Geophysical Research Abstracts
Vol. 14, EGU2012-12151, 2012
EGU General Assembly 2012

Mechanisms for lithospheric shear localization and the generation of plate tectonics by two-phase grain-damage and pinning

D. Bercovici (1) and Y. Ricard (2)

(1) Yale University, Geology & Geophysics, New Haven, CT, United States (david.bercovici@yale.edu), (2) Laboratoire des Sciences de la Terre, CNRS, ENS, Université de Lyon, Lyon, France (yanick.ricard@ens-lyon.fr)

Shear localization in the lithosphere is an essential ingredient for understanding how and whether plate tectonics is generated from mantle convection on terrestrial planets. We present a new theoretical model for the mechanism of lithospheric shear-localization and hence plate generation through damage, grain evolution and Zener pinning in two-phase (polycrystalline) lithospheric rocks. Grain size evolves through the competition of coarsening, which drives grain-growth, with damage, which drives grain reduction. However, in a two-phase medium the interface between phases induces Zener pinning, which impedes grain growth and facilitates damage. The size of the pinning surfaces is given by the roughness of the interface, and damage to the interface causes smaller pinning surfaces, which in turn drive down the grain-size, forcing the rheology into the grain-size-dependent diffusion creep regime. This process allows damage and rheological weakening to co-exist, which is normally considered impossible in single phase assemblages. Pinning also greatly inhibits grain-growth and shear-zone healing, which is much faster in single phase materials. Hence, the resulting shear-localization is rapid (less than 1Myr), but the healing time for a dormant weak zone is very slow (greater than 100Myrs). These effects therefore permit rapidly forming and long-lived plate boundaries, in both simple shear cases as well as two-dimensional source-sink flows that generate plate-like toroidal motion. The model therefore provides a key ingredient and predictive theory for the generation of plate tectonics on Earth and other planets.