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ACTIVE ROCK GLACIERS AT HOHE GAISL (EASTERN DOLOMITES)

Karl Krainer[1] and Kathrin Lang[2]

[1] Institute of Geology and Paleontology, Leopold-Franzens-University Innsrbuck, Innrain 52, A-6020 Innsbruck, Austria; Karl.Krainer@uibk.ac.at

[2] Amt für Geologie und Baustoffprüfung, Autonome Provinz Bozen, Eggentalerstraße 48, I-39053 Kardaun, Italien; Kathrin.Lang@provinz.bz.it

General Aspects

Aim of the excursion

This one-day trip will examine the dynamics of an active rock glacier situated in the Gletscherkar at the foot of the Hohe Gaisl in the eastern Dolomites (Fig. 1). The first stop will provide an overview on the rock glacier and the geology of the entire catchment area. The second stop includes several locations on the rock glacier where geomorphological aspects, composition, structure, ground temperatures, hydrology and surface velocities will be discussed. The third stop is at the base of the steep front of the northeastern lobe, where small amounts of meltwater are released from the rock glacier and infiltrate into the bedrock along karst cavities. In front of the rock glacier the bedrock (Dachstein limestone) shows a well developed karst morphology including karren, ponors, and dolines. Another active rock glacier is located in the Gaislkar. The tongue-shaped Gaislkar rock glacier is 650 m long, 125–95 m wide and covers an area of 0.1 km^2. The rock glacier ends at an altitude of 2425 m and extends to the highest point at 2525 m. The front slope is up to 50 m high, the gradient of the front slope measures 35– 40°. The surface is characterized by well developed transverse ridges and furrows. The rock glacier in the Gaislkar is not easy to access (no trail). Both rock glaciers have been described in detail by Lang (2006).

Geological Setting

The bedrock of the Hohe Gaisl massif and the catchment area of the rock glacier in the Gletscherkar are composed of carbonate rocks of the Upper Triassic (Norian – Rhaetian) Hauptdolomite and Dachsteinkalk formations (Fig. 2). The Hauptdolomite formation is a well bedded cyclic succession of intertidal stromatolite facies and thicker, subtidal mudstone beds locally containing abundant megalodonts and gastropods.

The Dachsteinkalk formation is composed of thick bedded gray limestone containing megalodonts. Intercalated are thin black pebble breccias. Locally the limestone is dolomitized. Limestone is intensively karstified and displays well developed karst morphology.

The block of the Hohe Gaisl Massif is composed of flat lying Hauptdolomite and Dachsteinkalk. This block was uplifted during the Neogene along two steep faults forming a positive flower structure. The ridge of the Gumpalspitzen east of the Hohe Gaisl is strongly folded and faulted. Due to their orientation these folds are ascribed to the Dinaric compressional event (top SW).

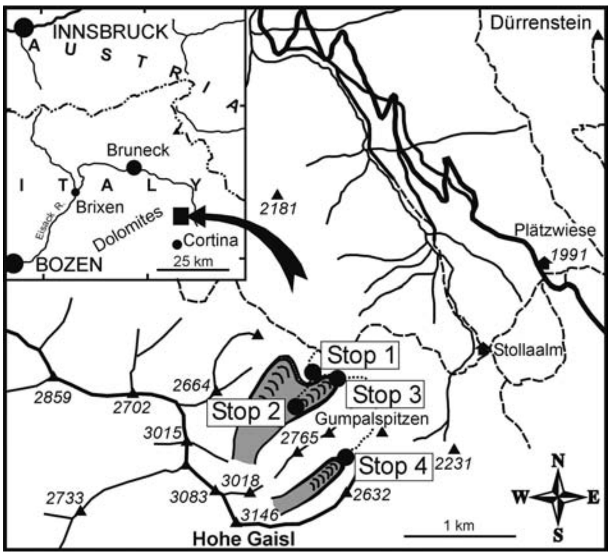

Fig. 1: Location map of Gletscherkar and Gaislkar rock glaciers in the eastern Dolomites, South Tyrol (Northern Italy).

