Cycle deformations in the Opalinus Clay
a laboratory experiment

Emanuel Huber[1], Peter Huggenberger[1], Andreas Möri[2], and Edi Meier[3]

[1]Applied and Environmental Geology, University of Basel, Switzerland
emanuel.huber@unibas.ch
peter.huggenberger@unibas.ch

[2]Swiss Geological Survey, Swisstopo, Switzerland
andreas.moeri@swisstopo.ch

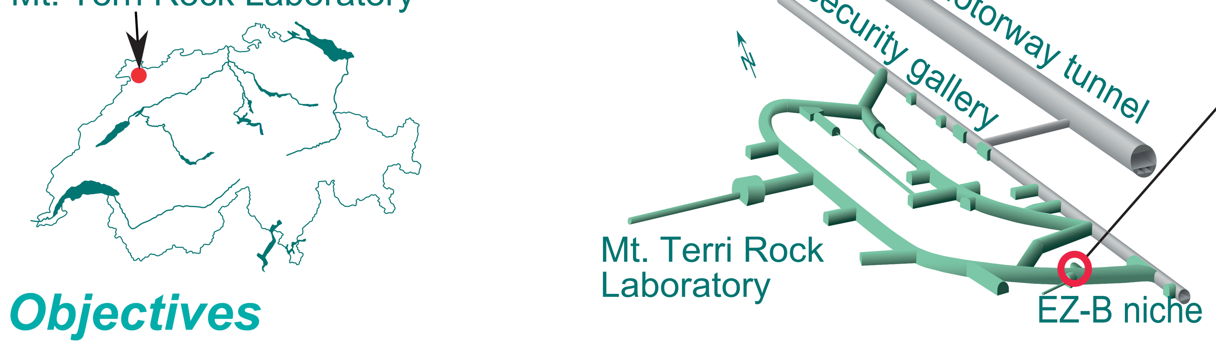
[3]Edi Meier + Partner AG, Technoparkstr. 2, 8406 Winterthur, Switzerland
info@emp-winterthur.ch

Research question

Rationale

At the EZ-B niche in Mt. Terri Rock Laboratory an experimental device was set-up to study the influence of seasonal variations in air temperature and humidity on Opalinus clay.

A cyclic deformation, expressed by an opening and closure of joints, has been observed with increasingly smaller apertures of joints. The deformation cycles correlated with the seasonal conditions.



Objectives

→ Set up a "controlled condition" laboratory experiment to assess the relation between the relative humidity and the deformation of Opalinus clay, excluding temperature effects and the effects of confining stress.

→ Evaluate the suitability of a crackmeter based on a two plates capacitor to quantify the dynamics of the opening and closing of a crack and the governing factors of the experimental device.

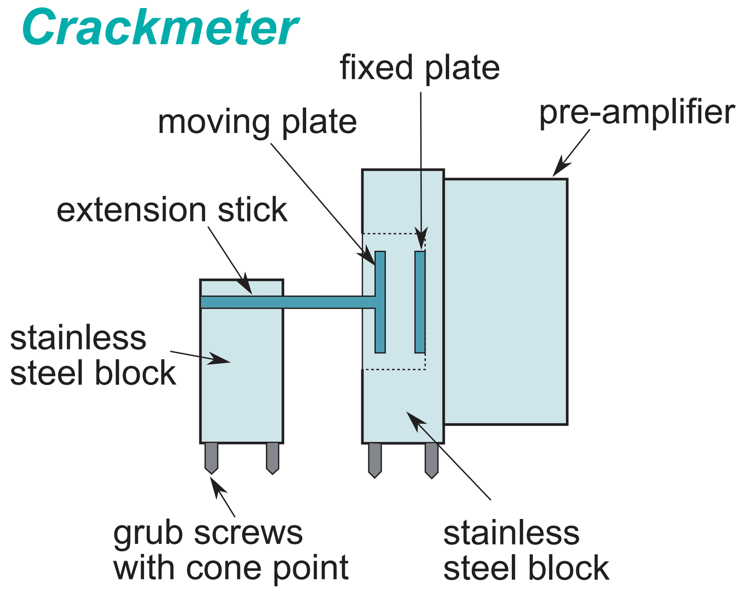
The laboratory experiment allows the cycles in air temperature and humidity to be shortened.

