Монографията **„Геология на България“** се отпечатва повече от 40 години след последните обобщения върху тази тема. За това време е натрупан огромен материал, частично публикуван (често в труднодостъпни издания) у нас и в чужбина. В настоящия том II са разгледани различни аспекти (стратиграфия, седиментология, магматизъм, метаморфизъм, палеогеография, палеогеодинамика) на мезозойската геология на българските земи. Наред с гледната точка на авторите се обсъждат и нерешени, и спорни проблеми, като се очертават перспективите за бъдещите изследвания.

Монографията е предназначена за специалисти от различни области на науките за Земята, както и за студенти по геология, геофизика и география.

The book **“Geology of Bulgaria”** appears more than 40 years after the last monographs on this topic. During this time an enormous material has been collected, and has been only partially published in a number of papers in Bulgarian and foreign journals.

The present Volume II treats different aspects (stratigraphy, sedimentology, igneous and metamorphic petrology, palaeogeography, geodynamics) of the Mesozoic geology of Bulgaria. The authors are distinguished researchers on the corresponding systems and series. Together with their own experience, they discuss unsolved and/or controversial problems, and trace the outlines and prospects of future studies.

The book is directed towards specialists from different domains of the Earth sciences, and students of geology, geophysics and geography.

Книгата **Геология на България** Том II се отпечатва със съдействието на Българската академия на науките, Геологическия институт при БАН, Министерството на околната среда и водите, Националната геоложка служба и Предприятието за управление на дейностите по охрана на околната среда.

The book **Geology of Bulgaria** Volume II is published with the assistance of the Bulgarian Academy of Sciences, the Geological Institute, the Ministry of Environment and Water, the National Geological Survey, and the Enterprise for Management of Environmental Protection Activities.

Геология на България

II том

Геология на България

Том II

Част 5. Мезозойска геология

Академично издателство „Проф. Марин Дринов"

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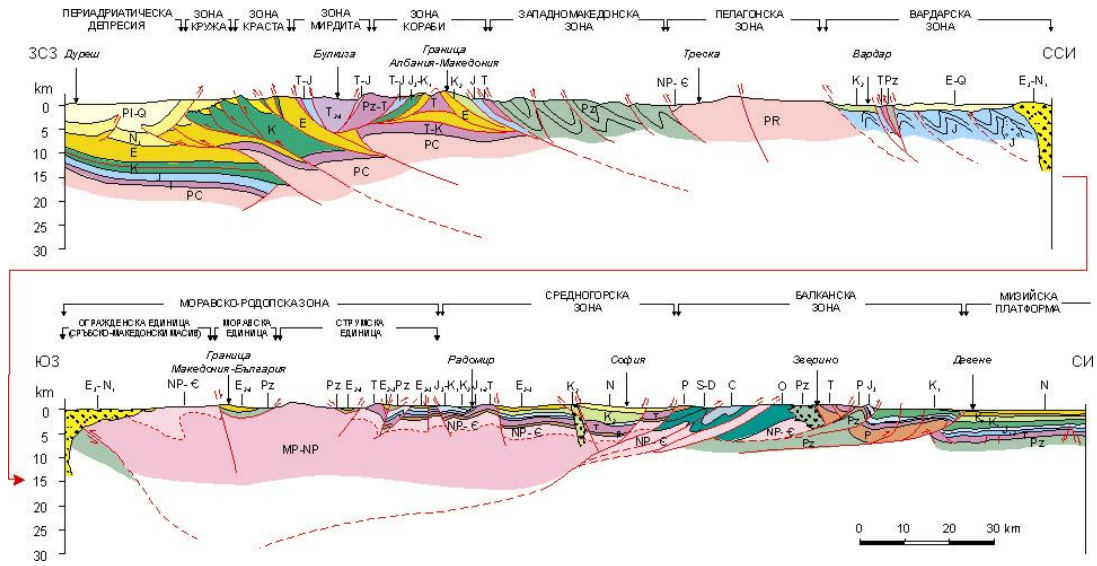
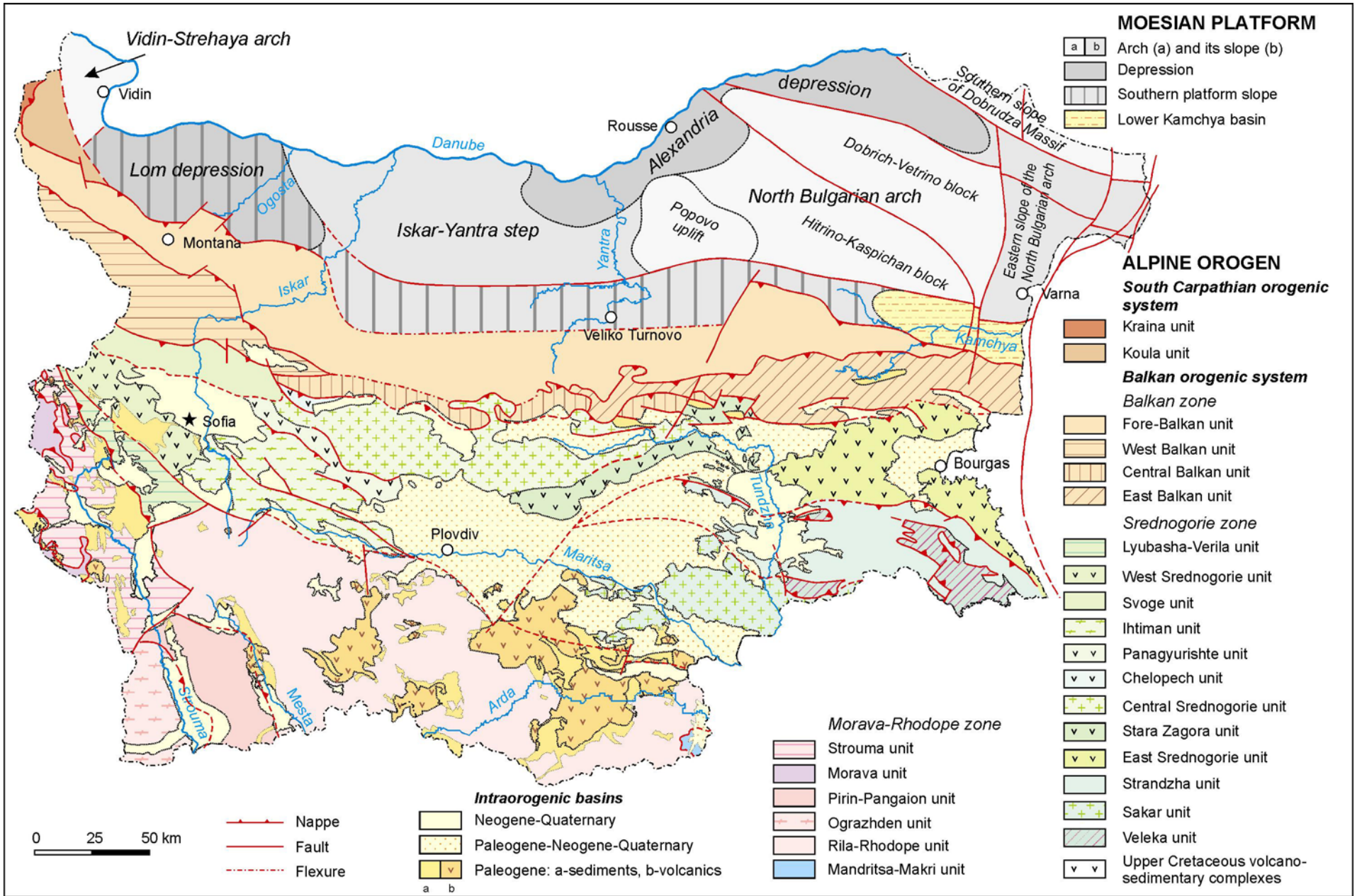


Tectonic map of Bulgaria



The territory of Bulgaria covers parts of two major tectonic units – the **Moesian platform** and the **Alpine orogenic belt**. The structure of the platform is dominated by vast positive (arches) and negative (depressions) structures that are faulted into blocks, horsts and grabens of different rank. The Alpine orogen is a generally WNW-ESE trending belt of predominantly north-verging folds and thrust sheets. Two orogenic systems can be distinguished – Carpathian and Balkan system. They are further subdivided into units of lower rank (zones, units, subunits).

The **Moesian platform** forms the foreland of the Alpine orogen. The sedimentary cover consists of subhorizontal Mesozoic and Cenozoic, mainly shallow-marine terrigenous-carbonate and carbonate platform successions up to 7–8 km thick, which overlie with angular unconformity a gently folded Palaeozoic basement. Major unconformities at the base of the Triassic, Jurassic, Upper Cretaceous and Middle Eocene correlate well with the main compressional events within the Alpine fold-and-thrust belt.

The Alpine orogenic belt consists of dominantly north-verging thrust sheets and fold structures of different rank that resulted from multiphase collisions and related compressional events in Late Triassic, mid-Jurassic, mid-Cretaceous, Late Cretaceous and mid-Eocene time. They were followed by crustal extension, collapse of the orogen and development of a system of Cenozoic intraorogenic basins.

Two orogenic systems are distinguished in the Alpine belt – South Carpathian and Balkan. They are well spatially differentiated and show some essential differences in rock composition, structure and geological evolution.

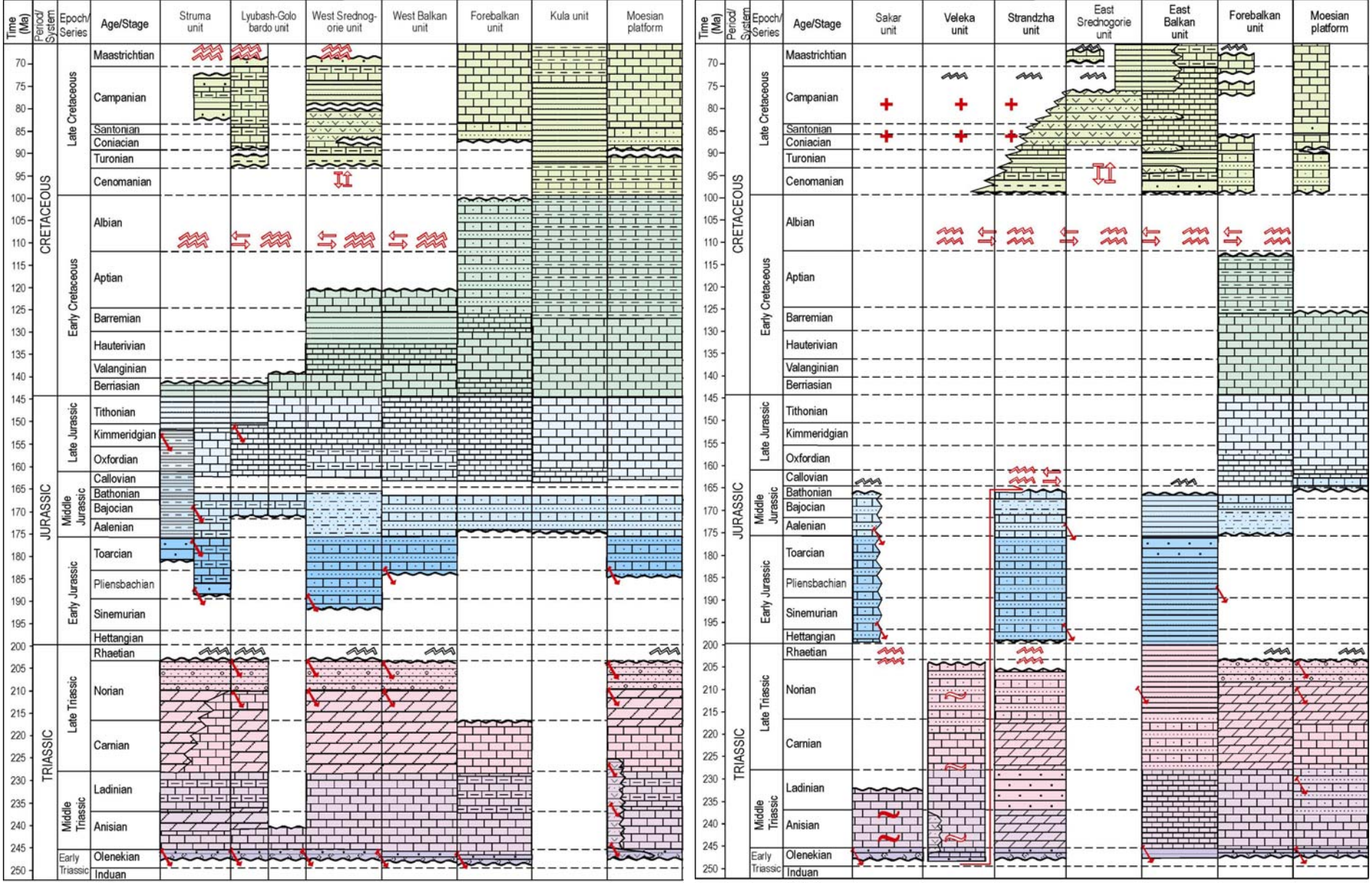
The South Carpathian orogenic system is poorly exposed only in north-westernmost Bulgaria under a thick cover of Neogene and Quaternary deposits. Two units are distinguished. ***Krayna unit*** is an allochthonous sheet traced as an extension of the Severin nappe in Serbia and Romania. It comprises Upper Jurassic – Lower Cretaceous flysch sequences that were deformed into east-verging folds in mid-Cretaceous time. Toward the end of the Late Cretaceous, this unit was thrust over the eastern, para-autochthonous ***Kula unit.*** It consists of Turonian–Senonian flysch that covers with gradual transition Albian–Cenomanian clay-carbonate sediments from the southern margin of the Moesian platform.

The Balkan orogenic system occupies the area between the Moesian platform and the units of the South Carpathians to the north, and the Vardar zone to the southwest and south. It is subdivided into three tectonic zones: Balkan, Srednogorie and Morava-Rhodope.

The Balkan zone (Balkanides) forms the external northern parts of the Alpine orogen. Its typical features are: (1) wide occurrence of Triassic and Jurassic–Lower Cretaceous platform carbonates transient from the Moesian platform; (2) development of Upper Jurassic–Lower Cretaceous and Upper Cretaceous–Palaeocene flysch associations; (3) almost full absence of Mesozoic magmatic products; (4) main and final compressional events towards the end of the Middle Eocene, preceded by Late Cretaceous, mid-Cretaceous and weak Triassic deformations. The zone is subdivided into four tectonic units: Fore-Balkan, West Balkan, Central Balkan and East Balkan.

The Srednogorie zone is characterized by wide distribution of Upper Cretaceous volcano-sedimentary succession and plutonic bodies. Its northern boundary with the Balkan zone is traced by north-verging mid-Eocene reverse faults and thrusts whereas the southern one with the Morava-Rhodope zone is a system of faults (Maritsa fault zone). The main compressional events took place toward the end of the Late Cretaceous, followed by north-verging thrusting during the mid-Eocene in the northern parts of the zone. Wide areas of the Srednogorie zone are covered by Cenozoic deposits. Based on tectonic relations and specific features of the pre-Mesozoic and Mesozoic sections we distinguish 12 tectonic units.

The Morava-Rhodope zone includes fragments of six tectonic units: Morava, Ograzhden, Struma, Pirin-Pangaion, Rila-Rhodope and Mandritsa-Makri, each of them with relatively independent pre-Late Cretaceous history. The common features of these units are: (1) widely exposed high-grade metamorphic basement complexes; (2) frequent Late Cretaceous and Tertiary intrusive bodies of different size; (3) development of isolated Palaeogene basins with continental and shallow marine sediments that associate with dominantly acid and intermediate volcanic rocks; (4) main mid-Cretaceous compressional deformations followed by Late Cretaceous–Tertiary extension and exhumation; (5) thick continental crust (50–52 km) in the central parts of the zone, thinning to 34–37 km in SE and NW direction. The age of the high-grade metamorphic complexes in some units is not well constrained and controversial. Conflicting alternatives suggest Precambrian and/or Palaeozoic age of the protolith, and Precambrian, mid-Cretaceous or even Late Cretaceous – Early Tertiary age of the high-grade metamorphic events.


Time (Ma)
Period/ System
Epoch/ Series
Age/Stage
Struma unit
Lyubash-Golo bardo unit
West Srednog-orie unit
West Balkan unit
Forebalkan unit
Kula unit
Moesian platform
CRETACEOUS
JURASSIC
TRIASSIC
Late Cretaceous
Early Cretaceous
Late Jurassic
Middle Jurassic
Early Jurassic
Late Triassic
Middle Triassic
Early Triassic
Maastrichtian
Campanian
Santonian
Coniacian
Turonian
Cenomanian
Albian
Aptian
Barremian
Hauterivian
Valanginian
Berriasian
Tithonian
Kimmeridgian
Oxfordian
Callovian
Bathonian
Bajocian
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Rhaetian
Norian
Carnian
Ladinian
Anisian
Olenekian
Induan
70
75
80
85
90
95
100
105
110
115
120
125
130
135
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235
240
245
250
Sakar unit
Veleka unit
Strandzha unit
East Srednogorie unit
East Balkan unit
Forebalkan unit
Moesian platform
Continental arid and subarid associations
Paralic coal-bearing associations
Terrigenous (mostly psammitic) associations
Shale-sandstone associations
Terrigenous-carbonate associations
Clayey or carbonate-clayey associations
Marly-carbonate associations
Platform-carbonate associations: a - limestones; b - dolomites
Pelagic carbonate associations
Flysch and flyschoid associations
Pelagic radiolarite-pelitic association
Red bed associations
Volcanic associations
Volcanogenic-sedim-entary associations
Unconformity
Intense folding
Folding
Thrusting
Rifting
Transtension
Red bed associations
Volcanogenic-sedimentary associations
Intrusive magmatism
Metamorphism: a - high-grade, b - low-grade

Main stages in the Mesozoic evolution

Based on the traditions in Bulgarian geology and the new information obtained, we divide four stages in the Mesozoic evolution of Bulgaria. They are well constrained by the major unconformities in the Mesozoic sections, and can be correlated with the global palaeogeodynamic events in the Eastern Mediterranean.

The Triassic stage began after the end of the Variscan orogeny, denudation of the orogen and formation of the Late Permian arid plain. During that stage the eastern part of the Balkan Peninsula developed as a segment of the passive European continental margin and part of the Peri-Tethyan region. During the Early Triassic Epoch braided fluvial systems of Buntsandstein type formed. Differential subsidence, accompanied by rifting, led to marine transgression towards the end of the Early Triassic, to a stable marine regime during the Middle and most of the Late Triassic, and regression in latest Triassic times. Tethyan-type deposits developed only in the East Balkan (Kotel, Mator) trough, and the arcs of the future Veleka unit (Strandzha type Triassic) and Mandritsa-Makri unit (Circum-Rhodope belt).

The Early–Middle Jurassic stage is characterized by renewal of the passive margin regime, extension and differential normal faulting that led to development of a system of horsts and grabens in the confines of the Moesian platform and the Early Cimmerian orogen to the south. This initiated gradual marine transgression, extending over the whole interval from Hettangian to Bathonian time with deposition of terrigenous sediments and shallow-marine carbonates. The sedimentation continued without break only in the Kotel (Mator) trough where thick wildflysch and olistostromes were deposited, with closure of the basin in late Middle Jurassic times.

*The **Late Jurassic–Early Cretaceous stage*** records the transition from passive to convergent continental margin as a result of beginning subduction of back-arc oceanic basins beneath the Rhodope and Serbo-Macedonian “massifs”. In front of the growing mid-Cretaceous (“Austrian”) orogen a flexural foredeep developed – the Nish-Troyan flysch trough, which accumulated turbidites (during the Kimmeridgian, Tithonian and Berriasian Age) passing to molasse deposits after the Berriasian. It was bordered to the north by the Moesian epicontinental shallow-marine basin.

Three substages are distinguished in the Early Cretaceous evolution. The first, *Berriasian–Early Barremian substage* is a continuation of the stable regime and extensional tendencies from the Late Jurassic. At the beginning of the second, *Late Barremian–Aptian substage*, a considerable differentiation of the basin started due to renewed faulting activity that resulted in the development of numerous large carbonate platforms and surrounding depressions with intense terrigenous deposition. The *Albian substage* is dominated by compressional regime (“Austrian orogeny”s.l.). The gradual narrowing of the marine basins culminated in almost total emersion above sea level.

