American Mineralogist, Volume 109, pages 1348–1358, 2024

Single-crystal elasticity of humite-group minerals by Brillouin scattering

Qingchun Zhang[1], Xinyue Zhang[1], Luo Li[1], Zhu Mao[1,2,3,*], and Xiang Wu[4]

[1]Deep Space Exploration Laboratory/School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230026, China
[2]CAS Center for Excellence in Comparative Planetology, University of Science and Technology of China, Hefei, Anhui 230026, China
[3]Frontiers Science Center for Planetary Exploration and Emerging Technologies, University of Science and Technology of China, Hefei, Anhui 230026, China
[4]State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan 430074, China

Abstract

Humite-group minerals play a crucial role in transporting water and fluorine to the Earth's deep mantle through slab sinking. In this study, we have used Brillouin scattering to determine the single-crystal elastic constants of four natural humite-group minerals with varying H_2O and fluorite contents under ambient conditions, including one chondrodite [$Mg_{4.88}Si_{1.94}O_8(OH_{0.78}F_{1.22})$] ($F_{61}$-Chn), one humite [$Mg_{7.03}Si_{3.07}O_{12}(OH_{1.26}F_{0.74})$] ($F_{37}$-Hu), and two clinohumite [$Mg_{8.85}Ti_{0.19}Si_{3.93}O_{16}(OH_{1.11}F_{0.89})$ and $Mg_{8.63}Fe_{0.10}Ti_{0.24}Si_{3.97}O_{16}(OH_{1.84}F_{0.16})$] ($F_{45}$-Chu and F_8-Chu) samples. The adiabatic bulk (K_{S0}) and shear (G_0) moduli calculated from the elastic constants using Voigt-Reuss-Hill averages are: K_{S0} = 120.4(3) GPa and G_0 = 74.1(5) GPa for F_{61}-Chn, K_{S0} = 122.4(3) GPa and G_0 = 78.4(2) GPa for F_{37}-Hu, K_{S0} = 126.2(3) GPa and G_0 = 79.7(2) GPa for F_{45}-Chu, and K_{S0} = 120.5(3) GPa and G_0 = 76.8(2) GPa for F_8-Chu. Our results indicate that the addition of F leads to a noticeable increase in the elasticity of clinohumite and chondrodite, which is in contrast to the effect of H_2O. Although Fe has a negligible effect on the bulk modulus of clinohumite, it can produce a substantial decrease in the shear modulus. These results provide important insights into the influence of humite-group minerals on the mantle velocity structure. Furthermore, we have investigated the effects of composition on the elasticity and sound velocities of minerals along the forsterite-brucite join in the MgO-SiO_2-H_2O system, confirming previous observations. Increasing H_2O content along the forsterite-brucite join leads to apparent reductions in the elasticity and sound velocities. The influence of Fe on the elasticity and sound velocities of these minerals has also been evaluated.

Keywords: Clinohumite, humite, chondrodite, single-crystal elasticity, Brillouin spectroscopy