IODP Expedition 345: Hess Deep Plutonic Crust

Week 6 Report (13–19 January 2013)

This week of IODP Hess Deep Expedition consisted of (1) remedial cementing, RCB coring, and ultimate abandonment of Hole U1415J and (2) a failed attempt to establish re-entry capability in Hole U1415K. In Hole U1415J, we obtained three RCB cores (U1415J-21R, -23R, -26R) from 98.8 to 111.8 mbsf and three cores from previously cored intervals (U1415J-22G, -24G, 25G). The overall recovery from seafloor to 111.8 mbsf from Hole U1415J is 16%. The lithologies recovered this week include troctolitic gabbro and gabbroic cataclasite.

Operations

As this week started, we had challenges washing and reaming back to the total depth of Hole U1415J (103.8 mbsf). In the end we were unable to get completely back to bottom and our pump pressures remained abnormally high, leading us to suspect that one or more bit nozzles were plugged. We decided to attempt cementing the lower 20 m of the hole (our third cement job in this hole) and then retrieve the drill string to replace the bit while the cement hardened. Before pumping the cement, we retrieved Core U1415J-24G, which contained 0.21 m of gabbroic rocks. After positioning the bit at 96 mbsf, we pumped 12.5 barrels of cement. The bit was raised up to 76 mbsf while pumping the cement. The bit was then pulled to 15 mbsf so any cement remaining in the casing/free-fall funnel could be circulated out. We pulled the bit out of the hole at 1605 h on 13 January. The drill string was then flushed of any remaining cement and the bit was back on the rig floor at 0135 h on 14 January. A new RCB (C-7) bit with a mechanical bit release (MBR) was assembled to the bottom of the bottom-hole assembly (BHA) and a fourth stand of drill collars was added to the BHA. After tripping to the seafloor, operations were put on hold while a slip and cut of the drill line was completed. We reentered Hole U1415J at 1542 h on 14 January. Once the camera system was back on board, the driller commenced lowering the pipe into the hole. The drill string took some weight at 36 mbsf but was able to pass this interval relatively easily. The bit encountered cement at 78 mbsf and was drilled out at a depth of 99 mbsf (3 m below the bit depth when cementing). We washed and reamed the rest of the way back down to the bottom of the hole (103.8 mbsf). After we retrieved the core barrel that was in place while washing and reaming from 99.0 to 103.8 mbsf (Core U1415J-25G; 0.48 m recovered), we resumed RCB coring. While cutting Core U1415J-26R (103.8 to 111.8 mbsf), the first 4.2 m drilled at a slow 1.3 m/h, but the last 3.8 m was penetrated in less than three minutes (70 m/h). Core 26R was recovered on-deck by 0830 h on 15 January and contained 0.78 m of gabbroic rocks. While retrieving the core, the drill pipe became stuck. We tried to free the drill string for over an hour before deciding to release the bit as the next step in freeing the drill string. When lowering the MBR shifting tool with the sinker bars to release the bit, we attached the core orientation (Flexit) tool so we could determine the hole inclination. We had to offset the ship ~260 m (~5.0%) to drop the tool joint down nearly 8 m at the rig floor so that the core barrels could be removed and the shifting/Flexit tools deployed. Our attempt to shift the MBR sleeve and release the bit was unsuccessful, so we retrieved the shifting tool. Data from the Flexit tool indicated the hole was ±3° from vertical. This put to rest one proposed theory that we had been tracking down a high angle fault and might never drill out of the fractured material. On our

second attempt to release the bit, we added a core barrel to the shifting tool and pumped it down to the bit at 70 spm. The sinker bars were then run into the hole to retrieve the shifting tool and release the bit. However, before the sinker bars reached the core barrel, the drill string worked itself free. The sinker bars were recovered, leaving the core barrel and shifting tool in place. If we had recovered the core barrel, the sleeve would have shifted leaving the bit and MBR in the hole. Once the pipe was free, we were able to pull the drill string and the bit was back on the rig floor at 0130 h on 16 January. Because of the continually problematic and deteriorating hole conditions and the diminishing return on recovering core samples for science, the decision was made to abandon Hole U1415J and move to a different location.

