What characterizes a rock glacier?

Geo-ecosystems in Transition on the Tibetan Plateau (TransTiP)

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Introduction

The character and genesis of a rockglacier depends mostly on the situated climate conditions. At the Tibetan plateau (TP), a **complex, regional climate situation** (Fig. 1) -seasonal influence of the Westerlies (blue arrows), the Indian Summer Monsoon (red arrows), and the East Asian Monsoon (black arrows) - is combined with a high-elevation, periglacial environment. Rock glaciers as climate-sensitive periglacial landforms provide a local state in the otherwise complex climatic situation. Both current state and genesis can be indicative of past and present climatic conditions. Therefore, we investigate an rockglacier in the **Qugaqie basin (4722 - 6119 m a.s.l., area: 60 km²)** that is characterized by a semiarid climate (annual precipitation: **281 mm (July-September)**; MAAT **0°C**) (Mügler et al. 2010) to see what makes a rock glacier. It is located in the northern part of the Nyainqêntanglha, which forms a natural orographic barrier, thus reducing monsoonal moisture (Fig. 1, B).

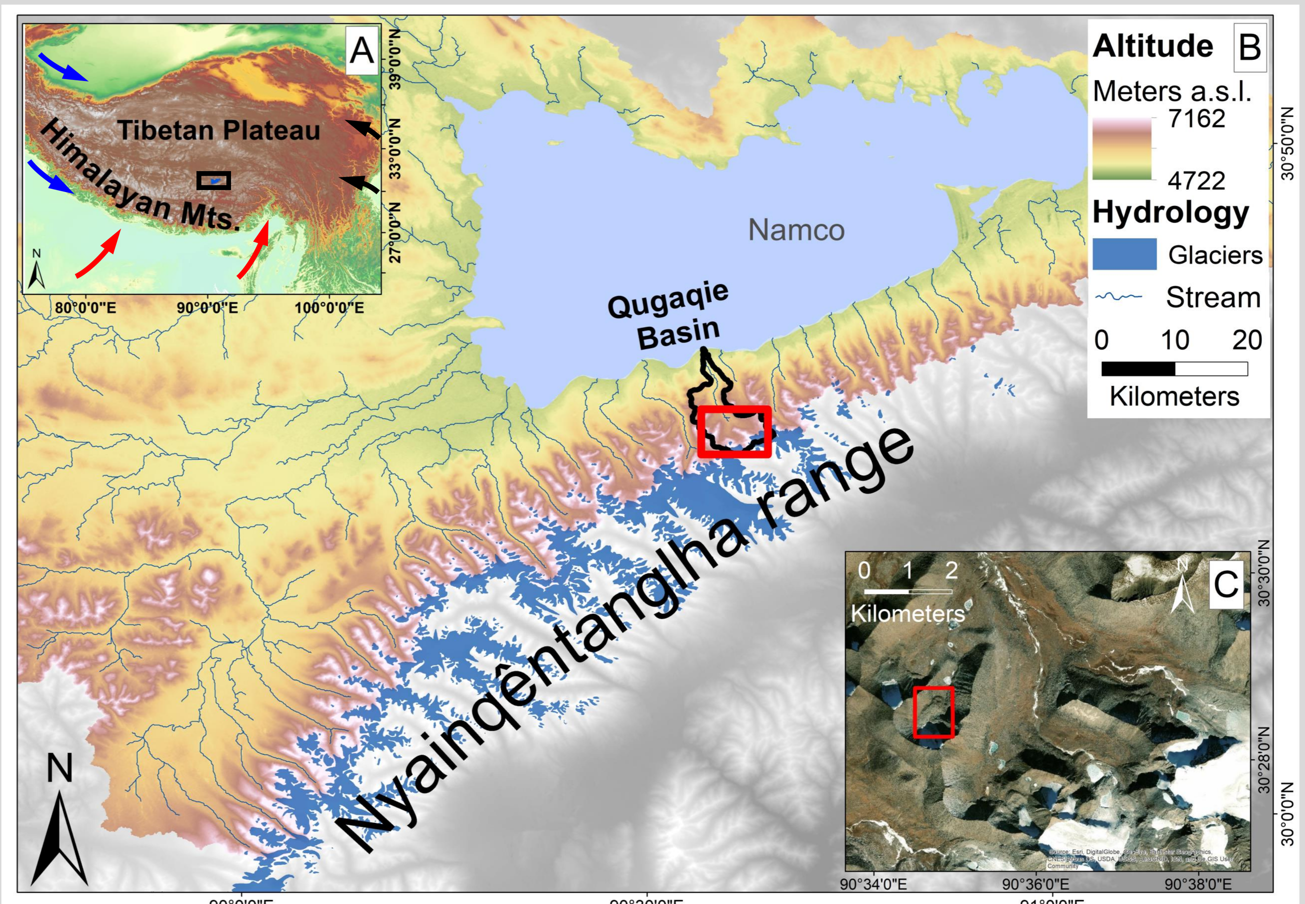


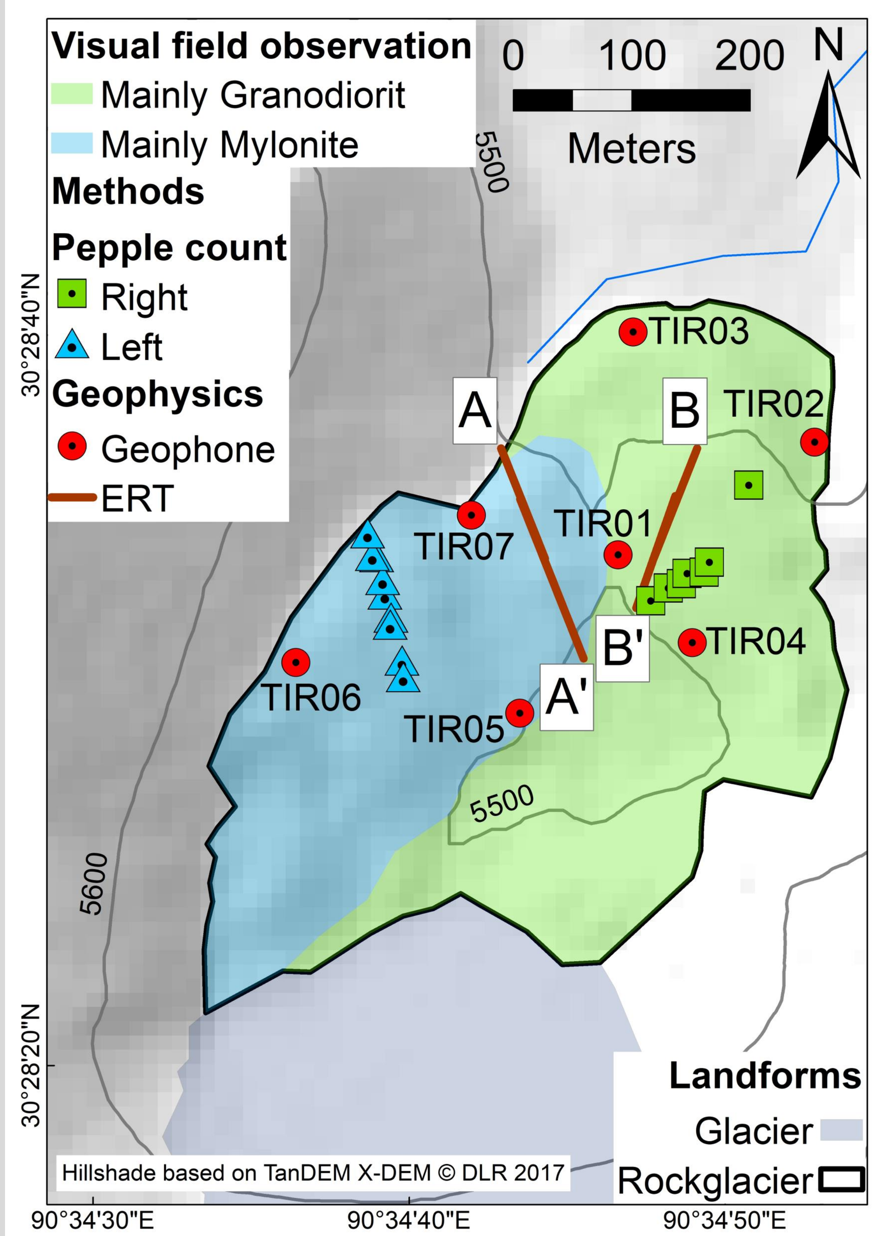
Figure 1, A: Location of the overall study area (Based on SRTM DEM v4; Jarvis et al., 2008). Wind systems based on Yao et al. (2013). **B:** Overview map of the Nam Co catchment and the study area of the Qugaqie catchment (black thick lines). Glacier extents originate from GLIMS database. Red rectangle locates Fig. C. **C:** Orthophoto of the periglacial and glacial environment. The red rectangle locates of Fig. 2, 7 & 8.

Aims of the study

1. Characterising an active rockglacier at the TP based on a multi-method approach: Field work, ERT, environmental seismology, InSAR time-series analysis.
2. Using this information defining what makes a rock glacier, interpreting the genesis and deriving how it would respond to climate change.

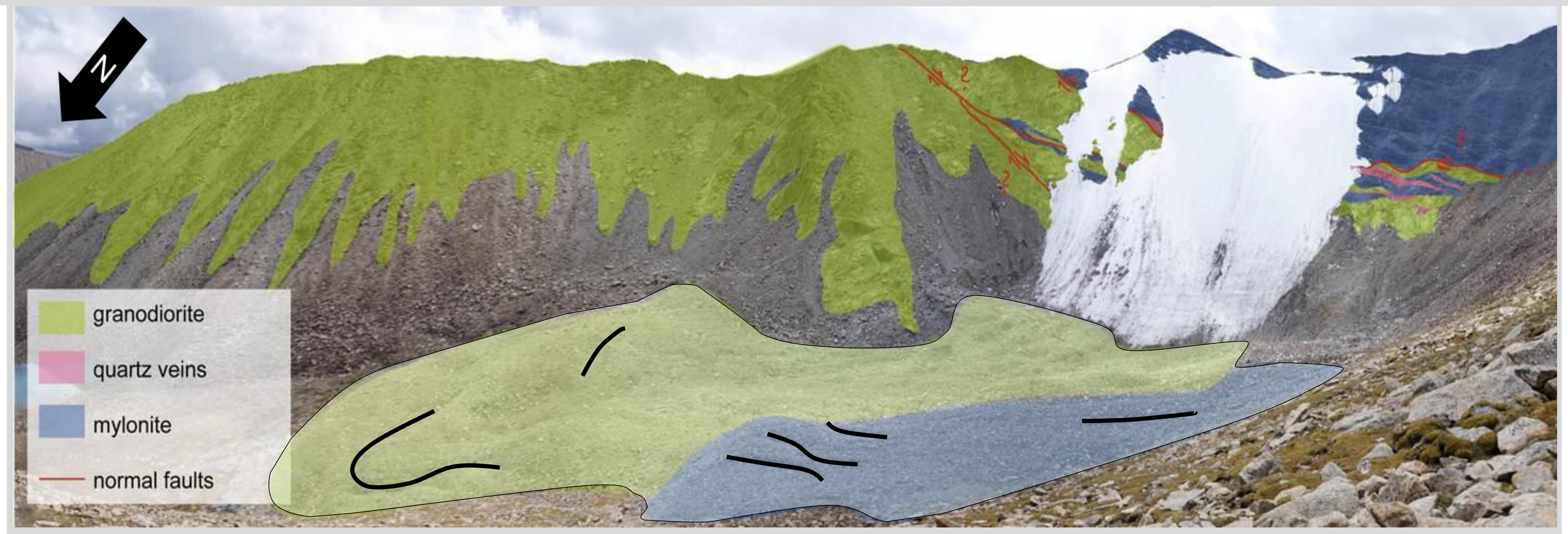
Insights into the structure and dynamics of an active rock glacier on the Tibetan Plateau

Substrate characteristics



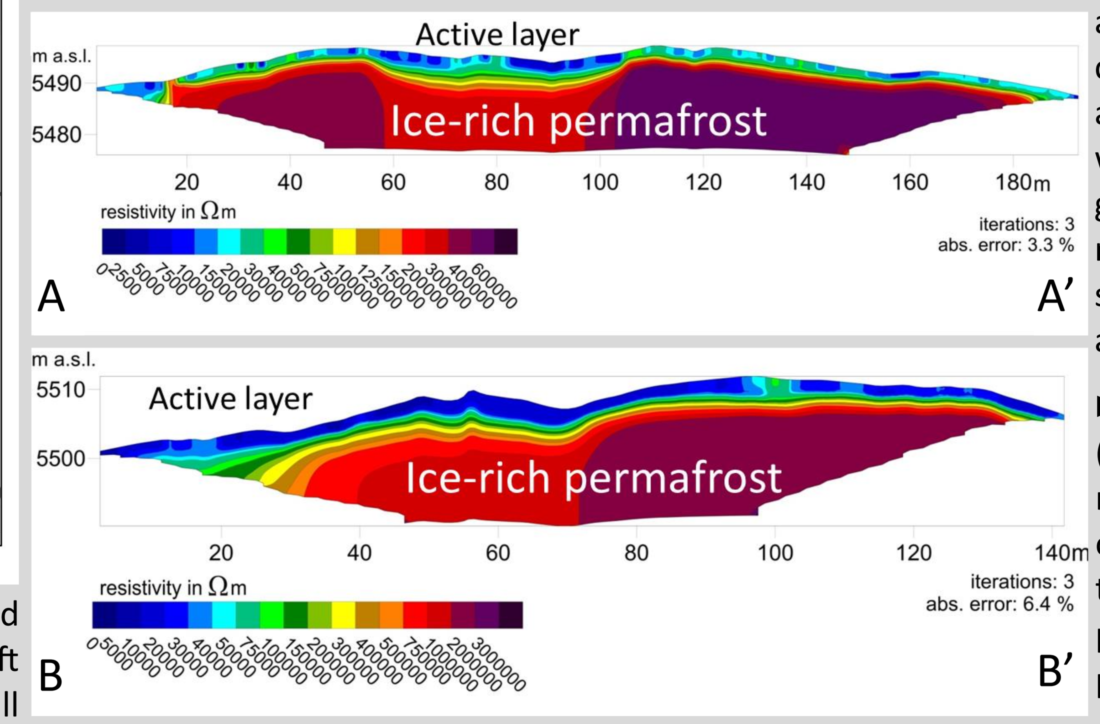
▲**Figure 2**: Lithologic composition based on field observation: Darker, smaller sediments occur on the left side and vice versa. Survey layout: pebble count (all pepples along a 2 m section were measured in the a, b, c direction), ERT, Geophones for environmental seismology.

Catchment characteristics

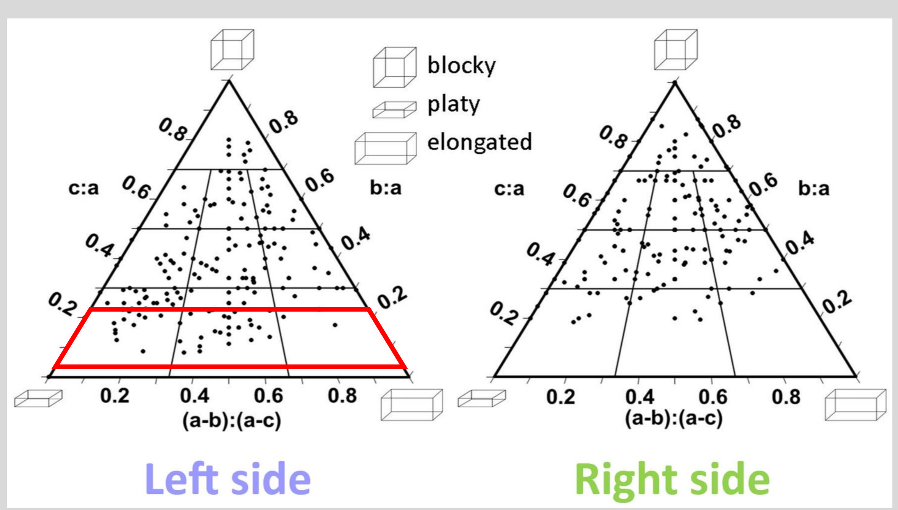


▲**Figure 4**: Rockglacier substrate (bright green and blue sourrounded by a black polygon) originated by the catchment lithology: Granodiorites are a intrusive magmatic rocks (hard, weathering resistant, blocky, bigger grain sizes). Mylonite are Metamorphic rocks, near ductile faults (soft, pebbles, smaller grain sizes). Black lines indicate an active status by furrows and lobes

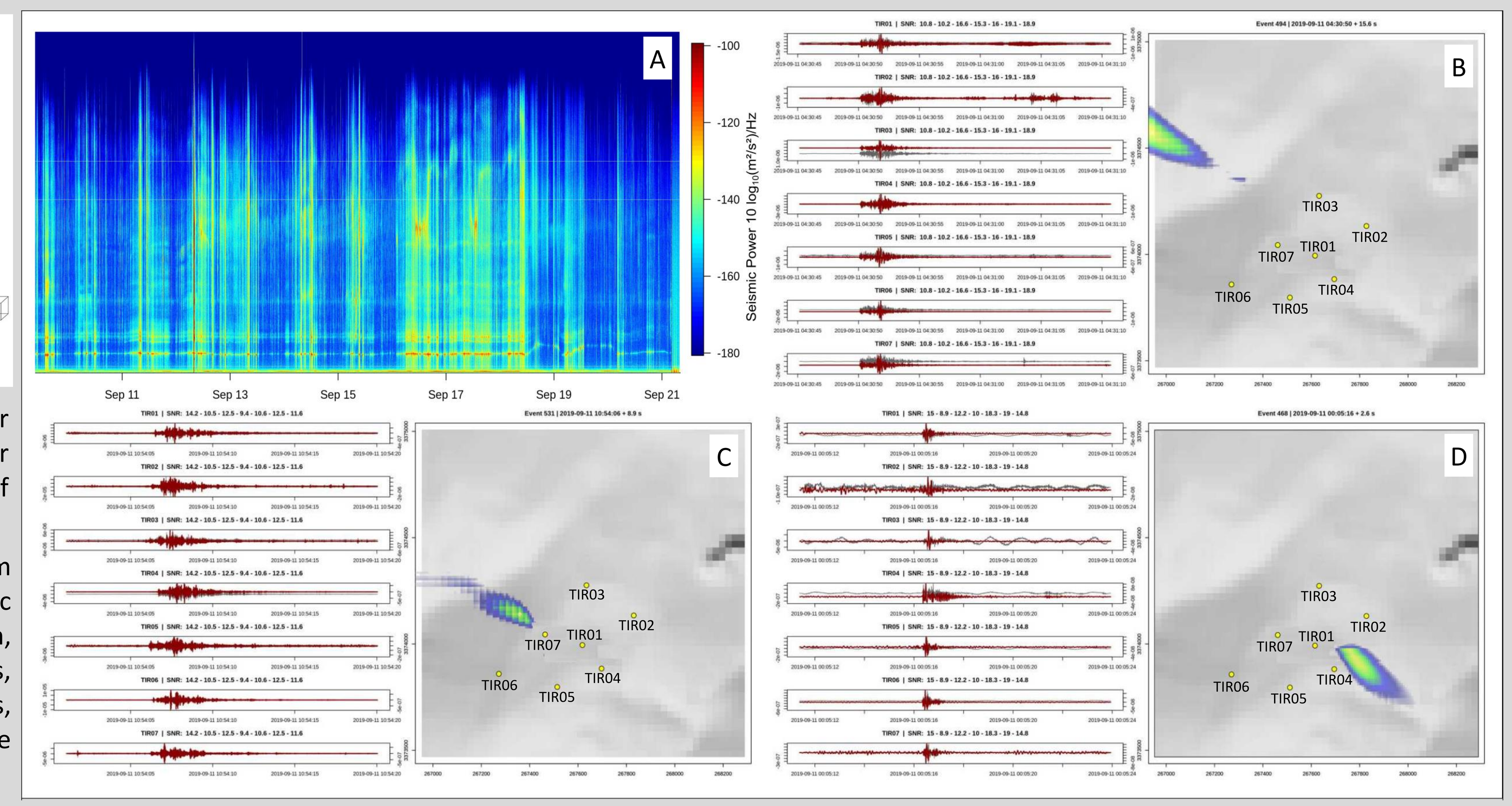
Internal structure



▲**Figure 5:** ERT data to detect subsurface ice content. Extremly high resistivity values indicate ice-rich permafrost. Location of Profiles are indicated in Fig. 2. All data were recorded in July 2018.

