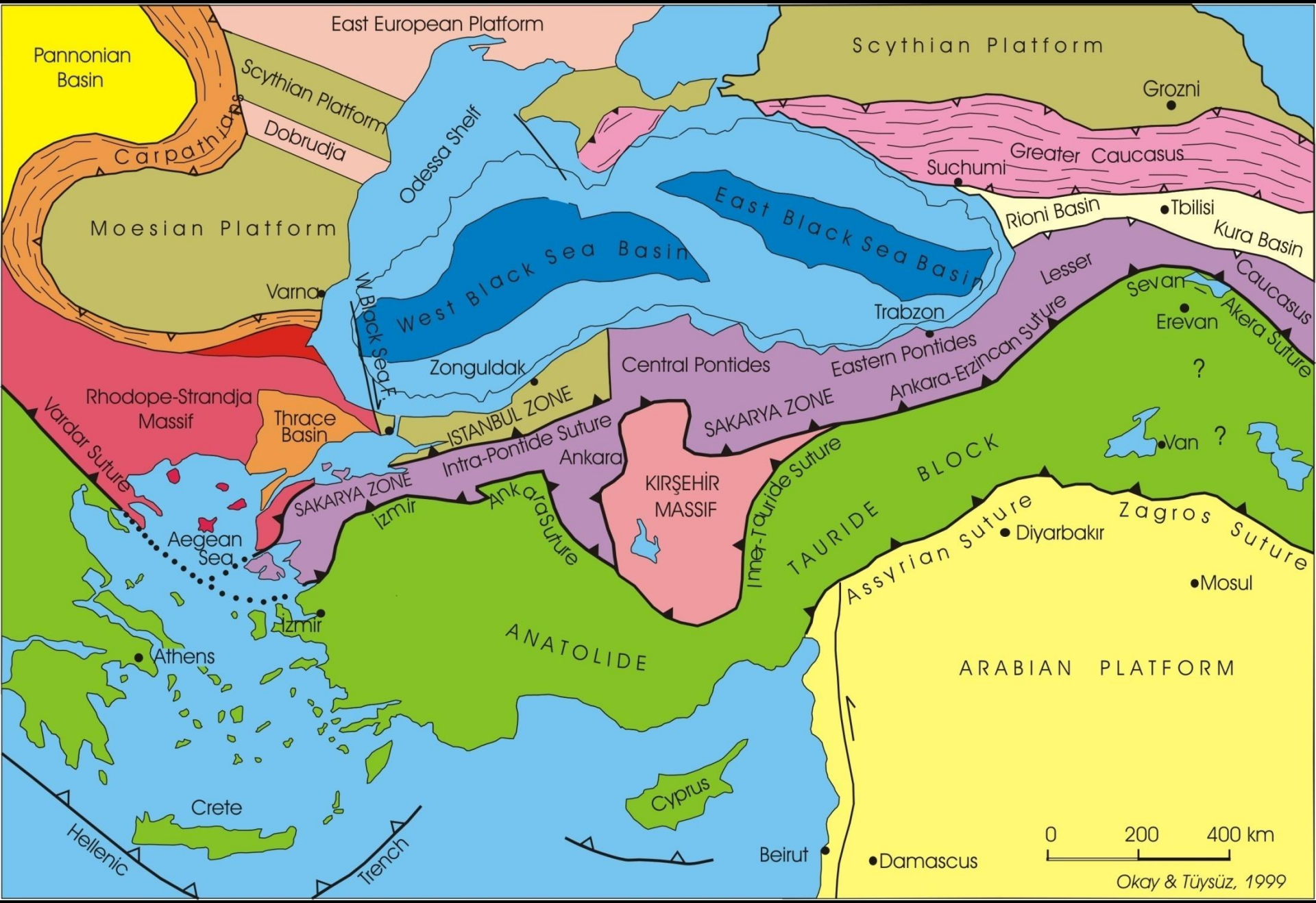
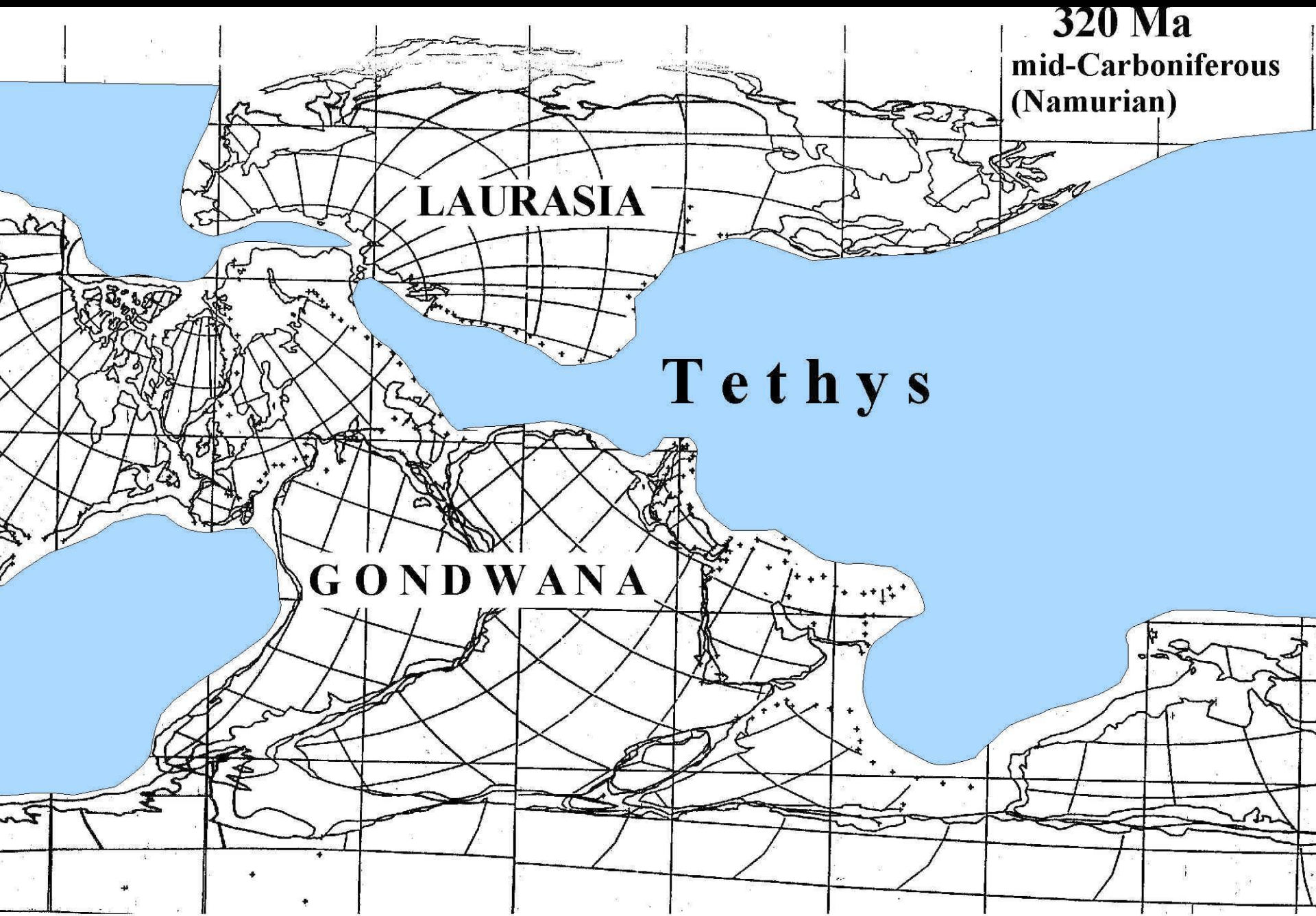
TÜRKİYE JEOLOJİSİNDE PALEO-TETİS VE NEO-TETİS PROBLEMİ – SAKARYA ZONU'NUN EVRİMİ

Aral I. Okay

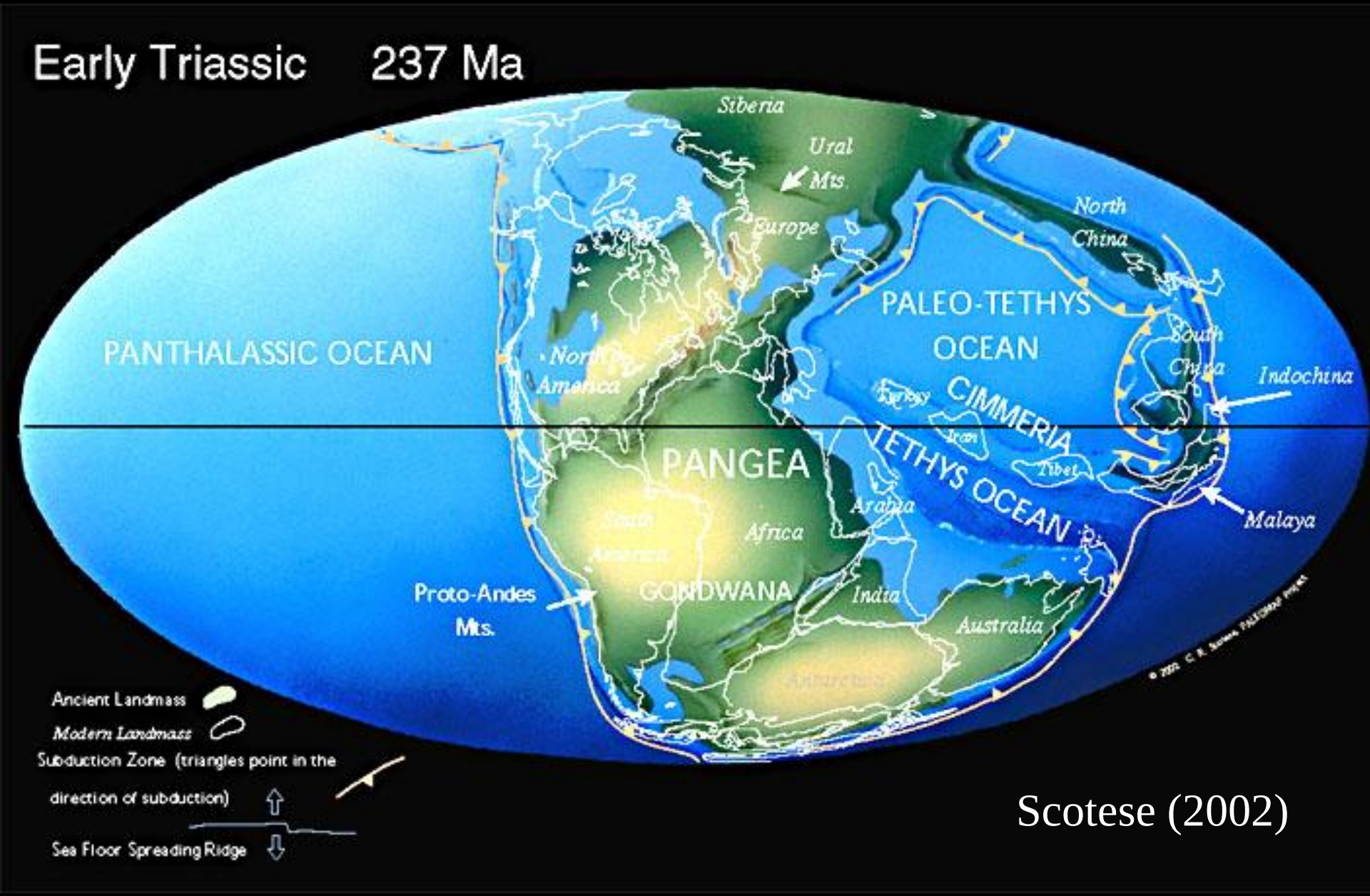
Istanbul Teknik Üniversitesi, Avrasya Yerbilimleri Enstitüsü ve Maden Fakültesi, Jeoloji Müh. Bölümü


LAURASIA
GONDWANA
AFRICA
Mediterranean
ARABIAN SHIELD
Zagros suture
Tibet
Makran
Himalaya
Oman
LAND
INDIAN SHIELD
Laurasia outside the Alpide orogen
Alpide Laurasia
Gondwana-Land outside the Alpide orogen
Alpide Gondwana-Land

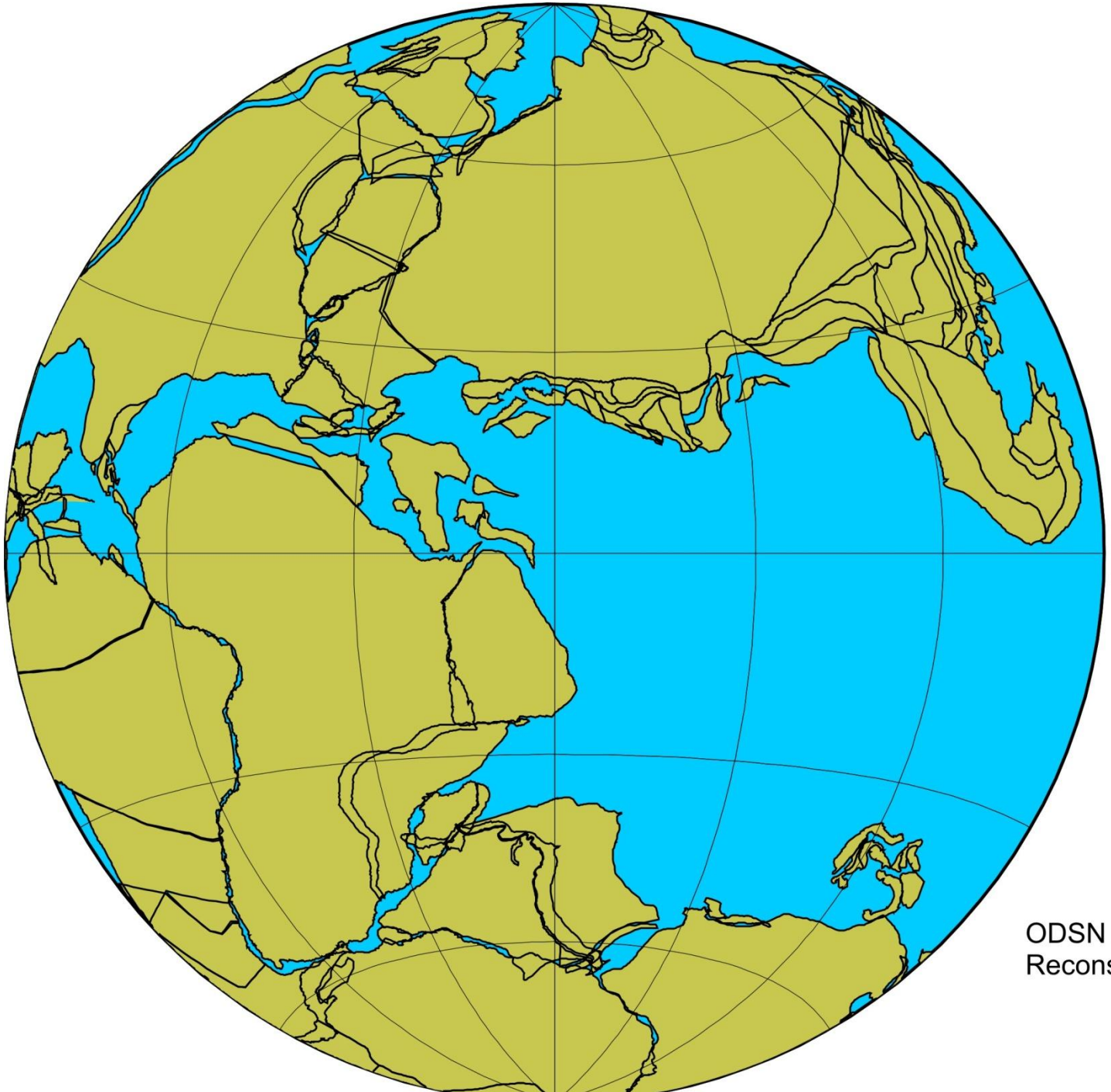

East European Platform
Scythian Platform
Pannonian Basin
Carpathians
Dobrudja
Moesian Platform
Varna
Odessa Shelf
West Black Sea Basin
W. Black Sea f.
East Black Sea Basin
Grozni
Greater Caucasus
Suchumi
Rioni Basin
Tbilisi
Kura Basin
Lesser Caucasus
Sevan
Akera Suture
Erevan
Trabzon
Eastern Pontides
Ankara-Erzincan Suture
Central Pontides
Zonguldak
ISTANBUL ZONE
SAKARYA ZONE
Intra-Pontide Suture
Ankara
Rhodope-Strandja Massif
Thrace Basin
Vardar Suture
KIRŞEHİR MASSIF
Inner-Tauride Suture
TAURIDE BLOCK
Van
?
Aegean Sea
İzmir
Ankara Suture
Assyrian Suture
Zagros Suture
Diyarbakır
Mosul
ANATOLIDE
ARABIAN PLATFORM
Athens
Crete
Hellenic Trench
Cyprus
Beirut
Damascus
0 200 400 km
Okay & Tüysüz, 1999



Smith et al. (1981)

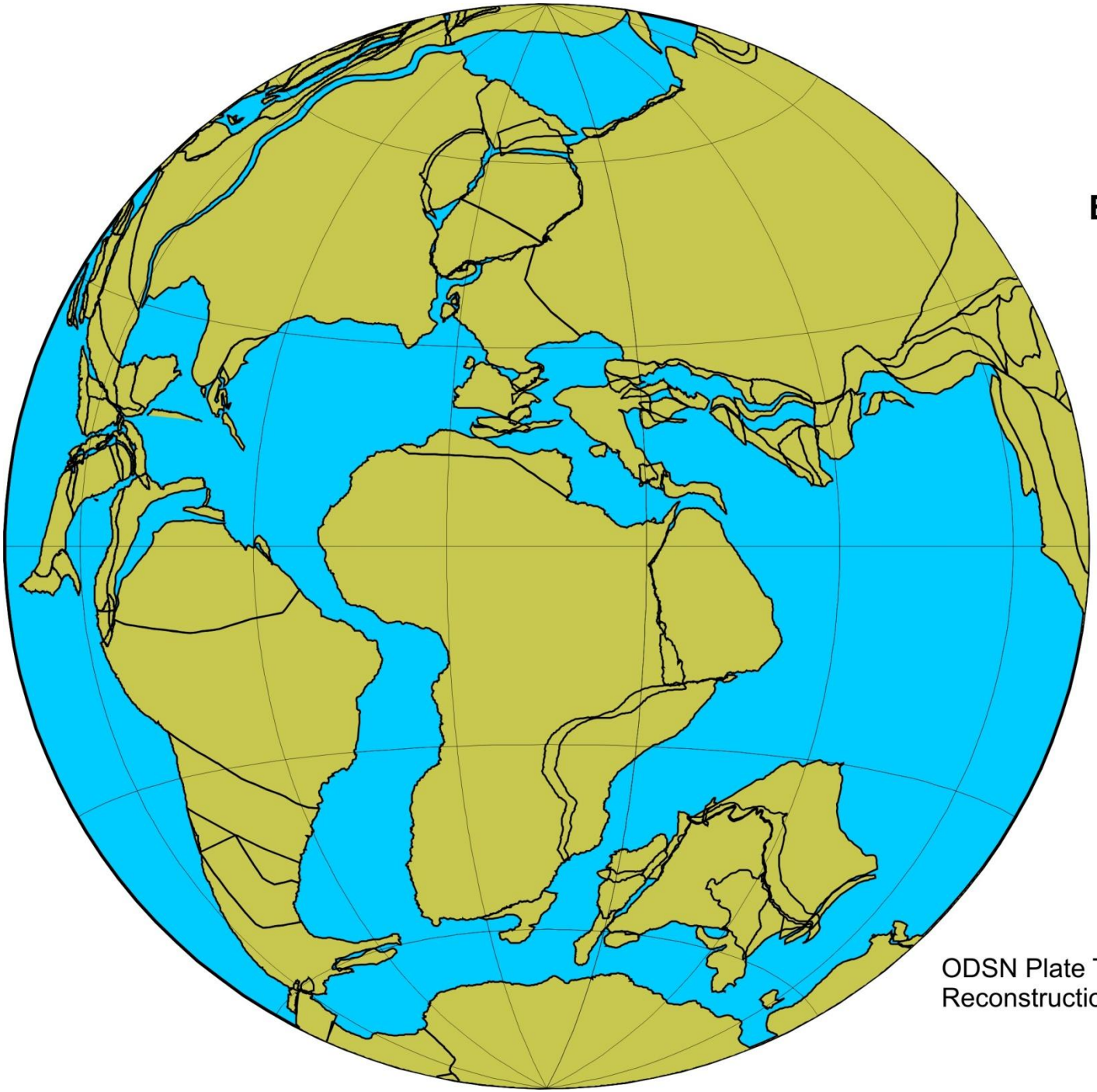


Scotese (2002)



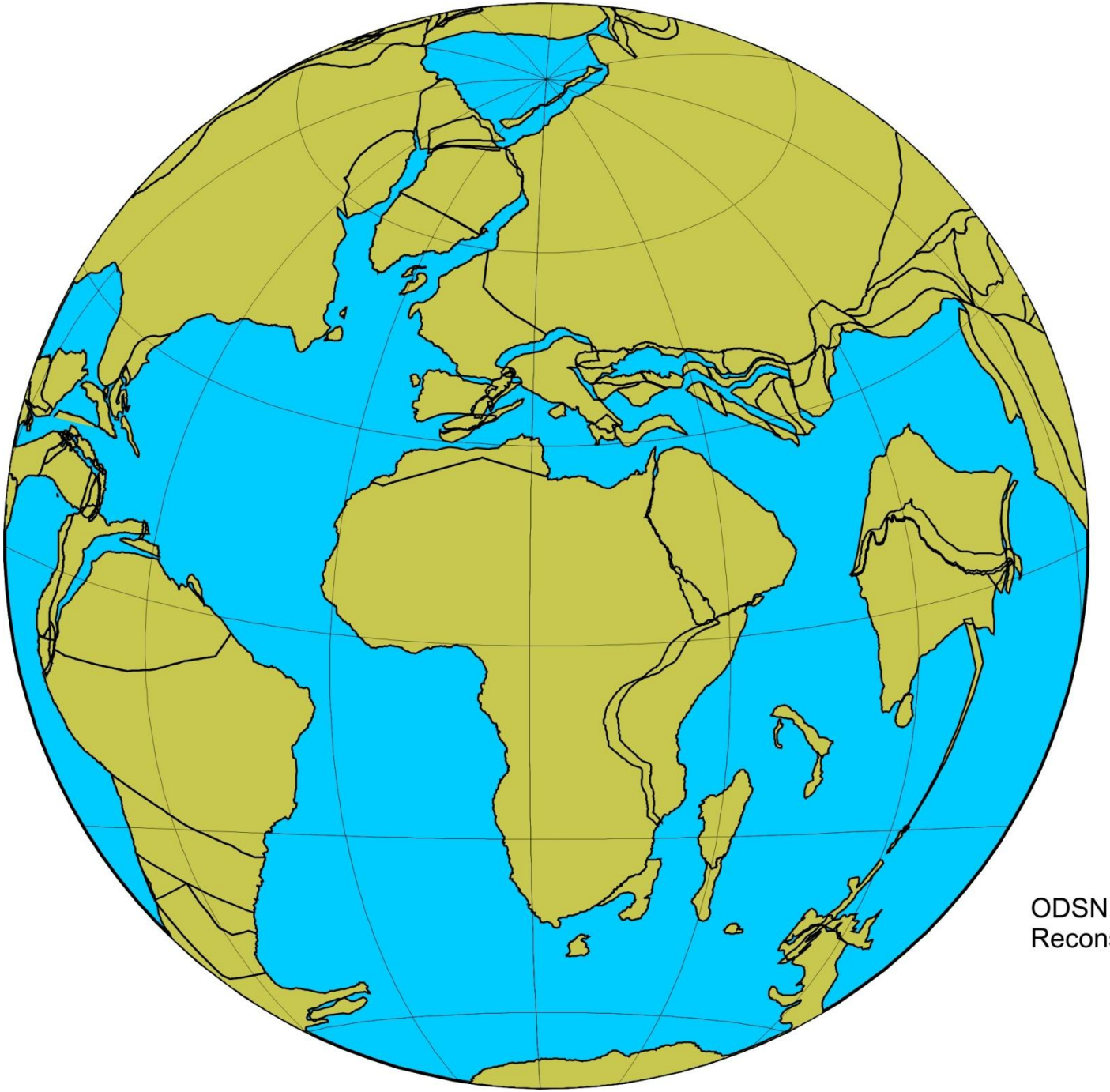
150 Ma
Latest Jurassic

ODSN Plate Tectonic
Reconstruction Service



100 Ma
Early Cretaceous
(Albian)

ODSN Plate Tectonic
Reconstruction Service



50 Ma
Eocene

ODSN Plate Tectonic
Reconstruction Service

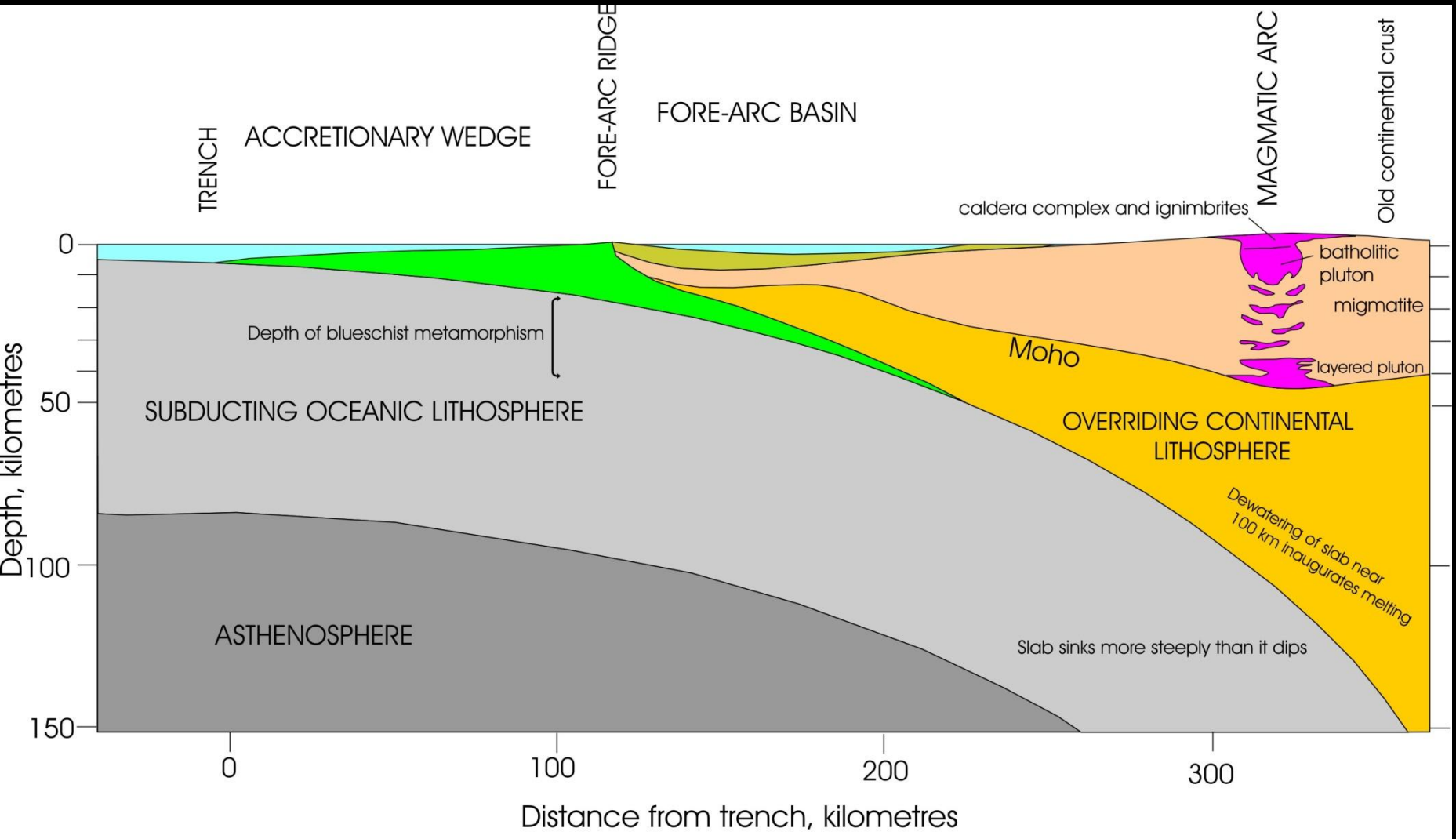


25 Ma
Oligocene

ODSN Plate Tectonic
Reconstruction Service

Anadolu son 400 milyon senede bir araya gelmiş okyanusal ve kıtasal parçalardan oluşmuştur.

