- PhD Position -

Combined modeling and Magnetic Resonance Imaging (MRI): a novel approach for characterizing the fate of solutes in complex porous media

Applications are invited for a three-year PhD position at the interface between transport in porous media and magnetic resonance imaging (MRI) at the Navier Laboratory (Paris, France) and EMMAH laboratory (Avignon, France).

Context. In both civil engineering and environmental sciences, the transport of solutes through complex porous media is a matter of concern. Chloride ions may penetrate into the pores of the concrete, and corrode its steel reinforcements. This may affect the durability of the structures, and lead to their collapse. Similarly, harmful chemicals may infiltrate through the soil, reach the aquifers and impair the quality of groundwater.

Current methods for measuring the permeability of concretes to chloride ions cannot readily be transposed to concretes made of geopolymers, a promising environmental friendly alternative to traditional cement. Similarly, the transport properties from the soil surface to the groundwater of newly marketed perfluorinated surfactants - a class of persistent organic pollutants - have not been assessed yet.

Job description. An innovative approach that combines numerical modeling and magnetic resonance to study solute fate in complex porous media was developed recently at Navier and EMMAH.[(1)] This approach is able to open the black box constituted by the porous media and provides time-resolved quantitative data on the amount of solute *inside* the porous media, *in different environments* (e.g. adsorbed, in solution) during *batch experiments*.

The PhD student will:

- Extend this approach so that it can provide spatially resolved data (for example as a function of sample depth) during column scale *transport experiments*.

- Test the extended MRI approach to record the dynamics of solute transport (and retention if applicable) in porous media of increasing complexity (ranging from quartz sand to unsaturated and undisturbed soil cores or geopolymer concrete) and identify the environment of the solute.

- Compare the MRI data to the outputs of a solute transport model that will be adapted from the models currently available within the VSoil modeling platform[(2)] developed at EMMAH.

- Use this extended MRI approach to tackle a selection of scientific questions related to the fate of chlorine in geopolymer cements and perfluorinated surfactants in soils.

Requirements. We seek candidates who demonstrate willingness and ability to study solute transport in complex porous media *both on an experimental and modeling point of view*. Previous experience with NMR or MRI would be highly appreciated but not mandatory. A successful candidate with no previous NMR or MRI experience will be trained in these techniques and become a knowledgeable user. Similarly, previous experience with modeling would be highly appreciated but not mandatory. The VSoil platform is a user-friendly tool to take its first steps as a modeler. The candidates should hold a master degree in physics, physical chemistry, environmental sciences, computational sciences, or applied mathematics with *excellent grades*. *Good oral and written command of English or French is required*.

About Navier and EMMAH labs. The successful candidate will share its time between Navier and EMMAH laboratories. Navier[(3)] is located in Champs sur Marne, twenty minutes train ride east of Paris, and offers a high level scientific working environment. It is equipped with an MRI system adequate to study porous samples[(4)] and has extensive experience on studying solute transport by MRI. EMMAH[(5)] offers a friendly and effective working environment settled in Provence (city of Avignon) at a one-hour drive north of the Mediterranean sea. It has a substantial expertise in the study and modeling of water, solutes and colloids transfer in soils and hosts the scientific head and development team of the VSoil modeling platform.

How to apply: Applications should include a resume and a copy of master degree grades, as well as contact information for one or two references and should be sent by April, 3rd 2018 to:

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(1) https://pubs.acs.org/doi/10.1021/acs.est.6b05671
(2) https://www6.inra.fr/vsoil
(3) http://navier.enpc.fr/?lang=en
(4) http://www.respore.fr/en/equipements/mri-navier
(5) https://www6.paca.inra.fr/emmah_eng/