Drilling a Heterogeneous Lower Ocean Crust and Mantle

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Deep drilling in the lower ocean crust and mantle has provided enormous scientific return from remarkably few expeditions. Deep drilling has penetrated through the lavas and dikes to the dike-gabbro transition in fast spread East Pacific Rise Crust, down through the seismic layer 2-3 boundary in sheeted dikes in slow-spread Costa Rica rift crust, a 1400 m section of slow-spreading Mid-Atlantic Ridge lower crust, another 1508-m section of lower crust at the ultraslow spreading SW Indian Ridge, and short sections of the lowermost and uppermost East Pacific Rise crust at Hess Deep. Viewed from the perspective of the Penrose Model of a uniform layered ocean crust and mantle, then, the composition and architecture of the ocean crust should be well determined. These various pieces of crust, however, formed over a wide range of magma flux and spreading rates from 60 to 14 mm/yr. The long section of MAR crust formed at low melt flux, and bears only modest resemblance to the long section of ultraslow spread SW Indian Ridge crust formed at moderate melt flux. The latter has as much in common with East Pacific Rise crust as it does with the former. On the Gakkel and SW Indian Ridges, there are large regions with little or no crust at all, and at slow spreading ridges, both seismology and sampling and mapping show that large portions of the crust is composed only of lavas and dikes overlying the mantle. Thus, the composition and architecture of the ocean crust is highly variable and remains poorly constrained. The diversity of what has been found to date, however, provides the basis for planning a systematic program of seafloor drilling that will provide a realistic image of how the lower ocean crust forms, and how extension at accretionary ocean ridge plate boundaries is accommodated, and how that relates to evolution of the underlying mantle.

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