

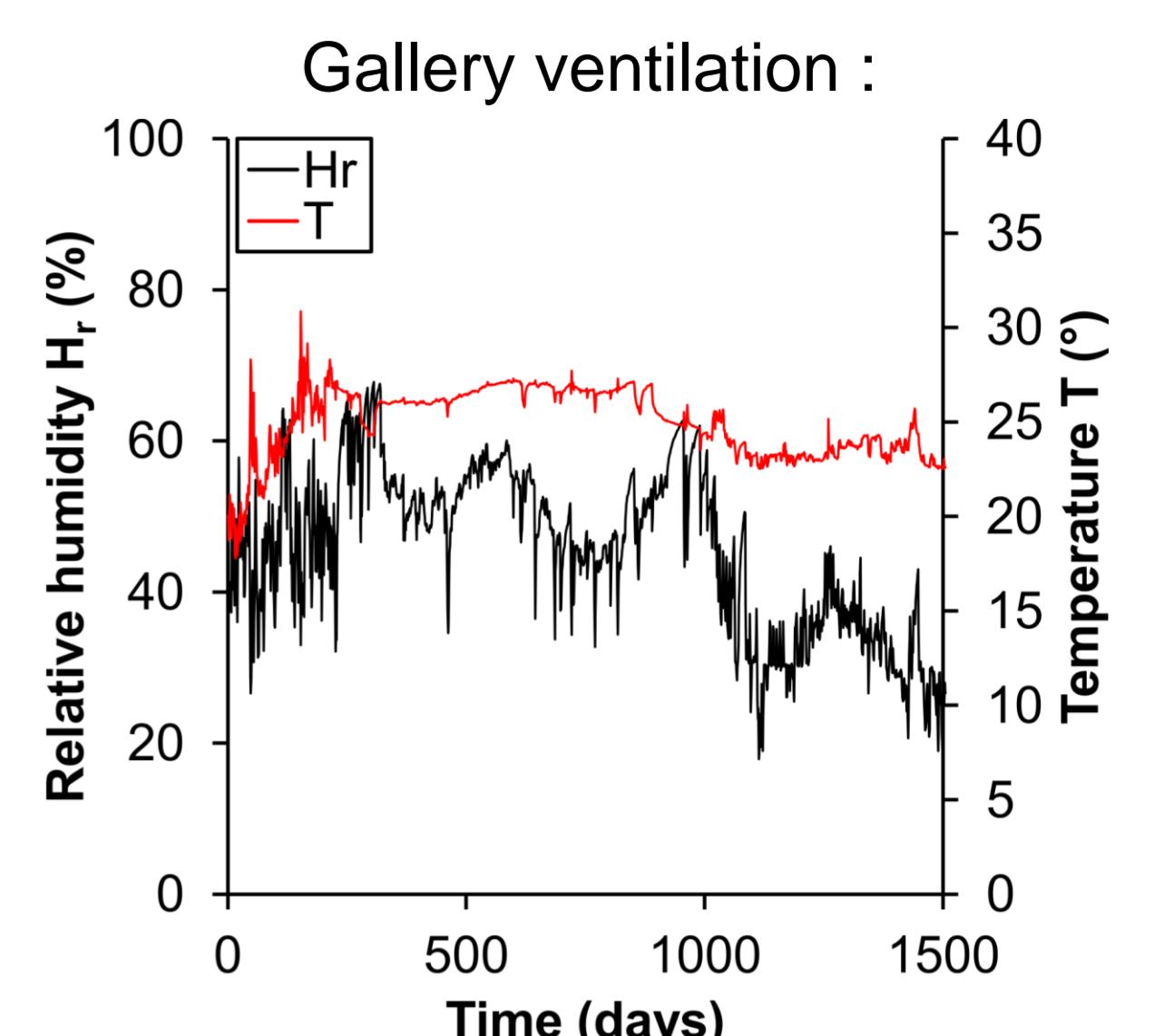
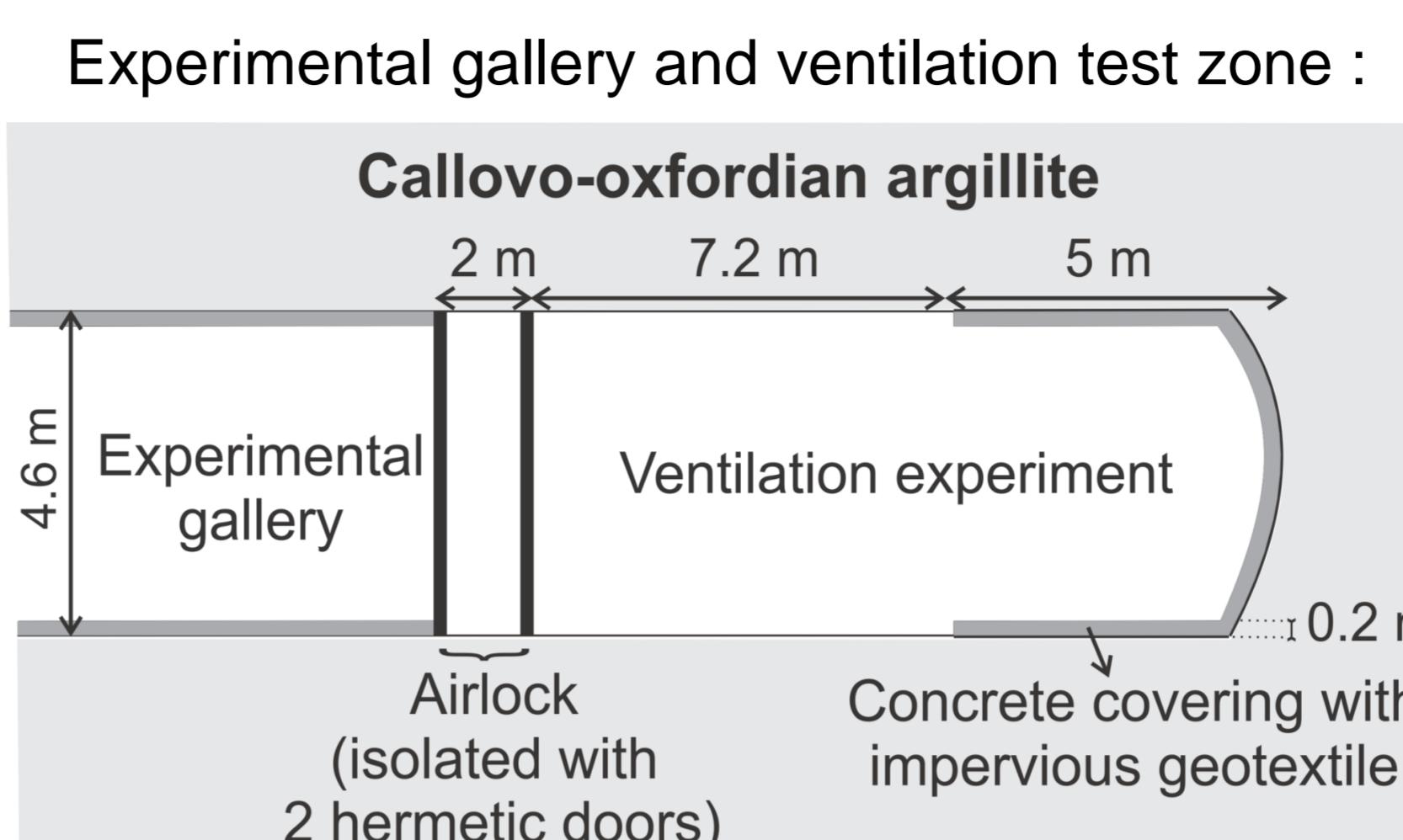
Modelling of large-scale in situ ventilation test in clayey rock

