

STIMTEC

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many thanks to

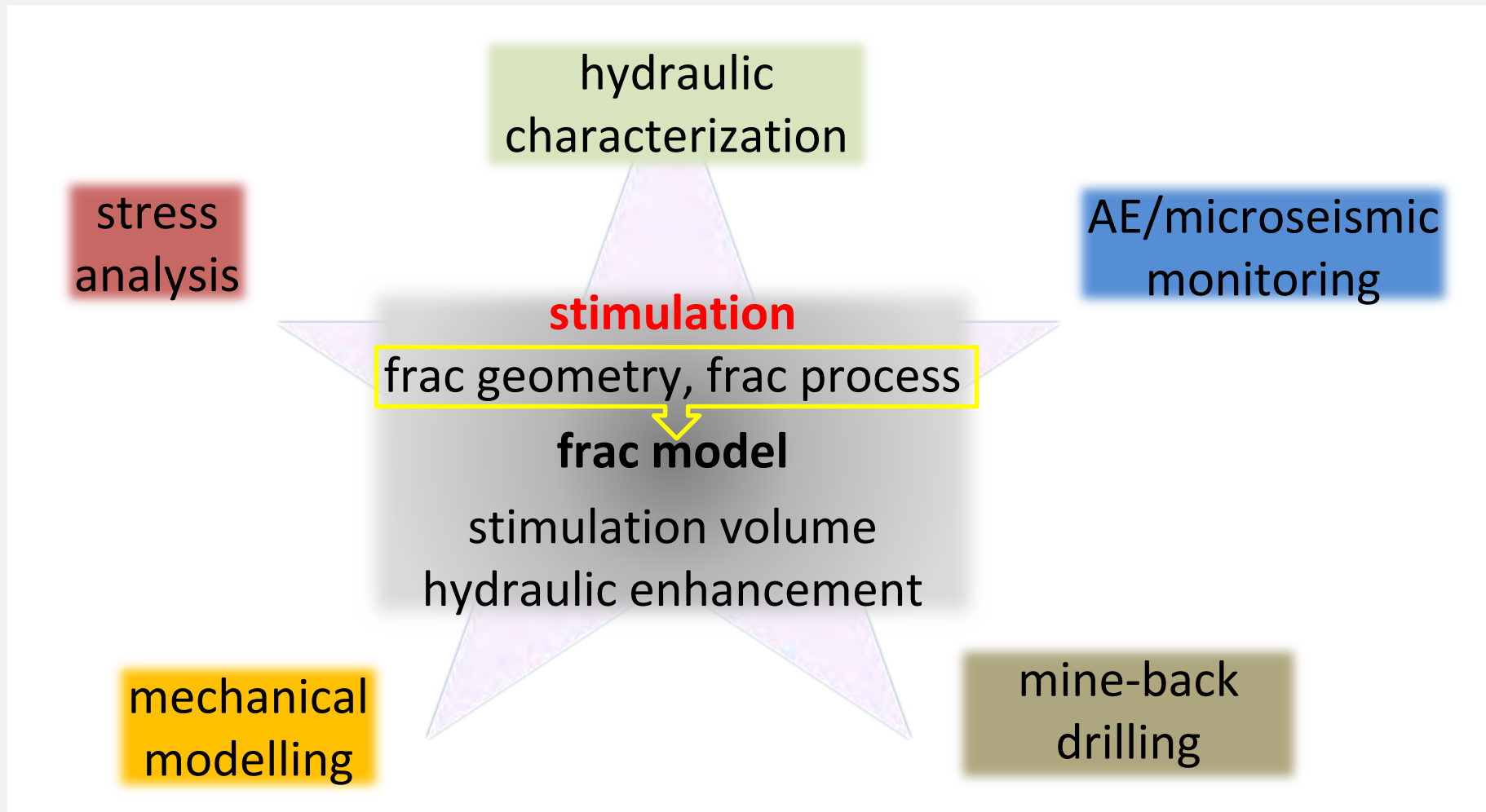


STIMulation tests with periodic pumping and high-resolution seismic monitoring: The quest for improving models and monitoring **TECH**nologies for the creation of hydraulic conduits in crystalline rocks...*and avoid the term ,fracking‘*...

- What happened so far?
- What are we doing right now?
- What are further plans?



goals, methods and deliverables

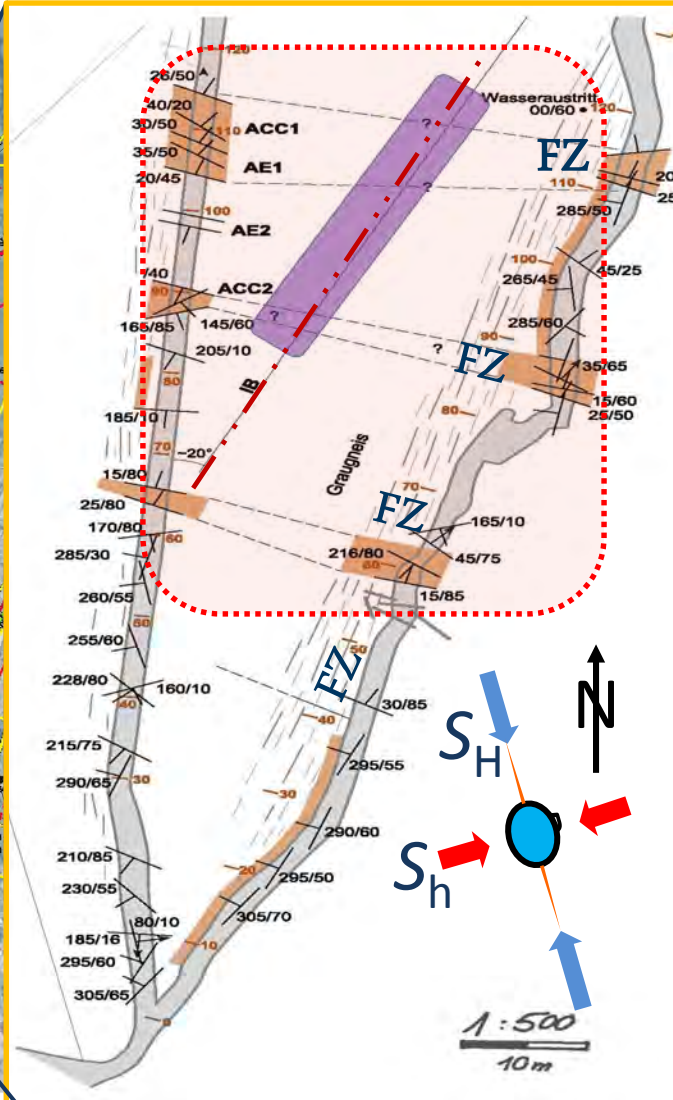
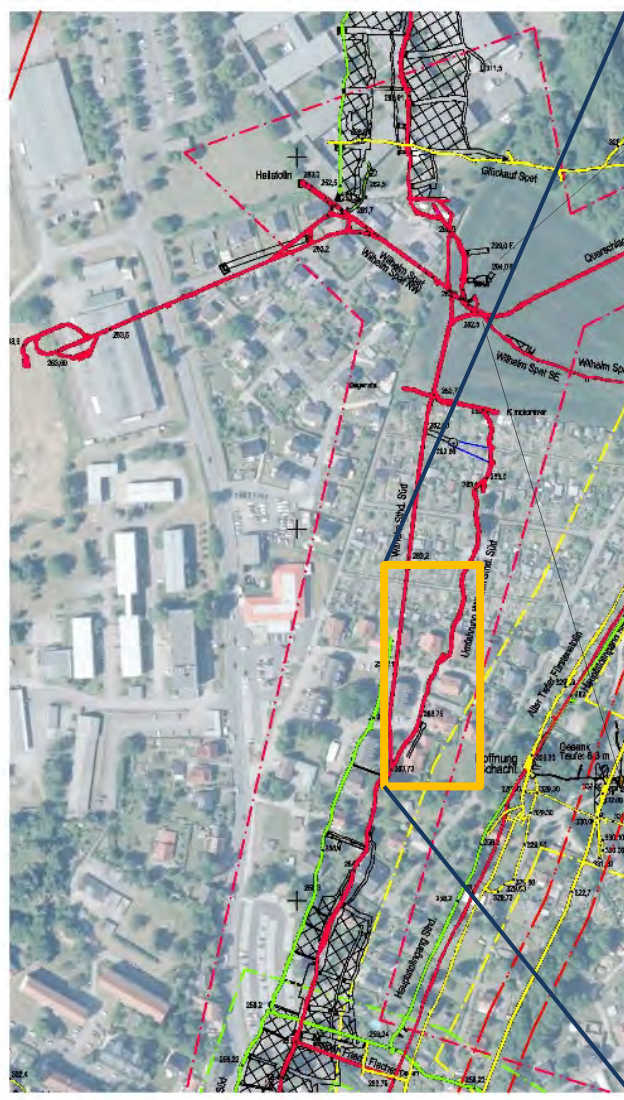


