Geophysical Research Abstracts
Vol. 19, EGU2017-19357, 2017
EGU General Assembly 2017

Wave-flume experiments of soft-rock cliff erosion under monochromatic waves

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We investigate how cliffs erode under wave attack. Rocky coast erosion works through cycles, each one corresponding to three successive phases: (i) notch creation at cliff toe by mechanical action of waves, (ii) cliff fracturation leading to collapse, and (iii) evacuation of scree aprons by waves and currents. We performed experiments in a 5m x 14cm x 25cm wave flume (15 cm water depth) to investigate how waves are eroding a rocky coast. The cliff is made of wet sand and models a relatively soft rock. We used 3 different grain size (D50 = 0.28-0.41-0.48 mm), changing the cliff rheology. Waves are monochromatic; their height and period differ for the various experiments. Actual wave parameters are estimated by capacitive probes located offshore. The experiments are monitored by two video cameras both on the side and above the flume. Pictures are taken at a rate of 1Hz during the first 4h and then the rate is decreased to 0.1Hz till the end of experiment (about 1 day). The monitoring ensure a confident characterization of experiments in terms of waves (surf similarity parameter ξ and the incident wave energy flux F) and in terms of sediment (Dean number Ω and Shields number θb at breakers).
Experiments begin by an initial phase of quick cliff retreat. Then the system evolves with slower cliff retreat. We focus on bottom morphology which we characterize in function of wave forcing (ξ, F). We show that the bottom morphology mainly depends on ξ. For our reference sediment (Dm = 0.41 mm), we observed: (i) surging breakers on a steep terrace (type T1) for ξ > 0.65; (ii)collapsing breakers on a bared profile attached to the inner platform (type T2) for 0.55< ξ <0.6; (iii) spilling breakers on gentle terrace (type T3) for F < 1.3 W/m and 0.55< ξ <0.6. Another bottom morphology, type T4, displays two sub-systems, an outer system with a double-bar profile where breaking waves are plunging, and an inner system with a T1, T2 or T3 profile. Some of these bottom morphologies are unsteady with sandbar oscillation. When changing sediment grain size, we observed that the bottom typology is similar but evolves in function of the Ω value. Finally, we observed that the cliff recession is proportional to F, is not monotonic with ξ and decreases with the sediment grain diameter.