SELFRAC Exchange Meeting
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STUDY OF THE SEALING/HEALING PROCESSES BY ACOUSTIC EMISSION MEASUREMENTS

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Aim of research

Around excavations in clay formations:

Micro- and macro-fractures occur

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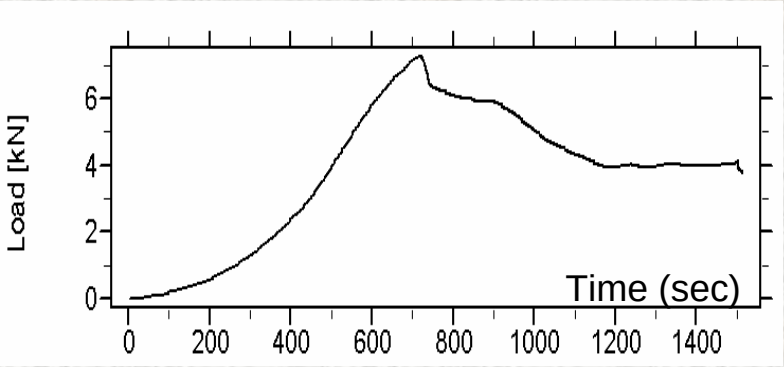
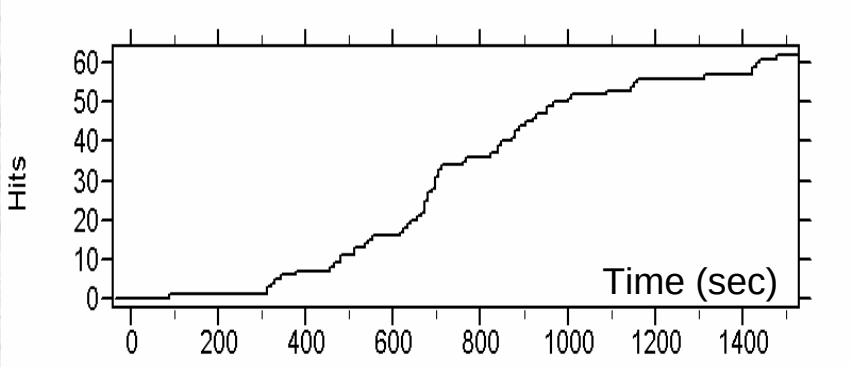
What happens with time ?

1. Acoustic Emission (AE) method was applied
2. Memory or Kaiser effect (KE) was analysed

Acoustic Emission (AE)

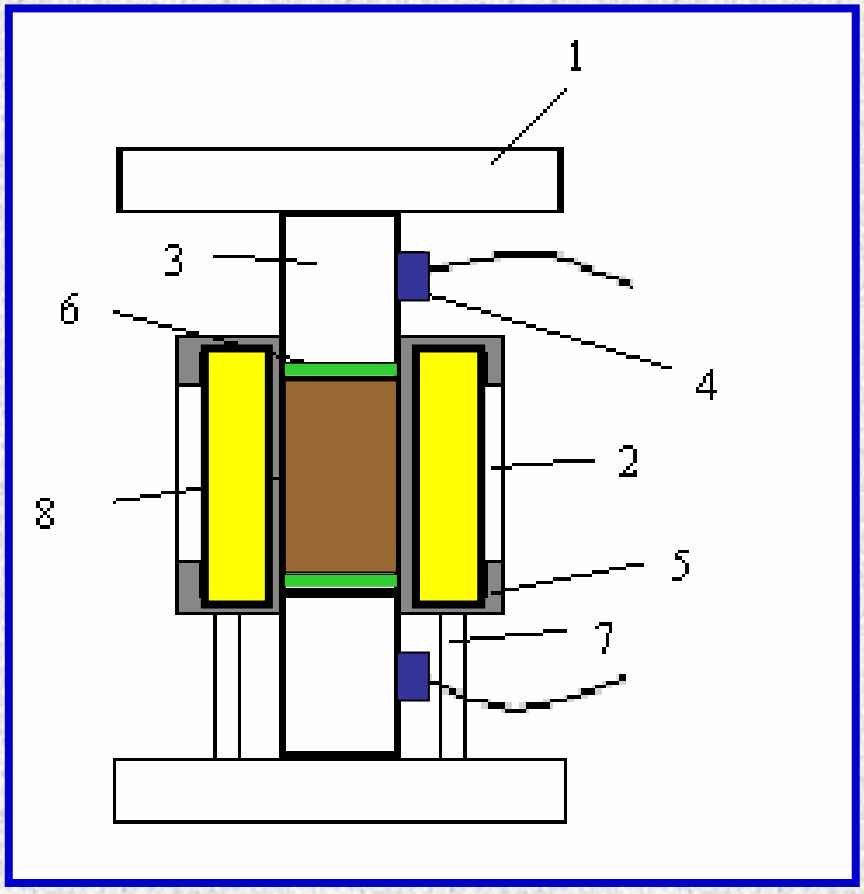
During ‘micro-fracturing’, energy strain wave is released and can be recorded.

