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KOSINA/WEIMOS Collaborations in Salt (Germany)

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SFWST Working Group Meeting
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What is KOSINA?

KOSINA Project

- BMWi/PTKA launched the R&D project KOSINA on July 1 , 2015

  (Konzeptentwicklung für ein generisches Endlager für wärmeentwickelnde Abfälle in flach lagernden Salzschichten in Deutschland und Überprüfung des entwickelten Sicherheits- und Nachweiskonzeptes)

  = development of a concept for a generic repository for heat generating waste in bedded salt in Germany as well as the review (adaptation) of existing safety and safety demonstration concepts

- Partners: BGR, GRS, IfG, and DBE TEC
- Duration: 32 months (end of project: February 28, 2018)

W. Bollingerfehr – 03/2016
7th Project Meeting KOSINA
Hanover, 16.03.2016

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KOSINA Overview – Moving the German Disposal Concept from Domal Salt to Bedded Salt

Objectives

- major objective:
  - development of a technical site-independent concept for a repository for heat generating waste and spent fuel on the basis of generic geologic models for bedded salt including a safety and safety demonstration concept
- detailed objectives:
  - development of a generic geologic model (+ parameters)
  - development of a safety and safety demonstration concept
  - development of technical repository designs
  - demonstration of geomechanical integrity

➢ provide a technical-scientific basis for the safety oriented evaluation of repository systems in different host rocks according to the site selection law.

W. Bollingerfehr – 03/2016
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Structure of KOSINA Work Packages

Work Program

WP 1: Compilation of basic planning data and requirements (all)

WP2: Development of generic geologic models and derivation of model parameters (BGR and IfG)

WP3: Development of safety / safety demonstration concepts (GRS)

WP4: Analysis of geo-mechanical integrity (BGR und IfG)

WP5: Development of repository designs for 4 variants (DBE TEC)

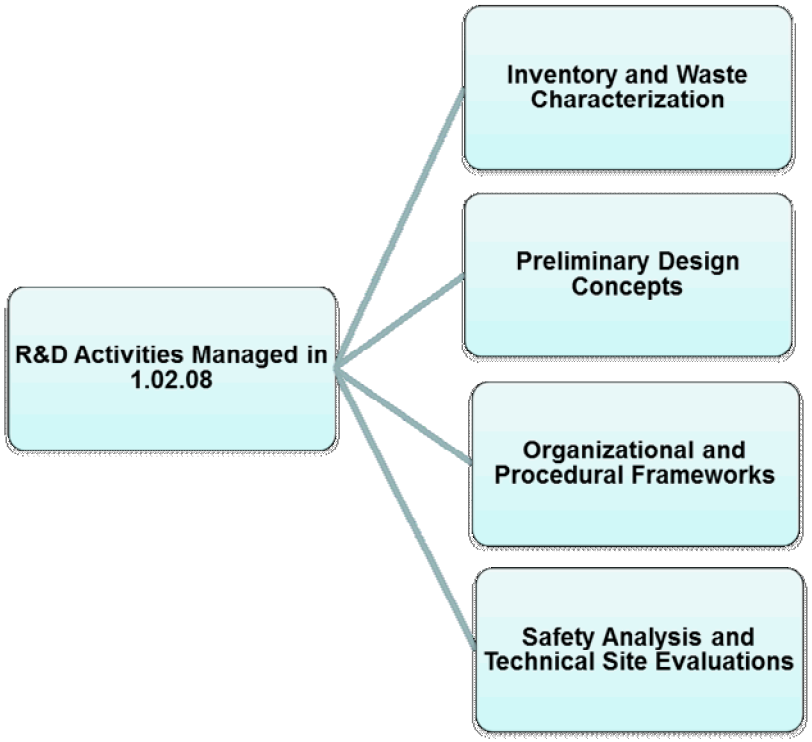
WP6: Analysis of radiological consequences (GRS)

WP7: Evaluation of operational safety (DBE TEC)

