MR13C-0066 Olivine's High Radiative Conductivity Increases Slab Temperature by 100-200 K

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Abstract

Temperature (T) is a key parameter for subducting slabs because it controls their buoyancy and rheology, the depth of phase transitions, and it causes the breakdown of hydrous phases. Therefore, modelling slab thermal evolution is fundamental to understand Earth's geodynamic processes. The temperature increase inside the subducting slabs is mainly caused by heat diffusion, which is controlled by thermal conductivity. In electrical insulators, thermal conductivity is the sum of the contributions by lattice vibrations (phonons) and by photon radiation. The lattice thermal conductivity is controlled by the stiffness and the density of the material, whereas the radiative thermal conductivity is controlled by T and the transparency of the material, i.e. the absorption coefficient in the visible and infrared is small. Both components of the thermal conductivity depend on T, pressure (P), composition, and crystal structure. For most mantle minerals, however, these dependencies are generally unconstrained because the physical measurements are difficult to execute at appropriate P-T conditions of the mantle. As a result, in most thermal evolution models of slabs, the lattice component is often assumed constant, while the radiative is ignored. Here we measured the optical absorption coefficient of olivine – the most abundant mineral in the upper mantle – at T up to 1000 K and P up to 10 GPa to estimate its radiative thermal conductivity. We found that the radiative contribution is as important as the lattice, representing 40-60% of olivine´s thermal conductivity. To test the large-scale implications of our findings, we designed a 2D model to compute slab thermal evolution with the finite-difference method. We run two sets of models: one with radiative heat transport and one without. The slabs heated by radiative and lattice heat transport are ~100-200 K warmer than the slabs heated with only the lattice contribution. As a consequence of the faster heating, the upper 10 km of the slabs heated by radiative contributions, dehydrates completely before reaching the Mantle Transition Zone (MTZ). Water delivery into the MTZ is only possible within the cold core, i.e. ~30 km from the slab surface, of old (>60 Myrs) sinking slabs. The depths of the main dehydration reactions correlate well with the depths of intermediate-deep seismicity.

First Author

M

Enrico Marzotto

Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

Authors

L

Sergey Lobanov

Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

K

Alexander Koptev

GFZ German Research Centre for Geosciences

K

Monika Koch-Müller

Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

S

Sergio Speziale

Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

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