Sulphur solubility of reduced iron-rich melts

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Although much work has been done to understand the controls on the sulphur content at sulphide saturation (SCSS) for low FeO terrestrial melt compositions, little information exists to evaluate the SCSS for the high FeO compositions typical of lunar magmas, and at the reduced conditions of the Moon's interior. Such results are also applicable to terrestrial ferro-picrites, and to the effects of assimilation of reduced crustal material. Experiments were done to measure the SCSS for a model low Ti mare basalt with 20 wt.% FeO at 1400ºC as a function of fO_2 and pressure. Synthetic lunar basalt was encapsulated along with stoichiometric FeS in capsules made from Fe-Ir alloy. The fO_2 of the experiment can be estimated by the heterogeneous equilibrium: $Fe_{metal} + ½ O_2 = FeO_{silicate}$.

Variation in the metal composition, by addition of Ir, serves to change the fO_2 of the experiment. Capsule compositions spanning the range $Fe_{25}Ir_{75}$ to $Fe_{96}Ir_4$ (at%) were synthesized by sintering of pressed powders under reducing conditions. Fe_{100} capsules were fabricated from pure Fe rod. For a melt with 20 wt.% FeO, this range in capsule composition spans the fO_2 interval of ~IW-1 (Fe_{100}, $Fe_{96}Ir_4$) to IW+2.2 ($Fe_{25}Ir_{75}$). Experiments were done over pressures of 0.1 MPa to 2 GPa. Results involving Fe_{100} capsules indicate that the SCSS decreases from ~2000 ppm (0.1 MPa) to 700 ppm (2 GPa). Experiments done at 1 GPa, involving the range of capsule compositions indicated, show a marked decrease in SCSS as the Fe content of the capsule increases (fO_2 decreases). Complementary to the decrease in SCSS is a drop in them sulphur content of the coexisting sulphide melt, from ~50 at% at ΔIW = +2.2 to ~20 at% at ΔIW-1. This is consistent with a decrease in the activity of FeS (a_{FeS}) in the sulphide melt, which results in a lowering of the SCSS, as predicted by a simple thermodynamic treatment of the sulphide-silicate equilibrium. Data for experiments done with $Fe_{96}Ir_4$ and Fe_{100} compositions are nearly indistinguishable in terms of sulphide melt composition and SCSS, reflecting the rapid drop in a_{FeS} as Fe saturation is approached. Results thus far indicate that at reduced conditions and high pressure, the SCSS for high FeO lunar compositions is low, and overlaps with Apollo 11 melt inclusion data. Importantly, such low SCSS does not require Fe metal saturation and suggests that some lunar source regions could be saturated in a lowsulphur, sulphide melt.

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