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Using apatite to unravel the complex evolution of primitive crusts: example from the Western Dharwar craton (India)

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Apatite, $Ca_5(PO_4)_3(Cl,F,OH)$, is ubiquitous in continental lithologies and can form during both magmatic, metamorphic and metasomatic events, therefore, offering a means to potentially record all processes that the continental crust experienced [1]. Several geochemical tools can be applied to apatite in order to obtain chronological and source information [2,3]. In this study, we analyzed apatite crystals from Archean granitoids using a multi-tool approach involving CL images, trace element concentrations, as well as U-Th-Pb, and Rb-Sr isotopes. This study focuses on the Western Dharwar Craton (India) which comprises Archean rocks (3.4-2.5 Ga) including diverse granitoids (TTG suite, potassic granites, sanukitoids) affected by lower-amphibolite to granulite facies metamorphism. Our goal is to evaluate the capacity of apatite to record granitoid basement histories.

Apatite crystals were imaged by cathodoluminescence and analyzed by LA-ICP-MS for trace-element concentrations and U-Th-Pb ages. Apatites and their host-rocks were measured for Rb-Sr isotopes by LA-MC-ICP-MS and TIMS, respectively. Within the same rock, apatite crystals display very diverse textures, trace-element concentrations, U-Th-Pb ages (time span of ~2 Ga), and Sr isotopic compositions ($^{87}Sr/^{86}Sr \sim 0.700$ to 0.710).

Our results show a strong consistency between apatite textures, REE patterns, Light Rare Earth Element concentrations, and Sr isotope signatures, which altogether allow the distinction between magmatic and post-magmatic event(s). Moreover, the Sr isotopic compositions of the least radiogenic apatite crystals are consistent with that of their host-rock, thereby reinforcing our interpretation of their magmatic origin. Contrary to other tools, U-Th-Pb ages in apatite appear quite complex and not correlated with trace elements, nor Sr isotopic data. We propose that Pb mobility is responsible for observed complexities which affected our capability to resolve growth/recrystallization/perturbation events in analyzed crystals. Although our data do not fully constrain the timing, or duration of crustal processes, our study highlights the strength of apatite to record multiple events (magmatic, metamorphic and metasomatic) that the continental crust experienced, provided that apatite is studied using a multi-tool approach.

References: [1] Bruand et al. (2020) *GPL* 13; [2] Antoine et al. (2020) *Gcubed* 21; [3] Emo et al. (2018) *GCA* 235