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EXPERIMENTAL STUDY OF THE IMPACT OF SELF-SEALING ON THE WATER AND GAS PERMEABILITY OF FRACTURES IN CALLOVO-OXFORDIAN CLAYSTONE

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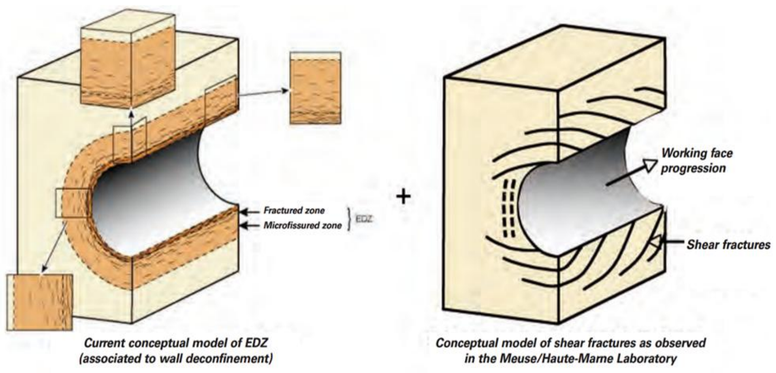
Introduction & Scientific issue

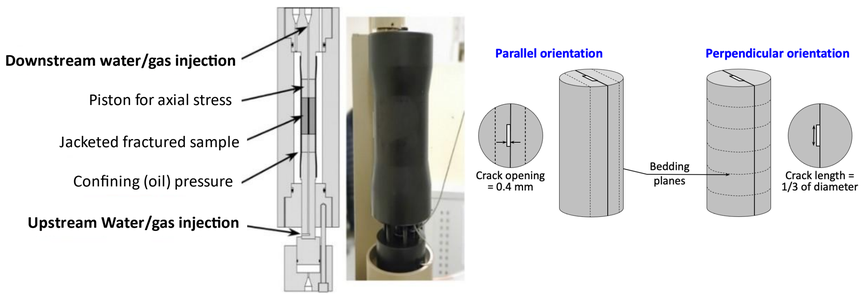
Claystone is a rock that possesses advantageous properties for the deep geological repository of radioactive waste. Excavation of underground galleries creates a cracks network in the near field called **Excavation Damaged Zone** (**EDZ**), such as in the Underground Research Laboratory (URL) of the National Agency of Radioactive waste Management (Andra) located in Meuse/Haute-Marne (Bure, France) and excavated in the **Callovo-Oxfordian (COx) claystone**.



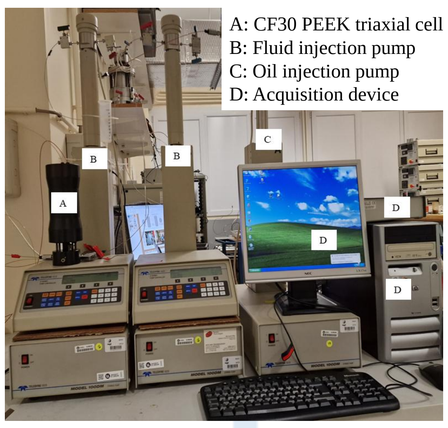
Conceptual representation of the EDZ [1]

These cracks possess a remarkable ability to self-seal, primarily driven by water resaturation and swelling of clay minerals (smectites). This phenomenon leads to a partial restoration of the claystone's original mechanical and hydraulic properties. Furthermore, heat and gas generated by waste containers/canisters could influence the self-sealing mechanism. Therefore, the knowledge of this long-term **self-sealing process** is of great importance. This study investigates experimentally the impact of self-sealing on both water and gas permeability of the COx claystone.

