Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20124

A multi-stage origin for juvenile continental crust in the Archean: Evidence from Titanium isotope compositions in Eoarchean rocks from the Isua supracrustal belt, SW Greenland

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Remnants of Earth's juvenile continental crust are preserved in the form of tonalite-trondhjemite-granodiorite (TTG) plutonic rocks. However, due to the incomplete nature of this record, there are varying interpretations on their petrogenesis and the prevailing tectonic regime responsible. Thus, robust geochemical proxies are required to understand TTG petrogenesis. Titanium (Ti) isotopes have been utilised to investigate magma evolution in both Phanerozoic and Archean rocks [1,2]. Titanium isotope fractionation occurs via incorporation of light isotopes in Ti-rich phases (e.g., Fe-Ti oxides, amphibole) [3,4]. Consequently, melts in equilibrium with these phases are enriched in heavy isotopes. Titanium isotopes are an ideal tool for tracing continental crust formation due to their sensitivity to rutile, ilmenite, amphibole, and (to a lesser extent), clinopyroxene and garnet – the main phases involved in TTG petrogenesis via partial melting of metabasalts [5].

We present Ti isotope compositions ($d^{49/47}Ti$) for a representative suite of Eoarchean amphibolites and TTGs from the Isua supracrustal belt (ISB). Amphibolites display limited variation in $d^{49/47}Ti$ (+0.01 to +0.09 ‰), whereas non-gneissic tonalites are isotopically heavier (+0.18 to +0.88 ‰). Migmatised tonalites and intra-crustal differentiates show substantial variability in $d^{49/47}Ti$ (+0.25 to +1.11 ‰). Amphibolites and non-gneissic tonalites define a shallow trend in SiO_2-$d^{49/47}Ti$ space compared to most tholeiitic and calc-alkaline Phanerozoic rocks. By combining phase equilibria modelling and experimental data with available Ti mineral-melt fractionation factors the $d^{49/47}Ti$ variation observed in ISB amphibolites and non-gneissic tonalites is best reproduced in two stages; (1) Partial melting of tholeiitic metabasalts to produce primitive tonalitic melts (60-65 wt.% SiO_2, $d^{49/47}Ti$ ~+0.2 ‰) and; (2) subsequent crystallisation of primitive tonalitic melts to produce evolved tonalites with $d^{49/47}Ti$ >+0.2 ‰. In addition, Ti isotopes, when combined with trace element ratios diagnostic of source mineralogy (e.g., Nb/Ta, Gd/Yb), indicates TTGs could represent evolved melts derived from partial melts produced at different degrees of melting over a range of pressures (~0.8-1.8 GPa).

[1] Hoare et al., (2020) *GCA*, 282, 38-54; [2] Aarons et al., (2020) *Sci. Adv.* 6, 50; [3] Hoare et al., (2022) *GCA, 326*, 253-272; [4] Mandl (2019), PhD thesis; [5] Hoffmann et al., (2011), GCA, *75*, 4157-4178