CO_2 sequestration within the ELEGANCY-ACT project:

Progress of the CS-D experiment on faulted caprock integrity in Mont Terri

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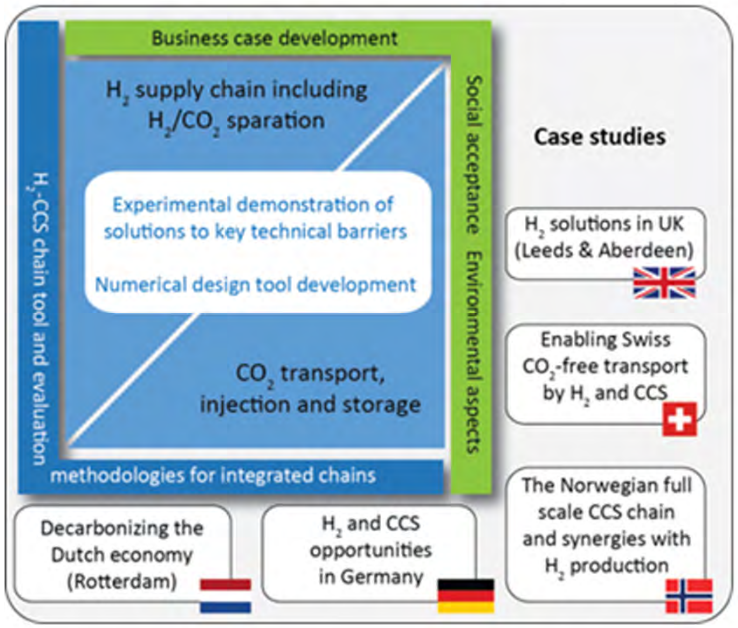
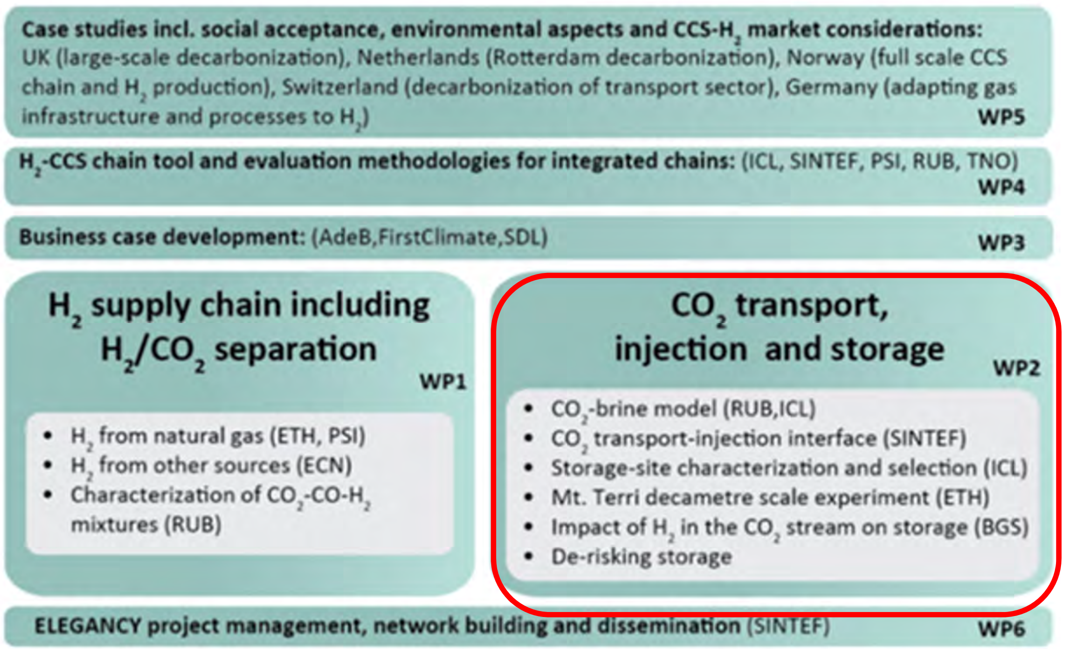
ELEGANCY

Accelerating CCS Technologies

Efficient generation of renewable H_2 from biomass, while harvesting geothermal heat and enabling negative CO_2 emissions
September 2017-August 2020

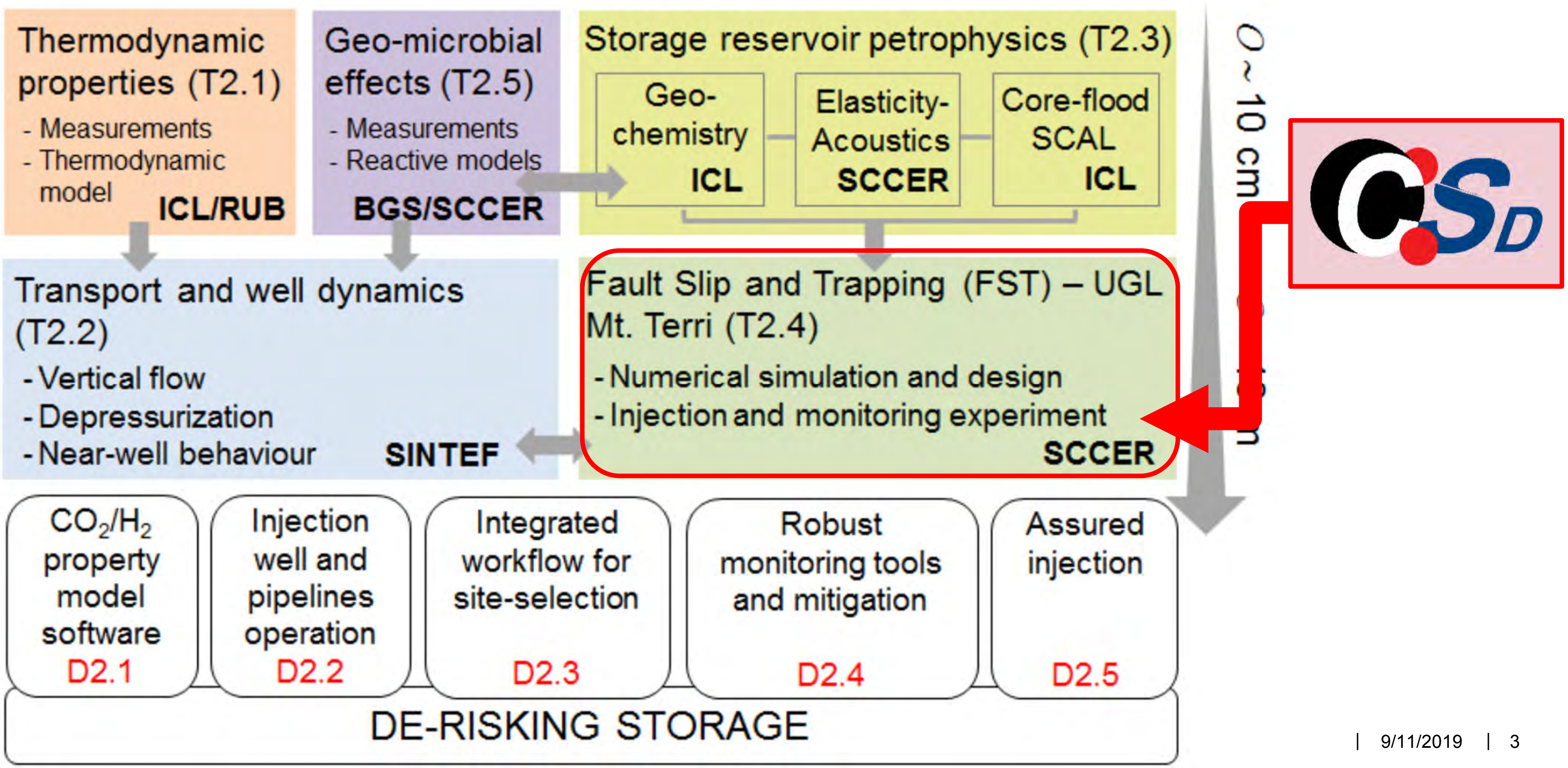




ELEGANCY

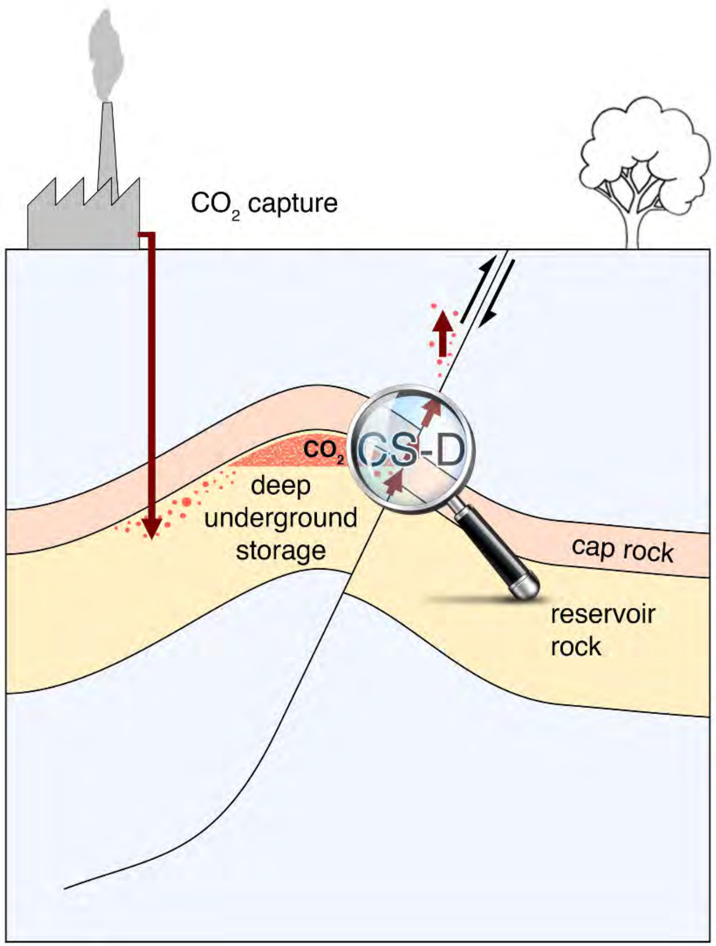
Accelerating CCS Technologies

WP 2: CO_2 transport and storage



Content:

1. The CS-D experiment in Mont Terri



Flow through faults, potential leaks through a cap rock:

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.

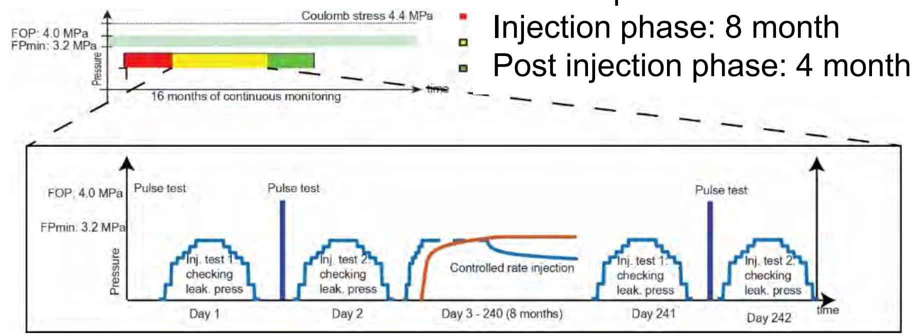
1. The CS-D experiment in Mont Terri

Inject CO_2 saturated formation water and tracers in Mont Terri main fault:
- Pulse/ pressure increase steps (at beginning and at end of the injection phase)
- Continuous/long term injection
- Activation of the fault by injecting water (FS-B experiment)

Scale: 1-10 m^3 Rock volume

Monitor injection effects:
- Electrical conductivity, tracers, fluid samples
- Recording flow rates and pressures
- Strain (Extensometers, FO)
- Seismic velocity changes
- Microseismic events

