What can we Learn about Induced Fracturing from Acoustic Emission Monitoring in the Laboratory?

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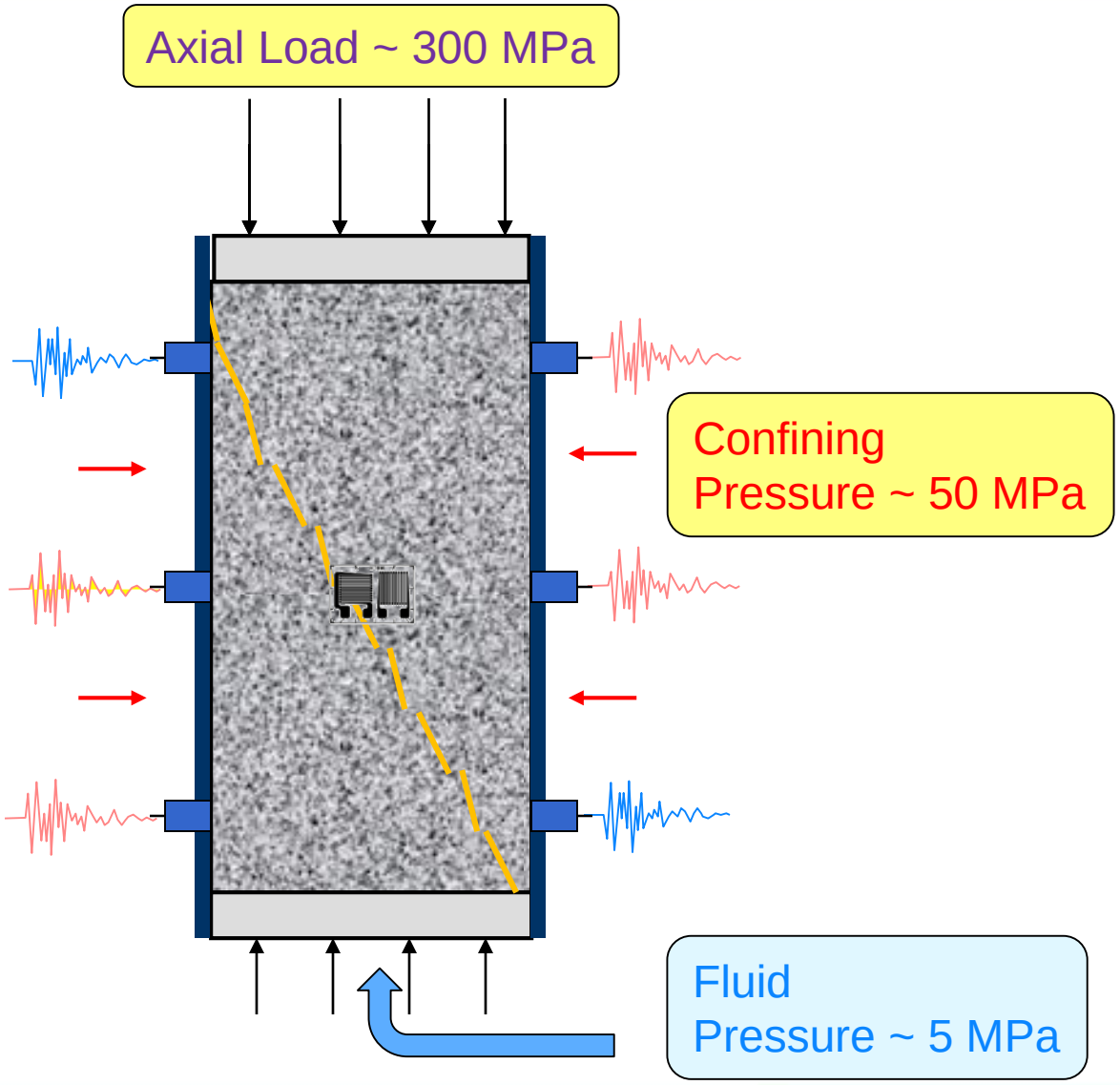
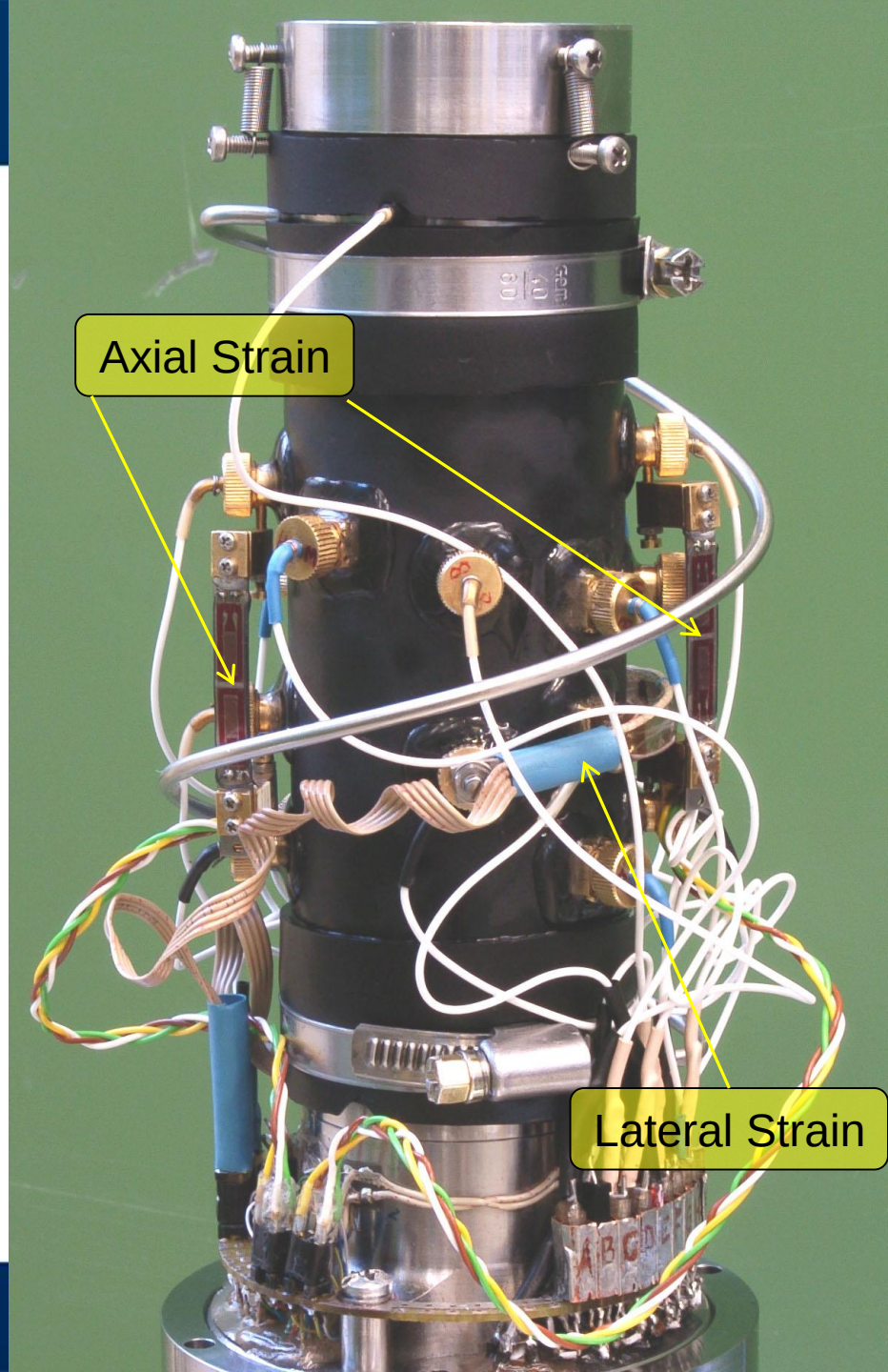
Outline

- Fracturing of Rock by Fluid Injection
  - High Stress – Low Fluid Pressure (GFZ-Potsdam)
  - Low Stress – High Fluid Pressure (TerraTek-USA)
- Monitoring of Induced Acoustic Emissions
- Interaction of Induced Fractures with Preexisting Interfaces
- Fracturing of Shale
- Conclusions

