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EFFECT OF FLUID PRESSURE ON THE LEAKAGE THROUGH WELLBORE CEMENT FRACTURES

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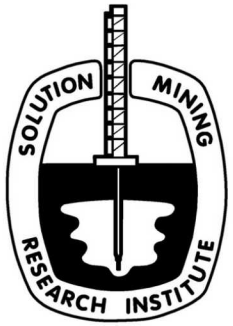
Presented by: Mahya Hatambeigi



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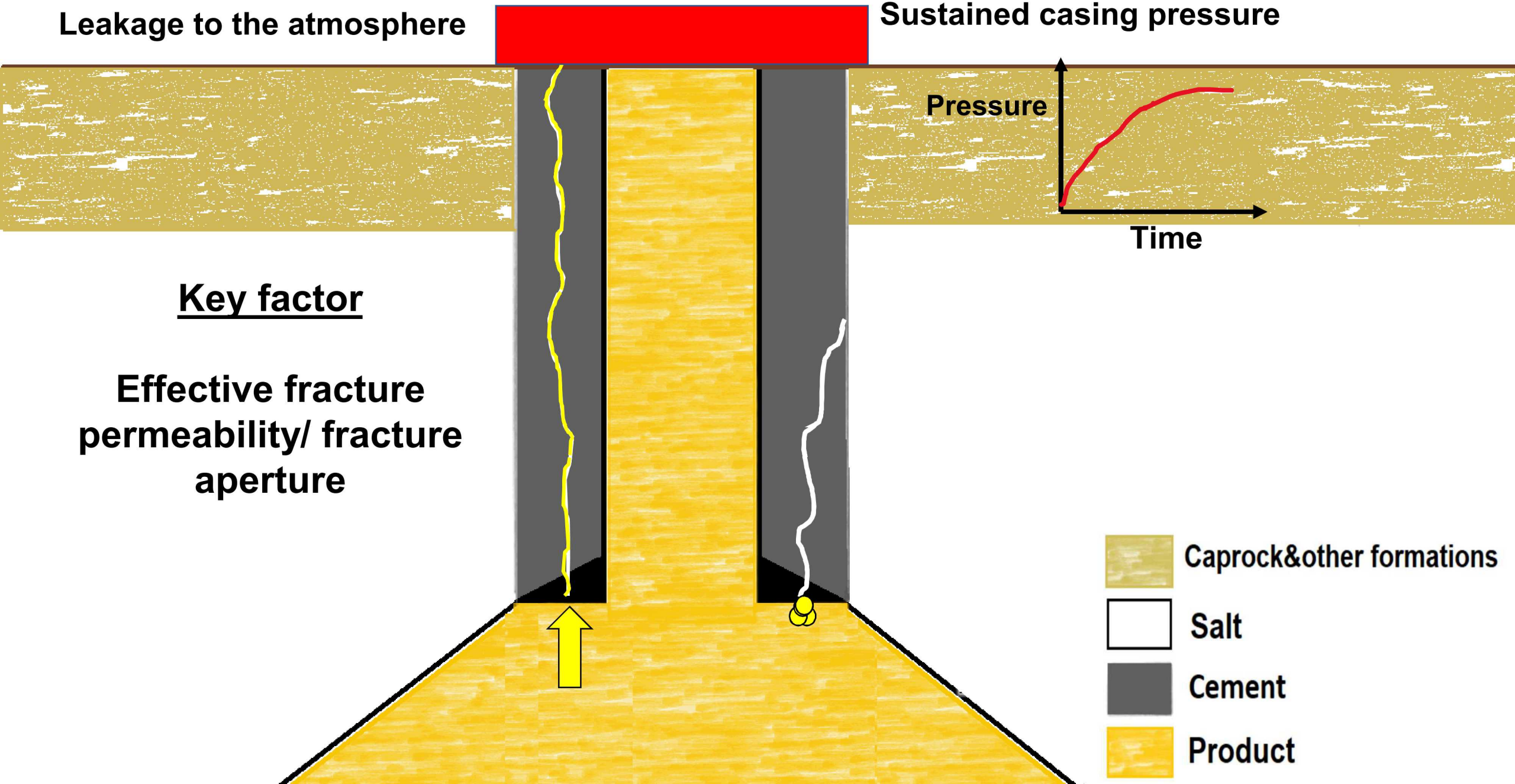
WELLHEAD OPEN
Leakage to the atmosphere