Charac. phase: 4 month
Injection phase: 8 month
Post injection phase: 4 month



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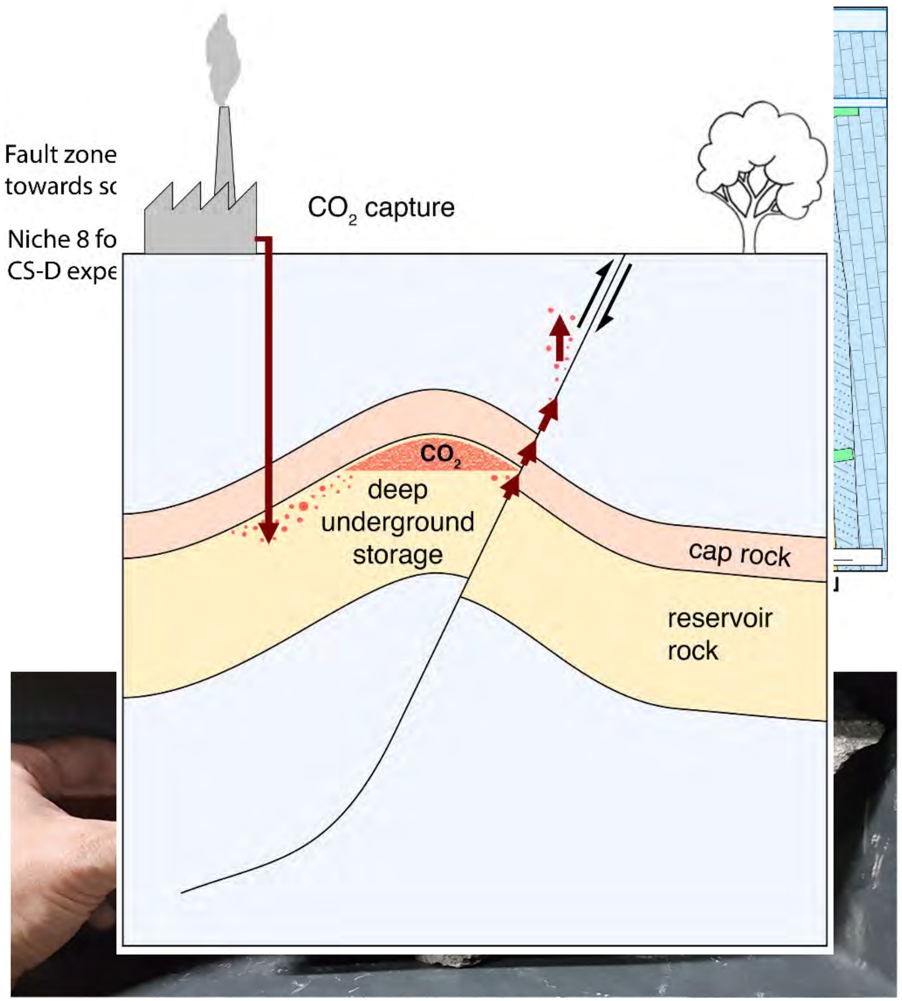
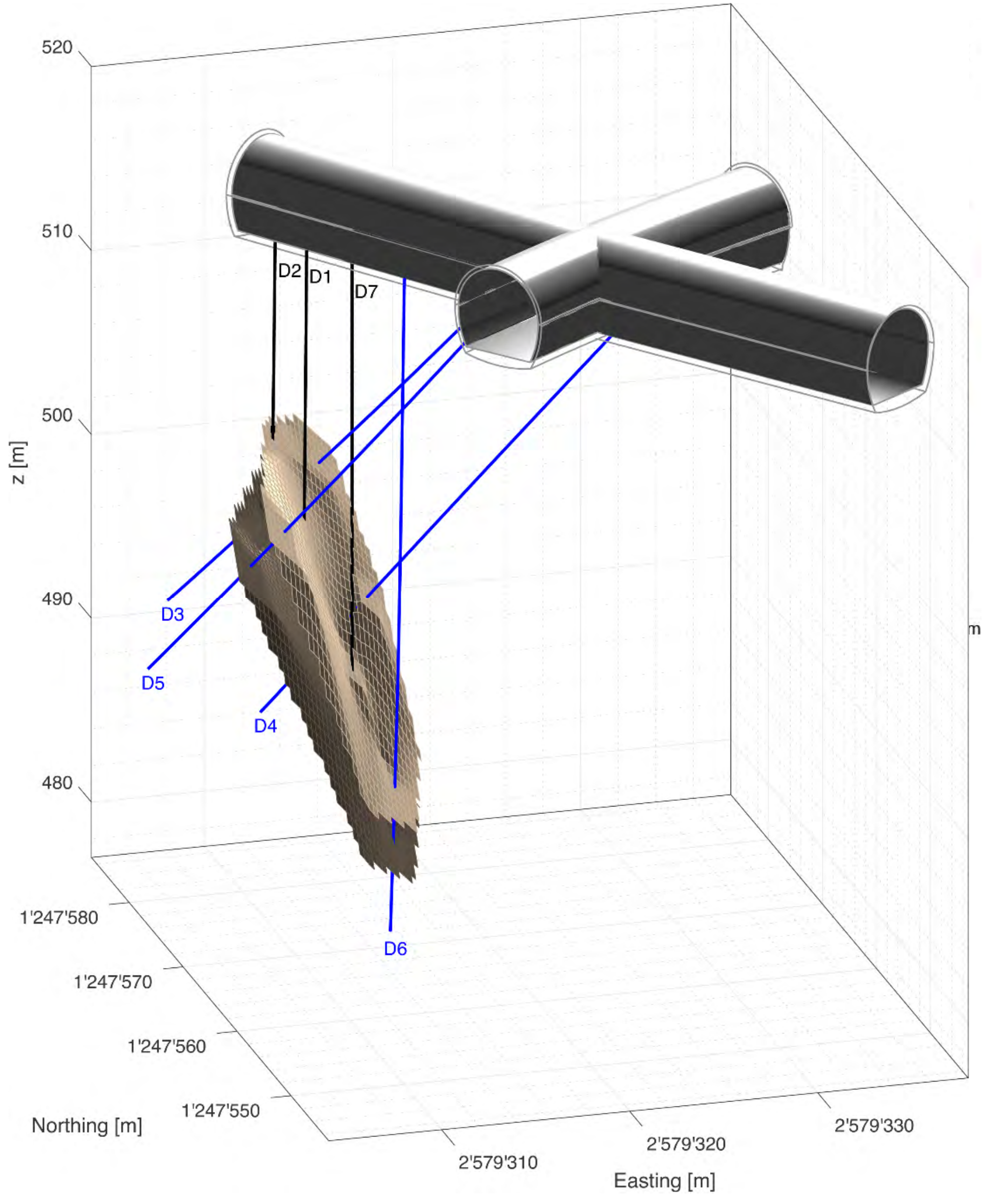


M. Lukovic, Q. Wenning



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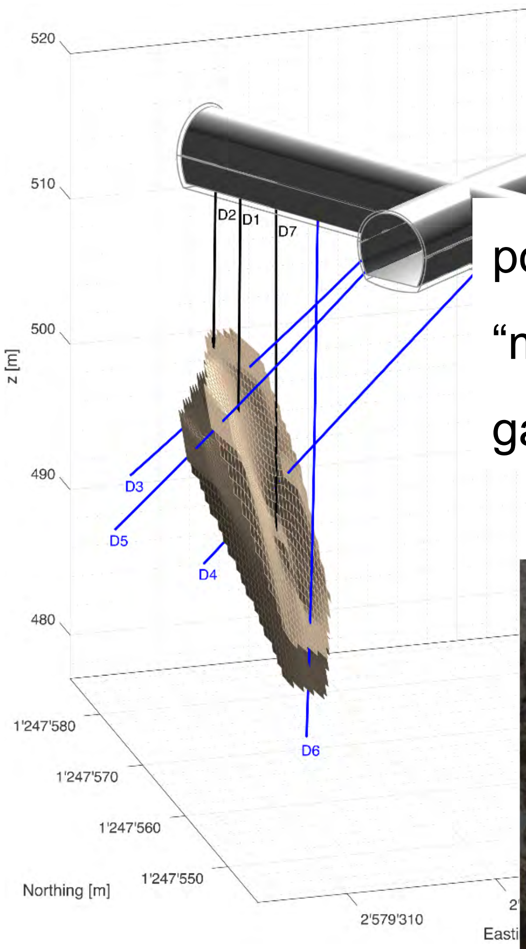
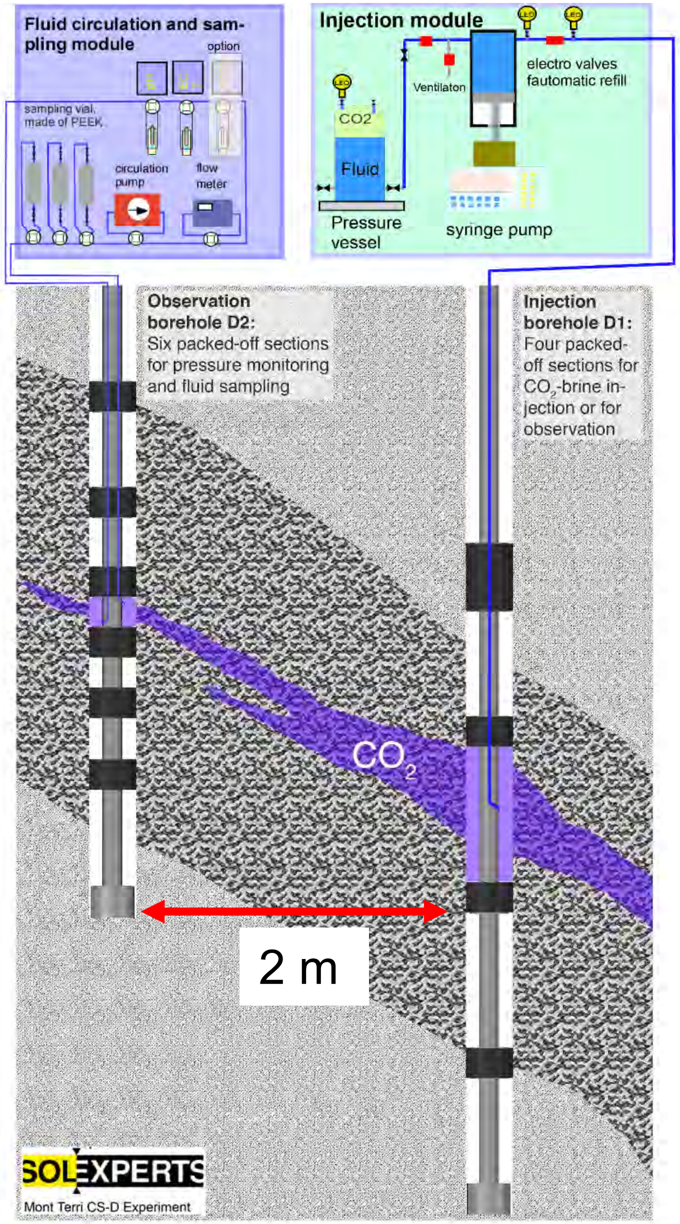
2. Instrumentation



portable gas spectrometer – "miniRuedi" by eawag aquatic research

gas tracer: krypton



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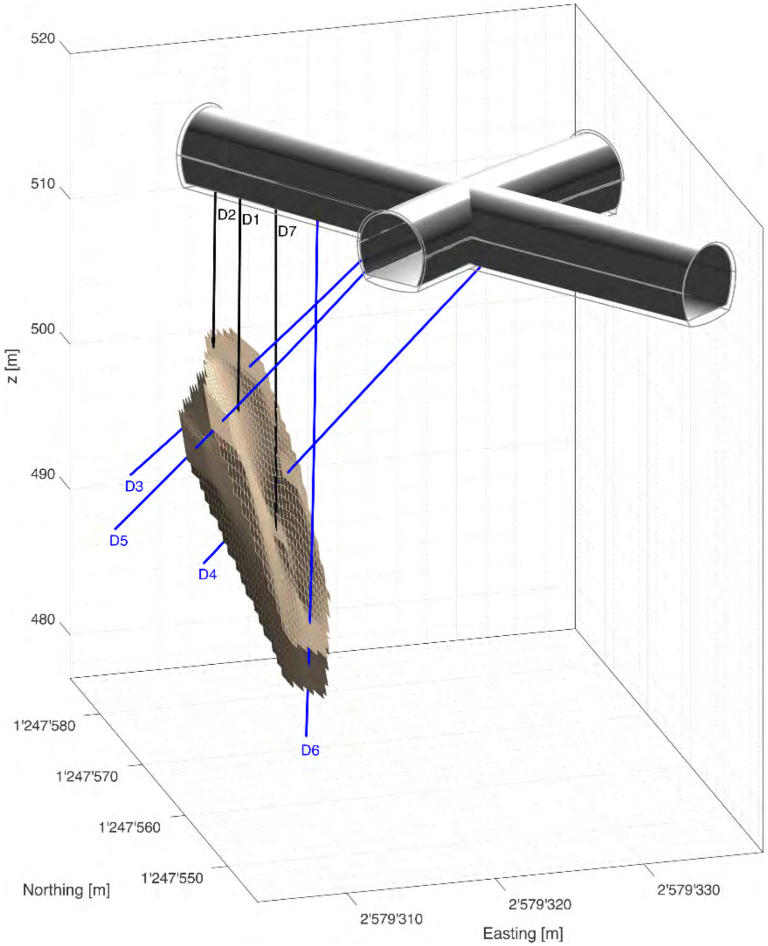