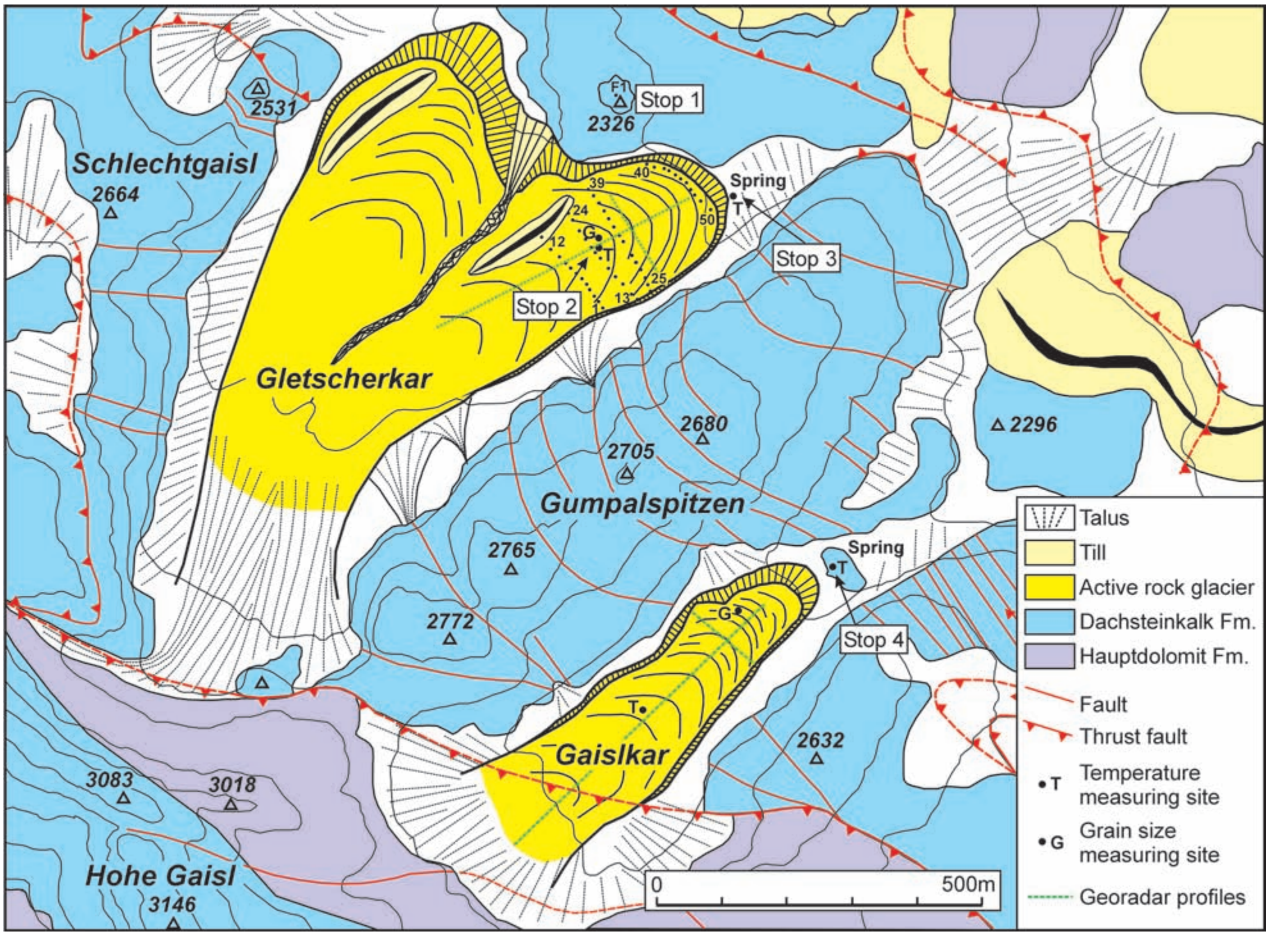

Fig. 2: Geologic/geomorphologic map of the northeastern part of the Hohe Gaisl massif in the eastern Dolomites with Gletscherkar and Gaislkar rock glaciers.

Active Rock Glaciers

Rock glaciers are considered as the product of alpine permafrost processes by some scientist. Rock glaciers are debris-covered, slowly flowing mixtures of rock and ice common in many alpine and arctic regions (for summary see Barsch, 1996; Haeberli, 1985; Whalley and Martin, 1992); they are striking morphological expressions of permafrost creep and belong to the most spectacular and most widespread periglacial phenomenon on earth. Rock glaciers are important agents of geomorphic modification of the landscape, particularly of alpine landscapes. They are widespread in alpine regions, but are less well studied than their "true" ice-glacier counterparts.

In the eastern part of the Alps a large number of rock glaciers is present (Lieb (1996), particularly in the central mountain ranges composed of metamorphic rocks ("Altkristallin"). Many of them are exceptionally large and highly active. Active rock glaciers are less common in the mountain ranges composed of carbonate rocks such as the Northern Calcareous Alps or the Dolomites. Although few active rock glaciers are present in the Dolomites, they have never been studied in detail.

Excursion
Excursion Route

The excursion route starts at Plätzwies and follows the Dolomitenhöhenweg (trail) Nr. 3 to Roßhütte: from Plätzwies (1991 m) towards southwest, passing the Stollaalm, then towards northwest to Gumpalboden. The route leaves the trail at an altitude of ca. 2250 m to climb the hill (2326 m) formed of karstified limestone ca 200 m south of the trail (Stop 1; Fig. 1).

Description of Stops
Stop 1: Overview Gletscherkar

The first Stop which is located on a hill in front of the rock glacier provides an excellent overview on the rock