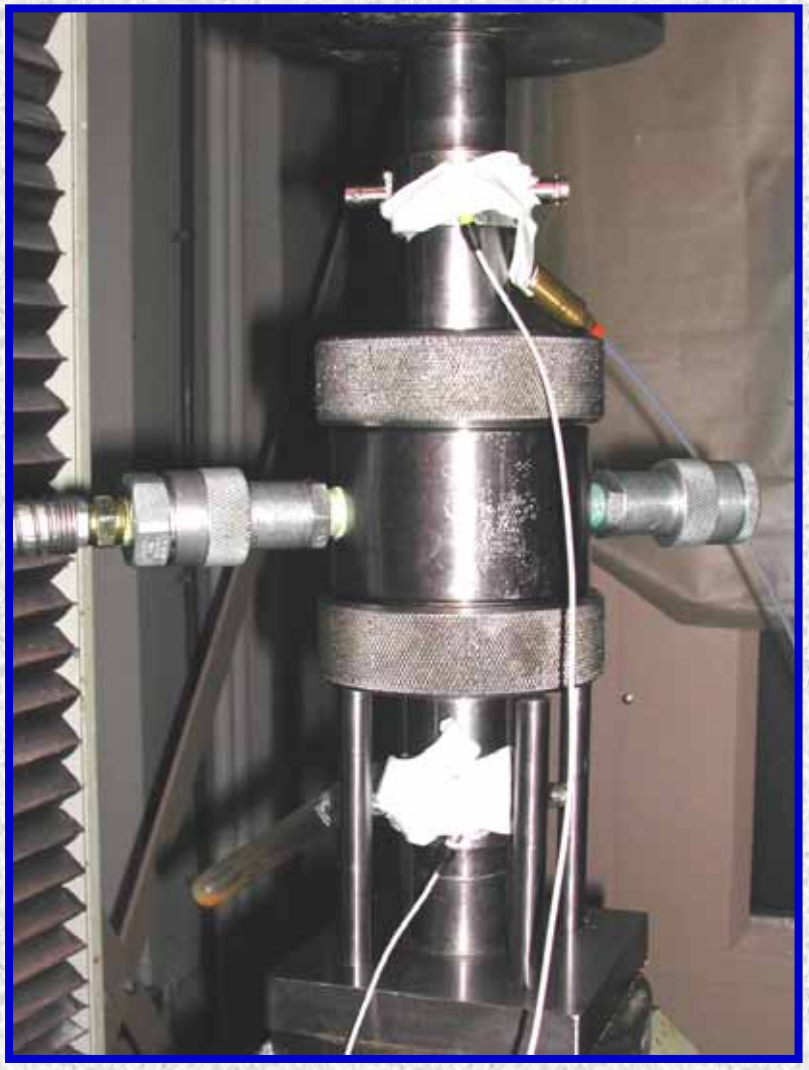




Acoustic Emission (AE)