Where?

Reiche Zeche („Rich (Silver) Mine“)
 Freiberg, Saxony
 surface elevation 390 to 410 m asl
 => 2. level 110 to 130 m depth



Freiberg/Reiche Zeche



Freiberger Gneis

biotite, oligoclase, Kfspar, qtz

stress state

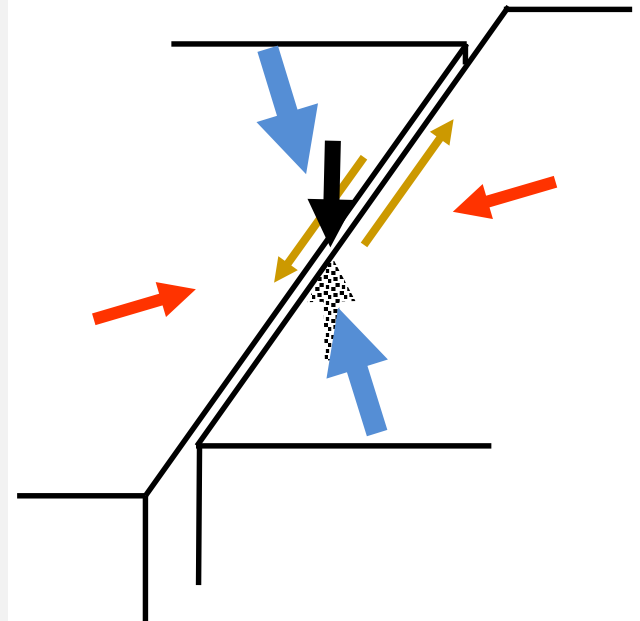
reported value for a depth of ~140 m

stress		value (MPa)	orientation (°)	
σ_1	S_H	4.5	347/0	NNW/horizontal
σ_2	S_V	3.6	0/90	-/vertical
σ_3	S_h	3.0	77/0	ENE/horizontal

A740 Freiberger Forschungshefte, Mjakischew (Untersuchung des Gebirgs-spannungszustandes im Süd-Ostteil der DDR, VEB Deutscher Verlag für Grund-stoffindustrie, Leipzig **1987**)

strike slip (trans-
form, wrench):

