Potassium isotopic fractionation during chemical weathering: a Hawaiian example

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Chemical weathering plays an important role in continental crust evolution, as it preferentially removes soluble elements such as K and Mg and shifts the crust towards more felsic compositions. Moreover, chemical weathering is critical in making Earth's surface habitable by regulating the global C and O cycles as well as by transporting nutrients to the oceans. Potassium isotopes have the potential to be used as tracers of weathering. Thus, an understanding of K isotopic fractionation during weathering is necessary before using K isotopes to trace weathering.

Here we investigate the K isotopic behaviors in laboratory dissolution and adsorption experiments, and K isotopic records preserved in two Hawaiian weathering profiles. Weathering of primary silicate rocks preferentially releases isotopically light K during the initial dissolution. However, after ~25% K dissolution the K isotopic fractionation between solid and leachate decreases to ~0‰. Secondary minerals preferentially adsorb isotopically heavy K, and both adsorption ratio and K isotopic fractionation correlate with mineralogy (kaolinite > smectite > illite > chlorite > ferrihydrite). Distinguishable K isotopic fractionation was found in humid (MAP~1730 mm/yr) and arid (MAP~385 mm/yr) regoliths at the Island of Hawaii. Humid regoliths have $\delta^{41}K$ of -0.76‰ to -0.31‰, close to that of their parent rock (-0.48‰). Arid regoliths have more heterogeneous isotopic compositions with $\delta^{41}K$ ranging from -0.87‰ to -0.02‰. Humid soils inherited K isotopic signature from the upper continental crust (ave. $\delta^{41}K_{UCC}$ = -0.44‰) enriched in illite (derived from dusts), while arid regoliths retained primary rock signals. This research demonstrates that significant K isotopic fractionation occurs during weathering, thereby laying the foundation for utilizing K isotopes in future studies of weathering processes and soil development.