MANCHESTER 1824

North Africa Research Group

Integrated source to sink analysis of NW Africa :

Provenance of the Mesozoic sandstones of the EAB

Sponsors meeting
14-feb-19

Emmanuel **Roquette**, 3rd year PhD student

Essaouira Agadir Basin (EAB)

The provenance paradox

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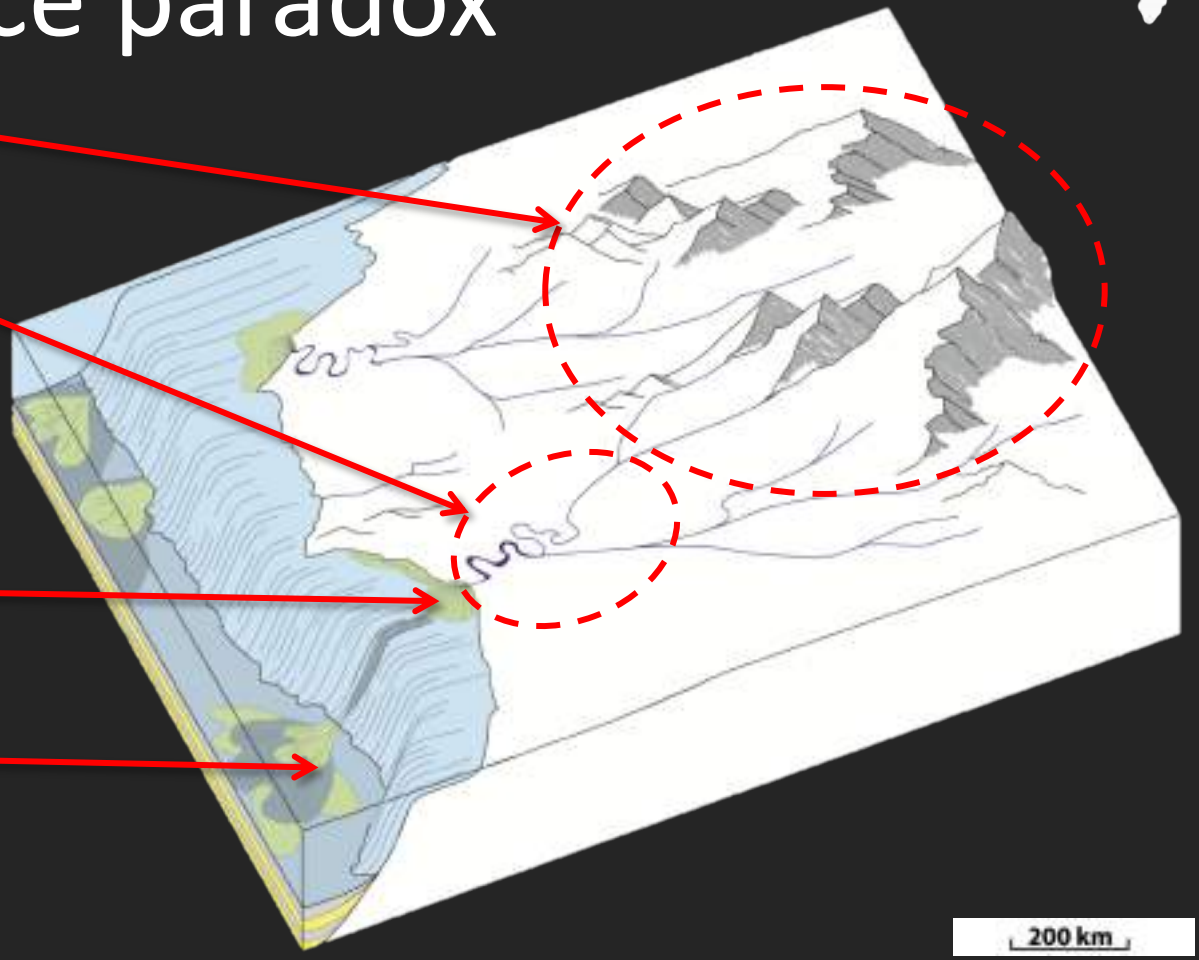

Provenance model

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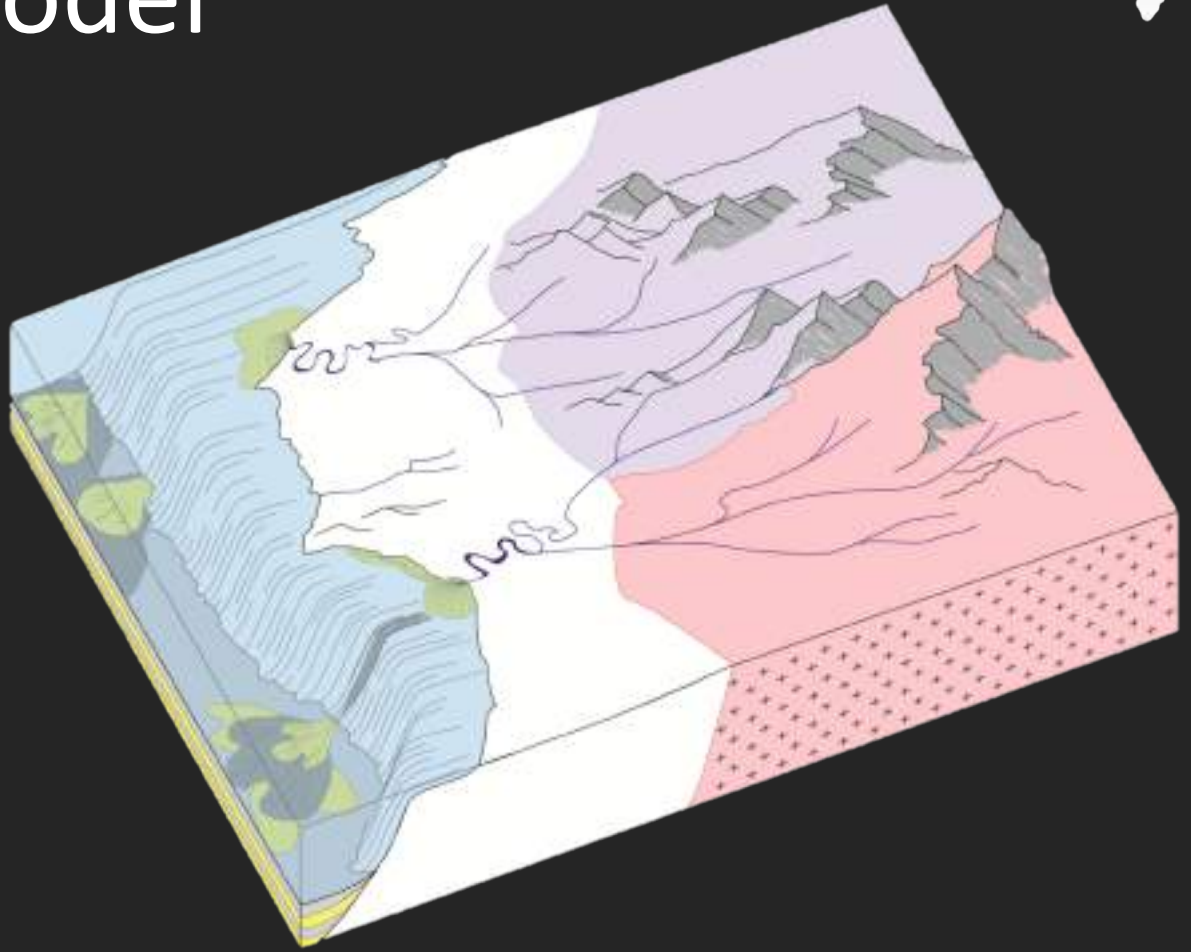
Studied system at

t=0



Provenance model

North Africa Research Group

Studied system at

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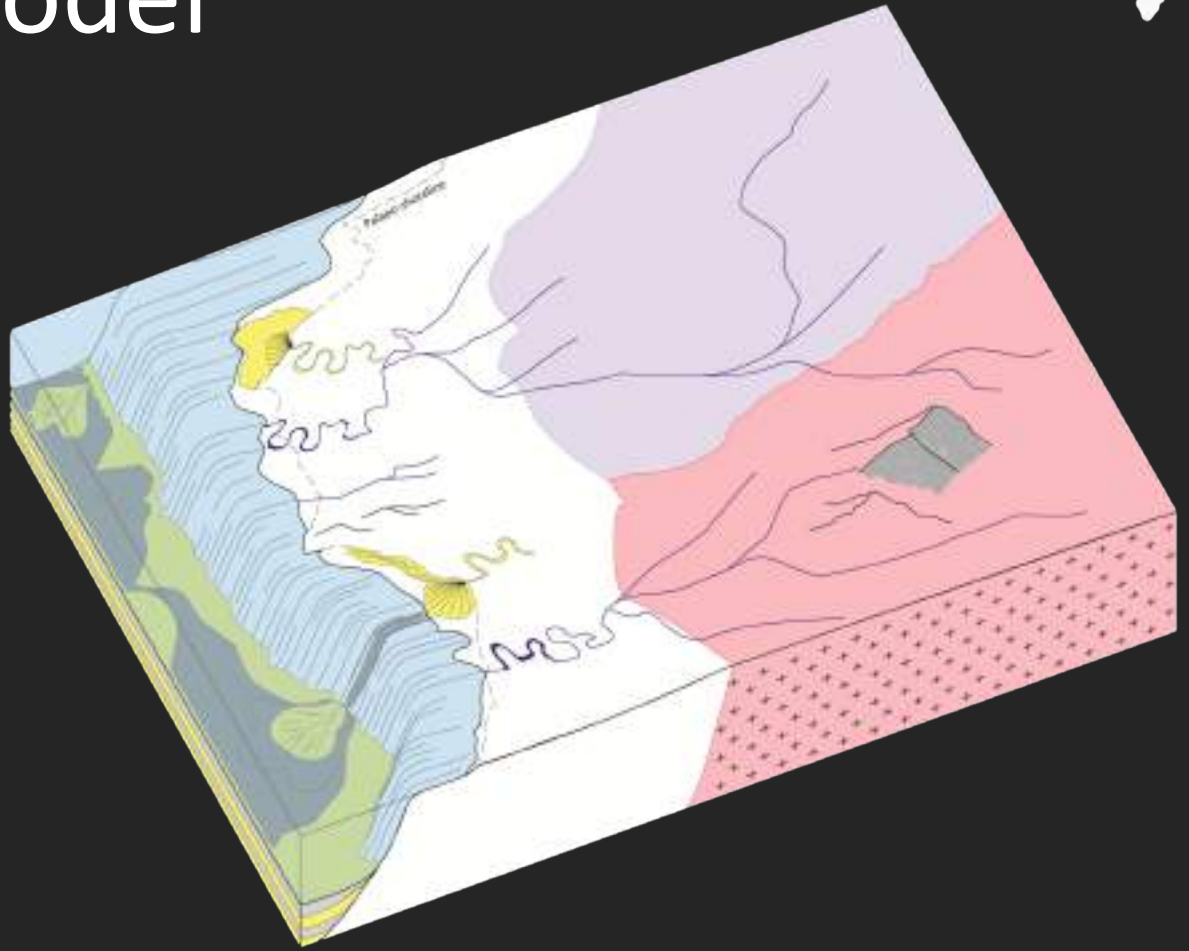
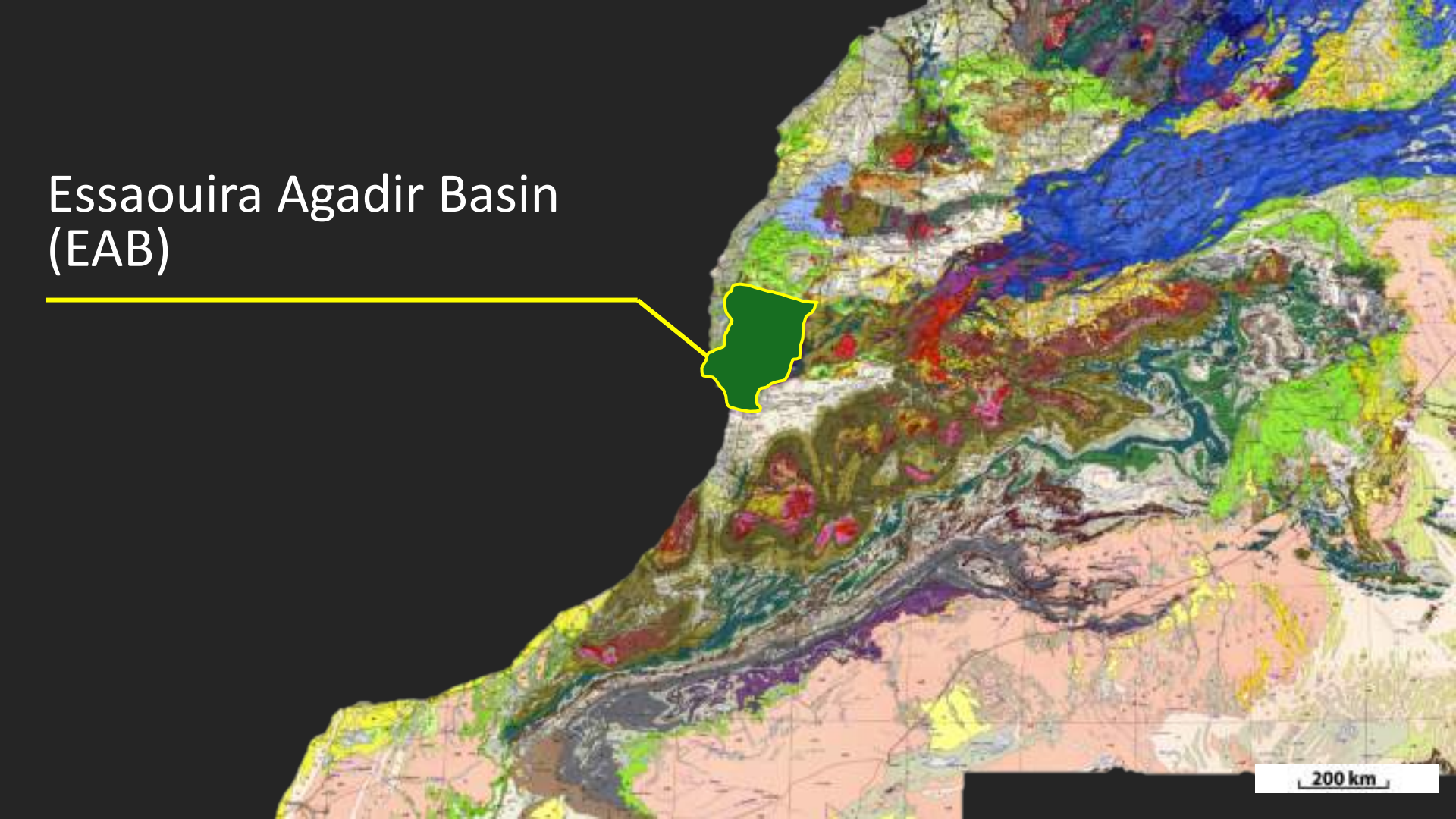


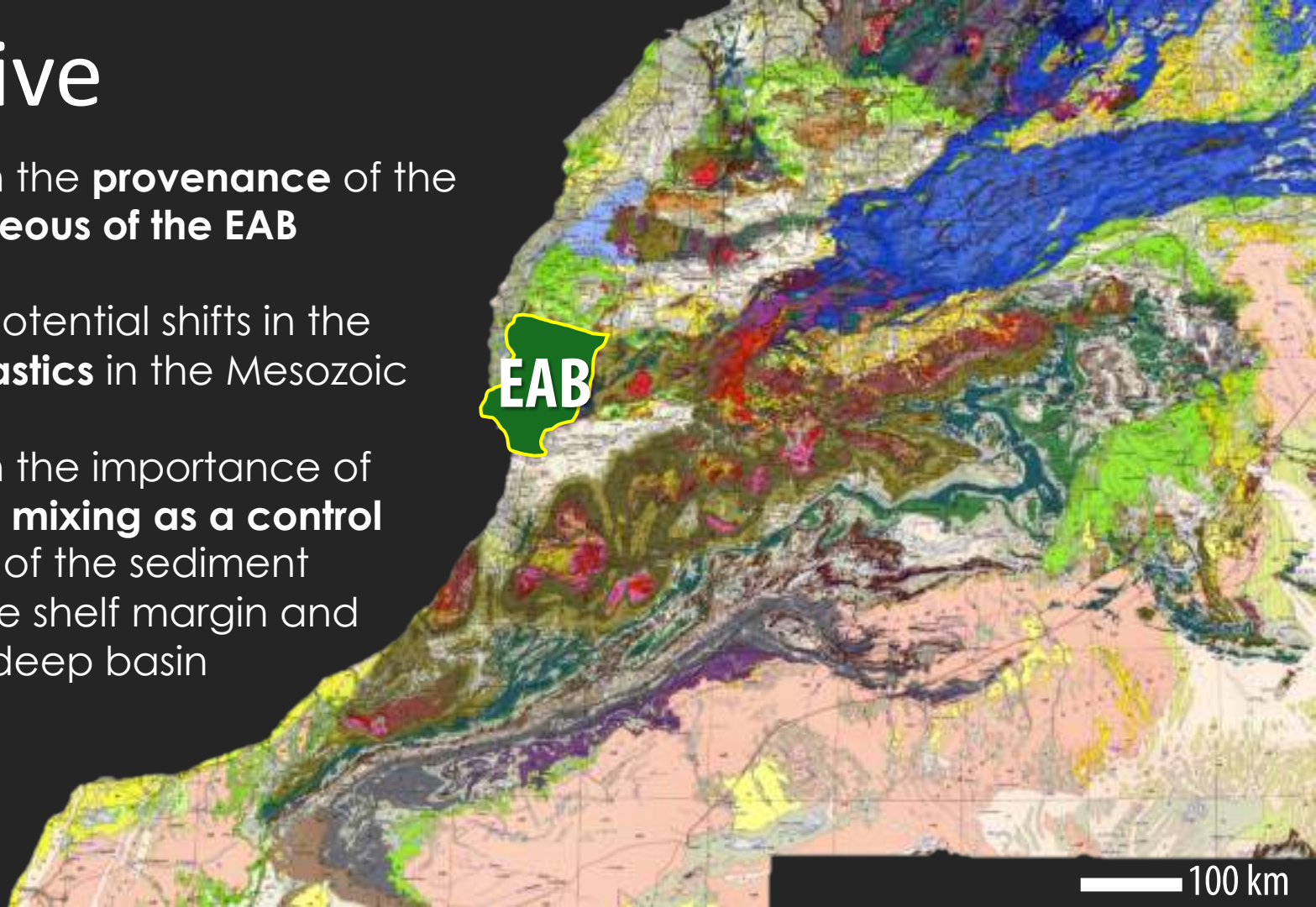

Essaouira Agadir Basin
(EAB)
200 km

Objective

- Constrain the **provenance** of the **Lower Cretaceous of the EAB**

- Identify potential shifts in the **sources** of **clastics** in the Mesozoic

- Constrain the importance of **transport** and **mixing as a control on character** of the sediment brought to the shelf margin and delivered to deep basin



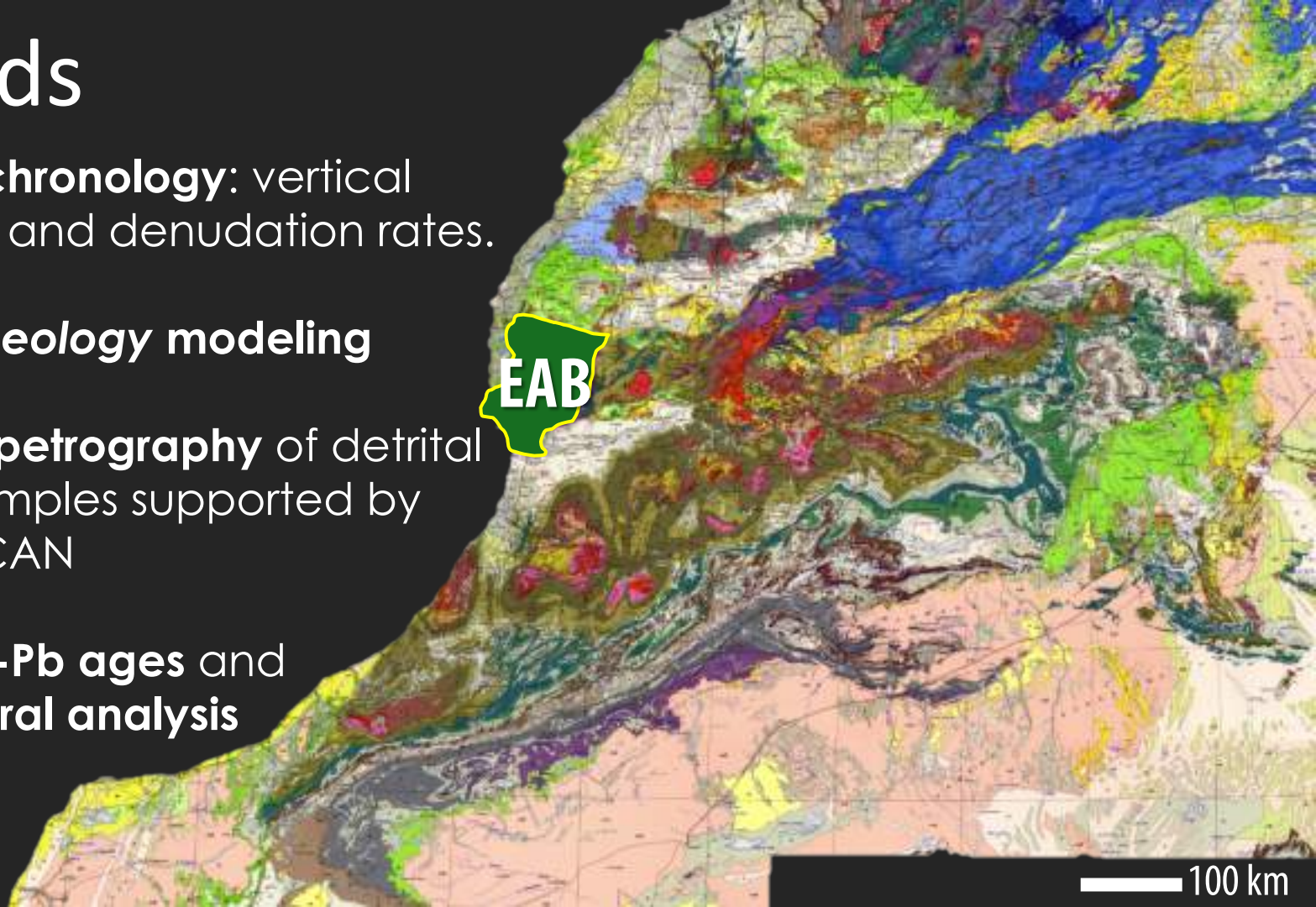
Methods

- **Thermochronology**: vertical movements and denudation rates.

