Geomechanical Analysis and Assessment of the Integrity of the Southern Part in the Morsleben Repository

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Morsleben Repository - History and status

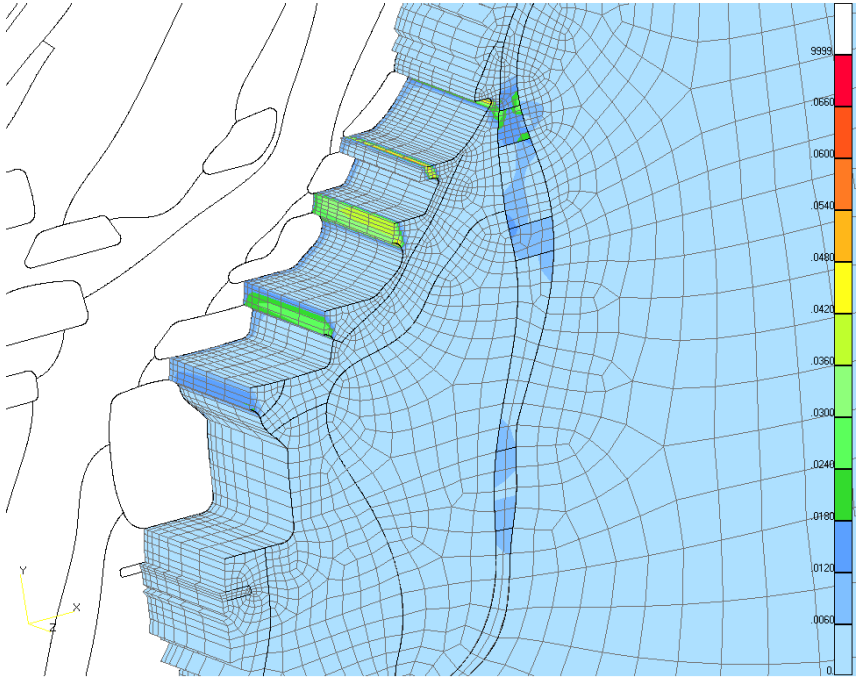
Disposal of waste drums

- 1912 - 1971: Salt & potash mine
- 1971 – 1998: Repository for MLW & LLW
- 2003 – 2011: Prevention of mining hazards in the central part (bGZ)
- present: Decommissioning concept & procedure (15 – 20 years)

Waste disposal in the eastern part

Backfilling of rooms

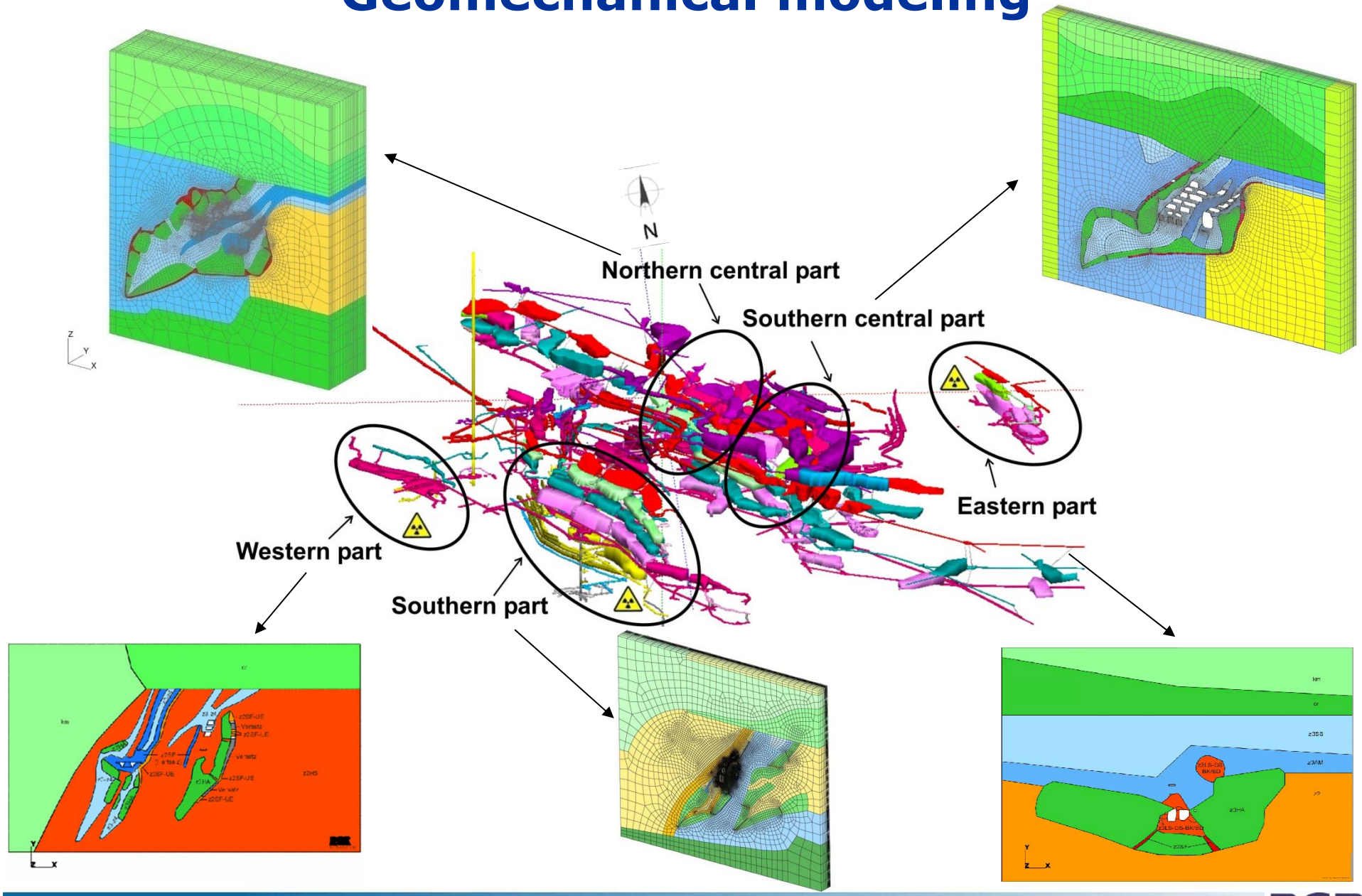
Geomechanical safety analysis



Cut-off of the 3-D model of the central part

- Analysis of the stability of the repository and the barrier integrity
- Consideration of backfilling of old mining rooms
- Prediction of the long-term safety of the repository (10,000 a)

