EGU General Assembly 2020

EGU – Session GD6.1

"The Earth-System-Science-based EGU-session […] aims to test the hypothesis:
That material flow in the ***earth's mantle affects the earth's lithosphere****, including its* ***surface topography*** *and the sedimentary record,* ***far beyond plate boundaries****"*

This study is a part of a project that aims to constrain the formation and evolution of the south Patagonian foreland, using a multi-methods approach. One part of this project applied low temperature thermochronology on the intraplate Deseado Massif to constrain it surface evolution,

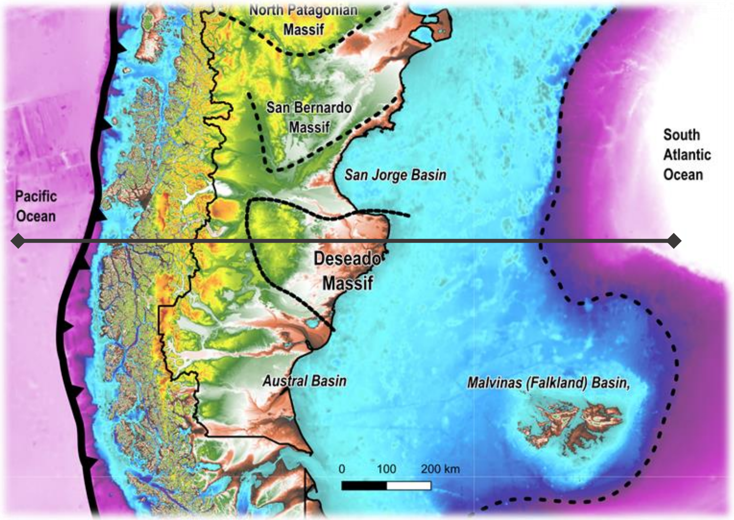
Here are presented a preview of our results, revealing a heating-cooling phase during the Mesozoic, which we attributed to a burial/exhumation event. The timing of this event is put in perspective with the regional geodynamics evolution, in order to constrain the mechanism that could produce it.

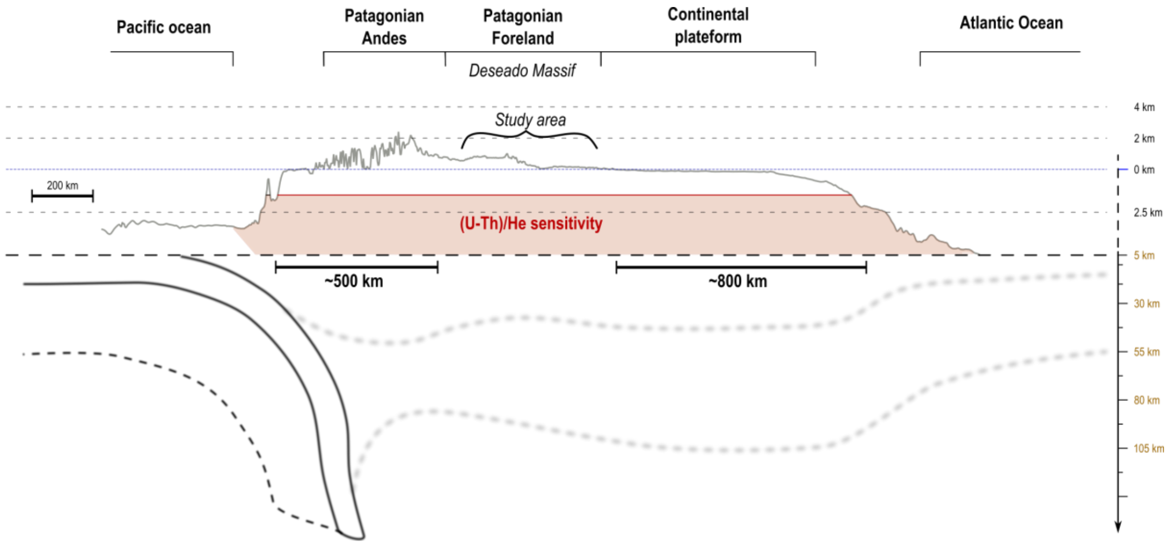
① GEOPS GEOSCIENCES PARIS SUD ② ⑤ SegemAR Servicio Geológico Minero Argentino ③ ④ Université de Lille 1 SCIENCES ET TECHNOLOGIES

Patagonian foreland burial and exhumation during Mesozoic revealed by low temperature thermochronology: a response to mantle processes?