- ***Palaeogeology* modeling**

- **Optical petrography** of detrital & source samples supported by SEM/QEMSCAN

- **Zircon U-Pb ages** and **Heavy mineral analysis**



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Tectonostratigraphic Framework

Mesozoic evolution of the EAB

I – Tectonostratigraphic Framework

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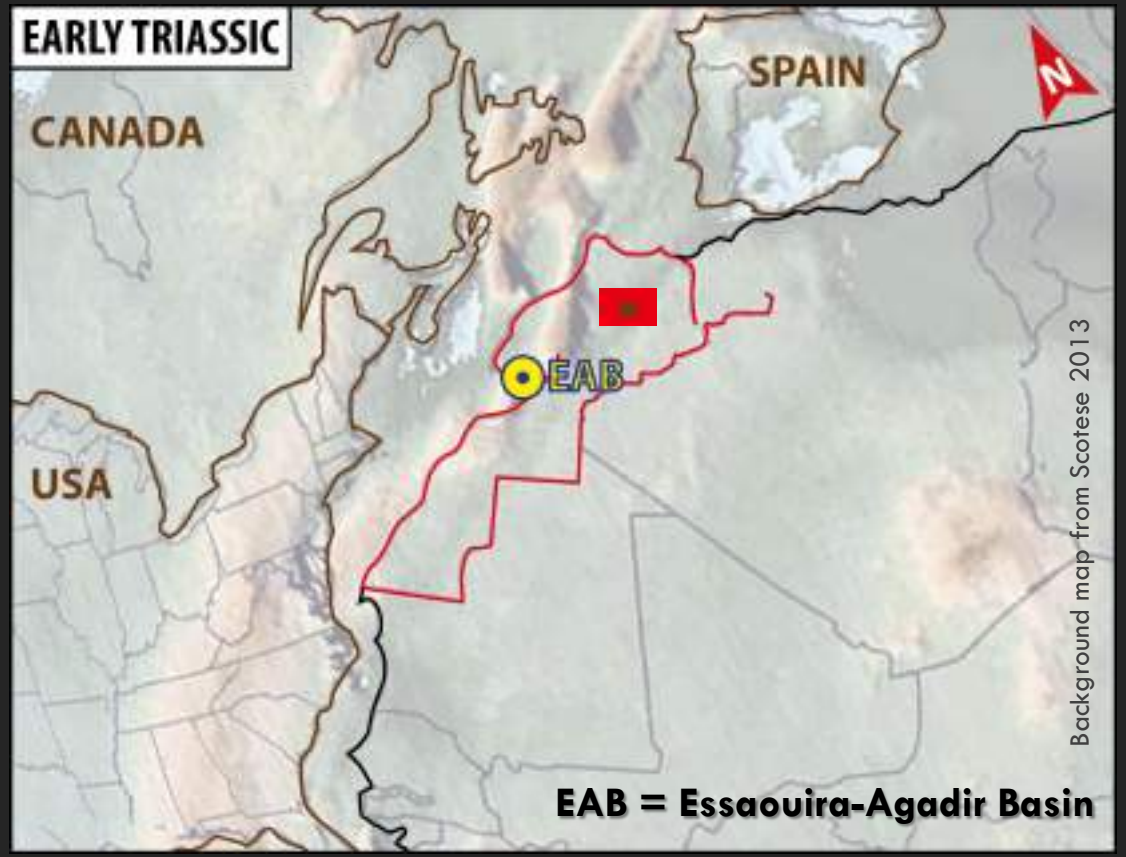

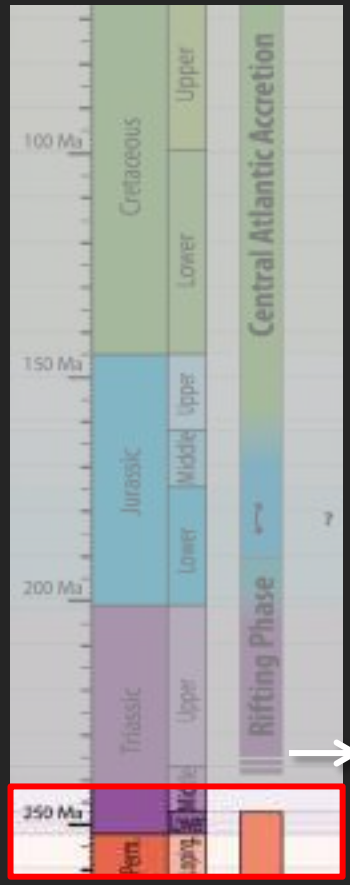

→ Rifting onset

Latest Hercynian magmatic events in Morocco

I – Tectonostratigraphic Framework

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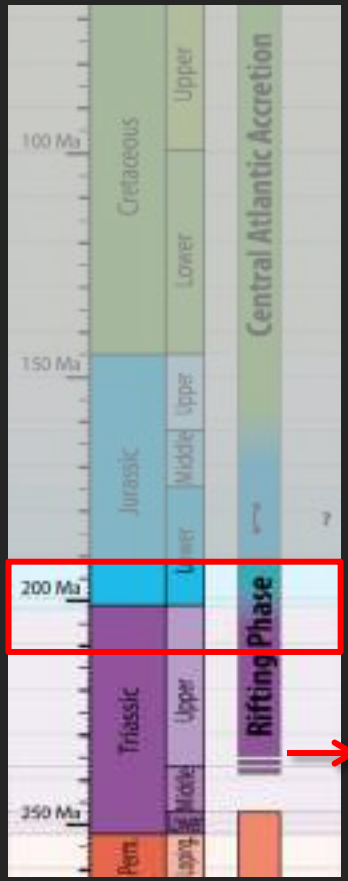

Earliest oceanic crust

Rifting climax

Rifting onset

Latest Hercynian magmatic events in Morocco

I – Tectonostratigraphic Framework

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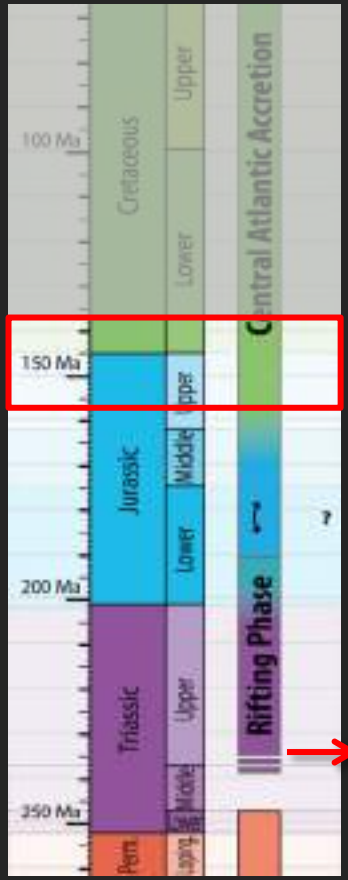

Earliest oceanic crust

Rifting climax

Rifting onset

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I – Tectonostratigraphic Framework

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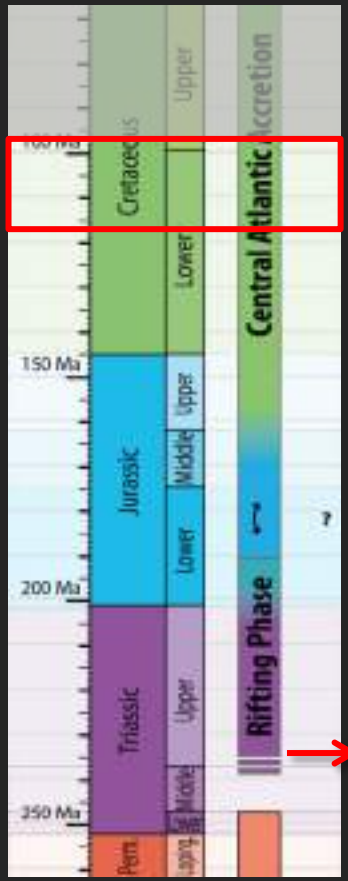

Mud dominated **shelfal** succession truncated by **shoreface** to **fluvial** sandstones.

Earliest oceanic crust

Rifting climax

Rifting onset

Latest Hercynian magmatic events in Morocco

I – Tectonostratigraphic Framework

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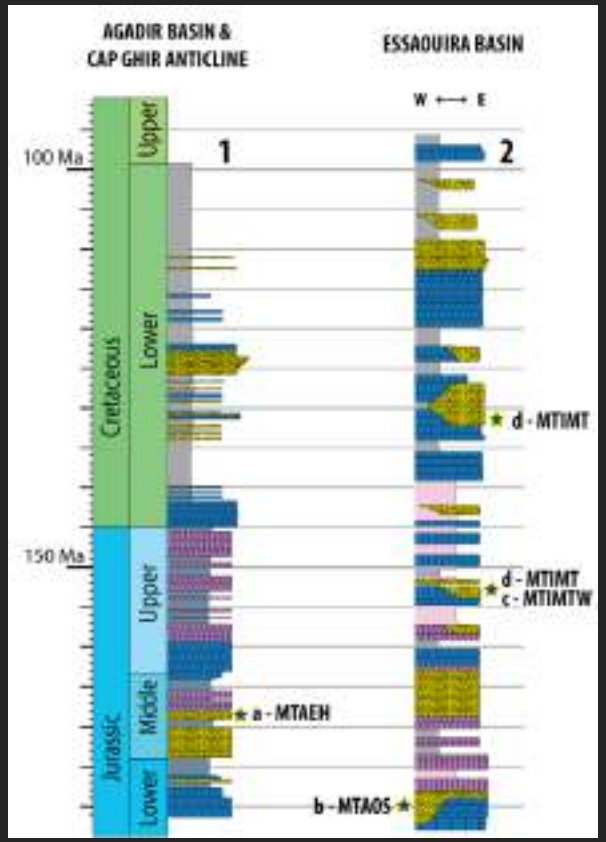

I – Tectonostratigraphic Framework

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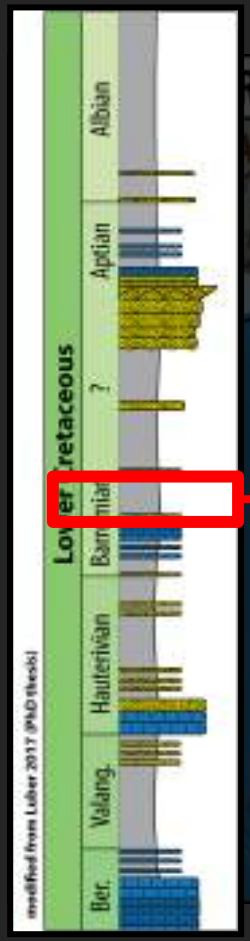
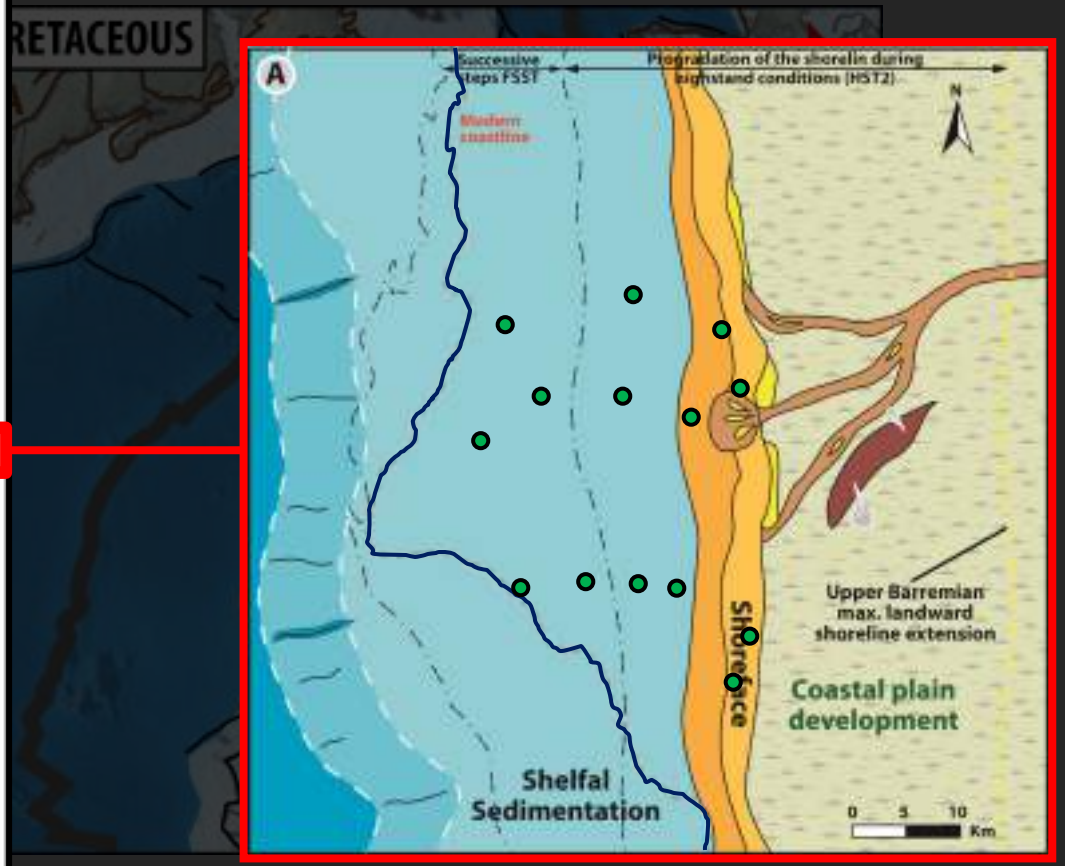
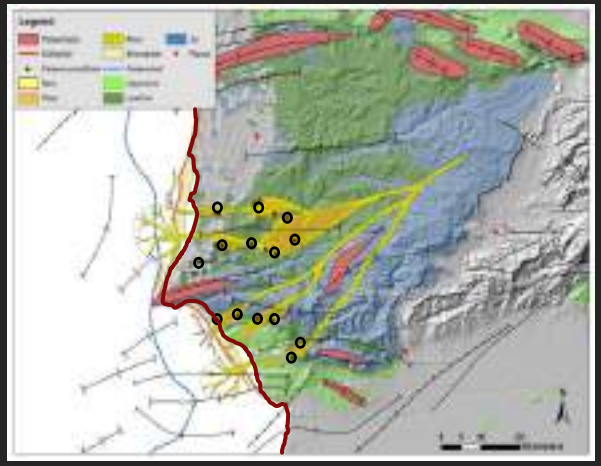




Pre-regression HST



From Tim Luber (PhD Thesis)

I – Tectonostratigraphic Framework

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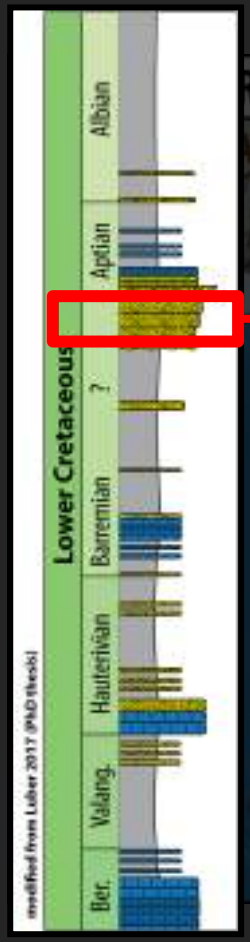
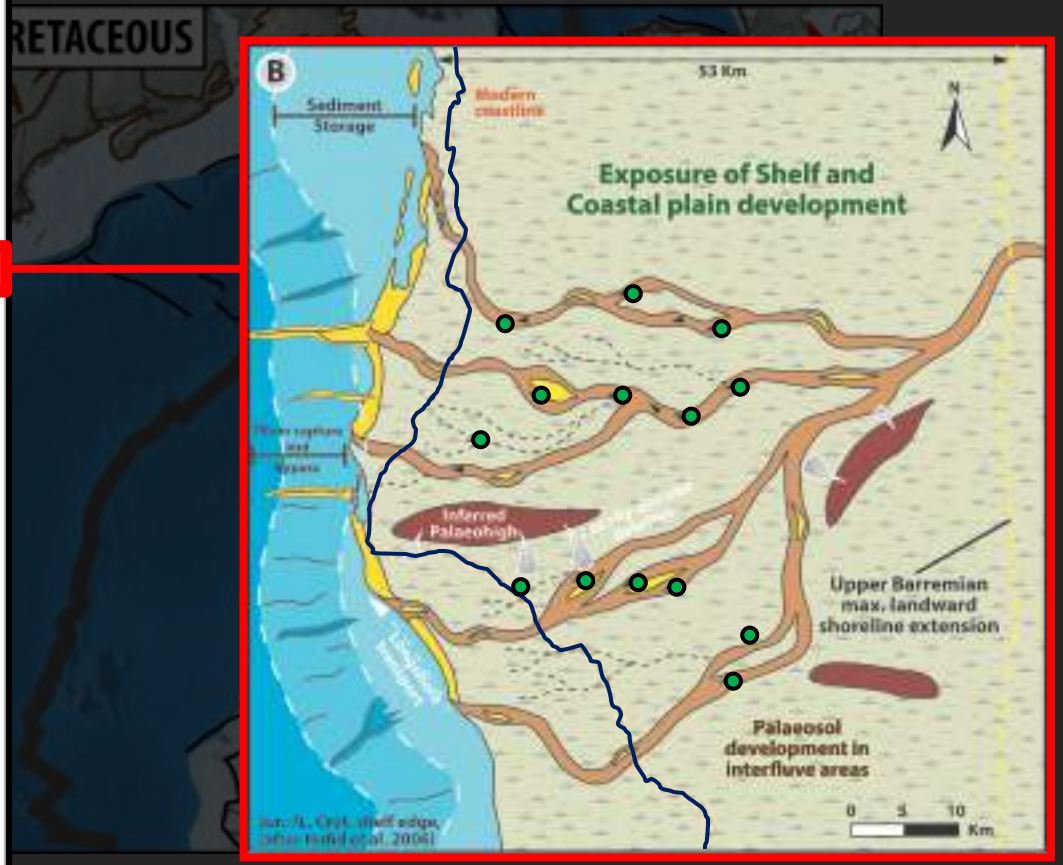
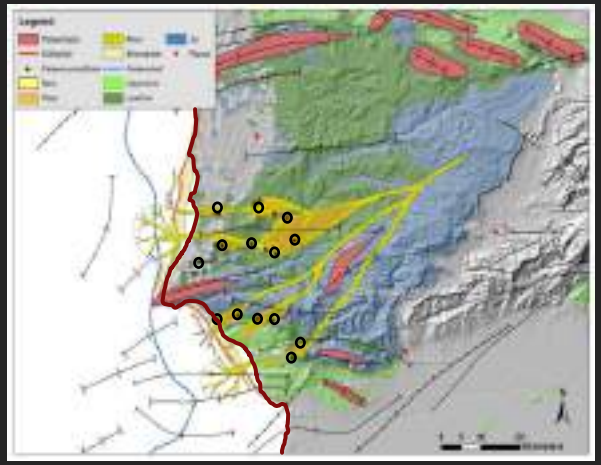




Max Regression LST



From Tim Luber (PhD Thesis)

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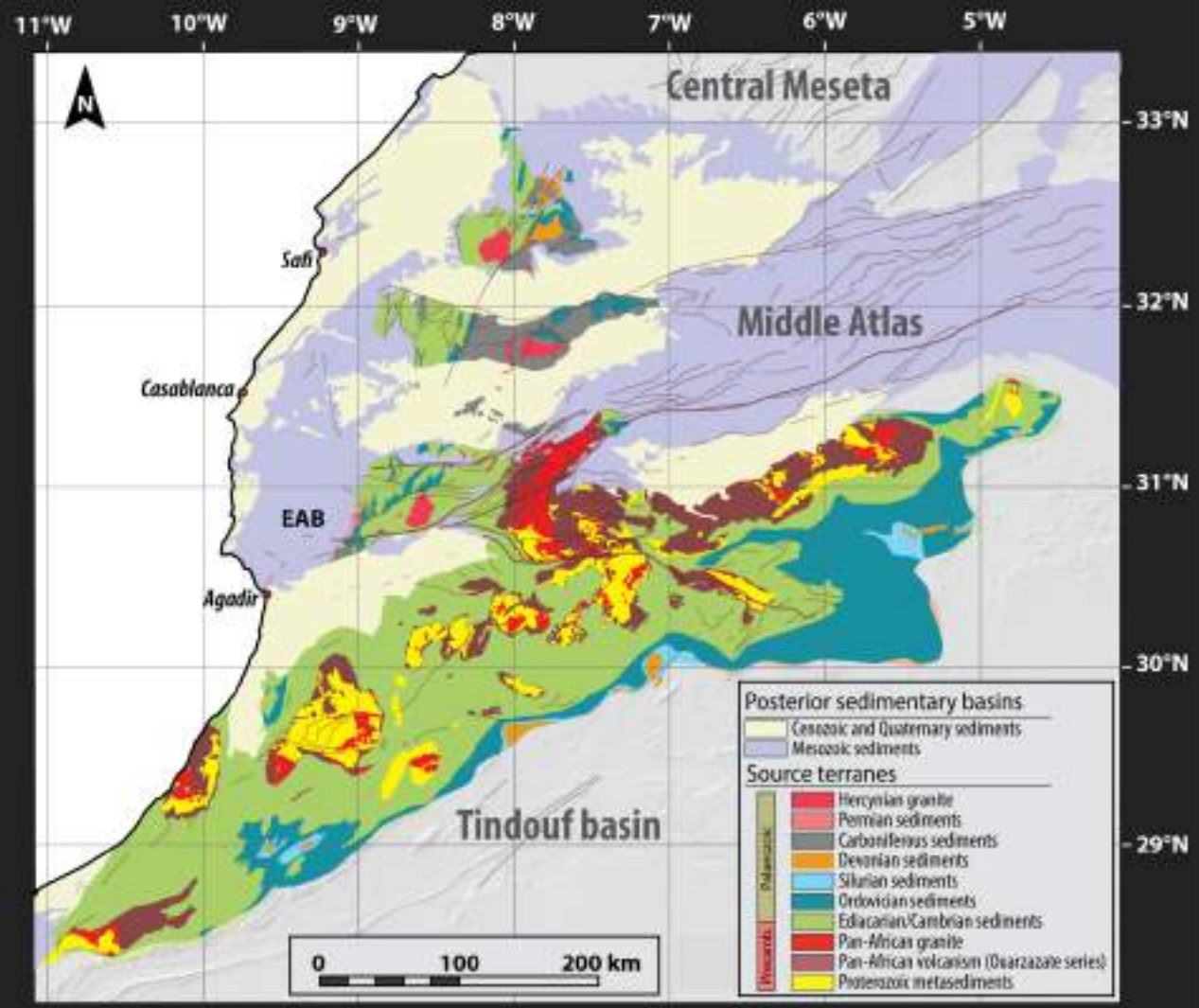
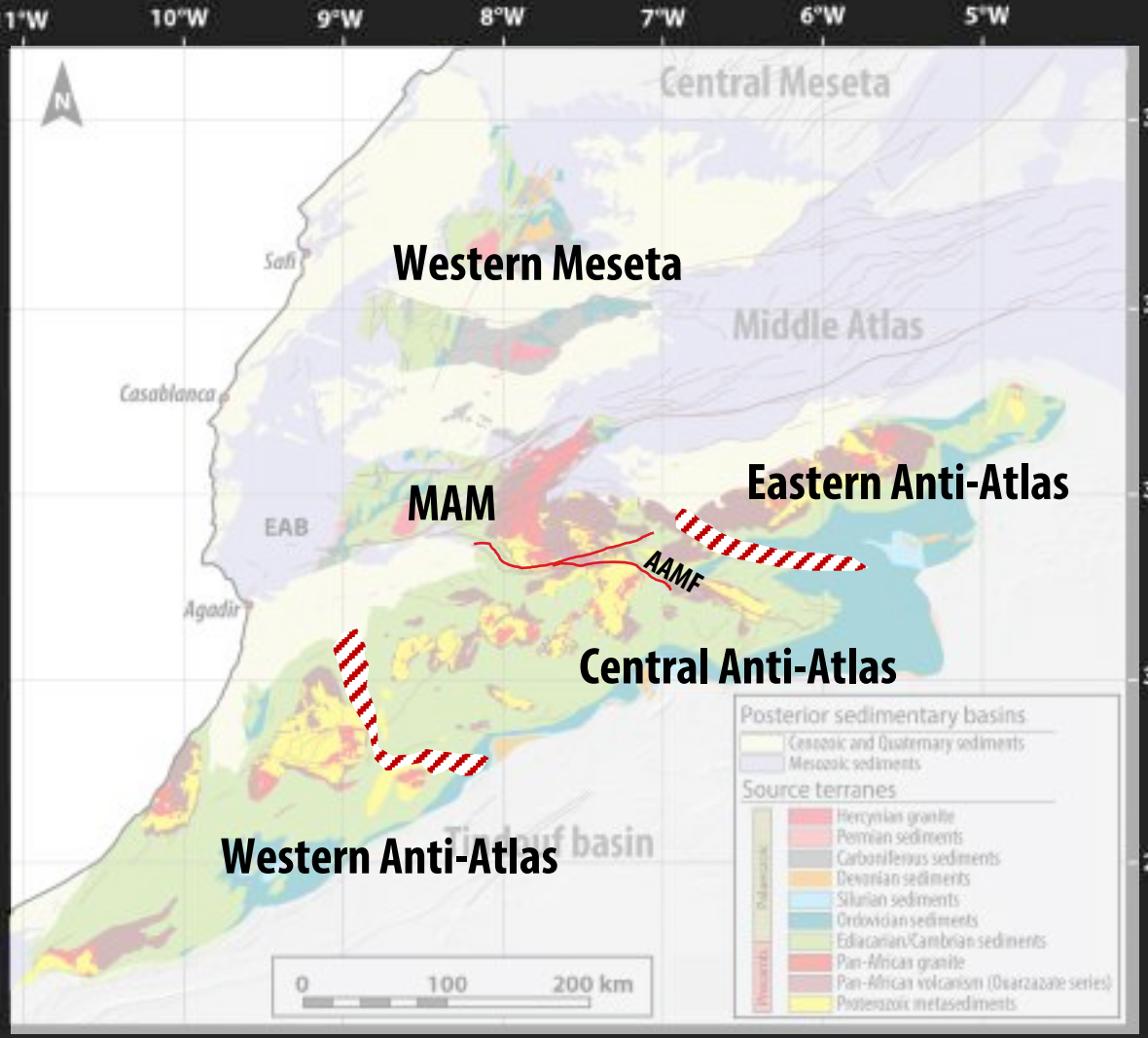
I – Modelling Palaeogeology

a) Basement evolution


11°W
10°W
9°W
8°W
7°W
6°W
5°W
33°N
32°N
31°N
30°N
29°N
N
Central Meseta
Middle Atlas
Safi
Casablanca
EAB
Agadir
Tindouf basin
0
100
200 km
Posterior sedimentary basins
Cenozoic and Quaternary sediments
Mesozoic sediments
Source terranes
Phanerozoic
Paleozoic
Hercynian granite
Permian sediments
Carboniferous sediments
Devonian sediments
Silurian sediments
Ordovician sediments
Ediacarian/Cambrian sediments
Pan-African granite
Pan-African volcanism (Ouarzazate series)
Proterozoic metasediments


11°W
10°W
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32°N
31°N
30°N
29°N
N
Central Meseta
Western Meseta
Middle Atlas
Safi
Casablanca
Eastern Anti-Atlas
MAM
EAB
AAMF
Agadir
Central Anti-Atlas
Tindouf basin
Western Anti-Atlas
0
100
200 km
Posterior sedimentary basins
Cenozoic and Quaternary sediments
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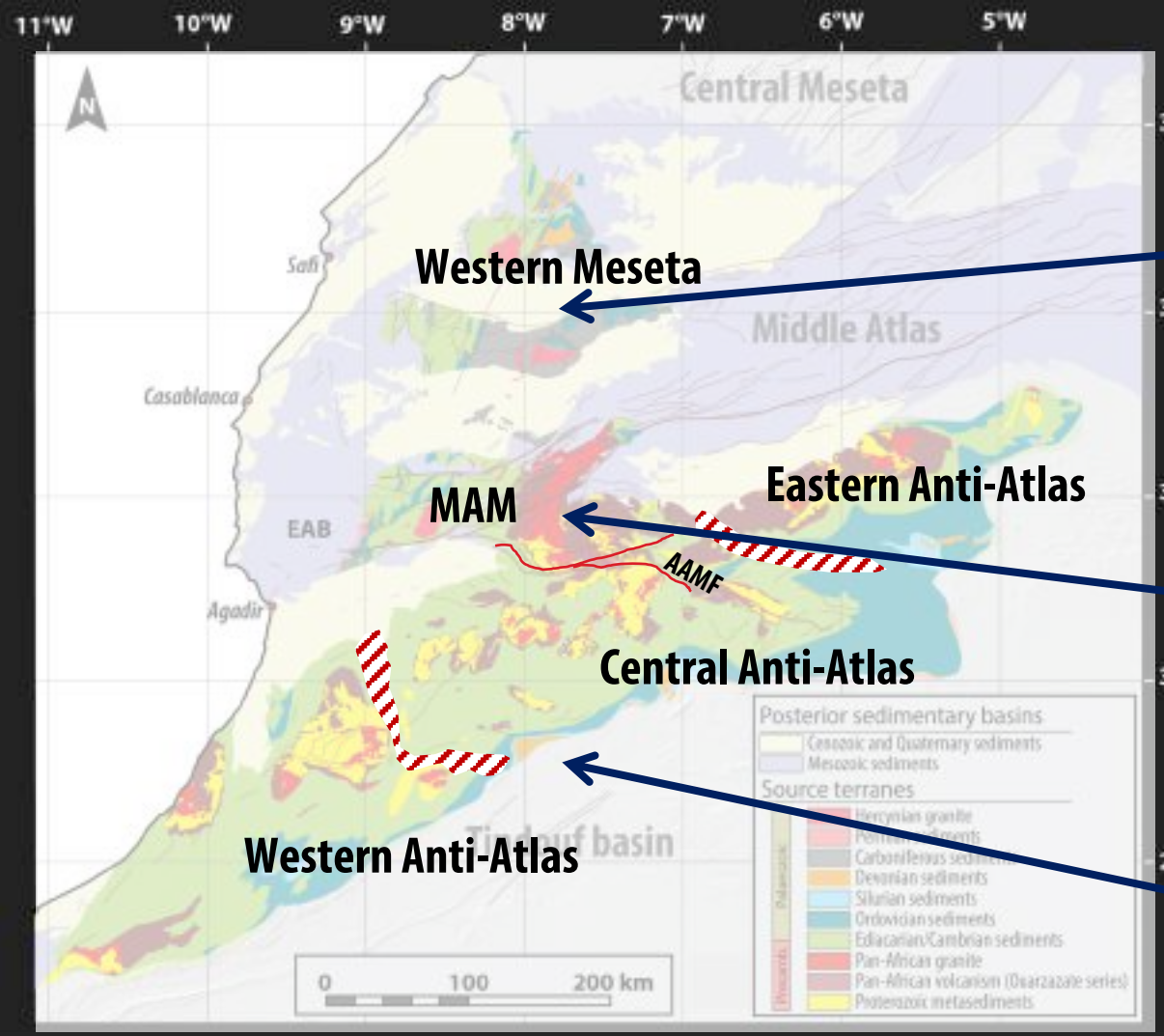
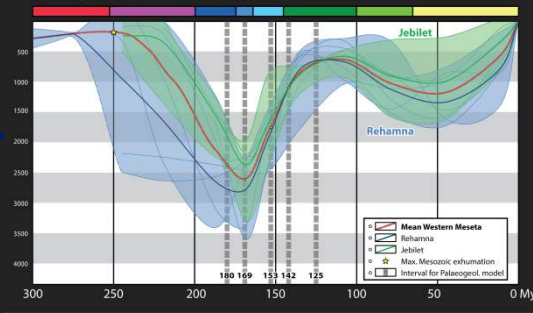
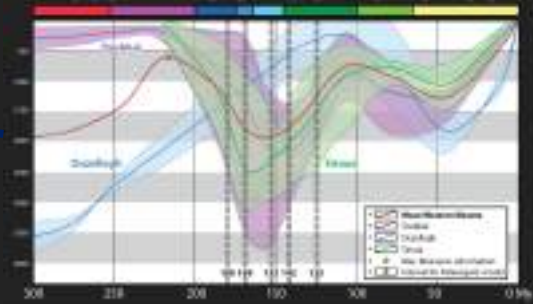
Pan-African granite
Pan-African volcanism (Ouarzazate series)
Proterozoic metasediments
Phanerozoic
Precambrian



