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MIDDLE JURASSIC-LOWER CRETACEOUS BIOSTRATIGRAPHY IN THE CENTRAL PONTIDES (TURKEY): REMARKS ON PALEOGEOGRAPHY AND TECTONIC EVOLUTION

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Riassunto. Nelle Pontidi, la deposizione dei carbonati del Giurassico-Cretacico Inferiore fu controllata dall' evoluzione di un margine continentale di tipo atlantico rivolto verso la Tetide. Lo studio di numerose sezioni stratigrafiche da scaglie e blocchi alloctoni del Melange Ofiolitico dell Anatolia Settentrionale, ha permesso di analizzare l'evoluzione paleogeografica delle Pontidi Centrali nel Giurassico Medio e nel Cretacico Inferiore. Le successioni Calloviane-Aptiane comprendono le seguenti biozone: *Globuligerina* gr. *oxfordiana*, *Clypeina jurassica* (equivalente alla zona a *Tubiphytes morronensis*), *Protopeneroplis ultragranulata* (inclusa la sottozona a *Haplophragmoides joukowskyi*), *Montsalevia salevensis*, *Hedbergella delrioensis* - *Hedbergella planispira* - *Leupoldina* - *Globigerinelloides* e *Globigerinelloides algerianus*.

Nelle successioni studiate vengono inoltre riscontrati due principali lacune stratigrafiche, corrispondenti ad età pre-Calloviano e Hauteriviano-Aptiano. Studi litostratigrafici e biostratigrafici documentano la presenza di notevoli analogie nell' evoluzione delle successioni nella regione di Amasya (Pontidi Centrali) e nel plateau di Biga-Bursa-Bilecick (Anatolia Nord Occidentale).

Abstract. The deposition of Jurassic-Lower Cretaceous carbonates in the Pontides was controlled mainly by the evolution of an Atlantic-type continental margin in the Tethys. The study of several stratigraphic sections from allochthonous slices and blocks of the North Anatolian Ophiolitic Melange provided insight into the Middle Jurassic-Early Cretaceous paleogeographic evolution of the Central Pontide Belt. The Callovian-Aptian successions span the *Globuligerina* gr. *oxfordiana*, *Clypeina jurassica* (equivalent of the *Tubiphytes morronensis* zone), *Protopeneroplis ultragranulata* (with the *Haplophragmoides joukowskyi* subzone), *Montsalevia salevensis*, *Hedbergella delrioensis* - *Hedbergella planispira* - *Leupoldina* - *Globigerinelloides* and *Globigerinelloides algerianus* biozones.

Two major stratigraphic gaps corresponding to the pre-Callovian and Hauterivian-Early Aptian ages are recognised within the successions. Lithostratigraphic and biostratigraphic studies indicate strong similarities in the evolution of the successions in the Amasya region (Central Pontides) and Biga-Bursa-Bilecik Platform (North-western Anatolia).

Introduction.

Tethyan ophiolites, Cretaceous ophiolitic melanges and Jurassic-Lower Cretaceous carbonates in northern Anatolia (Pontides) form a significant, continuous tectonic belt from the Vardar Zone (Aubouin, 1963), through the Izmir-Ankara-Erzincan Suture Belt (IAES) (Brinkmann, 1976; Sengör & Yilmaz, 1981), to the Sevan-Akera Zone (Adamia et al., 1977) (Fig. 1).

The Pontide Belt is an orogenic belt evolved since the Triassic by progressive accretion of continental terrains, with attached oceanic fragments, during the closure of the Paleo- and Neo-Tethyan oceans (Sengör &Yilmaz, 1981; Sengör, 1984). These overprinted processes and strike-slip tectonics made the central part of the Pontides much more fragmentary and complicated. The area under study lies within this fragmentary and complicated region, to the north of IAES (Fig. 1).

Jurassic-Lower Cretaceous units in the Central Pontides, between NAFZ and IAES (Fig. 1), were reported in several studies (Otkun, 1942; Blumenthal, 1950; Alp, 1972; Öztürk, 1979; Özcan et al., 1980; Rojay, 1993; 1995; Tüysüz, 1996).

Two different Liassic sequences underlying the Middle Jurassic-Lower Cretaceous carbonates were recognised in the southern Central Pontides, including the Amasya region (Blumenthal, 1950; Alp, 1972). Submarine volcanism is the major geologic criterion used to differentiate the two Liassic sequences. To the north of the Amasya region, submarine volcanism contributed to the Liassic deposition and continued to be active throughout the Middle Jurassic (Blumenthal, 1950; Alp, 1972; Öztürk, 1979; Özcan et al., 1980). However, evidence of submarine volcanism and units of Dogger age are missing in the Amasya region (Otkun, 1942; Blumenthal, 1950; Alp, 1972).

The unconformity between Upper Jurassic-Lower Cretaceous carbonates and Liassic clastics, together with an intra-Lower Cretaceous unconformity between the Neocomian and Aptian, have been documented in the

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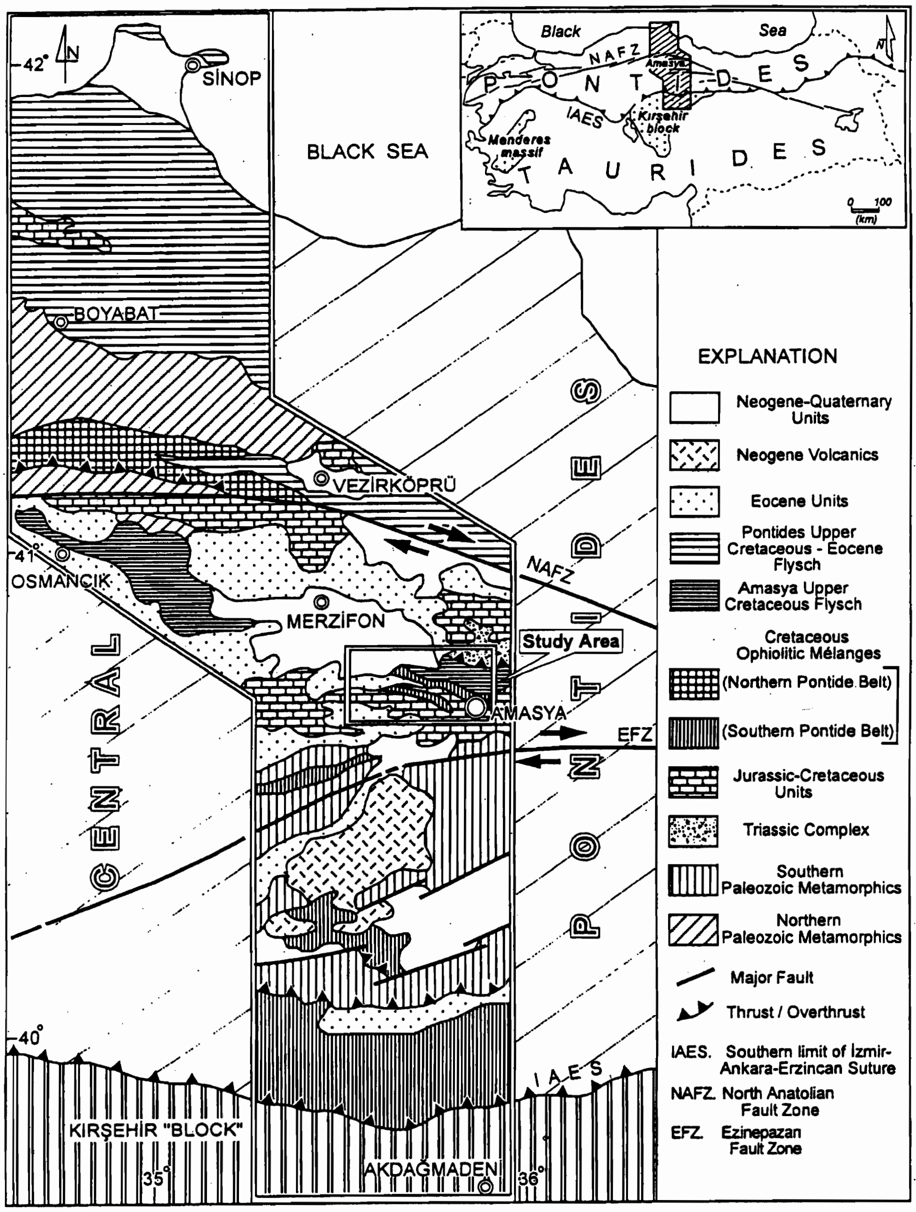


Fig. 1 - Simplified geologic map of the Central Pontides showing the major tectonic elements and location of the area under study.

