Geophysical Characterization of a Rock Glacier in the Turtmann Valley, Switzerland

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Kaspar Merz[1]*, Marian Hertrich[1], Hansruedi Maurer[1] and Sarah Springman[2]
[1]ETH Zürich, Institute of Geophysics, Zürich, Switzerland
[2]ETH Zürich, Institute of Geotechnics, Zürich, Switzerland
** kaspar@aug.ig.erdw.ethz.ch*

1 Motivation

Global warming may cause thermal degradation and ground instabilities of alpine permafrost structures, such as rock glaciers. To design appropriate countermeasures, advanced knowledge on its mechanical, thermal and hydrological behavior is required.

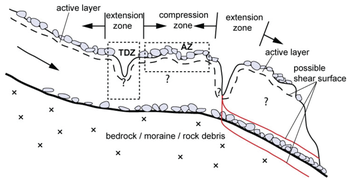


Fig 1. Schematic cross section of a degrading rock glacier.

2 Project Description

An interdisciplinary research project has been launched by three research institutes of ETH Zürich (Institute of Geophysics, Institute of Geotechnics and Institute of Environmental Engieering) to address this task. The aim of this project is to establish a full thermo-hydro-mechanical model of a Rock Glacier.

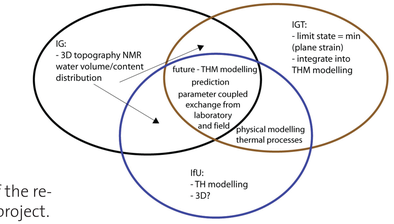


Fig 2. Contributions of the research groups to the project.

3 Study Site

A rock glacier in the Turtmann Valley , Switzerland was chosen as a study site. This rock glacier shows peculiar features including extension structures, surface depressions and increased moving speeds in some areas. [1]. Both of these phenomena are still poorly understood.

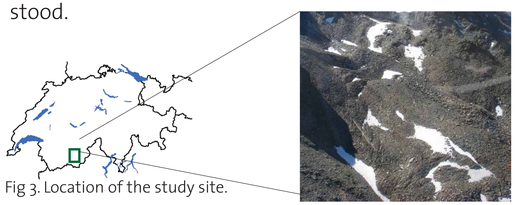


Fig 3. Location of the study site.

4 Geophysics

The aim of the geophysical measurements is to gain information about the volume of the rock glacier, as well as the distribution of ice and possible internal shear horizons. So far, two seismic lines, four georadar profiles and one geoelectrical profile have been acquired (see Figure 4). Furthermore, five about 25m deep boreholes have been drilled in a zone with visible surface depressions. In the collinear boreholes cross-hole seismic measurements were performed.

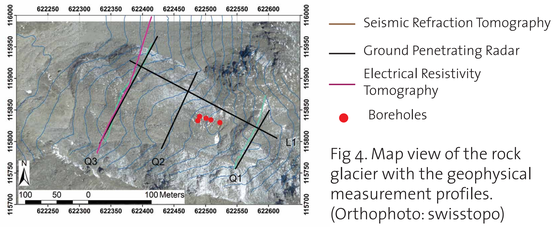


Fig 4. Map view of the rock glacier with the geophysical measurement profiles. (Orthophoto: swisstopo)

5 First Results

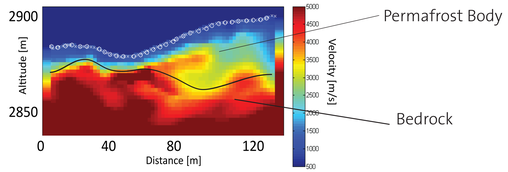


Fig 5. Seismic refraction Tomography along profile Q1 showing the bedrock topography of the permafrost body.

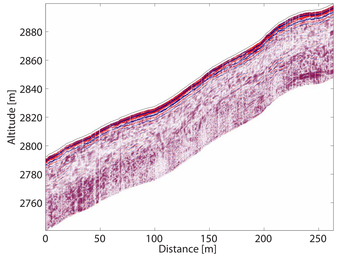


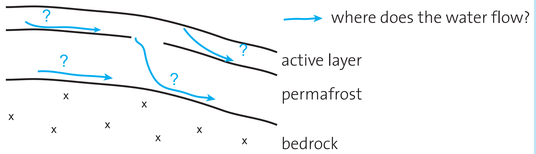
Fig 6. Georadar profile along profile L1. Internal reflectors are difficult to identify.

5 First Results - Discussion

Preliminary geophysical results show a very heterogeneous internal structure of the rock glacier. From the seismic tomograms the bedrock depth was estimated to lie between 20-25m. Continuous internal reflectors along the radar profiles are hard to identify and none of them seems to extend over larger distances. Also the influence of the three-dimensional heterogeneity of the rock glacier on the geophysical measurements is still under investigation.

7 Outlook

Additional measurements are planned to complete the geophysical image of the subsurface: The remaining 2D seismic and geoelectric profiles will be completed . 3D georadar and possibly 3D geoelectrical measurements over zones of particular interest are planned to understand the internal heterogeneity of the permafrost body.
Additionally, an attempt will be made to collect a comprehensive 3D nuclear magnetic resonance dataset over the rock glacier to detect water flow paths in the subsurface [2]. A joint interpretation of the geophysical measurements will serve as important constraints for the thermohydromechanical modeling.



8 References

[1] Roer, I. Kääb, A. & Dikau, R.; Rockglacier acceleration in the Turtmann valley (Swiss Alps): Probable controls; Norwegian Journal of Geography, 2005, 59, 157-163
[2]Hertrich, M.; Imaging of groundwater with nuclear magnetic resonance; Progress In Nuclear Magnetic Resonance Spectroscopy, 2008, 53, 227-248

Acknowledgenments

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