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Elastic flexure explains the offset of primary volcanic activity upstream of the Réunion and Hawaii plume axis

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Recent tomography reveals that surface volcanism at la Réunion and Hawaii develops offset by 150-180 km upstream to the plume axis with respect to plate motion. We use elasto-visco-plastic 2D numerical models to describe the development of compressional stresses at the base of the lithosphere, resulting from elastic plate bending above the upward load exerted by the plume head. This horizontal compression is ∼20 km thick, has a ∼ 150 km radius and lays around ∼50-70 km depth where temperature varies from ∼600°C to ∼750°C. It is suggested that the buoyant melts percolating in the plume head pond below this zone of compression and eventually spread laterally to the extent where compression vanishes. There, melts resume their ascension and propagate through dikes up to ∼35 km depth where the field stress rotates again due to plate curvature change. Flexural compression is a transient phenomenon that depends: (i) on the relaxation time of elasto-plastic stresses between ∼600° and ∼750°C, (ii) on the thermal erosion of the lithosphere induced by the plume, and (iii) on the ratio of the normal versus tangential stress exerted by the plume on the lithosphere. We find that for a plate 70 My old, this horizontal compression lasts for about 5 Myrs. This time span exceeds the time during which both the Indian and Pacific plates drift over the Reunion and Hawaii plumes, respectively. Accordingly, our model explains i) the ∼150 km shift between the surface volcanism and the axis of the plume, ii) the ∼5 Myrs synchronous activity of the volcanoes of la Réunion and Mauritius, and (iii) the present pounding of melts at 35 km depth detected below the Reunion and Mauritius Islands. Plume-lithosphere interaction is one of the numerous subjects that Genia Burov studied and modeled; the present study uses a similar code to the one he used, and is inspired by several of his assumptions. In support of his own goals and worries, we show here the importance of thermo-visco-elastic properties on first order characteristics of lithospheric deformation, and more specifically here on the localisation of magmatism in the two most active volcanic islands on Earth. Future studies still need to improve our understanding of these rheological aspects in combination with sharp geological and geophysical observations.