An experimental study of the chalcophile character of Re: the effect of fO_2, fS_2 and temperature

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It is known from empirical observations that Re fractionates from Os during partial melting of the mantle, with obvious implications for the Re/Os isotopic system. Partial melts have relatively high Re/Os whereas the residues have low Re/Os. Sulfide melt in the source region is thought to play an important role in the fractionation of Re and Os. However, the extent to which Re behaves as a chalcophile element under various mantle conditions, and how it compares to Os and other PGEs in this regard, is not fully understood.

We report the resuts of an experimental study of the solubility of Re in sulphide melts over a range of fO_2, fS_2 and temperatures, which allow extrapolation to conditions pertinent to the Earth's mantle. Experiments were carried out in a vertical muffle tube furnace, equiped for gas mixing, with fO_2 and fS_2 controlled by mixing SO_2, CO and CO_2. Run products were analyzed by electron microprobe for major elements, and by laser ablation ICP-MS for trace elements.

The solubility of Re in sulphide melts increases with increasing fS_2, with Re dissolving as Re^{4+} at high fS_2 and Re^0 at low fS_2. The effect of fO_2 is negligible except at high fO_2 where O in the melt becomes important. An increase in temperature leads to an increase of the solubility of Re in sulphide melts of ~0.5%/ºC.

Sulfide-melt/silicate-melt partition coefficients of Re ($D_{Re}^{sul/sil}$) can be calculated by dividing the alloy/silicate-melt solubility data from [1] with the alloy/sulfide-melt partitioning for Re obtained from our experiments. Assuming a relative fO_2 of QFM-1, and a fS_2 of $10^{-0.5}$ bars, the calculated $D_{Re}^{sul/sil}$ is 2 x 10^2, which is of a similar order of magnitude to the reported value of 46 obtained from sulfide blebs in MORB glasses [2]. It is consistent with the experimental data of [3], when recalculated at the same fO_2 and fS_2. Re is thus only partially chalcophile in actual mantle compositions, and the amount of residual sulfide is important for the observed fractionations of Re from Os during partial melting of the mantle.

References:

[1] Ertel et al. (2001) GCA **65,** 2161-2170
[2] Roy-Barman et al. (1998) EPSL **154**, 331-337
[3] Sattari et al. (2002) EG **97**, 395-398