Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36762

High-pressure melting and resistivity of iron with implications for Earth's core and lowermost mantle

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The melting temperatures and electrical resistivity of iron at high pressure are essential for understanding the thermal history and dynamics of Earth's core, but significant differences in experimental results have led to divergent Earth models. We developed a pulsed Joule heating system to investigate the melting temperature and electrical resistivity of iron under the high pressure of Earth's core. The system heats metal samples to temperatures exceeding 4000 K at pressures exceeding 2 Mbar. Precise sample fabrication, combined with a novel 5-color multianode spectroradiometer, enables high-precision heating control and temperature measurement (~ ±30 K) with sub-microsecond time resolution. Plateaus in temperature-time traces due to the latent heat of melting show outstanding reproducibility. Our findings on the high-pressure melting curve of iron, based on more than 200 melting measurements extending to over 2 Mbar, reveal lower melting temperatures and a shallower Clapeyron slope relative to previous studies. By extrapolating these to inner-core pressure and combining them with our measured resistivity of liquid iron (~75 μΩ cm), we propose that a relatively low adiabatic outer-core heat flow of < 10 TW and relatively low core-mantle boundary temperatures. Our results indicate that thermal convection alone may have powered the geodynamo before the formation of the inner core, and that today's lowermost mantle is likely to be fully solid.