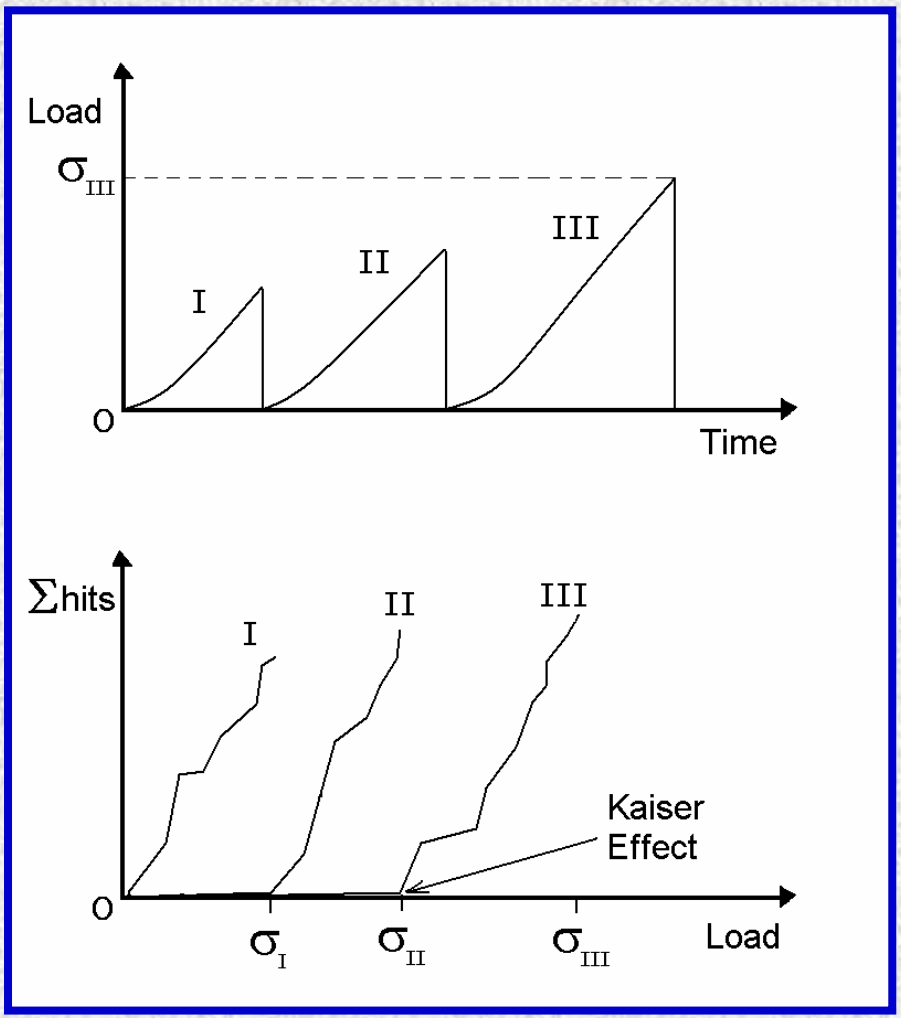
Experimental set-up





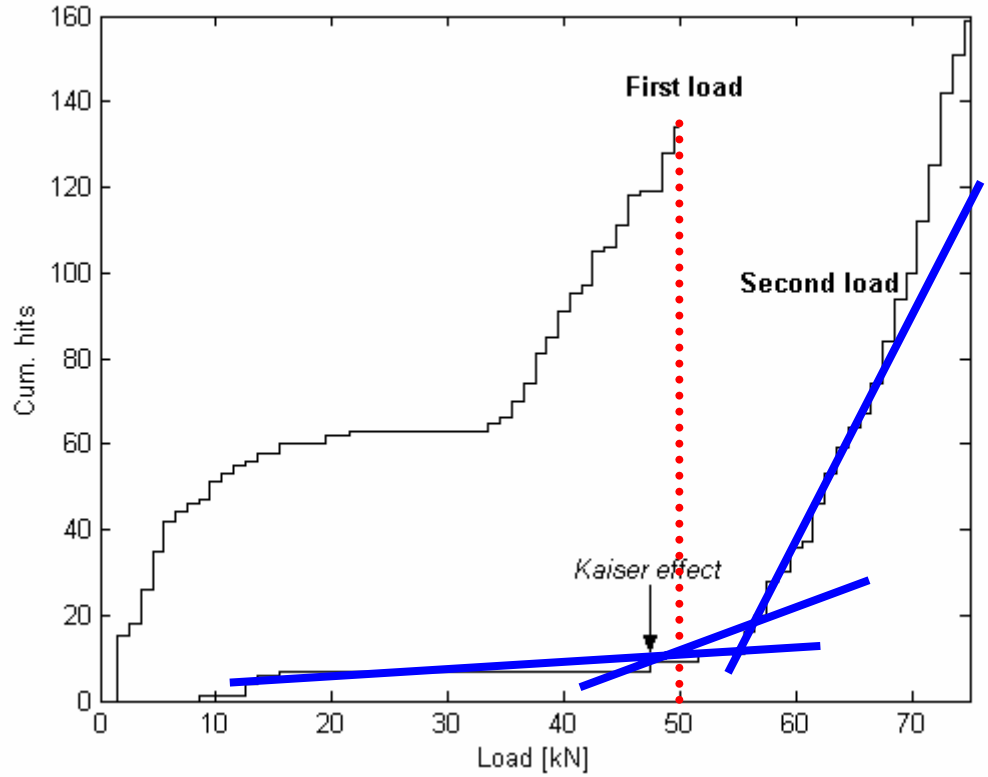
Memory or Kaiser effect (KE)

If rock under stress is unloaded and reloaded, it is generally observed that the AE activity remains low till the previous maximum load level is reached.



Memory or Kaiser effect (KE)

Kaiser effect in shales (uni-axial loading)



