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Laboratory Tests on WIPP Salt argillaceous salt

funded by federal ministry of economic affairs and energy

1. Objective
2. Overview test program
3. Results of short term tests to determine failure and dilation strength
4. Results of long term tests to determine damage free and damage induced creep behavior
5. Characterization of material properties based on lab tests

5th US/German Workshop on Salt Repository Research, Design and Operations
Santa Fe – 9th September 2014
apl. Prof. Dr.-Ing. habil. U. Düsterloh – Clausthal University of Technology - Chair for Waste Disposal Technologies and Geomechanics

Objective

- **Benchmark calculations of Room B and Room D**

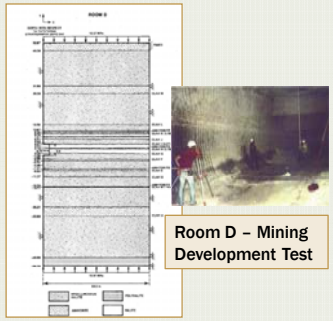
☺ A comprehensive data base for WIPP-salt exists from investigations in the 80 – 90's, but

☹ Due to the development of existing and new material laws tailored test series facilitating specific material parameters are missing.

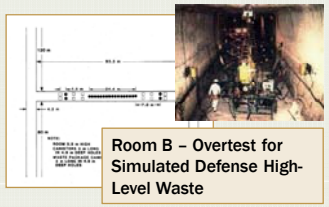
- **Geomechanical charakterization of the WIPP-rock salt :**
  - **"clean salt" or "Halite"**
  - **"argillaceous salt"**
  - **Temperature effect**

➔ **Strength testing**

➔ **Creep tests**



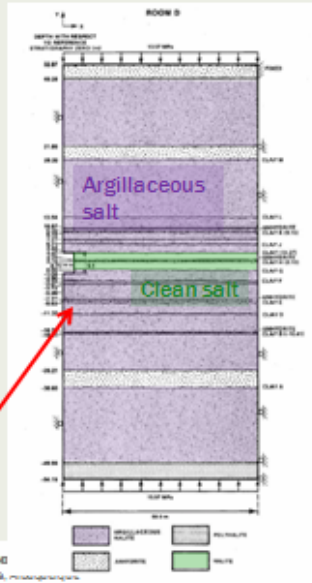
Room D – Mining Development Test



Room B – Overtest for Simulated Defense High-Level Waste

Lithology: „Clean salt" – „Argillaceous salt"

Note the lighter and darker bands. These indicate varying levels of other materials present in the salt, such as clay or wind-blown dust deposited.



Drilling and wrapping of cores at WIPP - site

Preparation of a test specimen on a lathe

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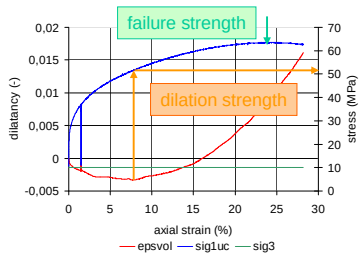
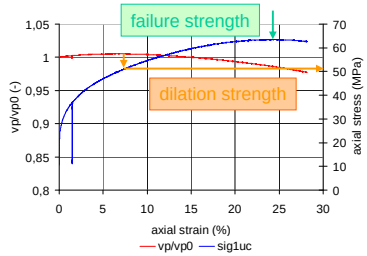
Laboratory program on argillaceous salt from WIPP to determine failure strength and dilation strength -

σ_3 MPa	strain rate 1/s	T °C	planned -	carried out -	in progress -
0,2 - 20	1,00E-05	27	14	10	0
0,2 - 20	1,00E-05	60	14	19	0
0,2 - 20	1,00E-05	100	14	14	0
0,2 - 20	1,00E-04	27	5	0	5
0,2 - 20	1,00E-06	27	14	14	0
Σ			**61**	**57**	**5**





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testing procedure and determination of physical parameters

(1) measure of length, diameter, mass in each case

(2) measure of unloaded ultrasonic wave velocity in each case

(3) digital photography of each sample prior to test

(4) one day isotropic recompaction at σ_{iso} = 20MPa and heating at 27°C, 60°C, 100°C respectively prior to each test