$$S_H > S_V > S_h$$

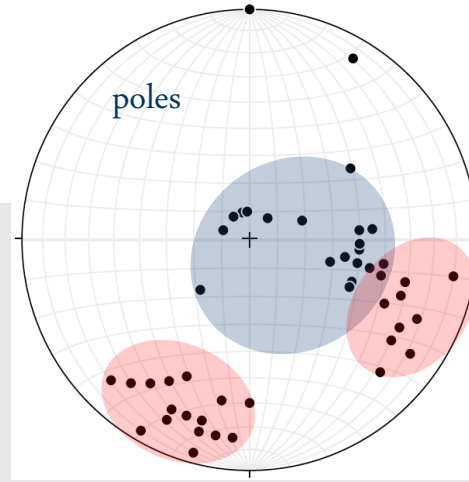


faults/damage zones

- fault zone: south
- fault zone: center
- fault zone: north



foliation



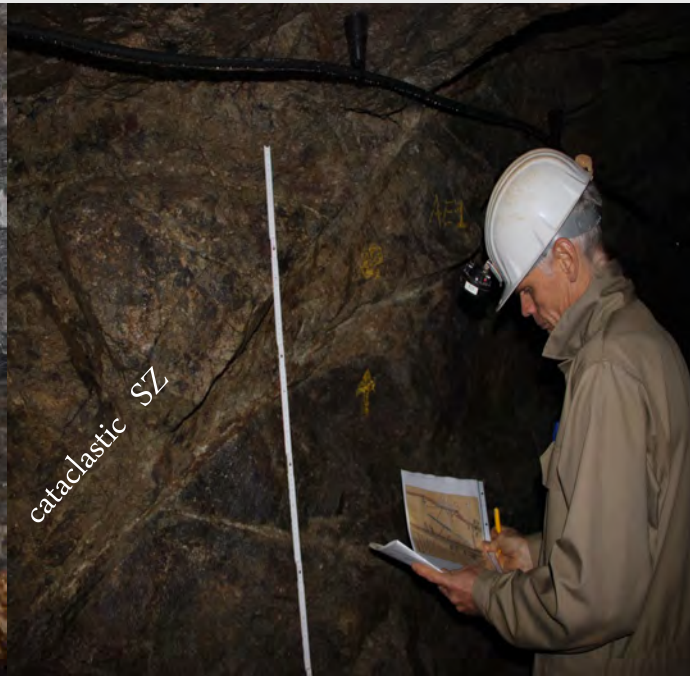
faults, joints

vein drift

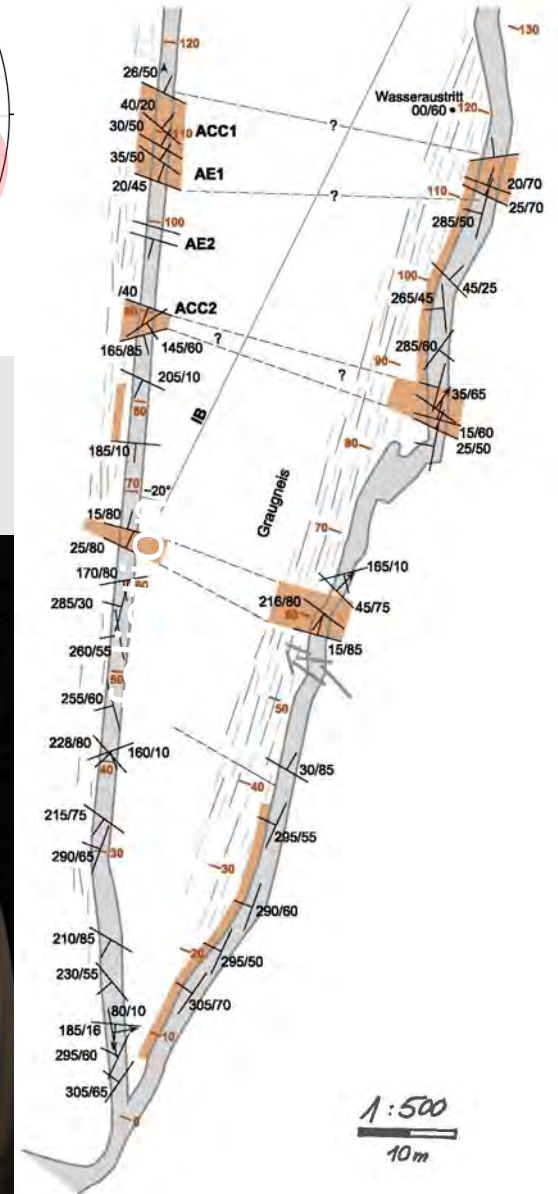
drift



cataclastic SZ
episodic fluid flow

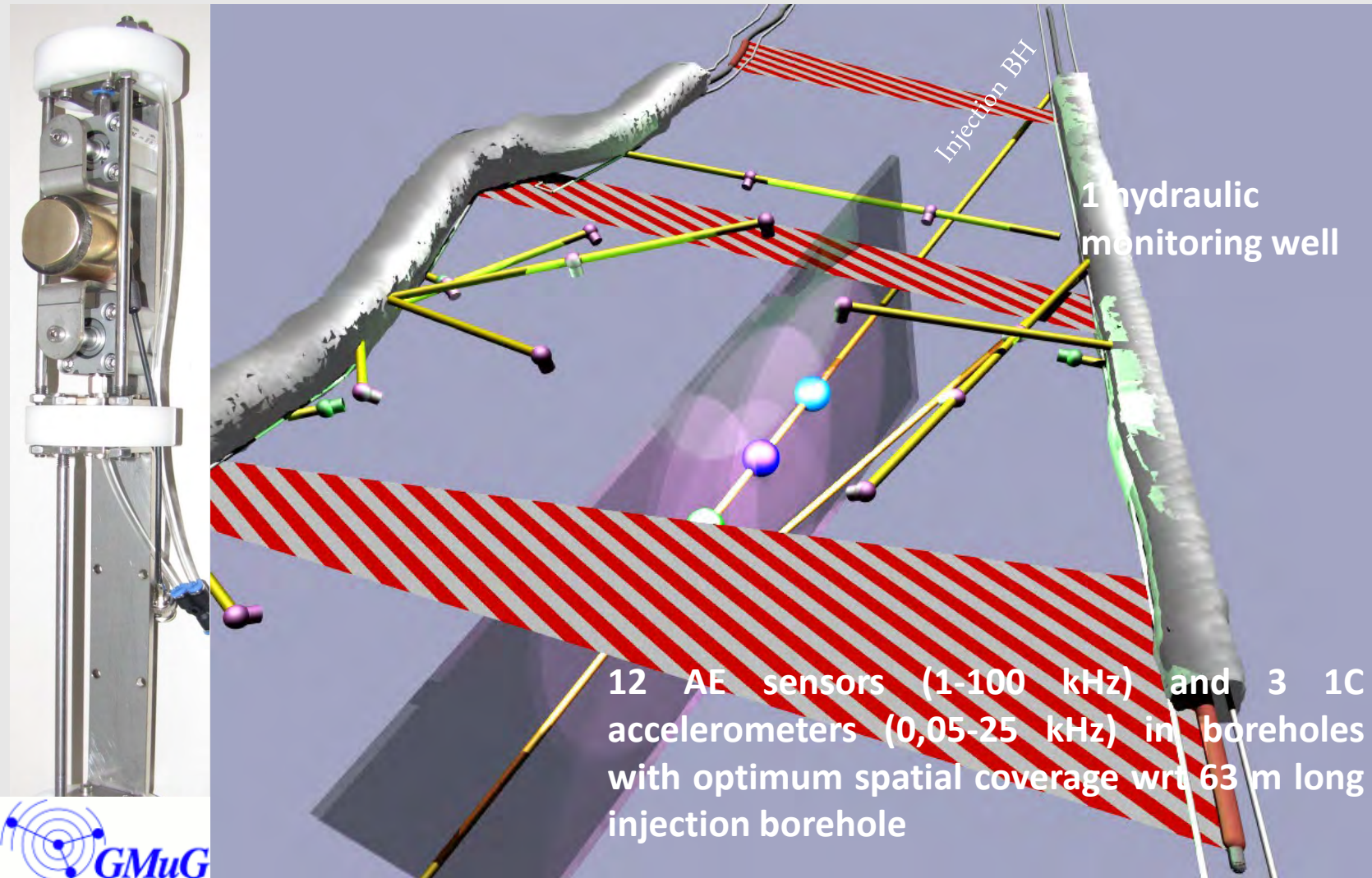


cataclastic SZ



experimental procedure: design

borehole diameter: 76 mm



experimental procedure: hydraulic testing

double-packer system: test interval 0.7 m

“downhole” pressure sensors

“downhole flowmeter”



