Influence of Continental Roots and Asthenosphere on Plate-Mantle Coupling

Clinton P. Conrad, *University of Hawaii at Manoa*
Carolina Lithgow-Bertelloni, *University College London*

The shear tractions that mantle flow exerts on the base of Earth's lithosphere contribute to plate-driving forces and lithospheric stresses. We investigate the sensitivity of these tractions to sub-lithospheric viscosity variations by comparing shear tractions computed from a mantle flow model featuring laterally-varying lithosphere and asthenosphere viscosity with those from a model with layered viscosity. Lateral viscosity variations generally do not change the direction of shear tractions, but deeply penetrating continental roots increase traction magnitudes by a factor of 2-5 compared to 100 km thick lithosphere. A low-viscosity asthenosphere decreases traction magnitudes by a smaller amount, and is important only if >100 km thick. Increased plate-mantle coupling beneath thick continental lithosphere may increase plate-driving forces, surface deformation, and mantle-derived lithospheric stresses in these regions. By contrast, a low-viscosity asthenosphere does not decouple the lithosphere from mantle flow, highlighting the geological importance of mantle tractions on the lithosphere.

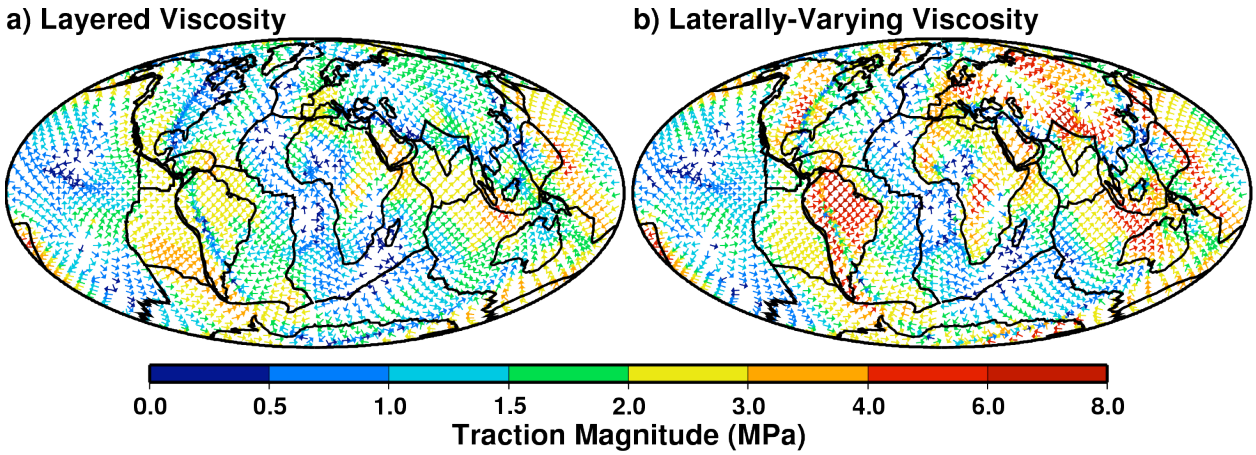

Figure 1. Shear tractions that mantle flow exerts on the base of the lithosphere, as computed using the CIG-supported spherical finite element code CitcomS. Shown are basal shear tractions for (a) a layered viscosity structure and (b) a viscosity structure that includes lateral variations in viscosity associated with lithospheric thickness variations (e.g., deeply-penetrating cratonic roots and thin lithosphere near oceanic ridges). Arrow directions and colors show shear traction azimuths and magnitudes, respectively. We found [Conrad & Lithgow-Bertelloni, 2006] that the magnitude of basal tractions is magnified beneath thick cratons by a factor of up to ~4, but the directions of these tractions are unaffected by the presence of cratons. The magnitude of these tractions, and their amplification beneath cratons, is important because the tractions are a primary driver of plate motions and can cause significant plate deformation at the surface.

Reference

Conrad, C.P., and C. Lithgow-Bertelloni, Influence of continental roots and asthenosphere on plate-mantle coupling, *Geophysical Research Letters, 33,* L05312, doi:10.1029/2005GL025621, 2007.