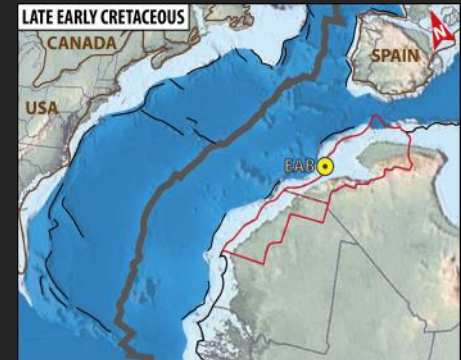


Integrated source to sink analysis of NW Africa :

*Provenance of the Barremian to Aptian
coarse sandstones of the EAB*

Emmanuel **Roquette**, 2nd year PhD student



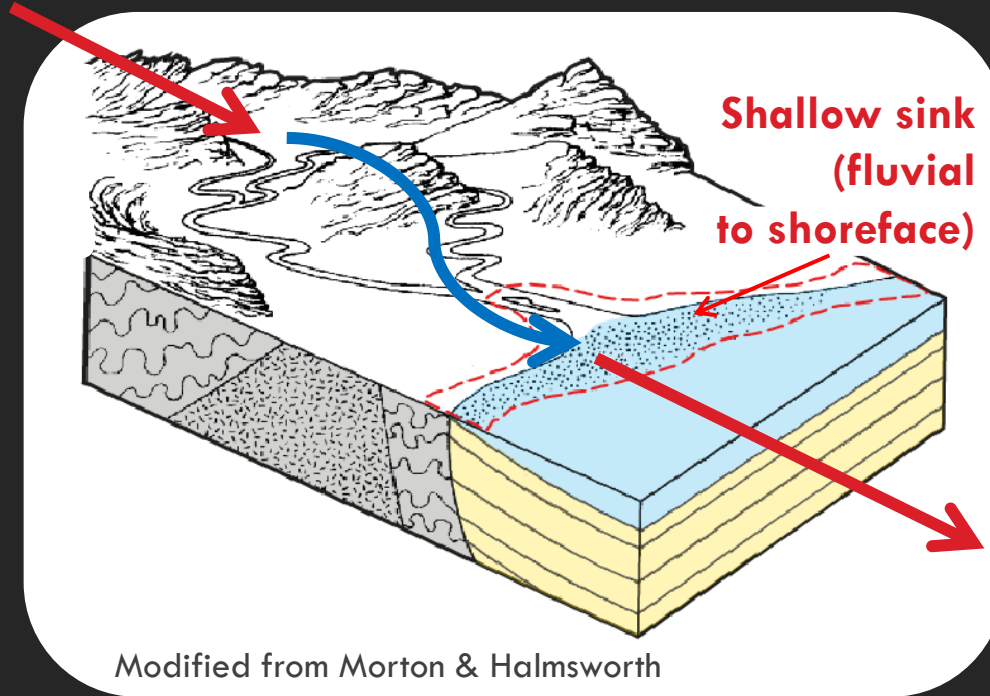
Introduction

SOURCE

Quantity,
timing and nature of
the sediment

TRANSPORT

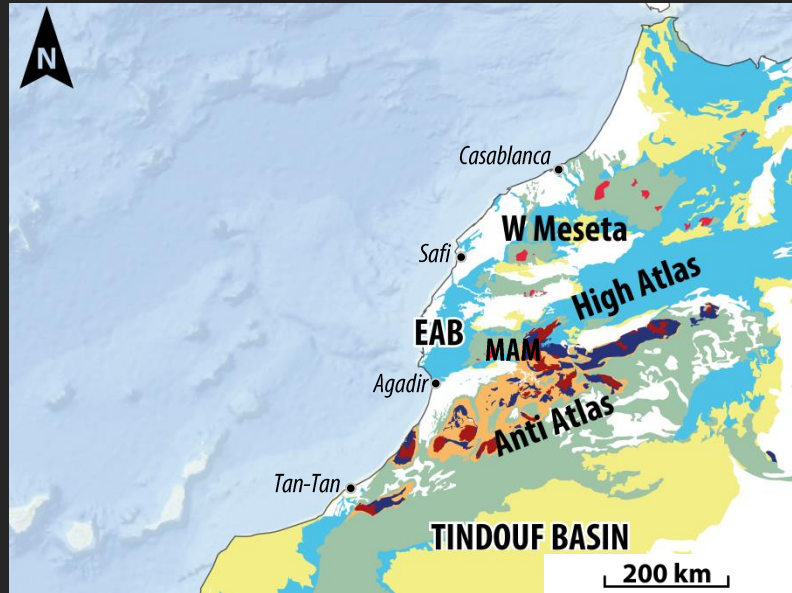
Texture,
maturation,
storage, mixing



BASIN

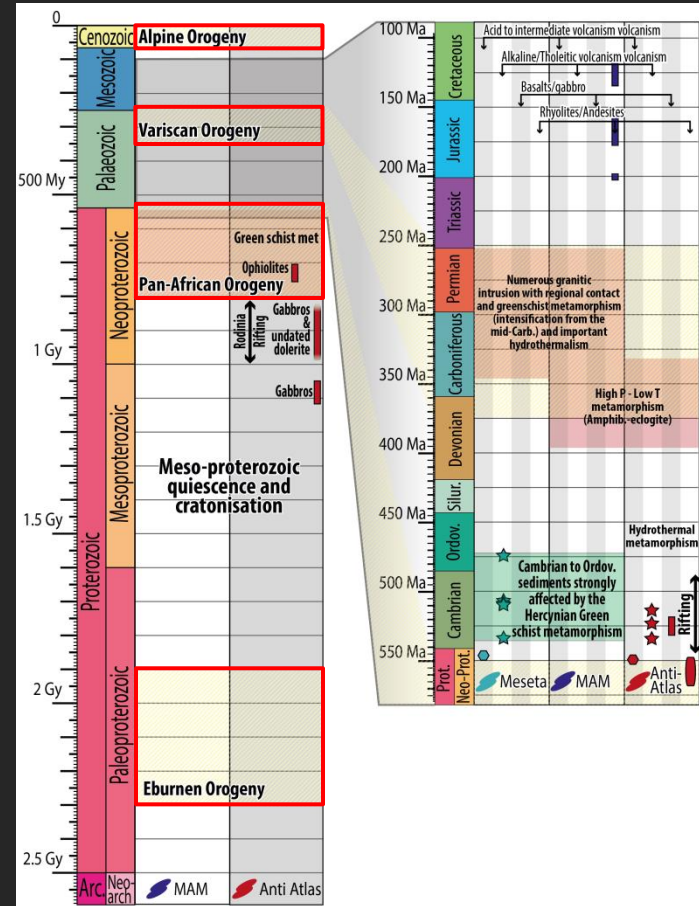
Deposition
processes,
compaction,
diagenesis

Tectonostratigraphic framework

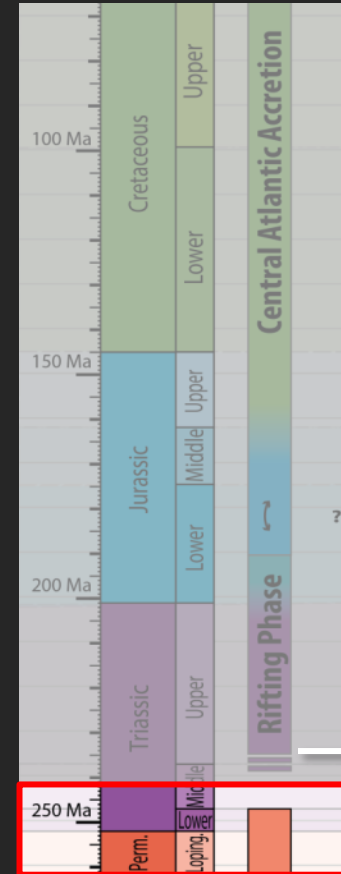
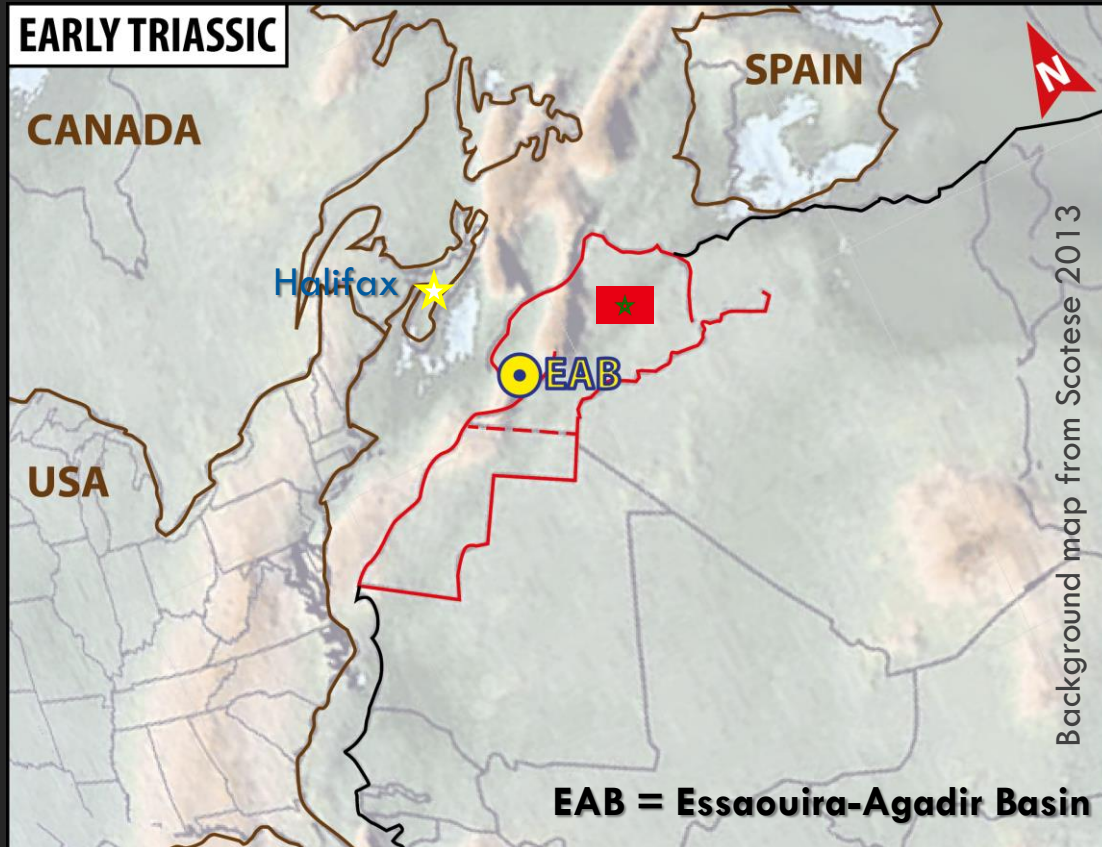


4 main orogenic cycles :

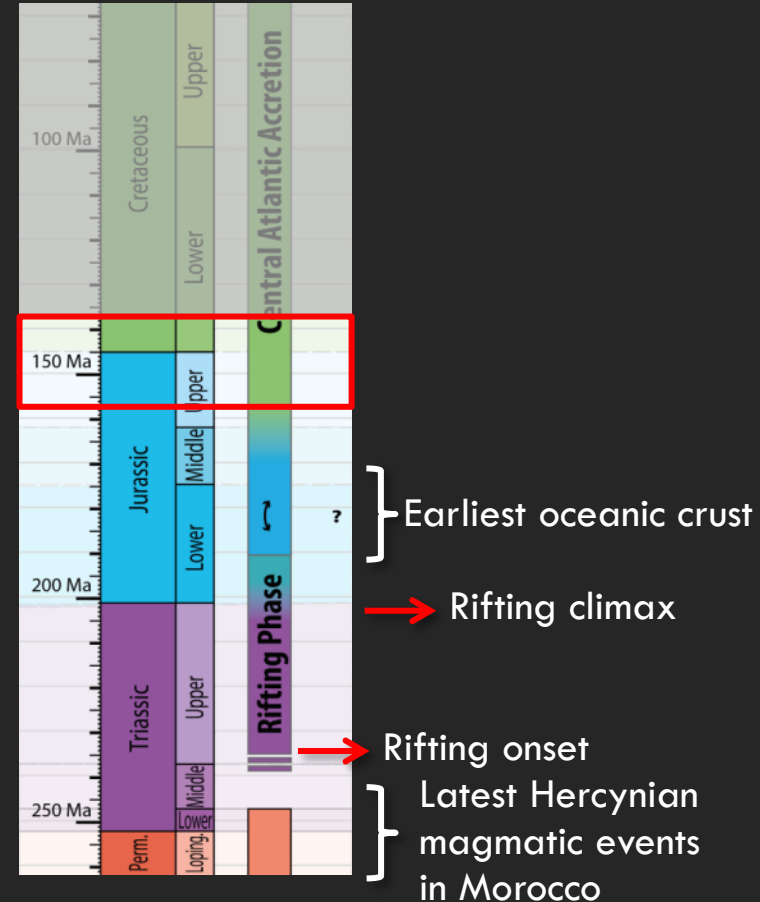
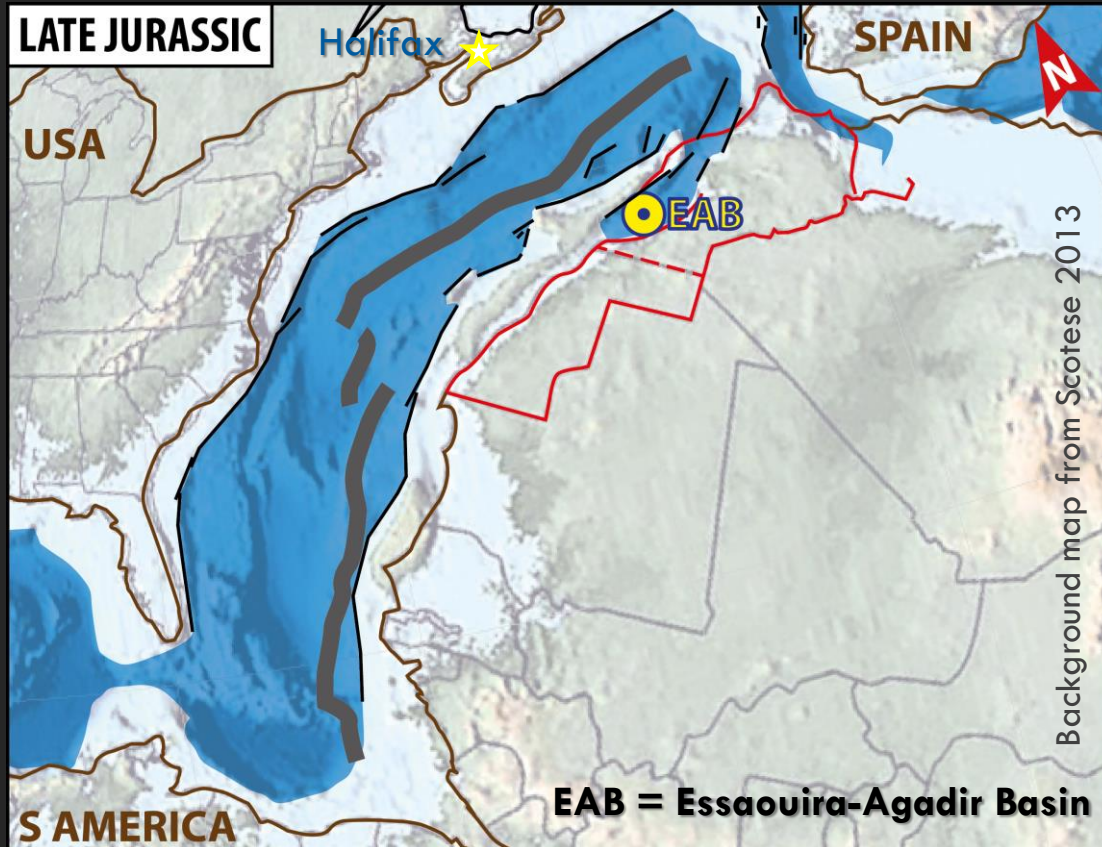
- Eburnean
- Pan African
- Variscan
- Alpine



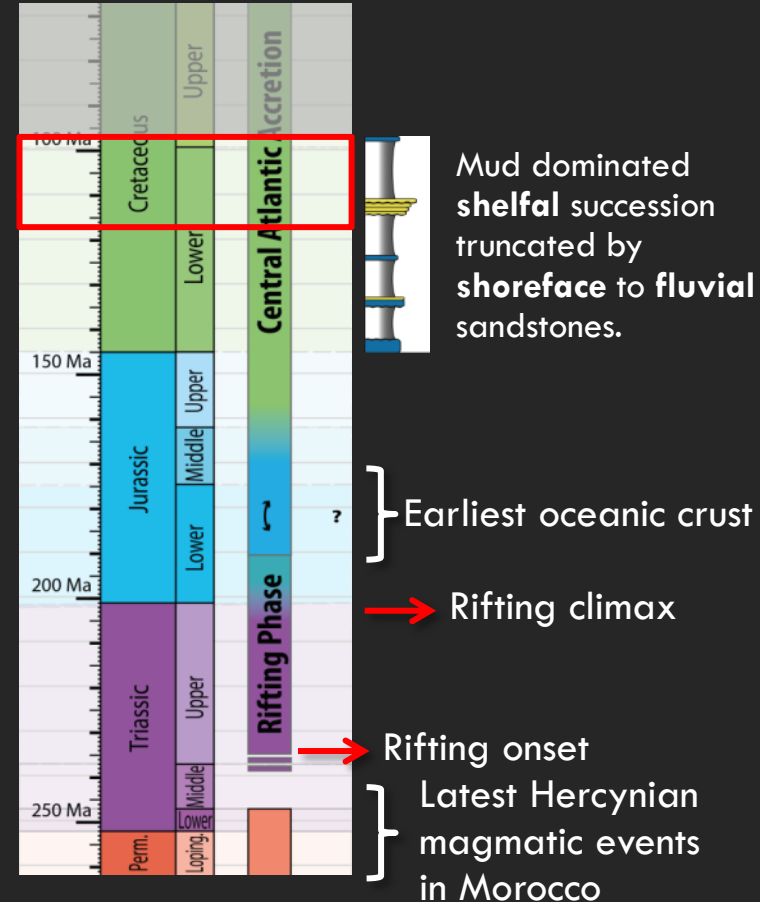
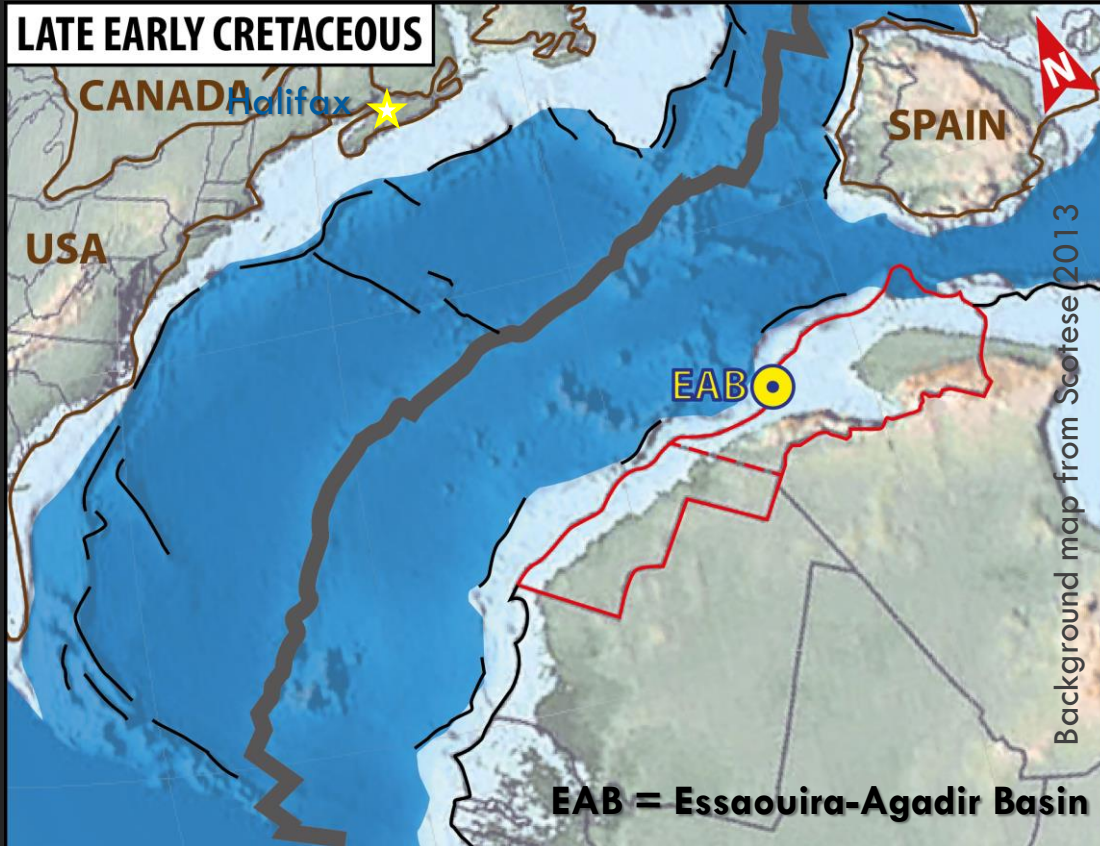
Tectonostratigraphic framework