Bununla ilgili olarak eklenir prizme, melanj, ofiyolit, mavişist, fliş ve magmatik yaylar Anadolu'da en yaygın kaya birimleri arasındadır.

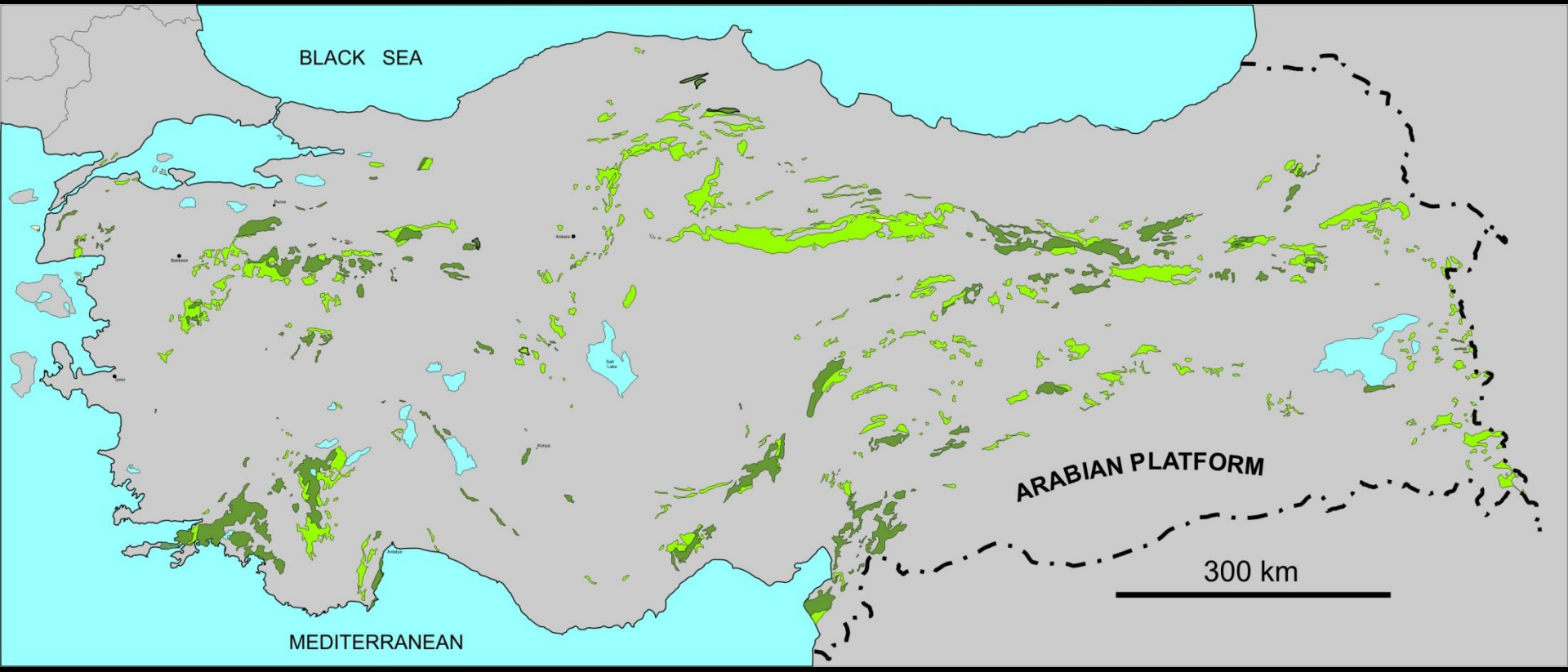


Section across a continental-margin subduction zone (Hamilton, 1988)

Anadolu’da başlıca iki tür eklenir prizma (yığışım karmaşası) yer alıyor:

1. Ofiyolitli melanj – bazalt, çört, pelajik şeyl, serpantinit, pelajik kireçtaşı

2. Karakaya Kompleksi – metabazit, mermer, grovak, şeyl


BLACK SEA
ARABIAN PLATFORM
300 km
MEDITERRANEAN









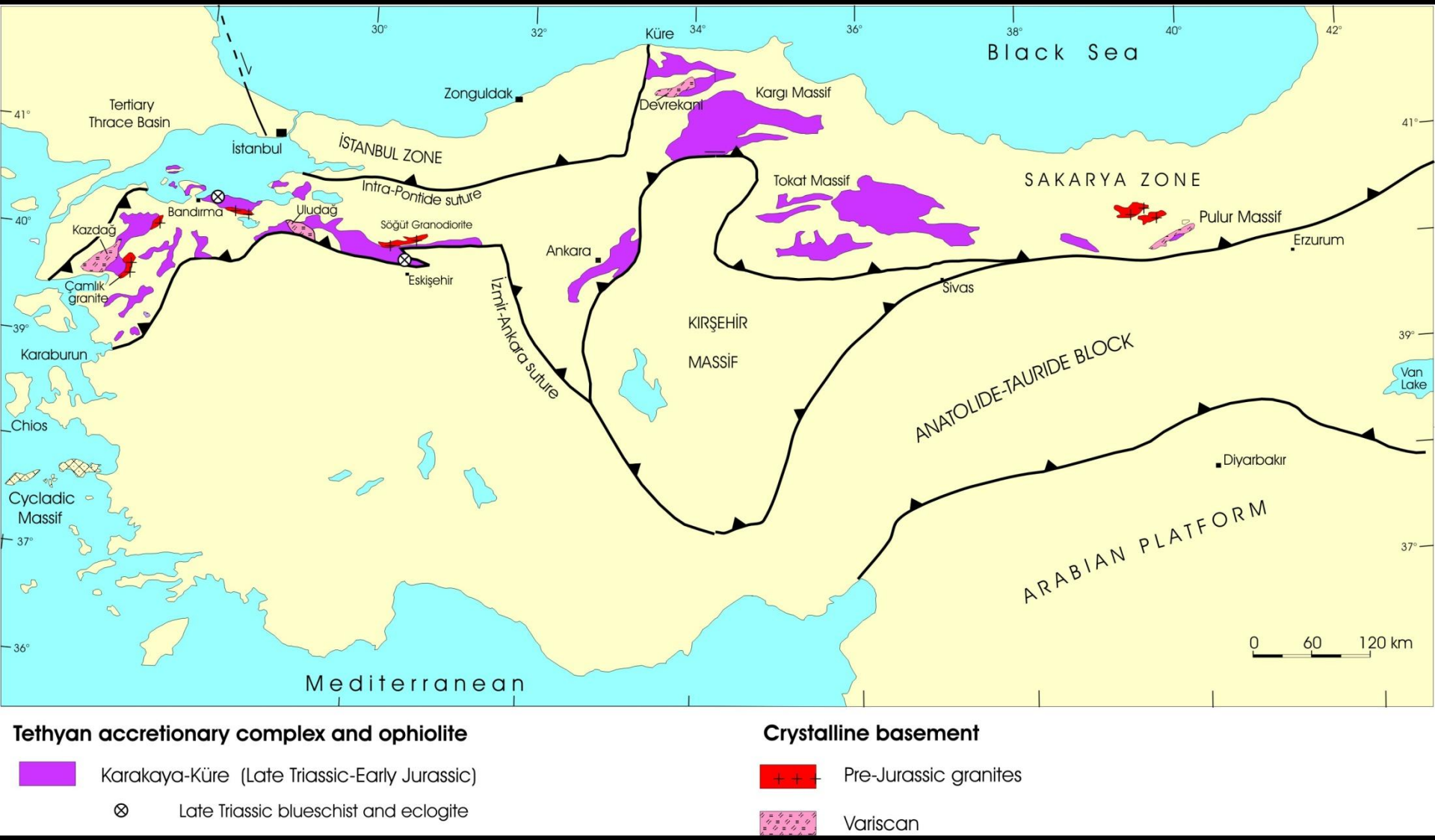


Ofiyolitli melanj içindeki çörtlerde radyolarya yaşları Triyas ile Kretase arasında

Neo-Tetis'e ait eklenir prizmalar

Neo-Tetis'in yaşı Triyas – Kretase.

Paleozoyik okyanus kalıntıları nerede?



Tethyan accretionary complex and ophiolite

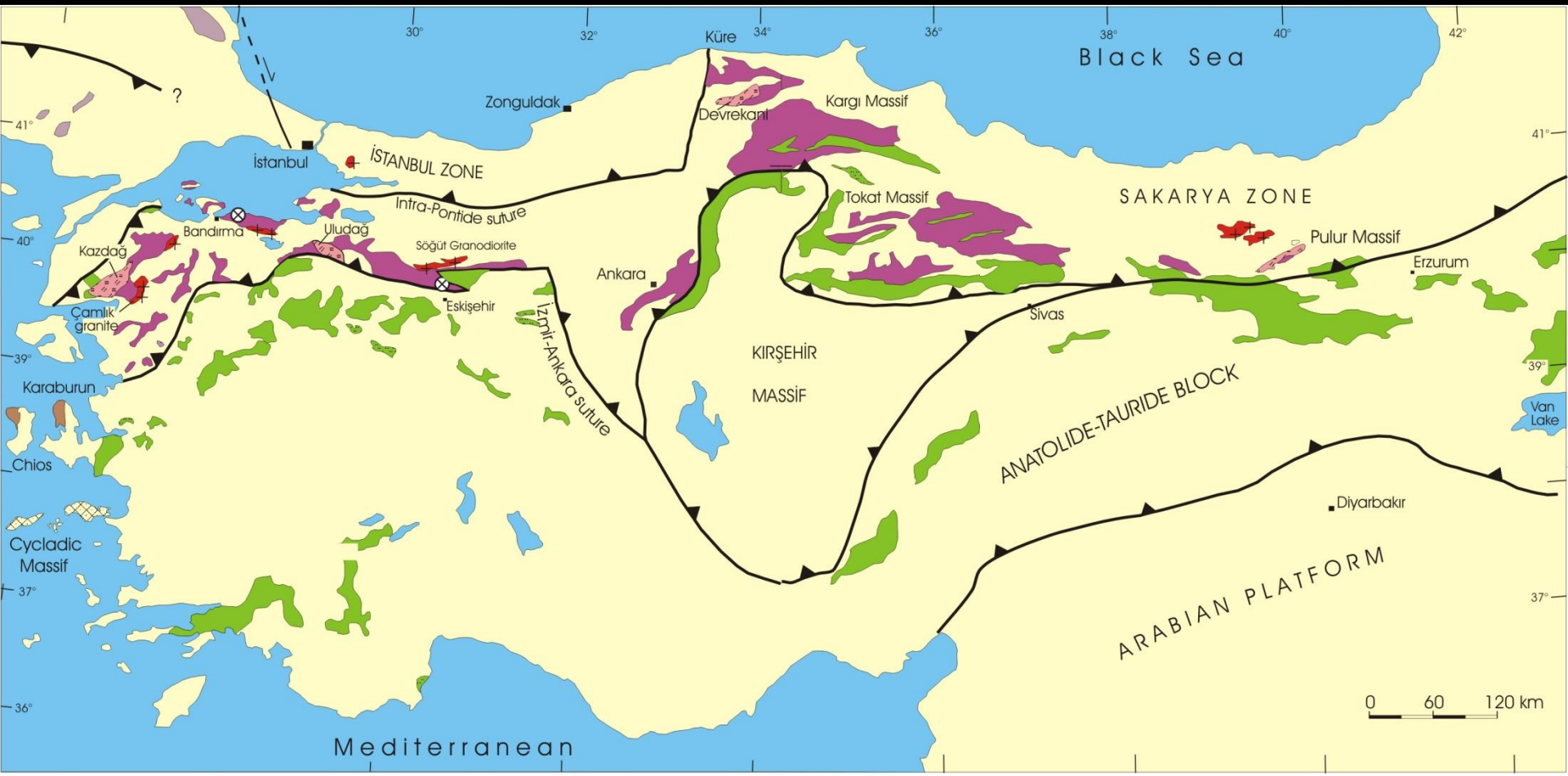
Karakaya-Küre (Late Triassic-Early Jurassic)

⊗ Late Triassic blueschist and eclogite

Crystalline basement

Pre-Jurassic granites

Variscan

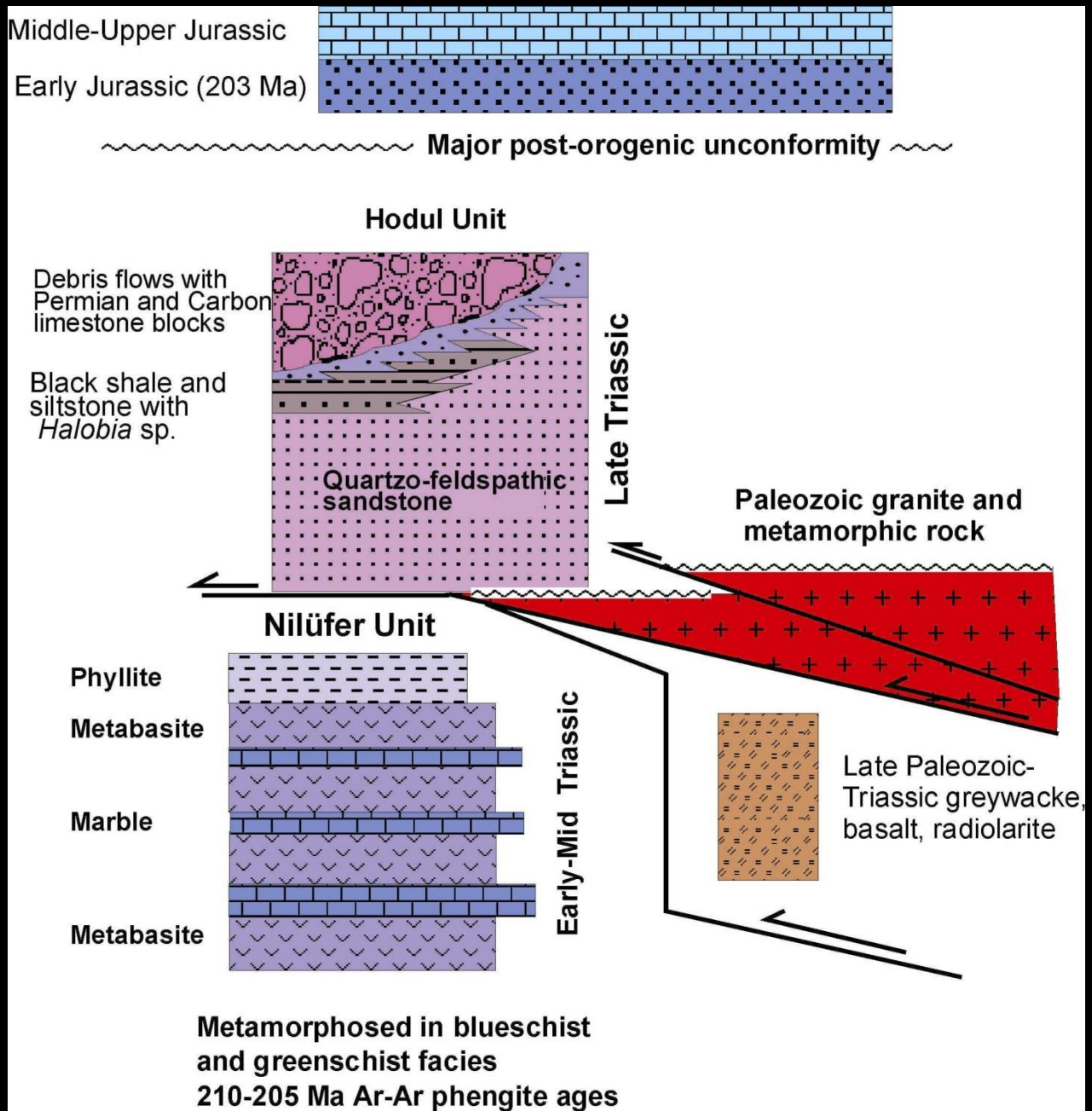


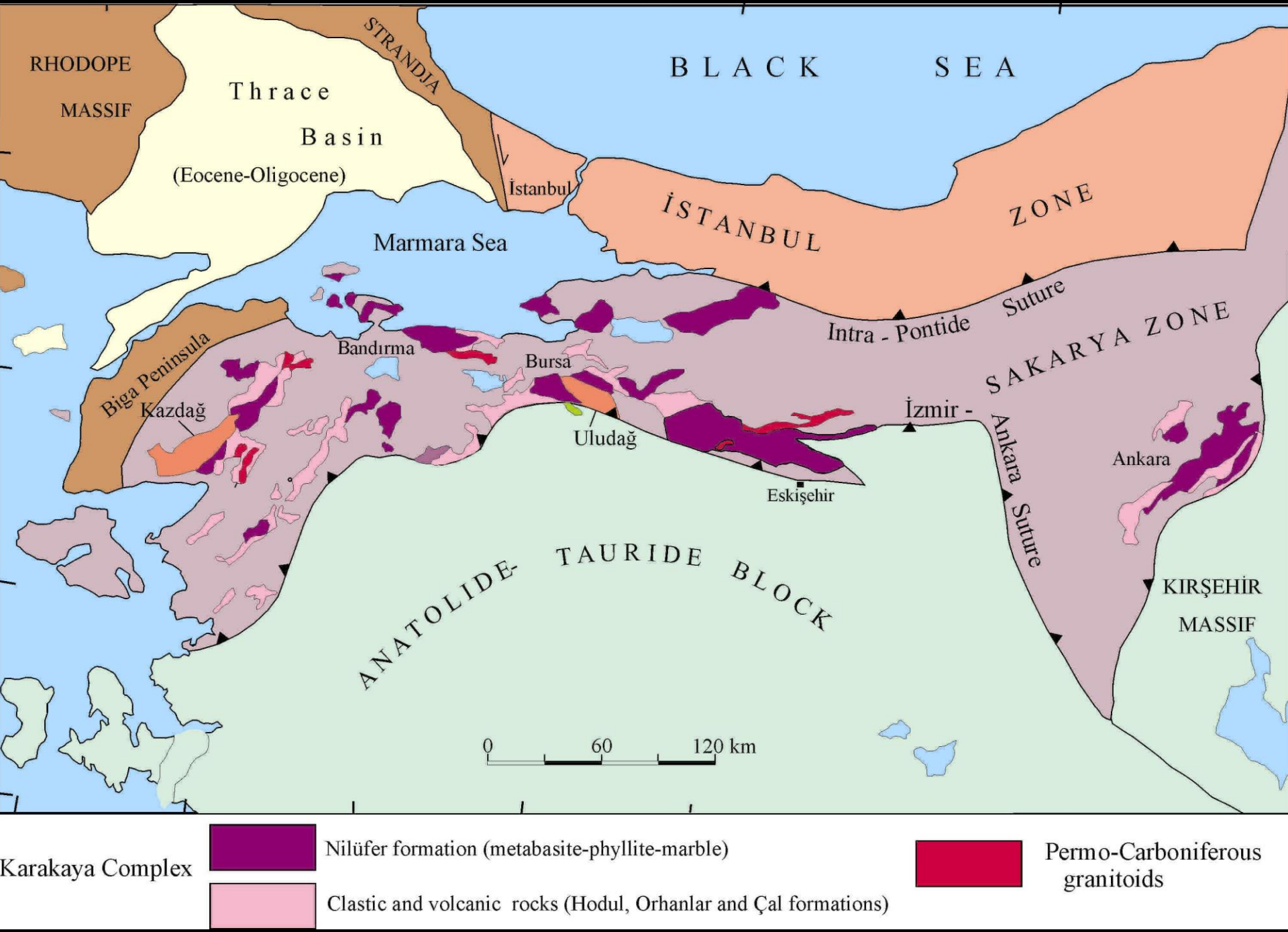
Tethyan accretionary complex and ophiolite

- İzmir-Ankara (Late Cretaceous)
- Strandja (Triassic-Early Jurassic)
- Karakaya-Küre (Late Triassic-Early Jurassic)
  - ⊗ Late Triassic blueschist and eclogite
- Carboniferous (Karaburun-Chios)

Crystalline basement

- Pre-Jurassic granites
- Variscan


Middle-Upper 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
Late Paleozoic-Triassic greywacke, basalt, radiolarite
Metamorphosed in blueschist and greenschist facies
210-205 Ma Ar-Ar phengite ages


RHODOPE
MASSIF
Thrace
Basin
(Eocene-Oligocene)
STRANDJA
BLACK SEA
İstanbul
İSTANBUL ZONE
Marmara Sea
Intra - Pontide Suture
SAKARYA ZONE
Biga Peninsula
Kazdağ
Bandırma
Bursa
Uludağ
İzmir - Ankara Suture
Ankara
Eskişehir
ANATOLIDE- TAURIDE BLOCK
KIRŞEHİR
MASSIF
0
60
120 km
Karakaya Complex
Nilüfer formation (metabasite-phyllite-marble)
Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
Permo-Carboniferous granitoids

