

Iron partitioning between basaltic melts and clinopyroxene as a function of oxygen fugacity

**MOLLY C. McCANTA,^{1,*} M. DARBY DYAR,² MALCOLM J. RUTHERFORD,¹
AND JEREMY S. DELANEY³**

¹Department of Geological Sciences, Brown University, 324 Brook Street, Providence, Rhode Island 02912, U.S.A.

²Department of Astronomy, Mount Holyoke College, 50 College Street, South Hadley, Massachusetts 01075, U.S.A.

³Department of Geological Sciences, Busch Campus, Rutgers University, Piscataway, New Jersey 08855, U.S.A.

ABSTRACT

Oxygen fugacity (f_{O_2}) is an important parameter because it influences the crystallization sequences of magmas, as well as the composition of the resultant minerals. Traditionally f_{O_2} has been estimated using coexisting Fe-Ti oxide compositions or Fe^{3+}/Fe^{2+} ratios in silicate melts, for which the relationship between f_{O_2} and Fe^{3+} has been calibrated. Problems arise in systems where oxides and/or glasses (melts) are absent, or when oxides are suspected to have been re-equilibrated. Therefore, it is important to develop alternate ways to look at f_{O_2} in volcanic rocks. In this work, we describe a set of experiments to establish the relationship between the Fe^{3+} content of clinopyroxene and a basaltic melt as a function of oxygen fugacity. The starting bulk compositions were chosen to be representative of martian parental melts, with pyroxene (either augite or pigeonite) on their liquid, in order for the results to be applicable to the martian meteorite magma source regions. Experimental conditions ranged from $f_{O_2} = IW$ to $\sim IW+8.6$ at 1165 °C for pigeonite/melt pairs and at 1235 °C for melts alone, and $f_{O_2} = IW-1$ to $IW+4$ at ~ 1190 °C for augite/melt pairs. Results show that Fe^{3+} varies from 0–65% of the total Fe over this range of experimental conditions, and mass D ($wt\% Fe_{Pyx}^{3+}/wt\% Fe_{melt}^{3+}$) ranged from 0.75–1.44 and from 0.00–0.77, for pigeonite and augite respectively. XANES and Mössbauer analytical methods give similar results within known error bars of the two techniques, with the best agreement in compositions with $>10\%$ Fe^{3+} . Our data show that only at high values of f_{O_2} ($>IW + 3.5$, or $\approx QFM$) can Fe^{3+} distribution in pyroxene be used to estimate crystallization oxygen fugacity.