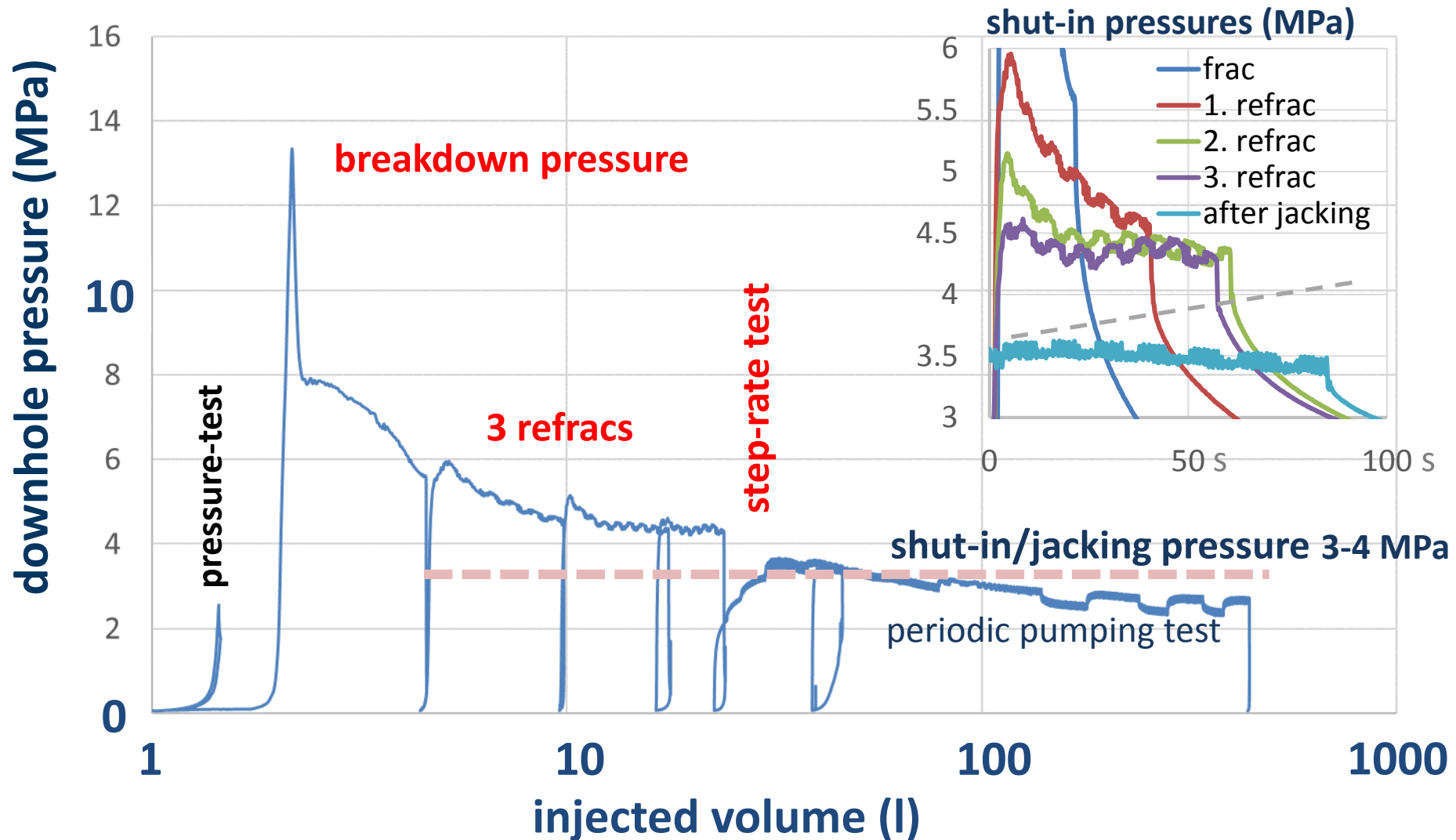
Felix Becker
Gerd Klee
Florian Seibold

stimulation July/August 2018: 10 stages

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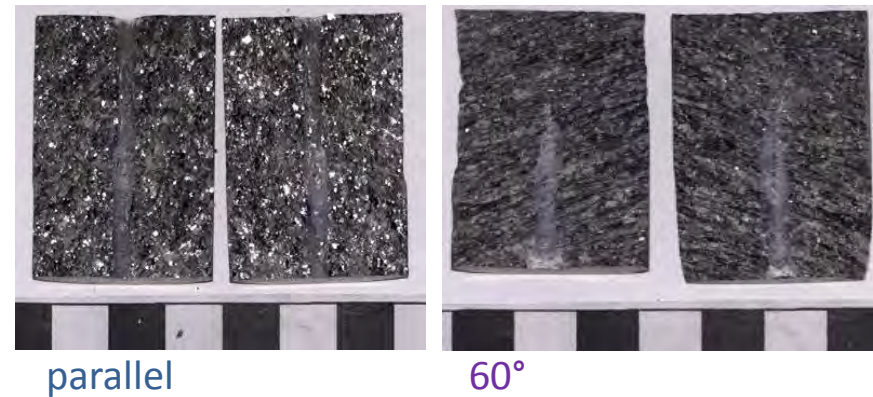
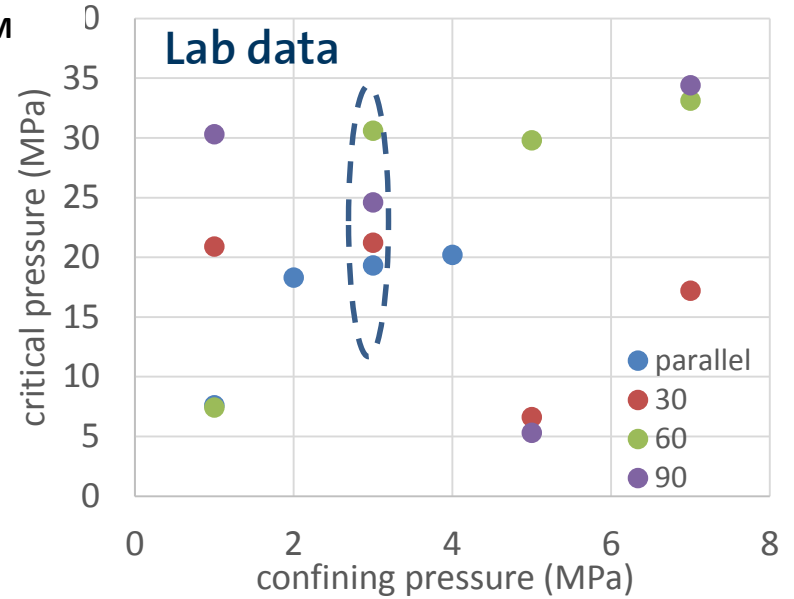
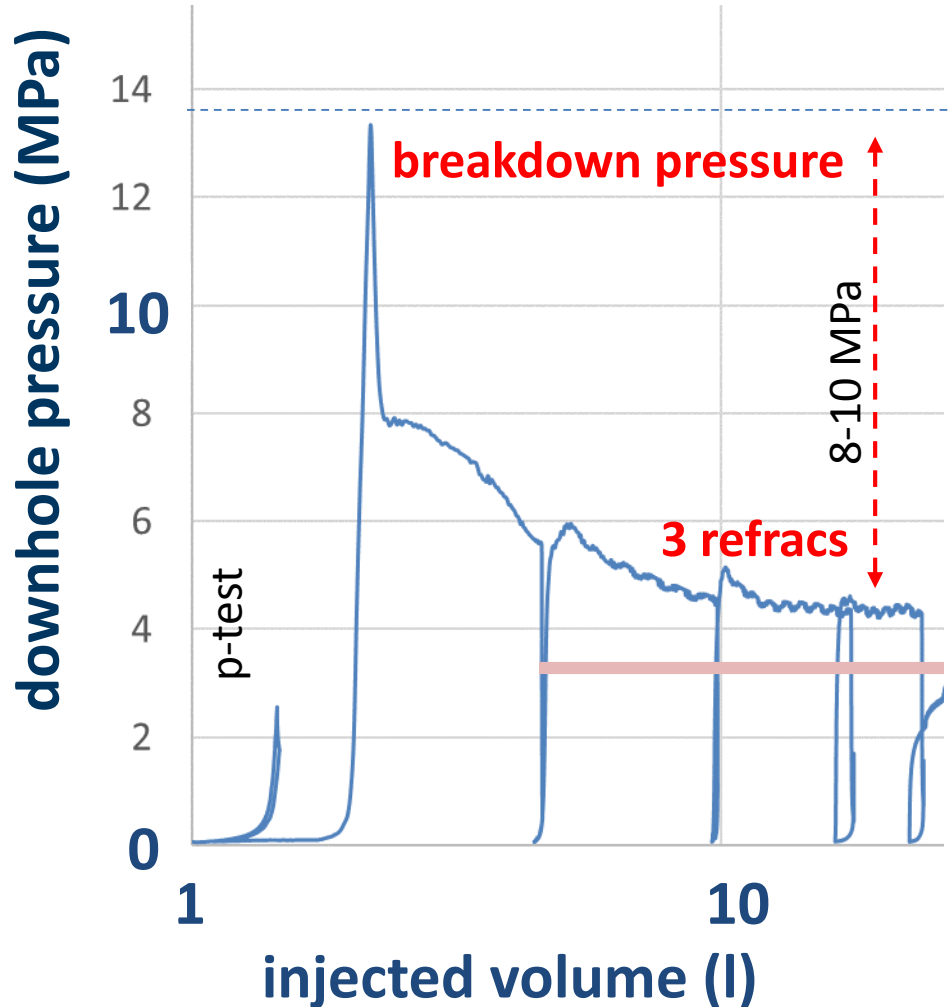
starting at bottom of well

