REDOX SYSTEMATICS OF MARTIAN MAGMAS WITH IMPLICATIONS FOR MAGNETITE STABILITY. K. Righter¹, L. Danielson², K. Pando³, R.V. Morris⁴, T. G. Graff⁵, D. G. Agresti⁶, A.M. Martin⁷, S. Sutton⁸, M. Newville⁹, A. Lanziotti¹⁰, ¹NASA/JSC, ²ESC, Houston, TX 77058, ³University of Alabama at Birmingham, ⁴Department of Geophysical Sciences and ⁵Center for Advanced Radiation Sources, Univ. Chicago.

Introduction: Iron redox systematics of the high FeO shergottitic liquids are poorly known, yet have a fundamental control on stability of phases such as magnetite, ilmenite, and pyroxenes [1].

Experiments: We undertook experiments to constrain the Fe³⁺/Fe(tot) in high FeO glasses as a function of fO₂, melt P₂O₅, temperature and pressure. We also performed a series of sub-liquidus experiment between 1100 and 1000 °C and FMQ+0.5 to FMQ-1 to define magnetite stability. Experiments were performed at JSC in either the 1 bar gas mixing lab, or in a piston cylinder or multi-anvil presses in the high pressure experimental petrology lab.

Analyses: Run products were analyzed for Fe³⁺ and Fe²⁺ by either Mössbauer spectroscopy [2] or micro-XANES (x-ray absorption near edge structure) spectroscopy [3].

Results: One bar glasses equilibrated at FMQ-3 to FMQ+3 show a much lower Fe³⁺/Fe(tot) than terrestrial basalts at the same conditions (Figure 1). As melt P₂O₅ contents increase from 0 to 3 wt% (at fixed pressure, temperature and fO₂), Fe³⁺/Fe(tot) decreases from 0.07 to 0.05. Temperature increases between 1200 and 1500 °C cause little to no variation in Fe³⁺/Fe(tot). Pressure increases from 1 to 4 GPa cause a slight decrease in Fe³⁺/Fe(tot). The trends with pressure and temperature are in agreement with results of previous studies on terrestrial compositions [4-6].

Implications: Combining our new series of data allows derivation of an expression to calculate Fe³⁺/Fe(tot) for high FeO melts such as martian magmas.

\[ \ln(\text{Fe}^{3+}/\text{Fe}^{2+}) = a \ln(fO_2) + b/T + cP/T + dXFeO + eX-Al_2O_3 + fXCaO + gXNa_2O + hXK_2O + iXP_2O_5 \]

This expression can be used to show that decompressed melts become slightly more oxidized at the surface (compared to 4 GPa).

Magnetite stability is suppressed by the lower Fe³⁺/Fe(tot) of the high FeO melts. Magnetite stability is a function of Fe₂O₃ and temperature and is stable ~50 °C lower than typical terrestrial basalt (Figure 2). Difficulty in producing magnetite as a liquidus phase in magmatic systems suggests either that many martian basalts are more oxidized, that the titanomagnetite only forms upon cooling below ~ 1000 °C at FMQ, or that the magnetite has a secondary origin.