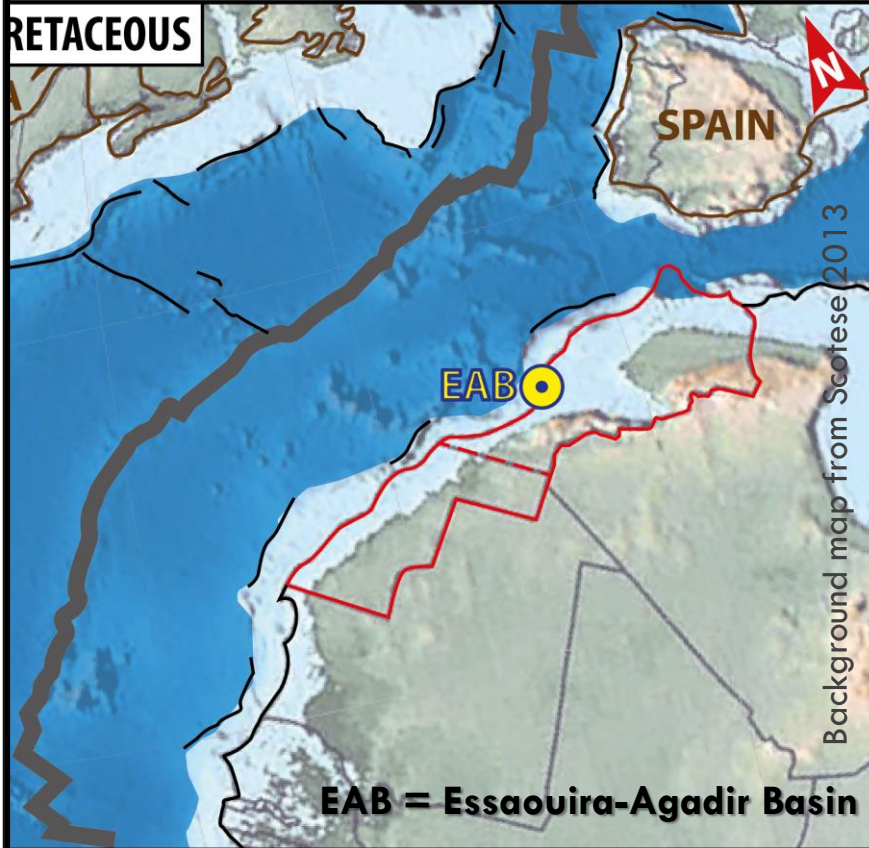
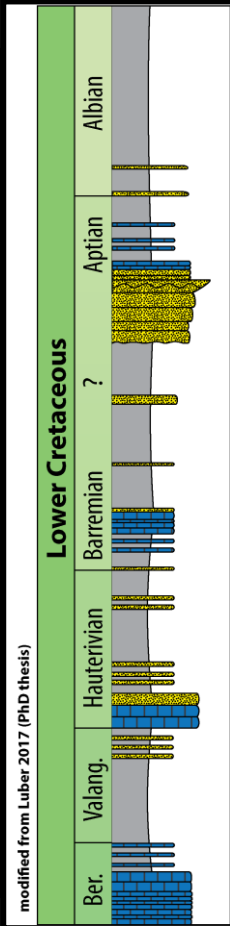
Tectonostratigraphic framework



Tectonostratigraphic framework



Tectonostratigraphic framework



Lower Cretaceous :

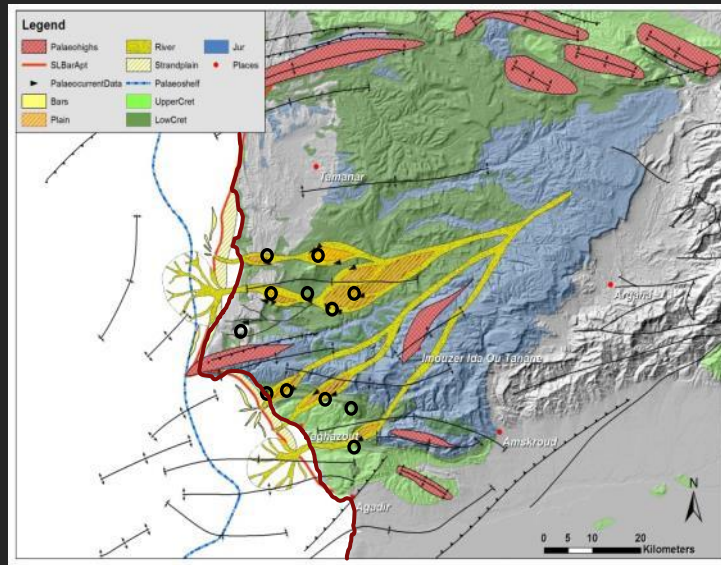
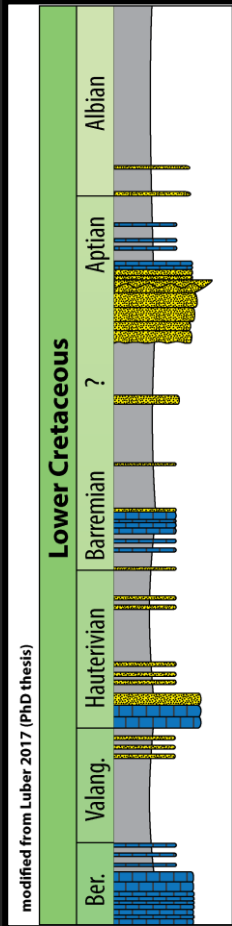
Mud dominated **shelfal** succession truncated by **shoreface** to **fluvial** sandstones.



Lower Cretaceous exposure

Tectonostratigraphic framework

Interval of interest: Fluvial to shoreface sandstones of the **Late Barremian to Earliest Aptian** regressive succession



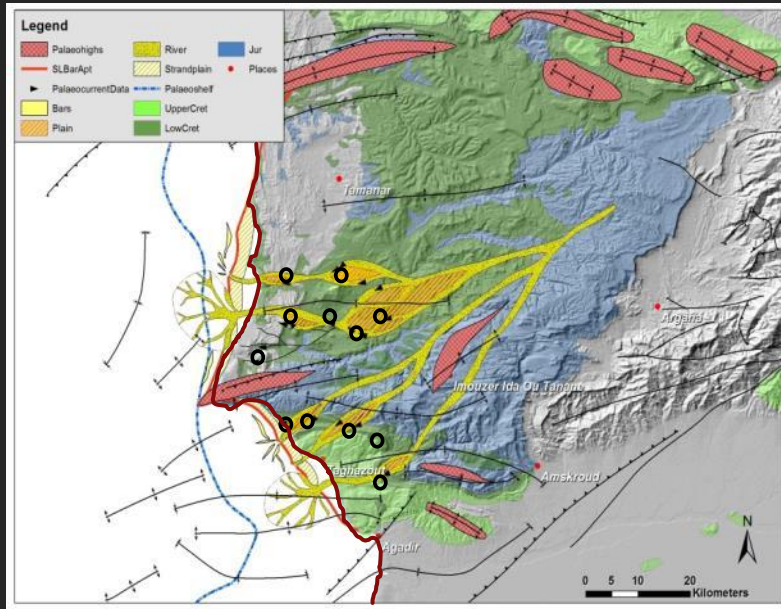
EAB = Essaouira-Agadir Basin



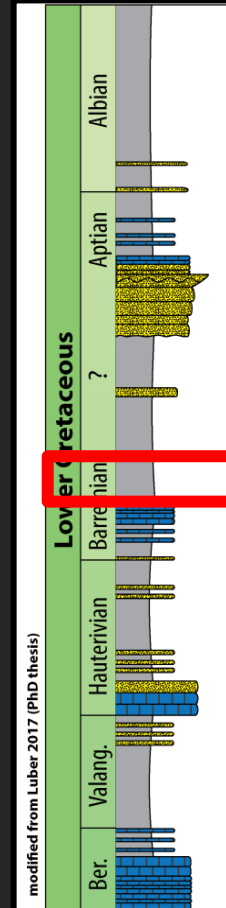
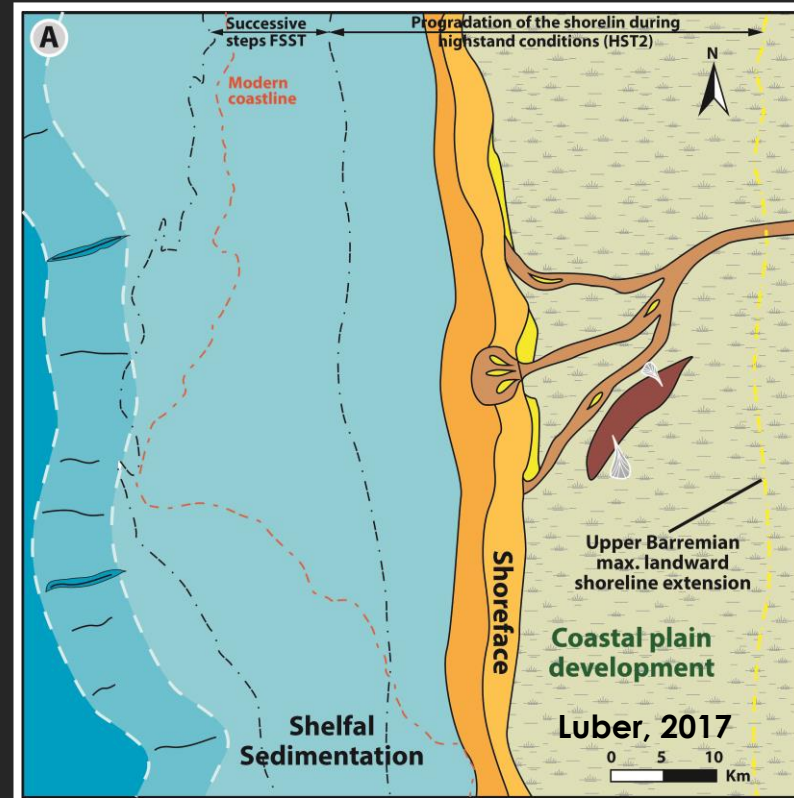
Lower Cretaceous exposure

Tectonostratigraphic framework

Barremian to lowermost
Aptian evolution

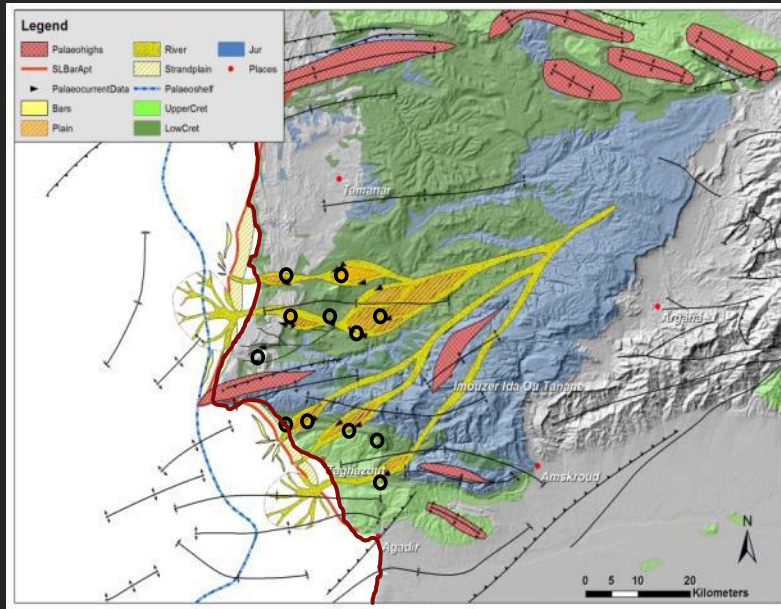


Pre-Regression - HST

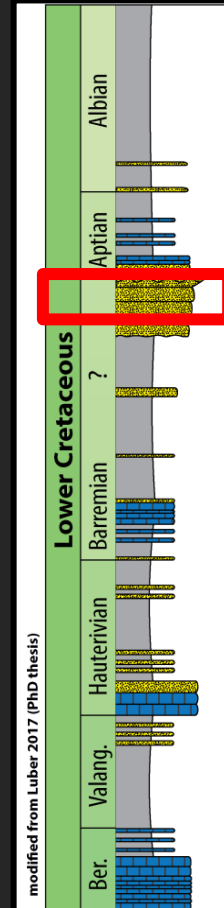
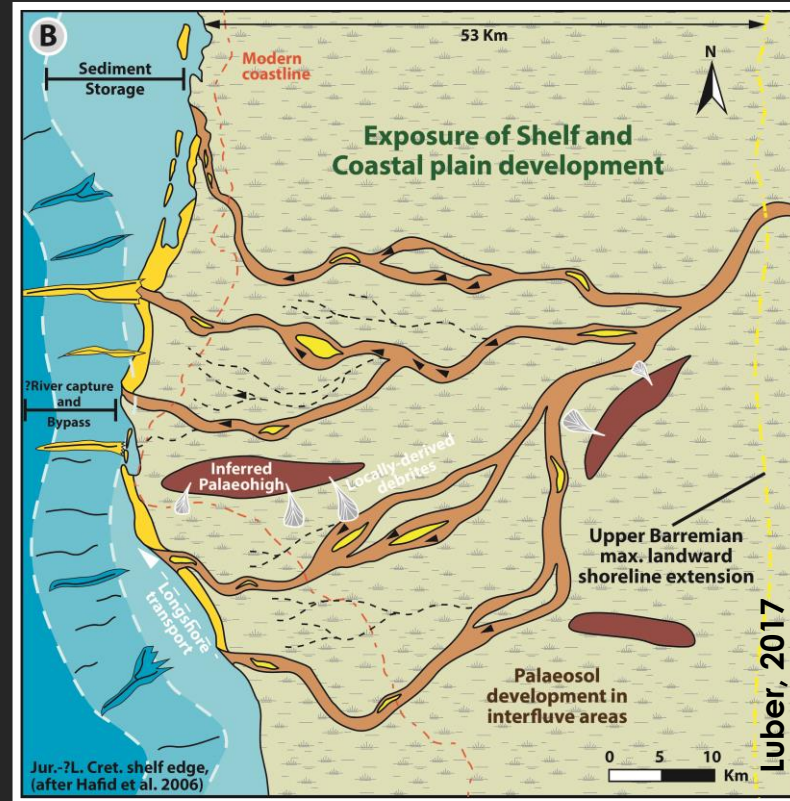


Tectonostratigraphic framework

Barremian to lowermost Aptian evolution



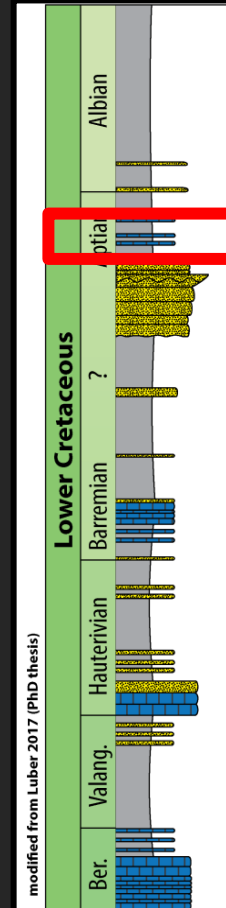
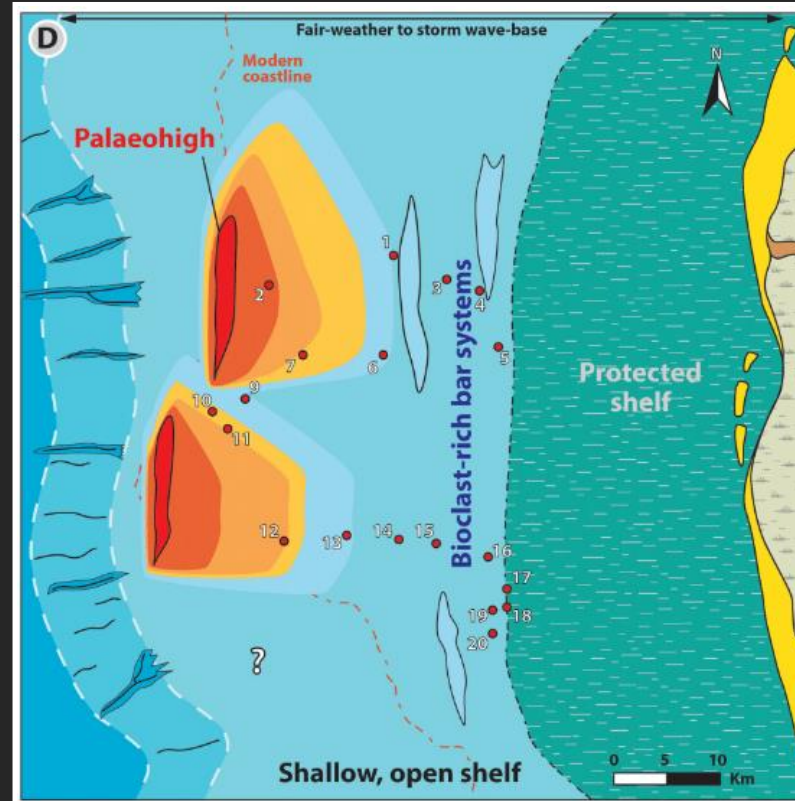
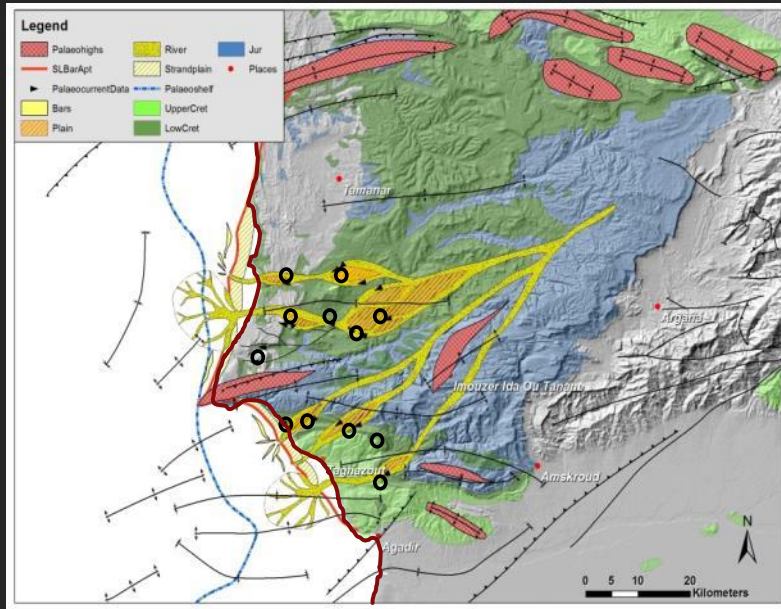
Maximum Regression - LST



