CO3 AND CH/CB CAIs SUGGEST ^{10}Be WAS DISTRIBUTED UNIFORMLY IN THE SOLAR NEBULA.

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Introduction: Studies of ^{10}Be-^{10}B isotope systematics in the first-formed Solar System solids (calcium-aluminum-rich inclusions, or CAIs) can provide insights into the astrophysical environment of the early Solar System. The short-lived radionuclide ^{10}Be decays to ^{10}B ($t_{1/2}$= 1.4 Ma) and is produced almost exclusively by energetic particle irradiation [1]. The most likely astrophysical sites for ^{10}Be production are: (1) in the molecular cloud, as galactic cosmic rays (GCRs) spalled heavier nuclei, followed by ^{10}Be homogenization as the cloud collapsed to form the solar nebula [2,3]; or (2) in the nebular disk, as solar flare high-energy particles interacted with nebular gas and solids, producing ^{10}Be heterogeneously in space and time [4-7]. Most normal CAIs studied thus far have been from CV3 chondrites; these have initial ^{10}Be/^{9}Be ~$(6\text{-}9)\times10^{-4}$ [5-11], although a few with higher ^{10}Be/^{9}Be have been reported [12,13]. The few CH/CB CAIs studied so far have ^{10}Be/^{9}Be like those in normal CV3 CAIs, but one CAI has a significantly higher ^{10}Be/^{9}Be ~10^{-2} [14]. CAIs with Fractionation and Unknown Nuclear effects (FUN CAIs) and hibonites have lower ^{10}Be/^{9}Be~$(3\text{-}5)\times10^{-4}$ [7,9,15,16]. Here we report ^{10}Be-^{10}B systematics in normal, pristine CAIs from CO3 and CH/CB chondrites, to better constrain how and where ^{10}Be was produced.

Methods: Epoxy-mounted polished thick sections of CO3 chondrites Dar al Gani (DaG) 005 and DaG 027 contained six coarse-grained CAIs, and two polished mounts of the CH/CB chondrite Isheyevo contained five coarse-grained CAIs. We characterized the CAIs with the JEOL JXA-8530F electron microprobe at Arizona State University, then determined the ^{10}Be–^{10}B isotope systematics in these 11 CAIs using the IMS-1290 secondary ion mass spectrometer (SIMS) at UCLA. Using a 1-2 nA $^{16}O_2^-$ primary beam (generated by a *Hyperion-II* source [17]), we pre-sputtered a 10×10 µm rastered square, then decreased the rastered area to 5×5 µm for the analysis. Secondary ion intensities were measured with multiple electron multipliers (EMs) with a mass resolving power of ~2,500 in dynamic multi-collection mode. A NIST 614 glass was used as a standard to determine the ^{9}Be/^{11}B relative sensitivity factor (RSF) and the ^{10}B/^{11}B instrumental mass fractionation (IMF).

Results: *CO3 CAIs.* The six CO3 CAIs range in their size, mineralogy, texture, and shape: 300-830 µm in size; coarse-grained texture with melilite ±spinel, hibonite, perovskite; rounded to irregularly fragmented in shape. The ^{10}Be-^{10}B data for each of these CAIs define isochrons that yield a weighted average initial ^{10}Be/^{9}Be = $(8.4\pm1.6)\times10^{-4}$ (2SE weighted, MSWD=0.3).

CH/CB (Isheyevo) CAIs. The five Isheyevo CAIs range in their size, mineralogy, and texture: 120-290 µm in size; fine- to coarse-grained texture with melilite ±hibonite, spine, grossite, and perovskite, all are rounded in shape. Taken together, the ^{10}Be-^{10}B data for all five CAIs yields an initial ^{10}Be/^{9}Be = $(10.5\pm2.8)\times10^{-4}$ (MSWD=1.2).

Discussion/Conclusions: The six CO3 CAIs and five CH/CB CAIs measured in this study record initial ^{10}Be/^{9}Be ratios similar to those in most normal CV3 CAIs, and all have the same ^{10}B/^{11}B initial value within error. If well-behaved ^{10}Be-^{10}B isochrons (i.e., with MSWDs close to ~1) of all previously studied normal CAIs from CV3 [5-12], CR2 [18], CH/CB [14], and CO3 chondrites are considered, they yield a weighted mean initial ^{10}Be/^{9}Be = $(7.0\pm0.3)\times10^{-4}$ (2SE weighted). This suggests that ^{10}Be was distributed homogeneously in at least those regions of the solar nebula where normal CAIs formed; in this scenario, FUN CAIs (with lower ^{10}Be/^{9}Be) either formed in an isotopically distinct region or formed later than normal CAIs. This further indicates that ^{10}Be was likely produced in the molecular cloud, and was mostly homogenized during its collapse and formation of the solar nebula. If we consider this initial ^{10}Be/^{9}Be value as the steady-state level generated in the molecular cloud by interactions with GCRs, the GCR ion flux ~4.6 billion years ago in the region where our molecular cloud core was forming was about 8 times higher than present-day GCR ion flux in the solar neighborhood [3].

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