VIII Congreso Ibérico Permafrost

UNIVERSITAT DE BARCELONA

PERMAPYRENEES — PERMAFROST EN PIRINEOS: PERGÉLISOL DANS LES PYRÉNÉES

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New evidence of permafrost in the highest lands of Pica d'Estats massif (Lleida, Spain)

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Context of the study

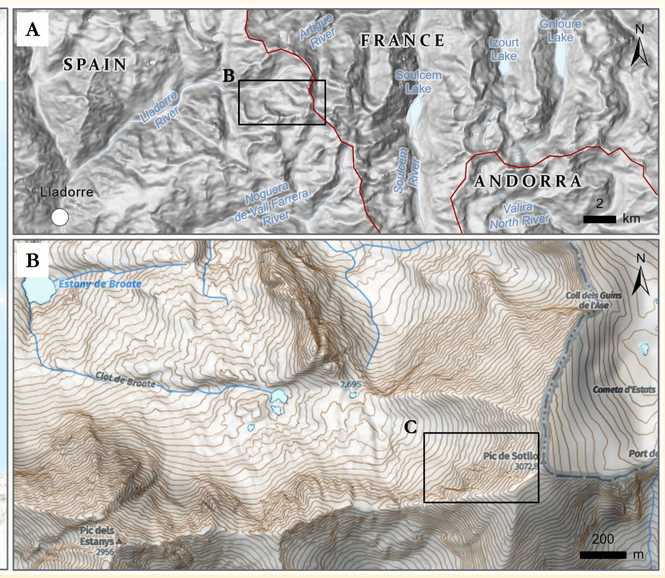
What?

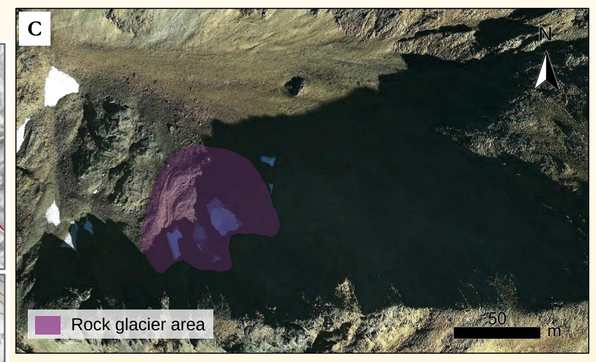
This study is part of the PERMAPYRENEES Project, which aims to detect and monitor permafrost across the Pyrenees.

In the autumns of **2022** and **2024**, two field campaigns were conducted to obtain data from the rock glacier in the **Broate cirque**, located at the foot of Sotllo Peak in the Central Southern Pyrenees (Lleida, Spain).

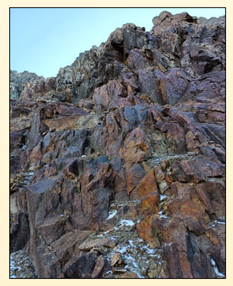
This area lies within the Pica d'Estats massif (Alt Pirineu Natural Park), at an elevation of **2,810–2,830 m**, with a NW orientation.

Where?





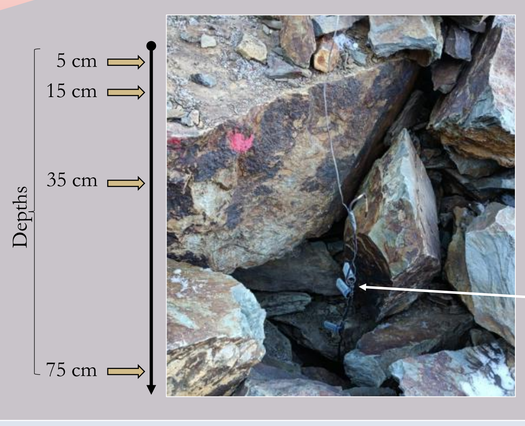
The Broate cirque contains a rock glacier that covers approximately **1.16 ha.**, with an average slope of **22º**, and composed primarily of **schist**.



How?

