

Orogenic Episodes in the Pontides*

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Abstract

Throughout much of the Mesozoic and Tertiary the Pontides have been an active margin subject to periods of shortening and extension. Most of this deformation was accretional rather than collisional and was related to the dynamics of the northward subduction of the Tethyan oceanic lithosphere. A further complexity is that the Pontides were not a single plate but consisted of three plates or terranes (Sakarya, Istanbul and Strandja) with independent histories prior to the Early Cretaceous.

A major contractional event occurred during the latest Triassic in the Sakarya terrane and involved the accretion of Upper Paleozoic - Triassic trench sediments and oceanic crust to the southern margin of Eurasia. The accretional unit, called the Karakaya Complex, comprises eclogites and blueschists with Late Triassic isotopic ages and is tectonically imbricated with Hercynian basement units. This Cimmeride orogeny is linked to the closure of the Paleo-Tethys and the opening of the Neo-Tethys; however, the spatial and temporal relations between these two oceanic domains are not clear. The Karakaya Complex and the Hercynian basement units are unconformably overlain by the Lower Jurassic conglomerates and sandstones, marking the beginning of a new depositional cycle in the Sakarya terrane. A significant disconformity marks the contact between the Lower-Middle Jurassic clastic rocks and the Upper Jurassic marine limestones. The Late Jurassic-Early Cretaceous (Oxfordian-Barremian) is represented throughout the Sakarya Zone by carbonate deposition interpreted as the development of a southward-facing passive carbonate margin. In contrast, a northward-vergent contractional orogen occurred at the Jurassic-Cretaceous boundary in the Strandja terrane in the western part of the Black Sea. It involved thrusting of the Hercynian basement over the Triassic-Jurassic cover sequence and associated regional metamorphism. The metamorphic rocks of the Strandja Massif are unconformably overlain by Cenomanian shallow-marine sandstones providing a firm upper age limit for the regional metamorphism. This orogenic event is probably linked to the collision between the Strandja and Rhodope terranes. No evidence for a latest Jurassic-earliest Cretaceous contraction is found in the neighboring Pontic terranes (Istanbul and Sakarya), indicating that the Strandja was part of a different plate at least up to the earliest Cretaceous.

A major accretional event occurred in the Sakarya terrane in the mid-Cretaceous (Albian), probably related to the collision of a microcontinent, as shown by the eclogites and blueschists in the Central Pontides with 100 Ma metamorphic ages. These metamorphic ages also imply ongoing subduction during the upper parts of the Early Cretaceous, although arc magmatism developed only in the Turonian-Coniacian. Aptian-Albian

was also the period of the amalgamation of the three Pontic and the rifting of the Western Black Sea basin. Late Cretaceous throughout the Pontides was a time of extension characterized by the deposition of a thick submarine volcanoclastic sequence. Several angular unconformities characterize the southern margin of the Pontides during the Late Cretaceous; these are probably related to the dynamics of oceanic subduction rather than to regional shortening.

References

Okay, A.I., I. Tansel, and O. Tuysuz, 2001, Obduction, subduction and collision as reflected in the Upper Cretaceous-lower Eocene sedimentary record of western Turkey: *Geological Magazine*, v. 138/2, p. 117-142.

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Okay, A.I., and O. Tuysuz, 1999, Tethyan sutures of northern Turkey, *in* B. Durand, L. Jolivet, F. Horvath, and M. Seranne (eds.) *The Mediterranean Basins; Tertiary Extension within the Alpine Orogen: Geological Society (London) Special Publication* 156, p. 475-515.

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Mesozoic-Tertiary orogenic episodes in the Pontides

Aral Okay

Istanbul Technical University





Mesozoic orogenic events in the Pontides

latest Triassic

Late Jurassic - Early Cretaceous

mid-Cretaceous

Late Paleocene - Early Eocene



S**N****Mid-Triassic**

Paleo-Tethys ocean

Sakarya Zone

Nilüfer oceanic plateau

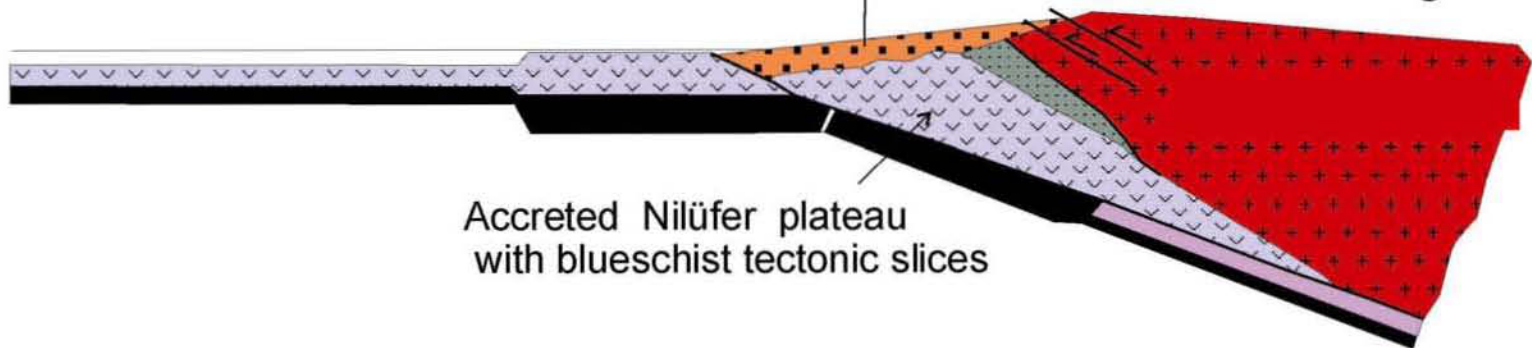
Laurasian margin

**Late Triassic**

Karakaya Complex

Clastic wedge fed from the
Hercynian granitic basement

Paleozoic granites

Accreted Nilüfer plateau
with blueschist tectonic slices

Tectonic setting of the Karakaya Complex (Okay, 2000)

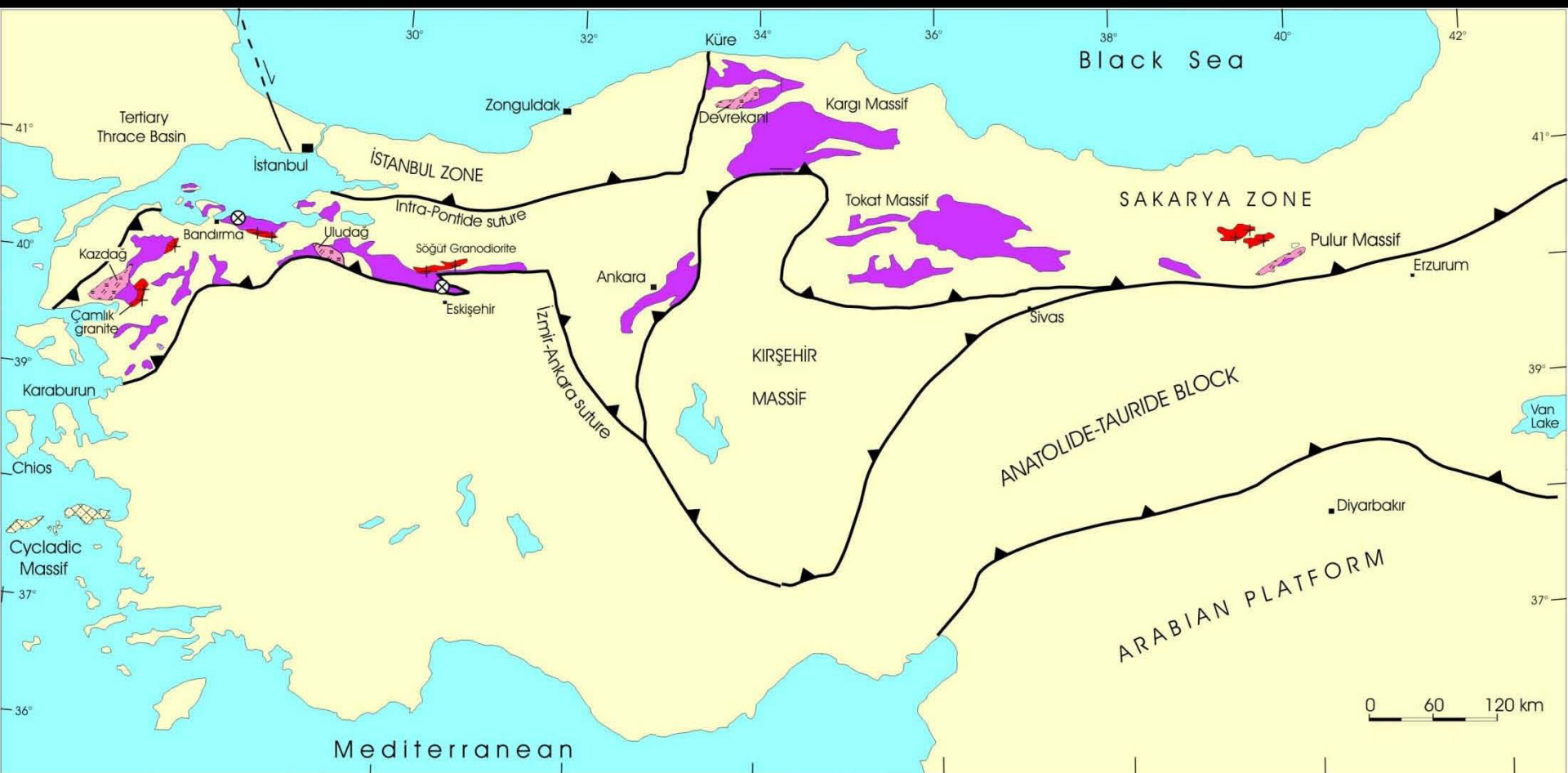
Late Triassic deformation and metamorphism:

