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In situ Raman spectroscopy of $MgSiO_3$ enstatite up to 1550 K

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Abstract

Significantly reduced detection of thermal radiation in gated spectroscopy allowed us to measure the Raman scattering of natural enstatite up to 1550 K at 1 bar. The intrinsic anharmonicity, $a_i = [(\partial \ln \nu_i)/(\partial T)]_V$, of the Raman-active modes in orthoenstatite (OEn) was obtained from temperature (T) shifts of vibrational frequencies measured in this study combined with previous high-pressure (P) Raman scattering data. Although the a_i values of the lattice modes of OEn are similar to those for forsterite (Fo), the Si-O stretching modes have significantly lower intrinsic anharmonicity in OEn than in Fo, suggesting that the connectivity of the SiO_4 tetrahedra plays an important role in mode anharmonicity. At the phase transition at 1500 K, a doublet related to the stretching vibration of bridging O atoms in the SiO_3 chains becomes a singlet, and a doublet related to the stretching vibration of non-bridging O atoms remains as a doublet, consistent with the expected spectral change for a phase transition from OEn to protoenstatite. Two intense, low-frequency modes of OEn show a strong nonlinear decrease in frequencies with heating that cannot be explained solely by thermal expansion. This may indicate the reorganization of the structure around Mg atoms and unkinking of the SiO_3 chains at temperatures well below the phase transition.

Keywords: Raman spectroscopy, gated spectroscopy, orthoenstatite, protoenstatite, phase transition, high temperature