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Pushing the limits: U-Pb dating of garnet by LA-MC-ICPMS at sub-ng/g U levels

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Recent advances in analytical techniques and instrumentation allow the analysis of ever smaller sample volumes and lower concentrations, which significantly expands the possibilities of in-situ geochronology, e.g. LA-MC-ICPMS. Minerals with low U and Pb contents become the target of in-situ U-Pb geochronology. Isochrons can be obtained potentially from one single (sub-)mm-sized garnet grain in thin sections. In this contribution, we explored the current limits of in-situ U-Pb geochronology: what are the minimum concentrations from which an accurate and precise U-Pb age can be obtained?

For that purpose, we have analysed low-U garnets from two ultrahigh temperature granulite xenolith, one garnet-bearing diorite and one vein-related almost pure andradite (demantoid) sample. The measurements were carried out at FIERCE using a Neptune Plus MC-ICP-MS coupled to a RESOLution-LR ArF Excimer laser. The analyses were performed in static mode measuring the masses ^{206}Pb and ^{207}Pb with Secondary Electron Multiplier (SEM) and ^{202}Hg, ^{204}Pb and ^{238}U with the Multiple Ion Counters (MIC). With a spot diameter of 193 µm (round) and a fluence of 2 J/cm^2 at 15 Hz ca. 18 µm pit depth was ablated in 18s analysis time, resulting in a total to 2 µg of ablated material. This is more than 2,000 times less material compared to conventional analyses by isotope dilution and 3,000 times less U as for a typical LA-ICPMS zircon analysis (20 µm spot). About 15–30 spot analyses are sufficient for a regression line in the Tera-Wasserburg diagram, yielding a precision of typically <3 % for the lower intercept age.

The Uranium concentration in the investigated granulitic and demantoid garnet crystals is generally ≤1 ng/g. The garnet crystals from the granitoid have slightly higher U concentrations of up to 10 ng/g. The diorite U-Pb age replicates the published Lu-Hf ages and the Mesoarchean garnet ages of the granulites record successive high-grade metamorphic events and can be well coincided with discrete magmatism in the Archean during early cratonization and crustal differentiation. The age of the demantoid represents the first data of the veins cross-cutting older rock units. Challenges and details of the method will be discussed.