Greenschist to eclogite facies metamorphism
(latest Triassic - ca. 200 Ma)

A short event

Sealed by Lower Jurassic molasse

Accretion of oceanic plateau/islands to the southern
margin of Eurasia



Tethyan accretionary complex and ophiolite

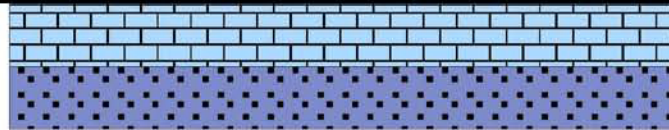
- Karakaya-Küre (Late Triassic-Early Jurassic)
- ⊗ Upper Triassic blueschist and eclogite

Crystalline basement

- + Pre-Jurassic granites
- + Variscan

Middle-Late Jurassic

Early Jurassic (203 Ma)



~~~~~ Major post-orogenic unconformity ~~~~~

### Hodul Unit

Debris flows with  
Permian and Carbon  
limestone blocks

Black shale and  
siltstone with  
*Halobia* sp.

Quartzo-feldspathic  
sandstone

Late Triassic

Paleozoic granite and  
metamorphic rock

### Nilüfer Unit

Phyllite

Metabasite

Marble

Metabasite

Early-Mid Triassic

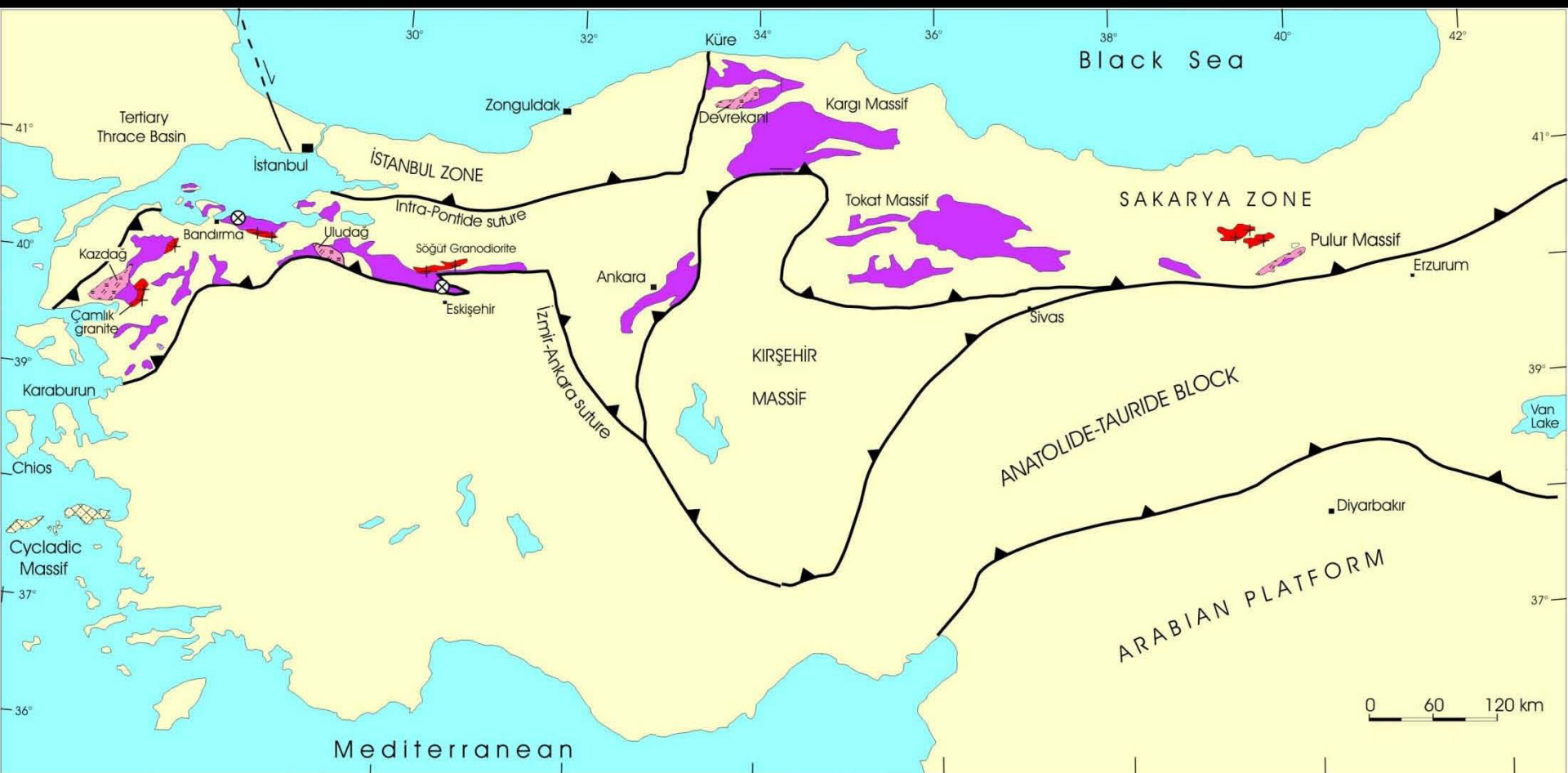
Upper Paleozoic-  
Triassic greywacke,  