The mid-Cretaceous (“Austrian”) orogeny is the most important tectonic event in the Mesozoic history of the eastern parts of the Balkan Peninsula. It is expressed in intense folding and thrusting, inversion and full closure of the troughs, and drying out of the epicontinental basins in the Moesian platform. Fragments of the mid-Cretaceous orogenic edifice are included in almost all later tectonic units. In them, the Early- and mid-Cretaceous tectonometamorphic events are recorded by isotopic data both in the pre-Alpine (Precambrian and Palaeozoic) cores (Rhodopes, Sakar and Struma units) and in their Triassic–Jurassic cover.

The Late Cretaceous stage was the time of continuous subduction of Tethyan oceanic lithosphere (Vardar ocean according to most authors) beneath the Rhodope and Serbo-Macedonian “massifs”. This resulted in the development of a volcanic island-arc system consisting of Morava-Rhodope frontal arc (magmatic), Srednogorie intra-arc sedimentary basin with dominantly submarine volcanic activity, Balkanide rear-arc (amagmatic) and Carpathian back-arc basin.

The Moesian epicontinental basin invaded the foreland of the mid-Cretaceous orogen (present Moesian platform and Fore-Balkan) by gradual transgression from east to west. The deposition began during the Cenomanian or Turonian Age with terrigenous and terrigenous carbonate sediments (with glauconite) passing upwards into clay-carbonate and carbonate successions.

The Carpathian basin developed since the beginning of the Early Cretaceous Epoch as a flexural foredeep in the NW slope of the Moesian platform and accumulated turbidite and later clay-carbonate deposits in the interval Turonian–Middle Eocene.

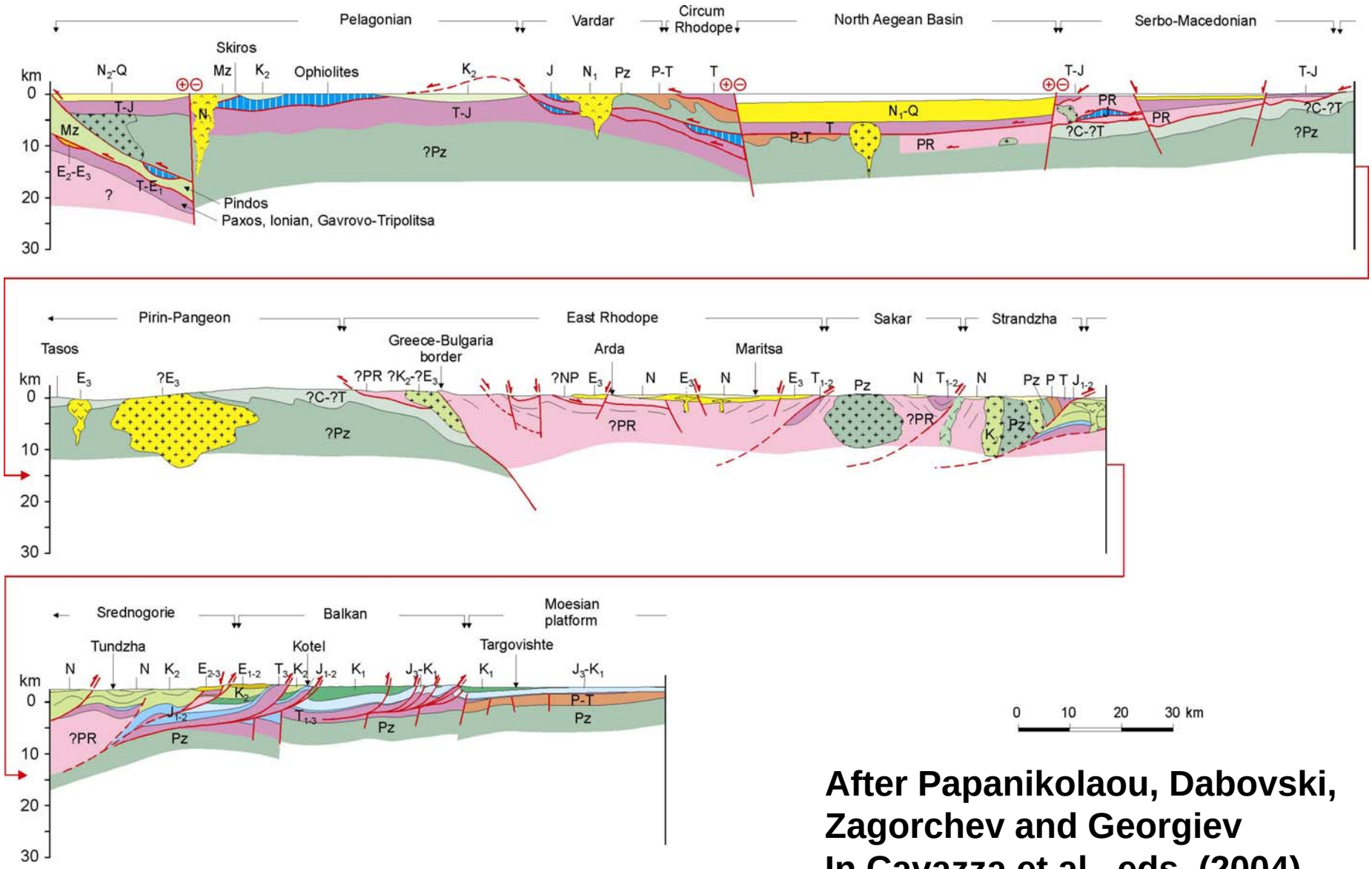
The Srednogorie basin formed and evolved upon the deeply eroded mid-Cretaceous orogen located south of the platform. Likewise the Moesian basin, the transgression advanced from east to west. Sedimentation began during the Cenomanian (East Srednogorie) or Turonian (West Srednogorie) with continental (locally coal-bearing) to shallow-marine deposits that passed upwards (Coniacian–Early Maastrichtian) into deeper-marine clay-carbonate, volcano-sedimentary and “post-volcanic” turbidite associations. The evolution of the basin terminated with regressive terrigenous deposits of Maastrichtian age in isolated “remnant” basins.

The Balkanide arc divided the Moesian and Srednogorie basins during most of the Late Cretaceous Epoch. It was a dry land, higher on the west and lower on the east, where the two basins probably merged for short periods.

The Morava-Rhodope frontal arc was also a dry land that separated the Srednogorie basin from the Vardar ocean. The high-grade metamorphic complexes of the arc were intruded by Late Cretaceous plutons of Coniacian to Maastrichtian age (by radiometric dating). There are also isolated small outcrops of Campanian volcano-sedimentary successions (East Rhodope) and Campanian sediments (SW Bulgaria).

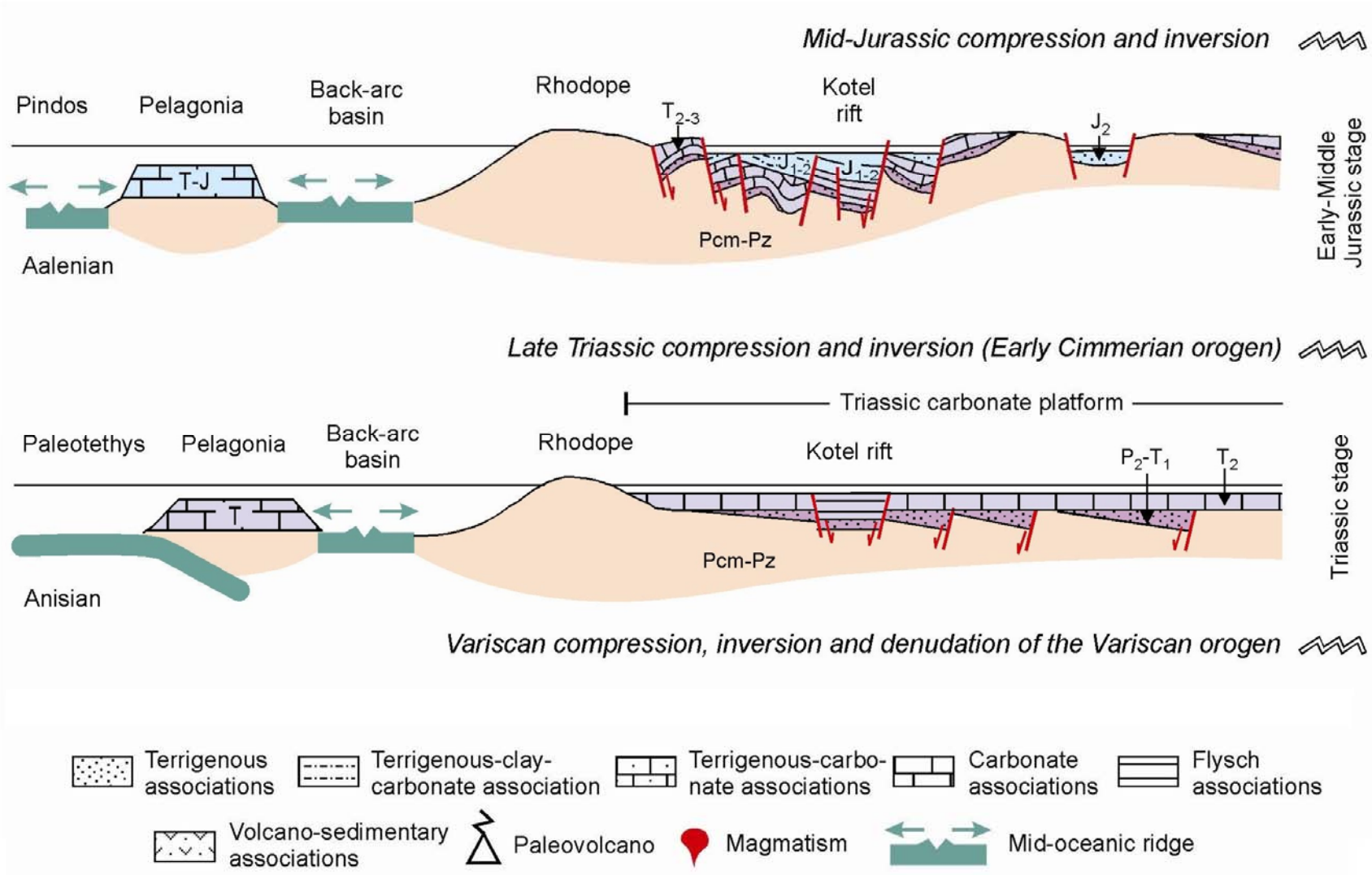
The Late Cretaceous stage, and in general the Mesozoic evolution, ended with compressive events towards the end of the Early Campanian and the end of the Maastrichtian that led to the final shaping of the Late Cretaceous orogen on the territory of South Bulgaria. In front of the orogen, the Carpathian and Emine flysch troughs developed from Late Maastrichtian to mid-Eocene time as typical foreland basins. Large parts of the orogen and the Moesian platform emerged above sea level but locally, mainly in the eastern parts of the platform and in the East Balkan, sedimentation continued without interruption also during the Paleocene.

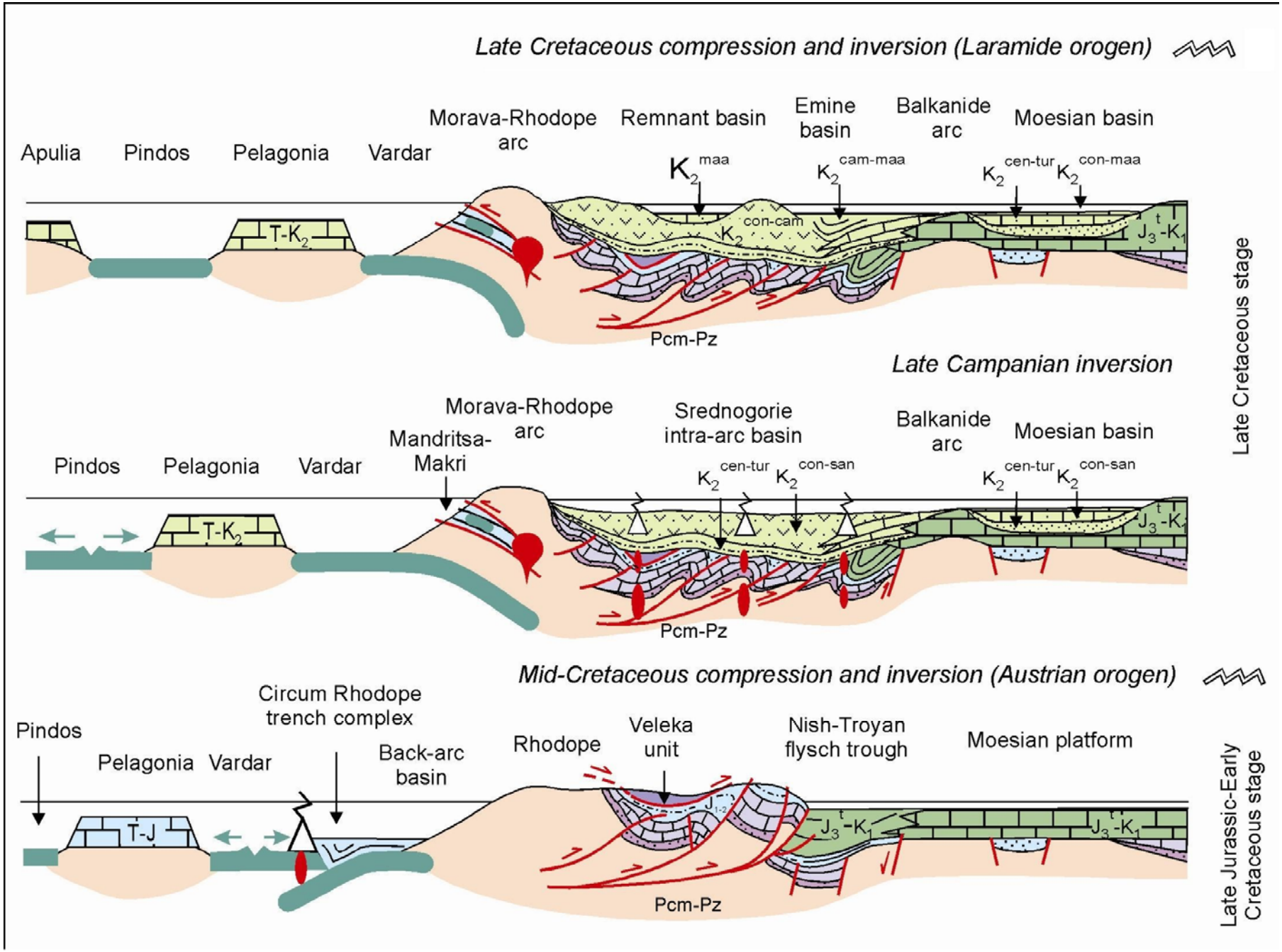
Transect through Greece and East Bulgaria



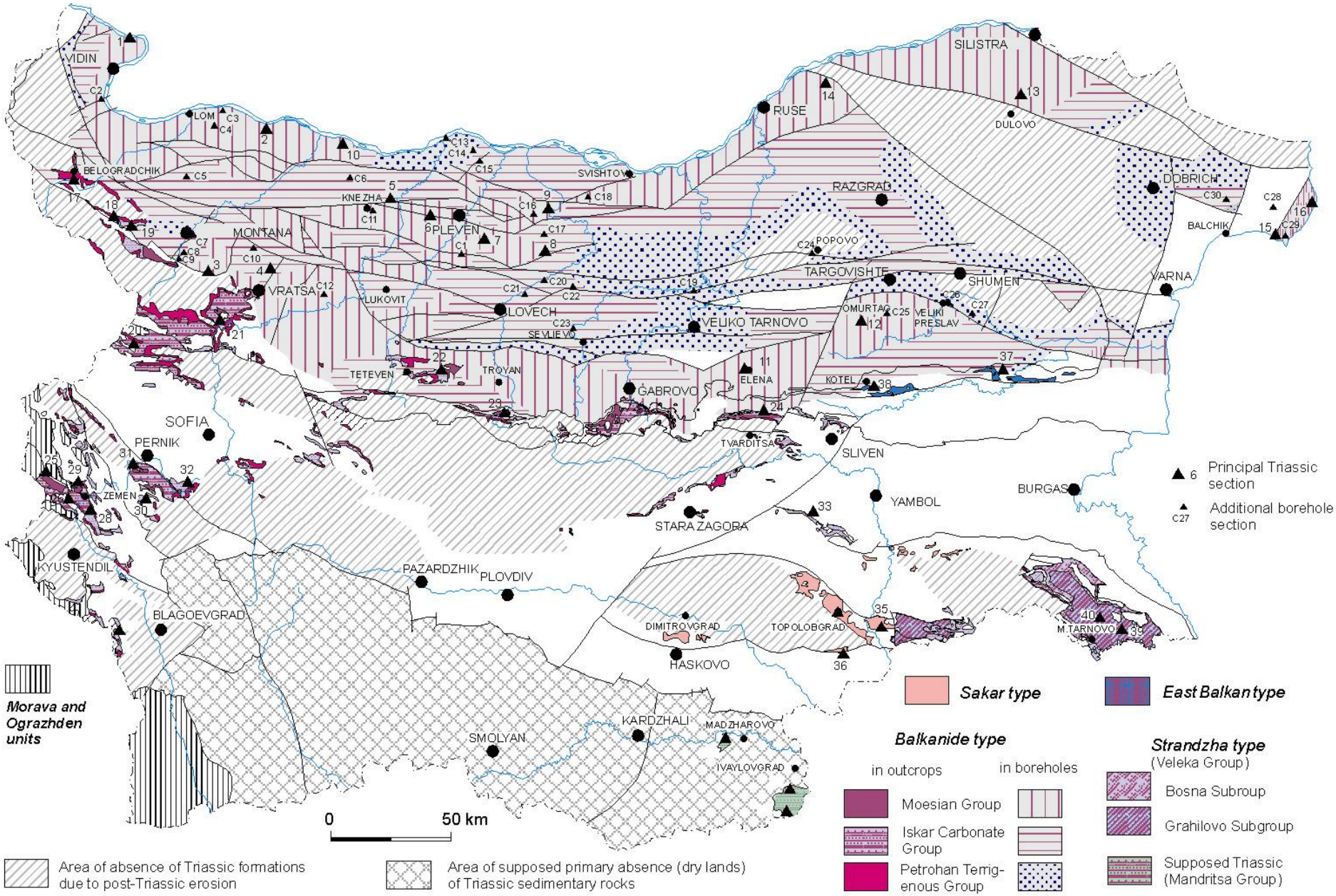
After Papanikolaou, Dabovski, Zagorchev and Georgiev In Cavazza et al., eds. (2004)

