EGU General Assembly 2020

Thermal evolution of the Khenifra Basin, Morocco: a Raman study

How does it renew our vision of the NW Africa Variscan belt ?

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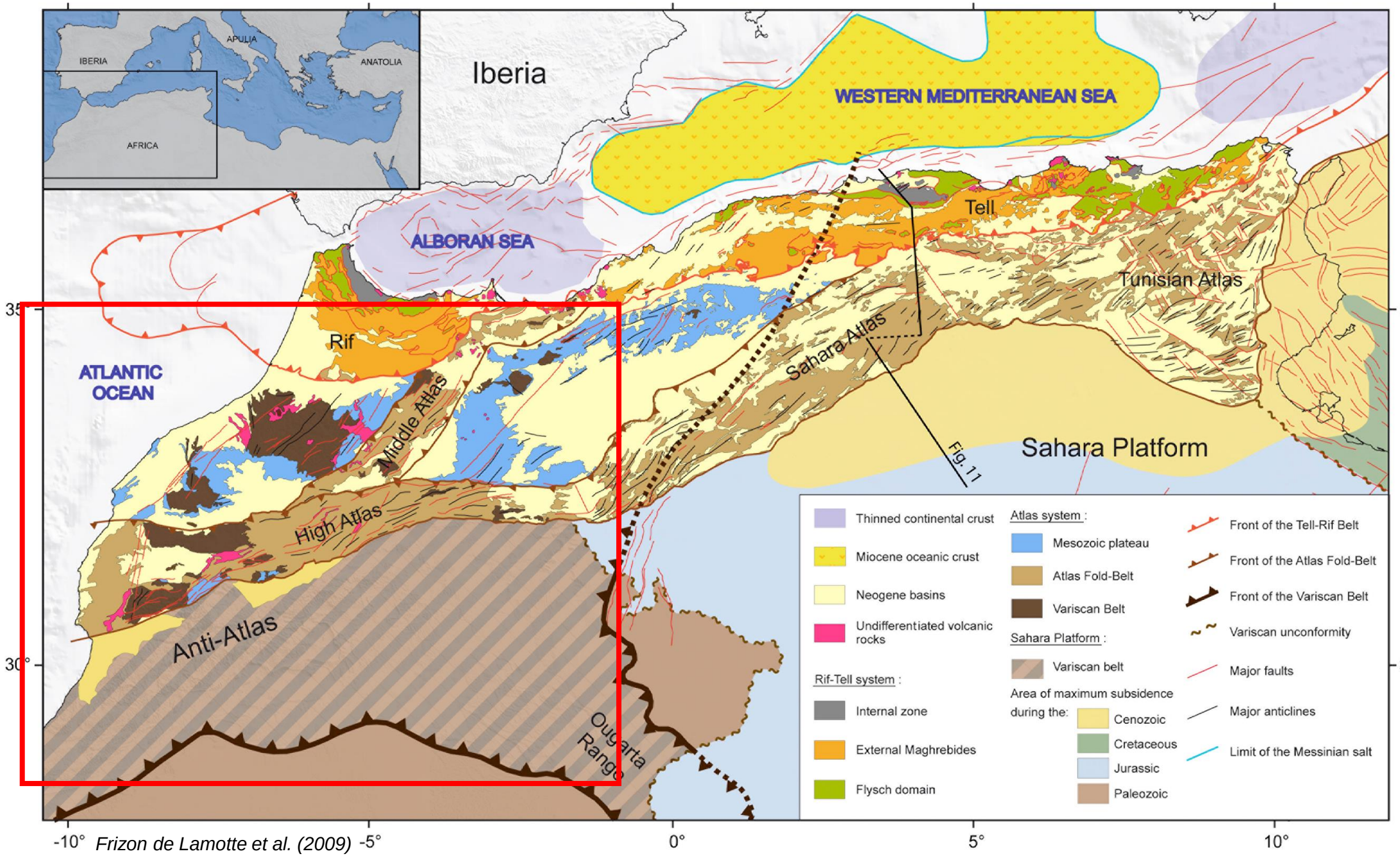
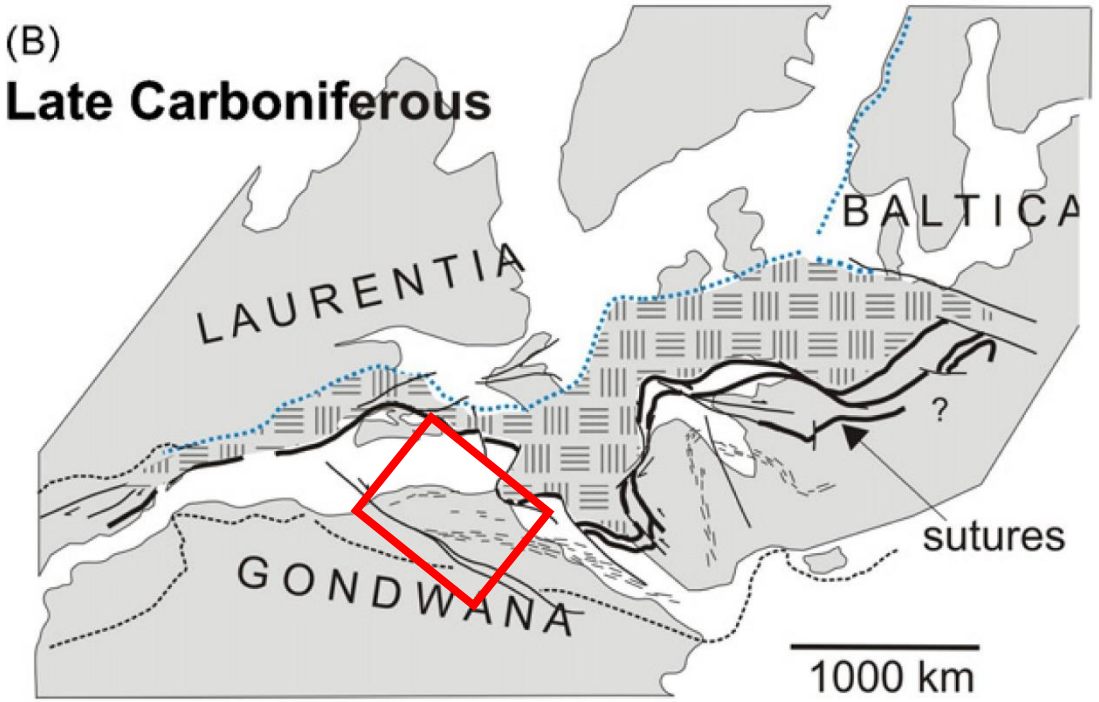
NW Africa Geology

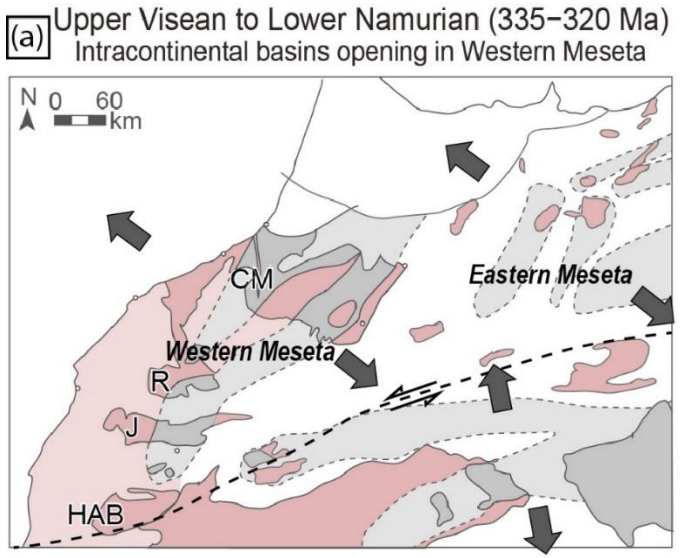


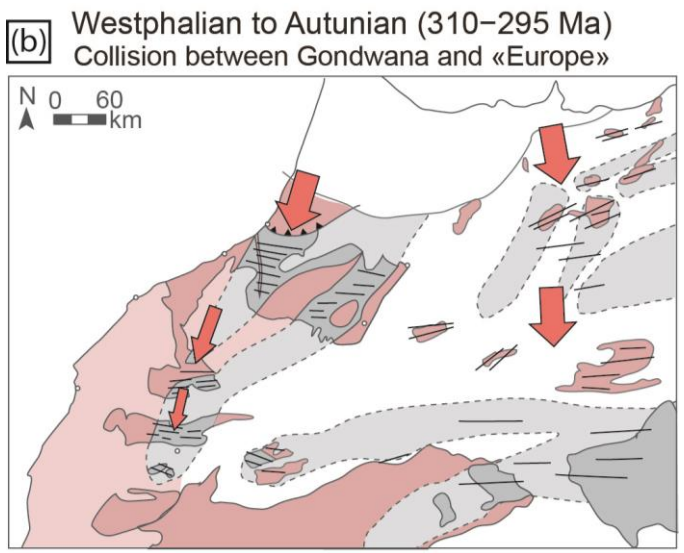
Frizon de Lamotte et al. (2009)

