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Effects of glimmer rich rocks on the failure criterion of ice-filled permafrost rock joints

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Degrading permafrost is an increasingly important problem in high altitude alpine mountains and Arctic regions around the world because it exerts a primary control on rock falls and landslides in these areas. Rock type dependence on the failure criterion of permafrost rock joints has not yet been studied and the present study focuses on glimmers, which are mica rich rocks with well developed foliation. The shear strength and the cohesion in glimmers are partly controlled by weak hydrogen-bonds due to the presence of OH groups at the surface of hydrated silicate minerals and ice. During shearing, glimmers are expected to release ions at the rock-ice interface, which would increase the surface charge and thereby the cohesion in glimmer rich rocks. We tested this hypothesis, in the framework of the CryoWall project, by shearing glimmer rich rocks sampled from the Ramnanosi active landslide in southwestern Norway, the Nordnesfjellet landslide in northern Norway and the Matterhorn mountain rock falls in the Swiss Alps. In these three areas, the cohesion of the rock volume is partly controlled by the presence of ice in rock joints. The samples sliding surface were grinded with a grinding powder to ensure reproducibility of the initial roughness. A direct shear machine was used to conduct 72 tests on rock-ice-rock sandwich samples. A constant strain rate was applied, provoking fracturing while a constant normal stress equivalent to 4, 8 or 15 meter overburden was maintained. The temperature was controlled at -10, -6 and -2 °C. Results provide a unique dataset that allows defining a rock failure criterion for glimmer rich rocks in the presence of ice. A validation of the failure criterion for permafrost rock joints may improve estimations of the degrading permafrost rock slopes in Arctic and alpine mountain areas, where the effects of global warming are known to be large.