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Study description

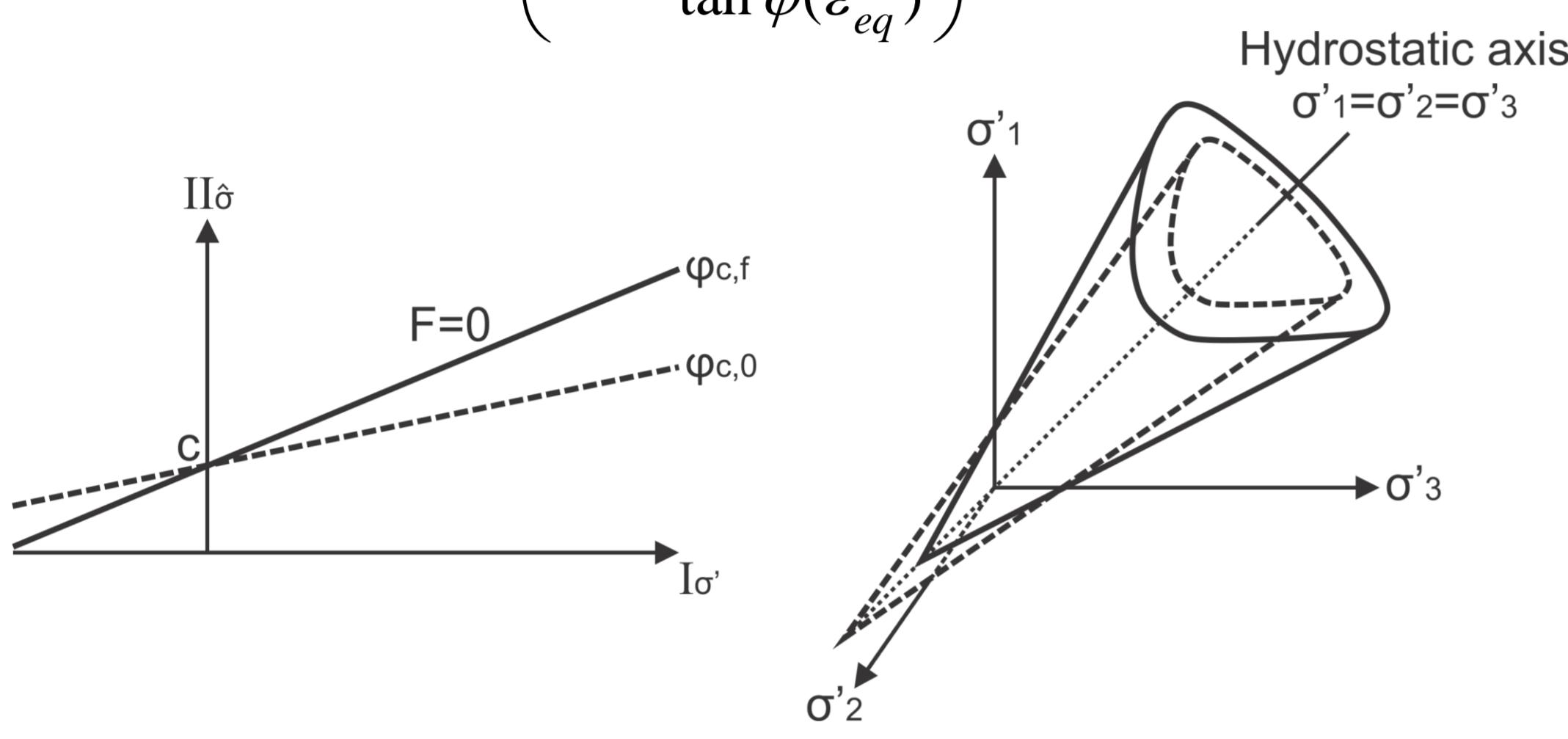
Excavation and ventilation processes engender damage and permeability modification in the rock mass close to underground galleries. A numerical modelling of a ventilation experiment performed by Andra (SDZ) is realised to study the rock and damaged zone behaviour [1].



Constitutive models

Mechanical :
 cross-anisotropic elastoplastic model with a hardening Van Eekelen yield surface.

