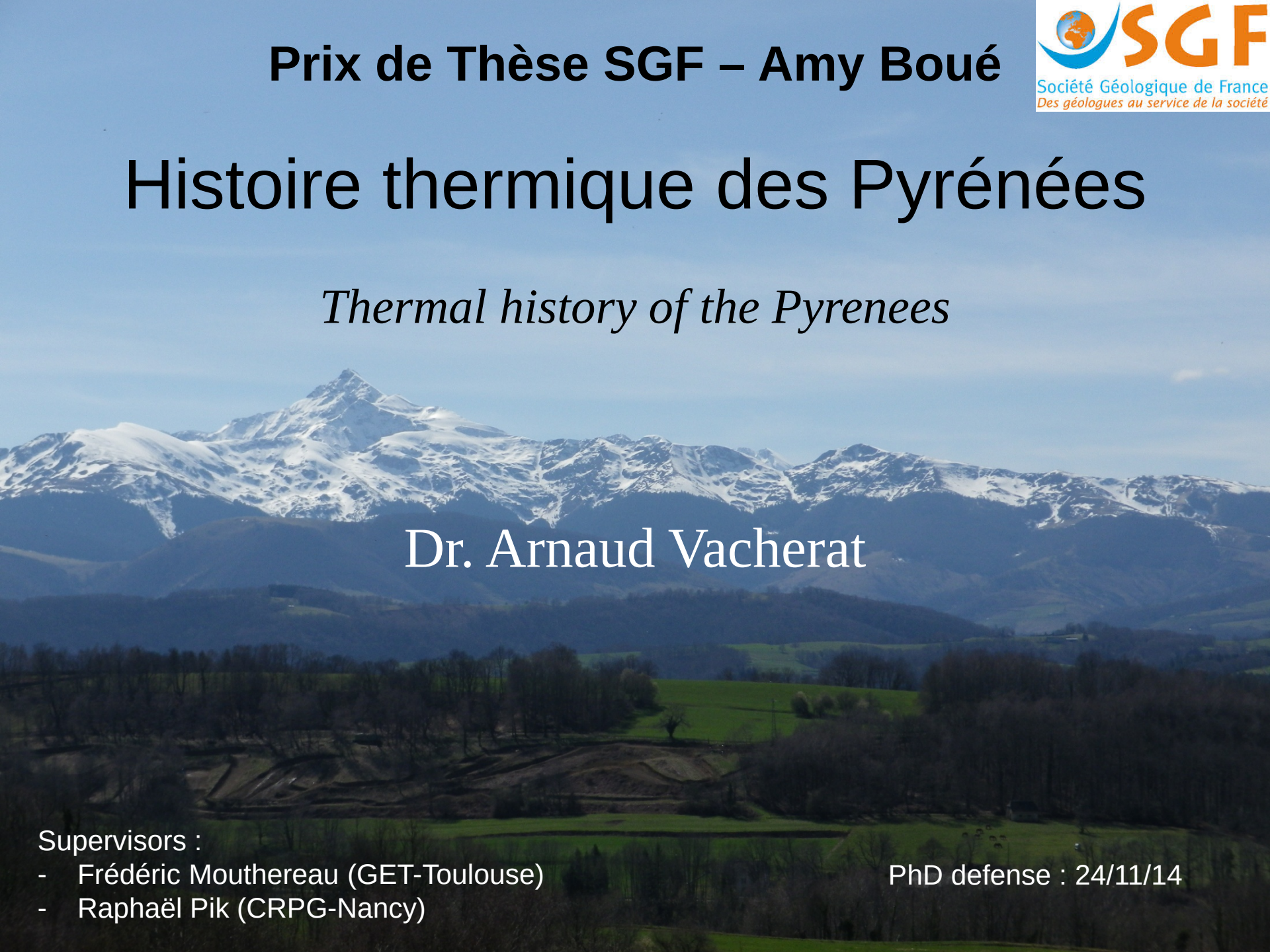
Prix de Thèse SGF – Amy Boué

Histoire thermique des Pyrénées

Thermal history of the Pyrenees



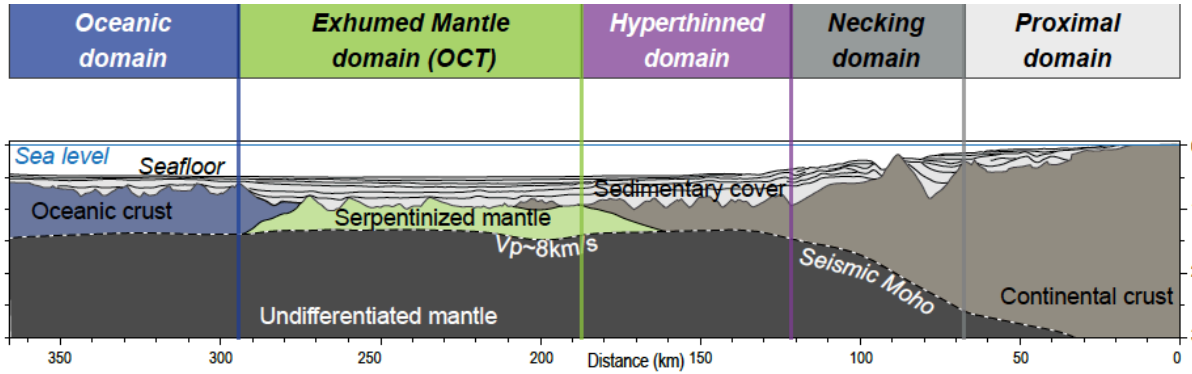
Dr. Arnaud Vacherat

Supervisors :

- Frédéric Mouthereau (GET-Toulouse)
- Raphaël Pik (CRPG-Nancy)

PhD defense : 24/11/14

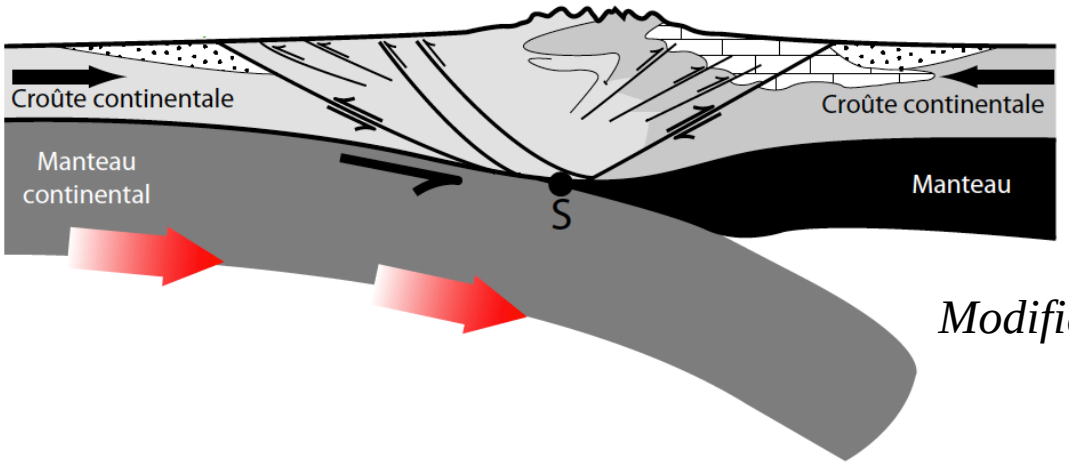
What about inversion ?



Tugend et al. (2014)

Thermal evolution of an inverted hyper-extended domain ?

Impact of thermal rift inheritance on mountain building ?

