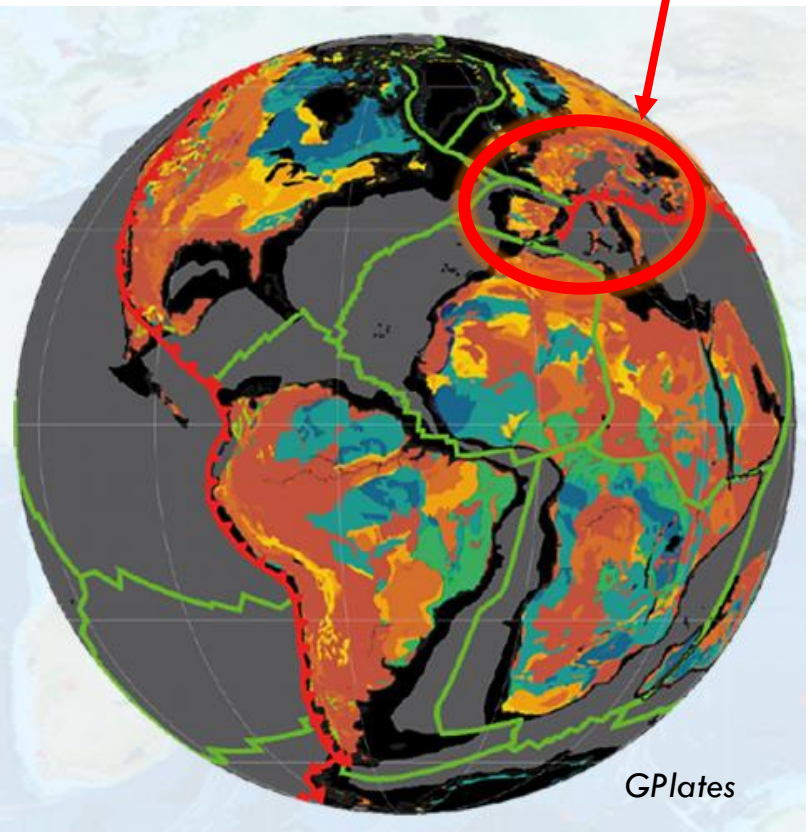
EXTENSION OF A LOWER PLATE PASSIVE MARGIN COEVAL WITH SUBDUCTION OF THE ADJACENT SLAB: THE WESTERN ALPS AND MAGHREBIDES CASES

ABOUBAKER FARAH, OMAR SADDIQI , MOULLEY CHARAF CHABO AND ANDRÉ MICHARD

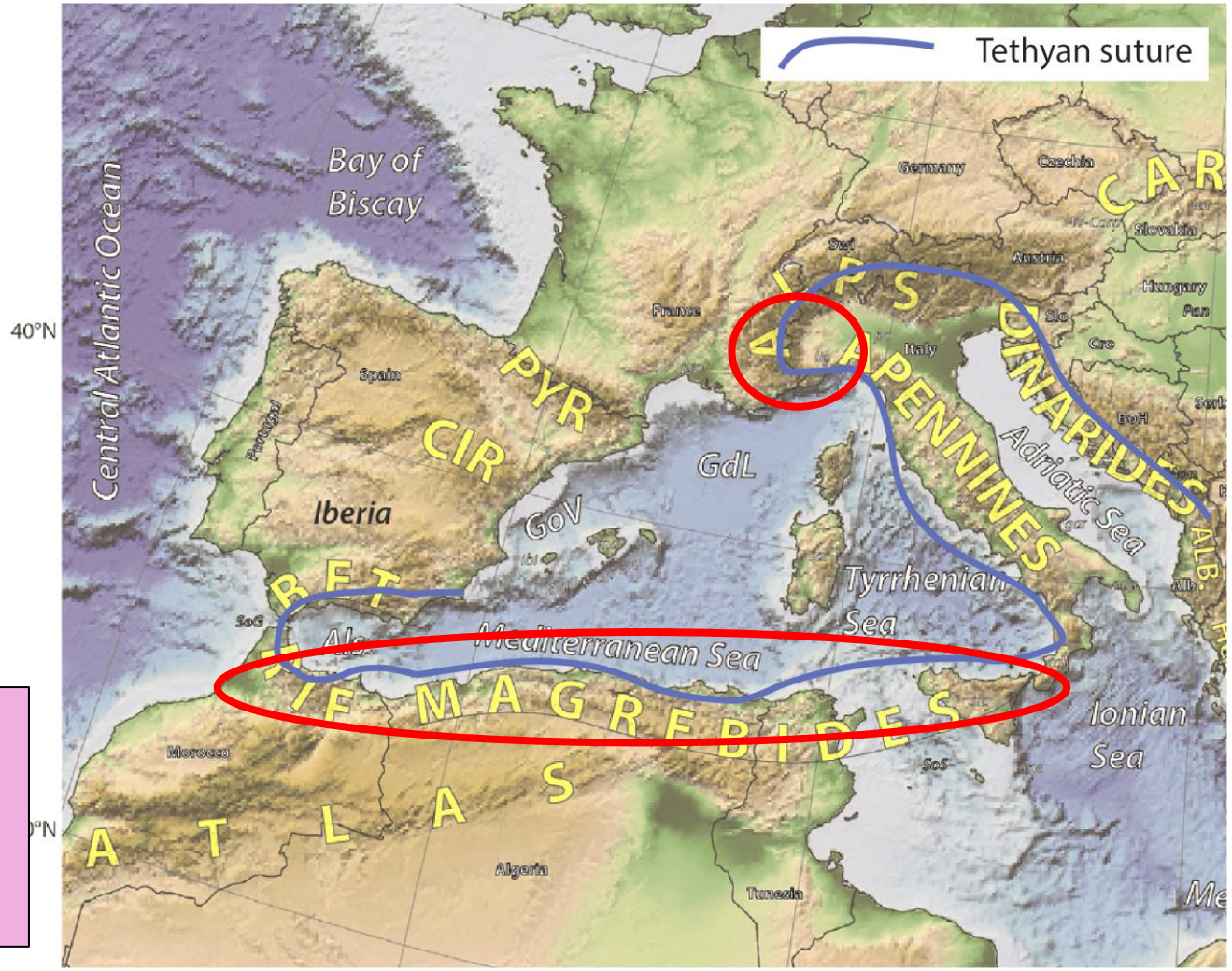
It's over there



PLAN

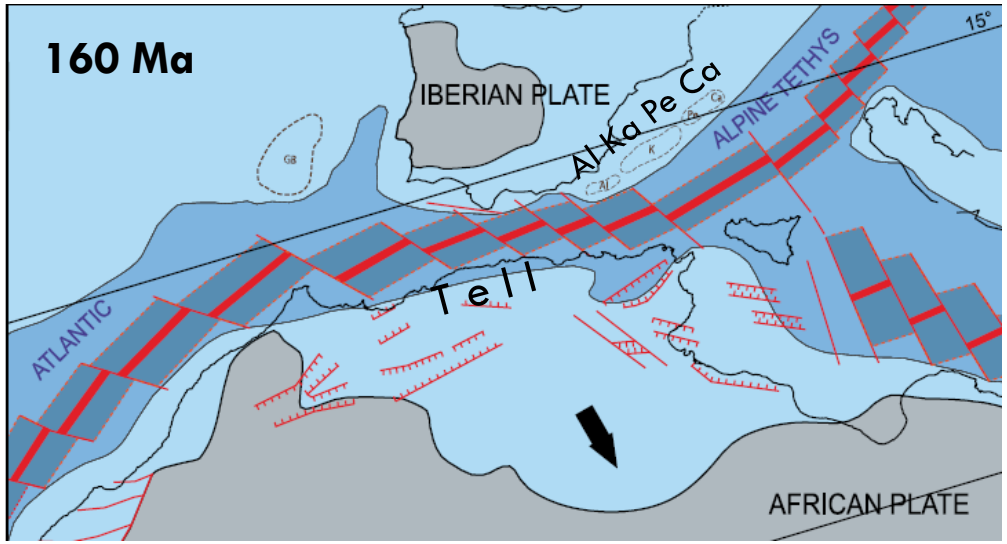
1: **Introduction (1)**
2: Briançonnais paleomargin
3: Maghrebides
4: Discussion
5: Conclusion

Alps & Maghrebides: common origin by closing of Alpine Tethys (suture = Jurassic ophiolites) => Looking at the Alps to better interpret the Maghrebides



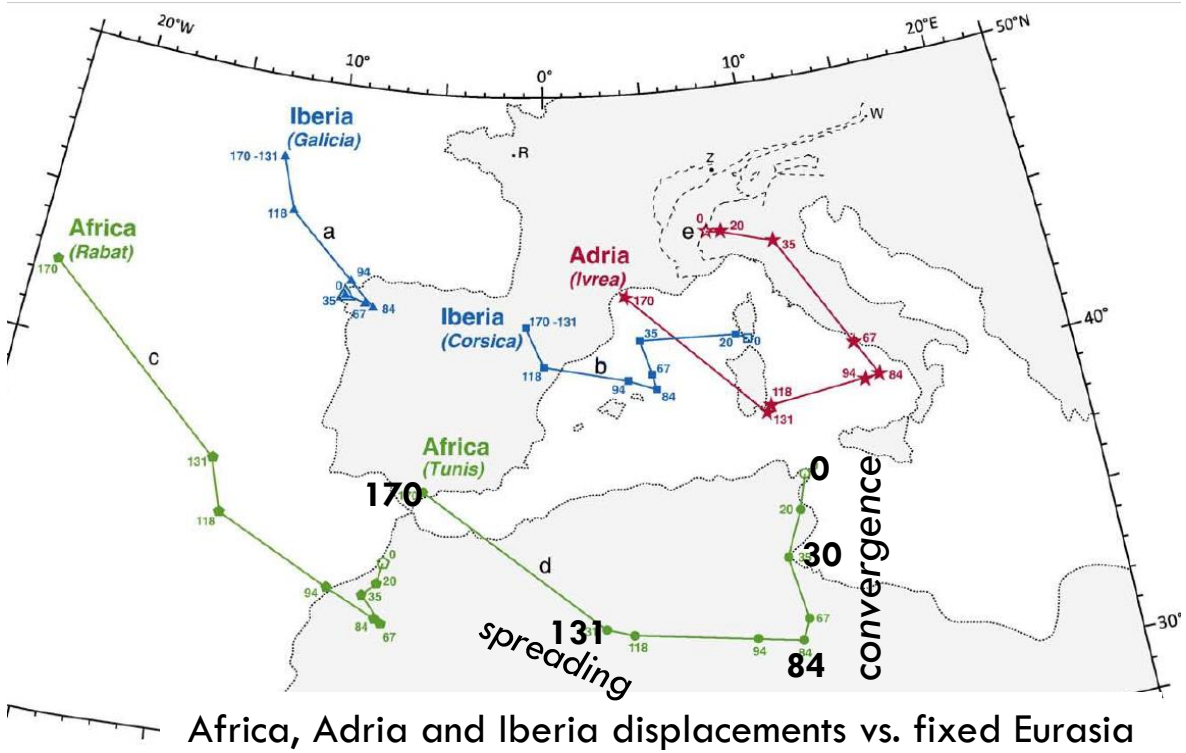
Van Hinsbergen et al., 2020

INTRODUCTION (2)



Restored Callovian setting (Frizon de Lamotte et al. 2011)

