TEXAS Geosciences
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NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY

Hydromechanical Properties of Hydrate Reservoirs through Pressure Core Analysis: GC 955, Gulf of Mexico

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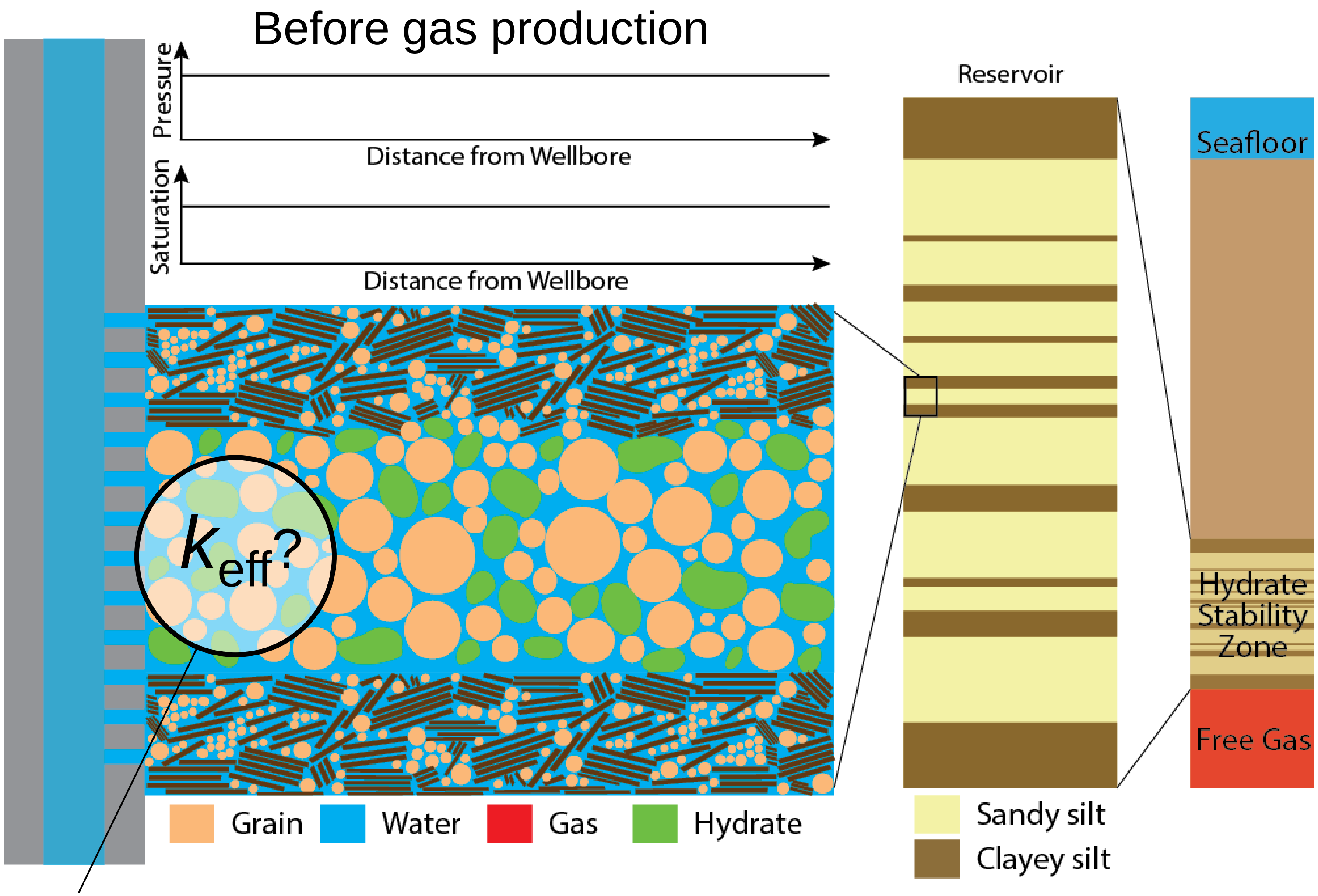
Key points

1. The in situ effective permeabilities are 0.1 to 2.4 mD for hydrate-bearing pressure cores with over 80% hydrate saturation.

2. The intrinsic permeabilities are 12 to 41 mD.

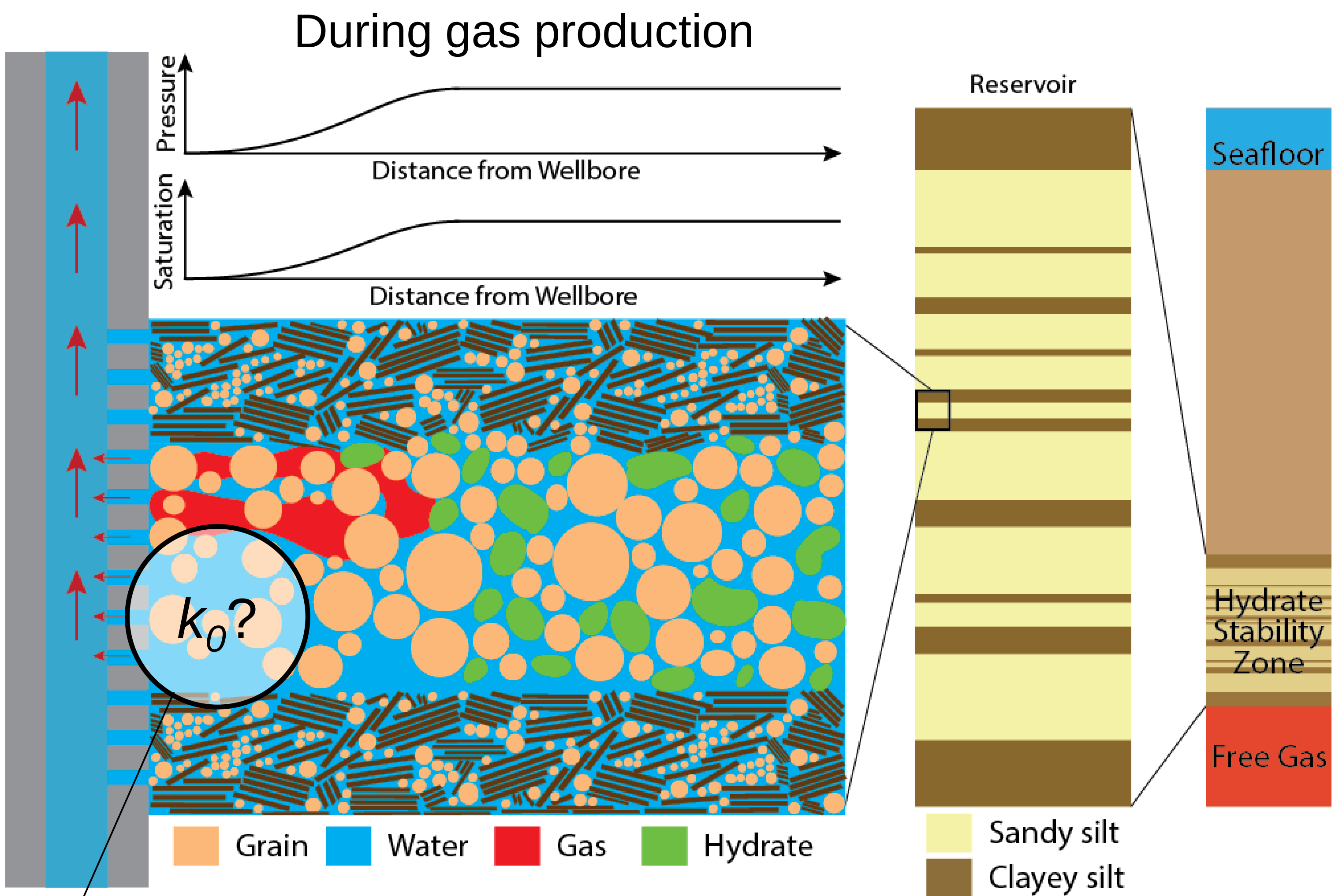
3. The average K_0 stress ratio of hydrate-bearing sandy silt samples is about 0.44.

