IODP Expedition 376: Brothers Arc Flux

Week 6 Report (10–16 June 2018)

The sixth week of the International Ocean Discovery Program (IODP) Brothers Arc Flux Expedition (376) consisted of (a) Hole U1528D fishing and cleaning operations and (b) rotary core barrel (RCB) coring in Hole U1530A. All times in this report are in ship local time (UTC + 12 h).

Operations

The first half of this week was marked by continued cleaning and fishing operations to remove the leftovers of the Kuster Flow-Through Sampler (KFTS) tool from the bottom of Hole U1528D. On 10 June, we continued lowering the tri-cone drill bit to clean out Hole U1528D and encountered fill at 326 m. At 0030 h, we started cleaning the hole from 326 to 356 m, the depth of the top of the KFTS tool that was left in the bottom of the hole. After reaching that depth, we circulated two 30-barrel high-viscosity mud sweeps and started pulling the drill string out of the hole at 0330 h with the bit clearing the seafloor at 0535 h and the rig floor at 0840 h. Before we could resume coring deeper, first we had to get rid of the lost KFTS in the bottom of the hole. We assembled a milling bit and two boot-type junk baskets and started lowering the drill string to the seafloor to grind up the KFTS. We reentered Hole U1528D for the sixth time at 1519 h on 10 June, lowered the bit to 356 m, and started grinding up the KTFS with the milling bit from 356 to 359 m. No torque was observed during the milling. After reaching 359 m, we worked the junk basket multiple times, circulated high-viscosity mud sweeps, and started pulling the drill string out of the hole at 2145 h. The milling bit cleared the rig floor at 0225 h on 11 June. The junk baskets contained rock debris, but no leftovers of the lost KFTS tool. We then started assembling the reverse circulation junk basket (RCJB) tool with twin boot-type baskets for another attempt at clearing the hole so we could continue coring. At 0415 h, we needed to stop operations due to storm-force winds and high seas. The next 31.75 h were spent waiting on weather to improve enough to continue operations. We then completed assembling the RCJB tool bottom-hole assembly (BHA) and started lowering it to the seafloor. At 1515 h on 12 June, we deployed the subsea camera and sonar system and continued lowering the drill string. After positioning the ship for reentry, we reentered Hole U1528D for the seventh time at 1714 h. We continued lowering the drill string into the hole, retrieved the subsea camera, picked up the top drive at 1930 h, and washed down from 327 to 352.3 m. At this depth, we tagged a hard fill that led to high torque. We continued attempting to work the drill string back to the bottom of the hole, starting to divert the flow path on the RCJB at 2100 h. When we reached 359.3 m by the end of the day, we pumped a 25-barrel high-viscosity mud sweep and worked the RCJB BHA down to the bottom of Hole U1528D and circulated for 15 min in an attempt to recover any parts

of the lost KFTS tool. At 0030 h on 13 June, we started pulling the drill string out of the hole. The drill string cleared the seafloor at 0220 h. When the end of the drill string arrived back on the rig floor at 0405 h, we discovered that the lowermost 172.8 m of the drill string was missing; this ended our Hole U1528D operations. The drill string failed in a piece of 5 inch pipe above the BHA. Furthermore, the broken piece that was recovered showed significant damage from the corrosive pit crater downhole environment. We then moved the ship to the northwestern caldera rim in dynamic positioning mode and began preparations for RCB coring at Site U1530 (proposed Site NWC-3A). We lowered the RCB bit to the seafloor, deployed the subsea camera system at 1345 h, and conducted a seafloor survey of three possible hole locations. We also tagged the seafloor with the bit at each location to verify the precise seafloor depth. After recovering the subsea camera system at 1715 h, we picked up the top drive, pumped a pig to clean out the inside of the new pieces of drill string, and started RCB coring in Hole U1530A at 1900 h. Cores U1530A-1R to 57R penetrated from the seafloor to 280.3 m by the end of 16 June, and recovered 54.8 m (20%). We switched to half-length (4.8 m) advancements after Core 2R. We pumped 30-barrel high-viscosity mud sweeps on every other core to keep the hole clean. Hole conditions were good throughout coring.

