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Outstanding Student & PhD candidate Presentation contest

Exhumation signals and forcing mechanisms in the Southern Patagonian Andes (Torres del Paine and Fitz Roy plutonic complexes)

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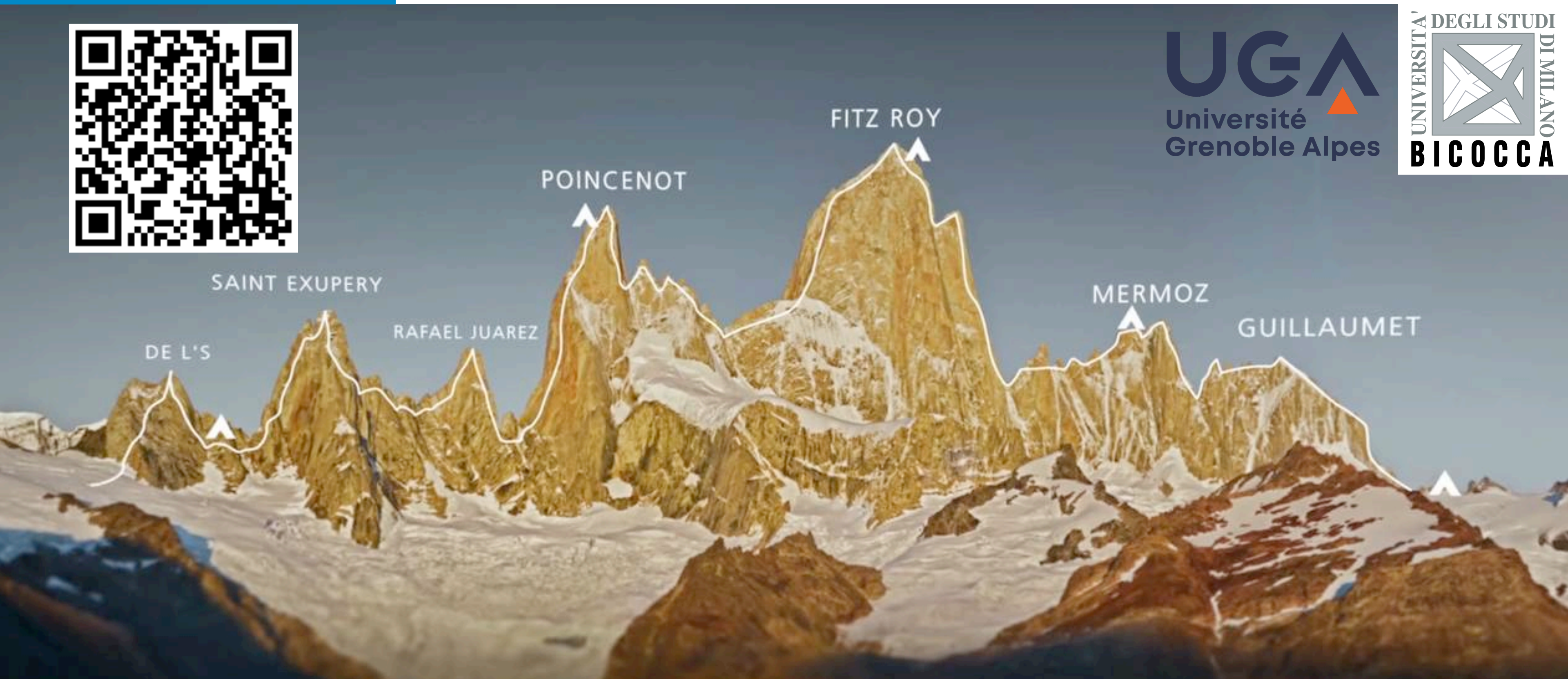
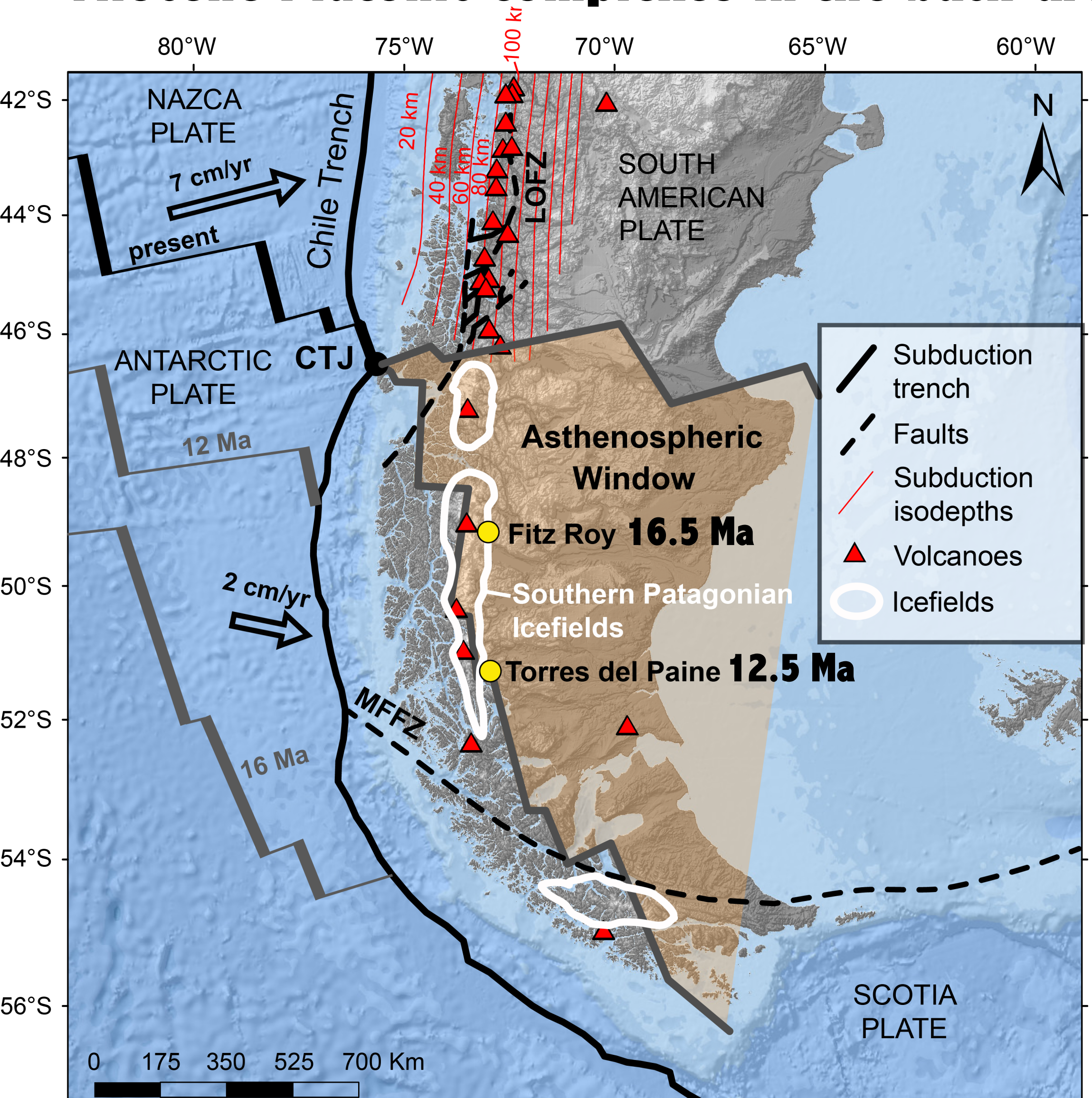


TECTONIC CONTEXT

Miocene Plutonic Complexes in the back-arc of the Patagonian Andes



- **Ridge subduction ~16 Ma – present CTJ**: Chile Triple Junction
- Dynamic surface uplift
- **Fitz Roy** ~16.5 Ma (Ramírez de Arellano et al., 2012)
- **Torres del Paine** ~12.5 Ma (Leuthold et al., 2012)