Motivation: characterize the effective permeability (k_{eff})



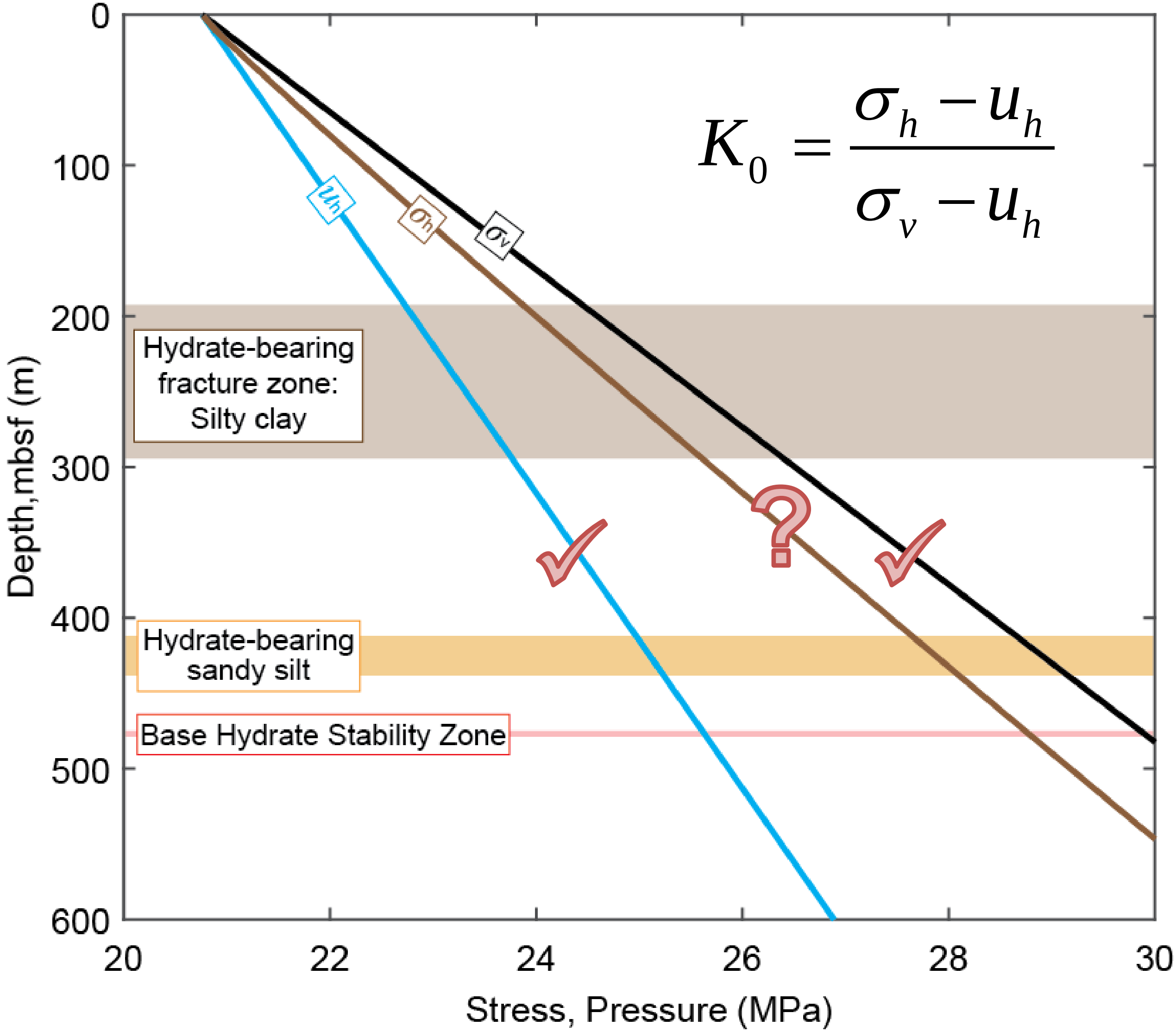
- What is the porosity (n)? What is the hydrate saturation (S_h)?
- What is the water permeability (k_{eff}) in presence of hydrate?

Motivation: characterize the intrinsic permeability (k_0)



- What is the water permeability (k_0) without presence of hydrate?

Motivation: characterize horizontal stress (σ_h) in the reservoir



- What is possible horizontal stress in the hydrate reservoir?

Three samples selected for analysis to represent the reservoir

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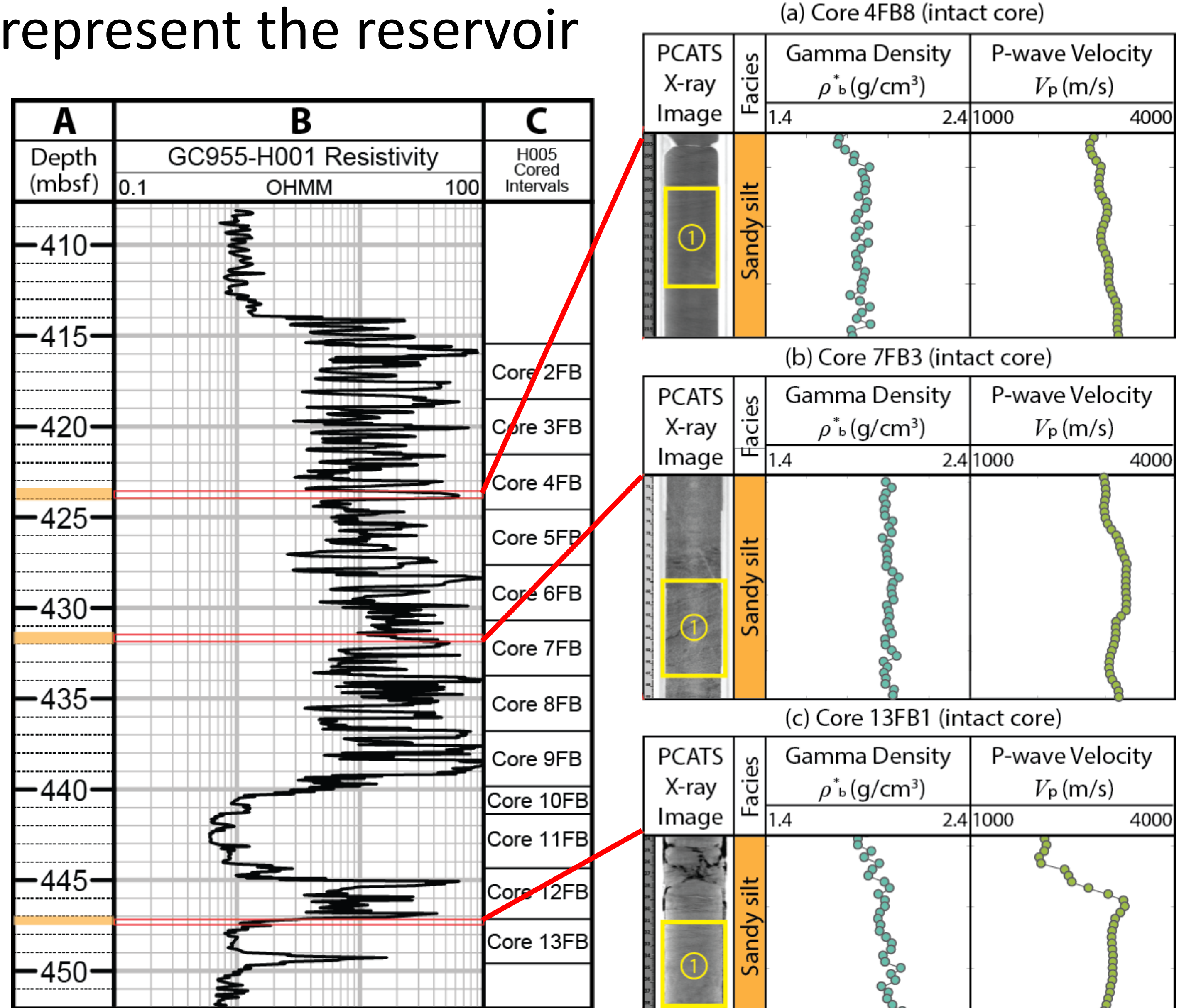

Core 4FB8

n = ~ 0.38

S_h = 83%

Core 7FB3

n = ~ 0.39

S_h = 84%

Core 13FB1

n = ~ 0.39

S_h = 93%

(Fang et al., AAPG Bulletin, in preparation)

