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Fluid metasomatism in eclogite facies (Alpine Corsica) documented by microscale oxygen analysis of garnet

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The presence of aqueous fluids and/or melts is a necessary condition for the transport of elements during metamorphism, particularly in the relatively cold subduction environment. The major dehydration and melting reactions during subduction are well known from phase equilibria studies. However, it is more difficult to trace the fluid pathways, their chemical signature and quantify element transport across the subducting slab.
We present detailed microtextures, major and trace element geochemistry and in-situ oxygen isotope analysis of garnet in an eclogite facies rock to reconstruct its evolution and constrain fluid infiltration at high pressure. The lawsonitite is part of a continental sliver located in a former tectonic contact and now sandwiched between metasediments and serpentinites from Alpine Corsica. The sample shows a peculiar bulk composition characterised by high $Al2O_3$ and CaO contents. It is composed of lawsonite (75%), albite, garnet, amphibole, titanite, chlorite, pumpellyite and epidote. Garnet forms anhedral, rounded crystals that occasionally have atoll shape. They preserve strong zoning with four different domains with distinct major and REE compositions (Martin et al., 2011).
The lawsonitite originated from a Permian granulite, as recorded by relict garnet cores and metamorphic zircons dated at 292.5±3.3 Ma. The δ18O of garnet cores is 9.7±0.6‰ and the δ18O of the bulk rock, as recalculated from a suitable paragenesis, is >11‰This value is within the range of crustal sediments.
Garnet mantle and rims document a complex Alpine history in the lawsonite-blueschist and lawsonite-eclogite facies, respectively. Garnet mantles show a typical, prograde depletion in Mn toward the rims. δ18O values are constant throughout the mantles and equal to 7.6±0.5‰ from which a δ18O >10‰ can be recalculated for the bulk rock. This indicates that the hydration of the former granulite and the development of the first hydrous high pressure assemblage did not produce a significant shift in bulk rock oxygen composition.
At the metamorphic peak (490-550°C and 2.2-2.6 GPa, Vitale Brovarone et al. 2011), the sample experienced Ca-metasomatism that triggered pervasive crystallisation of lawsonite and formation of atoll garnet. Alpine zircon rims date this stage at 34.4±0.8 Ma. The garnet inner and outer rims formed at the peak and during early retrogression respectively. Both domains have δ18O values of 5.4±0.5‰ corresponding to a δ18O of ~8‰ for the bulk rock. The abrupt decrease in δ18O between garnet mantle and rim indicate that the lawsonitite experienced pervasive fluid influx, characterised by a high fluid/rock ratio.
Potential source lithologies for this metasomatism are the surrounding mafic and ultramafic rocks (gabbro 4-9‰ or peridotite/serpentinite 4-7‰ Miller et al., 2001). In fact, nearby eclogites display high-pressure veins, providing evidence for localised fluid production within the mafic rock units. Such fluid must have been channelled at the lithological boundary between metasediments and serpentinites where it triggered extensive recrystallization removing alkaline elements and Si, and adding Ca and water. Our study highlights how the combination of petrology and in-situ isotope geochemistry can be used to track the timing and conditions of fluid extraction zones in subduction zones.