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Trace elements and oxygen isotopes in garnet for reconstructing metamorphic reactions and fluid-rock interaction

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The capacity of garnet to preserve successive growth stages over the *P–T* evolution of the host rock remains unsurpassed. The distributions of major elements, trace elements and oxygen isotopes, can be mapped at high spatial resolution to decode this information. The combination of experimental studies and investigation of natural samples is needed to determine the systematics of garnet compositional zoning and translate it into petrological information.

Trace element mapping of garnet from different metamorphic settings reveals that different categories of elements record distinct mineral reactions and that trace elements zoning in garnet is related to growth conditions (Rubatto et al. 2020). During sub-solidus growth of garnet, Y+REE zoning is mainly controlled by Rayleigh fractionation with the sporadic breakdown of accessory phases producing annuli. However, additional processes overprinting equilibrium growth can be recognised. Fluid-induced garnet replacement can decouple major elements from compatible trace elements, whereby only the major elements are subject to replacement along veinlets. Trace element zoning can also reveal inheritance from precursor and neighbouring phases, such as epidote, lawsonite and biotite. At higher temperature, partial melting results in enrichment of V and Cr in garnet due to mica consumption, as well as Zr, Y and HREE from dissolution of zircon and monazite.

In situ oxygen isotope analyses of garnet are particularly suitable to retrieve information on fluid-rock interaction. In eclogite facies rocks that underwent relatively low T conditions (<600°C), the different isotopic compositions of garnet growth zones within and across samples is preserved and can assist in determining the pervasive or localized nature of fluid flow. In different metamorphic units, garnet is instrumental in recognising high-pressure fluid-rock interaction versus inherited alteration from previous stages (Vho et al. 2020, Bovay et al. 2021). Supported by thermodynamic and geochemical modelling, the oxygen isotopic composition of garnet can be translated into time-integrated fluid fluxes at specific stages of the *P–T* path.

At higher temperatures, diffusion of oxygen isotopes has to be considered, but remains poorly constrained. The results of a comprehensive experimental study (Scicchitano et al. 2022) show that the diffusivity of oxygen is similar to Fe-Mn diffusivity at 1000-1100 °C. However, the activation energy for O diffusion is larger, leading to lower diffusivities at *P*–*T* conditions characterizing crustal metamorphism. Therefore, original oxygen isotopic signatures can be retained in garnet showing Fe-Mn element zoning partially re-equilibrated by diffusion.

Scicchitano MR, Jollands MC, William IS, Hermann J, Rubatto D, Kita NT, Williams ON, Valley JW, Escrig S, Meibom A (2022) American Mineralogist, doi.org/10.2138/am-2022-7970

Bovay T, Rubatto D, Lanari P (2021) Contribution to Mineralogy and Petrology, 176:55, doi.org/10.1007/s00410-021-01806-4

Rubatto D, Burger M, Lanari P, Hattendorf B, Schwarz G, Neff C, Keresztes Schmidt P, Hermann J, Vho A, Günther D (2020) Contribution to Mineralogy and Petrology, 175:61, doi.org/10.1007/s00410-020-01700-5

Vho A, Rubatto D, Lanari P, Giuntoli F, Regis D, Hermann J (2020) Contribution to Mineralogy and Petrology, 175:109, doi.org/10.1007/s00410-020-01745-6