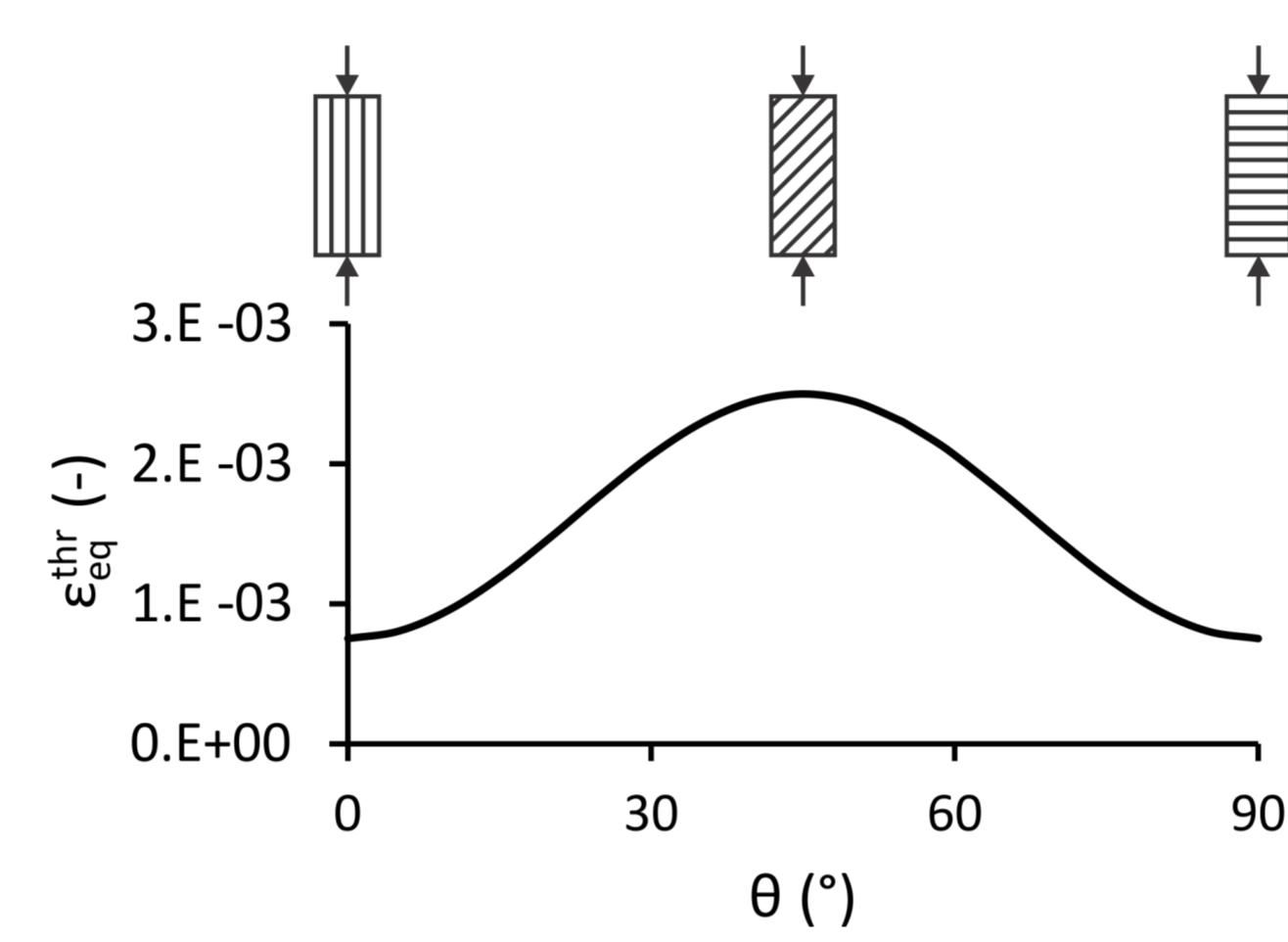
$$F \equiv II_{\dot{\sigma}} - m \left(I_{\sigma} + \frac{3c}{\tan \varphi(\varepsilon_{eq}^p)} \right)$$



Hydraulic :
 water flow in unsaturated porous media with anisotropic permeability evolution.

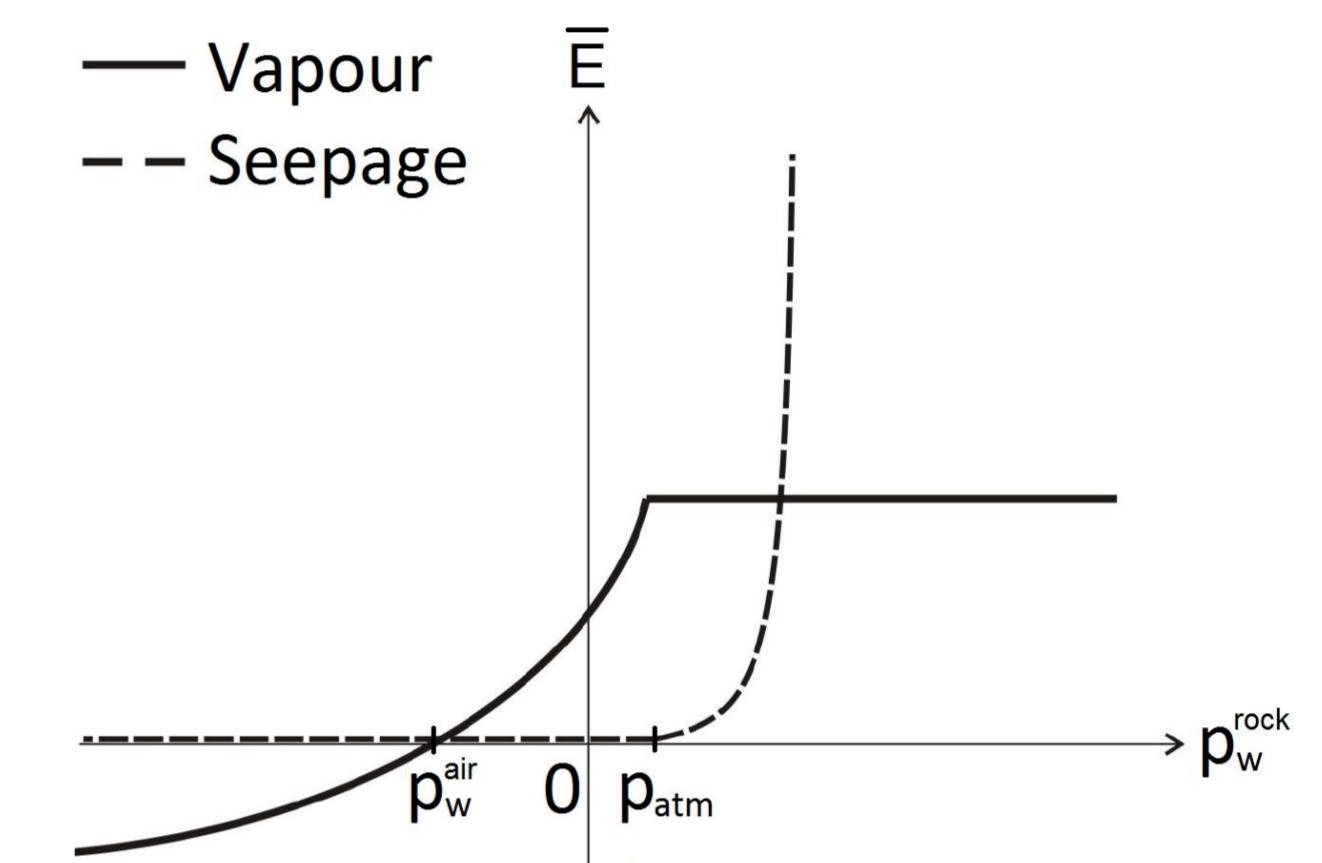
$$\underline{m}_w = -\rho_w \frac{k(\varepsilon_{eq}) k_{r,w}(S_{r,w})}{\mu_w} \nabla p_w$$

$$k = k_0 \left(1 + \beta (\varepsilon_{eq} - \varepsilon_{eq}^{thr}(\theta))^3 \right)$$