Tectonostratigraphic framework

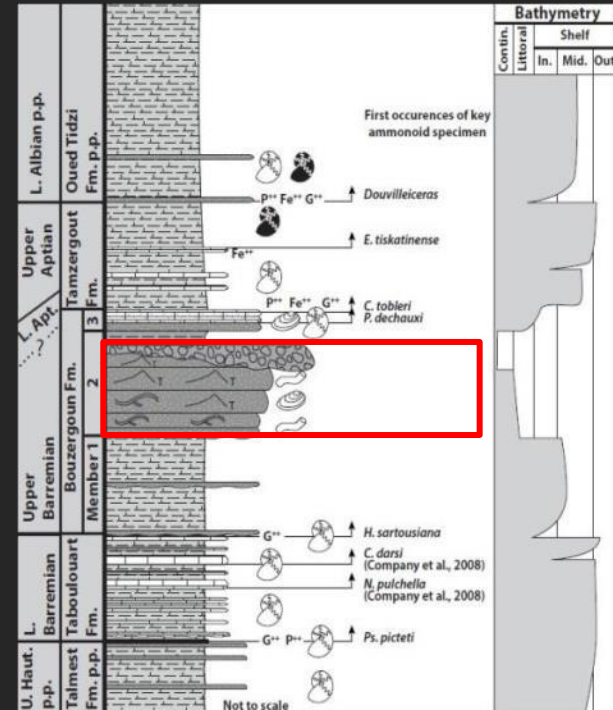
Barremian to lowermost
Aptian evolution

Pre-Regression - HST



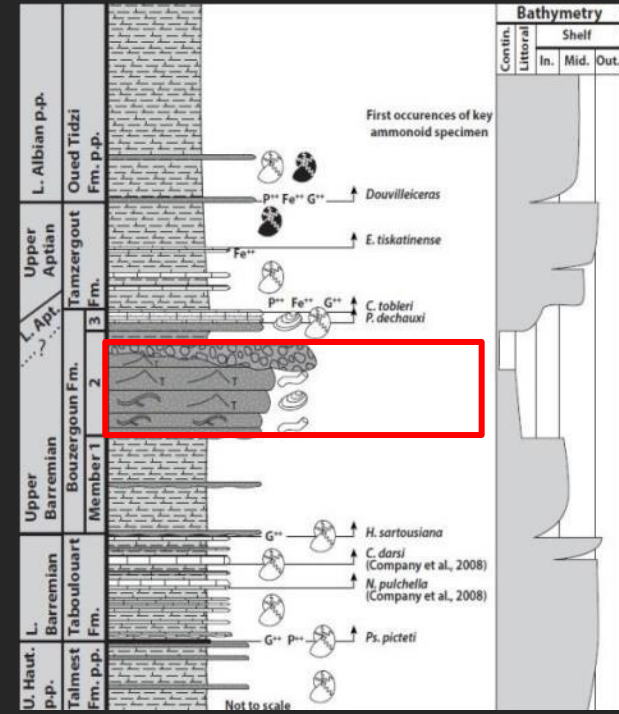
Objectives:

- Constrain the **provenance** of the **Barremian Aptian regressive interval**
- Identify shifts in the **sources** of the Lower Cretaceous **clastics** across NW Africa
- 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



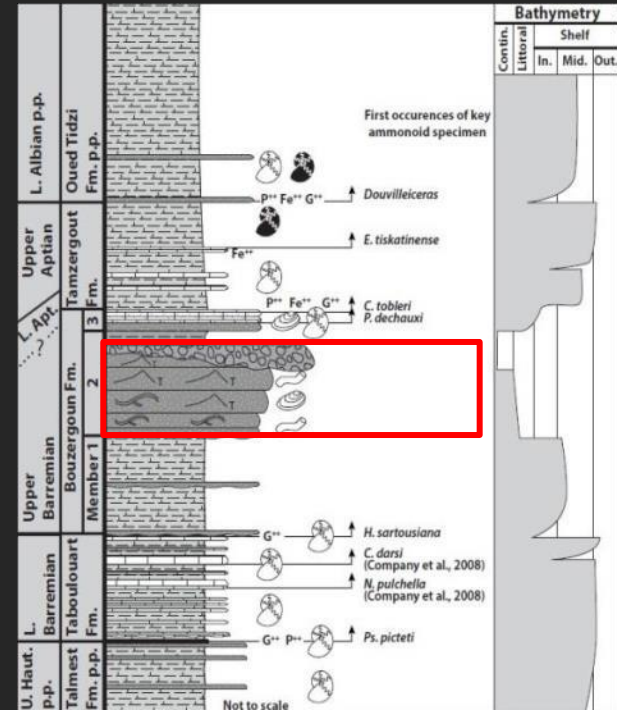
Methods:

- **Thermochronology:** assessment of the main vertical movements affecting the post rift evolution of the margin.
- **Petrography** and mineral populations supported by SEM/QEMSCAN
- **Palaeogeology modeling**
- **Zircon U-Pb Geochronology**
- **Heavy mineral analysis**



Methods:

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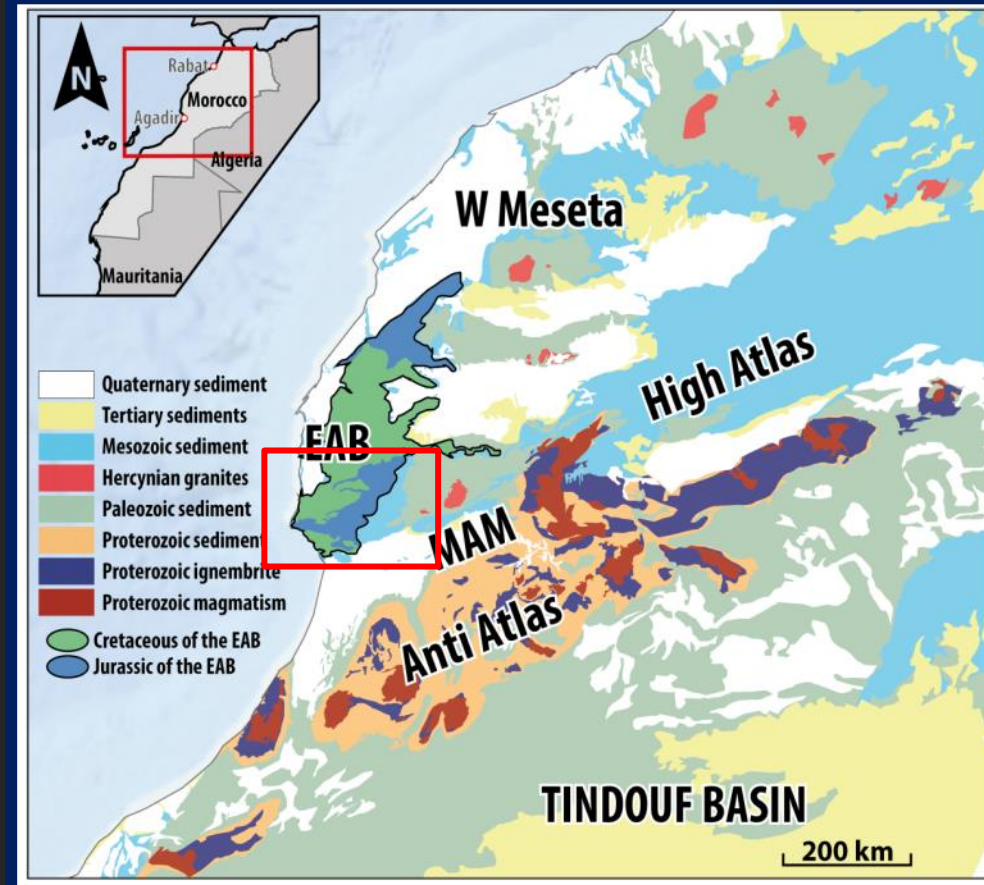
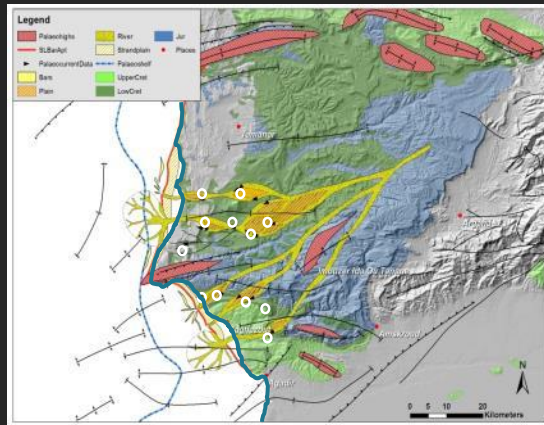


Provenance model

Western
Meseta

Massif
Ancien de
Marrakech

Anti Atlas



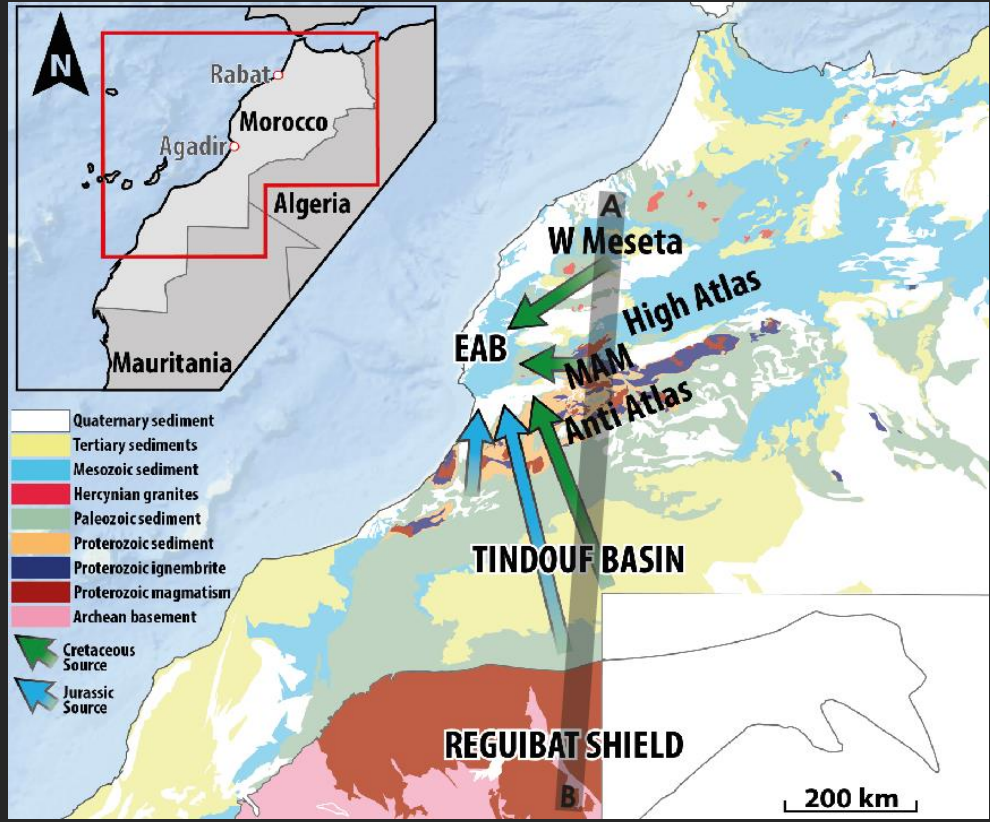
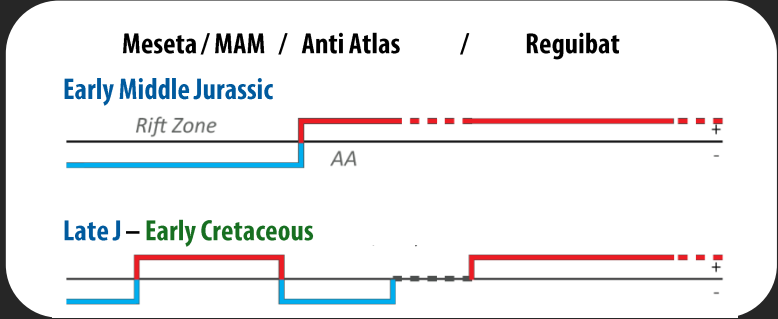
Provenance model

Western Meseta

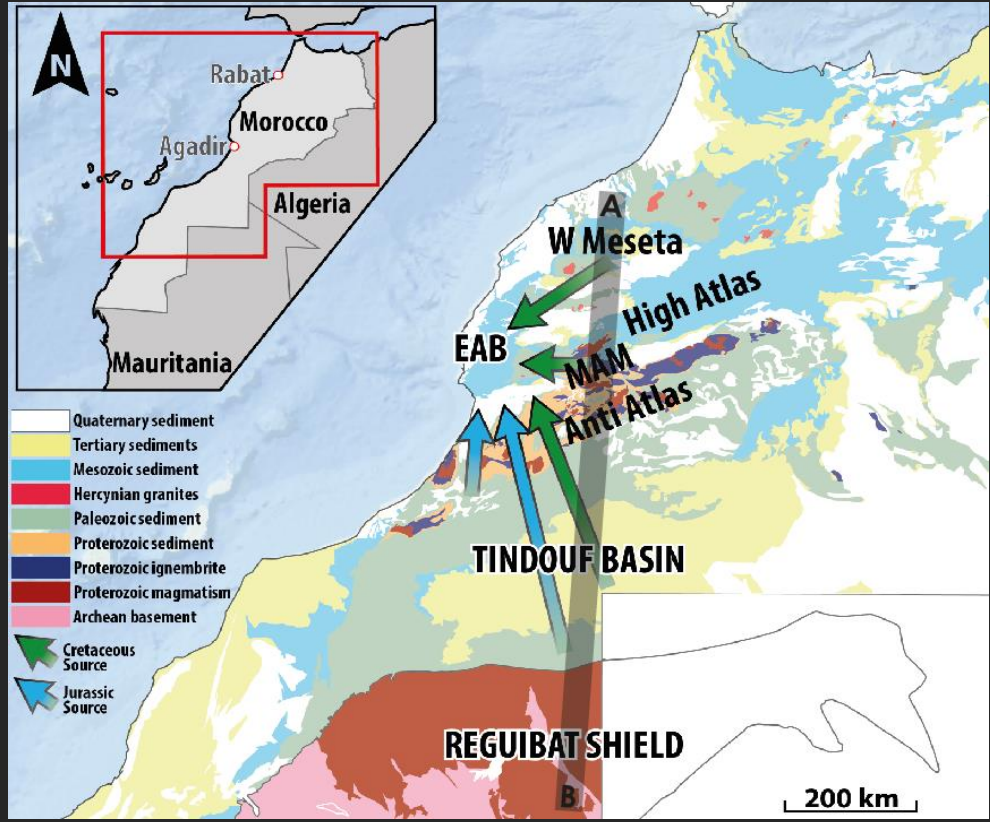
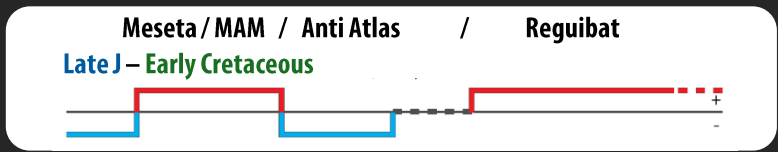


Massif Ancien de Marrakech

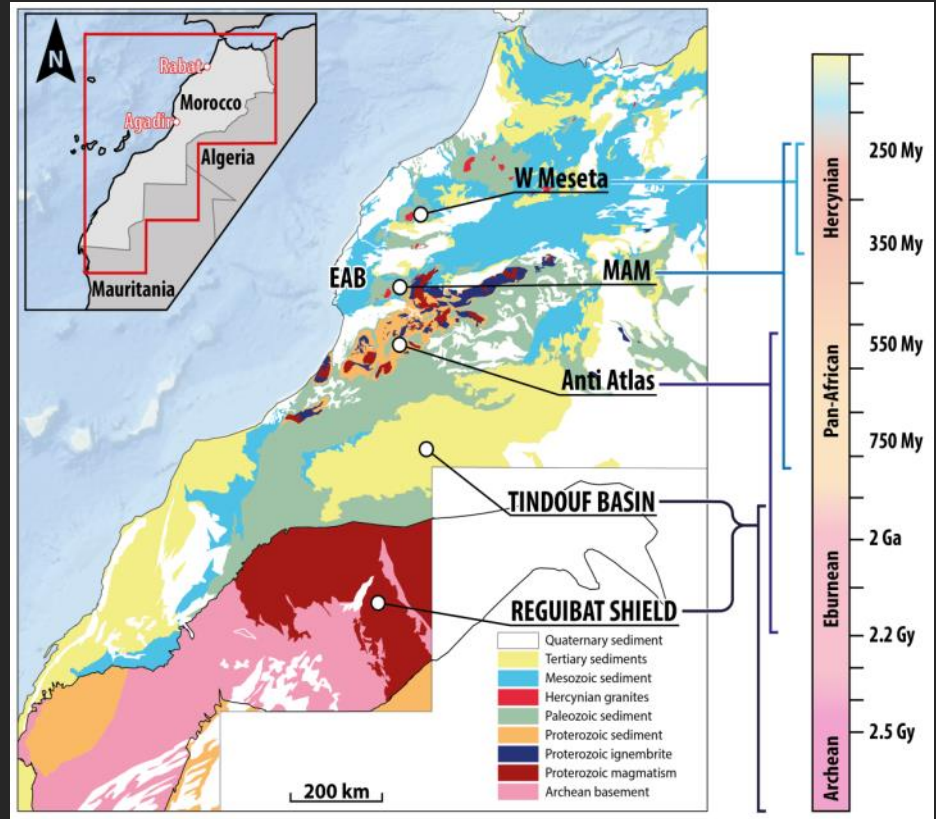
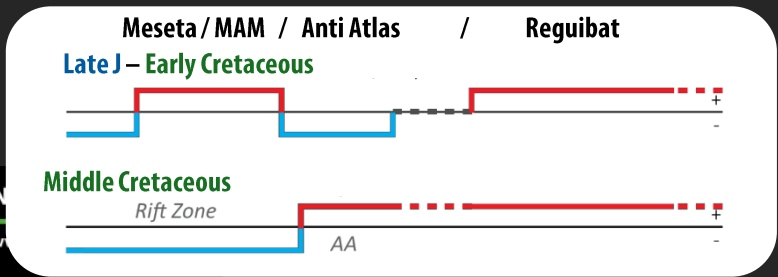
Anti Atlas



Provenance model



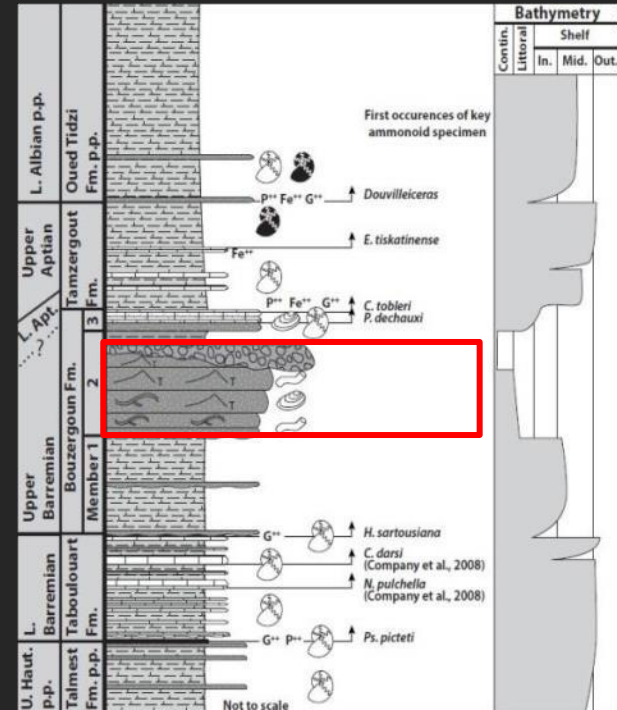
Provenance model



Increasing ages southward

Methods:

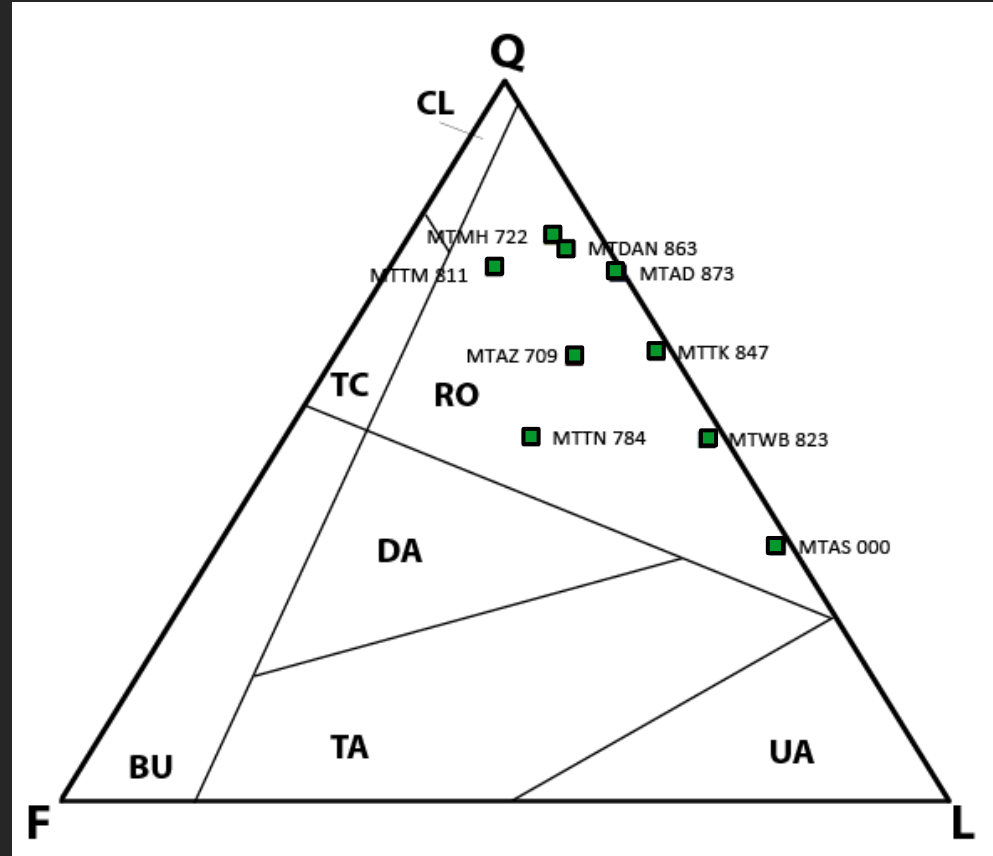
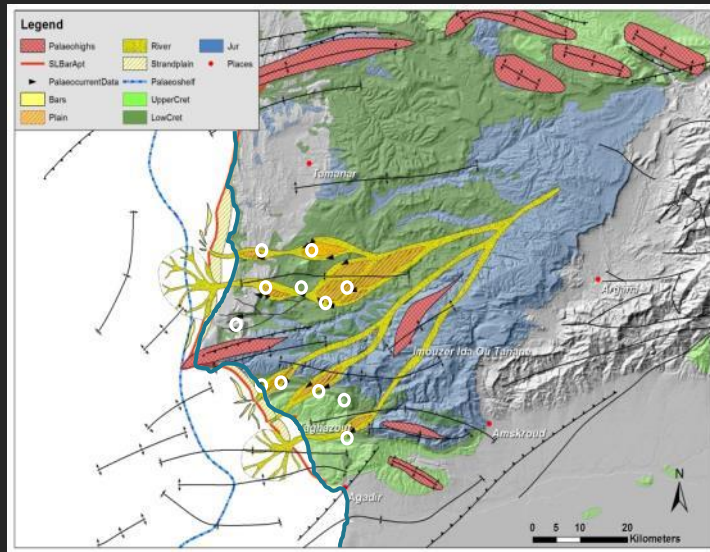
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- **Zircon U-Pb Geochronology**
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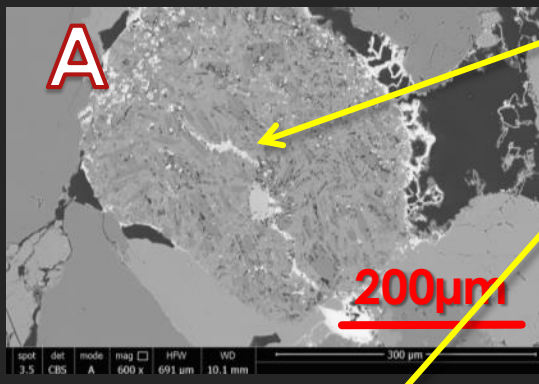
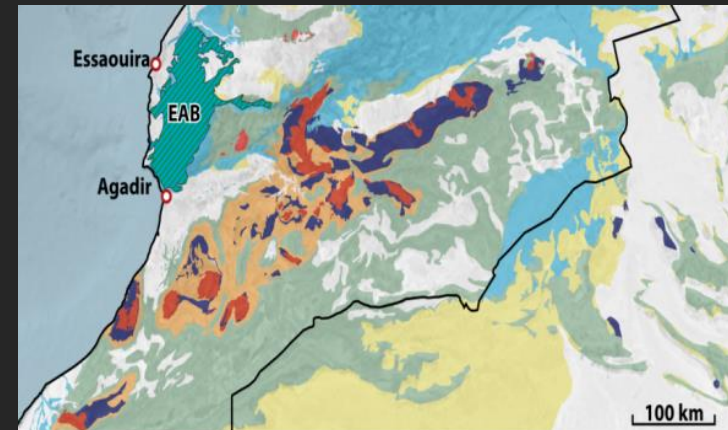
Petrography:

QFL

- Recycled orogen,
- No visible trend north and south of the paleo-high



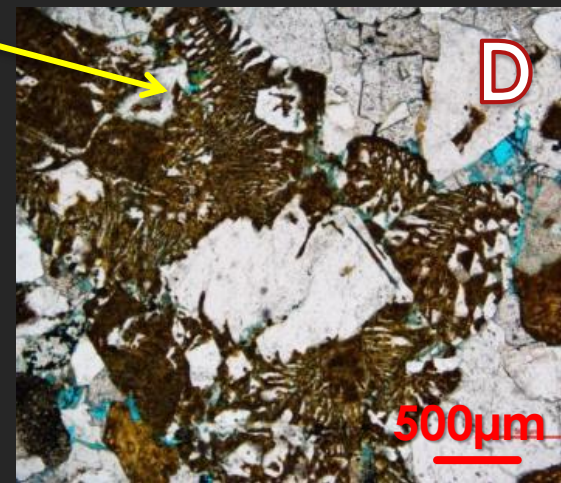
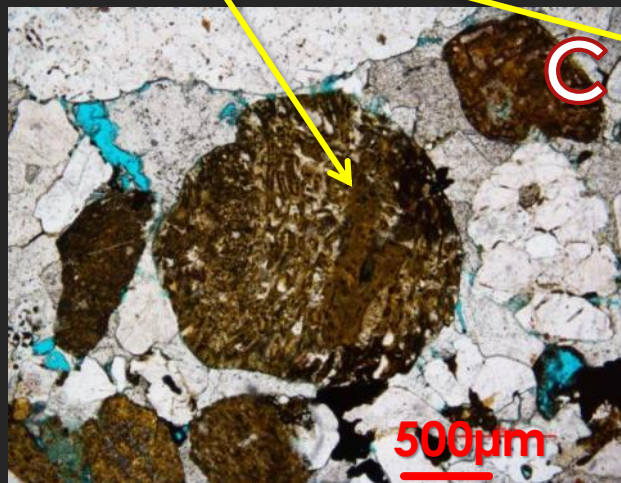
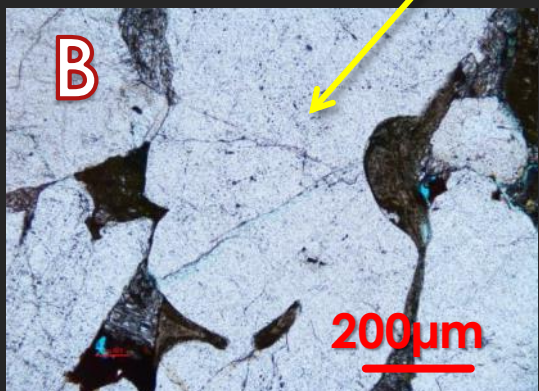
Petrography: Volcanic products



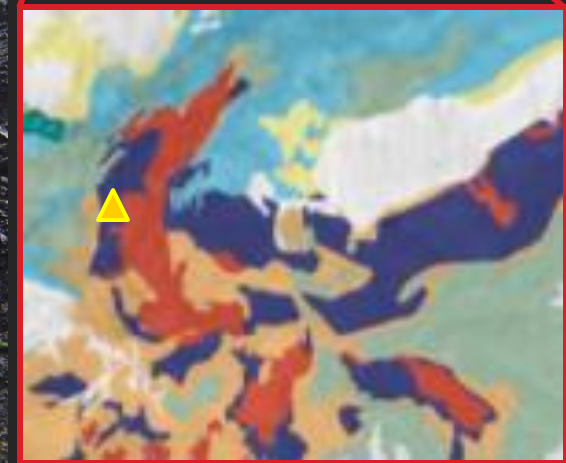
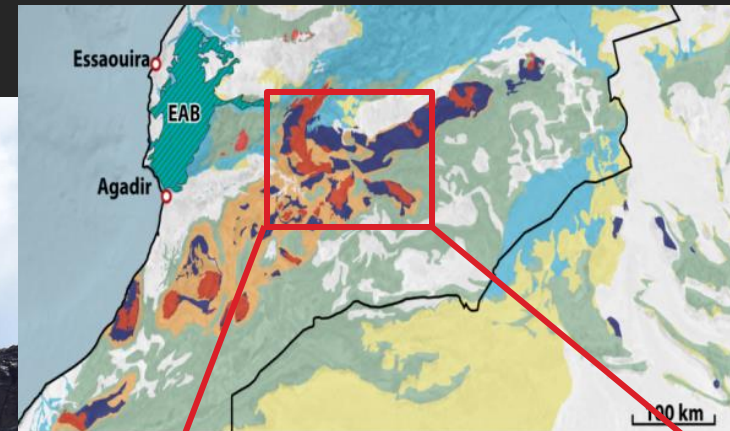
Rhyolite

Embayed Quartz
(pyroclasts)

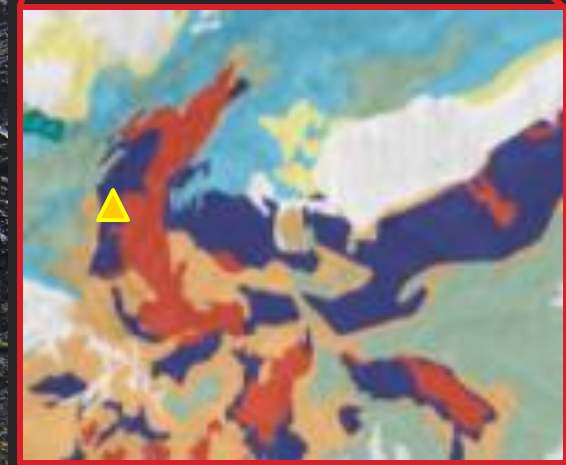
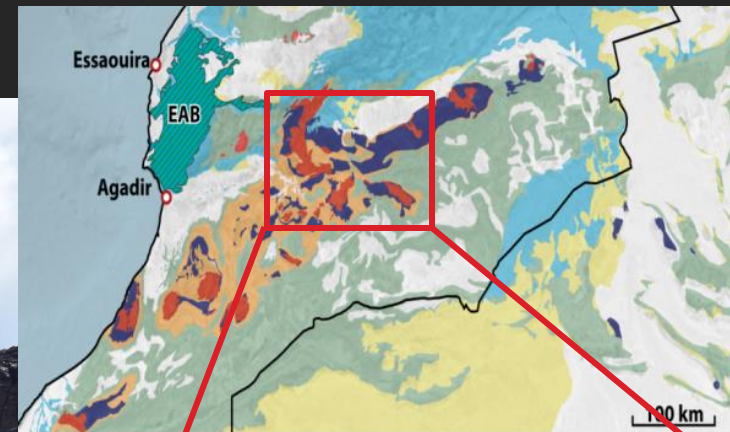
Pumice, ignimbrite ?



Petrography: Volcanic products



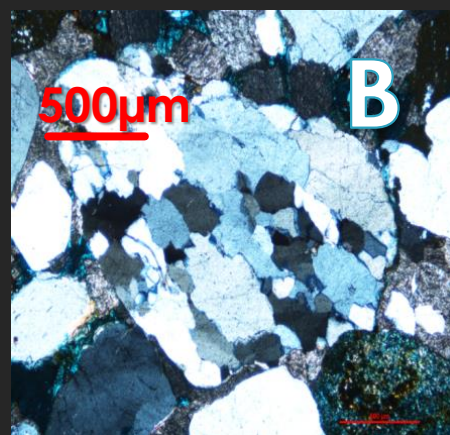
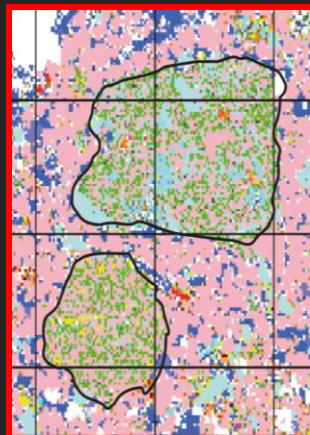
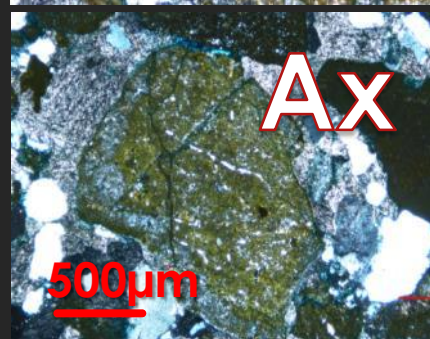
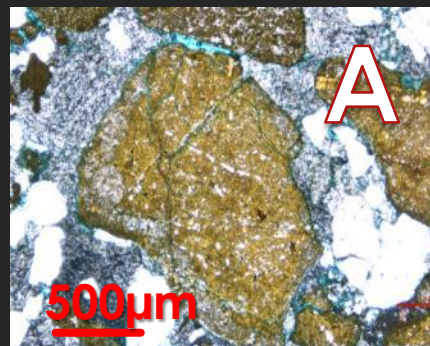
Petrography: Volcanic products



Petrography: recycling of sediments

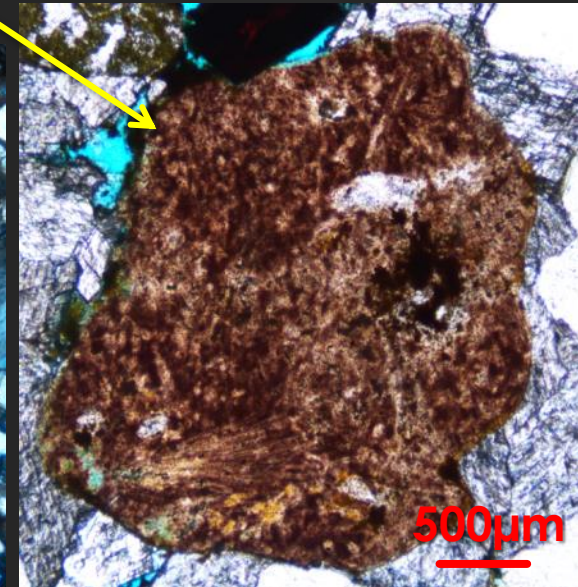
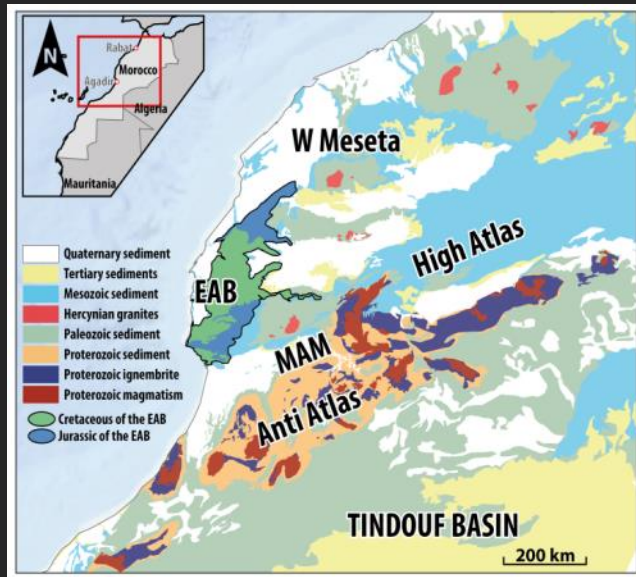
1st or 2nd
cycle origin ?

Feldspars : - 1st origin indicator
(unlikely to survive recycling)
Granitic clasts
Vermicular chlorite
(hydrothermal metamorphism)



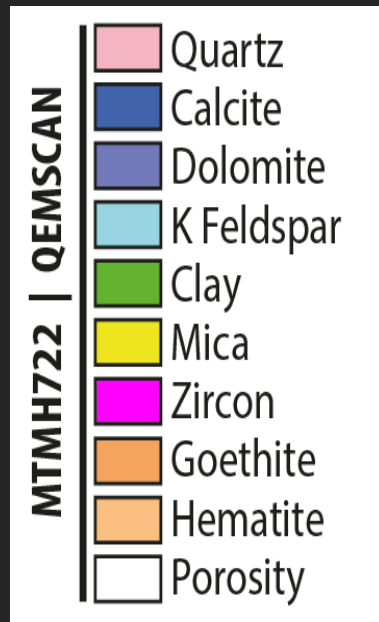
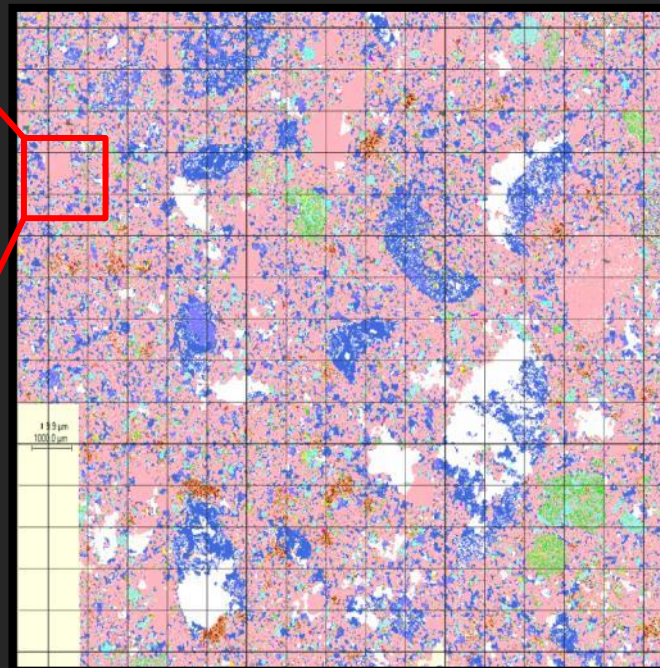
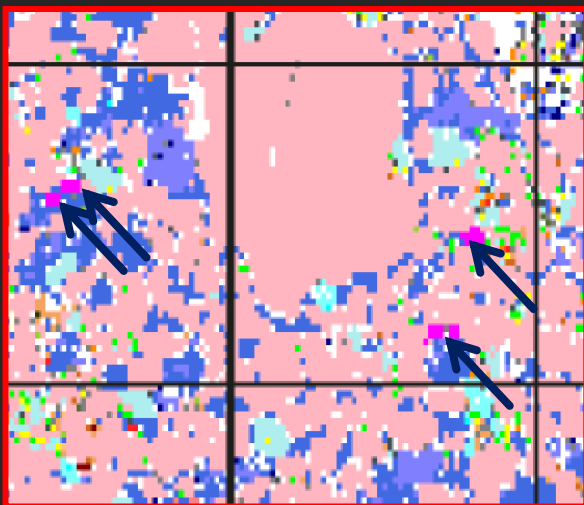
Petrography: Intrabasinal

Carbonate clasts



Petrography:

1st or 2nd cycle origin ?

