IODP Expedition 350: Izu Bonin Mariana Rear Arc

Week 3 Report (14–20 April 2014)

Operations

Hole U1437B

The last core from Hole U1437B arrived on deck at 0000 h on 14 April 2014. We cored 439.1 m and recovered 242.6 m in Hole U1437B (55% recovery). The drill string was recovered and the bit cleared the seafloor at 0220 h on 14 April, ending the hole.

Hole U1437C

A rotary core barrel (RCB) bottom hole assembly (BHA) was made up with three stands of drill collars, and a core barrel with a center bit was installed. Our plan was to drill without coring to 425 m, several meters above the total depth cored in Hole U1437B, and then start RCB coring. The ship was moved to a location 20 m south of Hole U1437B and the bit was lowered to the seafloor. Drilling in Hole U1437C began at 1530 h on 14 April. At 232 m, the center bit was pulled for inspection, and then deployed again. Circulation and rotation was lost at 309.7 m. The stuck pipe was worked for several hours without success. The ship was offset 140 m to allow the rig crew to pull the center bit and run the rotary shifting tool to drop the bit. A single joint of drill pipe was laid out at this time as well. With the bit dropped, the ship moved back to the Hole U1437C coordinates and the pipe was worked for two more hours. The drill pipe was finally worked free at 0910 h on 15 April. The pipe was pulled up to 183.7 m using the top drive. After the top drive was set back, the drill string was pulled out of the hole and cleared the seafloor at 1055 h on 15 April. Hole U1437C was completed when the end of the drill string was recovered on the rig floor at 1305 h on 15 April.

Hole U1437D

A new Mechanical Bit Release (MBR) and RCB bit were made up and the drill string was run into the hole again while the vessel was repositioned 10 m west of Hole U1437A.

Drilling without coring in Hole U1437D began at 2250 h on 15 April and extended from the seafloor to 427 m. The center bit was retrieved and a RCB core barrel was deployed. The first core (U1437D-2R) arrived on deck at 2045 h on 16 April. RCB coring continued to 909 mbsf, recovering 371 m of core (77% recovery).

Science Results

Holes U1437B and U1437D

The additional 45 m of core obtained from Hole U1437B (Cores U1437B-36X through -55X; 252 to 432 mbsf) this week continued to be predominantly mud with ash, intercalated with mafic and evolved ash (with mud) layers. Over this entire section, the mud and minor clay layers amount to a total thickness of 38 m, and the ash (with mud) and minor lapilli-ash layers amount to 2.8 m, a ratio of ~14:1. That is, recovered ash is only half as common as higher in Hole U1437B. Only four ash intervals are observed in 19 m of mud between 368 and 379 mbsf. The ~70 identified ash layers throughout this part of Hole U1437B are 5 cm thick on average. Approximately 85% of them are evolved, and ~15% are mafic. Ash is exclusively evolved from 322 to 398 mbsf but otherwise the distribution appears random. Many glass shards are unaltered, vesicular, and curved. Crystals are subordinate in the felsic ash but visible in half the mafic ashes.

In Hole U1437D, we have described Cores U1437D-2R through -39R (427–789 mbsf). Approximately 87% of the thickness is tuffaceous mudstone, 11% evolved tuff, 1% bimodal tuff, and <1% mafic tuff.

The tuffaceous mudstones consist mostly of fine clear and brown glass shards, clay, and carbonate. They are extensively bioturbated. Three mudstone layers are 2–4 m thick but most are tens of cm thick.

The tuffaceous mudstones are intercalated with layers of evolved, mafic, and bimodal tuff that are on average 10 cm thick. About 550 evolved tuff layers are present, of which ~95% are evolved. Above Core U1437D-28R (681 mbsf) the evolved layers are light to dark gray, with silt-sized, clear to light brown glass shards, and they are normally graded. Evolved tuff layers are the most dominant lithology in Cores U1437D-28R through -35R (681 to 748 mbsf). In this interval they are coarser and contain greater amounts of lapilli-sized pumice and possibly obsidian. Of the 71 lapilli-tuff, lapillistone and tuff-breccia layers so far reported in Hole U1437D, 65 come from this interval. Below Core U1437D-35R the proportion of evolved tuff layers decreases and mudstone dominates again, and the grain size in the evolved tuff layers decreases. However, the proportion of evolved tuff layers still remains high compared to the interval above Core U1437D-28R. About 10% of all evolved tuff and lapilli-tuff layers contain crystals, usually feldspar.

