PURE *s*-PROCESS MOLYBDENUM FOUND IN PRESOLAR SILICON CARBIDE GRAINS.

T. Stephan[1,2], R. Trappitsch[1,2], P. Boehnke[1,2], A. M. Davis[1,2,3], M. J. Pellin[1,2,3,4], and O. S. Pardo[1,2],
[1]Department of the Geophysical Sciences, The University of Chicago, Chicago, IL 60637, USA, [2]Chicago Center for Cosmochemistry, [3]The Enrico Fermi Institute, The University of Chicago, Chicago, IL 60637, USA, [4]Materials Science Division, Argonne National Laboratory, Argonne, IL 60439, USA. E-mail: tstephan@uchicago.edu.

Introduction: We have measured Sr, Zr, Mo, and Ba isotopes in presolar silicon carbide (SiC) grains with the Chicago Instrument for Laser Ionization (CHILI) [1, 2]. These elements are particularly important for understanding the *s*-process during stellar nucleosynthesis. Here, we focus on results from Mo isotopes analyzed in 18 SiC grains. Molybdenum has seven stable isotopes: two *p*-process isotopes (^{92}Mo and ^{94}Mo), three *s*- and *r*-process isotopes (^{95}Mo, ^{97}Mo, and ^{98}Mo), one *s*-process-only isotope (^{96}Mo), and one *r*-process-only isotope (^{100}Mo).

Samples and Analytical Procedures: Thirty-one randomly selected SiC grains from the Murchison (CM2) KJG (1.5–3 μm) size separate [3] were analyzed in this study. CHILI uses resonance ionization mass spectrometry (RIMS) to measure isotopic abundances from a cloud of atoms liberated from a sample by a desorption laser and selectively ionized with a set of lasers tuned to element-specific electronic transitions. CHILI is equipped with six tunable Ti:sapphire lasers, which allow simultaneous analysis of three elements with independent two-photon resonance ionization schemes. Fifteen grains were analyzed for Sr, Zr, and Ba isotopes, and 18 grains, including two grains from the first round, were analyzed for Sr, Mo, and Ba.

Results: Traces of Sr and Ba were found in all 31 SiC grains, and Zr and Mo were detected in all grains analyzed for these elements. Some of the Sr, Zr, and Ba analyses suffered from very low count rates, and, in a few cases, we observed some mass interferences from nonresonantly ionized molecules. However, Mo was detected in all 18 grains analyzed and seems to be free of any mass interference. For five of the 31 grains, all measured isotope ratios are consistent with terrestrial ratios within 2σ. For all other grains, the measured isotope ratios are consistent with an origin in asymptotic giant branch (AGB) stars, the source of ~95 % of all presolar SiC grains [4].

Compared to previous RIMS analyses of Mo in presolar grains [5, 6], our measurement precision was improved by factors of 1.6–4.4. Molybdenum clearly shows an *s*-process signature in our grains. Relative to the *s*-process-only isotope ^{96}Mo, all other stable Mo isotopes are depleted. Three-isotope plots of δ^{i}Mo (= $[(^{i}\mathrm{Mo}/^{96}\mathrm{Mo})_{\mathrm{grain}}/(^{i}\mathrm{Mo}/^{96}\mathrm{Mo})_{\mathrm{standard}} - 1] \times 1000$) versus δ^{92}Mo show mixing lines between two endmember compositions. One endmember is indistinguishable from terrestrial or Solar System isotope ratios and could either come from parent stars with close to solar Mo composition or from contamination with Solar System material. The other endmember can be interpreted as pure *s*-process Mo and calculated from the intercepts of δ^{i}Mo of weighted linear regression lines [7] at δ^{92}Mo = –1000 ‰, which is reasonable since ^{92}Mo is completely destroyed in the *s*-process. Furthermore, the largest deviation from normal for δ^{92}Mo in our data set was –942±2 ‰. From the intercepts, we derive *s*-process Mo to have δ^{94}Mo = –963±2 ‰, δ^{95}Mo = –617±2 ‰, δ^{97}Mo = –533±3 ‰, δ^{98}Mo = –255±3 ‰, and δ^{100}Mo = –979±2 ‰. For all regression lines, the goodness of fit was determined by calculating mean square weighted deviation (MSWD) values: 4.4 for δ^{94}Mo vs. δ^{92}Mo, 14 for δ^{95}Mo vs. δ^{92}Mo, 0.9 for δ^{97}Mo vs. δ^{92}Mo, 1.5 for δ^{98}Mo vs. δ^{92}Mo, and 8.2 for δ^{100}Mo vs. δ^{92}Mo.

Discussion: The large variation in MSWD values provides information about the variability of conditions (neutron density and temperature) during *s*-process nucleosynthesis in the grains' parent stars. MSWD values close to one for δ^{97}Mo vs. δ^{92}Mo and δ^{98}Mo vs. δ^{92}Mo suggest little relative variation in *s*-process production rates for ^{96}Mo, ^{97}Mo, and ^{98}Mo. Branching in the *s*-process path at ^{95}Zr would bypass ^{96}Mo leading to relative ^{97}Mo and ^{98}Mo enrichments, which can therefore be excluded for our 18 grains. Large MSWD values for δ^{94}Mo vs. δ^{92}Mo, δ^{95}Mo vs. δ^{92}Mo, and δ^{100}Mo vs. δ^{92}Mo suggest variable conditions in the production of ^{94}Mo, ^{95}Mo, and ^{100}Mo relative to ^{96}Mo. This could be explained by slightly varying conditions under which these grains formed affecting branch points at ^{93}Zr, ^{94}Nb, ^{95}Nb, and ^{99}Mo, of which all but ^{95}Nb show significant temperature dependence [8].

Conclusions: Because of their increased precision, the variability of the new Mo isotope data is no longer dominated by statistical uncertainties from counting statistics but reflects true variability of conditions in stellar environments during *s*-process nucleosynthesis.

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