basalt, radiolarite

Metamorphosed in blueschist  
and greenschist facies  
210-205 Ma Ar-Ar phengite ages









### Tethyan accretionary complex and ophiolite

- Karakaya-Küre (Late Triassic-Early Jurassic)
- Upper Triassic blueschist and eclogite

### Crystalline basement

- Pre-Jurassic granites
- Variscan

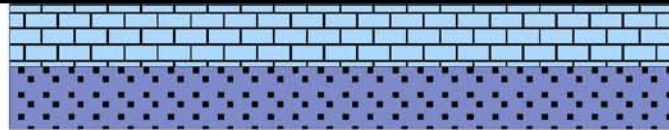






Middle-Late Jurassic

Early Jurassic (203 Ma)



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Late Triassic

Paleozoic granite and
metamorphic rock

Nilüfer Unit

Phyllite

Metabasite

Marble

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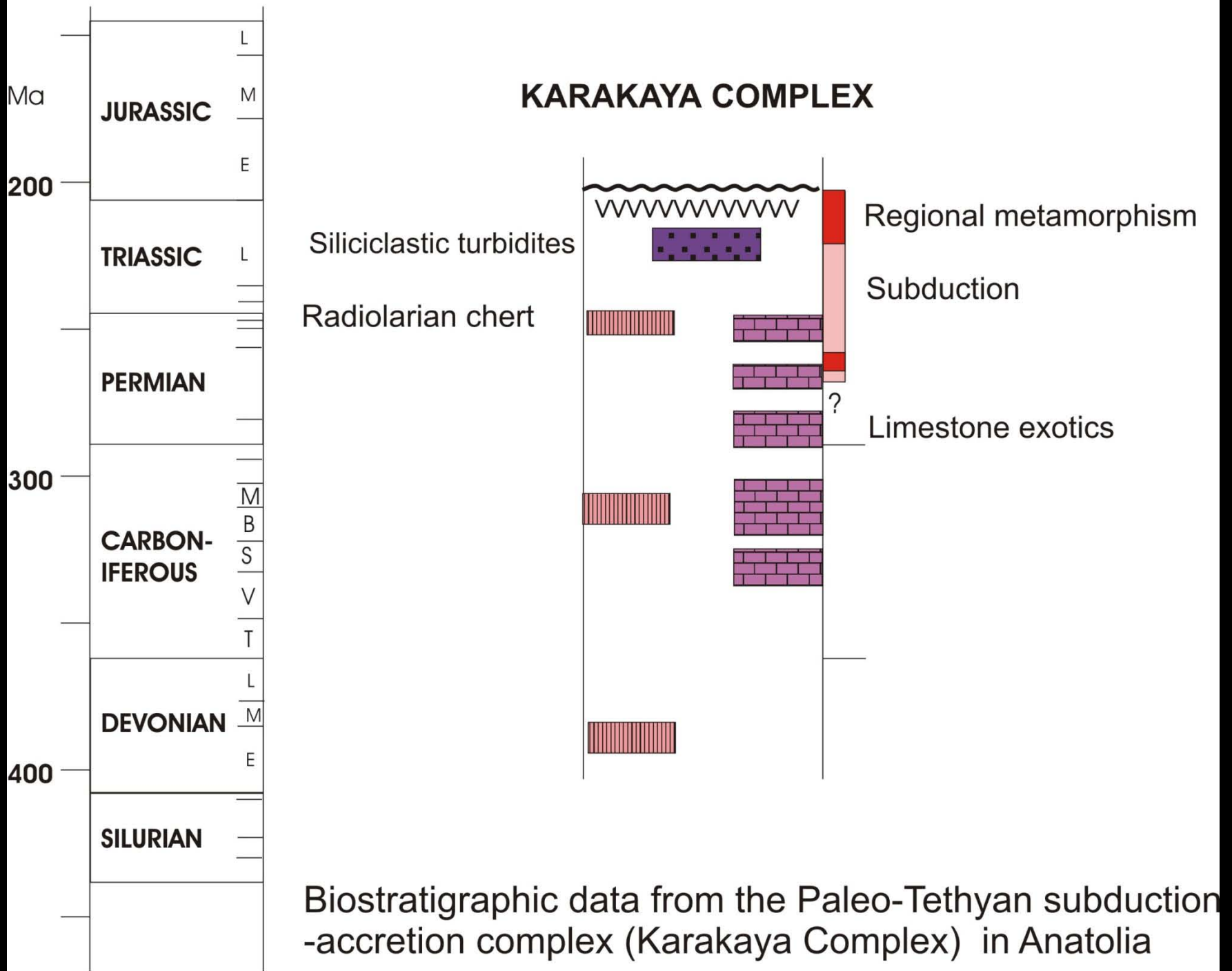
Early-Mid Triassic

Upper Paleozoic-
Triassic greywacke,
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Metamorphosed in blueschist
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210-205 Ma Ar-Ar phengite ages







