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Heterogeneous structure of a sheared mantle plume

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The relation between spatio-temporal geochemical variability of Hawaiian lavas and the geochemical structure of the underlying mantle plume is still a matter of debate. We investigate this important aspect using a three-dimensional numerical model for the dynamics of a vigorous plume sheared by a fast moving oceanic lithosphere. The calculated plume flow differs considerably from the commonly assumed axisymmetric concentric flow, therefore it is no more straightforward to individuate which part of the plume is sampled by each volcano. As a working hypothesis we consider two age progressive volcanic alignments, that have a central and a peripheral position with respect to the plume axis. Beneath each volcano the supposed 'magma capture zone' is filled with passive tracers which are backward advected, using the time dependent, fully three dimensional velocity field of the dynamic model. This allows us to reconstruct the flow trajectories of the plume material beneath each volcano and to estimate its melting history.

We then investigate the dynamics of geochemical heterogeneities rising in the plume conduit and explore a number of possible heterogeneous plume structure, ranging form large-scale (e.g., radial vs. bilateral symmetry) to small-scale size heterogeneities that, under certain conditions, may lead to a time dependent geochemical cross section of the very central part. Two main questions are addressed: How are heterogeneities transported and deformed by the flow in the plume tail? How is the plume heterogeneous structure sampled by different volcanoes, as the oceanic plate moves over the plume?

Our work builds towards a fluid dynamically consistent framework to interpret geographic and temporal isotopic variations in volcanoes fed by a sheared mantle plume.