Mafic tuff and bimodal tuff layers are typically black to dark gray. Bimodal tuff layers are uncommon; when they do occur they are composed of dark-opaque and light-translucent, silt- and sand-sized glass shards, and very few crystals. Mafic tuffs are composed of sand-sized grains, and are thicker than evolved and bimodal tuffs; about half the mafic tuffs contain crystals, and they are commonly normally graded.

Below Core U1437D-28R the rocks are extensively silicified and contain disseminated and patches of pyrite. Green (chloritic?) alteration increases in intensity from Core U1437D-28R downhole, becoming pervasive in Core U1437D-38R.

Headspace analysis reports low methane concentrations of 2–9 ppmv down to Core U1437D-35R. Below U1437D-35R, methane becomes more variable ranging between 6 and 64 ppmv. The most recently sampled Cores U1437D-42R and -43R (854 and 856 mbsf) show an increase in methane to values of 295 and 422 ppmv respectively. The origin of this increase likely represents changes in microbial activity.

Site U1437 pore water samples (n = 32) were analyzed for nearly all recovered cores between 8 and 693 mbsf. Pore water sampling was discontinued after Core U1437D-29R due to decreasing volumes of interstitial fluids recovered and an increasing percentage of lithified pyroclastic deposits in the core. Determinations included alkalinity, chlorinity, salinity, and major and minor components. Chloride in Site U1437 interstitial water remained relatively constant near seawater values (560 ± 5 mM) up to 400 mbsf. Below 428 mbsf, Cl concentration peaks at 580 mM and then decreases gradually back to 557 mM at 488 mbsf. Below 488 mbsf, Cl concentrations increase gradually from 557 to 579 mM until sampling was terminated. Alkalinity increases rapidly from seawater values to 25.67 mM between 8 and 65 mbsf; thereafter it decreases to ~2.5 mM at 250 mbsf and remains near seawater values to 693 mbsf.

Total carbon and $CaCO_3$ abundance analyses (n = 131) were partly completed from mud layer samples in Hole U1437B between ~0.5 and 212 mbsf. Every core section was sampled for Cores of U1437B-1H to -11F (to ~90 mbsf). At lower depths, sampling frequency was reduced to one mud sample per core because of limited core recovery. Between 0 and ~100 mbsf, total carbon concentrations vary between 0.5 and 5.1 wt% whereas $CaCO_3$ varies from 1.6 wt% (16.8 mbsf) to 46.6 wt% (58.7 mbsf), averaging 25.5 wt%. Organic carbon (determined by subtraction of $CaCO_3$ carbon from total carbon) was below the detection limit.

Rapid whole-rock geochemical analyses on small samples (~0.5 g) using a Niton XL3 portable X-ray fluorescence (pXRF) instrument have proven useful for geochemical reconnaissance of volcanic rocks and sediment. Instrument performance is being monitored by replicate analysis of JB-2 standard (basalt from Izu-Oshima volcano) whose composition closely matches mafic tephra sampled during Expedition 350. Analytical precision ranges from 0.7–4.5% (1 σ, n = 54) for several useful indicator elements, and accuracy (tested for multiple rock standards ranging from basalt to rhyolite) is generally <20% (rel.). In most cases offsets from certified values are consistent, allowing for relative comparisons even if minor bias exists. Analyses of mud and volcanic rocks for Sites U1436 and U1437 have revealed contributions in the volcaniclastic sediments and intercalated ashes from at least three major components: (1) bimodal ashes from the volcanic front, mainly in the shallower section (<750 mbsf) of Site U1437; (2) rear-arc volcanics with high K_2O/CaO, which agree with the compositions of local dredged rocks; and (3) a carbonate component that mixes into the mud. The pXRF data are insufficient to directly

identify the presence or absence of a distal sedimentary component ("Chinese Loess"). Relative abundances of ash and carbonate in muds indicated by geochemical mixing calculations are broadly consistent with local rear arc rhyolites mixed with 20–25% $CaCO_3$. These estimates are consistent with smear slide descriptions and $CaCO_3$ abundance analyses. We are presently conducting ICP-AES whole rock analyses to further address this hypothesis.