Methods

Temperature monitoring

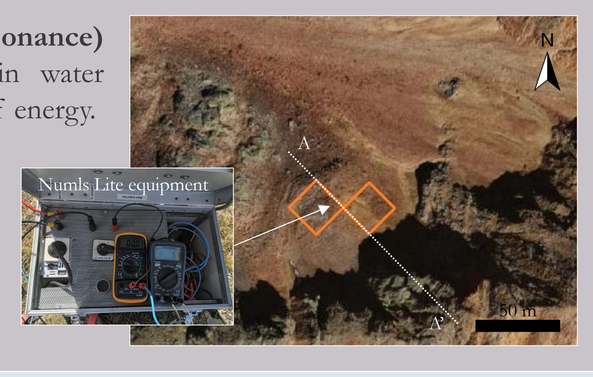


Four **HOBO sensors** were installed at diferent depths of the rock glacier : -5, -15, -35 and -75 cm. These sensors registered temperatures hour by hour with an accuracy of ±0.5°C from 0° to 50°C.

Magnetic Resonance Sounding (MRS)

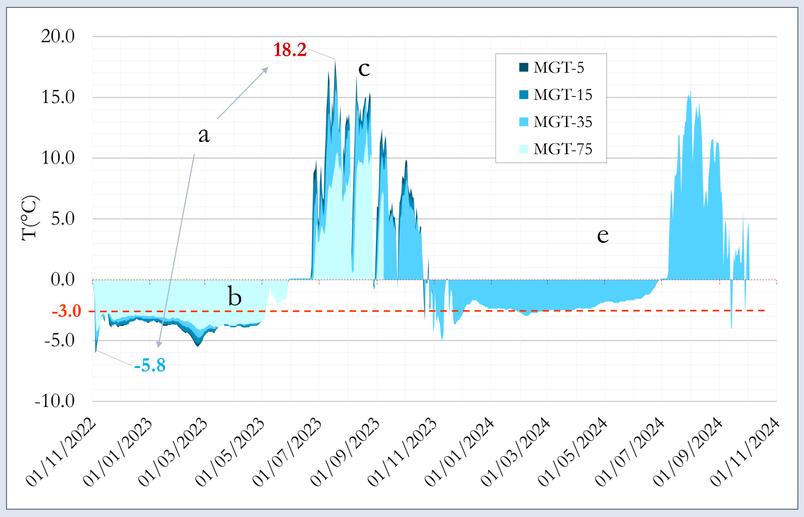
MRS is based on **NMR (Nuclear Magnetic Resonance) signal** detection: it is a response of protons in water molecules to a magnetic field due to the absorption of energy.

For the MRS (carried out by IGEOTEST S.L.U), two soundings were played with Numls Lite equipment, by installing a square eight shaped antenna of 30 x 30 m, with W-E orientation.



Results

Ground temperature and active layer

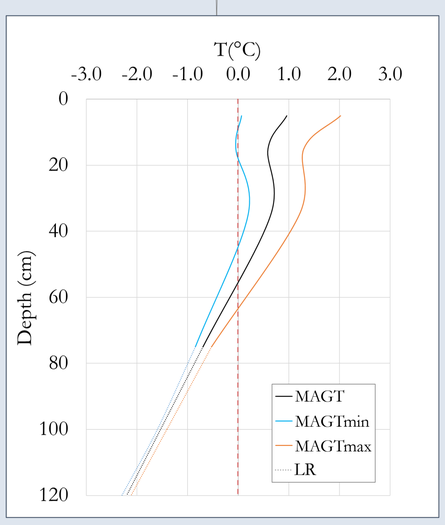


a) The **annual maximum variation** in ground temperature is approximately 11.4°C at -5 cm, with sub-zero temperatures from November until the end of May.

b) During the **winter season**, these cold temperatures stabilize at **-3.0°C**, indicating seasonally frozen ground with possibility of permafrost.

c) Following the snow melt, positive **temperatures** increase abruptly and with large daily **oscillations**.

d



d) For the 2022–23 period, the mean annual ground temperature (**MAGT**) ranges from **1° to -0.5°C** at first 75 cm.

e) Despite in 2023–24 the ground temperature can only been registered at -35 cm (the other three sensors ceased recording), the **trend** is similar to that of the previous year.

Therefore, it is possible to define the thermal state of the **active layer** over the entire period.

