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Hydrothermal activity at mid-ocean ridges at magmatic temperatures: evidence from ODP Leg 153 (Mid-Atlantic Ridge, Kane Fracture Zone, 23˚N)

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We investigated about 25 gabbros drilled by ODP (Ocean Drilling Program) at Leg 153 from the MARK area (Mid-Atlantic Ridge, Kane Fracture Zone, 23˚N) in detail with electron microprobe and electron backscattered images. Our results, in combination with experimental findings suggest that the late-stage magmatic evolution of these gabbros is characterized by pervasive hydrous partial melting triggered by percolating water-rich fluids [Koepke et al., 2005].

Water-saturated melting experiments on a variety of natural gabbros between 900 and 1000˚C at 200 MPa produced newly formed minerals forming a characteristic paragenesis consisting of plagioclase, orthopyroxene and pargasitic amphibole $\pm$ clinopyroxene [Koepke et al., 2004]. The An content of the new plagioclases is uniformly higher than that of the protolith. Olivine and clinopyroxene primocrysts react to form neoblastic orthopyroxene and pargasitic amphibole. These features can also be observed in the gabbros from the MARK area. Here we found zones at plagioclase grain boundaries showing a strong enrichment in An component, with An contents up to 20 to 25 mol% higher than those of the host plagioclase. Primary olivines and clinopyroxenes in contact with such zones react to orthopyroxene and pargasitic amphibole. These phases rim olivine and clinopyroxene and grow "interstitially", typical petrographic characteristics of a late-stage magmatic phase. The observed late-stage microstructures in the gabbros thus appear to be the results of partial melting processes triggered by water-rich fluids and are not crystallization products of a percolating differentiated late melt. Here we demonstrate that hydrothermal circulation within the

gabbroic layer starts at much higher temperatures (900˚ - 1000˚C) than up to now believed. Water-rich fluids propagate on grain boundaries in a ductile regime, causing hydrous partial melting on a large scale. A cracks system, a prerequisite in current models for enabling hydrothermal circulation, is not necessary. The observed process has the potential for transfer of heat and mass between the upper and lower oceanic crust. Provided that the water-rich fluids triggering the partial melting process are seawater-derived, this process may have a significant influence on the cooling of the deep oceanic crust which is in concordance with new thermal models implying that high-temperature hydrothermal circulation is regarded to play an important role in transport of heat in the deep oceanic crust.

Koepke, J., Feig, S.T., Snow, J., Freise, M., 2004. Contrib. Mineral. Petrol. 146, 414-432.

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