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UAV surveys, 3D geomodels and Virtual Reality supporting the structural geology analysis of large rockslides

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Geological structures, such as bedding, faults, folds, joints and fractures often contribute to decreased stability of rock slopes according to their strike and dip with respect to the general orientation of the main slope. Additionally, a rock slope may undergo many forms of gravitational displacement-induced (e.g. toppling), erosional (e.g. river undercutting) and/or weathering-induced destabilisation.

A variety of deep-seated very large (with a volume of > 10^7 m^3) rock slope failures have been analyzed according to their structural characteristics. Studies include field surveys with structural geology measurements and image collection with Unmanned Aerial Vehicles (UAVs). The latter were then used to construct digital twins of the rockslide sites. Structural elements were analysed by using stereoplot tools that can also produce 3D outputs of the studied planes. In a few cases additional geophysical data were collected in the field (both on the rockslide deposits and on bedrock around the scarps). All those data were then combined within 3D geomodels of the studied sites and related 3D representations were integrated in immersive virtual environments.

One first practical objective of the use of 3D constructions from UAV imagery within Virtual Reality is to investigate sites that are barely accessible in the field, such as the rock outcrops within high and very steep rockslide scarps. Second, 3D geomodels help reconstruct the subsurface domain and allow for viewing the geological structures from all sides in order to understand better the spatial relationships between different structural elements (including different joint families, and toppling-related folding and fracturing).

For a few cases, also numerical models have been developed to study the influence of structural and geomechanical elements on (potentially seismically induced) rock slope failure. The main goal is to identify features that would allow us to distinguish seismic trigger modes from climatic ones, notably on the basis of the source zone rock structures. For instance, anti-dip slope bedding orientation may hint at a seismic origin, but we also consider a series of mixed structural types, which are more difficult to be interpreted as markers for a seismic or of climatic rocsk slope failure origin.

Most of our studied rockslide sites are located in seismically active mountain ranges (southeastern Carpathians, Caucasus, Tien Shan, Eastern Tibet and Longmenshan). However, outcomes of this study could also help identify rockslides with a partly seismic origin in less seismically active mountain regions, such as the northern and western Carpathians and the Alps. In the Alps, sites previously studied include the Fernpass, Tamins, and the Oeschinensee and Kandersteg rockslides and avalanches.