

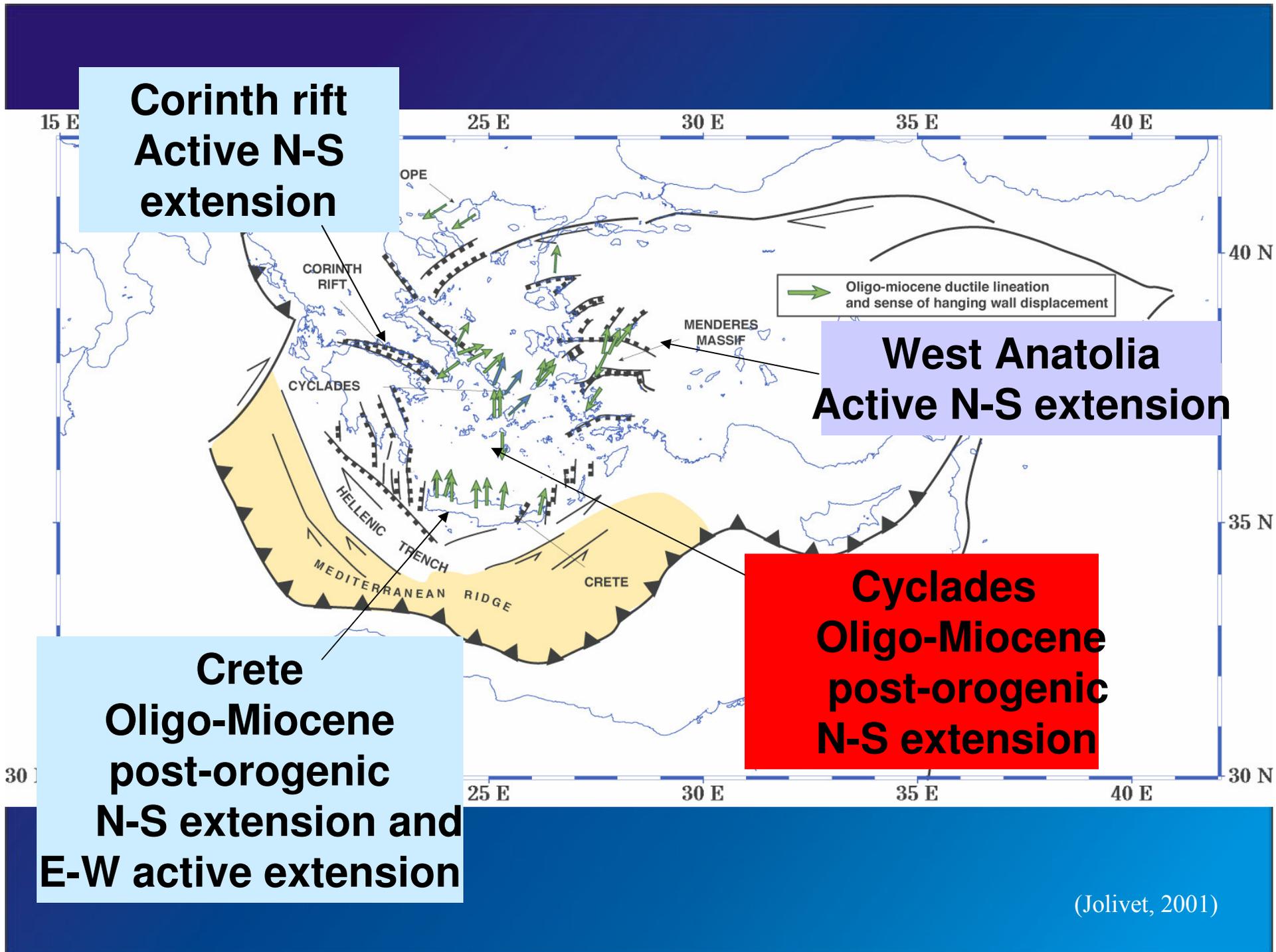
Localisation de la déformation et transition ductile-cassant dans une croûte continentale en extension post-orogénique : Exemple des Cyclades

Olivier LACOMBE

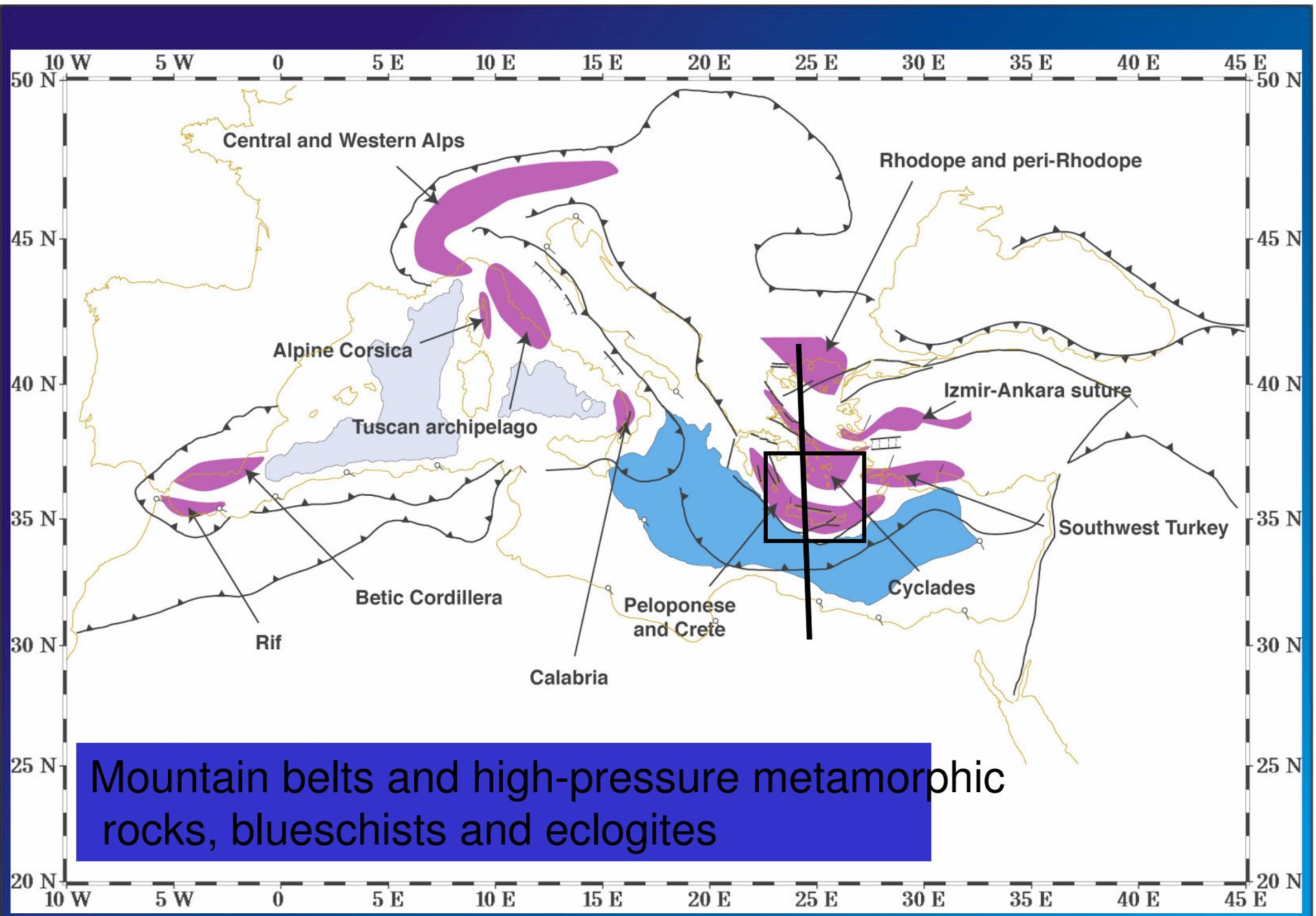
Laboratoire de Tectonique, UMR CNRS 7072, Université Pierre et Marie Curie, Paris, France



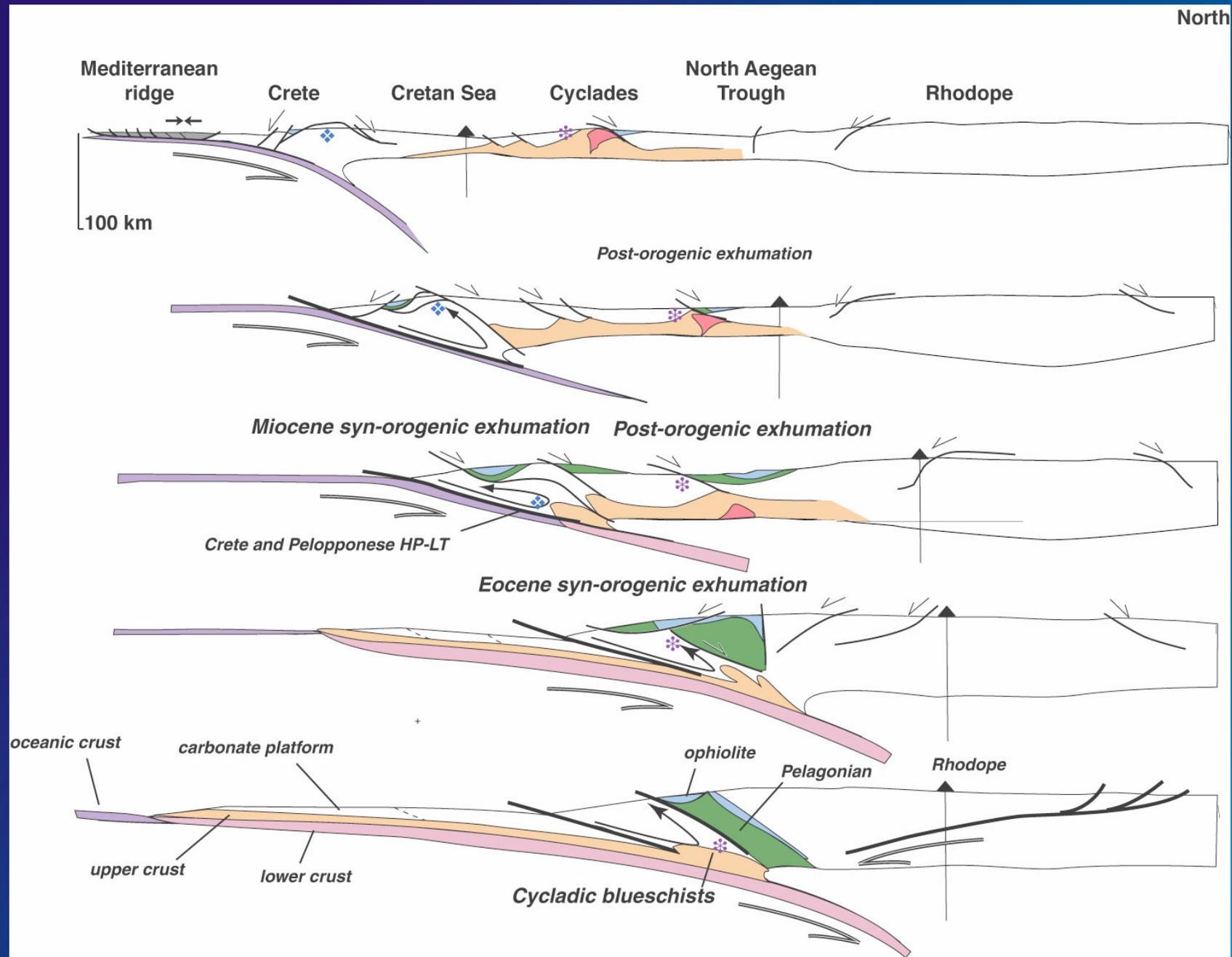
Géodynamique et contexte tectonique de l'Egée



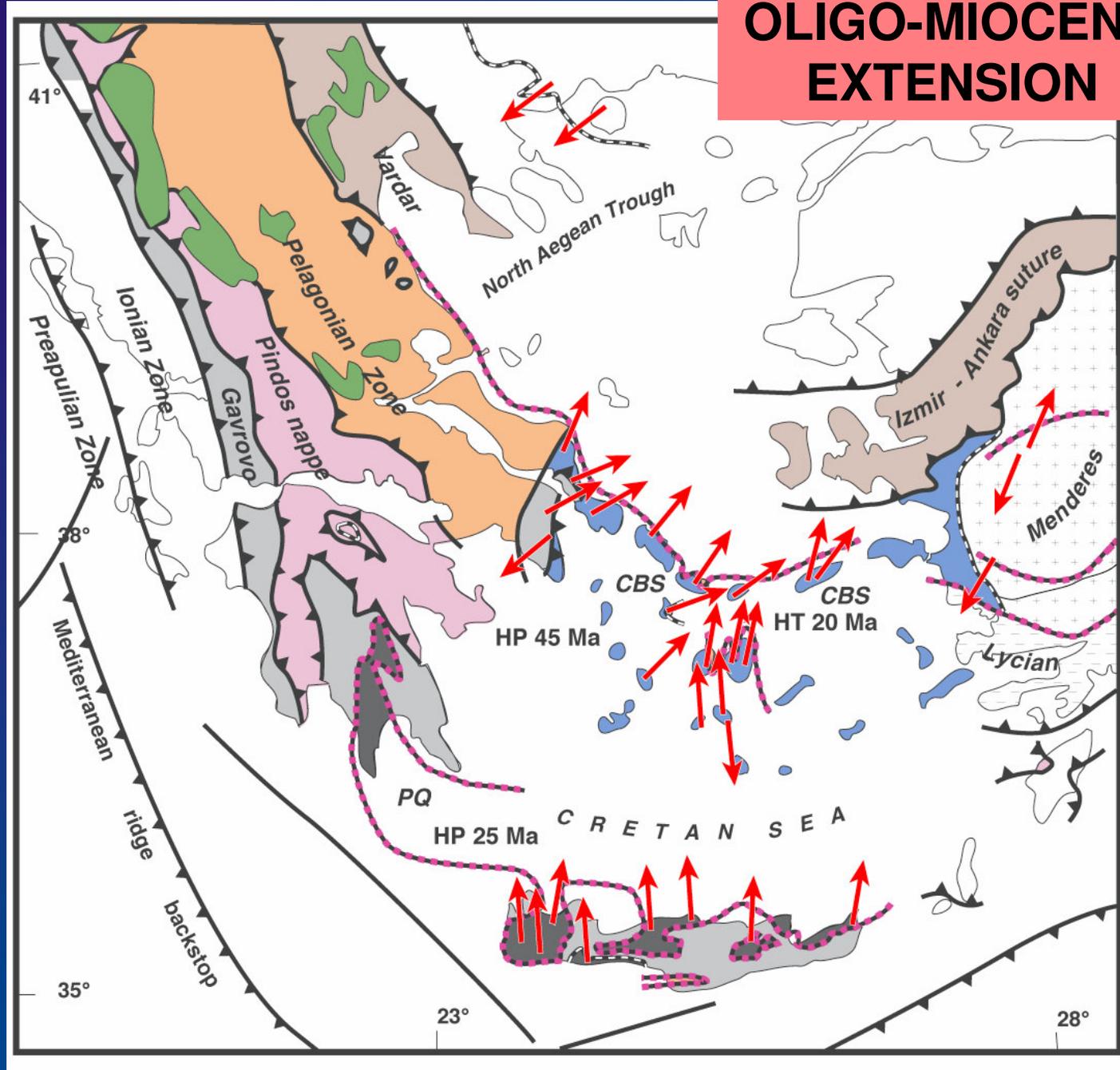
(Jolivet, 2001)



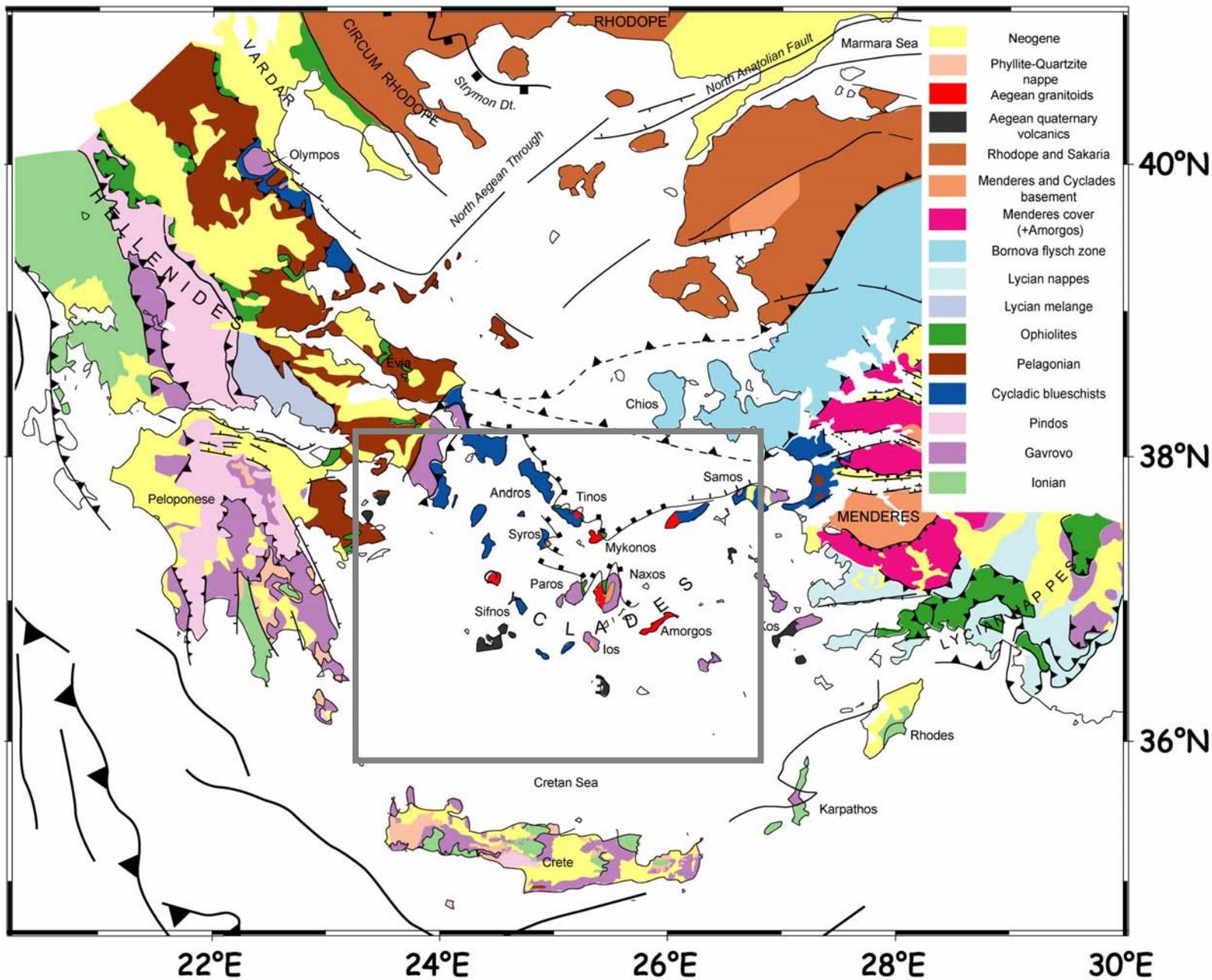
(Jolivet et al., 2003)