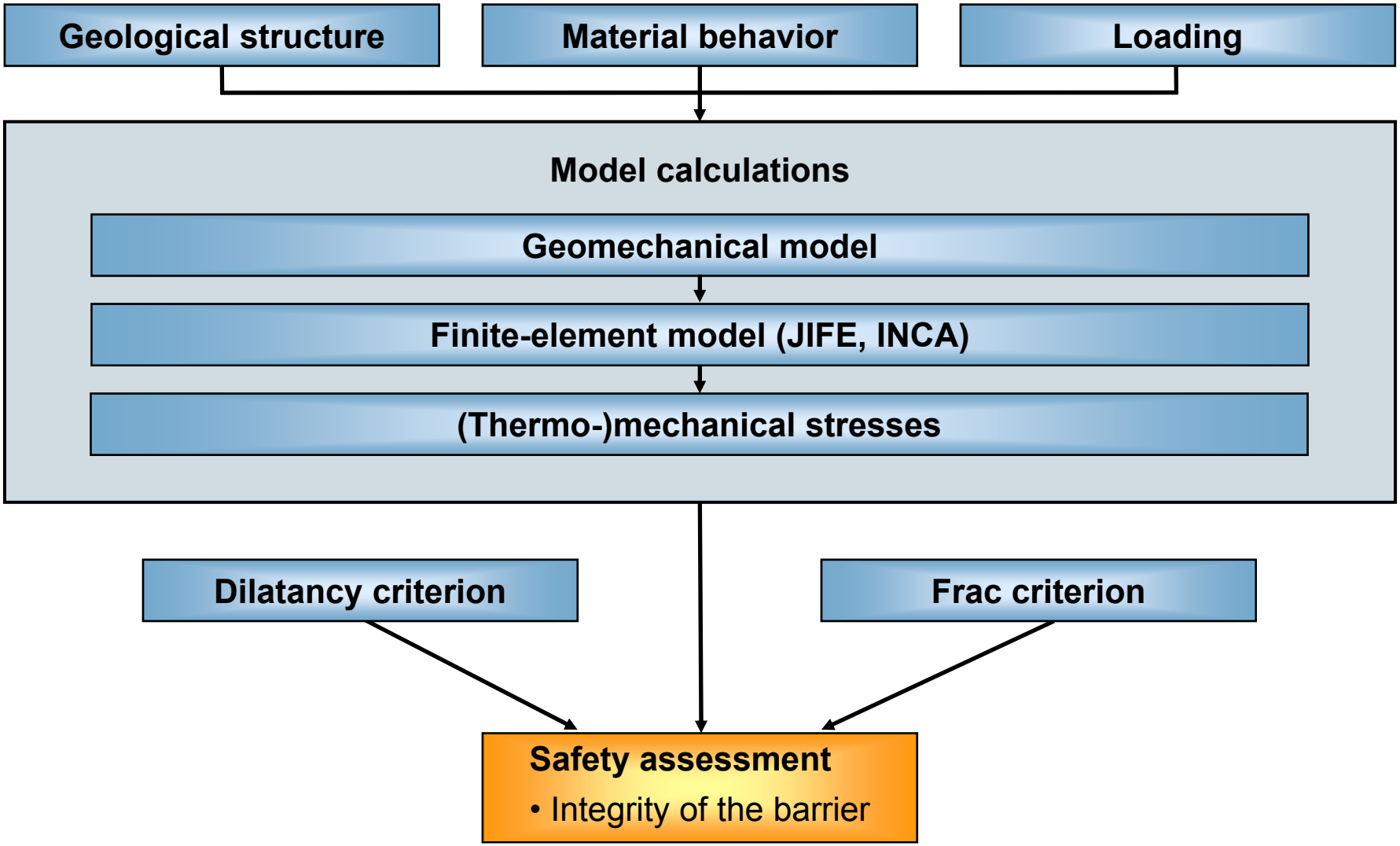
Geomechanical modeling



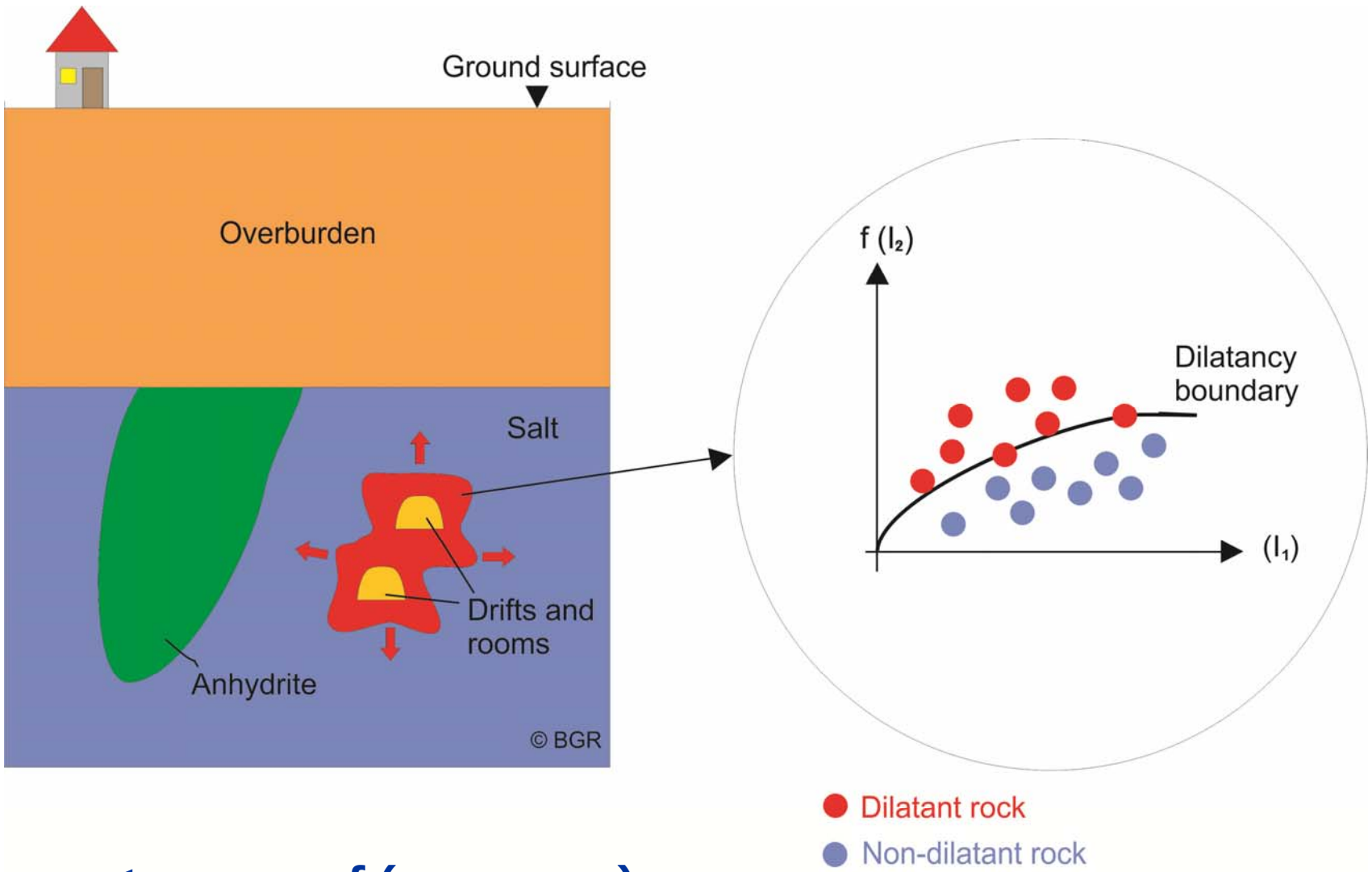
Integrity of rock salt - Definition

- Isolation capability
- No interconnected pore space
- No hydraulic flow process
- Ability to prevent the inflow of fluids
- Ability to prevent a leakage of contaminated fluids

