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LETTER

Optical and near infrared spectra of ringwoodite to 21.5 GPa: Implications for radiative heat transport in the mantle

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ABSTRACT

High pressure optical and near infrared spectra of a single crystal of ringwoodite with composition $(Mg_{0.90}Fe_{0.10})_2SiO_4$ were measured to 21.5 GPa. The spectrum at ambient pressure shows a strong band at 12 265 cm^{-1} with two shoulders at 8678 cm^{-1} and 17 482 cm^{-1}. The bands at 12 265 cm^{-1} and at 8678 cm^{-1} are due to spin–allowed crystal field transitions of octahedral Fe^{2+}, while the band at 17 482 cm^{-1} is most likely due to $Fe^{2+} \rightarrow Fe^{3+}$ charge transfer. The absorption edge due to ligand-to-metal charge transfer occurs close to 30 000 cm^{-1}. With increasing pressure, both the crystal field and the charge transfer bands shift to higher frequencies. Whereas this is expected for the crystal field bands, this blue shift is surprising for an intervalence charge transfer band. Moreover, neither the crystal field nor the charge transfer bands broaden or intensify significantly with pressure. These results have major implications for radiative heat transfer in the Earth's mantle. It has commonly been assumed that radiative heat transfer is blocked in the mantle, because it was believed that the red shift and the increased intensity of charge transfer bands with pressure would effectively make mantle minerals opaque throughout the near infrared and visible range. Our results demonstrate that this effect does not occur for ringwoodite with a Mg/Fe ratio realistic for the Earth's mantle. Quite to the contrary, the mean free path of photons in ringwoodite actually increases with pressure, because the absorption bands move away from the maximum of the blackbody radiation.