Links between remagnetizations and superchrons. New experiments and new results.

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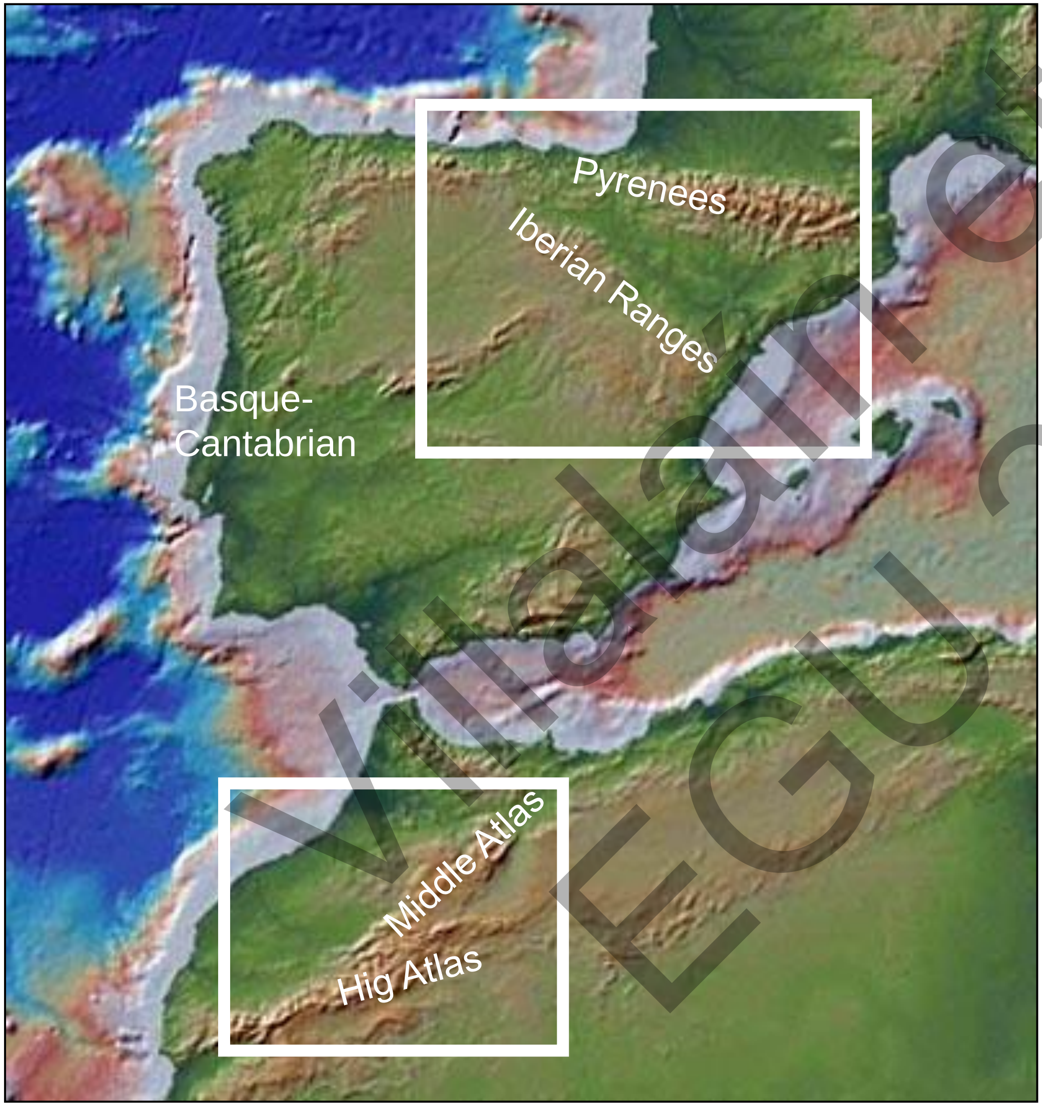
BACKGROUND
Widespread cretaceous remagnetizations
in inverted Mesozoic basins of the Iberia and North Africa



- Thick **lower cretaceous** syn-rift sediments in Iberia

REMAGNETIZED

- Thick **lower Jurassic** syn-rift sediments in Atlas ranges.

REMAGNETIZED

North Iberian cretaceous remagnetizations

ChRM
Systematic Normal polarity

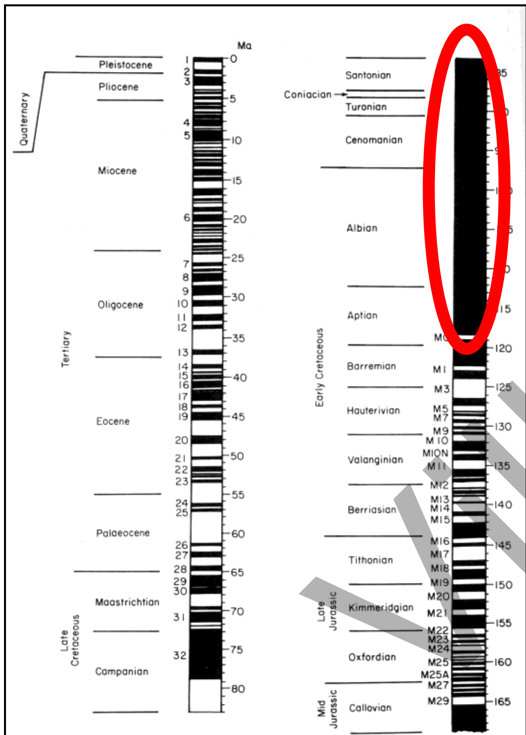
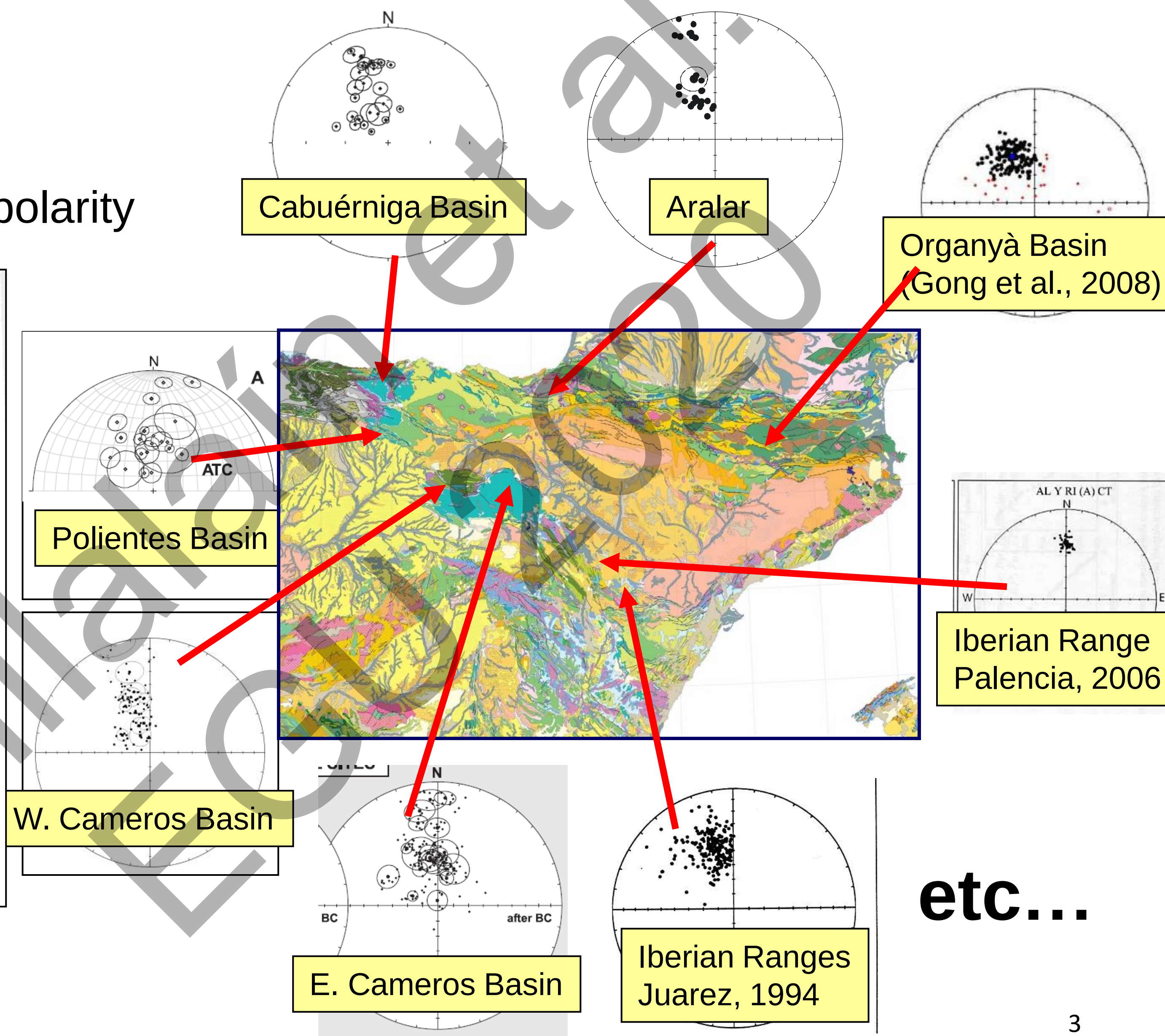


Fig. 5.9. Reversal time-scale for the past 170 Ma (after Cox, 1982).

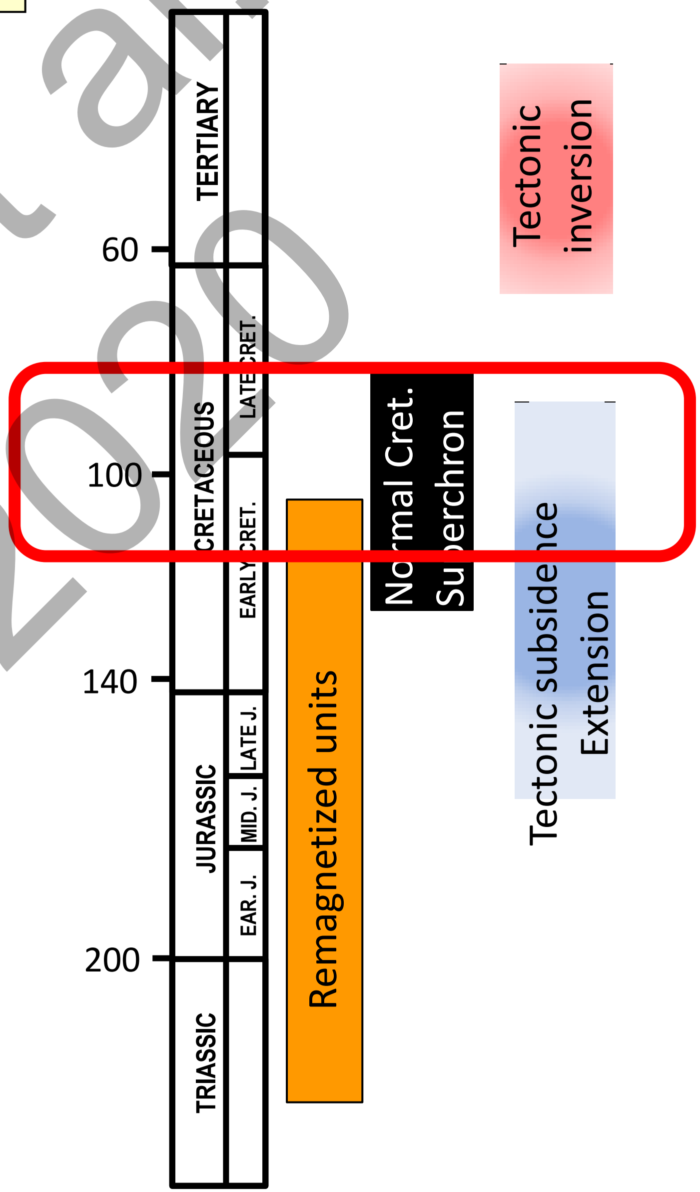


Timing of Iberian remagnetizations

AGE:

- Pre basin-inversion (Oligocene)
- Post- o syn- extensión
- Post Aptian sediments
- Normal polarity (K Superchron)

CRETACEOUS REMAGNETIZATION



High Atlas cretaceous remagnetization

ChRM
Systematic Normal polarity

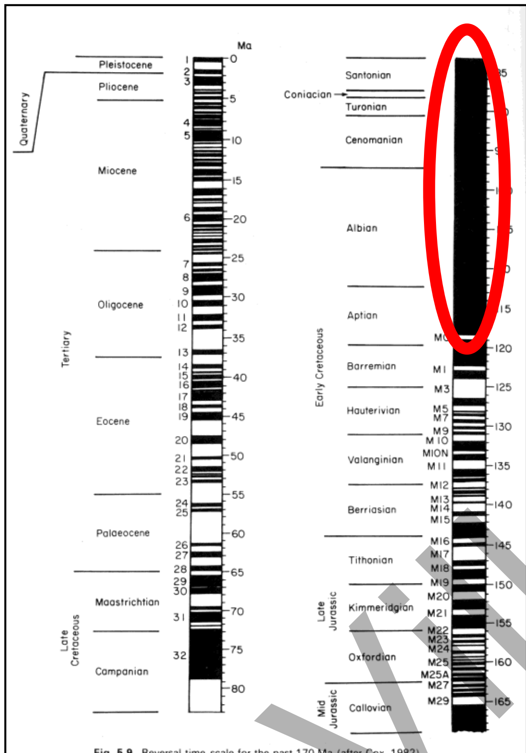
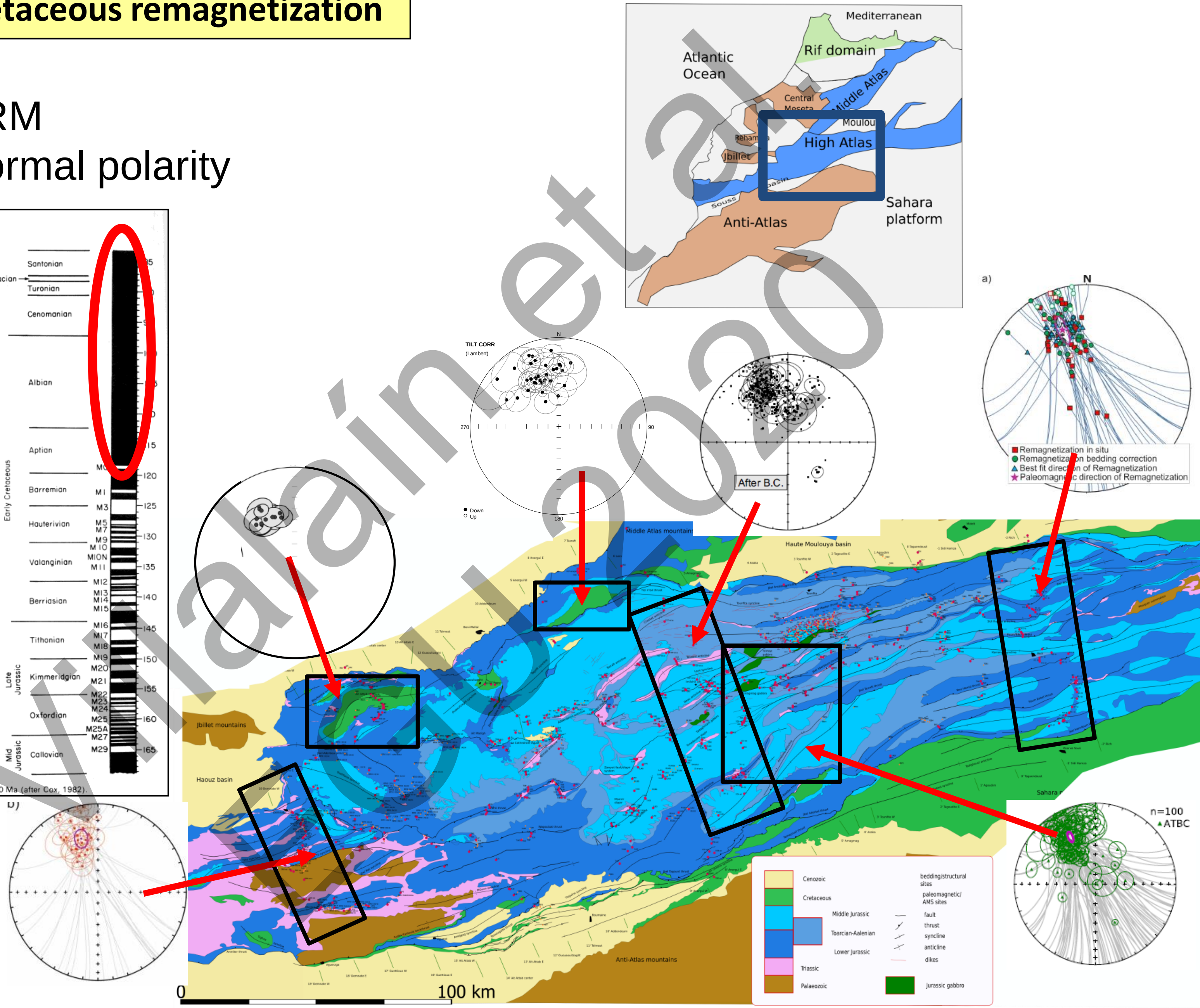
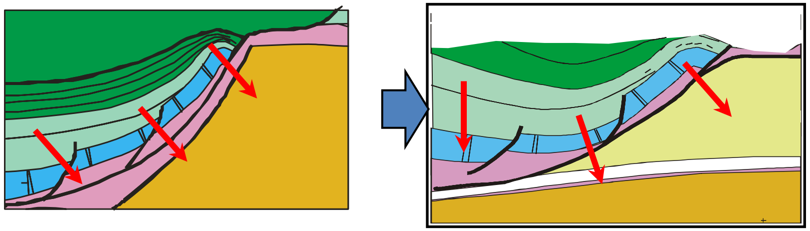


Fig. 5.9. Reversal time-scale for the past 170 Ma (after Cox, 1982).



