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Potassium isotopic constraints on the emergence of microcontinents in orogenic belts

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The formation and evolution of the continental crust is a fundamental focus in Earth science; however, when and how Earth's earliest continents (especially microcontinents within orogenic belts) emerged above sea level remains a topic of debate. Potassium isotopic data are a new tracer of planetary accretion and differentiation. Here we report the K isotopic compositions of Neoarchean–Paleoproterozoic granitoids from a microcontinent (i.e., the Xing'an Massif) in the eastern Central Asian Orogenic Belt to constrain the early evolution of microcontinents within orogenic belts. The 2568 and 1881 Ma monzogranites have $\delta^{41}K$ values of −0.22‰ to −0.05‰ and −0.39‰ to −0.18‰, respectively, heavier than that of the bulk silicate Earth, suggesting that submarine interactions occurred between seawater (the heaviest terrestrial K isotopic reservoir) and the surface of ancient continental crust (probably tonalite-trondhjemite-granodiorite rocks; TTGs). The emersion of the Xing'an Massif probably began during the late Mesoarchean (*ca*. 2.8 Ga) and the exposed crustal material subsequently experienced subaerial weathering and deposition. The sources of the 2568 Ma strongly peraluminous monzogranite and 1881 Ma adakitic monzogranite are therefore a mixture of TTGs with recycled meta-sediments and thickened TTGs, respectively. In contrast, the 1843 Ma ultrapotassic and peraluminous syenogranite has relatively light K isotopic compositions ($\delta^{41}K$ = −0.45‰ to −0.38‰), implying that its sedimentary source was subjected to more intense subaerial weathering after the Great Oxidation Event, lowering its $\delta^{41}K$ values. The K isotopic fractionation between different reservoirs recorded by granitoids thus records continental emersion, subaerial weathering, and crustal recycling in microcontinents. Combined with observations from global cratons, the emersion of Earth's continental crust began at *ca.* 3.3–3.0 Ga, and progressed gradually and diachronously in different cratons and microcontinents. Our case study fills a global gap in our understanding of the early crustal evolution of accretionary orogens.

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