IODP Expedition 345: Hess Deep Plutonic Crust

Week 3 Report (23–29 December 2012)

The third week of IODP Hess Deep Expedition (345) consisted of operations intended to select a site and characterize the near subsurface in preparation for deeper drilling on the deep bench on the wall of Hess Deep. This has included a series of jet-in tests to verify sediment thickness as well as shallow coring in three holes.

Operations

Our initial operations were designed to verify our position relative to the site survey micro-bathymetric data. After arriving at the location of proposed Site HD-01B, we tripped the drill pipe to the seafloor and offset the ship 300 m south of the site coordinates. This allowed the drill string to be extended to a depth of 4886 mbrf, or 20 m below the estimated seafloor depth of the first proposed drill site located on the bench. Once the VIT subsea camera system was in position just above the seafloor, we moved the ship to the north, upslope to the site coordinates. From there the ship was moved an additional 35 m north where the depth began to decrease, consistent with the site survey bathymetry. By monitoring the changes in water depth we were able to confirm that the drill site was indeed located in the area of interest on the target bench. The ship was then moved back to the site coordinates and from there due west 100 m where a seafloor positioning beacon attached to the subsea camera was released without difficulty. Once again the ship returned to the site coordinates where a drill string seafloor depth of 4850.5 mbrf was visually observed. The subsea camera was then recovered to turn on the previously mounted 3.5 kHz subbottom profiling system (pinger).

Hole U1415A

The camera system was re-deployed to the seafloor, and with the ship positioned over the site coordinates, Hole U1415A was spudded at 0255 h on 23 December 2012. This jet-in penetrated 10.3 m into the sediment from 4848.5 mbrf to 4858.8 mbrf. The 3.5 kHz pinger and camera survey to determine sediment distribution and thickness continued along the length of the bench per the arranged co-chief survey plan.

Hole U1415B

The drill string was then spaced out for a second jet-in test and Hole U1415B was spudded at 0905 h. This test penetrated 11.7 m into the seafloor (4856.3 mbrf to 4868.0 mbrf) before the driller had to make a drill string connection to add another drilling knobby. After making the connection the driller was unable to get back to bottom indicating something had fallen into the hole preventing further advancement. The drill string was then pulled clear of the seafloor ending Hole U1415B.

Hole U1415C

Hole U1415C was spudded at 0945 h in the same location as Hole U1415B, only this time the driller made a connection before penetrating the seafloor. The third jet-in test extended from a seafloor depth of 4856.3 mbrf to 4932.7 mbrf (76.4 mbsf). As it turned out this penetration was

only perceived and in reality the bottom hole assembly (BHA) was likely laying over on the seafloor. This reality was not discovered until the camera system had been recovered and the driller found that the drill string could not be rotated. Spudding on hard rock is inherently difficult. Little or no sediment overburden does not help much and operating in deep water with long drill strings accentuated the problem even more. On the day this occurred the swells and resulting heave the ship was experiencing led to large weight fluctuations (±50,000 lbs) on the driller's weight indicator. Because of the high drill string stress knobby drilling joints were being used at the top of the drill string. In reality, as drill collars were laid out at the seafloor knobby drilling joints were being added at the top of the string which were significantly heavier than a normal joint of 5-1/2 inch drill pipe. This masked the weight change to an extent that it was not detected in the large hanging weight load swings evidenced on the drillers console. The seafloor was cleared at 1445 h on 23 December, all 30 ft drilling knobbies in the string were laid out, and the remaining drill string was recovered. At the surface the BHA was inspected resulting in one joint of 5-1/2 inch transition drill pipe, one tapered drill collar (TDC), and five control length drill collars (CLDC) all being taken out of service because they were bent.

Hole U1415D

After making up a new BHA and tripping the drill string to the seafloor another seafloor survey was conducted using the camera system and the 3.5 kHz pinger. However, the pinger ceased working ~100 m into the survey. Therefore, survey area was abbreviated somewhat and completed using only visual observations of the seafloor. A new spud location was determined and after a routine slip and cut of the drill string, the seafloor depth was visually observed to be 4850.8 mbrf. The camera system was recovered and Hole U1415D was spudded at 2355 h. This jet-in test advanced 4.2 m into the seafloor and the bit was pulled clear of the mudline at 0026 h on 25 December, ending Hole U1415D.

