

Paleomagnetic studies of rotational deformations in western Greece at large and small geographic scale.



Why paleomagnetism in the study of the edification of orogens?

Carlo Laj

Ecole Normale Supérieure, PSL Research University, Département de Géosciences, Paris, France.

Large-scale rotations in the Aegean area

Catherine Kissel

Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS-UVSQ, Gif-sur-Yvette, France

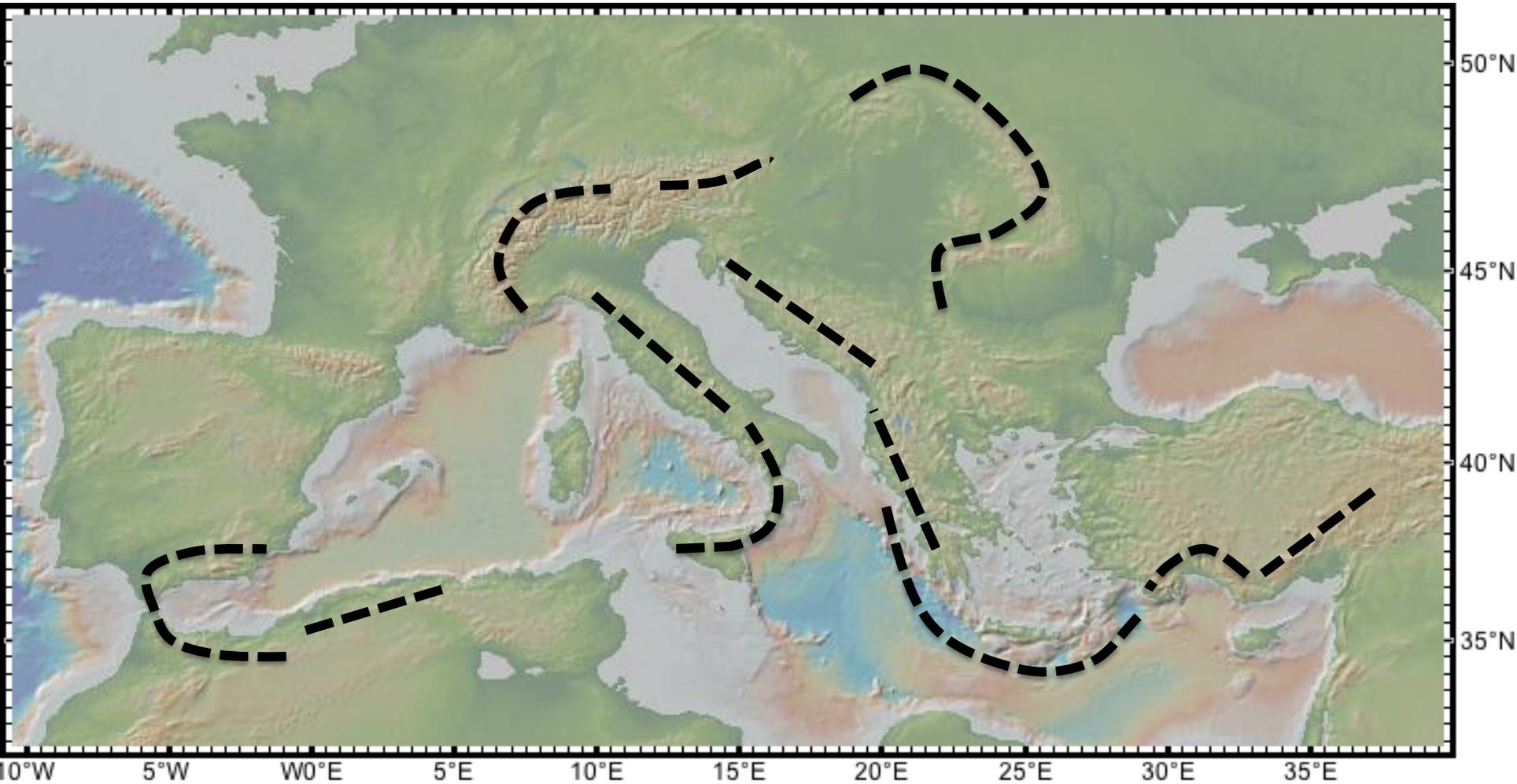
Small-scale rotations around the Gulf of Corinth

Massimo Mattei

Dipartimento di Scienze, Universita Roma Tre, Roma, Italy

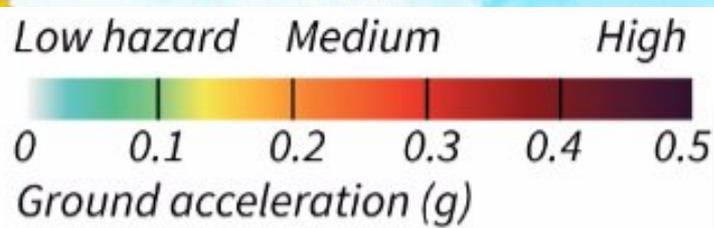
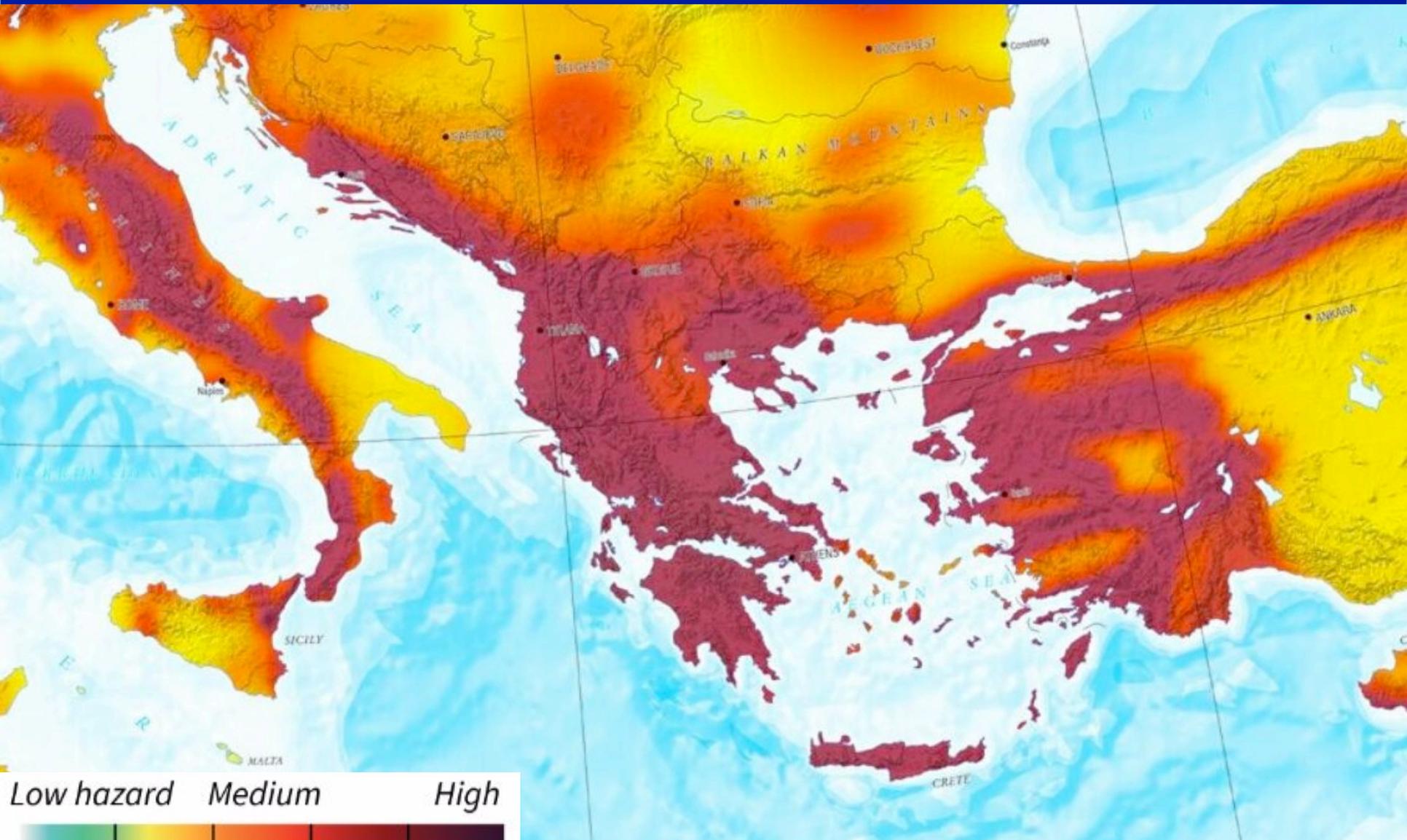


Alpine chain around the Mediterranean



How and when were these orogens formed?

Very recent and very active tectonic

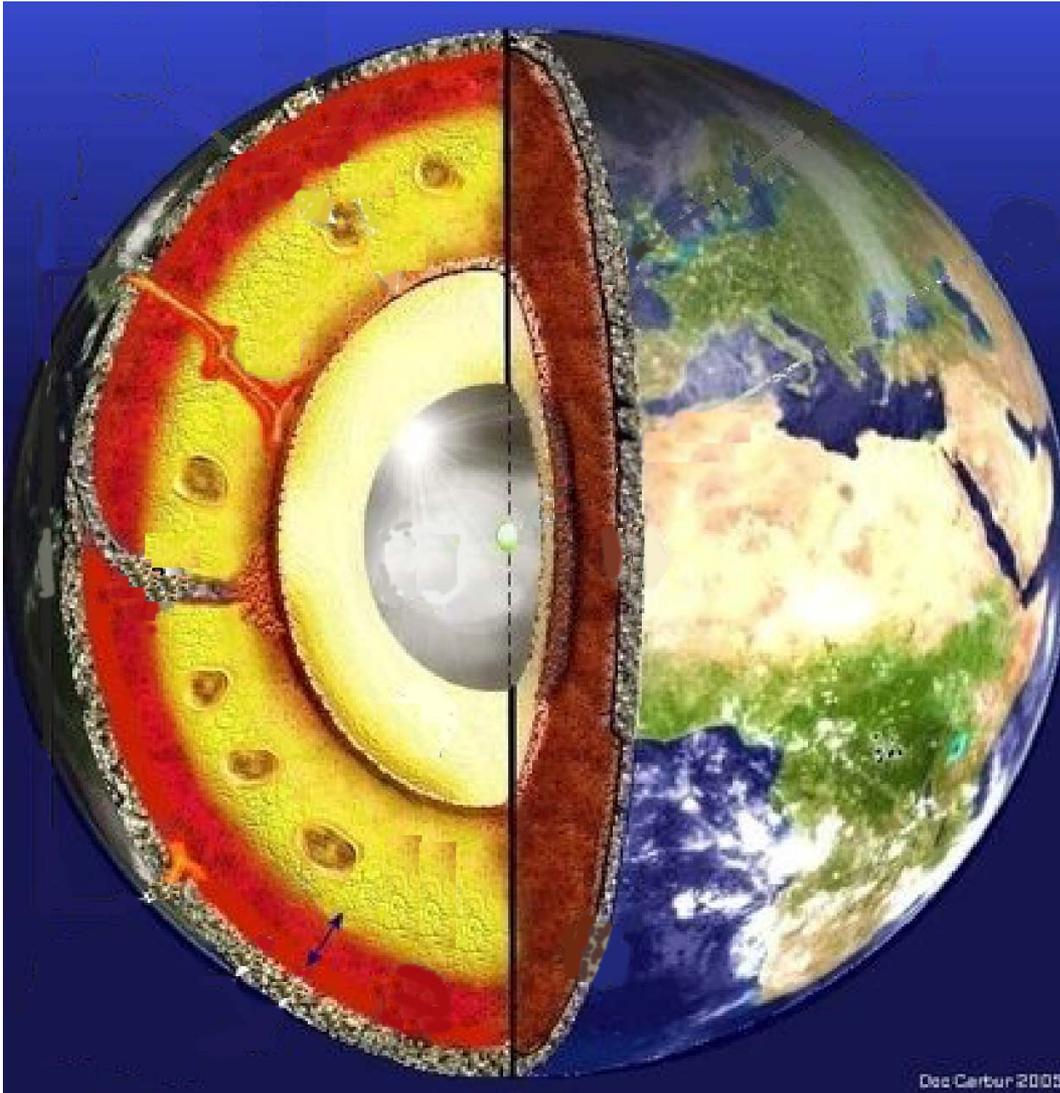


What is the role of rotations around vertical axis in the construction of orogens?

Unique tool = Paleomagnetism

WHY?

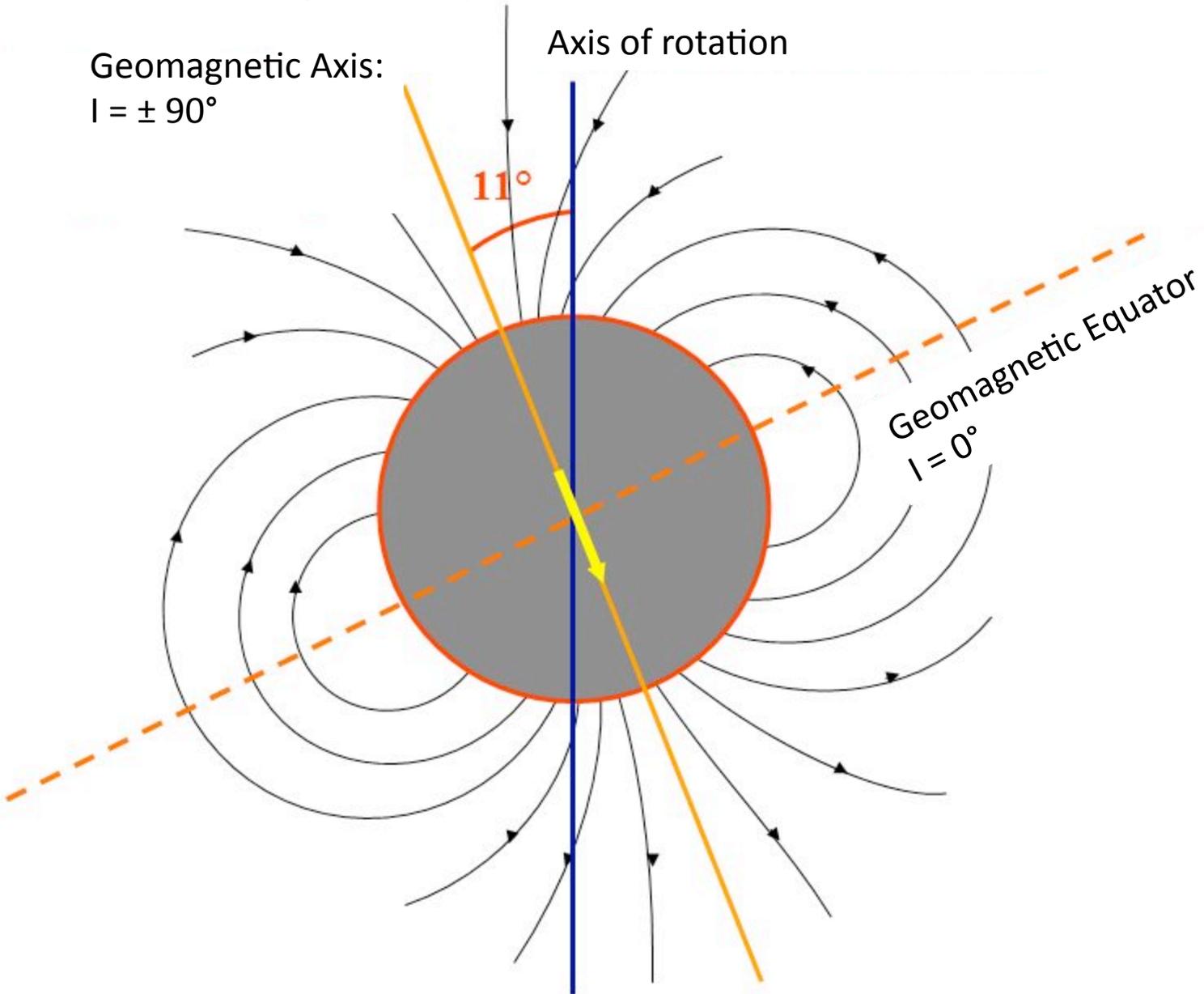
Paleomagnetism – origin of the Earth magnetic field



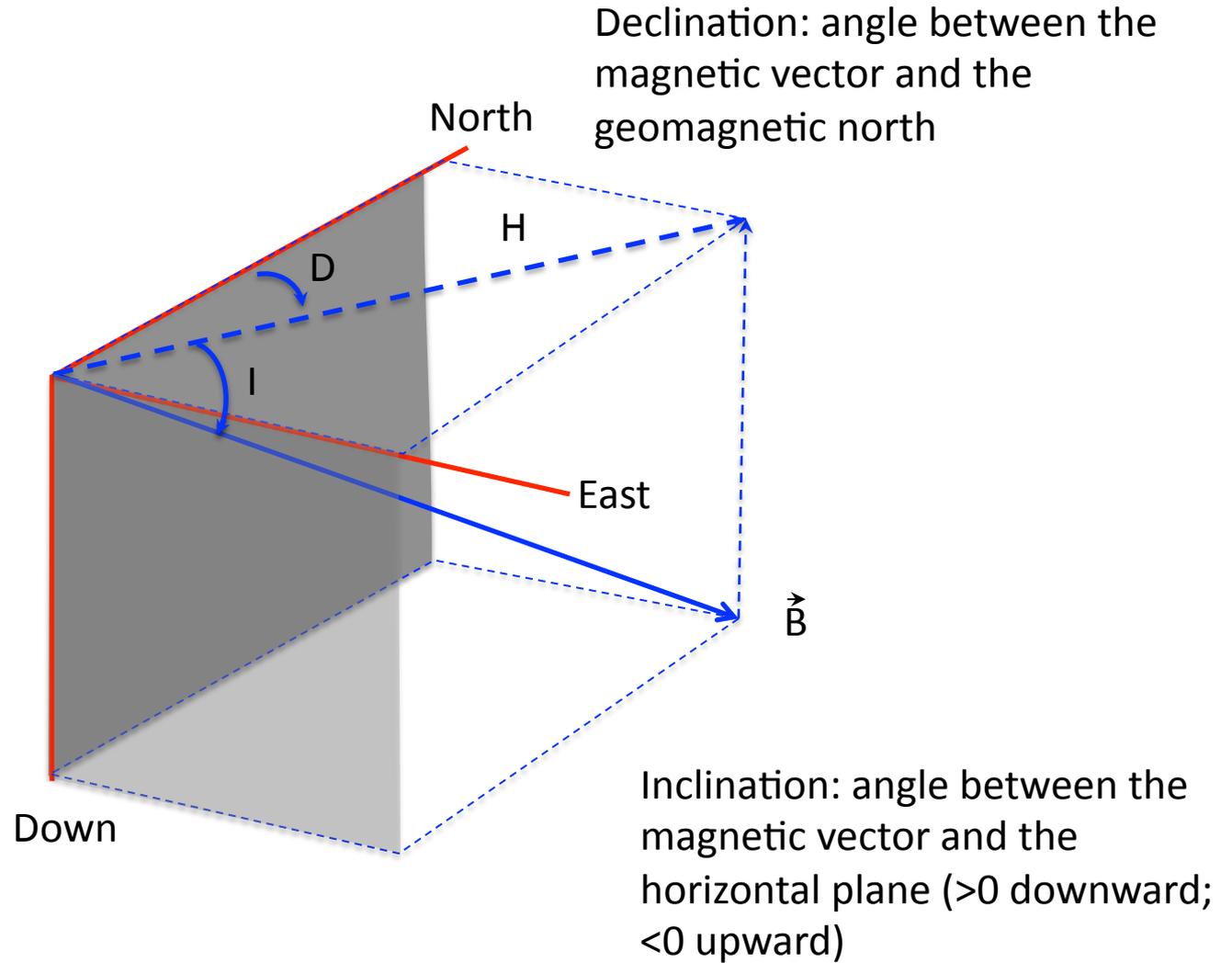
Generated in the center
of the earth

Very simplified
expression at the
surface

Earth magnetic field: present dipole
+ non dipolar components

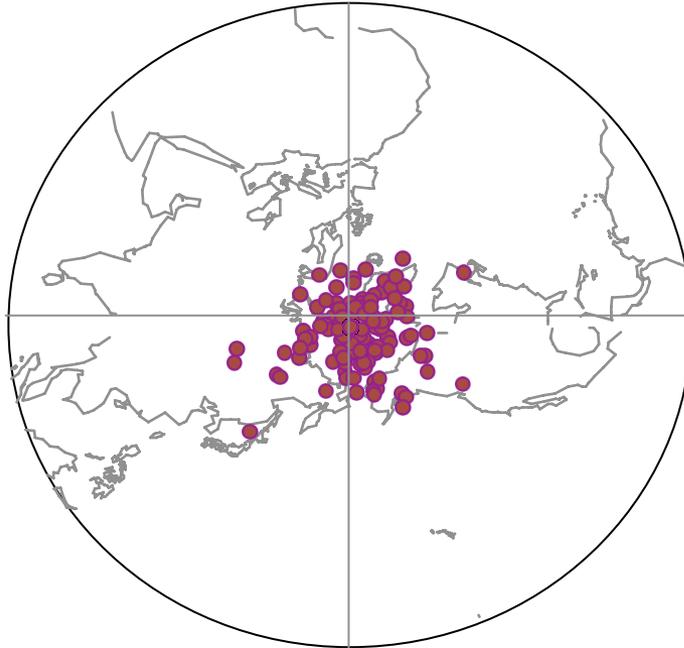


Paleomagnetism:
Decomposition of the vector



Paleomagnetism:

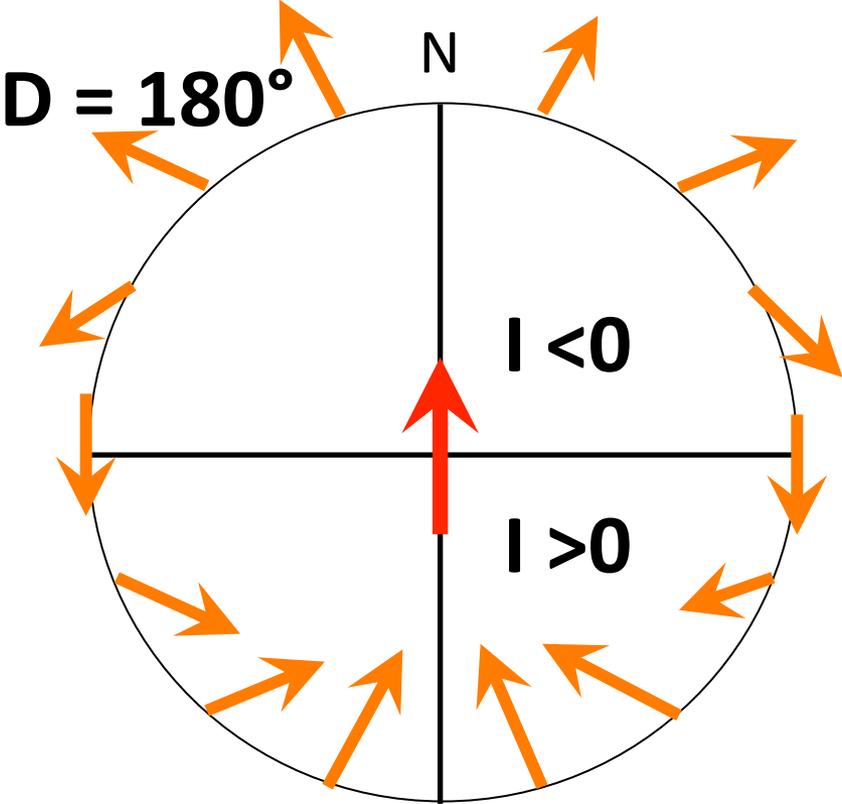
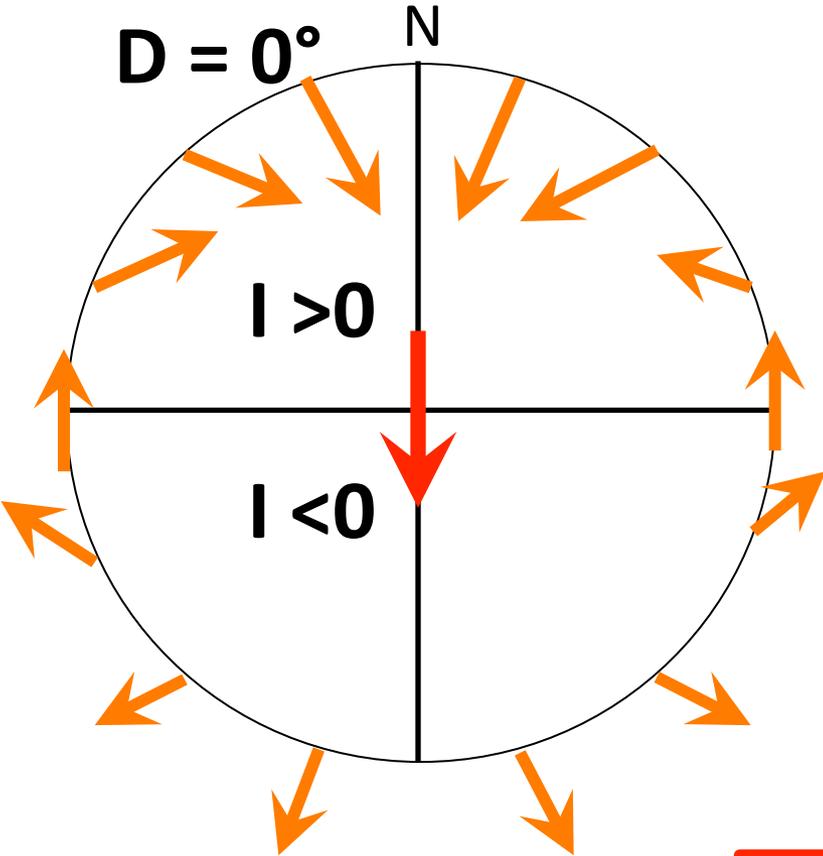
On the long term: geomagnetic axis = rotation axis



Earth magnetic field: Centered axial dipolar magnetic field

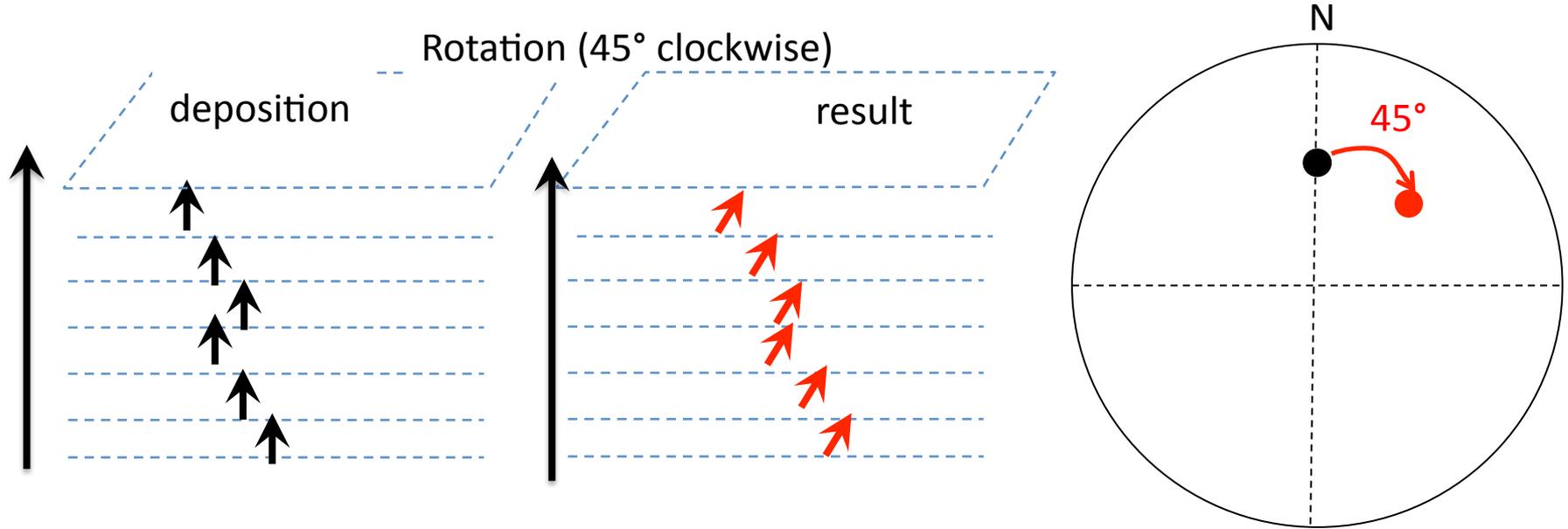
Period: **Normal polarity**

Reverse polarity



$\text{tgl} = 2\text{tg } \lambda$

The Earth magnetic field is fixed in the rock during emplacement (cooling or deposition)



How to be sure that the measured magnetization is that acquired during deposition or cooling?

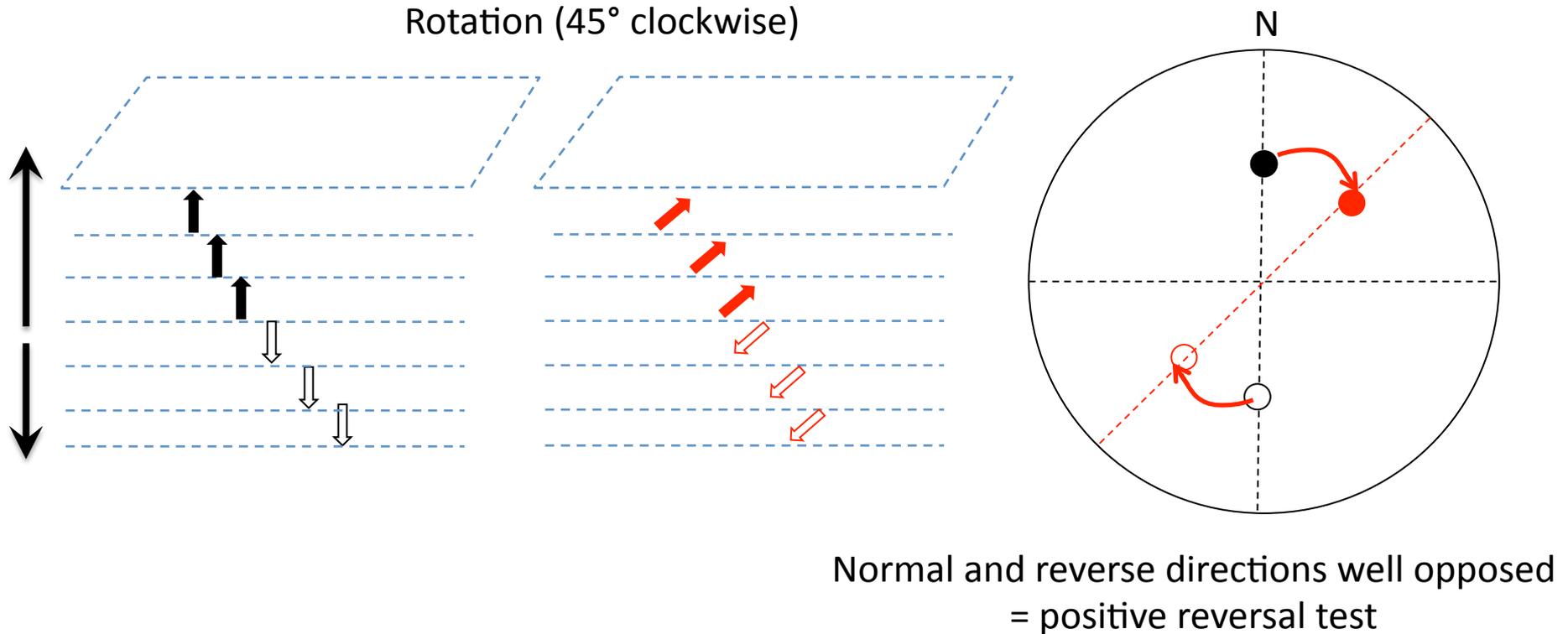
How to assign an age to the rotation?

=> Several « field tests »....

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How to be sure that the measured magnetization is that acquired during deposition or cooling?

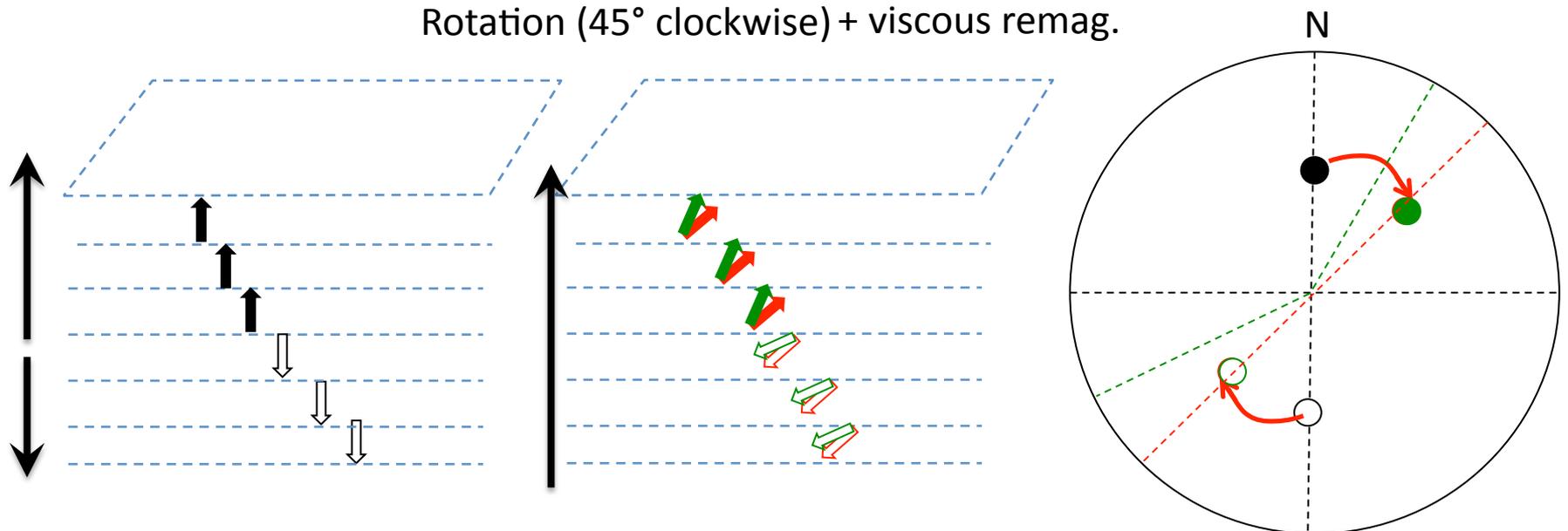
1) Reversal test



The Earth magnetic field is fixed in the rock during emplacement (cooling or deposition)

How to be sure that the measured magnetization is that acquired during deposition or cooling?

1) Reversal test



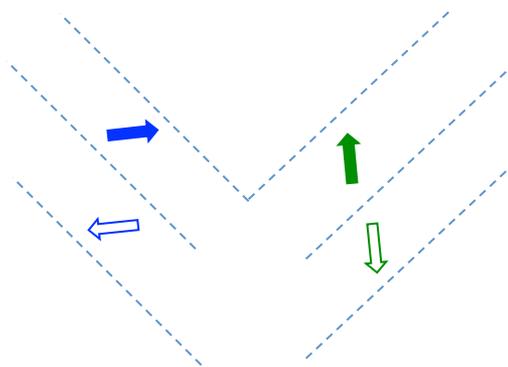
Normal and reverse directions well opposed
= positive reversal test
Normal and reverse directions non opposed
= remagnetization

The Earth magnetic field is fixed in the rock during emplacement (cooling or deposition)

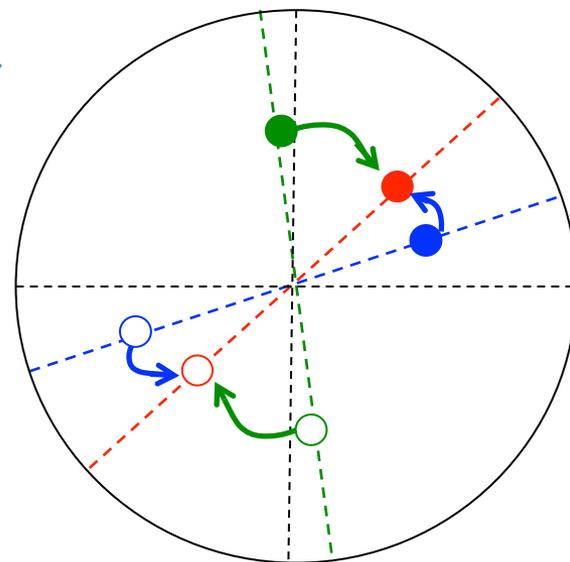
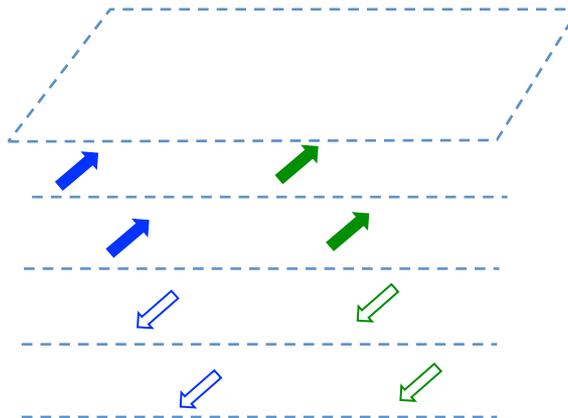
How to assign an age to the rotation?

1) Fold test

Folding



Unfolding



⇒ Better groupment after unfolding ⇒ magnetization pre-dates the folding

Requisite in the field = statistical aspect

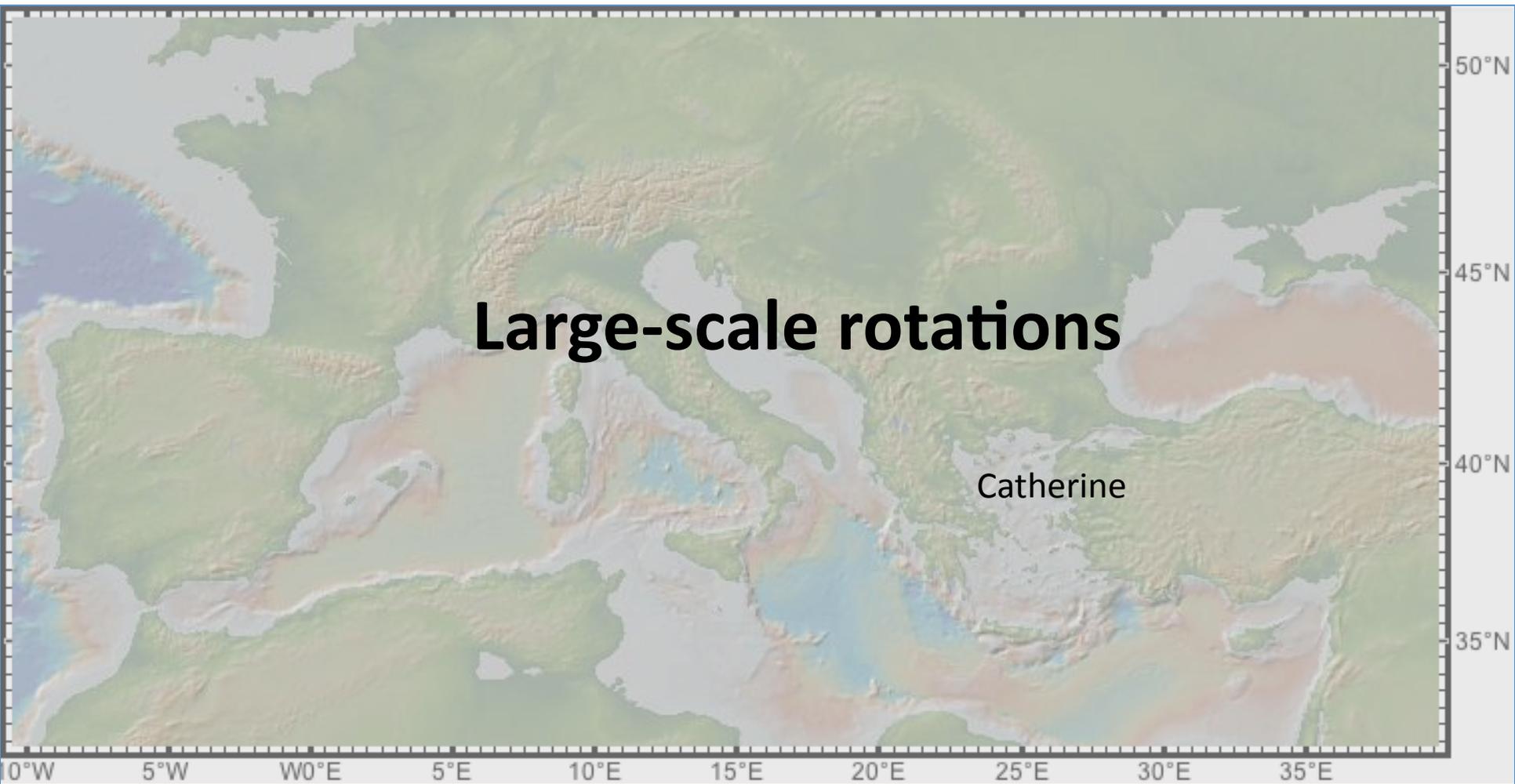
- 1) Outcrops with regional trend
- 2) Large distribution of cores in the site/outcrop (average short time constant of the earth magnetic field)
- 3) Large number of sites of the same age in the same structure

Requisites in the laboratory

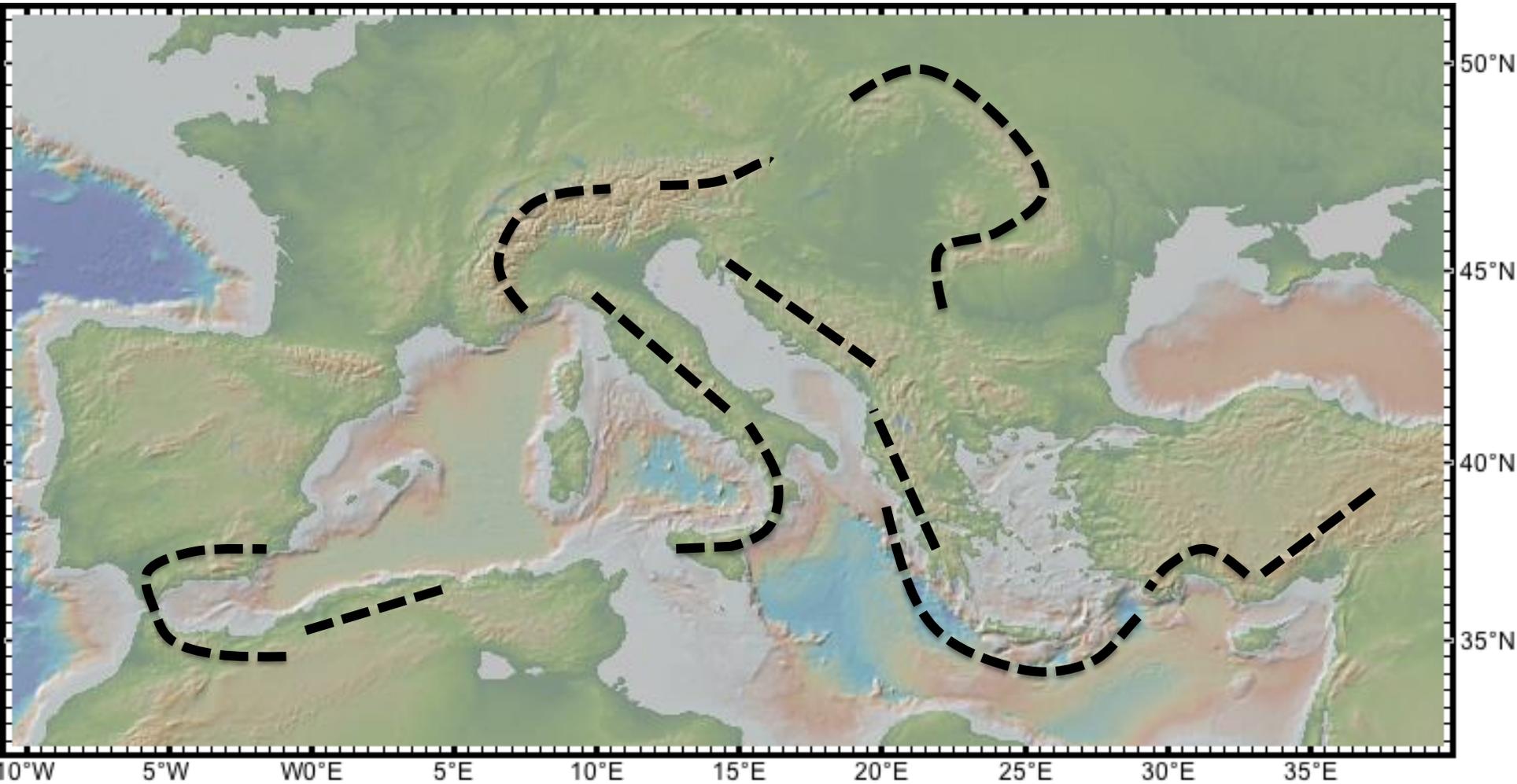
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Large-scale rotations

Catherine

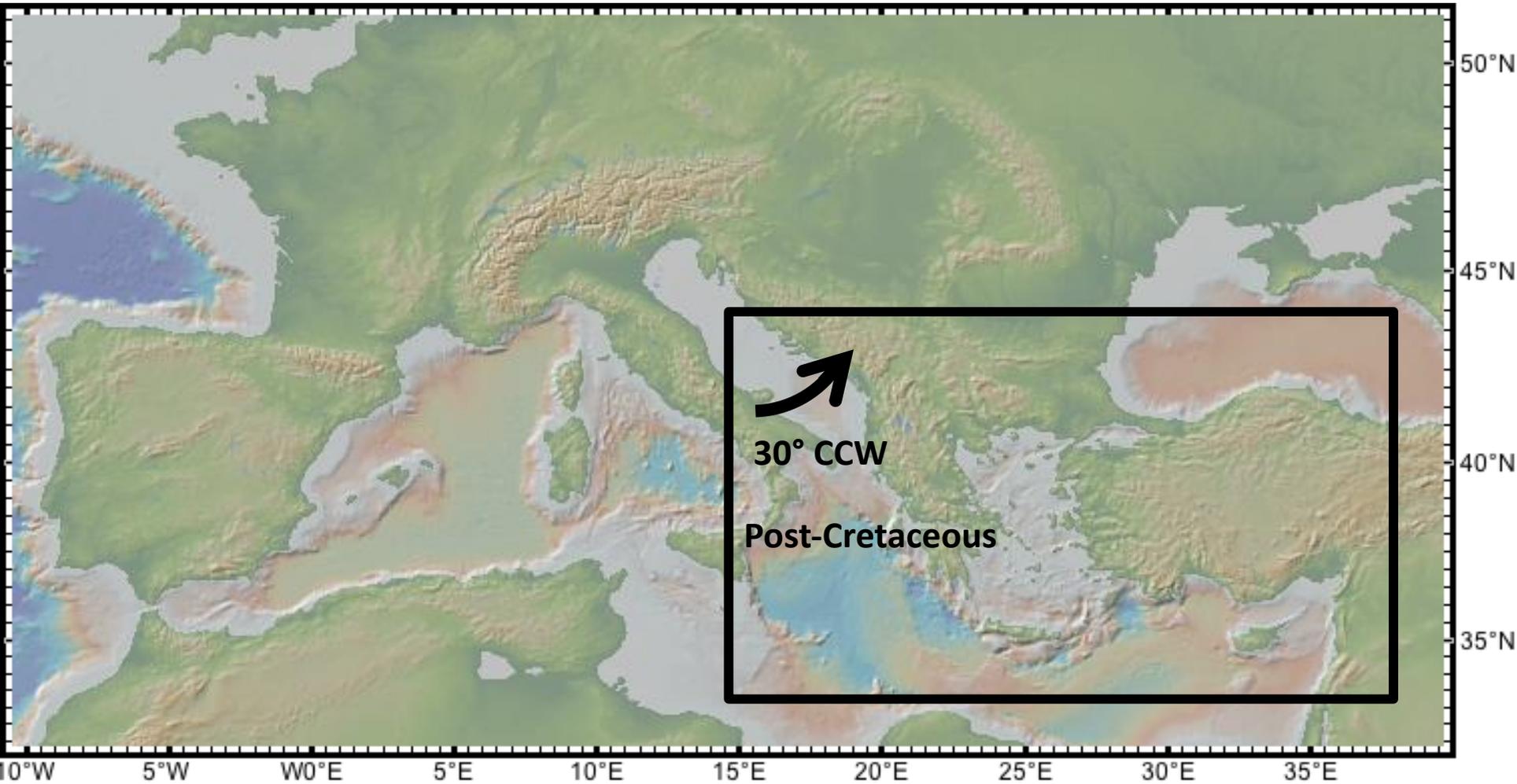


Role of rotations in the acquisition of the curvatures?



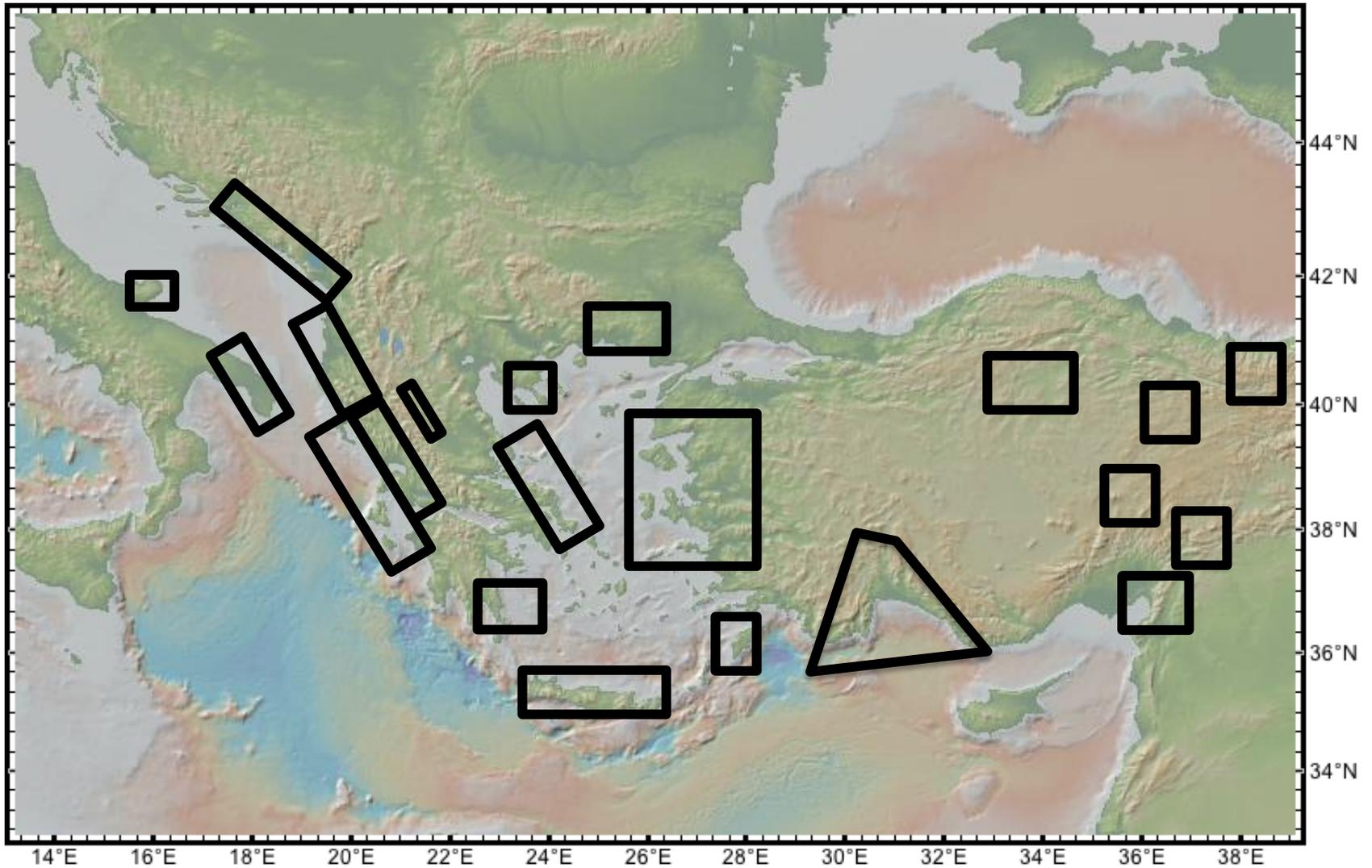
How and when were these orogens formed?

Role of rotations in the acquisition of the curvatures?



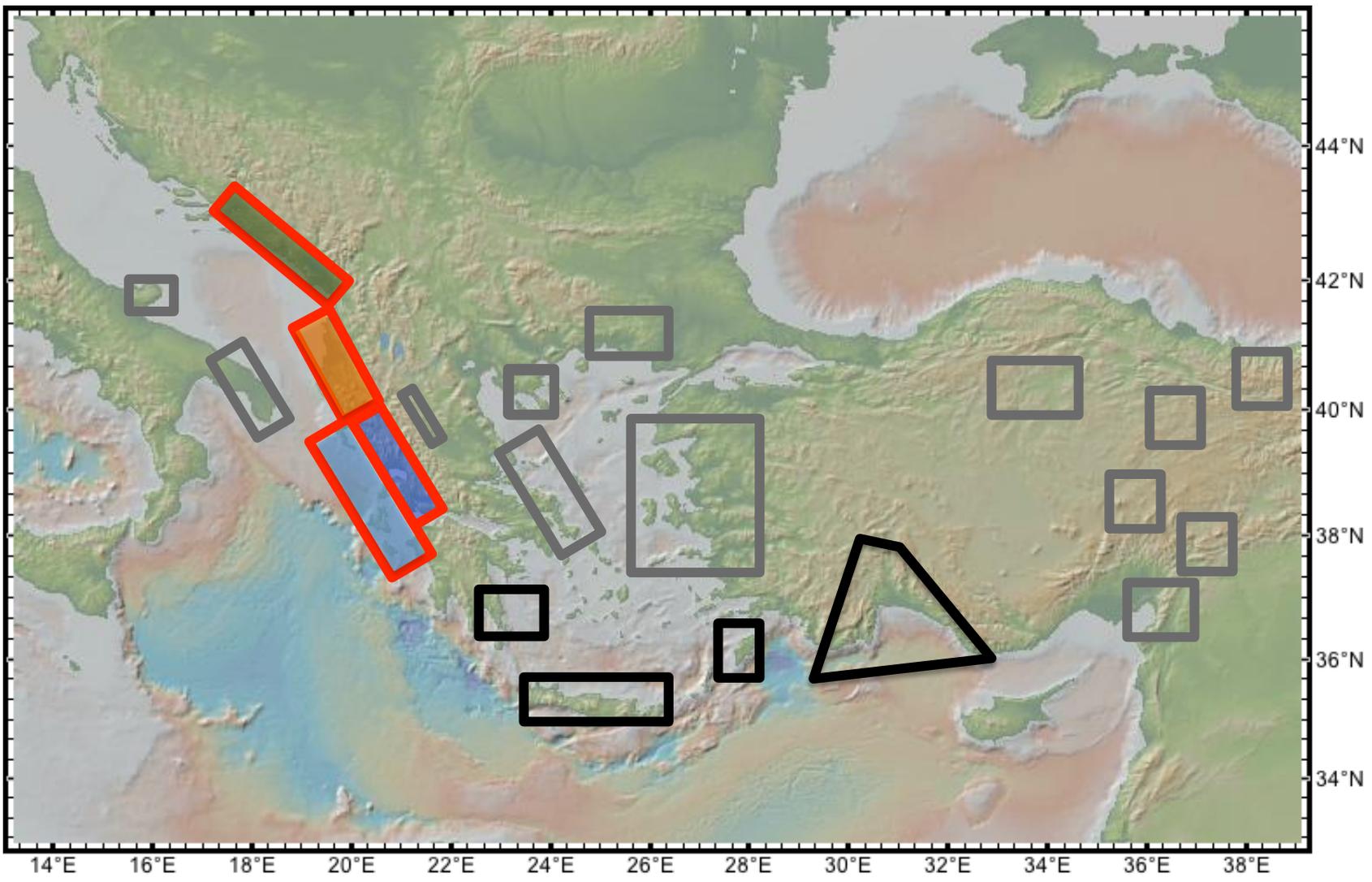
Strategy: going back in time

Role of rotations in the acquisition of the curvatures?

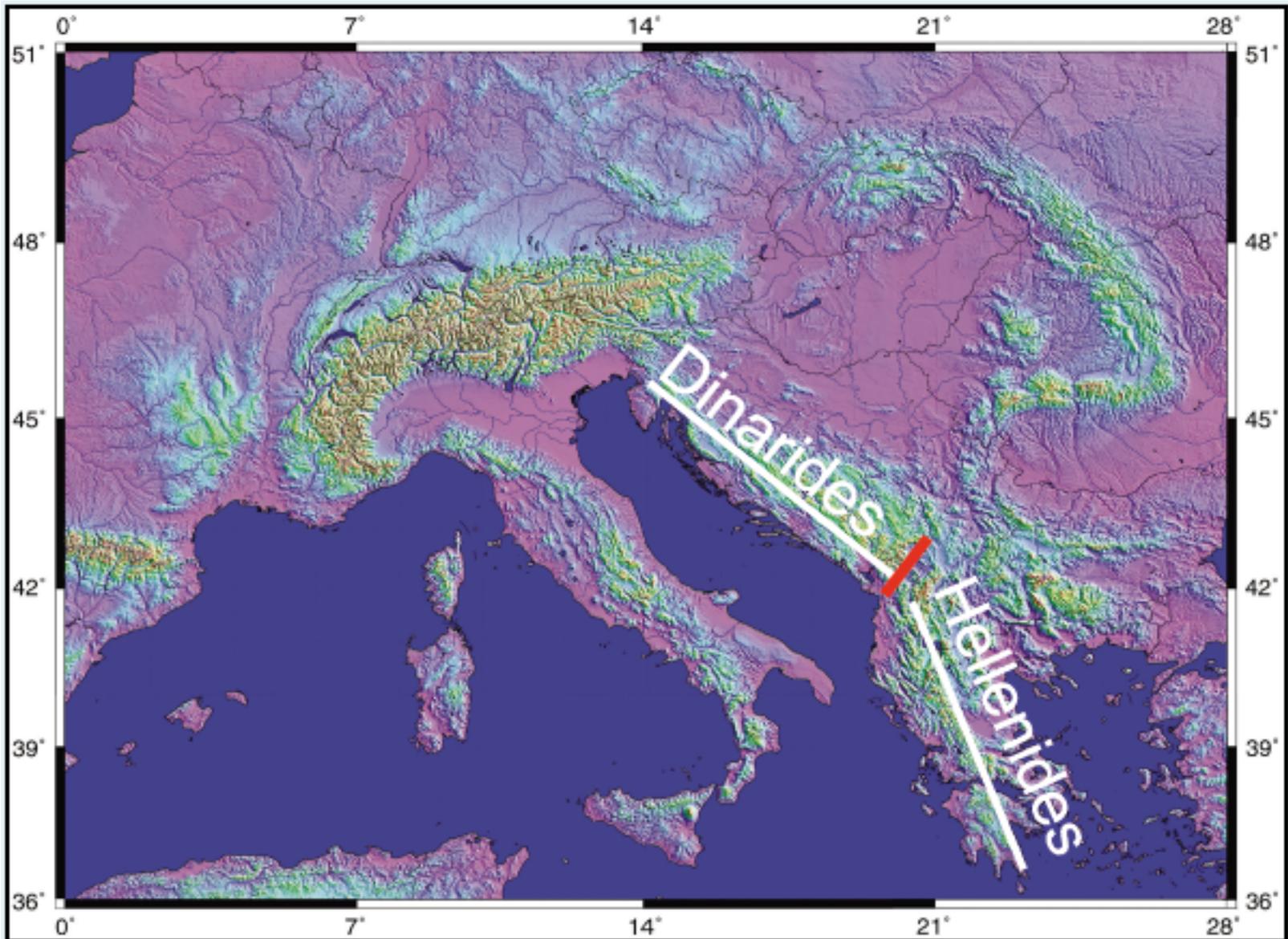


738 sites (10240 cores) from Pliocene to Maestrichtian

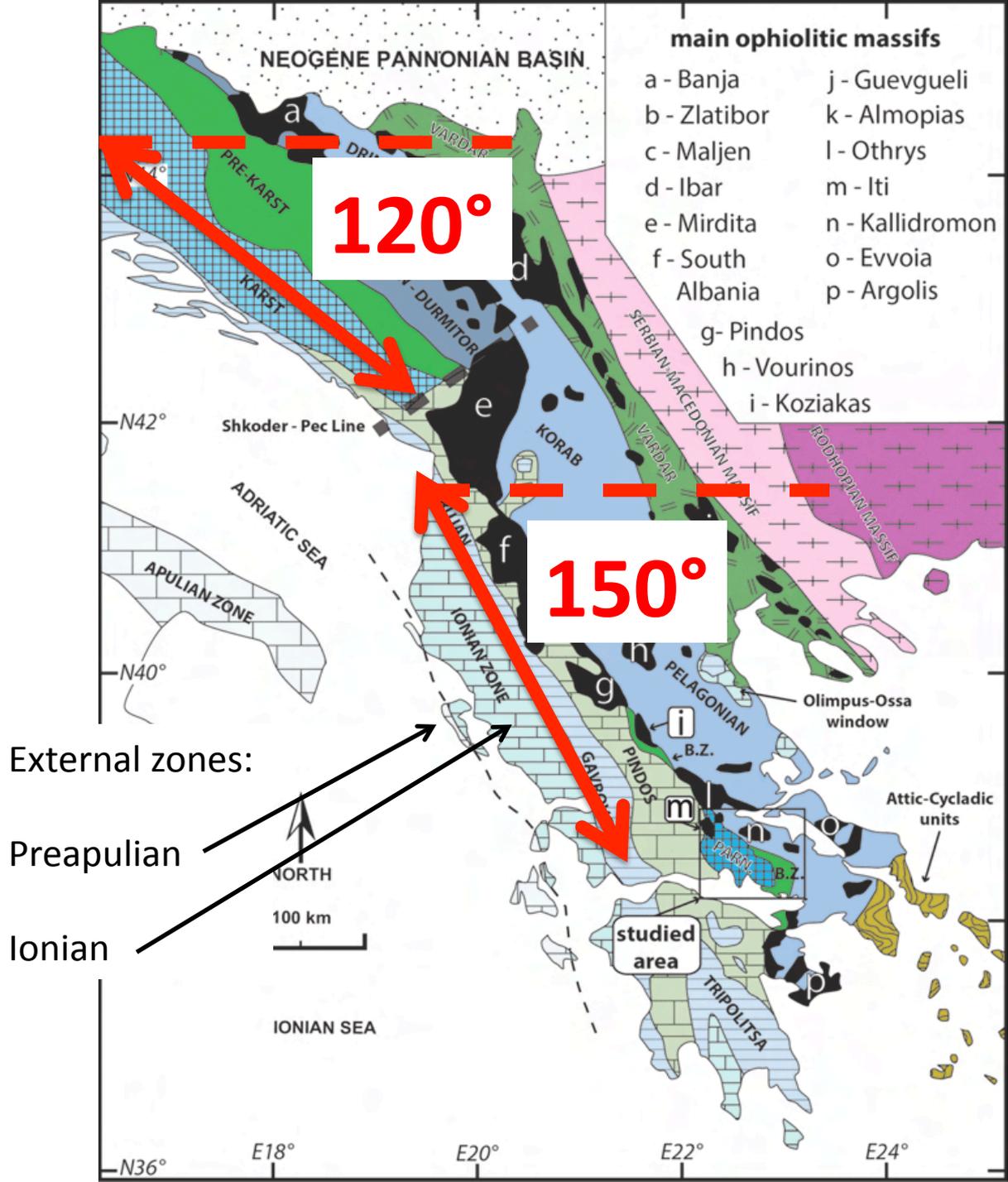
Role of rotations in the acquisition of the curvatures?



