Archean TTG petrogenesis – The U/Pb-O-Hf isotopic perspective

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An understanding of the processes that generated the Earth's oldest continental crust remains elusive. Here, a multi-isotopic approach has been applied to constrain the petrogenesis of Archean TTG suites of SW Greenland via >250 analyses of zircon from 11 rocks ranging in age from 3.88 to 2.55 Ga. Samples include the most ancient tonalites of the Itsaq Gneiss Complex through to Neoarchean granitoids of the Qôrqut Granite Complex. Zircon grains were characterized by CL, SEM, reflected and transmitted light imaging. U/Pb ages were determined using SHRIMP RG, coinciding $^{18}O/^{16}O$ ratios were measured by SHRIMP II multi-collector, $^{176}Hf/^{177}Hf$ was subsequently acquired by LA-MC-ICPMS.

High spatial resolution techniques allow selective analysis of individual domains within zoned igneous zircon crystals, robustly recording protolith magma compositions. This information has been utilized to image the anatomy of Archean felsic crust, and resolve the processes of continental growth, differentiation and recycling that operated on the early Earth.

Zircon from the oldest, 3.88-3.70 Ga, tonalites records $\delta^{18}O$ compositions within 1‰ of mantle values ($\delta^{18}O$ mantle = 5.3±0.3), and initial ε_{Hf} values largely within ±1 epsilon unit of chondritic composition (calculated using $\lambda^{176}Lu = 1.867x10^{-11}yr^{-1}$). In contrast, Hf isotopic compositions of zircon from younger 3.69-2.55 Ga samples are sub-chondritic, suggesting an origin by the remelting of older Eoarchean rocks. Also of note is the prevalence of low $\delta^{18}O$ values, with 4 samples from 3.69 to 2.55 Ga, recording compositions 1-3‰ below mantle values.

A striking feature of the entire Archean dataset is the absence of high (>7‰) $\delta^{18}O$ values, highlighting the lack of recycled weathered supracrustal material in the genesis of the TTG. Such high values are observed in classic Phanerozoic 'I-type' granitic systems [1]. These petrogenetic variations present a graphic contrast to modern magmatism and reflect a secular shift in the style of felsic magmatism through Earth history.

[1] Kemp *et al.* (2007) *Science* **315**, 980-983.

Magnesium isotope profiles in deep-sea sediments

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Magnesium concentrations in deep-sea sediment pore-waters typically decrease steadily down-core due to precipitation of dolomite or clay minerals in the sediments or underlying basalt. To better characterize and differentiate these processes, we have measured magnesium isotopes in pore-waters from ODP sites in a range of oceanographic settings including. At sites with high organic carbon including the Benguela Current and California Borderland Basins, magnesium depletions are generally attributed to the precipitation of dolomite. At these sites, $\delta^{26}Mg$ values increase down-core by as much as 2‰ from an initial $\delta^{26}Mg$ seawater value of -0.75‰. As dolomite preferentially incorporates isotopically depleted magnesium [1], the increase in $\delta^{26}Mg$ and decrease in magnesium concentrations down-core is consistent with dolomite precipitation as the principle magnesium sink. In contrast, at sites with low organic carbon including the Bjorn Drift, the Equatorial Pacific, and the Ceara Rise, $\delta^{26}Mg$ values decrease down-core by as much as 1.5‰. Because clay minerals are enriched in ^{26}Mg [2], the decline in $\delta^{26}Mg$ and magnesium concentrations at these sites likely reflects cation exchange on and/or the precipitation of clay minerals.

Given the large difference in magnesium isotope profiles between sites dominated by carbonate and silicate magnesium sinks, we can use these profiles to test conventional interpretations of magnesium gradients deep-sea sediments. In addition, using a diffusion-reaction model of magnesium isotopes in deep-sea sediments we can calculate the fractionation factors for magnesium isotopes associated with the precipitation of dolomite and clay minerals.

[1] Carder, E.A., Galy, A. *et al.* (2005) *Geochim. Cosmochim. Acta,* **69,** A213. [2] Tipper, E.T., Galy, A. & M.J. Bickle (2006) *Earth & Planetary Science Letters* **247**, 267-279.