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Multidisciplinary investigations on coupled rockwall-talus-systems (Turtmann valley, Swiss Alps)

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Talus slopes covering the base of steep, unstable rockwalls are characteristic periglacial landforms and major sediment storages in mountain systems. In the Turtmann valley (Swiss Alps), rockfall deposits account for 1/8 of the debris volume stored in the hanging valleys. To evaluate the spatio-temporal efficiency of rockfalls for long-term talus evolution, geophysical measurements on rockwalls and talus slopes are increasingly applied during the last decades. However, the correct interpretation of the geophysical data is still a difficult task due to the landforms' specific material properties. Moreover, no comprehensive geophysical study exists investigating the coupled rockwall-talus-system.

Here, we studied two rockwalls and corresponding talus slopes in a tributary of the Turtmann valley. The active rockfall source areas dominate on rockwalls, for which a high permafrost probability was modelled (Nyenhuis et al. 2005). Rockwalls were selected based on their contrasting lithology, activity degree and valley location. By combining geophysical, geotechnical and geomorphological methods, we investigated (i) the rockwalls' mechanical characteristics as well as (ii) the material properties of the talus slopes in order to (iii) gain a further process understanding of the coupled rockwall-talus system.

(i) At the rockwalls, Electrical Resistivity Tomography (ERT) and Seismic Refraction Tomography (SRT) were applied along 40-50m transects with an electrode/geophone spacing of 1-1.25m. In addition, detailed geotechnical surveys of the rock mass and its discontinuity properties were performed. The combined results reveal that high resistivity (>10'000kΩm) and high p-wave velocities (>3'000m/s) correlate with dried bedrock consisting of amphibolites with large joint spacing (52cm) and long persistences (> 220cm). In contrast, the small joint spacing (17cm) and short persistences (<48cm) of the paragneiss are linked to a lower resistivity (<5000kΩm) and low p-wave velocities (<3'000m/s) reflecting wet bedrock and fractured areas. In both rockwalls, the geophysical surveys disprove the local existence of permafrost.

(ii) At the rockwalls' corresponding talus slopes, ERT and SRT were performed along 200m transects. Every 5m, equivalent to the electrode spacing, the block sizes (a, b, c-axis) of rockfall deposits were mapped in detail. The specific ERT seems to indicate the specific material properties, as high resistivities at the talus foot are linked to large block sizes, while patches of fine, relatively wet sediments near the apex are reflected by low resistivities. The very high p-wave velocities at the distal base of one of the talus may indicate the existence of ice.

(iii) The synthesis of all data indicates that the joint spacing, lithology and the rock moisture patterns are major small-scale controls on the present-day destabilisation of the rockwalls, favouring the activity of wetting-drying and freeze-thaw cycles. Given the absence of permafrost in both rock faces, permafrost seems not to be relevant for the bedrock stability today, instead, unidirectional freezing on near-surface might be an effective breakdown mechanism. Depending on the contrasting rock mechanical and material properties of the rockwalls, different rockfall block sizes may be involved in the talus evolution, respectively.

Therefore, our study reveals that the process understanding of the coupled rockwall-talus-system can be improved when geophysical data are interpreted in the light of the specific geotechnical and geomorphological landform conditions.

Nyenhuis, M., M. Hoelzle, and R. Dikau, 2005, Rock glacier mapping and permafrost distribution modelling in the Turtmanntal, Valais, Switzerland, Zeitschrift für Geomorphologie, 49(3), 275-292.