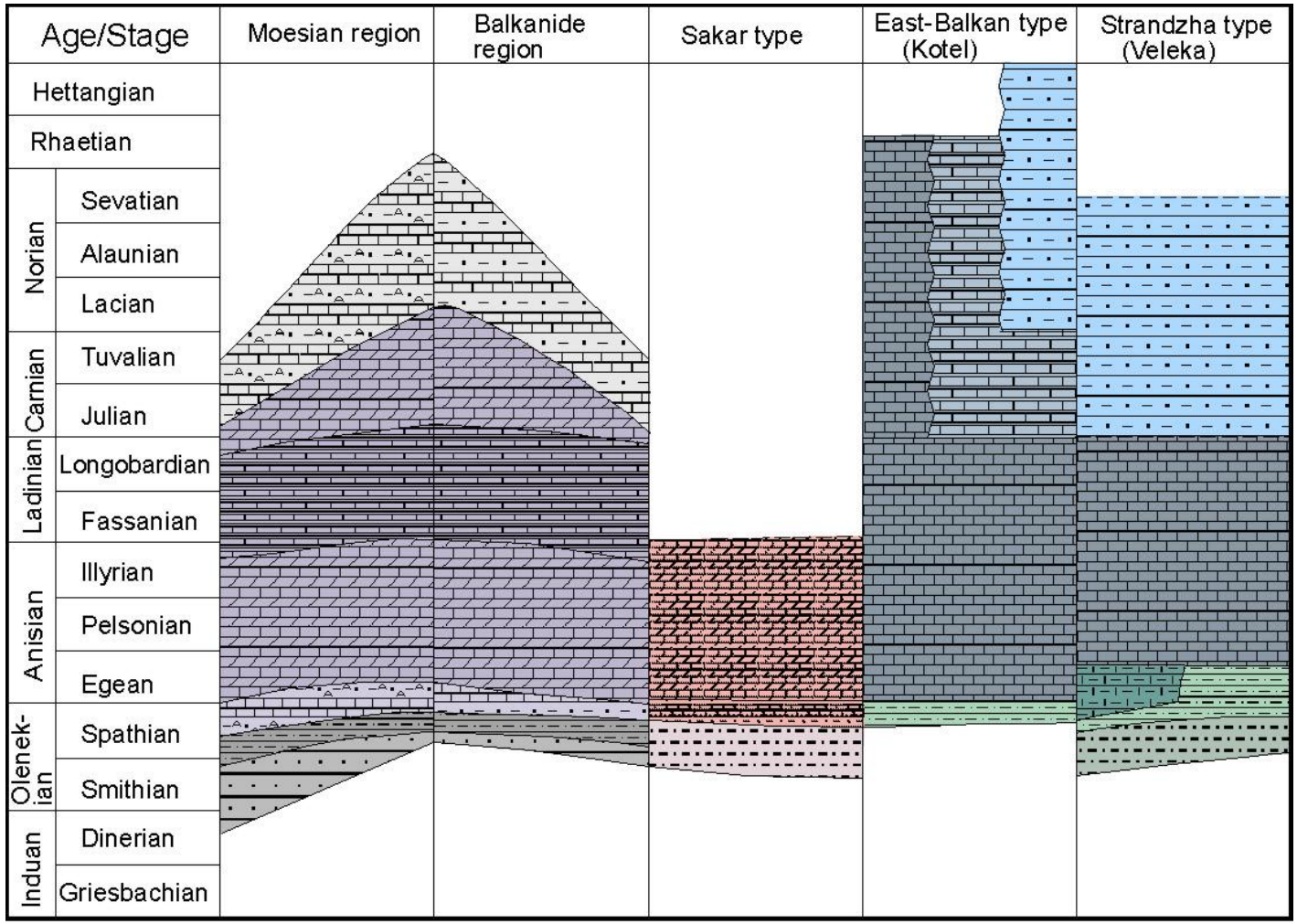
Schematic representation (cartoons) of the Mesozoic geodynamics in the eastern parts of the Balkan Peninsula




Late Cretaceous compression and inversion (Laramide orogen)
Apulia
Pindos
Pelagonia
Vardar
Morava-Rhodope arc
Remnant basin
Emine basin
Balkanide arc
Moesian basin
K2 maa
K2 cam-maa
K2 cen-tur
K2 con-maa
K2 con-cam
T-K2
J3t-K1
Pcm-Pz
Late Campanian inversion
Pindos
Pelagonia
Vardar
Mandritsa-Makri
Morava-Rhodope arc
Srednogorie intra-arc basin
Balkanide arc
Moesian basin
K2 cen-tur
K2 con-san
T-K2
J3t-K1
Pcm-Pz
Late Cretaceous stage
Mid-Cretaceous compression and inversion (Austrian orogen)
Pindos
Pelagonia
Vardar
Circum Rhodope trench complex
Back-arc basin
Rhodope
Veleka unit
Nish-Troyan flysch trough
Moesian platform
T-J
J1-2
J3t-K1
Pcm-Pz
Late Jurassic-Early Cretaceous stage

Occurrence of the Triassic in Bulgaria





Variegated carbonate-terrigenous association

Variegated carbonate-terrigenous association with evaporites

Upper limestone-dolomite association

Terrigenous-carbonate association with black shales

Lower limestone-dolomite association

Paralic and transgressive limestone-terrigenous facieses

Paralic and transgressive limestone-terrigenous facieses with evaporites

Association of arid red lacustrine siltstones

Association of arid red sandstones

Carbonate association

Carbonate-terrigenous facies

Continental terrigenous facies

Upper flysch association (black flysch)

Upper flysch association (carbonate flysch)

Carbonate association

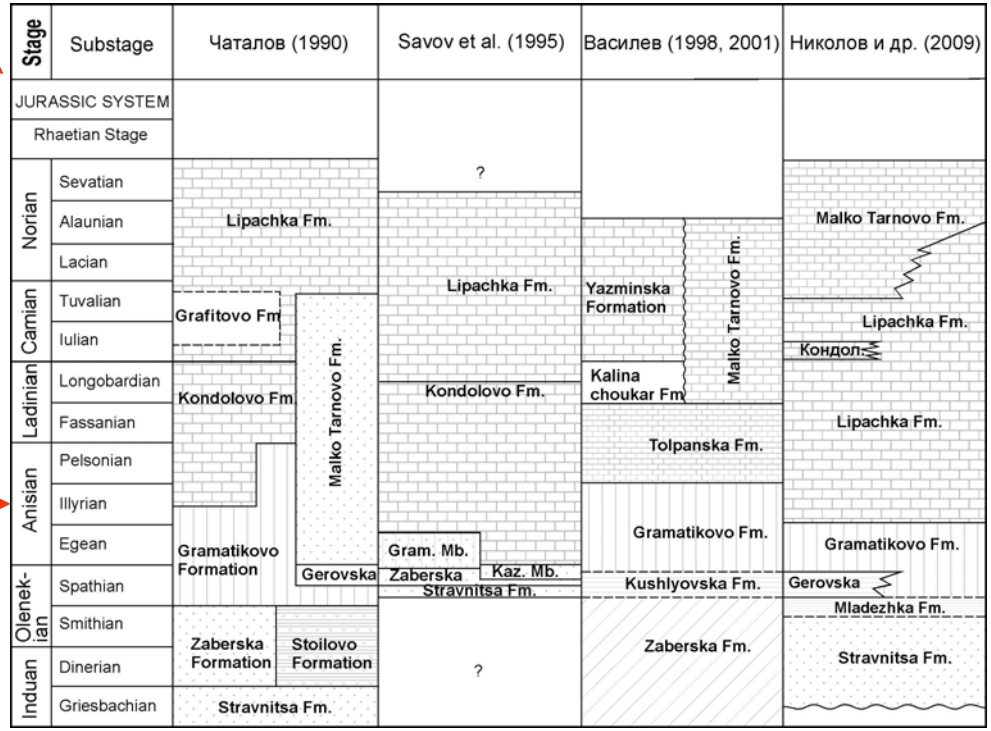
Lower flyschoid association

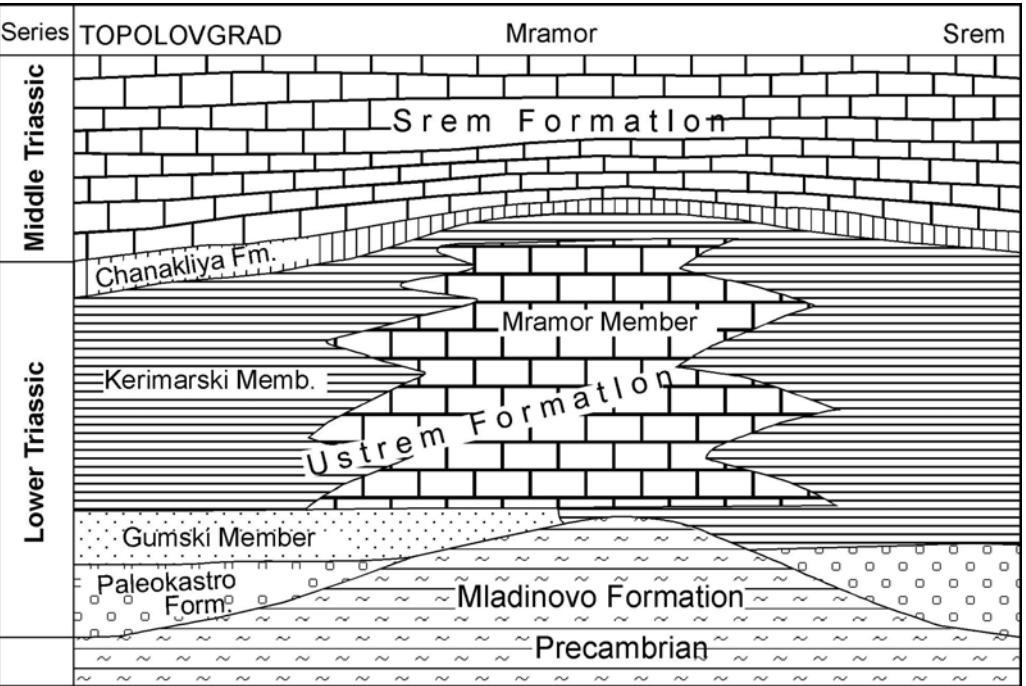
Lower volcano-sedimentary flyschoid association

Shale-sandstone facies

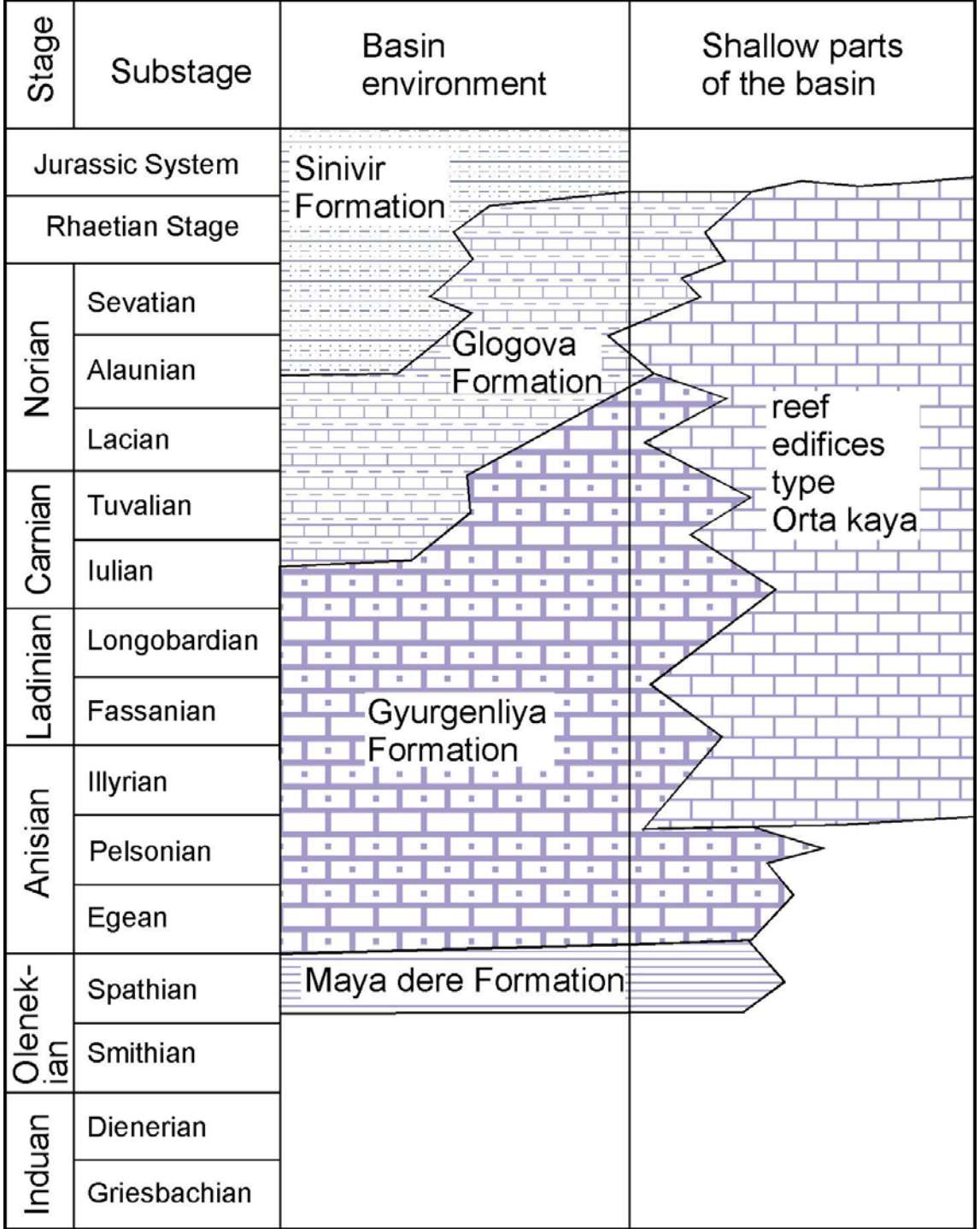
Previous page: facies associations of the Bulgarian Triassic

Litho- and chronostratigraphy of the Strandzha-type Triassic (Veleka unit)



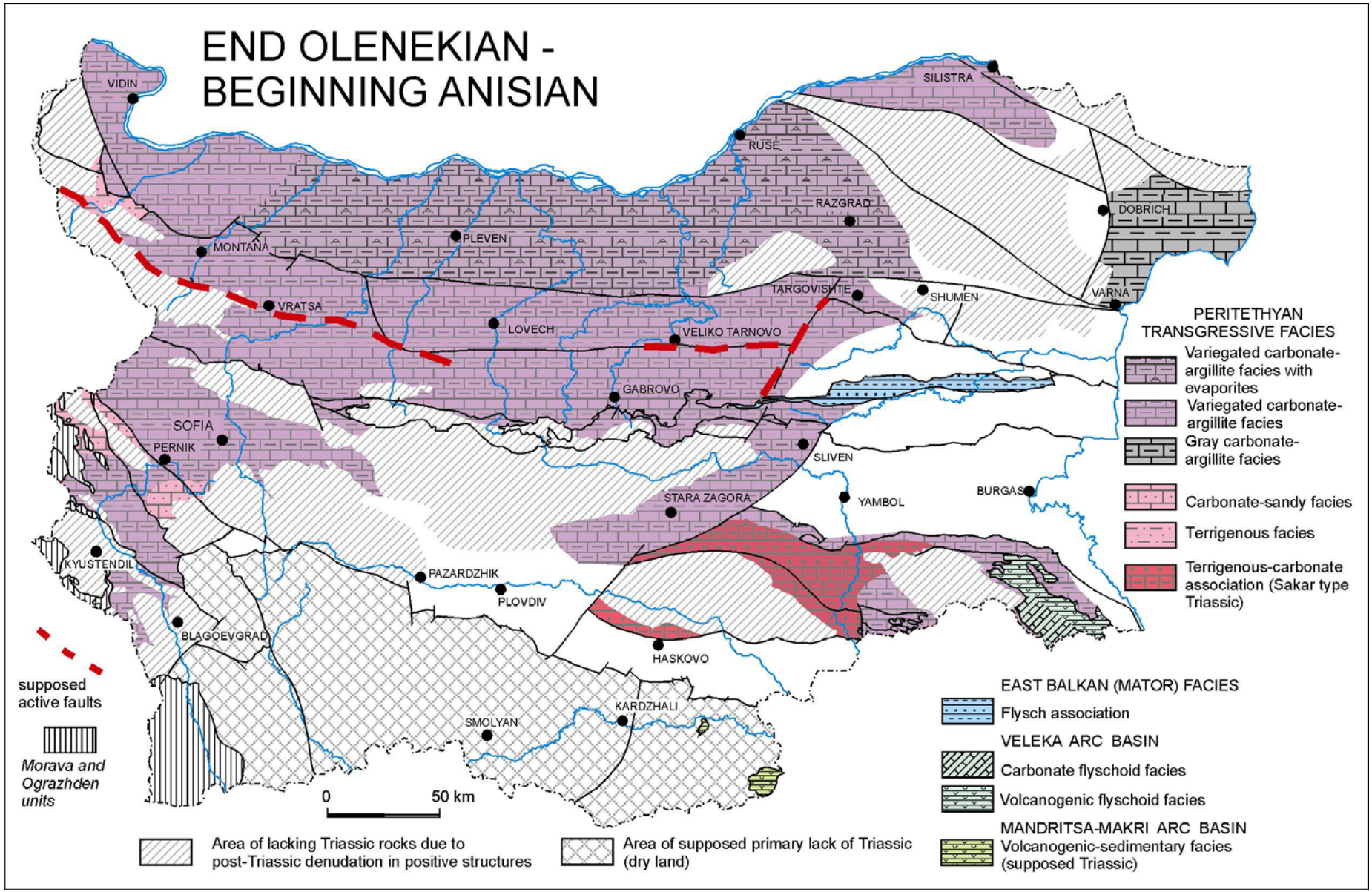


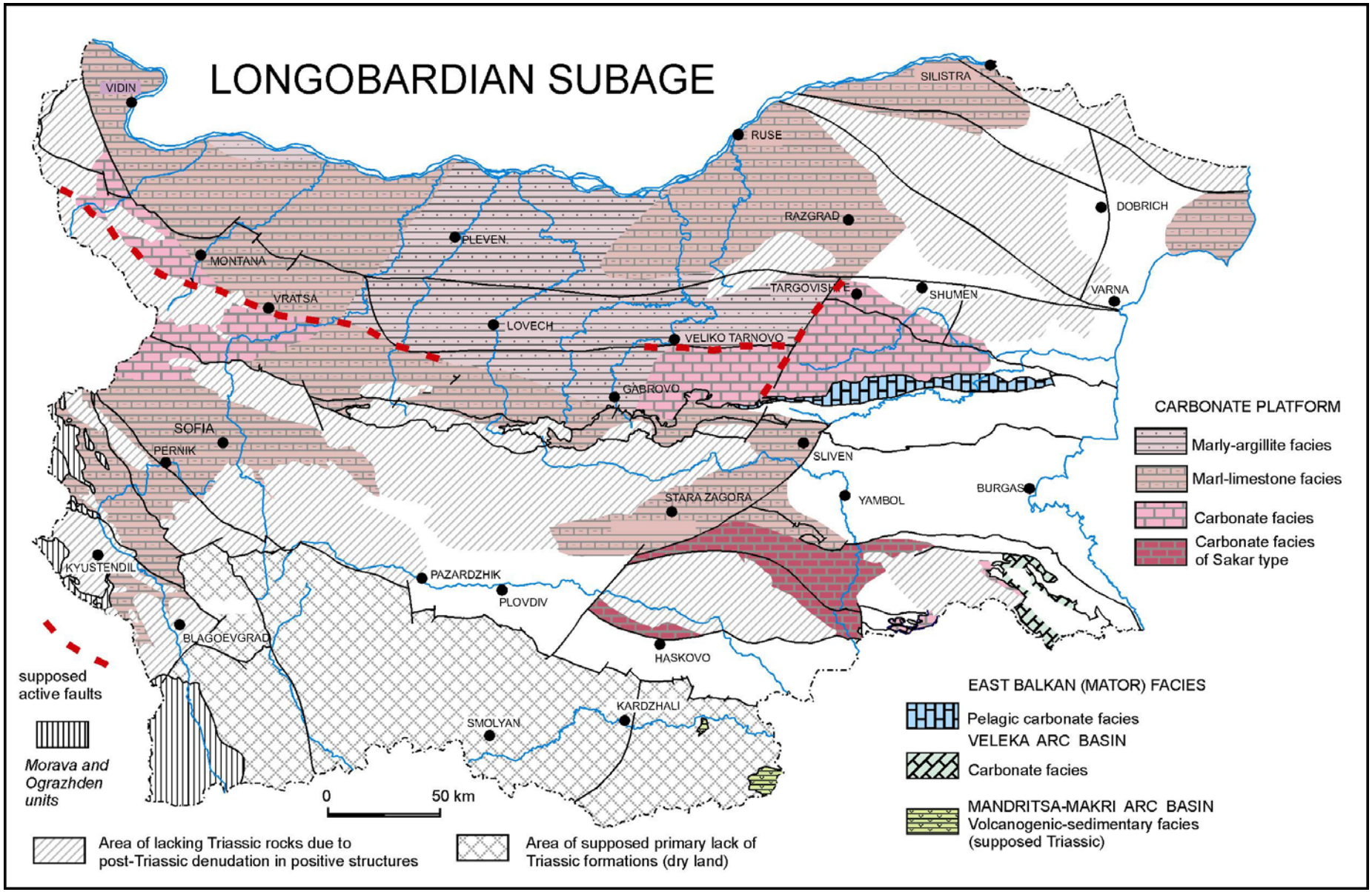
Litho- and chronostratigraphy of the Sakar-type Triassic (after Chatalov)

