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Primary Pressure Scale of KCl B2 Phase to the Core-Mantle Boundary

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Reliable pressure determination is crucial for high pressure and temperature experiments and meaningful interpretation of their geophysical implications. So far most commonly-used pressure scales such as equation of states (EOS) on reference materials, Ruby fluorescence and diamond anvil Raman gauges are secondary in nature, meaning they were calibrated based predominantly on shock-compression-based pressure standards, which itself due to its dynamic compression nature, large uncertainty in peak shock temperature estimation and electronic thermal pressure contribution can yield substantial (>10%) uncertainties at Mbar conditions.

Pressure can also be expressed as a function of elastic modulus and density/volume through equation of state equations and a primary pressure scale can thus be established under static and isothermal conditions without assuming any external pressure scales (shock compressed-based). In this study, a self-consistent primary pressure scale of KCl B2 phase was experimentally calibrated up to 85 GPa at ambient temperature through simultaneously measuring the acoustic wave velocities and molar volume using Brillouin spectroscopy and Synchrotron X-ray diffraction (XRD). Our best fitting using Birch-Murnaghan EOS yields V_0= 32.48 (9) cm^3/mole, K_{T0}= 21.33 (70) GPa, K_0'= 4.836 (83), the reference grüneisen parameter γ_0 and Debye temperature θ_{Debye} are estimated to be 1.923 (108) and 250.9 (219) K according to Mie-Grüneisen-Debye formalism. The resulted EOS can be extended also to high temperatures in combination with thermal pressure effect calculated using Mie–Grüneisen–Debye model. Our results demonstrate that at pressure above 40 GPa, previously studies consistently underestimate pressure by up to ~6 GPa at 1 Mbar, ~10 GPa at 1.4 Mbar. Our newly established KCl B2 EOS thus enables easy and accurate pressure determinations at simultaneously high pressure and temperature conditions up to Earth's core-mantle boundary (CMB) and can serve as a benchmark for calibrating other secondary pressure scales.