Evaluation of the barrier integrity

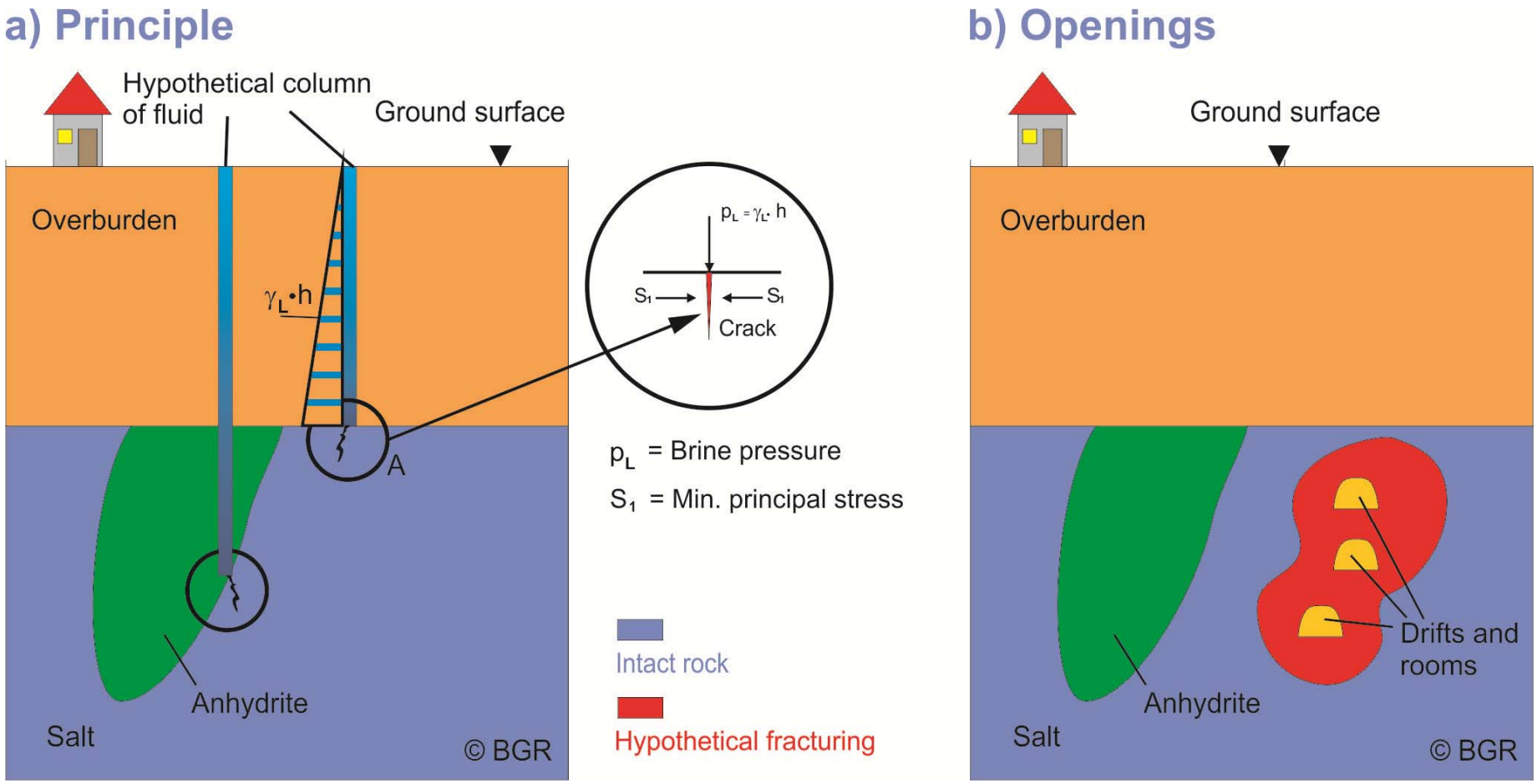


Dilatancy criterion



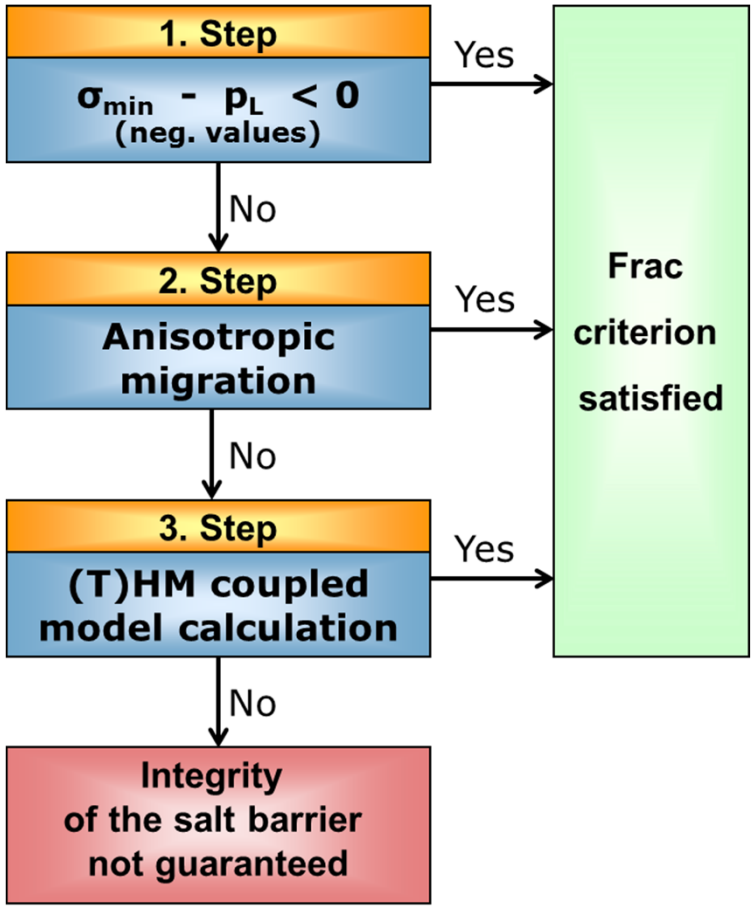
$$\sigma_{dev} < \sigma_{dev,dil} = f(\sigma_{min}, \sigma_{dev})$$

Frac criterion

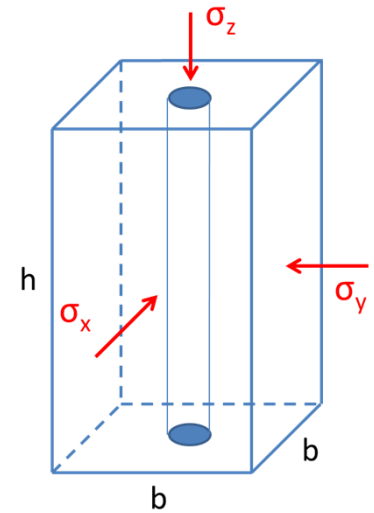


$\sigma_{min} - p_L < 0$ (neg. values)

