Geophysical Research Abstracts, Vol. 7, 00099, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00099

Initiation of ductile shear-localization in visco-elasto-plastic rocks.

B. Kaus (1), Y. Podladchikov (2)

(1) University of Southern California Los Angeles, USA, (2) PGP, University of Oslo, Norway

Shear-localization is a process of primary importance for the onset of subduction and the evolution of plate-tectonics on Earth. Previous numerical modelling (e.g. Regenauer-Lieb et. al., 2001), which employed a rheology consisting of diffusion creep, dislocation creep and Peierls low-temperature plasticity, demonstrated that shear-heating combined with elasticity and plasticity can produce lithospheric-scale shearzones which may lead to subduction-initiation. The mechanics of their model is however relatively poorly understood, partly because of the large number of parameters in the employed rheology.

The goal of the current study is to come up with a simpler ('effective') rheological model that still catches the main physics of the model of Regenauer-Lieb et.al. (2001). This simpler model than allows the identification of key parameters governing shear-localization. We employ a linear Maxwell viscoelastic rheology with von Mises plasticity and an exponential dependence of viscosity on temperature.

Dimensional analysis reveals that four non-dimensional parameters control the initiation of shear-zones. The onset of shear-localization is systematically studied with 0-D, 1-D and 2-D numerical models, both under constant stress and under constant velocity boundary conditions. Mechanical phase-diagrams demonstrate that six deformation modes exist under constant velocity boundary conditions. A constant stress boundary condition, on the other hand, exhibits only two deformation modes (localization versus no-localization). Scaling laws for the growth rate of temperature are computed for all deformation modes. Numerical and analytical solutions demonstrate that diffusion of heat may inhibit localization. Initial heterogeneities are required to initiate localization.

The derived scaling laws are applied to Earth-like parameters. For a given

heterogeneity-size, stable (non-seismic) localization only occurs for a range of effective viscosities. Localization is inhibited, under constant velocity boundary conditions, if viscosity is smaller then a minimum threshold, which is a function of the heterogeneity size. Two-dimensional models are presented for a lithosphere subjected to homogeneous extension with an initially circular inclusion. The models demonstrate that both plasticity and elasticity are required to form lithospheric-scale shear-zones. Late-stage simulations of lithospheric-scale shear-localization are presented that confirm the findings of the initial stage analysis.

The simplified rheological model is compared with a more realistic, and more complex model of olivine that takes diffusion-, powerlaw and Peierls creep into account. Good agreement exists between the models. The simplified model proposed in this study thus reproduces the main physics of ductile faulting, and is an interesting candidate to incorporate into next-generation global convection models.

References

Regenauer-Lieb, Yuen, Branlund, (2001) Science, 294:578-580.