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Stratification of the top of the core due to chemical interactions with the mantle

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Chemical interactions between the core and the mantle have been proposed as a mechanism to transfer O and Si to the core. Adding light elements to the top of the core creates a stratified layer, which grows by chemical diffusion into the underlying convecting region. We develop a physical model to describe the evolution of the layer and estimate physical properties to aid in its detection. The interface between the stratified layer and the convecting interior is defined by the onset of double diffusive instabilities. Oscillatory instabilities arise from the interplay of a stable compositional stratification and an unstable thermal stratification due to a superadiabatic heat flow at the core-mantle boundary. Double diffusive convection in the region of neutral stratification establishes the base of the layer and sets the rate of entrainment of excess light element into the interior of the core. Growth of the layer by diffusion is interrupted by nucleation of the inner core, which segregates light elements into the convecting part of the core. For calculations using O as the sole light element, we find that the base of the stratified layer retreats toward the core-mantle boundary as the radius of the inner core increases. Representative (but uncertain) model parameters yield a present-day layer thickness of 60 to 70 km. We also calculate the anomaly in P-wave velocity relative to the value for a well-mixed core. The velocity anomaly decreases almost linearly across the layer with a peak value of 2¥% at the core-mantle boundary. This anomaly should be large enough to detect in seismic observations, although the sign of the anomaly is opposite to estimates obtained in previous seismic studies. We suggest possible explanations for this discrepancy and speculate about the implications for the structure of the Earth's interior.

Keywords: core-mantle boundary, double-diffusive convection, thermal evolution