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Biogeographic distribution of rudists and benthic foraminifera: An approach to Campanian-Maastrichtian palaeobiogeography of Turkey☆

Distribution biogéographique des rudistes et foraminifères benthiques : une approche paléobiogéographique du Campanien-Maestrichtien de Turquie

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Abstract

Transgressive sequences of Campanian-Maastrichtian Stages in Turkey generally begin with medium- to coarse-grained clastics and continue with shallow marine limestones, reefal limestones and then open marine rhythmic fine-grained clastics. These mixed siliciclastic-carbonate sequences are observed on three main platforms known as Rhodope-Pontide (RPP), Anatolide-Tauride (ATP) and Arabian (AP). New species of the rudist genera *Gorjanovicia, Radiolites, Sauvagesia, Durania* and *Sabinia* are observed on the RPP. *Yvaniella* and *Ugarella* are only found on this platform. *Orbitoides gruenbachensis* Papp is the most abundant species of benthic foraminifera on the RPP. *Cideina soezerii* (Sirel), *Dizerina anatolica* Meriç, *Helicorbitoides boluensis* Sirel, *Ilgazina unilateralis* Erdoğan, *Nummofallotia kastamonica* Özgen-Erdem, *Selimina spinalis* İnan, *Sirelina orduensis* Meriç and İnan, *Smoutina cruysi* Drooger are also observed on this platform. Rudist and benthic foraminifera on the ATP have both high diversity and abundance in comparison with RPP and AP faunas. Genus and species diversity of the rudist fauna is quite high: 17 genera and 36 species are described. New rudist genera such as *Darendeella*, *Kurtinia* and *Balabania* and many new species of Radiolitidae and Hippuritidae may be restricted to this platform. Characteristic larger benthic foraminifera contain 18 genera and 37 species. Among benthic foraminifera *Loftusia ketini* Meriç, *L. turcica* Meriç and Avşar, *Postomphalocyclus merici* İnan and *Pseudoedomia hekimhanensis* Görmüş are also likely restricted to this platform. Rudist diversity on the AP is poor. Four endemic genera (*Vautrinia, Dictyoptychus*, *Paracaprinula* and *Hatayia*) and two species (*Hippurites syriaca* Vautrin, *Pironaea syriaca* Vautrin) characterize the fauna on this platform. *Loftusia* diversity and abundance among the benthic foraminifera is quite high. *Arnaudella grossouvreii* Douvillé, *Discyclina schlumbergeri* Munier-Chalmas, *Loftusia harrisoni* Cox, *L. elongata* Cox, *L. matsumaruii* Meriç and Görmüş and *Pseudorbitolina marthae* Douvillé are only documented from southeastern Anatolia. Biogeographic distributions of rudist and benthic foraminifera show different faunal associations on the three main platforms (RPP, ATP and AP). Our data from both rudist and benthic foraminifera indicate that different faunal associations and existence of restricted genera and species may be associated with a deep marine barrier to circulation during the Campanian-Maastrichtian. Southern and northern branches of the Neotethyan Ocean are considered to be barriers in preventing migration of the species.

Keywords: Rudist; Benthic foraminifera; Campanian; Maastrichtian; Paleobiogeography

Résumé

La séquence transgressive du Campanien-Maestrichtien de Turquie démarre généralement avec des dépôts silicoclastiques moyens à grossiers suivis par des calcaires marins néritiques, des calcaires récifaux, puis des dépôts silicoclastiques fins de mer ouverte. Ces séquences mixtes sont observées sur les trois principales plates-formes connues sous les noms de Rhodope-Pontide (RPP), Anatolide-Tauride (ATP) et Arabe (AP). De nouvelles espèces des genres de rudistes *Gorjanovicia*, *Radiolites*, *Sauvagesia*, *Durania* et *Sabinia* sont observées sur la plate-forme RPP. Les genres *Yvaniella* et *Ugarella* sont uniquement trouvés sur cette plate-forme. *Orbitoides gruenbachensis* Papp est l'espèce de foraminifère

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benthique la plus abondante sur la plate-forme RPP. *Cideina soezerii* (Sirel), *Dizerina anatolica* Meriç, *Helicorbitoides boluensis* Sirel, *Ilgazina unilateralis* Erdoğan, *Nummofallotia kastamonica* Özgen-Erdem, *Selimina spinalis* İnan, *Sirelina orduensis* Meriç et İnan, *Smoutina cruysi* Drooger sont également présents sur cette plate-forme. Les rudistes et les foraminifères benthiques sont plus abondants et plus diversifiés sur la plate-forme ATP par rapport aux plates-formes RPP et AP. La diversité générique et spécifique des rudistes sur la plate-forme ATP est élevée. Dix-sept genres et 36 espèces sont décrits. La présence de nouveaux genres de rudistes comme *Darendeella*, *Kurtinia* et *Balabania*, ainsi que plusieurs espèces de Radiolitidae et Hippuritidae pourrait être limitée à cette plate-forme. Les foraminifères benthiques sont grands et caractéristiques et sont composés de 18 genres et 37 espèces. *Loftusia ketini* Meriç, *L. turcica* Meriç et Avşar, *Postomphalocyclus merici* İnan et *Pseudoedomia hekimhanensis* Görmüş sont limités à cette plate-forme. La faune de rudistes de la plate-forme AP est pauvre. Cependant, quatre genres endémiques (*Vautrinia*, *Dictyoptychus*, *Paracaprinula* et *Hatayia*) et deux espèces (*Hippurites syriaca* Vautrin et *Pironaea syriaca* Vautrin) caractérisent cette plate-forme. Chez les foraminifères benthiques, l'abondance et la diversité du genre *Loftusia* est relativement élevée. *Arnaudella grossouvreii* Douvillé, *Discyclina schlumbergeri* Munier-Chalmas, *Loftusia harrisoni* Cox, *L. elongata* Cox, *L. matsumaruii* Meriç et Görmüş et *Pseudorbitolina marthae* Douvillé ne sont présents que dans la partie sud-est de l'Anatolie. Les distributions biogéographiques des rudistes et des foraminifères benthiques montrent différentes associations faunistiques sur les trois principales plates-formes (RPP, ATP et AP). Les différentes associations observées et le fait que certains genres et espèces soient inféodés à une seule plate-forme indiquent que des barrières marines profondes, empêchant les migrations, ont pu fonctionner durant le Campanien et le Maestrichtien. Ces barrières pourraient correspondre aux branches sud et nord de la Néotéthys.

Mots clés : Rudiste ; Foraminifère benthique ; Campanien ; Maestrichtien ; Paléobiogéographie

1. Introduction and geological setting

Between the Laurasian and African superplates, Turkey is one of the most important Alpine regions in the world. Tectonically, it consists of three main plate fragments, from north to south as follows (Fig. 1; Ketin, 1966; Şengör and Yılmaz, 1981; Şengün et al., 1990; Meriç and Görmüş, 2001):