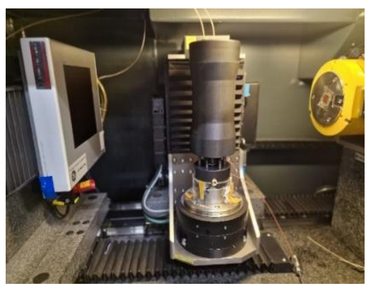
Experimental methods & samples



X-rays transparent triaxial compression cell (left) and artificially fractured cylindrical samples (Ø = 20 mm; h = 40 mm) for self-sealing tests (right)

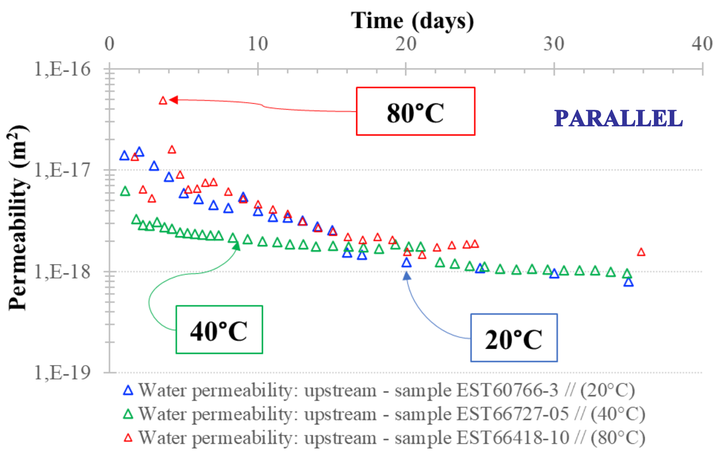


A: CF30 PEEK triaxial cell
B: Fluid injection pump
C: Oil injection pump
D: Acquisition device

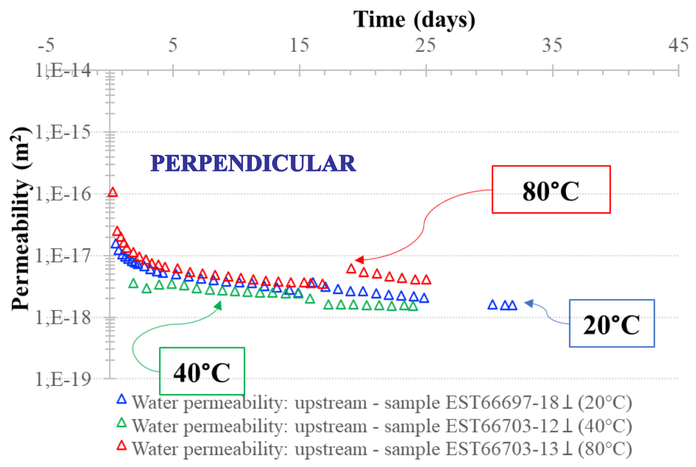


A data logger and pumps to control confining, water inlet and outlet pressures (left) and triaxial cell for self-sealing tests in an X-ray nano-tomograph [2] (right)