Hole U1415K

After moving ~400 m to the northwest of Hole U1415J, we lowered a new BHA with a 14.75 inch tricone bit to the seafloor and prepared to conduct a short camera survey prior to spudding the Hole U1415K. However, the camera developed problems during the trip in and it had to be recovered and a spare camera installed before it was re-deployed. We conducted an expanding box survey extending out 10 m and a location to start Hole U1415K was chosen. We verified the seafloor depth (4698.4 mbrf) by tagging the seafloor with the bit, retrieved the camera system, and started Hole U1415K at 2155 h on 16 January. The 14.75 inch hole reached a total depth of 35.3 mbsf by 0400 h on 17 January. A wiper trip was performed and the bit pulled back up to 6.6 mbsf. A 16 inch free fall funnel without any stinger was then deployed to facilitate subsequent reentries. The driller waited 1.25 h before pulling out of the hole to allow time for the FFF to reach the seafloor. The bit was then pulled clear of the seafloor at 2310 h on 17 January. We deployed the camera to observe the FFF cone; it was not upright and appeared to be nearly on its side. We felt that the base of the FFF cone was still in or immediately adjacent to the hole. We decided to retrieve the bit, change to an RCB BHA, and attempt to reenter the hole (either through the FFF cone or by a bare rock reentry). The ultimate goal was to deploy a second FFF cone with 10.75 inch casing to stabilize the upper ~35 m of hole to allow deeper coring. The 14.75 inch bit arrived back on the rig floor at 1110 h on 18 January. A 36 m length of 10.75 inch casing string was assembled and hung off in the moon pool doors using C-plates and casing elevators. The RCB BHA was assembled and lowered through the casing and back to the seafloor. The camera was deployed and a seafloor survey was conducted from 2333 h on 18 January until 0051 h on 19 January in an attempt to locate Hole U1415K. No discernible hole or cuttings mound could be identified during the survey and it was decided that the hole was located at the base of the leaning FFF cone. A reentry was attempted by placing the bit at the base of the cone. This was accomplished relatively quickly (~45 min) and the bit was lowered into the seafloor penetrating 1–2 m before taking weight. We decided to retrieve the camera and to attempt to walk the bit into the hole using light bit weight and low rpm. A perceived reentry into Hole U1415K occurred at 0140 h. Rotation was applied for approximately two hours without any luck in penetrating further into the hole. We decided to abandon our attempts to continue operations at Hole U1415K, retrieve the RCB BHA, and start a new hole with a 14.75 inch tri-cone bit. As of 1200 h on 19 January, the RCB BHA was still being recovered back to the surface.

Science Results

Igneous Petrology

Main work this week focused on the macroscopic microscopic description of Cores U1415J-16G to -26R. Considering all pieces recovered by RCB coring, this part of Hole U1415J consists mainly of primitive gabbro: 51% troctolite and 30% olivine gabbro. Typical oikocryst-bearing gabbro, which is the dominant gabbro type above in Cores U1415J-5R to -9R, no longer occurs, although some of the clinopyroxene in the olivine gabbros and troctolites show poikilitic growth. The remaining lithologies (19%) are mainly cataclasites (13%, most have olivine gabbro clasts, but some also have basalt clasts, in part with rapid quench textures interpreted as former chilled margins), completely altered possible chromitite (4%, now a magnetite-chlorite-amphibole mixture) and basalt (1%).

Metamorphic Petrology

This week we described Cores U1415J-17G to -26R. Many of the cored intervals are cataclastic, some with minor igneous texture or mineralogy remaining and others that are less deformed with original igneous mineralogy preserved. The alteration observed in these cores is variable, ranging from moderately altered (30–60%) to completely altered (>90%), with typical ranges from 60–90% mineral replacement. Alteration intensity is generally greater than shallower in this hole, which typically ranged from <30% to 60%.

Cores U1415J-19R to -26R include zones of intense cataclasis, and pervasive greenschist to sub-greenschist facies alteration. In the cataclastic zones, comminuted plagioclase is strongly replaced by prehnite (60 to >90%). Chlorite, clay minerals, and carbonates are associated with the cataclastic zones as well, implying low temperature conditions of brittle deformation. In the deepest cores from this hole we observed the first evidence of higher temperature conditions: epidote veining was fairly common, and these veins crosscut cataclastic fabrics. We also observed actinolite veining, as well as brown amphibole replacing pyroxene. These observations suggest that alteration conditions were higher temperature than in the shallower cores from this hole.

Structure

Cores U1415J-21R to -26G were described and work started on summarizing the results from the entire hole. Cores U1415J-21R to -23R recovered an additional zone of cataclasis similar to that previously seen above in Cores U1415J-12R and -13R, albeit with the presence of epidote suggesting slightly higher temperatures. Work is in progress to assess whether this zone is related to the cataclastite recovered in Cores 12R and 13R, and whether these cataclastic zones formed at the EPR or the Nazca–Cocos Ridge. Intermingled fine grained diabase, and chilled margins suggests that some magmatism may have accompanied the faulting.