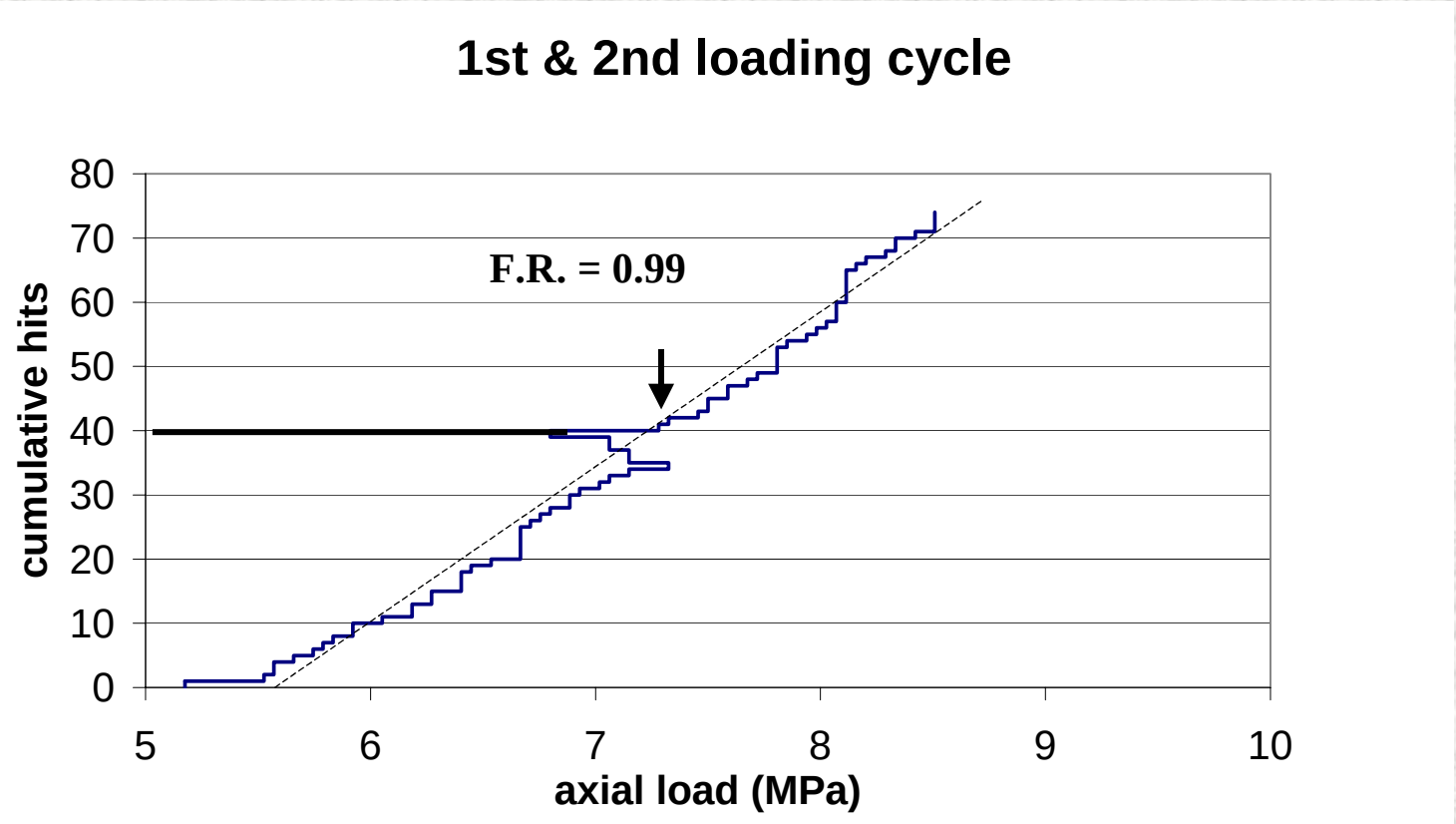
Memory or Kaiser effect (KE)

Kaiser effect in Opalinus Clay (tri-axial loading)

1. Isotropic tri-axial load of 5 MPa & pore pressure of 0.5 MPa (minimum of 48 hours)
2. Circumferential load and pore pressure remain constant, while axial load increases (e.g. to 7.5 MPa)
3. Axial load decreases, followed by a new increase (e.g. till failure)

Memory or Kaiser effect (KE)

Kaiser effect in Opalinus Clay (tri-axial loading)



Evolution with time

Healing of induced micro-fractures

What happens with the Kaiser effect as a function of time ?

What happens with the micro-fractures as a function of time ?

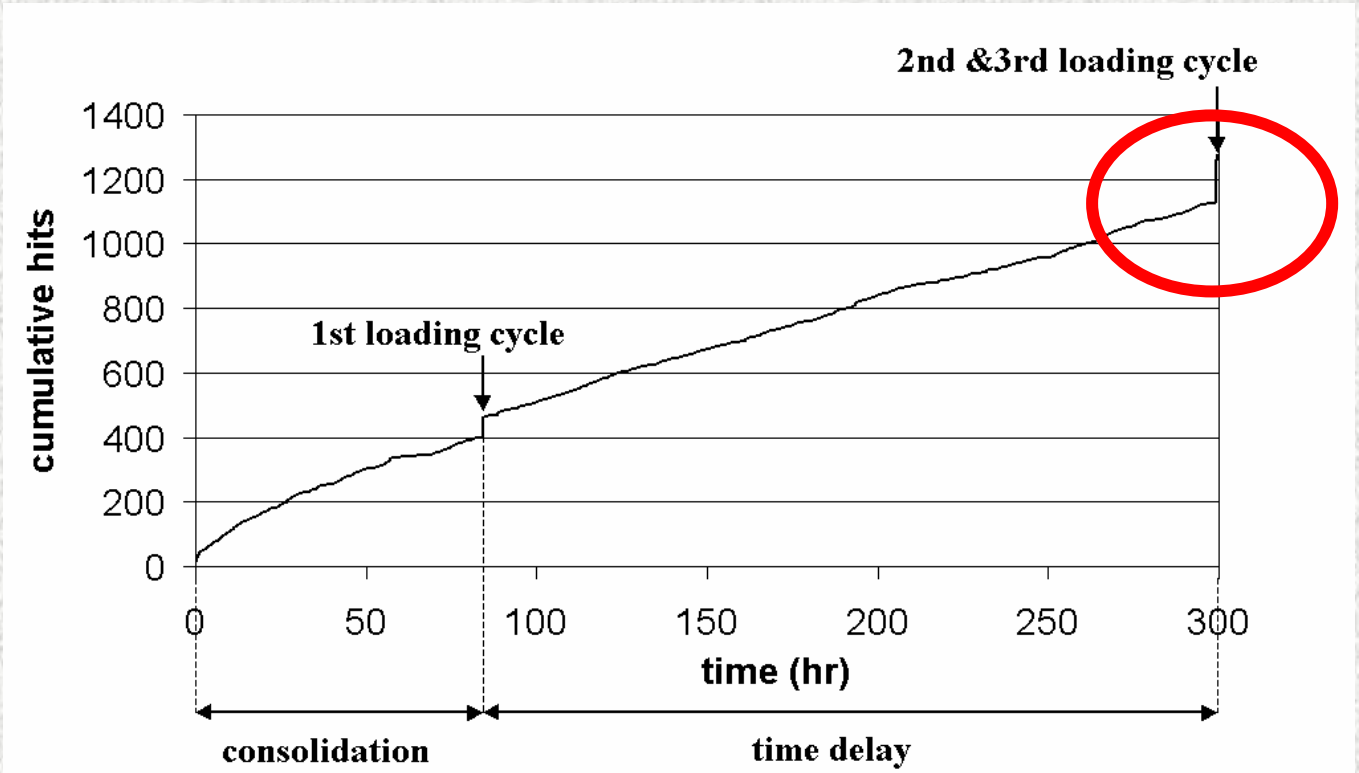
Between 1st and 2nd cycle: interval of 1 to 30 days