3 Steps of evaluating the frac criterion



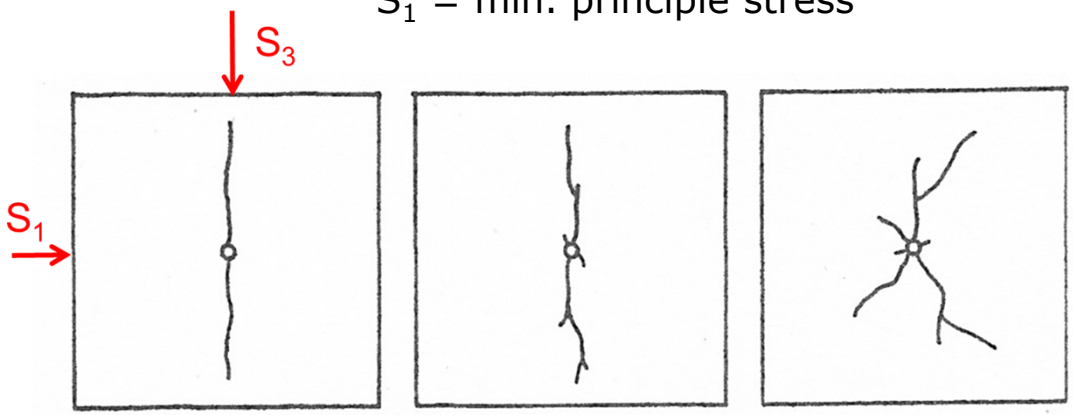
2. Step: Qualitative evaluation



„Stress ratio" $S_R = \sigma_x / \sigma_y = S_3 / S_1$

S_3 = max. principle stress

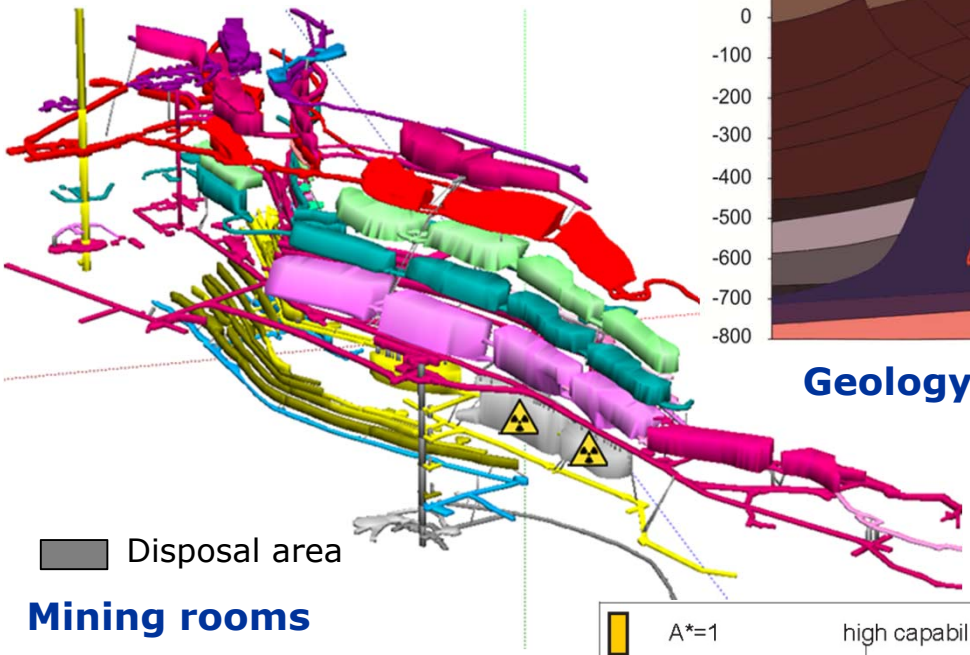
S_1 = min. principle stress



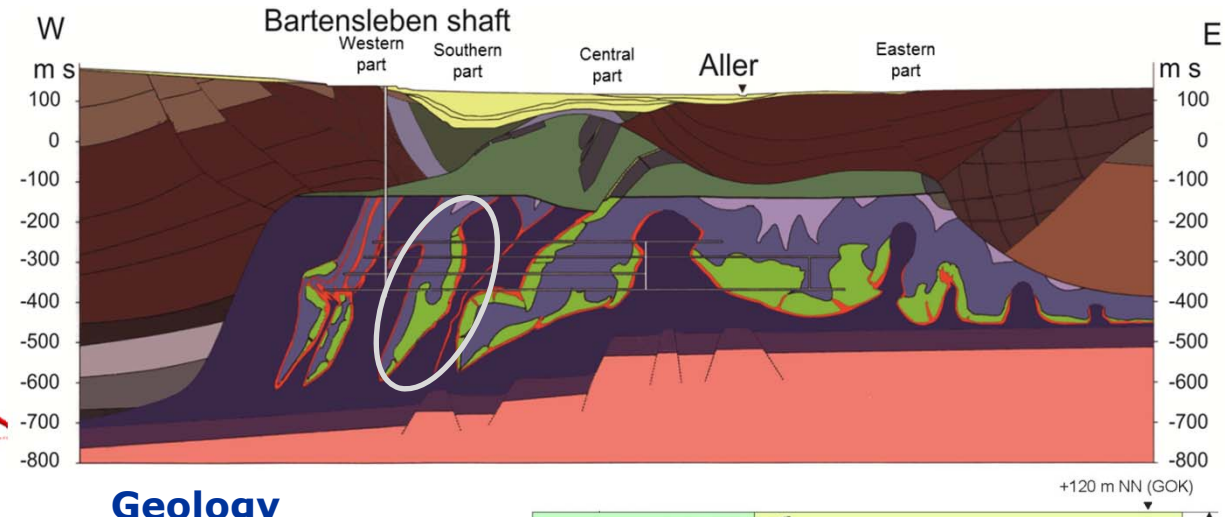
a) $S_R > 1{,}4$ b) $S_R = 1{,}4 \div 1{,}1$ c) $S_R < 1{,}1$

Reference:T. Doe & G. Boyce (1989)

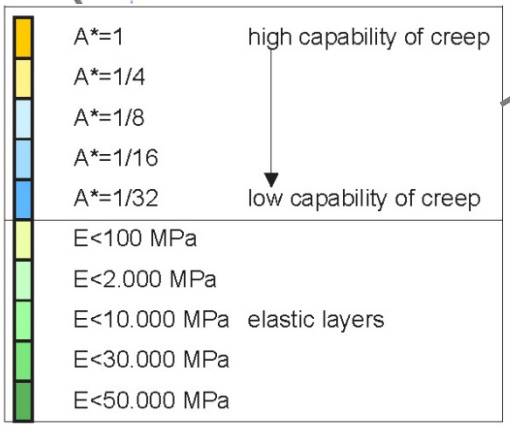
Morsleben repository – Southern part



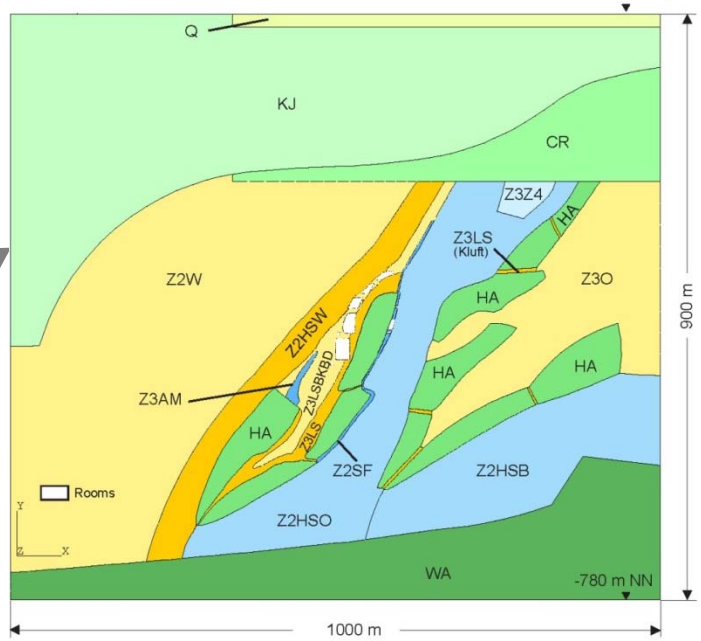
Mining rooms



Geology



Creep capability and elasticity



Homogeneous layers

Constitutive material models

- **Elasticity (rock salt, anhydrite, overburden)**
- **Steady-state creep of rock salt**

$$\dot{\varepsilon}_{dev}^{cr} = A \cdot e^{-\frac{Q}{R \cdot T}} \cdot \left(\frac{\sigma_{dev}}{\sigma^*} \right)^n$$

(BGRa)

