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The equation of state of lawsonite to 7 GPa and 873 K, and calculation of its high pressure stability

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ABSTRACT

The volume of lawsonite, $CaAl_2Si_2O_7(OH)_2{\cdot}H_2O$, has been measured up to 7 GPa and 873 K using in situ energy dispersive powder diffraction and a multi-anvil high pressure-temperature cell at the Synchrotron Radiation Source, Daresbury Laboratory, U.K. Measurements were made on isotherms at 298, 323, 373, 473, 573, 673, 773, and 873 K within the pressure range. Sample pressure was measured from a NaCl standard mixed with the sample; the unit-cell volume of lawsonite was taken from the same diffraction pattern. The data gave an ambient temperature isothermal bulk modulus of K_{298} 112 ± 6 GPa, similar to previous values. This value overestimates the temperature stability of lawsonite in thermodynamic calculations. A fit of the Birch-Murnaghan equation of state to the whole high pressure and temperature data set gave an isothermal bulk modulus of $K_{298} = 125 \pm 5$ GPa and a dK/dT of -0.01 ± 0.01/K, with K' set to a value of 4 and the expansivity set to 3.16×10^{-5}/K. Using these values to calculate the pressure-temperature positions of three of lawsonite's dehydration reactions improved the agreement between observed and calculated positions of the lawsonite dehydration reactions to within experimental and calculation error. This work shows that the ambient temperature bulk modulus and ambient pressure expansivity do not adequately describe the volume behavior of lawsonite at combined high pressure and temperature.