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Tracing fluid-rock interactions in the subducted slab: insight from the Theodul Gletscher Unit (Western Alps, Switzerland)

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Subduction of oceanic and continental crust leads to dehydration reactions that liberate fluids, which can interact with surrounding rocks at depth. The Theodul Gletscher tectonic Unit outcrops within the Zermat Saas ophiolite (Western Alps) consists of an association of schists and mafic boudins that underwent eclogitic facies metamorphism during Alpine subduction (2.2±0.1 GPa and 580±50 °C; [1]). Schists located close to an eclogitic boudin systematically display textural evidences for fluid rock interaction suggesting heterogeneous fluid activity and permeability at the outcrop scale.

In order to characterise the fluid rock interaction along the P-T evolution, garnet was targeted since it preserves prograde to peak metamorphic zoning for major elements and is present in every lithology of the tectonic unit. The contact zones between schists and eclogitic boudins are characterized by the occurrence of euhedral garnet porphyroblasts within the schists. The size (ranging from several cm to tens of μm in diameter) and abundance of garnet increase towards the contact. Garnet investigated under BSE imaging and analysed by quantitative chemical mapping show evidence of a multi-phase history. In the schists, garnet grains are composed of a fractured Fe-rich core and a Fe-Ca-rich rim. The textural relationships between the two garnet compositions suggest fracture filling of the core by the new generation, rim-core replacement and merging of distinct grains during rim growth. Garnet in the eclogite displays both normal growth zoning and complex textures, similar to what is observed in the schists.

In situ oxygen isotope analyses of garnet porphyroblasts in the schists show a marked change in δ18O signatures from 12‰ in the core to 4‰ in the rim, this decrease is coherent with chemical zoning observed for major elements. Several permils of variation is significant for oxygen isotopic composition and is a good evidence for open system behaviour. We interpret this as the consequence of fluid exchanges between schists, mafic boudins and surrounding ultramafic rocks. This petrological, micro-textural and geochemical investigation highlights multiple stages of fluid exchanges and possibly diverse fluid sources and pathways during prograde to peak subduction.

[1] Weber and Bucher (2015), Lithos 232, 336-359