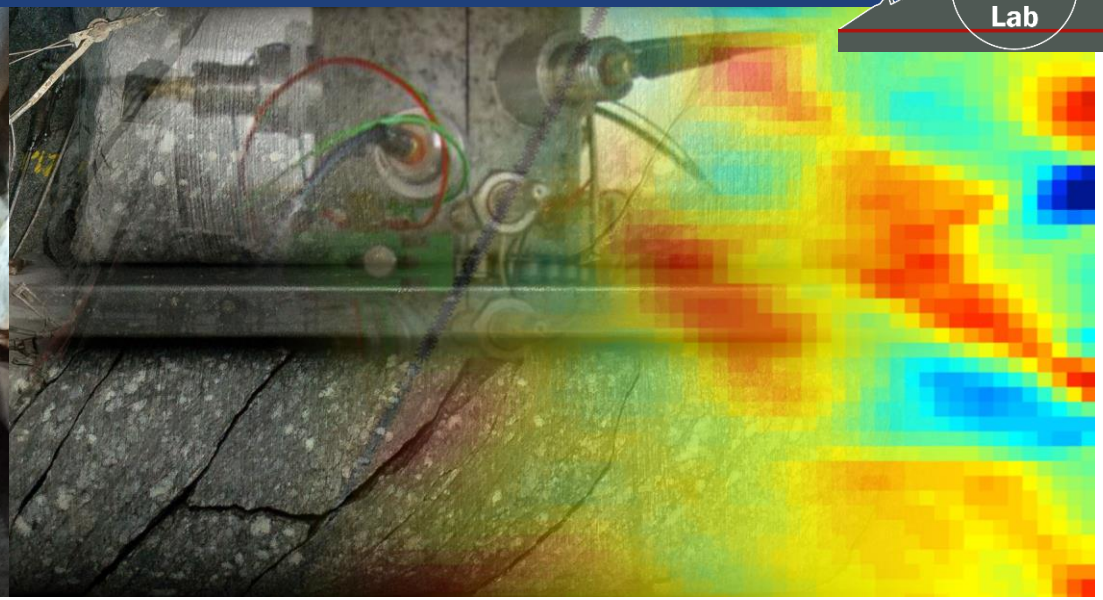
ETH zürich

Bedretto Lab



Bedretto Underground Laboratory for Geoenergies: Ongoing Activities and Monitoring Concept

Katrin Plenkers and the Bedretto Team:

Marian Hertrich, Nima Gholizadeh, Hannes Krietsch, Xiaodong Ma, Morteza Nejati, Anne Obermann, Andreas Reinicke, Alexis Shakas, Domenico Giardini

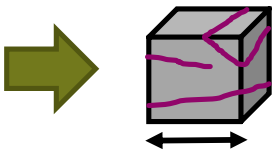
SCCER SoE

Introduction Stimulation Experiments

So far:

Lab shear experiments

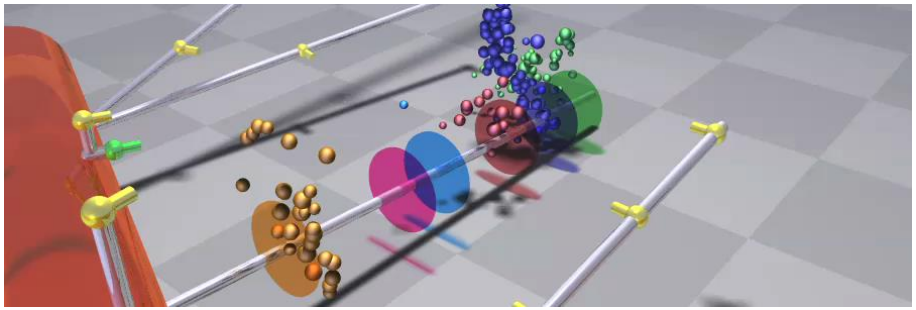
ISC @ Grimsel



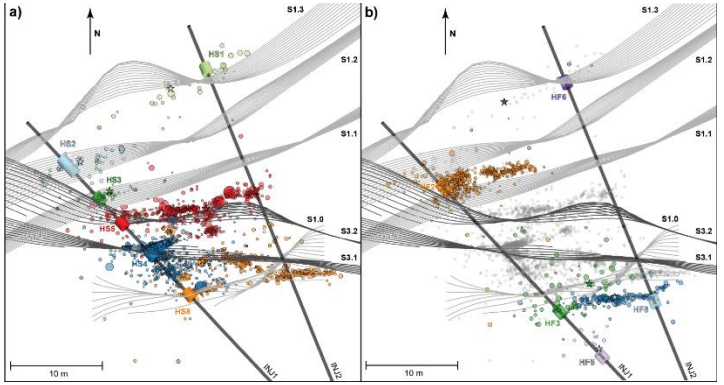
0.01-1m scale

10m scale

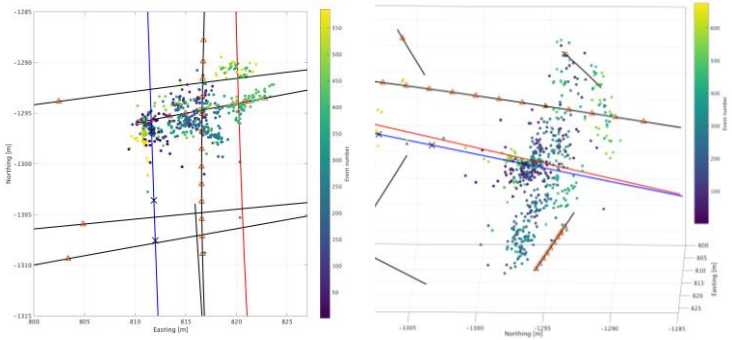
In-situ stimulation experiments at the 10m-scale were successfully implemented in various settings.



