IODP Expedition 327: Juan de Fuca Ridge-Flank Hydrogeology

Week 5 Report (2–8 August 2010)

9 August 2010

OPERATIONS

Hole U1362A

The third stage of operations at Hole U1362A continued with rotary core barrel (RCB) coring through difficult conditions. The formation alternated between massive and highly fractured zones with rapid penetration rates associated with high drill string torque and circulation pressures. These conditions almost always led to the pipe getting stuck with loss of rotation and circulation. The highest vulnerability seemed to be when making drill pipe connections after completing a cored interval. Ultimately what seemed to work best was the use of more frequent and larger mud sweeps (35–50 barrels each), and spotting heavy mud pills in the pipe just prior to making a connection. Coring continued at an average pace of ~23 m per day, which included many hours of lost time getting unstuck and making impromptu wiper trips to get coring parameters back to normal.

Cores U1362A-6R through 14R were recovered to a depth of 3120.6 m (448.6 m below seafloor). The drill string was recovered for a bit change and to extend the length of the bottom-hole assembly (BHA). We believe that the only reason coring was maintained in this hole is because only slick pipe (i.e., 8-1/4 inch drill collars) extended into the open hole below the 10-3/4 inch casing shoe. Having the collars in the hole with no external upsets allowed the pipe to be pulled back up the hole when required to re-establish rotation and circulation. Therefore, when the drill string was tripped to the surface to change the core bit to a new C-7 RCB bit, an additional 9 drill collars were added to the drill string. Severe damage was noted on the upward looking shoulder of the used bit due to the back reaming required by the multiple incidents of stuck pipe. The BHA was heavily sandblasted/polished on all joints that extended below the re-entry cone.

The pipe was tripped to bottom once again and in <15 minutes Hole U1362A was reentered for the eighth time at 2335 hr on 5 August 2010. After picking up the top drive the bit was washed/reamed to within 1 m of the total depth without any major issues. At that point, however, the drill string became stuck and an additional 6 hr were required to work the drill string free and condition the hole before coring could resume. RCB coring continued with Core 15R at a depth of 448.6 mbsf and continued through Core 21R to a total depth of 3168 m (496.0 mbsf). Core 21R was on deck at 1255 hr on 8 August. Cores 15R–18R were cut with very slow rates of penetration (ROP) of 1–2 m/hr or less in a much more massive and less fractured formation. Recovery through this interval was excellent, averaging >75%. Cores 19R–21R, however, were recovered from highly fractured material with ROPs in the 4–5 m/hr range and recovery dropping to 24.3%. The last core (21R) was cut with elevated drill string torque indicative of potential hole problems to come. The use of significantly larger mud sweeps (65–150 barrels each) seemed to contribute to more effective hole cleaning and fewer stuck pipe incidents.

The coring cycle was followed by three wiper trips to the 10-3/4 inch casing shoe and back to total depth. The hole conditions improved with each cycle but not to an acceptable level for wireline logging, packer testing, and ultimately the CORK deployment. The first wiper trip required 7 hr of washing/reaming and had 54 m of fill to remove from the bottom of the hole. The second wiper trip required 4-1/2 hr of washing/reaming and had 46 m of bottom fill. The third wiper trip required only 3-1/2 hr of washing/reaming and had 28 m of fill. Further wiper trips were abandoned in favor of deepening the hole by drilling. The decision was made to switch the

RCB coring assembly to a 9-7/8 inch tri-cone drilling assembly, and at 0700 hr on 9 August the pipe trip began back to the surface.

SCIENCE RESULTS

Cores U1362A-5R to 21R were recovered between Monday and Saturday, ending coring at Hole U1362A.

Of the 21 cores recovered from Hole U1362A, Sections 2R-1 to 14R-2 have been described to date. These descriptions cover the igneous composition, hydrothermal alteration, structural measurements (Sections 2R-1 to 12R-2) and a preliminary interpretation on the mode of formation. All of the samples recovered are volcanic rock of basaltic composition. The cores described have been allocated into 10 preliminary units based on their igneous lithology, which was defined by phenocryst abundance and further divided into subunits where groundmass grain size changes.

Units 1, 2, and 4 are sparsely to moderately phyric and are distinguished by the presence of olivine phenocrysts in Unit 2 only. Both units are divided into subunits based on groundmass grain size that varies from crypto- to microcrystalline on varying scales. These units are interpreted to be pillow lavas based on the abundance and nature of chilled margins. Unit 3 is similar compositionally to those above but occurs as more massive pieces. It has only rare chilled margins and is interpreted to be a sheet flow. Units 1–4 are generally moderately altered and are dominated by pale gray background alteration and alteration halos of dark gray, light gray, and iron-rich zones.

Units 5–9 are crypto- to microcrystalline and are generally sparsely plagioclase and clinopyroxene phyric. Chilled margins are rare. Core pieces are more coherent and are interpreted to be sheet or massive flows. This unit is moderately to highly altered and is characterized by large halos of varying composition and color.

Unit 10 is moderate- to highly plagioclase phyric cryptocrystalline basalt and has abundant chilled margins. Hydrothermal alteration in this unit is similar to that of Units 5–9 with extensive background alteration and large alteration halos. This unit is interpreted to be either pillow lavas or thin sheet flows.