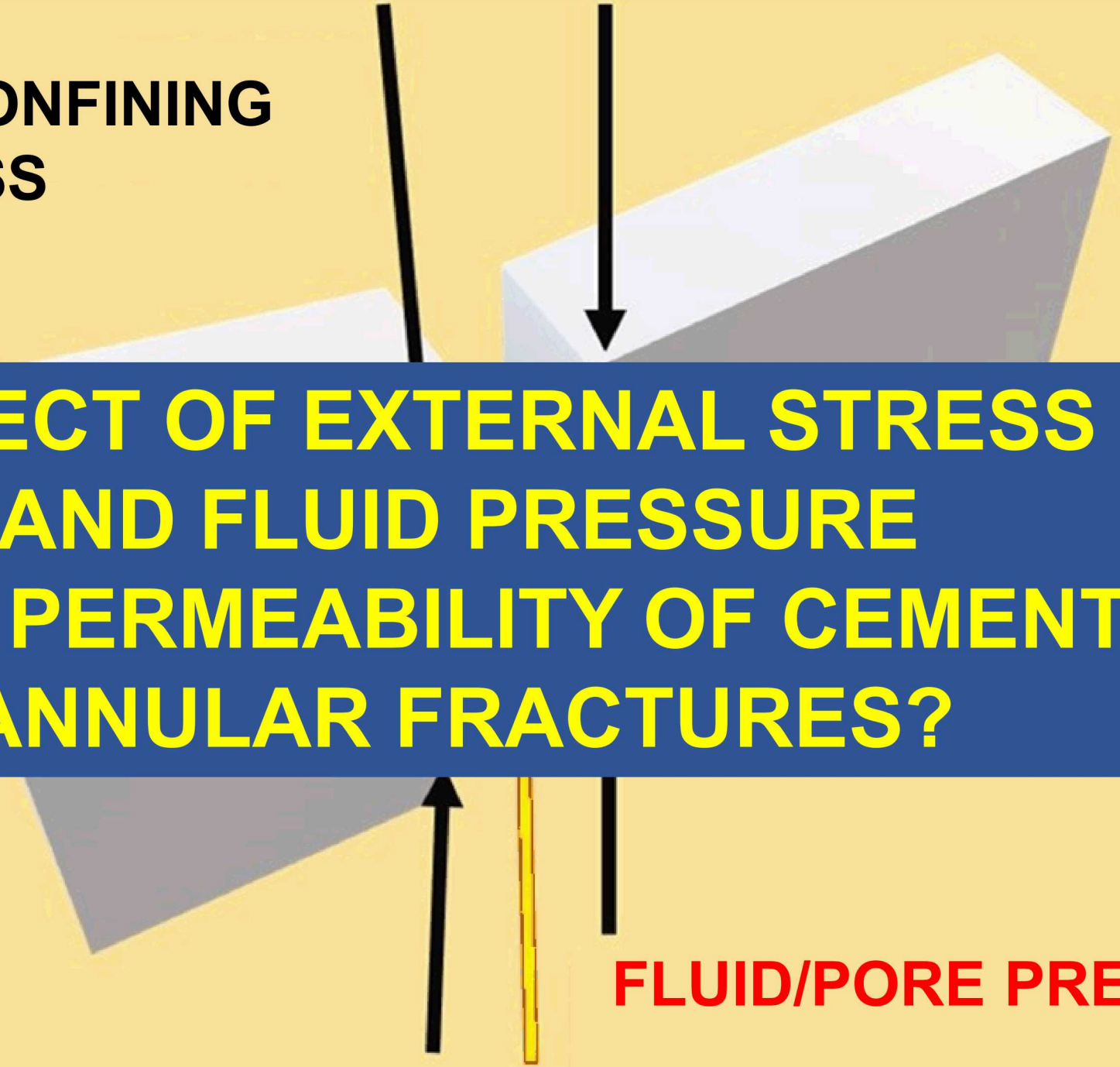
WELLHEAD CLOSED
Sustained casing pressure