Equipment for cutting, transfer and measurement

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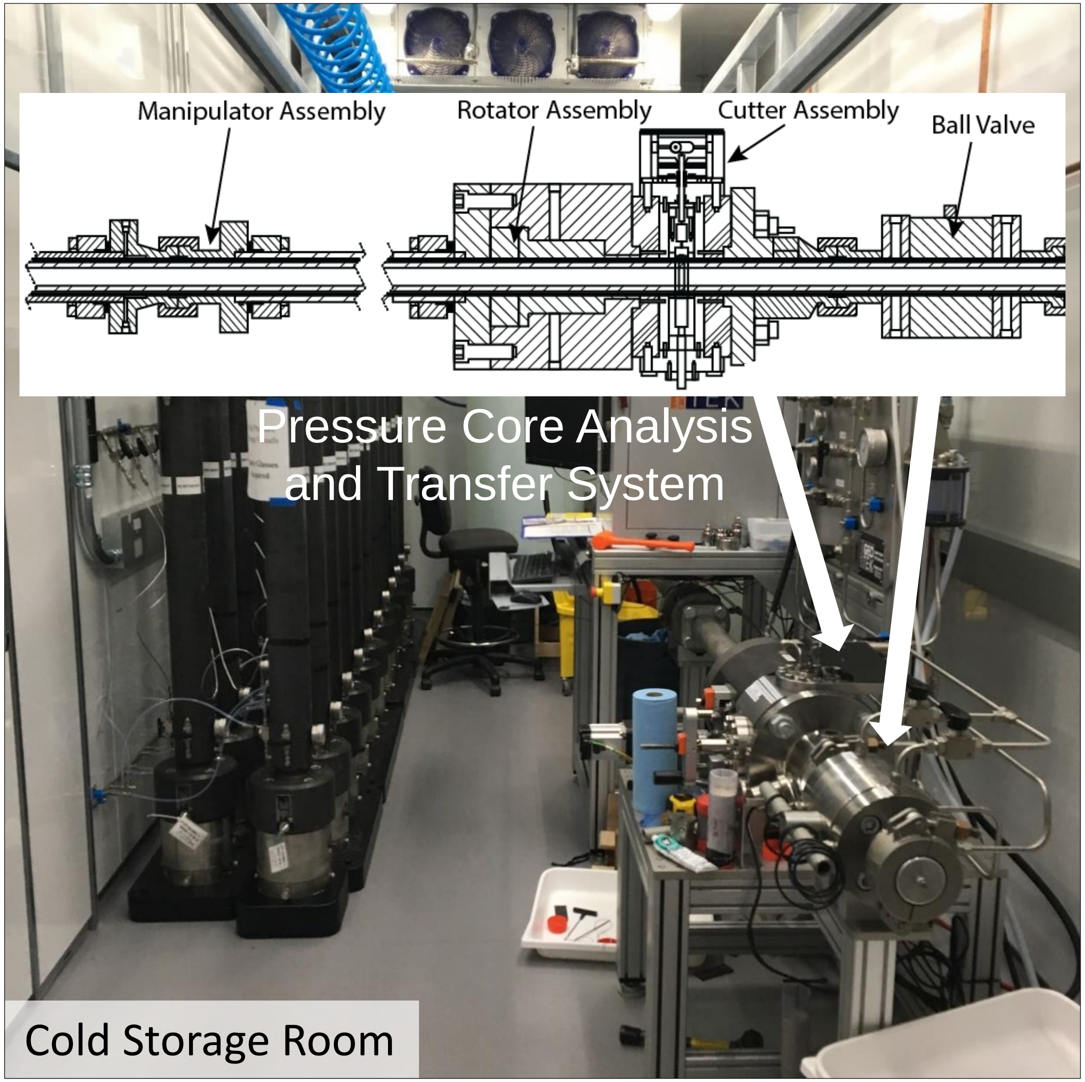
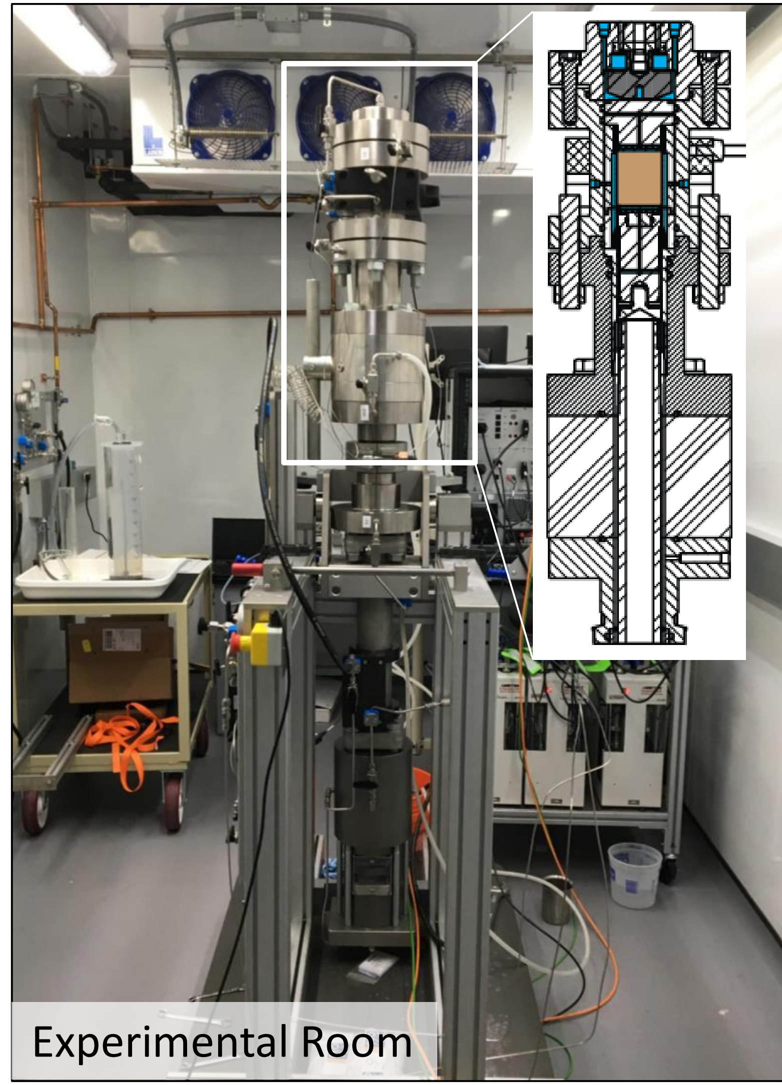
(a) Pressure Core Chamber and Mini-PCATS