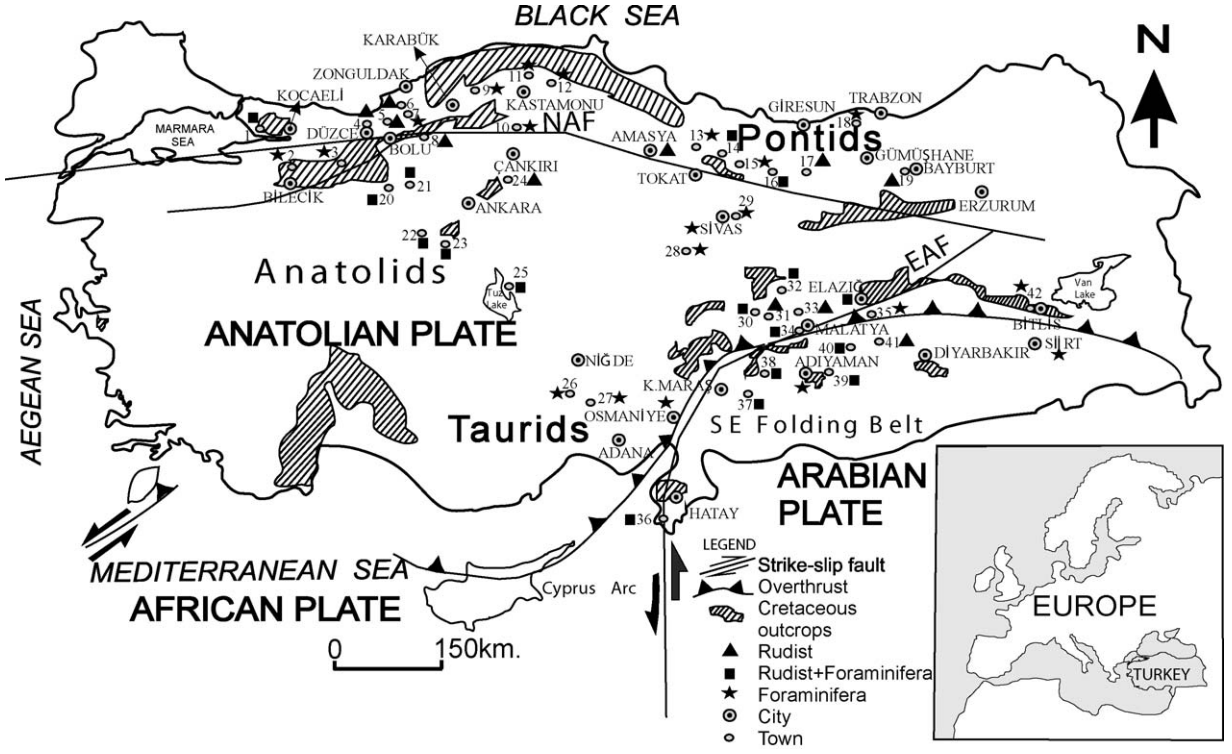

Fig. 1. Campanian-Maastrichtian main outcrops in Turkey and studied locations: NAF, North Anatolian Fault; EAF, East Anatolian Fault. **1**. Hereke (Kocaeli). **2**. Osmaneli (Bilecik). **3**. Göynük (Bolu). **4**. Konuralp (Düzce). **5**. Yığılca (Düzce). **6**. Hatipler (Zonguldak). **7**. Dirgine (Zonguldak). **8**. Gücükler (Bolu). **9**. Eflani (Karabük). **10**. Ilgaz (Çankırı). **11**. Devrekani (Kastamonu). **12**. Taşköprü (Kastamonu). **13**. Erbaa (Tokat). **14**. Niksar (Tokat). **15**. Reşadiye (Tokat). **16**. Koyulhisar (Sivas). **17**. Şebinkarahisar (Giresun). **18**. Tonya (Trabzon). **19**. Maden (Bayburt). **20**. Çayırhan (Ankara). **21**. Beypazarı (Ankara). **22**. Polatlı (Ankara). **23**. Haymana (Ankara). **24**. Malıboğazı (Ankara). **25**. Şereflikoçhisar (Ankara). **26**. Ulukışla (Niğde). **27**. Pozantı (Adana). **28**. Şarkışla (Sivas). **29**. Tecer (Sivas). **30**. Darende (Malatya). **31**. Balaban (Malatya). **32**. Hekimhan (Malatya). **33**. Yazıhan (Malatya). **34**. Yeşilyurt (Malatya). **35**. Sivrice (Elazığ). **36**. Yayladağ (Hatay). **37**. Pazarcık (K.Maraş). **38**. Gölbaşı (Adıyaman). **39**. Kahta (Adıyaman). **40**. Gerger (Adıyaman). **41**. Çermik (Diyarbakır). **42**. Mutki (Bitlis).

- the Rhodope-Pontide fragment/platform (RPP), consisting of the southernmost part of Laurasia;
- the Anatolian plate/Anatolide-Tauride platform (ATP) connected to the Apulian platform to the west;
- the Arabian platform (AP), included to the northernmost part of the African plate.

Sequences rich in rudist and benthic foraminiferal faunas of uppermost Senonian age are widely exposed on these platforms. Campanian-Maastrichtian clast-supported sediments occur within a reef complex consisting mainly of biostromes-type reefs; however biohermal limestones also exist. Both sequences with reefs and those without reef complexes should be taken into consideration when interpreting in detail the paleoenvironmental distribution of rudists and foraminifera and their stratigraphical positions.

2. Data used to identify rudist-foraminifera faunal associations

Comprehensive studies on Upper Cretaceous rudist-benthic foraminifera associations in Turkey are few. Even though there have been some studies about their paleobiogeography and paleoecology (Meriç, 1975, 1985; Meriç and Mojab, 1977; Meriç et al., 1985; Özer, 1987, 1988a, 1988b, 1991, 1992a, 1992b; Görmüş et al., 1995; Meriç and Görmüş, 2001; Meriç et al., 2001), most studies mainly addressed systematic paleontology and biostratigraphy of benthic foraminifera (Meriç, 1965, 1967, 1974, 1979; İnan, 1987; Görmüş, 1990; Avşar, 1991; Görmüş et al., 1994) and rudists (Karacabey, 1968, 1969, 1970, 1974; Karacabey-Öztemür, 1976, 1979a, 1979b, 1980; Karacabey-Öztemür and Selçuk, 1981; Özer, 1982, 1983, 1985, 1986, 1987, 1988a, 1988b, 1991, 1992c, 1994; Özer and Fenerci, 1993; Fenerci, 1994, 1999; Sarı et al., 2004). In contrast, there have been many studies on the paleobiogeography of rudists and benthic foraminifera associated with other taxa like corals, ammonites, some bivalvia and algae especially in the periphery of the Mediterranean province (Philip, 1981, 1982, 1985, 1998; Philip and Allemann, 1982; Sladic-Trifunovic, 1987; Gili et al., 1987; Camoin et al., 1983; Pons and Sirna, 1992) and other provinces of the Tethyan realm (Coates, 1973; Kauffman, 1973; Skelton and Wright, 1987; Philip, 1999; Philip and Platel, 1987; Johnson and Kauffman, 1990). Our paper compiles the data from the scientific literature on the Campanian-Maastrichtian sequences from Turkey and provides valuable information about rudist-benthic foraminifera associations and their paleobiogeographical significance within the various plates of the eastern Mediterranean province, specifically from Turkey. The definition of rudist-foraminifera faunal provinces are based on a comparison of faunas having a consistent and reliable taxonomy within the respective platforms. So, the relationship between the RPP, ATP and AP during the Campanian-Maastrichtian is interpreted in the light of these faunal associations. The data presented herein will be useful in elucidating the paleobiogeography of the Late Cretaceous Epoch in this region.

3. Stratigraphy and rudist-foraminifera faunas

Campanian-Maastrichtian sequences deposited on the flanks of the RPP, ATP and AP are characterized by clastic-dominated sediments and consist of the following units, from bottom to top:

- reddish-conglomerates, sandstones and mudstones;
- greenish-gray bioclastic and biostromal reefal sandy limestones rich in benthic fauna;
- gray mudstones with planktic foraminifera indicating a transgressive system tract.

These systems are clearly observed in all Campanian-Maastrichtian localities. Görmüş (1990) described a transgressive to regressive succession from the Upper Cretaceous of the Hekimhan area (NW Malatya). The Campanian-Maastrichtian boundary is usually conformable in Turkey, and it is difficult to distinguish the exact boundary. These three units mentioned above show lateral and vertical changes and different thicknesses. They unconformably overlie Triassic, Jurassic and Lower Cretaceous carbonates, metamorphic and ophiolitic rocks and are overlain generally by conformable sequences but sometimes by an unconformity covered by Tertiary clastic sediments. Rudist-foraminifera content for each platform is summarized below.

3.1. Rhodope-Pontide platform (RPP)

The RPP was located in the southern part of the Pontide volcanic arc complex (Fig. 1). From East to West, Hereke (Kocaeli), Osmaneli (Bilecik), Konuralp and Yığılca (Düzce), Göynük and Gücükler (Bolu), Dirgine and Hatipler (Zonguldak), Eflani (Karabük), Devrekani and Taşköprü (Kastamonu), Ilgaz (Çankırı), Erbaa, Niksar and Reşadiye (Tokat), Koyulhisar (Sivas), Şebinkarahisar (Giresun), Tonya (Trabzon), Amasya and Maden (Bayburt) areas include upper Senonian benthic foraminifera and rudists (Fig. 1).

In the Hereke (Kocaeli) area, late Campanian-Maastrichtian sequence begins with coarse clastics and carbonates with rich rudists and continues with clastics and clastic carbonates known as Akveren Formation (Fig. 2). They contain rudists (Boehm, 1927; Özer, 1982, 1983, 1992c; Kaya et al., 1987a, 1987b; Özer et al., 1990; Fenerci, 1999, 2004) and benthic foraminifera (Özer et al., 1990; Fenerci, 1999) indicating a late Campanian-Maastrichtian age (Figs. 3 and 4). The rudist-bearing limestones pass upward to marly pelagic limestones and mudstones and yield many planktonic foraminifera indicating an early-late Maastrichtian-Danian age (Özer et al., 1990; Fenerci, 1999).

