Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20314

Isotopic evidence for a common origin of CAIs and AOAs

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The origin of nucleosynthetic isotope anomalies among meteorites is debated. Proposed mechanisms include processing of presolar dust grains in the accretion disk [e.g., 1,2] and inheritance from an isotopically heterogeneous molecular cloud [e.g., 3-5]. Distinguishing between these disparate origins is critical for using the nucleosynthetic isotope anomalies to reconstruct the early dynamical evolution of the disk. For instance, for most elements, Ca,Al-rich inclusions (CAIs) are isotopically distinct from bulk meteorites, indicating that CAIs formed from distinct precursor material [6]. However, the origin of the distinct isotopic composition of CAI, and whether it reflects extreme processing of presolar carriers in the CAI-forming region [1] or simply records the isotopic composition of the Sun and the early disk [3-5] is debated. Amoeboid olivine aggregates (AOAs) are, like CAIs, classified as refractory inclusions and are abundant in carbonaceous chondrites. They are less refractory than CAI and are often found in close association with and surrounding CAI. However, although AOAs are more common than CAIs, they are less well studied, such that their isotopic composition and, hence, genetic relationship to CAIs is not well known. We obtained O-Ti-Cr isotopic data for eight well-characterized AOAs from the Allende CV3 chondrite using SIMS, TIMS, and MC-ICPMS. Our results reveal a close genetic link between AOAs and CAIs, indicating formation from a common reservoir. A corollary of this observation is that the isotope anomalies in CAIs are unlikely to be the result of extreme thermal processing, but that instead the CAI/AOA forming reservoir included a large part of the condensation sequence. This supports models in which the nucleosynthetic isotope variability of the solar system is inherited from its parental molecular cloud, and where the isotopic composition of CAIs represents that of the early infall.

[1] Paton et al., (2013) ApJL 763:L40

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[3] Nanne et al., (2019) EPSL 511, 44-54

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[6] Brennecka et al., (2020) Science 370, 837-840