IODP Expedition 352: Izu-Bonin-Mariana Forearc

Week 7 Report (7–13 September 2014)

Operations

Week 7 of Expedition 352 (IBM Forearc) began while rotary coring Core U1439C-35R at 515.8 mbsf. Coring continued through Core 45R to a final depth of 544.3 mbsf. Core 46G was recovered while trying to get back to the bottom of the hole to continue coring. As we approached 40 h of rotating time on the bit, and given the amount of reaming required on this bit, we decided to make a bit trip. As we pulled out of the hole, high torque, loss of rotation, and loss of circulation forced us to discontinue coring operations on Hole U1439C. At one point, we lost rotation or circulation for several hours. The drill string was eventually freed by a combination of overpull (190 klbs) and forced circulation. The drill string was then pulled back to surface and the bit arrived back on the rig floor at 2220 h on 8 September.

A logging bottom-hole assembly (BHA) was assembled with a 9.875 inch tri-cone bit equipped with a mechanical bit release (MBR). The assembly was lowered to the seafloor, but sea conditions were too rough to deploy the underwater camera system. After waiting on the weather to calm down for 8.25 h, the camera was deployed. The vessel was repositioned and Hole U1439C was reentered for the fourth time at 1530 h on 9 September. The bit was lowered to 396 mbsf where it encountered fill and the hole was cleaned down to 533 mbsf. At 533 mbsf, we started losing circulation and the decision was made to release the bit at that depth. After the bit was released, the drill string was raised to ~150 mbsf for logging. The triple combo–magnetic susceptibility sonde (MSS) tool string was assembled and two passes were made down to 402 mbsf. Next, the Formation MicroScanner (FMS)-sonic tool string was assembled. The first pass reached down to 402 mbsf, and the second pass reached 392 mbsf. The tool string was pulled to the surface and the logging equipment was secured at 0530 h on 11 September.

The drill string was pulled to the surface and cleared the rig floor at 1105 h on 11 September, ending Hole U1439C and Site U1439. A total of 45 rotary cores were taken over a 362.3 m interval and recovered 107.8 m (30%). An additional 1.5 m of material was recovered during hole cleaning operations. The total time spent on Hole U1439C was 382.75 h.

A rotary core barrel (RCB) BHA was assembled with a C-4 bit. The vessel arrived at Site U1441 (proposed Site BON-6A) at 1512 h on 11 September while the drill string was still being lowered to the seafloor. Hole U1441A was spudded at 2245 h. The hole was advanced to 92.6 mbsf after which Cores U1441A-11R and 12R returned empty. We deployed a bit deplugger to unplug the bit and then continued coring to 189.9 mbsf (Core 20R). A wiper trip was conducted from 82 to 187 mbsf and 2.7 m of fill was cleaned from the bottom of the hole. At the end of the week, coring had resumed with Core 21R extending to 198.7 mbsf.

Science Results

Hole U1439C (7–11 September 2014)

Cores U1439C-38R to 43R contain aphyric, microcrystalline basalt, with modal plagioclase in the groundmass and sparse microphenocrysts of olivine. Pillow lava dominates in the shallower sections, but massive dark gray to black basalt becomes dominant downhole. Chilled margins are found in some massive basalt fragments, suggesting that many of these massive units are dike rocks. One probable dike has a composition similar to that of lavas higher in the section. Fault rocks are common in Cores 41R to 43R, including breccia and sheared phaccoidal fragments with polished chlorite ± serpentine surfaces.

Cores U1439C-44R and 45R contain aphyric, fine-grained basalt or dolerite, with modal plagioclase in the groundmass and sparse phenocrysts of augite. The rocks have a greenish tinge from incipient sausserization of plagioclase, and contain dark clots, which may be chlorite overgrowths. There is only one piece in either core that appears volcanic (Core U1439C-44R, Piece 11); all other pieces in both cores are fine grained to microcrystalline, with granular or doleritic textures. Chilled margins are found in some pieces, suggesting that these are dike rocks.

