IODP Expedition 376: Brothers Arc Flux

Week 4 Report (27 May–2 June 2018)

The fourth week of the International Ocean Discovery Program (IODP) Brothers Arc Flux Expedition (376) consisted of (a) terminating turbine-driven coring in Hole U1528C, (b) rotary core barrel (RCB) coring in Holes U1529A and U1529B, (c) a failed attempt to reenter Hole U1528B, and (d) installation of casing and RCB coring in Hole U1528D. All times in this report are in ship local time (UTC + 12 h).

Operations

This week began while we were continuing to pull the drill string out of Hole U1528C to recover the turbine-driven coring system with the broken core barrel. Hole U1528C ended when this arrived on the rig floor at 0430 on 27 May. We then made up the RCB bottom-hole assembly (BHA) and started lowering the drill string to the seafloor. We deployed the subsea camera system, while moving to Site U1529 on the western caldera floor. We surveyed the seafloor at Site U1529 and tagged possible hole positions. Upon picking up the top drive, we retrieved the subsea camera system and started RCB coring in Hole U1529A at 1610 h. After Core U1529A-1R penetrated to 12 m and recovered 1.9 m (16%), we observed high torque and had to work a tight hole from 12 m back up to the seafloor. We then pulled the drill string out of the hole because of bad hole conditions related to unconsolidated volcanic deposits. Hole U1529A ended when the bit cleared the seafloor at 1925 h on 27 May. We retrieved Core 1R, dropped the core barrel, and started RCB coring in Hole U1529B at 2030 h. Cores U1529B-1R to 3R penetrated from the seafloor to 34.4 m and recovered 0.3 m (2%). We observed a tight hole at the total depth and attempted to work it back to ~15 m. We dropped a core barrel to improve circulation, but circulation was lost when the bit was at 15 m. We decided to abandon Hole U1529B, as the drill bit and jets were plugged with debris and the hole conditions were extremely unstable. We pulled the drill string out of the hole and the bit cleared the seafloor at 1015 h on 28 May, ending Hole U1529B. We recovered the core barrel that was in place while attempting to get back to the bottom of the hole (ghost Core 4G; 8.17 m recovered). Then, we set back the top drive and continued raising the bit to a depth so that we could return to the shallower water Site U1528 in the Upper Cone of Brothers volcano using the dynamic positioning system. We arrived at the location of cased Hole U1528B at 1530 h on 28 May, deployed the subsea camera, and picked up the top drive. We started our attempts to reenter Hole U1528B at 1730 h, but immediately experienced excessive drill string torque and little downward progress. We were unable to operate below the reentry cone because the seafloor structure is tilted. We abandoned attempts to reenter Hole U1528B at 1915 h, started recovering the drill string, and the bit reached the rig floor at 0025 h on 29 May, ending Hole U1528B. The rest of the day was spent preparing a

reentry cone and casing that will be drilled into the seafloor at Hole U1528D. This consisted of (1) assembling a mud motor, underreamer, and 12¼ inch tri-cone drilling bit to form the drilling assembly; (2) connecting five joints of 13⅜ inch casing to form a ~59 m long casing string; (3) installing and testing the drilling assembly; and (4) landing the casing running tool (hydraulic release tool [HRT]) in the moonpool and attaching it to the casing string. We then installed and welded the reentry cone and hard rock frame. Although the reentry system was ready to deploy at 0500 h on 30 May, we had to wait for weather to improve to lower the reentry cone and casing to the seafloor. At 1200 h, we finally started lowering the reentry system to the seafloor, deployed the subsea camera and sonar system, picked up the top drive, and started drilling the casing into Hole U1528D at 1750 h. We encountered firm formation between 13 and 15 m. At 2100 h, the casing running tool (HRT) prematurely released at a depth of 33.5 m. We decided to continue drilling down with the possibility that the casing would continue to settle into the hole following the bit. The bit eventually reached 50 m, pumping mud sweeps at 25.9 and 35.5 m. However, after observing that the casing was not following the bit, we attempted to move the casing with the underreamer arms to no avail for 2 h. We then continued drilling the 16½ inch hole from 50 m to the planned total depth of 61 m, which was reached at 0640 h on 31 May. We reamed the hole and pulled the drill string out of the hole with the bit clearing the reentry cone at 0954 h. We were able to observe that the reentry cone remained standing independently despite being ~23 m above the seafloor. We also observed that Hole U1528D was drilled in the flat central area of the pit crater. We set back the top drive, recovered the subsea camera, and pulled the drill string out of the hole with the bit clearing the rig floor at 1605 h. Subsequent function tests of both the mud motor and underreamer indicated that they were both functioning properly. Our next objective was to reenter Hole U1528D to get the reentry cone and casing to settle to the appropriate depth. For this purpose, we installed a 13⅜ inch cup seal on top of the drilling assembly to seal the inside of the casing while circulating. This was intended to clean the annulus between casing and surrounding formation to promote complete settling of the casing string into the hole. We deployed the subsea camera and sonar system at 2245 h on 31 May, continued lowering the drill string to seafloor, picked up the top drive, and reentered the reentry cone of Hole U1528D at 0110 h on 1 June. We lowered the drill string to position the cup seal inside the casing with the mud motor and underreamer below the casing shoe, pumped a 20 barrel mud sweep, and began attempting to circulate and work the drill string down. After three hours, the casing began falling at 0534 h on 1 June and the reentry system finally landed on the seafloor at 0602 h. We started pulling the drill string out of the hole, set back the top drive, and the bit cleared the reentry cone at 0715 h. We recovered the subsea camera, recovered the drill string, disassembled the drilling assembly, flushed the mud motor and underreamer, and cleared the rig floor by 1500 h on 1 June. We then made up the RCB BHA, lowered it to the seafloor, deployed the subsea camera system, and reentered Hole U1528D at 2035 h. After installing the top drive and retrieving the subsea camera system, we lowered the bit through the casing, and circulated ~7 m of soft debris out of the bottom of the hole with 30 barrels of high viscosity mud. We started RCB coring from a depth of 61.3 m at 2337 h on 1 June. Half-length (4.8 m advance)

