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Benthonic Foraminiferal Biostratigraphy of the Upper Cretaceous (Middle Cenomanian−Coniacian) Sequences of the Bey Dağları Carbonate Platform, Western Taurides, Turkey

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Benthonic foraminiferal biostratigraphy of the Upper Cretaceous (Middle Cenomanian-Coniacian) sequences of the Bey Dağları carbonate platform, western Taurides, Turkey.

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Abstract

Identifications of the benthonic foraminiferal assemblages from ten stratigraphic sections measured from the inner platform limestones of the Middle Cenomanian-Coniacian successions of the Bey Dağları carbonate platform (BDCP) allowed the recognition of one biozone and two subzones. The lower part of the platform limestones (Middle-Upper Cenomanian) is represented by relatively rich benthonic foraminiferal assemblages, while the upper part (Turonian-Coniacian) contains poor assemblages. The benthonic foraminiferal assemblages determined in the BDCP are dominated by long-ranging species. The shorter-ranging, stratigraphically index species have been selected to date the Upper Cretaceous platform limestones of the BDCP based on the distributions of the species in the circum-Mediterranean region. *P. reicheli-P. dubia* Concurrent Range Zone is defined from the Middle-Upper Cenomanian platform limestones. The biozone includes *C. lehneri* Subzone and *C. zubairensis* Subzone, which correspond to the Middle Cenomanian and Upper

Cenomanian respectively. The first occurrences of *M. apenninica-compressa* and *P. sphaeroidea* indicate the Late Turonian and the Coniacian respectively.

The invasion of the BDCP during the Coniacian by the hemipelagic limestones shows that the neritic accumulation on the BDCP persisted from the Mid Cenomanian to the Coniacian. These data indicate that the global sea level rise at Cenomanian-Turonian boundary, which caused the general demise of many Tethyan carbonate platforms did not result in deepening on the BDCP.

Key Words: benthonic foraminifera, biostratigraphy, Upper Cretaceous, Bey Dağları carbonate platform, western Taurides.

Bey Dağları karbonat platformu Üst Kretase (Orta Senomaniyen-Koniasiyen) istiflerinin bentonik foraminifer biyostratigrafisi, batı Toroslar, Türkiye.

Özet

Bey Dağları karbonat platformunun (BDKP) Orta Senomaniyen-Koniasiyen yaşlı platform içi karbonatlarından ölçülen on stratigrafik kesitten saptanan bentonik foraminifer toplulukları bir bentonik foraminifer biyozonu ve iki alt zonun tanımlanmasını sağlamıştır. Platform karbonatlarının alt bölümü (Orta-Üst Senomaniyen) bağıl olarak zengin bentonik foraminifer toplulukları ile temsil edilir. Üst bölüm ise (Turoniyen-Koniasiyen) fakir topluluklar ile simgeseldir. BDKP'de saptanan bentonik foraminifer toplulukları düşey dağılımı geniş türlerce baskındır. BDKP'nin Üst Kretase kireçtaşlarını yaşlandırmak amacıyla, düşey dağılımı dar, stratigrafik açıdan karakteristik türler, Akdeniz kuşağındaki stratigrafik dağılımları esas alınarak seçilmiştir. *P. reicheli-P. dubia* Aşmalı Menzil Zonu platform kireçtaşlarının Orta-Üst Senomaniyen bölümünde tanımlanmıştır. Biyozon, sırasıya Orta Senomaniyen ve Üst Senomaniyen'e karşılık gelen *C. lehneri* Alt Zonu ve *C. zubairensis* Alt Zonu'nu içerir. *M. apenninica-compressa* ve *P. sphaeroidea*'nın ilk ortaya çıkışları sırasıyla Geç Turoniyen ve Koniasiyen'i işaret eder.

BDKP'nin Koniasiyen'de yarıpelajik kireçtaşları tarafından örtülmesi, BDKP'de neritik çökelimin Orta Senomaniyen'den Koniasiyen'e kadar sürdüğünü gösterir. Bu veriler, birçok Tetis karbonat platformunun sona ermesine neden olan Senomaniyen-Turoniyen sınırındaki küresel deniz seviyesi yükselmesinin BDKP'de derinleşmeye neden olmadığını gösterir.

Anahtar Sözcükler: bentonik foraminifer, biyostratigrafi, Üst Kretase, Bey Dağları karbonat platformu, batı Toroslar.

Introduction

Larger benthonic foraminifera are important tools to date the Cretaceous platform carbonates as the valued pelagic deposit markers such as ammonites and/or planktonic foraminifera are usually absent or very rare in neritic environments (Arnaud *et al*. 1981; Schroeder & Neumann 1985). However, the following points have been discussed in the literature, which limit the usage of benthonic foraminifera:

- benthonic foraminifera are facies dependent and sensible to the environmental changes (Gusic *et al*. 1988; Velic & Vlahovic 1994; Caus *et al*. 2003),
- many Cretaceous carbonate platforms, which hosted larger benthonic foraminifera, were sensible to the sea-level changes caused by eustacy and/or tectonic movements and so faced local and/or widespread emersions and drowning events (Chiocchini *et al*. 1984).

Hence, the apparent ranges of Late Cretaceous benthonic foraminifera may not correspond to their true evolutionary stratigraphic ranges (appearance-extinction) and they should be used for biostratigraphic correlations with great care, even in environments such as long-lasting carbonate platforms (Gusic *et al*. 1988; Caus *et al*. 2003). Although several benthonic foraminiferal stratigraphic distributions and biozonations have been suggested especially for local areas, a refined, standard biozonation, which can be applied for the Mediterranean region, has not been able to be created for the Upper Cretaceous up till now due to the limitations mentioned above.

Many studies have been carried out on the Bey Dağları Autochthon for nearly four decades. Although neritic limestones have wide geographic distribution throughout the Bey Dağları Autochthon, benthonic foraminiferal biostratigraphy of the Upper Cretaceous neritic limestones have been the subject of only a few detailed studies, including Bignot & Poisson (1974), Poisson (1977), Farinacci & Yeniay (1986), Sarı (1999), (2006b).

The objective of this paper is to establish detailed benthonic foraminiferal zonation of the Upper Cretaceous (Middle Cenomanian-Coniacian) neritic limestones of the BDCP and correlate it with the adjacent carbonate platforms. The study is based on twenty-two stratigraphic sections, which were measured from the northern part of the Bey Dağları Autochthon. Ten representative sections are illustrated and described herein (Figure 1).

Geological Setting of the Bey Dağları Carbonate Platform

The Bey Dağları Autochthon, which is approximately 150 km long oriented NE-SW from Kaş to Isparta (Figure 1) represents a segment of a Mesozoic Tethyan platform on which carbonate accumulation persisted from the Triassic to the Early Miocene. This segment was overthrusted by the Antalya nappes in the east and by the Lycian nappes in the northwest, and is partially exposed in the Göcek window (Özgül 1976; Poisson 1977; Farinacci & Köylüoğlu 1982; Naz *et al*. 1992; Robertson 1993). During the Mesozoic time, the autochthonous unit was part of a larger crustal fragment of the African palaeomargin which can be traced in the Taurides and Zagrides to the east, and the Hellenides, Dinarides and Apennines to the west (Şengör & Yılmaz 1981; Farinacci & Köylüoğlu 1982; Poisson *et al*. 1984; Özgül 1984;

Robertson & Dixon 1984; Robertson & Woodcock 1984; Waldron 1984; Farinacci & Yeniay 1986; Robertson *et al*. 1991; Robertson 1993; Robertson *et al*. 2003; Poisson *et al*. 2003).

The BDCP was one of the many Mesozoic Tethyan carbonate platforms initiated as a result of flooding of blocks, which had rifted from the northern margin of Gondwana during mid-Late Triassic (following Late Permian-Early Triassic rifting) throughout the southern part of the Eastern Mediterranean region (Robertson 2002). The BDCP underwent the entire predictible geodynamic spectrum of the Wilson cycle: rifting, drifting, transtension, transpression, and collision (Bosellini 1989). The BDCP is reconstructed as an isolated carbonate platform (Figure 2), which was the southernmost representative of the girdle of intraoceanic platforms extending from the western Mediterranean to the eastern Mediterranean Neotethys during the Late Cenomanian (Dercourt *et al*. 2000).

The Bey Dağları Autochthon was under the effect of different tectonic regimes during the Late Cretaceous, a time of intense tectonic movements in the eastern Mediterranean region. Late Cretaceous tectonic activities are thought to be responsible for the drowning of carbonate platforms, opening of small oceanic basins and collision of different tectonic units. Many studies have shown that the Upper Cretaceous sequences are characterized by breaks in deposition and important facies variations in both neritic and pelagic carbonates (Poisson 1977; Gutnic *et al*. 1979; Farinacci & Köylüoğlu 1982; Farinacci & Yeniay 1986; Özkan & Köylüoğlu 1988; Naz *et al*. 1992; Sarı 1999; Sarı & Özer 2001, 2002; Sarı *et al*. 2004; Sarı 2006a, 2006b).

Materials and Methods

Eight hundred and sixty-one thin sections of the limestone samples were collected from the twenty-two measured stratigraphic sections and examined in order to establish the biostratigraphic framework, and to date and detect depositional environments of the neritic limestones of the BDCP. Ten representative stratigraphic sections were selected to construct the biostratigraphical framework; other sections are characterized by either relatively poor benthonic foraminiferal assemblages, or generally similar distributions (Figure 1).

Benthonic foraminiferal biozonation is established based on the first and last occurrence datums of the taxa in accordance with the rules recommended by the North American Stratigraphic Code (NASC 1983) and International Stratigraphic Guide (ISG) (Salvador, 1994).

Previous Studies

Upper Cretaceous neritic limestones of the Bey Dağları Autochthon have been subject to a few studies dealing with the benthonic foraminiferal biostratigraphy. Altınlı (1944) was the first to mention the presence of Cenomanian benthonic foraminifera in the area between Burdur and Isparta. Later on Blumenthal (1960-1963) found *Actaeonella* and *Orbitolina* in Pınarbaşı and attributed these levels to Aptian and Cenomanian-Turonian. Colin (1962), Tolun (1965) and Lefevre (1966) are researchers, who mentioned the Cenomanian limestones with few benthonic foraminifera.

Poisson (1967) gave first detailed benthonic foraminifera assemblage from the Korkuteli area. He noted that the assemblage comprising *C. gradata*, *D. schlumbergeri*, *P.* cf. *reicheli*, *O.* cf. *ovum* and *Cuneolina* sp., which indicated Late Cenomanian age.

Bignot & Poisson (1974) described a rich benthonic foraminifera assemblage in the Katran Dağ area. They determined two different horizons, one with *P. laurinensis*, and the other one with *S. viallii*. They noted that the two species were not found together and they were content to accept that the level with *S. viallii* laid beneath the level with *P. laurinensis* on the basis of the following previous data from the Mediterranean region; *P. laurinensis*, associated with *C. gradata* and *C. fraasi*, is accepted as an indicator of the Late Cenomanian in Italy (de Castro 1965, 1966), Croatia (Husinec, 2002), Portugal (Berthou & Philip 1972), Greece (Guernet 1971; Bignot *et al*. 1971; Fleury 1972), Lebanon (Saint-Marc 1969, 1970) and probably in Iran (Sampo 1969). *S. viallii* was found in the level beneath *P. laurinensis* and *C. fraasi* in Italy (Sartoni & Crescenti 1962; Colalongo 1963; Devoto 1964; Farinacci & Radoicic 1965; de Castro 1966; Angelucci & Devoto 1966), former Yugoslavia (Radoicic 1960), Greece (Fleury 1972), Lebanon (Saint-Marc 1969, 1970) and Tunisia (Bismuth *et al*. 1967).

Poisson (1977) noted the presence of the Cenomanian assemblages through the stratigraphic sections in his detailed thesis.

Farinacci & Yeniay (1986) also found rich benthonic foraminiferal assemblages through the eight stratigraphic sections scattered throughout the autochthon. They noted that the assemblages indicated Cenomanian age and were overlain by the Lower Turonian with abundant rudist fragments, calcisphaerulids and planktonic foraminifera to firstly appear on the platform.