(5) including an unload-reload cycle to each test by reaching ε_1 = 1,5% (in case of $\sigma_3 \geq$ 1MPa) respectively ε_1 = 1,0% (in case of σ_3 < 1MPa)

(6) digital photography of each sample after test was finished

(7) oven drying of selected samples

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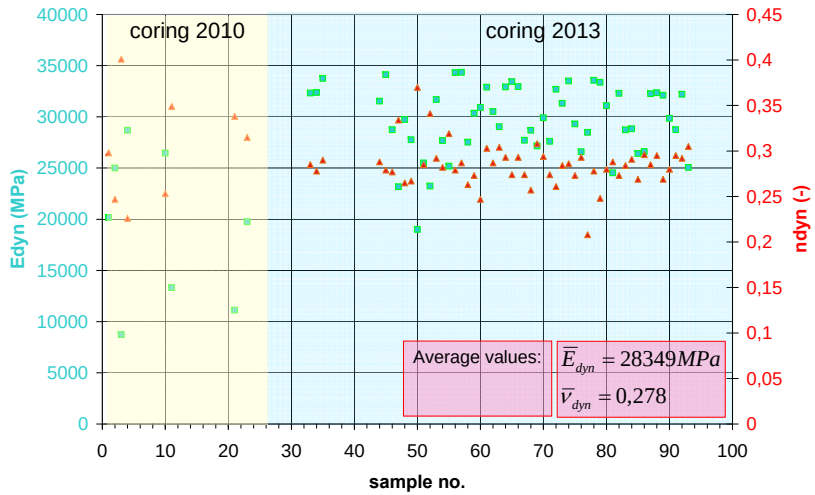
$$E_{dyn} = \frac{vs^2 \cdot \rho \cdot \left(3vp^2 - 4vs^2\right)}{vp^2 - vs^2}$$

$$\nu_{dyn} = \frac{vp^2 - 2vs^2}{2 \cdot \left(vp^2 - vs^2\right)}$$

physical parameter argillaceous salt WIPP



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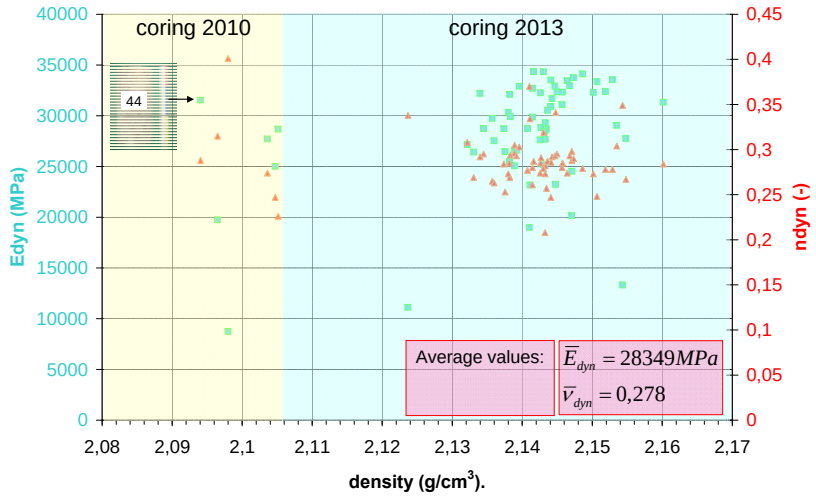

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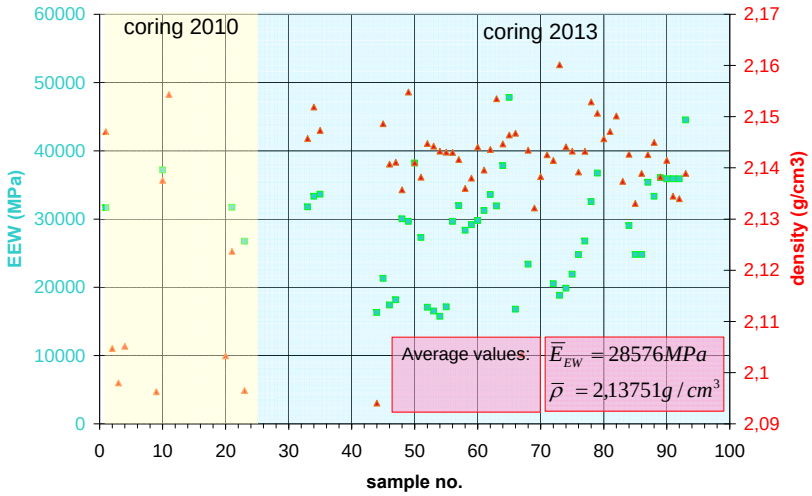