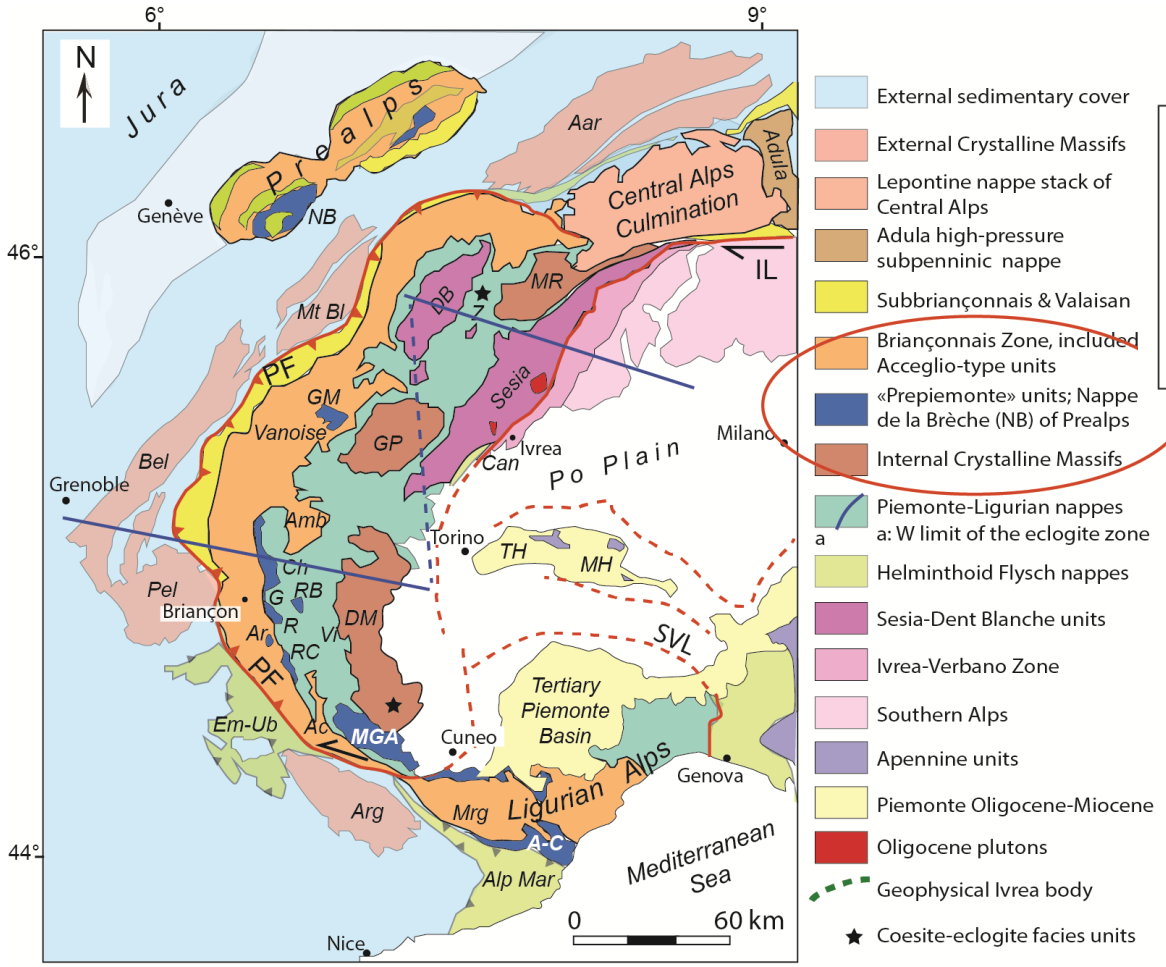
Major width (400 km?) of the Alpine Tethys at about 130 Ma



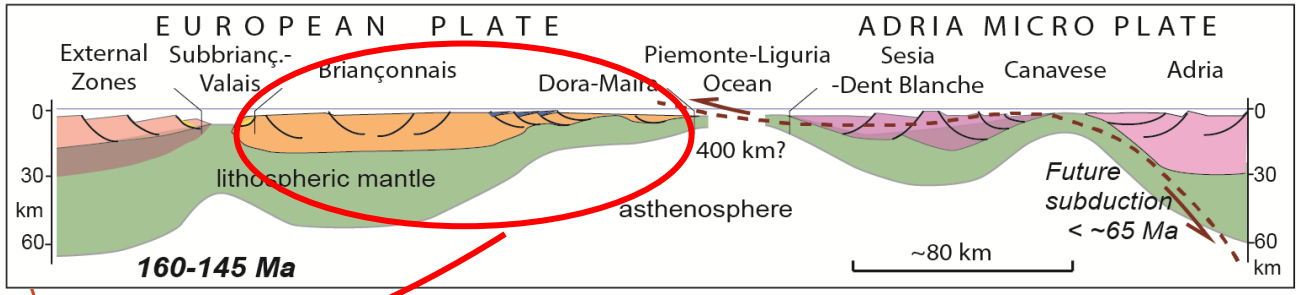
Africa, Adria and Iberia displacements vs. fixed Eurasia (Handy et al. 2015)

Major change in motion of Africa vs Eurasia at about 85-80 Ma = onset of convergence and subduction

2D PART WHAT IS THE BRIANÇONNAIS?

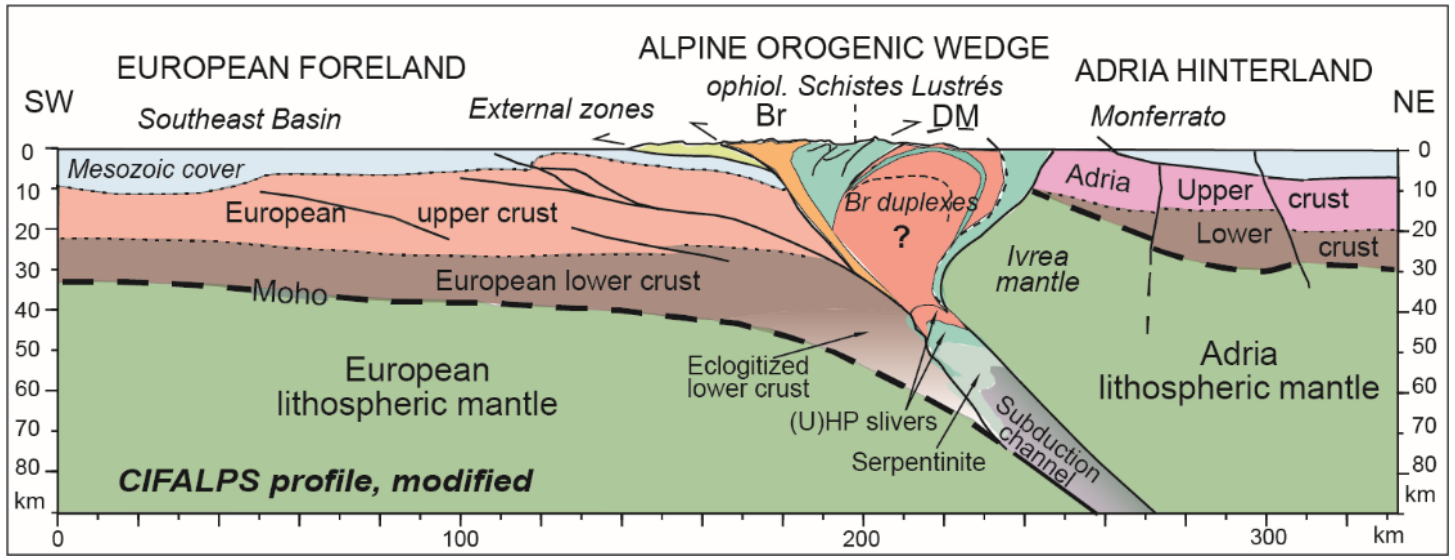


External sedimentary cover
External Crystalline Massifs
Lepontine nappe stack of Central Alps
Adula high-pressure subpenninic nappe
Subbriançonnais & Valaisan
Briançonnais Zone, included Acceglio-type units
«Prepiemonte» units; Nappe de la Brèche (NB) of Prealps
Internal Crystalline Massifs
Piemonte-Ligurian nappes
a: W limit of the eclogite zone
Helminthoid Flysch nappes
Sesia-Dent Blanche units
Ivrea-Verbano Zone
Southern Alps
Apennine units
Piemonte Oligocene-Miocene
Oligocene plutons
Geophysical Ivrea body
Coesite-eclogite facies units

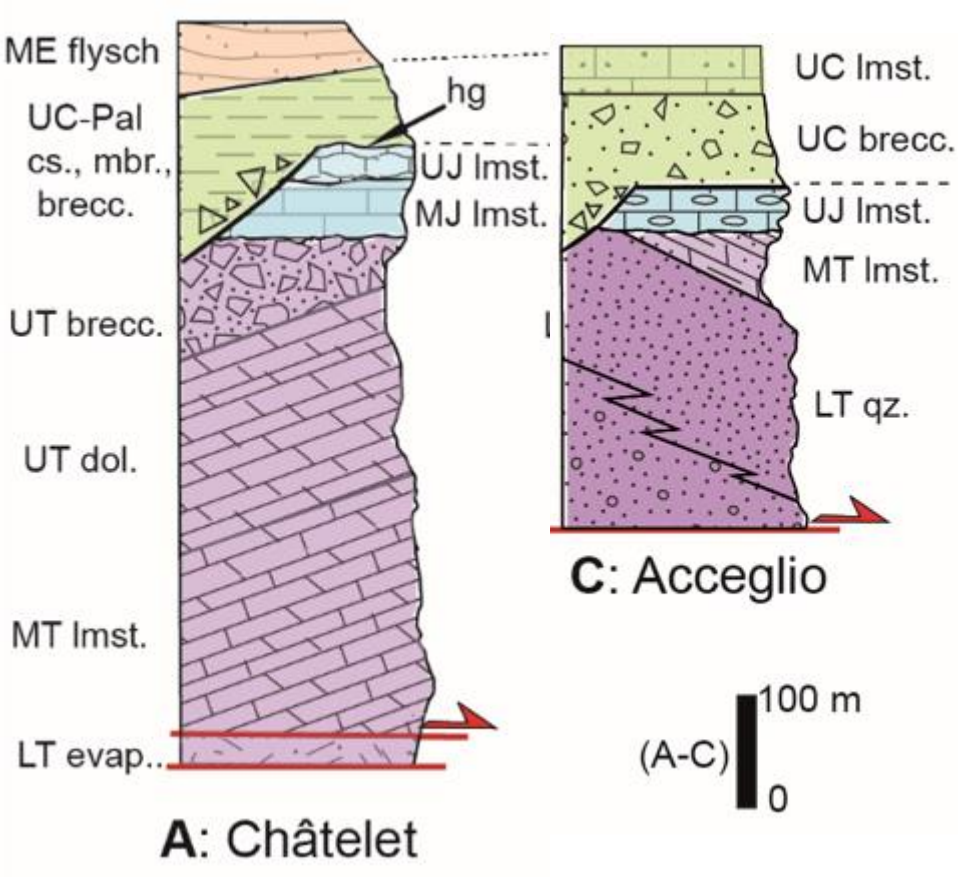


Michard et al 2022

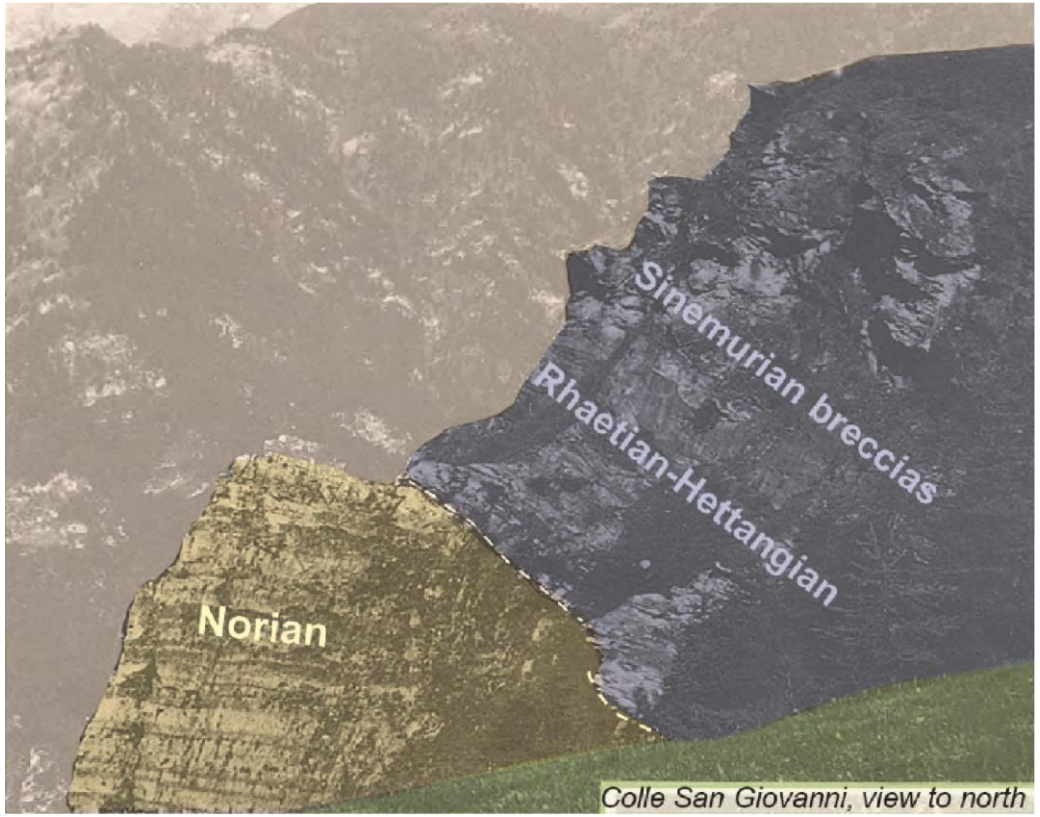
i) **Briançonnais was the distal European paleomargin during the Mesozoic**
ii) **Now complex of nappes in the Internal metamorphic prism**
iii) **It is overlain by the ophiolitic Schistes Lustrés and by the Sesia-Dent Blanche units = former Adria (African microplate) border**

