Transport modeling of noble gases during subduction

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Over twenty years ago, it was suggested that subduction zones are very efficient filters, returning >98% of subducted noble gases back into the atmosphere through arc volcanism [1]. As a result, the input of noble gases into subduction zones has been treated as having negligible importance for studies of the physical and chemical structure of the mantle. However, the finding of an atmospheric signature in Ar, Kr and Xe isotopes and abundances from mantle-derived gases challenges the popular notion of a 'subduction barrier', raising the possibility that a noble gas signature with seawater-like elemental ratios can be conveyed to mantle depths, surviving the effects of metamorphic devolatilisation [2]. This possibility is further supported by analyses of noble gases from exhumed slab materials and mantle wedge peridotites [3]. Recent experiments demonstrate that ring-structured minerals have very high solubilities of He, Ar and Ne providing a mechanism for subducting substantial quantities of noble gases [4]. However, due to the possible effects of diffusive noble gas loss, to an intergranular fluid, it is unclear whether the solubilities of the noble gases are representative of the ratios in which they are recycled back into the mantle. We address this question by combining thermodynamically-derived subduction fluid fluxes with a diffusive-reaction transport model to estimate interelemental noble gas fractionations and depth-dependent noble gas concentrations for typical MORB and pelite lithologies. The effects of both Darcian-type fluid flow and compaction-driven porosity wave scenarios on the retentivity of the solid phase are considered. Resultant noble gas fractionation factors and transport lengthscales provide important constraints on the magnitude of the recycled noble gas flux and the mechanism by which slabs devolatilize.

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