Fe-isotopic composition of CV chondrite chondrules

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Chondrites are conglomerates of various different components that record the physical and chemical history of the solar system prior to planet formation. Chondrules and matrix are the major components of chondrites with volumetric abundances of around 45% and 40%, respectively, in the group of CV chondrites (Brearley & Jones 1996). The few Fe-isotopic studies of chondrules from various carbonaceous and ordinary chondrite groups conducted so far show that their δ^{56}Fe range from -1.33 to +0.65‰ (Zhu et al., 2001; Alexander & Wang, 2001; Kehm et al., 2003; Mullane et al., 2005; Needham, 2007; Hezel et al., 2008) is among the largest of all solar system materials, including terrestrial samples (Beard & Johnson and references therein). Zhu et al. (2001) found that all solar system materials plot on a single mass-dependent fractionation line in the Fe-3-isotope plot (δ^{56}Fe vs. δ^{57}Fe), indicating that Fe-isotopes were homogeneously distributed in the inner part of the proto-planetary disk.

We measured the Fe-isotopic composition of 26 chondrules in the CV chondrites Mokoia (16), Allende (6) and Grosnaja (4) as well as matrix and bulk chondrite of Mokoia and Grosnaja, using a multi-collector ICP-MS at Oxford. Small bits of each chondrules have been saved and prepared as thick sections for imaging and petrologic study.

The δ^{56}Fe of the chondrules we measured range from -0.82 to +0.40‰. Bulk Mokoiaδ^{56}Fe is -0.07±0.09‰ and bulk Grosnaja +0.02±0.01‰, i.e. virtually indistinguishable from the standard. The same is found for the matrix. The Grosnaja matrix has a δ^{56}Fe of +0.09±0.14‰ and Mullane et al. (2005) report a value of -0.07±0.02 for the Allende matrix. This means, the average chondrule δ^{56}Fe must also be close to the bulk chondrite δ^{56}Fe. It therefore seems that all material started of with the same δ^{56}Fe and subsequent processes in the nebula or on the asteroid changed the Fe-isotopic compositions of the chondrules. There is no correlation of the Fe-isotopic composition of the chondrules with their size, FeO-concentration, sulfide content or texture. However, the scatter in δ^{56}Fe decreases with increasing chondrule size and/or FeO-concentration. The chondrule range from negative to positive δ^{56}Fe require processes that enrich chondrules in both, light and heavy Fe.

Possible mechanisms to achieve this are evaporation and re-condensation in the nebula or alteration on the asteroid. We currently perform calculations to study the impact of these effects. Preliminary results indicate that repeated evaporation and re-condensation can account for the observed data.

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Abs. No. **104**
Meeting: **DMG 2008**
submitted by: **Hezel, Dominik**
email: **d.hezel@nhm.ac.uk**
date: **2008-05-28**
Req. presentation: **Vortrag**
Req. session: **S02**