Recently Sarı (2006b) established the Upper Cretaceous biostratigraphy of the BDCP based on benthonic foraminifera, planktonic foraminifera and rudists.

Upper Cretaceous Litho-biostratigraphy and Depositional Environment of the BDCP.

The Upper Cretaceous sequence of the northern area of the autochthon is represented by two formations (Figure 3). The Bey Dağları Formation comprises thick neritic limestones at the base and thin hemipelagic limestones at the top. Approximately 700-m-thick, Middle Cenomanian-Coniacian neritic part consists of shallow water platform limestones, that were deposited in peritidal environments. The neritic limestones are capped by a 26-m-thick package of Coniacian-Santonian hemipelagic limestones. Thin-to medium-bedded cherty pelagic limestones of the Late Campanian-Late Maastrichtian Akdağ Formation reach a total thickness of 100 m and disconformably overlie various stratigraphic levels of the underlying Bey Dağları Formation. The pelagic marls of the Palaeogene, which locally begin with a pelagic conglomerates, disconformably overlie the different stratigraphic levels of the Upper Cretaceous sequence (Figure 3).

Neritic limestones of the Katran Dağ area are represented by the rudist-rich (mainly caprinids) Mid-Late Cenomanian Yağca Köy Formation, which is disconformably overlain by pelagic deposits of the Karakirse Formation. The lowermost part of the Karakirse Formation comprises large pebbles and blocks derived from the underlying rudist-rich limestones of the Yağca Köy Formation.

Benthonic foraminifera and rudists are the ony fossil components used to date the neritic limestones of the BDCP. The lower part of the neritic limestones corresponding to Middle-Upper Cenomanian is relatively rich in benthonic foraminifera. They are rich in number of individuals but poor in diversity probably due to restricted environment. The upper part, which corresponds to the Turonian-Coniacian interval, has a poor assemblage.

Two rudist formations have been observed in the neritic limestones. The lower level, which is observed in the Middle-Upper Cenomanian of the Sarp Dere Section is represented by scarce and unidentifiable caprinids associated with radiolitids (caprinid lithosome). The upper level is dominated by hippuritids and found near the top of the platform limestones (hippuritid lithosome). The fauna is represented by the dominance of *V. praegiganteus*, which is accompanied by rare *V. inferus*, *H socialis*, *H. resecta* and radiolitids in the Korkuteli area. The $^{87}Sr/^{86}Sr$ values of well preserved low-Mg calcite of the shells of *V. praegiganteus* show that the age of this level is Late Turonian (Sarı *et al*. 2004). The upper rudist level, which prominently occurs in the Korkuteli area, is observed patchyly throughout the northermost part of the platform. The occurrence of *M. heraki*, *D. bassani*, *B. angulosus* in the Koparan Tepe section also supports the Late Turonian age obtained by Sr-isotope analysis.

The faunal change after the Late Turonian (probably in the Coniacian) from predominantly rudists and benthonic foraminifera to planktonic foraminifera, indicates a incipient drowning of the platform and subsequent establishment of hemipelagic conditions on the platform that lasted until the end of the Santonian. The limestones deposited in hemipelagic conditions are massive, cream-coloured, fractured and contain rare planktonic foraminifera and abundant calcispheres. The neritic and hemipelagic limestones are both massive and cream-coloured and similar in appearance (i.e. textures on broken, fresh surface are the same), hence they are indistinguishable in the field. A special microfacies, containing abundant crinoids enclosed by syntaxial cement, has been determined between the neritic and hemipelagic facies in some stratigraphic sections. The crinoid grains enclosed by syntaxial cement are characteristic features of the drowning phase (Flügel 2004). Besides, there is no evidence to support an intense karstification before drowning. The maximum thickness of the hemipelagic levels was measured in the Kocaboğaz Dere section and is 26 m (Sarı 2006b).

Neritic limestones of the Bey Dağları Formation mainly accumulated in a platform interior environment that existed from Mid Cenomanian to Coniacian. Microfacies analyses of neritic limestones have indicated peritidal (tidal flat, ponds and channels), subtidal, shelf (restricted circulation), shelf lagoon (open circulation), winnowed edge, organic build up and foreslope environments (Sarı & Özer 2001; Sarı 2006b). The planktonic foraminifera-bearing Coniacian-Santonian massive limestones were deposited in hemipelagic environment (Sarı 2006a; 2006b). The following microfacies have been distinguished belonging to the mentioned environments. These are the main microfacies and they are transitional and intercalated: a) Laminated peloidal packstone and fenestral mudstone microfacies, b) Alternating cryptalgal and laminated peloidal packstone microfacies, c) Sparse benthonic foraminifera-bearing non-laminated peloidal packstone/grainstone microfacies, b) Rich benthonic foraminifera-bearing wackestone/packstone microfacies, d) Rudist fragments-bearing packstone microfacies (Sarı & Özer 2001; Sarı 2006b).

The neritic limestones of the Katran Dağ area (Karain and Yağca sections) are represented by the Yağca Köy Formation and have different facies characteristics from the other stratigraphic sections probably as a result of a different palaeogeographic evolution. The sequence in the Katran Dağ area comprises the Middle Cenomanian caprinid-rich neritic limestones and is dominated by the winnowed bioclastic rudstone/grainstone microfacies with rich rudist fragments and rare corals and gastropods. Coarse bioclastic grains are well-rounded, coated with micrite envelopes and replaced by sparry calcite. The microfacies indicate the dominance of winnowed platform edge environment, where lime mud is removed because of constant wave action, at or above wave base (Wilson 1975; Flügel 2004). The rudstone/grainstone microfacies rarely alternate with the 'coral framestone', 'floatstone with rudist fragments and intraclasts' and 'packstone with benthonic foraminifera and rare intraclasts' microfacies (Sarı 2006b).

Measured Stratigraphic Sections

As almost each stratigraphic section represents different biostratigraphic data, biostratigraphic characteristics of each section will be presented separately from north to south of the area investigated (See Figure 1 for location of the sections).

1. Koparan Tepe section

The occurrence of *C. lehneri* in the 36-m-thick lower part of the 230-m-thick succession suggests the Mid Cenomanian age (Figures 5 & 6). The middle part of the section is mostly represented by the scarce occurrences of the Cenomanian taxa like *P. reicheli*, *V. radoicicae*, *P. dubia*, *B. peneropliformis*, *M. cretacea*, *P. parvus*, *T. avnimelechi* and *B. bentori* (Figure 5). The occurrence of *C. fraasi* in sample 03-381 suggests a Late Cenomanian age (Figure 5). The last occurrence of the Cenomanian assemblage is seen in sample 03-322. The occurrence of *C. zubairensis* in sample 03-324 indicate that the age of this level is also Late Cenomanian.

The uppermost part of the section is characterized by the Upper Turonian rudist level (hippuritid lithosome), which is dominated by *V. praegiganteus*. The 62-m-thick level between the last occurrences of the Cenomanian assemblage and the first occurrence of the rudists may correspond to the Turonian. The benthonic foraminifera in this interval are very rare and include *B. capitata*, which is restricted to this interval. *N. regularis* is found in the middle part of this interval (sample 03-313). Association of *P. reicheli*, *V. radoicicae* and *B. peneropliformis* with *C. lehneri* in the lower part of the section support the data, which suggest the occurrence of these species in the Mid Cenomanian (Figure 5). *P. laurinensis* appears seven metres above the level, where *C. fraasi* disappears. *C. gradata*, *T. avnimelechi*, *N. regularis* and *B. bentori* appear at the uppermost part of the Upper Cenomanian in this section (samples 03-324-03-322). The absence of bauxitic and lateritic levels, which indicate subaerial exposure and pelagic interlayers clues of drowning, suggest that the platform conditions persisted from the Mid Cenomanian to the Late Turonian at least in this part of the platform.

2. Demirci Dere section

The 7-m-thick neritic limestones beneath the pelagic limestones include *C. zubairensis*, which suggest a Late Cenomanian age (Figures 5 & 7). *C. gradata* in sample 03-475 accompanies *C. zubairensis*. The 5.5-m-thick lower part of the neritic limestones, are brecciated and include rudist shell fragments at the lowermost part of the section. The 1.5-m-thick uppermost part is made up of thick-bedded limestones. Thin-bedded (10-15 cm) pelagic limestones, including sand to fine pebble-size intraclasts derived from various stratigraphic levels of neritic, hemipelagic and pelagic limestones, disconformably rest over the neritic limestones along a prominent erosional surface. The planktonic foraminifera associations indicate that the age of the lower part of the pelagic limestones is Late Campanian (Sarı 2006b).

3. Karain section

The section is represented by a rich caprinid, ichthyosarcolitid and radiolitid fauna (caprinid lithosome), which suggest a Mid-Late Cenomanian age and are associated with corals and gastropods. However, benthonic foraminifera are rather scarce (Figure 8). The uppermost part of the 120-m-thick sequence is characterized by the occurrence of *Orbitolina* sp. in three samples. The presence of *M. cretacea* and *P. laurinensis* within the assemblage determined in sample 03-634 close to the middle part of the succession indicates that the level where the sample 03-634 was taken should not be older than the Mid Cenomanian as these species are not older than the Mid Cenomanian (Figure 5).

The rudist fauna comprising *I. bicarinatus*, *I. triangularis*, *C. Schiosensis, N. gigantea*, *S.* cf. *Schiosensis, S. woodwardi*, *Durania* sp., *Radiolites* sp. and *Sauvagesia* sp. and unidentifiable radiolitids, was previously studied by Özer (1988) and has also been reported from Serinhisar (Denizli) by Özer (1998). The fauna has been reported from many Middle-Upper Cenomanian outcrops in the circum-Mediterranean region as well (Plenicar 1963; Sliskovic 1968; Polsak & Mamuzic 1969; Bilotte 1985; Accordi *et al*. 1989; Lupu 1992; Cherchi *et al*. 1993).

4. Yağca section

The neritic limestones at the lowermost part of the section are the lateral equivalent of limestones observed in the Karain section. The limestones have rather scarce foraminifera and rich rudist assemblage as in the Karain section. A different Cenomanian assemblage is observed in the pebbles of the Karakirse Formation (Figure 9). The pebbles and blocks of the neritic limestones are embedded in pelagic matrix with planktonic foraminifera, which indicate a latest Campanian-Early Maastrichtian age (Sarı 2006b).

5. Canavar Boğazı section

The neritic part of the section is mainly represented by scarce benthonic foraminifera. *P. laurinensis* is present in samples 07-627 and 97-630 and is known as a Mid-Late Cenomanian species (Figure 5 & 10). Occurrence of *P. reicheli, P. dubia, B. peneropliformis, N. regularis* and *C. gradata* in the uppermost part of the neritic limestones indicate that the neritic part of this section should not be younger than the Late Cenomanian. The uppermost part of the neritic succession is represented by the occurrence of unidentifiable radiolitid fragments. The neritic succession is disconformably overlain by pelagic limestones. Planktonic foraminifera assemblage observed in the pelagic limestones suggest a Late Campanian age (Sarı 2006b).

6. Kargalıköy section

The section is represented by cream-coloured, well-bedded (30-60 cm), indurated neritic limestones of the Bey Dağları Formation and one of the most important sections as it contains the remarkable road-cut outcrop of the Upper Turonian rudist level (hippuritid lithosome) (Figure 11). The lower part of the 20-m-thick lithosome is dominated by *V. praegiganteus*, which is associated with rare *V. inferus*, small-sized hippuritids and radiolitids. Analysis of geochemically well-preserved low-Mg calcite of shells of *V. praegiganteus* for $^{87}Sr/^{86}Sr$ values yielded a Late Turonian age (Sarı *et al*., 2004). The abundance of *V. praegiganteus* as well as the other rudists decrease towards the upper part of the lithosome, in which small-sized hippuritids and radiolitids are common. The lower part of the section has a Mid-Late Cenomanian foraminiferal assemblage. There is no paleontologic data for the level between the last occurrence of the Cenomanian assemblage and the first occurrence of rudists. The uppermost part of the neritic succession between the last occurrence of the rudists and the first occurrence of the ?Coniacian-Santonian planktonic foraminifera is also barren and may questionably correspond to the latest Turonian or Coniacian. The rare planktonic foraminifera content of the 10-m-thick hemipelagic level at the uppermost part of the section suggest a ?Coniacian-Santonian age (Sarı 2006b). The boundary relationship between the neritic and the hemipelagic limestones in this section is not clear.