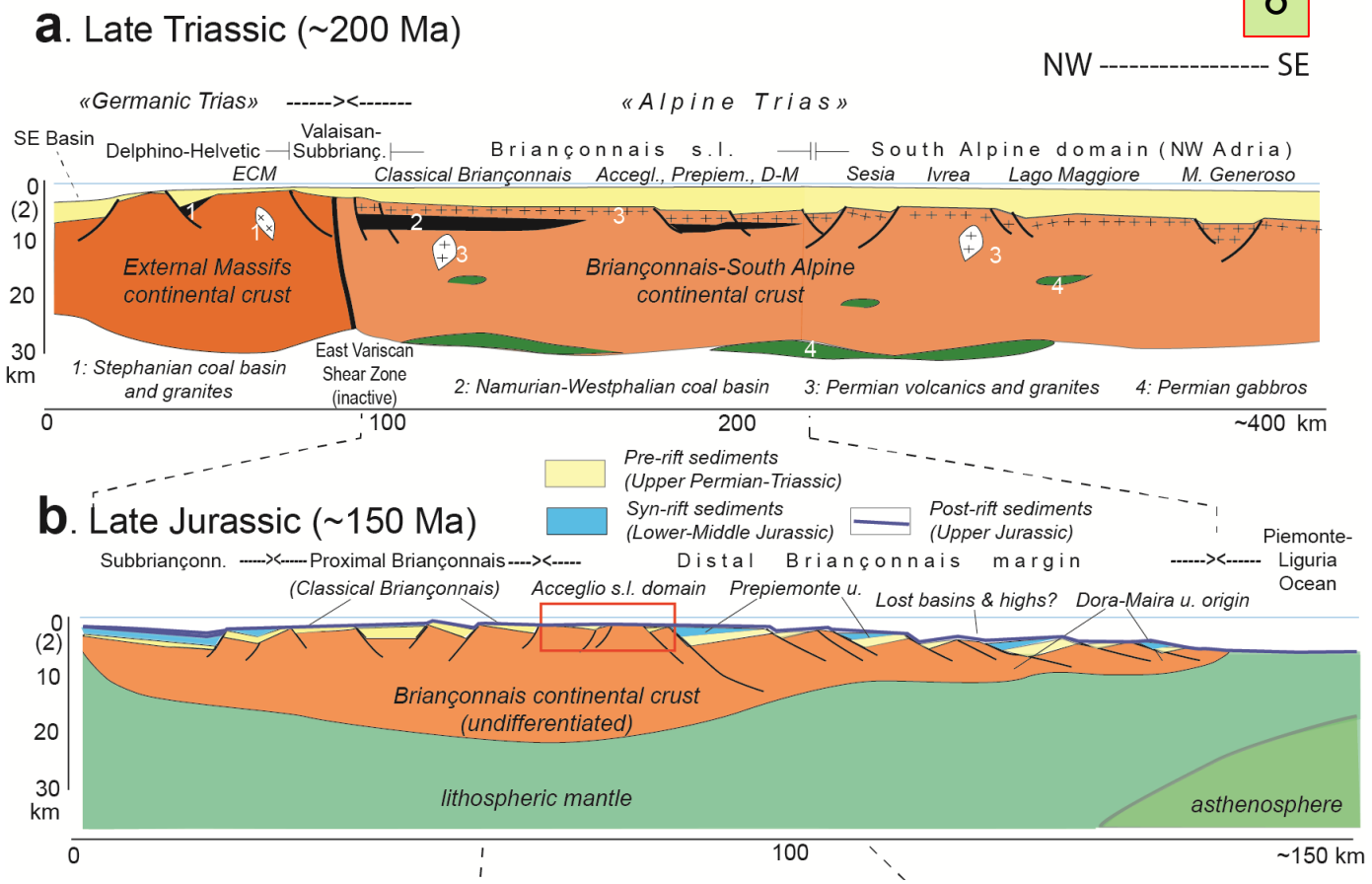


- **Briançonnais = complex of metamorphic nappes.**
- **Overlain by meta-ophiolites and meta-sediments (« Schistes Lustrés »)**
- **Stratigraphic record: rifting UT-LJ; thermal subsidence MJ-UJ-EC; renewed extension LC-Paleocene**



Liassic rifting in Internal Briançonnais



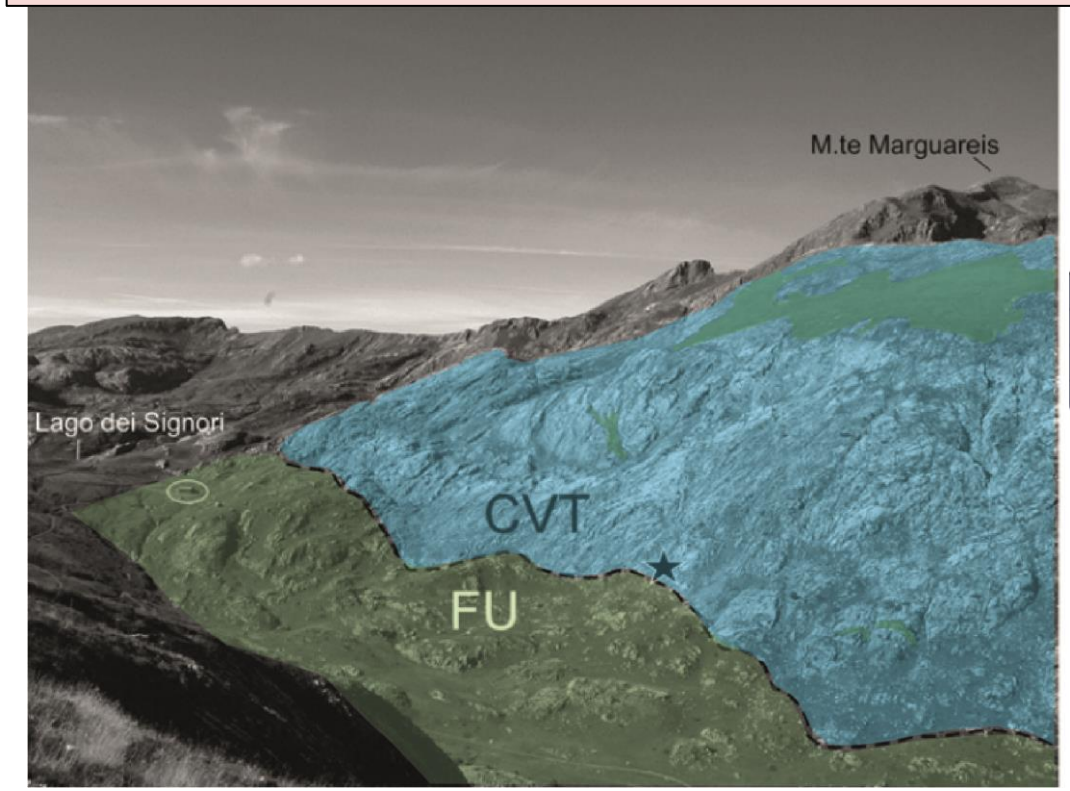


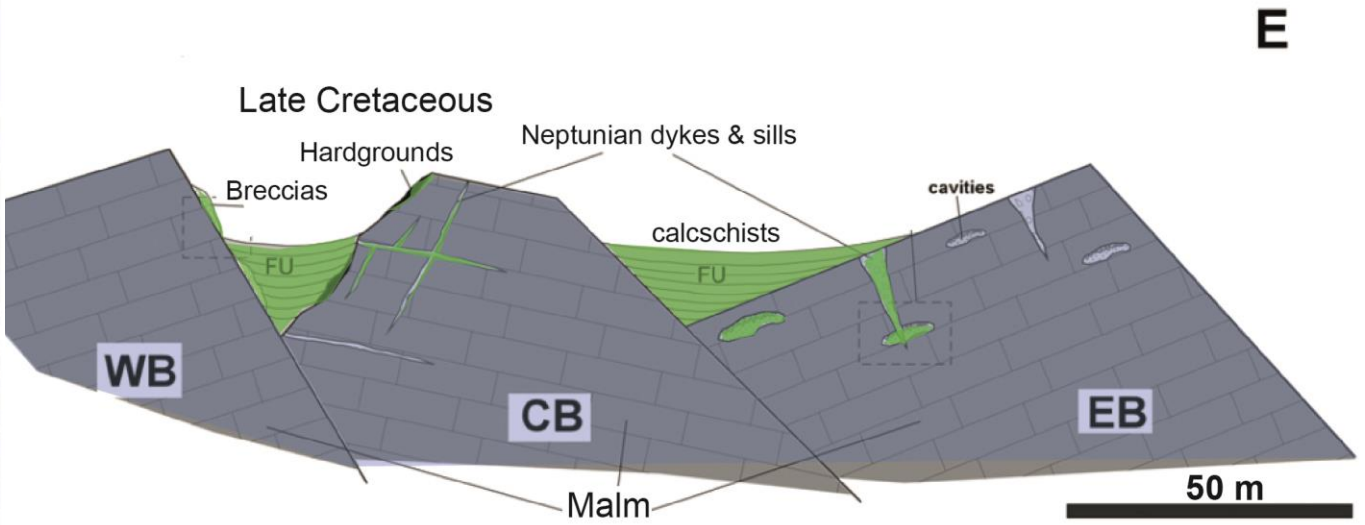
i) Rifting markers = Late Permian magmatism, Late Triassic facies, Liassic faulting and breccias;
ii) Hyperextension and thermal subsidence up to the Early Cretaceous

Haute Ubaye; J.P. Bouillin, person. comm., Sept. 2022

- **Paleofault escarpment cutting across Malm pelagic limestones**
- **Late Cretaceous calcschists with Malm blocks onto the fault escarpment**
- **In other places, blocks and pebbles of Triassic dolostones**

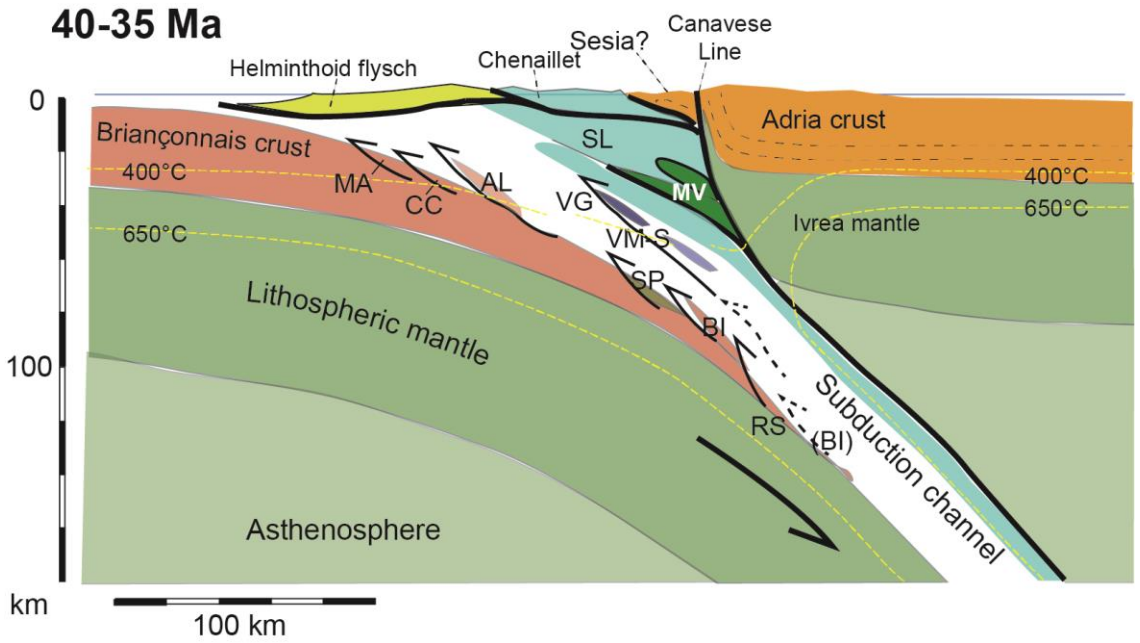
LATE CRETACEOUS EXTENSION IN THE LIGURIAN BRIANÇONNAIS



