

The Effects of Temperature on Cr-Redox Systematics in Basaltic Liquids

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Chromium is a minor yet consequential multi-valent element in basaltic magmas. Cr-valence ratios in basaltic melts are known to have important effects on the stability of Cr-spinel, as well as serving as the basis of a new Cr-valence in olivine (CrViO) oxybarometer. Although the effects of fO_2 on $Cr^{2+}/\Sigma Cr$ in silicate melts is reasonably well understood, robust Cr-valence data that illuminate how temperature controls the $Cr^{2+}/\Sigma Cr$ are non-existent. A series of gas-mixing experiments have been performed from 1100°C to 1450°C to investigate the relationship between temperature and $Cr^{2+}/\Sigma Cr$ in basaltic liquids. Experiments were conducted using a synthetic MORB, a synthetic ferrobasalt, and a low-liquidus CMAS composition. The $Cr^{2+}/\Sigma Cr$ of the quenched melts from the experiments were determined by synchrotron μ -XANES at the Advanced Photon Source, Argonne National Laboratory. XANES data from liquids of all three bulk compositions indicate that temperature exerts a significant influence on the equilibrium $Cr^{2+}/\Sigma Cr$. At constant fO_2 the $Cr^{2+}/\Sigma Cr$ increases by 0.08 per 50°C of temperature increase. The resultant data were also used to model how the Cr-valence ratio of a MORB liquid evolves with decreasing temperature. Modeling indicates that for cooling under strictly buffered fO_2 conditions, the expected decrease in $Cr^{2+}/\Sigma Cr$ is significantly damped by the parallel effect of temperature on the buffered fO_2 value. This finding has important implications for the CrViO, in that magmatic cooling (at buffered fO_2) results in only a minor effect on the $Cr^{2+}/\Sigma Cr$ of basaltic liquids and their early crystallized olivine.