Deglaciation, permafrost, and rock glacier activity in the Central-Eastern Pyrenees: Insights from the Clot de la Menera cirque (Andorra)

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27/06/2025, Salardú

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VIII Congreso Ibérico Permafrost

PERMAPYRENEES

Interreg POCTEFA

Cofinanciado por la UNIÓN EUROPEA

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Preliminary results

Multidisciplinary study

PERMAPYRENEES project

Figures from a submitted paper (Oliva et al., 2025)

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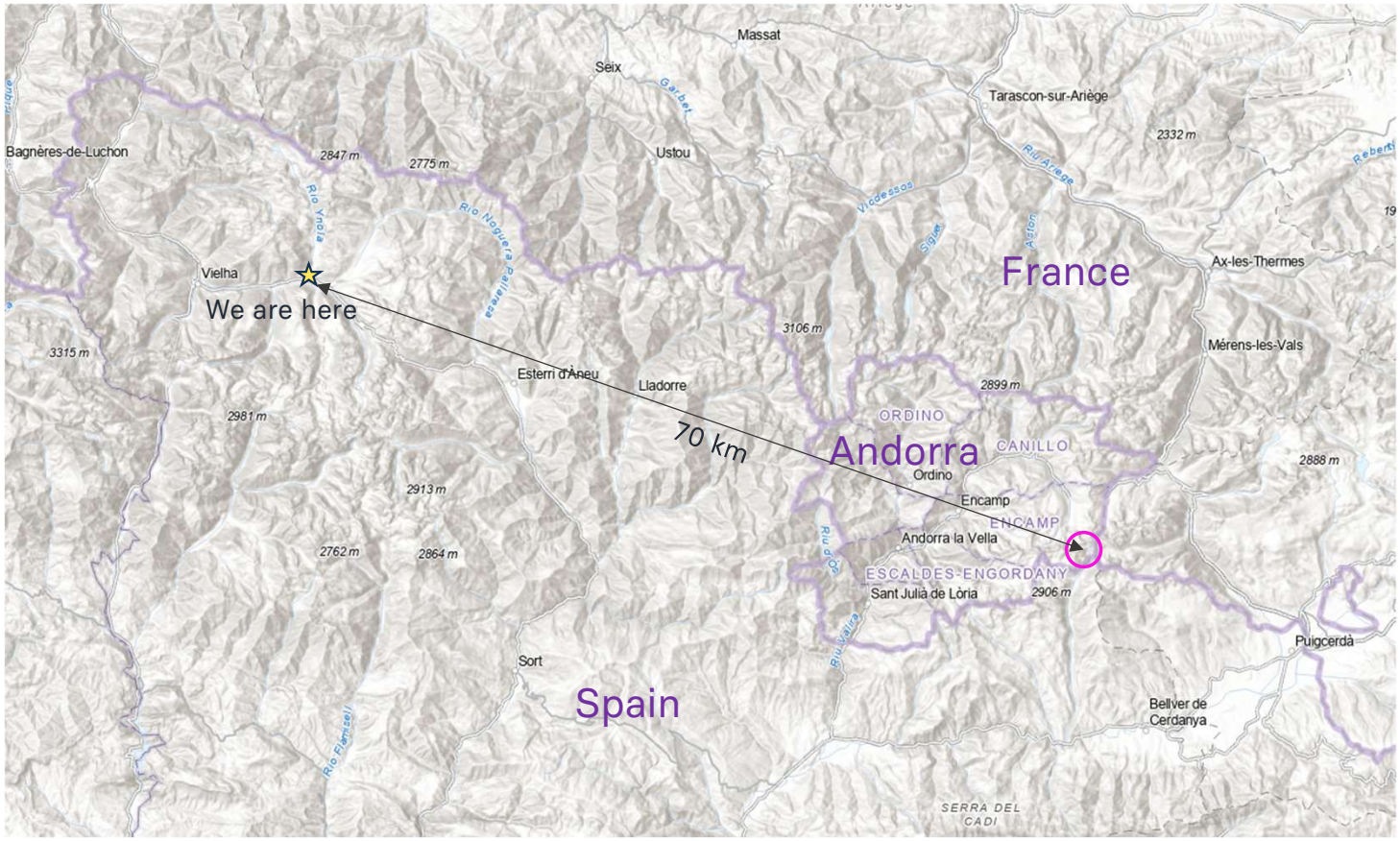
M. Cheralier

And more...

