The Partitioning of Volatile Elements between Metal and Silicate at high Pressures and Temperatures

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The conditions under which core formation occurred in the terrestrial planets can be defined by combining the extent to which siderophile elements have been depleted from the mantles of such bodies with experimentally determined metal-silicate partition coefficients. Additional constraints on accretion and core formation processes will be provided by including volatile elements into models [e.g. 1]. We are therefore studying the liquid metal – liquid silicate partitioning behaviour of the volatile elements Sn, Pb, P, Cu, Ge, Sb, As, Ag and Au (covering a range of 650 K in condensation temperatures [2]) as well as the refractory elements Ni, Co, W and Mo.

Experiments were performed over the P/T range 10-23 GPa and 2273–2673 K using a multianvil apparatus, with oxygen fugacities varying between -1.8 and -2.4 log units relative to the iron-wüstite (IW) buffer. Our starting compositions, either initially layered (sil-met-sil) or mixed, consisted of 34-82 wt% silicate (peridotitic composition) and 18-66 wt% metal (95-99.5 wt% Fe and 0.5-3 wt% elements/oxides of interest). The effect of adding Pb within the silicate rather than with the metal and the influence of the light element S (10 wt% S added to the metal phase of the starting composition) have also been determined.

The elements Sn and Pb have been depleted by about the same amount in the Earth´s mantle, which requires that their partition coefficients were similar during core formation. We find that pressures ≥30 GPa are necessary to avoid fractionating these elements. 10 wt% S in the metal phase has hardly any influence on the $D^{met/sil}$ of Pb but lowers the value for Sn by about 0.6 orders of magnitude, which emphasizes the importance of including S effects.

Our ultimate goals are to determine, for all elements studied, the dependencies of $D^{met/sil}$ on P, T, fO_2 and S content and incorporate these elements into multistage accretion/core formation models [e.g. 1].

[1] Rubie, D.C. et al. (2011a) EPSL 301, 31-42.
[2] Lodders, K. (2003) Astrophysical J. 591, 1220-1247.