Amasya region by several authors (Blumenthal, 1950; Alp, 1972; Öztürk, 1979; Özcan et al., 1980; Rojay, 1993; 1995; Tüysüz, 1996). The majority of the Upper Jurassic-Lower Cretaceous carbonate units were considered as tectonic slices and blocks within the Cretaceous ophiolitic melanges (Özcan et al., 1980; Kocyigit et al., 1988; Rojay, 1995; Tüysüz, 1996). Alternatively, the tectonic emplacement of these allochthonous carbonates has been interpreted as the result of regional "gravity tectonics" in the Amasya region (Alp, 1972).

Several studies carried out to the north of NAFZ (northern Central Pontides) report that the Malm-Lower Cretaceous units, which consist of a basal conglomerate (Bürnük Formation), shelf carbonates (Inalti Formation) and finally flyschoid clastics and carbonates (Caglayan Formation), unconformably overlie the pre-Malm crystalline basement rocks (Yilmaz, 1990; Tüysüz, 1990; Yilmaz & Tüysüz,. 1991). This succession displays a lithostratigraphic evolution considerably different from that of the Amasya region.

The stratigraphy and Tethyan plate tectonic evolution of the Central Pontides is still in question and needs further clarification. Consequently, the main focus of this paper will be the chronostratigraphic calibration of the Jurassic to Lower Cretaceous stratigraphy in this region, based on foraminiferal and algal biostratigraphy, followed by an interpretation of the Tethyan evolution in the Central Pontides.

Stratigraphy.

The tectonostratigraphic units of the Amasya region, distinguished by age, lithostratigraphic evolution, internal organisation and tectonic position, are grouped into two units, the pre-Campanian (allochthonous) and the Campanian-Neogene, respectively (Rojay, 1993; 1995). The pre-Campanian Units comprise pre-Liassic low-grade metamorphics, a Triassic sedimentary complex, Jurassic-Cretaceous clastics and carbonates, and a Cretaceous ophiolitic melange. The unconformably overlying Campanian-Neogene Units are characterised mainly by siliciclastic sedimentary sequences consisting of a Campanian-Maastrichtian forearc flysch sequence, Eocene molasse to peripheral basinal sequences and Plio-Pleistocene molasse deposits (Fig. 2, 3).

Within this stratigraphic frame, the Amasya Group, representing the main carbonate succession of the Phanerozoic of the Central Pontides, crops out extensively in the area under study (Fig. 3).

Amasya Group (Jka) (Amasya Kalke: Blumenthal, 1950).

The Amasya Group is a thick, predominantly carbonate sequence composed of: a) Liassic clastics, including bioclastic carbonates; b) Callovian-Valanginian carbonates, including Ammonitico Rosso facies at the base;

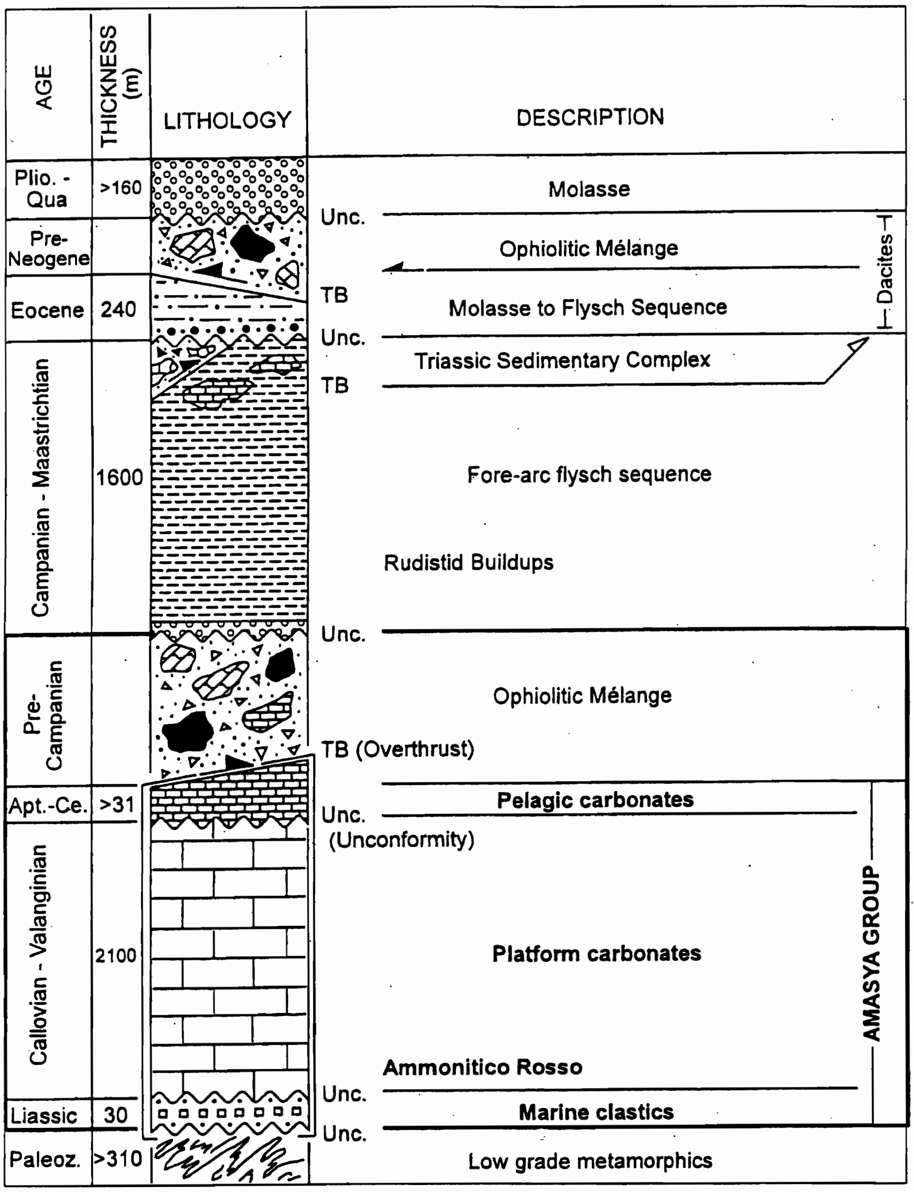


Fig. 2 - Simplified tectonostratigraphic log of the Amasya region showing the stratigraphic position of the Amasya Group (JKa) (Modified from Rojay, 1993; 1995).

followed. The Liassic sequence is overlain with a sharp boundary by Callovian carbonates.

