Recycled and primordial noble gas components in the upper mantle

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Exchange of volatiles between the deep Earth and surface reservoirs occurs in association with plate tectonics: mantle volatiles are outgassed via magmatism, and ingassed via the downgoing plate at subduction zones. Accordingly, noble gases in the mid-ocean ridge basalt (MORB) mantle source reflect mixing between primordial volatiles from Earth's accretion, radiogenic and fissiogenic components, and recycled surface volatiles.

Kr and Xe isotopes in continental well gases and basalts constrain the proportion of each gas derived from recycling in the MORB source, given a chondritic primordial endmember composition [1,2]. Similar determinations for Ne and Ar, however, are inhibited by uncertainties regarding the primordial Ne and Ar endmember compositions: the MORB source $^{20}Ne/^{22}Ne$ ratio is ~12.5 [3], which indicates either extensive or negligible recycling of atmospheric Ne ($^{20}Ne/^{22}Ne$ of 9.8), depending on whether MORB source primordial Ne is related the solar nebula ($^{20}Ne/^{22}Ne$ of 13.4; [4]) or later input (Ne-B, which is thought to reflect solar wind implantation and sputtering effects in late-accreting planetary material, $^{20}Ne/^{22}Ne$ of 12.5-12.8; [5]).

Here we examine noble gas mixing systematics between subducting lithologies and primordial components. We find that in order to explain MORB source Ne given solar primordial Ne, recycled material must have high Ne/(Ar,Xe) and must experience minimal elemental fractionation during subduction. A high Ne/(Ar,Xe) component is observed in altered oceanic crust [6,7], but preservation of this component is at odds with evidence for light noble gas enrichment in arc and back-arc lavas [8] (and complementary light noble gas depletion in the downgoing slab). Thus, mixing systematics favor Ne-B as the primordial MORB source Ne component, supporting delivery of primordial Ne by accreting planetary material rather than solar nebular ingassing. Given the Ne-rich nature of the solar nebula, its contribution to other MORB source volatiles should also be small.

[1] Holland et al., 2008, *Science* [2] Parai and Mukhopadhyay, 2015, *G*^{3} [3] Holland and Ballentine, 2005, Nature [4] Heber et al., 2012, ApJ [5] Moreira, 2013, *Geochem Pers*) [6] Kumagai et al., 2004, *G*^{3} [7] Kendrick et al., 2015, *CMP* [8] Hopp and Ionov, 2011, *EPSL*.