7. Boztaş Tepe section

The section includes an assemblage containing *P. dubia*, *P. laurinensis* and *C. gradata* at the base of the section (Figure 12). This association indicates a Mid-Late Cenomanian age. The rest of the succession has long-ranging taxa. The first occurrence of *M. apenninica-compressa* in sample 97-193 indicates the Coniacian (Figure 5). The uppermost part of the section is made up of massive neritic limestones, which are cut by an erosional surface and overlain by pelagic conglomerates. The planktonic foraminifera observed in the matrix of the pelagic conglomerates and the overlying pelagic limestones indicates Mid Eocene (Sarı 2006b). The absence of any pelagic interlayer or any sedimentary structures showing subaerial exposure throughout the 625-m-thick sequence indicates that the platform environment were not interrupted in this part of the platform.

8. Sarp Dere section

The Sarp Dere section is the only section where the caprinids (rudists) were determined in the whole Bey Dağları Autochthon outside the Katran Dağ area. The caprinids are observed in the middle part of the section as few unidentifiable individuals associated with rare radiolitids (Figure 13). The occurrence of the caprinids indicates Cenomanian. The poor benthonic foraminifeal assemblage determined in the lowermost part of the section is typical Mid-Late Cenomanian Bey Dağları assemblage observed in the other stratigraphic sections. The appearance of *P. sphaeroidea* in sample 97-9 at the uppermost part of the succession indicates the Coniacian. The neritic limestones are cut by an erosional surface and overlain by the thin-bedded pelagic limestones of the Akdağ Formation. Rich planktonic foraminiferal assemblage suggests a Late Campanian-Early Maastrichtian age (Sarı, 2006a).

9. Küçük Tepe section

The samples at the lower part of the section include Mid-Late Cenomanian assemblages (Figure 14). The occurrence of *P. sphaeroidea* in sample 97-68 allows to draw the Turonian-Coniacian boundary. The uppermost part of the neritic limestones is represented by a rudist level with abundant radiolitids. The neritic limestones are disconformably overlain by the pelagic limestones of the Akdağ Formation. The rich planktonic foraminifera assemblages suggest a Late Campanian-Early Maastrichtian age (Sarı 2006a).

10. Çamkuyusu section

The approximately 400-m-thick lower part of the sequence is almost barren and only sample 04-41 includes a poor assemblage, which is made up of a few species such as *C. gradata*, *N. picardi* and *P. reicheli*. The lower part of the second half includes a relatively rich assemblage. The last occurrences of *C. gradata* and *P. reicheli* in sample 04-65 draw the Cenomanian-Turonian boundary. The first occurrence of *P. sphaeroidea* in sample 04-69 suggests the Coniacian. The approximately 200-m-thick upper part of the section is represented only by long-ranging taxa. The sequence includes rare non-diagnostic rudists and non-rudist bivalves throughout.

Benthonic Foraminiferal Biostratigraphy

Detailed investigations of ten measured stratigraphic sections from the BDCP (Figures 6 through 15) show that the lower part of the platform limestones (Middle-Upper Cenomanian) is represented by relatively rich benthonic foraminiferal assemblages, while the upper part (Turonian-Coniacian) contains poor assemblages. These data consistent with the other Mediterranean successions (Figure 5). Numerous studies of the Upper Cretaceous benthonic foraminiferal biostratigraphy have been carried out in the Mediterranean region since the beginning of the second half of the last century. The data were compiled by Arnaud *et al*. (1981) and Schroeder & Neumann (1985). Bilotte (1998) presented the distributions of important Tethyan and Adriatic benthonic foraminiferal species. Correlation of the stratigraphic distribution of the important benthonic foraminiferal species, derived from the 22 published papers, is summarized in Figure 5. The species in this chart are only those that were also observed in the BDCP. Correlation of the biozonations offered for the Upper Cretaceous neritic successions is given in Figure 16. The benthonic foraminiferal biozonations proposed for each area are different due to the limitations mentioned in the introduction part.

The benthonic foraminiferal assemblages determined in the BDCP successions are dominated by long-ranging species. The presence of shorter-ranging, stratigraphically index species, the first (FO) and/or the last occurrence (LO) of the taxa and the co-occurrence of two or more taxa are all important for finer biostratigraphic subdivision. The benthonic foraminiferal biozones have been established based on the recommendations of the NASC (1983) and the ISG (Salvador, 1994).

P. reicheli-P. dubia Concurrent Range Zone has been defined from the Middle-Upper Cenomanian platform limestones. The biozone includes *C. lehneri* Subzone and *C. zubairensis* Subzone, which correspond to the Middle Cenomanian and Upper Cenomanian respectively (Figure 17). The biozones identified in this study are briefly described below from oldest to youngest (See Plates 1 to 4 for the images):

P. reicheli-P. dubia *Concurrent Range Zone*

This biozone is determined from the FO of *P. reicheli* and the LO of *P. dubia* (Figure 17). *P. reicheli* and *P. dubia* are selected as biozone markers, because they are the most common species observed in the BDCP. The species are also widely recorded from the Cenomanian shallow-water limestones of the circum-Mediterranean region. The biozone is defined from the Koparan Tepe section (Figure 7). *P. reicheli* firstly occurs in sample 03-424. The species is rare throughout the section and has its last occurrence in sample 03-324. The FO and the LO of *P. dubia* are observed in samples 03-417 and 03-322 respectively. The total thickness of the biozone is 176.5 metres in this section. *P. reicheli-P. dubia* Concurrent Range Zone includes many Cenomanian (i.e., *P. parvus, T. avnimelechi, V. radoicicae, B. bentori, B. peneropliformis, N. regularis, P. reicheli* and *C. gradata*) and Mid-Late Cenomanian (i.e., *M. cretacea, P. laurinensis, C. lehneri, C. fraasi* and *C. zubairensis*) species. Long-ranging species such as *D. schlumbergeri, C. pavonia, N. simplex, P. heimi* and *N. picardi* also occur within this biozone (Figures 6 & 17). The lower and the upper boundaries of the biozone can not be recognized properly in the other stratigraphic sections due to the rareness of the species and/or reduced thickness of neritic limestones in some stratigraphic sections. *P. reicheli-P. dubia* Concurrent Range Zone includes two subzones:

C. lehneri S*ubzone*: This biozone is defined by the total range of the nominate taxon in the Koparan Tepe section (Figures 6 & 17). The species has its FO and LO in samples 03-417 and 03-398 respectively and total thickness of the biozone is 35.5 metres in this section (Figure 6). The biozone includes *D. schlumbergeri, P. reicheli, C. pavonia, V. radoicicae, N. conica, N. simplex, P. dubia, P. heimi* and *B. peneropliformis* (Figures 6 & 17). *C. lehneri* is recorded from the Middle Cenomanian successions in the circum-Mediterranean region (Chiocchini *et al*. 1984; 1994; Schroeder & Neumann 1985). Hence, the age of the interval corresponding to this biozone should be Mid Cenomanian in the Koparan Tepe section (Figure 6).

C. zubairensis S*ubzone*: This biozone is defined from the FO to the LO of the nominate taxon in the Demirci Dere section (Figures 7 & 17). Total thickness of the biozone is 4.5 metres in this section. The biozone comprises *C. pavonia, N. simplex, P. reicheli, C. gradata, M. cretacea, N. picardi, N. conica* and *B. peneropliformis* in the Demirci Dere section (Figure 7). *C. zubairensis* is also observed in sample 03-324 in the Koparan Tepe section. The species is associated with *D. schlumbergeri, P. reicheli, N. conica, N. simplex, P. dubia, B.*

peneropliformis, M. cretacea, C. gradata and *T. avnimelechi* (Figure 6). *C. zubairensis* is recorded from the Upper Cenomanian successions of the circum-Mediterranean region (Saint-Marc 1977; 1981; Chiocchini *et al*. 1984; 1994). Therefore, the age of this biozone should be Late Cenomanian in the Demirci Dere section (Figure 7).

The other stratigraphically importat taxa: The FO of the two important species such as *M. apenninica-compressa* and *P. sphaeroidea* is also used to date the post Cenomanian limestones of the BDCP (Figure 17). The FO of *M. apenninica-compressa* is accepted within the Late Turonian (de Castro 1966; Gusic & Jelaska 1990; Chiocchini & Mancinelli 1977; Chiocchini *et al*. 1994; Korbar & Husinec 2003). *M. apenninica-compressa* is determined in two stratigraphic sections in this study. The FO of the species in sample 97-200 in the Boztaş Tepe section indicates the Late Turonian (Figure 12). The species is associated with P. sphaeroidea in sample 97-68 in the Küçük Tepe section (Figure 14).

The FO of *P. sphaeroidea* is used to draw the Turonian-Coniacian boundary (Bilotte 1984; 1998; Fucek *et al*. 1990) or the FO of the species is accepted within the Coniacian (Chiocchini & Mancinelli 1977; Bilotte 1985; Grosheny & Tronchetti 1993; Chiocchini *et al*. 1994). *P. sphaeroidea* is observed in four stratigraphic sections and its FO allows to draw the Turonian-Coniacian boundary (Figures 12-15 & 17)

In addition to the biozones and the 'index' species, the LO of some taxa are also useful to draw the Cenomanian-Turonian boundary in the absence of zone marker species. Many taxa are accepted as Cenomanian species in the peri Mediterranean region (Figure 5). Some of these taxa such as *B. peneropliformis, C. gradata, P. laurinesis, B. bentori, M. cretacea, N. regularis and T. avnimelechi* have been observed in the Bey Dağları successions and are used to draw the Cenomanian-Turonian boundary. *M. cretacea* and *P. laurinensis* are known as Mid-Late Cenomanan species (Figure 17).

Conclusions

Detailed investigations of the ten measured stratigraphic sections logged from the inner platform limestones have yielded new data to construct the Upper Cretaceous (Middle Cenomanian-Coniacian) benthonic foraminiferal biostratigraphy of the BDCP. These data have been integrated with the data obtained from rudists and planktonic foraminifera biostratigraphy and Sr-isotope stratigraphy. The lower part of the platform limestones (Middle-Upper Cenomanian) is represented by relatively rich benthonic foraminiferal assemblages, while the upper part (Turonian-Coniacian) contains poor assemblages. These data consistent with the other Mediterranean successions. The benthonic foraminiferal assemblages determined in the BDCP are dominated by long-ranging species. The shorter-ranging, stratigraphically index species have been selected to establish biostratigraphic framework and to date the Upper Cretaceous platform limestones of the BDCP based on the distributions of the species in the circum-Mediterranean region.

The benthonic foraminiferal assemblages identified from the neritic limestones have allowed recognition of one biozone and two subzones. *P. reicheli-P. dubia* Concurrent Range Zone is defined from the Middle-Upper Cenomanian part of the succession and includes two subzones. *C. lehneri* Subzone and *C. zubairensis* Subzone are characterized by the range of the nominate taxa and corresponds to the Middle Cenomanian and Upper Cenomanian respectively. *M. apenninica-compressa* and *P. sphaeroidea* are the stratigraphically important taxa for the post Cenomanian part of the Bey Dağları successions and they indicate the beginning of the Upper Turonian and the Coniacian respectively.

All the data mentioned above show that the neritic accummulation on the BDCP persisted from the Mid Cenomanian to the Coniacian and the subsidence event did not affect the DDCP before the Coniacian.

