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Iron and zinc isotopes insight into the continental crust formation

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Plagiogranites rarely exceed more than 1 vol.% of the oceanic crust, but their petrogenetic evolution provides great potential to explore the differentiation of mafic crust. Investigating the origin of plagiogranites is of essential importance for understanding the generation and evolution of the Earth's juvenile continental crust. Stable isotopes of iron (Fe) and zinc (Zn) are sensitive to chemical dynamic conditions and do not evolve with time, making them highly promising tracers for deciphering the origin of plagiogranites. In this study, we present high-precision Fe-Zn isotope analysis and thermodynamic modeling to investigate the formation of the largest known El-Shadli plagiogranite complex in the Arabian-Nubian Shield. These plagiogranite rocks share low potassium (K_2O <1wt.%) characteristics and exhibit a range of Fe-Zn isotopic compositions, with δ^{56}Fe values of 0.06 ± 0.04‰ to 0.19 ± 0.02‰ (2SD) and δ^{66}Zn values of 0.27 ± 0.03‰ to 0.41 ± 0.04‰ (2SD). Thermodynamic modeling indicates that water-fluxed melting of altered oceanic crust at shallow crustal depths (2–6 kbar) and elevated temperatures (800–900°C) was the primary mechanism driving plagiogranite formation. Sub-mantle oxygen isotopes in zircon (δ^{18}O from 4.06 ± 0.17‰ to 5.09 ± 0.20‰) indicate that the required fluid originated from seawater and regulates the partial melting of plagioclase and amphibole during anatexis, directly influencing Fe-Zn isotope fractionation between the resulting plagiogranite melts and their residual source. Our study highlights Fe-Zn isotopes as a powerful tool for tracing the origin of plagiogranites and underscores their potential in investigating continental crust formation.