Taking the pulse on orogens through zoned garnet Lu-Hf chronology: example of an Eo-Alpine metapelite

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Résumé

Garnet Lu-Hf chronology is among the most reliable methods to precisely date high-pressure and -temperature metamorphism. Conventionally, this technique is done on bulk grains or grain populations, providing grain-averaged ages that may not inform on individual growth pulses. Domain dating, i.e., dating of individual growth zones, would allow dating of such pulses but has so far been challenging for "common-sized" grains, due to sample size requirements and sample loss using conventional micro-mill sampling. To overcome these limitations, we developed a new method that combines low-loss micro-sampling by laser cutting with a refined Lu-Hf routine.

We applied this method to date multiple growth zones in a single 1.3 cm-sized garnet grain from a mica-schist from the Schneeberg Complex, Austria. The garnet grain was chemically characterized by major- and trace-element mapping (EPMA, LA-ICPMS) and five compositionally distinct micro-domains were extracted using a laser mill. Each single zone was divided into multiple garnet aliquots to enable multi-point isochrons. The four inner zones, corresponding to ¯˜ 85% of the total garnet volume, yielded identical ages with a weighted mean of 98.4 ± 0.1 Ma (2σ). The outermost zone shows a strong chemical contrast with the rest of the grain. This zone yielded a resolvably younger age of 97.8 ± 0.3 Ma. The timing of distinct garnet-growth episodes, together with the variations in trace-element chemistry, were evaluated in terms of mineral reactions.

Our new protocol for Lu-Hf domain geochronology of "common-sized" garnet allows distinct pulses and pauses of garnet growth to be resolved within less than 1 Ma. The data show that garnet growth in metapelites may take less than 1 Myr. Our results demonstrate that garnet growth occurs much faster than changes in P-T conditions caused by tectonic processes. This style of growth likely reflects reaction overstepping and the rapid pushes of the system to attain equilibrium during periods of efficient matrix element transport. Domain dating opens new possibilities for constraining the causes and rates of garnet growth in metamorphic rocks and determining the pace of associated tectonic processes.

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Mots-Clés: grenat, pétrochronologie, Lu, Hf, geochronologie