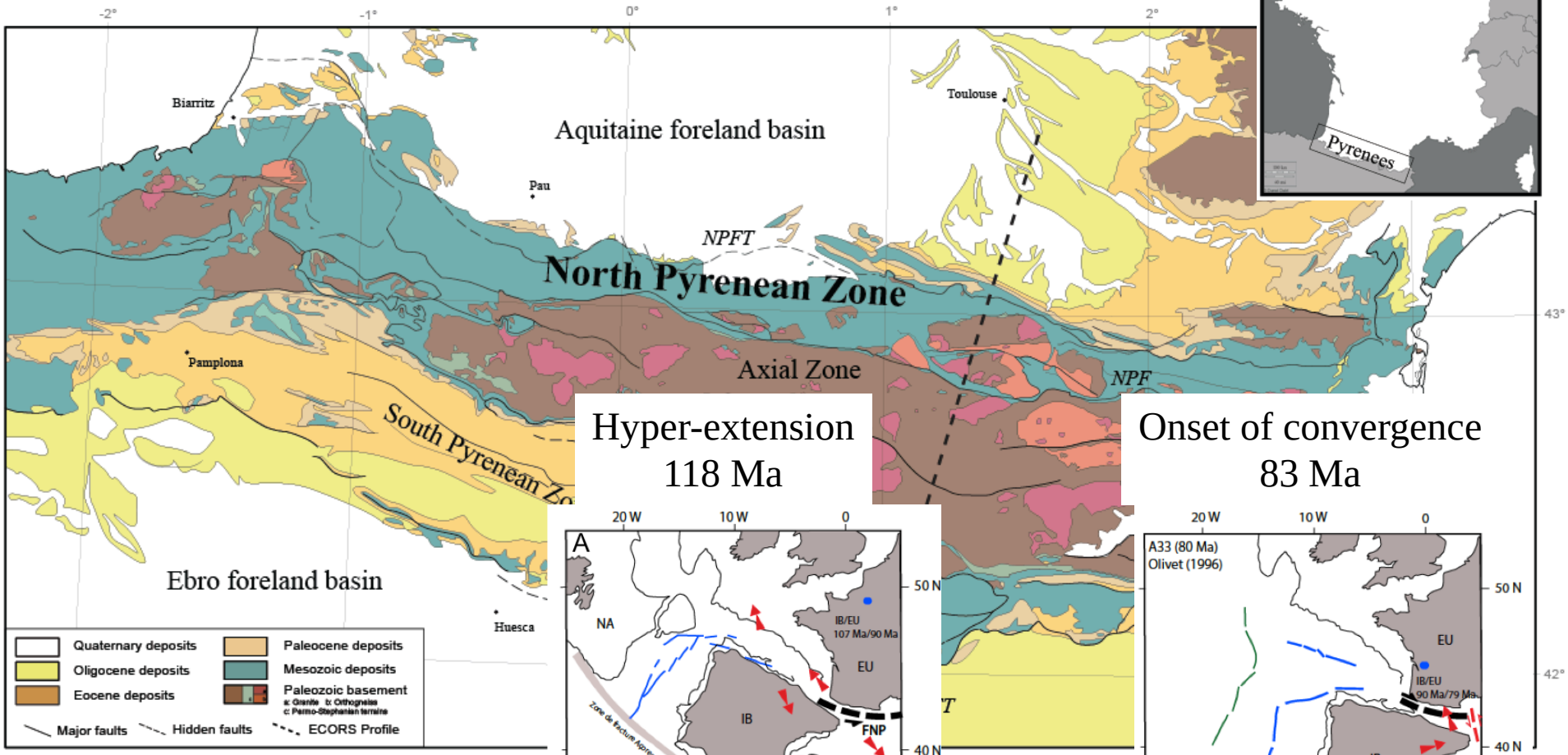


Modified after Willett (1999)

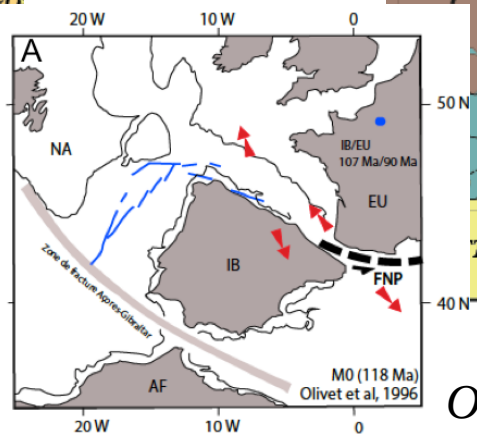
The Pyrenean domain

The Pyrenees

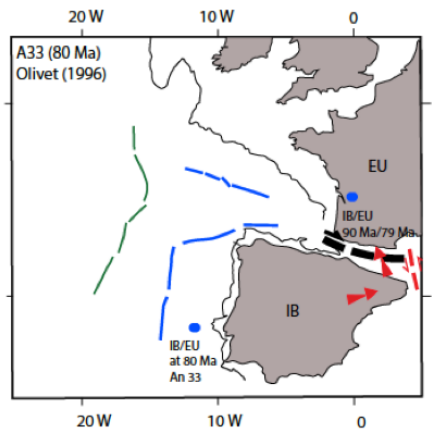
Geological map of the Pyrenean domain



Hyper-extension
118 Ma



Onset of convergence
83 Ma

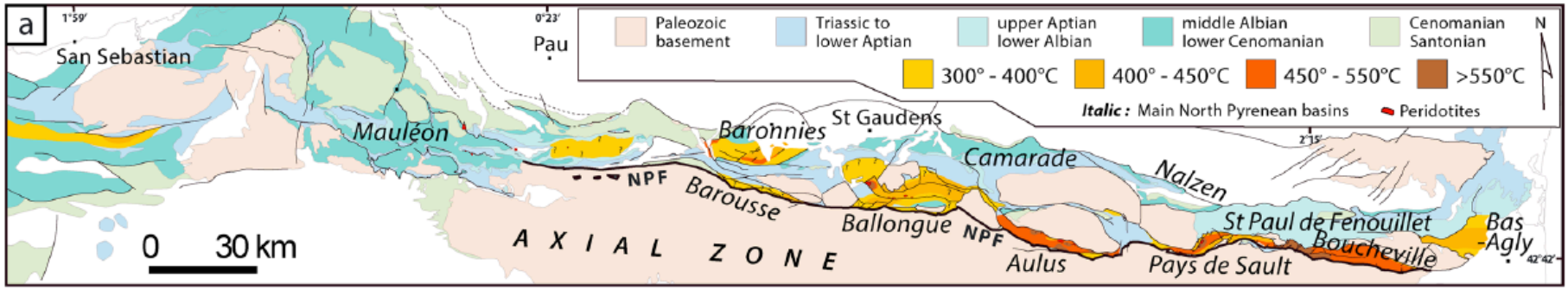


Olivet (1996)

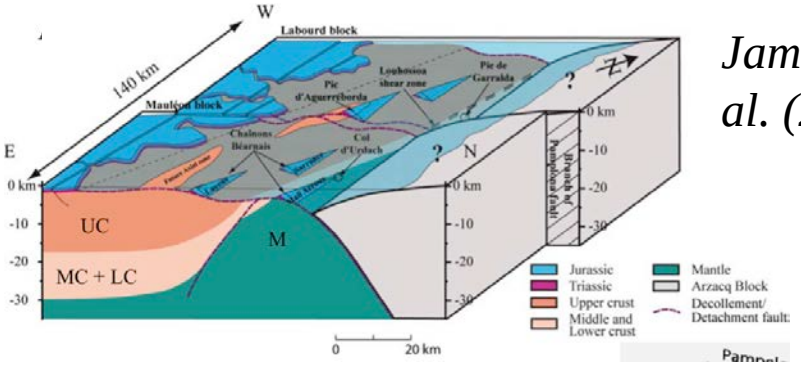
A well preserved rift-related architecture

The Pyrenees

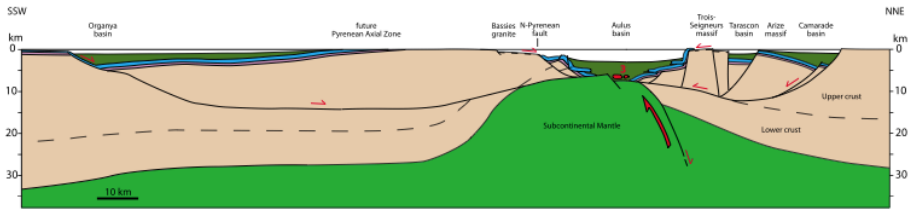
Clerc and Lagabrielle (2014)

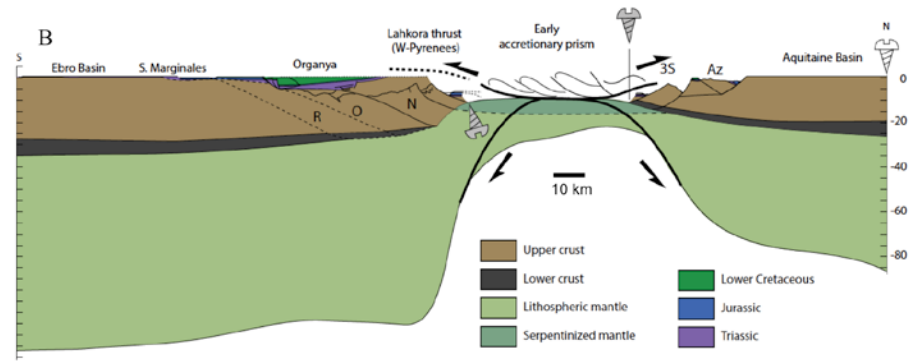


Jammes et al. (2009)

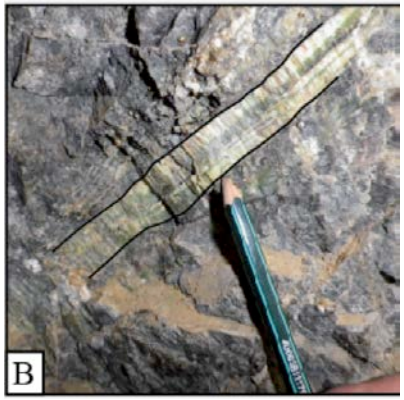


Lagabrielle et al. (2010)



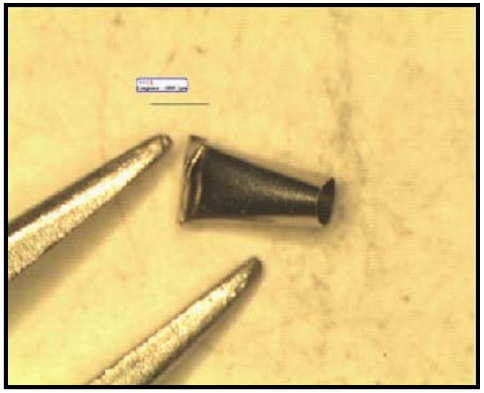


Mouthereau et al. (2014)