Cores U1528D-2R to 16R penetrated from 61.3 to 133.7 m and recovered 25.8 m (37%) by the end of 2 June. We pumped 30 barrels of mud sweeps on each core to keep the hole clean.

Science Results

This week scientists worked on acquiring, analyzing, and writing up reports for Holes U1529A, U1529B, and U1528C, as well as starting on the initial cores Hole U1528D later in the week. We also held science meetings to discuss initial results from Sites U1527 and U1528.

Core Description

The Igneous Petrology/Volcanology group made corrections to the Site U1527 report and submitted their final version. The team analyzed 16 thin sections from Site U1528 and one from Site U1529. To provide end-members for geochemical analyses, individual clasts were selected from Hole U1527C and prepared for inductively coupled plasma–atomic emission spectroscopy (ICP-AES).

Two igneous units were defined at Site U1528. Igneous Unit 1 consists of fresh to highly altered polymict lapilli tephra with at least two types of volcanic clasts and subrounded sulfur lapilli, recovered from Hole U1528A (0–6.0 m) and Hole U1528C (26.5–31.4 m). Igneous Unit 2 is mostly lapillistone, containing completely/intensely altered volcanic clasts in a completely altered matrix, recovered from Hole U1528A (0–6.0 m) and Hole U1528C (26.5–31.4 m).

At Site U1529, Cores 1529A-1R to 4G intersected plagioclase-pyroxene phyric dacitic lavas and black lapilli tephra in Hole U1529A (0–2.5 m) and Hole U1529B (0–24.8 m). Fresh, black lapilli-ash was recovered as "ghost core" after it collapsed into the hole (0–34.4 m). In hand specimens, the rock appears unaltered, and often fragmented or showing incipient fragmentation suggestive of hydrofacturing during magma emplacement under higher hydrostatic pressure (>1000 m water depth). Microscopically, the mineral assemblage comprises slightly altered, large millimeter-sized plagioclase and clinopyroxene phenocrysts, often forming glomerocrysts, and smaller Fe-Ti-oxides in a groundmass rich in plagioclase microlites. Portable X-ray fluorescence spectrometer (pXRF) analyses of three rock powders confirmed a dacite composition (66–67 wt% SiO_2) which is very similar to the dacites recovered from Sites U1527 and U1528.

After returning to Site U1528, successful coring in Hole U1528D recovered Cores 376-U1528D-1R to 14R. Most of the material was described as highly to intensely altered monomict and polymict lapilli tuffs and lapillistones in the upper portion of the hole, and then as completely altered volcanic rocks with no discernible primary volcanic features remaining in the lower portion of the hole.

Lastly, the Igneous Petrology/Volcanology team initiated discussion of sampling for postcruise research with all members of the science party planning to work on fresh volcanic rocks from Expedition 376.

The Alteration Mineralogy group continued to describe and document alteration minerals and textures in recovered core material from Holes U1528A, U1528C, U1529A, U1529B, and U1528D. Descriptions of alteration are integrated from a combination of hand sample observations (both visually and under binocular stereoscope), thin section descriptions, and alteration mineralogy determined by X-ray diffraction (XRD) analyses.