GFZ: Experimental Setup





Sample Diameter: 5 cm; Length 12.5 cm

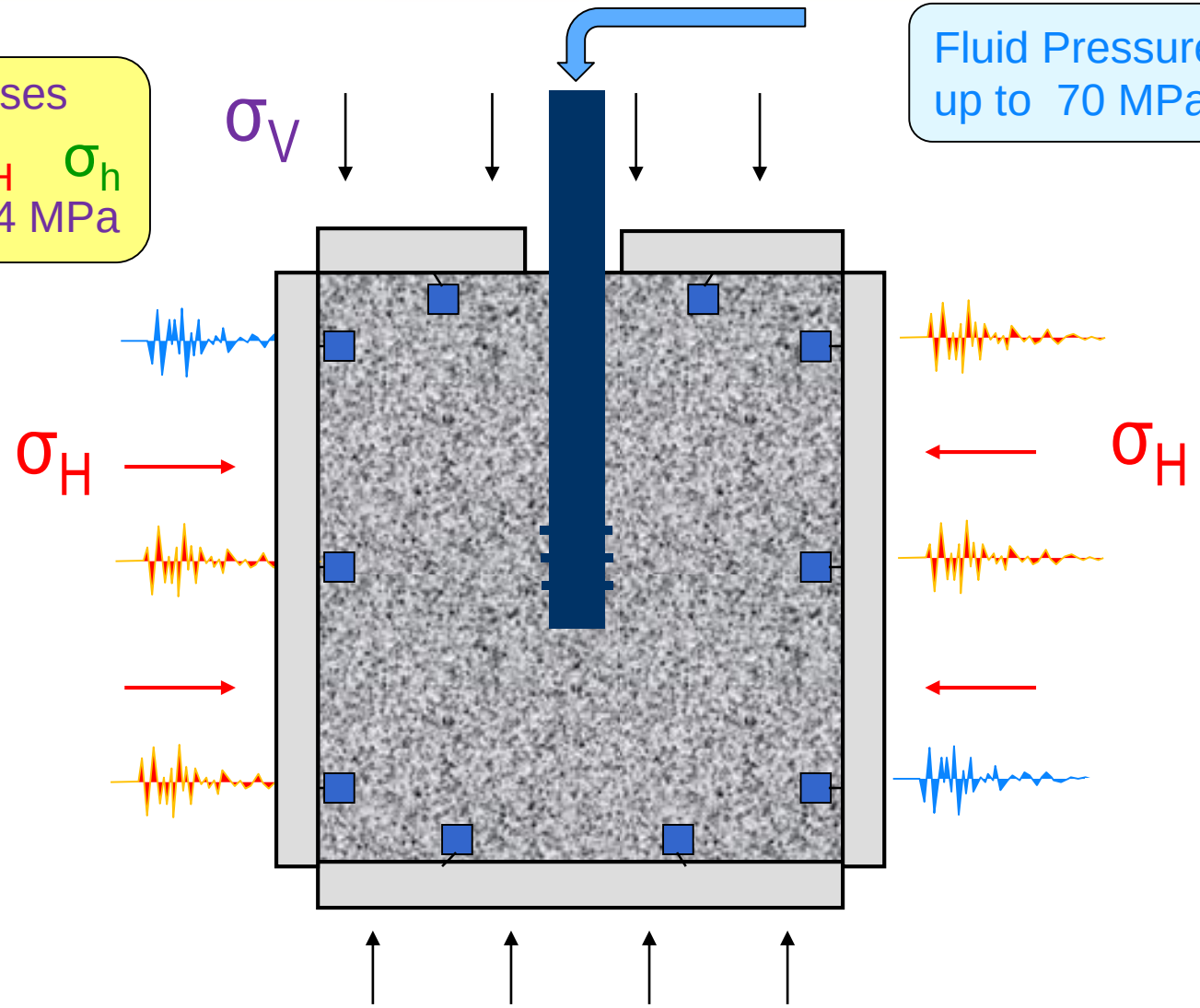
TerraTek: Experimental Setup

Stresses

σ_V σ_H σ_h

up to 24 MPa

Fluid Pressure up to 70 MPa



Sample Size: 76 x 76 x 91 cm

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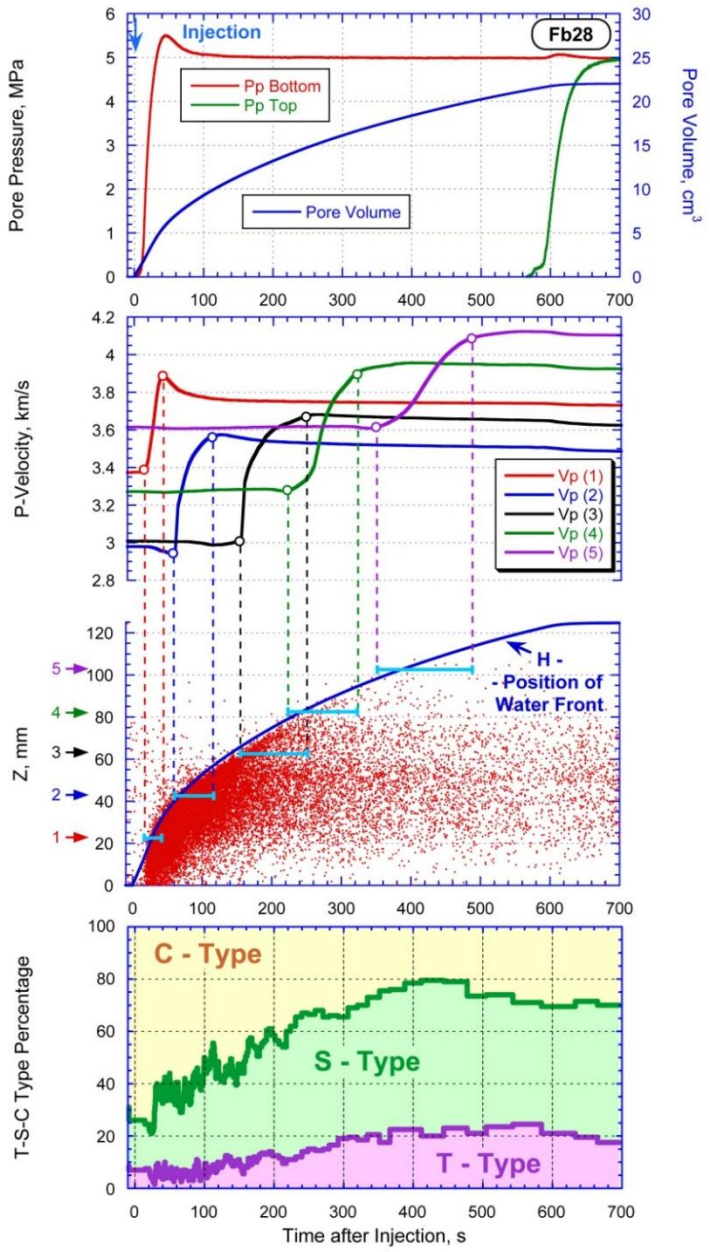
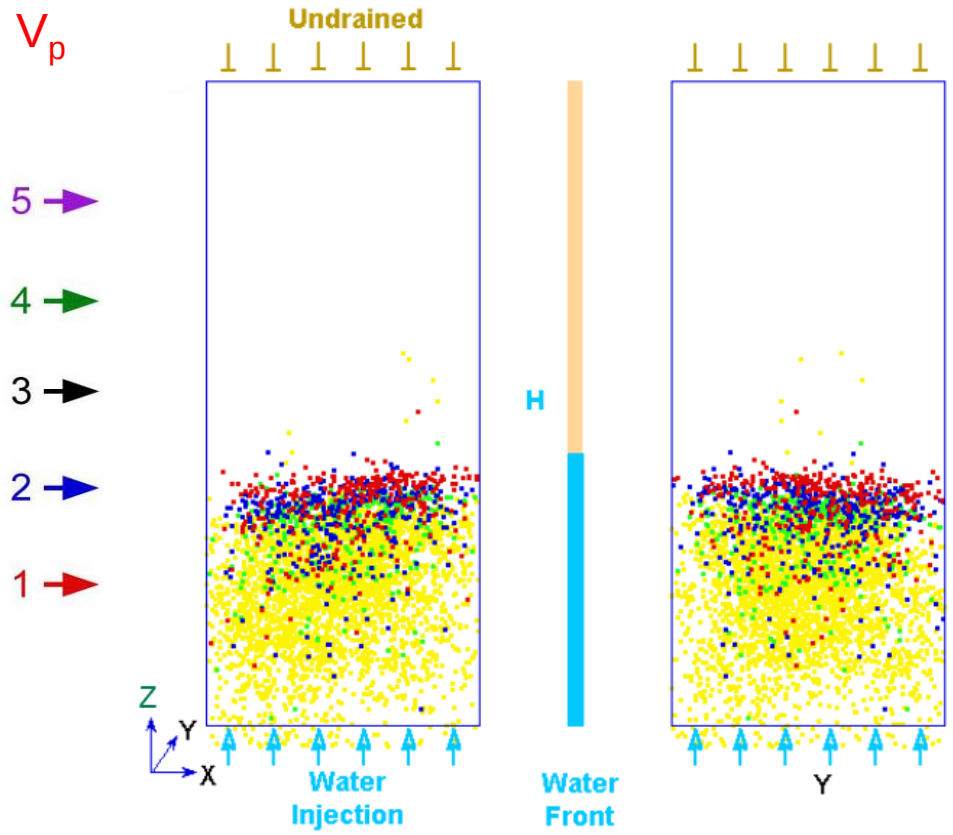
Fluid Injection into Stressed Intact Sandstone



