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SPECIAL COLLECTION: OLIVINE

Quantifying and correcting the effects of anisotropy in XANES measurements of chromium valence in olivine: Implications for a new olivine oxybarometer

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Abstract

Chromium valence ratios in igneous olivine may hold a wealth of redox information about the melts from which they crystallized. It has been experimentally shown that the $Cr^{2+}/\Sigma Cr$ of olivine varies systematically with f_{O_2}, therefore measurements of Cr valence in olivine could be employed as a quantitative oxybarometer. In situ synchrotron μ-XANES analyses of Cr valence ratios of individual olivine phenocrysts in thin section have the potential to unlock this stored magmatic redox information on a fine spatial scale. However, there are still obstacles to obtaining accurate XANES measurements of cation valence in crystalline materials, as the results from these measurements can be compromised by anisotropic absorption effects related to the crystallographic orientation of the sample. Improving the accuracy of XANES measurements of Cr valence ratios in olivine by calibrating an anisotropy correction is a vital step in developing Cr valence measurements in olivine as a rigorous oxybarometer. To accomplish this goal, we have used an integrated approach that combined experiments, electron backscatter diffraction analysis, and XANES measurements in olivine to systematically examine how orientation affects the resultant Cr *K*-edge XANES spectra and the Cr valence ratios that are calculated from them. The data set generated in this work was used to construct a model that mitigates the effects of anisotropy of the calculated $Cr^{2+}/\Sigma Cr$ values. The application of this correction procedure as a part of spectral processing improves the overall accuracy of the resultant $Cr^{2+}/\Sigma Cr$ values by nearly a factor of five. The increased accuracy of the XANES measured Cr valence ratios afforded by the anisotropy correction reduces the error on calculated f_{O_2} values from approximately ±1.2 to ±0.25 log units.

Keywords: XANES, Cr valence, anisotropy, olivine, oxybarometer