b) The unconformably overlying *Callovian-Valanginian carbonates* consist of nodular limestones (Ammonitico Rosso facies) and shallow marine platform carbonates (Fig. 4). The Ammonitico Rosso facies contains ammonites, belemnites, thin-shelled bivalves and foraminifers in a micritic matrix. This facies shows a gradual upward transition to oolitic limestones that are dolomitized at the top of the sequence and then continues with characteristic oncolithic and foraminiferal-pelletoidal limestones (N of Vermis village section, Fig. 4). Shallowing-upward, cyclic carbonate deposition (meter-scale) is represented by alternations of oncolithic (locally breccioid) and pelecypod- and gastropod-rich limestones, and stromatolithic-pelletoidal and algal limestones. After a densely stylolitic limestone level, the sequence continues upward with oncolithic-algal limestones, gastropod-rich intraclastic limestones, algal to breccioid limestones, pelletoidal limestones and oncolithic limestones (Sel Creek and Yanìklìcal Hill sections, Fig. 4). Algal, miliolid and other foraminifer-bearing limestones constitute the top of the Callovian-Valanginian carbonates (Yassìcal Hill section, Fig. 4). The micritic matrix and faunal assemblage of the basal parts indicate a relatively deep, stagnant and pelagic depositional setting on an emerged pelagic plateau. However, the fragmentary nature and heterogeneous distribution of fossils indicate current action during the deposition. These observations suggest that the depositional setting is an open sea environment, likely related to an emerged pelagic plateau (Aubouin, 1965; Jenkyns & Hsü, 1974; Farinacci & Elmi, 1981). The predominance of intrabiomicrites and oomicrites in a shallow marine carbonate sequence indicates a deposition in a wide, sheltered lagoon behind some kind of a barrier, or an open shelf affected by only moderate to

and c) Aptian-Cenomanian deep-sea pelagic carbonates and turbidite clastics (Fig. 2).

a) The *Liassic clastics* consist of massive polygenetic conglomerates, bioclastic calcareous conglomerates-sandstones and detrital limestones rich in echinoid and crinoid debris with subordinate rock fragments set in sparry calcite cement. The carbonate debris consists mainly of fossil fragments. These bioclasts were transported, sorted and deposited as carbonate sand bodies. The presence of metamorphic quartz and metamorphic rock fragments in the clastic portions indicates a continental source, likely represented by the underlying low-grade metamorphics.

The deposition of Liassic clastics consisting of both continental and shallow marine facies was interrupted by a major unconformity in the central Amasya region. The development of a typical Atlantic-type margin sequence ceased and the region was uplifted. A considerable hiatus, spanning almost the entire middle Jurassic, low wave action. Shallow marine detritus, remains of gastropods, echinoids and bivalves are all fragmented and were probably swept off the platform by underwater currents. The virtual absence of frame-building, massive colonial corals and the presence of dasycladacean algae and encrusting blue-green algae suggest that algal-foraminiferal facies may have been the most common facies types in northern Turkey. Fossil evidence also indicates a wide range of depositional settings, from restricted lagoon to open sea carbonate platform.

c) The *Aptian-Cenomanian sequence* consists predominantly of pelagic carbonates and turbidite pelagic clastics, and unconformably overlies the shallow marine Valanginian carbonates (Amasya Castle and TCK Camping area, Fig. 4). From bottom to top, the succession is characterised mainly by *Nannoconus*-bearing limestones, alternations of radiolaria- and planktonic foraminifera-bearing limestones, radiolaria-bearing limestones and turbidite sandstones-marls-siltstones. The Aptian age of the *Nannoconus*-bearing part of the sequence was determined on the basis of pelagic foraminifers. The radiolaria and planktonic foraminifer-rich facies range from the latest Aptian to the Cenomanian, while the clastic portion of the sequence is Albian-Cenomanian in age. The planktonic biota and the lithology with microturbidites and slump structures indicate a tectonically active, deep sea, pelagic depositional setting (Bernoulli & Jenkyns, 1974). The relationship between the direct onlap and overlap of the unit and the underlying platform carbonates possibly indicate a sudden deepening as a result of block faulting during the pre-Aptian period, and a progressive supply of sediments onto the sunken carbonate platform, likely through deep sea canyons. The lack of erosional features on the platform and the absence of carbonate clasts with shallow marine biota in the pelagic successions overlying the platform carbonates may indicate non-deposition (due to sweeping of underwater currents), sudden deepening (due to block faulting) or the occurrence of both processes.

Biostratigraphy.

The biostratigraphic framework of the Jurassic-Lower Cretaceous carbonates in the Amasya region is based on benthic and planktonic foraminifera and algae. It includes 4 zones and 2 subzones in the Callovian-Valanginian pelagic to shallow marine carbonates and 2 zones in the Aptian pelagic carbonates (Fig. 4). This biozonation scheme is nearly identical to that of the Biga-Bursa-Bilecik (BBB) platform (Altiner, 1991). The fundamental difference between the biozonation scheme of the Amasya and BBB platform is the presence of the Kimmeridgian-Tithonian *Clypeina jurassica* Zone in the Amasya region, corresponding chronostratigraphically to the *Tubiphytes morronensis* Zone in the BBB platform, and the general absence of Upper Valanginian-Barremian Zones, corresponding to a stratigraphic gap in the Amasya region (Fig. 4).

The Jurassic-Lower Cretaceous biostratigraphy in the Amasya region was studied along seven stratigraphic sections and with a large number of spot samples (Fig. 3, 4).

Zone I (*Globuligerina* gr. *oxfordiana* Zone).

The zone was recognised in the lowermost portion of the Jurassic-Lower Cretaceous carbonates, unconformably overlying the Liassic clastics (N of Vermis village section, Fig. 3, 4). The upper limit is poorly defined because of intense dolomitization. In addition to the consistent presence of *Globuligerina* gr. *oxfordiana* (Grigelis) (Pl. 1, fig. 1-3), the zone also contains *Globuligerina* sp. (Pl. 1, Fig. 4), *Palaeomiliolina strumosum* (Gümbel), *Ophthalmidium* sp., *Reophax* sp., *Spirillina* sp. and *Globochaete alpina* Lombard.

