Understanding preservation of primary signatures in apatite by comparing matrix and zircon-hosted crystals from the Eoarchean Acasta Gneiss Complex (Canada)

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A novel way to investigate the petrogenesis of ancient poly-metamorphosed terranes is to use zircon as a vessel and study protected mineral inclusions which are sensitive to melt evolution such as apatite. Recent contributions have shown that zircon-hosted apatite inclusions of unmetamorphosed granitoids can provide valuable petrogenetic information about a given pluton and, in turn, represent a way to circumvent effects of metamorphism. Yet, the impact of metamorphism on apatite inclusion has never been studied in detail. To address the issue of chemical and isotopic preservation of primary signals in apatite crystals both in the matrix and armored within zircons, we have studied apatite crystals from four 3.6-4.0 Ga orthogneisses of TTG affinity from the Acasta Gneiss Complex (Canada). Our results demonstrate that U-Th-Pb isotope systematics in matrix apatite crystals are reset at the time of the Wopmay orogen (1.8-1.7 Ga) whereas primary REE signatures were preserved in many crystals. On the contrary, zircon-hosted apatite inclusions all preserved primary REE signatures despite U-Th-Pb isotope systematics giving ages between 1.7 and 4.0 Ga. We interpret the variable resetting of these ages as a consequence of radiation damage accumulation in zircon lattice. Only the most pristine zircon has an apatite inclusion with a concordant age consistent with the magmatic age of the zircon (4.0 Ga). In addition, our results show that apatite crystals from TTG have distinct REE composition from post-Archean granitoids apatites, and that even apatites with reset ages preserved some of the chemical signatures characterizing TTG compositions (e.g. HREE). This capacity to retain primary information together with its discriminating power for granitoids makes apatite a very valuable tool for reconstructing the nature and evolution of ancient crustal rocks through the use of either detrital minerals or detrital-zircon hosting inclusions.