IODP Expedition 376: Brothers Arc Flux

Week 5 Report (3–9 June 2018)

The fifth week of the International Ocean Discovery Program (IODP) Brothers Arc Flux Expedition (376) consisted of (a) rotary core barrel (RCB) coring in Hole U1528D, (b) conducting downhole temperature measurements and recovering borehole fluid samples in Hole U1528D, (c) deploying downhole logging tools in Hole U1528D, and (d) implementing Hole U1528D fishing operations. All times in this report are in ship local time (UTC + 12 h).

Operations

The first half of this week was marked by the longest continuous period of coring during Expedition 376 to date. From 3 to 6 June, half-length RCB Cores U1528D-17R to 63R penetrated from 133.7 to 359.3 m and recovered 70.6 m (32%) in Hole U1528D. This was only temporarily interrupted by a hydraulic problem in the top drive at 0600 h on 5 June that took us 1.75 h to fix. After Core 63R was cut, we stopped coring as the bit had reached 40 h of rotating time and needed to be changed for us to continue coring deeper. Before recovering the drill string to change the bit and resume coring, we decided first to measure the borehole temperature and obtain a borehole water sample. At 0500 h on 6 June, we started preparing the Elevated Temperature Borehole Sensor (ETBS) memory tool and the Kuster Flow-Through Sampler (FTS) tool for deployment on the coring line. First, we lowered the ETBS attached to a core barrel and let the tool collect data for 15 min at the bottom of the hole. The ETBS was recovered at 0700 h and revealed an average temperature of 33°C. We then deployed the Kuster FTS tool with a core barrel to sample borehole fluid at the bottom of the hole. When the Kuster FTS was recovered on the rig floor, we discovered that most of the tool was left in the hole due to a failure of the tool thread connection between the Kuster FTS and the core barrel. We started recovering the drill string with the bit reaching the rig floor at 1450 h on 6 June. We then assembled a fishing tool assembly to recover the Kuster FTS, lowered it to the seafloor, and deployed the subsea camera and sonar system to prepare for reentering Hole U1528D. After the drill string had reached the seafloor at 2300 h, we conducted a survey of the pit crater to determine the exact location of the Hole U1528B reentry cone that was installed during the third week of the expedition, but then could not be utilized. Then we positioned the vessel for the reentry of Hole U1528D and reentered it at 0235 h on 7 June with a fishing tool/junk basket assembly to attempt to recover the lost Kuster FTS tool. We recovered the subsea camera system, picked up the top drive, and continued lowering the fishing tool assembly to the bottom of the hole. We started circulating at 335 m and had to work the assembly through soft and hard layers at 341 and 350 m, respectively. We tagged the bottom of the hole, pumped a mud sweep, and worked the fishing tool up and down. At 0800 h, we lowered the assembly back to the bottom of the hole

and circulated a high viscosity mud sweep. We then rotated on bottom and raised the assembly off bottom and stopped circulating two times. We started pulling the drill string out of the hole at 0945 h, set back the top drive, and the drill string cleared the seafloor at 1140 h on 7 June. When the fishing tool assembly arrived back on the rig floor at 1655 h, the junk basket was missing some parts (fingers for the junk basket catchers); we emptied the baskets and saved the samples that consist of rock debris and minor unidentifiable small pieces of metal. Then we were confronted with 5 m ship heave and needed to wait on weather to improve for 8 h before starting to prepare for downhole measurements and borehole fluid sampling in Hole U1528D. At 0330 h on 8 June, we made up a logging bottom-hole assembly (BHA) and started lowering it to the seafloor. We deployed the subsea camera system, continued lowering the drill string, and positioned the vessel for reentry by 0800 h. We reentered Hole U1528D for the fourth time at 0950 h, retrieved the subsea camera system, and continued lowering the drill string into the hole to 303 m where we tagged a hard fill at 1245 h. We then picked up the top drive. At 1315 h, we deployed our backup Kuster FTS tool on the coring line, followed by the ETBS memory tool. The Kuster FTS successfully recovered a borehole fluid sample and the ETBS measured a maximum temperature of 212°C. After recovering the temperature tool at 1600 h on 8 June, we started washing to the bottom of the hole with the logging/clean out bit. After the bit reached 323 m, we circulated a high-viscosity mud sweep to clean the hole, and raised the bit up to 51 m, inside the 13⅜ inch casing. We then assembled the high-temperature flasked wireline logging string, consisting of the litho-density, natural gamma ray, and logging head temperature tools, and started lowering it through the drill string at 2155 h on 8 June. We then conducted a downward (to 332 m) and an upward logging pass of the high-temperature logging tools. The logging string arrived back on the rig floor at 0210 h on 9 June. At 0330 h, we lowered the drill string back down to the bottom of Hole U1528D, picked up the top drive, and encountered fill in the bottom of the hole at 330 m. At 0615 h, we deployed the Kuster FTS tool again and successfully recovered a borehole fluid sample from 313 m. This was followed by deployment of the ETBS memory tool to 313 m, which yielded a temperature measurement of ~165°C. After recovering the ETBS tool, we started pulling the drill string out of the hole, set back the top drive, and the logging BHA cleared the seafloor at 1200 h on 9 June. We continued raising the drill string with the bit arriving on the rig floor at 1535 h. We then assembled a 9⅞ inch tri-cone bit BHA to clean out Hole U1528D. We started lowering the drill string at 1700 h, deployed the subsea camera system at 1915 h, and continued lowering the drill string. At 2030 h, we positioned the vessel for reentry and reentered Hole U1528D for the fifth time at 2110 h on 9 June. After lowering the bit to 34 m, we recovered the subsea camera, picked up the top drive, and lowered the bit to 303 m where hard fill was encountered.

