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ELEGANCY

Mt. Terri experiment: fault trapping

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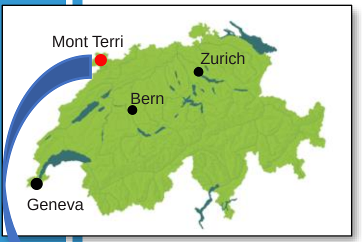
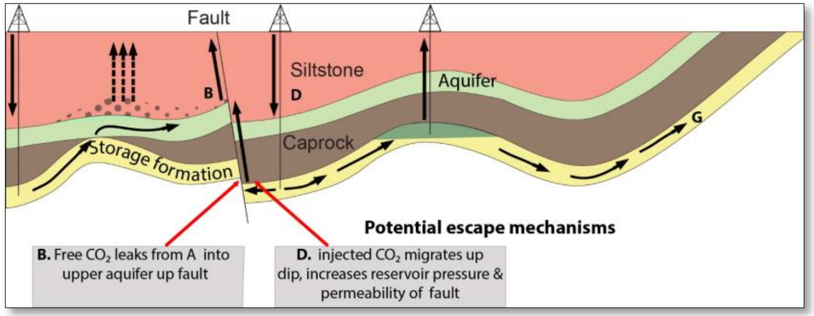
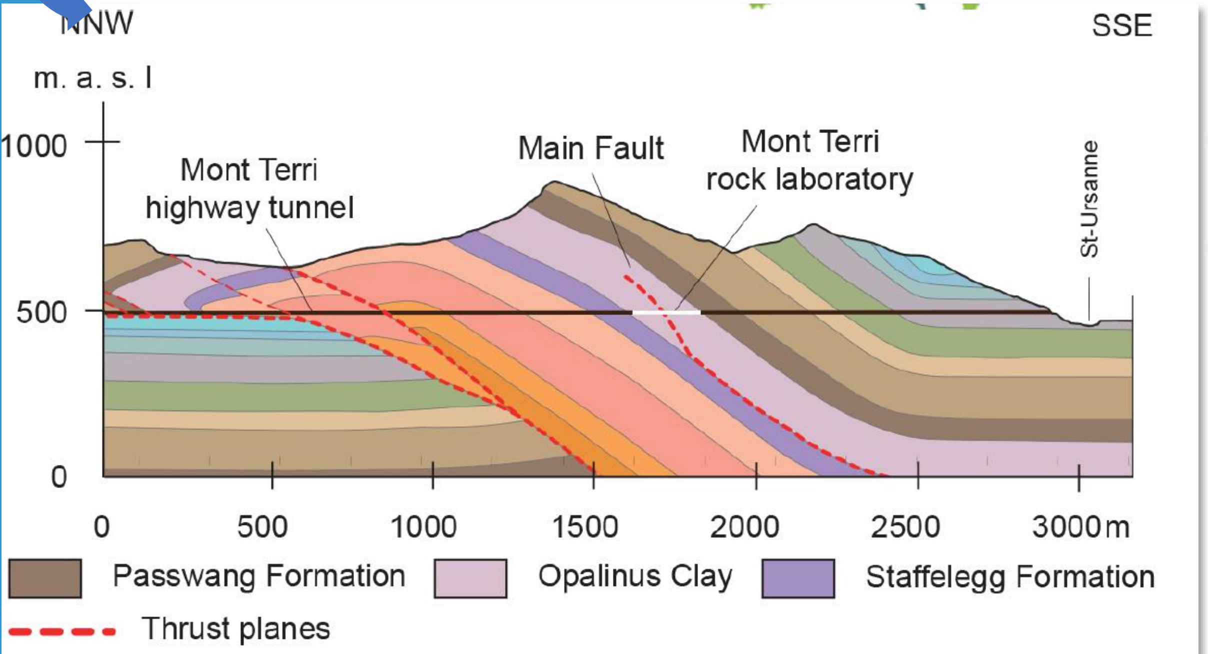
Scientific objectives







After Nussbaum et al. (2017): Tectonic evolution around the Mont Terri rock laboratory, northwestern Swiss Jura: constraints from kinematic forward modelling. Swiss Journal of Geosc., 110, DOI 10.1007/s00015-016-0248-x.

Flow through faults, potential leaks through a cap rock:

CS-D → Simulating CO_2 (dissolved in formation water) leaking trough a fault in a caprock

Objectives of the CS-D experiment:

- investigating how the exposure to CO_2-rich brine affects sealing integrity of a caprock, hosting a fault system (permeability changes, induced seismicity).
- observing directly the fluid migration along a fault and its interaction with the surrounding environment.
- testing instrumentation and methods for monitoring and imaging fluid transport.

More about the CS-D experiment:

Zappone et al. 2018. CO_2 Sequestration: Studying Caprock And Fault Sealing Integrity, The CS-D Experiment In Mont Terri, *First Break* , DOI: https://doi.org/10.3997/2214-4609.201803002

Zappone et al. 2020. Fault sealing and caprock integrity for CO_2 storage: an in-situ injection experiment. *Solid Earth*, submitted

Wenning et al. 2020. Shale fault zone structure and stress dependant anisotropic permeability and seismic velocity properties (Opalinus clay, Switzerland) *J. Struc. Geol.*

