Post-Variscan Vertical Movements in Morocco: Implications for Mesozoic Source-to-Sink Systems*

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Abstract

The post-Variscan history of Morocco is characterized by six major geological events. Four long known events were recognized from the rock records: the Variscan Peneplain prior to the Mesozoic, the break-up of Pangaea in Triassic to Jurassic times, the African and European plate convergence starting in the Late Cretaceous, and the Atlas rift system inversion. Two, however, were recently evidenced by low-temperature geochronology and time-temperature (t-T) modeling studies: a post-Triassic rift and pre-Atlas orogenesis km-scale exhumation and subsidence. The exhumation is responsible for the settlement of major source-to-sink systems throughout the Mesozoic in Morocco, which varied in terms of timing from north to south along the Atlantic margin. These sedimentary systems are yet to be constrained. Our works comprise new Apatite Fission tracks, (U-Th)/He dating, t-T modeling (HeFTy and PECUBE), and thorough analyses of sedimentary data and geometry from field works, published outcrop and well logs, and remote sensing observation.

In the Meseta and the Western High Atlas, which is called Western Moroccan Arch during the Mesozoic (WMA), t-T modeling showed that the presently outcropping basement rocks underwent Jurassic to Lower Cretaceous exhumation. The Anti-Atlas thermal history, suggested by our modeling results, is characterized by an Late Triassic to Dogger exhumation. Previous works show different results, as they do not consider fission tracks and (U-Th)/He dating for t-T modeling; neither the petrographic evidences from the Central Atlantic Magmatic Province related dikes, which suggesting that the outcropping rocks were at ca. 8 km in depth at 200 Ma. In the south, the Reguibat Shield post-Triassic rift exhumation starts in the Late Triassic and ends in the Early Cretaceous. After these exhumation phases, the above-mentioned areas are characterized by a mild subsidence.

The differences of exhumation timing directly influenced the location of source areas east of the Atlantic basins. Indeed during the Early Jurassic, the Reguibat Shield and the Anti-Atlas were sourcing sediments to the west and to the north, as the WMA was undergoing subsidence. During the Early Cretaceous, however, the Anti-Atlas had stop going up, while the WMA was being exhumed. Source areas were then the WMA and the Reguibat Shield, suggesting that the Anti-Atlas was completely to partially covered by Lower Cretaceous sediments.

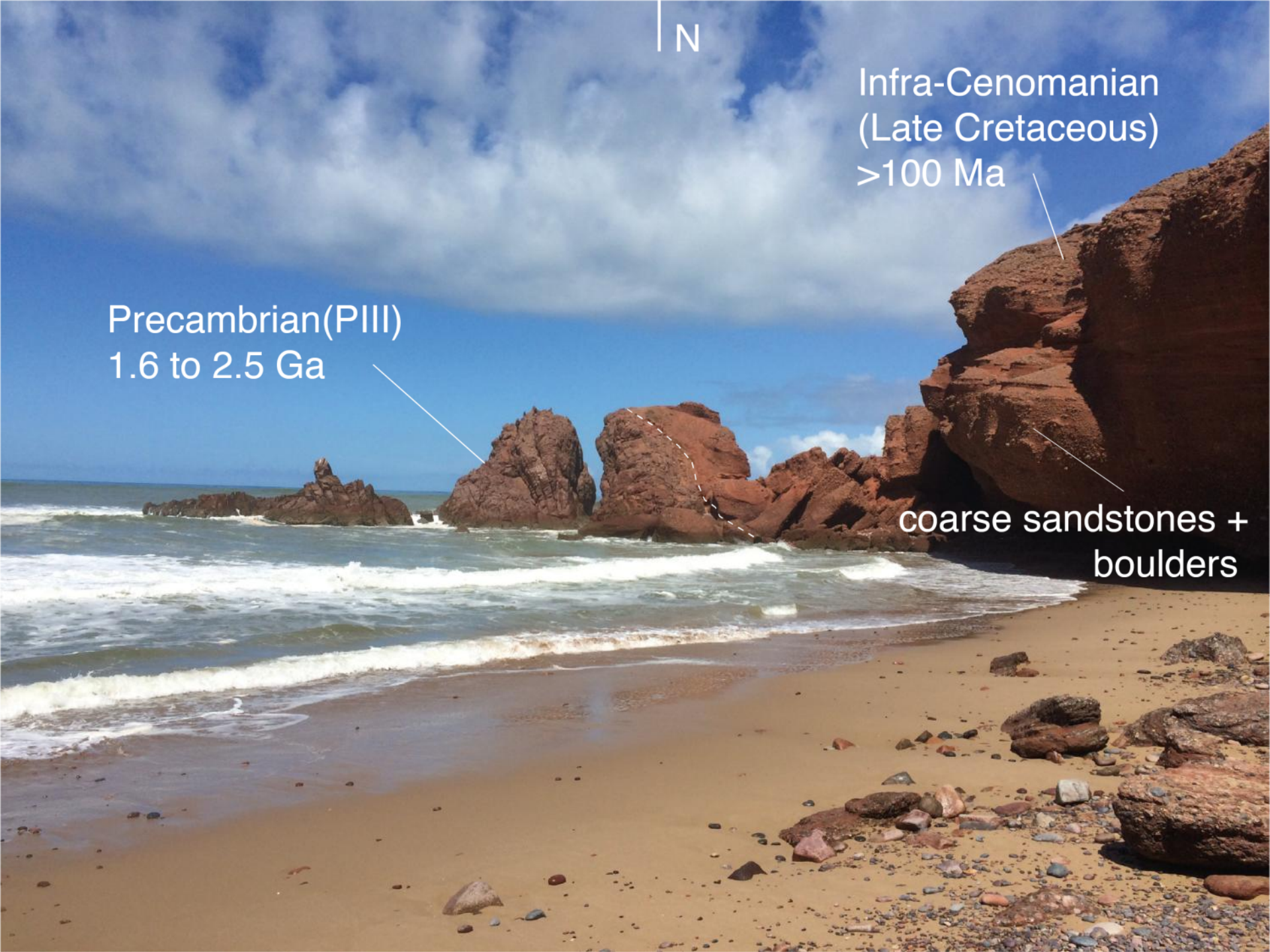
References Cited

Ali, S., K. Stattegger, D. Garbe-Schönberg, M. Frank, S. Kraft, and W. Kuhnt, 2014, The provenance of Cretaceous to Quaternary sediments in the Tarfaya basin, SW Morocco: Evidence from trace element geochemistry and radiogenic Nd–Sr isotopes: Journal of African Earth Sciences, v. 90, p. 64–76.