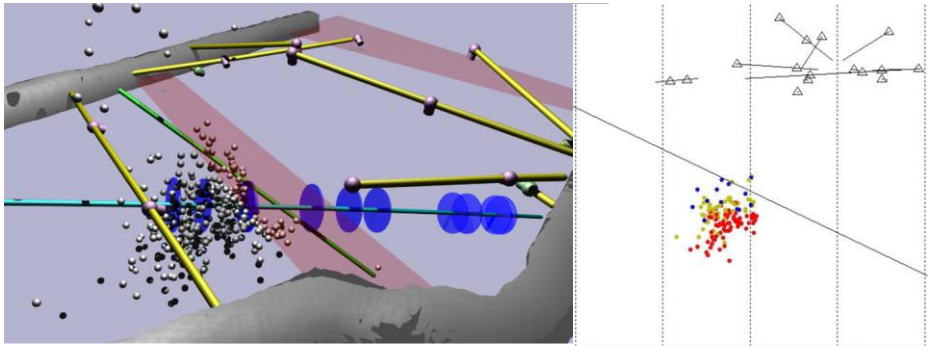
Äspö: Zang et al. 2017, Kwiatek et al. 2018



Grimsel: Amann et al. 2018, Gischig et al. 2018



Sanford: Kneafsey et al. 2019, Schoenball et al. 2019



Reiche Zeche: Renner et al. 2019, Plenkers et al. 2019

We are ready to take the next step…

Lab shear experiments

0.01-1m scale

ISC @ Grimsel

10m scale
500m depth

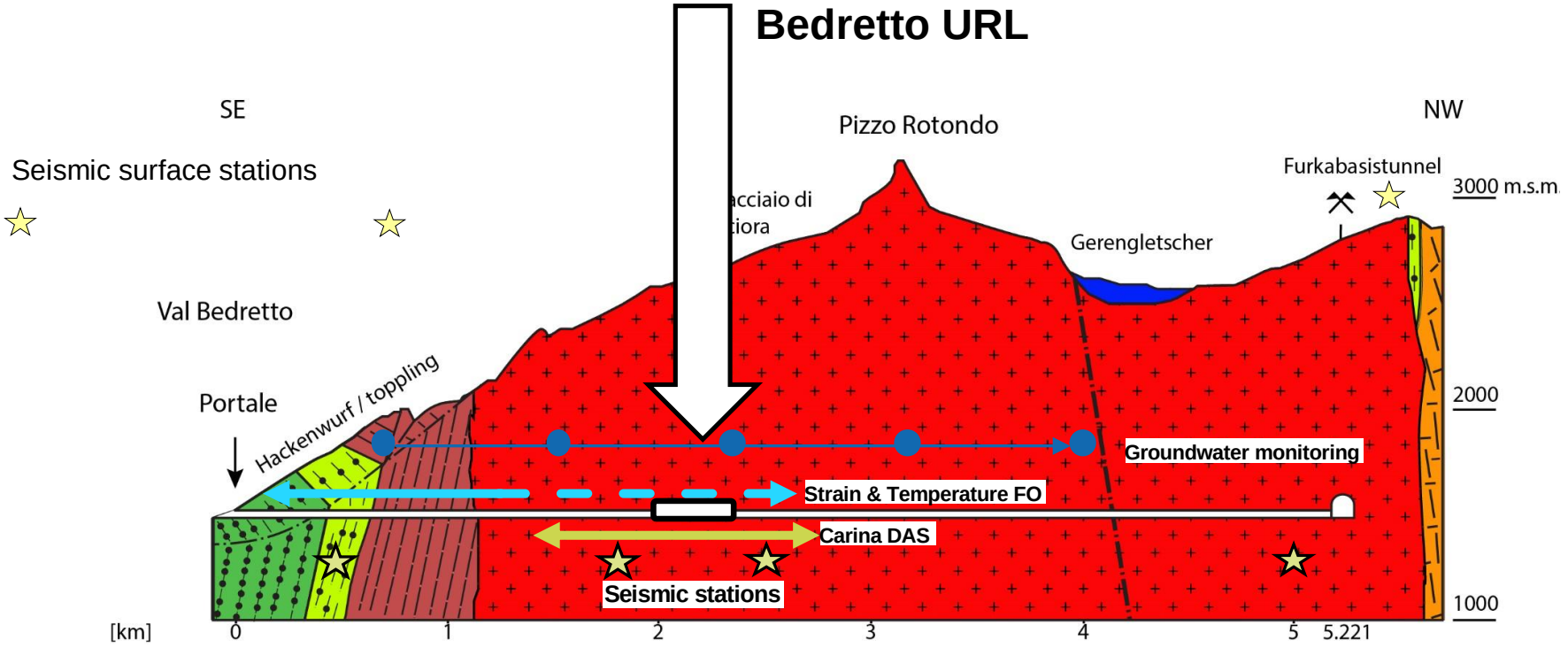
experiments @ Bedretto

100m scale
1000m depth

The Bedretto Deep Underground Laboraty for Geoenergies was inaugurated on 17 May 2019.