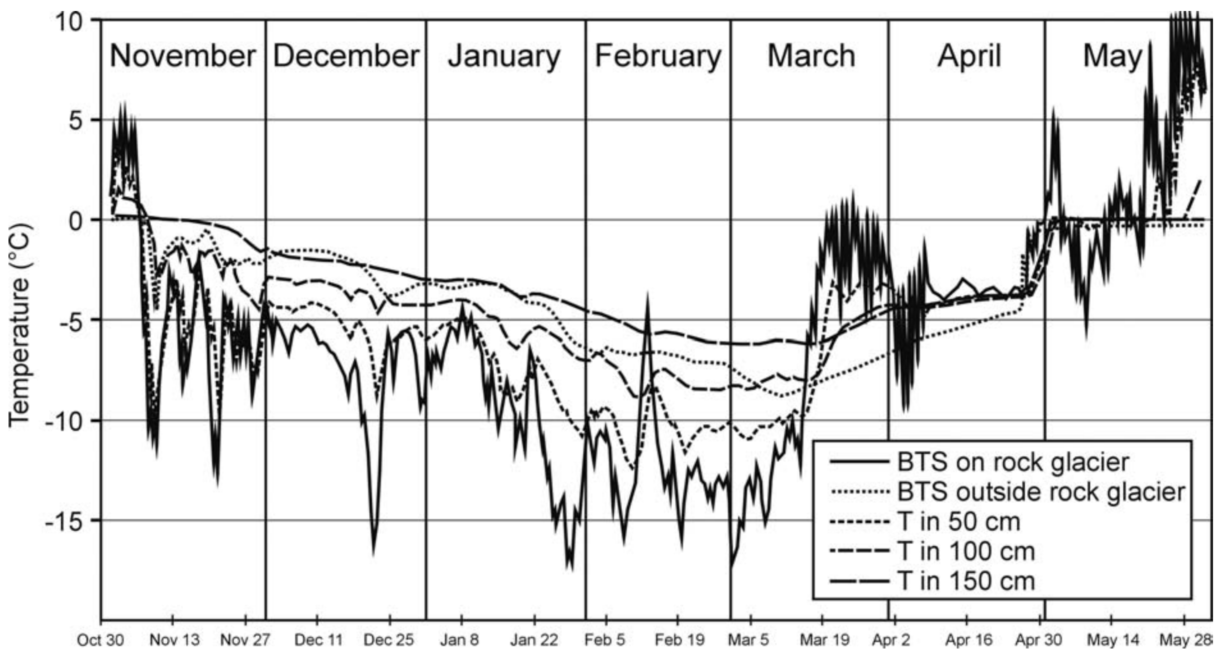

Fig. 3: Temperatures at the base of the snow cover (BTS) and within the derbis layer at Gletscherkar rock glacier from November 1, 2004 until May 31, 2005.

glacier and the entire catchment area (location see Fig. 1). The rock glacier is located in the Gletscherkar on the northeastern side of the Hohe Gaisl (3146 m). The rock glaciers lies in a cirque which is surrounded by steep walls composed of Upper Triassic carbonate rocks of the Hauptdolomite and Dachsteinkalk formations. Debris of the rock glacier is mainly derived from a prominent, NW-SE-trending fault, along which the bedrock is intensively deformed. The rock glacier is 850 m long, 300–550 m wide and covers an area of 0.3 km^2. The rock glacier extends from an altitude of 2340 m at the front to about 2500 m. The average gradient of the surface is 5°. The eastern lobe shows well developed surface topography of transverse ridges and furrows. The surface is coarse-grained; the front is very steep (35–40°) and composed of fresh, reddish material bare of vegetation.

Stop 2: Surface of the rock glacier

Stop 2 includes several locations on the rock glacier beginning in the upper part. All stops are located on the eastern lobe of the rock glacier, extending from ca. 2500 m to ca. 2350 m.

The debris layer ("active layer") of the rock glacier is composed of dolomite and limestone derived from the Hauptdolomite and Dachstein formations. The grain size of the uppermost layer (surface) varies from place to place; coarse-grained areas alternate with finer grained areas. In coarse grained areas most grains range from 1 to 30 cm in grain size, rarely exceeding 1 m. In fine-grained areas clasts 1–10 cm in size dominate; clasts larger than 20 cm are rare.

In the upper, steeper part of the rock glacier the debris has locally been reworked by flowing water, probably during summer thunderstorms showing characteristic features of debris flows, rarely of sieve deposits.

In the upper part massive ice is exposed during the summer months at several places below a less than 1 m thick debris layer. The ice is coarse-grained, banded, and contains thin, fine-grained debris layers parallel to the banding. Rarely larger clasts occur within the ice.

During the melting season small thermokarst lakes may be developed on the upper part of the rock glacier. Meltwater streams may be present flowing over short distances on the surface of the ice and within the thin debris layer. Downstream the meltwater disappears within the thicker debris layer and no meltwater is seen on the surface of the rock glacier on the lower and middle portions.

Temperatures within the debris layer are mainly controlled by the local weather conditions, the frozen core of the rock glacier and the thickness of the debris layer. During summer the temperature decreases rapidly within the debris layer. At a depth of 150 cm no daily temperature variations are recorded and the temperature never exceeded +2°C during summer 2004 and +3°C during summer 2005. During the winter 2005–2006 the temperatures at the base of the snow cover (BTS) on the rock glacier were significantly lower (-14.5 – -4.5°C) than outside the rock glacier (-5.5 – -2.9°C) (Fig. 3).