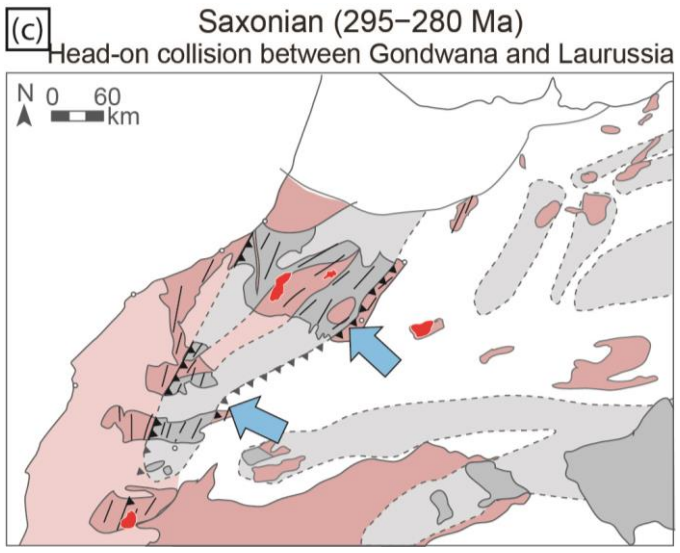
NW Africa Variscan belt



Simancas et al. (2009)







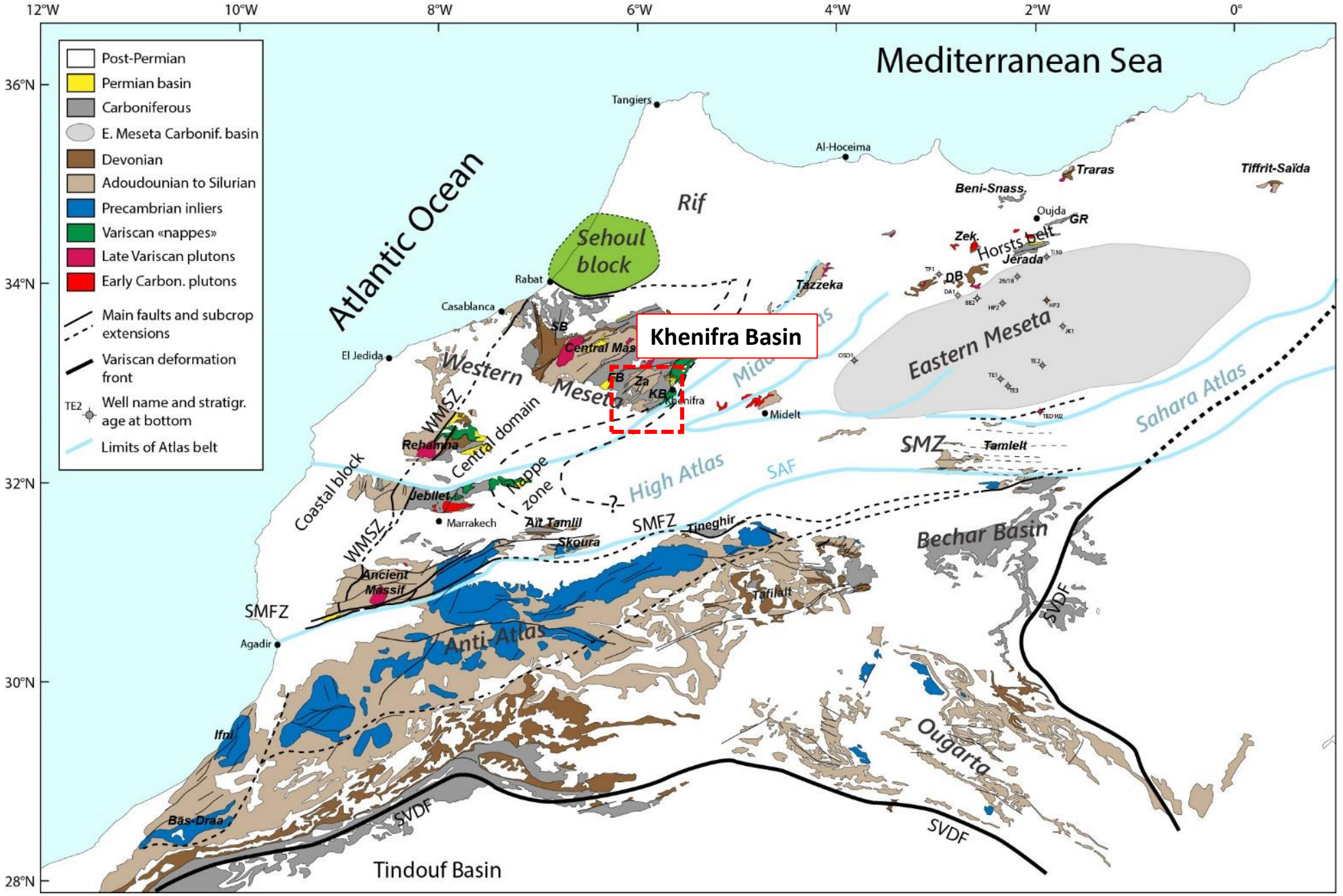
- **A Late Carboniferous/Early Permian intraplate belt**

- **Some features…**

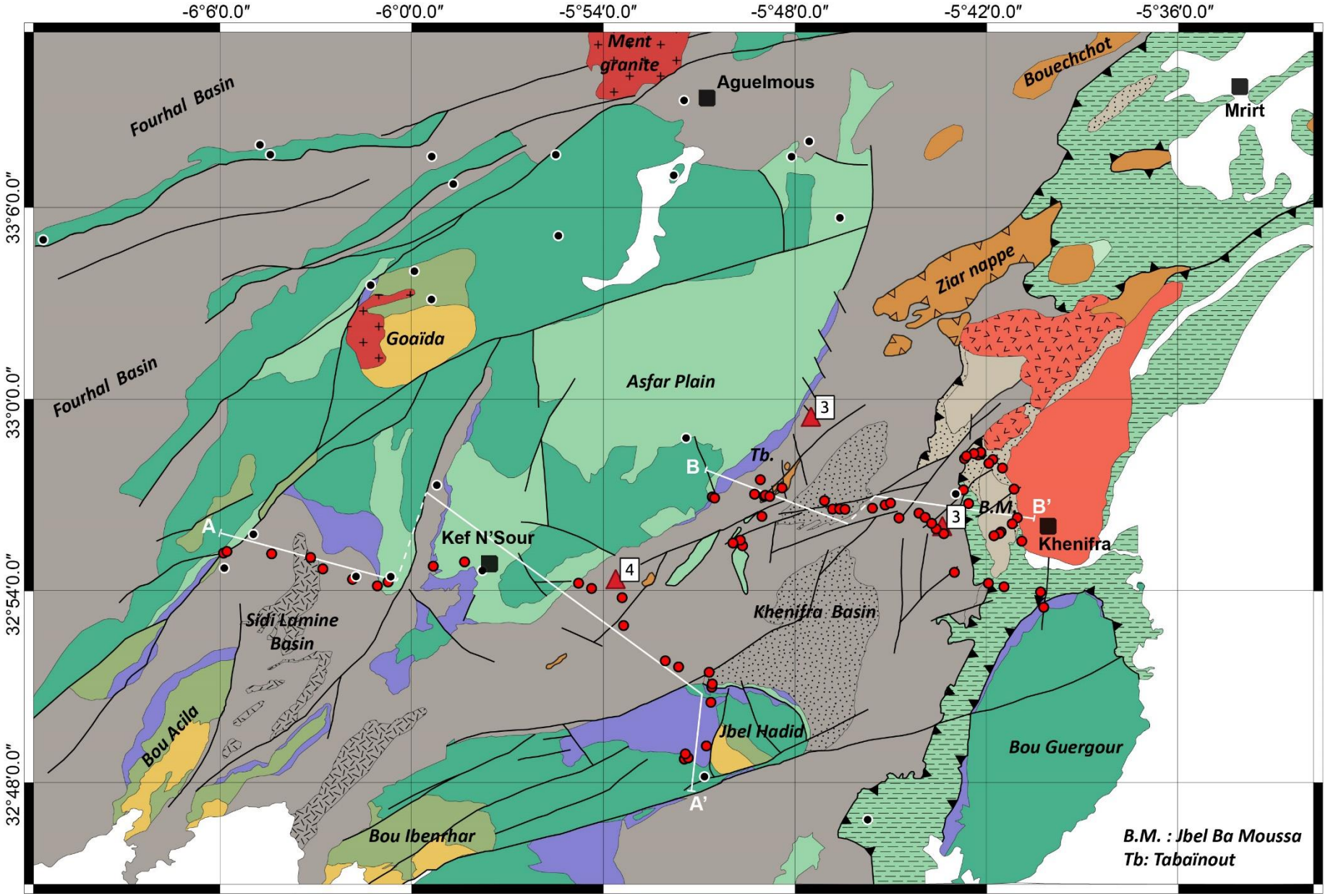
- Inward gobal vergences of tectonic structures
- No suture
- Overall low-degree metamorphism
- Abundant pre and syn-orogenic magmatism

