IODP Expedition 360: SW Indian Ridge Lower Crust and Moho

Week 6 Report (3–9 January 2016)

Operations

Week 6 of Expedition 360 (Southwest Indian Ridge Lower Crust and Moho) began while returning from a medical evacuation near Mauritius back to Hole U1473A with a distance of 600 nmi remaining. The ship arrived back at Site U1473 and switched from cruise mode to dynamic positioning mode at 1035 h on 5 January. The total transit distance covered for the medical evacuation was 1320 nmi and consumed 5.5 d of operational time allocated for Expedition 360.

In preparation for our second attempt to retrieve the three roller cones left at the bottom of Hole U1473A, the bottom-hole assembly (BHA) was made up with new drill collars and a Bowen fishing magnet with milling guide and two boot type junk baskets. Hole U1473A was reentered at 2146 h on 5 January (Run 8; reentry #7). The bit landed on fill at 316.7 mbsf and was washed to the bottom of the hole with slight rotation. A 30-barrel mud sweep was pumped and the string was worked up and down three times and slowly turned five times. The drill string was retrieved and the fishing magnet cleared the rig floor at 0800 h on 6 January. The magnet picked up some metal debris from the lost core catcher but none of the missing cones from the main RCB coring bit.

Next we made up a Gotco reverse circulating junk basket (RCJB) with milling guide and two boot type junk baskets and reentered Hole U1473A at 1330 h (Run 9; reentry #8). The bit was rotated and washed to the bottom of the hole with slight rotation. After tagging the bottom of the hole, a 20-barrel mud sweep was pumped to clean out the hole. The RCJB was worked up and down three times before the flow-deviating steel ball was dropped down the drill pipe to activate the reverse circulation. The driller attempted to advance the bit for 20 min using low weight (2 klb) before the drill string was tripped back to surface, clearing the rig floor at 0110 h on 7 January. The RCJB assembly recovered gravel, including a few boulders, of gabbroic and fault rock material but no signs of the missing roller cone parts.

The same RCJB assembly was made up once more and reentered in Hole U1473A at 0555 h (Run 10; reentry #9). With the bit near the bottom of the hole, two 30-barrel high-viscosity mud sweeps were pumped before the bit was worked up and down from 0845–1030 h. The reverse circulation was activated and the driller spent nearly an hour advancing to ~410.8 mbsf, using greater weight than during the previous run (2–4 klb, 200–400 A, 160 spm). The drill string was recovered, clearing the rig floor at 1510 h. To everyone's surprise, the RCJB had recovered an unprecedented 0.5 m long, 18 cm diameter core from a cored interval of 0.6 m (83% recovery). The core was given a new core type designation, Core U1473A-45J; however, none of the roller cones previously lost in the hole were recovered.

Given the tight fit of the RCJB assembly in the hole, it was extremely unlikely that any roller cone bits could have remained at the bottom of the hole. We speculated that the cones may have been lifted out of the hole with one or more of the previous three runs with two fishing magnets and the RCJB (Run 07-FM, Run 08-FMM, Run 09-RCJB) and dropped on the seafloor before they could reach the rig floor. We decided to resume RCB coring.

A BHA was assembled with a new RCB C-7 bit and at 2320 h on 7 January we reentered Hole U1473A for the tenth time (Run 11). A wash core barrel was deployed to facilitate the cleaning out of debris before resumption of coring. The last meter of the hole had to be reamed because the RCJB had created a slightly undersized hole. We pumped 50 barrels, then 30 barrels of high-viscosity mud and retrieved the wash core barrel at 0515 h. Another core barrel was dropped and Cores 46R–52R (410.8–469.6 mbsf) were recovered with a total recovery of 20.5 m (34%). Penetration rates were high for several cores, with a maximum of 8.9 m/h for Core 48R. In addition, recovery was low and cores were highly fractured, indicating a weak formation. Coring operations included five 30-barrel mud sweeps. Due to excessive torque (500 A) in the lowermost part of the hole, a wiper trip was conducted to condition the hole and an hour was spent reaming the hole. After advancing through 1.5 m of fill on the bottom of the hole, the bit was advanced 0.6 m for Core 52R, with erratic high torque. Given the large amount of reaming that had been required and despite the low bit hours (12.1 h), we decided to retrieve the drill string, which cleared the rig floor at 1545 h on 9 January 2016. We discovered that the RCB bit was missing one of its four roller cones.