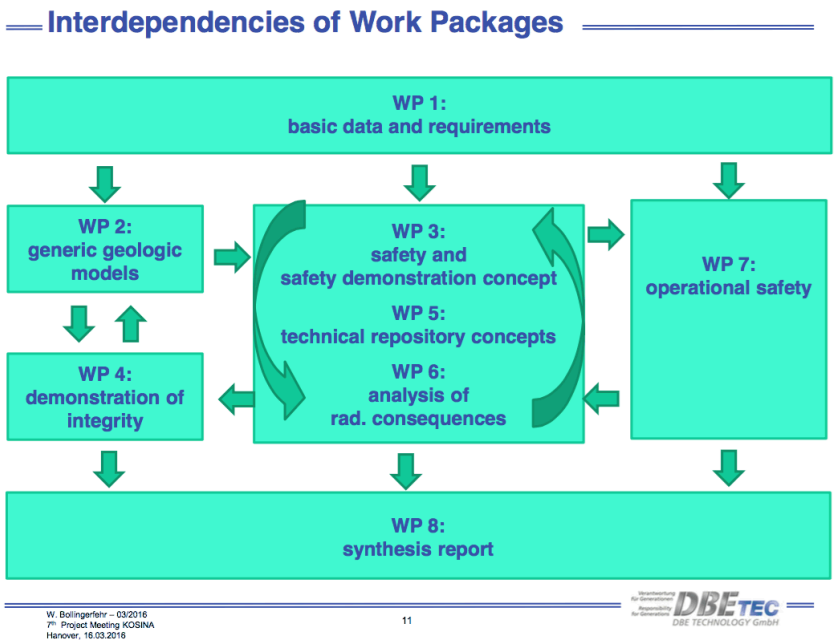
WP8: Synthesis report (all)

