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ETH Eidgenössische Technische Hochschule Zürich
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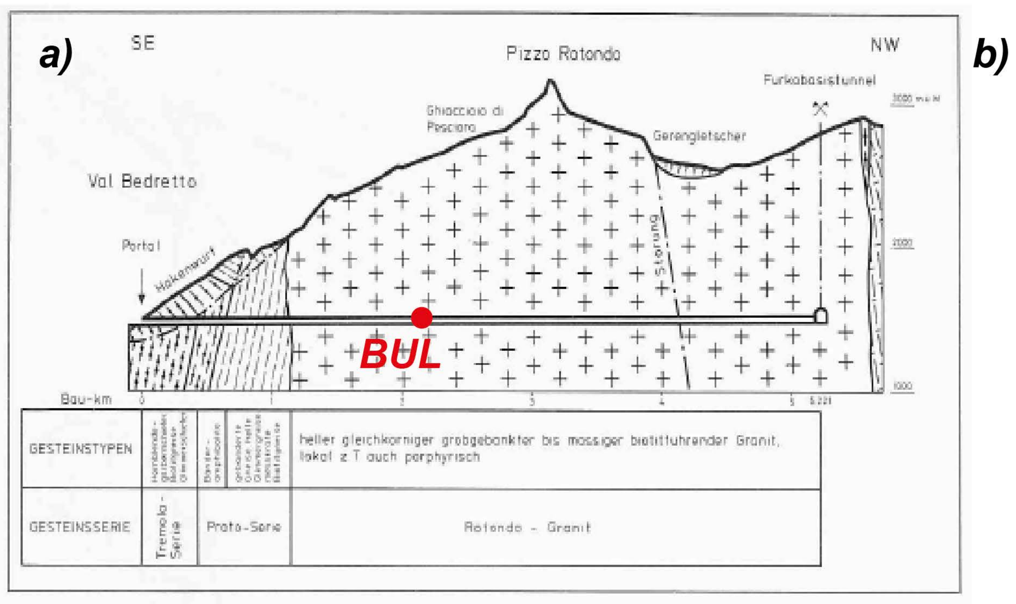
