IODP Expedition 350: Izu Bonin Mariana Rear Arc

Week 6 Report (5–11 May 2014)

Operations

Hole U1437E

This week continued with preparing Hole U1437E for deep coring. Drilling the 14.75 inch hole in preparation for 10.75 inch casing reached the target depth of 1104 mbsf (the total depth of RCB coring in Hole U1437D) at 1745 h on 5 May. The hole was cleaned with a 41 barrel mud sweep before the bit was raised to 988 mbsf and the top drive was disengaged. The bit was then further raised to 18.0 mbsf and lowered again to 260.1 mbsf, just above the bottom of the 16 inch casing string. The drill string remained in that position while the rig crew was slipping and cutting the drilling line.

A wiper trip was conducted to ensure the hole was clear. The bit was lowered into the hole, without the top drive, from 259.7 to 1016.7 mbsf. The top drive was then picked up to wash and ream to 1104 mbsf; fill was encountered at 1022.7 mbsf. High torque occurred at 1063.7 mbsf, and after raising the bit to 1035.7 mbsf, the hole was finally washed and reamed to total depth (1104 mbsf) at 0545 h on 6 May. The hole was swept with 40 barrels of high-viscosity mud and the bit raised to 1035.7 mbsf, where another 60 barrel high-viscosity mud sweep was circulated to ensure the hole was clean. The bit was then raised to 1016.7 mbsf, where the top drive was disengaged. The drill string was tripped out of the hole, clearing the seafloor at 1115 h and the rig floor at 1500 h on 5 May.

The 1085.6 m long 10.75 inch casing string was assembled with a total of 85 joints, with the couplings of the bottom seven joints welded in four places and the rest of the couplings tack-welded in two places. The casing hanger was installed, the running tool engaged, and the complete assembly was hung from the moon pool doors while the casing stinger was assembled. A mud motor and underreamer were made up and tested. When the underreamer arms failed to open, a backup unit was installed, which performed as expected with the arms opening at a circulation rate of 35 strokes per minute. The stinger bottom-hole assembly (BHA) and the running tool were made up and run and latched into the casing by 1945 h on 7 May. The casing was tripped to the seafloor, the camera was deployed, and Hole U1437E was reentered with the 10.75 inch casing at 2115 h. When the bit had passed below the 16 inch casing shoe (264.1 mbsf; 2200 h), the camera system was raised above the running tool at the top of the casing string, to be lowered together with the casing string. Tripping of the casing continued to 1000.7 mbsf, where the top drive was engaged. After further lowering the casing string to 1034.7 mbsf (0145 h on 8 May), fill was encountered in the hole. The pumps were engaged and the casing was washed down to 1086.7 mbsf. At that point, the 10.75 inch casing hanger latched into the 16 inch casing hanger at the reentry cone. The latch was verified with 20 klb of pull from the rig floor. The casing was released and the stinger assembly was raised to 1057.7 mbsf. The top drive was

disengaged and the trip to the surface continued, with a stop at 796.7 mbsf to retrieve the camera, clearing the seafloor at 0610 h, and arriving at the rig floor at 1100 h on 8 May.

The underreamer and mud motor were removed and a cementing bottom-hole assembly was made up consisting of a bull nose, two stands of drill collars, the casing running tool, and one stand of drill collars above. The cementing assembly was lowered to the seafloor and, after the camera was deployed, reentered Hole U1437E at 1700 h on 8 May. The running tool was landed in the reentry cone with the bit at 55.8 mbsf. Attempts to establish circulation failed, indicating that the bottom of the casing was sealed, and the cement job was aborted. The cementing string was raised and cleared the seafloor at 1830 h, and after recovering the camera, was tripped to the surface clearing the rig floor at 2235 h on 8 May. This ended the deepest casing deployment in the history of the *JOIDES Resolution*.

After several hours of routine rig maintenance, we were ready to resume RCB coring. An RCB coring bit was assembled and lowered to the seafloor, which was followed by the deployment of the camera to guide reentry of the bit into Hole U1437E at 0930 h on 9 May. The bit was lowered to 1048 mbsf, where the top drive was engaged, and the bit reached the bottom of the hole (1104 mbsf) at 1345 h. The hole was swept with 20 barrels of mud and coring in Hole U1437E began at 1500 h on 9 May. The first core arrived on deck at 1815 h.

The rotation rate (and thus the coring rate) was kept low while the 95 m long bottom-hole assembly was still within the 10.75 inch casing that extended to 1086 mbsf. Drill collars in the BHA have a larger diameter than the regular drill pipe above and may compromise the casing and/or deviate the hole from vertical if not advanced into the formation below the (uncemented) casing shoe with care.