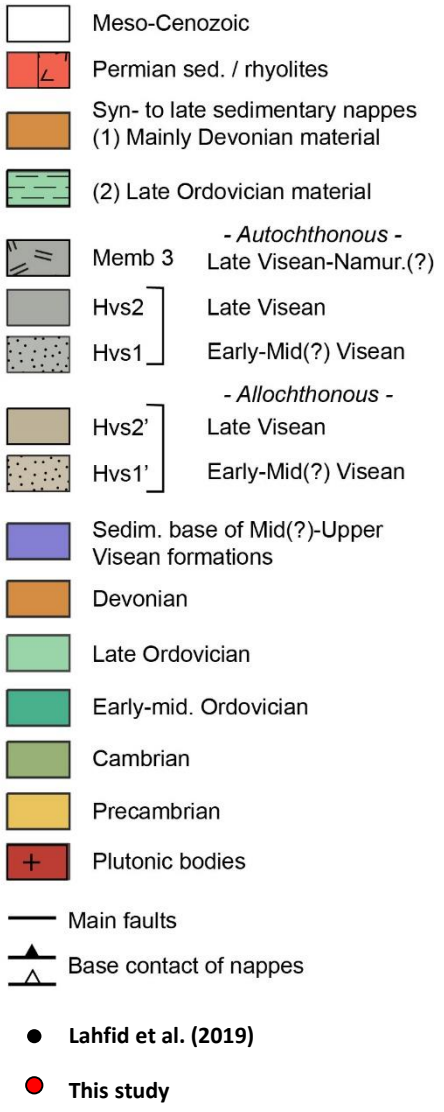
→ How can we understand the localization of the deformation within this crustal strip ?

Khenifra basin study



Khenifra basin geology

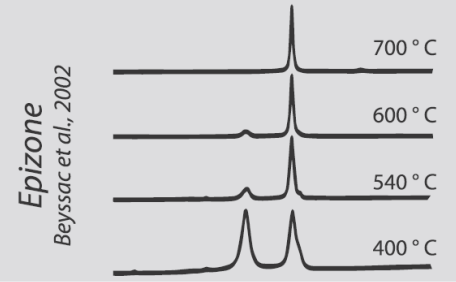




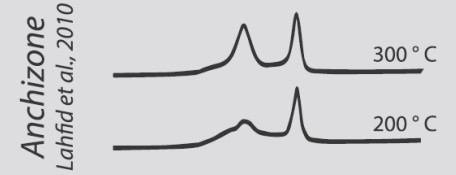
After Bouabdelli (1989), El Houicha et al. (1994), Lahfid et al. (2019) and field observations

Raman spectroscopy

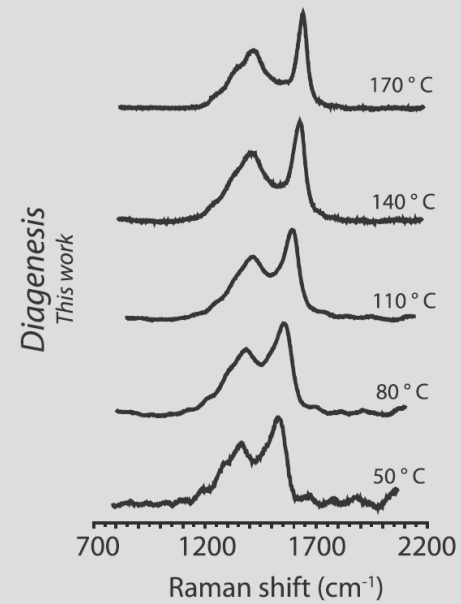
- ➔ Raman spectroscopy charaterizes crystallinity
- ➔ Crystalline state for organic matter is controlled at first order by the maximum temperature reached by the rock (Pasteris & Wopenka, 1991; Beyssac et al., 2002)
- ➔ Existing calibrations between Raman spectra and temperatures (***metam., vitrinite***; Beyssac et al., 2002; Lahfid et al., 2010; Schito et al., 2017)



Coal ranks
Anthracite to Graphite
Driving mechanism with Temperature increase
Decrease of the D band area and decraese of the full width at maximum height of the G band



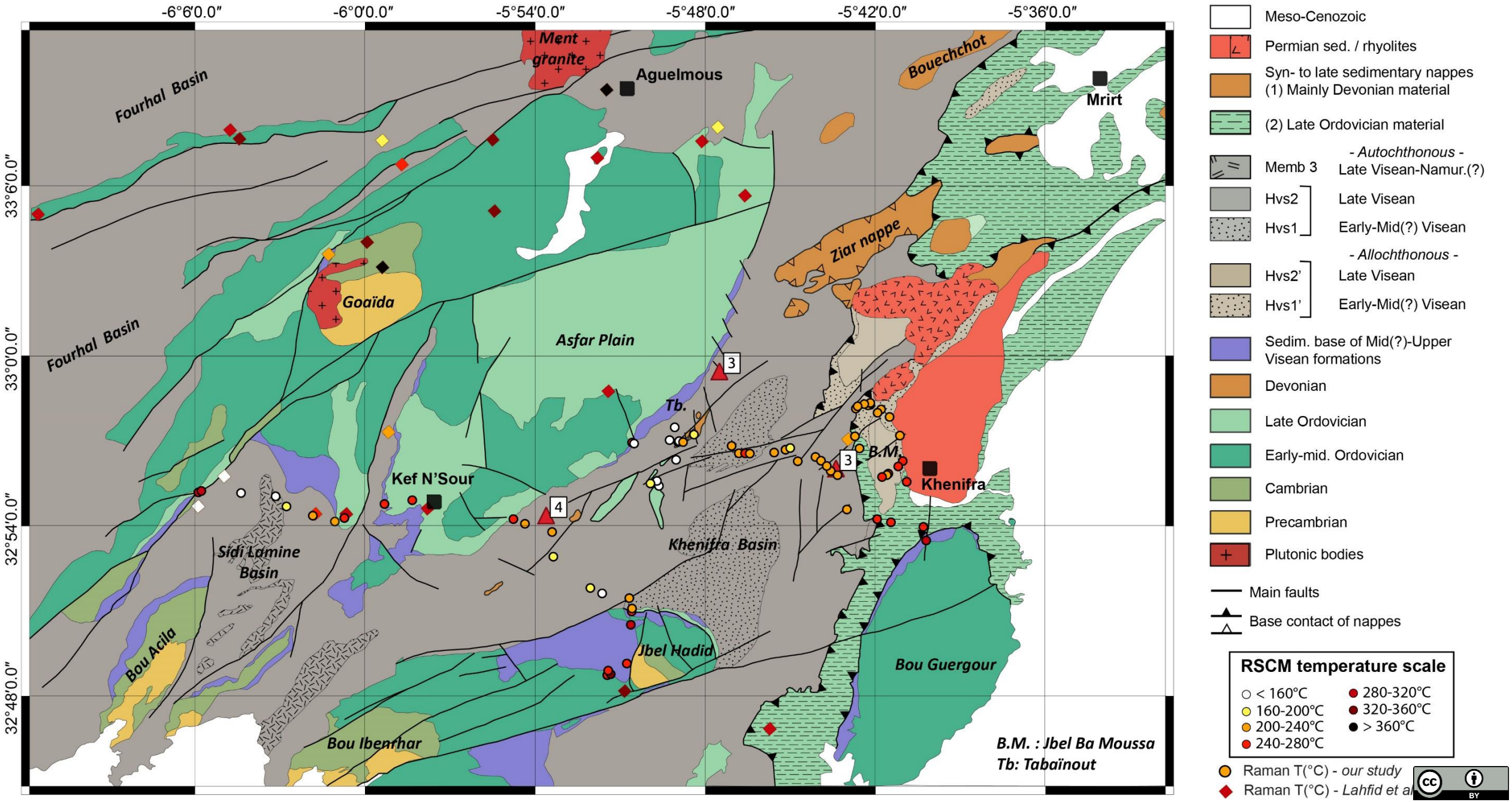
Coal ranks
Low volatile bituminous coal to anthracite
Driving mechanism with Temperature increase
Increase of the D band area and progressive desappearance of the minor bands



Coal ranks
Subituminous coals to medium volatile bituminous coal
Driving mechanism with Temperature increase
Decrease of the G band area due to a progressive shirnking of the G band and to the decreaes in the area of the Dl band assigned by recent work (Rebelo et al., 2016) to small aromatic rings and small polyene domains present only in kerogene at lo thermal maturity