Paleomagnetism

The paleomagnetic team performed experiments to determine the effectiveness of a combination of low temperature (liquid nitrogen) and thermal demagnetization in resolving remanence components in gabbros from Hole U1415J, prior to demagnetizing a suite of discrete samples from this hole.

Geochemistry

The gabbroic samples, basalts and sand cuttings collected in Holes U1415E, U1415H, U1415I and shallower than 75 mbsf in Hole U1415J were analyzed for major and trace elements and for volatile contents. All samples are altered to various degrees with Loss on Ignition (LOI) ranging from 0.46 to 8.46 wt%. Preliminary data indicate a correlation with H_2O concentrations. The suite of gabbros, troctolites, and gabbronorites is characterized by high magnesium numbers (Mg# > 80) and low TiO_2 (0.02–0.3 wt%) contents and are relatively trace element depleted. The gabbroic rock series is significantly more primitive than the upper gabbroic rocks at Hess Deep (Mg# 34–71, TiO_2 of 0.4–4 wt%). The aphyric basalt, sampled in the upper part Hole U1415J, is a primitive tholeiitic basalt, with Mg# 69 similar to basalts previously sampled at Hess Deep during ODP Leg 147.

Physical Properties

Most of the last core sections from Hole U1415J were measured with the Whole Round Multisensor Logger and the Section Half Multisensor Logger. Natural gamma ray radiation remains very low (<1.2 count/s), below background level. Magnetic susceptibility remains generally low (below ~8000 x 10^{-5} SI, about 400 x 10^{-5} SI on average). We also completed measurements on discrete samples from the last cores recovered in Hole U1415J. Grain density ranges from 2.7 to 2.85 g/cm^3, and porosity ranges from 1.9 to 4.1%. *P*-wave velocity measured in olivine gabbros and troctolites ranges from ~5.3 to 6.1 km/s. Overall in Hole U1415J, porosity progressively increases downhole (from 0.2 to 4 %), resulting in decreasing *P*-wave velocities and densities. Thermal conductivity was measured in four core pieces taken at irregularly spaced intervals from Cores U1415J-18R-1 to -21R-2. It ranges from ~4 W/m·K in troctolites to 2.2 W/m·K in olivine gabbros.

Education and Outreach

The E&O team completed 16 broadcasts this week. Nice feedback has appeared in newspapers articles about IODP Expedition 345 (e.g., one example in UK: http://www.hexhamcourant.co.uk/news/news-at-a-glance/whitfield-susan-s-teaching-makes-a-splash-1.1027767?referrerPath=home/2.3307). Students are utilizing our hands-on activities in classrooms (e.g., deep sea animals, draw the *JOIDES Resolution* in your classroom), and high school students are following English and French blogs.

We continue to follow the drifter (named "Drifty") launched from the *JOIDES Resolution* on Christmas day. This week continues sailing eastward in the Equatorial Counter Current. Drifty is now 540 km northeast of the *JOIDES Resolution* (azimuth 40°).

Technical Support

Science mission support:

- Technical staff continued to provide core processing and analytical support for the Science Party.
- Two sub-bottom surveys were attempted but failed due to battery issues.

Other technical activities:

- After the 3rd failure, the 3.5 kHz pinger was dismantled for inspection.
    - All batteries are fully charged (the past failure are not battery related as reported).
    - Water is leaking from the transducer chamber and a hole has been found in the rubber cap.
    - Found compromised resistors.
    - Trying to contact owner for electrical drawings.
- IT Servers and Tape Drives: issues partially resolved, testing continued
- Conference Room Video Cabinet: Cabinet installed, installation of video conferencing equipment pending.
- Underway Lab Instrument Hosts: No further progress on these issues due to higher priority work.
- Fantail Deck Crane: Maintenance and paint work were completed.
- SHMSL: Sensitivity to the thermal environment was identified as the cause of the spectrophotometer drift. Both internal and external heat sources can cause significant value jumps between calibrations. As a short term solution, we have attached a CPU heat sink and fan, and are currently testing the use of the "dark pixel" value as an internal real-time correction. Initial results are promising. A full report to the Geophysics LWG is in progress.
- New SHIL: The new SHIL camera and lights have been setup for testing using a new instrument host.

HSE activities:

- The weekly fire and abandon ship drill was held as scheduled.
- Positing NFPA signs continued.