

Master 2 internship 2026–27

Modeling the action of seasons on frozen grounds

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Permafrost (soil staying frozen at least two years in a row) is present on a fifth of emerged lands on Earth. The upper part of those soils, called the *active layer*, is cyclically frozen and thawed under the action of seasons (Fig. 1 and 2). The cyclic displacement of a freezing front in the active layer causes ground deformation and water flow. On a long term, those movements lead to ice segregation (Fig. 1) and pattern formation at the ground surface (Fig. 3). The physical mechanisms responsible for the formation of such morphologies are still not fully identified. However, it is essential to understand them in the current context, as the amplitude of the seasonal forcing is being altered by global warming, leading to irreversible changes in soil structure in the periglacial domain that causes landslides and alteration of the local hydrology.

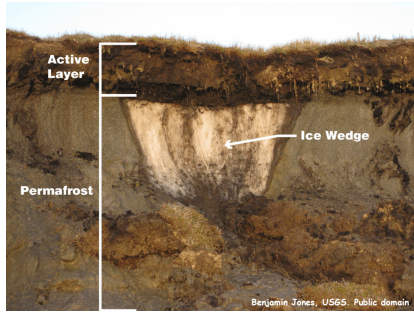


FIGURE 1 – Ground failure in the periglacial domain revealing an ice formation segregated from the surrounding soil [1].

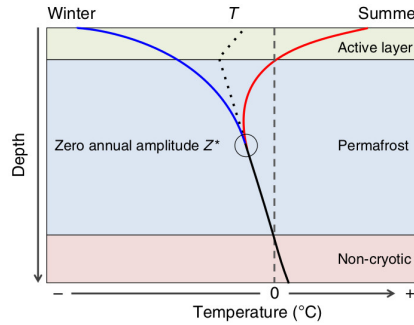


FIGURE 2 – Temperature profile as a function of depth for a periglacial soil. The *active layer* corresponds to the superficial part of the soil that thaws each summer [2].

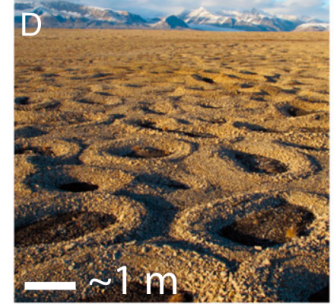


FIGURE 3 – Circles of stones in Svalbard, Norway [3].

At the Institut de Rennes, we have developed several laboratory analogs of an active layer in order to measure and understand the interaction between a freezing front and the porous material through which it moves. We use wet granular material as soil models and apply to them controlled temperature gradients mimicking the seasonal changes. Our goal is to measure the movements of the different phases of the system during the front displacement, to understand the mechanisms governing the internal changes and to propose physical models of the observed dynamics.

The aim of the internship is to study the displacement of a frozen front in a quasi-2D transparent cell submitted to a controlled temperature gradient. Images of the system during the process will allow to quantify both the grains displacement and water flows. The work will involve preparing samples, conducting experiments, analyzing images to identify the displacements of the different phases, and finally analyzing the results obtained in order to model them.

The internship will suit a student who enjoys experimental physics. A good background in continuum mechanics, thermodynamics and statistical physics is required. It will be supervised by Loredana Lazar, 3^d year PhD student, and Axelle Amon, her thesis advisor, at the Institut de Physique de Rennes (Rennes, France). The internship can be followed by a PhD thesis.

[1] <https://climatekids.nasa.gov/permafrost/>

[2] B. K. Biskaborn, *et al.*, *Nature communications*, **10**, 1 (2019).

[3] A. Li, *et al.*, *PNAS*, **118**, e2110670118 (2021).