Key factor

Effective fracture permeability/ fracture aperture

EXTERNAL/CONFINING STRESS

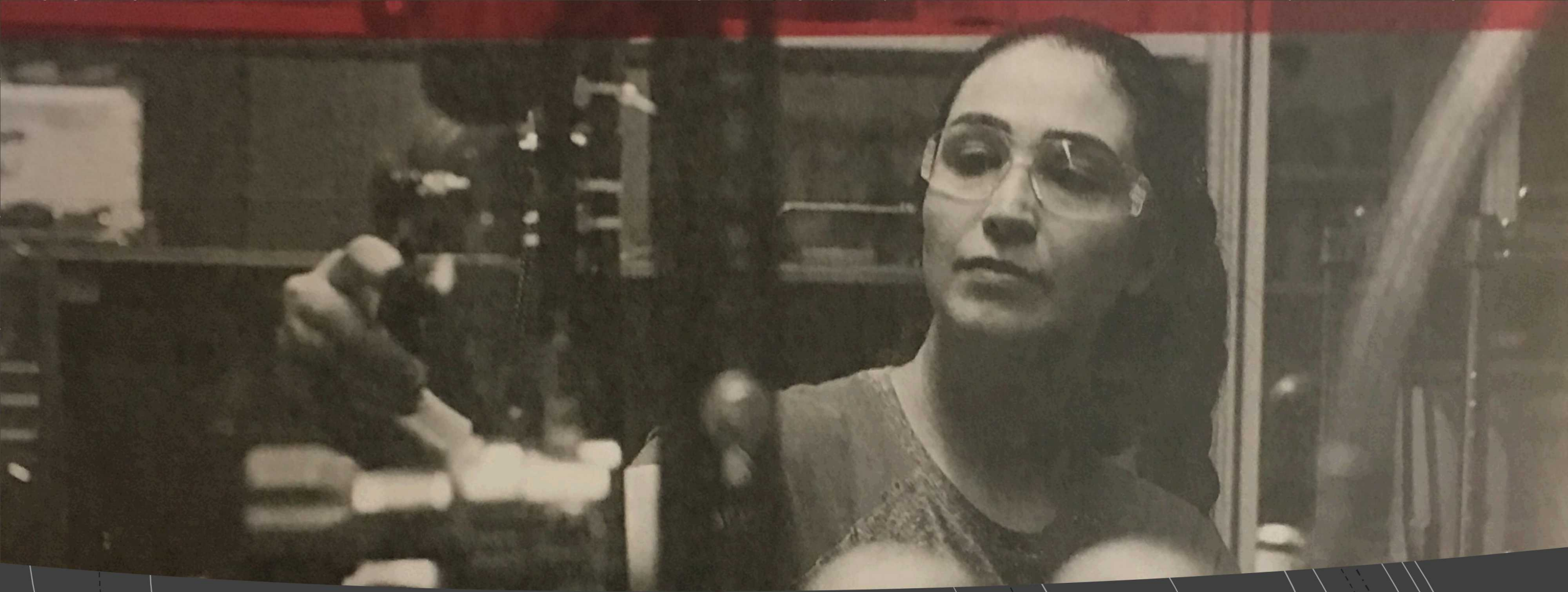


EFFECT OF EXTERNAL STRESS AND FLUID PRESSURE ON THE PERMEABILITY OF CEMENTED ANNULAR FRACTURES?

FLUID/PORE PRESSURE

- **LABORATORY EXPERIMENTS**

- **NUMERICAL SIMULATIONS**



LABORATORY EXPERIMENTS

Sample preparation

1- Cast and cure cylindrical cement samples: A and B

2- Create fracture (Brazilian tension test)

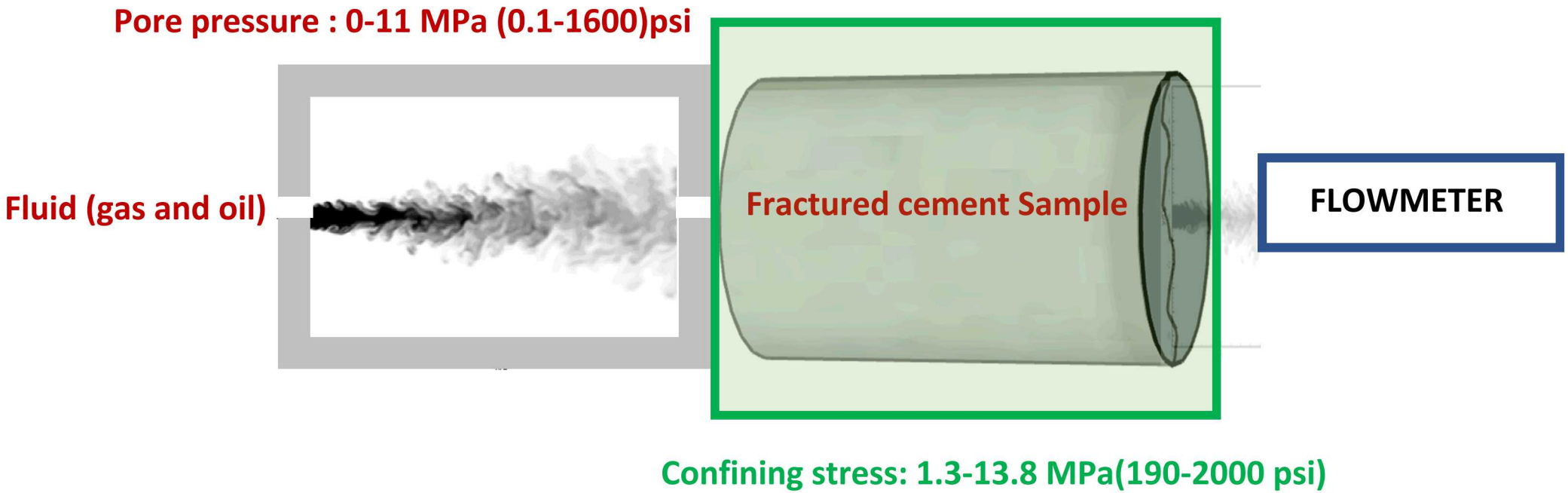
3- Create offset and cast with Epoxy

Sample top view

Sample side view

CK4
MH16

Flow tests



Pressure & Flowrate ⟶ Fracture permeability

Slide 7

CK4 Does that image of the jet need to be attributed to its owner/creater?
Chojnicki, Kirsten, 8/21/2020

