INTERNATIONAL M2 INTERNSHIP (FRANCE-ARGENTINA) : SOLIDIFICATION AND FLOW IN POROUS MEDIA

Supervisors : Thomas Séon (CNRS), Axel Huerre (CNRS)
Laboratories :
- Institut Franco-Argentin de Dynamique des Fluides pour l'Environnement (Buenos Aires)
- Matière et Systèmes Complexes (Paris)
Collaborations : M. Verónica D'Angelo (GMP, UBA), Christophe Josserand (LadHyX, CNRS)
Contacts : thomas.seon@cnrs.fr, axel.huerre@cnrs.fr, vdangelo@fi.uba.ar

Internship topic

Permafrost covers one-fifth of the planet's land surface. It consists of a first layer a few meters below the surface, known as the *active* layer, which freezes in winter and thaws in summer, situated above a thicker layer of soil constantly below the freezing point. The presence and displacement of a solidification front in the soil can cause underground water flows and change the soil structure, leading to the emergence of surprising shapes on the surface, some examples of which are illustrated in the figure below (left). With global warming and thawing permafrost, this type of event will become increasingly frequent, altering landscapes, their ecosystems, and infrastructures.

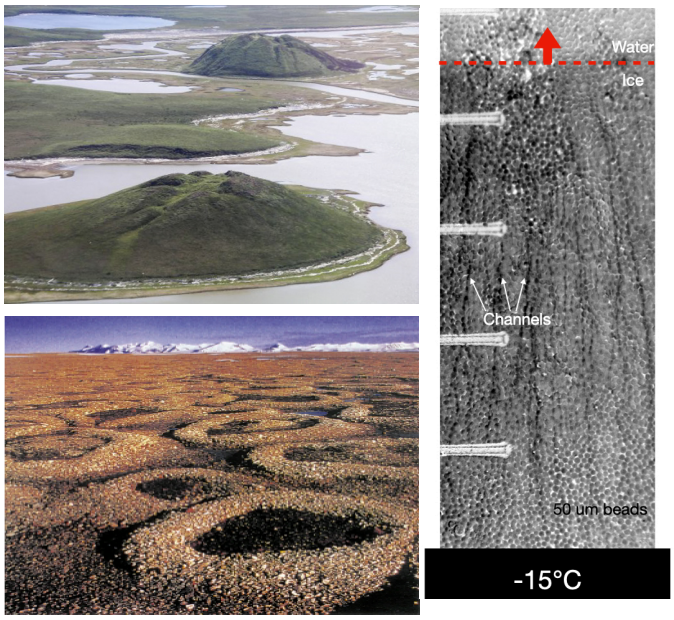

Figure: (Left top) Pingos near Tuktoyaktuk, Canada. A pingo is a land-covered ice hill (200 m wide) found in regions where permafrost, water, and loose soil coexist, such as the Arctic, Subarctic, and Antarctic. (Left bottom) Ring-shaped structures (1-2 m in diameter) above the permafrost on the Svalbard archipelago. (Right) Lab scale experiments of a frozen granular media. A pile of microbeads plunged in water is frozen from the bottom. The solidification front (red line) goes up and leaves behind channels that are larger than the inter-bead spaces.

All these behaviors are poorly understood. Indeed, the associated physical mechanisms are still unclear, and we lack consistent predictive models for heat transport, phase change dynamics, and induced groundwater flows in these complex media. The aim of this work is therefore to gain a better understanding of solidification in porous media and induced flows. To this end, we propose to carry out an **experimental study of freezing dynamics in two model porous media soaked in water**: a granular medium and a hollow solid matrix.

We propose to start by studying solidification dynamics in a stack of water-soaked grains. This stack could be placed between two plates, more or less close together, or in a tube. A typical experiment in a tube is presented on the right of the figure above. The propagation dynamics of the freezing front will be studied, paying particular attention to the coupling between the displacement of the front, the induced liquid flows, and the movement of the grains. Grain size, initial compaction, thermal parameters, and Young's modulus (from hard to deformable) will be varied. We will use model grains (ceramic and glass beads) and grains from real soils (clay, silt, sand). The structure of the granular medium when frozen, and after several freeze-thaw cycles, will be studied and interpreted. This work will enable us to improve our understanding of the mechanisms associated with soil freezing and thawing, and thus be able to predict the consequences, ranging from pavement destruction to the overall behavior of permafrost over the coming decades.

Working environment

The internship projet is part of the creation of the International Research Laboratory (IRL) *Institut Franco-Argentin de Dynamique des Fluides pour l'Environnement* (IFADyFE) in Buenos Aires (Argentina). It will be realised either in Buenos Aires at the IRL or at the *Matière et Systèmes Complexes* (MSC) laboratory in Paris (France) depending on the candidate's preferences. It will be supervised by Thomas Séon (IFADyFE - CNRS) and Axel Huerre (MSC - CNRS), in collaboration with M. Verónica D'Angelo (CONICET & UBA) of the *Porous Media Group* at the University of Buenos Aires and Christophe Josserand (Ecole polytechnique & CNRS) of *LadHyX* in Palaiseau (France).
The internship might be followed-up by a 3-year PhD contract as part of the 2024 edition of the CNRS international PhD program.