Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.33886

Molybdenum isotopes in Archean granitoids: the role of source evolution and melt polymerization on the systematics of early continental crust

DR. ERIC D. VANDENBURG, PHD[1,2], OLIVER NEBEL[3], LAURA M. SPENCER[4], MARC-ALBAN MILLET[5], R. HUGH SMITHIES[6,7], PETER A. CAWOOD[1], ALEXANDRA CHURCHUS[1], MR. WENLI LIANG, PHD[1], DR. EMILIE BRUAND[8], JEAN-FRANÇOIS MOYEN[9], DR. ALEX J MCCOY-WEST, PHD[10] AND PRIYADARSHI CHOWDHURY[11]

[1]Monash University
[2]Adelaide University
[3]GEOMAR Helmholtz Centre for Ocean Research Kiel
[4]Institut de Physique du Globe de Paris
[5]Cardiff University
[6]Geological Survey of Western Australia
[7]Curtin University
[8]CNRS, Geo-Ocean, Université Bretagne Occidentale
[9]Université Jean-Monnet
[10]James Cook University
[11]National Institute of Science Education and Research, Bhubaneswar

Numerous studies have investigated the metal stable isotope systematics of the continental crust, Earth's most evolved and diverse chemical reservoir, to understand its formation and temporal evolution. Molybdenum (Mo) isotopes are an emerging tracer of magmatic processes in the Phanerozoic, yet magmas in deep time remain underexplored. Notably, Archean granitoids, which comprise most of the early crust, remain uncharacterized.

Here, we present high-precision Mo isotope analyses of 3.52-2.63 Ga granitoids (n = 28) from the Australian Pilbara and Yilgarn cratons, covering a spectrum of magmatic series, including tonalite-trondhjemite-granodiorite (TTG), sanukitoid, potassic, and their hybrids. $\delta^{98/95}$Mo variability (-0.93 to 0.25‰) in our samples faithfully records original magmatic compositions. Mean/median $\delta^{98/95}$Mo values decrease from slightly heavier than chondrite and modern upper mantle in TTGs, TTG hybrids, and granitoids with unenriched metabasite and mantle-like sources, to isotopically lighter than mantle values in potassic, potassic hybrid and sanukitoid series granitoids and those with enriched metabasite and felsic crustal sources. Using a combination of elemental proxy relationships and geochemical models informed by phase equilibrium modelling of partial melting, we demonstrate that Mo isotope variability in Archean granitoids primarily tracks source composition and mineralogy. The isotopic signatures of crustally-derived granitoids become lighter with source evolution, reflecting increasing melt polymerization, and changes in the abundance and composition of feldspar - and, perhaps subordinately, of amphibole, garnet, and biotite – in the residuum. Thus, a craton's evolution, beginning with juvenile crust-derived TTG magmatism, giving way to metasomatized mantle-derived sanukitoid magmatism and finally to potassic granitoid magmatism sourced from the reworking of TTG-dominated grey gneiss, is sequentially mirrored by decreasing $\delta^{98/95}$Mo. This implies that intracrustal reworking alone can push the average continental $\delta^{98/95}$Mo to sub-mantle values. Given that the $\delta^{98/95}$Mo of average Archean continental crust is expected to cluster around upper mantle/chondritic values, the pronounced divergence between upper mantle and crustal Mo isotope compositions may have developed only after the onset of active crustal recycling.