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Effect of structural water on the elasticity of orthopyroxene

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ABSTRACT

As a major nominally anhydrous mineral (NAM) in the Earth's upper mantle, orthopyroxene could host up to several hundred parts per million H₂O in its crystal structure and transport the H₂O to the deep Earth. To study the effect of structural H₂O on the elasticity of orthopyroxene, we have measured the single-crystal elasticity of Mg_{1.991}Al_{0.065}Si_{1.951}O₆ with 842–900 ppm H₂O and 1.64 ± 0.20 wt% Al₂O₃ at ambient conditions using Brillouin spectroscopy. The best-fit single-crystal elastic moduli (C_{ij} s), bulk (K_{s0}), and shear (G_0) modulus of the hydrous Al-bearing orthopyroxene were determined as: $C_{11} = 235(2)$ GPa, $C_{22} = 173(2)$ GPa, $C_{33} = 222(2)$ GPa, $C_{44} = 86(1)$ GPa, $C_{55} = 82(1)$ GPa, $C_{66} =$ 82(1) GPa, $C_{12} = 75(3)$ GPa, $C_{13} = 67(2)$ GPa, and $C_{23} = 49(2)$ GPa, $K_{s0} = 111(2)$ GPa, and $G_0 = 78(1)$ GPa. Systematic analysis based on the results presented in this and previous studies suggests that the incorporation of 842–900 ppm H₂O would increase C_{13} by 12.0(7)% and decrease C_{23} by 8.6(8)%. The effects on C_{11} , C_{22} , C_{33} , C_{44} , C_{66} , K_{50} , and V_p are subtle if not negligible when considering the uncertainties. The C_{55} , C_{12} , G_0 , and V_s are not affected by the presence of structural H₂O. Although laboratory experiments show that Fe,Al-bearing orthopyroxenes can host up to 0.8 wt% H₂O in its structure, future high-pressure-temperature elasticity measurements on orthopyroxene with higher H₂O content are needed to help better quantify this effect.

Keywords: Elasticity, orthopyroxene, structural water, seismic velocities