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Characterization of landslide geometry using 3D seismic refraction traveltime tomography

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The geometry of the bedrock, internal layers and shear surfaces/bands controls the deformation pattern and the mechanisms of landslides. A challenge to progress in the forecast of landslide acceleration in terms of early-warning is therefore to characterize the 3D geometry of the unstable mass at a high level of spatial resolution, both in the horizontal and vertical directions, by integrating information from different surveying techniques. For such characterization, seismic investigations are potentially of a great interest. In the case of complex structures, the measure and the processing of seismic data need to be performed in 3D. The objective of this work is to present the implementation of a 3D seismic refraction traveltime tomography technique based on an existing 2D Simultaneous Iterative Reconstruction Technique (SIRT). First the processing algorithm is detailed and its performance is discussed, and second an application to the La Valette complex landslide is presented. Inversion of first-arrival traveltimes produces a 3D tomogram that underlines the presence of many areas characterized by low P-wave velocity of 500-1800 m.s-1. These low P-wave velocity structures result from the presence of reworked blocks, surficial cracks and in-depth fracture zones. These structures seem to extend to around 25 m in depth over a 80 x 130 m area. Based on borehole geotechnical data and previous geophysical investigations, an interface corresponding to an internal slip surface can be suspected near the isovalue of 1200 m.s-1 at a depth of -10 to -15 m. The stable substratum is characterized by higher values of P-wave velocity of 1800-3000 m.s-1. The features identified in the 3D tomogram allow to better (1) delineate the boundary between the landslide and the surrounding stable slopes, and (2) understand the morphological structures within the landslide at a hectometric scale. The integration of the 3D seismic tomography interpretation to previous geophysical acquisitions using a geostatistical approach allows to construct a 3D geometrical model of the middle and lower part of the La Valette landslide, and to estimate the volume of the unstable mass.