Geophysical Research Abstracts, Vol. 7, 04587, 2005
SRef-ID: 1607-7962/gra/EGU05-A-04587


# Strength estimates of the lower crust-the view from the laboratory

G. Dresen and E. Rybacki
GFZ-Potsdam, Potsdam, Germany

Quantitative viscosity estimates of lower crust and upper mantle are based on modeling postseismic surface deformation and extrapolation of laboratory measurements to natural conditions. Extrapolation of experimental data is largely in space and time and involves assumptions concerning material composition and prevailing thermodynamic conditions. Dominant mineral phases in lower crust and upper mantle are feldspar, pyroxene and olivine. Robust constitutive equations now exist for feldspar and olivine rocks and significant progress has been made with pyroxene rocks in recent years.

To specify quantitatively the effect of pressure and water weakening on the flow strength of feldspar we performed triaxial creep experiments in a gas deformation apparatus at temperatures of 1000-1150 ˚C, confining pressures of 100-450 MPa, and axial stresses of 10-400 MPa, resulting in strain rates of $\approx 6\cdot 10^{-7} - 3\cdot 10^{-3}$ $s^{-1}$. Dense samples with a grain size of about 3 $\mu$m were prepared by hot-isostatic pressing of anorthite glass powder. Hydrous samples contain about 0.33 $\pm$ 0.14 wt% $H_2O$ and dry specimens 0.0005-0.02 wt% $H_2O$, mainly as molecular water located at grain boundaries. The estimated residual glass content of wet samples is $<$ 2 vol%. Samples deformed in grain boundary diffusion-controlled creep but dislocation creep dominated at stresses $>$ 150 MPa. We estimate an activation volume of V = 24 $\pm$ 21 $cm^3mol^{-1}$ for anhydrous samples deforming in diffusion creep. Wet samples were deformed in hydrous conditions with varying buffers fixing oxygen fugacity. Creep rate of hydrous anorthite aggregates depends on water fugacity raised to a power of r = 0.7 $\pm$ 0.4, suggesting hydrolysis of oxygen bonds. Considering the effect of activation volume and water fugacity on extrapolation of constitutive laws to conditions prevailing in the continental lower crust, viscosities of hydrous feldspar aggregates increase by a factor of $<$ 2.

In extrapolating the data to conditions of the continental crust we use a strain rate of $10^{-12}$ $s^{-1}$ and 20 $\mu$m grain size for diffusion-controlled creep, which are typical values for localized deformation in high-temperature shear zones. For rocks deforming in dislocation creep, data is extrapolated to strain rates of $10^{-14}$ $s^{-1}$. At hydrous conditions feldspar rocks are predicted to be significantly weaker than pyroxenites and olivine rocks in agreement with field observations. Low viscosity estimates of $10^{18}$-$10^{19}$ Pa·s from modeling postseismic stress relaxation of the continental lower crust can only be reconciled with laboratory experiments assuming dislocation creep at high temperatures $>$ 900 ˚C or, at lower temperatures, diffusion creep of fine-grained rocks possibly localized in abundant high strain shear zones.