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Calcium isotope fractionation in CAIs arising from thermal processing in the solar nebula

CHRISTOPHER A PARENDO, STEIN B JACOBSEN AND MICHAIL I PETAEV

Harvard University

Presenting Author: cparendo@fas.harvard.edu

Refractory inclusions in chondritic meteorites provide a record of early solar nebula thermo-chemical processes. Prior work has demonstrated a relationship between rare earth element (REE) patterns and mass-dependent Ca-isotope variations in Calcium Aluminum Inclusions (CAIs) [1]. These observations were used to argue in favor of an evaporation event, and variable segregation of the evaporated materials from evaporation residue, as the probable mechanism for generating Group I and Group II REE patterns in CAIs [1].

We will present new Ca-isotope and REE-concentration data and modeling results that further investigate this relationship and the plausible mechanisms that can account for it. Isotopic analyses ($^{44}Ca/^{40}Ca$, $^{43}Ca/^{40}Ca$, and $^{42}Ca/^{40}Ca$ ratios) were collected using a Nu Sapphire MC-ICPMS. Our new, larger dataset (n = 22) supports the basic finding that Ca-isotope ratios differ in CAIs with Group I vs. Group II patterns. Group I inclusions have Ca-isotope compositions close to bulk chondrites, whereas Group II inclusions have markedly lighter compositions — with a difference in $^{44}Ca/^{40}Ca$ ratios between the two populations of about 2.8‰. Geochemical modeling of the behavior of Ca isotopes, along with other variables including REEs, during disequilibrium evaporation-condensation events will be used to narrow the range of events (and conditions) that can explain the set of elemental and isotopic constraints now available for CAIs.

Lastly, we document the presence of one CAI with a chemically and isotopically distinct core and rim. Preliminary EPMA imaging and X-ray mapping suggest this feature may be primary, despite the co-occurrence of some secondary alteration. The distinct domains of this inclusion may provide an additional constraint on isotopic fractionation during CAI thermal processing.

[1] Huang et al., GCA, (2012)