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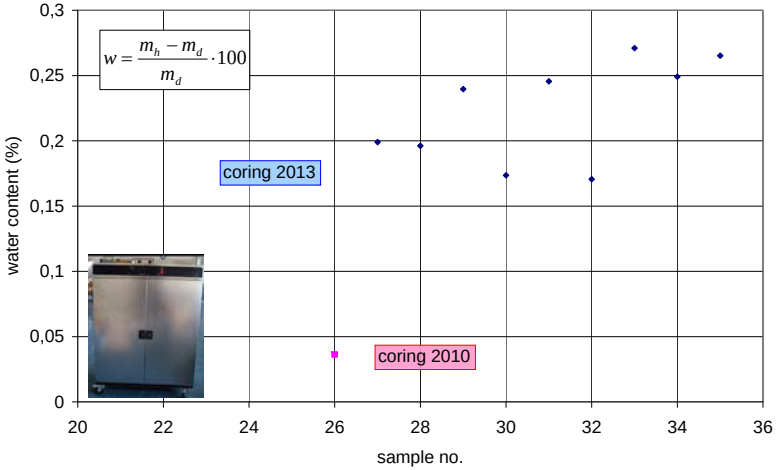

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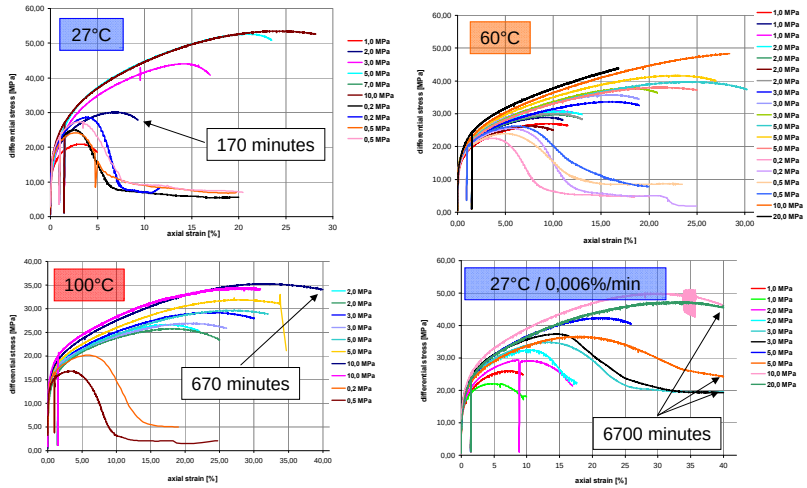
strength tests argillaceous salt WIPP



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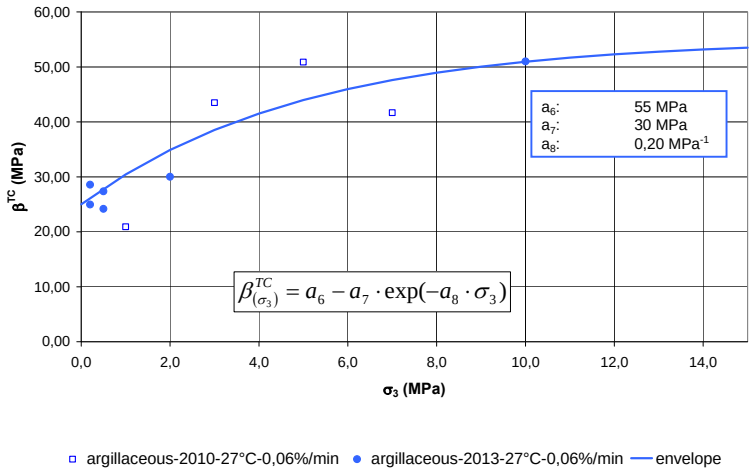
Failure strength argillaceous salt WIPP