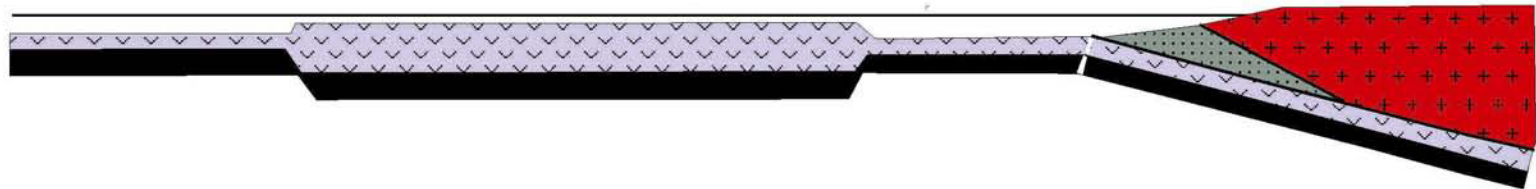
S**N*****Mid-Triassic***

Paleo-Tethys ocean

Sakarya Zone

Nilüfer oceanic plateau

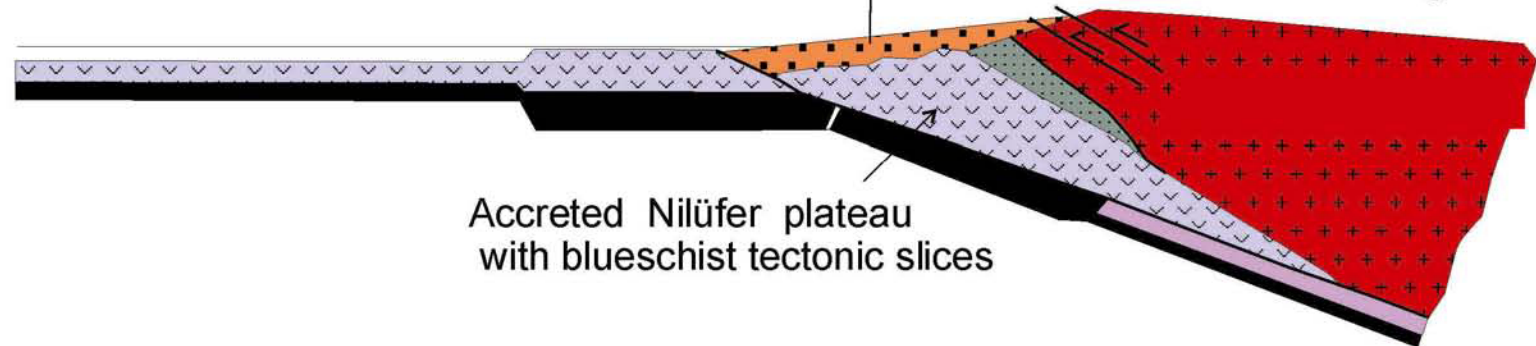
Laurasian margin

***Late Triassic***

Karakaya Complex

Clastic wedge fed from the
Hercynian granitic basement

Paleozoic granites

Accreted Nilüfer plateau
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Tectonic setting of the Karakaya Complex (Okay, 2000)



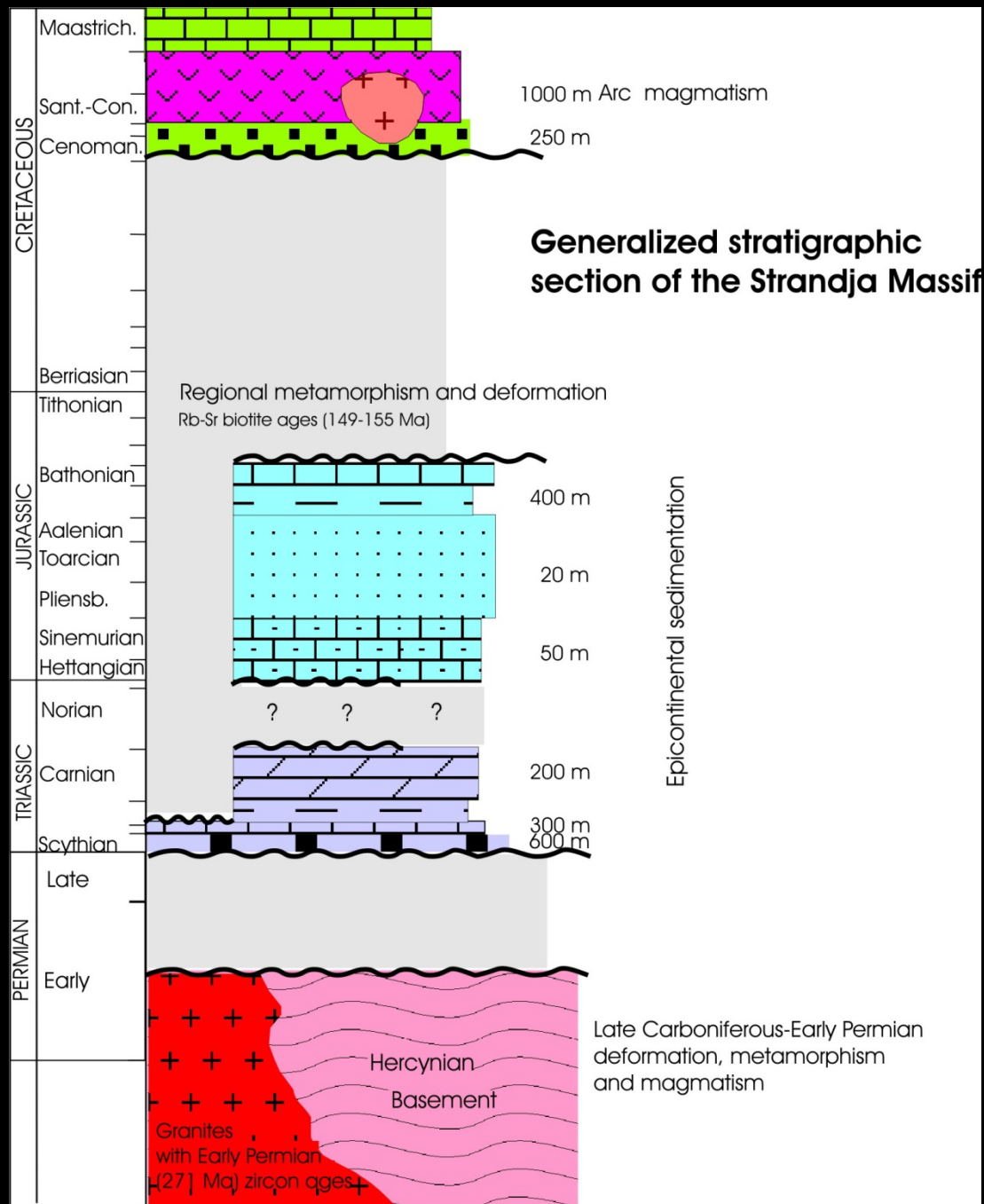
Late Jurassic – Early Cretaceous deformation and metamorphism:

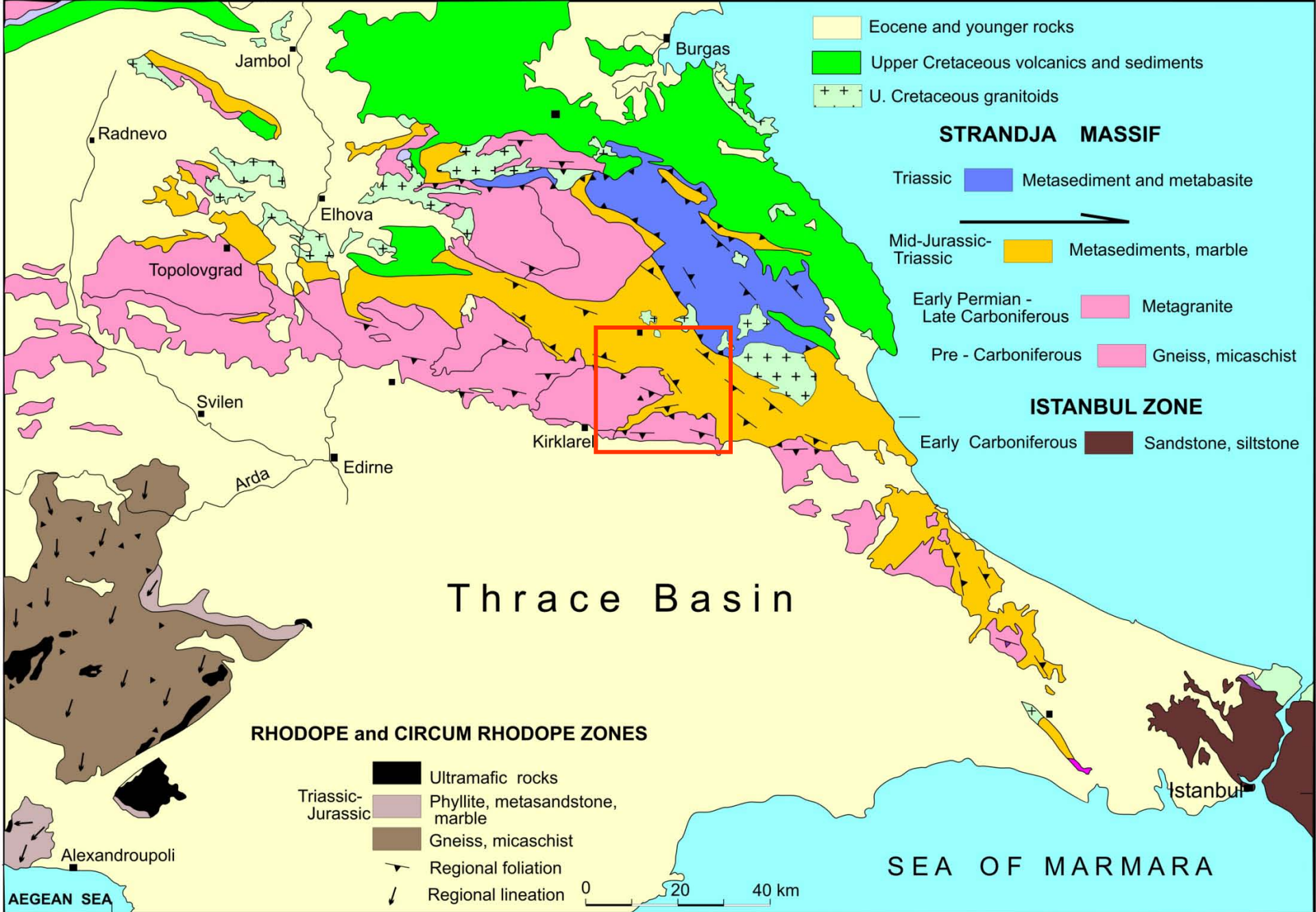
Observed only in the Strandja Massif

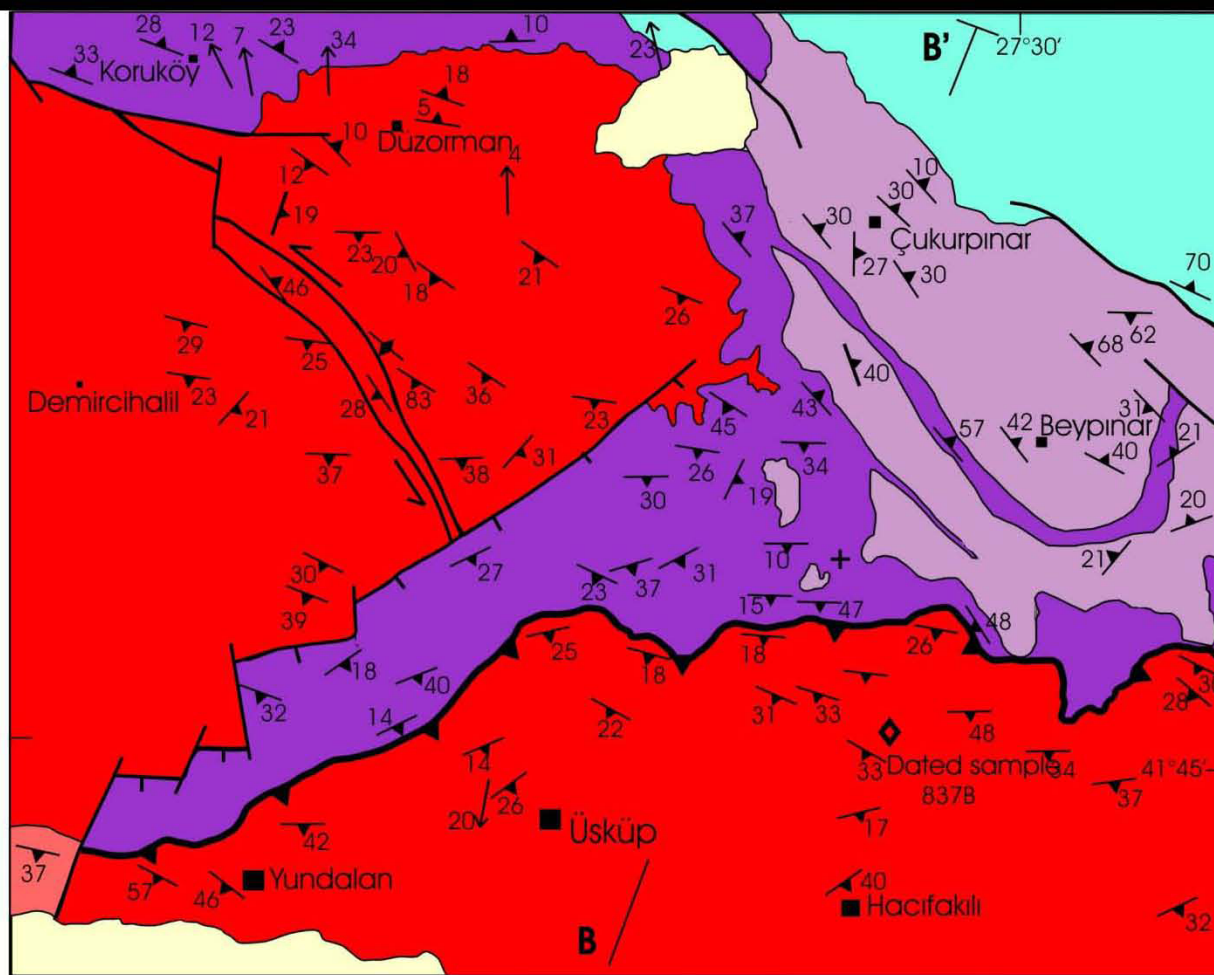
Orogeny involving continental collision

North-vergent, greenschist facies metamorphism

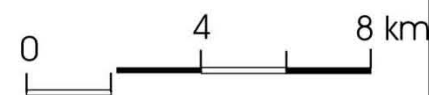
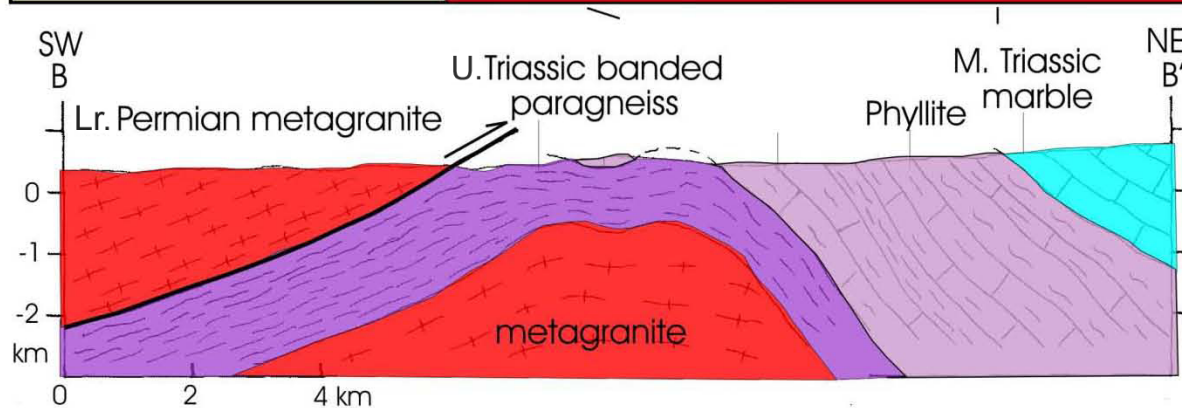
Sealed by Cenomanian molasse

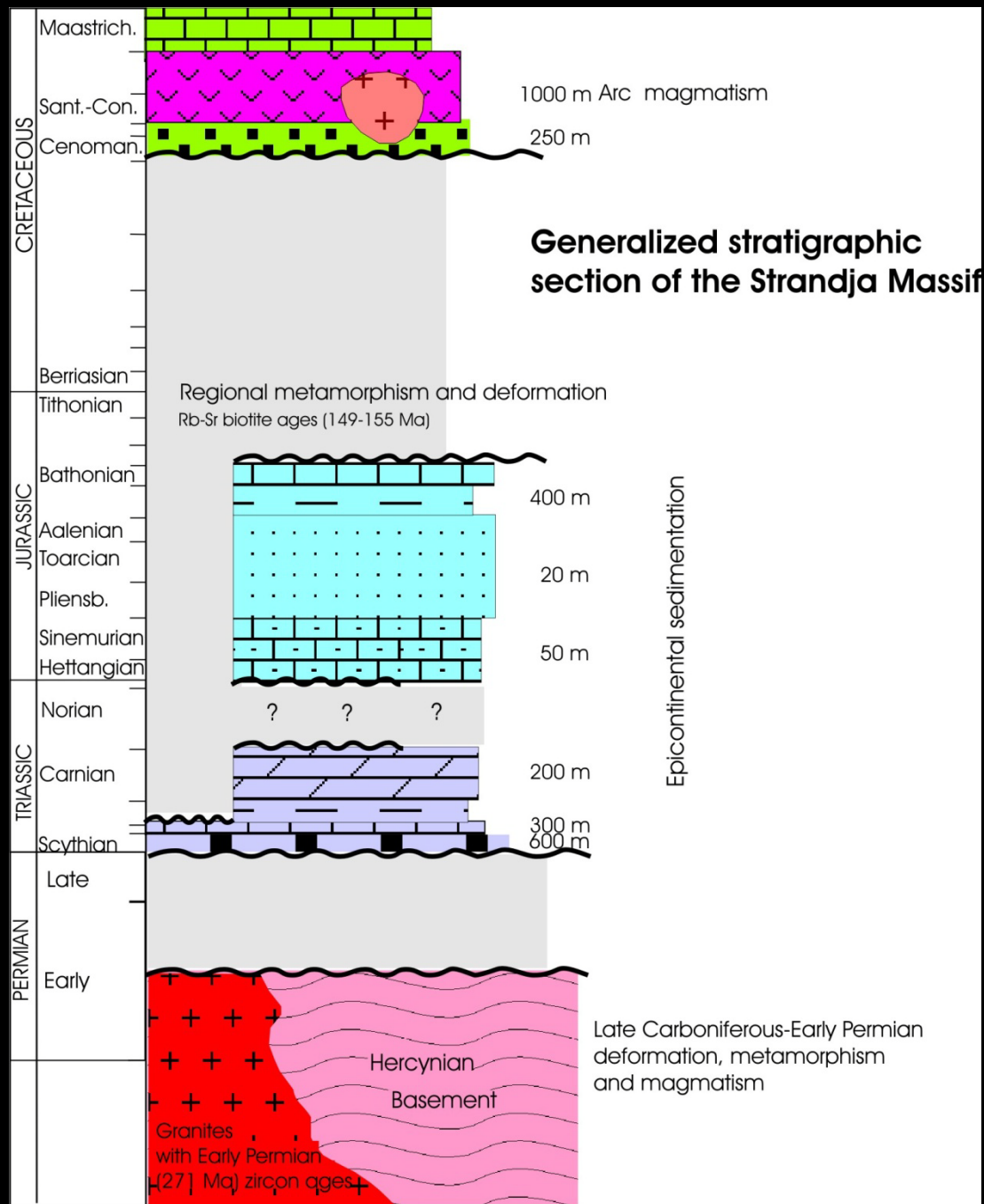