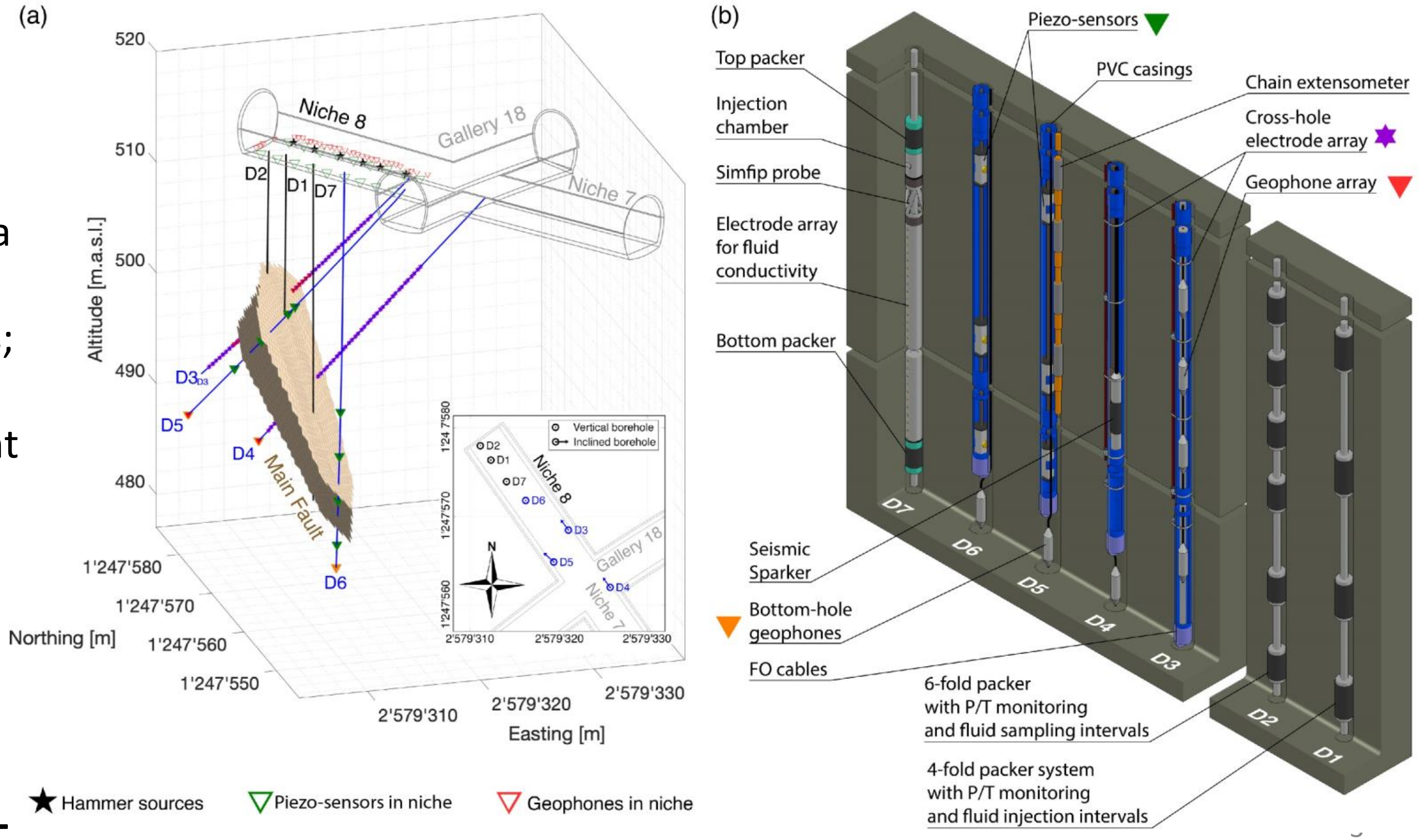
(4 more papers are in preparation)

Layout

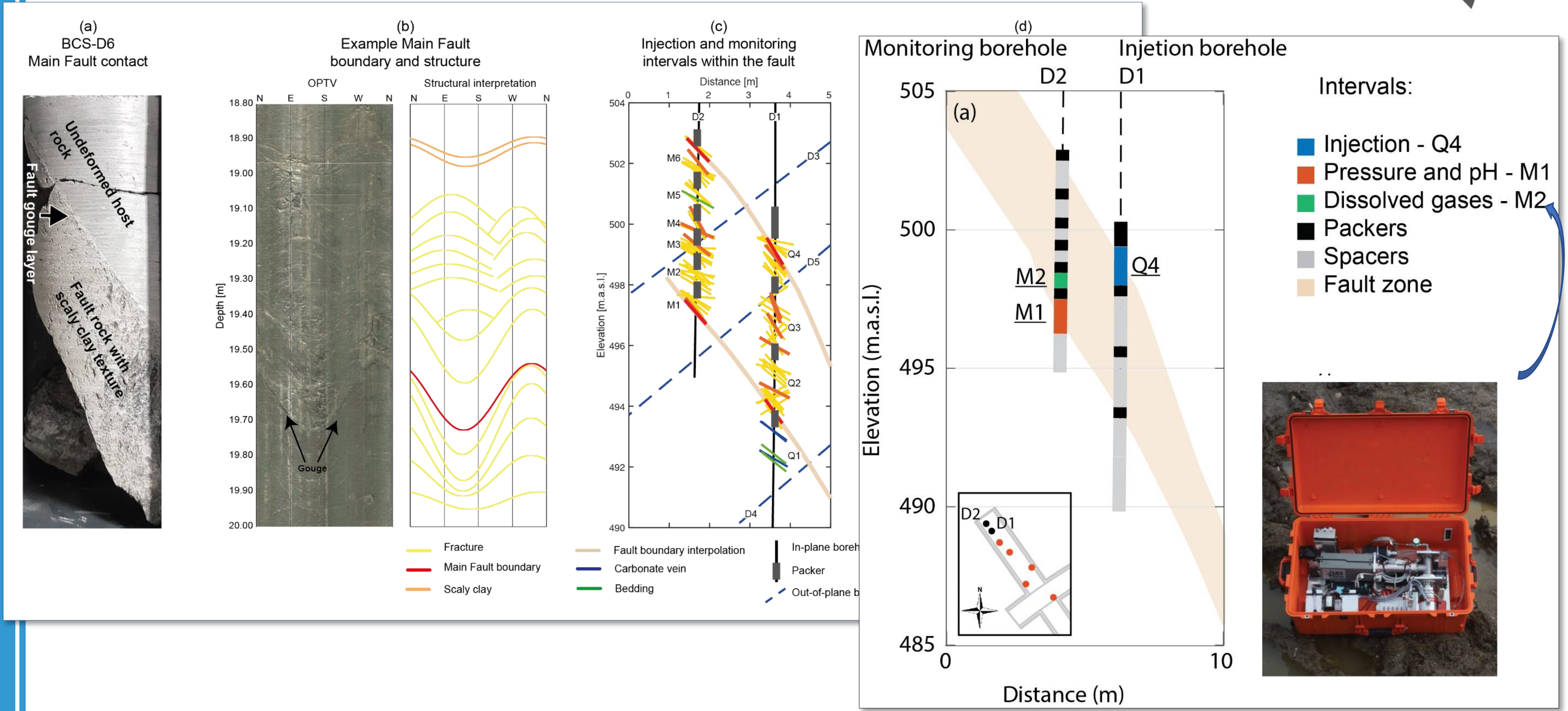
- The facility installed for the ELEGANCY experiment at Mont Terri is a semi-permanent in-situ research unit, ideal for studying CO_2 storage/safety related aspects and should be continued to be used in the future.

