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The Fe^{3+} partitioning in crust-derived fluid phases and implications for the slab-to-mantle element transfer

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The redox processes taking place in the portion of the mantle on top of the subducting slab is poorly investigated and the oxidising (or reducing) power of crust-derived fluids phases is still unknown.

A case study of suprasubduction mantle affected by metasomatism from crust-derived fluid phases is represented by garnet orthopyroxenites from the Maowu Ultramafic Complex (China) deriving from harzburgite precursors metasomatised at ~ 4 GPa, 750 °C by a silica- and incompatible trace element- rich fluid phase. This metasomatism produced poikilitic orthopyroxene and inclusion-rich garnet porphyroblasts. Solid multiphase primary micro-inclusions in garnet display negative crystal shapes and infilling minerals (spinel, amphibole, chlorite, talc, mica) occur with constant volume ratios indicating that derive from trapped solute-rich aqueous fluids (Malaspina et al., 2006). The epitaxial relationship between spinel and host garnet, and between some hydrous minerals has been demostrated by single-crystal X-ray diffraction experiments (Malaspina et al., 2015). Epitaxy drives a first-stage nucleation of spinel under near-to-equilibrium conditions, likely promoted by a dissolution and precipitation mechanism between the UHP fluid and the host garnet. A second-stage nucleation involved hydrous phases, which nucleate in a non-registered manner and under far-from-equilibrium conditions. Imaging FT-IR and micro-Raman spectroscopy, together with X-Ray microtomography performed on single inclusions indicate that free water is still preserved in spinel-free inclusions.

To investigate the redox budget of these fluid phases, we measured the Fe^{3+} concentration of the microprecipitates of multiphase inclusions using EELS on a TEM. Results indicate that spinel contain up to 12% of Fe^{3+} with respect to total iron, amphibole about 30%, while inclusion phases such as chlorite and phlogopite may contain up to 0.70 of $Fe^{3+}/\Sigma Fe$. The $Fe^{3+}/\Sigma Fe$ of the host garnet has been measured both by Flank Method electron probe microanalyses and EELS and corresponds to 0.10. An oxygen mass balance between crust-derived fluids and the host rock indicates that fluid precipitates appear more oxidised than the host rock. This suggests that even after their interaction with the metasomatic orthopyroxenites, the residual fluid phases could be potentially carrier of oxidised components when escaping the slab-mantle interface.

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