STELLAR ORIGINS OF PRESOLAR Y AND Z GRAINS: CONSTRAINTS FROM THEIR MOLYBDENUM ISOTOPIC COMPOSITIONS.

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Introduction: Mainstream (MS) grains, the dominant population (>90%) of presolar SiC grains, are believed to originate from low-mass asymptotic giant branch (AGB) stars with close-to-solar metallicities [e.g., 1]. In comparison, presolar Y and Z grains are two minor groups (~1−5% each) of presolar SiC grains. The main difference between Y/Z and MS grains is that the former are generally more depleted of ^{29}Si and enriched in ^{30}Si than the latter [1]. In addition, while MS and Z grains generally have lower-than-solar ^{12}C/^{13}C ratios, Y grains are defined as grains with ^{12}C/^{13}C > 100. Due to their rarity, there have been only a few studies on Y and Z grains, all of which focused on isotopic analysis of light elements (up to Ti) [2,3,4]. The large ^{30}Si and ^{50}Ti excesses observed in some of the Y and Z grains suggest that these grains come from AGB stars with lower-than-solar metallicities. Since AGB stars are the stellar site for the *s*-process, whose efficiency is inversely correlated with the stellar metallicity and sensitive to the stellar temperature, heavy-element isotopic data on Y and Z grains can, therefore, further verify their stellar origins, as well as provide more stringent constraints on the masses and metallicities of their parent stars.

Methods and Results: We analyzed 42 sub-µm- to µm-sized Y and Z grains separated from the Murchison CM chondrite for their Sr, Mo, and Ba isotopic compositions with CHILI [5]; 15 MS grains were also measured during the same session. These grains had been measured with a NanoSIMS 50L instrument at Carnegie for their C, N, and Si isotope ratios prior to the CHILI analysis. We obtained Mo isotope ratios in all 42 grains; Sr and Ba isotope ratios were obtained in only about one-third of the grains, indicating lower efficiencies of the Sr and Ba resonance ionization schemes and/or lower Sr and Ba concentrations in the grains.

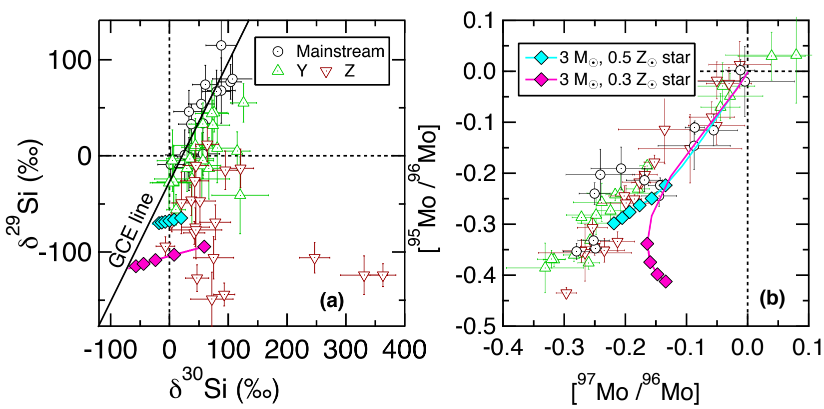

Figure 1. Grain data from this study are compared to updated Torino AGB models. The Mo isotope ratios are shown as the $\log_{10}$ of the solar system normalized isotope ratios instead of δ notations. Errors are 2σ. Each model evolves from the initial stellar composition (including GCE effect) along a colored line, with symbols plotted when C/O>1 in the envelope.

Discussion: Figure 1a shows that the Si isotope ratios of all grains, except for a few extreme Z grains, can be reasonably explained by *s*-process nucleosynthesis, if the stellar metallicity is reduced below the solar value (e.g., 0.5 $Z_⊙$, 0.3 $Z_⊙$) and if the effect of Galactic chemical evolution (GCE, solid black line) is considered. The three grains with the highest ^{30}Si enrichments in Fig. 1a, on the other hand, require AGB stars with even lower metallicities (<0.3 $Z_⊙$). The fact that the 0.3 $Z_⊙$ model predicts a reduced production of ^{95}Mo and enhanced production of ^{97}Mo, however, is inconsistent with the grain data, because the Z grains (including the three highly ^{30}Si-enriched grains) all overlap with the Y and MS grains in Fig. 1b. The deviation of the 0.3 $Z_⊙$ model from the 0.5 $Z_⊙$ model in Fig. 1b likely arises from the activation of the branch point at ^{95}Zr as a result of more efficient operation of the minor neutron source, ^{22}Ne(α,n)^{25}Mg, at increased stellar temperature in the 0.3 $Z_⊙$ model. The mismatch of the 3 $M_⊙$, 0.3 $Z_⊙$ model with the Z grains in Fig. 1b thus suggests lower stellar temperatures in their parent AGB stars. We will compare the grain data to Torino postprocessing model predictions for 1.5 $M_⊙$ AGB stars with lower-than-solar metallicities, which have lower stellar temperatures than the corresponding 3 $M_⊙$ AGB stars, to further investigate this discrepancy.

References: [1] Zinner E. (2014) *In Treatise on Geochemistry, Second edition* 1.4:181–213. [2] Amari S. et al. (2001) *The Astrophysical Journal* 546:248–266. [3] Zinner, E. et al. (2007) *Geochimica et Cosmochimica Acta* 71:4786–4813. [4] Nguyen A. N. et al. (2018) *Geochimica et Cosmochimica Acta* 221:162–181; [5] Stephan T. et al. (2016) *International Journal of Mass Spectrometry* 407:1−15. LLNL-ABS-744240.