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Single-crystal X-ray diffraction of spinels from the San Carlos Volcanic Field, Arizona: Spinel as a geothermometer

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ABSTRACT

Fourteen spinels from two types of mantle xenoliths from the San Carlos Volcanic Field in Arizona were characterized using single-crystal X-ray diffraction and electron microprobe analysis. The dominant feature seen in the chemistry of spinels from the Group I xenoliths is the extensive substitution of Cr for Al ($Cr_{0.20}Al_{1.76}$ to $Cr_{0.83}Al_{1.10}$) correlated with Mg for Fe^{2+} ($Mg_{0.69}Fe^{2+}_{0.31}$ to $Mg_{0.80}Fe^{2+}_{0.19}$). Although Group II spinels display consistently low Cr values, they also show a well-correlated substitution of Mg for Fe^{2+} ($Mg_{0.63}Fe^{2+}_{0.37}$ to $Mg_{0.69}Fe^{2+}_{0.31}$). Unit-cell parameters for spinels from the Group I xenoliths range from 8.1259 to 8.2167 Å, while those from the Group II xenoliths range from 8.1247 to 8.1569 Å. The cell parameters are linearly correlated with Fe^{2+} and Cr contents. Cation distributions were determined from experimental bond lengths and refined site occupancies using the algorithm of Lavina et al. (2002). The San Carlos spinels display variable degrees of order, with inversion parameters ranging from 0.10 to 0.16 for Group I and from 0.17 to 0.22 for Group II. Closure temperatures were computed with the Princivalle equation, giving averages of 808(37) °C for spinels from Group I xenoliths and 822(62) °C for samples from Group II xenoliths. We show that these results are reasonable, and thus extend the use of the Princivalle equation, or at least its functional form, to samples with significant Cr and Fe^{2+} contents. This study demonstrates that, in spite of the extensive chemical variability of the San Carlos spinels, and given that the origins of the two groups of xenoliths are different, the oxygen coordinates remain fixed, suggesting that the oxygen coordinate is a function of thermal history.