Dating from the Remagnetization Direction

Small Circles Intersection (SCI) method

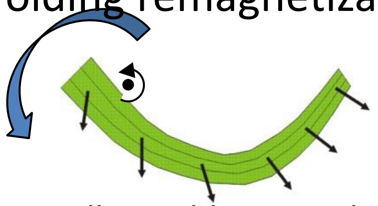


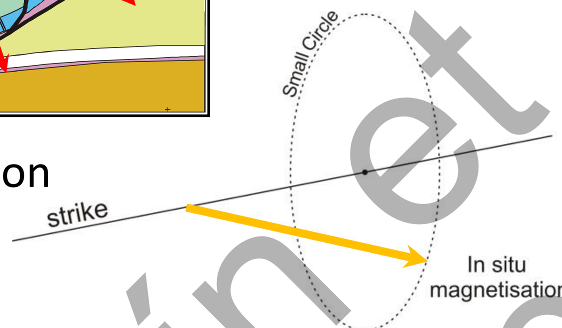
HYPOTHESIS

- If the different sites were remagnetized at the same time.
- If the deflection of the magnetization is only due to tilting around the bedding strike.

- The remagnetization direction is the intersection of the SC.

Interfolding remagnetization

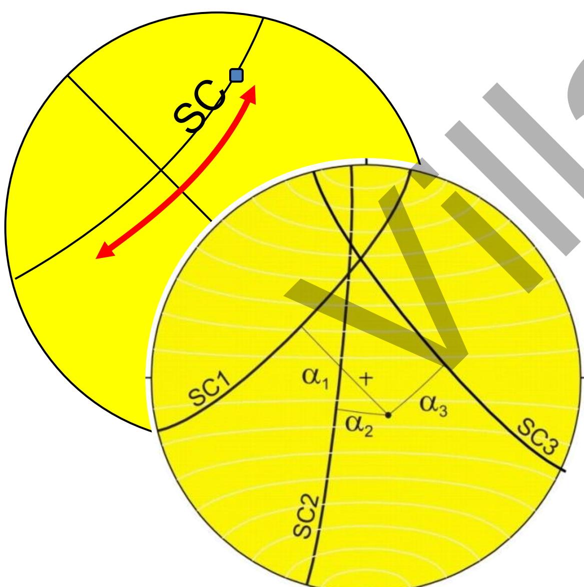


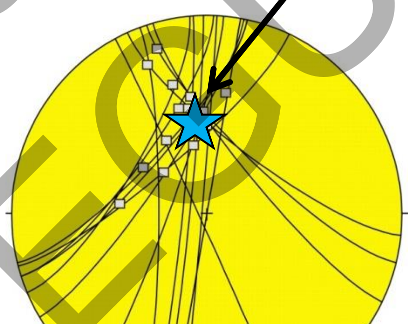


- SC gives all possible original direction in a rotation of the magnetization around the strike.

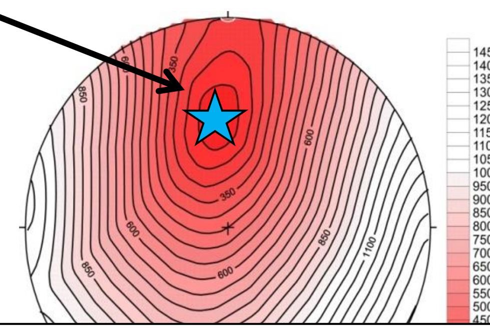
Small Circle Intersection method (SCI)
Shipunov, 1997; Waldhor & Appel, 2006; Callvín et al. 2017

$$A = \sum |\alpha_n| \Rightarrow \boldsymbol{A\ min}$$





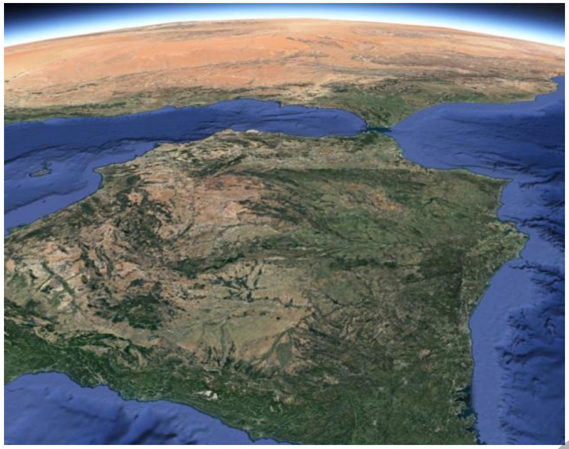
SC must intersect at the Remagnetization direction



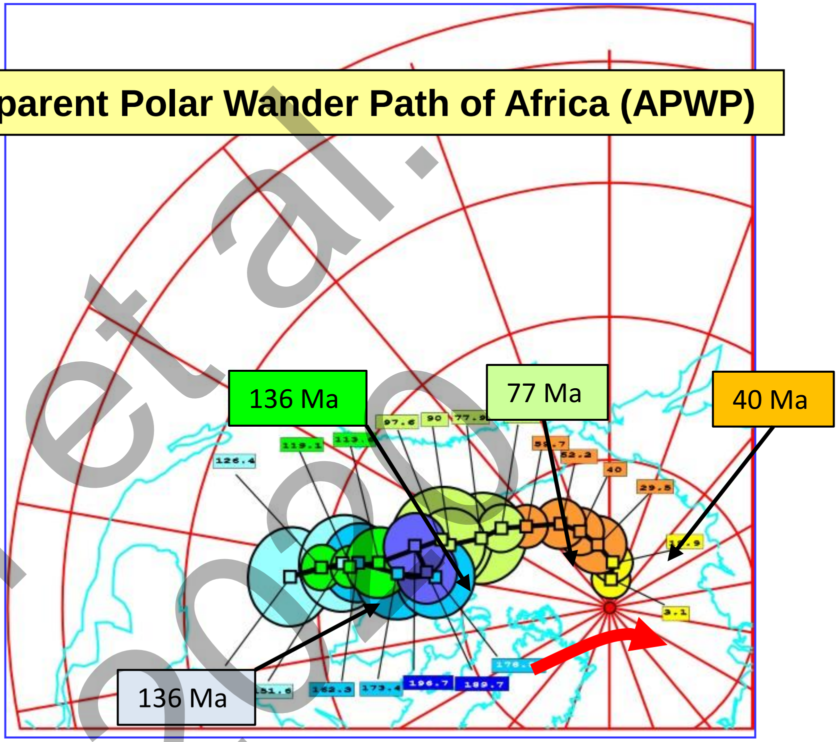
SCI
REMAGNETIZATION DIRECTION

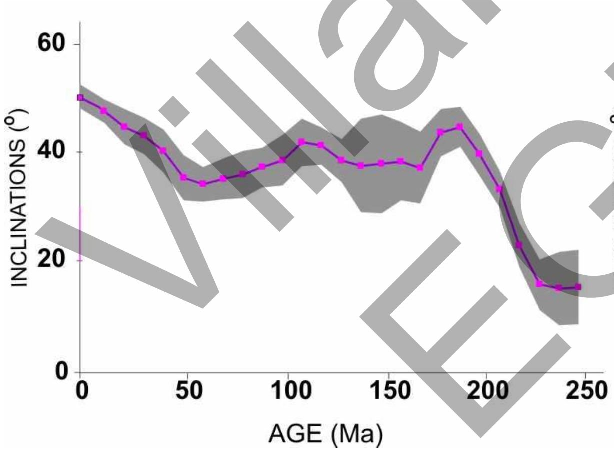
Contours of A values

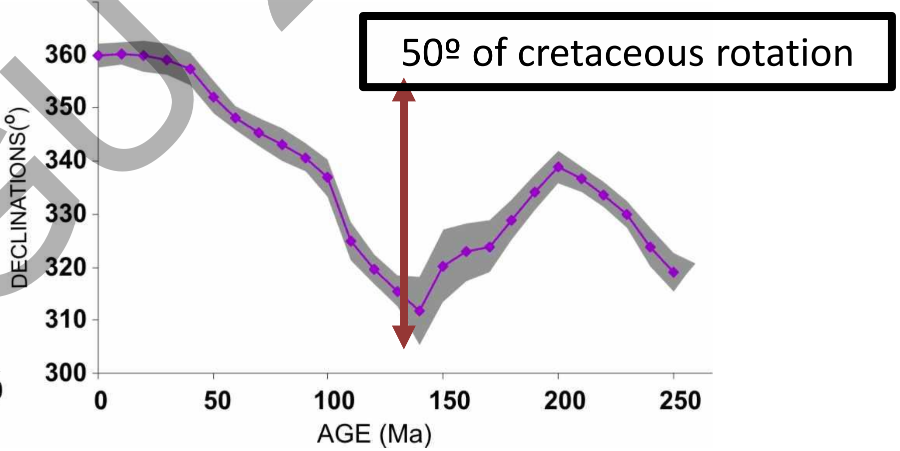
Systematic paleomagnetic studies in the Moroccan High Atlas



Aparent Polar Wander Path of Africa (APWP)

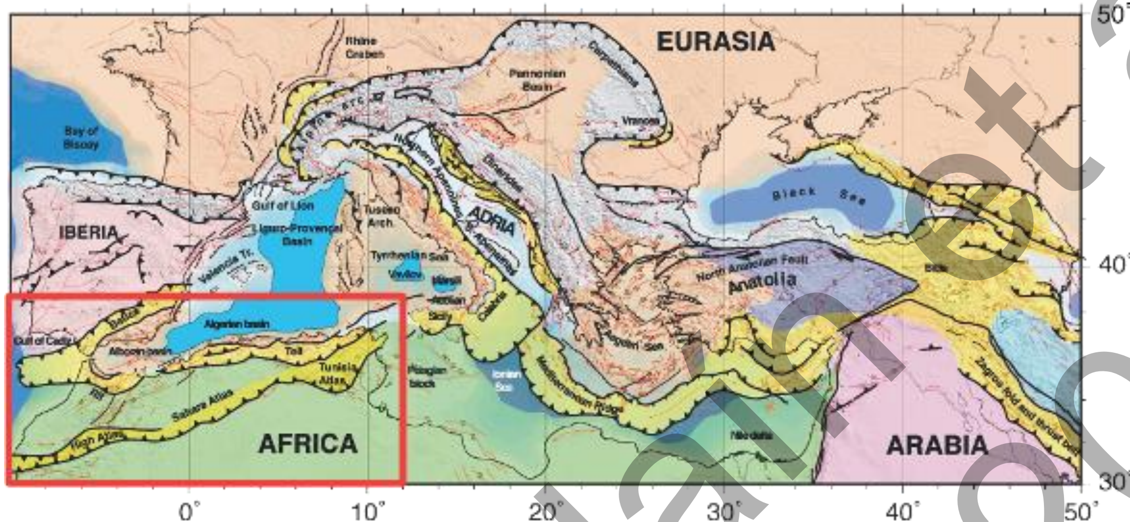




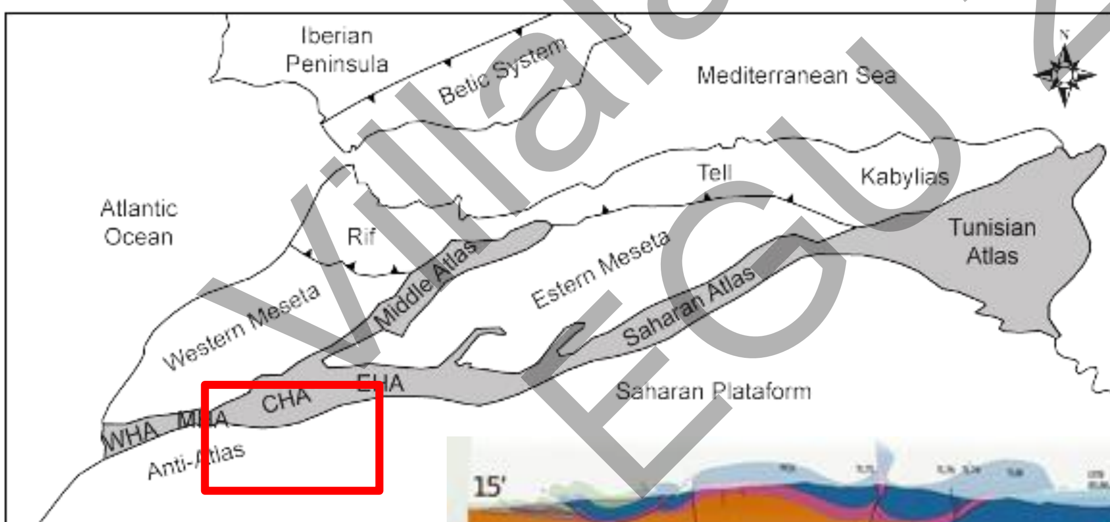


Expected directions in The High Atlas

Systematic paleomagnetic studies in the Moroccan High Atlas

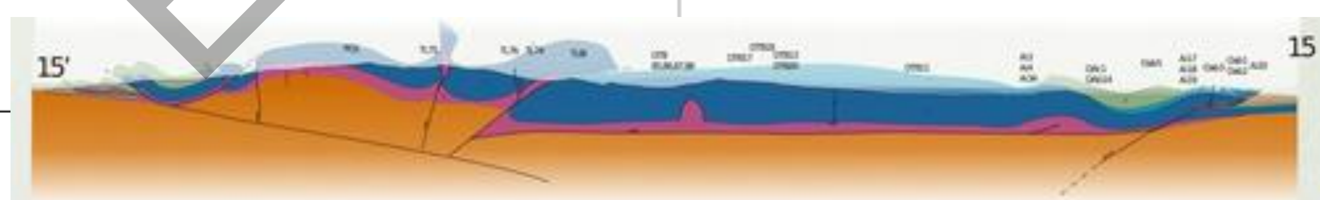


Foreland of the Alpine Mediterranean System

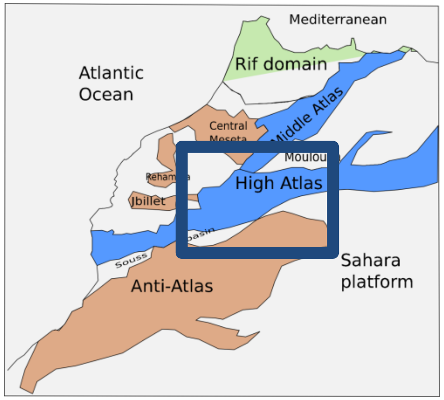


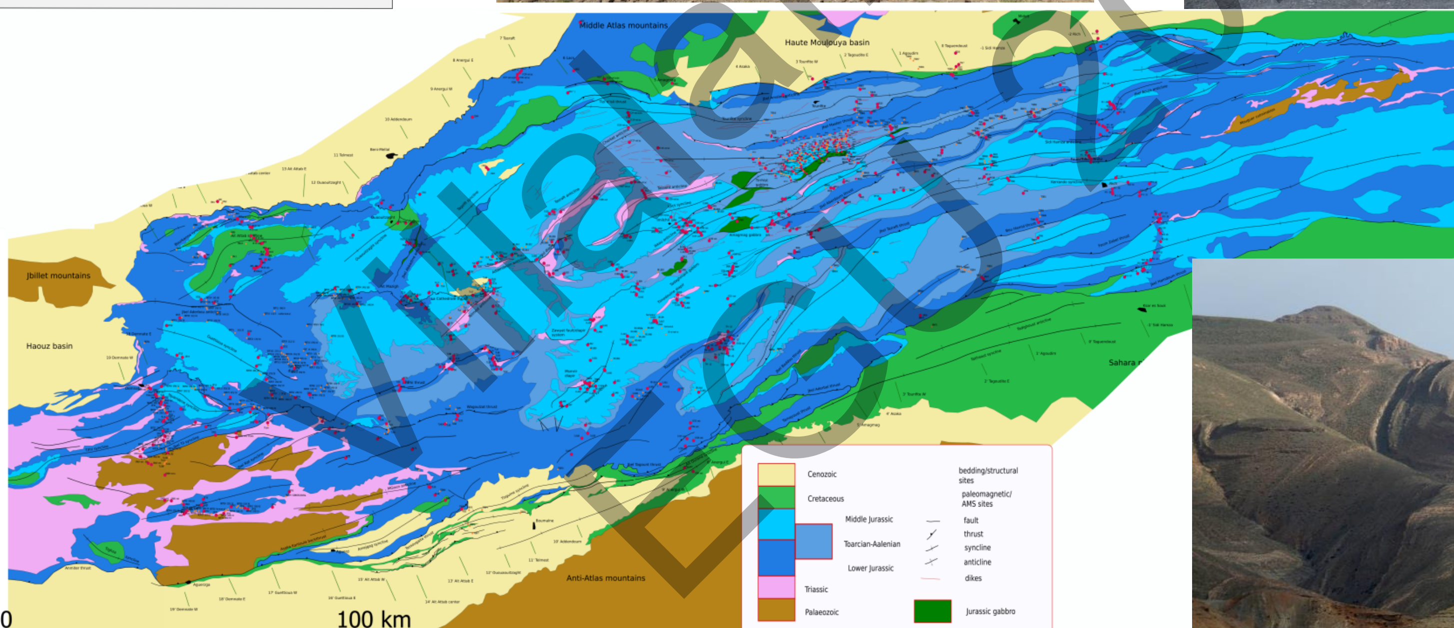
ENE-OSO / NE-SO

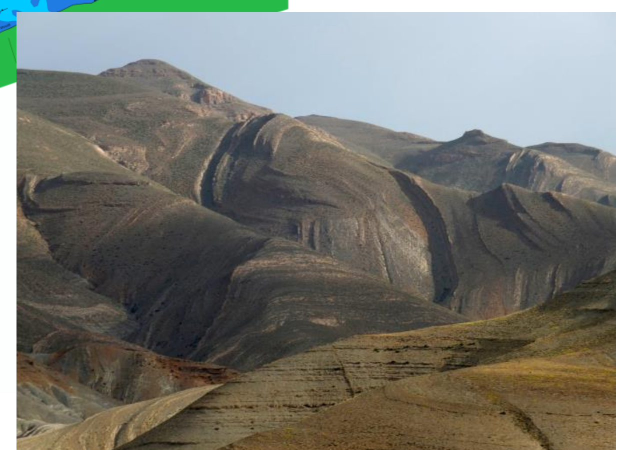
2000 km long / 100 km wide



Systematic paleomagnetic studies in the Central High Atlas (CHA)