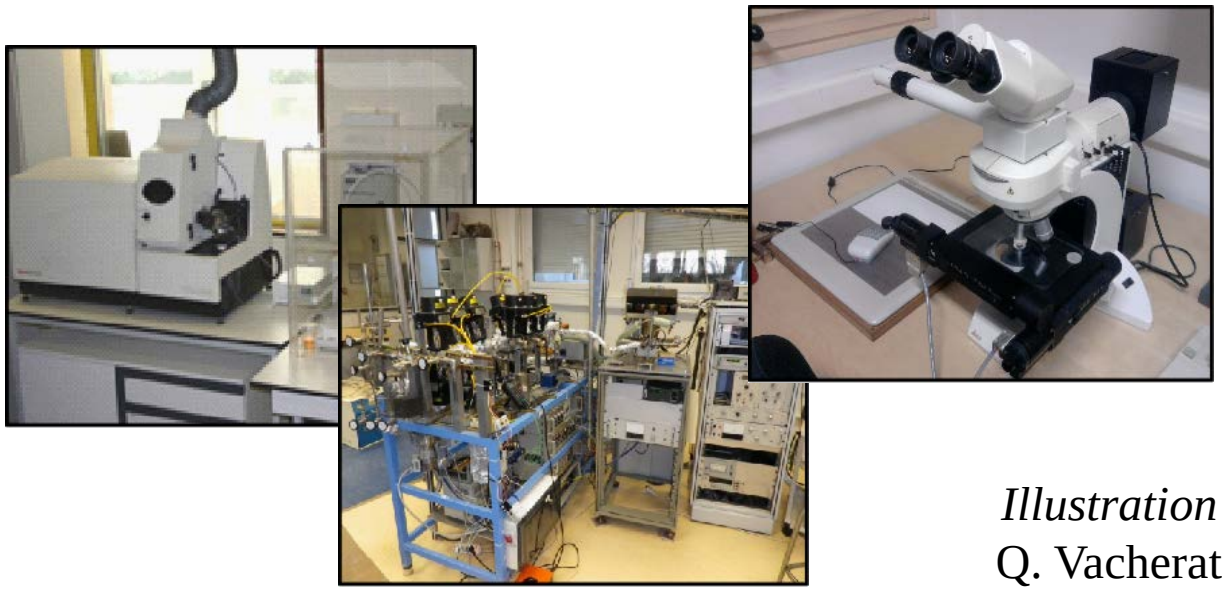


Thermochronological datings

Methodologies



- U/Pb on zircons : OPGC (Clermont-Ferrand, France)
- Fission tracks on apatite and zircon (**AFT**, **ZFT**) : ISTERRE (Grenoble, France)
- (U-Th-Sm)/He on zircons (**ZHe**) : CRPG (Nancy, France)
- (U-Th-Sm)/He on apatites (**AHe**) : Paris Sud University (Orsay, France)



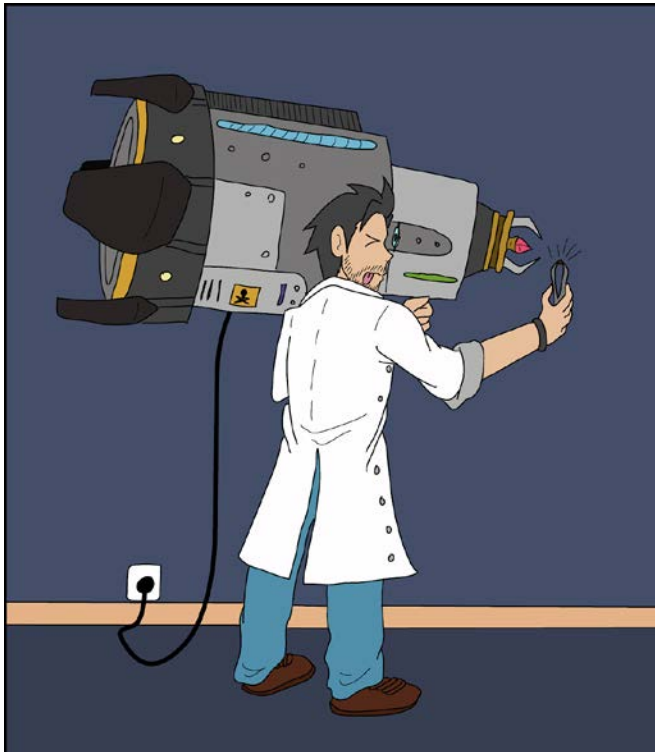


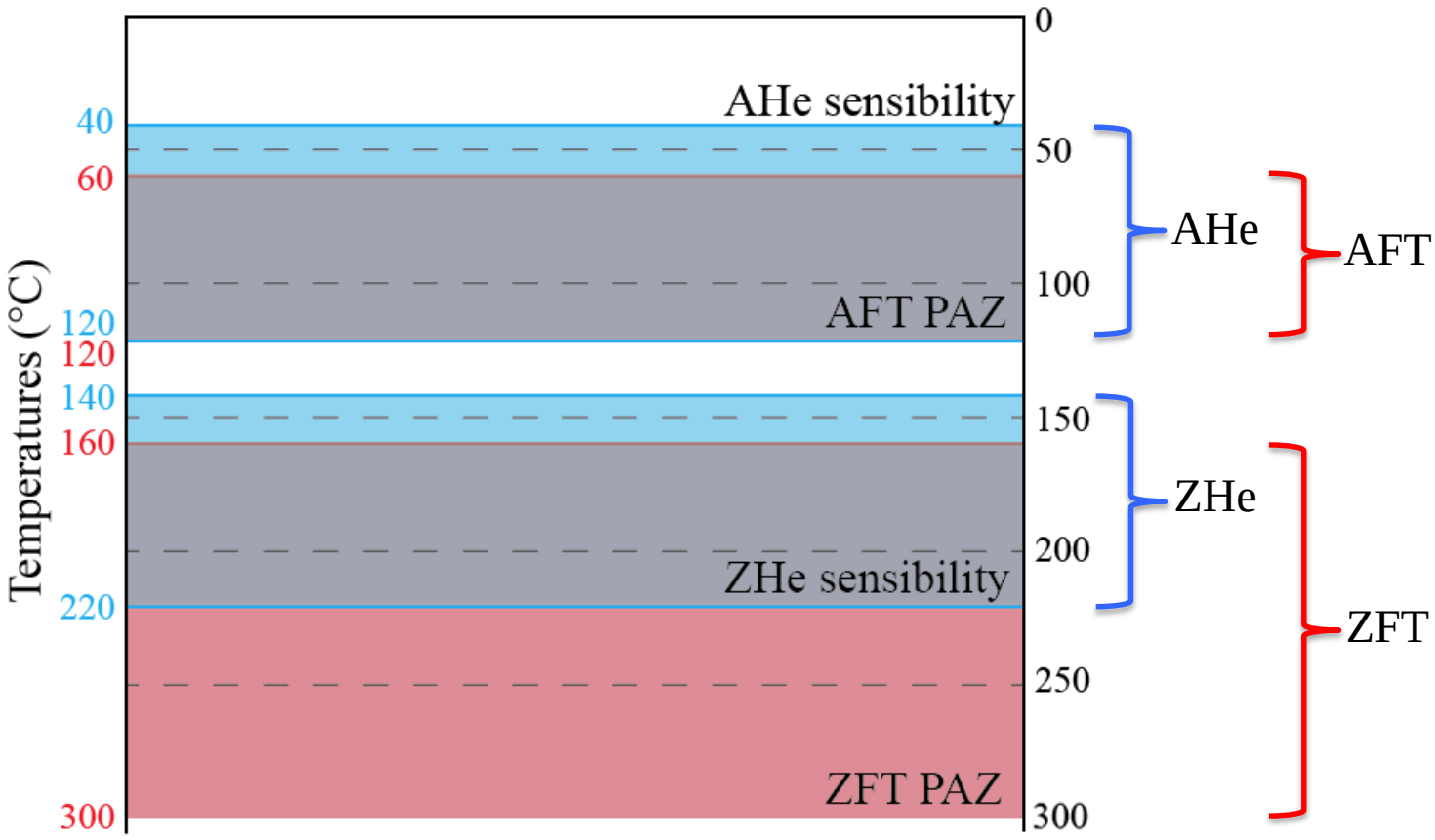
Illustration
Q. Vacherat

A thermo-dependent approach

A combined low-temperature thermochronological approach to constrain the thermal history of the Pyrenees :