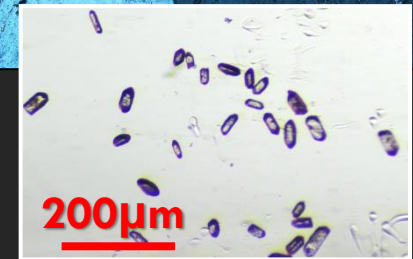
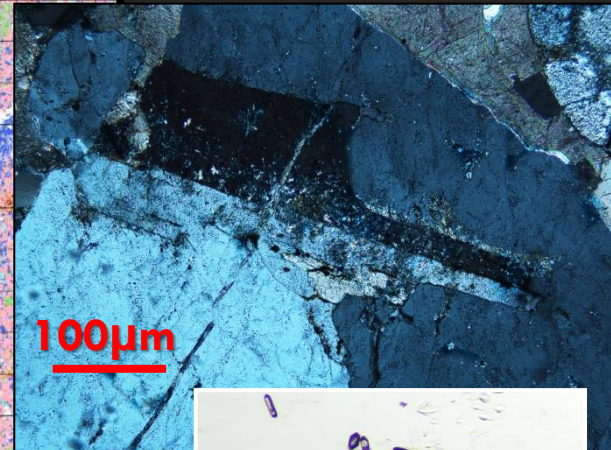
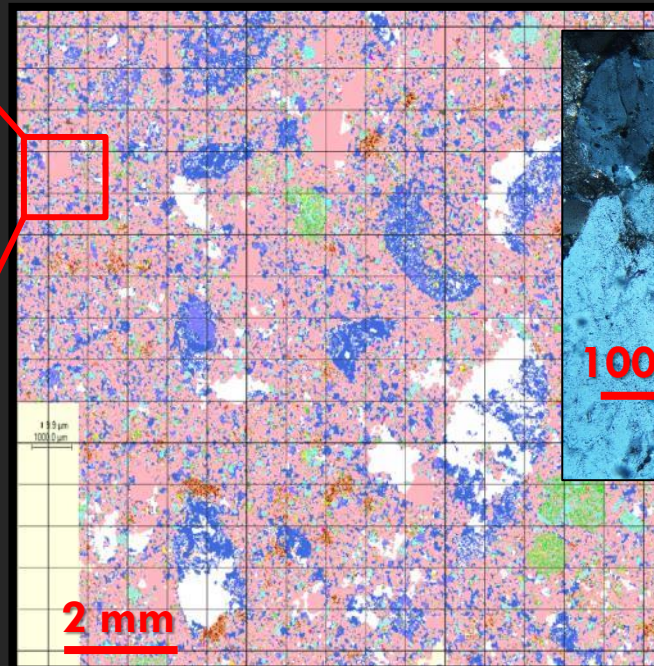
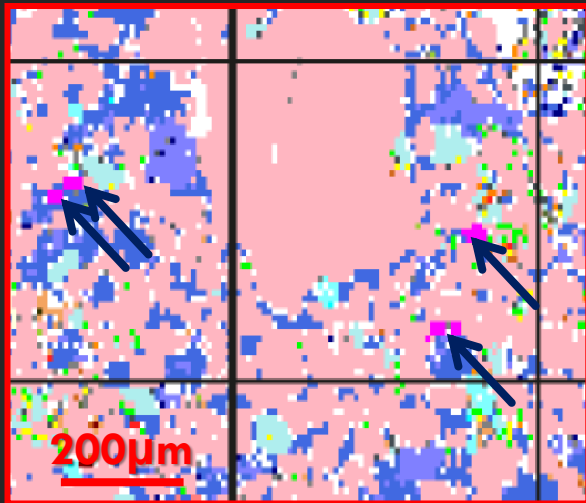


Petrography:

1st or 2nd cycle origin ?

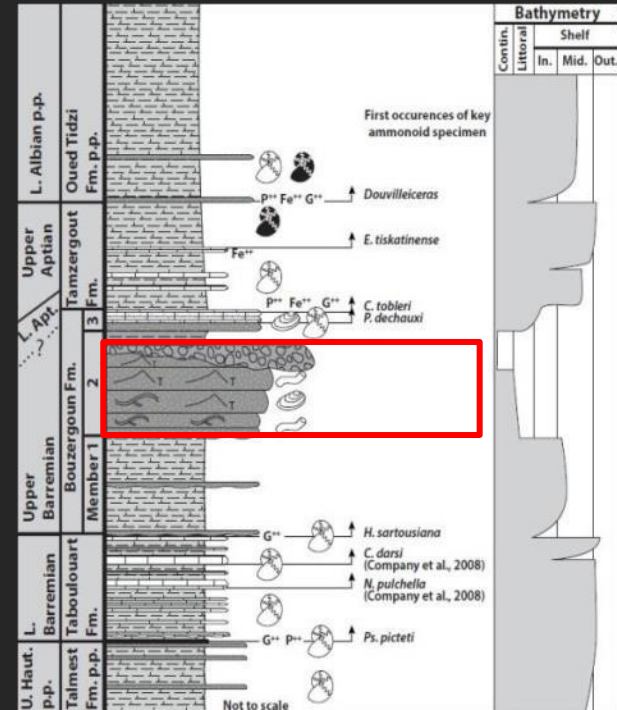
High yield of heavy mineral (<1% in the 63-125 μm fraction)

Few preserved feldspars and apatite

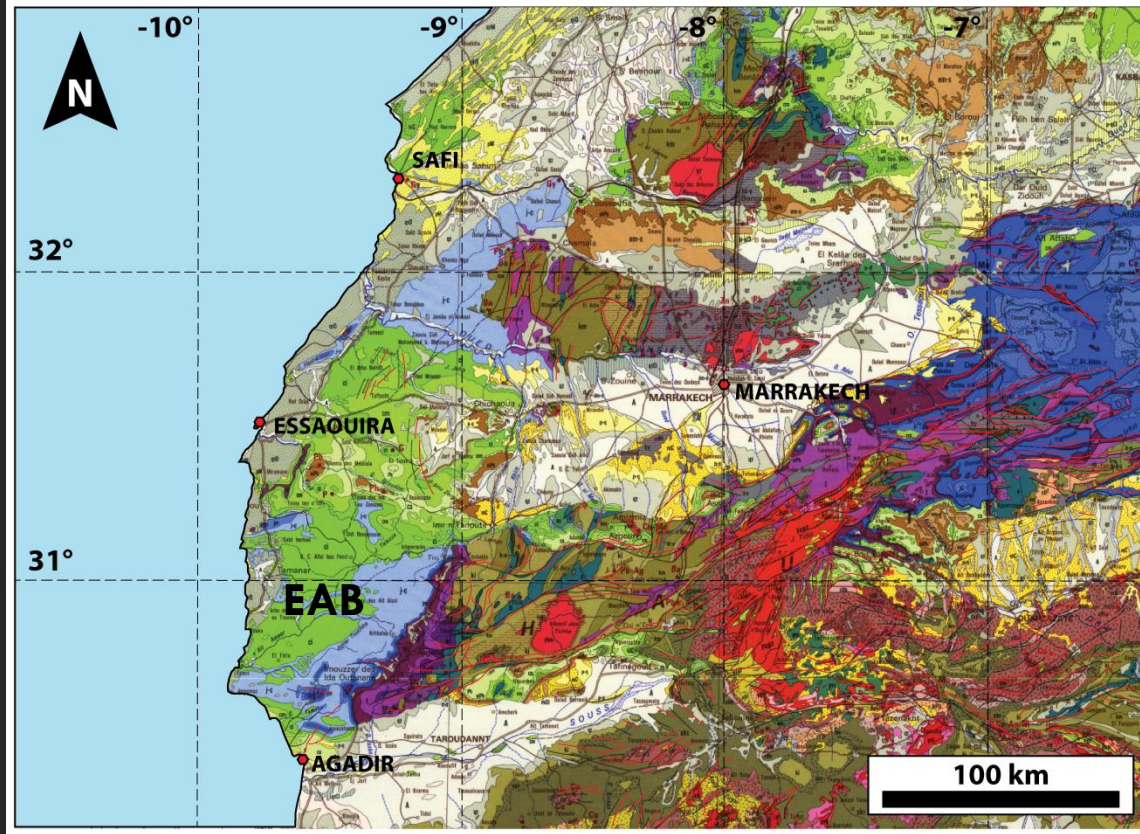


Methods:

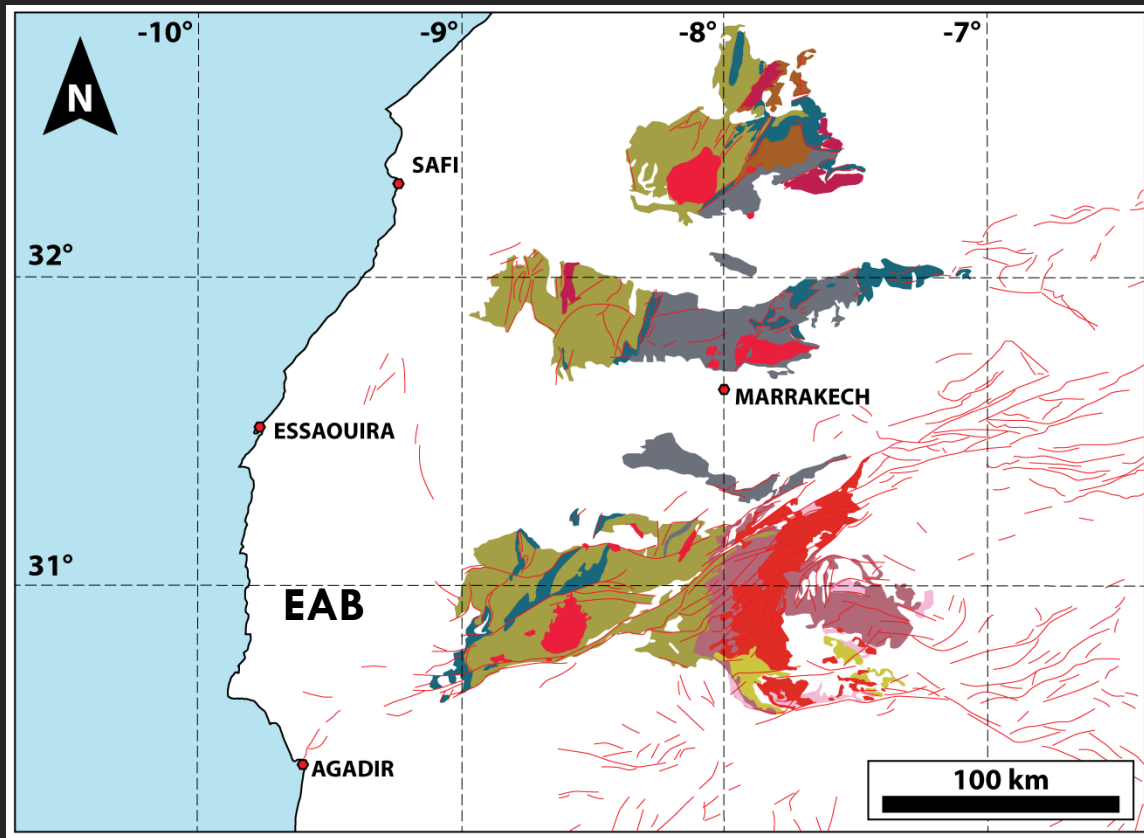
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Predicting exposed formations



Predicting exposed formations

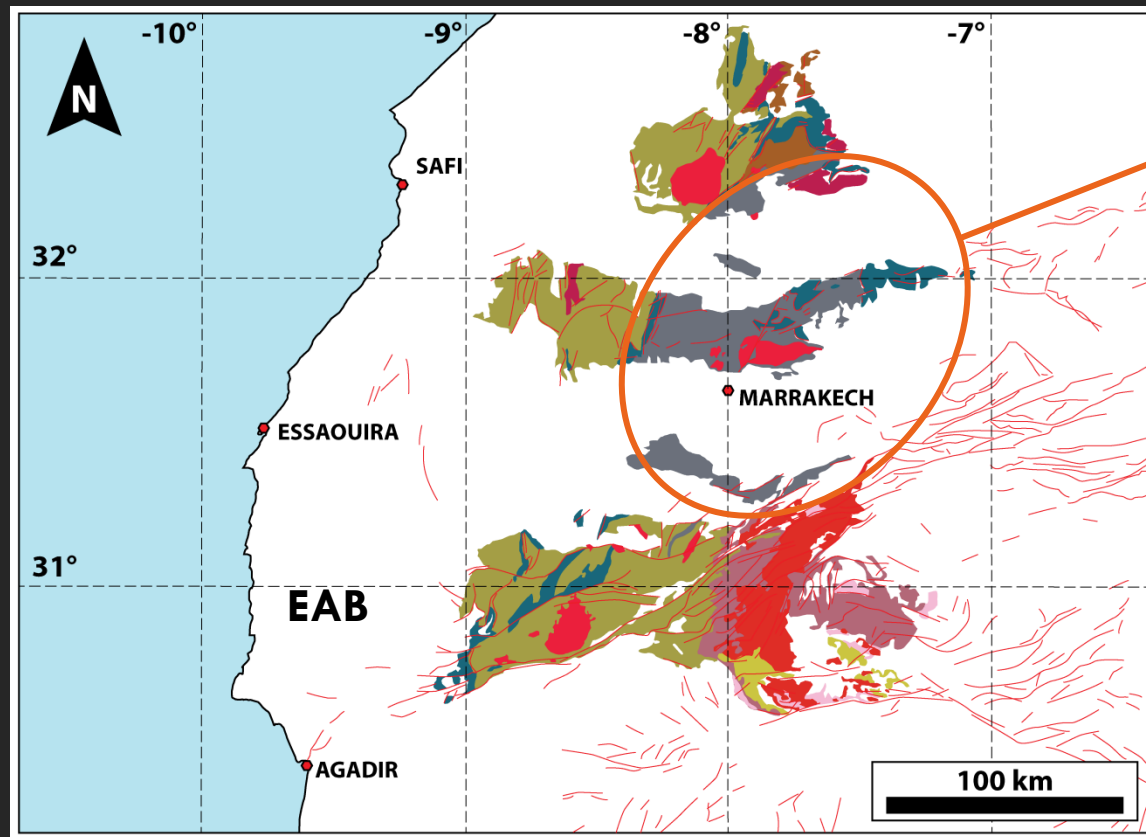


Basement outcrop in potential source terranes :

Western Meseta

MAM and Siroua group (Western High Atlas)

Predicting exposed formations

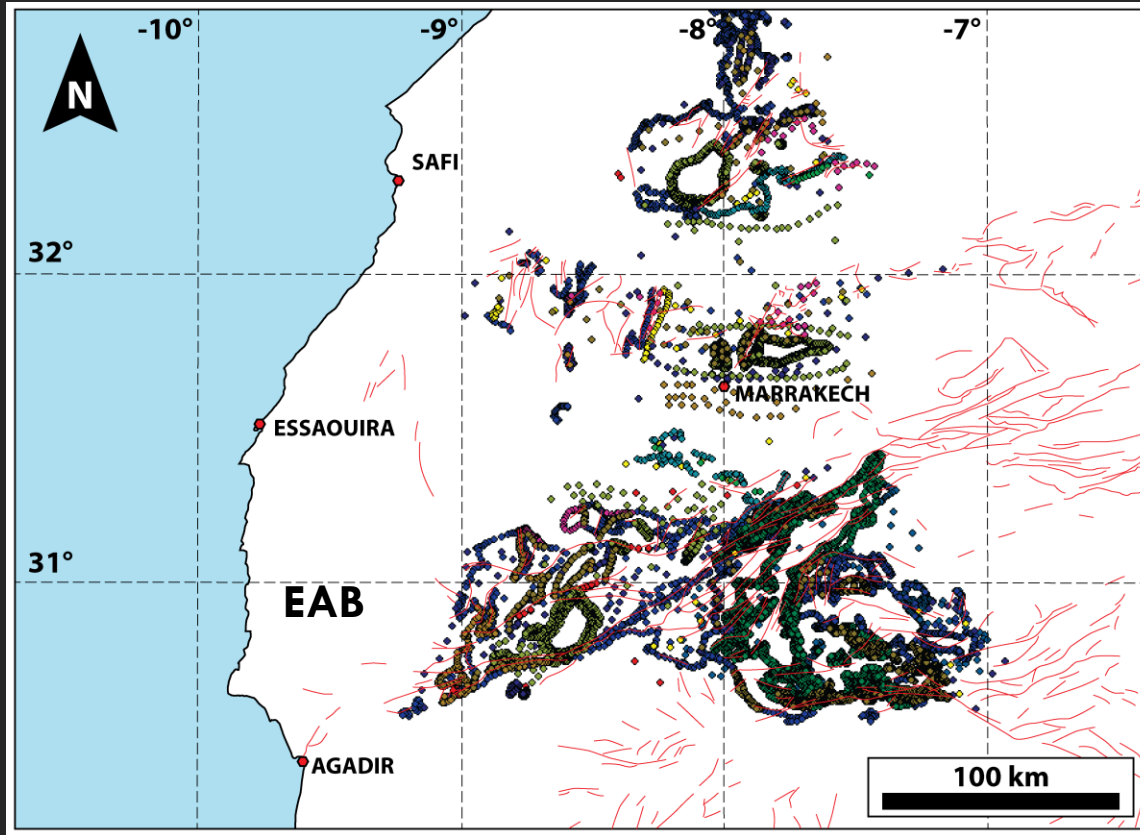


Marrakech nappe

Western Meseta

MAM and Siroua group
(Western High Atlas)

Predicting exposed formations

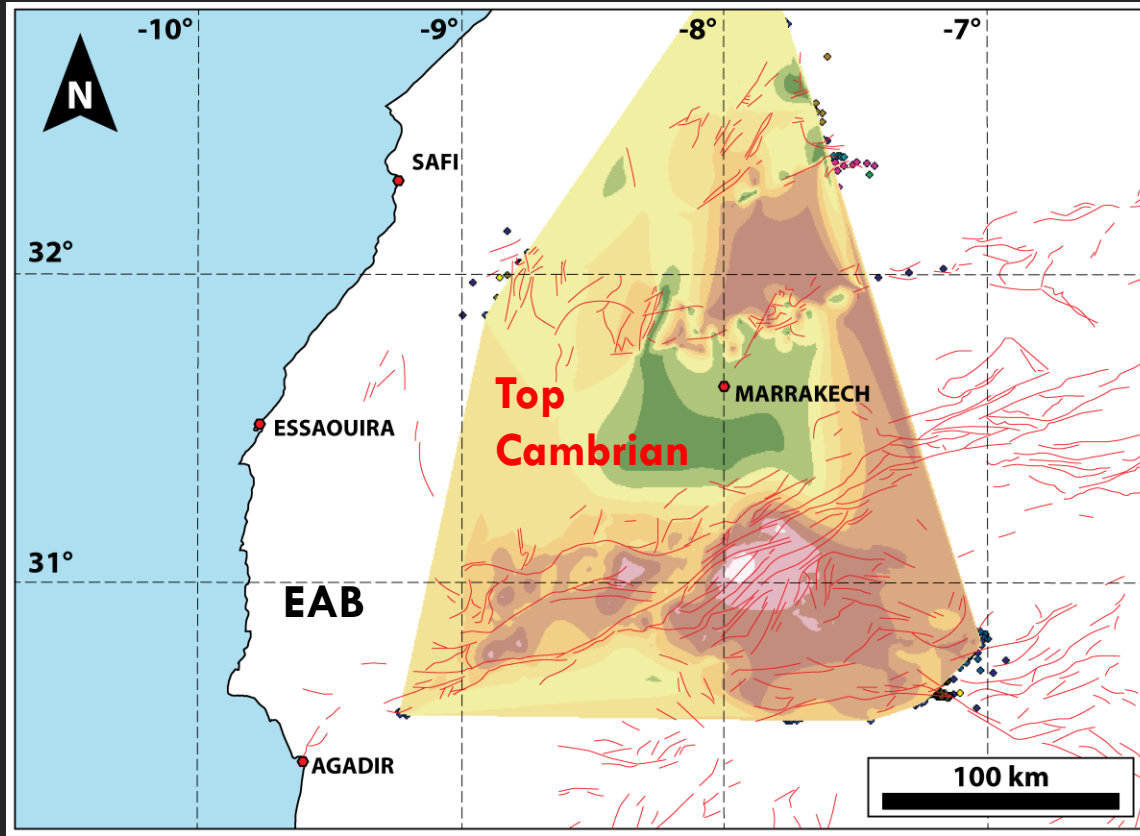


Modelling Cretaceous geology

Methods :