The clayey limestones, sandstones and mudstones of the Buldandere Formation in the Dirgine area located in northern Bolu include characteristic Campanian (probably late) benthic foraminifera (Sirel, 1995). The limestones at the top of the same formation contain Maastrichtian benthic foraminifera (Fig. 4; Meriç, 1978a, 1988; Dizer and Meriç, 1983; İnan, 1996; İnan et al., 1992, 1996a, 1996b; Yalçın and İnan, 1992; İnan and

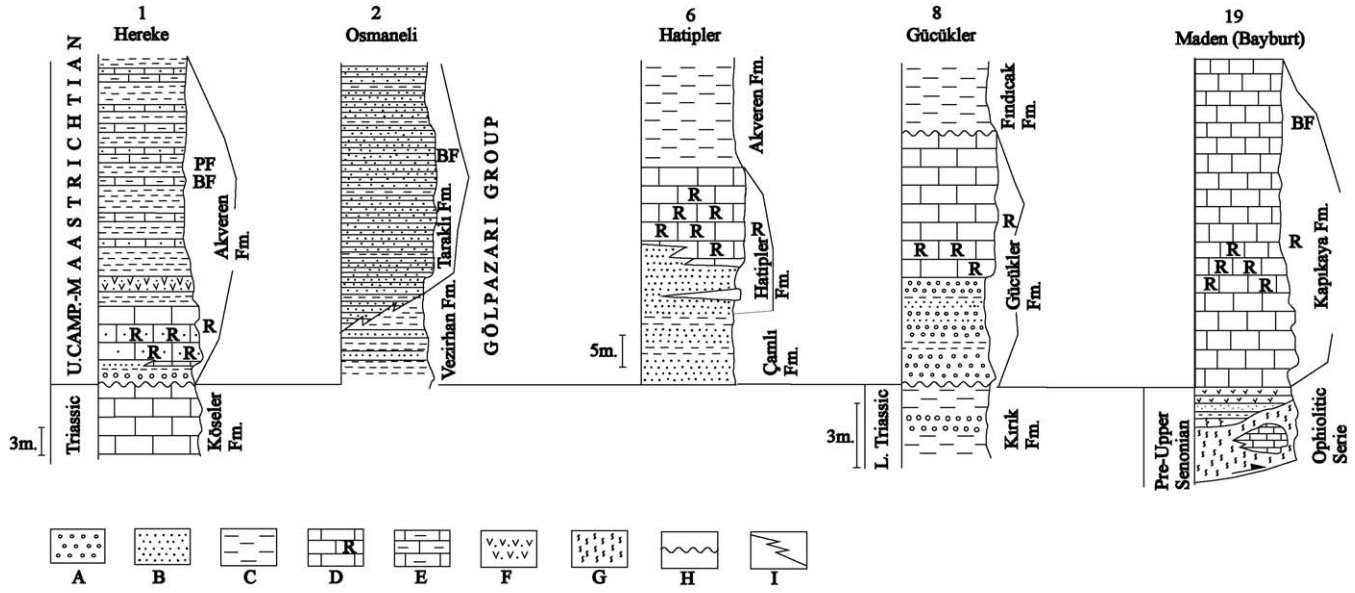

Fig. 2. Comparison of lithologic units related to the rudist-foraminifera associations in the Rhodope-Pontide platform (1, 2, Özer, 1994; 6, Özer et al., 1990; Özer, 1992a; Fenerci, 1999; 8, Saner, 1978a, 1978b; Görmüş, 1996-1997; 19, Fenerci, 1992). R: rudist; BF: benthic foraminifera; PF: planktic foraminifera; A: conglomerates; B: sandstones; C: claystones; D: reefal limestones; E: clayey limestones; F: volcanoclastics; G: ophiolites; H: unconformity; I, lateral facies changes.

Temiz, 1992; Erdoğan, 1995; Kaya and Meriç, 1996; Kaya, 1997; Özgen-Erdem, 2001; Akyazı and Özgen-Erdem, 2003). Around the Hatipler-Konuralp (Düzce) and Gücükler-Yığılca (Bolu) areas, the limestones of the Hatipler and Gücükler Formations (Fig. 2) yield a Maastrichtian rudist faunal association (Fig. 3; Kaya et al., 1987a, 1987b; Özer, 1994; Fenerci, 1999).

In the Göynük (Bolu) area, the benthic foraminifera indicate Maastrichtian age for the clastics of the Taraklı Formation (Fig. 2; Meriç, 1974). The benthic foraminiferal fauna in the Osmaneli (Bilecik) area is more or less similar to the Göynük area (Fig. 4; Dizer and Meriç, 1983; Görmüş, 1996-1997; Meriç and Görmüş, 1999).

The limestones of the Lokman Formation belong to the lower part of the Campanian-Maastrichtian volcanoclastic sequence of the Amasya region and include a rudist fauna (Fig. 3; Karacabey, 1968; Steuber et al., 1998; Özer, 2006). An early Campanian age was suggested by the rudist fauna (Steuber et al., 1998) based on isotope data.

Rudist faunas, though poor, indicate Campanian-Maastrichtian ages for the sandy limestone lenses of the volcanoclastic sequence of the Şebinkarahisar (Giresun) area (Fig. 3; Karaoğlu, 1985).

In the Maden (Bayburt) area, the bioclastic limestones of the Kapıkaya Formation yield rudist faunas (Figs. 2 and 3) which were interpreted to be late Campanian-Maastrichtian in age by Bergougnan (1987) and Maastrichtian by Fenerci (1992) and Özer and Fenerci (1993). The bioclastic limestones around Ilgaz (Çankırı), Niksar and Reşadiye (Tokat), Koyulhisar (Sivas) and Tonya (Trabzon) contain benthic foraminifera indicating a Maastrichtian age (Fig. 4) and also some rudist fragments (İnan and Temiz, 1992; İnan et al., 1992, 1999; İnan, 1988a; İnan and Meriç, 1995; Meriç and Tansel, 1995; Kaya and Meriç, 1996; Meriç and İnan, 1998).

3.2. Anatolide-Tauride Platform (ATP)

The ATP was located in the northern part of the Tethys Ocean. Beypazarı, Çayırhan, Polatlı, Haymana, Şereflikoçhisar and Malıboğazı (Ankara), Ulukışla (Niğde), Pozantı (Adana), Şarkışla and Tecer (Sivas), Hekimhan, Darende, Balaban and Yeşilyurt (Malatya), Sivrice (Elazığ) and Osmaniye are the typical localities where rocks from this platform are exposed (Figs. 1 and 5).

In the Beypazarı-Çayırhan area, sandy limestone lenses of the clastic Nardin Formation (Fig. 5) contain rudists and benthic foraminifera suggesting a late Campanian-Maastrichtian age (Figs. 3 and 4; Önal et al., 1988; Özer, 2002).

Campanian-Maastrichtian sediments are comprised of the following geological units from bottom to top in the Haymana-Polatlı area: Haymana Formation (marl-shale with siltstone and sandstone intercalations, 1630 m in thickness) (Özcan and Özkan-Altıner, 1997), Campanian to Maastrichtian in age; and the Kavak and Beyobası Formations (shallow water carbonates and clastics), Maastrichtian in age (Fig. 5). Upper Cretaceous sediment cover unconformably overlie the sedimentary basement. They are conformably overlain by Paleogene clastics and carbonates (Ünalan et al., 1976; Özer, 1983, 1985, 1988a, 1988b; Özcan and Özkan-Altıner, 1997). Shallow water clastics/carbonates of the Beyobası Formation contain benthic foraminifera (Özer, 1983, 1985; Sirel et al., 1986; Özcan and Özkan-Altıner, 1997, 1999) and rudists (Özer, 1983, 1985, 1988a, 1992c) indicating a Maastrichtian age (Fig. 3 and Table 1).