Comparison between DWR and KOSINA 1/3

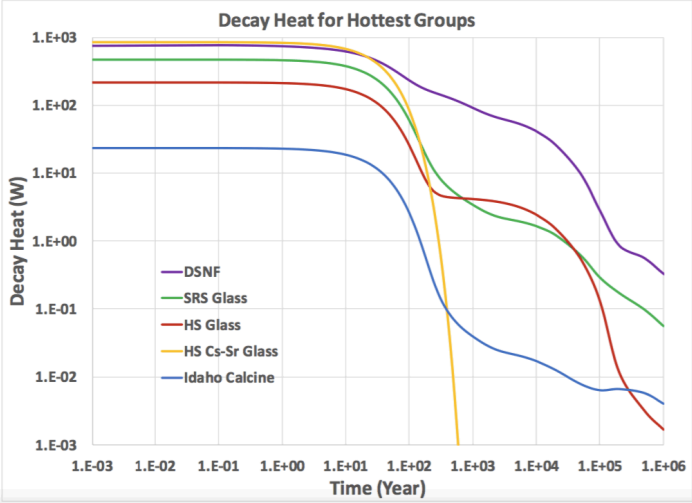
D-Rep Work Package Structure

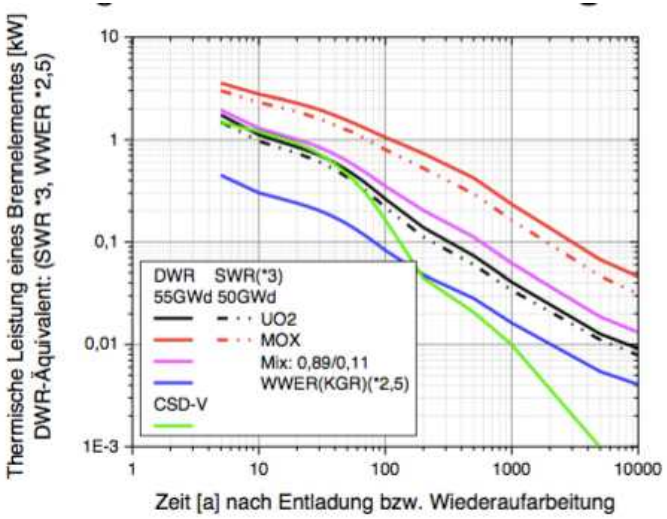


KOSINA Work Package Structure



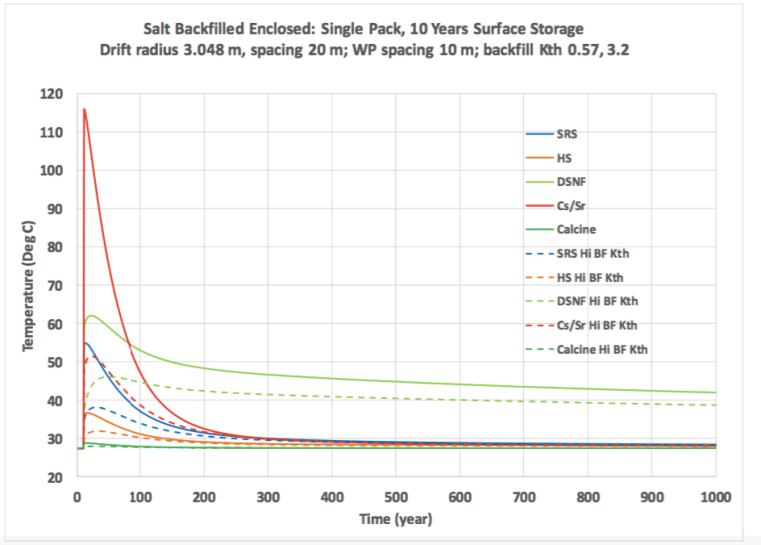
Comparison between DWR and KOSINA 2/3 – Decay Heat Differ

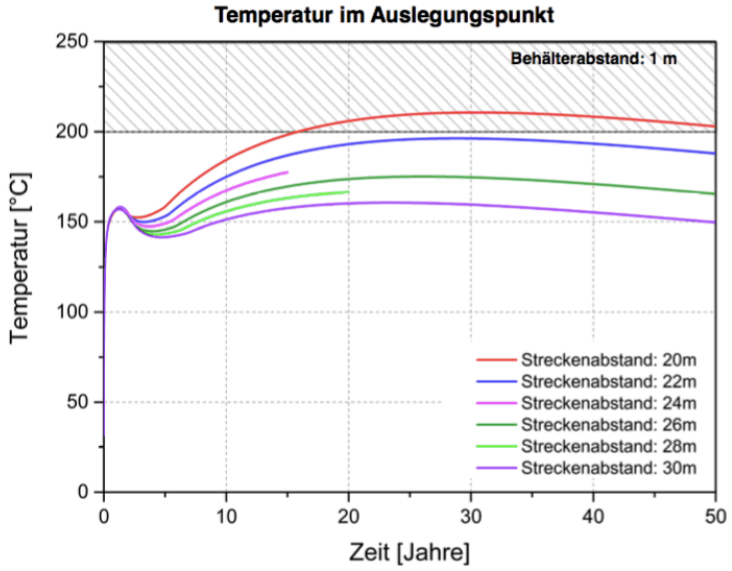




- KOSINA includes CSNF (Pollux-10 ~10 kW per can)
- DWR waste (HLW and DSNF) is much cooler (200-1000W per can)