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Appendix: List of species mentioned in the text and the figures with author attributions and date

Benthonic Foraminifera

Antalyna sp.
Belorussiella sp.
Biconcava bentori Hamaoui & Saint-Marc, 1970
Biplanata peneropliformis Hamaoui & Saint-Marc, 1970
Bolivinopsis capitata Yakovlev, 1891
Charentia sp.
Chrysalidina gradata D' Orbigny, 1839
Cisalveolina fraasi (Gümbel, 1872)
Cisalveolina lehneri Reichel, 1941
Coxites zubairensis Smout, 1956
Cuneolina pavonia D' Orbigny, 1846
Cuneolina sp.
Dicyclina schlumbergeri Munier-Chalmas, 1887
Merlingina cretacea Hamaoui & Saint-Marc, 1970
Moncharmontia apenninica-compressa
Nezzazata conica (Smout, 1956)
Nezzazata simplex Omara, 1956
Nezzazata sp.
Nezzazatinella picardi (Henson, 1948)
Nezzazatinella sp.
Nummoloculina regularis Philipson, 1887
Orbitolina sp.
Peneroplis parvus De Castro, 1965
Peneroplis sp.
Pseudocyclammina sphaeroidea Gendrot, 1968
Pseudocyclammina sp.
Pseudodomia drorimensis Reiss, Hamaoui & Ecker, 1964
Pseudolituonella reicheli Marie, 1952
Pseudonummoloculina heimi (Bonet, 1956)
Pseudonummoloculina sp.
Pseudorhapydionina dubia (De Castro, 1965)
Pseudorhapydionina laurinensis (De Castro, 1965),
Pseudorhapydionina sp.
Spiroloculina sp.
Textularia sp.
Trochospira avnimelechi Hamaoui & Saint-Marc, 1970
Vidalina radoicicae Cherchi & Schroeder, 1985

Rudists

Biradiolites angulosus D'Orbigny, 1850
Caprina schiosensis Boehm, 1892
Distefanella bassani Parona, 1901
Durania sp.
Hippurites socialis Douvillé, 1890
Hippuritella resecta (Defrance, 1821)
Ichthyosarcolites bicarinatus Gemmellaro, 1865
Ichthyosarcolites triangularis Desmarest, 1817
Milovanovicia heraki Polsak, 1967
Neocaprina gigantea Plenicar, 1961
Radiolites sp.
Sauvagesia sp.
Schiosia cf. *schiosensis* Boehm, 1892
Sphaerucaprina woodwardi Gemmellaro, 1865
Vaccinites inferus (Douvillé, 1891),
Vaccinites praegiganteus (Toucas, 1904)

Figure Captions

Figure 1. I) Main tectonic units of Turkey (after Görür & Tüysüz, 2001), II) Main tectonic belts of the western Taurides (simplified from Poisson *et al*., 1984) and the location of the measured stratigraphic sections a) Upper Miocene-Quaternary post-compressional tectonic formations, b) Neogene formations preceding the Aksu compressional event, c) Lower and Middle Miocene of the Bey Dağları Autochthon, d) Bey Dağları Autochthon (Upper Triassic to Oligocene), e) Antalya nappes, f) Lycian nappes.

Figure 2. Late Cenomanian palaeogeography of the Mediterranean Tethys (Simplified and modified from Dercourt *et al*., 2000). The Bey Dağları is restored as an isolated carbonate platform surrounded by pelagic basins.

Figure 3. Generalized stratigraphic columnar section of the northern part of the Bey Dağları Autochthon. (See Figure 4 for explanations).

Figure 4. Lithology, fossil and sedimentary structure explanation for all measured stratigraphic sections.

Figure 5. Correlation of the stratigraphic distributions of the benthonic foraminifera, which have also been recorded in the Bey Dağları carbonate platform. Data were derived from the following sources; 1. Fleury (1971) Greece, 2. Berthou (1973) Portugal, 3. Saint-Marc (1977) Mesogea, 4. Chiocchini & Mancinelli (1977) Italy, 5. Saint-Marc (1981) Lebanon, 6. Gargouri-Razgallah (1983) Tunisia, 7. Berthou (1984) Portugal, 8. Bilotte (1984) France & Spain, 9. Chiocchini *et al*. (1984) Italy, 10. Tronchetti (1984) France, 11. Bilotte (1985) France & Spain, 12. Moullade *et al*. (1985) Mesogea, 13. Schroeder & Neumann (1985) Mediterranean region, 14. Cherchi & Schroeder (1985) Italy, 15. Gusic *et al*. (1988) Croatia, 16. Fucek *et al*. (1990) Croatia, 17. Grosheny & Tronchetti, (1993) France, 18. Velic & Vlahovic (1994) Croatia, 19. Chiocchini *et al*. (1994) Italy,

20. Bilotte (1998) Tethyan & Adriatic, 21. Chiocchini & Mancinelli (2001) Italy, 22. Taslı *et al*. (2006) Turkey (Time scale is adapted from Gradstein *et al*. 1994).

Figure 6. Stratigraphic distribution of microfossils within the Koparan Tepe section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 7. Stratigraphic distribution of microfossils within the Demirci Dere section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 8. Stratigraphic distribution of microfossils within the Karain section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 9. Stratigraphic distribution of microfossils within the Yağca section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 10. Stratigraphic distribution of microfossils within the Canavar Boğazı section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 11. Stratigraphic distribution of microfossils within the Kargalıköy section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 12. Stratigraphic distribution of microfossils within the Boztaş Tepe section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 13. Stratigraphic distribution of microfossils within the Sarp Dere section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 14. Stratigraphic distribution of microfossils within the Küçük Tepe section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 15. Stratigraphic distribution of microfossils within the Çamkuyusu section. (See Figure 4 for explanations and Figure 1 for location of the section).

Figure 16. Local ranges of the benthonic foraminifera observed in the Upper Cretaceous carbonate successions of the BDCP.

Figure 17. Chart showing the benthonic foraminiferal biozonations offered for the peri-Mediterranean Upper Cretaceous platform limestones and correlation of these biozonations with the Upper Cretaceous benthonic foraminiferal biozonation of the northern part of the Bey Dağları carbonate platform. (Time scale is adapted from Gradstein *et al*. 1994).

Plate Captions

The bar below each photomicrographs is 500 µm.

Plate-1

1- *Cisalveolina lehneri*; sample 03-416.

2- *Cisalveolina lehneri*; sample 03-413.

3- *Cisalveolina lehneri*; sample 03-413.

4- *Cisalveolina fraasi*; sample 03-381.

5- *Cisalveolina fraasi*; sample 03-381.

6- *Orbitolina* sp.; sample 03-660.

7- *Vidalina radoicicae*; sample 03-418.

8- *Vidalina radoicicae*; sample 03-416.

9- *Bolivinopsis capitata*; sample 03-296.

Plate-2

1- *Biplanata peneropliformis*; sample 03-349.

2- *Biplanata peneropliformis*; sample 97-633.

3- *Merlingina cretacea*; sample 03-324.

4- *Merlingina cretacea*; sample 03-324.

5- *Biconcava bentori*; sample 97-631.

6- *Biconcava bentori*; sample 03-322.

7- *Nezzazata simplex*; sample 03-416.

8- *Nezzazata simplex*; sample 03-416.

9- *Nezzazata simplex*; sample 03-478.

10- *Nezzazata conica*; sample 03-671.

11- *Trochospira avnimelechi*; sample 03-324.

12- *Nezzazatinella picardi*; sample 03-310.

13- *Nezzazatinella picardi*; sample 97-185.

Plate-3

1- *Chrysalidina gradata*; sample 97-634.

2- *Chrysalidina gradata*; sample 97-38.

3- *Pseudorhapydionina laurinensis*; sample 03-378.

4- *Pseudorhapydionina laurinensis*; sample 97-627.

5- *Pseudorhapydionina laurinensis*; sample 97-627.

6- *Pseudorhapydionina dubia*; sample 03-416.

7- *Cuneolina pavonia*; sample 03-419.

8- *Dicyclina schlumbergeri*; sample 03-671.

9- *Dicyclina schlumbergeri*; sample 03-671.

10- *Pseudolituonella reicheli*; sample 03-478.

Plate-4

1- *Coxites zubairensis*; sample 03-324.

2- *Coxites zubairensis*; sample 03-474.

3- *Coxites zubairensis*; sample 03-479.

4- *Moncharmontia apenninica-compressa*; sample 97-191.

5- *Moncharmontia apenninica-compressa*; sample 97-200.

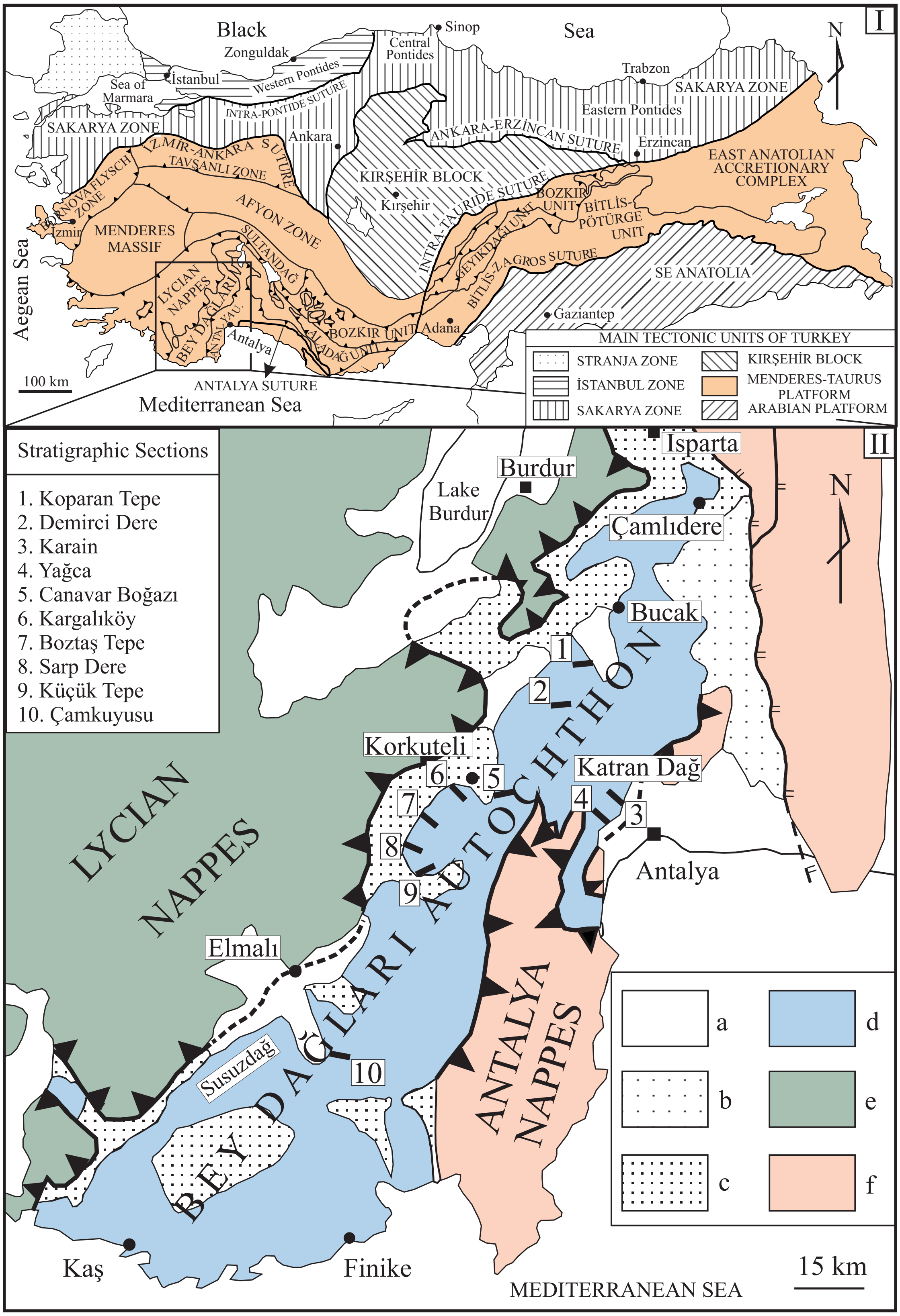
6- *Pseudonummoloculina heimi*; sample 97-627.

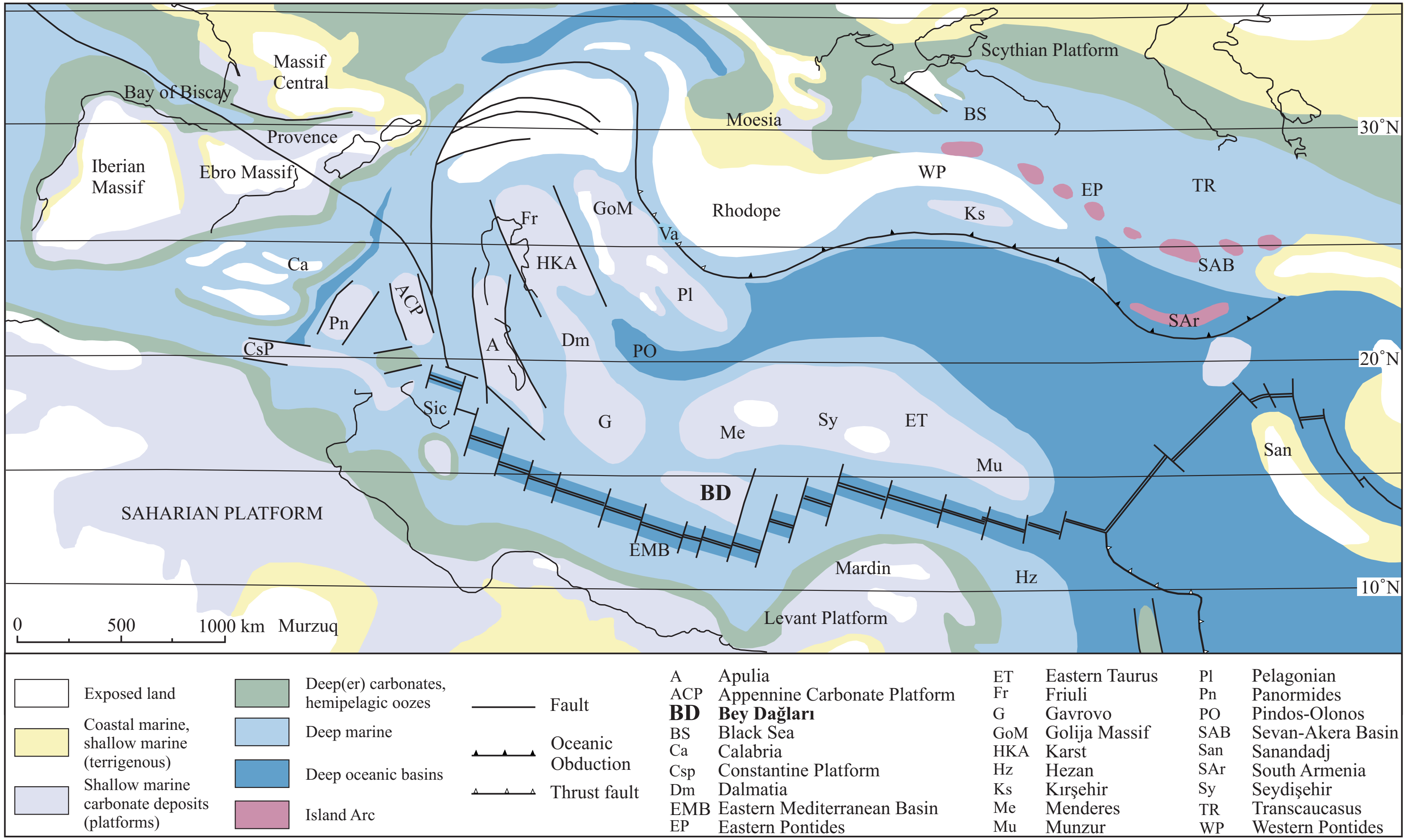
7- *Pseudonummoloculina heimi*; sample 03-368.

8- Nummoloculina regularis; sample 03-416.

9- *Pseudocyclammina sphaeroidea*; sample 97-193.

