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The use of DEM analysis for structural characterization of landslide-prone areas in crystalline rock slopes using GIS-based techniques. The case of the Matter Valley, Switzerland

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Mountainous regions influenced by glacial processes are often prone to slope instabilities. One reason for this relationship is their characteristic morphology (high relief and steep slopes) and the surface processes associated with glacial advance and retreat. In the Matter Valley, Switzerland these factors interact with brittle-ductile faults and joint sets and induce rock slope failures at multiple scales, including the $3x10^7$ m^3 Randa and the $1x10^5$ m^3 Medji events. The general lithological and tectonic disposition in the study area is quite homogeneous, while the local fracture systems and their characteristics vary spatially. These features provide the opportunity to evaluate potential relationships between the local fracture systems and the potential failure modes they develop with the observed slope morphology and its state of stability.

In order to investigate this hypothesis the fracture pattern of the area was analyzed using a new combination of data collected from the field and data extracted from an aerial-based LIDAR high resolution DEM (SWISSTOPO, 2m pixel resolution). This is possible for the area because the fracture pattern has been observed to have a strong influence in the morphology of the slopes. To identify slope faces controlled by structures a 3D shaded relief map of the area was produced. A 3D shaded relief map is a color-coded image based on HSV color composition showing changes in color according with the changes on slope orientation (dip and dip direction). A careful selection of the planes used for the analysis was carried out taking in consideration that not all values in the 3D shaded relief image represent fracture orientations; this is due to multiple factors such as cell size of the DEM, presence of land cover (soil), and presence of overhanging blocks. Selection of cells was done using 3D visualizations (an orthophoto mosaic created with aerial photographs acquired in 2005 was used as the top-most layer) and photographs of the slopes taken from different angles during the field data collection campaigns. The orientation values extracted from the DEM analysis needed an areal value correction. This correction is based on the fact that steep slopes are represented for a fewer number of cells than gentle slopes. A total of more than 120000 fracture orientations were obtained from this analysis and displayed in a total of 45 stereoplots. Field data and DEM derived data were compared each other and with data of previous works in order to assess the reliability of the method. As a product of the analysis the area was divided in two main structural domains based on the spatial distribution of the fracture patterns. These domains have shown a clear connection with the frequency of instabilities and therefore with the differences in morphology of the slopes.