HETEROGENEOUS Th-U-Pb ISOTOPE AND ELEMENTAL SYSTEMATICS IN CALCIUM-ALUMINUM-RICH INCLUSIONS DETERMINED BY LA-ICPMS.

K.P. Jochum[1], J.M. Friedrich[2], D.S. Ebel[2] and S.J.G. Galer[1]. [1]Max-Planck-Institut für Chemie, Postfach 3060, 55020 Mainz, Germany (kpj@mpch-mainz.mpg.de; sjg@mpch-mainz.mpg.de). [2]Department of Earth and Planetary Sciences, American Museum of Natural History, New York, NY 10024-5192, USA.(fried@amnh.org; debel@amnh.org).

Introduction: It is generally believed that Ca, Al-rich inclusions (CAIs) formed in the solar nebula very early by high temperature processes. Lead isotopes can provide absolute formation ages of CAIs with high precision [1,2]. The most precise ages of 4566 ± 2 Ma [3] and 4567.2 ± 0.6 Ma [4] have been determined for CAIs from the CV chondrites Allende and Efremovka, respectively. Lead isotopes also contain a record of the chemical environment in which the Pb resided via their uranogenic and thorogenic Pb components. There are only a few investigations of Th-U-Pb systematics in CAIs, and none with high spatial resolution. To obtain further insight, we used LA-ICPMS to determine $^{208}Pb/^{206}Pb$, $^{207}Pb/^{206}Pb$ ratios, and Pb, Th, U abundances in CAIs and matrix from the carbonaceous chondrites Allende, Axtell, Vigarano, Gao Guenie (b), Leoville and NWA-2364.

Experimental: Analyses were done with a New Wave UP 213 Nd:YAG laser ablation system combined with a single-collector sector-field ThermoFinnigan ELEMENT2 ICPMS [5]. To measure the Pb, Th and U isotopes as precisely as possible, the fast electrical mode was used. Point analyses were done using laser spot diameters of 80 – 120 µm at an energy density of about 7 J/cm^2. Ablation times were about 60 – 80 s, with a few µg sample being ablated per analysis. Typically, a single spot analysis consisted of about 150 blank and 500 ablation measurements. Mass fractionation was calibrated using intercalated measurements of the MPI-DING KL2-G reference glass [5]. We obtained in-run precisions (1 RSE) of about 0.2 – 0.5 % on $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ for concentrations of 2 to 0.2 ppm. Unfortunately, ^{204}Pb cannot be reliably determined at this level. Th/U and Pb/U elemental ratios could be measured with a precision of about 1 %.

Results and discussion: The Pb isotopic compositions of the matrix ($^{208}Pb/^{206}Pb$ = 3.1, $^{207}Pb/^{206}Pb$ = 1.1) from the various chondrites are almost primordial [6]. In contrast, 175 CAI measurements show extremely variable Pb isotope ratios: $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ ratios range from about 1 to 0.63, and 0.6 to 4.1, respectively. Measured Pb/U and Th/U ratios are also quite variable. For example, Th/U ratios in Allende CAIs vary from about 3 to 15 whereas the matrix value is 3.75 ± 0.11. Assuming a single-stage model and an age of CAIs of 4560 Ma, the µ ($^{238}U/^{204}Pb$) and κ ($^{232}Th/^{238}U$) values lie between about 2 - 300, and 3 - 18, respectively. Similarly, measured versus calculated U/Pb and Th/U ratios are well correlated for the inividual CAI spot analyses, showing that the Th-U-Pb system has not been significantly disturbed at the ~100 µm scale.

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