



## **Frequency analysis of rock cliff collapse seismic precursors and numerical modelling**

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We analyse seismic signals recorded within a chalk cliff during a few hours period preceding a large collapse (estimated rock fall volume about 2000  $\text{m}^3$ ).

About 500 events have been recorded during the six months before the collapse, and more than 250 during the six hours preceding the collapse. The collapse occurred within a seismic network of five microseismic stations, in such a manner that the central station was located at few meters of the failure surface. This allows us to investigate the properties of the seismicity emitted by the damage process leading to the cliff collapse. The study focused on the frequency content of the seismic events recorded by this station and how this changes as the failure approaches. We observed different types of signal characterized by a narrow-band or wide-band spectral spectrum respectively, suggesting that two types of sources mechanisms may operate during the phase before the collapse occurs. As the failure approach, we observed an increase of the proportion of wide-band signals and an increasing band-width of these last signals.

In order to provide a physical meaning to these observations, we realized numerical simulation based on finite elements method. The model simulates the failure of an interface (energy release when the failure criterion is reached) and the elastic wave propagation induced by the failure. The model is also able to simulate the friction along the interface after the failure. The analysis of the stress state of the cliff before the failure reveals that some zones are mainly under tension whereas others are mainly under shear. Signals emitted by tension failure are characterized by narrow (monofrequencial) spectrum whereas shearing failure leads to wide-band spectrum. As the collapse approaches, the proportion of shear failure increase dramatically. These numerical results are in good agreement with in situ observations and provide a physical interpretation mechanically well established.

This kind of analyse could provide elements to be incorporated in a study of the collapse prevision, which is not yet performed.