Geophysical Research Abstracts
Vol. 16, EGU2014-9568-1, 2014
EGU General Assembly 2014

The mechanical properties of the lithosphere-asthenosphere system for time-scales of a few years revealed by the postseismic motions after the megaearthquakes

Luce Fleitout, Olga Trubienko, Emilie Klein, Christophe Vigny, and Jean-Didier Garaud
ENS, Geologie, Paris, France (fleitout@geologie.ens.fr)

The megaearthquakes of Aceh, Maule or Tohoku are associated with conspicuous far-field post-seismic horizontal motions and subsidence. We use 2D and 3D finite element models to understand these postseismic deformations which can only be explained by relaxation in the asthenosphere. The far-field GPS data provide then an ideal dataset to study the mechanical response of the lithosphere-asthenosphere system to small stress perturbations over relatively short time scales (0.1 to 100 years).

The horizontal postseismic displacements, normalized by the coseismic displacements are similar for the three earthquakes: their amplitudes differ by at most 20% (see Trubienko et al. 2013). This suggests a linear creep law with viscosities unexpectedly similar below Sundaland, Japan-sea and South America. Using 3D finite element models with spherical geometry, with meshes modeling broad areas around each of the three giant earthquakes, we determine the geometrical and rheological characteristics of the lithosphere and asthenosphere which provide the best fit to the data. The 'elastic' lithospheres are found to be 60 to 80km thick and the low viscosity asthenosphere about 200 km thick with a certain trade-off between the thicknesses of the lithosphere and of the asthenosphere. For a time scale of a few years, the apparent viscosity in the asthenosphere is of the order of $2.10^{18} Pas$. A rapid deformation phase during the first months after the earthquake can be represented by a short-term viscosity (some $3.10^{17} Pas$) with an associated relaxed modulus of the order of the elastic modulus. The viscosity of the order of $2.10^{18} Pas$ which governs the deformation on a time-scale of a few years is most certainly itself a transient burger viscosity with a relaxed burger modulus quite low (one third of the elastic modulus or less) as seems suggested by the data in Aceh area: The long term viscosity in the asthenosphere is indeed expected to be rather of a few $10^{19} Pas$ according to 'small-scale convection' models with temperature dependent viscosity.

The existence of multiple-scale burger-type viscosities with relatively low Burger moduli is expected for heterogeneous viscoelastic media with heterogeneities over various spatial scales as can be infered from simple self-consistant homogenization models. On the other hand, the similarity of the deformations across South America, Sunda land and Eastern Asia is puzzling.

Ref: Trubienko et al. Solid Earth Discuss, 6, 1-40, 2014 doi: 10.5194