Geophysical Research Abstracts
Vol. 20, EGU2018-5343, 2018
EGU General Assembly 2018

Identification of periglacial and paraglacial processes and their implications for rockfall

Daniel Draebing (1), Samuel McColl (2), and Arne Brandschwede (3)

(1) Chair of Landslide Research, Technical University of Munich, München, Germany (d.draebing@tum.de), (2) Physical Geography Group, Institute of Agriculture and Environment, Massey University, Palmerston North, New Zealand, (3) Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark.

In alpine environments, rockfall is the primary process shaping deglaciated rockwalls. In addition to periglacial processes, rockwall stability concurrently adjusts to non-glacial conditions, evolving through time according to a suite of time-varying processes, all of which need to be accounted for to accurately model rockwall trajectories. While models exist to explain or simulate permafrost's influence on rockwall stability or frost weathering of rockwalls, few models integrate these processes and there is little field data to verify these models. In this field-based study, we quantify (i) geological controls, (ii) paraglacial stress-release histories, (iii) permafrost distribution, and (iv) the spatial and temporal patterns of frost weathering, and assess how these combine to influence rockfall processes at alpine rockwalls. To achieve this, we use geomorphic, geophysical and geotechnical techniques on three rockwalls (RW1-3) with different glacial history and altitude. All rockwalls are located in the Hungerli Valley (Swiss Alps) and lithology ranges from aplite (RW1) to amphibolite (RW2) and schisty quartz slate (RW3).

(i-ii) Laboratory seismics shows that schisty quartz slate is an order of magnitude more anisotropic than aplite or amphibolite due to foliation. Foliation represents planes of weakness where failures can occur. In the field, fractures will additionally control rock slope failures and seismic refraction tomography (SRT) results demonstrate that the fracture density of the rockwalls increases with proximity to the glacier. Therefore, our findings suggest that RW1 in proximity to the glacier is still undergoing paraglacial adjustment to glacier retreat, through active stress-release jointing.

(iii) Local permafrost modelling based on temperature logger data indicates that areas with likely permafrost occurrence (<-3°C) are limited to the peaks and upper Rothorn cirque walls. Possible permafrost (-2 to -3°C) areas are located in the middle cirque wall section including RW1. However, SRT demonstrate the absence of permafrost within the uppermost 6 m of the rockwall.

(iv) Crackmeter data were analysed according to the technique developed by Draebing et al. (2017) and resolve thermo-cryogenic movements controlled by altitudinal- and topography-dependent snow cover and temperature. RW1 experienced 191-221 days snow-covered and showed a seasonal thermal-induced opening and closing of 0.55 mm. Ice segregation occurs but permanent fracture widening is minor (<0.1 mm). The snow cover duration was less at RW2 (69-73 days) and the fracture underwent 0.15 mm of cyclic opening from thermal contraction, with ice segregation causing 0.05 - 0.1 mm widening. At RW3, snow cover was absent and crackmeters showed a high-frequency diurnal cyclic thermal-induced opening of up to 0.2 mm.

In conclusion, foliation preconditions rockfall at the low-lying RW3, which can be prepared and triggered by abundant thermal stresses. With increasing altitude, the importance of frost cracking increases as a preparing and triggering factor (RW2). In the highest RW1, permafrost may be limiting frost cracking due to decreased water availability, but increased stress-release and seasonal active layer thawing prepare and trigger rock slope failures.

References:
Draebing D., Krautblatter, M. and Hoffmann, T.: Thermo-cryogenic controls of fracture kinematics in permafrost rockwalls. Geophysical Research Letters 44: 3535-3544, 2017.