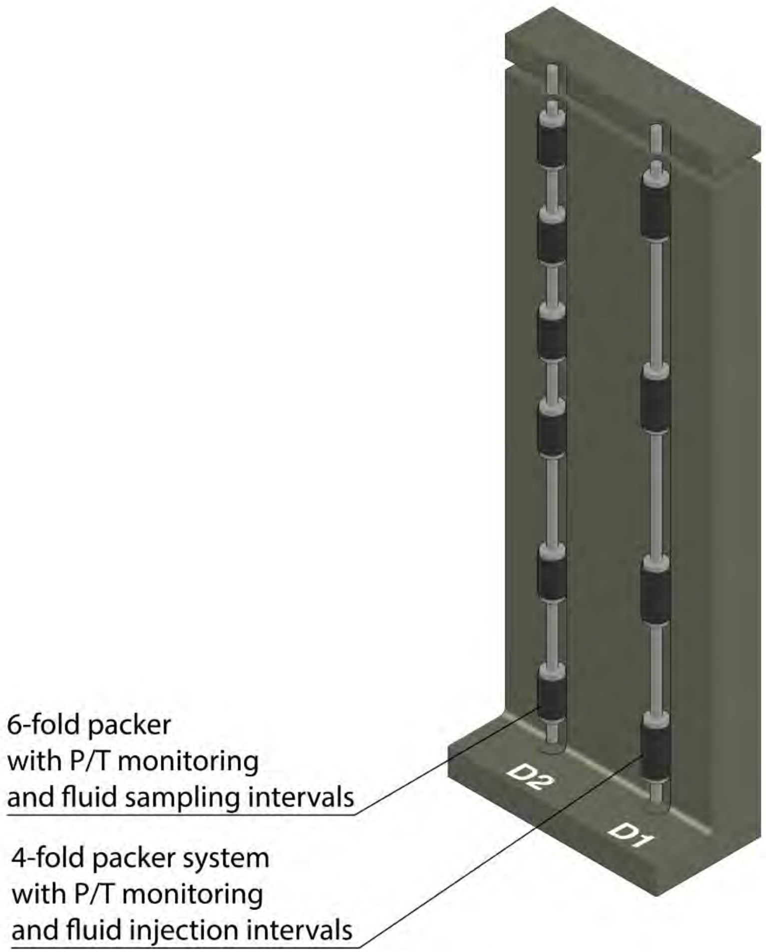

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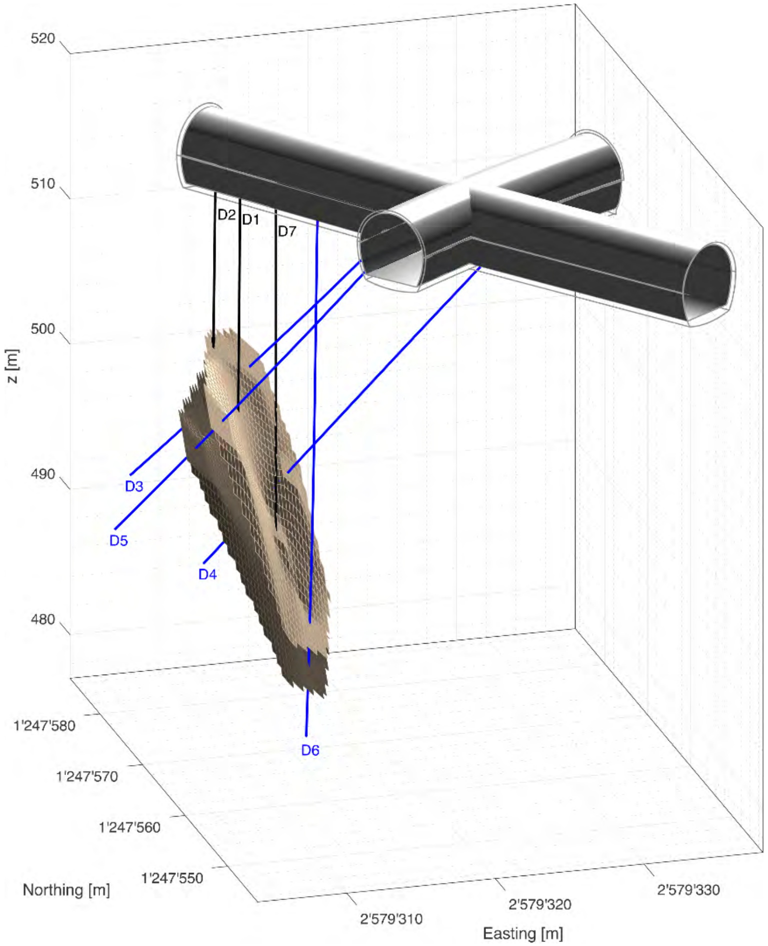

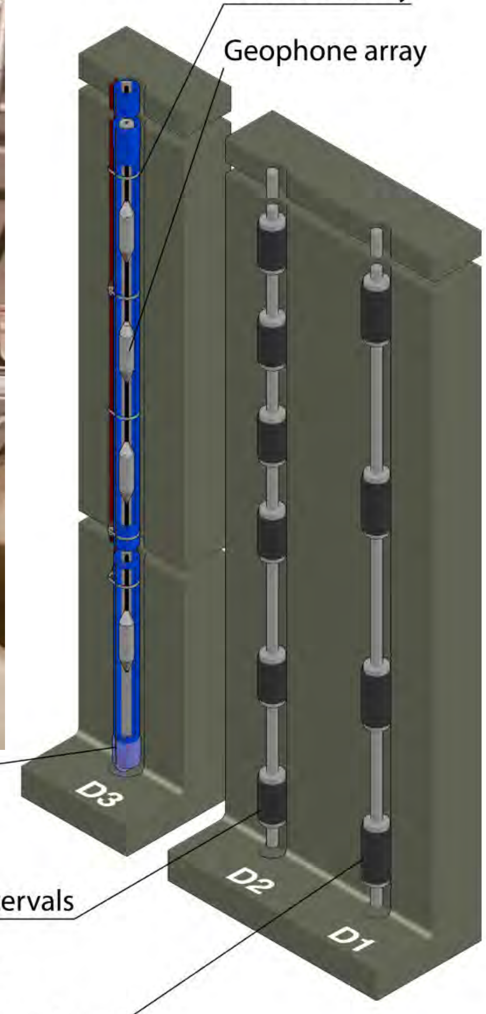

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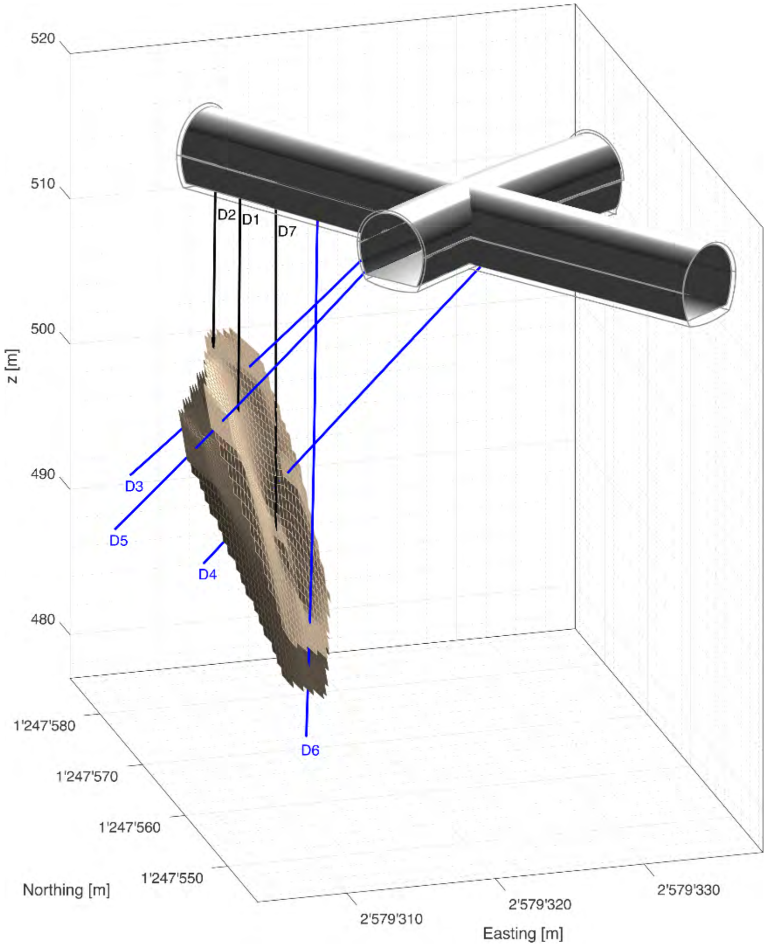

