Geophysical Research Abstracts,
Vol. 10, EGU2008-A-06920, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-06920
EGU General Assembly 2008

Changes in microstructure and CPO as a function of increasing shear strain – torsion experiments on synthetic rocksalt

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Rocks in shear zones are characterised by a fine grained, mylonitic microstructure resulting from high shear strains accompanied by dynamic recrystallisation. These rocks often show a characteristic strong crystallographic preferred orientation (CPO).

The aim of this study was to reconstruct the change in microstructure and CPO with increasing shear strain. To achieve high shear strains torsion experiments, using a Paterson deformation apparatus, were carried out to different shear strains ($\gamma \sim$1 - $\gamma \sim$8) on synthetic 'wet' (>9 ppm water) rocksalt. Experiments were conducted at 100 and 200˚C applying constant strain rates of 3x10^{-4} and 3x10^{-3}s^{-1} and a constant confining pressure of 250MPa.

At 100˚C and shear strains up to $\gamma \sim$3 the samples are characterised by sheared elongated grains containing blocky subgrains and wavy slip bands. The 200˚C samples up to this shear strain show elongated grains comprising polygonal shaped subgrains. New irregular shaped grains with bulged and cuspate/lobate grain boundaries appear. This indicates that dynamic recrystallisation in form of grain boundary migration was active. The high shear strain samples at both temperatures are characterised by a grain size reduction that is most pronounced in samples reaching $\gamma \sim$6 (100˚C) and $\gamma \sim$8 (200˚C). The grain size reduction, where the size of the new formed grains is similar to the size of the subgrains, suggests that dynamic recrystallisation took place by subgrain rotation. Additionally, at both temperatures new grains formed without any internal deformation substructure (i.e. subgrains). These grains are characterised

by straight grain boundaries. The lack of a deformation substructure suggests that these grains were formed after deformation by static recrystallisation processes (grain growth).

Texture analysis showed that crystallographic preferred orientation developed in all investigated samples. The CPOs at low shear strains ($\gamma \leq 3$) at 100 and 200˚C are characterised by a monoclinic symmetry and by two texture components, a more pronounced {111}$<$110$>$ and a weaker {001}$<$110$>$ component. The CPOs at high shear strains ($\gamma \geq 3$) are characterised by an orthorhombic symmetry with one single {001}$<$110$>$ texture component. This CPO is strongest developed in the high shear strain sample ($\gamma \sim 8$). A third type of CPO is characterised by a slightly rotated {110}$<$110$>$ texture component with a monoclinic symmetry and developed in samples showing grain growth to a major extend.

Our study shows that the microstructure of rocksalt sheared at the investigated temperatures is a ‘shear deformation’ microstructure up to a shear strain of $\gamma \sim 3$. This microstructure changes into a dynamic recrystallisation microstructure at shear strains $\gamma \geq 3$. These experimental microstructures are consistent with the development of the crystallographic preferred orientations that, in a similar way, can be separated in a deformation texture that changes with increasing shear strain into a dynamic recrystallisation texture. Furthermore, the presence of subgrains and the presence of a CPO suggest that deformation occurred by dislocation processes at the investigated conditions.