American Mineralogist, Volume 85, pages 953–962, 2000

Single-crystal thermometric calibration of Fe-Mg order-disorder in pigeonites

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ABSTRACT

The single-crystal X-ray technique was used to calibrate a new intracrystalline geothermometer based on equilibrium Mg-Fe* fractionation (Fe* = Fe^{2+} + Mn^{2+}) between M1 and M2 sites of natural $P2_1/c$ pigeonite. Suitable crystals free of exsolution textures and sharp diffraction maxima were selected by careful TEM and XRD investigations from a large number of samples. Two single crystals, PCA82506-3 ($Wo_6En_{76}Fs_{18}$) from the Pecora Escarpment 82506 Antarctic ureilite, and BTS308-2 ($Wo_{10}En_{47}Fs_{43}$) from the BTS308 Paranà rhyodacite, were annealed at temperatures ranging from 600 to 1000 °C. The TEM investigation, carried out on fragments of selected single crystals both before and after thermal treatment, shows heating-induced texture modifications preliminary to spinodal decomposition in both crystals and a size increase in antiphase domains in BTS308-2. The two geothermometric equations calculated by linear regression of ln K_D^* vs. $1/T$ are:

$$\ln K_D^* = -3291(\pm 269)/T(\mathrm{K}) + 0.971(\pm 0.253);\ (r^2 = 0.974)$$

$$\ln K_D^* = -2816(\pm 83)/T(\mathrm{K}) + 0.542(\pm 0.083);\ (r^2 = 0.995)$$

respectively for PCA82506-3 (X_{Fe*} = 0.20) and BTS308-2 (X_{Fe*} = 0.49) [X_{Fe*} = Fe*/(Fe* + Mg)]. These results imply negligible compositional effects on Mg-Fe* site partitioning within the range of compositions encompassed by the samples. Comparison of the intracrystalline fractionation data of pigeonites with those of *Pbca* orthopyroxenes shows a similar degree of ordering for both at a given temperature. This result suggests only a small effect of Ca on Fe*-Mg ordering in pyroxene with Ca content up to Wo_{10}.