Geophysical Research Abstracts
Vol. 20, EGU2018-7932, 2018
EGU General Assembly 2018

Boundary-element modeling of free subduction beneath an overriding plate: role of the subduction interface and partitioning of viscous dissipation

Gianluca Gerardi (1), Neil M. Ribe (1), and Paul J. Tackley (2)
(1) Univ Paris-Sud/Paris Saclay, CNRS, FAST, Orsay, France , (2) Institute of Geophysics, ETH, Zurich

Understanding the free subduction of a dense lithospheric plate (SP) beneath an overriding plate (OP) is a major challenge in current geodynamics. We use a two-dimensional boundary-element method (BEM) to study dynamically self-consistent free subduction of purely viscous plates immersed in an infinitely deep ambient fluid. We focus on two questions:

(1) What is the role of the subduction interface (SI) in controlling the convergence rate V_{Conv}? We find that V_{Conv} is strongly controlled by the width d_2 of the SI, the flexural stiffness St of the SP, and the slab's shape. We define the dimensionless strength of the SI as $\gamma = (\eta_{\mathrm{SI}}/\eta_0)\, h_{\mathrm{SP}}/d_2$, where η_{SI} is the viscosity of the SI, η_0 is the viscosity of the ambient mantle, and h_{SP} is the thickness of the SP. We estimate $\gamma \in [2, 6]$ for the central Aleutian subduction zone by comparing the observed V_{Conv} with the predictions of our BEM model using an appropriate slab geometry.

(2) How is the rate of viscous dissipation partitioned among the SP, the OP, the SI, and the ambient mantle? This question is motivated by the hypothesis of Conrad & Hager (*J. Geophys. Res.* **104**, 17,551-17,571, 1999) that viscous dissipation in the convecting mantle may be dominated by the contribution from the bending of strong plates. We define a dissipation ratio $R \equiv (D_{\mathrm{SP}} + D_{\mathrm{OP}} + D_{\mathrm{SI}})\,/D_{\mathrm{Total}}$, where D_i is the rate of viscous dissipation in the region denoted by i and D_{Total} is the total dissipation rate for the whole system (= rate of release of gravitational potential energy). A value $R = 0.5$ corresponds to equipartition of the dissipation rate between the plates (including the SI) and the ambient mantle. Beginning with instantaneous BEM solutions for a known geometry, we find that R is an increasing function of St but a decreasing function of the dip of the sinking slab. For low values of St, the SI accounts for a substantial fraction of the dissipation rate ($D_{\mathrm{SI}}/D_{\mathrm{SP}} \approx$ 0.5-2). Turning to unsteady subduction, we calculate R as a function of time until the leading end of the slab reaches 660 km depth. For reasonable viscosity ratios $\eta_{\mathrm{SP}}/\eta_0 \in [250, 2500]$ $R(t)$ generally increases with time but remains confined in the range 0.3-0.5. We conclude that the dissipation rate associated with plate bending is neither negligible ($R \ll 1$) nor dominant ($1 - R \ll 1$) with respect to ambient mantle dissipation. Ongoing work involves exploring the consequences of this result for the Nusselt number/Rayleigh number relationship for a convecting system with plates of moderate strength.