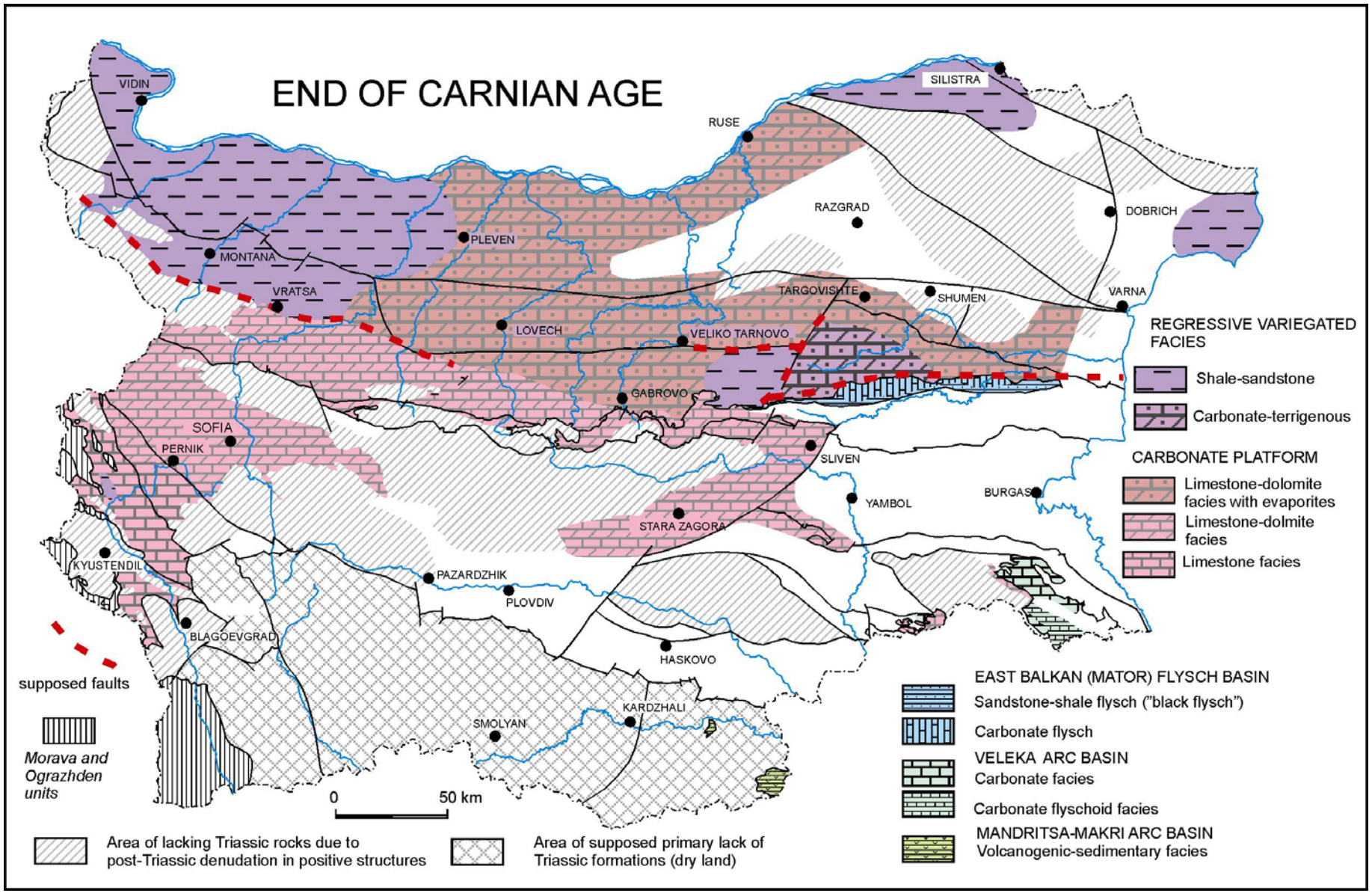


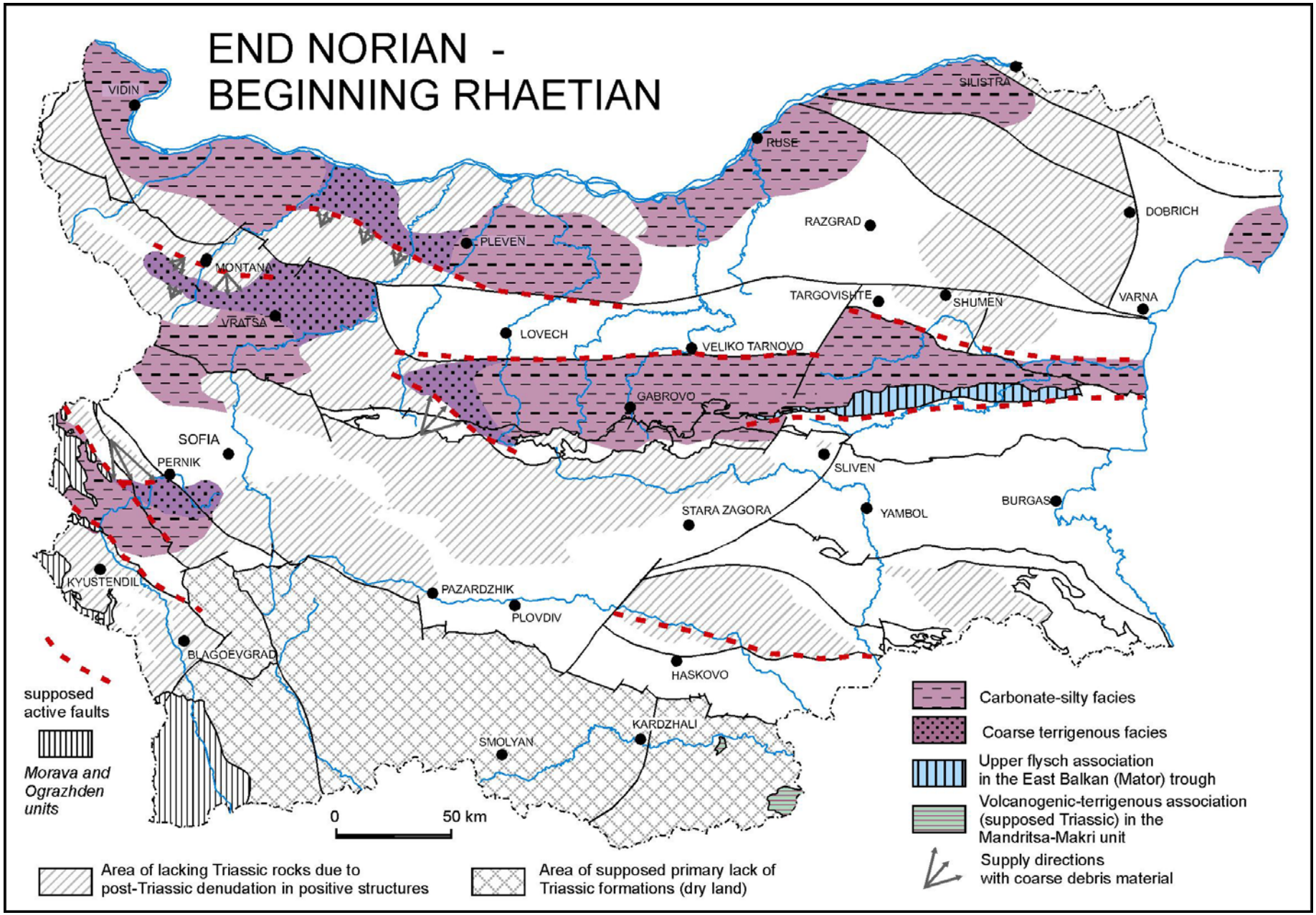
Stratigraphy of the East-Balkan Triassic type in the East-Balkan (Kotel, Mator) trough

Palaeogeographic maps (modern distribution of the environments, without palinspastics)

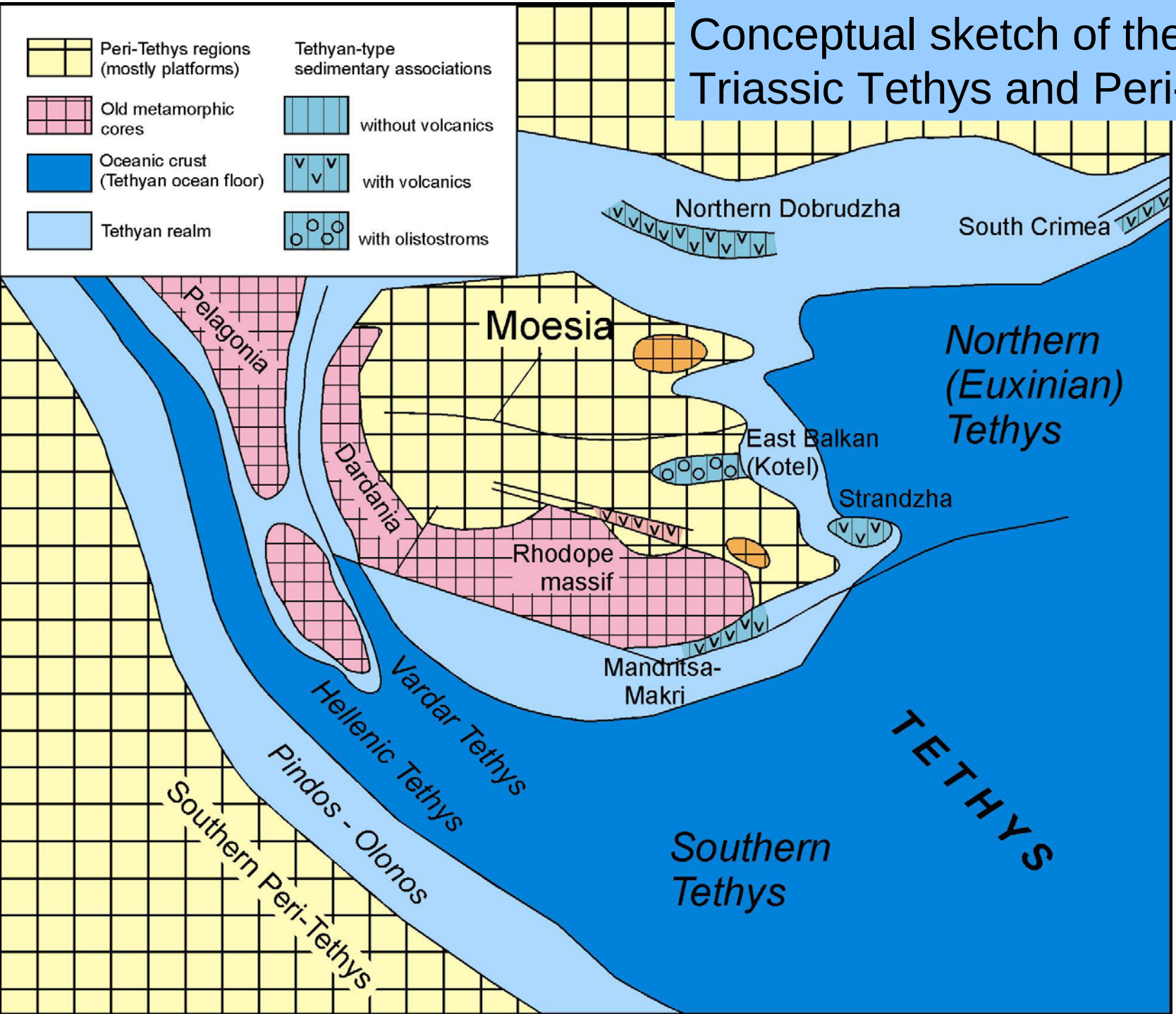



LONGOBARDIAN SUBAGE
VIDIN
MONTANA
VRATSA
PLEVEN
LOVECH
RUSE
RAZGRAD
SILISTRA
DOBRICH
TARGOVISHTE
SHUMEN
VARNA
VELIKO TARNOVO
GABROVO
SOFIA
PERNIK
SLIVEN
BURGAS
YAMBOL
STARA ZAGORA
KYUSTENDIL
PAZARDZHIK
PLOVDIV
BLAGOEVGRAD
HASKOVO
KARDZHALI
SMOLYAN
0
50 km
CARBONATE PLATFORM
Marly-argillite facies
Marl-limestone facies
Carbonate facies
Carbonate facies of Sakar type
EAST BALKAN (MATOR) FACIES
Pelagic carbonate facies
VELEKA ARC BASIN
Carbonate facies
MANDRITSA-MAKRI ARC BASIN
Volcanogenic-sedimentary facies (supposed Triassic)
supposed active faults
Morava and Ograzhden units
Area of lacking Triassic rocks due to post-Triassic denudation in positive structures
Area of supposed primary lack of Triassic formations (dry land)

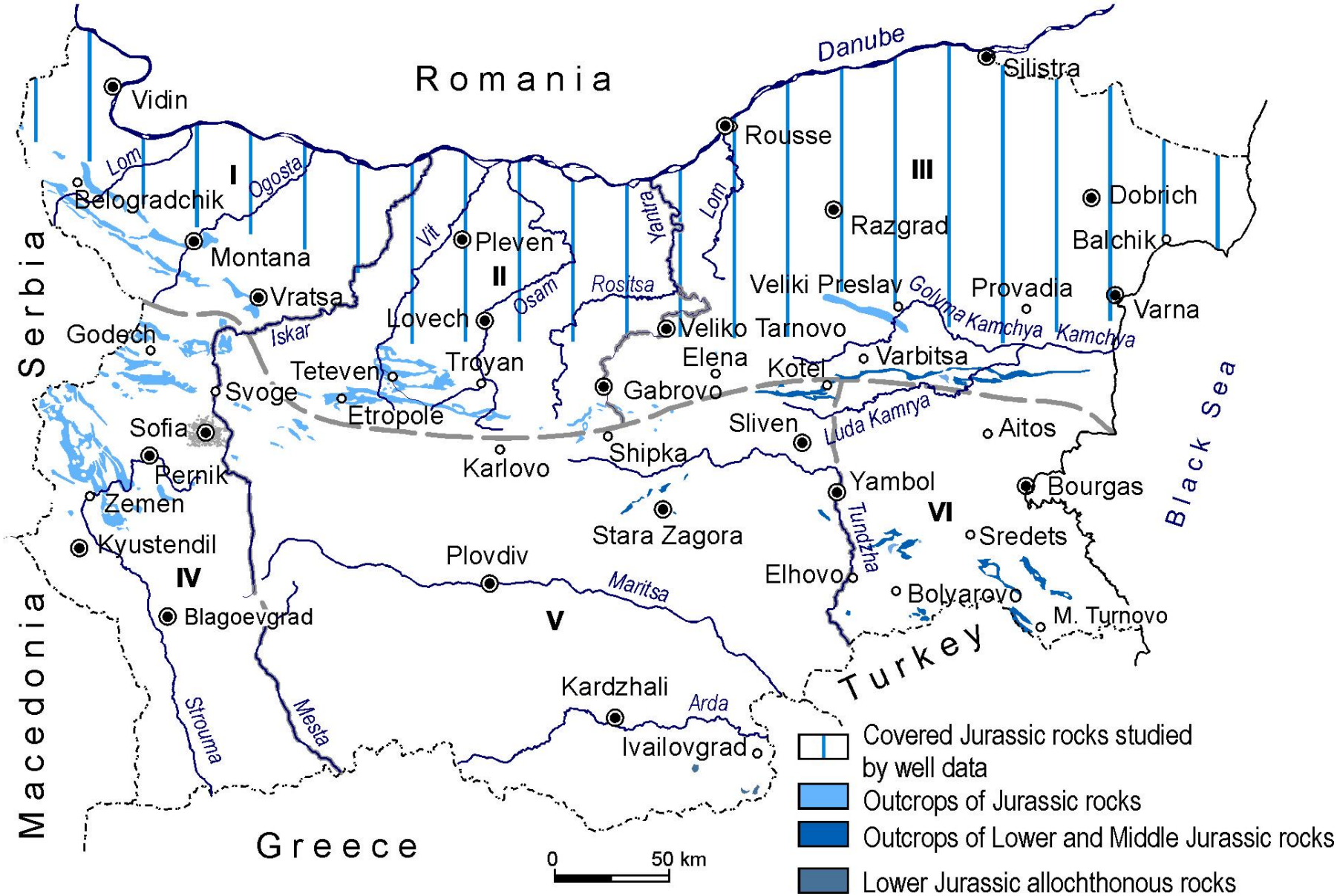

END OF CARNIAN AGE
VIDIN
MONTANA
VRATSA
PLEVEN
LOVECH
RUSE
SILISTRA
RAZGRAD
DOBRICH
TARGOVISHTE
SHUMEN
VARNA
VELIKO TARNOVO
GABROVO
SOFIA
PERNIK
SLIVEN
BURGAS
YAMBOL
STARA ZAGORA
KYUSTENDIL
PAZARDZHIK
PLOVDIV
BLAGOEVGRAD
HASKOVO
SMOLYAN
KARDZHALI
0
50 km
supposed faults
Morava and Ograzhden units
Area of lacking Triassic rocks due to post-Triassic denudation in positive structures
Area of supposed primary lack of Triassic formations (dry land)
REGRESSIVE VARIEGATED FACIES
Shale-sandstone
Carbonate-terrigenous
CARBONATE PLATFORM
Limestone-dolomite facies with evaporites
Limestone-dolmite facies
Limestone facies
EAST BALKAN (MATOR) FLYSCH BASIN
Sandstone-shale flysch ("black flysch")
Carbonate flysch
VELEKA ARC BASIN
Carbonate facies
Carbonate flyschoid facies
MANDRITSA-MAKRI ARC BASIN
Volcanogenic-sedimentary facies


END NORIAN -
BEGINNING RHAETIAN
VIDIN
MONTANA
VRATSA
PLEVEN
LOVECH
RUSE
SILISTRA
RAZGRAD
DOBRICH
TARGOVISHTE
SHUMEN
VARNA
VELIKO TARNOVO
GABROVO
SOFIA
PERNIK
SLIVEN
BURGAS
STARA ZAGORA
YAMBOL
KYUSTENDIL
PAZARDZHIK
PLOVDIV
BLAGOEVGRAD
HASKOVO
KARDZHALI
SMOLYAN
0
50 km
supposed active faults
Morava and Ograzhden units
Carbonate-silty facies
Coarse terrigenous facies
Upper flysch association in the East Balkan (Mator) trough
Volcanogenic-terrigenous association (supposed Triassic) in the Mandritsa-Makri unit
Supply directions with coarse debris material
Area of lacking Triassic rocks due to post-Triassic denudation in positive structures
Area of supposed primary lack of Triassic formations (dry land)

