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Elastic Anisotropy of Feldspars

Ross Angel
Dept Earth & Environmental Sciences, University of Pavia, Pavia, Italy (rossjohnangel@gmail.com)

The extreme elastic anisotropy of feldspars with the Reuss and Voigt bounds on the bulk moduli differing by 20%, makes them ideal for resolving many questions, from determining the origin of elastic anisotropy and how it changes with pressure, temperature and composition, to whether or not rock properties fall close to the (Hill) average between the upper and lower bounds and within the tighter Hashin-Shtrikman bounds. The origin of the elastic anisotropy in feldspars is well understood. It arises from the topology of their tetrahedral framework structure which only allows one specific combination of the many possible tilts of the AlO_4 and SiO_4 tetrahedra to generate volume change while not reducing the shortest non-bonded O-O distances [1,2]. These tilts of rigid tetrahedra cause one direction in the feldspar structure to accommodate up to 90% of volume expansion or compression with P, T or compositional change, and the elastic compliance of this direction is nearly 3 times that of the perpendicular directions in alkali feldspars [3].

In alkali feldspars the interaction between the extra-framework cations (Na^+,K^+) and the framework is relatively weak and isotropic, and the elastic anisotropy at room conditions remains approximately constant, with velocities of quasi-compressional waves ranging from 5.5 to >8 km/s [3]. In plagioclase feldspars the stronger interaction of the Ca^{2+} cation with the framework decreases the anisotropy. The range in quasi-compressional wave velocities at room conditions decreases to 6.7 – 8.2 km/s in anorthite [4]. The effect of P and T on the elastic tensors are in general unknown. But extensive experimental data on thermal expansion and compressibility of feldspars show that the anisotropy of both decrease at elevated P and T, and therefore one might expect that the elastic anisotropy may do the same.

[1] Amer Miner (2012) 97, 765-778. [2] Euro J Mineral (2013) 25, 597-614. [3] Amer Miner (2016) 101, 1228-1231. [4] JGR: Solid Earth (2016) 121, 663-675.