

Implications of a rapidly thinning ice-margin for annual moraine formation at Gornergletscher, Switzerland

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Moraines formed by annually advancing ice-margins can provide valuable insights into rates and drivers of recent glacial retreat as well as provide suitable modern analogues for the sedimentary processes of moraine formation. This study presents detailed insights into geomorphological and sedimentological characteristics of annual moraines in the foreland of Gornergletscher, Switzerland. Specifically, the implications of a rapidly thinning ice margin (cf. Fig. 1) for genetic processes and climatic significance of moraine formation are examined.



Fig. 1. The contemporary, thin ice-margin of Gornergletscher

Objectives and methodological approach

Geomorphological mapping in field aided by remotely sensed datasets to understand the distribution of annual moraine ridges in the glacial foreland (Chandler et al. 2018)

Sedimentological logging of representative moraine sections combined with field observations to reconstruct the dominant sedimentary processes of moraine formation (Evans & Benn 2004)

Statistical correlations between moraine spacing and climactic data from local weather stations to understand the drivers of recent frontal retreat (Beedle et al. 2009)

Key findings

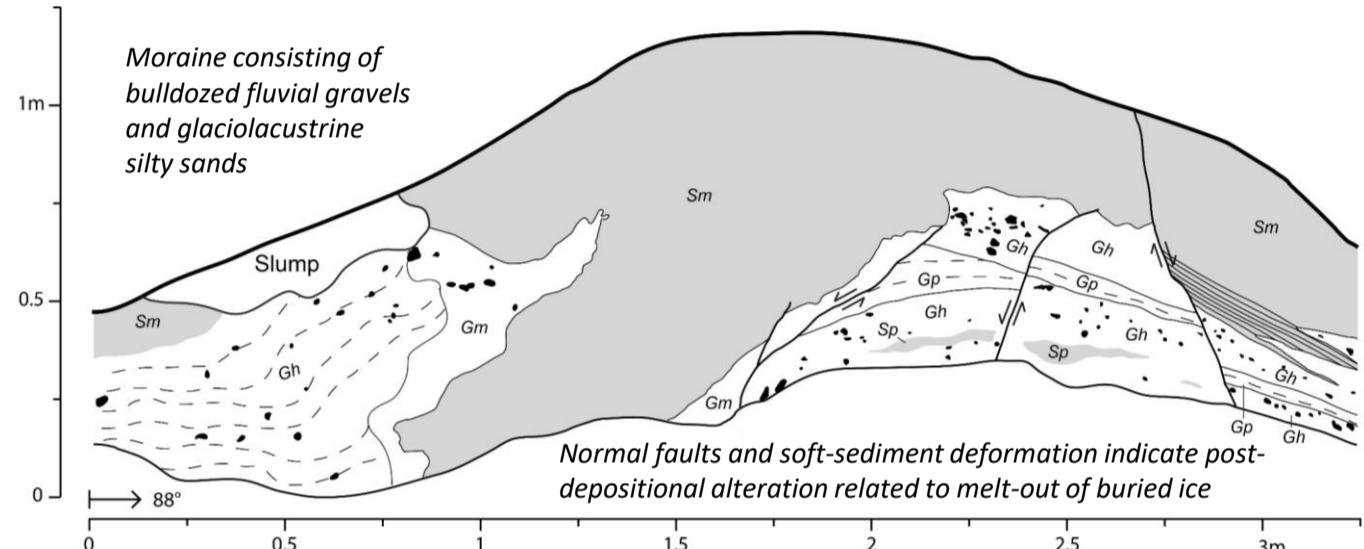


Fig. 2. Exemplary sedimentary log from a section through an annual moraine ridge at Gornergletscher.

Annual moraines at the present thin ice-margin of Gornergletscher are formed by processes of (**inefficient bulldozing** (cf. Fig. 2), **submarginal freeze-on** and as **controlled moraines**. Post-depositional alteration of the moraine ridges such as **meltout of buried ice** is common.

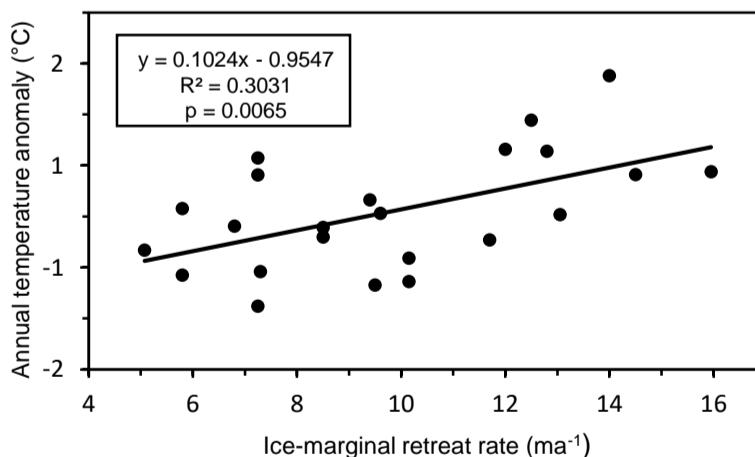


Fig. 3. Correlation between frontal retreat of Gornergletscher and annual temperatures (1994 – 2017). Part of the data retrieved from Lukas (2012).

Frontal retreat at Gornergletscher during the period 1994 to 2017 is most strongly **correlated to mean annual temperatures** (cf. Fig. 3). This link is specifically strong for recent years. However **non-climatic factors** can modulate retreat rates in a topographically complex glacial foreland.

Rapid ice-marginal thinning is likely to influence the formation of annual moraines at any alpine valley glacier. As moraine-forming processes operating along a thin glacier front are oftentimes coupled to the incorporation of buried ice into moraine bodies, the preservation potential of these moraines over longer timescales is largely limited. This highlights significant challenges that are connected with using annual moraines as a geomorphological proxy of glacial retreat in high-mountain settings.