Ghorbal, B., G. Bertotti, J. Foeken, and p. Andriessen, 2008, Unexpected vertical Jurassic to Neogene movements in “stable” parts of NW Africa revealed by low temperature geochronology: Terra Nova, v. 20, p.355–363.

Leprêtre, R., Y. Missenard, J. Barbarand, C. Gautheron, O. Saddiqi,and R. Pinna-Jamme, 2015, Postrift history of the eastern central Atlantic passive margin: Insights from the Saharan region of South Morocco: Journal of Geophysical Research, Solid Earth, v. 120/6, p. 4645-4666.

Oukassou, M., O. Saddiqi, J. Barbarand, S. Sebti, L. Baidder, and A. Michard, 2013, Post-Variscan exhumation of the Central Anti-Atlas (Morocco) constrained by zircon and apatite fission-track thermochronology: Terra Nova, v. 25, p. 151-159. Website accessed March 12, 2017, https://www.researchgate.net/publication/258509711_Post-Variscan_exhumation_of_the_Central_Anti-Atlas_Morocco_constrained_by_zircon_and_apatite_fission-track_thermochronology.


N
Infra-Cenomanian
(Late Cretaceous)
>100 Ma
Precambrian(PIII)
1.6 to 2.5 Ga
coarse sandstones +
boulders

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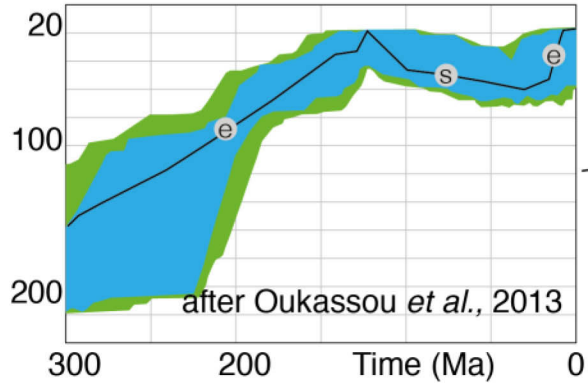
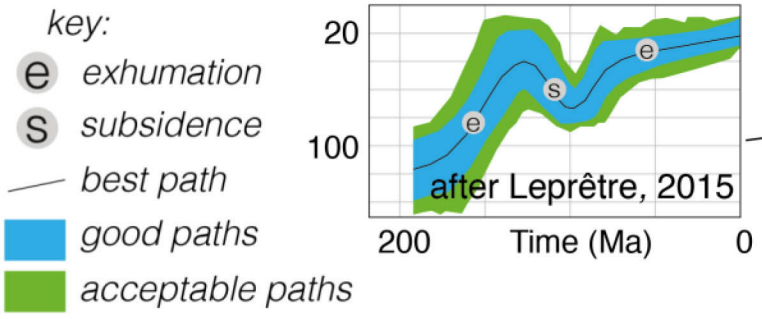
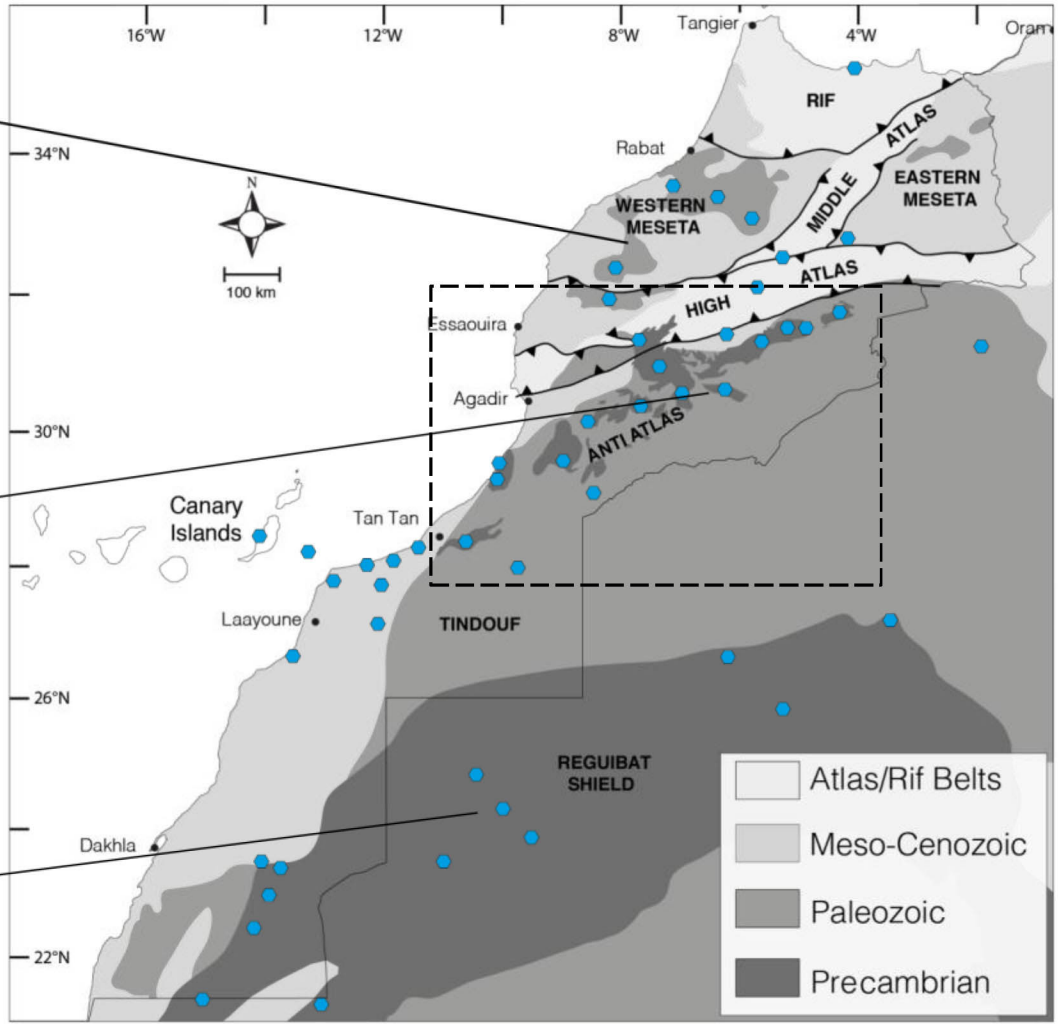
The ‘not-so-passive’ margin of Morocco







