IODP Expedition 336: Mid-Atlantic Ridge Microbiology
Site U1383 Summary

Site U1383 (Proposed Site NP-2) is located 5.9 km northeast of Site U1382 in an area of elevated conductive heat flow in 4414 m water depth. The primary objective at Site U1383 was to install a multi-level CORK observatory for long-term coupled microbiological, biogeochemical, and hydrological experiments in uppermost basaltic crust. Basement coring, downhole logging, and hydrologic experiments were also planned.

Hole U1383B at 22°48.1328'N, 46°03.1556'W was prepared for drilling 500 m into basement by installing a reentry cone with 20 inch casing extending to 35 mbsf. We then prepared the hole for 16 inch casing by drilling an 18.5 inch hole to 68 mbsf; the sediment/basement interface is at 53 mbsf. After installing and cementing the 16 inch casing to 54 mbsf, we started to prepare the hole for 10.75 inch casing by drilling a hole into basement with a 14.75 inch tricone bit. We decided to abandon Hole U1383B after this tricone bit failed at 89.8 mbsf resulting in large parts of the bit being left in the hole. Although deepening this hole was not pursued, it remains a viable CORK hole as it has a completely functional reentry cone and casing system with ~35 m of accessible basement. A ROV landing platform was therefore installed in the reentry cone to facilitate future ROV operations, which will include installation of an instrumented plug in Hole U1383B.

Hole U1383C was started at 22°48.1241'N, 46°03.1662'W, at the site of the original jet-in test, 25 m southwest of Hole U1383B. The primary objective was installing a multi-level CORK observatory within the uppermost ~300 m of basement. The depth of basement penetration achieved in Hole U1383C and the downhole logging results were to determine the ultimate configuration of the CORK observatory. A reentry cone with 16 inch casing to 34.8 mbsf was installed and a 14.75 inch hole drilled to 69.5 mbsf for the 10.75 inch casing string. The sediment/basement interface was encountered at 38.3 mbsf. After cementing the 10.75 inch casing at 60.4 m mbsf, drilling in Hole U1383C proceeded with an RCB bit from 69.5 to 331.5 mbsf. From this 262 m long interval, 50.3 m of core was recovered (19.2%). Rocks are glassy to fine-grained basalts with variable phenocryst (plagioclase and olivine) contents. Three major lithological units were distinguished based on primary texture and phenocryst abundance. Down to 127 mbsf, core consists of microcrystalline to fine-grained, sparsely plagioclase phyric basalt with abundant glassy margins and numerous intervals of hard interflow limestone. From 127 to 164 mbsf, massive, plagioclase-olivine phyric basalts are developed, which occasionally host limestone (with and without basalt clasts) as fracture fill. Below 164 mbsf, glassy to variolitic to cryptocrystalline basalts (most likely pillow flows) predominate and limestone is largely missing. Each of these three main lithologic units is divided into numerous subunits based on the occurrence of hyaloclastite layers and rare tectonic breccias. The overall abundance of glass is noticeably greater than in Hole U1382A, and the extent of palagonitization ranges from weak to moderate. Basalts are avesicular to sparsely vesicular and show vesicle fills of clay, zeolite (mainly phillipsite), calcium carbonate, and Fe-oxyhydroxide. Brownish alteration halos commonly track veins filled with clay and/or carbonate and zeolite. Within Unit III, a gradational change from glassy to variolitic with abundant hyaloclastite layers to more massive microcrystalline to fine-grained basalt with rare glassy margins can be observed. While the hyaloclastites are noticeably palagonitized throughout the whole, the extent of background alteration appears to decrease down section. Vein densities average at 33 veins/m and increase somewhat down section with up to 50 veins/m. Zeolite veins are abundant in the upper section of the drilled interval, while carbonate veins predominate in the lowermost part. Sparse vesicles are filled with zeolite and clay.

Physical property measurements reveal tight correlations between sonic velocity, density, and porosity of the basalt. These correlations reflect changes in physical properties as a result of low-temperature alteration. In basalts with up to 40% alteration, P-wave velocities and bulk densities as low as 4750 m/s and 2.43 g/cm^3 were recorded. These most altered basalts also show exceptionally high porosities, ranging up to 16.6%. Despite the locally high alteration intensity, natural gamma ray core scanning reveled fairly low average potassium and uranium concentrations (e.g., 0.19±0.05 wt.% K). Fresh basalts show physical properties and K concentrations typical for mid-ocean ridge basalt.