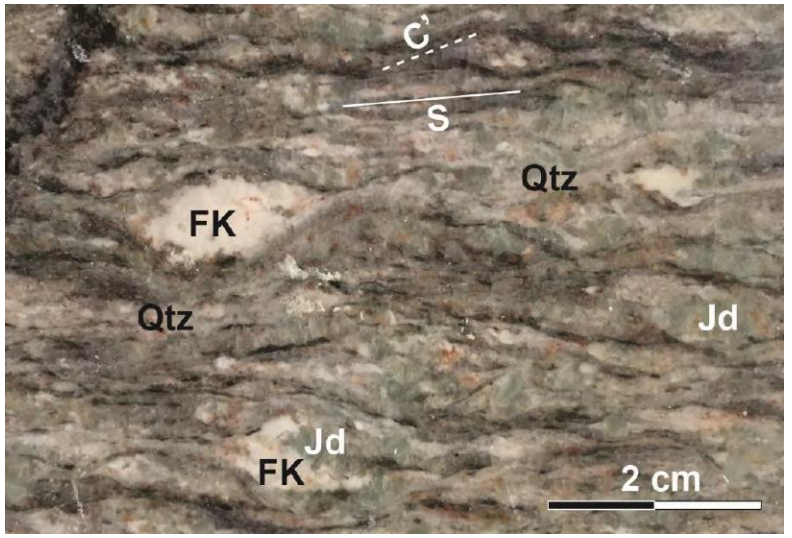


Tilted blocks of Mte Marguareis, Ligurian Briançonnais; Bertok et al. 2012

- **Paleofault escarpments bounding tilted blocks of Malm limestones**
- **Late Cretaceous age of extension**
- **Fault scarps buried by the Middle Eocene Flysch**

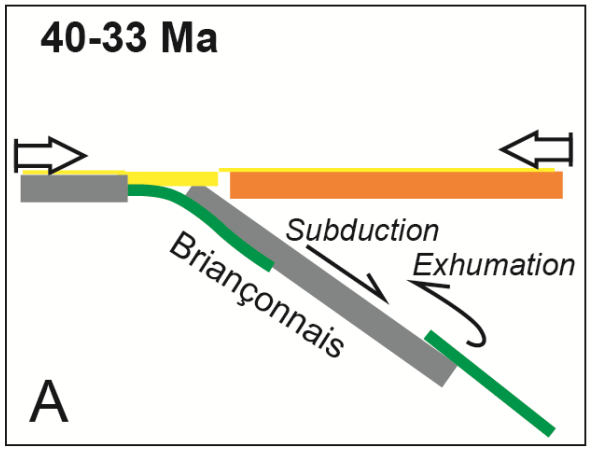


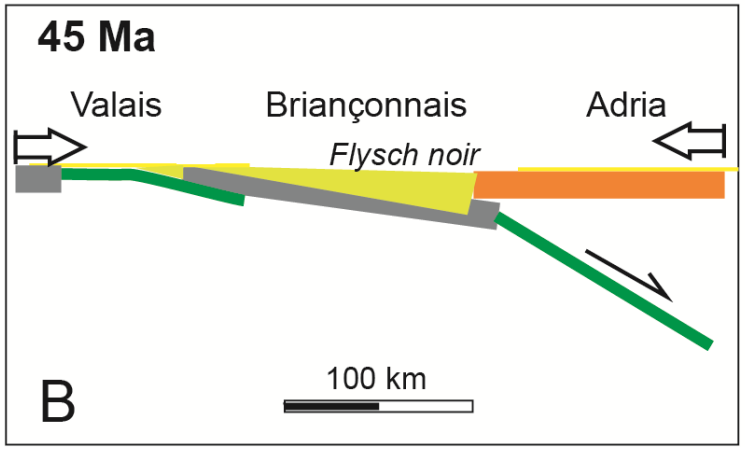
End of Briançonnais subduction, ongoing exhumation

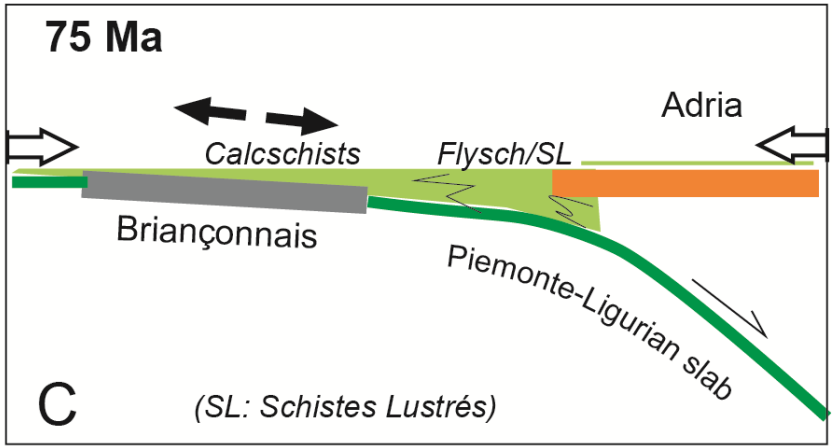


Internal Briançonnais reached the Jd-Qtz facies

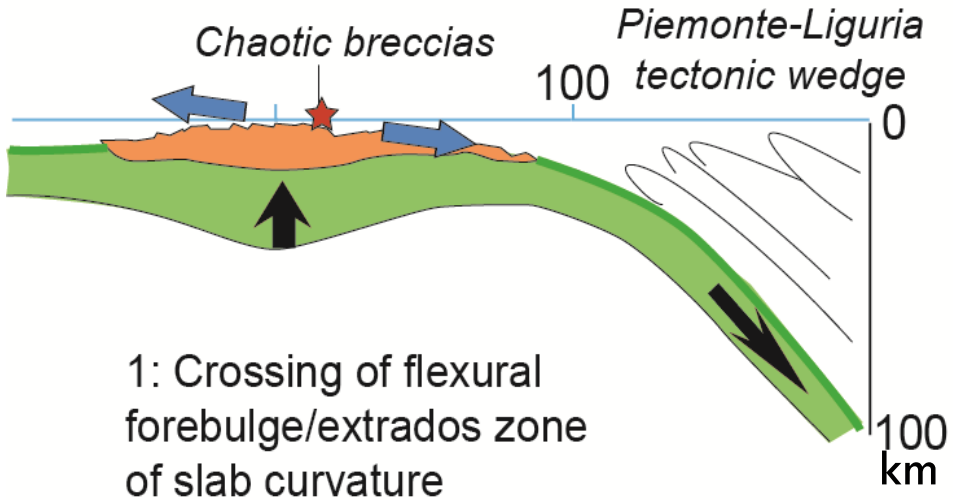
=> The Late Cretaceous extension occurred when the Briançonnais was approaching the subduction zone !



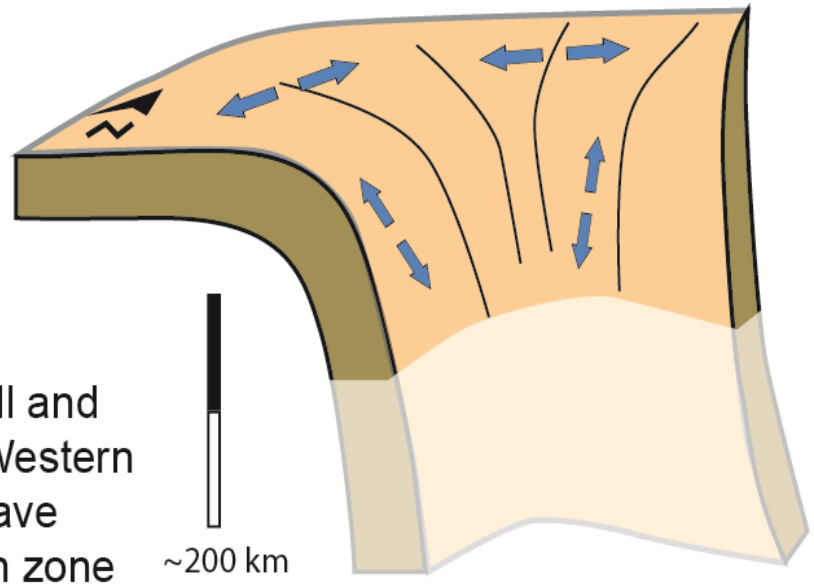




Going back in time



1: Crossing of flexural forebulge/extrados zone of slab curvature



2: Slab pull and stress in Western Alps concave subduction zone

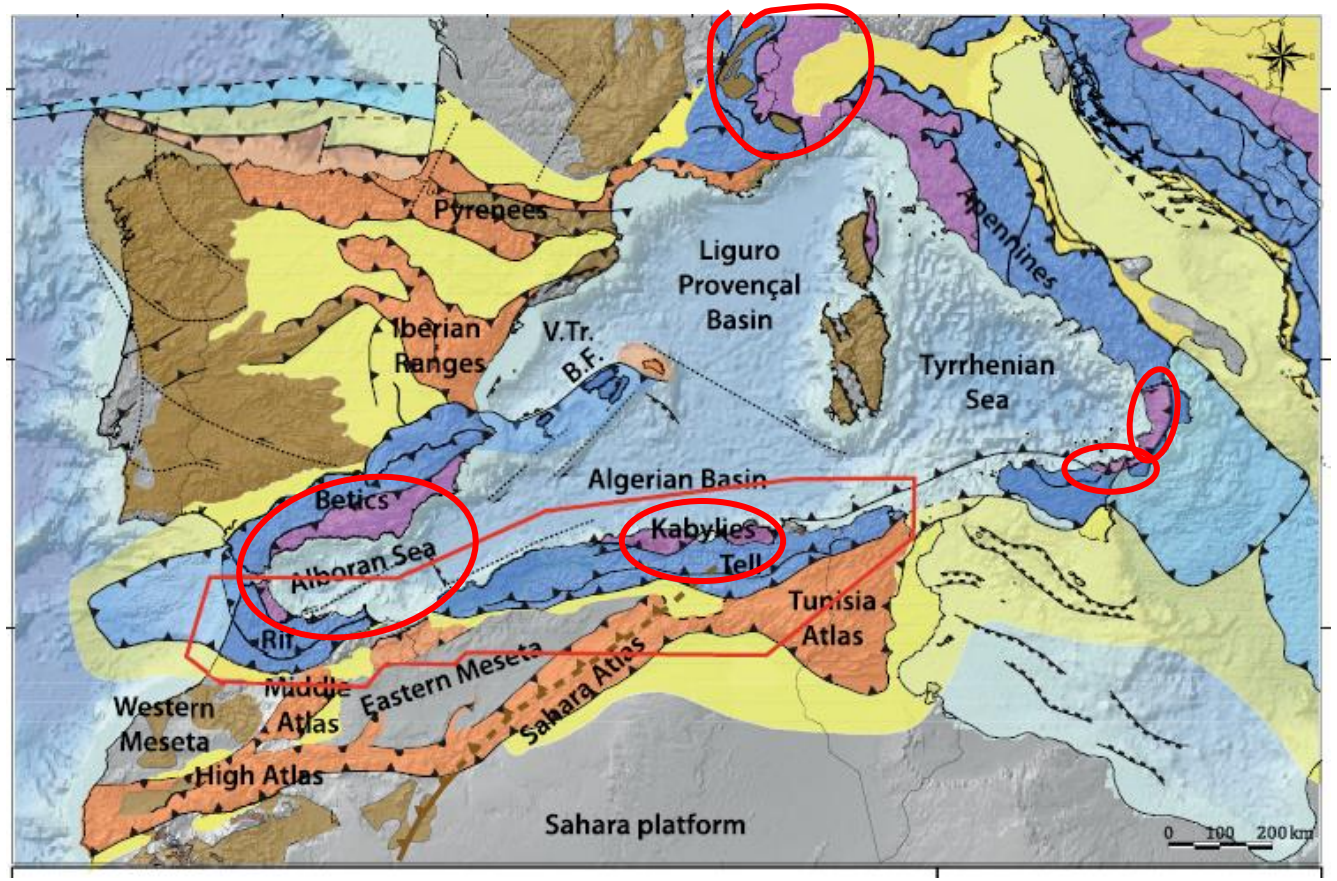
Possible origin of extensional stress:

i) Extrados bending

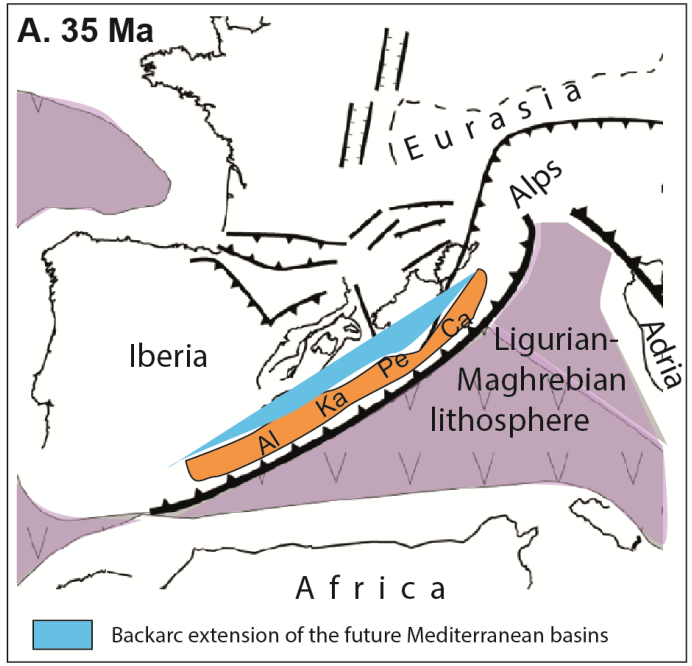
ii) Increased slab pull

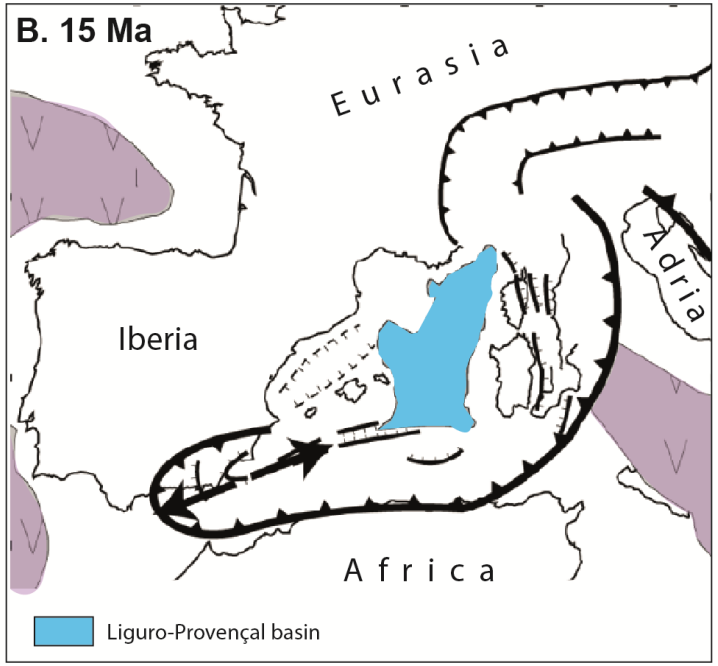
Quantitative modeling needed !

SHIFTING TO 3D PART 1: ALKAPECA



AlKaPeCa = continental block(s) detached from Iberia during the Jurassic and dismembered by the Mediterranean opening during the Late Eocene-Miocene.

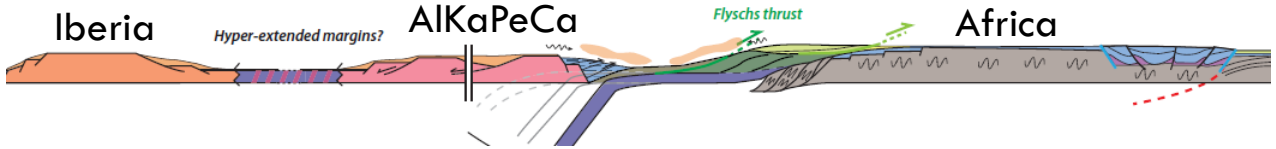




Jolivet et al. 2008, modified

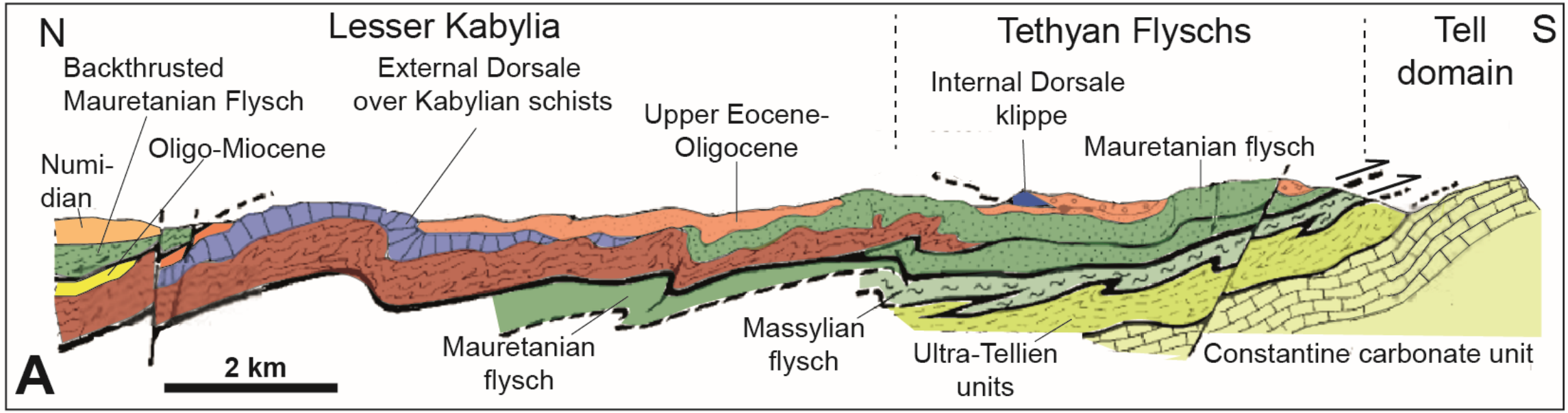
The Apenninic subduction

Late Olig.-Aquitanian, 25-21 Ma
(Leprêtre et al. 2018)



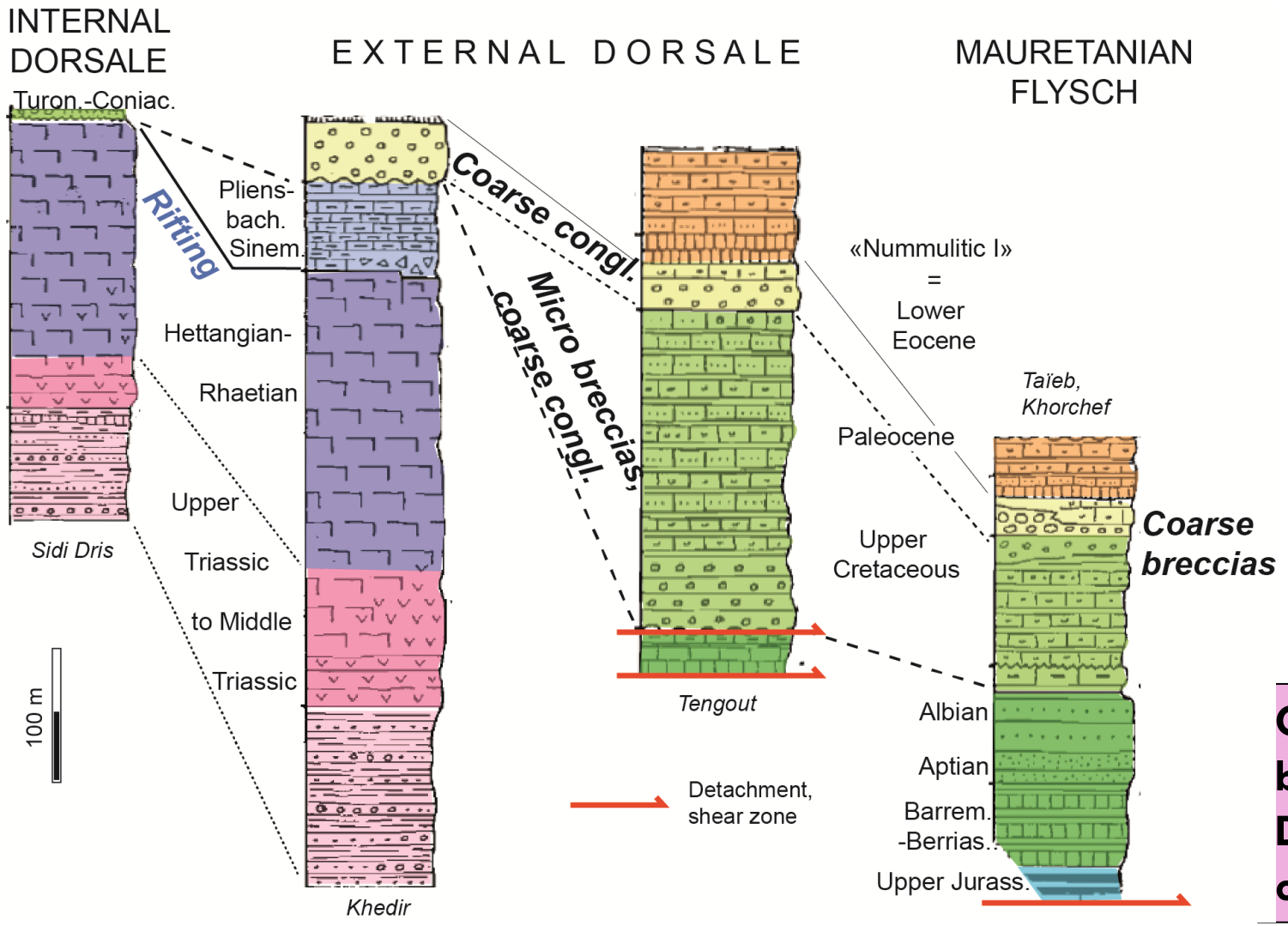
i) Dismembering of Alkapeca during NW-ward slab retreat from ~35 Ma to ~21 Ma
ii) The Apennine-type subduction dips opposite to the Late Cretaceous-Eocene Alpine subduction.

LESSER KABYLIA

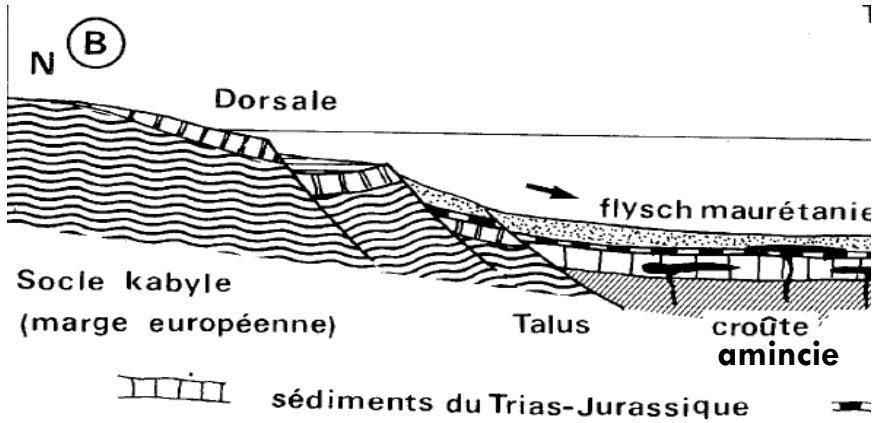


Raoult (1975), modified

- **Present structure contrasting with that of the Briançonnais**
- **Eocene – Miocene folding and thrusting on the African margin**
- **But « Dorsale calcaire » = Meso-Cenozoic of the Alkapeca margin**



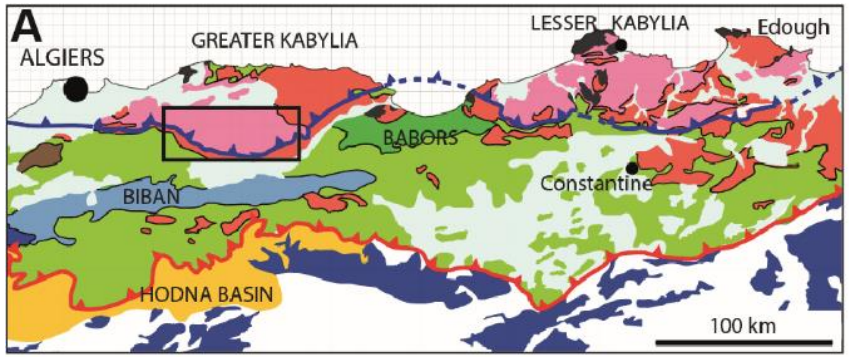
Stratigraphic data from Raoult (1975), modified.