Physical properties measurements continued to be taken on cores collected from Holes U1437B and U1437D to obtain density, porosity, thermal conductivity, magnetic susceptibility, natural gamma radiation, and *P*-wave velocity data. This week it became common that the sediment did not fill the core liner. Without good contact between core and liner it is not possible to obtain the whole-core measurements. Thermal conductivity needle probe measurements and shear strength measurements also ceased because it became impossible to push the needle or shear vane into the hard sediments. As the sediment became sufficiently lithified we switched to the puck probe to measure thermal conductivity. We are also changed the procedure for the moisture and density (MAD) measurements, using cubes cut for palaeomagnetic analysis, vacuum saturate them for 24 h, then measure discrete *P*-wave velocity on the cubes and continue the MAD analysis as before.

Analysis and interpretation of the obtained data are ongoing, particularly with regard to interpretation of data on volcanic ash layers, and investigations into links between the NGR values and geochemistry of the sediments. Marked changes in physical properties occur at approximately Core U1437D-28R, from generally high NGR values to more variable or low values, and from fairly consistent magnetic susceptibility values to more variable readings. These changes coincide with the onset of pyrite occurrence in the cores.

The paleomagnetic team completed the AF demagnetization up to 30–40 mT of the archive halves of Hole U1437B. The Brunhes/Matuyama (C1n/C1r) transition, at 0.781 Ma, was identified in Section U1437B-11F-1 (~90.6 mbsf). Below this depth, repeated short intervals of normal and reverse polarity made it difficult to establish the magnetostratigraphy in the C1r chron. Each interval was checked for lithology, core quality, and drilling disturbance. This step aimed at identifying the intervals where the magnetostratigraphy is not reliable. Intervals of the repeated successive polarity changes, i.e. remagnetization event, were also recognized. These are due to the formation of new minerals (likely greigite) recording the polarity at the time of formation, which could be different from the polarity at the time of deposition. This explains why normal polarity data are identified in the reverse C1r chron. After excluding unreliable measurents, two normal polarity events corresponding to C1r.1n (Jaramillo, 0.988–1.072 Ma) and C2n (Olduvai, 1.778–1.945 Ma) subchrons in the Matuyama chron were identified in Sections U1437B-17F-3 through 19F-2 and 32X-1 through 33X respectively. These dates are in agreement with the biostratigraphic datums in comparable intervals. At Interval U1437B-47X-3, 65 cm (362.65 mbsf) the Matuyama/Gauss (C1r/C2n) transition (2.581 Ma) is identified. Core U1437B-55X still belongs to the Gauss chron. Measurements of discrete samples confirm the results obtained from the section half measurements.

The drilling overprint imparted by the rotary core barrels in Hole U1437D was removed by AF demagnetization at 10 mT. This suggests a good record of the characteristic remanent magnetization. The first recovered cores at Hole U1437D belong to the Gauss normal chron. The first measurements indicate the occurrence of two reverse polarity events in C2An, C2An.1r (Kaena subchron, 2.581–3.116 Ma) and C2An.2r (Mammoth subchron, 3.207–3.30 Ma), in Sections U1437D-3R-2 through 4R-5 and 7R-1 through 9R-4, respectively. The C2An/C2r (Gauss/Gilbert) was identified in Interval U1437D-15R-1, 60 cm. That gives an age of 3.596 Ma for this depth, in agreement with the biostratigraphic datums.

The main focus of the paleontology group's efforts this week was on Holes U1437B and U1437D, where 432 and 348 m thick successions, respectively, were drilled. The biostratigraphy at each site was defined by examining the planktonic foraminifer and calcareous nannofossil content of all the 53 (Hole U1437B) and 40 (Hole U1437D) core catchers recovered. The standard bio-events for each fossil group were recognized and their ages assigned mainly with reference to Gradstein et al. (2012). In Hole U1437B, calcareous nannofossils and planktic foraminifer biostratigraphy indicated that the succession reaches back to the Late Pliocene and covers the last 2.8 Ma. There was overall good agreement between the nannofossil and foraminifer bioevents as well as with the paleomagnetic stratigraphy, which identified the Brunhes/Matuyama reversal in Section U1437B-11F-3. Biostratigraphy and paleomagnetic stratigraphy indicate that the top of Core U1347D-2R dates to approximately 2.59 Ma. Preservation was generally good with dates reaching back to ~3.7 Ma in Core U1347D-19R. Preservation in Core 29X and below was very poor with several barren intervals, making biostratigraphic assessment more challenging and dates less certain.

