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# Macroscopic model for flow in exuding porous media

*Tuesday, 1 June 2021 11:30 (15 minutes)*

Single-phase macroscopic flow in a rigid porous medium is traditionally described by classical Darcy's law which can be formally derived by upscaling the pore-scale flow equation in the creeping incompressible flow regime and the no-slip condition at the solid-fluid interfaces. However, there are many situations for which fluid release from the surface into the pores or, conversely, absorption from the pores into the solid through the interfaces may occur. To cite some but a few, this case is encountered in drying (Vu & Tsotsas, 2018) and pyrolysis (Mahmoudi et al., 2014) of porous materials, vapor bubble migration in ice due to temperature gradient (Shreve, 1967) or processes for which a chemical reaction in a porous material leads to a net production of fluid from the surface into the pores or, conversely, absorption from the pores into the solid through the interfaces. This translates into a local normal flux at the solid fluid-interface, featuring a generic problem which may be referred to as flow in exuding porous media. Although classical Darcy's law has been widely heuristically employed to describe this type of flow, the question remains on the physical relevance of such an assumption.

In this work, the upscaling of low Reynolds number incompressible Newtonian flow in a rigid homogeneous exuding porous medium is performed using a mixed volume averaging/adjoint method. The upscaled model shows that the macroscopic velocity is non-solenoidal despite incompressibility. Moreover, the macroscopic momentum equation involves a Darcy term with the classical intrinsic permeability tensor corrected by a vectorial term including an effective component related to the local fluid displacement induced by exuding effects and, in some special cases, a compensation to non-locality. The two effective coefficients are obtained from a single intrinsic ancillary (closure) problem (Lasseux et al., 2021). The relevance of the macroscopic model is illustrated in many different examples through comparison between pore-scale numerical simulations and the macroscopic model predictions, showing excellent agreement. The results of this work motivate further research about the influence of internal flow sources in transport phenomena in porous media.

## Time Block Preference

Time Block A (09:00-12:00 CET)

## References

Lasseux, D., Valdés-Parada, F. J., Thovert, J.-F. & Mourzenko, V. 2021 Exuding porous media: deviations from Darcy's law. Journal of Fluid Mechanics 911, 10.1017/jfm.2020.1081.
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Shreve, R. L. 1967 Migration of air bubbles, vapor figures, and brine pockets in ice under a temperature gradient. Journal of Geophysical Research 72, 4093–4100.
Vu, H. T. & Tsotsas, E. 2018 Mass and heat transport models for analysis of the drying process in porous media: A review and numerical implementation. International Journal of Chemical Engineering 2018, 9456418.

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