Period Plio-quaternary to Eocene in the external zones of the orogens
15 years long project!



From Schmid et al., ETH



From Nirta et al., 2016

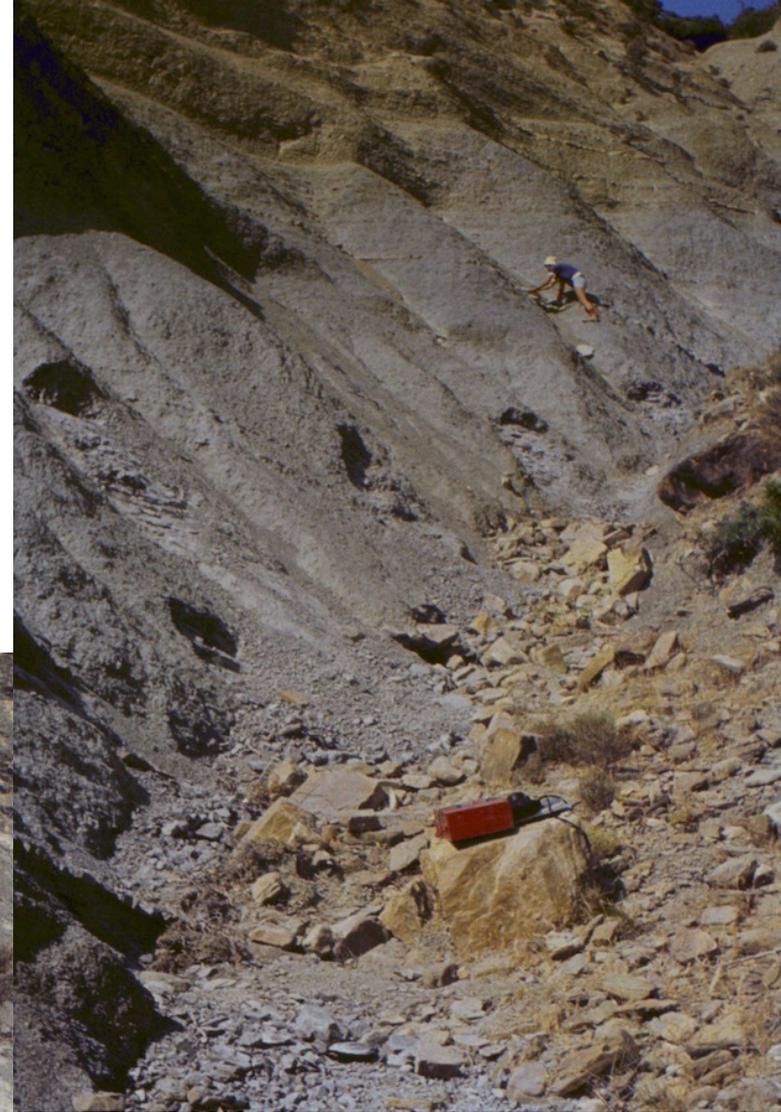
Requisite in the field = statistical aspect

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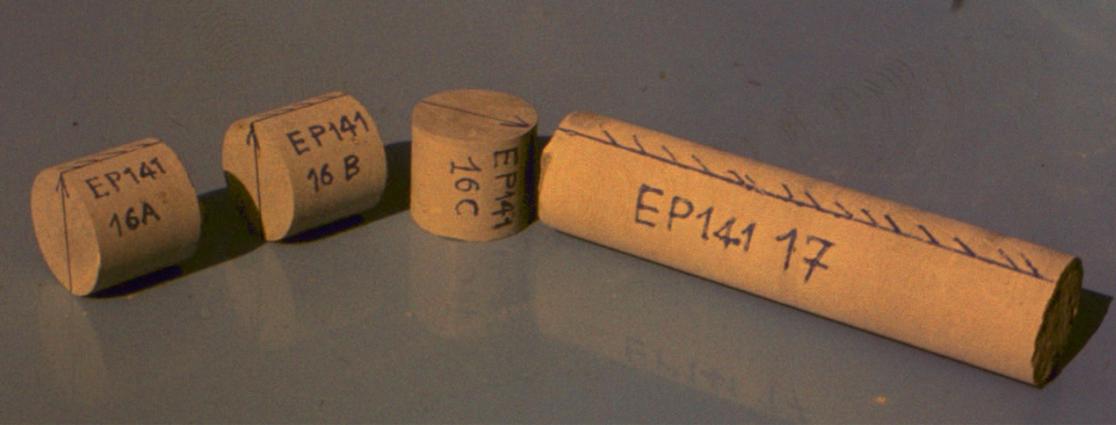
Pioneer study: starting from the most recent formations, not always easy to perform











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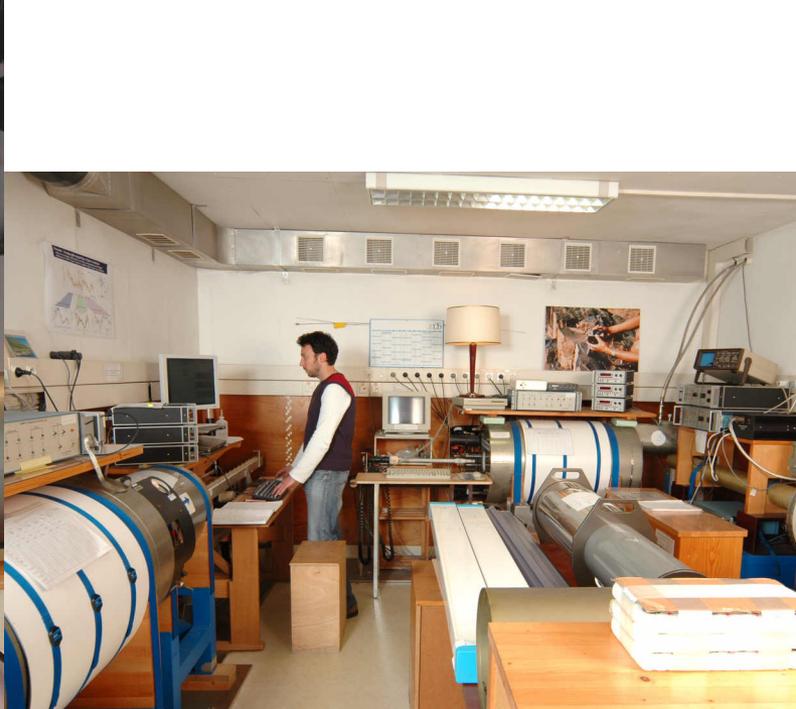
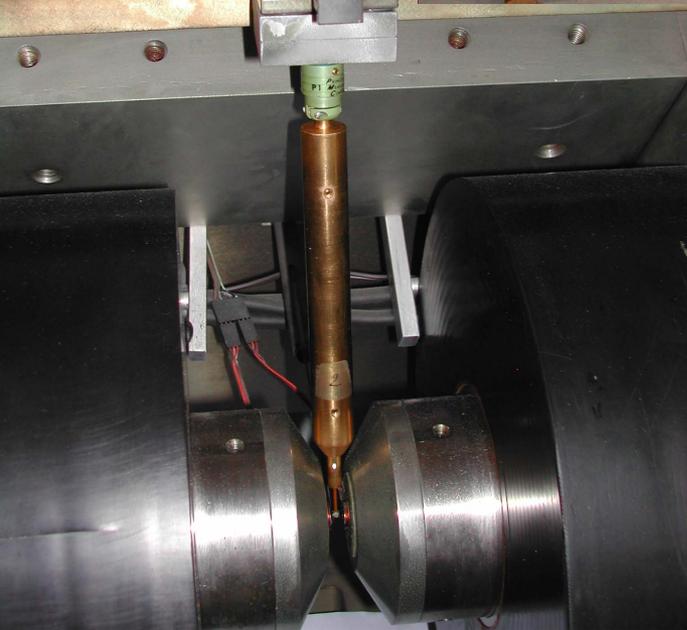
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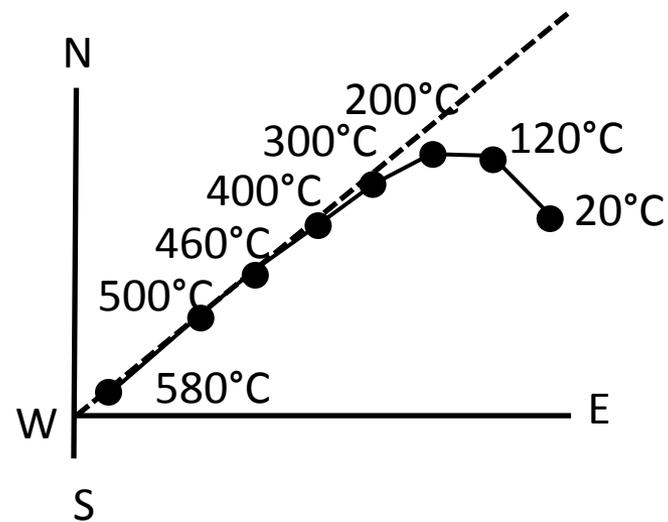
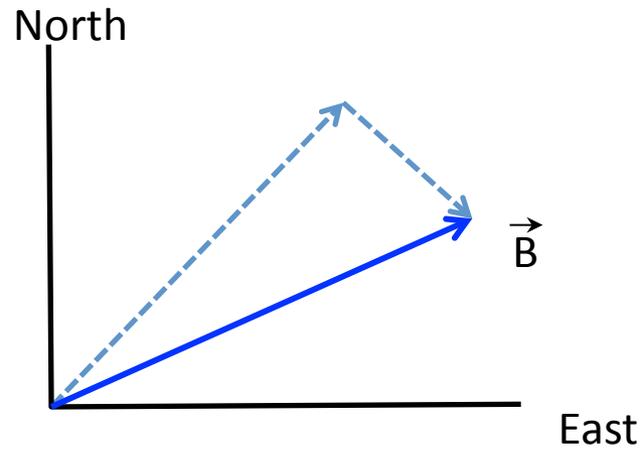
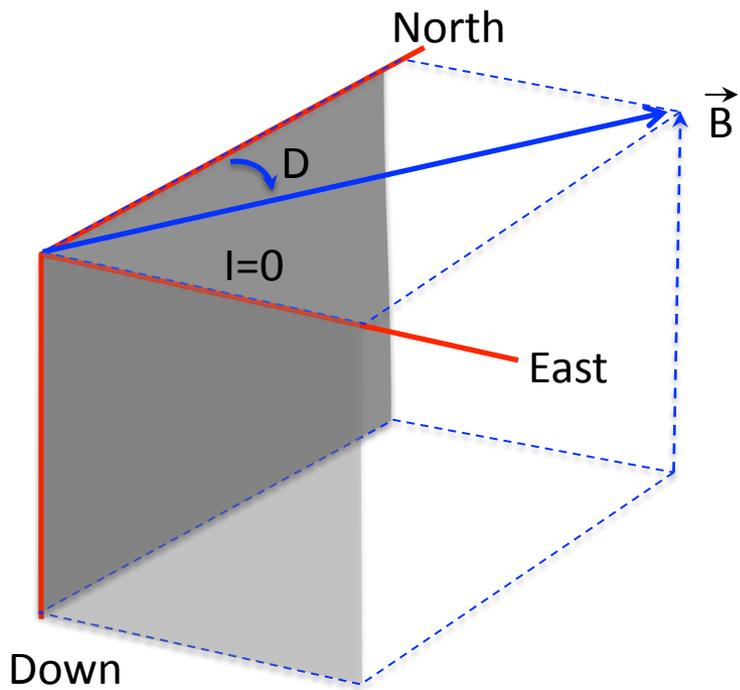
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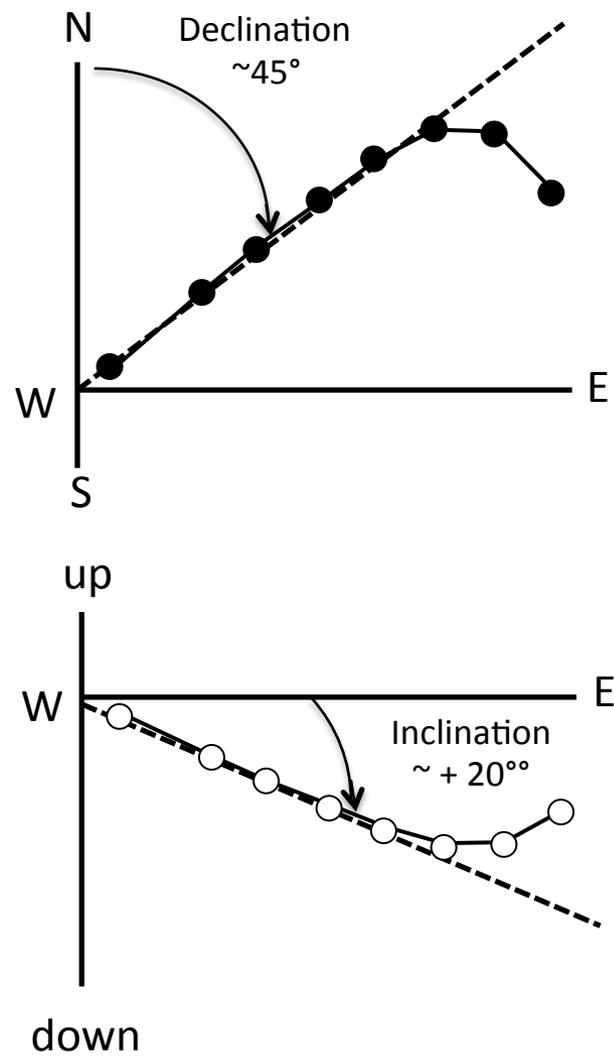
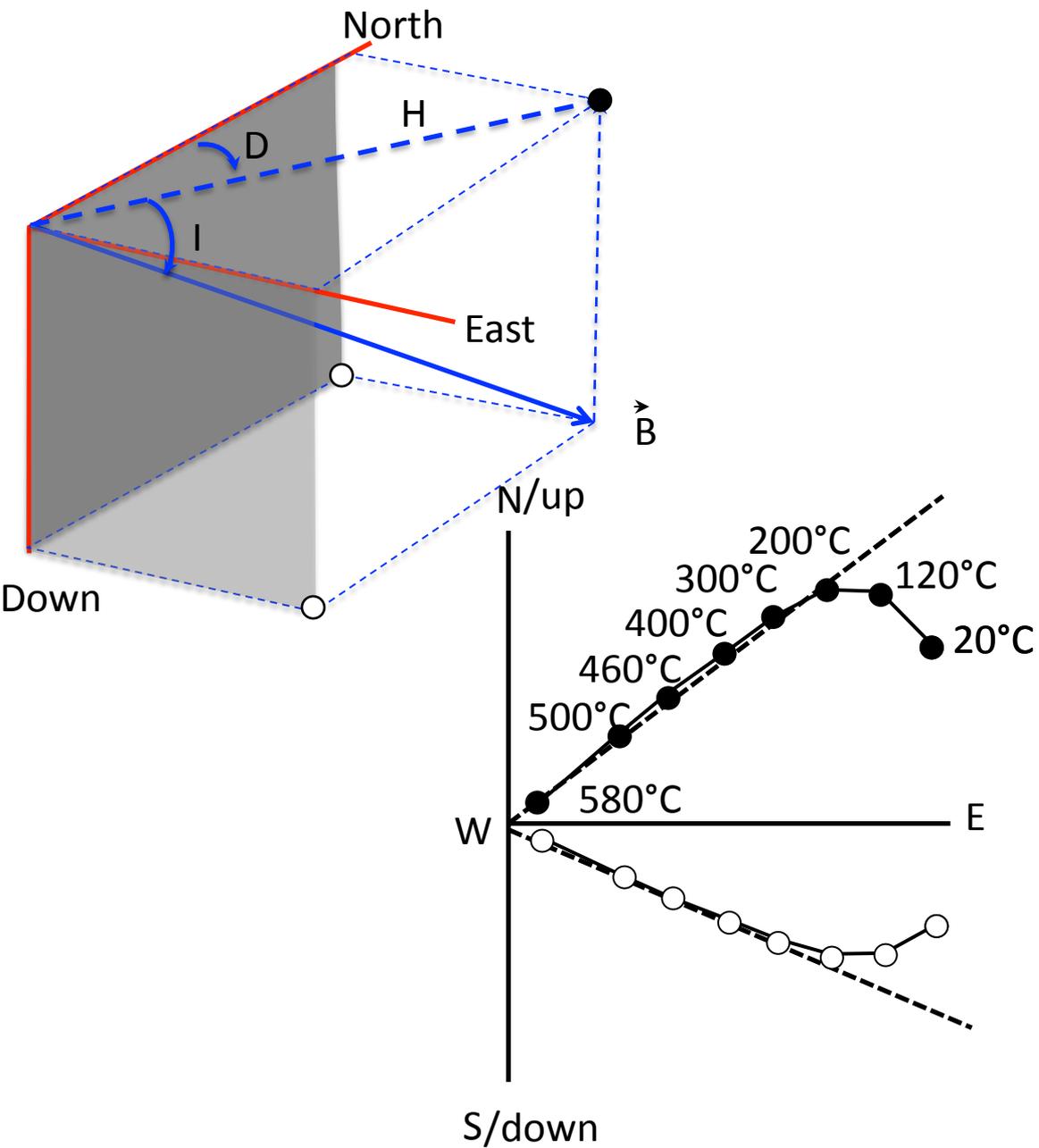
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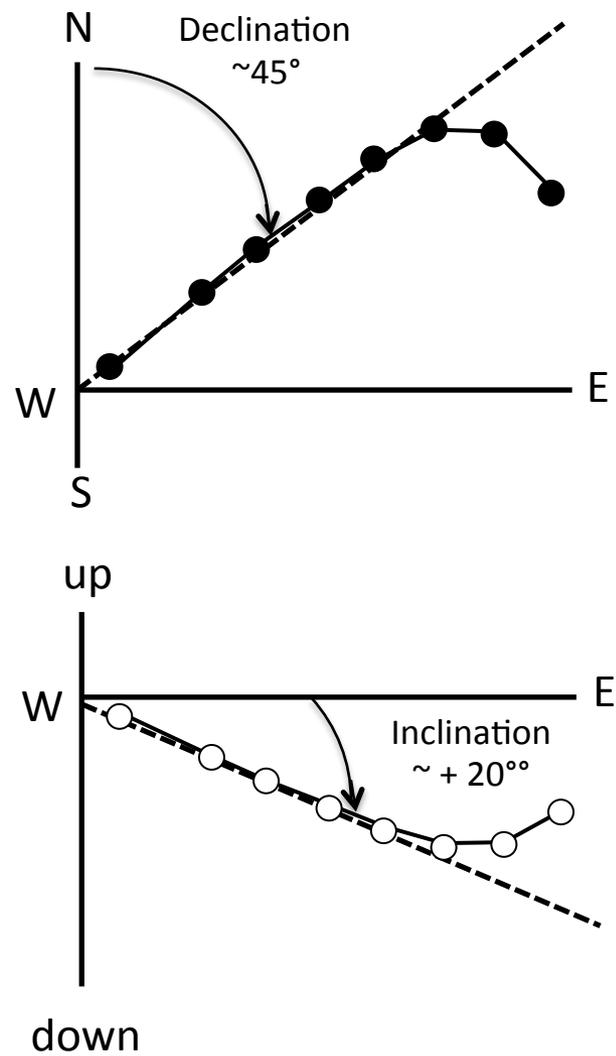
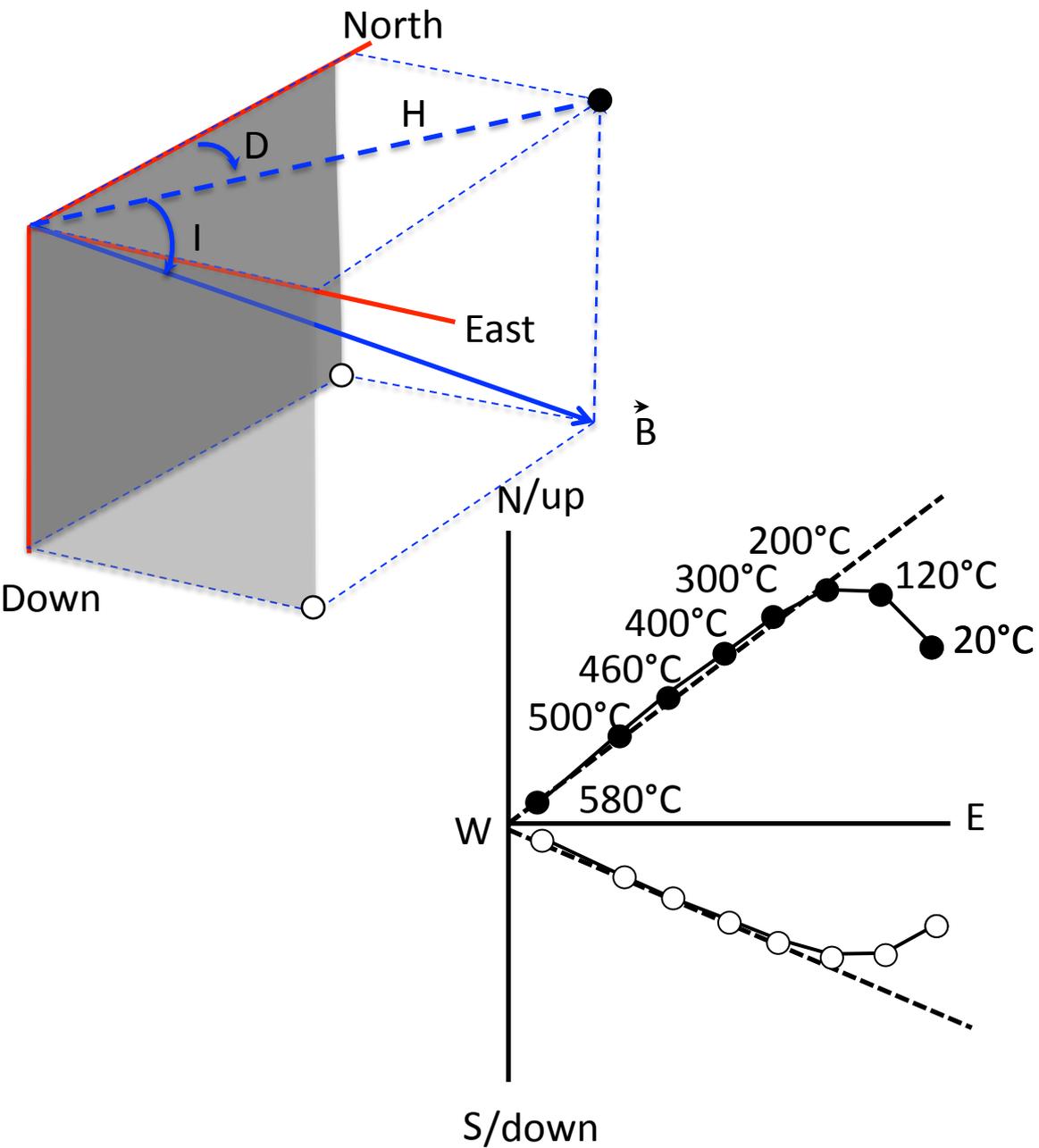
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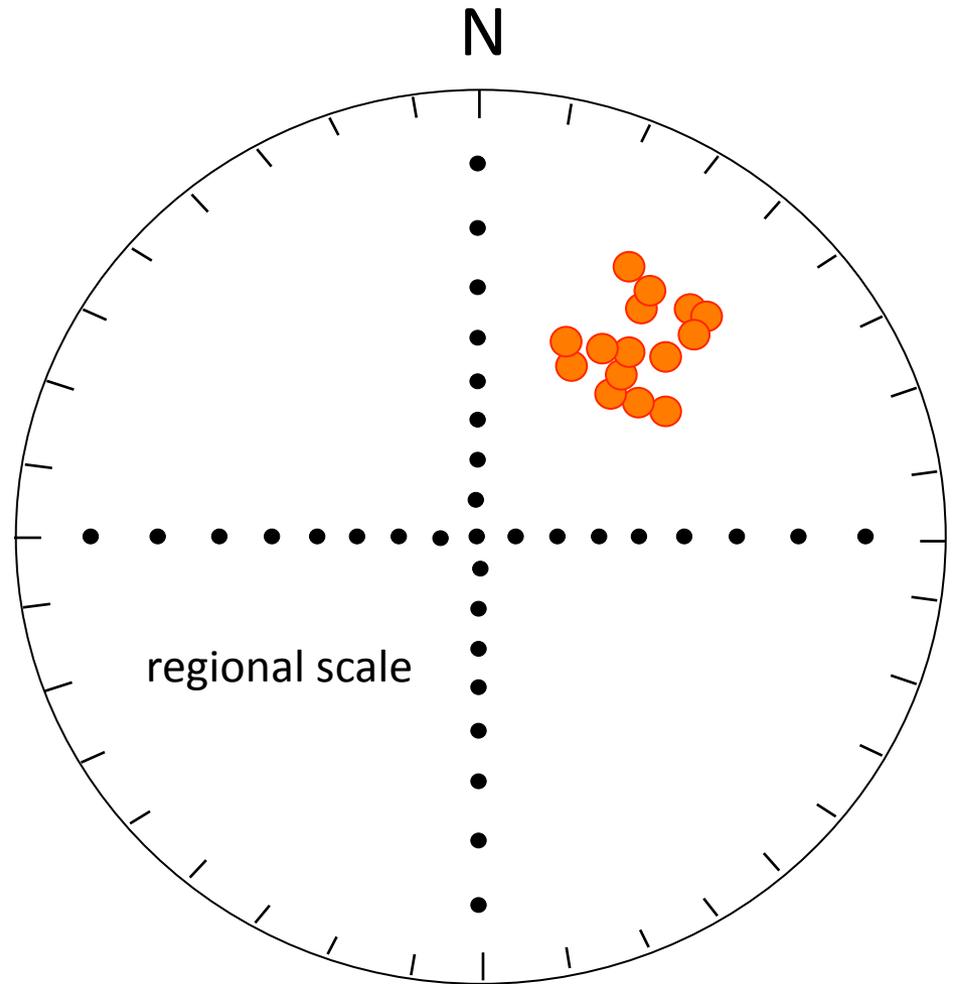
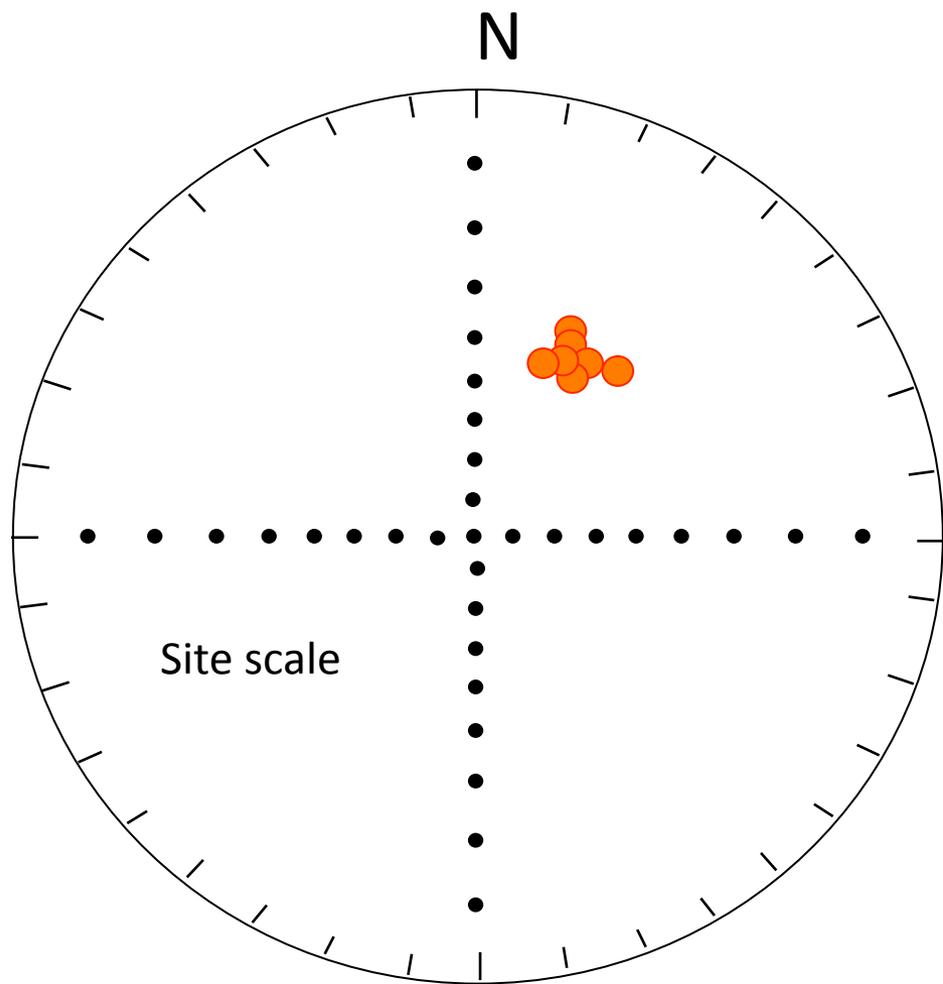
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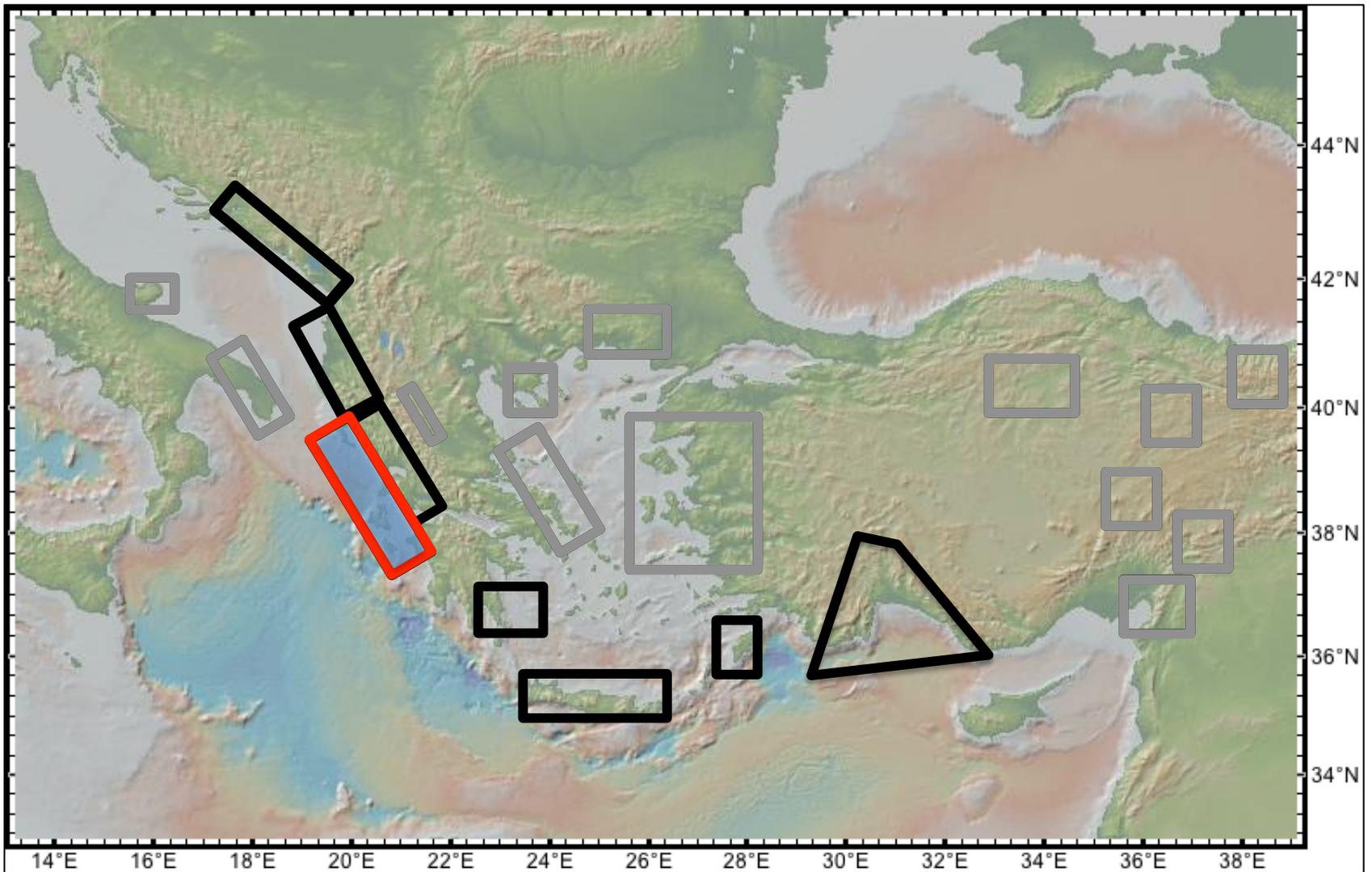




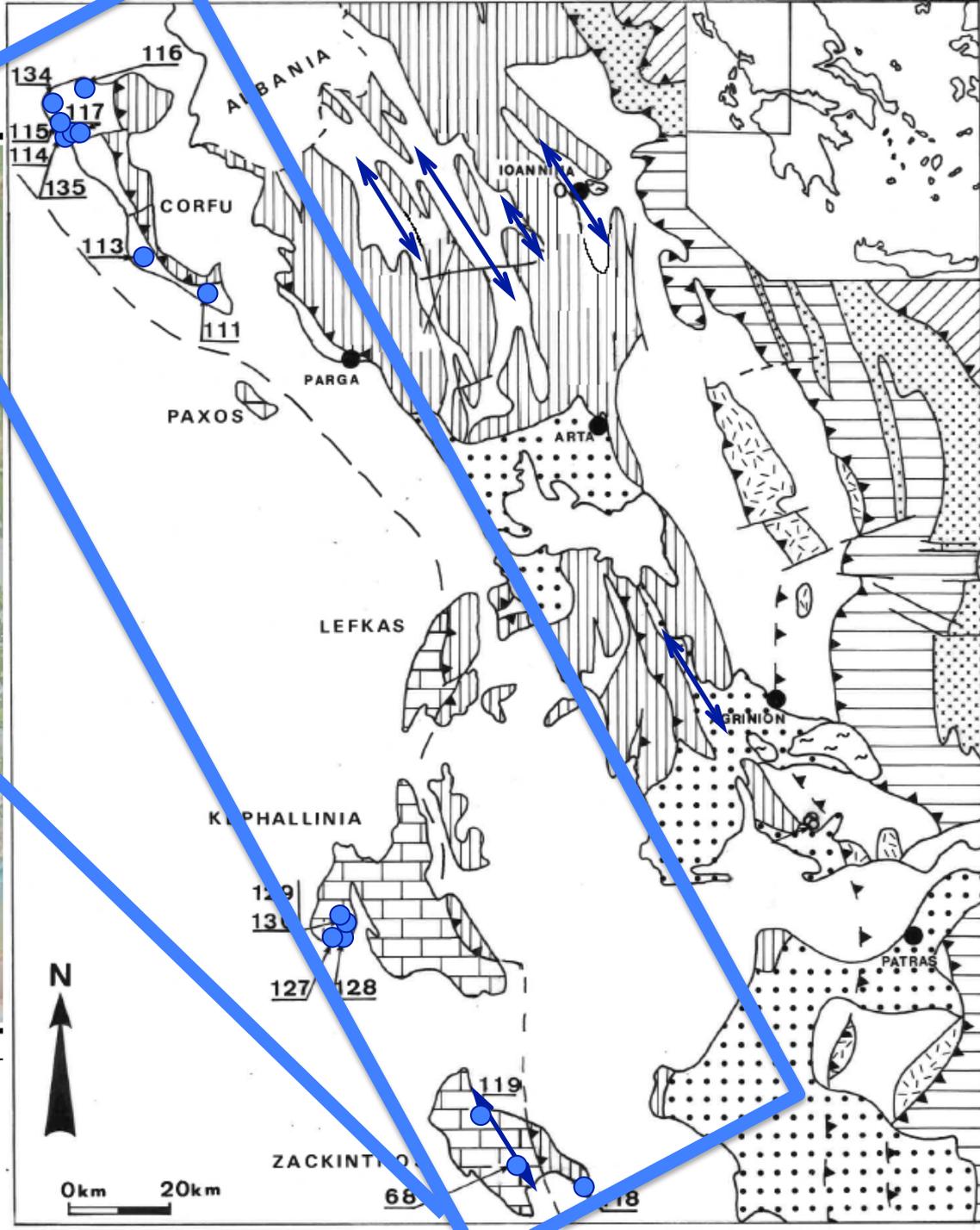
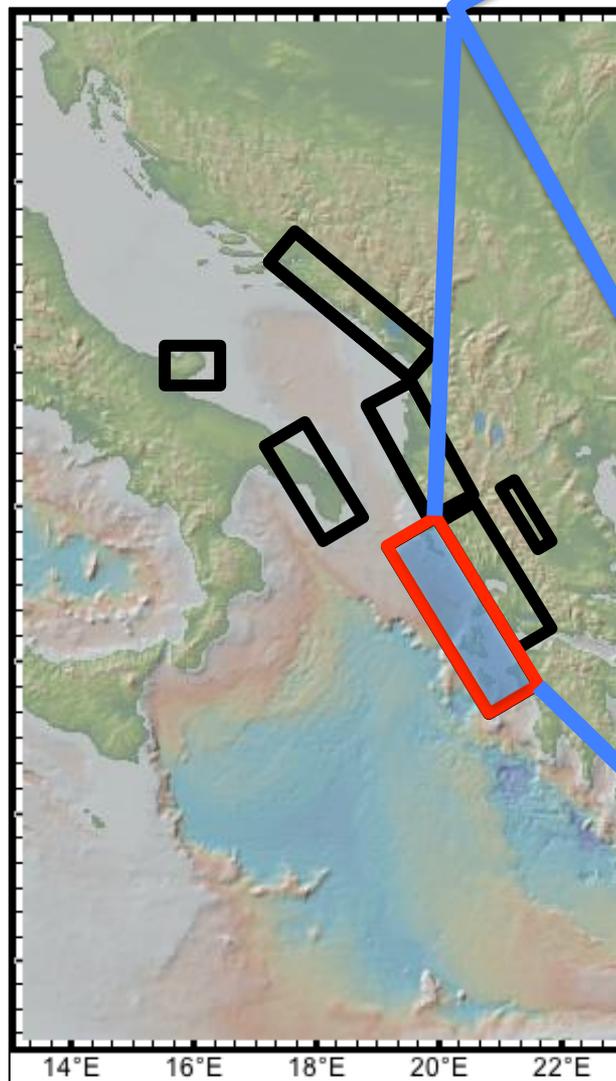








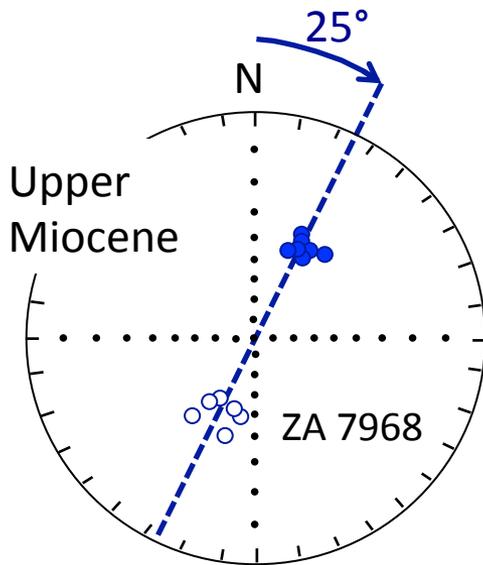
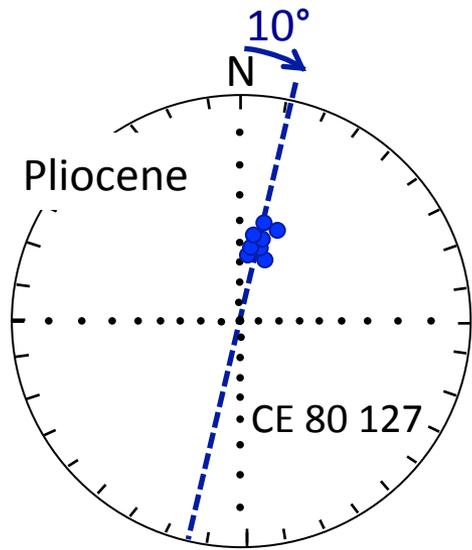
Period Plio-quaternary to Eocene in the external zones of the orogens
15 years long project!

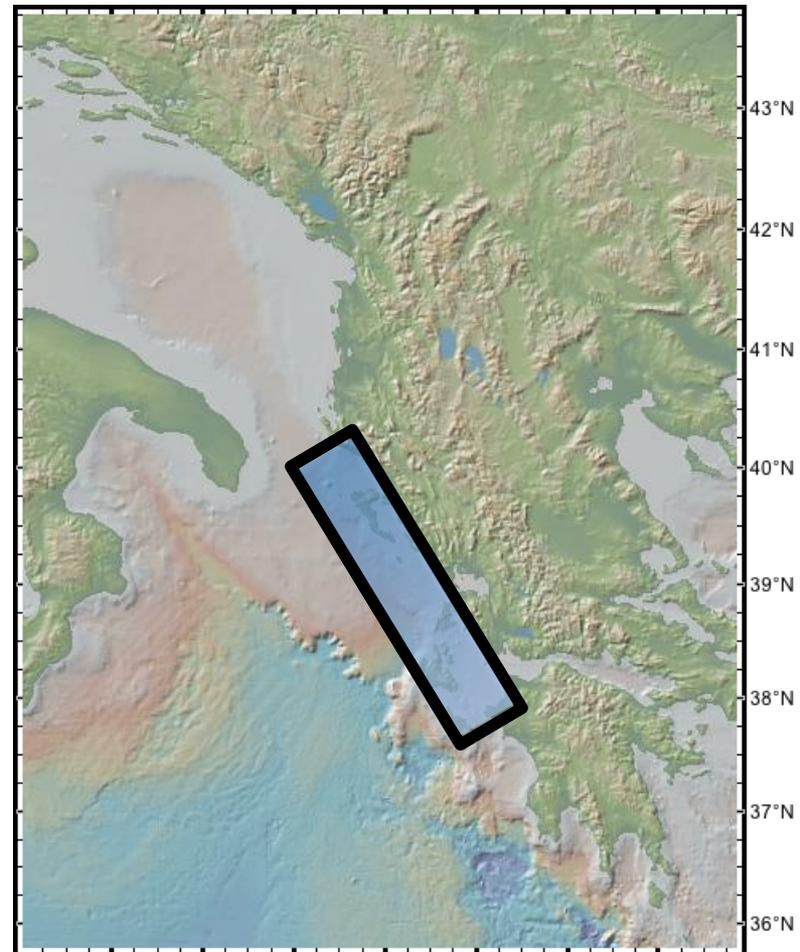
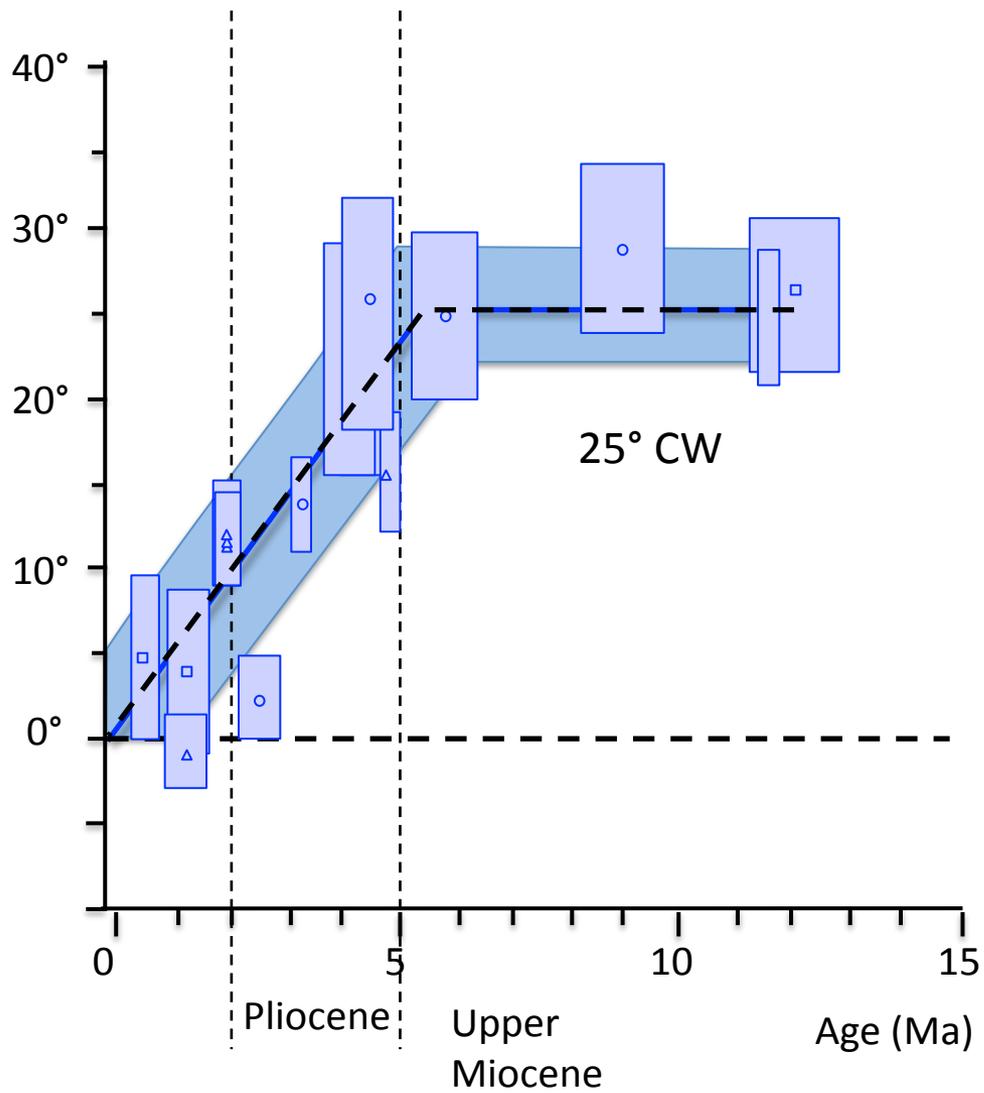


Laj et al. (1982)

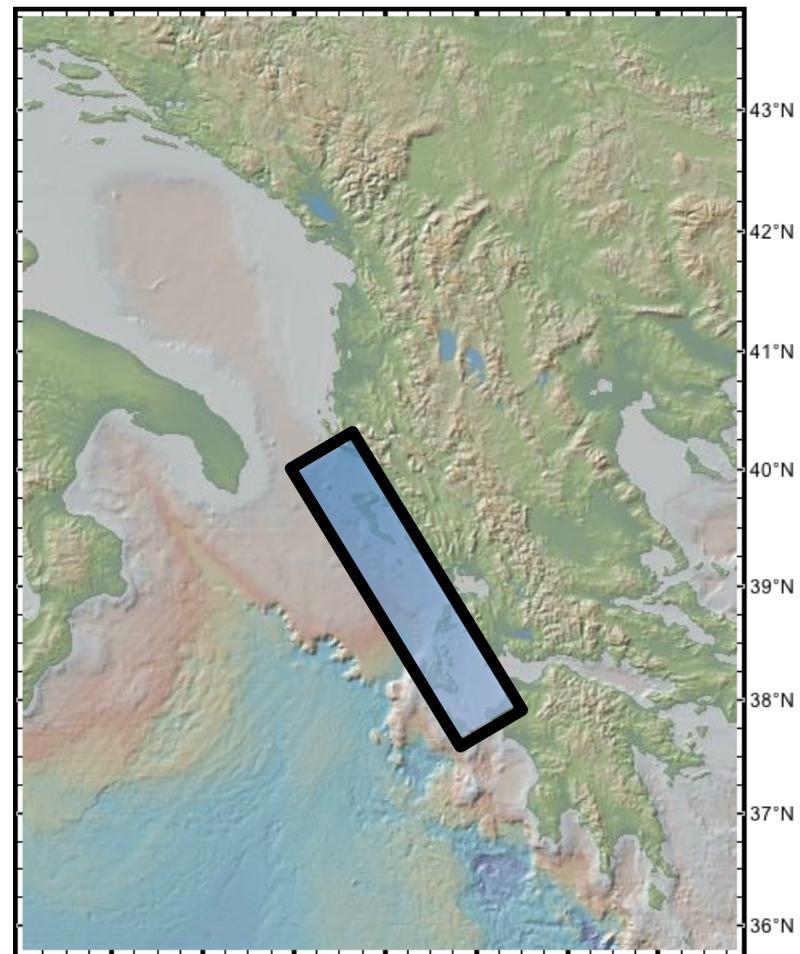
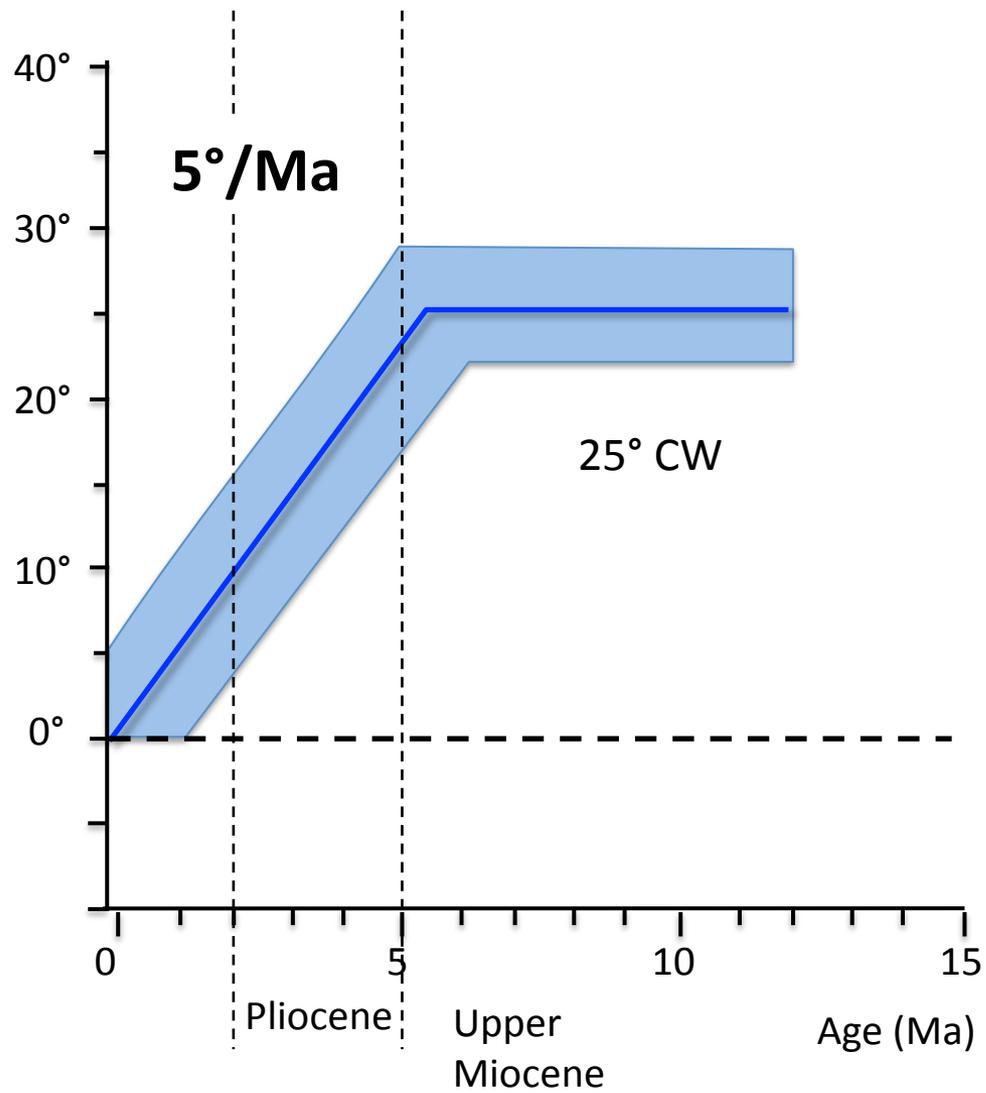
Ionian Islands

Site scale

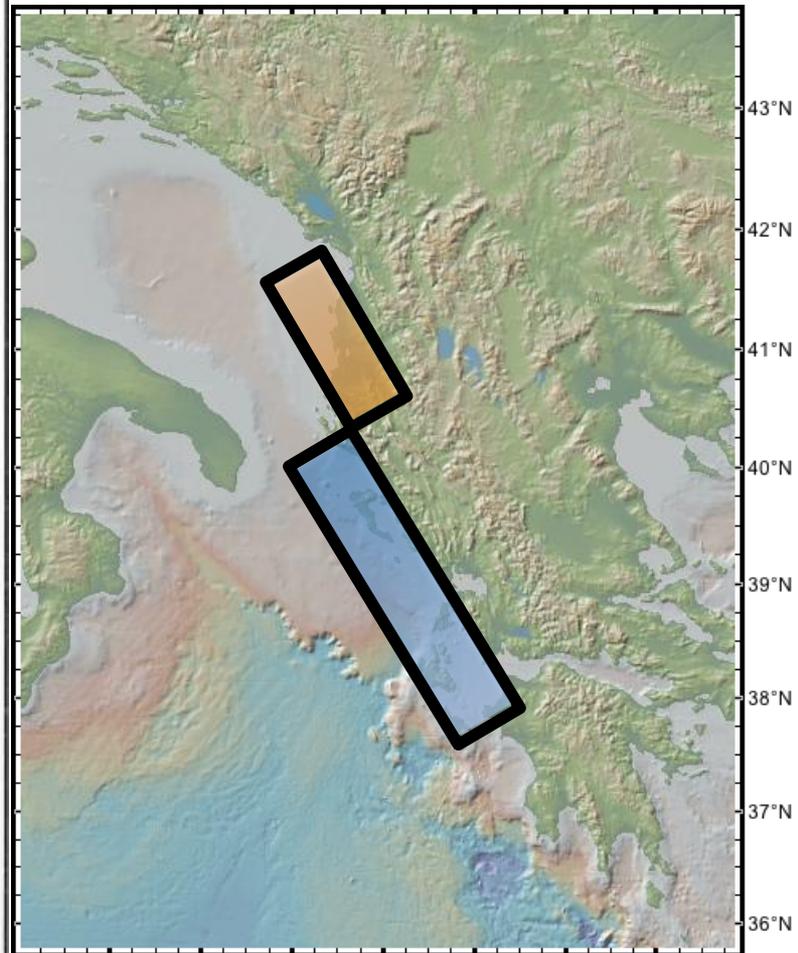
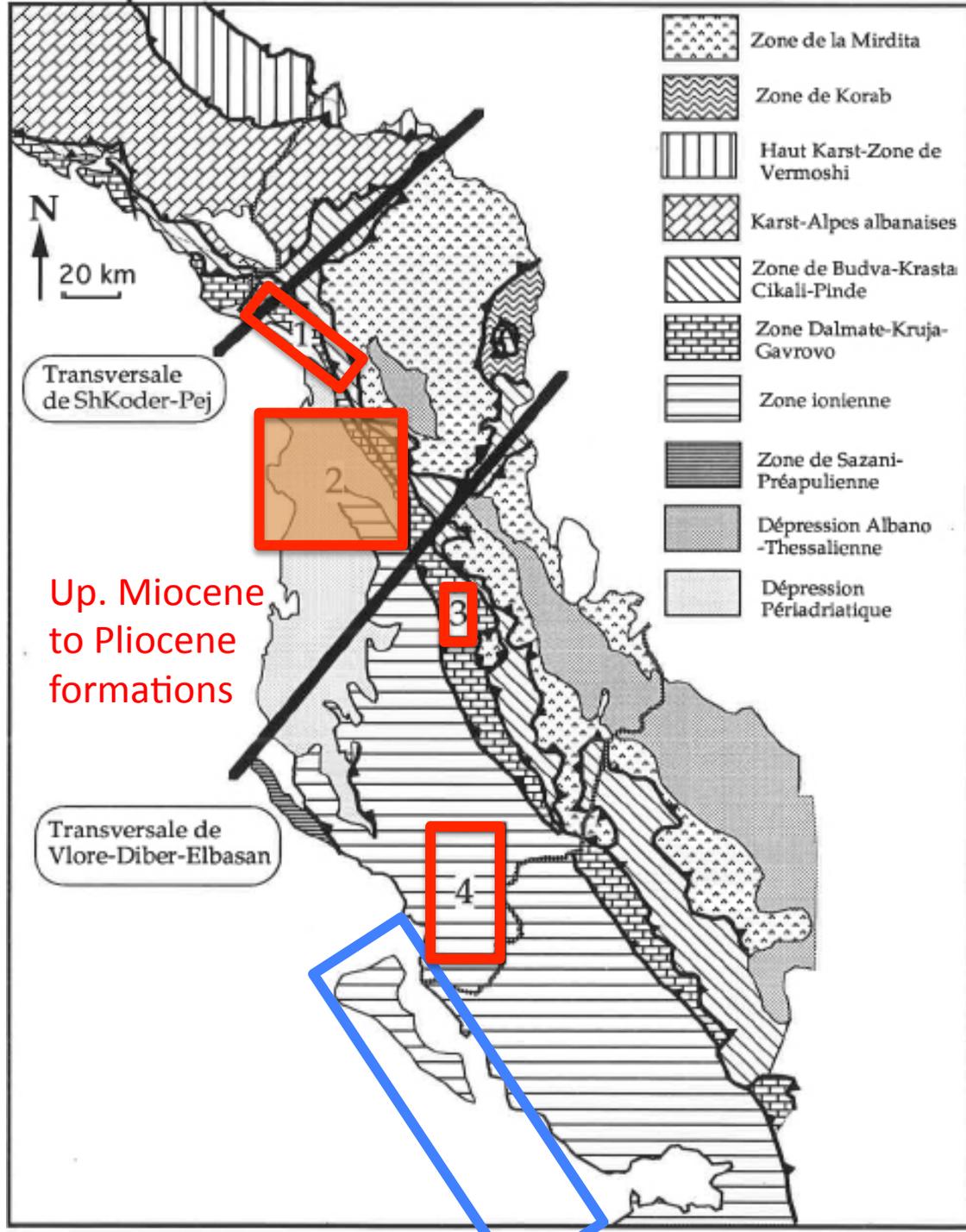




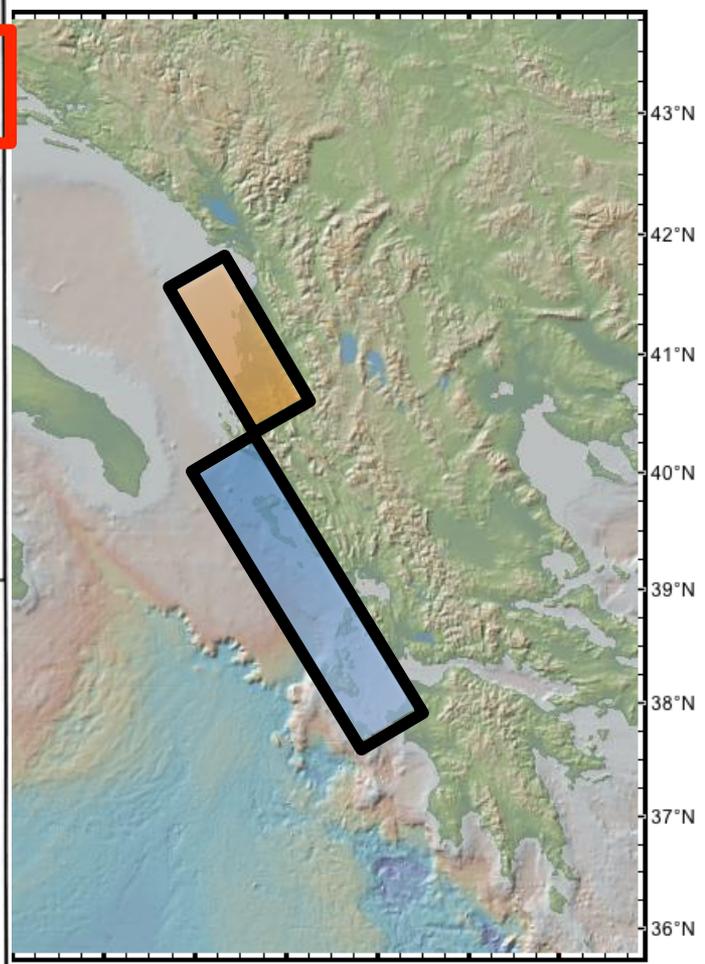
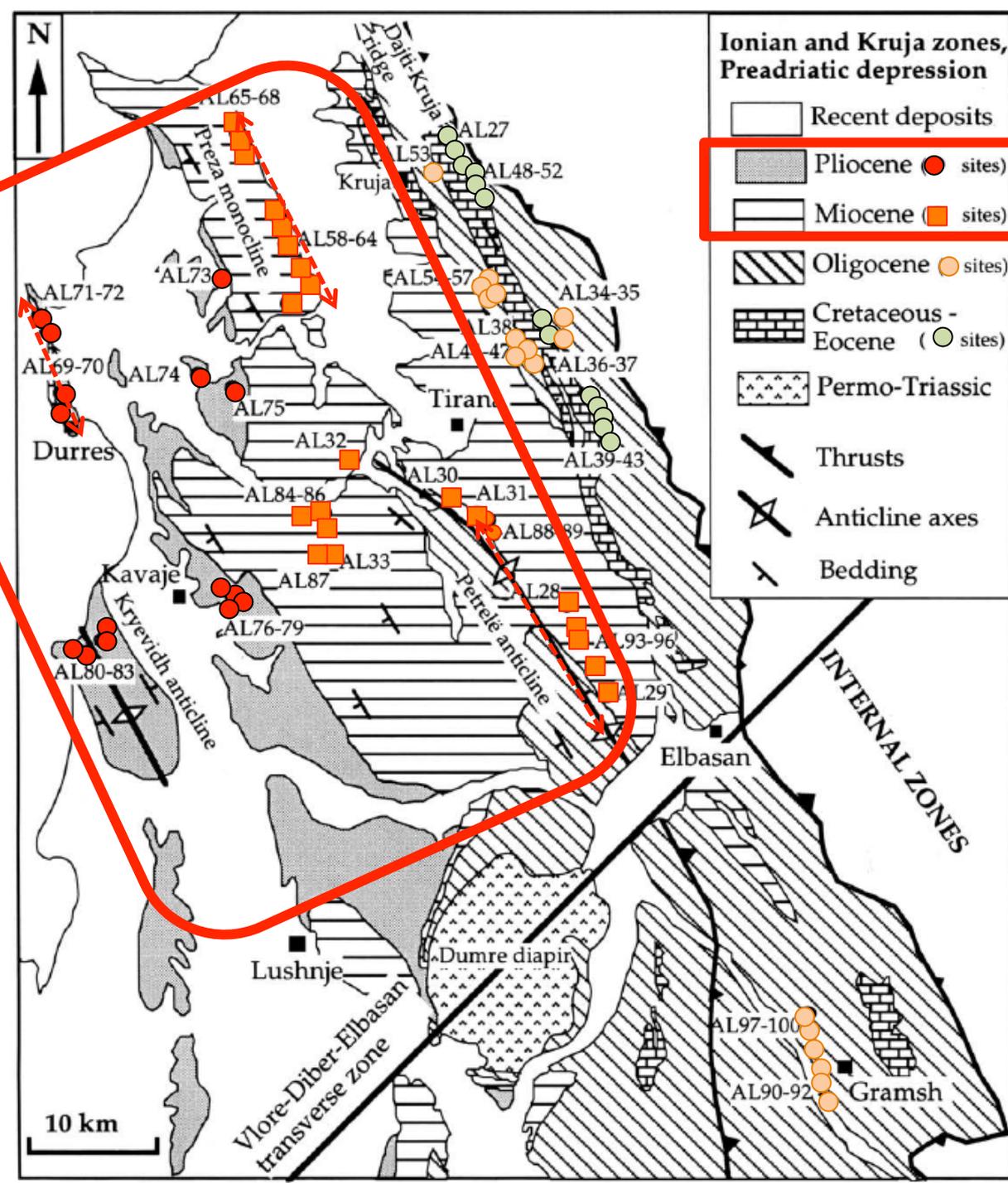
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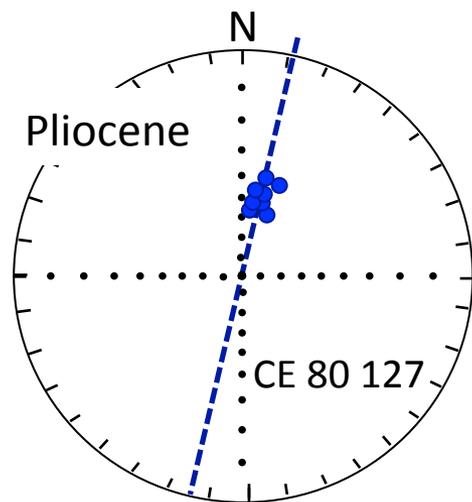


Upper Miocene –
Pliocene formations

Speranza et al. (1995)

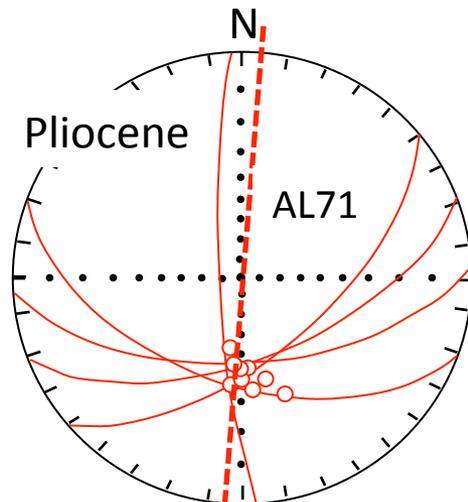
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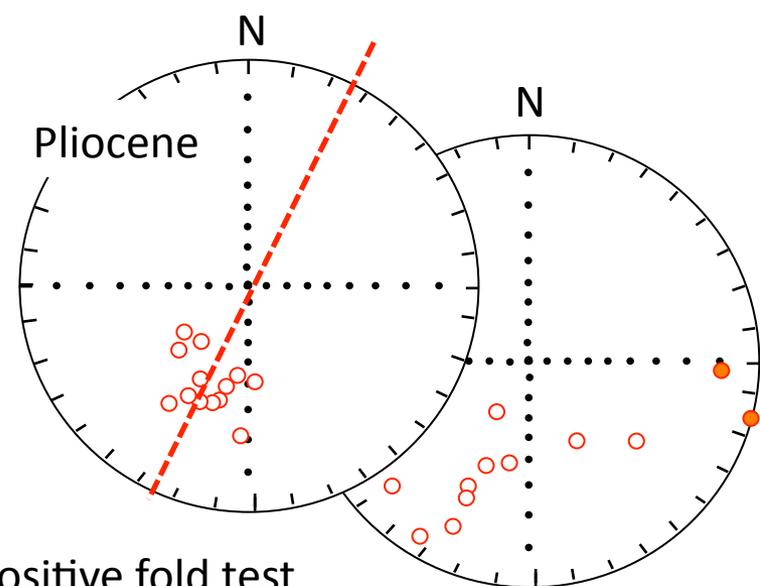


Albania

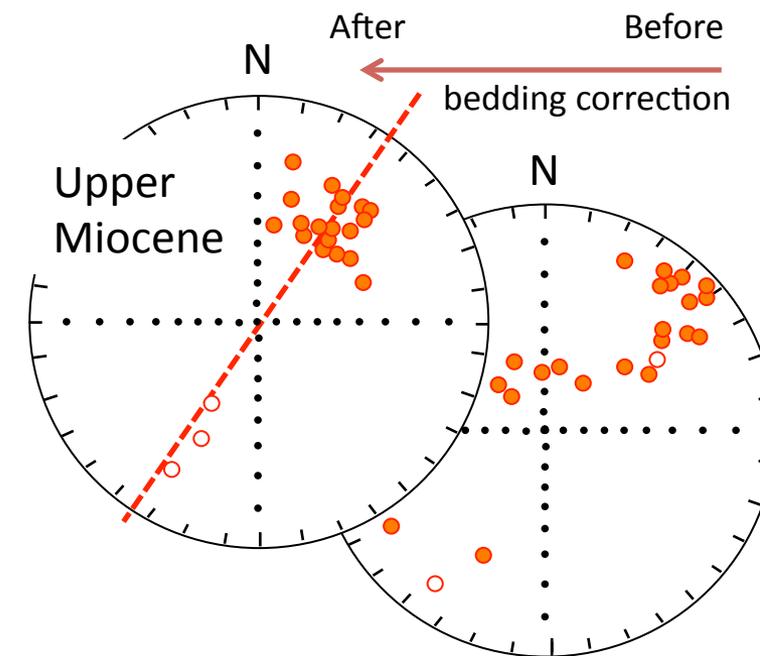
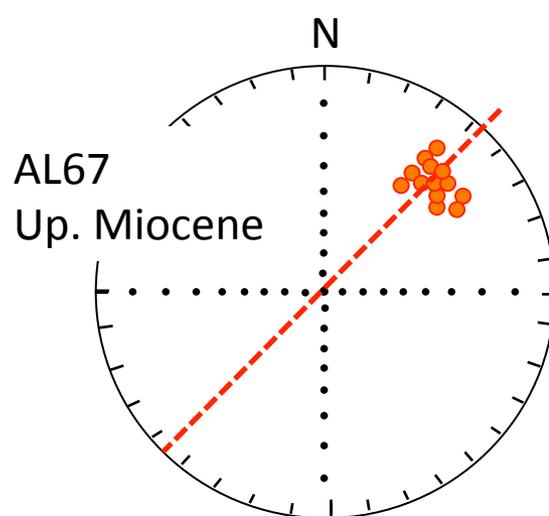
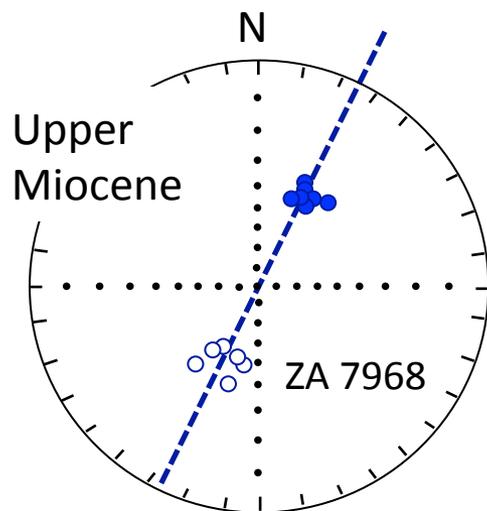
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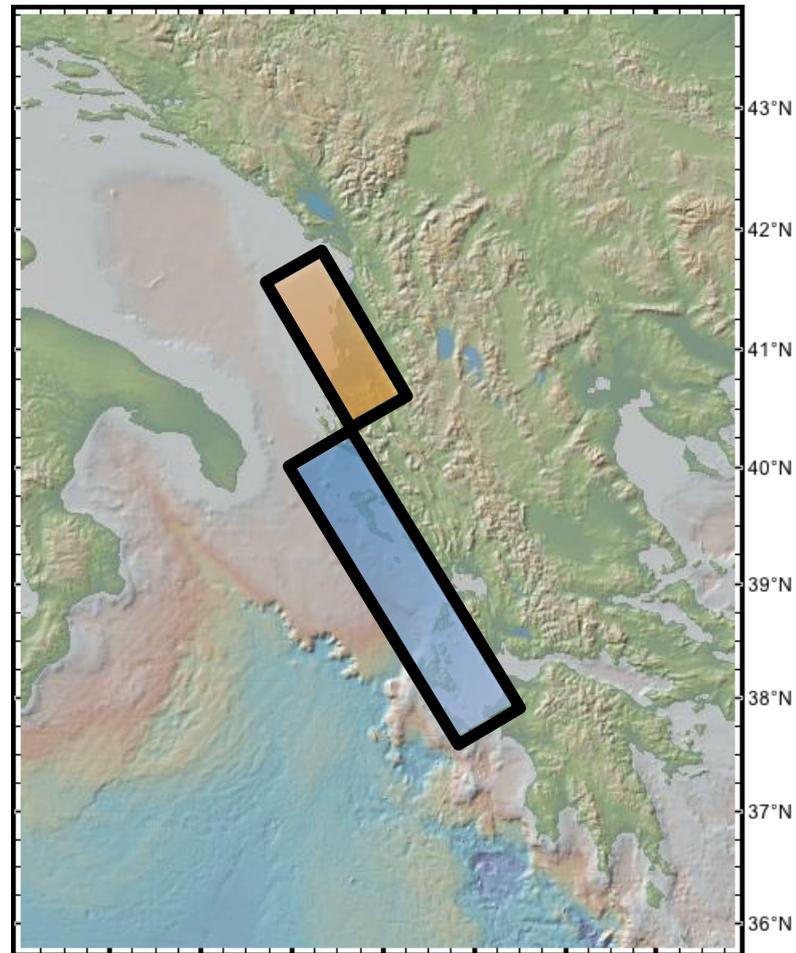
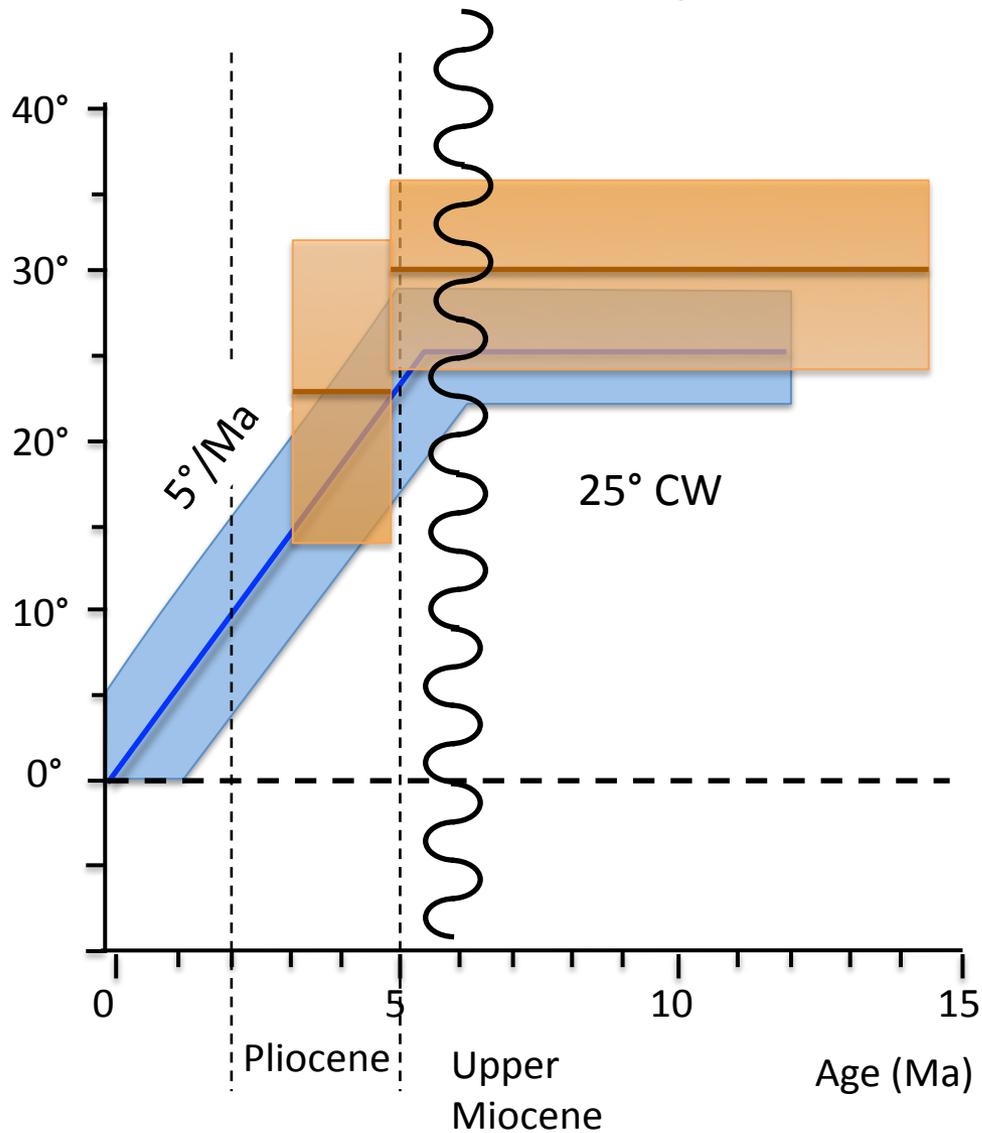
Regional scale



Positive fold test

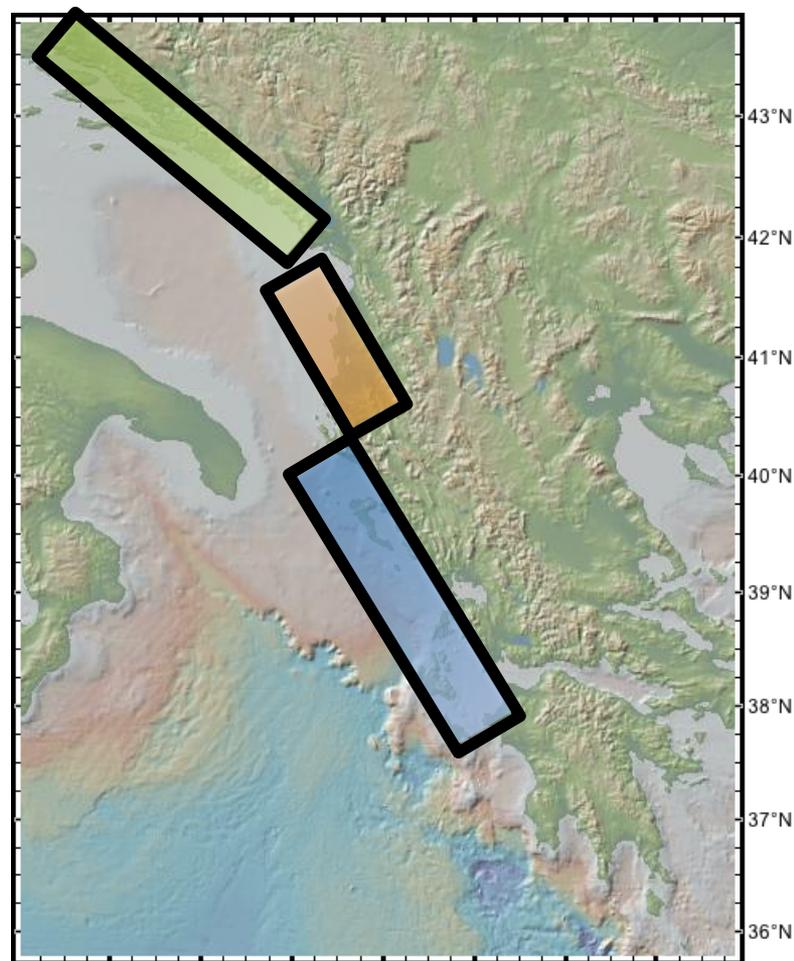
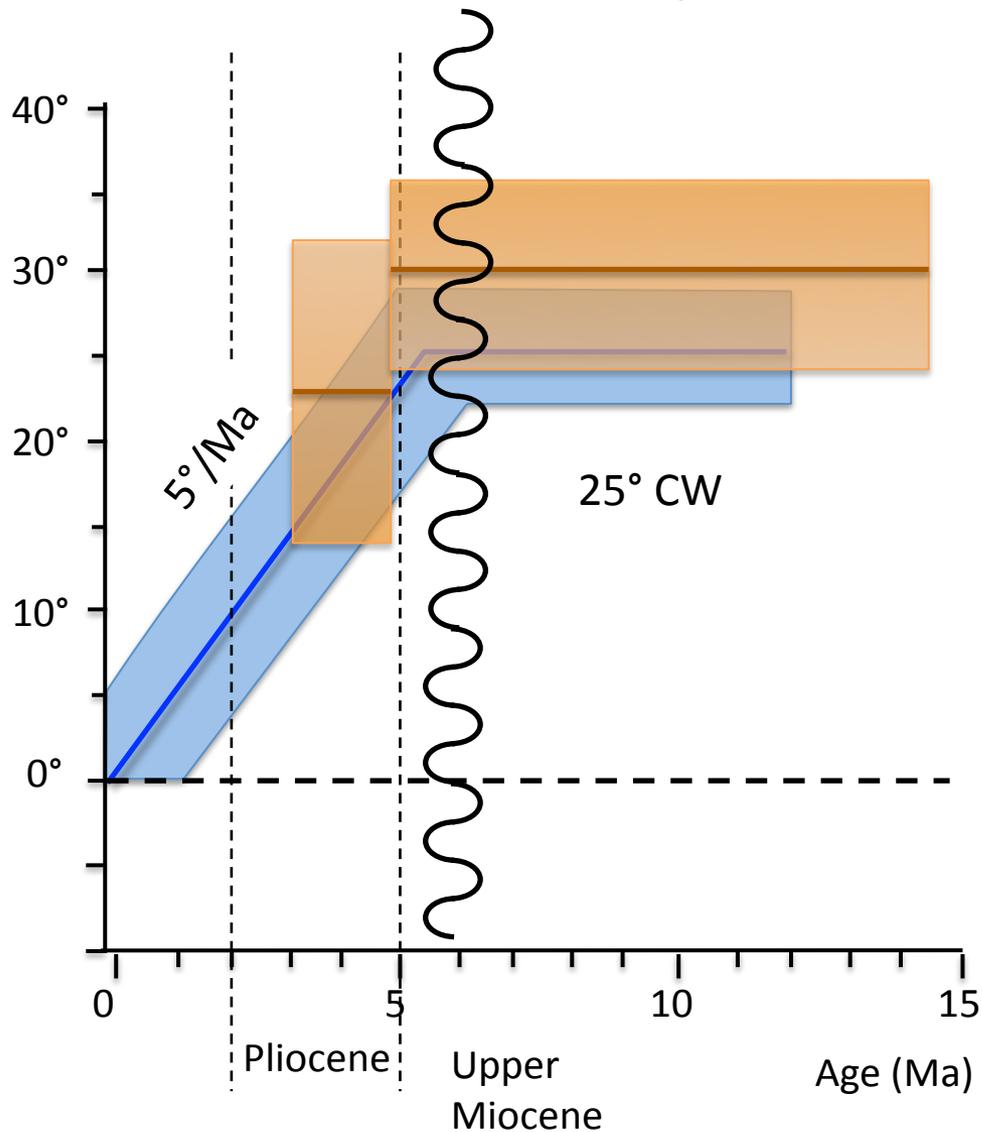


Lower Pliocene tectonic phase

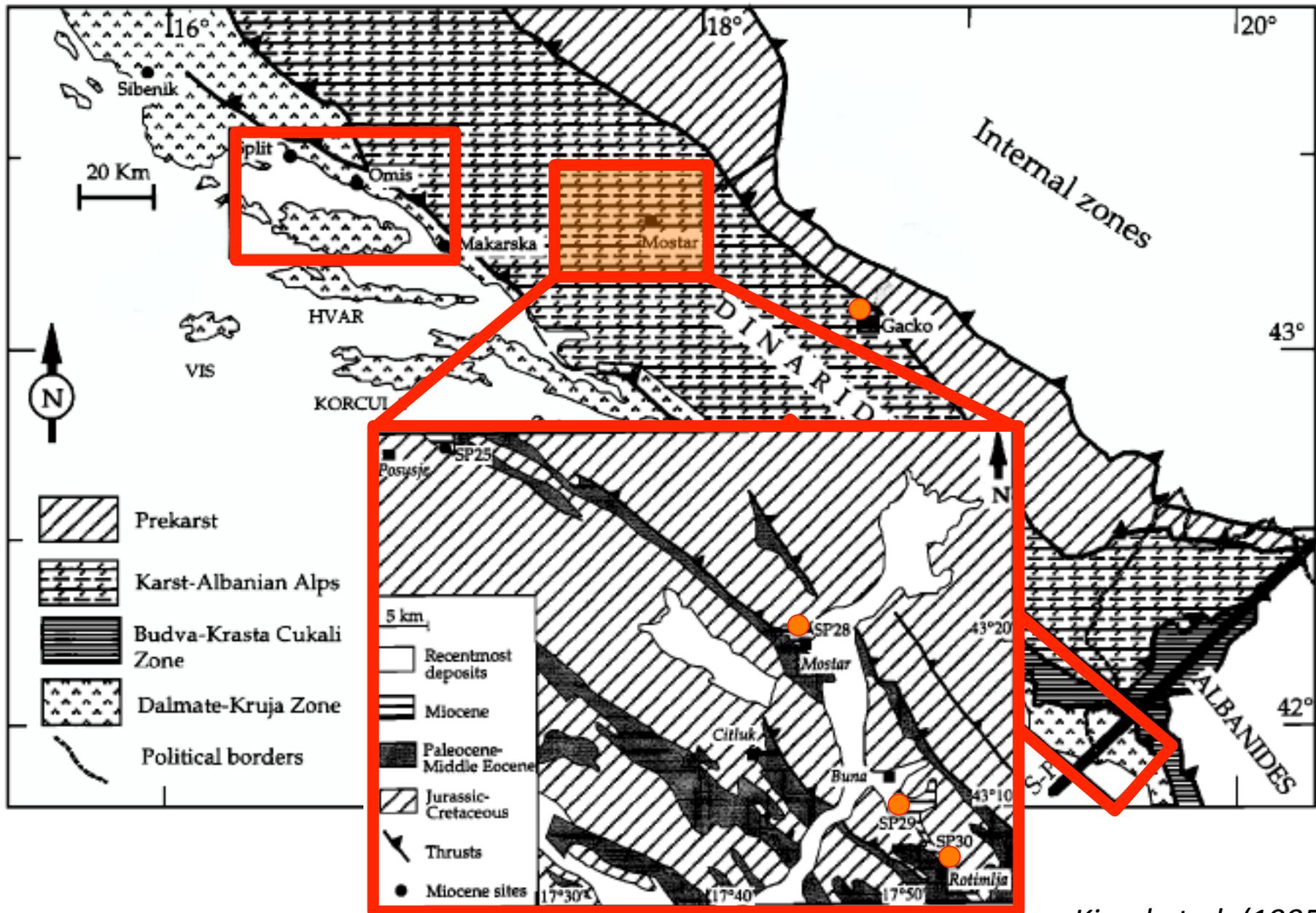


Kissel et al. (1995)
Speranza et al. (1995)
Laj et al. (1982)

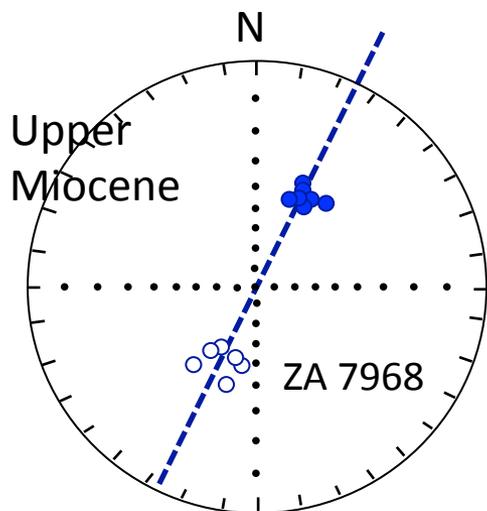
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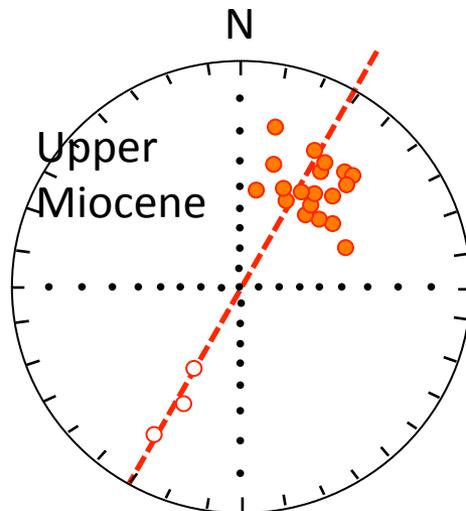
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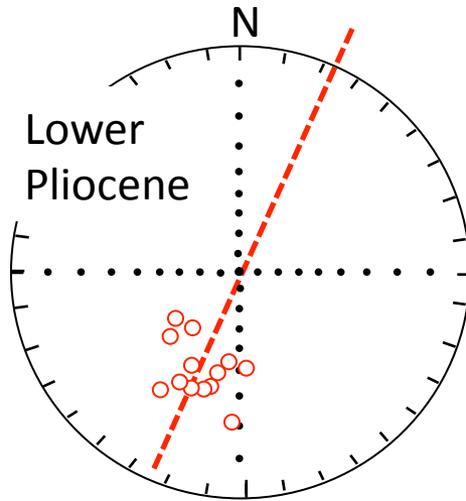
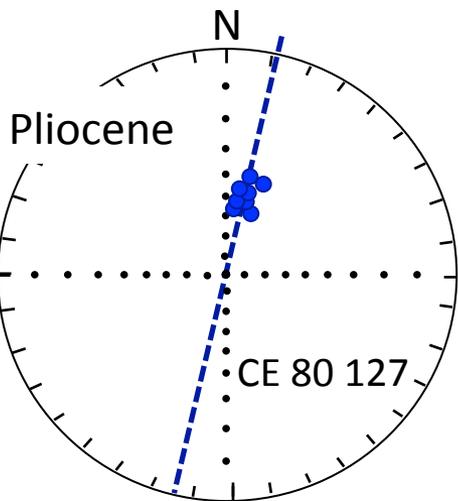
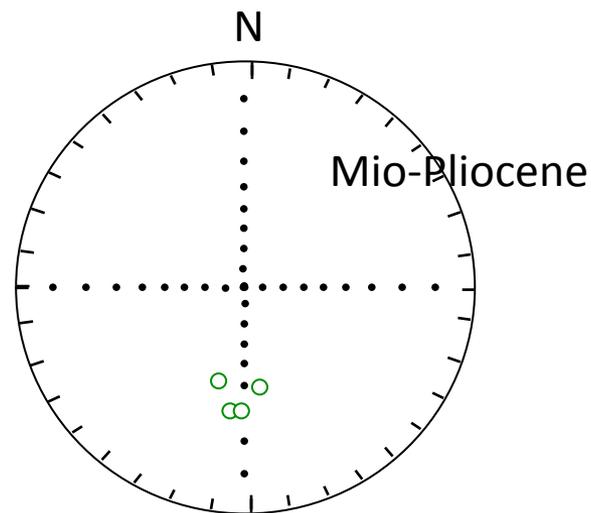
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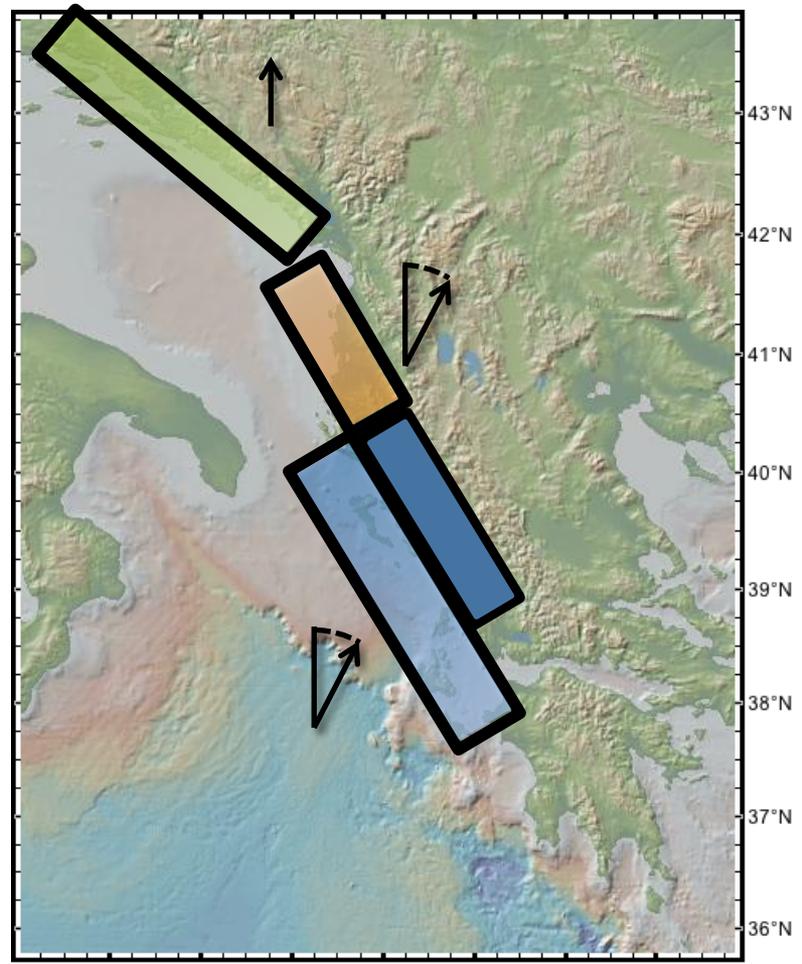
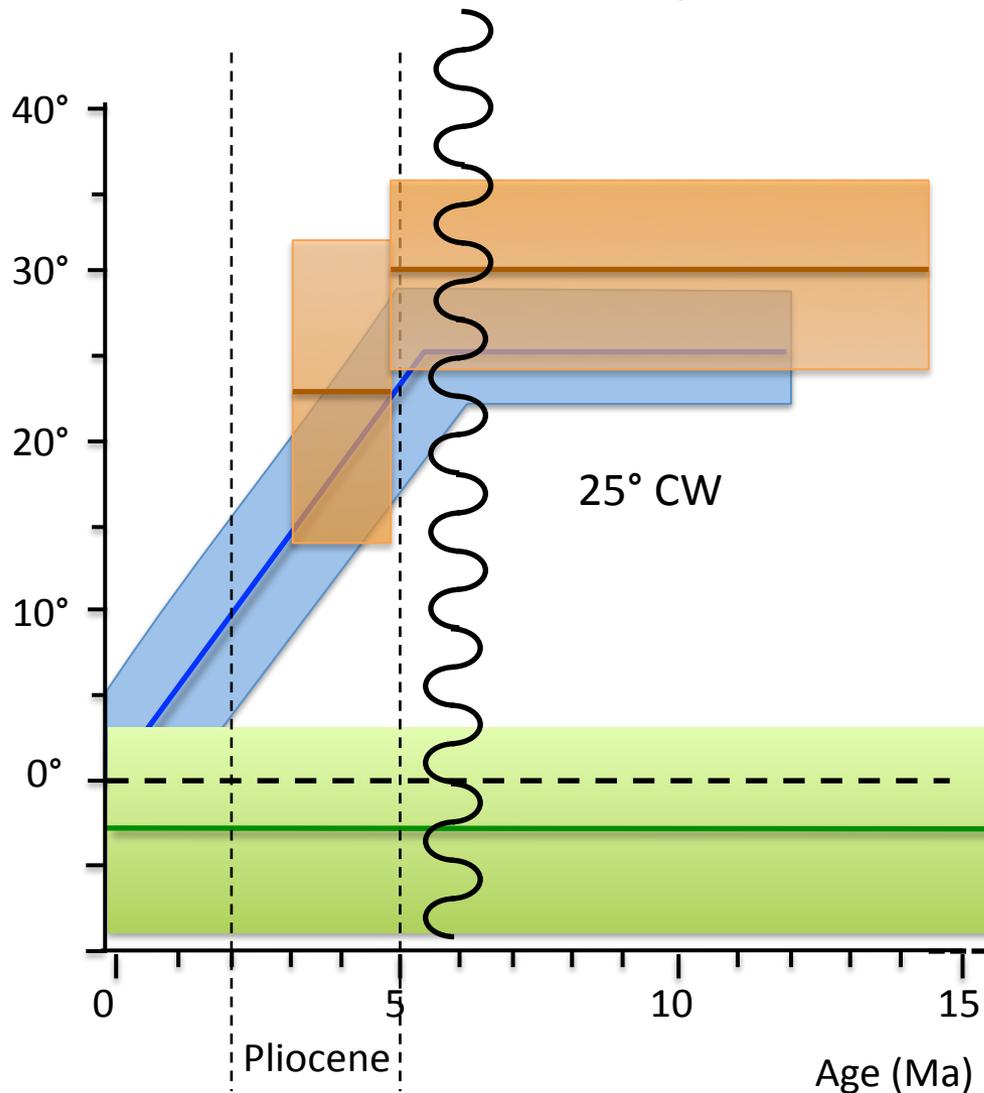
Albania
Regional scale



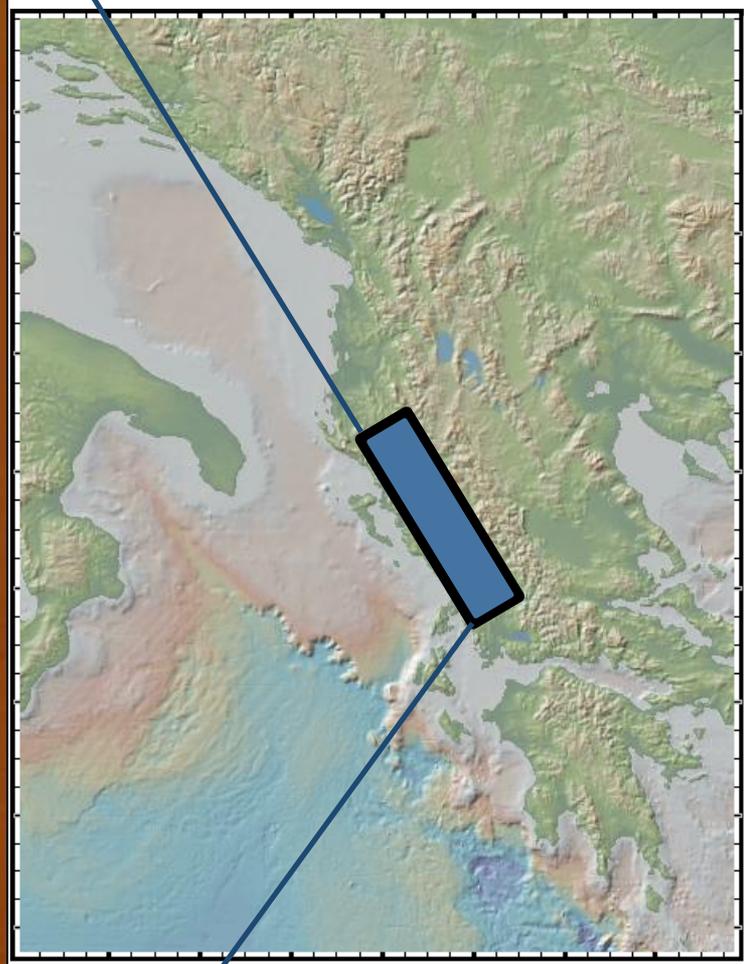
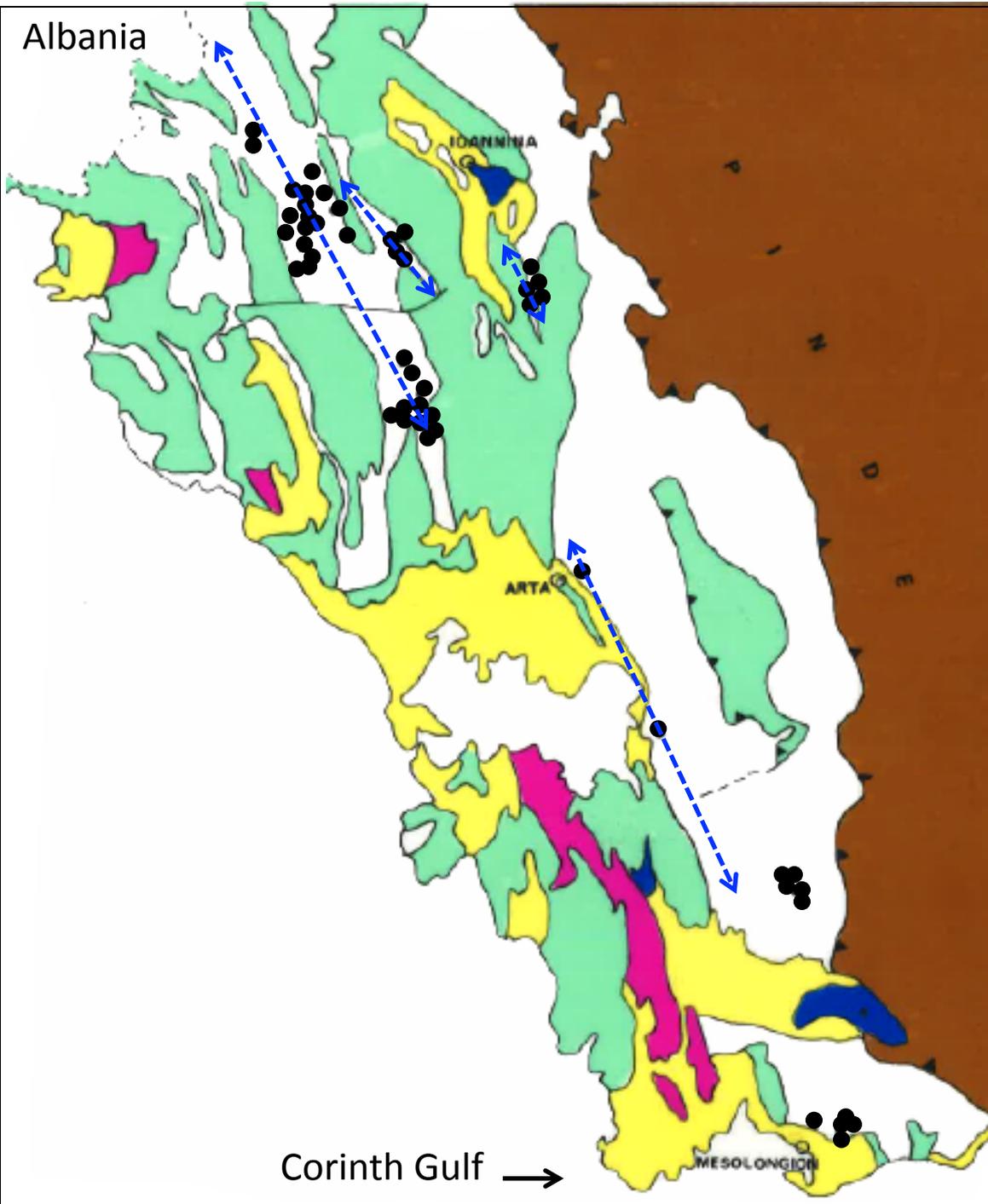
Dinarides (Yougo)
Regional scale



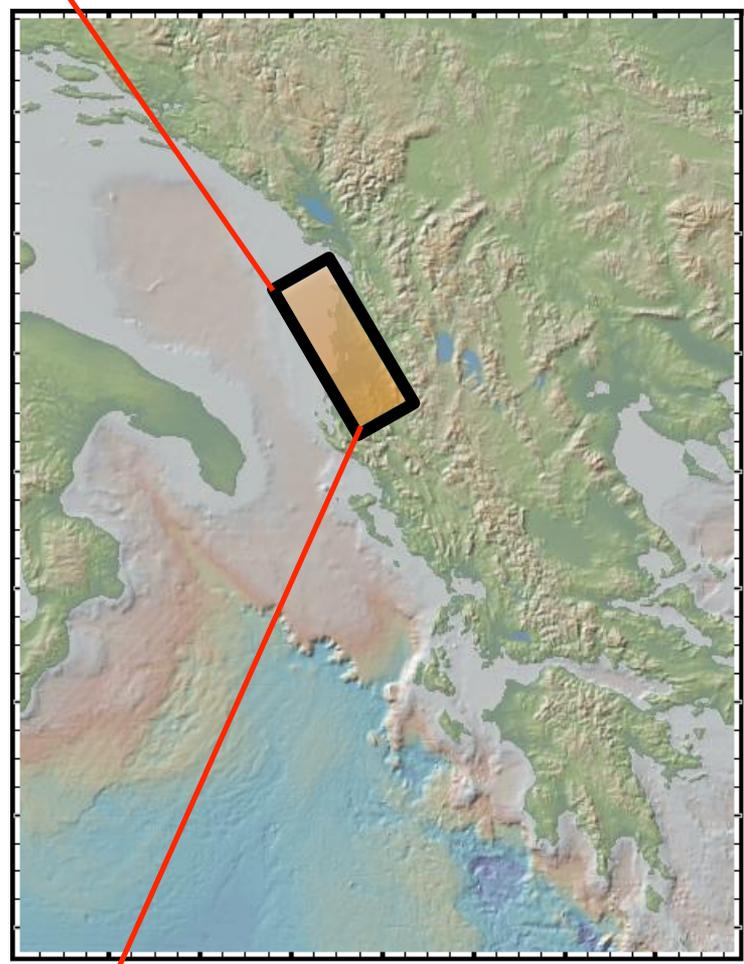
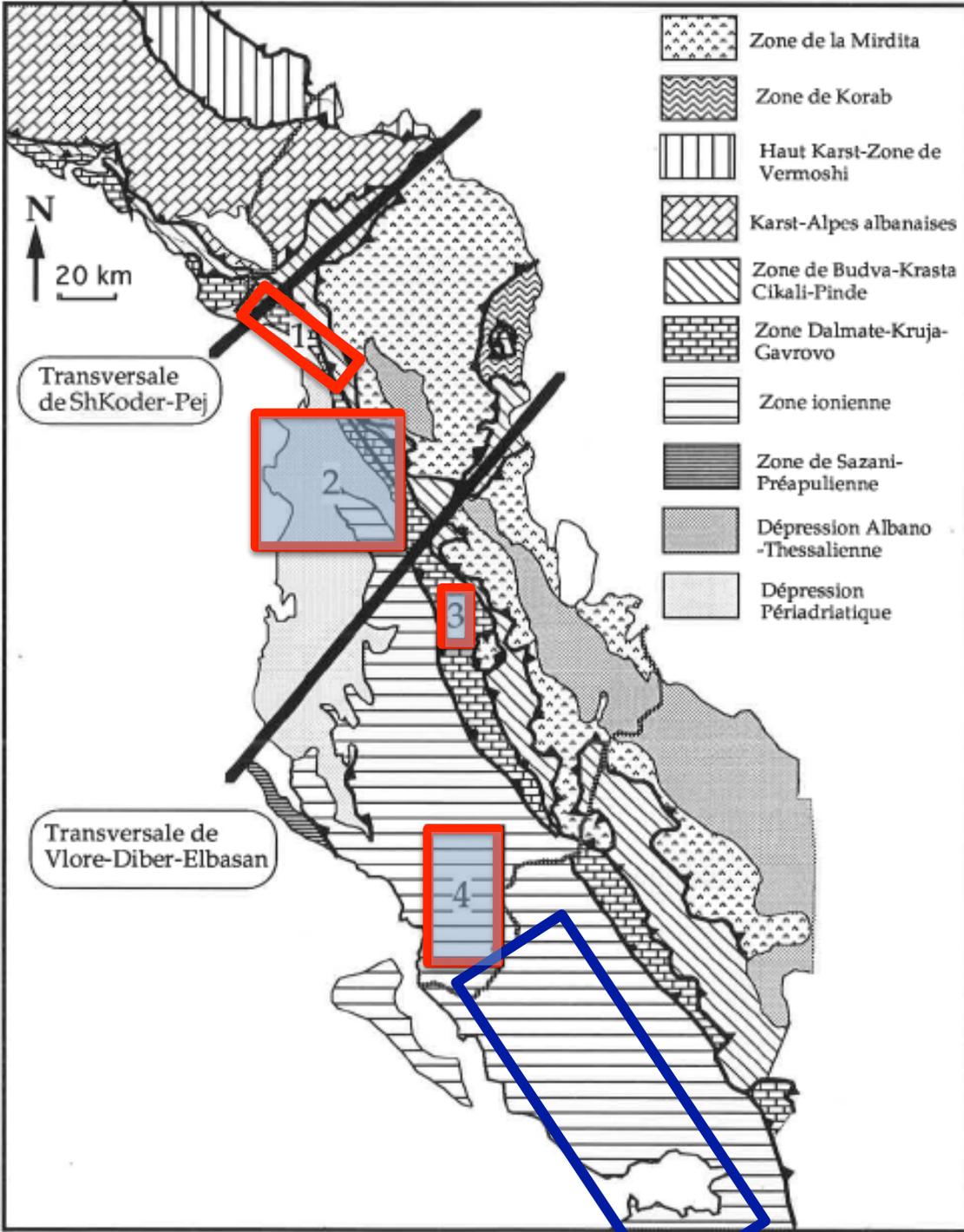
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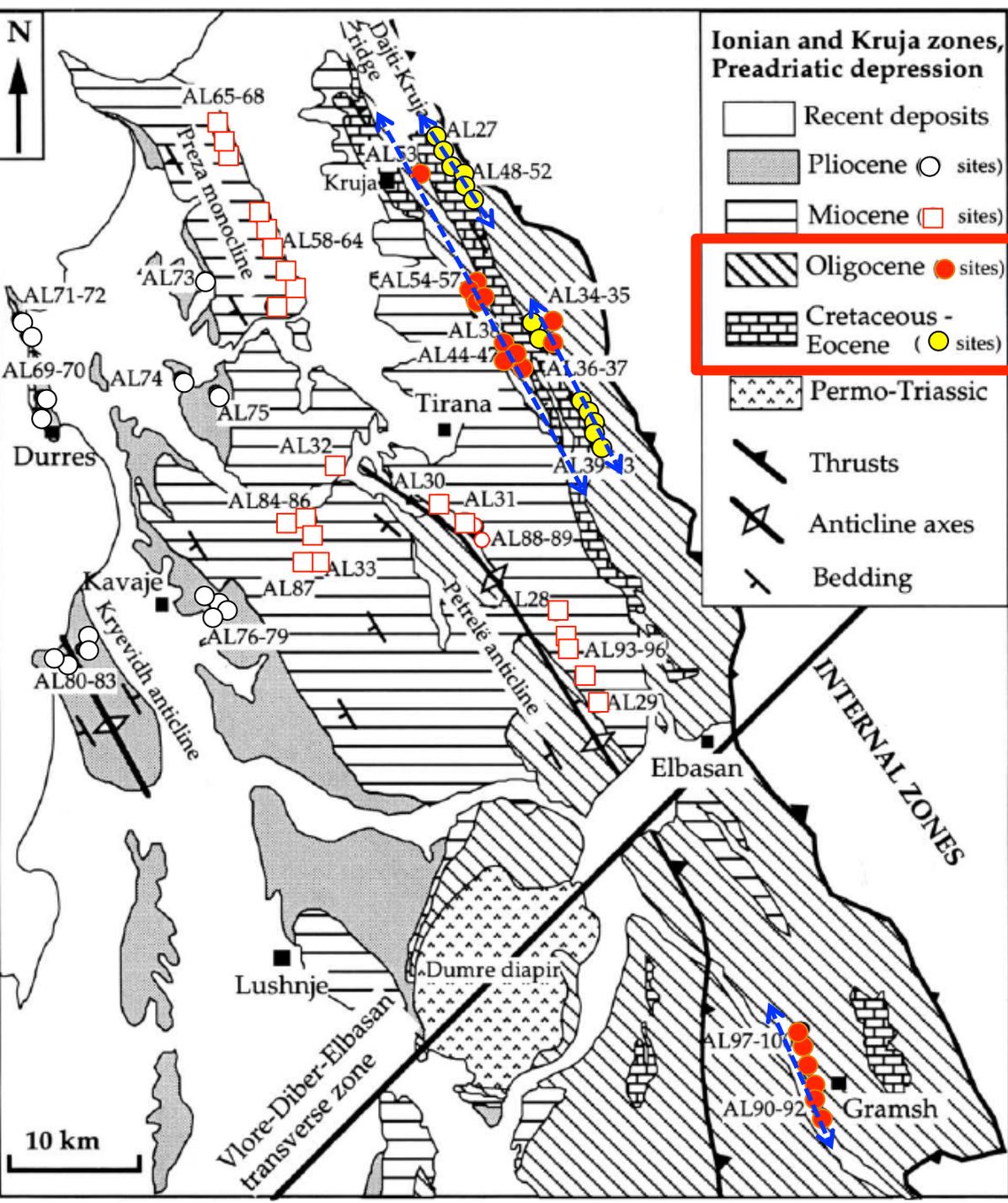
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Eocene – Oligocene formations
(= 50 to 24 Ma)

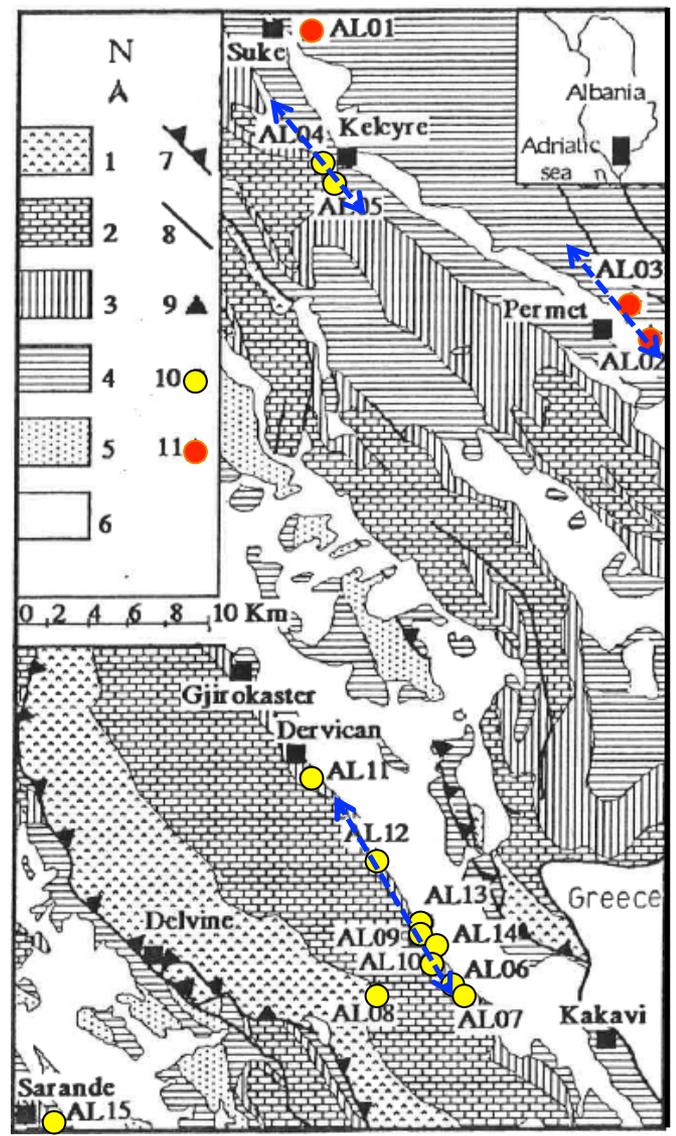


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 (= 50 to 24 Ma)

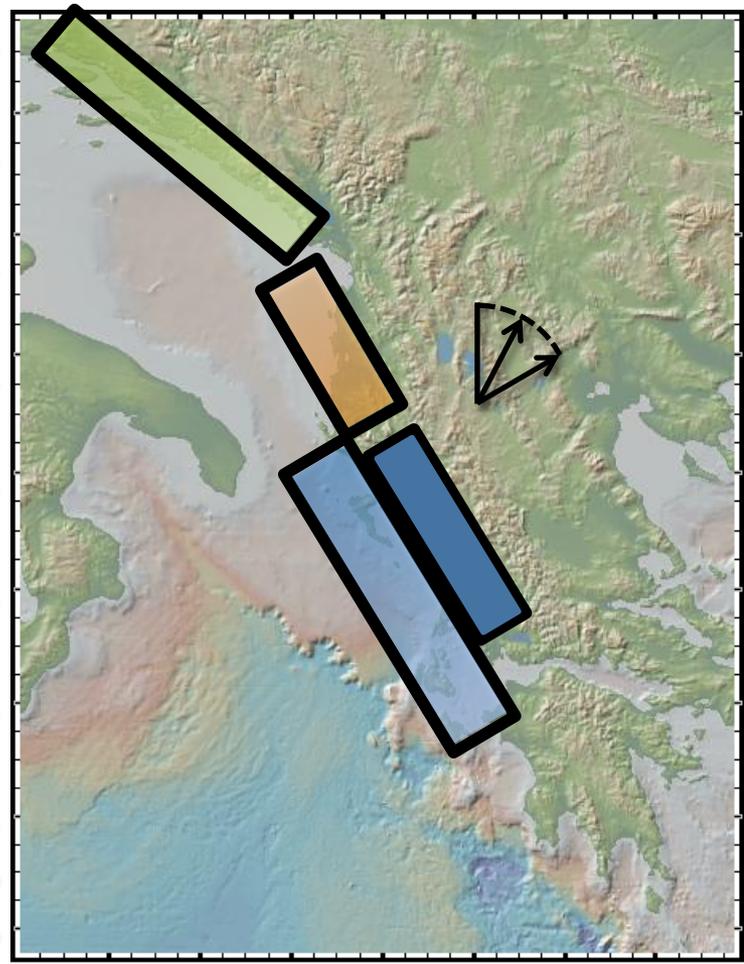
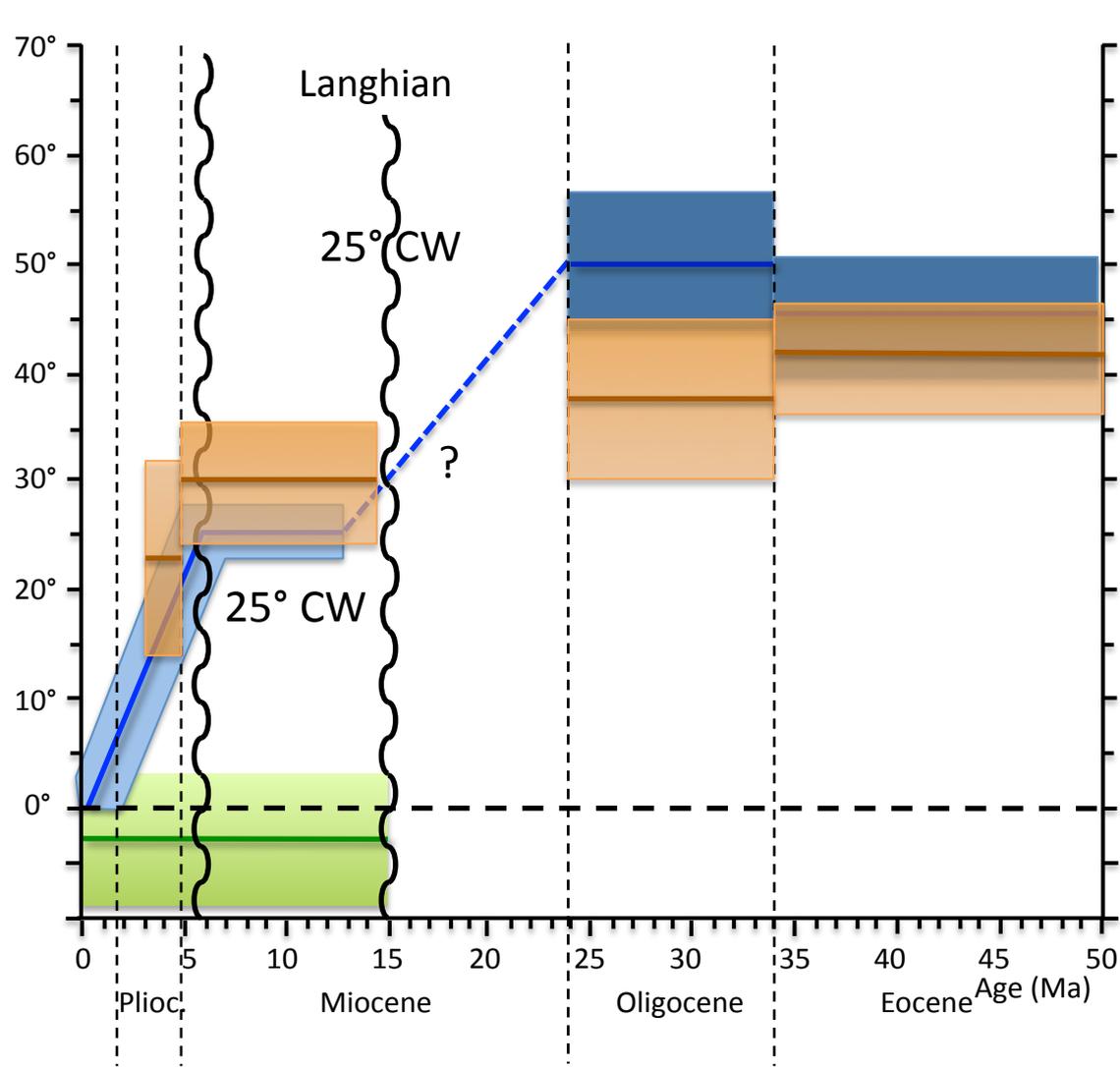