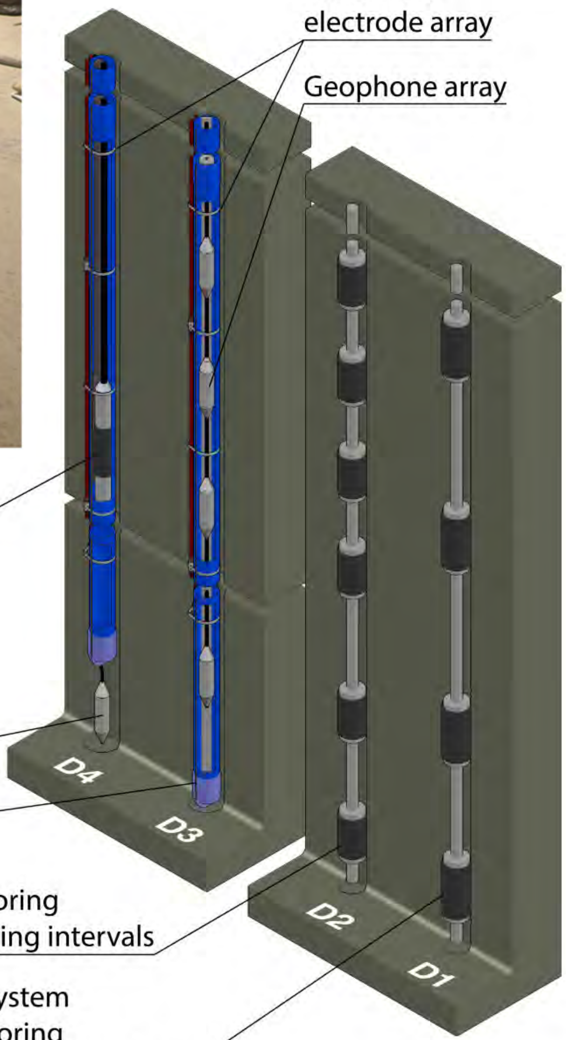

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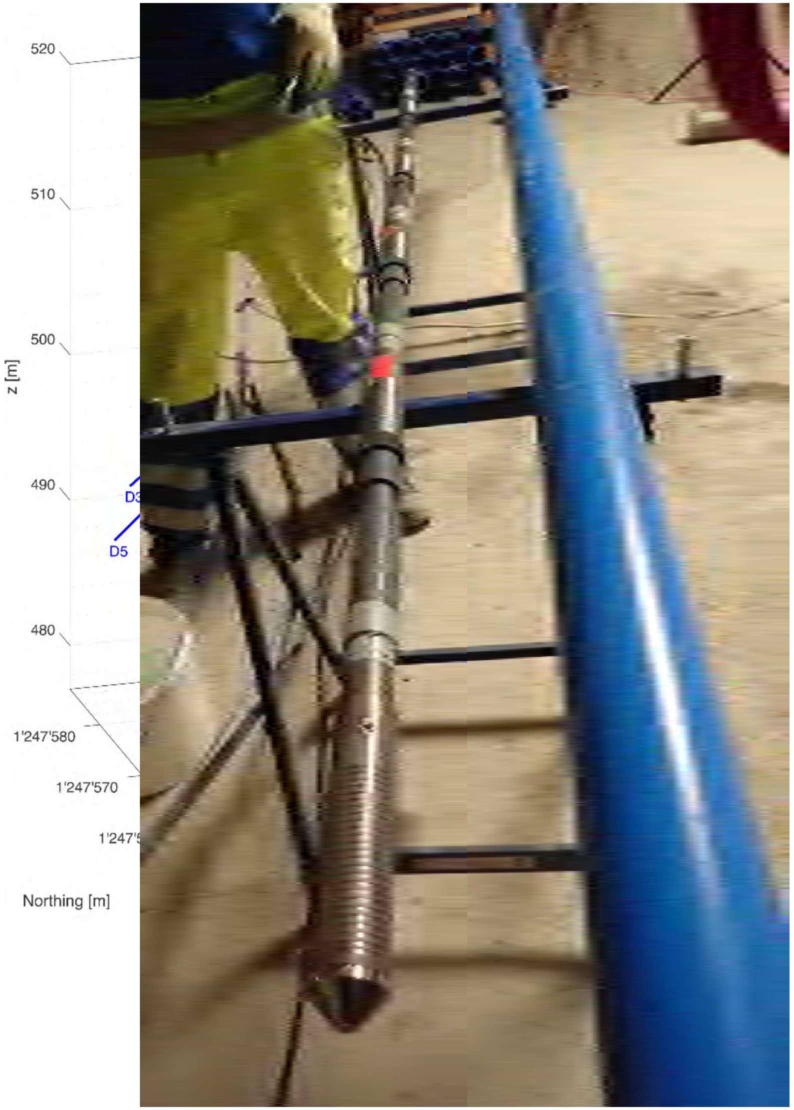

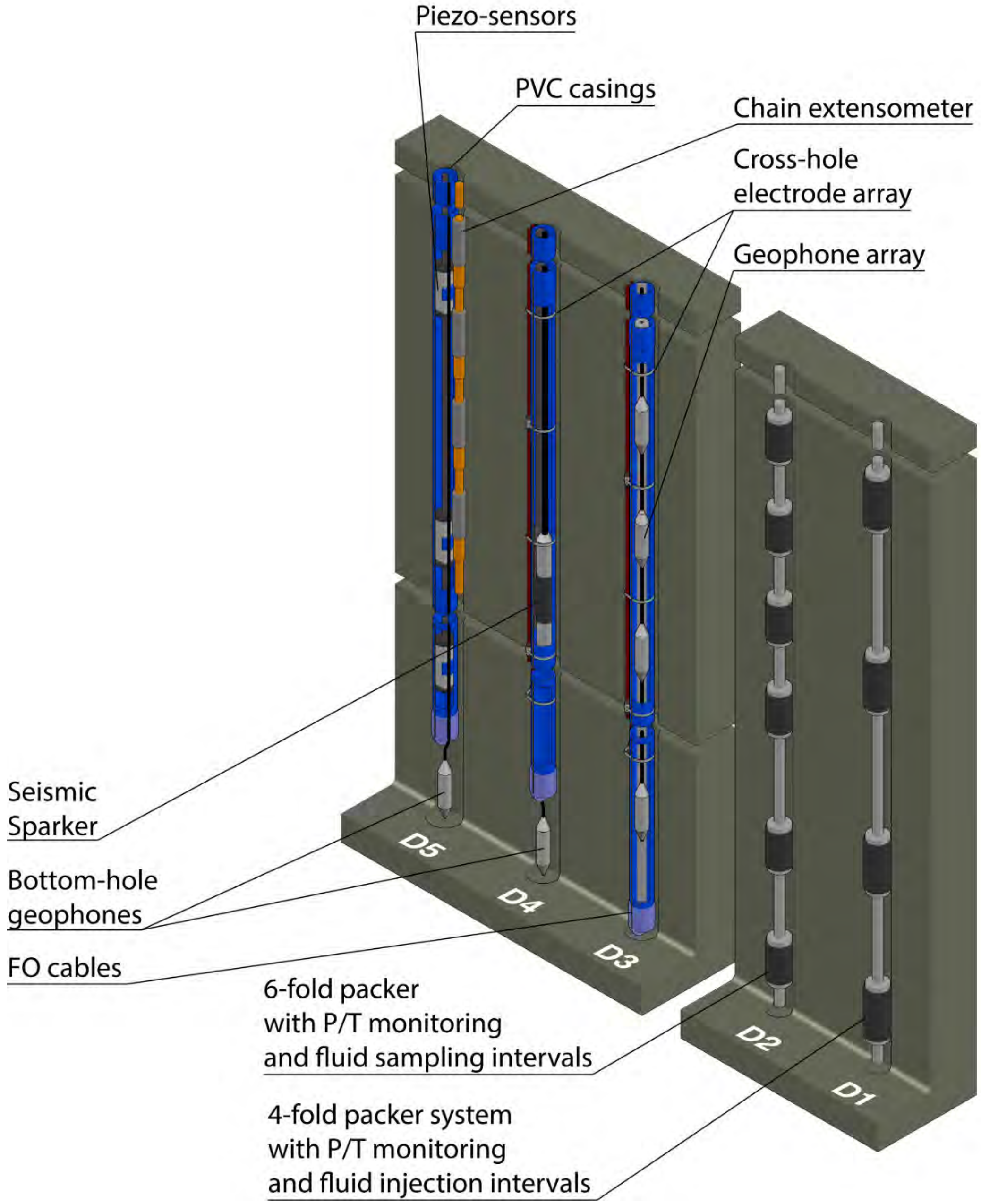

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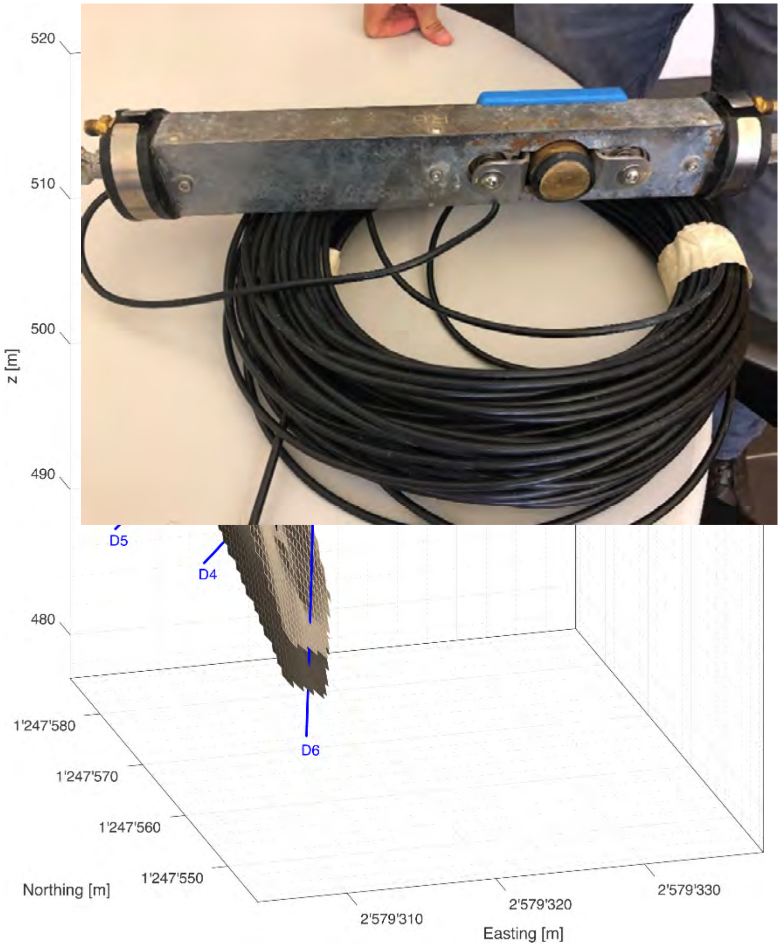

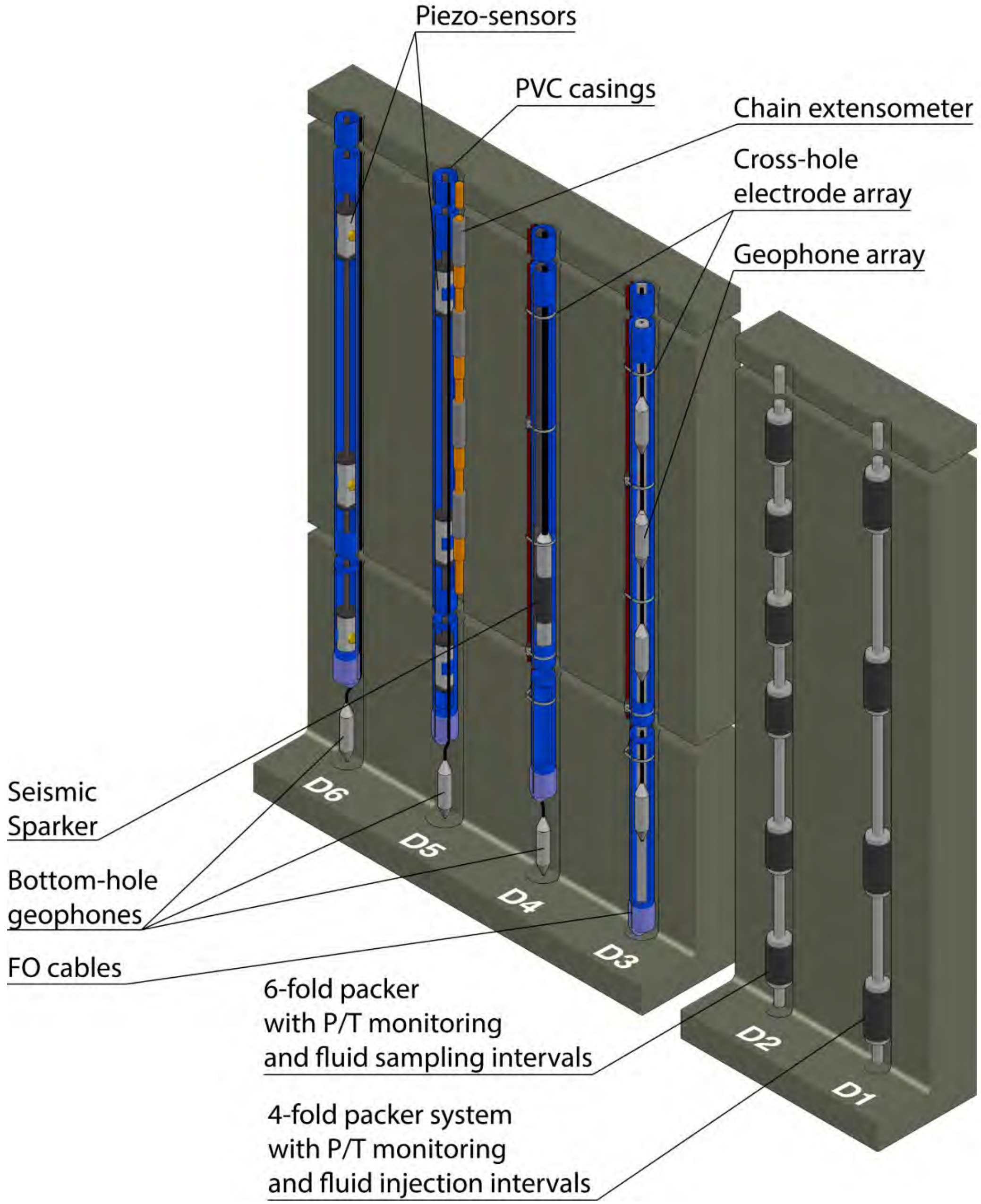

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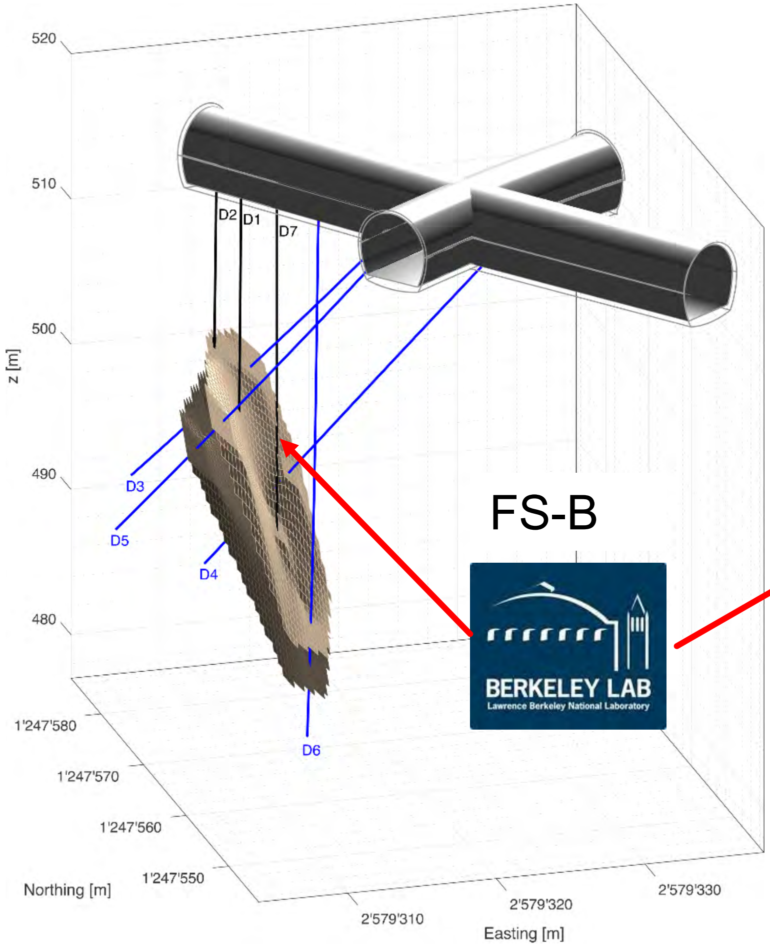