Deep incised glacial valleys with 2-3 km topographic relief

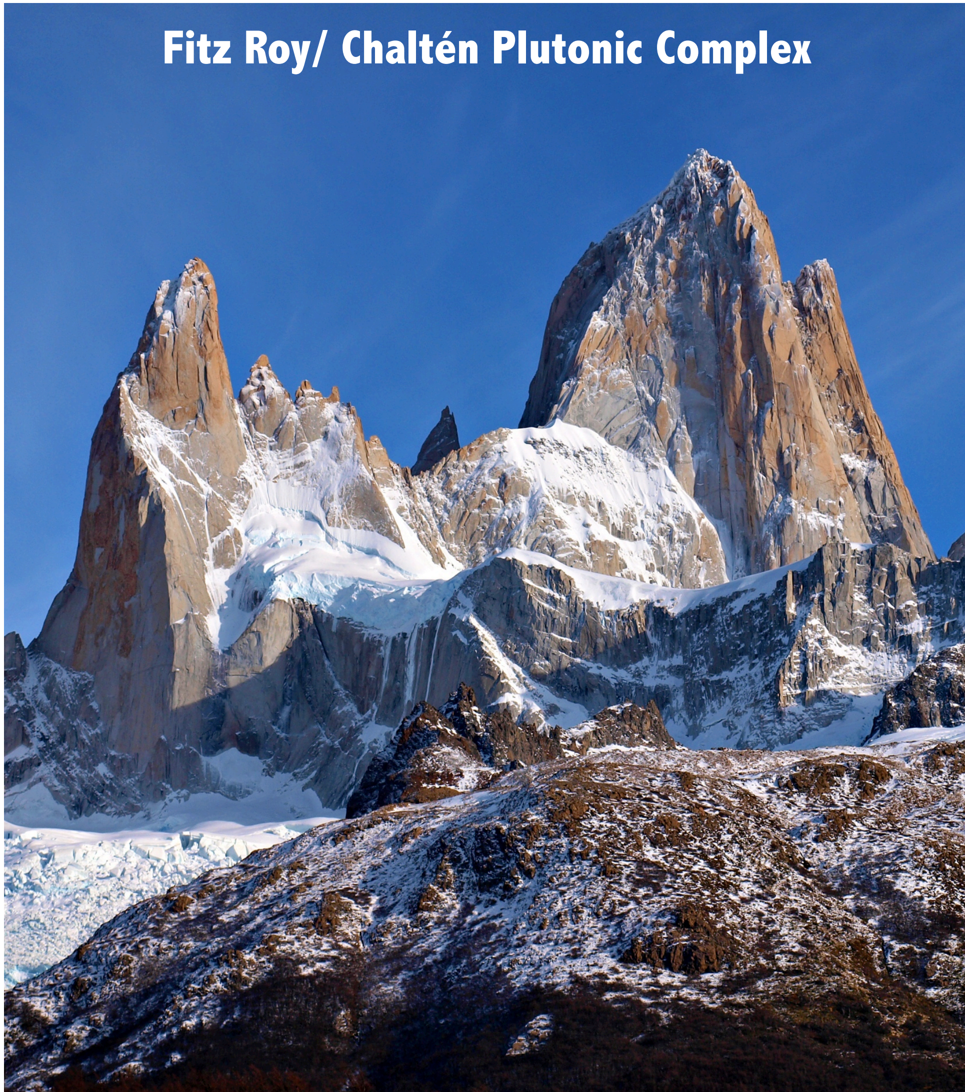
The height of mountain ranges reflects the balance between:

ROCK UPLIFT

- Tectonic (convergence, ridge collision, thrusting and strike slip deformation)
- Dynamic (asthenospheric window with mantle flow – thermal weakening of the crust and mechanic uplift)

