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The interplay of predefined rock mechanics and permafrost forcing in a steep alpine rock crest (Steintaelli, Mattertal, Switzerland)

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Freeze-thaw-processes in the active layer and degrading permafrost change ice and hydraulic pressures as well as rock- and ice-mechanical properties in rock masses which can cause instabilities. The characterization of the rock mass was determined by the geological strength index and a detailed discontinuity analysis along scanlines where the active layer reached depths of 5-15m (August 2012). Rock mass deformations and accordingly the divergence and convergence of deep reaching fractures were measured along 18 extensometer transects with various lengths from 2 to 27m.

(1) The Geological Strength Index provided rock mechanical parameters which indicate stable conditions on the slope scale. The friction angle of the rock mass (44°) is higher than the mean slope inclination (37°).

(2) The discontinuity analysis provided six joint sets, their geometries and mechanical properties. High roughness coefficients and wall strengths of the joints result in high total friction angles (>43°) and stable conditions on the block scale. However, the locations of several joints with wide apertures, ice fillings and joints influenced by snowmelt of the cornice at the crest are used as indicators for freeze-thaw related rock mass deformations.

(3) The rock mass deformation rates during late summer (2012) are multiple times (>3) higher than deformation rates for several years (2008-2012). Furthermore, the direction of deformation changes between divergence and convergence over time. Both aspects indicate that seasonal and annual changes affect the rock mass deformations.

We conclude, that rock mass deformation cannot be explained solely by rock mechanical parameters without freeze-thaw and permafrost influence. The higher deformation rates during the thaw season in late summer and the heterogeneity of deformation directions indicate that seasonal and annual changes of ice- and hydraulic pressures in discontinuities affect instabilities at the Steintaelli crestline. Here we show the interplay of predefined rock mechanics and seasonal forcing on permafrost rocks and provide an outline how the importance of permafrost on rock slope stability can be assessed. This study was performed as part of the project ISPR - Influences of snow cover on thermal and mechanical processes in steep permafrost rock walls.