Bedretto Laboratory

- Seismicity
- Temperature
- Deformation
- Groundwater



Keller & Schneider, 1982

Bedretto Lab

Experiments early 2020

ZoDrEx

GEOTHERMICA

In cooperation with the CTI

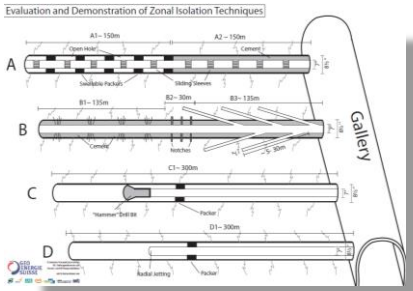
Energy
Swiss Competence Centers for Energy Research

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

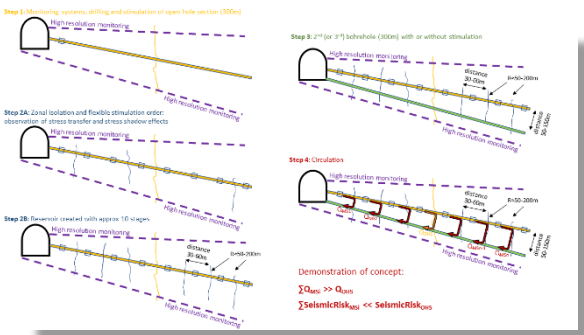
Commission for Technology and Innovation CTI

GEO ENERGIE SUISSE



DESTRESS

tion of soft stimulation treatments
of geothermal reservoirs



European Commission

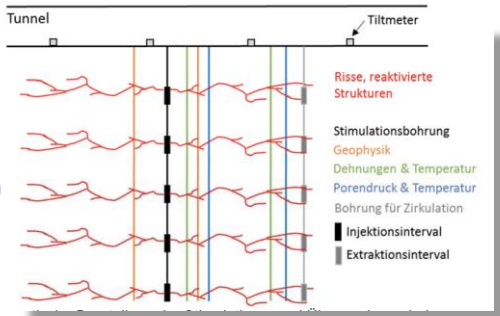
Horizon 2020
European Union funding
for Research & Innovation

GEO ENERGIE SUISSE

VALTER

SCCER SoE

SWISS COMPETENCE CENTER for ENERGY RESEARCH
SUPPLY of ELECTRICITY



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experiments @ BULG

100m scale
D=1000m

The three experiments will take place in rock volume undisturbed by the tunnel and in close vicinity to each other in order to optimize resources.

Valter = Validation of Technologies for reservoir engineering

- Which stimulation concepts are appropriate for enhancing the permeability by orders of magnitudes while minimizing induced seismicity?
- What are the relationships between the stimulation concept, transient hydro-mechanical response, permanent permeability creation, final effective porosity, and induced seismicity?
- What are the final heat-exchanger properties of the reservoir?

Timeline:

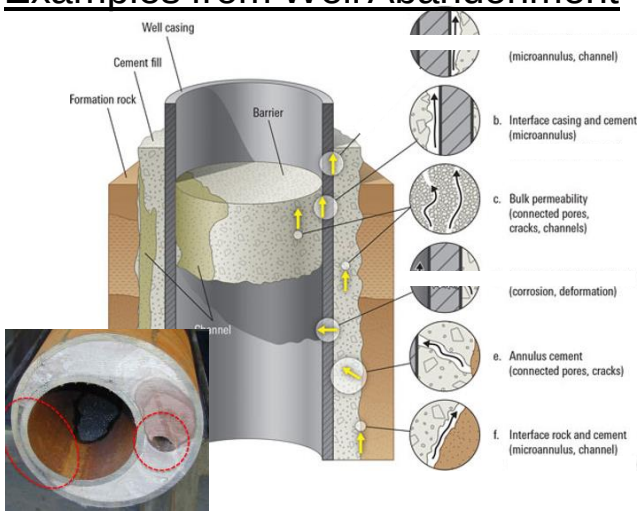
Aug. – Sep. 2019	Drilling of three characterization boreholes (length 180m to 300m)
May.- Dec. 2019	Characterization of rock volume
Jan. – Feb. 2020	Drilling of all remaining boreholes
March-April 2020	Installation permanent monitoring
Starting in May	Stimulation program

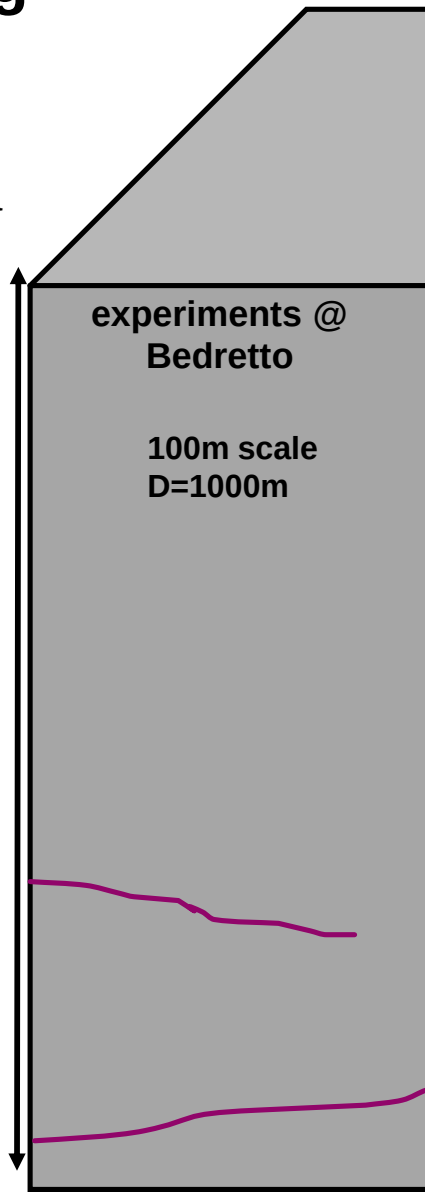
Challenges for characterization and monitoring

