The deep mantle thermo-chemical boundary layer: The putative mantle plume source

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ABSTRACT

Hypothetical narrow, cylindrical thermal plumes from great depths in the Earth, which are commonly invoked to account for relatively stationary and persistent concentrations of volcanism at the surface, are intimately linked to the notion of instabilities and upwellings of a deep thermal boundary layer in the mantle. If the mantle is undergoing whole-mantle convection with no internal stratification, the primary thermal boundary layer within the interior that may serve as a plume source is located above the core-mantle boundary. If the mantle convection regime is globally or locally stably stratified by compositional layering, thermal boundary layers should exist on the margins of the compositional contrasts, and any such boundary layers could serve as plume sources. Seismological, mineral physics, and geodynamic evidence favors the existence of a complex thermo-chemical boundary layer in the lowermost few hundred kilometers of the mantle, the so-called D0 region, involving extensive, if not global, chemical stratification. Although chemical stratification of the mid-mantle has not been ruled out, the lack of direct evidence for global existence of thermal boundary layers in the mid-mantle means that the lowermost mantle region is generally invoked as the source of thermal plumes that give rise to melting and chemical anomalies associated with hotspot volcanism. Observational constraints on this putative mantle plume source are summarized here, along with consideration of the attendant implications for plume existence.