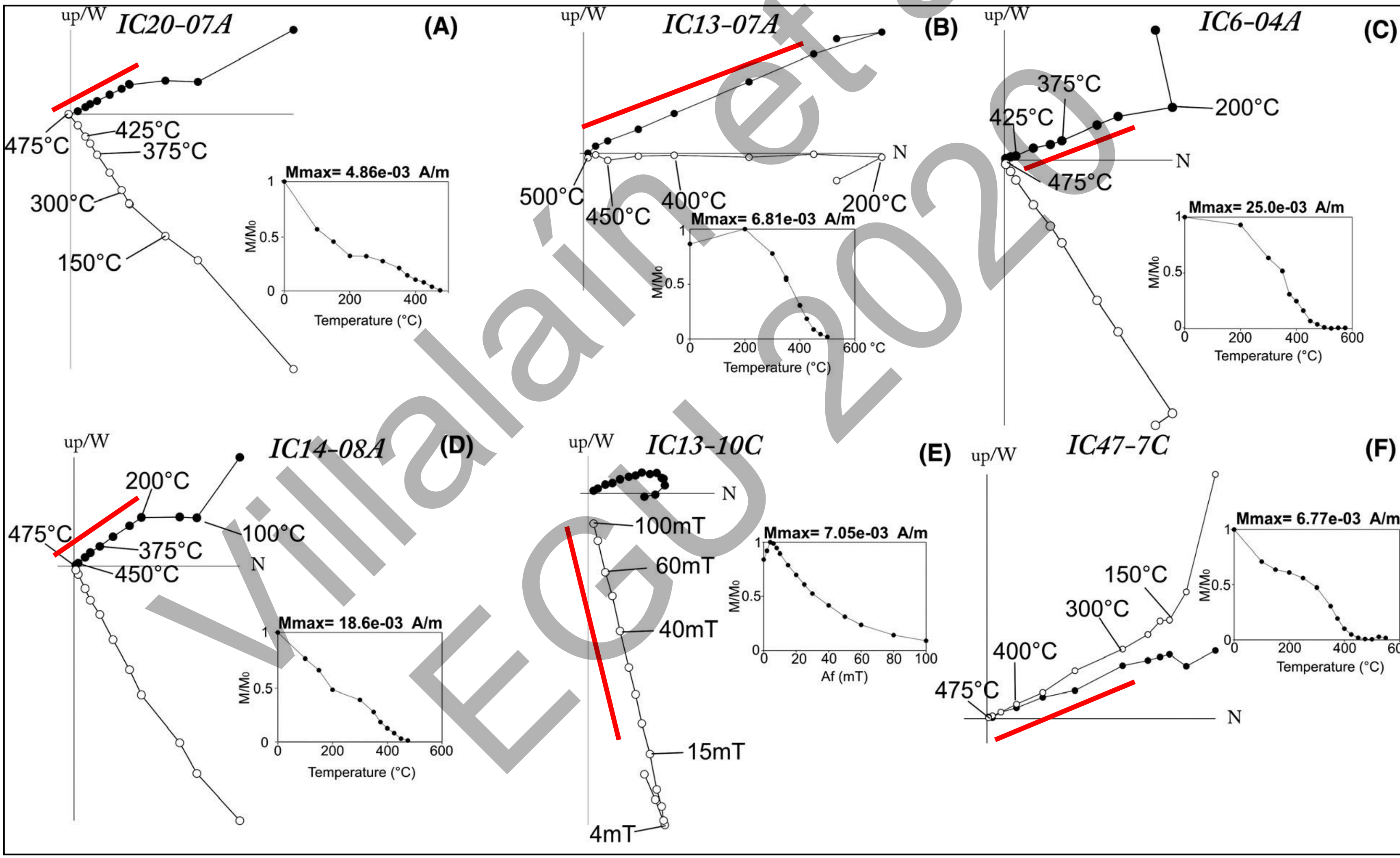






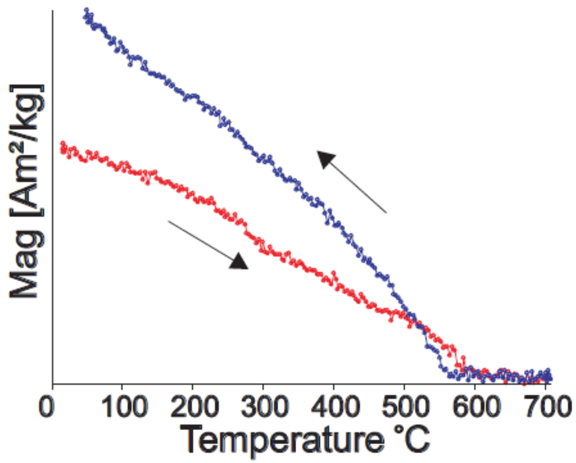
NRM OF REMAGNETIZED JURASSIC LIMESTONE

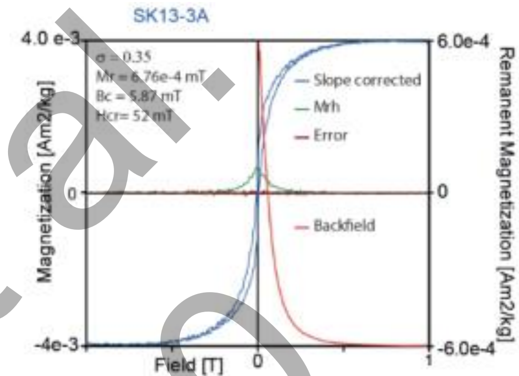
The CHA cretaceous remagnetization has been observed in all these sites with the same magnetic properties: a viscous paleomagnetic component with maximum unblocking temperatures of 200-250ºC and the remagnetization normal polarity component up to 450–500ºC.

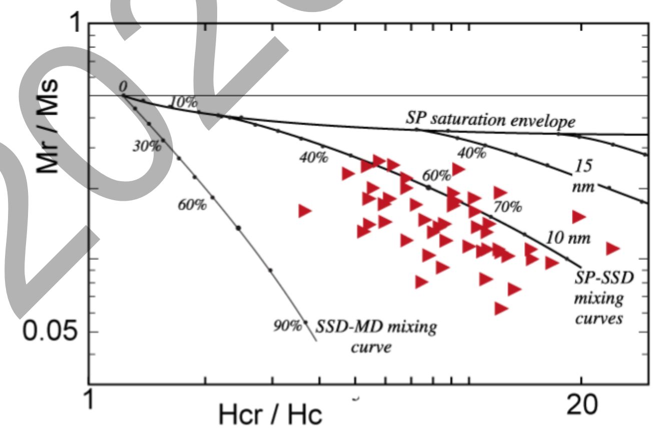


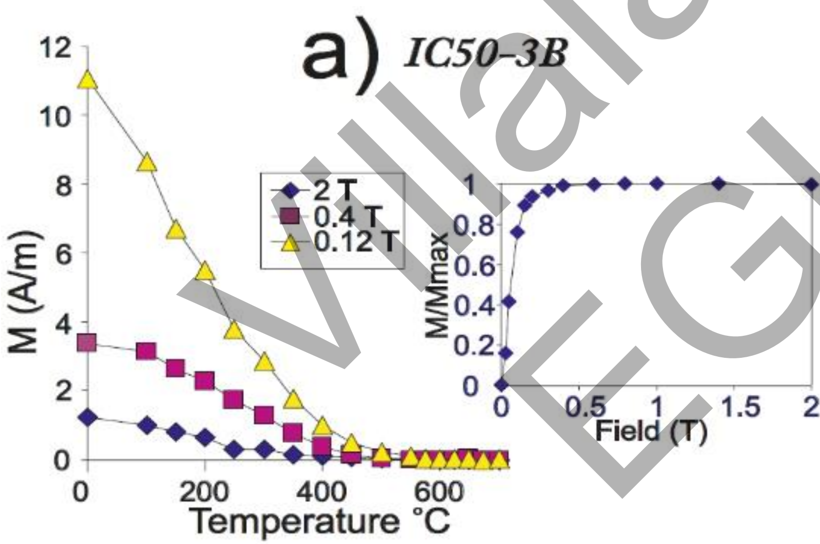
Magnetic properties:

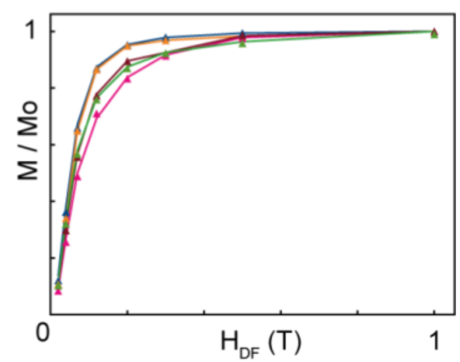
SD-SP uniaxial magnetite





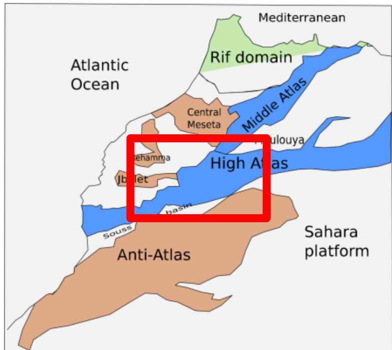


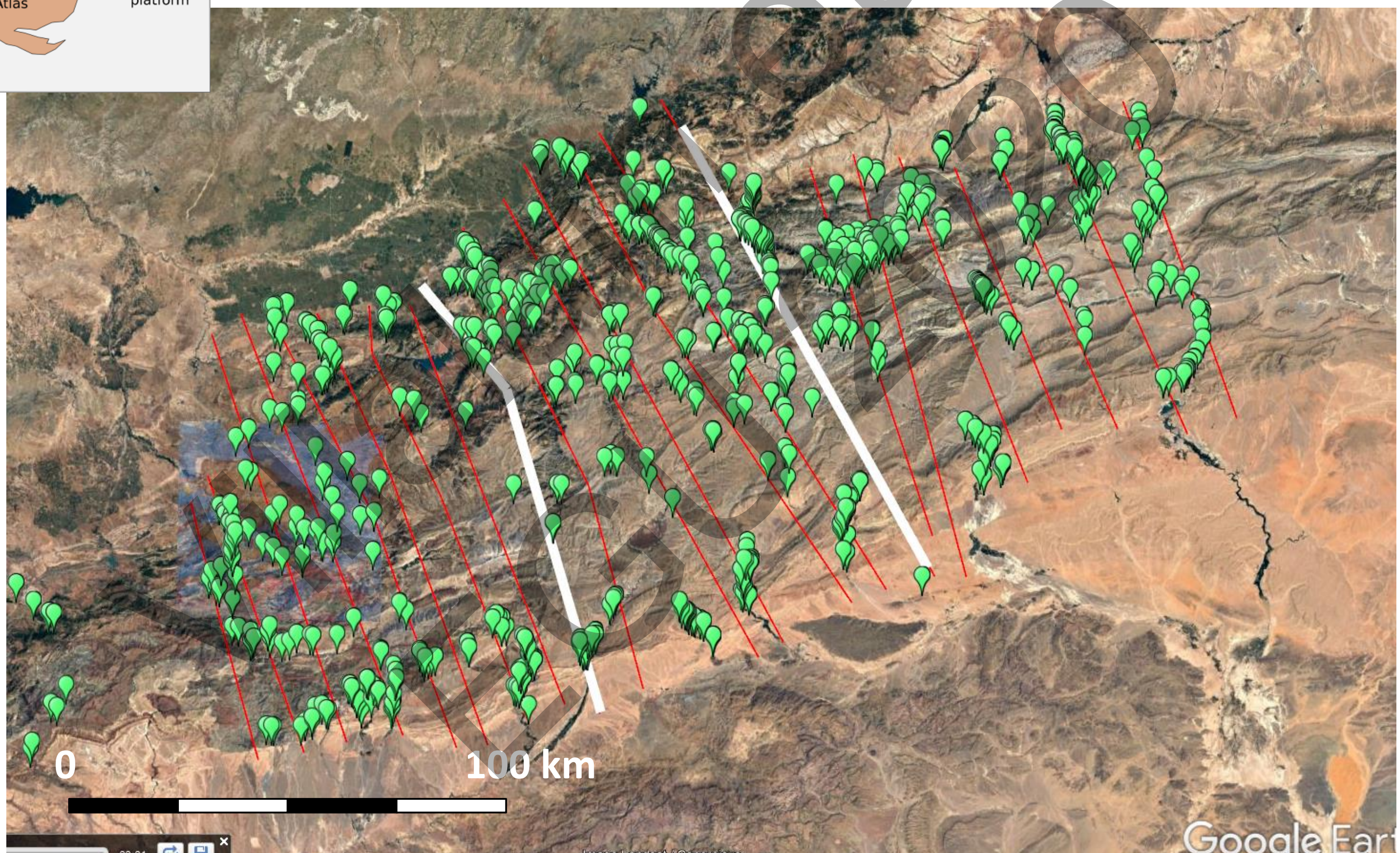




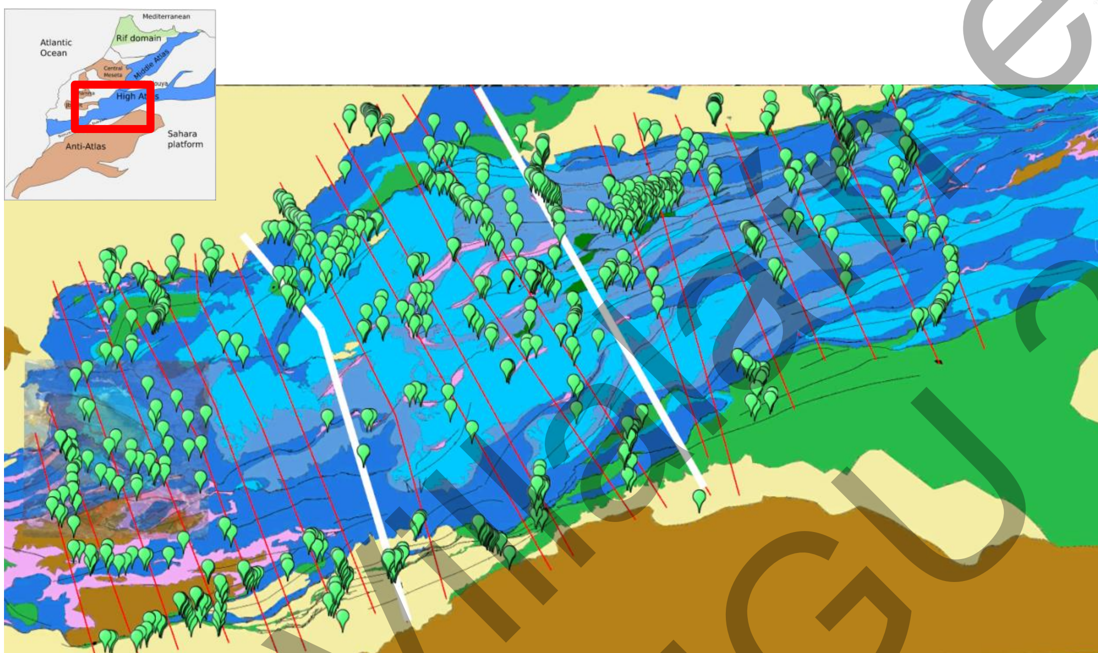
Aiming to perform a 3D palinspastic restorations using interfolding remagnetizations a high resolution sampling has been made.