With its dense network of monitoring systems, the experiment aims at:
1. collecting multi-parameter data from independent but strongly integrated monitoring techniques;
2. establish a dataset at high spatial resolution that yield insight into the interrelationship of hydraulic, geomechanical, and geochemical processes within a fault in a caprock.

In situ is complemented by lab tests at **Imperial College** and **EPFL**

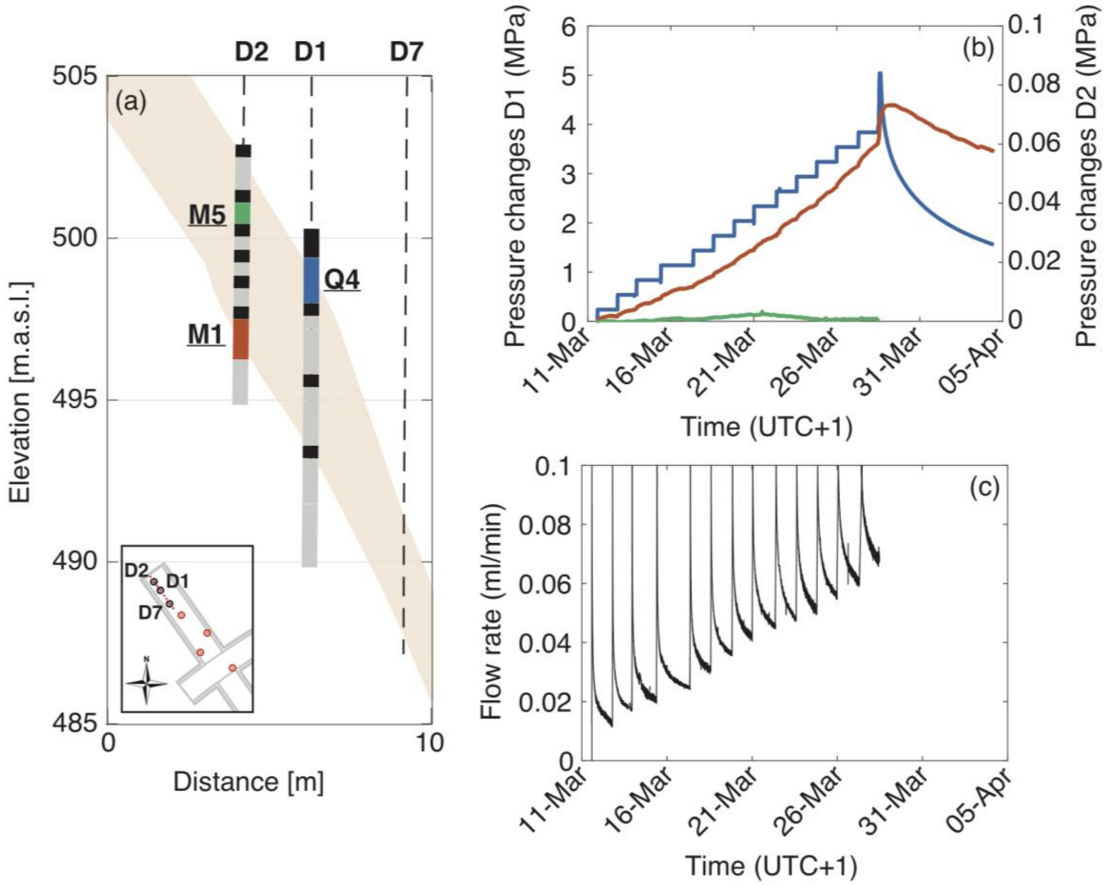


Fault characterization and D1,2 instrumentation



Fault transmissity and Fault Opening Pressure

Phase 1: Feb-May 2019, injection synthetic water



Prolonged step test:
Aim: understand the system response to pressurization

- P increased by steps of 300 kPa,
- Step 28-30 hours
- P_{max} 4.8 Mpa (FOP)

