Pressure Core Characterization and X-ray CT Visualization Tools (PCXT): bridging core scale behaviors and pore scale observations

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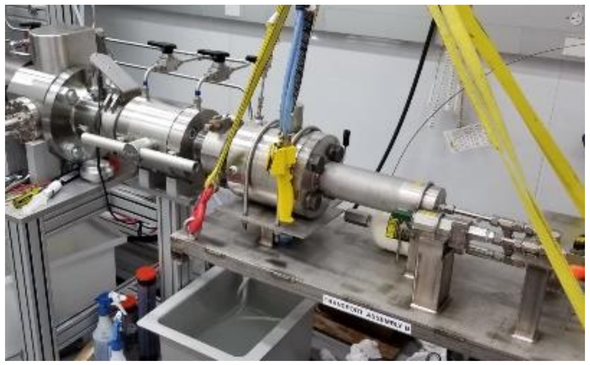
Introduction

The major project scope is to characterize compressibility, anisotropic permeability, strength and large-strain behavior of pressure cores, visualize natural hydrate bearing sediments in 3D at pore scale, maintain the state of art set of tools for pressure core characterization and develop new capabilities to facilitate the understanding of natural sediments from new aspects.

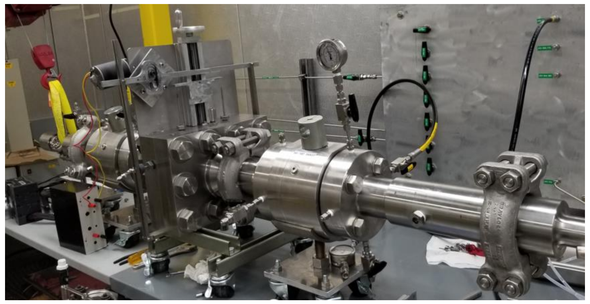
This set of tools will enable the mostly never-before core-scale physical properties under in-situ pressure and stress conditions, visualize pore habits of methane hydrate in natural sediments, develop linkage between pore-scale and core-scale behaviors and project the results to reservoir scale.

PCXT Capabilities

Handling Modules:

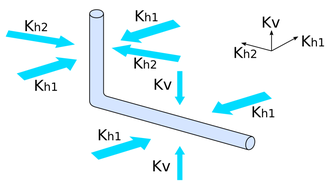


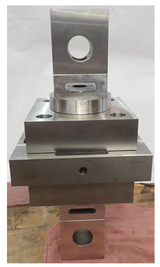
Transport Storage Chamber



Cutter & Manipulator

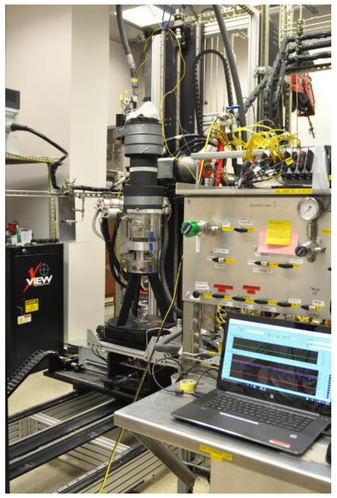
Testing Modules:

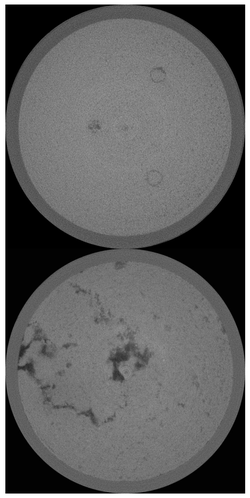




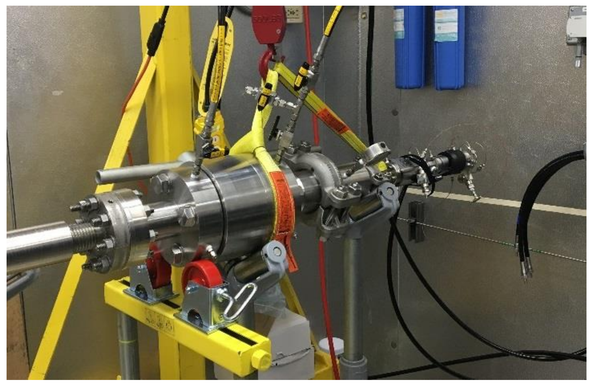
Anisotropic Permeability Cell

CT Scanning Chamber Effective Stress Chamber



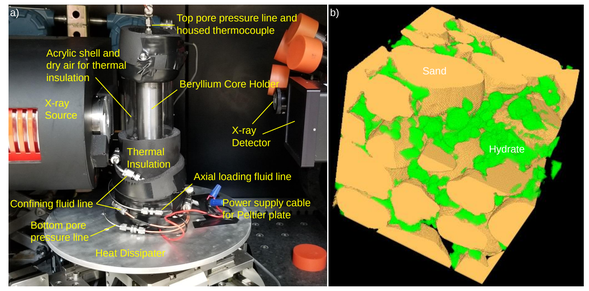


Industrial CT Scan & Results (Resolution 35 μm)



Sub-coring Assembly & Core Holder for Micro-CT

Sub-coring Tool



Micro-CT Scan and 3D Visualization[1]

Experience

Pore/Particle Scale:

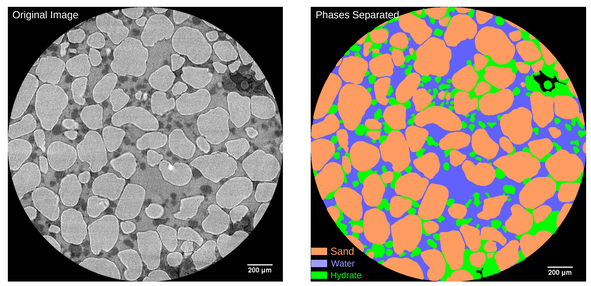
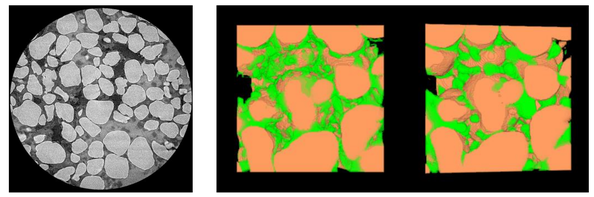
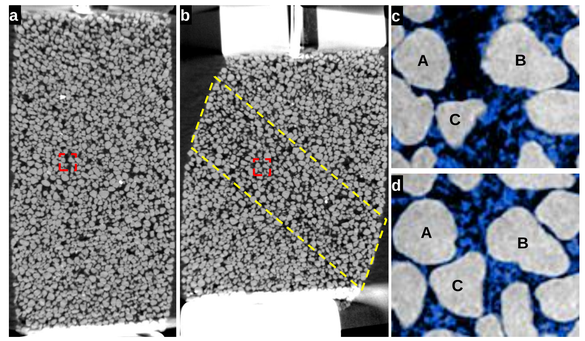


Image Processing: Segmentation[2]

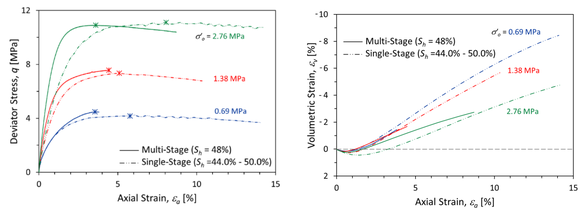


Hydrate Pore Habits[3]

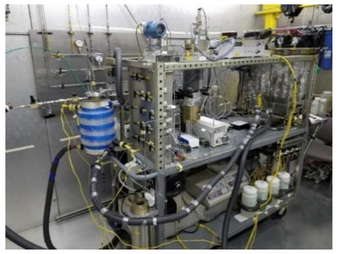


Hydrate-bearing Sediment Behavior under Loading[1]

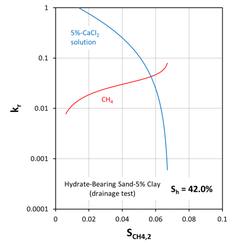
Core Scale:



Stress-strain Curves[4]

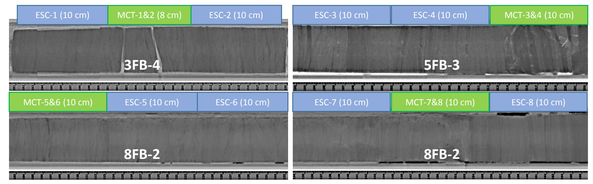


Testing Configuration



Relative Permeability

Pressure Core Testing Plan



Section ID	Initial	Step 2	Step 3	Step 4	Step 5	Step 6	Parameters
ESC-1&5	Initial Condition	Natural temperature, pore pressure *P* and effective stress σ'	σ' ↑ to 20 MPa *P* ↓	Dissociation at σ'=constant	Freezing	APC	Permeability (HBS), Compressibility, Anisotropic permeability, P-&S-wave velocity, Elastic moduli, Poisson's ratio, Stress-strain curve, HBS strength, 3D digital HBS, Contact angle.
MCT-1&5	ESC (all steps): Permeability Acoustic	Compressibility Permeability Acoustic MCT Scan			--	--	
ESC-2&6	MCT (all steps): Scan Permeability		Dissociation at σ'=constant	σ' ↑ to 20 MPa	Freezing	APC	
MCT-2&6					--	--	
ESC-3&7			Dissociation at σ'=constant	Freezing	APC	--	
MCT-3&7				--	--	--	
ESC-4&8			Multi-stage triaxial extension	Dissociation	Freezing	APC	
MCT-4&8				Triaxial compression	--	--	

References

[1] Seol, Y., & Lei, L. (2019). Micro-CT visualization of hydrate-bearing sediments to aid integrated mechanical-hydraulic-thermal-chemical characterization. Fire in the Ice, 19(1), 16-18.

[2] Lei, L., Seol, Y., & Jarvis, K. (2018). Pore-scale visualization of methane hydrate-bearing sediments with micro-CT. Geophysical Research Letters, 45(11), 5417-5426.

[3] Lei, L., Seol, Y., Choi, J.-H., & Kneafsey, T. J. (2019). Pore habit of methane hydrate and its evolution in sediment matrix – Laboratory visualization with phase-contrast micro-CT. Marine and Petroleum Geology, 104, 451-467.

[4] Choi, J.-H., Dai, S., Lin, J.-S., & Seol, Y. (2018). Multistage triaxial tests on laboratory-formed methane hydrate-bearing sediments. Journal of Geophysical Research: Solid Earth, 123(5), 3347-3357.