Geophysical Research Abstracts
Vol. 12, EGU2010-8079, 2010
EGU General Assembly 2010

Multi-scale convection in the heterogeneous mantle under the Pacific

Sophie ANDROVANDI (1), Anne DAVAILLE (2), and Eleonore STUZMANN (1)

(1) IPGP, Paris, France , (2) FAST (CNRS / UPMC / Univ. P-Sud), FAST, ORSAY, France (davaille@fast.u-psud.fr)

We studied the characteristics of thermal instabilities developping when a layer of sugar syrup, a fluid with a strongly temperature-dependent viscosity and high Prandtl number (>7000), is heated from below and cooled from above. The fluid layer was initially either homogeneous in temperature and density, or stratified in density (by the addition of salt at the bottom). A new visualization technique allowed to determine both the temperature, salt concentration and velocity fields inside the experimental tank. We focuss on high Rayleigh numbers (1.7e6 to 3.3e7), intermediate viscosity ratios (7 to 4100), and buoyancy ratio between 0 and 1.3. For this parameter range, “sluggish lid” convection occurs, in which three different scales of convection develop. Owing to the viscosity increase with decreasing temperature, the tank thermal structure becomes asymmetric: hot thermal boundary layer (TBL) instabilities, typical of high Rayleigh number convection, develop under the coldest, therefore most viscous, part of the upper thermal boundary layer which cannot move as fast as the less viscous fluid. The largest convective scale is therefore cellular, with cold downwelling sheets of viscous fluid encasing hotter parts of the tank. Within each of those cells develop several (typically 3 to 7) hot 3D upwelling plumes. The introduction of a denser layer at the bottom of the tank can vary the morphology, timing and spacing of the hot instabilities (from plumes to domes) but has no influence on the existence of the large-scale cold circulation.

Hence high Rayleigh thermal convection in the sluggish lid regim can produce large-scale cells delimited by cold subducting slabs, within which several 3D hot instabilities develop. On Earth, two of such cells exist, the Pacific and the Indo-Atlantic boxes. Our experiments further suggest that what has been named the two “hot superplumes”, i.e. the two seismically slow regions encased within the subduction rings, are in fact each constitued of several hot instabilities. By comparing seismic tomography images of the mantle to our experimental results, we put quantitative constraints on the heterogeneity distribution and time evolution of the mantle under the Pacific for the last 160 Myr.