Fluid Effects during Hydraulic Fracture

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Problem 1:

- How does the breakdown pressure depend on fluid rate and its properties?

Problem 2:

- How does the hydraulic fracture interact with another fracture?

Hydraulic fracture with different fluids

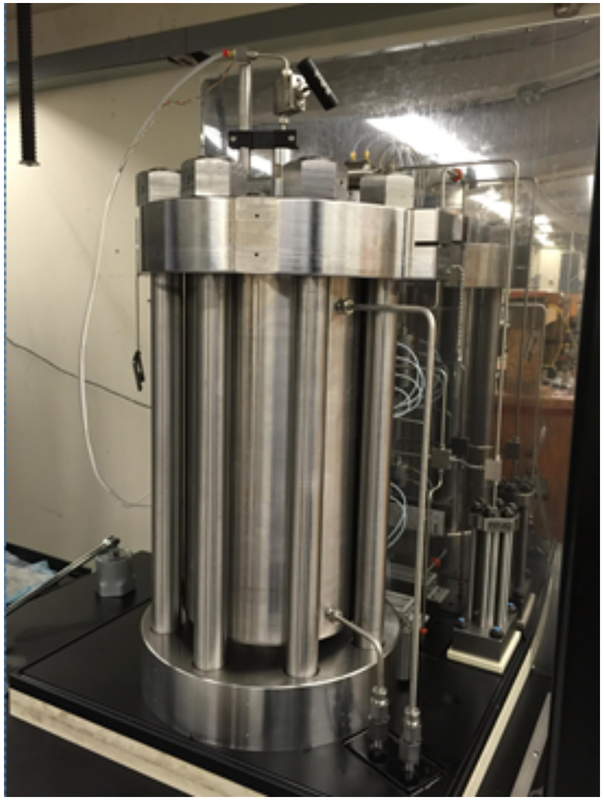
H2O | **Argon**

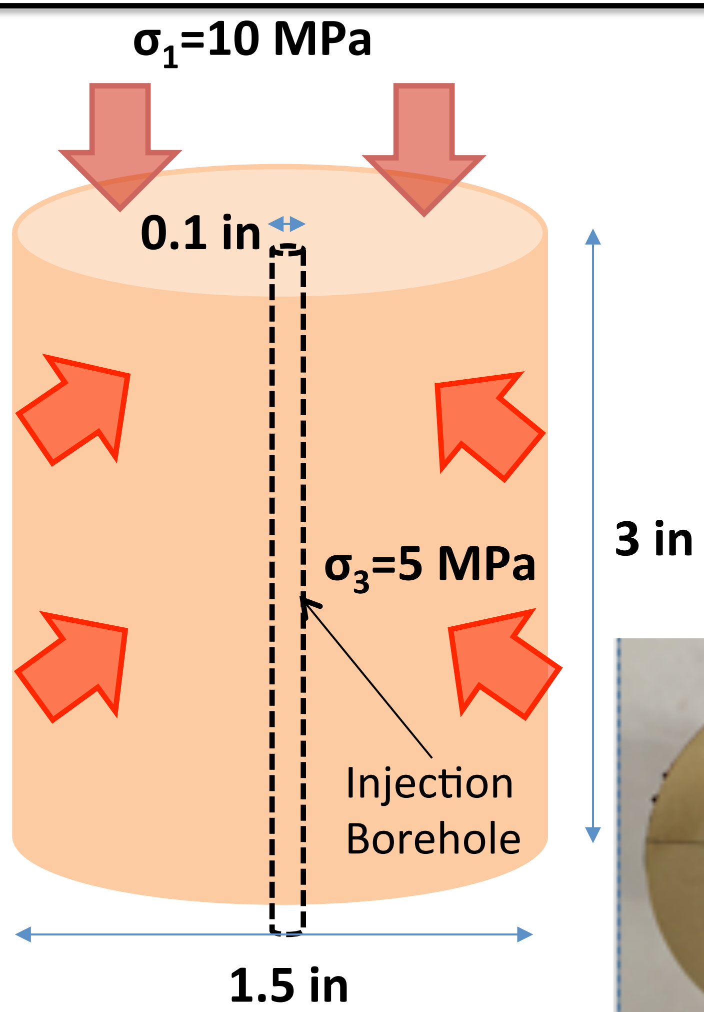