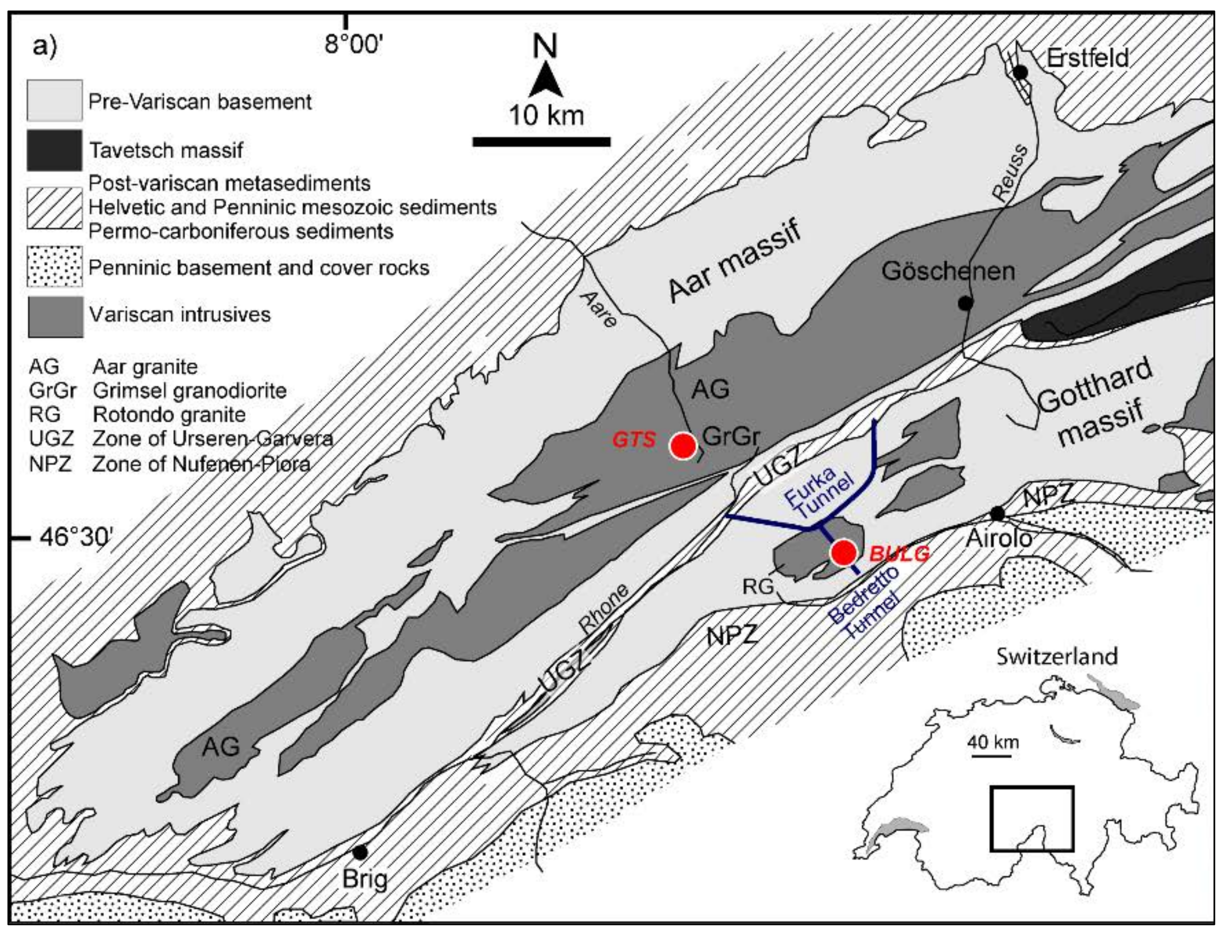
In situ stress characterization in the Bedretto Underground Laboratory: implications for induced slip of pre-existing fractures/faults

