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Felsic veins in gabbros of the lower crust from slow-spreading mid-ocean ridges – evidence for deep percolating of hydrothermal fluids in the magmatic regime

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Although in general basic in composition, the lower oceanic crust consisting of gabbro also contains evolved, SiO2-enriched lithologies (often named "oceanic plagiogranites"), but generally only in small amounts (< 1 vol% of the crust). Only from slow-spreading ridges mostly cm thick veins of SiO2-rich rocks are known (so-called felsic veins), cutting the lower, plutonic crust at many places. We focus here on two IODP (International Ocean Discovery Project) drillings into the lower gabbros from the Atlantis Bank at SWIR (Southwest Indian Ridge; Expedition 176 and 360), both showing hundreds of such veins. For the formation of these veins showing compositions from diorite to trondhjemite, three models are suggested: (1) last step of MORB differentiation, (2) hydrous partial melting of gabbro, and (3) liquid immiscibility.

Based on detailed petrographic/microanalytical observations and bulk chemical results we show here that these veins have been formed by partial melting of gabbro triggered by hydrothermal fluids percolating in shear zones at very high temperature in the magmatic regime. This result is based on three independent lines of evidence: (1) most gabbros hosting felsic veins show those typical microstructures characteristic for hydrous partial melting of gabbro. (2) Some magmatic amphiboles generated by the partial melting process both as residual phases in the gabbro and as crystallization product in the felsic melt show elevated chlorine contents implying a formation by seawater-derived fluids. (3) Bulk compositions of the veins in combination with MELTS modeling as well as trace element modeling argue for a formation of these veins by partial melting of gabbro and against formation models of late stage differentiation or liquid immiscibility. Considering the temperature of the wet solidus of an evolved gabbro (oxide gabbro) of ~ 800°C (Koepke et al., 2018) and the high number of felsic veins counted in the gabbro cores, we conclude that a large part of the Atlantis bank gabbro body prevailed at very high temperature in a wet environment, which has an impact of the overall rheology of the core complex at depth.

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