A REASSESSMENT OF ALUMINUM-26 IN FUN CAIs.

E. T. Dunham1, S. J. Desch2, Z. A. Torrano3, P. Mane4 and C. D. Williams4, 1Department of Earth, Planetary, and Space Sciences, UCLA, Los Angeles, CA (etdunham@g.ucla.edu), 2School of Earth and Space Exploration, Arizona State University, Tempe, AZ, 3Earth and Planets Laboratory, Carnegie Institution for Science, 4Lunar and Planetary Institute, USRA, Houston, TX. 5Earth and Planetary Sciences Department, University of California, Davis, CA.

Introduction: A vital, open question is whether 26Al was homogeneous or heterogeneous in the early Solar System, with implications for the origin of the Solar System, chronometry of solar nebula events, and the melting of planetesimals and planetary embryos in the early Solar System. Although most Ca-Al-rich inclusions (CAIs) recorded a uniform inferred initial 26Al/27Al ~ 5×10^{-5} (the “canonical” ratio) implying a homogeneous distribution of 26Al [1], some unique CAIs apparently have initial 26Al/27Al ratios significantly lower than the canonical value [2,3]. Fractionated and Unidentified Nuclear effect (FUN) CAIs like CV3 HAL, with (26Al/27Al) ~ 5 × 10^{-6}, are argued to have such low 26Al/27Al that it would be impossible for them to form after “canonical” CAIs and before being accreted into their parent body (CV3 Allende’s accretion time is ~3 Ma). This is argued to indicate that FUN CAIs formed before 26Al was introduced into the Solar System [2,3]. We test if this interpretation is demanded, by evaluating the possibility that 26Al-poor CAIs formed after “canonical” CAIs and before parent body accretion [4]. To achieve this, we have recalculated 26Al-26Mg isochrons based on data from the literature to create a self-consistent dataset with uniform selection criteria for 26Al-poor CAIs, including: corundum (Al2O3) grains, corundum-bearing inclusions, and FUN CAIs [3].

Methods: We regressed all the 26Al-26Mg data consistently, using the York method in IsoplotR [5]. Outputs include initial 26Al/27Al, initial δ26Mg*, associated uncertainties, and MSWD. The isochron is valid and has an undisturbed slope only if MSWD is < 1 + 2 (2/(N–2))^{1/2}, where the number of data points N must be ≥ 3 [6]. Assuming a valid isochron, we then calculated the time the CAIs were formed, or reset, based on the inferred initial 26Al/27Al and assuming a canonical value at the time of Solar System formation [7]. We assume that the 26Al-26Mg system would not be reset in inclusions on most unequilibrated chondrite parent bodies [8]. We determine if this set of CAIs could be formed before the approximate chondrite parent body accretion times [4]; CV (2.4–3.0 Ma), CM (3.0–4.2 Ma), CO (2.5–2.9 Ma), CR (3.7–4.0 Ma), CI (3.1–4.1 Ma), and OC (2.0–2.2 Ma).

Results:

Corundum Grains. In the study by [9], 15 of the corundum grains from CM chondrites have at least 3 data points each, allowing the regression of 26Al–26Mg isochrons; all 15 grains have valid isochrons and 26Al-26Mg formation times (26Al/27Al upper limits from 0.1×10^{-5} to canonical) before the CM parent body accreted.

Corundum-Bearing CAIs. Out of about 16 corundum-bearing CAIs (hibonite is commonly a major phase in these inclusions) with robust 26Al-26Mg systematics, 2 have 26Al–26Mg formation times after parent body accretion (with 26Al/27Al < 0.02×10^{-5}).

FUN CAIs. The family of FUN type CAIs can be divided into subtypes defined by their mineralogy, texture, and size. Here, we focus on the distinction between small (~100 µm) PLAty Crystals of hibonite (PLAC)-like FUN CAIs and larger (a few mm) Type A and B (including Forsterite-bearing Type Bs) FUN CAIs. Out of the 9 PLAC-like FUN CAIs with robust 26Al–26Mg isotope systematics, 4 are older than parent body accretion ages (GR-1, H030, 31-2, HAL with 26Al/27Al from 0 to 0.07×10^{-5}). Out of 11 Type A and B FUN CAIs, all 11 have robust 26Al-26Mg isotope systematics consistent with resetting before their parent bodies formed (26Al/27Al ~ 0.2×10^{-5} to canonical).

Discussion: Out of ~50 “low-26Al” CAIs for which we could derive an isochron and an 26Al/27Al time of formation, ~90% are consistent with resetting in the protoplanetary disk before parent body accretion. This contradicts the common perception that most FUN CAIs have anomalously low 26Al/27Al. The few exceptions appear to be strongly associated with the presence of hibonite and/or corundum. We suggest that PLACs and PLAC-like FUN CAIs are the only objects that conform to the standard picture of low-26Al objects with a wide range of nucleosynthetic anomalies. Type A and B FUN CAIs are consistent with formation in the disk at ~ 0.5 – 3 Ma and they do not show wide scatter in ε26Ti (unlike PLAC-like FUN CAIs), instead clustering around ε26Ti ~ -42 [10]. In conclusion, PLAC-like FUN CAIs and Type A and B FUN CAIs are two distinct populations and require separate interpretations; we suggest that PLAC-like FUNs formed before “canonical” CAIs and Type A and B FUNs formed after.