Cores U1437E-4R though -14R (1104.0–1194.0 mbsf) obtained 67.34 m (75% recovery) of intercalated tuff and tuffaceous mudstone. Although recovery was generally excellent (two cores with >100% recovery), we also had a barrel with zero recovery, presumably as a result of losing a perfectly cut core because it could not be broken off the formation or, upon retrieval, could not be kept in the barrel by the core catchers.

Science Results

While the rig crew prepared Hole U1437E for deep coring, scientists continued analyzing data from Holes U1436A, U1437B and U1437D, finalizing Site U1436 reports and Methods sections, and preparing draft reports for Site U1437. The first few cores of Hole U1437E were received during the last ~2 days of the week and regular laboratory activities started to pick up again.

Core describers shared summaries of core descriptions from Holes U1437B and U1437D with other groups, and submitted the detailed description of Units I–III in those holes. Topical interpretations are in the process of being drafted and refined, including: diagenetic and

compaction history including alteration; origin and significance of the dominant tuffaceous mud and mudstone lithology; origin and depositional processes of the discrete volcaniclastic intervals; periodicity of discrete ash and tuff intervals; and an integrated depositional model for the strata.

We described 28.9 m of new cores from 1104 to 1141 mbsf in Hole U1437E. Volcaniclastic intervals are slightly more abundant than tuffaceous mudstone intervals (55% versus 45%, respectively). The dominant lithology is a green to greenish gray tuff ranging from silt to medium sand grain size. It is commonly stratified, locally cross-bedded, and has darker, crystal-rich (plagioclase and pyroxene) layers and lighter vitric layers. Tuffaceous mudstone is the second order facies, in places containing dispersed volcanic clasts. Distinctive, 1–46 cm thick intervals of dark gray stratified tuff with high magnetic susceptibility were also recovered. A single interval of normally graded dark lapilli-tuff with flattened fiamme represents the only material coarser than ash. Contacts between intervals are generally moderately to highly bioturbated. Green-colored alteration, probably due to presence of chlorite, is pervasive and affects all lithologies. Some pyritized clasts were observed within bioturbated mudstones. Thin normal faults with cm-scale offset locally cut across the tuff and mudstone layers. These faults are sometimes filled with pyrite and a milky white mineral phase.

Hydrocarbon analyses from headspace samples (n = 5) of Hole U1437E yielded methane abundances up to 207 ppmv and ethane abundances up to 9.8 ppmv. $CaCO_3$ and inorganic carbon abundances were measured in 11 mud samples from core catchers of Hole U1437D between 930 and 1097 mbsf. Total carbon and nitrogen measurements were completed for 196 samples from Hole U1437D.

Ammonium concentrations were determined for interstitial water samples from Sites U1436 and U1437 (n = 69). The results show systematic increases in ammonium with decreasing sulfate and increasing alkalinity and phosphate, consistent with sulfate reduction at shallow depths (0–100 mbsf). Below 100 mbsf, ammonium decreases with depth but at a slower rate compared to alkalinity and phosphate, suggesting that NH_4 is potentially buffered by ion exchange reactions with clay and volcanic ash. Three major processes are identified according to the depth variations in pore fluid chemistry, which control the changes in major and trace element abundances in a fluid that started out as sediment-trapped seawater. Ranked according to increasing impact with depth, these processes include (1) biologic activity (i.e., sulfate reduction of organic material); (2) lateral fluid transport (fracture or formation controlled); and (3) diagenesis (i.e., carbonate recrystallization, alteration of volcanic glass). This ranking does not rule out a complex interplay between all these processes over the entire interval sampled.

Further analysis of the accuracy and precision of the portable X-ray fluorescence instrument (pXRF) was undertaken this week in the absence of new core. Powder pXRF analyses of JB-2 (basalt from Izu-Oshima volcano, Japan) measured over a two-week period (n = 97) are highly reproducible with relative standard deviations of 3.4% (K_2O), 1.3% (CaO), 1.7% (Sr), and 4.5% (Zr). Powders of unknowns analyzed by ICP-AES were also measured by pXRF to assess

relative accuracy. Analyses of K_2O, CaO, Sr, and Zr by pXRF and ICP-AES agree within <20% for Sites U1436 and U1437 samples.

Major and trace elemental compositions of tephras analyzed by ICP-AES and pXRF are summarized for the four lithostratigraphic units at Site U1437E defined in the Week 5 report.

