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Energy-stable discretization of two-phase flows in deformable porous media with frictional contact at matrix–fracture interfaces

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We address the discretization of two-phase Darcy flows in a fractured and deformable porous medium, including frictional contact between the matrix–fracture interfaces. Fractures are described as a network of planar surfaces leading to the so-called mixed- or hybrid-dimensional models. Small displacements and a linear elastic behavior are considered for the matrix. Phase pressures are supposed to be discontinuous at matrix–fracture interfaces, as they provide a better accuracy than continuous pressure models even for high fracture permeabilities. The general gradient discretization framework [1] is employed for the numerical analysis, allowing for a generic stability analysis and including several conforming and nonconforming discretizations. We establish energy estimates for the discretization, and prove existence of a solution. To simulate the coupled model, we employ a Two-Point Flux Approximation (TPFA) finite volume scheme for the flow and second-order ($\mathbb{P}_2$) finite elements for the mechanical displacement coupled with face-wise constant ($\mathbb{P}_0$) Lagrange multipliers on fractures, representing normal and tangential stresses, to discretize the frictional contact conditions. This choice allows to circumvent possible singularities at tips, corners, and intersections between fractures, and provides a local expression of the contact conditions. We present numerical simulations of benchmark examples and one realistic test case based on a drying model in a radioactive waste geological storage structure.

REFERENCES

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