A. Derycke [1,2], C. Gautheron [2], M.C. Genge [2,4], M. Zattin [2], S. Mazzoli [3], C. Witt [4], M. Marquez [5].

Study area:





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Background

Deseado Massif:

- Topographic high (400 to 1000 m)
- **> 400 km** from plate boundary
- Consider stable since the Middle Jurassic

Main geodynamic events:

- **Andean subduction** since ~250 Ma, with a **flat slab** morphology **between ~220M and ~200 Ma**
- Gondwana breakup starting at ~180 Ma with **the Karoo-Ferrar Plume** and finish at 124 Ma by the oceanisation
- **Chon Aike LIP event** between ~190 to ~150 Ma

The Deseado Massif is the southern massif of the Patagonian Foreland and it is mainly covered by a massif volcanic deposit associated with the Chon Aike LIP.

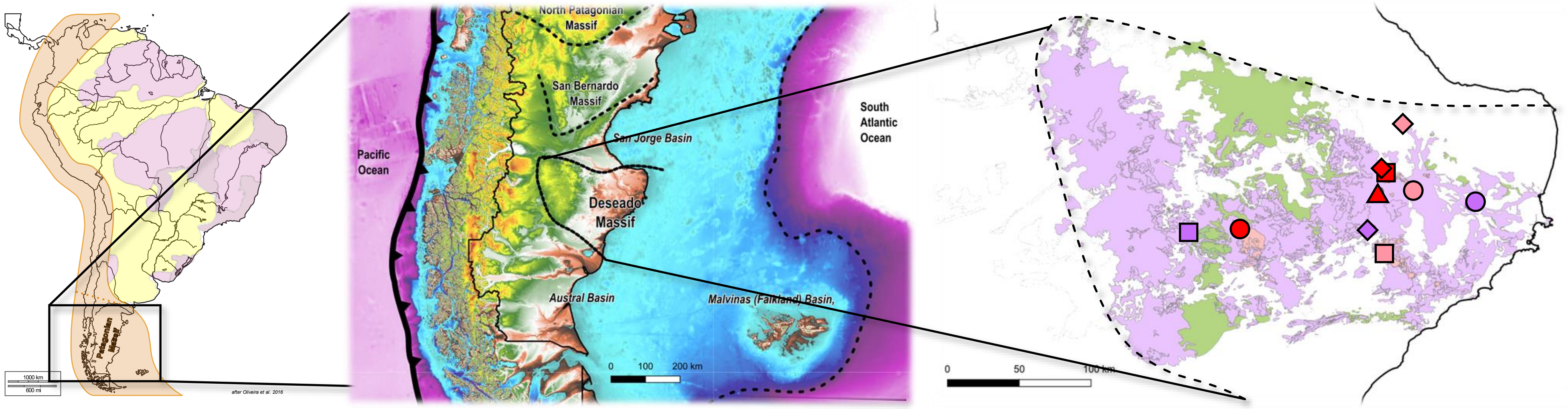
Local geology:

Cretaceous cover: restrain continental deposit (~100 Ma)

Chon Aike deposit: major volcanic Jurassic cover (~180 to ~150 Ma)

Basement: Paleozoic to Early Mesozoic rock, in surface at ~190 Ma

Deseado Massif position and morphology:



Geological background:

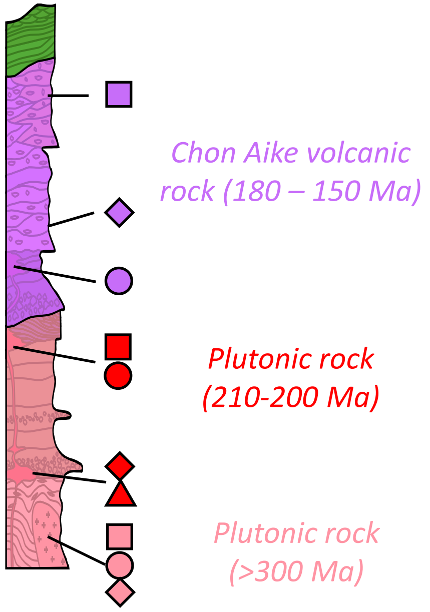
- Patagonia is divided in the **Andean range** itself, and the F**oreland**
- The Foreland is constituted by multiple **basins and massifs,** formed during **the Meso-Cenozoic periods**
- The lack of sedimentary deposits on those massifs conducted to suppose there were **"stable topographic high" since the Mesozoic**.

