# ISOTOPIC COMPOSITIONS OF STRONTIUM, MOLYBDENUM, AND BARIUM IN SINGLE PRESOLAR SILICON CARBIDE GRAINS OF TYPE AB FROM MURCHISON.

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**Introduction:** AB grains are a group of presolar SiC grains that are characterized by low $^{12}C/^{13}C$ ratios (≲10) with a wide range of $^{14}N/^{15}N$ ratios (~50 to 10,000). Proposed stellar sources include J-type carbon stars, born-again asymptotic giant branch (AGB) stars, novae, and Type II supernovae (SNe) [1,2,3]. A recent study of AB grains [4] showed systematic differences between $^{15}N$-rich AB ($^{14}N/^{15}N$<solar, AB1) and $^{14}N$-rich AB ($^{14}N/^{15}N$≥solar, AB2) grains. In detail, AB1 grains show negatively correlated $^{26}Al/^{27}Al$ and $^{14}N/^{15}N$ ratios (N-Al correlation) with higher $^{30}Si$ excesses (relative to AB2 grains), while AB2 grains do not show such a N-Al correlation.

**Methods and Results:** To better understand the sources of AB1 and AB2 grains, we analyzed 28 sub-μm- to μm-sized AB grains with a wide range of $^{14}N/^{15}N$ ratios (25 to ~6,000) for their Sr, Mo, and Ba isotopic compositions with CHILI [5]; 15 mainstream (MS) SiC grains were also measured during the same session. We obtained Mo isotope ratios in all 43 grains; correlated Sr and Ba isotope ratios were obtained in only a few cases, indicating lower efficiencies of the Sr and Ba resonance ionization schemes and/or lower Sr and Ba concentrations in the grains. We found anomalous isotopic compositions (>2σ different from solar values in at least one of the Sr, Mo, or Ba isotope ratios) in 9 of 16 AB1 (56%), 2 of 12 AB2 (17%), and all 15 MS (100%) grains. The isotopic anomalies are consistent with *s*-process isotopic signatures, in contrast to a previous study on AB grains, in which none of the AB grains had *s*-process signatures [6]. The different results could be explained by a higher degree of contamination in the previous study, as we used a focused ion beam to remove small grains adjacent to the grains of interest prior to the CHILI analysis to reduce potential contamination.

**Discussions**: A higher percentage of AB1 grains shows anomalous compositions compared to that of AB2 grains, providing further support for the two distinct subgroups. State-of-the-art model calculations and observations suggest that J-type carbon stars and born-again AGB stars are likely to be $^{14}N$-rich [2,7], and thus are potential stellar sources of AB2 grains. J-type carbon stars show no observable *s*-process elemental enhancements, while born-again AGB stars are expected to have similar or stronger *s*-process enhancements relative to AGB stars [2,7]. Although the normal compositions measured in some of the AB2 grains could be caused by surface contamination, the fact that a much higher fraction of AB2 grains had normal compositions than that of the MS grains from AGB stars on the same sample mounts suggests that J-type carbon stars are a dominant source for AB2 grains.

The N-Al correlation found in AB1 grains [4] strongly indicates that this subgroup came from SNe with H ingestion in the pre-SN phase that resulted in explosive H-burning in the He/C zone during the explosion [8]. The *s*-process Mo isotopic patterns observed in 56% of the AB1 grains, therefore, can be used to constrain the neutron-capture environment in SNe. Two regions in a SN are predicted to show *s*-process Mo isotope ratios [9]: the inner C/O zone as a result of neutron capture during the pre-SN phase, and a small region in the outer zone (He/C or He/N) with smaller anomalies as a result of neutron capture during the explosion. The C/O zone, however, is extremely O-rich and is unlikely to be a major contributor to the Mo budgets of the AB1 grains. In the outer zone, the explosive neutron-capture process produces a non-negligible amount of $^{94}Nb$ that decays to $^{94}Mo$ with a half-life of 20.3 kyr. To explain most of the AB1 grain data along the 1:1 line in the plot of $\delta^{94}Mo$ versus $\delta^{92}Mo$, only <30% of Nb relative to Mo could have condensed into the grains. Interestingly, two of the grains fall off the 1:1 line with slightly enhanced $^{94}Mo$ abundances, which could result from the *in-situ* decay of $^{94}Nb$. Since the Mo signatures in this region are produced by explosive nucleosynthesis, the predicted location and isotopic ratios depend on the explosive energy and the initial stellar mass adopted in the models. A new set of SN models is under development with a range of explosive energies, and we will compare the new models to AB1 grain data to provide constraints.

**Conclusions**: The comparison of the AB2 with the MS grains in this study clearly points to J-type carbon stars as a dominant source for AB2 grains. In contrast, a higher percentage of AB1 grains show anomalous isotopic compositions with *s*-process signatures that probably resulted from explosive neutron capture in the He/C or He/N zone of a SN, which is roughly consistent with the mixing of regions indicated by the N-Al correlation of AB1 grains [4].

**References:** [1] Amari S. et al. (2001) *The Astrophysical Journal* 559:463−483. [2] Fujiya F. et al. (2013) *The Astrophysical Journal Letters* 776:L29. [3] Liu N. et al. (2016) *The Astrophysical Journal* 820:140. [4] Liu N. et al. (2017) *The Astrophysical Journal Letters,* in revision. [5] Stephan T. et al. (2016) *International Journal of Mass Spectrometry* 407:1−15. [6] Savina M. R. et al. (2003) *LPS XXXIV,* Abstract #2079. [7] Hedrosa R. P. et al. (2013) *The Astrophysical Journal Letters* 768:L11. [8] Pignatari M. et al. (2015) *The Astrophysical Journal Letters* 808:L43. [9] Woosley S. E. and Heger A. (2007) *Physics Reports* 442:269−283.