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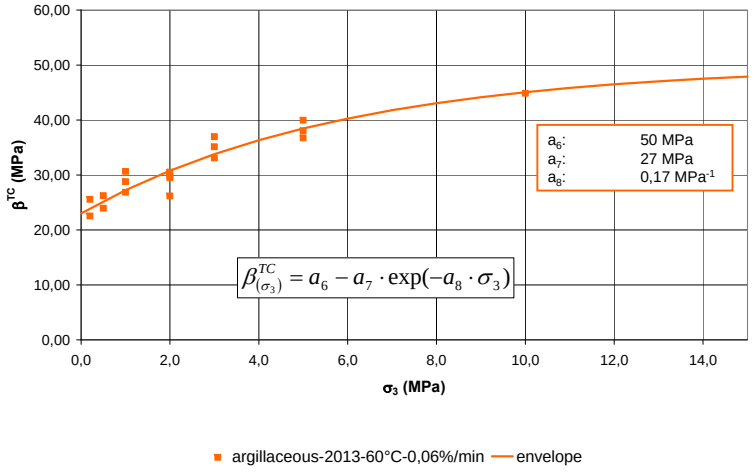

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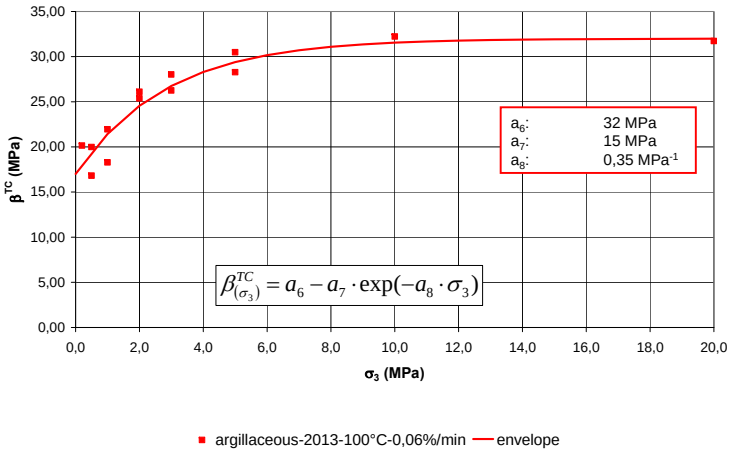

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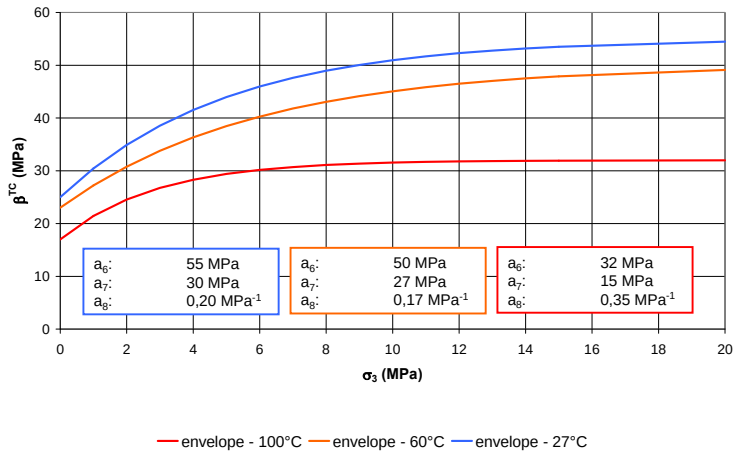
Failure strength argillaceous salt WIPP

