PhD thesis in Applied Geophysics

Experimental and numerical characterization of organic pollutant transport and bioremediation processes using the induced polarization method

Location of the position: Sorbonne University, UMR METIS (Paris) 80%; and BRGM (Orléans) 20%
Starting date: October 2022
Contract: Doctoral contract for 3 years
Funding: funded through ANR IMAGE (50%) and BRGM (50%)

Institutions:

- Sorbonne University
- BRGM (French Geological Survey)

Doctoral School: ED GRNE (Geosciences, Natural Ressources and Environment)

Research units in Sorbonne University: UMR METIS (Milieux Environnementaux, Transferts et Interactions dans les hydrosystèmes et les Sols)
BRGM units:
Risks and Prevention Department, Geophysical Imaging and Remote Sensing Unit (DRP/IGT),

Supervision:
Damien Jougnot (Main supervisor) – Forward model in METIS; Roger Guérin (co-supervisor) – Geophysical inversion in METIS; Pauline Kessouri (co-supervisor) – Experimental part in BRGM; Jacques Deparis (co-supervisor) – Data processing in BRGM

PhD thesis subject abstract

This thesis is part of the scientific program of the IMAGE project (French national research agency). The main objective of the IMAGE project is to explore, at different structural scales, from nm to ~10 m, the induced polarization (IP) signature of biogeochemical processes related to the biodegradation of hydrocarbons in the soil (in particular LNAPLs). Through theoretical, numerical and experimental work at different scales (from the representative elemental volume to the field), the IMAGE team will improve the accuracy and quantitative interpretation of the IP measurements.

In this thesis work, we aim to develop: (i) macro-scale petrophysical relationships linking complex conductivity to LNAPL biodegradation processes and (ii) inversion schemes of macro-scale IP measurements for imaging and interpretation of field-scale measurements. These developments will be supported by IP and biogeochemical measurements in the laboratory (cm to m scale, PRIME platform managed by BRGM) and using a highly instrumented multi-meter pilot (also PRIME platform) in which experiments will be conducted in permeable alluvium under controlled field conditions.

This thesis will contribute to further develop the use of the IP method for the quantitative characterization and monitoring of contaminated sites where petroleum hydrocarbons are biodegraded, thus providing new tools to improve the efficiency of in situ bioremediation, in order to sustainably treat subsoil resources (soils and water) for the ecological transition.

Objectives - main research questions

The main objective of the thesis is to answer the question: can we model and inverse the IP response induced by organic pollutant transport and bioremediation processes?

To answer this primary research question, several underlying questions will also need to be investigated during the course of the thesis:

- To which biogeochemical parameters and processes is IP most sensitive at the cm scale and beyond?
- What petrophysical models can be used to link biogeochemical processes and geophysical measurements?
- How can these direct models be integrated into a Bayesian inversion framework?

Keywords: Biogeophysics, Induced Polarization, forward and inverse modelling, organic pollutants, bioremediation

Formation - Requirements

You have a Master degree (Master 2 research, engineering school or equivalent) with an initial training in geophysics or physics. You have good knowledge in numerical modeling and Bayesian inversion based on the physics of natural processes. Computer skills are essential.

A good knowledge of geophysical modeling, biogeochemical processes, soil physics and applied mathematics will be appreciated. An interest in laboratory experimentation, as well as an availability for field measurement missions is expected.

Activities during the PhD:

- Participate in the ANR project associated with this thesis (ANR IMAGE);
- Contribute to the scientific communication;
- Carry out laboratory measurements, and development of inversion code;
- Provide expertise in the careful and accurate performance of laboratory measurements;
- Coordinate the team and organize progress meetings.

Required skills:

- Proficiency in a computer language such as Python;
- Ability to identify scientific issues and barriers;
- Strength of proposal with the taking in hand of the scientific questions, initiatives to solve these questions;
- Interest in leading and working in a team, supervising junior engineers/undergrad or Master, exchanging with supervisors and other PhD students;
- Organizational skills in order to manage the series of measurements in the laboratory;
- Ability to communicate and dialogue according to the interlocutor, i.e. be pedagogical and sharp;
- Ability to synthesize and write reports, memoirs, articles;
- Fluent in English for reading and writing articles, and for speaking at conferences. French language is not mandatory but would be a plus

How to apply:

Please send your application in French or English (updated CV and cover letter) before *31/05/2022* to the supervision team damien.jougnot@upmc.fr, roger.guerin@sorbonne-universite.fr, p.kessouri@brgm.fr, j.deparis@brgm.fr

References

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