

A spatio-temporal approach to melting investigations: Dissecting Earth's core-mantle boundary

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Abstract:

The boundary layer separating the liquid outer core from the mantle is a region of great complexity, where extreme contrasts in material properties promote the persistence of multi-scale structural heterogeneities, as evidenced through seismic observations. Thermochemical variations at Earth's mantle base play an important role in the evolutionary history of the Earth through regulation of heat flow that influences the dynamics of both the mantle and the core. Despite the significance of this region for Earth's evolution, many open questions remain regarding its thermal state, as well as the characteristics, origins, and dynamic interactions of seismically-distinct structures, such as large thermochemical piles, regions of ultralow seismic velocities, and subducted former oceanic material [1]. As observational studies of such features continue to develop, a synthesis of results involving geodynamic modeling and mineral physics provides new insights into this complex region.

We highlight new developments in mineral physics that investigate melting at high-pressures. By pairing independent in-situ synchrotron techniques, different time and length scales of the involved spatio-temporal atomic arrangements are emphasized: x-ray diffraction, sensitive to the loss of long-range crystalline order due to melting, and time-domain Mössbauer spectroscopy, sensitive exclusively to the dynamics of solid-bound iron nuclei. Our recent applications of this approach offer a comprehensive understanding of phase relations and melting of key materials in or proximal to planetary cores, an Fe-Ni-Si alloy [2] and FeO wüstite [3]. Our discussion will be on the thermal state of Earth's core and core-mantle boundary, with mineralogical implications for lowermost mantle plume roots, such as beneath Hawai'i [4,5].

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5. Wilding et al. (2022) Science, [10.1126/science.ade575](https://doi.org/10.1126/science.ade575)