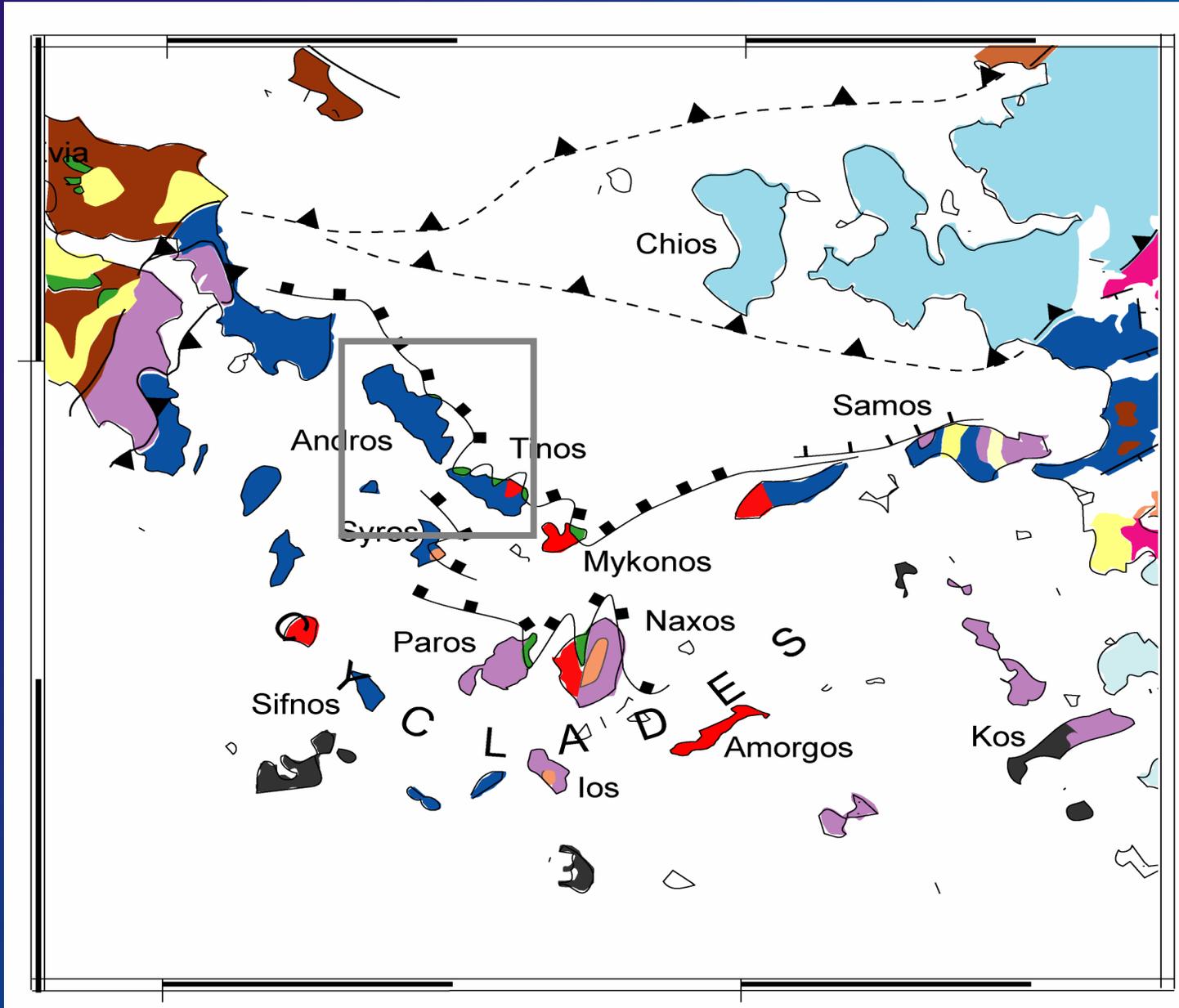
OLIGO-MIOCENE EXTENSION



(Courtesy of L. Jolivet)

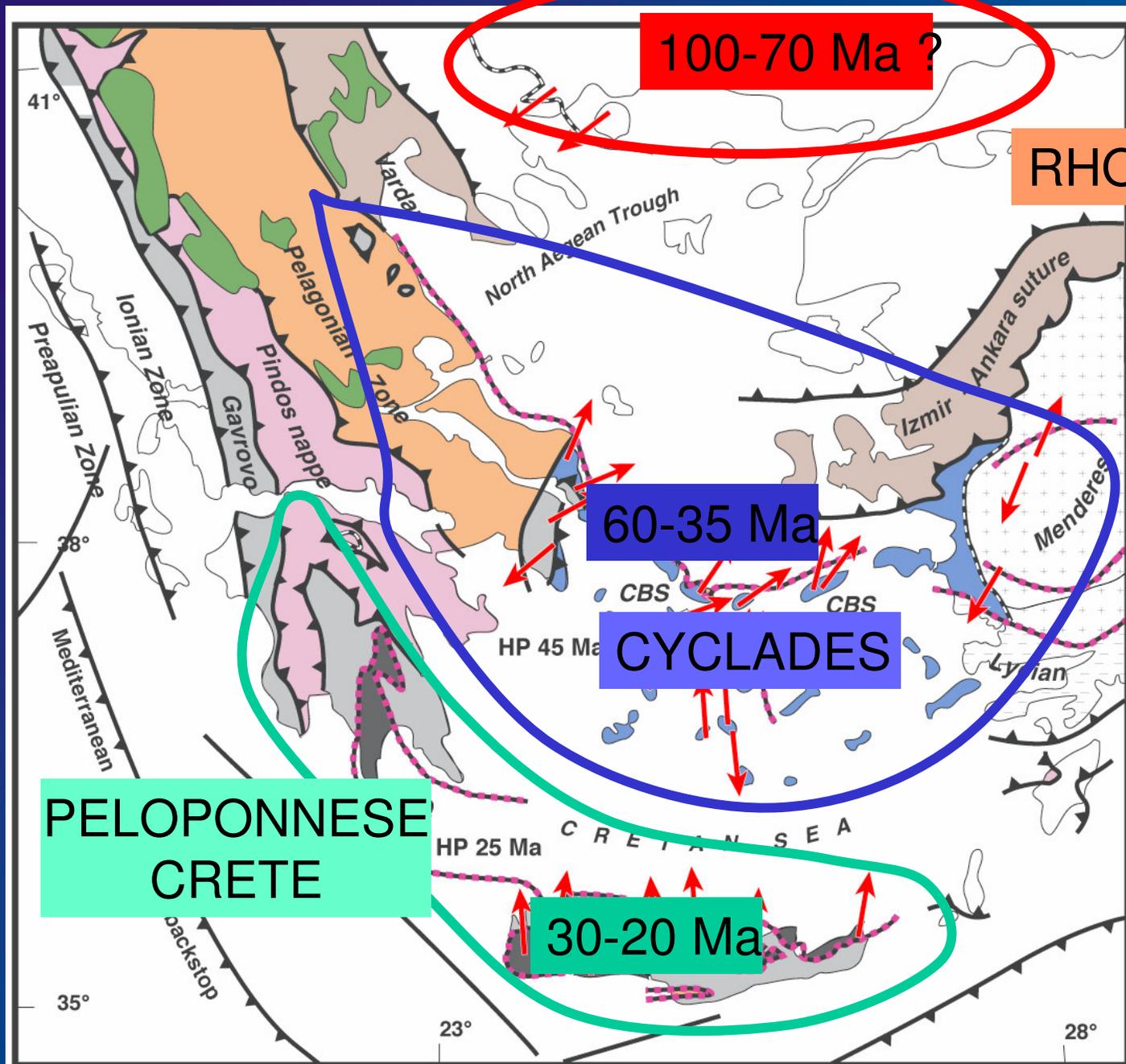


(Courtesy of L. Jolivet)



(Courtesy of L. Jolivet)

Age of HP metamorphism



100-70 Ma ?

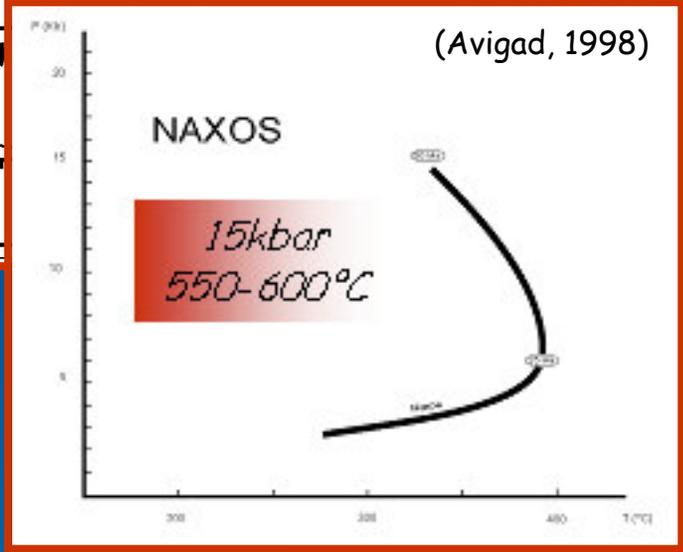
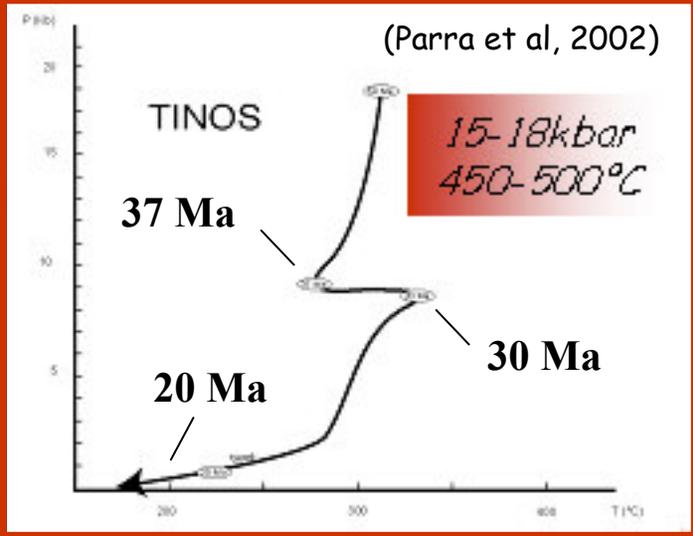
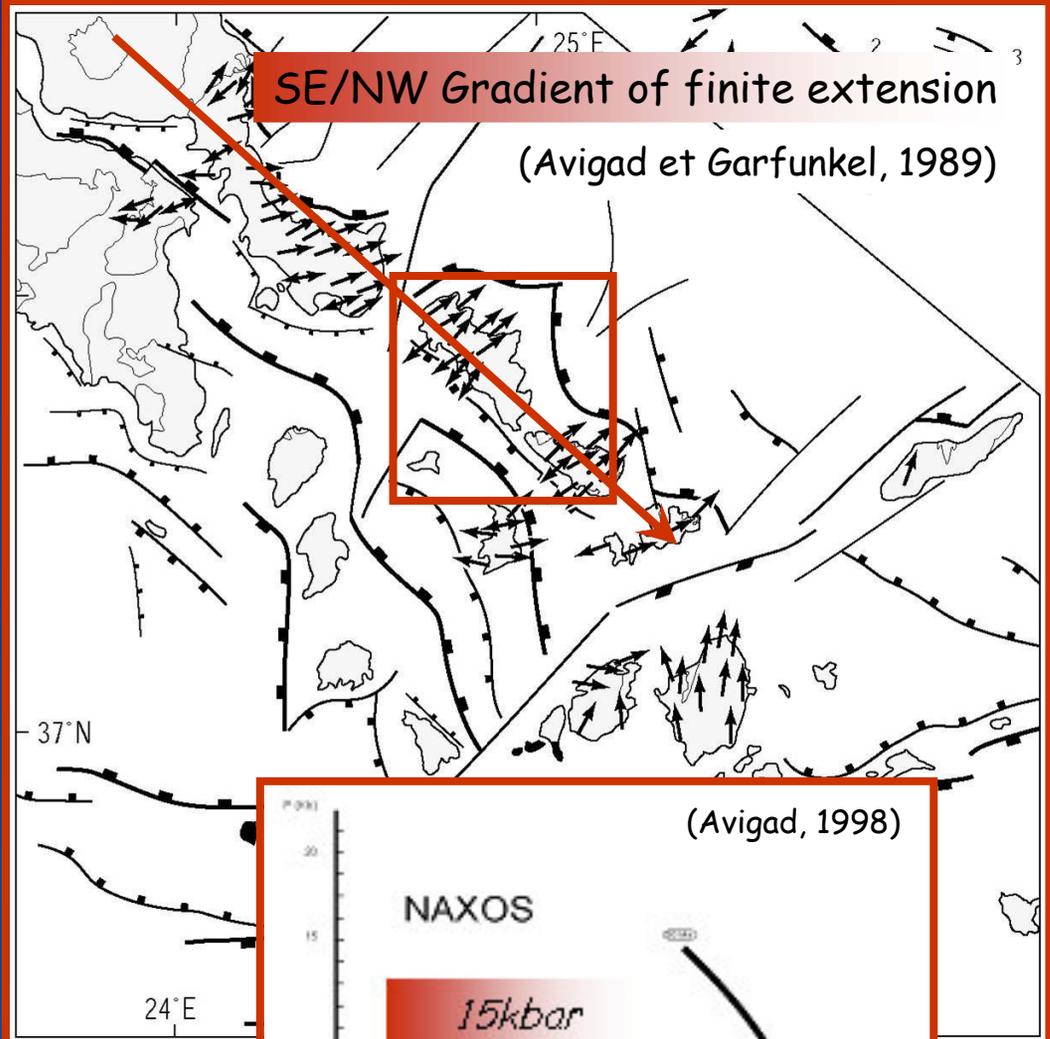
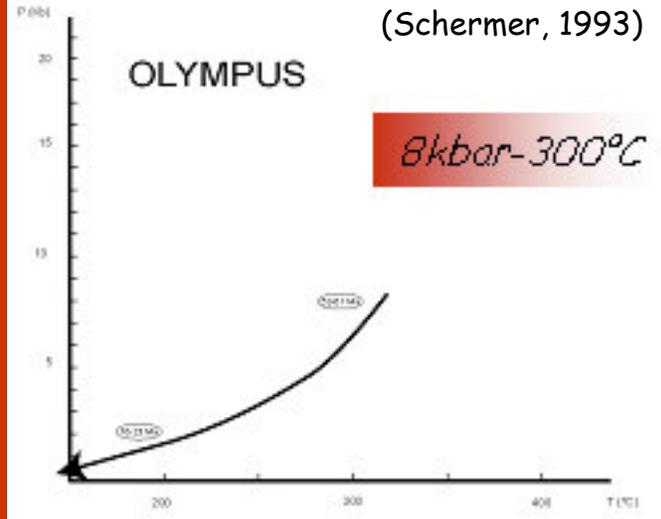
RHODOPE

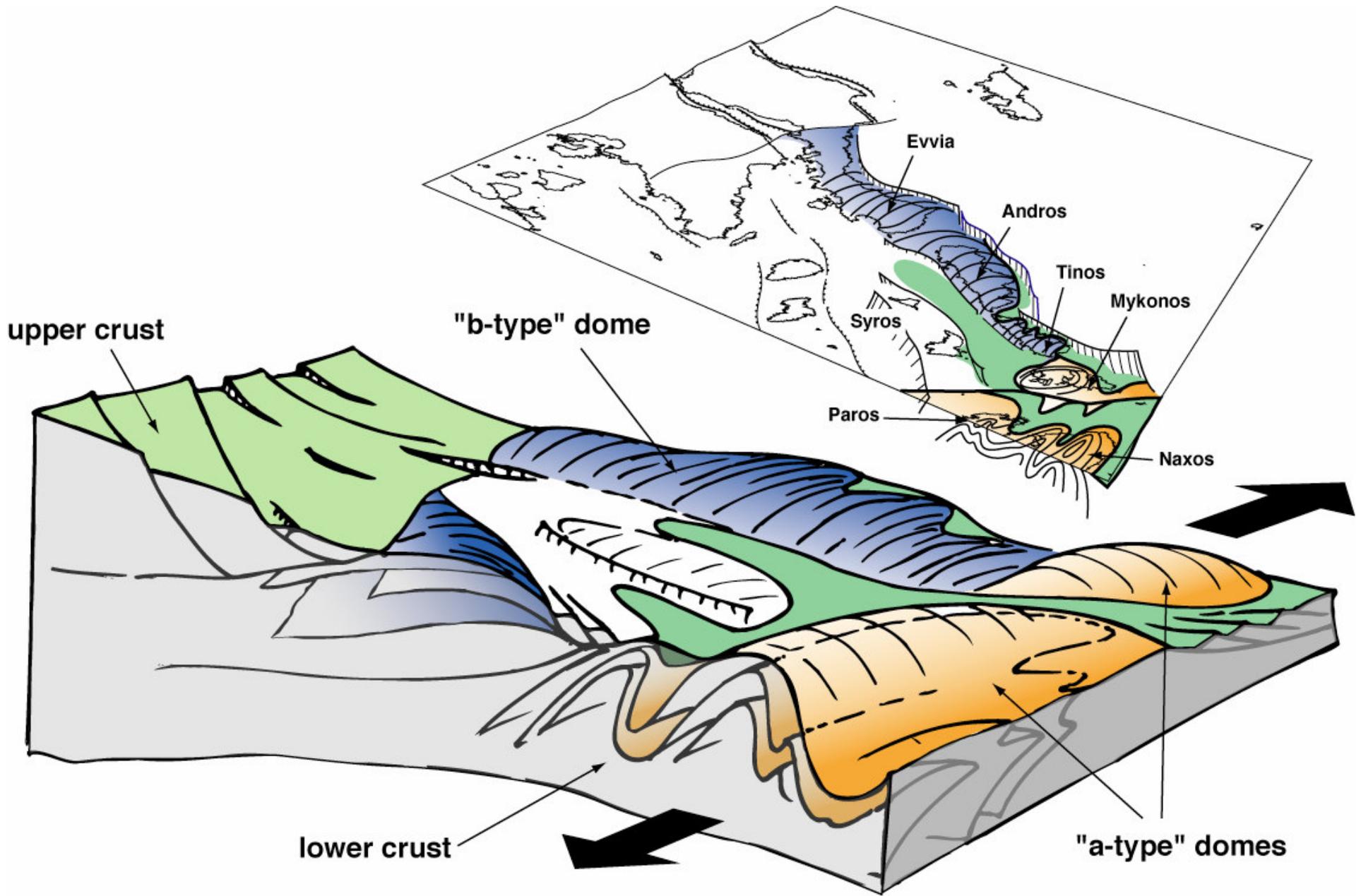
60-35 Ma

CYCLADES

PELOPONNESE
CRETE

30-20 Ma





(Jolivet et al., 2004)

Quelques points importants abordés :

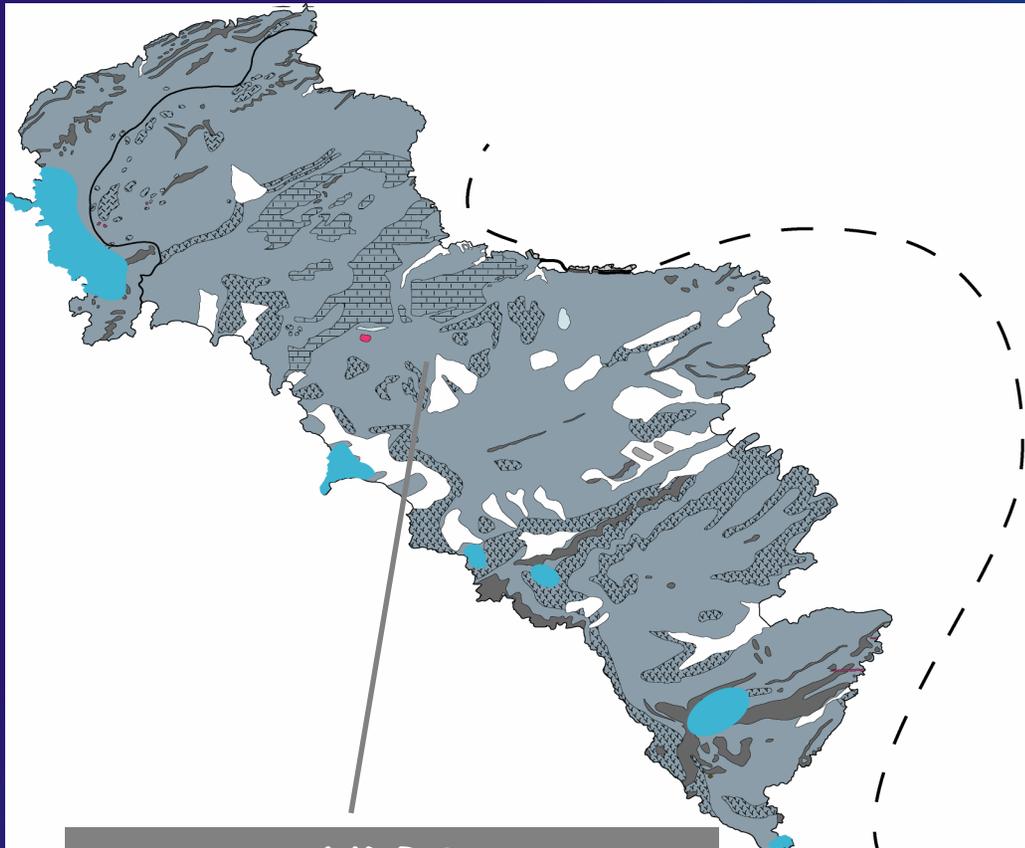
Description des structures et du comportement rhéologique des parties profondes de la croûte continentale en extension

Processus et de la séquence de localisation de la déformation

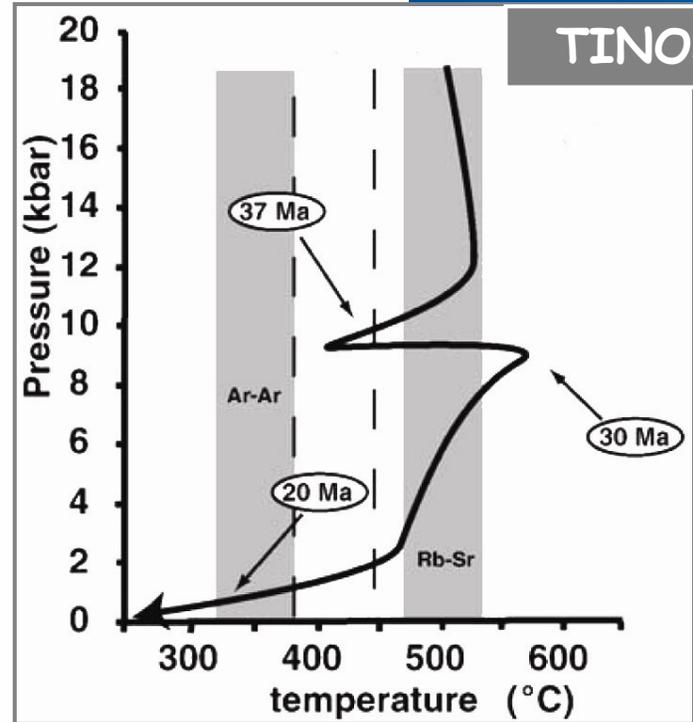
Le continuum ductile-cassant

Les failles normales à faible pendage

Vers la construction d'une coupe complète de la croûte continentale en extension

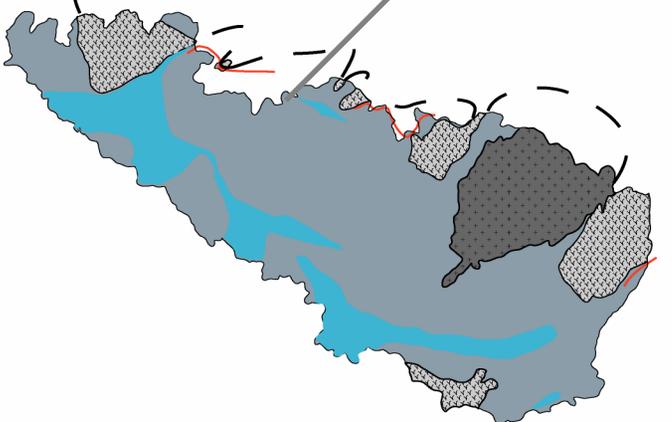


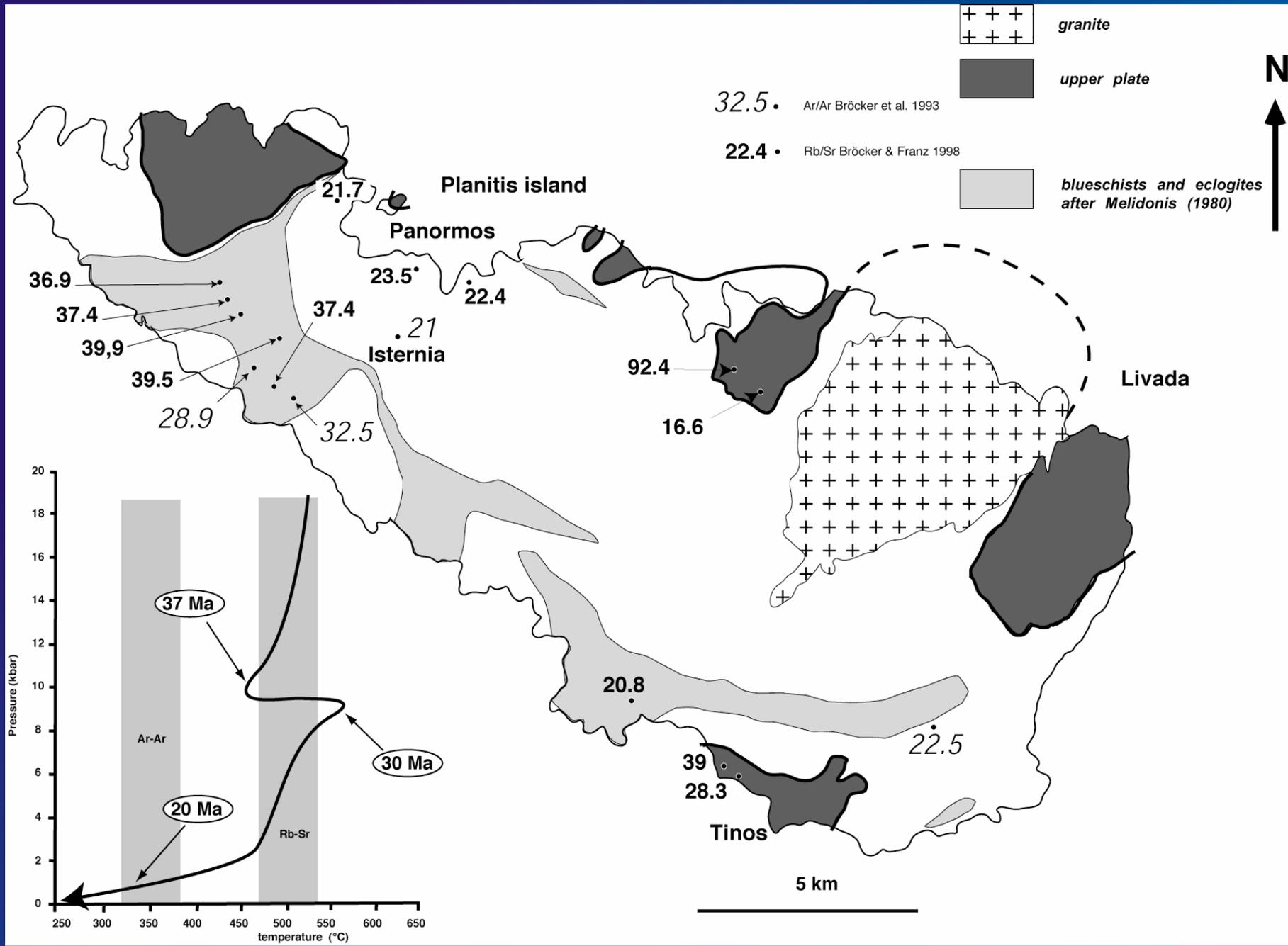
ANDROS
 Peak P-T conditions:
 T: 450-500°C - P > 10Kbar



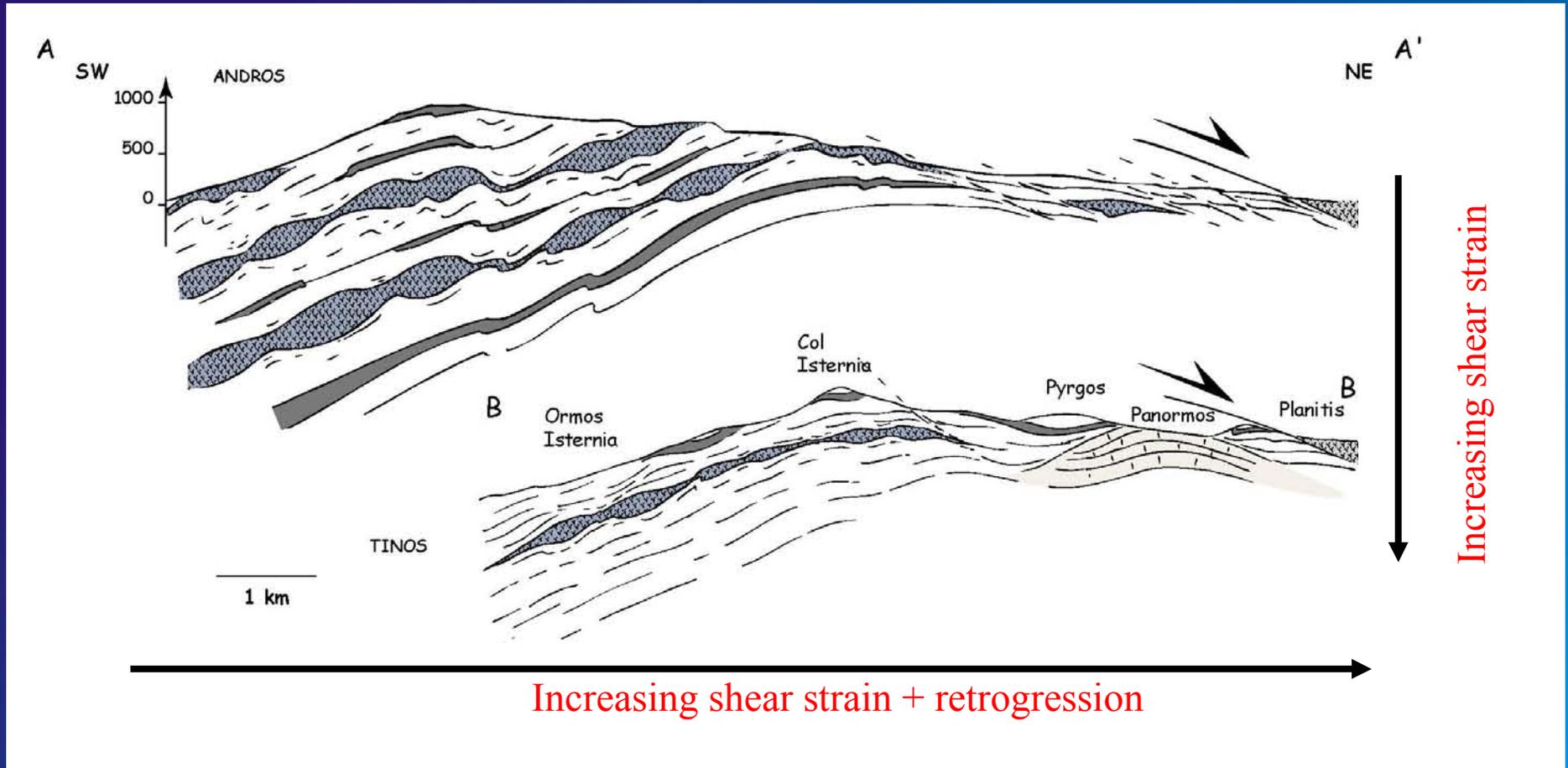
TINOS

Parra et al, Lithos, 2002





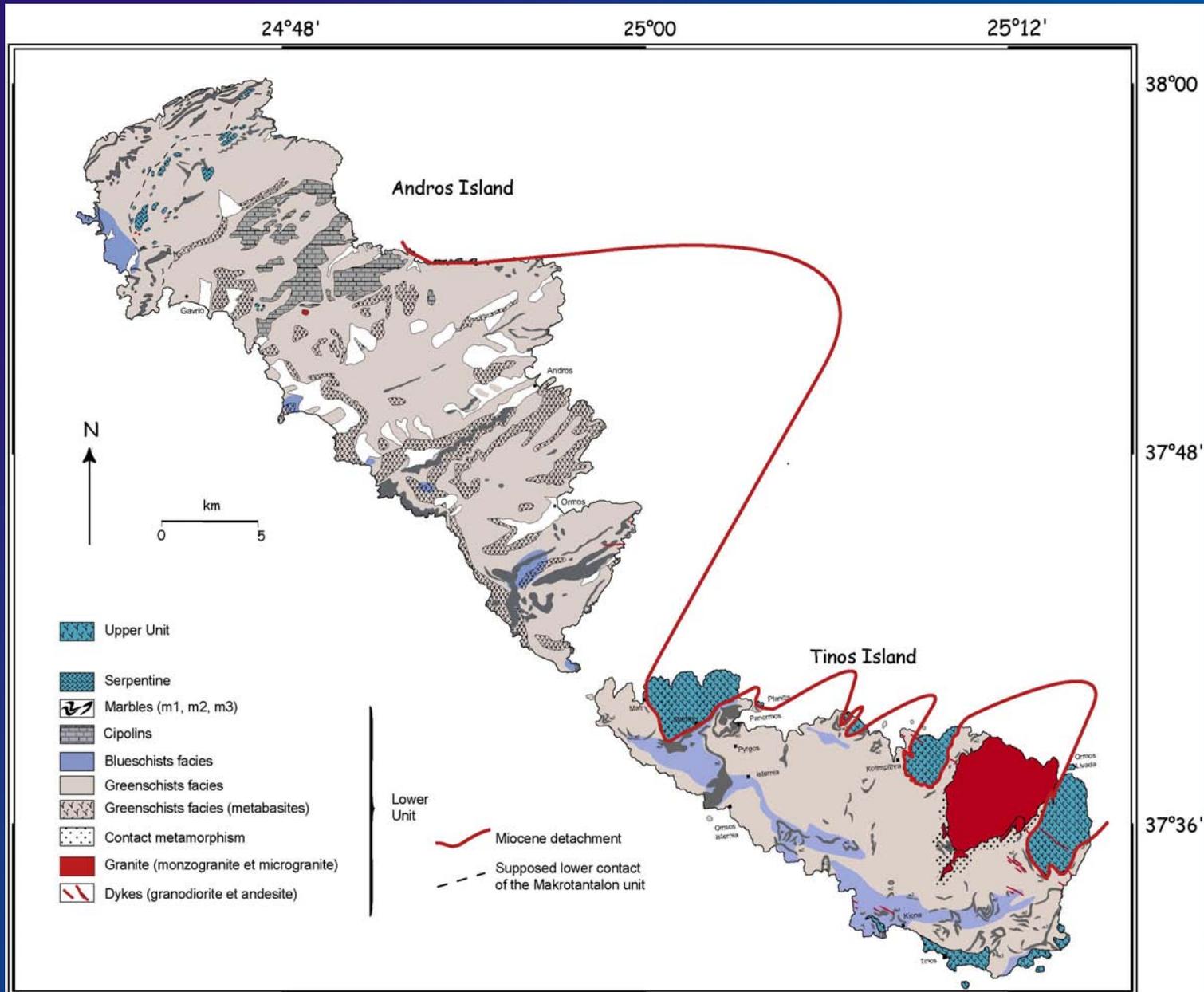
Lower unit :
Alternating metabasites, marbles and metapelites
Relics of HP metamorphism