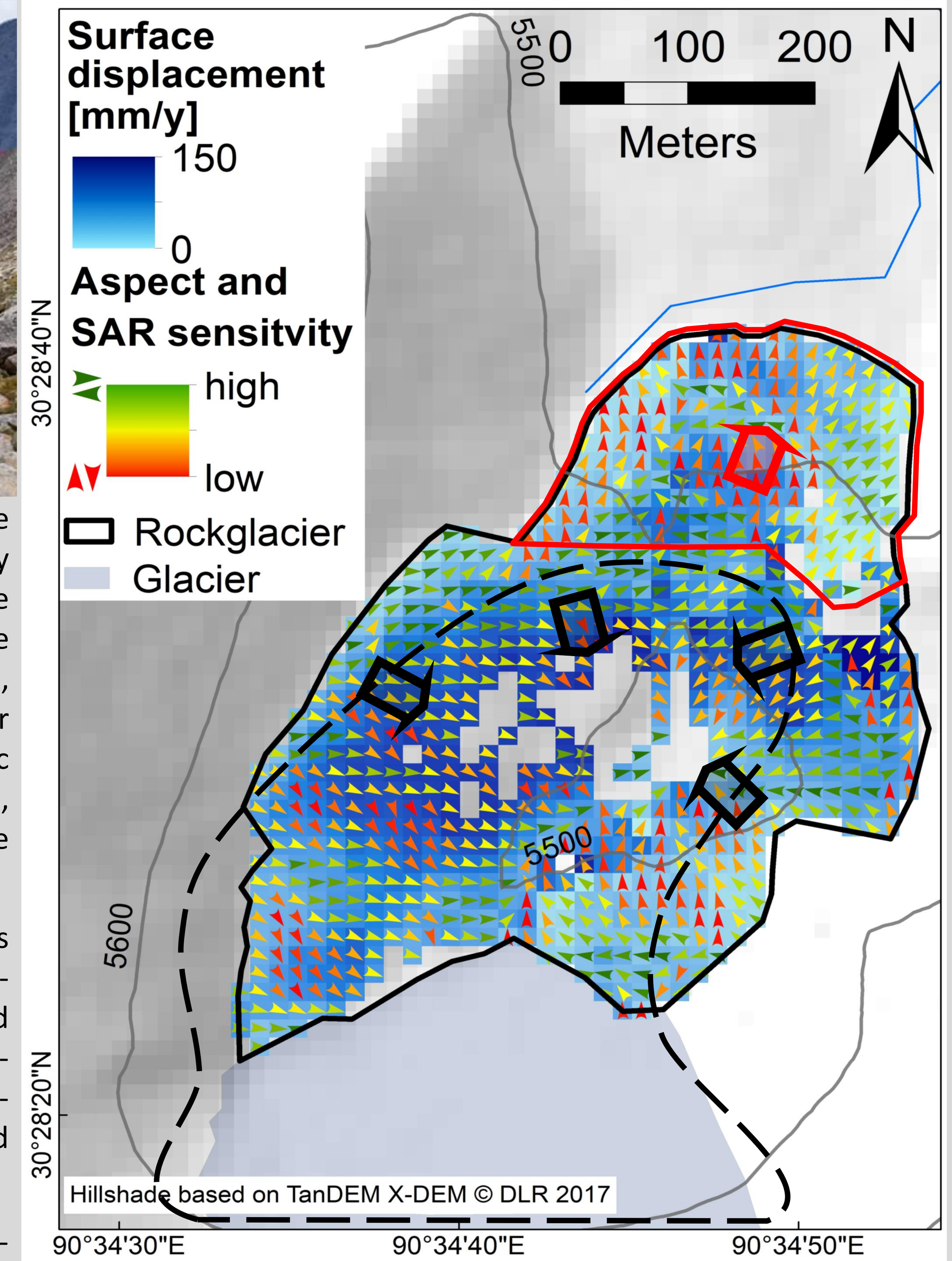


▲**Figure 3**: Results of the pebble count diagrammed after Graham & Midgley (2000). The left side indicates smaller grain sizes than the right side (red trapez). The pebbles of the left side are more platy and elongated, too.



►**Figure 6**: Seismic network results. A) Spectrogram (vertical component) of the entire survey period. Seismic events were picked with a classic STA-LTA algorithm, yielding three main categories of events: B) earth quakes, C) slope failures, contributing material from the hillslopes, and D) short crack signals that are located on or inside the rock glacier.

Surface displacement



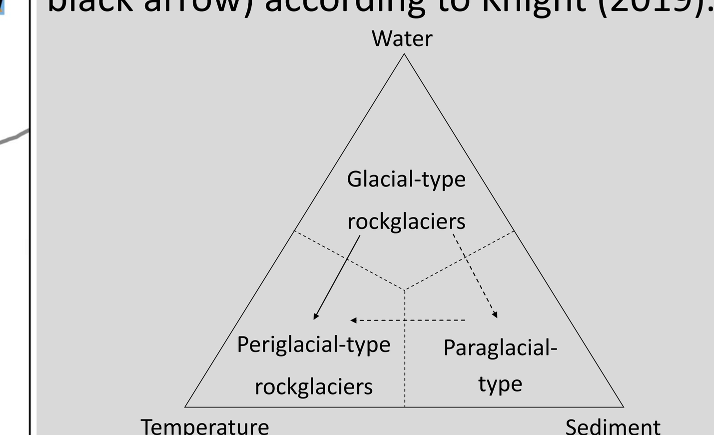
►**Figure 7**: Surface displacement rates (2015-2018) calculated with InSAR time series analysis and directions based on the slope. Note the dominant direction of displacement: (1) to relief depression and (2) the frontal lobe (red polygon) out of the valley.

Interpretation

- Depression originated by a melted ice body (Fig. 7).
- The sorting of sediments (Fig. 2,3,4) is attributable to the existence of a former ice body (black dashed feature).
- The edges of this former ice body were covered with debris (originated by different lithologies) and prevent ice-melting.
- Recent surface displacement (black arrows) occurs into the direction of the depression and out of the valley (Fig. 7, red polygon & arrow).

Outlook

The state of the rockglacier evolves from a glacial-type to a periglacial type, if ongoing temperature increase reduces the water availability of todays glacier (Fig. 8, black arrow) according to Knight (2019).



▲**Figure 8**: Integration (black arrow) of our rockglacier into the conceptual classification of Knight (2019).

Characteristics

- **Climate conditions**: Semi aridity based on the interaction of different wind systems and caused by the topographic barrier of the Nyainqêntanglha Range (Fig. 1, B). Due to high elevation and low cloud cover we suppose a high solar radiation.
- **Surface**: Furrows and lobes indicate an ice content and an active status (Fig 4).
- **Material**: The rockglacier sediment consists mainly of two lithologies that occur in the **catchment**, sorted on the left and right side (Fig. 2, 3, 4). Ongoing slope failures supplies the rockglacier with sediment (Fig. 6, C)
- **Internal structure**: ERT measurements corroborate the presence of ice-rich permafrost and an active layer at an elevation of 5500 m a.s.l. (Fig. 5). Short crack signals based on environmental seismology indicate internal deformation (Fig. 6, D).
- **Dynamics**: Surface displacement rates reach a maximum of 150 mm/y (Fig. 7). Two displacement directions are observed: The southern part moves to a depression in the middle of the rock glacier. The northern, frontal lobe creeps out of the valley (Fig. 7). Creeping pattern is recorded by crack signals and need more analyses.

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