Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report (January - March 2013)

Verification of capillary pressure functions and relative permeability equations for gas production

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SUMMARY

Task 1.0 Project Management and Planning
Done

Task 2.0 Pore Network Generation
In progress

Subtask 2.1 Information of relevant information of in-situ hydrate-bearing sediments
Done

Subtask 2.2 Generation of sediment packing using Discrete Element Model (DEM)
Done

Subtask 2.3 Extraction of pore-network from sediment packing
In progress

Task 3.0 Algorithm for conductivity and hydrate dissociation
In progress

Project timeline

	Year 1				Year 2			
	Qtr1	Qtr2	Qtr3	Qtr4	Qtr1	Qtr2	Qtr3	Qtr4
Task 1.0 Project Management and Planning	█	█	█	█	█	█	█	█
Task 2.0 Pore Network Generation	█	█	█					
Subtask 2.1: Information of grain size distribution	█							
Subtask 2.2: Sediment packing by DEM simulation	█	█						
Subtask 2.3: Extraction of pore network		█	█					
Milestone A			◆					
Task 3.0 Algorithm for conductivity and hydrate dissociation				█	█			
Decision Point 1				●				
Milestone B					◆			
Task 4.0 Characteristic Curve and Relative Permeability						█	█	█
Subtask 4.1: Effect of hydrate habit						█	█	
Subtask 4.2: Effect of hydrate saturation						█	█	
Subtask 4.3: Effect of gas viscosity							█	
Subtask 4.4: Suggestion of fitting parameters							█	█
Milestone C								◆

Subtask 2.1 Compilation of relevant information of in-situ hydrate bearing sediment

Information of hydrate-bearing sediments relevant to generate three-dimensional sediment packing using DEM simulation is compiled. Grain size distributions of several reservoirs are shown in Figure 1. This information is used as input parameters to generate numerical three-dimensional sediment packing in Subtask 2.2.

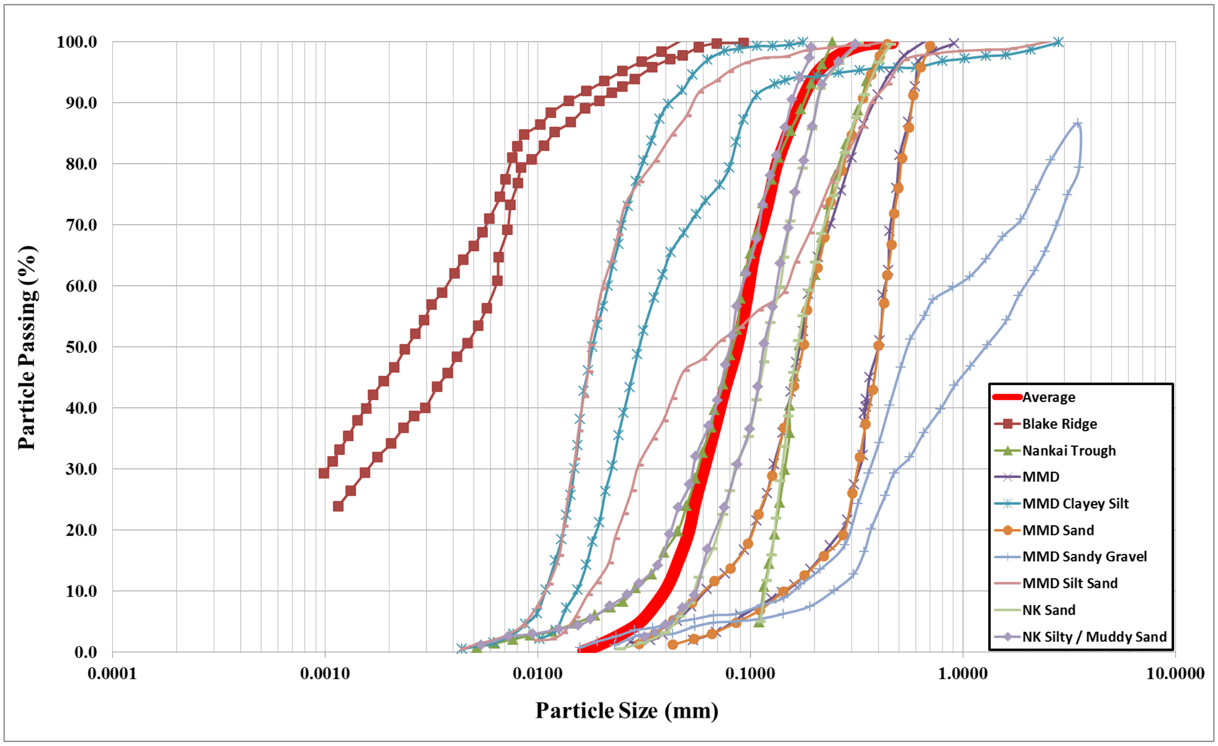

Figure 1. Compilation of grain size distribution curves in hydrate-bearing sediment (e.g., Black Ridge, Nankai Trough, Mallik-Mackenzie Delta, and Hydrate Ridge).