Science Results

This week, scientists worked on collecting, analyzing, and writing up results from Hole U1528D, and started to work on cores from Hole U1530A. We held four meetings to summarize the scientific results acquired from Hole U1528D. Also, the first sampling party for postcruise research was held.

Core Description

The Igneous Petrology/Volcanology team completed the microscopic description of Hole U1528D rocks (thin sections TS72 to TS84, Cores 41R to 63R, 249–359 m). Petrographic observations confirmed that the last three cores of Hole U1528D (59R to 63R) recovered less intensely altered volcanic rocks in which fresh plagioclase has been preserved. The changing intensity in alteration is also confirmed by portable X-ray fluorescence spectrometer (pXRF) data (n = 23) obtained from Cores 39R to 63R (240–359 m) using aliquots of powders prepared for shipboard X-ray diffraction (XRD) and inductively coupled plasma–atomic emission spectroscopy (ICP-AES) analyses. Unit and subunit boundaries for Site U1528 were revised following discussions with other laboratory groups. At Site U1530, we logged Cores U1530A-1R to 55R (0–268.4 m) as they were recovered and selected samples from Cores 1R to 38R for shipboard analyses together with other laboratory groups. Hole U1530A rocks comprise a sequence of mostly intensely altered, volcaniclastic, sedimentary, and igneous rocks, underlain by a thick sequence of variably altered volcaniclastic rocks. Shipboard analyses are in progress to determine the details of the cored sequence in Hole U1530A.

The Alteration Mineralogy group concluded all XRD analyses and thin section descriptions for Hole U1528D. In total, 118 XRD data and 43 thin sections were analyzed/described. Alteration descriptions, thin section observations, XRD, and pXRF analyses have been integrated to classify the alteration mineralogy into four Alteration Types. Alteration Type I consists of slightly altered volcanic gravel with native sulfur. Type II has a mineral assemblage of illite + smectite + cristobalite + quartz + pyrite + anhydrite, is blue gray in color, and is highly altered. Type III has a mineral assemblage of natroalunite + pyrophyllite + rutile ± quartz ± cristobalite ± pyrite ± smectite ± anhydrite ± gypsum, is gray in color, and is highly to intensely altered. Alteration Type IV is white-gray in color, and sulfur- and silica-rich forms veins/halos that overprint Alteration Types II and III. The mineral assemblages observed at Site U1528 indicate acidic fluid conditions and temperatures <300°C. Fluid inclusion measurements on crystals precipitated in the latest drusy vugs or veins of Hole U1528D have indicated temperatures similar to the ones suggested by the alteration mineral assemblages. The high sulfur contents of downhole fluids sampled in Hole U1528D are reflected in the presence of sulfur in some fluid inclusions.

The Alteration Mineralogy group also began to document alteration mineralogy and textures of material recovered from Hole U1530A (Cores 1R to 51R). These consist of blue-gray to green-gray altered volcaniclastic rocks, intercalated with more massive volcanic units that are classified as intensely altered. Sulfide abundance, mainly in the form of pyrite, varies from 0.2 to 20 wt%. Sulfides occur both as discrete veins, stockwork (crosscutting veins and stringer networks), and as disseminated grains. Anhydrite is abundant, forming 1–2 cm wide veins, and infilling vesicles. Silicification is highly variable, occurring in patches throughout the cores. Some cores contain more fine-grained sediment rich in anhydrite and pyrite. Magnetite was also identified using the binocular microscope, associated with veins of anhydrite. Initial shipboard XRD and thin section samples have been requested up to Core 37R.

