Elasticity of polycrystalline β-Mg_2SiO_4 containing 0.73 wt.% H_2O to 10 GPa and 600 K by ultrasonic interferometry technique combined with synchrotron X-radiation

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Abstract

The acoustic wave velocities of wadsleyite (β-Mg_2SiO_4) containing 0.73 wt.% (7300 ppm) of H_2O have been determined to 10 GPa and temperatures to 600 K. Finite strain analysis of elastic bulk (K) and shear (G) moduli yielded $K_{so} = K_s = 152.2(9)$ GPa, $G_o = 98.1(3)$ GPa and $(\partial K_s/\partial P)_T = 4.47(14)$, and $(\partial G/\partial P)_T = 1.43(5)$ for the bulk and shear moduli and their pressure derivatives respectively. Compared to the anhydrous phase, hydration of the wadsleyite leads to a decrease in the bulk and shear moduli by12.5% and 3.9%, respectively. The temperature derivatives of the elastic moduli obtained by linear fitting are: $(\partial K_S/\partial T)_P = -1.55(1)$ (1) x 10^{-2} GPa/K and $(\partial G/\partial T)_P = -1.39(7)$ x 10^{-2} GPa/K. The new data show that hydration of wadsleyite by 0.73 wt.% decreases both $(\partial K_S/\partial T)_P$ and $(\partial G/\partial T)_P$, in magnitude by 9.4–11% and 10-13%, respectively, when compared with current reported $(\partial K_S/\partial T)_P$ and $(\partial G/\partial T)_P$ ranges and predict a 45% orthosilicate content for the Earth's upper mantle. In contrast, the effect of Fe substituion in wadsleyite up to $X_{Fe} = 0.9$ show no measurable effect on the temperature derivatives of the elastic bulk and shear moduli.