- Long boreholes up to 300m depth
- High pore pressure (Background pressure 10MPa), Peak pressure 30 Mpa
- Significant limitations for monitoring from the tunnel due to sensitivity
- Monitoring boreholes within fracture volume need reliable sealing

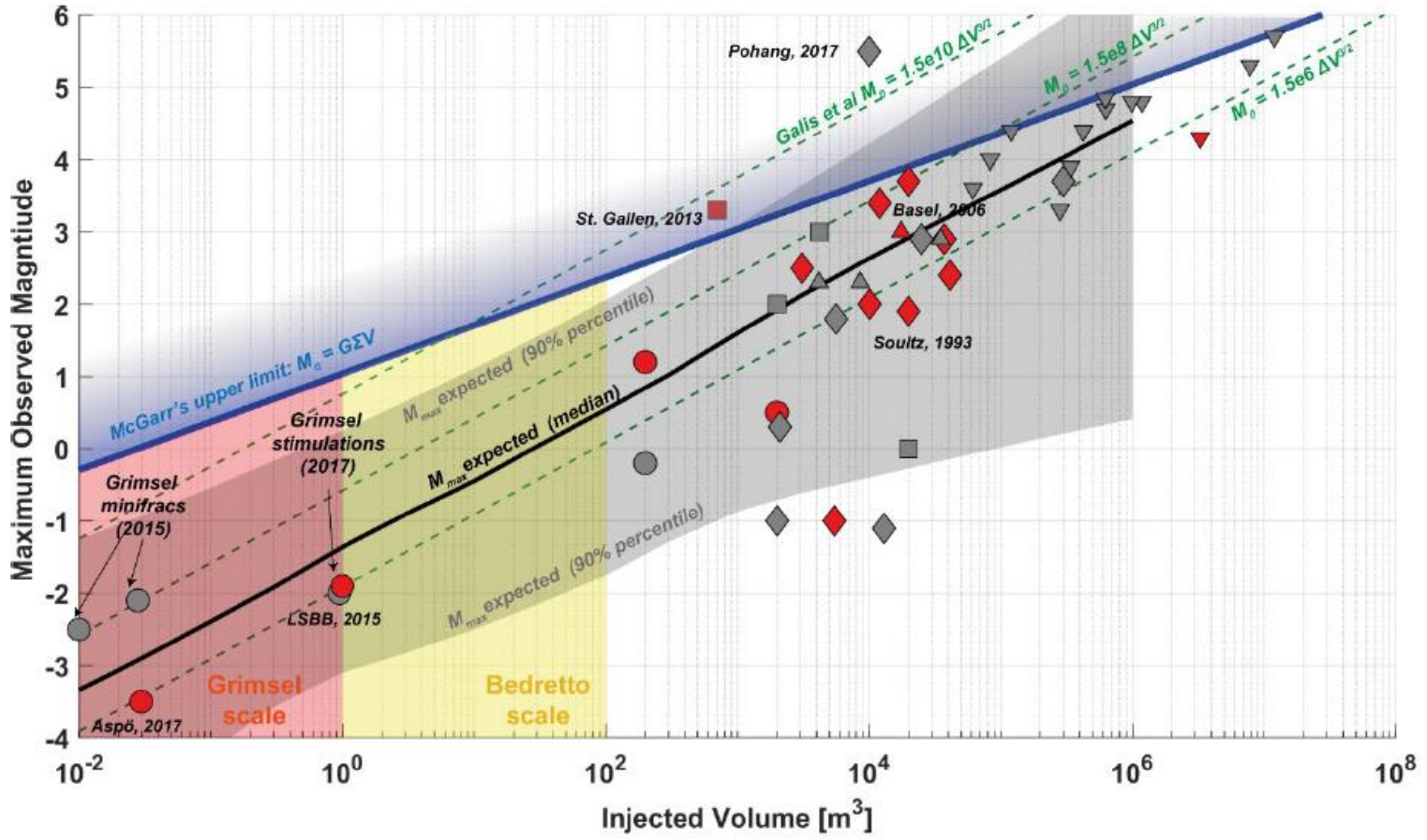
- Sensor prototype development
- Severe sensor testing
- Exchange with experts

Cement Integrity Concepts & Examples from Well Abandonment





Risk Study

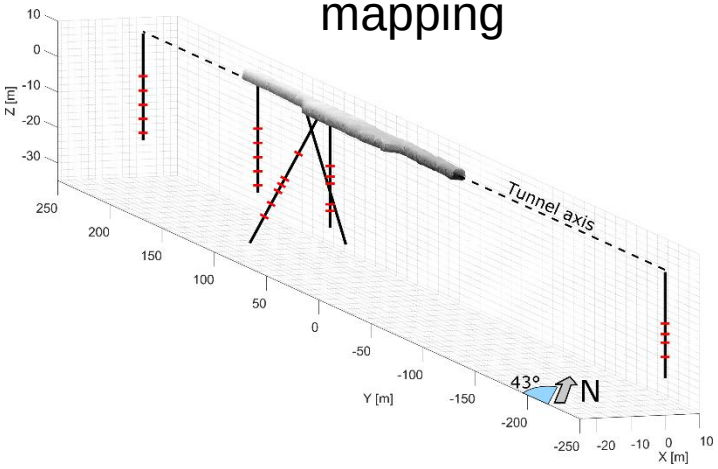


Gischig et al.