$$\beta^{TC}_{(\sigma_3)} = a_6 - a_7 \cdot \exp(-a_8 \cdot \sigma_3)$$



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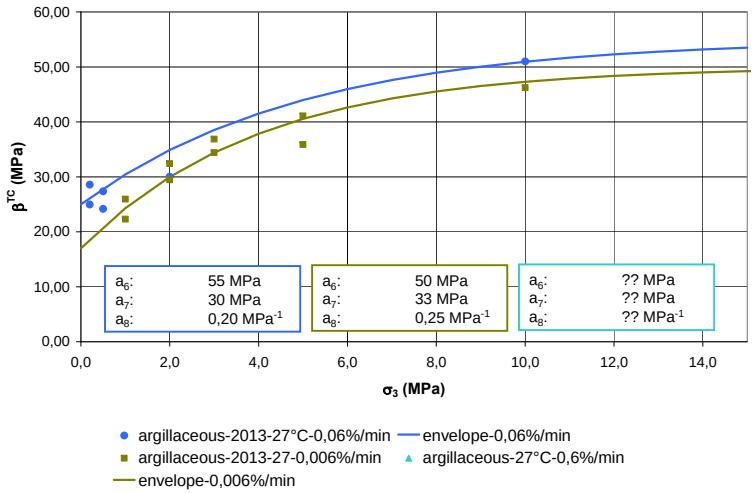

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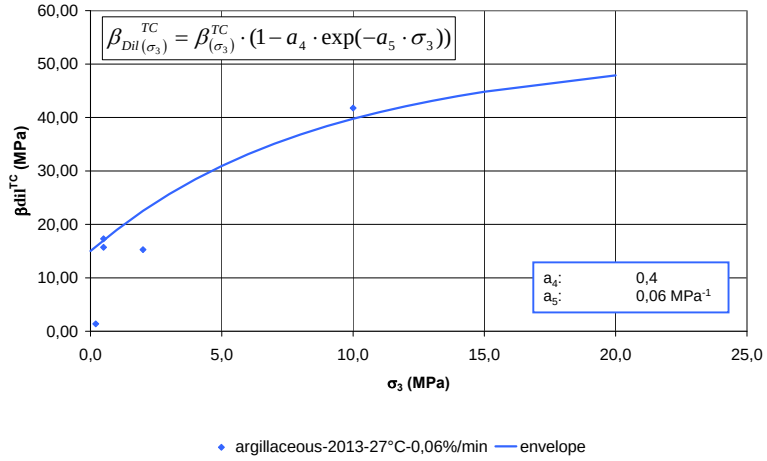
Dilation strength argillaceous salt WIPP

$$\beta^{TC}_{Dil(\sigma_3)} = \beta^{TC}_{(\sigma_3)} \cdot (1 - a_4 \cdot \exp(-a_5 \cdot \sigma_3))$$



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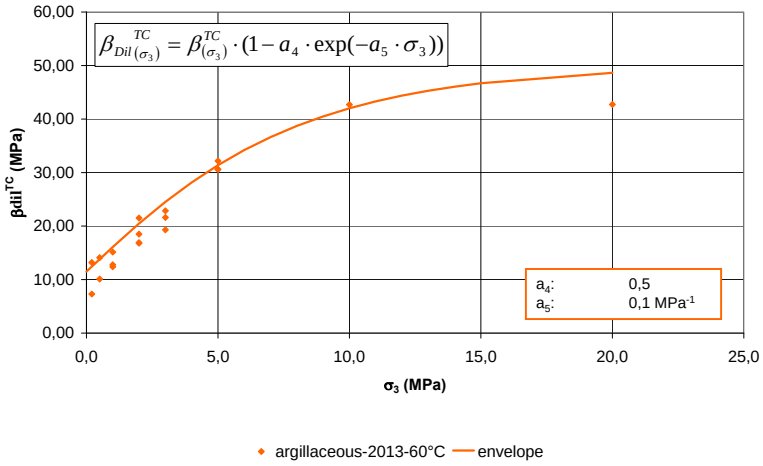

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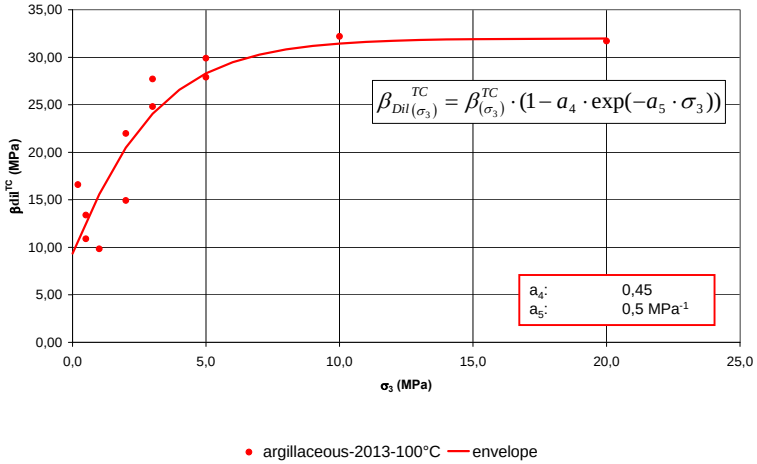

