Title: Evaluating zircon trace element proxies for Archean tectonic provenance using suites of cogenetic zircon from the Acasta Gneiss Complex

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Abstract: Covariation of trace elements (TE) U, Nb, Sc, Yb, Gd, and Ce in zircon has been shown to track Phanerozoic whole-rock based plate-tectonic discriminators and is therefore useful in distinguishing amongst 'MOR-zircon', 'arc-like zircon', and 'plume-associated zircon' in modern plate-tectonic regimes (e.g., Grimes et al., 2007; 2015). Application of elemental ratios minimizes compositional variation due to temperature, allowing for robust comparison of different zircon populations. Application of these zircon TE proxies to deciphering tectonic settings in the Archean has been limited (e.g., Drabon et al., 2021; 2022) and questions remain about the degree to which the geologic processes responsible for various provenance signatures in the Hadean-Archean may have differed from relatively modern processes. Furthermore, the paucity of rocks and minerals preserved from the Hadean and early Archean means data from detrital zircons are the most abundant and most often used constraints on the Earth's earliest continental crust.

Here, we present paired zircon oxygen isotope and TE systematics from uniquely preserved meta-igneous rocks exposed in one of the oldest crustal terranes, the Acasta Gneiss Complex (NW Territories, Canada). The intact nature of Acasta means that while overall sample size remains small, cogenetic suites of zircon representing > 1 Ga of magmatism allows assessment of geologically meaningful geochemical populations when compared with detrital datasets. This geologic context is valuable, because even in modern settings, the interpretation of single or ambiguously related zircon TE analyses is more likely to result in erroneous provenance association. To evaluate primary zircon geochemistry, we employ a rigorous approach involving correlation of O-isotope and TE analyses with U-Pb isotope information, pre- and post-analysis imaging, and consideration of geochemical indicators of alteration, such as $^{16}OH/^{16}O$ and non-formula unit elements. This integrated workflow allows us to interrogate the suitability of proposed TE-based tectonic regime proxies to application in the early Earth system.

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