Nilüfer Formasyonu

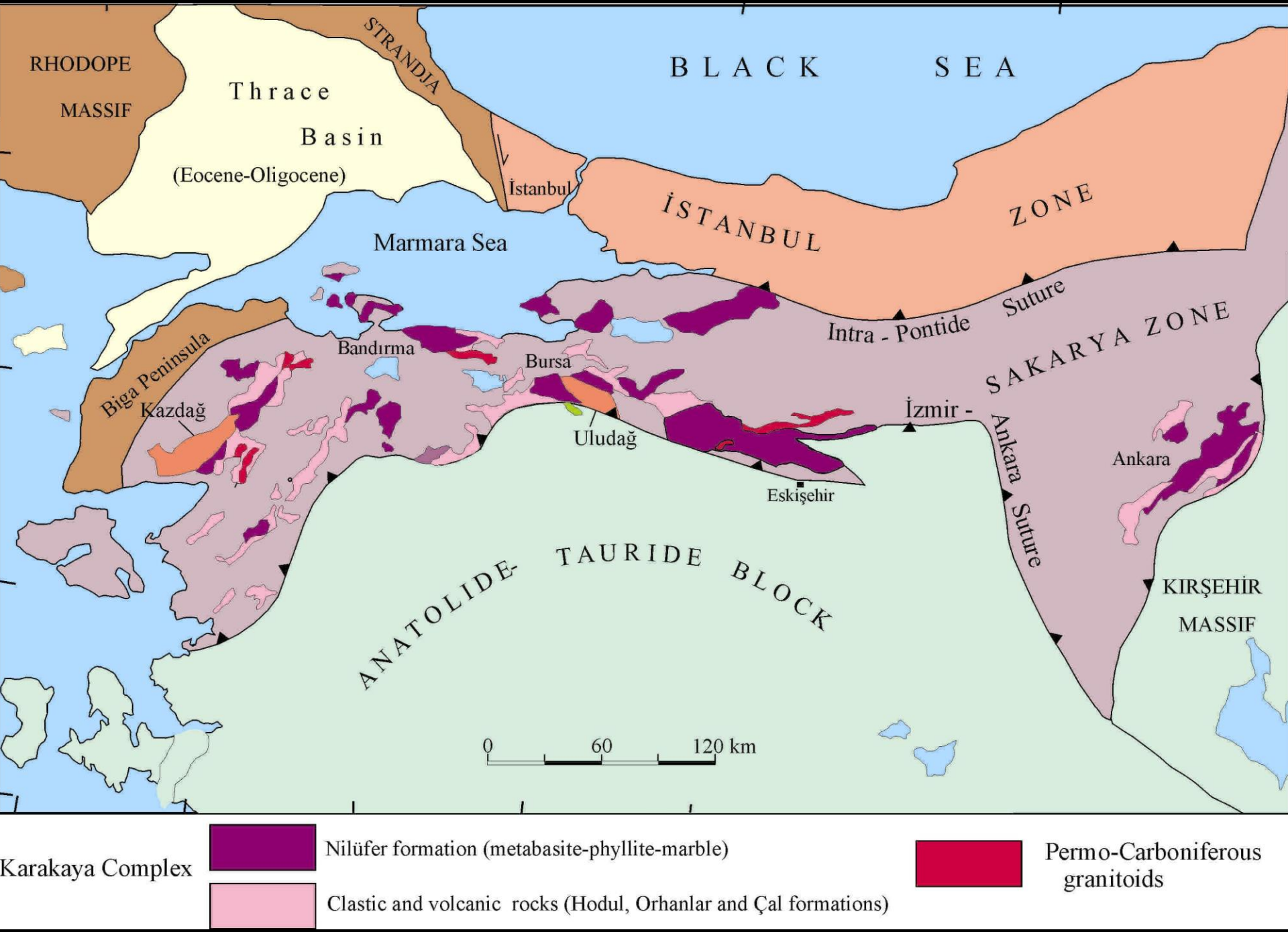
Litoloji:	Metabazit-mermer-fillat ardalanımı
Kalınlık:	> 2 km
Özellikleri:	Kuvvetli deformasyon, yeşilşist, mavişist ve eklojit fasiyesinde rejyonal metamorfizma
Oluşum yaşı:	Permiyen (?) - Erken-Orta Triyas
Metamorfizma yaşı:	en Geç Triyas
Alt sınır:	Kazdağ ve Uludağ Grubu üzerinde tektonik olarak yer alıyor.
Üst sınır:	Hodul Formasyonu ve Orhanlar Grovağı altında tektonik/stratigrafik bir dokanakla yer alıyor
Tip kesit:	Bursa güneyinde Nilüfer vadisini takip eden Bursa-Keles-Orhaneli yolu
Adlama:	Okay ve diğerleri (1991)
Kullanım:	Pickett ve diğerleri (1995) Pickett ve Robertson (1996) Leven ve Okay (1996) Okay ve diğerleri (1996) Monod ve Okay (1999) Kozur ve diğerleri (2000) Kozur ve diğerleri (2002) Okay ve diğerleri (2002) Genç (2003)



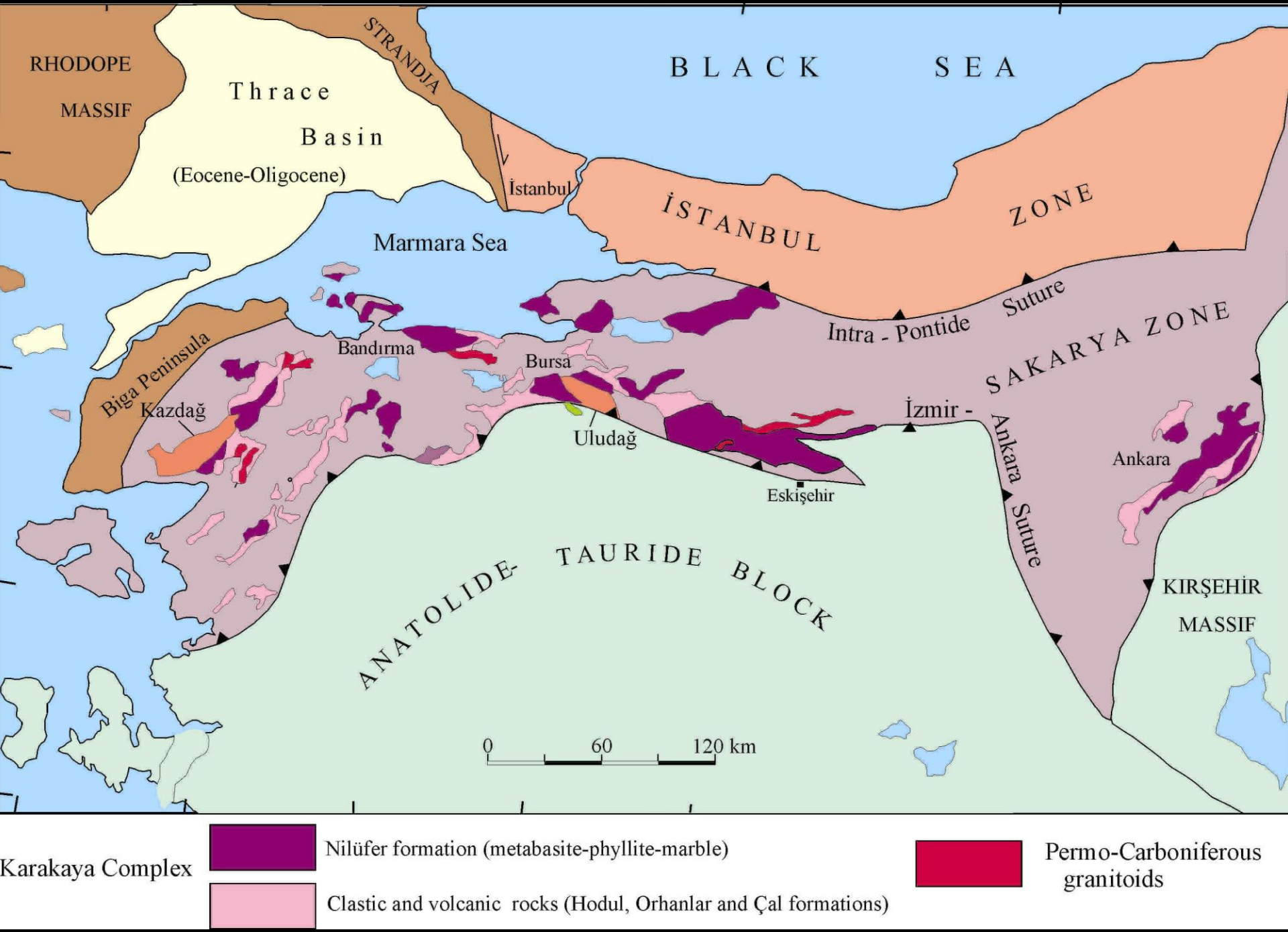

0.5mm
PV-151
OKYPEN

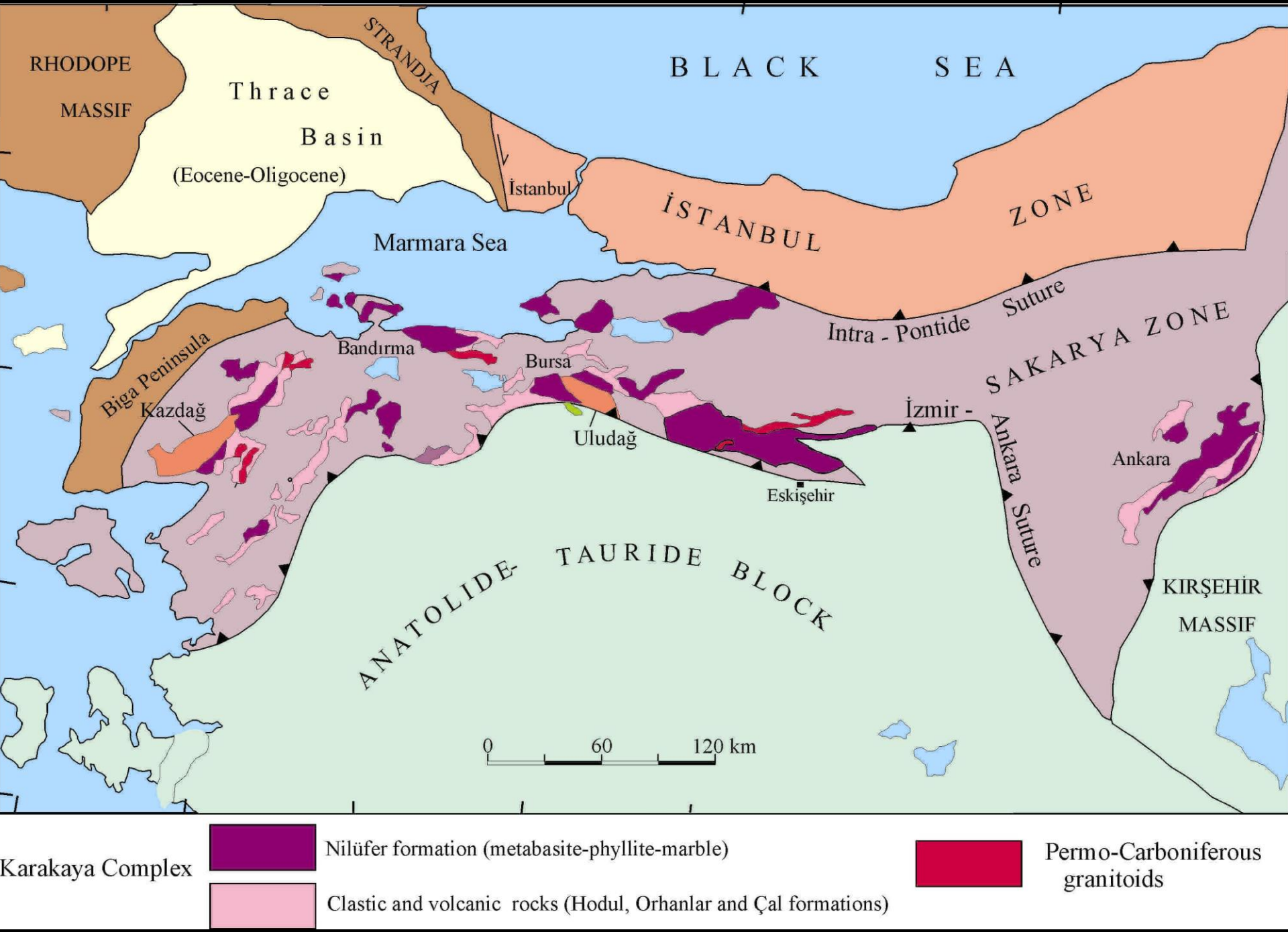





RHODOPE
MASSIF
Thrace
Basin
(Eocene-Oligocene)
STRANDJA
BLACK SEA
İstanbul
İSTANBUL ZONE
Marmara Sea
Intra - Pontide Suture
SAKARYA ZONE
Biga Peninsula
Kazdağ
Bandırma
Bursa
Uludağ
İzmir - Ankara Suture
Ankara
Eskişehir
ANATOLIDE- TAURIDE BLOCK
KIRŞEHİR
MASSIF
0
60
120 km
Karakaya Complex
Nilüfer formation (metabasite-phyllite-marble)
Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
Permo-Carboniferous granitoids

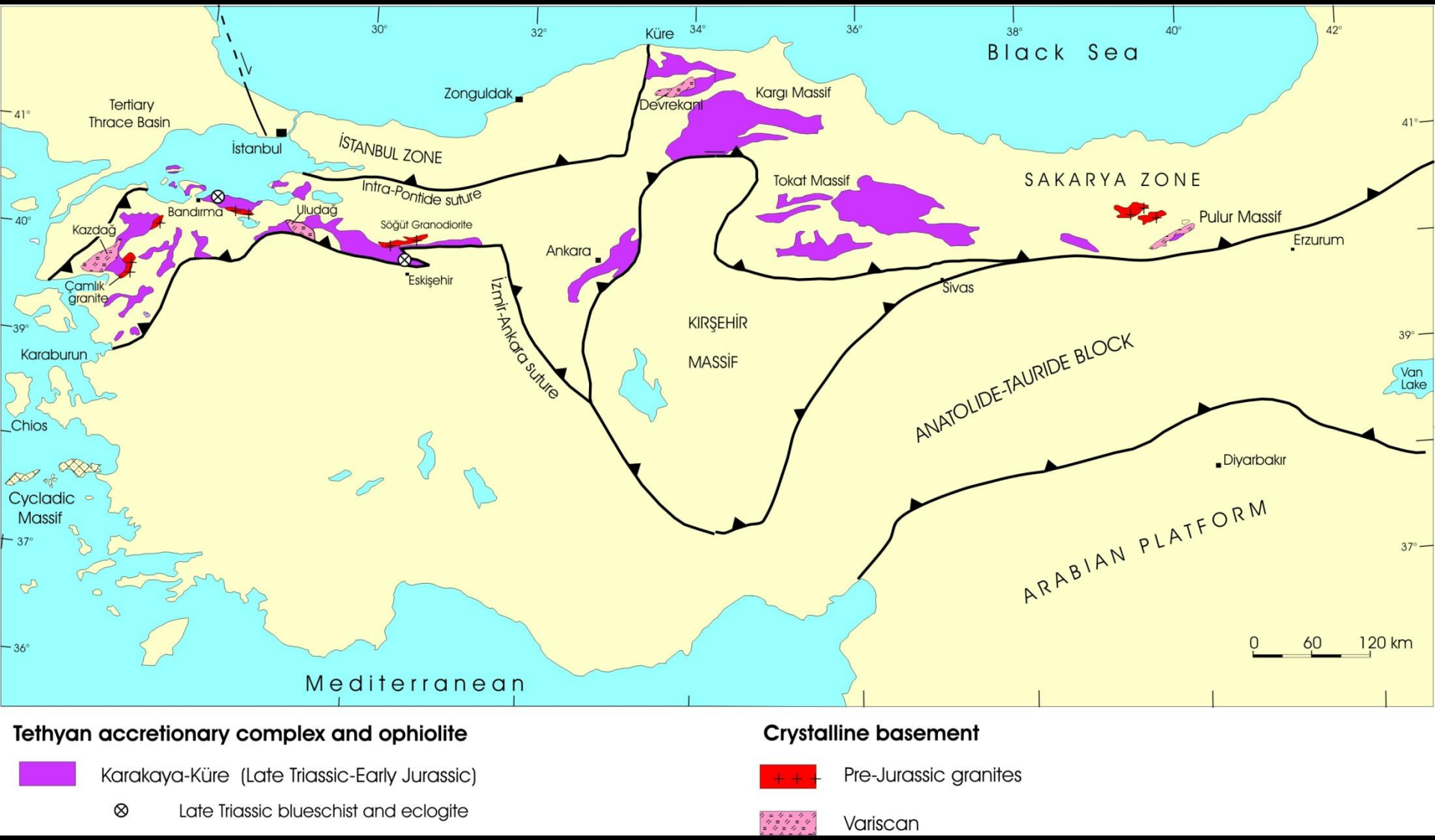



RHODOPE
MASSIF
Thrace
Basin
(Eocene-Oligocene)
STRANDJA
BLACK SEA
İstanbul
İSTANBUL ZONE
Marmara Sea
Intra - Pontide Suture
SAKARYA ZONE
Biga Peninsula
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RHODOPE
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Thrace
Basin
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İSTANBUL ZONE
Marmara Sea
Intra - Pontide Suture
SAKARYA ZONE
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Eskişehir
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60
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Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
Permo-Carboniferous granitoids







Tethyan accretionary complex and ophiolite

Karakaya-Küre (Late Triassic-Early Jurassic)