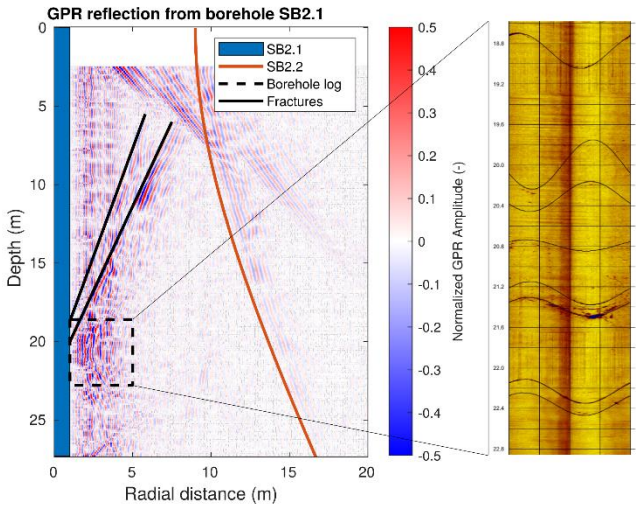
Characterization

In-situ Stess Measurements

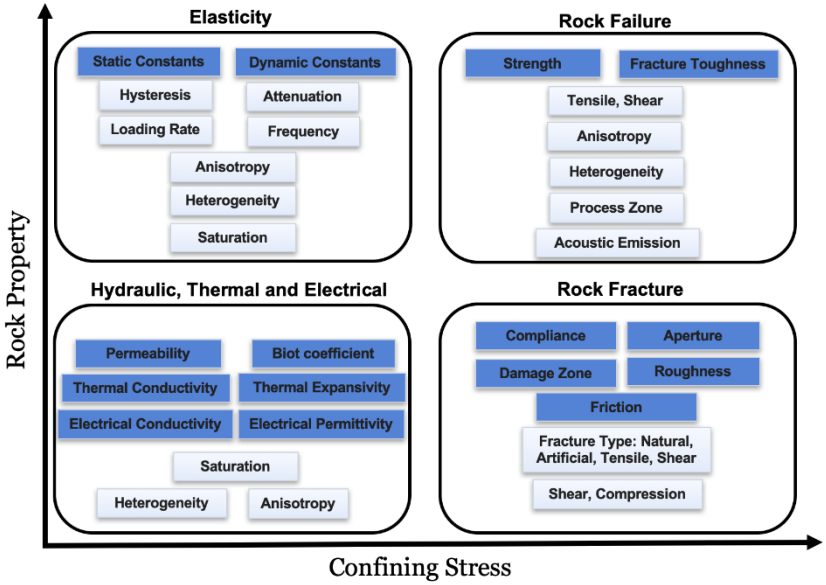
Fault and Fracture mapping



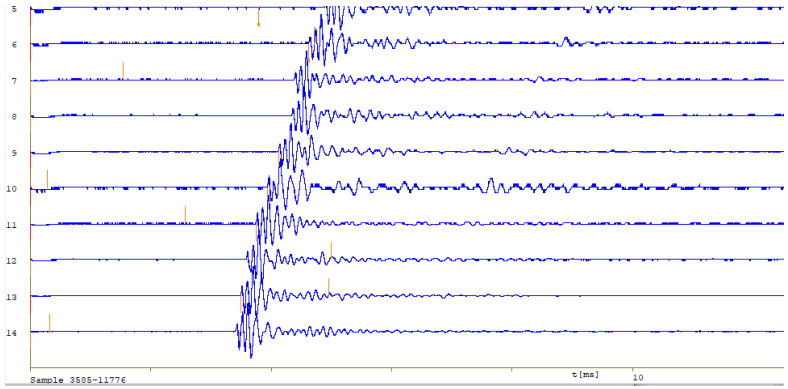
Georadar



Lab studies



Active Seismics

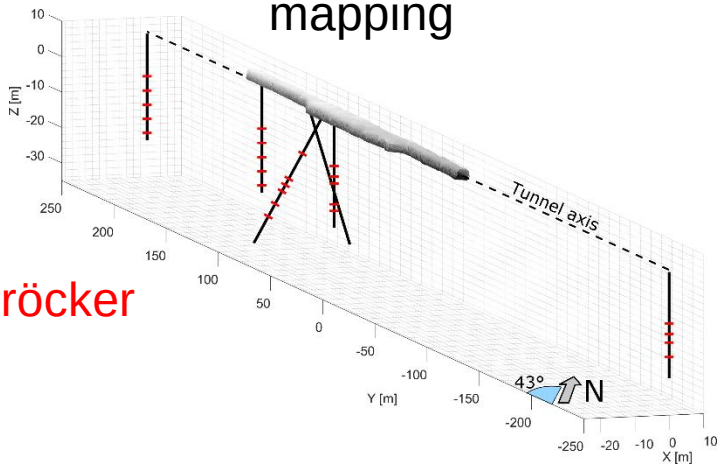


Hydraulic characterization

Geochemical characterization

Characterization

Fault and Fracture mapping

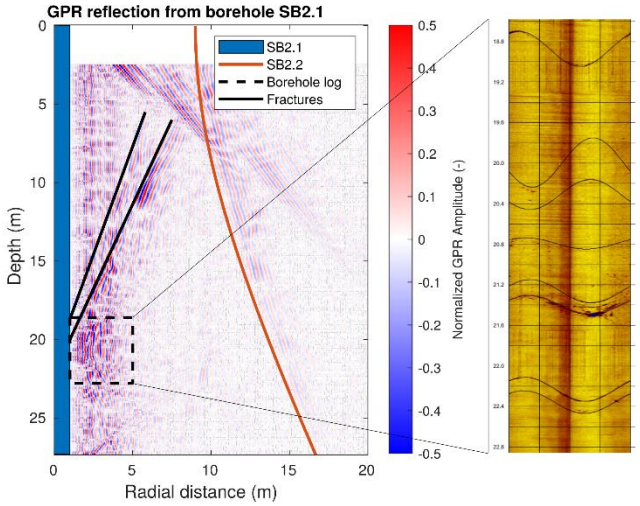


In-situ Stess Measurements

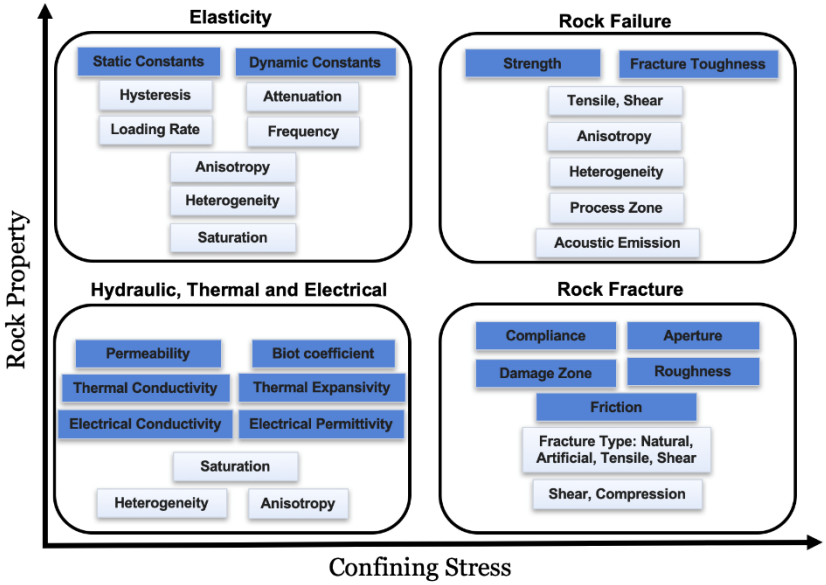
Poster by Kai Bröcker

Georadar