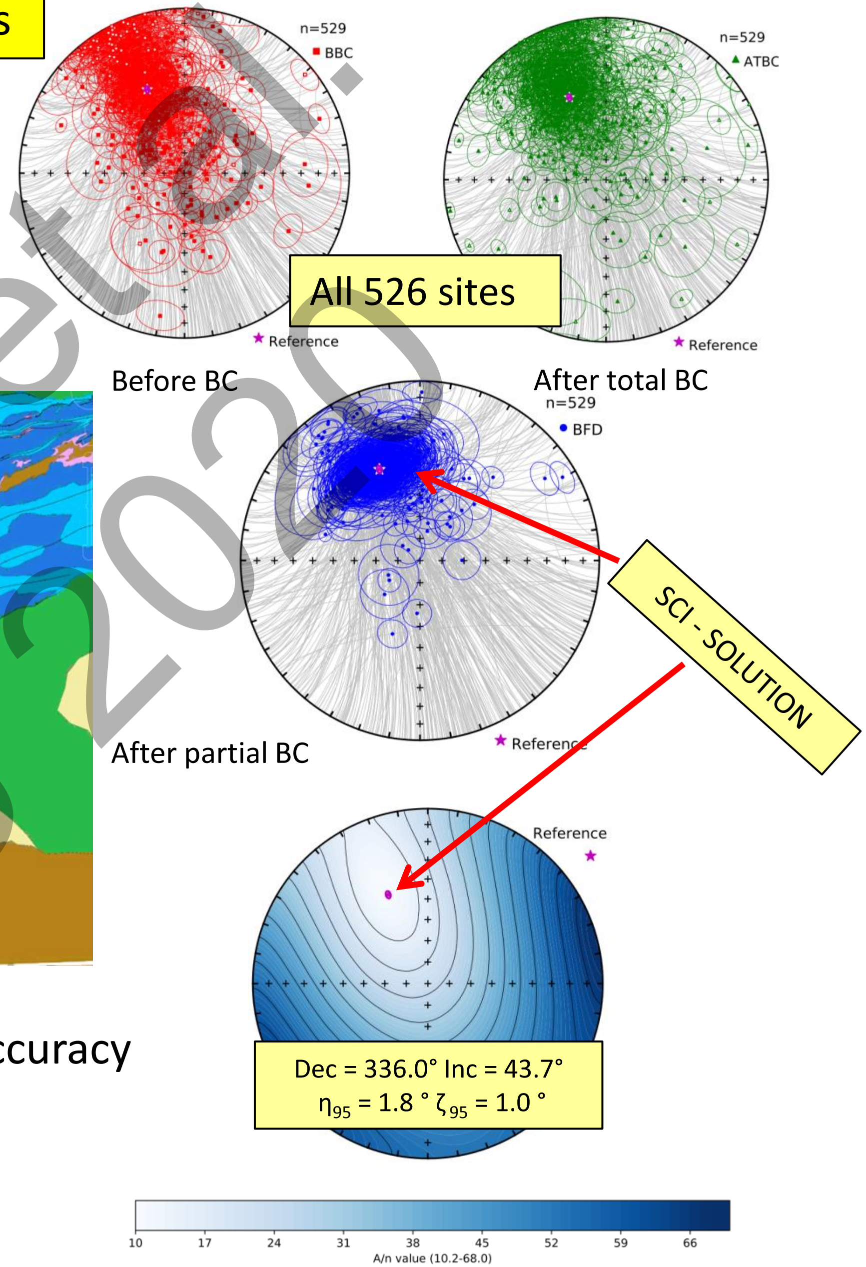
- $10.000\ Km^2$
- 20 profiles
- 600 paleomagnetic sites (calculating 600 paleobeddings)



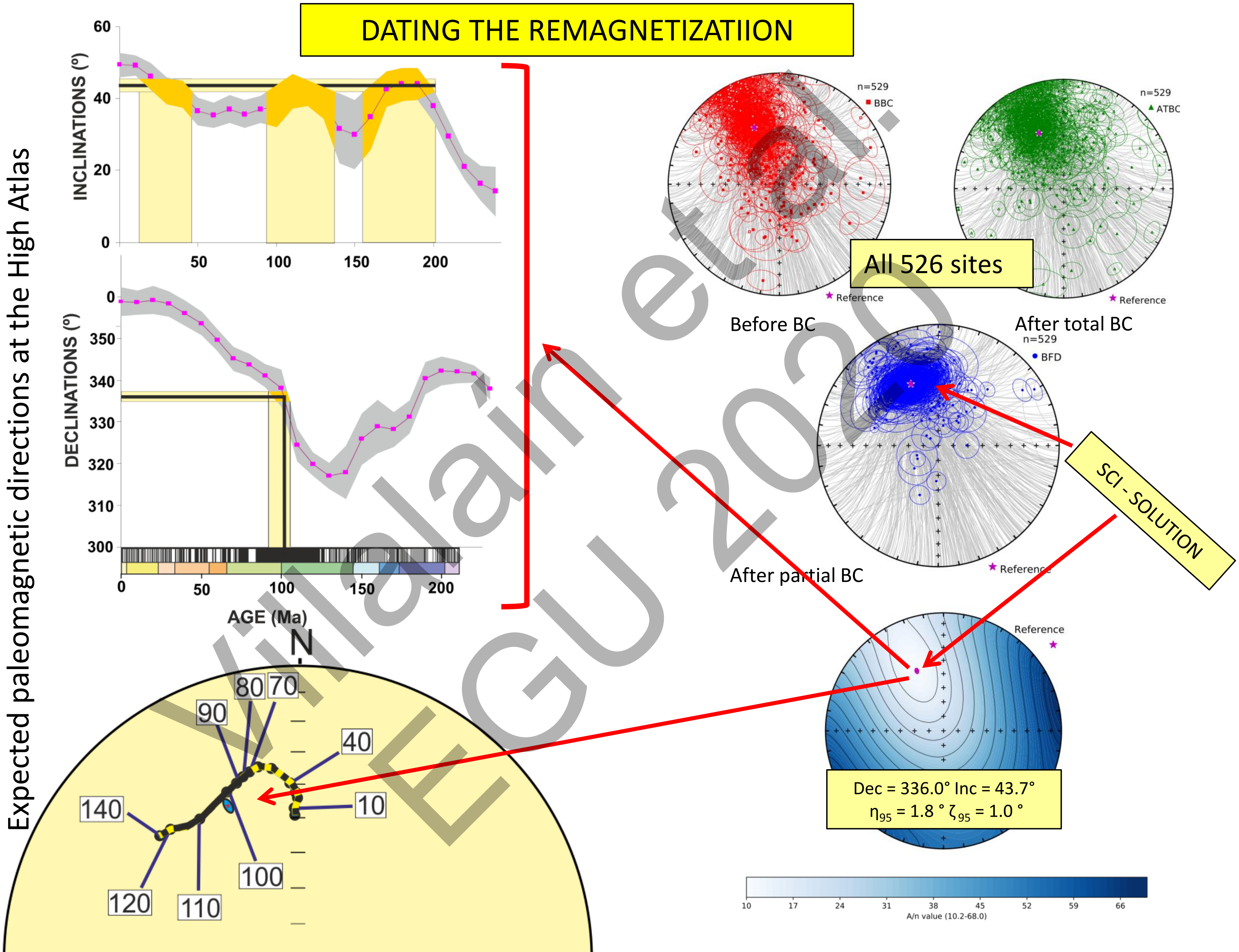


Direction of remagnetization
from Small Circle Intersection Method over 526 sites

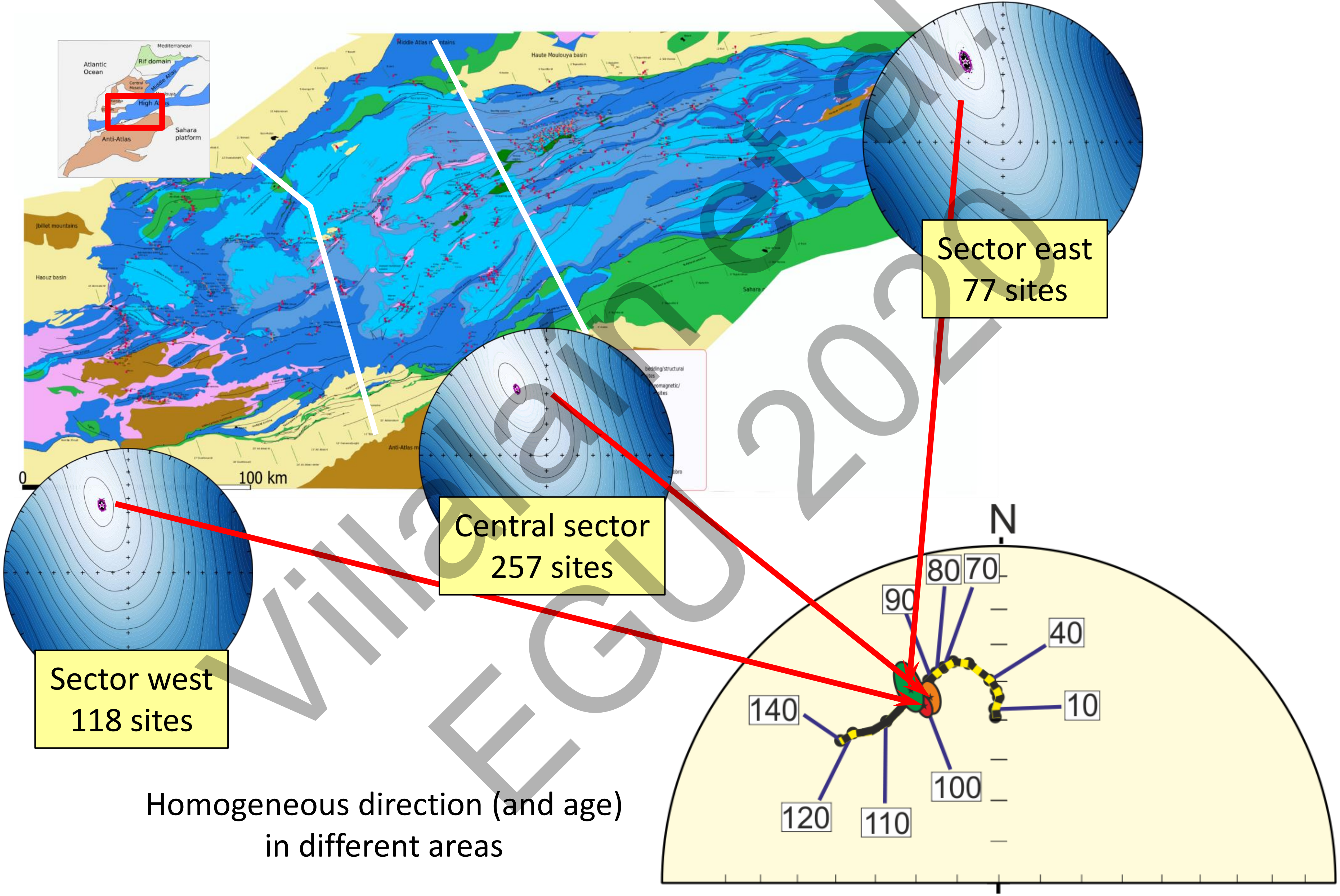




Very high accuracy

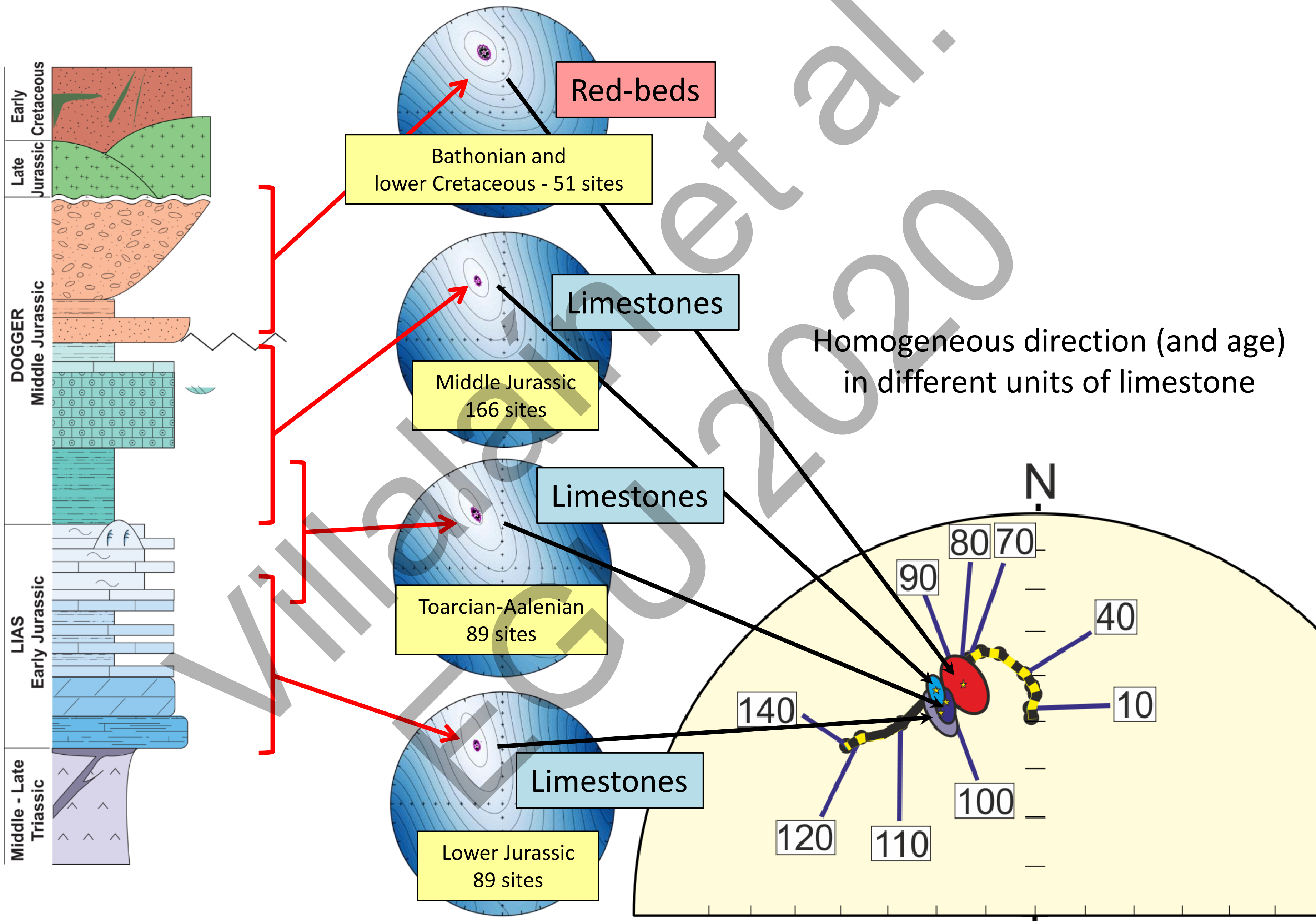

DATING THE REMAGNETIZATIION
Expected paleomagnetic directions at the High Atlas
INCLINATIONS (°)
60
40
20
0
50
100
150
200
DECLINATIONS (°)
0
350
340
330
320
310
300
AGE (Ma)
N
80
70
90
40
10
140
100
120
110
n=529
BBC
Reference
Before BC
n=529
ATBC
Reference
After total BC
All 526 sites
n=529
BFD
Reference
After partial BC
SCI - SOLUTION
Reference
Dec = 336.0° Inc = 43.7°
η95 = 1.8 ° ζ95 = 1.0 °
10
17
24
31
38
45
52
59
66
A/n value (10.2-68.0)
Villalaín et al. EGU 2020

