Thermal-Hydraulic-Chemical-Mechanical Coupled Behavior of Hydrate-Bearing Sediments: Pore Scale Investigations and Implications

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9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Hydrate formation and dissociation are inherent thermal-hydraulic-chemical-mechanical coupled processes. Hydrate formation is a chemical reaction that involves latent heat dissipation, hydrate forming constituent transportation toward hydrate formation front, impurity (such as ions) exclusion away from hydrate formation front. Meanwhile, the inclusion of solid hydrate in the pore space increases the stiffness and strength of the host sediments but significantly decreases the permeability. Reverse trends occur during hydrate dissociation with variations due to the imposed boundary conditions such as depressurization and thermal stimulation. This work summarizes the pore-scale observations of hydrate-bearing sediments under various simulated geological conditions at NETL. These micro-scale observations are made possible by the recently developed technique based on pore fluid doping and phase-contrast micro-CT. With 3D CT images, we show hydrate growth and dissociation in sediment pores, ion-exclusion during hydrate formation, pore water freshening during hydrate dissociation, permeability changes due to hydrate and external loading, behavior of sand skeleton and hydrate under mechanical loading, and effect of temperature and pressure on mechanical strength. These results enhance our understanding of the overall behavior of hydrate-bearing sediments and help explain previously reported core-scale or even reservoir scale observations.

Keywords: hydrate-bearing sediments, micro-CT, pore scale behavior, thermal-hydraulic-chemical-mechanical

AAPG Datapages/Search and Discovery Article # 91200 © 2020 AAPG Annual Convention & Exhibition Online, Sept. 29- Oct. 1.