GEOSTOR

Submarine Carbon Dioxide Storage in Geological Formations of the North Sea

Environmental Risks

Geotechnical risks (CAU)

Risk of leakage at natural structures and boreholes (BGR, GEOMAR)

CO_2-induced processes in the subsurface and leakage mitigation (GEOMAR)

CDRmare

Geotechnical Risks

- **Simulations of the borehole pressure (BHP) limit**:
  - Updated geometry and inclusion of spatial parameter distribution
  - Assessment of potential injection scenarios

- **Update on the seismic wave propagation simulation**
  - Updated formulation
  - Updated geometry and layer parameters
  - Computation (underway)

- **Slip tendency analysis for the assessment of fault vulnerabilit**y
  - Interpreted fault dataset is received
  - Development of numerical tool for the analysis (underway)

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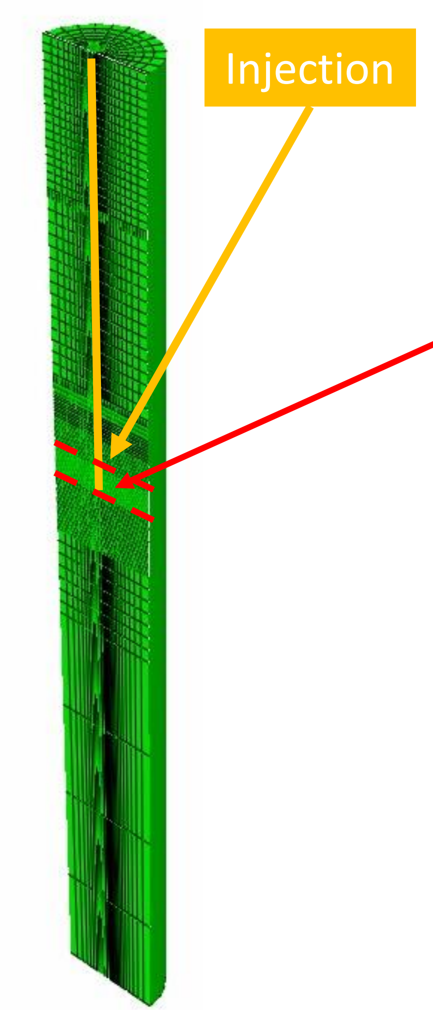
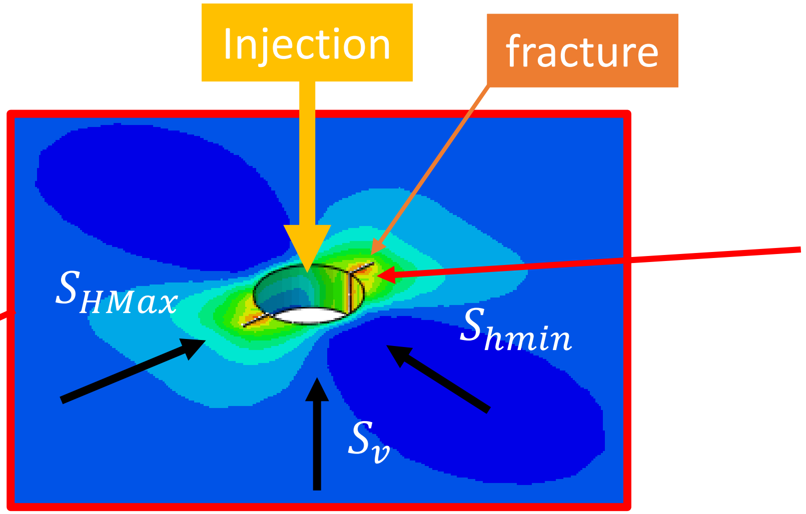
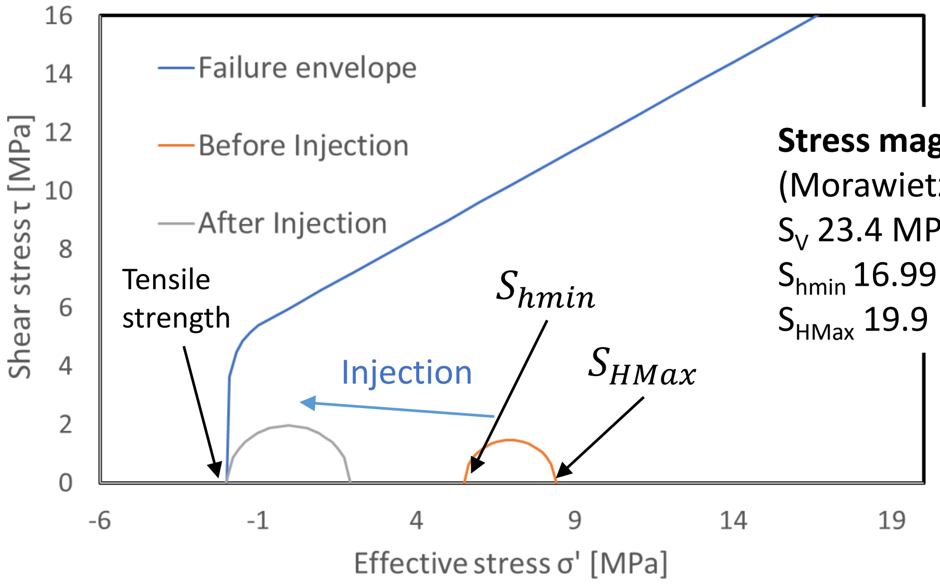
Geotechnical risks: Borehole pressure (BHP) limit