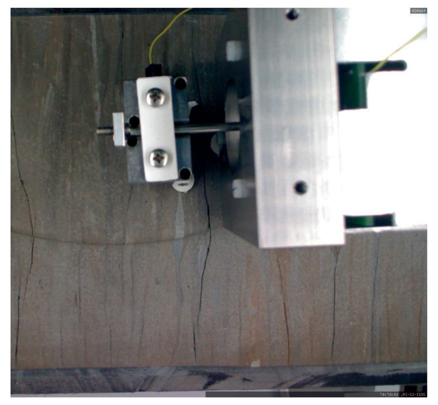
Experimental setup

Core sample

The Opalinus clay drill core used in this experiment was sampled from the EZ-B niche (Mont Terri rock laboratory).

Crackmeter

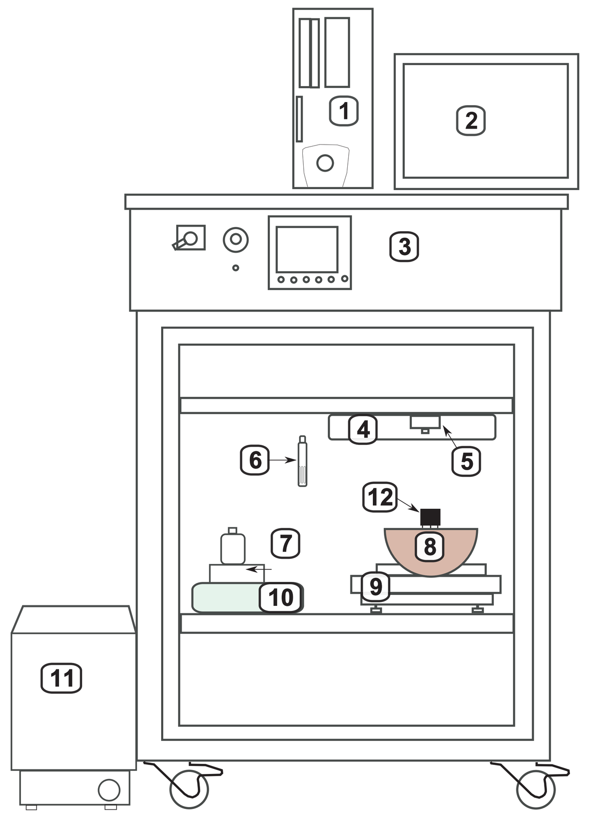




top view of the crackmeter

The grub screws of the crackmeter were placed in about 2 mm deep holes and fixed with resin.

Climate cabinet



Left: photographs of the climate cabinet
Right: experiment set up:
(1) unit PC, (2) PC display, (3) climate cabinet, (4) neon tube, (5) webcam, (6) humidity and temperature probe, (7) ultrasonic air humidifier, (8) half core sample of Opalinus clay, (9) balance with (10) display device, (11) air dryer, (12) crackmeter

Experiments

Test specifications

Test name	Cycle specification from	Cycle specification to	Cycle length	Comment
Calibration crackmeter	-	-	-	Conditions: 21.3°C and 29.9% rH
Test 10	7°C – 60%	14°C – 96%	Variable (1/2 month)	Sample BIS-D4 + crackmeter
Test 13	7°C – 60%	14°C – 96%	12h	Calibration crackmeter

Calibration crackmeter: the output signal of the preamplifier of the crackmeter is an AC voltage. The amplitude of this voltage is proportional to the electrical capacity of the plate capacitor between the two plates. The closer the distance between the plates, the higher is the amplitude. The output signal voltage versus distance is not linear.

