Thermal history of CO chondrite components - constraints from diffusion modeling of chondrule and matrix minerals

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We analyzed the Fe-Mg zoning in olivine and spinel in different chondrule types and in the matrix of three CO chondrites of different petrologic types (Colony, Kainsaz, Lance) using EMPA and STEM. Thermodynamic and diffusion modeling was used to identify and characterize the thermal processes that shaped the observed mineral zoning. To simulate growth zoning formed during chondrule crystallization we combined thermodynamic modeling using the MELTS software [1] with diffusion modeling. The measured zoning profiles were thereby fitted using the chondrule cooling rate as a fitting parameter. The Fe-Mg zoning in olivine could be reproduced by this model assuming cooling rates of 1-50°C/h. We infer only a minor modification of the zoning during parent body metamorphism for Kainsaz and Lance that is difficult to distinguish from growth zoning. Fe-Mg zoning in type II chondrule spinel and type IB chondrule olivine is not consistent with crystallization from the chondrule melt, but formed during later re-equilibration. The extent of this secondary zoning correlates with the petrologic sub-type of the respective chondrites (e.g. [3] [4]). By combining thermal modeling of parent body metamorphism with diffusion modeling of zoning in spinel, type IB chondrules and matrix olivine [2] we determined similar peak temperatures for a given meteorite, which is consistent with a formation of the zoning during parent body metamorphism.

[1] Ghiorso and Sack (1995), *Contrib Mineral Petrol* **119**, 197-212. [2] Schwinger et al. (2014), *LPSC* **45**, 1952. [3] Bonal et al. (2006), *Geochim. Cosmochim. Acta* **71**, 1605–1623. [4] Sears et al. (1991), *Symp. Antarct. Meteorites* **4**, 319-343.