Navarrete et al. (2019) **demonstrated that**, between ~220 and ~150 Ma, a **complex subduction setting** occurred **under the Deseado Massif,** highlighting its potential **impact and control the Deseado Massif surface evolution.**

Objective of this study:

Constrain the Deseado Massif thermal history in order to reconstruct its surface evolution and questioned its linked to the complex mantle/subduction setting.

Simplified log:



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Geodynamics statement & mantle setting

Geodynamics events:

The pre-Atlantic opening history of Patagonia corresponds to a **flat slab** emplacement, follow by the arrival of the **Karoo-Ferrar mantle plume** and **Chon Aike SLIP**.
This complex evolution **ended with the Atlantic opening**.

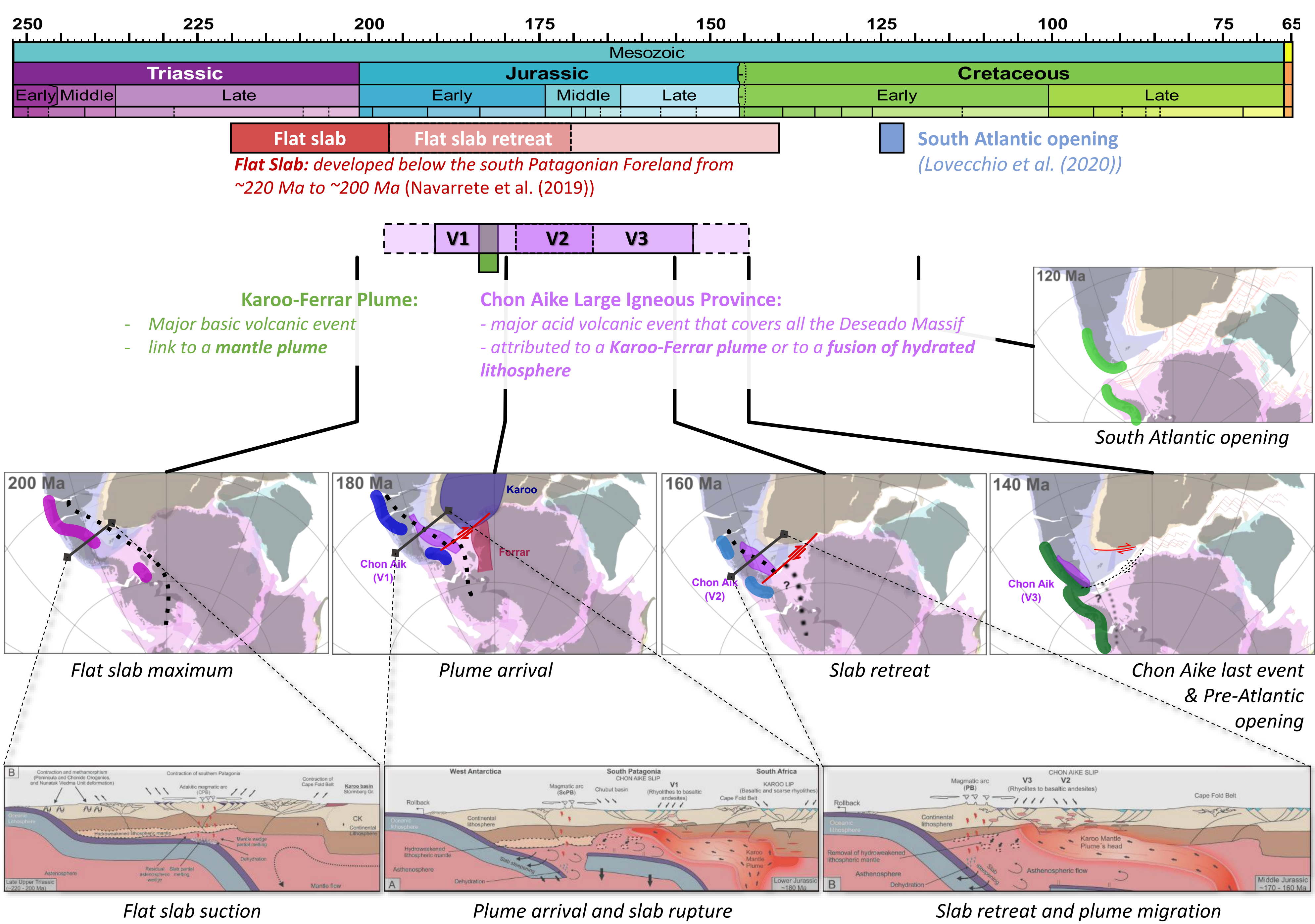
Paleogeographic evolution:
(base on Müller et al. (2016)*)*