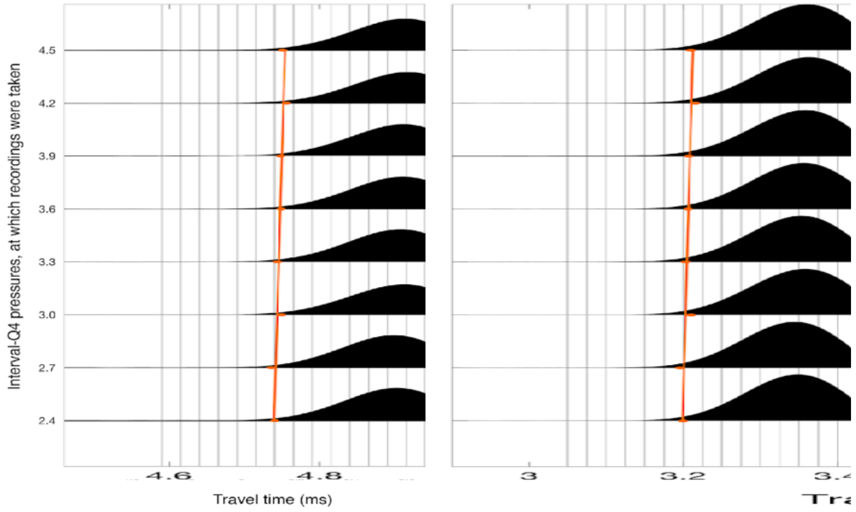
Analysis of pressure decay (3 days) :
- transmissivity in the order of 10^{-13} m^2/s
- ~10^{-21} m^2 permeability

The value is close to previous estimates (Marschall et al. 2005)

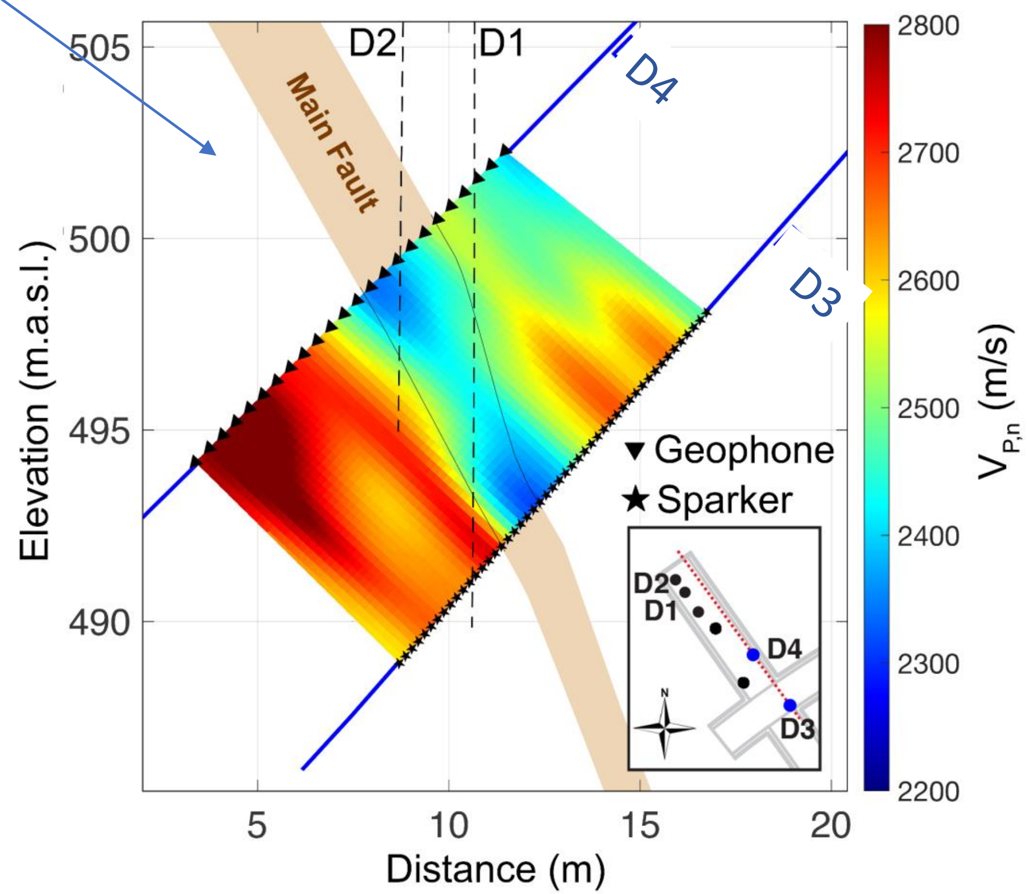
Estimated transmissivity at FOP: 9 ▪ 10^{-12} m^2/s

Active/passive seismic monitoring

- The fault at Mont Terri could be nicely detected by seismic tomographic data.
- Seismic velocities are sensible to pore pressure variation in the system with c.a. ~1 % variation (P waves)



