The Effect of Iron on Thermal Transport Properties of Olivines

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The dynamic Earth may be regarded as a huge thermal engine. Knowledge properties and mechanisms of heat transport of Earth materials is thus a fundamental prerequisite for understanding processes driving our surprisingly active planet. We present some first results on the influence of iron on thermal transport properties of olivine. Olivine is one of the most abundant minerals in the Earth and probably dominates the upper mantle properties. For most minerals the following observations hold true: thermal conductivity and thermal diffusivity decrease with increasing mean atomic weight, increasing density, decreasing sound velocity, and increasing complexity of the structure (e.g., increasing number of optical phonons). To test these hypotheses for olivine, a series of olivines with different iron contents were studied. A transient method was used to determine thermal diffusivity as a second rank tensor as a function of temperature. A synthetic forsterite, San Carlos olivine, fayalite (from the island of Fayal), and a knebelite from Norway were measured. The samples were characterized by XRD and microprobe techniques. The sound velocity of the knebelite was determined from ultrasonic P- and S-wave measurements. As is known from the literature, with increasing iron content mean sound velocity decreases in the system forsterite-fayalite. In the case of knebelite $(Fe_{0.5}Mn_{0.5})_2SiO_4$, density, mean atomic weight, and mean sound velocity are similar to those of fayalite (Fe_2SiO_4). However, its thermal diffusivity is significantly higher than that of fayalite. On the other hand, if the thermal diffusivity of the olivines is plotted against iron content, a good correlation is observed. Hence, the iron content seems to significantly control thermal diffusivity of iron bearing olivines. The variation of thermal diffusivity as a function of temperature will be presented and discussed in terms of heat transfer by phonons and photons.

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