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Inversion of surface wave data for shear wave velocity profiles: Case studies of thick buried low-velocity layers in Malta

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The islands composing the Maltese archipelago (Central Mediterranean) are characterised by a four layer sequence of limestones and clays, with the Lower Coralline Limestone being the oldest exposed layer. The hard Globigerina Limestone (GL) overlies this layer and is found outcropping in the eastern part of Malta and western part of Gozo. The rest of the islands are characterised by Upper Coralline Limestone (UCL) plateaus and hillcaps covering a soft Blue Clay (BC) layer which can be up to 75 m thick. Thus the BC layer introduces a velocity inversion in the stratigraphy, and makes the Vs30 parameter not always suitable for seismic microzonation purposes. Such a layer may still produce amplification effects, however would not contribute to the numerical mean of Vs in the upper 30m. Moreover, buildings are being increasingly constructed on this type of geological foundation. Obtaining the shear wave (Vs) profiles of the different layers around the islands is the first step needed for a detailed study of local seismic site response. A survey of Vs in each type of lithology and around the islands has never been undertaken.

Array measurements of ambient noise using vertical geophones were carried out at six sites in Malta and one in Gozo, characterised by the buried low-velocity layer. The array was set up in an L-shaped configuration and the Extended Spatial Autocorrelation (ESAC) technique was used to extract Rayleigh wave dispersion curves. The effective dispersion curve obtained at all the sites exhibited a 'normal' dispersive trend (i.e. velocity decreases with increasing frequency) at low frequencies, followed by an inverse dispersive trend at high frequencies. Such a shape can be tentatively explained in terms of the presence of higher mode Rayleigh waves, which are generally present when a stiff layer overlies a softer layer.

Additionally a series of three-component ambient noise measurements were taken at each of the sites and H/V curves obtained. The lithological sequence gives rise to a ubiquitous peak between 1 and 2 Hz which is observed in all the studied sites and is in agreement with studies previously done on the islands. The H/V curve and the Rayleigh wave dispersion curve were then jointly inverted using a genetic algorithm, considering higher modes, so that the Vs profiles are obtained.

All the curves were well fitted and the 10 final profiles extracted in each process show a good agreement especially in the velocity and thickness of the BC layer, emphasizing the sensitivity of the curves to this layer. Regional differences were observed for the velocities in the UCL and BC, e.g. highly fractured UCL demonstrates a lower Vs. The Vs in the clay also varied according to the depth of burial of the clay, clearly increasing from a surface outcrop of BC to a deeply buried layer. This could essentially be linked to the effective pressure caused by the UCL overburden which makes the BC more compact and having a higher Vs. Comparisons are also done with one particular site in Malta where the BC layer is not present in the geological sequence.