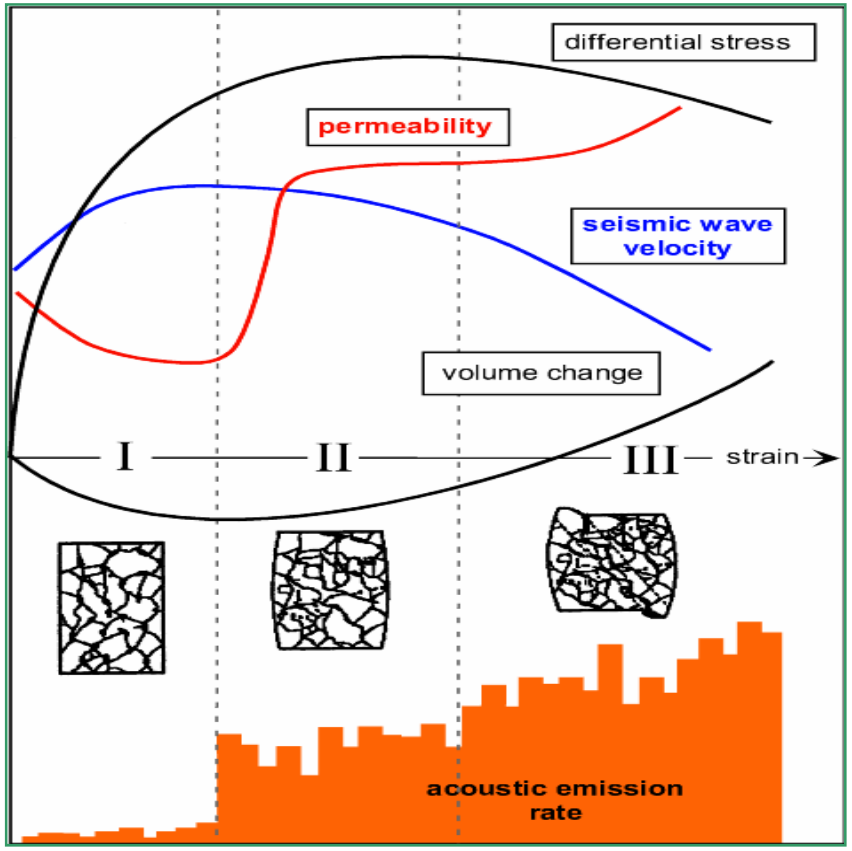
- **Dilatancy of rock salt (r_v-concept)**

$$\dot{\varepsilon}_{dil,vol} = r_v \cdot \dot{\varepsilon}_{cr,dev}$$

$$r_v = 0.8165 \cdot \left| \frac{\sigma_{dev} - \sigma_{dev,dil}}{| \sigma_{min} - 1/3 * \sigma_{dev} |} \right|^2 \quad if\ \sigma_{dev} > \sigma_{dev,dil}$$

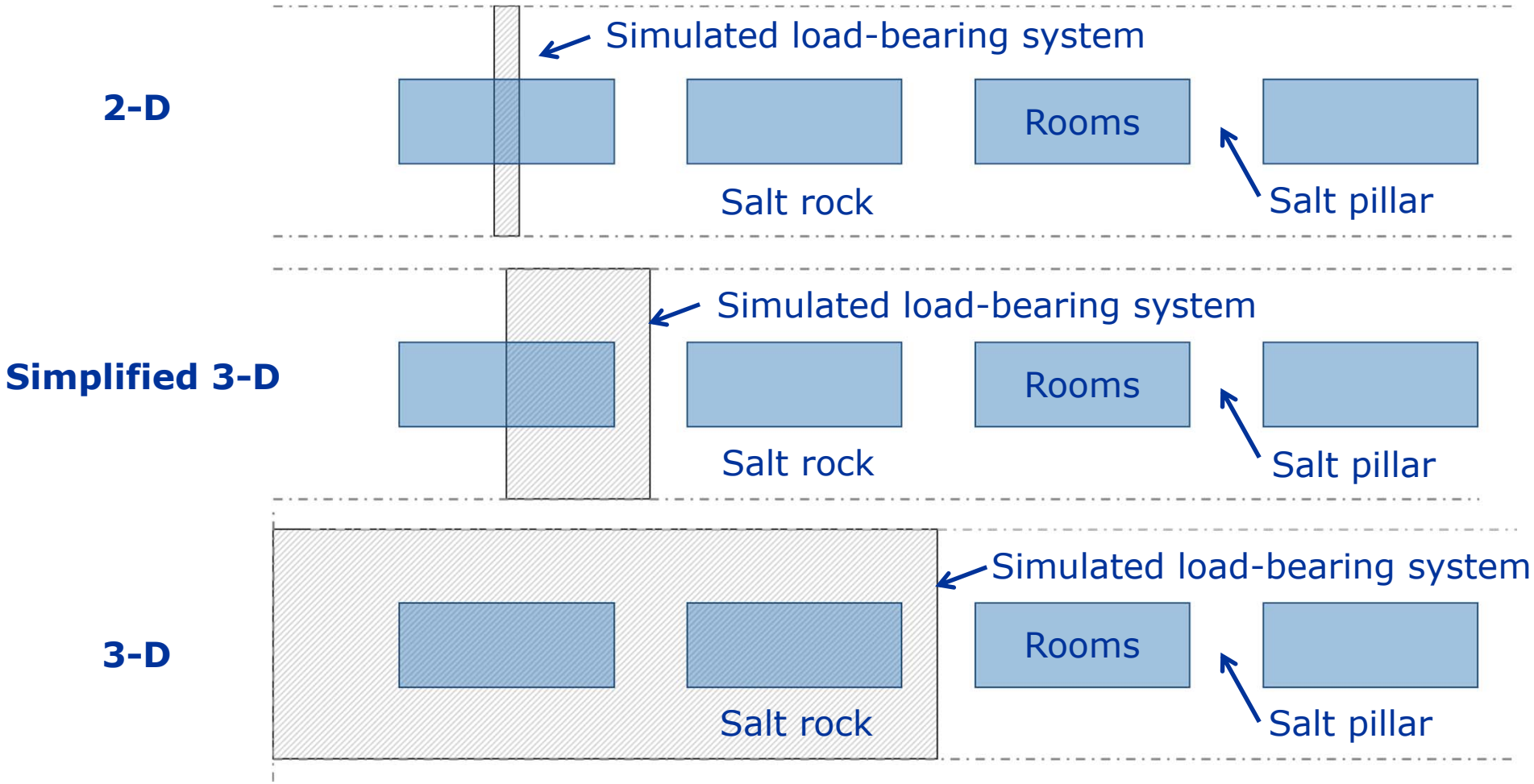
$$\sigma_{dev,dil} = b \cdot (\sigma_{min} - 1/3 * \sigma_{dev})^c$$

(→ for details see paper)



