Formation of oceanic crust as viewed from the Oman ophiolite and deep ocean-floor drilling

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Lower crust of oceanic crust comprises about two third of the crust and generally believed to be composed of gabbric rocks. Geophysical explorations for the oceanic crust beneath fast-spreading ridges showed a presence of thin but long-lived melt lens underlain by thick semi-consolidated crystal mush. Whereas, melt lenses are not detected beneath slow-spreading ridges. The behavior of melt lens may have significant role for the architecture of oceanic crust. The presence of thick and successive layered gabbro units is expected beneath fast spreading ridges, whereas discontinuous gabbro intrusions are expected beneath slow-spreading ridges where the melt lens was absent. These are generally agreed with many scientists, however, there is a fundamental question that how to accrete the thick lower oceanic crust from the thin melt lens. There are two extreme models for the accretion style of the lower crust, gabbro glacier model and sheeted sill model (e.g., [1], [2], [3]). These two extreme models result in contrastive behaviors for many fundamental parameters such as mode of fractional crystallization, hydrothermal circulation, and deformation in the lower crust. For example, gabbro glacier model expects less evolved monotonous layered gabbroic unit whereas sheeted sill model expect more advance of fractional crystallization in the layered gabbro unit. Therefore, it is important to study whether model is appropriate for the formation of the lower crust. On the other hand, the upper gabbro unit is regarded as fossilized melt lens [4]. Therefore, detailed study on the upper gabbro unit is required to understand the behavior of the melt lens.

The Oman ophiolite is regarded as a slice of oceanic lithosphere generated at fast-spreading ridges because of a presence of thick and successive layered gabbros (e.g., [5], [6]). The gabbroic layer is divided into layered gabbro unit and upper gabbro unit. The layered gabbro unit constitutes a main portion of the lower crust and the thickness ranges about 2 to 4 km, while, the upper gabbro unit is thinner than 1 km [6]. Second order segment architecture is shown by [7] and [8]. We have examined vertical mineralogical variations of layered gabbro unit along several routes in the different location of the segment architecture. The vertical mineralogical variations indicate a steady upward evolving tendency though the vertical variations show a notable zig-zag pattern.

The upper gabbro unit consisting of foliated gabbro, massive (uniform) gabbro and varitextured gabbro. The thickness of this unit is variable from about only 200 m to 800 m. Vertical profiles of mineral and bulk rock compositions are highly complicated, but they are characterized by following two features; 1) upward evolving tendency with zig-zag pattern and 2) most evolved gabbros appear at the intermediate stratigraphic height in the upper gabbro unit. The zig-zag patterns in the upper gabbro unit suggest a multiple injection of melts into the melt lens, whereas the appearance of most evolved rocks at the intermediate horizon suggests a sandwich horizon where the most evolved melts were finally crystallized. Furthermore, upward evolving tendency in both layered gabbro and upper gabbro unit indicates that the sheeted sill model is appropriate for the accretion style of the lower crust.

References: