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

- Thick lower Jurassic syn-rift sediments in Atlas ranges.
North Iberian cretaceous remagnetizations

ChRM
Systematic Normal polarity

W. Cameros Basin
E. Cameros Basin
Iberian Ranges
Juarez, 1994

Iberian Range
Palencia, 2006

Organyà Basin
(Gong et al., 2008)

Aralar

etc...
Timing of Iberian remagnetizations

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

CRETACEOUS REMAGNETIZATION

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High Atlas cretaceous remagnetization

ChRM
Systematic Normal polarity

Fig. 5b: Reversal time-scale for the past 1.7Ma following Cox (1997).
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.

\[ A = \sum |\alpha_n| \implies A_{\text{min}} \]

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

SC must intersect at the Remagnetization direction

SCI RE MAGNETIZATION DIRECTION

Contours of A values
Systematic paleomagnetic studies in the Moroccan High Atlas

Aparent Polar Wander Path of Africa (APWP)

50º of cretaceous rotation

Expected directions in The High Atlas

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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 interfoling remagnetizations a high resolution sampling has been made.

- 10,000 Km²
- 20 profiles
- 600 paleomagnetic sites (calculating 600 paleobeddings)
Direction of remagnetization from Small Circle Intersection Method over 526 sites

Very high accuracy

Dec = 336.0° Inc = 43.7°

$\eta_{95} = 1.8°$ $\zeta_{95} = 1.0°$
Expected paleomagnetic directions at the High Atlas:

Before BC | After total BC
Dec = 336.0° Inc = 43.7°

η_{95} = 1.8 ° ζ_{95} = 1.0 °

DATING THE REMAGNETIZATION

All 526 sites
Before BC
After partial BC
After total BC

SCI-SOLUTION

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Homogeneous direction (and age) in different areas

PALEOMAGNETIC DIRECTION AND LOCATION

Sector east
77 sites

Central sector
257 sites

Sector west
118 sites

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PALEOMAGNETIC DIRECTION AND STRATIGRAPHIC UNIT

Bathonian and lower Cretaceous - 51 sites

Middle Jurassic
- 166 sites

Toarcian-Aalenian
- 89 sites

Lower Jurassic
- 89 sites

Homogeneous direction (and age)
in different units of limestone

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PALEOMAGNETIC DIRECTION AND LITHOLOGIES

Red beds
51 sites

Carbonates
401 sites

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The mechanism proposed for this type of 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.
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.

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

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

\[\Sigma M = 33,6\text{ u.a.}\]
The Progressive model allows to explain the homogeneity in the directions of remagnetization.

160-84 Ma

$\Sigma M = 33.6$ u.a.

120-65 Ma

$\Sigma M = 41.4$ u.a.

160-65 Ma

$\Sigma M = 38.0$ u.a.

160-84 Ma

$\Sigma M = 33.6$ u.a.
**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

**EXPERIMENT to test the presence of SSD magnetite grains with opposed magnetic moments.**
Sequence: AF-ARM-AF

Thermal

450°C  300°C

N

Comp. A

VRM

A. F.

20mT

80mT

140mT

Comp. A

VRM

A. F.

40mT

80mT

20mT

140mT
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??)

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Comparing the NRM-ARM signal through the pseudo-Thellier approach.

**Type 1**

**DT38-5B**

**Arai diagram** (20-70 mT)

\[
y = -0.573x + 0.6443
\]

Comp. A

\[
y = -0.9173x + 0.9109
\]
Sequence: AF-ARM-AF

**Type 1**

**ARM DEM / ARM AQ / NRM DEM**

- ARM DEMAG
- ARM AQ
- NRM DEMAG

**Arai diagram (20-70 mT)**

- $y = -0.3959x + 0.5439$

**D ARM /DB**

- D ARM /DB
- D NRM / DB

**Δ ARM - Δ NRM / Δ B**

- Comp. A

**VRM**

- $y = -0.8358x + 0.8624$

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Sequence: AF-ARM-AF

Type 1

Consistent with progressive model (several polarities)

Type 2

Consistent with Punctual thermal event model (one polarity)