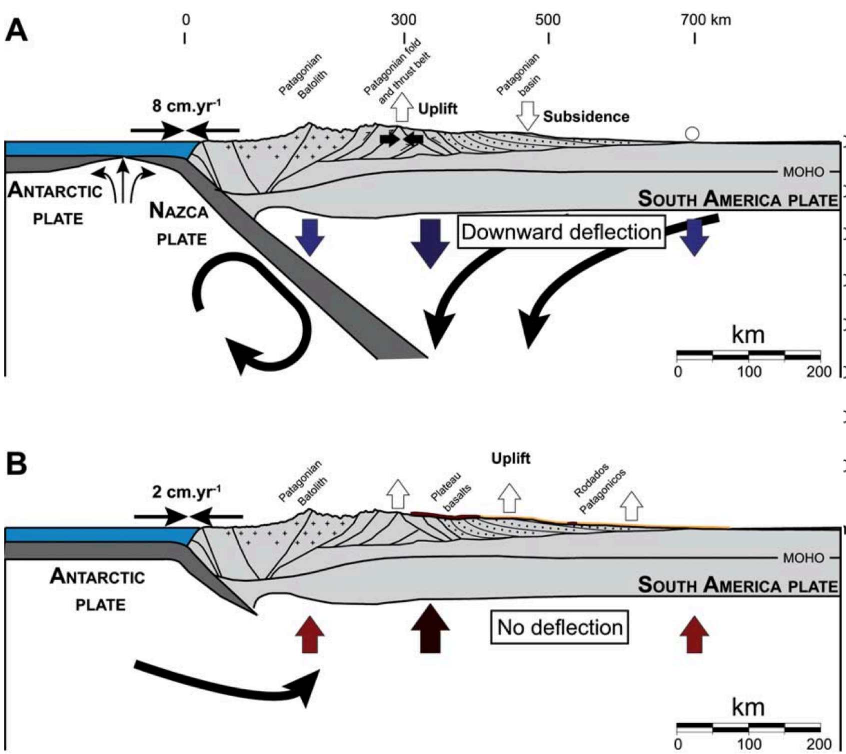
EROSION

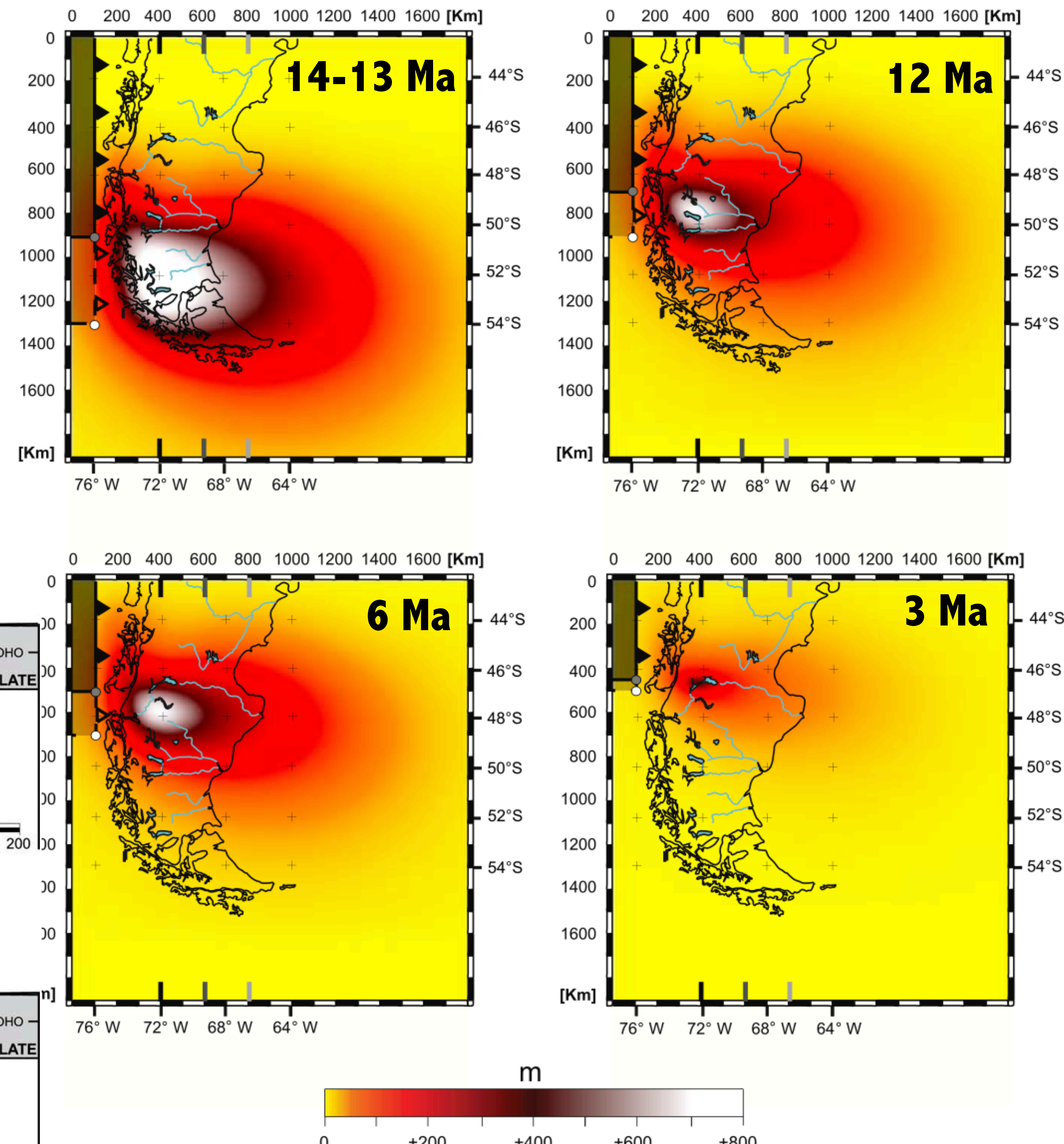
- Fluvial and Glacial



DYNAMIC UPLIFT

- Mantle dynamics in a ridge subduction context
- Before ridge subduction – depends on slab behaviour
- During ridge subduction – less dense hot mantle material entering in subduction, long-wavelength regional uplift

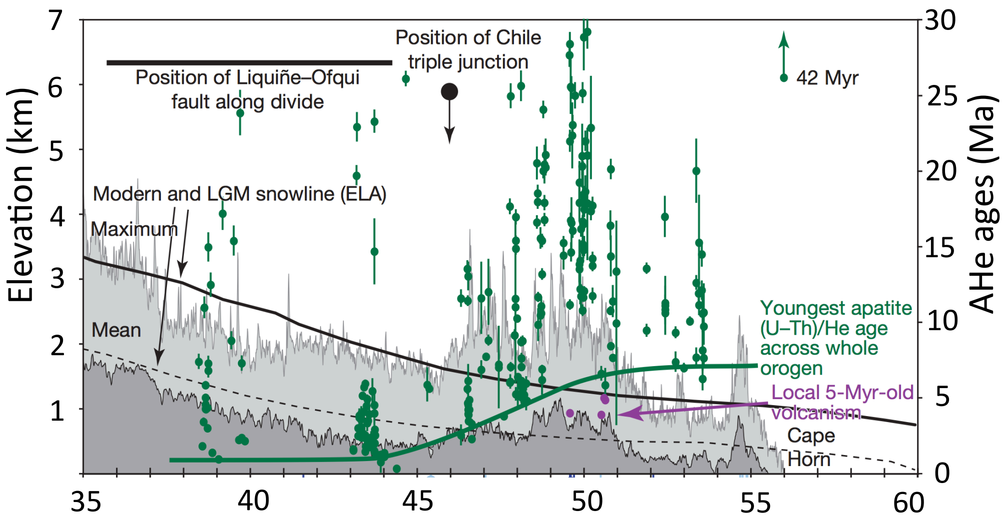




(Guillaume et al., 2009)

GLACIAL EROSION

- **How glacial erosion forms relief?**
- Glacial carving and circle retreat: Deep incised valleys and isostatic rebound
- Glacial equilibrium line altitude (ELA) limits the summits – exception in southern Patagonia
- Cold-based glaciers protect bedrock from erosion (?)



(Thomson, 2010)

CLIMATE CONTEXT

- **Onset of Patagonian glaciation around 7 Ma**
- Transition from fluvial to glacial dominant processes: initial phase of fast exhumation rates
- Return to equilibrium between uplift and erosion: slow exhumation rates

(Antarcticglaciers.org) Last Glacial Maximum

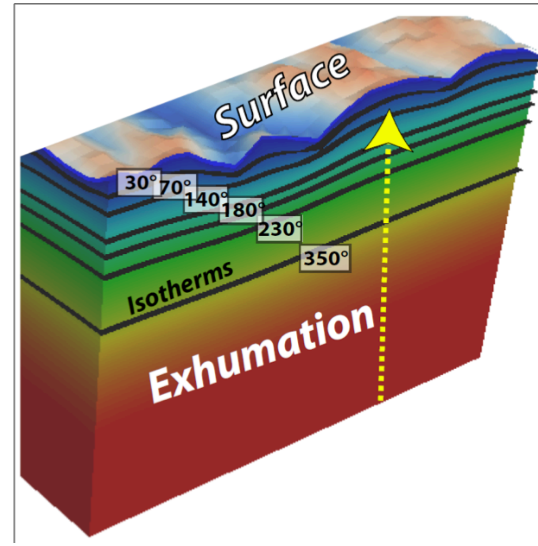
SCIENTIFIC QUESTION

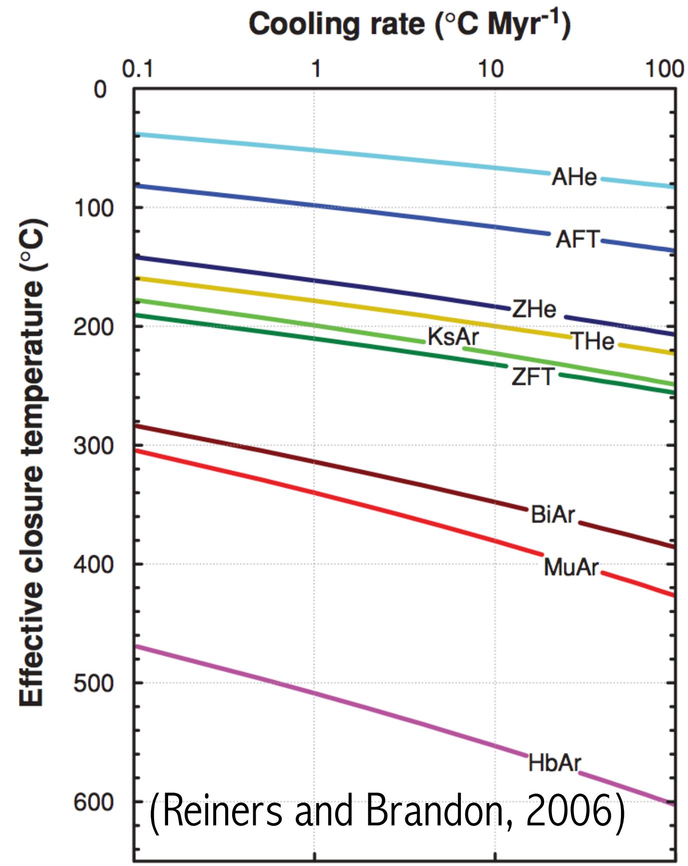
- Both plutons experienced glaciations since the 7 Ma, but only the Fitz Roy potentially experienced the asthenospheric window passage at 12 Ma

- Which are the similarities and differences in the thermochronological record?

