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A sulfide-saturated lunar mantle?

James M. Brenan (1) and James E. Mungall (2)

(1) Dalhousie University, Halifax, Canada (jbrenan@dal.ca), (2) University of Toronto, Toronto, Canada (mungall@es.utoronto.ca)

Although much work has been done to understand the controls on the sulfur content at sulfide saturation (SCSS) for 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. Experiments were done to measure the SCSS for a model low Ti mare basalt with 20 wt% FeO at 1400^{o}C 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:

$Fe_{metal} + {}^1\!/_2\, O_2 = FeO_{silicate}$

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 the pressure interval of 0.1 MPa to 2 GPa. Results for experiments involving Fe_{100}capsules indicate that the SCSS decreases from ~2000 ppm (0.1 MPa) to 700 ppm (2 GPa). Experiments done thus far 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 the sulfur content of the coexisting sulfide melt, from ~50 at% at ΔIW = +2.2 to ~20 at% at ΔIW-1. In fact, both the composition of the sulfide melt and the SCSS are essentially indistinguishable for $Fe_{96}Ir_4$ and Fe_{100} compositions. 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 low sulfur, sulfide melt. Additional sulfide-silicate partitioning experiments for the PGE and Re have also been done at Fe-metal saturation at 1400^{o}C, 0.1 MPa using chromite capsules sealed in silica ampoules. Results confirm that the highly siderophile elements (HSE) will be strongly sequestered by residual sulfide, and that the concentrations of these elements will be strongly depleted in lunar basalts. Hence, estimates of the HSE content of the lunar mantle from basalt compositions must take into account the fractionation imposed by sulfide-silicate partitioning at reduced conditions.