IODP Expedition 360: SW Indian Ridge Lower Crust and Moho

Week 7 Report (10–16 January 2016)

Operations

Week 7 of Expedition 360 (Southwest Indian Ridge Lower Crust and Moho) began while fishing for a roller cone left in Hole U1473A during Run 11 (fifth RCB bit). The reverse circulation junk basket (RCJB; Run 12) was deployed and worked up and down near the bottom of the hole. After activating the reverse circulation by dropping the steel ball down the hole and working some more on the bottom, the drill string was recovered. It cleared the rig floor at 0500 h on 10 January, recovering some gravel but no roller cone.

The RCJB was reassembled with a new mill tooth cutting shoe and catcher assembly and deployed once more (Run 13), reentering Hole U1473A at 0846 h. After a 30-barrel mud sweep the RCJB was worked and activated again according to protocol. The drill string was retrieved, clearing the rig floor at 1605 h on 10 January. This time the recovery consisted of a large cobble and the lost roller cone.

Planning to resume RCB coring, we made up an RCB bottom-hole assembly with a new RCB C-7 bit, lowered it to the seafloor, reentering Hole U1473A at 2037 h (Run 14; sixth RCB run). The bit was washed to the bottom of the hole, which included a 50-barrel mud sweep after noting 0.5 m of fill at the bottom. Our attempt to cut Core 53R (469.6–470.6 mbsf) from 0015–0400 h on 11 January advanced only 1 m and achieved no recovery. Erratic torque was observed during this advance and repeated mud sweeps were pumped. Then we cut Core 54R (470.6–480.3 mbsf), advancing the full 9.7 m but not recovering any core. Based on the assumption that rock had jammed the bit throat, we deployed a deplugger (1045–1130 h) in an attempt to dislodge the obstacle. This was followed with another failed attempt to core (Core 55R, 480.3–481.7 mbsf, 1.4 m advance, no recovery). We ran another bit deplugger and dropped another core barrel; however, no penetration could be achieved. At 1745 h on 11 January, we decided to recover the drill string and the bit cleared the rig floor at 2150 h. Upon inspection, the bit had lost most of the tungsten carbide inserts, particularly towards the inside of the roller cones, and was missing one of the four core guides.

The bit had obviously encountered metal at the bottom of the hole, at a minimum its own missing core guide, and possibly one of the missing cones lost in the hole a few days ago. At 2215 h on 11 January we began to make up and deploy a fishing magnet with mill tooth guide (FFM) and two boot type junk baskets in an attempt to recover the metal junk at the bottom of Hole U1473A (Run 15-FMM). We reentered Hole U1473A at 0321 h on 12 January and tagged the bottom of the hole at 0615 h without encountering any fill. Two 30-barrel mud sweeps were pumped while working the magnet and its milling shoe according to protocol. The drill string was retrieved, clearing the rig floor at 1105 h, and we found that the fishing magnet had successfully recovered a heavily eroded roller cone. As we suspected from inspection of the bit from Run 14, the cone had plugged the RCB bit and prevented advancement and recovery of core the previous day. Some gravel was recovered as well in the boot type junk baskets.

We decided to drill ahead without coring for an interval not to exceed 100 m using a tricone bit. The tricone drilling bit is more robust than the RCB coring bit and therefore more suitable to mitigate potential issues near the bottom of the hole, such as reaming a slightly tight hole. We also wanted to get an idea of how much faster drilling would deepen the hole compared to coring, and we wanted to do that before reaching the modeled depth interval (~600 mbsf or deeper) where we expect to penetrate the magnetic polarity transition from reversed to normal.

We started to make up a 9.875 inch tricone bit at 1200 h on 12 January, reentered Hole U1473A at 1545 h, washed and reamed down a tight hole to the bottom at 481.7 mbsf, began to drill new hole at 2300 h, and deepened the drilled interval to 519.2 mbsf. Drilling conditions were reasonably good; however, the rate of advance barely matched the rates we had achieved with RCB coring earlier in the hole. We decided in the afternoon of 13 January to switch back to coring. The drill string was retrieved and cleared the rig floor at 2010 h. Inspection of the tricone drill bit showed slight wear of the outside diameter caused by the narrow gauge hole, but the cones and bearings were all in good condition. The wear was severe enough to crack all four tungsten carbide bit nozzles.

