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Numerical investigation of the dynamics of the equatorial Large Low Velocity Provinces in the Earth's deep mantle

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Burke & Torsvik (2004) showed that the seismically observed Large Low Velocity Provinces (LLVPs) in the lower mantle under the African continent and the Pacific basin have remained stationary with respect to the hot spot reference frame throughout at least the last 200 million years. The authors reconstructed the location of Large Igneous Provinces (LIPs) at the time of eruption with respect to the hot spot reference frame, removing the effect of relative plate motions, and observed that most of the LIP-forming plumes originated from the edges of the seismically observed LLVPs in the deep mantle.

The low seismic velocities imply anomalously high temperatures in the LLVPs, a fact that can only be reconciled with their long-term gravitational stability if these regions are compositionally denser than the surrounding mantle or, alternatively, contain fractions of partial melt; melt is known to be denser than solid at high pressures due to its higher compressibility. Such a dense partial melt fraction is commonly assumed to be present in the Ultra Low Velocity Zone (ULVZ) around the Core Mantle Boundary (CMB) and this might as well be the case for the LLVPs.

It is most intriguing, from a dynamical point of view, that the LLVPs have remained in an equatorial and antipodal position throughout such long geological times. The question is whether centrifugal forces play a role in stabilizing the LLVPs in their position, given the existence of low viscous, dense material in the ULVZ and possibly in the LLVPs.

In our numerical model, we investigate this effect and the overall influence of the LLVPs anomalies on mantle convection. The asymmetry introduced by such features must strongly influence and modulate the patterns of mantle convection. Such forcing from the base of the mantle might provide an explanation for the yet unexplained long amplitude pattern of plate tectonics, evident e.g. from the distribution of most of the Earth's subduction zones along a N-S great circle.