Can the Earth's core be the source of primordial noble gases in the mantle?

*John Peter Brodholt[1], Kai Wang[2], Xiancai Lu[2]

1. University College London, 2. Nanjing University

It has been suggested a number of times that the Earth's core could be the source of primordial noble gases (He, Ne, Ar, etc) observed in OIBs. The core is an attractive option for storing noble gases since it has remained mostly isolated from the convecting mantle since its formation 4.5 Ga. This view is supported by experiments show that He partitioning into Fe during core formation at elevated pressures (>10 GPa) is higher than previously thought. However, even if the core does contain primordial noble gases, there has to be a mechanism for incorportating them into OIBs. Small amounts of background degassing from the core into the mantle does not work since the noble gases will simply mix into the convecting mantle and the primordial signal will appear to be the same in both OIBs and MORBs.

We propose an alternative model whereby noble gases diffuse from the core into the base of the large low shear velocity provinces (LLSVPs), where they are stored and concentrated until sampled by plumes. To assess the viability of this model, we have determined the diffusion coefficients of He, Ne and Ar in lower mantle minerals by first-principles methods. We show that diffusion of these noble gases is sufficiently fast that they can concentrate into LLSVPs. However, diffusion is not fast enough to concentrate noble gases throughout LLSVPs and some sort of mixing within LLSVPs is needed. Assuming that LLSVPs are internally convecting, and assuming a range of reasonable mixing times for LLSVPs, we show that LLSVPs can act as a staging post for noble gases and allow them to build up in concentration over time. If LLSVPs are then periodically sampled by plumes, this provides an attractive method for sampling primordial noble gases originally residing in the core.

Keywords: Core, Mantle, Noble gases, Diffusion, Ab initio, First principles

