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Diminishing friction of joint surfaces as initiating factor for destabilising permafrost rocks?

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Degrading alpine permafrost due to changing climate conditions causes instabilities in steep rock slopes. Due to a lack in process understanding, the hazard is still difficult to asses in terms of its timing, location, magnitude and frequency. Current research is focused on ice within joints which is considered to be the key-factor. Monitoring of permafrost-induced rock failure comprises monitoring of temperature and moisture in rock-joints. The effect of low temperatures on the strength of intact rock and its mechanical relevance for shear strength has not been considered yet. But this effect is signifcant since compressive and tensile strength is reduced by up to 50% and more when rock thaws (Mellor, 1973).

We hypotheisze, that the thawing of permafrost in rocks reduces the shear strength of joints by facilitating the shearing/damaging of asperities due to the drop of the compressive/tensile strength of rock. We think, that decreasing surface friction, a neglected factor in stability analysis, is crucial for the onset of destabilisation of permafrost rocks.

A potential rock slide within the permafrost zone in the Wetterstein Mountains (Zugspitze, Germany) is the basis for the data we use for the empirical joint model of Barton (1973) to estimate the peak shear strength of the shear plane. Parameters are the JRC (joint roughness coefficient), the JCS (joint compressive strength) and the residual friction angle (φ_r). The surface roughness is measured in the field with a profile gauge to create 2D-profiles of joint surfaces. Samples of rock were taken to the laboratory to measure compressive strength using a high-impact Schmidt-Hammer under air-dry, saturated and frozen conditions on weathered and unweathered surfaces. Plugs where cut out of the rock and sand blasted for shear tests under frozen and unfrozen conditions. Peak shear strength of frozen and unfrozen rocks will be calculated using Barton's model.

First results show a mean decrease of compressive strength of around 40% when frozen water-saturated rock is exposed to thawing. The friction of sand-blasted rock-plugs decreases by a mean value of 32% considering degradation of rocks by freeze-thaw cycles. Surface roughness could be measured succesfully with the profile gauge and the results show a significant difference between untouched and sheared joint surfaces in the field.

Here we show, that shear resistance of rock joints will be diminshed just by the thawing of intact rock. This study will help to establish a sound concept for the destabilization of rocks in permafrost and provide the data for first stability modelling. This will be crucial for predict rock instability in permafrost regions.

References:

Barton, N. (1973): Review of new shear strength criterion for rock jonts. Engineering Geology 7: 287-332

Mellor, M. (1973): Mechanical Properties of Rocks at Low Temperatures. 2nd International Conference on Permafrost, Yakutsk, Siberia, 334–343.