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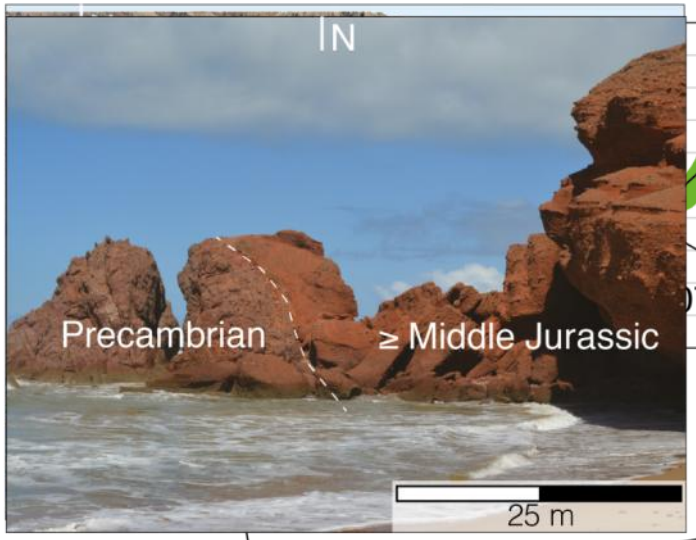
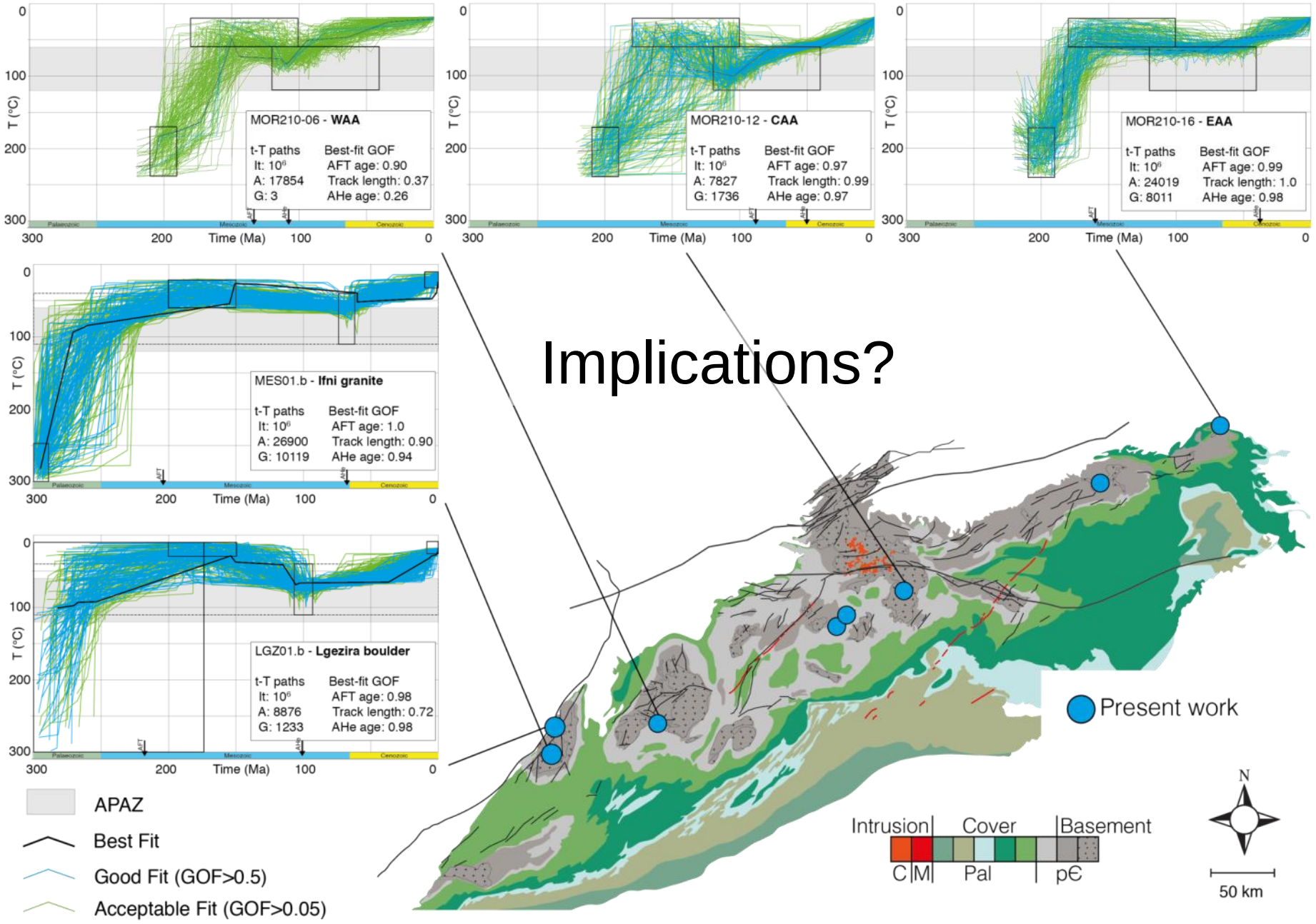
Anti-Atlas



Simplified from the geological map (1985)