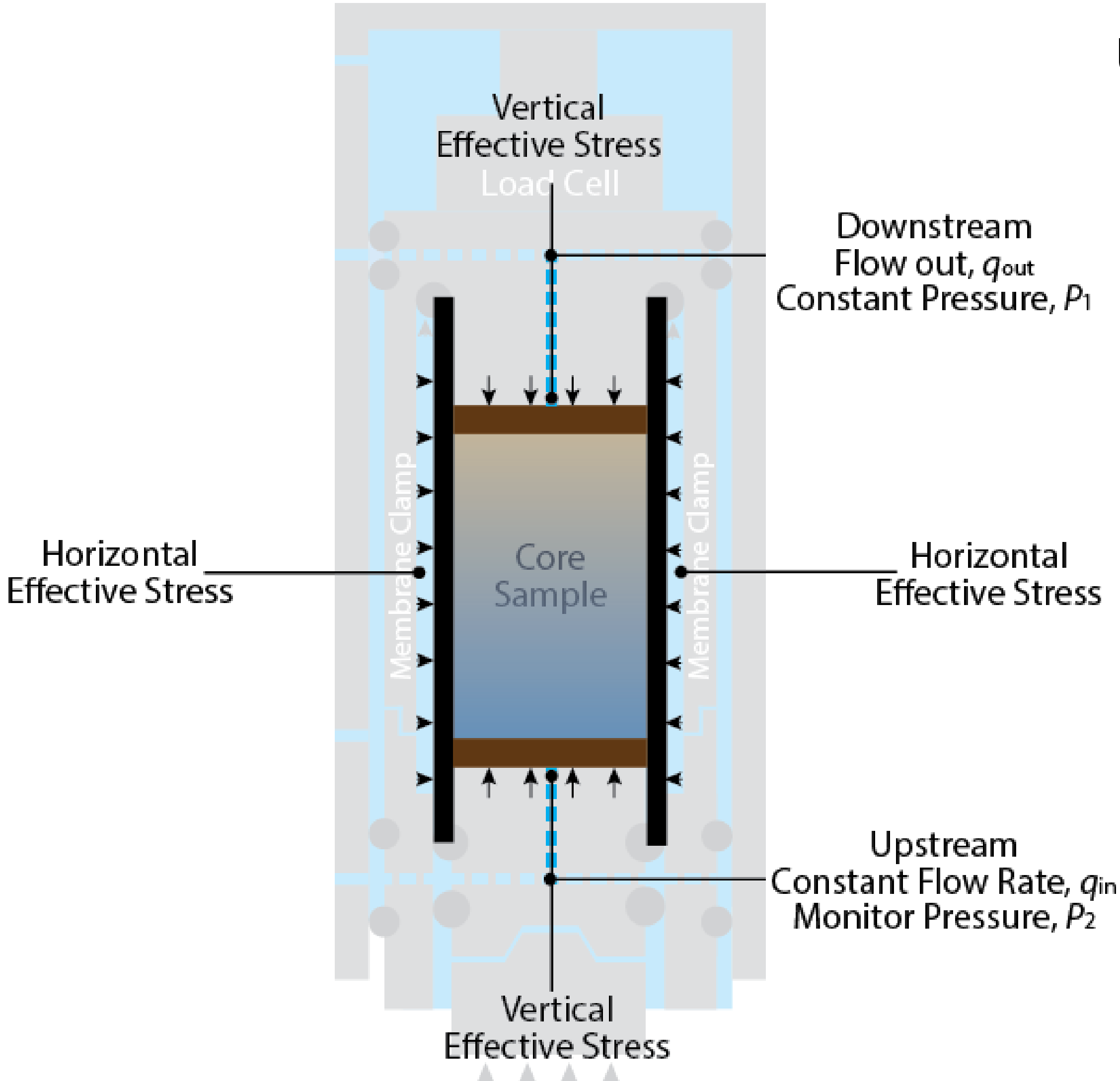


(b) Permeameter



(Location: UT Pressure Core Center, JGB Basement)

How are stress and permeability measured?



Uniaxial Compression

Permeability: $k = -\dfrac{q \cdot \mu \cdot L}{A \cdot (P_1 - P_2)}$

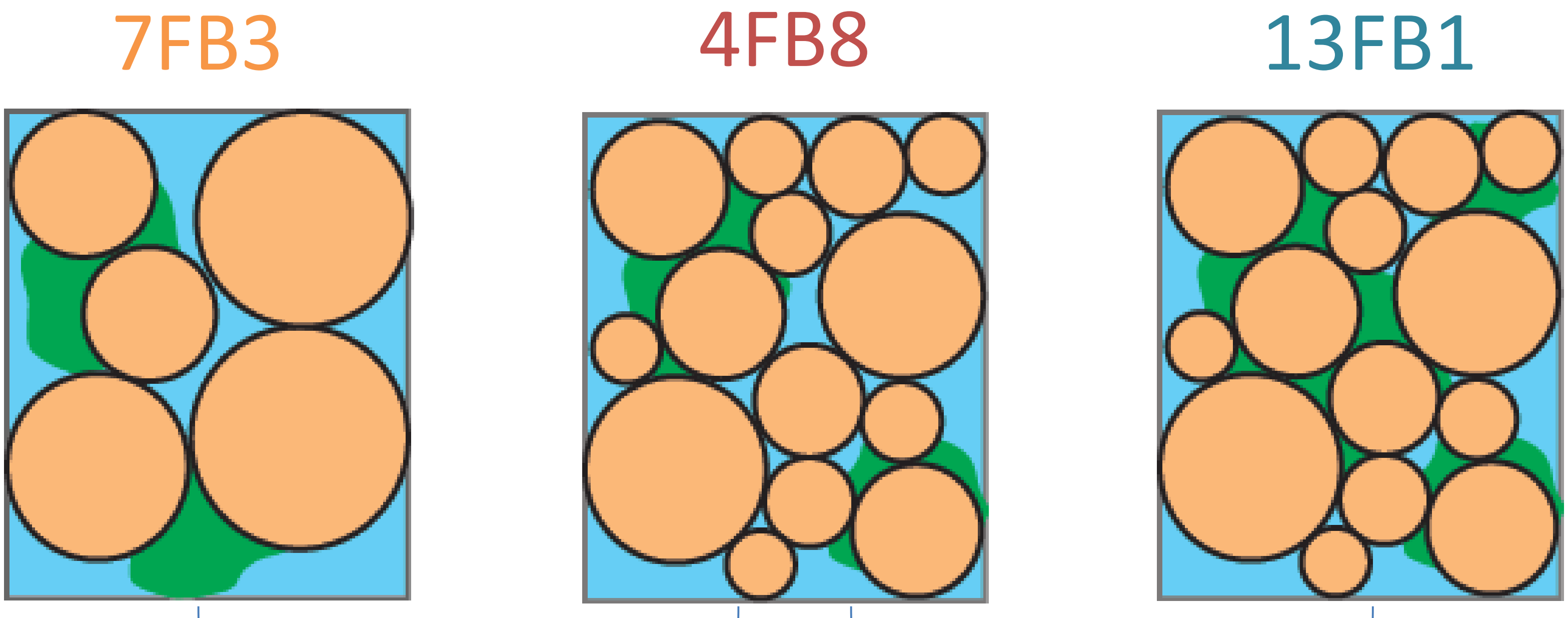
q: flow rate

μ: fluid viscosity

L: length of specimen

A: cross-section area

Effective permeability of pressure core samples



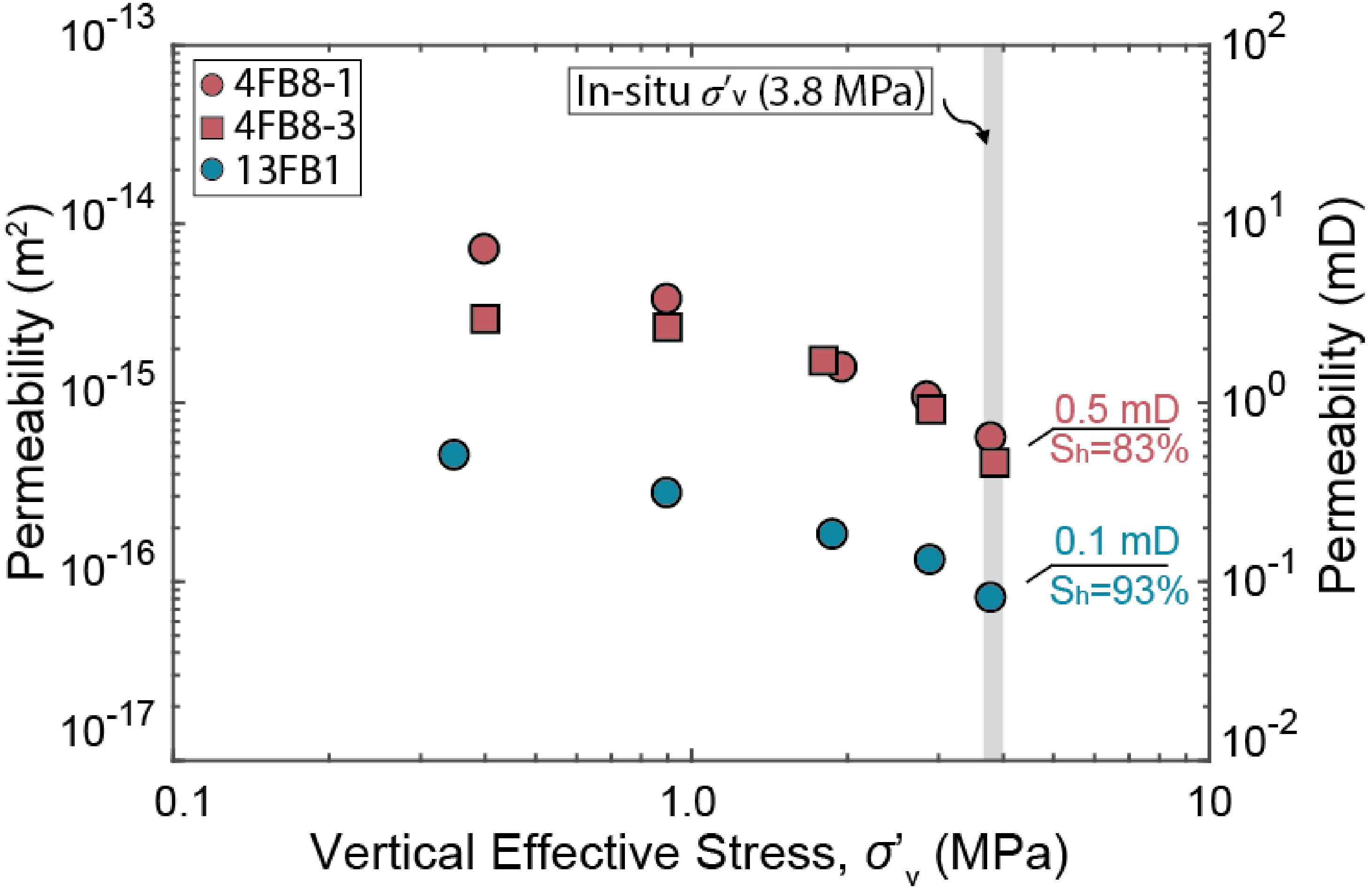
Same hydrate saturation,
Different grain size