Upper unit :
serpentinites, metagabbros.
No HP metamorphism

Le détachement

Le 'metamorphic core complex' de Tinos-Andros: Une unité supérieure et une unité inférieure séparées par un détachement



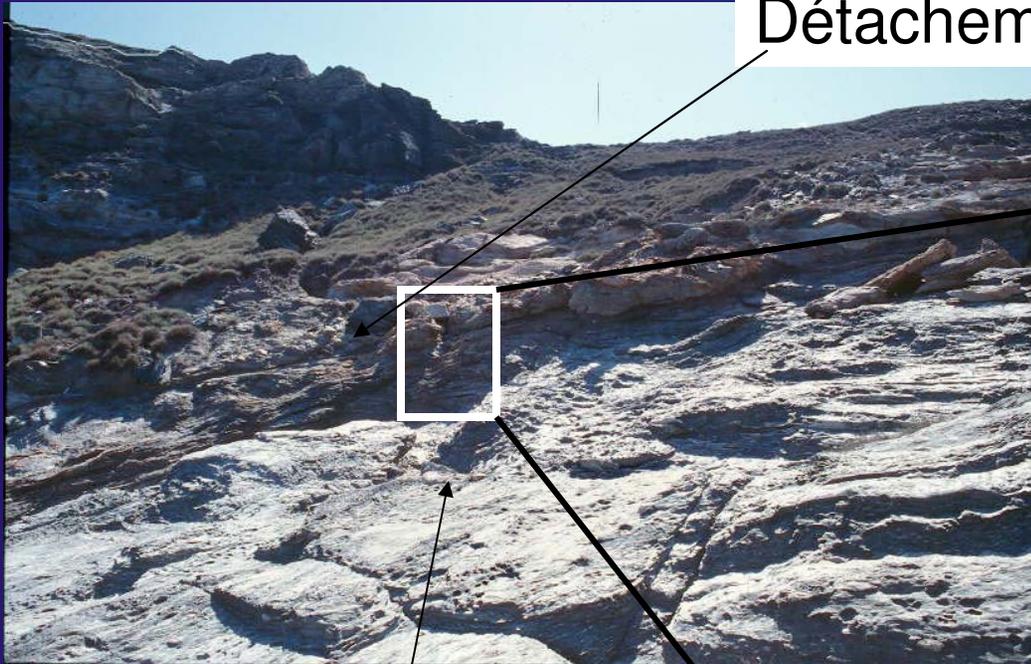


**The detachment :
Planitis, Tinos**





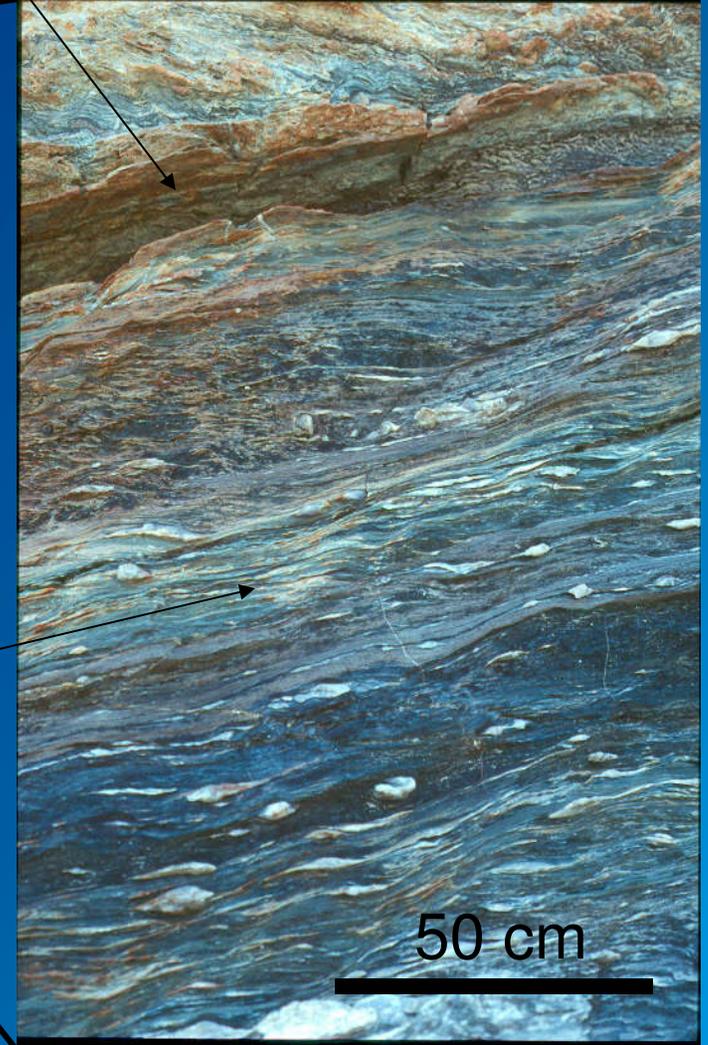
Détachement de Tinos



NE

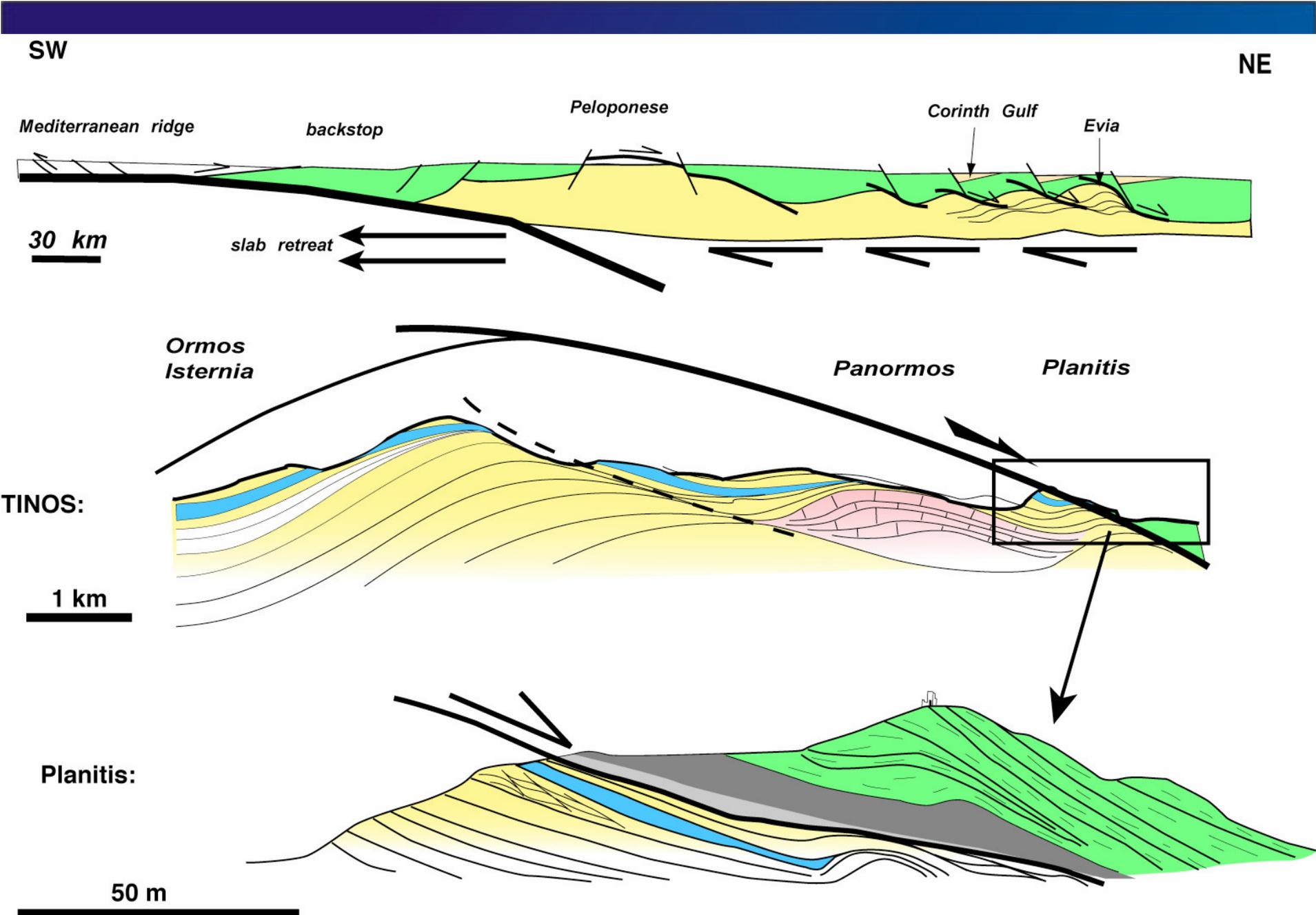
SW

Mylonites de l'unité inférieure



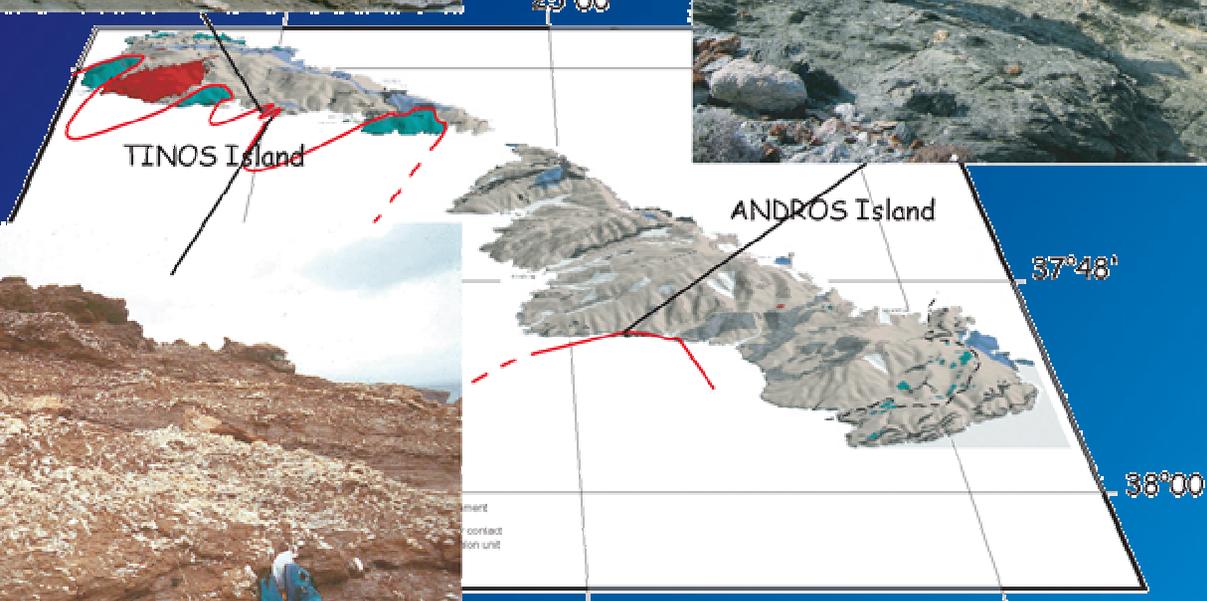
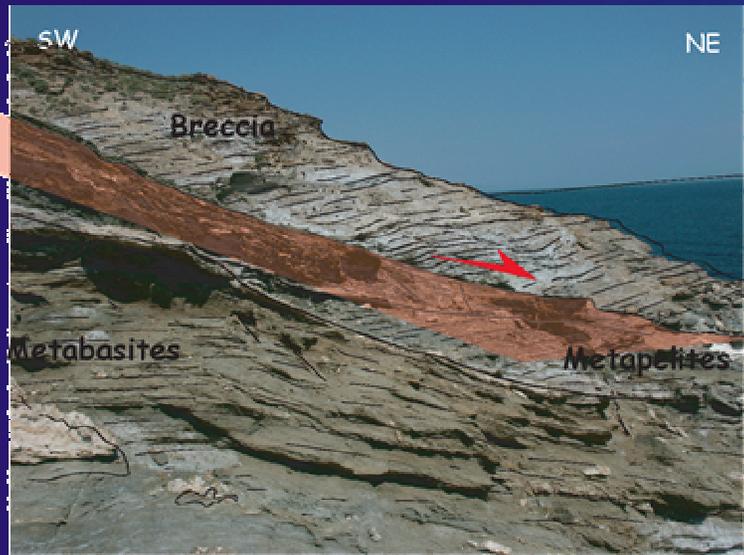
50 cm





(Courtesy of L. Jolivet)

Les cataclasites





L'unité supérieure



L'unité supérieure

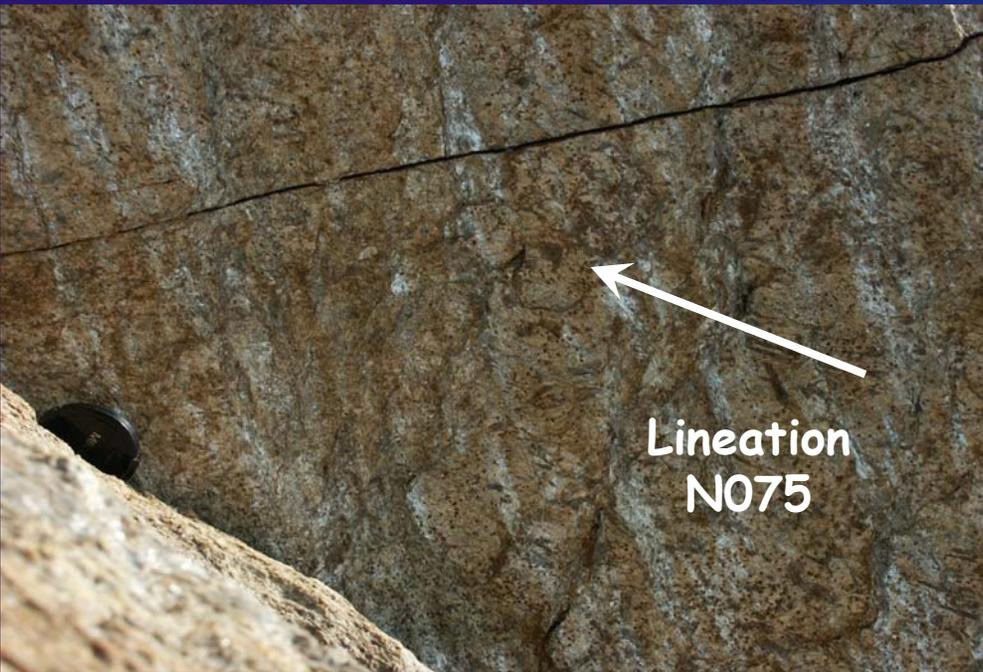


**Processus et séquence de localisation
de la déformation
dans l'unité inférieure**

Des reliques
de métamorphisme HP-BT
loin du détachement



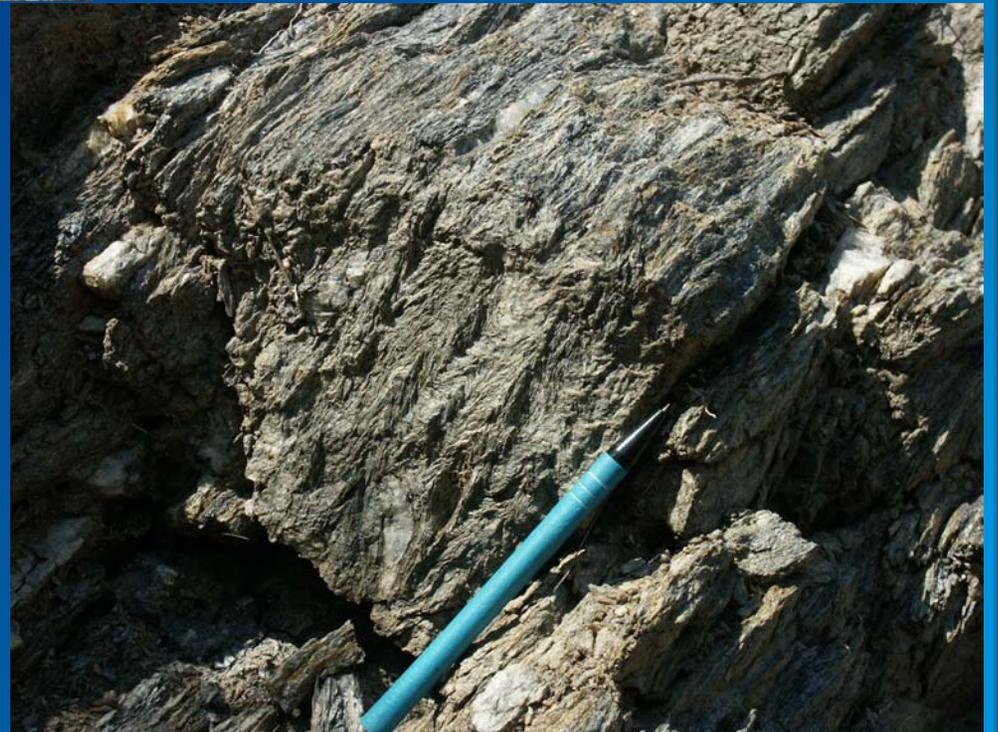
(Mehl et al., in press)



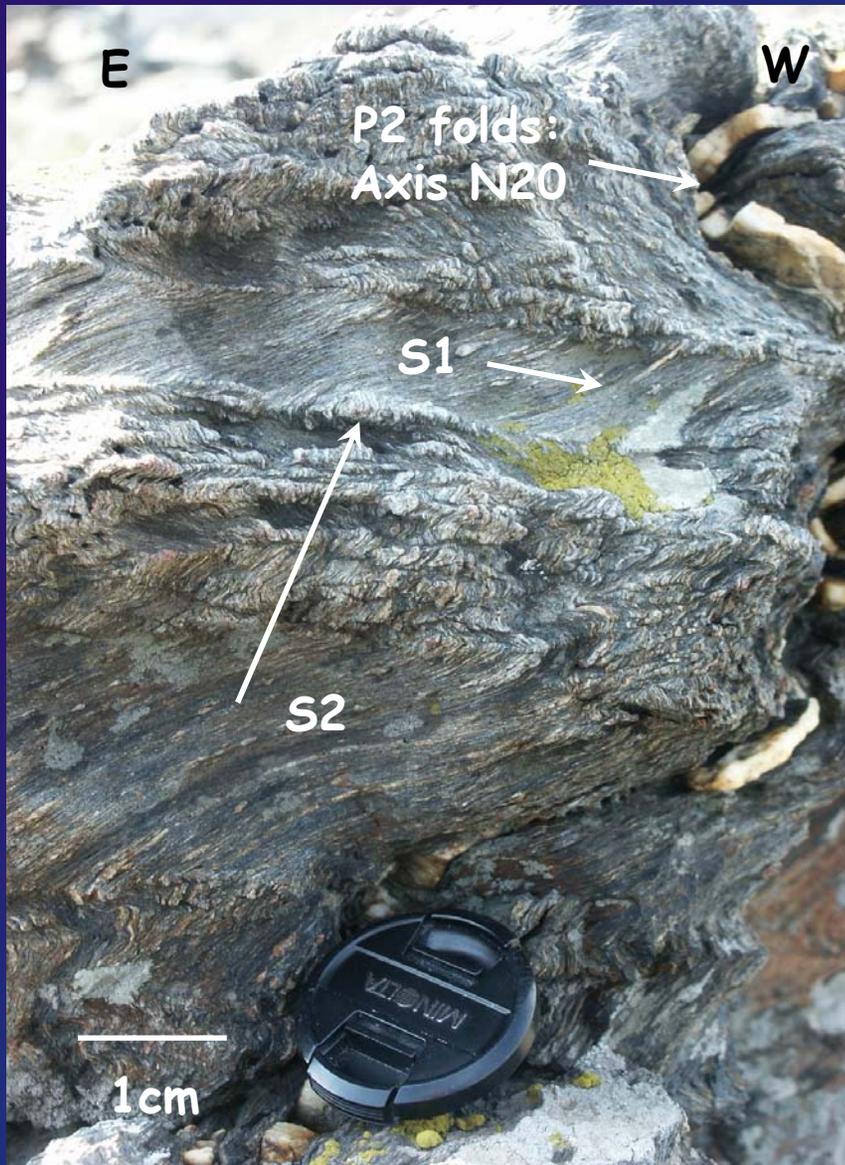
Linéation L1 HP

Lineation
N075

Schistosité de crénulation S2



(Mehl et al., in press)



(Mehl et al., in press)

Initiation des plis P2

Initiation des plis en fourreau

















BOUDINAGE

Every scale







BOUDINAGE
Every scale







Andros :
Symmetric boudinage
away from the detachment





Andros :
Asymmetric boudinage
closer to the detachment





Andros :
Asymmetric boudinage
closer to the detachment





LOCALIZATION OF SHEAR BANDS at the end or in the neck between boudins

(Mehl et al., in press)

Boudinage: un facteur de localisation ... à toutes les échelles

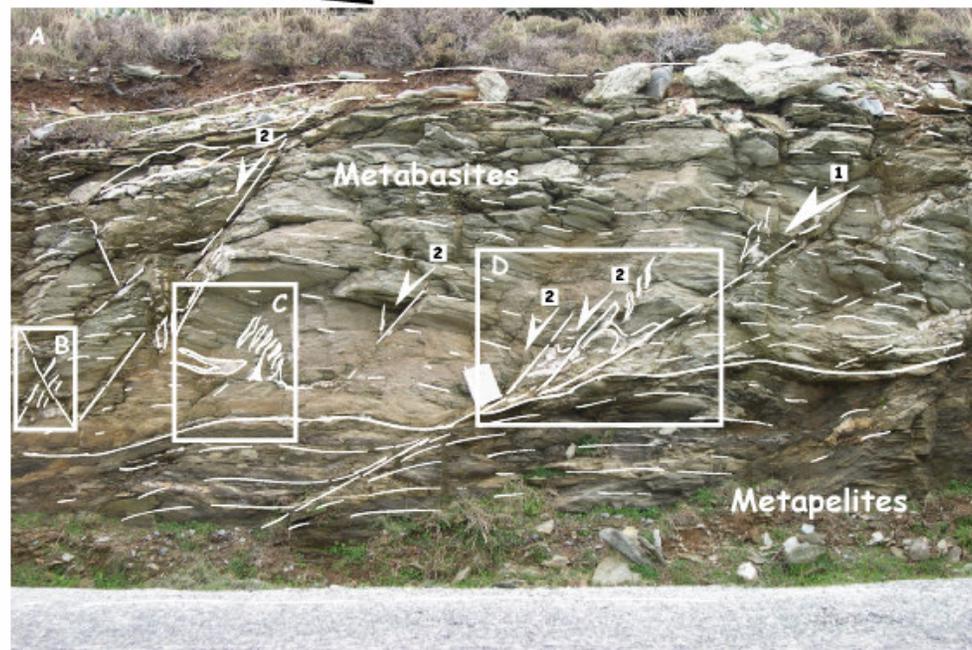
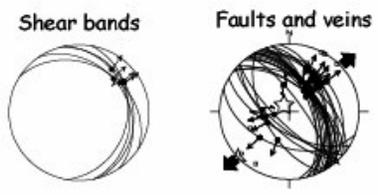
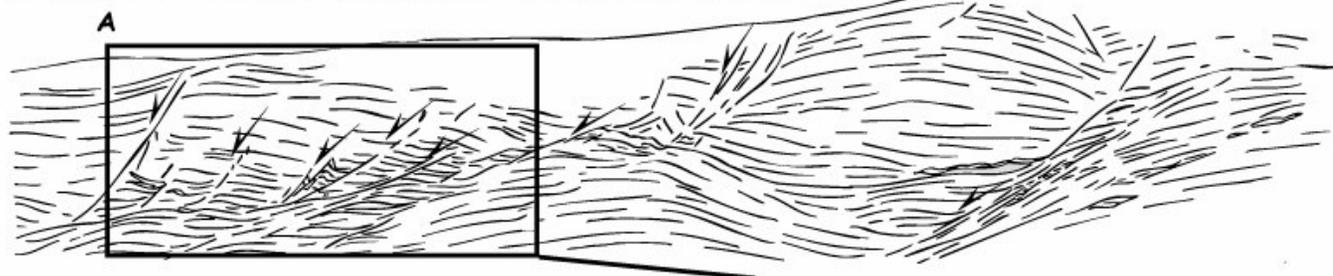


TINOS





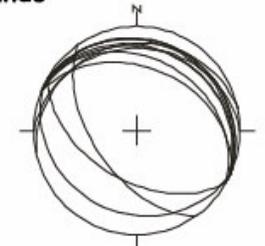
Outcrops 2-3
Lat: 37° 50,95' Long: 24° 55,62'
Lineation: N050



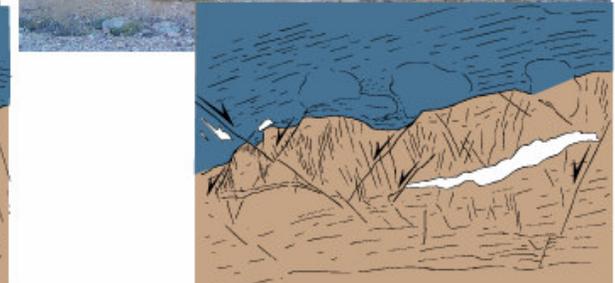
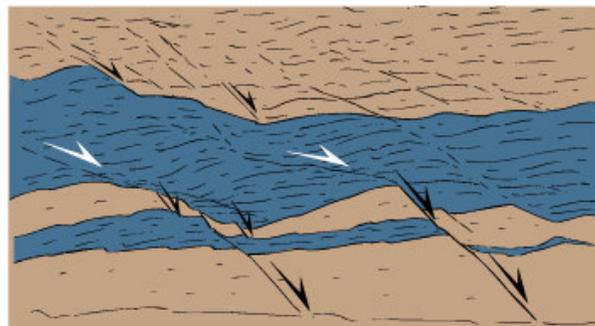
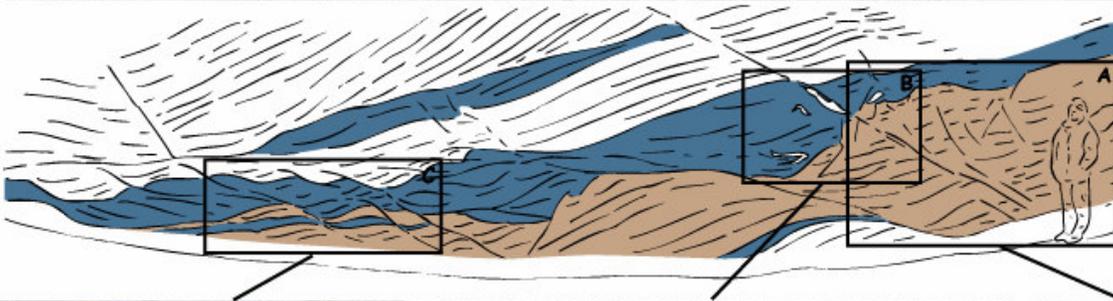
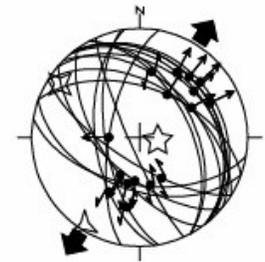
(Mehl, thèse, 2006; Mehl et al., in press)



Shear bands

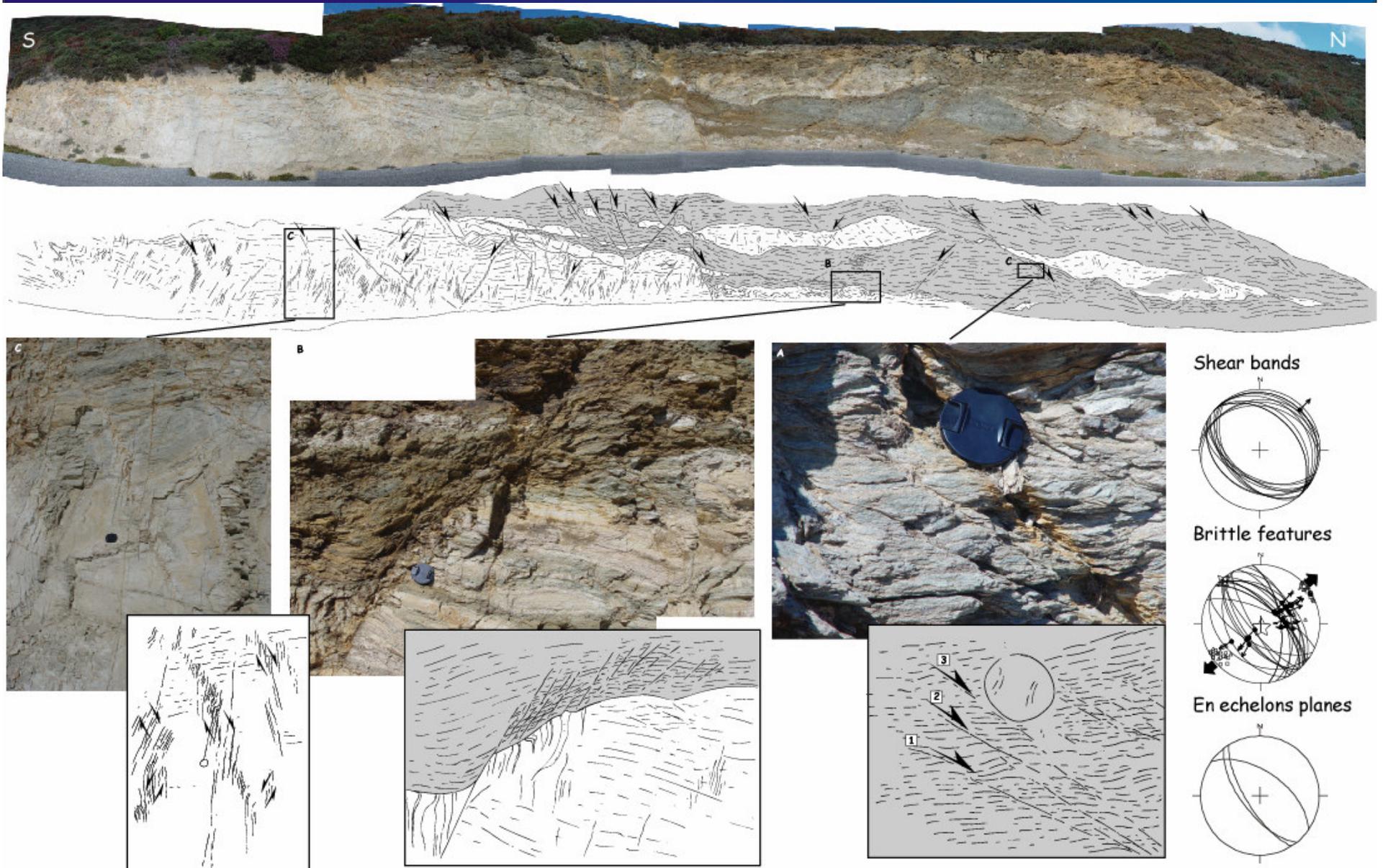


Faults



(Mehl, thèse, 2006; Mehl et al., in press)

Initiation de la déformation cassante

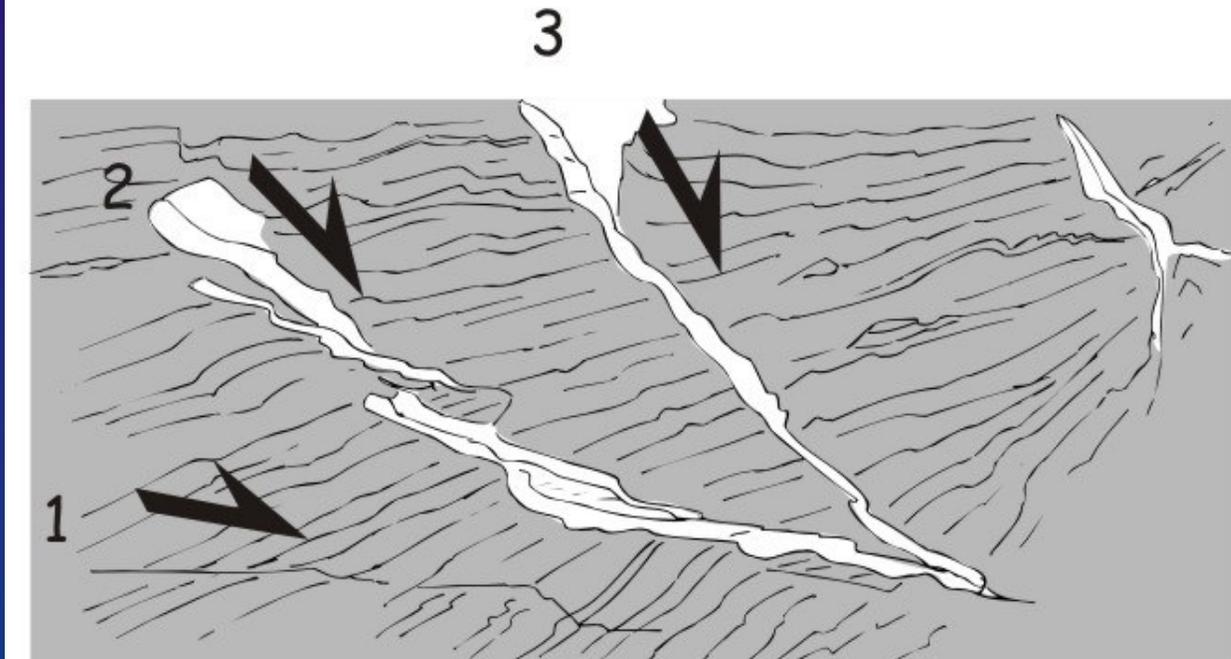
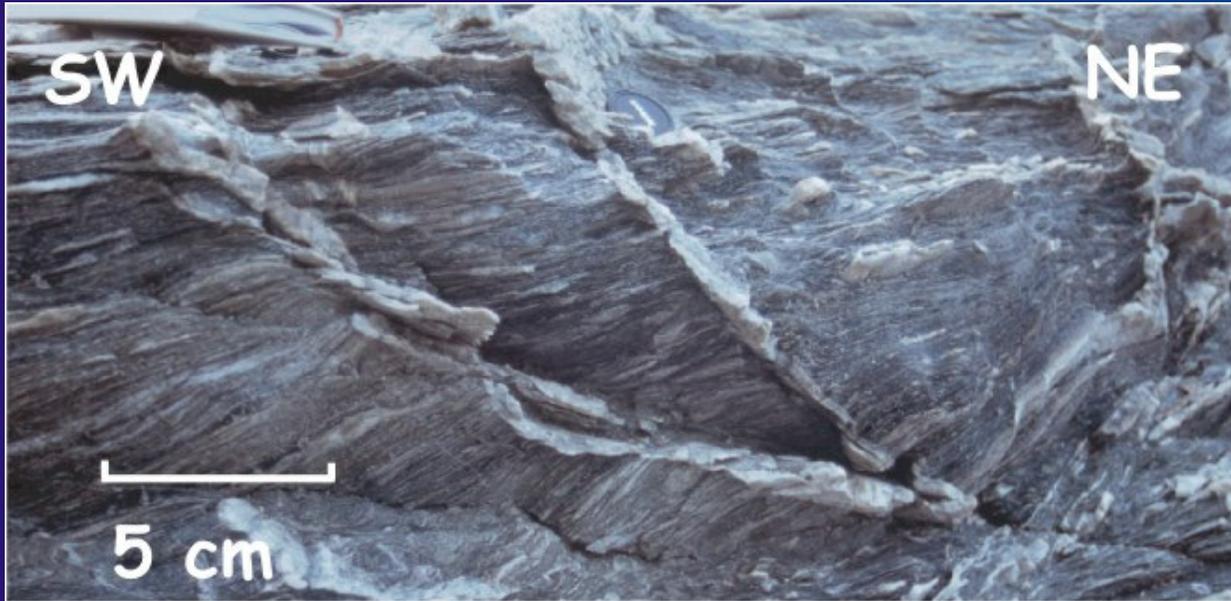


(Mehl, thèse, 2006; Mehl et al., in press)

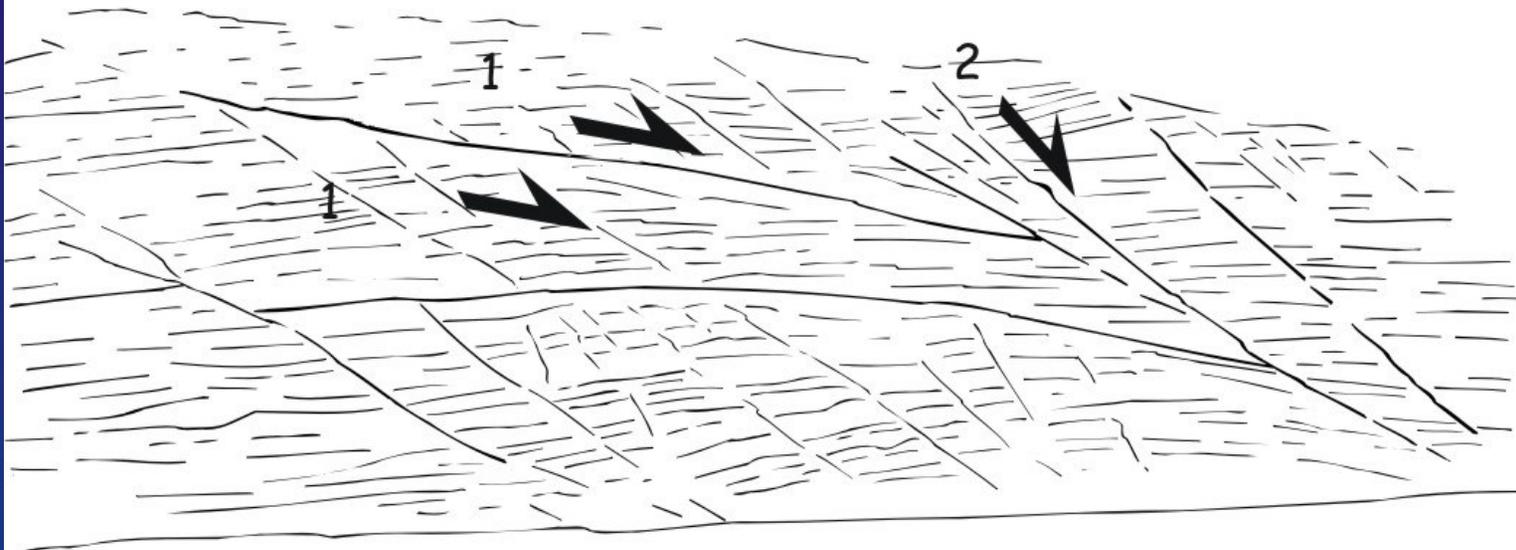




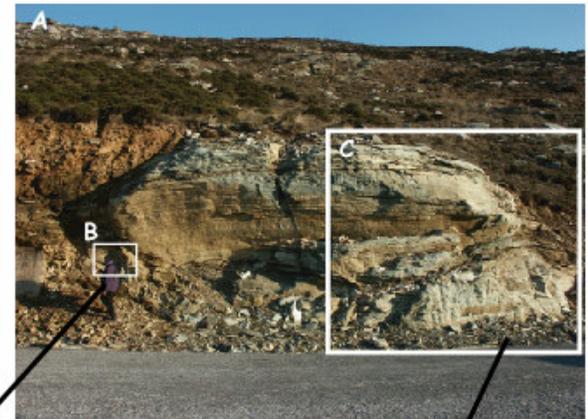
**Progressive
straightening of
structures
from ductile to
brittle**



(Mehl et al., 2005)

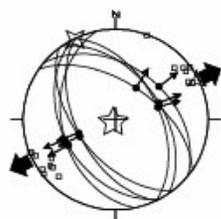
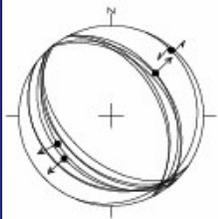


(Mehl et al., 2005)



Shear bands

Veins and faults



(Mehl, thèse, 2006; Mehl et al., in press)



