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High-pressure radiative conductivity of dense silicate glasses with implications for dark magmas

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The current structure of Earth's interior is believed to have developed through dynamic differentiation from a global magma ocean in the early Earth. Elucidation of the heat-transport properties of silicate melts in the deep Earth is fundamental to understanding the evolution and structure of Earth's interior. The possible presence of dense, gravitationally stable, silicate melts at the bottom of the current mantle, as a remnant of a deep magma ocean, has been proposed to explain observations of anomalously low seismic velocities above the core-mantle boundary. Thus, heat flux through the core-mantle boundary (CMB) region would strongly depend on the thermal conductivity, both lattice-vibrational and radiative , of such dense silicate melts, as well as that of constituent minerals of the lower mantle. However, the thermal properties of such silicate melts under relevant high-pressure conditions are poorly understood, while there have been several experimental studies on the thermal conductivity of lower mantle minerals such as magnesium-rich silicate perovskite (bridgmanite) and ferropericlase. Direct measurements of thermal conductivity on silicate melts under ultrahigh-pressure conditions remain a great challenge and are currently beyond experimental capabilities. Alternatively, silicate glasses have been studied as analogues for quenched silicate melts, to simulate high-pressure melt behavior. Previous experimental works on silicate glasses have, however, been still limited to lower pressure condition, which is far below the pressure condition of the bottom of the mantle.

Here we report in-situ high-pressure optical absorption and synchrotron Mossbauer spectroscopic measurements of iron-enriched dense silicate glasses, as analogues for dense magmas, up to pressures of 85 GPa. Our results reveal a significant increase in absorption coefficients, by almost one order of magnitude with increasing pressure to about 50 GPa, most likely due to gradual changes in electronic structure. This indicates that the radiative thermal conductivity of dense silicate melts may decrease with pressure and so may be significantly smaller than previously expected under the CMB conditions. Such dark magmas heterogeneously distributed in the lower mantle would result in significant lateral heterogeneity of heat flux through the CMB.