We completed geochemical analyses of the igneous rocks recovered from Hole U1439C: 18 igneous rocks were analyzed via ICP-AES (from Core U1439C-27R to 45R) and 46 igneous rocks were analyzed for H_2O and CO_2 contents via CHNS. The igneous rocks of Hole U1439C have variable LOI of 2.7–16.2 wt%, H_2O of 1.5–8.7 wt%, and CO_2 of 0.1–2.5 wt%, resulting from the relatively high degree of alteration of the recovered samples (including evidence of carbonate precipitation within the matrix). Even when the most altered samples are excluded, Hole U1439C igneous rocks display a broad range of compositions from basalts, basaltic andesites to andesites, with SiO_2 concentrations of 50.5–60.2 wt% and total alkali contents of 1.60–4.70 wt%. Hole U1439C igneous rocks fall into two groups based on petrographic observations: plagioclase-bearing samples and olivine-pyroxene–bearing samples (plagioclase free). Plagioclase-bearing samples have Cr concentrations of 51–750 ppm and Mg# of 59–76. Their chemical compositions are generally transitional between those of the igneous rocks recovered at Site U1440 and those of the olivine-pyroxene–bearing samples. Olivine-pyroxene–bearing samples have compositions commonly attributed to boninite series, with high Cr contents (221–1562 ppm), high Mg# (64–80), and SiO_2 concentrations ranging from basaltic to andesitic. Portable XRF measurements were carried out on pieces from Cores U1439C-34R to 45R. The results of these measurements were vital in the identification of igneous units in Hole U1439C.

Cores U1439C-41R to 43R are generally characterized by a downward increase in number of fractures and slickensides. This increase in deformation features begins at 514 mbsf with a shear zone, a cataclastic domain consisting of incohesive, friable fragments of host rock material, partly surrounded by fine-grained fault gouge and a network of irregularly oriented fractures. Some of these fractures are zeolite filled. Distinct cataclastic shear zones comprising incohesive

cataclasite (centimeter-sized host rock fragments embedded in a fine-grained fault gouge matrix) also occur at 525.4, 533.6, and 534.2 mbsf. The latter was defined as the bottom of this fault zone, as Cores 44R and 45R below had pieces of unfractured boninite/transitional forearc basalt. There is an interval with abundant slickensides from ~504 to 505 mbsf. Zones of slightly cohesive fault breccia (centimeter-sized fragments) were recovered at ~524 mbsf and from 529.4 to 525.5 mbsf, accompanied by a highly slickensided domain from 524.0 to 526.2 mbsf. The majority of slickensides are inclined or steeply dipping (dip angles >45°), with most of these showing normal or oblique normal kinematics and a few showing strike-slip or reverse sense of shear. The reverse sense of shear was often obtained from subvertically oriented slickensides (dip angle ≥85°). Kinematics on these, however, needs to be interpreted with caution, as the sense of shear would be inverted by deviation of the drill core axis. Well preserved cataclastic shear zones generally display top-down kinematics. The number of veins, as well as vein thickness, decrease remarkably downward. This coincides with an increasing abundance of slickensides and shear fractures. The cored interval below 515 mbsf is almost barren of veins.

The physical properties team completed the measurement for Cores U1439C-41R to 45R. Magnetic susceptibility (MSL) values obtained from whole-round cores increase to 1500 IU in this interval and this trend can is also seen in magnetic susceptibility (MSP) values obtained from archive-half sections. NGR values are low, <5 cps. Color reflectance parameters L*, a* and b* are mostly around 40, 1, and –2, respectively. *P*-wave values values obtained from discrete samples are ~4000 m/s. Thermal conductivity increases to 1.8 W/[m·K]. Moisture and density (MAD) bulk density values are ~2.5 g/cm^3 and MAD porosity values are mostly ~20 vol%.

Measurements of discrete samples from Hole U1439C were finished. In total, 80 discrete samples were measured from the Hole U1439C igneous units over the past two weeks. Most of these samples give shallow paleoinclinations, consistent with studies that have shown that the Izu-Bonin arc formed near the Equator. Some inclination values near faults appear spurious and may indicate structural rotation.

There were two downhole tool string deployments in Hole U1439C, the triple combo-MSS and the FMS-sonic tool string. The measurements acquired include caliper, gamma ray, density, resistivity, acoustic velocity, micro-resistivity images, and magnetic susceptibility. Both tool strings obtained ~220 m of data in open hole, reaching a total depth of ~400 mbsf (~144 m above the bottom of the cored hole). This depth is roughly coincident with a fault zone, as observed in the cores. Data from the triple combo caliper tool indicate a hole diameter of 11–14 inches through much of the open hole interval, with discrete washed-out zones of up to 16 inches in diameter. Hole conditions did not deteriorate through the course of logging operations but weather conditions did, with heave causing significant tool motion despite utilization of the wireline heave compensation system. Preliminary assessment of the logging data indicates reasonable data quality and some interesting comparisons with the corresponding core data sets.