- Pc = 50 Mpa; φ= 9 %;



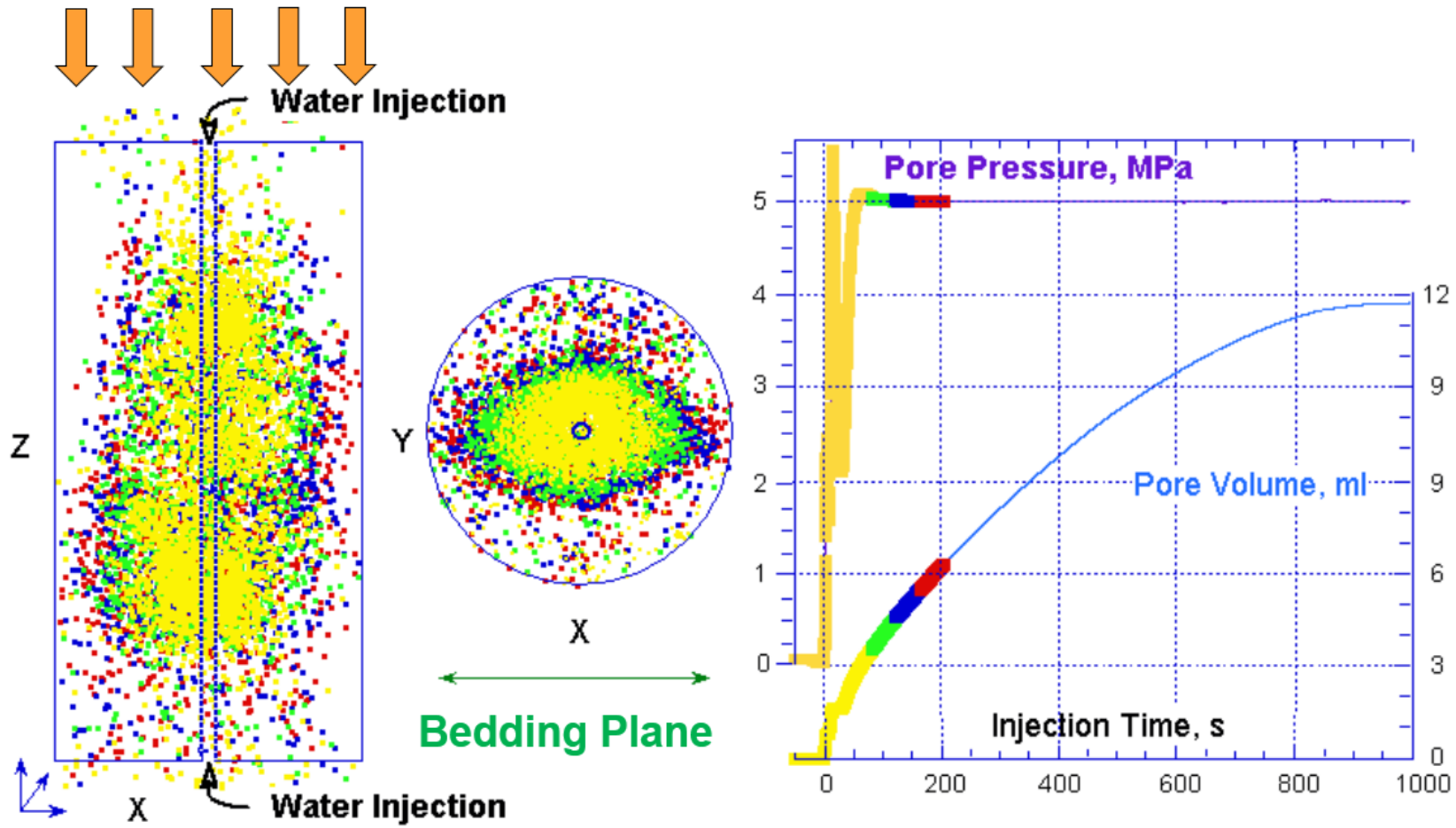
$$H = \frac{Pvol}{\pi r^2}\varphi^{-1}$$

Stanchits et al.(2011),

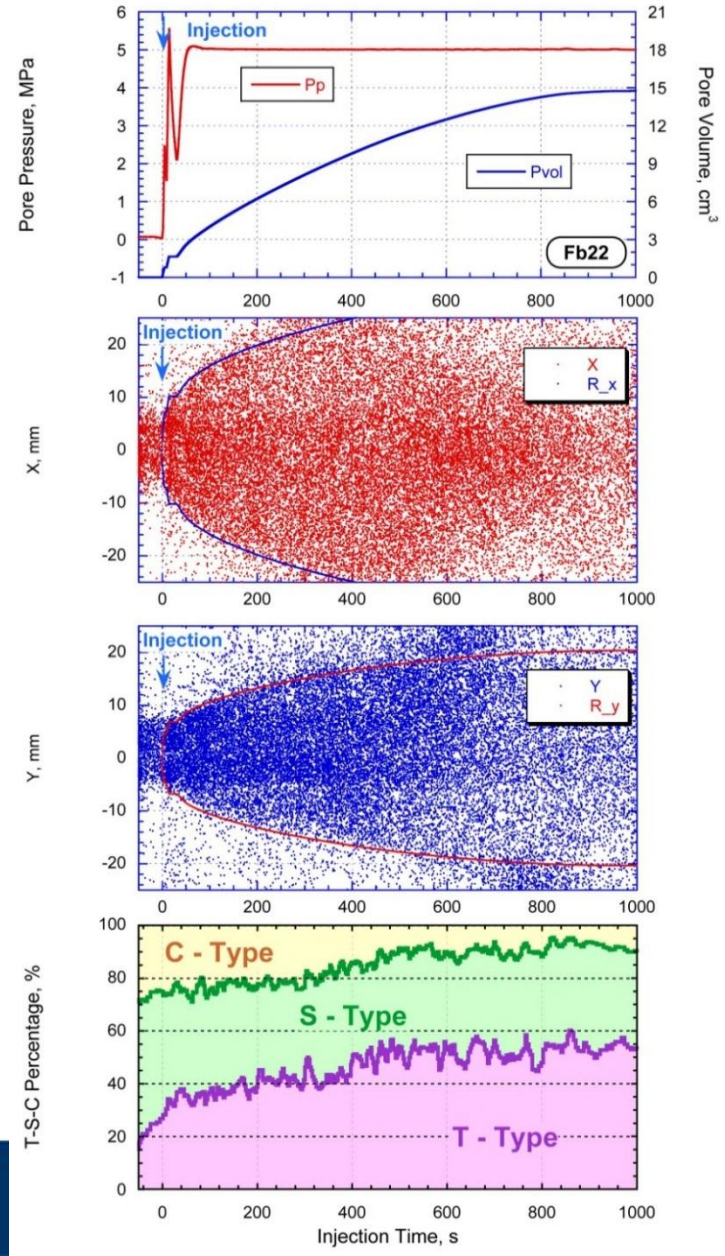
Tectonophysics

Fracturing by Water Injection into Borehole

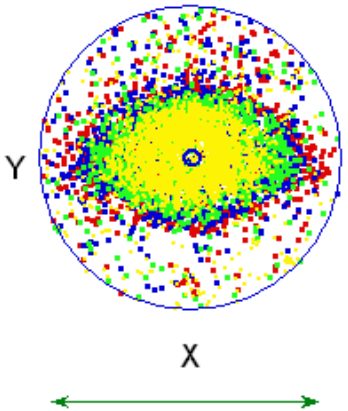
- Sandstone; Pc = 50 MPa



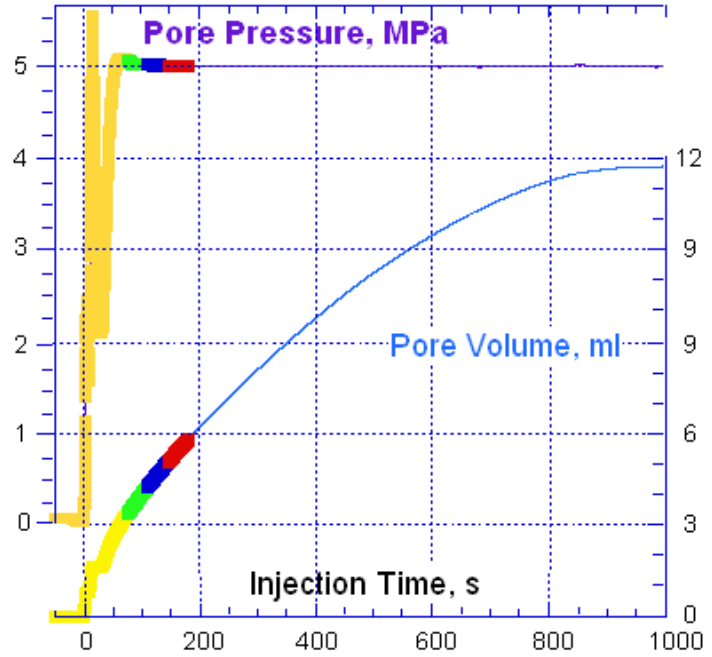
Fracturing by Water Injection into Borehole



