Geophysical Research Abstracts
Vol. 14, EGU2012-7986-2, 2012
EGU General Assembly 2012

The scale and time dependence of surface dynamic topography over the last 200 million years in the Atlantic and Indian ocean domains

R. D. Müller (1), N. Flament (1), and M. Gurnis (2)

(1) Univ. of Sydney, School of Geosciences, Sydney, Australia, (2) [U+0083] [U+0083] [U+0083] Seismological Laboratory, California Institute of Technology, Pasadena, USA

We evaluate the evolution of large-scale surface dynamic topography in the Atlantic and Indian Ocean domains using a mantle convection model constrained by a global tectonic model for the time period from 200 Ma to the present. We use the GPlates software to implement a global plate motion model with tectonic plates being represented as an interlocking set of closed topological polygons which evolve through time in a self-consistent manner. We generate plate velocity meshes as surface boundary conditions in 1 million year intervals to impose plate motions on a mantle convection model in order to study the driving factors of surface dynamic topography computed with CitcomS. We implement a mantle rheology with an upper-lower mantle viscosity contrast of 1:100, consistent with other observations constraining this ratio. We use a slab assimilation method in which the thermal structure of the slab, derived analytically, is progressively assimilated in the upper mantle into the dynamic models, improving the continuity of sinking slabs in the mantle. The models generate a global flow and dynamic topography pattern with hemispheric upwellings focused on the antipodal low-velocity seismic-shear-wave regions above the core–mantle boundary, even though these are not imposed on our model. Combined subduction along the western Pacific and northern Tethys margins drives a pronounced return flow centered on the reconstructed position of India in the Cretaceous, resulting in positive dynamic topography from India and Madagascar to the southeastern African margin. After 50 Ma a strong secondary surface topography high becomes established in the North Atlantic, straddling the margins of Northwest Africa and western Europe. This broadly coincides with the onset of alkali volcanism in central/southern Europe, north Africa, and the eastern central North Atlantic. Previous work on this widely-distributed small-scale volcanism had suggested that it may correspond to a broad mantle upwelling in response to a mantle avalanche. Our models suggest that it is rather the consequence of the time-dependence of subduction and associated mantle return flow on both sides of the Atlantic without the necessity for avalanches. Our model predict large-scale dynamic subsidence for both the Arabian peninsula as well as India during the Cenozoic as they move from a mantle upwelling into the downwelling region associated with the closure of the Meso-Tethys. Our model also predicts enhanced uplift of southern Africa during the last 30 million years, as well as major asymmetries not only in conjugate margin evolution but also along-strike passive margins especially where they straddle boundaries between large-scale upwellings and downwellings through time.