# Tectonic evolution of the External Hellenides

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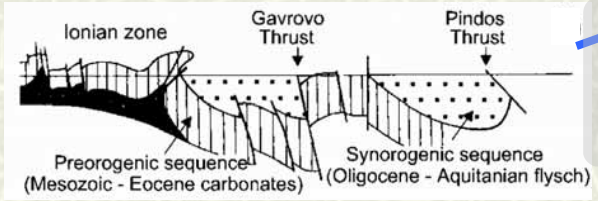
# The Hellenides and previous models

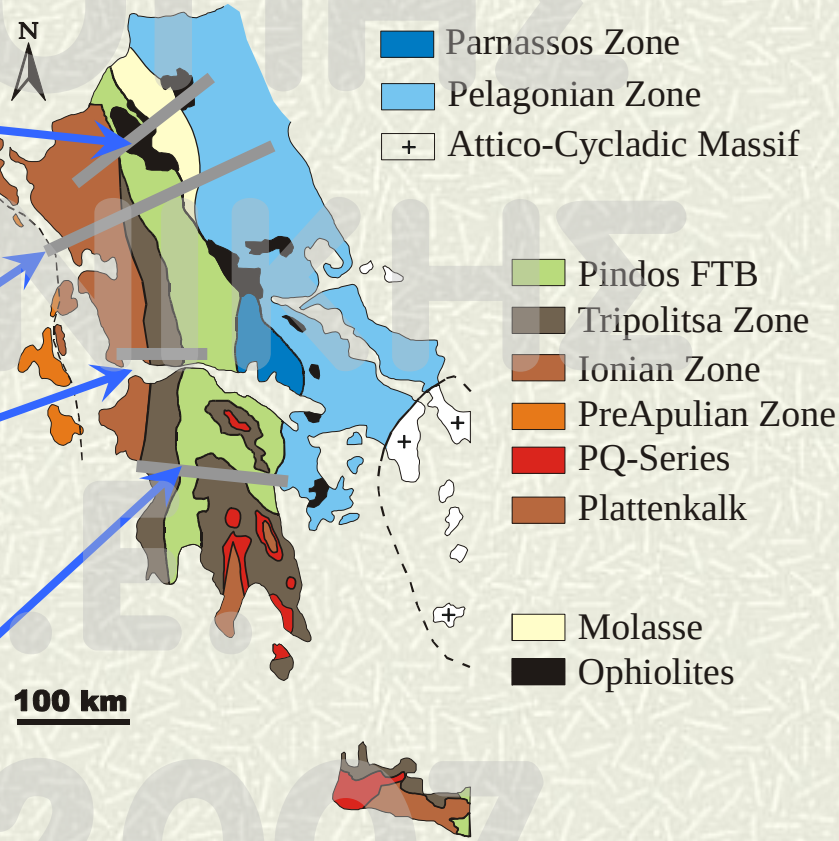

*by Jones and Robertson 1991*


*by Auboin et al. 1963*

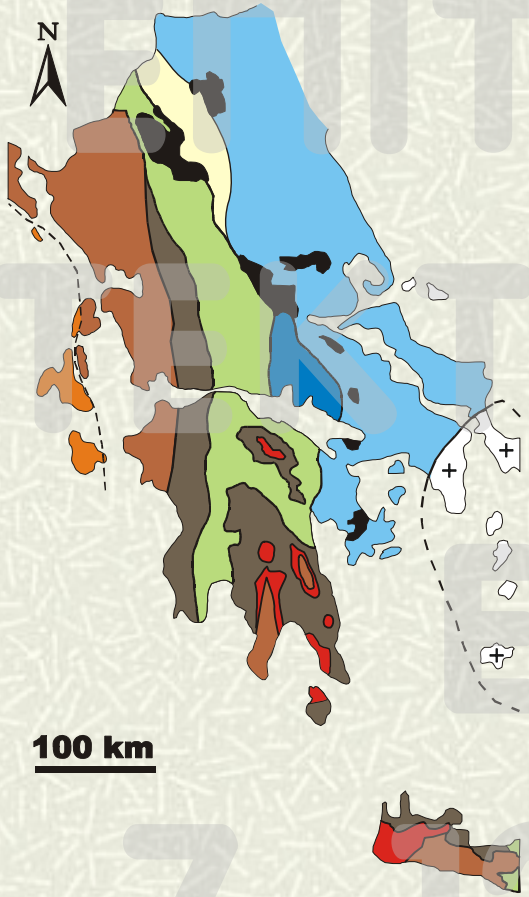


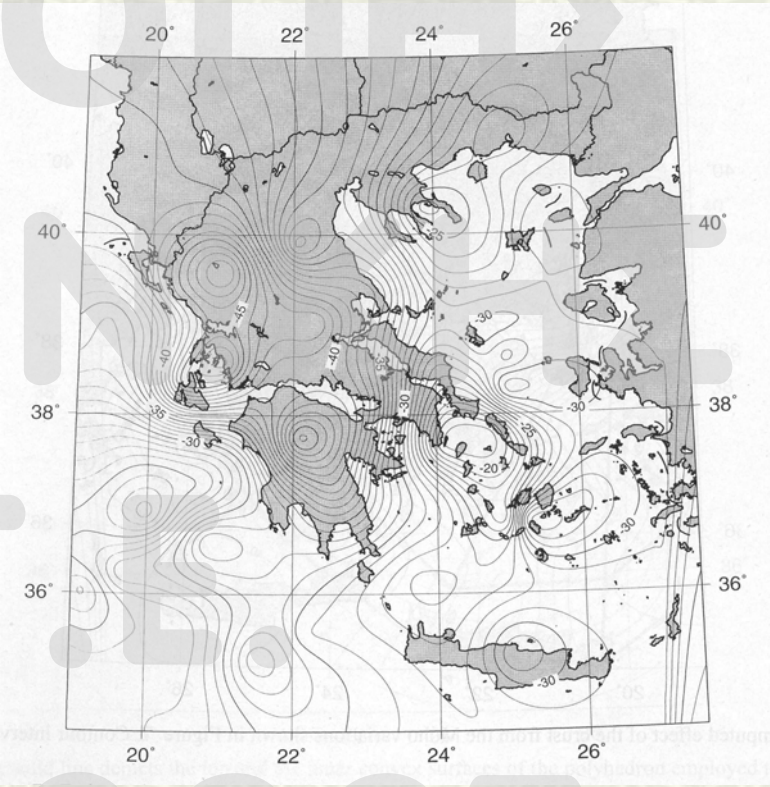

*by IFP 1966*


*by Temple 1968*



# The Hellenides and the Moho depth

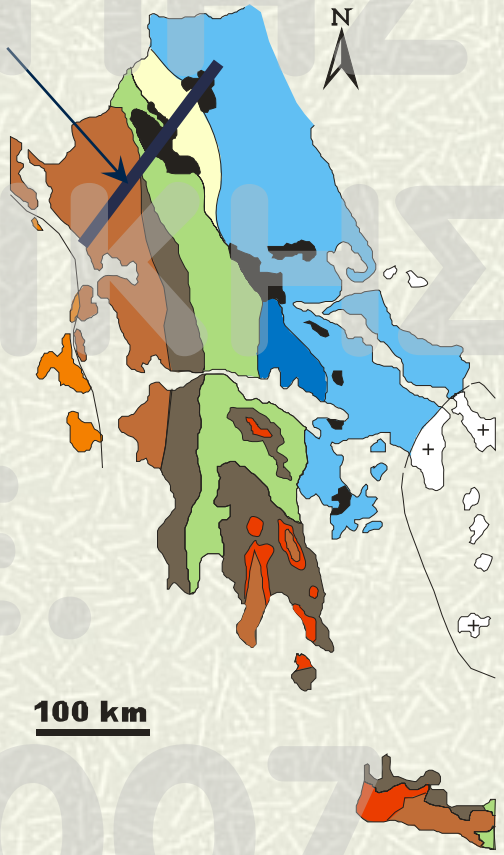



*by Tsokas and Hansen 1997*

# The northern part (Epirus section)

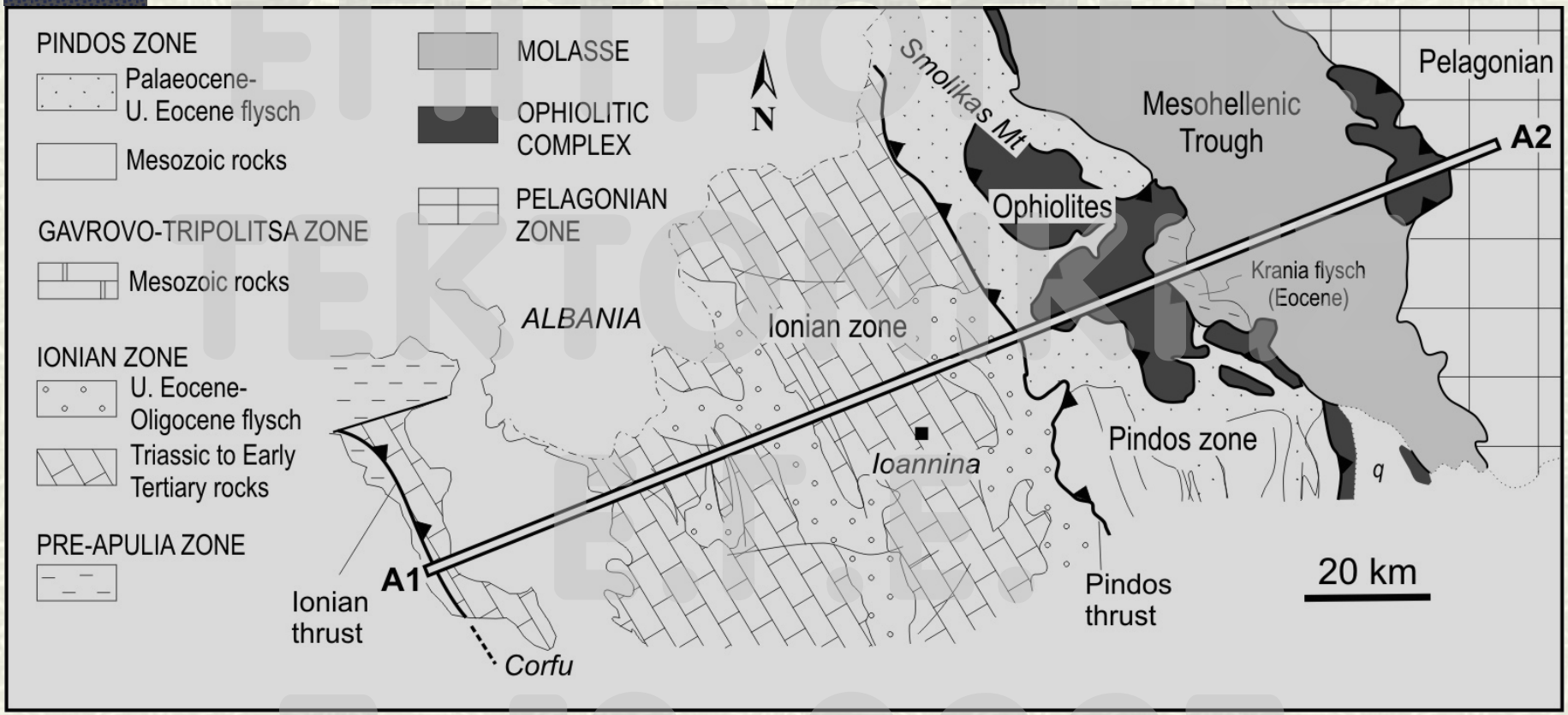
Epirus section



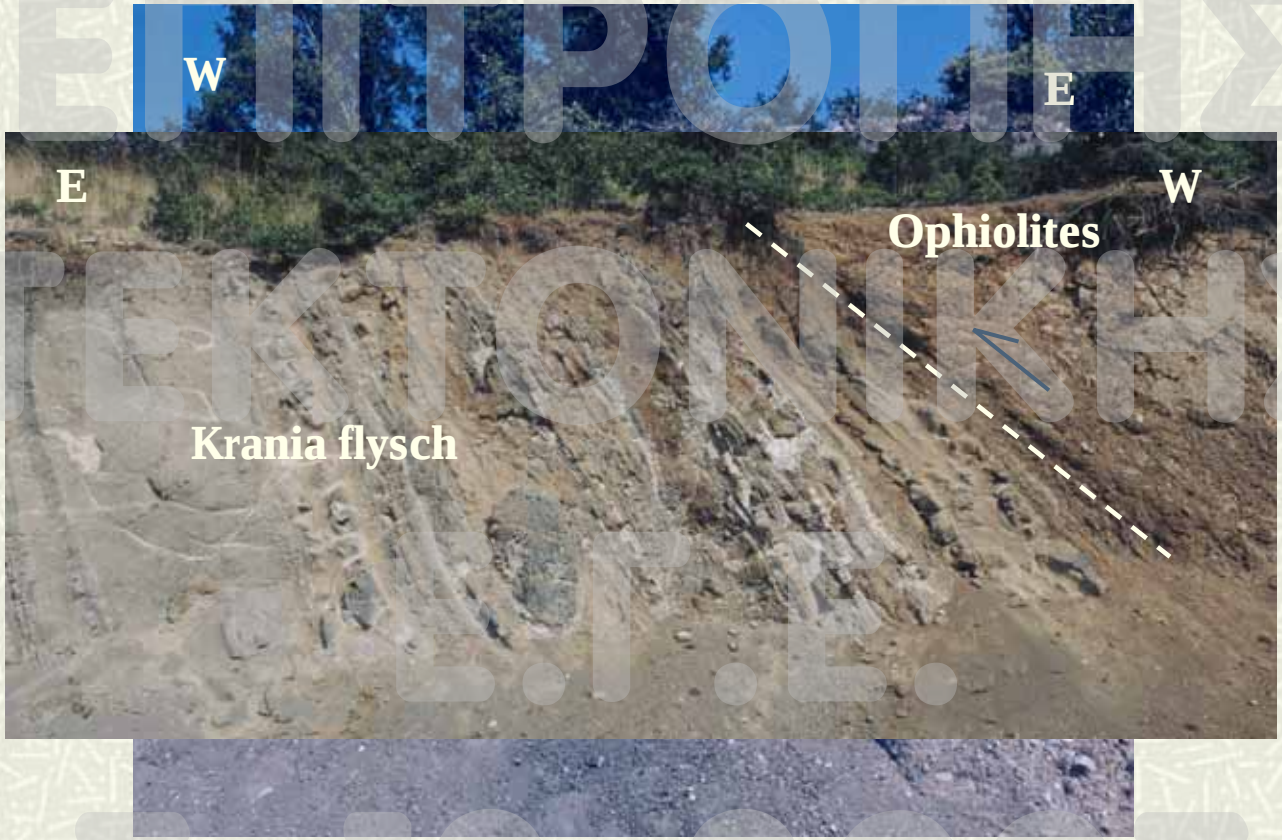

Data Sources:

**Doutsos et al. 2006**
**Kokkalas et al. 2006**
**Tselentis et al. 2006**
**Skourlis and Doutsos 2003**
**Doutsos 1994**
**BR Co 1971**
**IFP 1966**

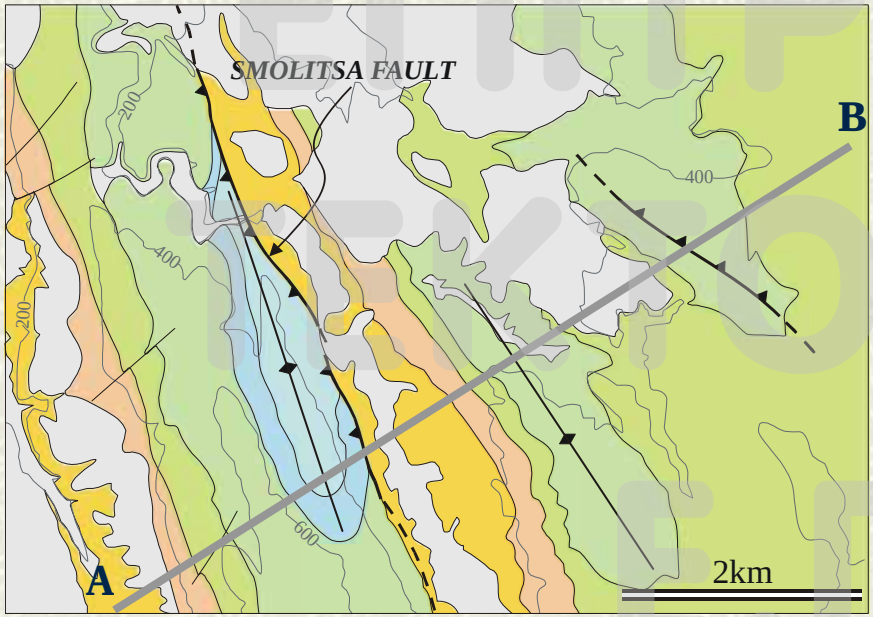
# The northern part (Epirus section)



# **Key structural observations in the northern part -** Mesohellenic Trough



# Key structural observations in the northern part – Ionian Zone




POST OROGENIC SEDIMENTS

UPPER EOCENE-BURDIGALIAN
Flysch

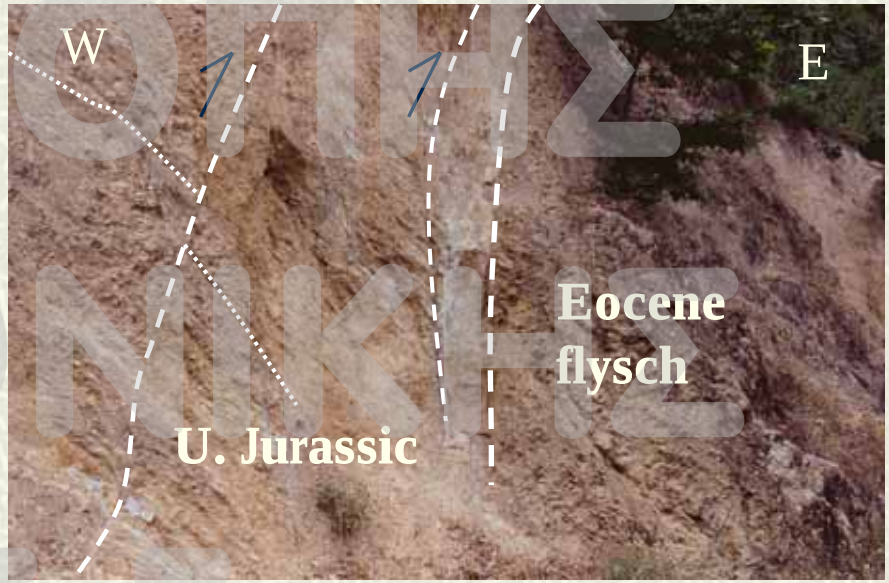
PALEOCENE-UPPER EOCENE
Sublithographic limestones

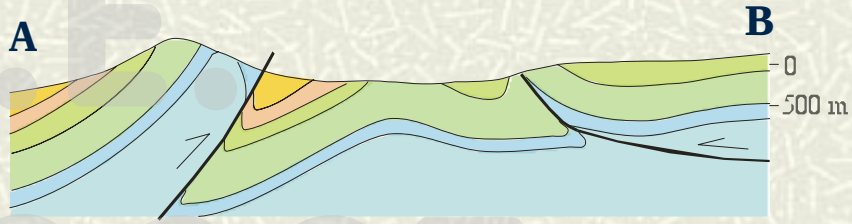
UPPER SENONIAN
Limestones with rudistes

UPPER JURASSIC-LOW SENONIAN
Vigla limestones

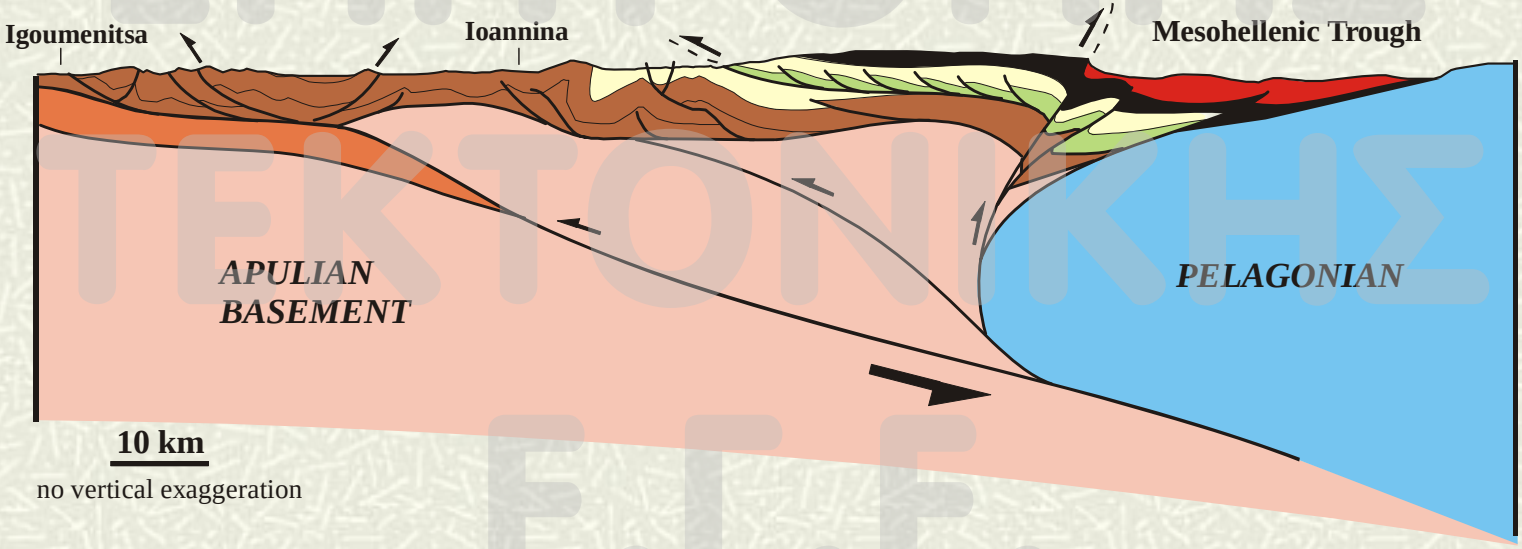
UPPER LIAS-UPPER JURASSIC
Posidonian beds