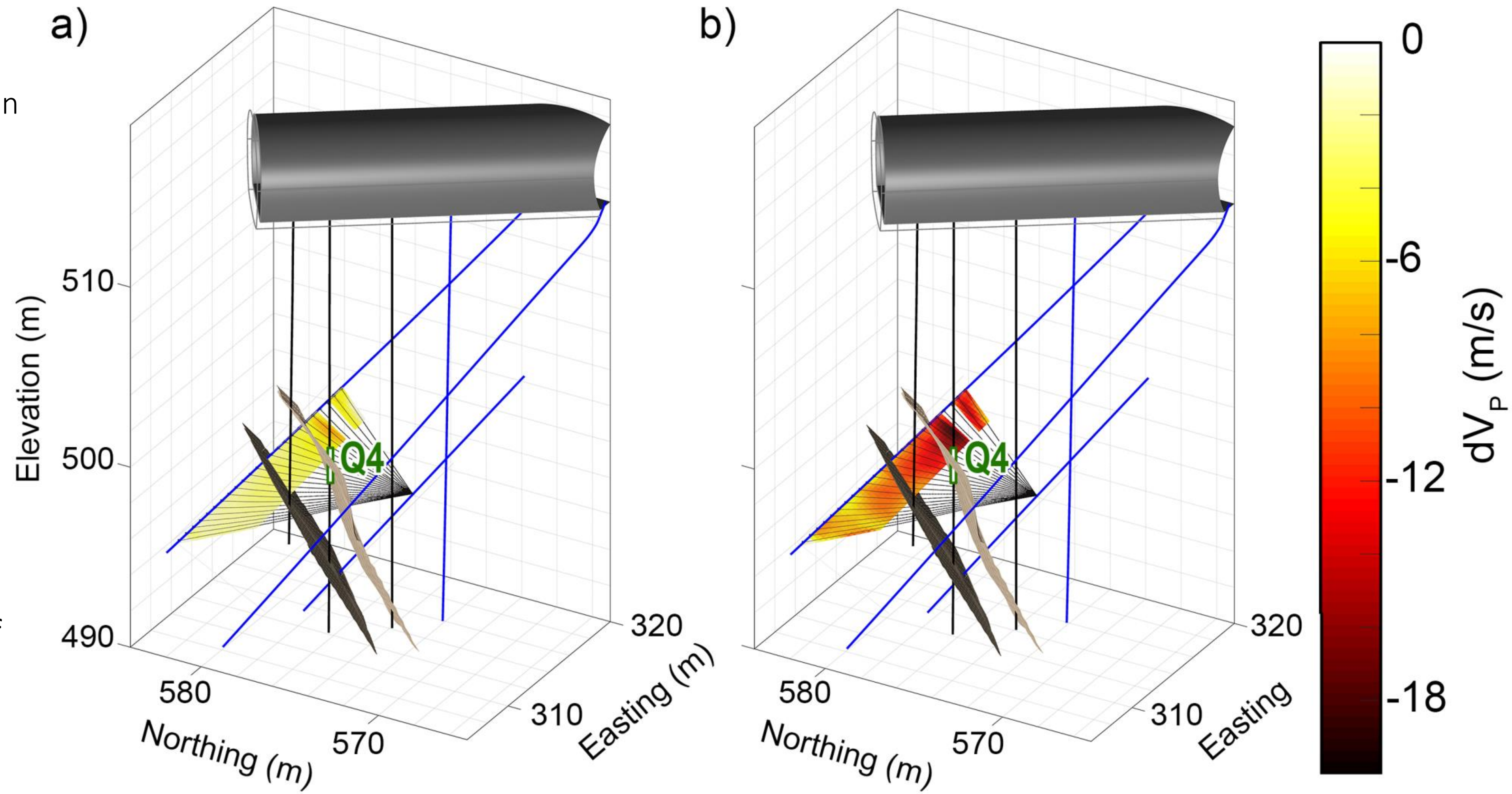
- No notable induced microseismic event was recorded.



