Chalcophile element partitioning between sulphide and silicate liquids: effect of temperature and melt composition

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A recent study by Kiseeva and Wood (2013) has shown that there is a simple relationship between sulphide/silicate partition coefficients $D_M^{sulph/sil}$ for individual trace elements and FeO contents of the silicate liquids, which can be generally represented by the following equation:

$$\log D_M^{sulph/sil} \approx A + \frac{n}{2}\log[FeO]$$

where A is a constant related to the free energy of Fe-M exchange, n is a constant related to the valence of the element and [FeO] is the FeO content of the silicate melt in mole fraction or weight %.

Here we report the results of a new set of piston cylinder experiments that account for the effects of temperature, silicate melt and sulphide liquid composition on sulphide-silicate partitioning of the elements (Cu, Ni, Ag, Co, Cd, Pb, Zn, Mn, Sb, In, Tl, Cr).

1. Variations of Cu, Ni and Fe in the sulphide liquid do not affect sulphide-silicate partitioning, provided FeO content of the silicate melt is corrected as follows:

$$[FeO]_{corrected} = \frac{[FeO]_{silicate}}{[Fe/(Fe+Ni+Cu)]_{sulphide}}$$

2. Oxygen dissolved in the sulphide acts to decrease partition coefficients for more chalcophile elements (e.g. Cu, Ni, Ag) and increase for more lithophile elements (e.g. Mn, Zn).

3. Measured temperature effects on partitioning are consistent with thermodynamic data on sulfides and oxides; Ni, Cu and Ag exhibiting the largest tenperature-dependences.

4. Tl and Pb show the strongest dependences on silicate melt composition with both elements becoming more chalcophile with higher NBO/T (ratio of nonbridging oxygens to tetrahedral cations).

Our results enable us to correctly predict the concentrations of chalcophile elements in MORB and to address such questions as the Ce/Pb and Nd/Pb ratios of primitive basalts. Recent measurements of the chalcophile element concentrations in sulfide globules found in MORB are consistent with our results at quenching temperatures of 1100-1200ºC (for Co, Ni, Cu, Zn, Ag, Cd and Pb). During fractional crystallisation from a basaltic parent, chalcophile element concentrations in silicate melt properly reflect the changing degree of sulfide saturation.