Evaluating volatile fluxes in subduction systems using stable isotope tracers

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It is widely considered that volatile species extracted from Earth's mantle to its surface through partial melting and magmatic degassing processes are recycled back into the deep mantle by subduction. Volatile species, taken up by oceanic lithosphere during hydrothermal alteration [1], are released as fluids from the downgoing slab during prograde metamorphism. These oxidizing fluids, likely carbonate-, sulfate- or halogen-bearing, interact with and serpentinize mantle wedge peridotites [2].

However, it is unclear exactly how much of the volatile budget is transferred by fluids from the slab to the mantle wedge. Debret et al. (2018) suggested that interactions between sediments and ultramafic lithologies during subduction result in the formation of a temporary carbon reservoir in the slab [3]. Critically, whether and how efficiently this reservoir mobilizes into the wedge or re-precipitates and stalls at the slab/mantle interface is unknown.

In order to better constrain the nature of slab-derived fluids and to quantify the proportion of fluids that transfer into the mantle wedge, we are using non-traditional stable isotopes that are sensitive to high-temperature petrogenetic processes (such as Fe (e.g. [3]), Zn (e.g. [4]), and Cu) as tracers. We obtained samples from the Shiraga meta-serpentinite body, which represents a shallow part of the mantle wedge above the Sanbagawa subduction zone and overlies slab-derived pelitic schists [5].

Preliminary data show significant Fe isotope variation among Shiraga samples. The variation does not appear to correlate with protolith heterogeneity or retrograde metamorphism. We will investigate the cause of variation and the implications for volatile transfer in subduction zones using a combination of other stable isotope systems and high-precision trace element data.

[1] Berndt et al. (1996) Geology 24, 351-354. [2] Arculus (1994) Lithos 33, 189-208. [3] Debret et al. (2018) J. Petrol. 59, 1145 – 1166. [4] Pons et al. (2016) Nat. Commun. 7, #13794. [5] Kawahara et al. (2016) Lithos 254-255, 53-66.