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Tilts and tetrahedra: The origin of the anisotropy of feldspars†

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ABSTRACT

Following the ideas of Helen Megaw, we describe the changes in the conformation of the tetrahedral framework of feldspars in terms of just four distinct tilt systems of rigid tetrahedra. These systems are based on the four allowed tilts of a ring of four corner-linked tetrahedra with point symmetry 2. Of the four tilt systems, only two result in significant volume change of the unit cell. We show that all of the essential features of the structures, unit-cell parameters and volumes of the $AlSi_3$ feldspars, and their expansion and compression induced by changes in pressure, temperature, and composition at crustal pressures, are generated by the simultaneous application of these two tilts to an un-tilted framework of regular tetrahedra. In combination these two tilts impose significant anisotropy upon the expansion of the unit cell of the feldspar with the majority of the expansion accommodated by the expansion of $d(100)$. This demonstrates that the fundamental reason for the anisotropy of feldspars lies in the topology of the tetrahedral framework. A comparison of the actual tilts observed in alkali feldspars with the model shows that the tilts maximize the shortest O-O distances in the structure, and therefore O-O repulsions along with the volume requirement control the values of the tetrahedral tilts in alkali feldspars and thus the anisotropy of the structure. Therefore, the bonding requirements of the bridging O atoms and the directionality of the bonding to the extraframework cations only play a secondary role in modifying this basic pattern of anisotropy, which is intrinsic to the common topology of the framework of all feldspars.

Keywords: Feldspars, elasticity, anisotropy, structure, compressibility, thermal expansion