Insights on CAI transport mechanisms from Ti isotopic signatures

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Ca-Al-rich inclusions (CAIs) are the oldest dated solids known to have formed in the Solar System [1]. They are found predominantly in carbonaceous chondrites, but also exist in more proximally formed enstatite/ordinary chondrites as well as in more distally assembled interplanetary dust particles and comets [2,3]. This widespread distribution is puzzling, since these extremely refractory mineral assemblages are thought to have all formed near the young Sun, where temperatures were high enough to evaporate their predecessor materials. One way to address this issue is by investigating isotopic variations of nucleosynthetic origin, as these signatures are characteristic of the source reservoir in which they formed. Up until this point, however, nucleosynthetic isotopic signatures of CAIs have only been analyzed in chondritic meteorites thought to have formed within a distance within ~3.5 AU from the Sun [e.g., 4-7]. Here we report Ti isotopic signatures of four CAIs from the ungrouped, CM-like chondrite WIS 91600 that is thought to have formed at a distance ≥9.8 AU [8] and, thus, significantly more distally than other known carbonaceous chondrite groups. The inclusions were extracted from the meteorite and processed as outlined in [7].

Unlike the more enigmatic populations of (F)UN-CAIs and hibonite-rich grains (*i.e.*, PLACs or SHIBs), the four inclusions of WIS 91600 lack large isotopic anomalies and have correlated excesses in ε^{50}Ti and ε^{46}Ti. These isotope systematics imply a close genetic kinship to many previously investigated 'regular' CAIs commonly found in other chondritic meteorites [4-7]. Combined with the reported accretion age of WIS 91600 [9], our Ti isotope data reveal that CAIs from a similar population must have been distributed over a substantial portion of the disk, to at least ~10 AU within ~3 Myr of Solar System formation. This imposes fundamental constraints on CAI transport from the inner to the outer protoplanetary disk.

[1] Connelly et al. (2012) Science 338. [2] McKeegan K. D. (1987) Science 237. [3] Brownlee et al. (2006) Science 314. [4] Davis et al. (2018) GCA 221. [5] Torrano et al. (2019) GCA 263. [6] Render et al. GCA 254. [7] Ebert et al. (2018) EPSL 498. [8] Bryson et al. (2020) ApJ, in review. [9] Desch et al. (2018) ApJS 238.