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Why continents uplift?

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Continents move up and down during their history. These large-scale movements are apparently unrelated to contractional or extensional tectonics and they have been classified as epeirogenic, regardless their nature. A few models tried to explain the uplift as related to the upraise of deep hot and light mantle plumes, for example responsible of the African volcanism, whereas the subsidence has been ascribed as to the underlying sinking of a cold dense detached mantle slab. However, new petrological results suggest a rather shallow mantle asthenospheric origin for the African magmatism [1] and the existence of slab detachment is also highly questionable [2]. We focus here our research on the uplift of Europe, Africa and India that underwent diffuse post Mesozoic uplift, larger than the other continental areas. These three areas have in common to be located to the east of oceanic ridges, i.e., the Mid Atlantic Ridge and the Indian Ridge. Although we agree that the generalized vertical movements of continents are associated with isostatic adjustment, in our research we further suggest that i) the isostatic rebound can be controlled also by horizontal mantle flow rather than vertical mantle movements alone and that ii) the origin of the density anomaly might be controlled not only by thermal anomalies, but also by compositional variations.

Following the diachronous post-Jurassic onset of seafloor spreading in the Atlantic and Indian oceans, the European, African and western Indian passive margins and the adjacent continents underwent a generalized uplift. Available evidence and age dating indicate a post- ocean rift age for the uplift of the three continents. When looking at regional paleogeographic reconstructions, it appears that the continents were not uplifted until crustal separation to the west was achieved in the oceanic embayments. We suggest that this long-wavelength Cenozoic uplift of continents could be attributed to the eastward shift of depleted asthenosphere formed at Mid-Atlantic and Indian Ridges beneath the continent because of the “westward” drift of the lithosphere [3,4,5,6]. The partial melting at the oceanic ridge leaves the asthenosphere lighter. When migrating beneath the European, African and Indian continental lithosphere, the substitution of the older, denser mantle with the depleted, lighter asthenosphere should have generated an isostatic rebound and associated uplift of about 300–600 m. Dynamic topography exerted by the mantle flowing eastward could have further enhanced the uplift process.

Therefore we interpret the long-term uplift of the continent as related to the underlying transit of a lighter asthenosphere, previously depleted along the oceanic ridges. In some areas local vertical motions controlled by regional tectonics and by sedimentary loading and erosion were superimposed on plate-scale motions induced by plate tectonic mechanisms (e.g., postrift thermal relaxation of attenuated lithosphere, rift shoulder uplift, eastward shift of depleted asthenosphere, glacio-isostasy). These processes were active on very different timescales. The interference resulted in a complicated pattern of uplifting and subsiding areas, with uplift and subsidence migrating through time. Moreover, if the long-wavelength uplift wave associated with the depletion of the mantle in the oceanic ridges was real, it should have interacted with local tectonic rates (both uplift and subsidence), and acted on a lithosphere with variable thickness and composition. This resulted in regional variable rates of vertical motions, these being the sum of different mechanisms.

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