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

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Project timeline

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**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-Poiseuille’s equation to calculate hydraulic conductivity.
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