A New Perspective on Refractory Element Fractionation From REE Isotope Systematics in CAIs

J.Y. HU[1], N. DAUPHAS[1], F.L.H. TISSOT[1,2], R. YOKOCHI[1,3] AND T.J. IRELAND[1]

[1]Origins Laboratory, Department of the Geophysical Sciences and Enrico Fermi Institute, The University of Chicago, Chicago IL (jingya@uchicago.edu)
[2]The Isotoparium, Division of Geological and Planetary Science, Caltech, Pasadena CA
[3]Department of Earth and Environmental Sciences, University of Illinois at Chicago, Chicago, IL

Calcium-aluminum inclusions (CAIs) have ceramic-like chemistry and mineralogy corresponding to theoretical expectations for high-T condensation of solar nebula gas. Their unusual chemical and isotopic compositions provide insights into the processes that have shaped the compostions of planetary materials. Some CAIs have a highly fractionationed REE abundances known as type II pattern, which is characterized by a uniform enrichment in moderately refractory REEs (Tm and La-Sm), a relative depletion in the most refractory REEs (Gd-Lu except Tm and Yb), and a depletion in the most volatile REEs (Eu, Yb) [1,2]. This pattern is interpreted to represent a snapshot of the condensation sequence, meaning that during cooling of solar nebula gas, the most refractory REEs were depleted by scavenging in an ultra-refractory phase, and the residual REEs left in the gas were condensed except for the most volatile Eu and Yb [3-5]. Nebular fractionation of the REE left its imprint at all scales, from CAIs to bulk planets, in the form of Tm anomalies. To test the scenario put forward for explaining type II REE pattern, we have analyzed the stable isotopic compositions of the REEs in several CAIs. Specifically, we have measured the mass-dependent fractionations of 8 REEs including Ce, Nd, Sm, Eu, Gd, Dy, Er and Yb in a suite of 8 well characterized CAIs. We found that the CAIs show diverse isotopic fractionation patterns. The heavy REEs generally show negative isotopic fractionations while the light REEs and Eu showed both negative and positive fractionations, which is inconsistent with the prevailing view on how these patterns were established. More complex thermal processing must have been involved.

[1]Tanaka & Masuda (1973) Icarus, 19(4), 523-530. [2]Mason & Taylor (1982) Inclusions in the Allende meteorite. [3]Boynton (1975) GCA, 39(5), 569-584. [4]Davis & Grossman (1979) GCA, 43(10), 1611-1632. [5]Kornacki & Fegley (1986) EPSL, 79(3), 217-234.