NE

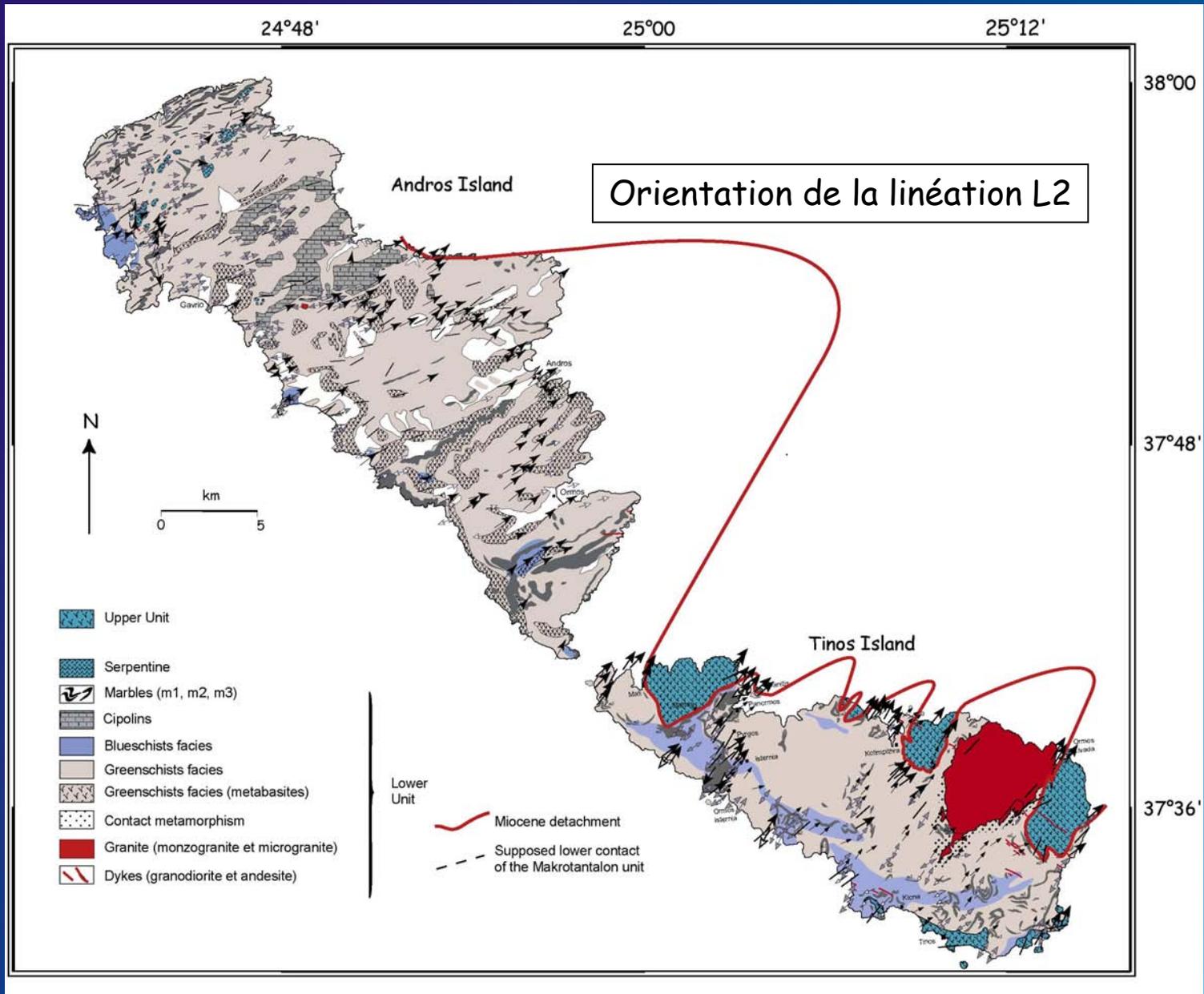
SW



15 cm



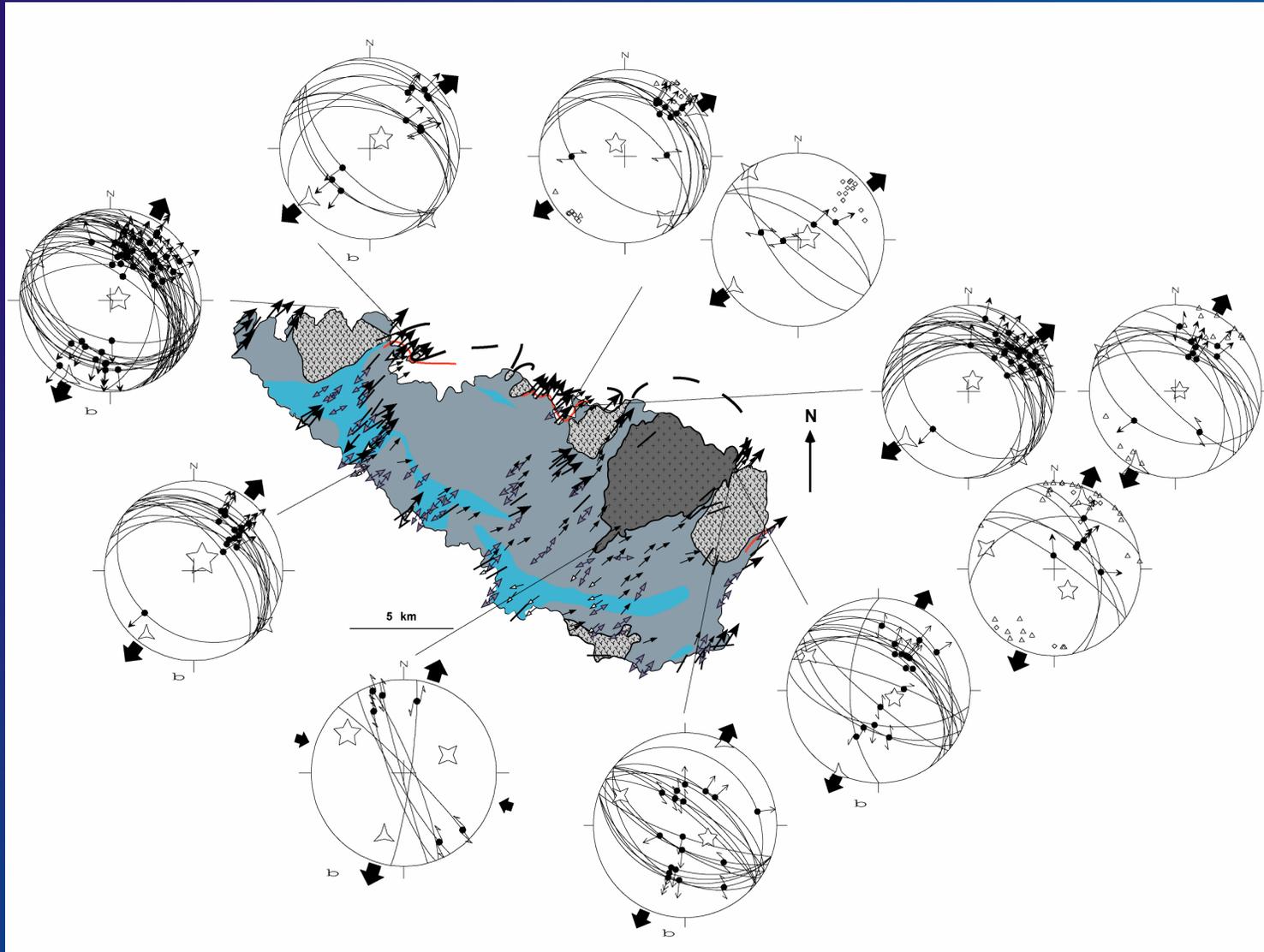
Continuum ductile-cassant



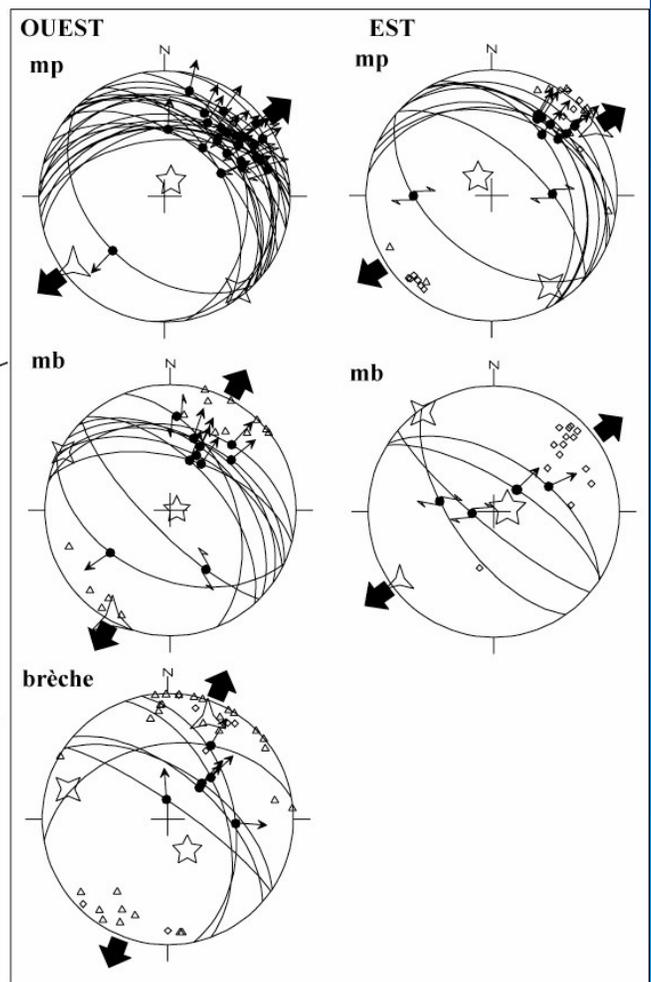
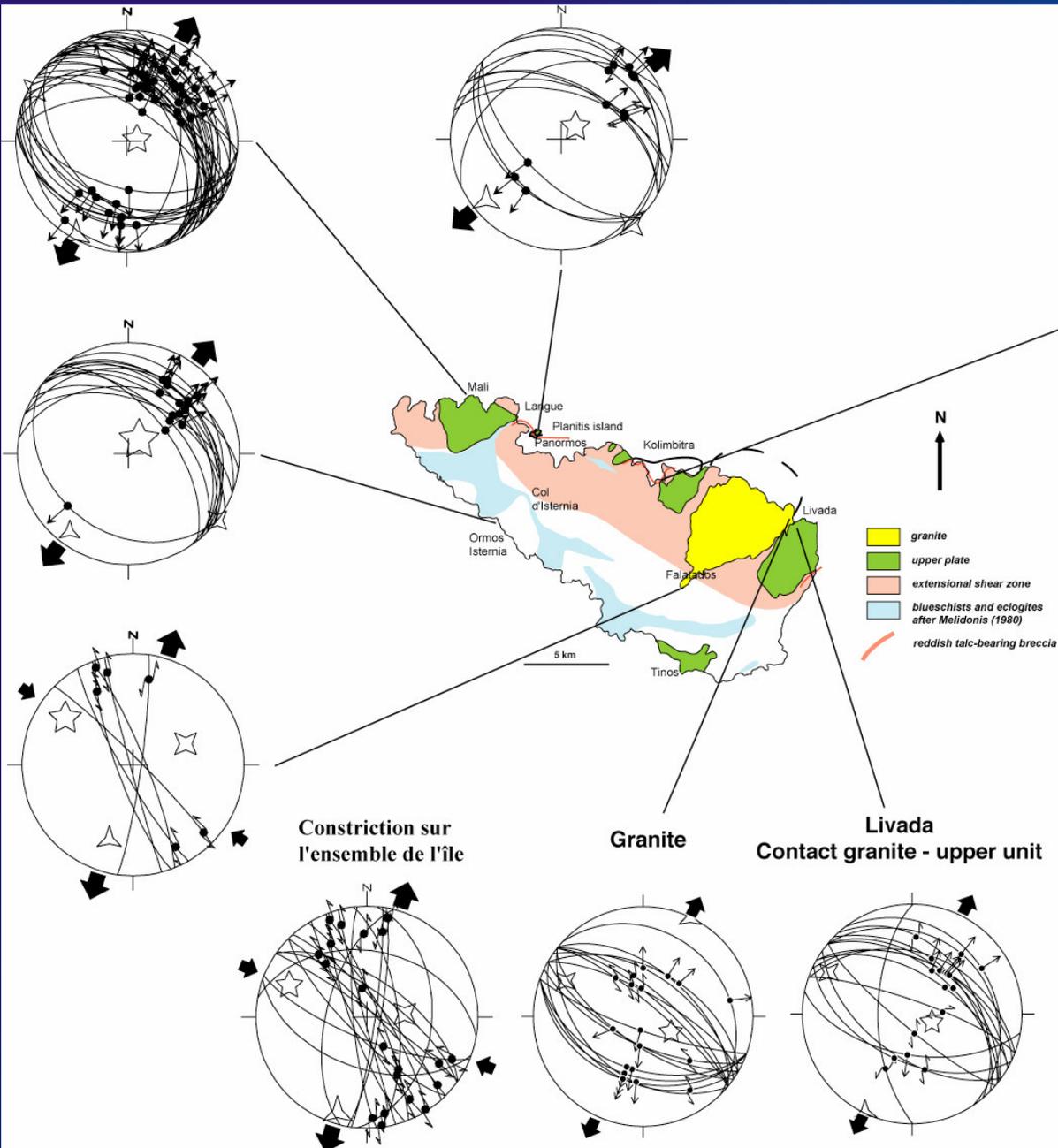
(Mehl, thèse, 2006; Mehl et al., in press)

Continuum ductile-cassant

Tinos



(Mehl et al., 2005)

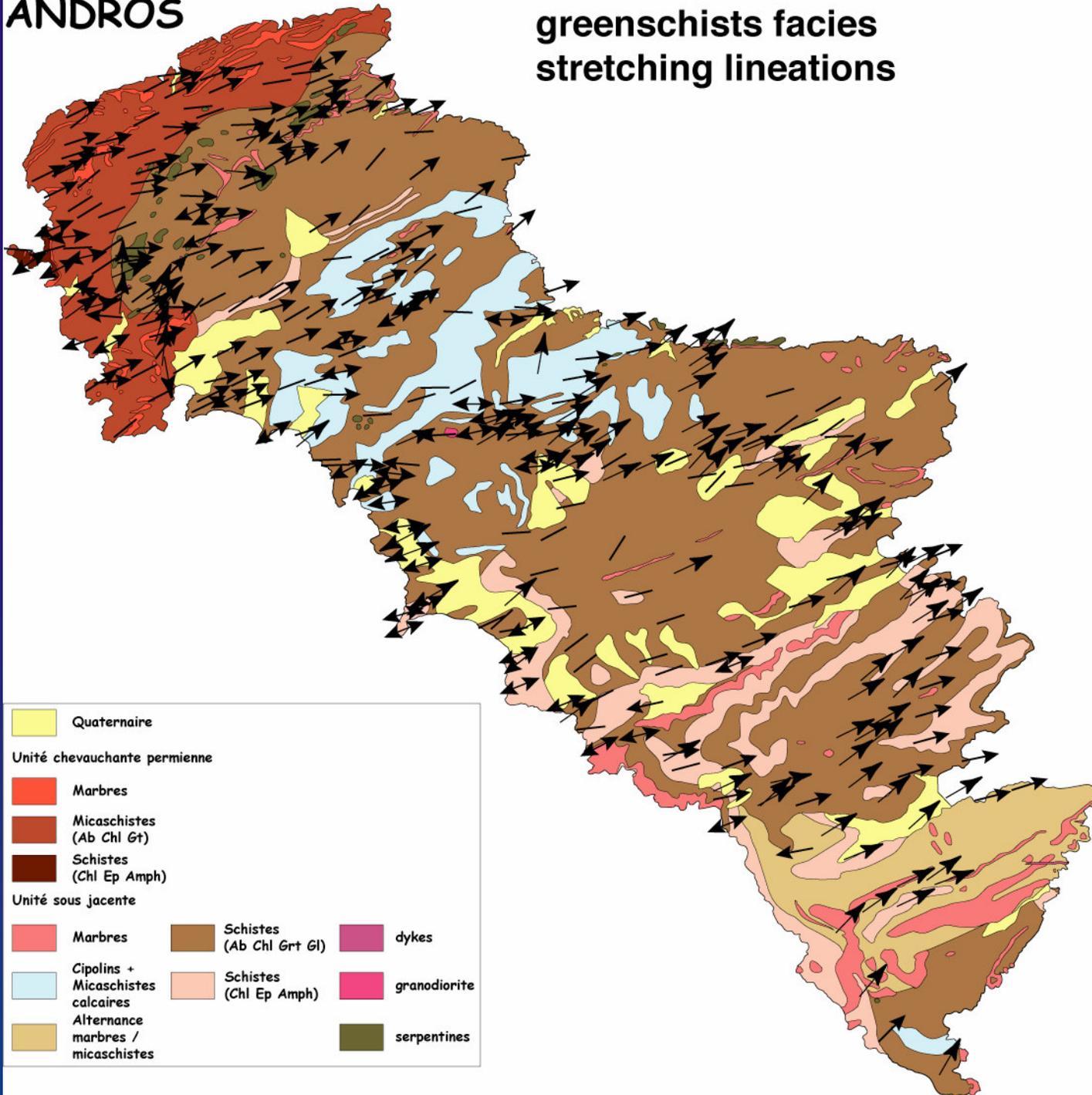


**Ile de TINOS:
structures cassantes**

(Mehl et al., 2005)

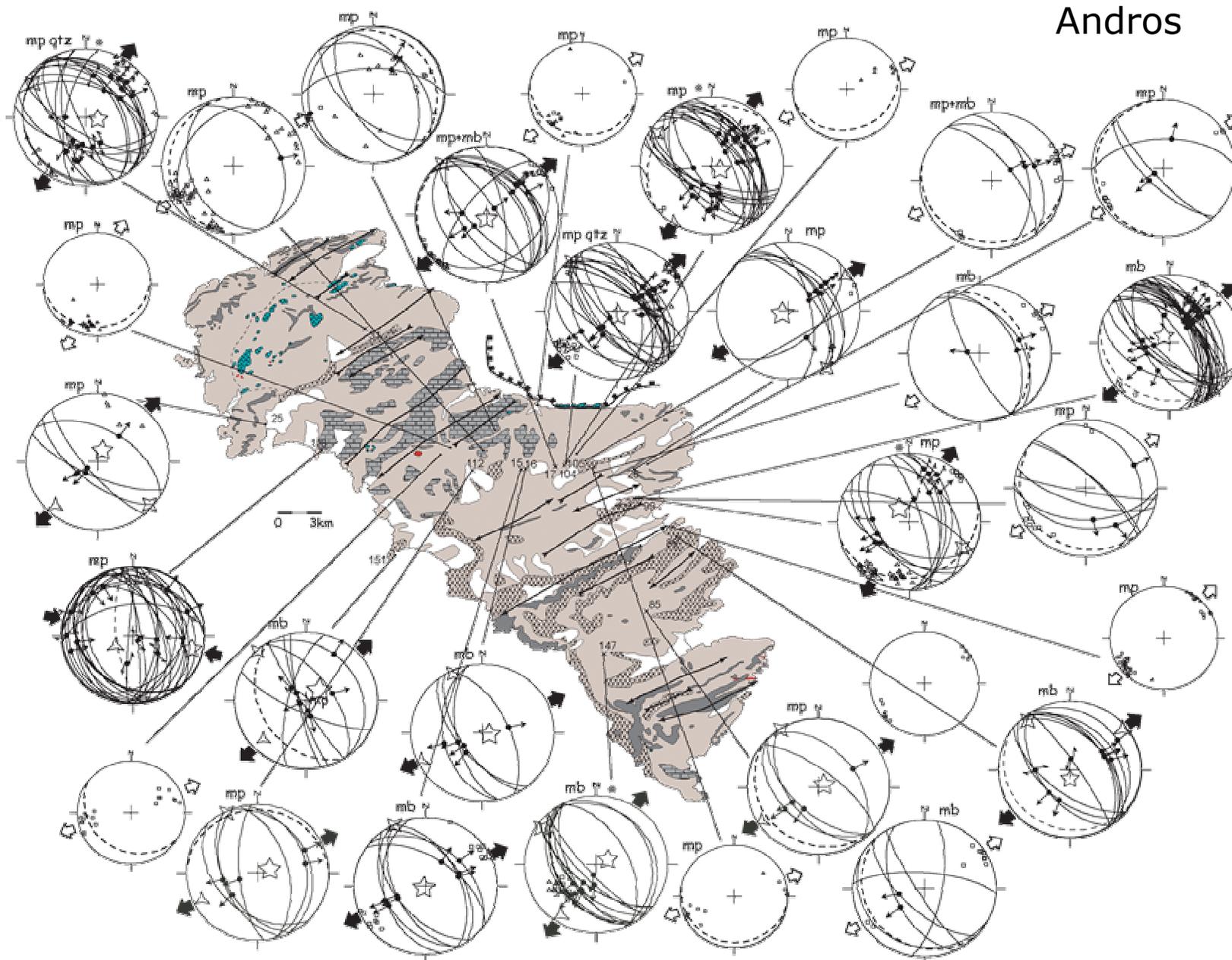
ANDROS

greenschists facies stretching lineations



(Mehl et al.,
in press)

Continuum ductile-cassant



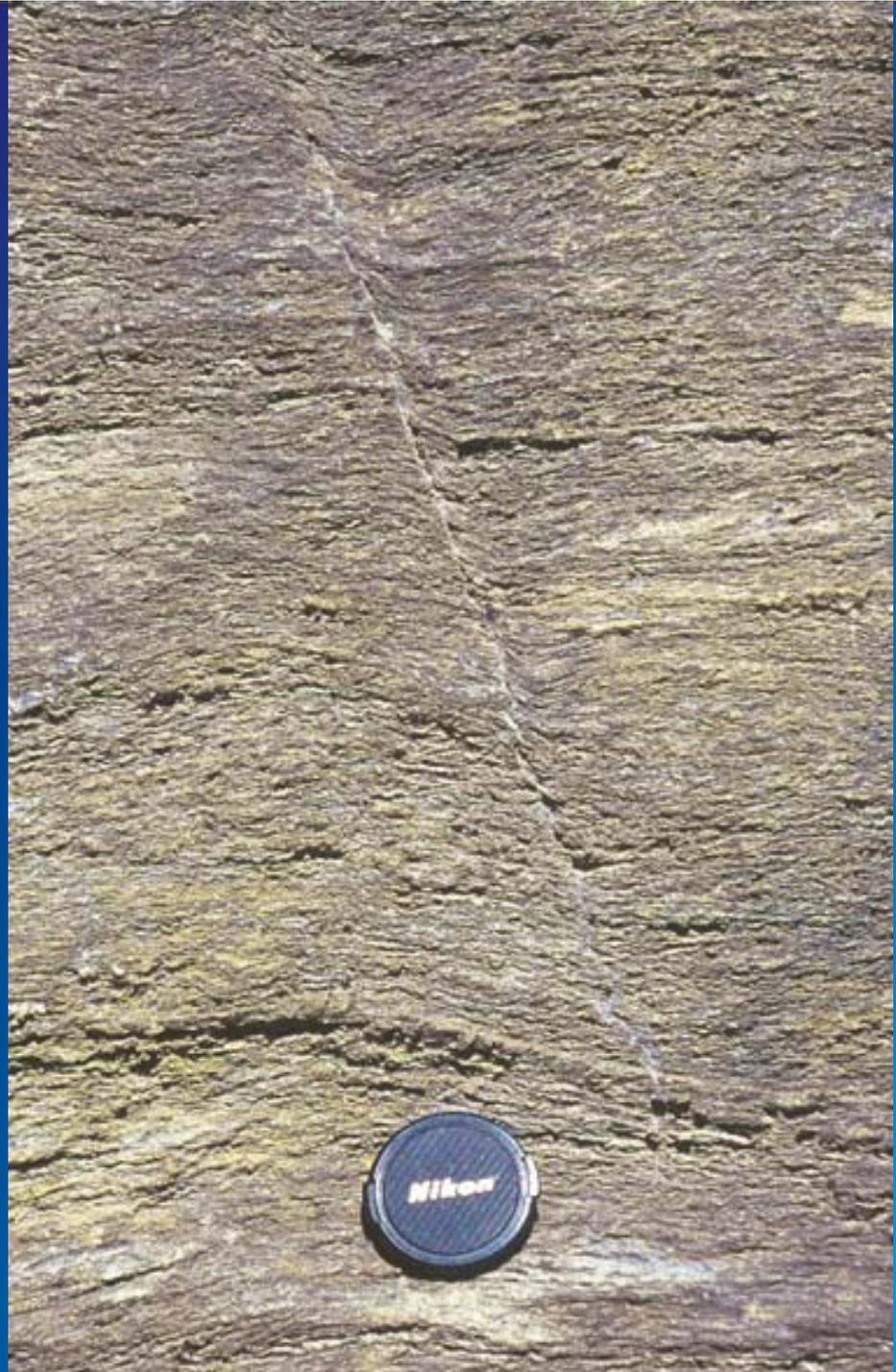
Andros

- Brittle features:**
- △ Poles of joints
 - Poles of veins
 - ↗ Slickensides
 - - Schistosity
 - Tilted structures
- Stress tensors:**
- Computed:
- ☆ σ₁ ↗ Extension direction
 - ⊠ σ₂ ↘ Compression direction
 - △ σ₃
- Inferred:
- ⊠ Extension direction

(Mehl et al.,
in press)



Des structures similaires
à celles observées
dans les Schistes Lustrés alpins ...





