Contribution ID: **599** Type: **Poster (+) Presentation**

Analytically Derived Upscaled Relative Permeability Curves for Viscous Limit Flow through Layered Porous Media

Thursday, 3 June 2021 14:40 (1 hour)

Layering is widely recognized in geologic porous media at multiple length scales ranging from the micrometer scale to the km scale. Incorporating the impact of the multi-phase flow on such heterogeneity on field-scale simulations demands upscaling not only of absolute permeability, but also the saturation functions; relative permeability and capillary pressure. If done correctly, upscaling of saturation functions preserves the flow features (sweep efficiency and micro-displacement) of the small-scale heterogeneity. Relative permeability upscaling, therefore, is one of the most important steps in reservoir simulation studies.

This study presents a mathematical approach for relative permeability upscaling devised specifically for non-communicating strata. Analytical solutions describe saturation and pressure distribution in each layer in the viscous limit. They are presented in a non-dimensional form derived for both linear and radial flow. Unlike the majority of earlier studies that assume piston-type displacement, our new solutions consider the complexities of frontal advance theory, including the rarefaction waves that follow the sharp flood fronts. However, potential gravity tonguing is ignored. The different multiphase flow properties of each layer (e.g. porosity, permeability, relative permeability endpoints, etc.) are taken into account by our new formulation. Three flow stages, each with its unique time-dependent characteristic variable, are considered for each layer. The overlap among the flow stages in the different layers determines the overall shape of the solution.

Our solutions enable a straightforward evaluation of the dynamics enameled in the relative permeability: the unsteady-state ensembled relative permeability is space-dependent with discontinuities associated with the flood-front saturation jumps. A comparison between the unsteady-state performance and the performance based on the commonly used steady-state upscaled relative permeability curves highlights the inadequacy of steady-state upscaling for viscous-limit flows. It also reveals the capability of the new relative permeability functions to predict the behaviour over the whole flow saturation range, not only for when both phases are mobile between the residual saturations. Beyond the interpretation of laboratory experiments, the applicability of this approach to field-scale simulation is discussed under a newly proposed dual-stage simulation technique.

Time Block Preference

Time Block B (14:00-17:00 CET)

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