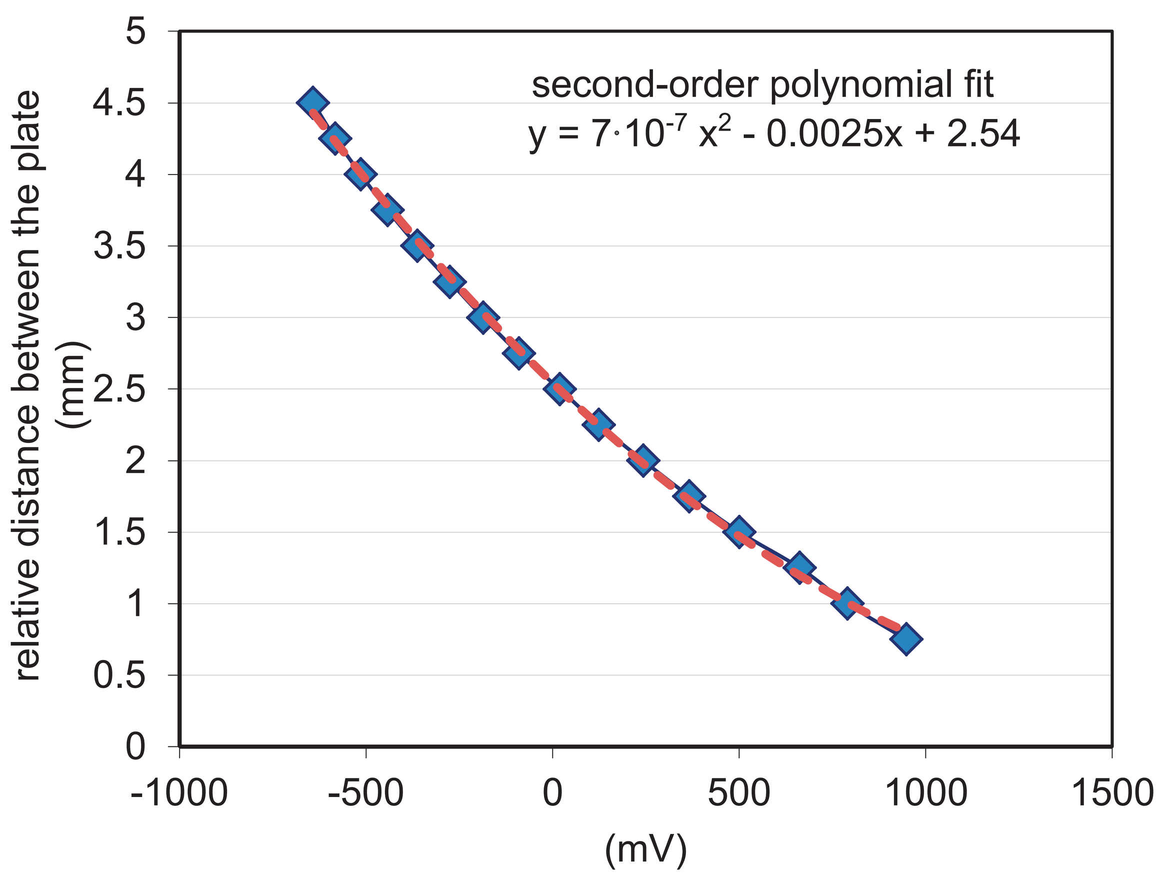
Test 10: crackmeter measurement on the core sample under varying relative humidity and temperature (tunnel conditions).

In test 13, the distance between the two plates of the crackmeter is **fixed** with screws and the influence of the operating conditions on the recorded crackmeter signal is assessed.

