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Global K cycles revisited: the role of arc hydrothermal systems

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Potassium (K) and its stable isotopes are among the most sensitive indicators for biogeochemical cycles. Previous studies on the oceanic budgets of K had focused on the hydrothermal activities at the Mid-ocean ridges (MORs), yet the role of arc volcanoes, which contribute to 10% of global hydrothermal heat flow, with rocks significantly more enriched in K, had been elusive. Here we investigate the K mobility and K isotope fractionation in active hydrothermal systems at the submarine volcano Brothers from the Kermadec-Tonga arc of the South Pacific ocean. IODP Drill core U1528 intersected a magmatically-influenced hydrothermal system, and the altered rocks are strongly depleted in K but enriched in heavy K isotopes, with K isotope values up to +0.21‰. By contrast, drill core U1530 intersects a seawater-dominated hydrothermal system, and the core samples are enriched in K, showing K isotope values comparable to unaltered rock, around -0.4‰. The distinct K elemental and isotopic behaviors from the two cores reflect the difference in mineral dissolution and neoformation during different types of alterations in arc hydrothermal systems. Our results challenge the traditional view that K exchange between hydrothermal fluids and oceanic crust is primarily controlled by temperature because both sites are dominated by hydrothermal alteration > 200 °C. By contributing about 30% of present-day K hydrothermal input, arc volcanoes may play a more important role in the global K cycle than previously recognized. Additionally, high-temperature hydrothermal alteration at MORs may also be a K sink in the case of illite precipitation.