METHODS

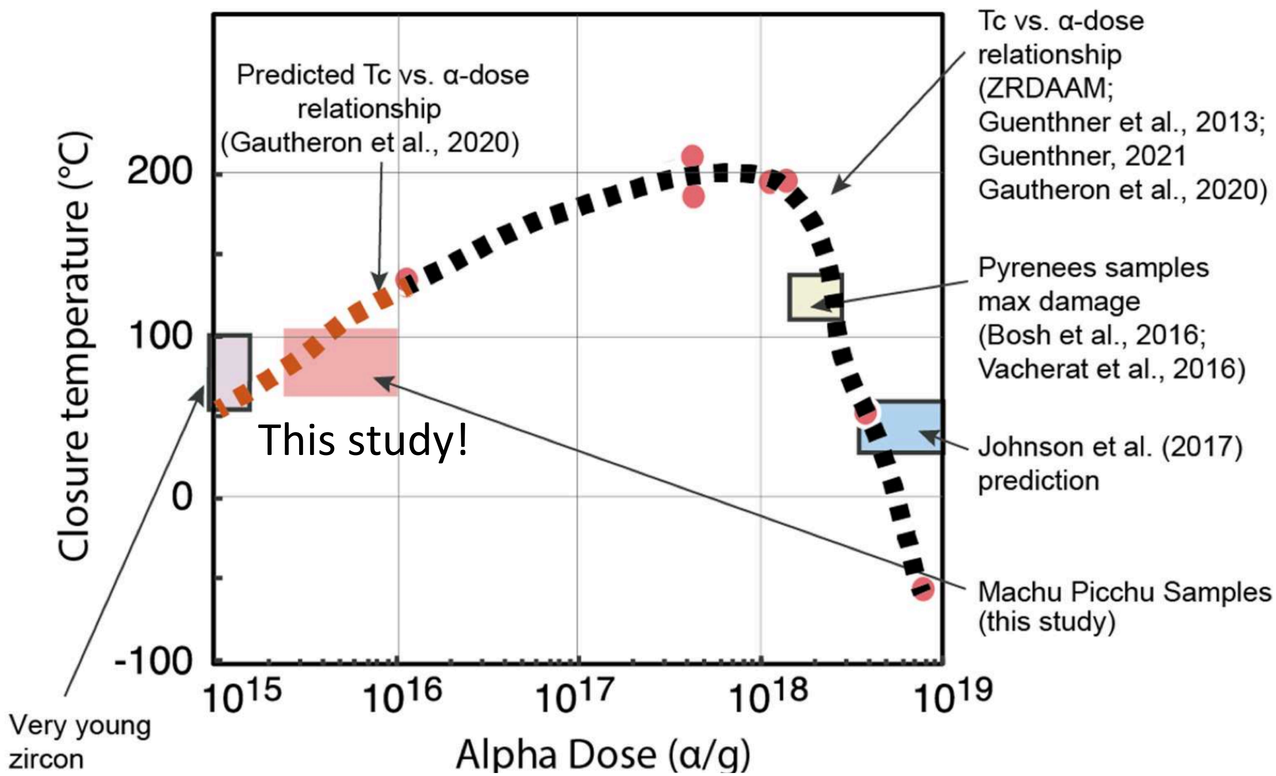
- New dataset of low temperature thermochronometric ages:
- **Apatite (U-Th)/He (AHe): 70 – 60°C**
- **Zircon (U-Th)/He (ZHe): 180 – 70°C**, changes according to diffusivity of He (Gautheron et al., 2020)
- **Apatite Fission Tracks (AFT): 80 – 140°C**
- **Apatite $^{4}He/^{3}He$:** post closure temperature history
- **Thermal history by inversion modeling** using QTQt (Gallagher, 2012)





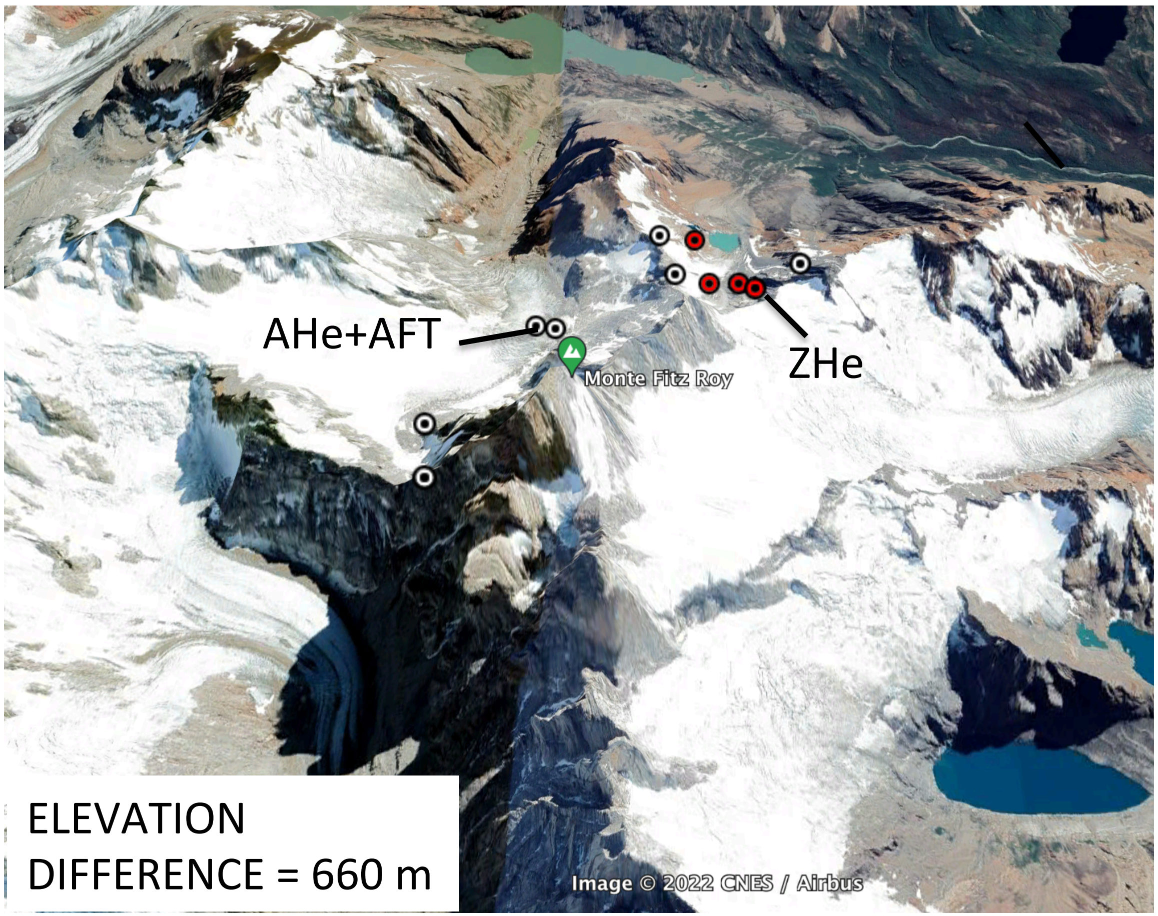
Closure Temperature of the ZHe system

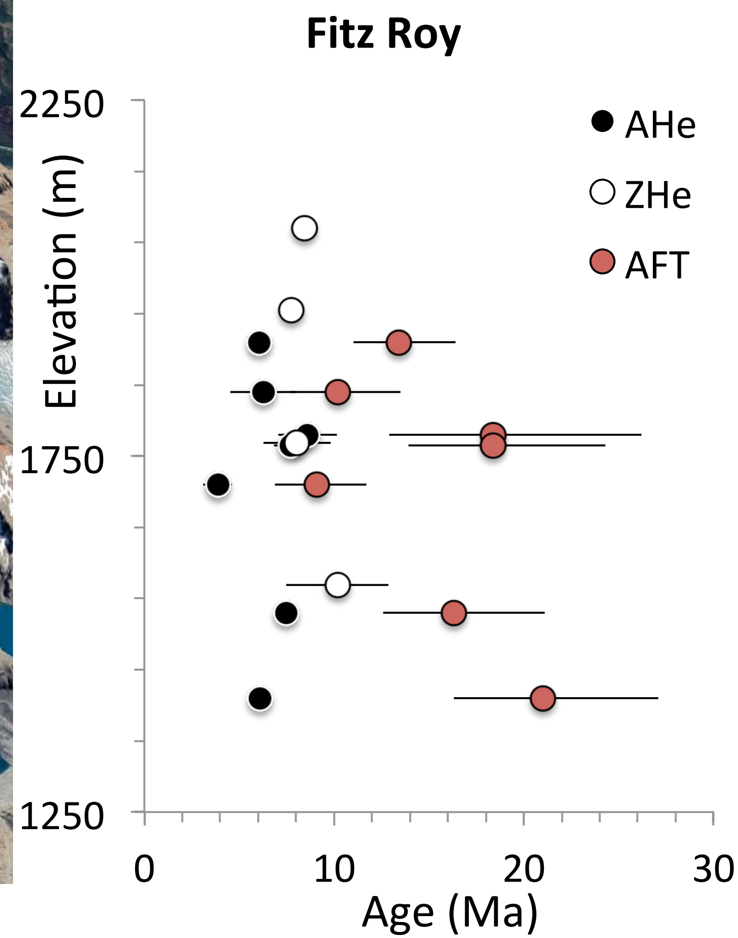
- Diffusivity of He changes the closure temperature of the system (U-Th)/He
- Young plutons: few time to damage
- Zircon with low radiation damage alpha dose (10^{15}-10^{16} alpha/g), low closure temperature of the system