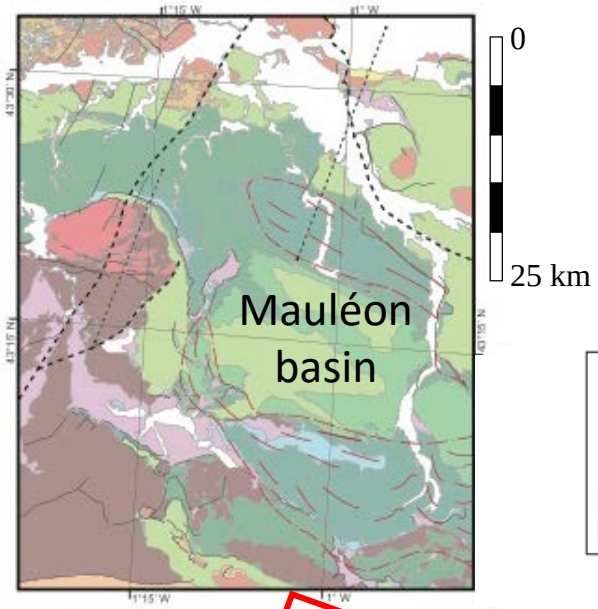
- From rift to collision

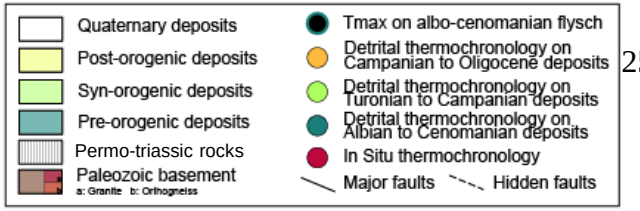
- From mid-crustal level to the surface

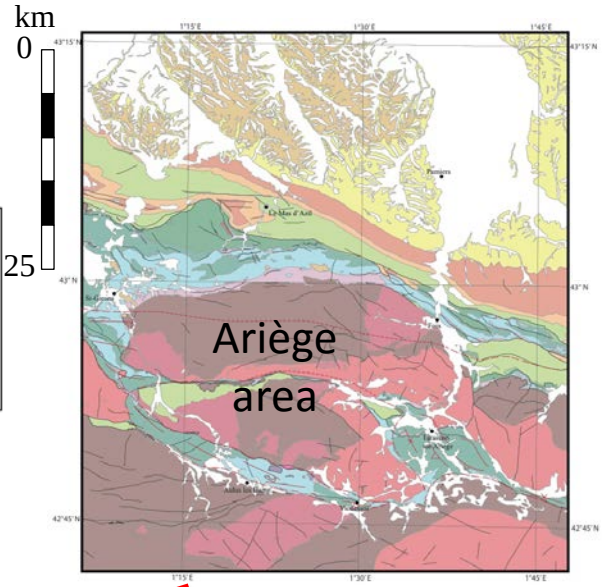


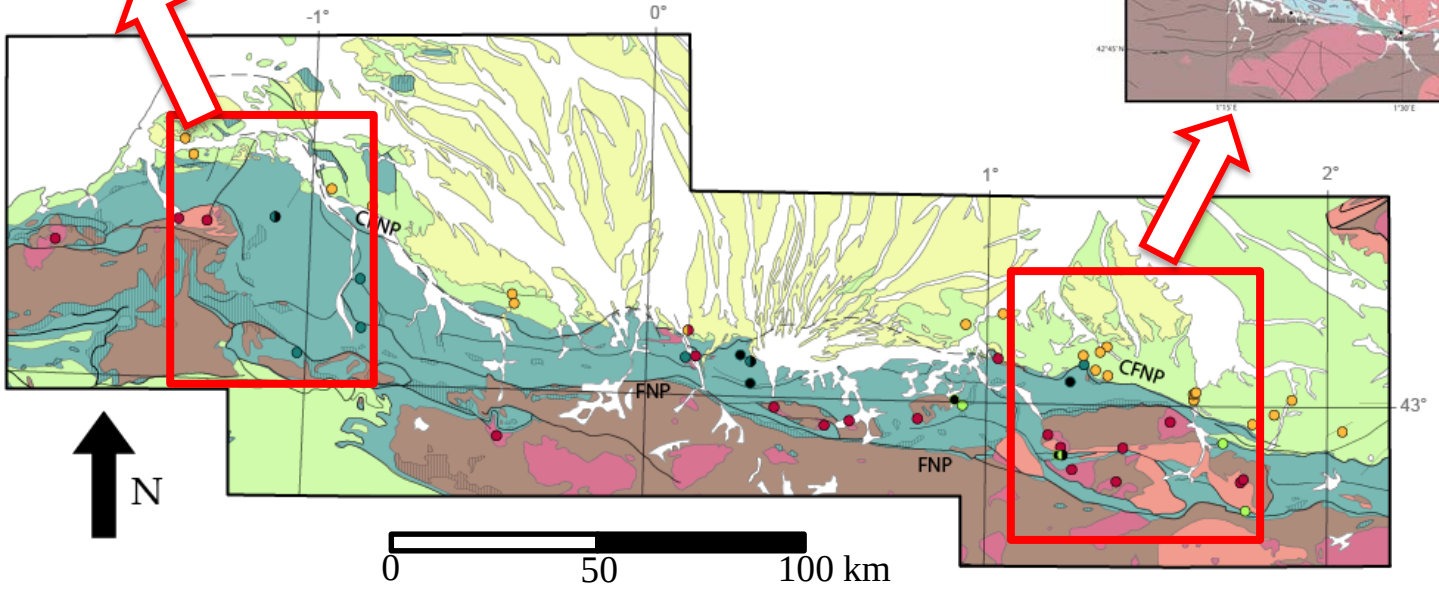
Study areas

Mauléon basin



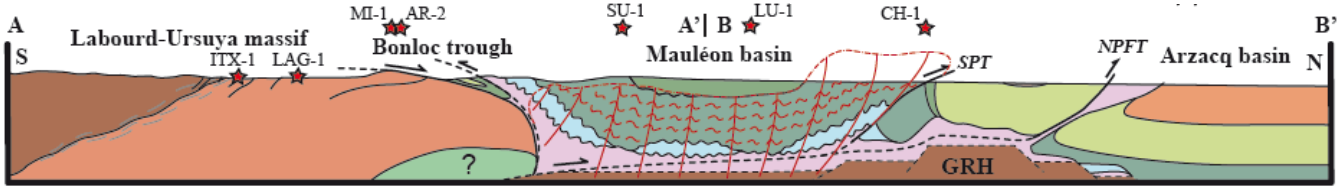




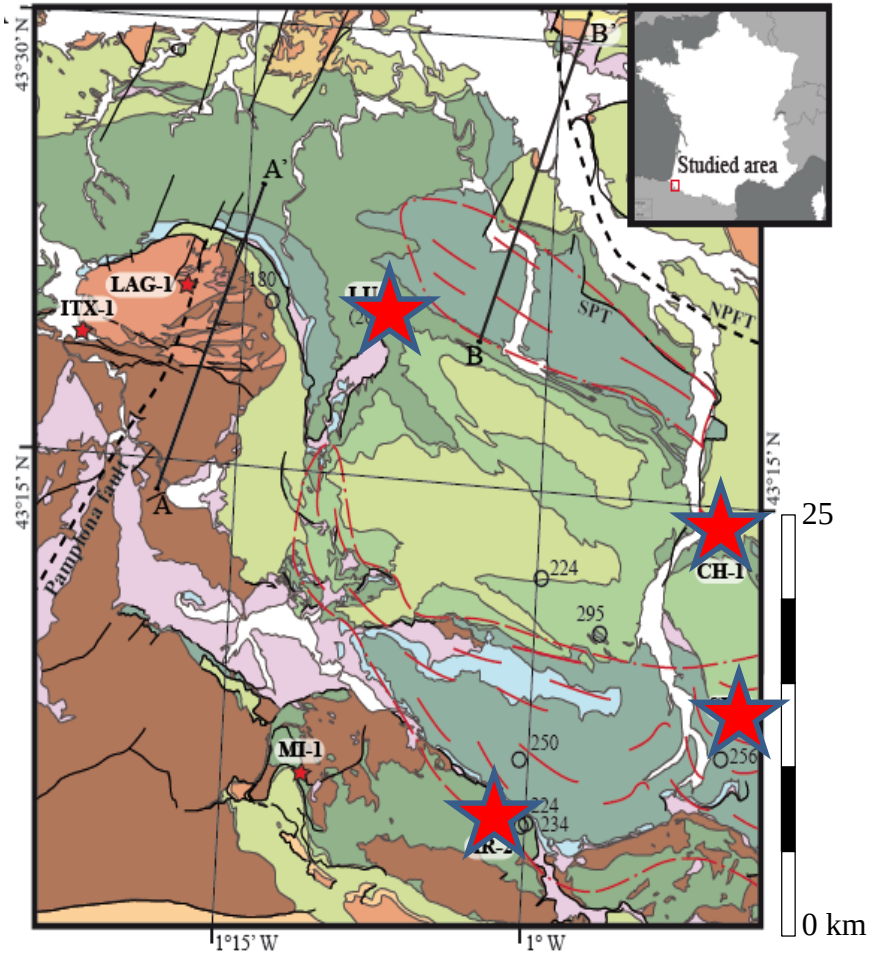


Sampling strategy

Mauléon basin



Lu-1



Ch-1

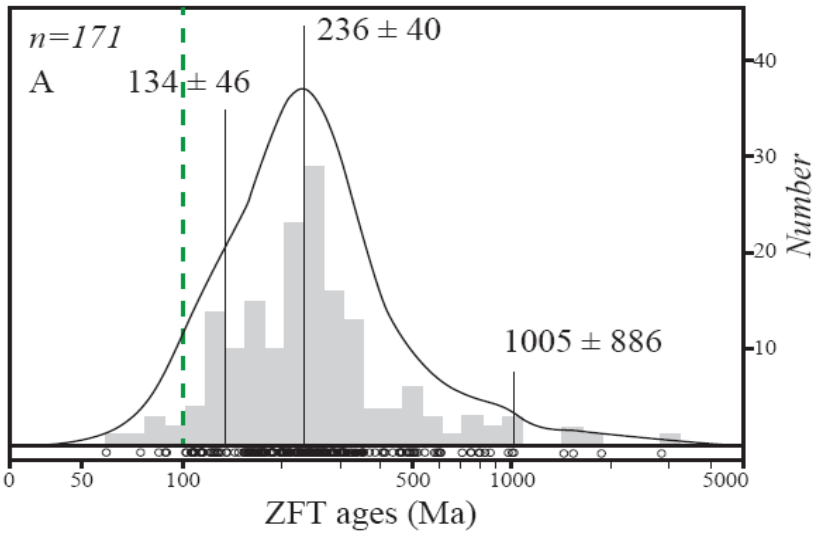
Ar-2

Su-1

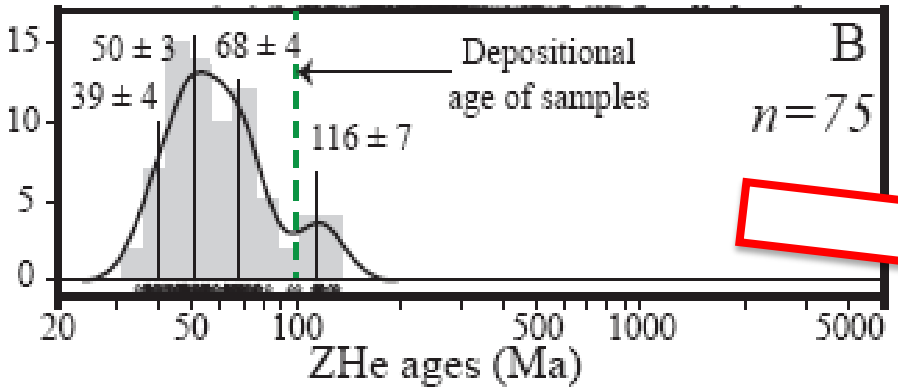
Thermochronological analyses

Mauléon basin

ZFT data



ZHe data



COOLING AGES

