



## Magnitude-frequency of landslide activity in sea cliffs

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The magnitude-frequency relationships of sea cliff failures was studied using systematic historical inventories carried out in Portugal and in the north-west coast of Morocco, in different geological and geomorphological settings, both in terms of volume of rock or soil displaced and of horizontal area lost. Inventories were made aerial photographs comparison for intermediate time (up to 53 years) and regional scale surveys, for characterization of the larger cliff movements, and sequential photos of cliff faces for short time (4 years long) and local scale surveys for the assessment of intermediate and small cliff movements. Cliff failures identified (517 failures in 11 datasets) range from small rockfalls to intermediate size planar and toppling failures, to comparatively large translational slides and a few cave roof collapses.

The cliff failures exhibit and inverse power-law behaviour for the frequency-volume relationship,  $f(V_{CF}) = 0.22 V_{CF}^{-1.03}$  ( $r^2 = 0.98$ ), and for frequency-area,  $f(A_{CF}) = 0.32 A_{CF}^{-1.08}$  ( $r^2 = 0.94$ ). The power-law exponents  $\beta$  are quite close and similar to one proposed for rock fall inventories and  $\alpha_v$  and  $\alpha_a$  are also quite close. It is also apparent that there is a slight increase of  $\beta$  for the larger failures, that may be explained by under sampling of the largest but least frequent events or by the influence of an upper limit for cliff failures volume and horizontal area lost, that depends mainly on cliff height and on the geotechnical properties of the rock masses.

The wide variation of geological and geomorphological conditions of the data sets used, and in spite of the variations in mechanisms of failure, suggest that the relations obtained will be useful for cliff retreat hazard assessment, in combination with reliable estimations for the spatial and time distribution of cliff failures.