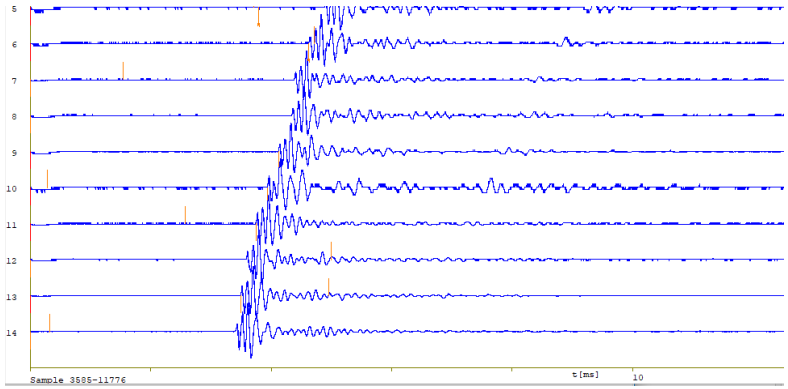
Poster by Alexis Shakas



Lab studies



Active Seismics



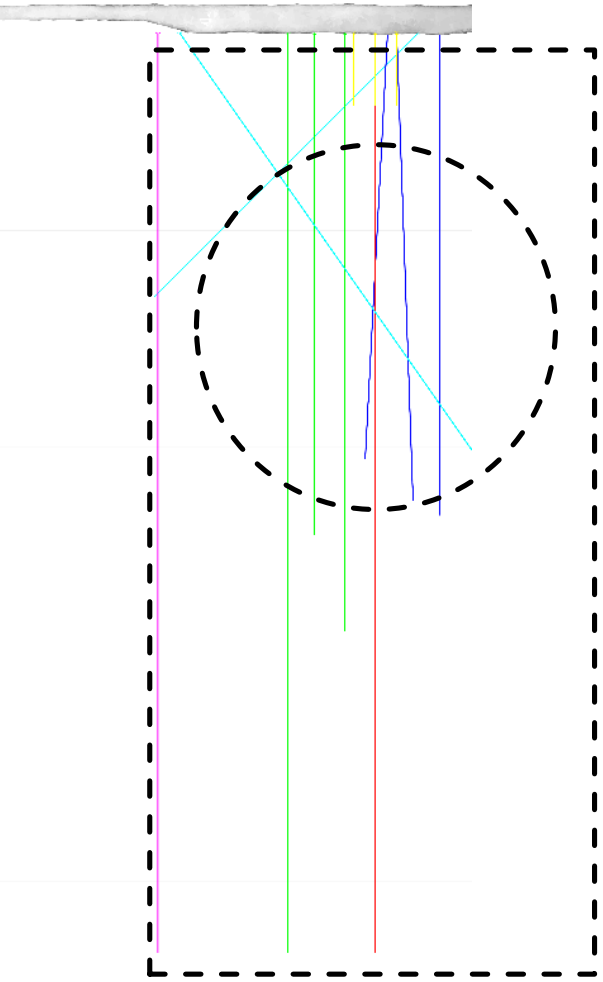
Geochemical characterization

Hydraulic characterization

Poster by Nima Gholizadeh

Valter Permanent Monitoring

Preliminary borehole geometry



High resolution monitoring

General monitoring

- Induced Seismicity
- Deformation
- Pressure
- Temperature
- Active Source

Six to eight boreholes will be equiped with sensors and fully grouted.

mapview

Induced seismicity

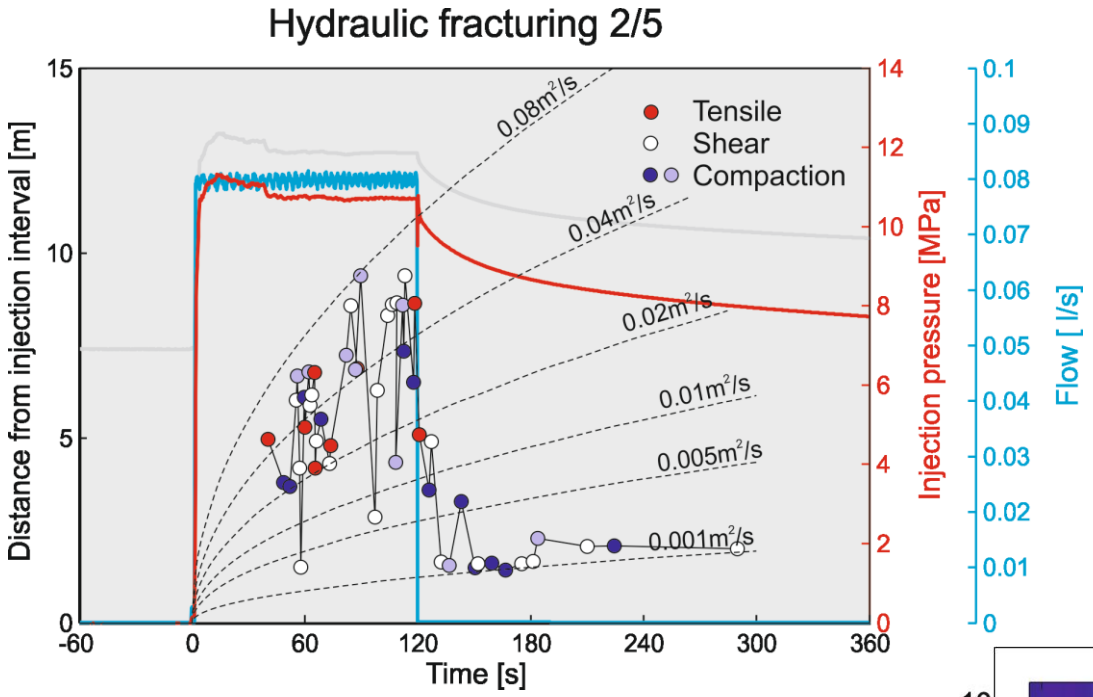
