The role of plate tectonic cycling in modulating Earth's $^{3}He/^{22}Ne$ ratio

N. DYGERT[1], C. R. M. JACKSON[2] AND M. HESSE[1]

[1]Jackson School of Geosciences, University of Texas at Austin, USA

[2]Geophysical Laboratory, Carnegie Institution for Science, District of Columbia, USA

Recent measurements have highlighted that the MORB mantle source has distinctly higher $^{3}He/^{22}Ne$ compared to primitive mantle (~10 vs. 2, respectively) [1]. We seek to understand the source of this difference by modeling chemical exchange between dunite-channel hosted basaltic liquids and harzburgitic wallrock during the percolation of melts to the surface.

Dunite channels are thought to represent pathways for efficient melt extraction from the upper mantle. Percolation of basaltic melts through dunite channels allows them to retain high-pressure multiple saturation depths and the trace element characteristics of their mantle source. However, diffusive interaction of basaltic melts with harzburgite wallrock has an inevitable effect on the chemistry of the lithospheric mantle. In terms of global geochemical cycles, this effect is inconsequential for slow diffusing elements but can be significant for fast diffusiving, incompatible elements. Helium and neon are highly incompatible during mantle melting [2] [3] and He is extremely mobile [4]. Measurements of He diffusion in olivine suggest it is orders of magnitude faster than U, Th, and Ne at mantle relevant temperatures. Fast diffusion of He out of dunite channel-hosted basaltic melts and into U, Th, and volatile element depleted harzburgitic wallrock can efficiently fractionate He from U, Th, and Ne. These fractionations can then be imparted onto the depleted mantle by subduction or delamination of lithospheric mantle.

Preliminary melt percolation-diffusive interaction calculations suggest that preferential ^{3}He ingassing at dunite channels can significantly increase $^{3}He/^{22}Ne$ of the depleted mantle. Because ingassing of peridotite by dunite-hosted basaltic melts has presumably occurred for most of geologic time, kinetic fractionation at dunite channels can effectively modulate He/Ne, U+Th/He, and potentially U+Th/Ne of the depleted mantle. This simple model represents an alternative to the multiple degassed magma oceans invoked by [1] to increase the $^{3}He/^{22}Ne$ of the depleted mantle.

[1] Tucker & Mukhopadhyay (2014) *EPSL* **393**, 254-265. [2] Heber *et al* (2007) *GCA* **71**, 1041-1061. [3] Jackson *et al* (2013) *EPSL* **384**, 178-187. [4] Cherniak & Watson (2012) *GCA* **84**, 269-279.