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The thermal behavior of richterite

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Abstract

The thermal behavior of synthetic richterite $^{A}Na^{B}(NaCa)^{C}Mg_5{}^{T}Si_8O_{22}(OH)_2$, crystallized at 800 °C and 0.35 GPa under hydrothermal conditions, was studied by serial powder diffraction experiments using synchrotron radiation between 123 and 873 K.

The *a*, *b*, and β cell parameters show a non-linear behavior, whereas the *c* parameter shows a linear trend; values of the saturation temperature θ_s are 410(3), 215(2), and 300(2) K for *a*, *b*, and *a*sinβ, respectively. The axial expansion pattern below room temperature is $\alpha_b > \alpha_c > \alpha_a$, whereas above room *T* it is $\alpha_b > \alpha_a > \alpha_c$, the difference being related to the different saturation temperatures of the individual cell parameters.

The thermal expansion was modeled following the Debye approximation for the density-of-state of phonons; the refined parameters are $V_0 = 908.20\ (0.04)$ Å^3, $k = 1\ (4)$, $Q_0 = 32\ (2)$ MJ, and the Debye temperature $\theta_D = 586(31)$ K. The non-linear behavior at low *T* is well described without systematic differences between the data and the model. The volume thermal expansion coefficient α_V changes significantly with temperature, also at temperatures higher than room temperature. It is suggested that this may occur also in other amphiboles and pyroxenes, requiring critical re-examination of the available data.

A comparison of the strain tensor for the thermal expansion between amphiboles and pyroxenes shows that in amphiboles the major deformation occurs onto the (010) plane, whereas in pyroxenes it occurs along the ***b*** axis. Moreover, the major deformation on (010) in Ca-bearing pyroxenes occurs along the bond of the M2 cation with the furthermost O3 atoms, whereas in compositionally related Ca-amphiboles (i.e., tremolite) it occurs in a direction rotated by 10–20° to **a***, i.e., in a direction not corresponding to that of the M4-O5 bonds. It is proposed that the M4 polyhedron contributes less to the thermal deformation of amphibole than the M2 polyhedron contributes to the thermal deformation of pyroxene.

Keywords: Richterite, amphibole, thermal expansion, Debye model, comparison with pyroxenes