ISA BTP ÉCOLE D'INGÉNIEURS	**PhD position at Université Pau & Pays de l'Adour, Anglet, France** Modélisation multi-physique de l'Endommagement des Falaises induit par la Cristallisation du Sel MEFACS

General context

The objective of the MEFACS project is to define a numerical model capable of analysing the phenomenon of haloclasty, i.e., the damage induced by salt crystallisation, within rocky cliffs, specifically those bordering the Basque coast. Rocky cliffs and coastlines exhibit variable lithology and geological structures. They are heavily influenced by a wide range of natural and anthropogenic processes that can lead to erosion. Chemo-mechanical alterations, such as salt crystallisation processes within pores, cause damage that is more gradual and progressive than that induced by wave impact during storms. However, these processes act as an aggravating factor for sudden phenomena and can also induce cracks that contribute directly to rock erosion.

Today, coastal erosion is accelerated by climate change through rising sea levels and increasingly frequent, intense storms. In addition to climatic impacts, there is the environmental pressure caused by over-tourism and intense human activity in coastal areas; while these exacerbate the problem on one hand, they also suffer its negative effects on the other.

In this context, the French Basque coast, a 50 km rocky shoreline located in southwest France near the Spanish border, is currently undergoing permanent coastal retreat.

While several studies have been conducted regarding crystallisation-induced damage in masonry, the degradation of cliffs remains less explored. Although the underlying phenomenon is the same, the lithostratigraphic and microstructural variability of the rock plays a fundamental role in the process, as it controls the preferential pathways for saline attack. Furthermore, while the development of advanced experimental techniques has improved our empirical understanding of the phenomenon, numerical modelling contributions remain limited.

The EZPONDA project[1] (2019-2022), led by the *communauté du Pays Basque*, aimed to characterise and quantify the continental, coastal, and marine parameters responsible for the erosion of Basque rocky cliffs. The project demonstrated that, under environmental conditions, haloclasty is not the primary factor triggering instabilities; rather, it induces continuous weakening of materials and degradation of their mechanical properties.

The experimental results obtained are highly promising and serve as a starting point for more in-depth analysis. They facilitate the development of a numerical-experimental dialogue capable of better understanding the multi-scale processes involved and correlating them with the microstructural heterogeneity and lithostratigraphy of the studied rocky cliffs.

Global project objectives

The main objective of the project is to better predict numerically how variability in rock lithology and geological structure influences salt-induced damage. The study focuses on the same application sites as previous research: the cliff cornice at Bidart and the Socoa cliffs.

The developed model could also be used to refine the hydrodynamic storm prediction models and cliff destabilisation models, accounting for the evolution of mechanical rock properties caused by haloclasty.

This approach is particularly critical within the current context of climate change, where the acceleration of underlying environmental phenomena necessitates more sophisticated and integrated predictive tools.

PhD candidate objectives

The PhD student will work on existing experimental data, more specifically on $\mu - CT$ (computed tomography) images from previous projects, in order to establish a close dialogue between the developed numerical modelling and existing experimental results. This involves refining image analysis techniques to meet two fundamental objectives and create robust numerical models that are able to:

- Improve the understanding of the microstructure and micromechanical behaviour of materials by identifying laws that link the dominant local parameters to the overall mechanical response.

[1] Étude des paramètres mécaniques et chimiques à l'origine de l'altération des falaises rocheuses de la côte basque et des ouvrages de défense

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- Refine the calibration of numerical models by relying not only on the overall mechanical response of the samples but also on local measurements of state variables (density, porosity, degree of saturation, interfaces, etc.).

Achieving these objectives requires the definition of a two-step homogenisation process, which will enable a transition from the micro-scale to the meso-scale, and then from the meso-scale to the macroscopic scale in order to predict the mechanical behaviour of an equivalent homogeneous rock mass incorporating multi-physical and multi-scale components. A diagram illustrating the homogenisation process mentioned is shown in Figure 1.

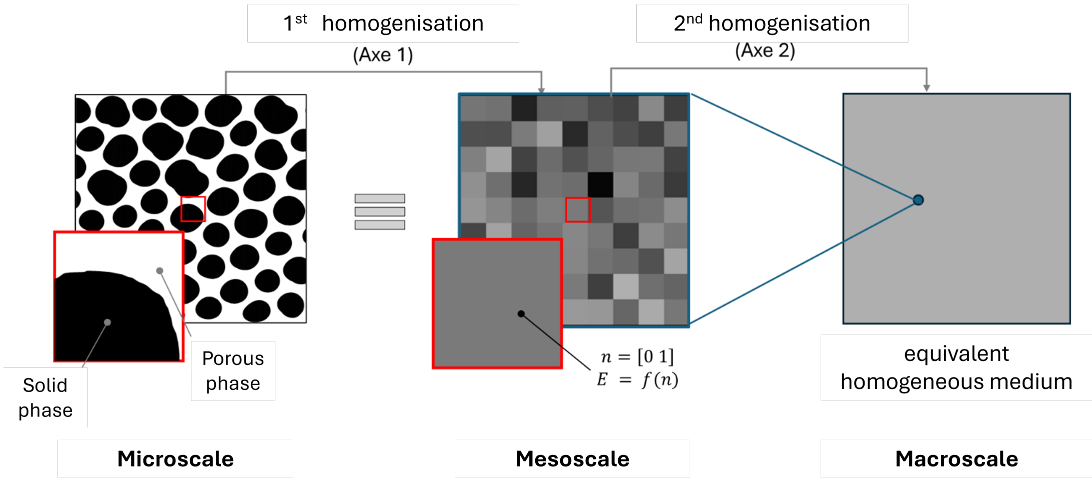

Figure 1: Microstructural homogenisation and mechanical response for a saturated porous medium

Candidate profile

The candidate should have expertise in numerical modelling and simulation, as well as in constitutive laws for soil and rock mechanics. Basic knowledge of the Python programming language would be an asset. Applicants must hold a Master's degree in numerical mechanics, civil engineering, geomechanics, or a related field. Proficiency in English is mandatory. Proficiency in French can be useful, but it is not mandatory.

Job details

The successful candidate will be hosted at ISABTP Civil Engineering School by LFCR (UMR5150, UPPA-CNRS). The PhD candidate will be fully supervised by Adriana Quacquarelli and Prof. David Grégoire. The envisioned starting date is October 1st, 2026, and the maximum duration is 3 years. Depending on the candidate profile and career plans, teaching lectures at ISABTP may be proposed with an additional salary.

Application and evaluation procedure

Applications should include a cover letter, CV, transcripts of diplomas, a list of courses attended (with grades obtained), recommendation letters, and the names and contact details of at least two references. Applications should be submitted before the 31st of May 2026 to adriana.quacquarelli@univ-pau.fr and david.gregoire@univ-pau.fr.

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