In the Şereflikoçhisar area, the Campanian-Maastrichtian succession starts with conglomerates of the Kartal Formation and continues with clastic and rudist-bearing carbonates of Asmaboğazı Formation (Fig. 5). The Kırkkavak Formation conformably overlies the Asmaboğazı Formation and its age

RUDISTS	RHODOPE-PONTIDE PLATFORM										ANATOLID-TAURIDE PLATFORM											ARABIAN PLATFORM					
	Hereke-1	Konuralp-4	Yığılca-5	Hatipler-6	Gücükler-8	AMASYA	Niksar-14	Koyulhisar-16	Ş.Karahisar-	Maden-19	Çayırhan-20	Beypazarı-21	Polatlı-22	Haymana-23	Malıboğazı-24	Ş.Koçhisar-25	Darende-30	Balaban-31	Hekimhan-32	Yazıhan-33	Yeşilyurt-34	ELAZIĞ	Yayladağı-36	Pazarcık-37	Gölbaşı-38	Kahta-39	Gerger-40	Çermik-41
Balabania acuticostata Karacabey-Öztemür																	●	●	●									
B. denticostata Karacabey-Öztemür																	●	●	●		●							
B. elongata Karacabey-Öztemür																	●		●									
B. meltinensis Karacabey-Öztemür																	●		●									
*Biradiolites bulgaricus*Pamouktchiev															●	●												
B. sp.													●	●	●						●		●	●		●		
Bournonia anatolica Özer															●													
B. sp.															●													
Branislavia baceviensis Milovanovic																			●									
B. orientalis Özer																	●		●									
B. sp.																			●									
Colveraia darendeneensis Karacabey																	●		●									
C. variabilis Klinghardt																	●		●									
C. sp.													●	●		●												
Darendeella anatolica																	●		●									
Dictyoptychus euphratica Karacabey-Öztemür																										●		
D. leesi Kühn																										●		
D. orantica Karacabey-Öztemür																							●					
D. striatus Douvillé																										●		
D. sp.																							●		●	●		
Durania carinata Özer					●																							
D. sp.													●	●														
Eoradiolites sp.														●														
Gorjanovicia akyolii Özer	●																											
G. beotica Steuber	●																											
G. bithyniana Böhm	●																											
G. costata Polsak	●																											
G. kayae Özer	●																											
G. lipparinii Polsak	●																											
G. sp.	●																		●									
Hatayia spinosus Karacabey-Öztemur&Selçuk																							●					
Hippuritella variabilis Munier-Chalmas																	●		●									
Hippuritella (Tetracoinites) sp.																												●
Hippurites colliciatus Woodward	●		●			●											●		●									
Hippurites cornucopiae Defrance									●				●	●		●							●	●		●		
Hippurites heritchi Kühn											●	●	●	●		●					●							
Hippurites lapeirousei Goldfuss	●	●	●										●	●		●	●		●									
Hippurites nabresinensis Defrance	●	●	●																									
Hippurites sulcatoides Douvillé		●	●							●																		
Hippurites syriaca Vautrin																							●	●		●		
Hippurites sp.								●	●													●			●			
Joufia cappadociensis (Cox)		●	●							●							●		●	●								
J. reticulata Boehm	●	●	●										●	●		●	●	●	●	●								
Kurtinia hemispherica Karacabey-Öztemür																	●	●	●									
Lapeirousella anatolica Karacabey-Öztemür&Selçuk																							●					
L. yalazensis Karacabey-Öztemür&Selçuk																							●					
Lapeirousia jouanneti (Des Moulins)											●	●	●	●		●												
Lapeirousia plana Milovanovic			●													●												
L. cf. *plana* Milovanovic													●	●														
L. sp.		●	●															●					●	●		●		
Miseia bilacunosa Özer																●	●		●									
M. hekimhanensis Karacabey-Öztemür	●																●		●									
M. merici Özer																			●									
M. osculata Karacabey-Öztemür																	●	●	●									
M. regularis Karacabey-Öztemür																	●		●									
M. sp.																					●							

Fig. 3. Rudist fauna distribution. See Fig. 1 for the numbers.

RUDİSTS	RHODOPE-PONTIDE PLATFORM										ANATOLID-TORIDE PLATFORM												ARABIAN PLATFORM					
	Hereke-1	Konuralp-4	Yığlca-5	Hatipler-6	Gücükler-8	AMASYA	Niksar-14	Koyulhisar-16	Ş.Karahisar-17	Maden-19	Çavırhan-20	Beypazarı-21	Polatlı-22	Haymana-23	Malıboğazı-24	Ş.Kochisar-25	Darende-30	Balaban-31	Hekimhan-32	Yazıhan-33	Yeşilyurt-34	ELAZIĞ	Yavladağı-36	Pazarcık-37	Gölbaşı-38	Kahta-39	Gerger-40	Çermik-41
Mitrocaprina bulgarica Tzankov																•												
M. madeniana Özer&Fenerci										•																		
M. sp.																					•							
Paracaprinula syriaca Piveteau																							•			•		
Pironaea anatolica Karacabey																	•		•						•			
P. polystyla (Pirona)											•	•	•	•		•	•		•	•			•	•	•	•		•
P. syriaca Vautrin																							•					
P. timacensis Milovanovic	•																•		•									
P. sp.																		•										
Plagioptycus sp.	•																											
Praeradiolites subtoucasi Toucas				•																								
P. sp.																					•				•	•		
Pseudopolyconites ovalis Milovanovic	•										•	•				•					•					•		
Pseudopolyconites cf. *ovalis*																							•			•		
Pseudosabinia klinghardti Böhm	•																									•		
P. rtanjica (Pejovic)																	•		•			•						
P. sp.																							•	•		•		
Radiolites angeoides Lapeirouse																	•		•									
R. corporatus Özer			•																									
R. simpliformis Özer	•	•	•																									
R. squamosus Orbigny																	•	•	•									
R. sp.							•	•	•																			
Sabinia ornata Özer&Fenerci										•																		
S. sp.																•						•						
Sauvagesia herekiana Özer	•	•	•																									
S. sulcata Özer					•																							
S. sp.						•																						
Sphraeolites solutus Petho															•	•												
Ugarella sladicae Polsak&Sliskovic	•		•																									
Vaccinites atheniensis Ktenas											•	•																
V. gosaviensis Douvillé	•																											
V. loftusi Woodward			•			•					•	•	•	•	•	•	•		•	•	•	•						
V. orientalis Milovanovic																•												
V. cf. *sulcatus* Defrance	•																											
V. ultimus Milovanovic	•	•	•			•				•			•	•		•	•		•			•						
V. vesiculosus Woodward	•																•		•				•	•		•		
Vautrinia syriaca Vautrin																							•	•	•	•		
Yvaniella alpani Karacabey						•																						
Y. maestrichtiensis Milovanovic						•																						

Fig. 3. (*Continued*).

extends to the Paleogene (Meriç et al., 1997). The Asmaboğazı Formation contains benthic foraminifera associations (Fig. 4) indicating late Campanian and Maastrichtian ages (Meriç et al., 1997). The rudists are also very rich in both quality and quantity, and consist of species indicating a Maastrichtian age (Fig. 3; Özer, 1983, 1985, 1988a, 1992c, 2002, 2006).

Hekimhan, Darende, Balaban and Yeşilyurt areas are close to each other (Fig. 1). Lithological comparisons indicate that they consist of widespread and thick sedimentary deposits (approximately 1640 m in the Hekimhan area) of Maastrichtian age rather than Campanian (Fig. 5). Maastrichtian deposits include carbonates and clastics mixed with carbonates (more than 1400 m in thickness) while the Campanian sediments contain only clastics (150 m in thickness). Thickness differences among the units are related to a Maastrichtian transgression (Görmüş, 1990). The succession can be summarized as follows: in the Hekimhan area, the Campanian-Maastrichtian succession starts with clastics of the Hekimhan conglomerate (Campanian) and continues with Campanian to Maastrichtian biohermal Tohma reef (Görmüş, 1990). Field work and correlations in the Hekimhan area show that reefal limestones generally unconformably overlie the basement (the Kuluncak Melange). But, the Hekimhan conglomerate (Campanian), which is barren of fossils, also occurs at the bottom of the Tohma reef. Both formations are conformable. Claystone to siltstone strata within the Tohma reef are interpreted to be restricted deposits between the Hekimhan conglomerate and the framework of the Tohma reef. The Tohma reef is divided into four main lithofacies (Görmüş, 1990):

- claystone to siltstone;
- biostromal limestones with rudists and corals;
- turbidites;
- biohermal reefal limestones.