Rock column model



Injection simulation



Stress magnitudes
(Morawietz et al., 2020)
S_V 23.4 MPa/km
S_{hmin} 16.99 MPa/km
S_{HMax} 19.9 MPa/km

Stress path during injection

Importance:

1. Dynamic storage capacity estimation
2. Injection strategy to achieve injection target

Previous analyses:

- Influence of model size
- Influence of sealing layer definition

Update:

1. Updated geological geometry
2. Spatial parameter distribution
3. Potential injection scenarios

Determination of BHP limit:

1. Collection of existing field data (leak-off test from nearby Dutch off-shore region)
2. Analytical/closed-form solution
3. Numerical study

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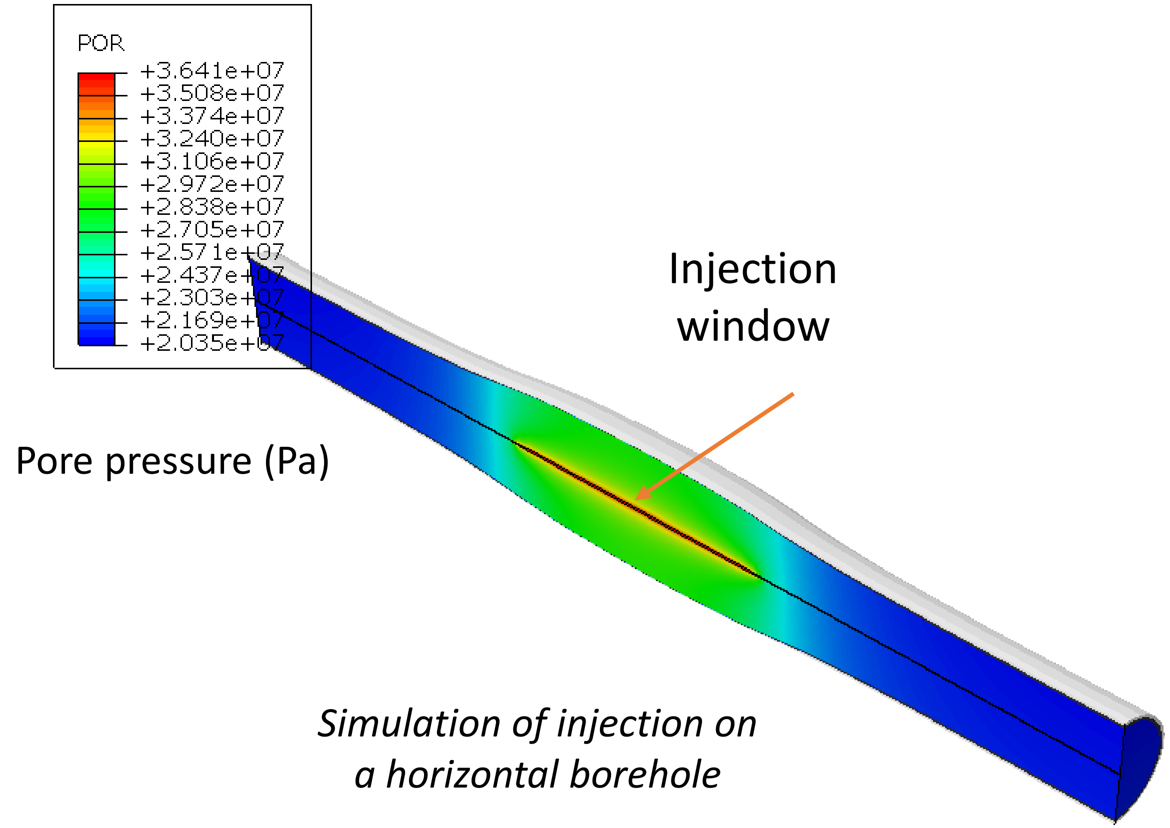