MOR210-06 - WAA
t-T paths
It: 10⁶
A: 17854
G: 3
Best-fit GOF
AFT age: 0.90
Track length: 0.37
AHe age: 0.26
MOR210-12 - CAA
t-T paths
It: 10⁶
A: 7827
G: 1736
Best-fit GOF
AFT age: 0.97
Track length: 0.99
AHe age: 0.97
MOR210-16 - EAA
t-T paths
It: 10⁶
A: 24019
G: 8011
Best-fit GOF
AFT age: 0.99
Track length: 1.0
AHe age: 0.98
MES01.b - Ifni granite
t-T paths
It: 10⁶
A: 26900
G: 10119
Best-fit GOF
AFT age: 1.0
Track length: 0.90
AHe age: 0.94
LGZ01.b - Lgezira boulder
t-T paths
It: 10⁶
A: 8876
G: 1233
Best-fit GOF
AFT age: 0.98
Track length: 0.72
AHe age: 0.98
T (°C)
Time (Ma)
Palaeozoic
Mesozoic
Cenozoic
APAZ
Best Fit
Good Fit (GOF>0.5)
Acceptable Fit (GOF>0.05)
Implications?
Present work
Intrusion
Cover
Basement
C
M
Pal
pЄ
N
50 km

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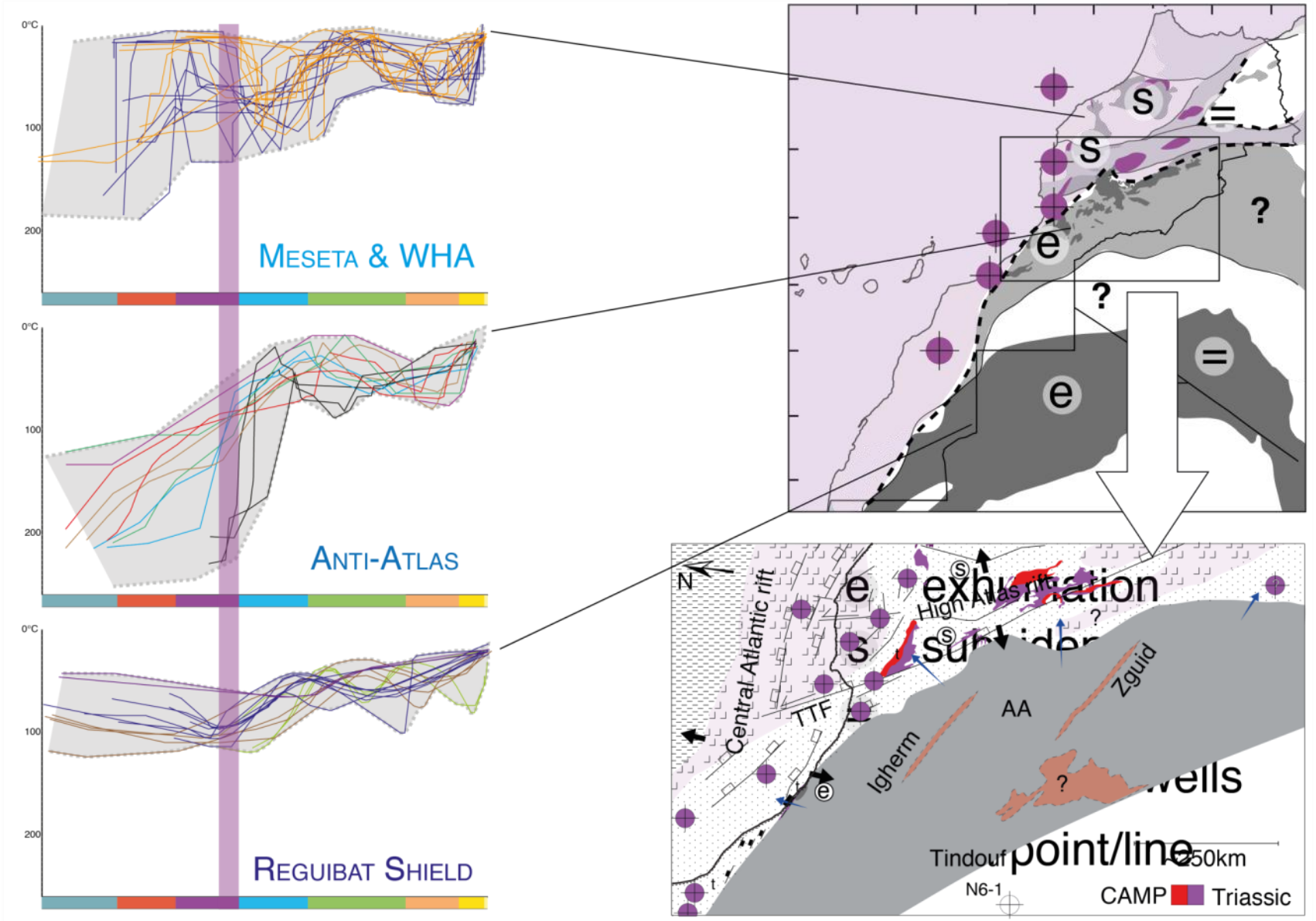
Late Triassic



