



Determination of the Permeability of the Callovo-Oxfordian Clay at the Metre to Decametre Scale



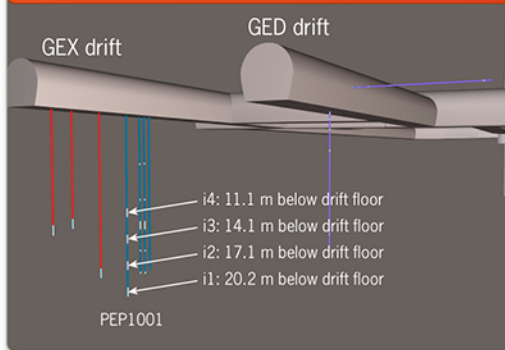
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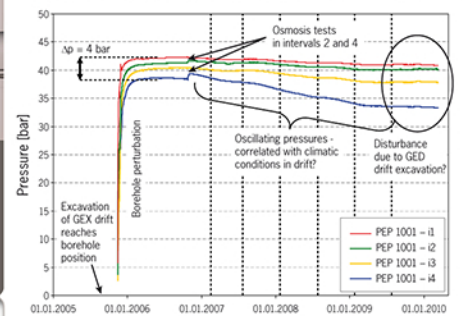
Background

- The hydraulic properties of the Callovo-Oxfordian clay at Andra's URL at Meuse/Haute-Marne have been characterised extensively.
- Hydraulic tests have been performed in boreholes perpendicular to the drift axes. Tests in packed off intervals aim to determine hydraulic conductivity at the borehole scale.
- Porewater pressure has been measured continuously in the borehole intervals since 2005.
- A substantial long-term pressure decrease has been observed around the URL's drifts and shafts with seasonal variations.

Data



Measured pressures in borehole PEP1001



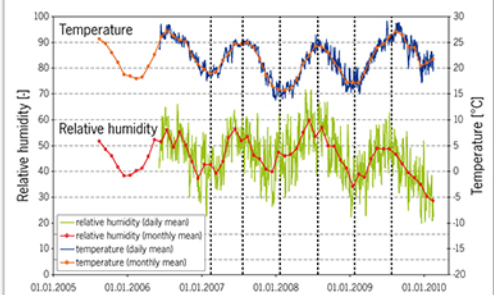
Objectives

- Investigation of the consistency between the hydraulic conductivities determined with hydraulic testing at the small scale (centimetre to decimetre) and the observed large scale (metre to decametre) pressure evolution by means of numerical simulation of the drainage/suction effect around/into drifts due to the ventilation
- Assessment of the climatic conditions in the drift as a potential driving force for the observed oscillation of the measured pressures

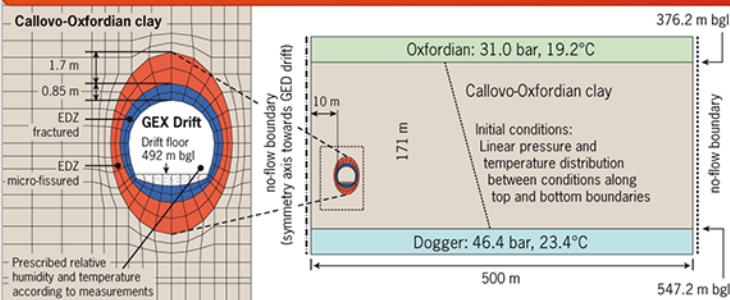
Processes and approach

- Transient non-isothermal 2-phase flow (water-air), with vapour pressure lowering effect due to capillarity
- 2D-modelling of ventilation-driven desaturation/depressurisation around drifts
- Ventilation conditions in drift according to measurements of relative humidity, temperature and pressure
- Comparison between observed and calculated pressure evolutions since drift excavation
- Code: TOUGH2-MP, EOS4

Measured climatic conditions in GEX drift



Model concept



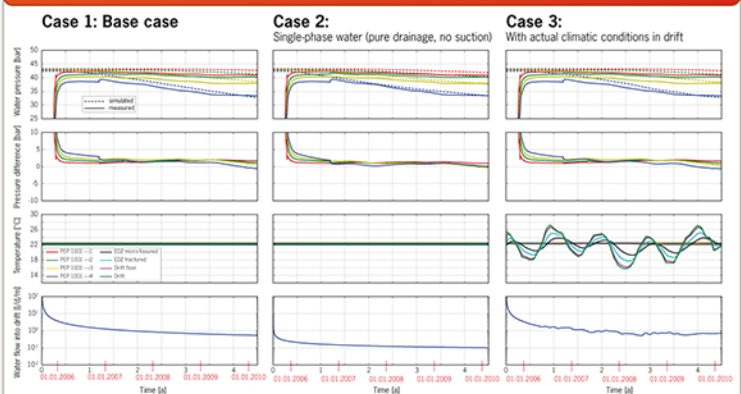
Selected parameters and cases

Hydraulic conductivity EDZ micro-fissured	$7 \cdot 10^{-11}$ m/s
Hydraulic conductivity EDZ fractured	$7 \cdot 10^{-9}$ m/s
Specific storage coefficient	$2 \cdot 10^{-6}$ l/s
Case 1: Base case	<ul style="list-style-type: none"> Horizontal hydraulic conductivity: $7 \cdot 10^{-13}$ m/s Vertical hydraulic conductivity: $4 \cdot 10^{-13}$ m/s Constant temperature and relative humidity in drift
Case 2: Single-phase water (pure drainage, no suction)	<ul style="list-style-type: none"> Isotropic: $7 \cdot 10^{-13}$ m/s Constant temperature and atmospheric pressure in drift
Case 3: With actual climatic conditions in drift	<ul style="list-style-type: none"> Base case with consideration of measured temperature and relative humidity in drift

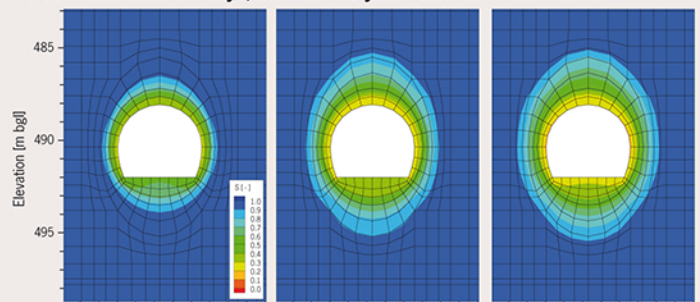
Conclusions

- The observed pressure decrease due to suction/drainage into the open drift is reproduced reasonably by the model.
- The best fit is achieved for an anisotropic Callovo-Oxfordian clay with $7 \cdot 10^{-13}$ m/s horizontal and $4 \cdot 10^{-13}$ m/s vertical hydraulic conductivity, i.e. consistency from centimetre to decametre scale.
- An equally good fit is obtained under single-phase water drainage (no suction, no desaturation) conditions and an isotropic hydraulic conductivity of $7 \cdot 10^{-13}$ m/s.
- A possible cause for deviations between the calculated and the measured conditions may be a drilling-induced EDZ around the borehole which would induce a stronger hydraulic gradient along the borehole.
- The observed pressure oscillations can be ascribed to fluctuating climatic conditions in the drift, e.g. temperature and relative humidity. However, the monitored oscillations are of low amplitude and do not affect the estimation of the hydraulic conductivity.

Results



Water saturation 17 days, 1.5 and 4.5 years after drift excavation



Water pressure 17 days, 1.5 and 4.5 years after drift excavation