⊗ Late Triassic blueschist and eclogite

Crystalline basement

Pre-Jurassic granites

Variscan

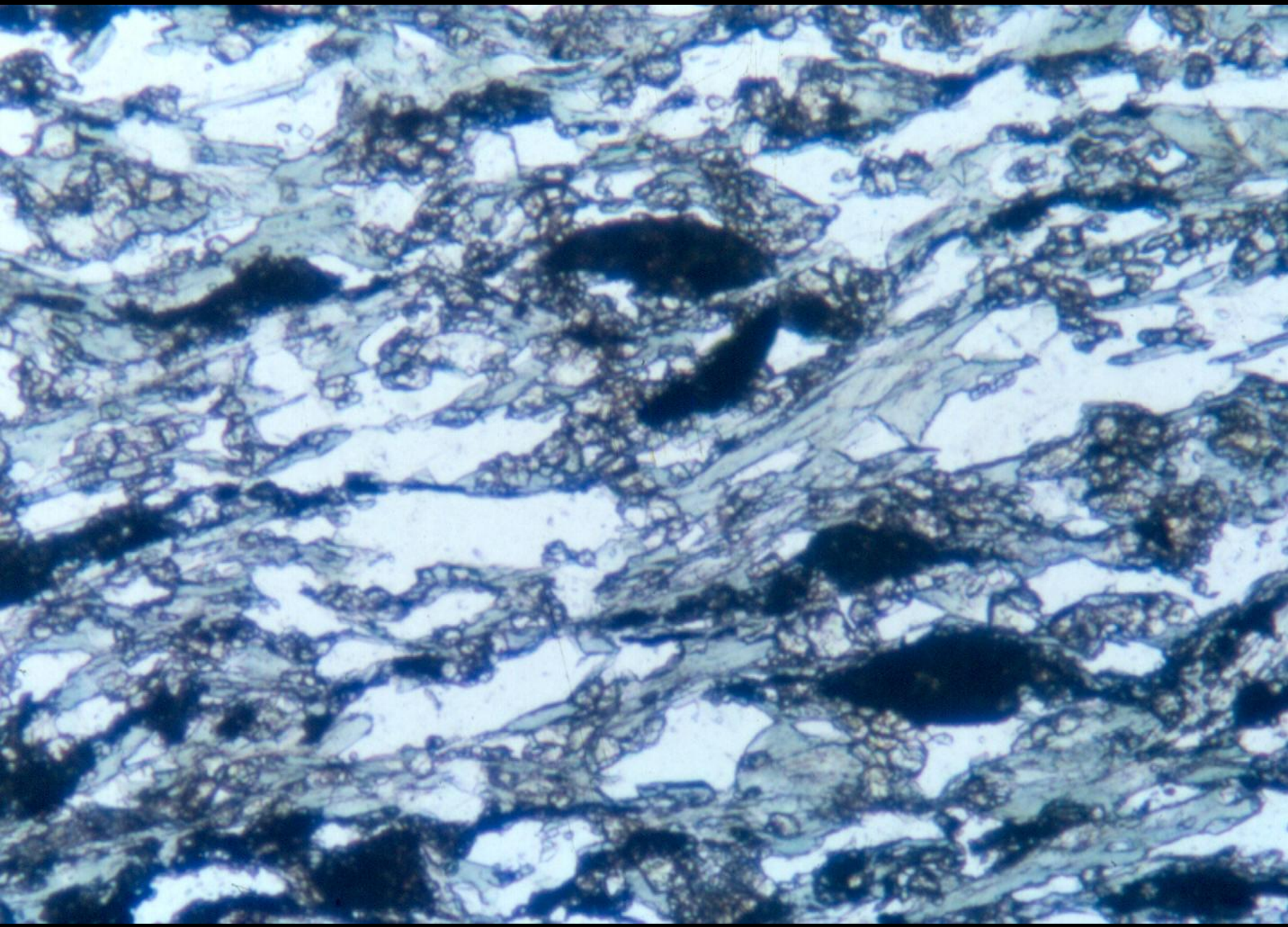




YAPI

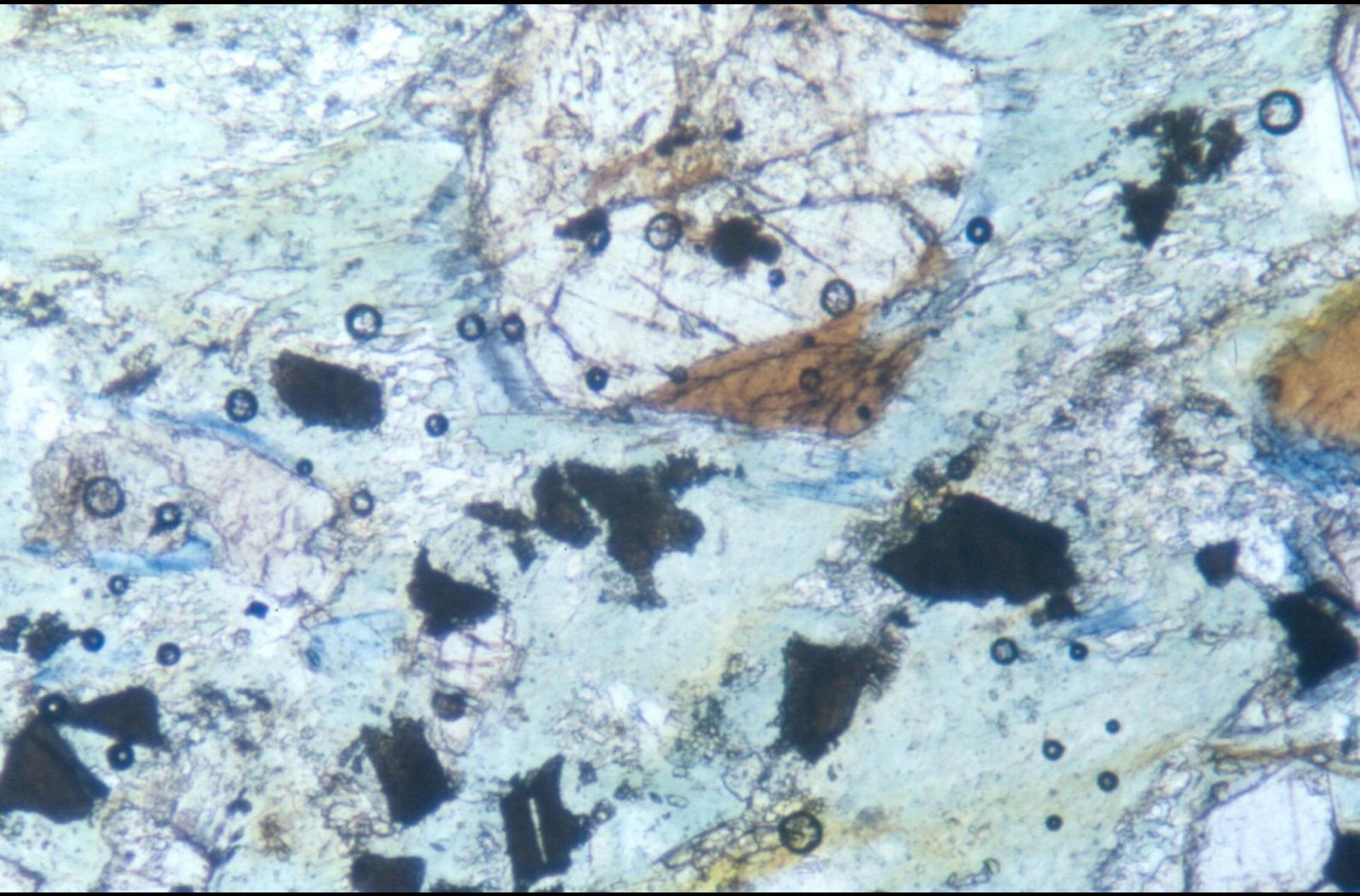
ve

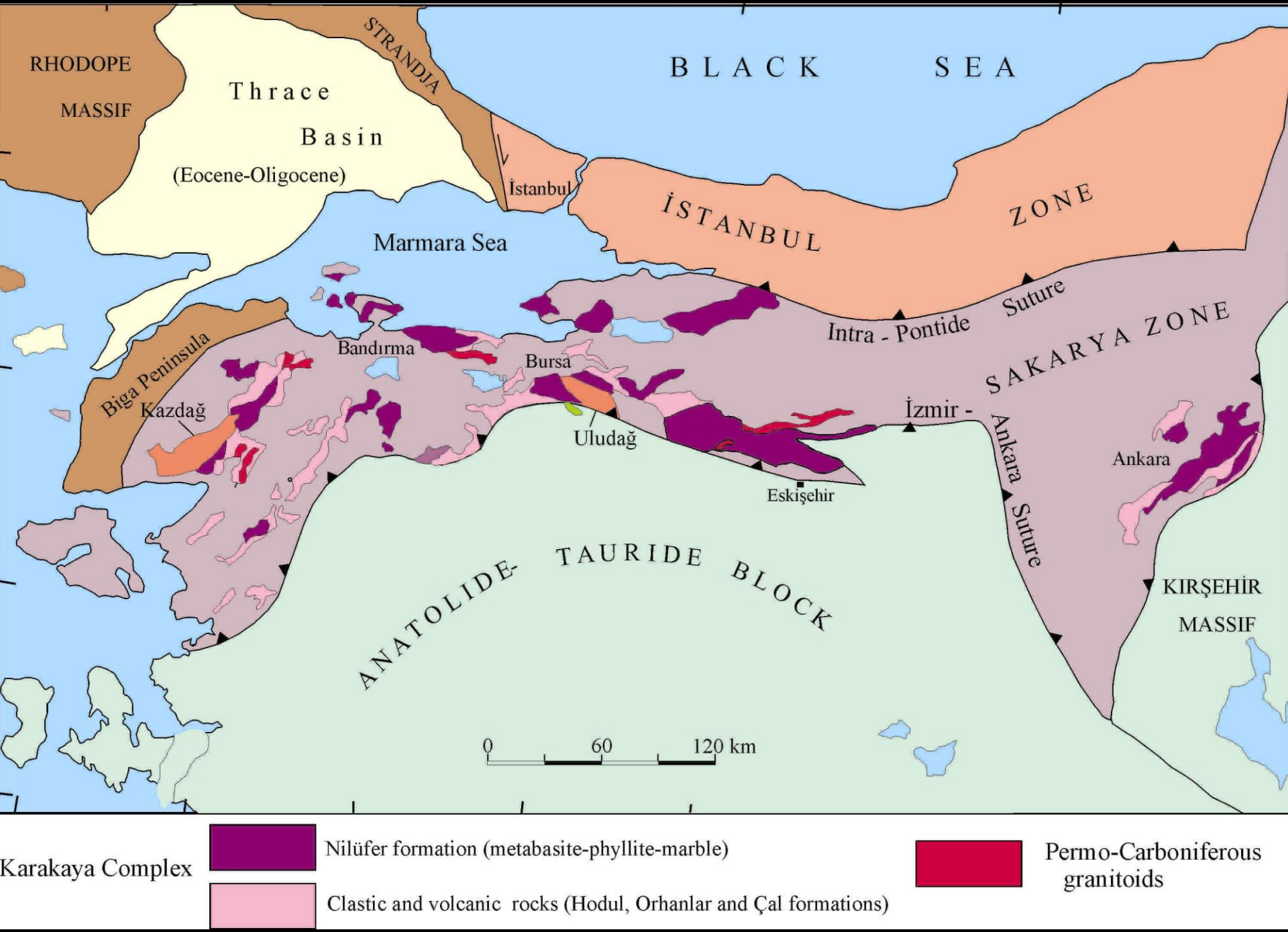
METAMORFİZMA

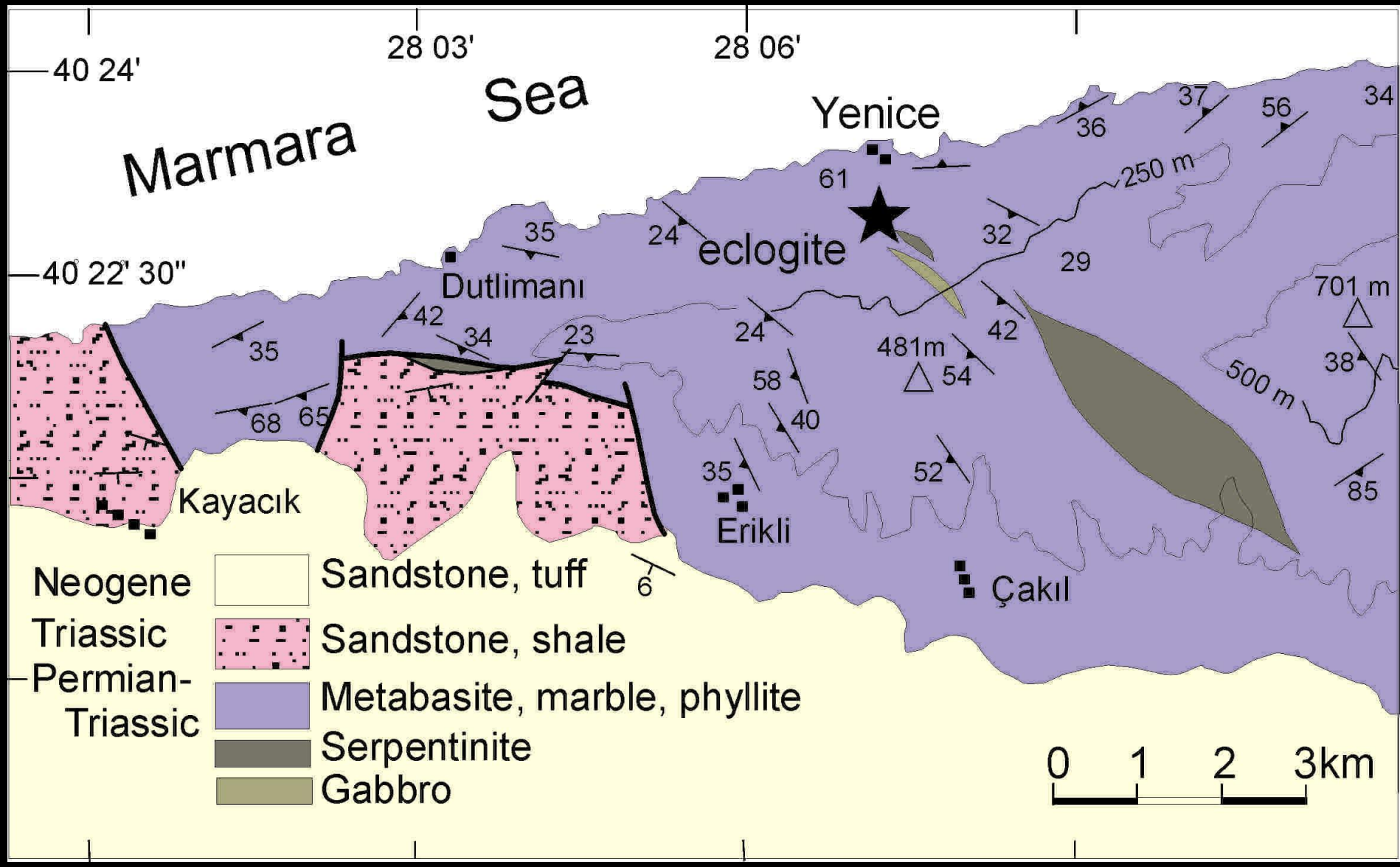









RHODOPE
MASSIF
Thrace
Basin
(Eocene-Oligocene)
STRANDJA
BLACK SEA
İstanbul
İSTANBUL ZONE
Marmara Sea
Intra - Pontide Suture
SAKARYA ZONE
Biga Peninsula
Kazdağ
Bandırma
Bursa
Uludağ
İzmir - Ankara Suture
Ankara
Eskişehir
ANATOLIDE- TAURIDE BLOCK
KIRŞEHİR
MASSIF
0
60
120 km
Karakaya Complex
Nilüfer formation (metabasite-phyllite-marble)
Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
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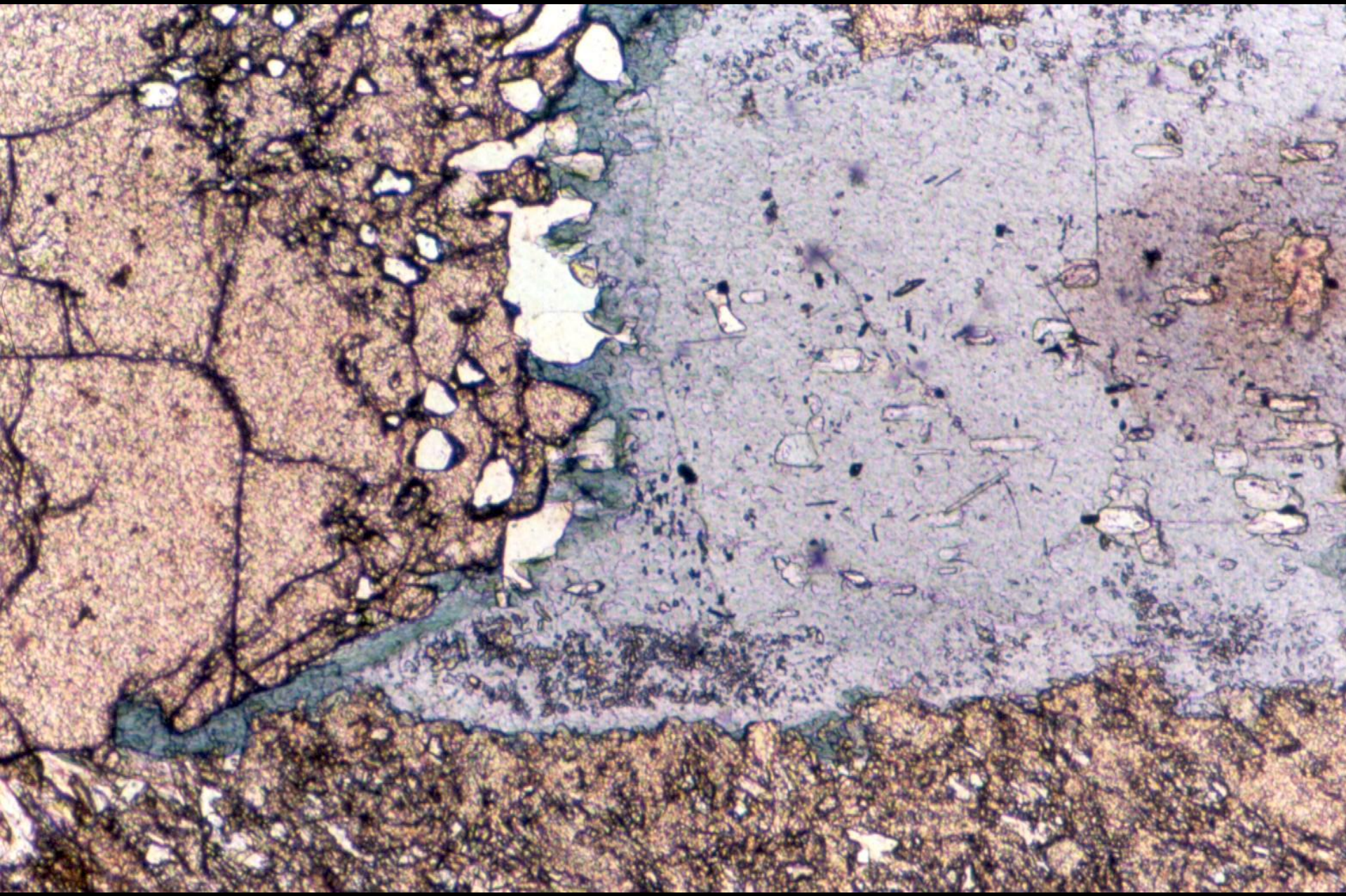

28 03'
28 06'
40 24'
40 22' 30"
Marmara Sea
Yenice
eclogite
Dutlimanı
Kayacık
Erikli
Çakıl
481m
701 m
250 m
500 m
Neogene
Triassic
Permian-Triassic
Sandstone, tuff
Sandstone, shale
Metabasite, marble, phyllite
Serpentinite
Gabbro
0 1 2 3km

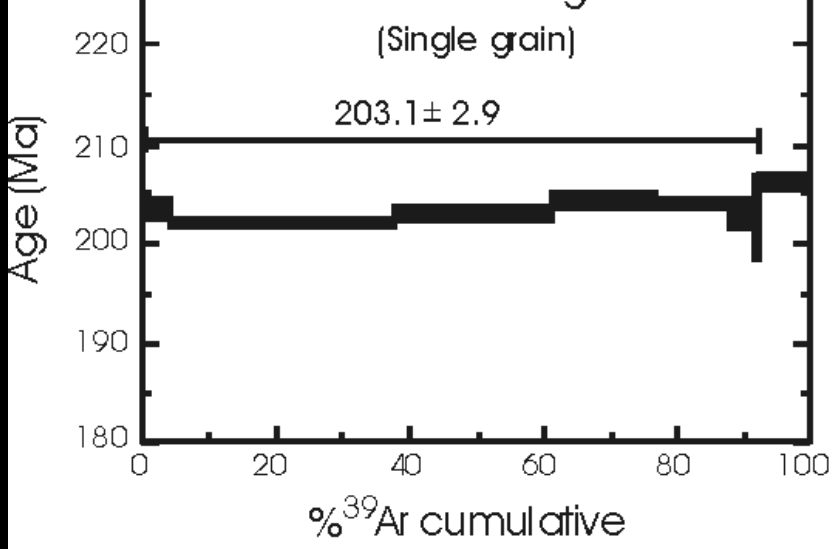


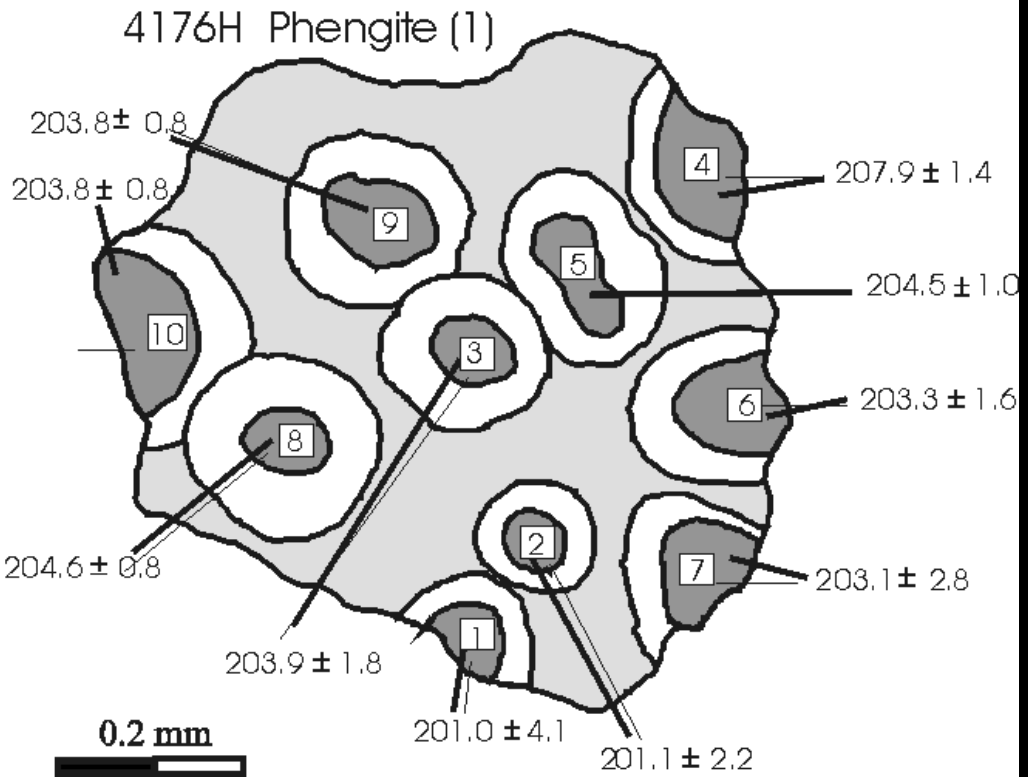


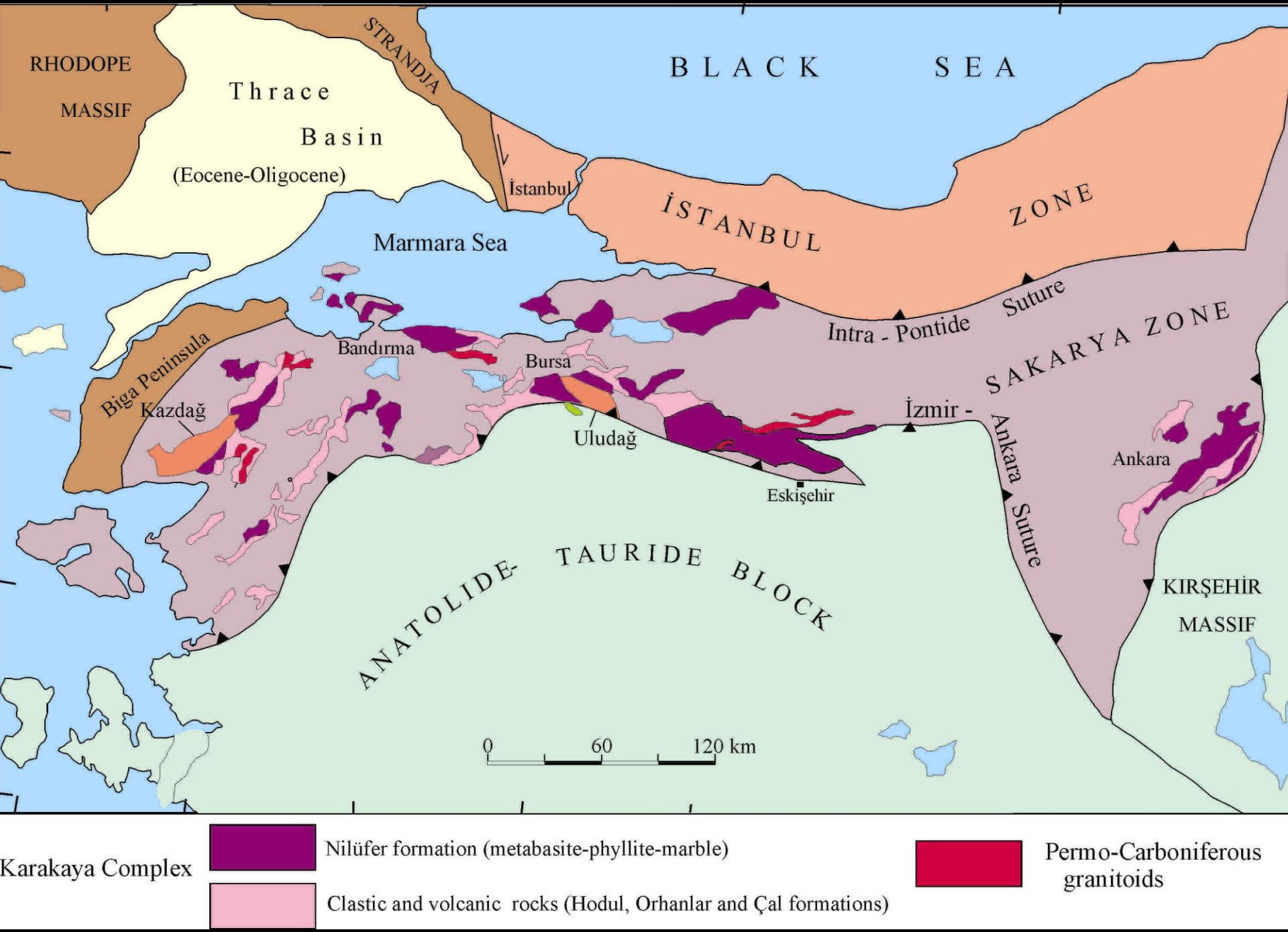

10






(Single grain)
203.1± 2.9
Age (Ma)
220
210
200
190
180
0
20
40
60
80
100
%39Ar cumulative


4176H Phengite (1)
203.8± 0.8
203.8± 0.8
207.9 ± 1.4
204.5 ± 1.0
203.3 ± 1.6
204.6 ± 0.8
203.1± 2.8
203.9 ± 1.8
201.0 ± 4.1
201.1 ± 2.2
0.2 mm

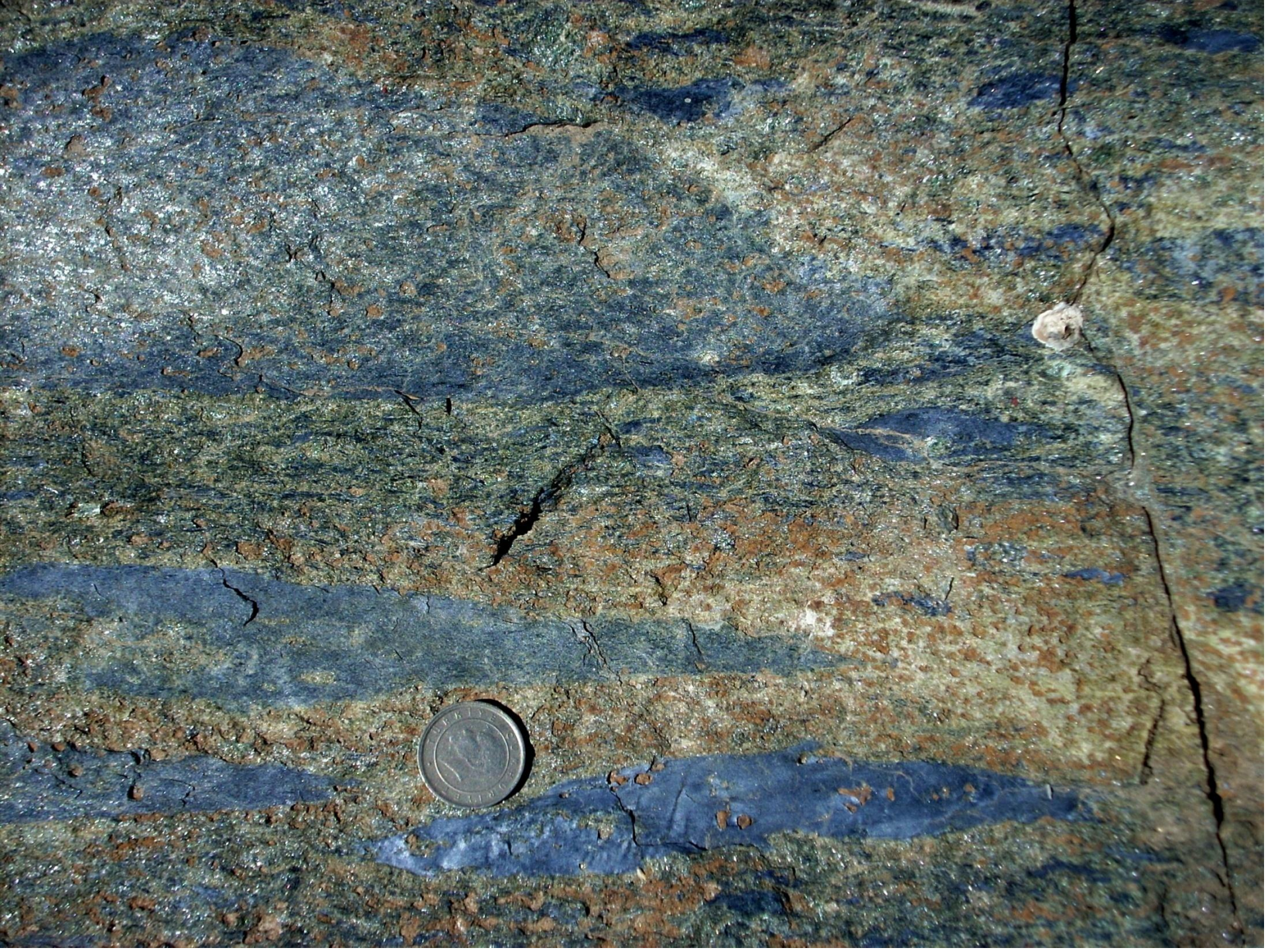

RHODOPE
MASSIF
Thrace
Basin
(Eocene-Oligocene)
STRANDJA
BLACK SEA
İstanbul
İSTANBUL ZONE
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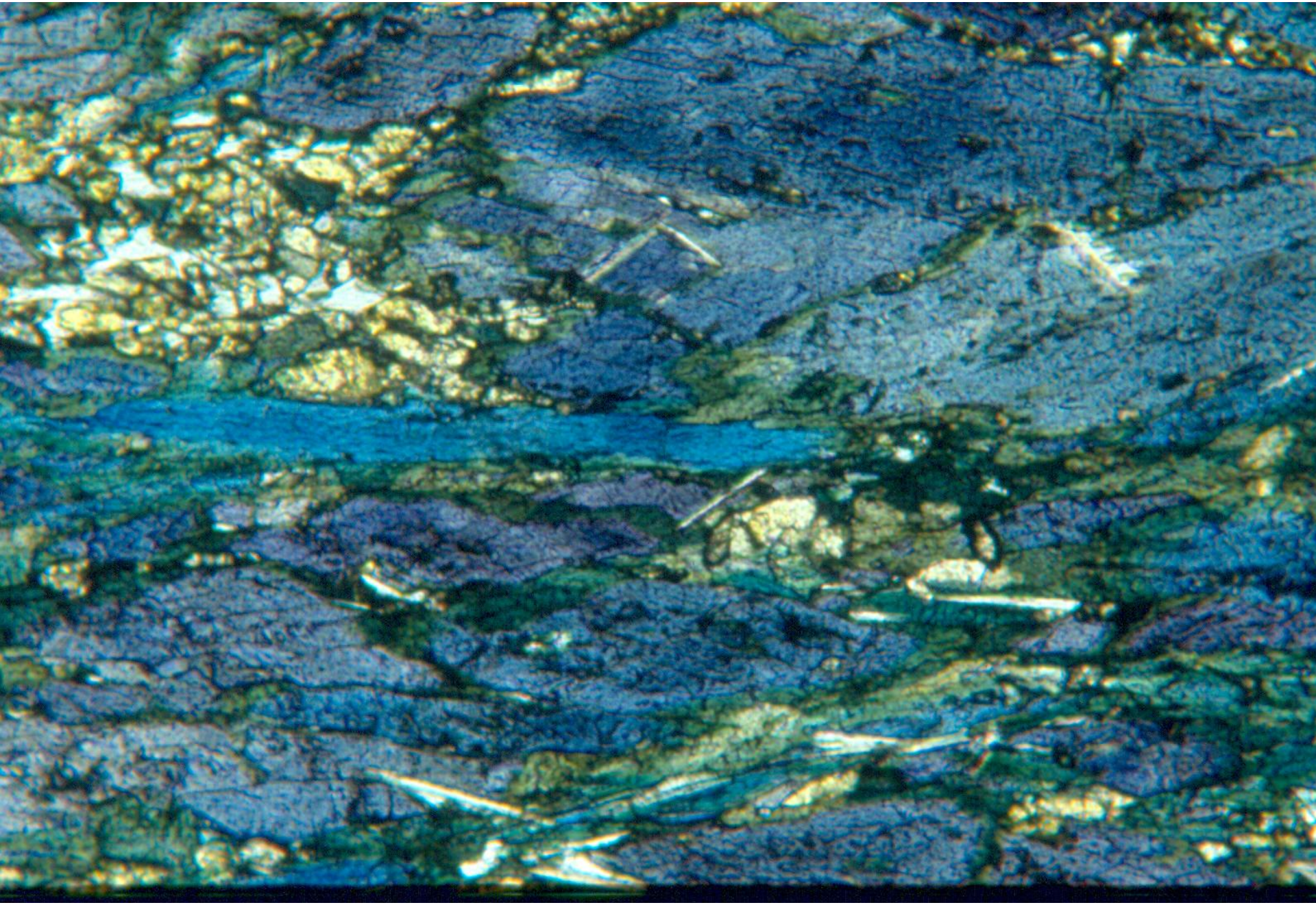