interval 24.6 m



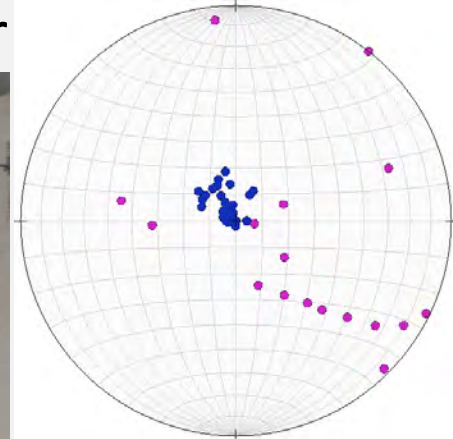
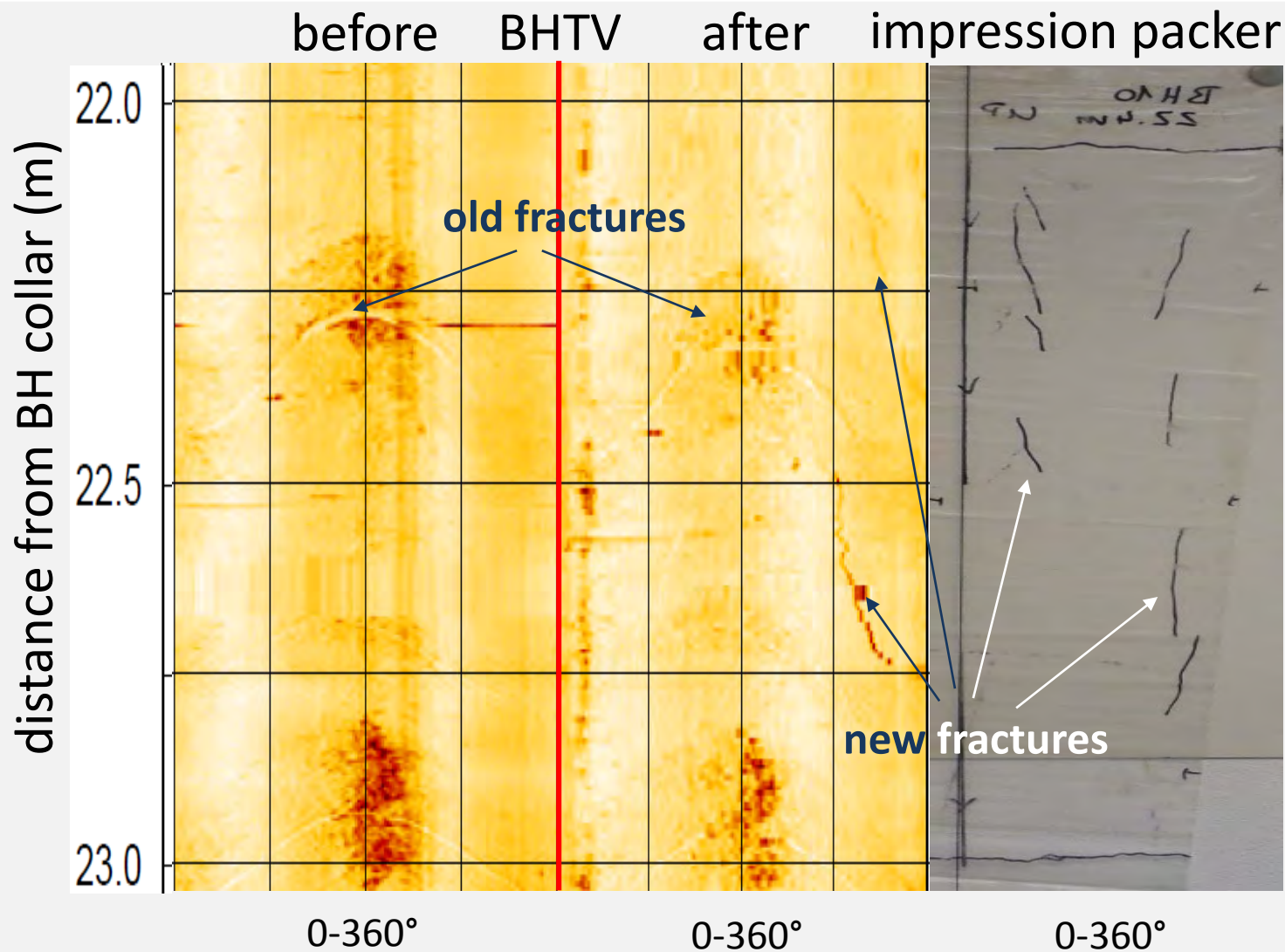
in-situ strength exceeds mean stress

Significant hydraulic tensile strength $\sim 10 \text{ MPa} > \sigma_M$



logs and impression-packer results

fractures in intervals
foliation at tunnel walls



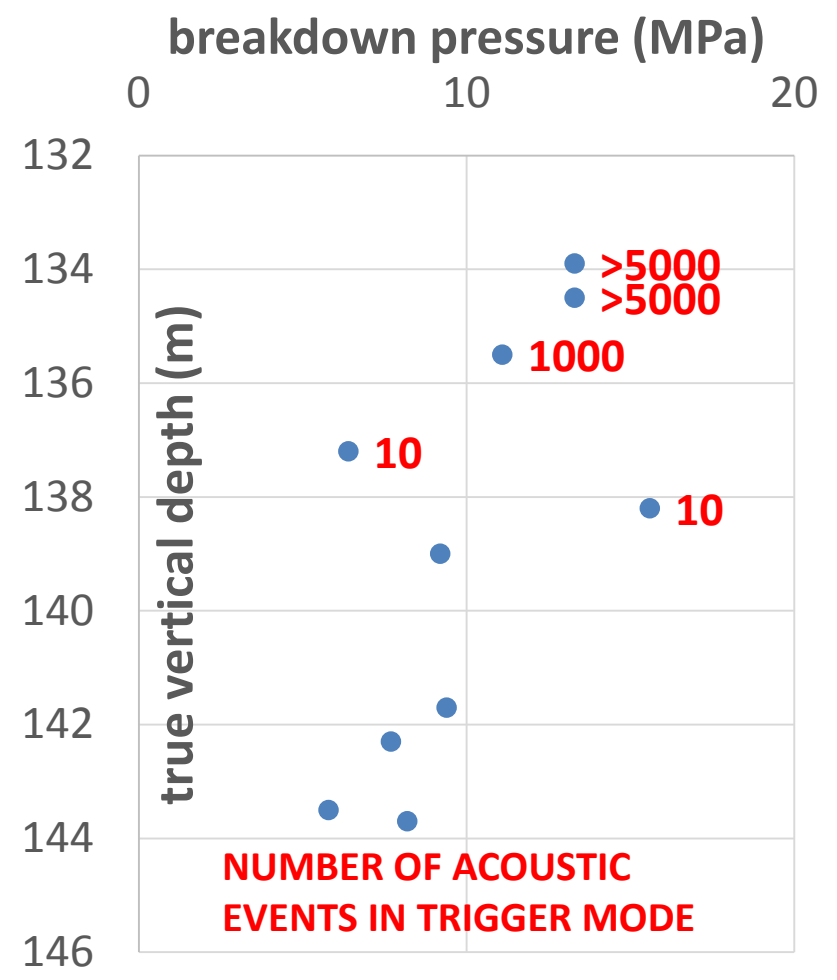
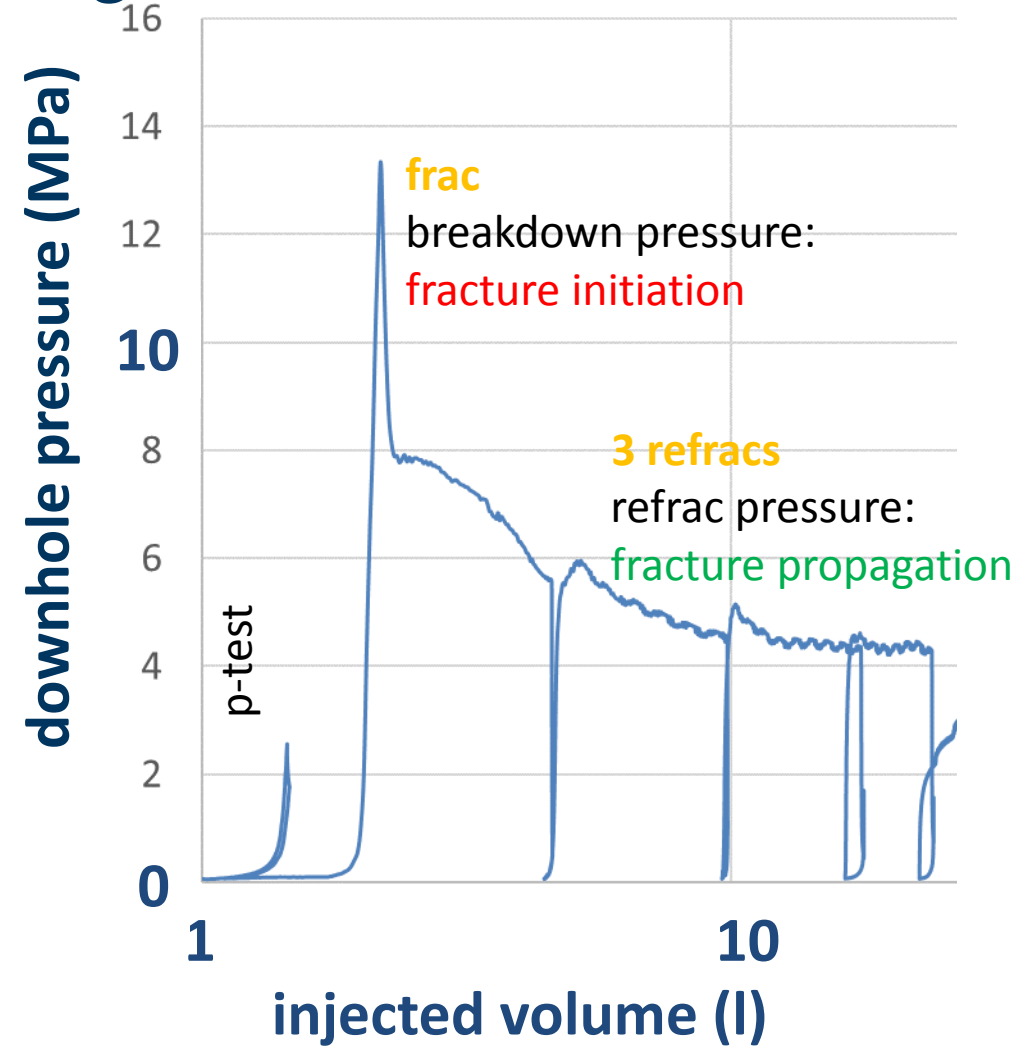
stimulation July/August 2018: 10 stages