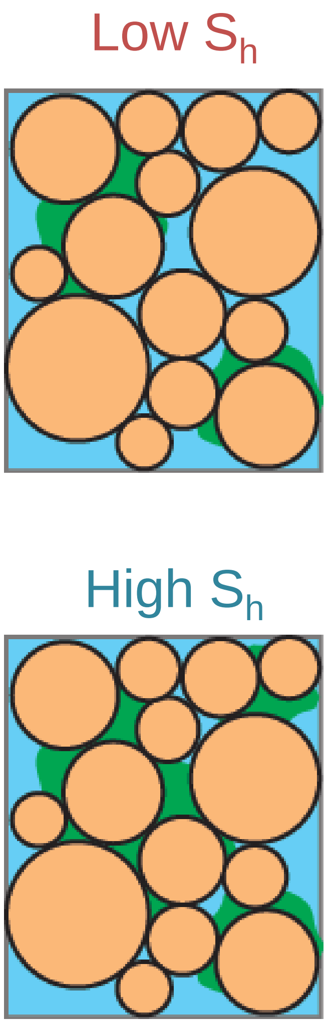
2

Same grain size,
Different hydrate saturation

1

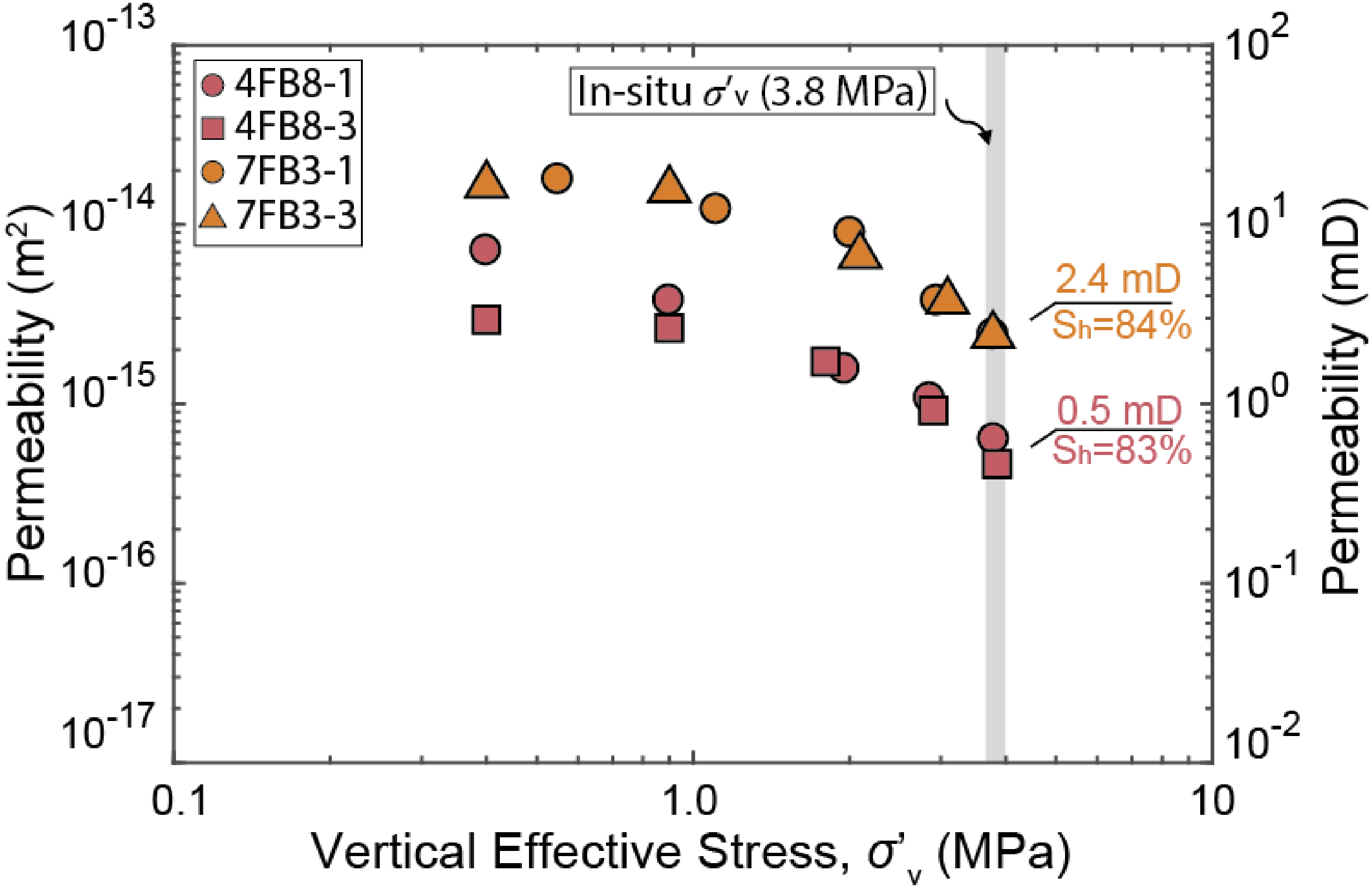
Same grain size, higher hydrate saturation results in lower effective permeability

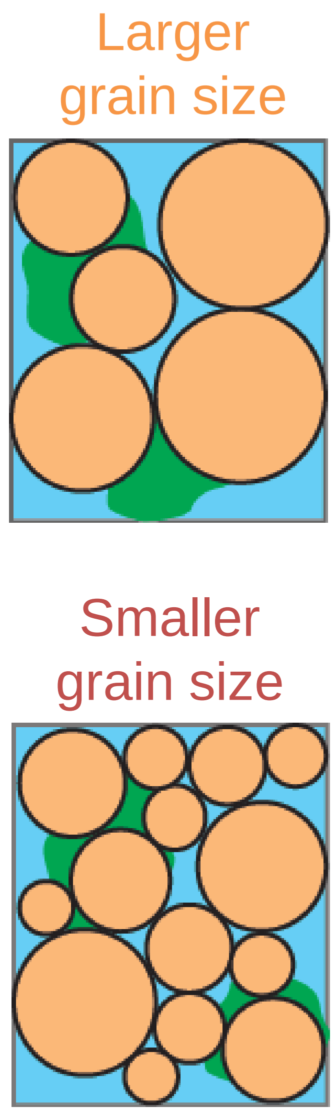




(Fang et al., AAPG Bulletin, in preparation)

