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High-pressure behavior of liebenbergite: The most incompressible olivine-structured silicate

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Abstract

Nickel is an abundant element in the bulk earth, and nickel-dominant olivine, liebenbergite, is the only igneous nickel-rich silicate found in nature. In this study, we used high-pressure single-crystal diffraction to explore the compressional behavior of a synthetic liebenbergite sample up to 42.6 GPa at ambient temperature. Over the studied pressure range, the liebenbergite sample retains the orthorhombic *Pbnm* structure, and no phase transition is observed. A third-order Birch-Murnaghan equation of state was used to fit the pressure behavior of the unit-cell volume, lattice parameters, the polyhedral volume, and the average bond length within each polyhedron. The best-fit bulk modulus K_{T0} = 163(3) GPa and its pressure derivative K'_{T0} = 4.5(3). We find that liebenbergite is the most incompressible olivine-group silicate reported thus far, and Ni^{2+} tends to increase the isothermal bulk modulus of both olivine- and spinel-structured silicates. Consequently, Ni-rich olivine has a higher density compared to Ni-poor olivine at the upper mantle *P-T* conditions; however enrichment of Ni in mantle olivine is generally too low to make this density difference relevant for fractionation or buoyancy.

Keywords: Olivine, Ni, high pressure, equation of states, single-crystal diffraction