# An experimental study of thallium partitioning and isotope fractionation during planetary core formation processes

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In a recent study [1] it was proposed on the basis of thallium (Tl) isotope variations in iron meteorites that the short-lived radioactive nuclide $^{205}Pb$, which decays to $^{205}Tl$ with $t_{1/2}$ of 15 Myrs, was present in the early solar system. Tl only has two isotopes, however ($^{203}Tl$ and $^{205}Tl$) and it is difficult to distinguish Tl isotope variations due to decay of $^{205}Pb$ from stable isotope fractionation. Specifically, it was concluded that the troilite nodules of iron meteorites contain Tl that is isotopically fractionated relative to the metal phase. These are therefore not suitable as indicators of $^{205}Pb$ decay.

Modeling of Terrestrial accretion and core formation implies that either Earth's core is highly enriched in Tl compared to iron meteorites or most of the original terrestrial Tl budget was lost to space, perhaps during the putative Moon-forming giant impact. Deciding between these alternatives requires knowledge of Tl partitioning behaviour during core formation.

We reacted mixtures of silicate, sulfide and metal in a piston-cylinder apparatus at 2 GPa and 1750°C. For Tl, liquid metal-liquid silicate $D^{met/sil} < 0.5$, which would result in a silicate Earth with a much higher Tl concentration than is observed. Tl is chalcophile, however, and for liquid sulfide $D^{sul/sil} \sim 20$. The partition coefficient for Tl at a sulfur concentration similar to that of the Earth's core (about 1.7%, [2]) is still too low to extract sufficient Tl from the mantle.

An alternative mechanism for placing additional Tl in the core is offered by late addition of sulfide, a process revisited by Wood and Halliday [3]. If the $D^{sul/sil}$ value determined here is representative of sulfide segregation from the mantle, then >10% (by weight) of the mantle is required to precipitate as sulfide in order to balance the Tl budget of the bulk Earth, which is clearly unrealistic. The only other ways to balance the Tl budget of the earth is either loss of Tl to space during volatile element depletion processes such as the giant impact or by assuming that the bulk Earth has a low Tl concentration, which in turn implies that bulk Earth $^{238}U/^{204}Pb > 2$.

[1] Nielsen S.G., Rehkämper M. and Halliday A.N., 2006. *Geochim. Cosmochim. Acta* **70**: 2643-2657.

[2] Dreibus, G and Palme, H. 1998. *Geochim. Cosmochim Acta* **60**: 1125-1130

[3] Wood B.J. and Halliday A.N., 2005. *Nature* **437**: 1345-1348.