Insights into the formation and evolution of ocean crust from deep drilling in ODP Hole 1256D

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The formation of new crust at mid-ocean ridges is the foundation step of plate tectonics and the major mechanism for the transfer of heat and mass from the interior of Earth. The intrusion of magmas into the ocean crust leads to hydrothermal circulation and the consequent seawater-basalt exchanges provide important controls on the composition of seawater. Thermal, chemical and biological exchanges occur over a range of temperatures and may continue for the lifetime of the ocean crust until the lithosphere is returned to the mantle by subduction. However, the location and extent of hydrothermal exchanges remain poorly understood, partly because of a lack of detailed knowledge of the magmatic processes that construct new crust. Deep ocean drilling is imperative to ground-truth remote geophysical observations, numerical models, and concepts of developed from ophiolites.

Ocean Drilling Program Hole 1256D is the first borehole prepared for deep drilling of igneous rocks, and the only hole to sample an intact section down to gabbros of upper oceanic crust formed at a fast spreading rate. Site 1256 resides on Cocos crust formed 15 million years-ago during an episode of superfast spreading (>200 mm/yr) of the East Pacific Rise. Drilling at Site 1256 successfully tested predictions from multi-channel seismic experiments at active ocean ridges that the depths to magma chambers decrease with spreading rate. Beneath 250 m of sediments, Hole 1256D samples ~800 m of lavas, ~350 m of sheeted dikes, the lowermost ~90 m recrystallized to granoblastic textures, and a >115 m-thick dike-gabbro transition zone of gabbro sills intruded into recrystallized dikes. Detailed petrology and geochemistry coupled with wireline logging reveal multiple phases of magmatic and hydrothermal activity during the accretion of the Site 1256 crust and its movement onto the ridge flank. Hydrothermal fluids were channeled along igneous boundaries such as flow margins or intrusive contacts However, estimated hydrothermal fluid fluxes are insufficient to extract sufficent heat to solidify the lower crust at Site 1256. Hole 1256D is open to its full depth and awaiting deepening into the cumulate gabbros.