Xiaodong Ma[1,2], Nima Gholizadeh Doonechaly[1], Marian Hertrich[1], Valentin Gischig[1,3], and David Jordan[1]
[1]Swiss Competence Center for Energy Research – Supply of Electricity, [2]Geothermal Energy and Geofluids Group, [3]CSD Ingenieure AG

Average overburden ~1000 m above the BUL -> $S_v \approx 26.5$ MPa (assuming granite density = 2.7 g/cm^3)

Bedretto Underground Laboratory (BUL)

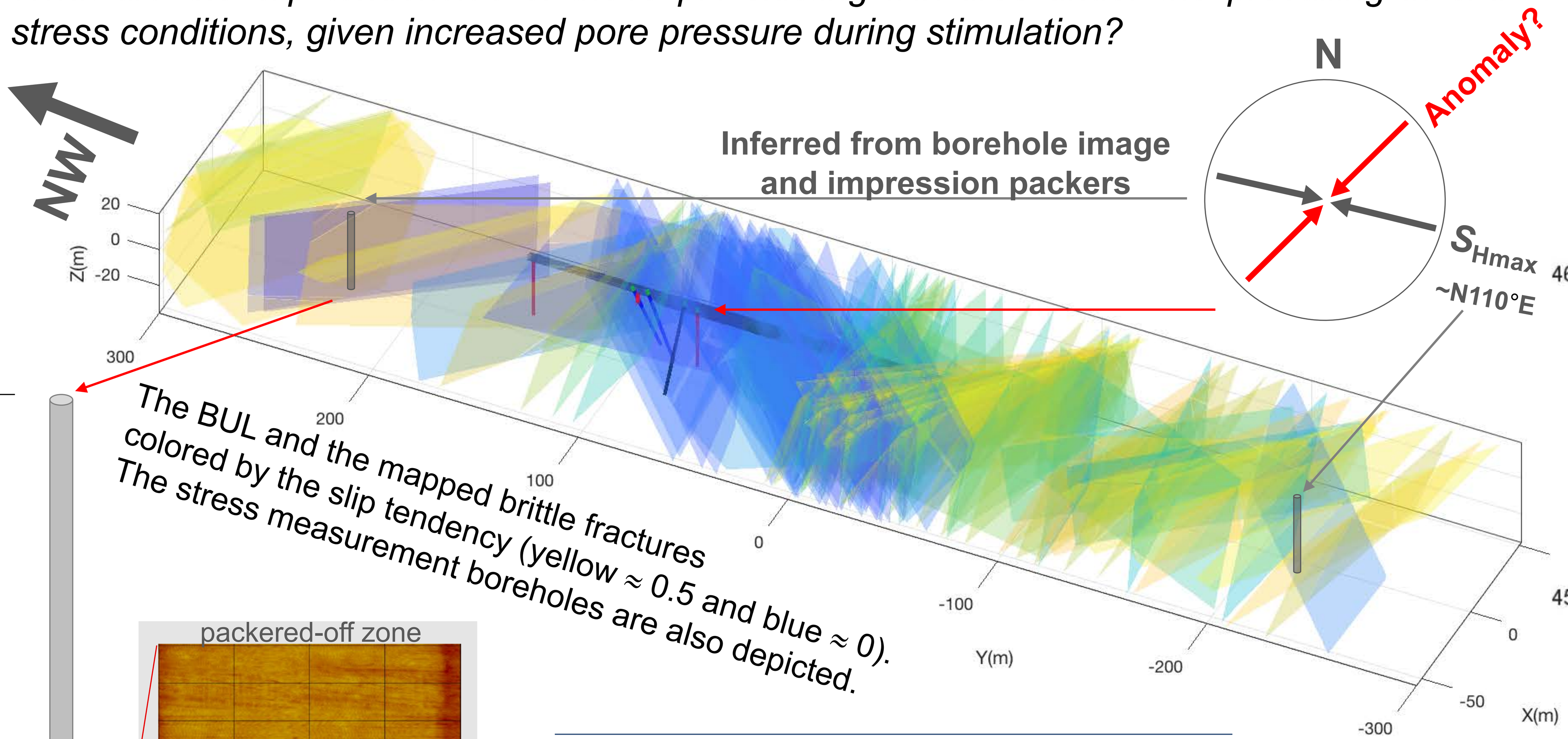




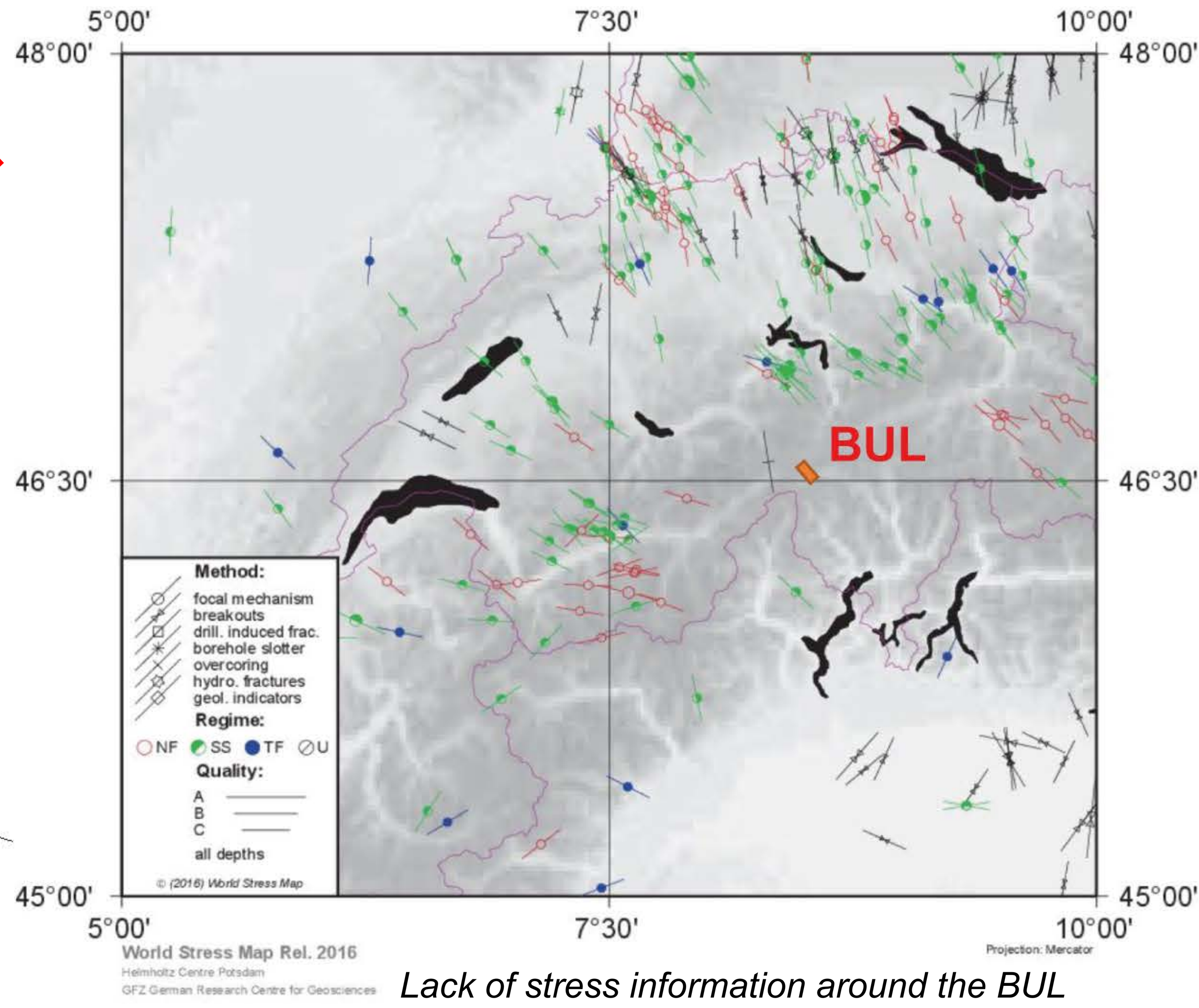
Gischig et al. (submitted to GETE)

Objectives of the in situ stress characterization

