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Static compression of $(Mg_{0.83},Fe_{0.17})O$ and $(Mg_{0.75},Fe_{0.25})O$ ferropericlase up to 58 GPa at 300, 700, and 1100 K

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Abstract

Static compression data of $(Mg_{0.83},Fe_{0.17})O$ and $(Mg_{0.75},Fe_{0.25})O$ ferropericlases have been measured up to 58 GPa along 300, 700, and 1100 K isotherms, using synchrotron powder X-ray diffraction experiments combined with a Kawai-type, multi-anvil, high-pressure apparatus and sintered diamond anvils. High-temperature and high-pressure equations of state for these two ferropericlases, which have high-spin Fe^{2+} ions, were developed using measured compression data below 47 GPa, based on the Mie-Grüneisen relation and the Debye thermal model, combined with the 300 K Birch-Murnaghan equation. When the isothermal bulk modulus (K_{0T}) and the Debye temperature (Θ_0) are fixed at 160 GPa and 500 K, respectively, the optimized equation-of-state parameters for these two phases are as follows: the pressure derivative of the bulk modulus (K'_{0T}), the Grüneisen constant (γ_0), and the q parameter are 4.08 ± 0.02, 1.53 ± 0.04, and 0.7 ± 0.2, respectively, for $(Mg_{0.83},Fe_{0.17})O$; and 4.22 ± 0.03, 1.64 ± 0.04, and 0.7 ± 0.2, respectively, for $(Mg_{0.75},Fe_{0.25})O$. We found that calculated pressures with these equation-of-state parameters accurately reproduce the measured pressures of each ferropericlase below ~50 GPa for the isotherms of 300, 700, and 1100 K. Furthermore, the compression curve indicates that for each ferropericlase at each isothermal compression of 300, 700, and 1100 K, an abrupt volume reduction occurs at ~50 GPa. This volume reduction becomes more pronounced with increasing pressure, as a result of the progressive transition from high-spin to low-spin of the Fe^{2+} ions in each ferropericlase.

Keywords: Static compression, ferropericlase, high pressure, spin transition, high temperature, lower mantle