A COMPUTATIONAL MODEL FOR CO_2 LEAKAGE IN HETEROGENEOUS FORMATION

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In this contribution, a computational model for CO_2 leakage in a heterogeneous layered medium domain exhibiting different permeability-saturation and capillary pressure-saturation relationships is introduced. In such a domain, the saturation field exhibits a discontinuity at the boundary between layers [1]. The governing equations are derived based on the averaging theory and solved numerically using a mixed-discretization finite element approach [2,3]. The saturation field is discretized using the partition of unity finite element method, and the pore pressure field is discretized using the standard Galerkin finite element method. The finite element mesh not necessarily coincides with the boundary between layers. This discretization scheme provides an accurate and effectively mesh-independent solution. It allows the use of structured and geometry-independent finite element meshes. These features are illustrated in a CO_2 injection numerical example, defined in Figure 1. Computational results obtained from the standard finite element method and the proposed mixed-discretization method are presented in Figure 2 for five different discretizations. The figure shows that the standard Galerkin model, even with relatively fine meshes, is not capable of simulating the saturation discontinuity at the interface between layers, giving a false impression about the amount of leakage. On the contrary, the proposed mixed-discretization model is capable of capturing the discontinuity in the saturation filed, even with coarse meshes.
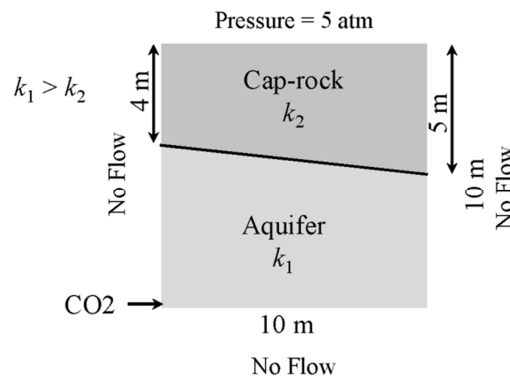

Figure 1. Geometry and boundary conditions of the CO_2 injection numerical example
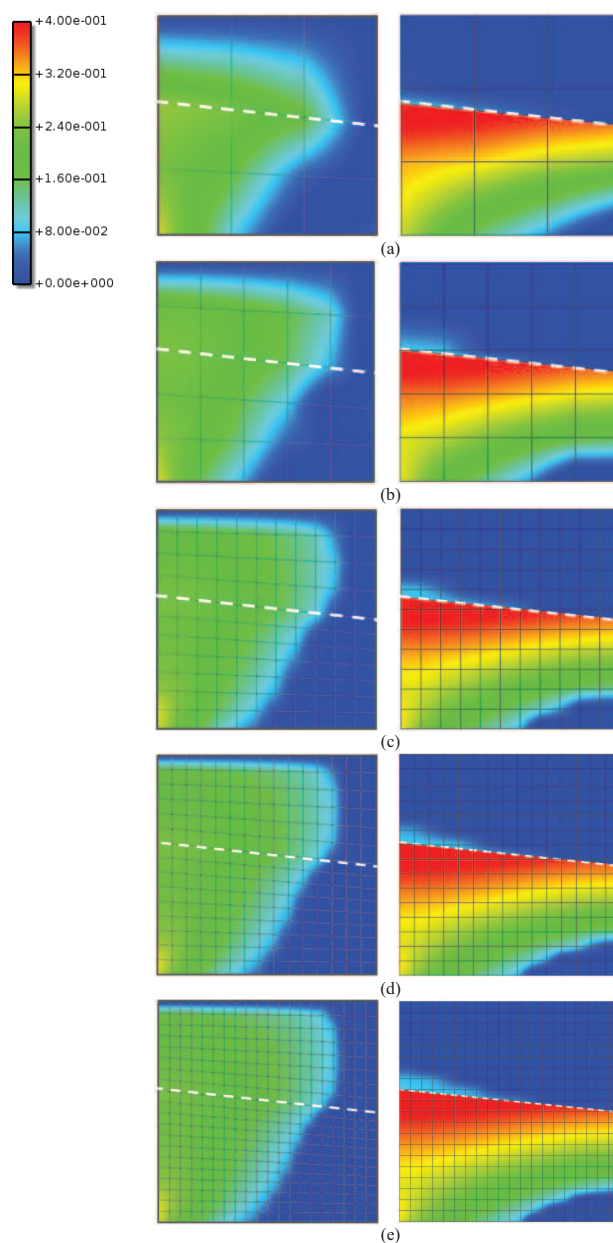
Figure 2. CO_2 phase saturation distribution at t = 82 days. Left: standard Galerkin model; Right: mixed-discretization model: a) 9 elements. b) 25 elements. c) 121 elements. d) 225 elements. e) 400 elements

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