A reverse circulation junk basket (RCJB) with tandem boot junk baskets was assembled and deployed in an attempt to recover the missing cone. The bit reentered Hole U1473A at 2007 h on 9 January and was washed to the bottom of the hole at 469.6 mbsf with circulation and slight rotation. At the end of Week 6, we were continuing to fish for the single roller cone in Hole U1473A.

Science Results

During Week 6, all laboratory teams described and measured Cores U1473A-45R to 52R (410.3–469.6 mbsf), which consist of gabbroic rocks.

Intervals not or little affected by crystal-plastic deformation are coarse-grained subophitic olivine gabbro. When deformation is more pronounced the texture is more granular. Rare olivine gabbro horizons displaying a medium-grained subophitic texture are present within the coarser grained gabbro. Rare horizons enriched in oxides are present and usually occur in deformed intervals. Several felsic veins crosscut the gabbro. Rare dikes were intruded within the gabbro and are commonly associated with felsic material.

Thin sections from Cores 32R to 44R reveal a wide range of secondary replacement, from high-temperature processes to late stage low-temperature overprints. Evidence was found that constrains hydrothermal or magmatic vein/dike formation processes, their effects on the alteration of host gabbros, and interrelationship with deformation. Noticeable examples are felsic veins with granophyric texture that display replacement of quartz by albite; a basaltic dike showing metamorphic granoblastic texture with clinopyroxene, brown amphibole, and plagioclase neoblasts; biotite formation in proximity to hydrous felsic veins; and low-temperature carbonate and clay formation associated with cataclastic deformation.

Static background alteration intensity in hand specimens of Cores 46R to 51R ranges from slight to extensive. Significant amounts of brownish clay minerals occur in association with carbonate veins or carbonate-clay veins. The low-temperature alteration and brittle deformation may well be the cause of the current drilling difficulties.

The vast majority (~95%) of thin sections from Cores 2R–49R contains evidence for crystal-plastic deformation and reveals a complete spectrum of deformation ranging from magmatic and weakly deformed through porphyroclastic to ultramylonitic. Thin sections from Section 23R-3 (199.8–201.3 mbsf) provide an excellent example of this continuum of deformation from magmatic to mylonitic. Near the top of Section 23R-3, samples range from undeformed to weakly deformed, characterized by kinked plagioclase and pyroxene. Further down the section, samples have a subhorizontal, weak to moderate crystal-plastic fabric with recrystallized plagioclase and elongate pyroxene. In the lower part of the section, the subhorizontal crystal-plastic fabric is cut by a later thin, subvertical, normal-sense mylonitic shear zone. This passes down into an interval dominated by high-strain mylonitic deformation extending to 230 mbsf, forming a major (>30 m thick) crystal-plastic damage zone.

Magmatic veins, observed in the core and thin sections, commonly intrude into deformed host rocks. In many cases, the magmatic veins have a limited crystal-plastic overprint. The lack of deformation indicates that the magmatic veins represent late-stage intrusions.

The fishing magnet Run 8, RCJB Run 9, and RCJB Core 45J recovered variably deformed gabbros. Run 8 had weakly to undeformed gabbro gravel, including one cobble with a porphyroclastic crystal-plastic fabric mixed with a chlorite breccia with high matrix-to-clast ratio. A similar chlorite-rich breccia was observed in Section 31R-1 at 274 mbsf, indicating that this section could be the source of the material recovered from Run 8. Run 9 material and Core 45J are characterized by undeformed to weakly deformed gabbros. Most of the pieces have at least one and, in some cases, four carbonate filled fracture surfaces.

Cores 46R–49R are characterized by variably distributed crystal-plastic deformation overprinting irregularly developed grain size variations, similar to what has been observed in the entire cored interval thus far. In some cases fine-grained gabbro is interpreted as intrusive and relatively undeformed, whereas in other cases the fine-grained gabbro is intrusive and deformed. This relationship indicates a coupling between melt intrusion and deformation. These cores also

contain several carbonate veins and breccias, including six breccias/cataclasites, more than any other comparable interval recovered so far. The breccias are characterized by clasts of pyroxene, amphibole, and plagioclase within a carbonate matrix. They are crosscut by later fractures filled with carbonate, indicating at least two generations of carbonate veining.

