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Toward unraveling a secret of the lower mantle: Detecting and characterizing piles using a grain size-dependent, composite rheology

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Seismic studies show two antipodal regions of low shear velocity at the core-mantle boundary (CMB), one beneath the Pacific and one beneath Africa. These regions, called Large Low Shear Velocity Provinces (LLSVPs), are thought to be thermally and chemically distinct and thus have a different density and viscosity. Whereas there is some general consensus about the density of the LLSVPs, their viscosity is still debated.

So far, in numerical studies the viscosity is treated as either depth- and/or temperature- dependent but the potential grain size-dependence of the viscosity is neglected most of the time. In this study we use a self-consistent convection model which includes a grain size- dependent rheology based on the approach by Rozel et al. (2011). Further, we consider a basal primordial layer and a time-dependent basalt production to dynamically form the present-day chemical heterogeneities, similar to earlier studies, e.g by Nakagawa & Tackley (2014).

Our study comprises three main parts:
1) We perform a parameter study which includes different densities and viscosities of the imposed primordial layer.
2) We detect possible piles and compute their average effective viscosity, density, rheology and grain size.
3) We test the influence of grain size evolution on the development and morphology of piles and compare it to non-grain size models.

Our preliminary results show that a higher density and/or viscosity of the piles is needed to keep them at the core-mantle boundary (CMB). Relatively to the ambient mantle grain size is high in the piles but due to the temperature at the CMB the viscosity is not remarkably different than the one of ordinary plumes. We observe that grain size is lower if the density of the imposed primordial material is lower than basalt. In that case the average temperature of the pile is also reduced. Interestingly, changing the reference viscosity is responsible for a change in the average viscosity of the pile but not for a different average grain size.