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Archean crustal formation and differentiation – clues from Ti stable isotopes

CAPUCINE ALBERT[1], MARTIJN KLAVER[1], LIAM HOARE[2], TIM JOHNSON[3], JONATHAN O'NEIL[4], HANIKA RIZO[5], HUGH SMITHIES[6], MATTHIAS WILLBOLD[7] AND MARC-ALBAN MILLET[1]

[1]Cardiff University
[2]Ruhr-Universität Bochum
[3]School of Earth and Planetary Sciences, Curtin University
[4]University of Ottawa
[5]Carleton University
[6]Curtin University
[7]Georg-August-Universität Göttingen

Presenting Author: albertc@cardiff.ac.uk

Archean tonalite-trondhjemite-granodiorite (TTG) plutonic rocks provide a unique yet genetically poorly understood record of the processes that formed continental crust. Because interpretations of crustal evolution are gathered from incomplete remnants, understanding the (non-unique) differentiation processes delivering the chemical signatures of Archean TTGs requires the use of robust chemical proxies. Titanium (Ti) isotopes have recently been leveraged to understand magma genesis and evolution in modern tectonic environments. The main driver of Ti stable isotope fractionation is the preferential sequestration of its light isotopes in Ti-rich minerals (e.g. Fe-Ti oxides, amphibole). The sensitivity of Ti isotopes to amphibole-, rutile- and (to a lesser extent) garnet-melt equilibrium – major phases involved in the generation of TTG melts by dehydration melting of a basaltic protolith – thus makes Ti isotopes a promising proxy for tracing the formation of early continental crust, provided the effect can be calibrated.

We measured Ti isotopes in granulite-facies mafic bodies and associated felsic rocks from the Archean Lewisian Gneiss Complex (LGC). These samples are ideally suited because they preserve unambiguous evidence of *in situ* amphibolite anatexis. The Ti isotope compositions (δ^{49}Ti) of Archean partial melts from the LGC are comparable (at given SiO_2) to modern TTG-like Icelandic lavas and modelled compositions from amphibolite melting experiments. These result define a trend (Amphibolite Melting Reference Line – AMRL) of increasing δ^{49}Ti with indices of differentiation (e.g. increasing SiO_2), reflecting the incorporation of light Ti isotopes in residual clinopyroxene and/or garnet. We compared our measured and modelled partial melt δ^{49}Ti compositions with those of TTGs from several Archean cratons. We find that the Ti isotope composition of granitoids from the Pilbara craton fall close to our modelled AMRL, which is consistent with their inferred origin mainly by low pressure partial melting rather than fractional crystallization. In contrast, Archean granitoids from the Yilgarn, Kapvaal, Slave and Superior provinces show variable enrichment in the heavy Ti isotopes compared to our AMRL, suggesting different source mineralogy and/or different degrees of fractional/equilibrium crystallization. This indicates that TTG formation processes are non-unique but also that these processes may be specific to each craton.