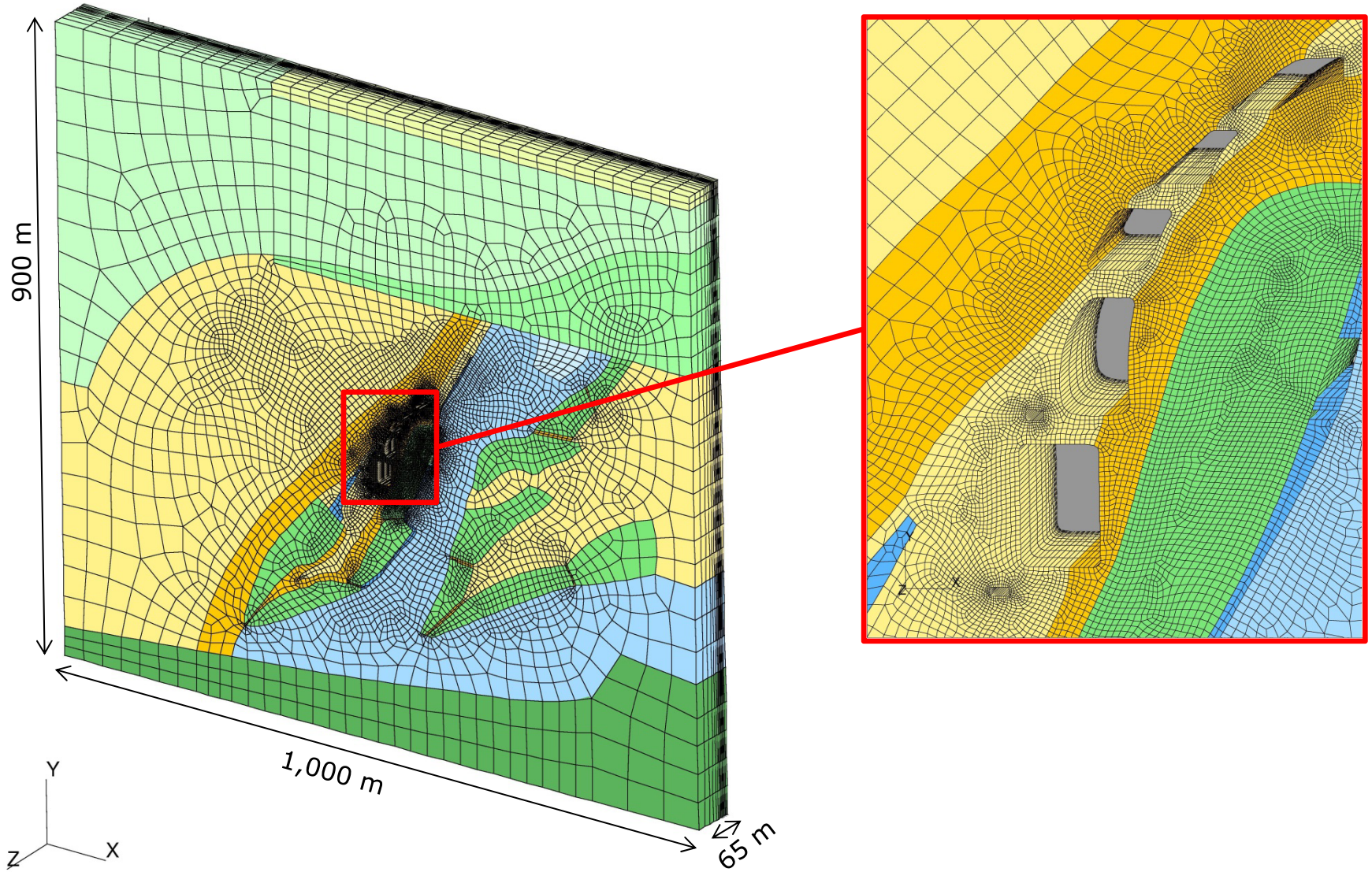
Determination of dilatancy in lab tests (Popp, Kern & Schulze, 2002)

