Thermal conductivity and compressibility of iron and aluminum-bearing bridgmanite: implications for spin-crossover of iron

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Bridgmanite (Bdg), iron (Fe)- and aluminum (Al)-bearing magnesium silicate perovskite is the most abundant mineral in the Earth's lower mantle. Thus, its thermal conductivity governs the lower mantle thermal conductivity that critically controls the thermo-chemical evolution of both the core and the lower mantle. While there is extensive research for the lattice thermal conductivity of $MgSiO_3$ Bdg, the effects of Fe and Al incorporation on its lattice thermal conduction are still controversial.
We measured the lattice thermal conductivity of Bdg with chemical compositions of $Mg_{0.832}Fe_{0.209}Al_{0.060}Si_{0.916}O_3$, $Mg_{0.793}Fe_{0.075}Al_{0.217}Si_{0.914}O_3$ and $Mg_{0.718}Fe_{0.123}Al_{0.281}Si_{0.878}O_3$ up to 142 GPa, 180 GPa and 74 GPa, respectively, at 300 K using the pulsed light heating thermoreflectance technique in a diamond anvil cell. The results show that the lattice thermal conductivity of $Mg_{0.832}Fe_{0.209}Al_{0.060}Si_{0.916}O_3$ Bdg is 25.5 ±2.2 W/m/K at 135 GPa and 300 K, which is 19% lower than that of Fe and Al-free Bdg at identical conditions. Considering the temperature effect on the lattice thermal conductivity and the contribution of radiative thermal conductivity, the total thermal conductivity of Fe and Al-bearing Bdg does not change very much with temperature at 135 GPa, and could be higher than that of post-perovskite with identical chemical composition. Our results imply that the compositional variation of bridgmanite do not induce heterogeneity of thermal conductivity in the lateral direction at the core-mantle boundary. The present results also revealed that the lattice thermal conductivities of $Mg_{0.793}Fe_{0.075}Al_{0.217}Si_{0.914}O_3$ Bdg and $Mg_{0.718}Fe_{0.123}Al_{0.281}Si_{0.878}O_3$ Bdg showed abnormal reduction in the pressure range of 20-40 GPa at 300 K, which may be due to the spin crossover of octahedral Fe^{3+}. This indicates that temperature in the subducted slab could be significantly lower than previously thought, which have a great potential to the lower mantle dynamics, and water transportation to the deeper part of the Earth's lower mantle.

Keywords: bridgmanite, lower mantle, spin transition