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AE activity:

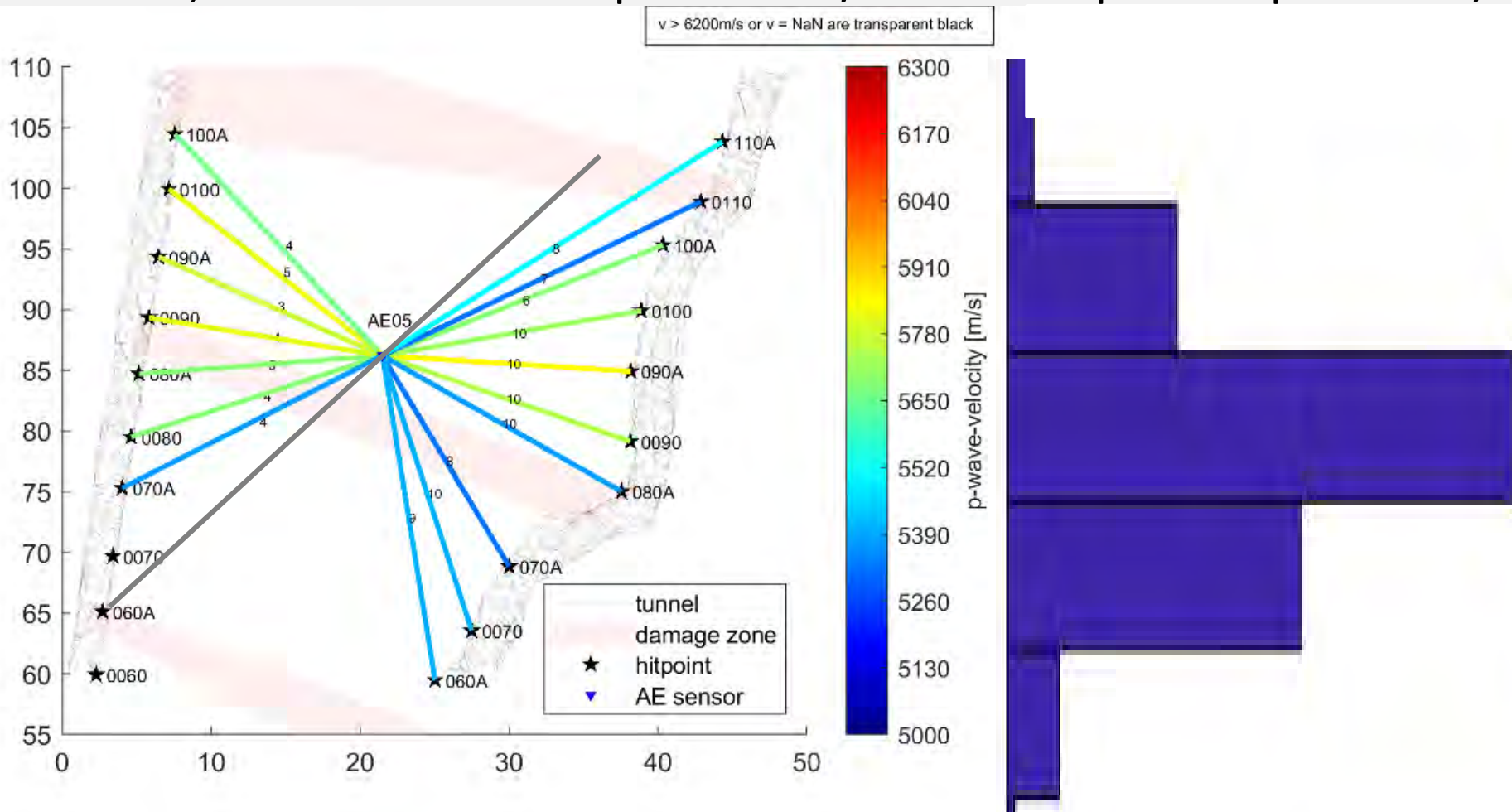
silent stages bottom hole but >10.000 events in top