ZFT populations : **~135 Ma (P1)** and **~235 Ma (P2)**

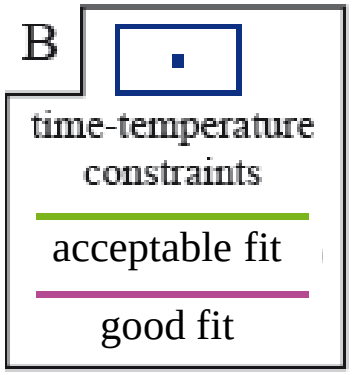
97% of the grains older than the depositional age

PARTIALLY RESET

87% of the grains younger than the depositional age

- Temperatures reached
- Duration of the thermal event

Thermal modeling

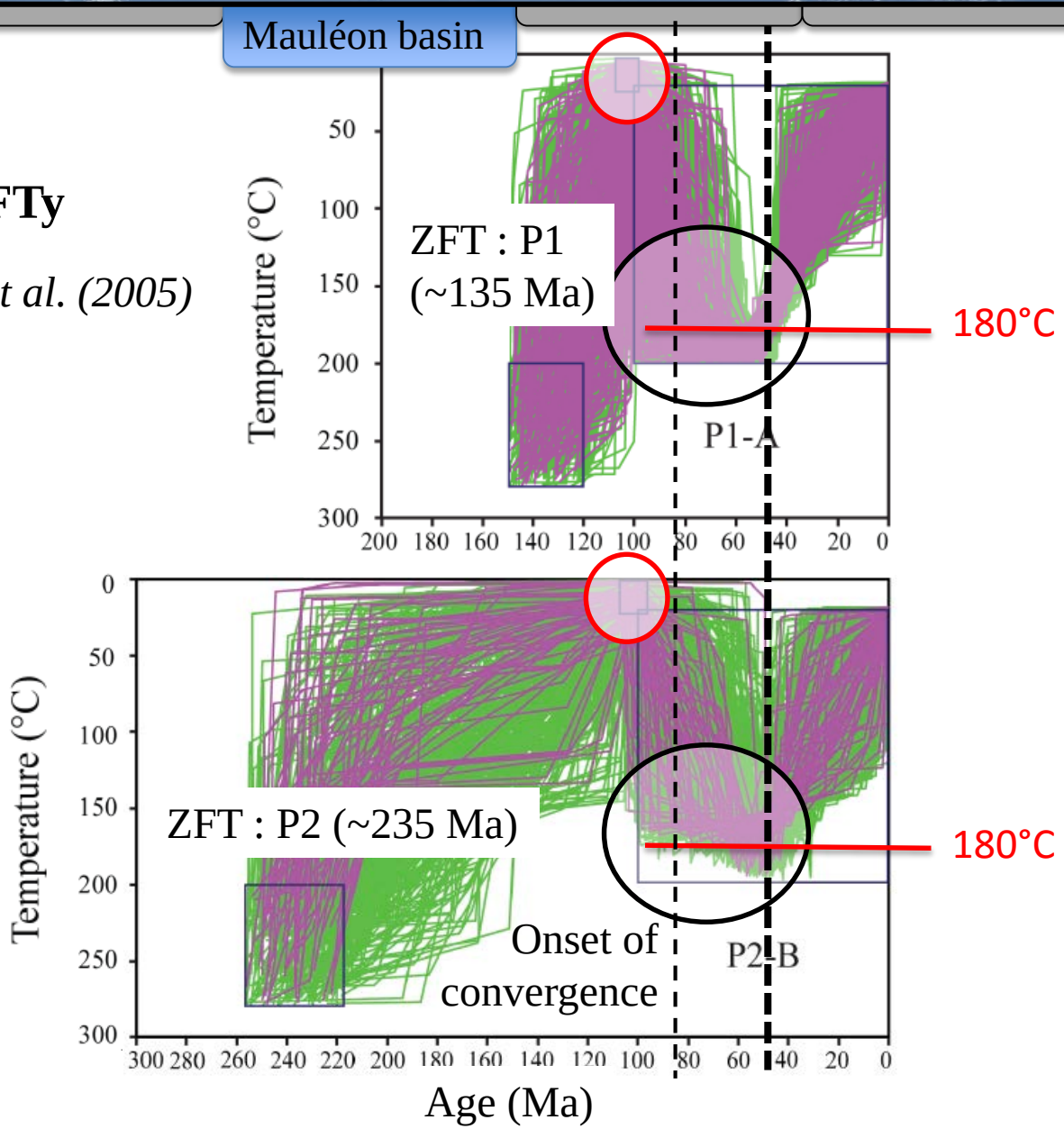


HeFTy

Ketcham et al. (2005)

Time-temperature history :

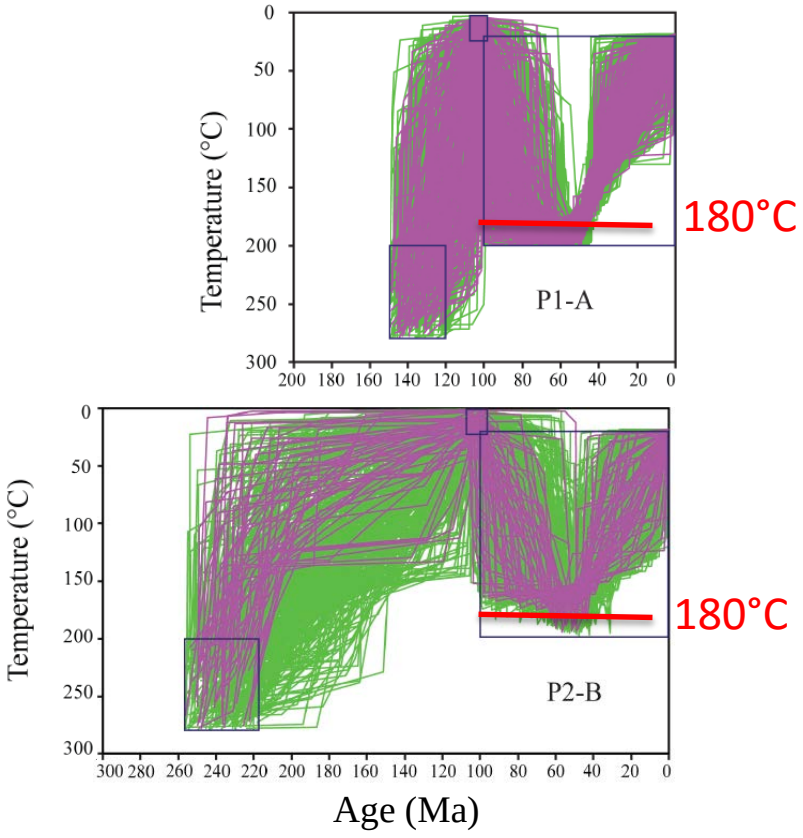
- Independant pre-deposition cooling
- Deposition (100 Ma)
- Heating phase until 80-70 Ma
- Isothermal stage (80 – 50 Ma)
- Cooling after 50 Ma.