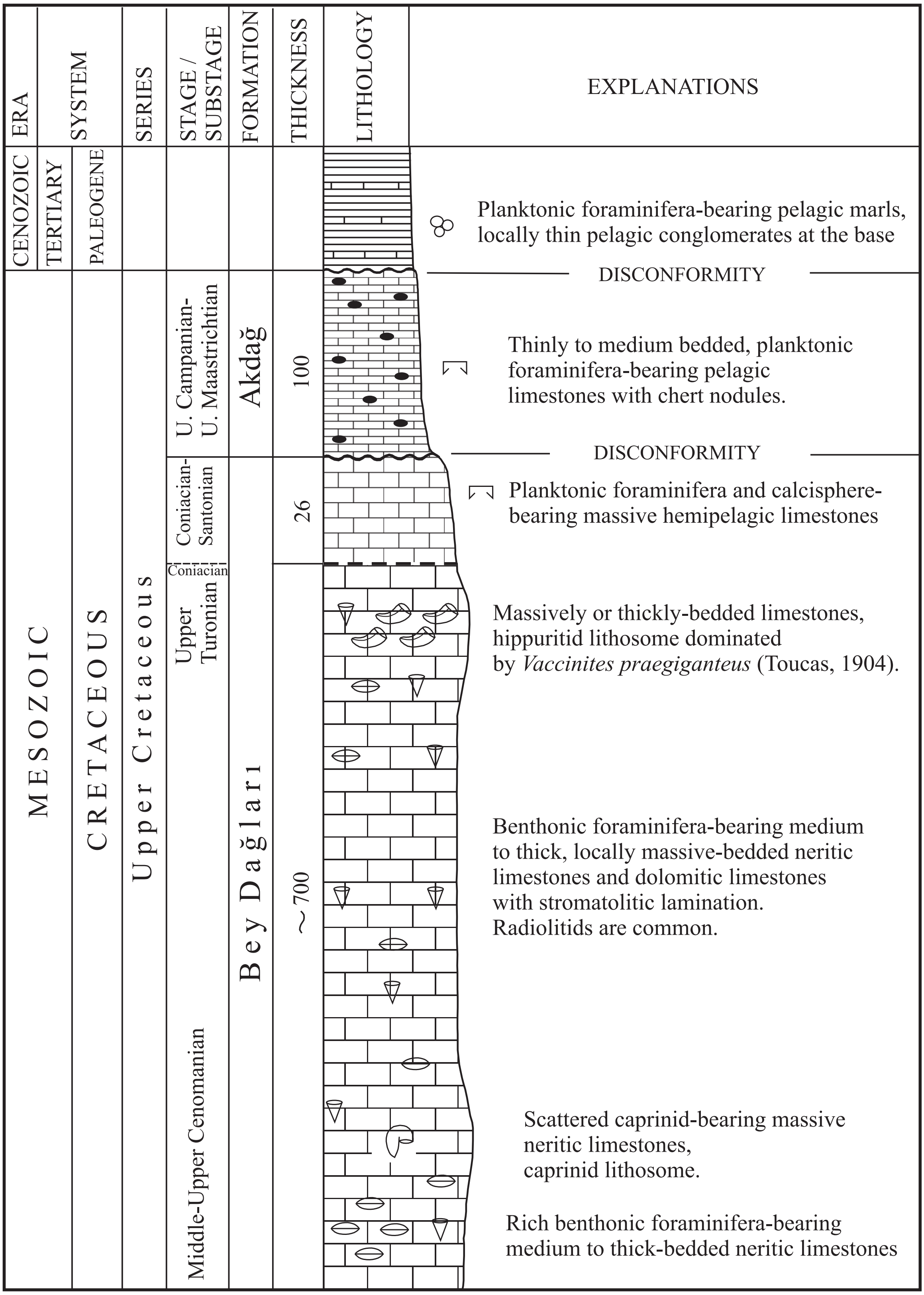
Sarı et al.- Fig. 1





Sarı et al.- Fig. 2

Sarı et al.- Fig. 3



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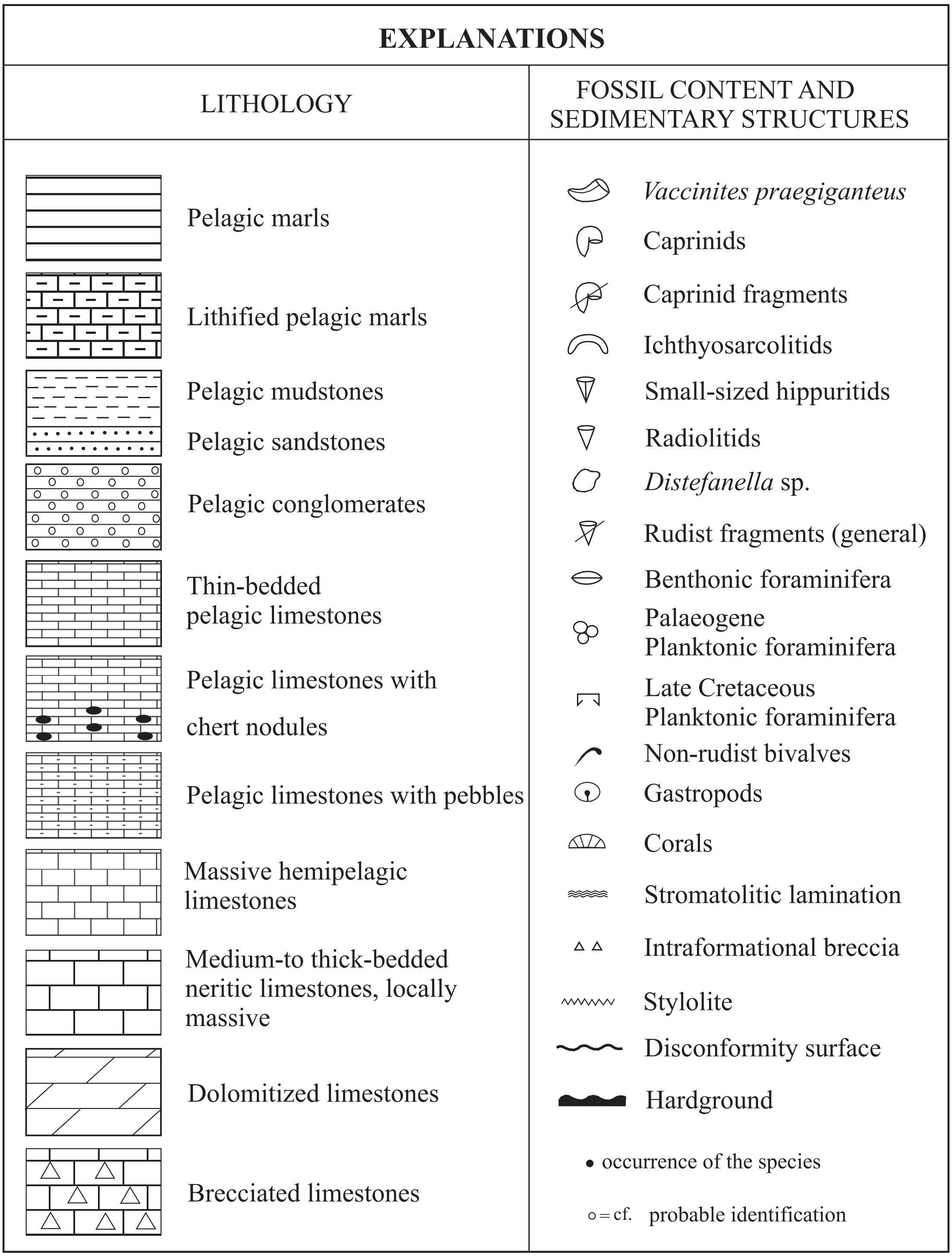
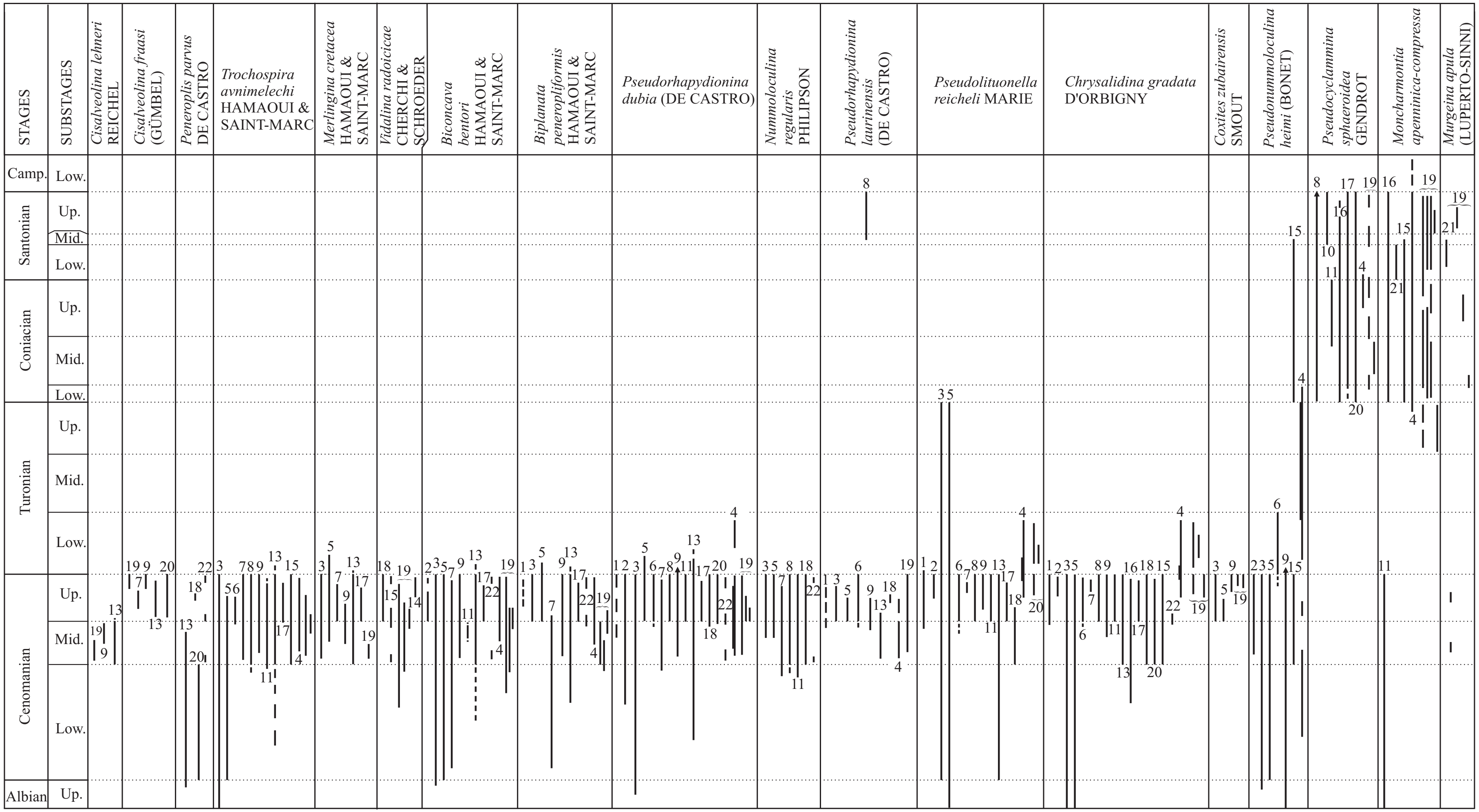
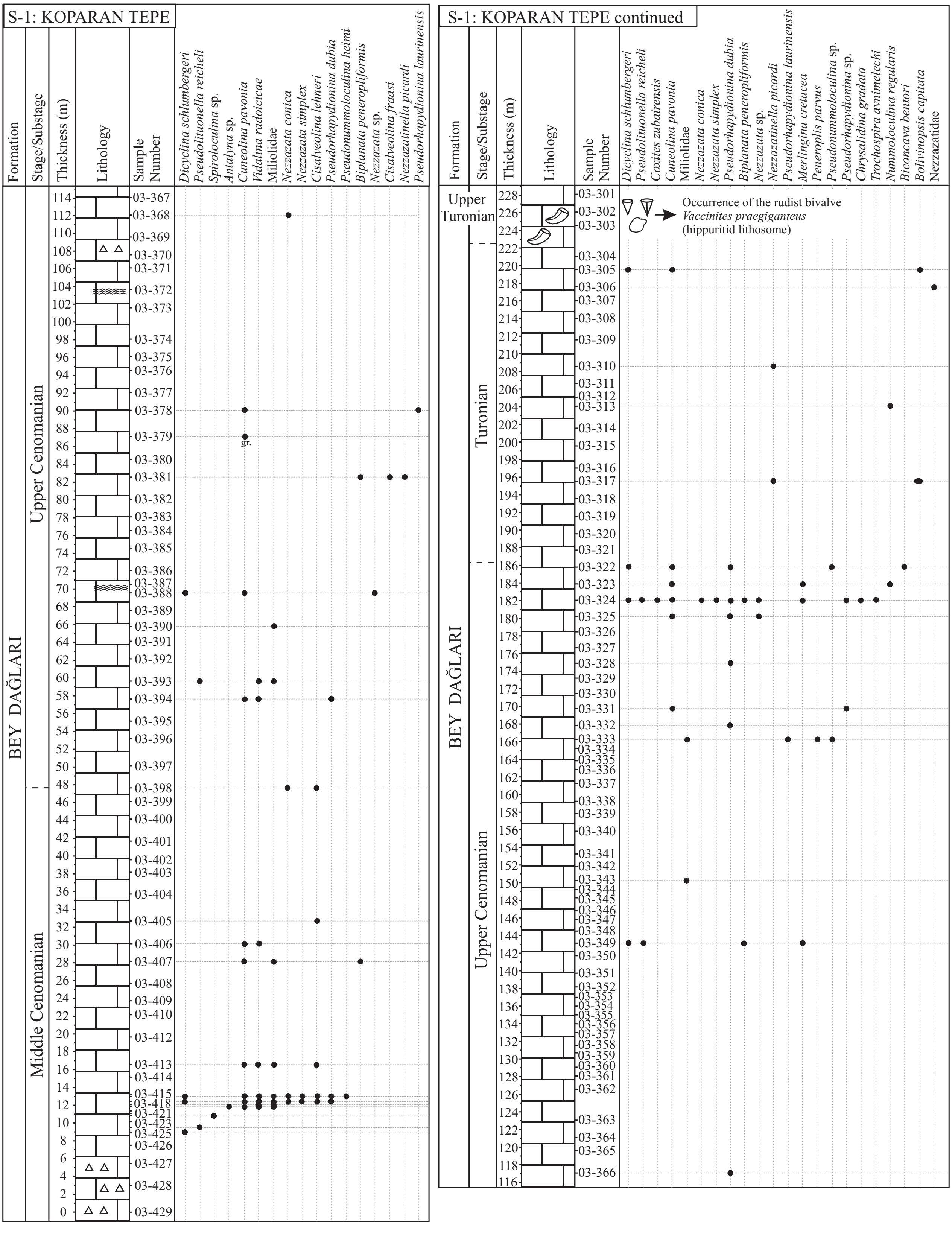




Sarı et al.- Fig. 5

Sarı et al.- Fig. 6



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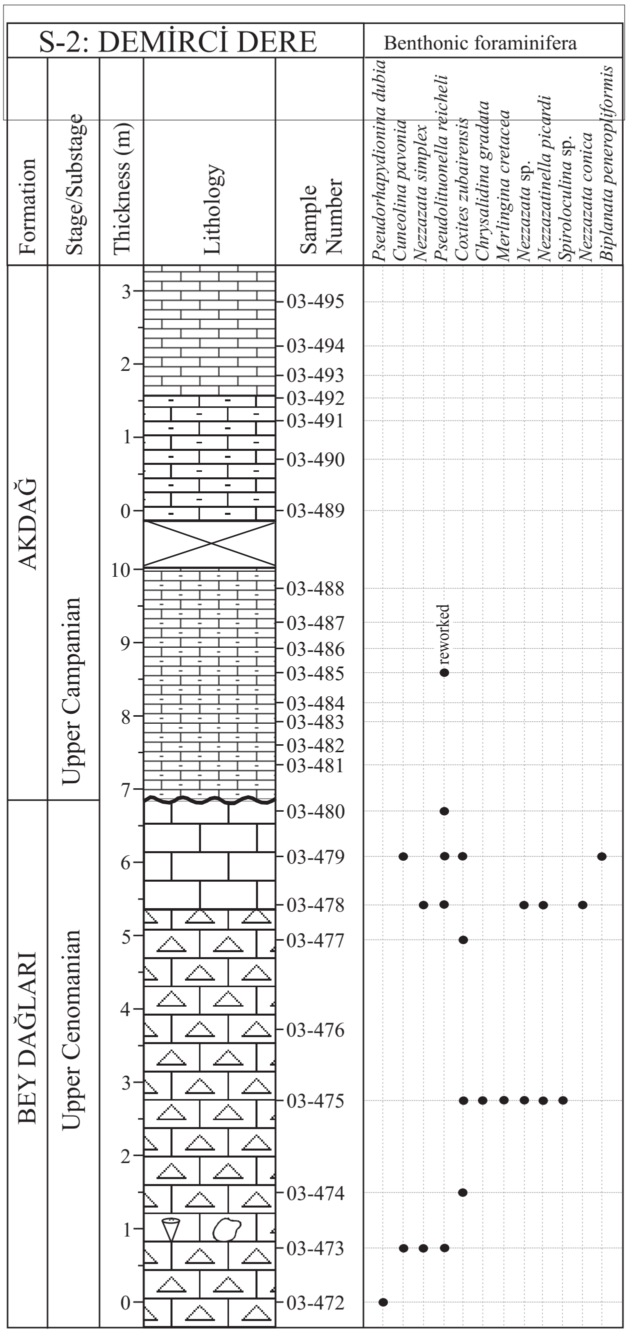

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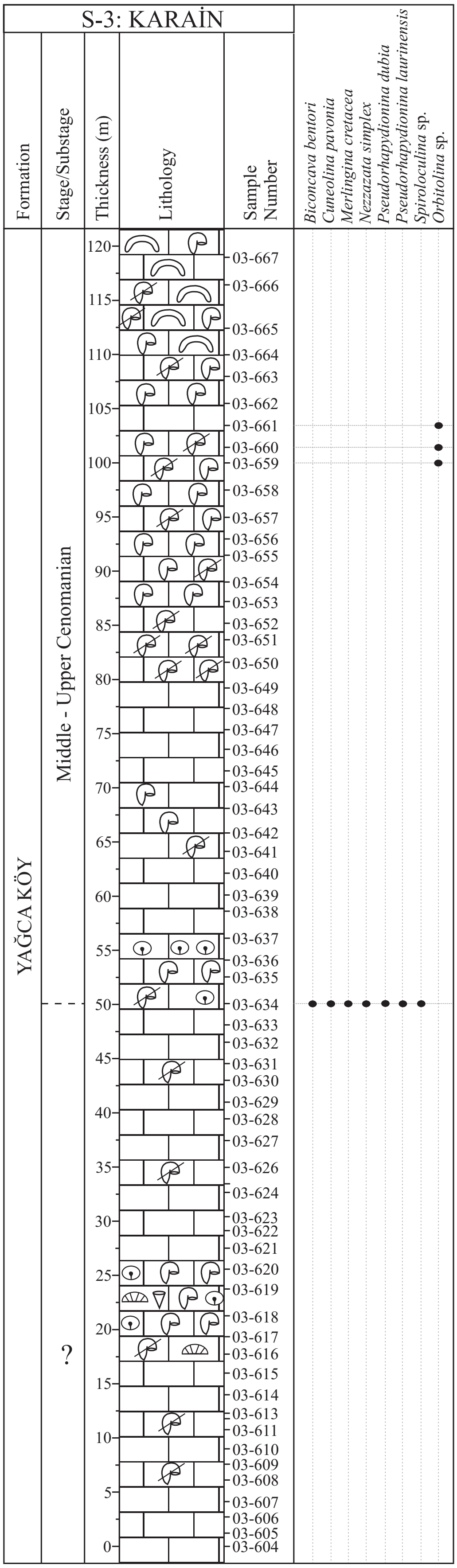

