A long in situ section of the lower ocean crust: results of ODP Leg 176 drilling at the Southwest Indian Ridge

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Abstract

Ocean Drilling Program Leg 176 deepened Hole 735B in gabbroic lower ocean crust by 1 km to 1.5 km. The section has the physical properties of seismic layer 3, and a total magnetization sufficient by itself to account for the overlying lineated sea-surface magnetic anomaly. The rocks from Hole 735B are principally olivine gabbro, with evidence for two principal and many secondary intrusive events. There are innumerable late small ferrogabbro intrusions, often associated with shear zones that cross-cut the olivine gabbros. The ferrogabbros dramatically increase upward in the section. Whereas there are many small patches of ferrogabbro representing late iron- and titanium-rich melt trapped intragranularly in olivine gabbro, most late melt was redistributed prior to complete solidification by compaction and deformation. This, rather than in situ upward differentiation of a large magma body, produced the principal igneous stratigraphy. The computed bulk composition of the hole is too evolved to mass balance mid-ocean ridge basalt back to a primary magma, and there must be a significant mass of missing primitive cumulates. These could lie either below the hole or out of the section. Possibly the gabbros were emplaced by along-axis intrusion of moderately differentiated melts into the near-transform environment. Alteration occurred in three stages. High-temperature granulite- to amphibolite-facies alteration is most important, coinciding with brittle^ductile deformation beneath the ridge. Minor greenschist-facies alteration occurred under largely static conditions, likely during block uplift at the ridge transform intersection. Late post-uplift low-temperature alteration produced locally abundant smectite, often in previously unaltered areas. The most important features of the high- and low-temperature alteration are their respective associations with ductile and cataclastic deformation, and an overall decrease downhole with hydrothermal alteration generally 95% in the bottom kilometer. Hole 735B provides evidence for a strongly heterogeneous lower ocean crust, and for the inherent interplay of deformation, alteration and igneous processes at slow-spreading ridges. It is strikingly different from gabbros sampled from fast-spreading ridges and at most well-described ophiolite complexes. We attribute this to the remarkable diversity of tectonic environments where crustal accretion occurs in the oceans and to the low probability of a section of old slow-spread crust formed near a major large-offset transform being emplaced onland compared to sections of young crust from small ocean basins.

Keywords: Leg 176; mid-ocean ridges; lower crust; gabbros; alteration; deformation

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