Thursday 2 October at 2 pm, (Room K118, first floor of building "K", LEGI)

Professor S. Majid Hassanizadeh (Utrecht University)

"Capillarity in Porous Media Revisited"

Abstract:

In many soil and aquifer systems, one encounters simultaneous movements of two or more immiscible fluids. These systems are modeled using a modified form of Darcy's law, mass or volume balance equations, and an

empirical relationship between capillary pressure and saturation. The general understanding is that capillary pressure is equal to the difference in pressures of two fluids. At microscale, this difference is given by the Young-Laplace equation, which prescribes an inverse relationship with the mean radius of curvature. At macroscale, the difference in fluid pressures is assumed to be an algebraic empirical function of saturation. In this lecture, we show that capillary pressure is not always equal to the difference in pressures of two fluids. We provided a unifying approach to the theory of capillarity based on rational thermodynamics and present alternative definitions of capillary pressure on both micro- and macroscales. In particular, we make a clear distinction between capillary pressure and pressure difference of fluids. In fact, based on theoretical, experimental, and computational results, we show that the difference in fluid pressures is a function of boundary conditions and dynamic properties of the system, such as flow rate or dynamic viscosities. But, the capillary pressure is considered to be an intrinsic property of the fluids/solid system and independent of dynamics of the system. We show that by introducing specific interfacial area (area of fluid/ fluid interfaces per unit volume of porous medium) as a new state variable, we can model capillary hysteresis. Then, instead of many capillary pressure-saturation curves, we should have a single capillary pressure-saturation-interfacial area surface. Theoretical, experimental, and computational evidences are presented to support the above-mentioned hypotheses. Also, a truly generalized Darcy's law is provided for two-phase flow.