HEAVY ELEMENT ISOTOPIC COMPOSITIONS OF PRESOLAR SiC GRAINS OF TYPES AB, X, Y AND Z. J. G. Barzyk[1,2,3*], M. R. Savina[2,3,†], A. M. Davis[1,3,4], F. Gyngard[5], S. Amari[5], E. Zinner[5], M. J. Pellin[2,3], R. S. Lewis[3,4] and R. N. Clayton[1,3,4,6]. [1]Dept. of the Geophysical Sciences, University of Chicago, Chicago, IL 60637 [2]Materials Science Division, Argonne National Laboratory, Argonne, IL 60439 [3]Chicago Center for Cosmochemistry, Chicago, IL 60637 [4]Enrico Fermi Institute, University of Chicago, Chicago, IL 60637 [5]Laboratory for Space Sciences and the Physics Dept., Washington University, St. Louis, MO 63130 [6]Dept. of Chemistry, University of Chicago, Chicago, IL 60637 *Present Address: U.S. Environmental Protection Agency, National Homeland Security Research Center, Research Triangle Park, NC 27711, barzyk.julia@epa.gov †msavina@anl.gov

Introduction: Approximately 90% of presolar SiC grains originate in asymptotic giant branch (AGB) stars of 1.5 to 3 $M_{\odot}$ and close to solar metallicity [1]. These "mainstream" grains [2] have been the focus of most heavy element studies. We determined the isotopic compositions of light (C, N, Si) and heavy (Zr, Mo, Ba) elements in 105 presolar SiC grains from the Murchison meteorite and identified 10 as non-mainstream on the basis of their C, N, and Si compositions [3]. We measured at least one heavy element in seven of these grains, which are of types AB, X, Y, Z and "other."

Methods: Grains were from the KJH fraction of the Murchison meteorite and had mean diameters of ~5 μm [4]. Light elements were measured at Washington University by secondary ion mass spectrometry. Heavy elements were measured at Argonne National Laboratory by resonant ionization mass spectrometry. Procedures and ionization schemes are given by [3, 5].

Results and Discussion: Results are reported as δ-values with 2σ uncertainties. The reference isotopes are ^{28}Si, ^{94}Zr, ^{96}Mo and ^{136}Ba.

AB grains. AB grains have $^{12}C/^{13}C \leq 10$ [2] and may come from C-rich J-stars [6]. Both grains reported here have normal (i.e. solar) $\delta^{90,91,92}$Zr within errors but D2-06 is depleted in ^{96}Zr while D3-07 has normal $^{96}Zr/^{94}Zr$ (Fig 1). The two grains in which Mo was measured (D4-04 & D3-07, not shown) have normal Mo isotopic compositions. The one grain in which Ba was measured (D2-06, not shown) has normal Ba.

The Zr isotopic compositions of these grains differ from previous measurements in which two of three grains showed positive δ^{96}Zr [7]. The current Mo result is consistent with [7], who found normal Mo in all three grains studied, and with [8], who found normal Mo in five of seven grains and unique isotopic compositions in the other two. Although terrestrial contamination of grains in Mo [3] and Ba [3, 9] has been observed it is not likely to account for the normal compositions of the AB grains in this and previous reports because 1) it appears to affect only ~1/3 of grains and 2) only rarely was the observed contamination in mainstream grains high enough to give normal isotopic compositions. However, if AB grains have lower trace element concentrations, they might be more sensitive to contamination.

AB grains can be divided into two groups: one with enhancement in *s*-process elements and one without [6]. We found evidence of the *s*-process in only one grain, the Zr signature of D2-06. These data, along with those reported by [7, 8], indicate that a variety of stellar origins is required to account for the AB grains, including ones that produce the elevated ^{96}Zr (evidence of neutron burst [10]), *p*-process enhancement [8], and the *s*-process signature observed in one grain here.

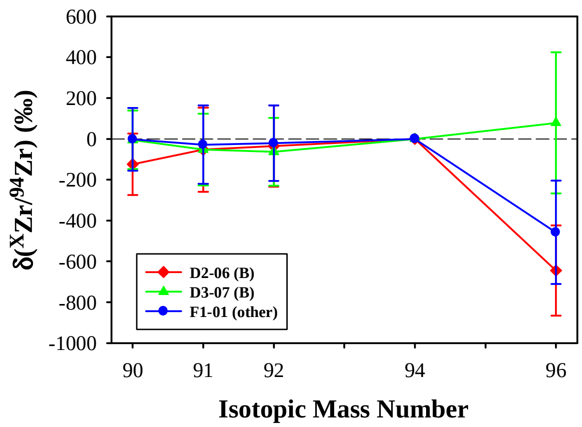

Figure 1. Zr isotopic compositions of two AB grains and one "other" type grain.

