Melt inclusions and olivine growth in MORB – what can we learn from phosphorus and $\delta^{18}O$?

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Melt inclusions (MI) from euhedral primitive olivine have been proposed to represent aliquot of the primitive melt composition, unaffected by subsequent processes occuring near the Earth's surface. Much larger compositional variations are generally observed in MIs than in glasses, which has often been interpreted to represent small-scale mantle-heterogeneity. In this study, we measured $\delta^{18}O$ in 22 MI from a MORB sample from the FAMOUS zone (North Atlantic). SIMS analyses, performed with the 1280-HR SIMS housed at the Université de Lausanne, reveal >2.5‰ variations (4.5-7.1‰) in $\delta^{18}O$ between different MIs from a single sample, whereas MORB glasses have a narrow $\delta^{18}O$ range (5.5±0.3‰). Based on our analyses, the $\delta^{18}O$ of MIs are not simply correlated with any major, trace or volatile elements. Furthermore, the $\delta^{18}O$ of some of the analyzed MIs are not found to be in equilibrium with their host olivine.

Phosphorous X-ray maps reveal complex zoning in some euhedral olivines, which can be interpreted as reflecting rapid crystal growth [1, 2]. A low-phosphorous (~30ppm) zone surrounds MIs located in high-phosphorous (>1000 ppm) regions. NanoSIMS profiles across these zones suggest that the low-P zone around the MIs is due to dissolution of the host-olivine followed by later precipitation of a new olivine halo around the MI, which is in agreement with the observation of [1].

Our results suggest that some MIs in this sample originally represent melts undersaturated in olivine, with a composition in $\delta^{18}O$ which is not in equilibrium with the fast growing olivine. The origin of these melts is currently being further investigated. We propose that some of the variations in $\delta^{18}O$ between different MIs might result from the process of MI formation.

1- Milman-Barris et al., Contrib. Min. Pet 155, pp. 739-765
2 - Welsch et al., Geology, 42, pp. 867-870