A new 9.785 inch RCB C-7 bit was made up and deployed to near the seafloor (Run 17; seventh RCB bit), at which point deployment was suspend to allow the rig crew to slip and cut 115 ft of drilling line as part of their routine rig maintenance. We reentered Hole U1473A at 0210 h on 14 January, reamed down from 510.6 to 519.2 mbsf, and circulated a 30-barrel mud sweep. When the wash barrel was recovered at 0730 h, it surprisingly contained a 0.2 m long freshly trimmed core plus 0.2 m of additional material, which was registered as Core U1473A-57R (519.2–519.6 mbsf). We subsequently recovered Cores 58R–66R (519.6–606.6 mbsf) and recovered 64.9 m (75%). Coring conditions were optimal during this run. Average torque on bottom remained ~350 A, and the recovery for the last three cores exceeded 90%. Thirty-barrel high-viscosity mud sweeps were pumped every 5 m.

With 39.6 h on the bit, we decided at 0700 h on 16 January to retrieve the drill string for another bit change, clearing the rig floor at 1055 h. Upon inspection, the RCB coring bit was intact, with very little wear on the skirt or its tungsten carbide inserts. The inserts on the nose of the bit showed appreciable signs of wear, but were intact. A new 9.875 inch C-7 bit was made up and, following some rig servicing tasks, reentered Hole U1473A at 1424 h (Run 18; eighth RCB bit). Coring resumed at 1830 h. At the end of Week 7 we are cutting Core U1473A-67R at 614.0 mbsf.

Science Results

During Week 7, all laboratory teams described and measured Cores U1473A-49R to 66R (439.9 to 606.6 mbsf) consisting of gabbros. They also worked on finalizing Methods sections, the Site 1105 chapter, and first drafts of the Site U1473 reports.

Intervals in Cores 49R–66R unaffected or little affected by crystal-plastic deformation are coarse-grained subophitic olivine gabbro. When deformation is more pronounced the texture is typically granular. Igneous layering is common and highlighted by grain size and modal variations. Other common grain size variations (from fine-to very coarse-grained) are common, and typically display a patchy organization. Horizons containing small amounts of oxide are rare and, in general, associated with high degrees of deformation. Several felsic veins crosscut the section. Rare dikes have intruded the gabbros and are commonly associated with felsic material.

Background static alteration of Cores 57R to 65R is variable, ranging from <3 vol% to 60 vol%. Intensely altered parts with significant amounts of brown clay could be wide halos of low-temperature carbonate or carbonate-clay veins. However, such veins and halos are much less frequent in these cores than in shallower ones; instead, chlorite veins and minerals indicative of greenschist facies alteration such as talc, actinolitic amphibole, and chlorite are dominant.

From a structural perspective Cores 57R–64R are characterized by extensive but varying crystal-plastic fabrics overprinting a sequence of olivine gabbros with variable grain size. An abundance of felsic veins, amphibole veins with halos, and a profusion of fractures with slickenlines further affect the section. The crystal-plastic fabric consists of a porphyroclastic coarse-grained foliation with moderate to shallow dips, mostly defined by the orientation of fractured clinopyroxene porphyroclasts and recrystallized plagioclase. This fabric is systematically crosscut by steeper (~45°–50°) mylonite and ultramylonite shear zones with both normal and reverse senses of shear. In Section 58R-8 (~520 mbsf) the contact between medium- and fine-grained gabbro is defined by one such shear zone. A 7 cm thick shear zone Section 61R-4 (~550 mbsf) displays the transition from ultramylonite to mylonite and crosscuts the previous coarse-grained solid-state foliation of the rock.

Felsic veins range from discrete planar features with sharp boundaries to magmatic breccias. The discrete magmatic veins often crosscut and are discordant to the preexisting crystal-plastic fabric. Alteration vein fill in Cores 57R–64R is predominantly amphibole, which is a change from the carbonate found at shallower levels. The amphibole and carbonate veins have a moderate to steep dip. In some cases, for example Section 63R-2 (~570 mbsf), the amphibole veins are sheared. Several of the amphibole veins form slickenlines along fractures; we counted 25 slickenlines over the interval described this week. The slickenlines have shallow (6°) to steep (90°) rakes indicating strike-slip to dip-slip movement. The amount of brittle deformation has decreased below the fault system and is mainly exhibited by discrete fractures.

