

**Phase transitions and confined crystallization in inelastic
geomaterials
(Newpores project)**

NewPores research project presentation

NewPores is an international hub dedicated to the mechanics and physics of porous materials, which intends to answer to new Energy and Environment challenges. This is a joint effort of the group on Geomechanics and Porous Materials (G2MP) of the Laboratoire des Fluides Complexes et leurs Réservoirs at E2S UPPA (France), the Centre for Sustainable Engineering of Geological and Infrastructure Materials (SEGIM) at Northwestern University (USA), the University of Vigo (Spain), the Technical University of Madrid (Spain) and University of Liège (Belgium).

Phase transitions and confined crystallization in inelastic geomaterials

Geomaterials are porous, discrete and heterogeneous media exposed to environmental interactions. These materials host multiple fluids with which they establish physico-chemical feedbacks. During the last decades, major shifts in climate and the continued exploration of remote environments encouraged the study of phase transitions within the pores of soils and rocks, which include salt crystallization, mineral precipitation, freeze/thaw dynamics, and methane hydrate dissociation, among others. Phase transitions are a key source of weathering, as they cause unprecedented alterations in the strength and deformation properties of natural deposits. Major challenges for the future generations are especially in the context of arctic regions, which are warming faster than everywhere else on Earth. In particular, scarcity of data and lack of scientifically sound predictive models make it very challenging to predict future scenarios. This opens the possibility of unprecedented risks for natural settings, as well as opportunities for rethinking the management and design of modern infrastructure.

This project is rooted in this context and aims to deepen our understanding of the multi-scale, multi-physical behavior of fluid-infiltrated porous geomaterials subjected to alternating cycles of freezing and melting. The project aims to address low-temperature processes starting from the micro-scale, where pore-size effects control the dynamics of liquid–solid transitions and the pressure jump across phases. We aim to upscale these processes at the level of porous continua, where the existence of coexisting phases affects the stresses acting on the solid matrix, as well as the very own constitution of the matrix. Finally, we aim to tackle the mechanics of failure in materials undergoing phase transitions, thus rethinking the methods currently used to assess natural risks and infrastructure deterioration for systems subjected to temperature-induced phase transitions. Research in this area can lead to numerous benefits, including the increase of the durability of materials subjected to frost action, with consequent major reductions in maintenance and repair costs, as well as the prevention of natural hazards and loss of lives in permafrost regions, i.e. some of those most heavily impacted by projected climate changes.

Partners

- *E2S Newpores project* (an international hub for the mechanics and physics of porous materials)
- *Centre for Sustainable Engineering of Geological and Infrastructure Materials (SEGIM)* at Northwestern Univ., USA.
- *Geomechanics and Porous Materials* research group (G2MP, LFCR UMR5150) at E2S UPPA, France.

Master candidate objectives

The overarching objective of this research project is to formulate and validate a computational multiscale and multiphysics model for the simulation of geomaterials under cycles of freezing and thawing. The modeling approach will be pursued within the framework of the Lattice Discrete Particle Model (LDPM) with multiphysical constitutive equations formulated in the context of damage-plasticity. The formulated model will be calibrated and validated on the basis of experimental data gathered from the literature and from tests performed during this project. The master candidate will be in charge of starting the project which will be pursued within a 4-years joint PhD with 2 years residency at E2S-UPPA and 2 years residency at Northwestern University.

Laboratory and internship location G2MP research team, LFCR lab (UMR5150 UPPA CNRS Total), Anglet, France.

Grant 560 € / month.

Duration From March to August 2021 (6 months).

PhD opportunity This research effort will be pursued through a PhD position funded by the same Newpores project (envisioned starting date is October 1st, 2021).

Supervision Pr. David Grégoire – www.davidgregoire.fr, Pr. Gilles Pijaudier-Cabot, Dr. Madura Pathirage.