THE THERMAL AND IMPACT HISTORY OF ASTEROIDS INFERRED FROM Hf-W CHRONOMETRY OF ORDINARY CHONDRITES

J. L. Hellmann[1], T. S. Kruijer[2], J. A. Van Orman[3], K. Metzler[1] and T. Kleine[1]. [1]University of Münster, Institut für Planetologie, 48149 Münster, Germany (jan.hellmann@wwu.de). [2]Lawrence Livermore National Laboratory, Livermore, USA. [3]Case Western Reserve University, Cleveland, USA.

The thermal metamorphism of ordinary chondrite parent bodies resulted in a concentrically layered 'onion-shell' structure, where more strongly metamorphosed material is located at increasing depth towards the center [1]. This initial structure was likely disturbed by subsequent impacts that partially or wholly disrupted the parent bodies [2]. However, the timing of these events, and how they are related to the high-temperature cooling history of ordinary chondrites are poorly constrained. To address these issues, the ^{182}Hf-^{182}W chronometer was applied to a suite of equilibrated H, L, and LL chondrites (type 4–6). All samples were separated into coarse-grained metal and silicate-dominated fractions, where the latter consist of variable mixtures of silicates and very fine-grained metal. All samples define precise Hf-W isochrons for the silicate separates, yielding Hf-W closure ages that become increasingly younger with increasing metamorphic grade. This observation is consistent with an onion-shell structure of ordinary chondrite parent bodies. However, for several samples the coarse-grained metals plot below the isochron defined by the silicate-dominated fractions. Numerical simulation of W diffusion among silicates and metal reveals that owing to the very low metal-silicate ratio of the bulk silicate-dominated fractions, the Hf-W system in these fractions closed later than in the coarse-grained metals. This is consistent with the observation that metal plots below the isochrons defined by silicate-dominated fractions. Conversely, for some of the investigated type 5 and 6 samples metal plots on the isochrons, which therefore requires rapid cooling below Hf-W closure. The estimated cooling rates for these samples are higher than expected for typical type 5–6 samples buried deep inside their parent bodies, suggesting that these samples were excavated to near surface locations by impacts. Based on the Hf-W data these excavation events occurred early, between ~6 and ~11 Ma after CAI formation. This coincides with a predicted period of increased high-velocity impacts due to the growth and migration of the gas giant planets [3, 4]. Of note, each group of ordinary chondrites contains slow and fast cooled type 5-6 samples, indicating only partial disruption of the parent bodies or, alternatively, several distinct parent bodies with different impact histories.

References: [1] Trieloff et al. (2003) *Nature* 422: 502-506. [2] Scott et al. (2014) *GCA* 136: 13-37. [3] Kruijer et al. (2017) *PNAS* 114: 6712-6716. [4] Walsh et al. (2011) *Nature* 475: 206-209.