Fe²⁺-Mg PARTITIONING BETWEEN OLIVINE AND MARTIAN BASALTIC MELTS.
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Introduction: The partitioning of elements between olivine and liquid is key to understanding igneous processes in mafic and ultramafic systems [1]. The landmark study of Roeder and Emslie [2] concluded that the olivine (ol)-liquid (liq) exchange coefficient, $K_{D,Fe^2+Mg} = (FeO/MgO)_{ol}/(FeO/MgO)_{liq}$ (by weight), is 0.30±0.03, independent of temperature ($T$) and liquid composition. Subsequent work [3] has shown a dependence on liquid composition, but the canonical value of 0.30 is still widely used in both terrestrial and Martian applications [e.g., 4, 5]. Here, we use previously published experiments on bulk compositions relevant to Martian magmas to determine the appropriate $K_{D,Fe^2+Mg}$ for Martian systems; we then use this value to test whether any of the ol-phyric shergottites represent liquids.

Experiments on Martian Compositions: One-atm experiments on model Martian compositions provide the tightest constraint on $K_{D,Fe^2+Mg}$ because $T$ and oxygen fugacity ($f_{O2}$) are well known, allowing us to use [6] to predict the amount of ferrous iron present in each liquid. The median of 17 published 1-atm experiments yields $K_{D,Fe^2+Mg} = 0.354±0.008$ (error is one mean absolute deviation, MAD). There are higher pressure ($P$) experiments on model Martian compositions, but their $f_{O2}$s are less well constrained. High-$P$ experiments in graphite capsules are reducing [7], but Fe³⁺ still materially affects estimates of $K_{D,Fe^2+Mg}$, correcting for the Fe³⁺ using [6,7] increases $K_{D,Fe^2+Mg}$ on average, by 0.016. We see no strong correlations of $K_{D,Fe^2+Mg}$ with liquid or ol composition for the high or low-$P$ experiments and a weak increase in $K_{D,Fe^2+Mg}$ with increasing $P$. A marked increase in $K_{D,Fe^2+Mg}$ for high-$P$ experiments at $T<~1150°C$ is likely due to lack of equilibrium. Accepting high-$P$ experiments with $T >1150°C$ leads to a median $K_{D,Fe^2+Mg}$ of 0.369±0.024 (MAD), higher than the 1-atm experiments but notably higher than the canonical value of 0.30 [2]. Combining 1-atm. and high-$P$, high-$T$ experiments yields a median $K_{D,Fe^2+Mg}$ of 0.360±0.013 (MAD), close to the recently reported value of 0.35±0.01 [8], which was obtained without correcting for Fe³⁺ in the liquid.

Olivine-phyric Shergottites: Using $K_{D,Fe^2+Mg} = 0.30$ leads to the result that none of the ol cores in ol-phyric shergottites are in equilibrium with liquids equivalent to their bulk. Applying our $K_{D,Fe^2+Mg}$ to these shergottites, leads to the possibility that Y860059, NWA 5789 and 2990 are liquid compositions (others are not), identical to the results of [8]. Accounting for Fe³⁺ in the liquid also allows us to constrain plausible $f_{O2}$s during cooling when independent measures are unavailable or not yet determined; e.g., if the olivines in NWA 2990 are in equilibrium with a liquid whose composition is that of the bulk meteorite, crystallization must have occurred under reducing conditions where the Fe³⁺/Fe total is small, ~IW+0.5 at 1 atm or IW+1 at 1 GPa.