The redox budget of crust-derived fluid phases: a snapshot of the slab-mantle interface

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The redox processes taking place in the portion of the mantle on top of the subducting slab are poorly investigated and the redox budget of crust-derived fluid phases is still poorly constrained. A case study of supra-subduction mantle affected by metasomatism from crust-derived fluid phases is the Maowu Ultramafic Complex (China) deriving from harzburgite precursors metasomatised at ~4 GPa, 750-800 °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, ±orthopyroxene, amphiboles, chlorite, ±talc, ±mica) occur with constant modal proportions, indicating that they derive from trapped solute-rich aqueous fluids. FT-IR hyper spectral imaging analyses and micro-Raman spectroscopy, together with X-Ray microtomography performed on single inclusions indicate that liquid water is still preserved at least in some inclusions.

To investigate the redox budget of these fluid phases, the Fe^{3+} concentration of the micron-sized precipitates of the multiphase inclusions has been measured for the first time using EELS on a TEM. Results indicate that spinel contains up to 12% of $Fe^{3+}/\Sigma Fe$, amphibole about 30%, while the ratio in inclusion phases such as chlorite and phlogopite may reach 70%. The Fe^{3+} fraction of the host garnet is equal to that measured in spinel as also confirmed by Flank Method EPMA measurements.

Forward modelling fO_2 calculations indicate that the garnet orthopyroxenites record $\Delta FMQ = -1.8 \div -1.5$, resulting apparently more reduced with respect to metasomatised supra-subduction garnet-peridotites. On the other hand, oxygen mass balance, performed both on the Maowu hybrid orthopyroxenite and on metasomatised supra-subduction garnet peridotites, indicate that the excess of oxygen (nO_2) is the same (10 mol m^{-3}). An oxygen mass balance of the crust-derived fluids also indicates that the fluid precipitates are more oxidised than the host rock, reaching up to 400 mol m^{-3} of nO_2. 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.