Ca and Ti isotope fractionation in Ca-, Al-rich inclusions

J.I. SIMON[1], M.K. JORDAN[2], M.J. TAPPA[1,3], I.E. KOHL[2] E.D. YOUNG[2]

[1] NASA, Johnson Space Center, TX 77058, USA justin.i.simon@nasa.gov.
[2]University of California at Los Angeles, CA 90095, USA.
[3]Boston College, MA 02467, USA.

Isotopic fractionation in Ca-, Al-rich inclusions (CAIs) is largely controlled by chemical volatitily. Their isotopic compositions can be used to understand the conditions and processes present in the protoplanetary disk where they formed. At issue is the degree to which the measured isotopic signatures of Ca and Ti compare to each other, to moderately refractory elements such as Mg and Si, and to theoretical models of fractionation.

Here we present Ca and Ti isotope data for Type A (Allende EK5-2-1), Type B1 (Allende AL4884 and Allende 461 "B"), reworked Type B (Northwest Africa, NWA 2364 "Crucible"), and fine-grained (Allende 3B3) inclusions. These data will be compared to mass fractionation modeling for condensation [2-4].

All studied CAIs have $\delta^{40/44}$Ca less than "normal" ~0‰ planetary-like values [1,4]. Measured CAI values range from -0.6 to -11.3‰, clearly resolved from the bulk Allende value [1,4]. Type B's "Crucible" and AL4884 were subsampled "*in situ*" by micro milling. No resolvable difference was observed between the core and outer edge of "Crucible". In contrast, a clear difference can be seen in AL4884, with the core yielding $\delta^{40/44}$Ca = -1.66±0.08‰ (2σ) and the melilite mantle yielding $\delta^{40/44}$Ca = -0.97±0.07‰ (2σ). The Ti isotopic compositions of "Crucible" and AL4884 are similar and unresolvable from a chondritic value, i.e., $\delta^{49/47}$Ti = 0.2±0.3‰ (2σ).

This multi-element isotopic work attests to the complicated formation histories of CAIs. This first report of intra-CAI Ca isotopic zoning implies that at least AL4884 condensed with isotopically light Ca compared to planetary materials and experienced later evaporation and/ or a changing reservoir that significantly affected its surrounding melilite mantle. It is noteworthy that the polarity of Ca zoning is inconsistent with typical Mg isotopic zoning profiles that often decrease from "heavy" in the interior to "normal" values at the edge, implying that Mg in CAIs is susceptible to later modification in the solid-state.

[1] Huang S. et al. (2012) *GCA*, 77, 252-265. [2] Jordan M. et al. (2015) *LPSC*, Abst. #2472, [3] Young E.D. and Schauble E.A. (2012) MetSoc, Abst. #5382. [4] Simon J.I. and DePaolo D.J. (2010) *EPSL*, 289, 457-466.