M2 internship 2018:
Erosion by dissolution, experiments and modelling

Keywords: Macroscopic Physics, Fluid Mechanics, Geomorphology, Morphogenesis, Chemical Physics
Internship location : Laboratoire MSC (Matière et Systèmes complexes). Université PARIS Diderot
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The M2 internship can start from January 2018 and can be funded.
The internship may be prolonged in a Phd Research project starting in fall 2018.

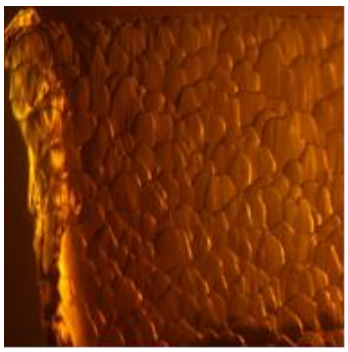
Subject: Landscapes are shaped under water flows and wind action, and the understanding of their morphodynamics goes through the identification of the physical mechanisms at play. The processes of erosion of sediment composed of macroscopic grains have been extensively studied, which is not the case 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 (limestone pavements, scallops, dissolution grooves, 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, 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 phenomenon. To decrease the timescales, fast dissolving materials like sugar, salt and plaster will be used. Hydrodynamical 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 of dissoluble plates submitted to a water current. Experiments will be performed in close collaboration with Sylvain Courrech du Pont. In the following of the research project, dissolution phenomena could be modeled using numerical simulations (finite elements methods) in collaboration with Julien Derr at MSC.


Tsingy or limestone forest in Madagascar

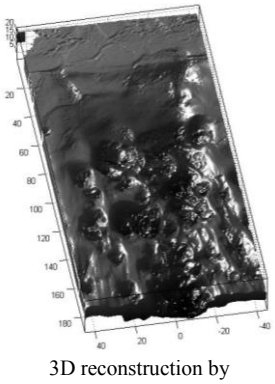

« Scallops » on the walls of a cave (limestone) created by a former underground river


Dissolution grooves on limestone exposed to rainfalls (runoff flow)

Dissolution of a submerged block of caramel. The flow is induced by solutal convection (Cohen et al. 2016)


Scallops on the bottom face of the caramel block (Cohen et al. 2016)


Experimental result of runoff flow on an inclined salt plate


3D reconstruction by profilometry of the eroded surface of the salt plate.

The internship will 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:

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

C. Cohen, M. Berhanu, J. Derr and S. Courrech du Pont
Erosion patterns on dissolving and melting bodies (2015 Gallery of Fluid motion) **Physical Review Fluids, 1, 050508 (2016)**