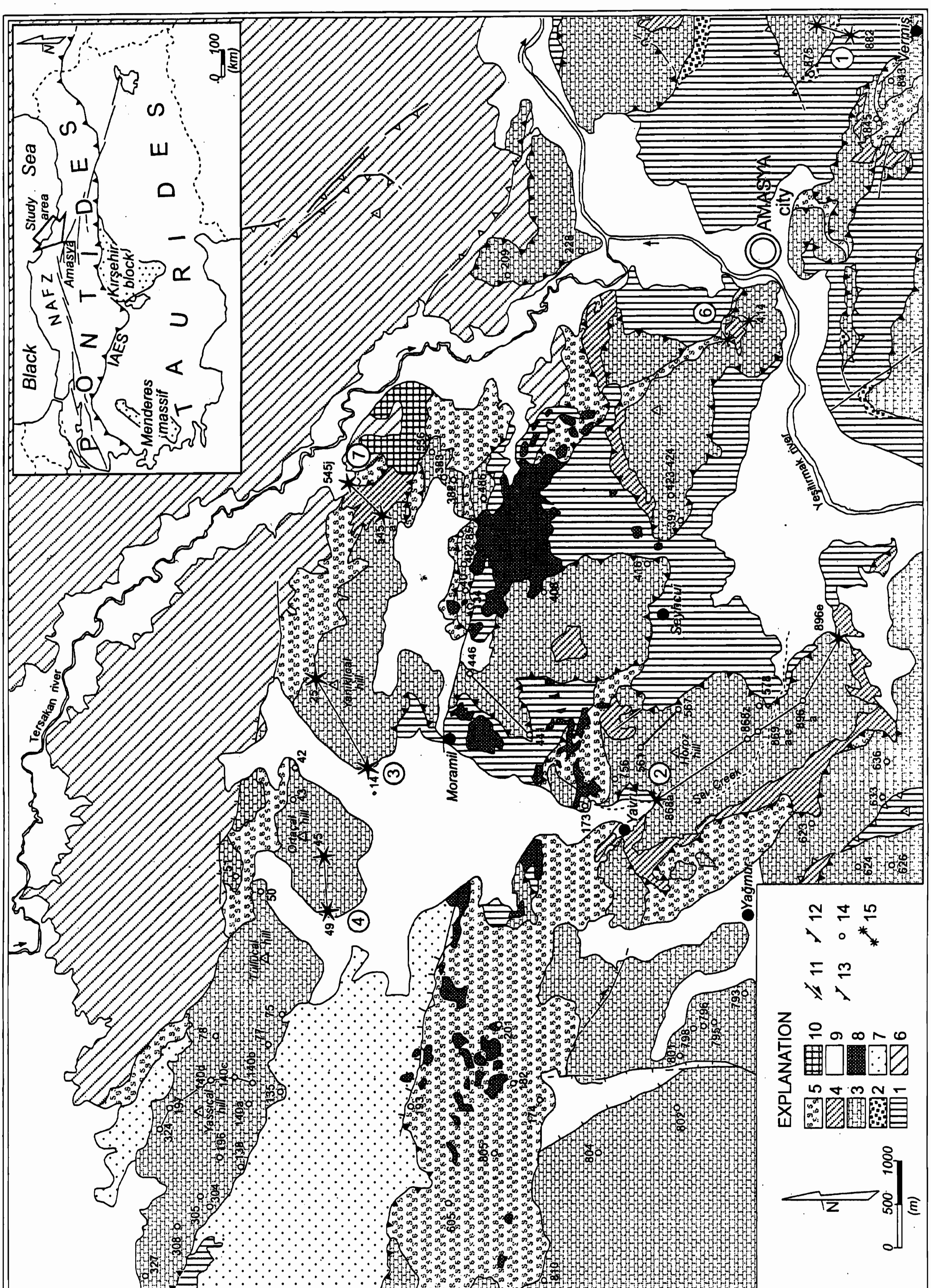
The association is nearly identical to that of the *Globuligerina* gr. *oxfordiana* Zone (Altiner, 1991) which is calibrated with the presence of Callovian and Oxfordian ammonites in the BBB platform (Cope, 1991). It should be noted that previously this characteristic lithostratigraphic horizon (Ammonitico Rosso facies) was dated imprecisely as Sinemurian-Toarcian, based on ammonites in the Amasya region (Alp, 1972).

Zone II (*Clypeina jurassica* Zone).

The *Clypeina jurassica* Zone, attainining a thickness of more than 1000 m in the Amasya region, is a well known biostratigraphic unit within the Mediterranean realm (Sartoni & Crescenti, 1962; Farinacci & Radoicic, 1964; Nikler & Sokac, 1968; Gusic, 1969; Velic, 1977; Altiner et al., 1986; Chiocchini et al., 1994). Although the lower limit is not defined precisely, the upper boundary is clear and marked by the first appearance of *Protopeneroplis ultragranulata* (Gorbatchik).

The zone was studied in three sections in the Amasya region (N of Vermis village, Sel Creek and Ya-

Fig. 3 - Geologic map showing sample locations and measured sections. 1. pre-Liassic low-grade metamorphics, 2. Liassic clastics, 3. Callovian-Valanginian platform carbonates, 4. Aptian-Cenomanian pelagic carbonates, 5. Cretaceous ophiolitic melange, 6. Campanian-Maastrichtian forearc sequences, 7. Lutetian sequences, 8. Neogene dacitic intrusions, 9. Pliocene-Quaternary units, 10. Quaternary travertine, 11. Fault, 12. Thrust, 13. Overthrust, 14. Spot sample location, 15. Line of measured section; the number corresponds to the sections of Fig. 4.


Black Sea
Study area
NAFZ
Amasya
IAES
Kırşehir block
Menderes massif
PONTIDES
TAURIDES
0 100 (km)
Tersakan river
AMASYA city
Yeşilırmak river
Moramil
Yavru
Yağmur
Vermiş
Horoz hill
EXPLANATION
0 500 1000 (m)

niklical Hill sections, Fig. 3, 4). It contains a rather diversified microfauna composed mostly of foraminifers and algae: *Earlandia* sp., *Glomospira* sp., *Ammobaculites* sp., *Nautiloculina oolithica* Möhler, *Mesoendothyra izjumiana* Dain (Pl. 1, fig. 6-7), *Charentia* sp., *Valvulina lugeoni* Septfontaine, Ataxophragmiidae, *Alveosepta* gr. *jaccardi* (Schrodt) (Pl. 1, fig. 8-10), *Rectocyclammina* ? sp., *Trocholina alpina* (Leupold), *Trocholina* sp., *Everticyclammina* sp., Miliolidae, *Clypeina jurassica* (Favre) (Pl. 1, fig. 4), *Salpingoporella annulata* Carozzi, *Cayeuxia* sp. and *Favreina* sp.

The *Clypeina jurassica* Zone of the Amasya region is the chronostratigraphic equivalent of the *Tubiphytes morronensis* Zone of the BBB platform. Both zones extend between the *Globuligerina* gr. *oxfordiana* and *Protopeneroplis ultragranulata* Zones. In the BBB platform, the first appearances of *Tubiphytes morronensis* Crescenti and *Protopeneroplis ultragranulata* were calibrated with ammonites as Kimmeridgian (Altiner 1991; Cope, 1991) and with calpionellids as Late Tithonian (A2 subzone; Altiner & Özkan, 1991), respectively. Therefore, the *Clypeina jurassica* Zone, as defined in this study, is considered to represent the Kimmeridgian-Upper Tithonian interval.

Subzone IIa (*Mesoendothyra izjumiana - Alveosepta - Labyrinthina -Protopeneroplis striata* Subzone).

The lower part of the *Clypeina jurassica* Zone in the Amasya region is characterised by two frequently occurring important markers of the Kimmeridgian, namely *Alveosepta* gr. *jaccardi* (Pl. 1, fig. 8-10) and *Mesoendothyra izjumiana* (Pl. 1, fig. 4-7). This subzone was calibrated with Kimmeridgian ammonites in the BBB platform, Mudurnu Trough and Aktas-Sekinindoruk High in NW Anatolia (Altiner, 1991; Altiner et al., 1991; Cope, 1991). The other two zonal markers, i.e. *Labyrinthina* and *Protopeneroplis striata* Weynschenk, were not recorded in the N of Vermis village and Sel Creek sections (Fig. 3, 4).

Zone III (*Protopeneroplis ultragranulata* Zone).

