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Processes and mechanisms governing hard rock cliff erosion in western Brittany, France

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The evolution of rocky coasts is controlled by the interplay between subaerial, marine as well as biological processes, and the geological context. In times of ongoing climate change it is difficult to predict how these erosional landscapes will respond for example to anticipated sea-level rise or to an increase in storminess. However, it can be expected that changes in the morphodynamics of rocky coasts will have a noticeable effect on society and infrastructure.
Recent studies have proven that monitoring cliff micro-seismic ground motion has been very effective in exploring both marine and atmospheric actions on coastal cliffs. But only few studies have focused so far on the effects of wave loading and water circulation (runoff, infiltration, water table variations) on cliff stability and subsequent erosion, considering the interaction between subaerial and marine processes.

This project focuses on the identification and quantification of environmental controls on hard rock cliff erosion with an emphasis on discriminating the relative contributions of subaerial and marine processes. We aim at relating different sources of mechanical stress (e.g. wave loading, direct wave impact, hydrostatic pressure, thermal expansion) to cliff-scale strain (cliff-top swaying and shaking) and micro-fracturing (generation, expansion and contraction of micro-cracks) with the objective to unravel and discriminate triggering mechanisms of cliff failure.
A four-month monitoring field experiment during the winter period (February-May) of 2017 is carried out at a cliff face located in Porsmilin beach (western Brittany, France). The selected cliff section is exposed to Atlantic swell from the south/southwest with a significant wave height of ca. 1.5 m on average and, reaching up to 4 m during storm events. The cliff rises ca. 20 m above the beach and is mainly formed of orthogneiss with intrusions of granodiorite. The entire cliff is highly fractured and altered, which can promote slope failure in the otherwise rather resistant rock. The density of the fracture network and the principal directions of fracturation play a significant role in controlling the rate of mass wasting.
The characterization of cliff micro-fracturing will be accomplished through in-situ monitoring of cliff-top ground motion with a seismometer installed at the cliff top and geophones installed within the cliff face. Wave impact will be monitored by setting up a real-time video system in front of the cliff face in combination with pressure- and wave load sensors that will be installed on the beach in a cross-shore array and directly at the cliff toe. Temperature sensors will be placed in shallow boreholes at the cliff face in order to record surface rock temperature. In addition, a weather station and a piezometer will be deployed in order to monitor local weather and groundwater conditions at the study site.

This novel combination of the different field measurements is expected to yield new insights into the processes controlling cliff erosion and retreat along rocky coastlines. In particular, we hope to gain understanding on the possible importance of rock micro-fracturing as a precursor to cliff failure.