Science Results

This week scientists worked on acquiring, analyzing, and writing up results from Hole U1528D, as well as compiling and submitting reports for Sites U1527 and U1529.

Core Description

The Igneous Petrology/Volcanology team continued to log Hole U1528D cores macroscopically (Cores 12R to 63R, 143–355 m) and microscopically (thin sections TS42 to TS71, Sections 3R-2 to 39R-1, 68–239 m). Hole U1528D recovered altered volcanic and volcaniclastic rocks. Petrographic observations and geochemical analyses are obscured by alteration, but are consistent with a plagioclase phyric dacitic protolith. Within intensely altered volcanic rocks, primary igneous minerals are replaced by a secondary mineral assemblage, so that only primary igneous textures remain. In some samples, primary volcanic or volcaniclastic textures are beyond recognition.

New portable X-ray fluorescence spectrometer (pXRF) data (n = 47) were obtained from Cores U1528D-3R to 38R (66–235 m) using aliquots of powders prepared for shipboard X-ray diffraction (XRD) and inductively coupled plasma–atomic emission spectroscopy (ICP-AES) analyses. Rb and K_2O abundances are consistently lower than unaltered Brothers dacites and confirm the pervasive, if variable, alteration. At the end of the week, the team presented initial results at the Site U1528D science update meeting and initiated a discussion on possible unit and subunit boundaries with other working groups. The team continued to analyze and write up results for the Site U1528 report.

The Alteration Mineralogy group continued to describe and document alteration minerals and textures in core materials recovered from Hole U1528D (Cores 2R to 63R). For a Hole U1528D science update meeting, descriptions of alteration were integrated from a combination of hand specimen observations (both visually and under binocular stereoscope), thin section descriptions, and alteration mineralogy determined by XRD analysis. An important outcome of this synthesis was that it is becoming increasingly difficult to visually differentiate different alteration mineral assemblages in the core, and even in thin section. Therefore, XRD analysis is essential for identifying the relevant alteration minerals that define the different alteration types. To date, 66 XRD analytical results for samples from Cores 2R to 29R have been processed.

Cores U1528D-2R to 9R are characterized by the mineral assemblage of alunite + cristobalite + pyrophyllite + quartz + pyrite ± anhydrite ± gypsum ± rutile that corresponds to Alteration Type IIb identified in Holes U1528A and U1528C. From Cores 10R to 18R, the color of the rock changes from light gray to a dark bluish gray, and a typical mineral assemblage of anhydrite + illite + cristobalite + pyrite ± pyrophyllite ± alunite is present. This mineral assemblage characterizes a newly introduced Alteration Type III, and relics of primary plagioclase phenocrysts and Fe-Ti oxides are commonly present. Abundant illite in Alteration Type III suggests that the pH of the hydrothermal fluid that led to this alteration was higher than that of

Alteration Type IIb, and the degree of alteration does not simply increase systematically with depth, and Alteration Types alternate downhole. Initial results of examination of alteration of rocks from Hole U1528D were presented to the rest of the onboard science party at the end of the week. The site report for Site U1529 was also finalized.

The Structural Geology team described and measured structures in Hole U1528D from 60–355 m. Hole U1528D has primary volcanic features defined by the alignment of vesicles and plagioclase phenocrysts, both altered and primary, several hundred alteration veins, and fractures. Volcanic fabrics have two forms observed both macro- and microscopically. In the majority of the rocks, consisting of lapilli tuffs, individual volcanic clasts have volcanic fabrics with distinct orientation, indicating fabric formation before brecciation and deposition. In more massive dacites, volcanic fabrics are mostly continuous over a few meters and have a consistent dip. Volcanic fabrics tend to have a moderate to steep dip. Alteration veins occur throughout the hole, are mostly filled with sulfates and pyrite, range in dip from shallow to steep, and have an average thickness of 15 mm. Some intervals have the full range of dip, while other intervals only have moderate to steeply dipping veins. The thickest veins are 2 cm thick. Fractures are less abundant than veins and tend to be moderately to steeply dipping.

