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Two-Phase Flow in Fractures

Intelligent management of fractured reservoirs requires an understanding of the fluid-displacement mechanisms that are operative. Here we describe numerical simulations of two-phase that are intended to improve our understanding of the physics of fluid movement through fractured systems. The fracture is treated as an equivalent continuum, represented by means of very small grid cells (2 microns). The entire model is only 10 x 15 cm, but consists of 150,000 cells. The fracture is contained within a low-permeability layer, which is sandwiched by reservoir-quality layers. This arrangement allows the flow in the fracture to evolve without being constrained by imposed boundary conditions. A standard reservoir simulation tool is used to calculate the fluxes and saturations during injection/production at the bottom/top (respectively) of the "reservoir layers". A variety of relative-permeability and entry-pressure relationships have been investigated, along with different flow rates. In slow flow situations (capillary-dominated), more oil is displaced from the low-quality layer, and the fracture retains a high oil saturation for much of the simulation run. At faster rates (viscous-dominated), the fracture waters-out sooner, and more oil is left behind in the low-quality layer. A significant observation is that these models develop large pressure anomalies in and near the fracture during the flow experiment. This behavior suggests that it would be inappropriate to simulate fracture flow with models where pressure boundary conditions are imposed at the ends of the fracture.