Fracture analysis

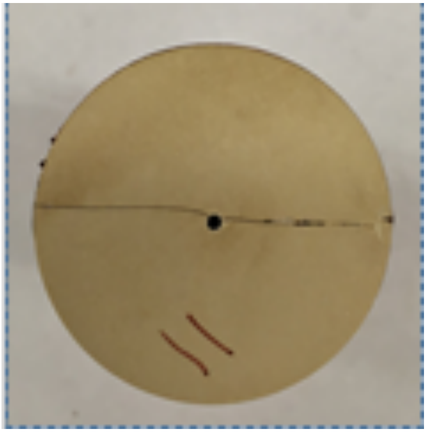
Surface profile | Fracture permeability

Problem 1:
Fluid effects

Triaxial hydraulic fracturing stress conditions



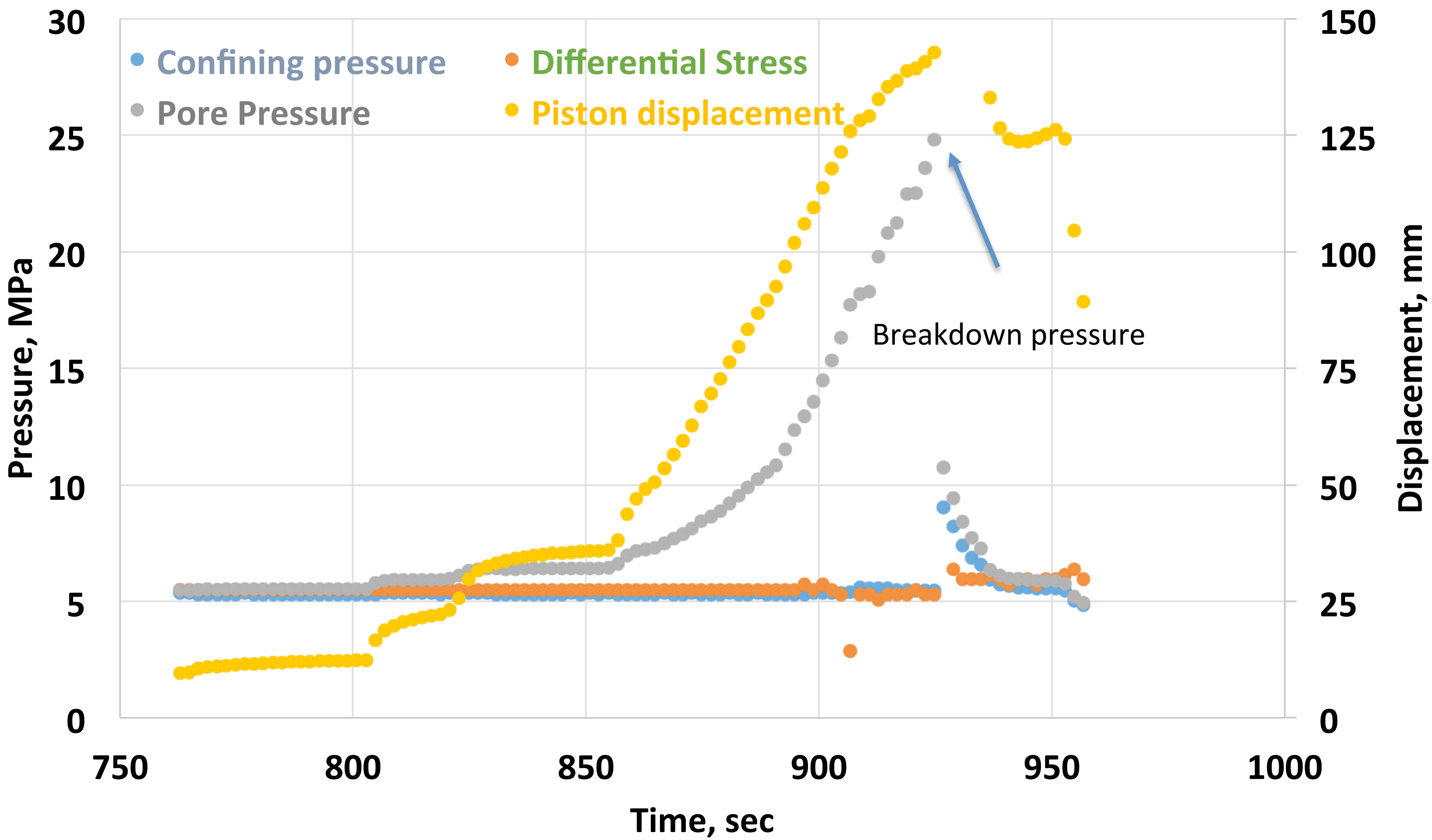




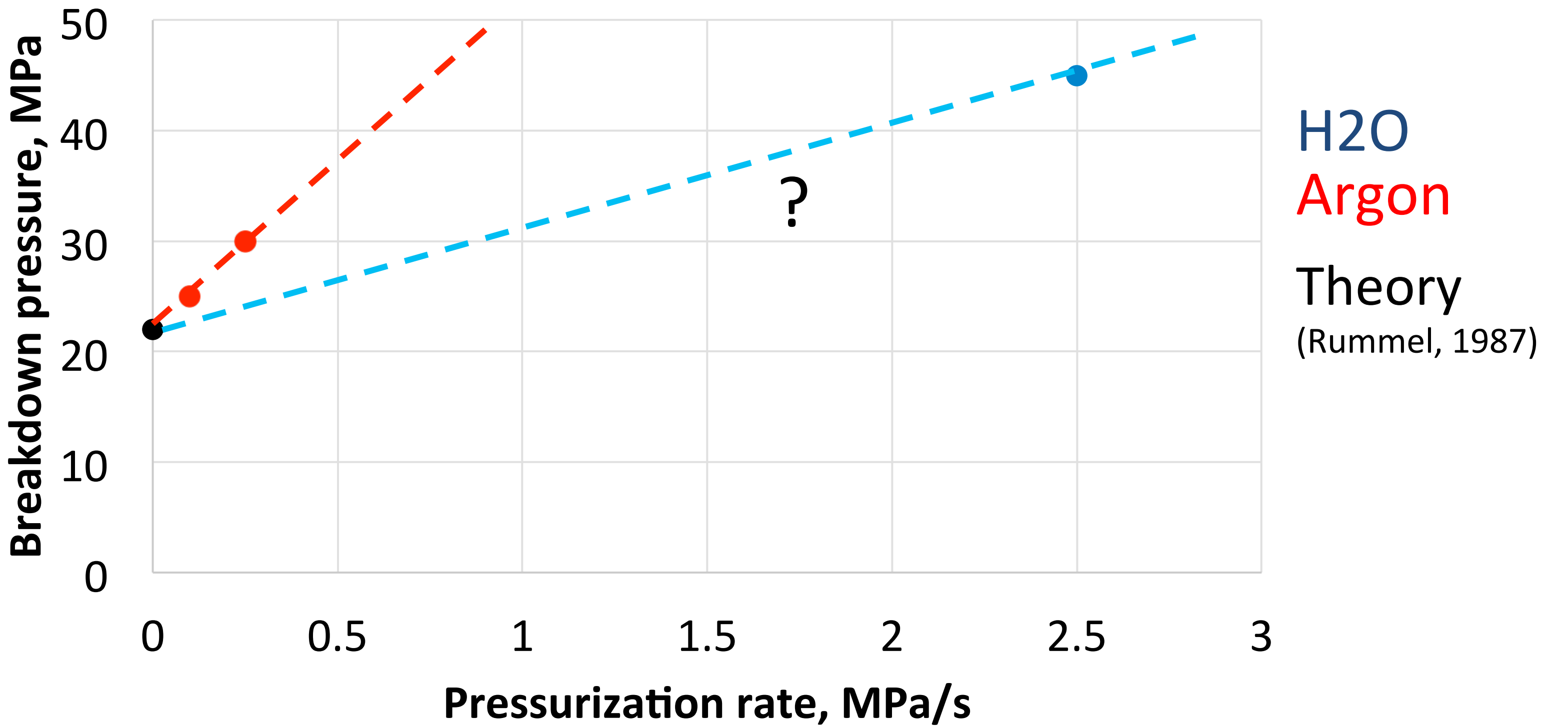
Rock and fluid properties

Rock properties: Solnhofen limestone				
Tensile strength: 10-15 Mpa	UCS: ~150 MPa	Porosity: 6%	Permeability: 20 nD	Grain size: <5 microns