Geochemistry

The Geochemistry team analyzed powdered rock samples from Hole U1528D (Cores 2R to 36R) via elemental analyzer to determine their total nitrogen, total carbon, and total sulfur contents. Headspace gas abundances were measured on rock fragments from Hole U1528D. Two successful deployments of the Kuster FTS tool recovered two borehole fluid samples from 279 and 313 m in Hole U1528D, respectively. The pH, alkalinity, hydrogen sulfide, molecular hydrogen, and major, minor, and trace element abundances of these fluids have been determined in the shipboard Geochemistry Laboratory. Results from all these activities are being processed and will be prepared for presentation to the shipboard science party next week.

Paleomagnetism

We have measured the natural remanent magnetization (NRM) of 48 archive-half sections from Hole U1528D using the superconducting cryogenic rock magnetometer (SRM), before and after alternating field (AF) demagnetization experiments applying the inline AF demagnetizer. The oriented pieces larger than ~10 cm in these archive sections showed 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, suggesting that these rocks have normal polarity magnetizations. Also, thermal demagnetization experiments were carried out on 37 discrete samples and AF demagnetization on 30 discrete samples, respectively. These samples have confirmed the NRM direction measured using the SRM and have generally shown a low NRM intensity compatible with intense hydrothermal alteration, with the exception of some more fresh samples from Cores 27R and 46R, which have shown larger NRM

intensities. Thermal demagnetization experiments have also shown changes in the magnetic minerals after heating the samples at temperatures >400°C, producing a significant increase in the NRM intensities and magnetic susceptibilities.

Petrophysics

The Physical Properties group completed the majority of physical properties measurements for Hole U1528D; a few remaining discrete sample cubes for moisture and density (MAD) and *P*-wave velocity measurements will be completed in the next few days. All Hole U1528D data to date were analyzed and interpreted in preparation for a Hole U1528D science update meeting of the science party. Some variations with depth appear to correlate with the depths of preliminary Igneous Units and Alteration Types identified so far Hole U1528D. For example, an increase in magnetic susceptibility (MS) and natural gamma radiation (NGR) counts occur around the transition between the proposed Alteration Types IIb and III (~100 m), while a decrease in *P*-wave velocity occurs at the same depth (~150 m). Other identified variations in physical properties data include an increase in grain density at ~180 m, and increases in *P*-wave velocities and thermal conductivity from ~210 m that peak at ~260 m before decreasing again with depth to ~300 m.

In addition to these data, two core sections with significant NGR counts were selected for additional 18 h NGR analyses. With these longer counting times, relative peak heights in NGR spectra enabled qualitative assessment of the source of NGR counts. High counts per second observed in Core U1528A-9R-1 (Igneous Unit 2, Alteration Type IIa) appear to be associated with low K and high Ra contents, whereas those in Core U1528D-48R-1 (preliminary Igneous Subunit 2e) are consistent with high K and low Ra contents. The Site U1529 Report was drafted, and the final Site U1527 Summary was submitted. An additional thermal conductivity measurement was completed for Site U1527 and the Site U1527 Report was revised accordingly.

The Downhole Measurements group ran a series of logging runs comprising the Kuster FTS, the high-temperature ETBS memory tool, and a Schlumberger high-temperature triple combo string composed of density, temperature, and natural gamma logging tools (total counts and spectral). The first Kuster FTS tool was unfortunately lost in the hole. This was followed by a successful ETBS run yielding a maximum temperature of 34°C at 359 m just after circulating cold seawater. The deployment of the Kuster FTS successfully retrieved a sample from 303 m, which was followed by an ETBS log, giving a maximum temperature 215°C after about one day without downhole seawater circulation. The high-temperature triple combo was then run in the open hole and recorded a maximum temperature of 248°C. These real-time temperature measurements were confirmed by the reading of 238°C of digital thermometers located within the Schlumberger tool string; it was not in direct contact with the borehole fluid. The FTS then again successfully recovered a fluid sample from 313 m, followed by an ETBS log (maximum temperature of 164.5°C). Detection of low levels of H_2S while retrieving the FTS required the addition of cold seawater in the hole, which explains the lower temperature recorded just after by

the ETBS. Fluid inclusion measurements of the latest mineral veins have indicated a temperature of 190–235°C. Capillary tube thermometers recovered as attachment to the RCB coring bit used in Hole U1528D indicated temperatures between 232°C and 327°C. We expect to receive the processed wireline log data from shore shortly, and interpretation of all temperature, fluid sample, and log data will continue in the coming week.

Microbiology

During Week 5, seven new samples from Hole U1528D were collected for postcruise microbiology research. Three of them had 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 decided to not sample for metagenomic analysis from Core 17R and to share reduced samples from Core 19R and 21R.

