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Insights into recycling of potassium beyond the sub-arc mantle from its isotopes

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Numerous studies by Catherine Chauvel and Dominique Weis have highlighted the profound impact of oceanic crust recycling on the chemical heterogeneity of the mantle. As a key heat-producing element, recycling of potassium (K) from subducted oceanic crust potentially affects the long-term heat budget and thermal structure of Earth's interior. High-pressure experimental results and recent K isotopic investigations of arc lavas suggest that a significant portion of the subducted K can be released into the sub-arc mantle wedge (<300 km) through slab dehydration or melting, which eventually returns to the crust via calc-alkaline magmatism. However, the extent to which K can be transported beyond subduction zones remains poorly understood.

Here, we present new K isotope data for Cenozoic intracontinental alkaline basalts from eastern China, which were sourced from the mantle transition zone that contains the stagnant Pacific slab. These basalts exhibit substantial variation in the $^{41}K/^{39}K$ ratio ($\delta^{41}K$ = -0.65‰ to 0.12‰), with values both higher and lower than the mean mantle (0.42 ± 0.08‰). Unlike the positive trends observed in many arc lavas, the $\delta^{41}K$ of these basalts is inversely correlated with K/Th, K/U, and Ba/Th. Together with correlated relationships between K isotopes and radiogenic isotopes, we suggest that various components of the subducted oceanic crust (e.g., sediments, altered upper crust, and gabbroic crust) contribute to the K isotope heterogeneity in the mantle sources of these basalts. Our findings indicate that a notable fraction of the K in subducting slabs survives the shallow subduction-zone processes and is transported into the deep mantle, with important implications for understanding the chemical heterogeneity and thermal evolution of the mantle.