Master internship 2023–24

Modeling the action of seasons on frozen grounds

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A fifth of the emerged lands on Earth are in the periglacial domain. In these areas, which corresponds to high latitude or altitude, the radiative balance is negative so that soils are frozen either permanently (the so-called permafrost) or during a large part of the year. Field observations show that periglacial soils display spatial structures both at their surface (patterned ground, figure 1) and in their depth (segregation of the ice from the surrounding soil, figure 2). Those patterns are indicators of the existence of fluxes in frozen grounds, driven by the alternation of seasons. Indeed, the thermal cycling of the surface generates temperature oscillations in the bulk, the amplitude of which decreases with depth (see figure 3). Understanding those flows is all the more important as the dynamic temperature gradient is altered by global warming, generating irreversible changes in soil structure, which in turn can be the cause of fractures and landslides.

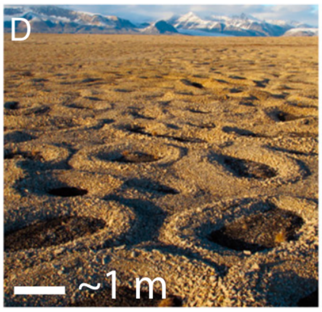

FIGURE 1 – Circles of stones in Svalbard, Norway [1].

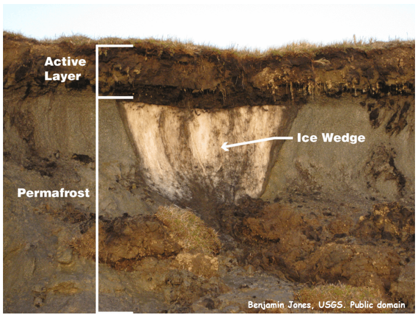

FIGURE 2 – Ground failure in the periglacial domain revealing an ice formation segregated from the surrounding soil [2].

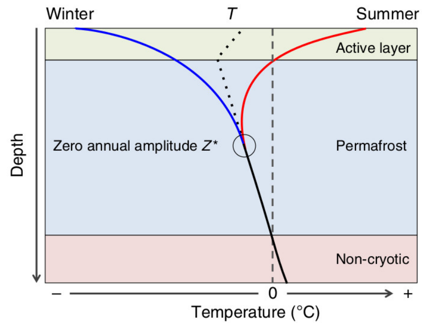

FIGURE 3 – Temperature profile as a function of depth for a periglacial soil. The *active layer* corresponds to the superficial part of the soil that thaws each summer [3].

The aim of the internship is to develop a model experiment in order to reproduce thawing/freezing cycles on a frozen soil in the laboratory and study the effect of such a dynamical temperature gradient on a model permafrost.

The model soil will consist in a granular material (typically glass beads or sand) mixed with a controlled amount of water. The experiment will be placed in a freezer and a heating device will be placed at the top of the sample to simulate the action of season on the soil. Different geometries will be used (3D or quasi-2D) coupled to specific methods of vizualisation to measure water fluxes and rearrangement of grains in the system. The resulting movements and emerging patterns will be analysed and modeled.

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 Axelle Amon at the Institut de Physique de Rennes (Rennes, France).

The internship can be followed by a PhD thesis. In that case, the student will join a collaborative project implying Thomas Séon (Institut Franco-Argentin de Dynamique des Fluides pour l'Environnement - CNRS, Buenos Aires, Argentina) and Axel Huerre (Matière et Système Complexe - CNRS, Paris, France).

[1] A. Li, *et al.*, *PNAS*, **118**, e2110670118 (2021).
[2] `https://climatekids.nasa.gov/permafrost/`
[3] B. K. Biskaborn , *et al.*, *Nature communications*, **10**, 1 (2019).