

Experimental constraints on noble gas recycling into the mantle

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Noble gases are powerful tracers of the deep volatile cycle of the Earth. Based upon our previous experiments [1, 2], the main carriers of noble gases and other volatiles in subducting lithosphere should be amphibole (altered crust) and serpentine (altered mantle). Here we extend our work to the solubility of heavy noble gases (Kr, Xe) in a fine grain, relatively inclusion-free serpentinite.

The solubility of He, Ne, Ar, Kr and Xe in serpentinite have been measured using high-pressure experiments in combination with laser-ablation noble gas mass spectrometry. The solubilities of the noble gases increase over an order of magnitude from Ne ($\sim 10^{-10}$ mol/g/bar) to Xe (3×10^{-9}). The measured gas likely contains contributions from grain boundaries, fluid inclusions and the mineral lattice, all of which will be present in subducting serpentinite.

Using the experimentally determined solubilities, altered oceanic mantle will have relatively high concentrations of noble gases, high enough to overprint the mantle. Serpentinite will also have high Kr/Ar and Xe/Ar ratios and could contribute to the high ratios in the MORB source [3]. OIB show a range of Xe/Kr that can be explained by varying contributions of serpentine and sediment, though a third, very high Xe/Kr source is needed to explain HIMU OIB. This third source could be amphibole in altered oceanic crust [4], though Kr and Xe solubilities have yet to be measured for this phase.

[1] Jackson et al., *Nat Geosci*, 2013. 6: 562-565. [2] Jackson et al., *GCA*, 2015. 159: 1-15. [3] Ballentine, C.J. and G. Holland, *Phil Trans Royal Soc A*, 2008. 366: 4183-4203. [4] Chavrit, et al., *GCA*, 2016. 183: 106-124.