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Equation of state measurements of chlorite, pyrophyllite, and talc

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ABSTRACT

The compressibilities of five sheet silicates—three chlorite compositions, pyrophyllite, and talc—have been measured in situ using energy-dispersive powder diffraction in a multi-anvil apparatus at the synchrotron radiation source, Daresbury Laboratory, U.K. Some high-temperature data were also collected. The three chlorite samples were a natural Mg-rich chlorite [$Mg_{4.49}Fe_{0.28}Cr_{0.12}Al_{2.10}Si_{2.95}O_{10}(OH)_8$], a natural Fe-rich chlorite [$Mg_{0.28}Fe_{4.11}Al_{2.71}Si_{2.77}O_{10}(OH)_8$], and a synthetic clinochlore [$Mg_5Al_2Si_3O_{10}(OH)_8$]. The compressibility data for all three samples, measured up to between 3 and 6 GPa, can be fit to a single equation of state with a bulk modulus of 86.9(16) GPa (using $K' = 4$). The thermal expansivity measured for the natural Mg-chlorite [$\alpha_0 = 2.5(6) \times 10^{-5}$/K] is similar to previous measurements on various chlorite compositions, suggesting that the thermal expansivity of chlorite also can be described by a single equation, independent of composition. The bulk modulus of the natural pyrophyllite [$Al_2Si_4O_{10}(OH)_2$], measured up to 6.3 GPa, is 37(3) GPa, with $K' = 10(1)$. The few high-temperature points agree with previous measurements. The natural talc [$Mg_3Si_4O_{10}(OH)_2$], measured up to 6.2 GPa, has a bulk modulus of 41(4) GPa, with $K' = 6(2)$.

Our bulk modulus of chlorite is much higher than previously determined using X-ray diffraction. This finding explains why calculations of chlorite reactions using the previous data considerably overestimate its stability when compared to experimentally determined reaction positions. The pyrophyllite compressibility data should be useful in calculations of metamorphic reactions involving this mineral. The talc data are essentially identical to previous measurements.