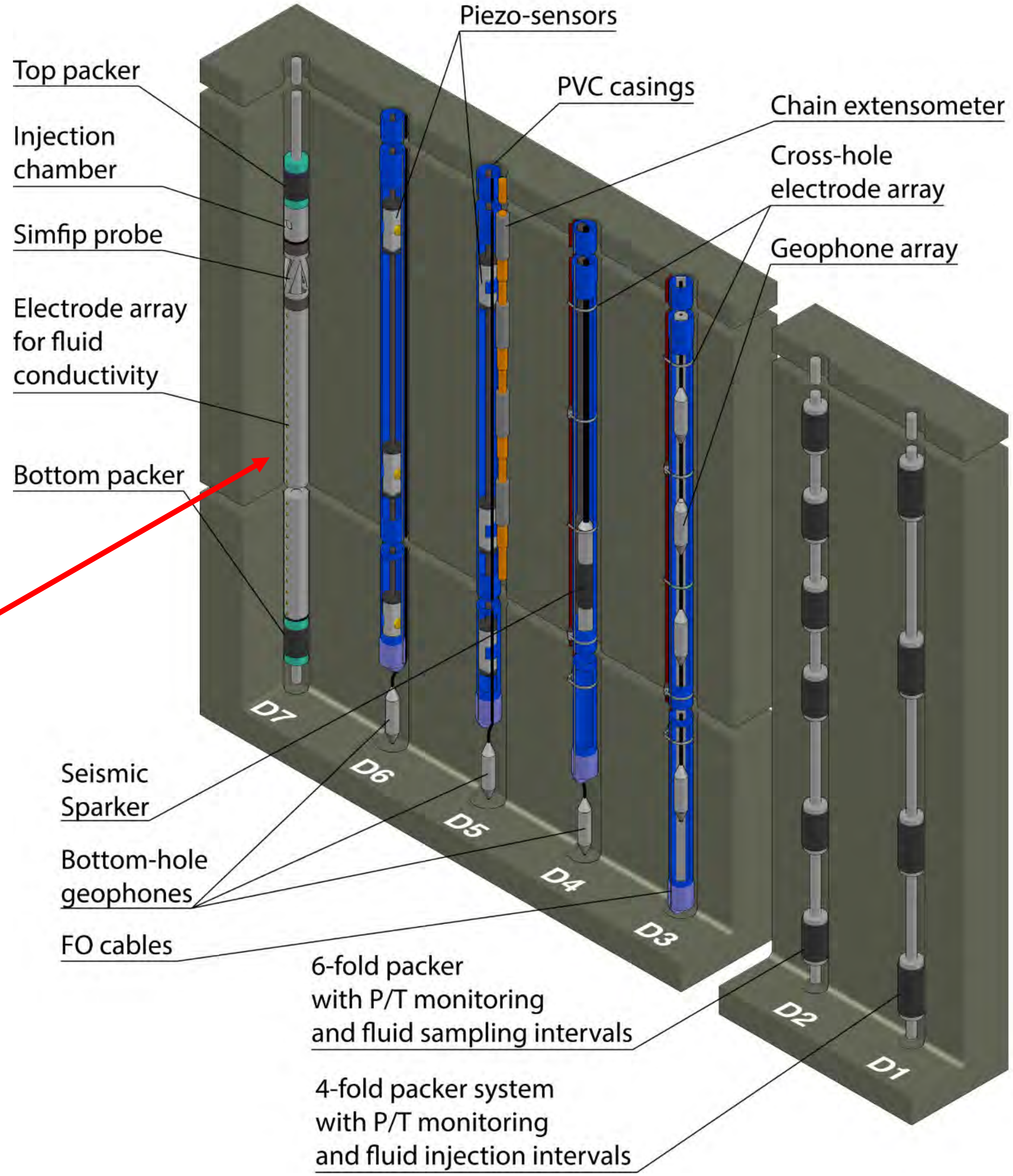

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   - 3.1 Fault characterization
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   - 3.3 Geophysical monitoring with active/passive seismic
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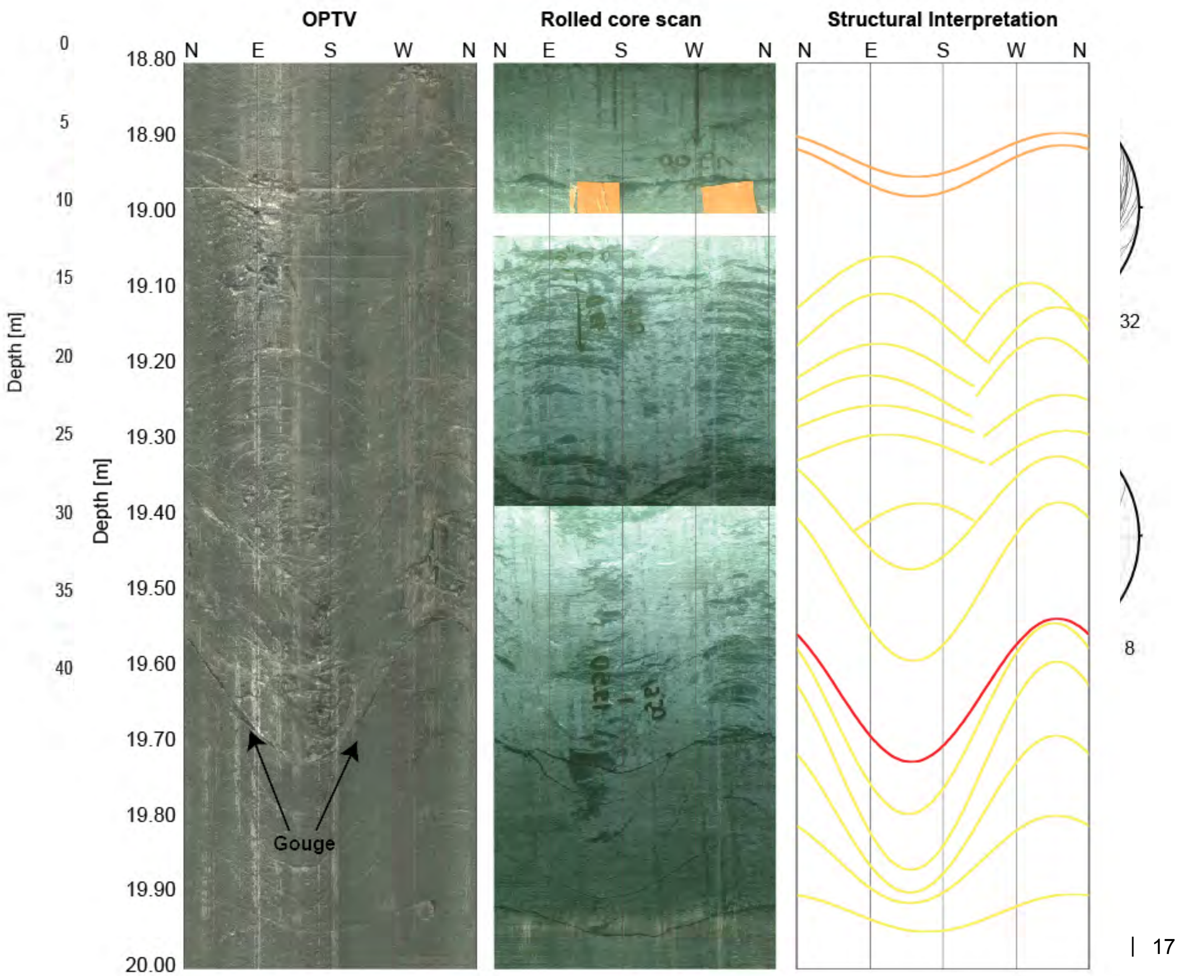
3.1 Fault characterization

by Quinn Wenning

Structure mapping vertical boreholes

(a) Fracture density estimated from core mapping and logging for the vertical boreholes. The log confidence shows the depth range where image logs are of good quality.

Stereonets show the orientation of (b) bedding, (c) calcite fractures, (d) all other fractures, and (e) the main fault.



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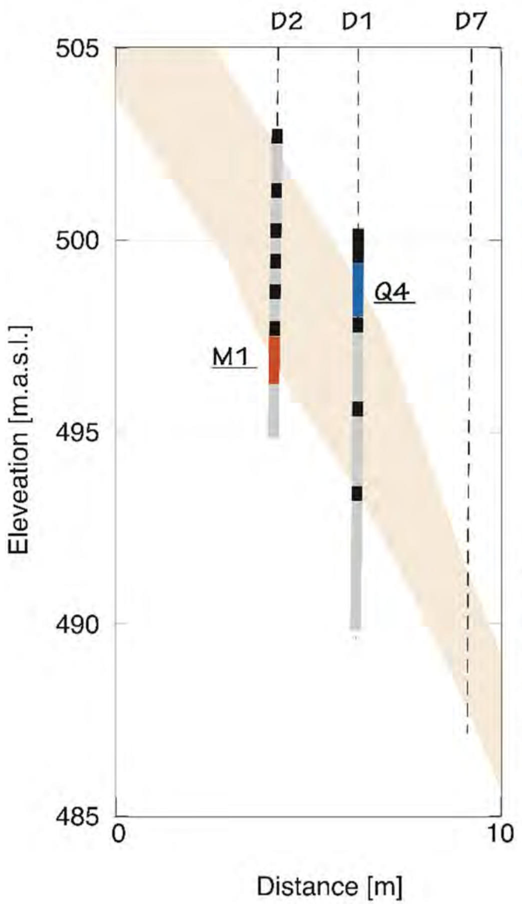
3.2 Injection tests – Results from interval 4

by Antonio Rinaldi



- Pressure increase by steps of 300 kPa, up to 4800 kPa.
- Each step was about 28/30 hours long.
- Injectivity of the system is estimated as 0.015 ml/min/MPa.