For Site U1528, two major alteration types with two subtypes were identified from core recovered from Holes U1528A and U1528C: Alteration Type I is characterized by slight alteration of unconsolidated volcanic gravels with an alteration mineral assemblage consisting of smectite, pyrite, and minor cristobalite. Alteration Type IIa is an intense and pervasive white-gray alteration of volcanic breccia by pyrophyllite, natroalunite, quartz, cristobalite, and anhydrite. Also, rutile and bassanite were identified by XRD analyses. Alteration Type IIb is composed of a mineral assemblage similar to Alteration Type IIa, with more silicified and vuggy silica textures.

For Site U1529, the material recovered from Holes U1529A and U1529B is relatively fresh volcanic material, with only minor, patchy secondary Fe-oxyhydroxide that appears to be replacing accessory disseminated pyrite found in rocks from Hole U1529B.

Finally, the Alteration Mineralogy group presented initial results from Holes U1528A and U1528C to the rest of the shipboard science party, finalized the Site U1527 summary, and started describing cores from Hole U1528D at the end of the week.

The Structural Geology group described and measured structures throughout Holes U1528C, U1529A, and U1529B. Hole U1528C has limited deformation present in the form of aligned vesicles, irregular, steeply dipping fractures, and two veins. No meaningful orientation measurements could be made on vesicle orientation. Fractures are lined with sulfur or pyrite and more rarely with both. Veins only occur in Interval U1528C-5N-1, 18–26 cm. Both Hole U1529A and U1529B have aligned vesicles with high aspect ratios, which sometimes define a lineation. In thin section, foliation is also defined by microlites of plagioclase, phenocrysts of plagioclase and clinopyroxene, and glomerocrysts. We started logging of structures in cores recovered from Hole U1528D at the end of the week.

Paleomagnetism

During this week, we have finalized alternating field (AF) and thermal demagnetization experiments on some discrete samples from Hole U1528A which have confirmed the results from the cryogenic magnetometer on archive-half sections from Hole U1528A. In particular, these samples have consistently confirmed an inclination parallel to the current geomagnetic

field at the latitude of Brothers volcano and a low intensity of magnetization with respect to samples from Site U1527. We have also prepared a presentation for the science party on the preliminary paleomagnetic results from Hole U1527A. Toward the end of the week, we processed 20 archive-half sections from Hole U1528D using the cryogenic magnetometer, and carried out AF demagnetization experiments on these archive-half sections. The oriented pieces larger than ~10 cm in these sections show a primary component with very minor drilling overprint and a consistent inclination of the magnetization compatible to the inclination of the geomagnetic field at the latitude of Brothers volcano.

Geochemistry

The Geochemistry team performed coulometer, elemental analyzer (EA), and ICP-AES analyses on rock powders from Sites U1528 and U1529. Interstitial waters were collected from soft materials recovered at two locations (Holes U1528C and U1529A), and were analyzed for pH, alkalinity, and major and minor ions via ion chromatography (IC) and ICP-AES. Methods improvements were conducted on the EA. Specifically, the EA baseline was assessed for total carbon, nitrogen, and sulfur using loss on ignition (LOI) powders. To assess the effect of a barium-rich matrix on sulfur recovery, various sulfur compounds were added to the powders to create in-house EA standards that match the matrix and sulfur content of Brothers volcano samples. These in-house standards were verified via repeat analysis against certified geo-referenced materials. Water-soluble sulfate was extracted by shaking rock powders from Site U1528 with deionized water, followed by analysis via IC and ICP. All rock powders from Sites U1528 and U1529 collected to date were submitted for LOI analysis. Headspace gas analysis of solid samples was conducted at Sites U1528 and U1529.

Petrophysics

All physical properties measurements were completed for Site U1529 and at Site U1528 for Holes U1528A and U1528C. After refinement of the set-up and measurement conditions for thermal conductivity analysis, additional samples from Sites U1527 and U1528 have been analyzed. Data have been processed, and our findings for Holes U1528A and U1528C have been presented to the other members of the science party. Overall, the correlations between density and porosity and between density and *P*-wave velocity are similar for Sites U1527 and U1528. In Hole U1528A, porosity is high in Igneous Unit 1, comprising fresh to highly altered polymict lapilli tephra. Porosity and *P*-wave velocities are lower in Igneous Unit 2, consisting of more altered rocks. Section U1528A-9R-1 of that unit produces relatively high natural gamma ray counts at the bottom. Subsequent pXRF analyses of the split half surface of this interval have failed to detect potassium or elevated uranium or thorium concentrations, and more detailed geochemical analyses are required to identify the cause of the natural gamma ray peak. At the end of the week, we began physical properties measurements on Hole U1528B cores.

