MULTIPHASE FLOW OF VISCOELASTIC FLUIDS IN POROUS MEDIUM SYSTEMS: A MULTISCALE MODELING APPROACH

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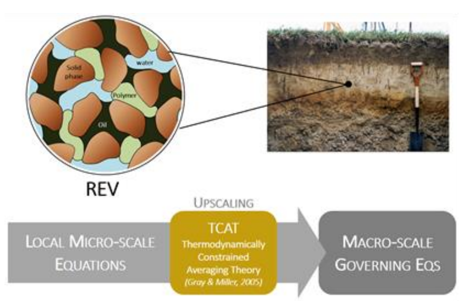
Multiphase flow of complex immiscible fluids in porous media is central in a lot of engineering applications so modeling of such a problem is of practical and scientific interest. Macroscale mathematical models exist but very often they have a weak phenomenological link with the microscale behavior since the governing equations do not emerge from a formal upscaling procedure. Actually the representativeness of available macroscopic models is quite limited in the sense that they do not capture fluid-fluid and fluid-solid interaction that take place on pore scale. The aim of our work is to fill this gap using the Thermodynamically Constrained Averaging Theory (TCAT), a recent and general mathematical framework for modeling of reactive multiphase flow in porous medium systems. TCAT allows to properly defining a rigorous connection between micro- and macro- scales. In fact, by formally averaging the microscale equations up to the macroscale scale (rather than postulating them directly at the larger scale), larger scale variables are expressed precisely in terms of microscale precursors and all assumptions and simplifications that are used to obtain the final system of macroscale equations are known explicitly. TCAT also provides guidance for definition of constitutive relationships that are typically required to obtain a solvable system of equations (e.g. pressure-saturation relationships, phase relative permeabilities, etc.).
The methodology proposed in the thesis has three main work-packages
1) to develop a reliable microscale multiphase model for which measured parameters are direct input for the numerical simulation and validate it with proper microfluidic experiments;
2) to up-scale this microscale model following the TCAT procedure to obtain a macroscale multiphase model;
3) to perform *in silico* experiments with the microscale multiphase model accounting for micro-scale geometrical and material parameters allowing us to derive microscale-informed constitutive relationships to be injected in the macroscale formulation.
To stress the method and finding, microfluidic experiments will be performed on well characterized fluids in well-defined microfluidic chips.



Multiscale modeling approach by mean of TCAT: the representative elementary volume (REV) is a point at the macroscopic level.