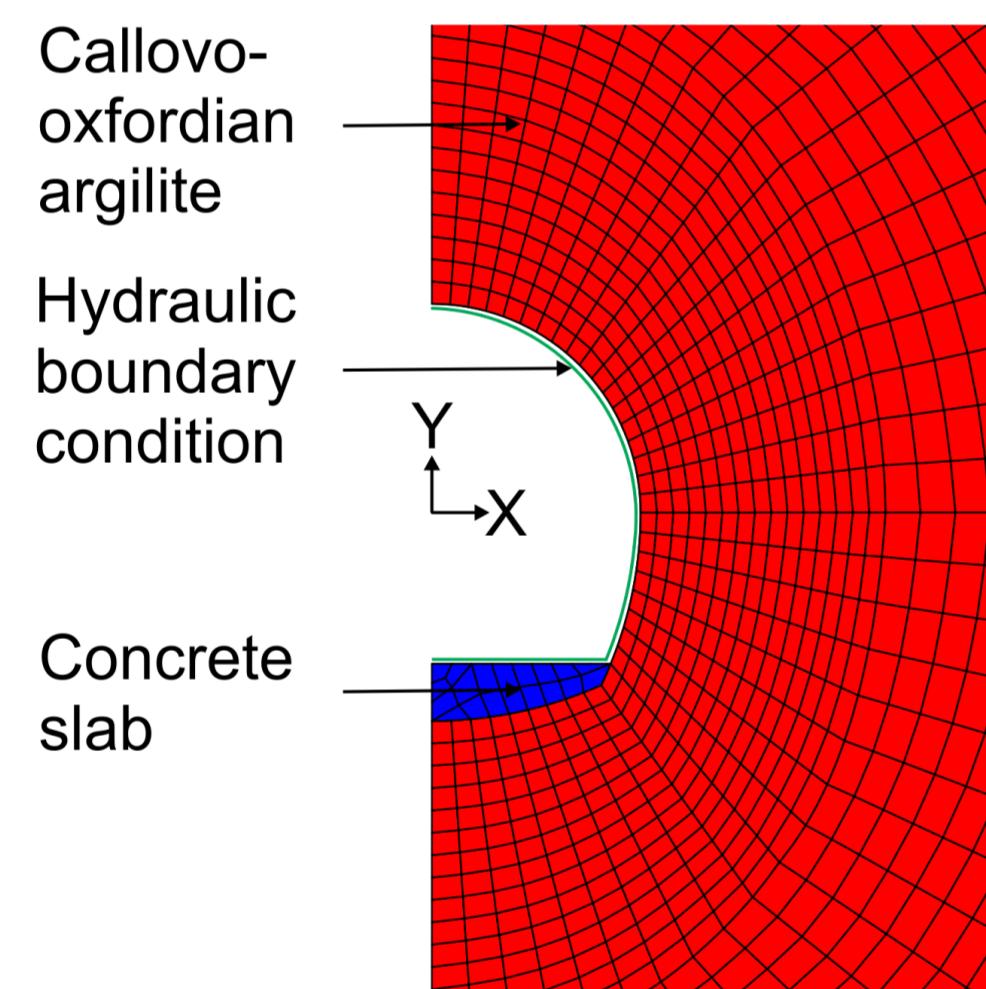
Hydraulic boundary condition :
 fluid exchanges between cavity and rock [2] :

$$\begin{cases} \bar{S} = K(p_w^{rock} - p_{atm})^2 & \text{if } p_w^{rock} \geq p_{atm} \\ \bar{S} = 0 & \text{if } p_w^{rock} < p_{atm} \end{cases} \quad \bar{E} = \bar{q} + \bar{S}$$



Numerical modelling

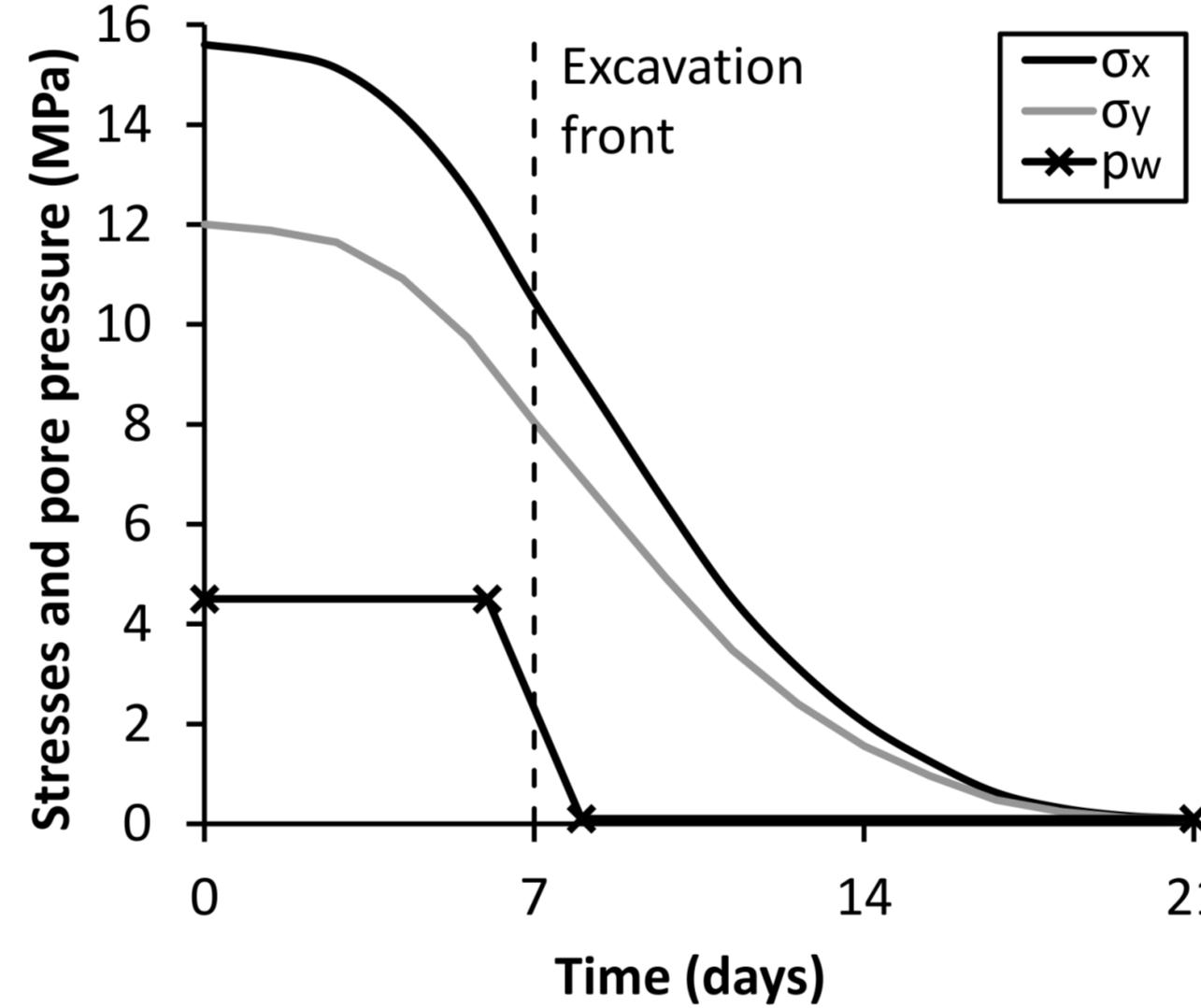
Mesh :



