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Thermodynamically consistent multiphase poroelasticity and its application to water-dissolved gas reservoir simulation

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In recent years, monitoring data of land surface displacement have been used for the evaluation of subsurface fluid flow by comparing observed results with coupled modeling of subsurface fluid flow and deformation. Though modeling multiphase fluid flow process is popular in the field of oil/gas production and CO_2sequestration, coupled modeling techniques for the two-phase fluid flow and deformation of porous media is still under developing phase. This study aimed to develop the thermodynamically consistent constitutive relations and a new simulator based on the obtained relations. The important parameters and conditions for modeling were discussed through the sensitivity analysis in water-dissolved gas reservoir simulations. The sensitive conditions for achieving the "Mobara-type" production of methane were the depth and extent of reservoir, initial gas saturation in the mudstone, thickness of the formations, and intrinsic and relative permeability of the sandstone. Especially, the high intrinsic permeability of sandstone caused the reduction of gas water ratio and the low initial gas saturation in mudstone prevented the increase of gas water ratio in the sandstone. The sensitive conditions for the land subsidence were the depth and extent of the reservoir, initial gas saturation in mudstone, intrinsic permeability and relative permeability of sandstone, drained Young's modulus, and drained Poisson's ratio.

Keywords: coupled modeling, thermodynamics, two-phase fluid flow, poroelasticity, numerical simulation, water-dissolved gas reservoir