Fluid properties:				
Water:	Viscosity: 1 cp	Compressibility: 5e-10 pa^{-1}		
Argon:	Viscosity: 0.02:0.03 cp	Compressibility: 2e-6:3e-8 pa^{-1} (0:30 Mpa & 21^{0}C)		

An example of experimental results

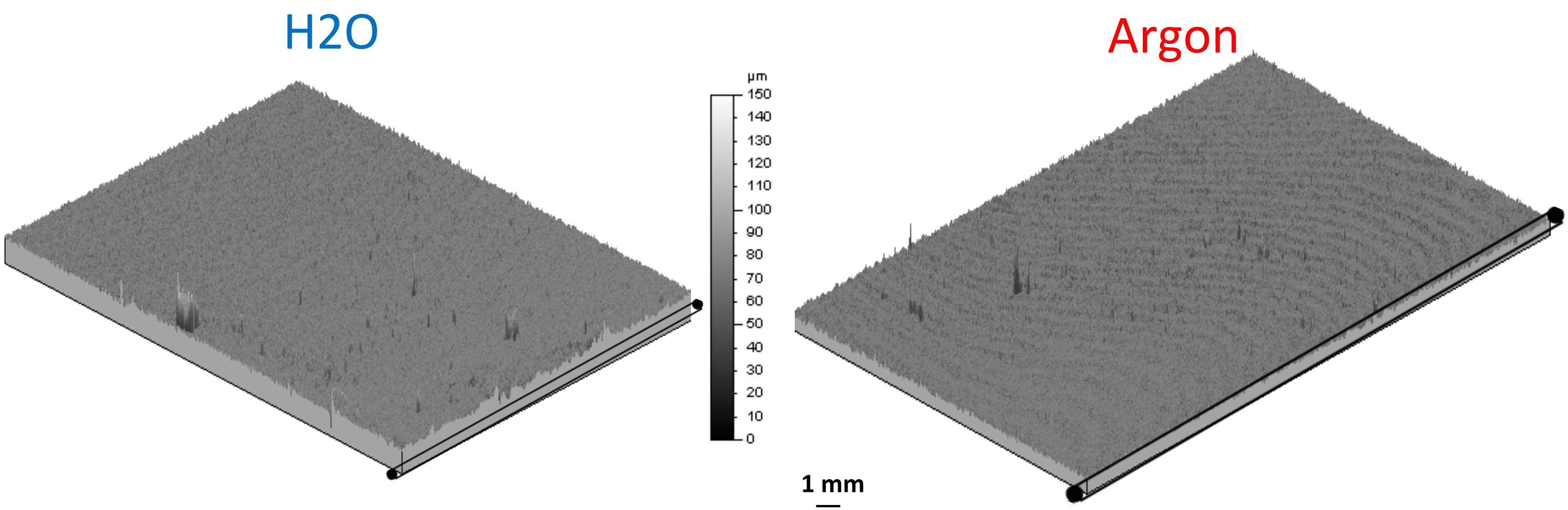


Pressurization Rate dependence



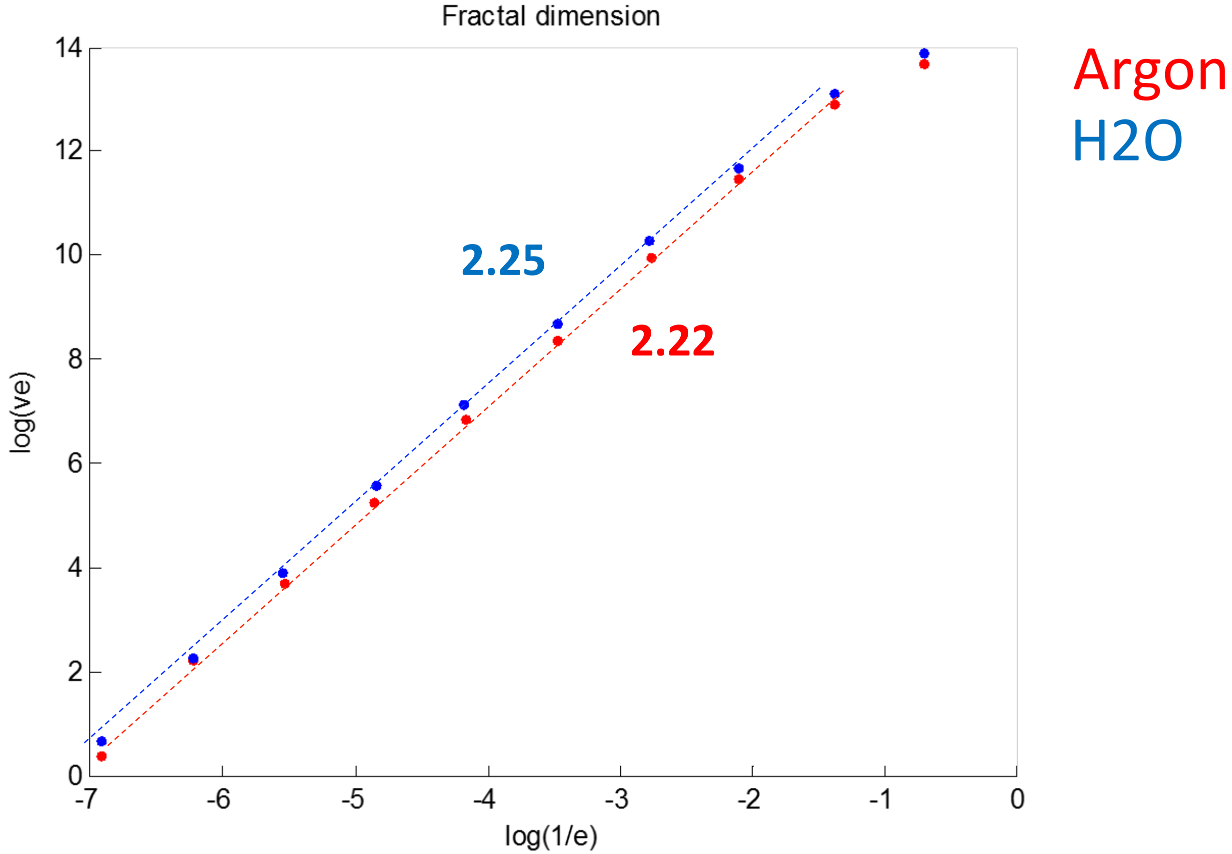
The viscosity effect would predict this the other way!

