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Subducted slabs and gravity anomalies: insights on viscosity stratification and mechanisms of energy dissipation in the mantle

Y. Krien, L. Fleitout

Laboratoire de geologie, ENS Paris, France (krien@geologie.ens.fr)

A finite element code is used to investigate the ability of relatively short-wavelength (100-1000 km) gravity anomalies data over subduction zones to put constraints on viscosity stratification and localization of energy dissipation in the mantle. We have developed 2D stationary viscous flow models of a subduction zone, incorporating a low viscosity wedge. Decoupling between the subducting and overriding plates is achieved by imposing a small weak zone, and by decreasing the flexural region viscosity. Density anomalies at 670km are introduced to simulate the phase transition ability to inhibit the flow between the upper and lower mantle. Topography, gravity, and geoid profiles are compared with the observations over several subduction zones. We show that these observables are only well reproduced by models in which the flexural region is weak, i.e. in which the deep mantle dissipates most of the energy. Models with strong bending region give much too large trenches and outer rises. Our results also point toward the significant effect of a layering at 660km, which seems to be able to eliminate the broad geoid maximum obtained in models of subduction zones at the 2000km length scale. The major drawback of our preferred models (with a weak bending region) is that the plate velocities asymmetry, a fundamental feature of plate tectonic, vanishes. Additional mechanisms such as lateral viscosity variations are needed to restore this asymmetry.