We established a geodetic network of 50 survey markers along four transects perpendicular to the flow direc-

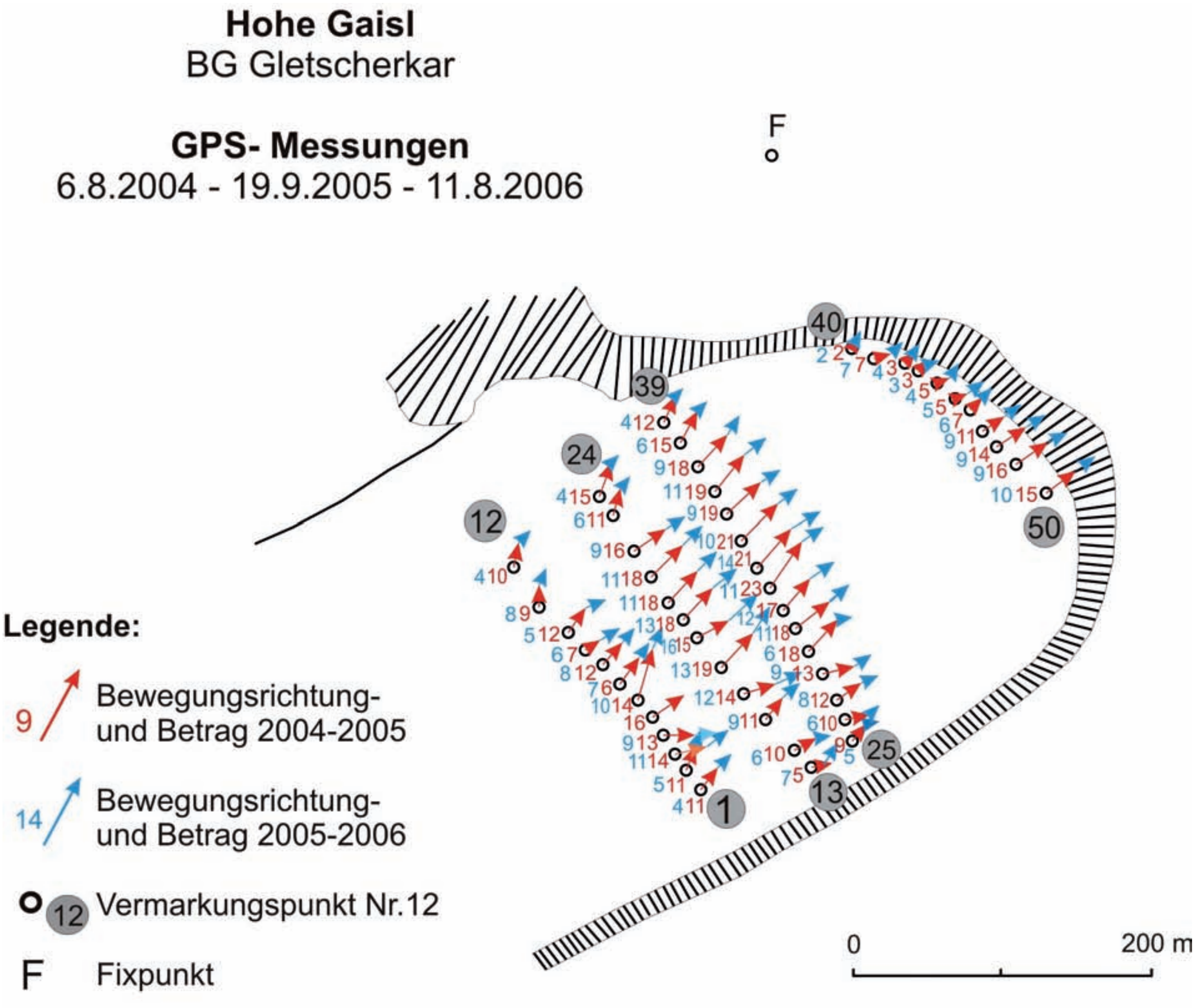

Fig. 4: Surface flow velocities on the lower part of Gletscherkar rock glacier recorded from August 6, 2004 to September 19, 2005, and from September 19, 2005 to August 11, 2006.

tion on the eastern lobe of the rock glacier and two fixed control points on the hill in front of the rock glacier in July 2004. The survey markers were first measured on August 6, 2004 using differential GPS technique (Ashtec Z-Max).

The survey markers were remeasured on September 19, 2005 and August 11, 2006.