Fracture Roughness surfaces: Gaussian filter, 0.25 mm



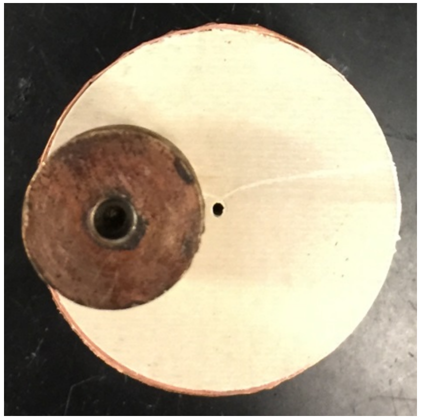
Fracture surface dimensions

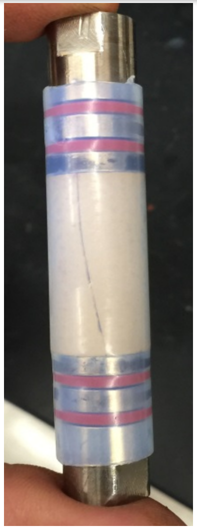
A higher fractal slope means a smoother surface



Fracture permeability

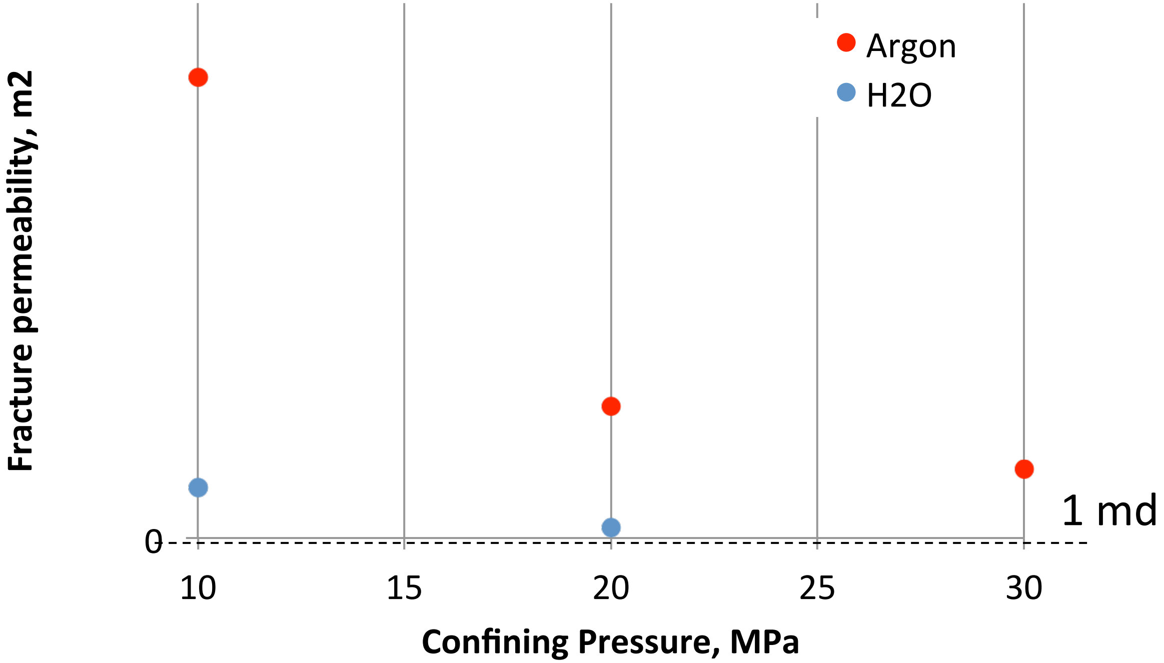
Method: Steady-state (water)





Argon permeability > H2O permeability

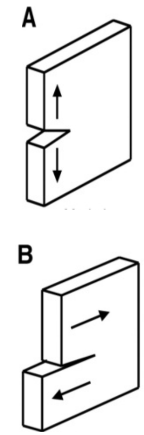
This suggests that higher damage was created during Argon fracture. This damage could be attributed to either a rougher surface or more branches.



