The hydrological significance of a high-Andean periglacial environment

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1 The HyPerm Project

The Andean cryosphere hosts major freshwater sources for adjacent lowlands in arid and semi-arid river catchments, providing runoff and groundwater recharge. Within sparsely glacierized basins, the hydrological system is fed by meltwaters from relatively small glacier cover, low annual precipitation, seasonal snowmelt (from ephemeral and isolated perennial snow fields) and the meltwaters from areas underlain by (degrading) permafrost (WGMS, 2020). HyPerm* focuses on the geomorphic characteristics and hydrological significance of Andean mountain permafrost in dominant landforms such as taluses and blockslopes (cover 82% of the surface area) using a multi-method approach in the Agua Negra catchment (30ºS and 69ºW, San Juan Province) (see Fig. 3).

*Spatial occurrence and **Hy**drological significance of Andean **Perm**afrost (DFG- funded project)

2 Surface and subsurface approaches

SURFACE

- Field- and remote sensing based geomorphological mapping and geostatistical modelling of block- and talus slopes
- Uncrewed aerial vehicle (UAV) flights and tristereo Pléiades data providing high-resolution topographical data
- Continuous water level measurements at six gauging stations complemented by salt tracing and water sampling **(3A)**

SUBSURFACE

- Geophysical prospection **(3B)** including:
  - Electrical Resistivity Tomography (ERT)
  - Seismic Refraction Tomography (SRT)
  - Ground Penetrating Radar (GPR)
- Continuous time-domain reflectometry (TDR) and temperature sensors (iButtons) for verification

3 Preliminary Results

A Hydrological studies in in the Agua Negra basin

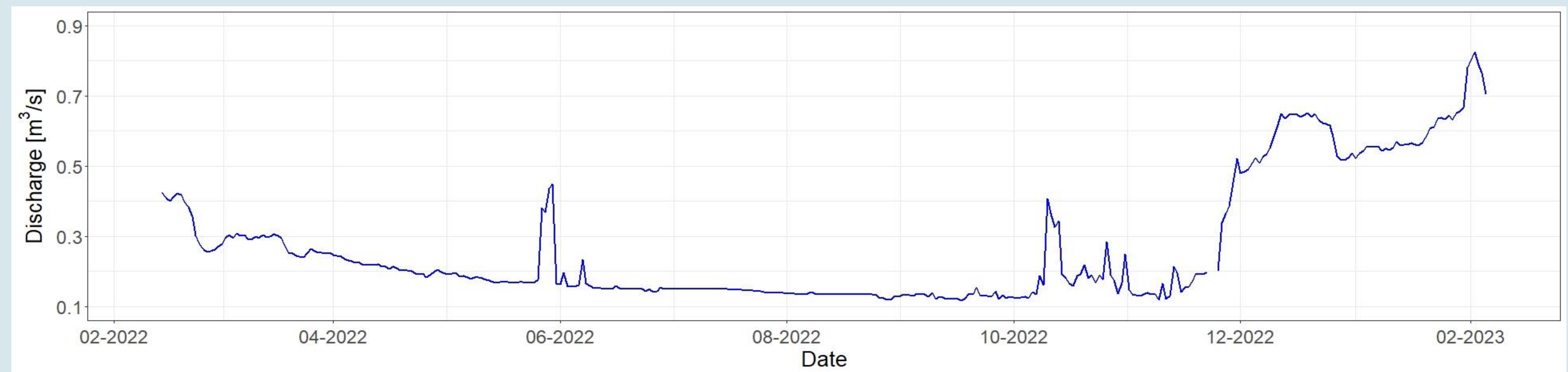

Fig. 1: Mean daily discharge time series of gauging station #3 (see Fig. 3, 4a). Conversion of water level to discharge is based on a power-law rating curve (R^2= 0.85).

Hydrograph analysis reveals a peak discharge of 0.82 m^3/s in February 2023 and minimum discharge in the winter months with values < ~0.15 m^3/s indicating mainly frozen water state. Hydrochemical analysis shows no uniform "periglacial imprint" but a wide range of water types with strong hydrothermal influences in the catchment.

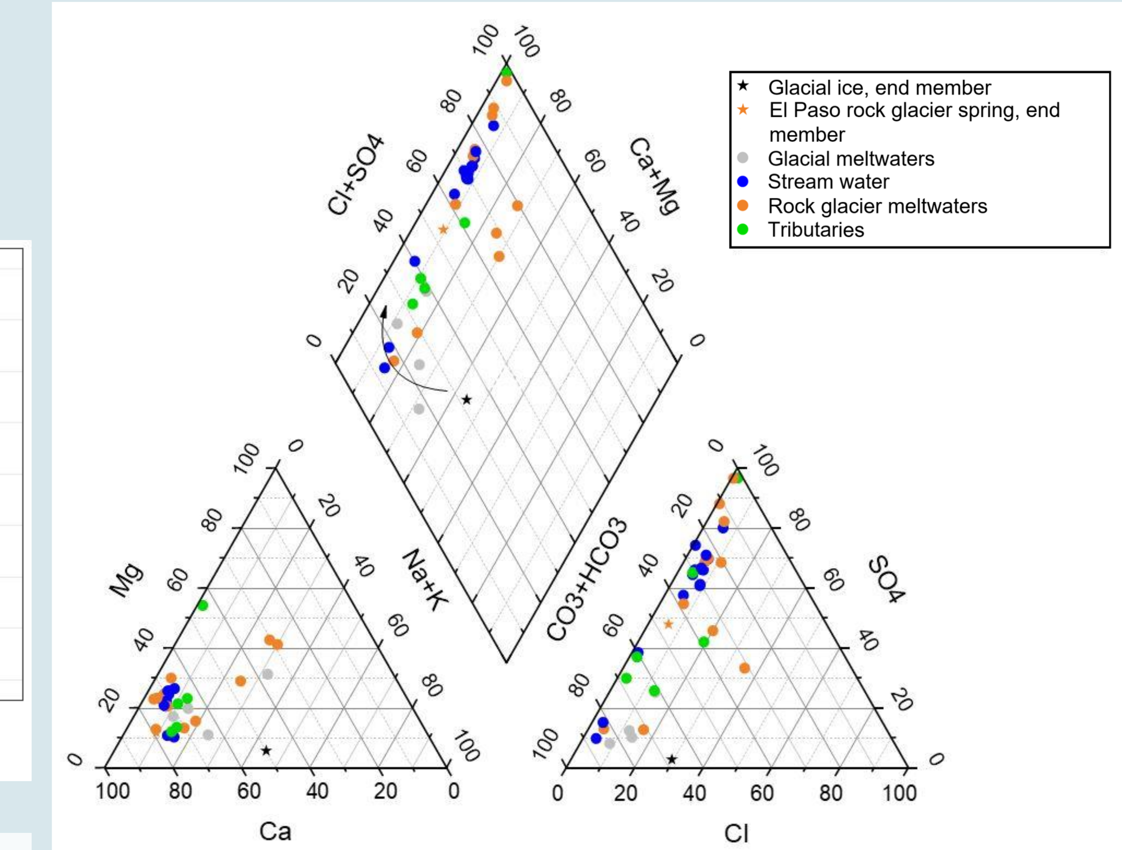

Fig. 2: Color classified piper diagram of 38 water samples from the study area taken in March 2022. A meltwater sample of the Agua Negra glacier as well as a spring sample of the large El Paso rock glacier in the upper catchment are assumed to be possible end members for the chemistry of glacial and periglacial imprint (Nelke, 2022).