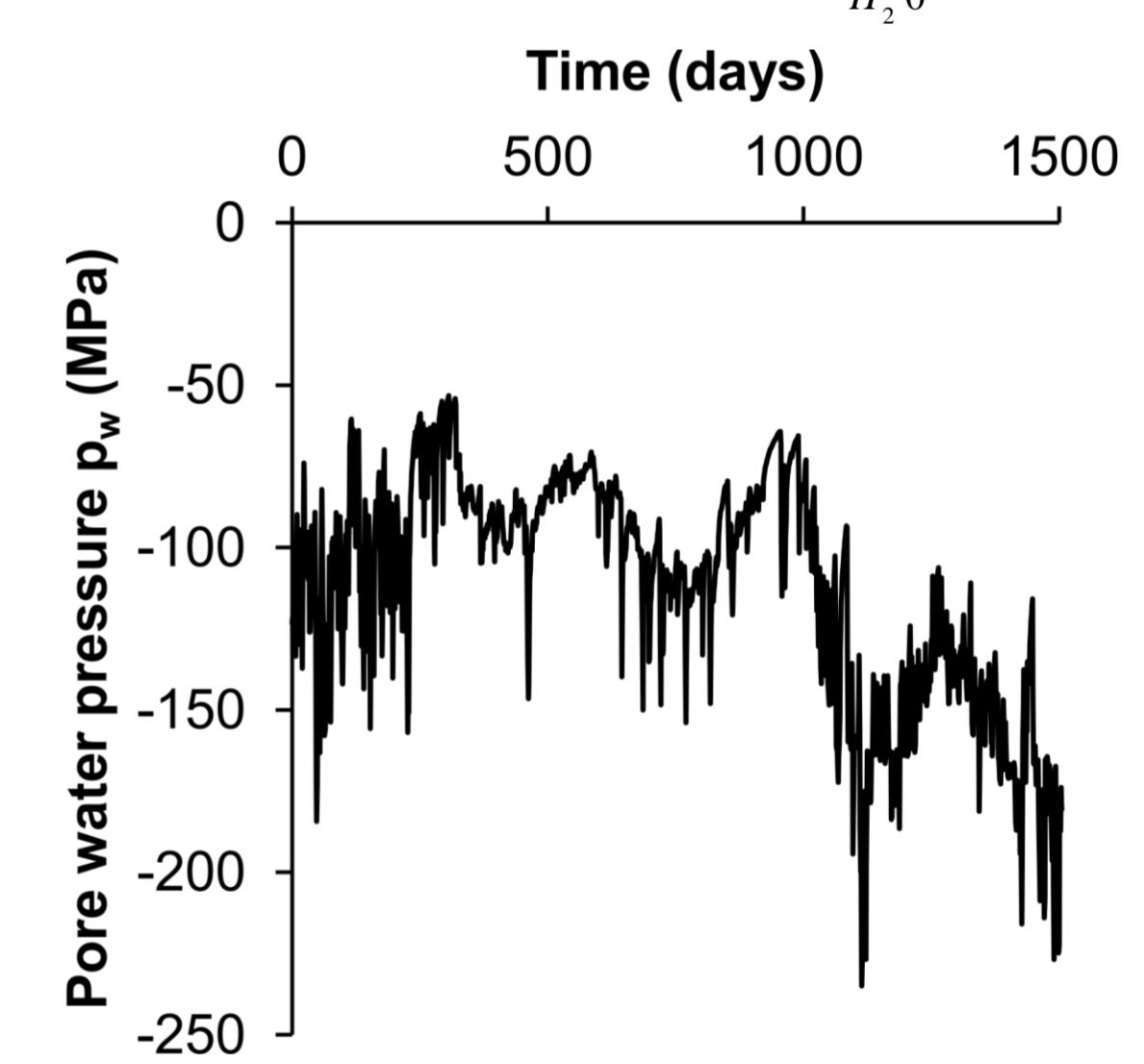
Initial state :

$$\begin{aligned} k_{x/y} &= 4 \cdot 10^{-20} / 1.33 \cdot 10^{-20} \text{ m}^2 \\ \sigma_{x/y} &= 15.6 / 12 \text{ MPa} \\ p_w &= 4.5 \text{ MPa} \end{aligned}$$

Excavation :



