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Investigation of deep geohazard sites with seismic and ambient noise methods, combined with 3D Geomodelling

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Conference topics/sessions
Advances in Site Investigation for Engineering Geology

Background

During the last years our group has studied a series of massive slope failures as well as deep geo-sites for engineering projects (dam and possible tunnel construction sites) located in various geohazard contexts. Therefore, we tested various combinations of active seismic and ambient noise methods and representation of related outputs in complex 3D Geomodels. Investigated sites include massive, likely seismically landslides in the Romanian Carpathian Mountains, slopes near the Rogun Dam construction site in Tajikistan, a very large active landslide in the Swiss Alps, an incipient volcanic flank collapse on El Hierro Canary Island and a site selected for the possible installation of an Einstein Telescope in the BE-NL-DE border region.

Methods

Our active seismic prospection includes seismic refraction tomography (SRT) and multi-channel analysis of surface waves (MASW) while ambient noise investigation methods cover the single station H/V and multi-station array techniques. Field data were collected during multiple geophysical campaigns (2015-2020) on the aforementioned sites. The geological, geophysical, and seismological analysis outputs were integrated in a 3D geomodel (most of them supported by 3D surface models constructed on the basis of UAV imagery) that was used as tool to assess basic elements of the slope stability, in terms of morphology and deeper internal structure, possible sliding horizons (basal and lateral) as well as elastic material properties, or in order to identify karst phenomena, and fault structures that may represent a problematic zone for tunnel construction projects. Some of those sites were later also analysed by applying a numerical modelling analysis, as for the Rogun site presented in Havenith et al. (2018), or for a massive landslide in the Romanian Carpathian Mountains described in detail in Mreyen et al. (2021).

Results

Results of the active seismic (SRT, MASW) are represented in terms of P-wave velocity (Vp) sections and S-wave velocity (Vs) logs; the ambient noise H/V noise data were first interpreted in terms of fundamental or higher resonance frequencies of the ground, which are in a second process, involving seismic velocity information, used to provide depth information on the resonant layers. Figure 1 presents an example for the Balta site in Romania, investigated by those seismic and ambient noise methods, with compilation of analysis outputs and interpreted structures in a 3D geomodel.

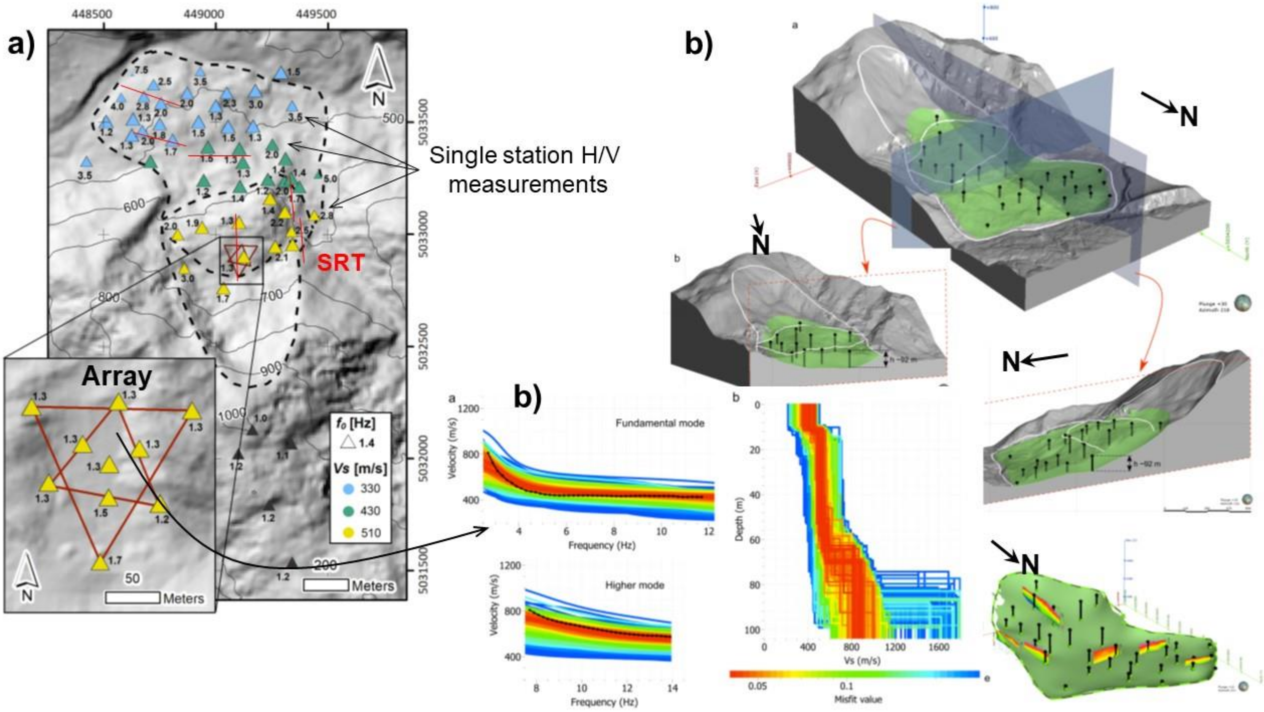

Figure 1. a) Survey map with active and passive seismic measurements on the massive Balta rockslide in the Romanian Carpathians, with location of H/V and array measurements, as well as seismic profiles, mainly used in this case for SRT analysis (some also used for MASW analysis); see also average Vs estimates for different parts of the landslide. b) Dispersion curves and Vs models derived from the seismological array measurement. c) 3D geomodel views of the site with H/V data transformed into depth-logs of the resonant landslide body, the green surface representing the sliding surface; see also SRT sections together with H/V logs in lower right corner.

<u>Conclusions</u>

We combined the seismic and ambient noise survey techniques to get the best information on the elastic properties of the subsurface (here, we do not consider the electrical resistivity measurements that were performed on most of the investigated sites as well – also to get information on the groundwater level depth). 3D geomodels allow us to represent different types of topographic data together with the geophysical outputs and inferred subsurface information. We estimate that this type of proceeding and representation will define the new state-of-the-art in landslide investigation, especially in seismic regions where the information on the Vs of the underground is essential to model dynamic effects caused by earthquakes.

REFERENCES

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