This zone is characterised as an interval between the successive appearances of *Protopeneroplis ultragranulata* (Pl. 1, fig. 11-13) and *Montsalevia salevensis* (Charollais, Brönnimann and Zaninetti) (Pl. 1, fig. 16-18). It contains a diversified foraminiferal fauna and algal flora, almost identical to those of the BBB platform, Mudurnu Trough and Aktas-Sekinindoruk High in NW Anatolia (Altiner, 1991; Altiner et al., 1991). The fossils are *Earlandia brevis* Arnaud-Vanneau, *Earlandia* sp., *Protopeneroplis ultragranulata* (Pl. 1, fig. 11-13), *Ammobaculites* sp., *Feurtilia* sp., *Everticyclammina* sp., *Pseudocyclammina lituus* Yokoyama, *Pseudocyclammina* sp., *Haplophragmoides joukowskyi* Charollais, Brönnimann and Zaninetti (Pl. 1, fig. 14-15), *Mayncina* sp., *Dobrogelina* sp., *Valvulina* sp., *Belorussiella* sp., Ataxophragmiidae, *Textularia* sp., *Quinqueloculina* cf. *robusta* Neagu, *Hechtina* sp., Miliolidae, *Trocholina odukpaniensis* Dessauvagie, *Trocholina alpina* (Leupold), *Trocholina elongata*, *Trocholina delphinensis* Arnaud-Vanneau, Boisseau and Darsac, *Trocholina* sp. and *Salpingoporella annulata*.

In the Amasya region, the *Protopeneroplis ultragranulata* Zone was recognised in the Sel Creek, Yaniklical Hill, Ortacal Hill and Yassical Hill sections (Fig. 3, 4). In the Sel Creek and Yaniklical Hill sections, the succession is truncated by an unconformity surface and followed by uppermost Aptian to Cenomanian pelagic units. The upper boundary of the zone was recognised only along the Yassical Hill section, where the levels containing the first *Montsalevia salevensis* overlie the *Protopeneroplis ultragranulata* Zone.

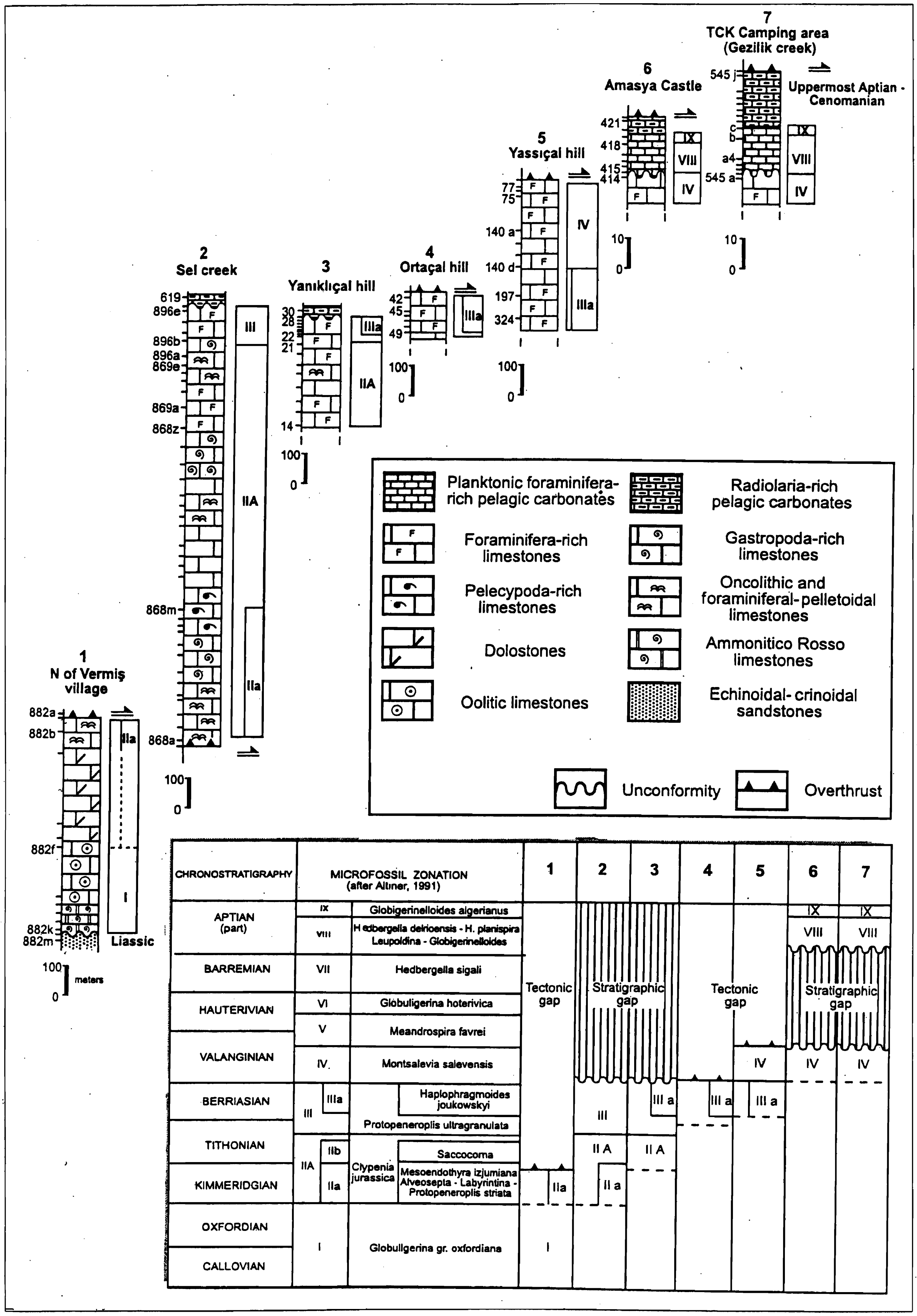
The successive occurrences of *Protopeneroplis ultragranulata* and *Montsalevia salevensis* were calibrated by calpionellids in NW Anatolia (Altiner, 1991; Altiner & Özkan, 1991). The first appearance of the former species was dated as Late Tithonian (A2 subzone of calpionellids). Therefore, the *Protopeneroplis ultragranulata* Zone is considered to represent the Upper Tithonian-Berriasian interval in the Amasya region.

Subzone IIIa (*Haplophragmoides joukowskyi* Subzone).

This subzone was defined in NW Anatolia as the interval between the first appearance of *Haplophragmoides joukowskyi* (Pl. 1, fig. 14-15) and the appearance of *Montsalevia salevensis* (Pl. 1, fig. 16-18) (Altiner, 1991). In the Amasya region, a similarly defined subzone contains most of the taxa already quoted in the *Protopeneroplis ultragranulata* Zone. Among them, the appearance of *Trocholina delphinensis* might be significant for the identification of the subzone.

The subzone was recognised in the Yaniklical Hill, Ortacal Hill and Yassical Hill sections. In its type section (Mudurnu Trough, NW Anatolia), the subzone was calibrated by the C, D1, D2 and part of D3 calpionellid zones and subzones (Altiner, 1991; Altiner & Özkan, 1991) and represents the Berriasian stage. The chronostratigraphic value of the first appearance of *Protopeneroplis ultragranulata*, which probably corresponds to a

Fig. 4 - Biostratigraphic correlation of the measured stratigraphic sections of the Amasya Group. Each measured section is correlated on the basis of Altiner (1991) which is slightly modified by replacing Zone II (*Tubiphytes morronensis* Zone) of Altiner (1991) with Zone IIA (*Clypeina jurassica* Zone) of this study. Ticks on the columns indicate the levels sampled.