Pc = 50 MPa



Bedding Plane



$$R\_x = \sqrt{\left(\frac{k_X}{k_Y}\right)^{0.5} \frac{Pvol}{\pi L \varphi}} \qquad R\_y = \sqrt{\left(\frac{k_Y}{k_X}\right)^{0.5} \frac{Pvol}{\pi L \varphi}}$$

k_X, k_Y - Permeability in directions X and Y

φ - Porosity; L - sample length

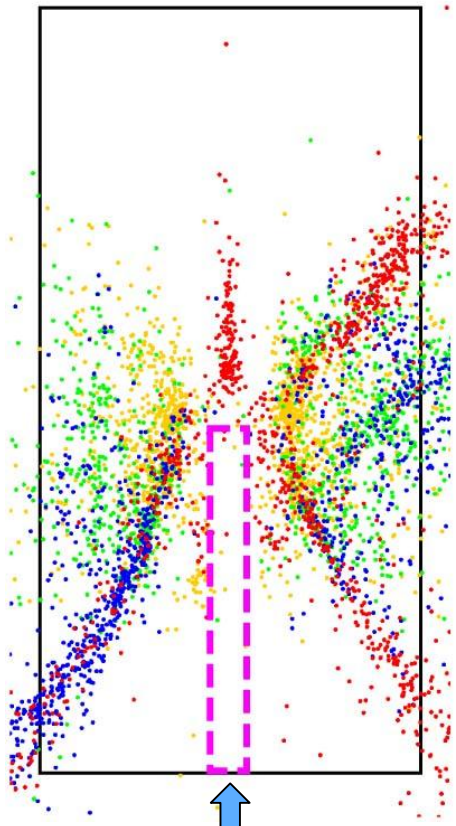
$Pvol$ - Volume of injected water

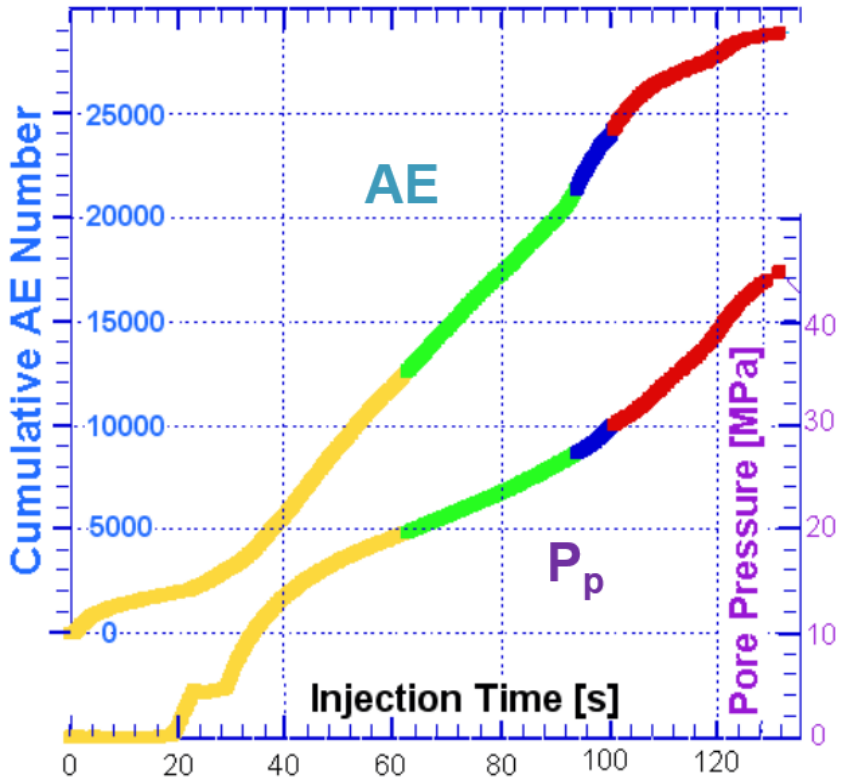
Stanchits et al.(2011),*Tectonophysics*

Fracturing by Increase of Fluid Pressure

Load

- Sandstone, Pc = 50 MPa



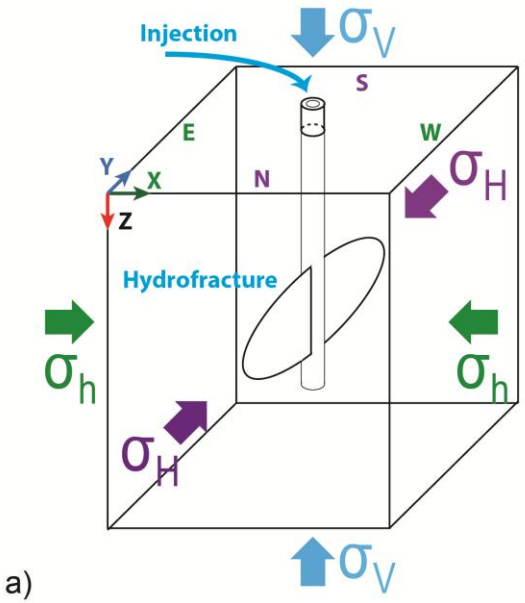


Water Injection

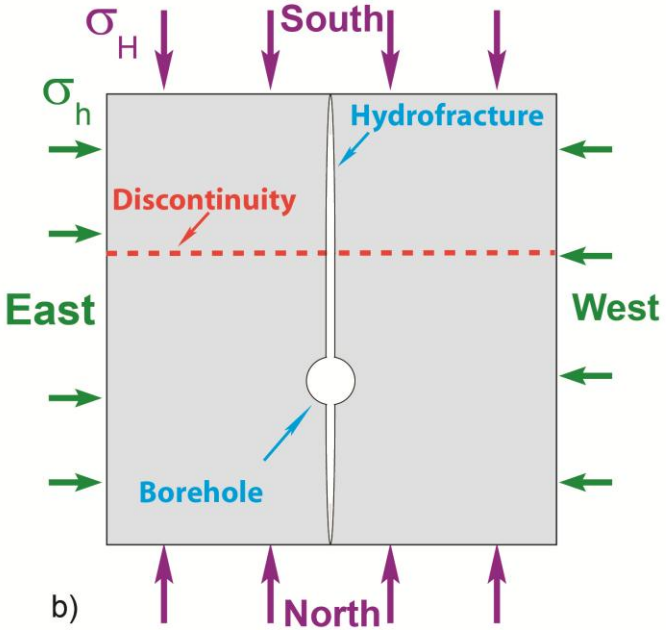
Stanchits et al.(2011), *Tectonophysics*

