CLIFF EROSION: IMPACT OF WAVES AND GROUNDWATER FLOW ON CLIFF MICRO-FRACTURING

KEYWORDS: COASTAL GEOMORPHOLOGY; PHYSICAL OCEANOGRAPHY; COASTAL CLIFF EROSION; MICRO-FRACTURING; ROCK MECHANICS

Motivation

The proposed post-doctoral research project addresses the prevalence between marine and continental processes in controlling cliff erosion. In addition to direct wave impact (undercutting), recent studies (Young et al, 2012[1]; Earlie et al, 2015[2]) underline the swaying effect generated by infragravity waves (downward and seaward micrometric cliff-top displacements due to wave loading). Such micro-movements can cause micro-fractures, reducing cliff resistance and therefore acting as a predisposing factor to failure. Various studies emphasize the role of continental factors, including precipitation, which induce reduced cliff stability through runoff, infiltration and groundwater table variations (Lahousse and Pierre, 2003[3]; Duperret et al., 2004[4]; Lissak et al., 2014[5]). Groundwater flow is particularly dependent on micro- and macro-cracking. Since both marine and subaerial actions tend to combine, discriminating their relative contribution is challenging. Hydrostatic pressure, generated by groundwater flow, as well as sea levels fluctuations due to wave impact against cliffs, can extend micro-fractures within cliff materials and thus reduce the mechanical resistance of cliffs, promoting their failure. On the contrary, enhanced microfracturing may release overpressure within the cliff.

Objectives, methodology and study sites

In a context of rocky cliffs exposed to oceanic swells and in macrotidal regime, this 18-month postdoctoral project focuses on the impact of waves and groundwater flow on micro-fracturing and subsequent erosion of cliffs in Brittany. The study will be based on field campaigns to be conducted at two sites with distinct cliff lithologies. Three main questions will be investigated:

- Characterization of cliff micro-fracturing from site scale to sample scale (using satellite imagery*, in situ* observations and mechanical tests in the laboratory) and characterization of hydrogeology, both deep and ground-surface, at the scale of watersheds and of the coastal fringe (with field analysis tools and numerical modeling);

- Monitoring of micro-fracturing and cliff erosion in relation to wave impact (using measurements from pressure sensors, accelerometers and sismometers to evaluate the hydrodynamical forcing and the mechanical response of the cliffs). Both energy dissipation of wave breaking on the cliff face and wave-induced sea-level loading will be considered. Because

[1] Young, A.P., Guza, R.T., Adams, P.N., O'Reilly, W.C., Flick, R.E., 2012. Cross-shore decay of cliff top ground motions driven by local ocean swell and infragravity waves. *J. Geophys. Res. C Oceans*, 117. doi:10.1029/2012JC007908

[2] Earlie, C. S., Young, A. P., Masselink, G., & Russell, P. E., 2015. Coastal cliff ground motions and response to extreme storm waves. *Geophysical Research Letters*, 42(3), 847-854.

[3] Lahousse, P., Pierre, G., 2003. The retreat of chalk cliffs at Cape Blanc-Nez (France): Autopsy of an erosional crisis. *J. Coast. Res.,* 19, 431–440.

[4] Duperret, A., Genter, A., Martinez, A., Mortimore, R. N., 2004. Coastal chalk cliff instability in NW France: role of lithology, fracture pattern and rainfall. *Geological Society, London, Engineering Geology Special Publications*, 20(1), 33-55.

[5] Lissak, C., Maquaire, O., Davidson, R., & Malet, J. P., 2014. Piezometric thresholds for triggering landslides along the Normandy coast, France. *Géomorphologie*, (2), 145-158.

dissipation of incident wave energy depends on beach morphodynamics at the cliff foot, beach profile topography will be monitored;

- Monitoring of micro-fracturing and cliff erosion in relation to runoff and groundwater flow (setting-up a network of weather stations and piezometers).

The analysis of the dataset is expected to bring insight into the relative contributions of structural, marine and continental factors in cliff erosion and retreat in the context of the study sites in Brittany and elsewhere. The originality of the project lies in the concomitant measurements of micro-fracturing (using accelerometers), cliff-top displacement (with seismometers), wave hydrodynamics and groundwater flow, in addition to topo-bathymetric surveys.

The sites of Déolen in Plouzané (figure 1) and Veryac'h in Camaret-sur-Mer (figure 2) have been selected for this project. Déolen consists of plunging cliffs carved in gneiss. The nearshore bathymetry is very reflective and reaches over 30m depth within hundreds of meters of the coastline. The Veryac'h cliffs are cut as an erosion platform into a succession of quartzite and shale. This site is located to the South of Pen-Hir bight, in a dissipative environment. Pending on the results obtained at these two sites in Brittany, a similar field survey may be considered at additional sites representative of other cliff types: cliffs with a thicker layer of "head" (periglacial formations) (Brittany coast), chalk cliffs (Normandy), sedimentary rock cliffs (California, USA) in collaboration with the University of San Diego (USA).

Figure 1: Site of Déolen (photo: M. Jaud)

Figure 2: Site of Veryac'h (photos: M. Jaud)

Job details

Eligibility:

- The candidate must have obtained her/his PhD within the last 5 years in a relevant speciality of Physical Geography (Geomorphology), Geology, Applied or Environmental Physics, or Soil Mechanics.

- The candidate must either be a foreign national to France or have spent a minimum of 12 months outside France during the last three years (between 02/04/2012 and 02/04/2015).

Additional requirements:

Proficiency in the following areas will be advantageous:

- Knowledge-base in the fields of geomorphology, geotechnics, geology, soil mechanics and fluid mechanics;

- Field instrumentation (including pressure transducers, accelerometers, seismometers, piezometers, DGPS, terrestrial laser scanner, photogrammetry);

- Data processing (Matlab, image analysis, satellite image processing);

- Proven record of scientific publication;

- Perseverance, scientific rigor, ability for team-work;

- Basics in French and/or willingness to learn French language.

Employment conditions

Post-doc duration: 18 months

Net monthly salary[6]: € 2047

Host laboratory: LETG-Brest Géomer (http://letg.cnrs.fr/rubrique17.html?id_mot=5)

Partner laboratory: LDO (http://www-iuem.univ-brest.fr/ldo/fr/Recherche/equipe-transferts-terre-mer/thematiques/thematiques-de-l-equipe-transferts-terre-mer#Axe%202)

Department: IUEM (Université de Bretagne Occidentale) (http://www-iuem.univ-brest.fr/en)

The post-doctoral project will be carried out in the framework of the partnership between the laboratory 'LETG-Brest Géomer' and the "Dynamics of Littoral and Coastal Environments" group of the laboratory 'Domaines Océaniques', both teams working on coastal morphodynamics and hydro-sedimentary processes, including in the context of the axis 5 of Labex MER (http://www.labexmer.eu/en/research/dynamics-vulnerability-of-coastal-zones/axis-5?set_language=en) and the topic 1 of the "Zone Atelier Brest-Iroise" (http://www-iuem.univ-brest.fr/zabri/fr/Projet/theme-1).

For more information about this position contact the PIs: Pauline Letortu (pauline.letortu@univ-brest.fr) and Nicolas Le Dantec (nicolas.ledantec@univ-brest.fr)

Application and recruitment process

To apply, send a detailed CV and research statement to the PIs (pauline.letortu@univ-brest.fr and nicolas.ledantec@univ-brest.fr)

Position must be filled by end of May 2016. Applications will be reviewed immediately and until the position has been filled.

[6] Subject to income tax