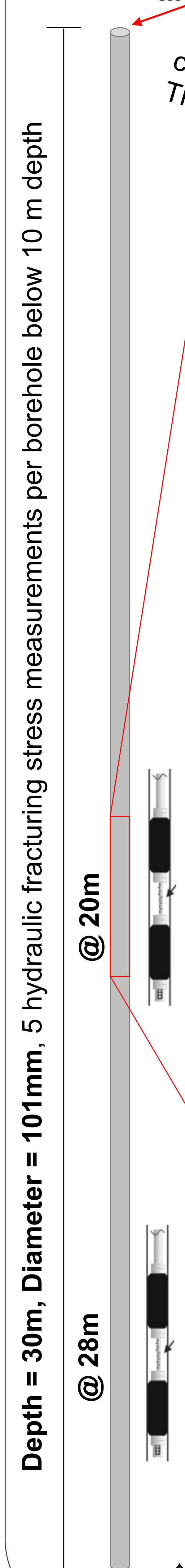
- *What are the in situ stress conditions (principal stress directions and magnitudes) and how significant are the stress variations at the BUL?*
- *What are the geometries and the distributions of the pre-existing fractures at the BUL? Are they natural fractures or induced due to tunnel excavation (blasting) and later perturbation?*
- *What are the slip tendencies of these pre-existing fractures under the prevailing in situ stress conditions, given increased pore pressure during stimulation?*

