

Iron redox systematics of shergottites and martian magmas.

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Introduction: Martian meteorites record a range of oxygen fugacities from near the IW buffer to above FMQ buffer [1]. In terrestrial magmas, $\text{Fe}^{3+}/\Sigma\text{Fe}$ for this $f\text{O}_2$ range are between 0 and 0.25 [2]. Such variation will affect the stability of oxides, pyroxenes, and how the melt equilibrates with volatile species. An understanding of the variation of $\text{Fe}^{3+}/\Sigma\text{Fe}$ for martian magmas is lacking, and previous work has been on FeO-poor and Al_2O_3 -rich terrestrial basalts. We have initiated a study of the iron redox systematics of martian magmas to better understand FeO and Fe_2O_3 stability, the stability of magnetite, and the low Ca/high Ca pyroxene [3] ratios observed at the surface.

Methods: A synthetic shergottite, of intermediate Mg#, was prepared from reagent grade oxides. Glasses were prepared by equilibrating this composition in gas mixing furnaces under controlled oxygen fugacity from FMQ to FMQ-3, and at 1250 °C. A second series of experiments examined the effect of adding up to 3 wt% P_2O_5 to the bulk composition, which is known to affect Fe_2O_3 stability in terrestrial basalts [4]. And finally, the effect of pressure was examined in several high pressure piston cylinder experiments at 1 and 2 GPa. After equilibration, samples were sectioned, polished and analyzed for major elements by electron microprobe analysis. Fe valence in the glasses was analyzed by XANES at the Advanced Photon Source Argonne National Lab. Fe-bearing minerals and FeO-rich glasses prepared by [5] were used as standards for the analysis.

Results: The new measurements yield lower $\text{Fe}^{3+}/\Sigma\text{Fe}$ than those predicted using expressions calibrated for terrestrial magmas (0.04 to 0.11 at FMQ compared to 0.13 using [3]). The results also indicate that $\text{Fe}^{3+}/\Sigma\text{Fe}$ changes only slightly between IW and FMQ. Higher values are only achieved at $f\text{O}_2$ higher than FMQ. This may indicate that there are more oxidized magmas at the surface of Mars (with abundant magnetite), since magnetite is not reported in many experiments at FMQ [6,7]. Although magnetite is reported in experiments of [8], the coexisting liquids are hydrous and andesitic. Adding P_2O_5 does not change the $\text{Fe}^{3+}/\Sigma\text{Fe}$ ratio substantially (0.02 with 3% P_2O_5), suggesting that the major change involves complexing between Fe^{3+} and P^{5+} [9]. This could explain the inverse correlation between magnetite and P_2O_5 of rocks at Gusev Crater sites [5,10].

Conclusions: New measurements of $\text{Fe}^{3+}/\Sigma\text{Fe}$ ratio in martian magmas are lower than predicted values (using terrestrial models). We will pursue derivation of an expression specific to martian magmas. Applications will be made to phase equilibria at magmatic temperatures and resolving some questions regarding the stabilities of oxides and pyroxenes in martian magmas.

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