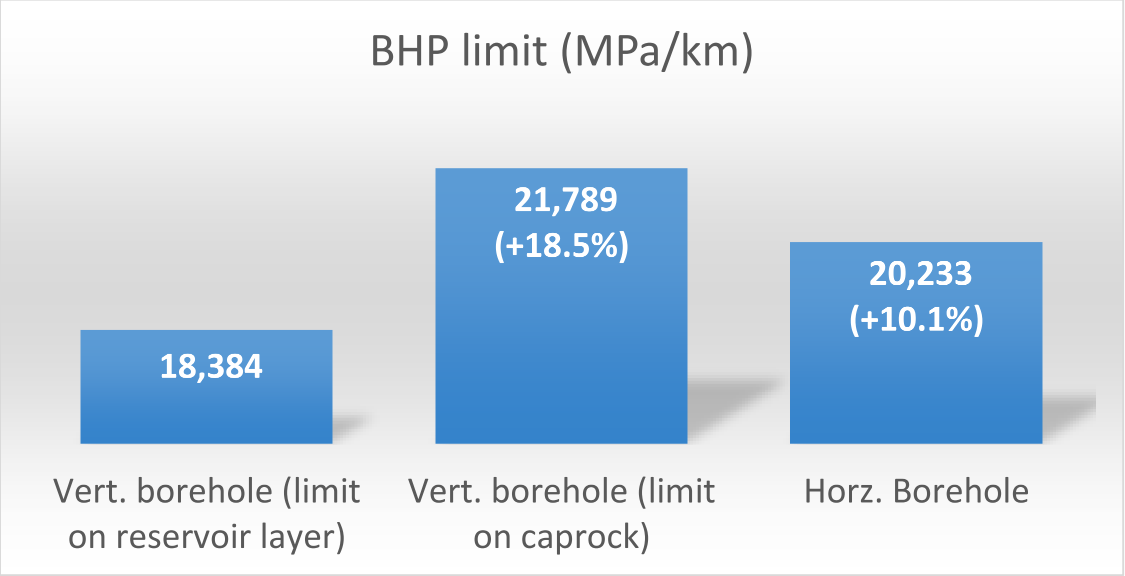
Geotechnical risks: Borehole pressure (BHP) limit



Simulation of injection on a horizontal borehole



Parameters:

- Tensile strength 2 MPa
- Horiz. Borehole is aligned to the direction of minimum horiz. stress

Multiple injection wells:

- Critical distance between injection points = 50 m

Increased BHP limit: tensile limit on caprock, horizontal borehole, and multiple injection wells

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Geotechnical risks: Seismic wave propagation using BEM-FEM

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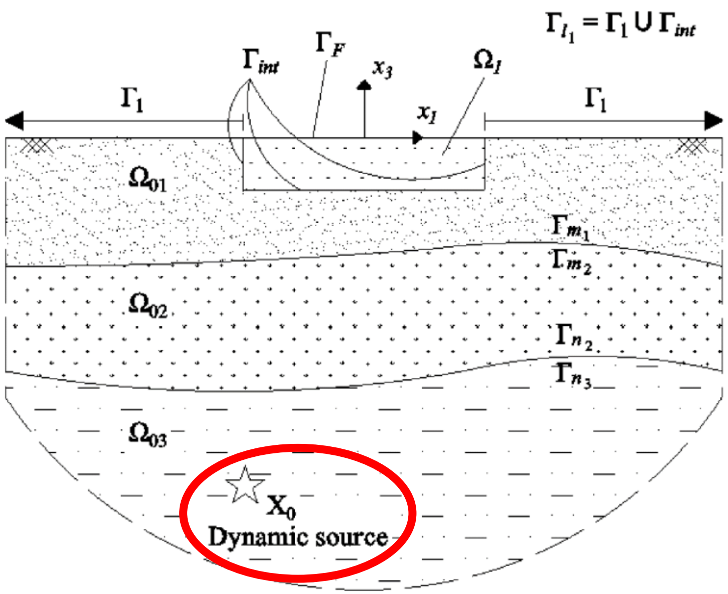
Importance:

