Calcic garnets as a promising U-Pb geochronometers

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Calcic garnets are an important – although somewhat neglected – member of the garnet group. Typically, these mineral are members of complex solid solutions involving largely substitutions in the Fe^{3+}/Al and Si sites and at least eight different end-members. The absolute majority of garnets in this family are Ti-Mg-Fe^{2+}(± Al ± Zr)-bearing andradite transitional to morimotoite and schorlomite. Importantly, these garnets occur as common accessory minerals in a wide range of igneous and rocks, including nepheline syenites, alkali feldspar syenites, melteigite-urtites, nephelinites, melilitolites, melilitites, calcite carbonatites, ultramafic lamprophyres, orangeites, contaminated kimberlites, skarns and rodingites. Calcic garnets have a great capacity for atomic substitutions involving high-field-strength elements and, even more importantly, rare earths (up to 4000 ppm, including Y), Th and U (both up to 100 ppm) at low levels of common Pb. Their $(La/Yb)_{cn}$ ratio varies over two orders of magnitude (from < 0.01 to ~1), making these minerals a sensitive indicator of crystal fractionation, degassing and other magma-evolution processes.

Given these unique compositional characteristics and surprising lack of interest in these minerals in the previous literature, we explored the possibility of using calcic garnets as a U-Pb geochronometer. For this purpose, we selected samples of well-crystallized igneous garnet from four very different rock types of different age, including: carbonatite (Afrikanda) from the Devonian Kola Alkaline Province, carbonatite from the Neoproterozoic Belaya Zima complex (Central-Asian mobile belt), ijolite from the Chick Ordovician igneous complex (Central-Asian mobile belt), granitic pegmatite from the Eden Lake complex in the Paleoproterozoic Trans-Hudson orogen, and feldspathoid syenite from the Cinder Lake alkaline complex in the Archean Knee Lake greenstone belt.

U-Pb TIMS ages of the studied garnets are mostly concordant and reveal perfect correspondence with reported U-Pb zircon or perovskite ages as well as Sm-Nd isochrone age for these complexes. Therefore we can advertise calcic garnets as a promising tool for U-Pb geochronological studies.

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