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High-pressure elasticity of a natural magnetite crystal

HANS J. REICHMANN[1,*] AND STEVEN D. JACOBSEN[2,†]

[1]Geoforschungszentrum Potsdam, Telegrafenberg, Division 4, 14473 Potsdam, Germany
[2]Bayerisches Geoinstitut, Universität Bayreuth, 95440 Bayreuth, Germany

ABSTRACT

Variation of the sound velocities, elastic constants, and compressibility of a natural magnetite crystal were determined using gigahertz ultrasonic interferometry and single-crystal X-ray diffraction to 8.7 GPa. At ambient pressure, the elastic constants are (in GPa): c_{11} = 260.5(1.0), c_{12} = 148.3(3.0), and c_{44} = 63.3(1.5). While c_{11} and c_{12} have similar positive pressure derivatives of 5.14(13) and 5.39(10), respectively, the c_{44} elastic constant exhibits mode-softening over this pressure range, with dc_{44}/dP = –0.13(4), calculated from the pressure dependence of the [100] shear velocity. The adiabatic bulk modulus (K_{0S}) is 185.7(3.0) GPa, with K_S = 5.1(1), and the shear modulus (G_0) is 60.3(3.0) GPa, with G' = –0.1(1). The bulk modulus and its pressure derivative obtained dynamically are consistent with the isothermal equation of state, measured on the same sample by single-crystal X-ray diffraction, yielding K_{0T} = 180.0(1.0) and K'_T = 5.2(4). Pressure-induced shear-mode softening in magnetite is most likely related to magnetoelastic coupling and the first-order phase transition to an orthorhombic structure above 21 GPa.