FORMATION CONDITIONS OF ZONED AND UNZONED METAL GRAINS IN CB AND CH CHONDRITES

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Introduction: CH and CB chondrites are unique among the primitive meteorites due to bulk enrichment in refractory siderophile and lithophile elements in comparison with other chondrite groups [1,2], an unusually high metal content of 40-70 vol% and absence of matrix in CB [3]. Probably the most striking characteristic is that CH and fine-grained CB_b chondrites contain chemically and isotopically zoned metal grains [e.g., 4]. Iron and Ni isotope profiles are parallel, with lighter compositions in cores than in rims, and indicate a condensation origin of zoned metal [5]. This is supported by the concentrations of refractory siderophile elements in zoned grains [5]. Unzoned metal grains are also thought to have formed by condensation [6]. The setting of condensation is controversially discussed: impact-induced vapor plume [7] vs. solar nebula [4]. A depletion of W relative to other refractory elements in zoned metal suggests elevated oxygen fugacities in the gas reservoir, and hence, is indicative for an impact event [5]. However, it is still unclear how zoned and unzoned metal are related with each other, and as well, how condensation in an impact plume proceeded. Here we present a potential formation model based on isotope and trace element data.

Samples and Methods: We identified zoned metals by EMPA element mappings in: Hammadah al Hamra 237 (HaH237), QUE 94411, MAC 02675 (all CB_b), Isheyevo (CH/CB_b breccia), Acfer 214, PAT 91546, and Sayh al Uhaymir 290 (SaU290; all CH). Iron and Ni isotope compositions of zoned and unzoned metal grains of those meteorites were determined *in situ*, using a Solstice *fs*-LA system in combination with a Thermo Neptune Plus MC-ICP-MS. Additionally, trace element abundances (PGE, Ge, Cu, Au, W, and Mo) were measured via *fs*-LA-SF-ICP-MS (Thermo Element XR). Moreover, unzoned metal grains of the CB_a chondrites Gujba, Bencubbin, and NWA 4025 were examined for their Fe and Ni isotope, and trace element compositions.

Results and Discussion: Combined data of Fe and Ni isotope composition and refractory elements, suggest that zoned and unzoned metals formed under somewhat different conditions. Unzoned grains scatter isotopically around 0 ‰ for both δ^{56}Fe and δ^{62}Ni. However, zoned metal grains have significantly lighter isotope compositions in the cores. The lightest composition occurs in a grain from MAC02675 with $\delta^{56}Fe \approx -7.4$ ‰ and $\delta^{62}Ni \approx -10.8$ ‰. Moreover, the depletion of W relative to element abundances of other refractory siderophiles, is not apparent in the majority of the unzoned metal grains. Though some rims of zoned metals have similar isotope composition to unzoned metal grains, rims of zoned metals vary more in their isotope composition and show rather narrow variability in refractory element concentrations. It is exactly the other way for unzoned metal grains. Among different grains the isotopic composition is more or less the same but refractory element concentrations vary largely. Correlation of isotopic compositions with concentration of refractory elements in zoned metal, and isotopic differences between cores and rims, reveal that condensation of zoned grains was dominated by kinetic fractionation. Such grains grew probably in the fast-cooling outer region of the impact plume, as high temperature gradients favour kinetic fractionation. Data for unzoned metal grains suggest condensation under more equilibrium-like conditions, and was likely situated in the slowly cooling interior of the impact plume.

Since the relationship of metals and silicates in CH and CB chondrites is still unclear, we performed first *in situ* Si isotope analyses via *fs*-LA-MC-ICP-MS of cryptocrystalline chondrules in Isheyevo and HaH237. Our preliminary data show no enrichment in light Si isoptopes for CC chondrules, which may be expected if assuming Si isotope fractionation due to reaction of chondrules with the surrounding gas phase [8]. The data are currently being evaluated considering the possibility of simultaneous condensation of cryptocrystalline chondrules and metal in CH and CB chondrites.

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