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High-temperature elasticity of polycrystalline orthoenstatite ($MgSiO_3$)

Jennifer Kung,[1,2,*] Ian Jackson,[3] and Robert C. Liebermann[2]

[1]Department of Earth Sciences, National Cheng Kung University, Tainan 70101 Taiwan
[2]Mineral Physics Institute and Department of Geosciences, Stony Brook University, New York 11794-2100, U.S.A.
[3]Research School of Earth Sciences, The Australian National University, Canberra, ACT 0200, Australia

Abstract

Compressional and shear wave velocities of a polycrystalline specimen of $MgSiO_3$ orthoenstatite have been measured by ultrasonic interferometry to 1373 K at 300 MPa in an internally heated gas-medium apparatus. The elastic wave velocities and bulk and shear moduli vary linearly with temperature to 1073 K. Below 1073 K, the temperature derivatives of the elastic moduli [$(\partial K_S/\partial T)_P = -28.3(7)$ MPa/K and $(\partial G/\partial T)_P = -14.5(1)$ MPa/K, respectively] determined in this study are consistent with averages of single-crystal elastic constants measured using Brillouin spectroscopy by Jackson et al. (2007). The measured temperature dependence of elastic moduli, along with pressure dependence of elastic moduli, thermal expansion and calorimetric data have been assimilated into a finite-strain equation of state of the type proposed by Stixrude and Lithgow-Bertelloni (2005). This analysis suggests significant revisions to the optimal values of the zero-pressure Grüneisen parameter γ_0 and its zero-pressure logarithmic volume derivative q_0. The unusually high absolute values of $(\partial K/\partial P)_T$ and $(\partial K/\partial T)_P$ are related through the extrinsic part of the temperature derivative. Above 1073 K, a pronounced softening of the elastic wave velocities is observed, which is plausibly associated with a phase transformation for which there is microstructural evidence: The recovered specimen was found to have transformed to the low-pressure clinoenstatite polymorph.

Keywords: $MgSiO_3$ orthoenstatite, elasticity, high temperature, elastic velocity softening, phase transition