Study area

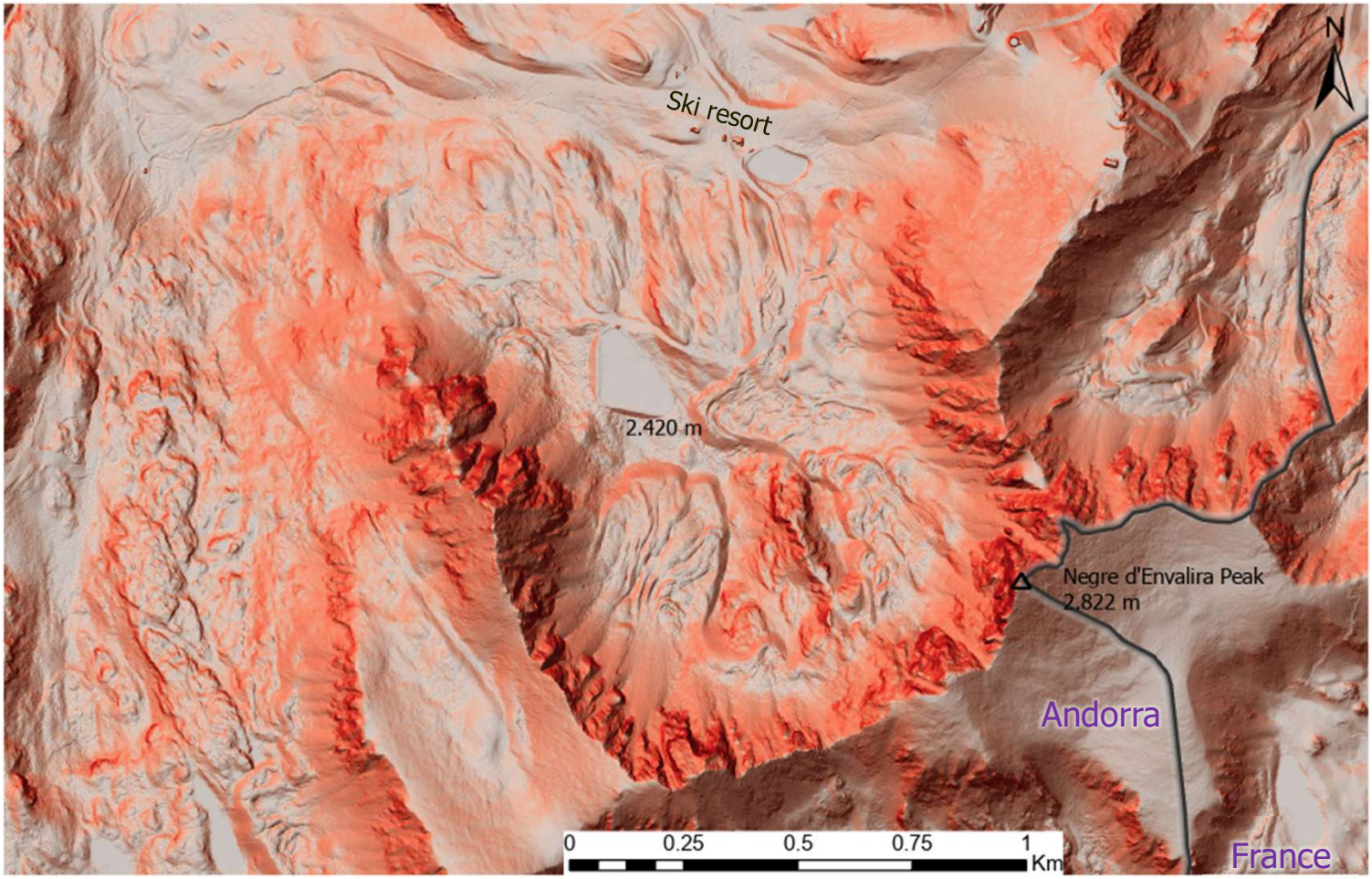


Clot de la Menera cirque

Central-Eastern Pyrenees

Andorra

Study area



Clot de la Menera cirque

Central-Eastern Pyrenees

Andorra

Grau Roig (ski resort)

Cirque: 1.5 km^2

~ 2.400-2.800 m.a.s.l.

Objectives and research questions

- When did deglaciation occur?
- How and when did the rock glaciers form?
- Are these landforms still active?
- Is permafrost still present?

HOW

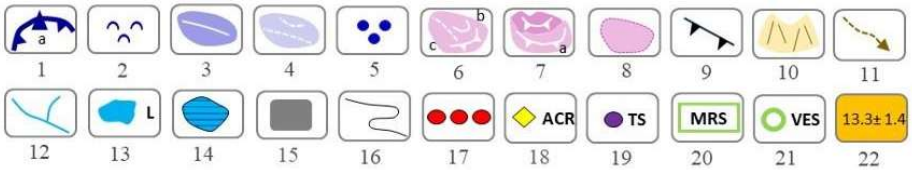
Multi-proxy approach

- ❖ Geomorphological mapping
- ❖ CRE dating
- ❖ Geophysical survey
- ❖ Ground temperature monitoring
- ❖ DInSAR velocity measurements
- ❖ ...