BENTHIC FORAMINIFERA	RHODOPE-PONTIDE PLATFORM													ANATOLID-TAURIDE PLATFORM																ARABIAN PLATFORM							
	Hereke-1	Osmaneli-2	Göynük-3	Dirgine-7	Eflani-9	Ilgaz-10	Devrekani-11	Taşköprü-12	Erbaa-13	Niksar-14	Reşadiye-15	Koyulhisar16	Tonya-18	Çayırhan-20	Beypazarı-21	Polatlı-22	Haymana-23	Ş.koçhisar-25	Ulukışla-26	Pozantı-27	OSMANİYE	Şarkışla-28	SİVAS	Tecer-29	Darende-30	Hekimhan-32	Yeşilyurt-34	ELAZIĞ	Sivrice-35	Yayladağı-36	Pazarcık-37	Gölbaşı-38	ADIYAMAN	Kahta-39	Gerger-40	Mutki-42	SİİRT
Antalyna korayi Farinacci and Köylüoğlu																									●											●
Arnaudiella grossouvrei Douville																																				●
Cideina soezerii (Sirel)						●			●	●	●	●	●			●	●	●																			
Clypeorbis mamillata (Schlumberger)																																		●		
Cuneolina ketini İnan										●									●	●				●												
Daviesina minuscula (Hofker)																									●	●					●					
Dizerina anatolica Meriç												●																								
Goupiloudina daguini Marie																									●	●										
G. cf. *schirazensis* Rahaghi																																		●		
G. sp.	●																										●									
Helicorbitoides boluensis Sirel				●																																
Hellenocyclina beotica Reichel			●				●	●		●		●				●	●	●					●		●		●									
Ilgazina unilateralis Erdoğan						●																														
Laffitteina marsicana Farinacci						●				●		●											●		●											
Lepidorbitoides bisambergensis (Jaeger)																	●	●															●			
L. bisambergensis asymmetrica Ozcan and Özkan-Altıner																	●																			
L. campaniensis Van Gorsel																	●	●																		
L. minor (Schlumberger)							●					●													●	●	●	●							●	●
L. socialis (Leymerie)												●	●				●											●		●				●	●	●
L. sp.			●			●								●	●	●	●	●				●												●			
Loftusia anatolica Meriç		●	●			●						●					●													●				●		●
L. baykali Meriç																					●										●			●	●	
L. elongata Cox																																	●	●		●
L. harrisoni Cox																																	●	●		●
L. kahtaensis Meriç																					●													●		
L. ketini Meriç																	●																			
L. matsumarui Meriç and Görmüş																																		●		
L. minor Cox										●									●	●				●									●	●		●
L. morgani Douville												●									●										●			●	●	
L. oktayi Meriç																					●										●			●	●	
L. turcica Meriç and Avşar																												●								
L. sp.																		●																		
Navarella joaquini Ciry and Rat																										●										

Fig. 4. Benthic foraminifer distribution. See Fig. 1 for the numbers.

BENTHIC FORAMINIFERA	RHODOPE-PONTIDE PLATFORM													ANATOLID-TAURIDE PLATFORM																ARABIAN PLATFORM							
	Hereke-1	Osmaneli-2	Göynük-3	Dirgine-7	Eflani-9	Ilgaz-10	Devrekani-11	Taşköprü-12	Erbaa-13	Niksar-14	Reşadiye-15	Koyulhisar16	Tonya-18	Çayırhan-20	Beypazarı-21	Polatlı-22	Haymana-23	Ş.koçhisar-25	Ulukışla-26	Pozantı-27	OSMANİYE	Şarkışla-28	SİVAS	Tecer-29	Darende-30	Hekimhan-32	Yeşilyurt-33	ELAZIĞ	Sivrice-34	Yayladağı-35	Pazarcık-36	Gölbaşı-37	ADIYAMAN	Kahta-38	Gerger-39	Mutki-40	SİİRT
Nummofallotia kastamonica Özgen-Erdem				●																																	
Omphalocyclus macroporus (Lamarck)						●	●	●	●	●	●	●	●			●	●	●	●		●			●	●	●		●	●	●	●		●	●	●	●	●
Orbitoides apiculatus Schlumberger		●	●		●	●	●	●	●	●	●	●	●	●	●		●	●	●					●		●		●		●			●				
O. gruenbachensis Papp		●	●		●		●			●		●		●	●		●																				
O. medius (d'Archiac)	●					●	●	●	●	●	●	●	●	●	●	●			●		●	●		●	●	●	●	●	●	●	●		●	●	●	●	●
O. megaliformis Papp and Kupper																	●	●							●	●					●			●			
O. (Simplorbites) papyraceous (Boubee)			●			●				●	●	●					●								●	●								●	●		
Orbitoides tissoti Schlumberger				●																																	
Postomphalocyclus merici İnan												●												●		●											
Praesiderolites dordoniensis Wannier	●													●	●																	●			●		
Praesiderolites douvillei Wannier	●																															●			●		
Pseudedomia hekimhanensis Görmüş																									●	●											
Pseudomphalocyclus blumenthali Meriç										●		●				●	●		●	●				●		●		●	●						●		
Pseudosiderolites vidali Douville	●			●										●	●											●						●			●		
Pseudorbitolina marthae Douville																																					●
Selimina spinalis İnan						●				●	●	●																									
Siderolites calcitrapoides Lamarck		●	●		●	●	●		●	●	●	●	●	●	●	●	●	●			●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●
Siderolites denticulatus Douville						●	●			●	●	●									●				●							●			●		
Sirelina orduensis Meriç and İnan						●				●																											
Sirtina orbitoidiformis Brönnimann and Wirz						●	●			●			●			●	●							●											●		
Sirtina sp.																									●												
Sivasella goekceni Meriç and İnan																											●										
Sivasella monolateralis Sirel and Gündüz																							●														
Smoutina cruysi Drooger						●				●	●	●												●	●			●									
Sulcoperculina globosa de Cizancourt																															●		●				
Sulcoperculina obesa de Cizancourt																●	●																●				
Sulcoperculina vermunti (Thaidens)																																	●				

Fig. 4. (*Continued*).

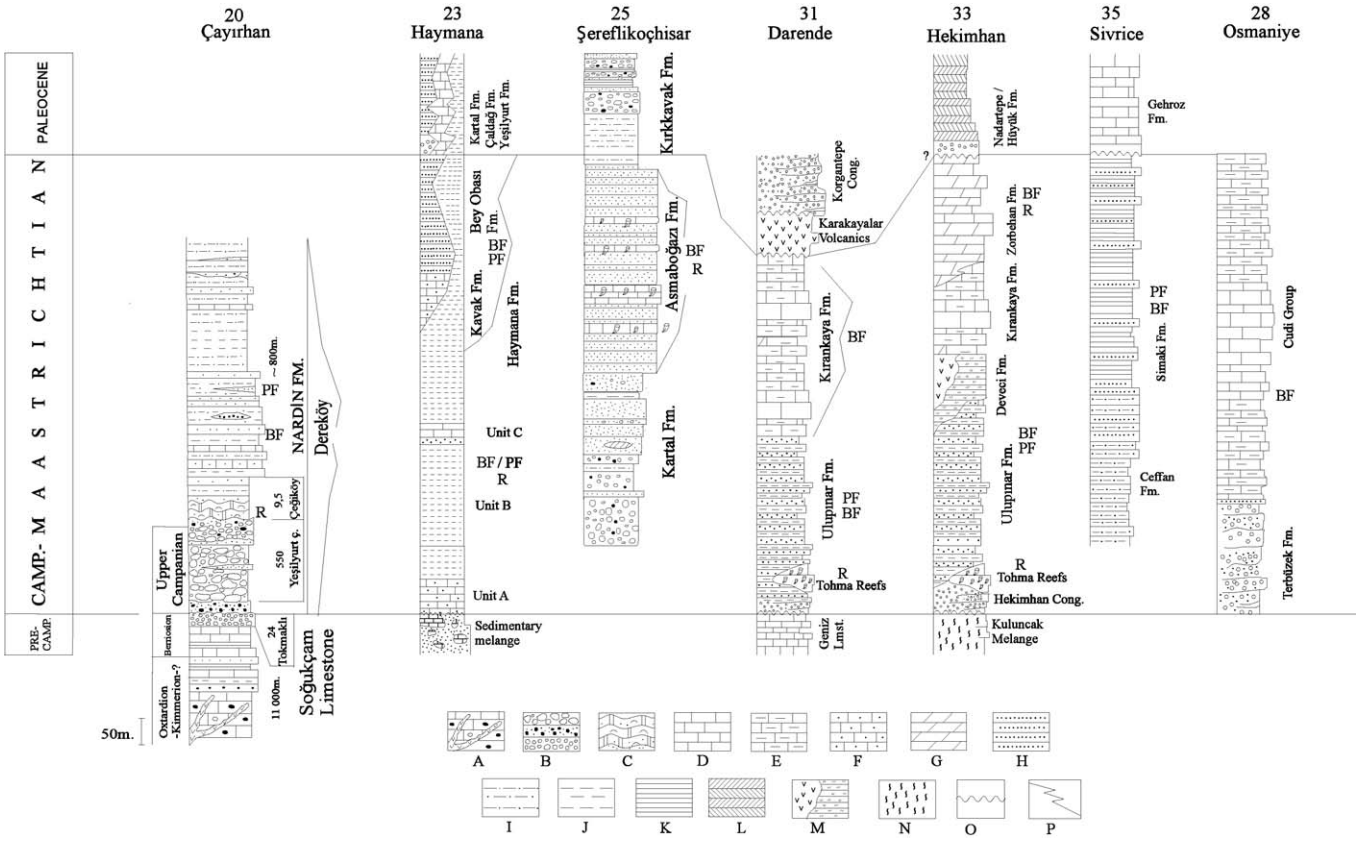

Fig. 5. Comparison of lithologic units related to the rudist-foraminifera associations in the Anatolide-Tauride platform (20, Önal et al., 1988; 23, Meriç et al., 1997; 25, Özcan and Özkan-Altıner, 1997; 31, Akkuş, 1971; 33, Görmüş, 1990; 35, Meriç and Avşar, 1992; 28, Avşar, 1991). R: rudist; BF: benthic foraminifera; PF: planktic foraminifera; A: nodular limestones; B: coarse sized clastics; C: reefal and sandy limestones; D: limestones; E: marl or clayey limestones; F: sandy limestones; G: dolomites; H: sandstones; I: siltstones; J: claystones; K: rhythmic clastics; L: gypsum; M: volcanics, volcanoclastics; N: ophiolites; O: unconformity; P: lateral facies changes.