Hole U1415E

The camera system was recovered, a fresh core barrel was deployed, and at 0330 h Hole U1415E was spudded. This hole was rotary cored from seafloor (4850.8 mbrf) to 22.2 mbsf (4873.0 mbrf). Very ratty hole conditions were encountered throughout the interval with high pump pressure, high drilling torque, and hole collapse every time the bit was picked up off bottom. While cutting Core UI1415E-3R (from 15.3 to 22.2 mbsf) the pump pressure dropped from 800 psi to 350 psi at 70 spm, top drive torque dropped off significantly, and the driller noticed a string weight loss of approximately 10,000 lbs, which indicated a likely BHA failure. The drill string was recovered and the fourth drill collar pin (first collar above the outer core barrel [OCB] stand) had broken off. Lost in hole besides the inner core barrel assembly, were three drill collars, and the entire OCB assembly. In addition two additional drill collars were found to be bent. Only the upper most stand was in working condition.

Hole U1415F

Once again a new BHA was assembled and the drill string tripped to the seafloor. The problem with the 3.5 kHz pinger was traced to dead batteries so after charging the batteries the pinger was considered operational again. The camera system was deployed to the seafloor and another near-bottom survey was initiated in an attempt to locate an area on the bench with thin sediment and little or no rubble in evidence. The top drive was picked up and jet-in test in Hole U1415F was

started at 2100 h on 26 December. The seafloor depth for this hole was established as 4857.0 mbrf. The bit was jetted into the formation 1.5 mbsf before being terminated. The bit was pulled clear of the seafloor and the camera system was recovered.

Hole U1415G

The drill string was spaced out and Hole U1415G was spudded at 2355 h on 26 December. RCB coring continued to 4868.4 mbrf (11.4 mbsf) before being terminated. Hole conditions were the same as in earlier holes making it highly risky to attempt making connections with the bit in the hole. The bit was pulled clear of the seafloor at 0445 h on 27 December, ending Hole U1415G.

Hole U1415H

The core barrel was recovered and the camera system was deployed once again for another seafloor survey to be conducted en route to the next target location located 20 m west and 15 m south of Hole U1415G. Visual observation of the drill bit seafloor tag indicated a depth of 4857.6 mbrf. The camera system was recovered and Hole U1415H was spudded at 1040 h on 27 December. Rotation began after penetrating approximately 1.0 m of soft material and RCB coring continued to a depth of 12.9 mbsf. This hole behaved vastly different that previous holes. All drilling parameters were much smoother/less erratic. However, when preparing to make a connection, the driller raised the bit off and then attempted to lower the bit back to bottom, immediate formation resistance was encountered. Drilling torque became elevated and erratic indicating the hole had collapsed. Because it was considered unsafe to attempt making a connection under these circumstances, the decision was made to terminate the hole before possible loss or damage to another BHA. The bit was pulled clear of the seafloor at 0410 h on 28 December, ending Hole U1415H.

Hole U1415I

The camera system was deployed again and the ship was moved ~50 m northwest to the next possible site. Once on location a brief visual survey was conducted with the subsea camera confined to an area ~5 m radius from the target coordinates. The area appeared to be relatively free of boulders or any indications of rubble. The camera system was recovered and Hole U1415I was spudded at 1110 h on 28 December. Drilling preceded much the same as in Hole U1415H albeit with a slower rate of penetration (ROP). After penetrating ~6 m, drilling was halted, the drill string was picked up a few meters off bottom and the circulating pumps were reduced. This initial test indicated that the hole was remaining stable. This test was repeated the following morning at ~9 mbsf with the same result. Although, once back on bottom the drilling torque temporarily increased slightly as if something was being ground up below the bit. Associated with this was an increase ROP from 0.4 m/h to 0.8 m/h. Slow penetration rates were to be expected given that the majority of the BHA was still unsupported above seafloor. This meant top drive rpm and weight-on-bit (WOB) had to remain low (30–40 rpm and 5000 lbs WOB). By mid-morning on 29 December enough penetration had been achieved to allow the core barrel to be recovered and a drill pipe connection to be attempted. The sinker bars were deployed and at 0945 h on 29 December and Core U1415I-1R was on deck with 0.16 m recovery. A connection was made, the bit was run back to bottom, and coring resumed after circulating ~3.0 m of fill out of the bottom of the hole. Total depth of Hole U1415I at then end of the week is 11.7 mbsf.