"Other" grain. Grain F1-01 has $^{12}C/^{13}C = 18$ and $^{14}N/^{15}N = 10{,}000$ and was classified as "other," though its $^{12}C/^{13}C$ ratio is close to the AB limit. Its Si isotopic composition falls on the mainstream line. It has a large depletion in ^{96}Zr (Fig 1), which is characteristic of the *s*-process, but the Mo isotopic composition is clearly not *s*-process (Fig 2). The C, N, Si, and Mo isotopic composition of this grain is similar to that of grain 054-5 from previous studies [6, 8], which was classified as type AB but which also had a very high $^{14}N/^{15}N$ ratio (10,107). In fact, the $^{14}N/^{15}N$ ratios in these two grains are among the highest known (see Fig 1 from [6]). Both show enhancements in ^{97}Mo and ^{98}Mo. Grain F1-01 also has enhanced ^{94}Mo, which is difficult to explain given that the delta value of the other *p*-process isotope, ^{92}Mo, is zero. These two grains are clearly distinct from any other SiC grains. Their stellar origins and nucleosynthetic histories are presently unknown.

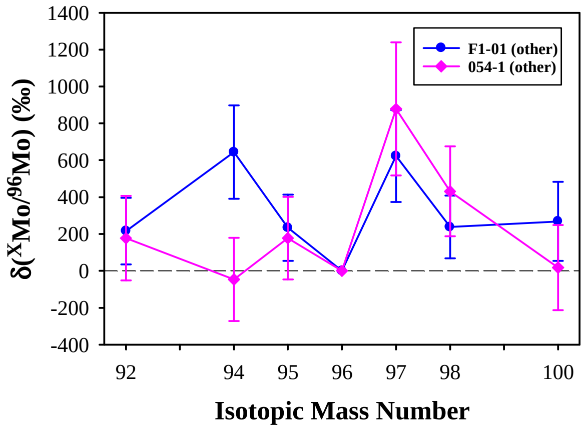

Figure 2. Mo isotopic compositions of "other" grains.

X grains. X grains are believed to come from Type II supernovae. Two grains (A3-03 and B2-05) were identified as X grains on the basis of their Si, C, and N isotopic compositions. The Mo isotopic composition of B2-05 was reported previously [11]. There, seven X grains had Mo isotopic patterns ranging from normal to extreme *n*-burst patterns (B2-05). One explanation may be varying degrees of contamination with normal Mo. Grain A3-03 shows normal Zr (Fig. 3), though Zr contamination of mainstream grains has not been observed [3]. It may be that this grain originated in a stellar region unaffected by the *n*-burst or *s*-process.

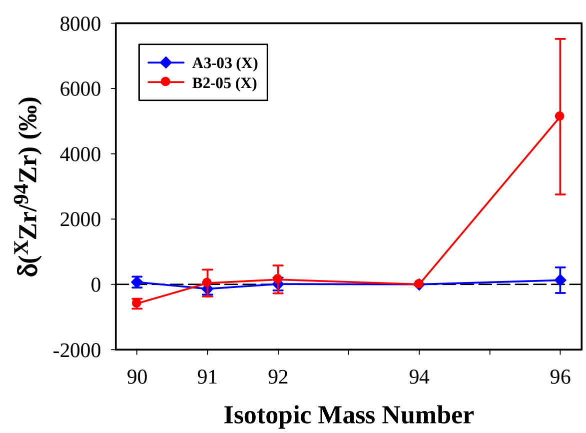

Figure 3. Zr isotopic compositions of two X grains.

Y and Z grains. D4-01 has excess δ^{30}Si relative to the mainstream correlation line and high ^{12}C/^{13}C and thus was placed in the Y group. Grain C2-02 has depleted δ^{29}Si and enhanced δ^{30}Si and has thus been placed in the Z group. Y and Z grains are believed to come from low-mass, low-metallicity AGB stars [12].

These two grains have Mo, Ba and Zr isotopic signatures consistent with *s*-process nucleosynthesis in stars of solar metallicity rather than of low metallicity. Models of low-metallicity (Z = 0.003) 3 $M_{\odot}$ AGB stars predict only small departures from the typical *s*-process signature in Mo [13], consistent with both the present Mo measurements and with one previous one [7]. The same models predict high variability in the Ba isotopic composition, and are consistent with the current Ba measurements for some choices of the ^{13}C pocket size, though the Mo composition would require larger ^{13}C pocket size. Zr should show the largest departure from *s*-process nucleosynthesis at solar metallicity. In particular, a large excess of ^{96}Zr should be observed in low-metallicity stars, which is clearly not the case (Fig. 4). Since low-metallicity AGB models of only one mass (3 $M_{\odot}$) were studied, it is difficult to say whether the model is appropriate; models of low-metallicity stars of lower mass may agree with our data.

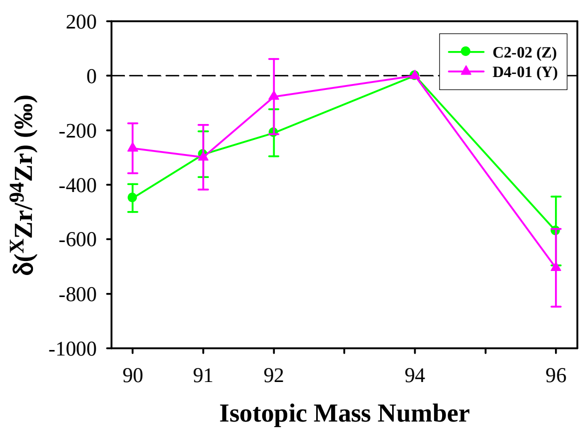

Figure 4. Zr isotopic compositions of Y and Z grains.

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