Dating of mass movements by rock glaciers: Examples from the Eastern Alps

Alfred GRUBER and Jürgen M. REITNER
Geological Survey of Austria, Vienna
alfred.gruber@geologie.ac.at
Juergen.reitner@geologie.ac.at

Introduction

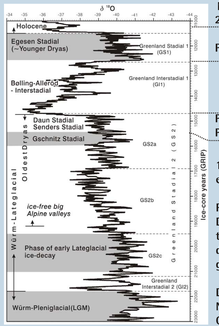
The dating of mass movements still remains a problem, despite great progress in geochronological techniques (e.g. surface exposure dating; SED) as appropriate material or the pre-requisite for dating (e.g. stabilised surface) is missing in many cases. Thus, we still have to rely on relative dating by comparing geomorphological features (e.g. weathering of scarps). However, uncertainties in interpretations of such geological phenomena may lead to ambiguous stratigraphic results.

Location of the study areas

A - Patscherkofel and Glungezer south of Innsbruck

B - Schobergruppe north of Lienz

Lateglacial chronostratigraphy and permafrost decay



	Northern Tyrol	Eastern Tyrol
Modern lower limit of permafrost [1]	2500-2700 m asl.	2450-2750 m asl.
		PFD 350 m
	PFD ~ 520 m	PFD 550-600 m
	PFD 650 m	PFD 650-700m
	PFD 650 m	PFD 650-700 m

1) altitudes vary with direction of exposition

PFD - Permafrost-depression: Difference between the modern and the former lower limit of discontinuous permafrost (rock glaciers)

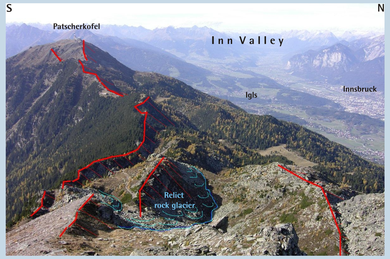
Data source:
Northern Tyrol : KERSCHNER (1985)
GRUBER (unpubl.)
Eastern Tyrol: BUCHENAUER (1990)

GRIP-Stratigraphy (BJÖRCK, 1998) vs. Alpine stratigraphy (generalised)

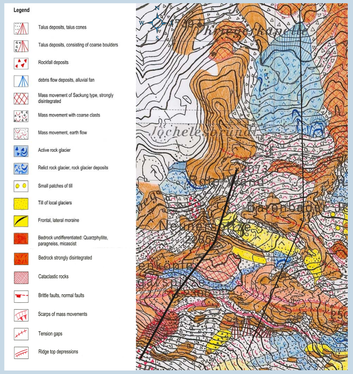
Lateglacial permafrost chronology of the Eastern Alps

High mountainous areas do not only resemble features of mass movements but also those of permafrost, especially rock glaciers. At least since the 1980s attempts to correlate relict rock glaciers with glacial stadials of Lateglacial age have been successful in the Eastern Alps. Thus, the lower boundaries of discontinuous permafrost during various Lateglacial stadials younger than ~ 16 ka as well as of Holocene cold phases can be constrained for some regions (e.g. KERSCHNER, 1985, BUCHENAUER, 1990).

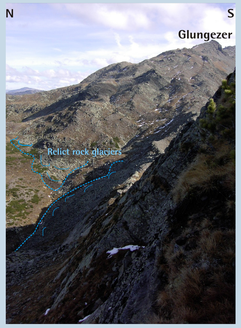
Case 2: Rock glaciers formed within ridge-top depressions



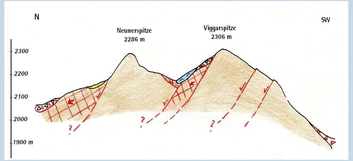
View from the top of the Viggarspitze towards Patscherkofel: The scarps and the ridge-top depressions of the giant Sackung-type mass movements towards north (Inn valley) are evident. The formation of the nowadays relict rock glacier in the foreground occured after the slope failure had started.



Geological map of the area Neunerspitze - Viggarspitze ((sheet ÖK 148 Brenner, S of Innsbruck) with the location of the section.

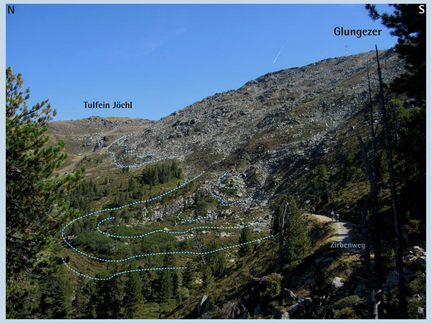


Eastward view from the top of the Viggarspitze: The scarp indicating dip-slip towards the north dominate the foreground. Small rock glaciers evolved from the debris of their disintegrated toe.