PALEOMAGNETIC DIRECTION AND LOCATION

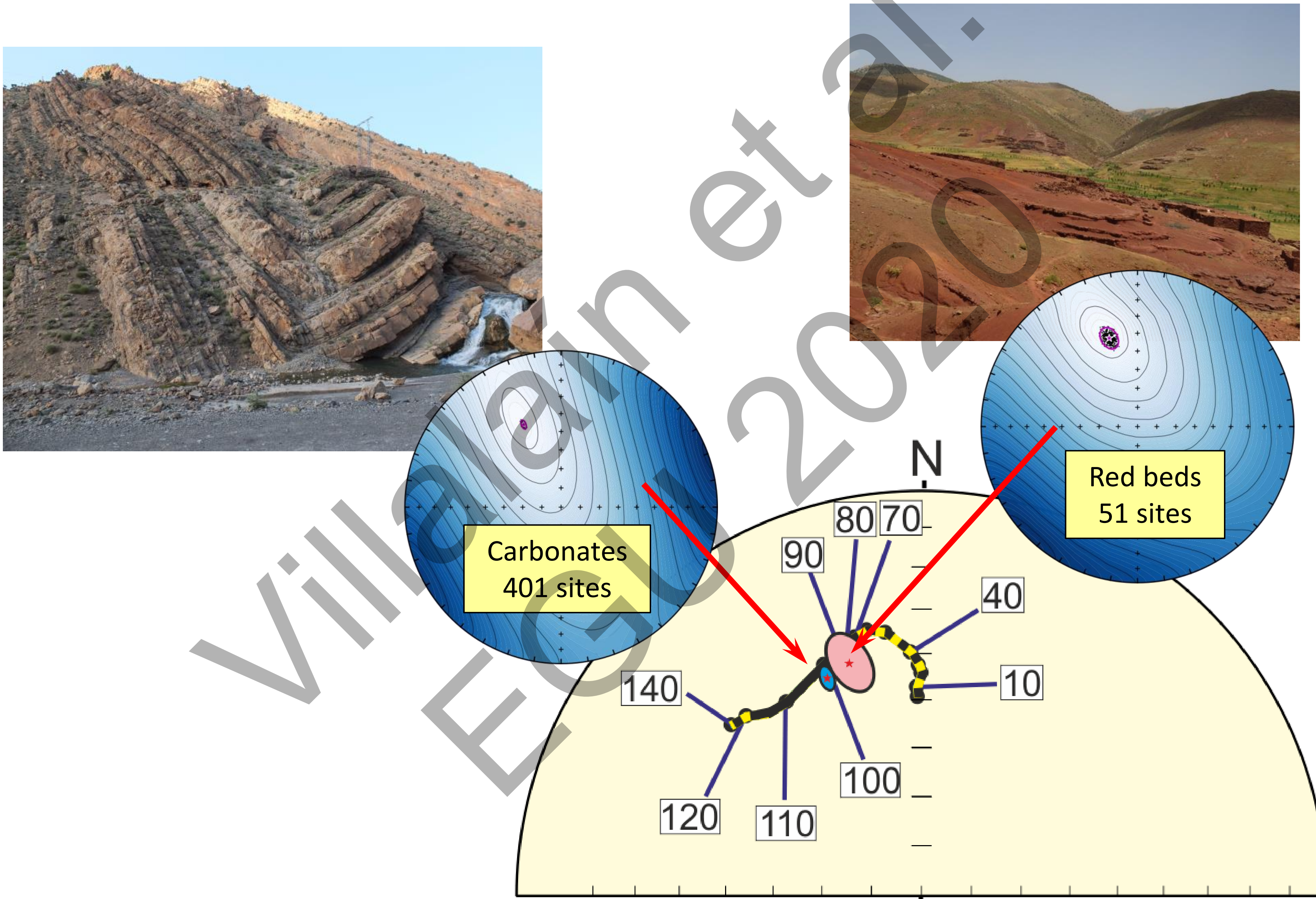


Homogeneous direction (and age)
in different areas

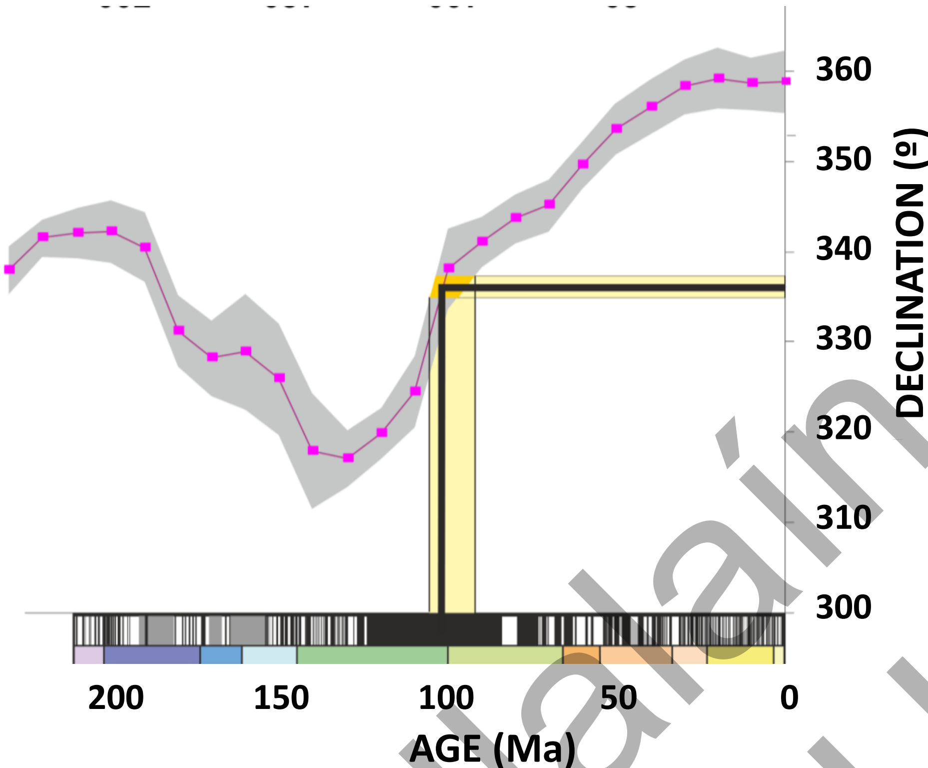
PALEOMAGNETIC DIRECTION AND STRATIGRAPHIC UNIT



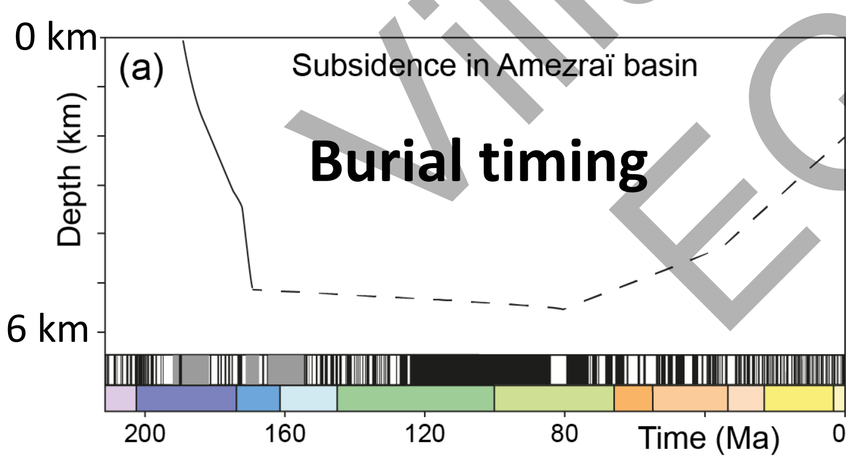
PALEOMAGNETIC DIRECTION AND LITHOLOGIES



Timing of the remagnetization



The mechanism proposed for this type of this burial widespread remagnetizations in limestones is the generation of magnetite grains due to the heating related with burial. The homogeneous direction of the remagnetization seems to suggest an acquisition for a short event at 100 Ma.

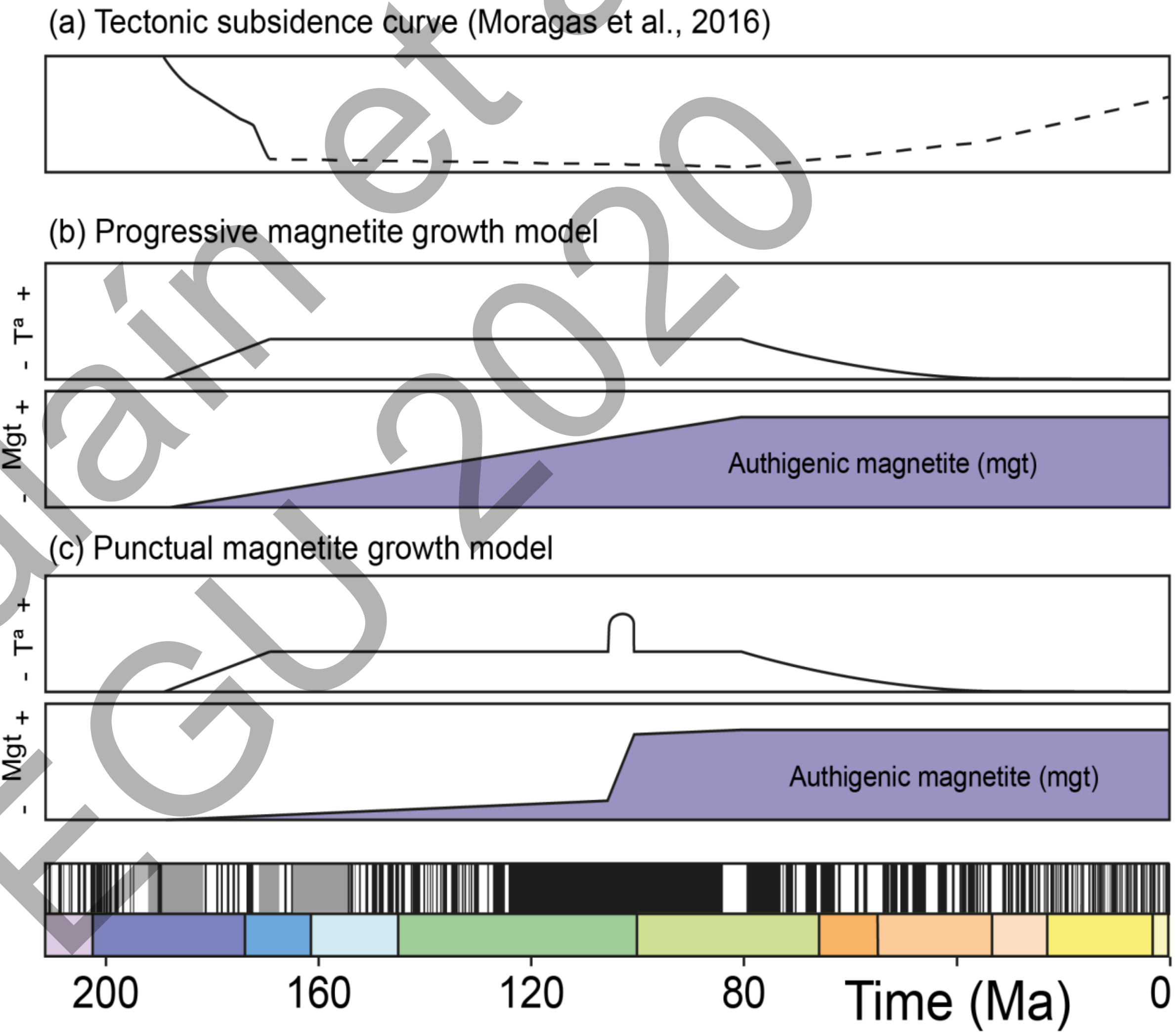


However, the extensional stage of these basins lasts tens of millions years keeping the necessary burial conditions for growth of magnetite grains covering several polarity chrons including the CNS.

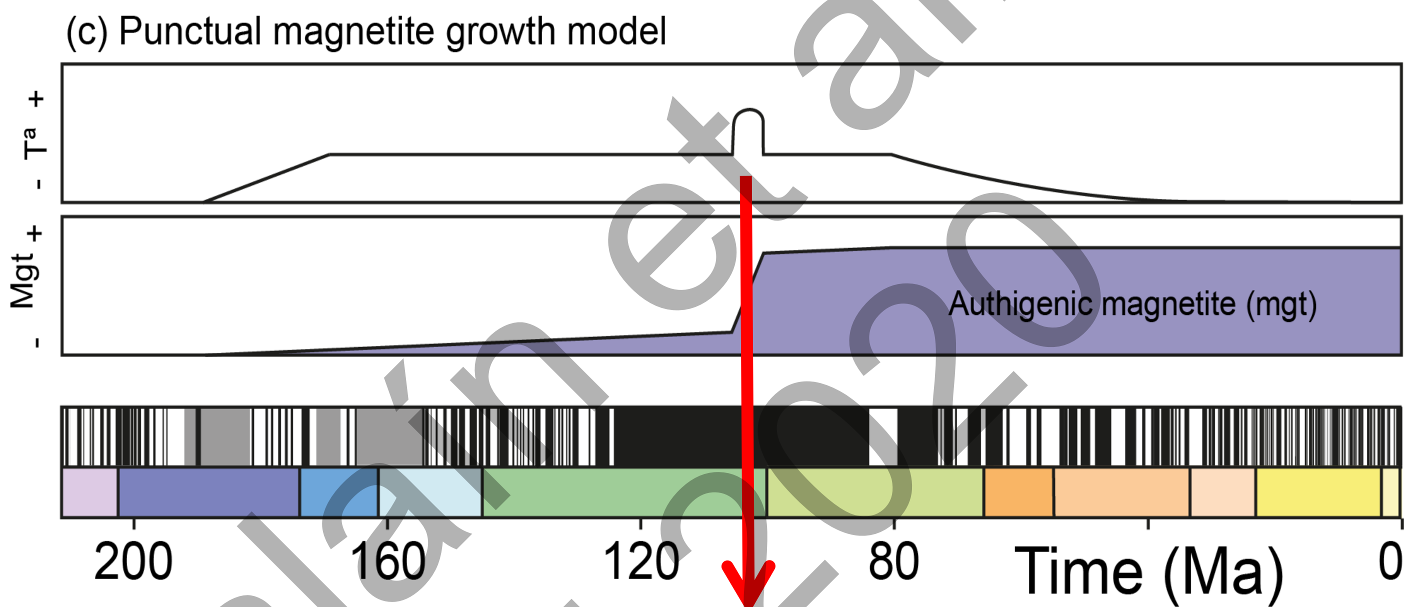
In this work we address the question of timing under with these processes happened, i.e. short vs. long remagnetization periods.

Progressive or punctual?

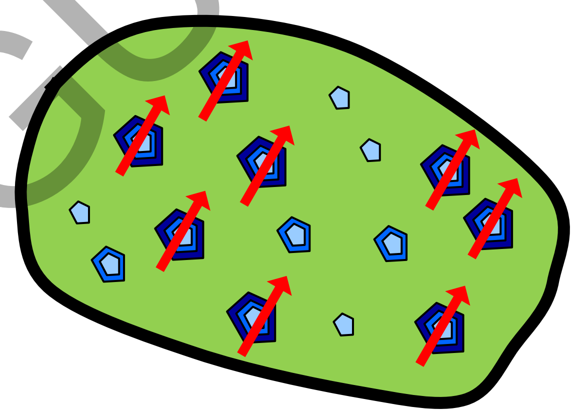
?



Punctual thermal event model



Magnetic moment of SSD magnetite grains shows all Normal polarity

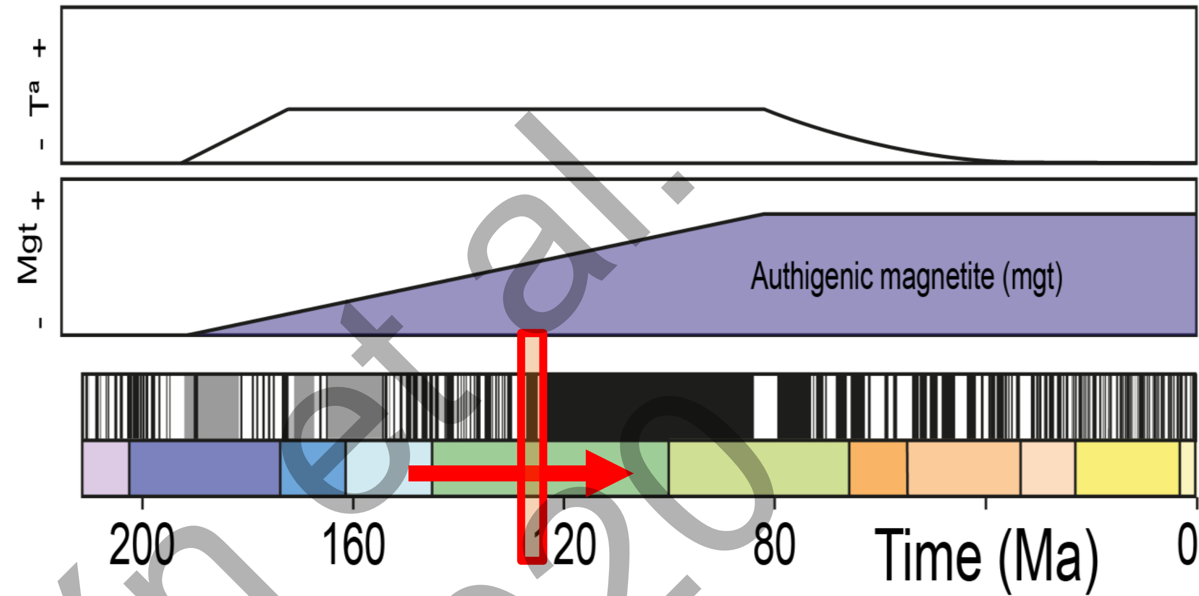


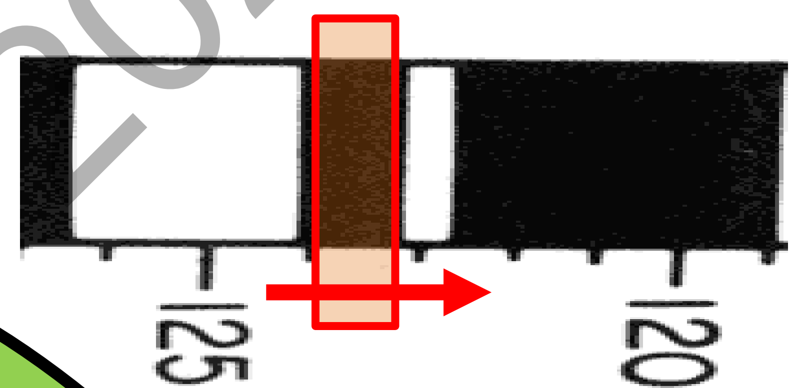
It can explain the homogeneous direction and age of remagnetization

Progressive generation of magnetite during deep basin condition

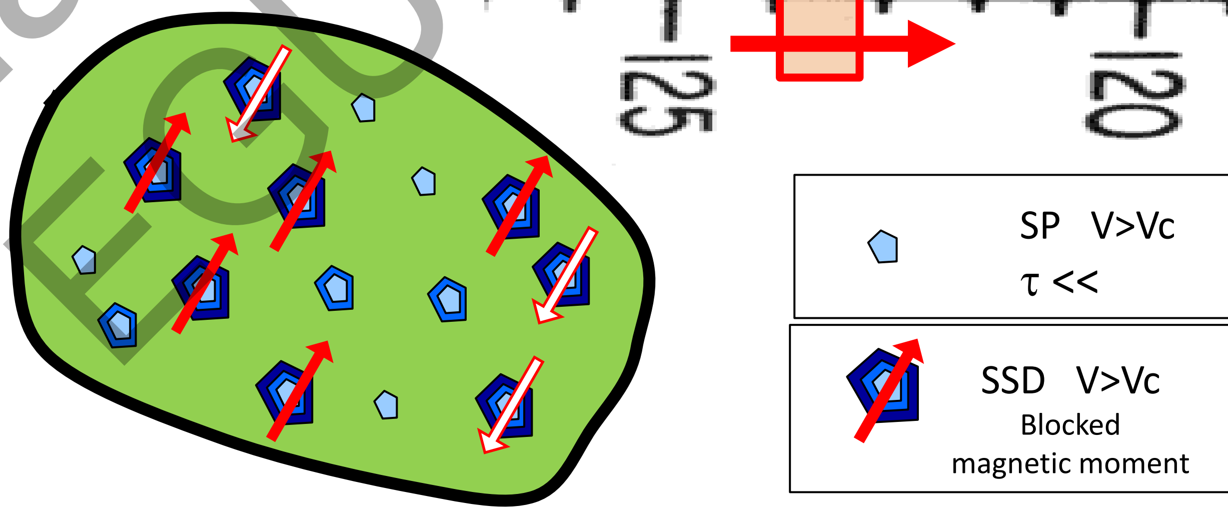
Magnetite grow blocking the magnetic moment at Vc.

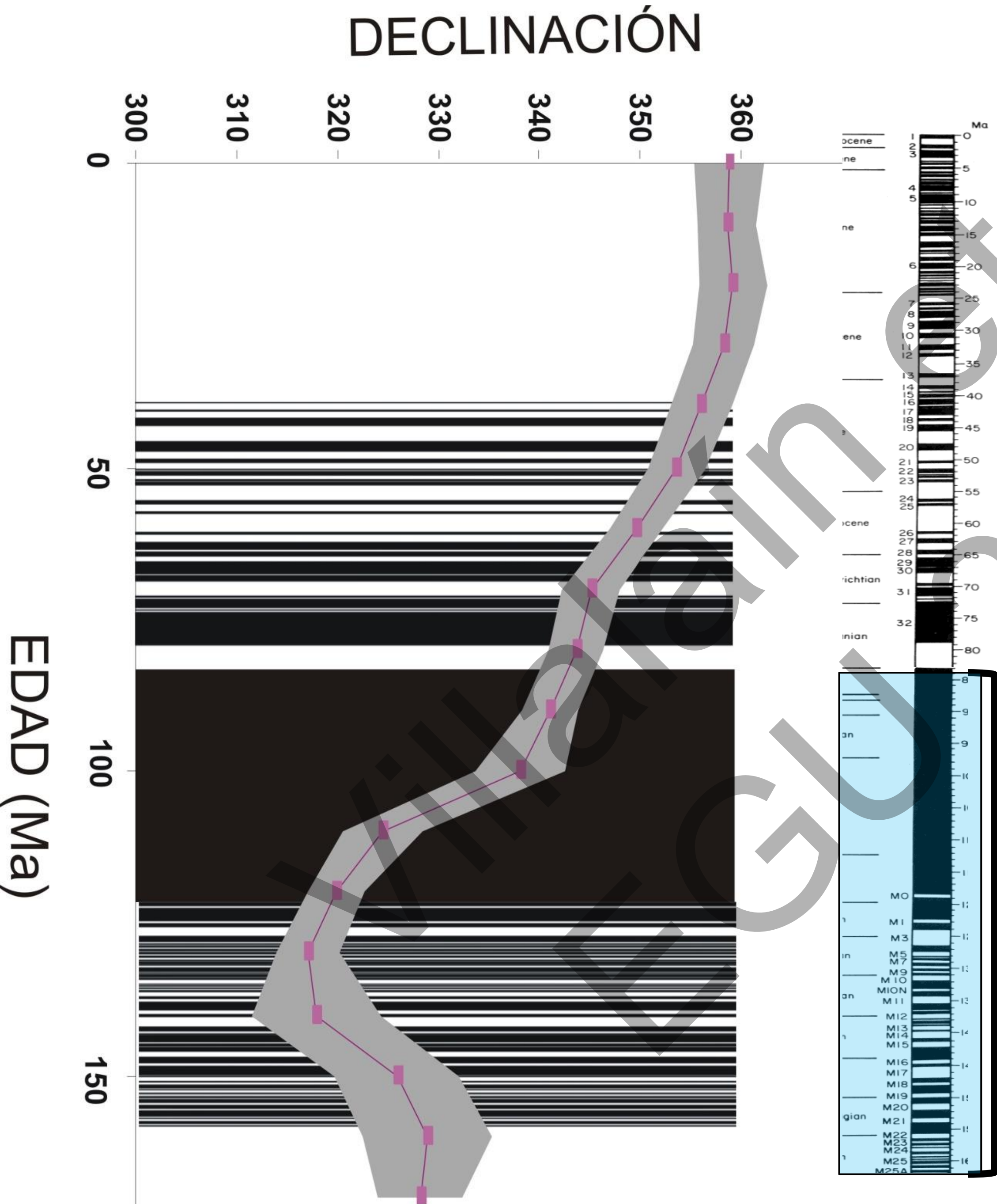
Two population of **N** and **R** SSD magnetite grains





We propose the hypothesis that the ca. 100 Ma paleomagnetic direction shows by the remagnetization is just the average of magnetic moments of the entire SSD magnetite population that grow from the Middle Jurassic up to the Cenozoic. Grains block the magnetic moments when they grow above their critical volume, keeping the magnetic polarity generating over time a distribution of grains in normal and reverse polarity groups.

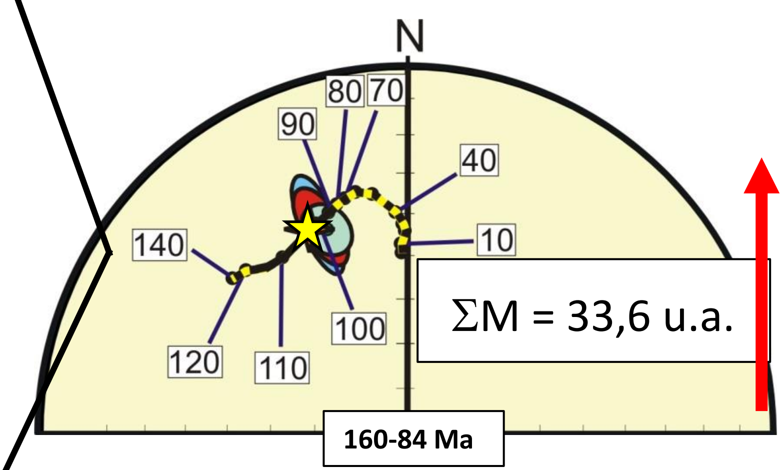


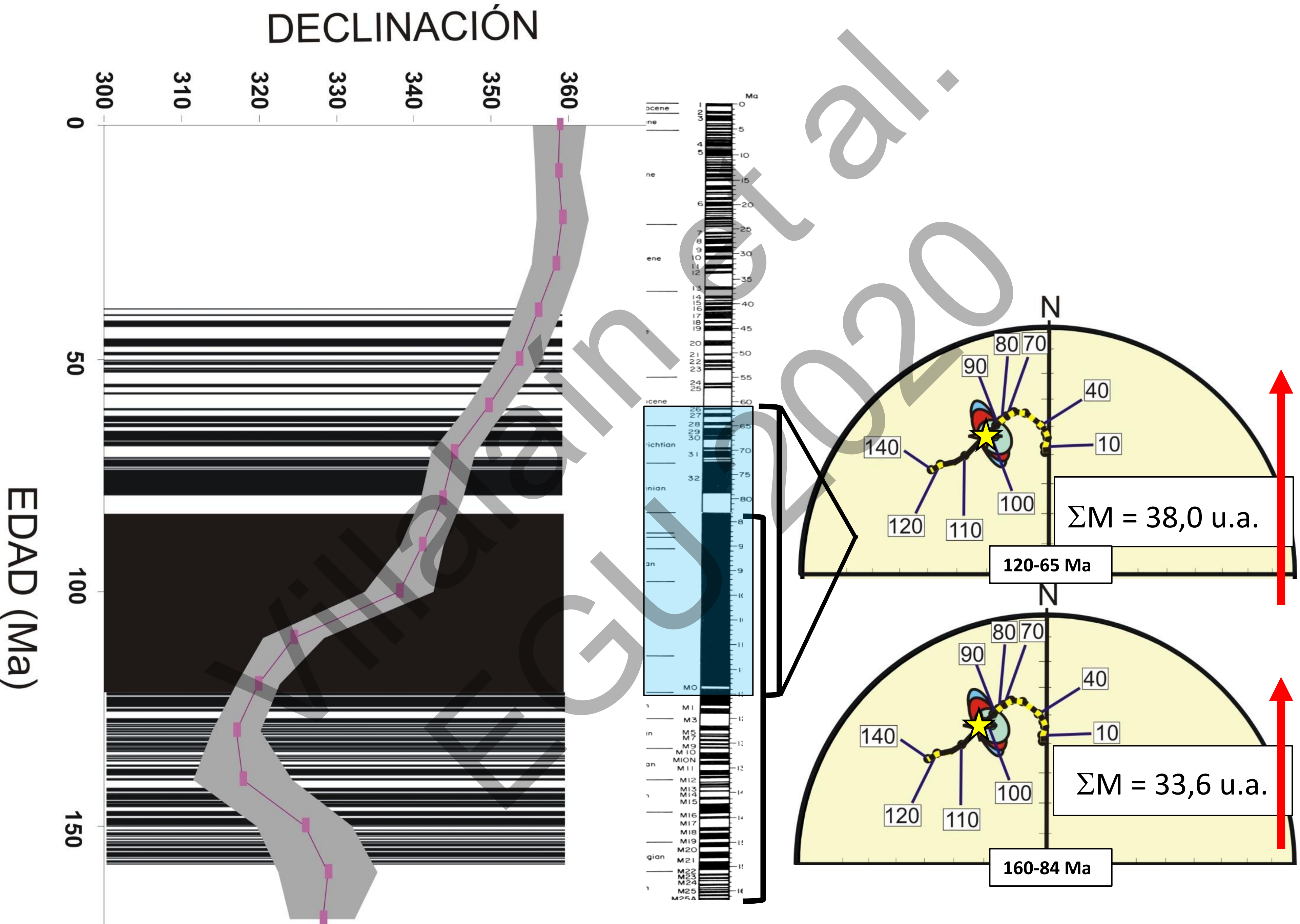


SIMULATION model for calculating remagnetization direction as sum of magnetic moments of grains with different directions and polarities.

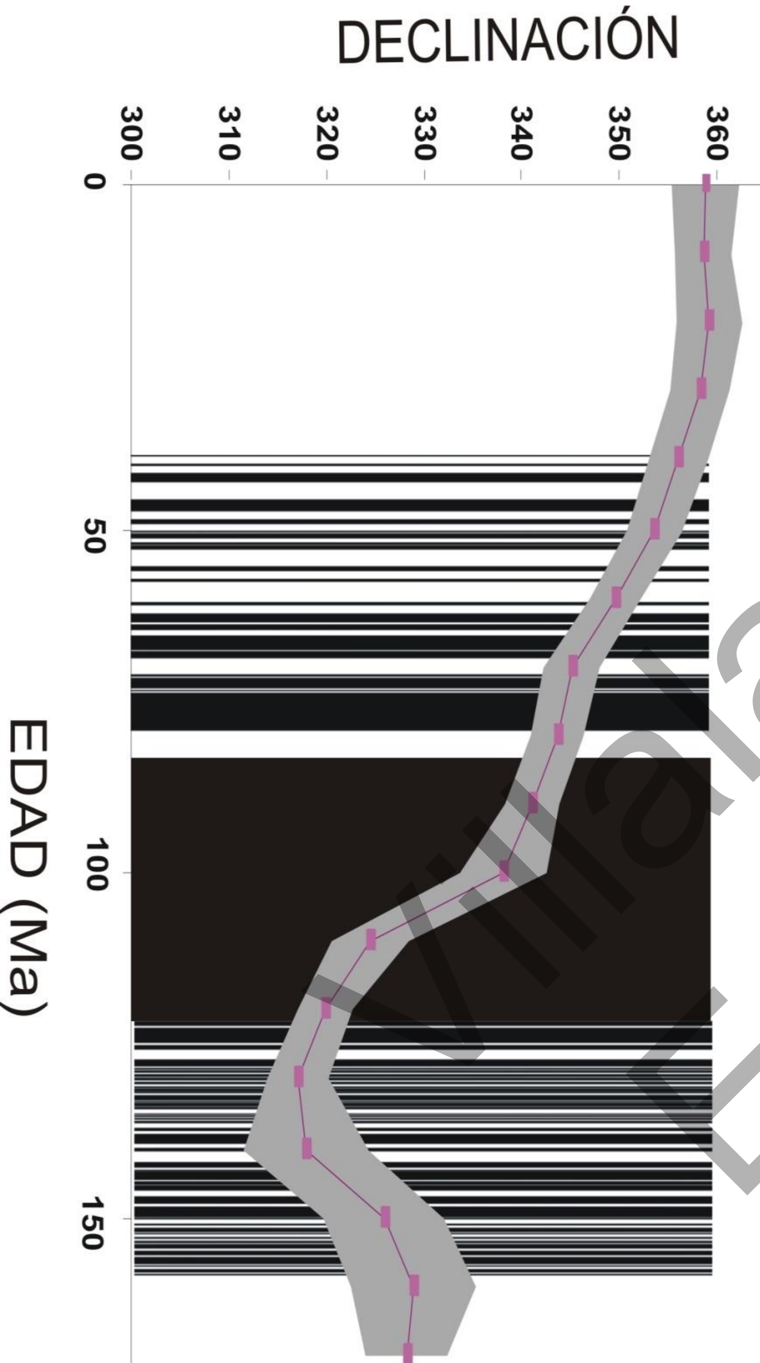
$$\vec{M} = \sum \vec{m_i} = \sum (k\Delta t_i)\vec{u_i}$$

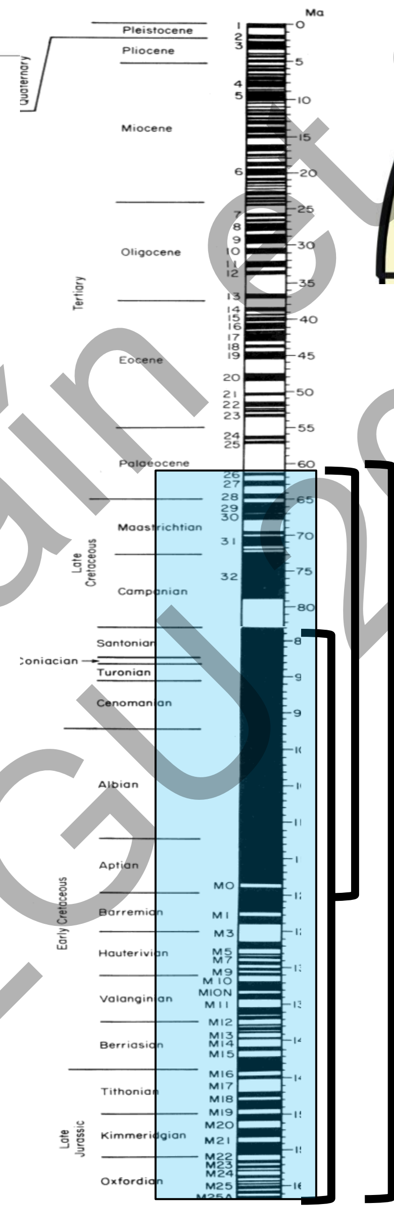
For each time interval Δt_i the corresponding magnetic moment is calculated with polarity from GPTS (Gradstein et al., 2004) and direction from the GAPWP (Torsvik et al., 2012).

