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Magmatism and metamorphism at the sheeted dyke-gabbro transition zone: new insight from beerbachite from ODP/IODP Hole 1256D and Oman ophiolite

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During IODP Expedition 335, two-pyroxenes bearing granulites (beerbachites) were extensively recovered as drilling cuttings at the gabbro-sheeted dyke transition zone of ODP Hole 1256D (East Pacific Rise, 6°44.163′N, 91°56.061′W). This lithology results from high-temperature metamorphism of previously hydrothermally altered diabases, basalts and/or gabbros; the heat source likely stems from the melt lens located at the top of the magmatic chambers imaged along present-day fast-spreading ridges. This lithology, associated with gabbroic bodies, characterises the transition zone between the sheeted dyke complex and the uppermost gabbroic section and represents the interface between magmatic and hydrothermal convecting systems in an oceanic crust formed at fast-spreading ridges.

Samples acquired during IODP Exp. 335 show a particularly high degree of recrystallisation and are characterised by the absence of hydrous phases like amphibole, suggesting very high-T metamorphism. The Beerbachites mineral chemical characteristics are rather homogeneous compared to gabbros or dolerite from the sheeted dyke but pyroxenes Mg#, Ti, Al and Cr contents as well as the anorthite content of plagioclase are closer to gabbro than dolerite. This similarity may be explained by two hypothesis: either beerbachites in Hole 1256D are metamorphosed gabbros, or they underwent a melt-rock reaction process with the gabbros parental magma and were re-equilibrated at high temperature until their mineral composition become similar to that of gabbros.

The gabbro-sheeted dyke transition zone in the Oman ophiolite is also outlined by the presence of high grade metamorphic rocks. Fine grained granulites and amphibolites that may be derived from the transformation of altered sheeted dyke diabases are in direct contact with fresh gabbroic and troctolitic bodies which are themselves cross-cut by dolerite dykes. The observation of textures show that high-T recrystallisation occurred in the fine grained beerbachite and amphibolites as well as in gabbros and troctolites. In completely recrystallised zones, the texture show a mosaic of small (<100 μm) Cpx and Pl grains with strait boundaries, and subrounded Opx. Textures and mineralogical assemblage are alike, independently of the nature of the protolith, suggesting that fine grained strongly recrystallised beerbachites may have formed from gabbro as well as from diabase. Moreover, the occurrence of unusual lithologies like Opx or amphibole-bearing troctolites and strongly metamorphosed amphibolites show that metamorphic processes at the sheeted dyke-gabbro boundary in the oceanic crust is not a simple reheating of hydrothermally altered diabases but involve complex interactions between newly injected magma and altered and non altered host. Partial melting of hydrothermally hydrated diabases and/or gabbros during reheating and the resulting probable magma mixing, together with melt-rock reaction are likely to play a critical role at this interface and, thus, in the ocean crust building.