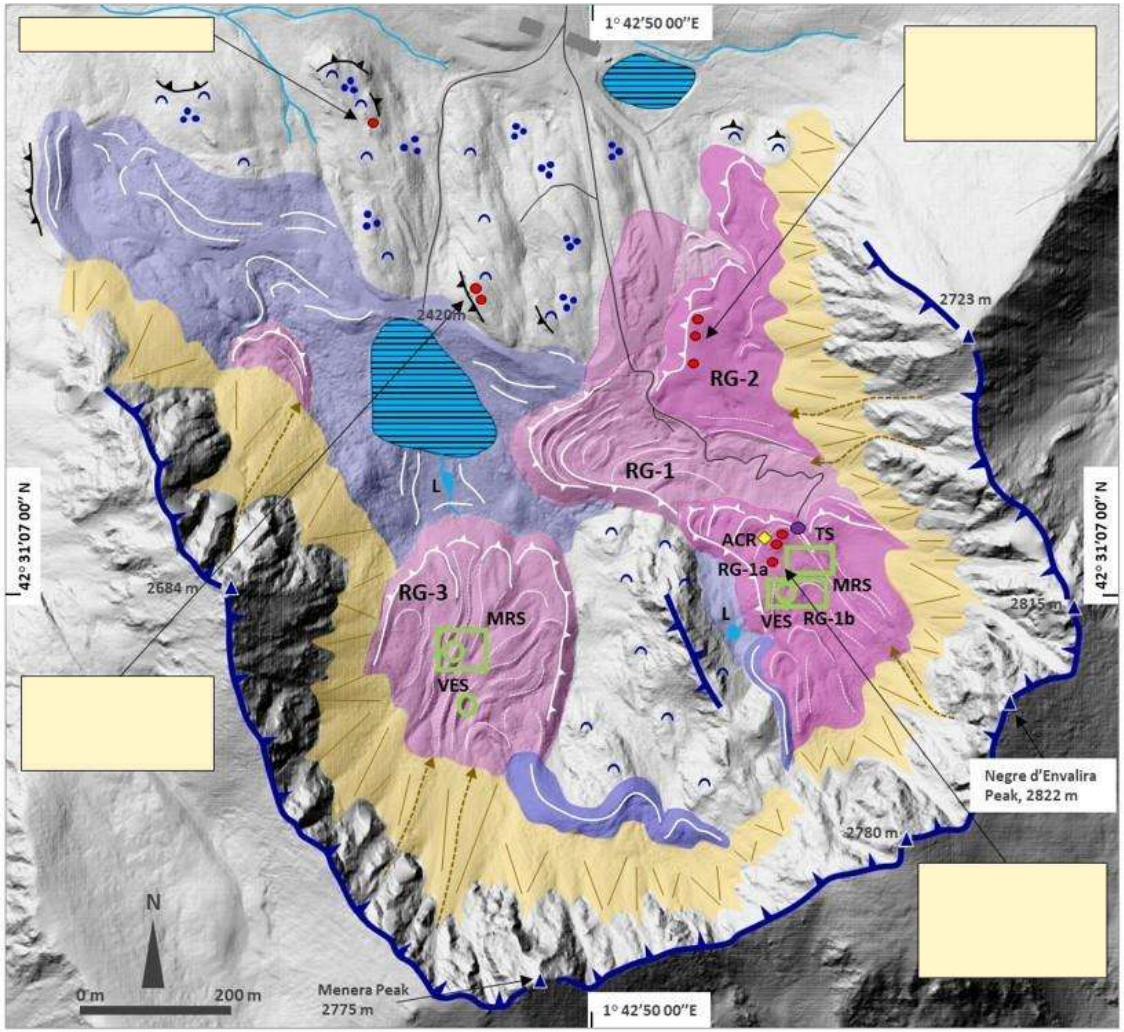
Geomorphological mapping

Composite rock glacier system

Anthropic modified



GLACIAL, 1: Glacial cirque (a-peak); 2: Roches moutonnées/Polished surface; 3: Moraine ridge; 4: Till (with small morainic ridges); 5: Moraine boulder; **CRYONIVAL**, 6: Rock glacier (a-front; b-transverse ridges; c-longitudinal ridges); 7: Rock glacier (overlapping units); 8: Rock glacier (anthropic modified); **SLOPE,** 9: Rock scarp; 10: Cone/Talus slope; 11: Debris flow; **HIDROGRAPHY**, 12: Intermittent stream; 13: Water bodies; 14: Water reservoir; **OTHERS**, 15: Anthropic infrastructures; 16: Road; 17: CRE samples; 18: Active corner reflector; 19: Temperature sensor; 20: Geophysical survey (RMS); 21: Geophysical survey (VES); 22: CRE ages (Error weighted mean age ± Error external).