MH16 It is created by us
Mahya Hatambeigi, 8/24/2020

Permeability measurements

$$-\nabla P = aQ + bQ^2$$ Forchheimer (1901)

$$a = \frac{\mu}{A_f k_f}$$ Viscous term

$$b = \frac{\beta \rho}{{A_f}^2}$$ Inertial term

∇P: Pressure gradient

Q: Flowrate

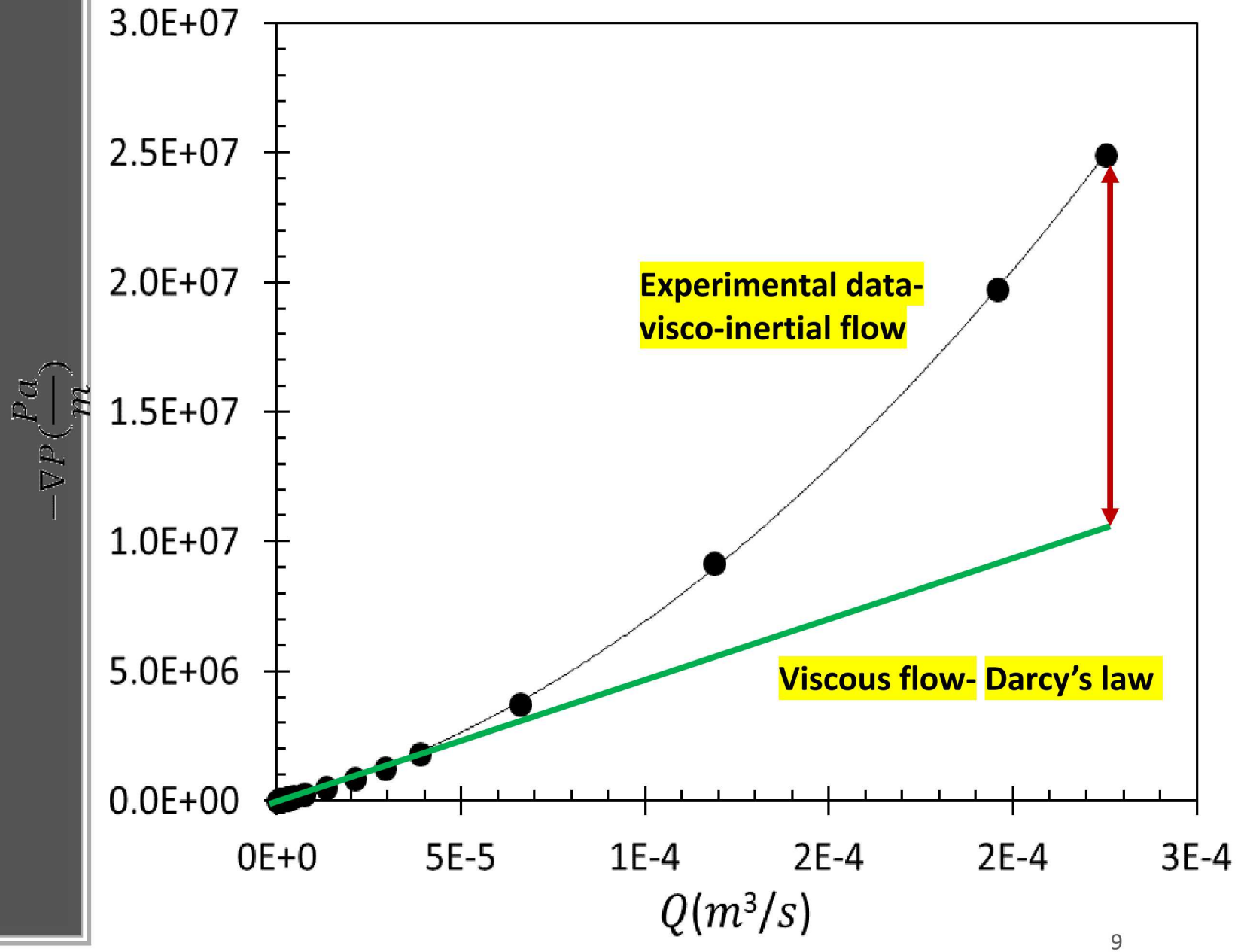
