Volume estimation of a rock glacier in Val Constainas

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1 Introduction

In the Eastern Alps, some alpine streams developed recently a significant white colour in their streambeds. This phenomenon is caused by precipitation of nanocrystalline basaluminite ($Al_4(SO_4)OH_{10}\cdot 3\text{-}5\ H_2O$)[1], due to high concentrations of Al in the stream. Other toxic elements such as Mn, Ni and F are present in the stream and their concentrations strongly exceed the drinking water limit [2]. The mobilization of the mentioned solutes is linked with the oxidation of pyrite, which produces sulfuric acid. With global warming and the melting of the ice will likely lead to an increase of pyrite oxidation and in a further step increased toxic mineral mobilization. This process might end with the total oxidation of the entire pyrite present in the system. [1]
The mobilization of toxic minerals appear to be promoted in permafrost bodies and rock glaciers as manifested by the high solute concentration in the rock glacier spring. The rock glacier may serve as an interim storage for the elements [2]. Therefore, the knowledge about rock glacier volume is key to assess future hazards caused by this mobilization.

2 Study Site

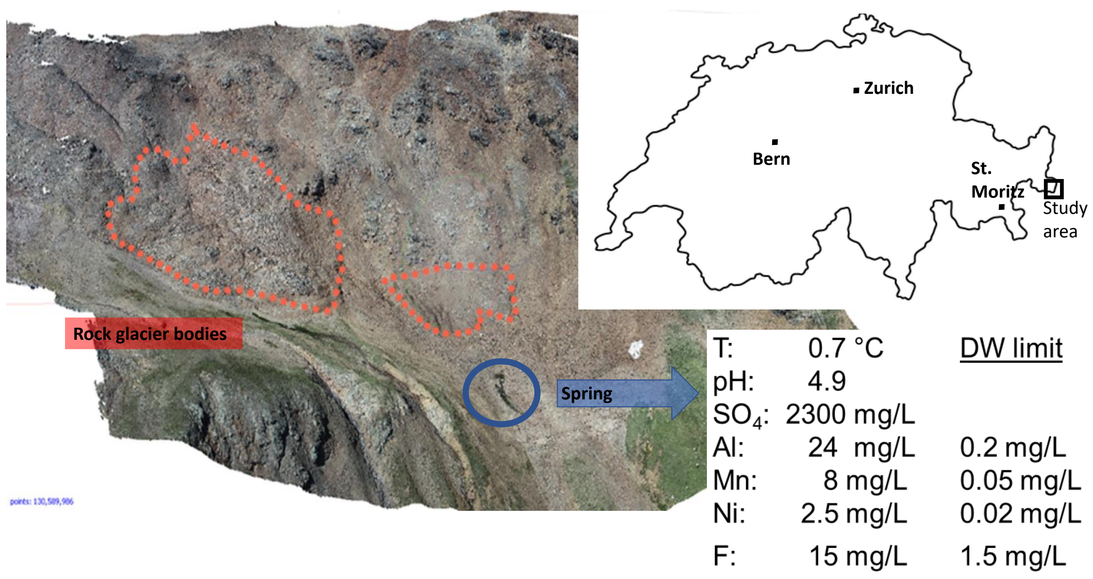
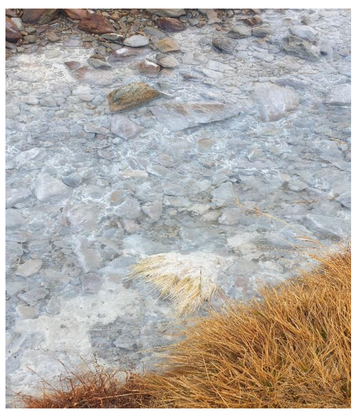


Fig. 1: Rock glacier of interest and the spring where a high amount of toxic minerals are present.



The area of interest is located in Val Costainas at 2600 meters above sealevel, in canton Graubünden. The catchment area lies in the basement of the Austroalpine nappes, which consist of paragneisses and micashists. Precipitated basaluminite in the streambed is shown in Figure 2.

Fig. 2: Aua da Prasüra streambed in Val Costainas.

3 Goals

High resolution DEM from ortho- rectified images → 3D Model of the rock glacier → Volume estimation of the rock glacier

4 Methods & Workflow

4.1 Fieldwork

- Field observation and delineation o the region of interest
- Collecting UAV images from the suggested region of interest

4.2 Structure from Motion (SfM) Photogrammetry

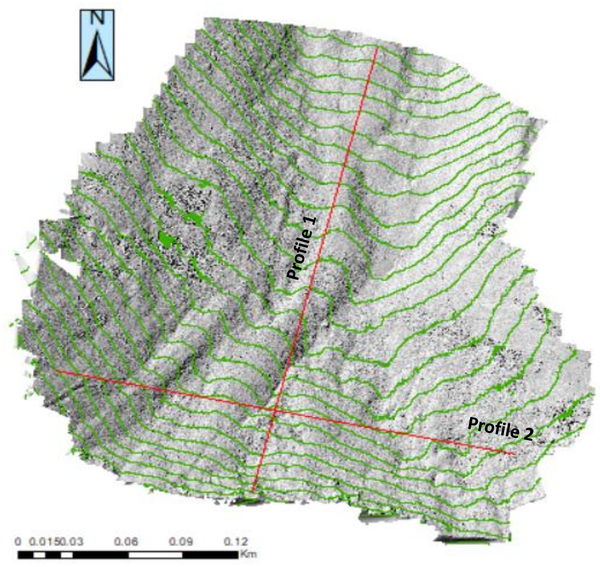
With the SfM method, we can create detailed topographic models from photographs that are made by unmanned aerial vehicles (UAVs). [3]

Further we can use these images to create image ortho-mosaics and detailed elevation models (DEMs) to derive surface changes [3]
The SfM method can be used by non experts and is affordable for most common people.

3.3 Digital Elevation Model (DEM) & 3D model of rock glacier

- Process drone images in Agisoft Metashape Software to create an ortho-mosaic image
- Create a DEM with Agisoft Metashape Software, using the ortho-mosaic.
- From the DEM in ArcGIS try to estimate the outline of the rock glacier by topographical and geomorphological observations (e.g. tongue shaped and lobate assemblages of poorly sorted, angular- rock debris and ice bodies [4])
- Volume estimation by extrapolating the topographical information into the subsurface

5 Preliminary Results



DEM in 3D with the hillshade tool, built from 3400 drone pictures (Figure 3) and two profiles across the DEM to determine any correlation of topography and rock glacier features shown in Figure 4.

Fig. 3: DEM of the region of interest

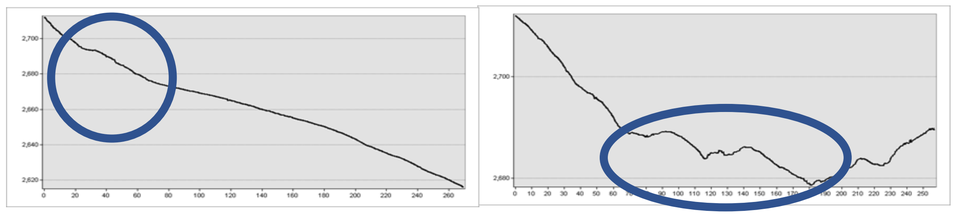


Fig. 4: Profiles through the region of interest and first interpretation where the rock glacier is located

6 Outlook

Relate element fluxes to the rock glacier volume and melt production in the rock glacier

References

[1] Ingold, P. (2020), Master Thesis, Basaluminite in natural and engineered systems: Insights on As retention and its use as proxy for the acidification of high-alpine catchments.
[2] Wanner, Christoph; Moradi, Hoda; Ingold, Philipp; Cardenas Bocanegra, Miguel A.; Mercurio, Romano; Furrer, Gerhard (2023): Rock Glaciers in the Central Eastern Alps – How Permafrost Degradation Can Cause Acid Rock Drainage, Mobilization of Toxic Elements and Formation of Basaluminite. In *SSRN Journal*. DOI: 10.2139/ssrn.4354725.
[3] James, M. R., Robson, S., & Smith, M. W. (2017). 3-D uncertainty-based topographic change detection with structure-from-motion photogrammetry: precision maps for ground control and directly georeferenced surveys. Earth Surface Processes and Landforms, 42(12), 1769-1788.
[4] Jones, Darren B.; Harrison, Stephan; Anderson, Karen; Whalley, W. Brian (2019): Rock glaciers and mountain hydrology: A review. In *Earth-Science Reviews* 193, pp. 66–90. DOI: 10.1016/j.earscirev.2019.04.001.

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