Isotropic stress state of 5 MPa

Pore pressure of 0.5 MPa

Evolution with time

Boom Clay: Entire test

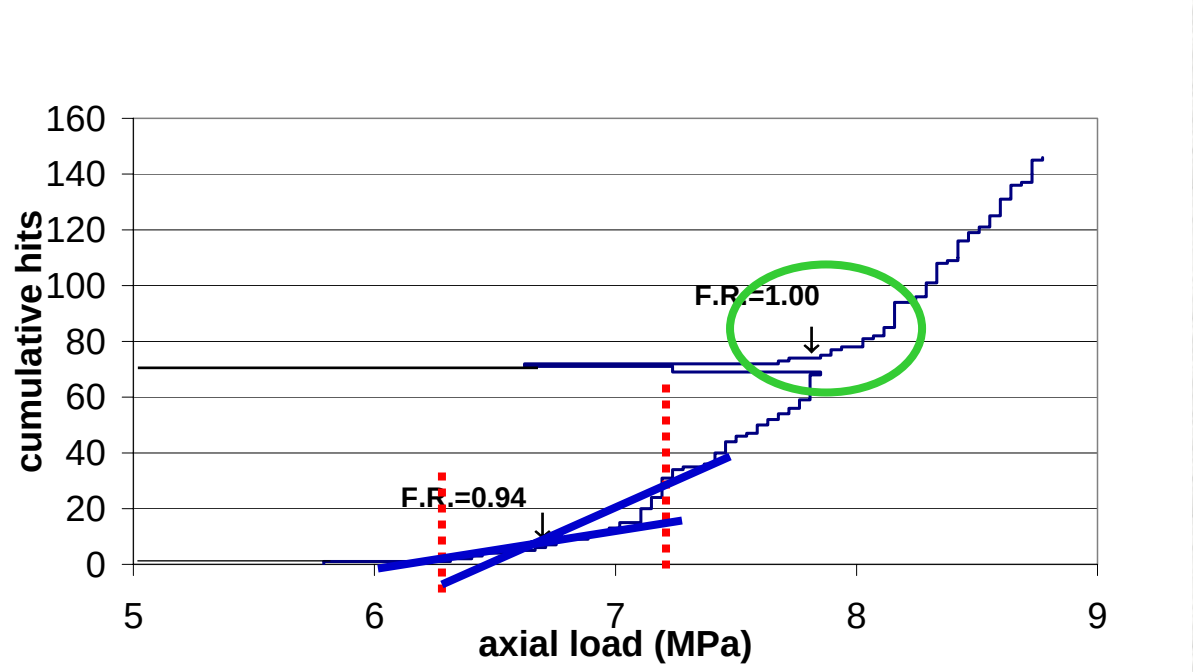


3 hits/hour

9 days delay

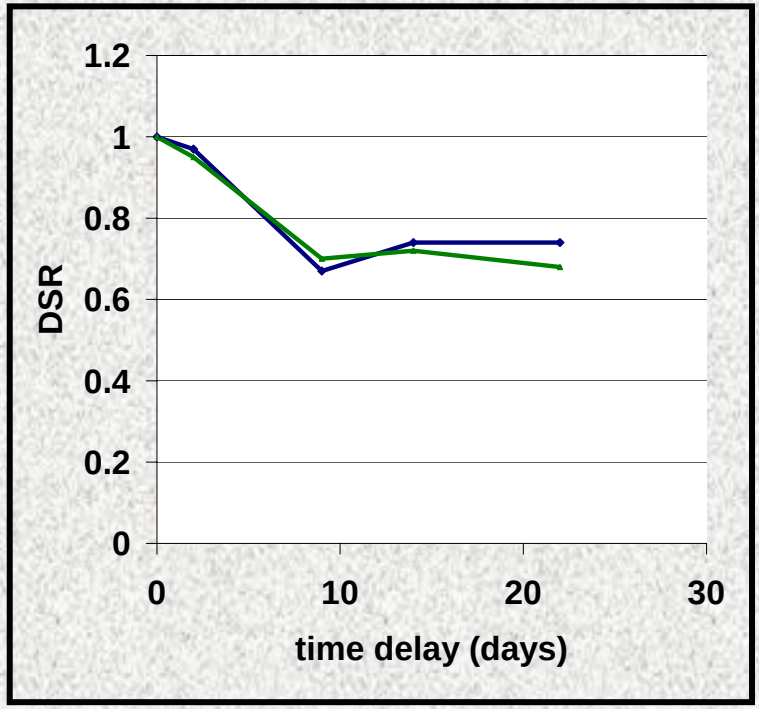
Evolution with time

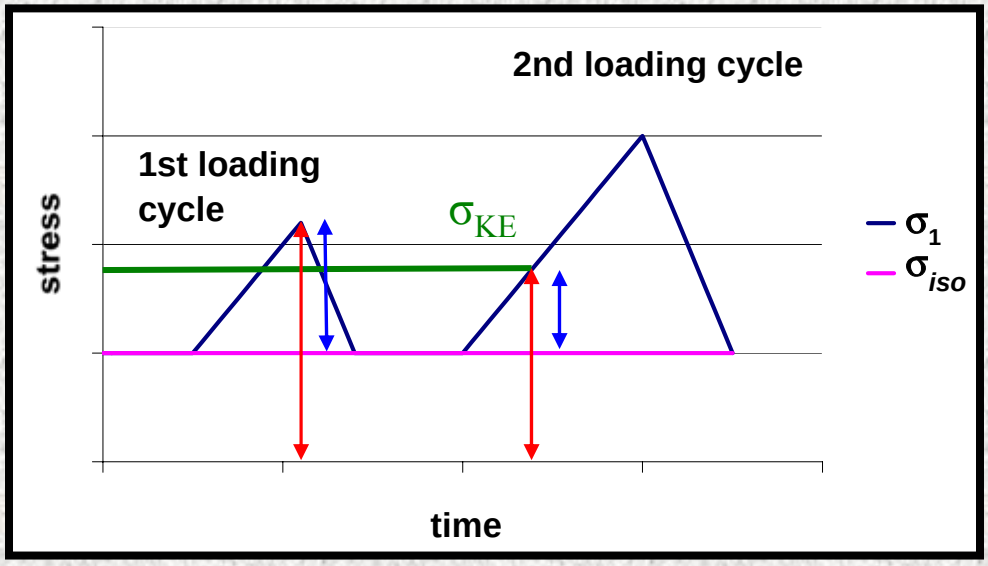
Boom Clay: 2nd (9 days delay) and 3rd cycle (immediately)



Evolution with time

Overview of all results





Boom clay

Opalinus clay

$$Fr = \frac{\sigma_{1K.E.}^{II}}{\sigma_{1max}^{I}}$$

