A BENCHMARK EXERCISE TO INVESTIGATE THE THERMAL EFFECTS ON THE EXCAVATED DAMAGE ZONE

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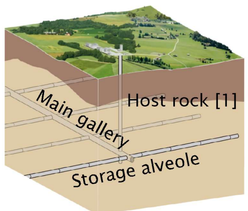
ON CLAYS IN NATURAL AND ENGINEERED BARRIERS FOR RADIOACTIVE WASTE CONFINEMENT

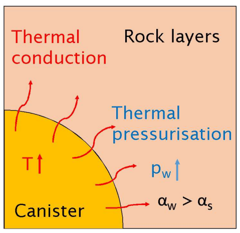
Context

Deep geological disposal:

- Multi-barrier confinement
- Long-term management
- T-H-M-C coupling process

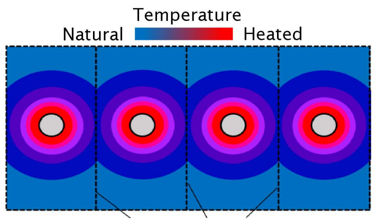


Thermal effects:



Near field:

- Excess pore pressure
- Fracture re-opening/propagation
- Alter permeability



Symmetric axes: No horizontal deformation
No horizontal heat/water flow [2]

Far field:

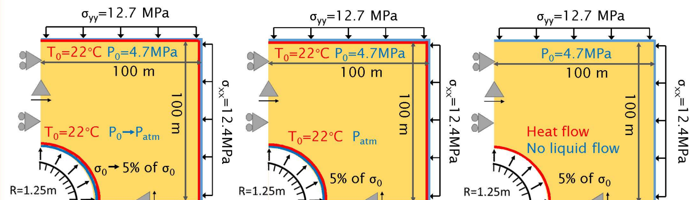
- Tensile failure
- Shear failure
- Reactivate old fractures/faults

Objective:

Reproduce the shear strain localisation and the in-situ observations induced by thermal effects.

Numerical modelling

- EURAD HITEC [3]: 2D plane strain generic model



Excavation 0~24 h | Waiting 24 h~180 days | Heating 180 days~10 years

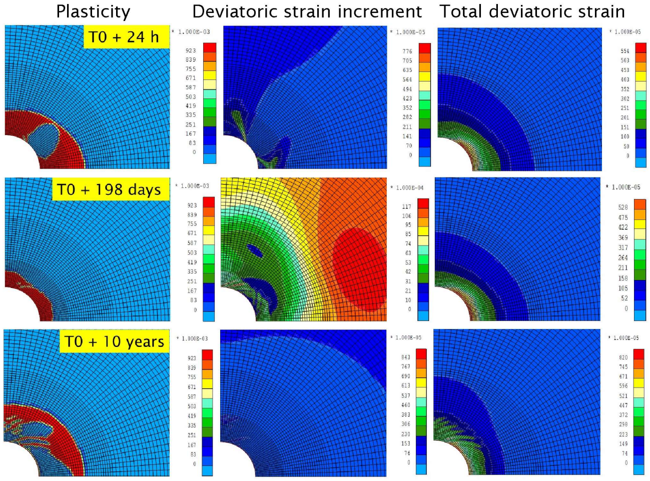
- Constitutive model:
  First gradient: Van Eekelen, hardening, softening
  Second gradient [4]: Internal length scale, microstructure effect
- Callovo-Oxfordian claystone parameters:

Elastic parameters		Plastic parameters		T-H parameters	
ρ_s (kg/m^3)	2639	$\psi_c = \psi_e$ (°)	5	c_s (J/kg/K)	790
n (-)	0.18	$\phi_{c,0}$ (°)	10	α_s (K^{-1})	1.25E^{-5}
$E_{//}$ (MPa)	8000	$\phi_{c,f}$ (°)	23	c_w (J/kg/K)	4180
$E_\perp$ (MPa)	5000	$\phi_{e,0}$ (°)	7	$\lambda_{//}$ (W/m/K)	1.88
$v_{////}$ (-)	0.21	$\phi_{e,f}$ (°)	23	$\lambda_\perp$ (W/m/K)	1.25
$v_{//\perp}$ (-)	0.35	$\bar{c}$ (MPa)	4.1	$k_{//}$ (m^2)	3.9E^{-20}
$G_\perp$ (MPa)	2500	$A_{//}$ (-)	0.117	$k_\perp$ (m^2)	1.3E^{-20}
$b_{//}$ (-)	0.83	$b1$ (-)	14.24	χ_w^{-1}(MPa^{-1})	4.5E^{-4}
$b_\perp$ (-)	0.87	ξ_c (-)	5	D (kN)	15

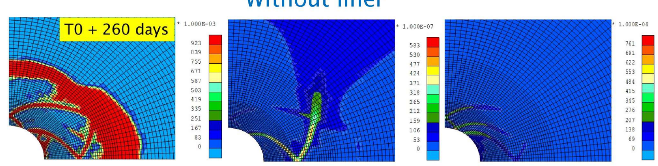
Numerical results (performed by Finite element code LAGAMINE)

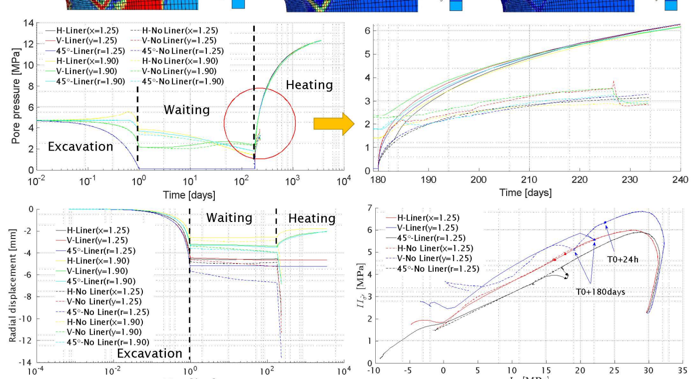
With liner (Gap = 4.63 mm)

Plasticity | Deviatoric strain increment | Total deviatoric strain



Without liner





Conclusions

- The shear banding zone develops preferentially in the direction of the minor principal stress. During the heating, the shear strain localisation is highly pronounced.
- The liner plays a critical role in reproducing the in-situ coupling behaviour at EDZ, both the development of plasticity and shear bands.
- A tensile failure criterion will be taken into account to better represent the extensional stress pathways.

References

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