A geodynamic model of plumes from the margins of Large Low Shear Velocity Provinces

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Using plate tectonic reconstructions in an absolute mantle reference frame, it has been shown that the eruption sites of most Large Igneous Provinces as well as kimberlites during the last few hundred Myr lie - like many present-day hotspots - above the margins of the two Large Low Shear Velocity Provinces (LLSVPs) of the lowermost mantle. This indicates that plumes preferrably get created at these margins, and that LLSVPs locations are rather stable for at least 200 Myr, and further supports the notion that the LLSVPs are chemically distinct from, and heavier than the rest of the mantle.
Here a geodynamic model that can explain this characteristic of the Earth's mantle is presented. Time-dependent density distribution of the Earth's mantle is modelled based on 300 Myrs of subduction history, with a spherical harmonic code and a radial viscosity structure constrained by mineral physics and surface observations. The initial condition also features a heavy chemical layer (3.2 % density anomaly) of 70 km thickness at the base of the mantle. Thermal density anomaly at the CMB is 2 % and thermal diffusivity about 10^-6 m^2/s. The sinking subducted slabs form the chemical layer to two distinct large piles under Africa and the Pacific whose location approximately coincides with the two LLSVPs, as well as a smaller pile under Siberia, which may correspond to a smaller Low Shear Velocity Province. They also push the thermal boundary layer towards the chemical piles. Once this hot material reaches the steep edges of these piles, it is forced upwards and begins to rise - in the lower part of the mantle as sheets, which then split up into individual plumes in the upper mantle. Each pile is thus crowned by 4-5 plumes, sitting like candles on a birthday cake, while a separate plume rises under Siberia. Plume conduits become tilted with their bases moving towards the centers of the piles, while their tops remain over the margins.
Due to high viscosities in the lower mantle up to about 10^23 Pas, plumes in our model are rather massive (diameters > 500 km) and entrain a substantial part of the chemical layer over the time of the model run. Future models with lateral viscosity variations will aim at maintaining the creation of plumes at the margin of piles, while additionally reducing entrainment and thus enabling longer-term stability of chemically distinct piles