Hydraulic Fracturing

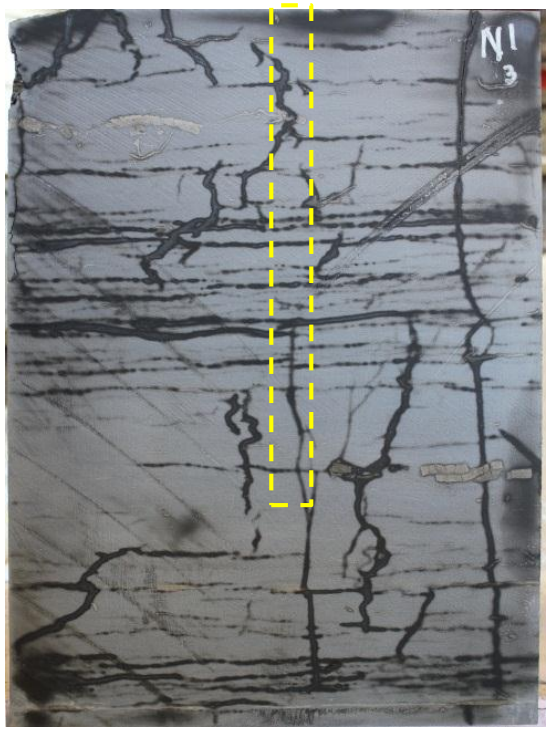
- Intact Homogeneous Rock



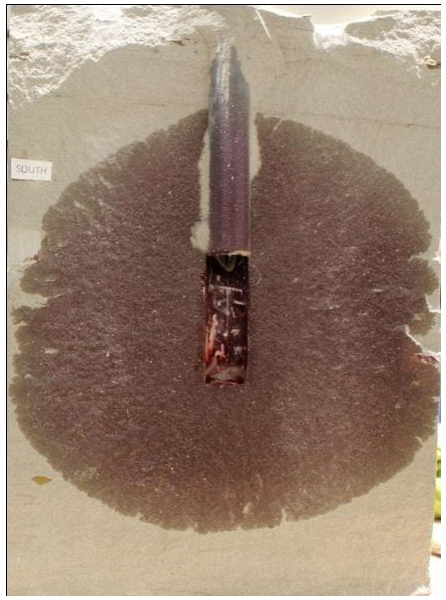
- Rock with Artificial Interface



- Shale with Strong Fabric



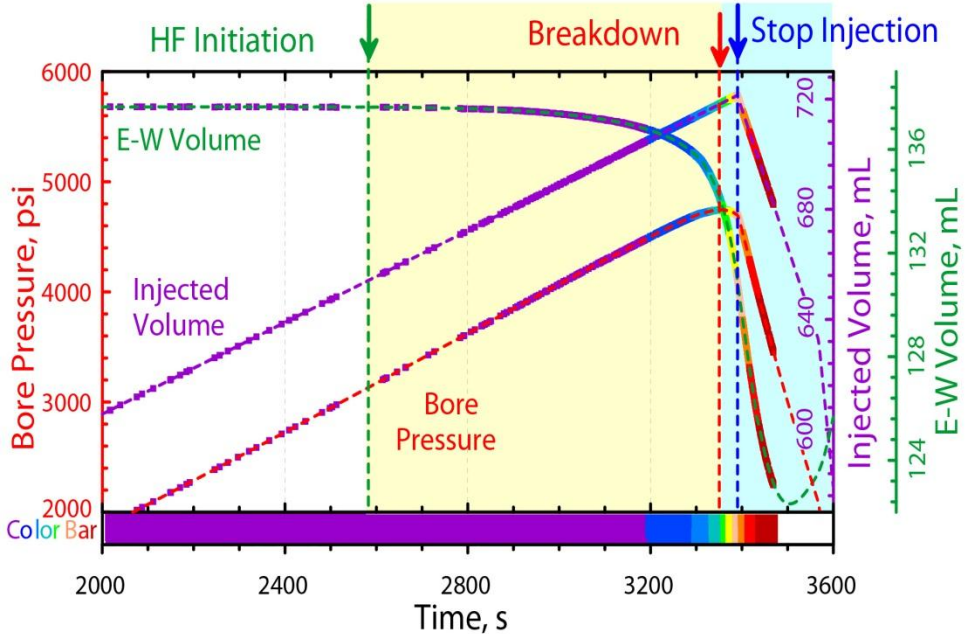
Fracturing of Homogeneous Sandstone: AE Hypocenters

