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Equation of state of Fe-bearing epidote-group minerals determined by X-ray diffraction

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Abstract

Minerals in the epidote group, such as zoisite, clinozoisite, and epidote, are important water carriers to the Earth's deep interior through subducting slabs. In this study, we have performed synchrotron X-ray diffraction (XRD) measurements on four epidote-group minerals up to 60 GPa at 300 K in diamond-anvil cells (DACs) to investigate the influence of structure and Fe content on the equation of state and density of these minerals. The obtained volume-pressure data were fitted using a third-order Birch-Murnaghan equation of state, giving $V_0 = 902.6(1)$ Å^3, $K_{T0} = 112(2)$ GPa, and $K'_{T0} = 7.1(3)$ for zoisite with $X_{Fe} = 0$ [$X_{Fe} = Fe^{3+}/(Fe^{3+} + Al\text{-}2)$], $V_0 = 455.0(2)$ Å^3, $K_{T0} = 160(6)$ GPa, and $K'_{T0} = 3.4(6)$ for clinozoisite with $X_{Fe} = 0.24$, $V_0 = 457.53(5)$ Å^3, $K_{T0} = 142(4)$ GPa, and $K'_{T0} = 4.5(3)$ for clinozoisite with $X_{Fe} = 0.47$, and $V_0 = 458.5(7)$ Å^3, $K_{T0} = 157(5)$ GPa, and $K'_{T0} = 2.9(2)$ for epidote with $X_{Fe} = 0.84$. Together with literature results, we found that elevating the Fe content will increase the density of epidote-group minerals but decrease the bulk modulus. Compared to monoclinic clinozoisite with the same iron content, the orthorhombic zoisite has a higher density but a lower bulk modulus. The axial-compression behavior of epidote-group minerals is also discussed. Combining the elastic properties and density of other minerals in the $CaO\text{-}Al_2O_3\text{-}SiO_2\text{-}H_2O$ (CASH) system, we discuss the effect of water and Fe on this system and further elucidate the role of epidote minerals in water circulation inside the Earth.

Keywords: Epidote group, X-ray diffraction, compression behavior, Fe content, CASH system