

# A Coupled Thermal, Chemical and Mechanical Model Using COMSOL Multiphysics® Software

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## Abstract

Many numerical coupling thermo-hydro-mechanical-chemical models for methane hydrate bearing sediments (MHBS) have been proposed to analyze the mechanical behavior of MHBS during methane gas production. However, most of them are based on finite differential method (FDM) or finite volume method (FVM). Few models for MHBS based on finite element method (FEM) and Galerkin variation principle are published. This paper uses COMSOL Multiphysics® software to simulate the multiphysics behavior of MHBS during the gas production. The model is built upon the PDE interface and Structural Mechanics module. Flow equations and heat equation are built on PDE interface. The Structural Mechanics module is used to simulate the deformation of MHBS influenced by other physical fields. A new feature called external material model in COMSOL® software is utilized to build an advanced critical state constitutive model for MHBS. It should be noticed that the differences between state variables and parameters need to be kept in mind during the implement of external material model. The comparison with other FVM models has been conducted to verify this model.