Results: VP-monitoring during step-up injection test

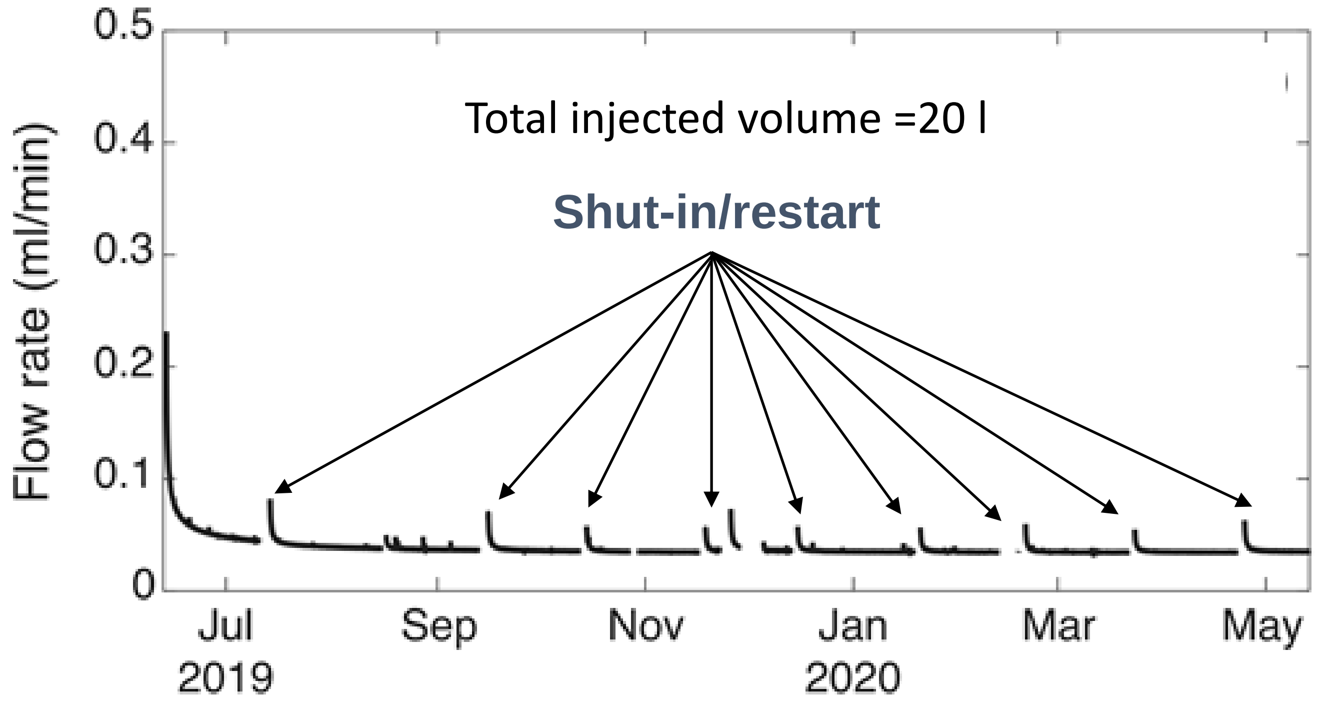
Active Seismic monitoring

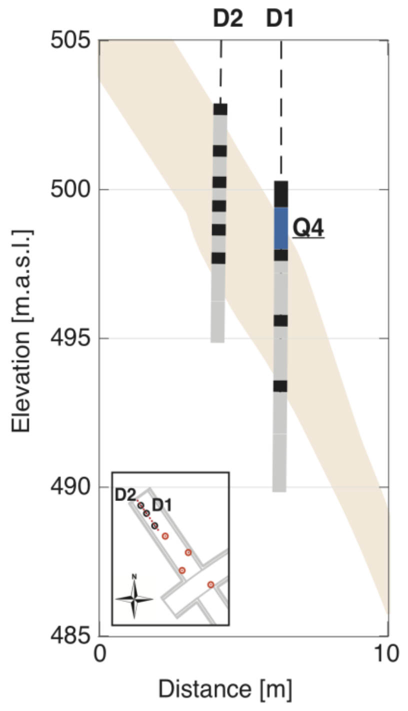
- P-wave sparker shots repeated after each injection step-up
- Change in P-wave velocity (dV_P), relative to V_P from baseline tomogram
- Figure a: dV_P at injection pressure of 2.4 MPa (first step)
- Figure b: dV_P at injection pressure of 4.5 MPa (last step)
- Reduction of V_P by around 1% in the vicinity of the injection interval



Injection of CO_2-enriched water

- **Phase 2**: injection at 4.5 MPa, syn. water+Kr+CO_2 (mixed at about 2.2 MPa)





