Interaction of the Hawaii'an plume with small-scale sublithospheric convection

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Plume models have been successful to predict most of the first-order observations at oceanic hotspots. However, the details of plume-plate interaction and the origin of secondary volcanism still remain to be understood. Small-scale convection (SSC) within a plume ponding beneath the lithosphere is a possible candidate for lithospheric thinning [*Moore et al.*, 1998], which may account for the compensation of hotspots swells together with dynamic uplift of the ascending plume [*Ribe*, 2004]. SSC may also trigger secondary decompression melting in its upwelling limbs. But most of the plume models yet presume relatively large mantle viscosities, and thus preclude the possibility of associated SSC.

SSC develops from small perturbations of an unstable thermal boundary layer (TBL). Therefore, it is advanced by a more unstable TBL (i. e., a thicker TBL beneath an older lithosphere, or a lower viscosity) or stronger lateral perturbations. Upwelling plumes both strongly perturb the density stratification and reduce the viscosity in the asthenosphere. Therefore, plumes most likely trigger SSC at their edges – where the perturbations are greatest. In the partially molten centre of the plume, buoyant decompression melting instabilities [*Tackley and Stevenson*, 1993] potentially trigger convection. However, SSC may be also already developed before the arrival of a plume beneath relatively old seafloor with implications for the thickness of the lithosphere at its arrival and the geometry of plume-plate interaction.

In this study, we take the step towards fully thermo-chemical 3D-numerical models of plumes associated with SSC (using the FEM-Code CITCOM) with a realistic, temperature- and depth-dependent rheology. We investigate a setting, in which SSC is already developed before the advent of the plume, such as expected for the Hawaii'an plume that hits a ~90 Ma old seafloor. We explore models with different plume excess temperatures and buoyancy fluxes within the observational uncertainties for Hawaii. Our models show that plumes with large buoyancy fluxes hitting a lithosphere already eroded by SSC are required to support the Hawaii'an swell, and that interaction of plumes with SSC may provide an alternative explanation for melt volume flux variations at Hawaii with typical timescales of ~15 Ma [*van Ark and Lin 2004*].

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