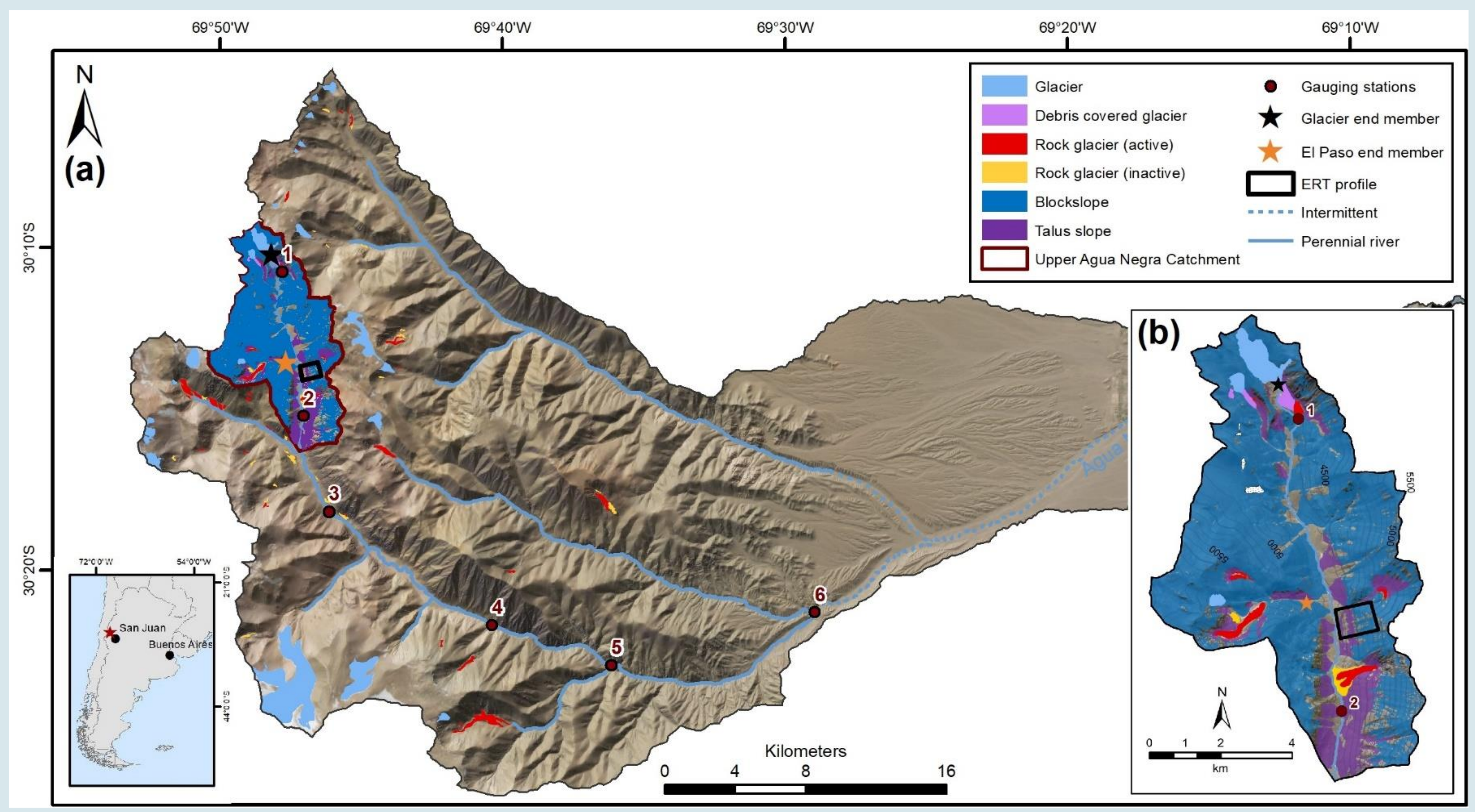

Fig. 3: The Agua Negra Catchment (a) with the six installed gauging stations along the Agua Negra river. Glaciers, rock glaciers (active/inactive), and debris-covered glaciers are from the National Glacier Inventory (IANIGLA-CONICET 2018). In the upper catchment area (b), the manual mapping of block- and talus slopes, the location of one ERT profile (**3B,** Fig. 5) and the end members identified from the hydrogeo-chemical analyzes (**3A**, Fig. 2) are shown.

