

Flow of Canary mantle plume material through a subcontinental lithospheric corridor beneath Africa to the Mediterranean: COMMENT

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The Atlas mountain range in Morocco, northwest Africa, represent an intracontinental belt with an elevation up to 4400 m, marked by the unexpected lack of a thick lithospheric root. This has been explained by the major role of thermal uplift in the Anti-, High- and Middle-Atlas, outlined by an outstanding thin linear lithosphere corridor, with the top of the asthenosphere being at a depth of ~60 km compared to ~120 km on both sides (Missenard et al., 2006). Duggen et al. (2009) proposed that the mantle plume postulated at the origin of Canary Island volcanism flowed, and is still flowing, beneath the Moroccan Atlas, triggering Atlas Cenozoic alkaline volcanism, and contributing to uplift and tectonic events such as the A.D. 1960 Agadir earthquake. The main arguments of Duggen et al. are (1) the similarities between their new geochemical data on basic-ultrabasic Middle Atlas lavas and those of primitive lavas from the Canary Islands, and (2) the preexisting thin lithosphere making plume flowage easier toward the northeast. This appealing idea astutely uses the wide flexibility of the plume model, but cannot survive if all available constraints (and not just a part of existing geophysical and geochemical data) are taken into account.

The Duggen et al. model implies the propagation of mantle plume material from 45 to 25 Ma (age of the linear lithospheric delamination) along the Atlas Mountains, and a correlation between the ages of the Atlas volcanic episodes and the distance to the Canary Islands hotspot. Figure 1A shows that lavas with Canary-like geochemical fingerprints had erupted already at the Mesozoic-Cenozoic boundary (i.e., before the 45–25 Ma event), and that there is no age-distance relationship that would support a mantle plume flowing northeastward.

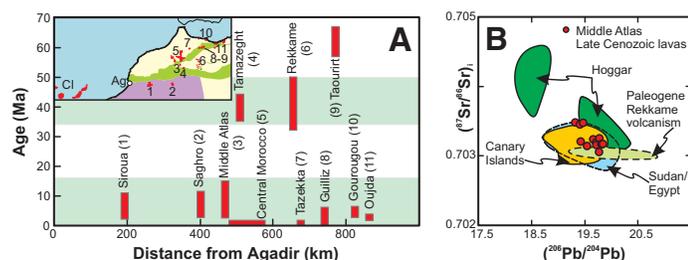


Figure 1. A: Relationship between ages of alkaline volcanic episodes and distance of volcanic centers to Agadir. Shaded areas represent timing of main compressive events in the Mediterranean/Atlas areas (Frizon de Lamotte et al., 2008). Inset shows position of the Cenozoic volcanic fields (orange/black) adjacent to the Moroccan Atlas belts (green/light gray) and the West African Craton (purple/dark gray). Cl—Canary Islands; Ag—Agadir. B: Initial Pb-Sr isotopic ratios for Cenozoic primitive alkaline lavas from Northern Africa (Hoggar—southern Algeria; Sudan-Egypt—northeast Africa; Rekkame—eastern Morocco) compared to those from Canary Islands and Middle Atlas. References available on request from the authors.

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Moreover, if the tectonic-driven Cenozoic uplift began at the Eocene-Oligocene boundary (ca. 34 Ma; Frizon de Lamotte et al., 2008), the main thermal uplift is much younger than the proposed ages for the lateral flow of Canary plume material. Apatite fission track dating and modeling indicate that it began during the Neogene (Balestrieri et al., 2009) and most probably after 5 Ma ago in the Middle Atlas (see references in Frizon de Lamotte et al., 2008). Volcanism, tectonics, and thermal uplifts are linked to reactivation of inherited structures (Precambrian sutures, Mesozoic rifts) in response to tectonic events induced by the Africa-Europe convergence (Liégeois et al., 2005, and references therein; Fig. 1A). No further constraints can justify a supplementary mantle plume flow process.

Duggen et al. claim that volcanic rocks with Canary-like geochemical compositions are restricted to areas above the lithospheric channel in Morocco. This conclusion ignores Cenozoic intraplate volcanic provinces sharing the same trace element fingerprints and isotopic characteristics of the mantle source in the continental African plate (i.e., in Algeria, Libya, Chad, Sudan, and Egypt) (Liégeois et al., 2005; Lustrino and Wilson, 2007; Lucassen et al., 2008; Fig. 1B).

We contend that field and geochemical evidence does not favor mantle plume flow under the Atlas mountain range. Early Paleocene to late Pleistocene alkaline volcanism and post-Miocene Atlas thermal uplift, though partly disconnected in time, resulted from both the interplay between reactivation of inherited geological structures and the thermal erosion of the metasomatized lithosphere (Raffone et al., 2009) during Africa-Europe convergence, not from a mantle plume flow process. The existence of the Canary mantle plume itself is strongly questionable (Lustrino and Wilson, 2007).

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