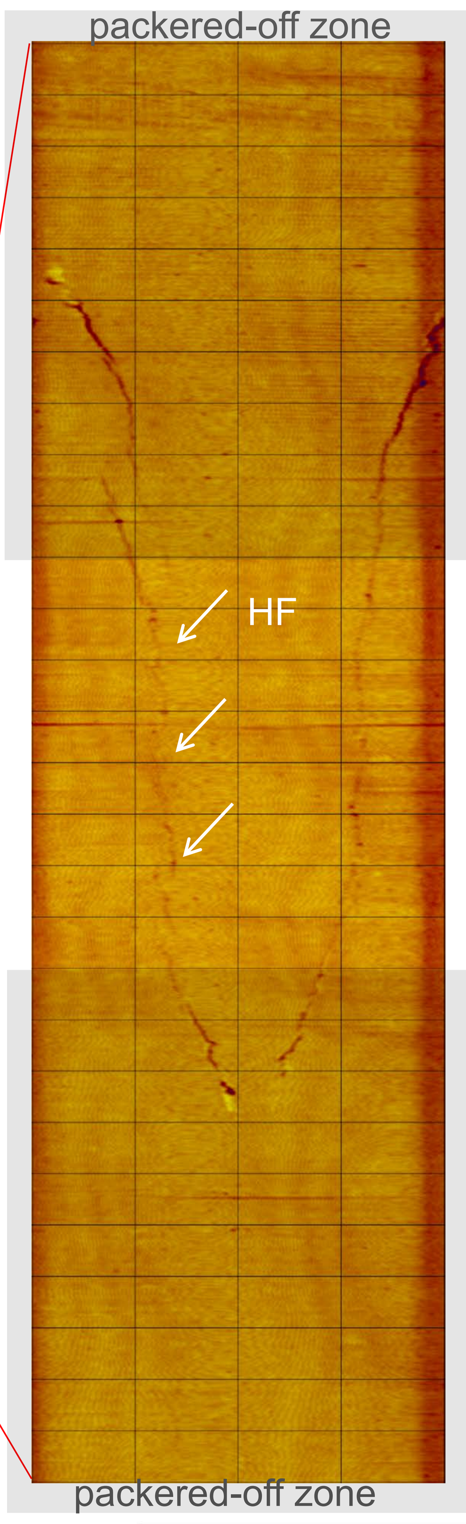


The BUL and the mapped brittle fractures colored by the slip tendency (yellow ≈ 0.5 and blue ≈ 0). The stress measurement boreholes are also depicted.



