Master 2 internship 2025:

Patterns generated by erosion by dissolution

Keywords: Macroscopic Physics, Fluid Mechanics, Geomorphology, Morphogenesis, Chemical Physics
Internship location : Laboratoire **MSC** (Matière et Systèmes complexes).
Université Paris Cité. Bâtiment Condorcet, Paris 75013. **Starting date**: first semester of 2025, flexible.

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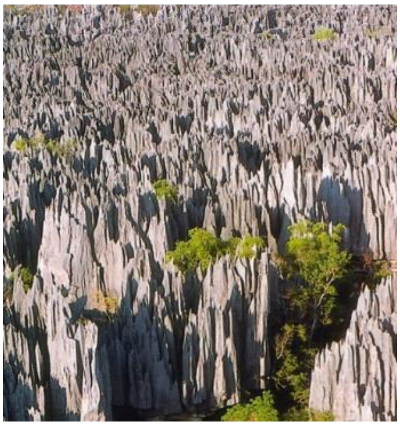
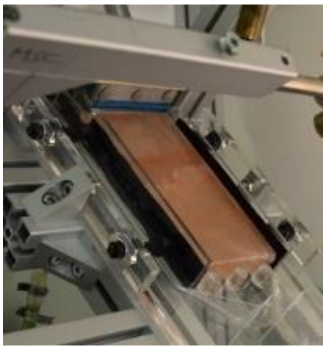
The internship can be followed in a PhD Research project starting in fall 2025.

Subject: Landscapes are shaped under water flows and wind action, and the understanding of their morphodynamics requires the identification of the physical mechanisms at play. The processes of erosion of sediment composed of macroscopic grains have been extensively studied, which is not the case of the erosion by dissolution. However, this process plays a significant role in area covered by a soluble mineral like in Karst regions and is the cause of the formation of remarkable patterns **[1]** (limestone pavements, scallops, dissolution channels **[2]**, dissolution pinnacles, limestone forests…) with characteristic length scales. We propose in this internship, by the mean of controlled laboratory experiments, to study the morphogenesis of dissolution patterns. The soluble media and the hydrodynamic flows will be tuned to downscale the characteristic size and time of the involved processes from geological values to "laboratory" values. Thanks to quantitative measurements of the flow and of the topography of eroded surfaces, we will identify the driving elementary physical mechanisms and thus develop mathematical models **[3]** and numerical simulations **[4]**, with the aim to explain complex geological systems and to predict the long term evolution of landscapes. Field missions are performed to measure dissolution shapes in nature and to compare with models and experiments.
In this internship, the student will develop in the group, one or several model experiments, reproducing dissolution erosion phenomena. To decrease the timescales, fast dissolving materials like salt and plaster will be used. Hydrodynamic properties of the flows will be characterized and the 3D shape evolution of eroded surfaces will be recorded. Several experimental projects are possible, depending on the water flow configuration (thin film, turbulent current …).

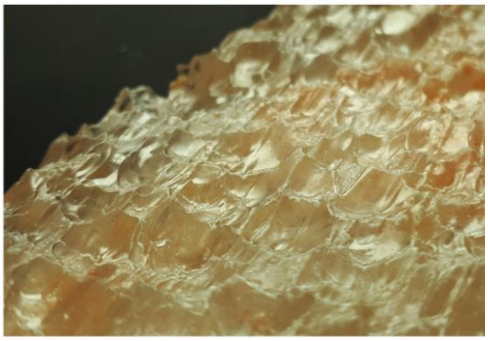

Tsingy or limestone forest in Madagascar


Dissolution channels on limestone pavement in Vercors (French Alps)

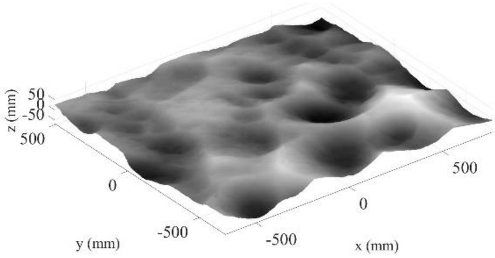

"Scallops" on the walls of a cave (limestone) created by a former underground river dissolving slowly the limestone. *Grotte Saint-Marcel,* Ardèche, France. Topography measurement.



Study of patterns generated by run-off flows on a pink salt plate **[2]**



Crests formed by dissolution of salt on water, when driven by the solutal convection **[5]**



3D reconstruction of the wall of the cave Saint Marcel, in presence of scallops (concave patterns surrounded by crests).

<u>References:</u>

[1] P. Meakin and B. Jamtveit, **Proc. Of the Royal Society A**, 466, 659 (2010) Geological pattern formation by growth and dissolution in aqueous systems.

[2] A. Guérin, J. Derr and S. Courrech du Pont and M. Berhanu, **Physical Review Letters**, 125, 194502 (2020) Streamwise dissolution patterns created by a flowing water film. (Editor's choice).

[3] M. Chaigne, S. Carpy, M. Massé, J Derr, S. Courrech du Pont, & M. Berhanu,. **Proceedings of the National Academy of Sciences**, 120(48), e2309379120 (2023), Emergence of tip singularities in dissolution patterns.

[4] J. Philippi, M. Berhanu, J. Derr and S. Courrech du Pont, **Physical Review Fluids**, 4, 103801 (2019) Solutal convection induced by dissolution

[5] C. Cohen, M. Berhanu, J. Derr and S. Courrech du Pont, **Physical Review Fluids**, 5, 053802 (2020) Buoyancy-driven dissolution of inclined blocks: Erosion rate and pattern formation.