k_f: Fracture permeability

A_f : Cross-sectional area of the fracture

μ: Dynamic viscosity of the fluid

β: Non-Darcy coefficient

Viscous and Visco-inertial flow



Hydraulic aperture

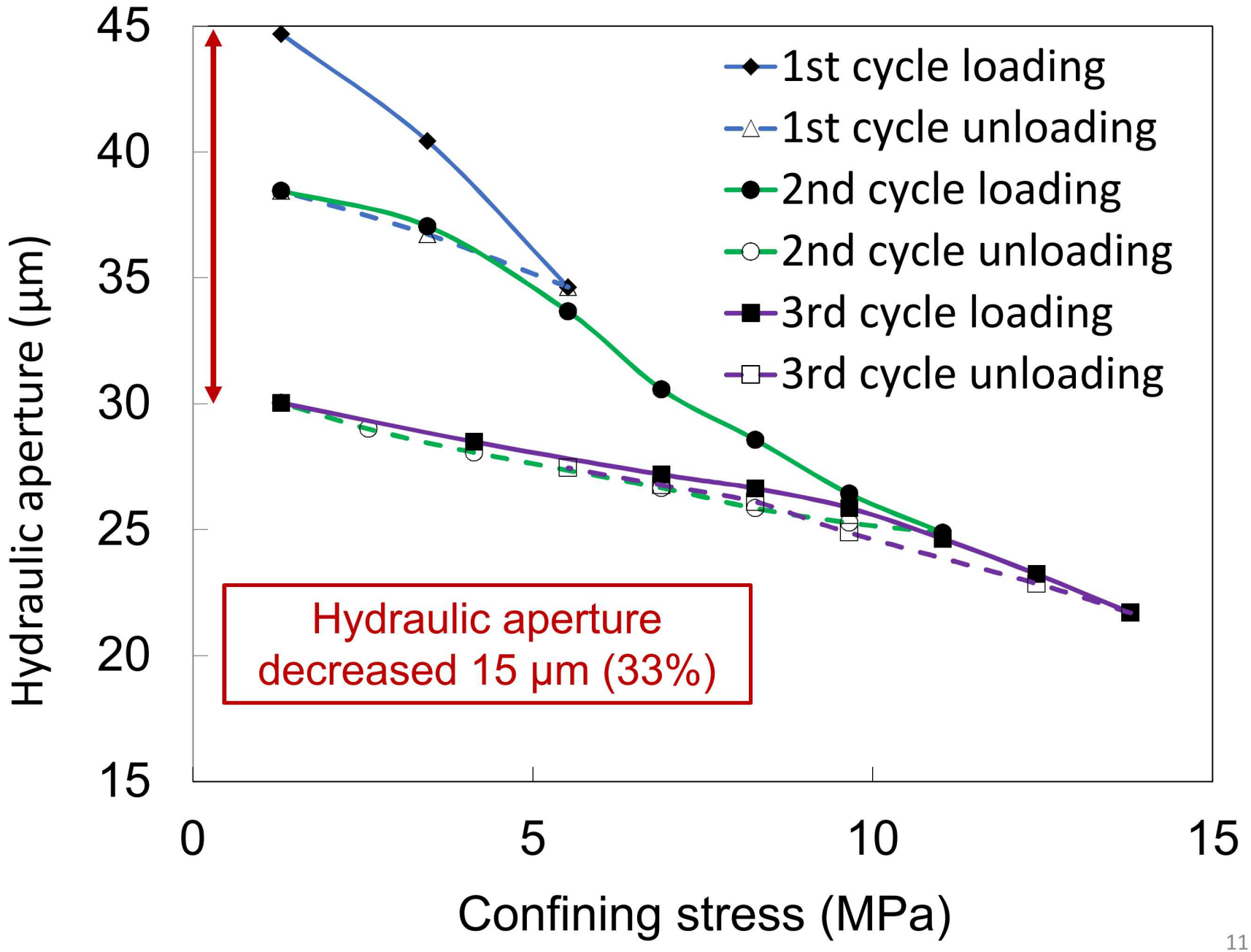
$$h^3 = \frac{12kA}{w}$$

Cubic law (Witherspoon et al., 1980)