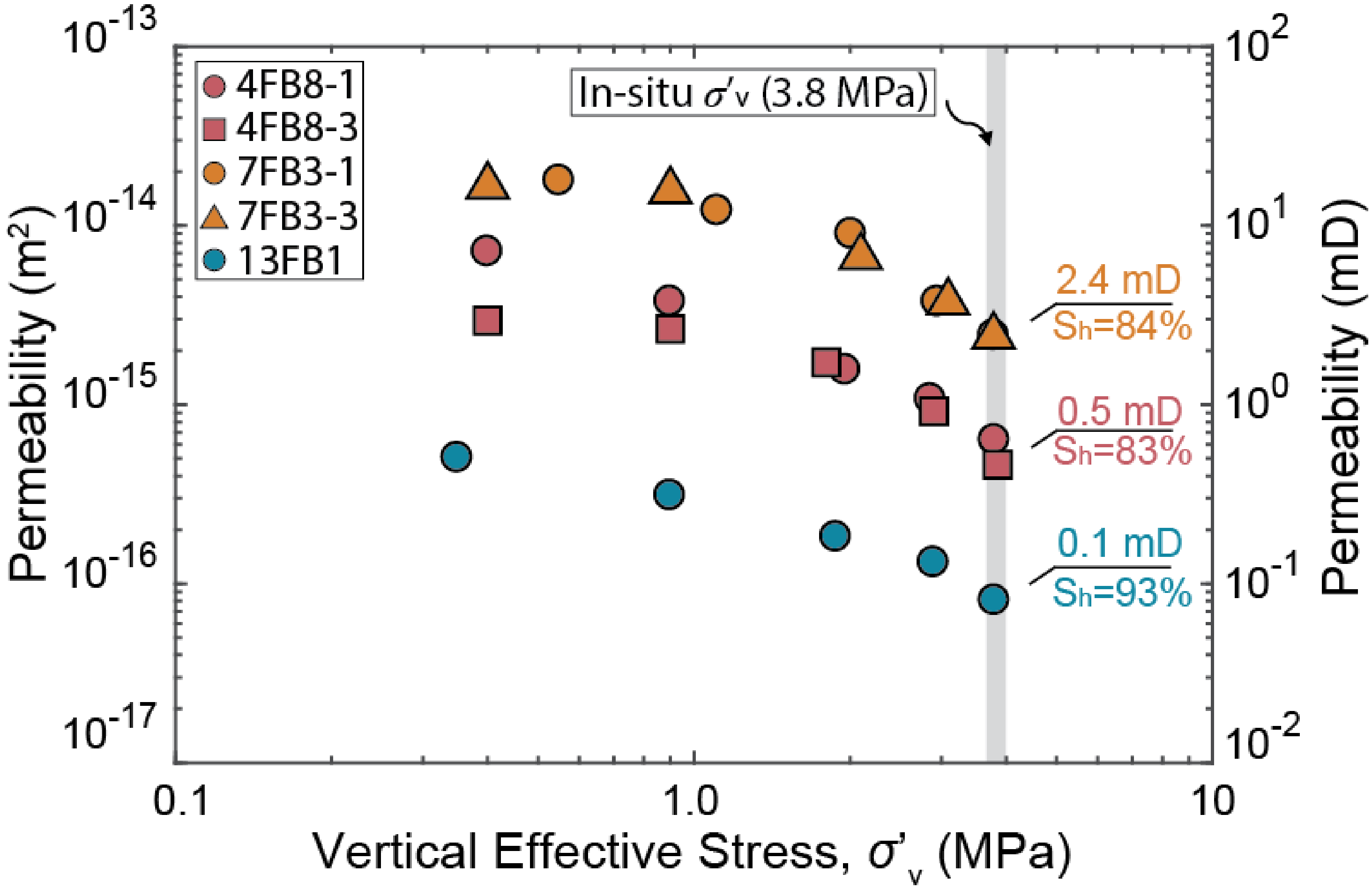
Same hydrate saturation, larger grain size results in higher effective permeability





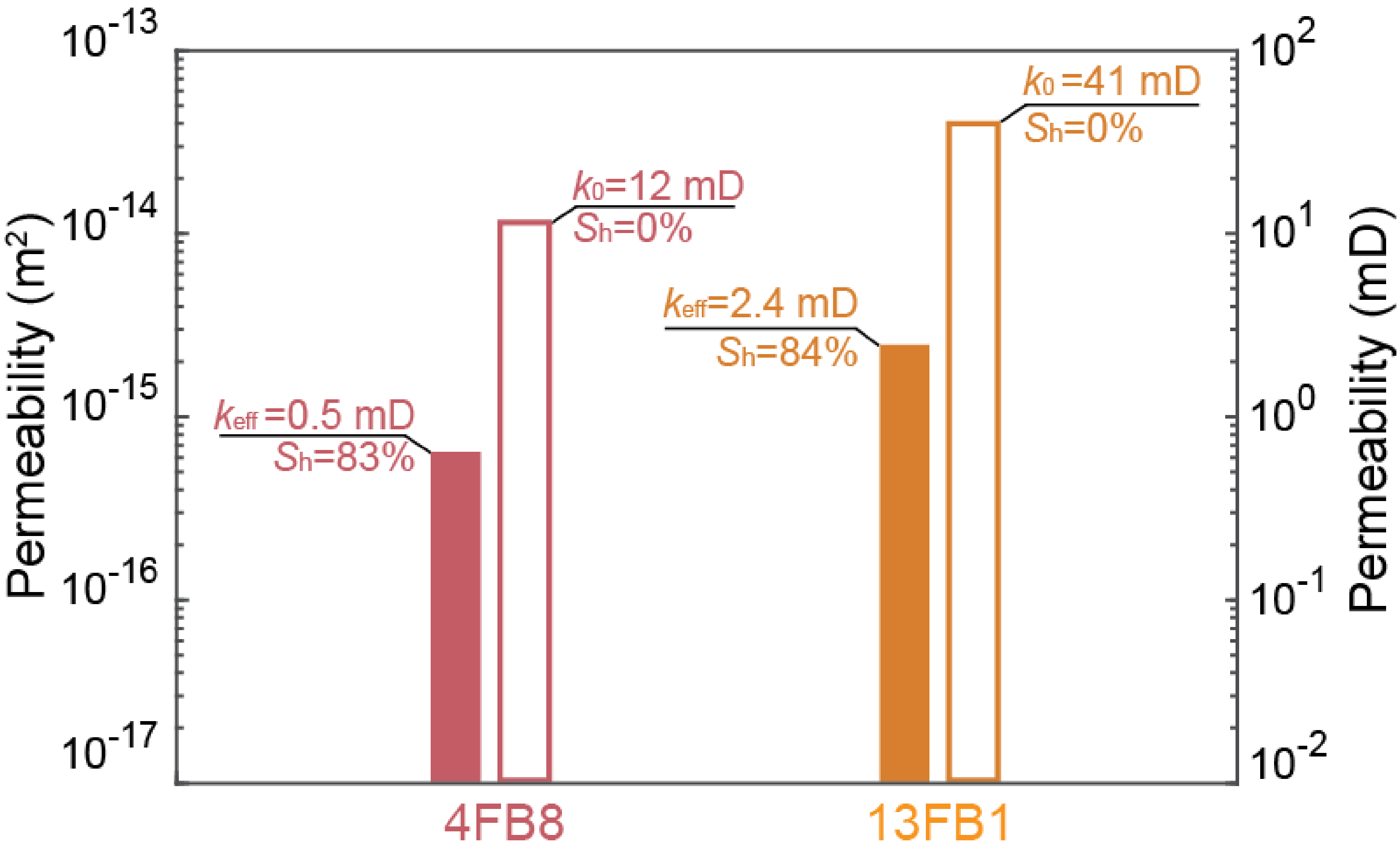
(Fang et al., AAPG Bulletin, in preparation)

Effective permeability is in the range of 0.1 to 2.4 mD at in situ stress for core samples over 80% hydrate saturation



