IODP Expedition 336: Mid-Atlantic Ridge Microbiology
Site U1382 Summary

Hole U1382A was drilled 50 m west of Hole 395A at 22°45.353'N, 46°04.891'W in a water depth of 4483 m below sea level (mbsl). The primary objective at Hole U1382A was to install a CORK observatory to perform long-term coupled microbiological, biogeochemical, and hydrological experiments in uppermost basaltic crust in this area of very low conductive heat flow. Coring and downhole logging of basement was also conducted.

After the re-entry cone with 53 m of 16 inch casing was jetted in, the hole was deepened by drilling with a 14.75 inch tri-cone bit to 110 m below seafloor (mbsf) without coring. Basement was encountered at 90 mbsf and three meters were penetrated in 30 minutes. The interval from 93-99 mbsf drilled very quickly and is inferred to be sediments; but the underlying formation to 110 mbsf drilled slowly (2-3 m per hour) without significant torque. Casing (10.75 inch) was installed and successfully cemented to 102 mbsf. RCB coring recovered basement from 110 to 210 mbsf (Cores U1382A-2R to -12R). In total, 32 m of core were retrieved, with recovery rates ranging from 15 to 63%. This succession resembles the lithostratigraphy encountered in DSDP Holes 395 and 395A and provided excellent sampling material for various microbiological and petrologic studies.

The shipboard petrologists divided the core into 8 lithologic units, comprising 17 subunits. Major unit boundaries are defined by contacts between massive and pillowed flow and interlayered sedimentary units. Each major lava flow unit consists of several cooling units, which are recognized by glassy or variolitic margins and/or marked changes in grain size. Results from thin section studies reveal a large range of grain sizes (glassy to medium-grained) and diverse textures (aphanitic to subophitic or intersertal). Basalts are either aphyric or plagioclase-olivine phyric and have <3% vesicles. Phenocryst contents range up to 25%, with plagioclase being more abundant than olivine. All of the basement volcanic rocks recovered from Hole U1382A are affected only by low-temperature alteration by seawater, manifesting as replacement of groundmass and phenocrysts, vesicle filling, glassy margin replacement, and vein formation with adjacent brown alteration halos. Chilled margins often show advanced palagonitization, which develops as blotchy alteration texture following the primary variolic texture of the mesostasis. The extent of alteration ranges up to 20%, with clay (smectite, celadonite) being the most abundant secondary phase, followed by Fe-

oxyhydroxides and minor zeolites and carbonates. The recovered section has between 13 and 20 veins/m, with vein thickness being generally less than 0.2 mm. A sedimentary unit in Cores 8R and 9R features a variety of clasts, including plutonic and mantle rocks. The peridotites are weakly serpentinitzed harzburgites and lherzolites with a protogranular texture. Intensity of deformation of the gabbroic lithologies ranges from undeformed to mylonitic. Minor cataclastic deformation of the peridotites has led to the development of carbonate-filled vein networks, along which the rocks have been subjected to oxidative alteration, resulting in the breakdown of olivine to clay, oxide, and carbonate.

Physical property measurements reveal typical P-wave velocities for these lithologies and a correlation between sonic velocity and porosity of the basalt. Elevated potassium and uranium concentrations in the oxidatively altered part of the core were revealed by natural gamma ray (NGR) core scanning. Thermal conductivity also reflected the typical values associated with basalt and peridotite and showed small variations with depth.

Whole rock geochemistry reveals systematic differences in compositions between aphyric and porphyritic basalt, which are due to plagioclase accumulation in the porphyritic basalt. The aphyric basalts show a liquid line of descent, which is controlled by the fractional crystallization of olivine. With increasing extent of alteration, loss on ignition values and potassium concentrations increase. Immobile trace element ratios (Zr/Y, Ti/Zr) indicate that parental magma compositions for the basalts above and below the sedimentary unit are different from each other. Petrographically and geochemically the basalts correspond to the uppermost lithological units identified in Hole 395A. Likewise, the sedimentary unit with varied plutonic and mantle rocks was also observed in Hole 395A.

A primary objective of the basement coring was to obtain samples for microbiological analysis. We collected 46 hard rock and 2 sediment whole-round samples for these studies (11% of core recovered). Samples were preserved for ship-based (deep UV fluorescence scanning, culturing and enrichment, fluorescent microsphere analysis) and shore-based (DNA and RNA analysis, shore-based fluorescence in situ hybridization, cell counting analysis, isotopic analysis) studies. Generally, one to three microbiological hard rock samples were collected from every core section. Hard rock samples span a range of lithological units, alteration states, presence of chilled margins, and some contain veins/fractures. Additionally,

a few recovered plastic bags that held the fluorescent microsphere solutions in the core catcher have been collected as a contamination check in DNA analysis.

An open hole section of 105.61 m was logged with two tool strings over a period of ~19.5 hours (Adapted Microbiology Combination I, FMS-HNGS). Downhole log measurements include natural total and spectral gamma ray, temperature, density, electrical resistivity, electrical images and deep UV-induced fluorescence (the new DEBI-t). The borehole remained in good condition throughout logging and no obvious tight spots were encountered in open hole. Integration of core and log measurements and observations showed excellent correspondence between potassium concentrations provided by shipboard NGR, spectral gamma ray logging tool and whole rock geochemical analyses. FMS data were combined with images of the external surfaces of whole round cores. Prominent veins with alteration halos in core of the massive flows can be matched up with fractures in the FMS images. Also, logging results constrain the depth of the peridotite interval from 165 to 167 mbsf (based on density and low K/U ratios).

Downhole hydrologic (packer) tests failed, because ship heave up to 3 m prevented the packer from sealing within the casing for more than 10 minutes.

A CORK observatory to monitor and sample a single interval in uppermost basement was successfully installed in Hole U1382A. The 210-m deep hole is sealed with a 189 m-long CORK completion string with 9 external umbilicals and a retrievable internal instrument string. The umbilicals include one for monitoring pressure, two for microbiological sampling, and six for fluid sampling. The retrievable internal instrument string comprises several osmotic pump-driven samplers for basement fluids and microorganisms as well as enrichment experiments, an oxygen probe, and a thermistor with data recorder. The samplers and probes extend from 152 to 174 mbsf and are kept in position by a 150-lbs sinker bar at 177 m. A pressure gauge and fast-pumping OsmoSamplers are situated in the wellhead and monitor/sample fluids from 161 mbsf.