

**HETEROGENEOUS Th-U-Pb ISOTOPE AND ELEMENTAL SYSTEMATICS IN CALCIUM-ALUMINUM-RICH INCLUSIONS DETERMINED BY LA-ICPMS.** K.P. Jochum<sup>1</sup>, J.M. Friedrich<sup>2</sup>, D.S. Ebel<sup>2</sup> and S.J.G. Galer<sup>1</sup>. <sup>1</sup>Max-Planck-Institut für Chemie, Postfach 3060, 55020 Mainz, Germany (kpj@mpch-mainz.mpg.de; sjg@mpch-mainz.mpg.de). <sup>2</sup>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  $4566 \pm 2$  Ma [3] and  $4567.2 \pm 0.6$  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  $^{208}\text{Pb}/^{206}\text{Pb}$ ,  $^{207}\text{Pb}/^{206}\text{Pb}$  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  $80 - 120 \mu\text{m}$  at an energy density of about  $7 \text{ J/cm}^2$ . Ablation times were about  $60 - 80$  s, with a few  $\mu\text{g}$  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  $^{207}\text{Pb}/^{206}\text{Pb}$  and  $^{208}\text{Pb}/^{206}\text{Pb}$  for concentrations of 2 to 0.2 ppm. Unfortunately,  $^{204}\text{Pb}$  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 ( $^{208}\text{Pb}/^{206}\text{Pb} = 3.1$ ,  $^{207}\text{Pb}/^{206}\text{Pb} = 1.1$ ) from the various chondrites are almost primordial [6]. In contrast, 175 CAI measurements show extremely variable Pb isotope ratios:  $^{207}\text{Pb}/^{206}\text{Pb}$  and  $^{208}\text{Pb}/^{206}\text{Pb}$  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  $3.75 \pm 0.11$ . Assuming a single-stage model and an age of CAIs of 4560 Ma, the  $\mu$  ( $^{238}\text{U}/^{204}\text{Pb}$ ) and  $\kappa$  ( $^{232}\text{Th}/^{238}\text{U}$ ) 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 individual CAI spot analyses, showing that the Th-U-Pb system has not been significantly disturbed at the  $\sim 100 \mu\text{m}$  scale.

**References:** [1] Chen J.H. and Wasserburg G.J. 1981. *Earth Planet. Sci. Lett.* 52:1-15. [2] Manhes G. et al. 1987. *Meteoritics* 22:453-454. [3] Allègre C.J. et al. 1995. *Geochim. Cosmochim. Acta* 59:1445. [4] Amelin Y. et al. 2002. *Science* 297:1678-1683. [5] Jochum K.P. et al. 2005. *Int. J. Mass Spectr.* 242:281-289. [6] Tatsumoto M. et al. 1973. *Science* 180:1279-1283.