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Stable Stratification at the top of Earth's outer core

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The debate over whether the top of Earth's liquid outer core is vigorously convecting or stably stratified has a long history. Elucidating the nature of core stratification has important implications for interpreting geomagnetic observations, which only probe the top of the core, and for understanding the thermo-chemical evolution of the deep Earth. Recent seismological studies advocate a ∼300km-thick stable layer beneath the core-mantle boundary (CMB) at the present day, while geomagnetic studies suggest that a stratified uppermost core is not inconsistent with the observed secular variation. Here I investigate core stratification by calculating the energetic requirements for sustaining the geomagnetic field over time. The assumption that thermo-chemical buoyancy sustains the present-day geomagnetic field requires a CMB heat-flux of 6-8TW, corresponding to a stable layer over 600km thick; however, this calculation predicts that there is insufficient energy available to sustain the field prior to ∼500Ga, contrary to paleomagnegic data. A calculation that allows rapid core cooling in recent times shows that thermochemical buoyancy can sustain a marginal field for the last 3.5Gyrs with a present-day CMB heat-flux of 10TW and a stable layer thickness comparable to the seismic estimate. All successful evolution models require an inner core around 500Myrs old and very high CMB temperatures at early times, suggesting pervasive melting in the early lower mantle.