

Heat and mass transfer by mantle plumes in heterogeneous mantle

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Geochemical and seismic observations support that the deep mantle plumes has a thermo-chemical nature, which are generated from the compositionally dense layer in the lowermost mantle. The plausible origins of those compositional anomalies are subducted slabs, chemical reaction at the core-mantle boundary (CMB), partial melting, etc. These anomalies are not evenly distributed above the CMB and seem to have a good correlation with the distribution of Large Igneous Provinces (LIPs) and the surface hotspot activities. Fluid dynamics show that a variety of thermochemical plumes is generated from a thermal boundary layer which is stratified in composition [1,2]. Those plumes have different morphologies which reflect the temporal and spatial variation of heat and mass transfers. The behaviors of thermochemical plumes depend on their initial buoyancy ratio B_0 , which is the ratio of the stabilizing chemical buoyancy to the destabilizing thermal buoyancy at the onset of convection, on Rayleigh number Ra , and also on time. Because a rising plume cools along the way by thermal diffusion, the thermochemical plume eventually attains a level of neutral buoyancy (i.e. $B=1$), at which it begins to collapse. Separation within the plume then occurs, whereby the compositionally denser material sinks back while the heated surrounding fluid keeps rising. The quantitative visualization of temperature, composition, and velocity fields (TLCs-LIF method) coupled with the fluid dynamics scalings based on [1] predicts that the maximum height of the hot thermochemical plume head in the Earth's mantle and the recurrence time of the plume generation. The maximum height increases with Ra and decreases with B . This provides tight constraints on the maximum compositional density contrast that a mantle plume is able to transport to the surface and provides a framework to interpret the increasing evidences of geochemical and seismological observations.

[1] Le Bars and Davaille (2004) *JGR* **109**, B03403, doi:10.1029/2003JB002617. [2] Kumagai et al. (2008) *GRL* **35**, L16301, doi:10.1029/2008GL035079.