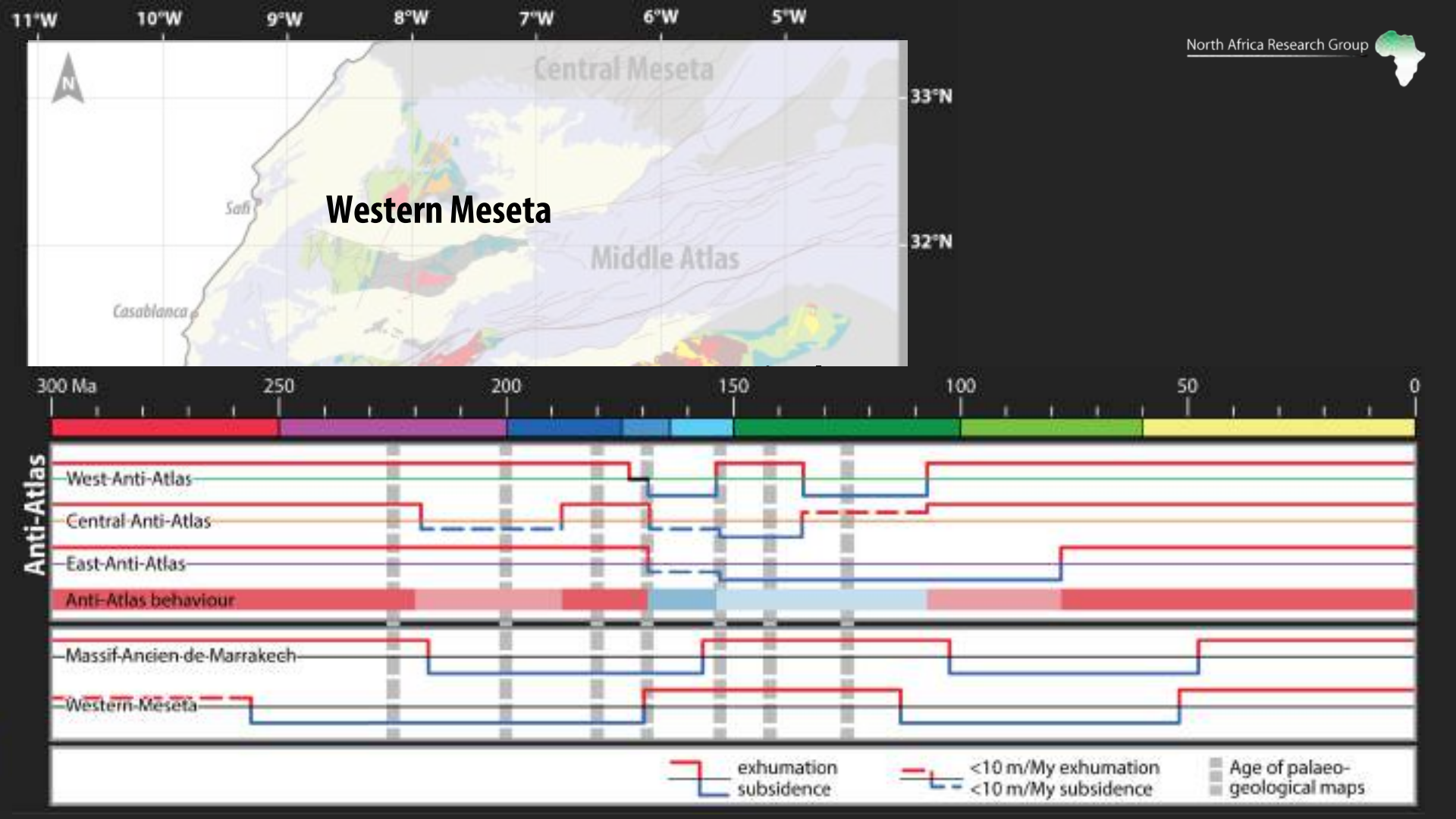
Western Meseta

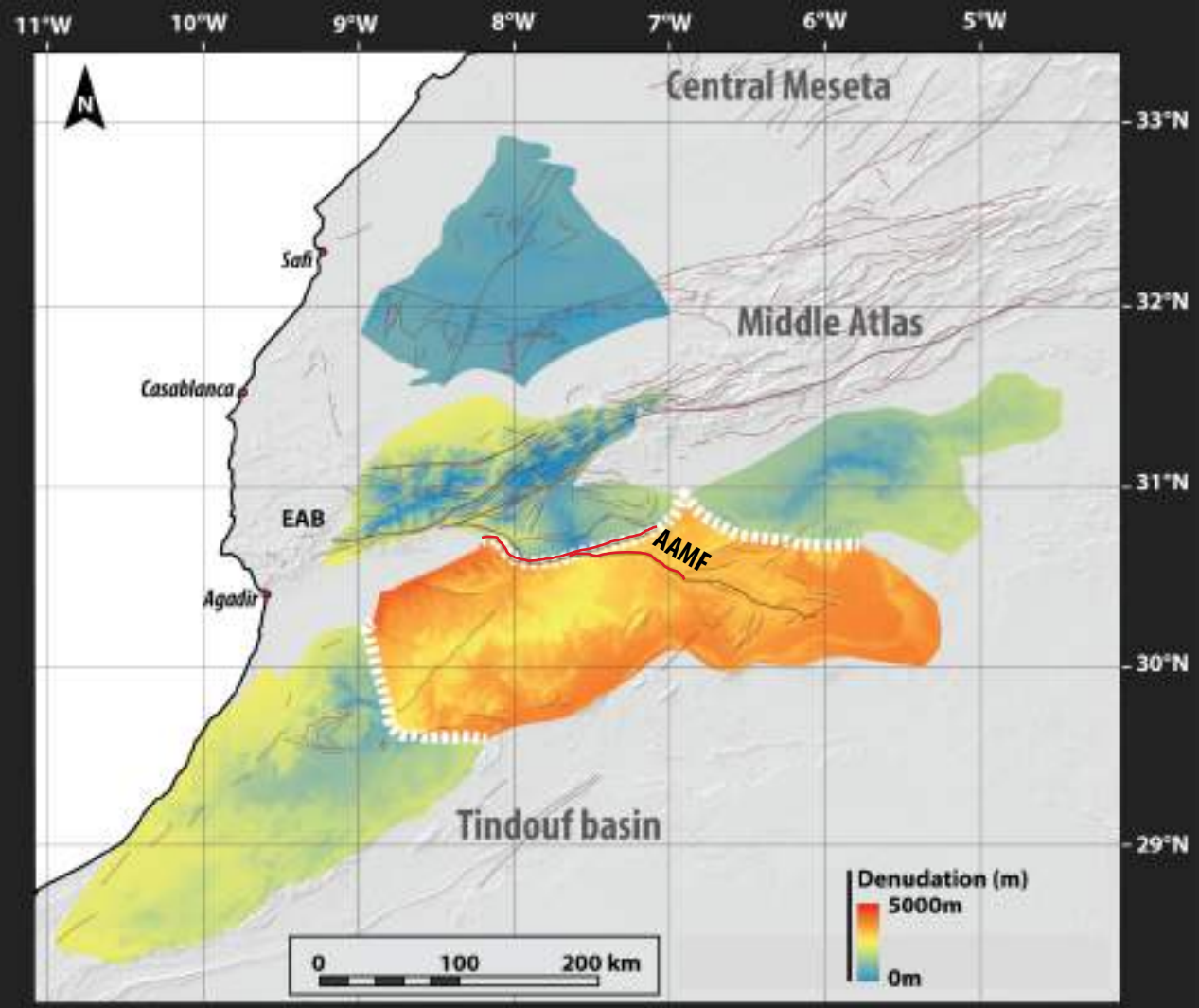


Massif Ancien de Marrakech



Anti-Atlas

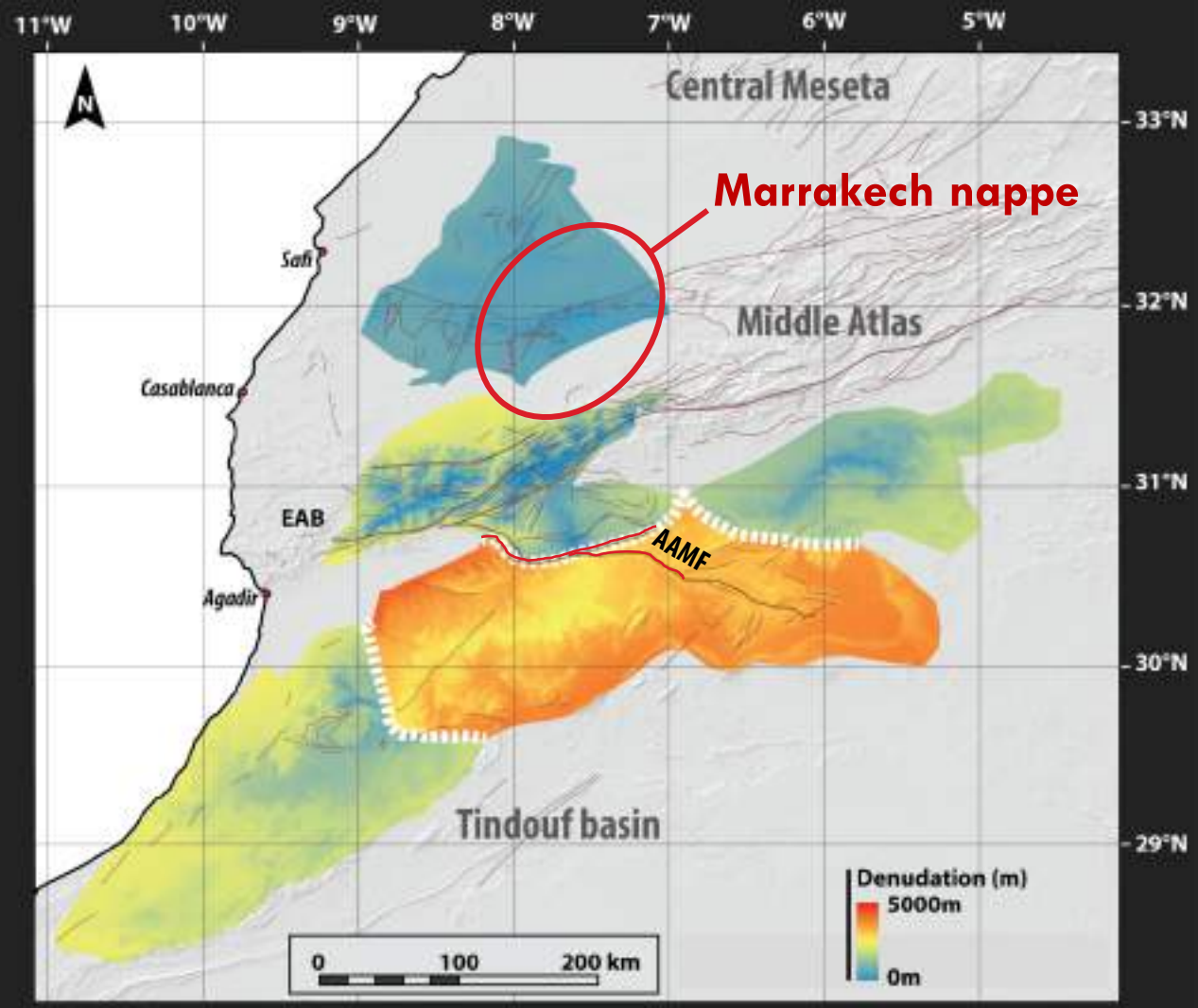

11°W
10°W
9°W
8°W
7°W
6°W
5°W
33°N
32°N
N
Central Meseta
Western Meseta
Middle Atlas
Safi
Casablanca
North Africa Research Group
300 Ma
250
200
150
100
50
0
Anti-Atlas
West-Anti-Atlas
Central-Anti-Atlas
East-Anti-Atlas
Anti-Atlas behaviour
Massif-Ancien-de-Marrakech
Western-Meseta
exhumation
subsidence
<10 m/My exhumation
<10 m/My subsidence
Age of palaeo-
geological maps



Basement modelling

Methods :

- Denudation map



Basement modelling

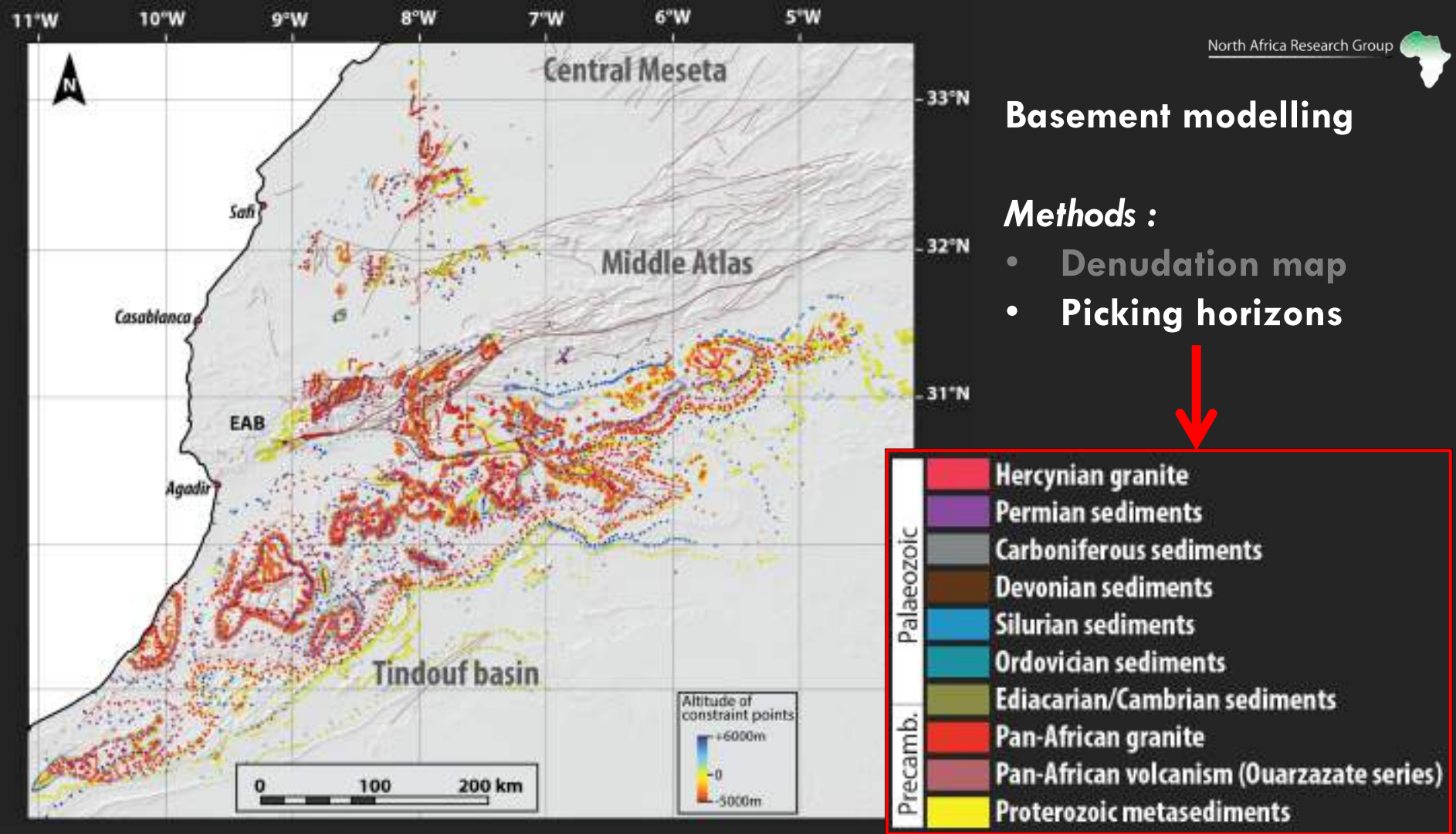
Methods :

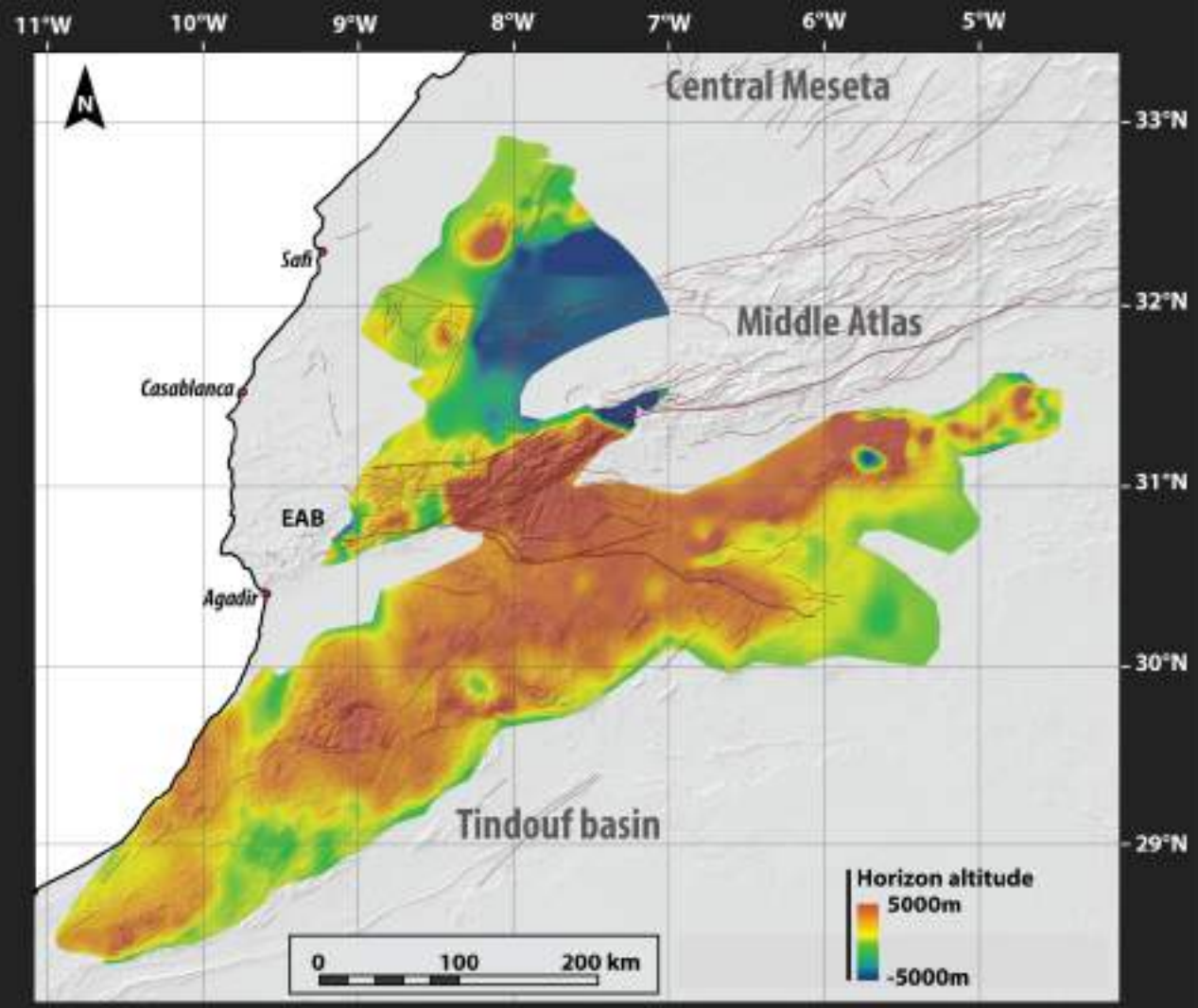
- Denudation map

Basement modelling

Methods :

- Denudation map
- Picking horizons

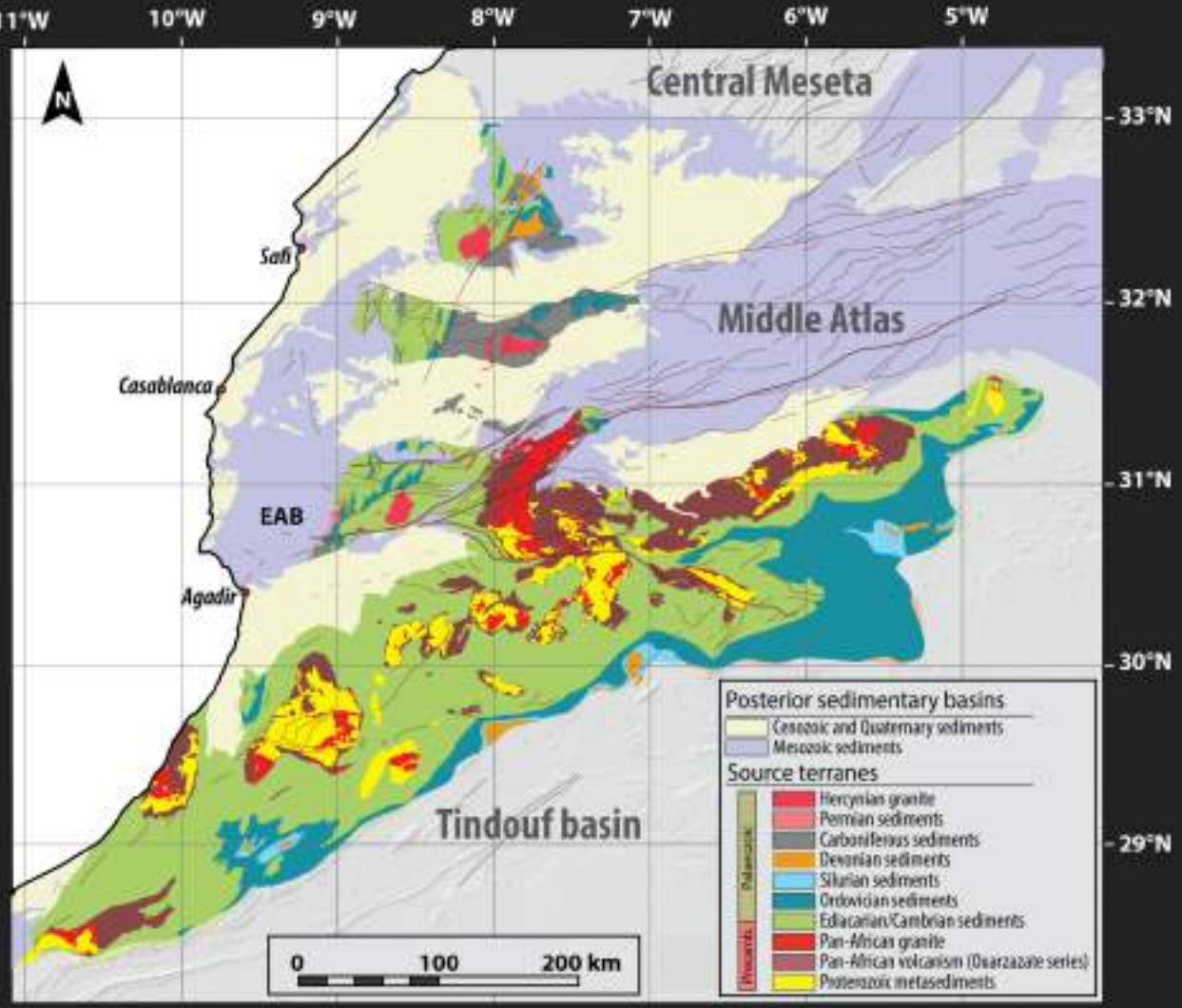




Basement modelling

Methods :

- Denudation map
- Picking horizons
- **Interpolation of horizons**



Basement modelling

Methods :

- Denudation map
- Picking horizons
- Interpolation of horizons
- **Intersection mapping of interpolated horizons with denudation maps**

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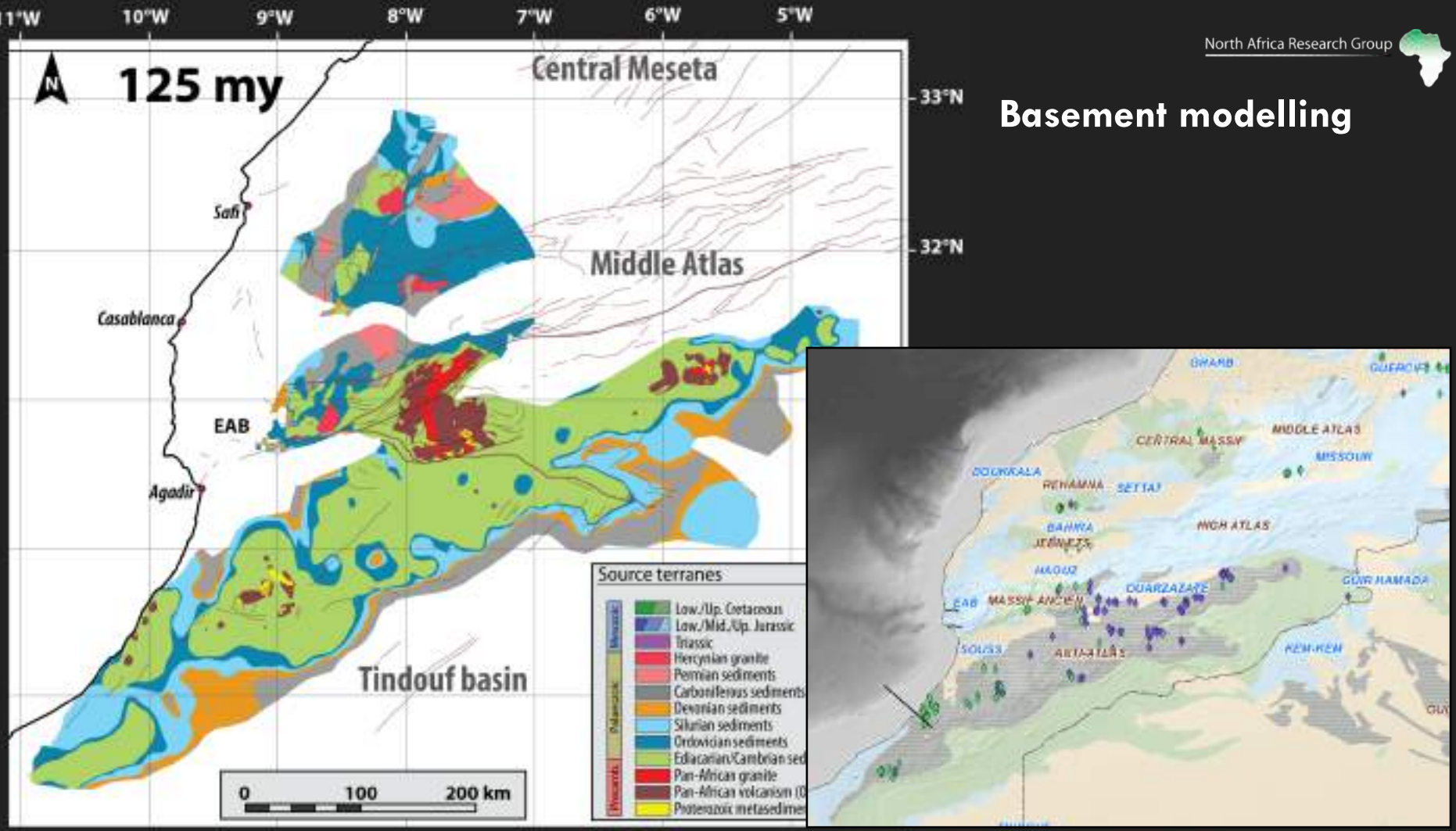
Basement modelling