Legend:

- position of subduction related magmatism
- supposed position of flat slab
- position of Large magmatic events

Est – West cross section evolution:

Theoretical section **from Navarrete et al. (2019),** supposing a westward migration of the plume, controlled by the flat slab morphology, and that triggered the Chon Aike event evolution



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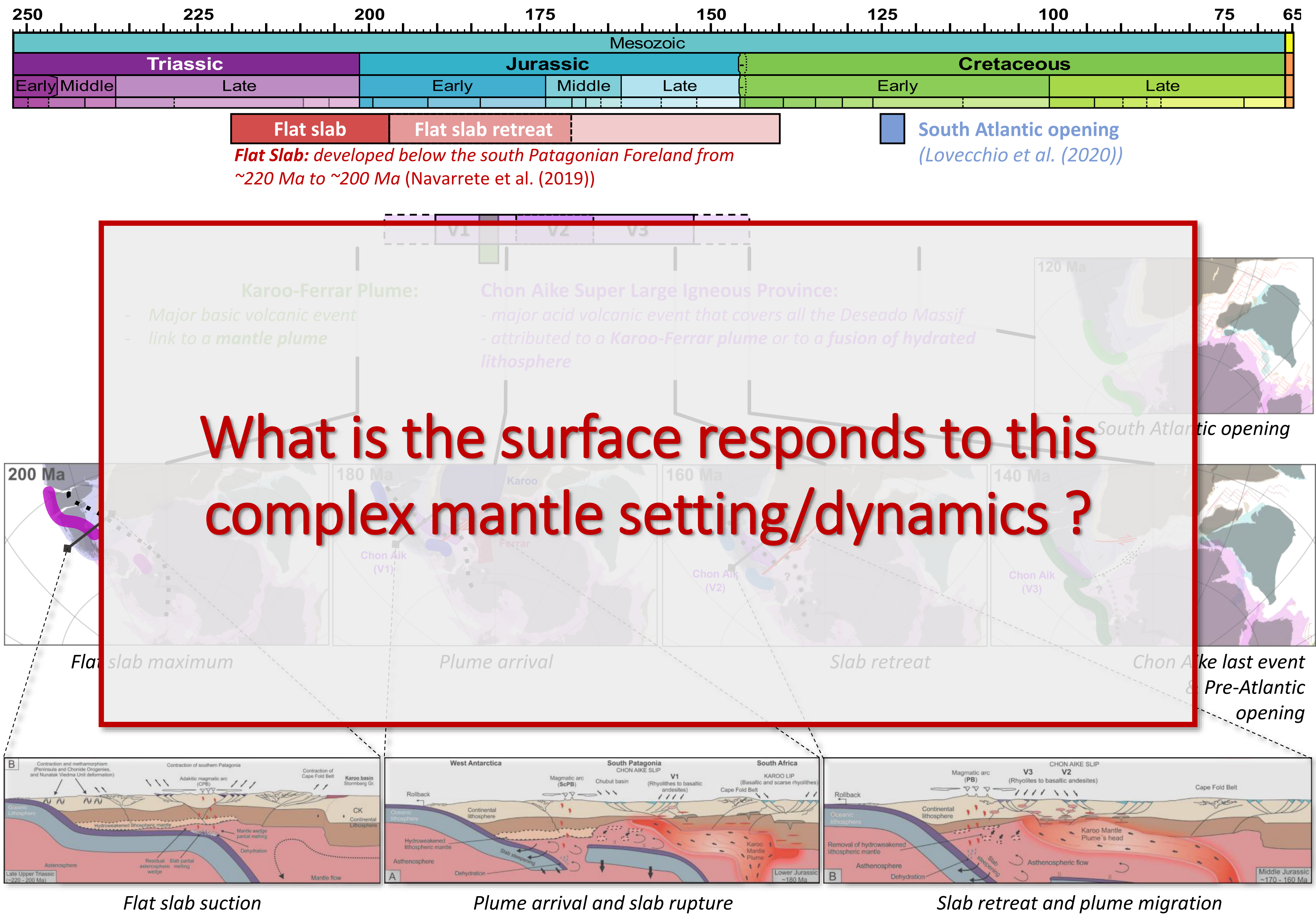

