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Neodymium in the Earth. 2022 Ingerson Lecture

ALAN BRANDON

University of Houston

Presenting Author: abrandon@uh.edu

Rare earth elements condense early during nebular cooling, and are present in pre-solar grains that have large variations in nucleosynthetic isotope compositions. Their abundances in materials that make up rocky bodies in the solar system are thus dependent on how early-formed materials and pre-solar grains are distributed in the protoplanetary disk. Neodymium isotopes track these materials from their variations in s- and r-process nucleosynthetic components. In addition, the ^{146}Sm-^{142}Nd decay system with a half-life of 103 million years, identifies potential differences in the Sm/Nd ratios of rocky body precursor materials, and once a rocky body has formed and begins to differentiate, consequent Sm/Nd fractionation can result in different present-day ^{142}Nd/^{144}Nd ratios relative to their precursor materials. For Earth, it is largely accepted that the convecting mantle today has a μ^{142}Nd of 0, and different from chondrites ranging in μ^{142}Nd from approximately -8 to -40. The open question remains on whether these differences are solely a function of a nucleosynthetic difference in Nd isotopes between Earth and chondrites, or if the present-day convecting mantle value for Earth represents a different Sm/Nd ratio in its precursor materials, or early internal differentiation and thus not representative of a bulk Earth. The current model favors the first scenario where the variations in μ^{142}Nd reflect only nucleosynthetic differences. This would mean that the bulk Earth's Sm/Nd ratio was the same as that for chondrites. Here, new high precision Nd isotope data for enstatite chondrites are combined with data for chondrites and the Moon from the literature in order to re-evaluate this conclusion. An alternative model that employs Nd isotope constraints from lunar materials, and a scenario where the Earth and Moon are derived from a well-homogenized Nd reservoir resulting from the Moon-forming giant impact, is considered. In this model, the Earth's Sm/Nd ratio is 2.4% higher than the average for chondrites and its initial ^{142}Nd/^{144}Nd ratio is closer to enstatite chondrites than previously proposed. These differences reflect mixing with the inner protoplanetary disk. Implications for an Earth with an elevated Sm/Nd ratio will be presented.