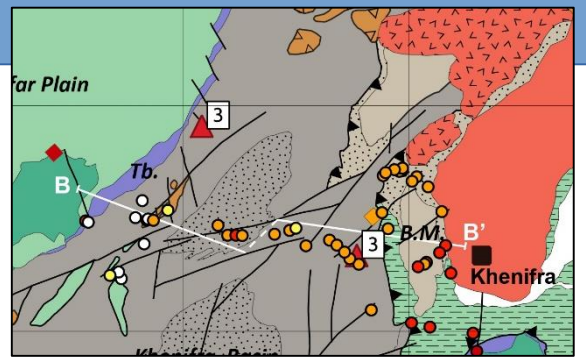
Schito et al. (2017)

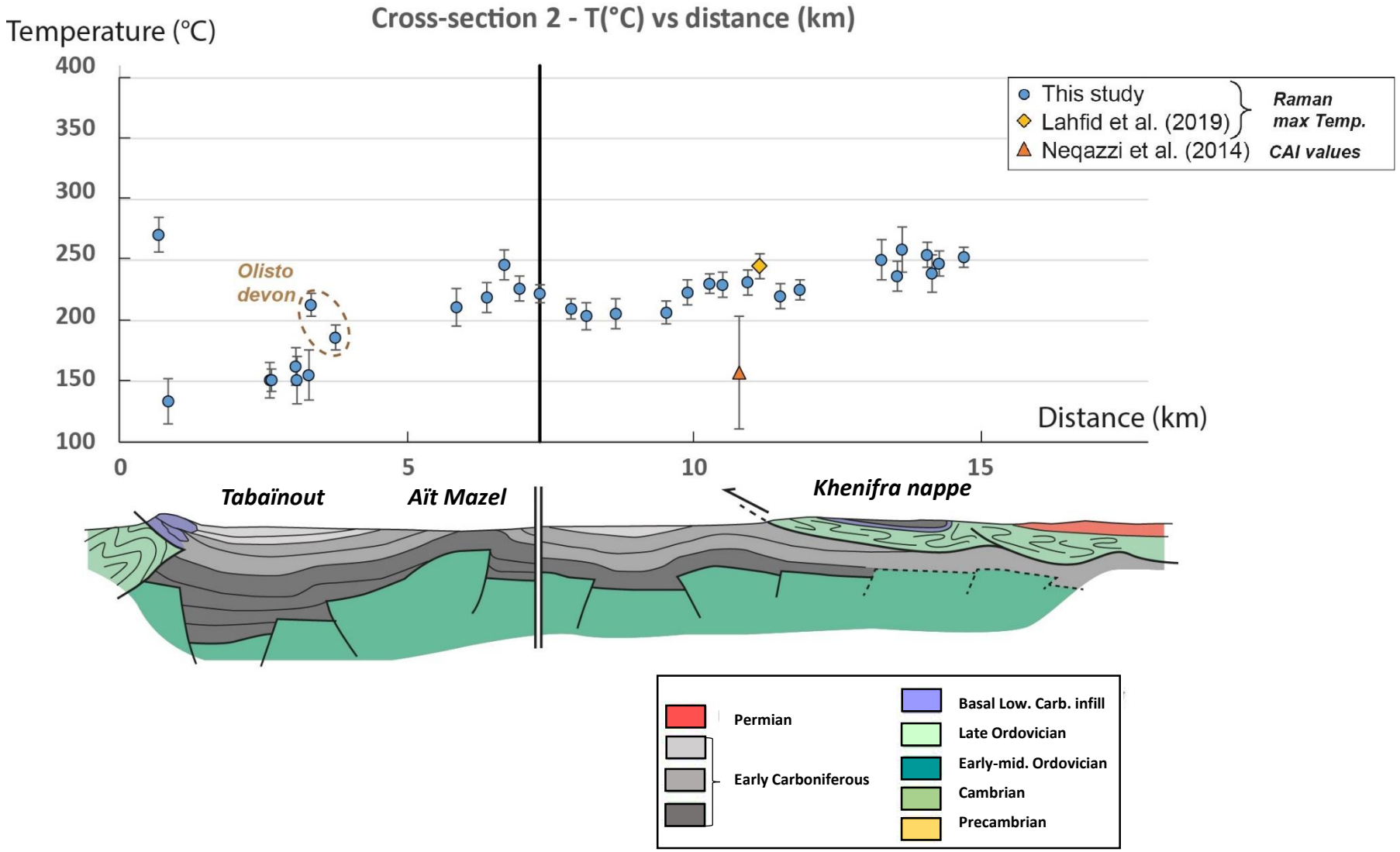
Results


-6°6'0.0"
-6°0'0.0"
-5°54'0.0"
-5°48'0.0"
-5°42'0.0"
-5°36'0.0"
33°6'0.0"
33°0'0.0"
32°54'0.0"
32°48'0.0"
Ment granite
Aguelmous
Bouechchot
Mrirt
Fourhal Basin
Fourhal Basin
Goaïda
Asfar Plain
Ziar nappe
Tb.
3
3
B.M.
Khenifra
Kef N'Sour
4
Sidi Lamine Basin
Khenifra Basin
Bou Acila
Jbel Hadid
Bou Guergour
Bou Ibenrhar
B.M. : Jbel Ba Moussa
Tb: Tabaïnout
Meso-Cenozoic
Permian sed. / rhyolites
Syn- to late sedimentary nappes
(1) Mainly Devonian material
(2) Late Ordovician material
- Autochthonous -
Memb 3
Late Visean-Namur.(?)
Hvs2
Late Visean
Hvs1
Early-Mid(?) Visean
- Allochthonous -
Hvs2'
Late Visean
Hvs1'
Early-Mid(?) Visean
Sedim. base of Mid(?)-Upper Visean formations
Devonian
Late Ordovician
Early-mid. Ordovician
Cambrian
Precambrian
Plutonic bodies
Main faults
Base contact of nappes
RSCM temperature scale
< 160°C
160-200°C
200-240°C
240-280°C
280-320°C
320-360°C
> 360°C
Raman T(°C) - our study
Raman T(°C) - Lahfid et al

Results

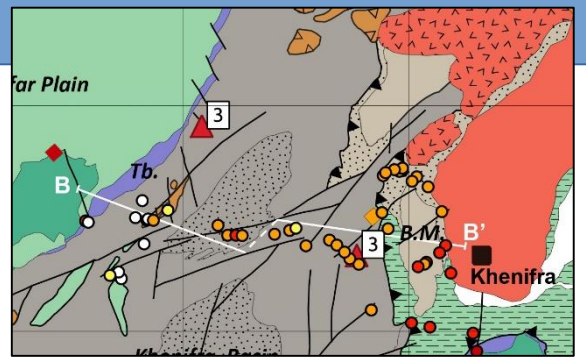
Coupe nord B-B’