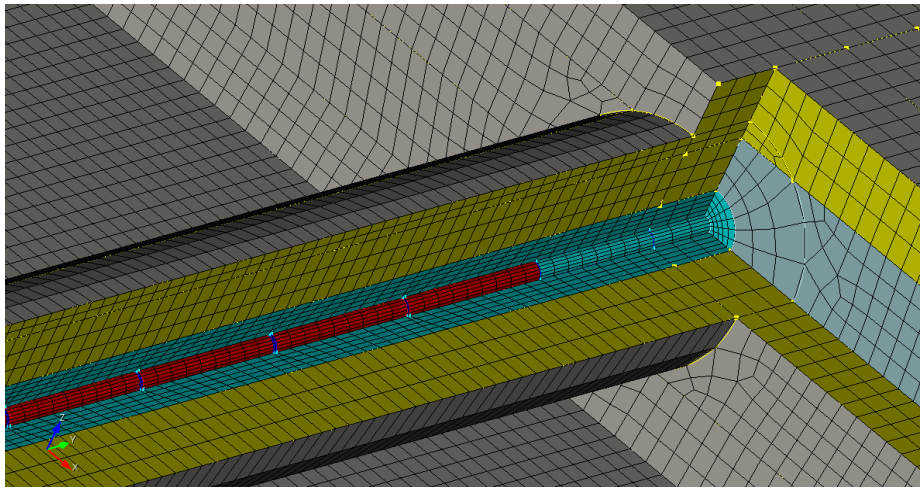
Comparison between DWR and KOSINA 3/3

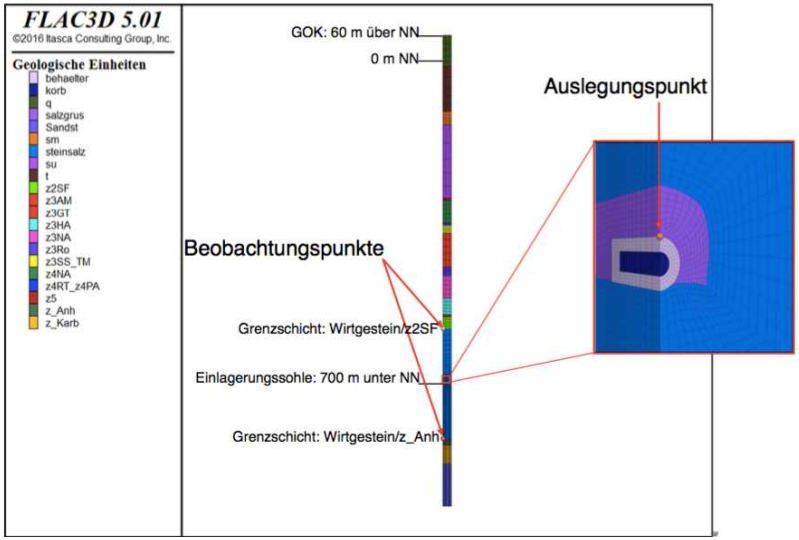




Thermal Design Benchmarking Study

- **Thermal Design**
  - DWR Semi-analytical vs. KOSINA FLAC3D
  - Benchmark of analytic codes – PFLOTRAN and FLAC3D
  - TH analysis – PFLOTRAN FLAC3D





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Joint Project WEIMOS (2016 – 2019)

Partners	Constitutive Models
Andreas Hampel, Mainz, Germany (Coordinator)	Composite Dilatancy Model (CDM)
IfG Leipzig, Germany	Günther/Salzer Model, Minkley Model
Leibniz Universität Hannover, Germany	Lubby-MDCF Model
Technische Universität Braunschweig, Germany	TUBSsalt
Technische Universität Clausthal, Germany	Lux/Wolters Model
Sandia National Laboratories, Albuquerque & Carlsbad, NM, USA	Munson-Dawson Model (creep)

Goal: Improved analysis and proof of long-term integrity of the rock salt geologic barrier

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Joint Project WEIMOS (April 2016 – March 2019)

WEIMOS ~ Further Development and Qualification of the Rock Mechanical Modeling for the Final HLW Disposal in Rock Salt

Identified needs for further development:

1. Deformation behavior at small deviatoric stresses
2. Deformation behavior resulting from tensile stresses
3. Influence of temperature and stress state on damage reduction and healing
4. Influence of inhomogeneities (layer boundaries, interfaces) on deformation

