Selenium isotopes trace crustal recycling in the upper mantle

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Selenium behaves as a chalcophile and siderophile element in magmatic systems. Stable Se isotopes fractionate during redox reactions and can thus be used to trace Earth's surface redox evolution [1]. Marine sediments show significant Se isotope variation, with $\delta^{82/76}$Se values ranging between −3‰ and +3‰, and an apparent shift towards lighter values from Precambrian (~+0.5‰) to Phanerozoic (~+0.1‰) times [1, 2, 3]. In contrast, Se isotope variability in mantle-derived melts, based on a limited dataset, is rather small yet still resolvable ($\delta^{82/76}$Se values ~−0.3‰–+0.3‰) [4, 5, 6]. Because there is little Se isotope fractionation (within ±0.09‰; 2 s.d.) caused by partial melting or magma differentiation [5], Se isotope variations in basaltic melts might track recycling of surface materials due to the contrasting difference in both Se abundances and isotope compositions between the igneous and surface reservoirs [e.g., 1, 5].

In this work, we present new high-precision Se isotope data for a suite of well-characterized MORB glasses from the Atlantic ridge, influenced locally by the Shona and Discovery plumes. Previous studies of these basalts revealed that recycled components were incorporated in their mantle sources [e.g., 7]. The samples devoid of plume influences show similar $\delta^{82/76}$Se values as average MORB (−0.16±0.13‰; 2 s.d., N = 27) previously reported for the Pacific-Antarctic ridge [5]. In contrast, the samples influenced by enriched components originating mainly from the Discovery plume show heavier $\delta^{82/76}$Se values. For the first time, we show that Se isotope ratios are correlated with sulfur isotope ratios, as well as radiogenic isotope tracers. This illustrates a binary mixing between the depleted mantle and subducted components, which must be of sedimentary origin. We constrain the Se isotope composition of the recycled component and compare it to literature data for sediments. We further address the implication of our results in the context of ancient redox conditions of the Earth's surface.

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