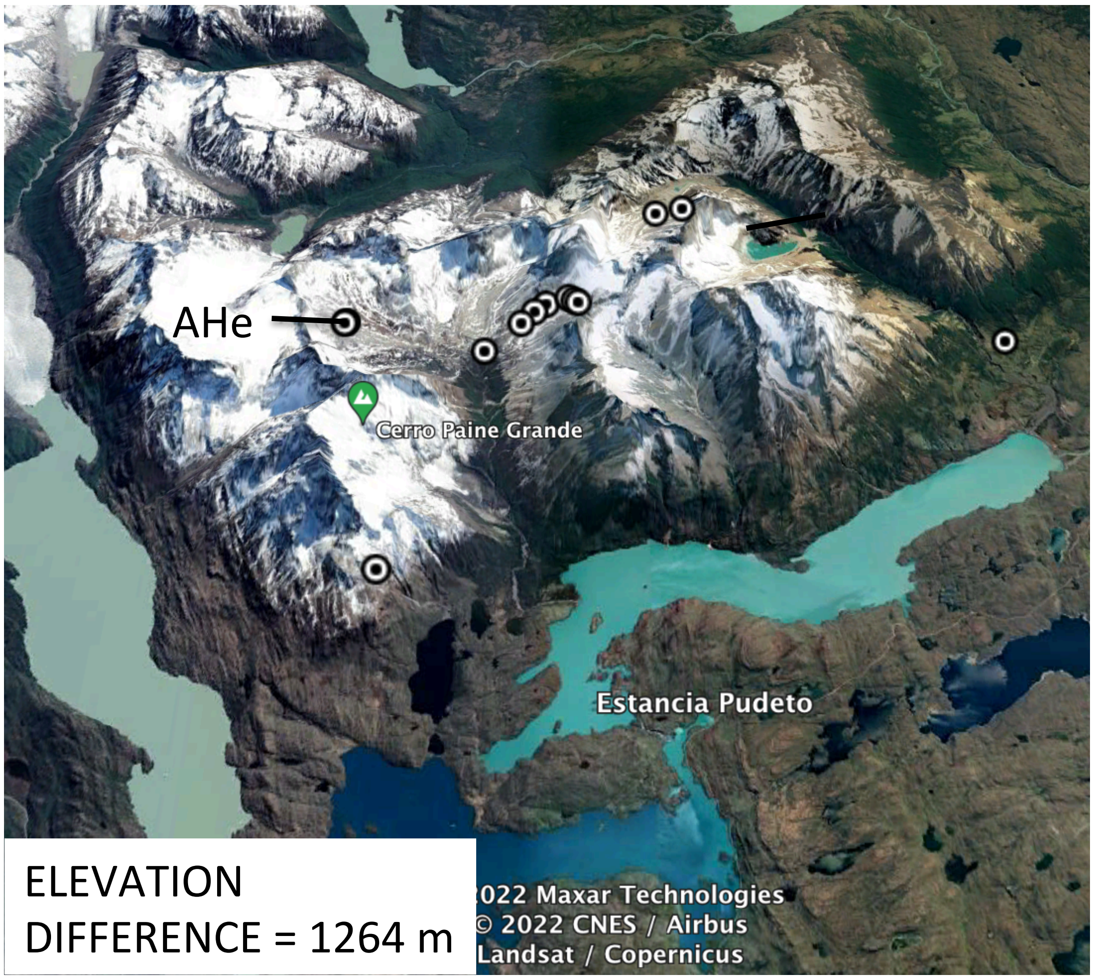
(Gerard et al., 2022)