The Ulupınar Formation conformably overlies the reefal limestones. Other lithostratigraphic formations of Maastrichtian age are from bottom to top as follows: Ulupınar (flysch), Deveci (submarine volcanoclastics-volcanics), Kırankaya (clayey limestones to limestones) and Zorbehan (limestones to dolomites) Formations (Fig. 5). The entire Campanian-Maastrichtian succession is unconformably underlain by the Kuluncak Melange and is also unconformably overlain by evaporate deposits of Early Tertiary age (Akkuş, 1971; Görmüş, 1990). However, the nature of the Cretaceous Tertiary boundary, whether conformable or unconformable, is controversial (Görmüş, 1990; Bozkaya, 1991). Rudist and foraminifer distributions and communities indicate a transgressive to regressive succession during the Campanian-Maastrichtian Stages. During the Campanian-early Maastrichtian transgression and late Maastrichtian regression, rudist and foraminifera lived expansively at a variety of water depths and paleoenvironments and they formed different communities. In the Darende-Balaban areas, Maastrichtian deposits, 580 m in thickness (Akkuş, 1971), start with the Tohma reef. It overlies unconformably the Geniz limestone, Jurassic to Cretaceous in age. Clastics can be seen at the bottom of the biohermal to biostromal limestones (Akkuş, 1971). The biostromal limestones with rudists and benthic foraminifera are overlain by the clastics of the Ulupınar Formation. Reefal limestones and clastics show vertical and lateral changes. The Kırankaya (clayey limestone, limestone) Formation is overlain unconformably by Tertiary sediments. In the Yeşilyurt area, the late Campanian-Maastrichtian sequence shows similar lithological successions as the Hekimhan area and contains rudist biostromes (Önal and Kaya, 2007; Özer and Sarı, 2007; Özer et al., 2007). Correlations of nearby places in the eastern ATP show that many different benthic larger and smaller benthic foraminifera and rudists lived in a reef complex around the Malatya basin.

In the Malatya basin, Campanian to Maastrichtian sediments contain rich larger benthic foraminifera (Akkuş, 1971; Görmüş, 1990, 1994, 1999; Meriç and Görmüş, 1997, 1999; Görmüş et al., 2001) and also smaller benthic textulariids, haurenids and rotaliids (Table 1; Görmüş, 1990). The rudist fauna of the region is remarkably well developed and consist of many new genera and species (Karacabey, 1970, 1974; Karacabey-Öztemür, 1976, 1979a, 1980; Özer, 1988b, 1992c, 2002, 2006).

The Maastrichtian sequences of the Kalkankaya (Ulukışla-Niğde), Pozantı (Adana), Tecer (Sivas), Sivrice (Elazığ) and Osmaniye areas consist of mainly clastics with sandy limestone lenses (Fig. 5). Although rudists were only observed in the Elazığ area (Fig. 3; İnceöz, 1996; Özer, 2002), benthic foraminifera were observed frequently (Fig. 4; Sirel and Gündüz, 1978; Meriç, 1980; İnan, 1988a, 1988b, 1988c, 1992;

Table 1
Main features of platforms in two giant continents and benthic foraminiferal and rudist distribution (modified from Meriç and Görmüş, 2001).

	Laurasia		Gondwana
	Rhodope-Pontide Platform	Anatolid-Tauride Platform	Arabian Platform
Lithology	Lmst. in the East, clastics in the West	Shallow water lmst., some of them are open sea lmst.	Clayey to sandy lmst., dolomitic lmst., lmst.
Dominant larger benthics and rudists	Orbitoids, Radiolitids	Orbitoids Hippuritids/radiolitids	Loftusiids Dictyoptychids/hippuritids
Depth and environment	Usually open sea paleoenvironments, very shallow	Usually contains reef complex in eastern Taurides, open sea shallow paleoenvironment in the western Taurides	Usually contain reef complex
Species diversity	High	Very high	High
Species distribution	Foraminifera: *Antalyna korayi, Goupillaudina daguini, Lepidorbitoides bisambergensis, L. minor, L. socialis, Loftusia morgani, L. anatolica, Omphalocyclus macroporus, Orbitoides apiculatus, O. medius, O. megaliformis, O. tissoti, Praesiderolites dordoniensis, Pseudomphalocyclus blumenthali, Pseudosiderolites vidali, Siderolites calcitrapoides, Sirtina orbitoidiformis* Rudist: *Hippurites colliciatus, H. cornucopiae, H. lapeirousei, Vaccinites braciensis, V. loftusi, V. ultimus, Pironaea polystyla, Joufia cappadociensis, J. reticulata, Pseudopolyconites ovalis, Pseudosabinia klinghardti*		
	Foraminifera: *Cideina soezerii, Dizerina anatolica, Helicorbitoides boluensis, Ilgazina unilateralis, Nummofallotia kastamonica, Selimina, spinalis, Sirelina orduensis, Smoutina cruysi*	Foraminifera: *Laffitteina marsicana, Loftusia turcica, L. ketini, Postomphalocyclus merici, Pseudedomia hekimhanensis*	Foraminifera: *Loftusia harrisoni, L. elongata, L. matsumaruii, Arnaudella grossouvreii, Praesiderolites douvillei, Dicyclina schlumbergeri, Pseudorbitolina marthae*
	Rudist: *Yvaniella alpani, Ugarella sladicae, Sabinia ornata, Radiolites corporatus, R. simpliformis, Mitrocaprina madeniana, Durania carinata, Gorjanovicia* ssp., *Sauvagesia herekeiana, S. Sulcata*	Rudist: *Balabania acuticostata B. densicostata, B. elongata, Kurtinia hemispherica, Colveraia variabilis, Darendeella anatolica, Miseia bilacunosa,* M. ssp., *Bournonia anatolica*	Rudist: *Dictyoptychus euphratica D. orantica, D. leesi, D. striatus, Vautrinia syriaca, Paracaprinula syriaca, Pironaea syriaca, Hatayia spinosus*

Avşar, 1991; Meriç and Avşar, 1992; Özgen-Erdem et al., 1993; Meriç and İnan, 1997; Aksoy et al., 1999).

3.3. Arabian Platform

The upper Campanian-Maastrichtian sequences were observed in the northernmost part of the AP around Pazarcık (K.Maraş), Gölbaşı, Kahta and Gerger (Adıyaman), Yayladağı (Antakya), Mutki (Bitlis) and Siirt (Fig. 1). Upper Campanian sediments in the region are called different lithostratigraphical units like the Beloka Formation (limestones), Sayındere Formation (clayey limestone), Bozova Formation (clayey limestone and marl), Kastel Formation (marl, siltstone and sandstone) (Fig. 6; Çoruh et al., 1997). Among them, Kastel and Bozova Formations also extend into the Maastrichtian. The overlying Maastrichtian sediments were also divided into different geological units named as: the Terbüzek Formation (conglomerates), Kıradağ Formation (fine to medium sized clastics), Besni Formation (sandy limestone and limestone with rudists), Garzan Formation (limestone), Haydarlı Formation (limestone), Lower Sinan Formation (limestone), Antak Formation (coarse clastics) and Lower Germav Formation (claystone). They show lateral facies changes (Fig. 6; Çoruh et al., 1997).

In the Kahta and Gerger (in Adıyaman) and Pazarcık (in K.Maraş) areas and other parts of southern Turkey, benthic foraminifera indicate a Maastrichtian age (Meriç, 1978b, 1988; Meriç et al., 1985, 1987; Farinacci and Köylüoğlu, 1985; Köylüoğlu, 1986; Özcan, 1993, 1995). Rudist fauna of the Kahta area are very rich compared with other localities mentioned above (Fig. 3; Karacabey-Öztemür, 1979a, 1979b, 1980; Özer, 1986, 1992a, 1992b, 1992d, 2002, 2006).