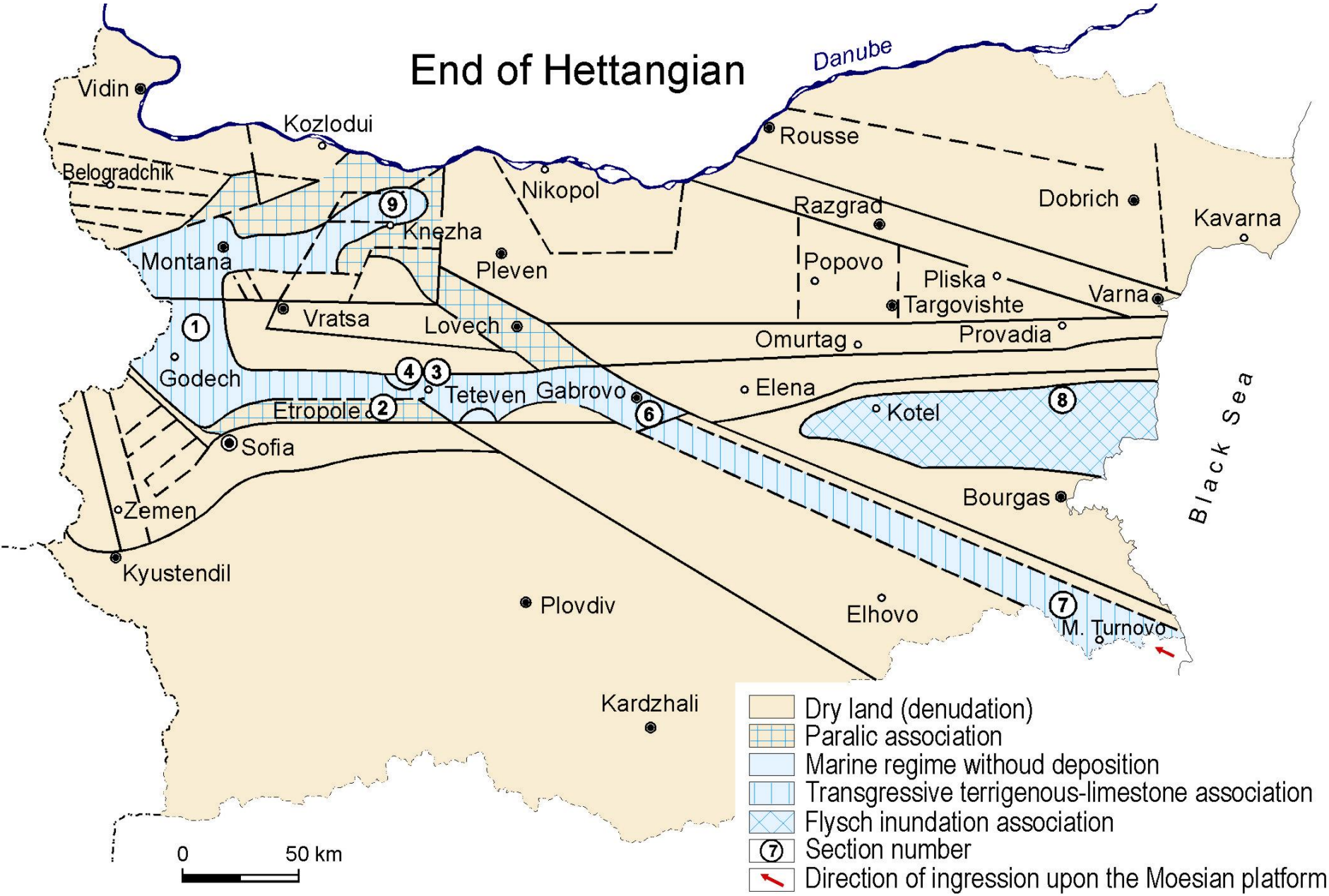
Conceptual sketch of the Triassic Tethys and Peri-Tethys

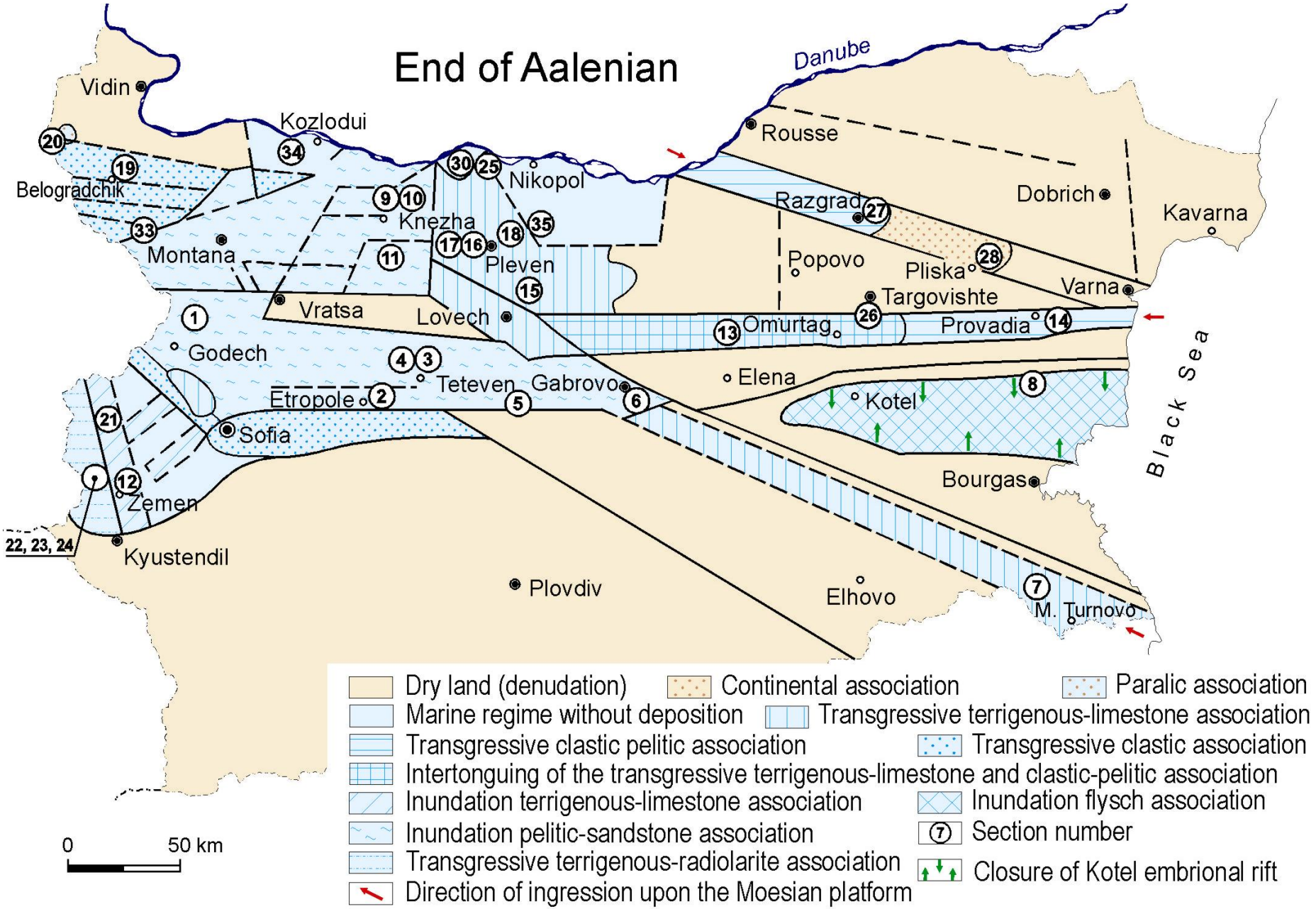


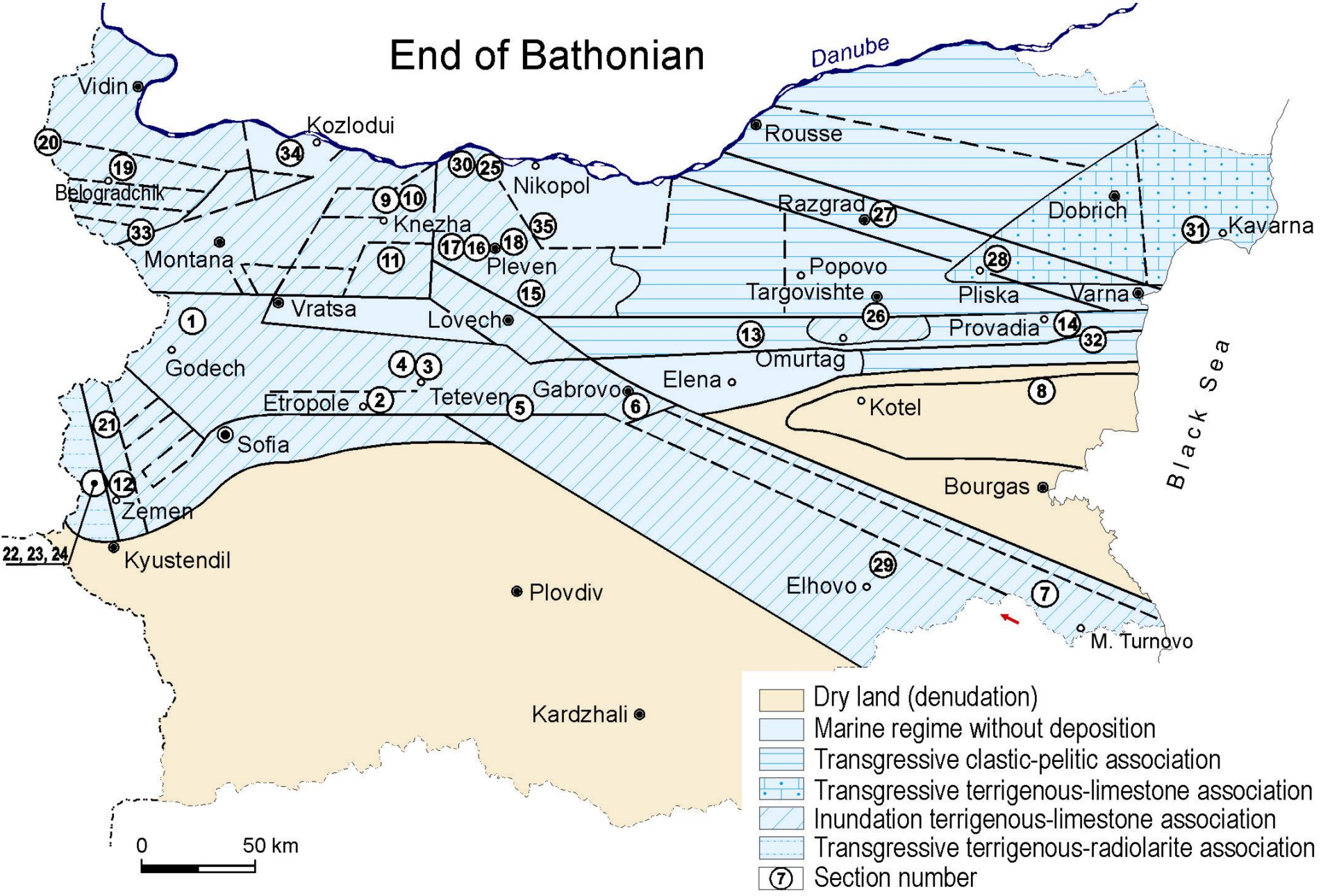
Distribution of the Jurassic in Bulgaria

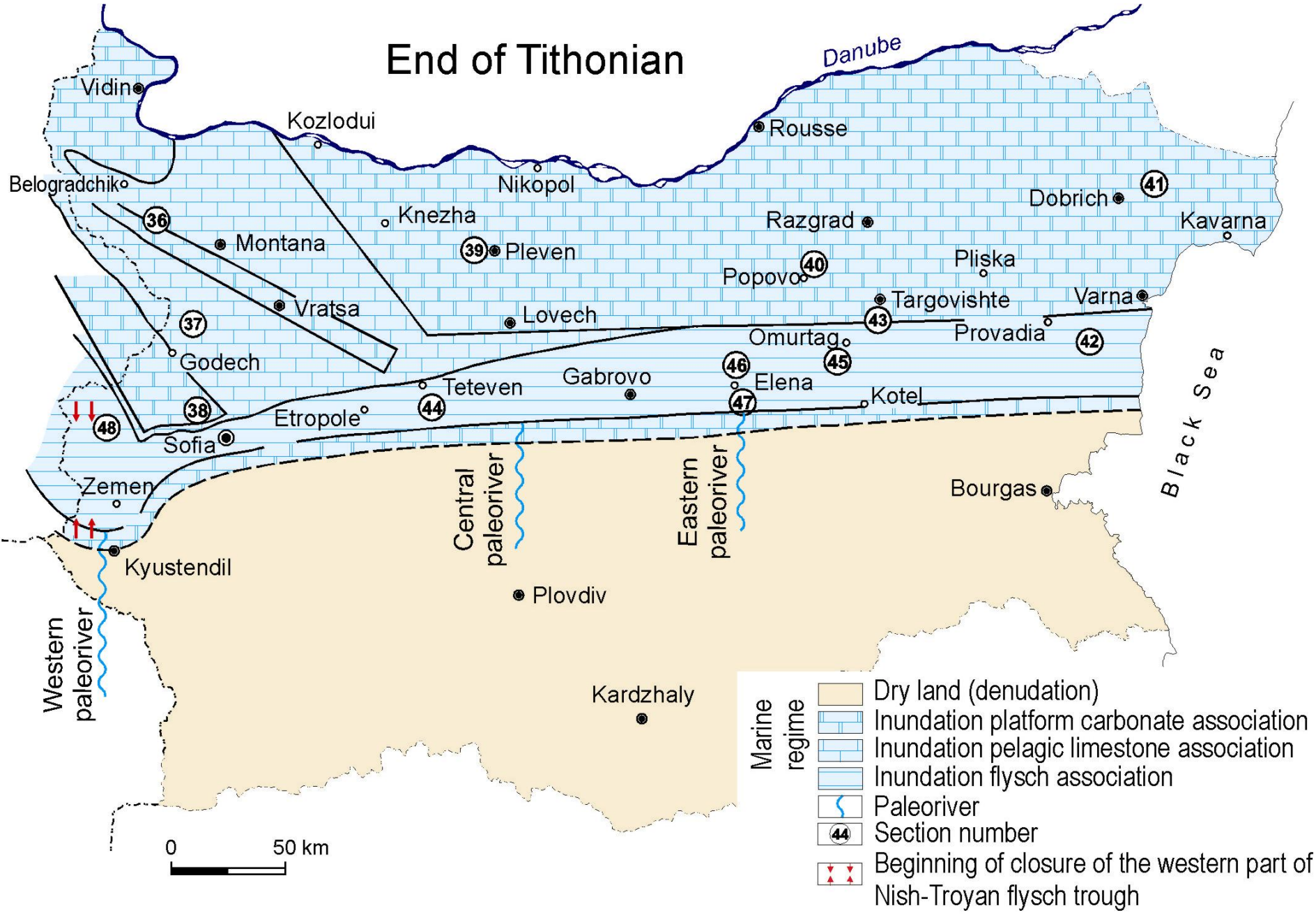


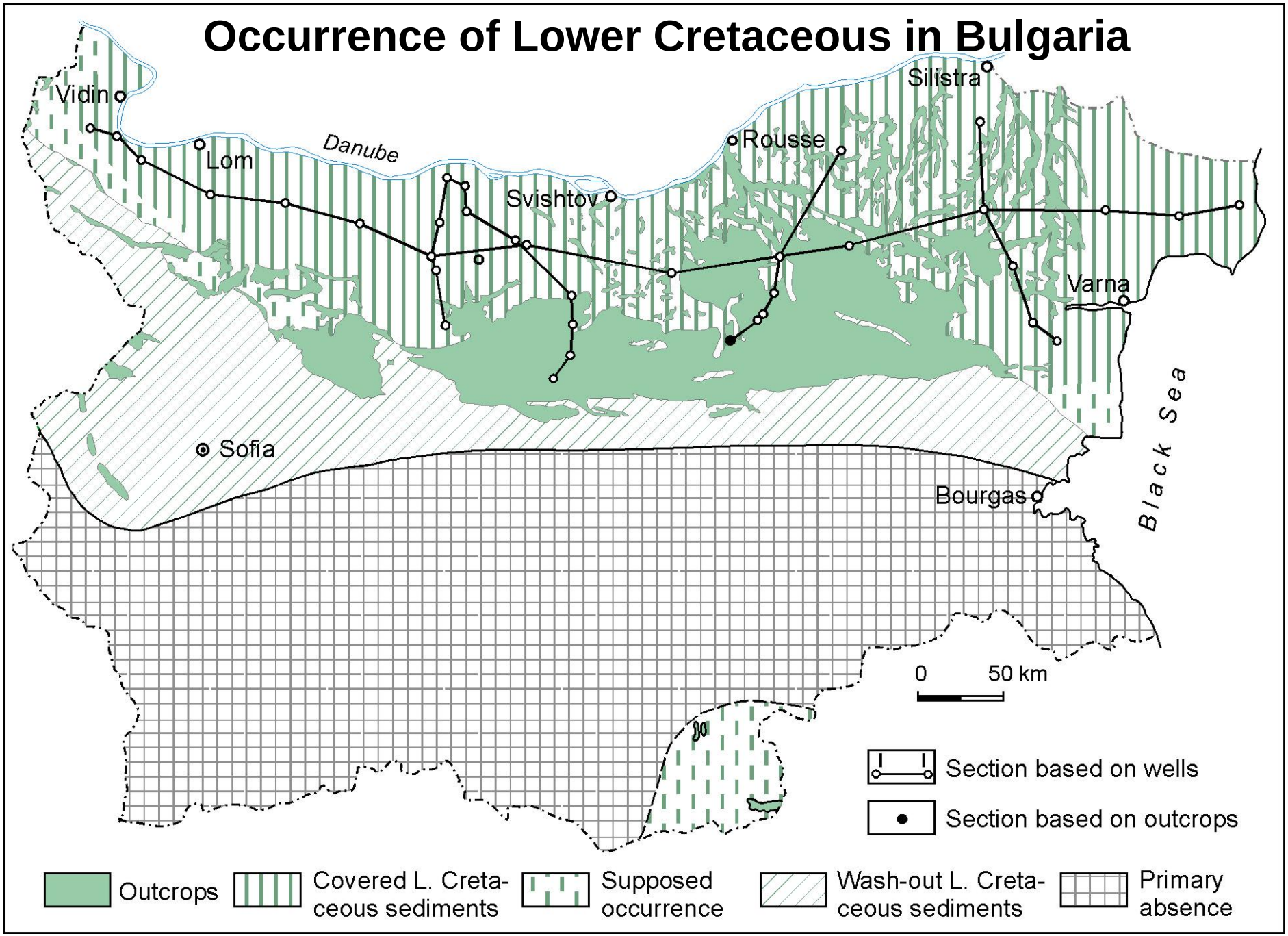
Jurassic palaeogeographic maps (without palinspastics)



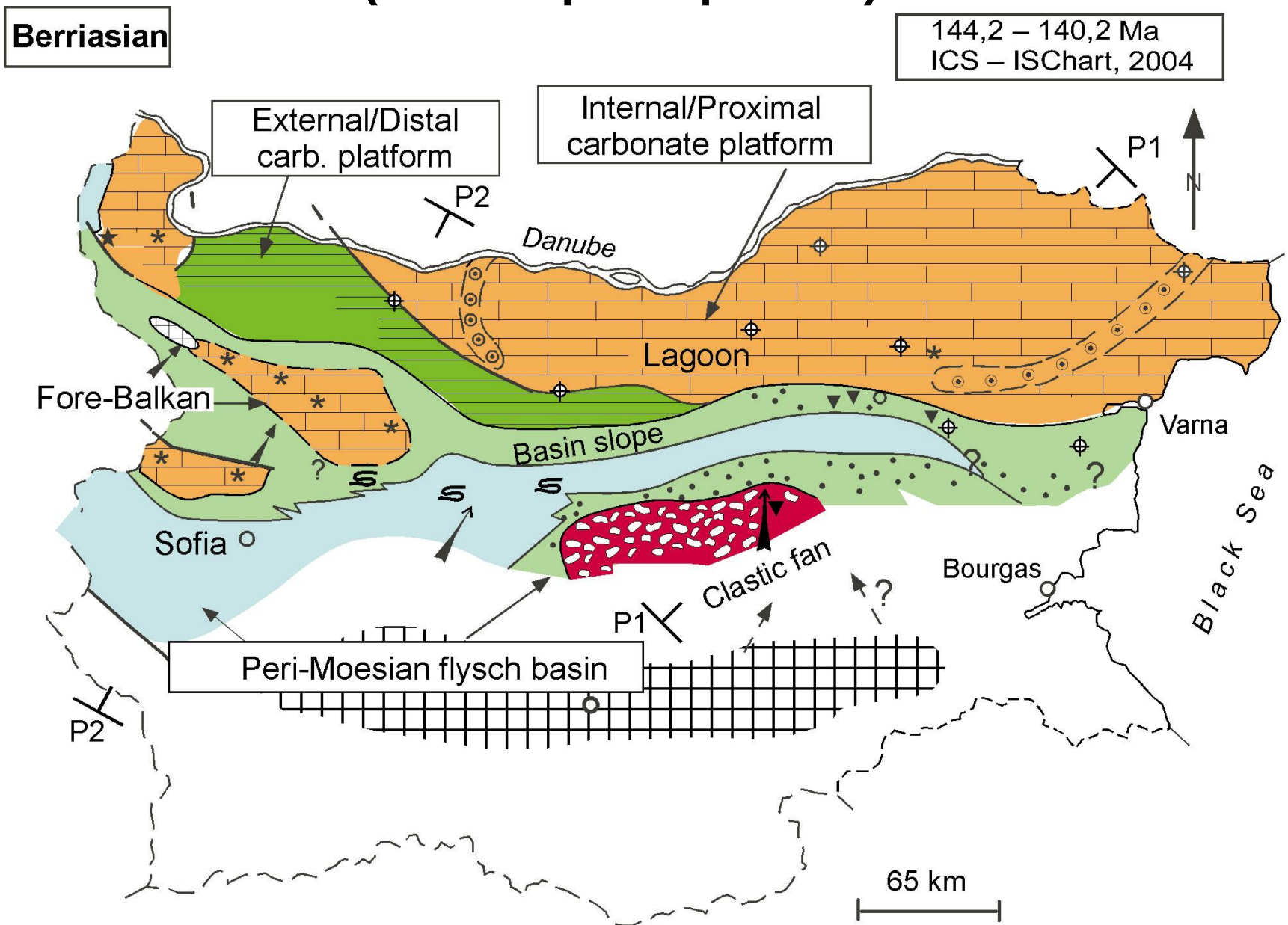

End of Aalenian
Danube
Vidin
Kozlodui
Rousse
Belogradchik
Nikopol
Dobrich
Kavarna
Razgrad
Knezha
Montana
Pleven
Popovo
Pliska
Varna
Targovishte
Vratsa
Lovech
Omurtag
Provadia
Godech
Teteven
Gabrovo
Elena
Etropole
Kotel
Black Sea
Sofia
Bourgas
Zemen
Kyustendil
Plovdiv
Elhovo
M. Turnovo
22, 23, 24
0
50 km
Dry land (denudation)
Continental association
Paralic association
Marine regime without deposition
Transgressive terrigenous-limestone association
Transgressive clastic pelitic association
Transgressive clastic association
Intertonguing of the transgressive terrigenous-limestone and clastic-pelitic association
Inundation terrigenous-limestone association
Inundation flysch association
Inundation pelitic-sandstone association
Section number
Transgressive terrigenous-radiolarite association
Closure of Kotel embrional rift
Direction of ingression upon the Moesian platform


