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A fixed-stress split strategy for two-phase flow in heterogeneous poroelastic media overlain by viscoelastic rock salt layers

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Abstract

We propose a new computational model for two-phase immiscible flow in a poroelastic medium overlain by a saline formation displaying creep behavior with viscous strain ruled by a nonlinear dependence of power-law type on the deviatoric stress. Within the framework of the fixed-stress split algorithm, hinged upon freezing the total mean stress in the flow equations, hydrodynamics and geomechanics subsystems are solved by mixed finite element methods whereas the hyperbolic equation for the water saturation is formulated in terms of the Lagrangian porosity and solved adopting an operator splitting fractional-step method combined with a higher-order non-oscillatory finite volume central scheme. Within this typical multi-physics setting, the sequential formulation allows greater flexibility in the choice of the meshes for the subsystems, particularly for the geomechanics module, which can be solved in the extended domain including the adjacent impervious formations (over-, under- and side-burdens). Considering the upper interface of the rock salt dictated by the profile of saline dome geobodies, whose impermeability property precludes hydraulic communication between adjacent formations, the initial *in situ* undrained state is also modeled by invoking Skempton's coefficient along with the characterization of the undrained bulk and shear modulus. By constructing a robust evolving algorithm between the discrete counterparts of the three subsystems in the reservoir, in conjunction with an iterative scheme underlying the mixed method for the nonlinear creep problem in the rock salt, numerical simulations of a water-flooding problem in secondary oil recovery are performed for different realizations of the input random fields. Numerical results illustrate the influence of viscoelastic effects in the cap rock upon subsidence, reservoir compaction, finger grow and breakthrough curves. Comparisons with the performance of traditional one-way formulation are also presented.

Keywords: Pre-salt reservoirs; Two phase flow; Creep and viscoelasticity; Heterogeneity; Locally conservative numerical schemes; Fixed-stress split

1. Introduction

The coupling between geomechanics and multiphase flows is becoming increasingly important in reservoir engineering as deeper formations are detected and explored. In this context the development of reliable geomechanical

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