

Hydrothermal origin of heavy K isotope composition in altered oceanic crust

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Potassium isotopes are fractionated by fluid-rock interactions and provide a tool to probe the role of hydrothermal alteration of the oceanic crust in modifying the chemical composition of seawater and, through subduction, the deep Earth. This study investigated a suite of samples of altered upper ocean crust, that formed at the East Pacific Rise and is exposed at Hess Deep, to constrain K isotope fractionation by combining elemental, isotopic, mineralogical and synchrotron-based spectroscopic approaches. Relative to fresh rocks, there is an enrichment of isotopically heavy K in the sheeted dike complex where the rocks are generally depleted in K through high-temperature fluid-rock reaction. In contrast, samples from the lava/dike boundary and lavas commonly show net K gains relative to the protolith due to low-temperature fluid-rock reaction and have $\delta^{41}\text{K}$ similar to fresh basalts. We attributed the isotopic variation in altered ocean crust primarily to the formation of albitic plagioclase, which is identified as an important ^{41}K carrier formed in altered dikes, although diffusive ^{39}K loss may also play a role. Based on isotope mass balance, we show that isotopic fractionation occurring during high-temperature alteration may be hard to identify in hydrothermal vent fluids because the $\delta^{41}\text{K}$ of the K leached from the rocks is only slighter lower than the protolith. Hence, hydrothermal K outputs to the oceans may not contribute significantly to elevating $\delta^{41}\text{K}$ of modern seawater relative to the silicate Earth. In contrast to ocean crust altered at low-temperature (<100 °C) and ocean floor sediments, subducting ocean crust altered at high-temperature adds rocks with $\delta^{41}\text{K}$ higher than BSE to the mantle. Because the high $\delta^{41}\text{K}$ signature of sheeted dikes is generated by K loss, and is hence best expressed in K-poor samples, tracking this signature in arc magmas and samples of the mantle will be challenging.

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