1
N of Vermiş village
882a
882b
882f
882k
882m
IIa
I
Liassic
100
0
meters
2
Sel creek
619
896e
896b
896a
869e
869a
868z
868m
868a
III
IIA
IIa
100
0
3
Yanıklıçal hill
30
28
22
21
14
IIIa
IIA
100
0
4
Ortaçal hill
42
45
49
IIIa
100
0
5
Yassıçal hill
77
75
140 a
140 d
197
324
IV
IIIa
100
0
6
Amasya Castle
421
418
415
414
IX
VIII
IV
10
0
7
TCK Camping area
(Gezilik creek)
545 j
c
b
a4
545 a
Uppermost Aptian - Cenomanian
IX
VIII
IV
10
0
Planktonic foraminifera-rich pelagic carbonates
Radiolaria-rich pelagic carbonates
Foraminifera-rich limestones
Gastropoda-rich limestones
Pelecypoda-rich limestones
Oncolithic and foraminiferal-pelletoidal limestones
Dolostones
Ammonitico Rosso limestones
Oolitic limestones
Echinoidal-crinoidal sandstones
Unconformity
Overthrust
CHRONOSTRATIGRAPHY
MICROFOSSIL ZONATION (after Altıner, 1991)
1
2
3
4
5
6
7
APTIAN (part)
IX
Globigerinelloides algerianus
VIII
Hedbergella delrioensis - H. planispira
Leupoldina - Globigerinelloides
BARREMIAN
VII
Hedbergella sigali
HAUTERIVIAN
VI
Globuligerina hoterivica
V
Meandrospira favrei
VALANGINIAN
IV
Montsalevia salevensis
BERRIASIAN
III
IIIa
Haplophragmoides joukowskyi
Protopeneroplis ultragranulata
TITHONIAN
IIA
IIb
Saccocoma
KIMMERIDGIAN
IIa
Clypenia jurassica
Mesoendothyra izjumiana
Alveosepta - Labyrintina -
Protopeneroplis striata
OXFORDIAN
CALLOVIAN
I
Globuligerina gr. oxfordiana
Tectonic gap
Stratigraphic gap
Tectonic gap
Stratigraphic gap
III
III a
III a
III a
II A
II A
II a
II a
IV
IV
IV
VIII
VIII
IX
IX
I

well-defined datum in the Tithonian, was emphasised by data from Sicily (Italy) (Bucur et al. 1996).

Zone IV (*Montsalevia salevensis* Zone).

The zone, which was originally defined as the interval between the successive first appearances of *Montsalevia salevensis* and *Meandrospira favrei* Charollais, Brönnimann and Zaninetti (Altiner, 1991), is unconformably overlain by lower Aptian pelagic units in the Amasya region (Fig. 4). In addition to *Montsalevia salevensis* (Pl. 1, fig. 16-18), the other foraminifer associations are *Earlandia* sp., *Haplophragmoides joukowskyi* (Pl. 1, fig. 14-15), *Quinqueloculina* cf. *robusta* and *Trocholina* spp.

The rock unit representing the Valanginian was recognised in the Yassical Hill, Amasya Castle and TCK camping area sections in the Amasya region (Fig. 3, 4). The chrono-stratigraphic calibration of the zone was made with calpionellids in the Mudurnu Trough (NW Anatolia) (Altiner, 1991; Altiner & Özkan, 1991). When it is associated with calpionellids, *Montsalevia salevensis* appears in the upper part of the D3 subzone and disappears above the E Zone, corresponding to the latest occurrence of *Tintinnopsella carpathica* (Murgeanu and Filipescu) (F Zone of Altiner & Özkan, 1991).

Zone VIII (*Hedbergella delrioensis - Hedbergella planispira - Leupoldina -Globigerinelloides* Zone).

The pelagic carbonate succession in the Amasya region (Amasya Castle and TCK camping area sections, Fig. 3, 4), unconformably overlying the *Montsalevia salevensis* Zone, contains at its base an assemblage of planktonic foraminifera comprising *Hedbergella delrioensis* (Casey) (Pl. 1, fig. 19-22), *Hedbergella planispira* (Tappan), Favusellidae, *Leupoldina cabri* (Sigal), *Globigerinelloides ferroelensis* (Moullade) (Pl. 1, fig. 28-29) and *Globigerinelloides* spp. This interval, whose upper boundary is marked by the appearance of *Globigerinelloides algerianus* Cushman and Ten Dam (Pl. 1, Fig. 30), is identical to Zone VIII, defined in the Sogukcam Limestone, a lithostratigraphic unit widely exposed in NW Anatolia (Altiner, 1991).

The chronostratigraphic interval of the Zone is defined by the appearance of the taxa quoted above (Caron, 1985; Sliter, 1989; Altiner, 1991) and corresponds to the Lower to Upper Aptian.

Zone IX (*Globigerinelloides algerianus* Zone).

This Zone, introduced in NW Anatolia as the total range interval of *Globigerinelloides algerianus* (Altiner, 1991), was recognised also in the Amasya Castle and TCK camping area sections. The planktonic foraminifers recognised in the Zone are *Globigerinelloides algerianus* (Pl. 1, fig. 30) *Globigerinelloides ferroelensis* (Pl. 1, fig. 28-29), *Hedbergella delrioensis* (Pl. 1, fig. 19-22), *Hedbergella planispira* (Pl. 1, fig. 24), *Hedbergella gorbachikae* Longoria (Pl. 1, fig. 27), *Hedbergella trocoidea* (Gandolfi) (Pl. 1, fig. 25-26) and *Hedbergella* spp.

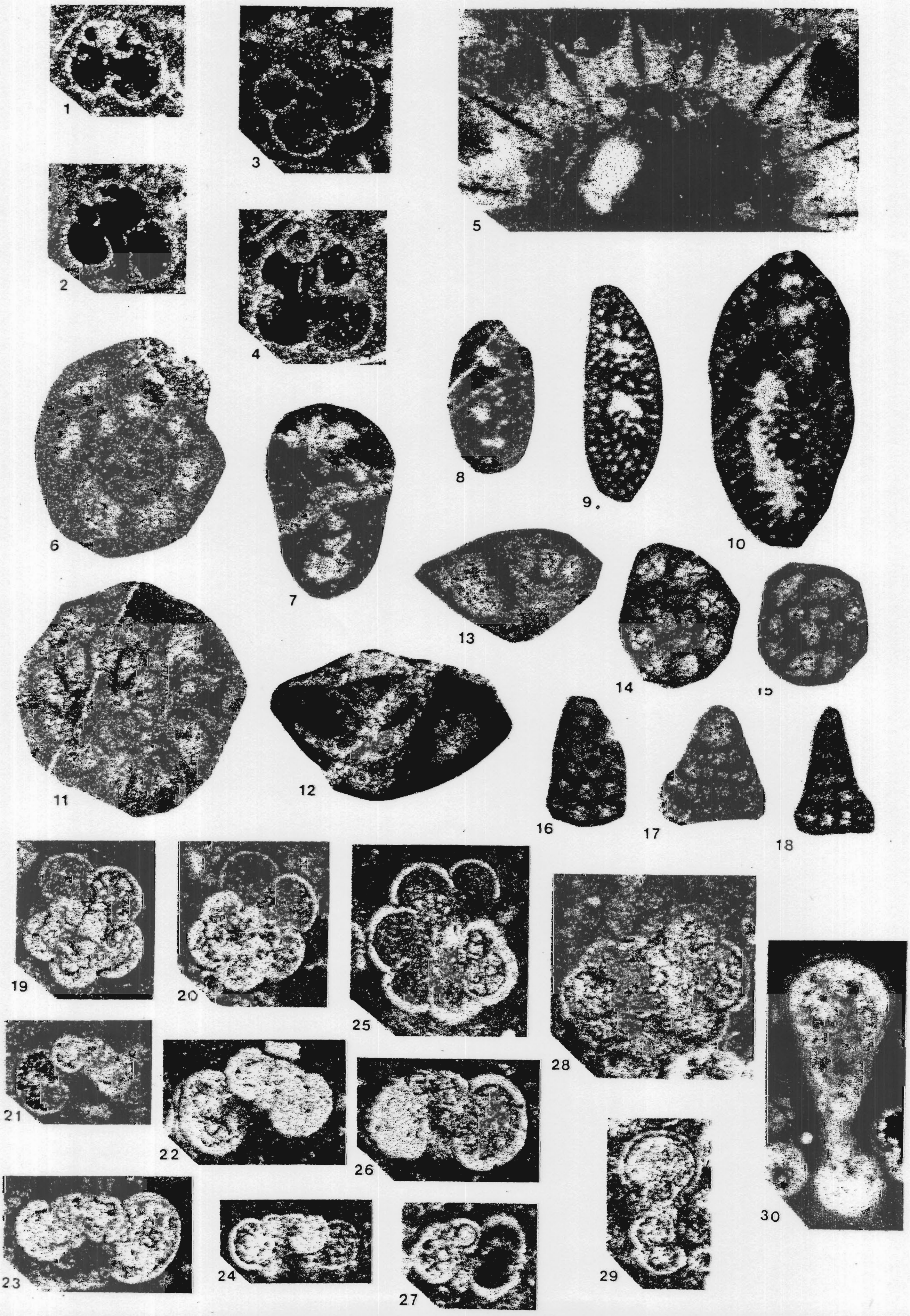
Several authors agree on the chronostratigraphic value of *Globigerinelloides algerianus*, which is a Late Aptian index fossil (Moullade, 1966; Longoria, 1974; Van Hinte, 1976; Sigal, 1977; Caron, 1985; Sliter, 1989; Altiner, 1991; Chiocchini et al., 1994).