The Yayladağı (Antakya) area shows approximately the same rudist and benthic foraminifera faunas as the Kahta region (Piveteau, 1939; Déchaseaux, 1954; Selçuk, 1981; Karacabey-Öztemür and Selçuk, 1981; Özer, 1991, 2002, 2006).

4. Paleobiogeography

According to paleotectonic reconstructions (Şengör and Yılmaz, 1981; Şengör et al., 1984; Görür et al., 1984), three main platforms (RPP, ATP and AP), separated by the Sakarya Continent, the Kırşehir Block and remnants of various Tethyan branches (İzmir-Ankara-Erzincan Suture Zone, Intra-Tauride Suture Zone and Bitlis-Zagros Suture Zone), are present in the tectonostratigraphic make-up of Turkey (Fig. 7). Recently, the western part of the Pontides was named the İstanbul Zone and the Sakarya Zone was proposed to extend to the eastern Pontides (Okay, 1989; Tüysüz, 1999; Görür and Tüysüz, 2001).

The geographic distributions and faunal content of the rudists and benthic foraminifers allow us to determine the paleogeographic relationships between the RPP, ATP and AP during the Campanian-Maastrichtian.

4.1. Rudist paleobiogeography

The taxonomic diversity, evolutionary range and geographic distribution of Upper Cretaceous rudists were important criteria for the determination of the paleobiogeographic units and subunits within the Tethyan realm (Coates, 1973; Kauffmann,

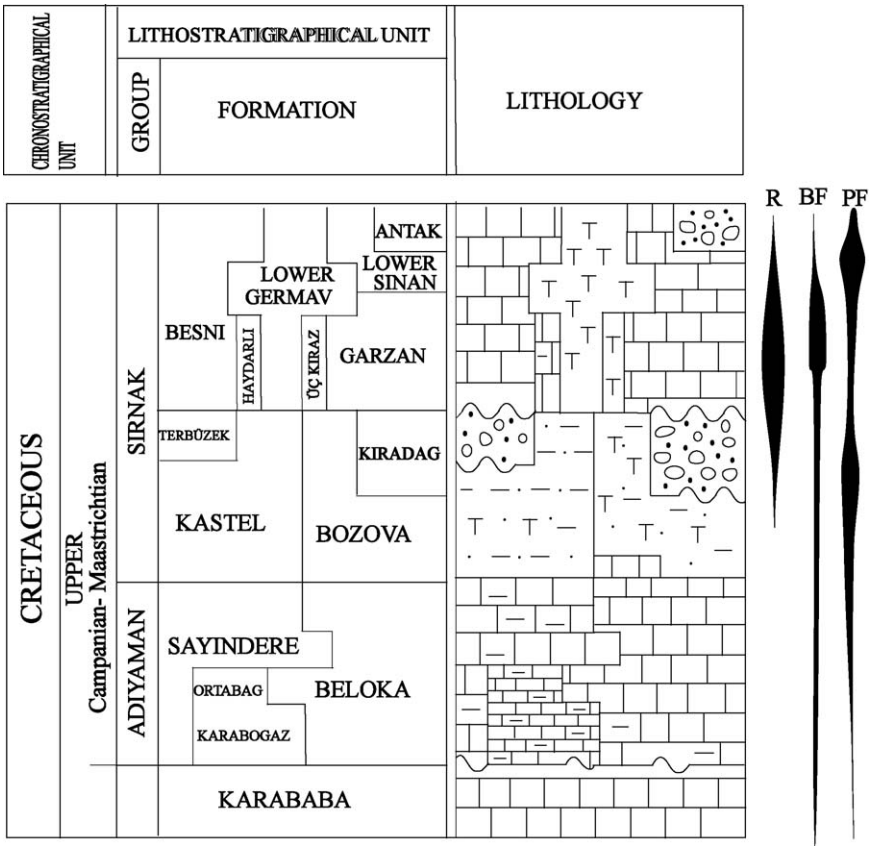

Fig. 6. Generalized stratigraphic column of the SE Turkey in the northern Arabian platform (modified after Çoruh et al., 1997).

1973; Philip and Allemann, 1982; Camoin et al., 1983; Ferrandini et al., 1985; Negra and Philip, 1986; Philip and Platel, 1987; Sladic-Trifunovic, 1987; Gili et al., 1987; Pons and Vicens, 1986). In Turkey, distribution of the Upper Senonian rudists has been studied by Özer (1983, 1985) and paleobiogeographical relationship between the ATP and AP have been interpreted based on their rudist content (Özer, 1992a, 1992b). Recently, the Upper Cretaceous rudist faunal composition and its relationship with all platforms in Turkey were presented by Özer (2006). The rudists of these platforms are listed in Fig. 3 and species diversity is shown in Fig. 8(a).

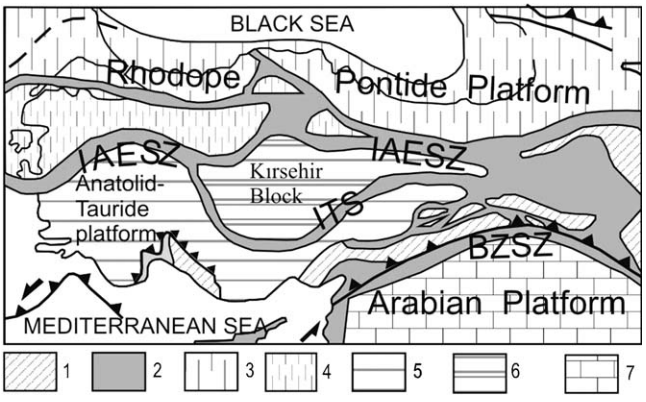

Fig. 7. Palaeotectonic map of Turkey (simplified from Şengör and Yılmaz, 1981; Şengör et al., 1984; Görür et al., 1984). **1**. Bitlis-Pötürge-Malatya-Alanya metamorphic. **2**. Ophiolites and accretionary wedge materials. **3**. Rhodope-Pontide Platform. **4**. Sakarya Continent. **5**. Anatolide-Tauride Platform. **6**. Kırşehir Block. **7**. Arabian Platform. BZSZ, Bitlis Zagros Suture Zone; IAESZ, İzmir-Ankara-Erzincan Suture Zone; ITS, Intra-Tauride Suture Zone.

The RPP, ATP and AP show inconsistent taxonomic diversity and abundance among rudists:

- rudist fauna of the RPP are very poor and represented by new species under the genera *Gorjanovicia, Durania, Sauvagesia, Radiolites, Mitrocaprina* and *Sabinia* which are restricted only to this platform. Radiolitids are richer than hippuritids. The genus *Yvaniella* and *Ugarella* are only observed on this platform in Turkey;
- the ATP is characterized by a rich rudist fauna with very high taxonomic diversity in contrast to the other platforms. This platform is also characterized by the presence of new genera and species such as *Balabania, Kurtinia* and *Darendeella* and *Miseia regularis* Karacabey-Öztemür, *M. hekimhanensis* Karacabey-Öztemür, *M. osculate* Karacabey-Öztemür, *M. bilacunosa* Özer, *M. merici* Özer and *Bournonia anatolica* Özer (Karacabey, 1970; Karacabey-Öztemür, 1976; Özer, 1983, 1987, 1988a, 1988b, 1992a, 1992c, 2006);
- the AP is characterized by four endemic genera (*Vautrinia, Dictyoptychus, Hatayia* and *Paracaprinula*) and two species (*Pironaea syriaca* Vautrin and *Hippurites syriaca* Vautrin) presenting a geographic distribution restricted to southeastern Anatolia (Özer, 1992d). These rudists also show a restricted geographic distribution in other Tethyan provinces. The genus *Vautrinia* was described from Syria, and *Dictyoptychus* from Somalia and the Oman Peninsula (Kühn, 1929; Vautrin,

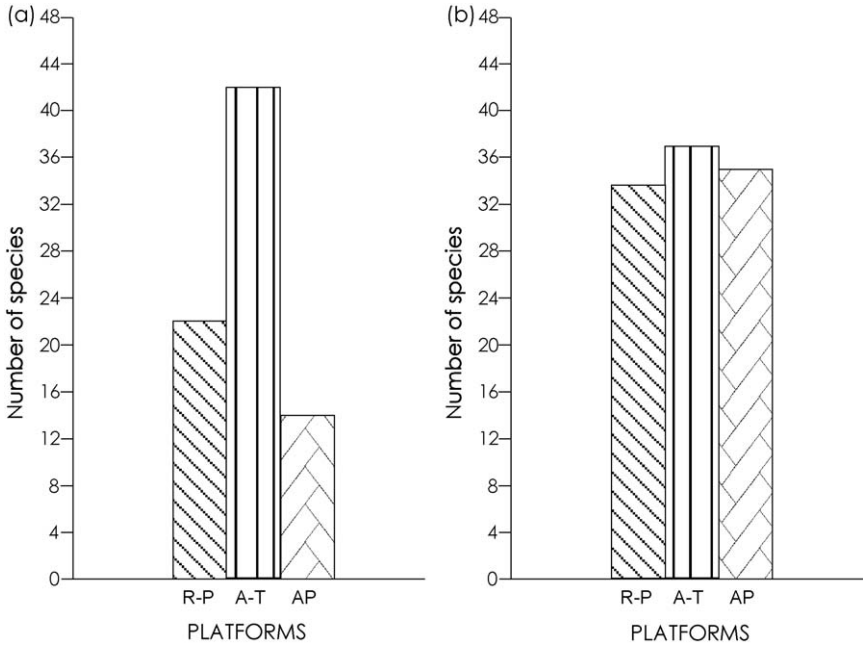

Fig. 8. Number of rudists (**a**) and benthic foraminifera (**b**) species identified in the three studied platforms.

