6 month Master 2 thesis

– Laboratoire Géosciences Rennes (France) –

«An analog model of solute transfer through porous river beds»

Deadline for application: 01/12/2019

Internship dates: 6 months between February and September 2020

Supervisors: Joris Heyman (CNRS) & Tanguy Le Borgne (CNAP)

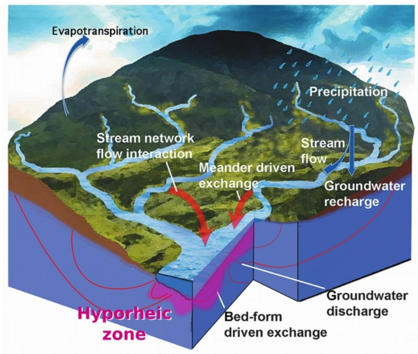

Figure 1: The hyporheic zone forms a thin interface where rapidly flowing, young surface waters mix with older groundwaters in the riverbed sediment.

This ecotone presents strong physico-chemical gradients that are believed to promote biogeochemical activity. Figure modified from Boano et al. 2014 [1]

Context The hyporheic zone – named from the Greek hypo (under) - rheos (flow) –, is a sharp and puzzling interface connecting surface water (rivers) to the groundwater (aquifers) [1,2,3,4]. Sharp, because its thickness (a few meters) is small compared to the typical scales involved in the critical zone (several kilometers), and also because strong biogeochemical gradients[5] develop in this layer, in response to mixing between surface and subsurface water of differing ages and compositions (Fig 1). Puzzling, because of its key, yet debated, role in altering biogeochemical signals at the basin scale, notably on greenhouse gases such as nitrous oxide[6] (via denitrification), carbon[7](via biomass production) and other contaminants such as arsenic (via redox reactions)[8]and nitrates (via nitrification)[9]. Today, a better understanding of the small-scale flow processes occurring through the hyporheic interface is necessary to correctly model hyporheic exchanges of river beds. An appealing strategy to gather such new knowledge is via the experimental study simplified analogical models[10] of the hyporheic zone.

Objectives The first objective of the internship is to adapt an experimental setup available in the laboratory to monitor hyporheic fluxes under controlled surface and groundwater flow conditions. The student will work in collaboration with an engineer to recreate an analog model of the hyporheic zone that preserve physical significance. The second objective is to calibrate the model in terms of surface turbulence and porous fluxes, sediment roughness and permeability and basic solute transfer via specific optical methods (PIV, laser induced fluorescence). These techniques have been developed by the host team during several years and has reach a great level of maturity.

Research team The Géosciences Rennes laboratory team gathers 160 scientists of various background: physics, fluid mechanics, geophysics, geochemistry and geomorphology. It is located in a dynamical campus in the middle of an historical town, Rennes, at 1h25 of Paris. Hyporheic exchanges have been already considered in the lab through river-groundwater exchanges at medium to large scales (1m-1km) in local rivers (Olivier Bour, Alain Crave, Camille Bouchez). In turn, the recent experimental breakthroughs in porous columns (ERC ReactiveFronts, Tanguy Le Borgne) offer promising perspective for a finer characterization of hyporheic flows linking pore scale to the reach scale, and a possible reinterpretation of field data. The student will join a 4 years research project founded by the French National Science Agency and starting in 2020. The student will work in close collaboration with 2 senior researchers (Joris Heyman and Tanguy Le Borgne), 1 Engineer, 4 post-doc researchers and 4 PhD students. The project offer possible collaborations with Australian and Austrian colleges.

Required skills The applicant should be in the course of a Master 2 degree (or equivalent) in the domain of Engineering, Mechanics, Physics, or Geosciences. Good knowledge of the mechanics of porous and open fluid flows is required. A strong desire to work with experimental apparatus is required. A basic knowledge of scientific programming is expected, and will be reinforced during the internship (including Python, Matlab, OpenFoam, ...). Further abilities includes : autonomy, writing skills, sense of synthesis. A boundless curiosity is not a shortcoming.

Professional openings Academic research, Water resources management, Natural hazards prediction, Climate change policies, Oil industry. **Possibility to join a 3-years PhD program after the internship.**

Application:

- CV and cover letter demonstrating your interest with the thesis subject, and your carrier objectives.
- Master 1 and Master 2 provisional grades.

Applications have to be submitted by email before **01/12/2019** to Joris Heyman : joris.heyman@univ-rennes1.fr

1. Boano et al. (2014) *Rev. Geophys.* 52, http://doi.org/10.1002/2012RG000417.
2. Cardenas (2015) *Water Resour. Res.* 51, http://doi.org/10.1002/2015WR017028.
3. Brunner et al. (2017) *Rev. Geophys.* 55, http://doi.org/10.1002/2017RG000556.
4. Hester et al. (2017) *Water Resour. Res.* 53, http://doi.org/10.1002/2016WR020005.
5. O'Connor et al. (2008) *Water Resour. Res.* 44, http://doi.org/10.1029/2008WR007160.
6. Marzadri et al. (2017) *Proc. Nat. Acad. Sc.* 114, http://doi.org/10.1073/pnas.1617454114.
7. Argerich et al. (2016) *J. Geophys. Res. G: Biogeosci.* 121, http://doi.org/10.1002/2015JG003050.
8. Datta et al. (2009) *Proc. Nat. Acad. Sc.* 106, http://doi.org/10.1073/pnas.0908168106.
9. Duncan et al. (2015) *Water Resour. Res.* 51, http://doi.org/10.1002/2015WR016937.
10. Chandler et al. (2016) *Water resources research* 52, http://doi.org/10.1002/2015WR018274.