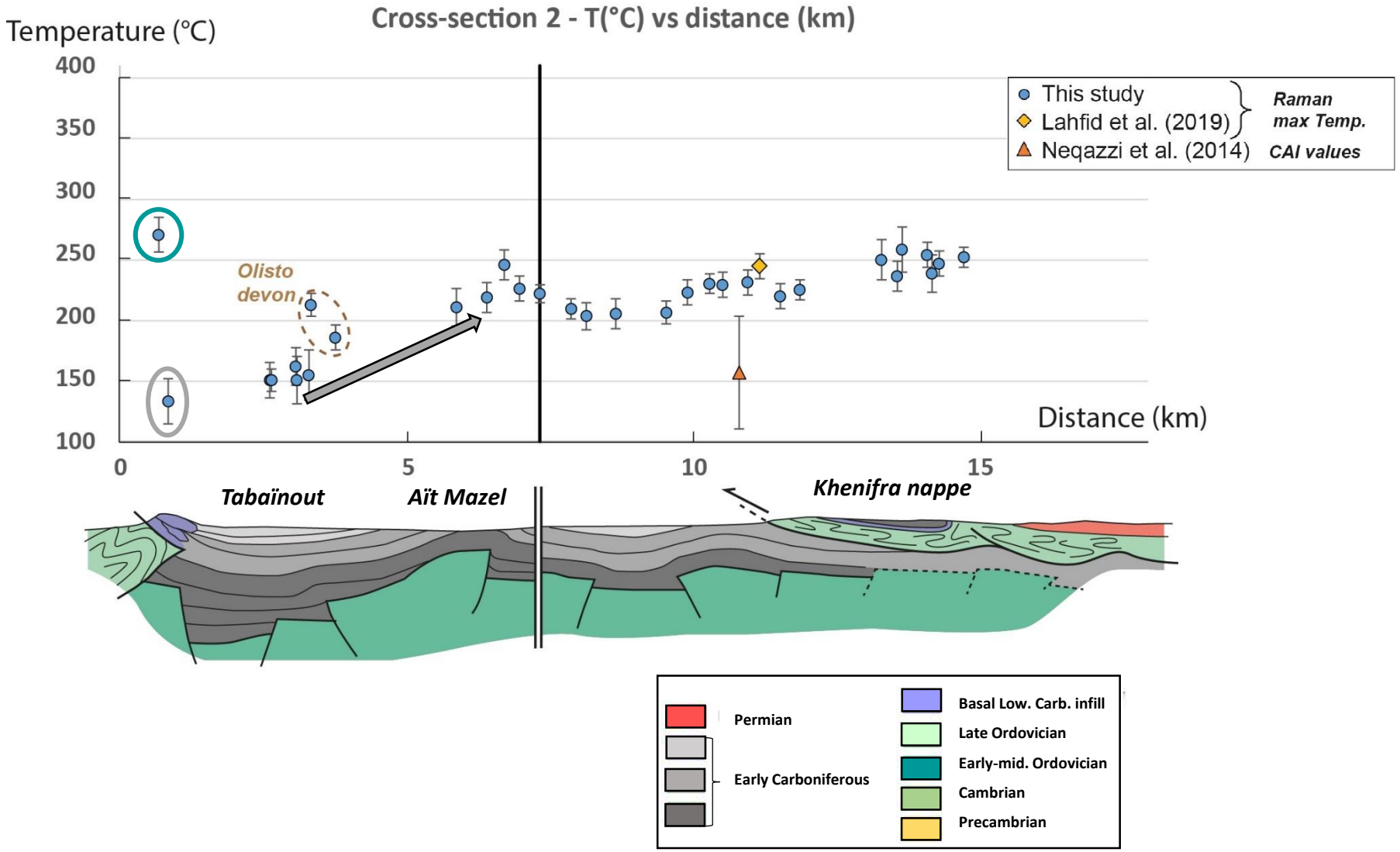




Results

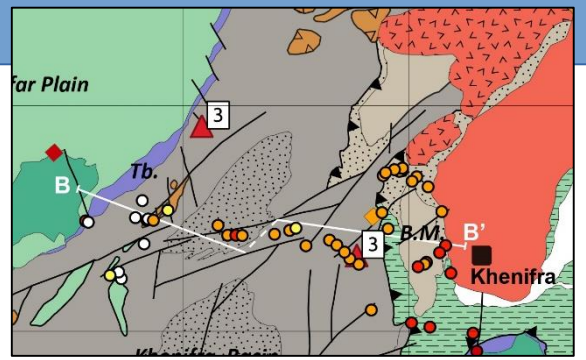
Coupe nord B-B’

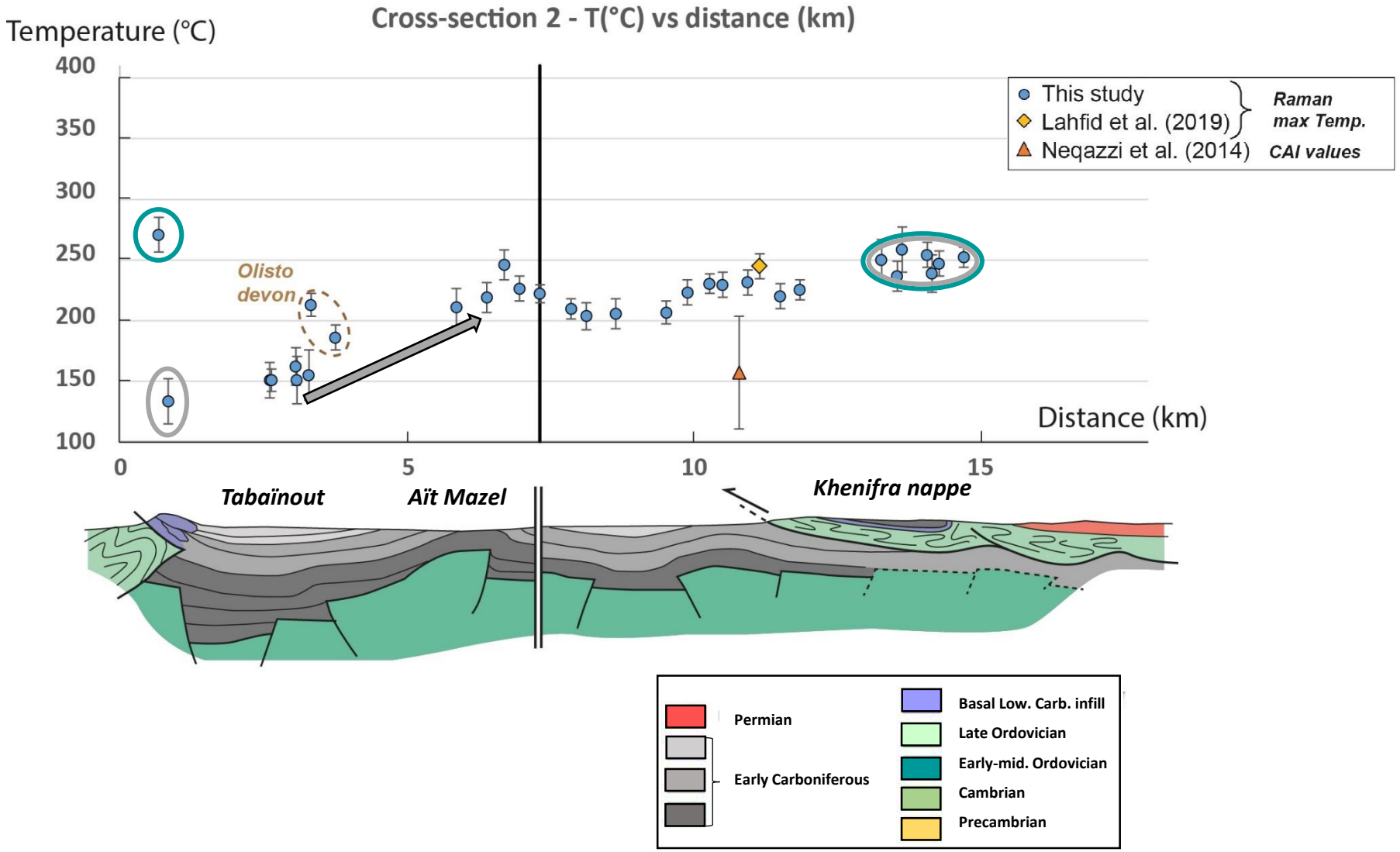




Results

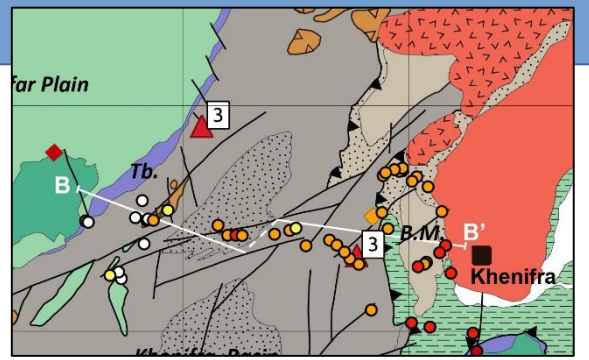
Coupe nord B-B’

