Geophysical Research Abstracts
Vol. 15, EGU2013-5044, 2013
EGU General Assembly 2013

The initiation, temporal evolution and dynamics of deep mantle heterogeneities

Abigail Bull-Aller, Trond Torsvik, Mathew Domeier, and Pavel Doubrovine
Centre for Earth Evolution and Dynamics, University of Oslo, Norway (a.l.bull@fys.uio.no)

Understanding the first-order dynamical structure and temporal evolution of Earth's mantle is a fundamental goal in solid-earth geophysics. Recent tomographic observations reveal a lower mantle characterised by higher-than-average shear-wave speeds beneath Asia and encircling the Pacific, consistent with cold slabs of descending lithosphere beneath regions of ancient subduction, and lower-than-average shear-wave speeds in broad regional areas beneath Africa and the Central Pacific (LLSVPs). The LLSVPs, although not as easily understood from a dynamical perspective, are inferred to be broad upwelling centres between Mesozoic and Cenozoic subduction zones. Heterogeneous mantle models place these anomalies into the context of thermochemical piles, characterised by an anomalously dense component, with their location and geometry being controlled by the movement of subducting slabs. The origin and temporal evolution of the LLSVPs remain enigmatic. Recent numerical studies propose that the LLSVP beneath Africa formed as a result of return flow in the mantle due to circum-Pacific subduction beneath the Pangean supercontinent. This suggests that prior to the formation of Pangea, the lower mantle was dominated by a degree-1 convection pattern, with a major upwelling centred close to the present-day Pacific LLSVP and subduction concentrated in the antipodal hemisphere. The African LLSVP would thus have developed within the time frame of the Pangean supercontinent (i.e. 300Ma-180Ma), in contrast to a much older Pacific LLSVP. It is further proposed that a cyclic alternation between a degree-1 pattern and a degree-2 pattern of mantle convection may accompany the supercontinent cycle and characterise the temporal convective evolution of Earth's mantle. In contrast, a more long-term persistence for both the African and Pacific LLSVPs, and thus for the planform of mantle convection within the Earth as a whole, is suggested by recent palaeomagnetic studies, which show that over 80% of all kimberlites erupted in the past 542 Myr lay, at the time of their eruption, above the edges of the African and Pacific LLSVPs. Such a finding requires both LLSVPs to be stationary in their present-day positions for at least the past 500 Ma, and thus be insensitive, to first-order, to the formation and subsequent break-up of the Pangean supercontinent. In this work, we investigate the temporal evolution and possible long-term persistence of LLSVPs by integrating plate tectonics into numerical models of mantle dynamics. We improve upon previous studies by employing a new palaeomagnetically-derived global plate motion data set to impose surface velocity boundary conditions for a time period which encompasses the creation and subsequent break-up of the Pangean supercontinent. We aim to understand the role that Earth's plate motion history plays on the development of LLSVPs within Earth's mantle. Specifically, we investigate the effect of plate history on the degree-2 structure of the mantle and explore the possibility that both LLSVPs existed prior to the Pangean supercontinent.