

Slope stability evaluation and run-out simulation for an unstable rock slope above an industrial area in the Leventina valley, Switzerland.

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Slope instabilities are often considered a major hazard if they are situated above inhabited alpine areas. In such cases remedial measures and effective early warning systems require a good understanding of the processes acting on the unstable rock volume. To this end also run-out predictions are necessary to evaluate the areas at risk. Within an ETH project, the potential failure mechanisms, associated volumes and run-outs for an unstable rock slope above the industrial area of Preonzo (Leventina valley) were investigated. Already two large rockslide events have occurred in 1760 and 2002 originating from the area around the investigated rock slope instability. The landslide lies in the Penninic Simano nappe composed of slightly south dipping gneisses, amphibolites and shists. Lithologic contacts and foliation dip about 25° into the slope. At an elevation of 1300 m above the valley floor, a large opening and widening tension crack indicates significant activity and provides an upper limit of the instability. The front of the instability corresponds to a near-vertical cliff running parallel to steeply east dipping (unloading) fractures of the Leventina valley. The lateral release planes are formed by steep N-S striking fractures. However, the depth to the instability is not well defined. The Servizio Forestale Cantonale has installed and operated a monitoring and early warning system consisting of a geodetic network, tension crack displacement monitoring with 5 extensometers and three geophones to monitor microseismic activity. In addition, Interferometric Synthetic Aperture Radar (SAR) measurements have been performed by the BAFU in collaboration with LisaLab.

To obtain an initial estimate of the volume involved in the instability and to explain the measured displacement fields at the site, continuum and discontinuum numerical models (FLAC and UDEC, ITASCA 2000) were run. Based on these investigations a basal limitation of the instability is likely to coincide with a schistose band at the foot of the cliff. The models also include the effect of rising water pressures after heavy precipitation. Based on the integrated analysis of monitoring and modelling, an estimate of the volume of the unstable rock mass could be obtained and used as input into run-out simulations using the Dynamic Landslide Analysis tool DAN (Hungry 1995). As the use of this tool requires physical parameters to be derived from back-analysis of rockslides with approximately the same volume, material and topographic setting, a series of documented rockslides in Switzerland were analysed. The results of the run-out analysis show that for a larger rockslide event (>300.000 m³) and even for a smaller volume under specific conditions, the industrial area below the unstable slope is not sufficiently protected by a dam built in 2002.

In conclusion, the investigations provide a basis for the local authorities to define hazard zones and design the necessary counter measures such as early-warning systems, evacuation plans and further development plans of this region.

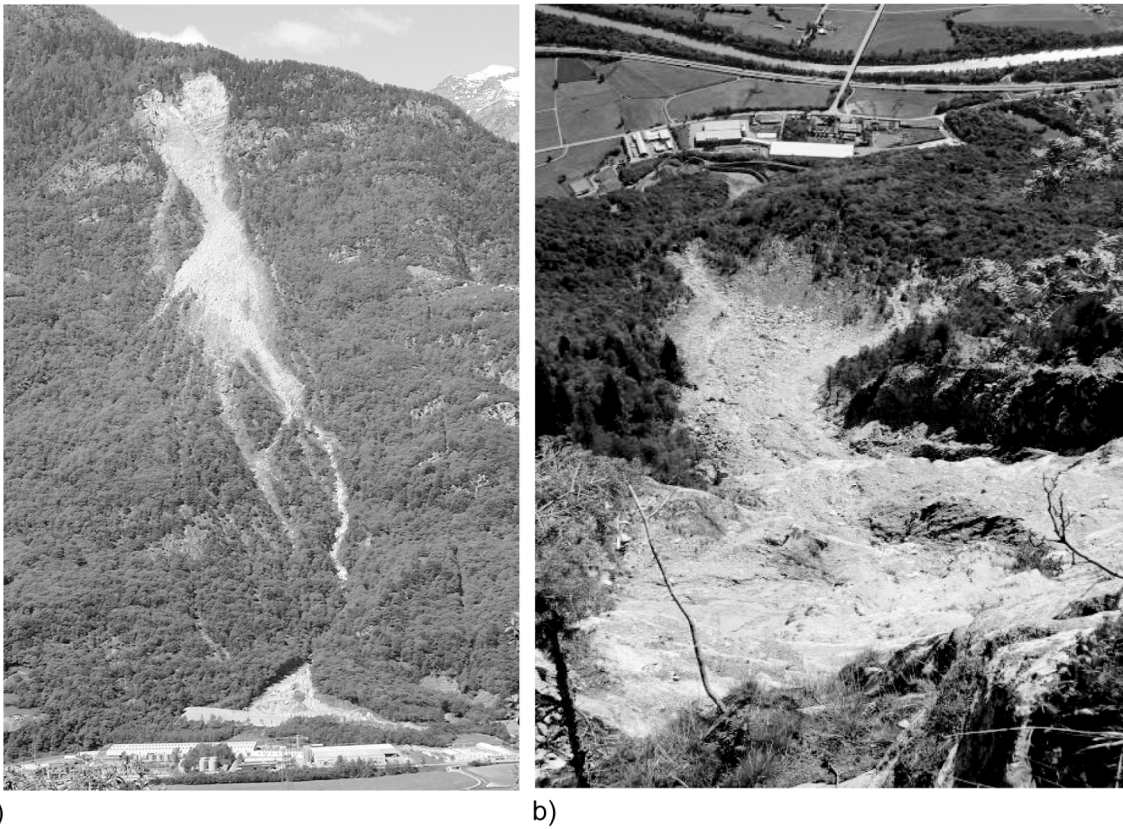


Figure 1: a) Photo of the investigated slope with debris of the 2002 rockslide event (photo by G. Valenti). b) View from the top of the investigated area to the valley.

REFERENCES

- Hungr, O. (1995): A model for the run out analysis of rapid flow slides, debris flows and avalanches. *Canadian Geotechnical Journal* 32: 610-623.
- ITASCA (2000): *FLAC and UDEC – Fast Lagrangian Analysis of Continua and Universal Distinct Element Code*. Minneapolis, Itasca Consulting Group, Inc.