Low-temperature oceanic crust alteration and the isotopic budgets of K and Mg in seawater

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Low-temperature alteration of oceanic crust plays an important role in a number of geochemical cycles, thus modulating the chemical composition of the oceans. In particular, it has been established that low-temperature ($T<60°C$) alteration of basalt is a major sink of seawater potassium. However, little is known about the effects of this process on the potassium isotope composition of seawater, which is ~0.50‰ enriched relative to bulk silicate Earth ($\delta^{41}K_{BSE}$=-0.54‰). Here, we measure a number of isotope systems ($\delta^{41}K$, $\delta^{26}Mg$, $^{87}Sr/^{86}Sr$) in bulk rock material from the upper volcanic section of Cretaceous (Troodos Ophiolite) and Jurassic (ODP 801C) oceanic crust using a MC-ICP-MS. The goal is to estimate the K isotopic fractionation associated with basalt alteration in low-temperature conditions, and how it might affect the K isotope composition of seawater relative to BSE. We find that marine hydrothermal samples from Troodos and ODP site 801C are enriched in potassium relative to the unaltered glass compositions and have $\delta^{41}K$ values both higher and lower than BSE, ranging from 0.01‰ to -0.69‰ (n = 28) and -0.32‰ to -0.71‰ (n = 5), respectively. The lowest measured $\delta^{41}K$ values are consistent with preferential uptake of ^{39}K from seawater ($\delta^{41}K_{SW}$~0‰) during the formation of K-rich authigenic aluminosilicates (e.g. celadonite). This fractionation (α~0.9993) may explain, in part, the observed seawater ^{41}K enrichment relative to BSE. Heavier $\delta^{41}K$ values are indistinguishable from seawater and might suggest alteration under higher temperatures and/or exchanges with compositionally evolved fluids. Measurements of $\delta^{26}Mg$ (n=88) and $^{87}Sr/^{86}Sr$ (n=40) in these samples generally yield enriched values relative to BSE and indicate that alteration likely happened under high water-to-rock ratios in both Troodos and ODP 801C. Finally, the heaviest $\delta^{26}Mg$ values measured here are consistent with previous estimates for Mg isotope fractionation (α~1.0012) during exchange between basalt and seawater, suggesting that hydrothermal activity also affects the $\delta^{26}Mg$ of seawater. The uniquely heavy $\delta^{26}Mg$ character of altered oceanic crust may render it a useful proxy for studies on the subduction recycling of crustal material.