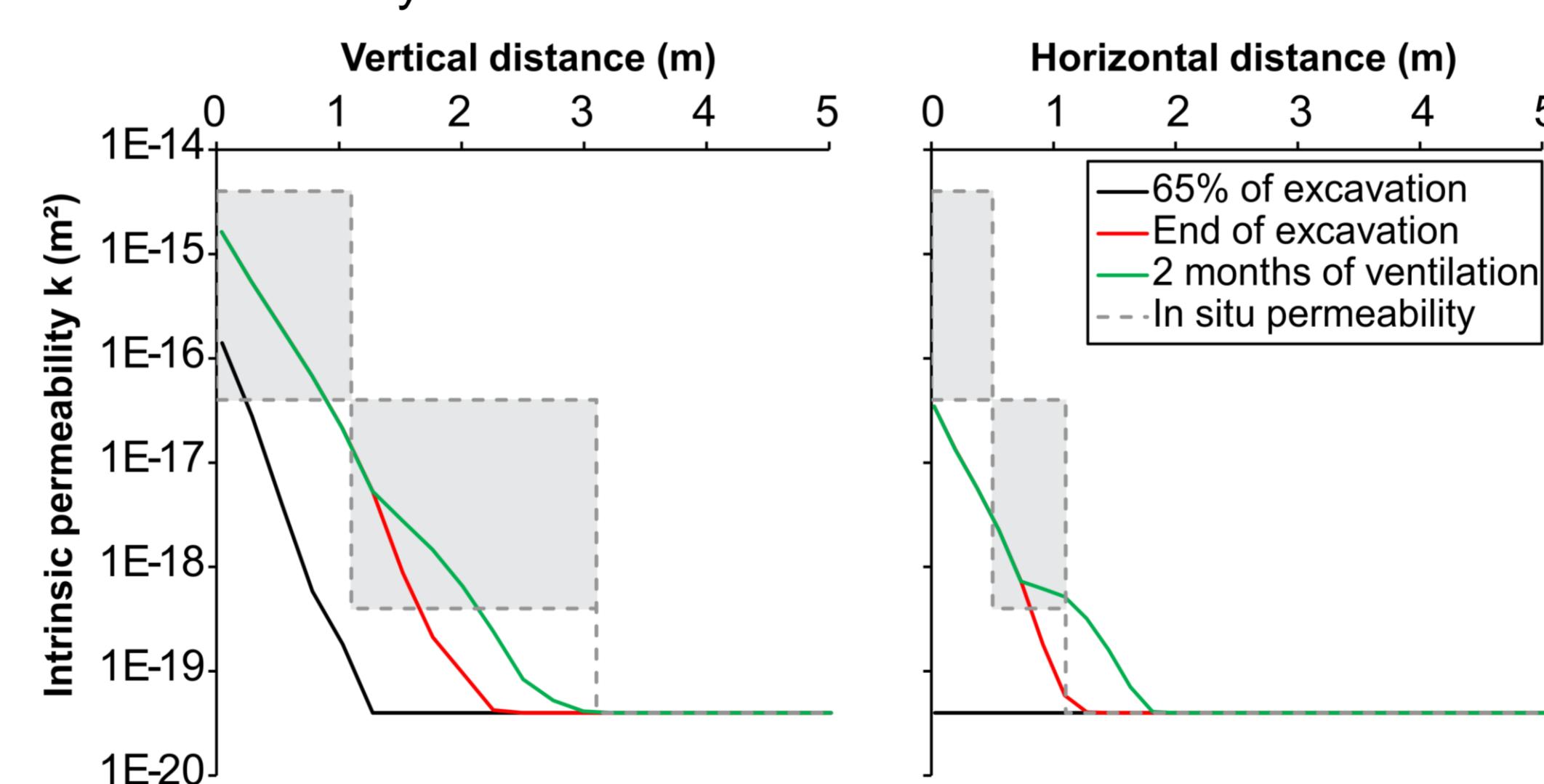
$$\text{Ventilation : } p_w = \frac{\rho_w RT}{M_{H_2O}} \ln(H_r) + p_g$$



