Beyond REE Abundance Patterns: REE Stable Isotopic Compositions

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Studies of the isotopic compositions of the REEs are primarily focused on radiogenic systems such as $^{147}Sm/^{143}Nd$, which is used for dating purposes and as a tracer of provenance. By comparison, the stable isotopic variations of the REEs still remain largely unexplored [1-3]. REE stable isotopic fractionations can potentially provide insight into the processes that govern REE patterns such as distinguishing between kinetic and equilibrium processes. Research on REE isotopic fractionations has been hindered by shortcomings in existing analytical methods. The extremely similar chemical properties of the REEs on resins hampers complete separation of individual REEs by standard ion exchange chromatography.

Here, we present the first systematic study on stable isotopic compostitions of 7 REEs including Ce, Nd, Sm, Eu, Gd, Dy and Yb using the novel technique of FPLC [4,5]. The samples analyzed are geostandards comprising a wide range of geological settings, from high temperature igneous rocks to low temperature ferromanganese nodules. All systems with 4 isotopes or more were measured using a double-spike approach. The typical external precision of the isotopic analyses is ~0.02‰/amu. The stable isotopic fractionation of each REE cover ranges from 0.10 to 0.25‰/amu. The stable isotopic fractionations are most prominent for medium REEs and show correlations with the global slope of the REE patterns for igneous rocks. The estimated average isotopic composition of the bulk silicate earth is -0.02‰ for $\delta^{142/140}Ce$, -0.02‰ for $\delta^{146/145}Nd$, -0.18‰ for $\delta^{149/147}Sm$, +0.34‰ for $\delta^{153/151}Eu$, +0.06‰ for $\delta^{157/158}Gd$, 0.00‰ for $\delta^{163/162}Dy$ and +0.02‰ for $\delta^{174/173}Yb$. Determination of REE stable isotopic fractionation adds a new dimension to REE patterns and sheds new light on a variety of natural processes.

[1]Albalat et al. (2012) *Earth & Planetary Sci Lett* **355**, 39-50. [2] Saji et al. (2016) *JAAS*, **31(7)**, 1490-1504. [3] McCoy-West et al. (2017) *Earth & Planetary Sci Lett* **480**, 121-132. [4] Ireland et al. (2013) *Chem. Geol.* **357**, 203-214 [5] Dauphas et al. U.S. Patent 9,884,266, issued Feb. 6, 2018.