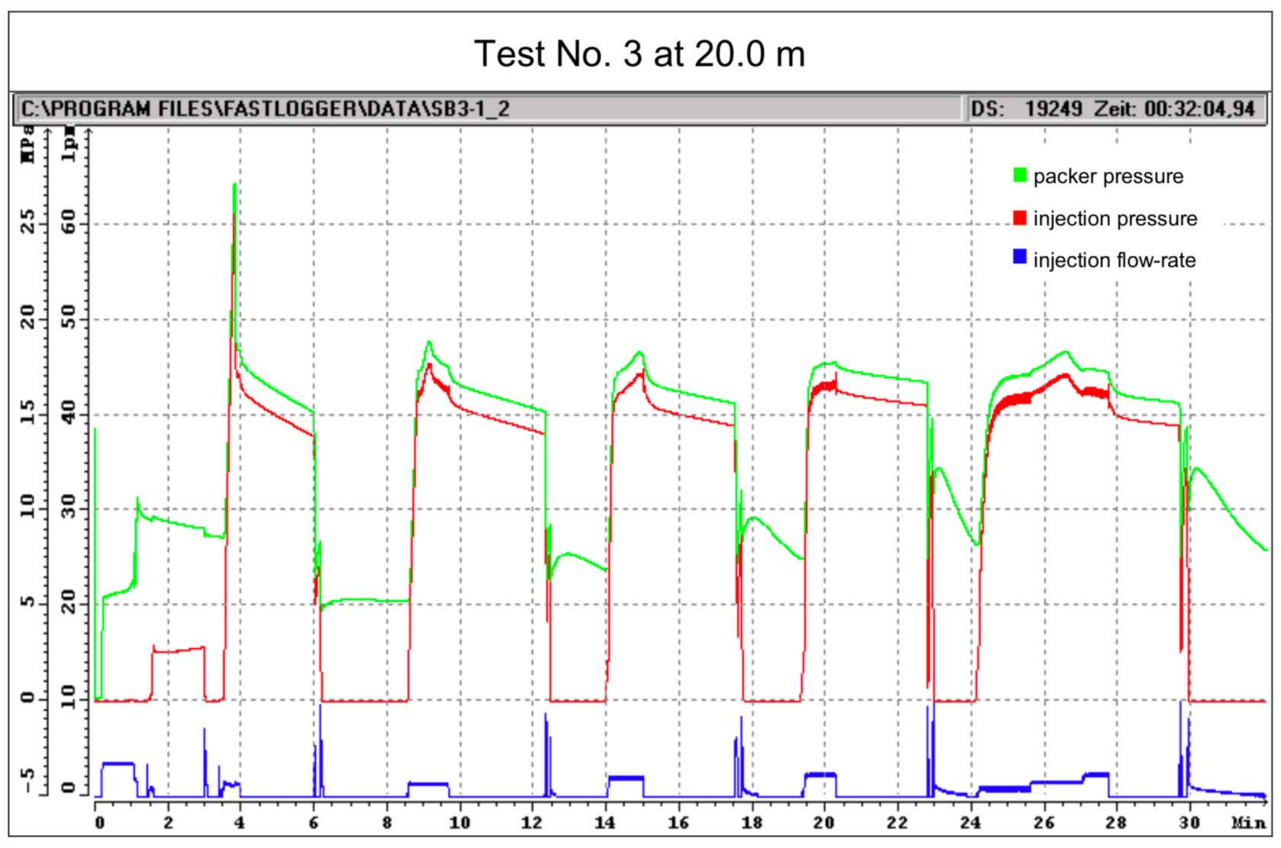
Lack of stress information around the BUL (Heidbach et al., 2016, World Stress Map)





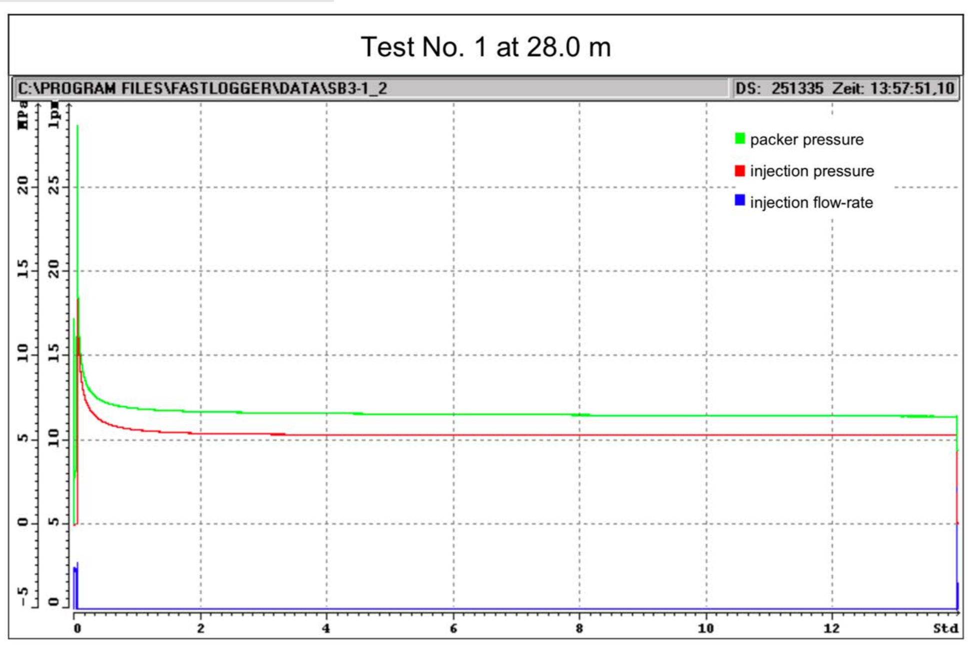
post-fracturing ↑ acoustic televiewer log