The Downhole Measurements team has started studying downhole proxies for potential activity of formation fluids in the form of investigating crystals deployed with the RCB bit and late-stage minerals for fluid inclusion studies in Hole U1528D. Results will be provided in the next weekly report. Borehole temperature measurements are being made using thermal strips and capillary tube thermometers deployed in the core barrel heads in Hole U1528D.

Microbiology

During Week 4, one sample from Hole U1528C and six samples from Hole U1528D were collected by microbiologists for postcruise research. Contamination tests in Hole U1528C resulted in perfluoromethyl decaline (PFMD) that was barely above detection limit on both the outside and inside of the core, suggesting only minimial contamination. In addition, microbial activity measurement by adenosine triphosphate (ATP) quantification as well as microscopic observations using staining dyes were conducted for samples from Holes U1528A and U1528C. Results from both ATP quantification and microscopy indicate that two samples from Hole U1528A may host microbial life.

Education and Outreach

The Education and Outreach team successfully conducted 13 live streams with schools and museums in the United States and New Zealand, totaling an audience of 426 people. The highlight was a live connection to the National Museum of New Zealand Te Papa Tongarewa for the second live event in a series of four biweekly connections with 35 people in attendance. We completed a virtual-reality video for upload next week, created an infographic of the microbe *Archaeoglobus sulfaticallidus*, concluded a shipboard poetry contest and posted results on the ship's website, and started recording and editing "Scientist Spotlight" videos. Three blogs were posted on http://joidesresolution.org. Overall, there have been 16 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 ~13,300 users initiated by seven posts in total, including the most popular post being a video addressing how calderas form (4,200 reached; 591 engagements; 2,200 views). On Twitter, four tweets garnered ~7,000 impressions. Instagram registered 233 likes and 260 views for five posts.

Technical Support and HSE Activities

During this week, IODP JRSO technical staff continued supporting the science operations at Site U1528 and Site U1529. As time was available, staff crossed trained, reviewed shipboard manuals, and performed laboratory maintenance.

Laboratory Activities

- Underway Geophysics Laboratory:
    - We removed the map case removed and refinished the countertop. The table was relocated against the inboard wall. Magnetometer storage was built on the outboard side and additional storage was built underneath.
    - We moved sonar dome parts and miscellaneous hardware from the subsea shop to the Underway Geophysics Laboratory.
    - We continued moving, sorting, and storing material from the Upper Tween Deck shop.
- Fantail:
    - Work on the port level wind system refurbishment continued:
        - We rebuilt the spare level wind motor;
        - We repaired a damaged integrated circuit on the level wind control board.
- Physical Properties Laboratory:
    - We continued testing on a new algorithm for the *P*-wave measurement that does not use a threshold detection procedure and more reliably picks the first arrival and not the bulk velocity arrival.
    - We investigated the causes for incorrect liner velocities being determined during the water core calibration.
- Chemistry Laboratory:
    - We have been troubleshooting the Ion Chromatograph for the past several shifts because the anion determinations were coming out about three times less than what they should have been; yet, the cations values were normal. After exchanging the two detectors, we saw that there was some blockage in the anion detector. We back flushed the system and cleaned it with oxalic acid, sulfuric acid, and acetone based on the vendor's recommendation. This appears to have solved the issue.
    - Interlock for a circuit voltage went off on the Elemental Analyzer. We restarted the system and it is back online. We still do not know what caused the error.

Application Support Activities

- Evaluation of server Tomcat 8.5.30: We are preparing for the ship production upgrade. More testing of the newer Tomcat server continues.
- The ship's build box was modified to allow Angular Code builds to read the Node Package Manager (NPM) libraries locally instead of trying to go to shore.
- Data Publishing: We corrected the code to handle dates correctly.
- Cahn Balance: A few changes have been made per user requests, mostly to make visual improvements to the user interface.

- Laser Engraver: We applied the Integrated Measurement System (IMS) common library code changes to the sample hierarchy browser, being part of an ongoing objective of upgrading all systems to IMS-10.
- Thermal Conductivity Analysis for LORE: We removed the IODP computed columns from the report per user request.
- The Subversion Code Repository was fully mirrored so that ship and shore synch again.
- Data Publishing: We created a new Web Service for updating and adding tag values in files.
- Investigation continues on a process to obtain a consistent set of comments from the loggers and other systems: Some use TEST table and some use RESULT table. This causes downstream confusion for LORE Reports.

HSE Activities

- Technical staff completed the weekly check of safety showers and eyewash stations.
- We held the weekly fire and boat drill as scheduled.
- Technical staff completed an online hazardous shipping training.