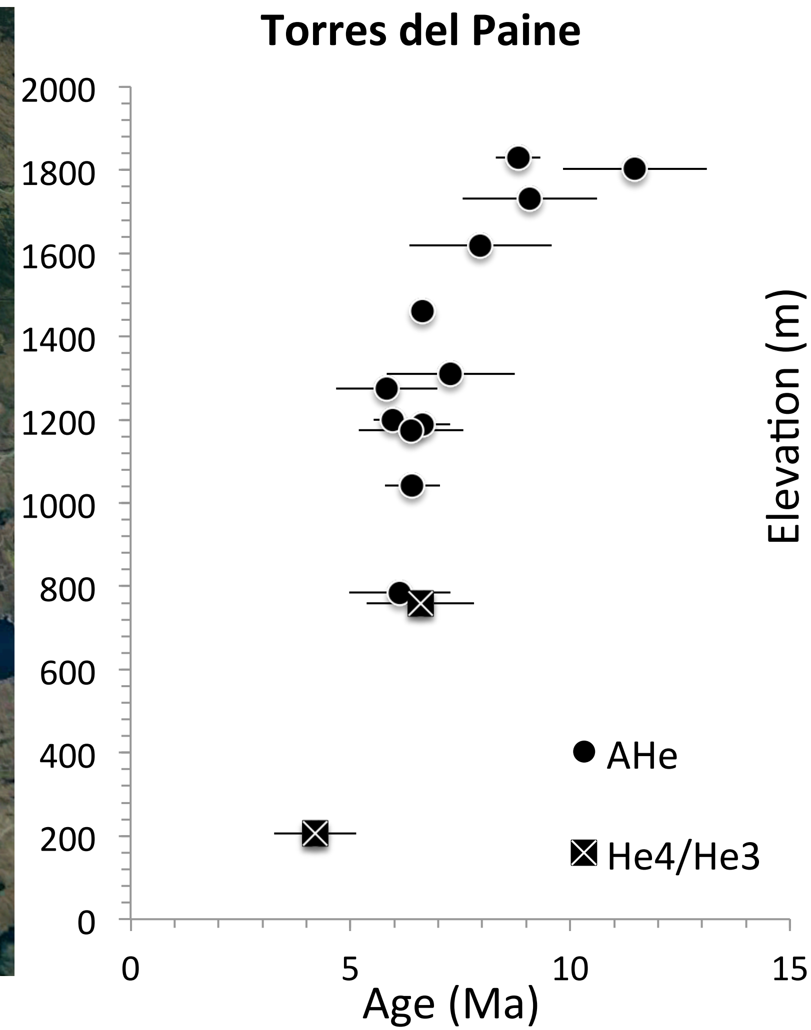
FITZ ROY/CHALTÉN PLUTONIC COMPLEX





TORRES DEL PAINE PLUTONIC COMPLEX

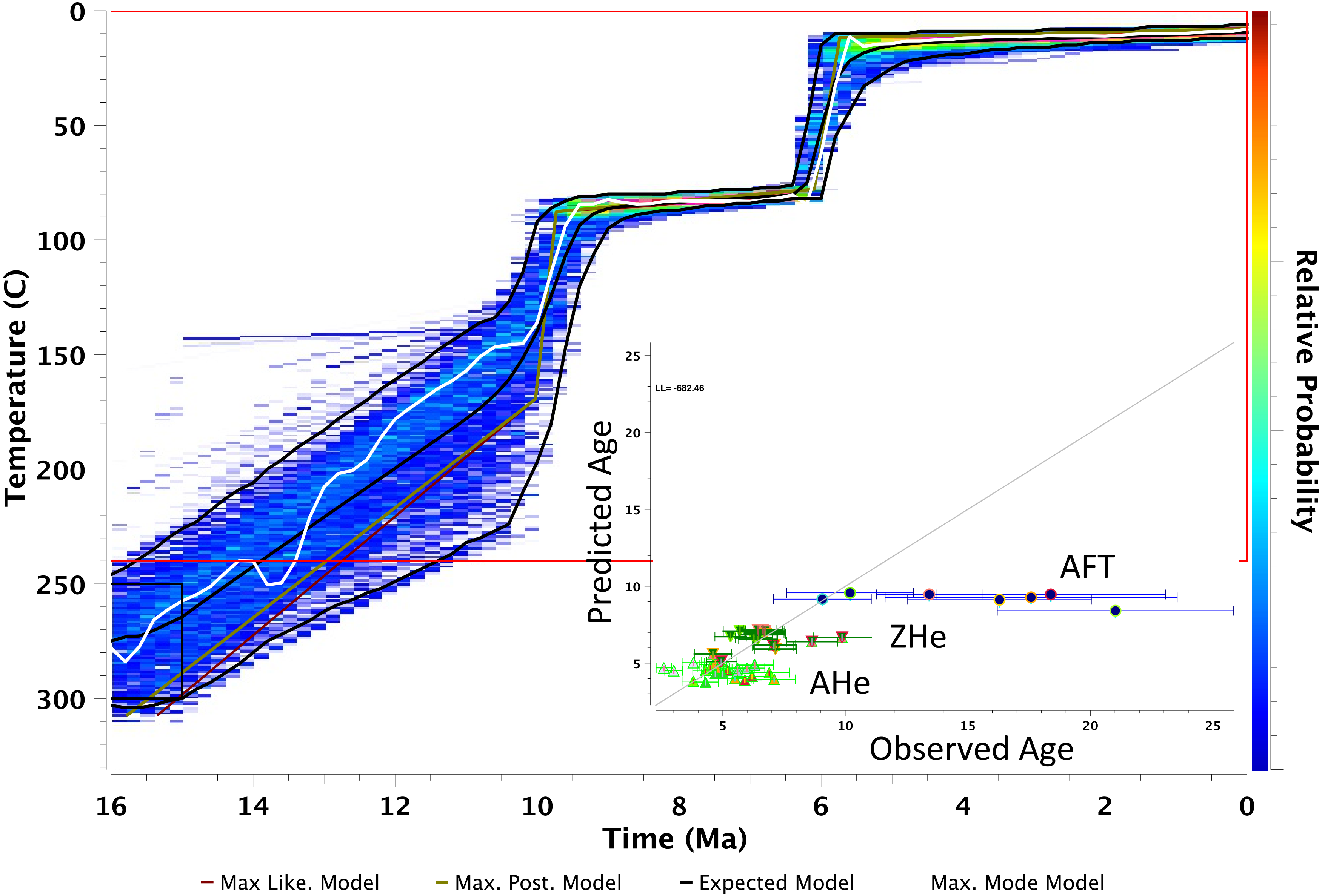




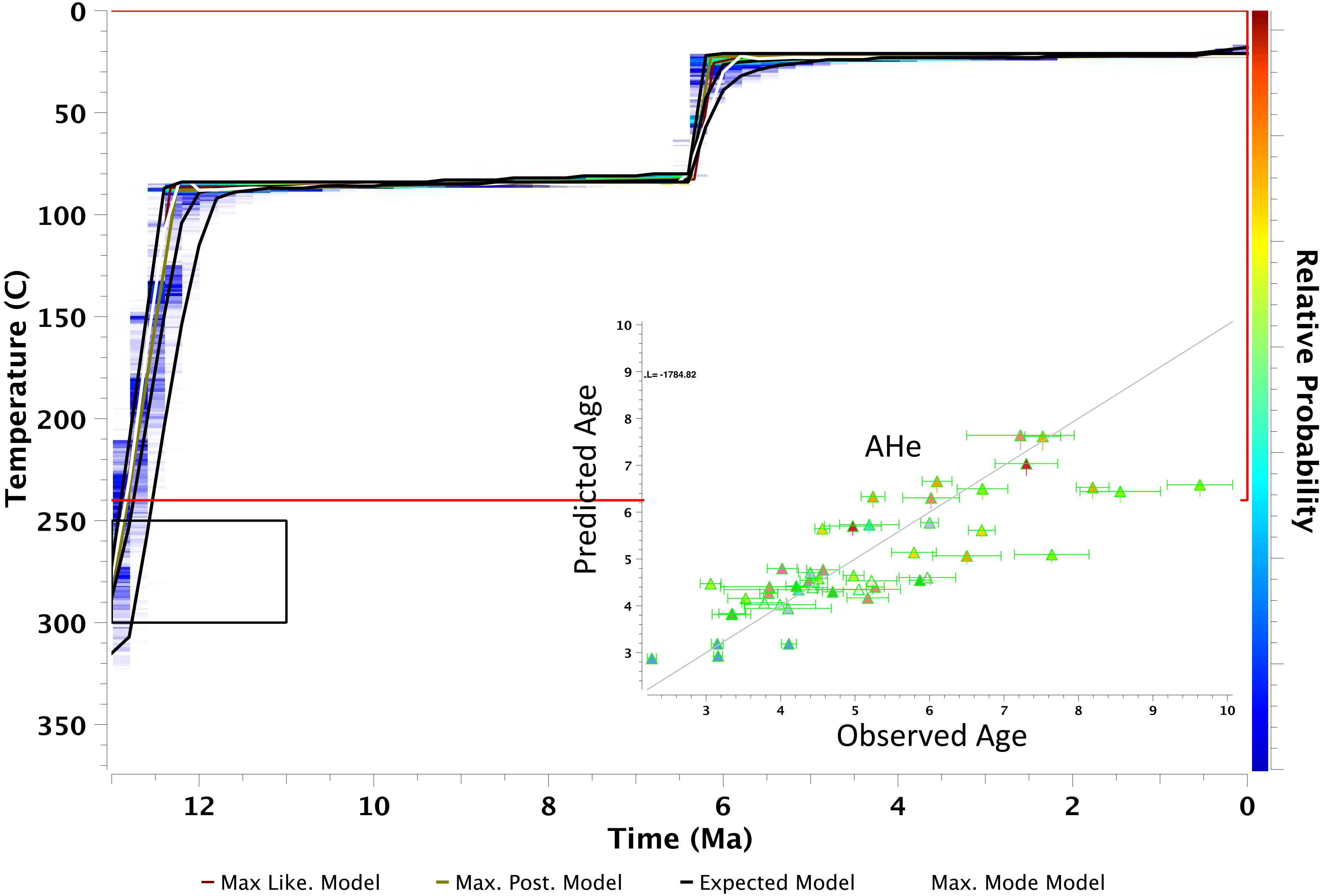
Thermal history of an elevation profile Inversion Modeling

- Geothermal gradient of 35 +/- 10 °C/km
- Surface temperature of 10 +/- 10 °C/km
- No reheating allowed
- Imposed pluton age:
- Fitz Roy 16 +/- 1 Ma (Ramírez de Arellano et al., 2012)
- Torres del Paine 12 +/- 1 Ma (Leuthold et al., 2012)
- Imposed pluton temperature 275 +/- 25 °C