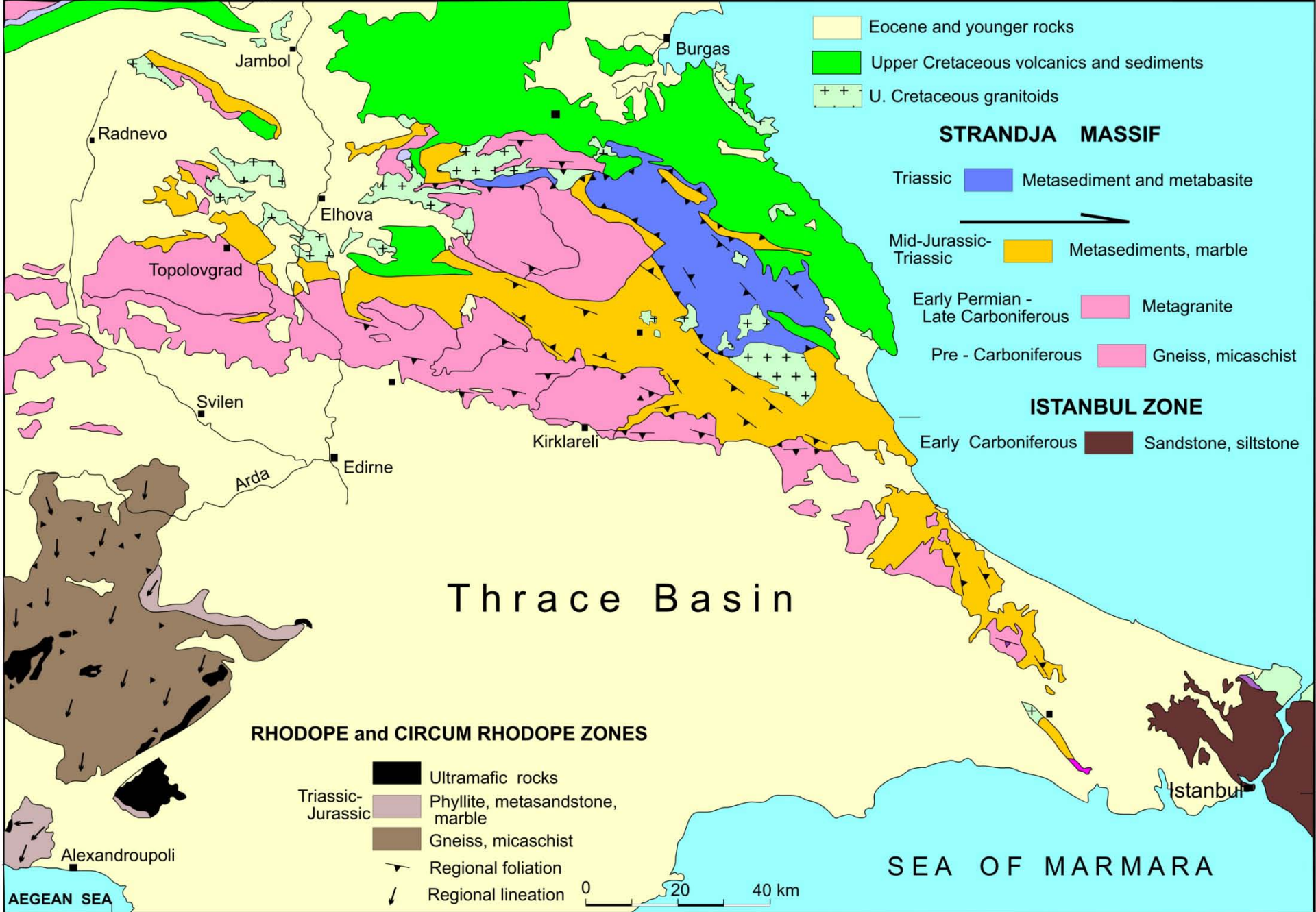




Geological map and cross-section of the south-central Strandja Masif, Turkey (Okay et al. 2001)











Alpide orogeny – Subduction-accretion stage:

Mid-Cretaceous deformation and metamorphism:

Sakarya Zone (Central and Eastern Pontides)

Northward thrusting of subduction complexes/melanges.

Associated with blueschist/eclogite facies metamorphism
(Albian, 105 Ma)

Sealed by Coniacian/Santonian sediments

EASTERN PONTIDES

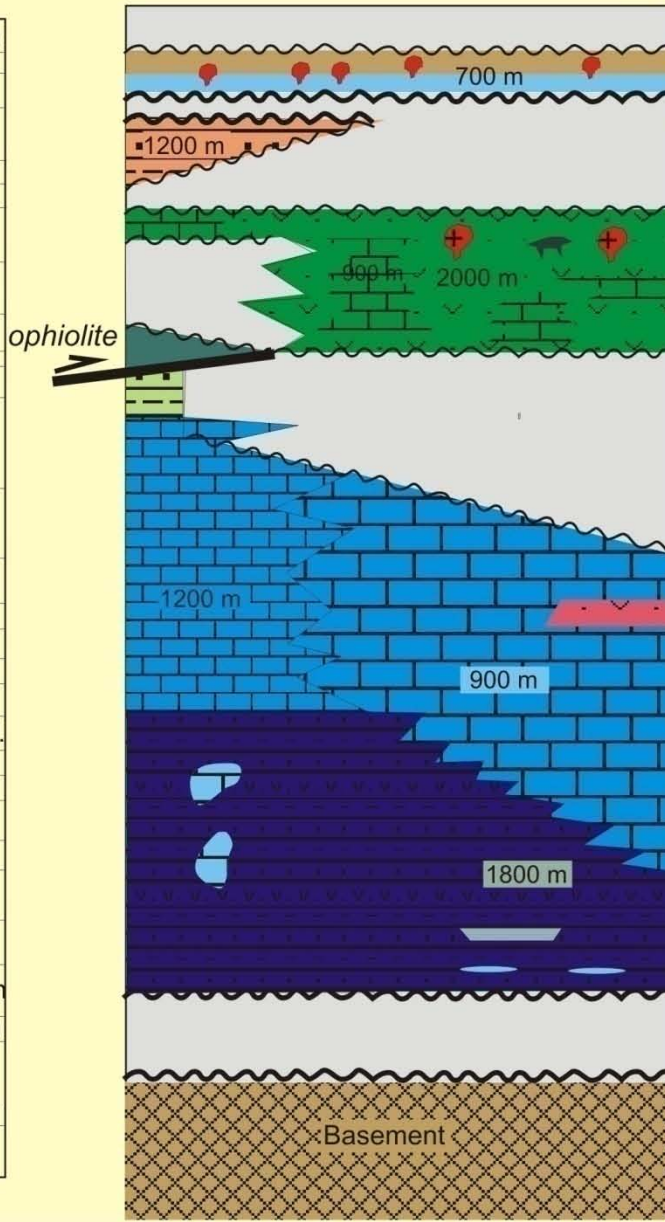
Inner Pontides

Outer Pontides

S

N

| | |
|------------|------------|
| PALEOCENE | Priabonian |
| | Bartonian |
| | Lutetian |
| PALEOCENE | Ypresian |
| | Thanetian |
| | Danian |
| CRETACEOUS | Maastrich. |
| | Campanian |
| | Sant.-Con. |
| | Turonian |
| | Cenoman. |
| | Albian |
| | Aptian |
| | Barremian |
| | Hauteriv. |
| | Valangin. |
| | Berriasian |
| JURASSIC | Tithonian |