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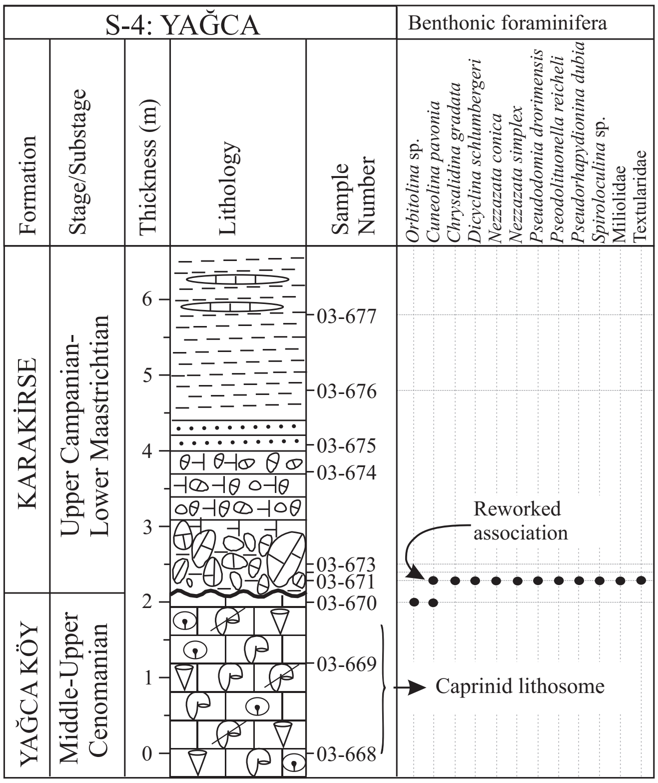

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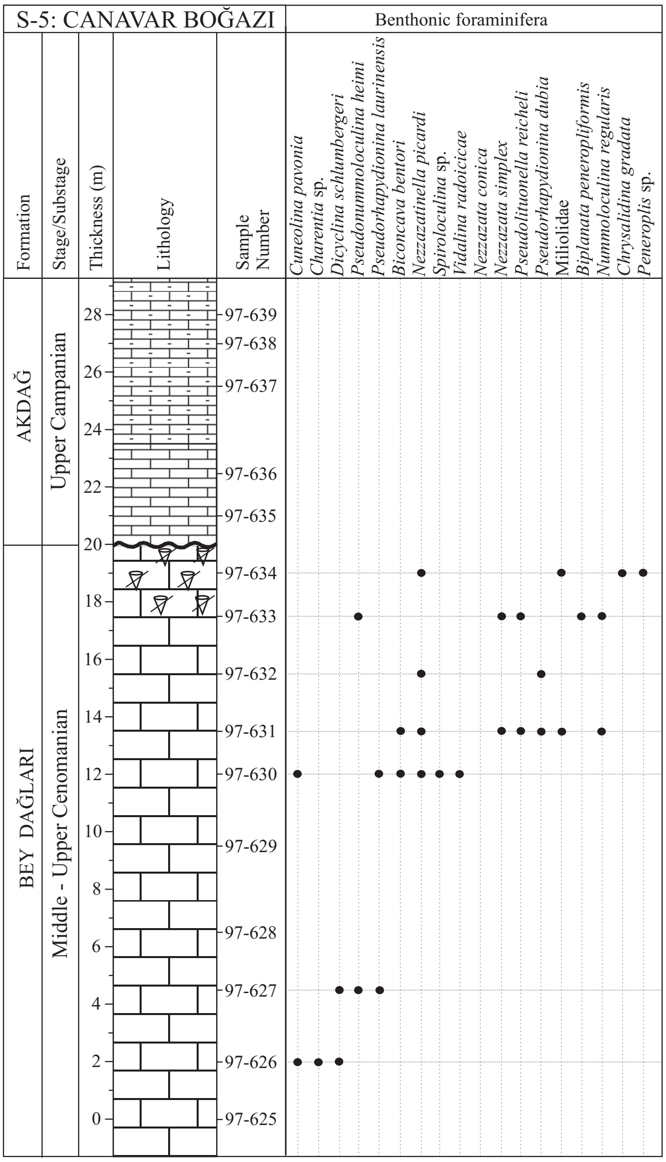

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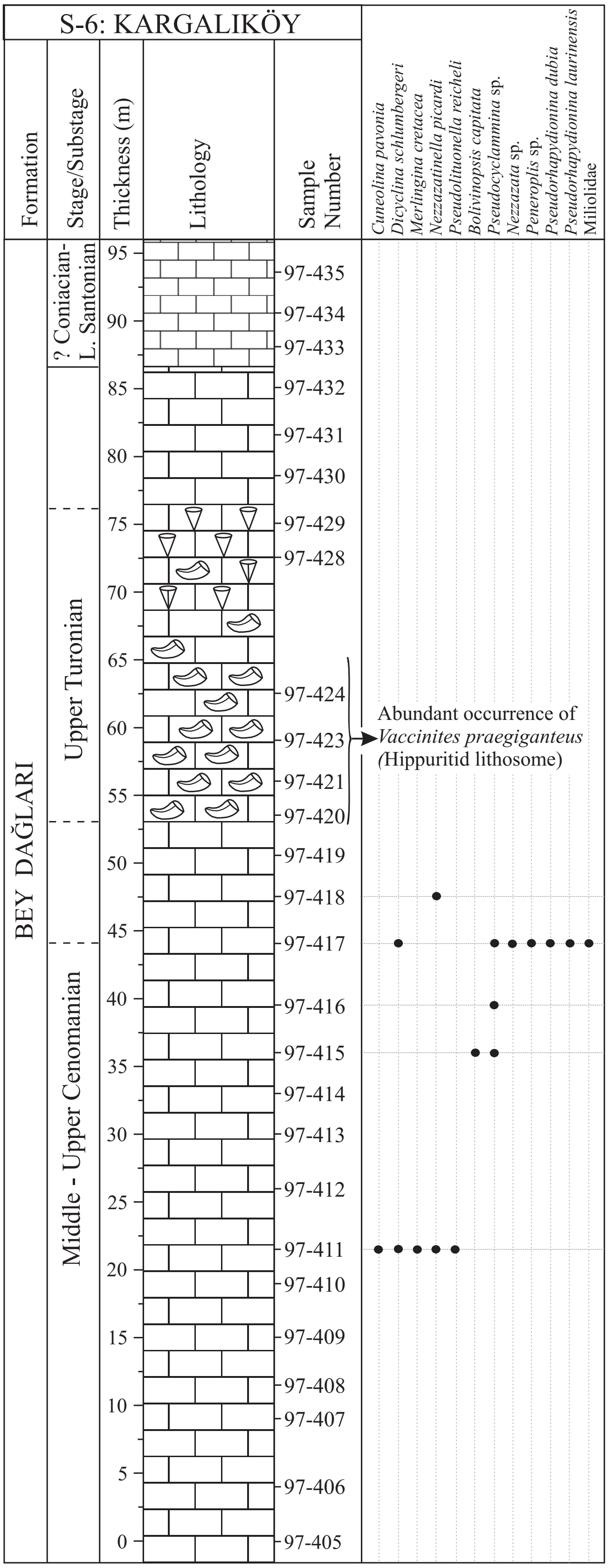

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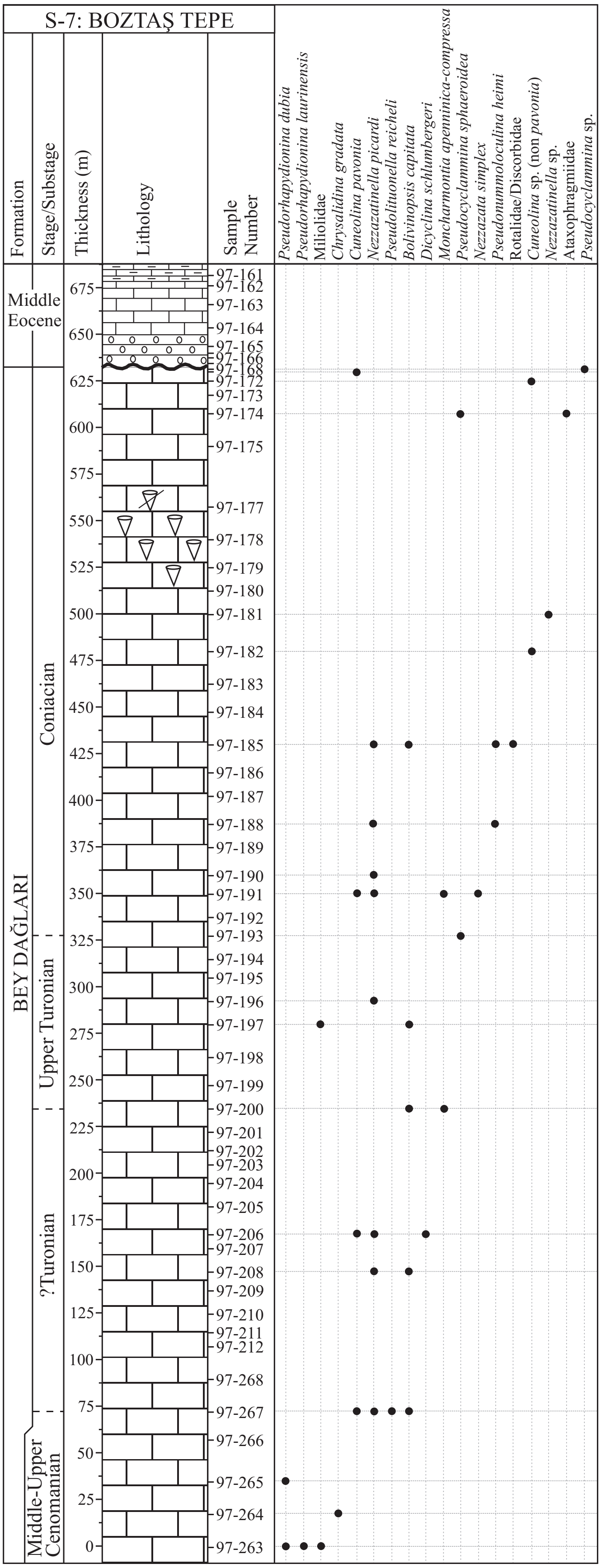

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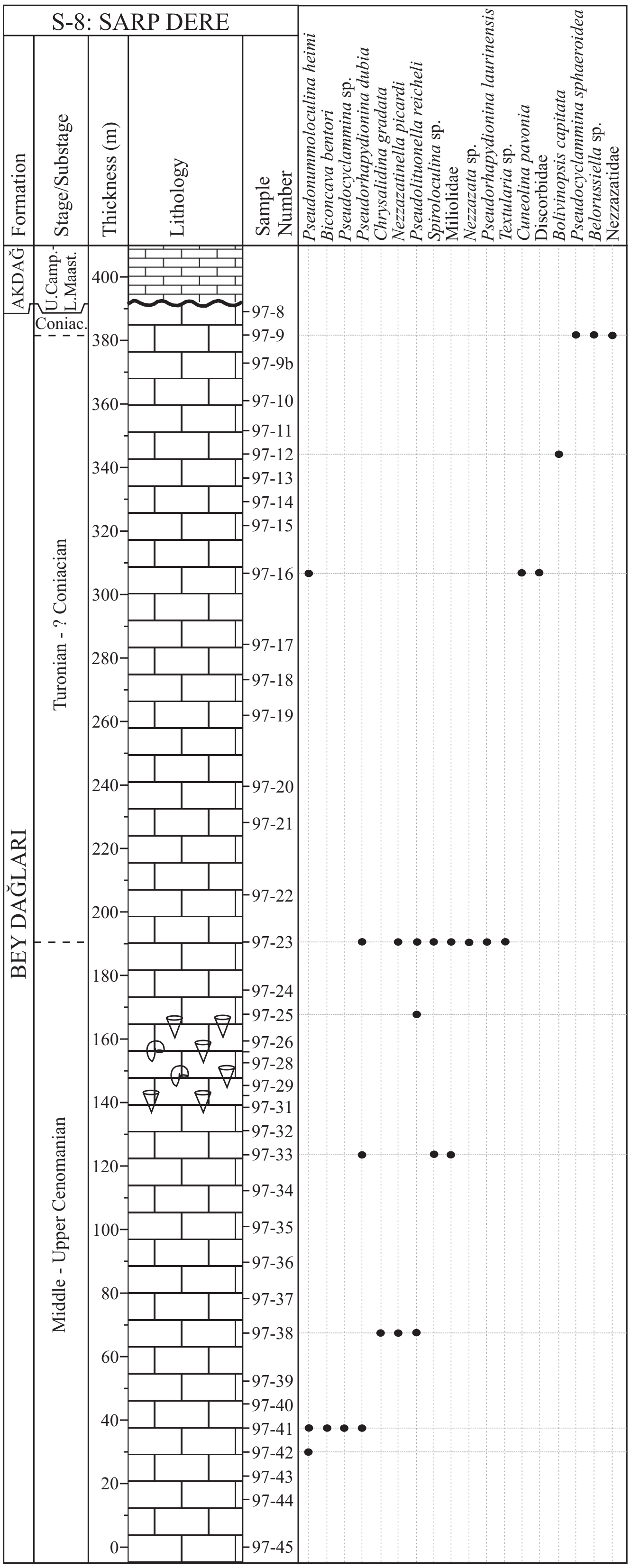