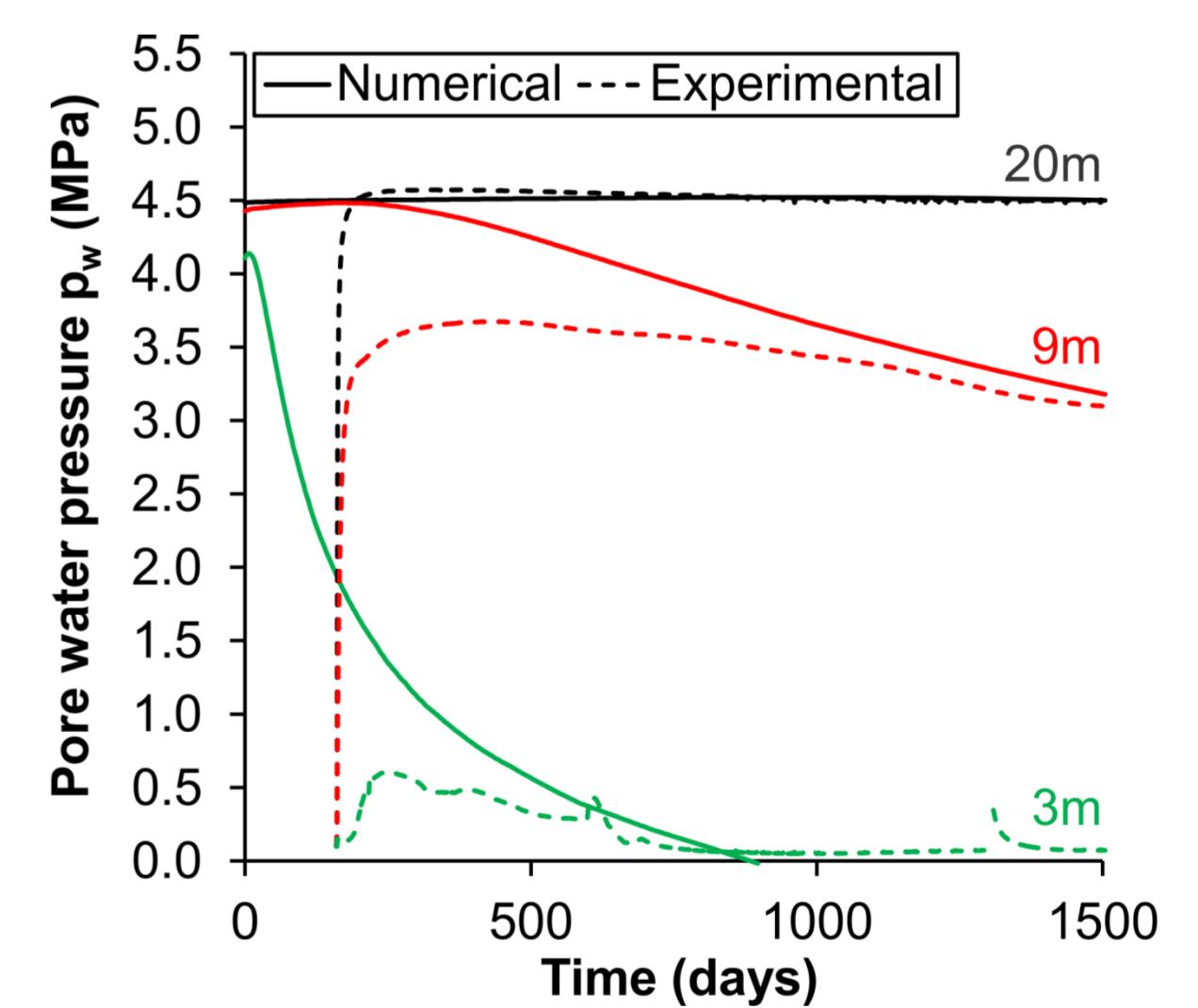
Results

- significant influence of \underline{k} evolution and \bar{q} on the reproduction of p_w and w ,
- \underline{k} evolution is well reproduced,
- fluid transfers take place in the damaged zone,
- plastic zone fairly corresponds to *in situ* measurements of the damaged zone extension.

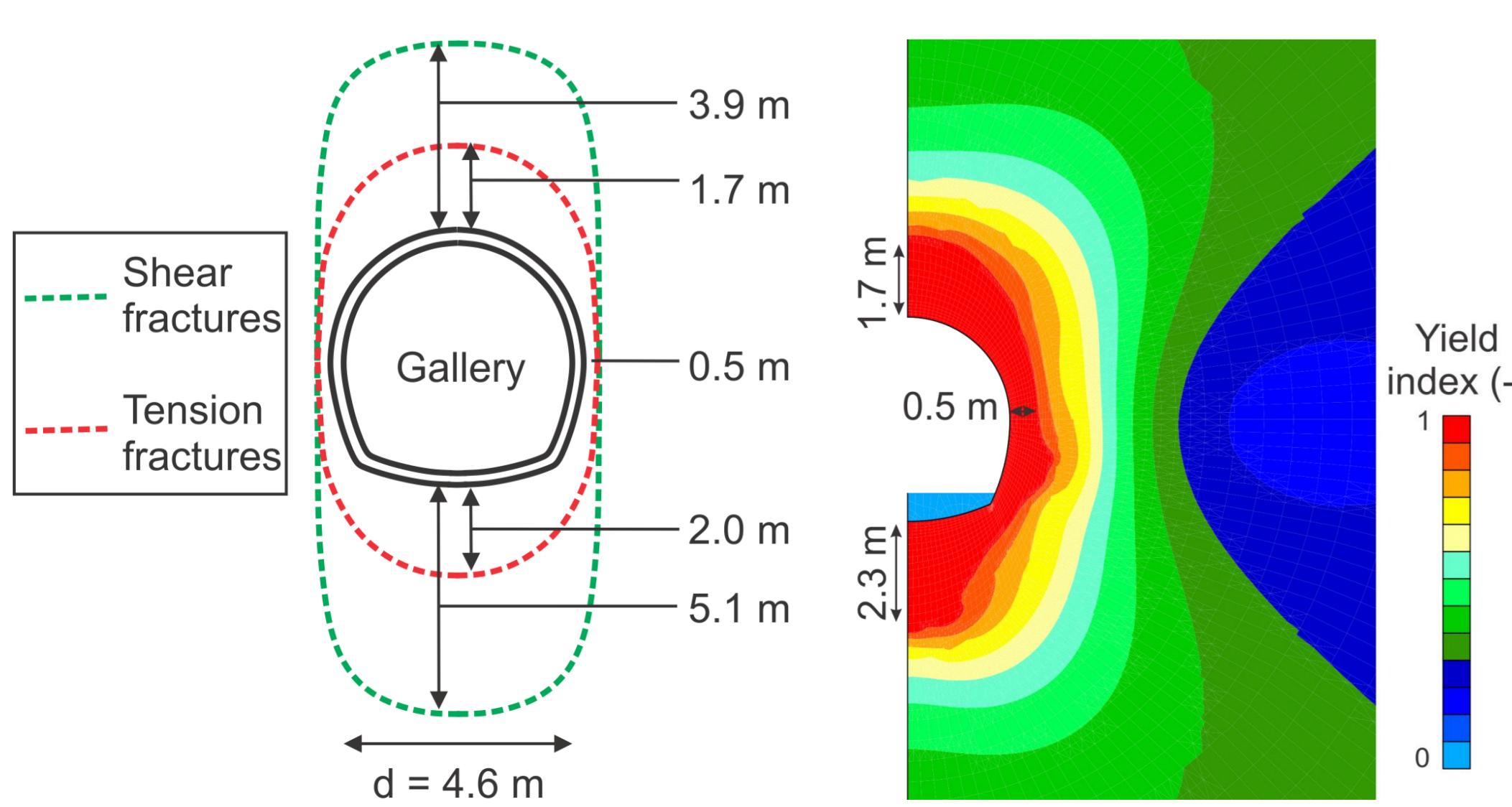
Permeability evolution in vertical and horizontal directions :