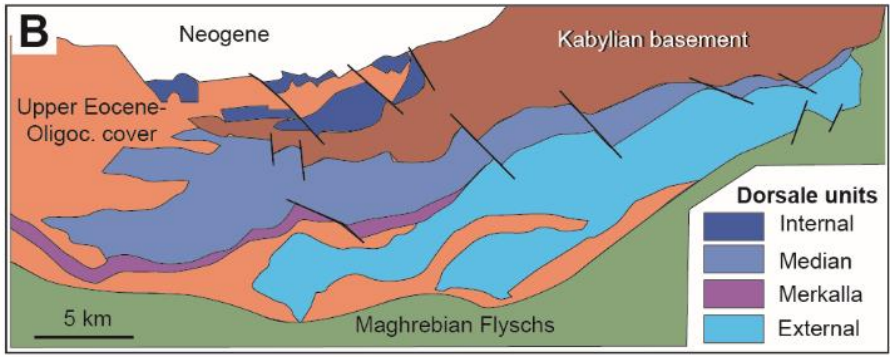


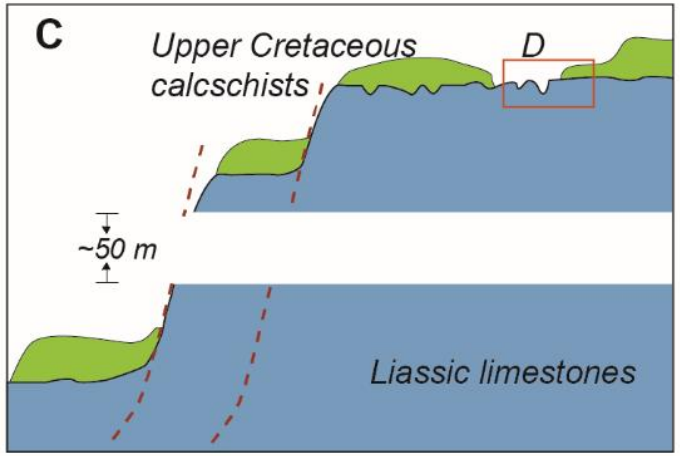
Bouillin, 1986

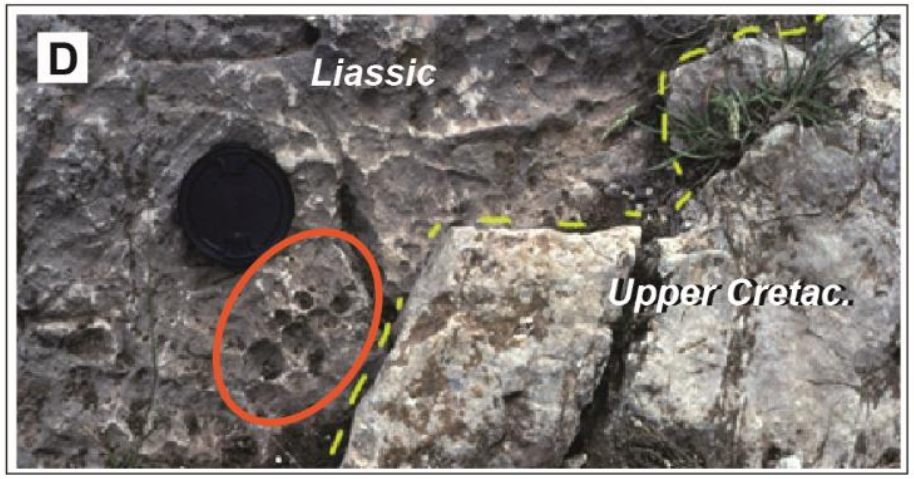
Campanian-Paleocene conglomerates, breccias & turbidites in the External Dorsale and adjacent Flysch => markers of extension !

GREATER KABYLIA







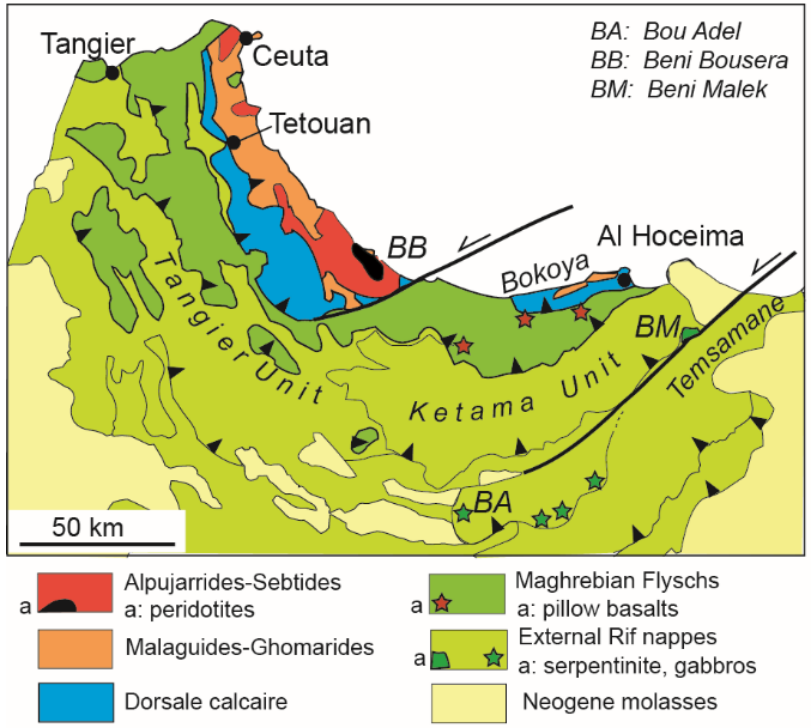


Courtesy JP Bouillin, unpubl. observ. 1989

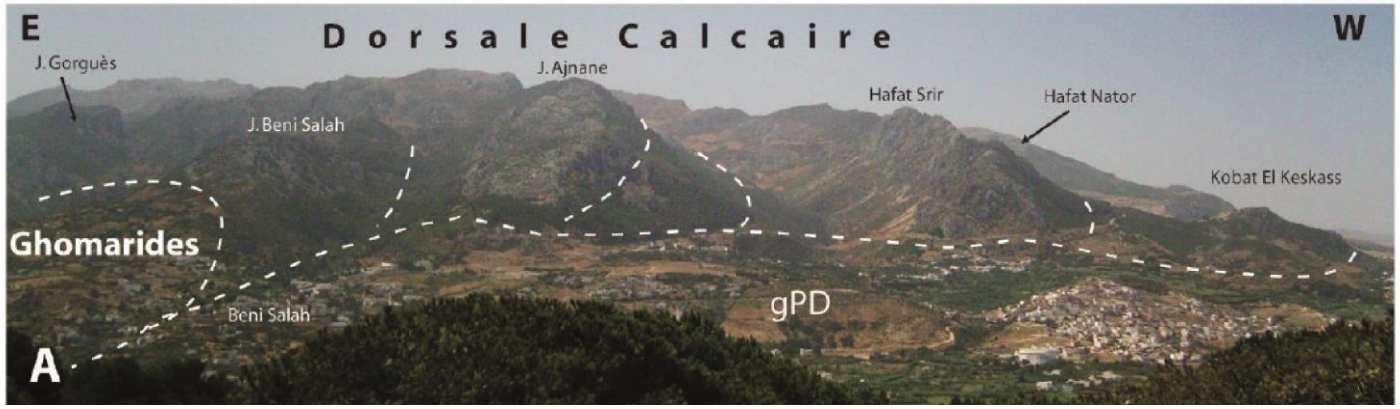
Courtesy JP Bouillin,
unpubl. observ. 1973

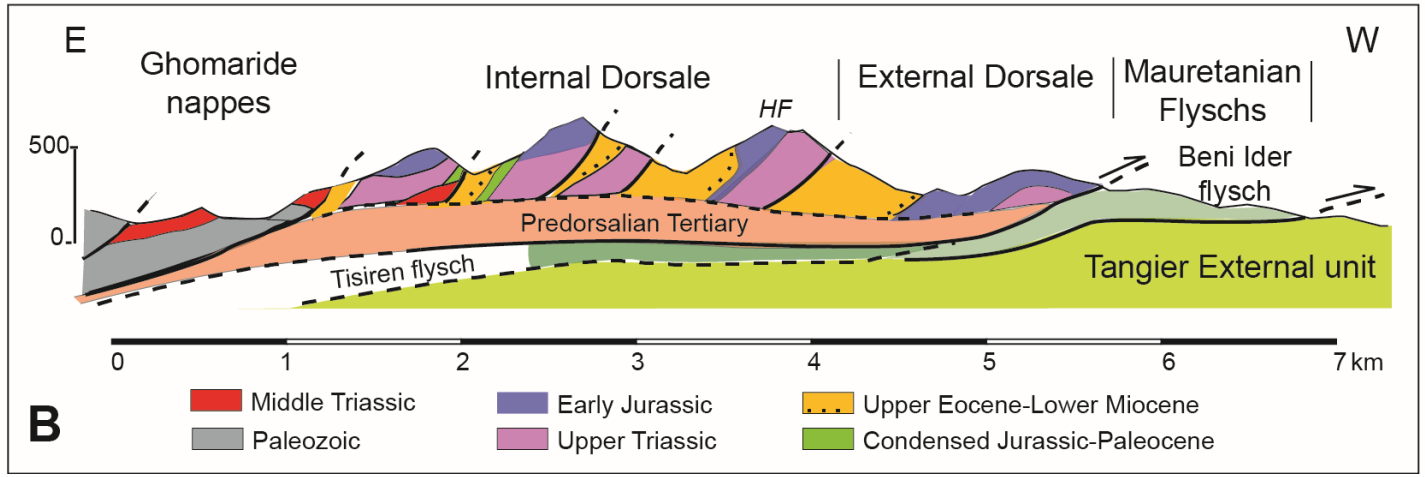
- **Tilted blocks in pelagic setting: => Likely an extensional setting**
- **Coarse breccias in adjoining Mauretanian Flysch**

