THE RANGE OF INITIAL $^{10}Be/^{9}Be$ RATIOS IN THE EARLY SOLAR SYSTEM: A RE-ASSESSMENT BASED ON ANALYSES OF NEW CAIs AND MELILITE COMPOSITION GLASS STANDARDS.

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Introduction: Beryllium-10, which decays to ^{10}B with a half-life of 1.4 Ma, is produced almost exclusively by irradiation reactions induced by solar or galactic cosmic rays ([1], and references therein). Previous studies have demonstrated that primitive calcium-aluminum-rich inclusions (CAIs) in several carbonaceous chondrite types record the prior existence of this short-lived radionuclide with an initial $^{10}Be/^{9}Be$ ratio typically in the range of ~3 to ~10 × 10^{-4} [2-8]. These secondary ion mass spectrometer (SIMS) studies used NIST glass standards to calculate the Be/B ratios in the samples analyzed. It was shown recently that for an accurate quantification of the Be/B ratios in melilite via SIMS analyses, the relative sensitivity factor (RSF, defined as $(^{9}Be^{+}/^{11}B^{+})/(^{9}Be/^{11}B)$) needs to be determined using melilite composition glass standards [9]. In this study, we synthesized and determined the composition of melilite glass standards to revise our previously obtained data for several CAIs [10], and to accurately quantify the initial $^{10}Be/^{9}Be$ ratio of a new CAI (Saguaro) from Northwest Africa (NWA) 5508 (CV3) and the FUN CAI CMS-1 [11, 12] from Allende (CV3). The goal of this work is to obtain better constraints on the origin of ^{10}Be in these refractory inclusions and, ultimately, the astrophysical birth environment of our Solar System.

Analytical Methods: Mineralogical characterization of the Saguaro CAI was performed using the JEOL JXA-8530F electron microprobe at ASU, while that for CMS-1 (including element maps and mineral compositions) was reported previously by [11]. Three melilite-composition glasses doped with varying amounts of Be and B were synthesized using procedures described previously by [12]. The major element compositions and compositional uniformity of these glasses were determined using the JEOL JXA-8530F electron microprobe at Arizona State University (ASU), Be and B concentrations were measured using the iCAP-Q ICP-MS at ASU, and the RSF for accurately determining the Be/B ratios was determined for the Cameca IMS-6f SIMS at ASU and the Cameca IMS-1290 SIMS at UCLA. The Be-B isotope systematics of the Saguaro CAI were measured on the Cameca IMS-6f SIMS using techniques described by [12]; a primary beam current of 15-30 nA resulted in a ~30 µm diameter spot. Analyses of the B isotopic composition and the Be/B ratios of individual melilites in the CMS-1 FUN CAI were performed with the Cameca IMS-1290 SIMS at UCLA using an $^{16}O^{-}$ primary beam generated by a *Hyperion-II* source. The primary beam current was 10-15 nA (resulting in a beam size ~5 × 4 µm), the mass resolving power was ~2000, and ^{9}Be (10s), ^{10}B (20s), ^{11}B (15s), and $^{28}Si^{++}$ (3s) were counted for 10-50 cycles depending on the B count rates. IMt-1 clay and NIST614 glass standard were measured during the analysis sessions on both SIMS instruments to correct the measured $^{10}B/^{11}B$ ratio for instrumental mass fractionation.

Results and Discussion: The three synthetic melilite composition glasses have Åk contents of 20, 54, 75 and $^{9}Be/^{11}B$ atomic ratios of ~11, 21, and 56. The resulting RSFs are 1.9 ± 0.2 and 2.1± 0.2 (2σ) for the IMS-6f and the IMS-1290, respectively; these are ~30% lower than RSFs calculated for non-matrix matched NIST glasses for these instruments. We recalculated the initial $^{10}Be/^{9}Be$ ratios based on our previous data [10] using the new RSF, and these recalculated values are in the range of (6-50) × 10^{-4} (somewhat broader than that determined by [9] of (9-20) × 10^{-4}). The CAI Saguaro from NWA 5508 (CV3) is a large (~18 mm on the longest axis) coarse-grained compact type A inclusion. Our Be-B data for this inclusion (obtained with the IMS-6f) yielded a $^{10}Be/^{9}Be$ = 7.9 ± 2.0 × 10^{-4} and an initial $^{10}B/^{11}B$ = 0.239 ± 0.002 (2σ). We had previously measured the Be-B isotope systematics in the FUN CAI CMS-1 with the IMS-6f at ASU but had been unable to locate clean melilite areas with Be/B ratios >~5 [12]. To obtain better constraints on the initial $^{10}Be/^{9}Be$ ratio for this sample, we re-analyzed it with the IMS-1290 at UCLA (which is equipped with a new *Hyperion* source) because a smaller spot size could be achieved with this instrument. Seven analysis spots on CMS-1 melilites range in $^{9}Be/^{11}B$ ratios from ~1 to ~87. However, even with these new Be-B data, we were only able to define an upper limit on the $^{10}Be/^{9}Be$ ratio for this CAI of ≤3.8 × 10^{-4}, with an initial $^{10}B/^{11}B$ = 0.262 ± 0.005 (2σ, which is ~5% higher than the chondritic value 0.248 [13]). This upper limit is slightly higher than the $^{10}Be/^{9}Be$ ratio of ~ 3 × 10^{-4} defined by three other FUN CAIs [4,7,14] but is still lower than the range for normal CAIs. These results further suggest that FUN inclusions were formed in a different irradiation environment than normal CAIs, and that ^{10}Be is predominately produced by spallation of CAI precursors in the solar nebula.

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