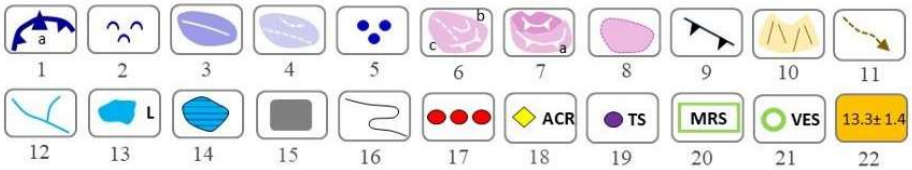
CRE dating

RG-1a: **9.7** ± 0.4 ka
RG-2: **11.1** ± 0.6 ka

^{10}Be and ^{36}Cl

Samples:

- 1 polished bedrock surface
- 3 from morraine ridge
- 6 from 2 RG



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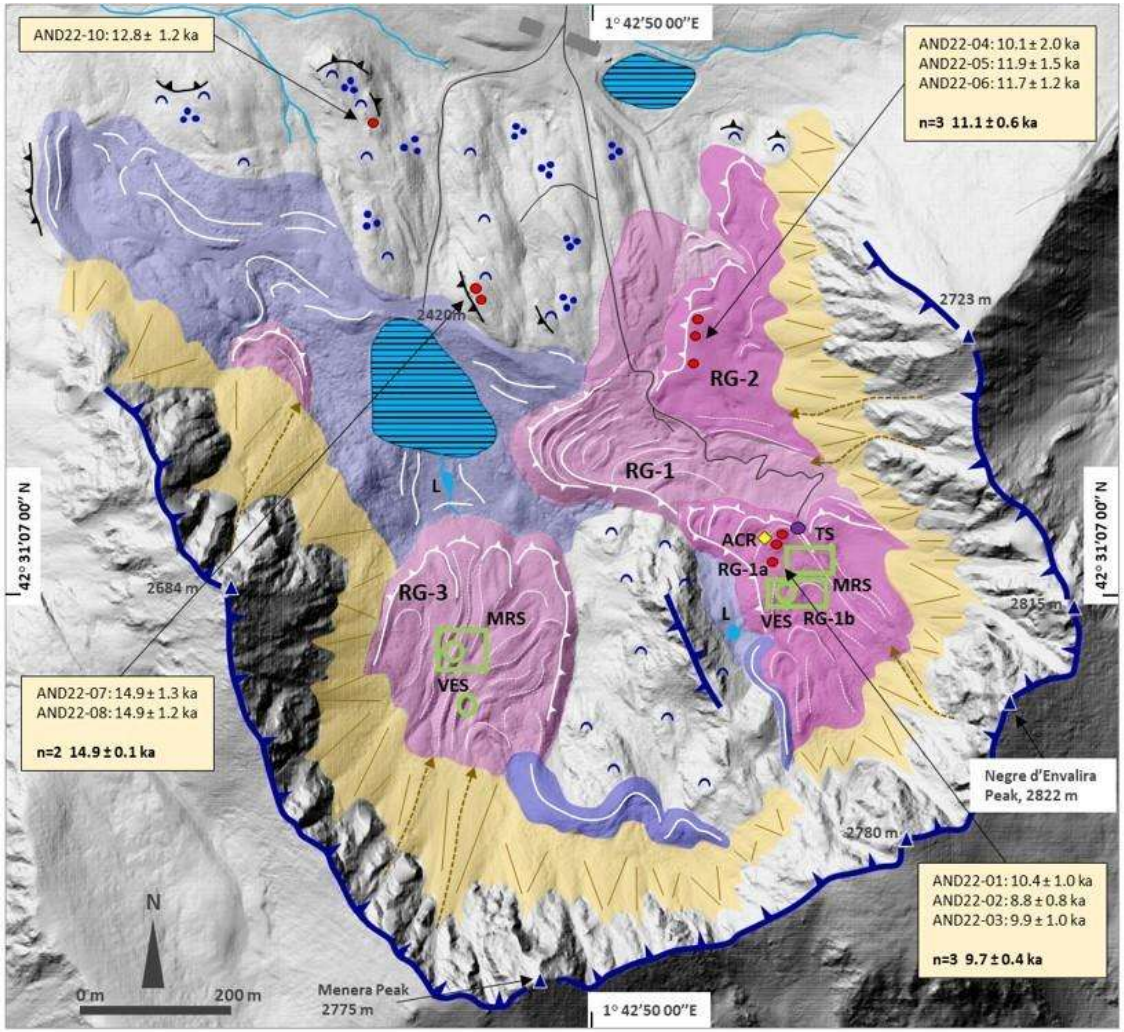


