Optical Absorption Spectra of Silicate Perovskite to 1.25 Mbar

Keppler, Hans[1] Dubrovinsky, Leonid S[1] Narygina, Olga[1] Kantor, Innokenty[1]
[1]Bayerisches Geoinstitut, 95440 Bayreuth, Germany

At the temperatures prevailing in the lower mantle, one would normally expect that radiation contributes significantly to thermal conductivity. However, in geodynamic modeling, the radiative contribution to thermal conductivity is usually neglected, since early high-pressure studies appeared to indicate that iron-bearing mantle minerals become completely opaque already under moderate pressures. Moreover, recently it has been proposed that pressure-induced spin-pairing may further reduce the radiative thermal conductivity of mantle minerals (Gocharov et al. 2006).

We therefore measured the optical absorption spectrum of a sample of iron-bearing aluminous magnesium silicate perovskite, the main constituent of Earth´s lower mantle, to a pressure of 1.25 megabar. Experiments were carried out in a diamond cell with neon pressure medium and using diamonds selected for high optical transparency. Absorption spectra of a single crystal of perovskite with 30 μm thickness were recorded in the range from 2500 to 30000 cm^{-1} using a Bruker IFS 125 spectrometer together with a Bruker microscope.

The perovskite sample remains optically quite transparent to the highest pressures studied. The main feature in the absorption spectrum at ambient conditions is a very broad intervalence charge transfer band at15000 cm^{-1}. This band shifts only slightly to about 17500 cm^{-1} at the highest pressures studied. At the same time, the UV absorption edge moves somewhat into the blue region of the spectrum. However, even at the highest pressures, there is very little absorption in near infrared range where the maximum of blackbody radiation is expected to occur in the lower mantle.

While high-pressure Moessbauer data would be consistent with an electronic transition of iron from a high-spin to an intermediate spin state, the optical spectra show no evidence at all for effects of spin-pairing. If spin-pairing of iron indeed occurred in perovskite, its effects on the optical properties are negligible.

Together with similar results for ferropericlase (Keppler et al. 2007), our data demonstrate that lower mantle minerals remain optically very transparent even at pressures prevailing close to the core-mantle boundary. The radiative contribution to the thermal conductivity will therefore be significant in the lower mantle. This should have major implications for models of mantle dynamics and of the thermal evolution of the Earth in general.

References

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email: **Hans.Keppler@Uni-Bayreuth.De**
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