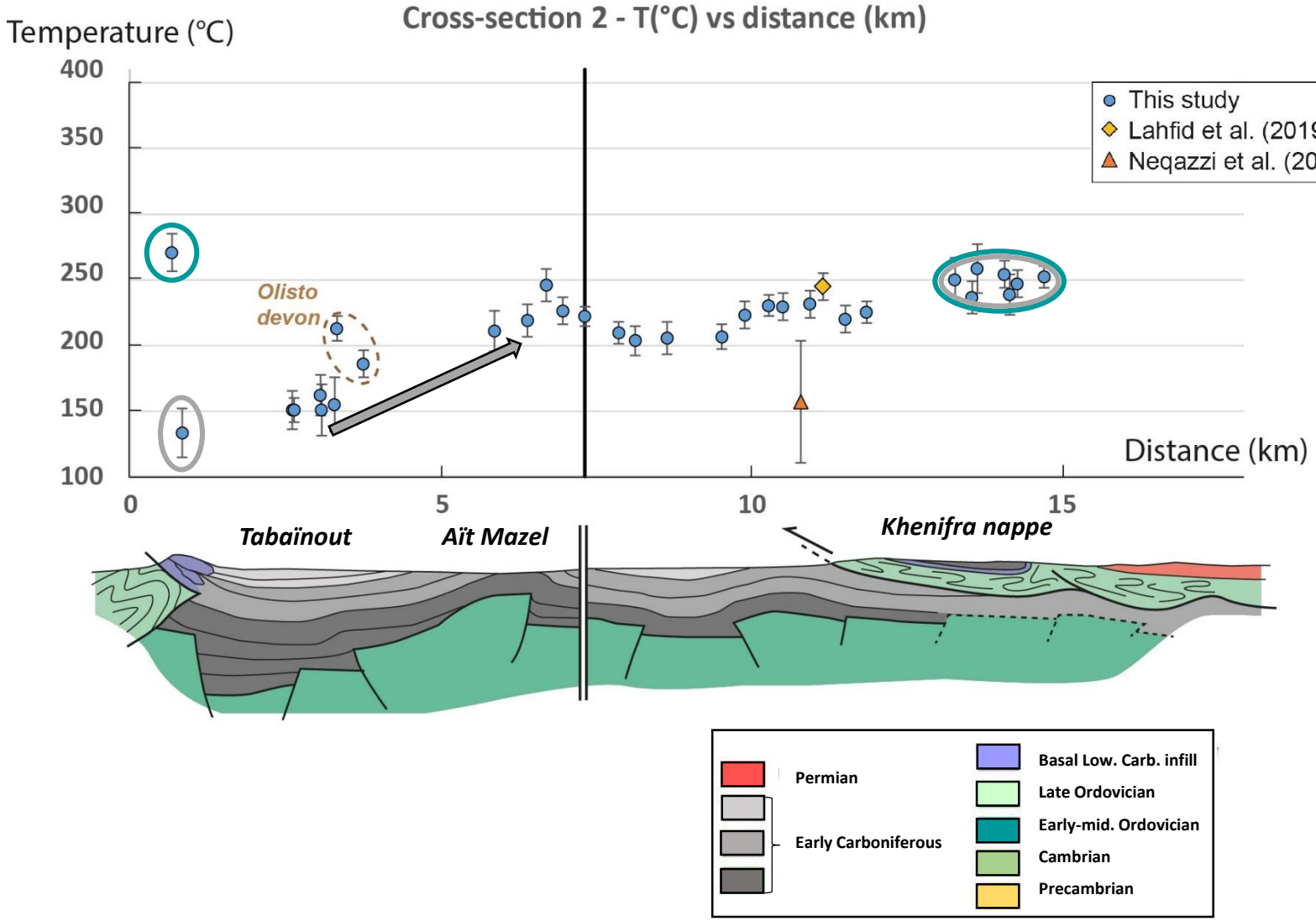




Results

Coupe nord B-B’





- $T(°C)_{visean}$ (63 samples)

➔ **132 ± 18°C to 259 ± 10°C**

➔ **Strong E/W variations**

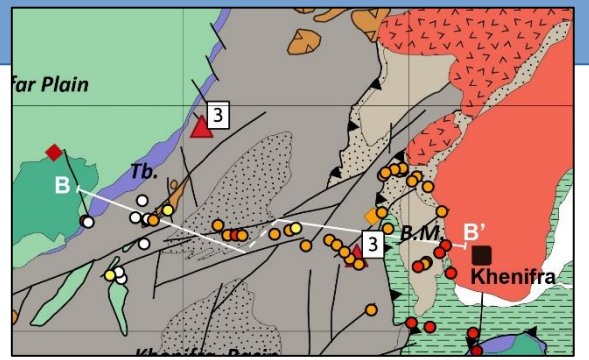
- $T(°C)_{ordovician}$ (14 samples):

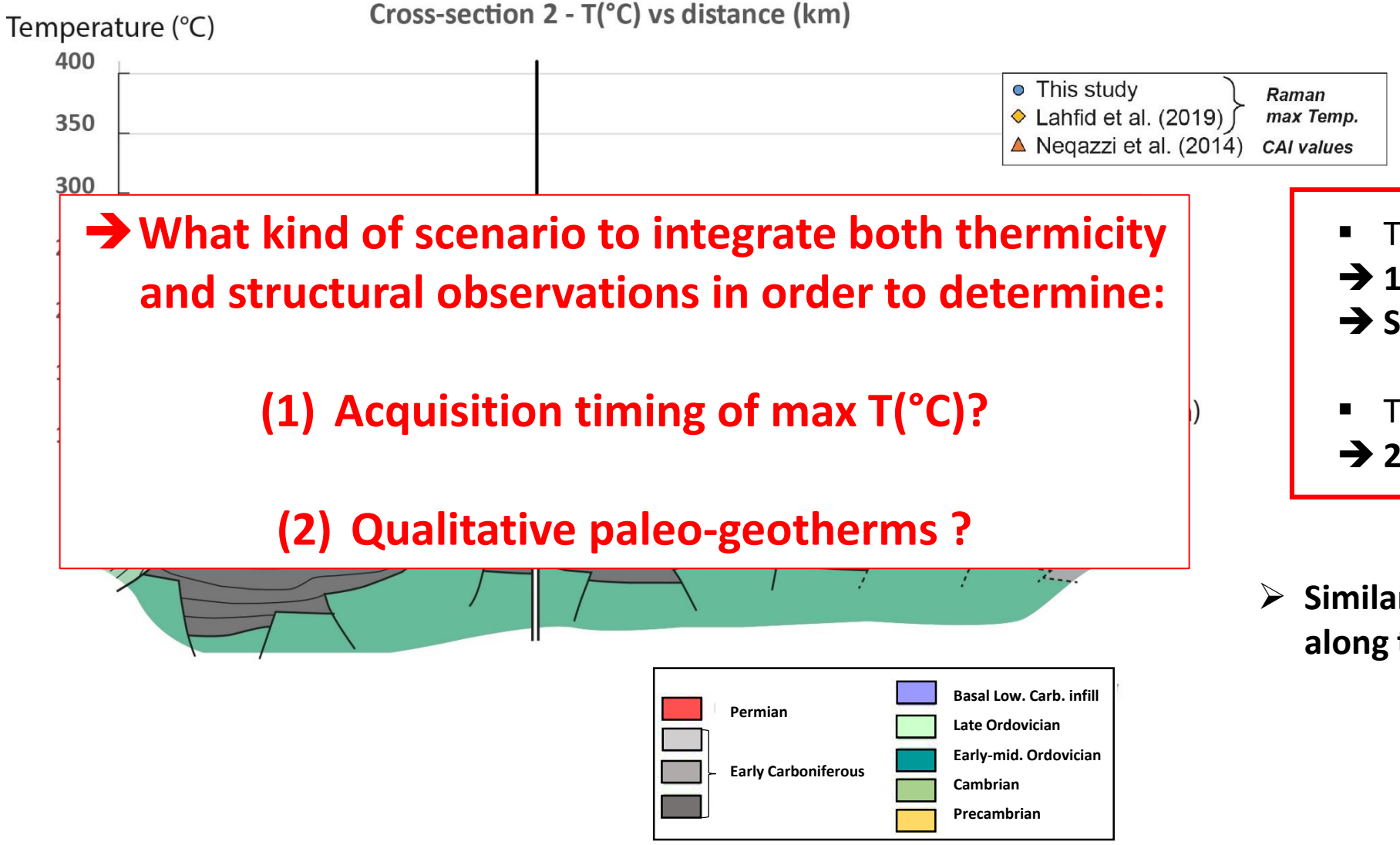
➔ **229 ± 16°C to 301 ± 19°C**

➢ **Similar thermal observations along the southern cross-section**

Results

Coupe nord B-B'





➔ **What kind of scenario to integrate both thermicity and structural observations in order to determine:**

(1) Acquisition timing of max T(°C)?

(2) Qualitative paleo-geotherms ?

- $T(°C)_{visean}$ (63 samples)

➔ **132 ± 18°C to 259 ± 10°C**

➔ **Strong E/W variations**

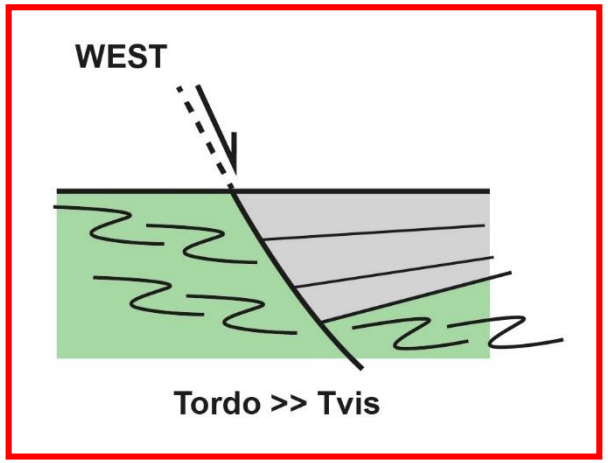
- $T(°C)_{ordovician}$ (14 samples):

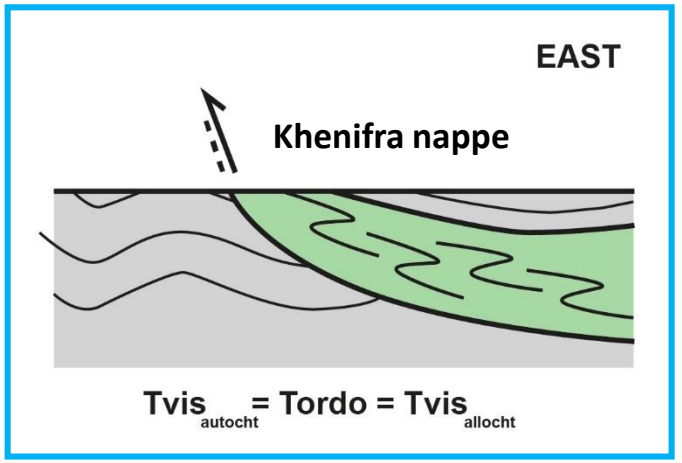
➔ **229 ± 16°C to 301 ± 19°C**

➢ **Similar thermal observations along the southern cross-section**

Discussion

(1) Acquisition timing for max T (°C) ?