Results & discussion

Crackmeter calibration

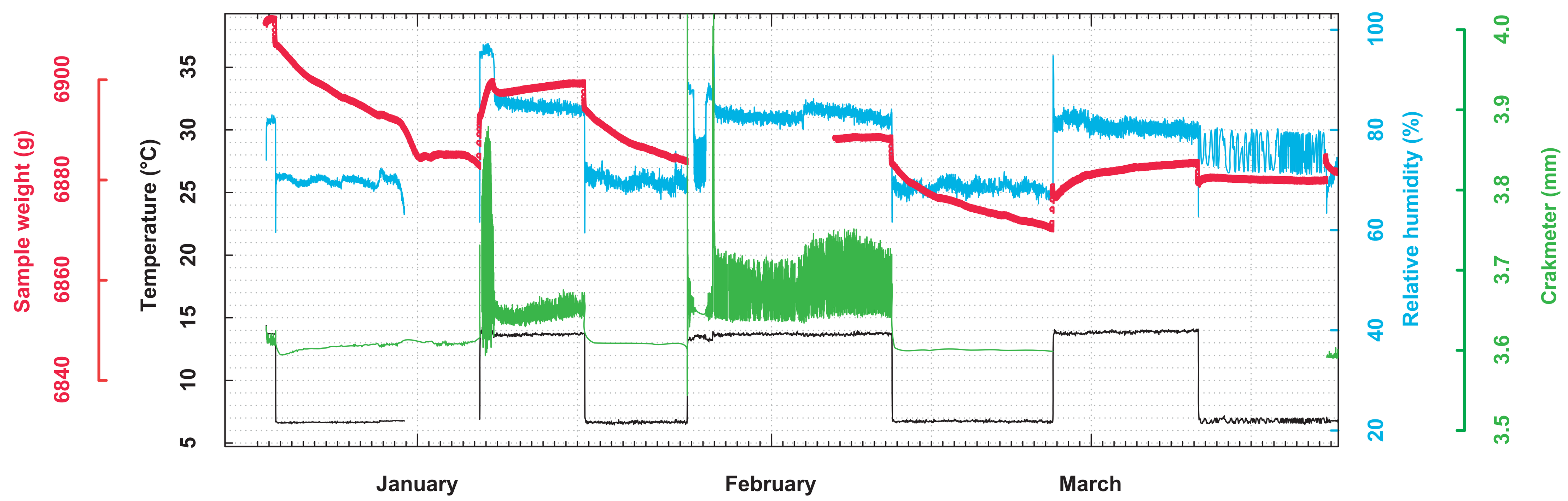
With the calibration screw the Crackmeter was calibrated before placing it on the Opalinus core. A special 90° angled hexagon key was used to turn the calibration screw in steps of 0.25 mm.



relationship between the measured potential and the relative distance between the plates of the crackmeter at 21.3 °C and 29.90% relative humidity.

To get applicable results for the experiment, the crackmeter should be calibrated at specific operating conditions.

Test 10 (Opalinus clay sample with crackmeter)



Due to few technical problems the time series are not complete.

Operating conditions: The measured temperatures agree very well with the operating settings (7°C – 14°C). This is not the case for the measured relative humidity that varies between 68% and 85%.
The relative humidity is hard to control:
(i) small temperature variations cause large variations of the relative humidity and (ii) the humidity of the air in the laboratory has an influence on the air humidity in the climate cabinet.
The dew point at time step t (estimated with the Magnus formula) was always lower than the temperature at time step t+1, meaning that no condensation is to be expected.