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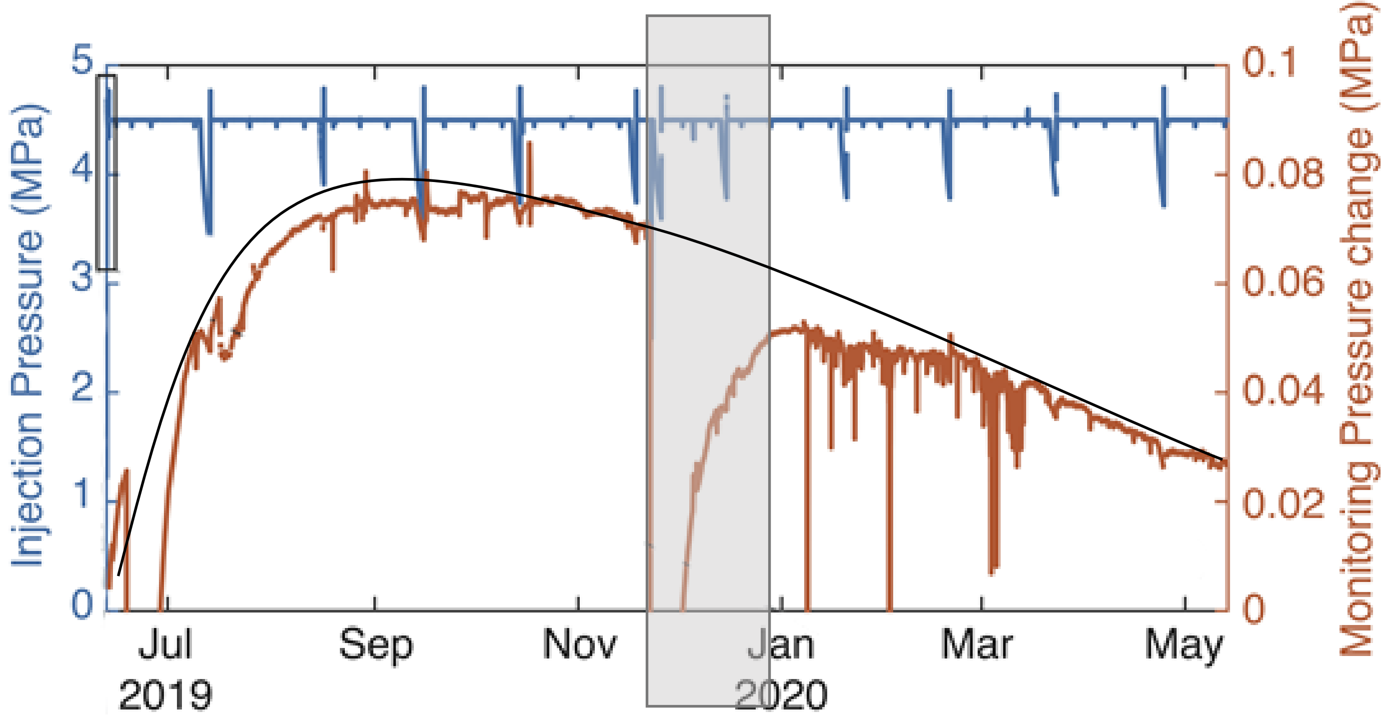
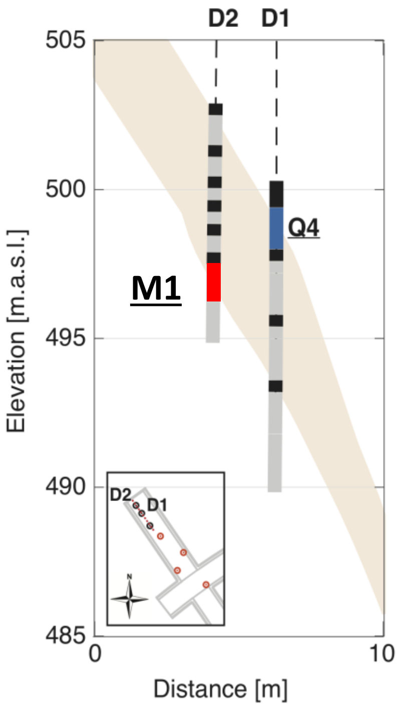
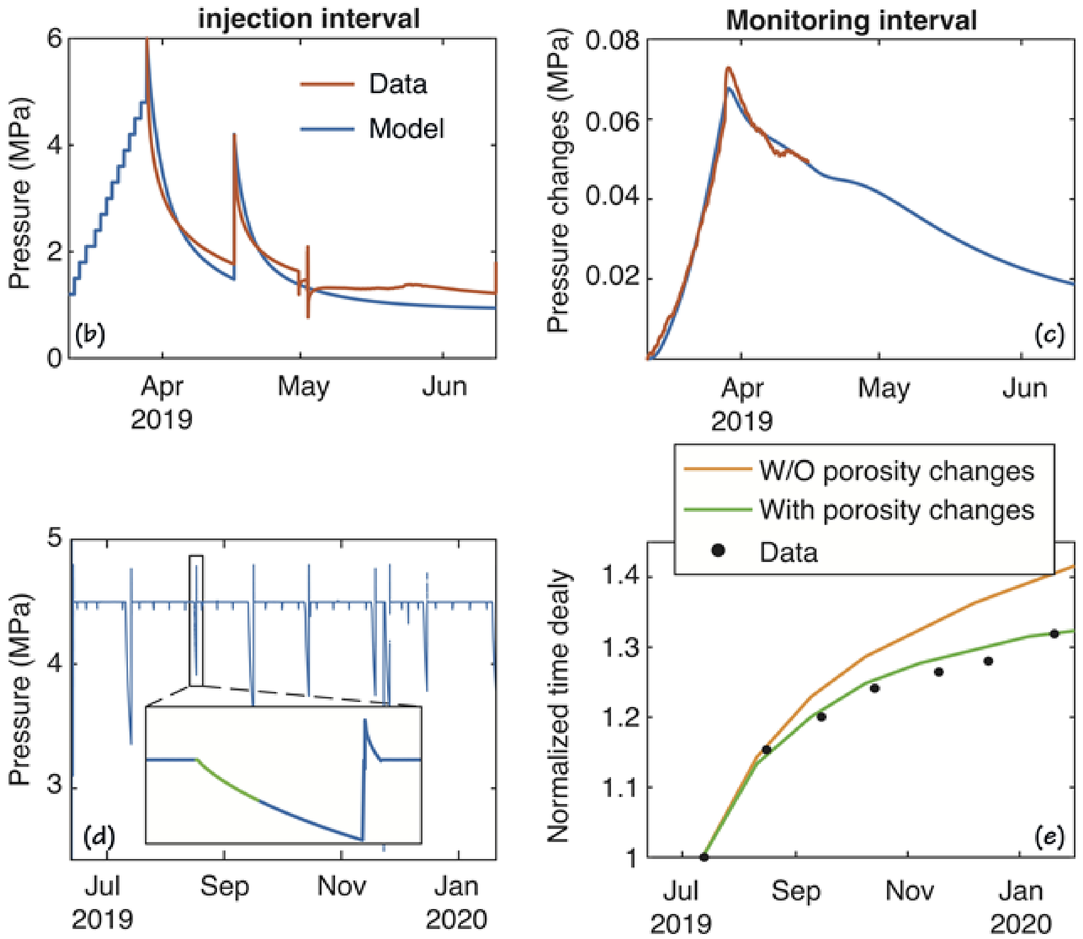


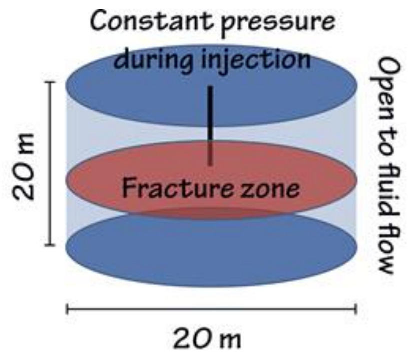


Pressure at monitor first increased then decreased after plateau
Could it be fault/fracture self-sealing? Swelling?

