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Composition dependence of spin transition in $(Mg,Fe)SiO_3$ bridgmanite

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Abstract

Spin transitions in $(Mg,Fe)SiO_3$ bridgmanite have important implications for the chemistry and dynamics of Earth's lower mantle, but have been complex to characterize in experiments. We examine the spin state of Fe in highly Fe-enriched bridgmanite synthesized from enstatites with measured compositions $(Mg_{0.61}Fe_{0.38}Ca_{0.01})SiO_3$ and $(Mg_{0.25}Fe_{0.74}Ca_{0.01})SiO_3$. Bridgmanite was synthesized at 78–88 GPa and 1800–2400 K and X-ray emission spectra were measured on decompression to 1 bar (both compositions) and compression to 126 GPa [$(Mg_{0.61}Fe_{0.38}Ca_{0.01})SiO_3$ only] without additional laser heating. Observed spectra confirm that Fe in these bridgmanites is dominantly high spin in the lower mantle. However, the total spin moment begins to decrease at ~50 GPa in the 74% $FeSiO_3$ composition. These results support density functional theory predictions of a lower spin transition pressure in highly Fe-enriched bridgmanite and potentially explain the high solubility of $FeSiO_3$ in bridgmanite at pressures corresponding to Earth's deep lower mantle.

Keywords: Bridgmanite, spin transition, iron-bearing silicates, lower mantle