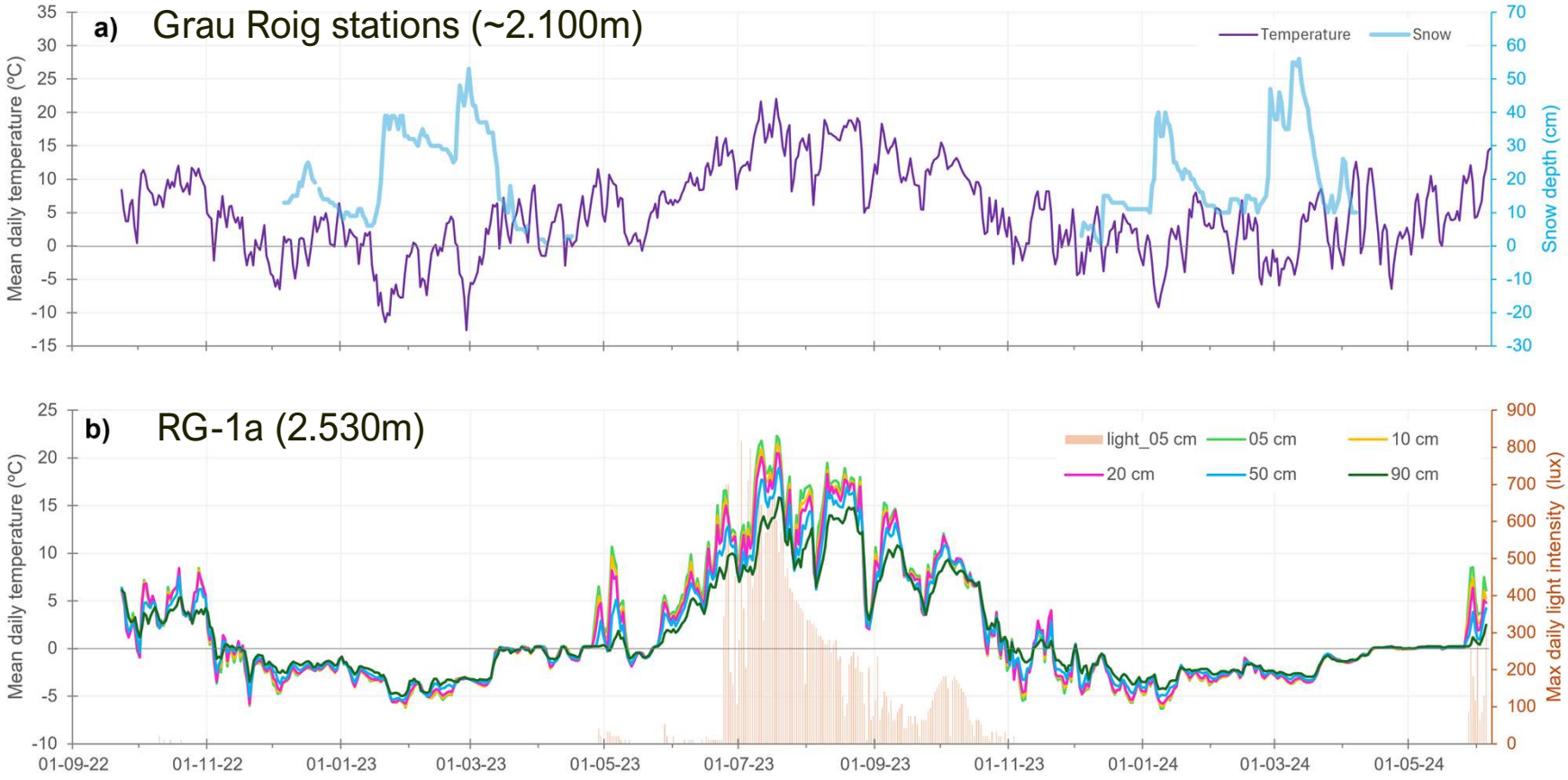
Ground temperature monitoring

Sensors at 5, 10, 20, 50, 90 cm depth (2022–2024)

Ground temperature monitoring

Winter stabilization at -3 to -4°C under snow cover

Max: 16.3°C (90 cm), Min: -6.3°C (5 cm)