Problem 2:
Hydraulic Fracture interactions with

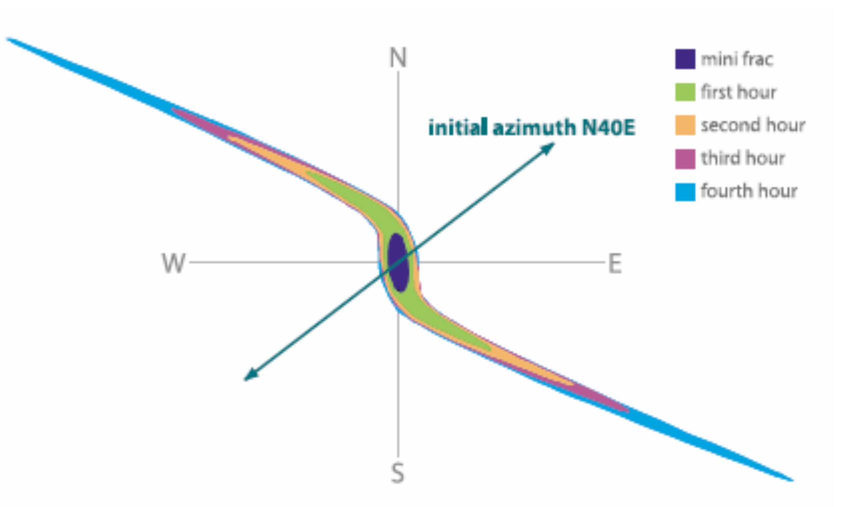
Mode I fracture

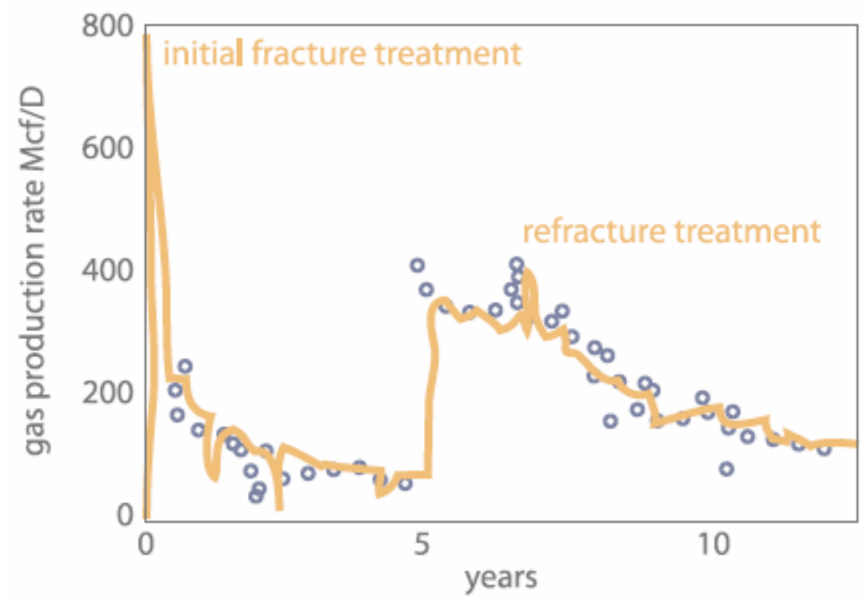
Mode II fracture



Mode II

HF interaction with a previous HF (Refrack)