Hole U1441A (11–13 September 2014)

Cores U1441A-1R to 4R contain pale brown, silty nannofossil ooze with four discrete ash layers, followed by a muddy volcanic breccia-conglomerate interbedded by some volcaniclastic sand layers to a depth of 24 mbsf. In Cores U1441A-5R to 9R, the sediment is dominated by brown to greenish gray silty mud, partly enriched in silicic microfossils and occasional ash layers.

Nine core catcher samples were examined for microfossils. Nannofossils in Samples U1441A-1R-CC and 2R-CC yield an approximate Late Pleistocene age, whereas Sample 5R-CC yields an approximately late Miocene age (5.59–8.12 Ma).

The majority of primary sedimentary structures in Cores U1441A-1R to 9R are severely disturbed by RCB drilling. Only five bedding planes were observed in sections where the sediment was more competent. The general bedding attitude in these intervals is horizontal.

Headspace gas samples were analyzed for hydrocarbon safety monitoring from all Hole U1441A sediment cores. Portable XRF measurements were carried out on pieces from Cores 10R to 22R. The results of these measurements helped identify igneous units in Hole U1441A.

Cores U1441A-10R and 13R–16R (Cores 11R–12R had no recovery) contain a homolithic breccia deposit that is well cemented in Cores 14R–16R and composed of angular to subrounded volcanic clasts in a matrix of coarse volcanic sand. All of the lava clasts are likely from the same flow or source. Large, coarser grained clasts are found in the upper parts of Core 10R. Below that, fine-grained to aphanitic volcanic clasts dominate. The coarser grained clasts have diktytaxitic textures and rare pipe vesicles. The fine-grained to aphanitic volcanic clasts are characterized by segregation pipe vesicles up to several centimeters long, and commonly retain portions of their chilled or glassy margins, showing that they originate from a pillow lava flow. The segregation vesicles are filled with a frothy glass, probably formed by continued outgassing of the late stage intra-telluric melt from the crystalline portion of the rock. Pipe vesicles may splay over a few degrees in their orientation within an individual fragment, but in general give a good indication of the "up" direction. The pipe vesicle orientations within individual clasts are subparallel, but their orientations vary widely between pieces, indicating that these are in fact clasts and not an intact lava flow. This is consistent with the recovery of well-cemented breccia in Cores U1441A-13R and 14R. The Hole U1441A rocks are interpreted to represent a mass wasting deposit. Most clasts are angular, and many fine-grained clasts preserve fresh glass on their margins.

Physical properties measurements were made on sediment Cores U1441A-1R to 9R and igneous rock Cores 10R–18R. MSL values are 50–300 IU in the sediments and 300–1200 IU in the igneous units. GRA values are 1.3–1.5 g/cm^3 in the sediments and 2.0–2.2 g/cm^3 in the igneous units. NGR values are 10–20 cps in the sediments and 5–20 cps in the igneous units. PWL values are 1500–1600 m/s in the sediment cores.

The remanent magnetization of archive-half sediment sections from Cores U1441A-3R to 9R was measured with the cryogenic magnetometer.

Education and Outreach

The following activities took place: (1) Facebook (https://www.facebook.com/joidesresolution) and Twitter (https://twitter.com/TheJR) posts with photo albums and short science summaries; (2) blogs on http://joidesresolution.org/ and scientists' sites; (3) video conferences with Whitehall Middle School (Montague, MI), Exeter high School (NH), St. Bruno Catholic School (IL), Our Lady of Providence school (IN), University of South Florida, Colorado State University, and Long Beach Aquarium (for the JR Outreach Network); (4) GoPro footage of rig floor coring and logging activities; (5) Podcast narration and final edits; and (6) networking with AGU outreach staff on expedition activities.

Technical Support and HSE Activities

Technical staff supported science operations at Sites U1439 and U1441.

Laboratories:

- Completed two Hole U1439C sampling parties.
- Broken wire repaired on JR-6 Spinner magnetometer arm.
- Created software utility to reformat XRF data from Excel into a format suitable for the SpreadsheetUploader and uploaded the data into the LIMS.
- Preparation of new core splitter user manual is in progress.
- Fixed bug that prevented MADMAX from showing the correct volume value of pycnometer standards but deferred deployment until after Expedition 352.

HSE activities:

- Eye wash stations and safety showers were tested in the laboratories.
- An abandon ship and fire drill took place on 7 September.