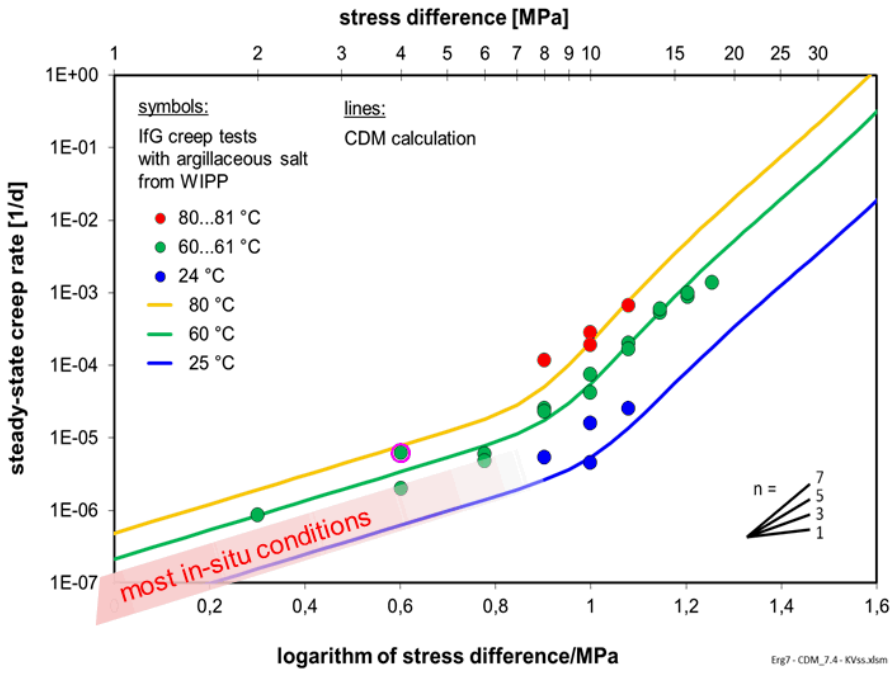
Main goal: Improved analysis and proof of long-term integrity of the geological barrier rock salt (CRZ: Containment providing Rock Zone)

Basis for WEIMOS: Joint Projects I – III

Joint Project	Period	**Main objectives: document, investigate and compare constitutive models and modeling procedures (parameter determination, performance of numerical calculations)**
I	2004 – 2006	Modeling of the basic deformation phenomena in rock salt: transient & steady-state creep, evolution of damage & dilatancy, creep failure, post-failure behavior, residual strength
II	2007 – 2010	Suitability to perform 3-D simulations of real underground structures (incl. temporal extrapolations, calculation of permeability in the DRZ)
III	2010 – 2016	Modeling of the • temperature dependence of deformation (-> HLW) • damage reduction and healing (-> long-term integrity)

Deformation at small, in-situ relevant deviatoric stresses

Example: steady-state creep rates of WIPP salt



Problem:

- *Currently, most lab test results at higher differential stresses $\Delta\sigma$*
- *at small differential stresses: very small creep rates*
- *modeling of deformation at small diff. stresses has strong influence on simulation of underground structures*
- *more experimental results and improved modeling at small differential (deviatoric) stresses are required*

WEIMOS:

- *triaxial lab creep tests at RT and small $\Delta\sigma$*
- *very stable boundary conditions*
- *strain measurement with very high resolution*

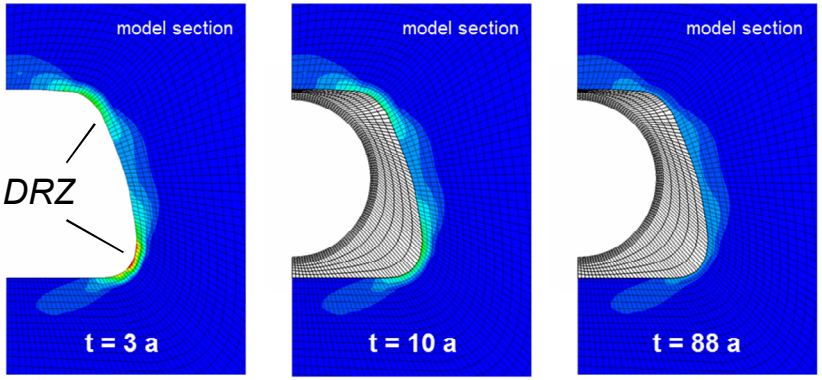
=> *improved and more reliable modeling*