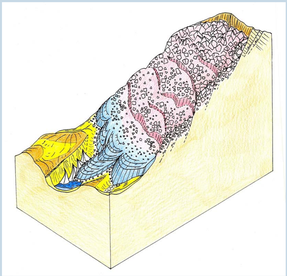


N-S section with evidence of ridge-top-depression due to dip-slip along pre-existing tectonic faults and rock glacier formation at the toe of the scarps.

Case 1: Rock glaciers generated from the toe of mass movements



View of the toe of the mass movement at the northern flank of peak Glungezer. The dis-integrated mass merges into the relict rock glacier downslope (blue lines indicate ridges of the rock glacier).

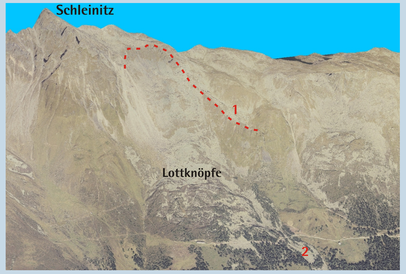


Block diagram showing the progressive deformation of the rock mass caused by deep-seated mass movement and the formation of rock glaciers at the toe of the slope.

Rock glaciers and their relation to mass movements

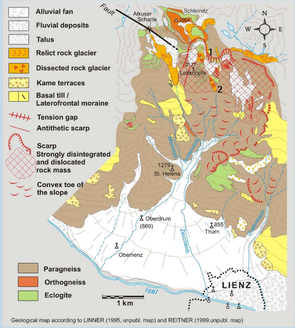
We present the results of recent mapping campaigns in Northern and Eastern Tyrol (Tuxer Alpen GRUBER, 2005, Schober Gruppe REITNER, 2003) where relict rock glaciers are linked to mass movements in different ways:

1. rock glaciers generated from the disintegrated slope of sagging masses.
2. rock glaciers that were formed within ridge-top depressions (tension gaps) or beyond scarps
3. rock glaciers that were dissected by mass movements

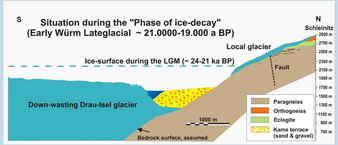


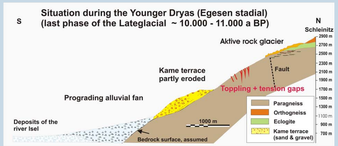
View towards N onto the disintegrated rock mass of Lottknöpfe with the scarp (red dotted line) above. The upper (original) and the lower (moved) part are indicated (localities 1 and 2).

Case 3: Rock glaciers dissected by mass movements

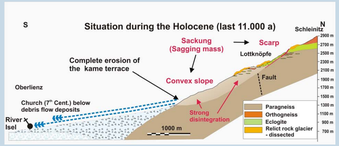


Map of the Sackung (sagging mass) Lottknöpfe.
Localities 1 and 2 are indicated.





Locality 1 - view towards south: The ridge made up of big boulders (A) in the foreground is the remaining original part of the rock glacier. (B) indicates a moraine of a local glacier. The scarp (dotted line) and the displaced part of the rock glacier (locality 2) are visible.



Evolution of the mass movement in relation to the glacial and permafrost chronology. The Sackung started after the Younger Dryas according to the dissected relict rock glacier.

Conclusions

The altitudes of such rock glaciers in combination with the known chronology of Permafrost retreat within the Lateglacial time enable to constrain the minimum (case 1and 2) or the maximum age (case 3) of mass movements. In addition to this relative dating potential we emphasise the continuous transition from gravitational to periglacial processes in high Alpine areas.

References

BUCHENAUER, H.W. (1990): Gletscher- und Blockgletschergeschichte der westlichen Schobergruppe (Osttirol), Marburger geographische Schriften, 117, 276 S, Marburg/Lahn.
GRUBER, A. (2005): Bericht 2004 über geologische Aufnahmen im Quartär der Nördlichen Tuxer Alpen auf Blatt 148 Brenner.- Jahrbuch der Geologischen Bundesanstalt, 145, 337-343, Wien.
KERSCHNER, H. (1985): Quantitative palaeoclimatic inferences from lateglacial snowline, timberline and rockglacier data, Tyrolean Alps, Austria.- Zeitschrift für Gletscherkunde und Glazialgeologie, 21, 363-369, Innsbruck
REITNER, J. M. (2003): Bericht 1998-99 über geologische Aufnahmen im Quartär und Kristallin auf Blatt 179 Lienz.- Jahrbuch der Geologischen Bundesanstalt, 143, 514-522, Wien.