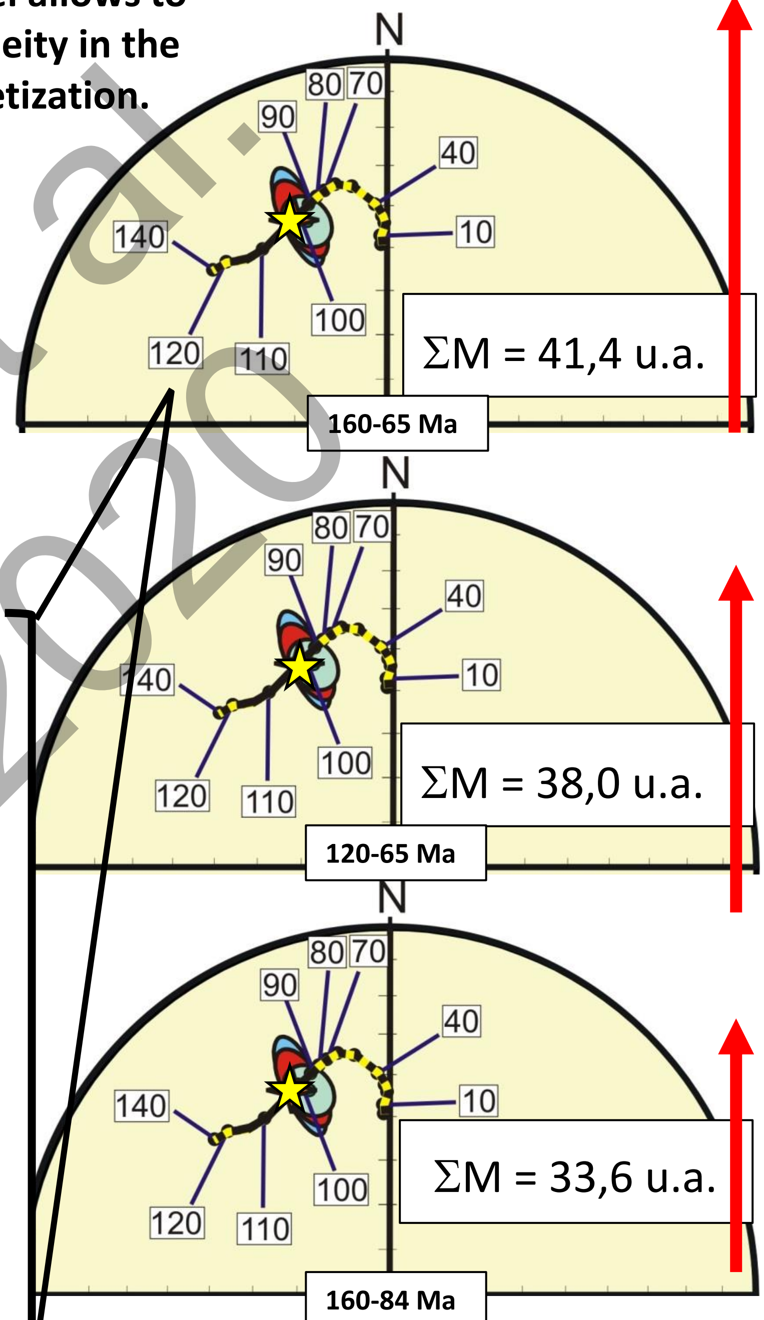



DECLINACIÓN
300
310
320
330
340
350
360
0
50
100
150
EDAD (Ma)
N
80
70
90
40
140
10
100
120
110
ΣM = 38,0 u.a.
120-65 Ma
ΣM = 33,6 u.a.
160-84 Ma

The Progressive model allows to explain the homogeneity in the directions of remagnetization.







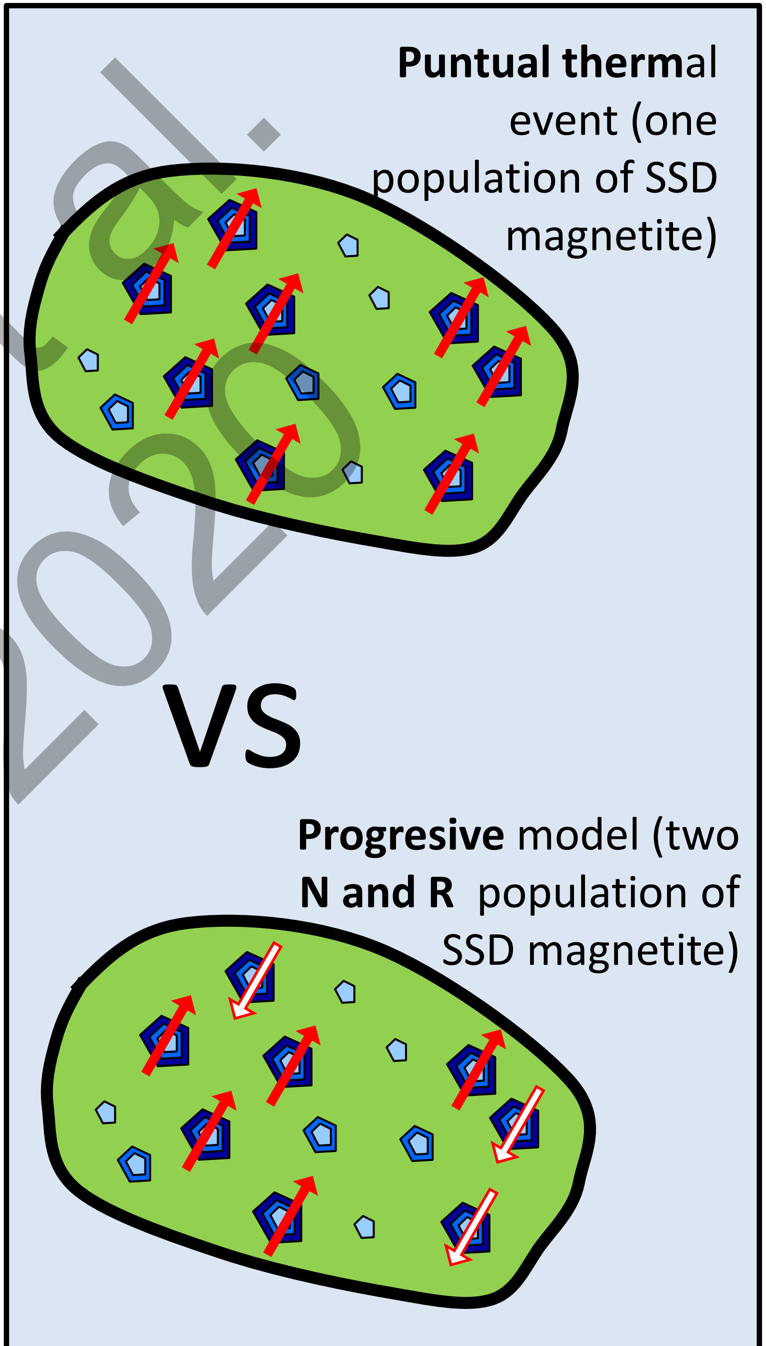
EXPERIMENT to test the presence of SSD magnetite grains with opposed magnetic moments.

OBJETIVE: Quantify the effectiveness of the SSD magnetite grains contributing to the NRM

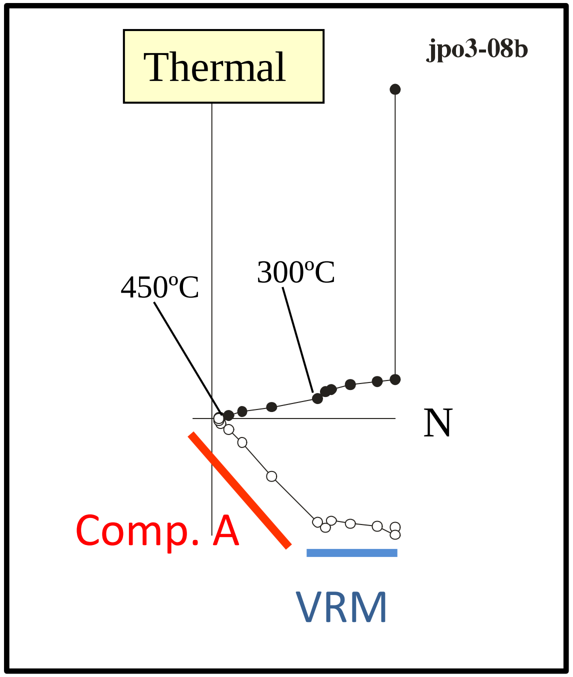
METHOD

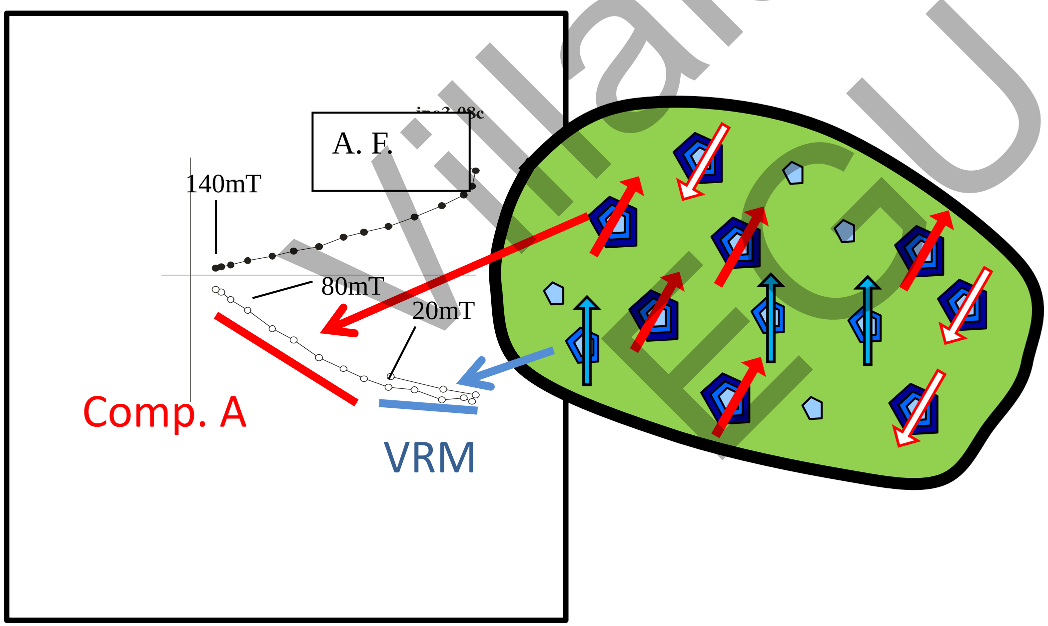
Sequence:

- AF demagnetization of NRM
- ARM acquisition
- AF demagnetization of ARM
- ARM acquisition in progressive DC field

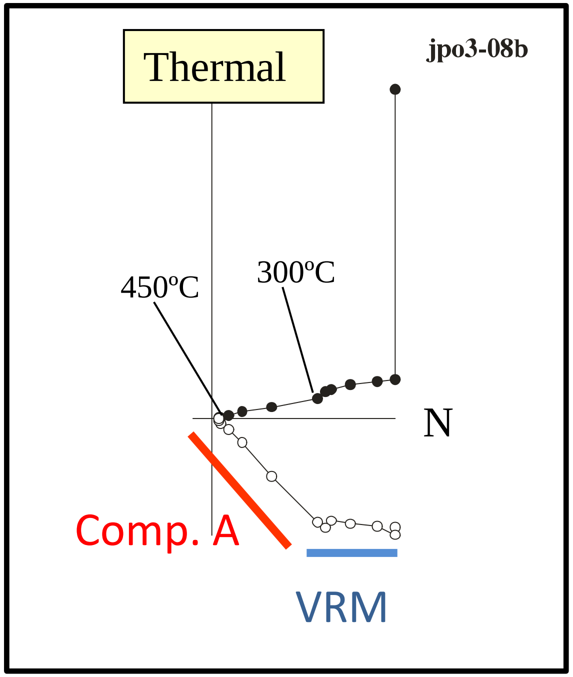


Sequence: AF-ARM-AF





Sequence: AF-ARM-AF



Two components:

A: Cretaceous Remagnetization

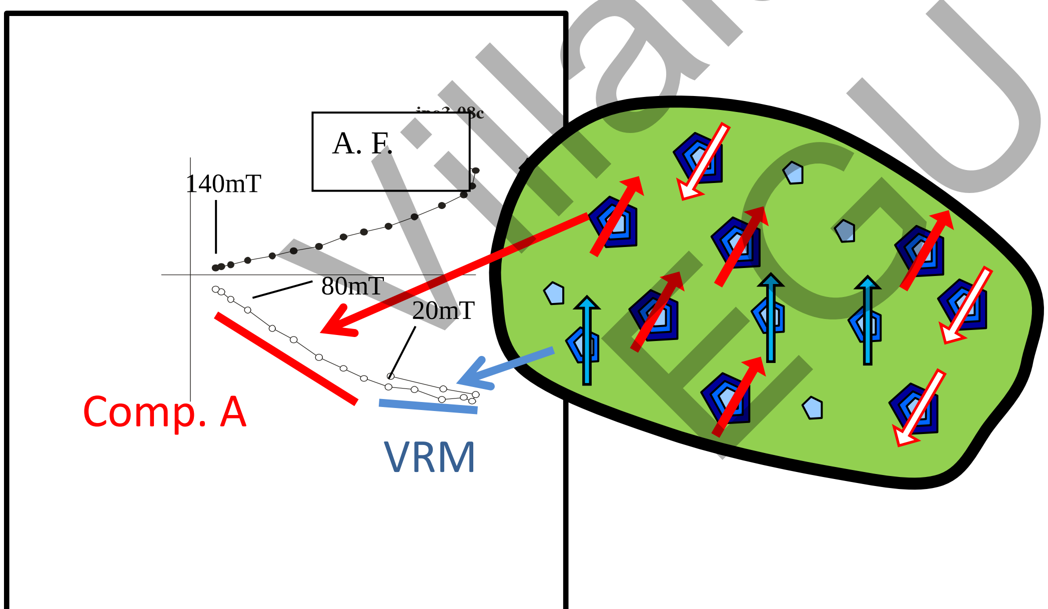
VRM: Viscous Normal Brunes component

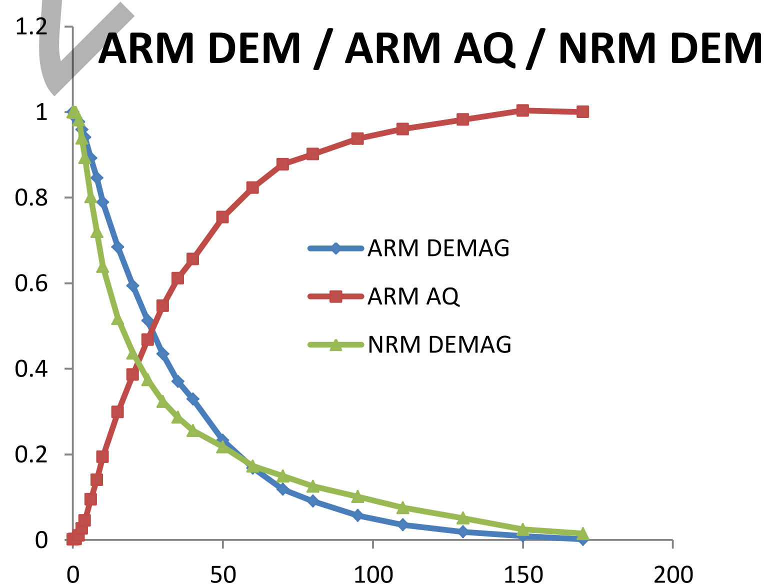
Test the effectiveness:

NRM VS ARM

0-20 mT fraction (paralels)

20-80 mT fraction (antiparaleles??)



