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About long time asymptotic solutions of non-linear counter current two-phase flow in rock matrix blocks

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Counter-current flow can be encountered under quite general conditions in two D or 3D two-phase flows in fractured medium. It may describe the imbibition of a wetting fluid replacing a non-wetting fluid inside the rock matrix. As the first order term of the driving transport equation drops-out, the resulting transport equation is a singular non-linear diffusion equation.
Although the early time solution of such equations is quite well known, it turns out that the long-time asymptotics describing the asymptotic decay of the overall non-wetting fluid saturation is less known.
In that contribution, we develop a general self-similar solution, the time dependance of which is a power law of time, with an expoennt related to the NAPL rel perm decay at law NAPL saturation. The spatial part of the solution can be computed using a suitable fixed point algorithm that solves a non-linear eigenvalue problem. In stratified media, a complete analytical solution can be developped. In the genral case, numerical tests performed with accurate complete simulations confirm the relevance of that solution for many matrix block shapes. Consequences about the matrix to fracture overall fluw are also expected.
As the convergence of the solution to its asymptotic appears to be quite slow, a perturbative approach was developped to get a firther understanding of that observation. That allows us to develop an asymptotic solution under the form of a series of time power-laws that may describe the NAPL overall saturation decay once lower than 40% of its initial value.
Such solutions may be used to look for physically based proxys of matrix to fracture exchanges well-suited for developping an averaged description when considering a population of matrix blocks of random sizes and shapes.
In that talk, we will present previous findings published in following paper, as well as more recent results.
Douarche, F., Braconnier, B., Momeni, S., Quintard, M., & Nœtinger, B. (2022). Counter-current imbibition and non-linear diffusion in fractured porous media: Analysis of early-and late-time regimes and application to inter-porosity flux. Advances in Water Resources, 169, 104319.

Participation

In-Person

References

Douarche, F., Braconnier, B., Momeni, S., Quintard, M., & Nœtinger, B. (2022). Counter-current imbibition and non-linear diffusion in fractured porous media: Analysis of early-and late-time regimes and application to inter-porosity flux. Advances in Water Resources, 169, 104319.

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