stages



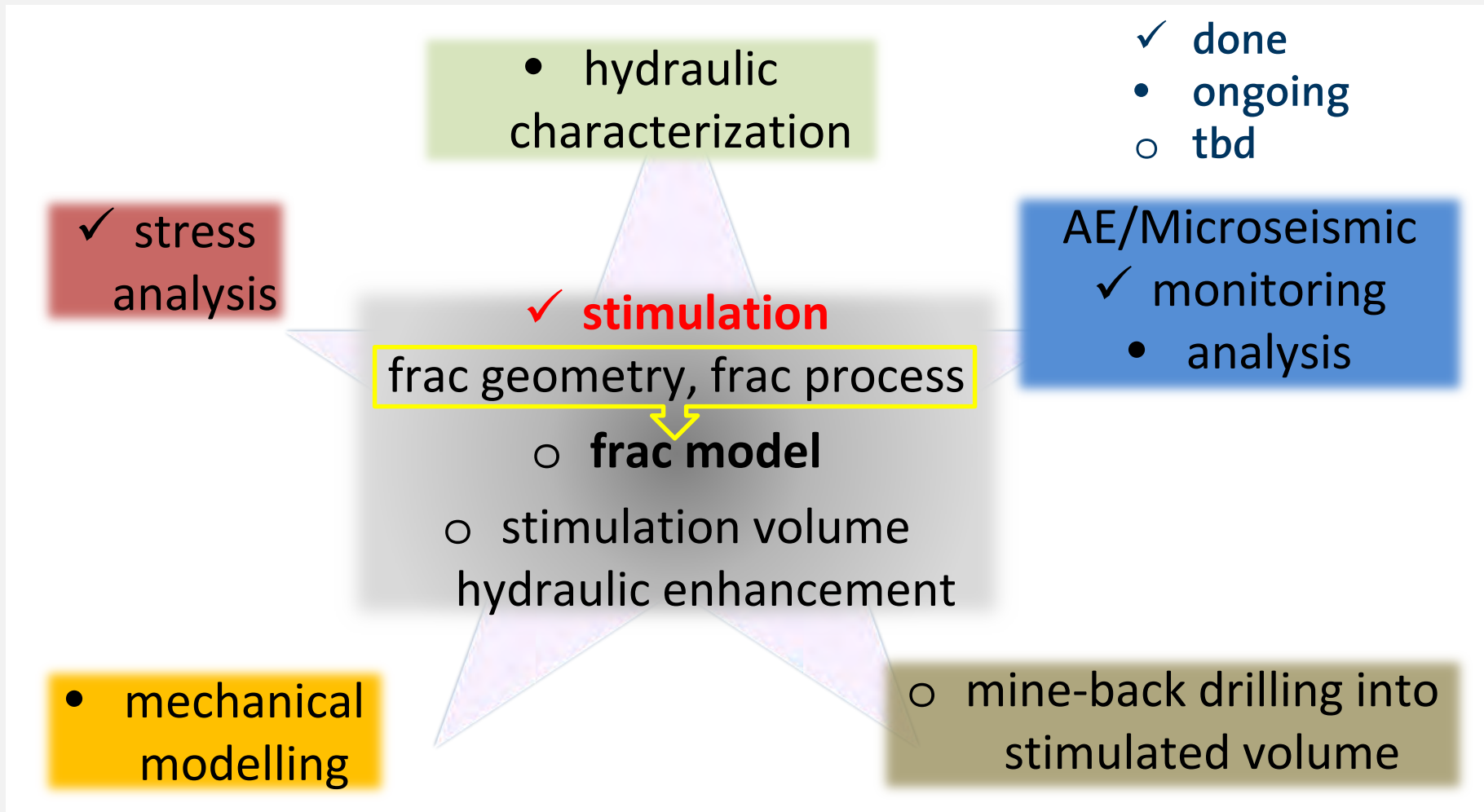
up to 18% p-wave velocity anisotropy/heterogeneity

OT and hammer hits to establish a velocity model of the test volume
 EDZ and SZ, foliation normal: $V_p < 5500$ m/s foliation parall: $V_p > 5500$ m/s





deliverables



summary and outlook

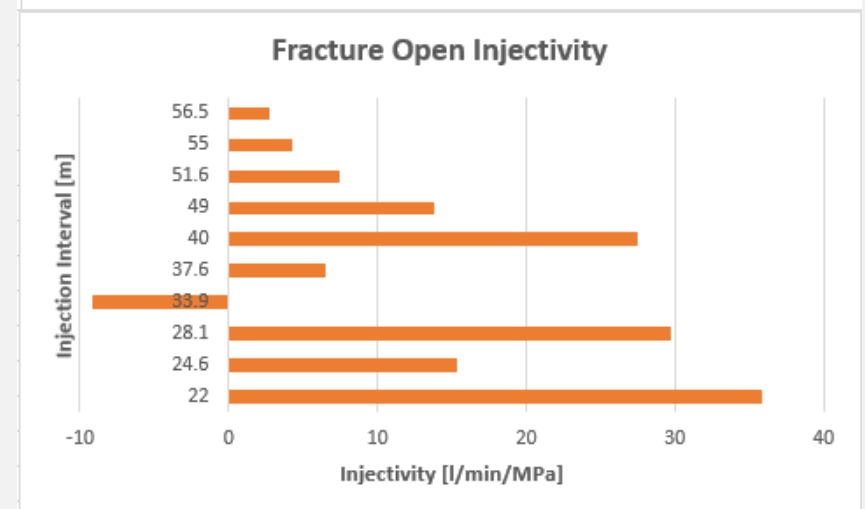
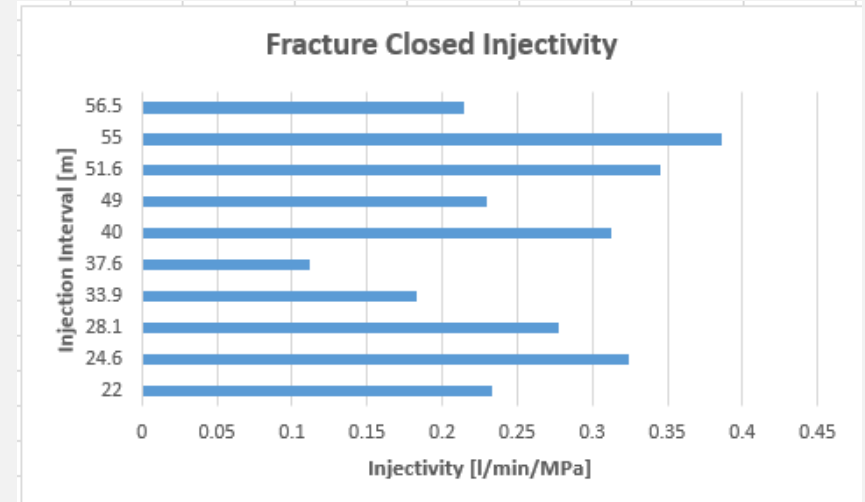
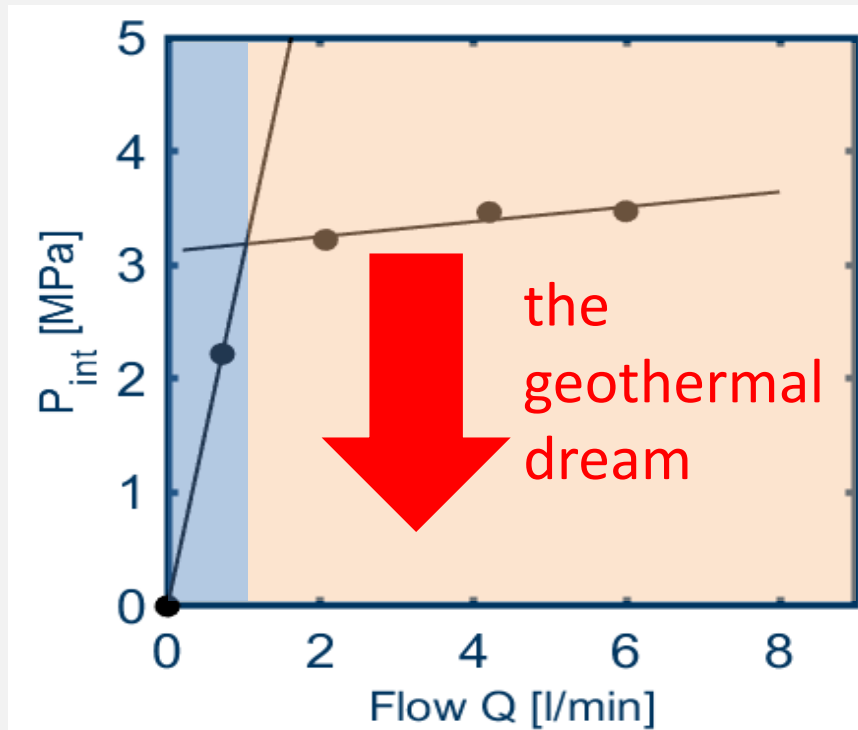
STIMTEC: validation experiment for stimulation processes in anisotropic rock

