ICG2022-572, updated on 08 Jun 2023
https://doi.org/10.5194/icg2022-572
10th International Conference on Geomorphology

Insights on the morphodynamical evolution of an alpine Little Ice Age glacier forefield (Ritord, western Swiss Alps)

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Glaciers and frozen-debris landforms have coexisted and episodically or continuously interacted throughout the Holocene at elevations where the climate conditions are cold enough for permafrost to occur. In the European Alps, the Little Ice Age (LIA) characterized the apogee of the last interaction phase. In areas of consecutive post-LIA glacier shrinkage, the geomorphological dominant conditioning of the ongoing paraglacial phase may have transited from glacial to periglacial and later even shifted to post-periglacial. Such transitions can be observed through the morphodynamics of glacitectonized frozen landforms (GFL), which are permafrost-related pre-existing frozen masses of debris deformed (tectonized) by the pressure exerted by an interacting glacier.

This contribution aims at evidencing the processes driving the ongoing morphodynamical evolution of two actively back-creeping GFL and a debris-covered glacier within the LIA forefield of the Challand and Epée glaciers on the basis of long-term time series of ground surface temperature, in-situ geodetic and geophysical measurements. Our observations for the last two decades (1997-2021), which have been the warmest since LIA, reveal a resistivity decrease in the permafrost body of the two GFL and a surface subsidence of a few centimetres per year up to locally a few decimetres per year. The former indicate a liquid water-to-ice content ratio increase within the permafrost body and the latter a ground ice melt at the permafrost table, both processes having taken place heterogeneously at the scale of the two GFL. These observations can be interpreted as the system is entering post-periglacial conditioning. In comparison, the still widespread debris-covered tongue of the Epée glacier, almost immobile and disconnected from the glacier active part, suffers a melt-induced subsidence of about 50 centimetres per year, indicating the insufficiency of the debris cover thickness to insure a long-term preservation of the ice under current climate conditions.

This study enhances the importance of decadal-scale and multi-disciplinary approach in understanding driving processes contributing to surface elevation changes due to ice melt or thawing frozen ground in permafrost-prone alpine LIA glacier forefields and to the dynamics of associated GFL.