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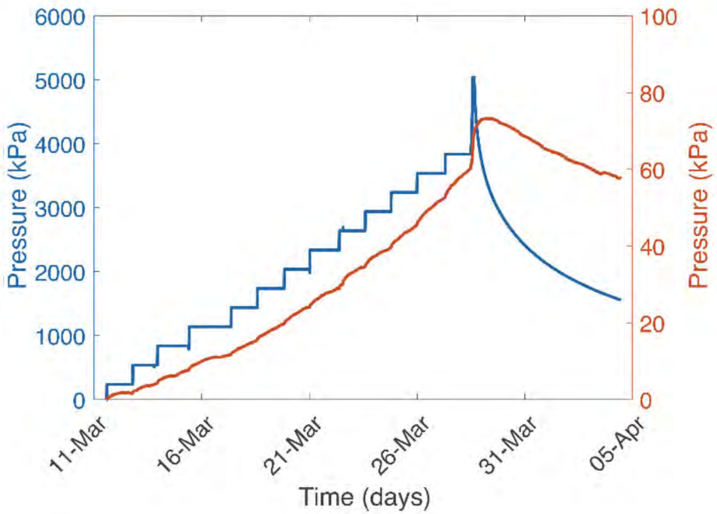
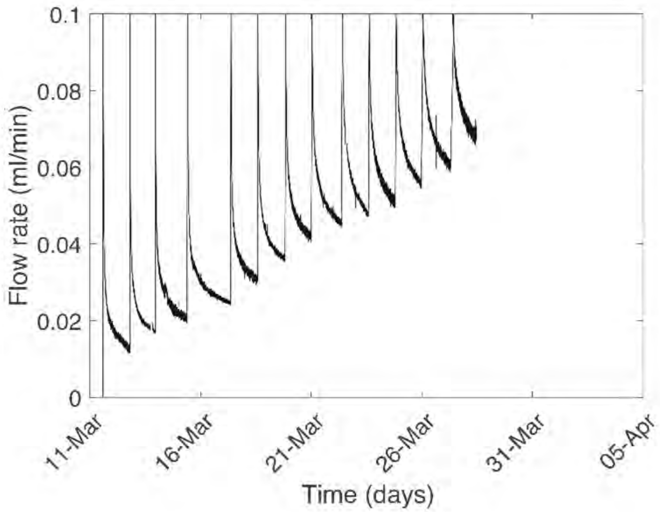
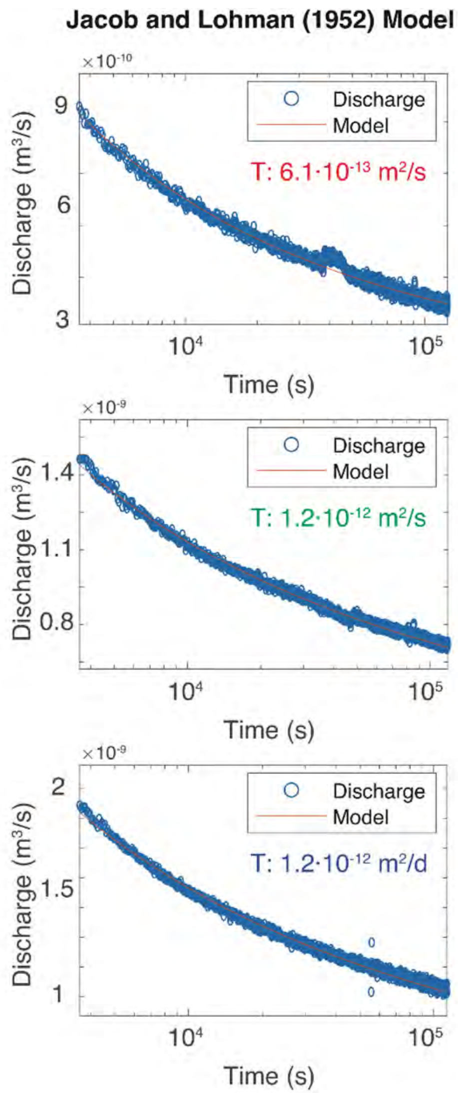
by Antonio Rinaldi





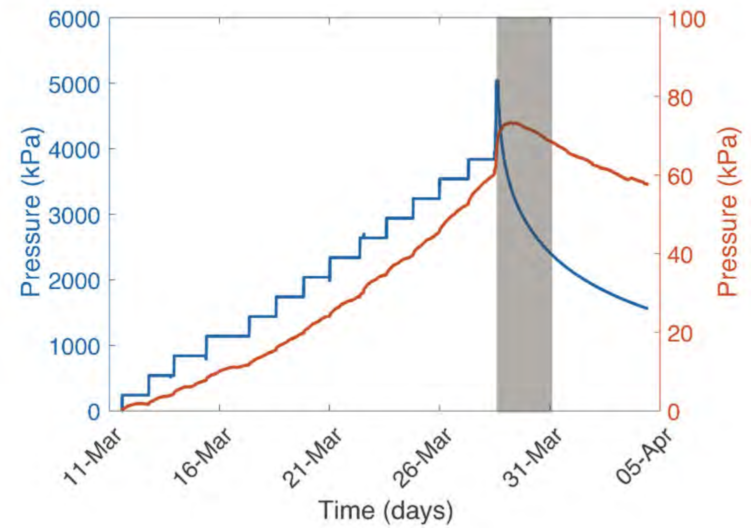


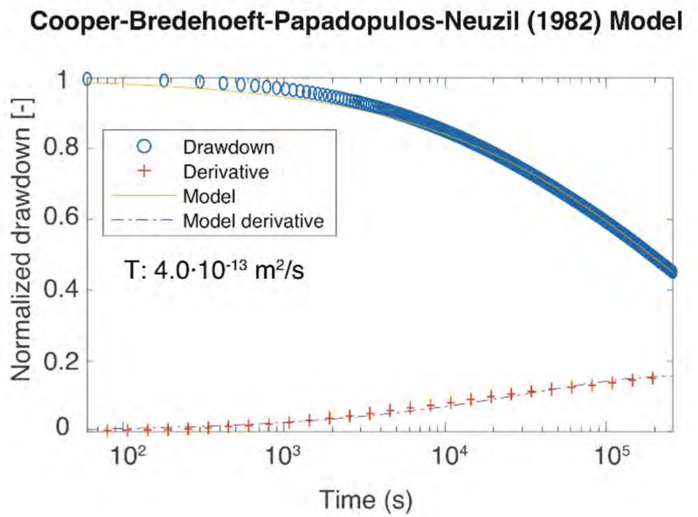
- Analysis of constant head test with the Jacob and Lohman analytical solution
- Transmissivity: ~10^{-12} m^2/s
- Permeability: ~10^{-20} m^2

Not yet steady flow rate, but the estimate is only a little higher compared to previous estimates (Marschall et al., 2003)

3.2 Injection tests – Results from interval 4

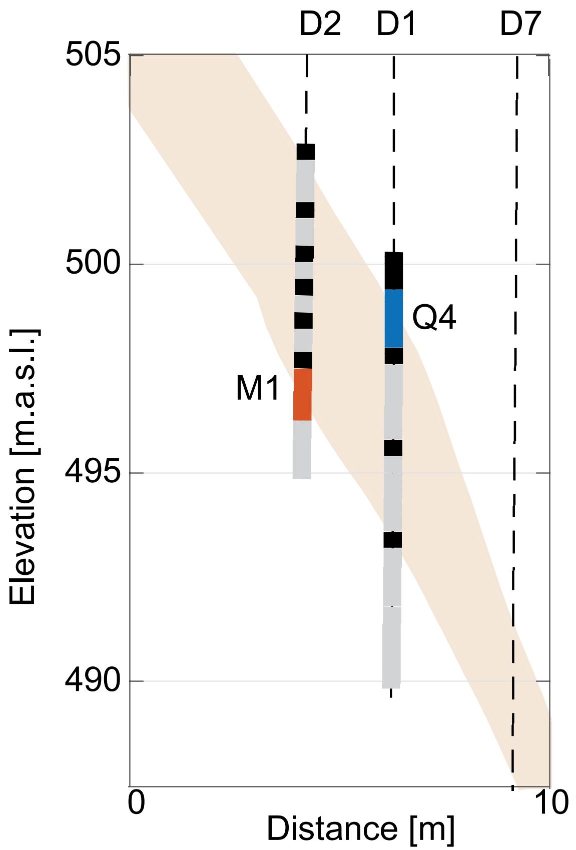
by Antonio Rinaldi

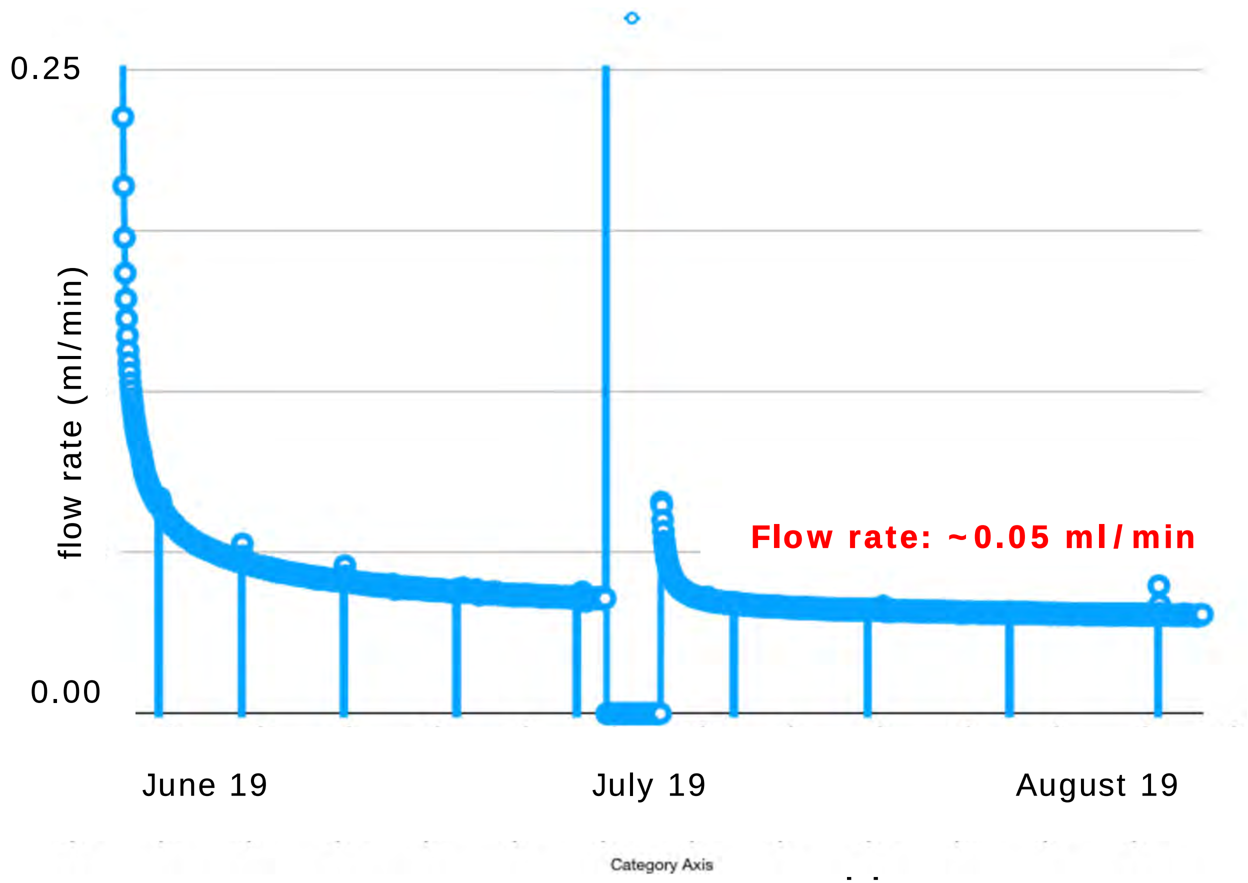




- Analysis of pressure decay (3 days) with the Neuzil model (model for pulse tests)
- Transmissivity: ~10^{-13} m^2/s
- Permeability: ~10^{-21} m^2 (comparable to Marschall et al. 2003)

3.2 Injection tests





Currently:

