Sequestration of tungsten into the core during Earth's accretion

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The metal-silicate partitioning of tungsten during core formation is important for understanding the evolution of the Earth and other planetary bodies because the Hf-W isotopic system is used to date early planetary evolution [1]. Based on new experimental results and previously published data [e.g. 2], we fit W partition coefficients as a function of *T*, *P* and activities of C, Si, O and S in the metal. W interacts strongly with C in the metal, and experiments performed in graphite capsules show a ~1 log unit increase in K_D^W relative to C-free experiments. We use the revised parameterization for W in our combined accretion/core mantle differentiation model which is refined by least squares optimization in order to obtain a model Earth's mantle with BSE concentrations of siderophile elements [3,4]. Excellent results are obtained in reproducing BSE concentrations of FeO, SiO_2, Ni, Co, Nb, Ta, V, Cr, Mo, Pt, Pd, Ru, Ir, S and H_2O. However, the calculated mantle W concentration is 40-50 ppb: this is much higher than the BSE estimate of 12 ppb [5]. Additionally, the calculated carbon concentration of ≥ 220 ppm is much higher than the estimated BSE value of ~100 ppm, even when assuming a very high metal-silicate partition coefficient for C. An additional mechanism is therefore required to reduce the calculated W and C mantle concentrations. One possibility is the crystallization and segregation of dispersed iron carbide or C-saturated iron liquid to the core during magma ocean differentiation. This could occur through Fe^{2+} disproportionation to Fe^{3+} and metal during bridgmanite crystallisation [6], by pressure-driven disproportionation in silicate liquid, or by redox reactions with variably oxidised late impactors.

References: [1] Kleine, T. et al. (2009) *GCA 73,* 5150-5188. [2] Wade, J., Wood, B.J. and Tuff, J. (2012) *GCA, 85,* 58-74. [3] Rubie, D.C. et al., (2015) *Icarus 248*, 89-108. [4] Rubie, D.C. et al., (2016) *Science 353*, 1141-1144. [5] König et al. (2011) *GCA 75*, 2119-2136. [6] Frost et al. (2004) *Nature 428*, 409-412.