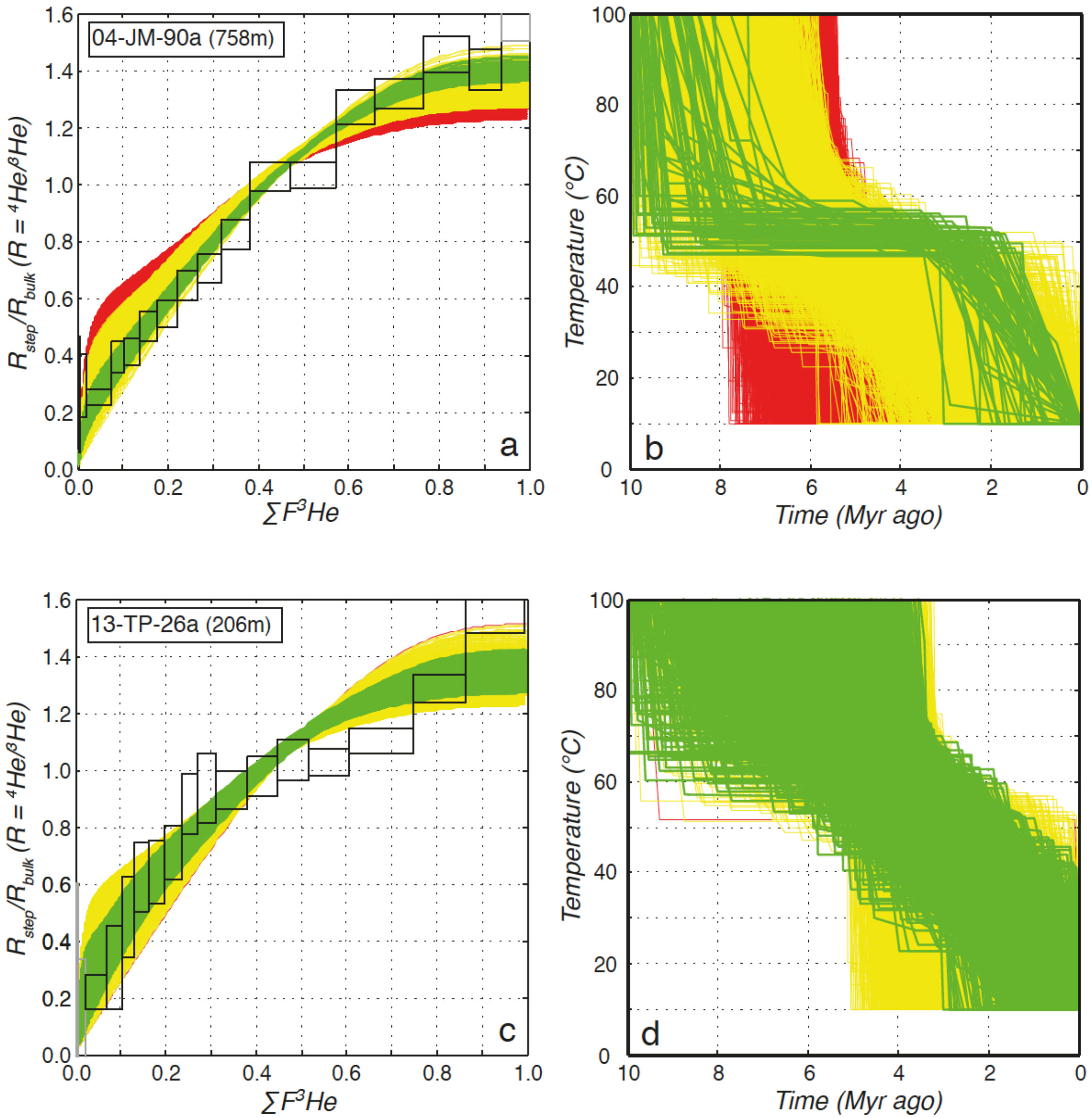
THERMAL INVERSION MODELING
FITZ ROY – AFT, AHe, ZHe



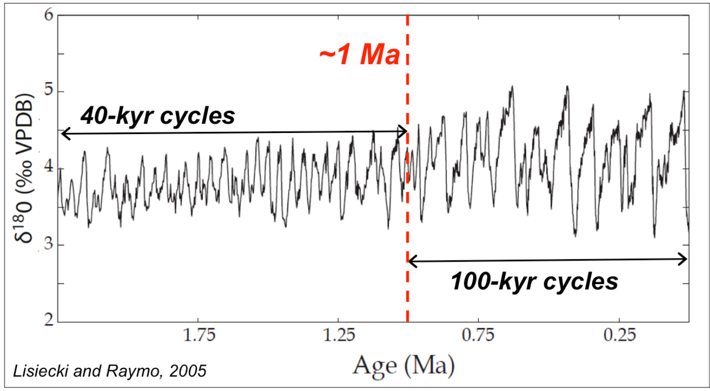
TORRES DEL PAINE - AHe



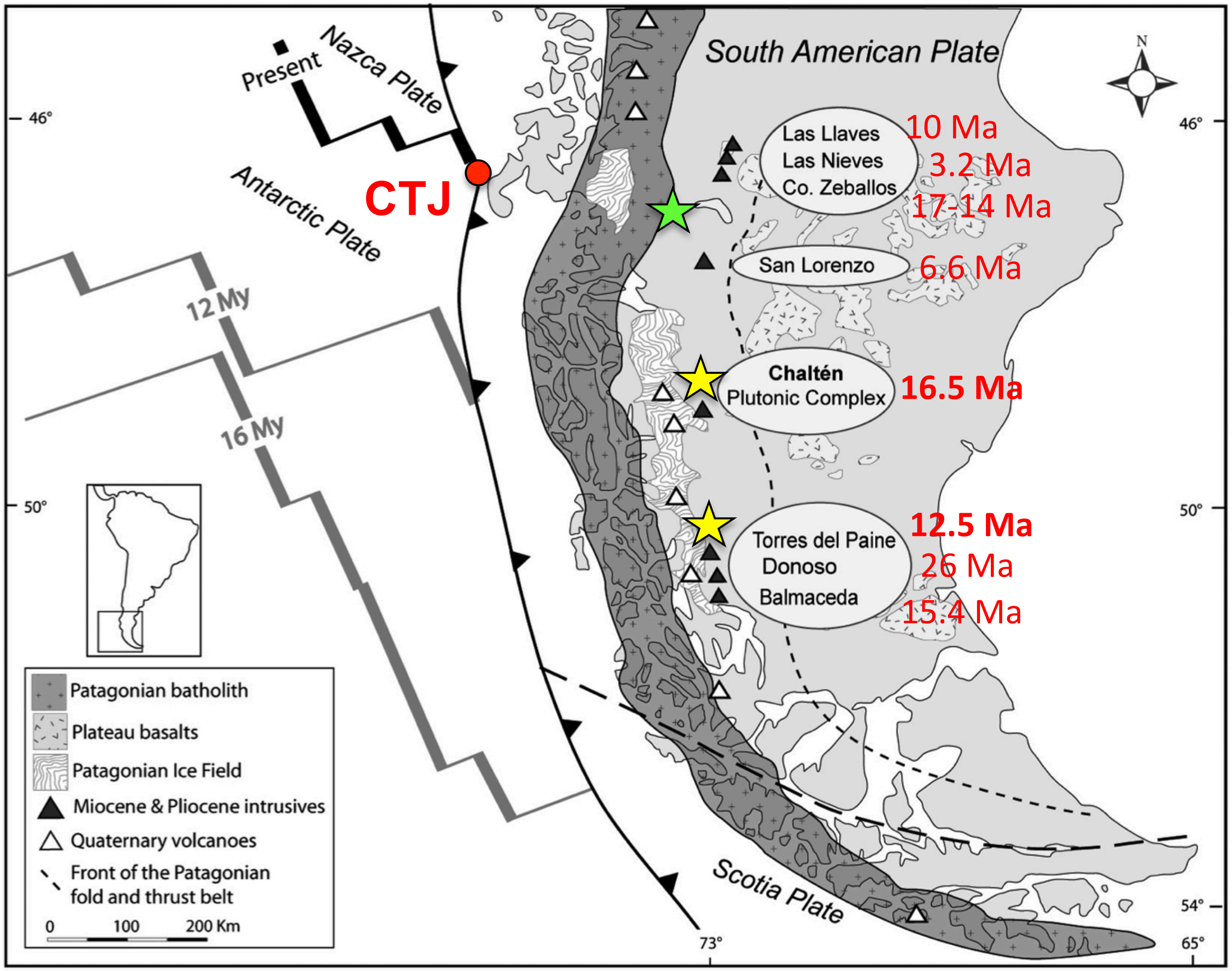
TORRES DEL PAINE $^4He/^3He$



- **10 – 6 Ma:** Beggining of glaciations
- **2.0 – 0 Ma:** mid-Pleistocene transition, (changing glacial cyclicity)