- Constant pressure of 4500 kPa
- Injection rate approx 0.05 ml/min

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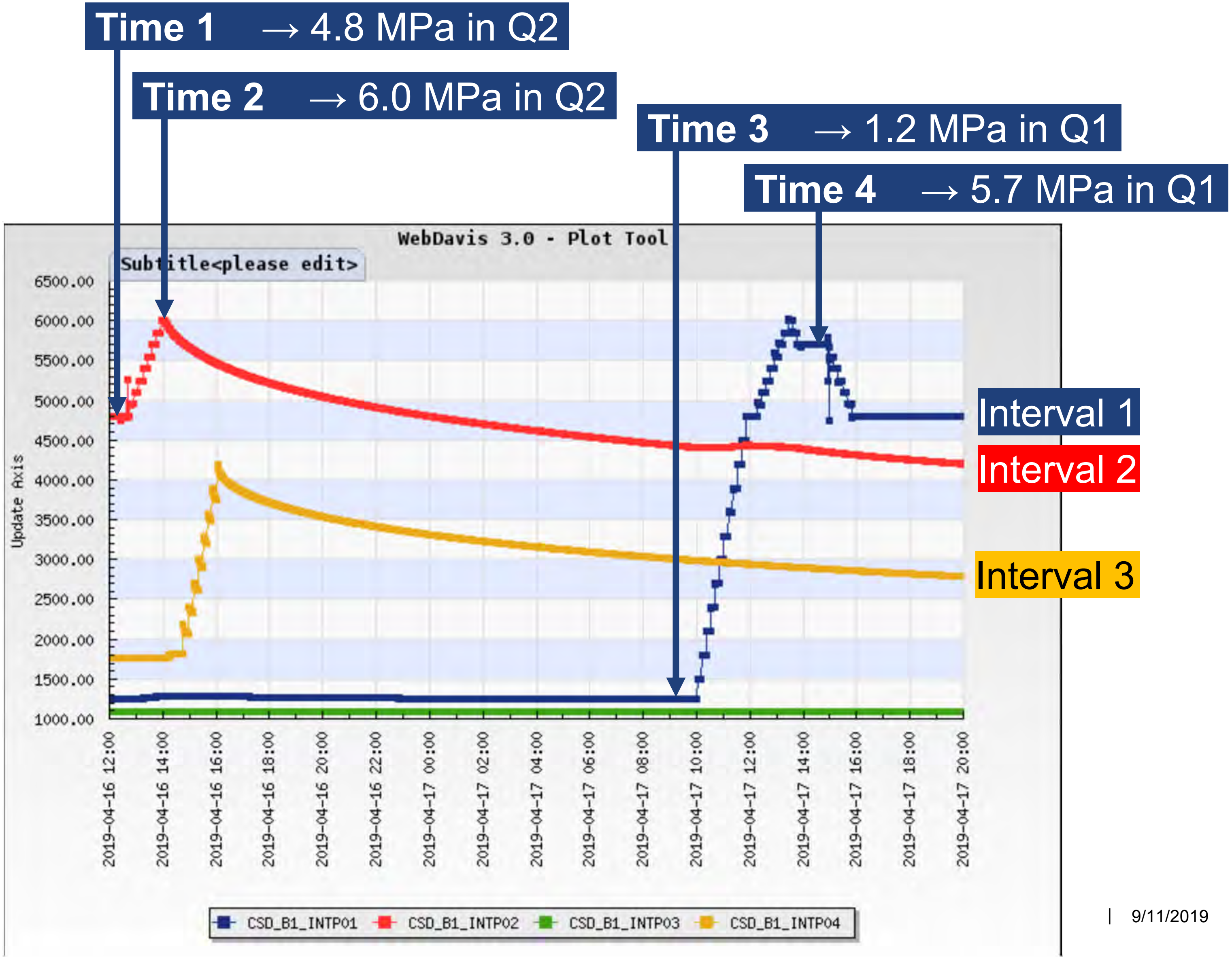
3.2 Active seismic experiments during injection tests



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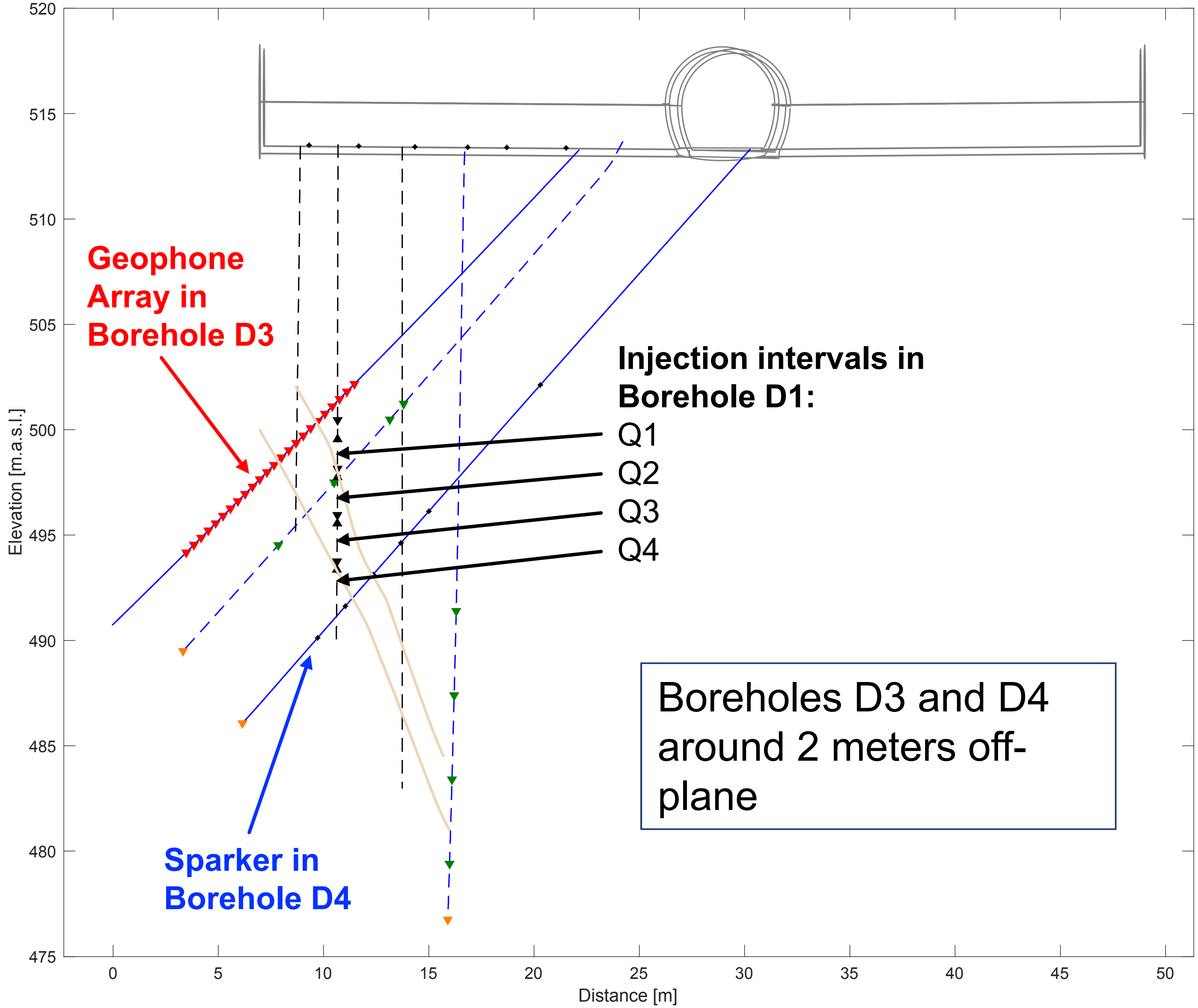
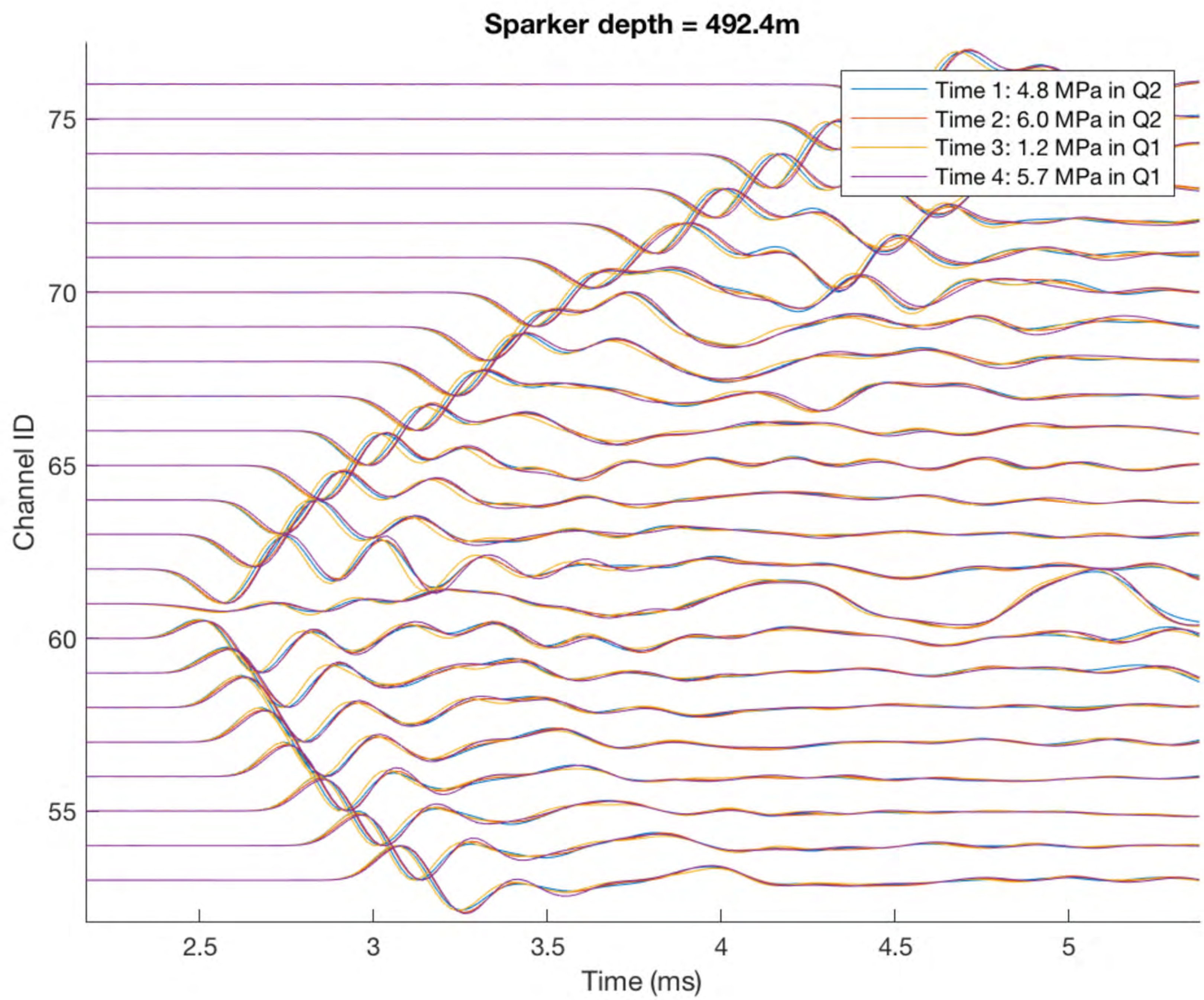


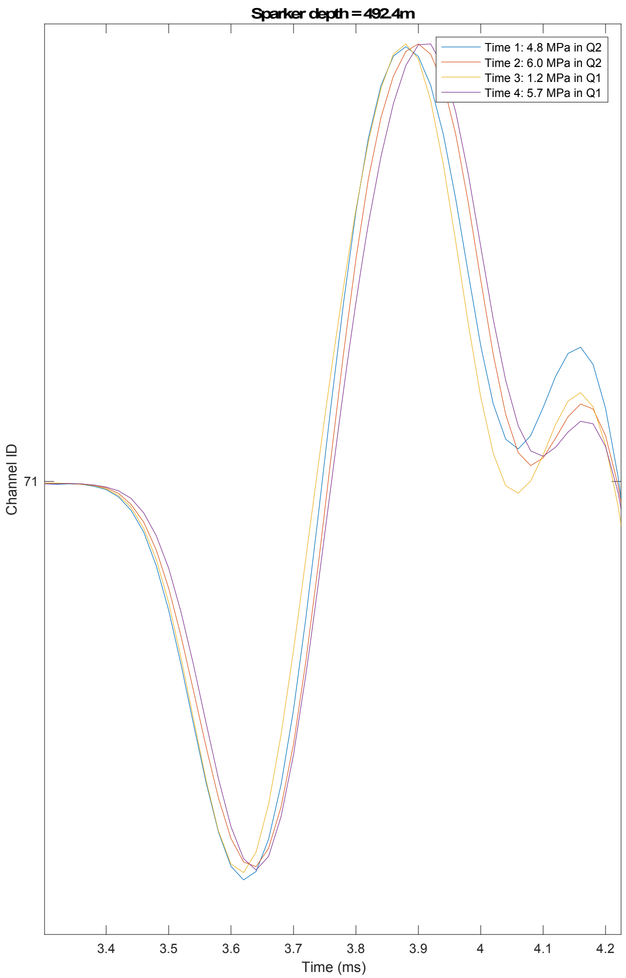


Sparker depth = 492.4m
Time 1: 4.8 MPa in Q2
Time 2: 6.0 MPa in Q2
Time 3: 1.2 MPa in Q1
Time 4: 5.7 MPa in Q1
Channel ID
75
70
65
60
55
2.5
3
3.5
4
4.5
5
Time (ms)

