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A new Control Volume Finite Element Method with Discontinuous Pressure Representation for Multi-phase Flow with Implicit Adaptive time Integration and Dynamic Unstructured mesh Optimization[1] PABLO SALINAS, DIMITRIOS PAVLIDIS, JAMES PERCIVAL, ALEXANDER ADAM, ZHIHUA XIE, CHRISTOPHER PAIN, MATTHEW JACKSON, Imperial College London — We present a new, high-order, control-volume-finite-element (CVFE) method with discontinuous representation for pressure and velocity to simulate multiphase flow in heterogeneous porous media. Time is discretized using an adaptive, fully implicit method. Heterogeneous geologic features are represented as volumes bounded by surfaces. Our approach conserves mass and does not require the use of CVs that span domain boundaries. Computational efficiency is increased by use of dynamic mesh optimization. We demonstrate that the approach, amongst other features, accurately preserves sharp saturation changes associated with high aspect ratio geologic domains, allowing efficient simulation of flow in highly heterogeneous models. Moreover, accurate solutions are obtained at lower cost than an equivalent fine, fixed mesh and conventional CVFE methods. The use of implicit time integration allows the method to efficiently converge using highly anisotropic meshes without having to reduce the time-step. The work is significant for two key reasons. First, it resolves a long-standing problem associated with the use of classical CVFE methods. Second, it reduces computational cost/increases solution accuracy through the use of dynamic mesh optimization and time-stepping with large Courant number.

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