PRESOLAR SILICON CARBIDE GRAINS OF TYPES Y AND Z: STARDUST FROM LOW-METALLICITY ASYMPTOTIC GIANT BRANCH STARS?

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Introduction: Mainstream (MS) grains – the dominant population (>90%) of presolar SiC – are believed to have originated from low-mass asymptotic giant branch (AGB) stars with close-to-solar metallicities. In comparison, presolar Y and Z grains are two minor populations (~1−5% each) of presolar SiC. The main difference between Y/Z and MS grains is that the former are generally more depleted in $^{29}Si/^{28}Si$ and enriched in $^{30}Si/^{28}Si$ than the latter. In addition, while MS and Z grains generally have lower-than-solar $^{12}C/^{13}C$ ratios, Y grains are defined as grains with $^{12}C/^{13}C \geq 100$. In some Y and Z grains, large $^{30}Si/^{28}Si$ and $^{50}Ti/^{48}Ti$ excesses were observed, suggesting that these two minor types came from AGB stars with 1/3−1/2 $Z_\odot$ [1]. However, the low-metallicity AGB stellar origins of Y and Z grains are challenged by the indistinguishable Mo isotopic compositions of MS, Y, and Z grains, in contrast to the varying Mo isotopic patterns predicted by AGB models for low-mass AGB stars of different metallicities [2]. Thus, the stellar origins of Y and Z grains remain enigmatic. Here, we provide the first piece of evidence that Y and Z grains show heavy-element isotopic compositions different than MS grains, namely higher $^{88}Sr/^{87}Sr$ and $^{138}Ba/^{136}Ba$ ratios.

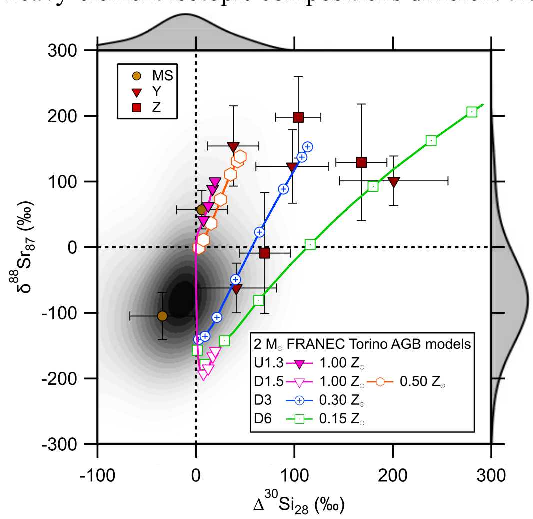

Fig. 1. *A plot of $\delta^{88}Sr/^{87}Sr$ versus $\Delta^{30}Si$ (a measure of ^{30}Si excess; see [1] for details) compares our MS, Y, and Z grains with MS grains from the literature (in grayscale density map). For AGB models, lines represent thermal pulses resulting in C/O<1 in the envelope and lines with symbols later pulses where C/O>1, allowing SiC to condense in AGB stellar winds. Compared to the reference case, the amount of ^{13}C is increased by a factor of 1.3 in U1.3 case and reduced by factors of 6.0, 3.0, and 1.5 in D6, D3, and D1.5 cases, respectively.*

Results and Discussion: Light- and heavy-element isotopic data were collected with the Carnegie NanoSIMS 50L ion microprobe and the University of Chicago's CHILI instrument, respectively. Preliminary Sr and Ba data were reported in [3]. We obtained sufficiently precise Sr and Ba isotopic data for 11 Y and seven Z grains. We found that the Y and Z grains show higher $^{88}Sr/^{87}Sr$ (Fig. 1) and $^{138}Ba/^{136}Ba$ ratios when compared to MS grains data from the literature. The Si, Sr, and Ba isotopic compositions of our Y and Z grains can be consistently explained if the amount of ^{13}C – the major neutron source for the *s*-process – is reduced by a factor of 1.0–7.8 (D6–D1.5 cases) in FRANEC Torino AGB models for 0.15–0.50 $Z_\odot$ AGB stars with respect to those (D1.5–U1.3 cases) required by MS grains for a 1.0 $Z_\odot$ AGB star (Fig. 1). This scenario is in line with the previous finding based on Ti isotopes [2], but it fails to explain the indistinguishable Mo isotopic compositions of MS, Y, and Z grains. Also, our inferred amounts of ^{13}C (D6–D1.5 cases) for the parent low-metallicity AGB stars of Y and Z grains, lie within those inferred for low-metallicity AGB stars based on stellar observations [4] but are, on average, relatively low. The unrepresentativeness of the parent stars of Y and Z grains may stem from the fact that the grains originated from a limited number of ancient low-metallicity stars, given that the abundance of Y and Z grains is more than an order of magnitude lower than the abundance of MS grains in primitive meteorites.

Conclusions: The higher $^{88}Sr/^{87}Sr$ and $^{138}Ba/^{136}Ba$ ratios of our Y and Z grains provide strong support to the suggestion that these two minor types originated from low-metallicity AGB stars, which, however, is challenged by the indistinguishable Mo isotopic compositions of MS, Y, and Z grains. Since the varying Mo isotopic patterns predicted by AGB models for stars with different metallicities result mainly from the energy dependences of $^{95,96,97,98}Mo(n,\gamma)$ cross-sections [2], new cross-section measurements are needed.

References: [1] Zinner E. (2007) *Geochimica et Cosmochimica Acta* 71:4786–4813. [2] Liu N. et al. (2019) *The Astrophysical Journal* 881:28 (14 pp). [3] Liu N. et al. (2019) *LPS* 50, Abstract #1349. [4] Busso M. et al. (2001) *The Astrophysical Journal* 557:802–821.