Tin Isotope Fractionation during Magmatic Processes

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Sn is a moderately volatile element whose isotope composition can be used to investigate planetary differentiation and the early history of the Solar System. For this purpose, it is important to determine the Sn isotope composition of the bulk silicate Earth. Although the Sn stable isotope composition of several geological and archaeological samples has been reported, there is currently no information on the effect of igneous processes on Sn isotopes. In this study, high-precision Sn isotope measurements of mantle rocks (peridotites) and their partial melting products (basalts) were obtained by MC-ICP-MS with a double-spike technique developed by Wang et al. (in revision) [1]. The basalt samples display small variations in δ^{124}Sn from -0.01±0.11 to 0.27±0.11‰ (2 s.d.) while peridotites have more dispersed and more negative δ^{124}Sn ranging from -1.04±0.11 to -0.07±0.11‰ (2 s.d.).

There is a weak trend between δ^{124}Sn and the extent of partial melting of basalts such that the Sn isotope compositions become lighter from OIB to MORB. In addition, a negative correlation between δ^{124}Sn in peridotites and the degree of melt depletion was observed. This result can be explained by the different behavior of Sn^{4+} and Sn^{2+} during partial melting. Sn^{4+} is believed to be more incompatible than Sn^{2+} during partial melting, resulting in Sn^{4+}-rich silicate melt and Sn^{2+}-rich residue. Considering that Sn^{4+} is enriched in heavier isotopes compared with Sn^{2+} (Polyakov et al. 2005 [2]), the effect of melting is to enrich residual peridotites in relatively more compatible Sn^{2+}, which results in isotopically lighter peridotites and isotopically heavier mantle-derived melts.

The most primitive peridotite analyzed in this study was used for estimating the Sn isotope composition of the BSE, with δ^{124}Sn = -0.08±0.11‰ (2 s.d.) relative to the Sn NIST SRM 3161a standard solution. Altogether, this suggests that Sn isotopes may thus be a powerful probe of redox processes in the mantle.

[1] Wang, X. et al. submitted to JAAS [2] Polyakov, V. B. et al. (2005) GCA, 69(23), 5531-5536.