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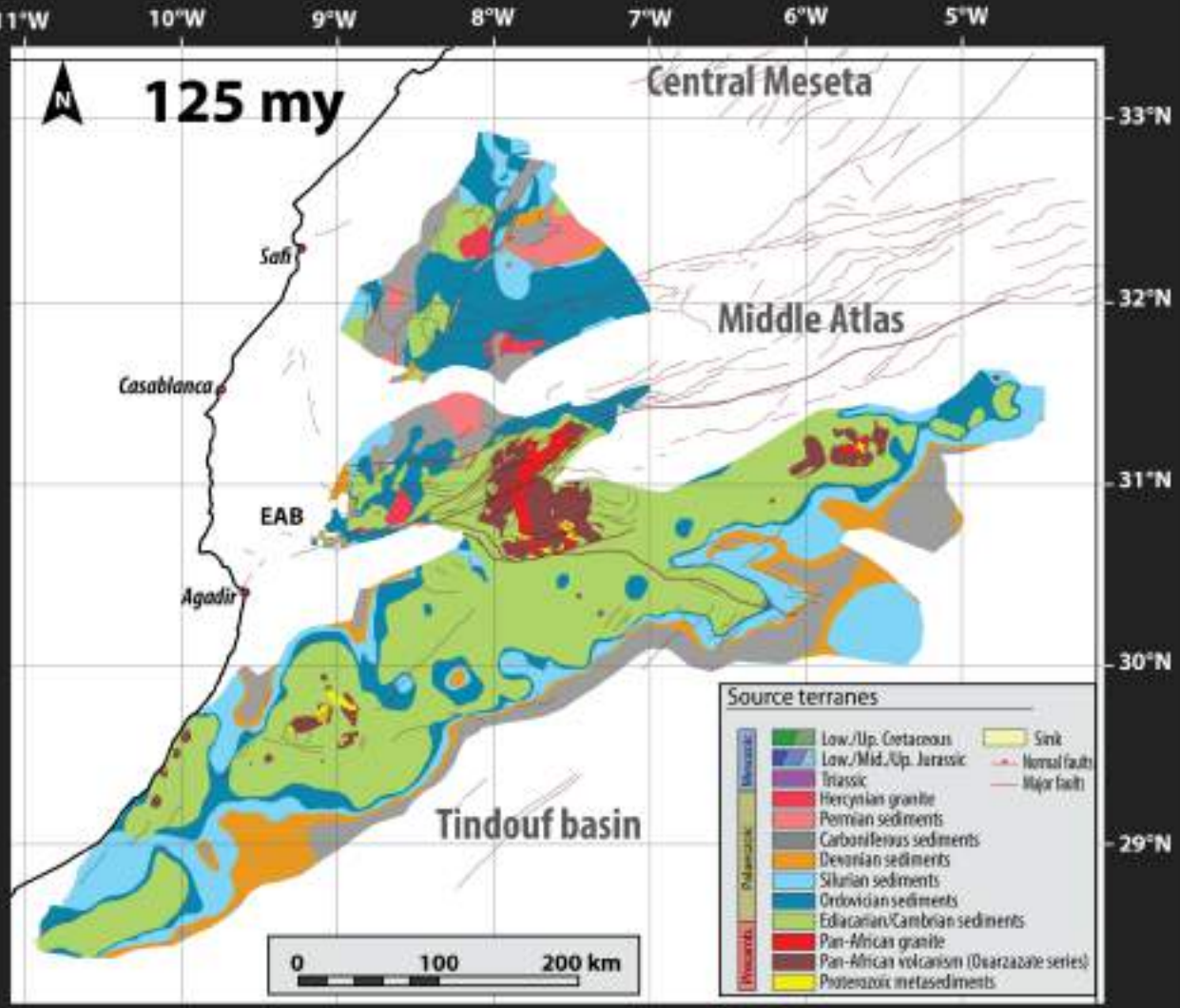
I – Modelling Palaeogeology

b) Mesozoic + sinks



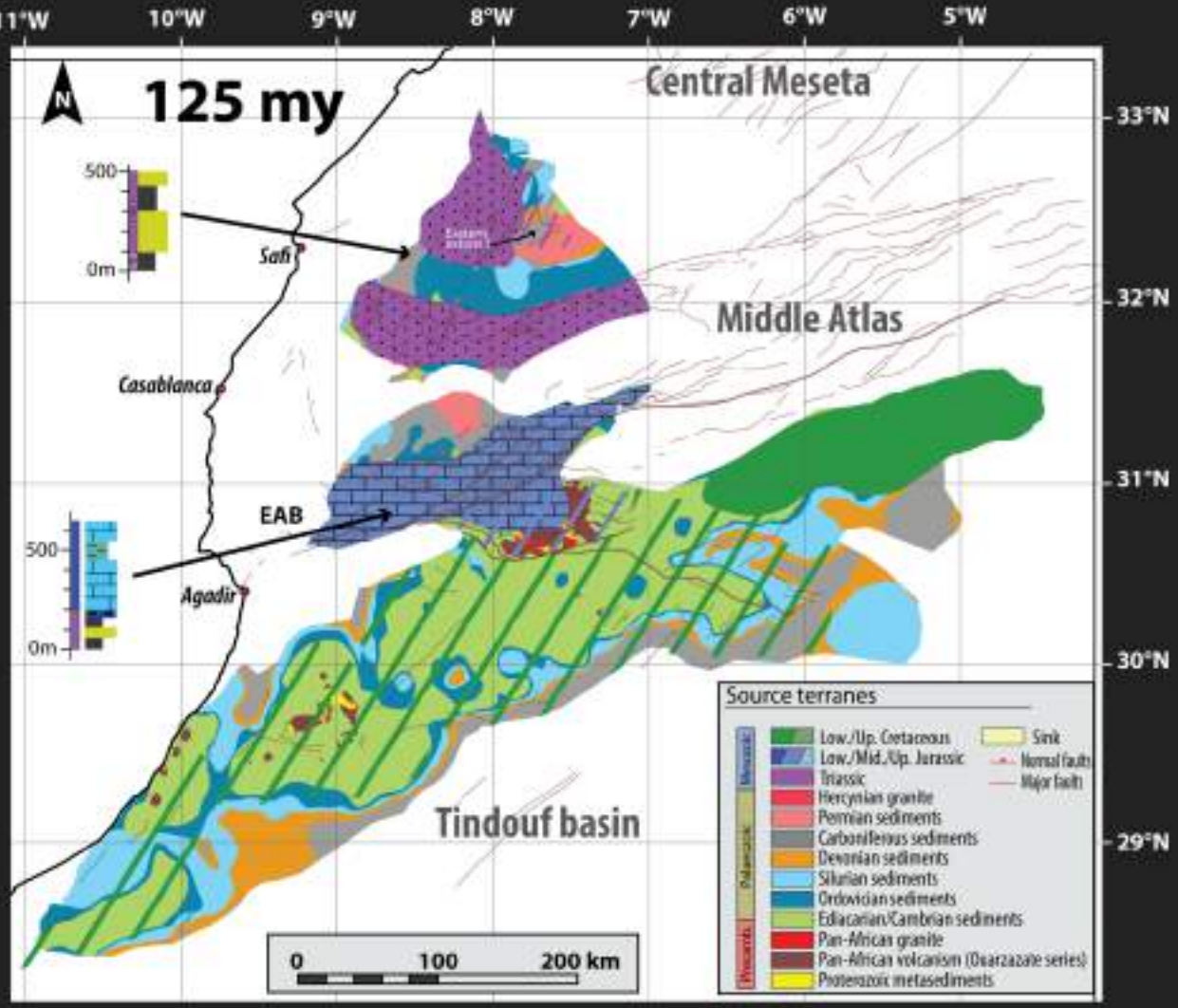
Modelling Cretaceous geology

Model of cropping out lithologies at paleo altitude (at 125 My)

Layer 1: Basement

↓

Model output

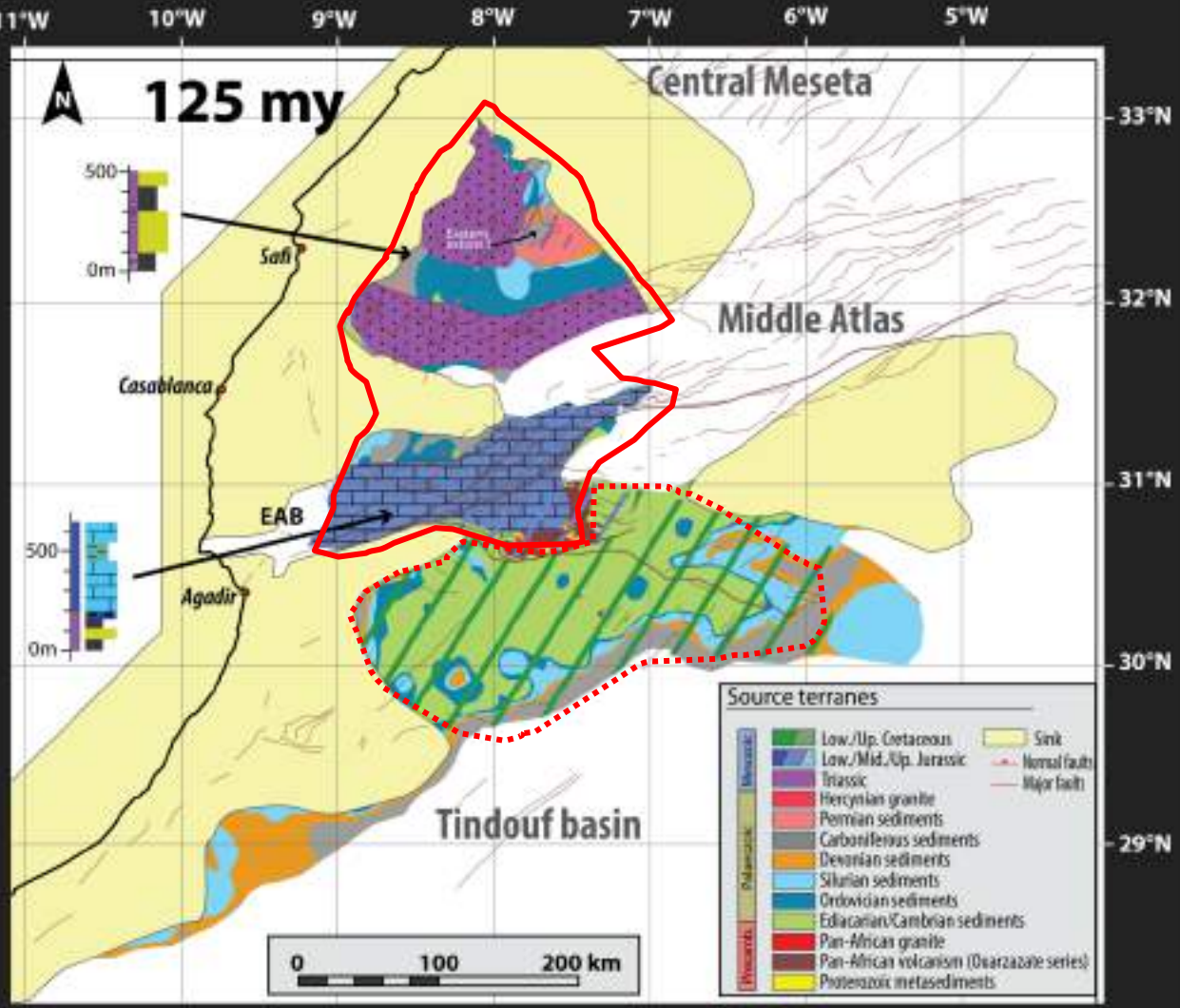


Modelling Cretaceous geology

Model of cropping out lithologies at paleo altitude (at 125 My)
Layer 1: Basement
Layer 2: Mesozoic cover

↓

Based on subsidence data, GDE maps and preserved basins



Modelling Cretaceous geology

Model of cropping out lithologies at paleo altitude (at 125 My)

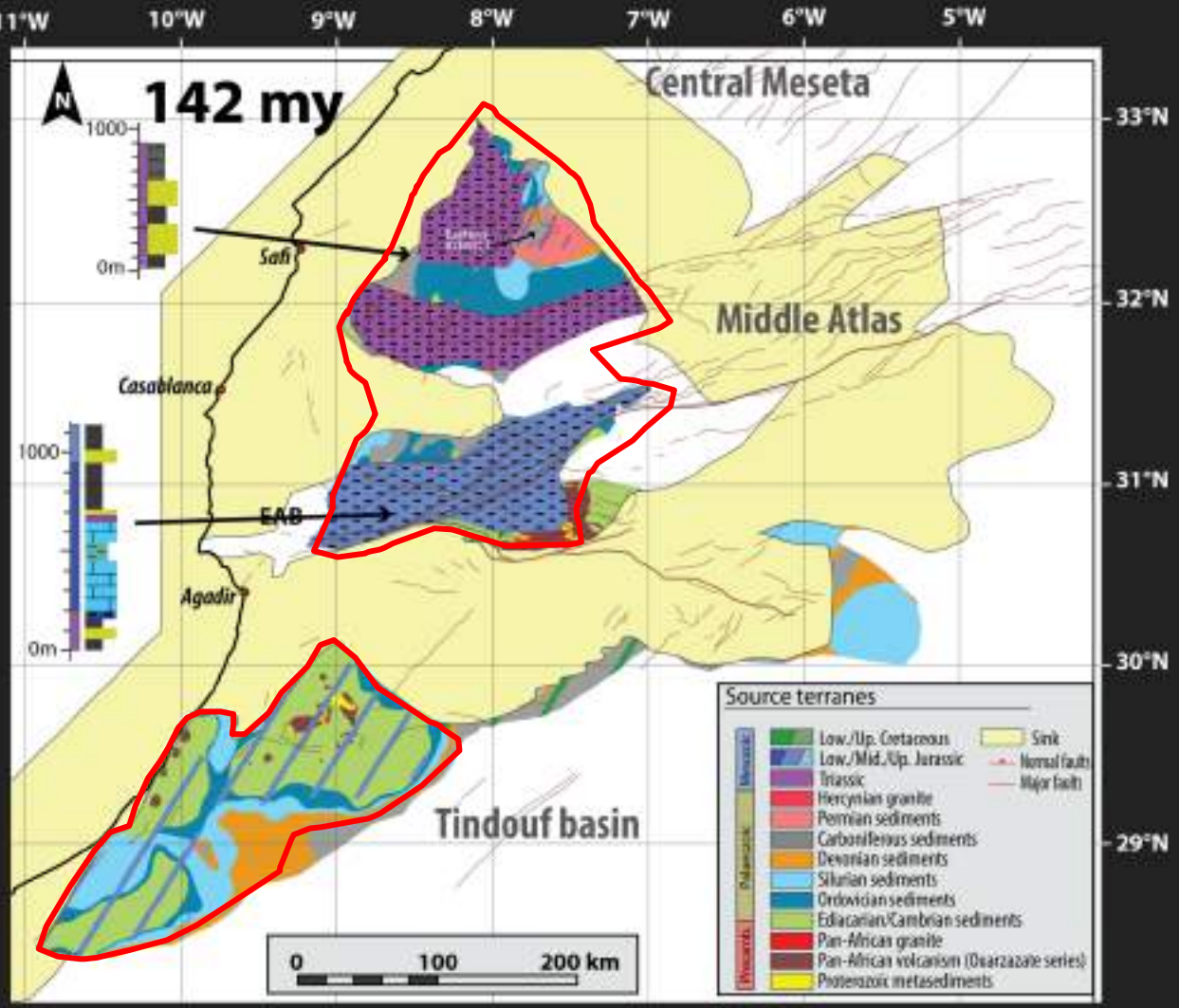
Layer 1: Basement

Layer 2: Mesozoic cover

Layer 3: Sinks

↓

Based on subsidence data and preserved basins



Modelling Cretaceous geology

Model of cropping out lithologies at paleo altitude (at 125 My)

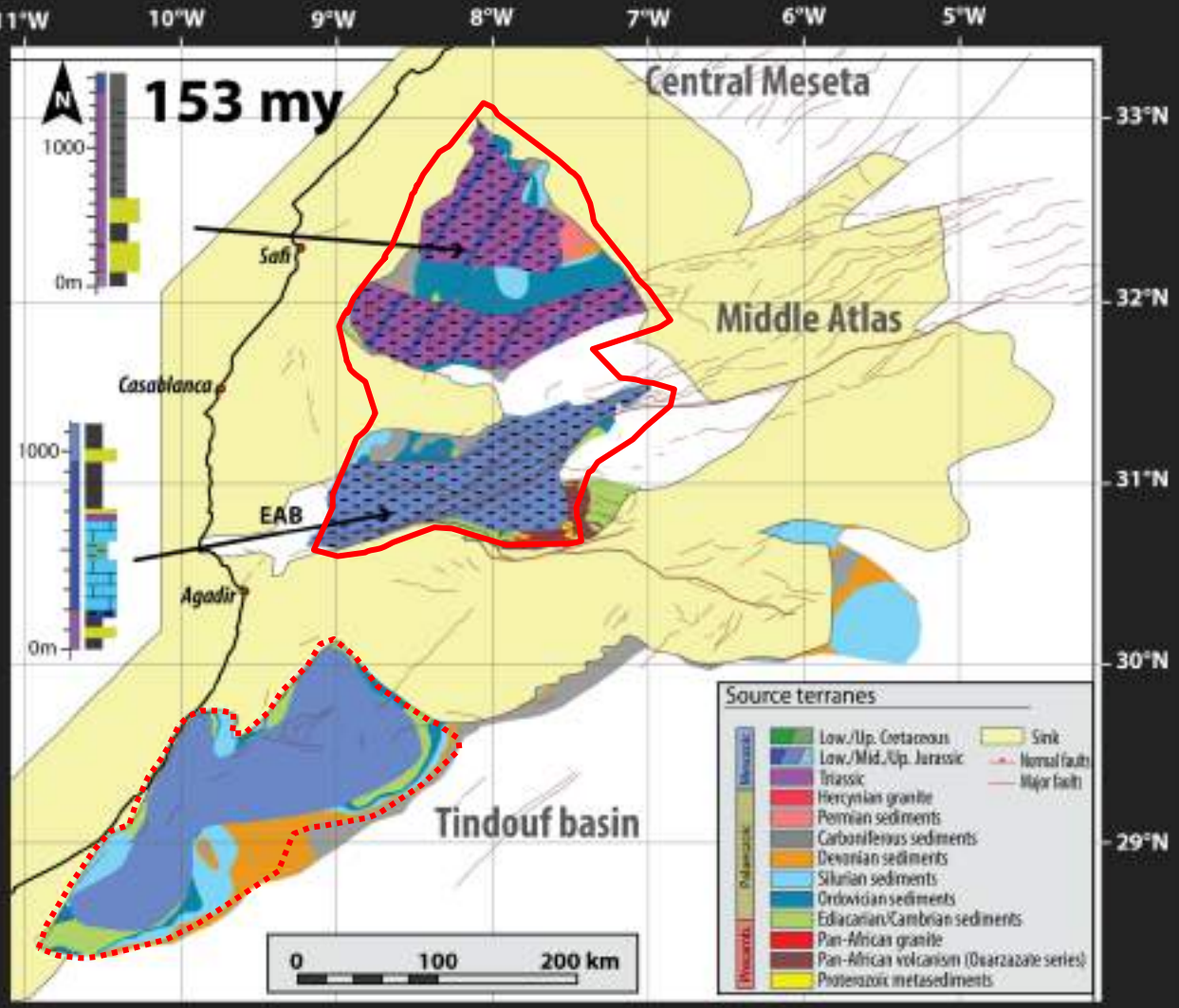
Layer 1: Basement

Layer 2: Mesozoic cover

Layer 3: Sinks

↓

Based on subsidence data and preserved basins



Modelling Cretaceous geology

Model of cropping out lithologies at paleo altitude (at 125 My)

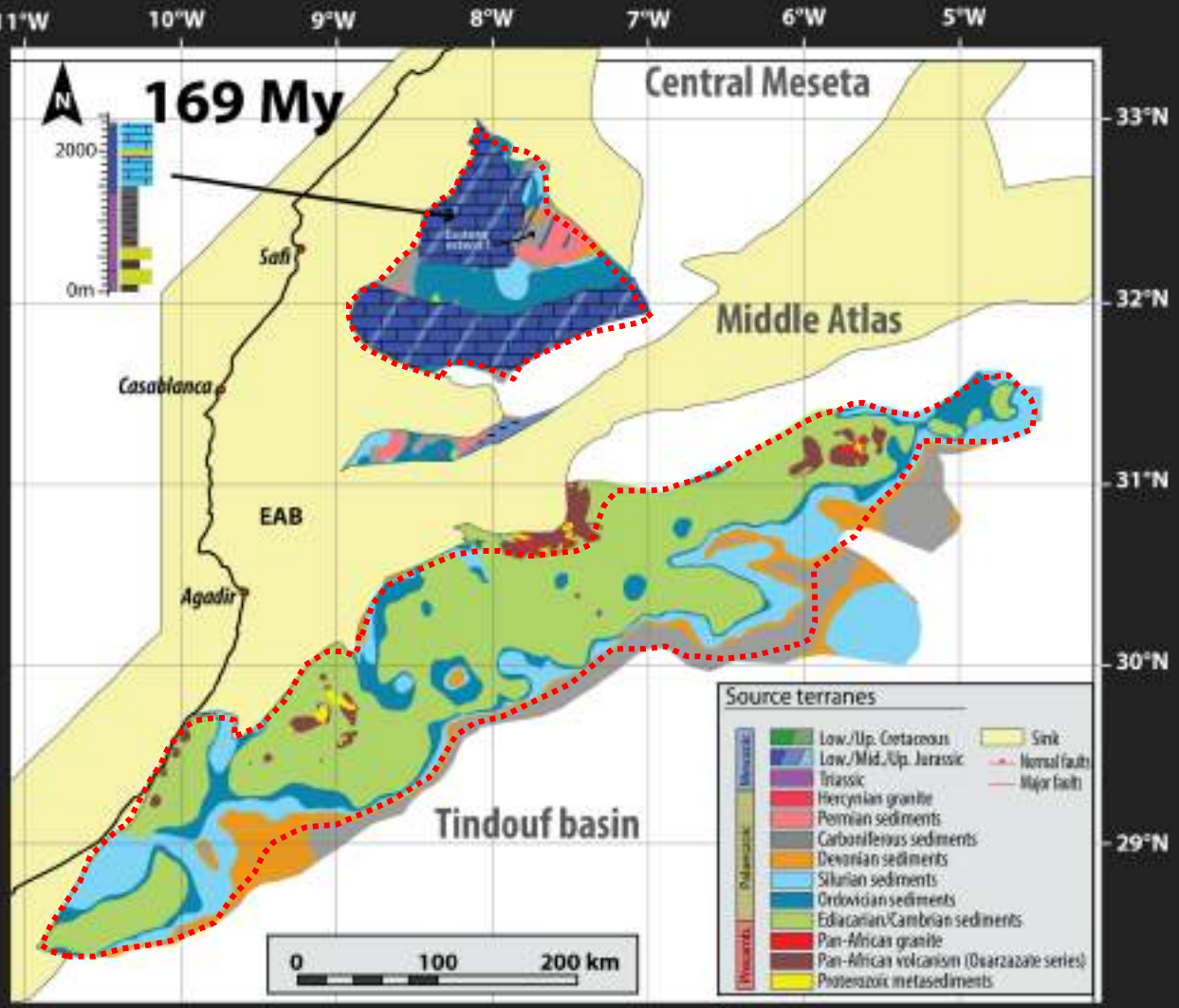
Layer 1: Basement

Layer 2: Mesozoic cover

Layer 3: Sinks

↓

Based on subsidence data and preserved basins



Modelling Cretaceous geology

Model of cropping out lithologies at paleo altitude (at 125 My)