- Assessment of the effect of potential microseismic events on offshore structures

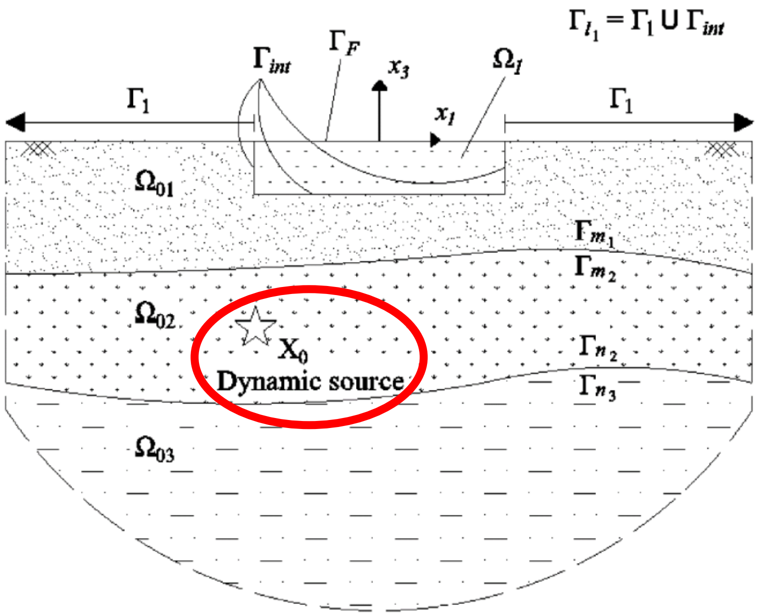
Boundary integral equation considering a double-couple source (Aji, Wuttke, in progress)

$$c_{lj}u_j^{(\Omega_0)}(\xi,t) = \int_{\Gamma_{\Omega_0}} U_{lj}^{*(\Omega_0)}(\mathbf{x},\xi,t) * t_j^{(\Omega_0)}(\mathbf{x},t)\,d\Gamma_{\Omega_0} - \int_{\Gamma_{\Omega_0}} P_{lj}^{*(\Omega_0)}(\mathbf{x},\xi,t) * u_j^{(\Omega_0)}(\mathbf{x},t)\,d\Gamma_{\Omega_0} + M_{jk}^{(\Omega_0)} f(t) * U_{lj,k}^{*(\Omega_0)}(\mathbf{x},\mathbf{X}_0,t), \xi \in \Gamma_{\Omega_0}, \mathbf{x} \in \Gamma_{\Omega_0}, \mathbf{X}_0 \in \Omega_0.$$

Multilayer formulation (Aji, Wuttke, Dineva, 2022)



Updated formulation (Aji, Wuttke, in progress)