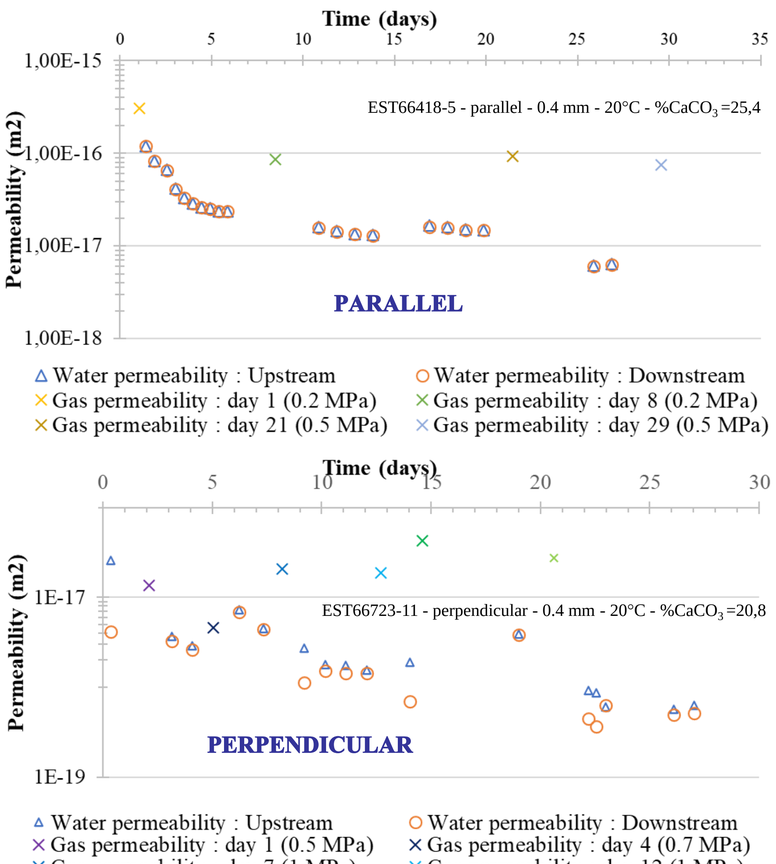
Results



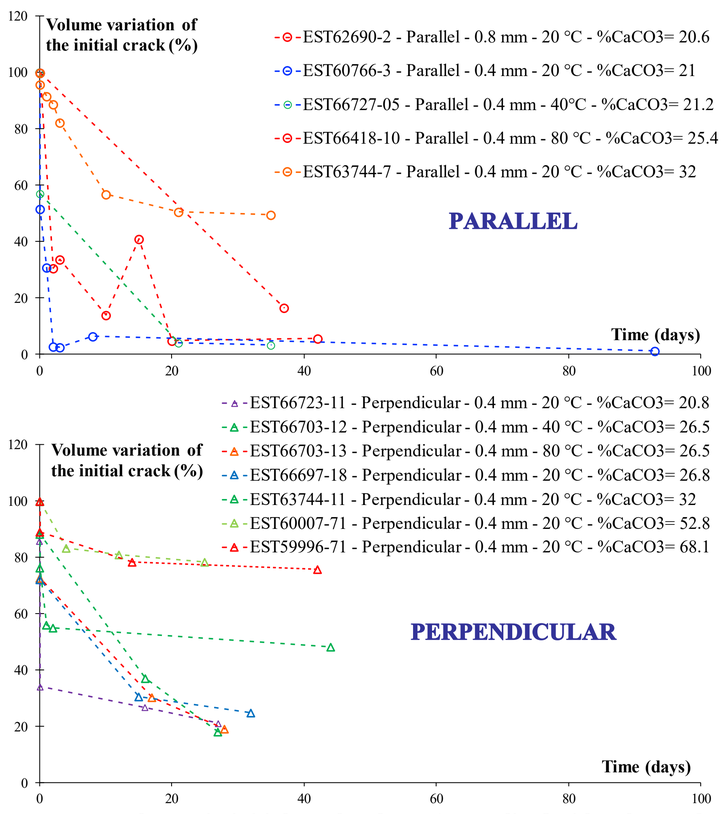
Evolution of water permeability during self-sealing tests on parallel samples at 20, 40 and 80°C



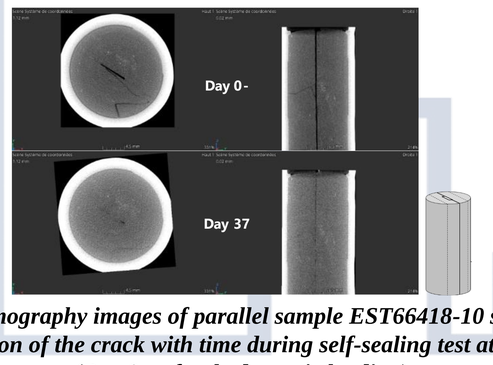
Evolution of water permeability during self-sealing tests on perpendicular samples at 20, 40 and 80°C



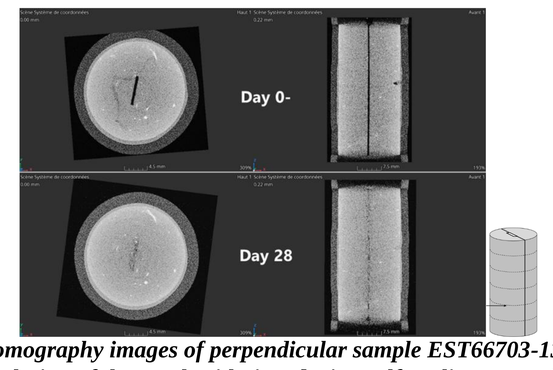
Evolution of water and gas permeability during self-sealing tests on a parallel (EST66418-5) and a perpendicular (EST66723-11) sample



