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Evolution of the Acasta Gneiss Complex through Sr isotope analysis of apatite inclusions in zircon

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The early evolution of Earth's continental crust can be studied through the analysis of Eoarchean and Hadean rocks. However, such rocks are often poorly preserved in the geological record. The Acasta Gneiss Complex (AGC), Northwest Territories, Canada, is one of the few areas where intact rocks of this age are found. Studies have suggested the involvement of a Hadean source in the formation of the AGC [1,2], yet the nature of this source remains enigmatic. Rb-Sr and Sr isotope analysis may be used to reveal the composition of this ancient source as the Rb-Sr system provides a potentially powerful proxy for crustal evolution and composition [3]. As Rb is a highly incompatible element, it is enriched in felsic reservoirs relative to Sr, and subsequently develops to higher 87Sr/86Sr with time. However, whole rock open-system behaviour is prevalent during metamorphism and hydrothermal alteration, and therefore the Rb-Sr system has thus far been underutilised in early crustal evolution studies. To avoid this issue, we analyse primary apatite inclusions preserved in robust zircon host crystals. Recent advances in laser ablation multi-collector inductively coupled plasma mass spectrometry now allows for 87Sr/86Sr analysis of small apatite inclusions within zircon (30-50 μm). These analyses can be combined with U-Pb age data of the host zircon grains to constrain the initial 87Sr/86Sr of rocks from the AGC. This result is then used to estimate the Rb/Sr value of the Hadean source of these rocks, and so investigate its composition and evolution. The data demonstrate that vestiges of intermediate to felsic rocks were present in the source of the AGC. These vestiges appear to be a so far underappreciated low-Sm/Nd and -Lu/Hf component of the Hadean Earth, which may have contributed to the unradiogenic 143Nd/144Nd and 176Hf/177Hf observed for some of Earth's oldest rocks.

References: [1] Reimink et al. (2016) Nat. Geosci. 9, 777-780. [2] Bauer et al. (2017) Earth Planet. Sci. Lett. 458, 37-48. [3] Dhuime et al. (2015) Nat. Geosci. 8, 552-555.