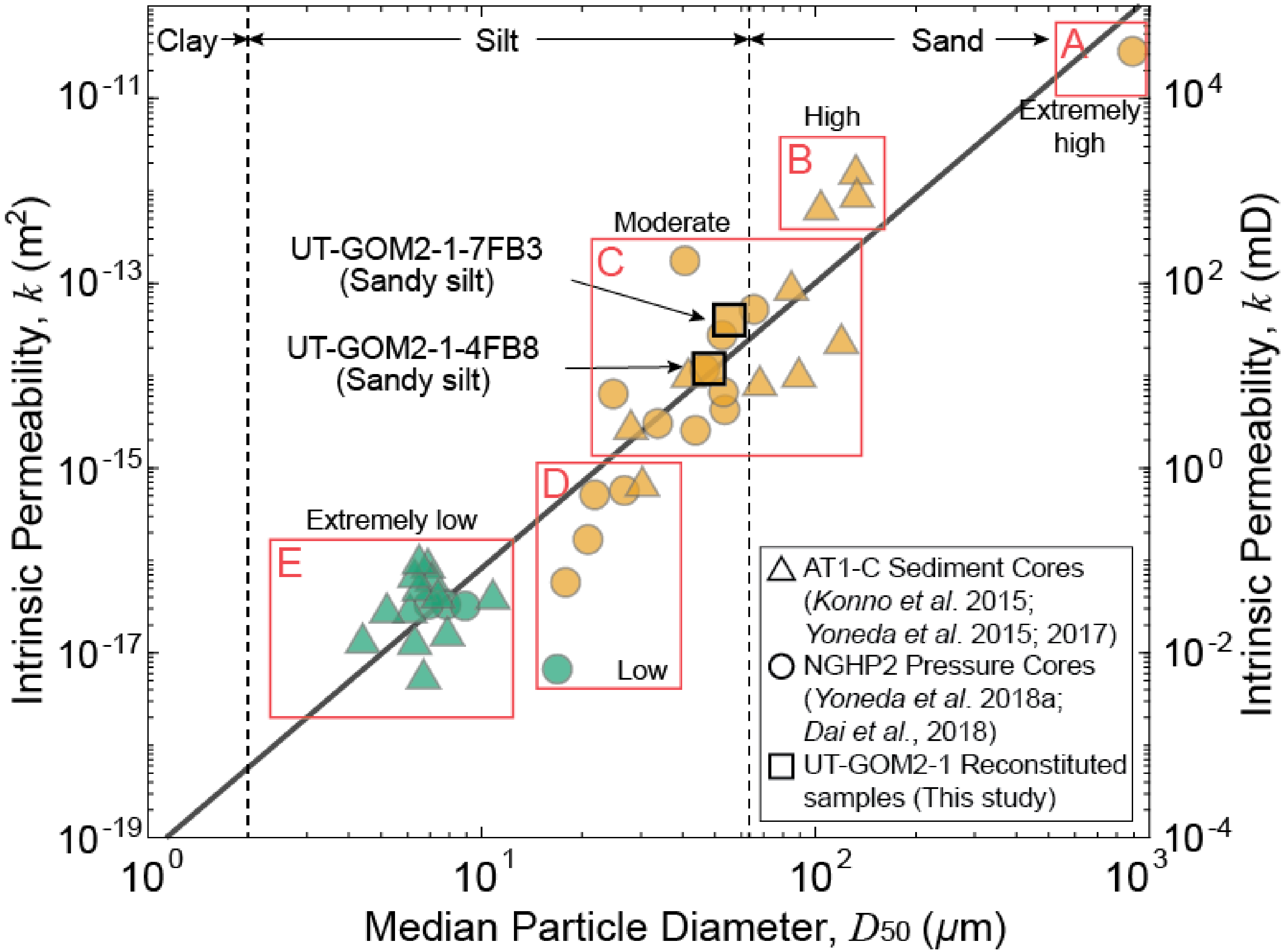
(Fang et al., AAPG Bulletin, in preparation)

Intrinsic permeability is about 20-fold larger than its effective permeability at in-situ effective stress



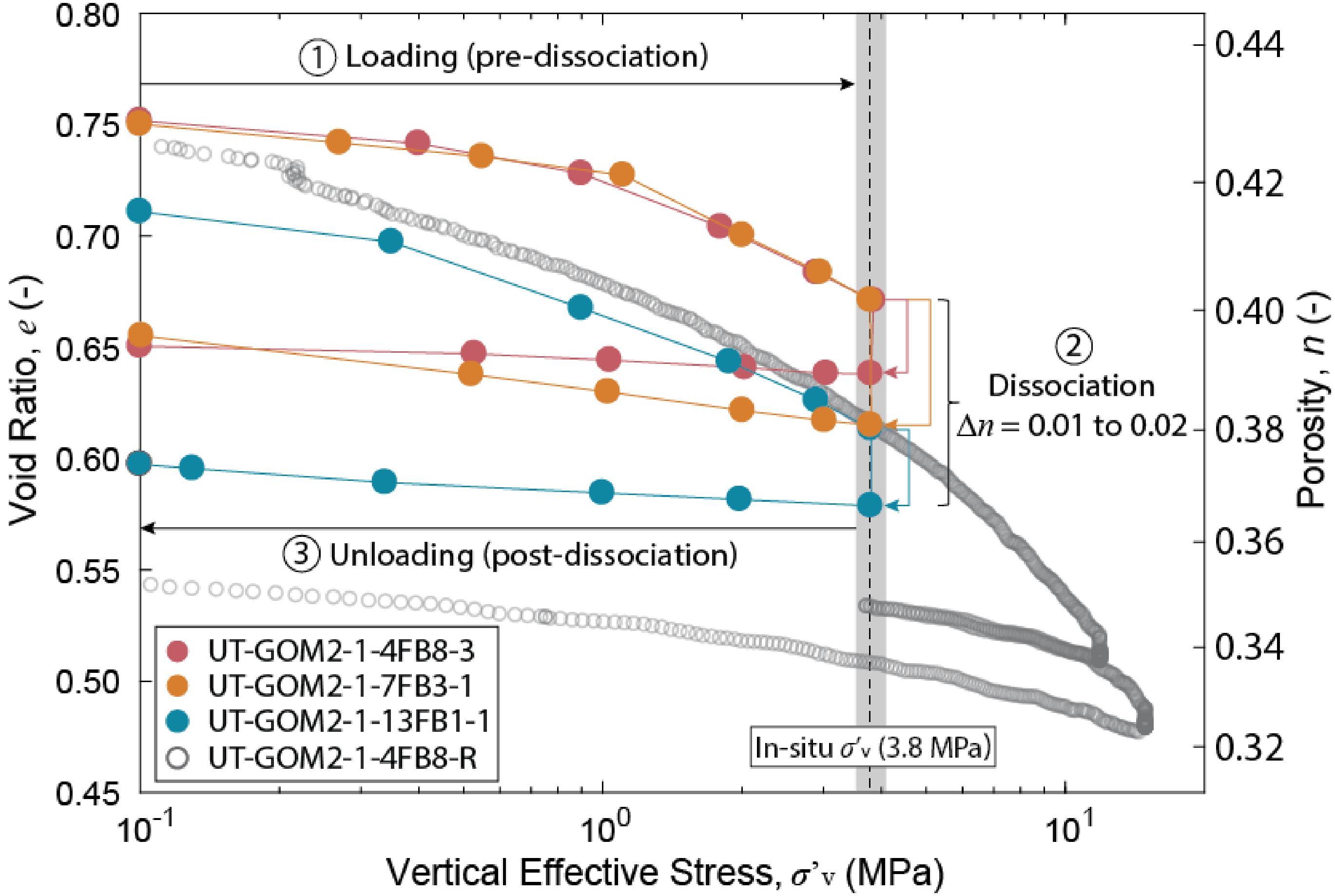
(Fang et al., AAPG Bulletin, in preparation)

Implication: GC 955 hydrate reservoir has moderate quality in comparison with other hydrate reservoirs.