h: Hydraulic aperture

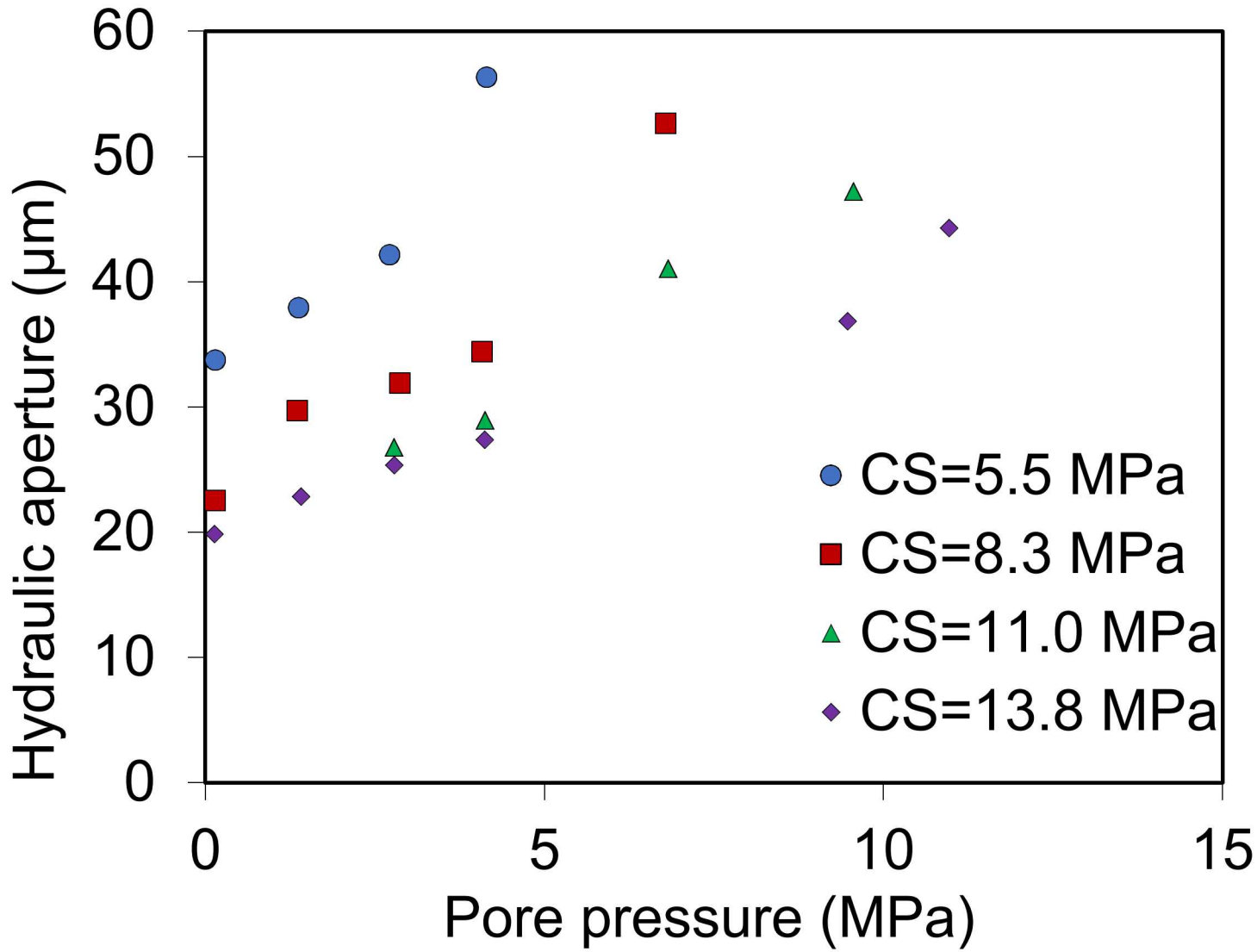
w: width of the fracture

1- Effect of confining stress cycles (Sample A)