Science Results

The operational goal of week 3 was to explore the formation characteristics of different regions along the bench area, with the aim of drilling a series of pilot holes to examine the thickness of the sediment cover and the nature of the basement. Thus far, operations indicate that bench is covered with <10 m of pelagic sediment and that the substrate includes rubble whose characteristics are not yet well constrained. Cores have been recovered in three holes so far: Holes U1415E, U1415G, and U1415H.

The rock types recovered in these holes fall within the range of gabbroic rocks expected for this area. The relative stratigraphic positions of the gabbroic lithologies are not known, as all of the core pieces from these holes were rounded fragments (not cored) that are likely rubble that were buried by a thin sediment cover. The lithologies, in decreasing order of abundance, are gabbro, olivine gabbro, gabbronorite, clinopyroxene-bearing troctolite and anorthositic gabbro to anorthosite. Core pieces are mainly medium grained, with lesser fine and coarse grained pieces and mainly equigranular, granular, with lesser subophitic to seriate textures.

These rocks are variably altered, with most samples exhibiting 20 to 60% primary mineral replacement. Typical replacements are amphibole after pyroxene, secondary plagioclase and serpentine after olivine. Corona textures are evident in the olivine-bearing pieces. Vein assemblages include mixed-layer clays/chlorite, prehnite, and/or epidote that are indicative of low temperatures.

The core pieces recovered so far are not oriented, hence no rock fabrics are oriented. Approximately 50% of the gabbroic rocks display magmatic fabrics (layering and/or foliation development). Most fine-grained samples show a weak to moderately strong magmatic foliation defined by the alignment of plagioclase. Pieces of the more coarse grained gabbro are too small to allow recognition of a magmatic foliation, however strong fabrics are not present. Evidence of subsolidus deformation (crystal plastic and/or brittle) is rare and localized in the recovered pieces. Alteration veins are present in roughly 75% of the recovered pieces, with a very low vein density. All veins are irregular in geometry, very thin (thickness <0.1 cm), with length greater than the piece size, and form fine networks of cross-cutting veins with no marked preferred orientation.

No whole rock geochemical, paleomagnetic, or physical properties data were collected for Holes U1415E, U1415G, and U1415H due to the nature of the recovered material. Each of these disciplinary teams worked to establish their methodology protocols and test their equipment.

Education and Outreach

Broadcasts have been slower this week due to the holidays; we have had three with specific focus on art and biology. On Christmas Day, we deployed a drifter that monitors the currents in the Pacific. After only four days, the drifter had floated 283 km to the northwest of the ship. Our expedition social media pages are showing a healthy increase in readership with the help of the

scientists' assistance in disseminating their research. The team continues with the development of educational packages.

Technical Support

Science mission support:

- Technical staff continue to provide core processing and analytical support for the Science Party;
- Three camera / sub-bottom surveys were conducted with good results except for one early shut down due to issues with battery charge level;
- Scientists are pleased with thin sections produced;
- Whole-round core scanning and thin section imaging proceeded well.

Other technical activities:

- Continue to assist scientists with DESCLogik;
- Minor software updates completed;
- XRD sound enclosure built and installed;
- Started basic electronics and Arduino training classes;
- NGR drift issues unresolved but do not affect total-count measurements;

HSE activities:

- The weekly fire and abandon ship drill was held as scheduled.