The Structural Geology team completed logging of the final cores from Hole U1528D and started on those from Hole U1530A. The bottom of Hole U1528D has steep volcanic fabrics defined by the alignment of vesicles, plagioclase microlites, and to a lesser extent plagioclase phenocrysts. There are steep alteration veins filled with anhydrite, silica, pyrite, and to a lesser extent native sulfur. Vein thickness averages around 0.2 cm, consistent with the rest of the hole. At Site U1530, Hole U1530A cores show several veins mostly filled by anhydrite, then deeper in the hole filled with anhydrite, silica, and pyrite. Veins have a large range in dips from steep to shallow. Average vein thickness is ~0.2 cm, similar to other sites. There is a lack of veins between 100 and 185 m. Fractures are more abundant than any other site so far. Dips are variable from steep to shallow. There is also a lack of fractures from 100 to 150 m. A few discrete faults have been identified with slickenlines indicating dip- to oblique-slip with a normal sense of shear.

Geochemistry

Geochemical analysis of 75 powders from Hole U1528D was performed via ICP-AES and elemental analysis. Results of these analyses were integrated with pXRF data and used to define major geochemical changes during hydrothermal fluid-seawater-rock interactions. Variable extent of depletion in alkalis (potassium, sodium), magnesium, iron, and manganese, and strong enrichment in sulfur (up to 15 wt%) occurs throughout the hole, allowing the definition of geochemical units. The geochemical unit assessment was described in tandem with volcanic and alteration unit boundaries. Following the termination of drilling activities at Hole U1528D, acid leach tests and samples of steel drill pipe were collected for the assessment of contaminants that may have been introduced to borehole fluids by fluid-steel reaction at elevated temperature and acidity. At Site U1530, headspace gas compositions of cores from Hole U1530A via gas chromatography detected methane only at shallow depths (Cores 3R to 5R). Headspace H_2, CO, CH_4, and C_2H_6 abundances otherwise have remained low or undetectable throughout Hole U1530A so far.

Paleomagnetism

During the first part of this week, we continued thermal and alternating field (AF) demagnetization experiments on the last discrete samples from Hole U1528D. These final experiments confirmed that the magnetization direction is consistent with the inclination of the geomagnetic field at the latitude of Brothers volcano, suggesting that these rocks have normal polarity magnetizations. The samples from Hole U1528D also consistently show a low natural remanent magnetization (NRM) intensity compatible with intense hydrothermal alteration, with the exception of some more fresh samples from Core 63R, which has larger NRM intensities. Thermal demagnetization experiments show that changes in the magnetic minerals occur after heating the samples at temperatures >400°C, producing a significant increase in the NRM intensities and magnetic susceptibilities. During the second half of the week, we started processing the first archive-half sections from Hole U1530A and as well as conducting demagnetization experiments on the first discrete samples.

Petrophysics

Physical properties measurements were performed on cores recovered from Site U1530. Core U1530A-4R contains a core fragment with thick veins of anhydrite that has a natural gamma ray (NGR) count of ~340 counts/s, which is an order of magnitude higher than previously seen during this expedition. This piece also has the highest magnetic susceptibility (MS) measurement yet recorded in Hole U1530A (~1800×10^{-5} IU). Below this core, NGR and MS values are at least an order of magnitude lower. Smaller peaks in MS are also seen at ~60 m (Core 12R) and below ~240 m (from Core 49R). *P*-wave velocity shows a sharp increase from <2000 m/s to >3500 m/s between Cores 17R and 18R (~90 m). The low velocity values are associated with clay-rich material in Core 17R.

We started to correlate geological, structural, and mineralogical characteristics with anomalous values in the downhole wireline log data. Downhole measurements of temperature, potassium, density, and caliper have been correlated to mineralogical, textural, and structural observations made on cores. These data suggest fluid flow between the formation and the borehole at ~100 m, 150 m, and from 270 to 300 m. Density measurements on discrete samples correlate very well with downhole neutron-density from 63–250 m. Enlarged borehole diameter (washouts) in the bottom part of the hole affected the neutron-density downhole measurement. Analysis of temperature rebound profiles made at various times after circulating the surface seawater drilling fluid provides estimates of the undisturbed formation temperatures that can be compared to temperatures derived from alteration mineralogy and fluid inclusion studies.

