On the Zoology of Mantle Upwellings: Fluid Mechanics constraints

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Our image of mantle upwellings is still dominated by plumes issued from a steady point source of buoyancy. In a fluid whose viscosity depends strongly on temperature, this set-up generates steady "cavity plumes" with large heads and thin trailing conduits. So traps could be produced by impingement under the lithosphere of 1000 km heads and long-lived hot spot tracks by impingement of 100 km conduits. This model has been successful in explaining quantitatively a number of hotspots features such as the dynamic swell or the volume ratio between head/flood basalts and stem/island chain for a number of prominent hot spots. On the other hand, a growing body of observations shows that neither intraplate volcanism, nor seismic images, can entirely be explained by what has become the classical "mantle plume" model.

However, in an heterogeneous viscous fluid like the mantle, several kinds of upwellings may develop, from the classical, mushroom-shaped, thermal plume to more complicated thermo-chemical structures. A broad terminology involving "superplumes", "mega-plumes", "plume clusters", "diapirs", "cavity plumes", "domes", "piles", "ridges" or "anchored plumes" has been developed in order to differentiate observations made either in seismic images or in convection experiments from "the" mantle plume model. Fluid Mechanics studies give definite constraints on the necessary conditions for these upwellings existence, characteristics (spacing, recurrence time, temperature anomaly, . . .), ability to reach the lithosphere, and geophysical signatures (superswells, volcanism, geochemistry, seismic anomalies, . . .).

This poster will first review these constraints and then used them to identify: 1) what types of upwellings could develop in the Earth's mantle; 2) what observations, if any, CAN be explained by a mantle upwelling; 3) what observations can NOT be explained by a mantle upwelling.