94 10 10

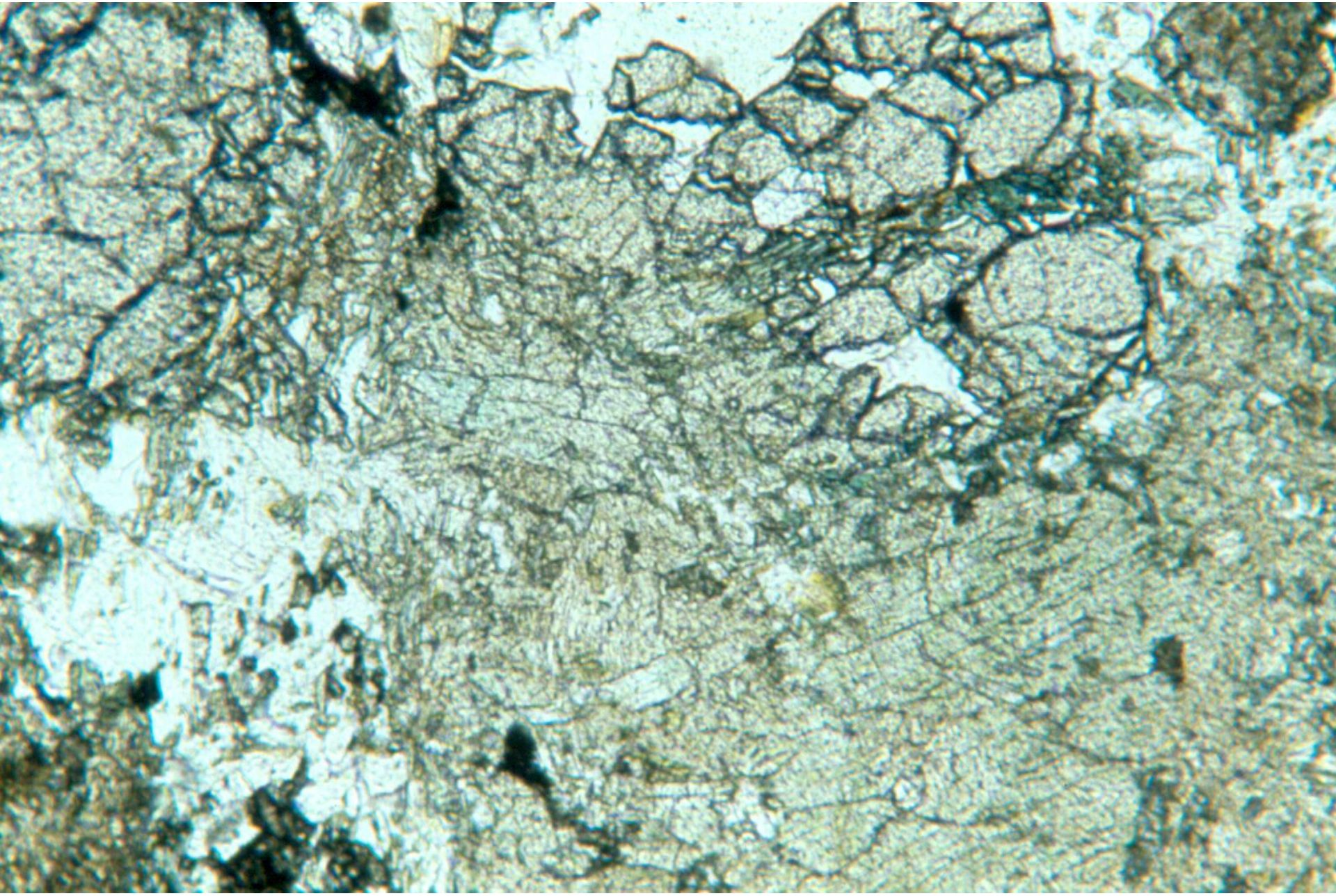

Nikon

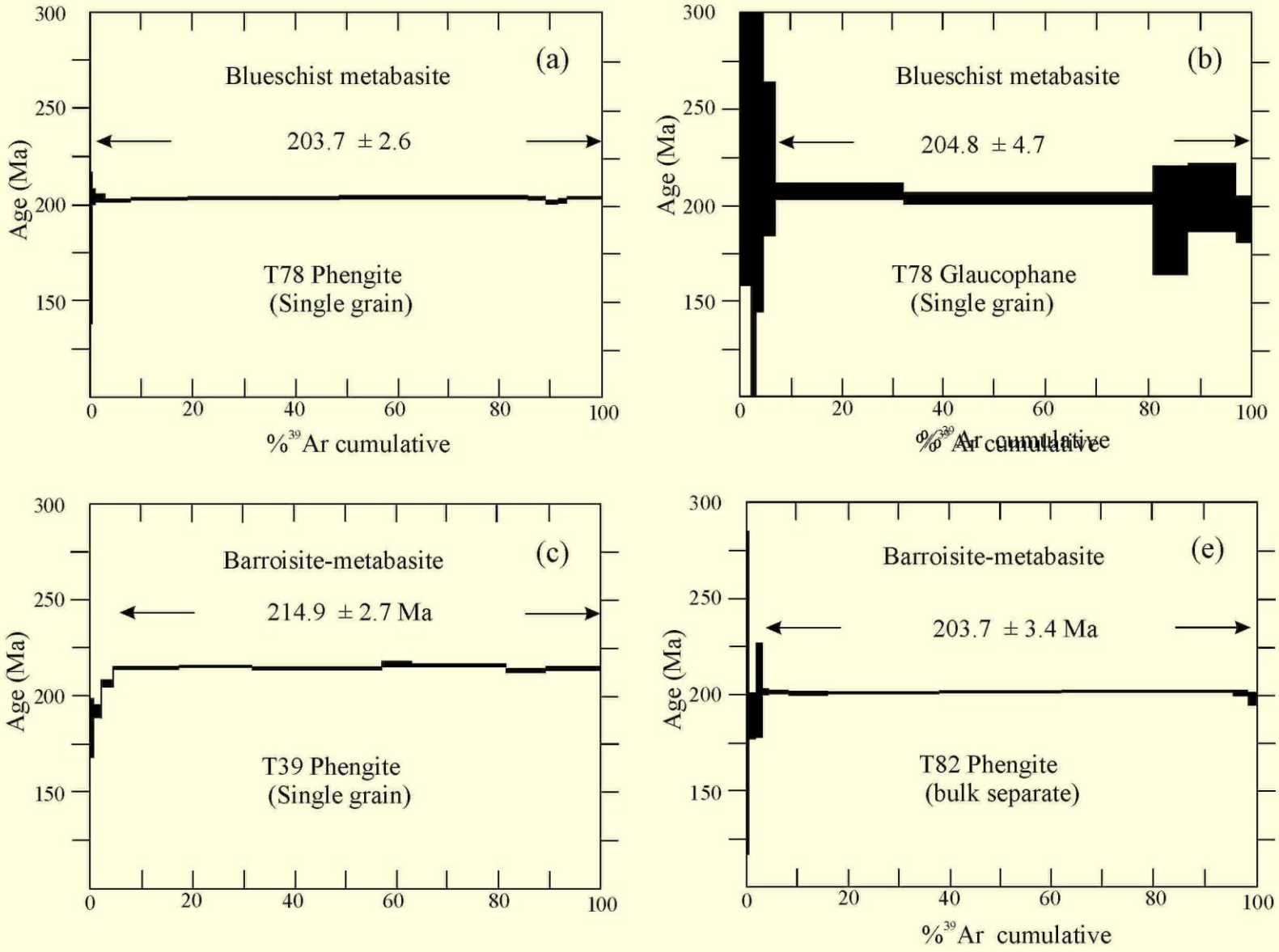



10
YENİ KURUŞ
2005



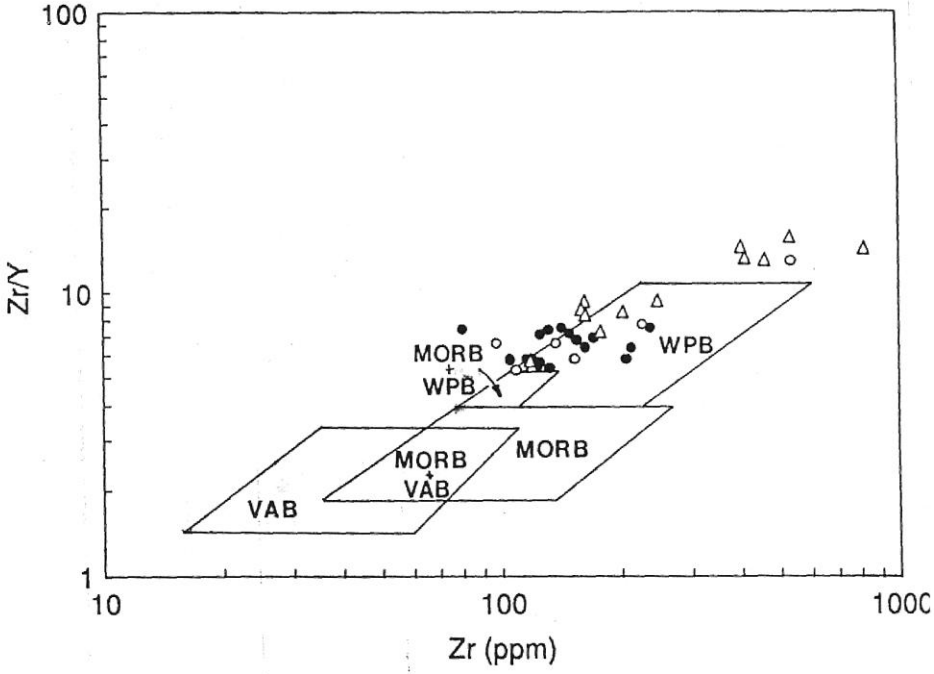


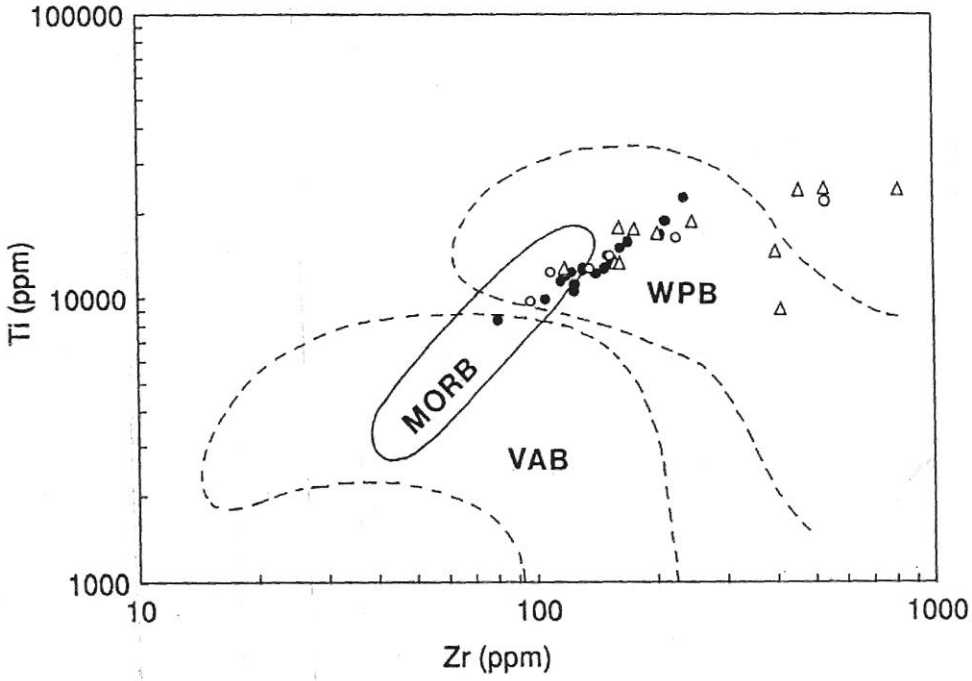




Ar-Ar ages from the Triassic blueschists andbarroisite-metabasites from the Eskişehir region, northwest Turkey (Okay et al., 2002).

JEOKİMYA

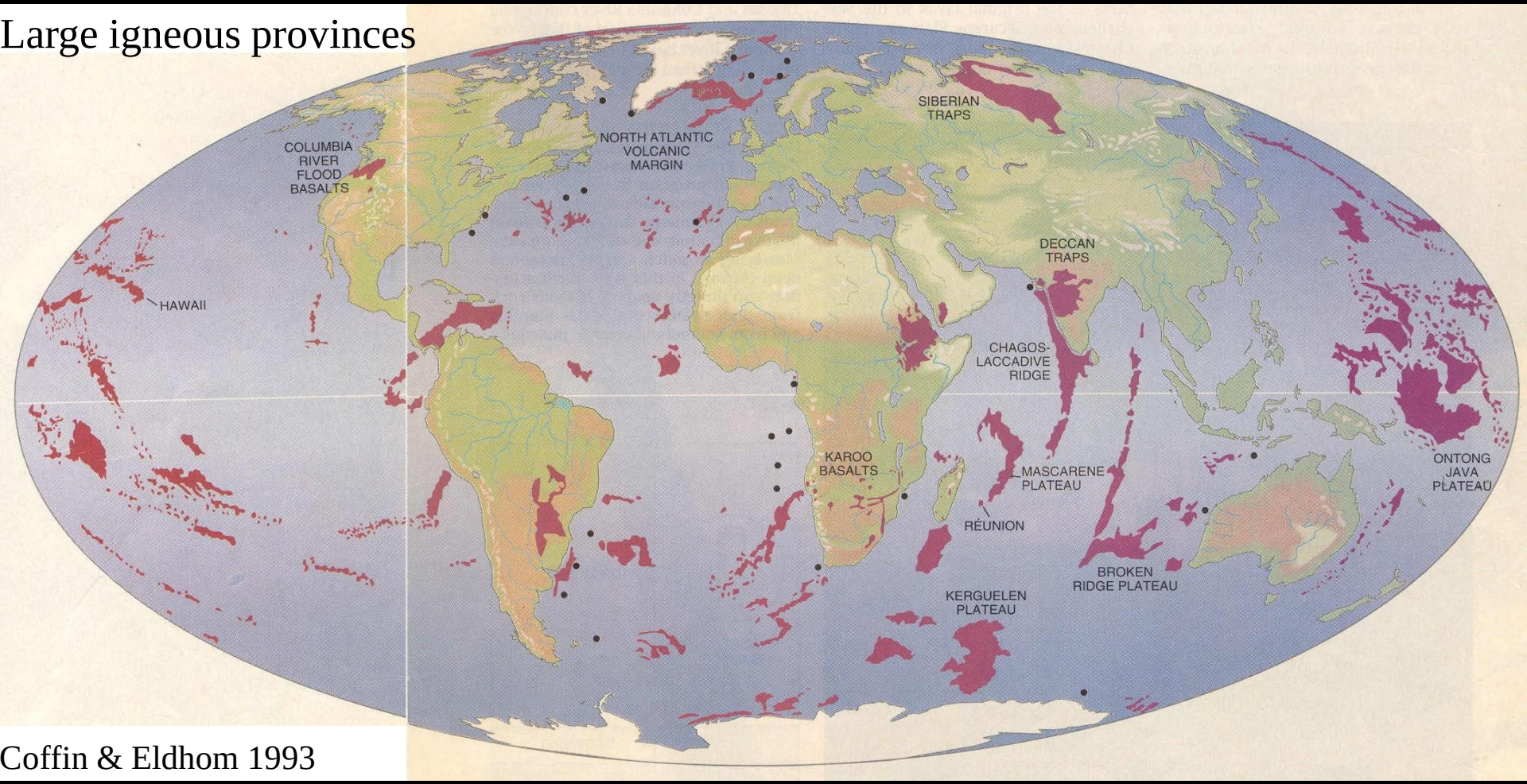




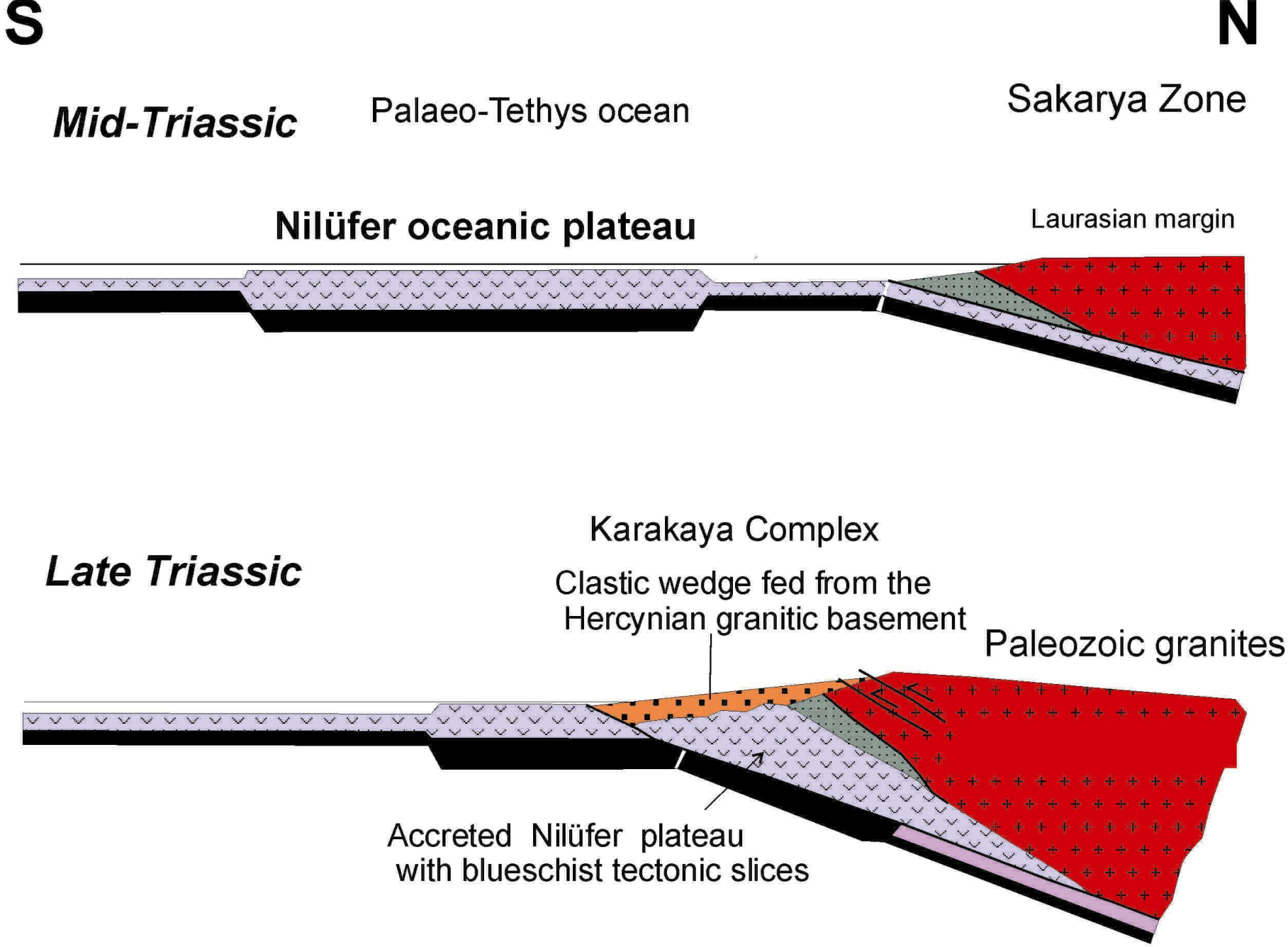
Tectonic discrimination diagrams from the Nilüfer formation from northwest Turkey (Pickett, 1994)

MORB: mid-ocean ridge basalt, WPB, within-plate basalt, VAB, volcanic-arc basalt

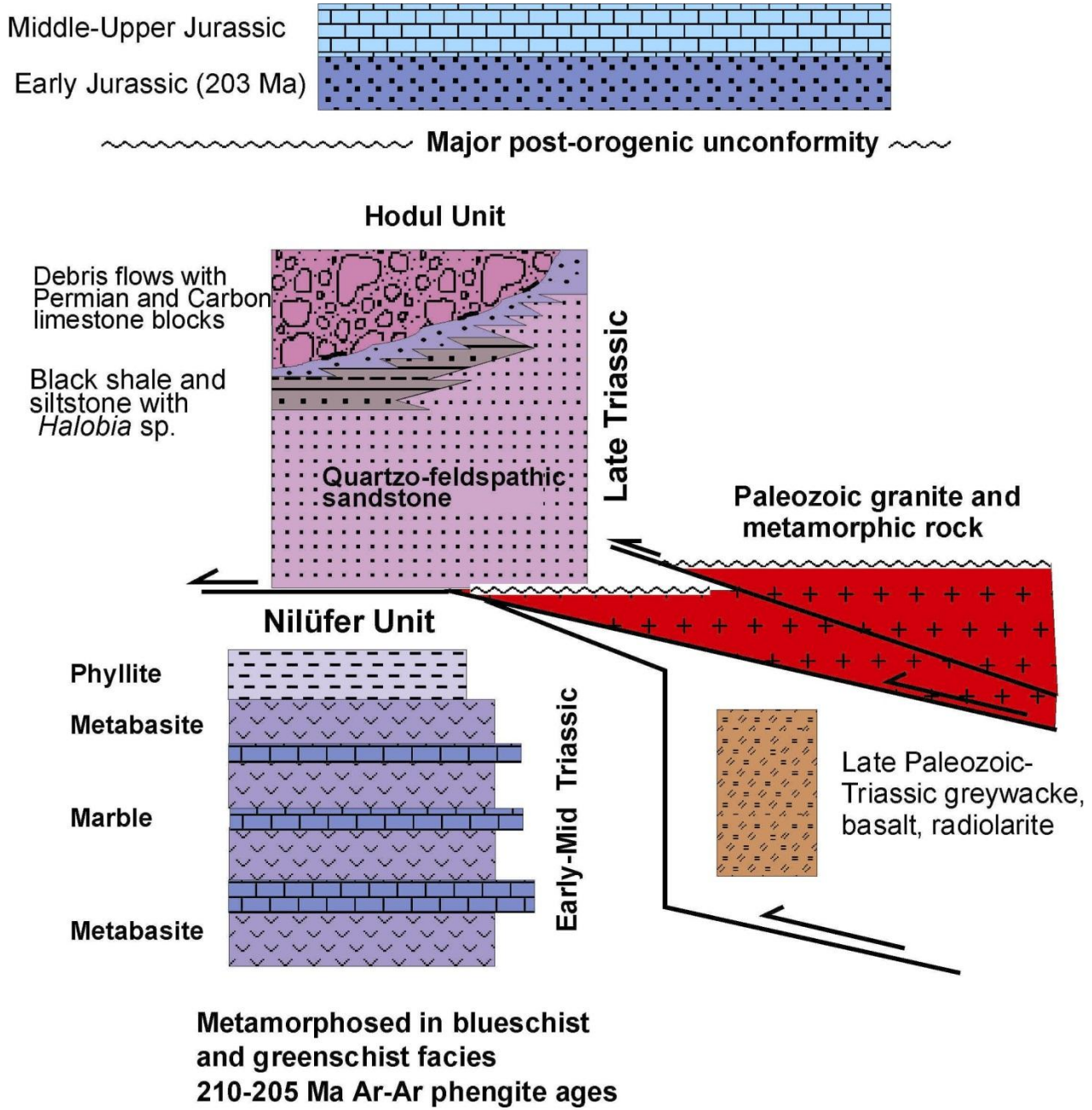
Large igneous provinces



Coffin & Eldhom 1993



Tectonic setting of the Karakaya Complex (Okay, 2000)


