Global scale cycling of seawater

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Earth's mantle is dominated by non-radiogenic Ar, Kr and Xe of a subducted atmospheric origin [1,2]. However, the extent to which subducted noble gases are coupled with other seawater components, and the mechanisms for retaining noble gases in subducting slabs, have been unclear. This talk summarises recent investigations of seawater (re)cycling and subduction based on the analysis of: i) halogens and water in volcanic glasses, and ii) noble gases and halogens in metamorphic rocks.

Pristine OIB and MORB glasses unaffected by late-stage seawater contamination have been shown to have narrow overlapping ranges of Br/Cl and I/Cl that demonstrate the I/Cl of the modern mantle (~0.00006) is significantly lower than the primitive mantle value (0.00027 ± 0.00012). This is consistent with subducted halogens overwhelming primordial halogens throughout the entire mantle. Broad correlations between trace element signatures characteristic of dehydrated oceanic crust and water + halogen enrichement suggest that serpentinised lithospheric mantle (underlying dehydrated ocean crust) may be the dominant subduction zone reservoir responsible for introducing H_2O and halogens into the Earth's mantle [3].

The interpreted importance of serpentinites is explored further by: i) extending previous analysis of metamorphosed serpentinites to include eclogite facies garnet peridotites from Cima di Gagnone, and ii) investigating new submarine glasses from arc settings in the SW Pacific (Hunter Ridge (Fiji Basin) and Tonga). The garnet peridotite least affected by retrogression retains halogen and noble gas abundances of ~10-20 times the depleted mantle (e.g. 20-70 ppm Cl and 2-5×10^{-14} mols/g ^{36}Ar) and has an I/Cl ratio of much lower than the likely protolith. Arc glasses including bonninites and adakites with strong Cl enrichment have Br/Cl and I/Cl ratios close to mantle values. These data confirm that preferential loss of I relative to Cl occurs from subducting slabs in the forearc environment and that dehydrated-serpentinites are a potential source of volatile enrichment in the Earth's mantle. Efficient subduction of seawater volatiles into the deep mantle is however most likely to occur when serpentinites bypass the arc before complete dehydration.

[1] Holland and Ballentine, 2006, Nature 441, 186-191. [2] Mukhopadhyay, 2012, Nature 486, 101-104. [3] Kendrick et al., 2017, Nature Geoscence 10, 222-228.