Les failles normales à faible pendage



NE

SW

Occurrence of shallow-dipping fault planes, Andros



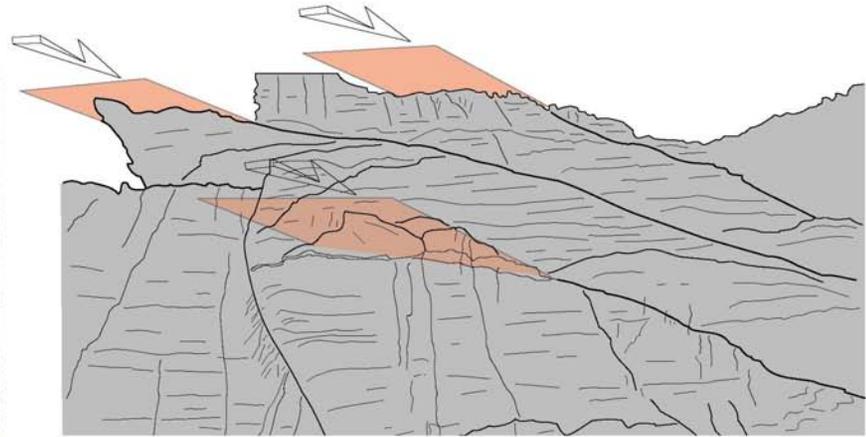








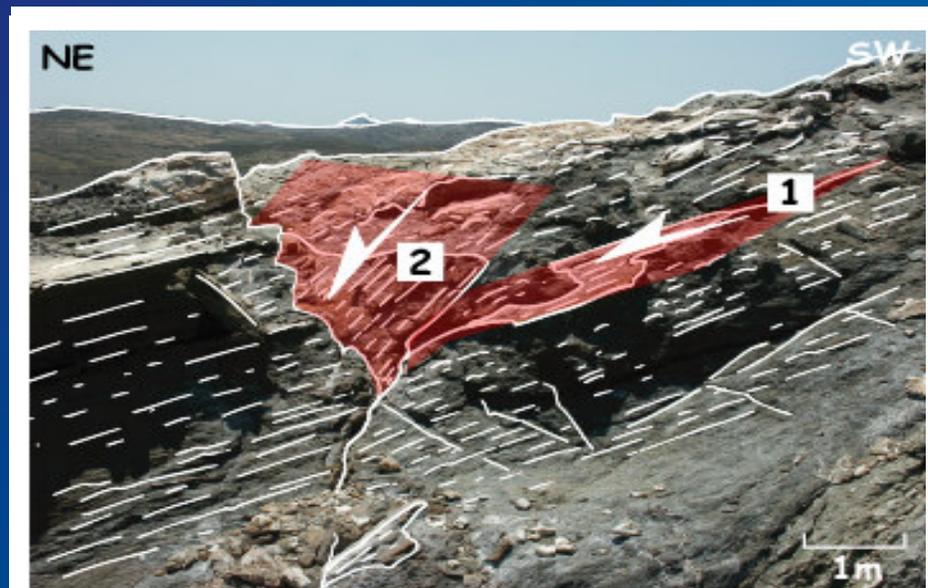


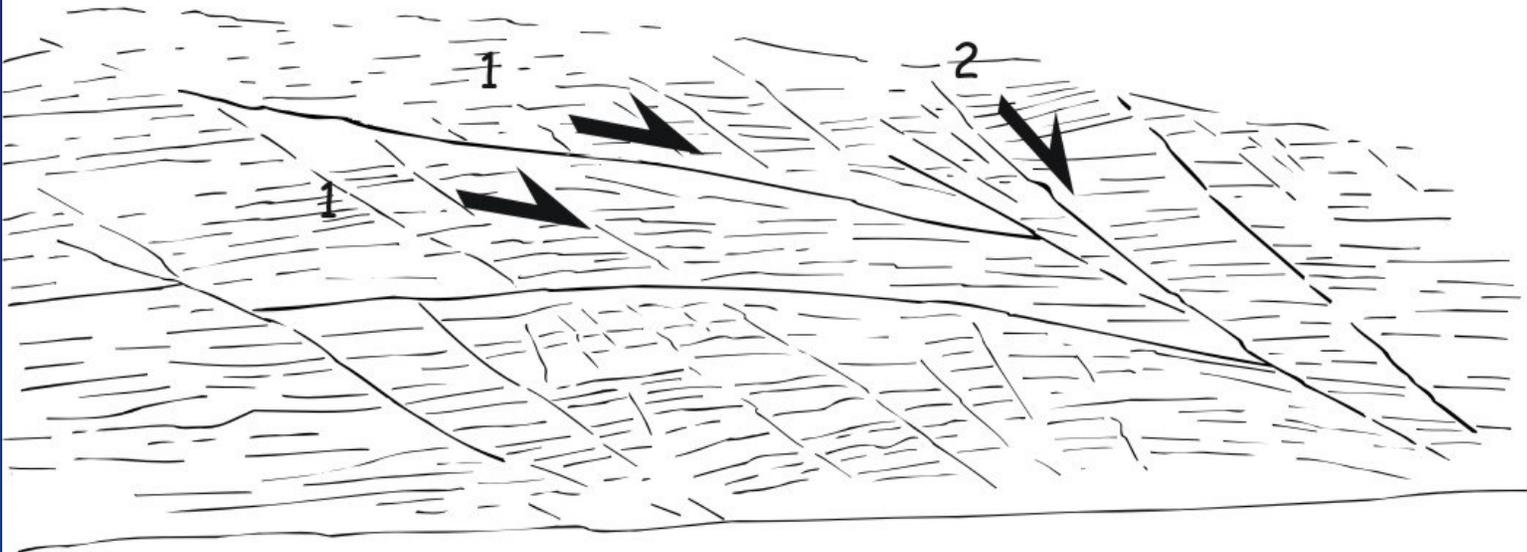


σ_1 axis remained vertical and at high angle to the minor low-angle normal faults and to the detachment as indicated by widespread vertical joints and veins

→ rules out low-angle normal fault models involving rotations of either principal stresses or fault plane
 → implies that the detachment initiated and moved as a weak fault.

Chronologie entre les failles normale à faible et fort pendages

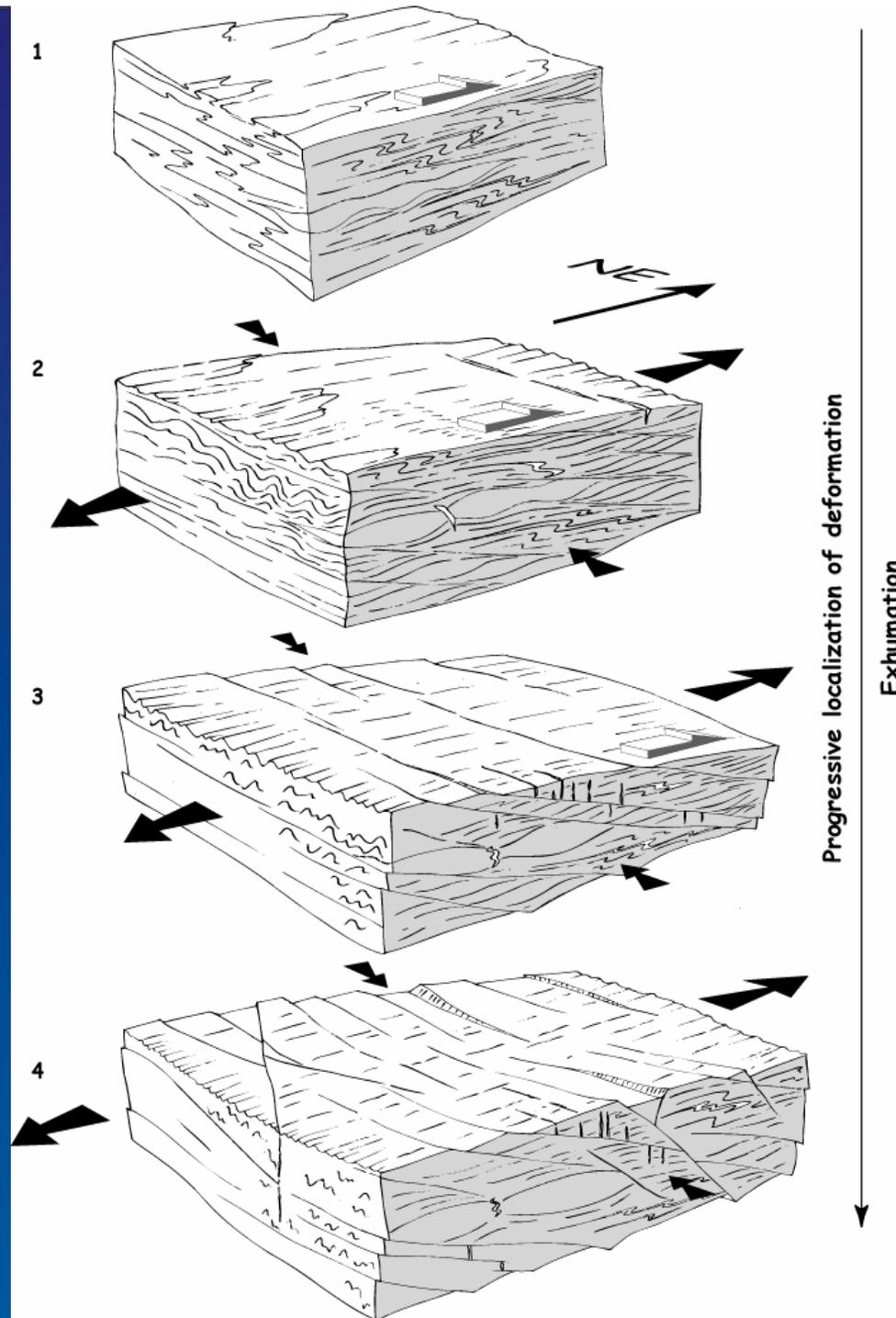


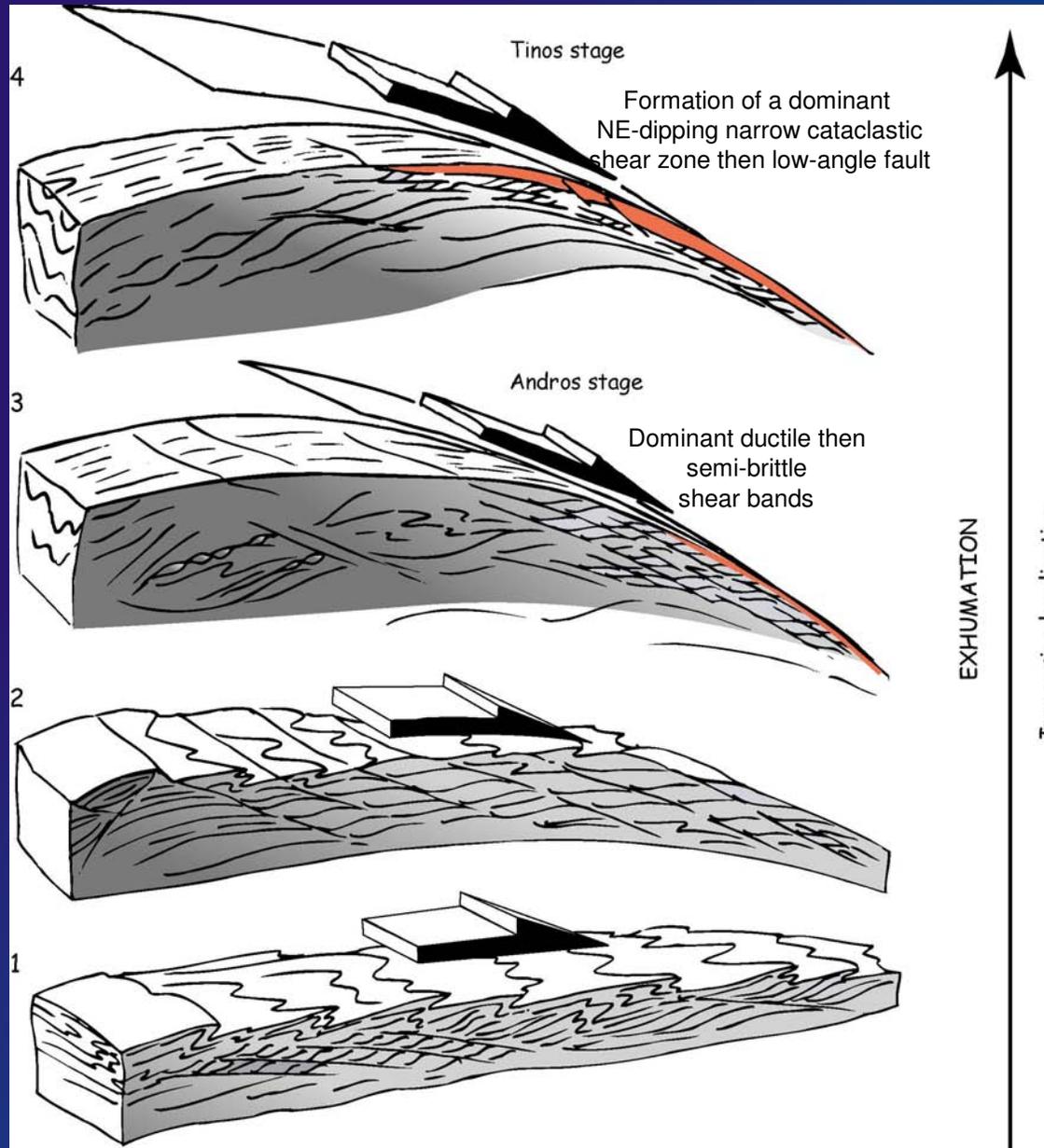


**Vers une coupe complète
de la croûte continentale en extension**

Strain localization sequence at the outcrop scale

(Mehl et al., 2005)





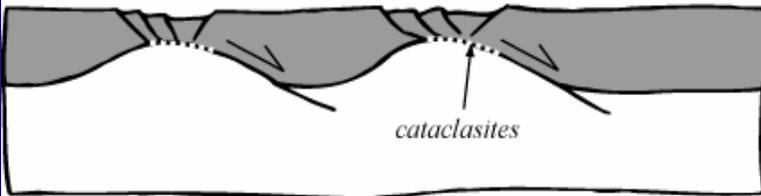
Strain localization at the island scale

(Mehl et al., in press)

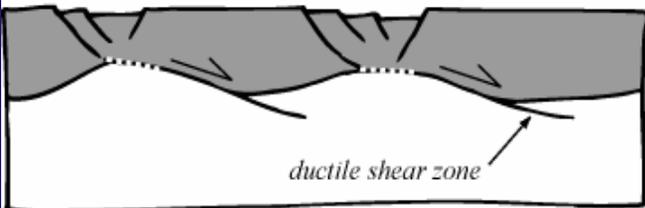
4: the cataclastic shear zone reaches the uppermost portions of the crust and the last increments of motion along the detachment give rise to brittle faulting within the breccia



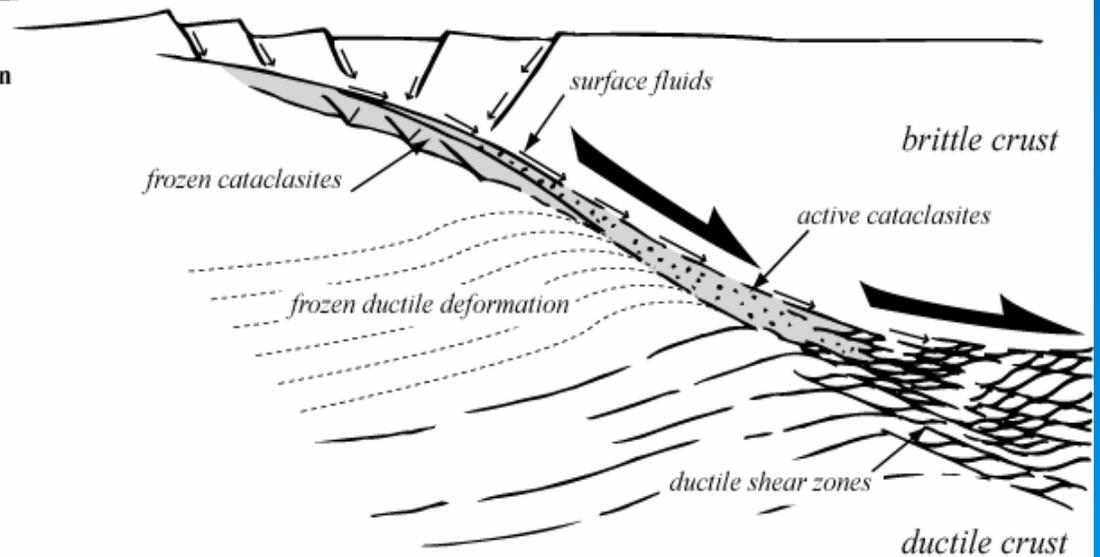
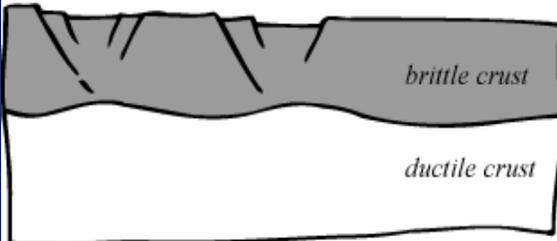
3: shear zones exhumation and formation of a cataclastic shear zone
downward propagation of ductile shear zones



2: initiation of shallow-dipping ductile shear zones and exhumation



1: crustal-scale boudinage, and formation of the first faults in the upper crust



Two possible models, two philosophies

```
graph TD; A[Two possible models, two philosophies] --> B["'Evolutive shear band' model (Lister and Davis, 1989)"]; A --> C[Rolling hinge model (Buck, 1988; Brun and Van Der Driech, 1994)];
```

"Evolutive shear band" model
(Lister and Davis, 1989)

Initially shallow-dipping detachment

Upward propagation of structures
by progressive localization of
structures

Major part of the exhumation process
by ductile mean

**The detachment is a consequence of
the exhumation**

Rolling hinge model
(Buck, 1988; Brun and Van Der
Driech, 1994)

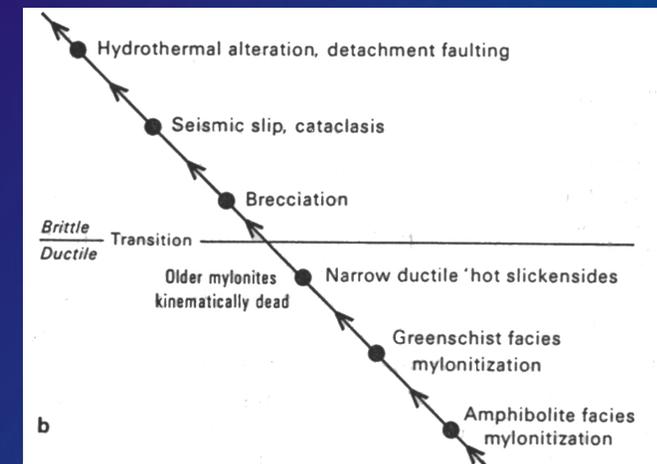
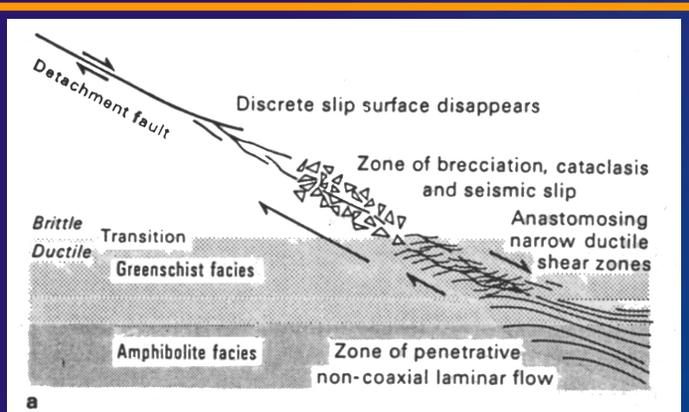
Initially steeply-dipping detachment

Downward propagation of structures

Major part of the exhumation process
by brittle mean

The detachment induces the exhumation

"Evolutive shear band" model (Lister and Davis, 1989)



Rolling hinge model (Buck, 1988; Brun and Van Den Driessche, 1999)