Middle-Upper 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
Late Paleozoic-Triassic greywacke, basalt, radiolarite
Metamorphosed in blueschist and greenschist facies
210-205 Ma Ar-Ar phengite ages

Orhanlar Grovakı

Litoloji:	Grovak, şeyl, seyrek siyah çört ve ufak Alt Karbonifer kireçtaşı blokları
Kalınlık:	> 1 km
Özellikleri:	Kuvvetli deformasyon geçirmiş fakat metamorfizma göstermiyor. Bazı bölgelerde (Mustafa Kemalpaşa-Uludağ arası) Hodul Formasyonu'nun yanal eşleneği olabilir.
Çökelme yaşı:	? Triyas (Erken Karbonifer sonrası)
Alt sınır:	Mustafa Kemalpaşa-Uludağ arasında Nilüfer formasyonu üzerinde tektonik/stratigrafik bir dokanakla yer alıyor.
Üst sınır:	Liyas yaşta Bayırköy Formasyonu ile uyumsuzlukla örtülüyor.
Tip kesit:	Balya kuzeyinde Orhanlar ileDanişment köyleri arasındaİğnecik vadisini takip eden yol.
Adlama:	Brinkmann (1971)
Kullanım:	Okay ve diğerleri (1991) Pickett ve diğerleri (1995) Pickett ve Robertson (1996) Leven ve Okay (1996) Okay ve diğerleri (1996) Monod ve Okay (1999) Okay ve diğerleri (2002)

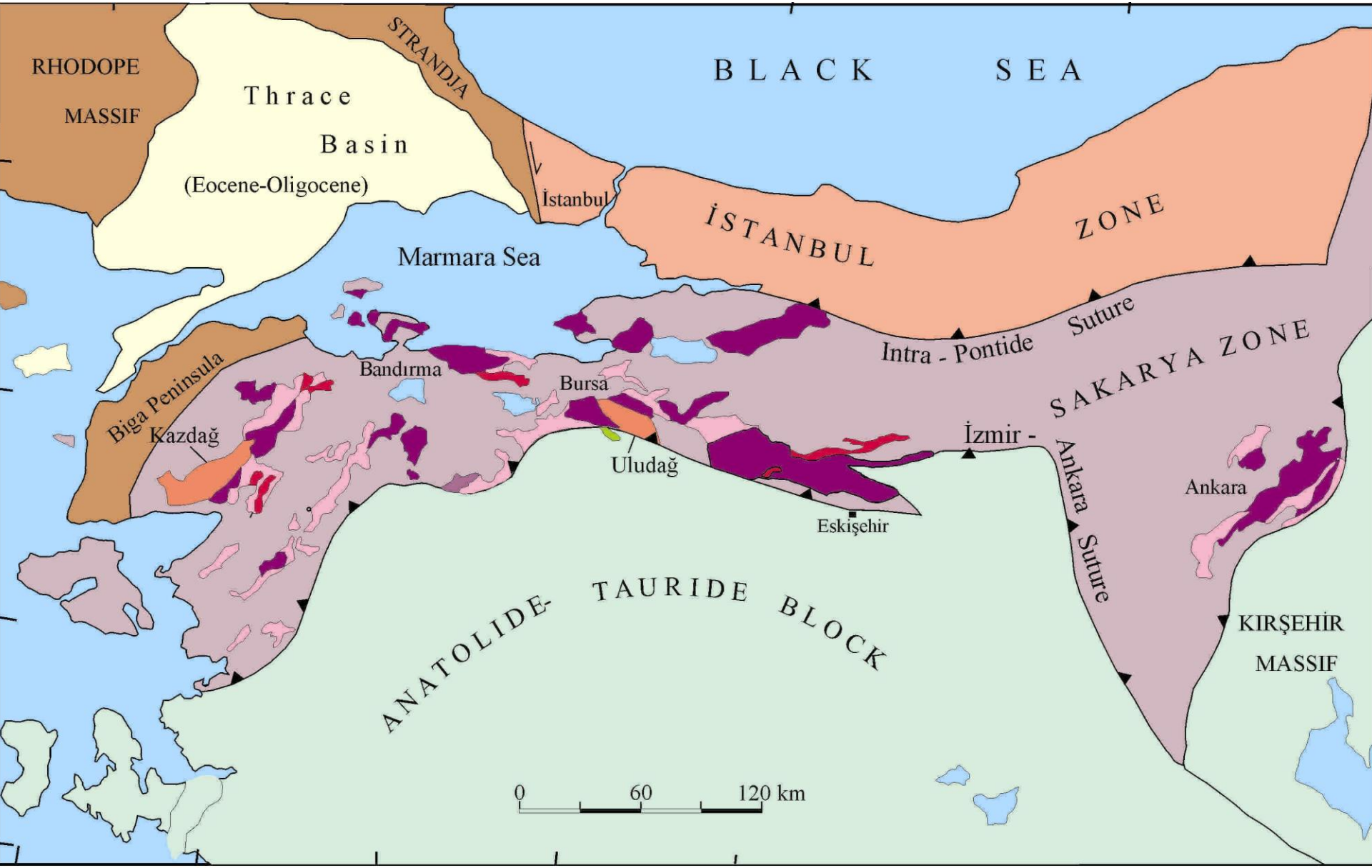






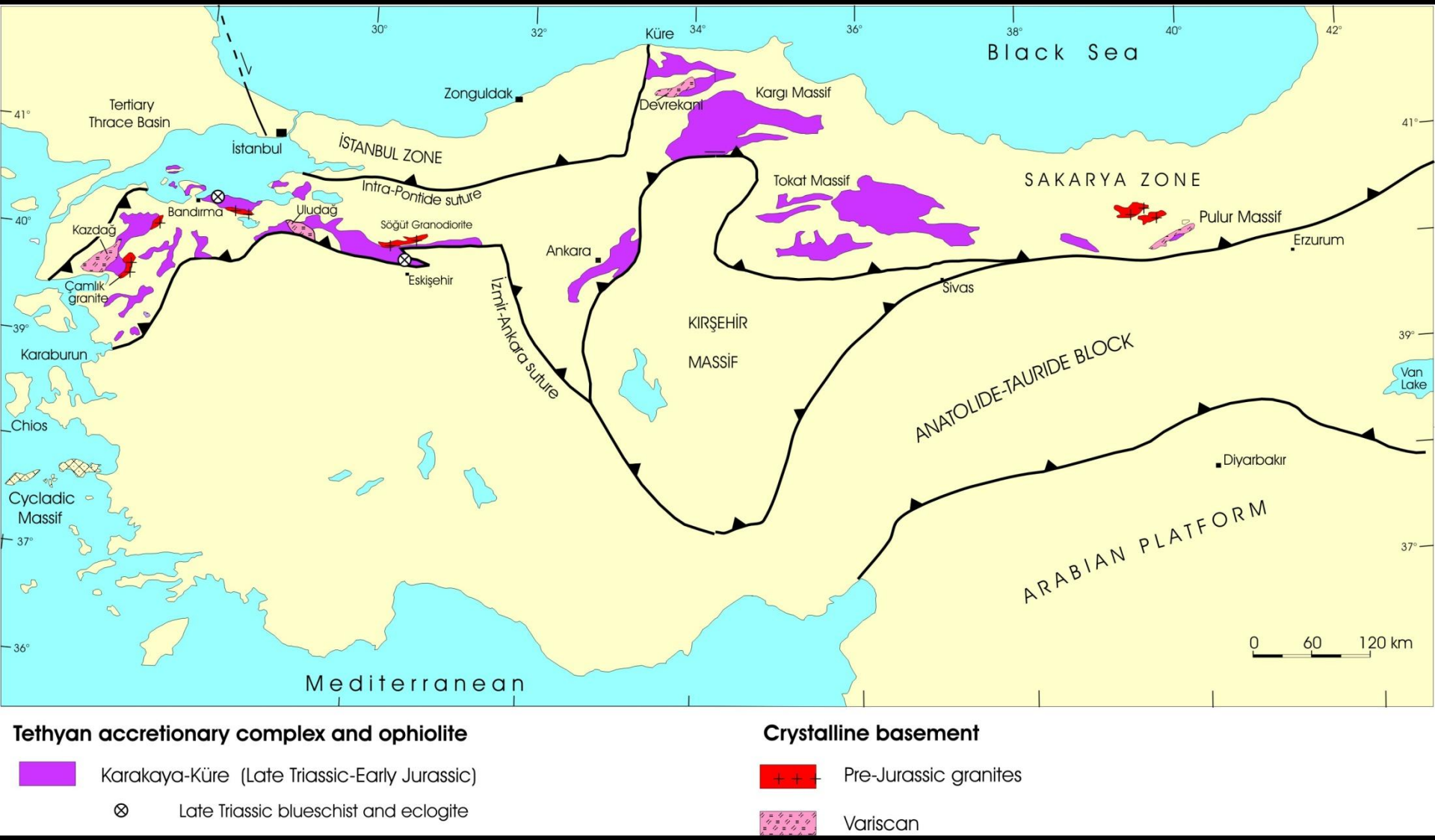





RHODOPE
MASSIF
Thrace
Basin
(Eocene-Oligocene)
STRANDJA
BLACK SEA
İstanbul
İSTANBUL ZONE
Marmara Sea
Intra - Pontide Suture
SAKARYA ZONE
Biga Peninsula
Kazdağ
Bandırma
Bursa
Uludağ
İzmir - Ankara Suture
Ankara
Eskişehir
ANATOLIDE- TAURIDE BLOCK
KIRŞEHİR
MASSIF
0
60
120 km
Karakaya Complex
Nilüfer formation (metabasite-phyllite-marble)
Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
Permo-Carboniferous granitoids







Tethyan accretionary complex and ophiolite

Karakaya-Küre (Late Triassic-Early Jurassic)

⊗ Late Triassic blueschist and eclogite

Crystalline basement

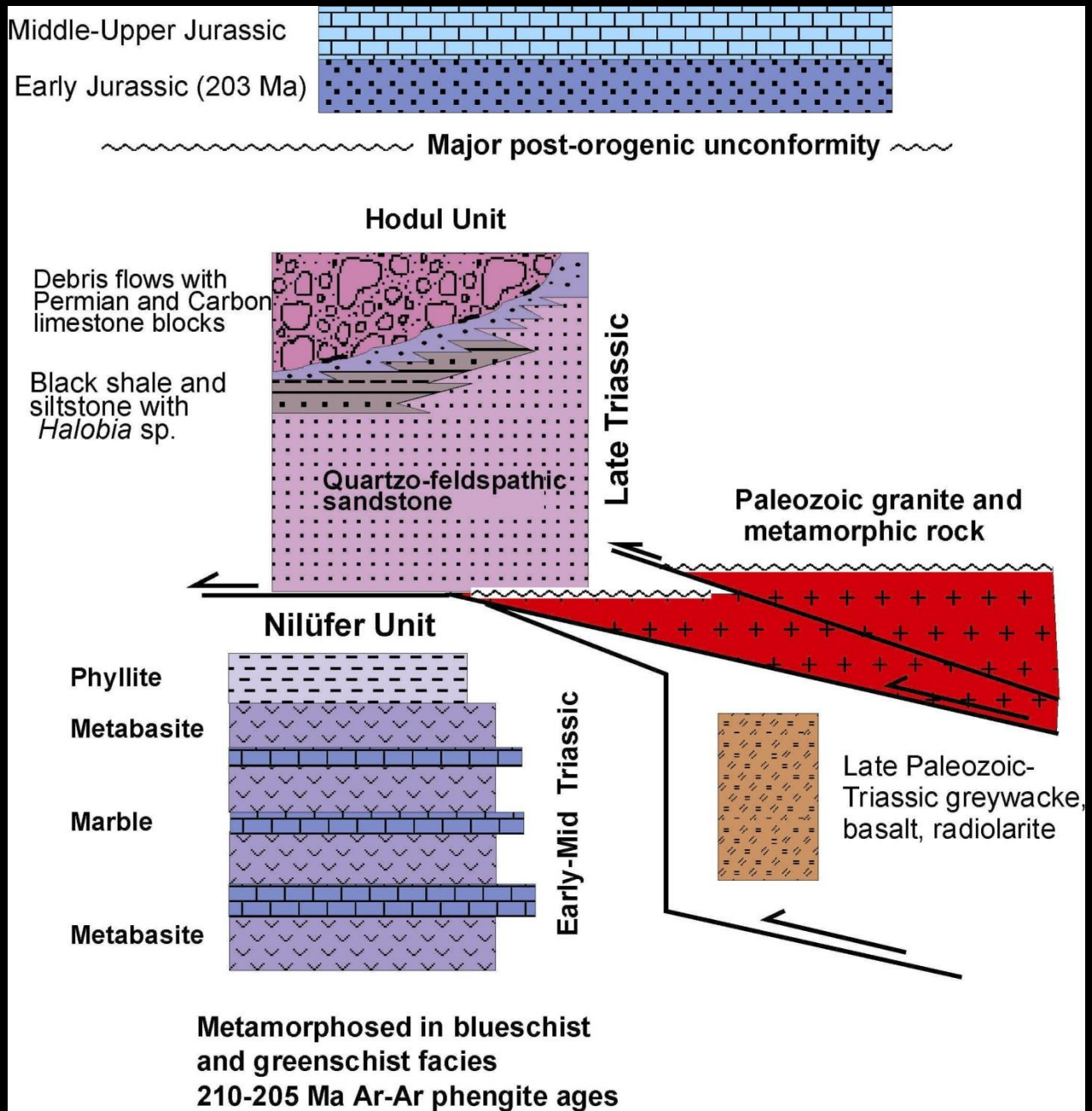
Pre-Jurassic granites

Variscan



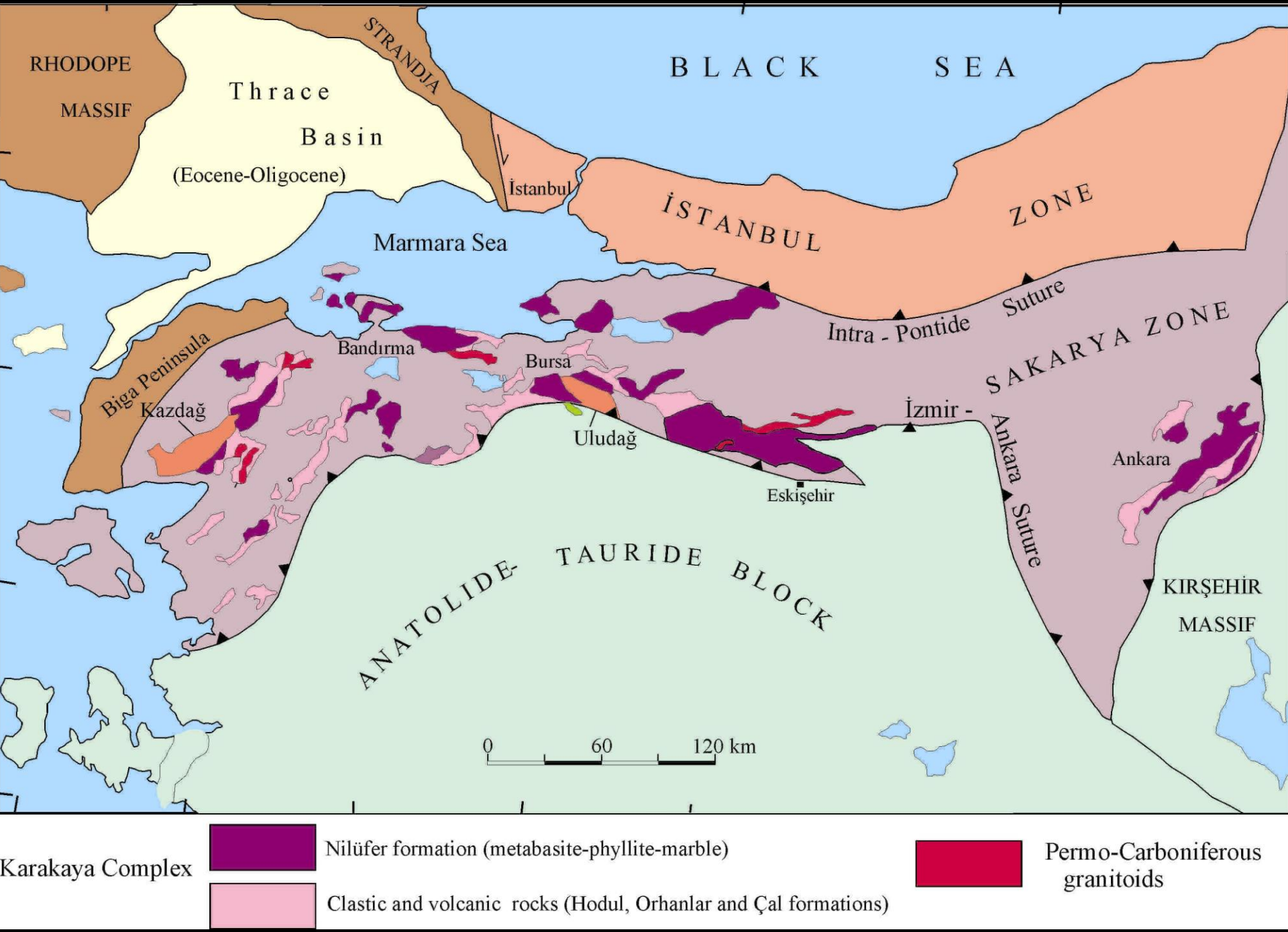





Middle-Upper Jurassic
Early Jurassic (203 Ma)
Major post-orogenic unconformity
Hodul Unit
Debris flows with Permian and Carbon limestone blocks
Black shale and siltstone with *Halobia* sp.
Quartzo-feldspathic sandstone
Late Triassic
Paleozoic granite and metamorphic rock
Nilüfer Unit
Phyllite
Metabasite
Marble
Metabasite
Early-Mid Triassic
Late Paleozoic-Triassic greywacke, basalt, radiolarite
Metamorphosed in blueschist and greenschist facies
210-205 Ma Ar-Ar phengite ages

Hodul Formasyonu/Grubu

Litoloji:	Arkozik kumtaşı, silttaşı, şeyl, tane akıntısı, moloz akıntısı, olistostrom, Karbonifer-Permiyen yaşta kireçtaşı blokları, bazalt blakları, Karbonifer çört blokları
Kalınlık:	> 1 km
Özellikleri:	Kuvvetli deformasyon geçirmiş fakat metamorfizma göstermiyor. Geç Triyas yaşta, kıtadan okyanusa uzanan çok kalın bir sedimenter kamayı temsil ediyor.
Çökelme yaşı:	Geç Triyas (Noriyen)
Alt sınır:	Havran kuzeyinde Devoniyen yaşta Çamlık granodiyoriti üzerinde uyumsuzlukla oturuyor, edremit batısında okyanusal (?) bazaltların stratigrafik olarak üzerinde, diğer bölgelerde Nilüfer formasyonu üzerinde tektonik/stratigrafik bir dokanakla yer alıyor.
Üst sınır:	Liyas yaşta Bayırköy Formasyonu ile uyumsuzlukla örtülüyor.
Tip kesit:	
Adlama:	Okay ve diğerleri (1991)
Kullanım:	Pickett ve diğerleri (1995) Pickett ve Robertson (1996) Leven ve Okay (1996) Okay ve diğerleri (1996) Monod ve Okay (1999) Okay ve diğerleri (2002)


RHODOPE
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İSTANBUL ZONE
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SAKARYA ZONE
Biga Peninsula
Kazdağ
Bandırma
Bursa
Uludağ
İzmir - Ankara Suture
Ankara
Eskişehir
ANATOLIDE- TAURIDE BLOCK
KIRŞEHİR
MASSIF
0
60
120 km
Karakaya Complex
Nilüfer formation (metabasite-phyllite-marble)
Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
Permo-Carboniferous granitoids





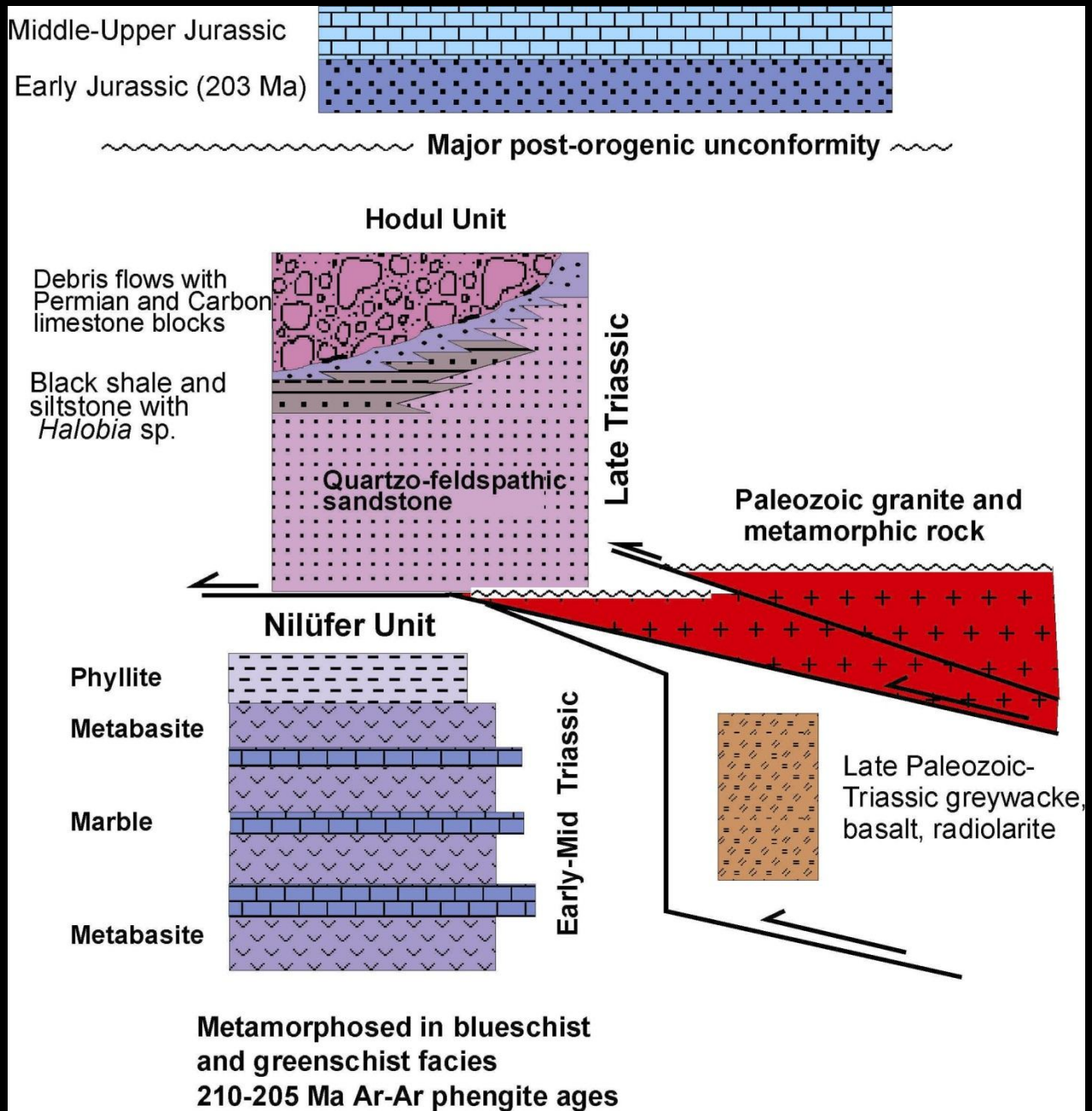











Middle-Upper Jurassic
Early Jurassic (203 Ma)
Major post-orogenic unconformity
Hodul Unit
Debris flows with Permian and Carbon limestone blocks
Black shale and siltstone with *Halobia* sp.
Quartzo-feldspathic sandstone
Late Triassic
Paleozoic granite and metamorphic rock
Nilüfer Unit
Phyllite
Metabasite
Marble
Metabasite
Early-Mid Triassic
Late Paleozoic-Triassic greywacke, basalt, radiolarite
Metamorphosed in blueschist and greenschist facies
210-205 Ma Ar-Ar phengite ages