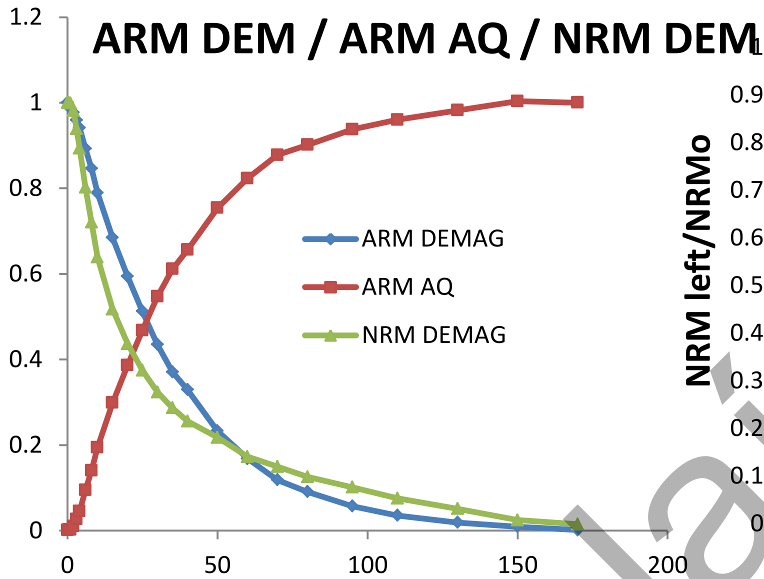


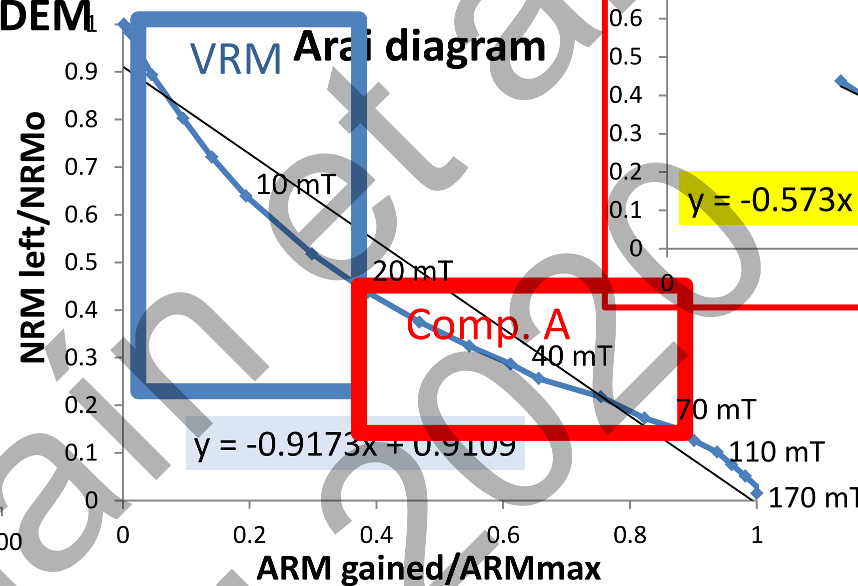
Sequence: AF-ARM-AF

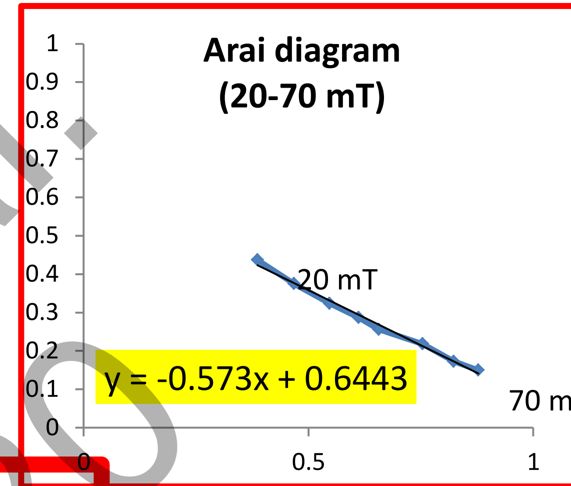
comparing the NRM -ARM signal through the pseudo-Thellier approach

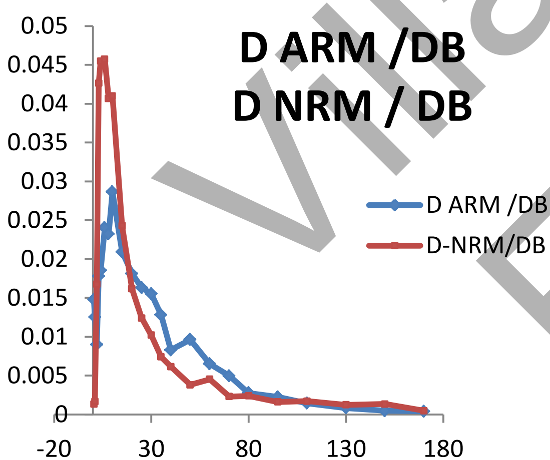
Type 1

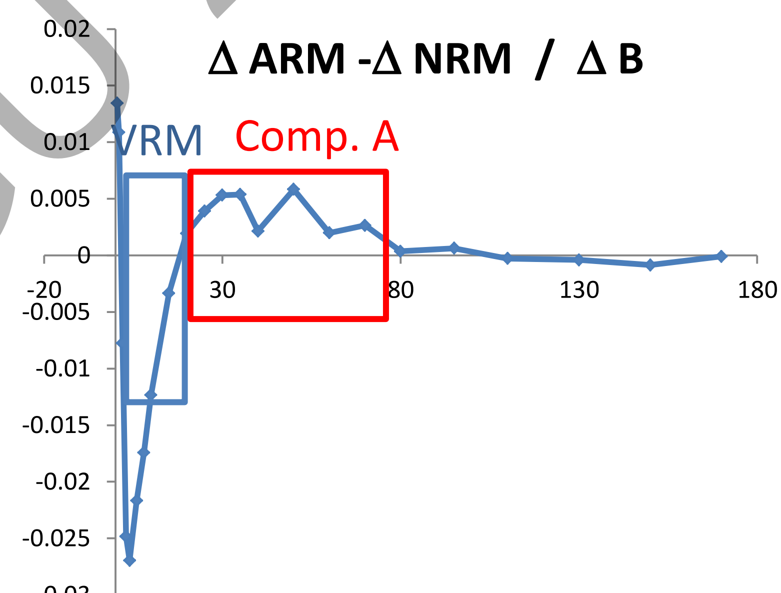
DT38-5B





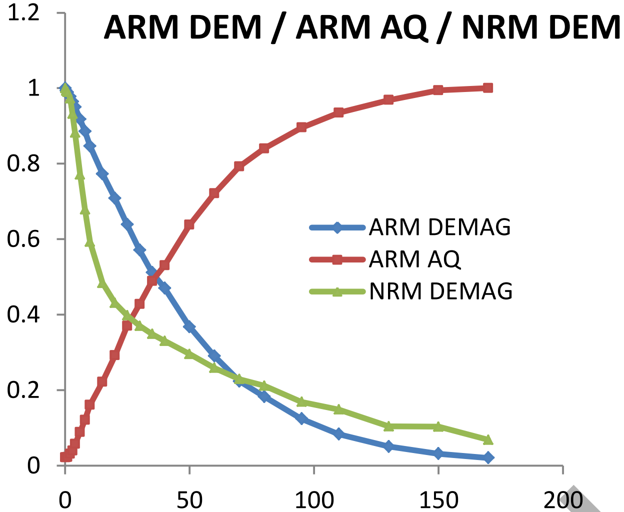


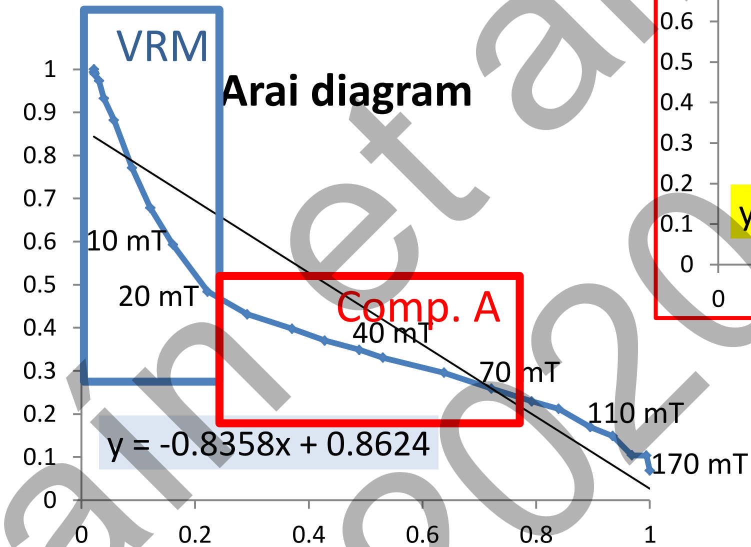


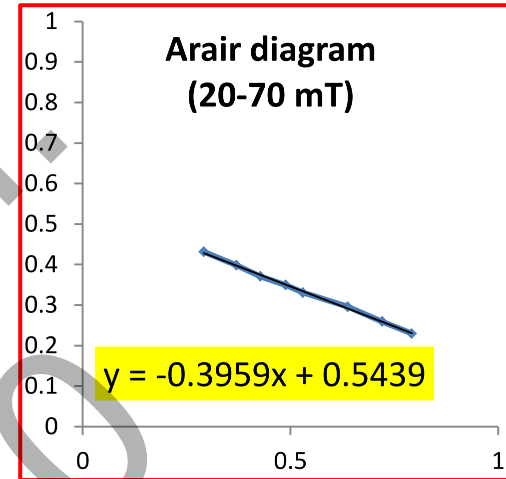


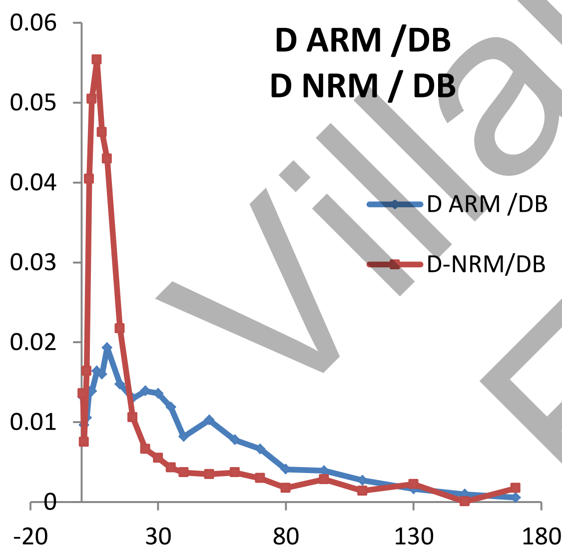
Sequence: AF-ARM-AF

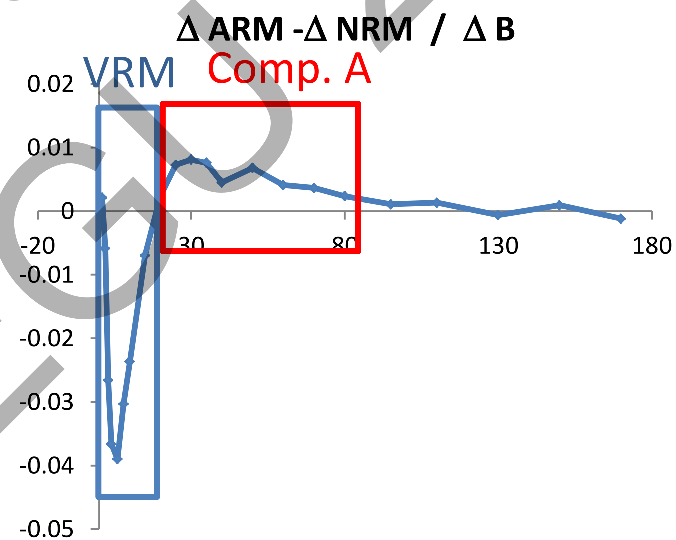
Type 1







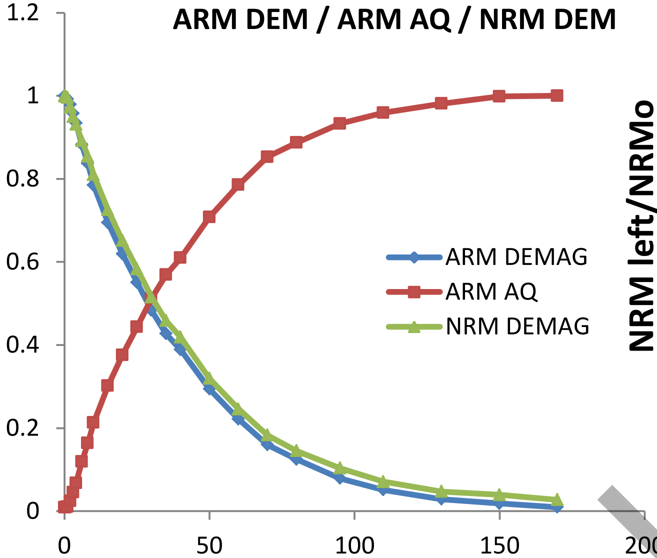


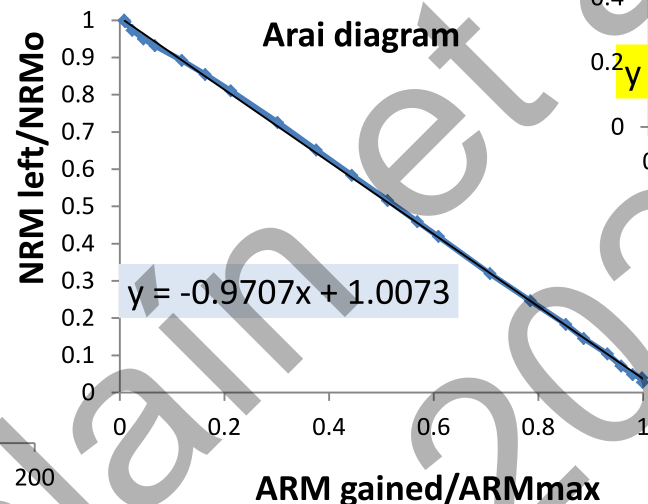


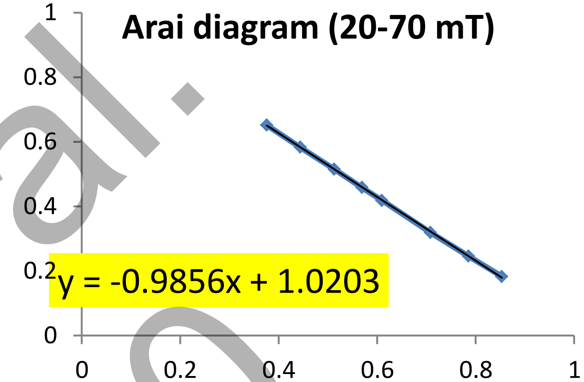
Sequence: AF-ARM-AF

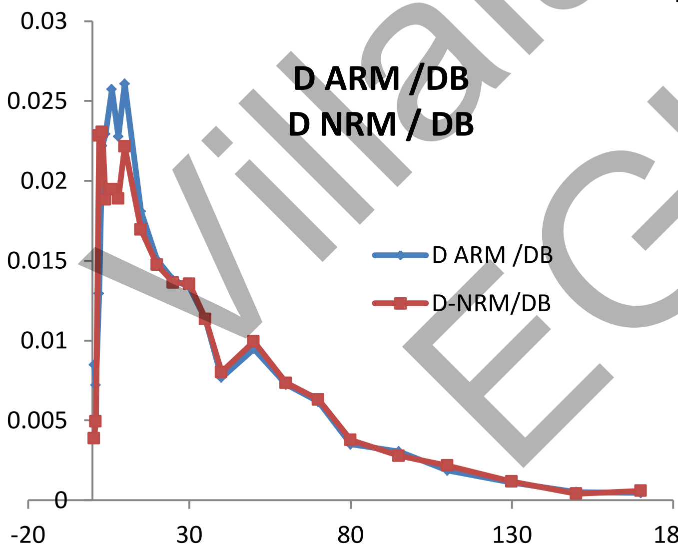
Tipo 2

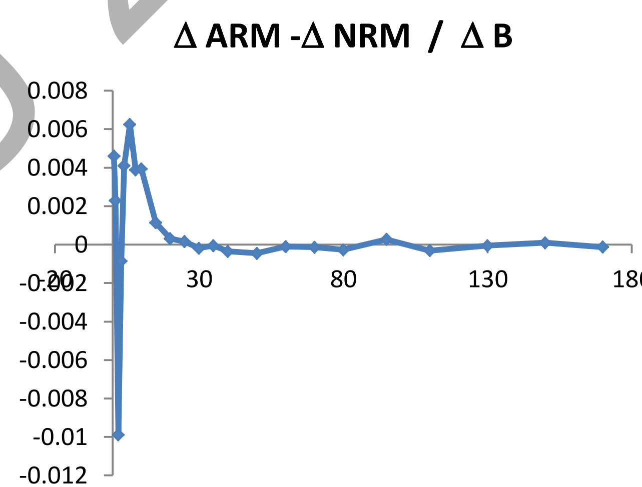
DT33-1B





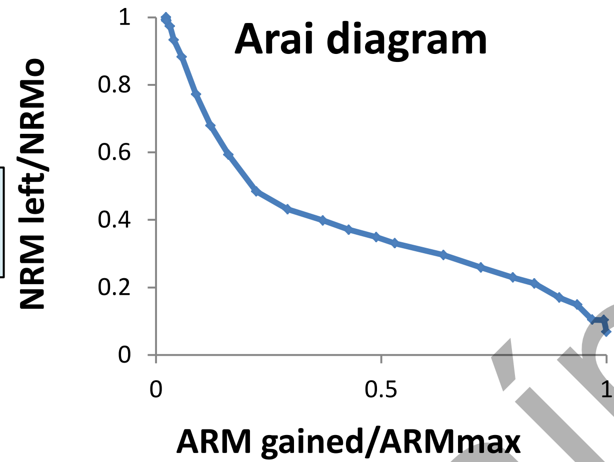




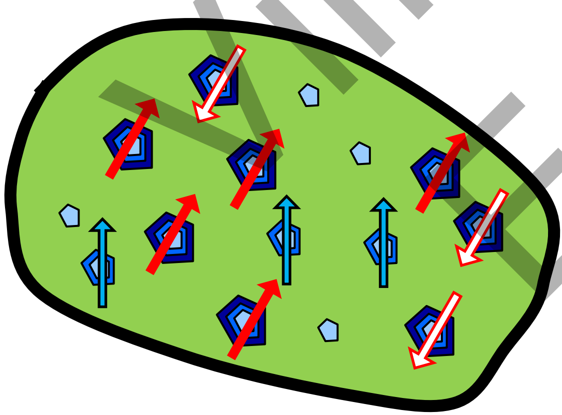


Sequence: AF-ARM-AF

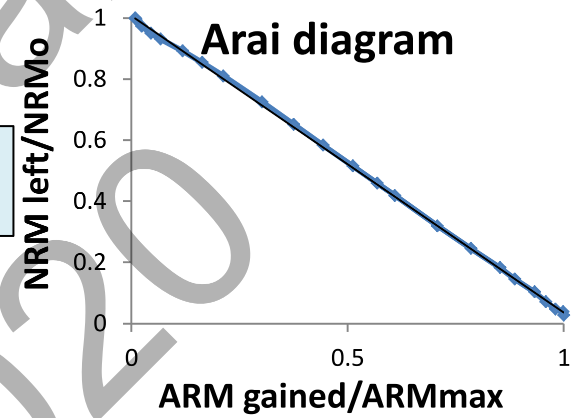
Type 1



Consistent with progressive model
(several polarities)



Type 2



Consistent with Punctual thermal event model
(one polarity)