BERYLLIUM-BORON SYSTEMATICS OF REFRACTORY INCLUSIONS IN CR2 AND CV3 CHONDRITES: EVIDENCE FOR ^{10}BE HETEROGENEITY.

E. Dunham[1], M. Wadhwa[1], S. Simon[2], and L. Grossman[2] [1] School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287 (email: etduham@asu.edu), [2] Department of Geophysical Sciences, The University of Chicago, Chicago IL, 60637.

Introduction: Beryllium-10 decays to ^{10}B with a half-life of 1.4 Ma, and is of interest because it is produced almost exclusively by irradiation reactions, unlike other short-lived radionuclides [1]. Previous studies have shown that the initial Solar System ^{10}Be/^{9}Be ratio was in the range of ~10^{-4}-10^{-2} [2-9], higher than the value expected from the galactic background (~10^{-5}) [2]. While this live ^{10}Be in the early Solar System was most likely formed by spallogenesis during energetic particle irradiation, the astrophysical setting of this process (i.e., in the molecular cloud or in the solar nebula) is not yet clear. We have determined Be-B systematics in well-characterized, relatively unaltered calcium-aluminum-rich inclusions (CAIs) from Allende (CV3), Axtell (CV3) and Northwest Africa (NWA) 5028 (CR2) chondrites, to better constrain the origin of ^{10}Be in the early Solar System.

Analytical Methods: Sample characterization, including mapping of mineral phases and determination of mineral chemistries, was performed using electron microprobe techniques. Analyses of the B isotopic composition and the Be/B ratios of individual phases (primarily melilite) in the CAIs were obtained with the Cameca IMS-6f secondary ion mass spectrometer at ASU using a $^{16}O^{-}$ primary beam. The primary accelerating voltage was -12.5 kV, the primary current ranged from 15-40 nA (resulting in a beam diameter of ~20-30 um), and the mass resolving power was ~1000. Each measurement of a standard (NIST610 and IMT-1 illite) or an unknown sample consisted of 20 to 150 cycles, where ^{9}Be (8s), ^{10}B (16s) and ^{11}B (4s) were measured during each cycle.

Results and Discussion: The results of analyses of the CAIs measured here are summarized in the table below. The ^{10}Be/^{9}Be ratios inferred for Allende CAIs in this study (TS23 and TS68) fall within the range of previously determined values for CAIs from this meteorite [2-5]. The ^{10}Be/^{9}Be ratios inferred for two normal Axtell CAIs, AX4 and AX30, are consistent, within the errors, with the ^{10}Be/^{9}Be ratios inferred for an Axtell FUN CAI (AXCAI2771) in two previous studies ($3.6 \pm 0.9 \times 10^{-4}$ [4]; $2.75 \pm 0.24 \times 10^{-4}$ [7]). This suggests that the origin of ^{10}Be (i.e., the astrophysical setting of its production) was similar for both the normal and FUN CAIs.

Sample	CAI type	Alteration	^{10}Be/^{9}Be ($\times 10^{-4}$)	Initial ^{10}B/^{11}B	MSWD
Allende TS23[1]	B1	Some secondary anorthite	11.6 ± 1.9	0.240 ± 0.002	2.80
Allende TS68[2]	CTA	Lightly altered	3.8 ± 0.7	0.249 ± 0.004	1.80
Axtell AX4[2]	CTA	Lightly altered	3.2 ± 0.5	0.245 ± 0.001	1.07
Axtell AX30[2]	CTA	Some secondary anorthite	≤4.4	0.246 ± 0.001	0.11
NWA 5028_1	B1?	Minimal alteration	2.4 ± 0.4	0.246 ± 0.003	1.07
NWA 5028_2	FTA	Minimal secondary anorthite	8.6 ± 1.7	0.241 ± 0.005	0.97

[1]Previously studied by [10]; [2]Previously studied by [11]; CTA = Compact Type A; FTA = Fluffy Type A.

The CAIs 5028_1 and 5028_2 from the CR2 chondrite, as well as AX4 from the Axtell CV3 chondrite, define good isochrons (with MSWDs close to ~1). This is consistent with our petrographic observations that suggest only minimal, if any, alteration of these inclusions. In this context, it is significant that these CAIs record a large range (a factor of ~3) in initial ^{10}Be/^{9}Be, similar to the range recorded in more altered CAIs (such as TS23 from Allende and AX30 from Axtell). This indicates that the range in ^{10}Be/^{9}Be ratios observed here cannot be attributed to secondary processes, and is indicative that Be was distributed heterogeneously in the solar nebula. This further suggests that ^{10}Be was likely produced by local irradiation of nebular gas or dust rather than in the molecular cloud, since in that case its abundance would likely have been homogenized during the process of collapse and formation of the solar nebula.

References: [1] Davis A.M. and McKeegan K.D. 2014. *Treatise on Geochemistry* 2nd Ed*:*361. [2] McKeegan K. et al. 2000 *Science* 289:1334. [3] Sugiura N. et al. 2001. *Meteoritics & Planetary Science* 36:1397. [4] MacPherson G. et al. 2003. *Geochimica et Cosmochimica Acta* 67:3165. [5] Chaussidon M. et al. 2006. *Geochimica et Cosmochimica Acta* 70*:*224. [6] Liu M.-C. 2009. *Geochimica et Cosmochimica Acta* 73:5051. [7] Wielandt D. et al. 2012. *Astrophysical Journal* 748:25. [8] Gounelle M. et al. 2013. *Astrophysical Journal* 763:33. [9] Marhas K.K. et al. 2002. *Science* 298: 2182-2184. [10] Keuhner S. M. et al. 1989. *Geophysical Research Letters* 16:77. [11] Simon S. et al. 1999. *Geochimica et Cosmochimica Acta* 63:1233.