American Mineralogist, Volume 95, pages 1060–1068, 2010

Principles of thermal expansion in the feldspar system

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Abstract

Following the recent thermal expansion work of Hovis et al. (2008) on $AlSi_3$ feldspars, we have investigated the thermal expansion of plagioclase, Ba-K, and Ca-K feldspar crystalline solutions. X-ray powder diffraction data were collected between room temperature and 925 °C on six natural plagioclase specimens ranging in composition from anorthite to oligoclase (and as well on their K-exchanged equivalents) and five synthetic Ba-K feldspars with compositions from 25 to 99 mol% $BaAl_2Si_2O_8$. The resulting thermal expansion coefficients for volume (α_V) have been combined with earlier results for end-member Na- and K-feldspars. Unlike $AlSi_3$ feldspars, Al_2Si_2 feldspars, including anorthite and celsian from the present study, and Sr- and Pb-feldspar from other workers, show essentially constant, and relatively limited, thermal expansion. In the context of structures where the Lowenstein rule requires Al and Si to alternate among tetrahedra, the proximity of bridging Al-O-Si O atoms to divalent neighbors (ranging from 0 to 2) results in Ca-O (or Ba-O) bonds that are especially short. It is suggested that short bonds such as these have a partly covalent character resulting from the requirement for local charge balance. This, in turn, stiffens the structure. For feldspar series with coupled substitution, the change away from a purely divalent M-site occupant gives the substituting (less strongly bonded) monovalent cations increasingly greater influence on thermal expansion. Overall, thermal expansion in the feldspar system is well represented on a plot of α_V against room-temperature volume (V_{RT}), where one sees a quadrilateral bounded by data for: (1) $AlSi_3$ feldspars whose expansion behavior is governed largely by the size of the monovalent alkali-site occupant; (2) Al_2Si_2 feldspars whose expansion is uniformly limited by divalent cations having stronger, partially covalent, bonds to bridging Al-O-Si O atoms; and (3,4) plagioclase and Ba-K feldspars where expansion behavior across the series transitions from one control to the other. Overall, the coefficient of thermal expansion in any binary feldspar series is a linear function of V_{RT} between the pertinent end-members. This makes it possible to predict the thermal expansion behavior of any feldspar simply from knowledge of its chemical system and room-temperature volume.

Keywords: Thermal expansion, feldspars, plagioclase, celsian