Evidence from HP/UHP metasediments for recycling of isotopically heterogeneous potassium into the mantle

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**Abstract**

Potassium isotopes may provide a novel approach for fingerprinting recycled sediments in the mantle due to the significant differences in K abundance and isotopic ratio between subducing sediment and the mantle. However, the behavior of K isotopes in sediments during subduction zone metamorphism is still unknown. Here we investigate K isotopic composition of a set of well-characterized high-to-ultrahigh-pressure metasediments from the Schistes Lustrés nappe (western Alps), which represents marine sediments subducted down to ~90 km depth in a cold subduction zone, and their protoliths from the Lavagna nappe (Apennines, Italy). The metasediments display $\delta^{41}$K values from $-0.76\%$ to $-0.48\%$, which are on average lower than the mantle value ($-0.43\%$) but similar to those of non-metamorphic equivalents ($-0.79\%$ to $-0.49\%$). No systemic variation of $\delta^{41}$K with metamorphic grade is observed, suggesting negligible K isotope fractionation in these sediments during prograde metamorphism. This is in accord with the limited loss of K during the entire metamorphic history as evidenced by the constancy of K/Rb and K/Cs ratios between metamorphic and non-metamorphic sediments and the absence of correlations of $\delta^{41}$K with K/Rb and K/Cs. The heterogeneous $\delta^{41}$K values of metasediments are most likely inherited from their protoliths, which experienced different degrees of chemical weathering depending on their provenances. Our results demonstrate that the variable and light K isotopic signatures in subducting sediments could be preserved to depths of at least 90 km along a cold geotherm gradient, indicating that the introduction of sediments into the mantle could produce K isotope heterogeneity in the source regions of mantle-derived lavas.

**Keywords:** Potassium isotopes, metasediment, metamorphism, subduction zone; Isotopes, Minerals, and Petrology: Honoring John Valley

**Introduction**

Global subducting sediment (GLOSS) has an average K\textsubscript{2}O content (2.21 wt%; Plank 2014) several orders of magnitude higher than that of the mantle (0.03 wt%; McDonough and Sun 1995). Accordingly, recycling of sediments into the mantle has been commonly invoked to explain the significant K enrichment observed in many mantle-derived lavas such as arc volcanic rocks and EM-type oceanic island basalts (OIBs) relative to mid-ocean ridge basalts (MORBs) (e.g., Plank and Langmuir 1993; Tatsumi and Eggins 1995; Elliott 2003; Jackson and Dasgupta 2008; Rapp et al. 2008). Recent developments in high-precision K isotope measurements revealed that, compared with the mantle with a mean value of $-0.43\%$ defined by global oceanic basalts (Tuller-Ross et al. 2019), subducting sediments display an overall $-1.3\%$ variation in $\delta^{41}$K and commonly have $\delta^{41}$K values (down to $-1.31\%$) lower than the mantle (Hu et al. 2020). Low $\delta^{41}$K values of sediments were mainly ascribed to preferential leaching of heavy K isotopes during chemical weathering (Li et al. 2019a, 2019b; Chen et al. 2020; Hu et al. 2020; Huang et al. 2020; Teng et al. 2020) or incorporation of light K isotopes into authigenic clays during diagenesis (Santiago Ramos et al. 2018; Hu et al. 2020). By contrast, altered oceanic crust (AOC), another major K sink in subducting slabs, has an average $\delta^{41}$K similar to or higher than the mantle due to interaction with isotopically heavy seawater (Parendo et al. 2017; Hille et al. 2019; Hu et al. 2020; Santiago Ramos et al. 2020). Hence, K isotopes have great potential to discriminate recycled sediments in the mantle. In this regard, the lighter K isotopic compositions relative to the mantle observed in some mantle-derived lavas have been explained to reflect recycled sediments in their mantle sources (e.g., $\delta^{41}$K down to $-0.81\%$ for potassic basalts from Northeast China and $\delta^{41}$K down to $-0.60\%$ for arc volcanic rocks from Lesser Antilles; Sun et al. 2020; Hu et al. 2021). However, this conclusion relies on the assumption that K isotopes are not fractionated in sediments during slab subduction into deep mantle, which still requires to be verified.

To date, only one recent study investigated the K isotope behavior during dehydration of subducted oceanic crust. Based on data for eclogites from Tibet, Liu et al. (2020) proposed that dehydration of oceanic crust preferentially releases heavy...