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Drilling a complete in situ section of upper oceanic crust formed at a superfast spreading rate: Hole 1256D

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The Superfast Spreading Rate Crust mission is a multi-cruise program to drill a complete section of the upper oceanic crust into the underlying gabbros. Hole 1256D was initiated during Ocean Drilling Program Leg 206 in the eastern equatorial Pacific in 15 Ma crust that formed at the East Pacific Rise during a period of superfast spreading ($\sim$220 mm/y). This site was chosen to exploit the inverse relationship between spreading rate and the depth to axial low-velocity zones, thought to be magma chambers now frozen as gabbros, observed from seismic experiments. During Integrated Ocean Drilling Program (IODP) Expedition 309 in Jul-Aug 2005, Hole 1256D was deepened to a total depth of 1255 meters below seafloor (mbsf; 1005 m subbasement). Expedition 312 returned to Hole 1256D in Nov-Dec 2005 and deepened it to 1507 mbsf. The hole now extends through 810 m of extrusive normal mid-ocean-ridge basalt, 345 m of sheeted dikes, and 101 m into plutonic rocks, completing the first penetration of an intact section of the upper oceanic crust. Gabbros were encountered at 1407 mbsf, precisely within the depth range predicted from the extrapolation of multichannel seismic results at modern mid ocean ridges to this superfast spreading rate.

The uppermost crust at Site 1256 comprises a $>$74 m thick ponded lava overlying

massive, sheet, and minor pillow flows. Dike contacts, and mineralized breccias indicate a lithologic transition from 1004 to 1061 mbsf. Below the transition zone, massive basalts with doleritic textures, commonly with brecciated and mineralized chilled margins, dominate the sheeted dikes. The transition zone marks a change from predominantly low temperature secondary alteration minerals to greenschist hydrothermal assemblages. Actinolite, hornblende, and secondary plagioclase occur within 100-200 meters of the dike transition indicating a very steep thermal gradient in the dikes. The lowermost $\sim$70 m of dikes are strongly recrystallized to granoblastic minerals resulting from intrusion of underlying gabbros. The plutonic complex comprises a $\sim$60 m thick upper gabbroic body that intrudes the sheeted dikes, separated from a lower gabbroic body by a screen of granoblastic dikes. Gabbroic rocks are highly altered, fine to coarse grained and range from gabbro to oxide gabbro and gabbronorite with some differentiated rocks (quartz-rich oxide diorite and trondhjemite). The gabbro compositions are evolved compared to primary magmas in equilibrium with mantle olivine but similar to the overlying dikes and lavas, precluding the formation of the lower oceanic crust from the geophysically imaged melts lens.