Nannofossils were generally abundant and well preserved, with minimum signal of reworking in Hole U1437B and in Hole U1437D down to Core U1437D-29R. Based on calcareous nannofossil bioevents, the succession in Hole U1437B spans from the Pleistocene (Samples U1437B-1H-CC through 50X-CC) to late Pliocene (Samples U1437B-50X-CC through 55X-CC). The succession at Hole U1437B is continuous and all the standard bioevents were recognizable: X (cross over) *Gephyrocapsa caribbeanica–Emiliania huxleyi* (U1437B-1H-CC), B (bottom; first occurrence) *E. huxleyi* (2H-CC), T (top; last occurrence) *Pseudoemiliania lacunosa* (6H-5, 75–76 cm), Tc (top common; common last occurrence) *Reticulofenestra asanoi* (15F-3, 80–81 cm), Bc (bottom common; common first occurrence) *Reticulofenestra asanoi* (16F-CC), T large *Gephyrocapsa* spp. (24X-CC), T *Helicosphaera sellii* (27X-CC), B large *Gephyrocapsa* spp. (28X-CC), T *Calidiscus macintyrei* (30X-1, 75–76 cm), T *Discoaster brouweri* (35X-CC), T *Discoaster pentaradiatus* (44X-CC), T *Discoaster surculus* (47X-CC) and T *Discoaster tamalis* (49X-CC). In Hole U1437D, the succession started in the Pliocene and successive bioevents were recognizable: T *Discoaster tamalis* (4R-CC), T *Sphenolithus* spp. (16R-CC), T *Reticulofenestra pseudoumbilicus* (19R-3, 32 cm). This latter datum was the last reliable nannofossil datum as the preservation of nannofossils in the core quickly deteriorated below Core U1437B-29X.

Extracting the foraminifers from the progressively more lithified sediments presented increasing difficulty, particularly in Hole U1437D. Because average sample preparation time was around 24 h, foraminifer biostratigraphers are now significantly lagging behind their nannofossil colleagues. Nonetheless, samples down to Sample U1437D-40R-CC (estimated age ~6 Ma) have now been examined. The foraminifers are generally reasonably well preserved when present but many intervals were barren of foraminifera, particularly in the lower part of Hole U1437D (e.g. Samples U1437D-27R-CC, 29R-CC, 36R-CC) or present in very low concentrations. Both the low concentrations of foraminifers, along with the difficulties in extracting any specimens present from the rock, have made biostratigraphic assessment of samples difficult. In spite of these challenges, data from the nannofossil and foraminifer fossil groups are in reasonably good agreement over the last 6 Ma. Most foraminifer datums known for the Pacific Ocean between T *Globigerinoides ruber* (pink) (0.12 Ma) and B *Globorotalia margaritae* (6.08 Ma) have been recognized.

Education and Outreach

Test videoconference sessions have been completed with JAMSTEC/Nihon University in preparation for further undergraduate sessions in late April/May. One JAMSTEC and one UK session were successfully completed. The schedule for all April and early May scheduled school/college videoconferences (~80 in Europe and USA) was updated. We are still trying to schedule more US schools and colleges; the UK timeslots are pretty full.

Daily blogs on the *JOIDES Resolution* website (http://joidesresolution.org) have covered a mixture of science, drilling technology, and daily life on board. Other social media was updated, including an embedded quiz.

Education Resources are in development for Deep Earth Academy, for varying age groups up to undergraduate. Topics in production include navigation concepts and instruments as well as sediment grain sizes and crystallography. A printable board game for younger students based on compass points and navigating to the drill site is now in testing phase.

Technical Support and HSE Activities

Laboratory

The technical staff supported four separate sampling parties that resulted in almost 2900 samples for postcruise investigations in addition to the almost 2100 samples for shipboard analysis.

We resolved an issue with SyQuest regarding non-functional spares for the Bathy 2010 system. The spares were configured to support their newest software and communication upgrades.

We started to prepare for the upcoming vertical-seismic profile (VSP) experiment.

Development and Information Technology

Developers updated the code for the Alkalinity program; implemented a new function for resteasy-lime to retrieve sample and test information for the SHIL and LaserKatje programs; fixed a bug in the LSIMG QAQC report; fixed the problem with the extra spaces in the DESClogik exports; and deployed a new version of LIMS Report to fix the incorrect total interval number in the Hole summary report.

Developers are currently tracing down a randomly occurring DESCLogik error, and are writing requirements for a sample Child Test Project as well as a Code Request Management project.

IT personnel started working with the new Fluke network analyzer to study network traffic flow and patterns.

Safety

The weekly fire and boat drill as well as a safety inspection with the Captain were completed as scheduled.