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Dynamic characteristics of a coastal area of lateral spreading using ambient noise time series – Anchor Bay, Malta

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Anchor Bay and surrounding regions are located on the northwest coast of the island of Malta, Central Mediterranean. The area is characterized by a coastal cliff environment having an outcropping layer of hard coralline limestone (UCL) resting on a thick (up to 50m) layer of clays and marls (Blue Clay, BC). This configuration gives rise to a number of processes leading to coastal instability, in particular lateral spreading phenomena and rock falls. Previous and ongoing studies have identified both lateral spreading rates and vertical motions of up to 27mm per year (Mantovani et al, 2012). The area is an interesting natural laboratory as coastal detachment processes in a number of different stages can be identified and are easily accessible. We investigate the site dynamic characteristics of this study area by recording ambient noise time series (20 minutes long) at over 20 points, over an area of 0.07 km2, using a portable 3-component seismograph (Tromino) The time series are processed to give both horizontal-to-vertical spectral ratio graphs (HVSR) as well as frequency-dependent polarisation analysis as proposed by Burjanek (2011, 2012). The HVSR graphs illustrate and quantify aspects of site resonance effects due both to underlying geology as well as to mechanical resonance of partly or wholly detached boulders or blocks. The polarization diagrams indicate predominant directions of vibrational effects.
Results from this study show an unambiguous distinction between the behavior of "stable" areas, away from the cliff edges, the region of the unstable cliff edge and the actual rockfall areas. Stable regions are characterized by a single and pronounced HVSR resonance peak at around 1.5Hz that are characteristic of all other areas in the Maltese islands having the same underlying geological sequence, while HVSR curves closer to the cliff edge show more complex responses at higher frequencies characteristic of the dynamic behavior of individual detached blocks. Large partly detached blocks (dimensions of several tens of metres) separated from the mainland by deep fractures show the largest HVSR resonance effects with clear peaks in the 3 – 25Hz range and amplitudes up to 6. Polarization effects are visualized through polar-plot representations of frequency histograms, and are also consistent with the geomorphological dynamics of the area. The whole unstable area shows strongly directional polarization, at well-defined frequencies and approximately perpendicular to the cliff edge, but with appreciable differences in frequency and directionality between the individual partly detached blocks. This behavior is indicative of normal-mode vibration. Stable inland areas, on the other hand, show no predominant polarization direction. These results, which will be compared with those from other experiments in the area, have important implications for the understanding of ongoing processes in geologically active and unstable coastal environments.