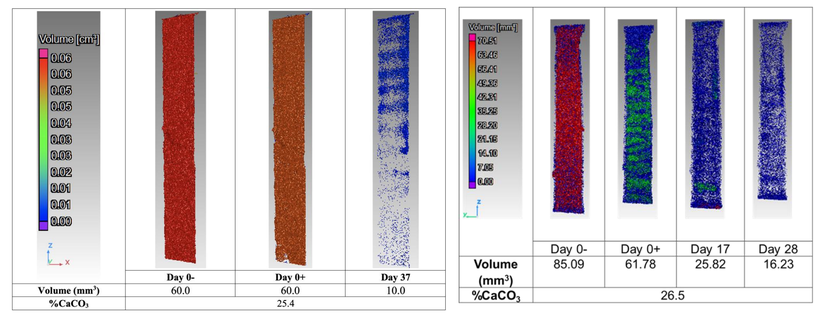
Percentage change in initial crack volume (normalized with volume after hydrostatic loading) obtained from 3D X-ray tomography images during self-sealing tests performed on parallel and perpendicular samples



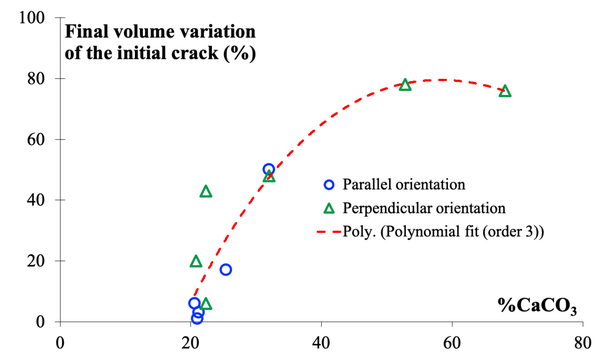
3D X-ray tomography images of parallel sample EST66418-10 showing the evolution of the crack with time during self-sealing test at 80°C (Day 0-: after hydrostatic loading)



3D X-ray tomography images of perpendicular sample EST66703-13 showing the evolution of the crack with time during self-sealing test at 80°C (Day 0-: after hydrostatic loading)



3D X-ray tomography images of parallel sample EST66418-10 (left) and perpendicular sample EST66703-13 (right) showing the evolution of crack volume with time during self-sealing tests at 80°C (Day 0-: after hydrostatic loading; Day 0+: after crack saturation)



Volume variation percentage of the initial crack (obtained from 3D X-ray tomography images) at the end of self-sealing tests as a function of calcite content

Conclusions

- **Self-sealing tests** were performed on initially fractured samples of **COx claystone** with **different temperatures, orientations and calcite contents**.
- Self-sealing process was analyzed thanks to **permeability measurements** and crack volume estimation from **3D X-ray tomography** images.
- The **self-sealing process** (crack closure and permeability decrease) is **fast at the beginning** of the test and then **stabilizes after one month**.
- The **permeability** of the COx claystone samples is **partially restored** (10^{-18}-10^{-19} **m²**) compared to the initial healthy state (10^{-20}-10^{-21} **m²**).
- To have an effective sealing, it is necessary to have a **calcite content < 40%**.
- Self-sealing is efficient in both directions (**parallel** and **perpendicular**).
- Self-sealing is efficient for all tested **temperatures** (**20°C**, **40°C**, **80°C**).
- Slight **delay** in the decrease in permeability at the very beginning of the tests carried out at a temperature of **80°C** (due to **water overpressure**).
- **Slightly slower** self-sealing kinetics due to **gas-injection-induced** desaturation.

These results, which must be confirmed with additional similar experiments, are very promising and give confidence to the positive impact of the self-sealing process on the restoration of the initial hydraulic and mechanical properties of the COx claystone.

Acknowledgements

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[1] Andra, 2005. Dossier Argile 2005.

[2] Agboli, M., Grgic, D., Moumni, M., Giraud, A. 2024. Study under X-ray tomography of the impact of self-sealing process on the permeability of the Callovo-Oxfordian claystone. Rock Mechanics and Rock Engineering, Volume 57, Issue 6, pp. 4213-4229.