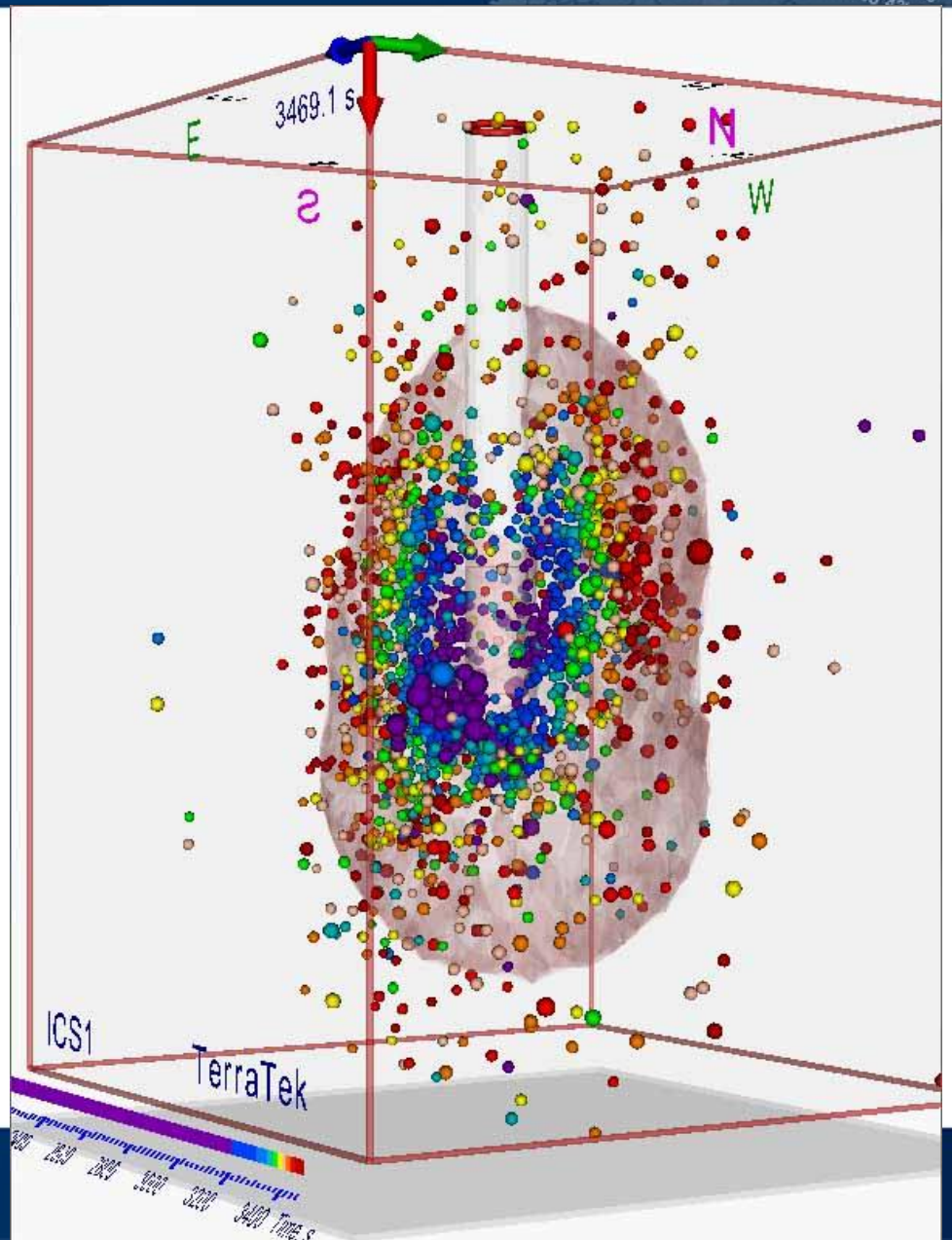


- Photo of Fractured Sample

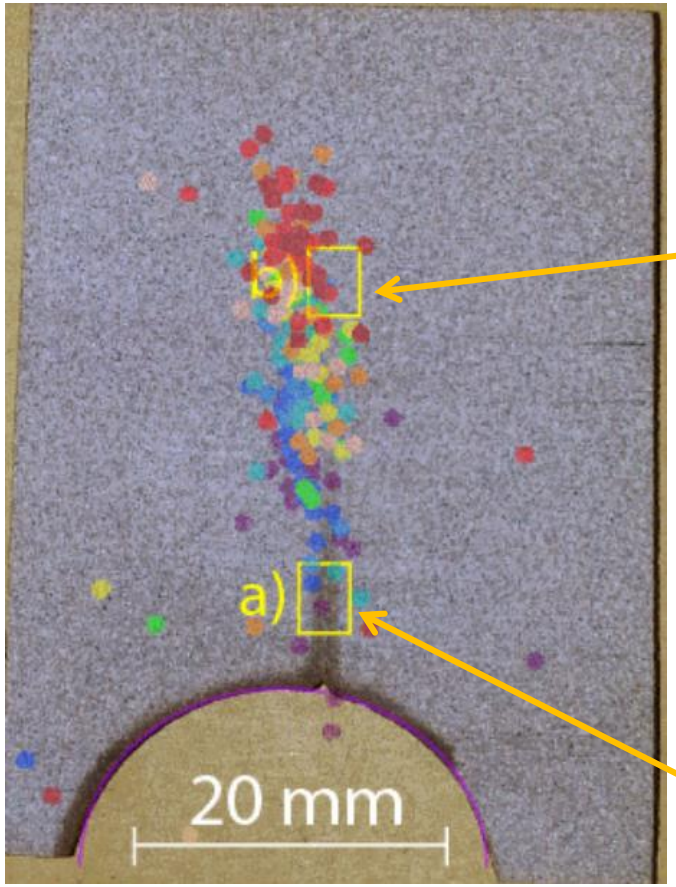
2.5 McP Fluid Viscosity

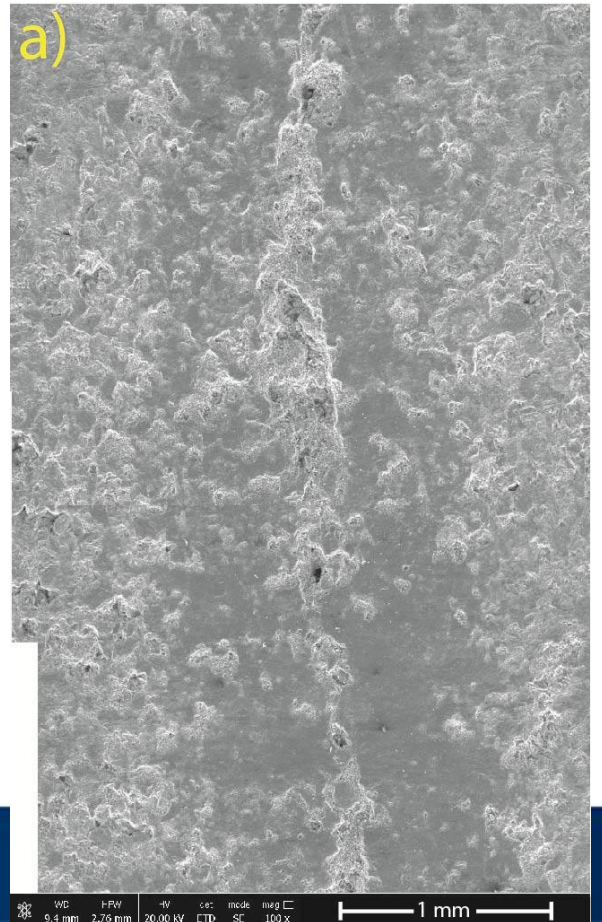
5 mL/m Injection Rate

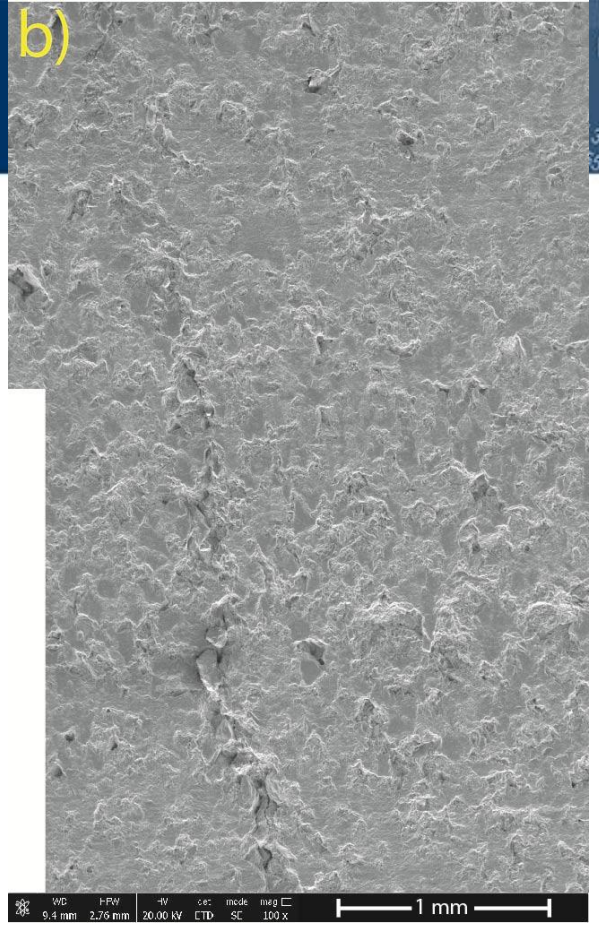




Hydraulic Fracture: SEM Images

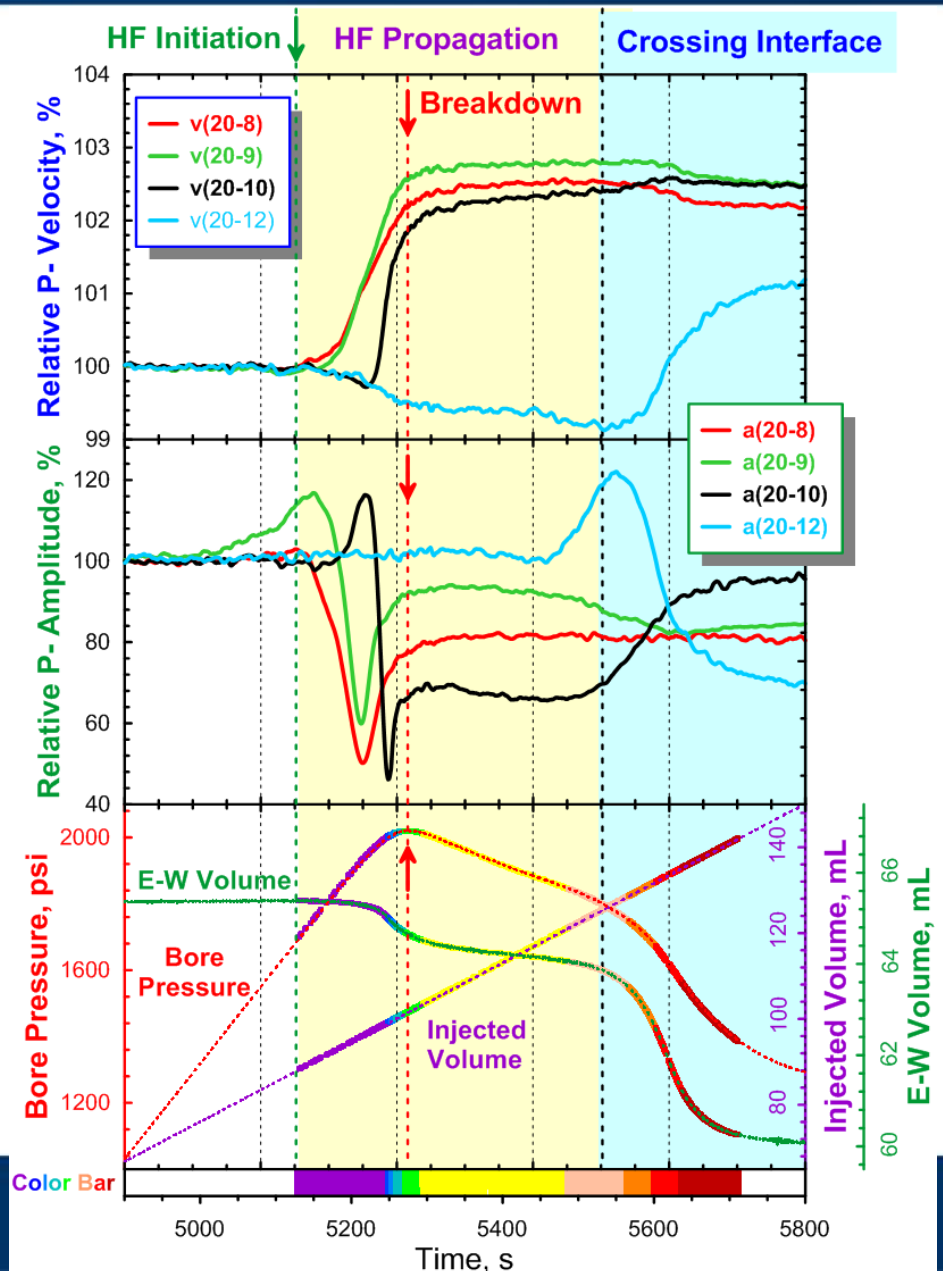


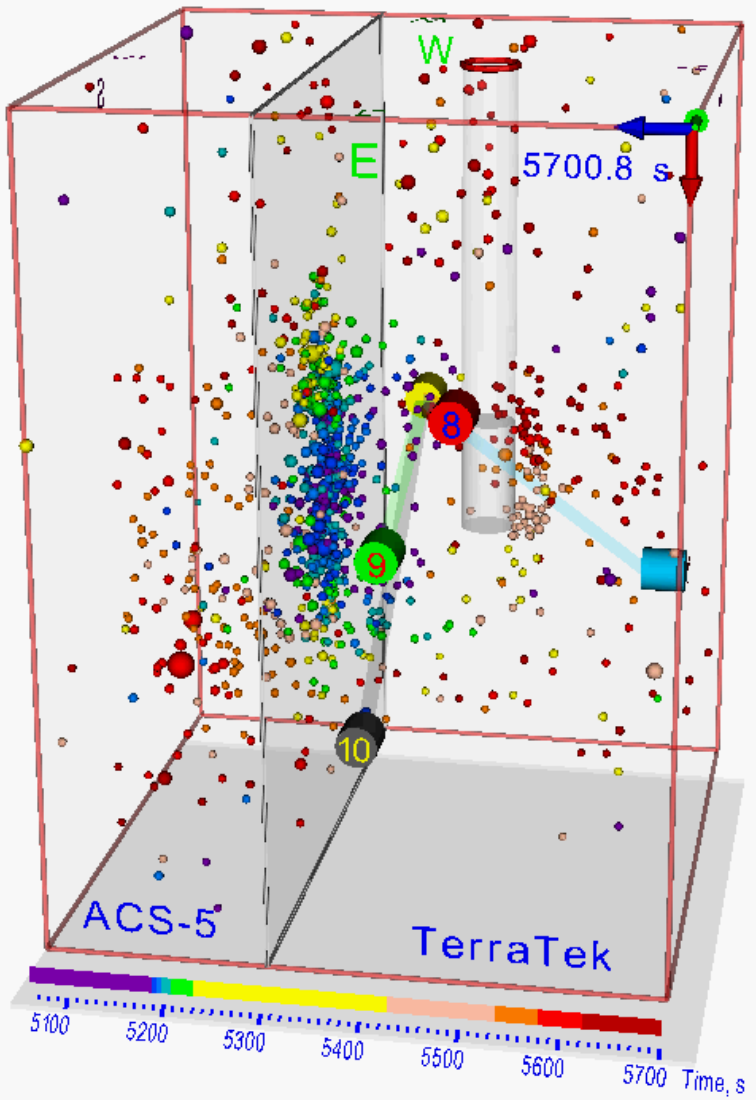