(Fang et al., AAPG Bulletin, 2020)

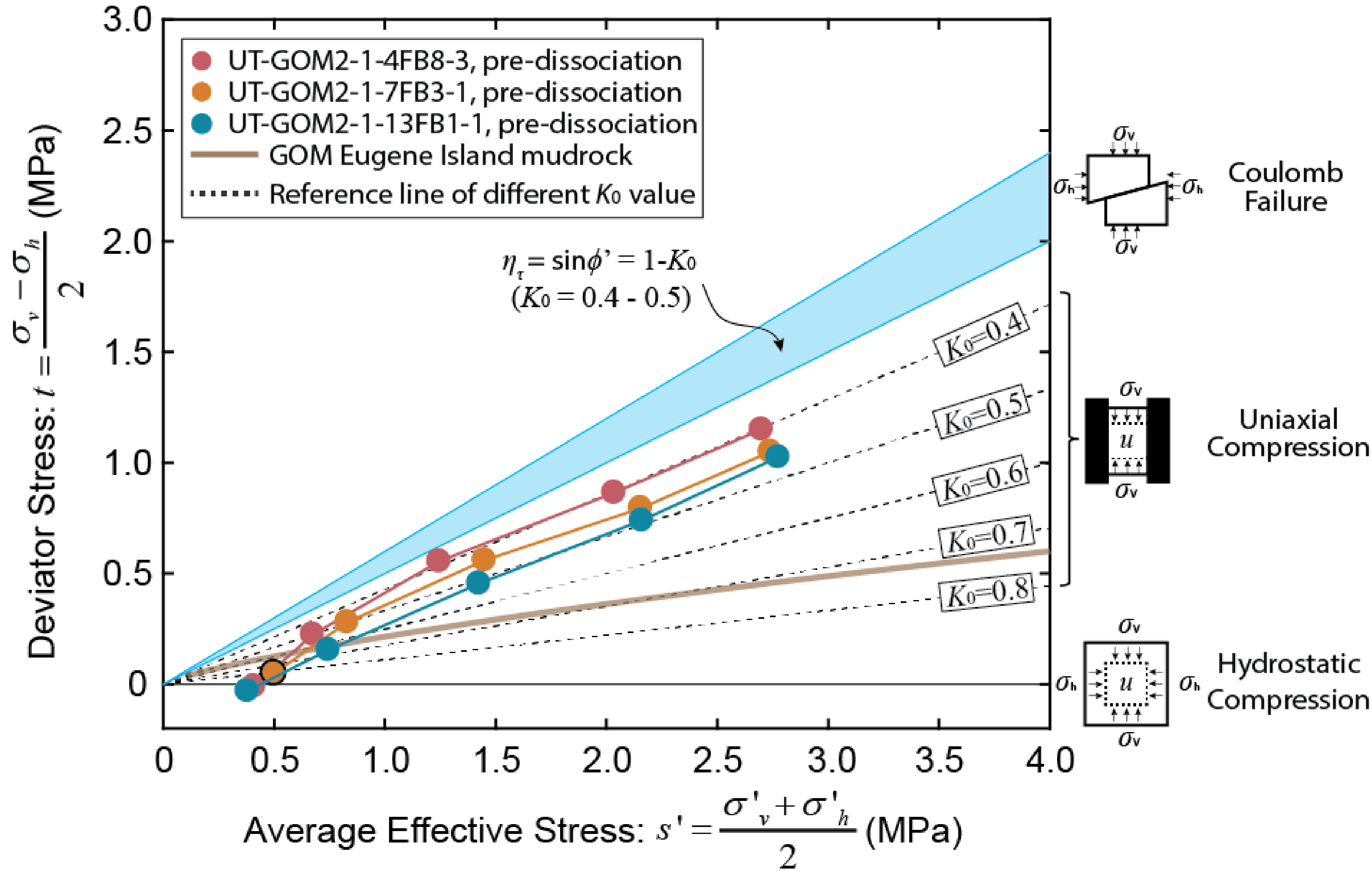
Results: compression behavior



- In situ porosity is 0.38 to 0.40
- About 1 to 2 unit porosity drop after hydrate dissociation
- Similar characteristic compression curve for all samples

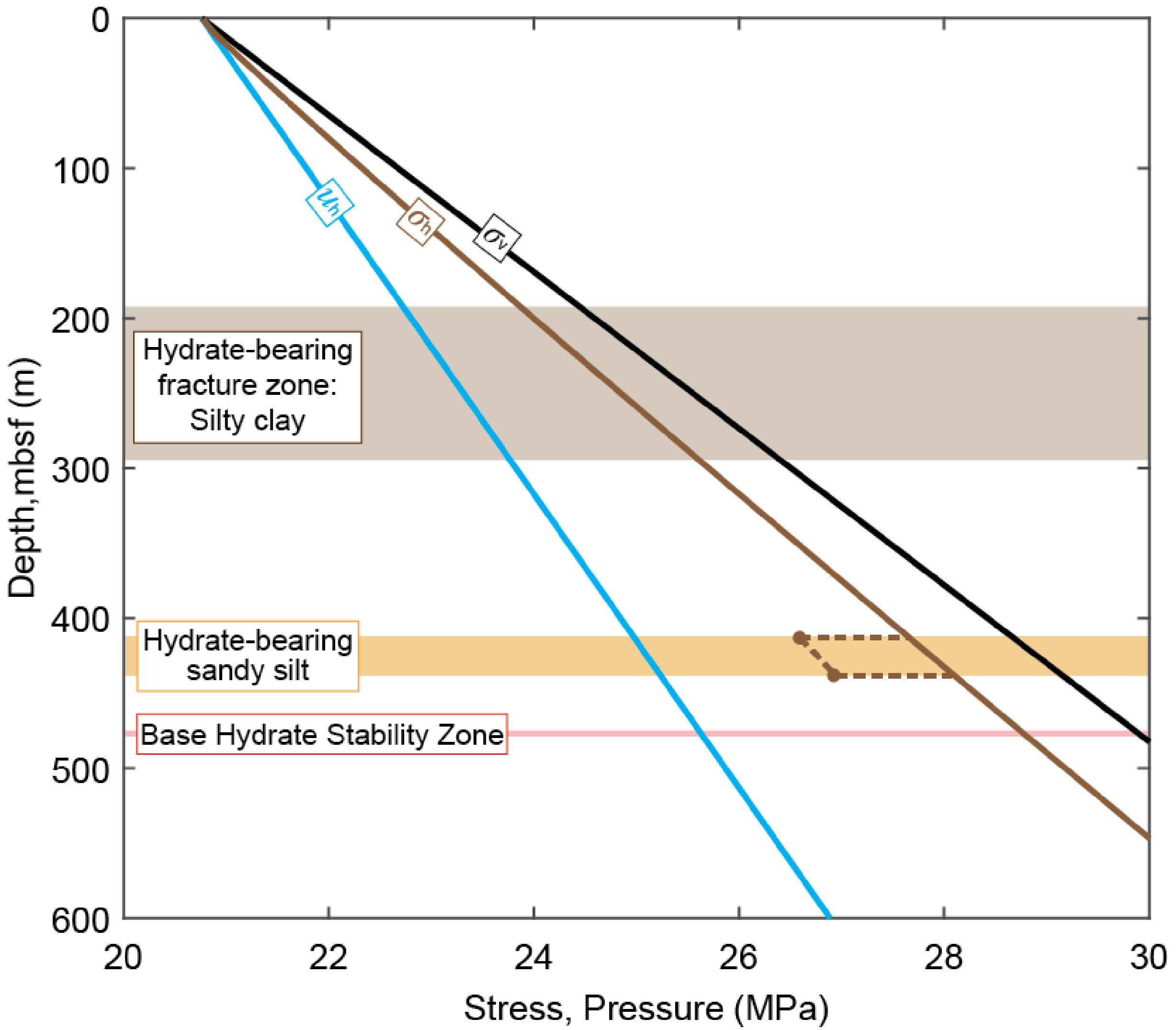
(Fang et al., AAPG Bulletin, in preparation)

Results: K_0 stress ratio of hydrate bearing sandy silts is between 0.4 and 0.5.



(Fang et al., AAPG Bulletin, in preparation)

In hydrate formation, the horizontal effective stress is lower than that of non-hydrate formation.



$$\sigma'_h = K_0 \times \sigma'_v$$

- Non-reservoir σ'_h : GOM EI Mudrock K_0 = ~ 0.7
- Reservoir σ'_h : GOM2 Sandy silt K_0 = ~ 0.44
- Reservoir σ'_h = 1.57 to 1.71 MPa

Key takeaways

1. The intrinsic permeabilities (12 to 41 mD) are identified by the reconstitution analysis, suggesting a moderate reservoir quality.

2. The in situ effective permeabilities (0.1 to 2.4 mD) of hydrate-bearing siltstones in GC 955 gas hydrate reservoir, which is sufficiently low for hydrate formation to be a hydraulic barrier.

3. Hydrate-saturated samples have a stress ratio less than 0.5, resulting in a lower horizontal effective stress than the non-hydrate formation.

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- Kevin Meazell (UT-DGS)

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Thank you for your attention!

Any questions ?