Potassium cycling in seawater and aquatic organisms: Insights from stable potassium isotopes ($^{41}K/^{39}K$)

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Potassium is the most abundant intracellular cation in all animal cells and is a major cation in seawater. However, the behavior of stable potassium isotopes ($^{41}K/^{39}K$) in these systems has been largely unexplored. Here we use high-resolution, inductively coupled (cold) plasma multi-collector mass spectrometry to measure $^{41}K/^{39}K$ ratios in a wide range of geological and biological samples.

Measurements of potassium isotopes in rivers, siliciclastic sediments, deep-sea pore-fluids, and altered oceanic crust permit a preliminary characterization of the potassium isotope mass-balance in seawater. Our results suggest that K isotope fractionation during 1) continental silicate weathering, 2) marine sedimentary diagenesis and 3) low-temperature oceanic crust alteration all likely contribute to the high $^{41}K/^{39}K$ ratio of seawater ($\delta^{41}K$~0‰) compared to bulk silicate Earth ($\delta^{41}K$ ~-0.55‰). We propose that this seawater isotopic enrichment results from both clay formation (when ^{39}K is preferentially removed) and chemical diffusion (since ^{39}K has a higher diffusion rate than ^{41}K in liquid water[1]).

Additionally, we here consider diffusive K fractionation in biological systems. Measurements of potassium isotopes in both freshwater and marine vertebrates and invertebrates indicate that different strategies for osmoregulation result in internal pools of K that may be either enriched or depleted in ^{41}K compared to potassium in the environment. Results from simple 1D model simulations of K transport through these marine and freshwater teleosts suggest an important role for diffusion in setting the $\delta^{41}K$ composition of muscle tissues.

Overall our results demonstrate that high-precision measurements of $^{41}K/^{39}K$ ratios can provide new constraints on the relative importance of different sources and sinks within the global potassium cycle in seawater, and show promise for understanding the mass transport of potassium associated with osmoregulation and potassium homeostasis.

[1] Bourg et al. (2010) GCA 74, 2249-2256.