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Investigation of Thermal and Chemical Structures at the Core-Mantle Boundary in a Mantle Convection Model with a Complex Rheology

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Beneath Africa and the Pacific large low shear velocity provinces (LLSVPs) with small-scale ultra-low velocity zones (ULVZs) at their edges have been detected seismically at the core-mantle boundary (CMB). In thermo-chemical mantle convection dense material at the bottom boundary layer is viscously trapped by the flow and piled beneath plumes. Both thermal plumes and thermochemical piles have been considered to explain the elevated structures at the CMB, but also deep subducting slabs can affect the CMB topography.

We use a numerical thermochemical model of mantle convection with a complex rheology to study the structure and dynamics of the lower mantle. Plate-like motion is obtained by a strong temperature-dependent viscosity in combination with a stress- and pressure-dependence of the viscosity. In this way we can investigate thermal plumes, thermochemical piles and deep subduction. Besides the piles and the deep subducted slabs we find a variety of plume classes leaving a complex structure in the CMB topography. Single plumes cause a peak-like elevation in topography, whereas plume clusters give a broader elevation with several spikes. Additionally, we find line-plumes interconnecting strong plumes.

We discuss the resulting topographic structure and compare our results to the observed LLSVPS and ULVZ on Earth.