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NUMERICAL FLOW SIMULATOR FOR THREE-PHASE COMPRESSIBLE FLOW IN POROUS MEDIA BASED ON A TOTAL DIFFERENTIAL COMPATIBLE CONDITION

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Abstract. A global pressure formulation for three-phase flow in porous media is introduced. The construction of Total Differential (TD) three-phase data is given for the implementation of the exact global pressure formulation for the modeling of three-phase compressible flow in porous media. This global formulation reduces the coupling between the pressure and saturation equations, compared to traditional phase formulation and improves its computational efficiency. However, the developed global pressure approach only exists for three-phase data (relative permeabilities, capillary pressures) which satisfy a TD condition. To determine TD three-phase data, a global capillary pressure function and a global mobility function are built for both water and gas saturations and global pressure level as primary variables. The numerical construction of global capillary pressure and global mobility functions by C^1 and C^0 finite elements is performed using biharmonic and harmonic interpolation.

Corresponding TD three-phase data are then given to solve fractional flow equations using an implicit global pressure-explicit saturation (IMPES) approach. Each saturation equation is treated by operator splitting i.e. a mixed-hybrid finite element method is used to solve diffusion terms while discontinuous finite element discretization deals with advection terms. The developed model is tested by comparison with analytical solutions for two-phase problems (McWhorter-Sunada, 1990 and Buckley-Levrett, 1942). The computational efficiency and robustness of the formulation is also compared for incompressible/compressible three-phase flows with the industrial flow simulator SIMUSCOPP.