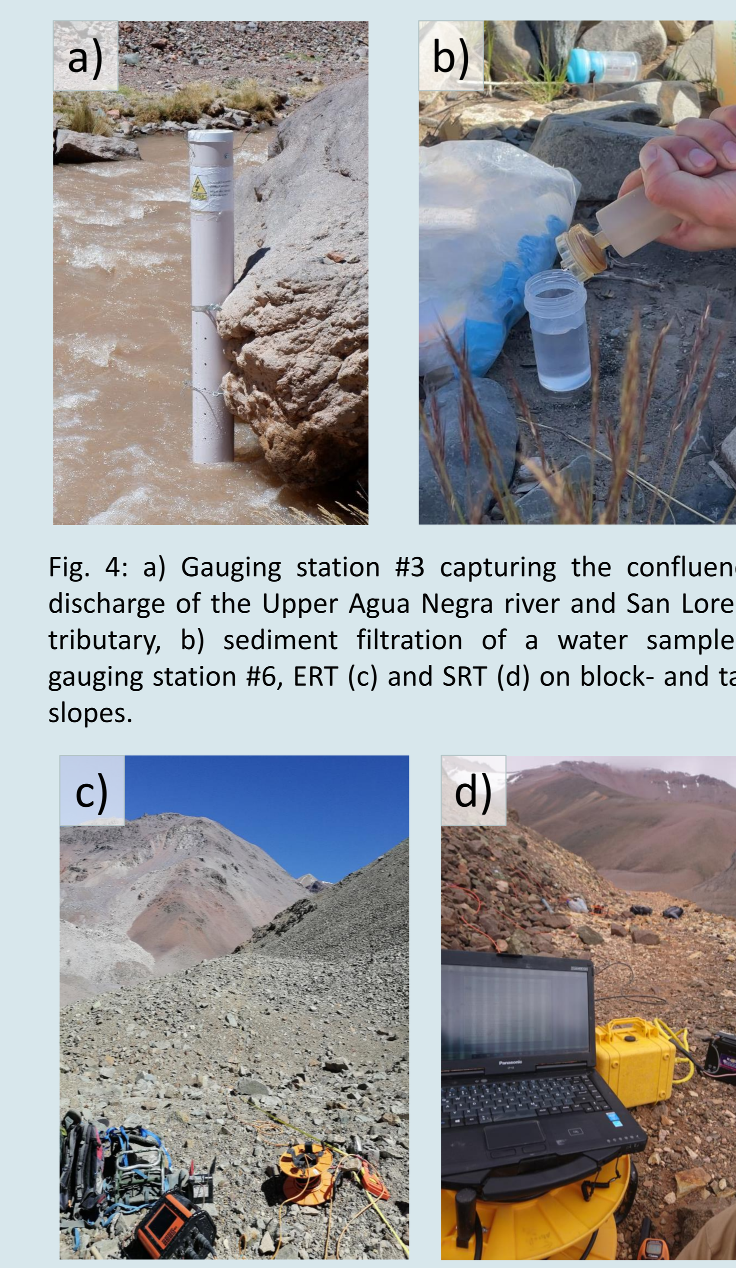

Fig. 4: a) Gauging station #3 capturing the confluenced discharge of the Upper Agua Negra river and San Lorenzo tributary, b) sediment filtration of a water sample at gauging station #6, ERT (c) and SRT (d) on block- and talus slopes.

B Ice content and water storage capacities of blockslopes and taluses

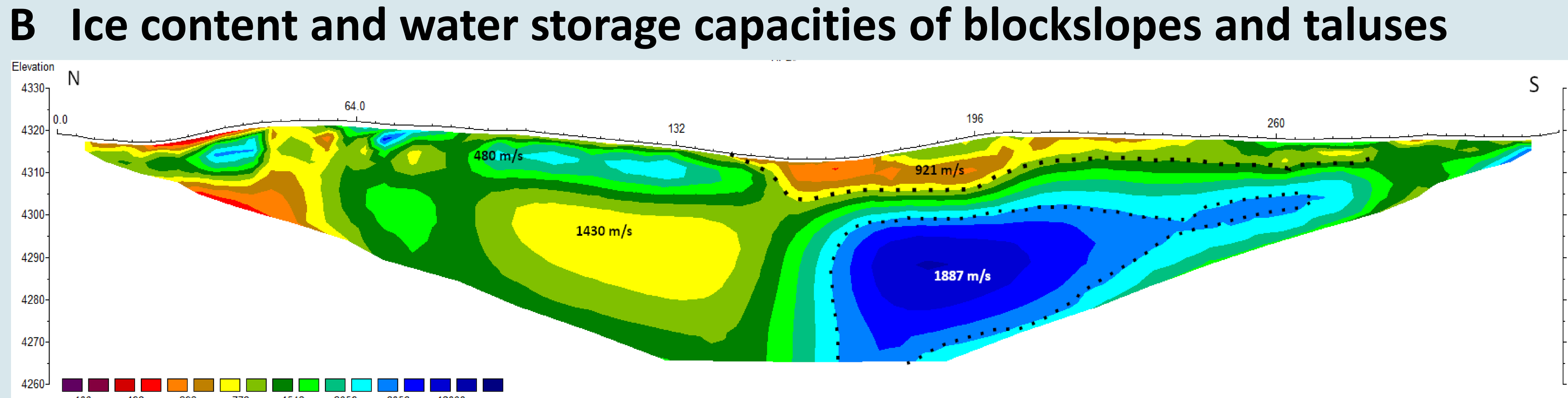

Fig. 5: Results of an overlapping longitudinal ERT and SRT profile (N-S) measured on a protalus rampart (see Fig. 3b and close-up on the right).

Maximum resistivities of ~12 kΩm together with seismic velocities of about 1900 m/s (southern sector of the profile) indicate the presence of a permafrost body with low ice content. Four-Phase modelling will further be used to estimate the volumetric ice content.

HyPerm will address a significant research gap and further add to a more accurate estimation of solid-state water reserves stored in periglacial landforms of arid Andean regions.

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Project Abstract

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