Subtask 2.2 Generation of sediment packing using Discrete Element Model (DEM)

Commercial software (*PFC 3D*, ITASCA) is purchased and installed in the PI's group. The information of grain size distribution is used to generate sediment packing under different conditions (left in Figure 2). Pore space is also extracted from the sediment packing (right in Figure 2). The extracted pore image will be used for pore-network extraction in Subtask 2.3. The verification of the generated sediment packing will be done by next quarter as planned in project timeline. Porosity, lateral earth pressure, and effective stress will be checked.

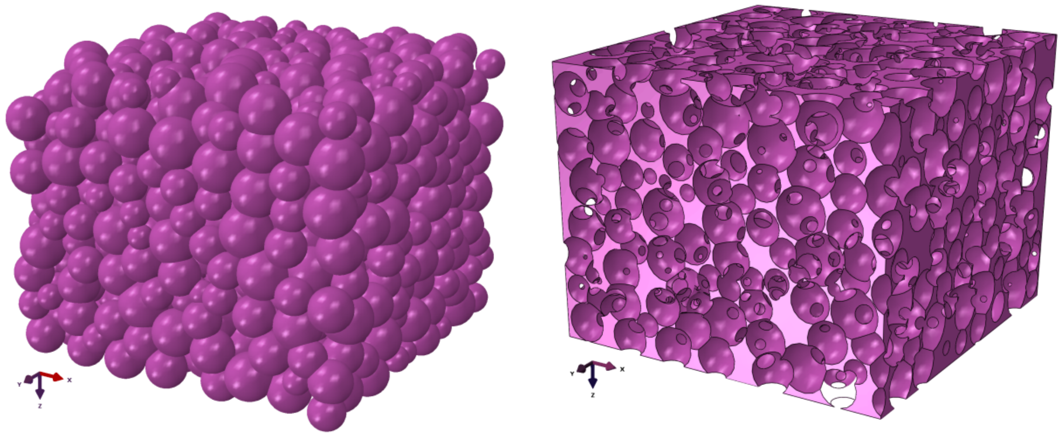

Figure 2. Sediment packing generated by discrete element model (*PFC 3D*) using in-situ data of grain size distribution and effective stress (left). Pore space of the sediment packing (right).

Subtask 2.3 Extraction of pore-network from sediment packing

The algorithm development for pore-network model extraction is initiated ahead of schedule. Currently, extraction algorithm is being verified.

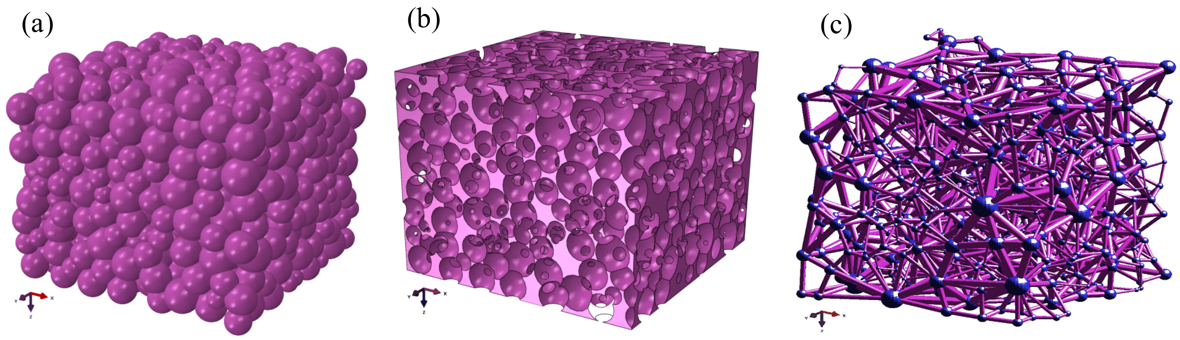

Figure 3. Pore-network model extracted from simulated sediment packing. (a) Sediment packing generated by discrete element model (*PFC 3D*) using in-situ data of grain size distribution and effective stress (**Subtask 2.2**). (b) Pore space of the sediment packing (**Subtask 2.2**). (c) Pore-network model extracted from pore space by using maximum ball theory (**Subtask 2.3**).

Task 3.0 Algorithm development for gas expansion and relative permeability during hydrate dissociation

A new algorithm for the pore-network models is being developed to simulate gas hydrate dissociation, gas expansion, water displacement, capillary pressure, and gas and water relative permeability. The algorithm adopts the modified Peng-Robinson equation to calculate gas pressure, multiple invasion percolation theory modified to predict gas expansion and capillary pressure, and Hagen-Poisueille's equation to calculate hydraulic conductivity.

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