Thermal History of ODP Hole 1256D Lower Sheeted Dikes: Petrology, Chemistry and Geothermometry of the Granoblastic Dikes

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Abstract

The creation of new ocean crust along the mid-ocean ridges plays a critical role in the formation and evolution of the Earth's surface and is the principal mechanism of heat loss from the Earth's interior. However, due to difficulties associated with geophysical imaging and direct sampling, the nature of the magma chambers beneath mid-ocean ridges and their role in lower crustal accretion remain poorly constrained. Understanding how heat is removed from such magma chambers is therefore important. Ocean Drilling Program (ODP) Hole 1256, located on 15 Ma superfast spread crust that formed at the East Pacific Rise, provides the only continuous section of in-situ ocean crust through the extrusive lavas and sheeted dikes into the plutonic gabbros that form in magma chambers. Hole 1256D penetrated two gabbro bodies that were intruded into, and chilled against the sheeted dikes. The sheeted dikes overlying the upper (50 m thick) gabbro body are partially to completely recrystallised to a granoblastic texture comprising microcrystalline granular aggregates of secondary clinopyroxene, orthopyroxene, and plagioclase with sub- rounded magnetite and ilmenite. This recrystallisation, which overprints earlier hydrothermal metamorphism, is attributed to contact metamorphism during the emplacement and subsequent cooling of the underlying gabbros. We investigate the textural, mineralogical, and chemical variations through the 'granoblastic' dikes, and determine the temperatures at which minerals recrystallised using geothermometry, to test the hypothesis that conductive cooling of the upper gabbro was sufficient to produce the observed contact metamorphism. Magnetite and ilmenite are recrystallised through the lowermost 90 m of sheeted dikes, exhibiting a general trend of increasing recrystallisation intensity with depth, with equilibration temperatures of 550 to 600 °C. In contrast silicate minerals are only recrystallised through the lowermost 60 m of sheeted dikes, most intensely between 10 and 30 m above the dike-gabbro boundary, with clinopyroxene and orthopyroxene re-equilibrating at between 850 and 950 °C. The intensity of silicate mineral recrystallisation varies on a mm-scale and appears to be controlled by the earlier hydrous metamorphism, being greatest in recrystallised hydrothermal veins. Although a decrease in maximum metamorphic temperature with distance from the upper gabbro is consistent with conductive cooling, the thickness of the observed metamorphosed zone is inconsistent with that predicted from simple 1-dimentional conductive cooling models for a 50 m thick magma body. This indicates that the magma chamber that provided the heat for the granoblastic recrystallisation in Hole 1256D was either thicker, or was maintained at higher temperatures for longer as a result of magma replenishment.

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