Unit I samples from 0 to 440 mbsf (<3 Ma) included six ICP-AES and 10 pXRF analyses of tuff. They range from basaltic andesite to rhyolite, have relatively low K_2O abundances (0.35–1.48 wt%), and generally overlap with compositions of rift-type and arc front volcanic rocks. Unit I samples from 440 to 682 mbsf (3–4.2 Ma) included two ICP-AES and 17 pXRF analyses of tuffs that range from andesite to rhyolite, and have slightly higher K_2O contents (0.50–2.43 wt%) compared to the <3 Ma rocks; these are compositionally transitional between arc front and rear arc volcanic rocks.

Unit II samples included three ICP-AES and four pXRF analyses on tuffs and lapilli tuffs ranging from andesite to dacite with K_2O contents of 0.39 to 2.22 wt%. Lapilli tuffs with higher K_2O are likely of rear arc origin, consistent with their comparatively coarse grain size indicating a proximal source. Unit II tuffs with low K_2O are assigned an arc front origin.

Unit III samples included 13 ICP-AES and 25 pXRF analyses on tuffs ranging from basaltic andesite to dacite. Their K_2O contents (0.34–1.28 wt%) are low, and generally plot in the field defined by arc front volcanic rocks.

Unit IV samples included three ICP-AES and 19 pXRF analyses of tuffs and lapilli tuffs that range from basaltic andesite to andesite. Unit IV lapilli tuffs have relatively high K_2O contents (up to 4.88 wt%) which suggest alteration. Tuffs with low K_2O are more similar to arc front volcanic rocks, whereas one andesite block with moderately elevated K_2O is compositionally similar to dredged lavas from Manji seamount.

In summary, the combination of shipboard reconnaissance pXRF and ICP-AES analyses is useful to relatively rapidly distinguish between arc front and rear arc sources that have variably contributed to the tephra and volcanic clast populations at Site U1437.

The physical properties group started to analyze in detail the differences in the NGR, MS, *P*-wave, and color values obtained from the different kinds of lithofacies. Initial observations are that mafic ash layers often give a low NGR and reflectance L* signal, and a high magnetic susceptibility. Evolved ash layers are less consistent, giving a range of NGR and magnetic susceptibility readings with a generally higher reflectance L* value. Calibration and verification of the physical property shipboard instrumentation were carried out during the last day of casing. Physical properties measurements were performed on ~48 m of volcaniclastic rocks and mudstones from Hole U1437E. GRA density, MS, NGR, *P*-wave velocity, thermal conductivity, and color were measured on whole-round sections and working section halves. Discrete cube samples were taken from the working half sections and were kept in the seawater saturator for 24 h before starting the moisture and density (MAD) measurements.

The paleomagnetic team completed the interpretation of anisotropy of magnetic susceptibility (AMS) measurements from Holes U1437B and U1437D. The degree of planar anisotropy overall increases downhole, in accord with observations of increased compaction with depth, although the degree of magnetic foliation is less than the compaction determined from observations of strain markers. Unlike the strain marker evidence, no significant elongation in the magnetic fabric is seen in the upper 400 m at Site U1437, possibly because of the preferential selection of cubes in undisturbed material. Instead, a weak increase in magnetic foliation develops from the surface to about 400 mbsf, where it resets in a sharp step to lower values, before the steady downhole increase in magnetic foliation resumes. Scattered low values of magnetic foliation occur below ~1000 mbsf in Hole U1437D, corresponding roughly to lithostratigraphic Unit IV.