Injection volume: ~ 10 Liter in total
Injection rate: ~ 0.5 Liter/min for initial mini-frac ↓

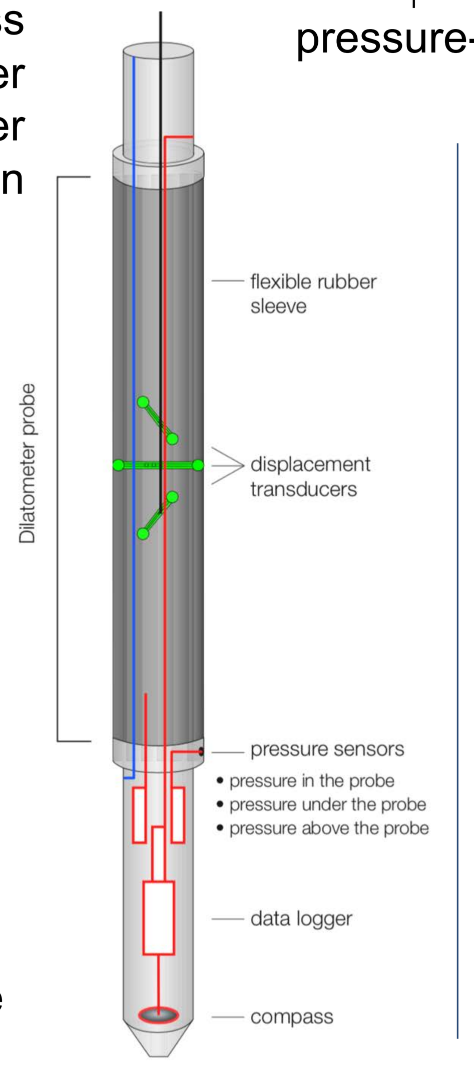


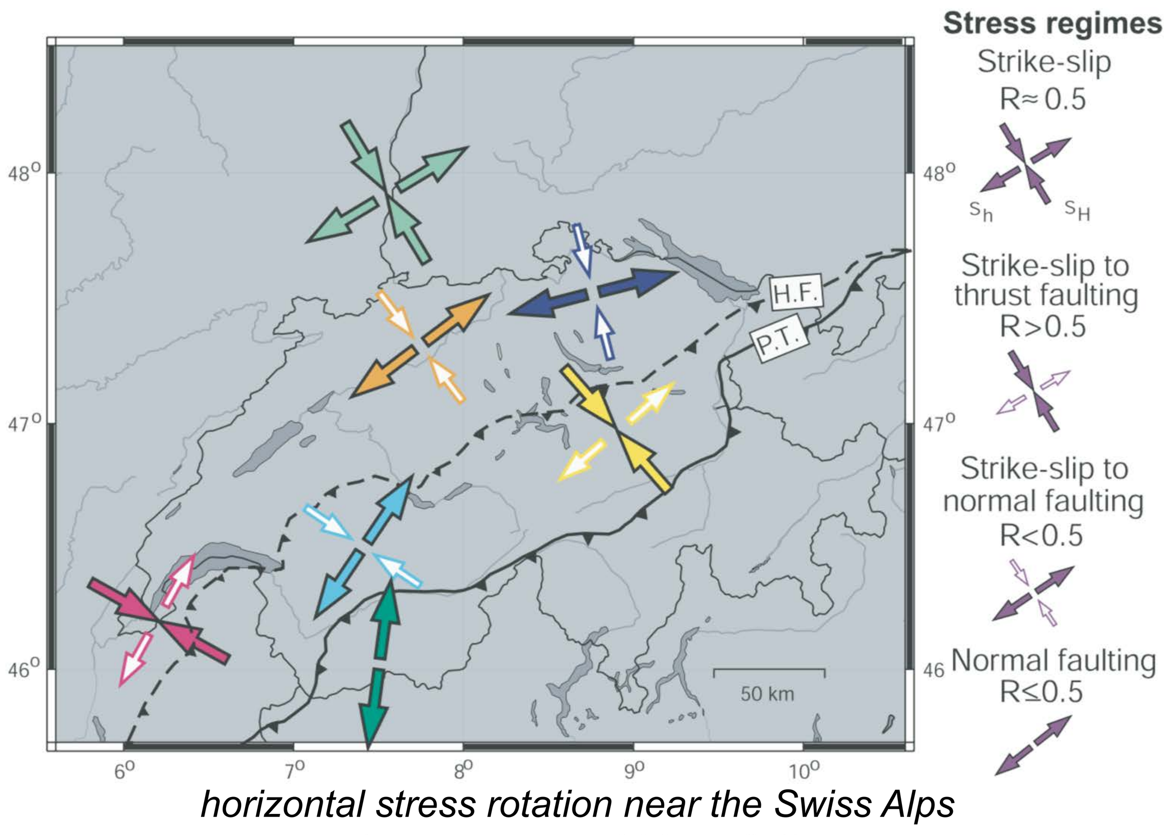
↑ mini-frac pressure-time records

Formation bulk stiffness measurement via dilatometer while conducting dry-packer test to obtain the formation re-opening pressure →



↑ Overnight shut-in test (~14 hours) to obtain formation pore pressure and permeability

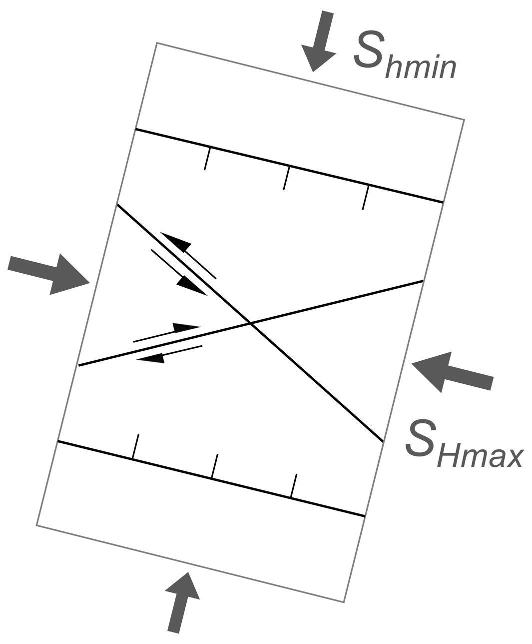




horizontal stress rotation near the Swiss Alps (Kastrup et al., 2004, JGR)

Preliminary conclusions

$S_v \approx 26.5$ MPa
$S_{Hmax} \approx 0.8 \sim 1 * S_v$
$S_{hmin} \approx 13 \sim 16$ MPa



The BUL is generally in a normal faulting and/or strike-slip stress regime, and is close to being critically-stressed. Both type of faults can be potentially active or stimulated.

Future work

- Core-based stress inversion, i.e., Diametrical core deformation analysis (DCDA) -> ($S_{Hmax} - S_{hmin}$)
- Microseismic monitoring of hydraulic fracture propagation -> S_{Hmax} direction
- Analyzing en echelon Drilling Induced Tensile Fractures (DITF's) in deviated boreholes -> (S_{Hmax}, S_{hmin}, S_V)
- Resolving stress heterogeneity due to fracture density variations in the rock mass volume