- Picking horizons at known depth

Predicting exposed formations

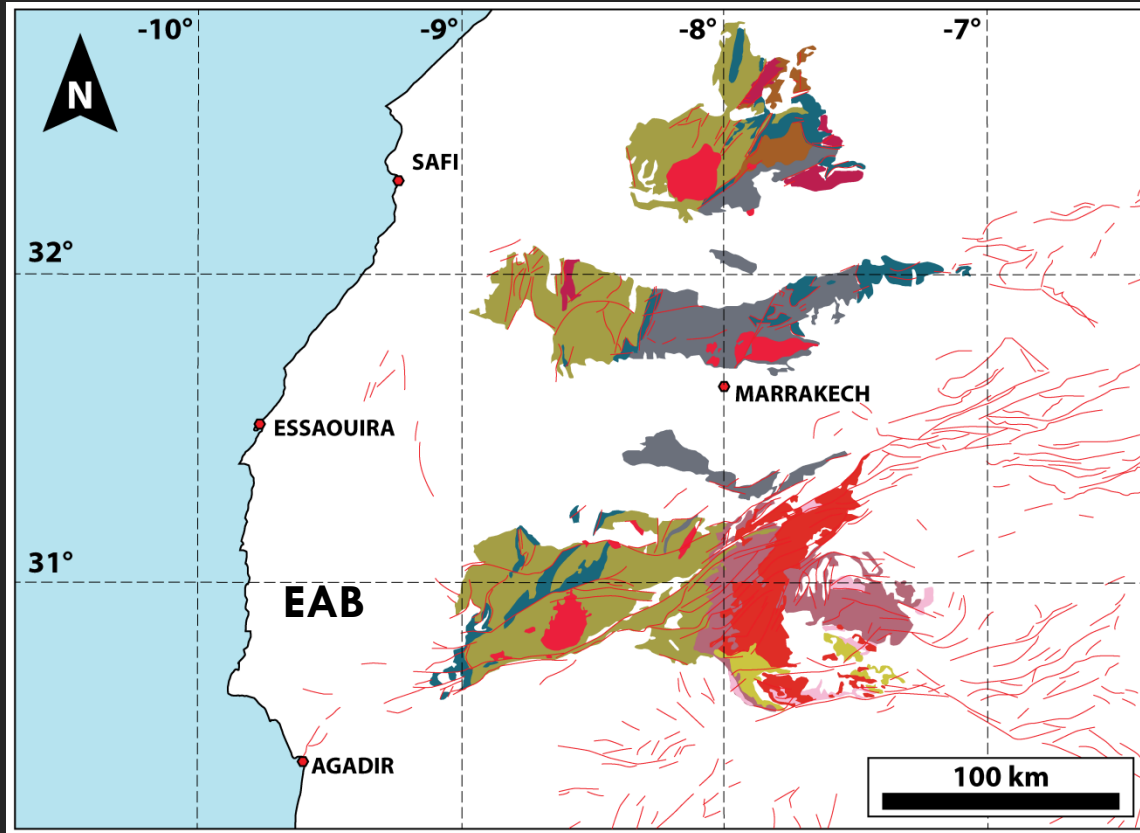


Modelling Cretaceous geology

Methods :

- Picking horizons at known depth
- **Interpolation of horizons**

Predicting exposed formations

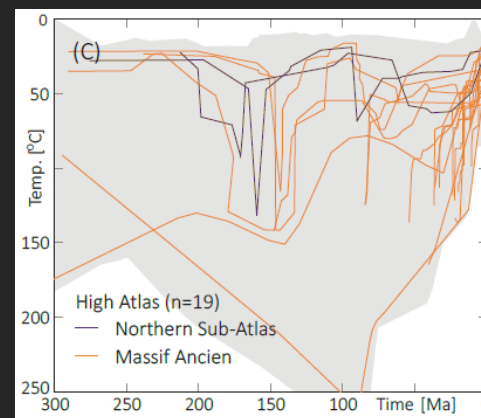
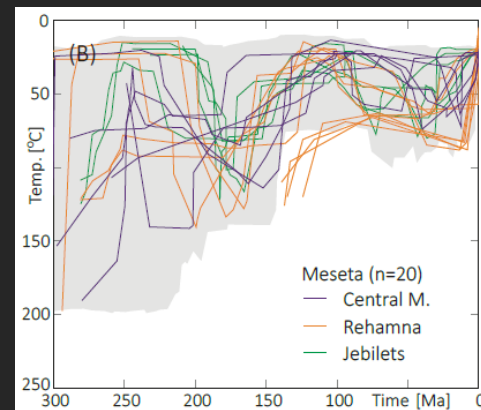
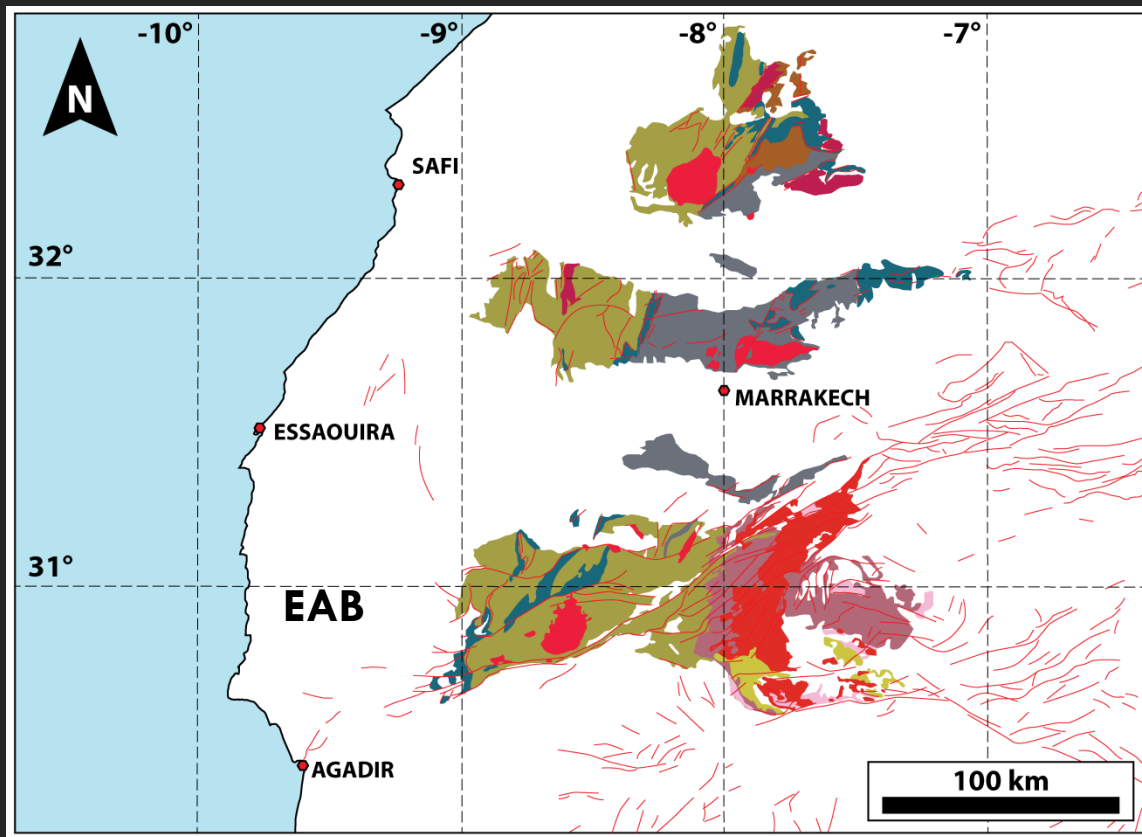


Modelling Cretaceous geology

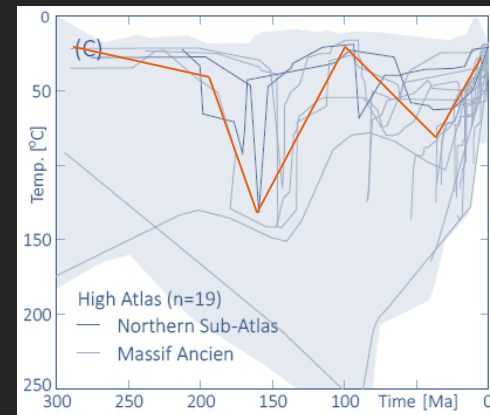
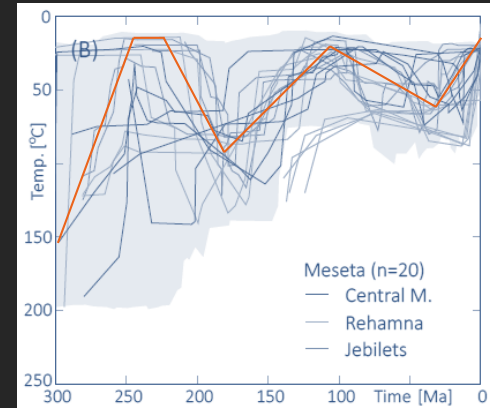
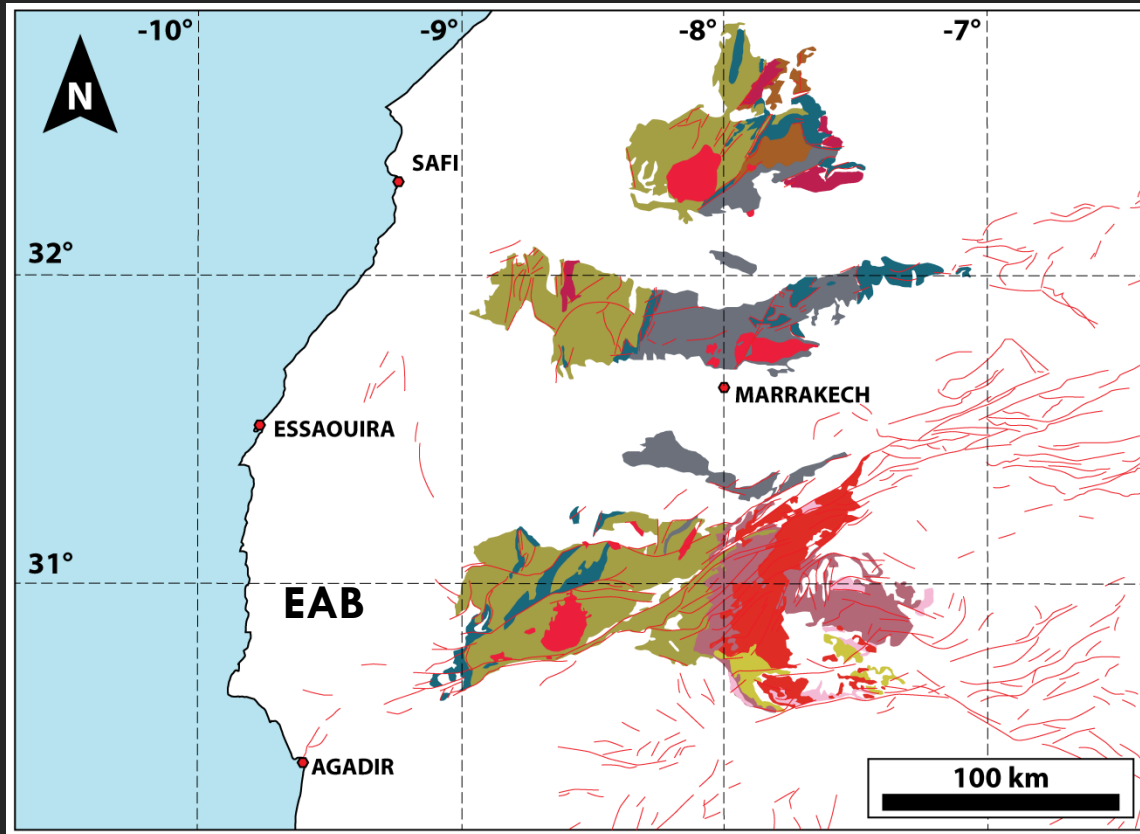
Methods :

- Picking horizons at known depth
- Interpolation of horizons
- **Denudation model based on uplift rates**
(thermochronology from Remi Charton's PhD Thesis)

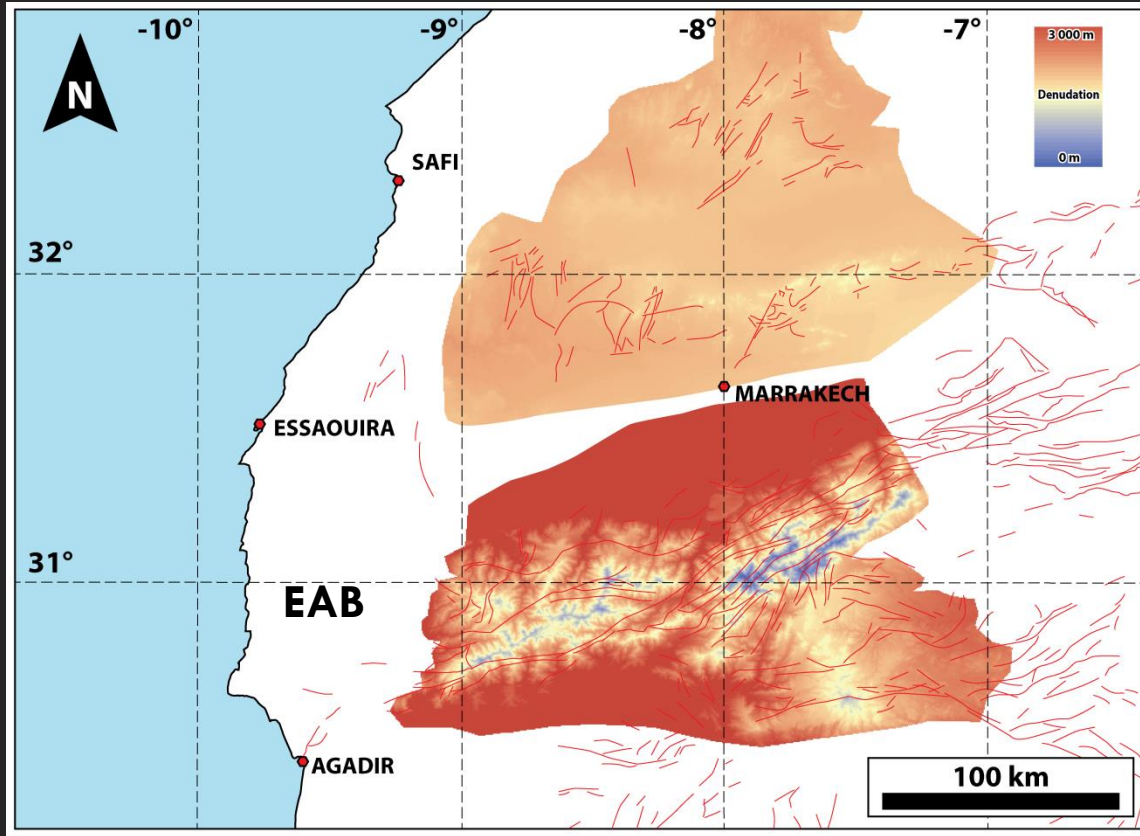
Predicting exposed formations



Predicting exposed formations



Predicting exposed formations

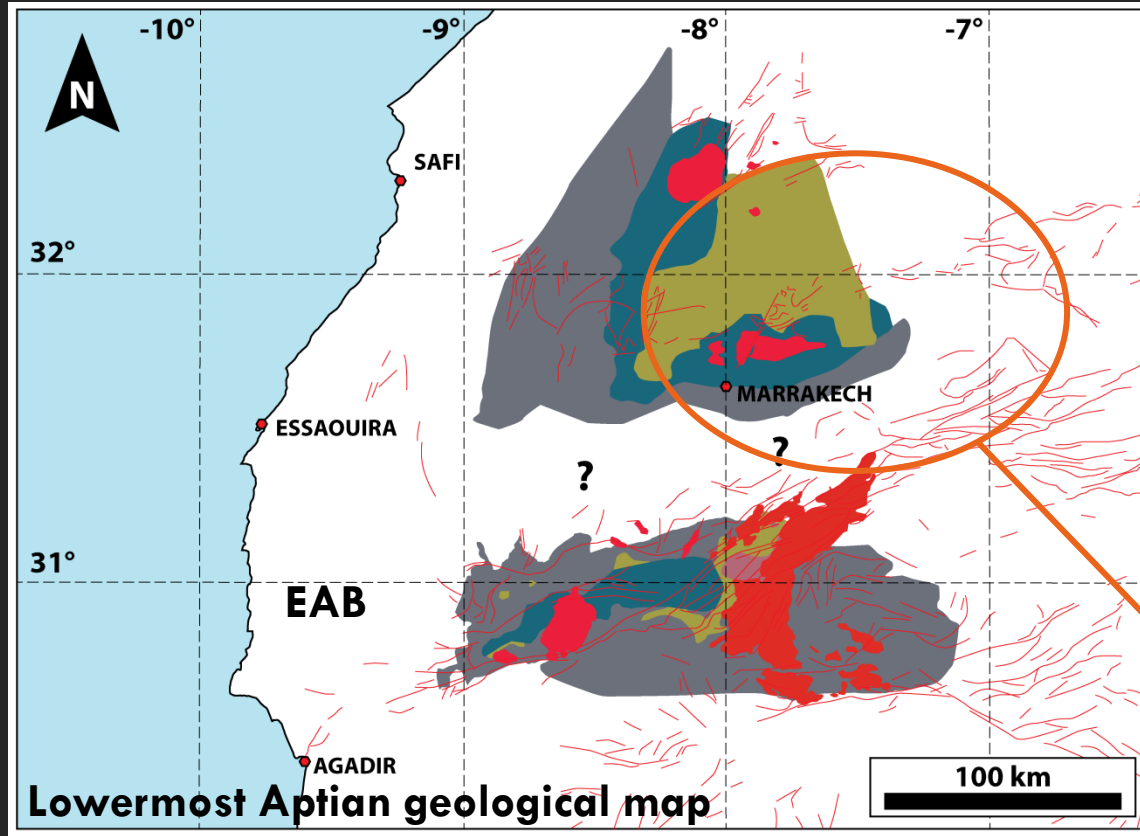


Modelling Cretaceous geology

Methods :

- Picking horizons at known depth
- Horizon Interpolation
- **Denudation model based on uplift rates (thermochronology)**

Predicting exposed formations



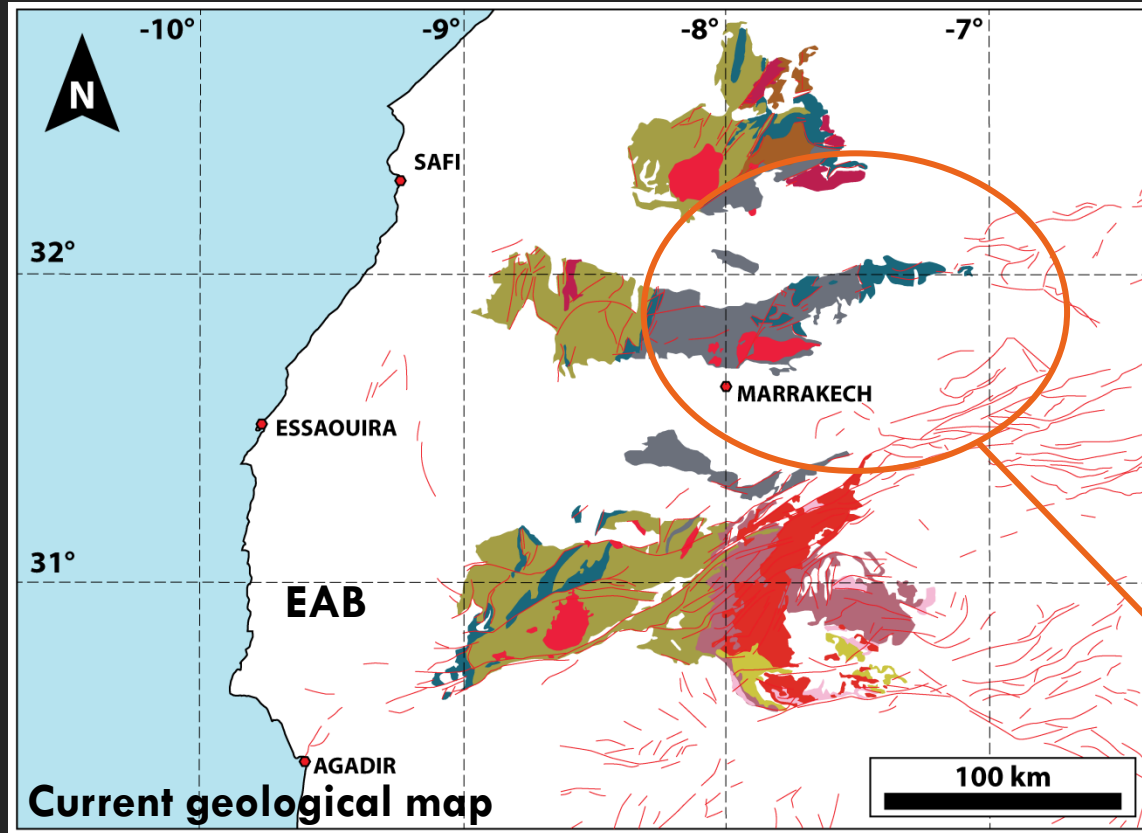
Modelling Cretaceous geology

Methods & Resulting map :

- Picking horizons at known depth
- Horizon Interpolation
- Denudation model based on uplift rates
- **Model of cropping out lithologies at paleo altitude**

