Metal isotope fractionation as a tracer of core formation?

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The study of siderophile element isotope compositions in planetary mantle offers a new methodology to constrain the temperatures of core formation, provided there is an appropriate calibration of the temperature dependence of isotope fractionation between metal and silicate and of the metal-silicate partitioning for this element. Recent studies have shown that Si, Fe, Mo, Cr and Ni could potentially be used to constrain the temperature of metal-silicate equilibration using single stage or continuous models of core formation, yielding contrasted results. Existing isotope observations and experimental calibrations of metal-silicate isotope fractionation will be first reviewed. The assumptions made in these models will be reexamined critically, and compared with recent parameterizations for metal-silicate equilibration.

If the metal-silicate equilibration is incomplete, as is the case for giant impacts, then the composition of the mantle of the impactor and the fraction of metal that equilibrate needs to be assessed carefully. The study of Deguen et al. [1] shows that the degree of equilibration will be a function of the metal-silicate partition coefficient and will be hence very different for Si, Cr, or Mo, an aspect that has not been considered in previous studies. For example it would predict for the same large impact equilibration of 2‰, 15% and 60% for Mo, Cr and Si respectively. Hence the expected temperatures of equilibration are quite variable and are a function of the impactor's conditions of metal-silicate segregation. Another complication arises when considering continuous models of core formation: the most siderophile elements will be sensitive to the last episodes of core formation, while the budget of less siderophile elements will reflect its integrated accretion (e.g. Cr or Si). In addition, the assumption that the starting material has a chondritic composition can also be questioned, as the building blocks of the Earth could have been affected by thermal processing. Similarly, the estimation of the mantle isotope composition could depend on the effect of whole mantle differentiation.

[1] R. Deguen et al. *Earth and Planetary Science Letters* **391** (2014) 274–287.