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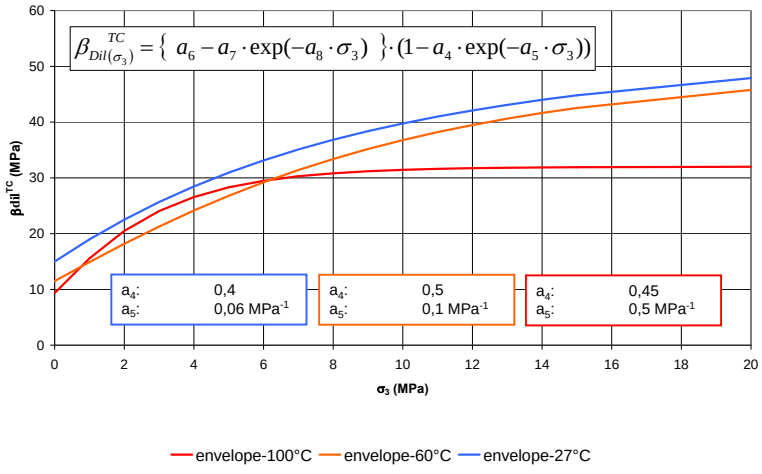
Dilation strength argillaceous salt WIPP



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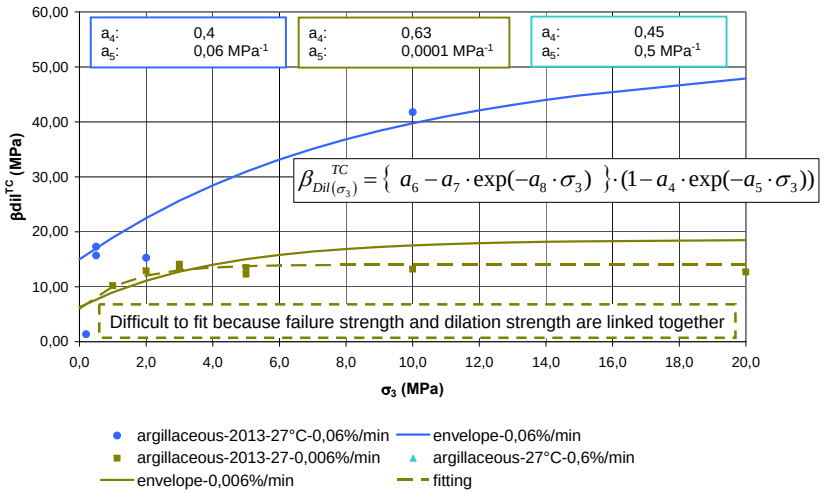
Dilation strength argillaceous salt WIPP



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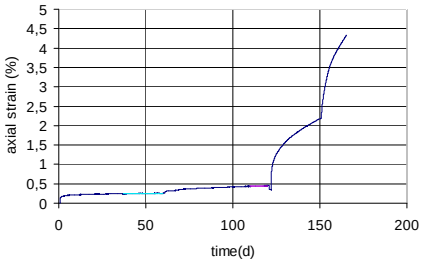
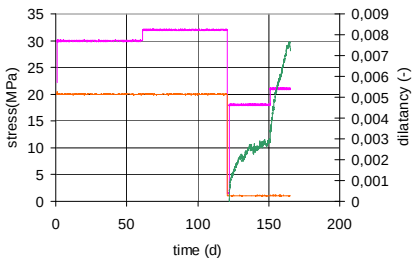
Laboratory program on argillaceous salt from WIPP to determine creep behaviour

