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Cu refertilization of abyssal harzburgites by melt percolation

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Primitive mantle is depleted in many elements by partial melting processes, but it can be subsequently refertilized by impregnation with percolating melts. It is known that Cu can be enriched in primitive melts, depleting mantle residue, due to the former process (Patten et al. 2013). However, the behavior of Cu in the processes of mantle-melt interaction is poorly understood. The only comprehensive study is based on compositions of orogenic peridotites, representing the subcontinental mantle (Lorand et al. 1993; 2013), where a moderate enrichment of the mantle in Cu (up to $\sim$50 ppm) has been observed. Here, we present the first results obtained for a suite of rocks from an oceanic core complex (OCC), the Kane Megamullion at 22°30'N at the Mid-Atlantic Ridge (Dick et al. 2008). OCC's provide large exposures of mantle and lower crustal rocks on the seafloor on detachment fault footwalls at slow and ultraslow spreading ridges. The mantle rocks are composed of spinel and plagioclase harzburgites. The spinel harzburgites represent depleted mantle, whereas the plagioclase harzburgites were formed by subsequent late-stage melt impregnation in the depleted mantle (Dick et al. 2010). We have determined Cu concentrations in 22 residual spinel harzburgites and 4 plagioclase harzburgites using total digestion ICP-MS.

The average Cu concentration in spinel harzburgites is 35$\pm$11 ppm Cu (2σ). The average Cu concentration obtained for plagioclase harzburgites is 131$\pm$33 ppm Cu (2σ). Additionally, we have analyzed one 1.5 cm thick contact zone between an oxide gabbro vein and residual peridotite. The contact zone, which has been heavily impregnated by the melt, contains 284 ppm Cu. In contrast, the neighboring oxide gabbro vein and the hosting peridotite contain 147 and 68 ppm Cu, respectively. Furthermore, we have determined the concentration of Cu in a dunite (118 ppm), formed in a reaction between the mantle and melt ascending through the lithosphere (Dick et al. 2010).

Magmatic processes in the rocks coming from OCCs can be obscured by deformation and alteration. Plastically deformed rocks are common in the damaged zone related to the detachment fault. Metaperidotites from these zones, which show protomylonitic to ultramylonitic textures, are systematically depleted in Cu (15$\pm$5 ppm, 2σ) in comparison to non-deformed spinel harzburgites. We have not included the values obtained from non-deformed harzburgites in the calculation of the averages presented above. Thus, the effect of deformation processes does not influence our results. The relatively narrow 0.95 confidence intervals of the means obtained for non-deformed spinel and plagioclase harzburgite species and a large difference between the two means indicate a relatively low influence of alteration. Therefore, we believe the significant enrichment in Cu exhibited by the refertilized mantle rocks is caused exclusively by mantle impregnation with late-stage melts. Enhanced Cu concentrations indicate that the scale of this enrichment can be significantly underestimated in previous studies (Lorand et al. 2013).

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