(1) **East and West Ordovician basement = similar pre-Visean deformation** ➔ ***Single metamorphic event (> 340 Ma)***

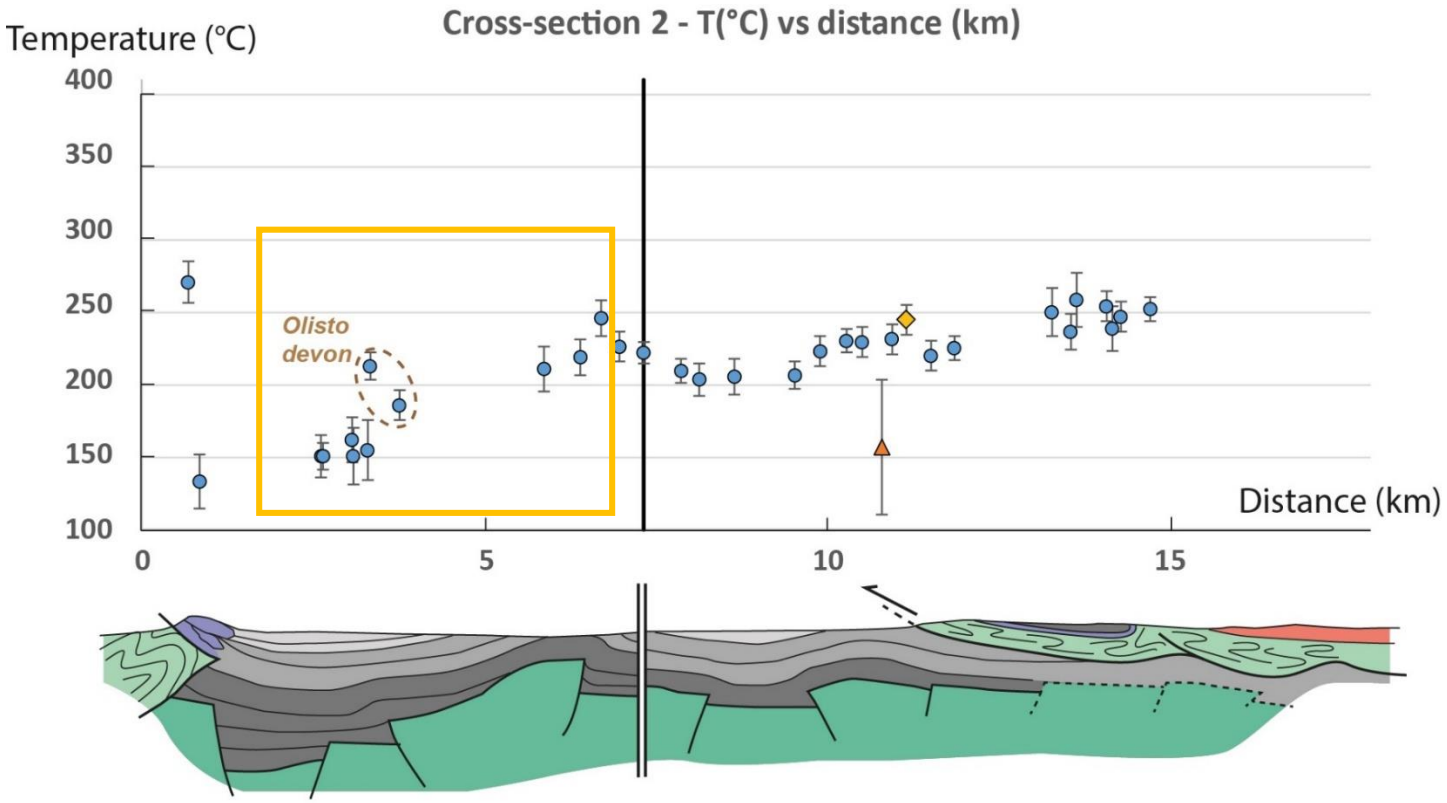
(2) **« Thermal stratification »** ➔ Thermal acquisition during basin infill, ***before*** Variscan compressional events (315-280 Ma)

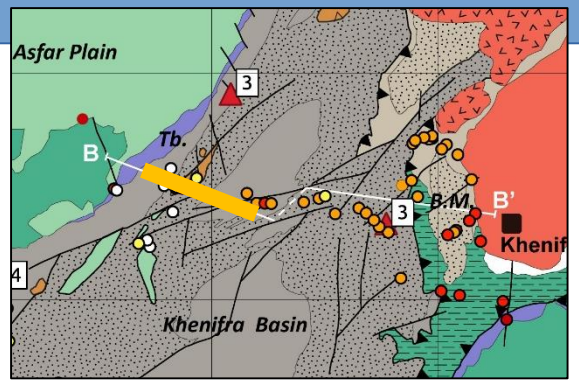
(3) **$T_{ordo} \approx T_{vis}$ in East** ➔ ***(1) Thermal reset is unlikely !*** → réchauffement précisément identique au max thermique éovarisque & pourquoi pas partout ? + ***(2) Thermal acquisition through Visean but likely later***

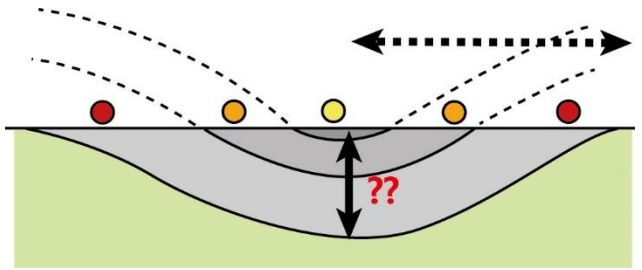
➔ **A thermal acquisition related the Visean/Namurian basin formation quickly following the extensional pre-Visean metamorphic event**

Discussion

(2) Paleo-geotherms ?







- No vertical wells ➔ qualitative estimates

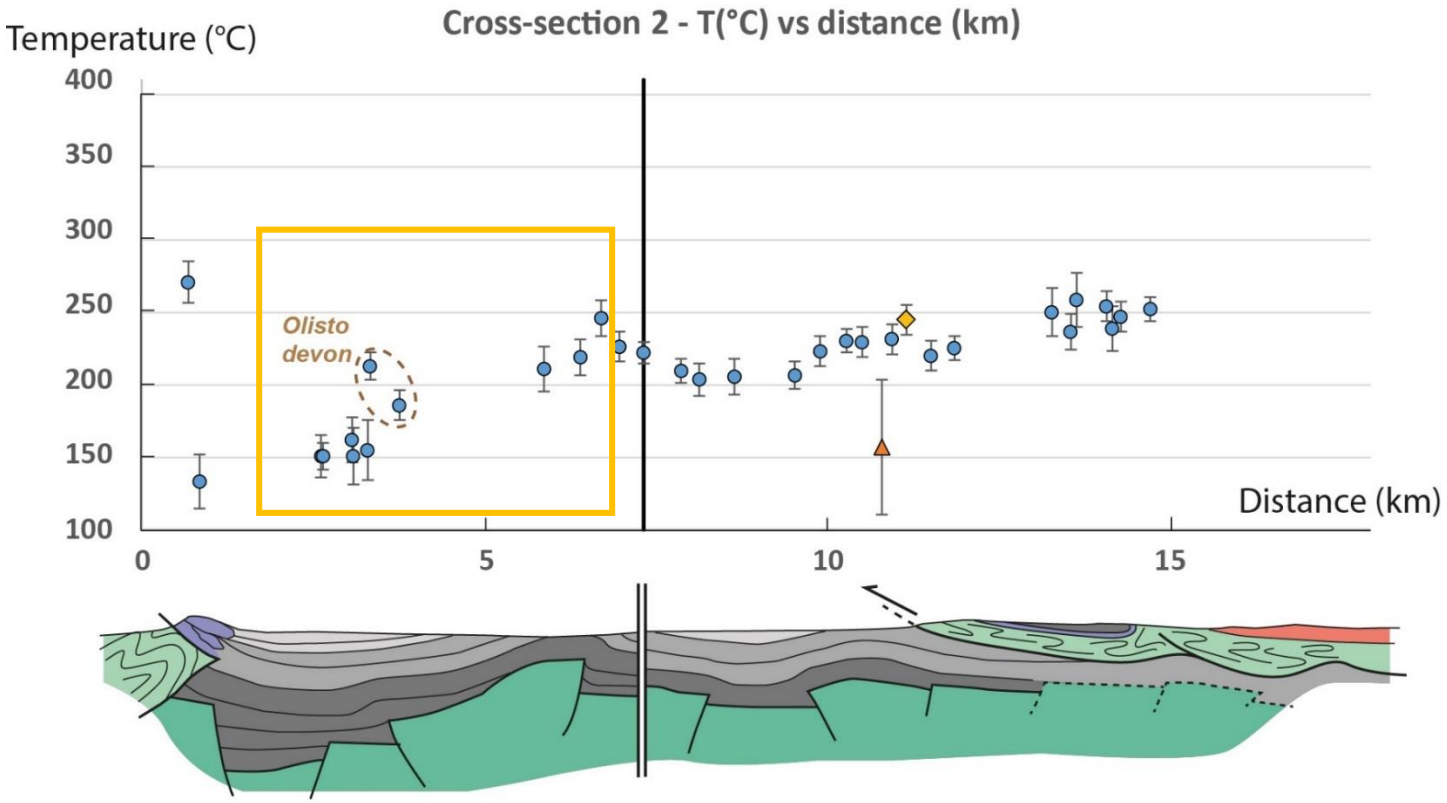
- Attempts on the two westernmost synclines