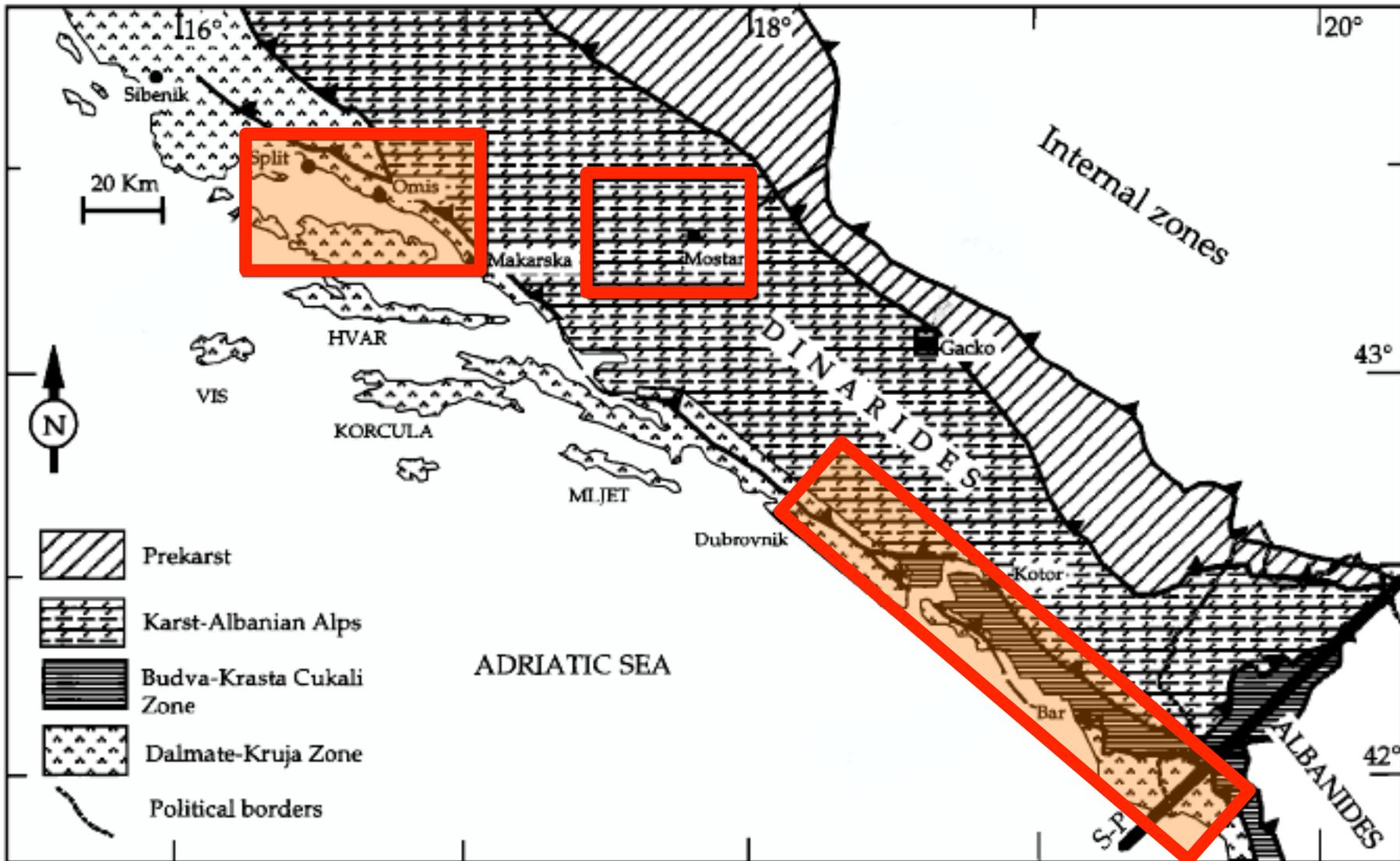
Center and Northern Albania

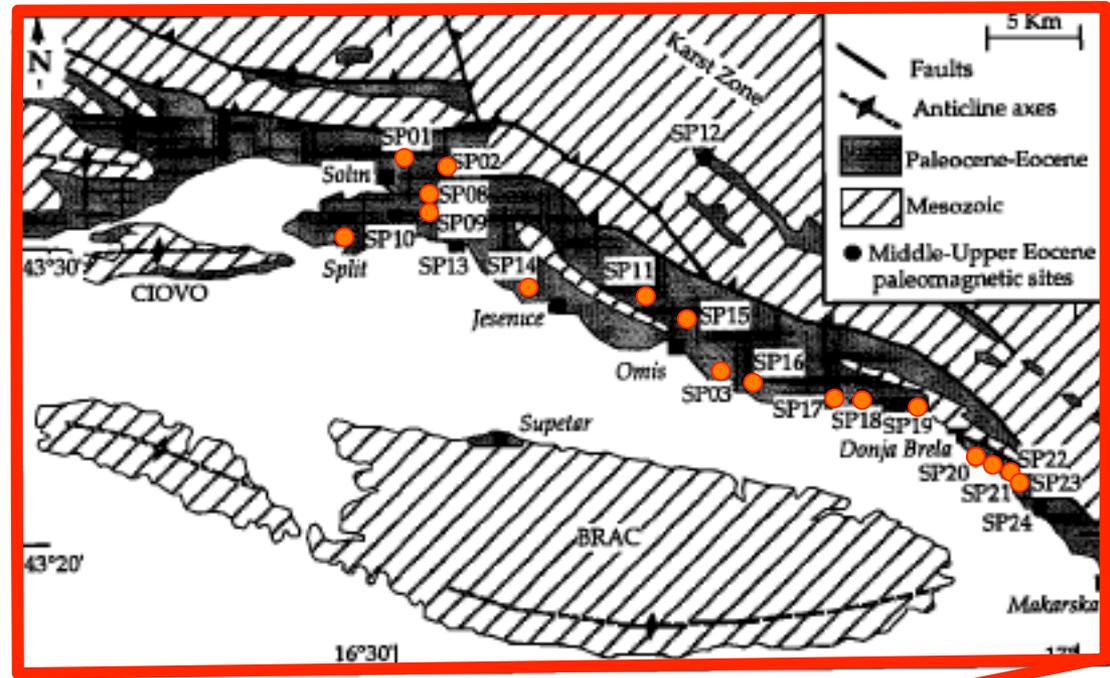
Southern Albania



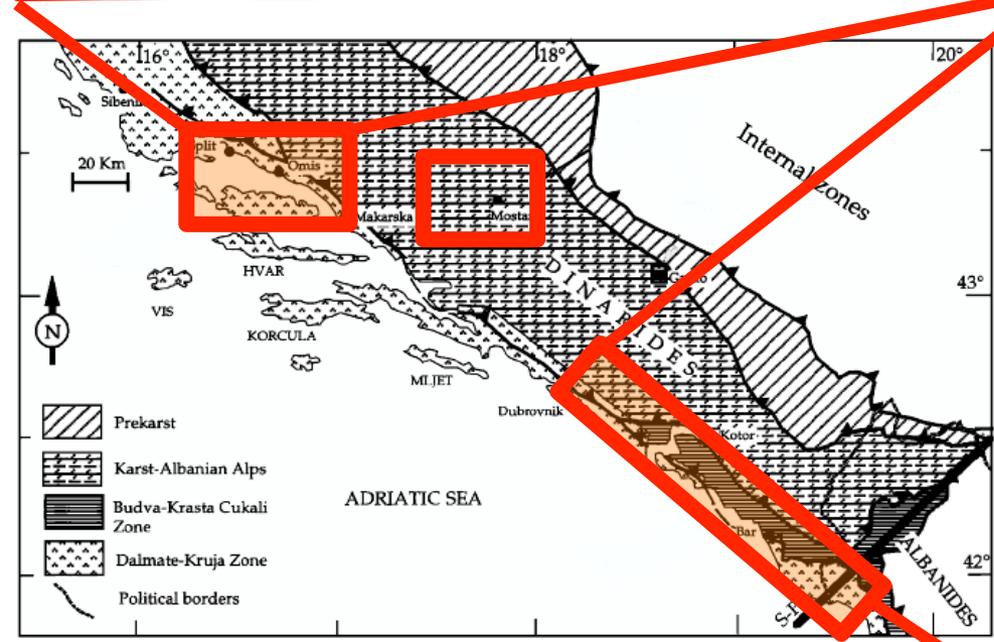
Rotation with respect to Africa



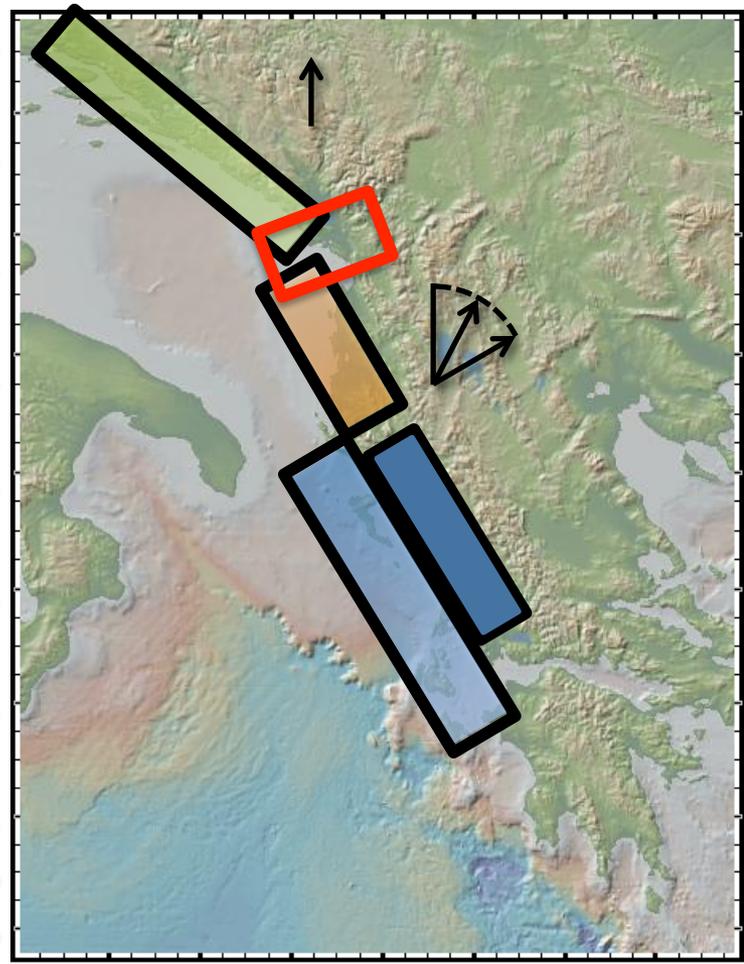
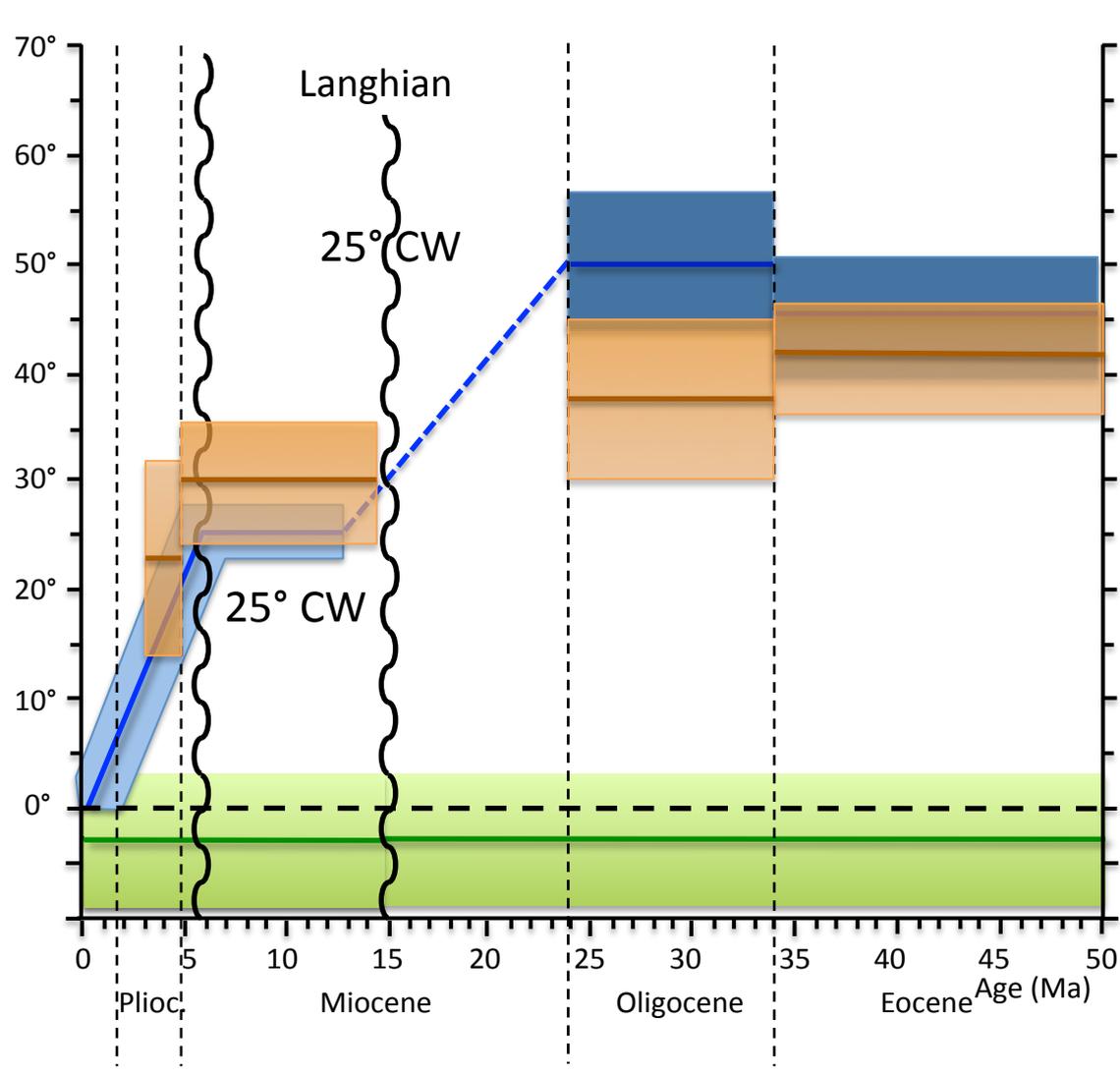


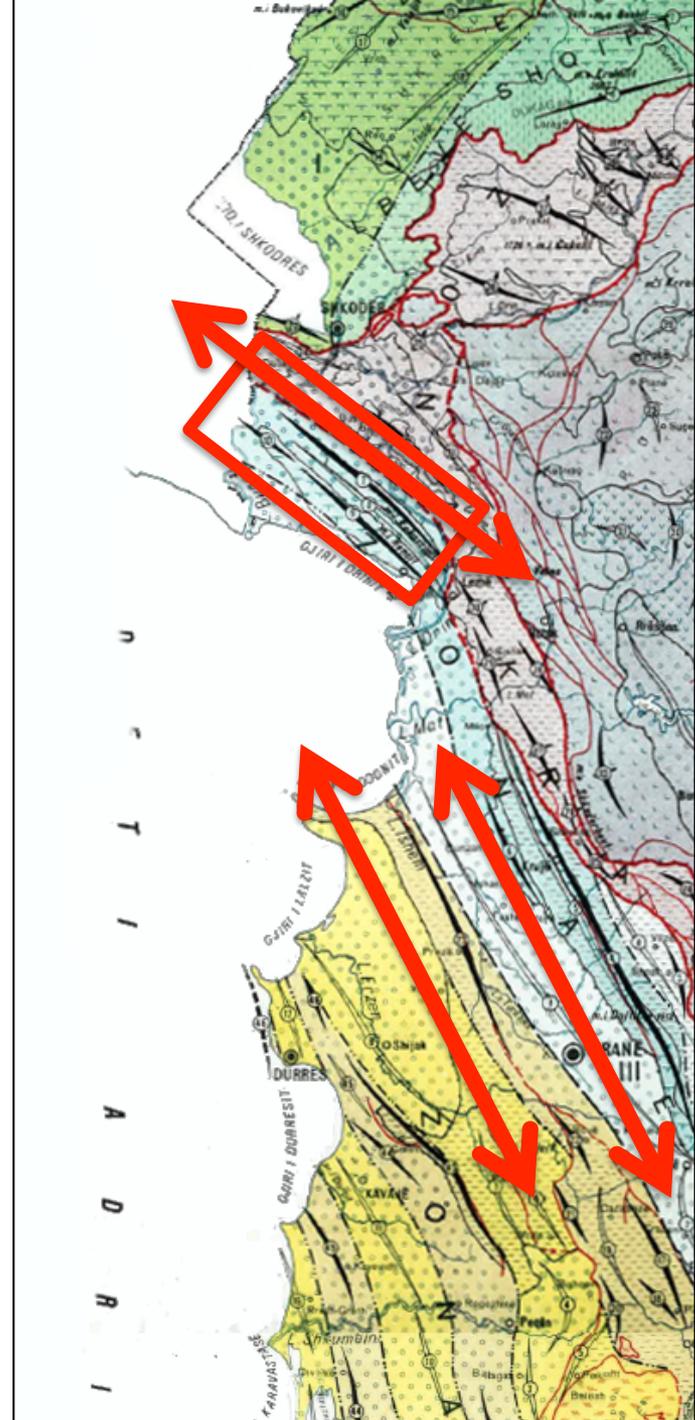
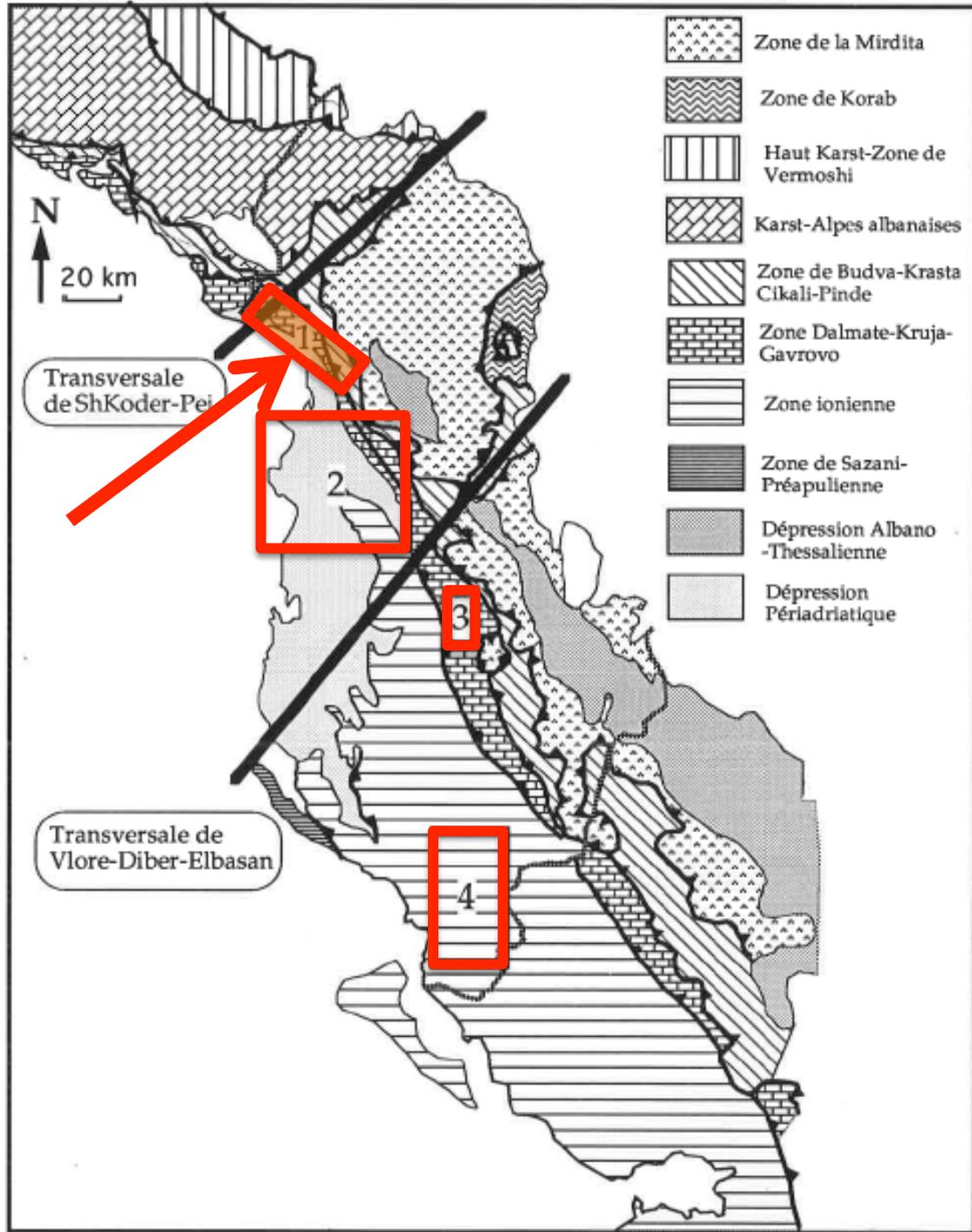


