Iron content induced pressure- and temperature-dependency change of thermal conductivity of ferropericlase: implications for mantle dynamics

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The thermal conductivity of Earth's materials is an important factor to govern the heat transport in the Earth's interior, and consequently plays a critical role in thermal evolution and dynamics of the mantle and core. Ferropericlase, which is the second most abundant mineral in the Earth's lower mantle, is of great importance for the control of heat flux across core-mantle boundary. Recent studies have revealed that at the bottom of mantle some areas can be enriched in iron oxides, in particular iron-rich ferropericlase, which believed to be one of possible candidates to explain the origin of ultra-low velocity zones (ULVZs) [1]. The effect of iron content on thermal conductivity of ferropericlase thus becomes indispensable for understanding the origin of ULVZs and lateral heat flux heterogeneity at the core-mantle boundary (CMB). Although several laboratory measurement results of lattice thermal conductivity of ferropericlase are available, the inconsistent pressure dependence and lack of data regarding temperature dependence make it difficult to discuss such issue [2–5].

In this study, thermal conductivity and diffusivity of ferropericlase were determined simultaneously by combining multi-anvil high pressure experimental technique and pulse heating method. Thermal properties of ferropericlase with six different Fe contents (Fp_3, Fp_5, Fp_{10}, Fp_{20}, Fp_{30}, Fp_{50}) were measured under high pressure and high temperature in a Kawai type multi-anvil press. The experiment results show that even small addition of iron can strongly reduce the thermal conductivity of ferropericlase at room temperature. The effects of pressure and temperature on thermal conductivity of ferropericlase are also highly correlated with the iron concentration and decrease with increasing iron content. Such high sensitivity for iron content suggests that the global iron fraction, iron enrichment at some regions of lowermost mantle and iron partitioning between ferropericlase and other mantle phases could largely influence the heat transport and temperature distribution in the lower mantle. Iron-rich ferropericlase is expected to have much lower thermal conductivity than iron-poor one due to the small pressure dependence. It means that in iron enrichment regions heat loss will be suppressed and allow the persistence of small pockets of hot materials at the bottom of mantle up to now. Inversely, much faster heat transport is anticipated for relatively iron poor area.

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Keywords: Thermal conductivity, Ferropericlase, High pressure, Mantle