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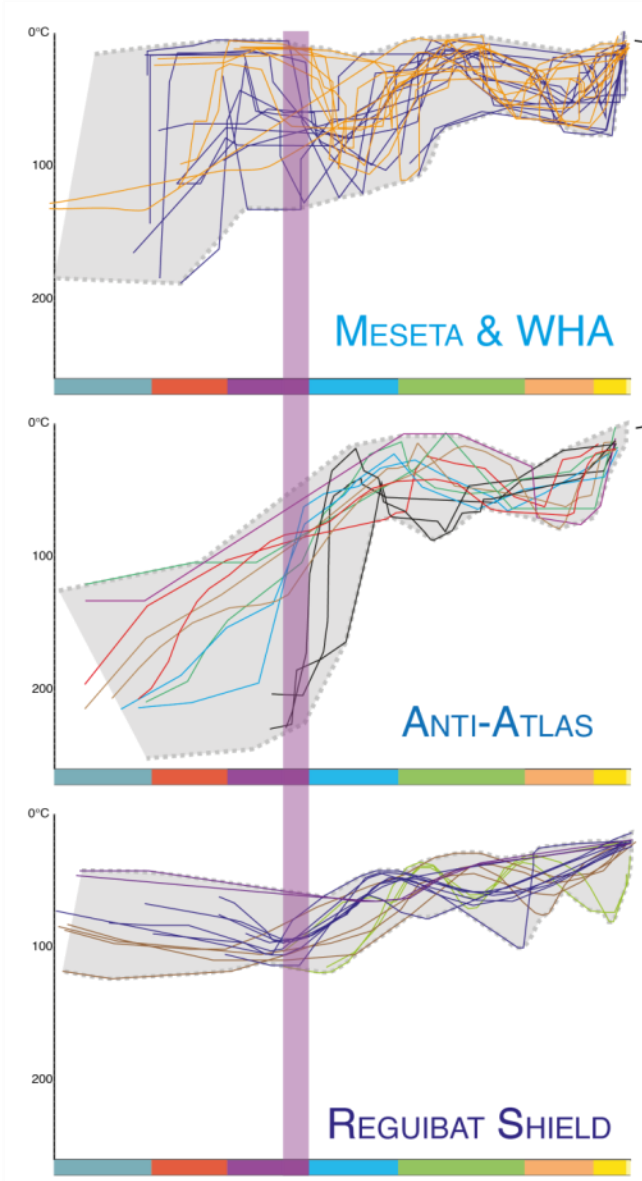
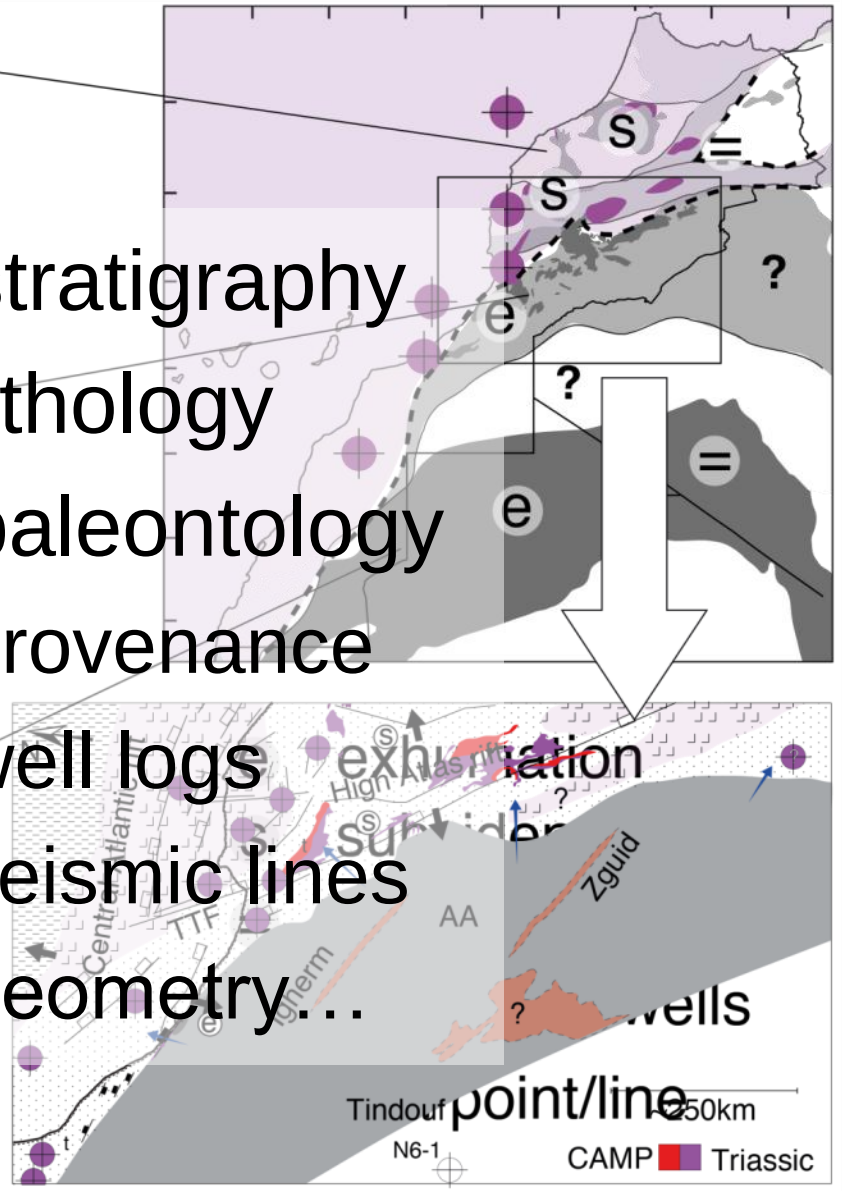
Late Triassic



+ stratigraphy
+ lithology
+ paleontology
+ provenance
+ well logs
+ seismic lines
+ geometry…