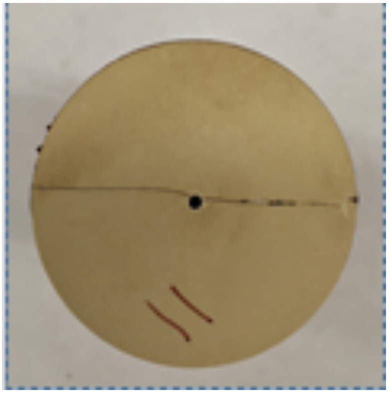
Wright and Weijers, 2001

HF interaction with a previous HF (Refrack)
Fluid: H_2O

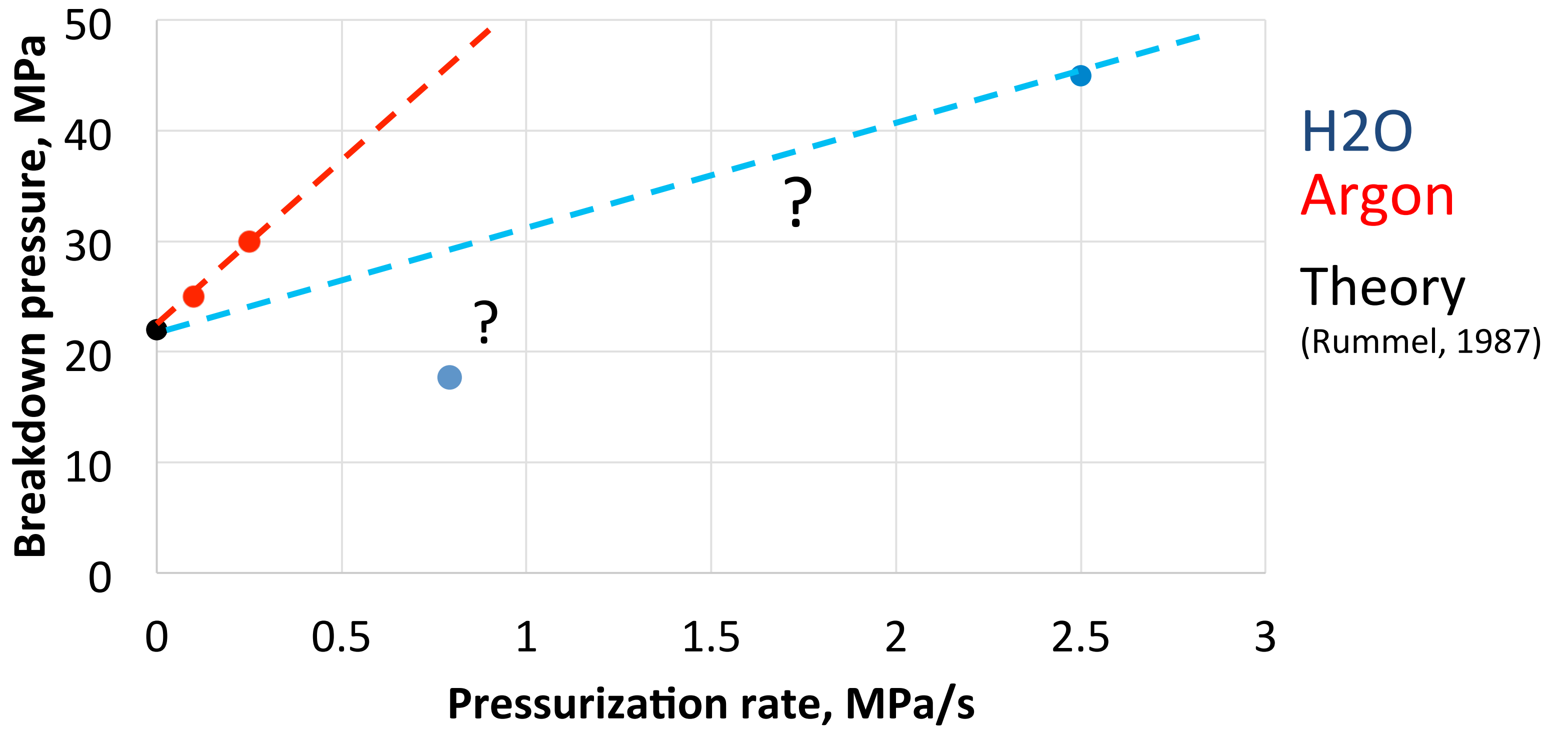
1- Pressurize the borehole

2- Seal the first hydraulic fracture

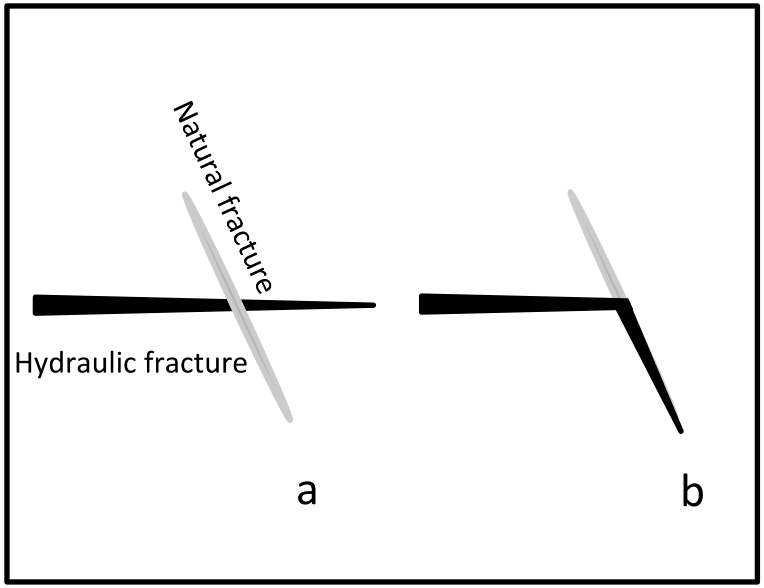
3- Pressurize the borehole

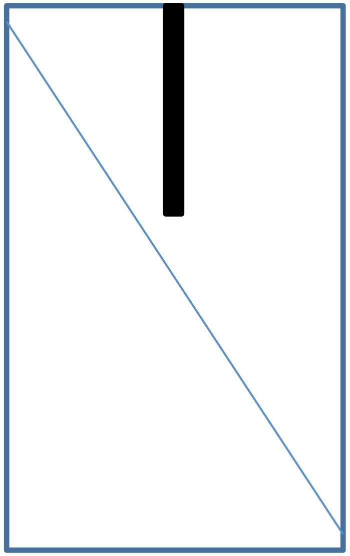


Pressurization Rate dependence

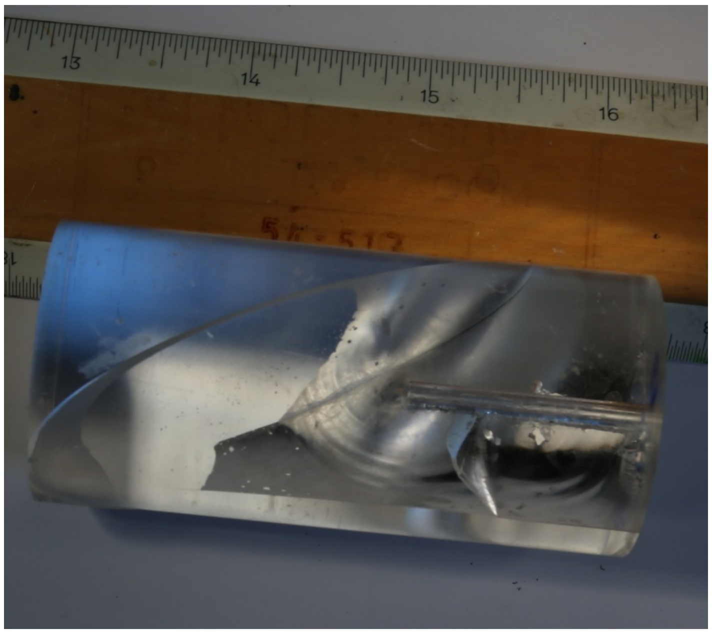


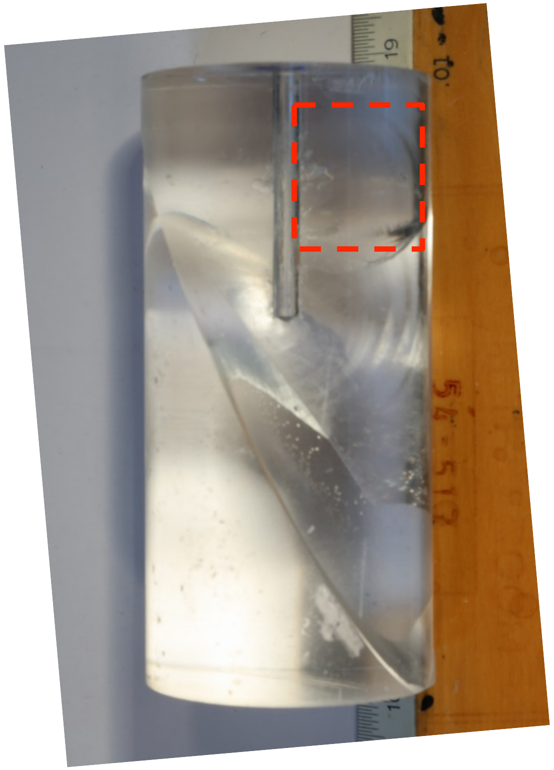
HF interaction with a fault-PMMA