LOWER-MIDDLE LIAS
Pantocrator limestones



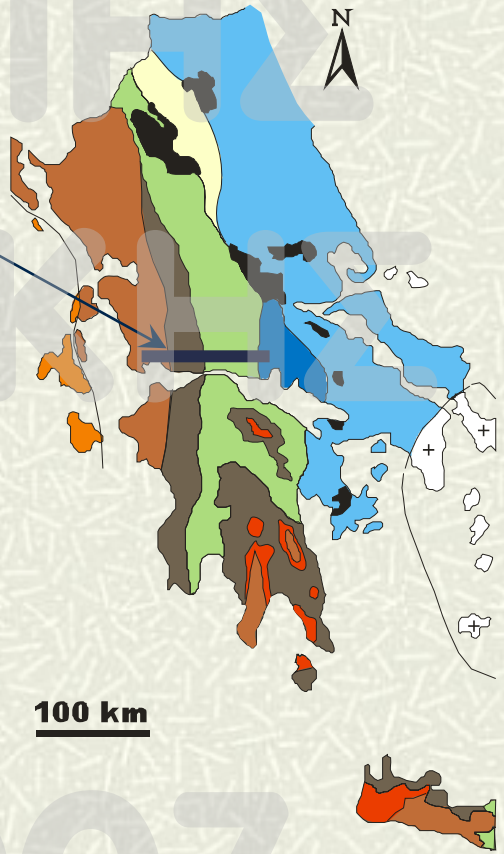
# The northern part (Epirus section)



# Summary of key structural observation in northern part

- A-subduction with significant back-thrusting and thick-skinned deformation (double-vergent orogen)
- Thickest crust underneath Ioannina
- Double-verging orogen produce flysch basins to the west (Epirus) and to the east (Mesohellenic Trough)
- Flysch deposition within Ionian zone outlasted until the Lower Miocene

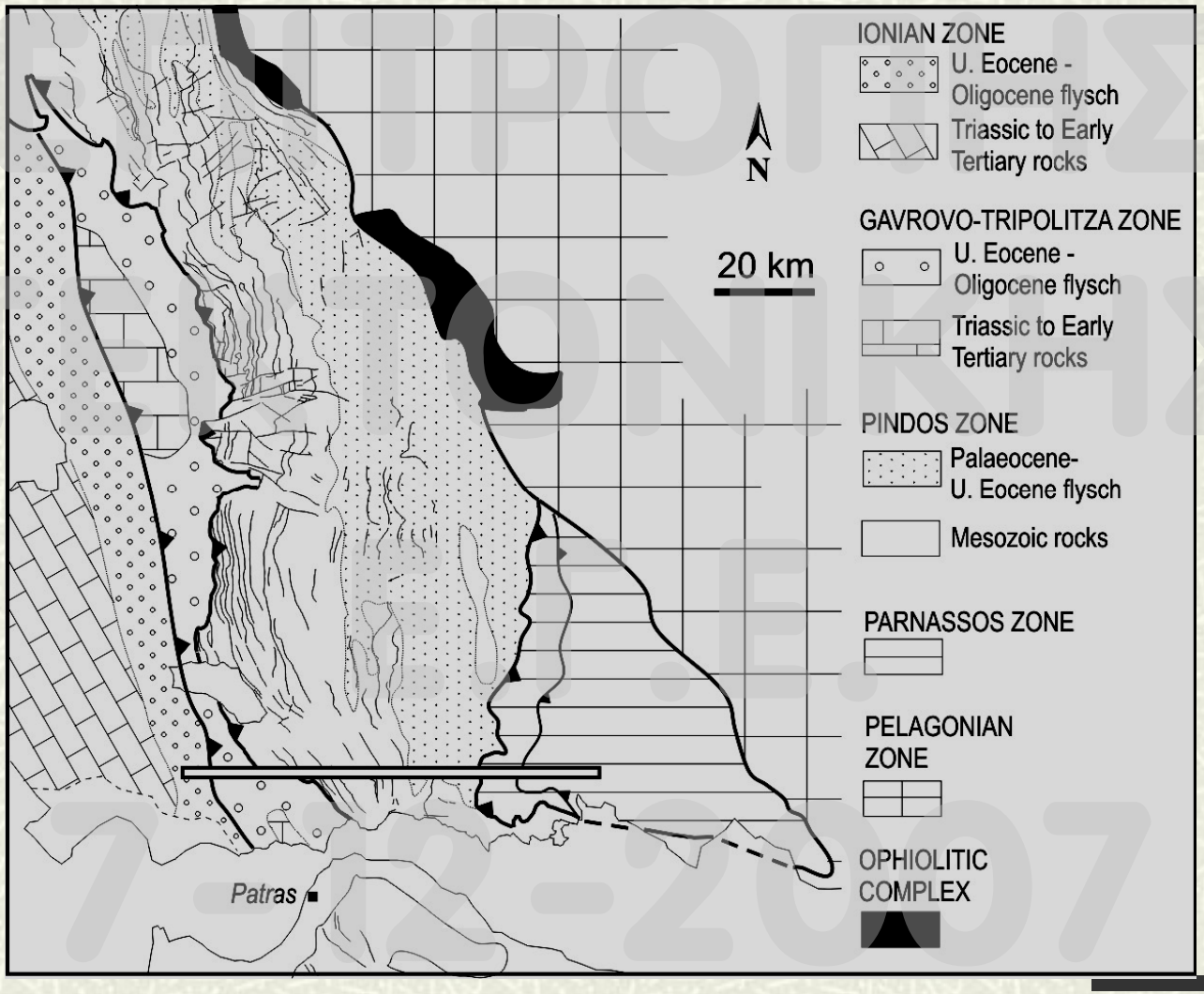
# The central part (Nafpaktos section)



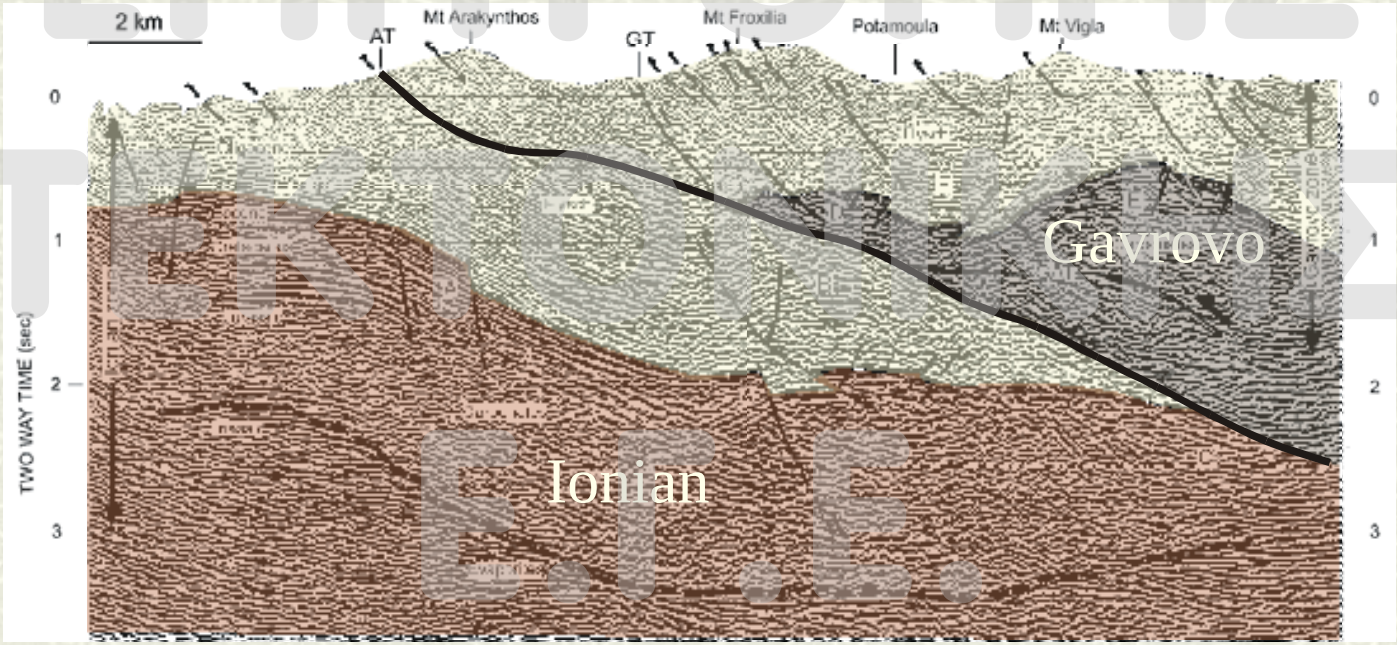

Data Sources:

**Doutsos et al. 2006**
**Xypolias & Koukouvelas 2005**
**Sotiropoulos et al. 2004**
**Skourlis and Doutsos 2003**
**Doutsos 1994**
**BR Co 1971**
**IFP 1966**

# The central part (Nafpaktos section)

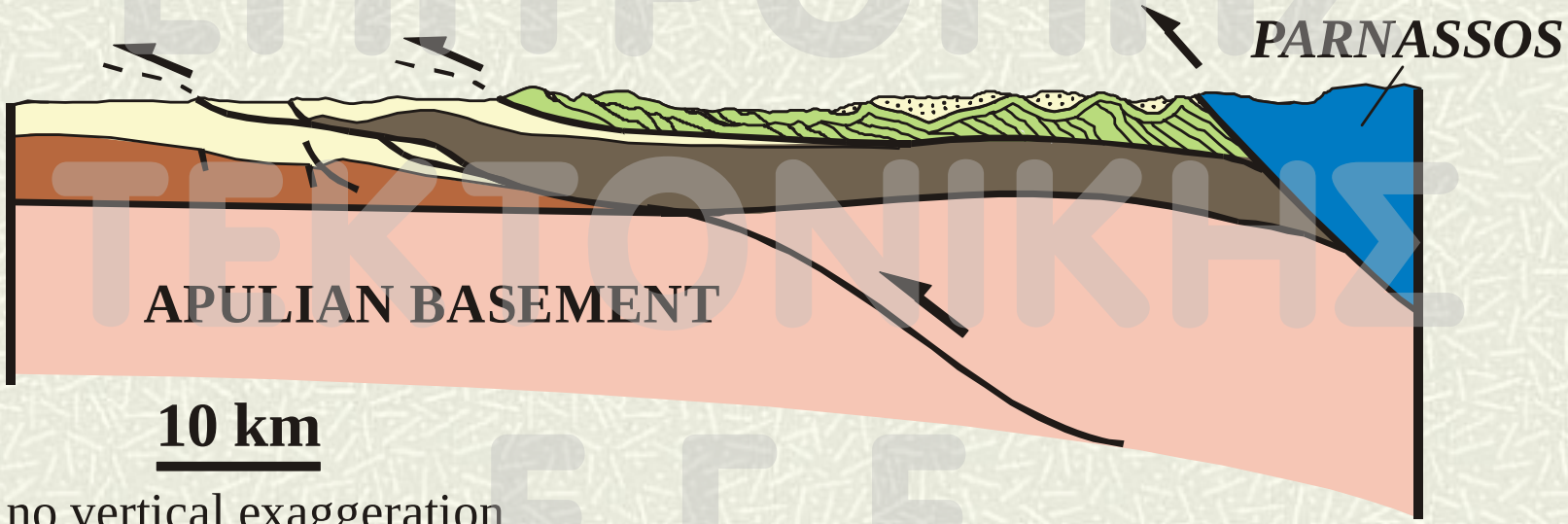


# **Key structural observations in the central part -** Deep seismic data



# **Key structural observations in the central part -** Pindos Thrust Belt

# The central part (Nafpaktos section)




no vertical exaggeration

# Summary of key structural observations in the central part

**Pindos thrust**

Displacement rate: 6 mm/yr

Displacement 100 km

Activity early Eocene to Oligocene-Miocene boundary

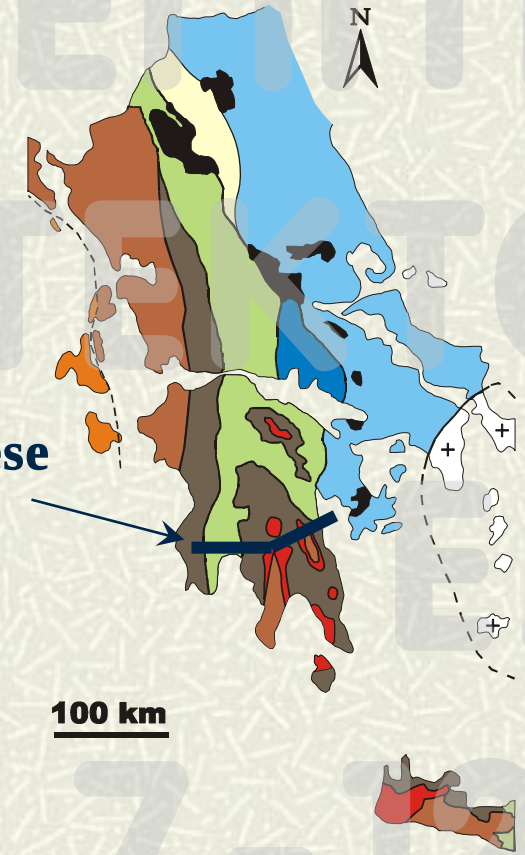
**Gavrovo thrust**

Displacement rate 1 mm/yr

Displacement >15 km

Activity Eocene to Oligocene-Miocene boundary

# The southern part (Peloponnese section)

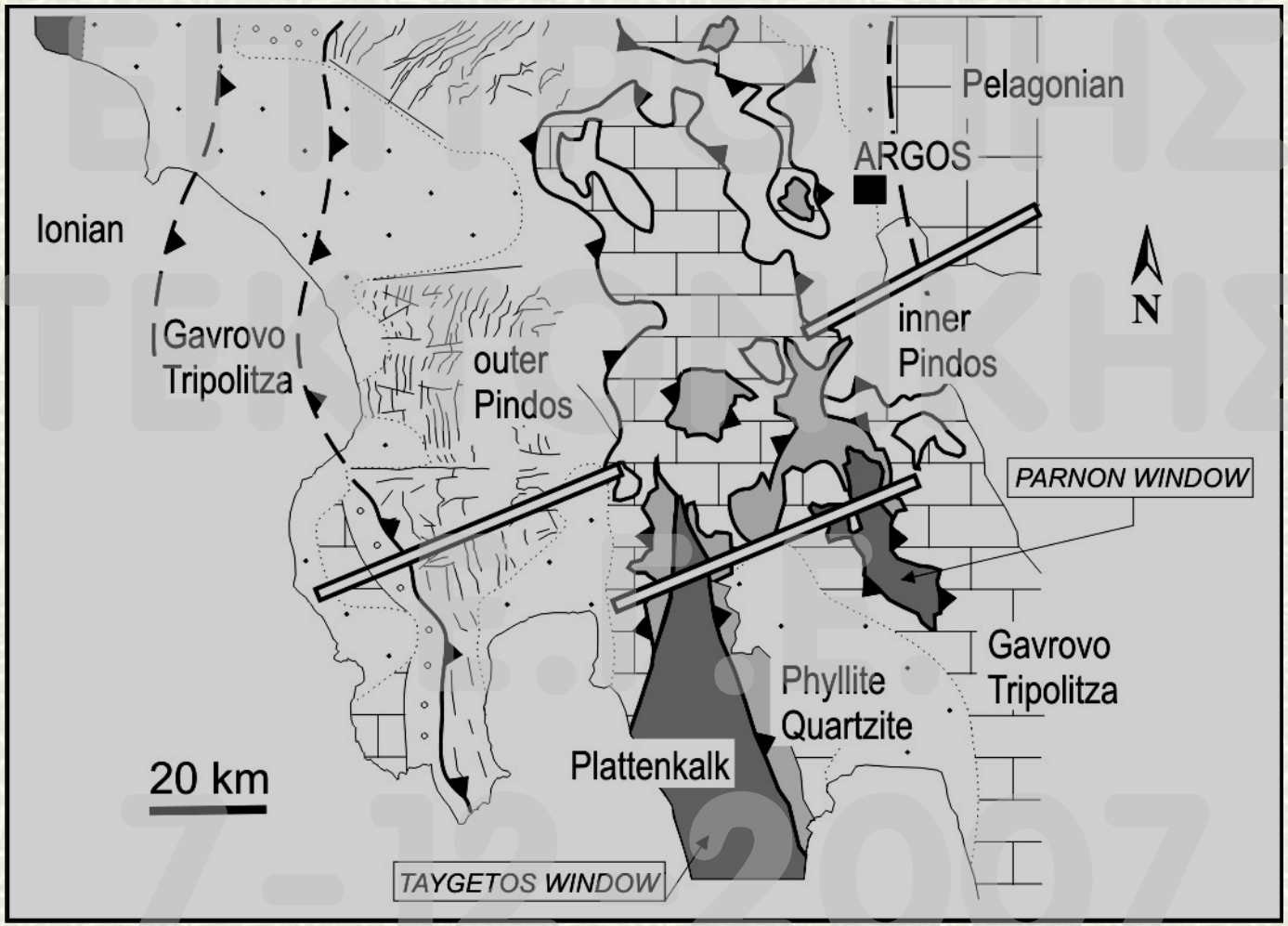



Peloponnese section

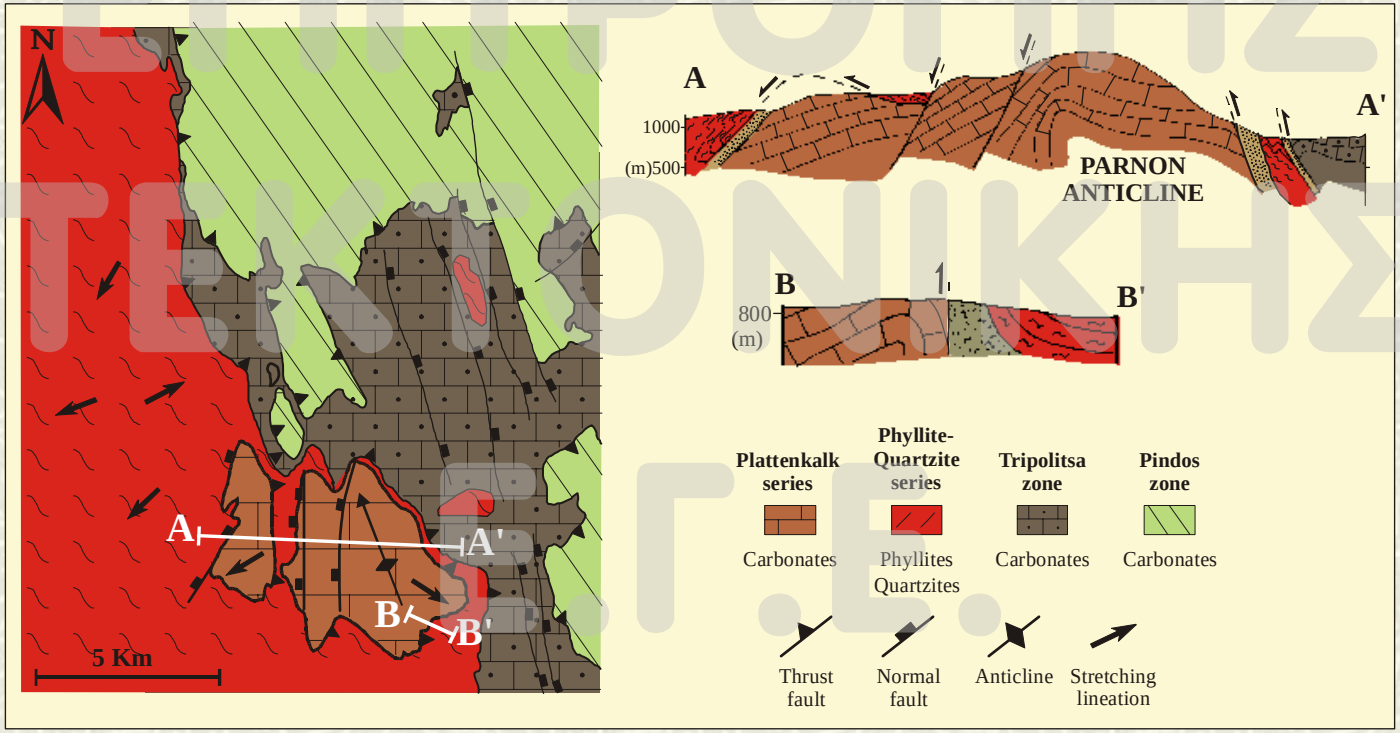
Data Sources:

**Doutsos et al. 2000, 2006**
**Xypolias and Doutsos 2000**
**Xypolias and Koukouvelas 2001**
**Xypolias & Kokkalas 2006**
**Xypolias et al. 2007**
**Xypolias et al. 2008**

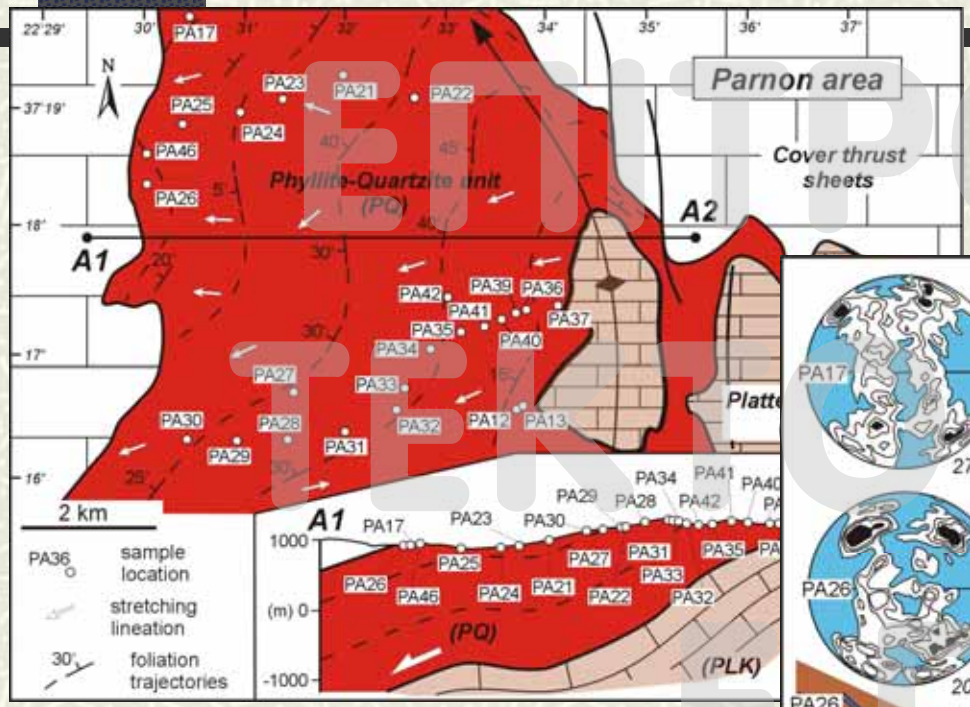
# The southern part (Peloponnese section)