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Methods & Results

Methods: (U-Th)/He on apatite (AHe)

- Thermal sensitivity: 40° to 120°C
- **2 – 5 km depth**

Results:

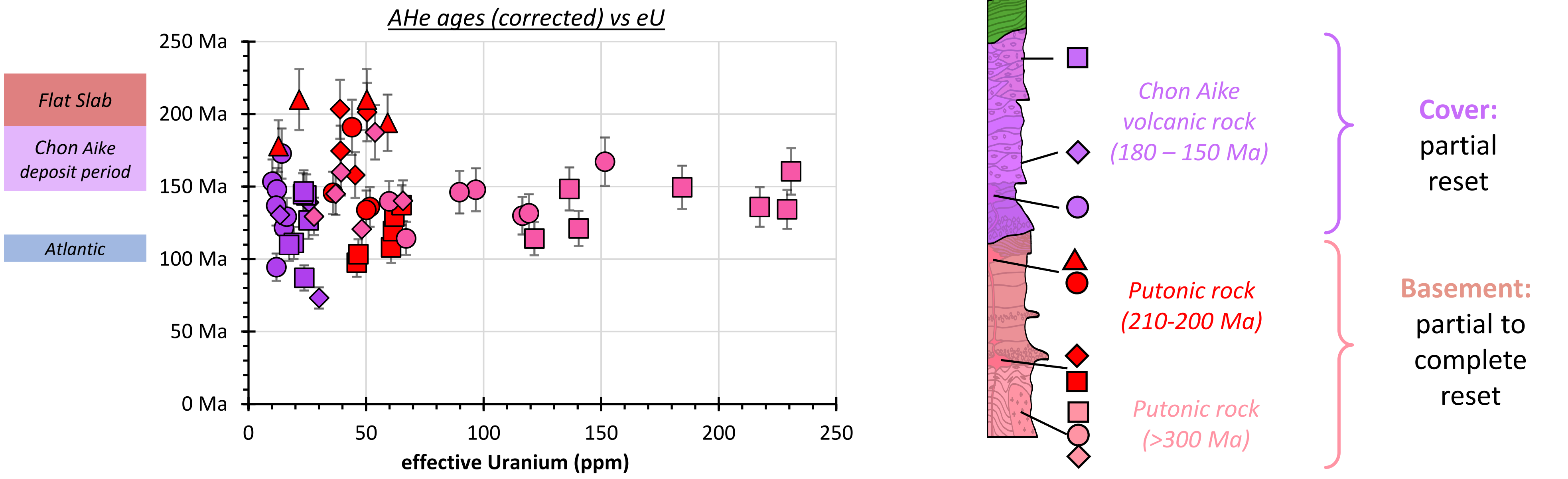
- **11 samples dated in AHe**
- 4 samples were dated in AFT by Fernandez et al. (2019) and were used during the modeling

Ages spread from a ~200 Ma to ~100 Ma, with a large range of eU

Thermal modeling:

- Thermal inversion using **QTQt** software (Gallagher, 2012)
- Apatite Helium diffusion using **Gerin** et al. (2017) model

(U-Th)/He on apatite results:



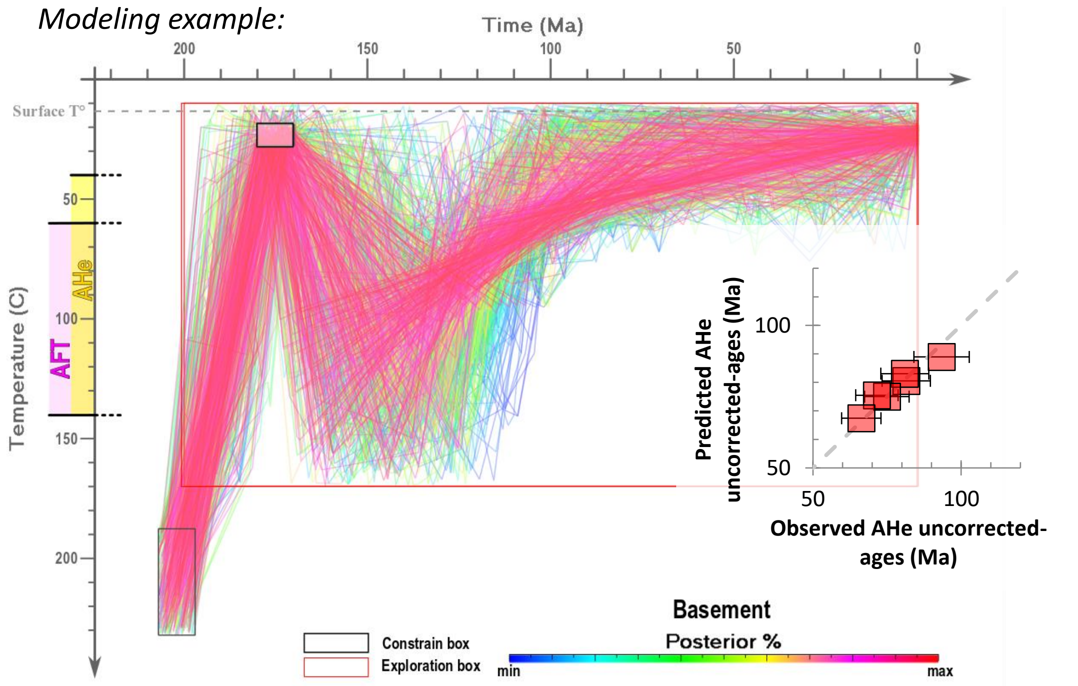
Modeling results:

- All samples show a clear **heating event,** up to ~100°-120°C, **before ~150 Ma**
- Followed by a **cooling up to 100 Ma**

This event could be interpreted as:

- **A burial and exhumation event**
- **A thermic event**, linked to the geodynamic setting/evolution

⇒ Necessity to **characterize the impact of the thermic event**



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Thermic Event ?

The Chon Aike LIP impact:

- LIP link to a mantle plume or a hydrated lithosphere fusion.

➡ **No significant gradient modification**

- surface hot deposit (rhyolite/ignimbrite)

➡ **Only a local effect**

Interpretation:

The impact of the Chon Aike thermal event is negligible regarding to the heating recorded.

Chon Aike SLIP could produced two potential thermal impacts:

- **Geothermal gradient increased**, linked to the plume arrival/life or lithosphere fusion.

Tested by 1D lithospheric model:
No significant impact on the geothermal gradient
(< 20°C increase in shallow surface)

