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Assessing the properties of ground ice and its influence on surface dynamics at Gruben, Swiss Alps

Julie Wee*, Christian Hauck*, Christophe Lambiel**

** Department of Geosciences, University of Fribourg, Ch. du Musée 4, CH-1700 Fribourg (julie.wee@unifr.ch)*
*** Institute of Earth Surface Dynamics (IDYST), University of Lausanne, Bâtiment Géopolis UNIL Mouline, CH-1015 Lausanne*

High alpine environments are characterized by glacial and periglacial landforms that are currently undergoing transformations that illustrate a degrading cryosphere. While glacier shrinkage stands among the most evident signs of a transitioning alpine landscape, visible changes in the periglacial belt such as the degradation of permafrost or the melt of ground ice are more subtle, especially in environments where both glacial and periglacial processes have occurred or still occur simultaneously. From a geomorphological perspective, they constitute complex environments sitting astride the glacial and periglacial domains, whose consecutive response to atmospheric forcing is little known and deserve in-depth investigation.

This contribution aims at understanding the extent to which ground ice properties influence the surface dynamics of a) a rock glacier disturbed by the advance of a glacier during the Little Ice Age and b) a nearby debris-covered glacier at Gruben (VS), on the basis of long-term time series of ground surface temperature, together with in-situ geodetic and geophysical measurements.

In the glacier-affected upper part of the rock glacier, where surface elevation changes are the highest (from 0.2 m/y up to more than 0.5 m/y), preliminary results reveal the presence of ground ice with high electrical resistivities close to the subsurface. On the other hand, in the undisturbed lower part of the rock glacier the uppermost boundary of the permafrost body can be observed at a depth of approximately 5-7 meters. In contrast to the upper zone, this area expresses surface elevation changes solely due to downslope movement along the topographical slope, enhanced by an extensive flow pattern. The debris-covered zone of the Gruben glacier expresses a non-uniform kinematic behaviour: the upper zone shows important surface displacement velocities, while in the lower zone, close to the margins, velocities tend to strongly decrease (Gärtner-Roer et al., 2022).

These observations confirm the heterogeneous distribution of the ground ice content throughout the investigated rock glacier as well as the non-uniform geometrical behaviour of the landform. The undisturbed zone of the rock glacier expresses a constant behaviour of downslope creep movement, while the glacier-affected zone of the rock glacier suffers a melt-induced subsidence, not only indicating the presence of buried glacier ice in this zone, but also the insufficiency of the debris-cover thickness to ensure a long-term preservation of the ice under the current climate conditions. The debris-covered part of the Gruben glacier shows strong signs of downwasting, particularly in its margins inferring the absence of ice.

REFERENCES

Gärtner-Roer, I., Brunner, N., Delaloye, R., Haeberli, W., Kääb, A. and Thee, P. (2022). Glacier-permafrost relations in a high-mountain environment: 5 decades of kinematic monitoring at the Gruben site, Swiss Alps. The Cryosphere, 16, 2083–2101.