DInSAR velocity measurements

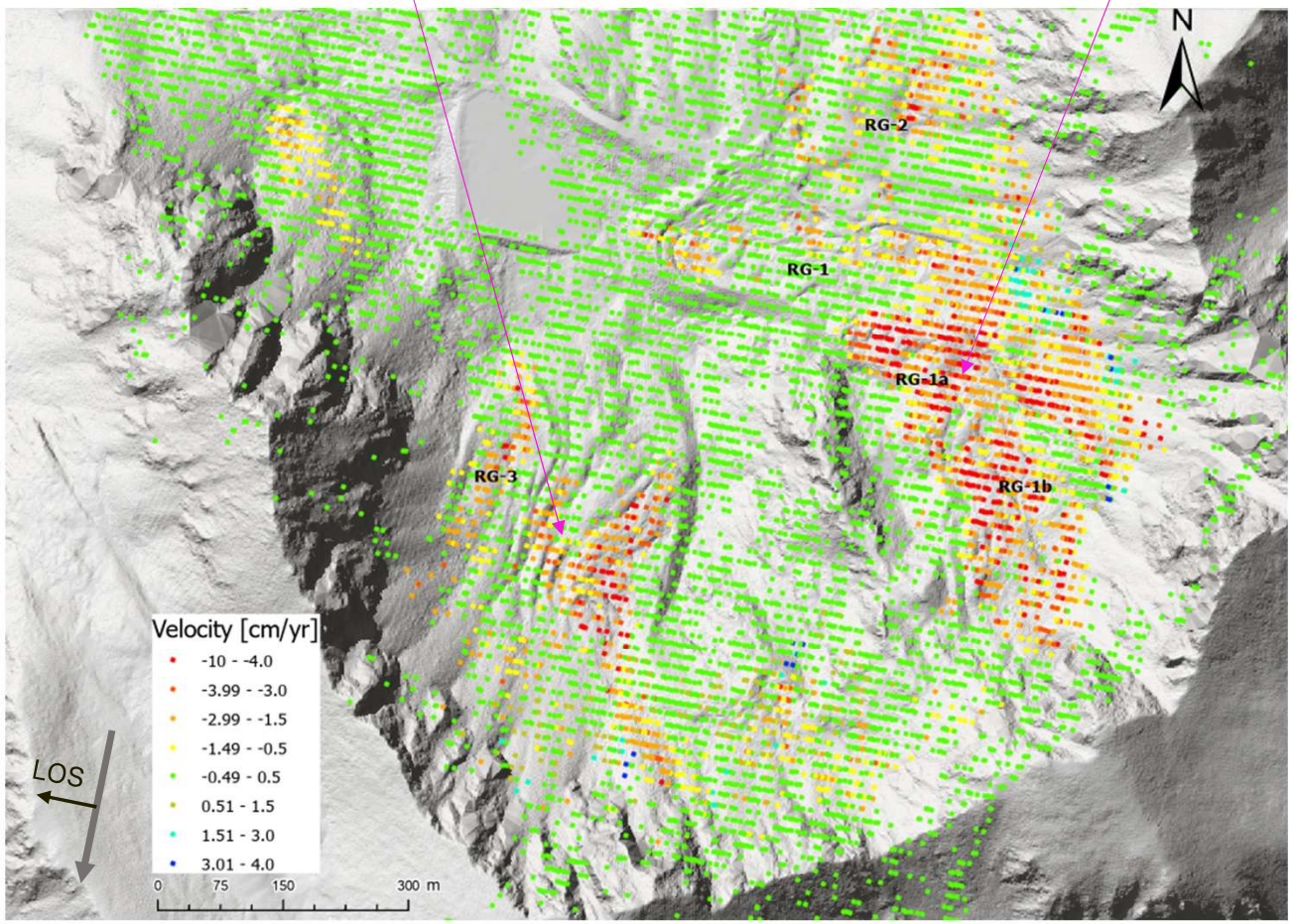
Snow-free Sentinel-1 SAR images

10/06/2022 – 14/11/2024

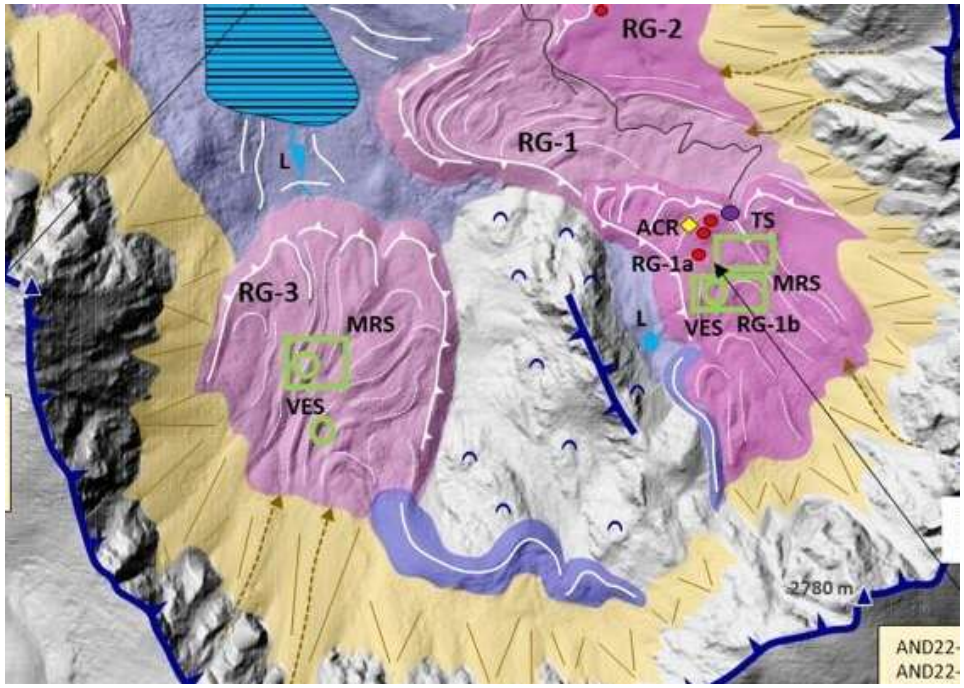
Ascending & descending

East-West and vertical displacement components

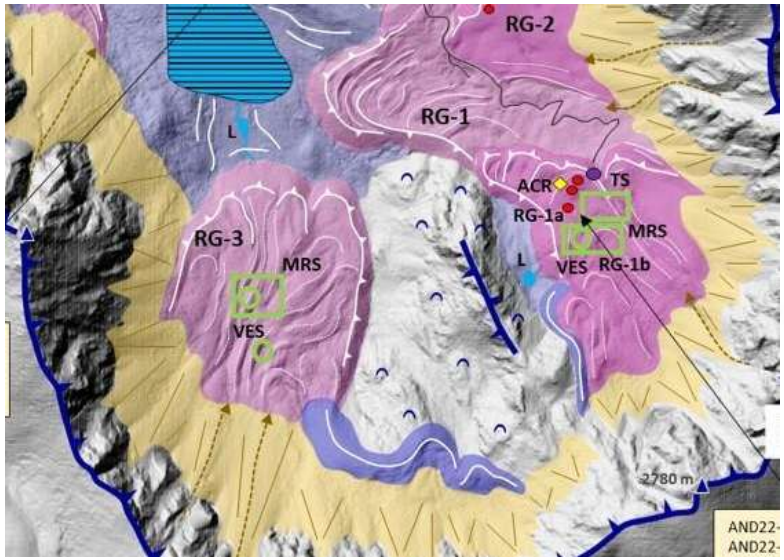
RG-1 and RG-3 show slow displacement (RG-1 LOS 1.1–4.1 cm/yr; RG-3: 0.6-2.6 cm/yr)