Whole rock geochemistry shows that basalts from Units I and II systematically differ in Zr/Y and Zr/Ti ratios from basalts from Unit III. The compositional variability within the different units is primarily due to fractionation of olivine, but some trends (gain of K, loss of Mg) are also related to increased alteration intensity. The porphyritic basalts do not show the distinct plagioclase accumulation signature revealed in similar basalts from Holes U1382A and 395A. Correlations between Sites U1382/395 and U1383 based on geochemical composition cannot be made for individual flow units, indicating that the sites belong to different volcanic centers that were fed by mantle sources with variable compositions.

Hard rock samples for microbiological analysis were collected from every RCB cored interval of Hole U1382C. Roughly 12% (6.11 m total) of core recovered from Hole U1383C was taken as whole-round samples from the core splitting room and dedicated to microbiological analysis. The seventy-nine hard rock microbiology samples span a range of lithological units, alteration states, presence of chilled margins, and some contain at least one vein or fracture. Additionally, a few 'background contamination' samples were collected for shore-based DNA analysis, including any recovered plastic bags that held the fluorescent microsphere solutions in the core catcher.

Samples recovered were preserved for shore-based DNA and RNA analysis, shore-based fluorescence in situ hybridization and cell counting analysis, ship-based culturing and enrichments, shore-based isotopic analysis, and ship-based fluorescent microsphere analysis. Microspheres were used during all coring operations to help in evaluating core contamination. Enrichment and cultivation experiments initiated included carbon fixation incubations, carbon and nitrogen cycling experiments, enrichments for methanogens, sulfate reducers, sulfide oxidizers, and nitrate-reducing iron-oxidizing bacteria, and enrichments for heterotrophic metabolisms.
Deep UV scanning of hard rock materials was used to identify regions of the sample with concentrations of biomass and organic material. At this time, the exact biomass density on the sample is unknown, but studies are underway to investigate this.

Wireline logging data include natural total and spectral gamma ray, density, compressional velocity, electrical images and deep UV-induced fluorescence (DEBI-t) of an open hole section of 274.5 m. Lithologic Unit I is characterized by variable caliper, density and sonic velocity values. Gamma ray intensities are generally low, but increase in the bottom part of the unit. Lithologic Unit II has a uniform caliper, high densities and apparent sonic velocities and shows high-resistivity massive flows with fractures in the FMS images. Lithologic Unit III has an upper section (153-166 mbsf) characterized by a drop in density, apparent resistivity and velocity and an increase in gamma ray intensity. This interval corresponds to thin flows with inter-pillow/flow sediments and tectonic breccias. From 166 mbsf to the bottom of the hole, the logging data reveal fairly uniform values for density and apparent velocity and resistivity. Areas with peaks in gamma ray intensity correspond to intervals with abundant hyaloclastite in the recovered core (in particular around 175 mbsf, and from 220 to 250 mbsf).

Drill string packer experiments were attempted in Hole U1383C to assess the transmissivity and average permeability of open-hole zones bounded by the bottom of the hole at 331.5 mbsf and three different packer inflation seats (at 53, 141, and 197 mbsf). The packer experiments were not successful.

In preparation for the CORK observatory, Hole U1383C was cased through the 38.3 m-thick sediment section with 10.75 inch casing to a depth of 60.4 mbsf and a 14.75 inch rathole to 69.5 mbsf. After the hole was RCB-cored to 331.5 mbsf and cleaned in five wiper trips, there was no noticeable fill, which was also verified during logging. The CORK screens and downhole instrument string targeted three zones, selected mainly on the basis of recovered core and caliper log. An upper zone extends from the combination packer and landing seat at 58.4 mbsf in the casing to the first open hole packer and landing seat at 145.7 mbsf. Within this section the mini-screens were centered at 100 mbsf with the slotted portion of the casing from 76 to 129 mbsf. The middle zone extends to an open-hole packer and landing seat at 199.9 mbsf. Within this section the screens were centered at 163 mbsf with the slotted casing from 146 to 181 mbsf. The deep zone reaches to the bottom of the hole (331.5 mbsf) with mini-screens at 203 mbsf. The mini-screens are connected to the wellhead by five umbilicals with internal stainless steel or tefzel tubing that were strapped to the outside of the casing. The downhole tool string consists of six different OsmoSampler packages, a dissolved oxygen sensor and recorder, two miniature temperature recorders, sinker bars, sealing plugs, and interspersed sections of 3/8” (0.95 cm) spectra line. The wellhead was instrumented with a pressure logger monitoring each of the three horizons and bottom seawater and a fast flow OsmoSampler with a Standard and a microbiological sampling package. The CORK extends to 247.6 mbsf, yet leaves the bottom portion of the hole open for future logging and access (247.6 to 331.5 mbsf).