Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05532, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05532
EGU General Assembly 2008

Strain localization in direct shear experiments on Solnhofen limestone at high temperature

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Some features of natural shear zones formed under non-coaxial strain geometries can be simulated in the laboratory by using the direct shear experimental configuration. Slices of ∼1 mm-thick Solnhofen limestone were deformed in direct shear between two stronger forcing blocks of cores of Tennessee sandstone pre-cut at ∼45º to the cylinder axis. Experiments were run dry at 600 ºC, 200 MPa confining pressure and bulk strain rates of $\sim 7 \cdot 10^{-3} s^{-1}$, at which conditions Solnhofen limestone deformed by dislocation creep with a stress exponent of 4.7. When loaded, strain concentrates in the limestone band, producing non-coaxial deformation as one pre-cut block slides past the other. The orientation and intensity of the shape fabric developed in calcite grains indicates that strain is heterogeneous across the specimen, with the formation of two high strain shear bands close to the limestone-sandstone interface, separated by a central zone of low strain. Crystallographic preferred orientation (CPO) patterns in the calcite grains measured by EBSD are consistent with a switch in deformation geometry from flattening-dominated in the middle of the specimen towards shear-dominated in the high strain bands. From tests on thin slices of the same material compressed axisymmetrically (without shearing) normal to the layer, heterogeneous thinning of the slice develops, from a maximum in the centre of the slice to zero at the edges. The formation of the paired shear zones observed in the sheared experiments is interpreted in terms of superposed strain fields, with shearing in the centre of the slice being inhibited by the strain hardening that accompanies the higher flattening strain in the centre of the specimen.