Chalcophile or lithophile?: A question of environment

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Many chalcophile elements exhibit a simple relationship between their sulfide liquid-silicate melt partition coefficients and the FeO contents of the coexisting silicate [1]: $\log D_i \cong A - 0.5n\log[FeO]$ where n is the valency of element i, [FeO] is the concentration of FeO in the silicate melt and A is a constant. Elements which closely obey the simple model are Pb, In, Sb, Cd, Co, Zn and Cr. Other elements deviate, markedly however, because of their interactions with oxygen dissolved in sulfide, which increases with increasing FeO in the silicate and, under certain circumstances sulfur dissolved in the silicate.

Partition coefficients of lithophile Nb, Ta, Ce and Ti between sulfide and basaltic melt all exhibit concave upwards behavior on a plot of logD versus log[FeO] due to their strong interaction with oxygen in sulfide. New experiments on chalcophile Cu and Ag at low FeO contents confirm that these elements show the opposite behavior (concave downwards). Surprisingly, as the FeO content of the silicate melt declines below about 1 wt%, the partition coefficient of Cu, $D_{Cu}^{sulf/sil}$ declines to low values whereas those for Nb and rare earths become very high. Both these changes correlate with increasing S content of the silicate melt (up to 11 wt%) as the FeO content of the silicate melt declines to ~0.3wt%. An experiment at 1.5 GPa/1420ºC having 4 wt%S and 0.28wt% FeO in the silicate melt has $D_{Nb}^{sulf/sil}$ of 604, while $D_{Cu}^{sulf/sil}$ ~ 84. Thus, Nb becomes substantially more “chalcophile” than Cu in that it partitions more strongly into sulfide relative to silicate.

We now have a comprehensive understanding of the chalcophile nature of >20 elements. One potential application relates to strong partitioning of U, Nd and Sm into sulfide under reducing conditions. Addition of a S-rich reduced component to the accreting Earth could generate a significant ^{142}Nd anomaly in the mantle and transfer sufficient U and Th to the core to drive the geodynamo [2].

[1] Kiseeva, E.S., Wood, B.J. (2013) *EPSL* **383**, p. 68-81. [2] Wohlers, A., Wood, B.J. (2015) *Nature* (in press)