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Growth, replacement and element diffusion in metamorphic garnet revealed by trace element mapping

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Garnet is one of the most robust and ubiquitous minerals that record element zoning during crustal metamorphism. In addition to major element distribution, zoning in trace elements can provide a wealth of information to document the changing conditions of garnet growth and modification. Trace element distribution in garnet grains was mapped in 2D in thin section with laser ablation inductively coupled plasma time of flight mass spectrometry (LA-ICP-TOFMS) and conventional LA-ICP-MS to achieve a lateral resolution of 15-5 μm and limits of detection for the heavy rare earth elements (REE) down to 0.2 $\mu\text{g/g}$ (Rubatto et al. 2020).

In granulite-facies garnet, major elements show diffusional resetting, whereas trace elements still largely document the growth history. Enrichment of trace elements in the garnet mantle is attributed to the consumption of biotite (V, Cr) and the dissolution of zircon (Zr) and monazite (Y+REE) in the coexisting melt. Lu is notably enriched in the garnet mantle with implications for geochronology. The gradual zoning of Y+HREE between mantle and core is reconcilable with diffusion over $\sim 200 \mu\text{m}$ in 10 My at temperatures of 750–800°C

In amphibolite facies garnet, Y+REE trace element zoning closely matches the growth zoning in Ca with no notable diffusive modification. Y+REE zoning is dominated by Rayleigh fractionation in the core and in the outer zones it shows annuli that mark the sporadic breakdown of accessory phases.

Garnet in eclogite facies samples that underwent fluid-rock interaction show growth zoning in major and trace elements, with local oscillations and sectors. In certain samples, the overall distribution of REE can be reconciled with diffusion-limited uptake. Where garnet displays fluid-related veinlets, visible in major elements, that cross-cut the primary growth zoning, the regular Y+REE and Cr growth zoning is not affected by the veinlets. This indicates that the veinlets did not form by a crack-seal mechanism but are rather related to a selective replacement process.

References

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