On zircon petrogenesis during high-grade metamorphism: a correlation of in situ and "in context" U-Pb, Lu-Hf, δO, REE and the input of local equilibrium

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Zircon is one of the key minerals used to characterize metamorphic stages, as it is ubiquitous in most rocks and provides qualitative petrogenetic insights through its Trace Element (TE) record. Decoupling or uncoupling between U-Pb ages and chemistry have however been documented, hampering P–T correlation and large-scale interpretations. This study builds on the well constrained P-T-t evolution of the variscan Najac eclogite described by Lotout *et al*. (2018), the prograde and peak eclogitic conditions of which have been dated via Lu-Hf and Sm-Nd on garnet at 382.8±1.0Ma and 376.7±3.3Ma respectively. Despite a single concordant age of 385.5±2.3Ma, similar to the garnet Lu-Hf age, the eclogitic zircon grains recorded variable Rare Earth Element (REE) patterns, positive, negative or no Europium anomalies (Eu*), and variable enrichment in Heavy-REE (HREE) (Lotout et al., 2018).

New U-Pb, Lu-Hf, δO^{18} and TE analyses were performed in-context on thick sections from this eclogite via SIMS (U-Pb, δO^{18}) and LA-SS-ICPMS (Lu-Hf, TE). Zircon is found in 4 textural positions: included in garnet, in symplectite, or in contact with post-eclogite facies amphibole or Fe-Ti oxides. New U-Pb data range from 415 to 360Ma, a variability that was not previously documented. Large zircon grains, up to 1mm in size, record magmatic emplacement of the eclogite protolith at ca. 415 Ma, preserving an initial ε_{Hf} of 11.1, negative Eu*, enrichment in HREE and relatively stable δO^{18} of ca. 8‰. The remaining grains present an important variability with either positive, negative or no Eu*, enriched or flat HREE patterns, ε_{Hf} ranging from 8 to 14.6 and δO^{18} spreading from -0.69±0.49 to 9.01±0.3‰. The different REE patterns are found indistinctively in zircon CL zones *i)* whose ages are either older, similar to or younger than the one of garnet, and *ii)* display ε_{Hf} values not related to the magmatic stage, *i.e.,* zones not disturbed by U-Pb resetting. Consequently, garnet crystallization in the sample did not consistently influence the zircon REE record. Zircon grains associated with Fe-Ti phases systematically present the lowest δO^{18} values, grains found 2cm apart show a δO^{18} variation higher than 6‰ despite the same U-Pb age, while zircon grains in an area <0.5mm² exhibit a δO^{18} variation of 2‰, testifying to grain scale control of redox conditions and fluid interaction.

This study confirms the robustness of the ε_{Hf} to decipher new zircon growth from recrystallisation, documents more precisely the inherited REE spectrum in zircon that postdates garnet growth, and testifies to the strong control of equilibrium at the grain scale in the δO^{18} zircon record. The absence of direct correlation between REE, U-Pb, ε_{Hf} and δO^{18} highlights that zircon can record multiple local chemical equilibrium and redox states during its metamorphic journey. Therefore, the use of REE in zircon to ascertain the specific paragenesis to which it belonged is not straightforward.

Lotout, C., Pitra, P., Poujol, M., Anczkiewicz, R., & Van Den Driessche, J. (2018). Timing and duration of Variscan high-pressure metamorphism in the French Massif Central: A multimethod geochronological study from the Najac Massif. *Lithos*, *308*, 381-394.