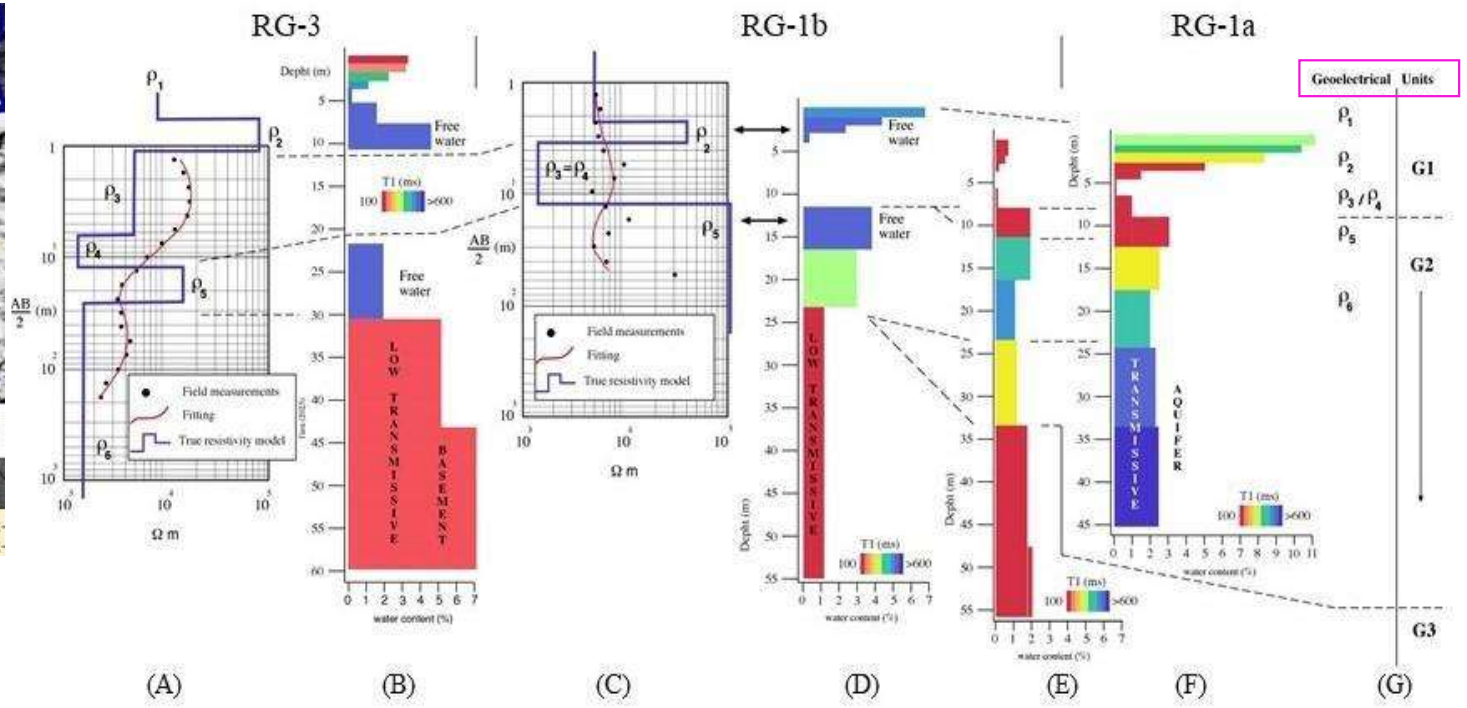


Geophysical survey



Geophysical survey

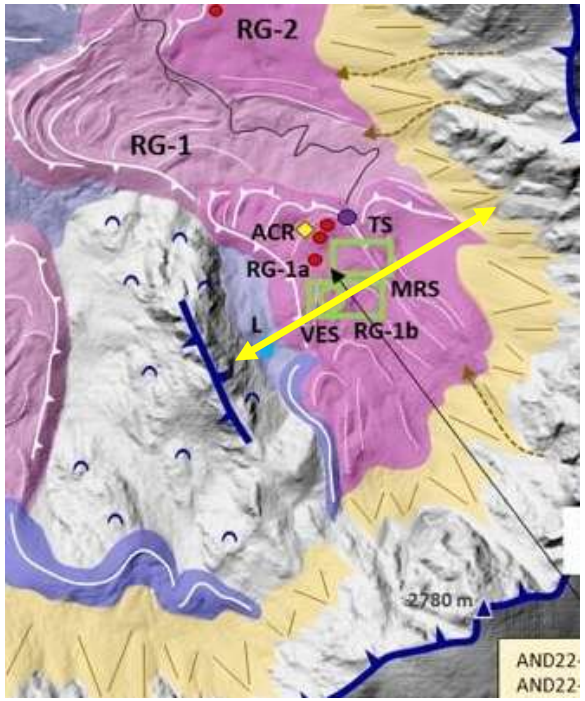


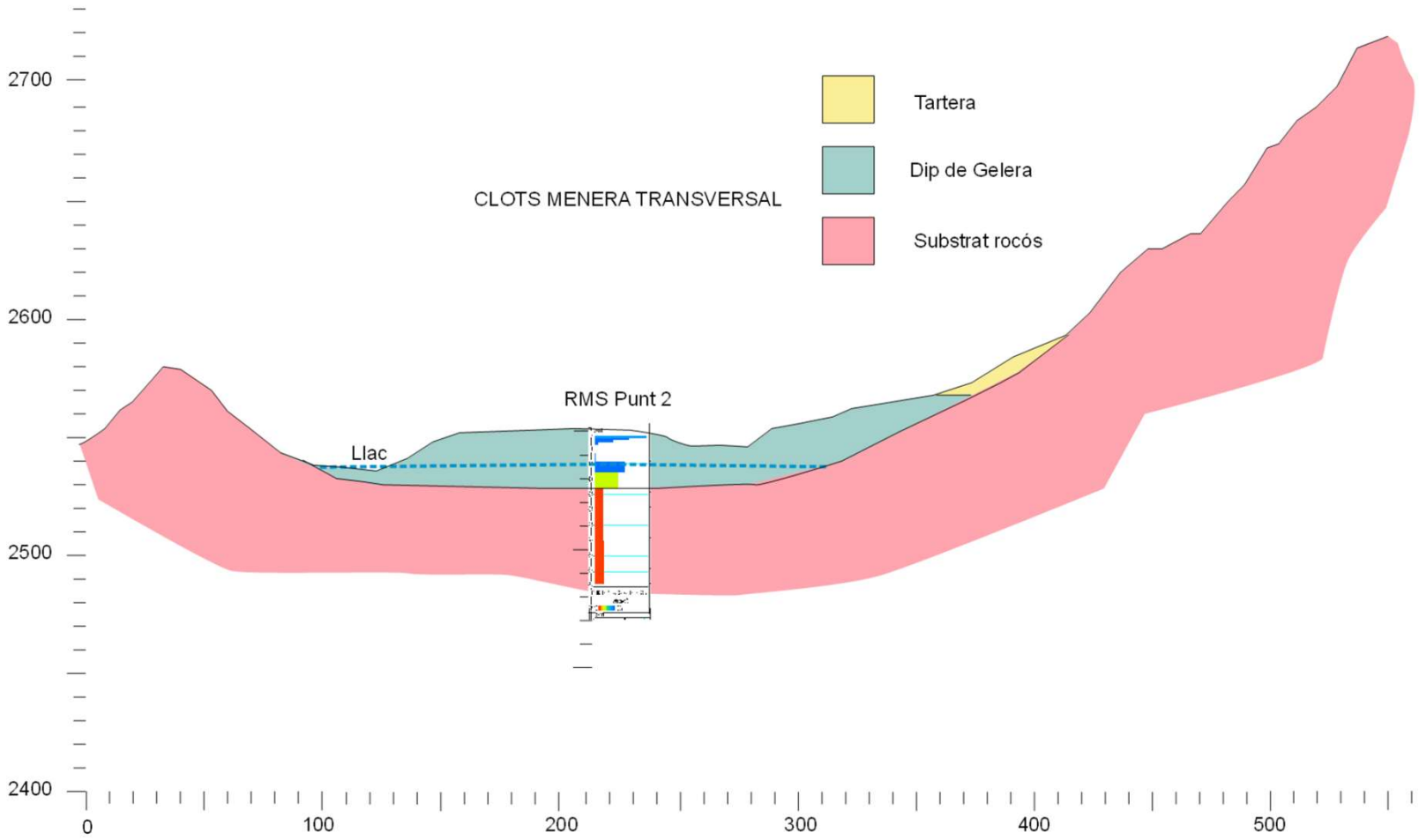


G1-G2: Possible frozen masses

Free liquid water at the top

Geophysical survey





Conclusions

Rock glaciers have been exposed for approximately 10–11 ka

RG continue to creep downhill at 1-4 cm/yr

Evidence of frozen masses (~30m): permafrost and/or buried ice

Rock glaciers out of balance with the current climate (MAAT> 0ºC)

Permafrost and/or buried ice presence likely but needs nature confirmation (future borehole)

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Moltes gràcies per la vostra atenció!