Motivation, Objective

- Deep geological repositories are suitable to isolate dangerous wastes from the biosphere for extremely long periods of time.
- Excavation disturbed zones (EDZ) develop near the surface of opening as consequence of formation of a crack network caused by the change of stress during excavation.
- The quality and degree of disturbance influence the permeability of sealing systems.
- Acoustic Emission is used to investigate the formation of cracks in time and space.

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In-situ investigation of excavation disturbed zones close to drives in salt mines
AE Laboratory in the drift EU1 of salt mine Sondershausen

A dropping roof is an indication for a disturbed rock in the salt mine

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Evaluation Methods
- 3D location
- from moment tensor
  - Kind of cracks
  - Orientation of cracks
- from frequency spectra
  - Size of cracks

New Evaluation Algorithms
- Transversal wave was used for location and moment tensor analysis, too
- Correct directional diagram of AE sensors was taken into account

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Results of location

An accumulation of AE events marks a large disturbed zone running along a geological fault in the salt mine Merkers.

Distribution of AE events one day after the excavation of a new drive by blasting in the salt mine Sondershausen.

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Moment Tensor Analysis

- Resolution of moment tensor is not unique.
- The physically best resolution depends on the loading.
- In the excavation disturbed zone the main stress component is small. Therefore the fracture-mechanics resolution [NSC+SC+E] is more suitable than the seismic [SC+CLVD+E].

\[
\text{Normal stress crack [NSC]} \\
M_{pq} = \begin{pmatrix} \lambda & 0 & 0 \\ 0 & \lambda & 0 \\ 0 & 0 & \lambda + 2\mu \end{pmatrix}
\]

\[
\text{Shear crack [SC]} \\
M_{pq} = \begin{pmatrix} 0 & 0 & \mu \\ 0 & 0 & 0 \\ \mu & 0 & 0 \end{pmatrix}
\]

\[
\text{Compensated crack [CLVD]} \\
M_{pq} = \begin{pmatrix} -\frac{3}{2}\mu & 0 & 0 \\ 0 & -\frac{3}{2}\mu & 0 \\ 0 & 0 & \frac{1}{3}\mu \end{pmatrix}
\]

\[
\text{Explosion [E]} \\
M_{pq} = \begin{pmatrix} \lambda + \frac{3}{2}\mu & 0 & 0 \\ 0 & \lambda + \frac{3}{2}\mu & 0 \\ 0 & 0 & \lambda + \frac{3}{2}\mu \end{pmatrix}
\]

\[
\text{CLVD} = \text{NCS} - \text{E}
\]

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Summary

- Acoustic Emission is qualified for the investigation of temporal and spatial formation of disturbed zones after the excavation.
- In salt rock the size of disturbed zone depends primarily on the cross sectional area, the method of excavation, the life time of drive. In case of a circular cross section, a careful excavation, and a short life time, the disturbed zone can be very small, for instance 0.3 m. For rectangular cross sections, excavation by blasting, and a long life time, sizes up to 20 m are possible.
- Moment tensor analysis shows that cracks are orientated parallel to the surface of drive.
- Rate of crack formation decreases exponentially with life time and distance of the wall.
- The most dominant crack type is determined by moment tensor analysis as normal stress fracture.
- Crack length of recorded AE events varies between 0.05 and 0.8 m.

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