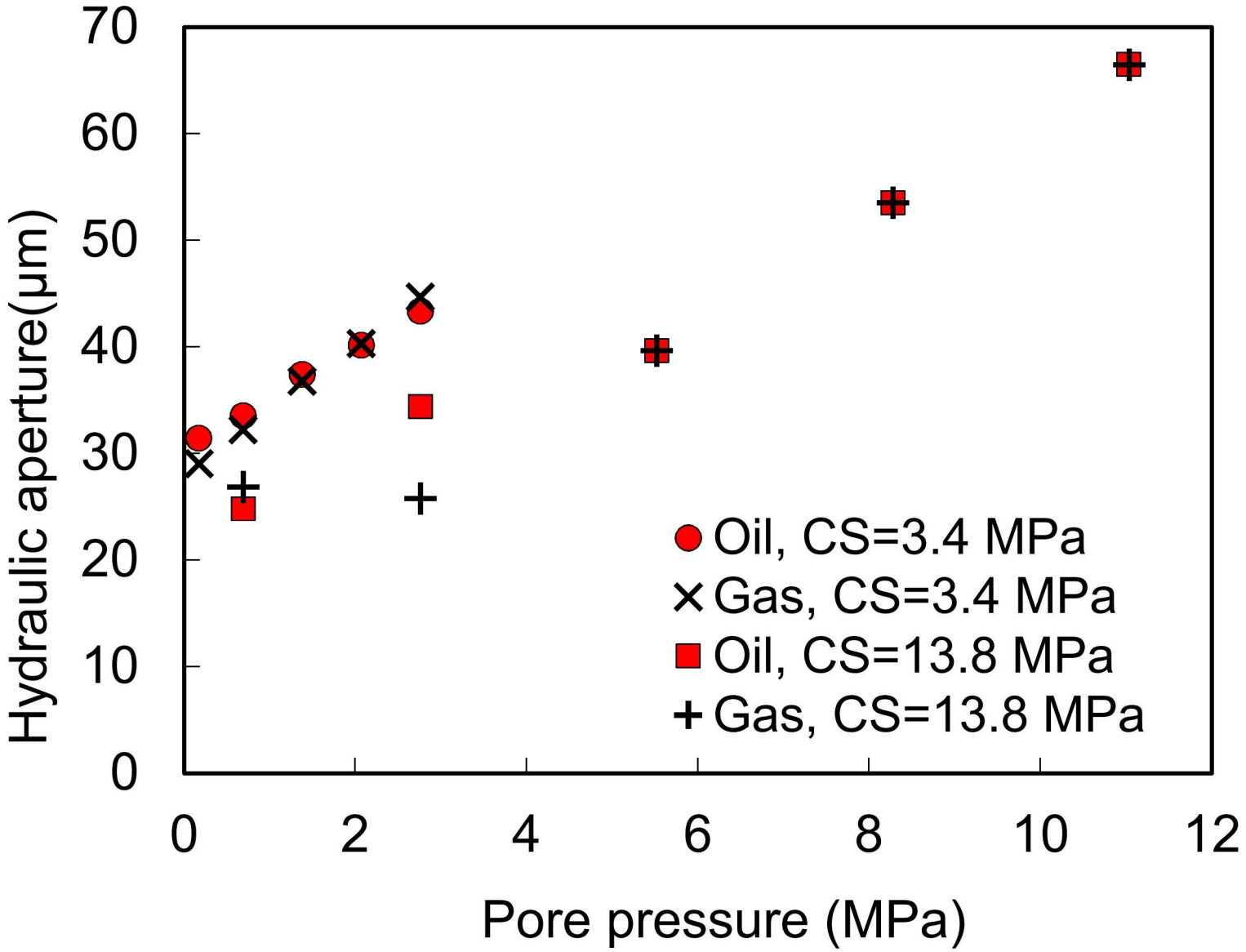
2- Effect of pore (gas) pressure on hydraulic aperture of Sample A

Fracture props open with pore pressure at all confining stresses



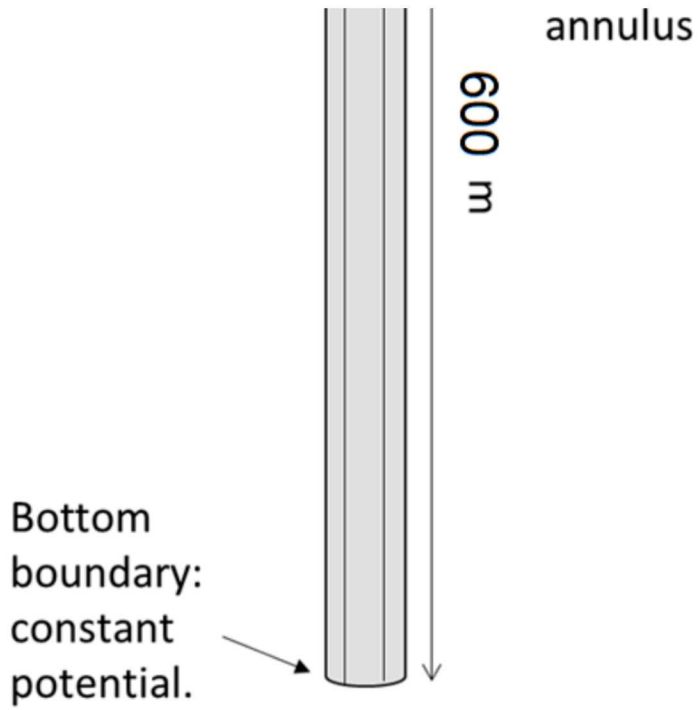
3- Effect of pore (gas and oil) pressure on hydraulic aperture of Sample B

