Geophysical Research Abstracts, Vol. 7, 00284, 2005
SRef-ID: 1607-7962/gra/EGU05-A-00284

Rheology of the lithosphere

B. I. Birger

The Earth's Physics Institute, Russian Academy of Sciences, Moscow, Russia
(birgerbor@mail.ru)

A power-law fluid is usually assumed to model slow flows in the mantle. This model adequately describes a steady-state dislocation creep which is observed in laboratory studies carried out at constant stresses. However, the power-law model has no memory, in contrast to a real material, and the use of this model in the case of time-dependent process is doubtful. Furthermore, the model does not take into account a transient creep observed in laboratory studies at small strains (not greater than several per cent). The non-linear integral (having a memory) rheological model has been proposed by the author earlier to describe dislocation creep of the mantle rocks. The model equation can be simplified for specific types of flows. The most important characteristic of flow is the memory depth (ratio of the transition strain fixed in the model to the strain rate of flow): the strains which existed before the instant determined by the memory depth do not influence the stress at the instant of observation. The model reduces to the power-law model for stationary flows and for flows which have the typical period of velocity change much exceeding the memory depth (such flows are called quasi-stationary). For small-strain flows, the model reduces to the linear integral model, which describes transient dislocation creep and leads to the Andrade law in the case of constant stress. It is shown that the flow associated with time-dependent convection in the mantle under the lithosphere is quasi-stationary. Rheology is determined by the mechanism which gives minimal effective viscosity. The pseudo-plasticity, caused by the frictional response of rocks with pre-existing fractures, and the elasticity dominate the crust. The steady-state dislocation creep dominates the upper mantle where strains and strain rates are large (the lower mantle is rather dominated by the diffusion creep). Since the lithosphere is a boundary layer formed by mantle convection, strains are small here (localized regions are occasionally able to undergo significant deformations but these regions can be considered as boundaries between large undeformed lithospheric blocks) and the transient creep dominates the lithosphere. The

vertical gradient of temperature in the lithosphere is sufficiently high and the transient creep effective viscosity is sufficiently small to cause convective instability. Since the transient creep effective viscosity is frequency-dependent and goes to infinity when frequency goes to zero, the convective instability is oscillatory. Small-amplitude thermoconvective waves and oscillations in the lithosphere are considered by the author as a mechanism for sedimentary basins formation on the continental cratons.