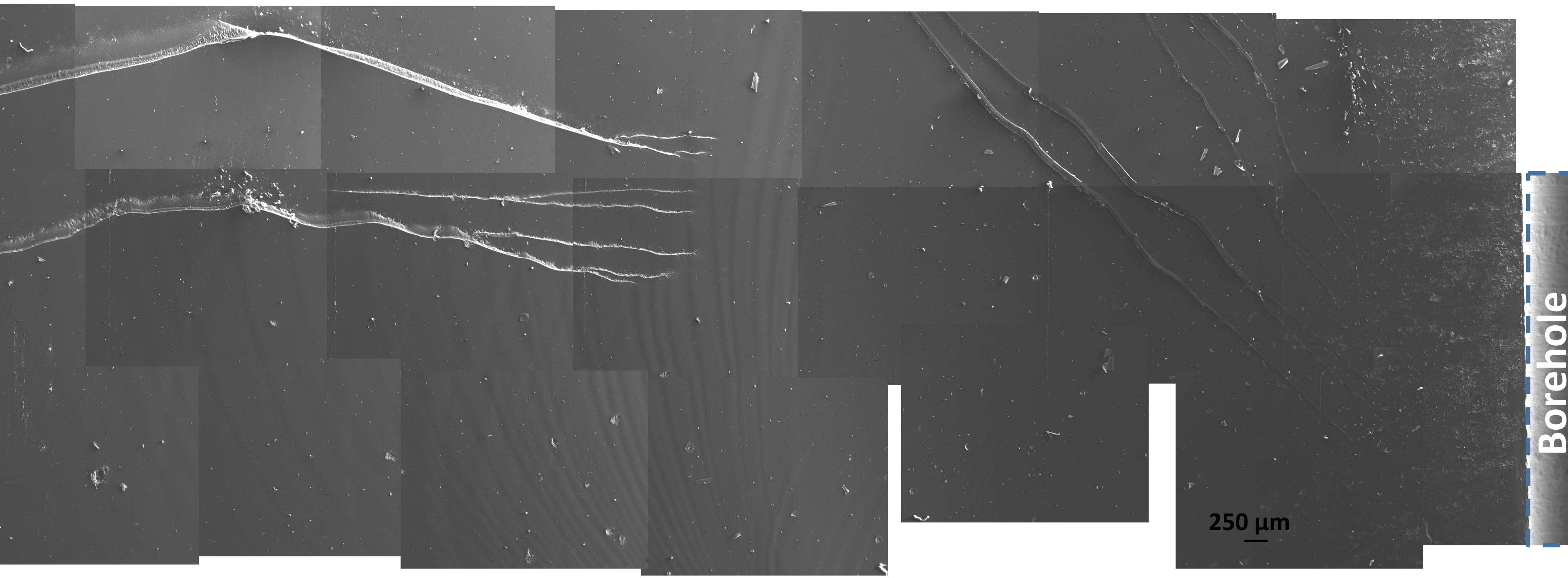


HF interaction with a fault-PMMA



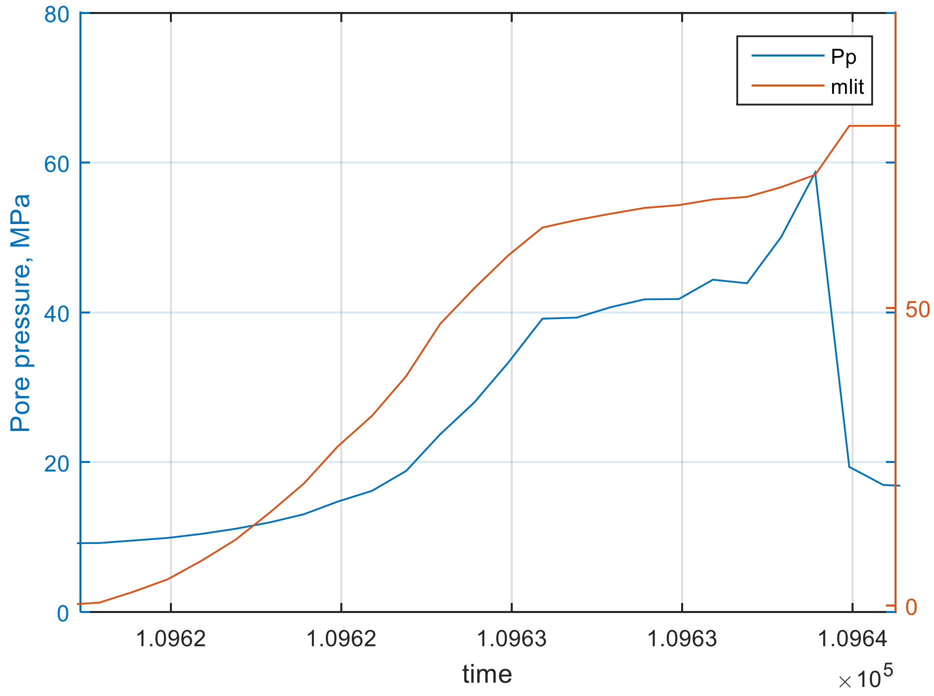


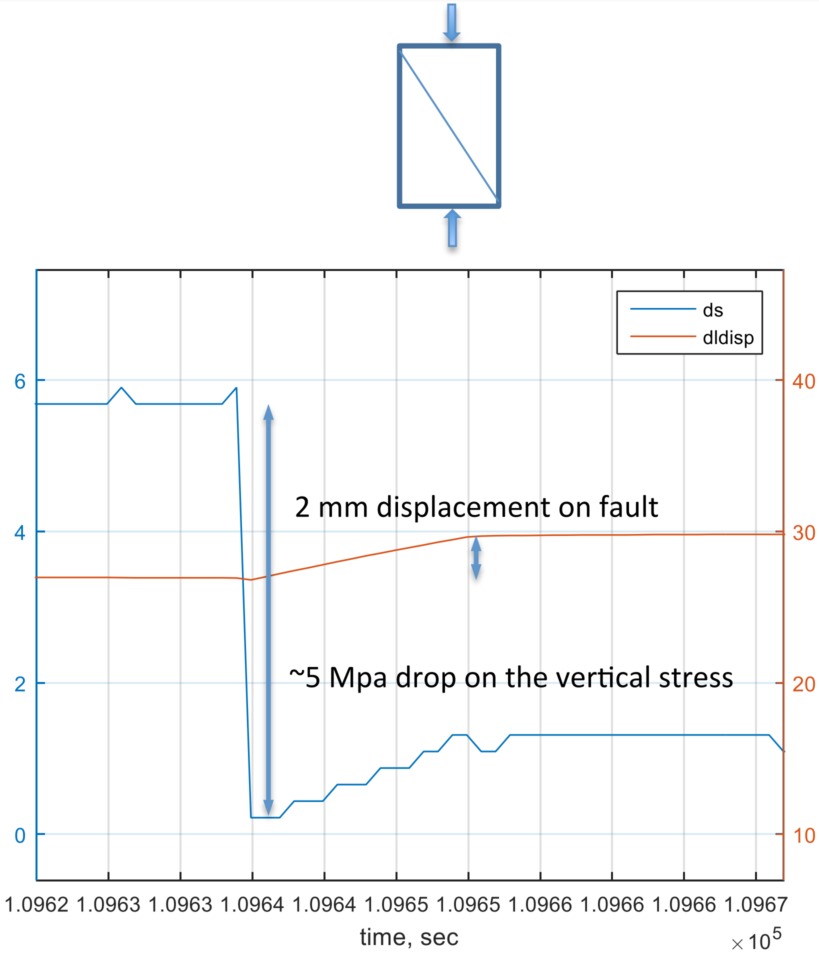
HF fracture surface in PMMA
Fluid: Argon



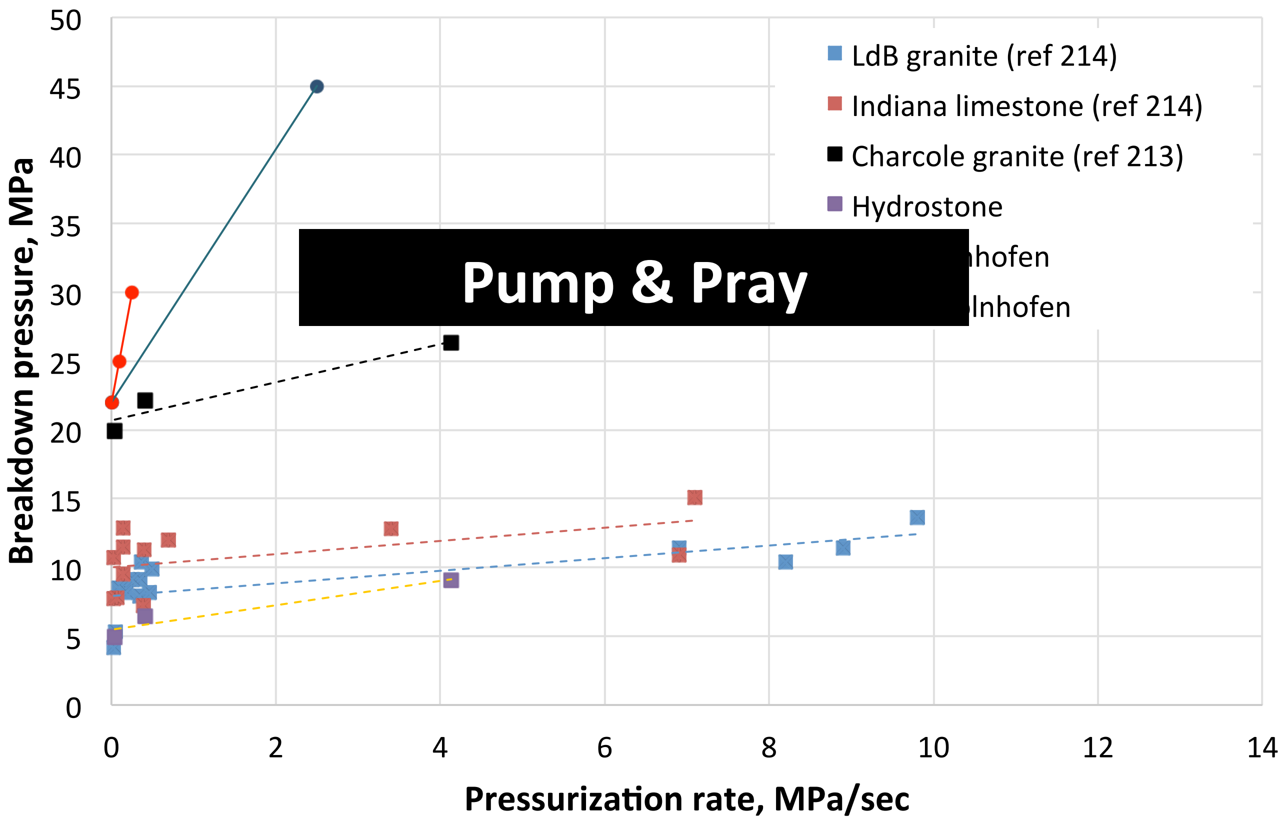
Notice the rib lines, they have similar pattern and spacing as Argon fracture !

HF fracture surface in PMMA
Fluid: Argon





Pressurization Rate dependence



Learnings

1- Breakdown pressure for Argon > H_2O. This can not be explained based on simple fluid diffusion calculations. More physics (and of course chemistry!) is involved in this phenomenon.

2- The fracture created by Argon (compressible fluid) seems to be more complex with higher damage compared with H_2O.

3- The HF interact with the previous HF and fault, both orthogonally.

Future Work

1- Design experiments to separate the fluid viscosity and compressibility effects.
2- How do fault properties affect this interaction ?