1933; Dubertret, 1966; Pons et al., 1992; Steuber, 2002). The genera *Vautrinia, Dictyoptychus, Hatayia* and *Paracaprinula*, and species *Pironaea syriaca* Vautrin and *Hippurites syriaca* Vautrin were not observed until today in other platforms in Turkey or within the Mediterranean province.

The geographic distribution of rudists and the sharp breaks in their diversity indicate the presence of geographic barriers between the RPP, ATP and AP during the Campanian-Maastrichtian. These obstacles correspond to the northern and southern branches of the Neo-Tethyan Ocean (Fig. 7). The connection among the platforms was greatly prevented and thus faunal migration and mixing was interrupted.

4.2. Benthic foraminifera paleobiogeography

Paleobiogeographical distribution of the genus *Loftusia* and orbitoidal foraminifera present valuable data about their history. They were classified as restricted forms and genera of worldwide occurrence in literature (Van Gorsel, 1978; Meriç and Görmüş, 1999, 2001). The previous studies only show some characteristic Late Cretaceous forms. However, consideration of all index benthic Campanian to Maastrichtian foraminifera in Turkey will offer a better understanding of the Late Cretaceous paleobiogeography. So, the paleobiogeographic distributions and faunal content of the benthic foraminifera allow us to determine paleobiogeographical relationships among the RPP, ATP and AP during the Campanian-Maastrichtian in addition to the rudists. The foraminifera of these platforms are listed in Fig. 4 and Table 1 and species diversity is shown in Fig. 8(b).

The taxonomic diversity, abundance, faunal assemblages and paleobiogeographic distribution of benthic foraminifera are different on various Campanian to Maastrichtian platforms in Turkey. The generic diversity of foraminifera in the RPP is more than on other platforms. There are new species from RPP: *Sirelina orduensis* Meriç and İnan, *Dizerina anatolica* Meriç, *Ilgazina unilateralis* Erdoğan, *Postomphalocyclus merici* İnan, *Cideina soezerii* (Sirel), *Selimina spinalis* İnan and *Nummofallotia kastamonica* Özgen-Erdem (Meriç, 1978b; İnan, 1996; İnan et al., 1992, 1996b; Erdoğan, 1995; Özgen-Erdem, 2001). Description of each genus from its only one species is an interesting point to note. This means future quantitative studies and detailed species descriptions may clarify the occurrences of these genera in other platforms. The RPP is characterized by abundant occurrences of *Orbitoides gruenbachensis* Papp and new species listed above. Orbitoidal forms are dominant. Benthic rotaliid assemblages are mainly composed of *Orbitoides-Siderolites-Praesiderolites* in shallow open marine paleoenvironments without barriers such as the Osmaneli area (Görmüş, 1996-1997). Among the textulariids, *Loftusia anatolica* Meriç and *Loftusia morgani* Douvillé occur predominantly in very shallow palaeoenvironments of the platform such as Göynük, Reşadiye, and Koyulhisar areas (Meriç and Görmüş, 2001).

The ATP is the richest among the platforms based on benthic foraminiferal diversity and abundance (Fig. 8). However, it also has different assemblages in different parts of the platform. Particularly, diversity peaks in the eastern part of the platform. In the western part of the platform, lower benthic faunal abundance may be related to a deep marine barrier or different physical paleoenvironmental conditions. The platform may be subdivided into three parts according to benthic foraminiferal distribution and lithologic features. Orbitoidal foraminifera are dominant in the northern part of the platform including the Çayırhan area while high diversity with *Loftusia* and other orbitoidal foraminifera is seen in the eastern part of the platform. The third part is in the southwestern region of the

ATP. *Loftusia turcica* Meriç and Avşar, *L. ketini* Meriç, *Postomphalocyclus merici* İnan and *Pseudoedomia hekimhanensis* Görmüş are index forms of the eastern ATP.

The AP is characterized by various and abundant *Loftusia* species. *Arnaudiella grossouvrei* Douvillé, *Discyclina schlumbergeri* Munier-Chalmas, *Loftusia harrisoni* Cox, *L. elongata* Cox, *L. matsumaruii* Meriç and Görmüş, *Praesiderolites douvillei* Wannier and *Pseudorbitolina marthae* Douvillé are also other benthic foraminifera reported only from this platform.

According to data from literature, *Antalyna korayi* Farinacci and Köylüoğlu, *Goupillaudina daguini* Marie, *Lepidorbitoides minor* (Schlumberger), *L. bisambergensis* (Jaeger), *L. socialis* (Leymerie), *Clypeorbis mamillata* (Schlumberger), *Orbitoides apiculatus* Schlumberger, *O. medius* (d'Archiac), *O. (Simplorbites) papyraceus* (Boubée), *Omphalocyclus macroporus* (Lamarck), *Pseudomphalocyclus blumenthali* Meriç, *Pseudosiderolites vidali* (Douvillé), *Siderolites calcitrapoides* Lamarck and Sirtina *orbitoidiformis* (Brönnimann and Wirz) have been observed on all platforms in Turkey.

5. Conclusions

During the Campanian-Maastrichtian, a transgression developed over the three main platforms/small plates. From North to South, these platforms are the RPP, the ATP and the AP. Transgressive sequences characterize all platforms. In ascending order, these sequences contain alluvial reddish clastics, shallow marine limestones with rudists and benthic foraminifera and pelagic mudstones with planktonic foraminifera. Particularly, the eastern part of the ATP and AP generally contain back reef and reef framework units with rudists or corals while some northwestern parts of the RPP mainly include clastic sediments of an open shallow marine paleoenvironment. Towards the middle Maastrichtian, maximum transgression caused the decrease of rudist-coral reef formations. Shallow water carbonates of the Maastrichtian regression outcrop in the eastern portion of the ATP. In contrast, late Maastrichtian open marine sediments are exposed expansively in the southwest ATP and AP.

The distribution of rudists and benthic foraminifera in time and place within the Campanian-Maastrichtian transgressive-regressive sequences in Turkey reveal the presence of different faunal associations with varying abundances on the three main platforms:

- the ATP contains remarkably abundant and highly diverse rudist and benthic foraminifer associations when compared with the RPP and AP;
- each platform consists of restricted rudist and benthic foraminiferal faunas such as:
  - *Balabania*, *Darendeella, Kurtinia*, many species of Hippuritidae and Radiolitidae, *Loftusia ketini* Meriç, *L. turcica* Meriç and Avşar, *Postomphalocyclus merici* İnan, and *Pseudoedomia hekimhanensis* Görmüş within the ATP;
  - *Yvaniella*, *Ugarella*, new species of Radiolitidae, *Cideina soezerii* (Sirel), *Dizerina anatolica* Meriç, *Helicorbitoides boluensis* Sirel, *Ilgazina unilateralis* Erdoğan, *Nummofallotia kastamonica* Özgen-Erdem, *Selimina spinalis* İnan, *Sirelina orduensis* Meriç and İnan and *Smoutina cruysi* Drooger on the RPP;
  - *Vautrinia, Dictyoptychus*, *Hatayia*, *Paracaprinula*, *Hippurites syriaca* Vautrin, *Pironeae syriaca* Vautrin, *Arnaudella grossouvreii* Douvillé, *Discyclina schlumbergeri* Munier-Chalmas, *Loftusia harrisoni* Cox, *L. elongata* Cox, *L. matsumaruii* Meriç and Görmüş, and *Pseudorbitolina marthae* Douvillé on the AP.

The occurrence of different rudist and benthic foraminifer associations and index genera and species suggest the presence of barriers to larval exchanges between the three platforms. These barriers were most likely the southern and northern branches of the Neo-Tethyan Ocean.

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