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TWO-PHASE FLOW FROM THE PORE SCALE TO THE FIELD SCALE

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Summary. The prediction of two-phase flows in fractured porous media is a challenging problem, because of the multiple scales that are involved and of the nonlinearity of the governing equations, but also of the structure of the media on these scales. The present contribution is composed of two parts.

The first one is on the pore scale where the flow can be determined by means of a lattice Boltzmann algorithm. Various aspects will be discussed such as the importance of the initial conditions. Several applications to real media (geological media and industrial artefacts) will be illustrated. Moreover, propagation of acoustic waves can be analysed through these media and their speeds calculated as functions of the saturations of the two fluids.

The second part is devoted to the analysis of two phase flow in fractured porous media on the Darcy scale. Typically, the scale may vary between one and fifty meters. The mathematical framework is provided, including the transport and the constitutive equations that are eventually reformulated in dimensionless form. Dimensionless parameters and criteria are also introduced to quantify various physical regimes. In particular, an a priori criterion for the possibility of upscaling generalized Darcy's equation is devised, which is later confirmed by the numerical simulations. Then, the 3D meshing of randomly fractured media is described and the spatial and temporal discretizations of the equations and the solution algorithm are presented. The illustrative simple example of an array of infinite parallel fractures is treated analytically in order to provide a direct check of the numerical codes. A generalization for steady-state two-phase flow of the classical result of Snow for single-phase flow in networks of infinite plane fractures is given. The simulation of the flow in a closed regularly compartmented reservoir is detailed and discussed in comparison with homogenized models.

Finally, illustrative cases of complex realistic situations with random fractures embedded in a permeable rock matrix are presented. The temporal evolution of the local saturations is illustrated and discussed. Then, systematic results related to the steady-state macroscale phase relative permeabilities are given as functions of saturation, for typical situations with percolating or nonpercolating fracture networks. The influence of the other parameters is briefly considered.