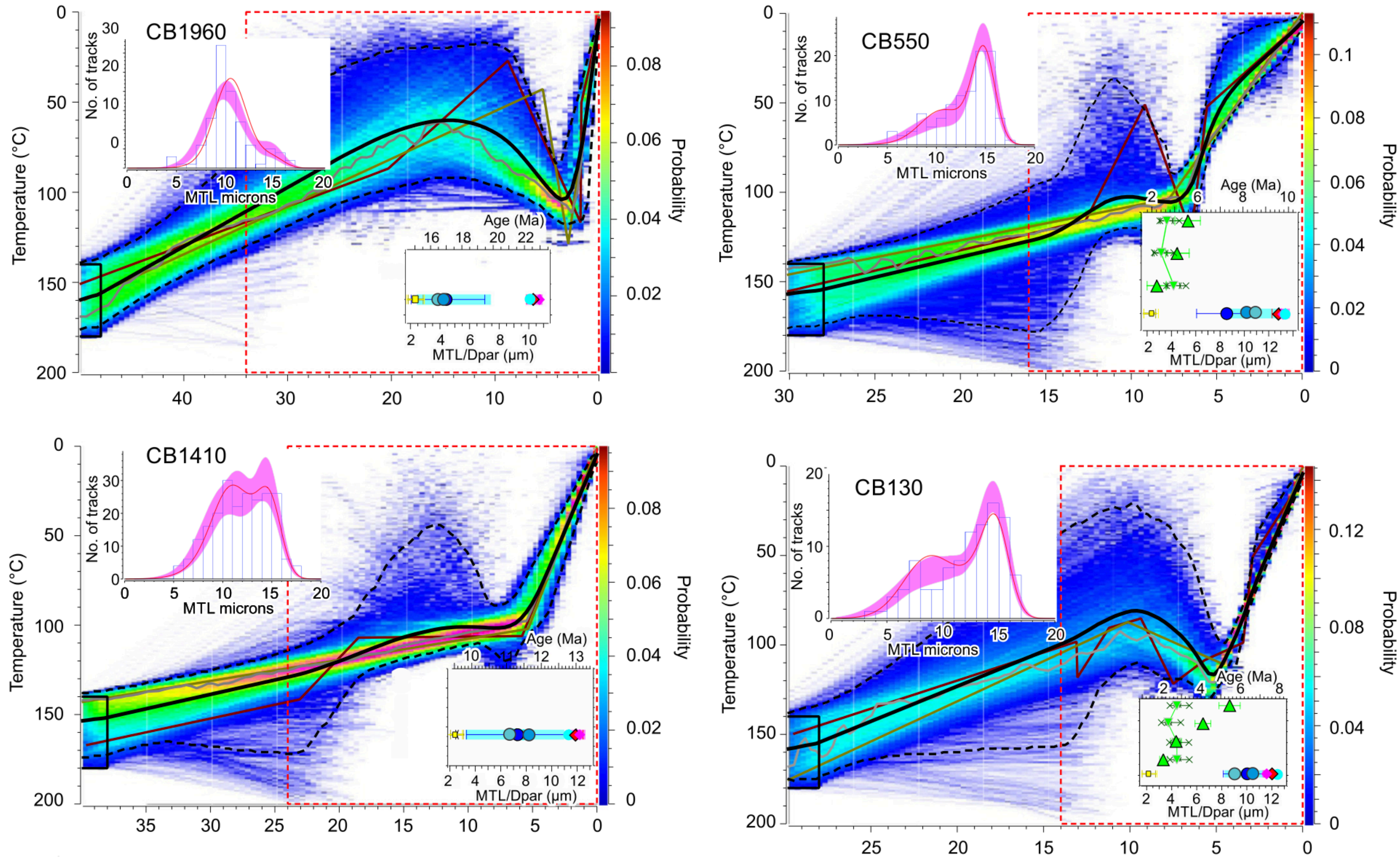
Ridge Collision timing



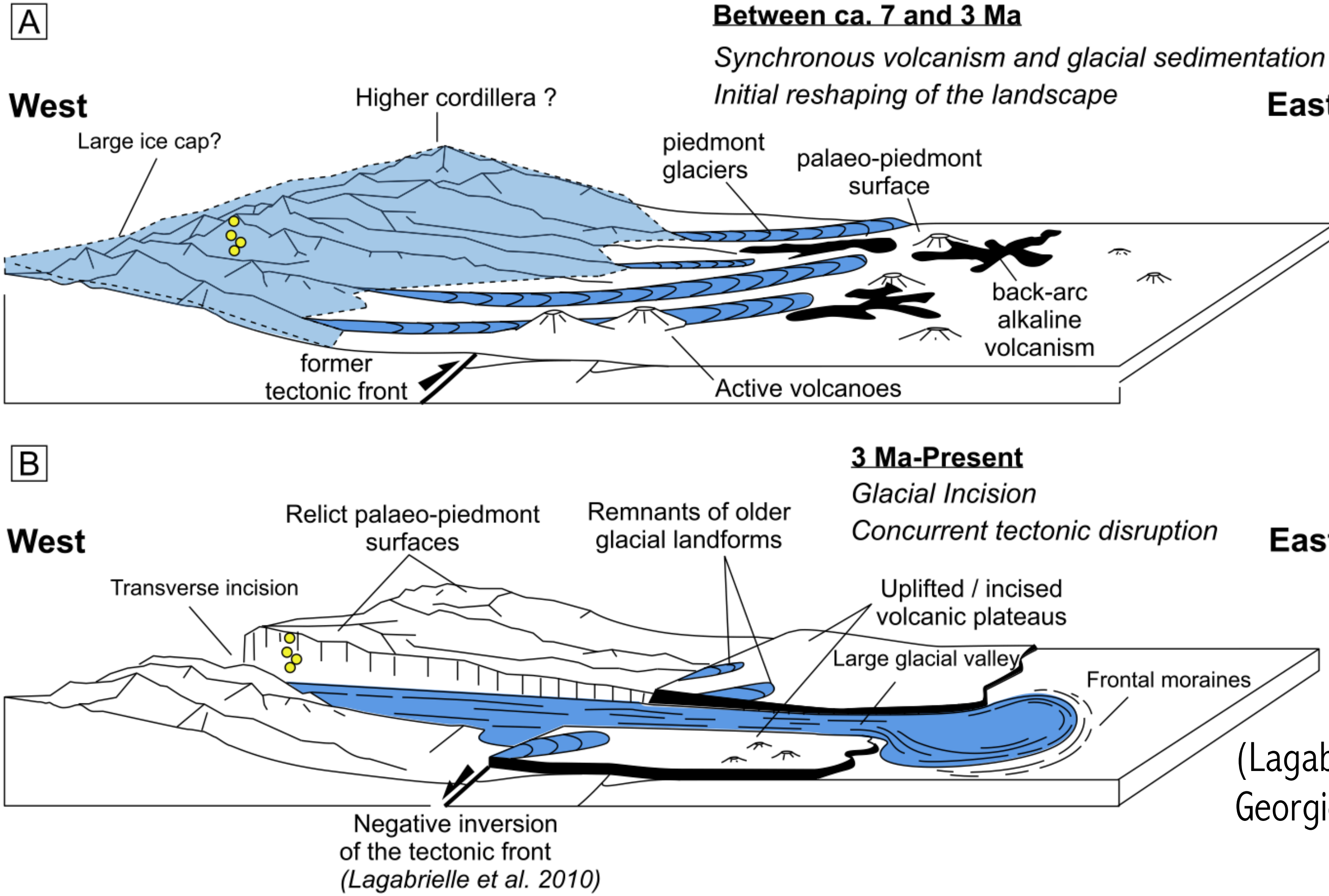
(Ramírez de Arellano et al., 2012)

- **Lago General Carrera Buenos Aires (47°S):** 4-3 Ma, NPI
- **Fitz Roy/Chaltén (49°S):** 12 Ma, SPI
- **Torres del Paine (51°S):** 14 Ma, SPI

Data from the Chile Triple Junction and Northern Patagonian Icefields (lat ~ 47 °S)



(Georgieva et al., 2019)



(Lagabrielle et al., 2010
Georgieva et al., 2019)

- Episode of cooling from 4-3 Ma to the present: coeval neotectonics due to ridge collision with glacial incision during Plio-Pleistocene transition (Lagabrielle et al., 2010, Georgieva et al., 2019, Willet et al., 2020) – SUPERPOSITION
- **We have the advange of not superposing climatic with geodynamic processes!**

CONCLUSIONS

- Our models agree with the regional onset of glaciation at ca. 6 Ma causing a rapid exhumation episode of 1,6 km of erosion in ca. 1 Ma

- Fast exhumation at 10 Ma in the Fitz Roy could indicate the passage of the asthenospheric window at the latitude 49 °S

- However the kinetics of low-damage zircons make ZHe cooling ages uncertain

Thank you very much!

Searching for a work in Research!

Acknowledgements:
Italian MIUR – Dipartimenti di Eccellenza 2018–2022, DISAT, University of Milano-Bicocca;
Erasmus Program – Period abbroad in the Université Grenoble Alpes,
TRB team in ISTerre;
All university and institutes that performed analysis and supported this work (first slide)

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