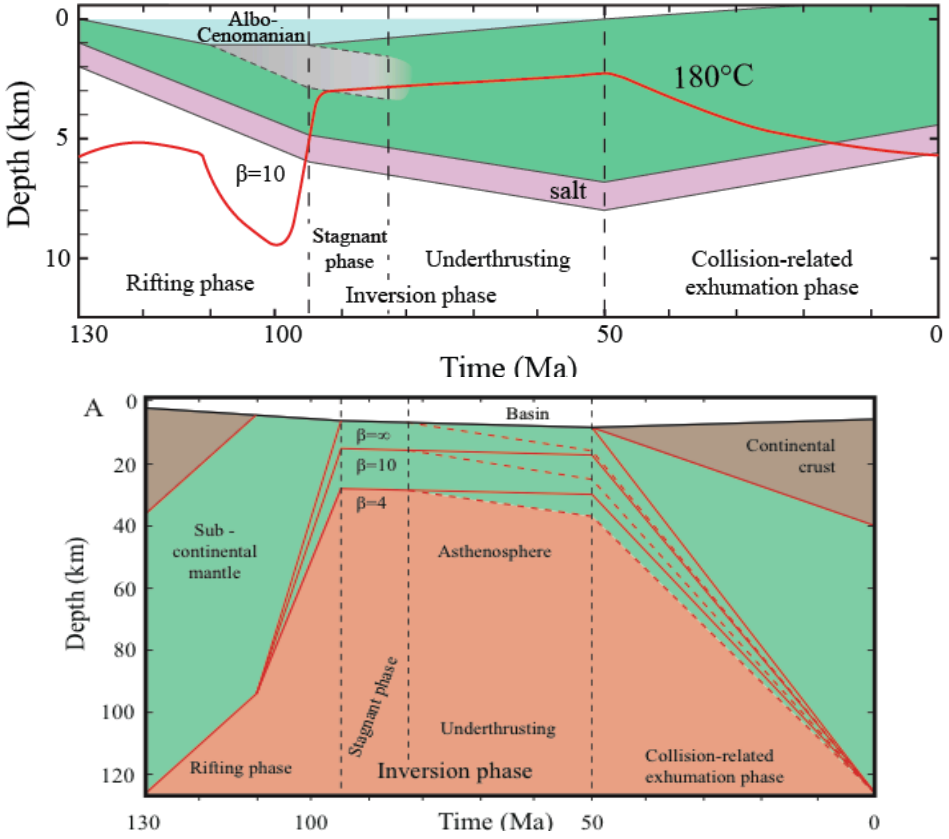
Thermo-kinematic numerical modeling

Mauléon basin

Time-temperature histories



2D thermo-kinematic model



Conclusions :

- High geothermal gradient : ~80°C/km
- Thermal anomaly lasted 30 Myrs and was responsible for syn-convergence ductile deformations
- Cooling phase at 50 Ma when proximal domains are accreted

