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Thermal properties of pyroxene under high pressure

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Thermal properties, i.e. thermal conductivity and thermal diffusivity of major mantle materials control dynamics of the Earth. We determined thermal conductivity and thermal diffusivity olivine and garnet, and provided thermal conductivity values in the condition of the upper mantle. The thermal property of another major material, pyroxene, is of course indispensable. Olivine reveals strong anisotropy in the thermal conductivity (or diffusivity) probably in its P-T conditions in the mantle. It is predicted that pyroxene also has anisotropy in thermal conductivity equivalent or excess to that in olivine at the conditions of the mantle. In parenthesis, the anisotropy in thermal conductivity of the mantle would gradually reduce with depth because the pyroxene component dissolves to the garnet, which is isotropic in thermal conduction. Despite the important role in the mantle dynamics, the thermal properties of pyroxene under pressure have not yet been well elucidated. One of the reasons for the lack of data is come from that proper samples of pyroxene are hard to prepare for the thermal property measurements.

We have measured thermal properties of jadeite, an analog material of pyroxene, at pressures to 10 GPa, applying a pulse heating method for simultaneous thermal conductivity and thermal diffusivity measurement. The measurements were conducted using a Kawai-type high-pressure apparatus at the Institute for Study of the Earth's Interior, Misasa. The result shows that jadeite has higher (around 30 %) thermal conductivity than olivine, and its pressure derivative is 2.5 % per 1GPa, which is lower than that of olivine. However, the measured thermal conductivity and thermal diffusivity and their pressure derivatives do not settles within the reasonable errors, unlike the measurements for olivine and garnet. The cause of this fluctuation perhaps comes from coarse-grained texture of the jadeite samples. The position of junction of the thermocouple is different for the crystallographic orientation of the sample in the each run of measurement. This accounts for the discrepancy of values in the thermal diffusivity or thermal conductivity. Whereas the cause of differences of the pressure derivatives among runs is not unknown. Thus the measurements using jadeite is not so suitable to examine the thermal properties of pyroxene as the mantle material.

Thermal properties measurements for pyroxene single crystals should be conducted in a smaller pressure cell than that used for the measurement of olivine and garnet, because only tiny cuts of the sample are used. We design a pressure cell using a sample of 3 mm in diameter and 0.7 mm in thickness. The measurement has not been performed at present, however, this assembly will provide the thermal properties of the mantle materials at pressures up to 15 GPa. This covers the condition in the upper mantle, where the anisotropy of the thermal conductivity may be effective to the dynamics of the lithosphere and descending slabs.