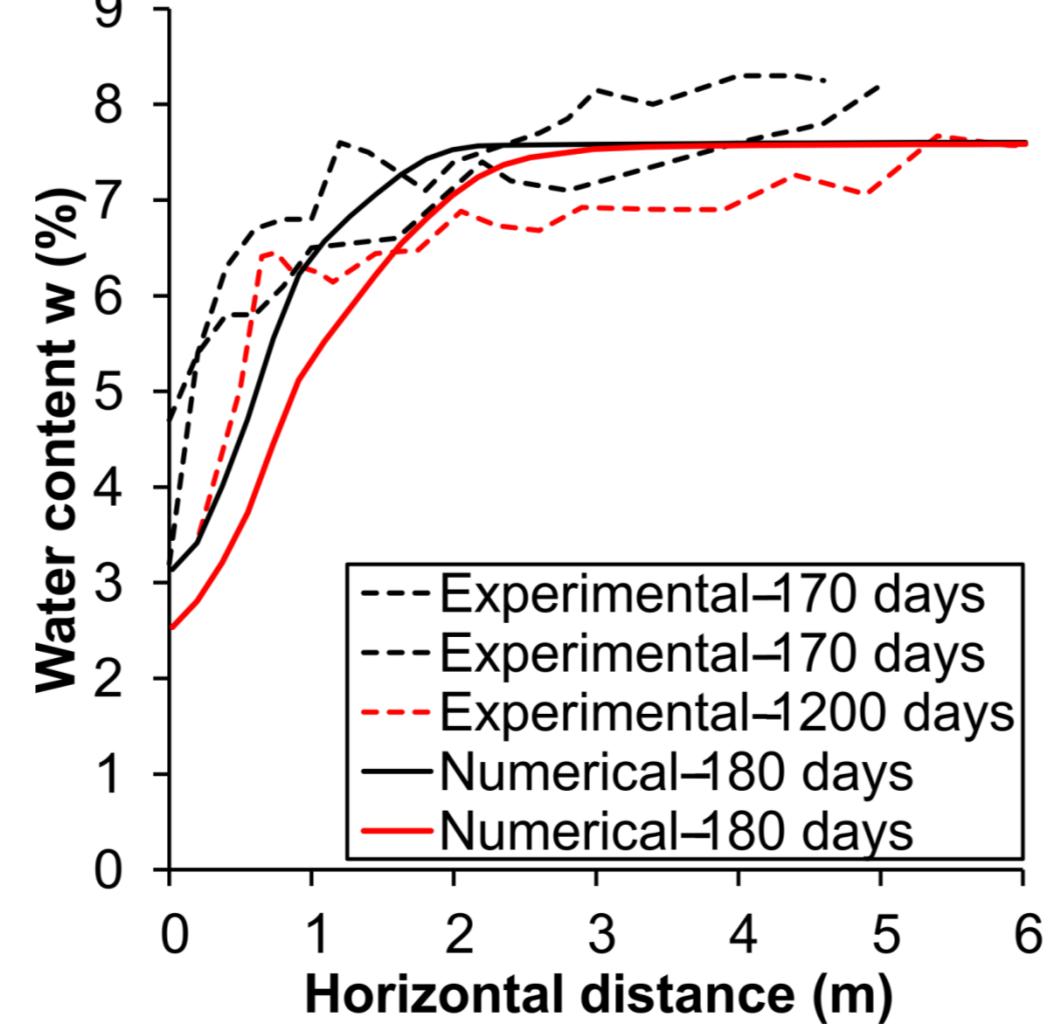
Pore water pressure at different distances from the gallery wall :



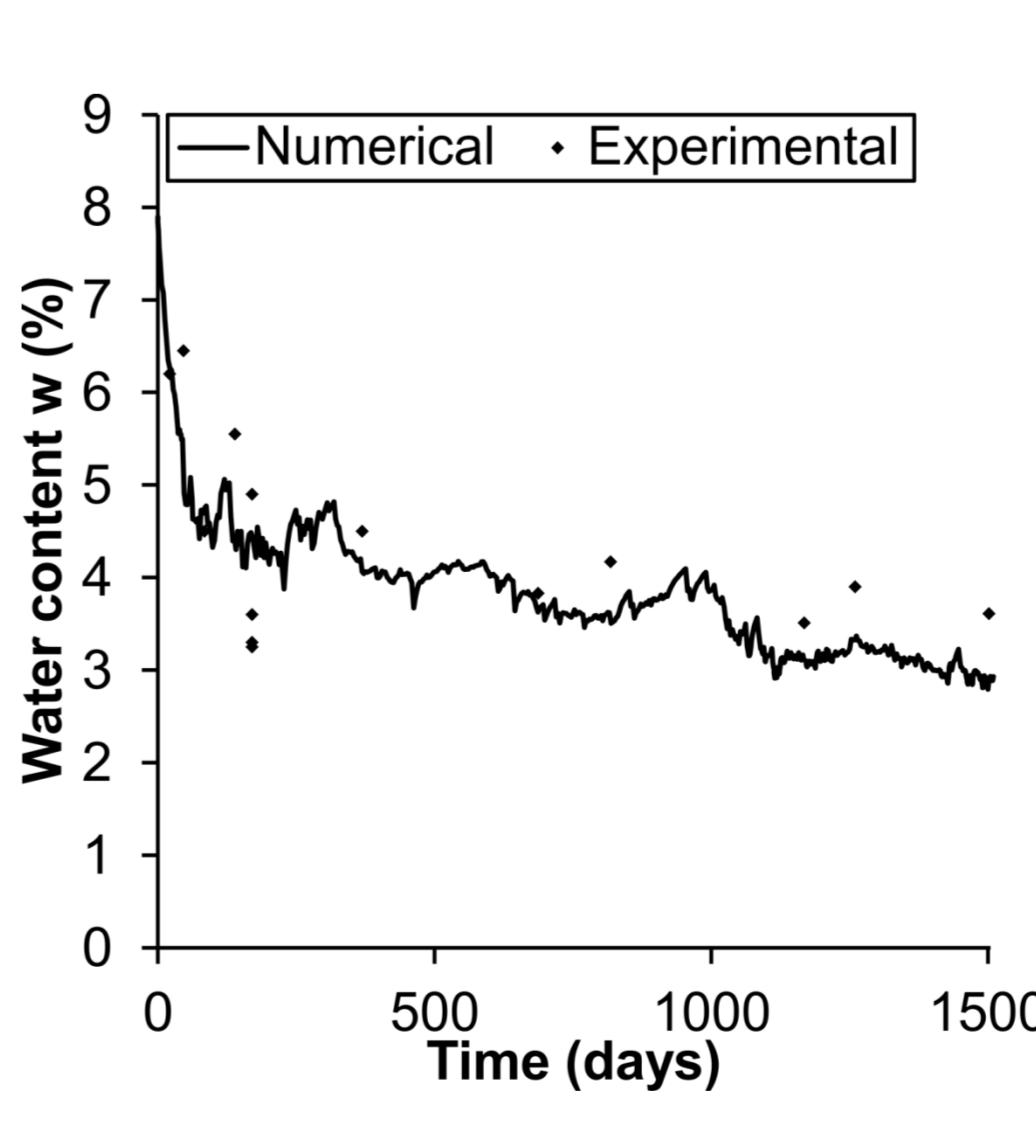
Fractures measurement and numerical plastic zone :



Water content for horizontal cross-section :



Water content at gallery wall :



Gallery horizontal convergence :