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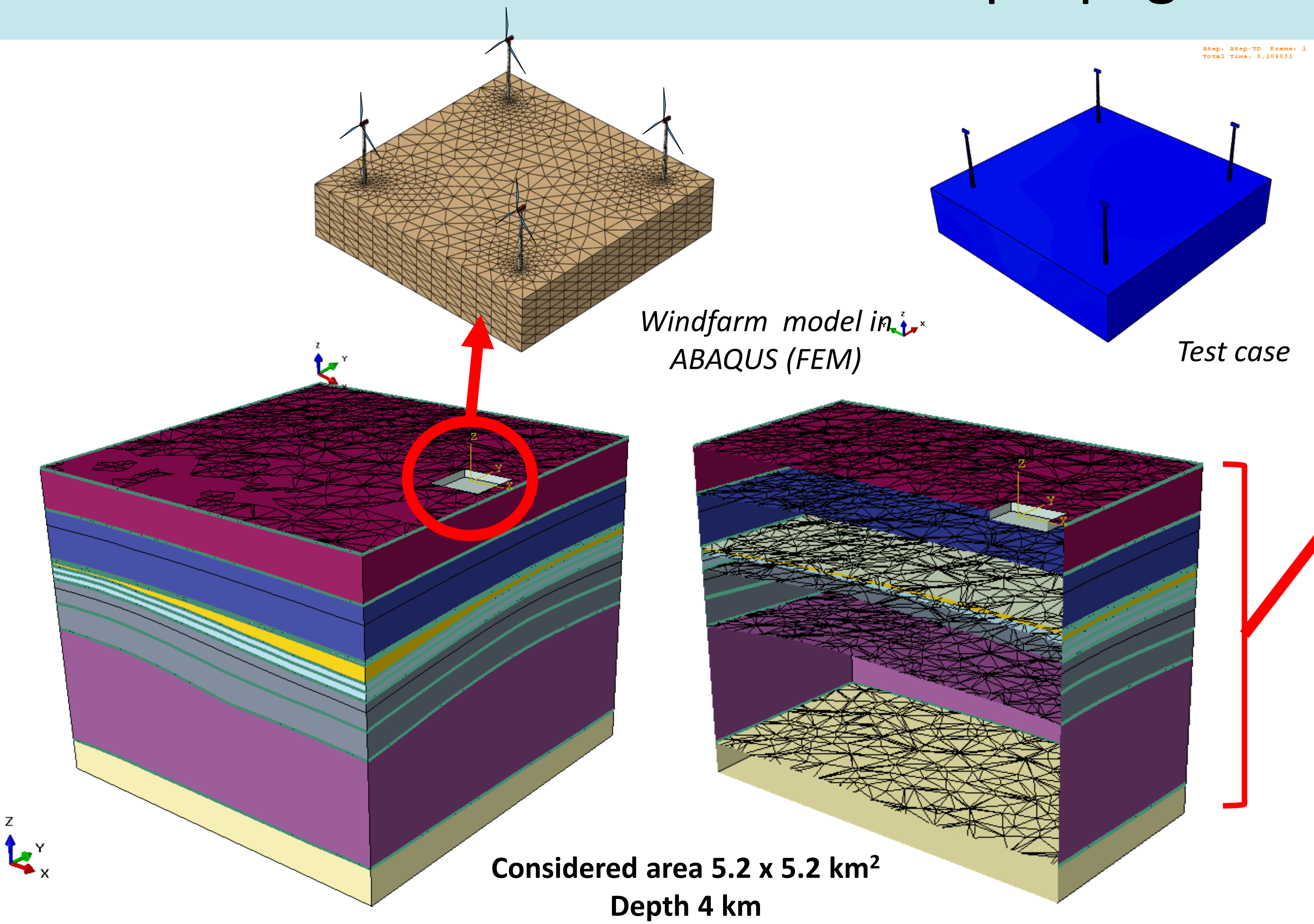
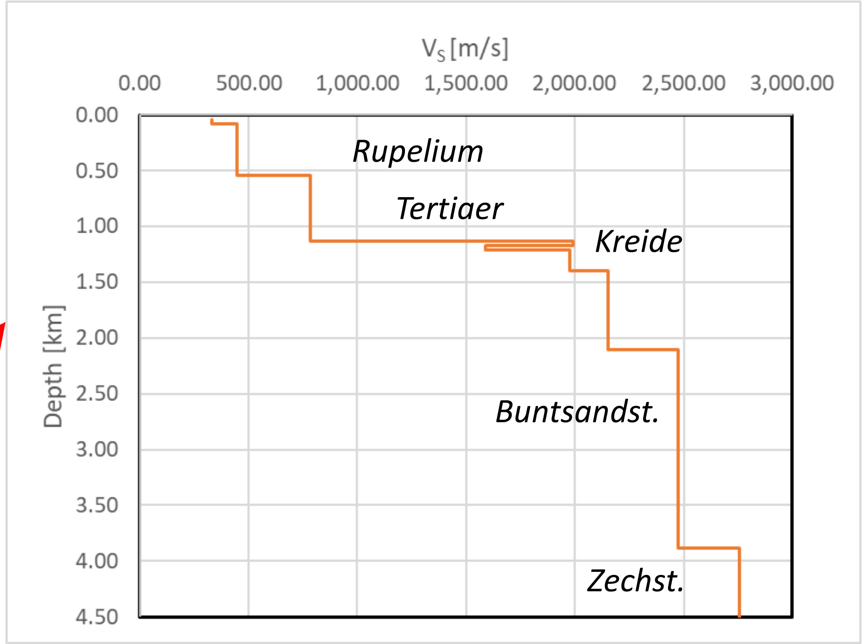
Geotechnical risks: Seismic wave propagation using BEM-FEM