σ_3 MPa	σ_{eq} MPa	T °C	load level -	duration d	loading / unloading	above/below dilation strength	planned -	carried out -	in progress -
20	>10	27	2	60/60	L/U	b/b	3	6	0
20	>10	60	2	60/60	L/U	b/b	5	8	0
20	>10	80	2	60/60	L/U	b/b	2	2	0
20	<10	60	1	120	L	b	2	0	0
20		27/60/80	3	60/60/60	L/L/L	b	2	0	0
different	different	27	4	60/60/30/30	L/L/L/L	b/b/a/a	3	4	0
?	?	?	?	?	?	?	3	0	0
							Σ = 20	**Σ = 20**	**Σ = 0**





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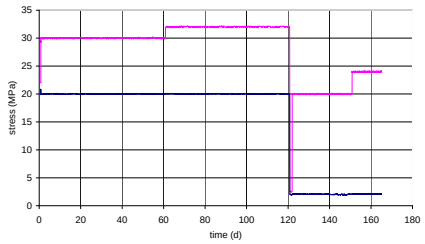
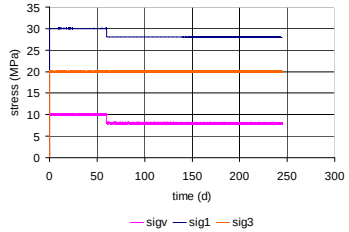
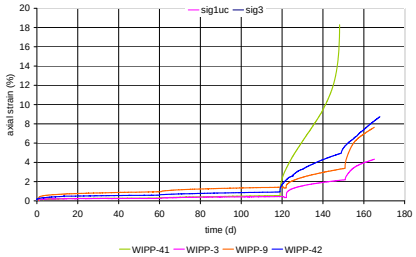
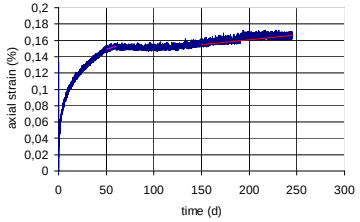
Creep tests argillaceous salt WIPP

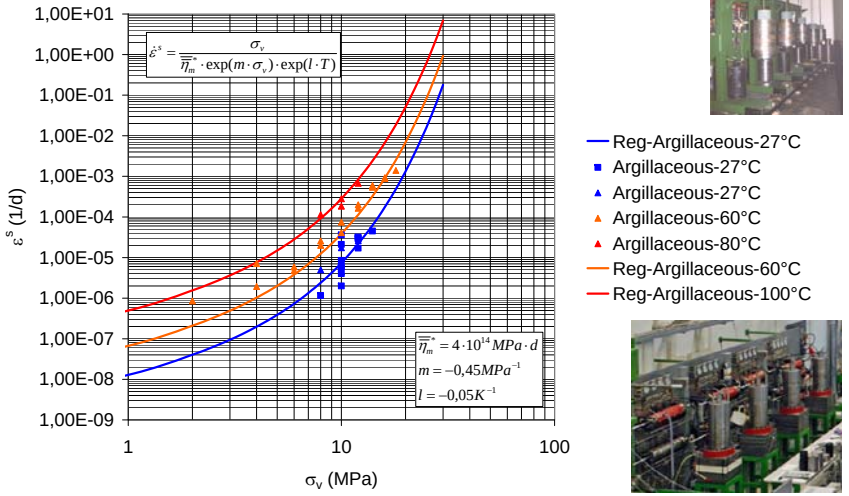
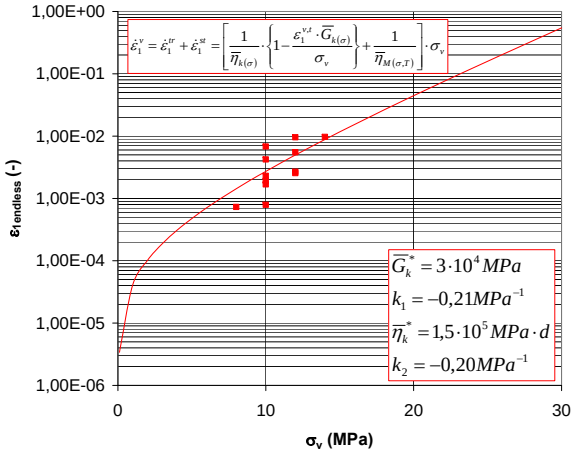
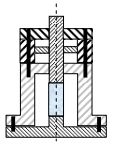








Stationary creep parameter argillaceous salt WIPP



Transient creep parameter argillaceous salt WIPP