- ✓ 10 stimulation sequences performed
 - ✓ large number of events
 - ✓ increase in injectivity by two orders
 - ✓ induced fractures: range of orientations!
 - ✓ some pre-existing fractures/foliation stimulated at bottom hole
- ongoing
 - data analyses (velocities, event catalog, hydraulic model, ...)
 - modeling (stress, frac simulation, ...)
 - account for **ANISOTROPY**
- next: validation boreholes: spring 2019
 - core analysis
 - logging
 - hydraulic tests



stimulation results

injectivity: how much gain in flow rate per change in pressure



experimental procedure: sensors

3 accelerometer

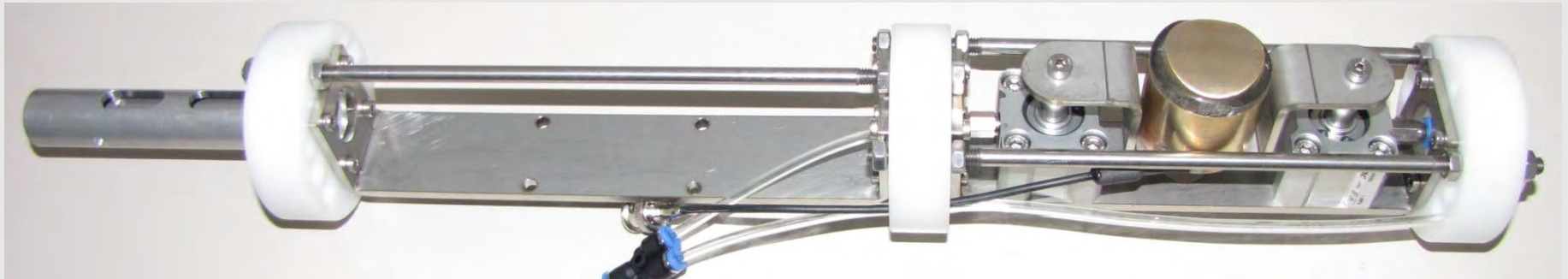
Wilcoxon 736T

(sensitivity 0,05 kHz to 25 kHz)

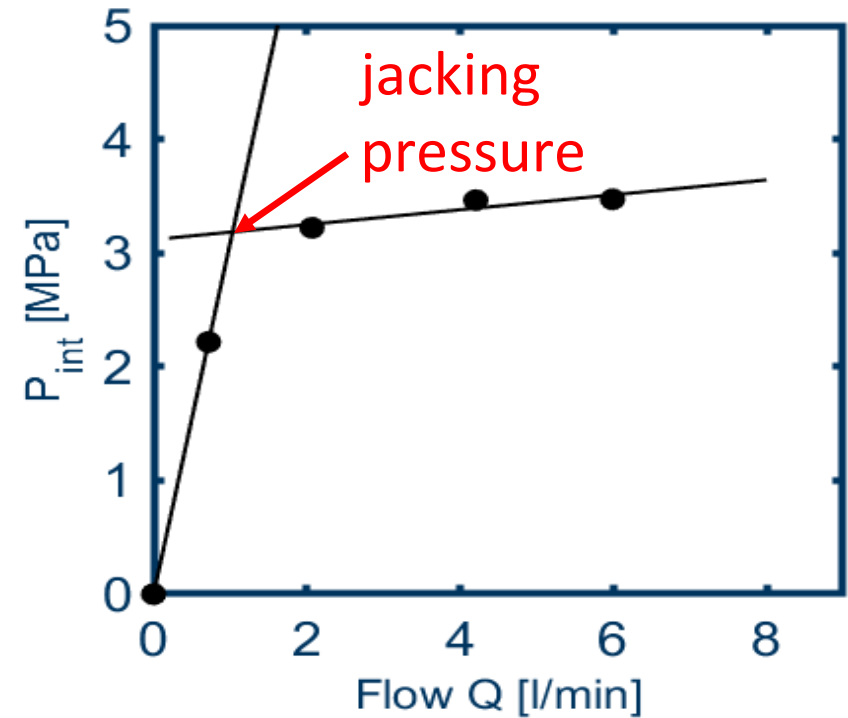
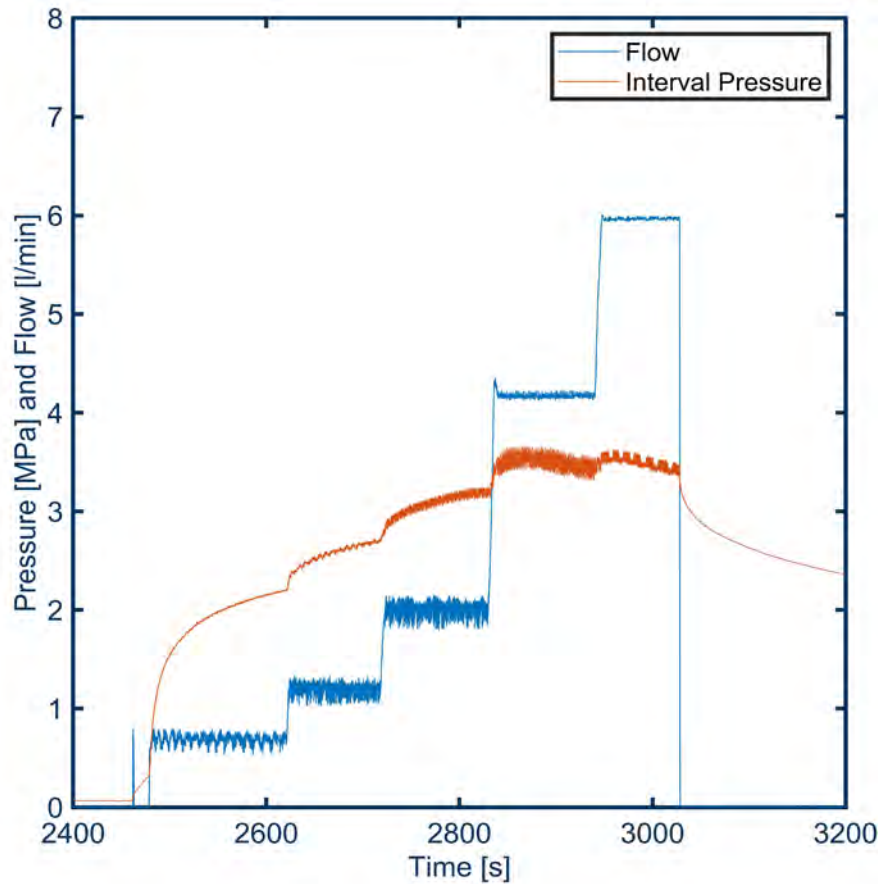
12 broad-band **ultrasonic transducer**

GMuG MA Blw-7-70-75

(sensitivity 1 kHz to 100 kHz)



step-rate test



jacking pressure corresponds to normal stress on fracture