Sampling strategy

Ariège area

1°15' E

1°45' E

ERC-1

LAC-2

Le Mas d'Azil

Arize

~305 Ma

FOI-1

Foix

LAC-1

~302 Ma

LAC-2

BOU-1

ERC-1

~307 Ma

Trois Seigneurs

MAS-1

3S-1

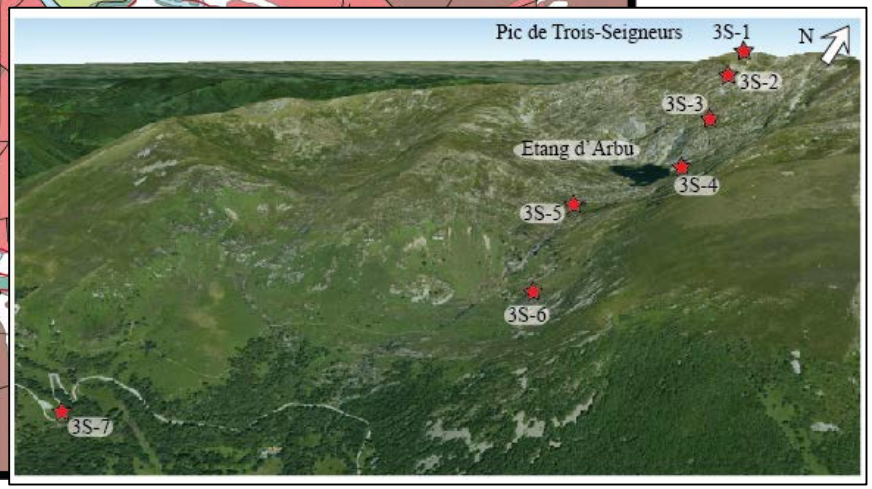
3S-7

~307 Ma

Aulus les Bains

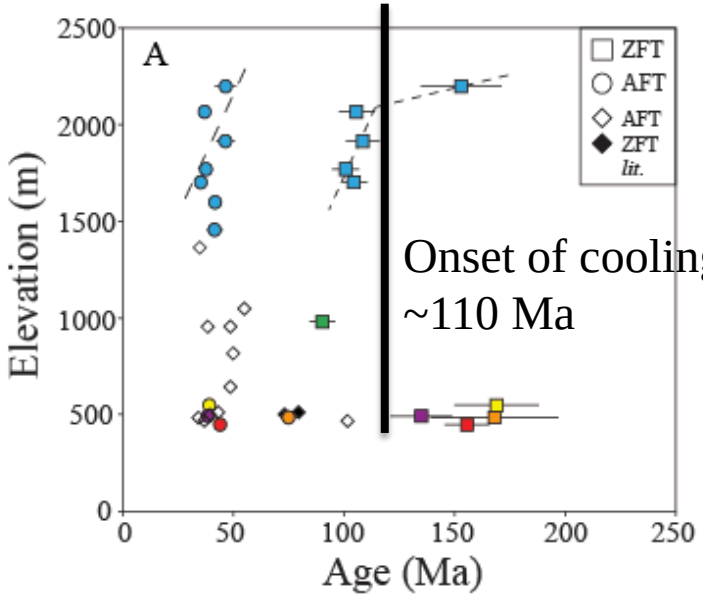
25

0 km

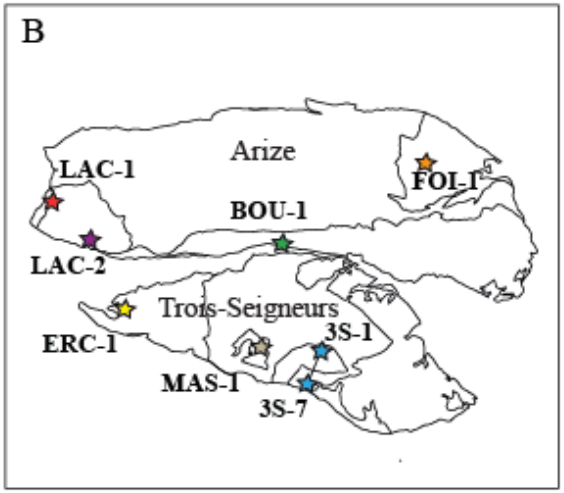


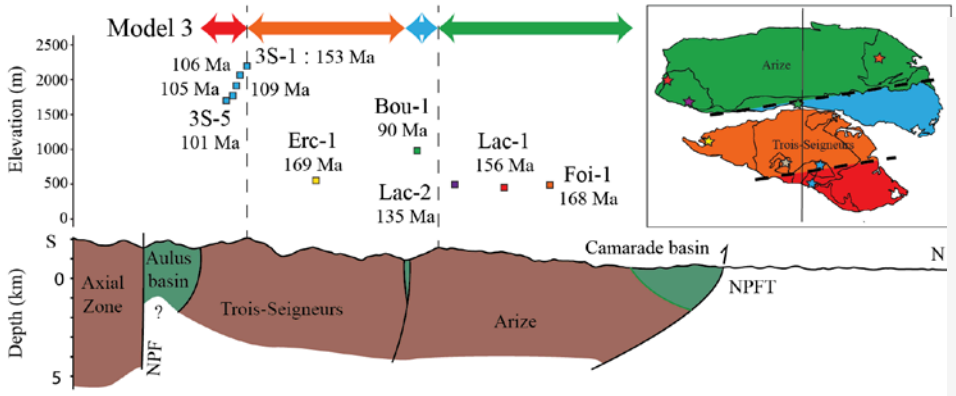
Thermochronological results

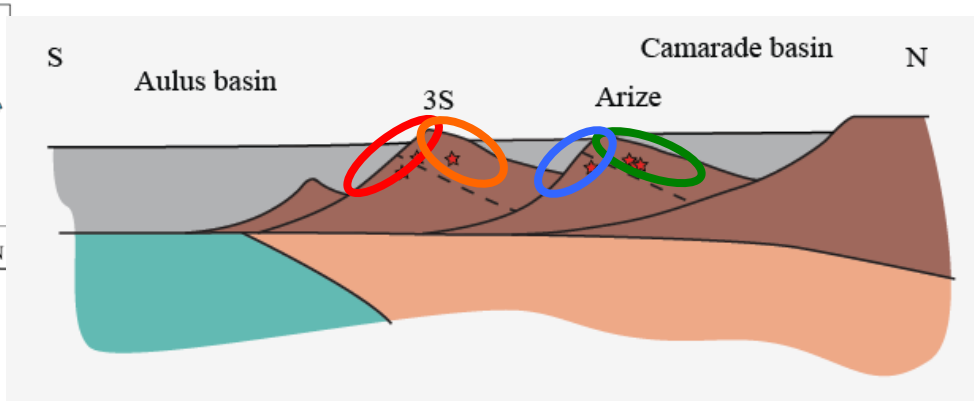
Ariège area



Onset of cooling
~110 Ma

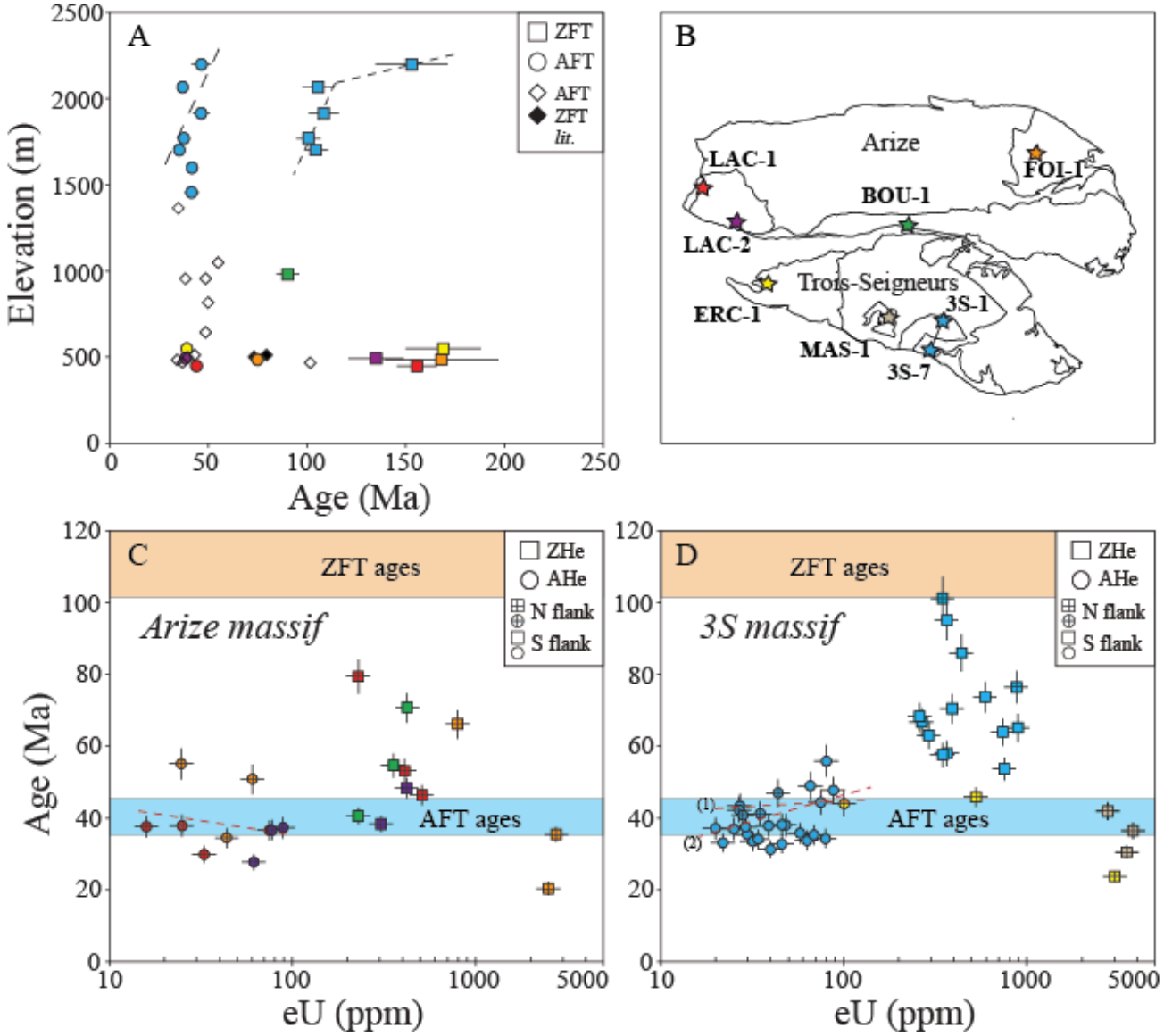






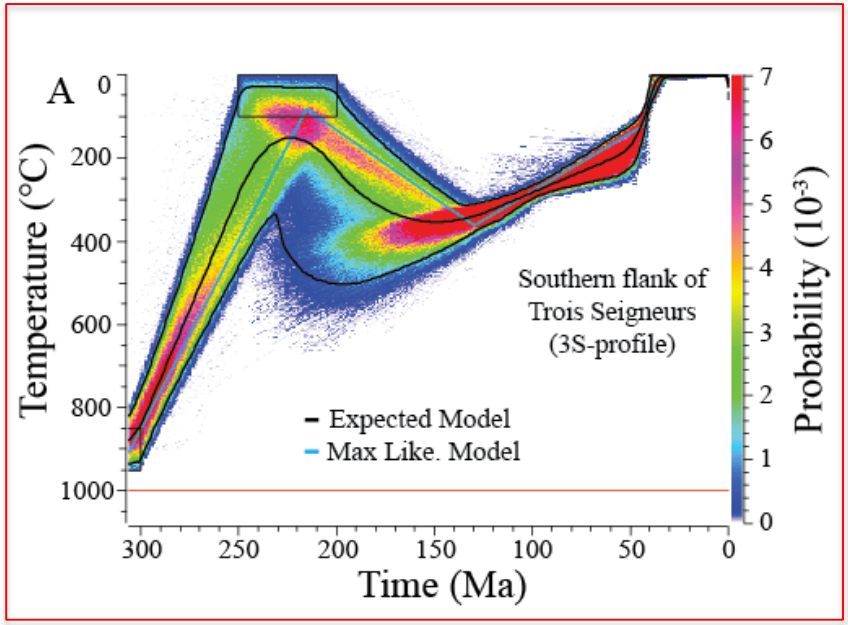
Thermochronological results

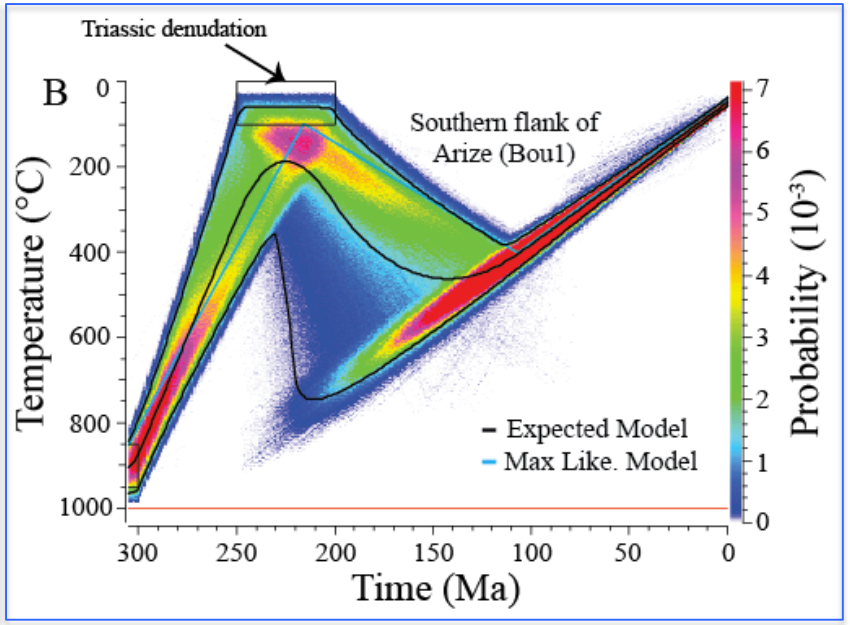
Ariège area



Thermal modeling : thermal histories

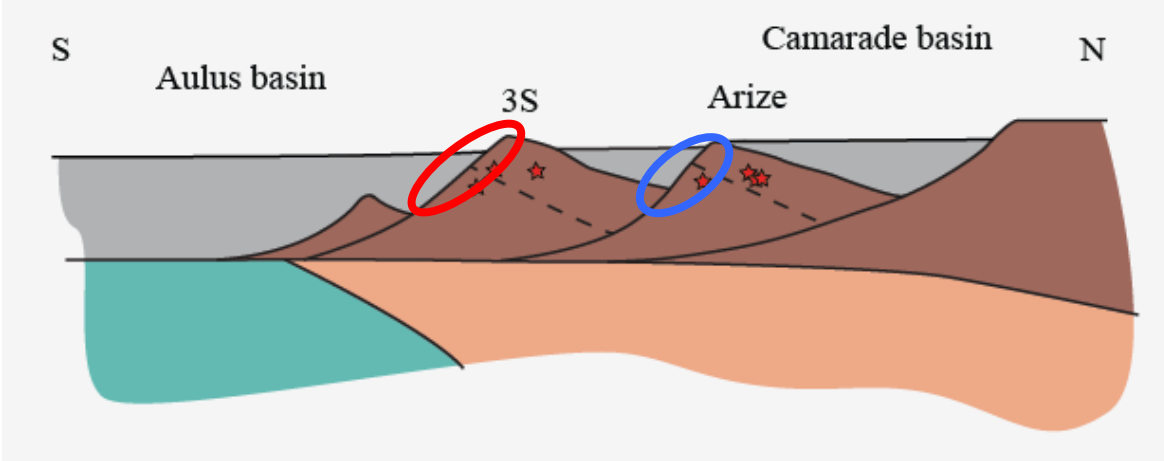
Ariège area





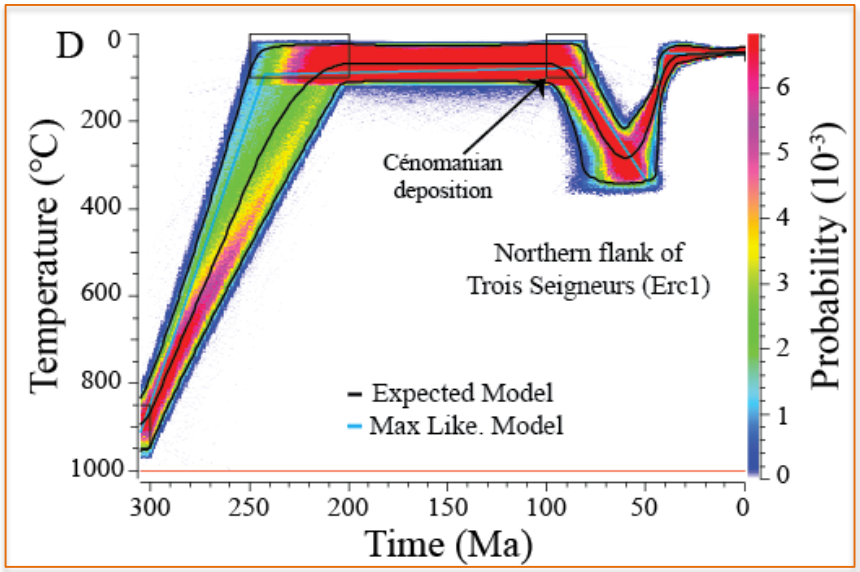
QTQt

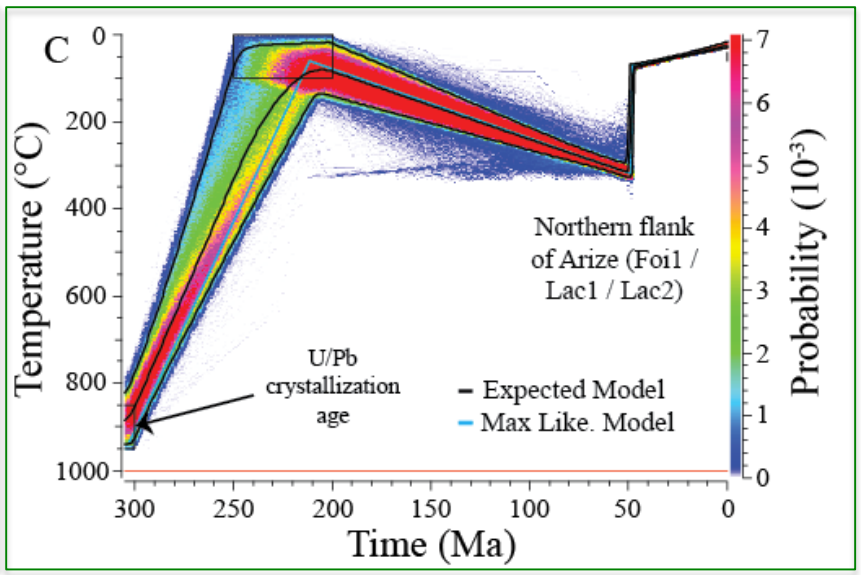
Gallagher et al., 2009;
Gallagher, 2012



Thermal modeling : thermal histories

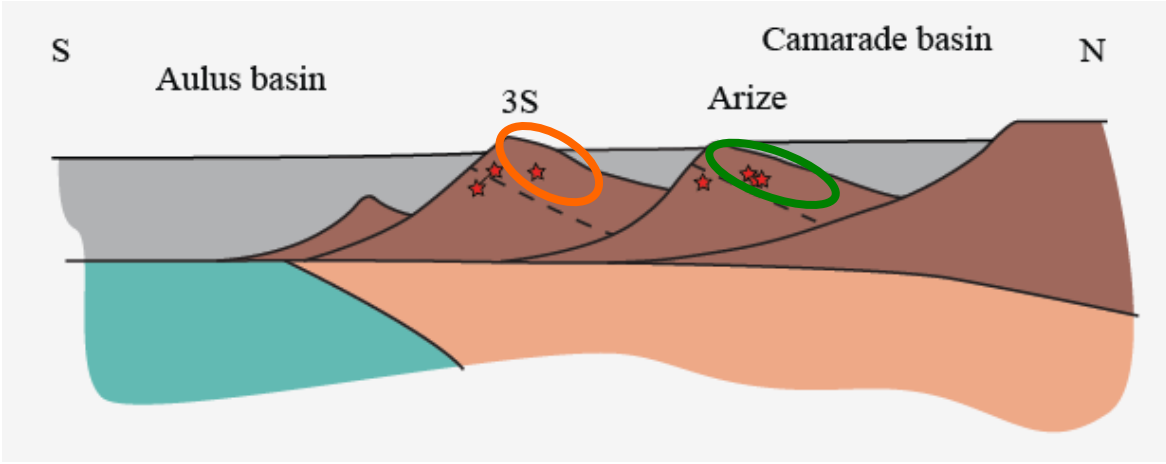
Ariège area





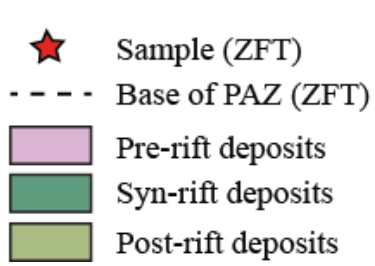
QTQt

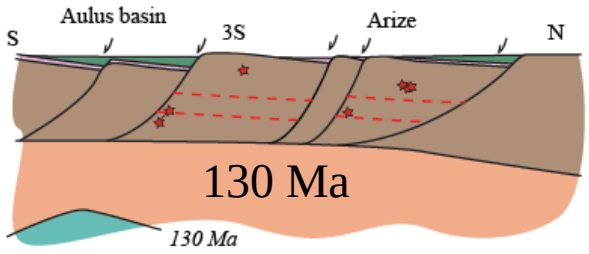
Gallagher et al., 2009; Gallagher, 2012

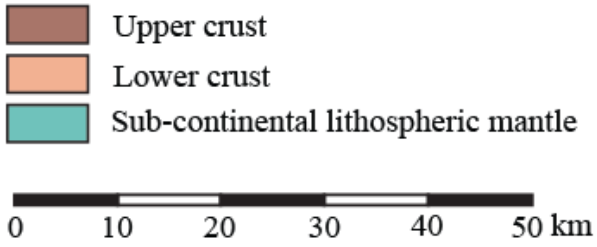