| | Kimm.-Oxf. |
| | Callovian |
| | Bathonian |
| | Bajocian |
| | Aalenian |
| | Toarcian |
| | Pliensb. |
| TRIASSIC | Sinemurian |
| | Hettangian |
| | Nor.-Rhae. |



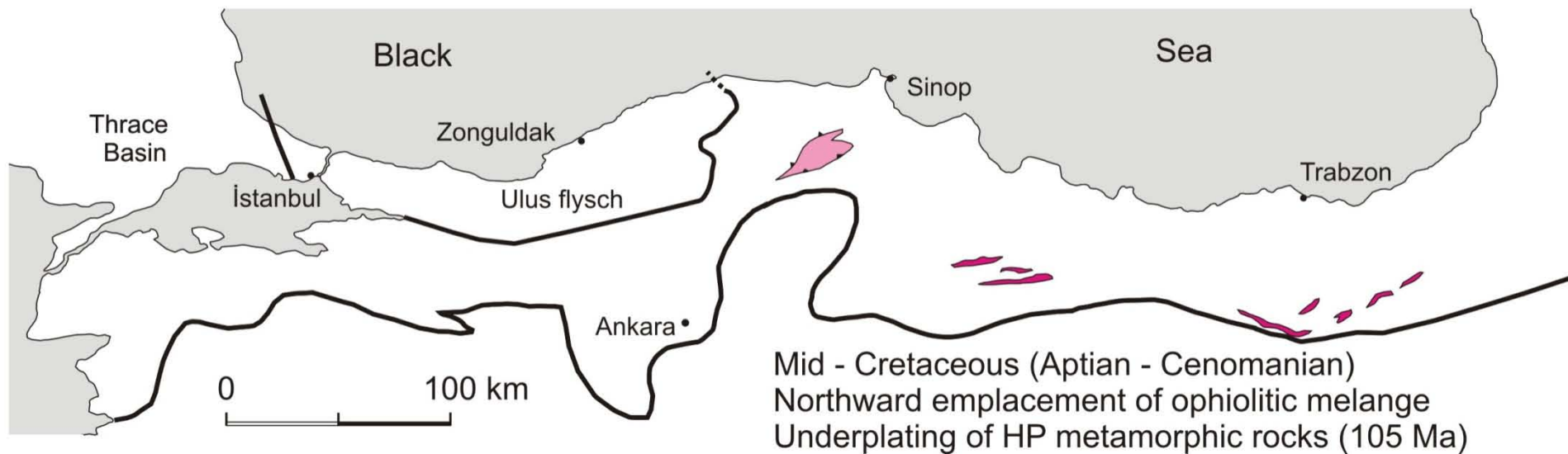
Extension
Continental collision

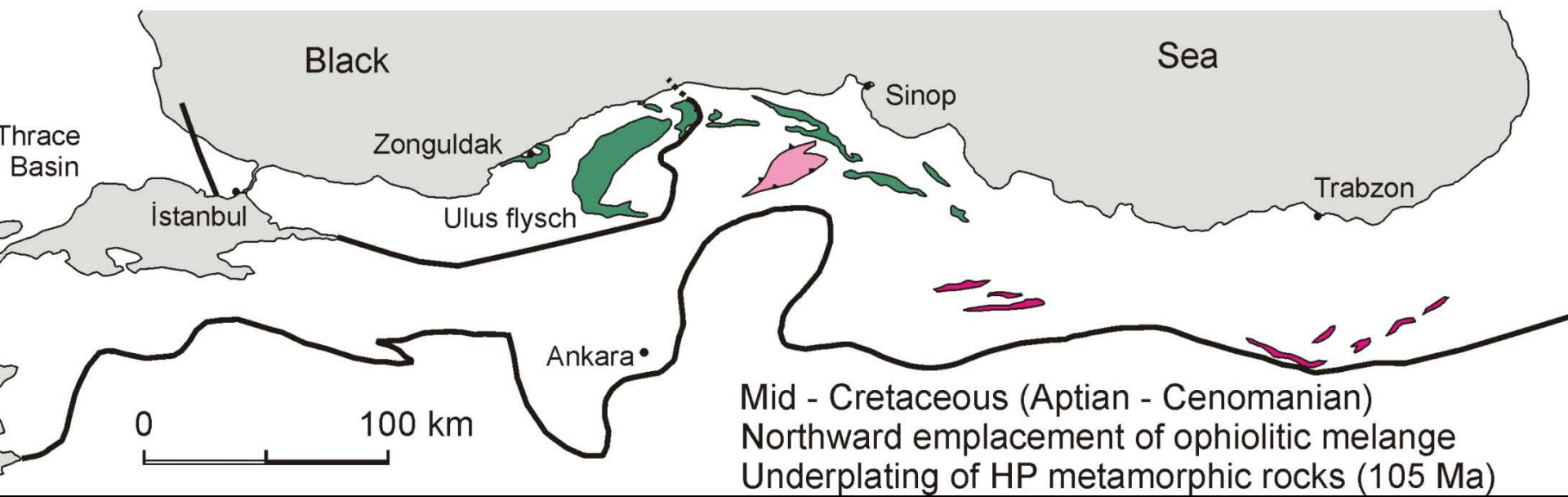
Magmatic arc and fore-arc development

1. Northward emplacement of ophiolitic melange
2. Underplating and HP/LT metamorphism
3. W. Black Sea rifting
4. Amalgamation of the Pontic terranes

Passive margin development

Rifting or subduction?





EASTERN PONTIDES

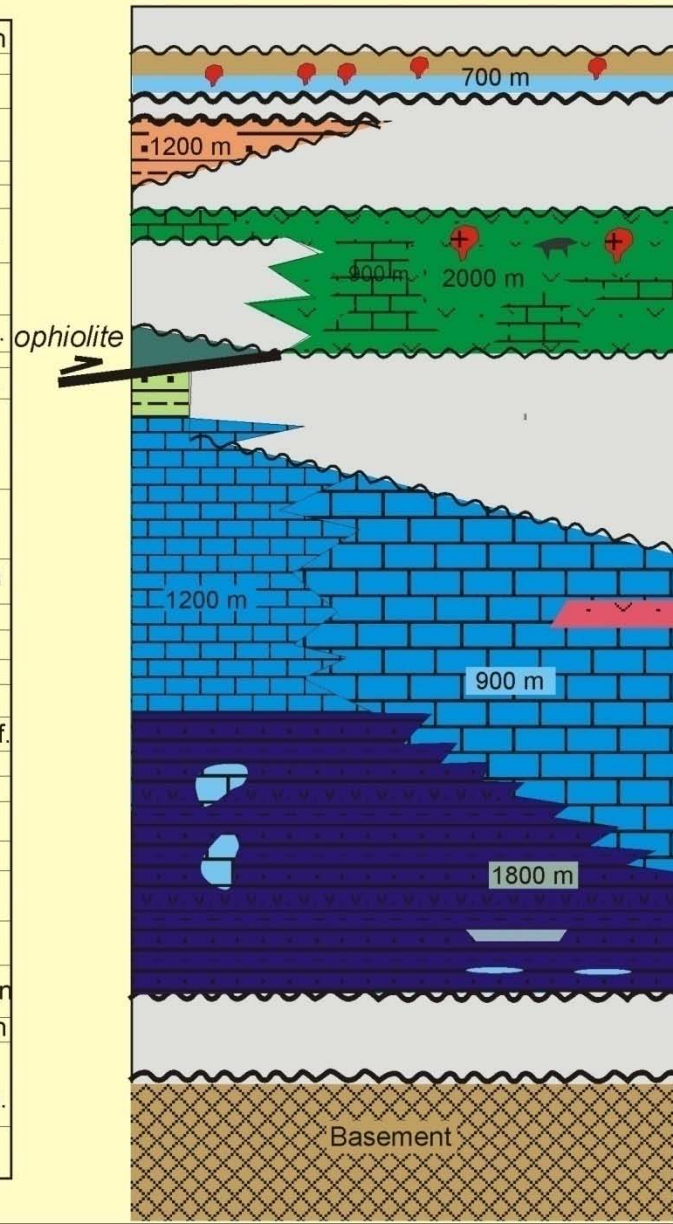
Inner Pontides

Outer Pontides

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| PALEOCENE | Priabonian |
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| | Bathonian |
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| | Aalenian |
| | Toarcian |
| | Pliensb. |
| TRIASSIC | Sinemurian |
