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Thermal conductivity of oxidized bridgmanite across the spin transition

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Variation in thermal conductivity with composition may affect mantle heat flow and the dynamical stability of thermochemical heterogeneities. Existing data on the effects of iron on thermal conductivity in the deep lower mantle have been inconsistent due to complex crystal chemistry with multiple valence and spin states. In this study, we measure the lattice thermal conductivity of bridgmanite across an unambiguous electronic spin transition due to oxidized Fe^{3+} incorporated in both cation sites. A fully oxidized $(Mg_{0.95}Fe_{0.05})(Fe_{0.05}Si_{0.95})O_3$ bridgmanite was synthesized from a stoichiometric mixture of 99.99% Fe_2O_3, MgO, and SiO_2 in a multi-anvil press by heating to 1600 °C for 24 hours at 24 GPa. Polycrystalline samples were polished to <15 microns thick and coated with Al before loading into diamond anvil cells. Lattice thermal conductivity was measured by time-domain thermoreflectance spectroscopy at ambient temperature and pressures up to 100 GPa in 2-5 GPa steps. At pressures from 1 bar up to ~50 GPa, lattice thermal conductivity of Fe^{3+}-bearing bridgmanite increases linearly with pressure from 6-7 to ~18 W/m-K, similar or slightly higher than values obtained for Fe-free, Fe^{2+}-bearing, and Fe,Al-bearing bridgmanite. At 50 GPa, we observe a sharp ~50% decrease in thermal conductivity corresponding to the pressure-induced electronic spin transition in Fe^{3+} in the bridgmanite octahedral site. Low-spin Fe^{3+}-bearing bridgmanite exhibits nearly pressure-invariant thermal conductivity. The magnitude of the decrease across the spin transition is stronger than any transition in lattice thermal conductivity observed in previous studies of bridgmanite. Regions of the lowermost mantle with low-spin Fe^{3+}-bearing bridgmanite will be more thermally insulating relative to reduced or Al-rich regions, and may be anomalously warm.