Thermal history of asteroids inferred from Hf-W and Mn-Cr chronometry

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Short-lived chronometers such as the ^{182}Hf-^{182}W ($t_{1/2}$ ~8.9 Ma) and ^{53}Mn-^{53}Cr ($t_{1/2}$ ~3.7 Ma) systems are powerful tools for constraining the accretion, thermal and impact history of meteorite parent bodies. Here, ^{182}Hf-^{182}W and ^{53}Mn-^{53}Cr ages for a comprehensive set of equilibrated ordinary chondrites are reported. The sample preparation, chemical separation and mass spectrometry followed our established protocols [1,2]. For all samples analyzed, the Hf-W and Mn-Cr ages agree within uncertainties, suggesting that both systems closed about simultaneously. Furthermore, with the exception of one H4 chondrite, the Pb-Pb ages determined in phosphates from some of the same samples [3,4] are consistently younger. Collectively, these ages indicate closure temperatures are similar for Mn-Cr and Hf-W, but much lower for U-Pb. Using the combined Hf-W, Mn-Cr and Pb-Pb data, cooling curves for some of the samples can be reconstructed. These cooling rates (at 800 °C) are ~11 °C/Ma for Guarena (H6) and Bruderheim (L6), ~22 °C/Ma for Barwell (L5) and ~70 °C/Ma for Nadiabondi (H5). The more rapid cooling for Nadiabondi is noteworthy, as it is the only sample in this study for which metal and silicates plot on a single Hf-W isochron. For the other three aforementioned samples, and several other type 5-6 chondrites [2], coarse-grained metal separates typically plot below the isochron defined by silicate-dominated fractions (consisting of silicates and fine-grained metals), most likely reflecting slightly different closure temperatures for the metal and silicate fractions. This difference is small, on the order of ~20 °C, and so only for slowly cooled samples metal will plot below the isochron [2]. This is consistent with the results for Nadiabondi from this study, which indicates rather rapid cooling and therefore contemporaneous closure of the Hf-W system in metals and silicates. This more rapid cooling indicates a shallower burial depth in the parentbody that may reflect either the original location of the sample, or impact excavation of initally more deeply buried material.

[1] Göpel C. et al. (2015) *GCA*, *156*, 1-24. [2] Hellmann J.L. et al. (2018) *EPSL*, *subm*. [3] Göpel C. et al. (1994) *EPSL*, *121*, 153-171. [4] Amelin Y. (2000) *LPSC* 31, #1201