$$DSR = \frac{(\sigma_1 - \sigma_{ISO})_{K.E.}^{II}}{(\sigma_1 - \sigma_{ISO})_{max}^{I}}$$

Discussion

Laboratory

Loading of sample

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Damage induced

Characterised by AE

Partial unloading, **time delay**, reloading

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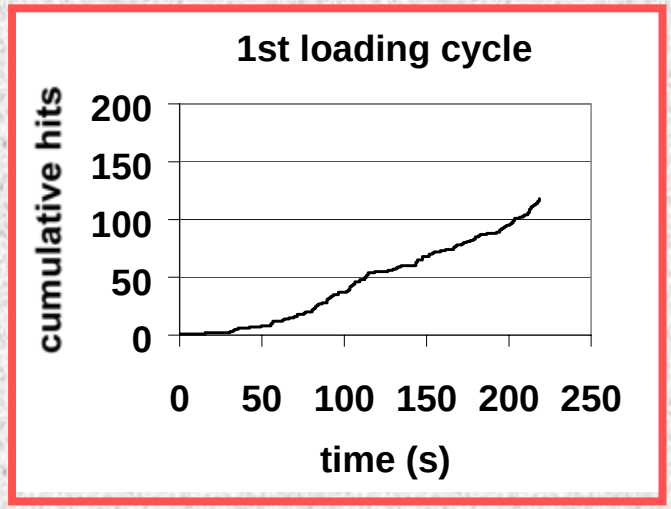
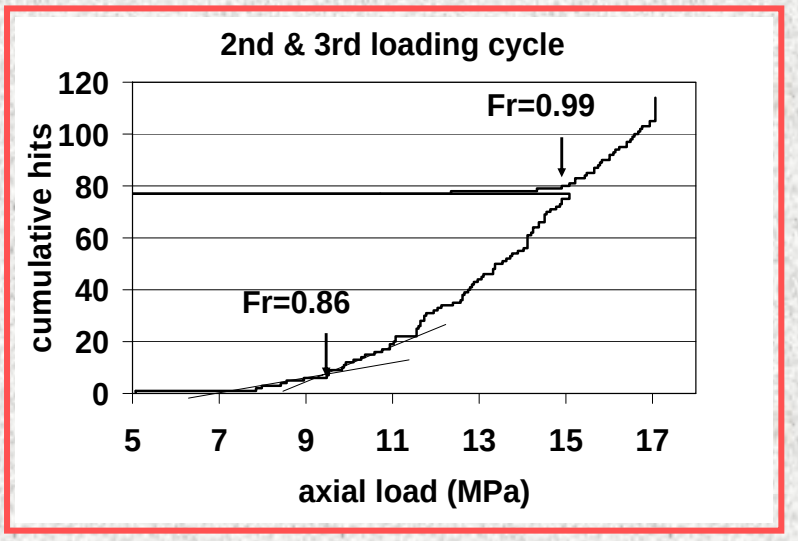
KE is less (decrease in Fr and in DSR)