End of Bathonian
Danube
Vidin
Kozlodui
Belogradchik
Montana
Vratsa
Godech
Etropole
Sofia
Zemen
Kyustendil
22, 23, 24
Knezha
Nikopol
Pleven
Lovech
Teteven
Gabrovo
Rousse
Razgrad
Popovo
Targovishte
Omurtag
Elena
Kotel
Dobrich
Kavarna
Pliska
Varna
Provadia
Bourgas
Black Sea
Elhovo
M. Turnovo
Plovdiv
Kardzhali
0
50 km
Dry land (denudation)
Marine regime without deposition
Transgressive clastic-pelitic association
Transgressive terrigenous-limestone association
Inundation terrigenous-limestone association
Transgressive terrigenous-radiolarite association
Section number


End of Tithonian
Danube
Vidin
Kozlodui
Rousse
Belogradchik
Nikopol
Knezha
Dobrich
Kavarna
Razgrad
Montana
Pleven
Pliska
Popovo
Vratsa
Lovech
Targovishte
Varna
Provadia
Omurtag
Godech
Teteven
Gabrovo
Elena
Kotel
Etropole
Sofia
Black Sea
Zemen
Central paleoriver
Eastern paleoriver
Bourgas
Kyustendil
Plovdiv
Western paleoriver
Kardzhaly
0
50 km
Marine regime
Dry land (denudation)
Inundation platform carbonate association
Inundation pelagic limestone association
Inundation flysch association
Paleoriver
Section number
Beginning of closure of the western part of Nish-Troyan flysch trough

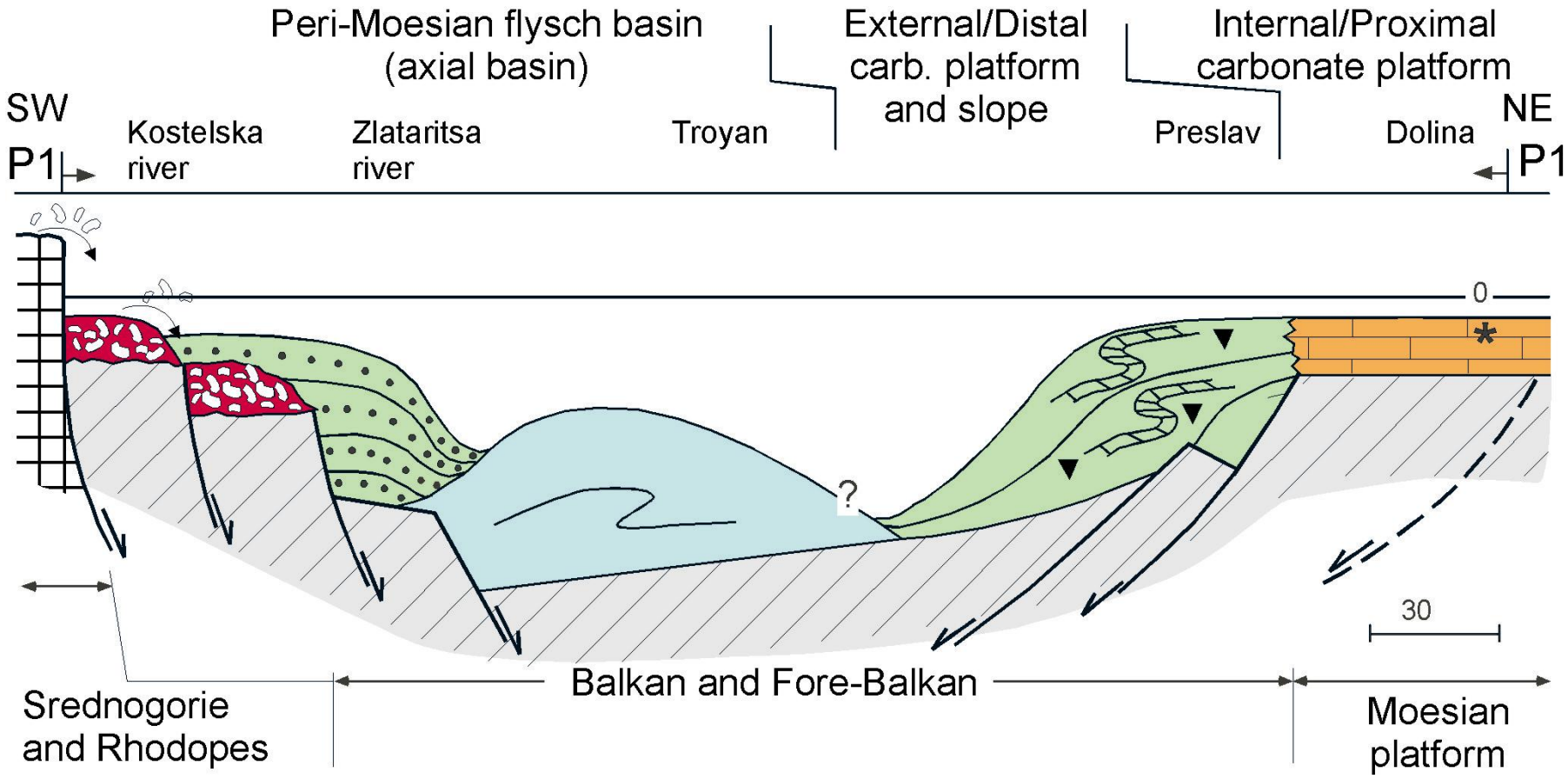

Occurrence of Lower Cretaceous in Bulgaria
Vidin
Lom
Danube
Svishtov
Rousse
Silistra
Varna
Black Sea
Sofia
Bourgas
0
50 km
Section based on wells
Section based on outcrops
Outcrops
Covered L. Creta-ceous sediments
Supposed occurrence
Wash-out L. Creta-ceous sediments
Primary absence

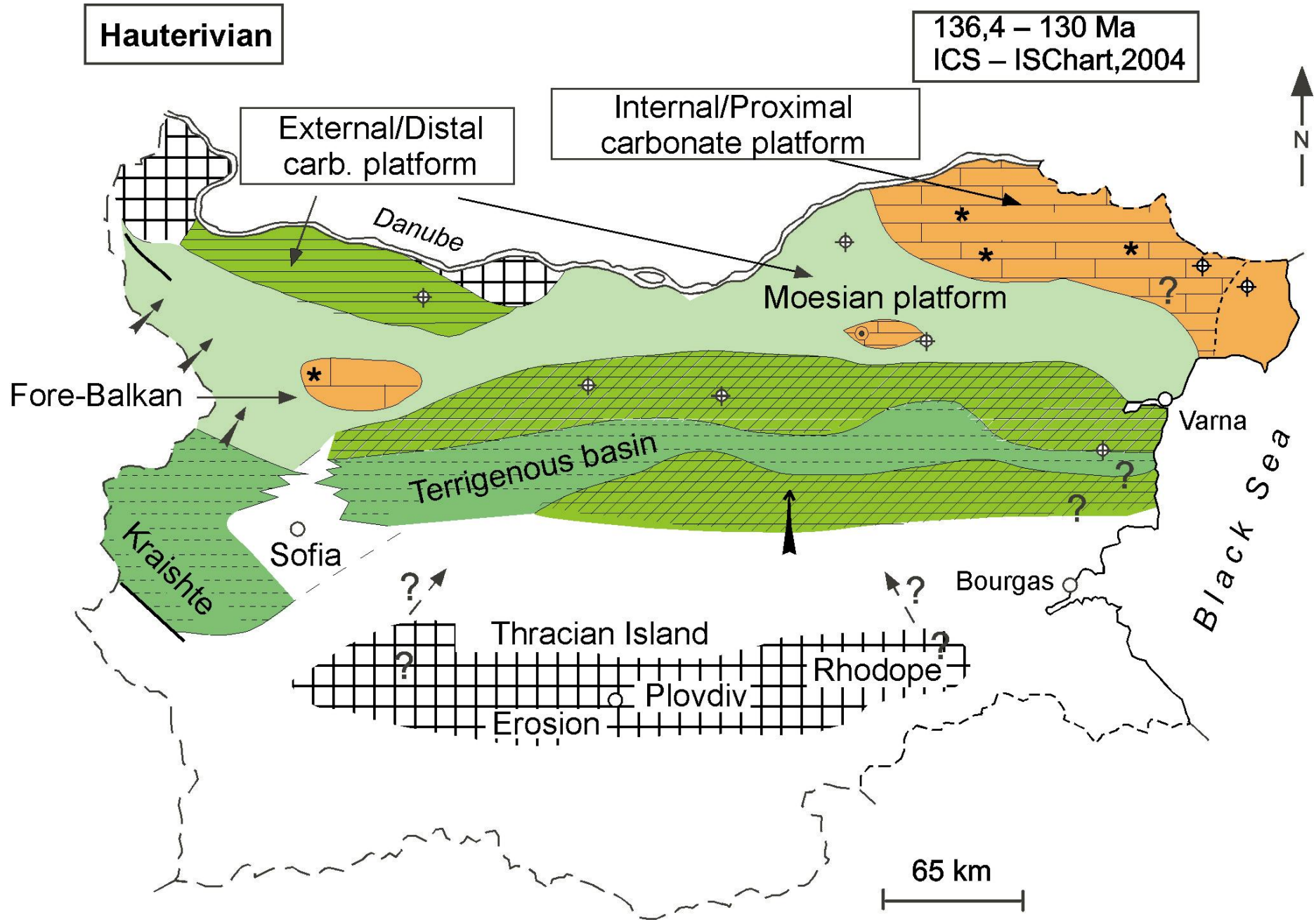
Early Cretaceous palaeogeographic maps (without palinspastics)