Whole round physical properties analyses have been completed for most cores from Hole U1362A, but discrete sampling has only been performed on the upper sections. Gamma ray attenuation (GRA) density data vary widely due to unfilled core liners. Despite this, we obtained consistent peak bulk density values of ~2.5 g/cm^3 for much of the core recovered. For the more cohesive, massive sections recovered in deeper cores, GRA density values were slightly higher than 2.5 g/cm^3. Magnetic susceptibility values were widely variable, ranging from <1000 x 10^5 SI to >3000 x 10^5 SI, with the highest values again found in massive sections. Total counts from the natural gamma ray logger were low (between 1 and 5 counts per second) for all cores.

Thermal conductivity measurements were taken on three samples of igneous material, yielding values from 1.67 to 1.72 W/m·K. These values compare well with data collected at similar depths into basement at nearby Hole U1301B (Expedition 301) and Hole 1027C (Leg 168), at 1.70 ± 0.09 and 1.63 ± 0.25 W/m·K, respectively. Only three values were collected due to equipment failure that prevented further measurements.

Discrete (cylinder shaped and cube shaped) samples were taken for moisture and density and *P*-wave velocity measurements. We extracted ~2 samples from each section. From the oriented samples, we extracted cube-shaped samples and measured *P*-wave velocity in three orthogonal directions. Fourteen samples have been processed. Bulk densities range from 2.57 to 2.89 g/cm^3. Grain densities range from 2.66 to 2.96 g/ cm^3. Porosities range from 2.76% to 7.92%.

Because the estimated *P*-wave velocities are erroneously higher than the expected velocity for basaltic samples, we frequently calibrated the measurement device using acrylic standard and cylindrical samples measured on samples from Hole U1301B during Expedition 301. Furthermore, we calculated the *P*-wave velocity by manually picking first arrivals and checked the reliability of the estimated velocity. *P*-wave velocities estimated in saturated conditions range from 5.29 to 6.09 km/s, which are faster than seen in Hole U1301B samples. From these properties, we obtained a velocity vs. porosity relationship.

Twenty five whole-round samples of 4–20 cm length were collected from Hole U1362A for microbiological analysis. Samples were selected in the core splitting room as quickly as possible after core recovery, following initial discussion with the petrologists and imaging of the sample before removal from the core liner. When sample volume permitted, samples were preserved for shore-based DNA analysis, shore-based fluorescence in situ hybridization and cell counting analysis, and shipboard fluorescent microsphere analysis. One sample was also collected for shore-based analysis of particulate organic carbon and nitrogen as well as carbon and nitrogen isotopic compositions. Subsamples were taken both prior to and following flame sterilization of the outer surfaces of the hard rock pieces. Generally, one hard rock sample was collected per section. Hard rock samples span a range of lithologic units, alteration states, presence of chilled margins, and most contain at least one vein/fracture. Additionally, a few recovered plastic bags that held the fluorescent microspheres have been collected as a contamination check in DNA analysis. Examination of the microsphere abundance in or on the recovered samples is ongoing.

Meetings were held every day at noon to select samples for shipboard analyses. Overall, we collected 20 inductively coupled plasma–atomic emission spectroscopy (ICP-AES), 42 moisture and density (MAD), 19 thin section, and 8 X-ray diffraction samples for shipboard analyses. Whole rounds were also collected for postcruise research: 25 for microbiology and 3 for physical properties.

Measurements of the remanent magnetization were made on several oriented pieces from the archive half. Data are being analyzed.

The engineering staff and ship's crew worked on several projects. The pressure bay valve handles were welded with arrows and reassembled on the CORKs, and extensions were welded to the fins on the two L-CORKs so that they extend into the ROV platform. Layout drawings were completed for all three CORK installations, although the length will have to be revised when total depth is known each hole. A total of 550 straps were cut and assembled from stainless steel banding to secure the CORK umbilical cables. Some of the fixed blade centralizers were modified for use in the open portion of Hole U1362A. CORK scientists selected the locations of the miniscreens. Pressure testing and troubleshooting of the electronic RS (ERS) tool continued according to Stress Engineering's directions.

OUTREACH

Outreach activities resumed with finishing the ROV construction and deploying the ROVs in a pool on the top deck. Several videoconferences were conducted with a science camp in SeaWorld (Florida), the Ocean Hall at the Smithsonian Institution (Washington, DC), and students in Nouméa (New Caledonia). Scientists and crew painted the CORK bodies under the direction of outreach officer Dinah Bowman. Individual projects are continuing on curriculum materials and experiments to be used in schools, art, and computer animation.

TECHNICAL SUPPORT AND HSE ACTIVITIES

HSE activities: The weekly fire and boat drill was postponed for Monday.

Laboratory activities:

Technical staff engaged in hard rock coring operations. Staff continues to provide support for various science, education and engineering projects. Laboratory projects in progress include the following: section half multisensor logger software upgrade, whole core multisensor logger software upgrade in user testing, moisture and density/pycnometer software upgrade, upgrade plan for the gas delivery manifold in the Science Pallet Stores, and lab documentation updates. Minor updates were released for several LIMS applications.