Extreme mantle depletion recorded in abyssal peridotites impacts global models of Earth's differentiation

ANDREAS STRACKE [1]

[1]Westfälische Wilhelms Universität Münster, Münster, Germany

The isotopic composition of the Earth's mantle has mostly been inferred from analyses of mid-ocean ridge basalts (MORB), which are thought to provide an adequate time-integrated record of mantle depletion. Far fewer isotope analyses of actual oceanic mantle rocks (i.e. abyssal peridotites) exist, owing to their scarcity and often altered state.

Recent Hf-Os isotope analysis of abyssal peridotites identified previously elusive, ultra-depleted oceanic mantle domains [1, 2]. These show that the range of mantle depletion inferred from Nd isotope ratios in abyssal peridotites and especially MORB does not capture the full extent of mantle depletion. Abyssal peridotite Hf-Os isotope ratios preserve a multistage, Gyr-long history of depletion and enrichment during processing at mid ocean ridges. The end-product is a highly heterogeneous, variably depleted peridotitic mantle that ranges from ultra-depleted to MORB-like compositions on km to sub-km scale.

The limited number of Hf-Os-(Nd) isotope analysis in abyssal peridotites alone does not justify estimating the abundance of ultra-depleted components in the Earth's mantle. However, Hf-Nd isotope ratios in MORB from different oceanic basins [3, 4] have also identified the presence of ultra-depleted components in their upper mantle sources. Hence ultra-depleted mantle domains may be more ubiquitous than the limited available data on oceanic peridotites may suggest, and may require revising estimates of the average composition of the depleted mantle (DM) to more depleted isotope compositions.

An average DM composition that is more depleted than traditionally invoked from MORB (εNd_{DM} ~11), has wide-ranging implications for global mass balance models of Earth's differentiation [5, 6]. A depleted mantle with εNd_{DM} ~16, for example, would decrease the mass fraction of the DM from about 50 to 20% of the total mantle [5]. Moreover, in recent models based on ^{142}Nd isotope systematics [7, 8], a DM that is, on average, more depleted than MORB would permit prolonged timescales for early Earth differentiation (longer than 30 m.y. for average $\varepsilon^{143}Nd_{DM} > 10$–11).

[1] Liu *et al* 2008. *Nature* **452**, 311-316 [2] Stracke *et al* 2011. *Earth Planet. Sci Lett.* **308**, 359-368 [3] Salters *et al* 2011. G^3 12, Q10017, doi:10010.11029/12011GC003874 [4] Hamelin *et al* 2013. *Chem. Geol. et al* 128-139 [5] O'Nions *et al* 1979. *J. Geophys. Res.* **84**, 6091-6101. [6] DePaolo, D.J., 1980. *Geochim. Cosmochim. Acta* **44**, 1185-1196. [7] Bourdon *et al* 2008. *Philos. Trans. R. Soc.* **366**, 4105–4128. [8] Boyet & Carlson, 2006. *Earth Planet. Sci. Lett.* **262**, 505–516.