High-pressure radiative conductivity of dense silicate glasses

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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 (CMB). Thus, heat flux through the core-mantle boundary region would strongly depend on the thermal conductivity 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 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. Here we report in-situ high-pressure optical absorption and synchrotron Mössbauer 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. We find that dense silicate melts with basaltic composition are about 5 to 25 times less radiatively conductive than the silicate perovskite phase with representative lower-mantle iron contents under conditions at the base of the mantle. This remarkable contrast at high pressures indicates the formation of deep magmas with higher heat absorption than the surrounding solid mantle phases. A heterogeneous distribution of such dense and "dark" magmas with low radiative thermal conductivity would result in lateral heterogeneity of heat flux through the CMB, thus potentially constraining the locations of stable hot mantle plumes rooted in CMB.