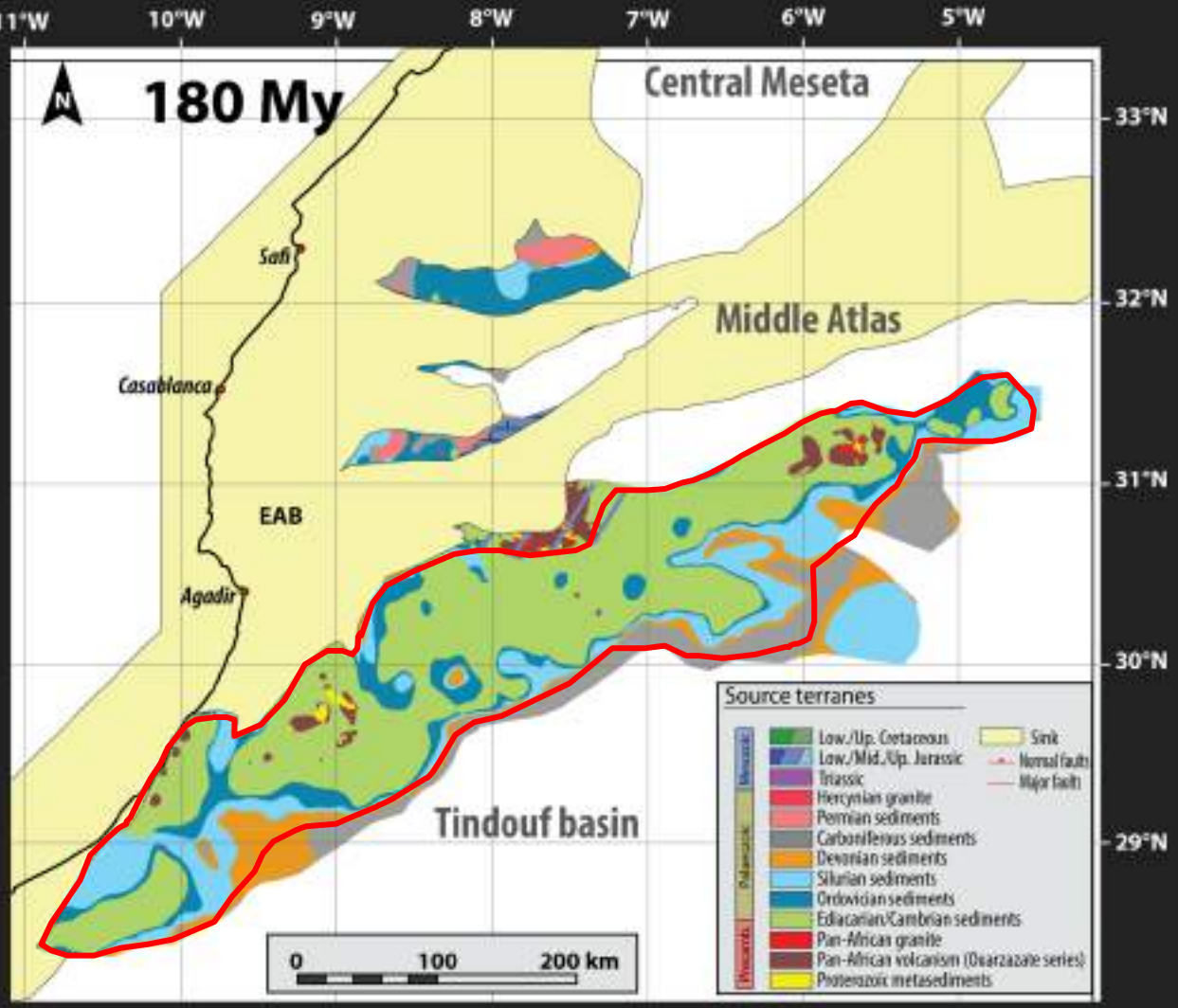
Layer 1: Basement

Layer 2: Mesozoic cover

Layer 3: Sinks

↓

Based on subsidence data and preserved basins



Modelling Cretaceous geology

Model of cropping out lithologies at paleo altitude (at 125 My)

Layer 1: Basement

Layer 2: Mesozoic cover

Layer 3: Sinks

↓

Based on subsidence data and preserved basins

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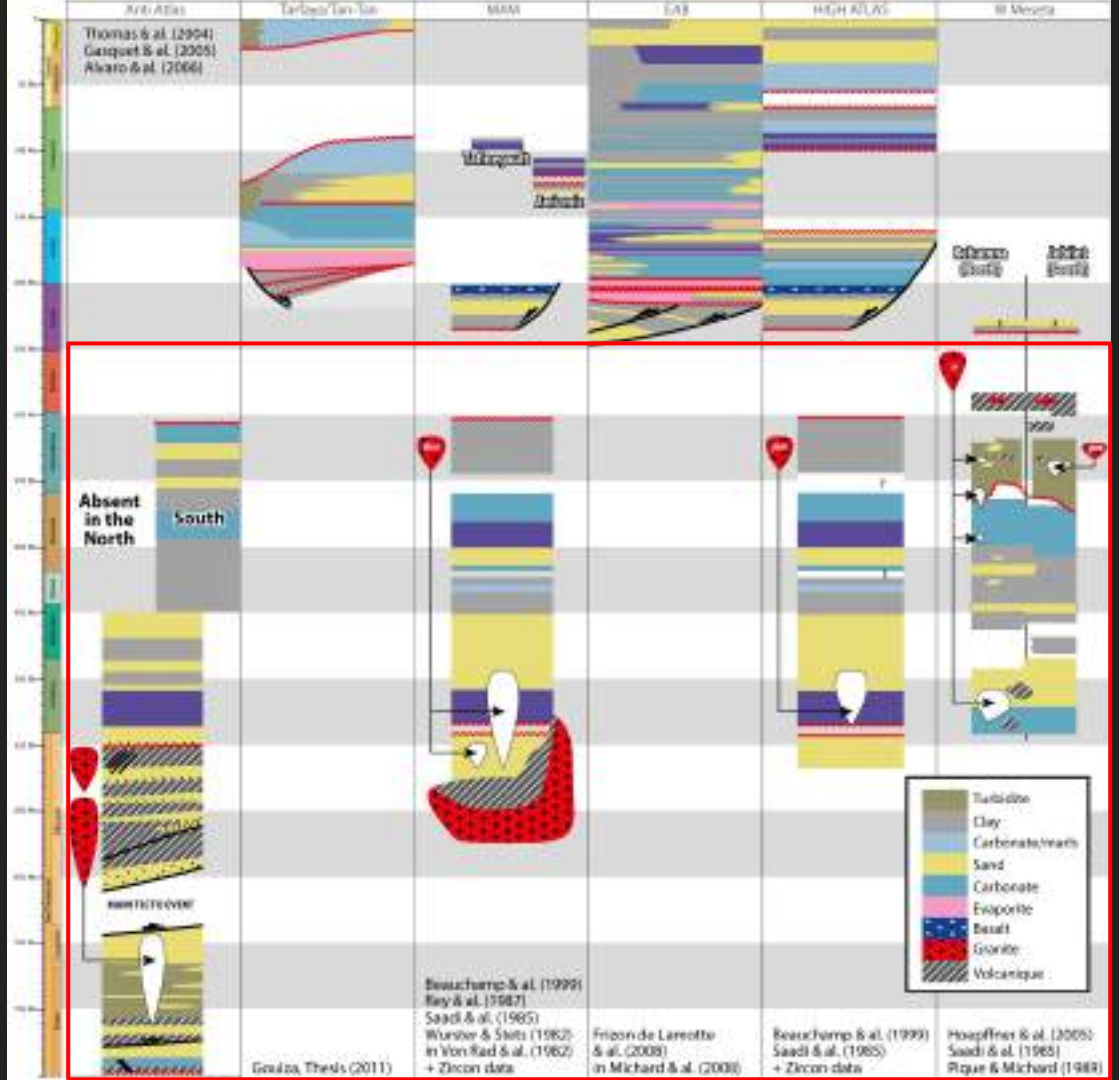
I – Modelling Palaeogeology

c) Basement lithology


Absent in the North
South
Turbidite
Clay
Carbonate/marls
Sand
Carbonate
Evaporite
Basalt
Granite
Volcanique
Beauchamp & al. (1999)
Ray & al. (1987)
Saadi & al. (1985)
Wunster & Stets (1982)
in Von Rad & al. (1982)
+ Zircon data
Frizon de Lamotte
& al. (2008)
in Michard & al. (2008)
Beauchamp & al. (1999)
Saadi & al. (1985)
+ Zircon data
Hoepffner & al. (2005)
Saadi & al. (1985)
Piqué & Michard (1989)

ONGOING

Modelling Palaeogeology

Sum up:

- Barely any inlier or primary source signal exposed throughout the Mesozoic
- Palaeogeological maps reconstructed with basement reconstruction, Mesozoic overburden and probable sink areas
- Lithological associations with modelled units to predict sediment nature and volumes

QUESTIONS
?

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II – Source to Sink correlations

a) Barremian Aptian Regression

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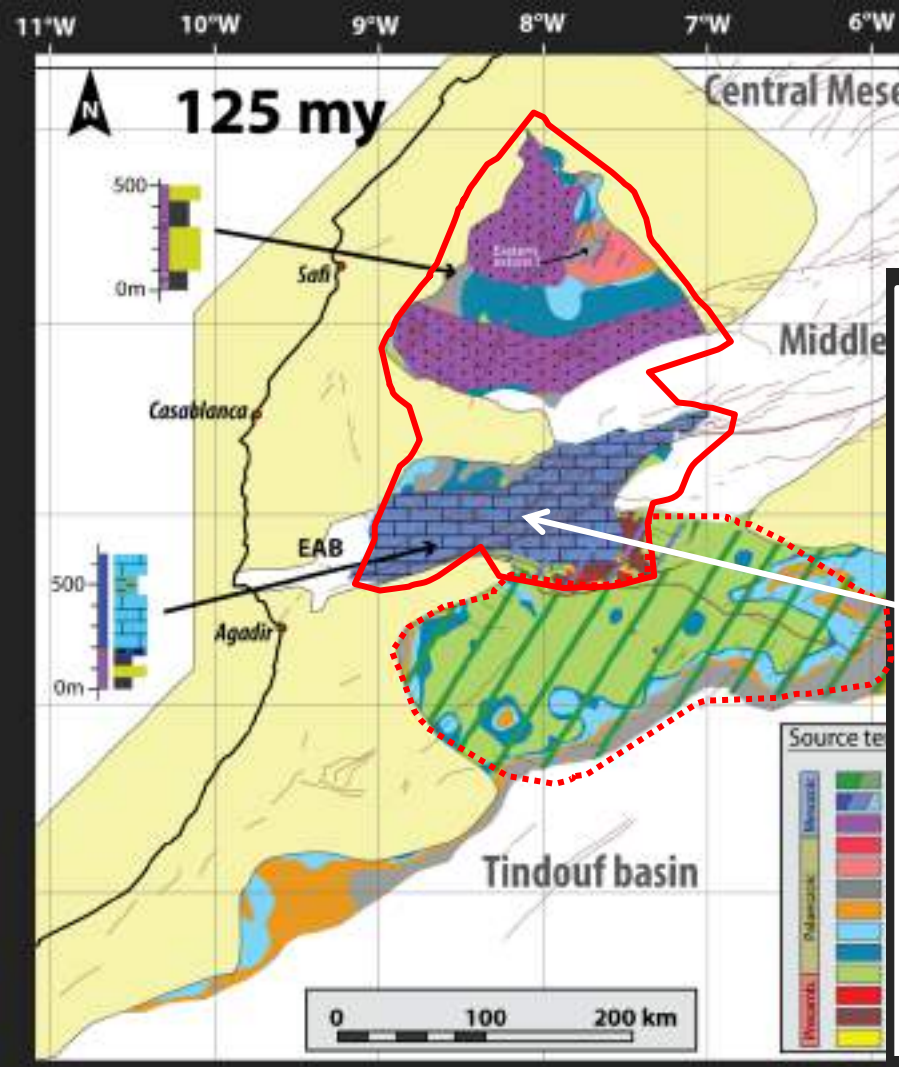
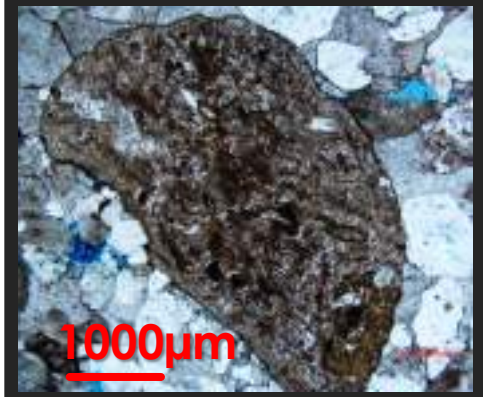
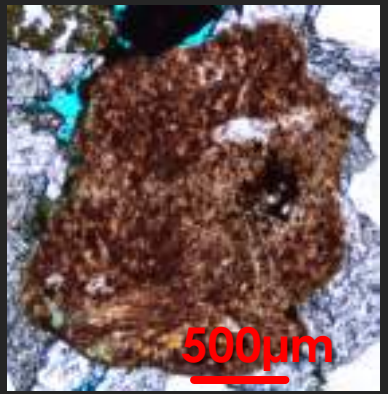
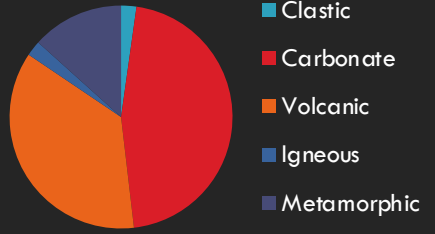


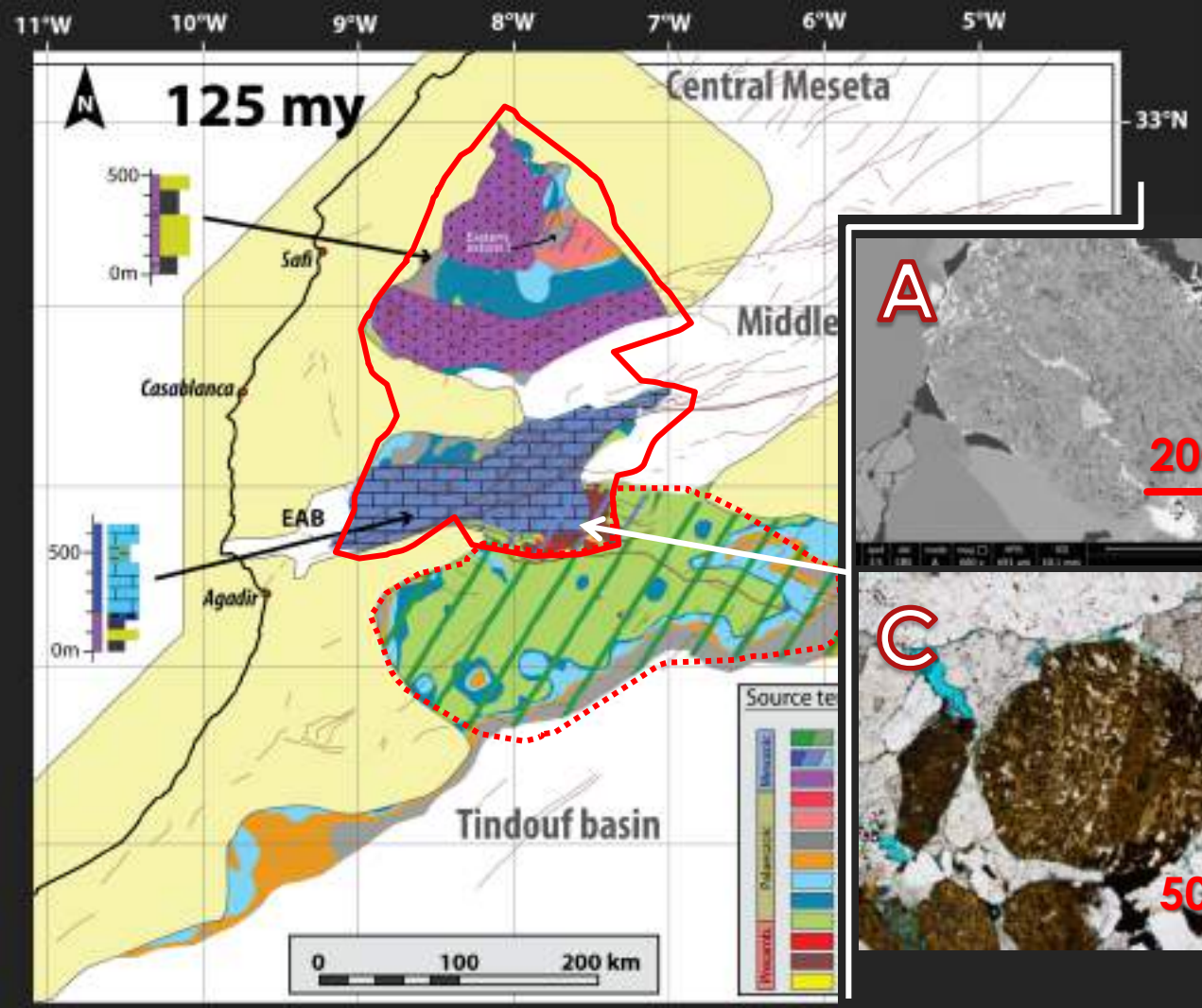
Carbonate clasts

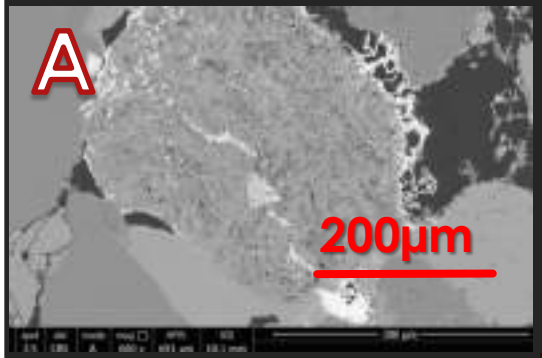


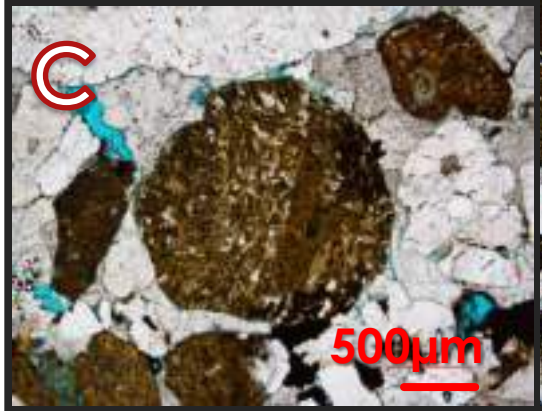


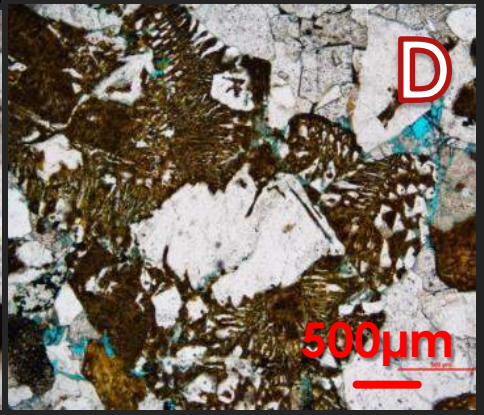
Bar-Apt fluvial




11°W
10°W
9°W
8°W
7°W
6°W
5°W
125 my
Central Meseta
33°N
500
0m
Safi
Casablanca
Middle
EAB
Agadir
Tindouf basin
Source te
0
100
200 km