1 CENT
KURS
2002



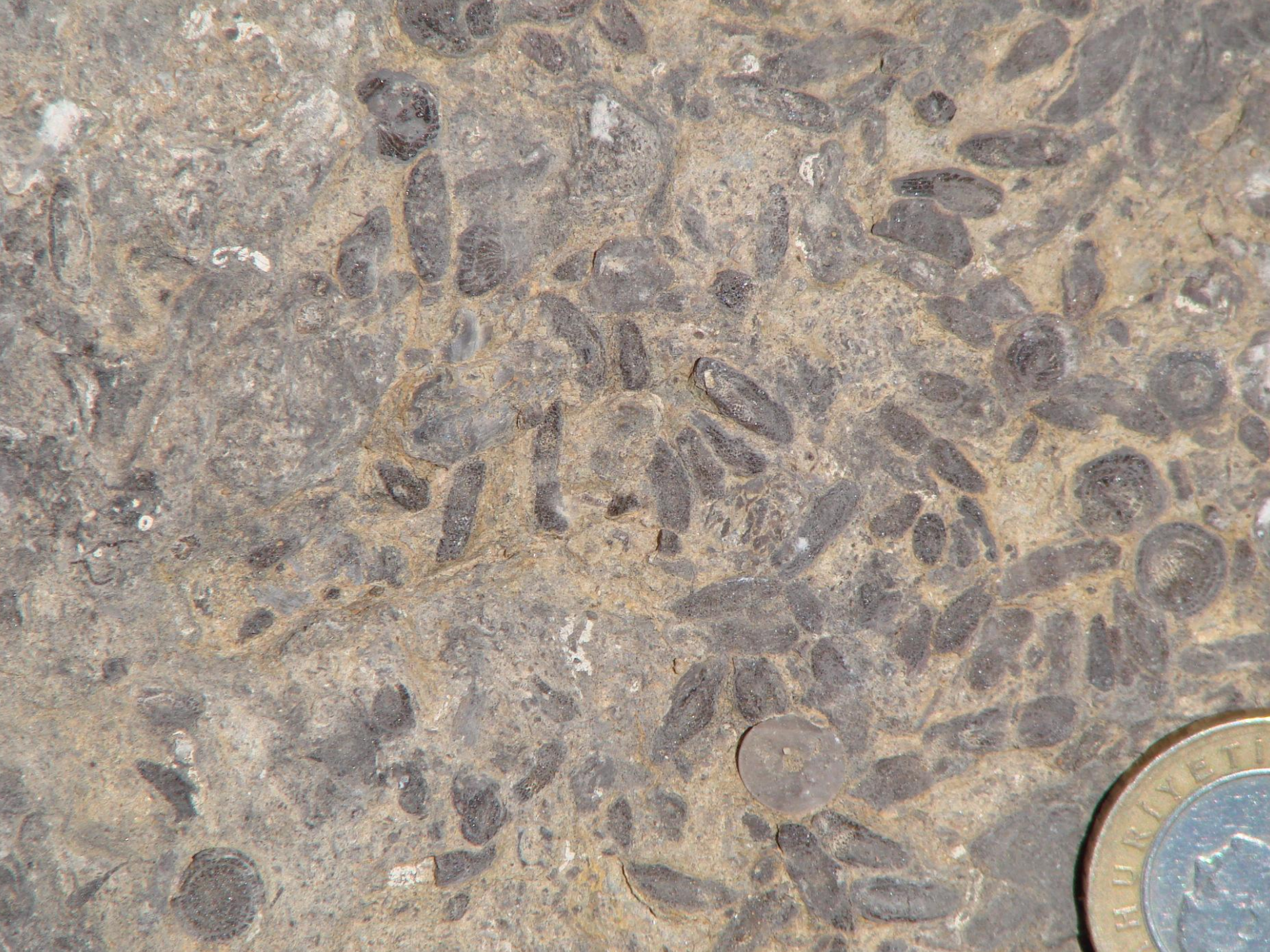






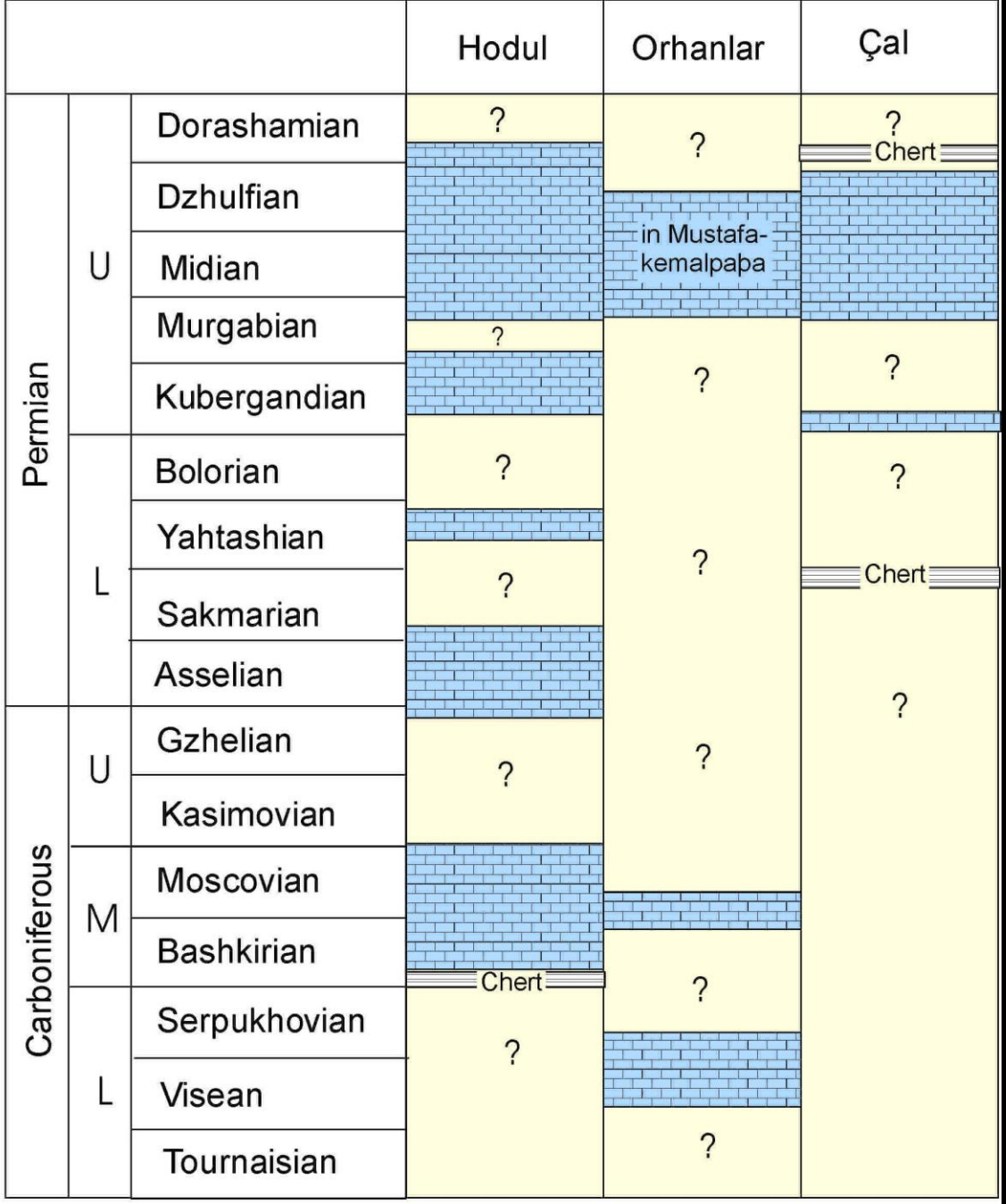








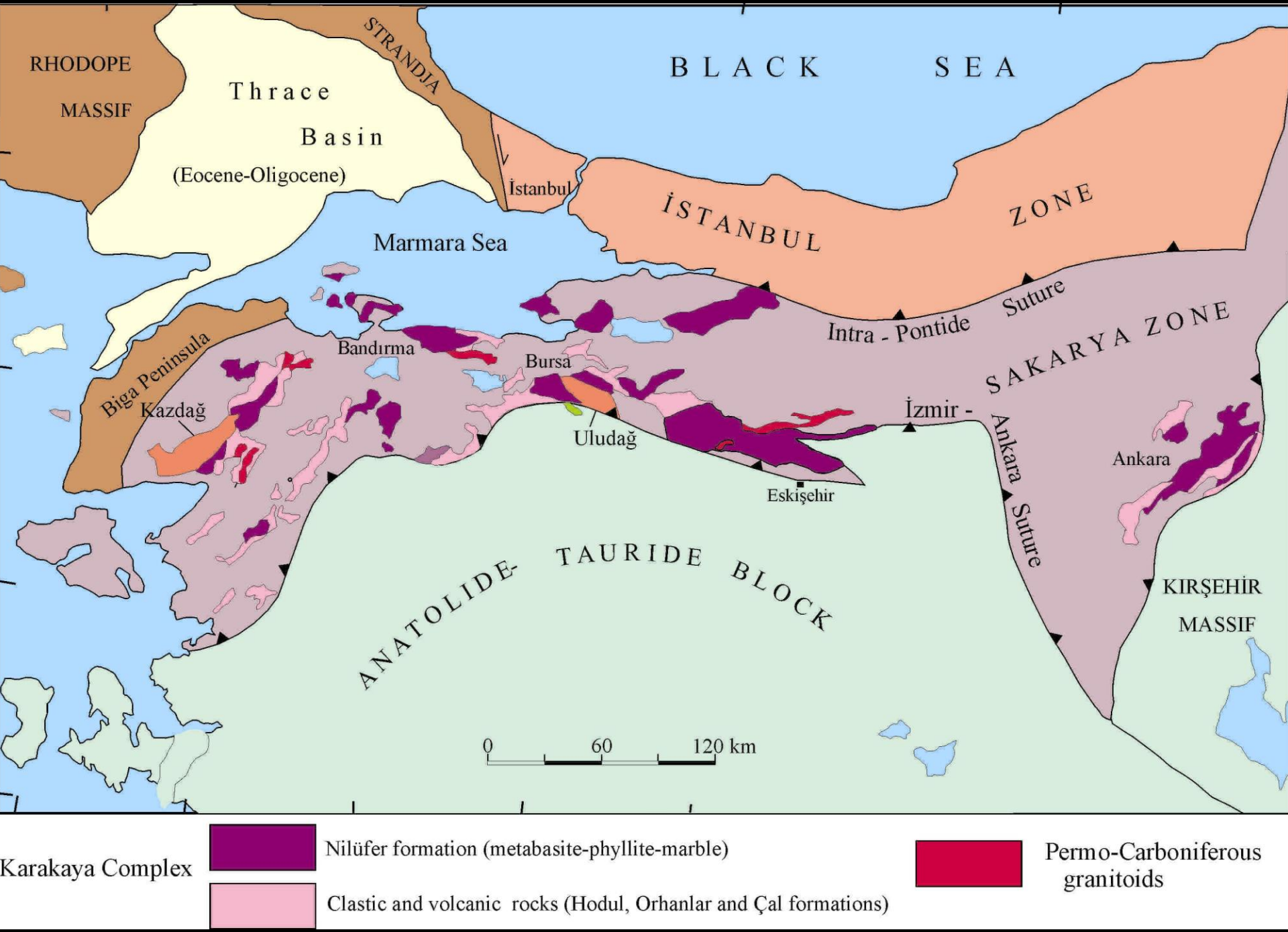

TÜRKİYE CUMHURİYETİ

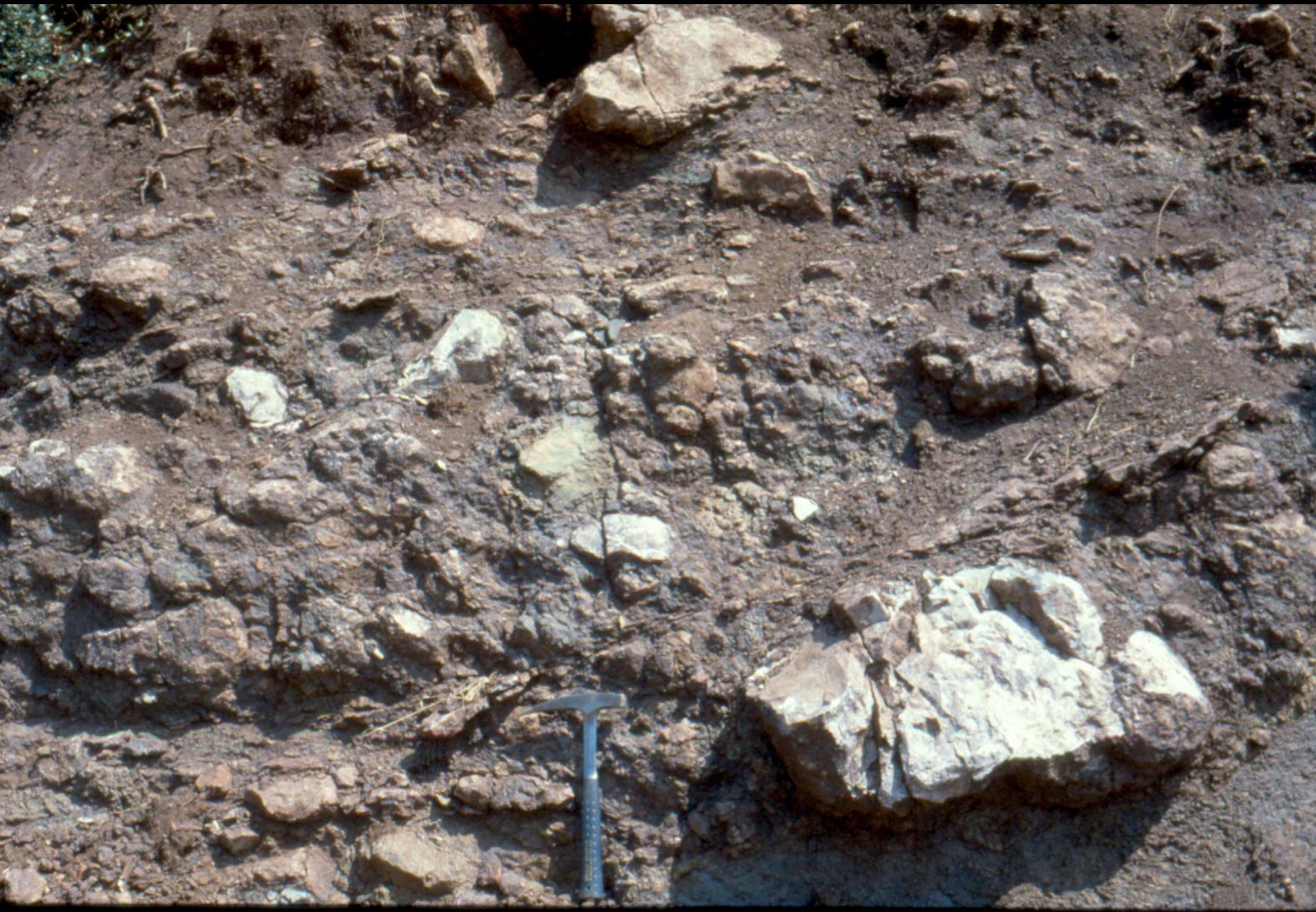


The age range of the blocks in the various Karakaya formations (Leven and Okay, 1996)

Çal Formasyonu/Grubu

Litoloji:	Bazalt ve Üst Permiyen kireçtaşı taneli olistostrom, tane akıntısı, kumtaşı, bazalt akıntısı, radyolaryalı çört, kalsitürbidit, Aniziyen kireçtaşı, pelajik şeyl
Kalınlık:	? 500 m
Özellikleri:	Kuvvetli kırılgan deformasyon, metamorfik değil
Yaşı:	Permiyen - Orta Triyas
Alt sınır:	Diğer Karakaya Kompleksi birimleri ile tektonik dokanaklı
Üst sınır:	Liyas yaşta Bayırköy Formasyonu ile uyumsuzlukla örtülüyor.
Tip kesit:	Biga yarımadası'nda Yenice Kasabası ile Derenti Köyü arasındaki yolboyu.
Referans kesitler:	Aşağı ve Yukarıkaraaşık köyleri arasındaki yol boyu. Çan-Yenice yolundan ayrılan ve Çal Köyü'ne çıkan köy yolu
Adlama:	Blanc (1965, 1969) Çal Köy Serisi olarak
Kullanım:	Okay ve diğerleri (1991) Pickett ve diğerleri (1995) Pickett ve Robertson (1996) Leven ve Okay (1996) Okay ve diğerleri (1996) Kozur ve diğerleri (2000)


RHODOPE
MASSIF
Thrace
Basin
(Eocene-Oligocene)
STRANDJA
BLACK SEA
İstanbul
İSTANBUL ZONE
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SAKARYA ZONE
Biga Peninsula
Kazdağ
Bandırma
Bursa
Uludağ
İzmir - Ankara Suture
Ankara
Eskişehir
ANATOLIDE- TAURIDE BLOCK
KIRŞEHİR
MASSIF
0
60
120 km
Karakaya Complex
Nilüfer formation (metabasite-phyllite-marble)
Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
Permo-Carboniferous granitoids



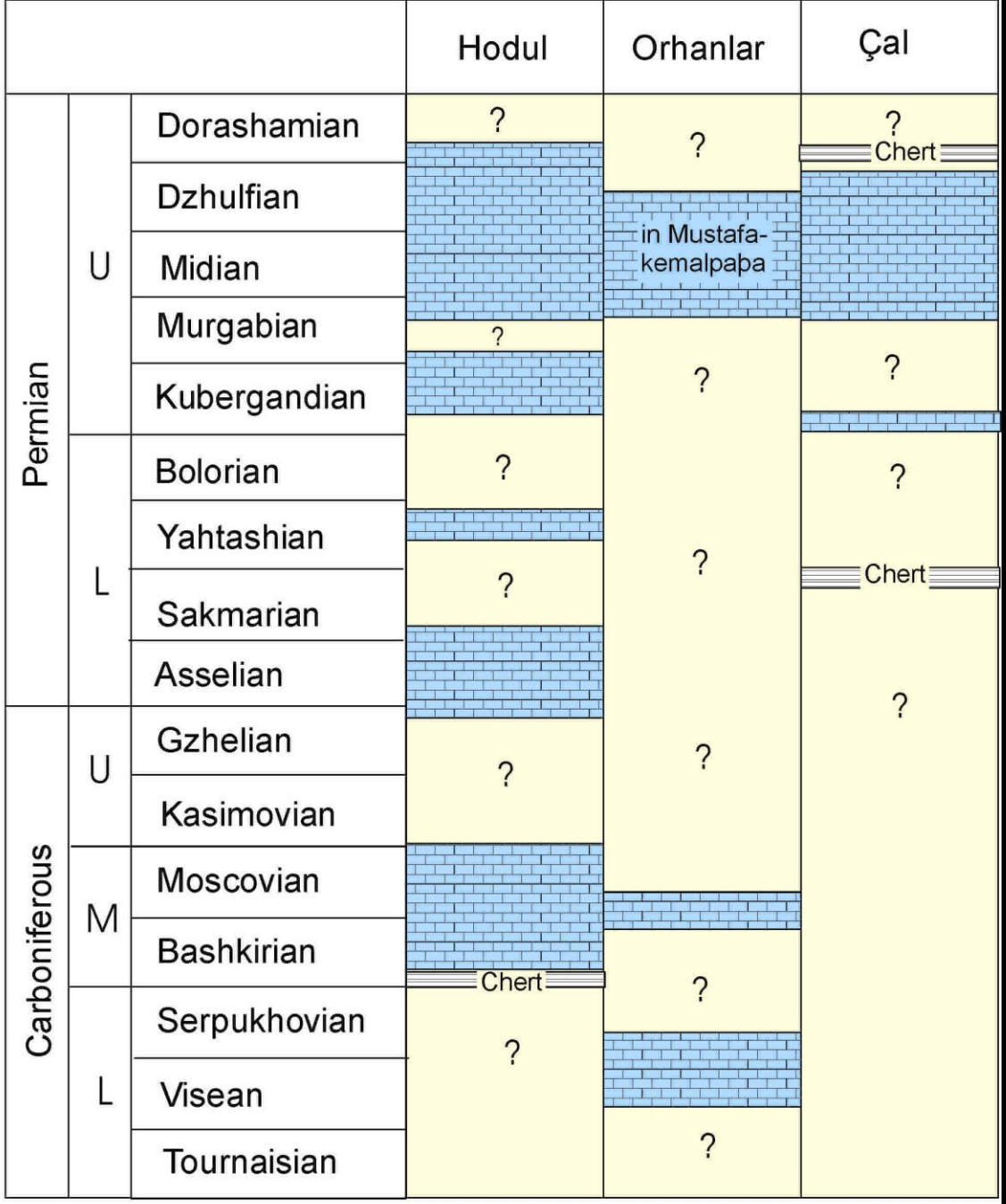




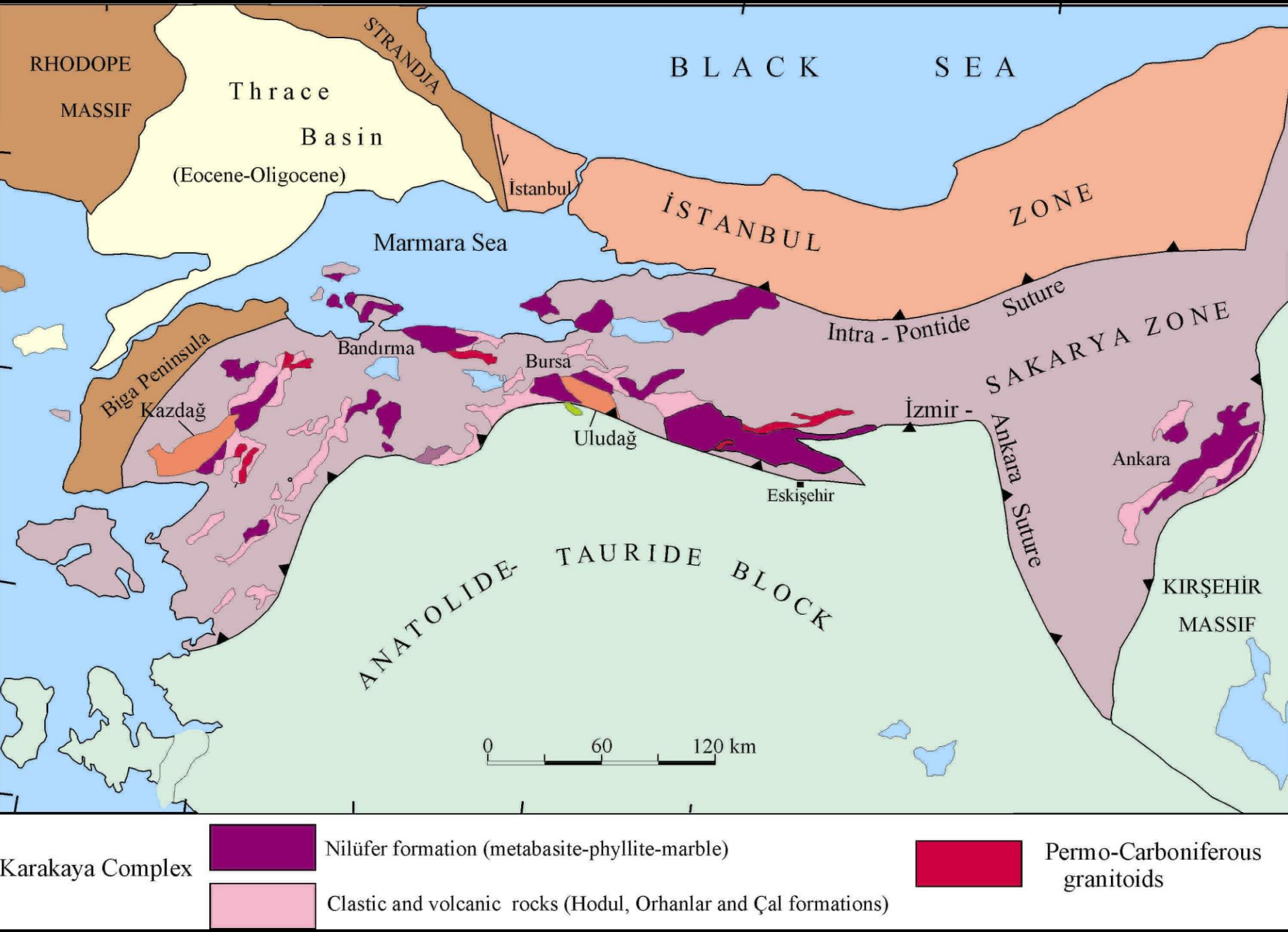


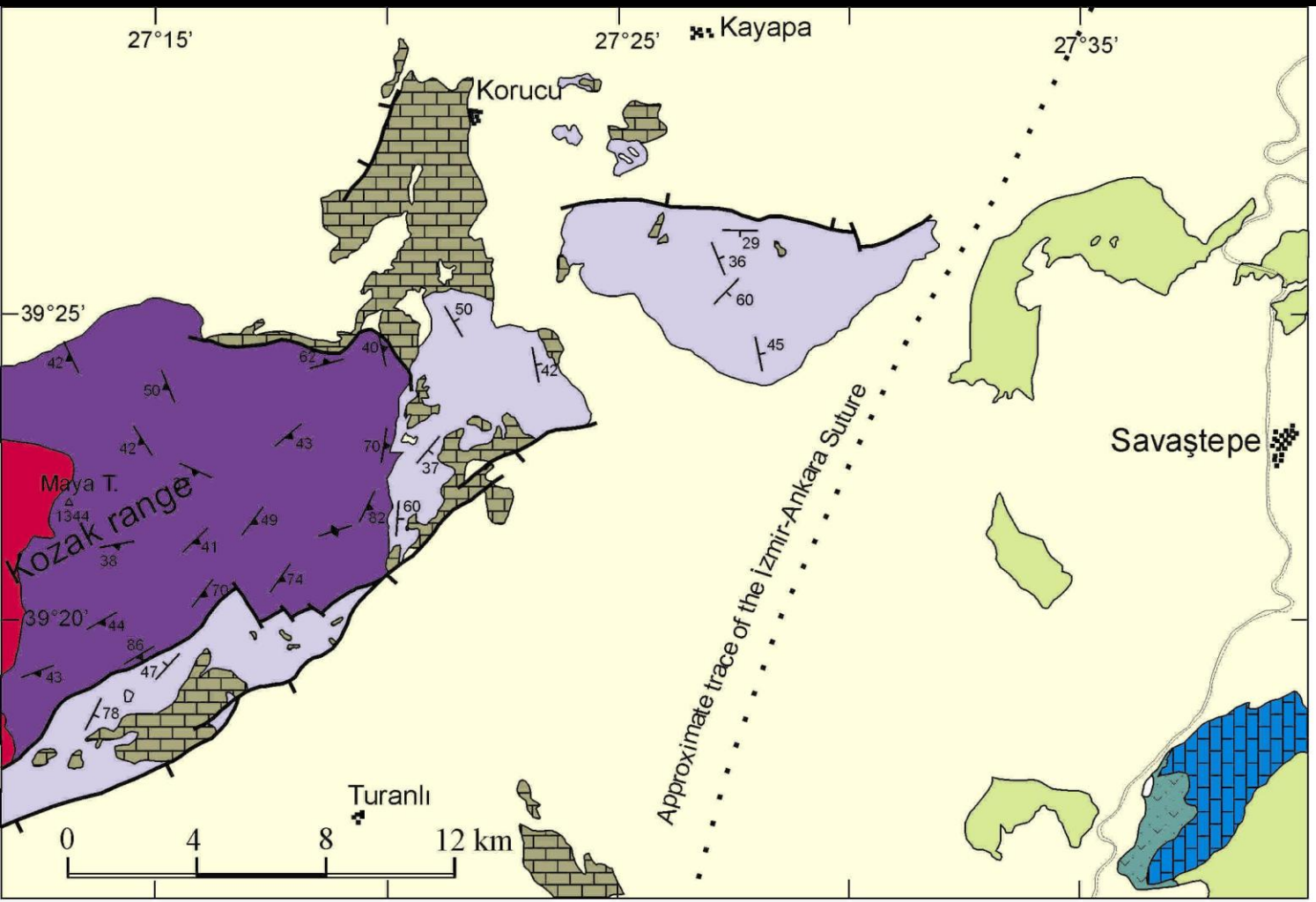






The age range of the blocks in the various Karakaya formations (Leven and Okay, 1996)


