Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20130

Ti and Fe isotopic signatures of basalt melting and crustal reworking in Archean granitoids

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How and when Earth's felsic crust was established and how Earth's geodynamics evolved are important questions for understanding the habitability of our planet. Titanium (Ti) isotopes are useful tools for probing crustal generation because of two distinct isotopic trends observed for modern igneous systems with highly fractionated tholeiitic rocks and a relatively "muted" trend for calc-alkaline rocks. Aarons et al. (2020) measured 4.03 Ga and 3.6 Ga granitoids from the Acasta Gneiss Complex in the Slave craton and identified a clear transition between 4.02 to 3.75 Ga from a highly fractionated tholeiitic trend to calc-alkaline trend and suggested a local scale tectonic-style shift from a plume setting to subduction-like processes. However, we still don't know why the post 3.74 Ga Archean TTGs closely follow a modern calc-alkaline trend and what the mechanism is for their "muted" Ti isotopic fractionation.

In this contribution, we carried out iron (Fe)-Ti isotope analysis for granitoids (primarily TTGs) spanning the Eoarchean to Mesoarchean from the ~3.8-3.6 Ga Itsaq Gneiss Complex, West Greenland craton and ~3.3 Ga Mt. Edger Complex, East Pilbara craton. The Ti isotopes of Archean granitoids from both locations follow the same trend as modern calc-alkaline rocks with very limited fractionation. We utilize thermodynamic isotopic modeling and show that the Ti isotopic fractionation in Archean TTGs can be readily explained by partial melting of hydrous basalt following by additional fractionation of tonalite magmas. Our new Ti isotope data of TTGs, combined with previous findings, reveal a widespread 'muted' signature across multiple cratons (Slave, West Greenland, Pilbara, Kaapvaal) during the Archean Eon.

[1] Aarons, S.M., Reimink, J.R., Greber, N.D., Heard, A.W., Zhang, Z., Dauphas, N., (2020), Science Advances 6, eabc9959.