Different steps of modeling



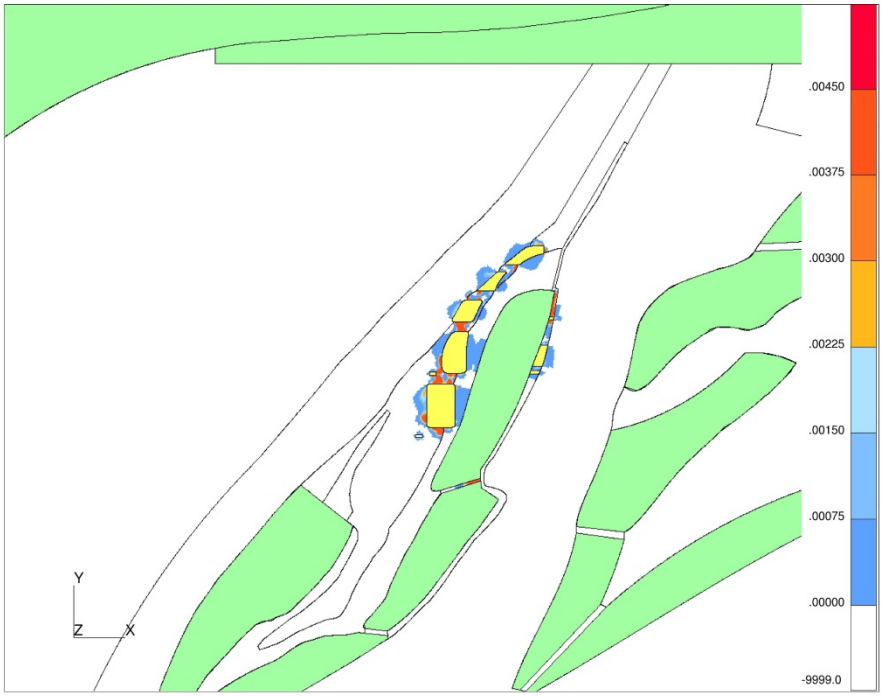
Schematic layout plan of a mine level

Southern part
Simplified 3-D finite-element model



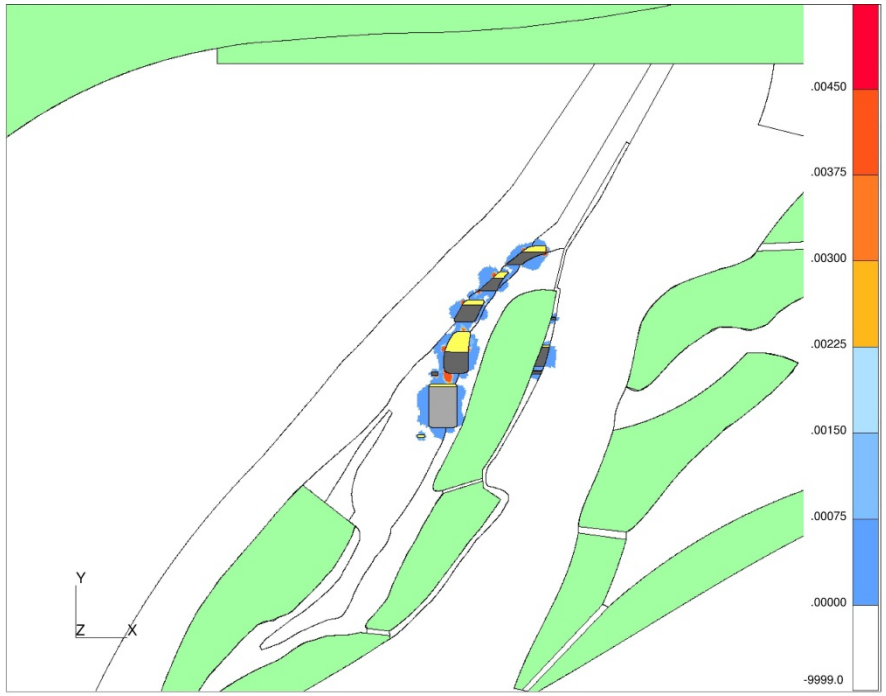
Dilatant zones after 10,000 years

Rooms not backfilled



not backfilled

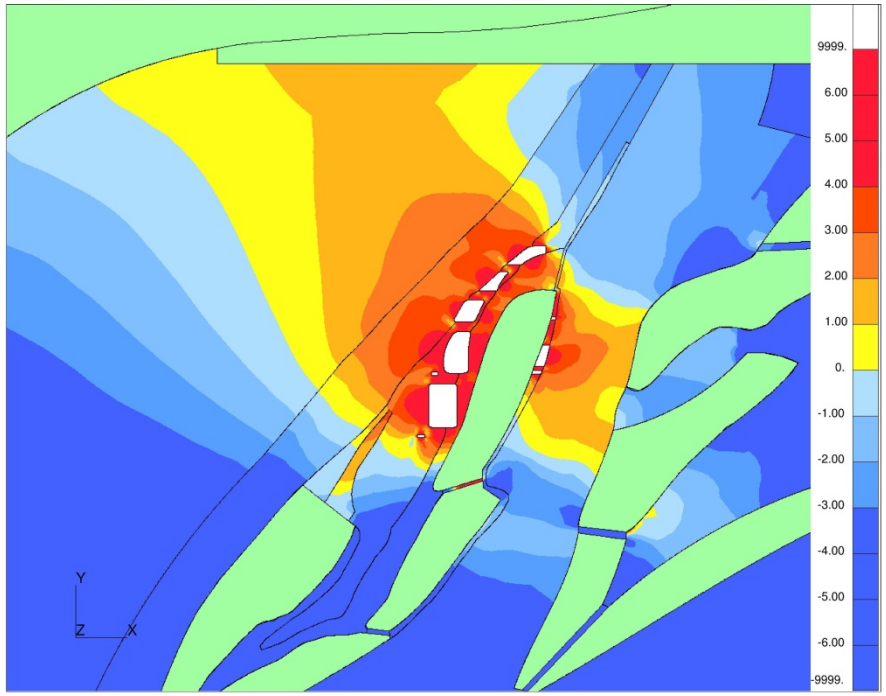
Backfilled rooms



not backfilled
waste disposal & backfilled with lignite fly-ash since t=80a
backfilled with saltcrete since t=80a

