Single crystal elastic properties of prehnite at ambient condition—implication of the relationship between hydroxyl group and Cij tensor

YINGZHE LI, AND JAY D. BASS

Department of Geology, University of Illinois, Urbana, Illinois 61801, U.S.A.

Hyrdogen (or "water") can play an important role on many physical and thermal properties of minerals. For some hydrated mineral such as lawsonite and hemimorphite, we have found that the rotational freedom of M-O polyhedra can be reduced by the hydrogen bonds connecting polyhedra together. This can increase shear moduli in the plane of the hydrogen bonds. Besides molecular, nominally anhydrous minerals (NAM's) such as olivine, wadsleyite, ringwoodite and garnet can store water by the formation of -OH groups. The presence of hydroxyl groups in the structure affects the density and elastic properties. However, the magnitudes of these hydration effects are still a matter of debate. Prehnite, with the formula $Ca_2Al[AlSi_3O_{10}](OH)_2$, contains hydroxyl groups as an integral structural component. In contrast with NAM's, the relatively larger water contents (8%-9% wt %) makes prehnite a promising material for investigating the relationship between the single crystal elasticity tensor (Cij) and mechanisms of hydroxyl incorporation. We have determined the elastic properties of single-crystal prehnite by Brillouin spectroscopy sound velocity measurements at ambient conditions. Our results yielding tight constraints on all nine single-crystal elastic moduli (Cij). C_{11} is the weakest of the principal longitudinal moduli, making prehnite much more compressible along the **a** direction. The Voigt-Reuss-Hill averaged aggregate isotropic elastic moduli are Ks (VRH)= 111.7±1.2 GPa and μ (VRH) =57.9±0.9 GPa, for the adiabatic bulk modulus and shear modulus, respectively. The average P velocity Vp=8.05(5) km/s, and the averaged shear velocity Vs =4.46(3) km/s. The RMS error in acoustic velocities is 17 m/s, indicating a high degree of internal consistency in the data set. The longitudinal anisotropy is $(Vp_{,max}-Vp_{,min})/Vp_{,\ VRH}$ = 19.8%. Shear velocity anisotropy is 19.1%. Prehnite has moderate average Vp/Vs ratio = 1.80. The orientation of -OH groups are related to variation of the Vp/Vs with crystallographic direction strongly affect the single-crystal shear moduli. Addition of hydrogen bonds has a larger impact on the shear moduli than longitudinal moduli.