IODP Expedition 345: Hess Deep Plutonic Crust
Site U1415 Summary

Integrated Ocean Drilling Program Hess Deep Expedition 345 was designed to sample lower crustal primitive gabbroic rocks that formed at the fast-spreading East Pacific Rise (EPR) in order to test models of magmatic accretion and the intensity of hydrothermal cooling at depth. The Hess Deep Rift was selected to exploit tectonic exposures of young EPR plutonic crust, building upon results from ODP Leg 147 as well as more recent submersible, ROV, and near-bottom surveys. The primary goal was to acquire the observations required to test end-member crustal accretion models that were in large part based on relationships from ophiolites, in combination with mid-ocean ridge geophysical studies. This goal was achieved with the recovery of primitive layered olivine gabbros and troctolites with many unexpected mineralogical and textural relationships.

Site U1415 is located along the southern slope of an intrarift ridge within the Hess Deep Rift between 4675–4850 mbsl. Specific hole locations were selected in the general area of the proposed drill sites (HD-01B- to -03B) using a combination of geomorphology, seafloor observations, and shallow subsurface seismic data. A total of 16 holes were drilled. The primary science results were obtained from coring of two ~110 m deep re-entry holes (Holes U1415J and U1415P) and five single bit holes (Holes U1415E, U1415G, U1415H, and U1415I). Despite deep water depths and challenging drilling conditions, reasonable recovery for hard rock expeditions (15–30%) was achieved at three 35–110 m deep holes (Holes U1415I, U1415J, and U1415P). The other holes occupied during this expedition included two failed attempts to establish re-entry capability (Holes U1415K and U1415M) and six jet-in tests to assess sediment thickness (Holes U1415A, U1415B, U1415C, U1415D, U1415F, U1415L).

Olivine gabbro and troctolite are the dominant plutonic rock types recovered at Site U1415, with minor gabbro, clinopyroxene oikocryst-bearing troctolite, clinopyroxene oikocryst-bearing gabbro and gabbronorite. These rocks exhibit cumulate textures similar to those found in layered basic intrusions and some ophiolite complexes. All lithologies are primitive, with Mg numbers between 75 and 90, falling within the

global range of primitive oceanic gabbros. Although most lithologies display a magmatic foliation defined largely by the shape-preferred orientation of plagioclase, preservation of delicate mineral textures shows that at this location the lower crust was not subjected to significant hypersolidus strain. After that, little or no minor sub-solidus crystal plastic deformation took place. The metamorphic mineral assemblages record the cooling of primitive gabbroic lithologies from EPR magmatic conditions (>1000°C) to zeolite facies conditions (<200°C) associated with Cocos-Nazca rifting and exposure onto the seafloor. Greenschist to sub-greenschist facies alteration dominates and is most pervasive in olivine-rich lithologies and within zones of brittle fracturing and cataclasis. Amphibolite facies metamorphism is not abundant in comparison to the upper gabbros at the Hess Deep Rift.

The mineralogical and textural relationships show that in several respects the Oman ophiolite is not the ideal model for fast-spreading ocean crust and call into question the some aspects of both of the end-member accretion models that were to be tested. The results of the IODP Hess Deep Expedition 345 provide a reference section for primitive fast-spreading lower crust that did not exist before. This highlights the necessity of ocean drilling to address questions related to the origin and evolution of the lower ocean crust.