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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 dependence of which is a power law of time, with an exponent related to the NAPL relative permeability decay at low 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 developed. In the general 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 flow are also expected.

As the convergence of the solution to its asymptotic appears to be quite slow, a perturbative approach was developed to get a further 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 proxies of matrix to fracture exchanges well-suited for developing 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., & Nøttinger, 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., & Nøttinger, 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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