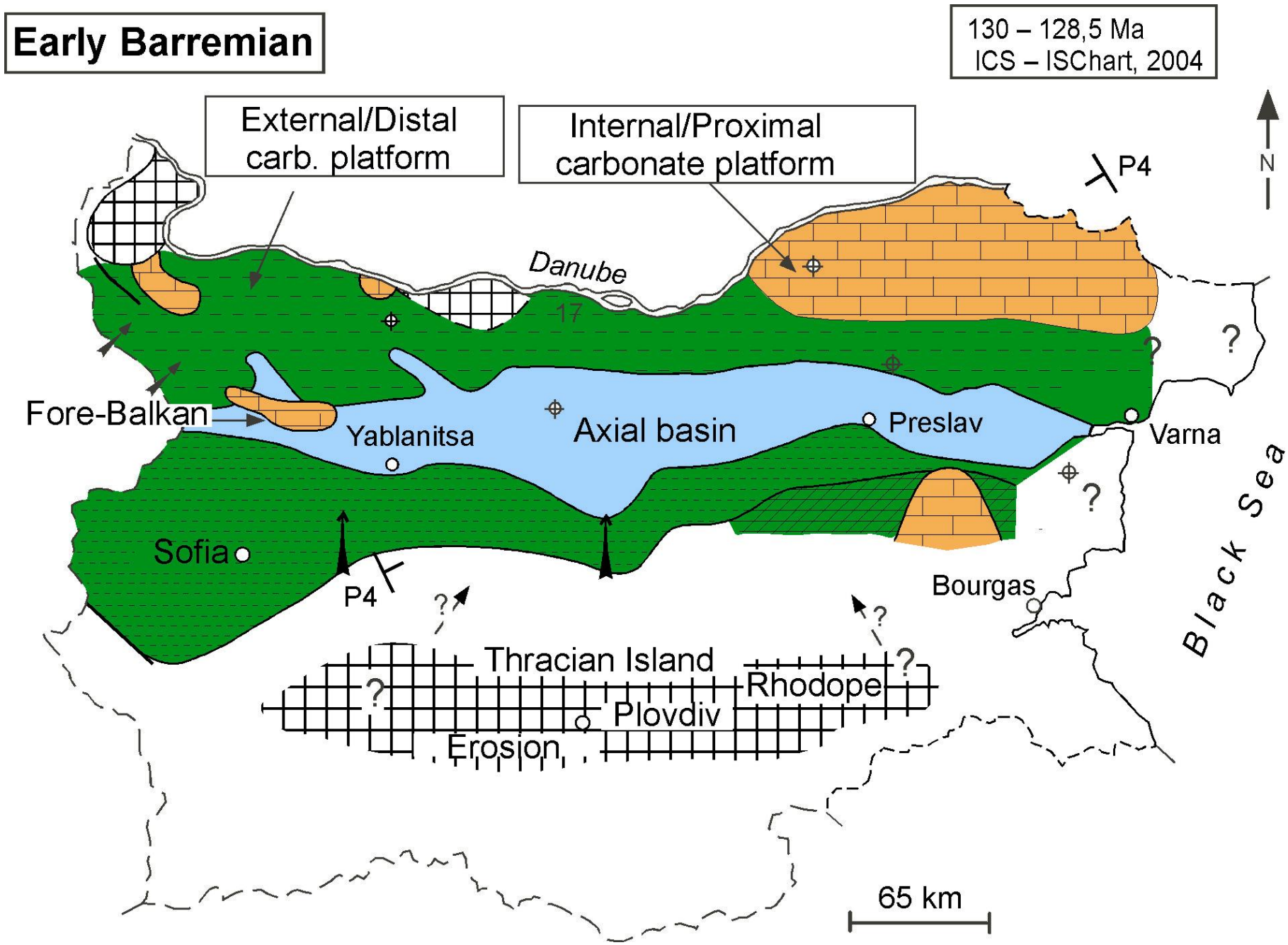


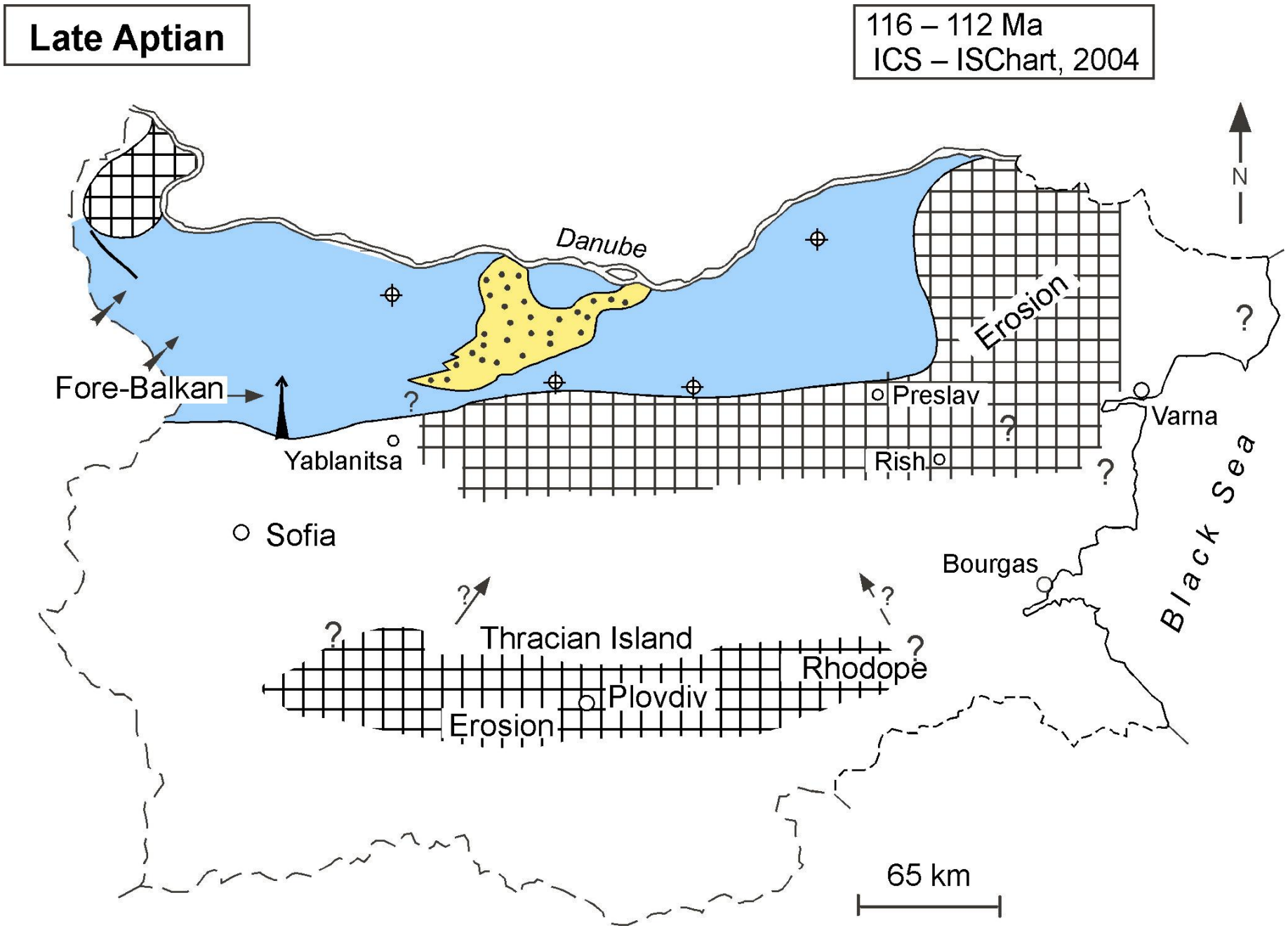
Berriasian P1-P1

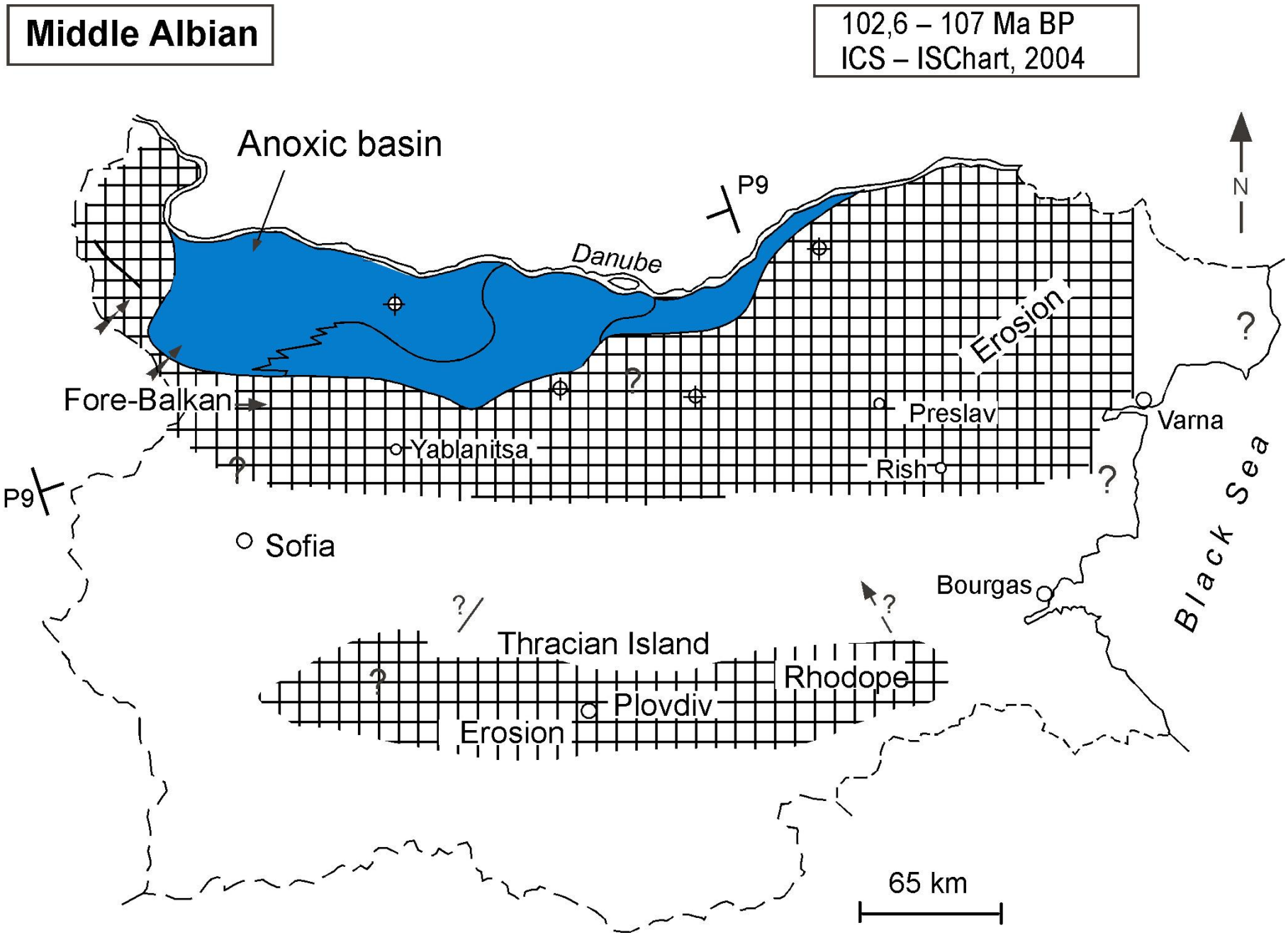
Zones *P. grandis – T. occitanica*

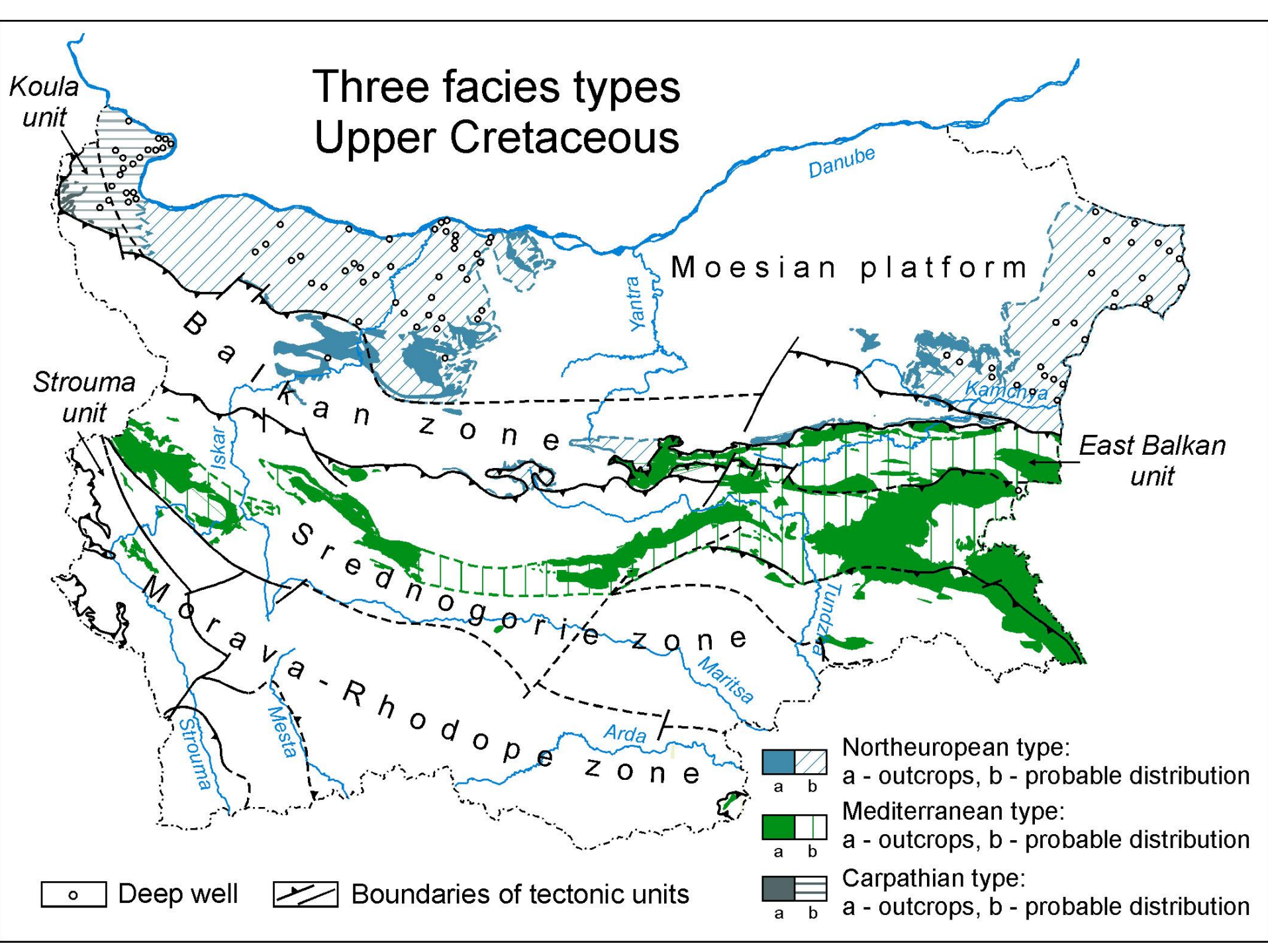


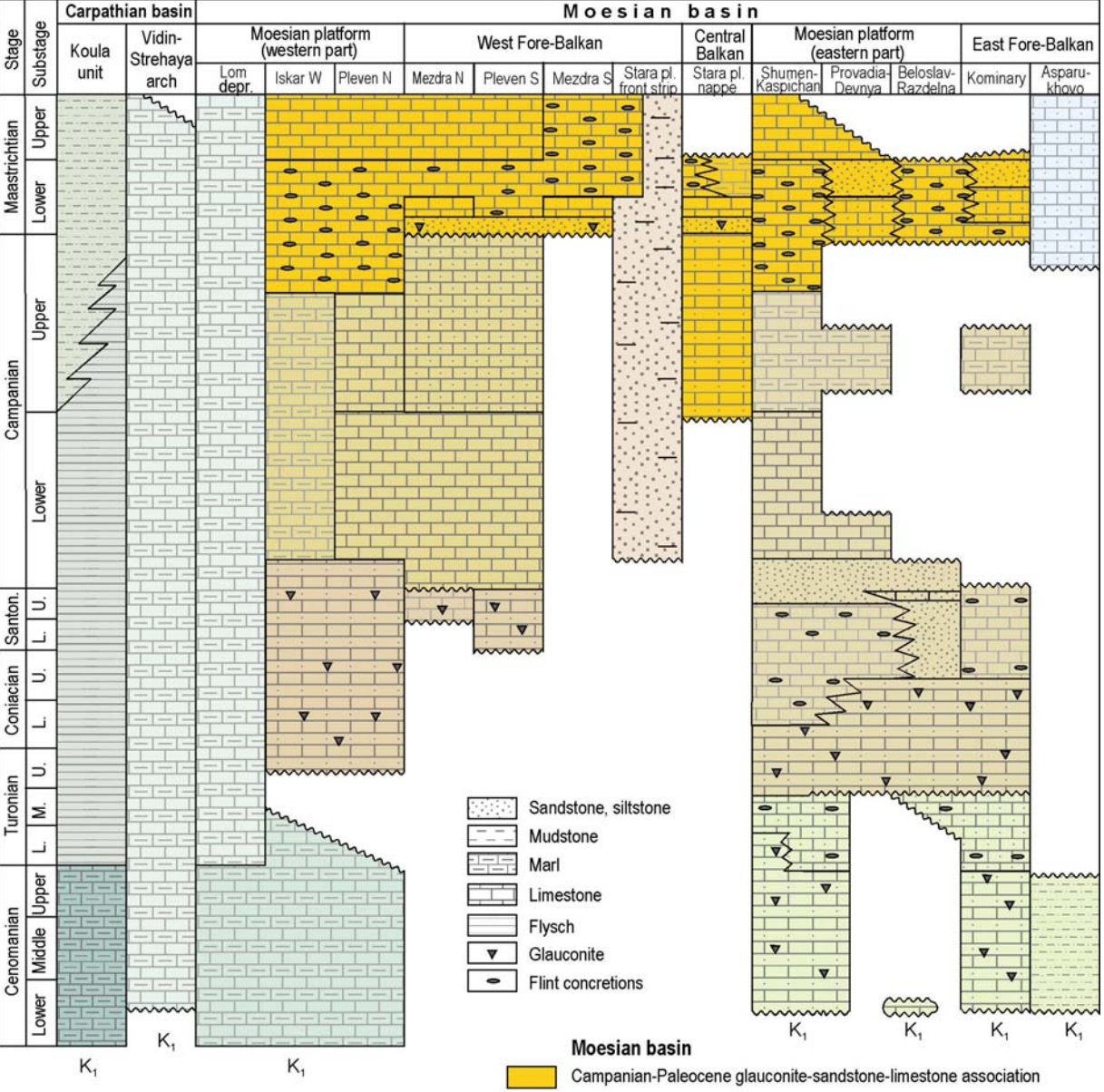

Hauterivian
136,4 – 130 Ma
ICS – ISChart,2004
External/Distal
carb. platform
Internal/Proximal
carbonate platform
N
Danube
Moesian platform
Fore-Balkan
Varna
Terrigenous basin
Black Sea
Kraishte
Sofia
Bourgas
Thracian Island
Rhodope
Plovdiv
Erosion
65 km

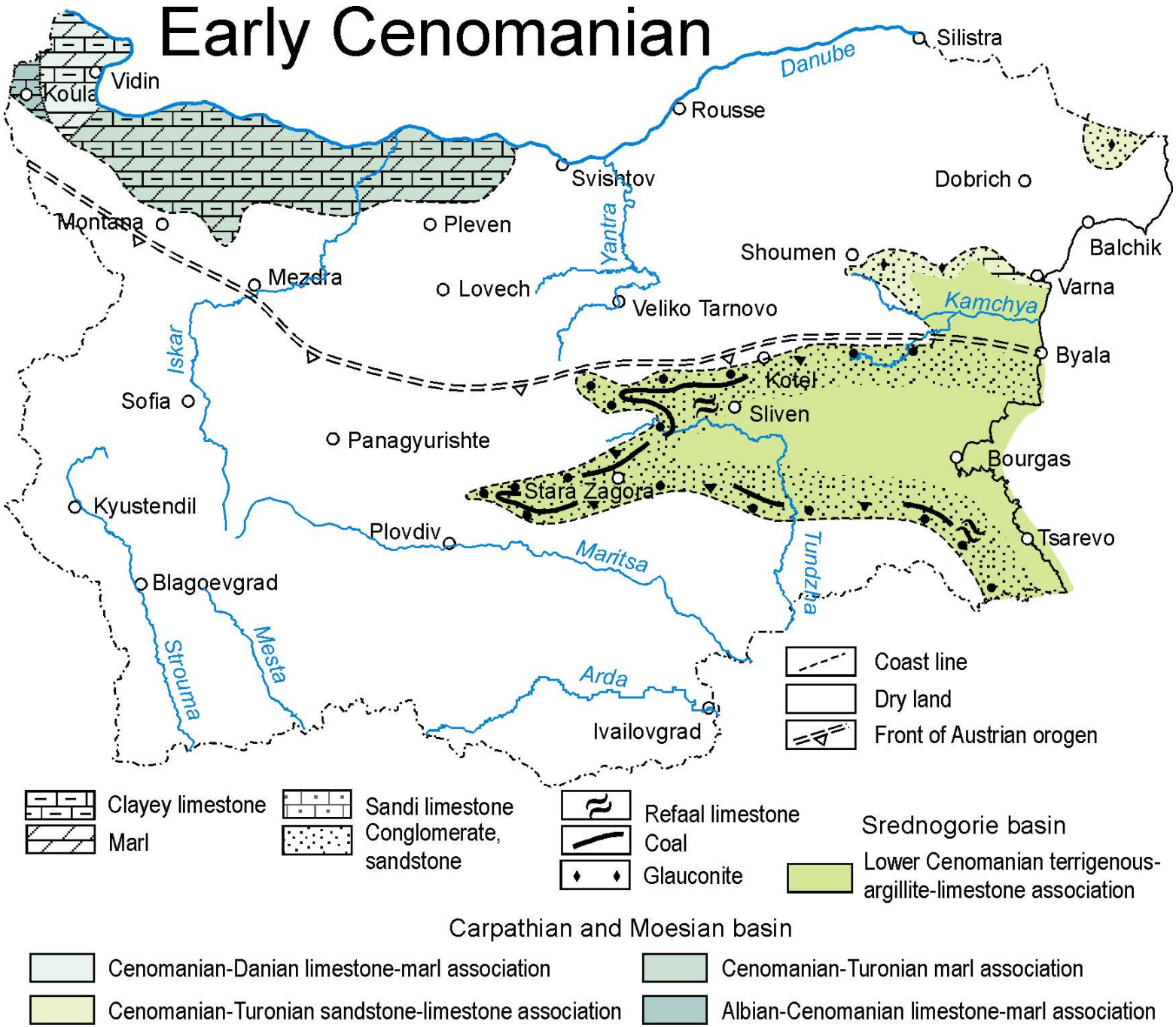

Early Barremian
130 – 128,5 Ma
ICS – ISChart, 2004
External/Distal
carb. platform
Internal/Proximal
carbonate platform
P4
N
Danube
17
Fore-Balkan
Yablanitsa
Axial basin
Preslav
Varna
Sofia
P4
Bourgas
Black Sea
Thracian Island
Rhodope
Plovdiv
Erosion
65 km

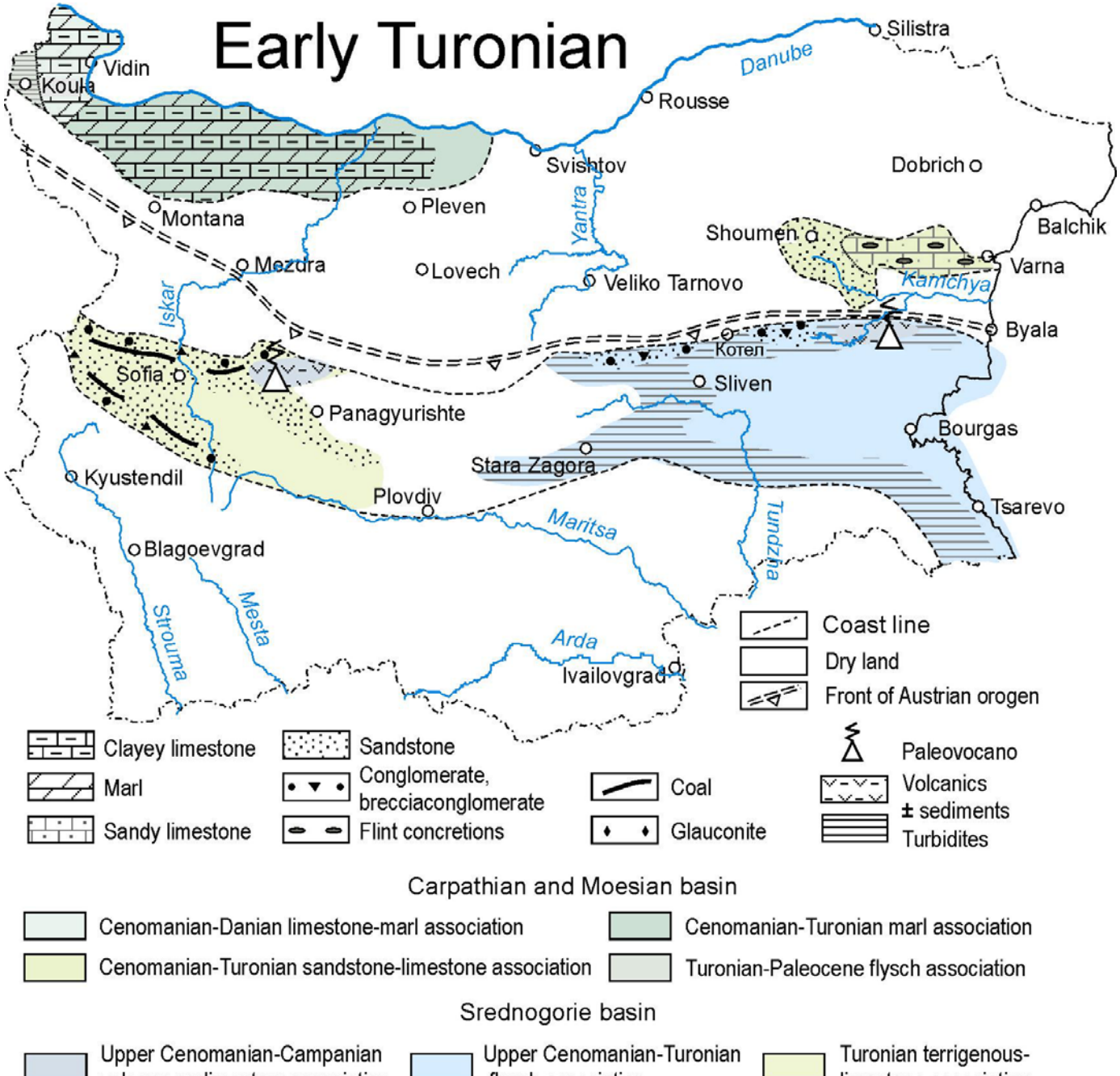

Late Aptian
116 – 112 Ma
ICS – ISChart, 2004
N
Danube
Fore-Balkan
Erosion
Preslav
Varna
Yablanitsa
Rish
Sofia
Bourgas
Black Sea
Thracian Island
Rhodope
Plovdiv
Erosion
65 km