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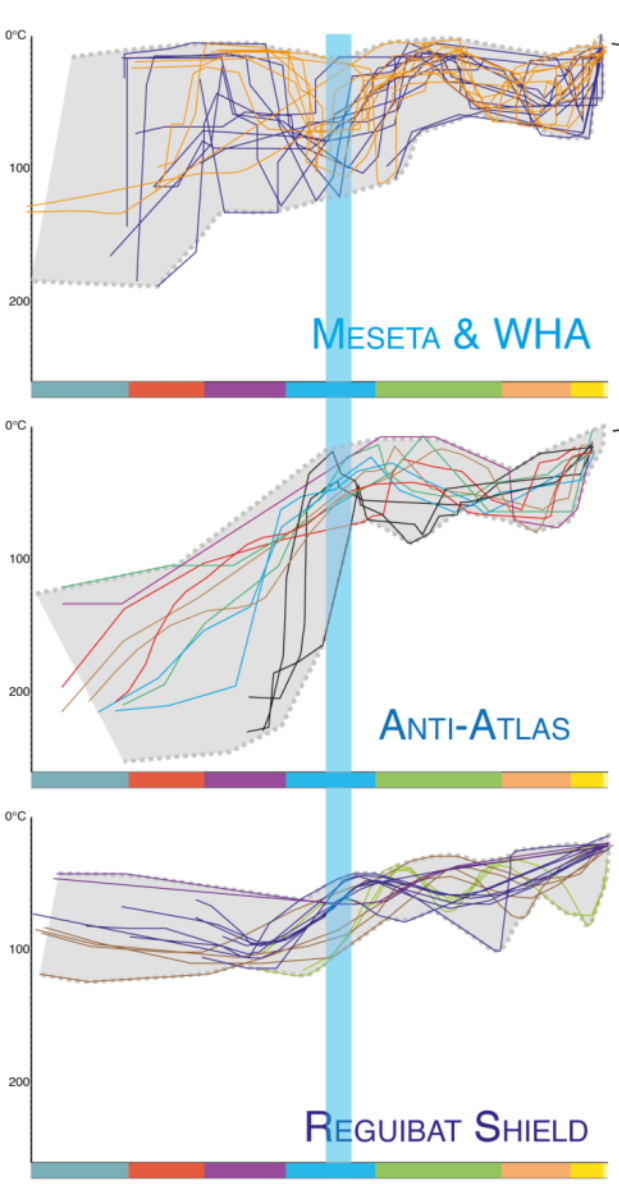
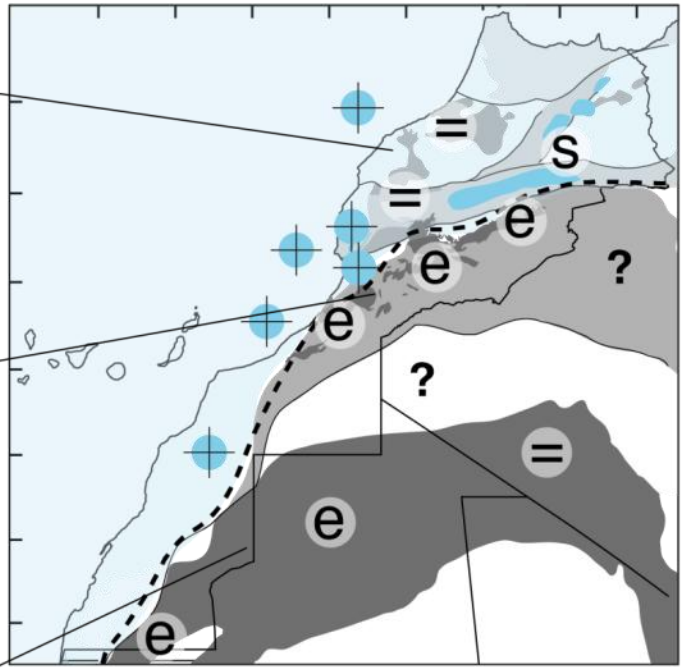
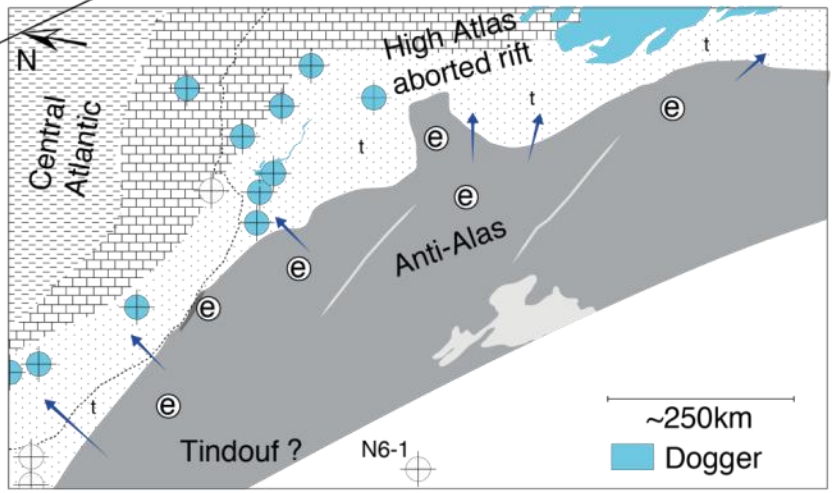
Middle Jurassic







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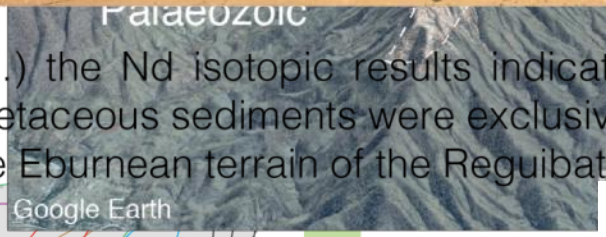
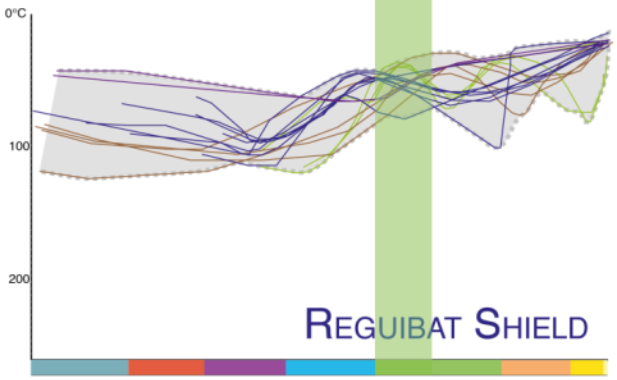
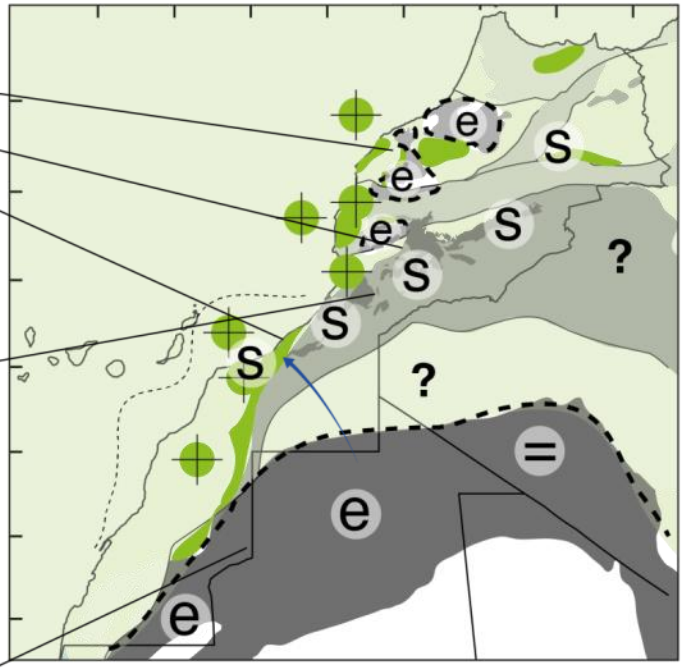
early Early Cretaceous