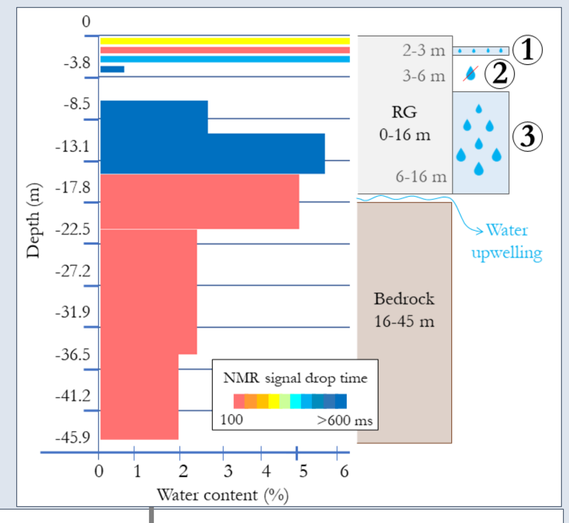
Rock glacier inner structure

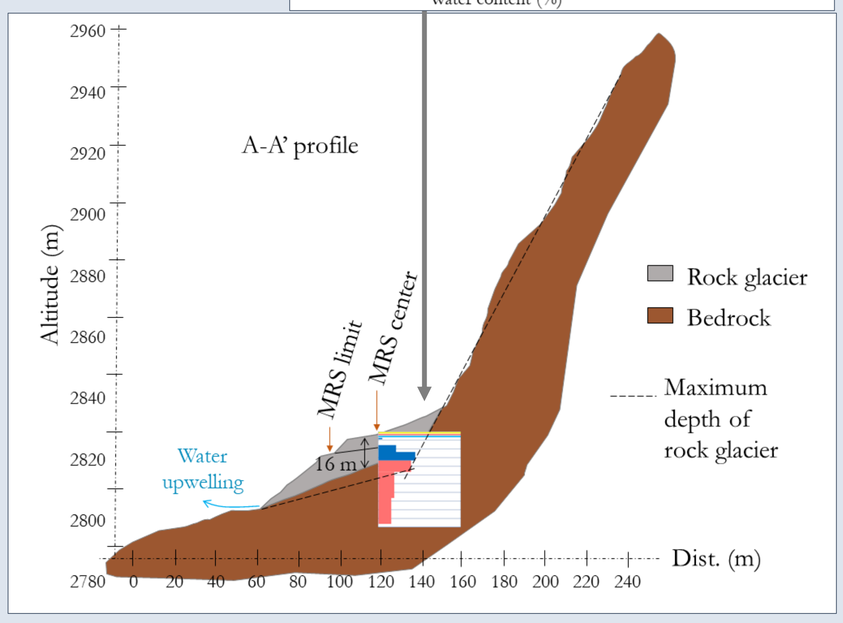
MRS profile show a maximum rock glacier depth of 16 m, a water upwelling at this point (visual confirmation in field) and different layers and boundaries:

1) A first layer (2-3 m) with interstitial **water**.
2) A **water-free** layer (3-6 m) of 3 meters thickness.
3) A **permeable** layer (6-16 m) with **water** until the top of the bedrock (non-permeable).

Why is there water in layers 1 and 3 but not in **layer 2**?

Because it is **frozen**.





In a nutshell…

Ground temperatures → based on the temperature range, **permafrost** is **possible** and its **active layer** was detected for the period 2022-24.

MRS→ confirm the existence of a deep-frozen layer at 3-6 m after the summer season, which means that **conditions** are favourable for the existence of **permafrost** in this area.

Conclusions

- The ground temperature regime between 2022 and 2024 reflects the presence of an **active layer** with differential seasonal dynamics due to **climate variability**.
- **Distinct subsurface layers** were identified, some of which exhibited signs of interstitial meltwater, while others indicated the presence of **frozen masses** at greater depths.
- The detection of frozen water at depth following the summer period and the presence of sub-zero ground temperatures, strongly suggest the existence of **permafrost**.
- It is evident from the results that there is an ongoing **need** to continue **monitoring temperatures**. Furthermore, the **drilling of boreholes** in the area is essential for the purpose of monitoring changes in the state of permafrost.

References

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Acknowledgements

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