Discussion

Laboratory

Loading of sample

↓

Damage induced

Characterised by AE

Partial unloading, **time delay**, reloading

↓

KE is less (decrease in Fr and in DSR)

In situ

Stress re-distribution during excavation

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Damage induced (micro- and macro-fractures)

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Loss of cohesion

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Increase of cohesion with time

= Healing

?

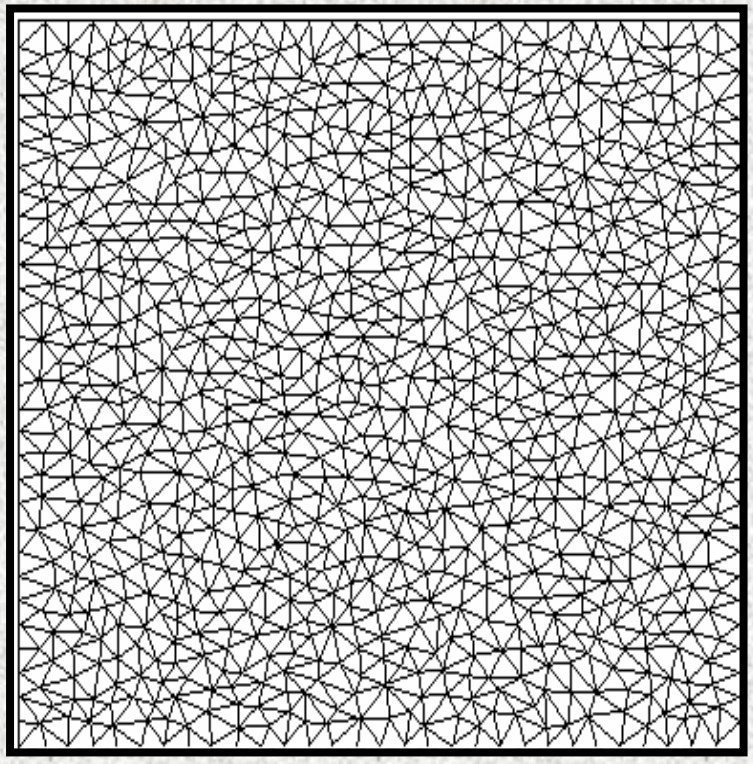
Numerical simulations

Boundary element code DIGS:

Pre-defined mesh of elements

Different properties given to elements (e.g. flaws, intact elements, …)

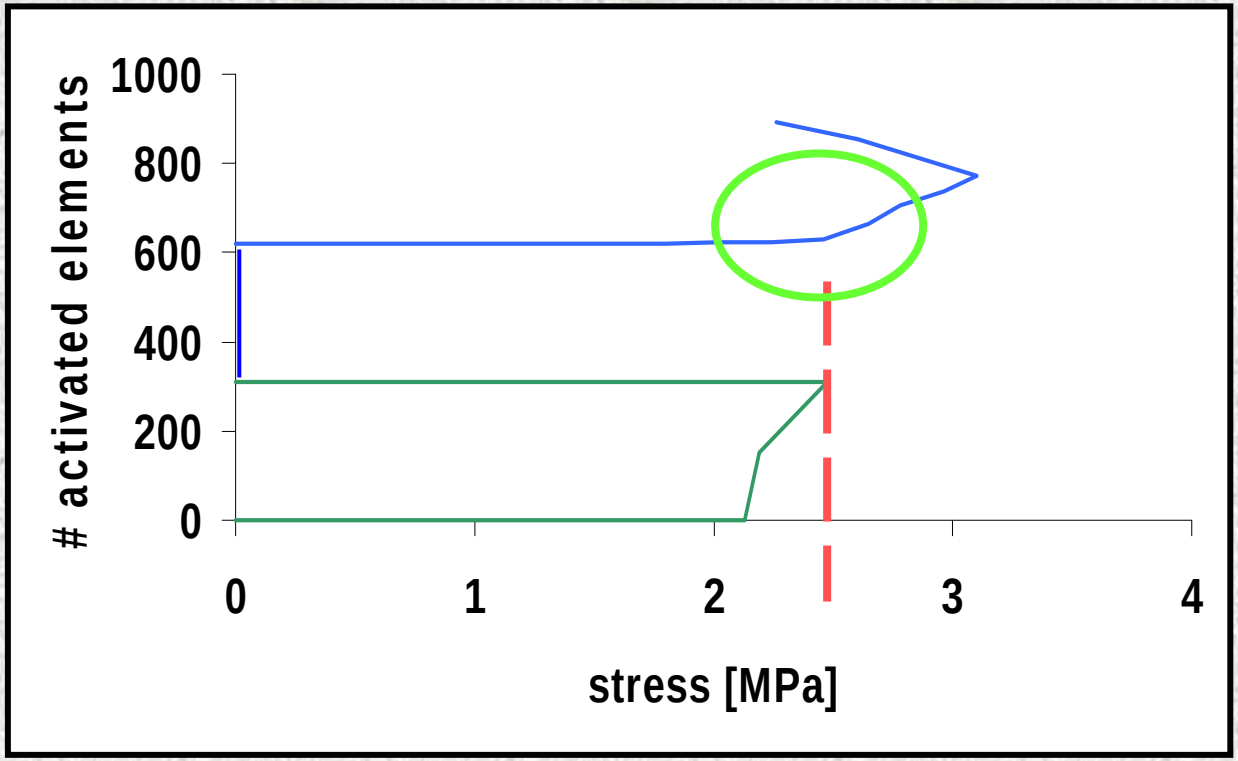
Different initial and residual properties



