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

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In their Comment, Berger et al. (2009) question the model of flow of Canary mantle plume material through a subcontinental lithospheric corridor beneath northwest Africa to the Mediterranean proposed by Duggen et al. (2009). They question 1) if a plume exists beneath the Canary Islands, 2) if the geochemical composition of intraplate lavas allows distinction between Canary and other northern African (from Morocco to Egypt/Sudan) sublithospheric mantle sources, and 3) if the timing of volcanism in northwest Africa is consistent with a lateral inflow of mantle plume material.

1) As we presented (Duggen et al., 2009), there is strong evidence supporting the presence of a mantle plume beneath the Canary Islands. No other model has been proposed thus far that can adequately explain the geophysical, geochronological, geochemical, and geological data of the region.

2) Berger et al. argue, on the basis of the Pb-Sr-isotope diagram, that the geochemical composition of mafic intraplate lavas, located outside the northwest African lithospheric corridor (such as Pliocene Oujda, Oligocene to Miocene Algerian Hoggar, and Late Mesozoic to Quaternary Egypt/Sudan volcanism), point to the same sublithospheric mantle source as tapped by mafic lavas above the corridor (Gourougou, Guilliz, Middle Atlas) and thus as those from the Canary Islands (Berger et al., 2009). We note that the Pb-Sr-isotope diagram alone is inappropriate to evaluate the composition of the sublithospheric mantle source(s) of northern African intraplate volcanic fields. As illustrated in the $^{206}Pb/^{204}Pb$ versus $^{207}Pb/^{204}Pb$ isotope diagram (Fig. 1), mafic lavas from the Canary Islands and those from volcanic fields above the lithospheric corridor form a trend that extends from below the Northern Hemisphere Reference Line toward the lithosphere with higher $^{207}Pb/^{204}Pb$ (metasomatized subcontinental lithospheric mantle and/or continental crust). Mafic intraplate lavas (ca. 70 Ma to Recent) found in Oujda, Hoggar, and Egypt/Sudan clearly define separate trends toward higher $^{206}Pb/^{204}Pb$. Therefore, the isotopic data available is consistent with derivation of the volcanism above the lithospheric corridor from a Canary-type sublithospheric mantle source, which cannot be inferred for the lavas outside the corridor. Further high-quality major and trace element, Sr-Nd-Pb-Hf-isotope, and age data (allowing precise age correction) of northern African lavas, however, will be required to address these issues in more detail.

3) Concerning timing, Berger et al. argue that progressive inflow of mantle material into the lithospheric corridor should produce "a correlation between the ages of the Atlas volcanic episodes and the distance to the Canary Islands hotspot." There are several reasons why our model does not require an age progression in Atlas volcanism with increasing distance from the Canary Islands: 1) Delamination of subcontinental lithosphere since ca. 25–45 Ma probably occurred in multiple events, causing discontinuous inflow of Canary-type mantle material; 2) decompression melting of the laterally migrating sublithospheric mantle requires a vertical flow component, thus only when the extent of thinning lithosphere of a particular part of the corridor allowed sufficient upwelling did decompression melting occur; and 3) much of the residual Canary plume mantle was too depleted after earlier melt extraction beneath the Canary hotspot track to produce melts everywhere beneath the corridor.

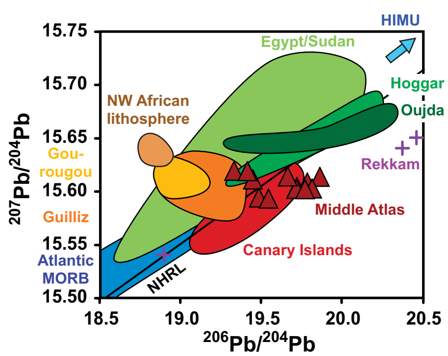

Figure 1. Pb-isotope diagram showing the composition of lavas from volcanic fields above (Gourougou, Guilliz, Middle Atlas, Tamazert) and outside (Oujda, Hoggar, and Egypt/Sudan) the lithospheric corridor in northern Africa. Data sources: Duggen et al., (2009, and references therein); Hoggar lavas (age corrected to 27 Ma using the average Pb, Th, U concentrations of mafic Oujda lavas) (Allegre et al., 1981); Egypt/Sudan lavas <70 Ma (corrected to the respective age) (Lucassen et al., 2008).

Finally, we note that there is no contradiction between a mantle flow model as proposed by Duggen et al. (2009) and substantial involvement of lithospheric processes in magma generation and ascent as suggested by Berger et al. (2009): the temporal and spatial distribution of intraplate volcanism above the northwest African lithospheric corridor most likely results from an interplay between delamination of subcontinental lithospheric mantle material, inflow of Canary-type mantle plume material, and reactivation of inherited geological structures, possibly driven by the African-Europe convergence.

REFERENCES CITED

Allegre, C.-J., Dupre, B., Lambret, B., and Richard, P., 1981, The subcontinental versus suboceanic debate: I. Lead-neodymium-strontium isotopes in primary alkali basalts from a shield area: The Ahaggar volcanic suite: Earth and Planetary Science Letters, v. 52, p. 85–92.

Berger, J., Liégeois, J.-P., Ennih, N., and Bonin, B., 2009, Flow of Canary mantle plume material through a subcontinental lithospheric corridor beneath Africa to the Mediterranean: Comment: Geology, doi: 10.1130/G30516C.1.

Duggen, S., Hoernle, K., Hauff, F., Klügel, A., Bouabdellah, M., and Thirlwall, M.F., 2009, Flow of Canary mantle plume material through a subcontinental lithospheric corridor beneath Africa to the Mediterranean: Geology, v. 37, p. 283–286, doi: 10.1130/G25426A.1.

Lucassen, F., Franz, G., Romer, R.L., Pudlo, D., and Dulski, P., 2008, Nd, Pb, and Sr isotope composition of Late Mesozoic to Quaternary intra-plate magmatism in NE-Africa (Sudan, Egypt): High-l signatures from the mantle lithosphere: Contributions to Mineralogy and Petrology, v. 156, p. 765–784.

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