Marrakech nappe :
inverse stratigraphic age

Predicting exposed formations



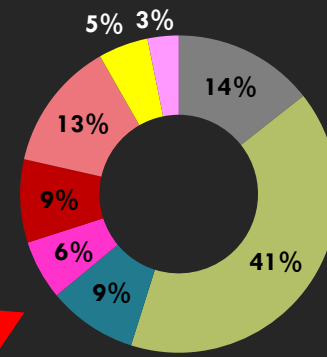
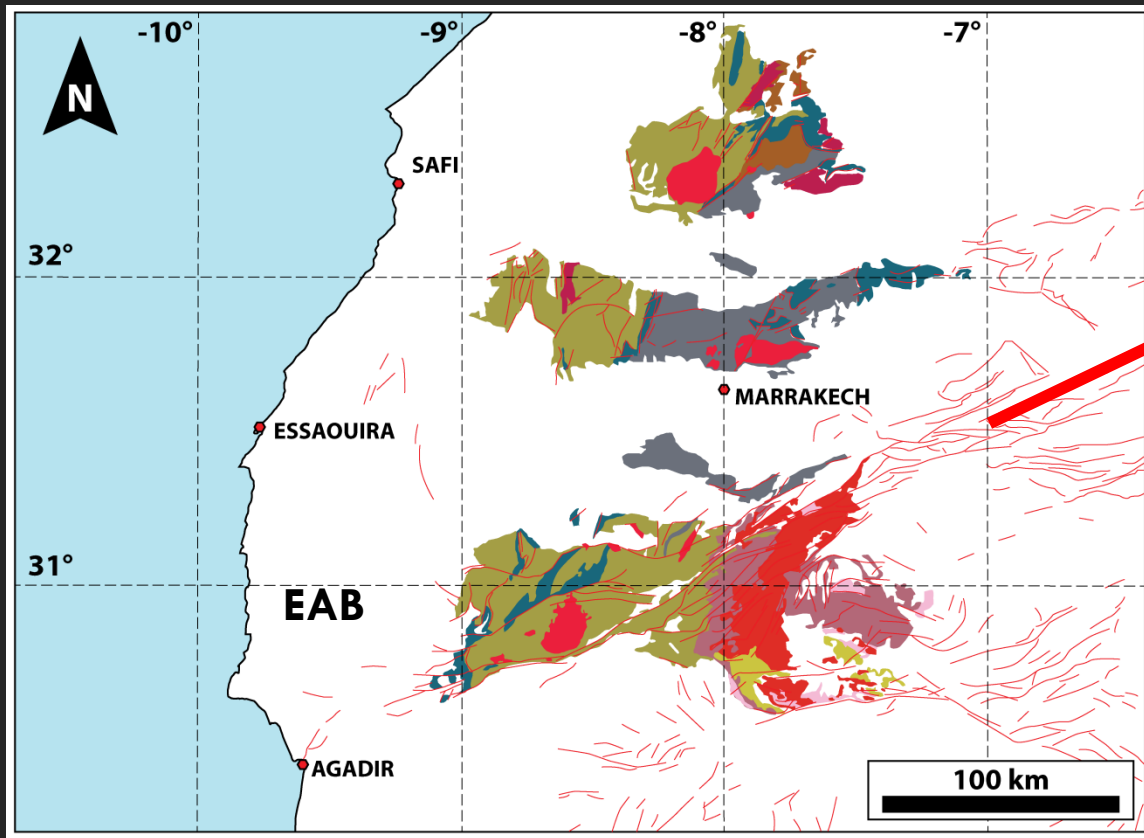
Modelling Cretaceous geology

Methods & Resulting map :

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- Horizon Interpolation
- Denudation model based on uplift rates
- **Model of cropping out lithologies at paleo altitude**

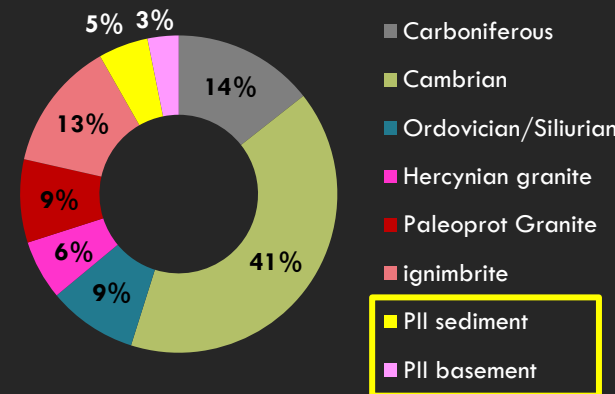
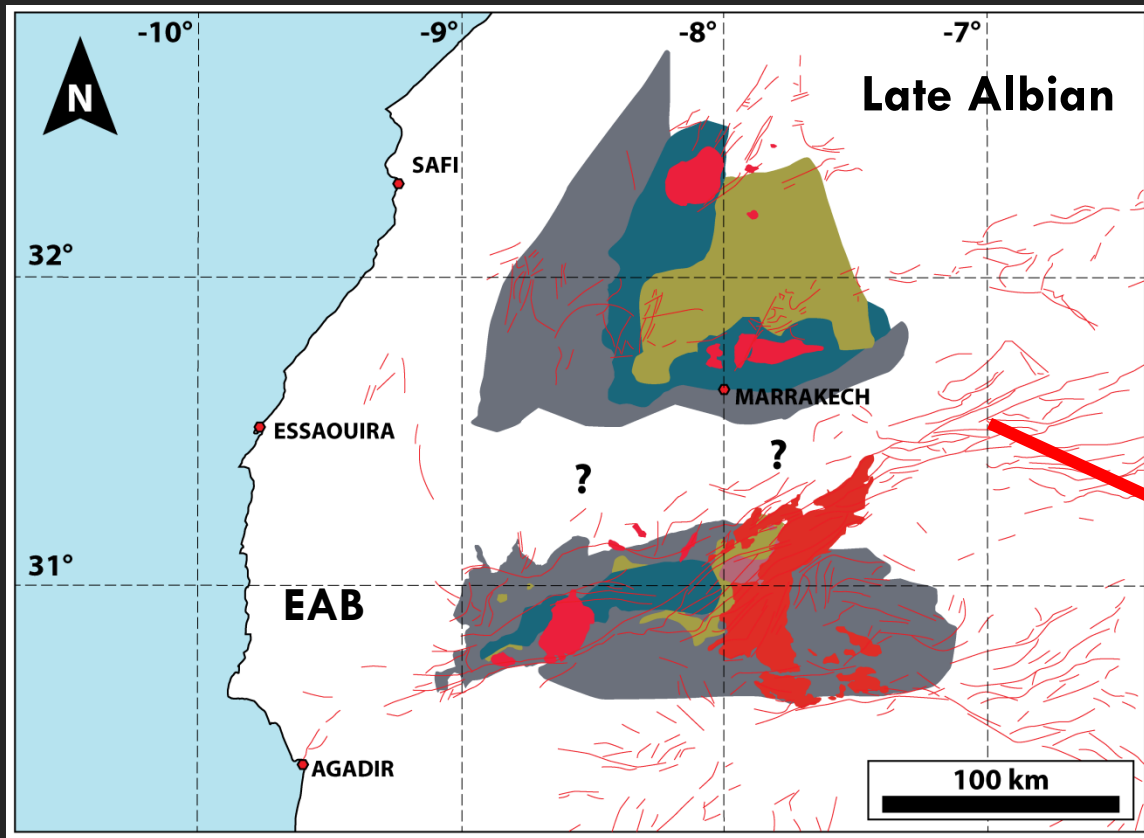
Marrakech nappe :
inverse stratigraphic age

Predicting exposed formations

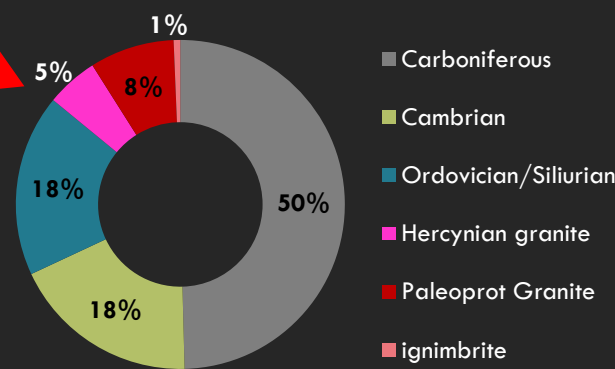


- Carboniferous
- Cambrian
- Ordovician/Silurian
- Hercynian granite
- Paleoprot Granite
- ignimbrite
- Pll sediment
- Pll basement

Predicting exposed formations



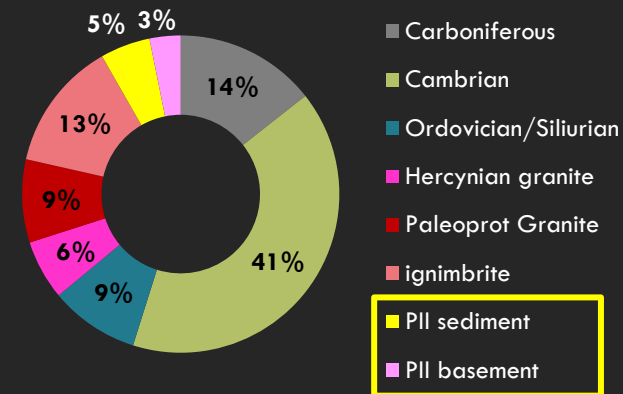
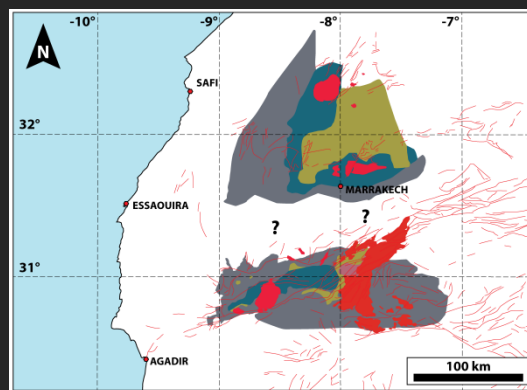
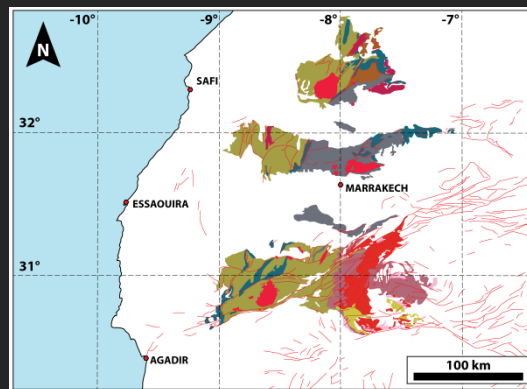
Unexposed during the Cretaceous



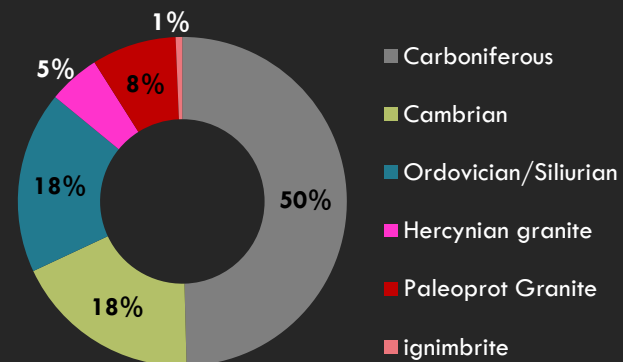
Predicting exposed formations

Results :

- PII sediment and basement not cropping out
- Probable large input of metamorphic sediments from Carboniferous and Ordovician age
- Ignimbrite units largely buried under Palaeozoic sediments



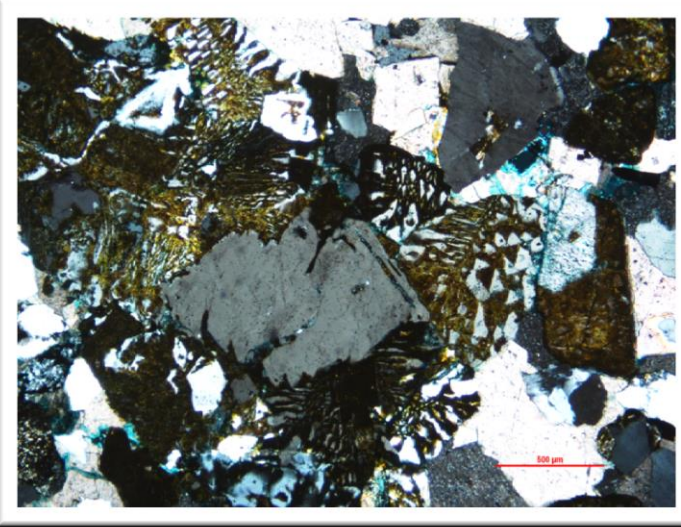
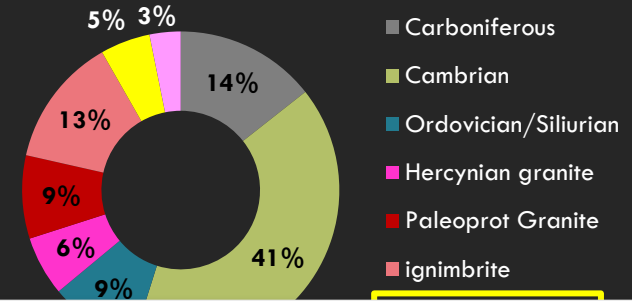
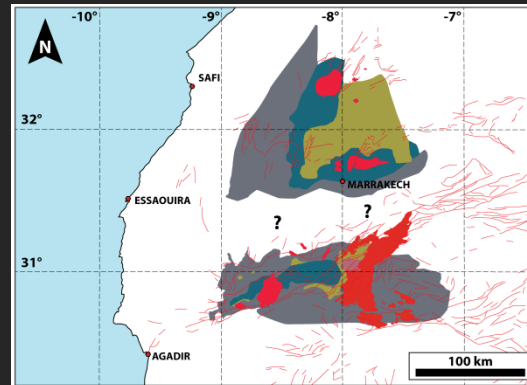
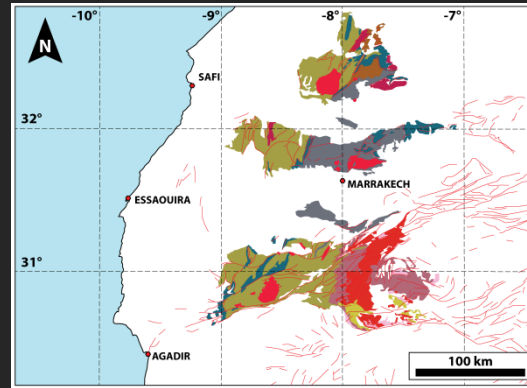
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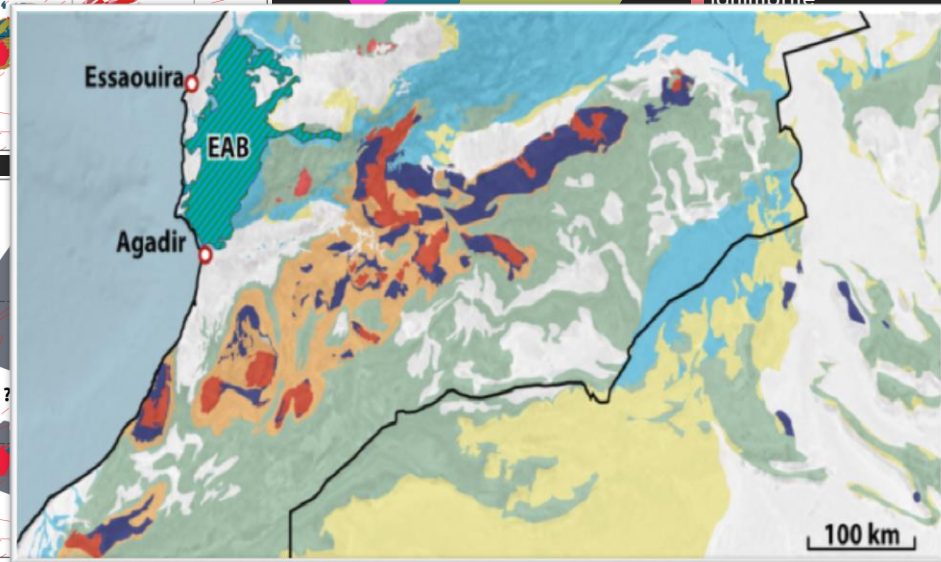
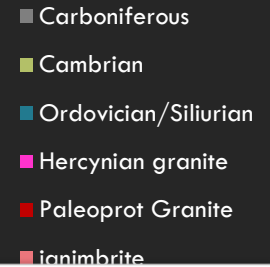
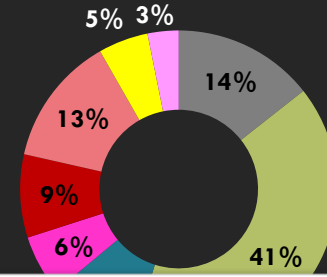
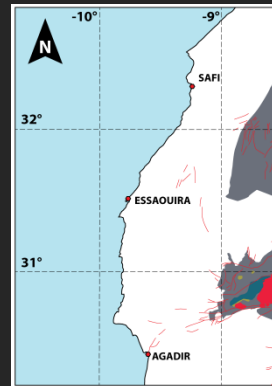


Predicting exposed formations

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Anti Atlas contribution ?



Predicting exposed formations

Limits :

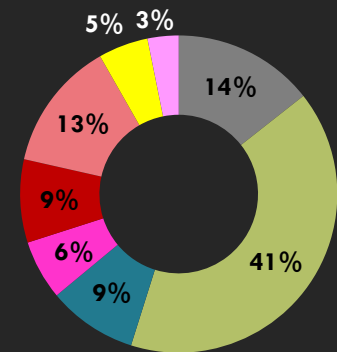
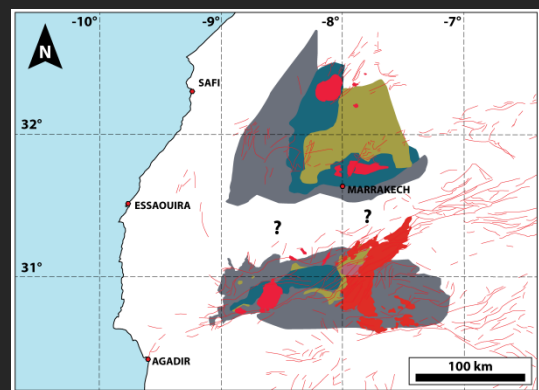
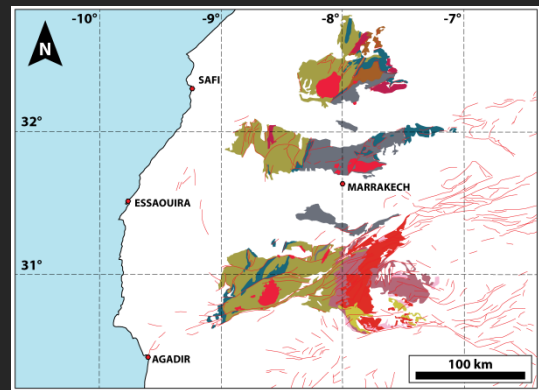
Many assumptions :

- Thermochronology data repartition (uniform uplift)

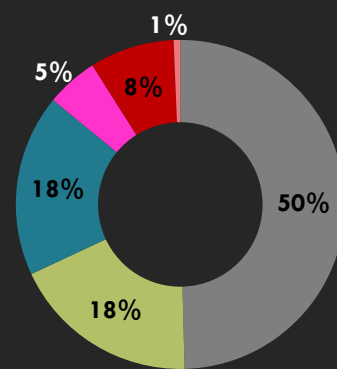
- Reconstruction based on

Cross sections, unable to reconstruct any unit/nappes entirely eroded away.