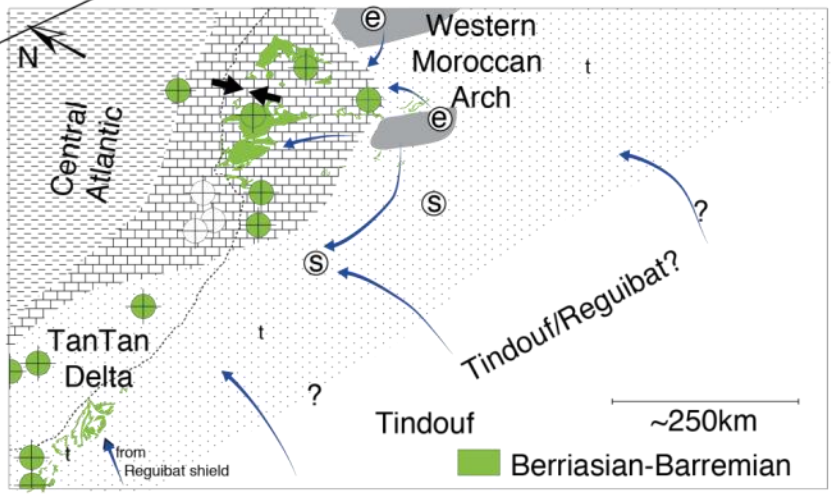


'(…) the Nd isotopic results indicate that the Early Cretaceous sediments were exclusively derived from the Eburnean terrain of the Reguibat Shield.'

Ali *et al.*, 2014







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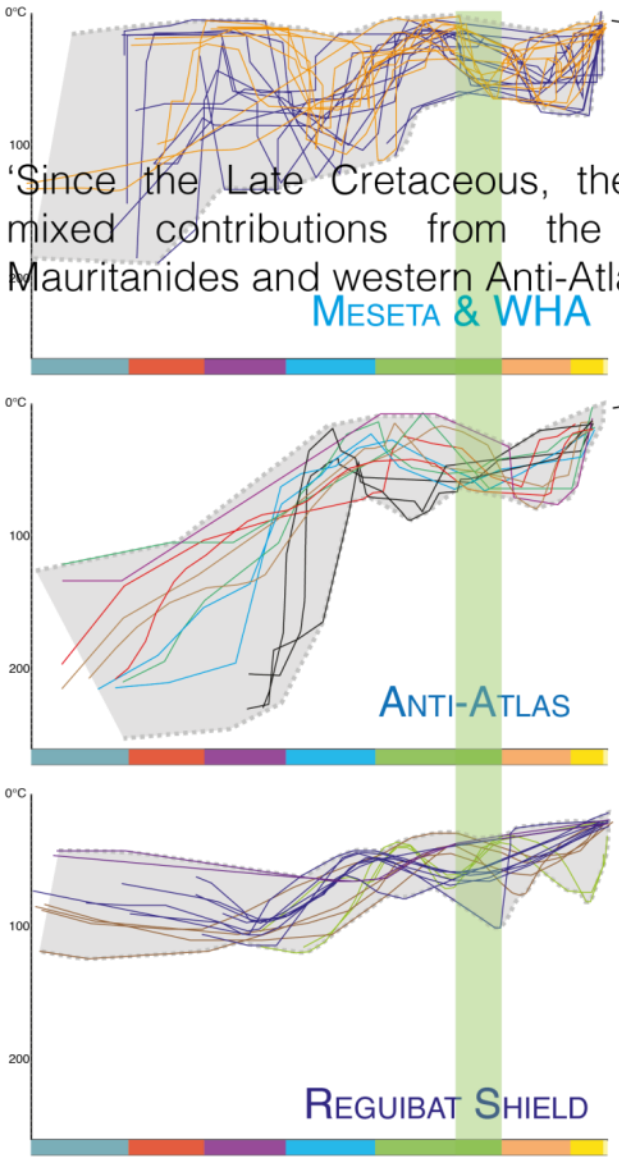
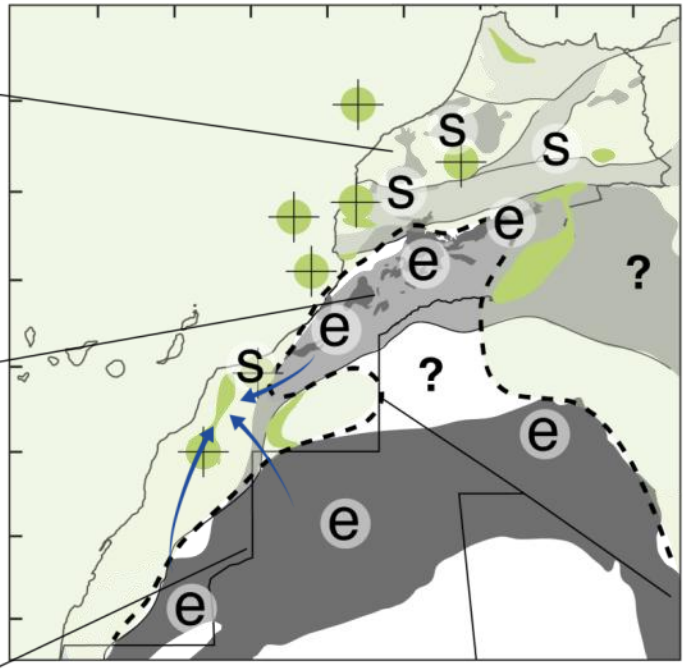
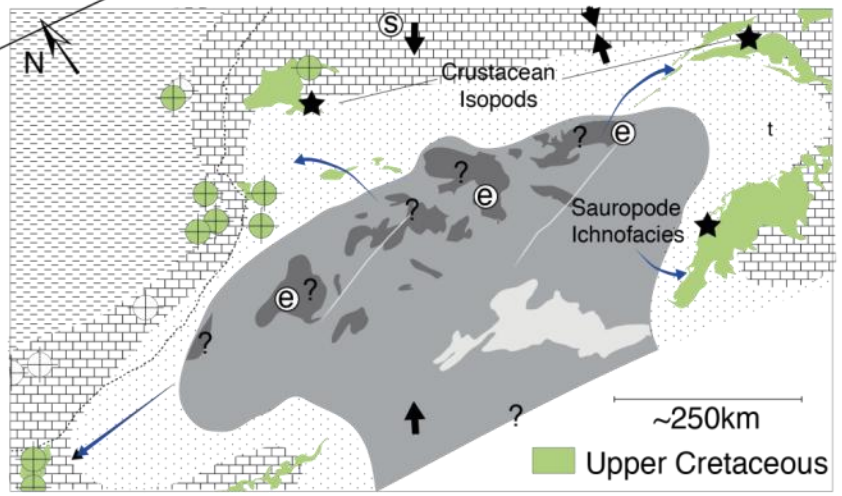
Late Cretaceous



