Self-consistent PVT equation of state of MgO

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Pressure determination is one of the most crucial issues in high-pressure mineral physics studies, which affects locations and slopes of phase transformation boundaries, pressure derivatives of physical properties, pressure-volume-temperature (P-V-T) relations, etc. Efforts have been made to determine self-consistent P-V-T equation of state for adequate pressure reference materials, while seriously disagree with one another. As the equation of state of a solid at the conditions of the Earth's mantle is generally parameterized by unit cell volume, zero pressure isothermal bulk modulus (Kt0) and its pressure derivative (Kt'), independent determination of bulk modulus and its pressure derivative by elasticity measurement enables us to establish self-consistent P-V-T equation of state without pressure scale. Here we carried out simultaneous measurements of elastic wave velocities and unit cell volume of MgO, and directly determined sample pressure without any pressure scale. The experimentally observed elastic wave velocity and density leads to determine adiabatic bulk modulus. The adiabatic bulk modulus can convert to isothermal bulk modulus (Kt) with using thermal expansion coefficient and Gruneisen parameter. In contrast, the Kt is expressed with Kt0 and Kt' by using finite strain equation. Combining these two equations, the Kt0 and Kt' are determined from the experimental results of adiabatic bulk modulus and unit cell volume. In order to optimize a parameter q, which is the volume dependence of Gruneisen parameter, we used zero pressure thermal expansion data of Dubrovinsky and Saxena (1997). Then pressure was determined by using the Birch-Murnaghan equation of state and Debye model. Our determined self-consistent PVT equation of state shows good agreement with the shock wave P-V-T data of Duffy and Ahrens (1993) up to 196 GPa and 3663 K. It should be noted that our determined self-consistent PVT equation of state does not depend on any previous pressure-scale. The PVT equation of state satisfies other self-consistent PVT data of zero pressure thermal expansion and shock wave result, and is the most reliable pressure scale. Our newly developed pressure scale would clarify the phase transformation boundaries (e.g. postspinel and post-perovskite transformations), and leads to discovering the nature of the Earth's interior.