RHODOPE
MASSIF
Thrace
Basin
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STRANDJA
BLACK SEA
İstanbul
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SAKARYA ZONE
Biga Peninsula
Kazdağ
Bandırma
Bursa
Uludağ
İzmir - Ankara Suture
Ankara
Eskişehir
ANATOLIDE- TAURIDE BLOCK
KIRŞEHİR
MASSIF
0
60
120 km
Karakaya Complex
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Clastic and volcanic rocks (Hodul, Orhanlar and Çal formations)
Permo-Carboniferous granitoids



Tertiary-Quaternary

Volcanic and sedimentary r

Miocene

Granodiorite

SAKARYA ZONE

Upper Triassic (Norian)

Olistostromes with Permian limestone blocks

Hodul Formation

Arkosic sandstone, shale

Middle Triassic (Anisian-Ladinian)

Nilüfer Formation

Metabasite, phyllite, marble

BORNOVA FLYSCH ZONE

Maastrichtian-Palaeocene

Upper Triassic-Cretaceous limestone blocks

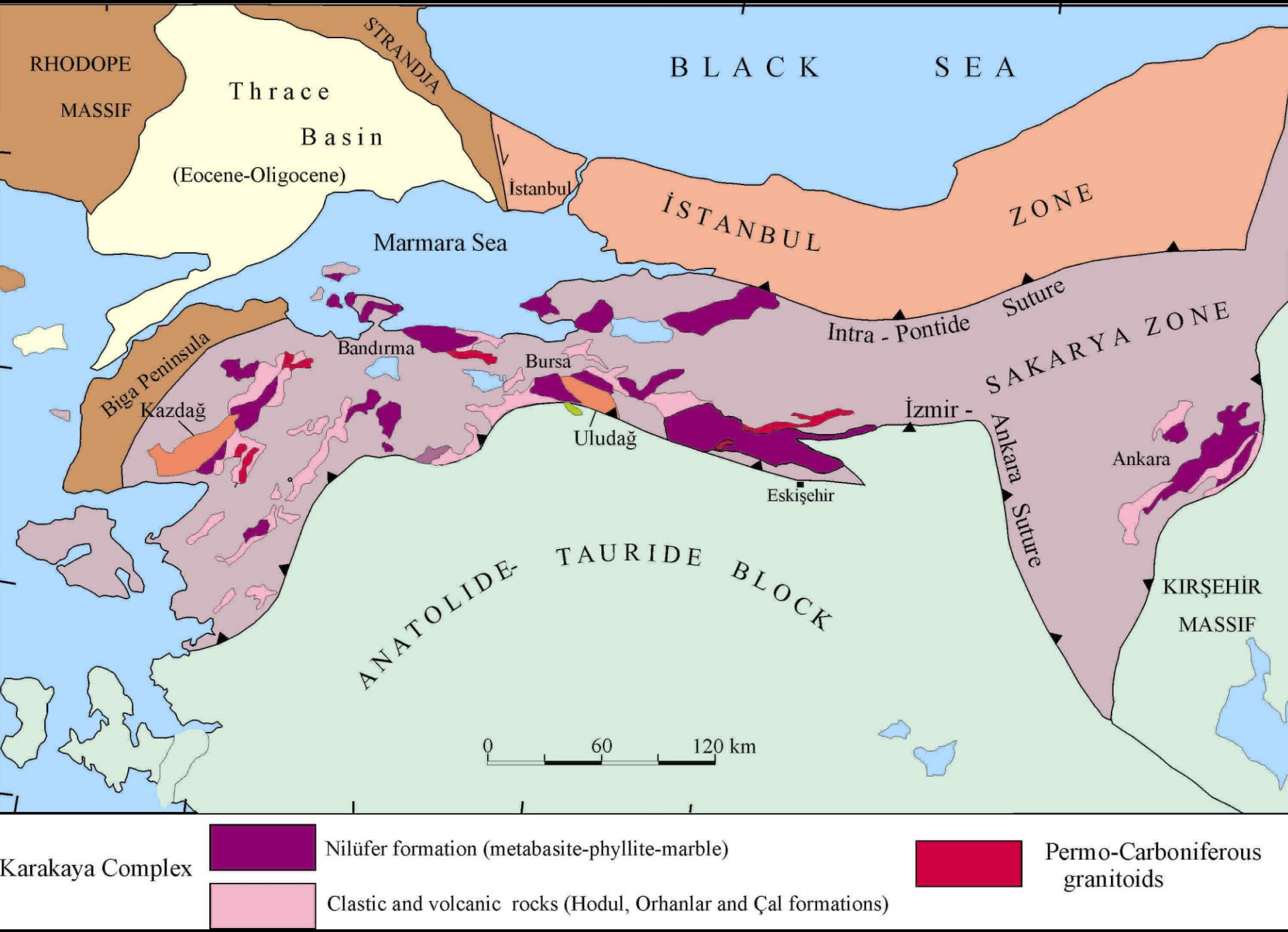
Basalt limestone blocks

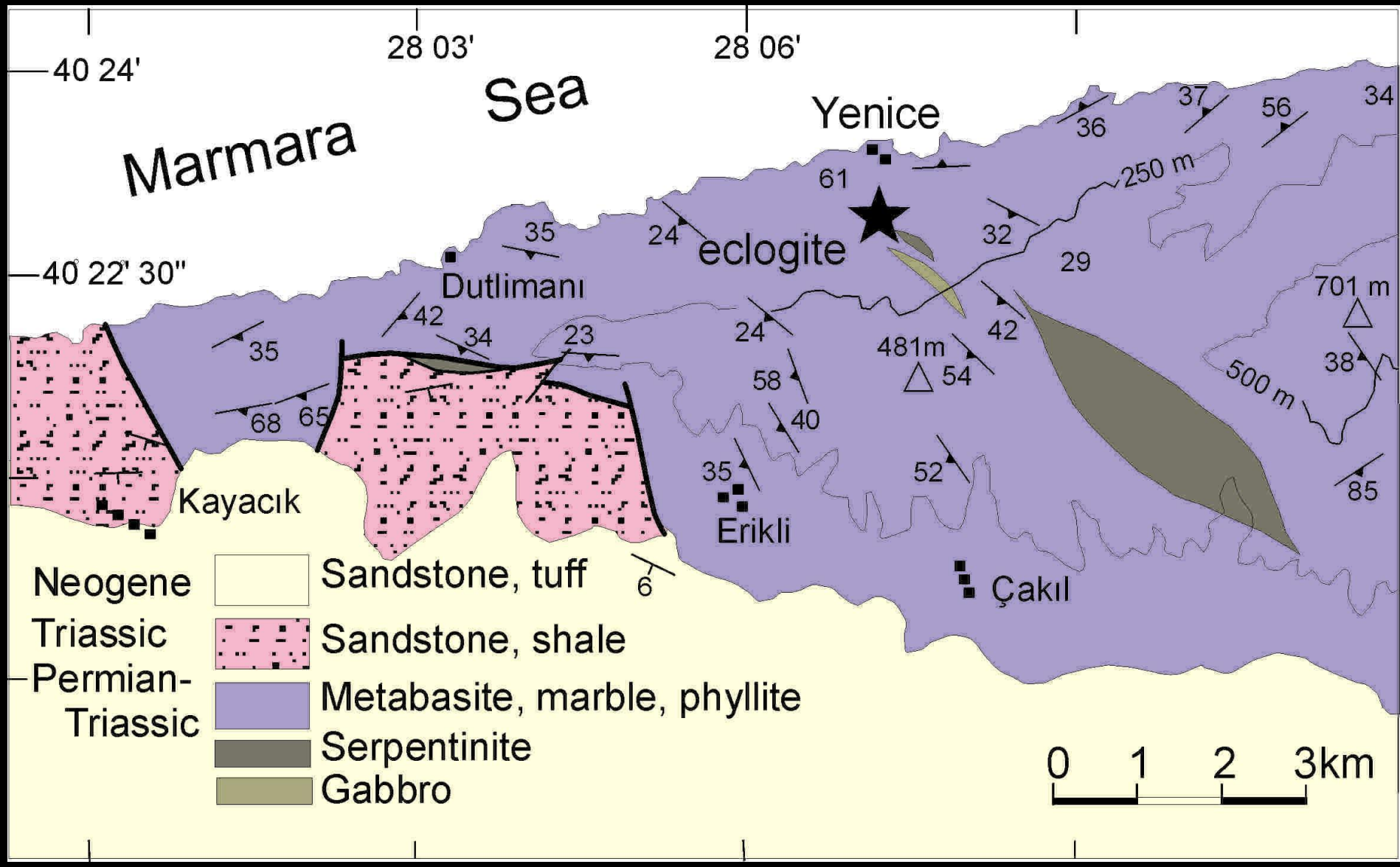
Greywacke, shale








RHODOPE
MASSIF
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STRANDJA
BLACK SEA
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Permo-Carboniferous granitoids


28 03'
28 06'
40 24'
40 22' 30"
Marmara Sea
Yenice
eclogite
Dutlimanı
Kayacık
Erikli
Çakıl
481m
701 m
250 m
500 m
Neogene
Triassic
Permian-Triassic
Sandstone, tuff
Sandstone, shale
Metabasite, marble, phyllite
Serpentinite
Gabbro
0 1 2 3km











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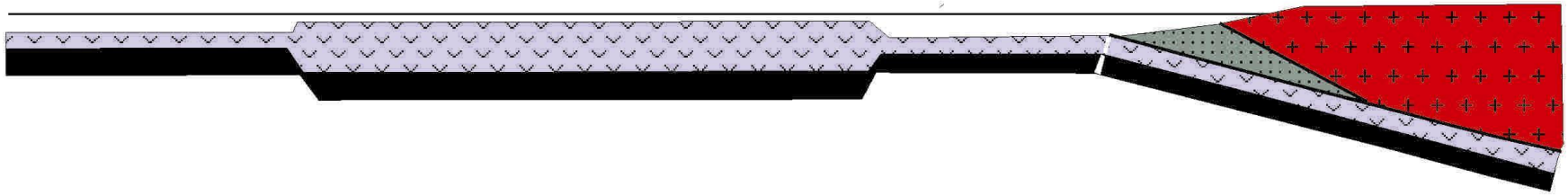
Mid-Triassic

Palaeo-Tethys ocean

Sakarya Zone

Nilüfer oceanic plateau

Laurasian margin

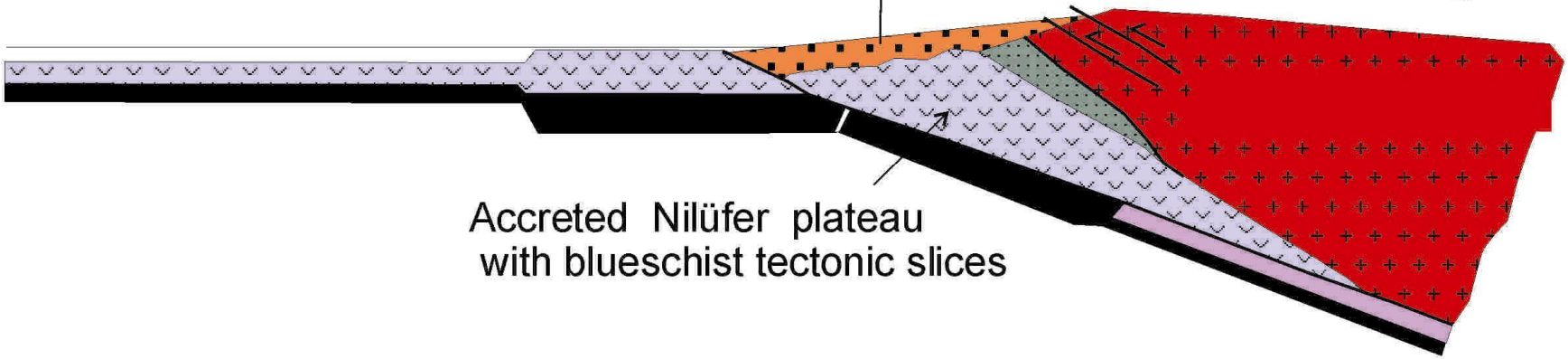


Late Triassic

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)



Sakarya Zonu'nun Triyas sonrası evrimi.









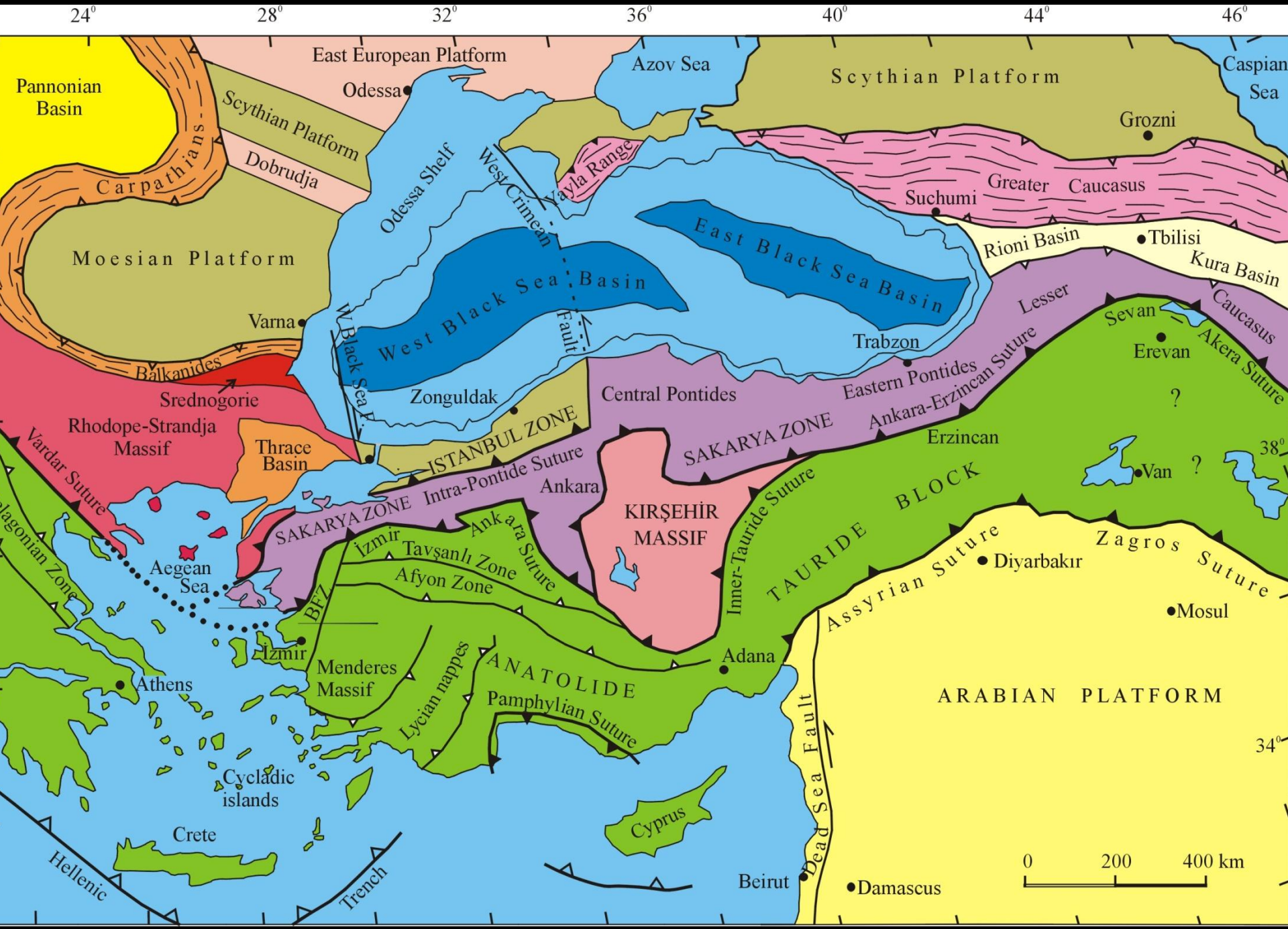




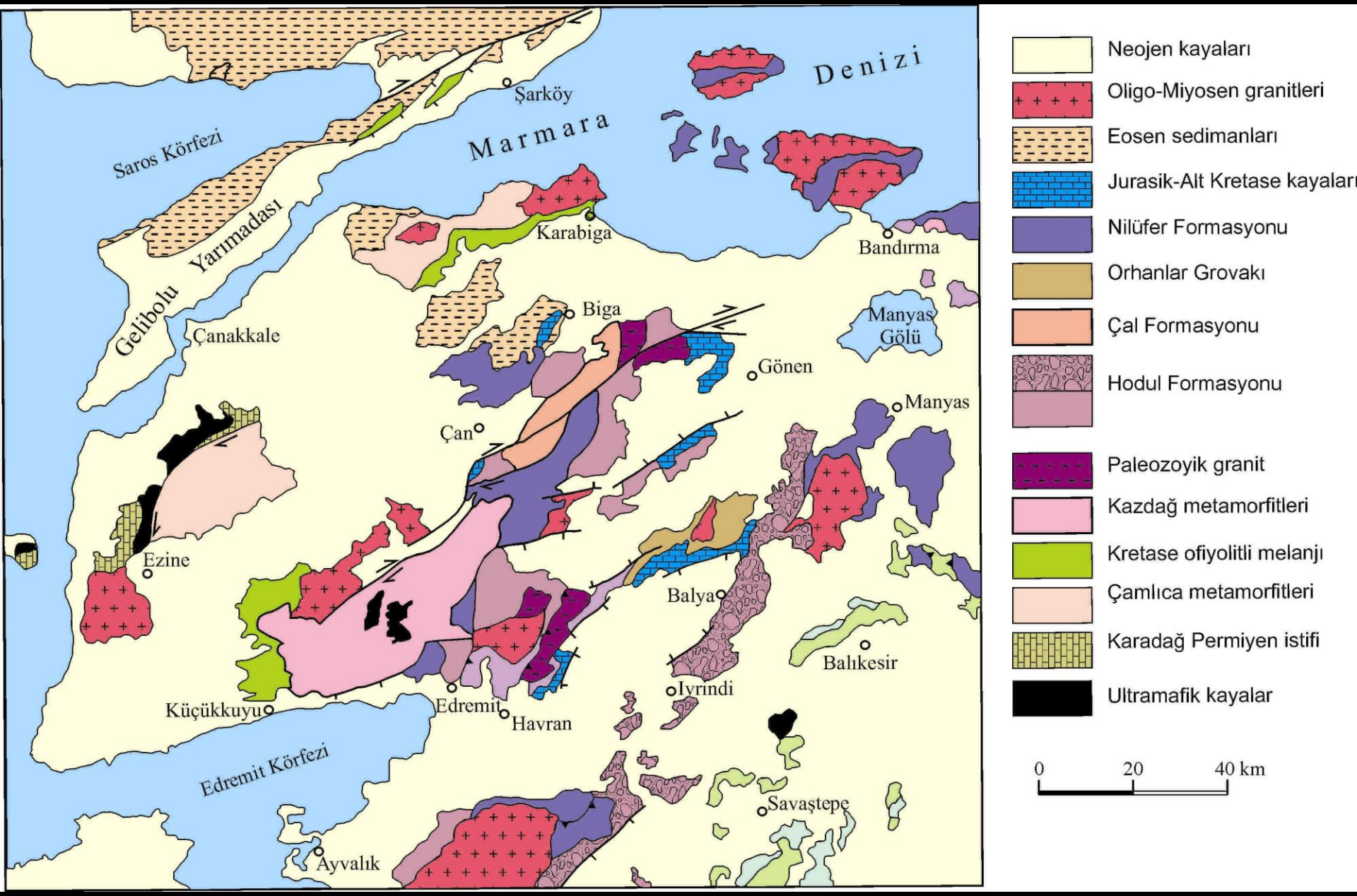







24°
28°
32°
36°
40°
44°
46°
East European Platform
Azov Sea
Scythian Platform
Caspian Sea
Pannonian Basin
Odessa
Grozni
Carpathians
Scythian Platform
Dobrudja
Odessa Shelf
West Crimean Fault
Yayla Range
Greater Caucasus
Suchumi
Moesian Platform
East Black Sea Basin
Rioni Basin
Tbilisi
Kura Basin
West Black Sea Basin
Lesser Caucasus
Varna
W.Black Sea F.
Fault
Trabzon
Sevan
Akera Suture
Balkanides
Erevan
Srednogorie
Zonguldak
Central Pontides
Eastern Pontides
Ankara-Erzincan Suture
?
Rhodope-Strandja Massif
Thrace Basin
ISTANBUL ZONE
SAKARYA ZONE
Erzincan
Vardar Suture
Intra-Pontide Suture
Ankara
38°
Van
?
KIRŞEHİR MASSIF
Inner-Tauride Suture
TAURIDE BLOCK
SAKARYA ZONE
İzmir
Ankara Suture
Tavşanlı Zone
Afyon Zone
Assyrian Suture
Zagros Suture
Diyarbakır
Aegean Sea
BFZ
Mosul
İzmir
Menderes Massif
Lycian nappes
ANATOLIDE
Adana
Athens
Pamphylian Suture
ARABIAN PLATFORM
Dead Sea Fault
34°
Cycladic islands
Cyprus
Crete
Hellenic Trench
Beirut
Damascus
0
200
400 km


SM
BLACK SEA
Thrace Basin
İSTANBUL ZONE
Marmara Sea
Tokat Massif
SAKARYA ZONE
Pulur
Ağvanis
Ankara
Suture
Tavşanlı Zone
Kırşehir Massif
TAURIDES
Lesbos
İzmir - Ankara
BFZ
Menderes Massif
TAURIDES
Tufanbeyli
Hazro
Bitlis Suture
Hadim nappes
ARABIAN PLATFO
MEDITERRANEAN SEA
Okay &
Karakaya Complex
Major Palaeozoic outcrops in the Taurides, BFZ Bornova Flysch Zone, SM Stra


Denizi
Marmara
Şarköy
Saros Körfezi
Yarımadası
Gelibolu
Çanakkale
Karabiga
Bandırma
Biga
Manyas
Gölü
Gönen
Manyas
Çan
Ezine
Balya
Balıkesir
Küçükkuyu
Edremit
Havran
Iyrindi
Edremit Körfezi
Savaştepe
Ayvalık
Neojen kayaları
Oligo-Miyosen granitleri
Eosen sedimanları
Jurasik-Alt Kretase kayaları
Nilüfer Formasyonu
Orhanlar Grovakı
Çal Formasyonu
Hodul Formasyonu
Paleozoyik granit
Kazdağ metamorfitleri
Kretase ofiyolitli melanjı
Çamlıca metamorfitleri
Karadağ Permiyen istifi
Ultramafik kayalar
0
20
40 km