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P-V-T equation of state of hydrous phase A up to 10.5 GPa

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Abstract

Pressure-volume-temperature (*P-V-T*) data of synthetic $Mg_7Si_2O_8(OH)_6$ phase A were collected under *P-T* conditions up to ~10.5 GPa and 900 K by energy-dispersive X-ray diffraction using a cubic type multi-anvil apparatus, MAX80, located at the Photon Factory–Advanced Ring (PF-AR) at the High Energy Accelerator Research Organization (KEK). *P-V* EoS using only room-temperature data yielded V_0 = 511.6(2) Å^3, K_{T0} = 106.8(18) GPa, and pressure derivative K'_T = 3.88(38). These parameters were consistent with the subsequent equation of state (EoS) analysis. The compressibility of phase A was anisotropic, with its *a*-axis being ~26% more compressible than the *c*-axis, which is normal to the plane of the distorted close-packed layers. A fit of the present data to the high-temperature Birch-Murnaghan EoS yielded V_0 = 511.7(3) Å^3, K_0 = 104.4(24) GPa, K' = 4.39(48), $(\partial K_T/\partial T)_P$ = –0.027(5) GPa K^{-1}, and thermal expansion $\alpha = a + b$T with values of $a = 2.88(27) \times 10^{-5}$ K^{-1} and $b = 3.54(68) \times 10^{-8}$ K^{-2}. The lattice dynamical approach by the Mie-Grüneisen-Debye EoS yielded θ_0 = 928(114) K, q = 2.9(10), and γ_0 = 1.19(8). The isobaric heat capacity C_P of phase A at 1 atm. was calculated based on the Mie-Grüneisen-Debye EoS fit of present *P-V-T* data. In addition, the density profiles of subducting slabs with different degrees of serpentinization were also calculated along the cold geotherm up to ~13 GPa. The serpentinization of subducting slab will significantly lower the density of slab at shallower depth; however, this effect becomes negligible when antigorite dehydrates to phase A. Because the phase A bearing subducting slab is supposed to be denser than the surrounding mantle, the water can transport into deeper parts of the upper mantle and the transition zone.

Keywords: Bulk modulus, phase A, dense hydrous magnesium silicate (DHMS), equation of state (EoS), heat capacity, high pressure and high temperature (HPHT), thermal expansion; Physics and Chemistry of Earth's Deep Mantle and Core