Nucleosynthetic Sr and Nd isotopic anomalies of bulk differentiated meteorites

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Nucleosynthetic isotope anomalies have been discovered in bulk meteorites for refractory heavy elements (e.g., Cr, Ru [1, 2]). In the most cases, the extent of isotope anomalies is variable across different types of meteorites. These results point to the existence of planetary-scale isotope heterogeneities, which are most likely caused by the heterogeneous distribution of presolar dust grains in the early Solar System.

Although nucleosynthetic isotopic anomalies of bulk chondrites have been extensively studied in the last decade (e.g., [3]), the high-precision isotopic data of trans-iron elements in differentiated meteorites are still limited. Commonly, the parent bodies of differentiated meteorites possessed earlier accretional ages than those of chondrites. The comparison for the nucleosynthetic isotopic anomalies between chondrites and differentiated meteorites must provide vital information for understanding the physicochemical evolution of the early Solar System. Here we focus on refractory lithophile elements (Sr and Nd), whose carrier grains are silicate dust grains that were main constituents in the protoplanetary disk. In this study, we report high precision Sr and Nd isotope data of bulk differentiated meteorites.

We investigated two eucrites (Béréba and Millbillillie), an aubrite (Norton County), and an angrite (D'Orbigny). Powdered samples were treated with H_2O and distilled acetone to reduce the effects of terrestrial alteration. Subsequently, these meteorite samples were digested with HF and HNO_3 under high temperature and high pressure using a high pressure digestion system (DAB-2, Berghof). After the high-pressure digestion, samples were dissolved with $HClO_4$ and HNO_3. For Sr and Nd isotope analysis, a 5-step column separation procedure was conducted. Sr and Nd isotopic compositions were measured with TIMS (Triton *Plus*). Sr and Nd isotopic ratio measurements were conducted with the 2-line and 3-line dynamic multi-collection methods, respectively, in which $^{84}Sr/^{86}Sr$, $^{142}Nd/^{144}Nd$, $^{143}Nd/^{144}Nd$, $^{145}Nd/^{144}Nd$, $^{148}Nd/^{144}Nd$, and $^{150}Nd/^{144}Nd$ ratios can be obtained by reducing the effect of Faraday cup deterioration. The Sr and Nd isotope ratios are reported in the μM notation that is parts par 10^6 relative deviations from the terrestrial rocks.

Most of the samples we measured showed Sr and Nd isotopic ratios indistinguishable from the terrestrial rocks. Béréba (eucrite) possessed the most deviated isotopic compositions from the terrestrial rocks ($\mu^{84}Sr$ = 16 ±24 ppm, $\mu^{145}Nd$ = 5.5 ±1.9 ppm, $\mu^{148}Nd$ = 9.6 ±11 ppm, and $\mu^{150}Nd$ = 9.4 ±22 ppm, 2SDs). The inconsistency of the isotopic compositions for the same meteorite group (Béréba and Millbillillie) would be attributed to the possible terrestrial alteration for Millbillillie [4].

The nucleosynthetic Sr and Nd isotope anomalies for Béréba were indistinguishable from the data for non-carbonaceous meteorites (enstatite and ordinary chondrites) [3]. In the $\mu^{84}Sr$ versus $\mu^{145, 148, 150}Nd$ diagrams, Béréba are plotted on the mixing line of the isotopic compositions for terrestrial rocks and presolar SiC [5]. These data imply that the parent bodies for enstatite chondrites, ordinary chondrites, and eucrites were formed within homogeneous isotopic reservoir with respect to Sr and Nd in which a part of building blocks of the Earth were not formed.

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