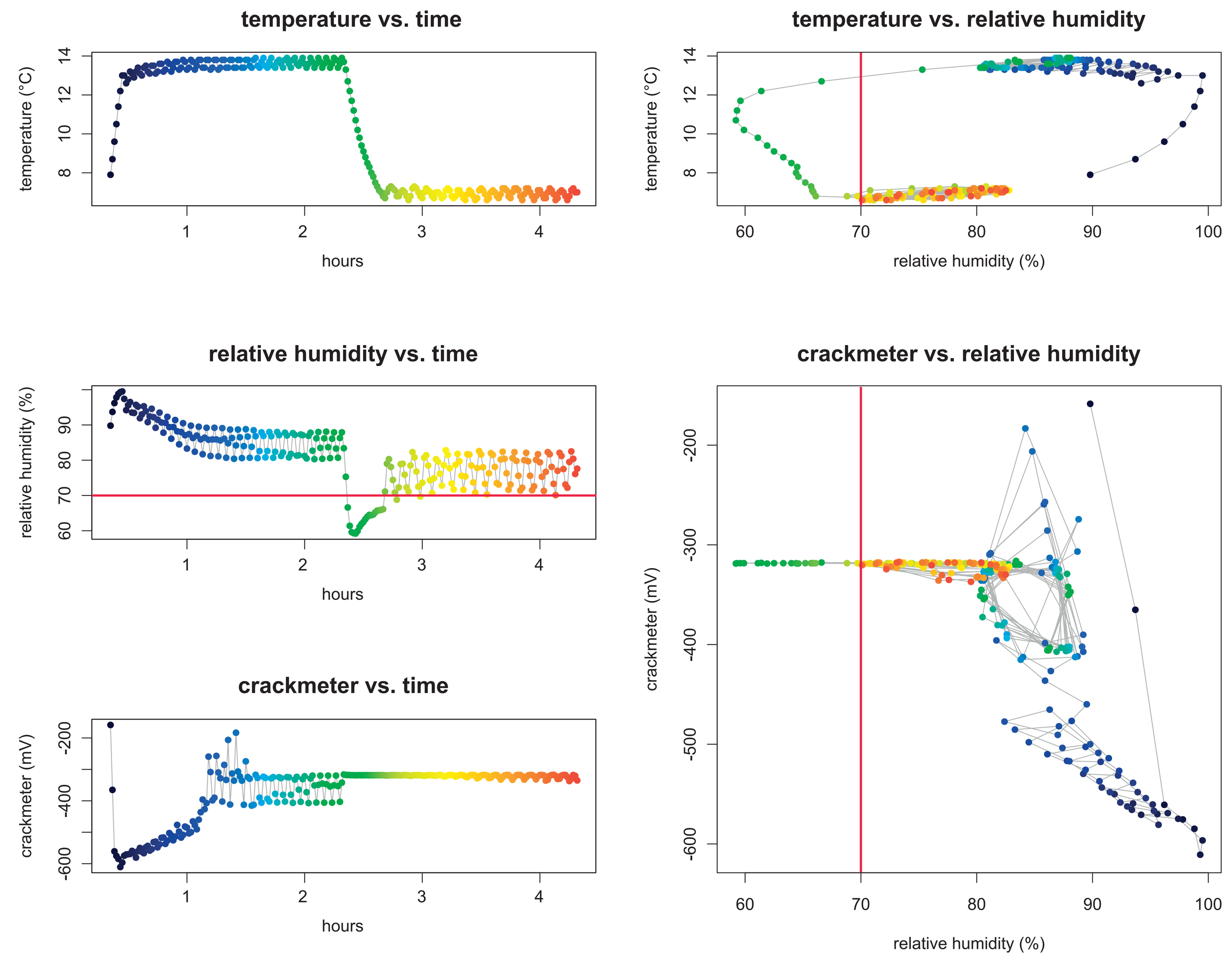
Weight: during the cold and dry period the core sample loses weight (inverse exponential decay) whereas it gains some weight during the wet and warm period (logarithmic gain). The overall trend is a weight loss. The sharp weight jumps might be due to the electronic sensitivity to the temperature and humidity variations.

Crackmeter: The measured potential values have been transformed into relative distance according to the fitted second-order polynomial fit. The observed sharp jumps may be due to the electronic sensitivity to the temperature and humidity variations.

The crackmeter signal is much noisier under warm and wet conditions than under cold and dry conditions. Below 80% of relative humidity the crackmeter signal is quite stable. The sharp jumps as well as the oscillating signal under warm and dry conditions are not well understood yet. However, by observing the signal only under the cold and dry conditions a slightly decreasing trend is perceptible.

Further analysis (i.e. correlation between the operating conditions and the crackmeter signal) are necessary to draw reliable conclusions.

Test 13 (fixed condensator plates)



a single cycle of test 13

Hystereses effects:
- a global hysteresis over the whole cycle;
- series of small scales hystereses under the more or less constant condition.

The hystereses observed between the temperature and the relative humidity may be related to the hystereses observed between the humidity and the crackmeter.