Geophysical Research Abstracts
Vol. 21, EGU2019-7236, 2019
EGU General Assembly 2019

Poiseuille and Couette flow regimes within the sub-Pacific asthenosphere: implications for the Pacific plate driving and resisting forces since mid Miocene

Ingo Leonardo Stotz (1), Giampiero Iaffaldano (1), and D. Rhodri Davies (2)

(1) Københavns Universitet, Institut for Geovidenskab og Naturforvaltning, København K, Denmark (ilsc@ign.ku.dk), (2) Australian National University, Research School of Earth Sciences, Canberra, Australia

The Pacific plate is thought to be driven mainly by slab pull, associated with subduction along the Aleutians-Japan, Marianas-Izu-Bonin and Tonga-Kermadec trenches. This implies that viscous flow within the sub-Pacific asthenosphere is mainly generated by overlying plate motion (i.e. Couette flow), and that the associated shear-stresses at the lithosphere's base are resisting such motion. Recent studies on glacial isostatic adjustment and lithosphere dynamics provide tighter constraints on the viscosity and thickness of Earth's asthenosphere and, therefore, on the amount of shear-stress that the asthenosphere transmits to the lithosphere. In light of these constraints, the notion that subduction is the main driver of present-day Pacific plate motion becomes somewhat unviable, as the pulling force that would be required by slabs exceeds the maximum available from their negative buoyancy.

Here we use our coupled global models of mantle and lithosphere dynamics to show that the sub-Pacific asthenosphere features a significant component of pressure-driven (i.e. Poiseuille) flow, and that this has driven at least 50% of the Pacific plate motion since, at least, 15 Ma. Our models build on the available codes TERRA and SHELLS. Terra is a global, spherical finite-element code for mantle convection. SHELLS is a thin-sheet, finite-element code for lithosphere dynamics. By merging these two independent models we are able to simulate the rheological behavior of the brittle lithosphere and viscous mantle. We compare the plate velocities output by our models with the available Pacific plate kinematic reconstructions to validate our results.

The results indicate that mantle convection plays an active role in driving Pacific plate motion through pressure driven upper mantle flow (i.e. Poiseuille flow), and that the force balance of a tectonic plate can be modeled quantitatively in global geodynamic models of mantle and lithosphere dynamics.