ALBORAN DOMAIN, INTERNAL RIF

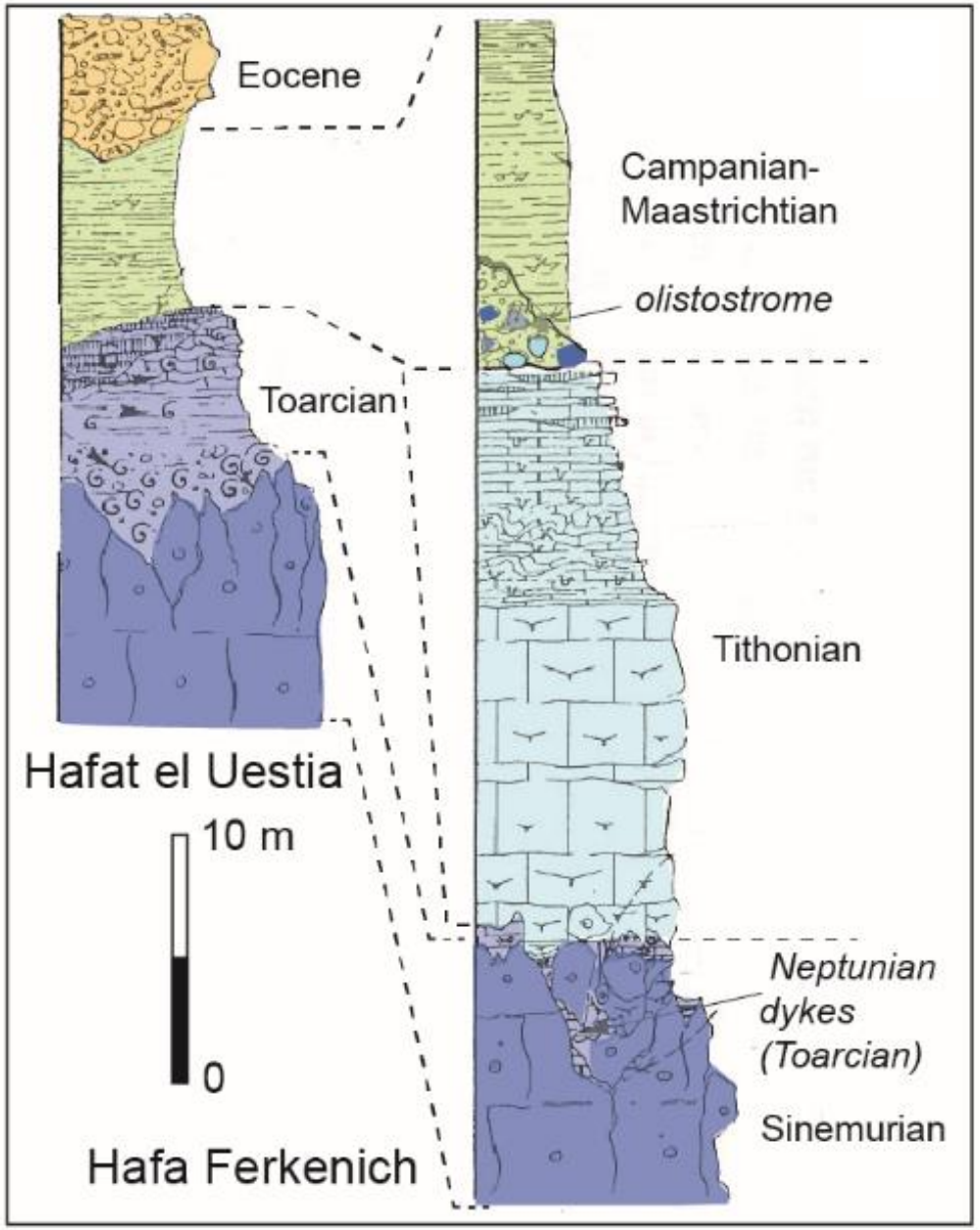


Chalouan et al., 2011, modified

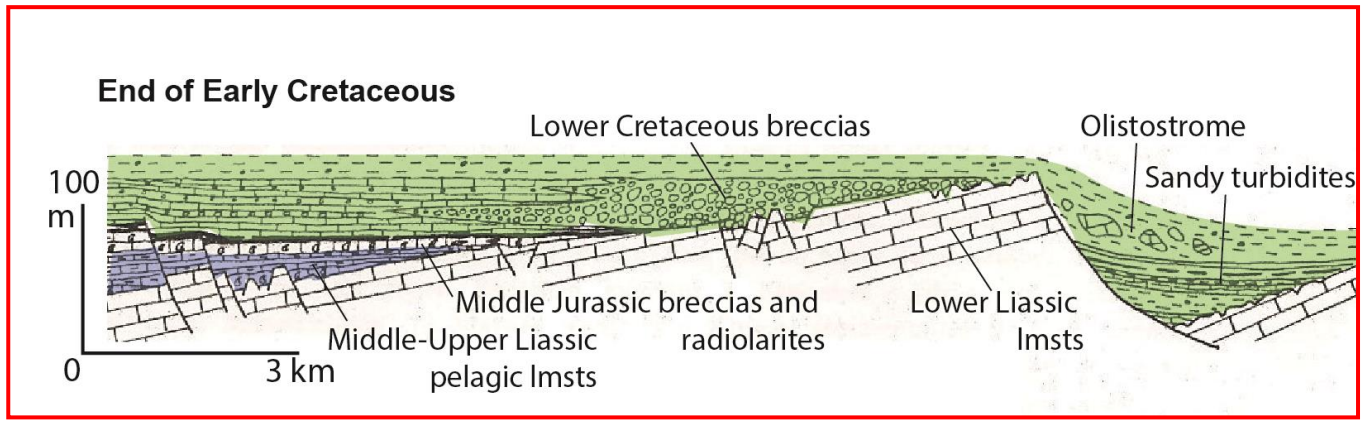




Post-Early Miocene structure equivalent to that of the Kabylia/Tell transect



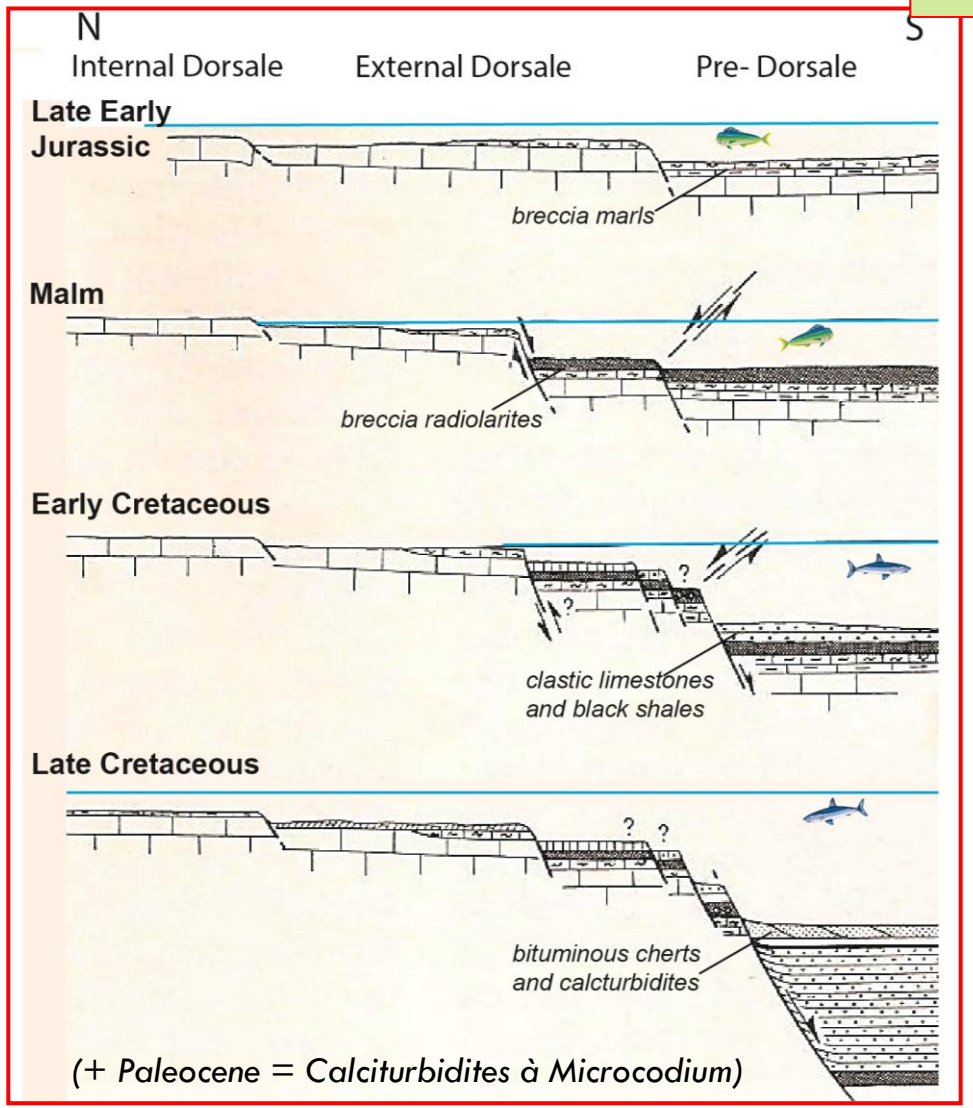
Two columns of the Internal Dorsale from the Tetuan area,
after El Kadiri et al, 1989



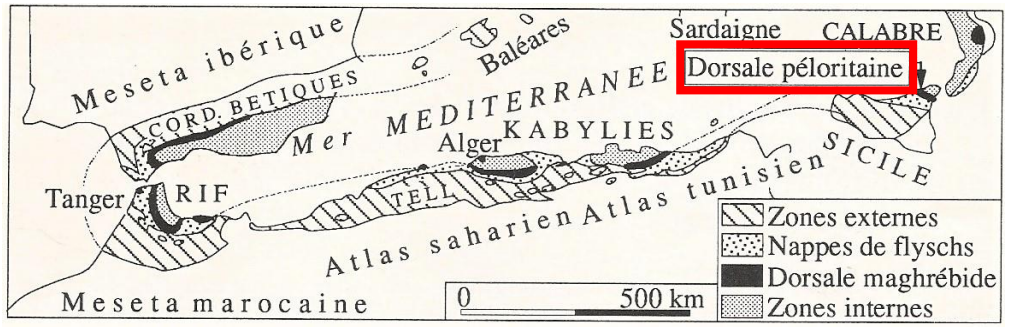
Albian extension and tilted blocks (El Hatimi & Duée, 1989)

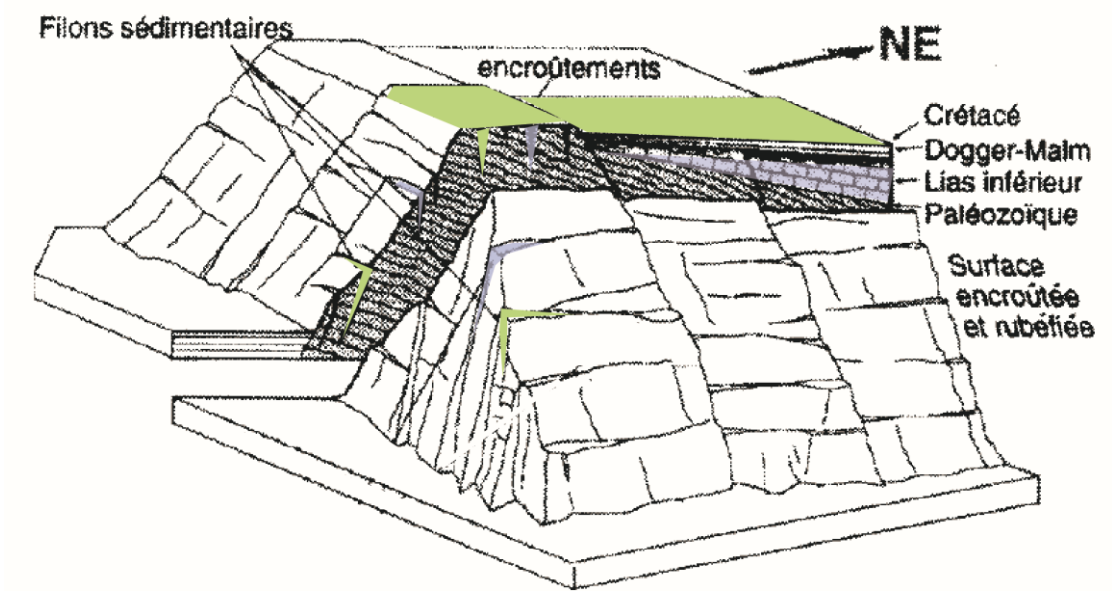
Permanent normal faulting in the Predorsalian unit = most external Dorsale (Olivier, 1990)

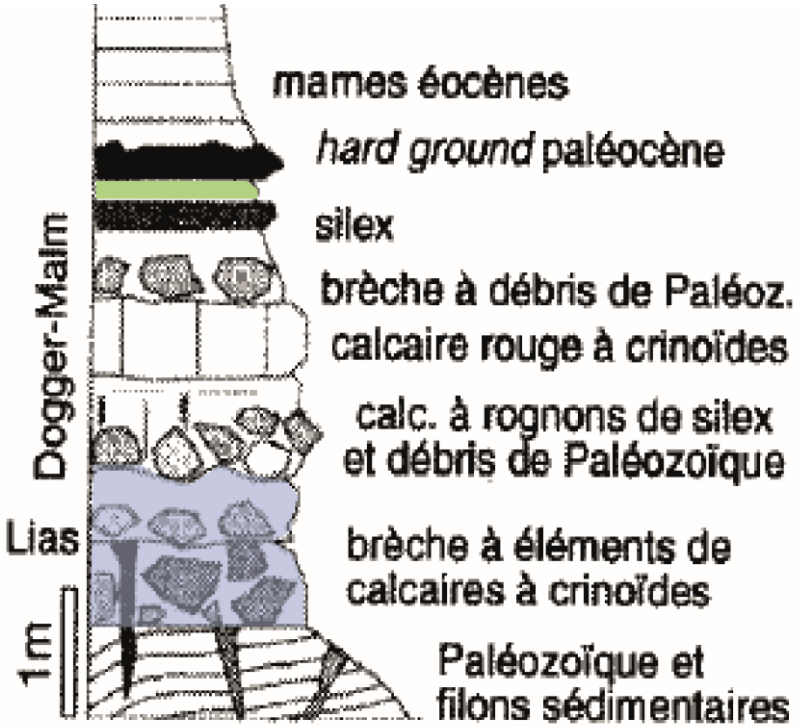
=> Post-rift extensional setting from the Malm to the Late Cretaceous-Paleocene



