Geophysical Research Abstracts
Vol. 19, EGU2017-5666, 2017
EGU General Assembly 2017

Elastic plate flexure above mantle plumes explains the upstream offset of volcanic activity at la Réunion and Hawaii

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Surface volcanism at la Réunion and Hawaii occurs with an offset of 150-180 km upstream to the plume axis with respect to the plate motion. This striking observation raises questions about the forcing of plume-lithosphere thermo-mechanical interactions on melt trajectories beneath these islands. Based on visco-elasto-plastic numerical models handled at kilometric resolution, we propose to explain this offset by the development of compressional stresses at the base of the lithosphere, that result from elastic plate bending above the upward load exerted by the plume head. This horizontal compression adopts a disc shape centered around the plume axis, 20 km thick and 150 km in radius, at ∼50-70 km depth where the temperature varies from ∼600°C to ∼750°C. It lasts for 5 to 10 My in an oceanic plate of age greater than 70 My, a timing that is controlled by the visco-elastic relaxation time at ∼50-70 km depth. This period of time exceeds the time during which both the Somalian/East-African and Pacific plates drift over the Reunion and Hawaii plumes, respectively, thus rendering this basal compression a persistent feature. It is inferred that the buoyant melts percolating in the plume head pond below this zone of compression and eventually spread laterally until the most compressive principal elastic stresses reverse to the vertical, i.e. ∼150 km away from the plume head. There, melts propagate through dikes upwards to ∼35 km depth, where the plate curvature reverses and ambient compression diminishes. This 30-35 km depth may thus host magmatic reservoirs where melts pond, until further differentiation can relaunch ascension up to the surface and form a volcanic edifice. In a second stage, as the volcano grows because of melt accumulation at the top of the plate, the lithosphere is flexed downwards, inducing extra tensile stress at 30-35 km depth and compression at ∼15 km depth. It implies that now the melts pond at ∼15 km and form another magmatic reservoir lying just underneath the crust. These two processes explain the ponding of primary (shield) melts at ∼35 km and ∼15 km depths as partialy recorded below La Reunion, Mauritius or Hawaii volcanoes with seismic tomography.