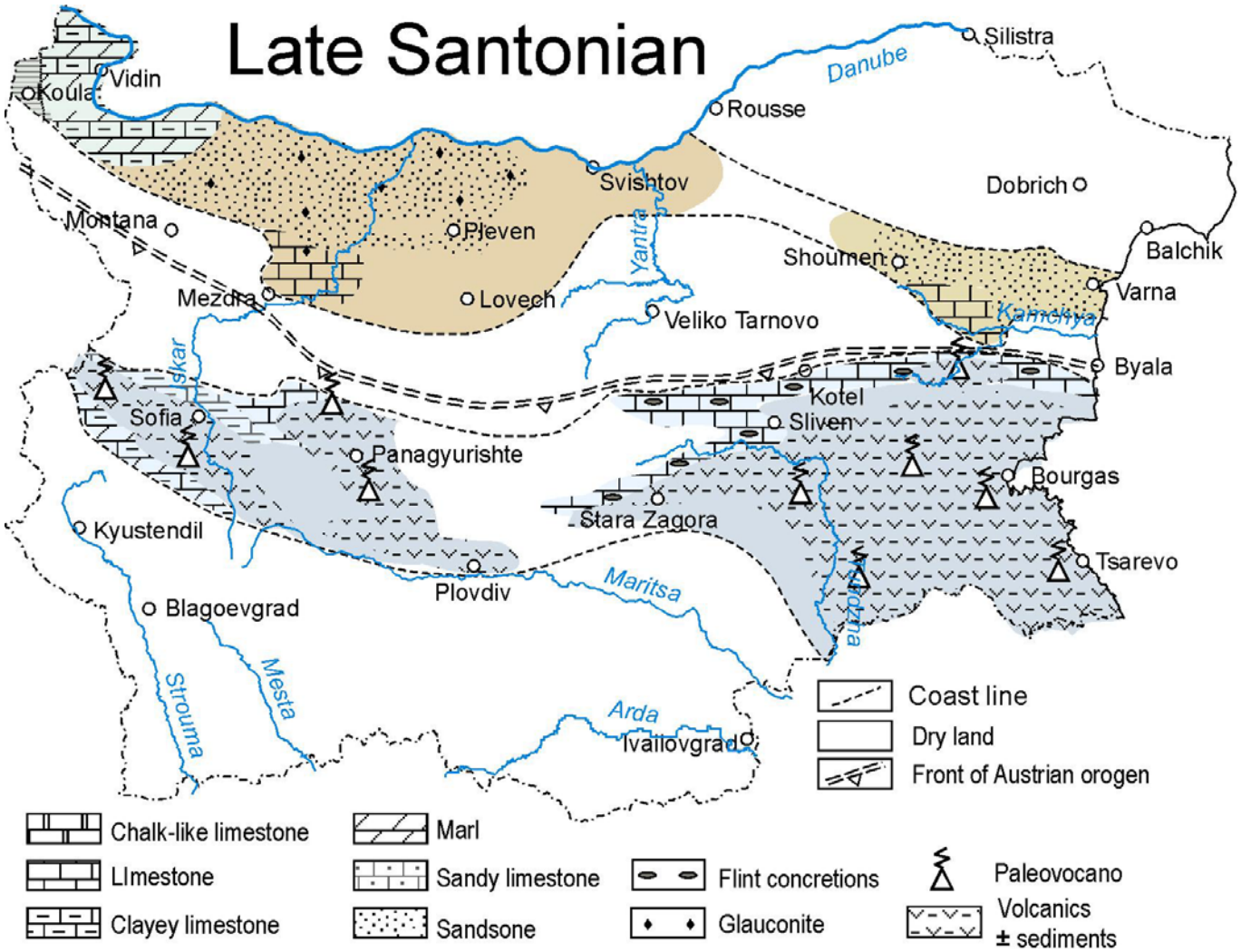

Middle Albian
102,6 – 107 Ma BP
ICS – ISChart, 2004
Anoxic basin
P9
Danube
N
Erosion
?
Fore-Balkan
Preslav
Varna
Yablanitsa
Rish
P9
Sofia
Black Sea
Bourgas
Thracian Island
Rhodope
Plovdiv
Erosion
65 km

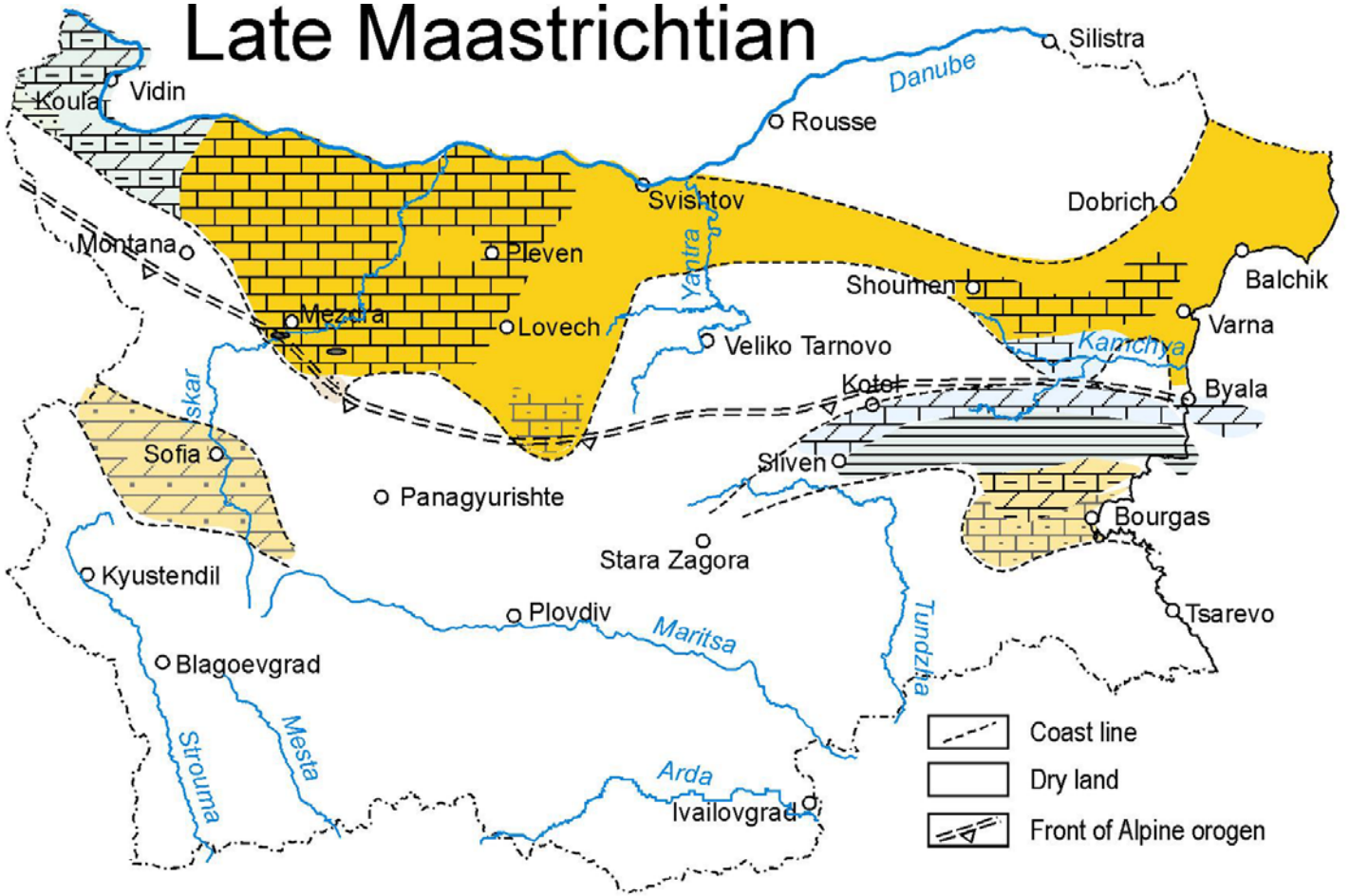

Three facies types
Upper Cretaceous
Koula unit
Strouma unit
Danube
Moesian platform
Yantra
Balkan zone
Iskar
Kamchya
East Balkan unit
Srednogorie zone
Tundzha
Maritsa
Arda
Mesta
Strouma
Rhodope zone
Northeuropean type:
a - outcrops, b - probable distribution
Mediterranean type:
a - outcrops, b - probable distribution
Carpathian type:
a - outcrops, b - probable distribution
a b
Deep well
Boundaries of tectonic units


Stage
Substage
Carpathian basin
Moesian basin
Koula unit
Vidin-Strehaya arch
Moesian platform (western part)
West Fore-Balkan
Central Balkan
Moesian platform (eastern part)
East Fore-Balkan
Lom depr.
Iskar W
Pleven N
Mezdra N
Pleven S
Mezdra S
Stara pl. front strip
Stara pl. nappe
Shumen-Kaspichan
Provadia-Devnya
Beloslav-Razdelna
Kominary
Asparu-khovo
Maastrichtian
Upper
Lower
Campanian
Upper
Lower
Santon.
U.
L.
Coniacian
U.
L.
Turonian
U.
M.
L.
Cenomanian
Upper
Middle
Lower
Sandstone, siltstone
Mudstone
Marl
Limestone
Flysch
Glauconite
Flint concretions
K1
Carpathian basin
Turonian-Paleocene flysch association
Cenomanian-Danian limestone-marl association
Alb-Cenomanian limestone-marl association
Moesian basin
Campanian-Paleocene glauconite-sandstone-limestone association
Campanian-Maastrichtian limestone association
Campanian-Maastrichtian sandstone association
Campanian terrigenous-limestone association
Upper Turonian-Campanian sandstone limestone association
Upper Turonian-Lower Campanian terrigenous-limestone association
Cenomanian-Turonian sandstone-limestone association
Cenomanian-Turonain marl assocuation


Early Cenomanian
Vidin
Koula
Montana
Mezdra
Sofia
Kyustendil
Blagoevgrad
Pleven
Lovech
Svishtov
Rousse
Silistra
Danube
Yantra
Iskar
Panagyurishte
Plovdiv
Maritsa
Stara Zagora
Kotel
Sliven
Veliko Tarnovo
Shoumen
Dobrich
Balchik
Varna
Kamchya
Byala
Bourgas
Tsarevo
Tundzha
Mesta
Strouma
Arda
Ivailovgrad
Coast line
Dry land
Front of Austrian orogen
Clayey limestone
Marl
Sandi limestone
Conglomerate, sandstone
Refaal limestone
Coal
Glauconite
Srednogorie basin
Lower Cenomanian terrigenous-argillite-limestone association
Carpathian and Moesian basin
Cenomanian-Danian limestone-marl association
Cenomanian-Turonian marl association
Cenomanian-Turonian sandstone-limestone association
Albian-Cenomanian limestone-marl association


Early Turonian
Vidin
Kouka
Montana
Mezdra
Pleven
Lovech
Svishtov
Rousse
Silistra
Danube
Yantra
Dobrich
Balchik
Shoumen
Varna
Kamchya
Veliko Tarnovo
Byala
Iskar
Sofia
Panagyurishte
Kyustendil
Plovdiv
Stara Zagora
Sliven
Bourgas
Tsarevo
Maritsa
Tundzha
Blagoevgrad
Struma
Mesta
Arda
Ivailovgrad
Coast line
Dry land
Front of Austrian orogen
Clayey limestone
Marl
Sandy limestone
Sandstone
Conglomerate, brecciaconglomerate
Flint concretions
Coal
Glauconite
Paleovocano
Volcanics ± sediments
Turbidites
Carpathian and Moesian basin
Cenomanian-Danian limestone-marl association
Cenomanian-Turonian marl association
Cenomanian-Turonian sandstone-limestone association
Turonian-Paleocene flysch association
Srednogorie basin
Upper Cenomanian-Campanian volcano-sedimentary association
Upper Cenomanian-Turonian flysch association
Turonian terrigenous-limestone association


Late Santonian
Vidin
Koula
Montana
Mezdra
Pleven
Lovech
Svishtov
Rousse
Silistra
Danube
Yantra
Dobrich
Shoumen
Balchik
Varna
Kamchiya
Veliko Tarnovo
Byala
Iskar
Sofia
Panagyurishte
Kotel
Sliven
Bourgas
Stara Zagora
Kyustendil
Tsarevo
Maritsa
Plovdiv
Blagoevgrad
Mesta
Strouma
Arda
Ivailovgrad
Coast line
Dry land
Front of Austrian orogen
Chalk-like limestone
LImestone
Clayey limestone
Marl
Sandy limestone
Sandsone
Flint concretions
Glauconite
Paleovocano
Volcanics ± sediments
Carpathian and Moesian basin
Cenomanian-Danian limestone-marl association
Upper Turonian-Campanian sandstone-limestone association
Upper Turonian-Lower Campanian terrige-nous-limestone association
Turonian-Paleocene flysch association
Srednogorie basin
Upper Cenomanian-Campanian volcano-sedimentary association
Coniacian-Maastrichtian limestone-marl association



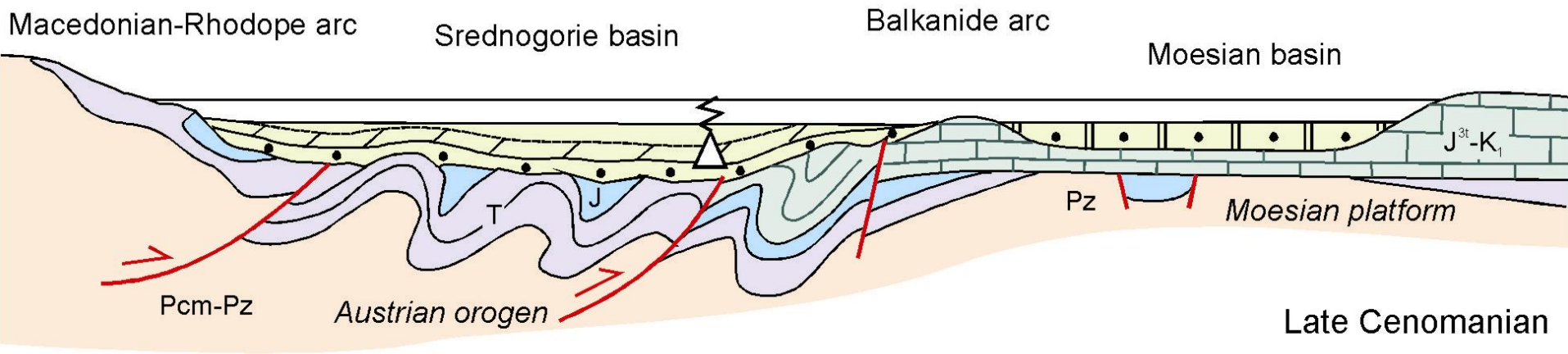
Carpathian and Moesian basin

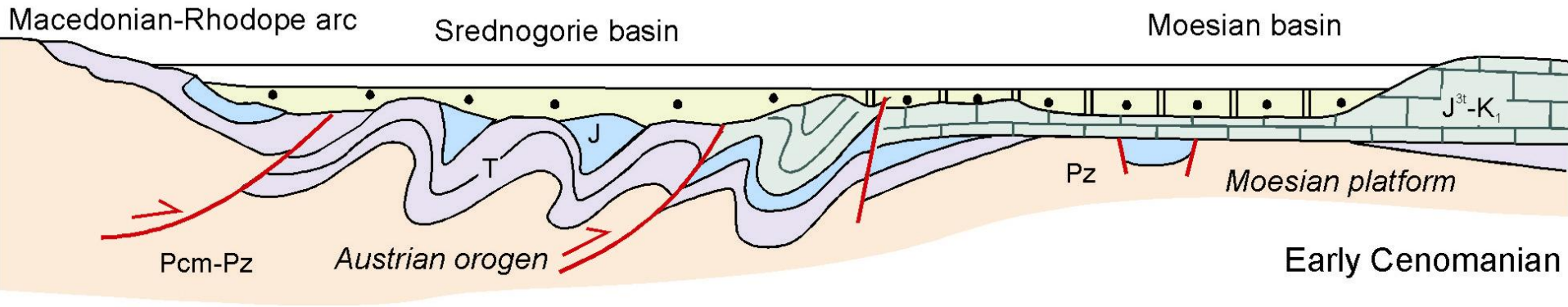
- Campanian-Paleocene glauconite-sandstone-limestone association
- Turonian-Paleocene flysch association
- Cenomanian-Danian limestone-marl assoication

Srednogorie basin

- Maastrichtian terrigenous-limestone association
- Campanian-Maastrichtian flysch association
- Coniacian-Maastrichtian limestone-marl association

Cartoons for the geodynamic evolution in Late Cretaceous times



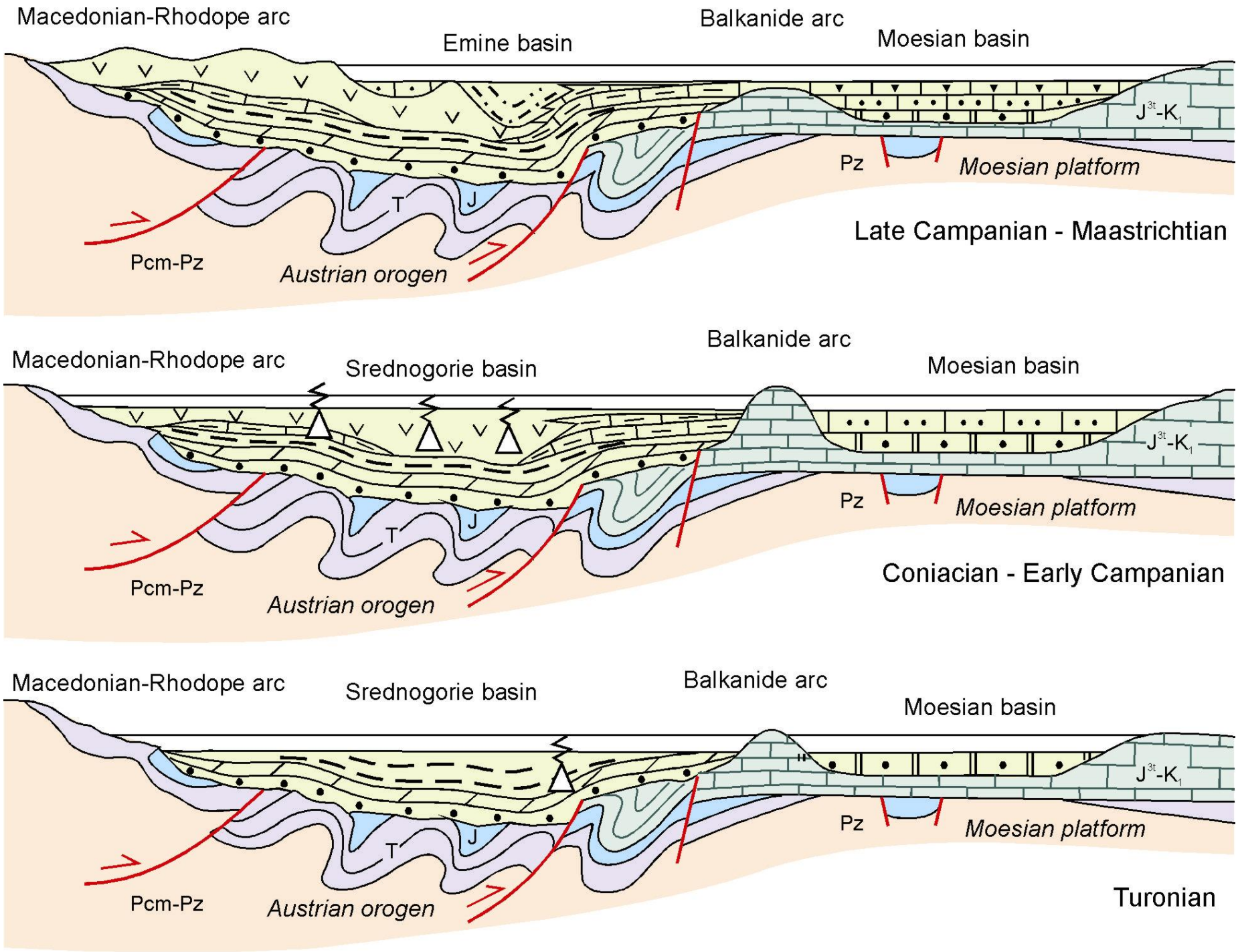


SREDNOGORIE BASIN

- U. Cenomanian - Campanian volcano-sedimentary association
- Upper Cenomanian - Turonian flysch/flyschoid association
- Upper Cenomanian marl association
- Lower Cenomanian terrigenous-shale-limestone association
- Maastrichtian terrigenous-limestone association
- Campanian - Maastrichtian flysch association
- Coniacian - Maastrichtian limestone-marl association

MOESIAN BASIN

- Campanian - Palaeocene glauconite-sandstone-limestone association
- Upper Turonian - Campanian sandstone - limestone association
- Cenomanian - Turonian sandstone - limestone association


Macedonian-Rhodope arc
Emine basin
Balkanide arc
Moesian basin
J3t-K1
Pz
Moesian platform
T
J
Pcm-Pz
Austrian orogen
Late Campanian - Maastrichtian
Macedonian-Rhodope arc
Srednogorie basin
Balkanide arc
Moesian basin
J3t-K1
Pz
Moesian platform
T
J
Pcm-Pz
Austrian orogen
Coniacian - Early Campanian
Macedonian-Rhodope arc
Srednogorie basin
Balkanide arc
Moesian basin
J3t-K1
Pz
Moesian platform
T
J
Pcm-Pz
Austrian orogen
Turonian