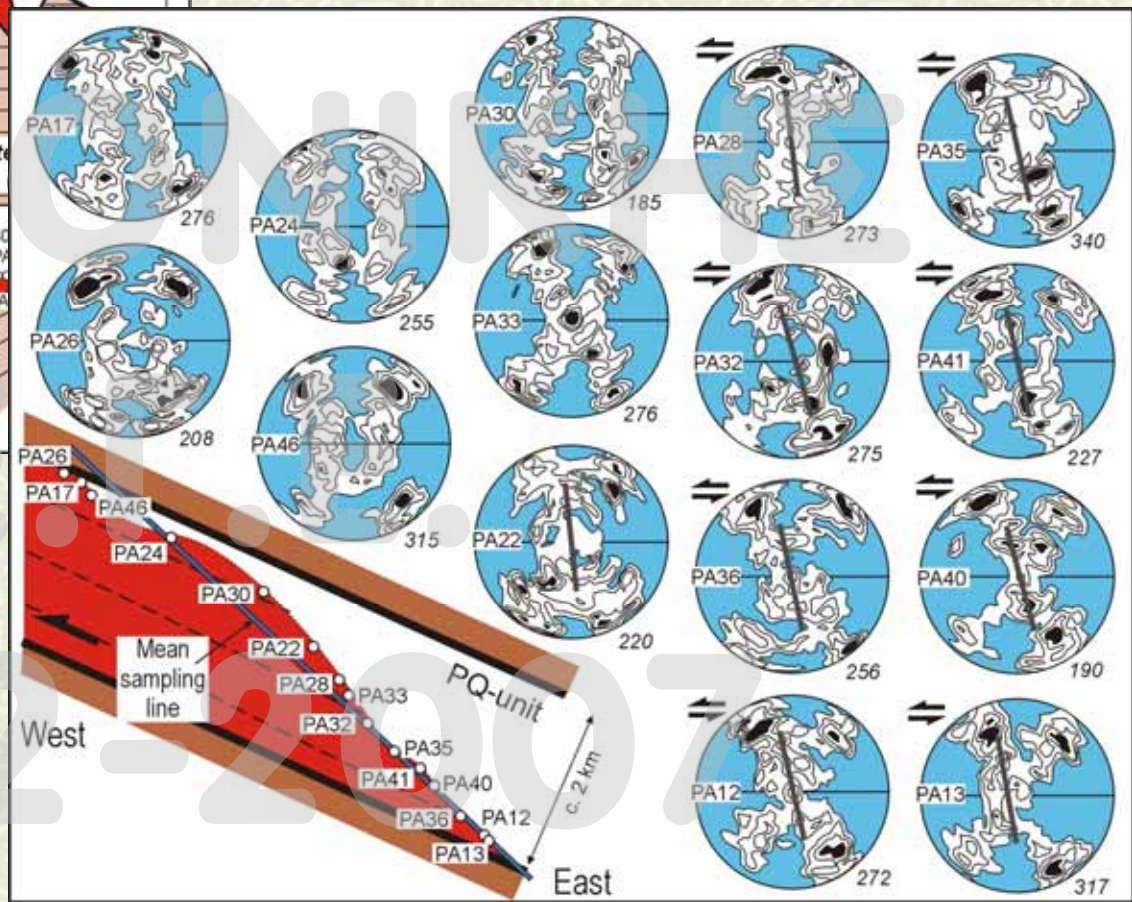


# Key structural observations in the southern part – Parnon Window

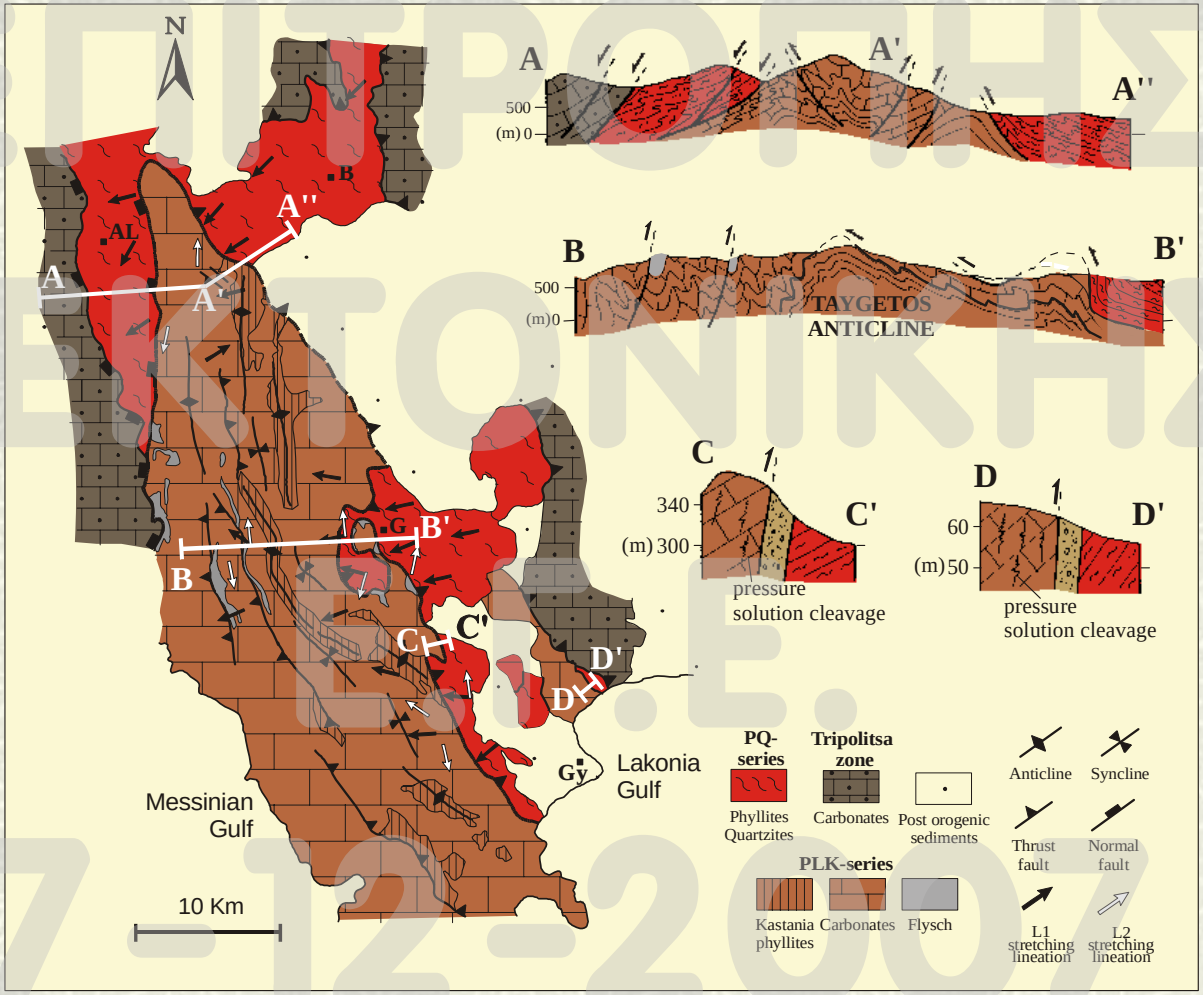


# Key structural observations in the southern part – Parnon Window

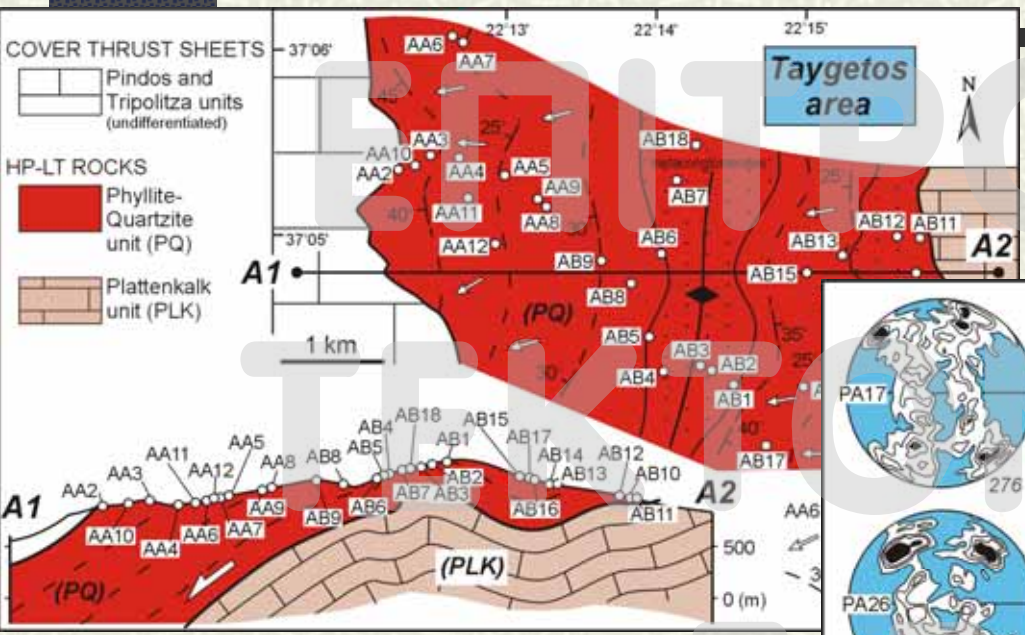


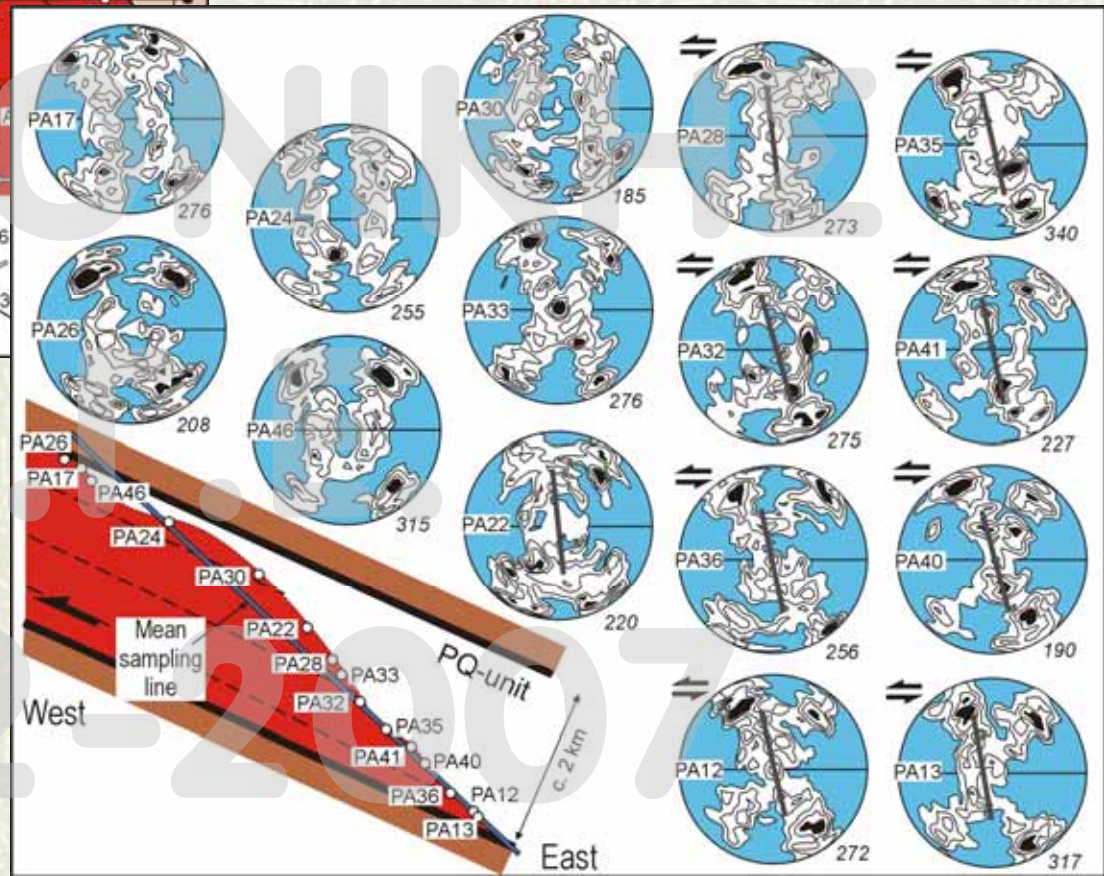



# Key structural observations in the southern part – Taygetos Window

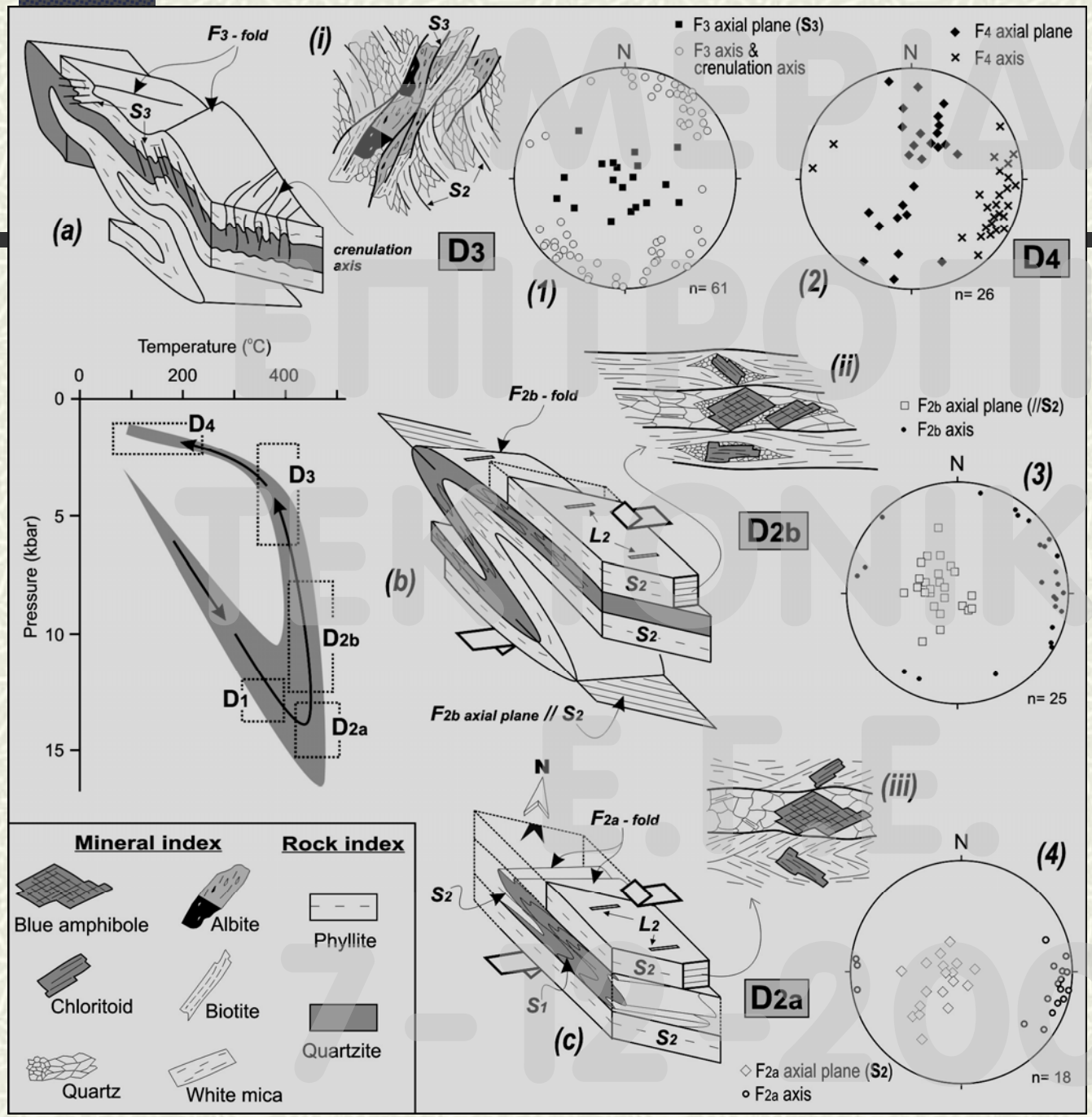