Microbiology

This week we collected ten samples from Hole U1530A for postcruise microbiology research. Due to lower core recovery, three of them had a reduced size (shorter than the standard 12 cm whole round requested for routine sampling) and were insufficient to cover all of the desired microbiological analysis. For this reason, the microbiologists shared the smaller sample from Core 7R and did not sample Cores 24R and 39R for metatranscriptomic analyses. Perfluoromethyl decaline (PFMD) contamination tests for core and drilling fluid samples are ongoing. In addition, the borehole fluid samples collected from Hole U1528D were inoculated with culture media to allow growth of extremophiles halophile acidophiles and incubated at 40°C and 50°C. These cultures will be allowed to incubate in the laboratory postcruise for at least six months prior to sampling to test for cell growth and microbial diversity.

Education and Outreach

The Education and Outreach team conducted six live streams with schools in New Zealand, United States, Italy, Germany, and Brazil, totaling an audience of 211 people. We successfully delivered part three of our live series with the Museum of New Zealand Te Papa Tongarewa that focused on microbiology aboard the *JOIDES Resolution* and life in extreme conditions. We created an infographic of magnetotactic bacteria that was posted on the ship's website along with a "Microbe Monday" science presentation and three blogs (http://joidesresolution.org). A "Reddit Ask Me Anything" event was hosted on 16 June with scientists answering 17 questions during the 2 h event. We started developing a card game involving extremophiles, which we may develop after the expedition. We created three more lesson plans ("Rock cycle & identifying rocks," "Biodiversity of Microbes at Hydrothermal Vents," and "Modeling Volcanoes & Hydrothermal Vents"). We made 11 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 ~10,500 users, including ~1,700 views initiated by our video post on "Fluid flows through funnel" (a video

showing and explaining the hydrothermal phenomenon witnessed at the Upper Cone in Hole U1528D). On Twitter, six tweets garnered 81 Likes and 27 Retweets. Instagram registered 102 Likes and 322 views for three posts.

Technical Support and HSE Activities

During this week, IODP JRSO technical staff continued to support science operations at Site U1528 and started support at Site U1530. In addition, sampling of recovered material from previous sites was conducted.

Laboratory Activities

- Underway Geophysics Laboratory:
    - We continued investigating an issue with the aft Trimble Satellite navigation system dropping its network connection to the WinFROG navigation software computer. We have currently swapped the forward and aft GPS receivers to see if the issue moved with the receiver. It has not—the issue has disappeared for 2 d, now we are trying to figure out why.
- Downhole Measurements Laboratory:
    - We repaired and reassembled the spare borehole fluid sampling tool after successful deployment in Hole U1528D.

Application Support Activities

- Operational activity:
    - Supported data management for: PWAVE_C (*P*-wave velocity caliper gantry), WRLSC (whole-round line scanner), TCON (thermal conductivity), KappaBridge magnetic susceptibility meter, and JR6A spinner magnetometer.
- Project work:
    - Data publishing project: implementation of page generation and tagging services continued.
    - Moisture and density (MAD): we evaluated replacement of multifunction input/output device USB-6225. An alternative is required.
    - LabVIEW 2017 software updates implemented or ongoing:
        - MADMax: software updates are in progress.
        - WINFROG1 & 2 integrated navigation software was updated.
        - Vibration isolated television (VIT; subsea camera system): feature additions are in progress; LabVIEW 2017 upgrade added to the mix.

IT Support Activities

- We have been working on troubleshooting aft Trimble issues with the unit dropping offline in WinFROG navigation software running on WinFROG1 computer.

HSE Activities

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