université de BORDEAUX

PhD thesis
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Ecole Doctorale
des Sciences Physiques et de l'Ingénieur

Title: A multiphase model for flow of viscoelastic fluids in porous media

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Research Laboratory: **I2M / *Institut de Mécanique et d'Ingénierie – Bordeaux* (CNRS UMR 5295)**

Scientific domain: **COMPUTATIONAL MECHANICS***

*The ideal candidate should have expertise in continuum mechanics, constitutive modeling, numerical solution methods, scientific programming.

Abstract

The PhD thesis aims to develop a model for multiphase flow of a viscoelastic fluid through a porous medium saturated by one or two other fluids. This model will be established within a general mathematical framework and then specialized for application in biomedical field (tumor growth modeling) and petroleum engineering (enhanced oil recovery, EOR).

At the state of the art, multiphase models for flow in porous media are usually based on extensions of Biot's theory; often the mathematical model is directly formulated at the macroscale, or – and this is preferable – it is obtained by upscaling microscale conservation equations. This second option is the most suitable because it allows to properly define the connection between micro- and macro- scales and to know all assumptions and simplifications needed to obtain the final system of macroscale conservation equations.

A general mathematical framework for multiphase porous media mechanics has been recently provided by Thermodynamically Constrained Averaging Theory (TCAT) (Gray and Miller, 2005). TCAT allows developing mathematical models for multiphase systems at any scale of interest and assures a rigorous connection between microscale and larger scale conservation equations. However, once mathematical upscaling is achieved a number of constitutive relationships are typically required to obtain a solvable system of equations (*e.g.* pressure-saturation relationships, phase relative permeabilities, etc.). These constitutive relationships can be often obtained experimentally; nevertheless, depending on specific features of the analyzed multiphase system (*e.g.* fluids' viscoelasticity, chemical reactions, etc.) a proper experimental setup for detection of macroscale constitutive behavior (representative of the microscale physics) can be difficult to realize.

In this PhD thesis a microscale multiphase model will be developed for overcoming these difficulties. This model must be rich enough to properly represent porous microstructure and to allow identification of major factors impacting relative mobility of fluids. Pore scale modeling will facilitate definition of sound constitutive relationships which will be used for closure of a continuum multiphase model at a larger scale: relevant experiments will be performed numerically accounting for micro-scale geometrical and material parameters (porous microstructure, fluids relative wettability, fluid-fluid interfacial tension, etc.); then numerical upscaling will give information for the derivation of microscale-informed constitutive relationships to be injected in the macroscale model.

REFERENCES

W. G. Gray and C. T. Miller. Thermodynamically constrained averaging theory approach for modeling flow and transport phenomena in porous medium systems: 1. motivation and overview. *Advances in Water Resources*, 28(2):161–180, 2005.

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