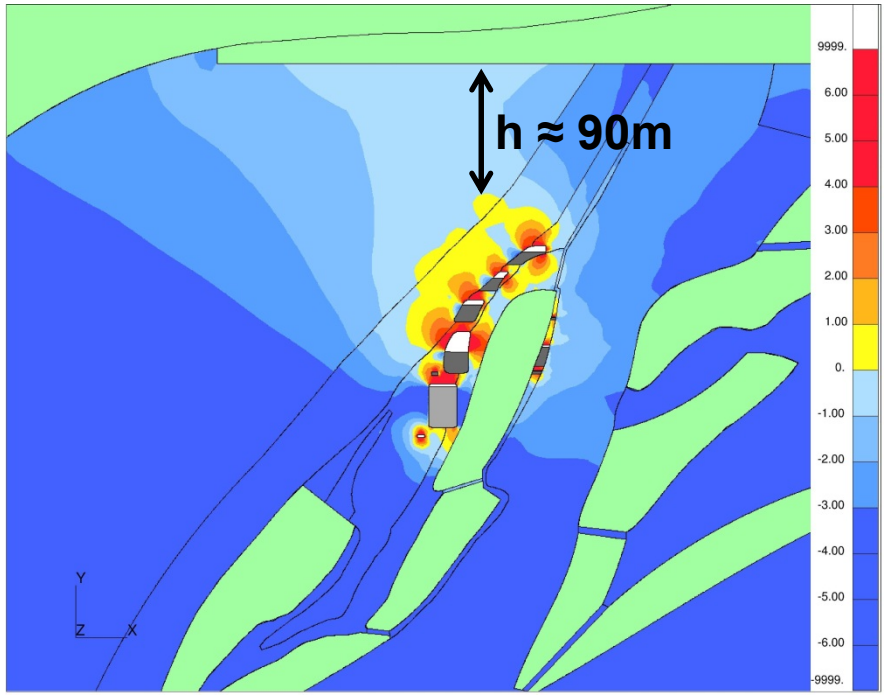
Frac-risked zones after 10,000 years

Rooms not backfilled



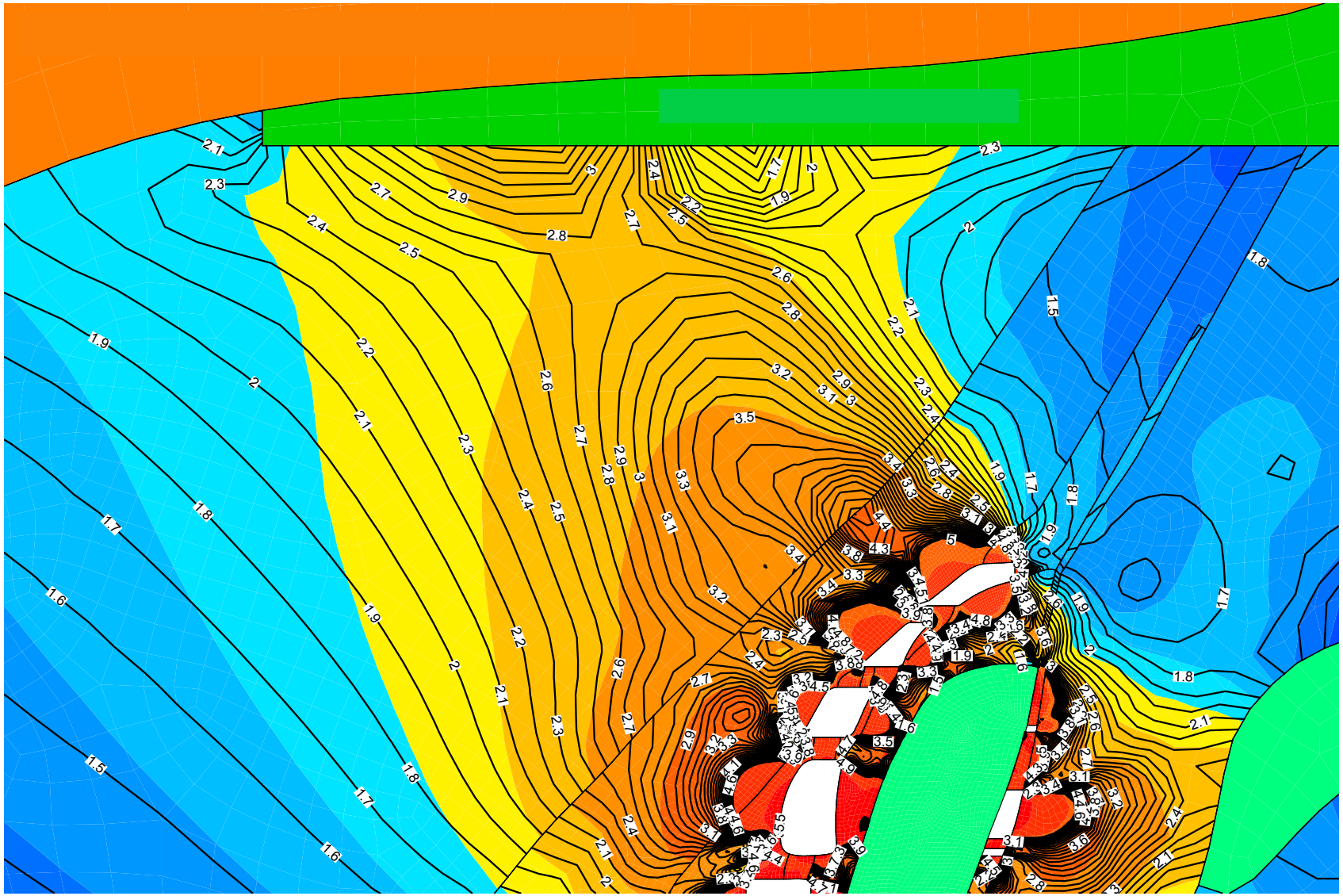
not backfilled

Backfilled rooms

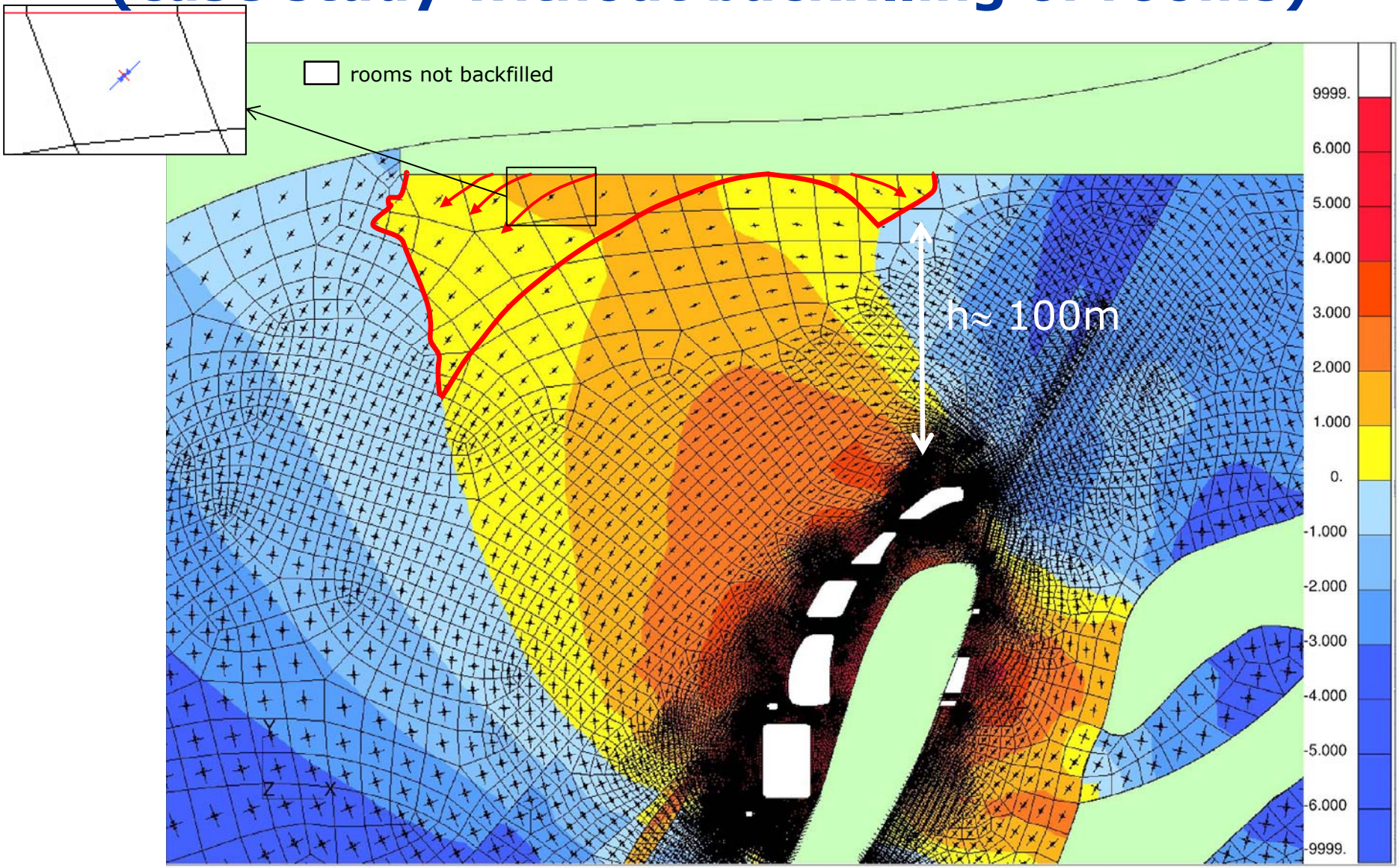


not backfilled
waste disposal & backfilled with lignite fly-ash since t=80a
backfilled with saltcrete since t=80a

„Stress ratio“ S_R in the salt barrier



Qualitative evaluation of the frac criterion (case study without backfilling of rooms)

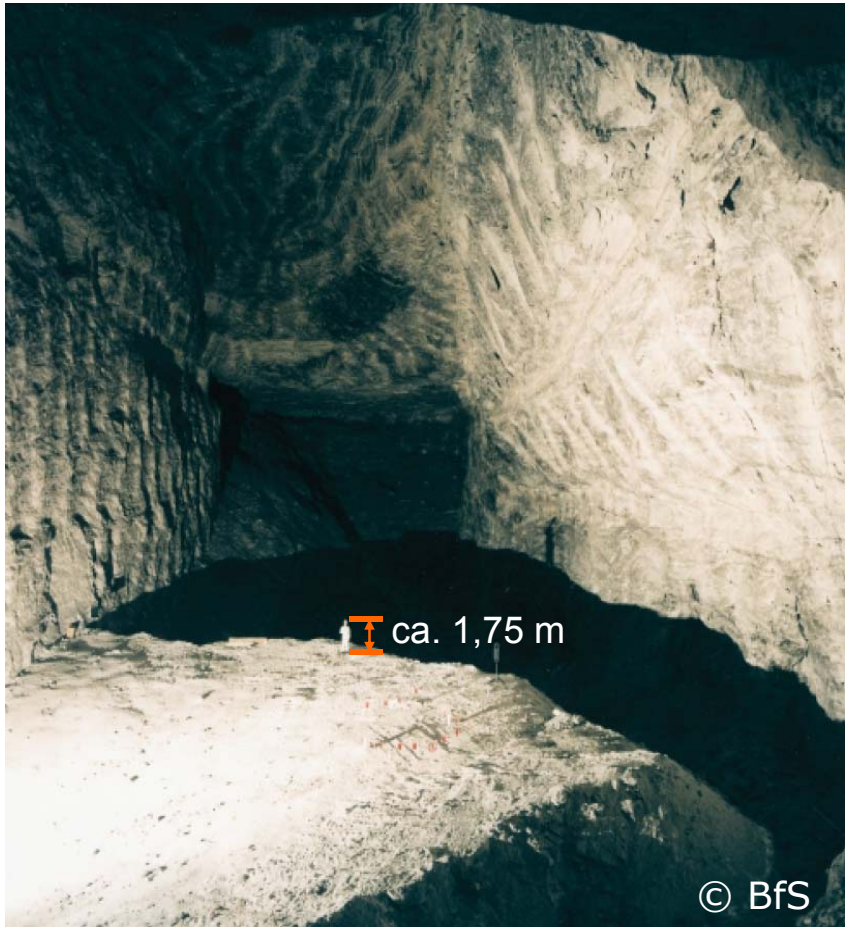


Conclusions and outlook

- **Overview of geomechanical safety analysis of the Morsleben repository**
- **Procedure of evaluation of the barrier integrity**
- **Dilatancy and frac criterion for rock salt**
- **Long-term safety analysis**
  (a) no backfilling: Extensive violation of frac criterion
  (b) with backfilling: Both criteria are satisfied

Future work:

- **3-D modeling**
- **Considering of large deformation**
- **Use of contact elements**
- **Prediction over 100,000 a**
- **Different concepts of backfilling**



Thank you for your attention!