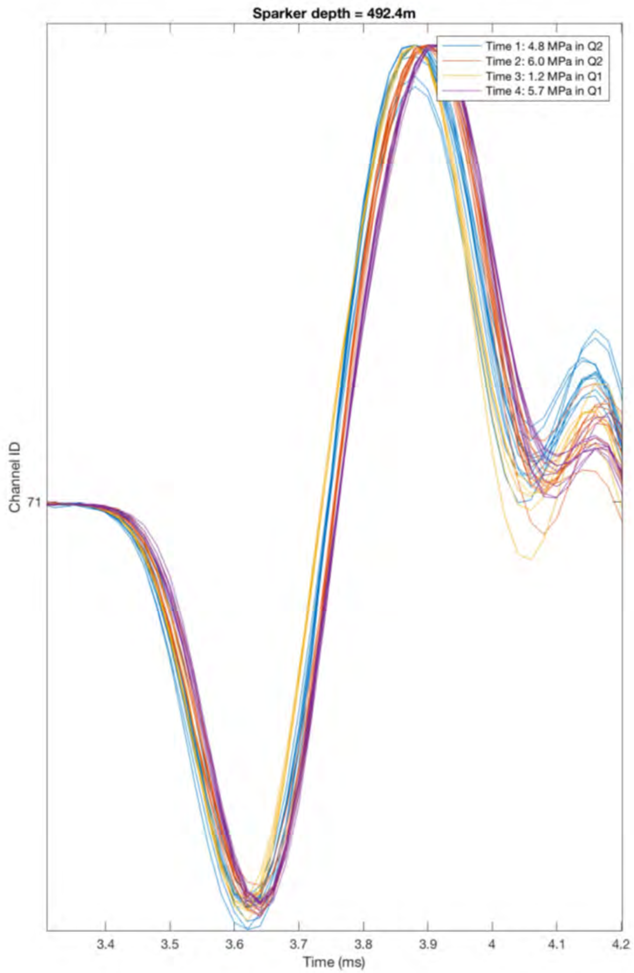
3.2 Active seismic experiments during injection tests

Significance of arrival time differences relative to sparker repeatability

Stacked trace



Same trace before stacking



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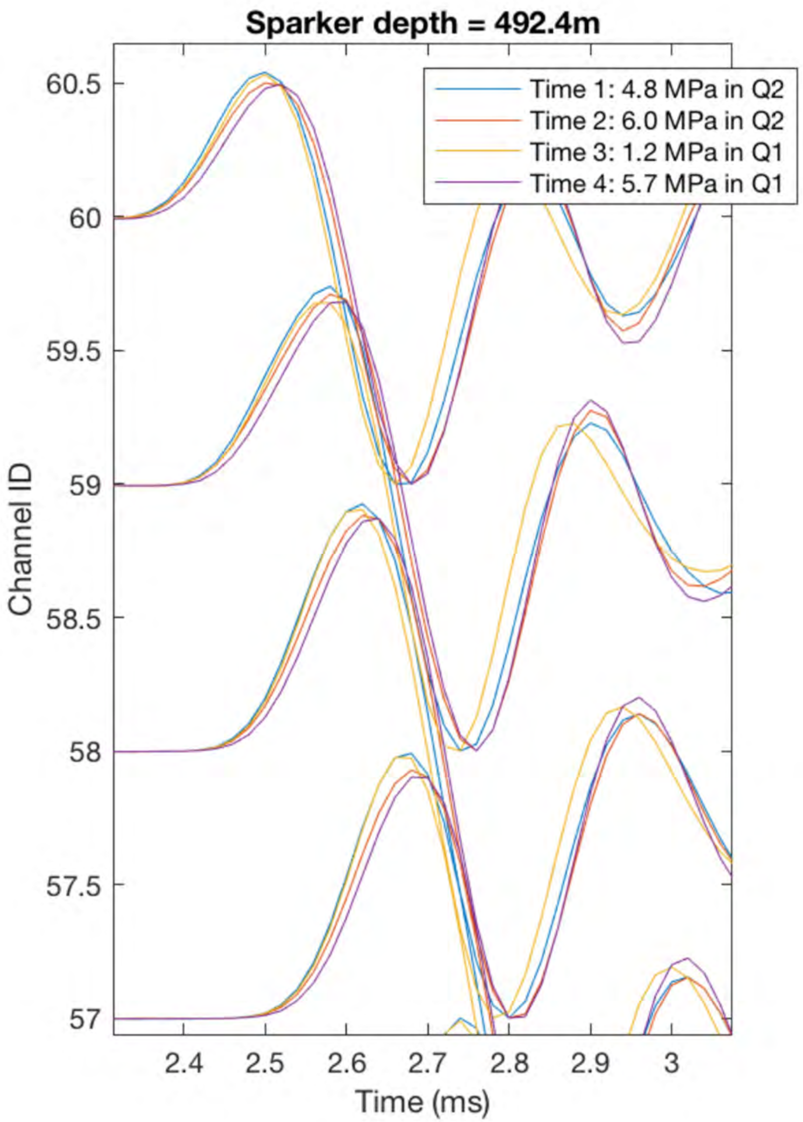
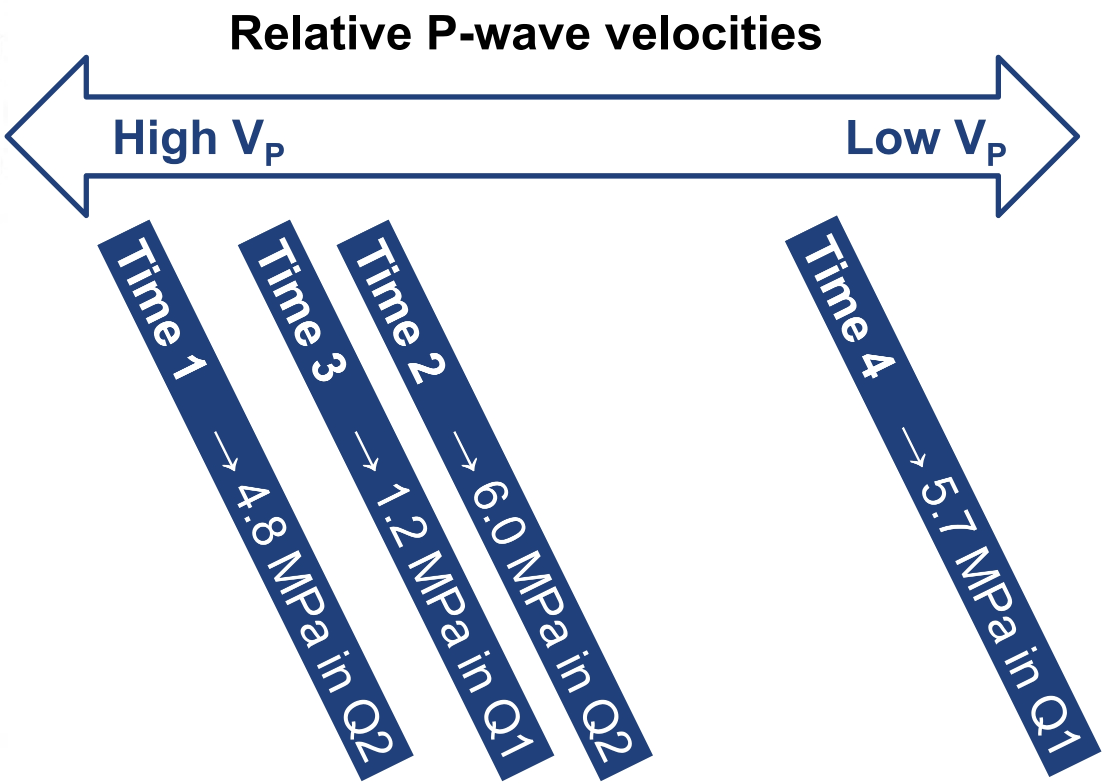
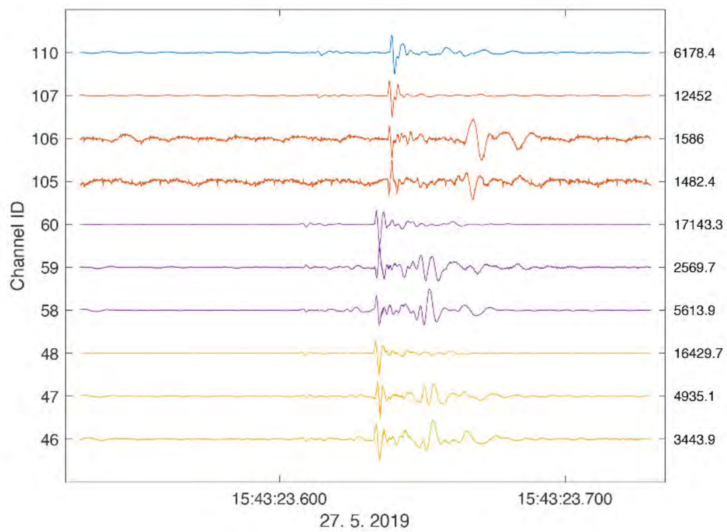
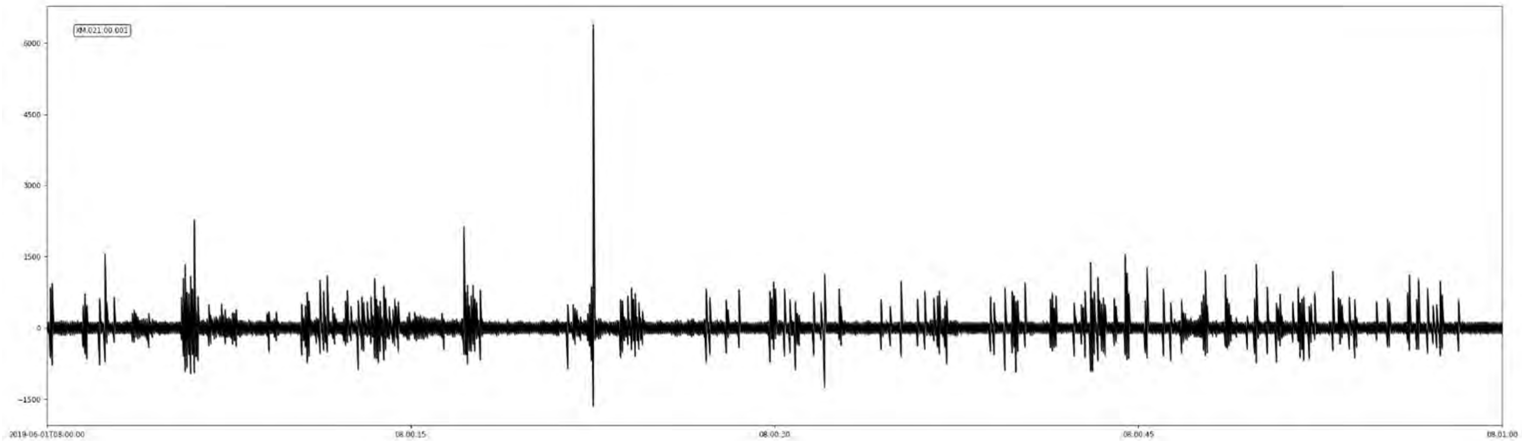




3.2 Induced seismicity

- No seismicity detected during injection tests
- “Events” recorded with 3C geophones and piezos at the time after the break through
  - Related to deformation across the fault?
  - Related to work taking place in the lab gallery?





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Conclusions

- Installation completed.
- Pre-characterization (core interpretation, geophysical baseline measurements, injection tests).
- Long-term injection since <3 months with constantly low flow rates accompanied with repeated geophysical measurements.

Outlook

- Data processing ongoing
- Will we observe an increase in flow rates?
- Stimulation of the fault by water injection, e.g. from borehole D7.

Thank you for your attention!
Questions?

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