Stanchits et al (2014)
Rock Mech. Rock Eng.

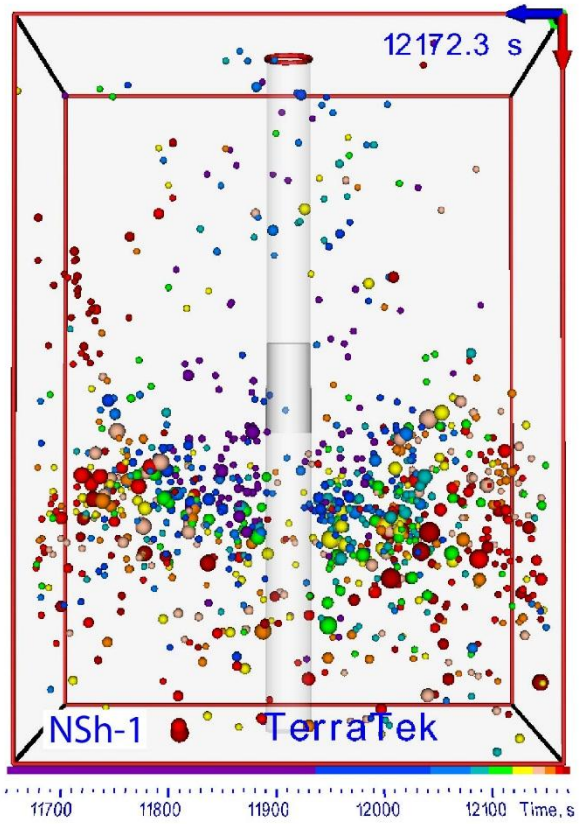
Combined Monitoring of AE and Velocities



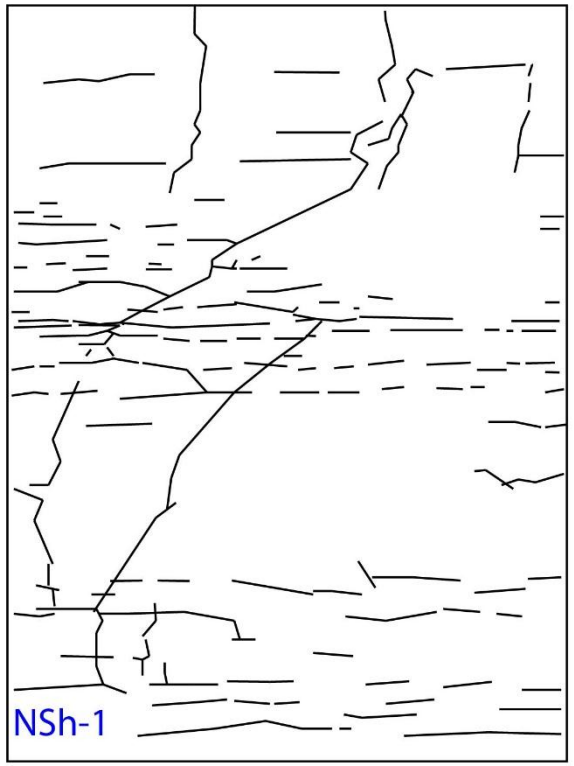


Influence of Fluid Viscosity on Hydraulic Fracturing

- **2.5 McP Fluid Viscosity, 5 mL/m**

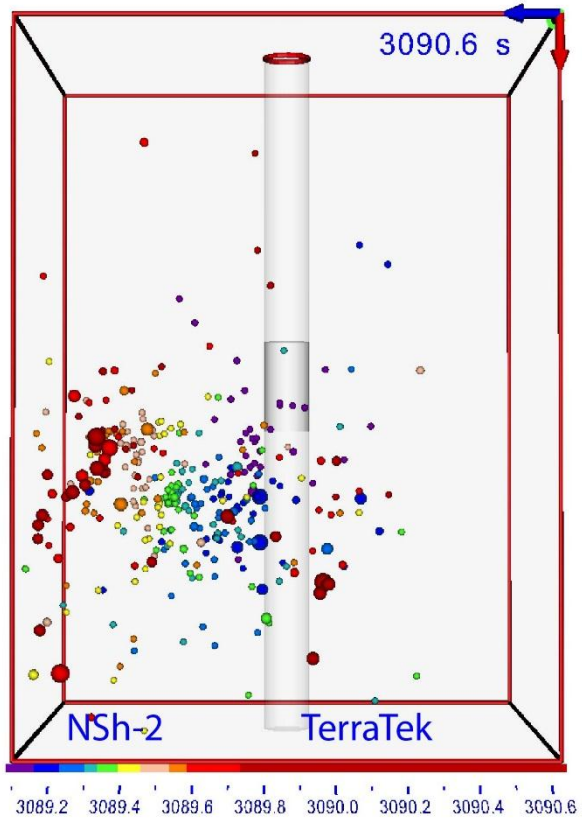


a)

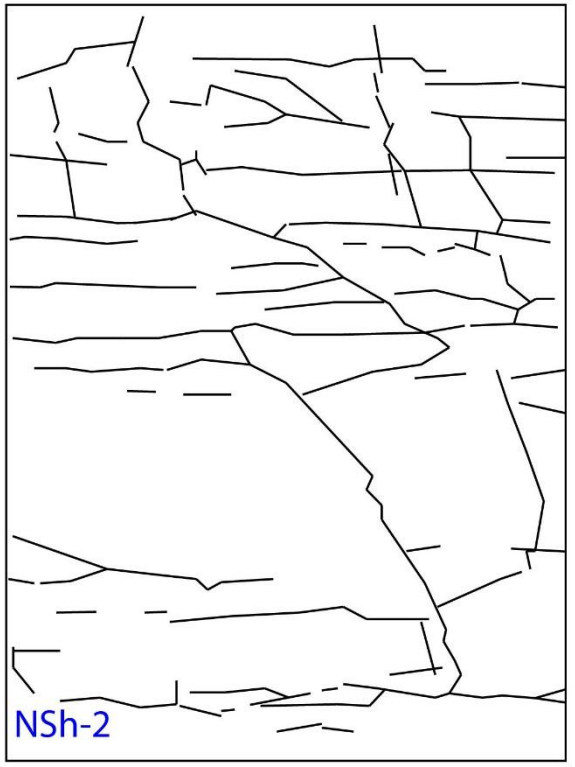


b)