'Since the Late Cretaceous, the sediments show mixed contributions from the Reguibat Shield, Mauritanides and western Anti-Atlas.'

Ali *et al.*, 2014





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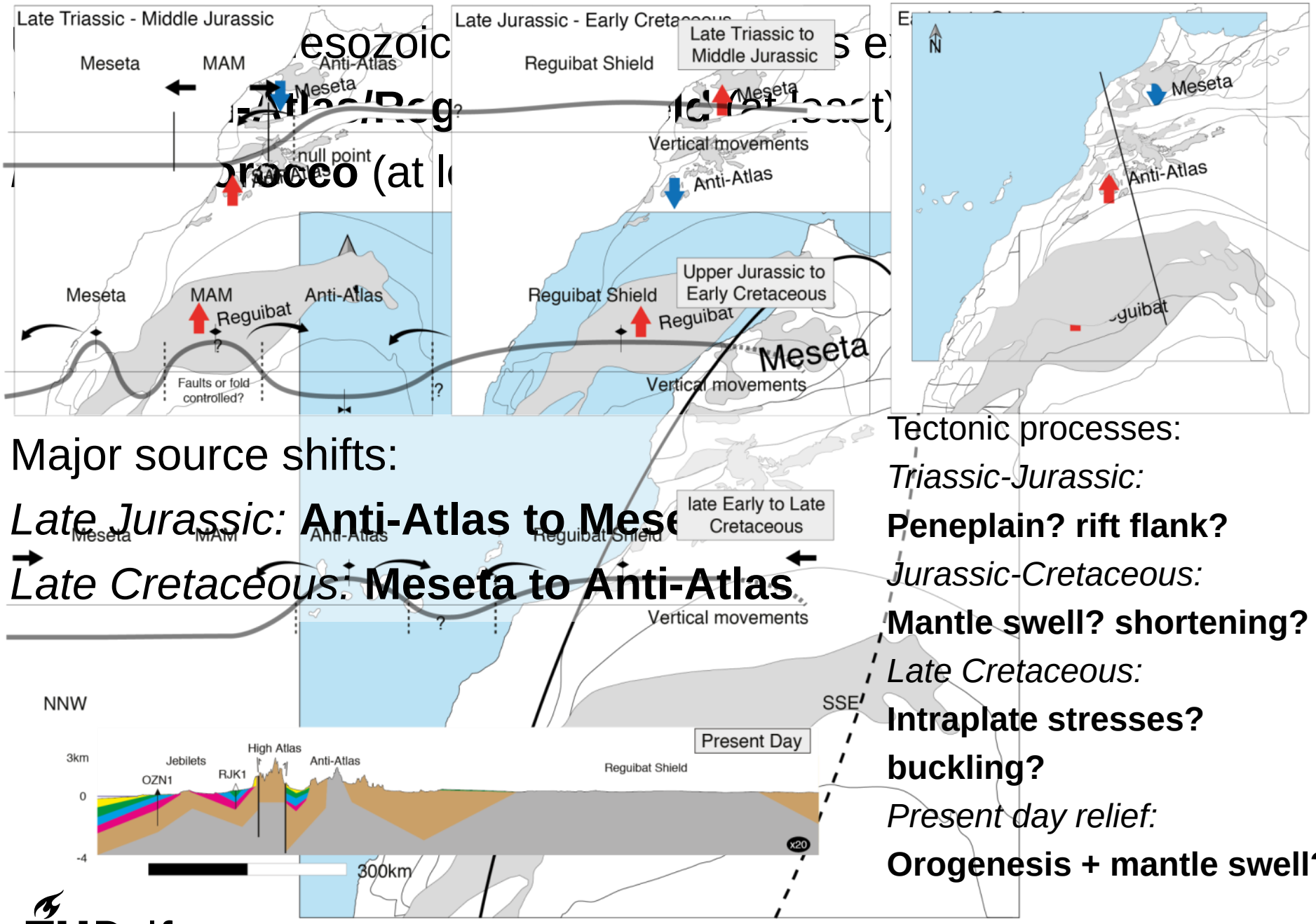

esozoic

-Atlas/Reg

oracco (at l

ld (at least)

Major source shifts:

Late Jurassic: **Anti-Atlas to Mese**

Late Cretaceous: **Meseta to Anti-Atlas**

Tectonic processes:

Triassic-Jurassic:

Peneplain? rift flank?

Jurassic-Cretaceous:

Mantle swell? shortening?

Late Cretaceous:

Intraplate stresses? buckling?

Present day relief:

Orogenesis + mantle swell?

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Questions?
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