A
200µm


C
500µm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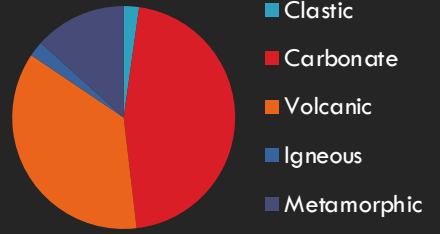
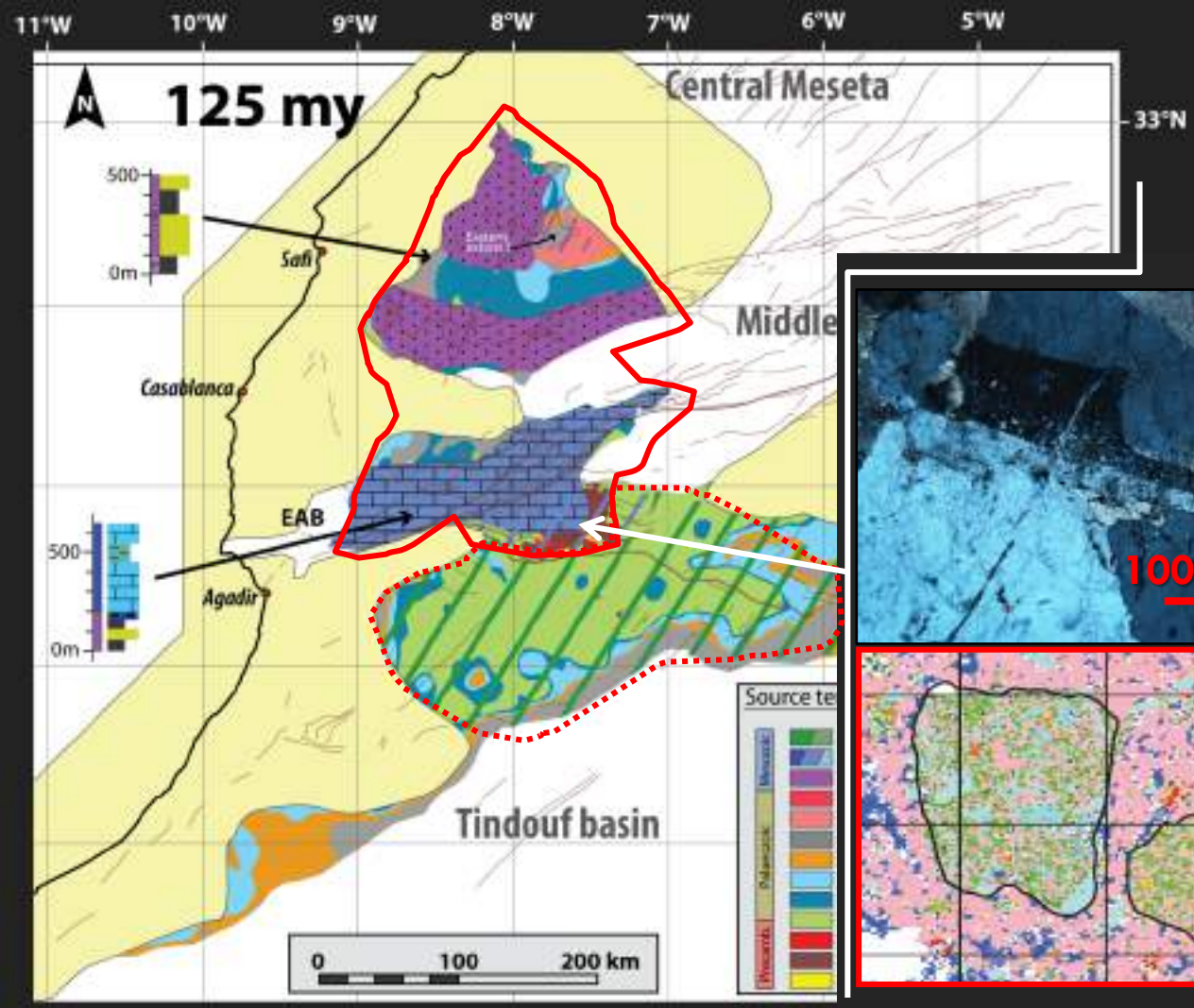
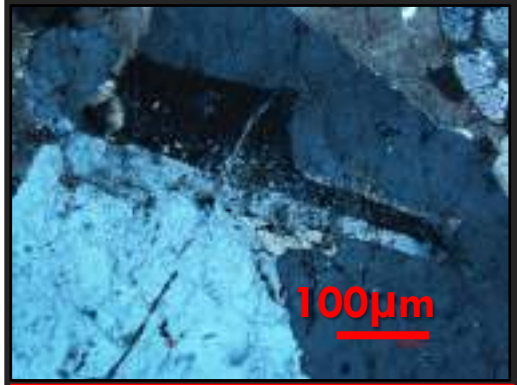
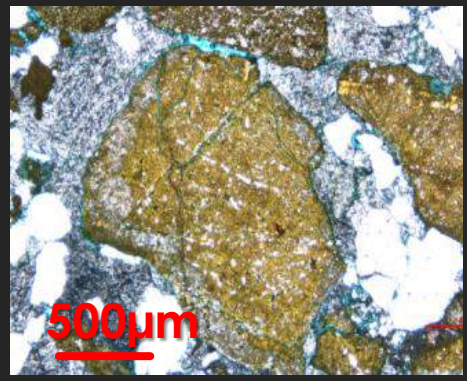
500µm

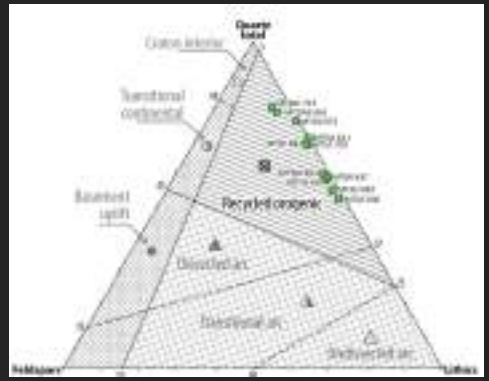

Bar-Apt fluvial
Clastic
Carbonate
Volcanic
Igneous
Metamorphic

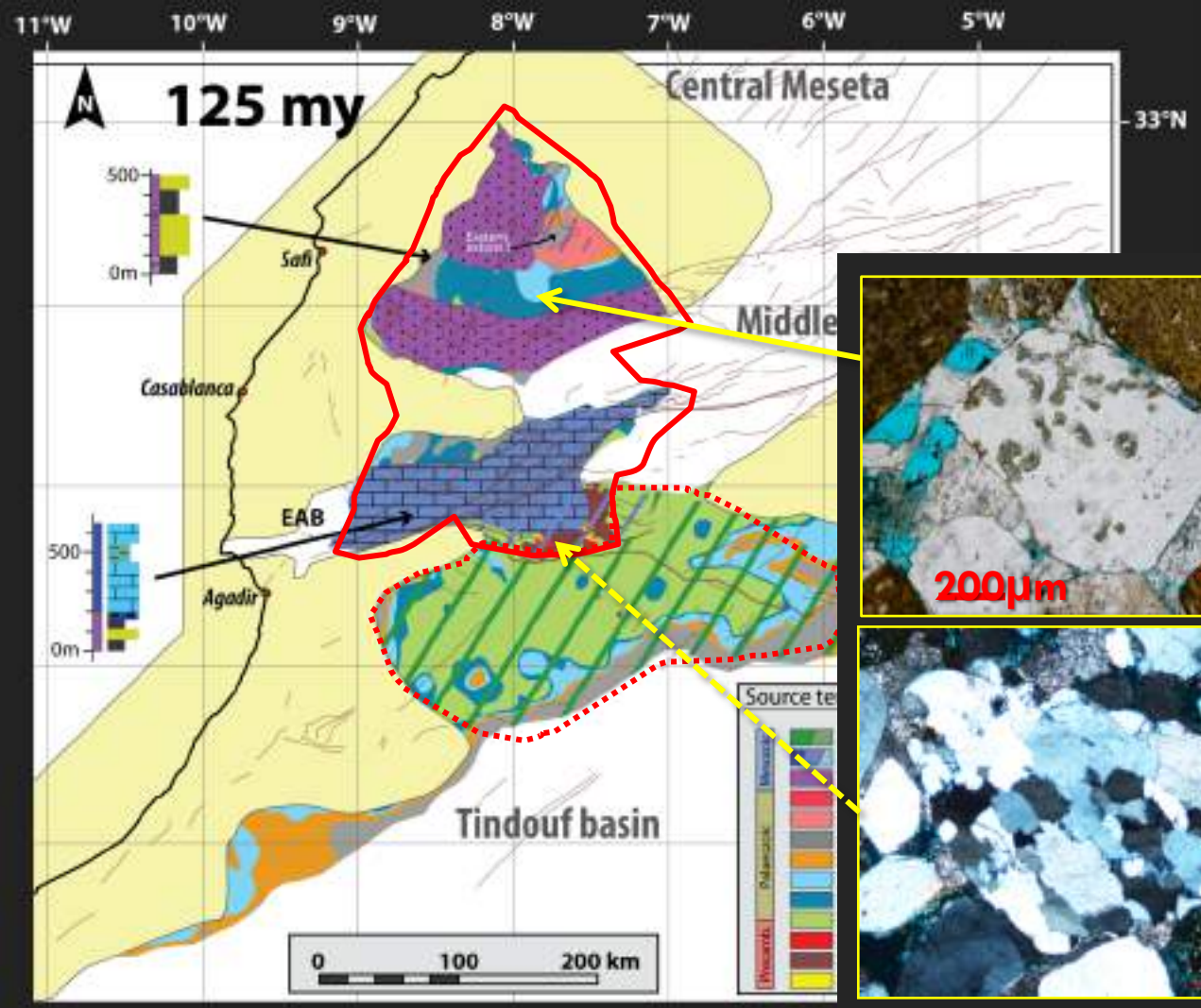
Feldspars (1st degree indicators) very rares

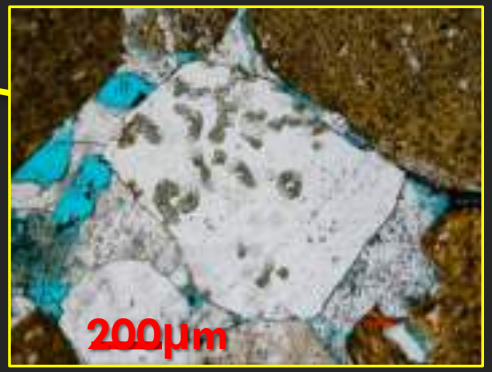


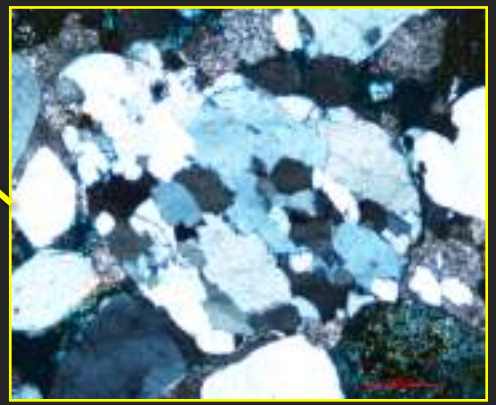




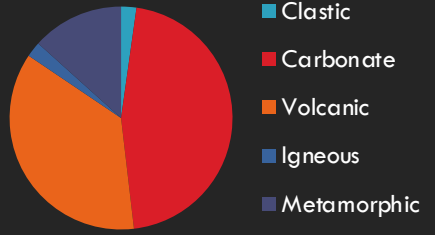




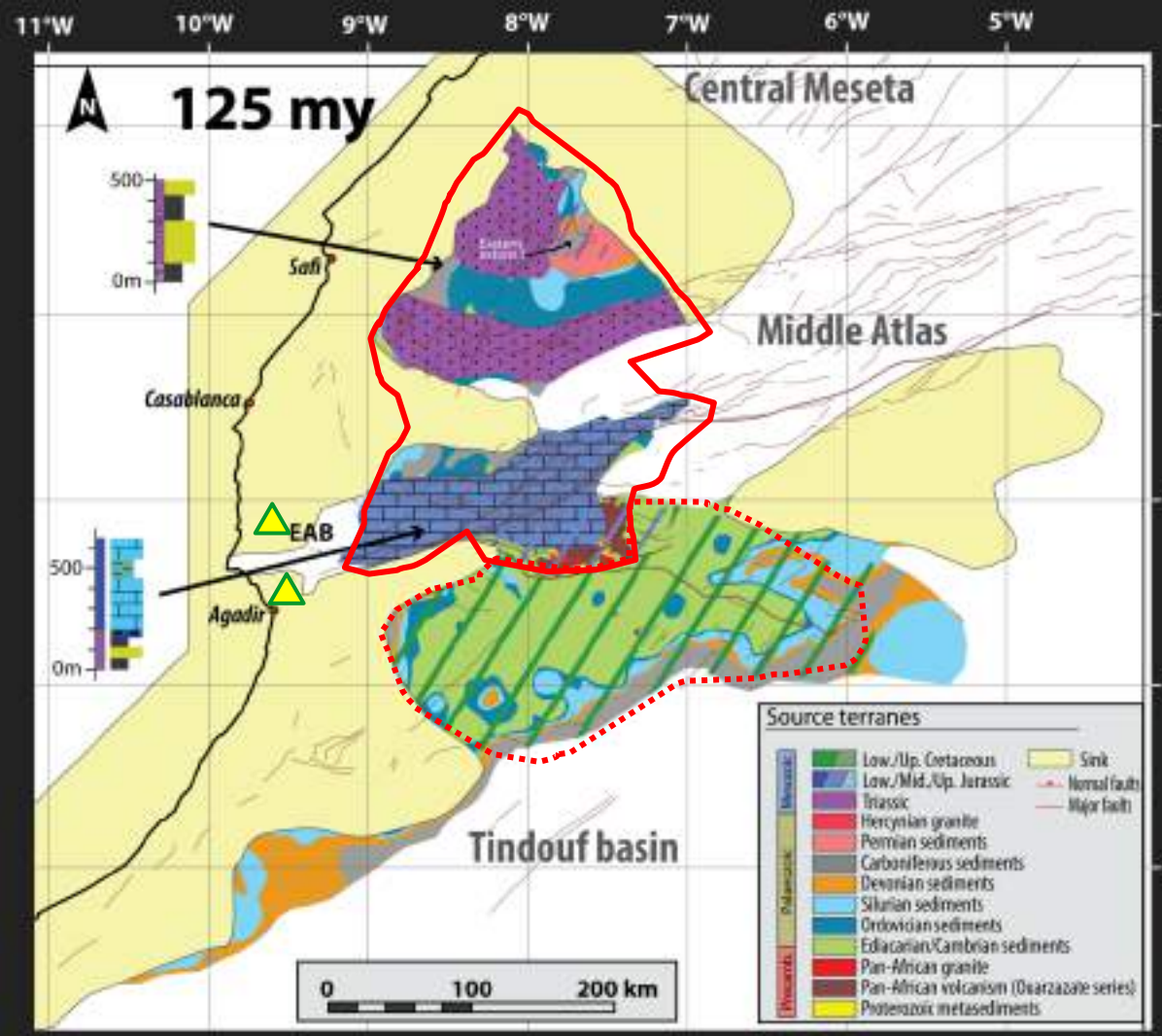


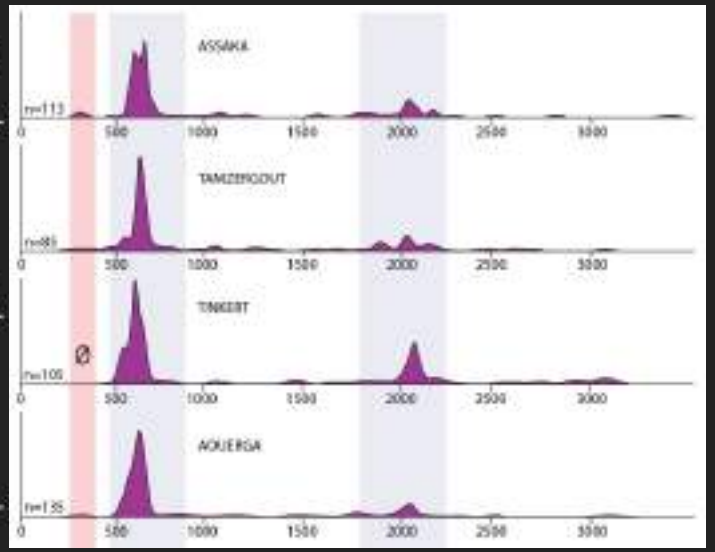


Bar-Apt fluvial

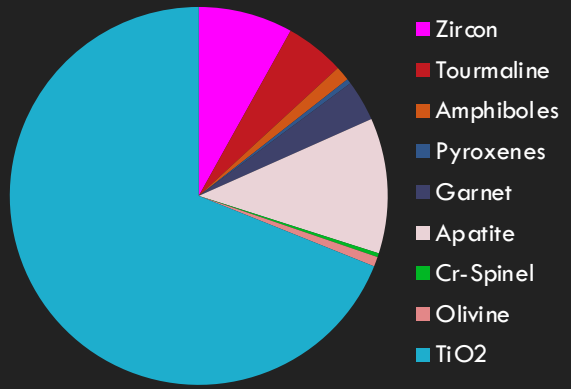


Vermicular chlorite (hydrothermal metamorphism)
Granitic clasts (MAM or recycled)





125 My Bar-Apt



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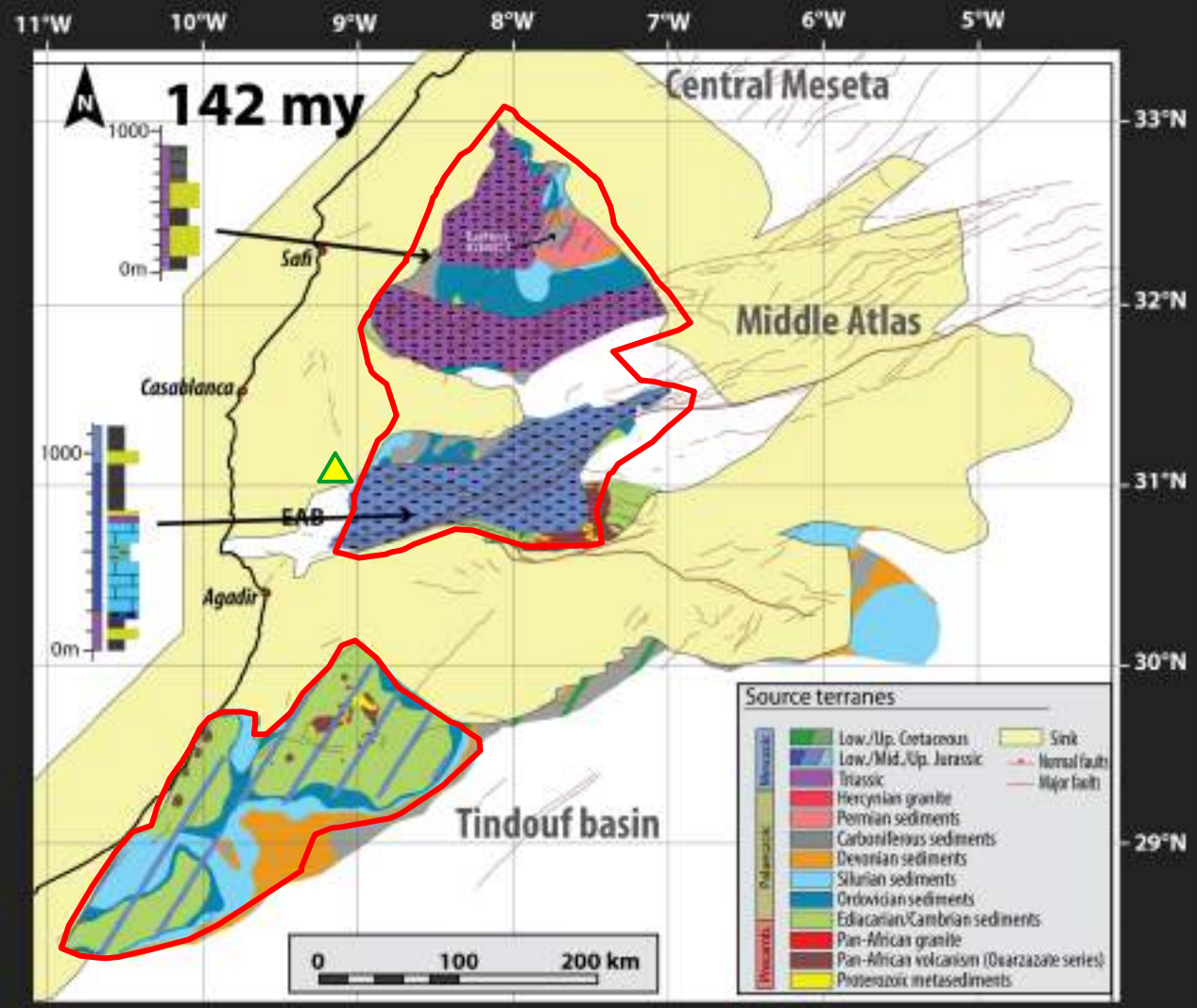
II – Source to Sink correlations

