HEAVY ELEMENT ISOTOPIC COMPOSITIONS OF PRESOLAR SiC GRAINS OF TYPES AB, X, Y AND Z. J. G. Barzyk1,2,3*, M. R. Savina2,3,4*, A. M. Davis1,3,4, F. Gyngard1,2, S. Amari5, E. Zinner5, M. J. Pellin2,3, R. S. Lewis1,3,4 and R. N. Clayton1,3,4,6. 1Dept. of the Geophysical Sciences, University of Chicago, Chicago, IL 60637 2Materials Science Division, Argonne National Laboratory, Argonne, IL 60439 3Chicago Center for Cosmochemistry, Chicago, IL 60637 4Enrico Fermi Institute, University of Chicago, Chicago, IL 60637 5Laboratory for Space Sciences and the Physics Dept., Washington University, St. Louis, MO 63130 6Dept. 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☉, 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 28Si, 94Zr, 96Mo and 136Ba.

AB grains. AB grains have 12C/13C ≤ 10 [2] and may come from C-rich J-stars [6]. Both grains reported here have normal (i.e. solar) δ90,91,92Zr within errors but D2-06 is depleted in 96Zr while D3-07 has normal 96Zr/94Zr (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 δ96Zr [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 96Zr (evidence of neutron burst [10]), p-process enhancement [8], and the s-process signature observed in one grain here.

“Other” grain. Grain F1-01 has 12C/13C = 18 and 14N/15N = 10,000 and was classified as “other,” though its 14C/13C ratio is close to the AB limit. Its Si isotopic composition falls on the mainstream line. It has a large depletion in 96Zr (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 14N/15N ratio (10,107). In fact, the 14N/15N ratios in these two grains are among the highest known (see Fig 1 from [6]). Both show enhancements in 95Mo and 96Mo. Grain F1-01 also has enhanced 93Mo, which is difficult to explain given that the delta value of the other p-process isotope, 92Mo, is zero. These two grains are clearly distinct from any other SiC grains. Their stellar origins and nucleosynthetic histories are presently unknown.
Models of low-metallicity (Z = 0.003) 3 M☉ 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 13C pocket size, though the Mo composition would require larger 13C pocket size. Zr should show the largest departure from s-process nucleosynthesis at solar metallicity. In particular, a large excess of 96Zr 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☉) 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.

Acknowledgements: This work was supported by the U.S. Department of Energy Office of Science under contract no. DE-AC02-06CH11357, by the Argonne National Laboratory Graduate Fellowship program, and by the National Aeronautics and Space Administration, through grants to R.N.C., A.M.D., R.L., M.J.P., and E.Z.