# Key structural observations in the southern part – Taygetos Window

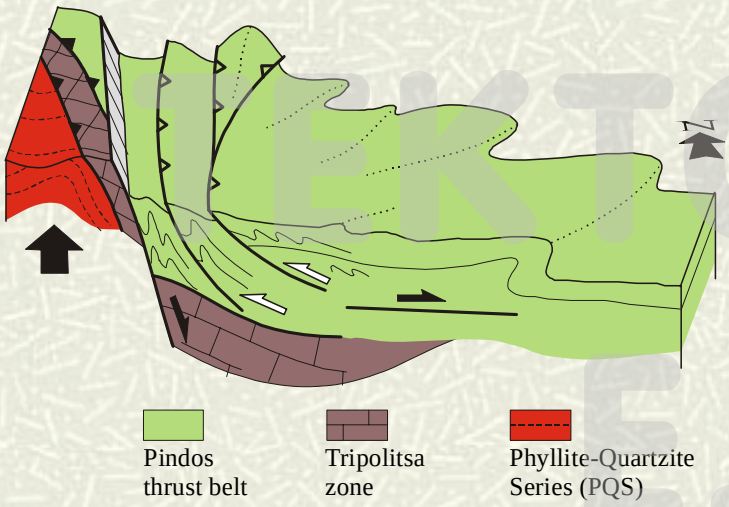


# Additional evidence from Kythira

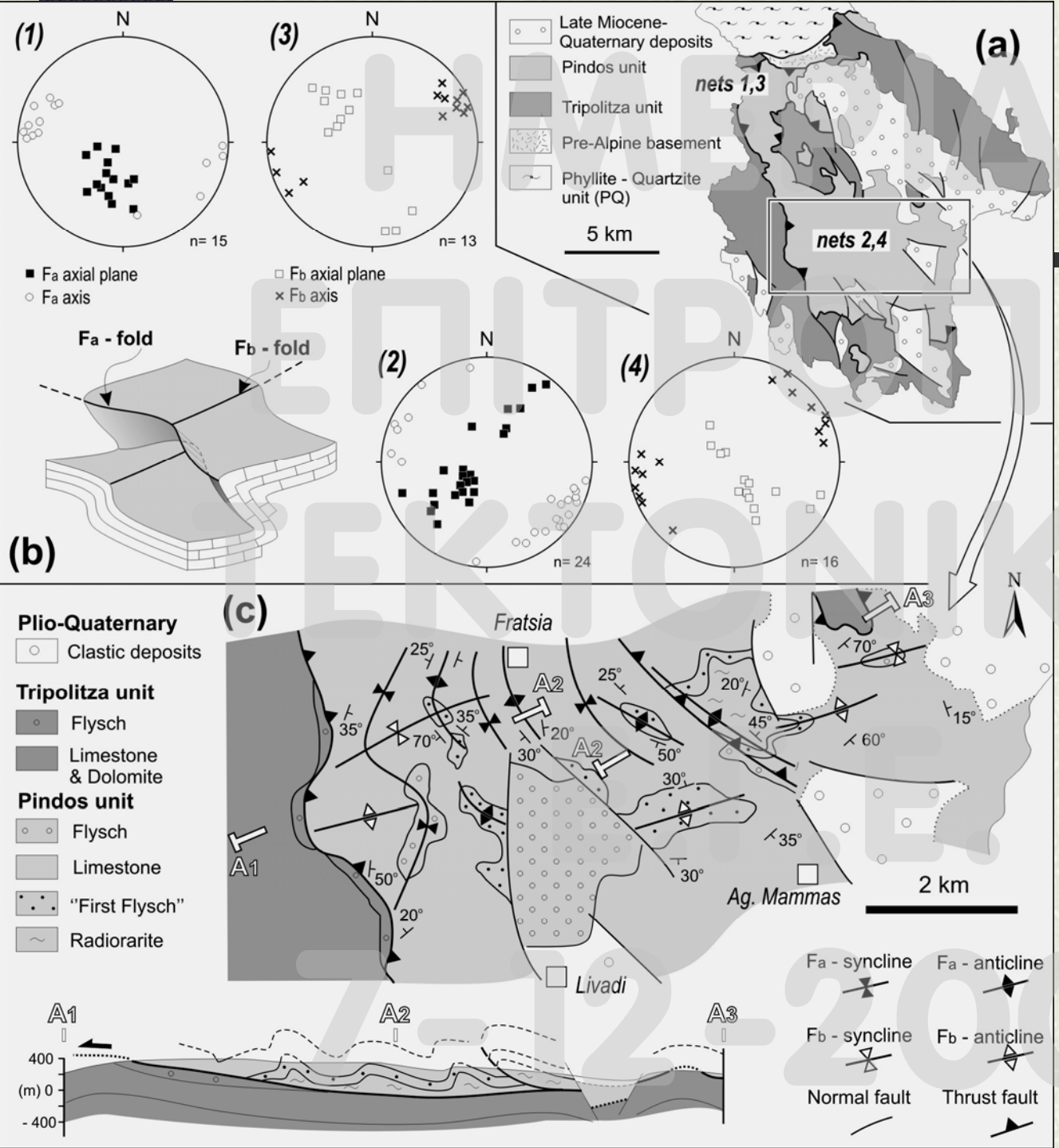


# **Key structural observations in the southern part –** Pindos Thrust Belt

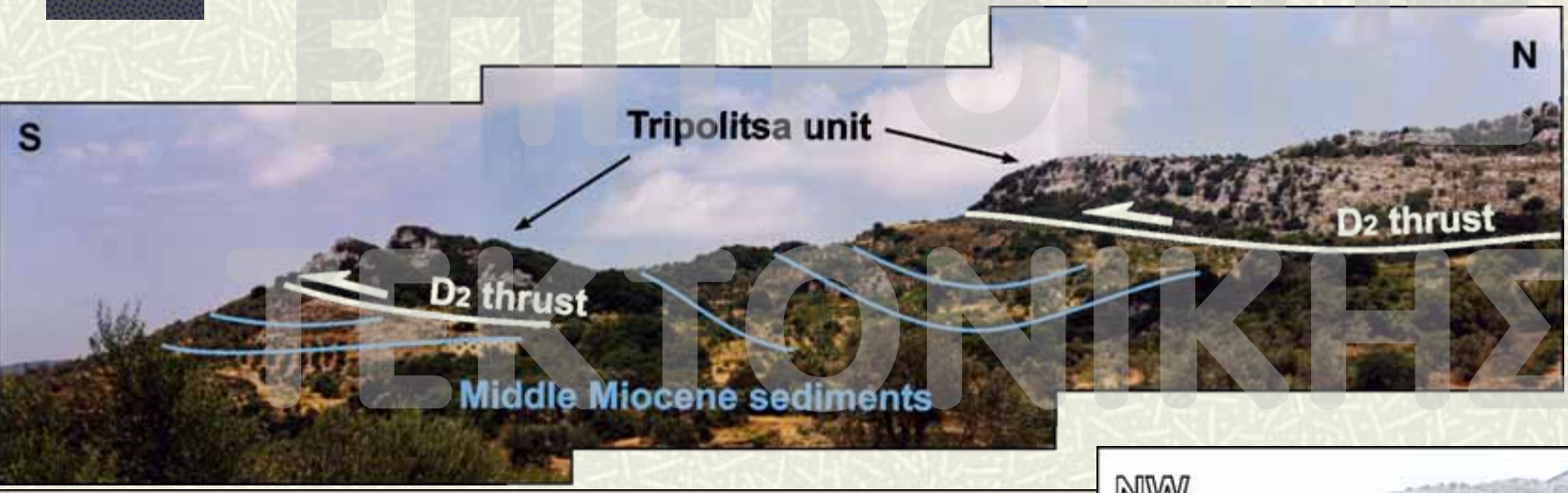


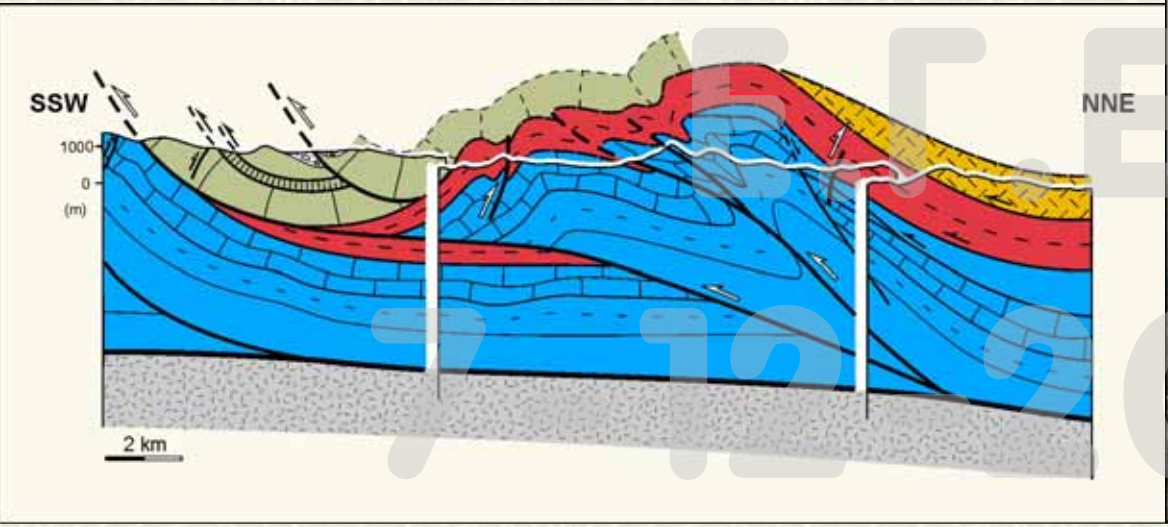

# Pindos Thrust Belt

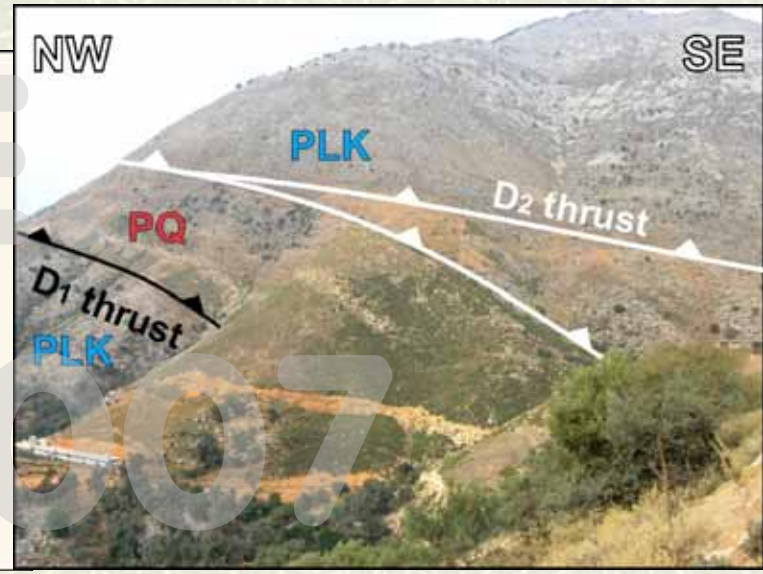
## Additional evidence from Kythira



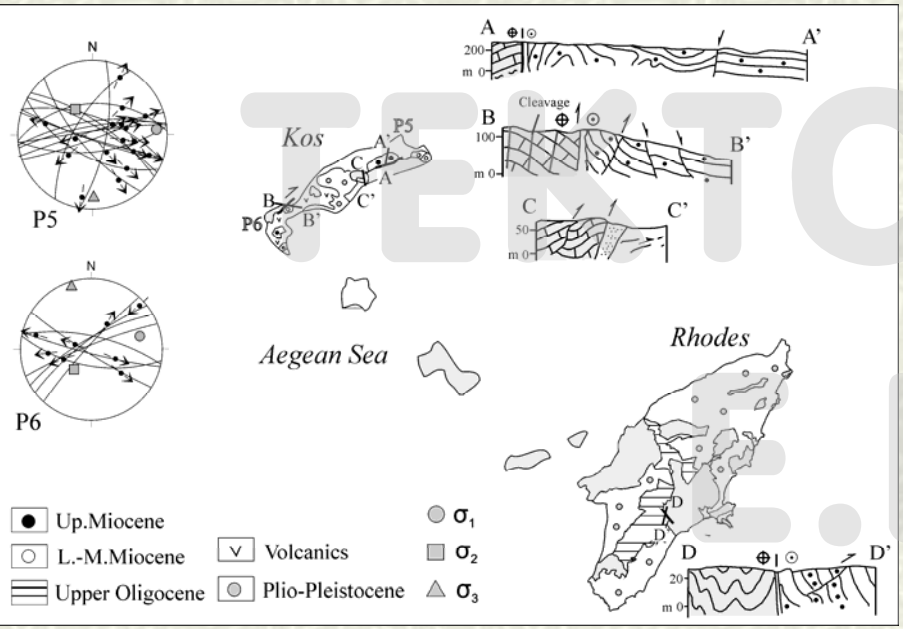
# Additional evidence from Crete



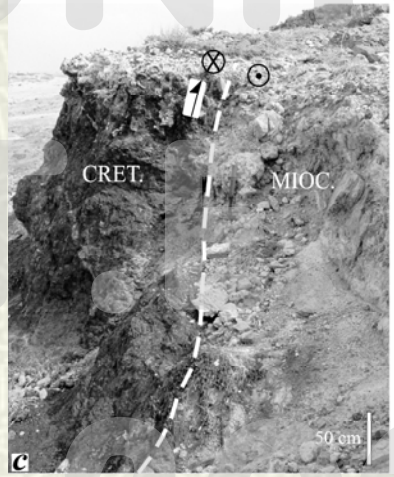
# Additional evidence from Eastern Crete and Dodecanese Islands



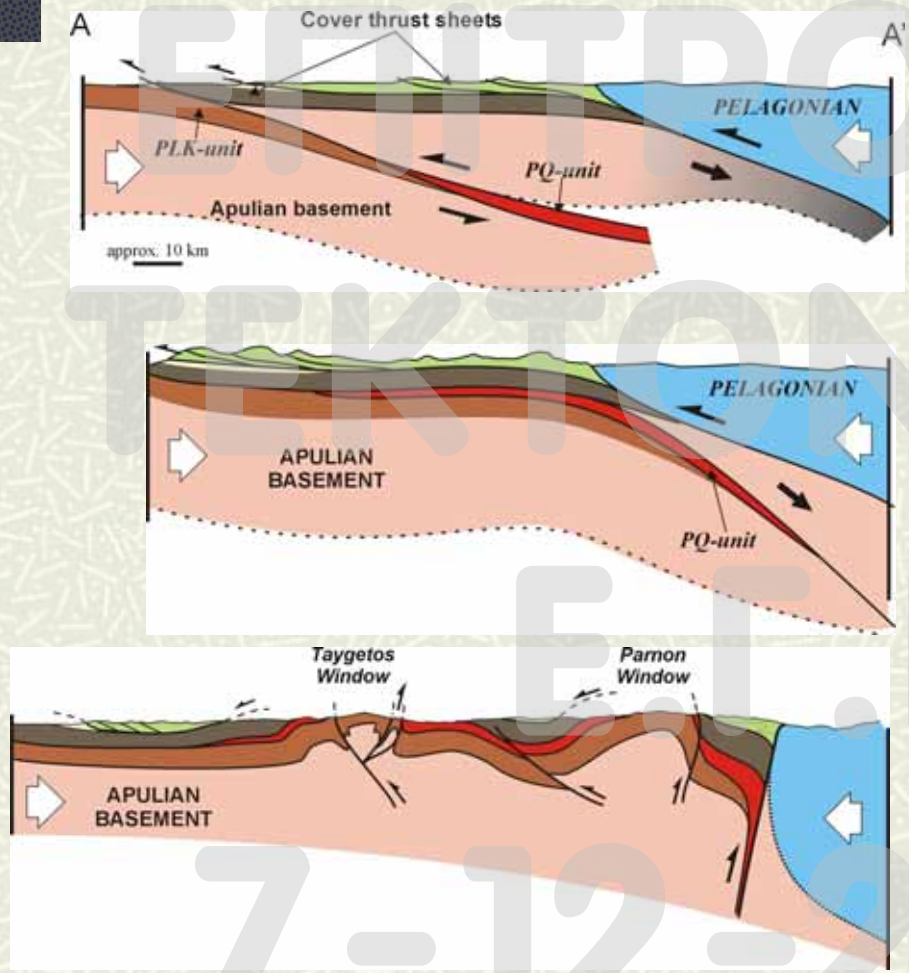

## Eastern Crete



## Kos Island




# Tectonic evolution




After Xypolias & Doutsos (2000); Doutsos *et al.* (2000)

