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Temporal evolution of the upper continental crust revealed by potassium isotope geochemistry of glacial diamictites

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The Earth is the only planet in the Solar System with continents, which, unlike the basaltic oceanic crust of the Earth and crusts of other planets, have an average andesitic composition. As the continental crust is critically linked to the Earth's differentiation, plate tectonics, and weathering, knowledge on the composition of the continental crust is essential for understanding our planet's evolution.

Potassium is a major element in the continental crust and an incompatible trace element in the mantle. Fractionation of its two stable isotopes is sensitive to both chemical weathering and crustal differentiation. Light K isotopes partition preferentially into weathered regolith and heavy isotopes partition into plagioclase during magmatic differentiation. These features make K isotopes useful for tracing how continental weathering and magmatic differentiation influenced the evolution of the upper continental crust (UCC).

Here we report high-precision K isotopic compositions for 24 glacial diamictite composites with depositional ages ranging from the Mesoarchean to the Paleozoic. These composites have been studied extensively as a probe of UCC through time. We document large (up to 1‰) variations of $\delta^{41}K$ in the Archean and Paleoproterozoic samples, with some heavier and some lighter than the post-Paleoproterozoic samples, which have $\delta^{41}K$ close to the average modern UCC. Samples with high clay content tend to be isotopically lighter, indicating extreme chemical weathering in the Archean. Samples with high Eu anomaly are isotopically heavy and result from Na-rich juvenile TTG crust. Our K isotopic results are consistent with a change from Na-rich to K-rich granites in the UCC across the Archean-Proterozoic boundary and extreme chemical weathering of the UCC in the Archean.