Injection of CO_2-enriched water

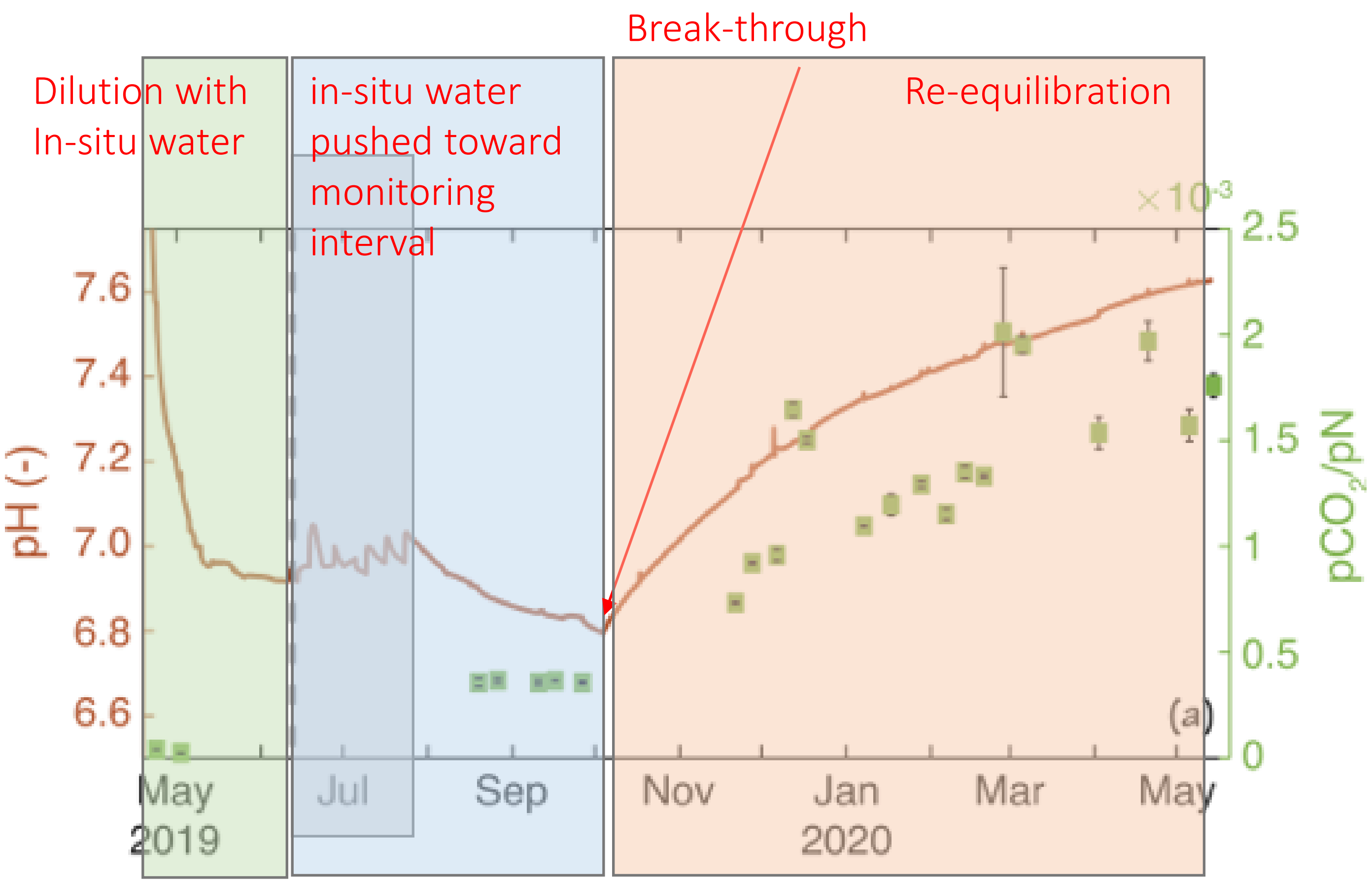
- **Modeling:** iTOUGH2 ; inverse modeling by accounting for the pressure recorded during one week long injection test

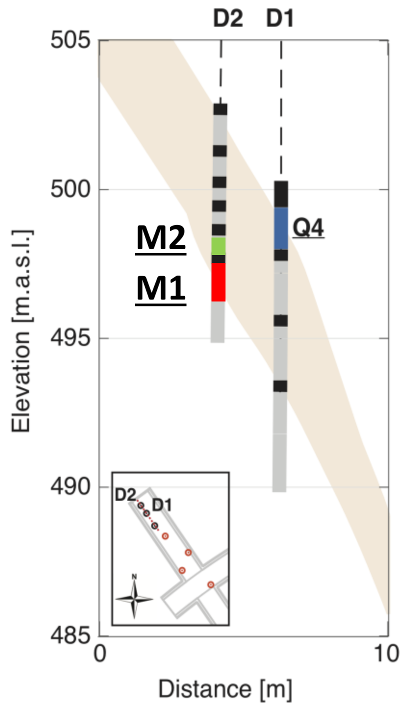




The behaviour at the monitoring point is captured when assuming the fracture not directly connected to the near well region, and allowing for closure (lower permeability) during shut-in (c).
The trend in (e) better agrees with a model where the porosity decreases in the vicinity through time of the injection interval (green line in Fig. 4e, with a fix 0.5% decrease at each step) compared to a model with no porosity changes (orange line).

Injection of CO_2-enriched water





pH synt. water in D2=7.8
pH injected water (syn+CO2)=5.5

Conclusions

- The leakage is confined along tiny fractures.
- Seismic velocity changes during pressurization, fault could be nicely imaged,however, results of a time-lapse tomography could not identify the connective fracture through which the CO_2 moved.
- Potential porosity decrease in the near injection region. Self healing?
- The time scale of CS-D was probably too short to have measurable effects
- The risk of induced seismicity in the caprock is confirmed very low.

Outreach

- Media event in January 2019, c.a. 20 journalists, c.a. 40 articles in local and national newspapers
- Interviews with Reuters, Radio France,
- A report broadcasted on the national TV
- Many schools, and other visitors

We can help social acceptance

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Acknowledgements

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ELEGANCY

Accelerating CCS Technologies

The EU Framework Programme for Research and Innovation
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