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The influence of snow cover on thermal and mechanical processes in a permafrost-affected rock wall at Steintaelli, Valais, Switzerland

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Degradation of permafrost rock wall causes instability due to changes in rock- and ice-mechanical as well hydraulic properties. Conductive, convective and advective thermal processes alter mechanical and hydraulic properties of rock walls (Draebing et al., in rev.). On a seasonal scale, snow cover is a poorly understood key control of timing and extent of thermal processes. We use (i) manual snow pole measurements to evaluate snow depth distribution, (ii) laboratory-calibrated time lapse Seismic Refraction Tomography (SRT) to quantify active-layer response and (iii) automatic continuous crackmeters to monitor mechanical response of a rock wall in the Steintaelli in August 2012 and 2013.

In August 2012, the mean air temperature in the Steintaelli at 3100 m a.s.l. (6.4°C) was slightly lower than in the heat summer 2003 (7.4°C) and slightly higher than in 2013 (5.1°C).

(i) Manual snow pole measurements show an up to 1.5 m thick snow cornice covered the crestline of the rockwall, south and north facing slopes were snow free, in 2012. In the following year, the snow cornice expands to thickness of 2-4 m and additional up to 2 m thick snow patches covered the less inclined parts of the north facing slope.

(ii) The active-layer thawing was quantified by using SRT (Krautblatter & Draebing, 2013). In 2012, the active layer thawed to depths of 5-15 m. Snow isolation prevented or delayed thawing and active layer extended to depth of 0-5 m in 2013. Time-lapse SRT shows an overall annual cooling effect due to snow cover.

(iii) Ten automatic crackmeters monitored fracture movements three-hourly between September 2012 and August 2013. During snow free periods temperature changes resulted in expansion and contraction of rocks and closing and dilation of fractures, respectively. Fracture dilation was observed during extreme low temperatures and zero curtain periods. During snow covered periods ice segregation resulted in fracture opening of 0.4-0.9 cm.

Here we show for the first time, how snow cover controls the timing and the extent of active layer thawing and kinematic processes in permafrost affected rock walls.

References:

Draebing, D., M. Krautblatter, and R. Dikau (in rev.), Interaction of thermal and mechanical processes in steep permafrost rock walls: a conceptual approach, Geomorphology.
Krautblatter, M., and D. Draebing (2013), Pseudo 3D - P-wave refraction seismic monitoring of permafrost in steep unstable bedrock, Journal of Geophysical Research: Earth Surface, 2012JF002638.