- **1 cP Fluid Viscosity, 5 mL/m**



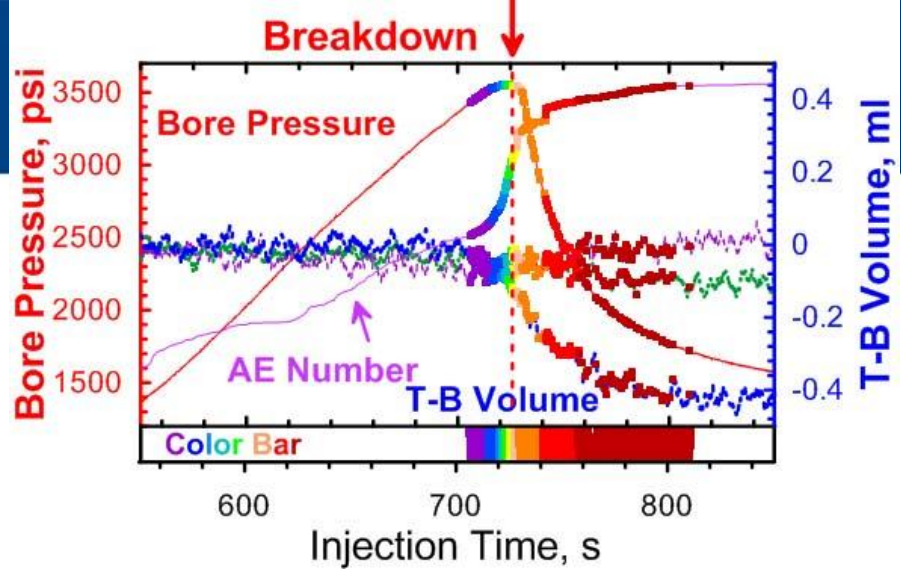
c)



d)

Stanchits et al, ARMA 14-7775

Fracturing by Epoxy Injection

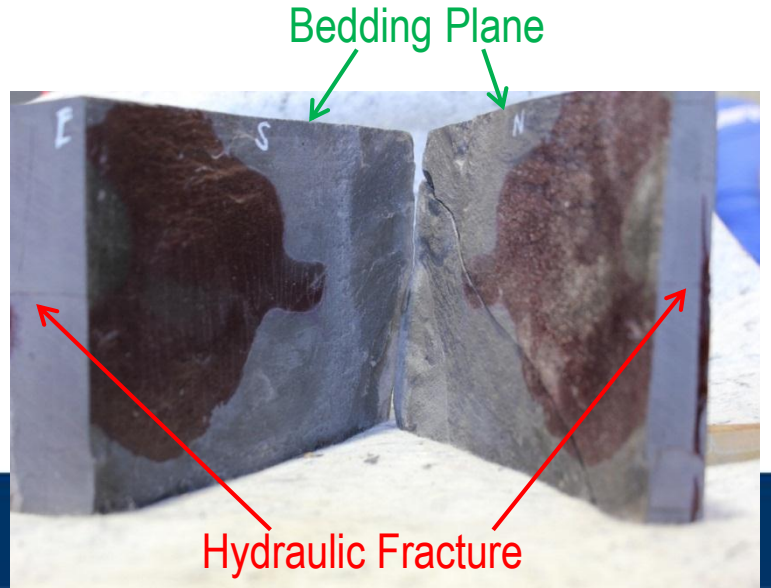


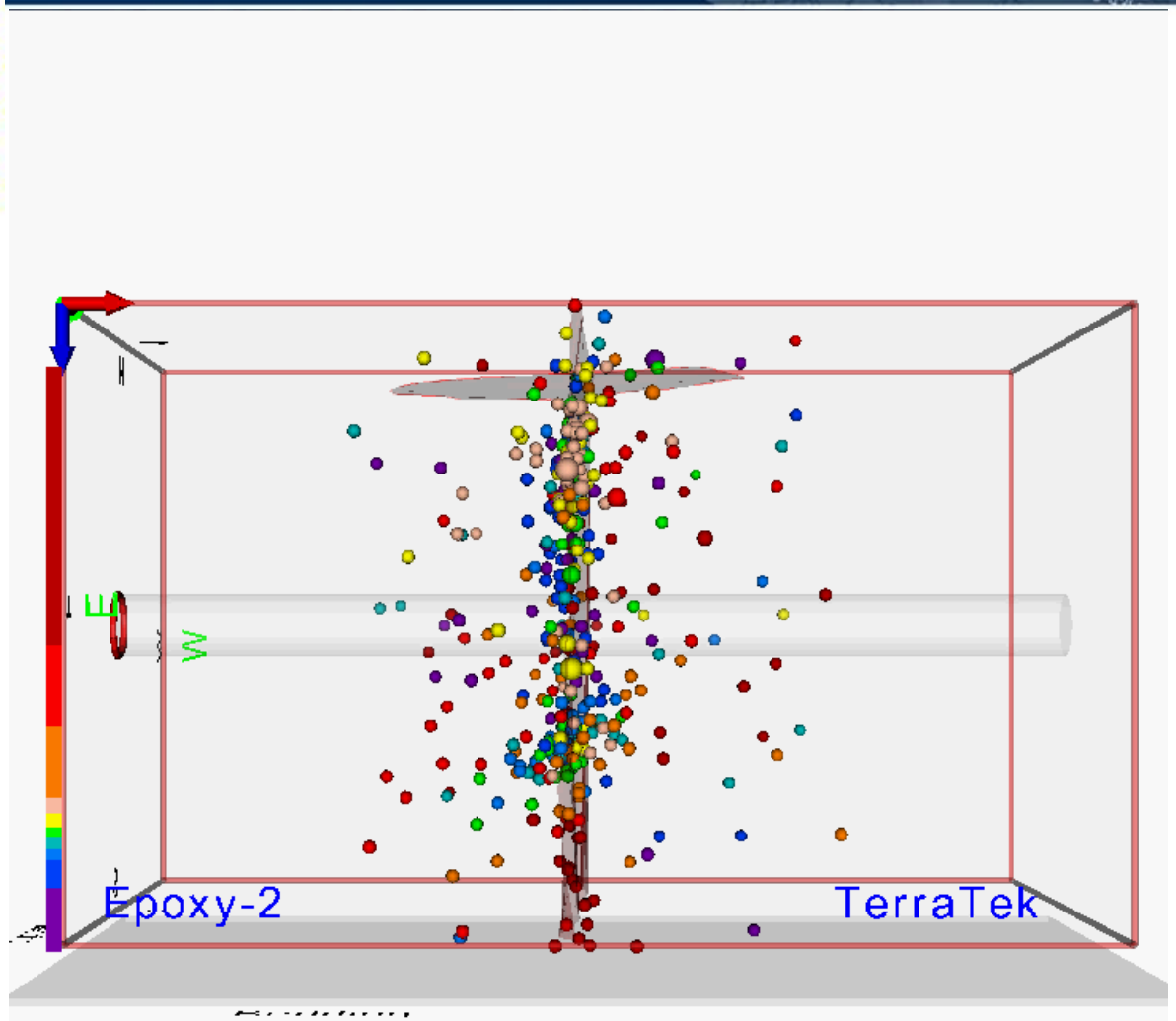
σ_h = 1700 psi

σ_H = 2500 psi

σ_V = 3500 psi

Hydraulic Fracture Crossing the Bedding Plane





Stanchits et al, AGU-2014

Conclusions

- Injection of water into dry porous sandstone induced appearance and diffusion of AE cloud, correlating with fluid migration;
- Microstructural analysis of fractured samples shows good agreement between location of AE hypocenters and faults;
- Fracture geometry in the shale depend strongly on fluid viscosity and the rock fabric;
- The presence of planes of weakness, such as mineralized natural fractures, can result in arrest of hydraulic fracture propagation;
- For successful stimulation of shale in the field conditions, the influence of rock fabric should be taken into account.

References

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- Stanchits, S., Surdi, A., Edelman, E. and Suarez-Rivera, R. (2012). Acoustic Emission and Ultrasonic Transmission Monitoring of Hydraulic Fracture Propagation in Heterogeneous Rock Samples. Proceedings of 46th U.S. Rock Mechanics / Geomechanics Symposium, ARMA-2012, Chicago, June 24-27, Chicago, IL, USA. Paper ARMA-12-257

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Thank you!

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