| | Hettangian |
| | Nor.-Rhae. |



Extension
Continental collision

Magmatic arc and
fore-arc evolution
Initiation of subduction

Passive margin
development

Rifting

Seal of Coniacian-Santonian sedimentary rocks





EASTERN PONTIDES

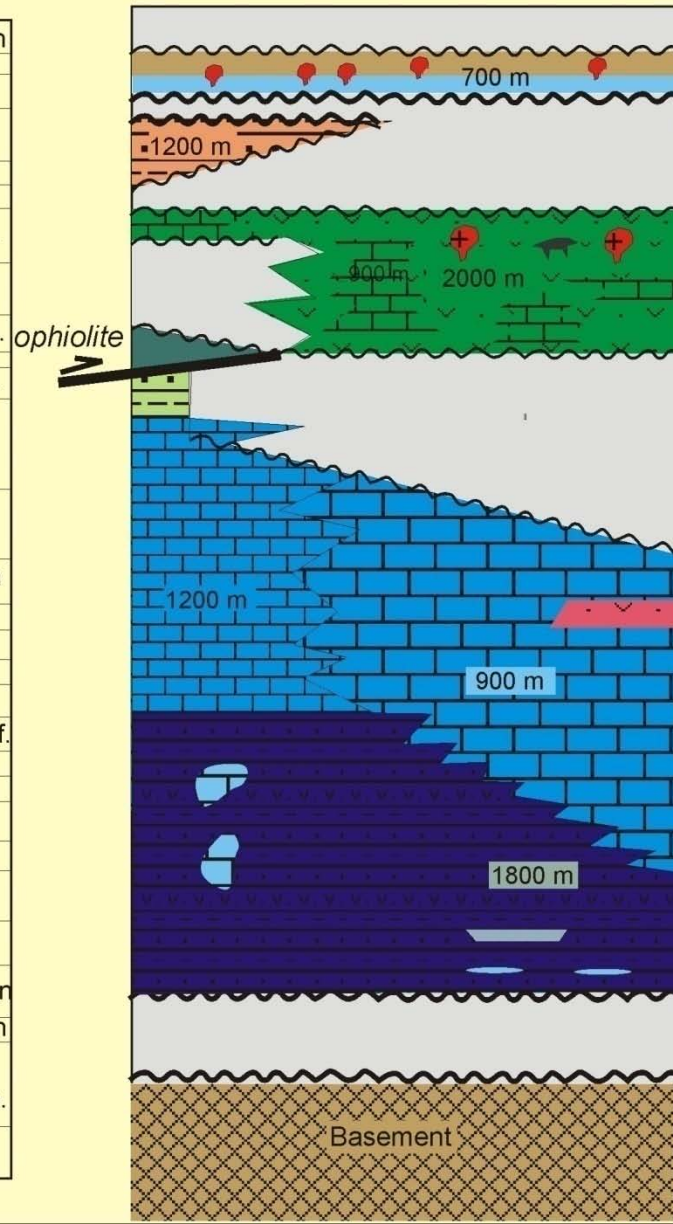
Inner Pontides

Outer Pontides

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| PALEOCENE | Priabonian |
| | Bartonian |
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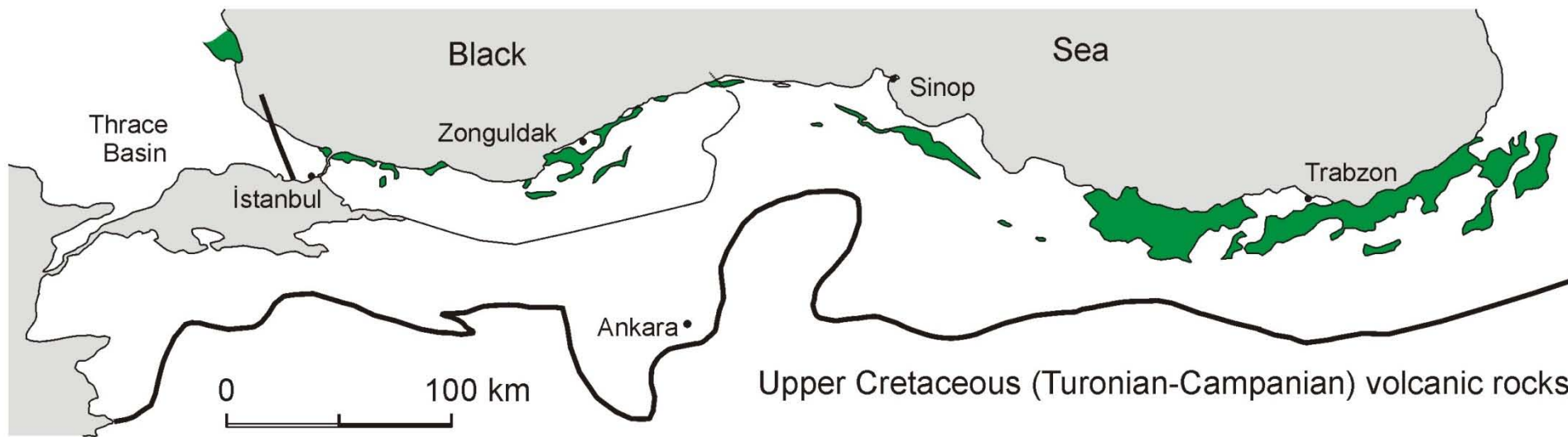
Extension
Continental collision

Magmatic arc and
fore-arc evolution
Initiation of subduction

Passive margin
development

Rifting

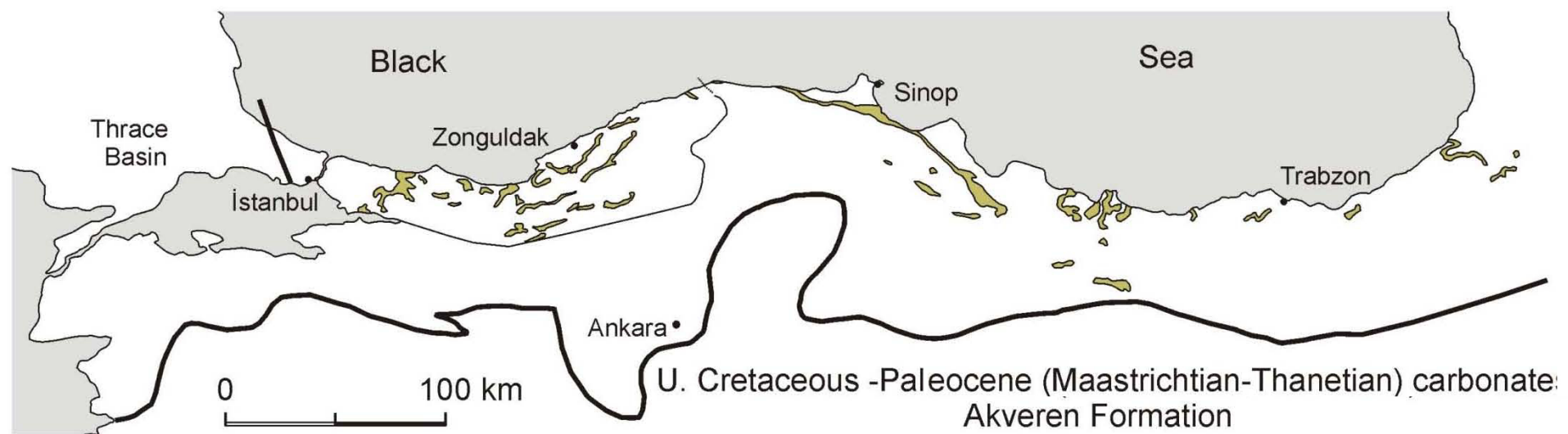
Development of the Pontide magmatic arc: Coniacian-Campanian





**End of magmatism and carbonate
deposition:**

Maastrichtian - Danian





Alpide orogeny – Collision stage:

Late Paleocene - Early Eocene deformation