Perflouromethyl decaline (PFMD) contamination tests were performed and detected at levels below that expected in the drilling fluid sample. In five of the seven samples, PFMD was barely above detection limit on both outside and inside of the core, indicating that the contamination is minimal. However, two samples showed the concentration of PFMD in the outside layer of core in levels higher than in the drilling fluid sample. We plan to conduct increased sampling of the drilling fluids to ensure the final concentration of the tracer used in the fluid is appropriate. In addition, microbial activity measurements by ATP quantification were conducted and showed negative results (luciferase enzyme not activated). Microscopic observations of samples using SYBR Green staining dye and culture observations are planned for next week.

Education and Outreach

The Education and Outreach team successfully conducted 13 live streams with schools and universities in the United States, New Zealand, Italy, Germany, and Brazil, totaling an audience of 592 people. The highlights were three live connections. We conducted two Google Hangouts with the website "Exploring by the Seat of your Pants" as part of their "World Oceans Week" campaign. Each session involved multiple schools and ages, with six classes participating in each session. At 0900 h on 9 June, we conducted a Facebook Live event to celebrate World Oceans Day. This hour-long event saw 579 people tuning in, and it accrued 51 likes and 48 comments. We created an infographic of the extremophile microbe *Sulfolobus solfataricus* that was posted on the ship's website along with a "Microbe Monday" science presentation and two blogs (http://joidesresolution.org). These addressed the scope and challenges of learning about what lies beneath the seafloor, as well as how to make thin sections and how petrologists identify minerals. We also created two more lesson plans, covering "Convection Currents in Hydrothermal Vents" and "Calculating Biodiversity at Black Smoker Chimneys at Brothers Volcano." Overall, there have been 21 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 ~17,100 users and ~6,200 views initiated by eight posts in total, including the most popular post being a video addressing World Oceans Day (7,000 reached; 309 engagements). On Twitter, seven tweets garnered 74 Likes and 38 Retweets. Instagram registered 184 Likes and 238 views for four posts.

Technical Support and HSE Activities

During this week, IODP JRSO technical staff continued to support the science operations at Site U1528. This included support for the first successful recovery of borehole fluid and gas from an active arc volcano. As time was available, staff cross trained, reviewed manuals, and performed laboratory maintenance.

Laboratory Activities

- Underway Geophysics Laboratory:
  - We updated LabVIEW on WinFROG computers;
  - We are investigating issue with aft Trimble Satellite navigation system dropping its network connection to the WinFROG navigation computer;
  - We continued moving, sorting, and storing material from the Upper Tween Deck Shop (as time is available).
- Physical Properties Laboratory:
  - Staff are working on a report regarding the proposed changes to how we identify the first arrival for velocity determination.
  - Work has begun on updating the Moisture and Density (MAD) station's Data Acquisition (DAQ) board upgrade.
- Chemistry Laboratory:
  - Issues reported last week with the Ion Chromatograph were resolved after cleaning.
- Downhole Measurements Laboratory:
  - Staff are assisting with the preparation and deployment of the temperature and water sampling tools.
  - Because of the high acidity and temperature, the water sampling tool requires extensive repairs, rebuild, and cleaning after each run.
  - Sample extraction from the water sampler was performed on the core receiving platform under strict safety controls and H_2S monitoring.
- Miscellaneous:
  - A full review of the UPS systems was performed and a recommendation was sent to shore.
  - Electrical technicians are evaluating the new back-up batteries for the emergency lights.

Application Support Activities

- The Data Publishing project continued with coding of tools for HTML file updates of Tag Names and Values.
- We implemented the DESCReport program change per shore requests.
- MADmax work on building the LabVIEW 2017 systems engineering software tool box continued along with implementing requested cosmetic changes to application.
- Signal Analysis tool of measurement data report software DIAdem was installed on the Development box in the logging office.
- We transferred documentation from old developer site on Google Sites to Confluence.
- We changed the MUTT software refresh timer from 5 s to 5 min to avoid an issue where MUTT steps on files it is still using.
- We revised the LIVE Summary Template per user request.
- We changed the PITALOG Purge script to run under the PITALOG user and automated it to run daily.

IT Support Activities

- We upgraded the Acronis backup and data protection software from version 11.7 to 12.5.
- We experienced a 3 h internet/phone outage. The cause remains unknown, but it was somewhere on shore. We are working with our vendors to track down the cause.

HSE Activities

- During this week, we had one H_2S rig floor area alarm and several handheld meter alarms while making drill pipe connections and extracting fluids from the Kuster FTS tool. Appropriate precautions have been implemented and once coring is resumed, staff will continue monitoring the recovered core. We expect H_2S levels to increase as we deepen this hole.
- Technical staff completed the weekly check of safety showers and eyewash stations.
- We held the weekly fire and boat drill as scheduled.