Potassium isotope geochemistry and magmatic processes

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Potassium stable isotopic ($^{41}K/^{39}K$) compositions are notoriously difficult to measure. TIMS measurements are hindered by variable fractionation patterns and too few isotopes to apply an internal spike method for instrumental mass fractionation corrections. Internal corrections via the $^{40}K/^{39}K$ ratio can provide precise values and are appropriate in some cases (e.g. identifying excess ^{41}K [1]) but not others (e.g., determining fractionation effects and metrologically-traceable isotopic abundances). SIMS analyses have yielded results with 0.25‰ precisions [2]. Improved precision with the technique presented here identifies the first conclusive evidence for terrestrial K isotopic fractionation.

We measured $\delta^{41}K$ values ($^{41}K/^{39}K$ relative to NIST SRM 999b) on NIST K standards with < 0.05‰ precisions (2σ) on the Thermo Scientific NEPTUNE *Plus* MC-ICP-MS. ^{39}K and ^{41}K were sufficiently resolved from the interfering $^{38}ArH^+$ and $^{40}ArH^+$ peaks in wet cold plasma and high-resolution mode. Measurements were made on narrow but flat, interference-free, plateaus (ca. 50 ppm by mass width for ^{41}K). Although ICP-MS does not yield accurate $^{41}K/^{39}K$ values due to significant instrumental mass fractionation (ca. 6%), this bias is sufficiently stable that relative $^{41}K/^{39}K$ values can be precisely determined via sample-standard bracketing. Measurement tolerances on matrix effects that are amplified by the cold plasma were tested; the use of clean samples and standards is critical.

Most high temperature phases from a diverse range of whole rock and mineral samples yield $\delta^{41}K$ values that span a range of 0.4‰. A few samples yield more extreme values, which indicate geological processes that may be informed by forthcoming work. In particular, there are indications for seawater recycling in subduction zones and fractionation during the formation of pegmatites. These and other potential future applications of stable K isotopic measurements will be discussed.

[1] Wielandt and Bizzarro, 2011. [2] Humayun and Clayton, 1995.