Evidence from Hole 735B gabbros, SWIR, for high-temperature fluid migration within oceanic Layer 3 beneath slow-spreading ridges

Jinichiro Maeda[1]

[1] Earth and Planetary Sci., Hokkaido Univ.

http://www.ep.sci.hokudai.ac.jp/~jinmaeda/

We found petrological evidence from the gabbros recovered at ODP Hole 735B (Leg 176, SW Indian Ridge) for the exsolution of high-temperature (940-800 C) fluid phase in the latest stage mafic magma. The microscopic veins found are composed of the high temperature silicate minerals (i.e., clinopyroxene, orthopyroxene, brown amphibole, and plagioclase), and the "along-vein-variation" in mineralogy, which is correlated with the magmatic minerals that they penetrate, is characteristically observed. The veins found in the Hole 735B gabbros yield information on transition from magmatic crystallization to high temperature metamorphism beneath the slow-spreading Southwest Indian Ridge.

The transition from magmatic crystallization to high temperature metamorphism in deep magma chambers beneath spreading ridges has not been fully described. High-temperature microscopic veins in olivine gabbros recovered at Ocean Drilling Program Hole 735B on the Southwest Indian Ridge during Leg 176, yield information on the magmatic/hydrothermal transition beneath spreading ridges. The microscopic veins found are composed of the high temperature silicate minerals, clinopyroxene, orthopyroxene, brown amphibole, and plagioclase. An important feature of these veins is the "along-vein-variation" in mineralogy, which is correlated with the magmatic minerals that they penetrate. Within grains of magmatic plagioclase, the veins are composed of less calcic plagioclase. In grains of olivine, the veins are composed of orthopyroxene + brown amphibole + plagioclase. In clinopyroxene grains, the veins consist of plagioclase + brown amphibole, and are accompanied by an intergrowth of brown amphibole + orthopyroxene. Occurrence of the intergrowth is completely symmetrical relative to the veins, indicating an intimate genetic relationship between them. The "along-vein-variation" can not be explained if these veins were crystallized from silicate melts. Consequently, these veins and nearby intergrowth are most likely to be formed by the reaction of magmatic minerals with fluid phases under the conditions of low fluid/rock ratios. Very similar intergrowths of brown amphibole + orthopyroxene are observed in clinopyroxene grains with "interfingering" texture. Similarities between the two kinds of intergrowths in terms of their petrographical features and the chemical compositions of their minerals indicates that these intergrowth textures were formed concomitantly under essentially the same conditions and by the same process. Comparison of the temperatures calculated for pyroxenes in these intergrowths with those of the magmatic pyroxenes indicates that the temperature conditions were gradational from magmatic to the intergrowth/vein forming stage. This suggests that the penetration of fluids and formation of intergrowths occurred during the latest stage of magmatic crystallization under the conditions of granulite to higher amphibolite facies, about 940-800 C. Textural evidence of the veins and the intergrowths also suggests that penetration of the fluids predated complete solidification of the gabbroic crystal mush as well as ductile deformation.

It is most plausible that the fluids responsible for the veins and intergrowths originated from evolved mafic magma by exsolution at high temperatures, because it is believed, in general, that the penetration of seawater does not predate the ductile deformation within Layer 3 gabbros of the slow-spreading ridges. Mafic magmas became enriched in fluid phases with evolution and saturated in fluid in the latest stages. It was proposed, based on fluid inclusion data, that the exsolution of fluid from the latest stage magma took place at temperatures greater than 700 C in the MARK area of the slow-spreading Mid-Atlantic Ridge. No obvious mineralogical expression, however, has been found for these magmatic fluids. The veins found in the Hole 735B gabbros yield mineralogical evidence for the migration of high-temperature fluid derived from the late stage mafic magma beneath the slow-spreading Southwest Indian Ridge. The veins described here may not be restricted to slow-spreading environments, and may be found also at fast-spreading ridges. If so, the evidence for hydration of gabbros at temperatures of 800-600 C at fast-spreading ridges, without axial faults and high-temperature ductile shearing in deep crust, can be explained by the exsolution of magmatic fluids without incorporation of seawater at such high temperature conditions.