Master 2 internship 2021:
Erosion by dissolution, experiments and modelling

Keywords: Macroscopic Physics, Fluid Mechanics, Geomorphology, Morphogenesis, Chemical Physics
Internship location : Laboratoire MSC (Matière et Systèmes complexes). Université de Paris.
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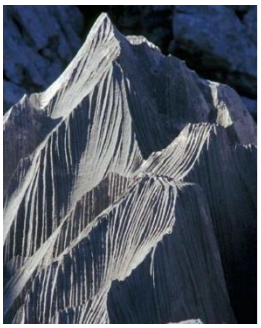
The M2 internship can start from January 2021 and can be funded.
The internship may be followed in a Phd Research project starting in fall 2021.

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 dissoluble mineral like in Karst regions and is the cause of the formation of remarkable patterns **[1]** (limestone pavements, scallops, dissolution grooves **[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 dissoluble 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 and numerical simulations **[3]**, with the aim to explain complex geological systems and to predict the long term evolution of landscapes.

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. A first project consists in studying erosion patterns appearing on dissoluble plates submitted to a controlled water current. As recently investigated theoretically **[4]**, we expect to observe the emergence of a pattern of "scallops", similar to the one observed in the walls of limestone caves.

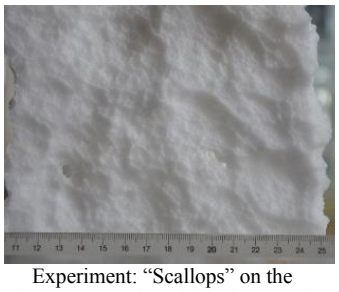

Tsingy or limestone forest in Madagascar

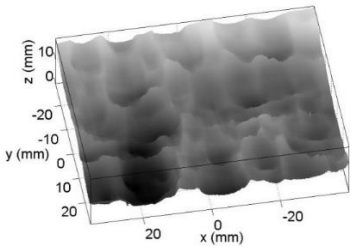

Dissolution grooves on limestone exposed to rainfalls (runoff flow)


"Scallops" on the walls of a cave (limestone) created by a former underground river dissolving slowly the limestone.


"Scallops" on a wall of a limestone cave
https://www.geocaching.com/geocache/GC2AGFY_scallop-cave


"Scallops" on the bottom face of the caramel block **[5]**, created by turbulent solutal convection.


Experiment: "Scallops" on the bottom face of a salt block created by turbulent solutal convection and removed from water.



3D reconstruction by laser profilometry of the eroded surface of the salt block.

The internship may be prolonged in a Phd Research project. During the Phd, application of research on the field will be possible, by comparing results of model experiment with specific geological examples.

References:

[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, in Press (2020)** Streamwise dissolution patterns created by a flowing water film.

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

[4] P. Claudin, O. Durán and B. Andreotti **J. Fluid Mech. 832, R2 (2017)** Dissolution instability and roughening transition**.**

[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.