Thrust imbrication of the Pontides

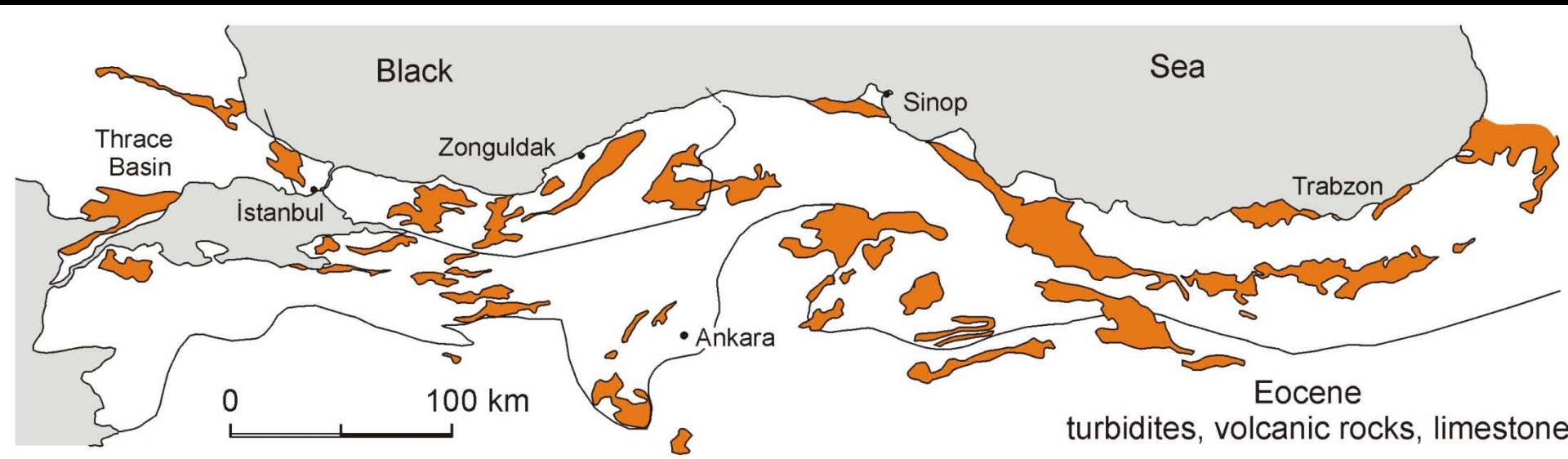
Sealed by Middle-Upper Eocene sediments

Continental collision between the Pontides
and the Anatolide-Taurides



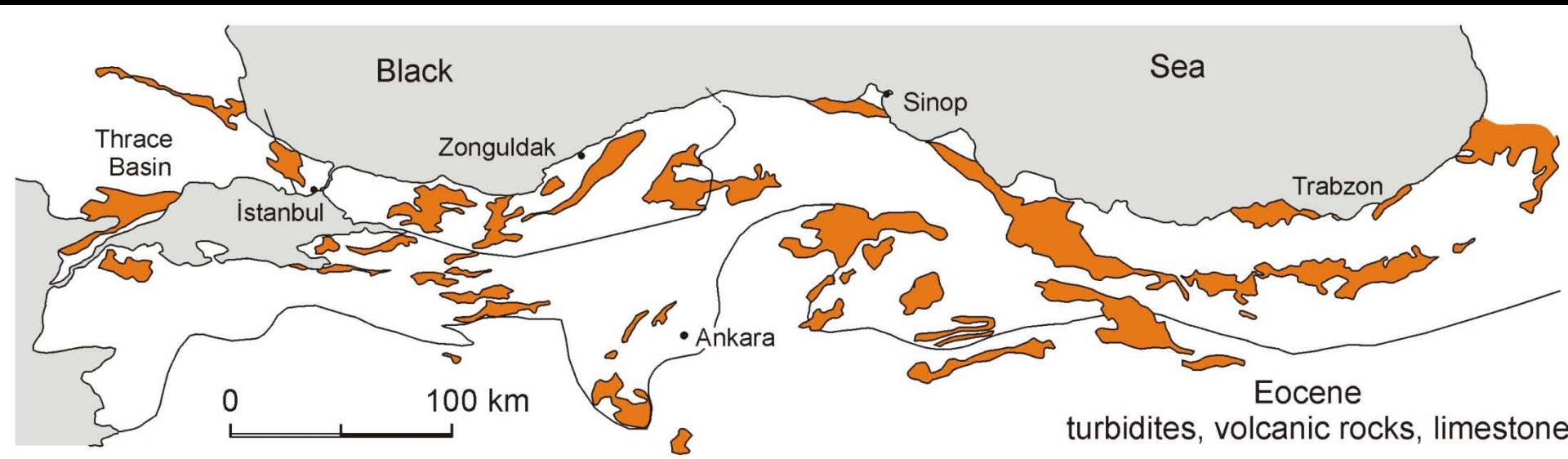
Middle – Late Eocene restoration

**Widespread marine sedimentation and
magmatism**









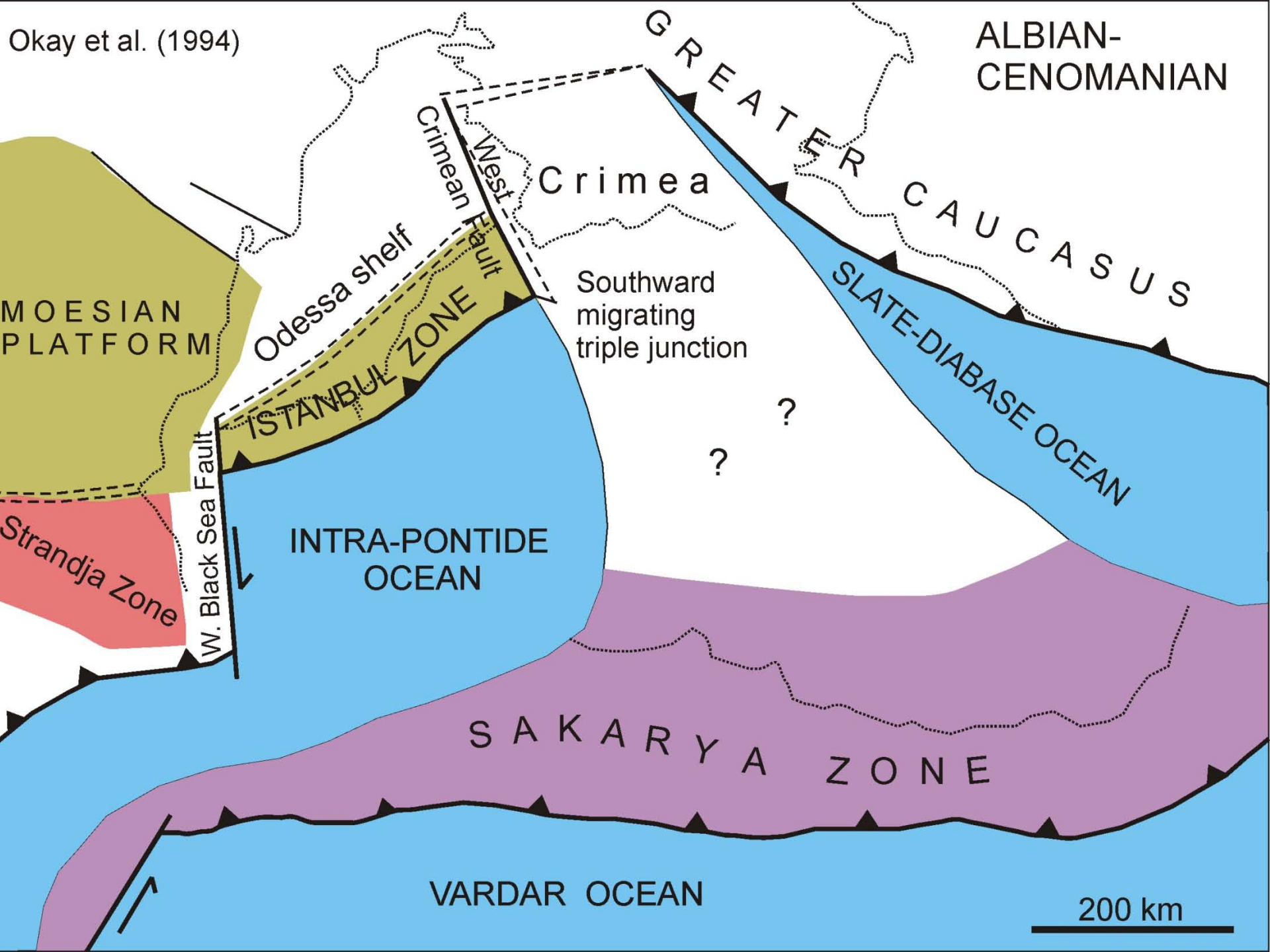


CONCLUSIONS

Several episodes of deformation and metamorphism in the Pontides during the Mesozoic-Tertiary – related to subduction/accretion and continental collision:

- 1. Latest Triassic –subduction-accretion event in the Sakarya Zone**
- 2. Late Jurassic-Early Cretaceous – Continental collision in the Balkans**
- 3. Mid-Cretaceous – subduction-accretion**
- 4. Late Paleocene – Early Eocene – continental collision between the Pontides and the Anatolide-Taurides.**

Okay et al. (1994)



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