Rising or falling snow: Constraints on core composition from the F-layer

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The crystallization of Earth’ s solid inner core fuels convective motions inside the well mixed outer core and maintains dynamo activity through the fractionation of buoyant light elements. Seismic velocity reductions on top of the inner core boundary (ICB) have been attributed to the presence of a dense, stably stratified region, referred to as the F-layer. The generation and long-term stability of such a layer is thought to be driven by the continuous flux of solid particles, which buffers its composition to the liquidus. This can occur by means of a “falling snow” of solid hcp-Fe settling from the top of the F-layer towards the ICB, or through a “rising snow” of buoyant alloy-rich crystals fractionated from the crystallizing inner core. The different alloy concentrations with respect to the eutectic implied by these two scenarios, and the resulting processes taking place within the F-layer would provide useful insights on core composition.

We employ constraints from mineral physics and seismology to determine core binary alloy compositions that are consistent with different solid particle fluxes within the F-layer. By allowing for the propagation of uncertainties of physical and chemical alloy properties at ICB pressures, we compute the thermal and compositional gradients across the layer. We find that a rising snow scenario is associated with the presence of a Si-rich core alloy, whereas the crystallization of hcp-Fe at the top of the F-layer favors an O-dominated core. These differences have strong implications for the resulting heat flow budget and for the driving forces for convection, which are of compositional nature for an Si-rich core, and are dominated by high heat fluxes and core secular cooling for an O-rich scenario.

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