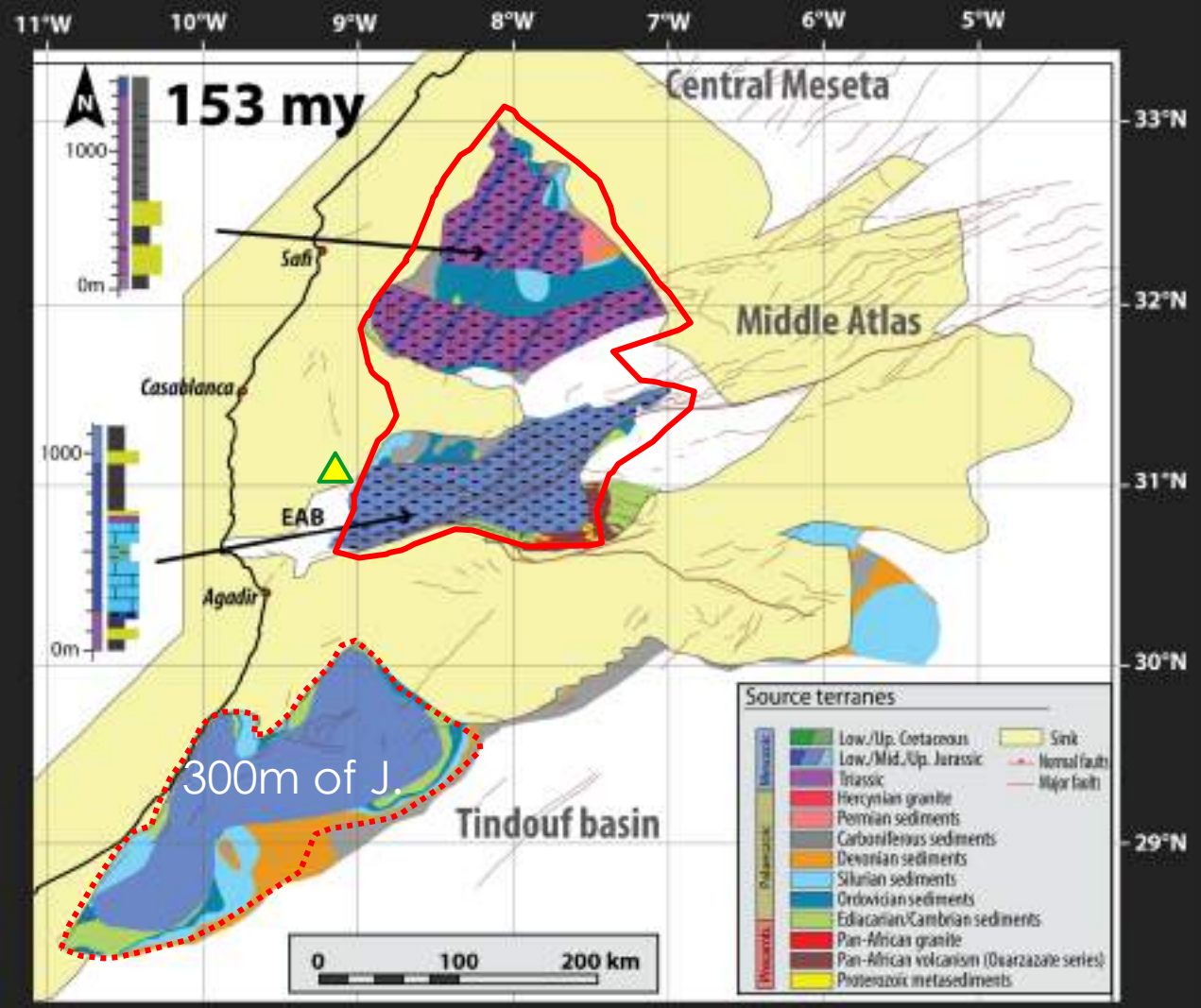
b) Mesozoic Evolution

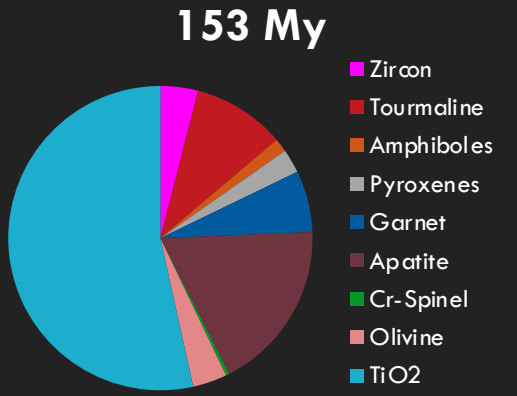


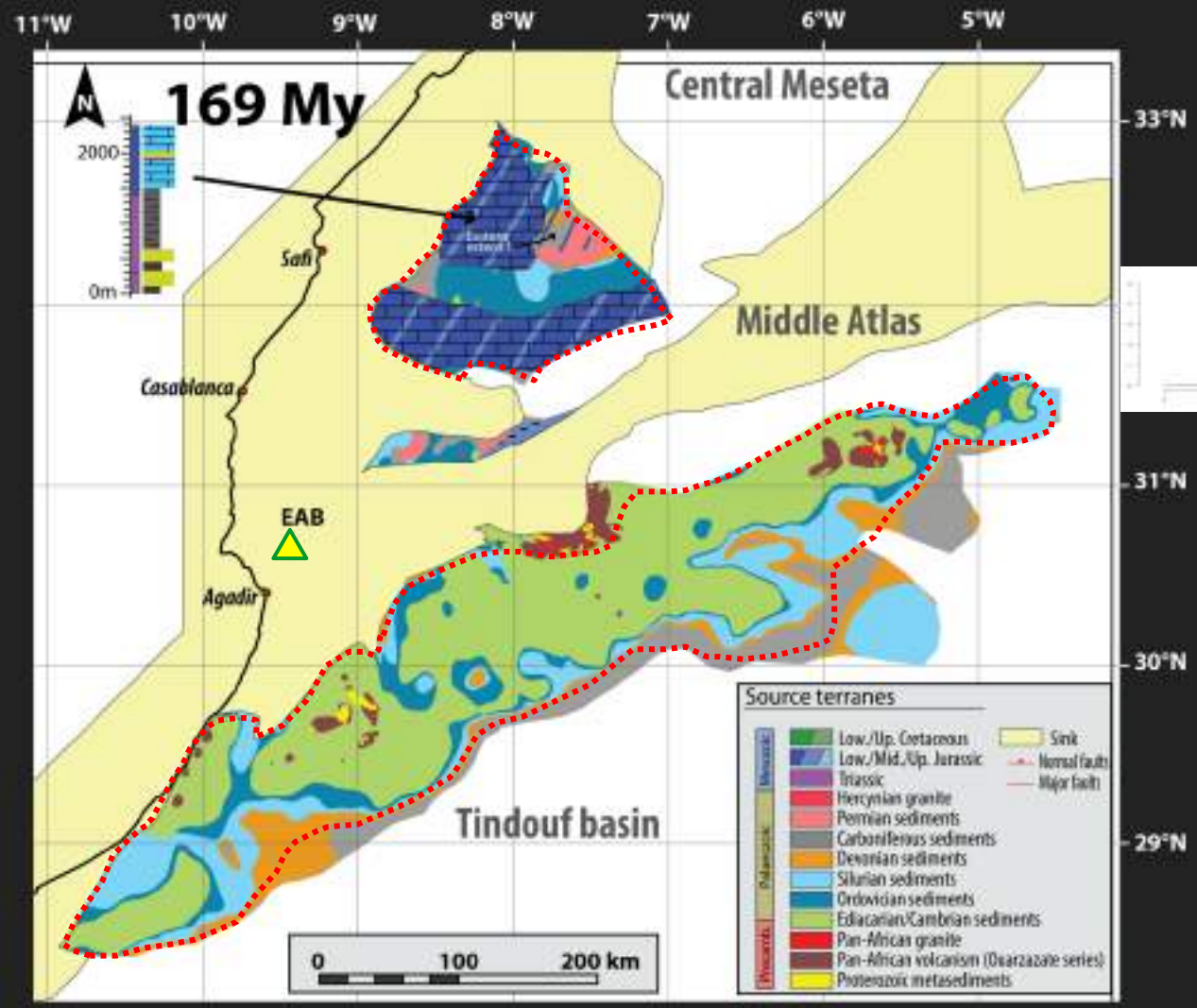
Imi N Tanout :

ONGOING

Imi N Tanout & Imi N Tanout West







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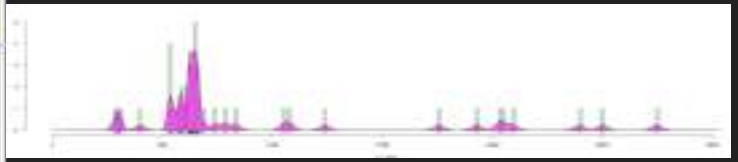
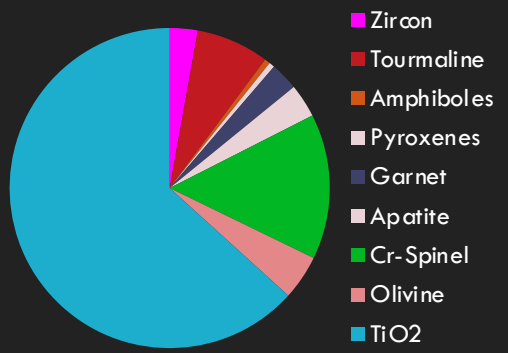
Assif El Hade



169 My



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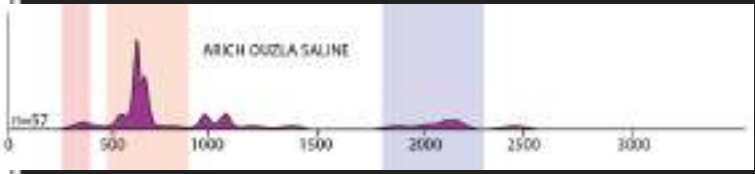

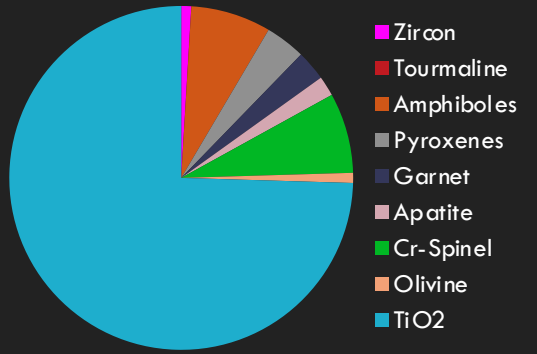

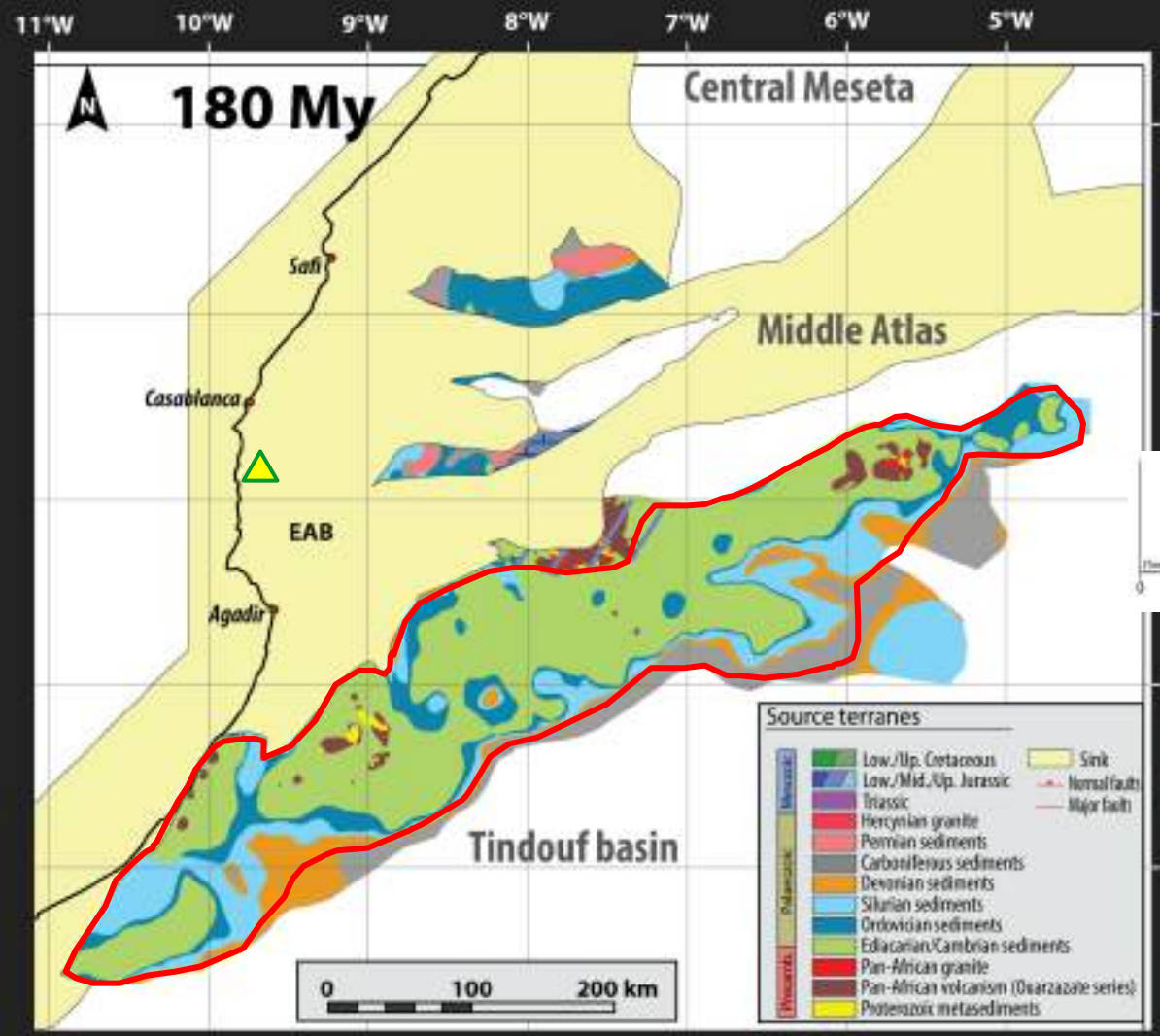

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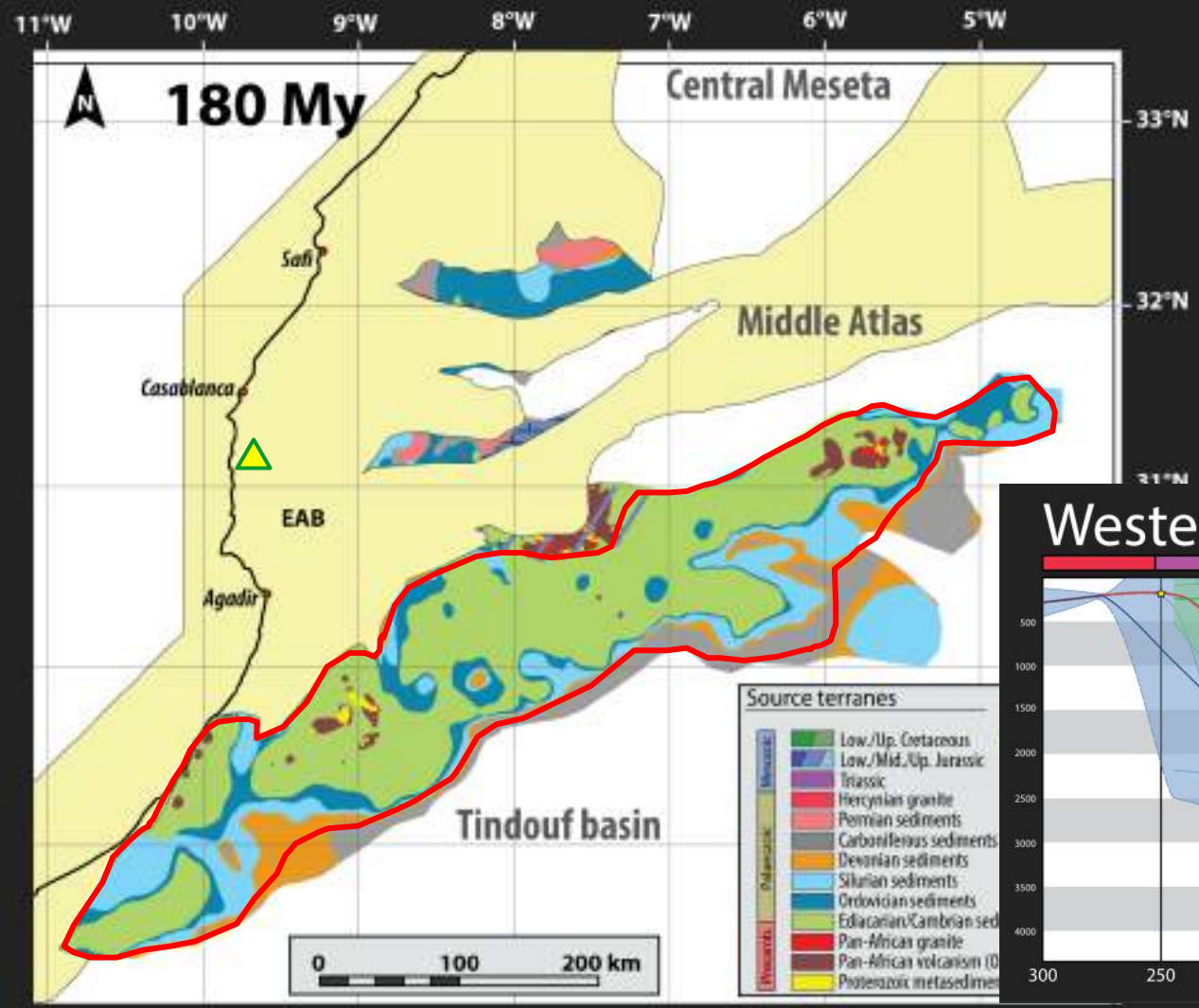
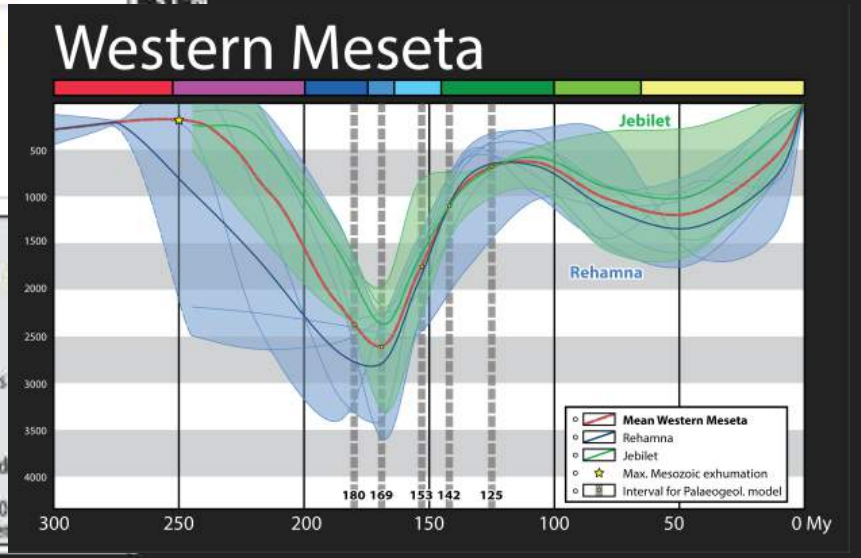
Arich Ouzla Saline





Source-to-Sink Correlations

Sum up:

- Sources of sediment likely from **MAM and Western Meseta** during the Bar-Apt. regression,
- Palaeogeological maps correlate with the **sediment grade** delivered to the fluvial system
- Very high degree of **recycling** throughout the Mesozoic observable in TS, HM and detrital zircons

QUESTIONS ?

Conclusion

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- Selection of the **main source candidates and main sediment sourcing lithologies** based on the **thermal history** of the margin

- Petrographic evidence of **source mixing** and highly probable contribution of the **Massif Ancien de Marrakech (MAM) and Meseta,** possible contribution from the south during the Jurassic

- Modelling of the geological formations exposed during the Mesozoic allows correlations between the basin and the surrounding terranes, and **discrimination among potential sources.**

Next steps

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- Raman quantification of polymorphs
- Integration of a Lower Cretaceous outcrop in the Essaouira basin (Imi N Tanout)
- Integration of TS statistical data (Point counting and Rock Fragments populations in the Jurassic)
- Considering conducting heavy mineral analysis on the Triassic of the EAB.

Thank you for your Support :

North Africa Research Group

Special thanks to :

Research partners :