Stress and Temperature dependence of damage reduction and healing

JP III: simulation of a drift with bulkhead:

t = 0 ... 3 a: open drift (evolution of DRZ)

t = 3 ... 88 a: drift with bulkhead (damage + dilatancy reduction)



Problem:

- *Currently, very few lab tests on damage and dilatancy reduction and healing of rock salt*
- *measurement of very small volume changes for > 100 days required*
- *modeling is necessary for correct simulation of evolution of tightness after closure of underground openings*
- *more experimental results and improved modeling required*

WEIMOS:

- *more healing tests at different T and stress states*
- *very stable boundary conditions for > 100 days*
- *dilatancy measurements with very high resolution*

=> improved and more reliable modeling

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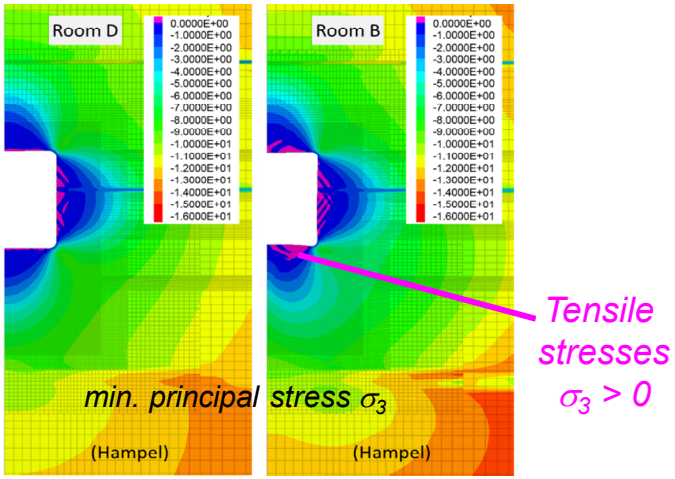
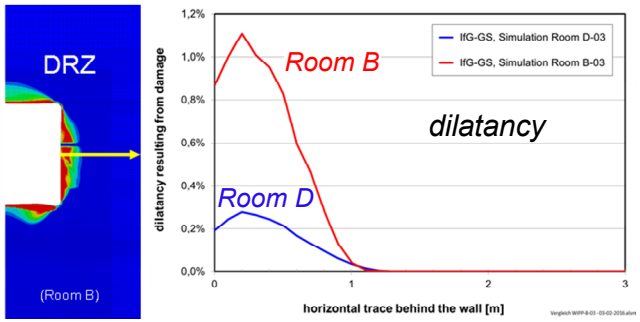
Deformation Resulting from Tensile Stresses

JP III: simulation of Rooms D & B (WIPP)





Problem:

- *tensile stresses have a strong influence on damage and dilatancy evolution in the DRZ*
- *modeling is necessary for correct simulation of evolution of DRZ around underground openings*
- *more studies and improved modeling required*

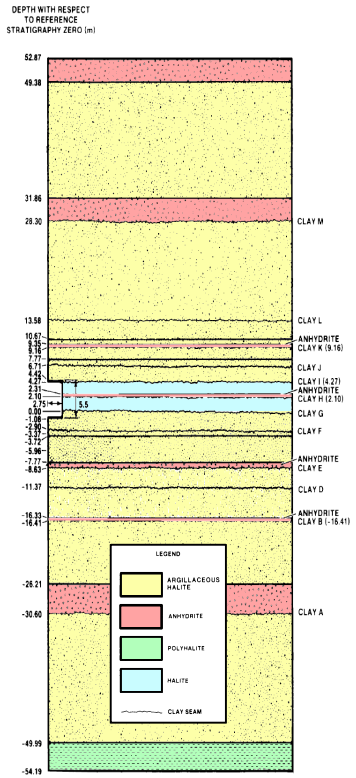
WEIMOS:

- *currently no lab tests possible (funding, time)*
- *=> basic calculation studies performed:*
  a) bending beam
  b) Brazilian test

=> comparison of partners' modeling of tensile deformation, documentation of current status of modeling, improvement of modeling

Modeling of Layer Boundaries and Interfaces

WIPP stratigraphy around Rooms B & D



Munson et al. (1990): Sandia Report SAND89-2671

Problem:

- *stratigraphic layers (anhydrite, clay seams) have influence on room convergence*
- *modeling is necessary for correct simulation of convergence of underground openings (especially in bedded salt like WIPP)*
- *more experimental results and improved modeling required*

WEIMOS:

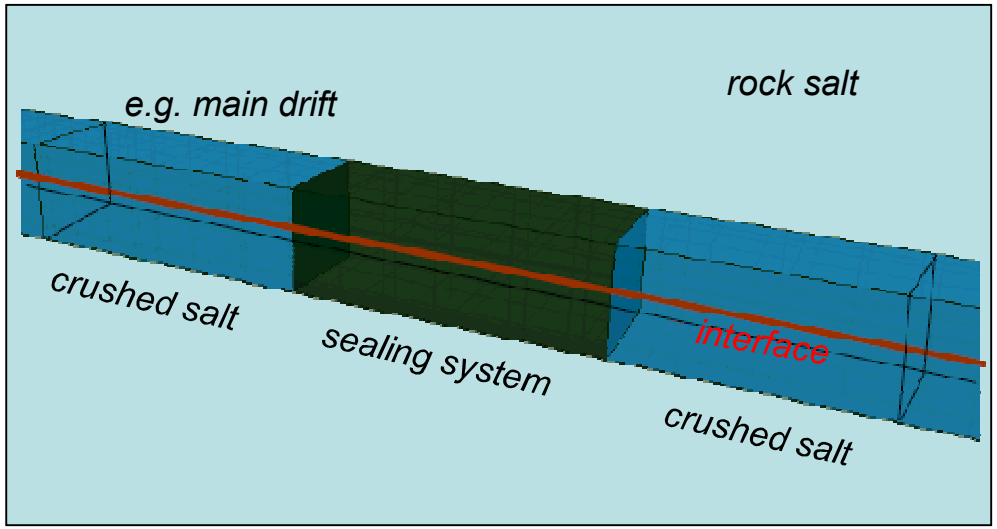
- *Sandia/RESPEC lab tests with layered samples planned (funding required)*

⇒ *basis for improvement of modeling*

⇒ *reduction of uncertainties of model predictions*

Demonstrating Improved Models in WEIMOS: Virtual Demonstrator

Simulation of a complex model to demonstrate the improved modeling of the various investigated phenomena



- *small deviatoric stresses*
- *damage reduction and healing*
- *influence of interfaces/layer boundaries*
- *influence of e.g. thermally induced tensile stresses*

Simulation:
step 1: open drift
step 2: installation of dam & backfill
step 3: post-operational phase and long-term behavior

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Summary: Joint Project WEIMOS (April 2016 – March 2019)

Identified needs for further development:

1. *Deformation behavior at small deviatoric stresses*
2. *Influence of temperature and stress state on damage reduction*
3. *Deformation behavior resulting from tensile stresses*
4. *Influence of inhomogeneities (layer boundaries, interfaces) on deformation*

Procedure:

→ *Laboratory tests, microstructural investigations, optional: in-situ measurements.*

→ *Recalculations of the lab tests, simulations of basic examples and real in-situ structures.*

→ *Further development of the rock mechanical modeling.*

→ *Comparison of results, validation and qualification of the models and modeling procedures.*

Main goal: Improved analysis and proof of long-term integrity of the geological barrier rock salt (CRZ: Containment providing Rock Zone)