Digital model of the updated horizon data in ABAQUS (BEM)

Shear wave velocity profile (after Jaritz et al., 1991; Roest & Kuilman, 1993; Castagna et al., 1985)



→ Recomputation is currently underway

Challenges:

- Unknown microseismic characteristic e.g., fault geometry, dominant frequencies from injection.
- Uncertainty in the relation between injection volume and potential magnitude.

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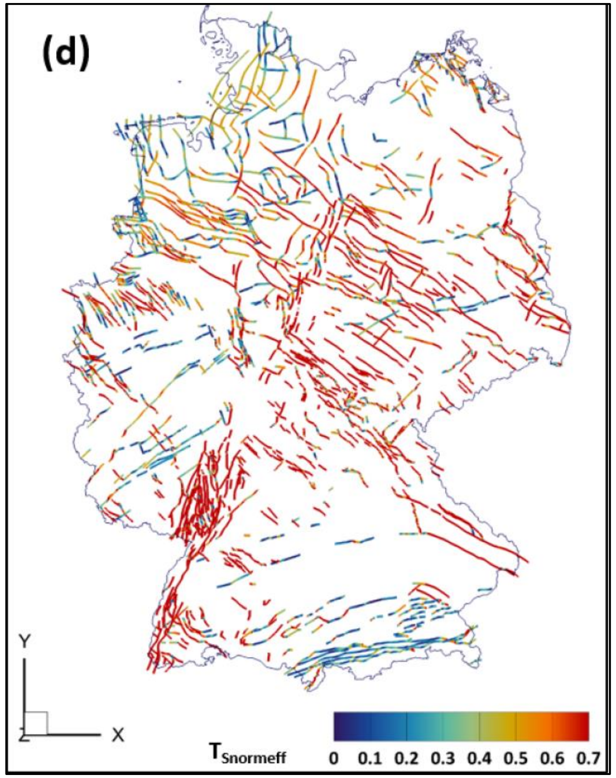
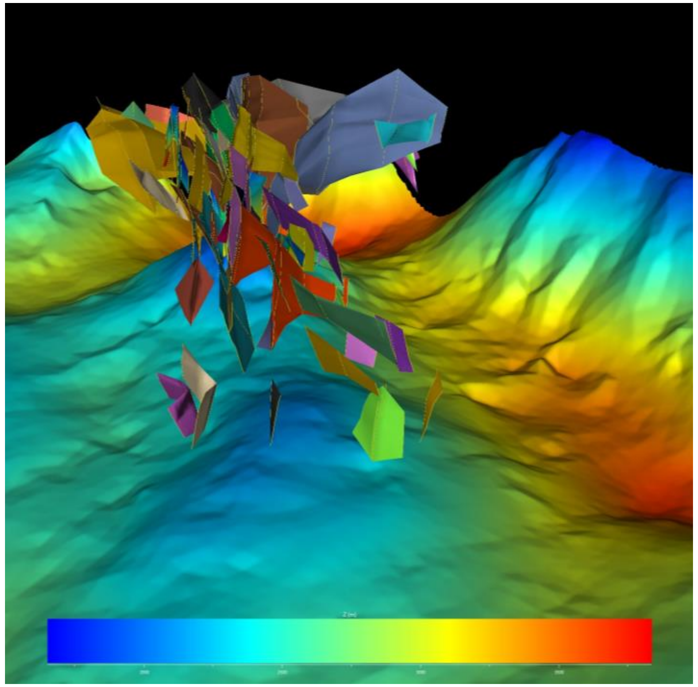
Geotechnical risks: Slip tendency analysis

Importance:
- Assessment of the vulnerability of faults to increased/migrated pore pressure.
- Identification of critical/determining fault in the vicinity of reservoir



Slip tendency of major vertical faults in onshore Germany (Röckel et al., 2022)



Overview of faults imposed on base Buntsandst. (BGR)

Progress:
- Interpreted dataset of the faults is obtained.
- Development of numerical algorithm and tool is underway.

Challenges:
- High uncertainty in the strength parameter due to lack of data

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