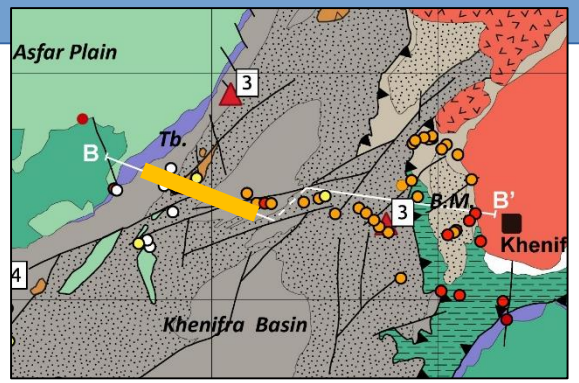
(1) Tabaïnout: ΔT(°C) 90°C for Δz de 1.3-1.7 km (El Houicha, 1994) ➔ 52-60°C/km

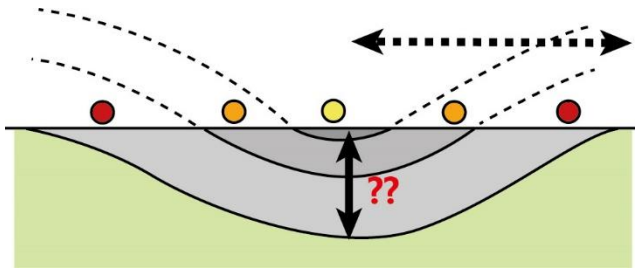
(2) Sidi Lamine: ΔT(°C) 120°C for Δz de 2.2 à 3 km (Verset, 1988) ➔ 40-55°C/km

Discussion

(2) Paleo-geotherms ?





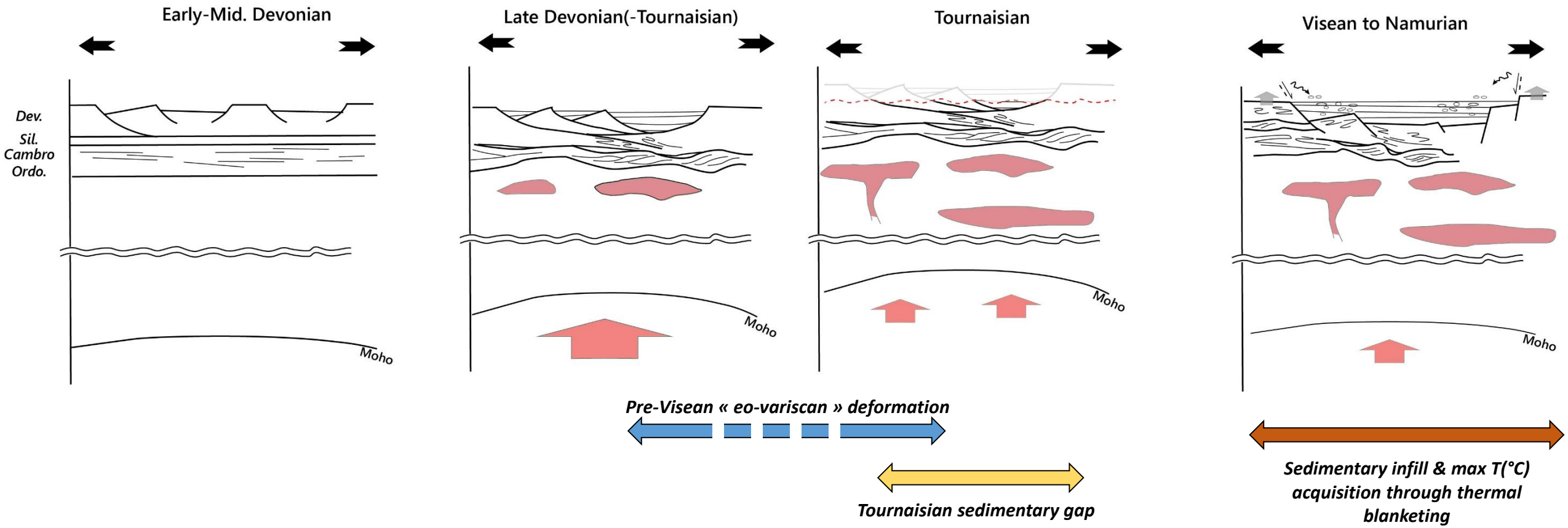


➔ High values for qualitative paleo-geotherms 40-60°C/km

➔In line with a strong extensional context from 370/360 to 330 Ma

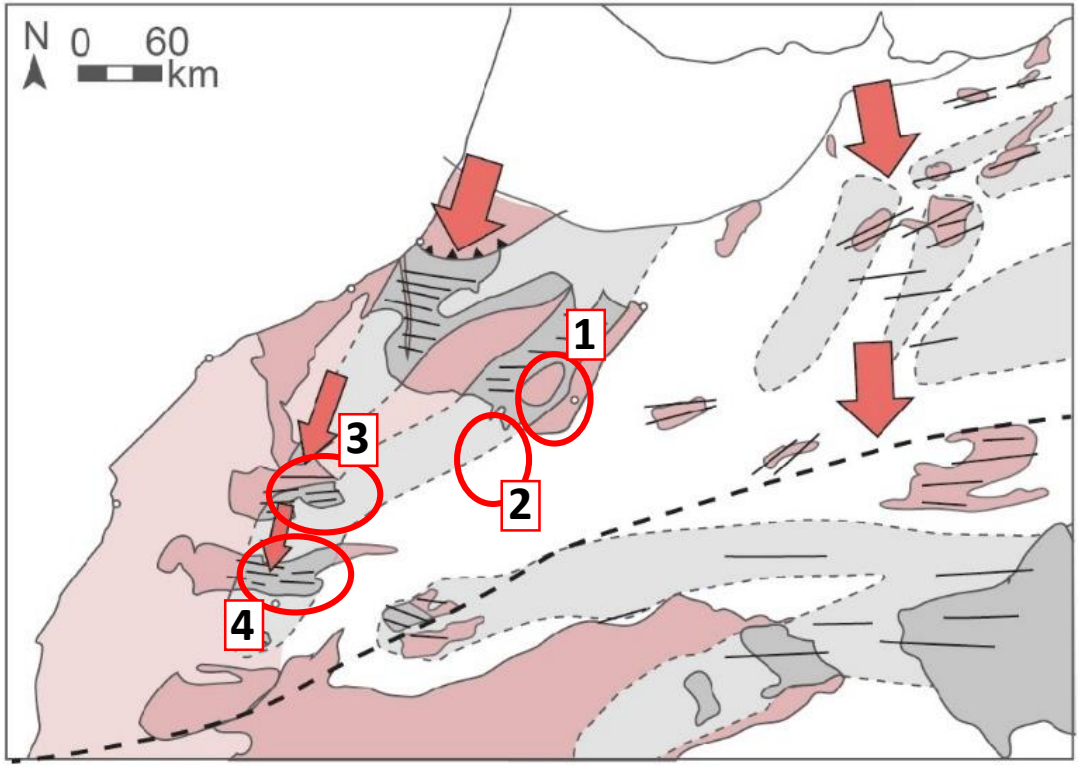
Discussion

Sketchy interpretation for the Khenifra Basin



Discussion: larger scale

MAIN VARISCAN PHASE
Westphalian to Autunian (310-295 Ma)



	Northeast regions	***Southwest regions***
	Cases 1 & 2 : Khenifra and Kasba-Tadla basins	**Cases 3 & 4: Rehamna & Jebilet basins**
	Pre-orogenic thermicities: 200-300°C	Pre-orogenic thermicities: >400°C
	Weak inversions, slight folding	Strong inversions & local barrovian metamorphism

➔ Different parameters (β factors/magmatism) = tectonic segmentation + varying thermicities during max T(°C) acquisition, **between 340 and 320 Ma**

➔ 1st order control on the type of inversion during the main N/S Variscan phase occurring **between 315-300 Ma**