PELORITAN DORSALE



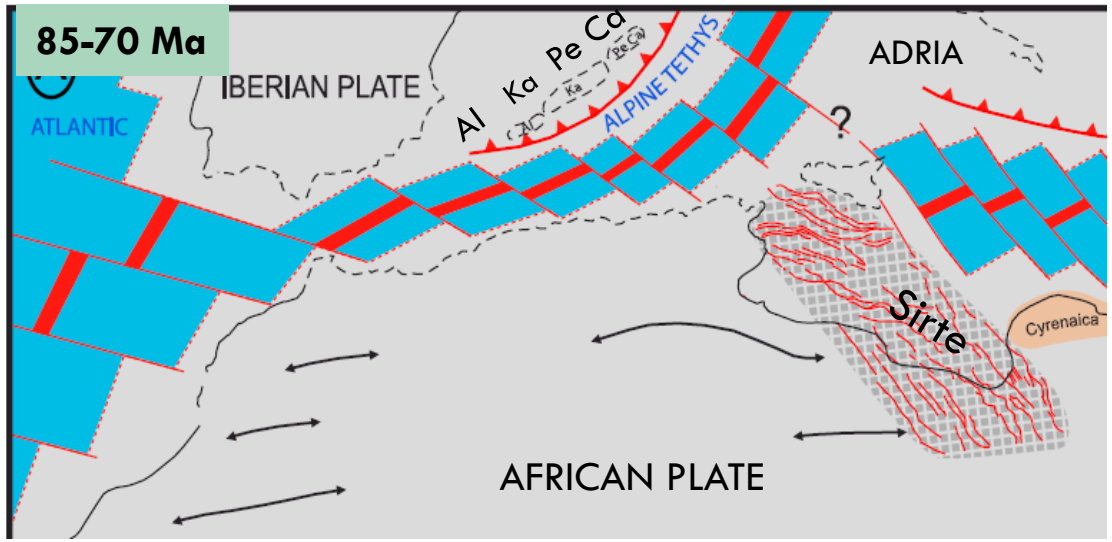




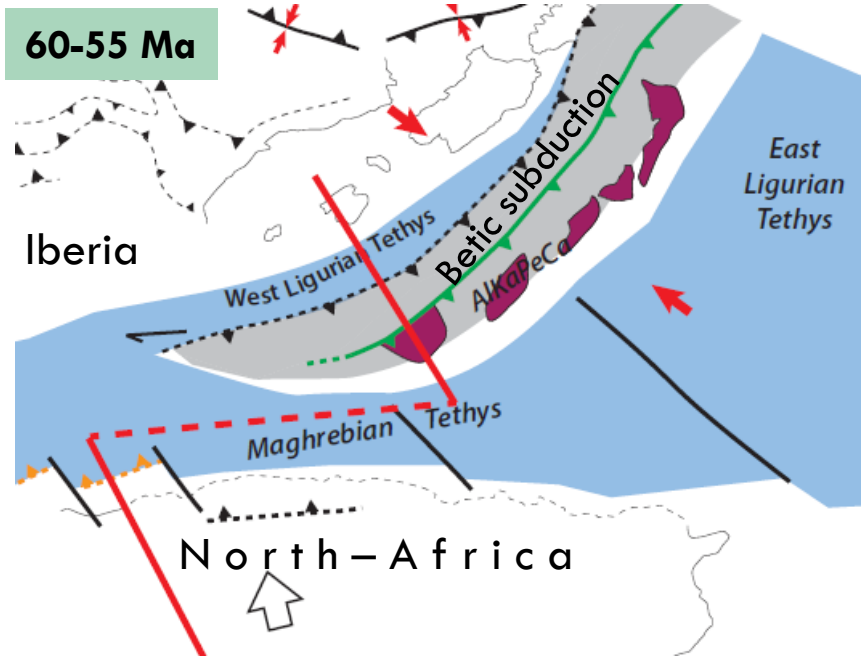
Bouillin et al., 1999

=> Again, post-rift extensional setting from the Late Jurassic to the Late Cretaceous-Paleocene

4D PART: DISCUSSION



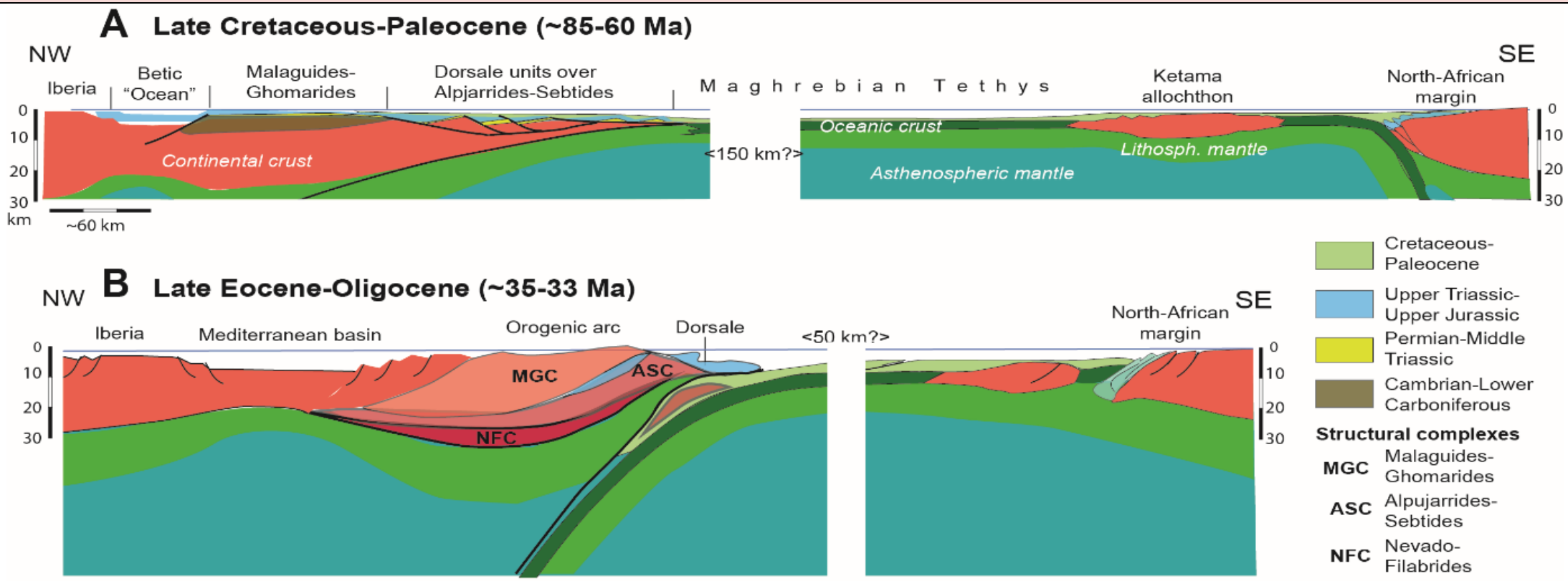
Subduction beneath Alkapeca (Frizon de Lamotte et al 2011)



Subduction within the Nevado-Filabrides, part of the Alboran Domain (Leprêtre et al 2018)

During the Late Cretaceous-Paleocene:
i) subduction of the Ligurian-Maghrebian slab must have occurred somewhere to accomodate convergence;
ii) the AlKaPeCa margin is still hyper-extending like the Briançonnais;
=> Subduction along North-Africa like in the Alps

PROPOSAL: ALPINE SUBDUCTION *BEFORE* THE APENNINIC



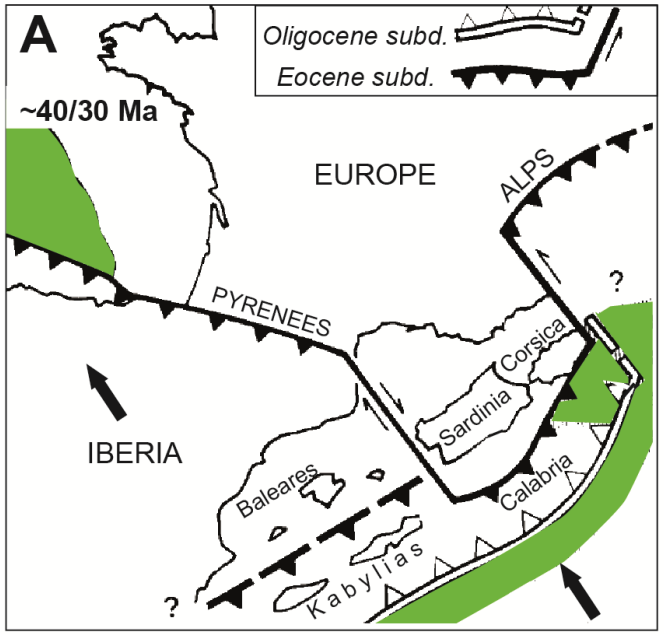
References: i) for A, see Farah et al, 2021; for B: Porkolab et al 2022

- **Subduction Polarity Reversal (SPR) at ~40-30 Ma, recorded by early metamorphic events in Alkapeca;**
- **SPR due to collision of continental allochthons against Africa?? Rather by age of slab greater to the N.**

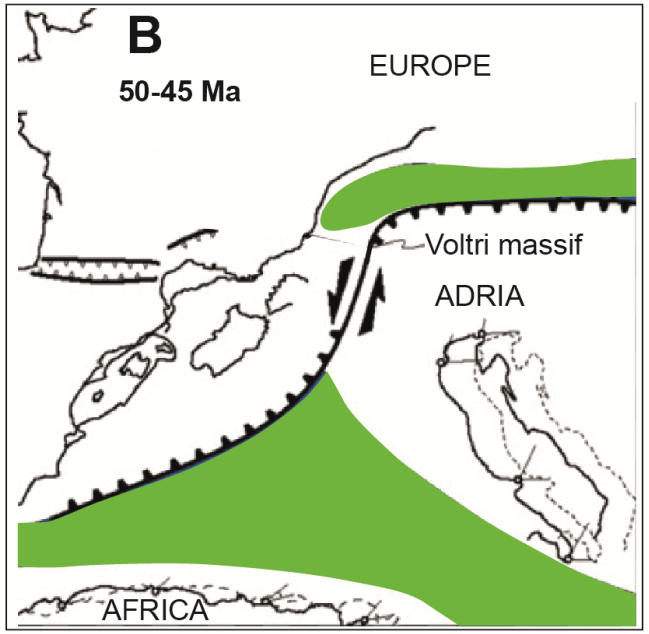
SUCCESSIVE INTERPRETATIONS

A: Rehault et al 1984;
B: Vignaroli et al 2008;
C: Molli 2008;
D: This work (modify a map by Schmid et al 2017) .

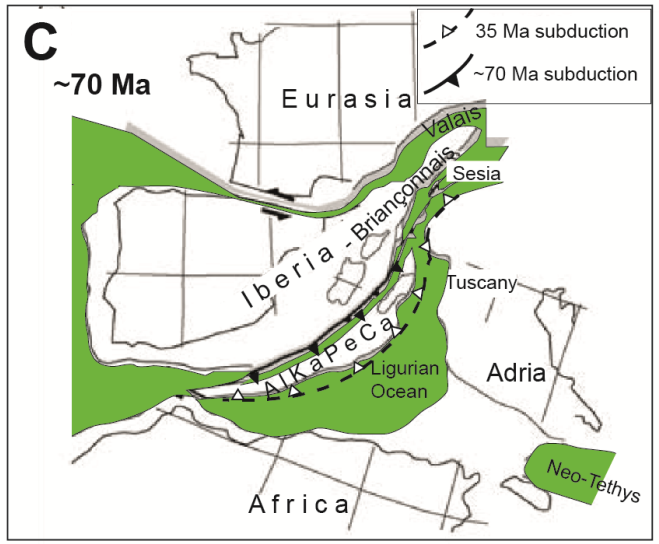
After the Alpine subduction shown in D, a flip of subduction polarity (SPR) occurred as proposed in A



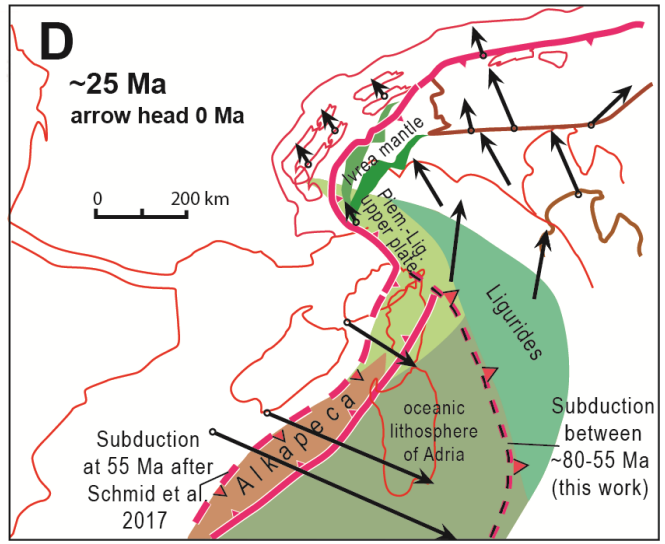
Rehault et al., 1984



Vignaroli et al., 2008



Molli, 2008 (modified)



Schmid et al., 2017 (modified)

CONCLUSION

- In the Western Alps transect, the Briançonnais European margin kept extending from the initial rifting until it encroached the Alpine subduction (Early Eocene).
- An Alpine subduction must be also considered for the Maghrebides transects during the Late Cretaceous-Paleocene.
- During the Late Eocene, a SPR created the Apenninic subduction, responsible for the Mediterranean opening and coeval to backthrust in the Western Alps.

Marrone et al., 2020

Thank you for attention !