

Effect of sulfur on siderophile element partitioning between olivine and a primary melt from the martian mantle

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ABSTRACT

Ni and Co variations in primary martian magmas exhibit anomalous incompatible behavior, which has remained an unexplained conundrum. Because martian magmas are S-rich, and some trace metals are reported to have enhanced solubility in S-bearing magmas, we have carried out a series of experiments to evaluate the effect of high-S melts on the olivine/melt partitioning of Ni, Co, Mn, V, and Cr. Near-liquidus experiments on a synthetic primary martian mantle melt (Yamato-980459 [Y98]) were completed in a piston-cylinder apparatus at 0.75 GPa. Previous studies in S-free systems illustrate that the partition coefficients for these elements are dependent chiefly on $D_{\text{Mg}(\text{Ol}/\text{melt})}$ (the partition coefficient defined as wt% Mg in olivine/wt% Mg in melt, a proxy for temperature), and were used to calibrate a predictive expression that includes the effects of temperature [i.e., $D_{\text{Mg}(\text{Ol}/\text{melt})}$], melt composition, and oxygen fugacity. These predictive expressions are then used to isolate any effect in D_{M} olivine/melt due to dissolved sulfur. The results show that S might have a small effect for Co, but not enough to change Co partitioning from compatible to incompatible in our experiments. The addition of a sulfur term to the D_{Co} predictive expressions shows that nearly 8000 ppm of sulfur would be required in the melt (at liquidus temperature of Y98) for D_{Co} to become <1 . These S contents are two times higher than those of a sulfide-saturated melt at the P - T conditions of a martian mantle source region. Therefore, the anomalous incompatible behavior observed in these primary magma suites must be due to another mechanism. High temperature, oxygen fugacity, and diffusion are not viable mechanisms, but magma mixing, assimilation, or kinetic crystallization effects remain possibilities.

Keywords: Shergottite, olivine, transition metals, sulfur, basaltic magma