- Last layer (Carboniferous) distorted/exaggerated

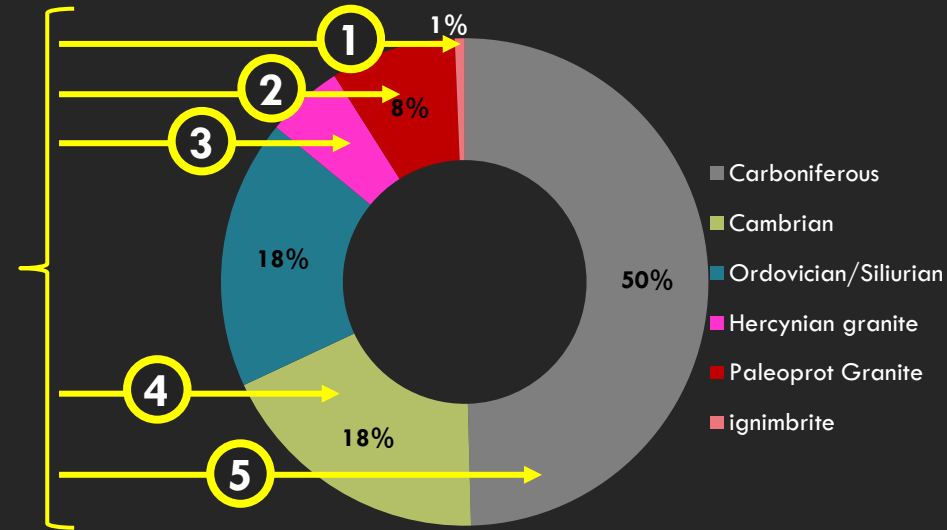


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Predicting exposed formations

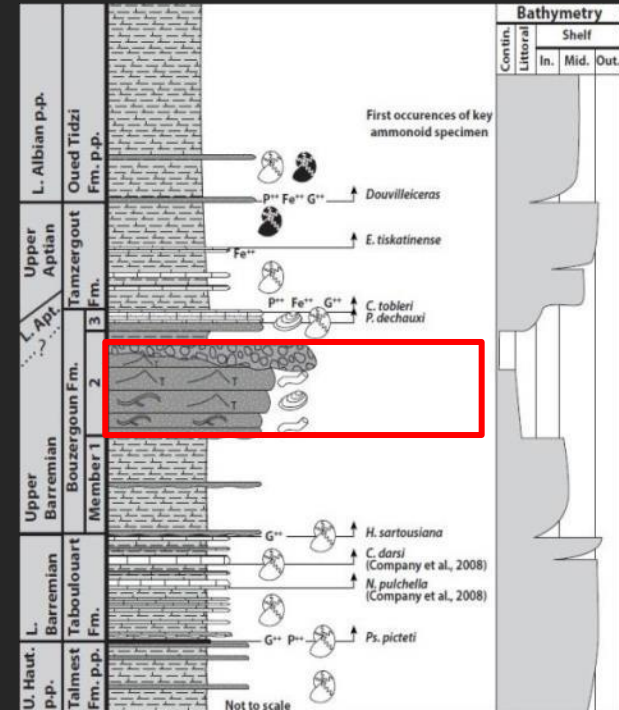


Lithologies cropping out during the late Albian in the MAM and Meseta

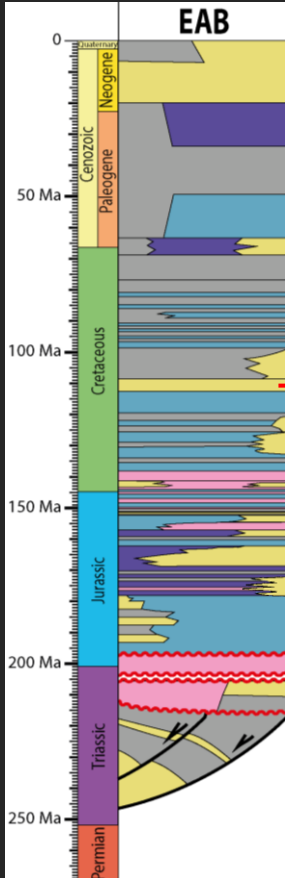
The model allows a more precise focus on the most probable sediment sources

Methods:

- **Thermochronology:** assessment of the main vertical movements affecting the post rift evolution of the margin.
- **Petrography** and mineral populations supported by SEM/QEMSCAN
- **Palaeogeology modeling**
- **Zircon U-Pb Geochronology**
- **Heavy mineral analysis**

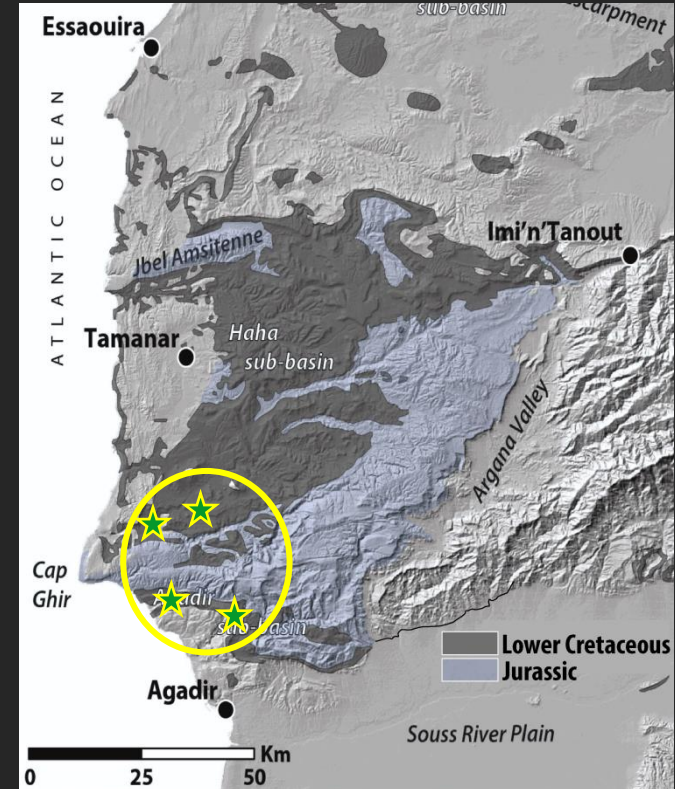


U-Pb dating : Targets

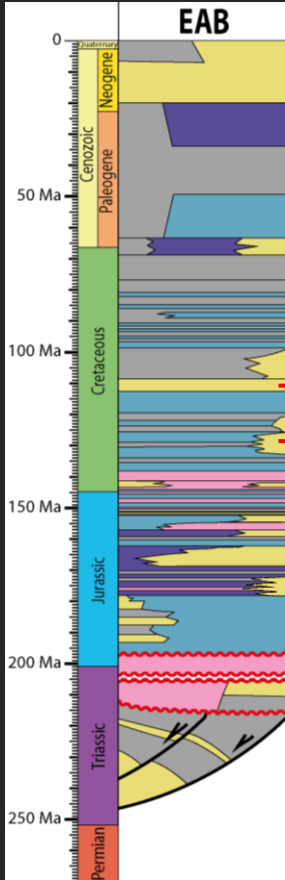


fluvial units of the
Barremian-Aptian
low-stand

Modified from Frizon de Lamotte &
al. (2008) in Michard & al. (2008)



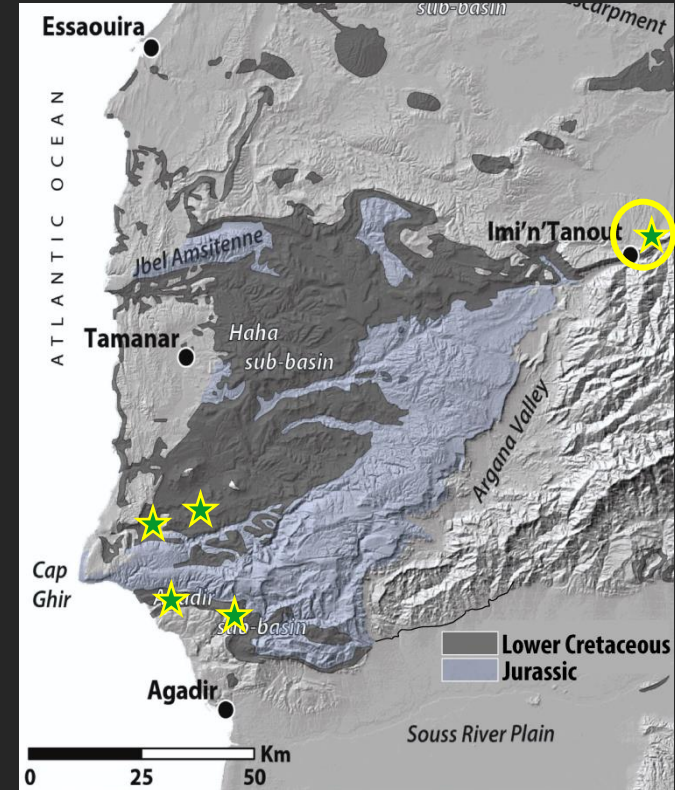
U-Pb dating : Targets



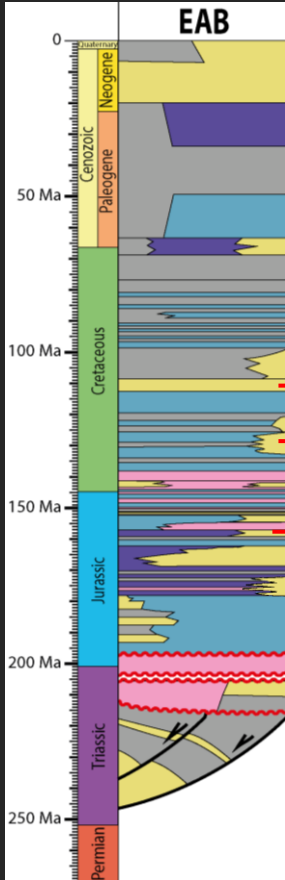
fluvial units of the
Barremian-Aptian
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*Distributary channel
In Hauterivian unit*

Modified from Frizon de Lamotte &
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U-Pb dating : Targets

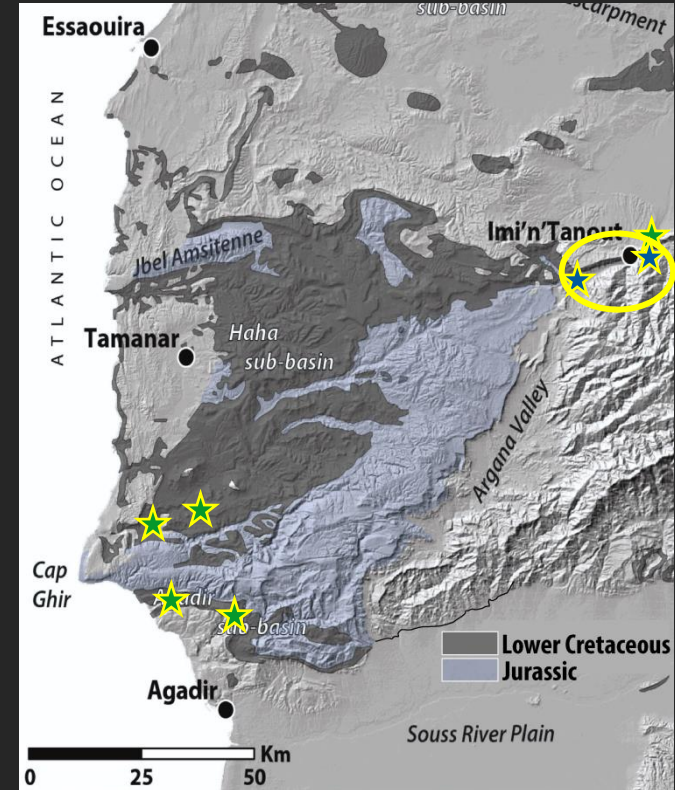


**fluvial units of the
Barremian-Aptian
low-stand**

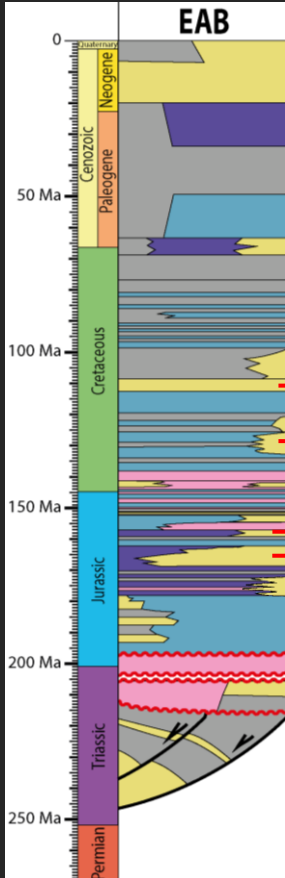
*Distributary channel
In Hauterivian unit*

*Kimmeridgian fluvial
units*

Modified from Frizon de Lamotte & al. (2008) in Michard & al. (2008)



U-Pb dating : Targets



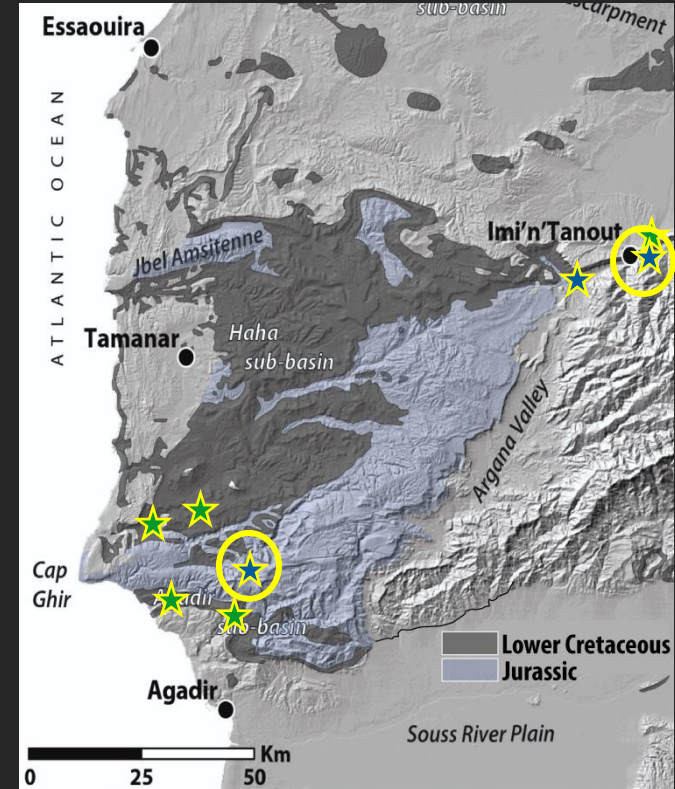
fluvial units of the Barremian-Aptian low-stand

Distributary channel in Hauterivian unit

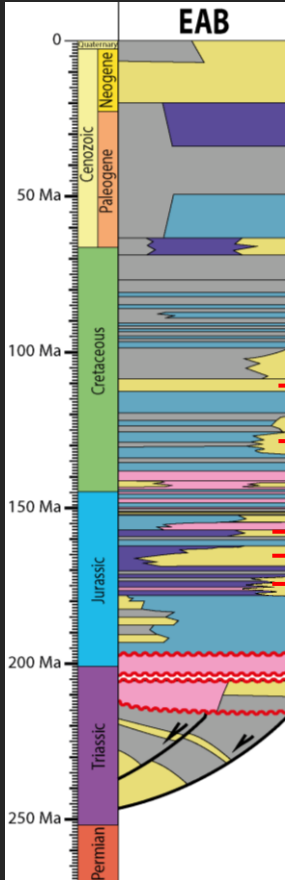
Kimmeridgian fluvial units

Dogger fluvial units

Modified from Frizon de Lamotte & al. (2008) in Michard & al. (2008)



U-Pb dating : Targets



**Fluvial units of the
Barremian-Aptian
low-stand**

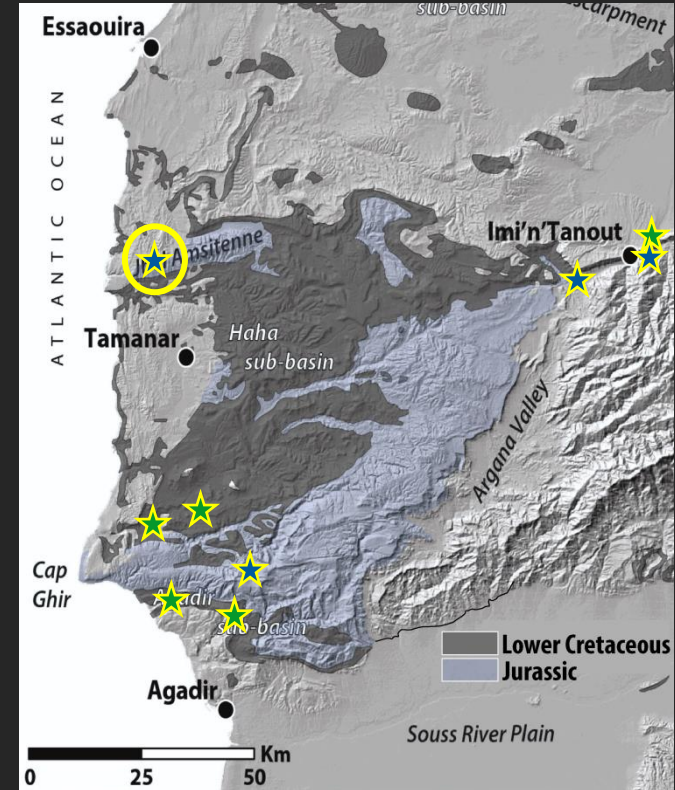
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*Kimmeridgian fluvial
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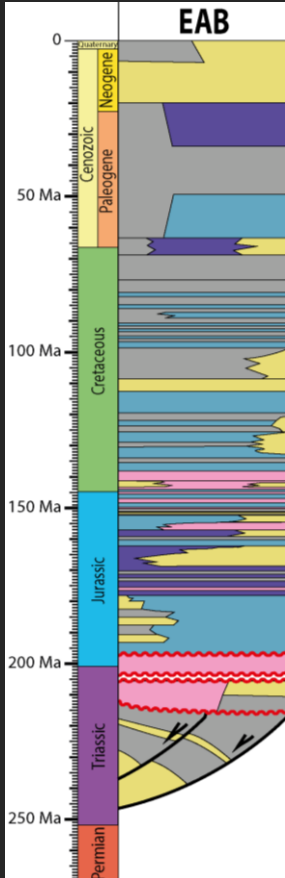
Dogger fluvial units

Toarcian fluvial units

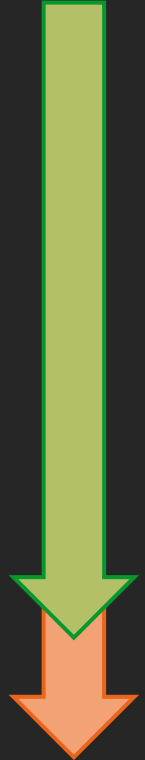
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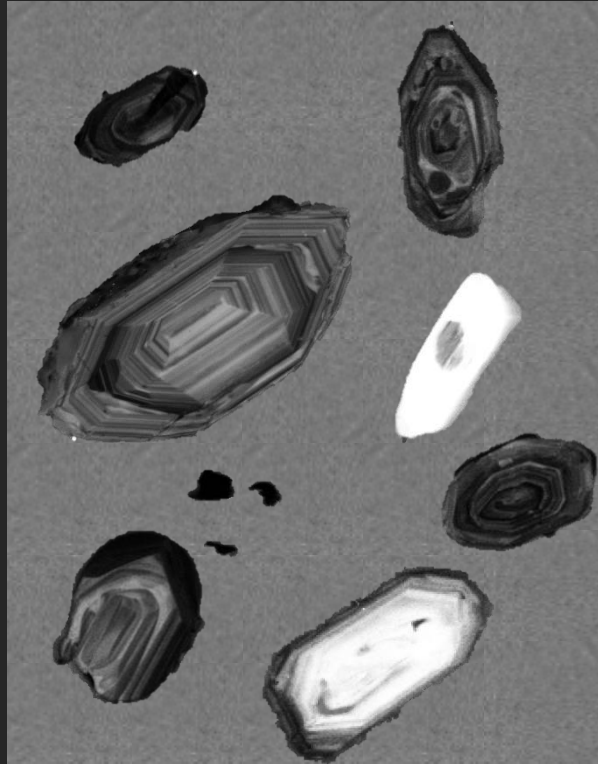
U-Pb dating : Current state



- Field sampling
- Crushing
- Sieving (30-250 μm)
- Concentrate of ultra dense minerals ($\rho > 3.3$)
- Picking
- Mounting / polishing
- CL mapping
- Mass spectrometer (3-10 Oct. 18)
- Data processing



U-Pb dating : CL imaging



(Very) early results :

- Very Heterogeneous population (sizes, overgrowths, shape, U-Th content)
- Mixed signal (Panafrican and metamorphic likely)



Conclusion

- • 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)**
 - Good yield of zircon of various origins, recycling and/or mixing of different sources likely
 - Modelling of the geological formations exposed during the Lower Cretaceous allows correlations between the basin and the surrounding massifs, and allows **discrimination among potential sources**: basement formation unlikely exposed at the time.



Next steps

- • U-Pb dating of detrital zircon grains from the Barremian of the EAB
- QEMSCAN / Raman quantification of heavy mineral ratios as an additional provenance marker
- Integration of new Cretaceous outcrops across the EAB to quantify local changes and variability of the sediment record throughout the basin
- Extension of the study toward the Jurassic to track potential changes of provenance during the Mesozoic

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North Africa Research Group



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Research partners :