In the Amasya region, the continuation of the pelagic carbonates characterised by radiolaria-bearing limestones and sandstone-marl-siltstone of turbidite origin was not zoned in this study. The radiolaria-bearing limestones either directly overly the *Globigerinelloides algerianus* Zone (Amasya Castle and TCK camping area sections, Fig. 4) or rest unconformably on the *Protopeneroplis ultragranulata* Zone (Sel Creek and Yaniklical Hill sections, Fig. 4). The ophiolitic melange of pre-Middle Campanian age tectonically overlies the unit upper boundary (Kocyigit et al., 1988) (Fig. 2, 3, 4). In addition to Radiolaria and *Pithonella*, more evolved planktonic foraminifer assemblages are present in the succession, including post-Aptian hedbergellid forms, *Praeglo-*

PLATE 1

Callovian - Aptian microfossil assemblage from the Central Pontides.

Fig. 1-3 - *Globuligerina* gr. *oxfordiana* (Grigelis) (Sample No:882k, X 200).
Fig. 4 - *Globuligerina* sp. (Sample No:882b, X 200).
Fig. 5 - *Clypeina jurassica* (Favre) (Sample No:868w, X 90).
Fig. 6-7 - *Mesoendothyra izjumiana* Dain (Sample No:868c,d, X 110).
Fig. 8-10 - *Alveosepta* gr. *jaccardi* (Schrodt) (Sample No:882b, 868b, X 60).
Fig. 11-13 - *Protopeneroplis ultragranulata* (Gorbatchik) (Sample No:545o,b, X100).
Fig. 14-15 - *Haplophramoides joukowskyi* Charollais, Brönnimann and Zaninetti (Sample No:545o,a, X 110).
Fig. 16-18 - *Montsalevia salevensis* (Charollais, Brönnimann and Zaninetti) (Sample No:545o,a, X 110).
Fig. 19-22 - *Hedbergella delrioensis* (Carsey) (Sample No:545b,e, X 110).
Fig. 23 - *Hedbergella* sp.(Sample No:545b, X 200).
Fig. 24 - *Hedbergella planispira* (Tappan) (Sample No:545b,c, X 200).
Fig. 25-26 - *Hedbergella trocoidea* (Gandolfi) (Sample No:545b, X 200).
Fig. 27 - *Hedbergella gorbachikae* Longoria (Sample No:545b, X 200).
Fig. 28-29 - *Globigerinelloides ferreolensis* (Moullade) (Sample No:545b, X 200).
Fig. 30 - - *Globigerinelloides algerianus* Cushman and Ten Dam (Sample No: 545b, X 200).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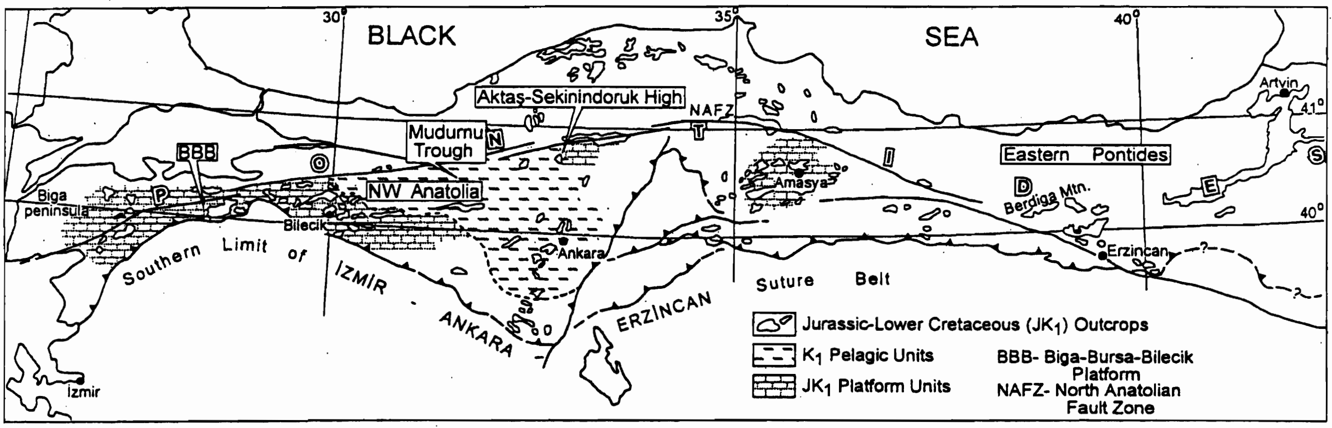

Fig. 5 - Simplified paleogeographic map of the Pontides showing the distribution of the Jurassic-Lower Cretaceous rock units of the Biga-Bursa-Bilecik Platform, Mudurnu Trough, Aktas-Sekinindoruk High (see Altiner et al., 1991; Kocyigit et al., 1991a) and Amasya region.

botruncana stephani (Gandolfi), *Praeglobotruncana gibba* Klaus, *Rotalipora greenhornensis* (Morrow), *Rotalipora* spp. A latest Aptian to Cenomanian age is attributed to the succession considering also the deposits overlying the *Globigerinelloides algerianus* Zone.

Jurassic-Early Cretaceous evolution of the Central Pontides in the Amasya region.

The Jurassic - Early Cretaceous interval is one of the most active periods in the evolution of the Neo-Tethys. The margins of the Northern Continents (Rhodope-Pontide and Sakarya Fragments) were passive throughout the entire Jurassic, but started to be destroyed by the Cretaceous subduction. The Tauride-Anatolide Platform and Northern Continents continued to converge and collided during the Cretaceous-Paleogene period in the Amasya region.

The Jurassic-Early Cretaceous Neo-Tethyan evolution began with the deposition of Liassic siliciclastics and detrital carbonates (Liassic transgression) on the rifted pre-Triassic basement of the Central Pontides (Blumenthal, 1950; Rojay, 1995) as recorded in NW Anatolia (Kruhensky et al., 1980; Altiner et al., 1991; Kocyigit et al., 1991a; 1991b), in the Ankara region (Kocyigit, 1987) and in the Eastern Pontides (Robinson et al., 1995) (Fig. 5, 6).

