Modelling frost weathering processes and related stresses in Alpine rockwalls

Till Mayer$^{1,2}$ and Daniel Draebing$^1$

$^1$University of Bayreuth, Chair of Geomorphology, Bayreuth, Germany (till.mayer@uni-bayreuth.de)
$^2$Chair of Landslide Research, Technical University of Munich, Munich, Germany

The periglacial areas of the European Alps are characterised by rugged peaks and steep rockwalls with adjacent scree slopes that reflect high rates of rockfall activity. The current state of knowledge regards ice segregation as the dominant mechanism responsible for the disintegration of rock and associated destabilization of rockwalls. In the present work, we (1) monitored rock temperature in Alpine rock walls, (2) determined rock properties in the laboratory and (3) simulated frost weathering using purely temperature-driven models (Hales and Roering, 2007; Anderson et al., 2013) and physical-based models (Walder and Hallet, 1985; Rempel et al., 2016).

(1) We monitored rock temperature in 9 rockwalls in the Hungerli Valley and 10 in the Gaisberg Valley at altitudes between 2400 m and 3000 m between 2016 and 2019. Mean annual rock temperature is between -2.8 and 7.9°C and is strongly affected by snow cover, which ranges between 3 and 283 days.

(2) Lithologies comprise Mica Schist in the Gaisberg Valley and Schisty Quartz Slate with inclusions of Aplite and Amphibolite in the Hungerli Valley. Rock density, seismic and strength properties were quantified in the lab (Draebing and Krautblatter, 2019) to be included in physical-based frost weathering models.

(3) Frost weathering due to ice segregation can be expressed as cracking intensity, crack growth and porosity change. Our model results show that an annual maximum of cracking intensity, crack growth and porosity change within the first meter of rock depth in the study areas’ rockwalls. Although frost weathering is highly dependent on the thermal distribution inside a rock mass, our data demonstrate that lithological parameters strongly determine frost weathering due to their influence on water migration and fracture toughness. Furthermore, the results suggest that there is no relationship between average annual rock temperature, frost weathering and exposure, a tentative conclusion that is broadly contrary to prevailing consensus.

In conclusion, rock walls are exposed to strong thermo-mechanical stresses due to ice segregation, which leads to a disintegration of rock and lowering of stability. The present work lends support to other studies, which regard frost weathering as the dominant mechanism responsible for rockfall in mountain periglacial settings.