Along all transects the surface flow velocities decreased from the axis to the rock glacier margins. From August 2004 to September 2005 the highest flow velocity was 23 cm measured at survey marker 32. Horizontal displacements along the axis measured 16–23 cm, decreased towards both margins to 5–15 cm. Lowest flow velocities of 2–7 cm were recorded near the northern part of the front From September 2005 to August 2006 the velocities decreased significantly. The highest flow velocity was 16 cm recorded at survey marker 18. Flow velocities varied between 9 and 16 cm along the axis and from 4 to 7 cm near the margins (Fig. 4).

Georadar measurements provided information on the internal structure and thickness of the rock glacier. We used a GSS SIR System 2000 equipped with a multiple low frequency antenna. We measured two profiles using antennas with a centre frequency of 35 MHz and constant antenna spacing in point mode (constant-offset profiling). Data were collected by fixed-offset reflection profiling (Fig. 5). Distance between transmitter and receiver was 4 m, step size (distance between the data collection points) was 1 m. The antennas were oriented perpendicular to the profile direction. The main record parameters were 1000 ns time range, 1024 samples/scan, 16 bits/sample, and 32-fold vertical stacking. The data indicate that the rock rock glacier has a total thickness of approximately 25 m. In the lower and middle part the debris layer is 3–5 m thick. Below the debris layer numerous, well developed reflectors are visible indicating the presence of shear planes in the frozen body of the rock glacier which according to ice exposures in the upper part is composed of coarse (glacier) ice with numerous thin debris layers parallel to the banding (Fig. 5). A thin sediment layer (?lodgement till) may be present at the base of the rock glacier.

Stop 3: Front of the rock glacier, karst features

The front of the eastern lobe of the rock glacier is steep, bare of vegetation and composed of debris containing a high amount of fine-grained sediment. Sieve analysis show that silt and mud (< 0.063 mm) constitute 6–16%, sand 10–28% and gravel 65–83%. The material is poorly sorted.

At the base of the steep front a rock glacier spring is present which releases only a small part of the meltwater. During the meltwater season discharge is mostly less than 1 l/sec, later in the season (August, September) the spring is partly dry. The water temperature of the spring at the front of the rock glacier remains constantly below 1°C during the entire melt season.

The meltwater released at the spring flow a few metres through the blocky material in front of the rock glacier and disappears along karst channels within a doline-like karst hole. The bedrock in front of the rock glacier is composed of Dachstein limestone, which displays a typical karst morphology including karren, karst holes and ponors.

Discussion

Internal structures (shear planes) and particularly ice exposures at the upper part of the rock glacier clearly indicate that the rock glacier in the Gletscherkar developed from a debris-covered cirque glacier. We suggest that the glacier has developed from a small cirque glacier during retreat through inefficiency of sediment transfer from the glacier ice to the meltwater. The presence of a cirque glacier at Gletscherkar is documented in the older literature and on older maps, for example on a topographic map published in 1902.

References

Barsch, D. (1996). Rockglaciers. Indicators for the Present and Former Geoecology in High Mountain Environments. – Springer-Verlag, Berlin.

Haeberli, W. (1985). Creep of mountain permafrost: Internal structure and flow of alpine rock glaciers. – Mitteilungen der Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie ETH Zürich 77: 1–142.

Lang, K. (2006): Geologie des Hohe Gaisl Massives (Pragser- und Ampezzaner Dolomiten) unter besonderer Berücksichtigung der aktiven Blockgletscher. – Unveröff. Diplomarbeit, Institut für Geologie und Paläontologie, Leopold- Franzens- Universität Innsbruck, 170 S.

Lieb, G. K. (1996). Permafrost und Blockgletscher in den östlichen österreichischen Alpen. – Arb. Inst. Geogr. Univ. Graz 33: 9-125.

Whalley, W. B. & Martin, H. E. (1992). Rock glaciers: II models and mechanisms. – Progress in Physical Geography 16, 127-186.