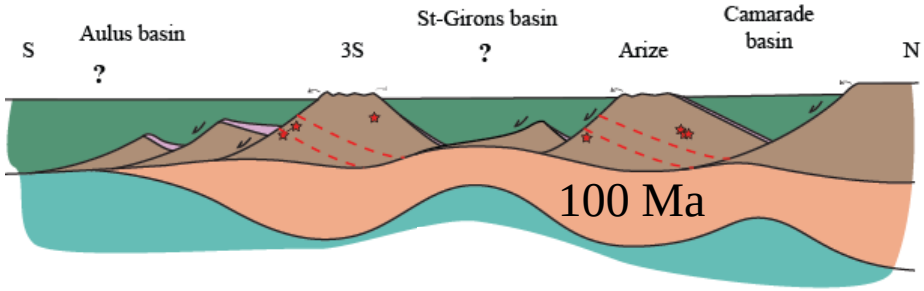
Conclusions : amazing sketchs

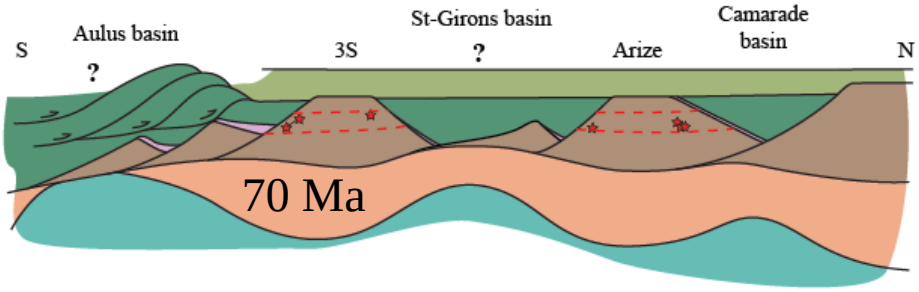
Ariège area

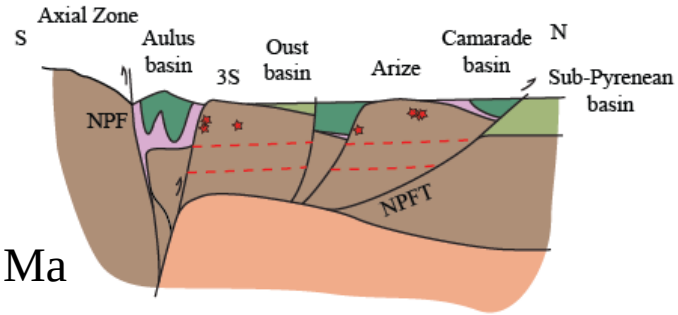












Conclusions :

- During extension, the massifs recorded cooling from high temperatures (~350°C), whereas the Aulus basin recorded a peak of temperature, up to 600°C

- This northern part may correspond to a well preserved moderately thinned domain close to the necking zone, whereas the Aulus basin may represent the distal domain.

Main conclusions

- **The Mauléon basin recorded heating as it developed on a distal part of the hyper-extended domain in agreement with high geothermal gradient of 80°C/km as well as the Aulus basin.**

- **The Ariège massifs recorded cooling during extension (130-110 Ma) and correspond to moderately thinned parts of the European margin. A similar history is expected for the Labourd massif.**

- **Heat inherited from extension in these distal domains is maintained over 20-30 Ma after convergence. Ductile deformation of Mesozoic basins might reflect accretion of an originally hot continental margin.**

Thank you for your attention and your support !