

The single-crystal elastic properties of the jadeite-diopside solid solution and their implications for the composition-dependent seismic properties of eclogite

MING HAO^{1,*}, CAROLINE E. PIEROTTI^{1,2}, SERGEY TKACHEV³, VITALI PRAKAPENKA³, AND JIN S. ZHANG^{1,4,*}

¹Department of Earth and Planetary Sciences, University of New Mexico, 221 Yale Boulevard NE, Albuquerque, New Mexico 87131, U.S.A.

²Albuquerque High School, 800 Odelia Road NE, Albuquerque, New Mexico 87102, U.S.A.

³GeoSoiEnviroCARS, University of Chicago, Argonne National Laboratory, Argonne, Illinois 60439, U.S.A.

⁴Institute of Meteoritics, University of New Mexico, 221 Yale Boulevard NE, Albuquerque, New Mexico 87131, U.S.A.

ABSTRACT

The 13 single-crystal adiabatic elastic moduli (C_{ij}) of a $C2/c$ jadeite sample close to the ideal composition ($\text{NaAlSi}_2\text{O}_6$) and a natural $P2/n$ diopside-rich omphacite sample have been measured at ambient condition by Brillouin spectroscopy. The obtained C_{ij} values for the jadeite sample are: $C_{11} = 265.4(9)$ GPa, $C_{22} = 247(1)$ GPa, $C_{33} = 274(1)$ GPa, $C_{44} = 85.8(7)$ GPa, $C_{55} = 69.3(5)$ GPa, $C_{66} = 93.0(7)$ GPa, $C_{12} = 84(1)$ GPa, $C_{13} = 66(1)$ GPa, $C_{23} = 87(2)$ GPa, $C_{15} = 5.4(7)$ GPa, $C_{25} = 17(1)$ GPa, $C_{35} = 28.7(6)$ GPa, $C_{46} = 14.6(6)$ GPa. Voigt-Reuss-Hill averaging of the C_{ij} values yields aggregate bulk modulus $K_S = 138(3)$ GPa and shear modulus $G = 84(2)$ GPa for jadeite. Systematic analysis combining previous single-crystal elasticity measurements within the diopside-jadeite solid solution indicates that the linear trends are valid for most C_{ij} values. The v_p and v_s of omphacite decrease with diopside content, though the velocity changes are small as diopside component exceeds 70%. We also found that both the isotropic v_p and v_s , as well as the seismic anisotropy of eclogite, changed strongly with the bulk-chemical composition. The relationship between the anisotropic velocities of eclogite and the chemical composition can be a useful tool to trace the origin of the eclogitic materials in the Earth's mantle.

Keywords: Clinopyroxene, Brillouin spectroscopy, elastic properties, jadeite