Single-crystal X-ray diffraction of phase egg ($AlSiO_3OH$) up to 25 GPa: Implications for the existing state of hydrogen in the earth interior

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Abstract

Water, which significantly affects the physical and chemical properties of the minerals contained it, plays a key role in the evolutionary process of planet in the earth's interior. The hydrous phases in the subducting slabs are the mainly mediums to transport water into the earth interior. Phase egg, ($AlSiO_3OH$), is an important hydrous mineral phase in the Al_2O_3-SiO_2-H_2O ternary which existed in the subducted oceanic crust and overlying sediments, and has been found in a superdeep diamond from the Juina area, Brazil. The studies on its stability field indicate that it is stable at least at the earth mantle transition zone along the normal mantle geotherm.

Here we report the elasticity of phase egg and the evolution of its crystal structure under pressure (up to 25 GPa) at room temperature. The obviously change in axial compressibility and stiffer in the bulk modulus above ~15 GPa have been observed, which accompanied by the anisotropy of compressibility significantly weakened. Fitting with separate Birch-Murnaghan equations of state at 15 GPa, bulk moduli at ambient condition K_0 of phase egg were determined to be 181(2) and 244(7) GPa for the pressures below and above 15 GPa, respectively, where K′ is fixed to 4. These transitions are consistent with the transform of hydrogen bond configuration in phase egg at ~15 GPa. Instead of the hydrogen bond symmetrization at the pressure range of this study, the proton transfers its position above 15 GPa which provides special understanding on the existing state of hydrogen in the earth interior. The bulk sound velocity of phase egg is much faster than the mainly minerals of mantle transition zone at the depths between ~430 km and ~660 km, which may provide a potential explanation on the high velocity anomaly zone in subduction zones. Our results also indicate that phase egg is denser than the main minerals in the earth mantle transition zone, and consequently contributes positively to its subducting at the corresponding depth.