Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.34864

Iron and zinc isotopic insights into the formation of Archean continental crust

JIANFENG MA[1], DR. HAMED GAMALELDIEN, PHD[2], ROBERT HUGH SMITHIES[3], TIM JOHNSON[4], YUANRU QU[5] AND SHENG-AO LIU[6]

[1]Khalifa University
[2]Polar Research Center, Khalifa University
[3]Geological Survey of Western Australia
[4]Curtin University
[5]China University of Geosciences (Beijing)
[6]China University of Geosciences, Beijing

Tonalite–trondhjemite–granodiorite (TTG) rocks that dominate Archean continental crust are traditionally viewed as representing the crystallized products of partial melting of hydrated basaltic rocks at various depths. However, the specific mechanisms and conditions of anatexis are debated, hindering our understanding of the tectonic mode of the early Earth. Here, we combine the Fe and Zn isotopic composition of TTG samples (n = 9) from Western Australia with thermodynamic modelling to investigate their petrogenesis. The TTG have crystallization ages between 3.4 and 2.6 Gyr and compositions that range from primitive (K_2O/Na_2O < 0.35, mantle-like zircon O isotopes) to evolved (K_2O/Na_2O = 0.35–0.6, heavy zircon O isotopes). The samples have relatively homogeneous iron ($\delta^{56}Fe$ = 0.13 ± 0.05‰ to 0.17 ± 0.05‰, all uncertainties at 2SD) and zinc ($\delta^{66}Zn$ = 0.29 ± 0.04‰ to 0.35 ± 0.03‰) isotopic compositions. Thermodynamic modelling indicates that the formation of primitive and evolved TTGs was driven by partial melting of fully hydrated (H_2O-saturated) but variably enriched basalts at temperatures (T) of 730–850°C and pressures (P) of 2–15 kbar. Regional variations in T, P, and H_2O content can account for the Fe–Zn isotope fractionation in the studied TTGs. The availability of sufficient H_2O, potentially sourced from both the mantle and crust, and heat derived from mafic underplating at depth, and from mantle plumes or meteorite impacts at shallower crustal levels, were essential for TTG formation, with no requirement for subduction-driven accretionary–collisional orogenesis.