Late Oligocene-Early Miocene

underthrusting of PQ protolith and its basement beneath the Tripolitza basement

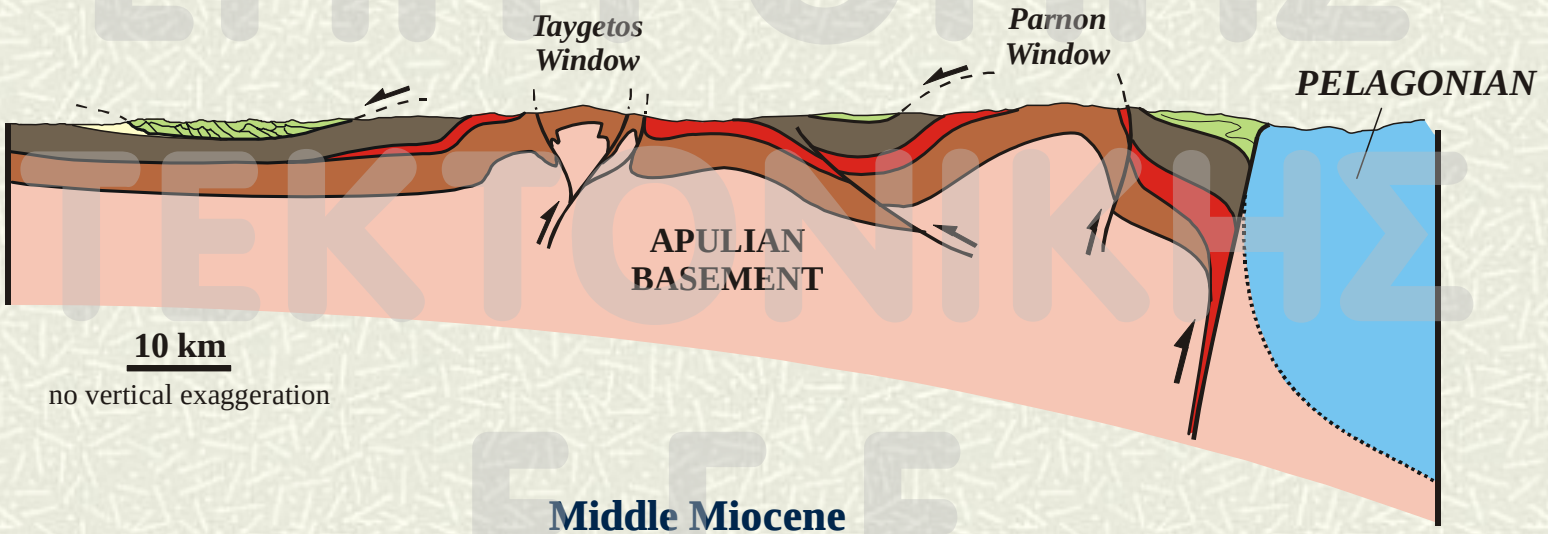
Lower Miocene

the PQ unit was detached from its basement and extruded upward between **a thrust fault at the base** and the Tripolitza basement at the top

Middle Miocene

regional backthrusting, folding of the major thrust contacts and gravity sliding of the cover thrust sheets

# The southern part (Peloponnese section)

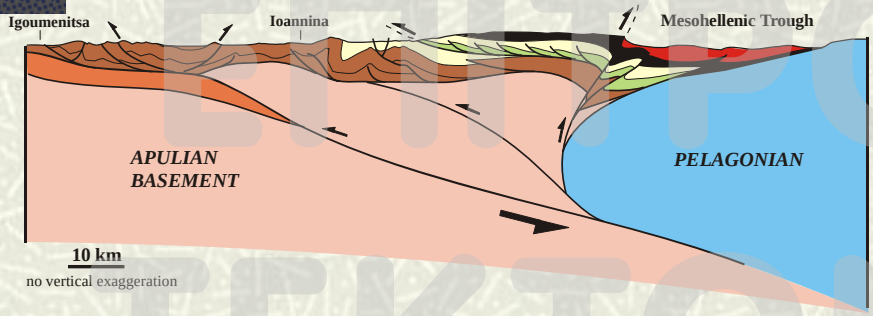


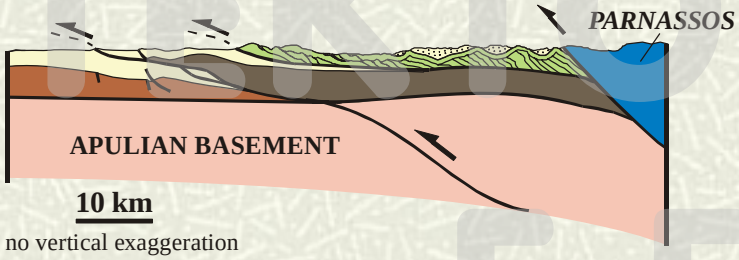

Middle Miocene

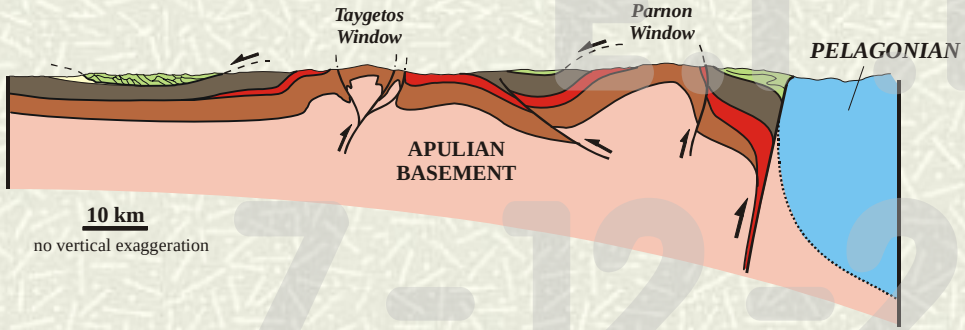
# Summary of key structural observations in the southern part

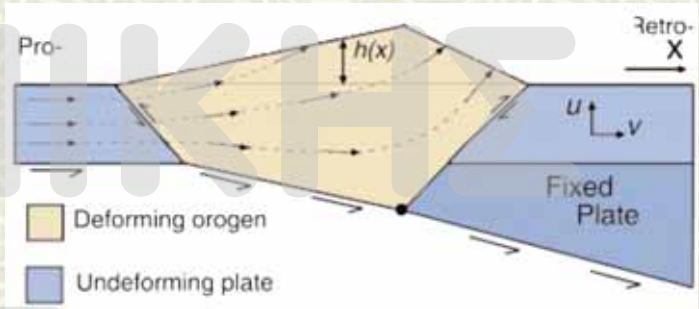
- The Oligocene flysch of Plattenkalk suggests that the thrusting in Peloponnese is coeval with thrusting in Gavrovo and Pindos.
- Thick-skinned deformation was responsible for back-thrusting and the exhumation of the Parnon and Taygetos tectonic windows
- Lower Miocene syn-compressional exhumation rate decreases from 7 to 1.5 mm/year.

# Synthesis

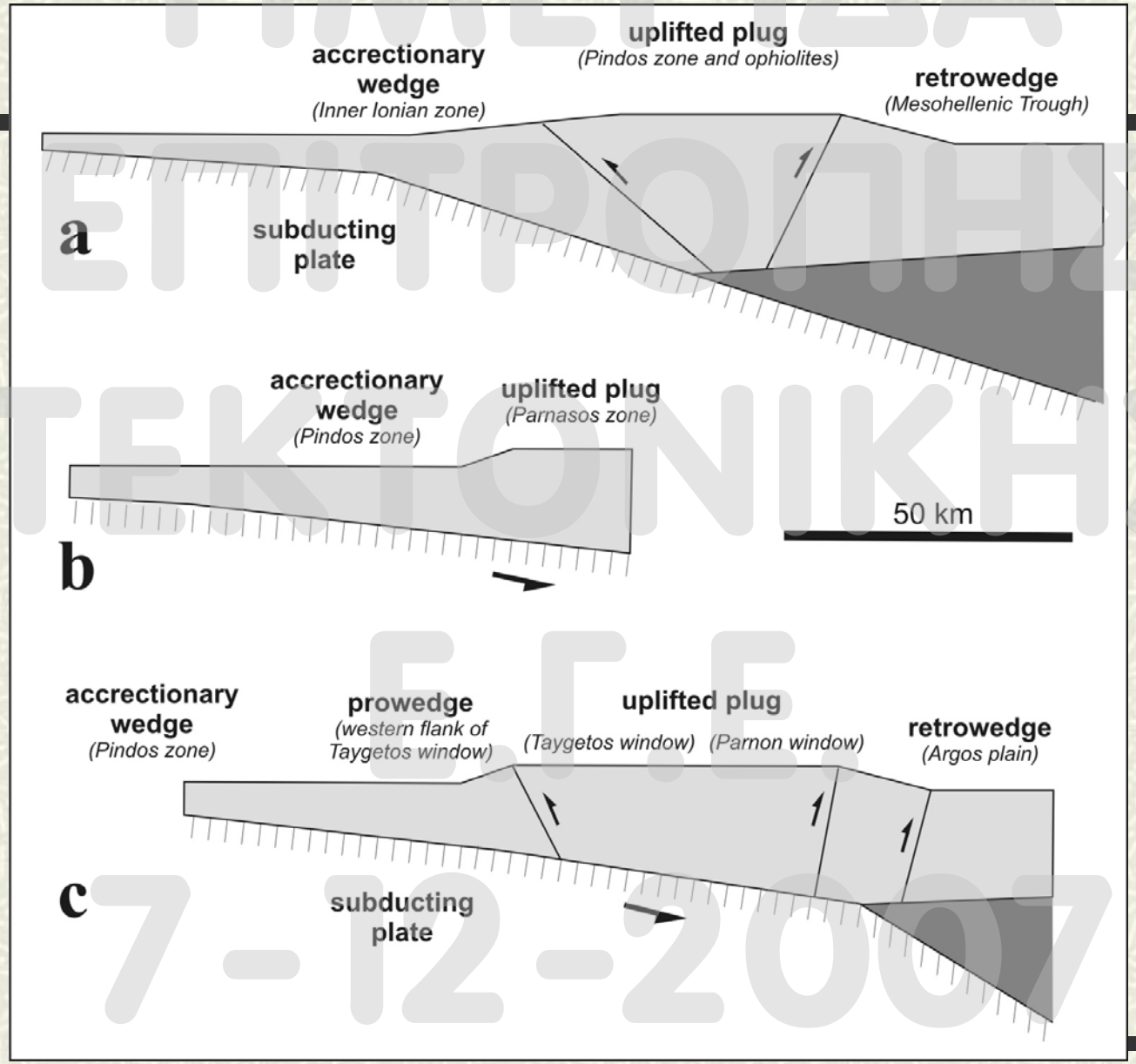



*by Willett et al. 2001*


accrectionary
wedge
(Inner Ionian zone)
uplifted plug
(Pindos zone and ophiolites)
retrowedge
(Mesohellenic Trough)
a
subducting
plate
accrectionary
wedge
(Pindos zone)
uplifted plug
(Parnasos zone)
50 km
b
accrectionary
wedge
(Pindos zone)
prowedge
(western flank of
Taygetos window)
uplifted plug
(Taygetos window)
(Parnon window)
retrowedge
(Argos plain)
c
subducting
plate

# Concluding remarks

## Existing models

- MT is an extensional basin
- Ionian and Gavrovo was deformed by open anticlines and the halokinesis of evaporites
- Thin-skinned deformation of the orogen
- West-verging orogen
- Moho depth distribution is not explained

## Our new model

- MT formed under compression until the end of Oligocene
- The contact is a major thrust causing thickening of the crust
- Thick-skinned deformation
- Double-verging orogen (basins in the north, windows in the south)
- Moho depth due to the weakness of the crust is expected to the west of the suture zone (Skourlis and Doutsos 2003)