



# Thermo-Hydro-Mechanical Behaviour of Indurated Clays

(C.-L. Zhang, T. Rothfuchs)

GRS has participated in a number of international research projects for the investigation of clay formations to host a repository for radioactive waste. Laboratory experiments have been performed on core samples taken from the Callovo-Oxfordian argillite at Bure and the Opalinus clay at Mont Terri to increase the knowledge about the thermo-hydro-mechanical (THM) behaviour of indurated clays.

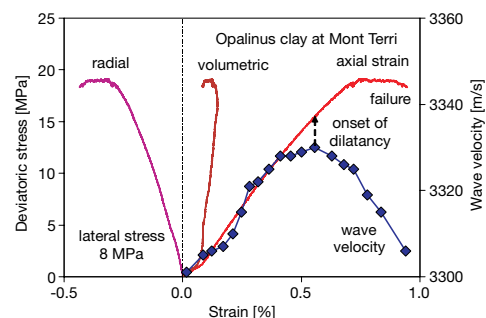
## > Short-term behaviour



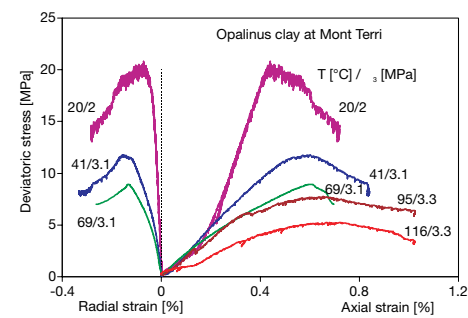
Triaxial testing apparatus



Before testing



Triaxial compressive behaviour



Stress/strain-curves obtained at different temperatures

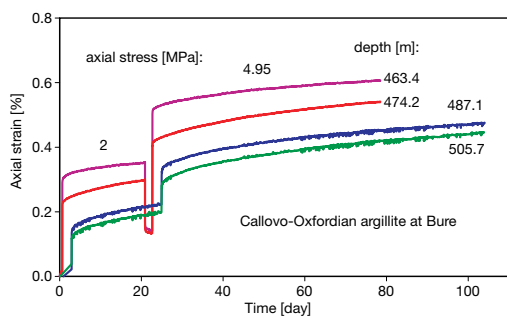


After testing

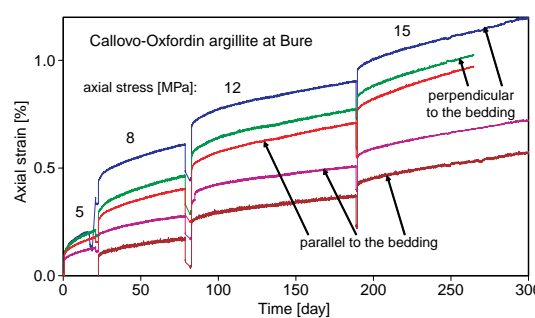
## > Long-term behaviour



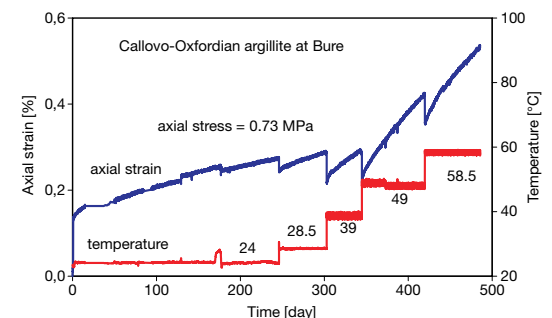
Creep testing apparatus



Creep of the samples taken from different depths at Bure

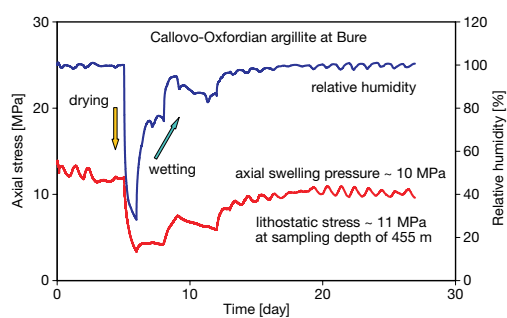


Creep perpendicular and parallel to the bedding plane

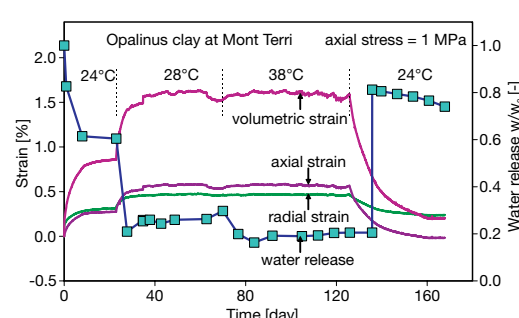


Temperature effect on the creep behaviour

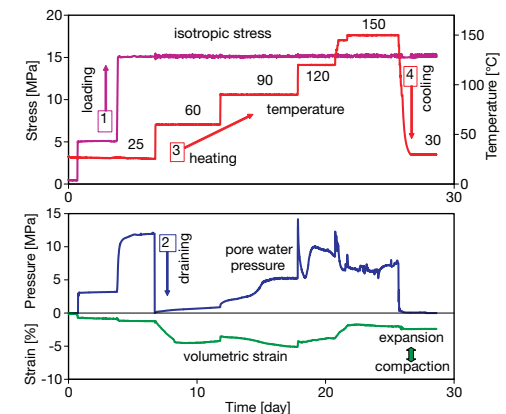
## > Responses to THM-loading



Stress response to drying and wetting under fixed axial strain



Shrinking by de-saturation and swelling by re-saturation



Coupled THM-processes

## > Major findings and conclusions

- Indurated clays exhibit relative high stiffness and strength and also show long-term creep capability, so that underground openings are of high stability. After sealing/backfilling, underground repositories will safely close with time.
- Clays react very sensible to moisture change. De-saturation increases stiffness and strength, but also causes shrinking and fracturing. Re-saturation leads to the development of swelling pressure and strain.
- Thermal effects on clays are very significant. Heating generates increase in pore water pressure, expansion and reduction in strength under undrained conditions.
- To improve existing constitutive models, investigations on the THM-behaviour of clays are to be continued intensively in the future.

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