Geophysical Research Abstracts,
Vol. 11, EGU2009-5021, 2009
EGU General Assembly 2009

Structures in an anhydrite layer embedded in halite matrix: Results from thermomechanical experiments under bulk plain strain

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Anhydrite layers from Gorleben salt dome, embedded in a halite matrix from Asse salt dome, both northern Germany, were deformed under bulk plain strain using a thermomechenical apparatus (Zulauf et al., 2007, 2009). The initial layer thickness H_i ranges from 0.85 to 2.5 mm. Further deformation conditions were as follows: T=345°C, σ_{max}=4.59 MPa, e_{zmax}=-40%, $\dot{e}$=2*10^{-7}s^{-1}.

During the deformation process, load cells record the stress along Y and Z. The displaced material could escape in X.

The deformed samples were scanned using a computer tomograph at the Universitätsklinikum Frankfurt/Main. The CT data allow the generation of 3D-modells using the software *Smoooth*.

We deformed six samples with the layer (S) perpendicular to the X-axis and four samples with the layer perpendicular to the Z-axis. Depending on the orientation of the layer ($S\perp X$ or $S\perp Z$), the expected structures should be folds or boudins, respectively, the geometry of which should strongly depend on H_i.

In cases were the layer was orientated parallel to the shortening axis ($S\perp X$), the anhydrite layer shows Mohr-Coulomb fractures. The fracture walls were thrust on top of each other. The space between hanging and foot wall is filled with salt. The angle between the fractures and the *YZ*-plain ranges from 10° to 25°, rarely up to 70°, dependent on the finite strain. In thin layers (H_i=0.85 and 1 mm) rarely non-cylindrical folds developed. In both cases ($S\perp X$ and $S\perp Z$) the layer thickness did not significantly change during deformation.

In cases were the layer was orientated perpendicular to the shortening axis ($S\perp Z$) boudins developed by extensional fracture. The number of boudins and their size depend strongly on the initial layer thickness H_i. With increasing layer thickness H_i the width of boudins W_a increases linearly.

W_a = -0.2 + 1.4 * H_i (1)

This relation between H_i and W_a is further compatible with equation (16.4) of Price and Cosgrove (1990) which also considers rheological parameters.

Moreover experiments carried out under bulk constrictional strain (Zulauf et al., 2007, 2009) show a similar dependency of the initial layer thickness and boudin width.

For microstructual investigations of the halite matrix, thin sections (*XZ*- and *YZ*-sections) were prepared and etched following the method of Urai et al. (1987). First microfabric data show that halite behaves viscous whereas anhydrite deforms by fracturing or rare folding under the chosen deformation conditions. Halite deforms by climb-controlled dislocation creep with strain hardening (Carter et al., 1993). Anhydrite, on the other hand, was deformed in the brittle-plastic regime, characterized by twinning, kinking and fracturing.

The subgrain size of halite has been used to estimate the differential stress (Schléder & Urai, 2005, 2007), that was compared with the stress recorded by the load cells. The subgrain size of deformed halite varies between 0.04 and 0.07mm, resulting in differential stresses between 3.3 +1.5/-0.8 MPa ($S\perp X$) and 4.2 +3.0/-1.2 MPa ($S\perp Z$), although the conditions for piezometry are not completely fulfilled (e.g. lack of steady state during deformation in some samples). These stress values in the matrix fit with the stress values recorded during deformation. Close to rigid anhydrite the subgrain size decreases to values of 0.02 - 0.03 mm, reflecting peak stress up to 6.7 +3.7/-0.7 MPa.

We do not know the reasons why folding of the anhydrite layer is largely lacking, although the viscosity contrast between halite and anhydrite should be appropriate for folding. Possible reasons are the lack in confining pressure or mechanical anisotropies in the undeformed anhydrite. Further investigations will focus on the texture of halite and on microfabrics of the anhydrite.

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