Microseismicity	Strong Motion	Nanoseismicity	Picoseismicity
0.008 < f < 50 Hz	0.01 < f < 100 Hz	50 < f < 10 kHz / 25 kHz	1’000 < f < 150’000 Hz
Distances < 200 km	Distances <50 km	Distances < 300m	Distances < 50 m
Surface: Trillium,STS2	Episensor	Geophones / Accelerom.	In-situ AE sensors
Observation of: 1) Regional Earthquakes 2) Noise	Observation of: 1) Microseismic Events M>0 in the tunnel	Observation of: 1) Seismic Events M> -2 in the tunnel	Observation of: 1) Picoseismicity -6 < Mw < -1 (M>-1 CLIPPED)

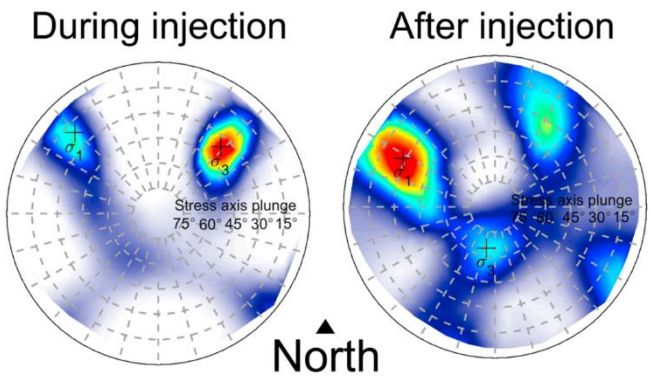
Bedretto Research:

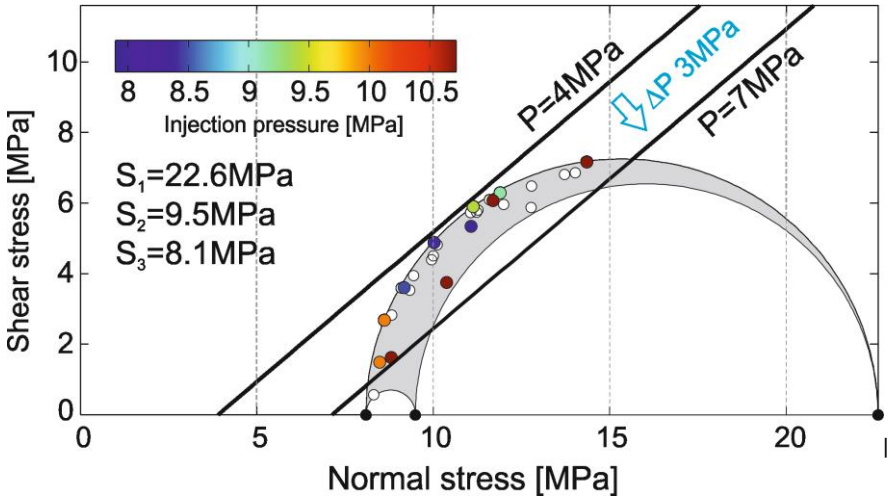
a) Which stimulation concepts are appropriate for enhancing the permeability by orders of magnitudes while minimizing induced seismicity?
b) Test advanced traffic light systems
c) Identify the source processes of seismic events. Do they represent opening or shear fracture ? How does the stress field envolve over time ?

Source parameters from Äspö Experiment

Kwiatek et al. 2018





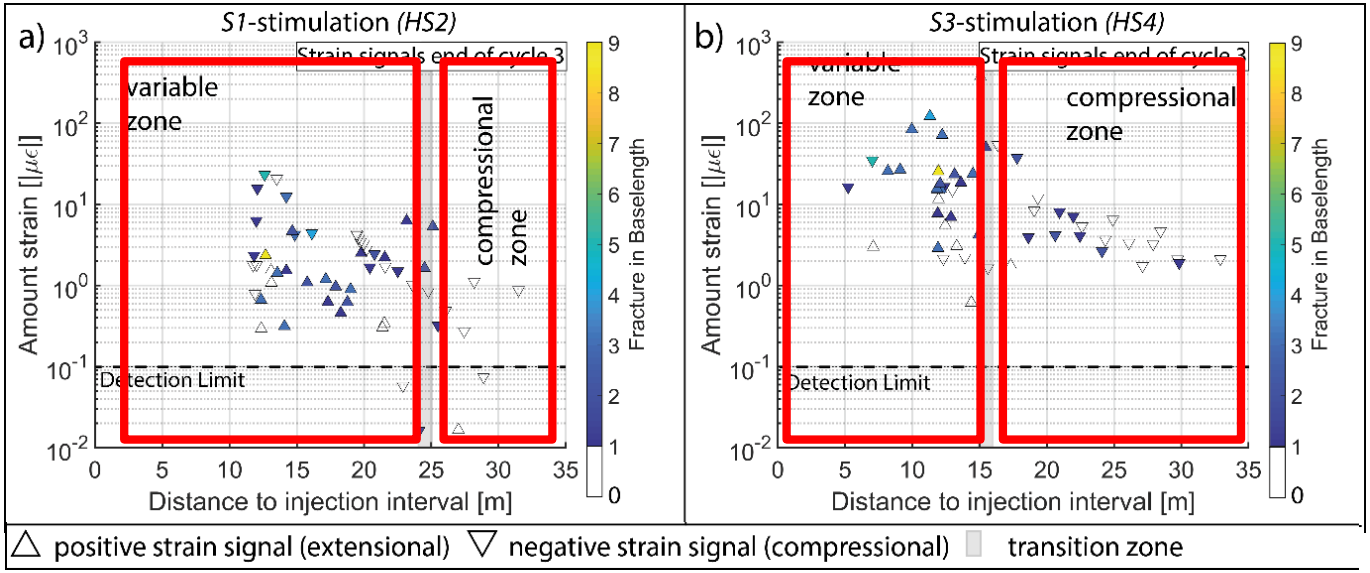


Strain measurements : Goals Bedretto

Lessons learnt from Grimsel

Krietsch 2019

- Zone of complex deformation close to injection point
- Compressional zone further away from injection point
- Transition Zone between 15 m & 25 m



Bedretto Research:

a) How does the transition zone evolve over time with respect to the injection volume?

b) How can the 'far-field' deformations (> 15 m distance to injection point) be described?
Are the deformations really elastic (i.e. poro-elastic)?

c) How do 'far-field' deformations link with induced seismicity?

d) What is the deformation mode of the stimulated structure(s)?

Fiber-Bragg Grating strain sensors in combination with tiltmeter and pressure sensors

Summary

- The Bedretto Underground Laboratry for Geoenergies is open.
- Characterization and drilling of first set of long boreholes (180m to 300m) is ongoing.
- Sophisticated monitoring is prepared including pico- and microseismic monitoring of induced seismicity, strain monitoring using fibre bragg graiting sensors, pressure and tilt monitoring, geochemical monitoring.
- Multi-stage stimulation experiments planned for spring 2020.

Thank you for your attention!