Thermal conductivity anomaly of $(Mg,Fe)CO_3$ solid solution across the spin transition

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Deep carbon cycle is a process carrying carbon into Earth's interior by subduction of slabs and returning to Earth's surface by volcanic activities. Given the abundance of iron in Earth's interior, it is believed that $(Mg,Fe)CO_3$ solid solution is an important candidate of carbon-hosting mineral in the mantle. Prior studies have shown that the iron in the $(Mg,Fe)CO_3$ solid solution undergoes a pressure-induced spin transition at 40-55 GPa and the iron content has a minor effect on the onset pressure of spin transition. Across the spin transition, the physical properties of $(Mg,Fe)CO_3$ solid solution, e.g. sound velocity and unit cell volume, typically change accordingly. Lattice thermal conductivity of mantle minerals is key to control the heat flux and temperature profile of the mantle. However, the thermal conductivity of $(Mg,Fe)CO_3$ solid solution under relevant mantle pressure-temperature conditions remains largely unknown. Here we used Raman spectroscopy to characterize the extent of spin transition of natural $(Fe_{0.18}Mn_{0.01}Mg_{0.80}Ca_{0.01})CO_3$ ferromagnesite and time-domain thermoreflectance to measure its thermal conductivity from ambient conditions to 65 GPa. Our preliminary study shows that the thermal conductivity of $(Fe_{0.18}Mn_{0.01}Mg_{0.80}Ca_{0.01})CO_3$ ferromagnesite is 20 W m^{-1} K^{-1} at 40 GPa and drastically increases to 80 W m^{-1} K^{-1} at the beginning of spin transition, and then suddenly drops to 20 W m^{-1} K^{-1} during the middle period of spin transition, similar to its iron-rich counterpart, $(Fe_{0.78}Mg_{0.22})CO_3$ siderite, investigated in our previous work. Our results suggest that if the $(Mg,Fe)CO_3$ carbonates can be transported by the subduction slabs to 1400-1800 km depth with iron contents of 18 to 78 %, their thermal conductivity anomalies across the spin transition may induce anomalies in local thermo-chemical profiles in subduction zones, which in turn alter the distribution fields of subducting minerals.

Keywords: Spin transition, Thermal conductivity, Ferromagnesite, Siderite