Simulation of closing of activated elements and of an increase of their strength

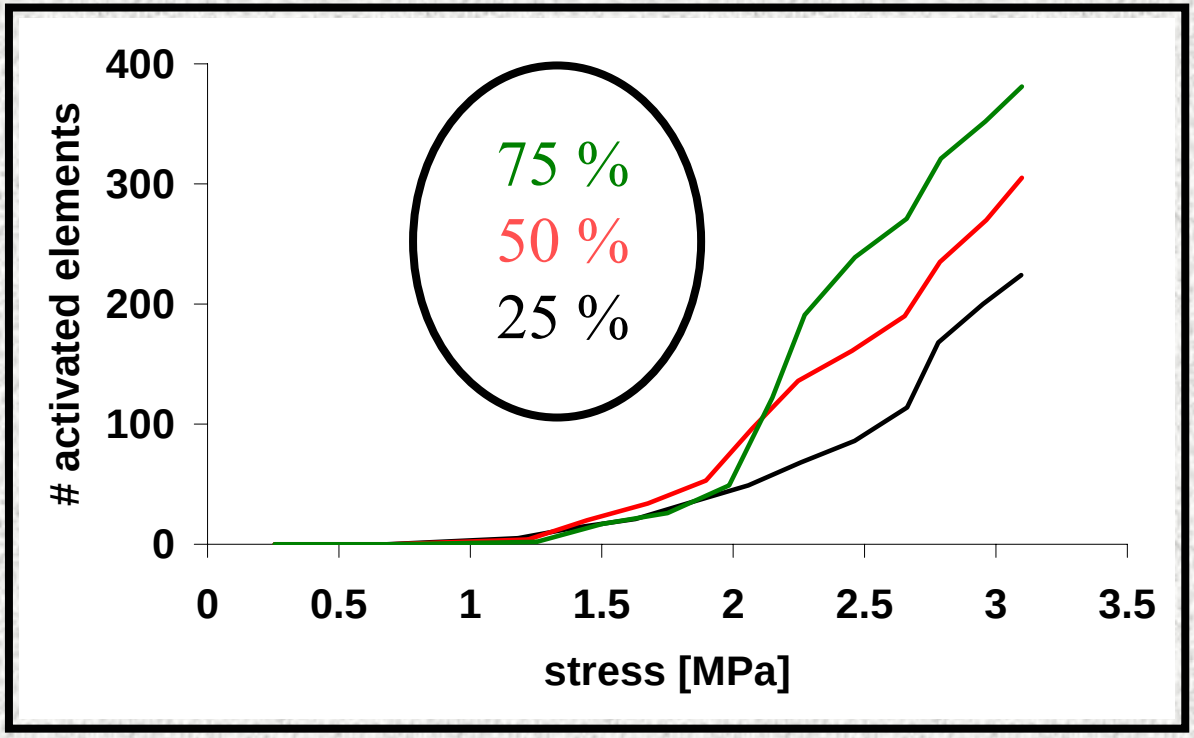
Numerical simulations

1. Loading of sample to 2.5 MPa, followed by unloading
2. All residual displacements of activated elements are put equal to zero (normal and shear displacement) ➔ SEALING
3. Reloading: inflection point is clearly visible at 2.5 MPa



Numerical simulations

1. Loading of sample to 2.5 MPa, followed by unloading
2. All residual displacements of activated elements are put equal to zero (normal and shear displacement) + % activated elements is given initial (strong) properties back ➔ HEALING
3. Reloading



Conclusion

Are we able to characterise and quantify the sealing/healing processes ?

It has been shown that ‘something’ is happening at micro-scale.

Link with other laboratory experiments (micro- and macro-scale) and with in situ situation (micro- and macro-scale) ?

Link with change in cohesion ?

→ More fundamental research required