Equilibration time of Fe and Zn concentrations and isotopes in high-pressure-temperature metal-silicate partitioning experiments

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The distribution of elements and their isotopes between planetary cores (metal) and mantles (silicate) can be studied under controlled P-T conditions using high-pressure-temperature metal-silicate partitioning experiments. To accurately assess the partitioning of Fe and Zn concentrations and isotopes simultaneously, we performed time-series (3 minutes up to 12 hours) experiments with the same starting composition (Fe metal doped with Zn and Apollo 15 Green Glass [1]) at constant conditions (1GPa, 1823K).

Major- and trace-element concentrations of metal and silicate phases of each experiment were determined by electron microprobe and laser ablation-ICPMS.

Fe and Zn are separated from the silicate and metal phases by ion-exchange chromatography with AG-X8 (Fe) and AG-MP-1 (Zn) resins [2]. Fe and Zn isotopes are measured on a multi-collector-ICPMS with a double spike technique. The standards IRMM-014 (Fe) and ETH-Zn indicate a precision of ±0.03‰ (2SD) for Fe isotopes and ±0.05‰ (2SD) for Zn isotopes.

The results show that elemental equilibrium is reached within 30 minutes at these conditions, whereas Fe and Zn isotopic equilibration times are longer. In the first two hours of an experiment, the fractionation factors Δ^{56}Fe(metal-silicate) and Δ^{66}Zn(metal-silicate) are positive and variable. Between 2 to 4 hours, the fractionation factors become negative and more stable. After 4 hours isotopic equilibrium is reached with Δ^{56}Fe(metal-silicate) = -0.04‰ ± 0.07 and Δ^{66}Zn(metal-silicate) = -0.11‰ ± 0.06. This initial data set suggests that there is a relatively uniform Fe and Zn isotope distribution between metal and silicate during core formation at high temperature, which corresponds with literature data [3,4]. Quantification of the effects of pressure, temperature and metal- and silicate composition will be needed to further test this hypothesis.

[1] Delano (1986) JGR 91, 201. [2] Moeller et al (2012) GGR 36, 177. [3] Hin et al (2012) GCA 93, 164. [4] Bridgestock et al (2014) EPSL 400, 153.