Geophysical Research Abstracts
Vol. 12, EGU2010-13187-5, 2010
EGU General Assembly 2010

Principles of Thermal Expansion in Feldspars

Guy Hovis, Aaron Medford, Maricate Conlon, Allison Tether, and Anthony Romanoski
Lafayette College, Geology and Environmental Geosciences, Easton, Pennsylvania, United States (hovisguy@lafayette.edu)

Following the recent thermal expansion work of Hovis et al. (1) 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, the K-exchanged equivalents of these plagioclase specimens, and five synthetic Ba-K feldspars with compositions ranging from 25 to 99 mol % $BaAl_2Si_2O_8$. The resulting thermal expansion coefficients (α) for volume have been combined with earlier results for end-member Na- and K-feldspars (2,3). Unlike $AlSi_3$ feldspars, Al_2Si_2 feldspars, including anorthite and celsian from the present study plus Sr- and Pb-feldspar from other workers (4,5), show essentially constant and very limited thermal expansion, regardless of divalent cation size. In the context of structures where the Lowenstein rule (6) requires Al and Si to alternate among tetrahedra, the proximity of bridging Al-O-Si oxygen ions to divalent neighbors (ranging from 0 to 2) produces short Ca-O (or Ba-O) bonds (7,8) that apparently are the result of local charge-balance requirements (9). Gibbs et al. (10) suggest that short bonds such as these have a partially covalent character. This in turn stiffens the structure. Thus, 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, then, thermal expansion in the feldspar system is well represented on a plot of α against room-temperature volume, where one sees a quadrilateral bounded by data for (A) $AlSi_3$ feldspars whose expansion behavior is controlled largely by the size of the monovalent alkali-site occupant, (B) Al_2Si_2 feldspars whose expansion is uniformly limited by partially-covalent bonds between divalent M-site occupants and bridging Al-O-Si oxygens, (C) plagioclase (11,12,13) and (D) Ba-K feldspars (12) where coupled substitution across the series produces expansion behavior that rapidly transitions from one control to the other. Generally, thermal expansion coefficients vary linearly as functions of room-temperature volume between the relevant end members. Thus, the thermal expansion of any feldspar can be estimated simply from knowledge of its chemical system and room-temperature volume.

References cited: (1) Hovis, Morabito, Spooner, Mott, Person, Henderson, Roux & Harlov (2008) American Mineralogist 93, 1568-1573. (2) Hovis & Graeme-Barber (1997) American Mineralogist 82, 158-164. (3) Hovis, Brennan, Keohane & Crelling (1999) The Canadian Mineralogist 37, 701-709. (4) Henderson (1984) Progress in Experimental Petrology, N.E.R.C. Report 6, 78-83. (5) Benna, Tribaudino & Bruno (1999) American Mineralogist 84, 120-129. (6) Lowenstein (1954) American Mineralogist 39, 92 -96. (7) Megaw, Kempster & Radosolovich (1962) Acta Crystallographica 15, 1017-1035. (8) Newham & Megaw (1960) Acta Crystallographica 13, 303–312. (9) Pauling (1929) Journal of the American Chemical Society 51, 1010-1026. (10) Gibbs, Rosso, Cox & Boisen (2003) Physics and Chemistry of Minerals 30, 317-320. (11) Grundy & Brown (1974) In The Feldspars, Eds. MacKenzie & Zussman, 163-173. (12) Hovis, Medford, Conlon, Tether & Romanoski (in review) American Mineralogist. (13) Tribaudino, Angel, Camara, Nestola, Pasqual, & Margiolaki (in review) Contributions to Mineralogy and Petrology.