Magma plumbing system in the superfast spread oceanic crust — Insights from deep ocean crustal drilling in ODP-Hole 1256D

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A sheeted dike complex is a distinctive constituent of most ophiolites which formed at a certain type of oceanic spreading centers under an extensional stress field. Sheeted dikes are the remnents of magma conduits which transferred magma from a magma chamber to the seafloor and extruded lava flows and accommodated the mid-crustal extension at spreading axes. The ophiolite lithostratigraphy as an analog of the uppermost oceanic crust has been confirmed by the drilling in DSDP/ODP Hole 504B in 6.9-Myr old oceanic crust formed at Cocos-Nazca Spreading Center where 781-m thick extrusive rocks are underlain by 1035 m thick sheeted dikes. In situ observations of sheeted dikes have been done on exposures along escarpments bounding the Hess Deep Rift, which was formed at the fast spreading (135 mm/yr) East Pacific Rise. Although only a limited number of direct observations of the entire upper oceanic crust is available, these studies suggest that a sheeted dike complex comprises a significant portion of the modern oceanic crust.

Recent IODP-Expeditions 309 and 312 proved contrary to our expectations poorly developed intrusives beneath thick extrusive rocks. Hole 1256D was first opened by ODP Leg 206 in the upper oceanic crust formed 15 Ma at the superfast (220 mm/yr) spread EPR in the Guatemala Basin on Cocos plate off Costa Rica. Leg 206 penetrated from 250-m thick sediments into the basaltic basement 500 m sub-basement. Following two IODP Expeditions deepened the hole through 811-m thick extrusives and a thin (346 m) sheeted dike complex and eventually reached the upper gabbro.

The contrasting upper crustal structures revealed by a series of deep ocean crust drilling provides us a clue to understand a necessary condition for the formation of a sheeted dike complex and an insight into the magma plumbing system beneath the mid-ocean ridges. This paper presents a new model of growth of the upper oceanic crust through dynamical counterbalance between the extrusives and intrusives and change in depth of the axial magma chamber (AMC) in response to the supply rate of magma to AMC.