Liassic rifting and transgression ceased, and the platform in the central Amasya region was uplifted to form a high-standing area, while the rate of ongoing rifting increased to the north and south (Alp, 1972; Öztürk, 1979; Özcan et al., 1980). A paleo-high thus emerged in the central Amasya region during the post-Liassic-pre-Callovian time. While sedimentation ceased and erosion affected the paleo-high, submarine volcanism contributed extensively to the deposition of the Liassic-Dogger clastic sequence in the north (Öztürk, 1979; Özcan et al., 1980).

The uplifted, eroded platform turned into an open marine depositional realm as a result of a sudden onsetting of subsidence during the Callovian. As rifting continued, the deposition of Ammonitico Rosso facies took place in an open marine, pelagic environment during the Callovian-Oxfordian interval (Fig. 6). However, this period of deepening, which resulted in an open marine to pelagic depositional environment, was followed by a regressive, restricted carbonate platform deposition. A lagoonal to tidal flat-subtidal environment, without the volcanic influx present in the Eastern Pontides (Robinson et al., 1995), developed during the Kimmeridgian-Valanginian, indicating sea-level fluctuations triggered by regional tectonics.

After a short period of non-deposition and/or sweeping by currents, the ongoing block faulting during the Aptian-Cenomanian produced a deepening of the basin, with deposition of deep-sea pelagic sediments and pelagic turbidites on the uplifted, tilted and faulted Callovian-Valanginian carbonate platform (Fig. 6). The passive (Atlantic-type) margin was destroyed during post-Cenomanian - pre-Campanian time in the Amasya region and turned into an active continental margin as a result of the northward subduction of the northern Neo-Tethyan oceanic crust beneath the Pontides. The accreted ophiolitic mass and the associated Jurassic to Lower Cretaceous carbonates were unconformably overlain by the middle Campanian-Maastrichtian forearc units (Kocyigit et al., 1988; Rojay, 1995).

Conclusion.

The geologic evolution of the Amasya region in the Pontides is a good example of a block-faulted Atlantic-type passive margin in the Mesozoic. Its Jurassic-Cretaceous evolution is marked by four main unconformities, namely pre-Liassic, pre-Callovian, pre-Aptian and pre-middle Campanian, which are all biostratigraphically calibrated.

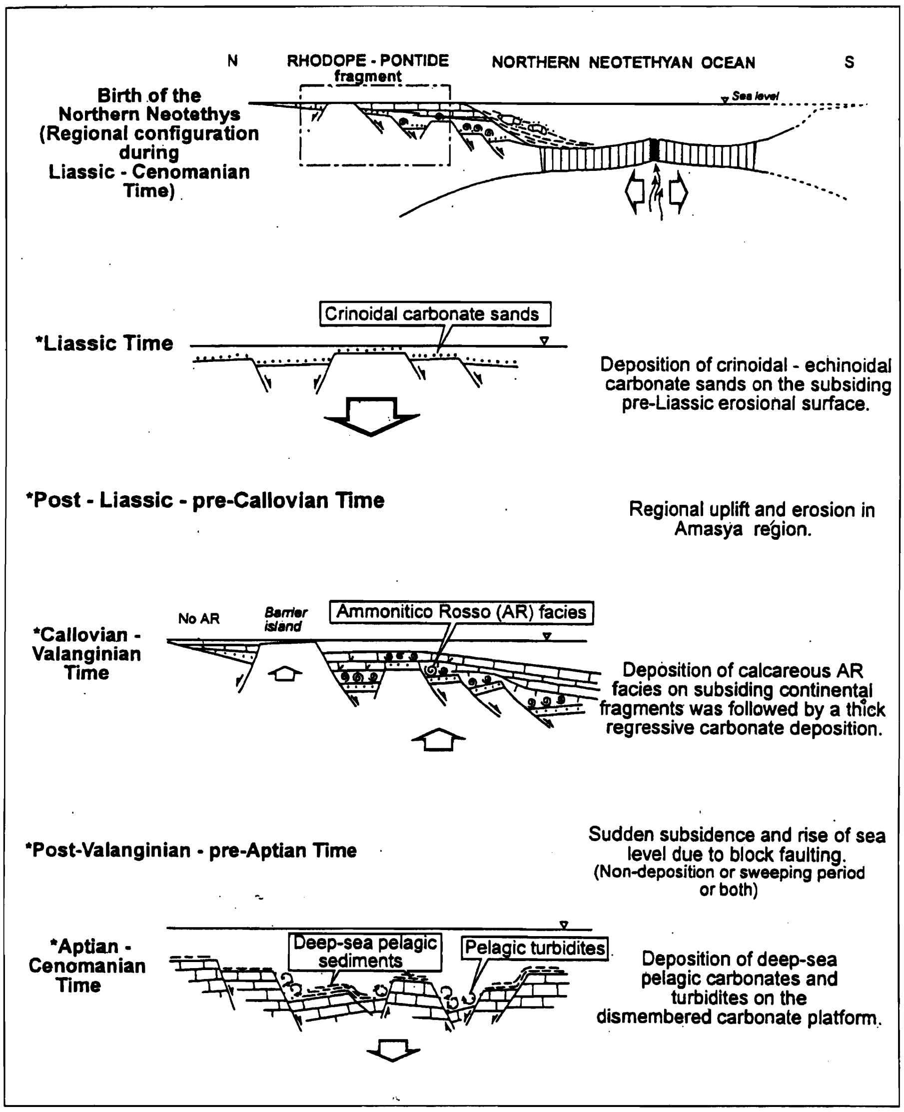

Fig. 6 - Tentative sketch of cross sections depicting the Atlantic-type continental margin evolution in the northern branch of the Neo-Tethys in the Amasya region during the Liassic-Cenomanian interval.

The pre-Liassic basement of the Central Pontides in the Amasya region was unconformably overlain by the Liassic siliciclastic-detrital carbonate sands (echinoid-crinoid sands) which were deposited during the initial rifting phase in the Amasya region.

After the aborted Liassic rifting in the central Amasya region, an intra-Jurassic unconformity was recorded by the deposition of Callovian Ammonitico Rosso facies (*Globuligerina* gr. *oxfordiana* Zone) over the Liassic detrital carbonate sands, indicating a new phase of sudden subsidence.

After the deposition of Ammonitico Rosso facies, the platform carbonate deposition continued with a regressive trend until the end of the Valanginian, that is represented by *Clypeina jurassica*, *Protopeneroplis ultragranulata* and *Montsalevia salevensis* Zones. After a period of non-deposition or sweeping by underwater currents, which was noted by the absence of the *Meandrospira favrei*, *Globuligerina hoterivica* and *Hedbergella sigali* Zones, the platform subsided and was unconformably overlain by Aptian-Cenomanian deep-sea pelagic sediments and turbidite pelagic clastics. The Aptian is represented by the *Hedbergella delrioensis* - *Hedbergella planispira* - *Leupoldina* - *Globigerinelloides* and *Globigerinelloides algerianus* Zones.

The biozonation in the Amasya region is nearly identical to that of the BBB platform. The fundamental difference between the biozonation patterns in the Amasya region and BBB platform is the presence of the Kimmeridgian-Tithonian *Clypeina jurassica* Zone in the Amasya region, which corresponds chronostratigraphically to the *Tubiphytes morronensis* Zone in the BBB platform, and the general absence of Upper Valanginian to Barremian zones that correspond to a stratigraphic gap in the Amasya region.

These close biostratigraphic similarities between the BBB Platform and Amasya Region, suggest that both paleogeographic domains were part of the same carbonate platform which extended from the western to the central Pontides.

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