Geophysical Research Abstracts, Vol. 9, 06098, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-06098

Behaviour of two-phase shear zones in high strain deformation experiments

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Flow laws used to model lithosphere dynamics are primarily based on data from low strain axial compression experiments on samples containing a single mineral phase, whereas deformation in the lithosphere is often localised in high strain shear zones and involve rocks that are in general polyphase. Deformation processes in these high strain shear zones lead to changes in the microstructure of the rock, resulting in foliated mylonitic microstructures. At present, quantitative understanding of the effect on rheology of developing microstructures in multiphase shear zones is still sparse. It is the aim of this study to help filling this gap, by performing high strain, direct shear, deformation experiments on salt-mica mixtures. The used experimental set-up is designed to generate a maximum shear strain of γ = 5. Salt (initial grainsize 60 μm) and mica (muscovite, grain size 13 μm) powders have been mixed and cold-pressed into tablets to prepare the samples. The samples were heated at 500ºC in Argon to dry before deformation. A series of mixtures, with mica content systematically varying from 0 to 50 %, has been tested at 200ºC, 100 MPa confining pressure, and a strain rate $5{\cdot}10^{-4}s^{-1}$. Under these conditions deformation in pure salt is dominated by climb-controlled dislocation creep, and in mica by frictional behaviour.

Resulting stress-strain curves show two stages in the deformation behaviour after yield. A period of strain hardening at relatively low strain, between γ = 0.5 and γ = 1.5, is followed by a period of deformation at near constant stress at higher strain. The amount of strain hardening in the first period, as well as the flow stress in the second period increases with increasing mica content. After deformation the samples were cut parallel to the shear direction, and analysed with SEM, BSE and EBSD. The BSE images were used to analyse the salt-mica distribution in the samples. The mica grains were found clustered in elongated patches of 10 to $>$100 μm long and max. 20 μm thickness, oriented at a small angle to the shear direction. This configuration is

very similar to microstructures of natural quartz-mica shear zones. The behaviour at low strain is thought to be related to the initial rearrangement, from the random starting distribution, of the mica grains in the sample, whereas at higher strain a steady state microstructure is formed. The EBSD maps are used to analyse the grain size and shape, and CPO of the salt crystals. The salt grains are elongated, contain many subgrains and are reduced in grain size compared to the starting material to 7-9 μm. Both the size and the aspect ratio of the salt grains show a decreasing trend with increasing mica content. The decrease in grain size can most likely be explained by the higher stress, and therefore smaller recrystallised grain size, in samples with more mica. The lower aspect ratio could suggest that grain boundary sliding along the mica-salt contact plays an important role in the deformation of these samples. The decrease in intensity of the CPO with increasing mica content of the sample supports this conclusion. This suggests that the resulting strength of the samples is determined by a combination of the friction behaviour of the salt-mica interface and the dislocation creep in the salt crystals.