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Soil Potassium Isotope Geochemistry as an Emerging Tracer of Weathering: Insights from the Hawaiian Critical Zone

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Chemical weathering of silicate rocks is a fundamental driver of Earth's surface processes, regulating atmospheric CO_2 and supplying essential nutrients to ecosystems. Potassium isotopes ($\delta^{41}K$) have recently emerged as a promising proxy for tracing chemical weathering. However, the complex interplay between profile age, source, climate, and biological cycling requires detailed characterization.

Here we investigate multiple Hawaiian soil profiles spanning strong gradients in rainfall and soil age to understand K isotope geochemistry. In paired wet and dry profiles, we observe that clay adsorption preferentially enriches the solid phase in heavy K isotopes, consistent with our experimental adsorption study[2], whereas structural incorporation of K into secondary clays favors isotopically lighter K[1]. In a classic chronosequence profile, we further demonstrate that progressive soil development, together with chemical weathering, eolian inputs, and plant cycling, exerts a first-order influence on bulk soil $\delta^{41}K$[3]. A complementary plant-focused work from the same sites shows that roots preferentially acquire isotopically light K from bioavailable pools, and that light K is associated with pectate fractions in plant tissues[4].

Collectively, these results reveal that $\delta^{41}K$ systematically responds to mineral transformation, atmospheric deposition, and biological recycling. Therefore, potassium isotopes offer a powerful yet process-sensitive tracer of chemical weathering processes and nutrient cycling in the critical zone, given that soil age, climate, sources, and biotic effects are well considered.

References

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