Material recovered in junk basket runs 12, 13, and 15 included chlorite-rich fault breccia, calcite vein material, and gabbro fragments. These gabbros displayed either a weak crystal-plastic fabric or no fabric at all. The chlorite breccia has anastomosing chlorite-plagioclase shear bands that surround grooved chlorite phacoids with clasts of pyroxene and plagioclase. The presence of fault breccias and carbonate veins together with low recovery rates and challenging drilling conditions indicates the presence of a (probably high-angle) fault zone between Cores 19R and 52R, with brittle deformation increasing with depth. Cores 57R–64R would appear to have penetrated the footwall of this fault zone.

Upon resumption of coring, the Petrophysics team performed measurements on discrete samples from Cores 45R to 52R. Sonic velocity (V_p) ranges from 6280 to 7040 m/s with an average of 6834 m/s. The average apparent anisotropy is 2%. Grain density ranges from 2.96 to 3.02 g/cm^3 and averages 2.99 g/cm^3. Porosity ranges from 0.10% to 2.0% and is 0.7% on average. Thermal conductivity was measured on six pieces from archive section halves. It ranges from 2.25 to 2.44 W/(m·K) and is 2.30 W/(m·K) on average.

Core logging measurements were done on Cores 57R to 67R. Magnetic susceptibility remains relatively low (~400 to 500 × 10^{-5} SI on average for the whole-round pass-through coil measurements), indicating an overall relatively low Fe-Ti oxide content. Natural gamma radiation from the gabbro cores remains very low (≤1 counts/s), except for peaks corresponding to felsic veins and patches.

The Microbiology team processed eleven samples from Cores 58R to 67R to perform a number of types of analysis. Three samples were processed for contamination controls using PFMD tracer tests of drill fluids, sample exteriors before and after cleaning, and sample interiors. Drill fluids were collected at the same times for DNA iTAG analyses for contamination controls. ATP activities were measured in another nine samples, and positive readings (above detection limits) were recorded for two of them (in Sections 58R-4 and 62R-5). Contamination tests are still awaiting completion on the gas chromatograph; however, so far all interior samples in all tests have been not been able to detect any of the tracer.

Education and Outreach

Interactions

- Held a total of 23 broadcasts to schools: 12 to the USA, seven to France, two to the UK, one to Canada, and one to Germany.
  - Total scientists engaged: 15
  - Total students reached: 1,143

Social Media

- *JOIDES Resolution* blog (http://joidesresolution.org/): five posts, 1,494 reads.
- Facebook (https://www.facebook.com/joidesresolution): nine posts, 19,632 people reached.
- Twitter (https://twitter.com/TheJR): eight tweets, 9,045 impressions.
- Instagram (http://instagram.com/joides_resolution): seven posts.

Media

- Three news stories and three photos were submitted to the Xinhua News Agency.

Technical Support and HSE Activities

Laboratories

- All laboratories supported processing of cores and samples and analytical measurements.
- Chemistry Laboratory Hood F-3 parts were ordered and will be delivered to Expedition 361.
- Microbiology Laboratory: 1 L of PFMB remains, which will cover two to three more cores, depending on pumping rate and time to cut core.

Development Work

- Continued development of replacement for Auther web services.
- Continued to debug and fix items on work list for Report Definition Builder and Thin Section Report Writer.
- Separated code for updating sample lengths from code for updating depths.

Data Management

- Recoded sample identifications for fishing magnet Cores U1473A-45J to 45M, ICP samples from CUTS (cuttings) to OTHER sample type, axes on PWS measurements, and re-parented mis-parented observations.
- Assisted with upload of whole-round line scanner (WRLSC) images to LIMS database.
- Began addressing data change request for Drill Report.
- Ensured test system configured for processing affine/splice data from Malidves Expedition (359).

Other Issues

- Performing debugging of Section Half Imaging Logger (SHIL-MUT). LabVIEW crashes continue. Auto-upload works for a time-period, then stops. Manual refresh must be applied.
- Core Description (DESCLogik): too many users downloading all tabs simultaneously (2–5) leads to some of those users receiving a silent failure with no data downloaded, or messages indicating the server is not responding.
- Investigating some problems with JanusWeb.

HSE Activities

- A Fire and Boat Drill was held on 15 January.
- Eyewash and safety showers were tested.