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The effect of sulphur in silicate melt on partitioning of Ni and other trace elements

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It has been suggested that variations in the sulphur contents of silicate melts affect the partitioning of trace chalcophile elements, particularly Ni, between silicate melt and crystalline phases such as olivine [1]. The general idea is that Ni (and other elements) complex with sulphur dissolved in the melt, thereby stabilising Ni in the melt and reducing the olivine-melt partition coefficient DNi.

More recent experiments lead to the assertion that any sulphur effect, if present is small and can be ignored [2]. Experiments aimed at addressing this problem have, however, struggled with the difficulty that the maximum S contents of olivine- precipitating melts do not exceed ∼0.5% even at sulphide saturation. Any effect is therefore difficult to establish unequivocally. Here we have taken advantage of the fact that experiments under strongly reducing conditions, where FeO activity in the silicate melt is very low lead to much higher concentrations of S than those associated with olivine precipitation. We have therefore investigated partitioning between sulphide melts and haplobasaltic silicate melt at concentrations of FeO between 0.3 and 10 weight% in order to investigate the "sulphur-effect" on partitioning. At the lowest FeO contents we are able to drive the S content of the melt to 10 weight% enabling the effects to be unequivocally established.

We find that partitioning of strongly lithophile elements Nb, Ta, U, REE partition more strongly out of silicate melt as its S content increases. The effect is, surprisingly, predominantly due to the effect of S on the activity coefficient of FeO in the melt. In contrast strongly chalcophile Ni, Cu, Ag partition more strongly into the melt as its S content increases. This is due to a dramatic lowering of the activity coefficients of these elements in the silicate as S increases. Elements which show little effect of S include Pb, Co and In. The results enable us to predict the effects of sulphur on olivine-melt and clinopyroxene-melt partition coefficients for a large number of trace elements.

[1] Li C., Ripley E. M. and Mathez E. A. (2003) The effect of S on the
partitioning of Ni between olivine and silicate melt in MORB.
Chem. Geol. 201, 295–306.
[2] Tuff, J. and O'Neill, HSC (2010) The effect of sulfur on the partitioning of Ni and other first-row transition elements between olivine and silicate melt. Geochim. Cosmochim Acta 74, 6180-6205