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Potassium isotopic constraints on Earth's earliest stable continental crust

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The formation of Earth's felsic continental crust is a unique process among rocky planets, with Archean cratons (4.0–2.5 Ga) preserving its earliest remnants. These cratons primarily consist of tonalite-trondhjemite-granodiorite (TTG) granites, representing early crust formation, and potassic granites, marking later stabilization. However, the origins of their mafic source rocks and formation mechanism—remain debated. Here, we present high-precision potassium (K) isotopic data from TTGs and potassic granites (3.46–2.67 Ga) from the Pilbara and Yilgarn Cratons to track their evolution. TTGs show $\delta^{41}K$ values ranging from –0.27 ± 0.07 ‰ to –1.01 ± 0.06 ‰, while potassic granites range from –0.35 ± 0.08 ‰ to –0.54 ± 0.04 ‰—both lighter than mantle values ($\delta^{41}K$ = –0.42 ± 0.08 ‰). Additionally, many TTGs exhibit mantle-like zircon $\delta^{18}O$ values (5.08–6.10‰), whereas potassic granites show heavier signatures (5.58–7.10‰). The O-K isotopic composition of TTGs reflects both mantle-like signatures and low-temperature hydrothermally altered basalts, indicating their formation through partial melting of upper basaltic crust (i.e., seawater-altered crust). In contrast, potassic granites likely formed from melting pre-existing TTG-like crust. These results suggest that Archean TTG source incorporated seawater-altered oceanic basalts, while potassic granites resulted from the reworking of juvenile crust. This supports a model of continental crust growth driven by early hydrothermal alteration of mafic crust and subsequent crustal reprocessing within the Archean crust that may not require subduction.