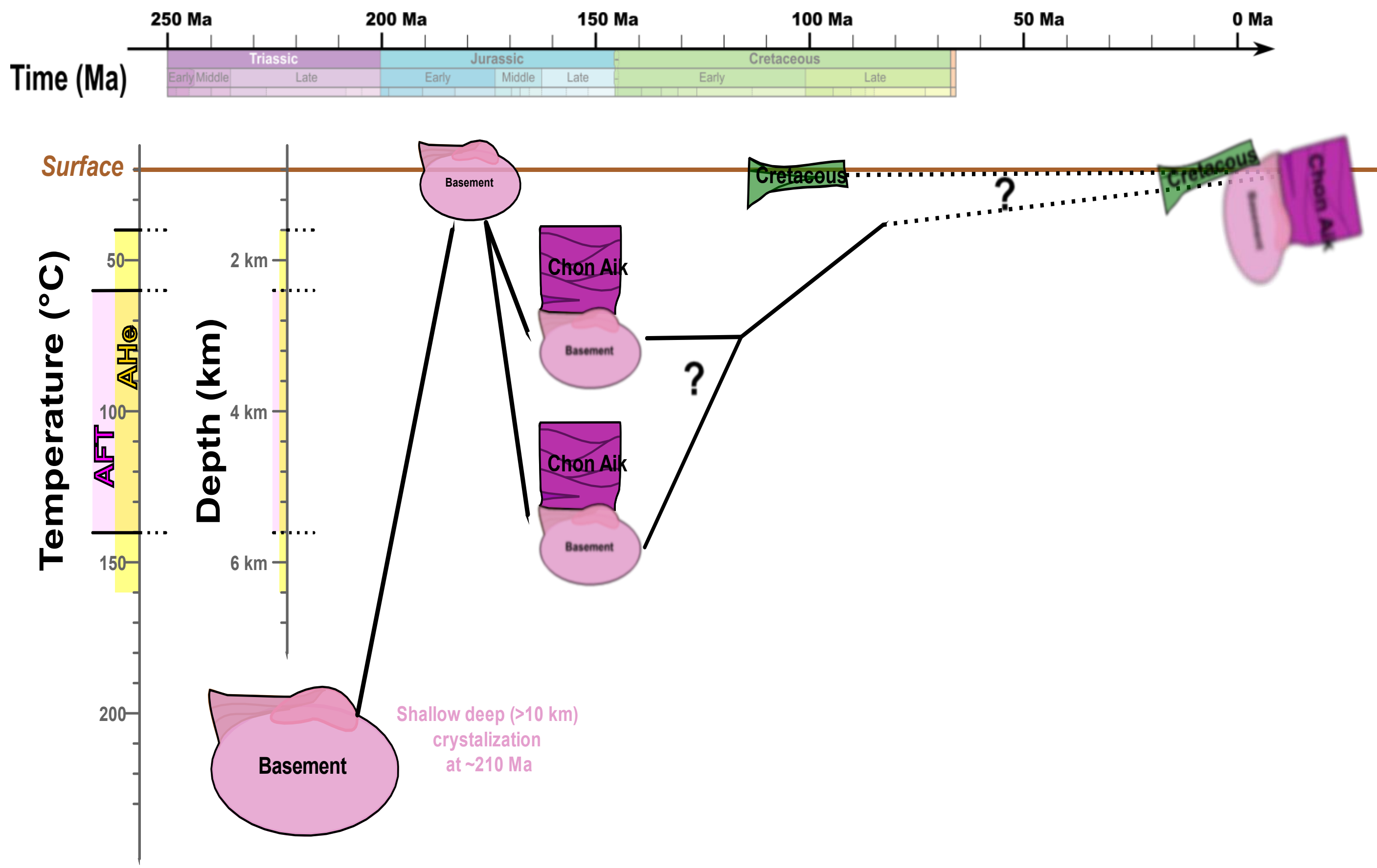
- Basement heating by **hot deposit emplacements**

Tested by 1D surface model:
Short-term event (< 2 Ma),
with a local impact (~200m deep)

Surface evolution:

- *~205 to ~195 Ma:* **first exhumation, of ~10 km,** put the basement in surface.
- *~170 to ~150 Ma:* the basement was buried **under 3 to 5 km** of deposits, probably the Chon Aike formation
- *~150 to 100 Ma:* the basement last exhumation

What mechanism triggered this surface evolution?



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Burial/exhumation origin ?

The early Mesozoic exhumation:

This exhumation was **produced by the flat slab emplacement** between 220 Ma and 200 Ma.

The Jurassic burial – Chon Aike event:

- ~50 Ma duration,
- **deposits and conservation of 3 to 5 km of material**
- the **Deseado Massif/Chon Aike event position** through time

The Cretaceous exhumation:

- ~50 Ma duration
- structurally asymmetric

So, this J-K surface evolution, far from any plate border, was controlled by two large scale phenomenon:

- **the plate strain/stress propagation**, triggered by the flat slab retreat and Atlantic opening
- **the crustal equilibration** and evolution, triggered by the mantle dynamics and lithosphere fusion

The burial and exhumation can be linked to:

1) Plate strain/stress propagation *(Plate model)*

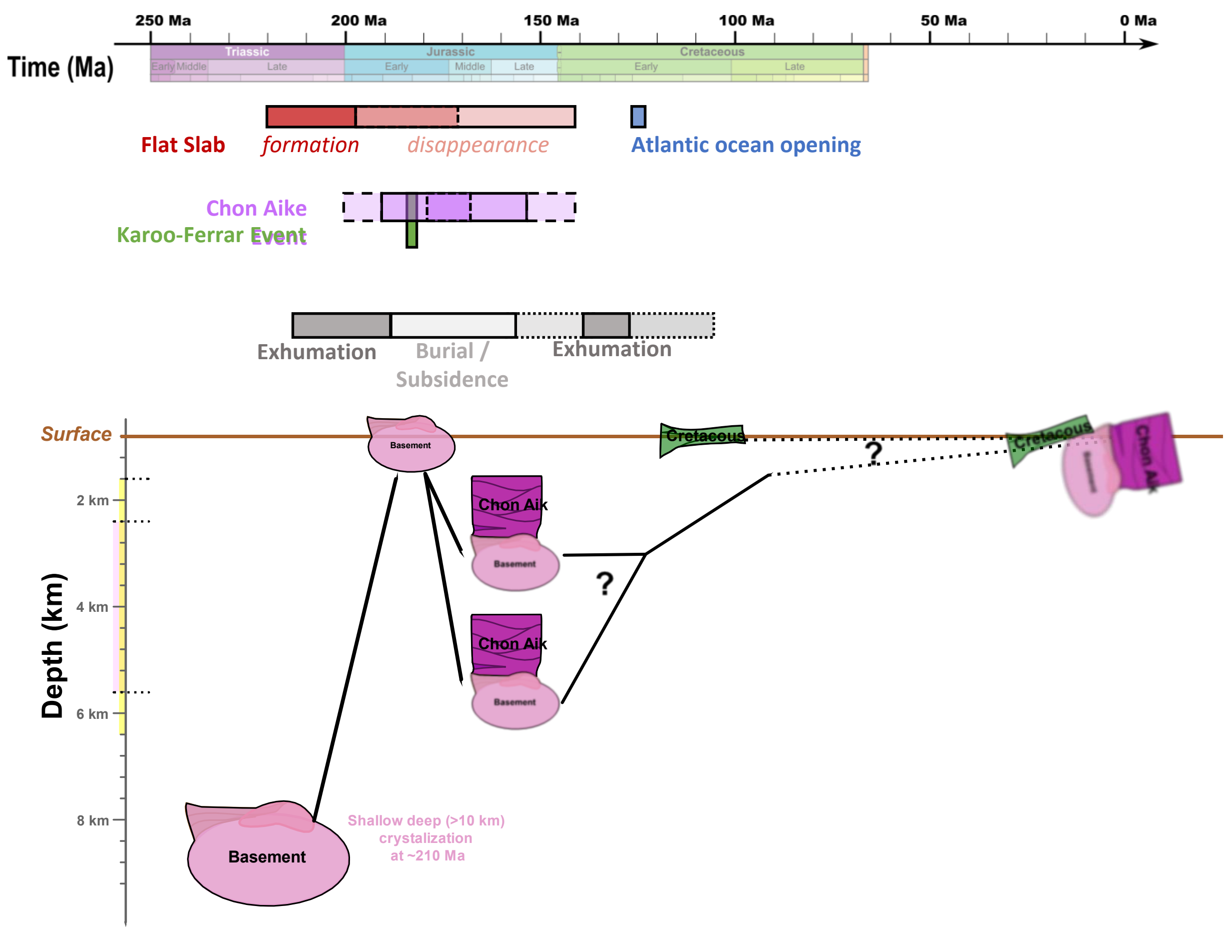
Arguments :

- Consistent with a **Jurassic extensional event**, produced by **the slab retreat**
- Consistent with a **Cretaceous compressional event**, produced by the **Atlantic opening**

2) Crust equilibration *(Plume model)*

Arguments :

- Consistent with the **Jurassic magmatic evolution**
- Could correspond to a **dynamic topography/isostatic equilibration response to the slab evolution and failure ?**



Conclusion:

- the **Patagonian Foreland** was **not completely stable** during the **Mesozoic** (3 to 5 km burial and exhumation).
- Its Mesozoic **surface evolution** was **controlled by large scale phenomenon.**
- Those results could be used, in the future, as **surface evolution constrains to improve the understanding of these phenomenon, here the exact mantle evolution** during and after the Chon Aike event.

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References

Thanks for your attention,

I hope the presentation was clear,
if you have any questions, feedback and comments, I'm in the chat room to answer or clarify!

Conclusion:

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- Its Mesozoic **surface evolution** was **controlled by large scale phenomenon.**
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Thank you for your attention !

Geology:

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