This week we also noted the correspondence of a number of significant features in the downhole distribution of rock magnetic properties with features in the physical properties, interstitial water geochemistry, and organic geochemistry records. Overall, the rock magnetic properties show a downhole trend indicating an initial biologically-mediated reduction in the sulfate reduction zone producing greigite. The proportion of greigite gradually decreases downhole, presumably though slow completion of the iron sulfide reduction chain to convert this ferrimagnetic sulfide to paramagnetic pyrite. Superimposed on this trend is step change in the SIRM/k and S-0.3T rock magnetic parameters, as well as magnetic foliation at ~400 mbsf. This represents a sudden downhole increase in the proportion of magnetic sulfides, followed by gradual returns to trend over the next 300 m downhole, to ~700 mbsf. The return to trend in SIRM and S-0.3T occurs in the lower part of lithostratigraphic Unit I, and appears to be complete by the Unit I/II boundary at about 680 mbsf, corresponding also to the top of physical properties Unit 2. Initial authigenesis of magnetic iron sulfides corresponds, as would be expected, to the sulfate reduction zone. After initial sulfate reduction, sulfate recovers and reaches a plateau concentration from about 275 mbsf to about 400 mbsf; over this interval S-0.3T values drop to below 0.97, suggesting renewed and enhanced production of greigite. Below ~400 mbsf sulfate increases again downhole to near-seawater concentrations at about 460 mbsf, corresponding to the highest value of SIRM/k in all samples measured at Site 1437, and remains high to the deepest interstitial water (IW) sample taken at 700 mbsf. Transport of sulfate in pore fluid appears to have been responsible for a history of renewed magnetic authigenesis. The step reduction in AMS foliation at about 400 mbsf can also be explained by renewed growth of magnetic sulfides, which would have a compaction history reset at zero at this sub-bottom depth. The deep methanogenesis zone also matches the rock magnetic record, corresponding to the highest S-0.3T values encountered at Site U1437 to date. Such high S-0.3T, indicating a very low-coercivity magnetic assemblage, suggests not only complete conversion of greigite to pyrite, but probably also dissolution of fine-grained magnetite; both may reflect further reduction of the sediments related to deep and ongoing microbial activity stimulated by influx of sulfate-rich pore fluids.

Early results from Hole U1437E appear to confirm the low coercivity seen near the base of Hole U1437D; samples are strongly overprinted, polarity is proving difficult to establish, and one sample showed a progressive 10% change in its NRM intensity and 14° in direction after 9 min

of measurement in field-free apace, illustrating the propensity of rocks in this interval to acquire a viscous remanence in the ambient field.

The nannofossil paleontologists have examined core catcher samples from Interval U1437E-4R-CC through 7R-CC. The nannofossil assemblages are similar to those seen in the last core catcher sample of Hole U1437D. Despite poor preservation of nannofossil specimens due to dissolution/overgrowth, the identification of *Triquetrorhabdulus rugosus* and a few specimens of *Amaurolithus amplificus* confirm an age younger than 6.91 Ma.

Due to longer processing time required for foraminifer sample, the foraminifer paleontologists have not yet examined any samples from Hole U1437E.

Education and Outreach

On 9 May, we had a very successful event with the Denver Museum of Nature & Science. During the four 45 min sessions, we reached 1,161 students across Colorado (with one class from Illinois) for their monthly "Scientist in Action" event. Quoted from a curator at the museum "Amazing, the best Scientist in Action ever." Additional feedback from teachers participating in the event is unanimously positive, and future partnerships will likely be made.

On 10 May, we had a successful one-hour connection with JAMSTEC Open House Day to a full lecture theatre of adults, and fitted around a lecture about our drill site and ongoing research in the area. We held the our first videoconference with an Australian School, and received excellent personal feedback from Durham University, UK, The American University in Iraq, and from various high-school groups in various countries.

Updates, photos, and blog posts were disseminated to our various social outlets, including Facebook, Instagram, Twitter, and the *JOIDES Resolution* blog. Short videos have been created and will be uploaded following approval.

Technical Support and HSE Activities

Coring has resumed and marine technicians have returned to supporting science operations. During the week, staff continued with performing minor equipment maintenance, updating their technical reports and working on various IODP projects.

Laboratory

Minor flooding occurred in the User Room when water backed up through the floor drains in the bathroom. The cause of the backup was repaired, and the carpets were cleaned and dried.

We are still waiting on vendor software upgrades for the Bathy 2010 system.

The ship's crew finished swapping out the chiller. The hatch in the Pallet Storage room is closed.

Staff are planning end-of-expedition activities.

Held meetings with shipboard staff on the Laboratory Electronic Notebook requirements. A proposal will be submitted shortly.

Development

Writing LIMS Peak's software requirements with shore and ship staff.

The following DESCLogik bug fixes have been released for testing:

- Column widths correctly sized when imported from configuration files;
- Extra spaces in the "auto link" columns removed;
- Strater export function fixed.

Staff fixed the extra comma issue in the LIMS ICPAES report; fixed the Thin Section Report Writer to recognize the asman_id in image field and deployed a new beta version; and deployed a test version of MUT for uploading Alkalinity data.

Information Technology

Encountered another DIMM memory modules error on our data server; reseating the memory modules cleared the problem, has been running for a week with no further incidents.

VSAT parts inventory was compiled into a spreadsheet and forwarded to shore.

The Apple File Protocol on Novell servers hung for VOL1 (Uservol); rebooting the server cleared the problem.

Created and tested Expedition 351 accounts.

Safety

The weekly fire and boat drill was completed as scheduled.

Safety showers and eye wash stations were tested.