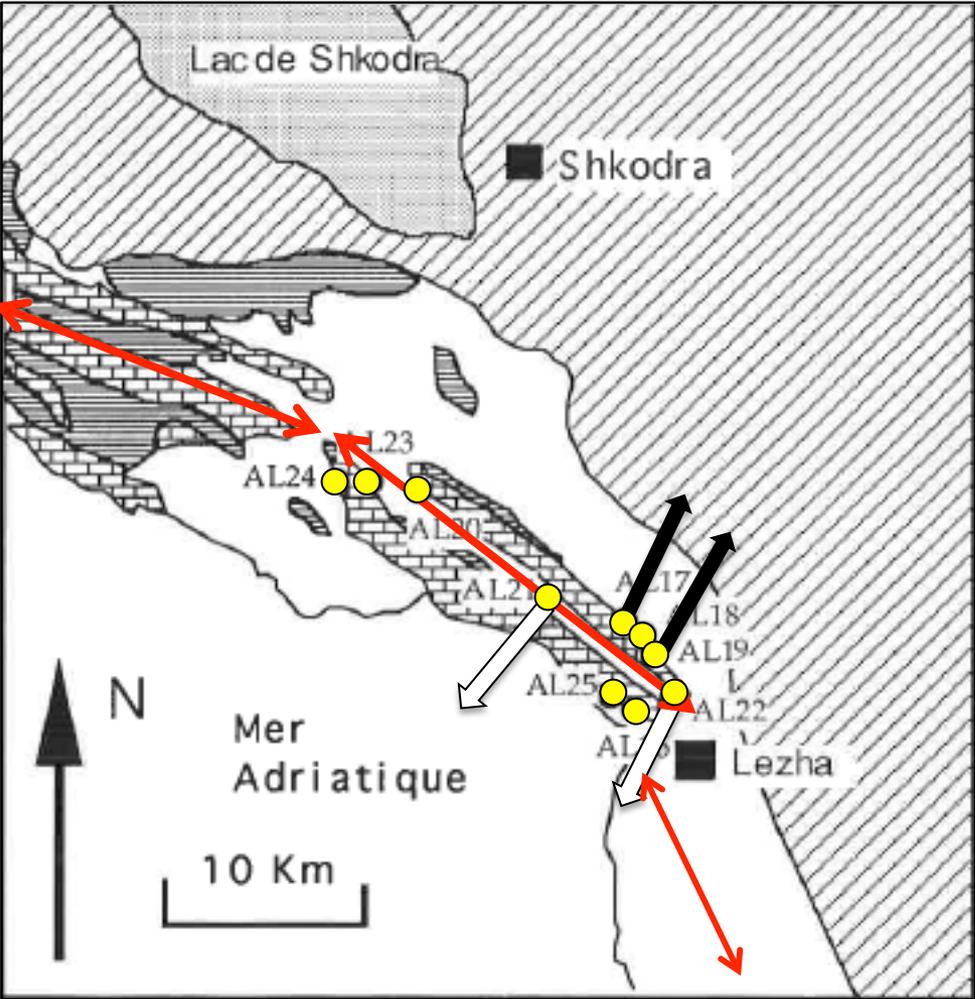
Middle-Upper Eocene sites



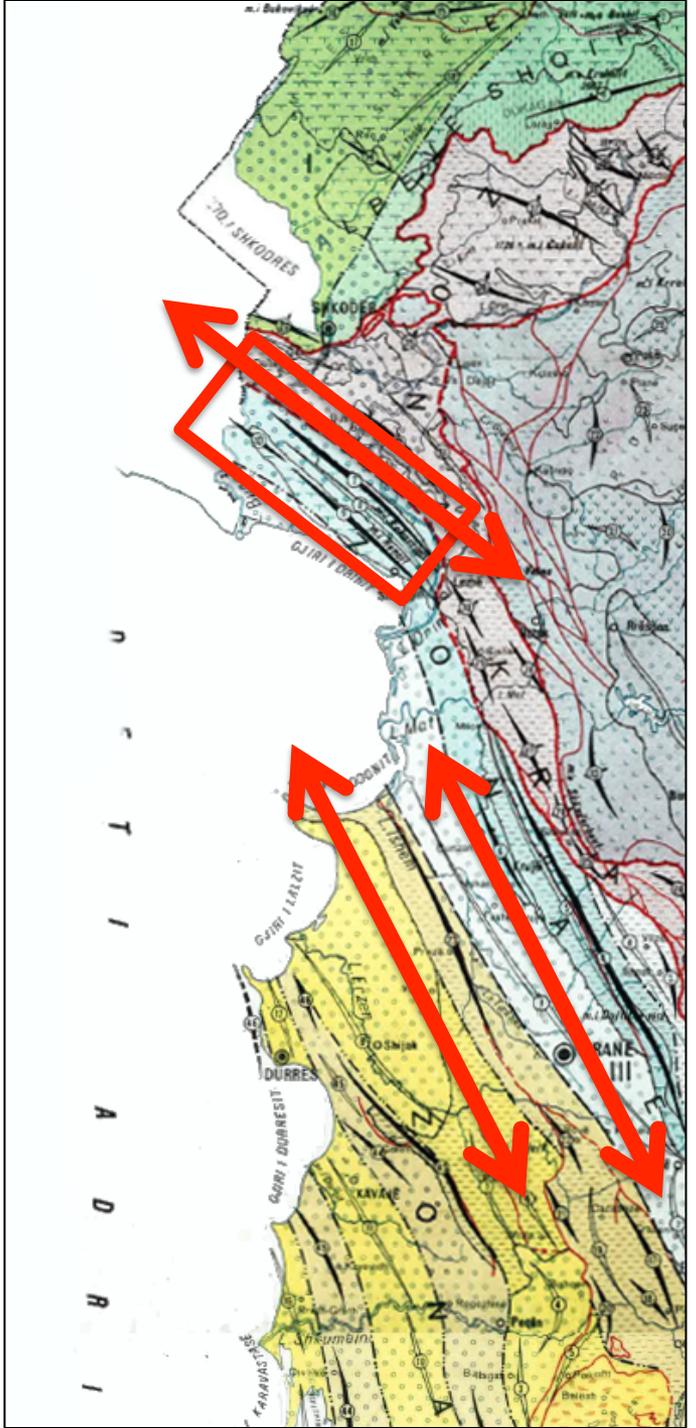
Rotation with respect to Africa

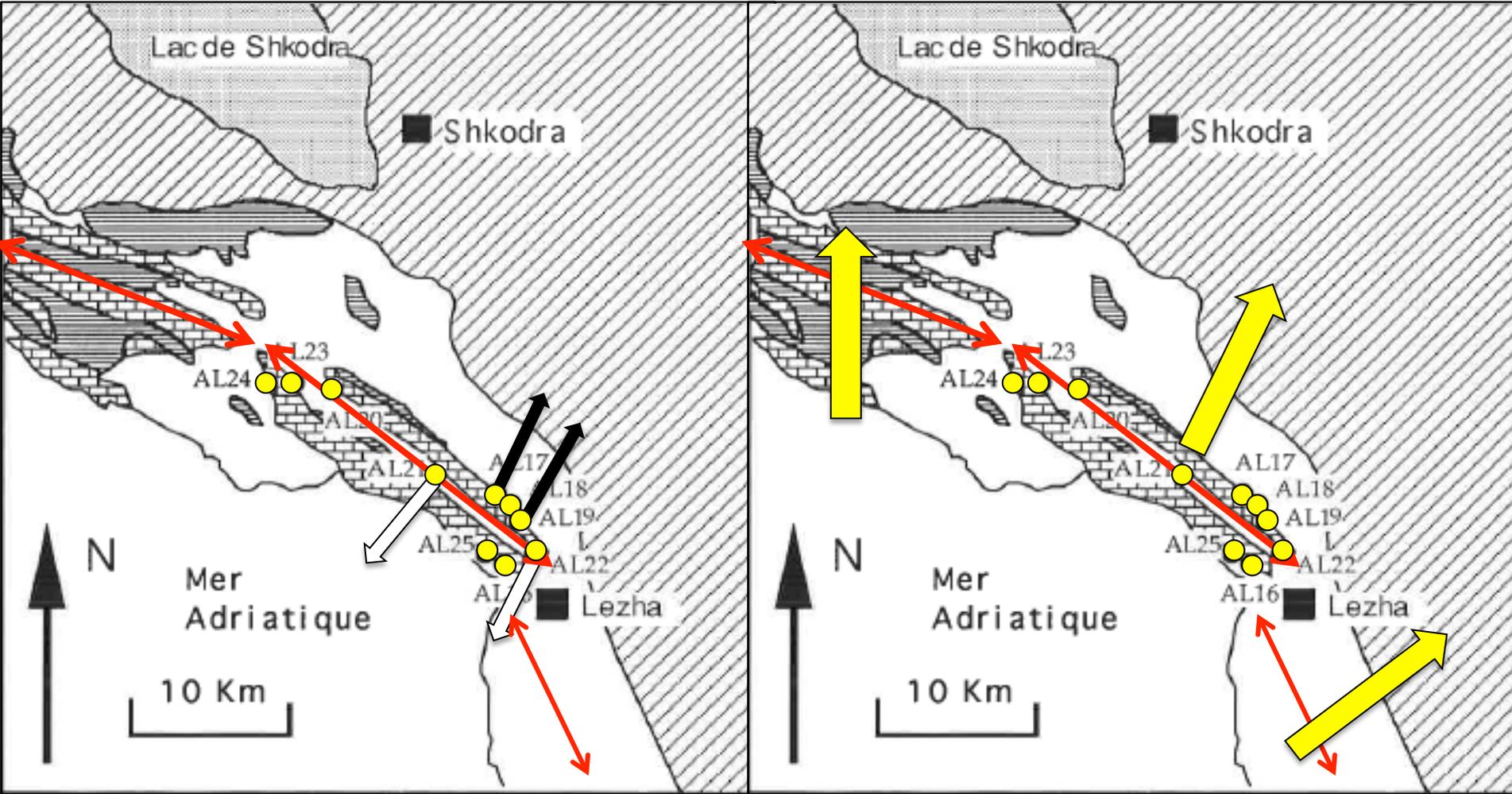




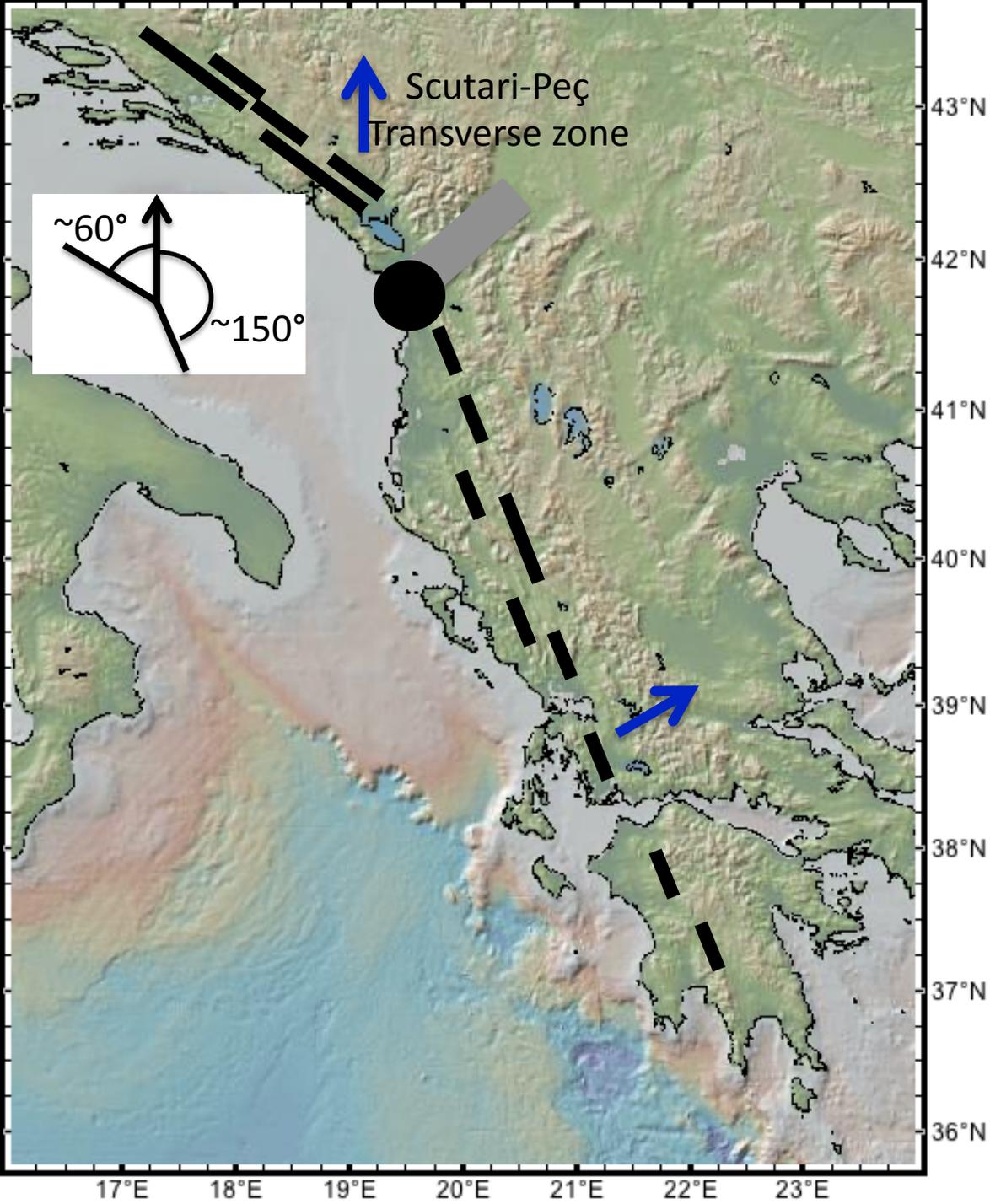


Eocene formations



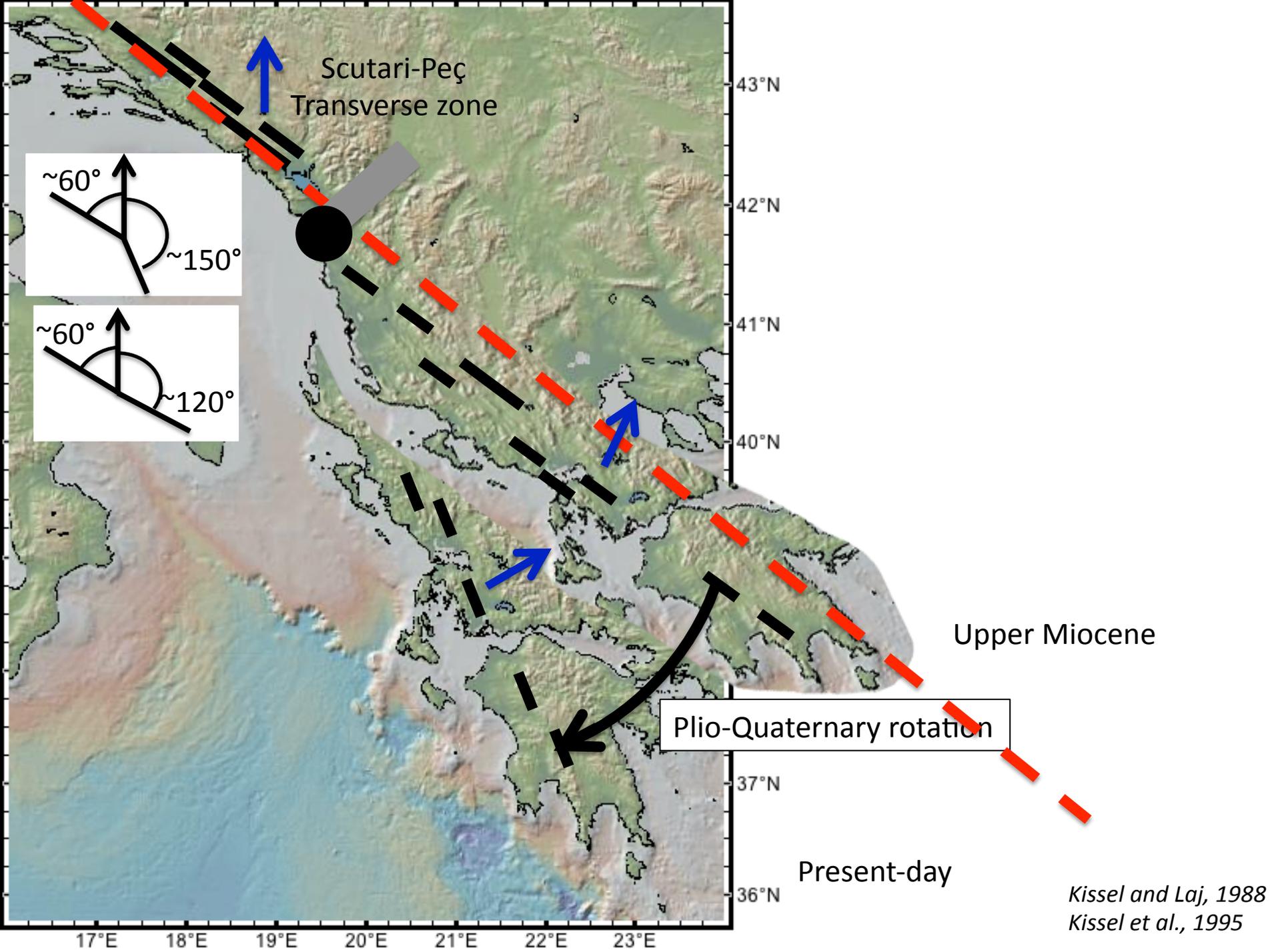


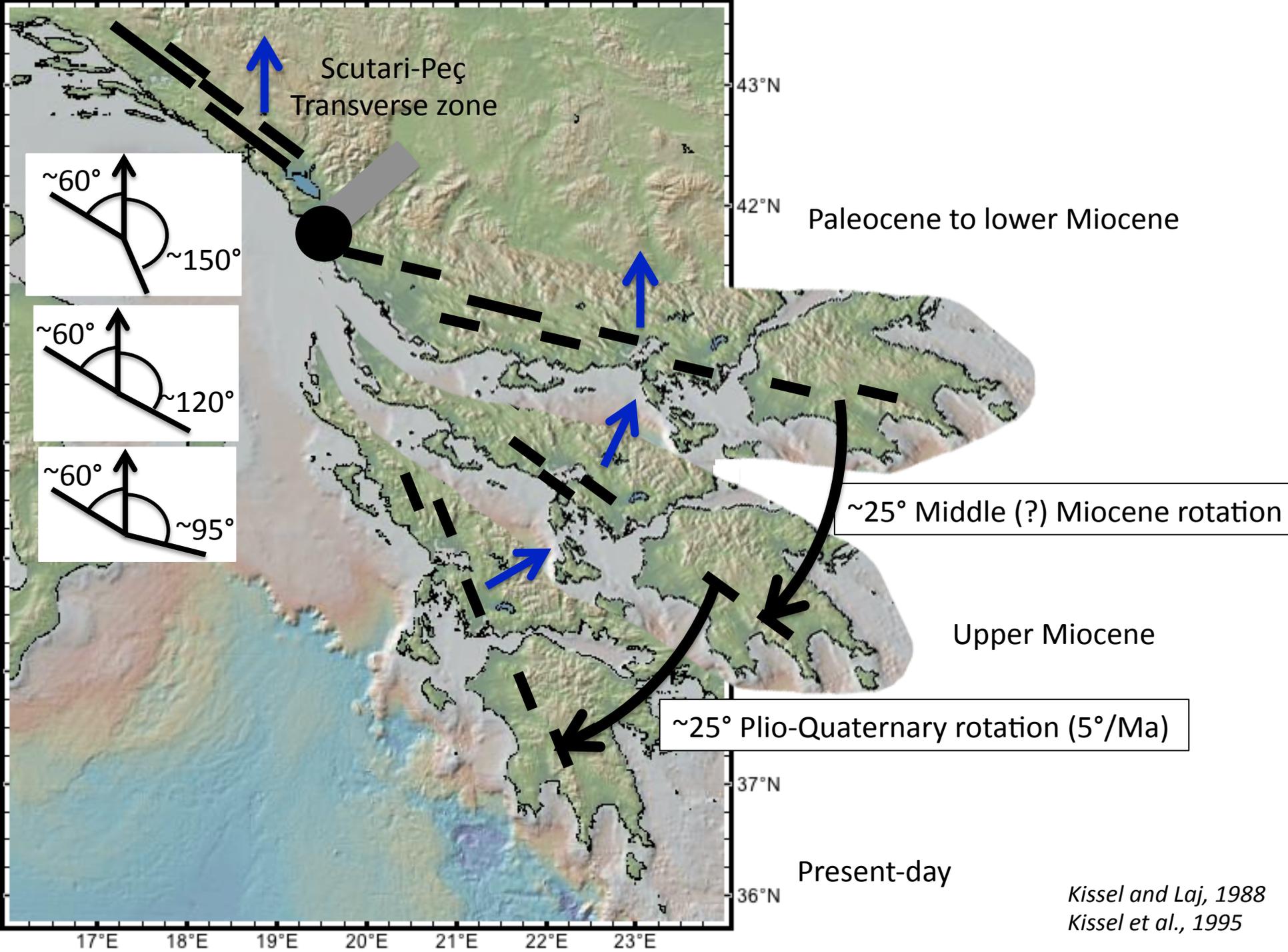
Eocene formations

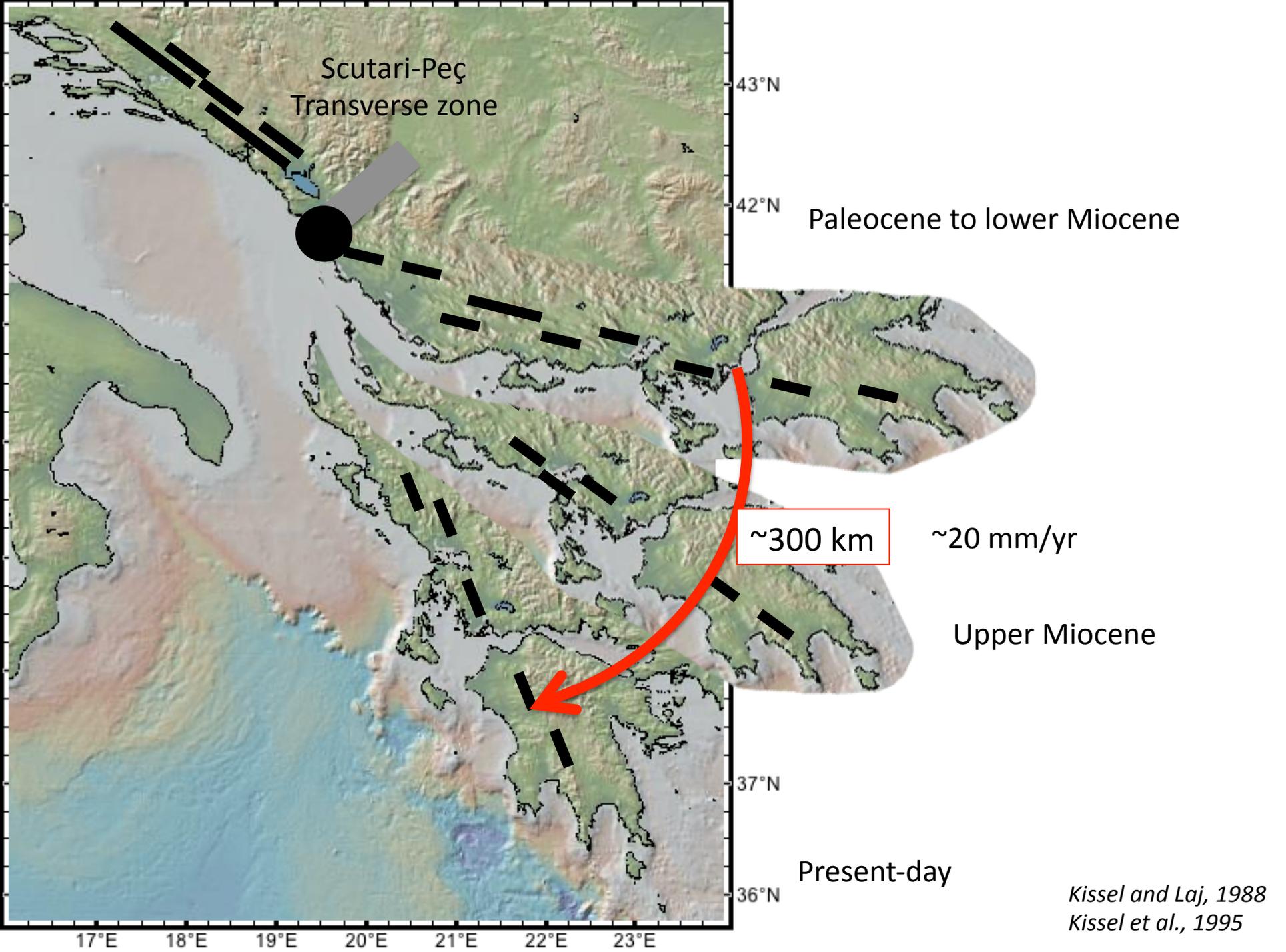


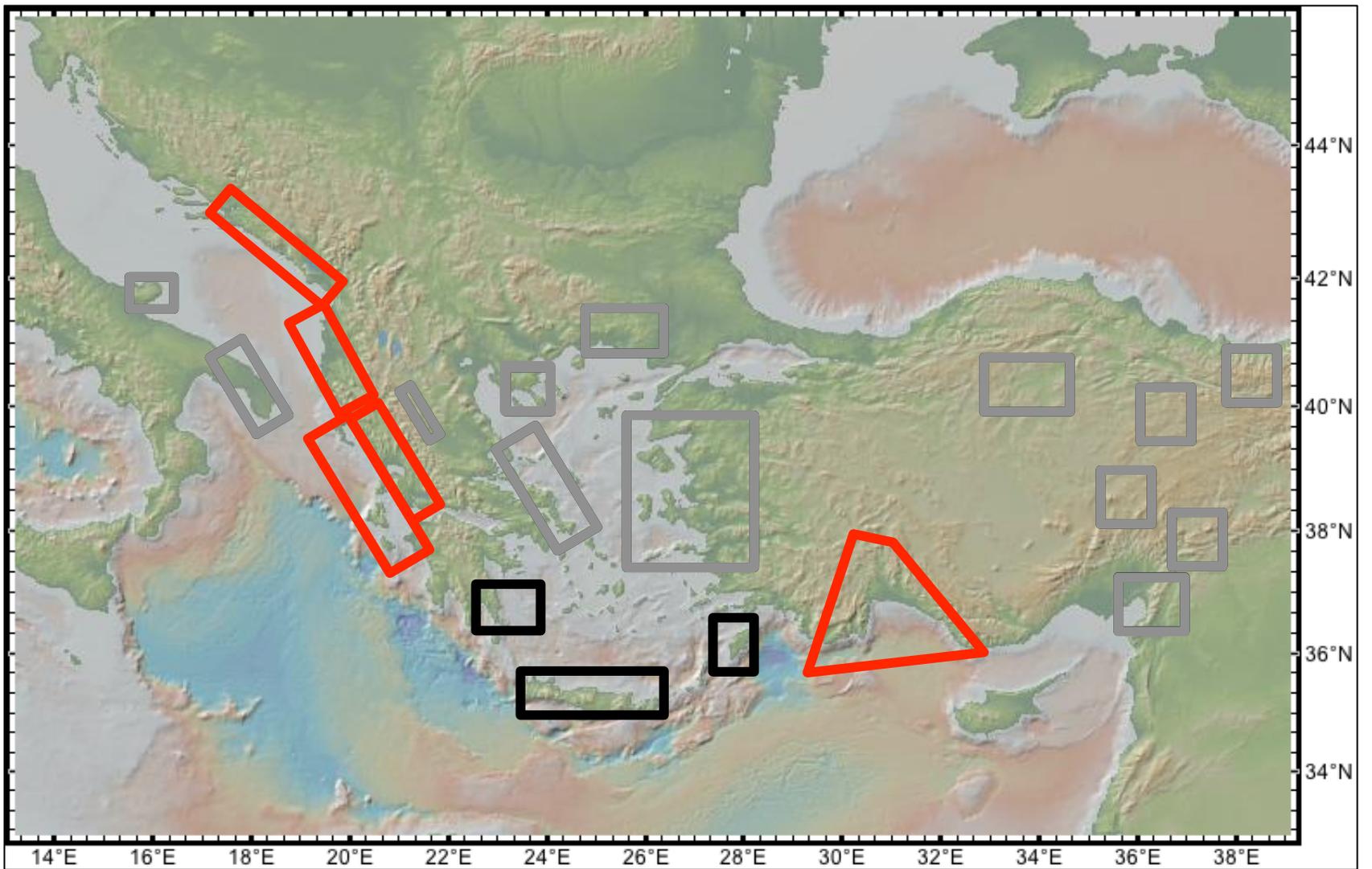
Present-day

Kissel and Laj, 1988
Kissel et al., 1995

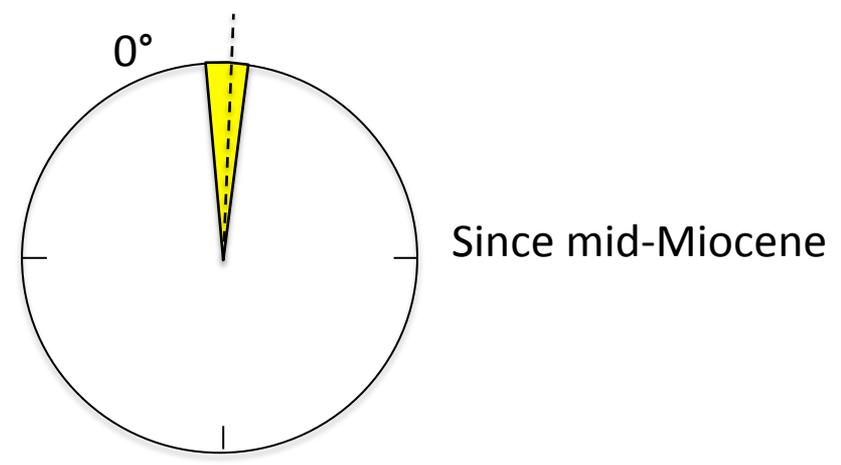
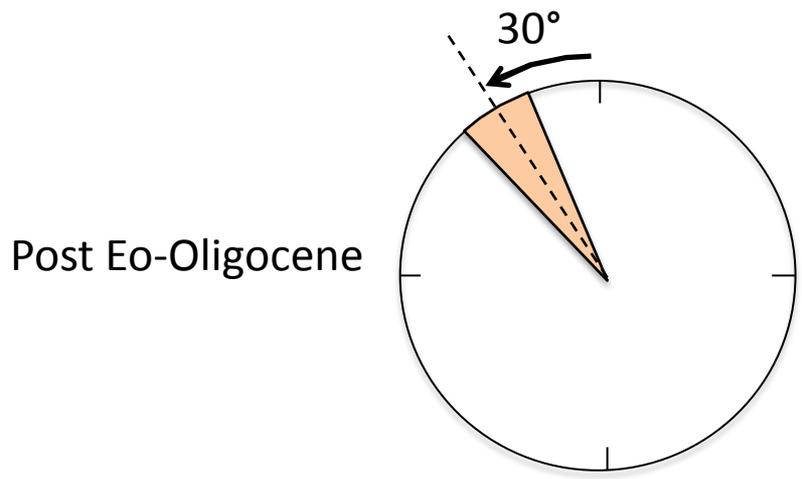
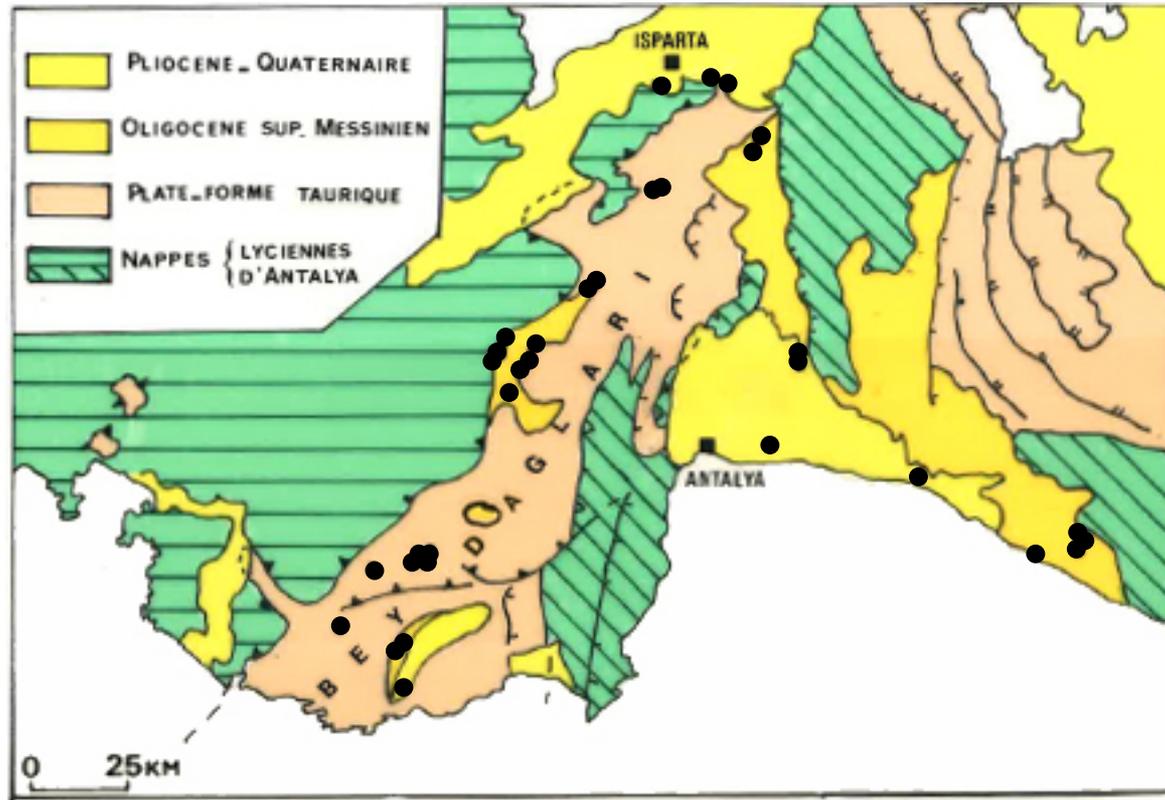


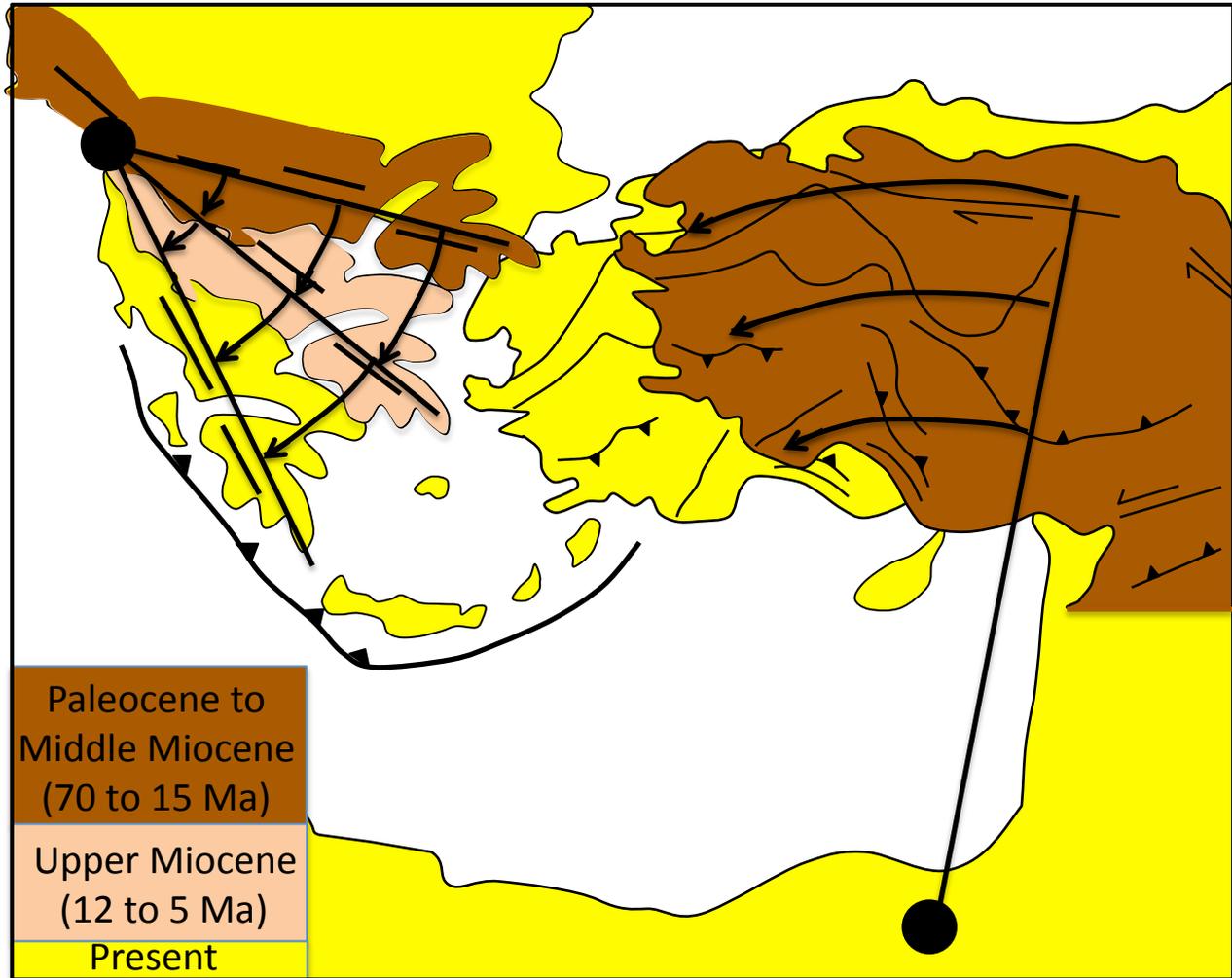






Eastern extremity of the Aegean Arc





εφχαριστο

Merci

Thank you

... Massimo ...