The Paleomagnetic team completed measurement and alternating field demagnetization of archive halves down to Core U1473A-51R (469.0 mbsf). These measurements confirm that the interval sampled so far has a consistent reversed polarity magnetization. The team continued to process batches of discrete samples using a combination of alternating field demagnetization as well as low temperature and thermal demagnetization. These samples are shared with the Physical Properties team, and are heated to 105°C in an oven with no field control (following measurement of their NRM) during moisture and density determinations. Demagnetization experiments show that this treatment imparts a significant spurious magnetization component to many samples that has a random direction. The effects of these laboratory-imparted magnetizations are often seen to persist after demagnetization to temperatures of >400°C, adding unnecessary complexity to the interpretation of the demagnetization data. Hence, the Paleomagnetic and Physical Properties teams have agreed to work on separate shipboard discrete samples for the remainder of the expedition.

The Petrophysics team measured a total of 94 gabbroic cube samples from Hole U1473A, down to Core 44R. *P*-wave velocity, V_p, ranges from 5936 to 7152 m/s, with an average of 6804 m/s and an average standard deviation of 25 m/s. The measured apparent anisotropy of V_p is 2.4% on average. Grain density ranges from 2.88 to 3.13 g/cm^3 and averages 2.97 g/cm^3. Porosity ranges from 0.1% to 4.2%, and averages 0.72%.

Thermal conductivity was measured on 42 pieces from archive section halves. It ranges from 1.77 to 2.38 W/(m·K), with an average of 2.21 W/(m·K) and standard deviation <2% (0.6% on average).

At the end of the week, the Petrophysics team measured magnetic susceptibility, density, and natural gamma radiation on Sections 46R-1 to 52R-1. Measured values are in the same range as those from previously measured Sections from Hole U1473A.

The Microbiology team processed six more core samples for various analyses. ATP, a molecule used as a source of energy for life processes and as building blocks of nucleic acids, was detected in two more samples that focused on carbonate veins in rock material. Two enrichment culturing plates (solid media) show evidence of cell growth; however, it is premature to tell the identity of this growth. All negative control plates have stayed clear to this date.

Education and Outreach

Interactions

- Held a total of 16 broadcasts to schools: seven to the USA, six to France, one to the UK, one to Canada, and one to Japan.
    - Total scientists engaged: 6
    - Total students reached: 717

Outreach Products

- The fourth podcast episode was published, currently at ~1100 listeners.

Social Media

- *JOIDES Resolution* blog (http://joidesresolution.org/): seven posts, 2,150 reads.
- Facebook (https://www.facebook.com/joidesresolution): eight posts, 16,972 people reached.
- Twitter (https://twitter.com/TheJR): eight tweets, 17,600 impressions.
- Instagram (http://instagram.com/joides_resolution): three posts.

Media

- Article published in de Volkskrant (Netherlands) and La Repubblica (Italy).
- Interview conducted with Radio Boston (WBUR/NPR).
- Three news stories and nine photos submitted to the Xinhua News Agency.

Technical Support and HSE Activities

Laboratories

- All laboratories provided standard support for scientific activities.
- Completed sampling party for postcruise research of Cores U1473A-2R through 44R.
- Chemistry Laboratory Hood F-3 taken out of service due to fiberglass intake damage. Hood fan is being examining and repairs planned.
- PFMB tracer used for microbiology while coring Core 52R and 53R.

Developer Report

- Continued development of new web services.
- Coded Thin Section Report Builder bug fixes and feature improvements.
- Repaired LIMS Reports download failure on Macs; current solution is interim.

- Assisted with cataloging Core 45J material recovered with the reverse circulation junk basket.
- Revised depth-calculator service toward repairing known edge cases seen on hard rock expeditions.
- Assisted with cataloging of 360° image composites to LIMS/ASMAN.

Information Technology

- Continue discussions with CommVault for backup software license adjustments.
- MCS office light tower alerter developed an issue where no sound was being produced. We worked with our vendor to troubleshoot the issue but no resolution could be found. We removed the light tower for further inspection and during testing the light tower began functioning again. The light tower is out of warranty so we may have to purchase a replacement if this tower fails again.
- Created user accounts for Expedition 361.

HSE Activities

- A Fire and Boat Drill was held on 7 January.