the Site U1527 science summary meeting. Two interstitial water (IW) samples were collected from unconsolidated pebble intervals in shallow regions of Hole U1528A. These IW samples were analyzed for pH, alkalinity, and major ions via ion chromatography (IC). Kuster Flow-Through Sampler (FTS) contamination tests were also run for major ions via IC. Hard rock samples collected from Hole U1528A were weighed and prepared for the generation of silica beads.

Petrophysics

All physical properties measurements were completed for Site U1527. Mean bulk density, porosity, and *P*-wave velocity generally show small variations and do not appear to be affected by transitions between alteration types defined by the alteration mineralogy group. Bulk density and porosity generally vary inversely as expected. A sharp increase in *P*-wave velocity and decrease in porosity is observed at the top of Igneous Subunit 2c, which coincides with observations of structural deformation. Thermal conductivity shows local variations in certain

subunits that corresponds well with changes in alteration types. These data were analyzed and written up in the Site U1527 report and a presentation of our findings was given to scientists in other groups. We continued to make physical properties measurements on samples from Site U1528. The *P*-wave velocity measurement software has been modified, so that the rapid acquisition of *P*-wave velocity data on representative pieces of the whole-round core that was trialed in the previous week has now been included as part of the standard workflow.

The Downhole Measurements team continued to prepare and modify the Kuster FTS to increase its efficacy in fluid sampling with the design of new connections by the IODP JRSO technical staff to allow the tool to pass through the RCB coring bit, which will increase the chances of obtaining more pristine fluids. The thermocouple memory tool has been assembled. Unfortunately, Hole U1527C was deemed too unstable to perform measurements. Thermal strips and capillary thermometers inserted in the core barrel housing during the cutting of Core U1528A-15R indicated temperatures <37°C (while circulating cold seawater) with sufficient time (>2 h) for the temperature to equilibrate, as corroborated by tests in the shipboard Chemistry Laboratory. Crystal microprobes enclosed in a perforated brass housing that had been attached to the RCB coring bit used in Hole U1528A were successfully recovered, but showed no effects of interaction with any kind of borehole fluid after 30 h below the seafloor.

Microbiology

During this week, Microbiology team members obtained three whole-round samples from Hole U1528A and processed them for onshore investigation. For these microbiological samples from Hole U1528A and from Hole U1527C, the perfluoromethyl decaline (PFMD) contamination test was performed. All the samples showed small PFMD peaks, except for the subsamples taken from interior parts of whole-round samples that showed relatively lower PFMD contamination. As the PFMD peaks were also found in negative laboratory controls, the contamination test indicated that the microbiology samples had minimal contamination. In addition, microbial activity measurement by adenosine triphosphate (ATP) quantification was conducted in microbiology samples from Hole U1527C. However, probably due to the high concentration of metal ions and other interference materials, the luciferase-specific ATP luminescence was not identified. This result did not refute the activity of subseafloor microbial communities.

Education and Outreach

The Education and Outreach team successfully conducted seven live streams with schools and universities in New Zealand, Australia, and the United States, totaling an audience of 233 people. The highlight was a live connection to the University of Wollongong with 70 students in attendance and 150 people via the university's intranet. We completed lesson plans on igneous rocks, developed a format for scientist interview videos, continued working on our 360° project, and developed a hydrothermal maze resource for schools. Six blogs were posted on

http://joidesresolution.org (9,470 page views). Overall, there have been 18 social media posts this week on Facebook (https://www.facebook.com/joidesresolution), Twitter (https://twitter.com/TheJR), and Instagram (http://instagram.com/joides_resolution). Facebook had a weekly total reach of ~23,700 users initiated by nine posts in total; the most popular post was ghost shark video footage from a seafloor camera survey in the crater of Site U1528 and associated blog of a Te Papa fish expert (11,500 reached; 1,800 engagements; 3,500 views). On Twitter, five tweets garnered ~8,600 impressions. Instagram registered 558 views for four posts.

Technical Support and HSE Activities

During this week, the IODP JRSO technical staff continued supporting science operations at Site U1528. As time was available, staff reviewed shipboard manuals and performed laboratory maintenance.

Laboratory Activities

- Underway Geophysics Laboratory:
  - Finished reorganizing the laboratory to create more storage space for items.
  - New desktops for computer monitors and keyboards installed.
  - Moving, sorting, and storing material from the Upper Tweendeck Shop continued.
- Fantail:
  - Work on the port level wind system refurbishment:
    - Issues with loose drive train fixed.
    - New end of travel switches installed.
    - Rust removed and both the level wind and wench repainted by Siem Offshore crew.
- Physical Properties Laboratory:
  - Continued testing on a new program algorithm for the *P*-wave measurement that does not use a threshold detection procedure and accurately picks the first arrival and not the bulk velocity arrival.
- Chemistry Laboratory:
  - We replaced tension cables on the autosampler on the Gas Chromatograph 2 to resolve an issue with bent needles.

IT Support Activities

- We replaced the core laser host with new hardware model termed z240.
- We built a new server for Net Crunch install.

Application Support Activities

- Files between ship and shore became disconnected and out of synchronization. We repopulated and resynced them.
- Completed code work for Data Publishing Project: Web services to maintain the DP_CATALOG and KY_KEYWORD tables.
- Whole-round core section .tiff and .jpg reports were modified to use the date_received instead of date_started for the reports.
- LIVE: We created a new template to show the four principal_lithologies for the TABS being used for this expedition; reworked *P*-wave velocity logger and *P*-wave caliper panel to separate the plots for clarity. Template name is PHYS_PROPS_Summary.
- LORE-XRD report: We added test and sample comment, and removed result comment (no tool provides it).
- Other LORE updates: We revised *P*-wave reports to show result comments in addition to the existing sample and test comment columns; we removed embedded filter for section half loggers to allow user to filter as desired.
- Drill Report: Knobbies counting in the report was incorrect; we started the fixing process.

HSE Activities

- Technical staff completed the weekly check of safety showers and eyewash stations.
- Held the weekly fire and boat drill as scheduled.
- Technical staff completed online hazardous shipping course.