Fracture props open with pore pressure applied from both gas and oil



NUMERICAL SIMULATIONS

CK1
MH14



MODEL GEOMETRY

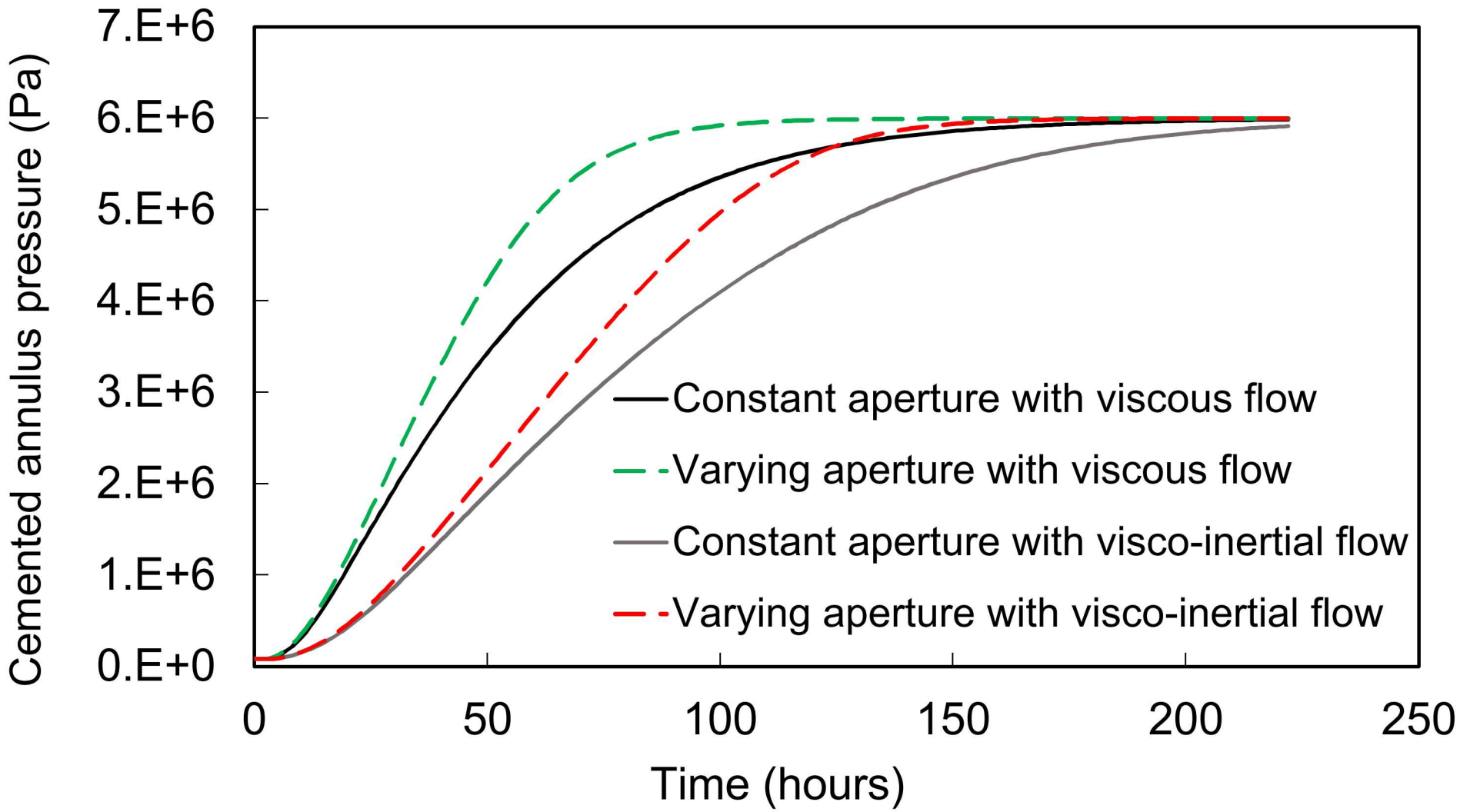
Hatambeigi et al., 2020

Slide 15

CK1 what is the orange box on this slide?
Chojnicki, Kirsten, 8/21/2020

MH14 It was part of the slide design. I removed it to avoid confusion
Mahya Hatambeigi, 8/24/2020

Pressure build-up at surface in the cemented annulus



CK2
MH17

Conclusions

- Elevated fluid pressure props wellbore cement fractures open
- Hydraulic aperture decreases when increasing the confining stress.
- Visco-inertial flow significantly slows the rate of pressure buildup.
- Pore pressure in the fracture accelerates the pressure buildup.
- Field measurements of pressure buildup or vent flow rate may be misinterpreted if pore pressure and visco-inertial flow effects are ignored.
- Consider the effects of visco-inertial flow and pore pressure when simulating the fluid flow through fractured wellbore systems.

Slide 17

CK2 consider adding another 'impact' bullet: can you comment on how your results may impact inferring wellbore integrity from wells with non-zero behind casing pressure?
Chojnicki, Kirsten, 8/21/2020

MH17 Added
Mahya Hatambeigi, 8/24/2020

CK3
MH15

Acknowledgements

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Slide 18

CK3 The SAND for the talk will be different than the SAND number for the paper so let's be sure to update this.
Chojnicki, Kirsten, 8/21/2020

MH15 Sure
Mahya Hatambeigi, 8/24/2020

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THANK YOU