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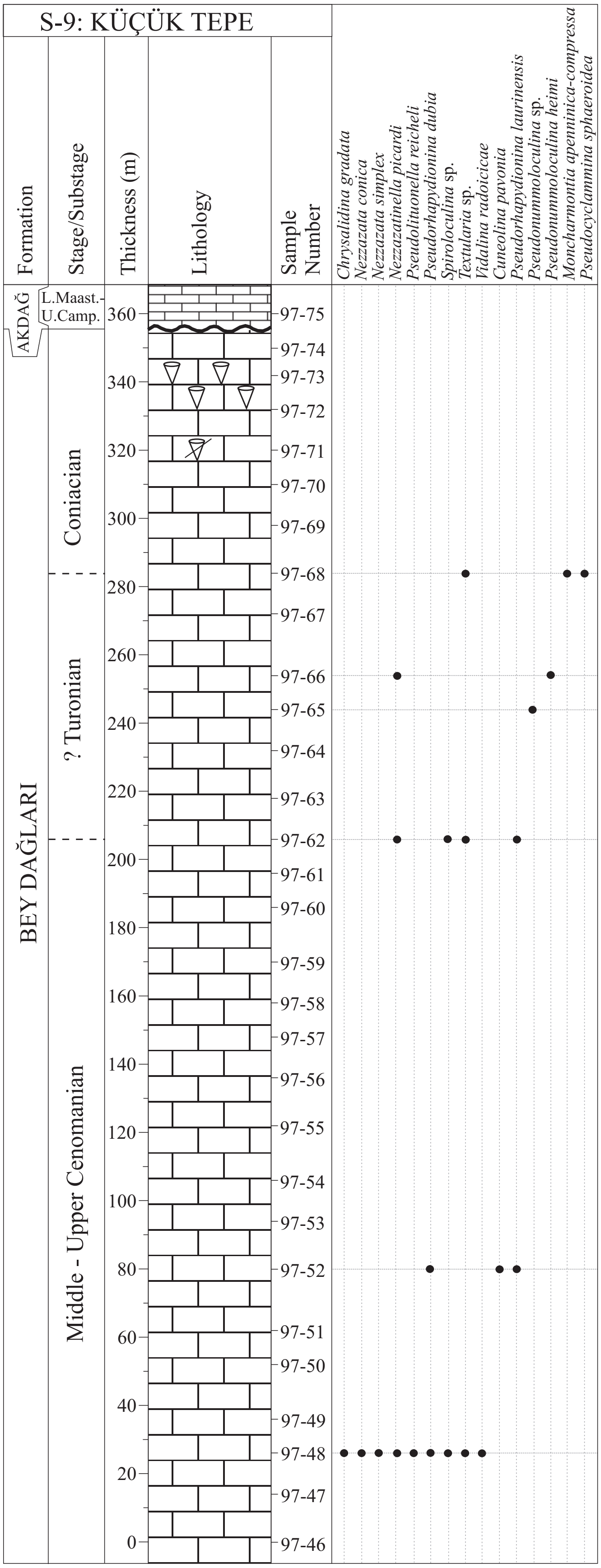

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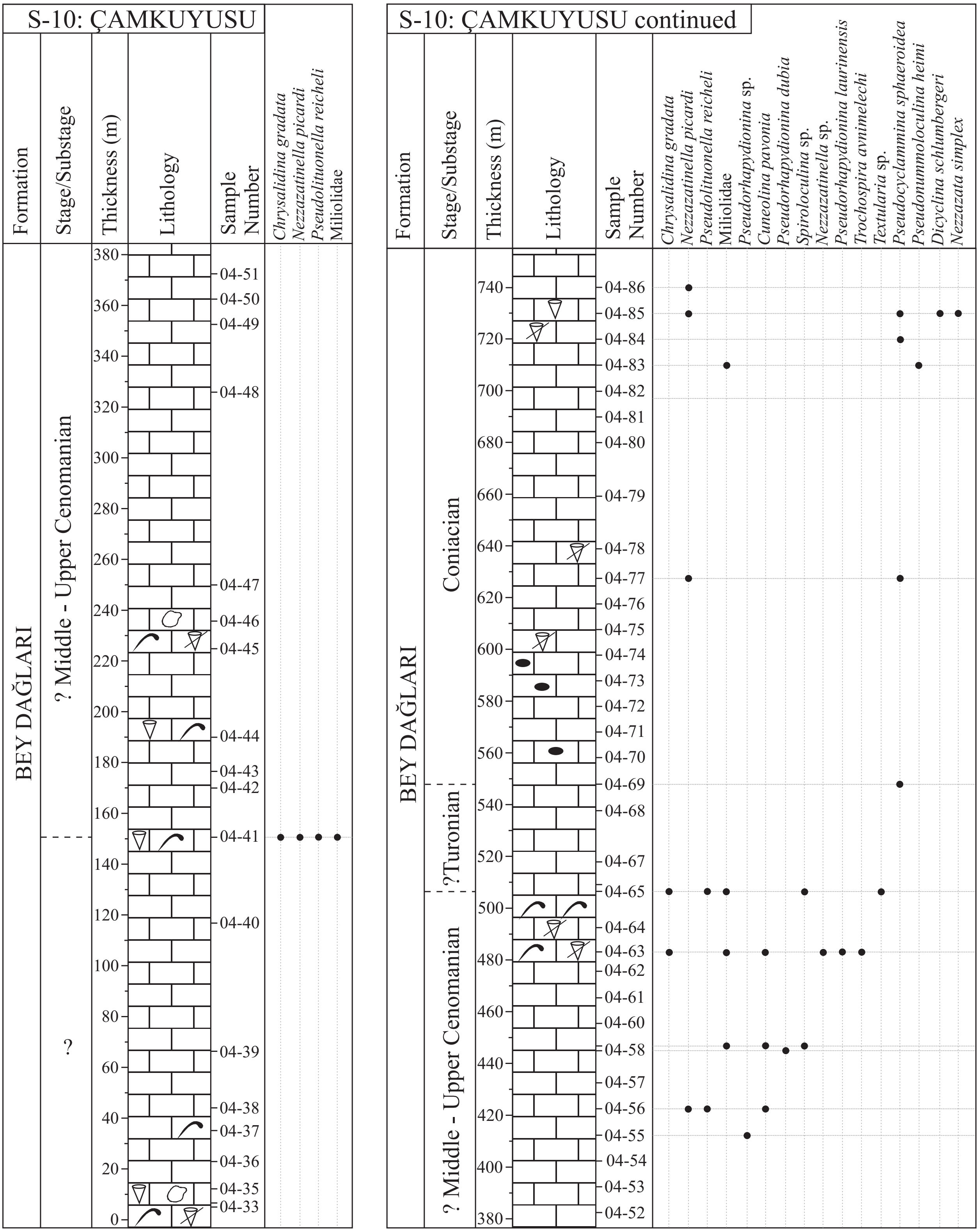

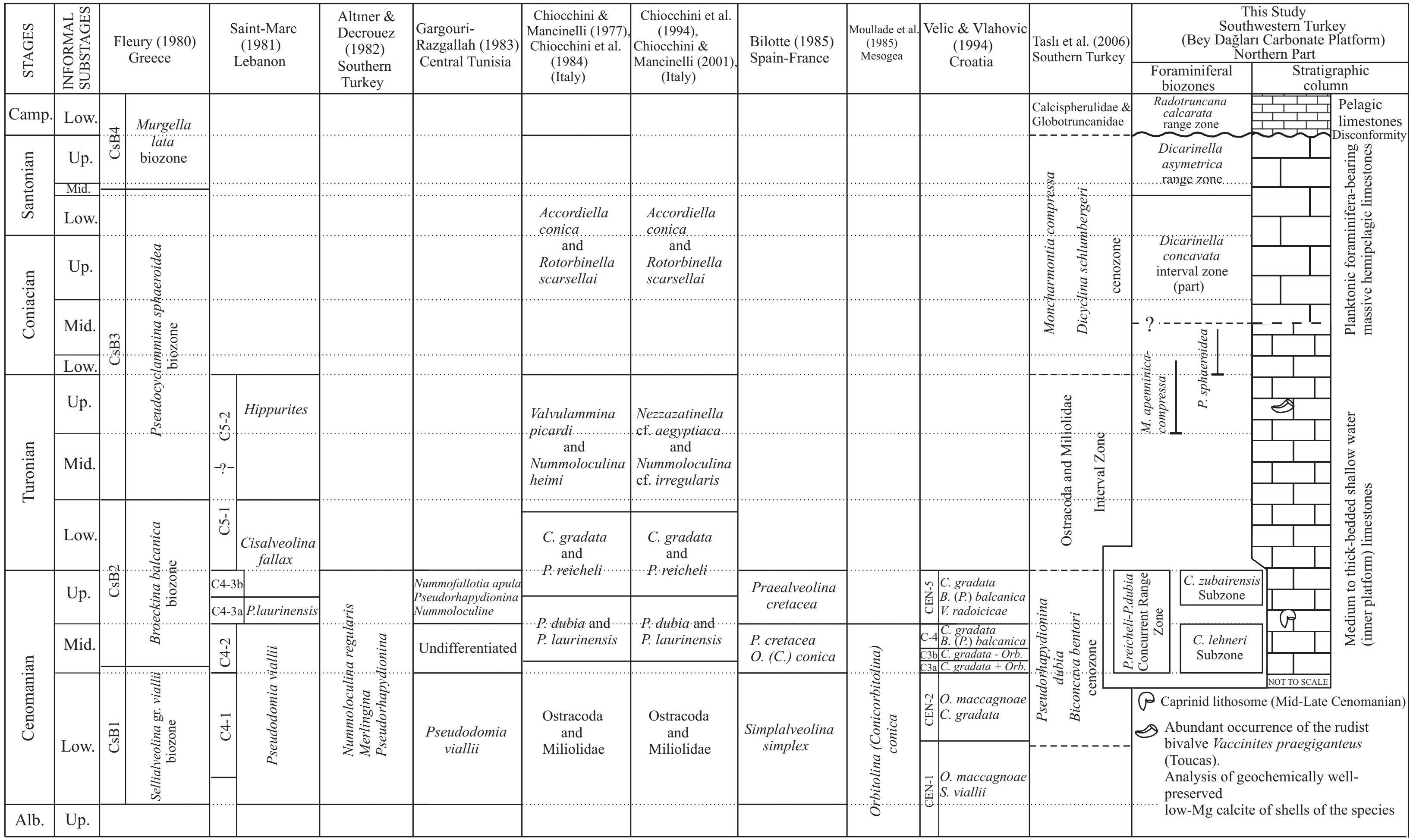

Sarı et al.- Fig. 16

Sarı et al.- Fig. 17

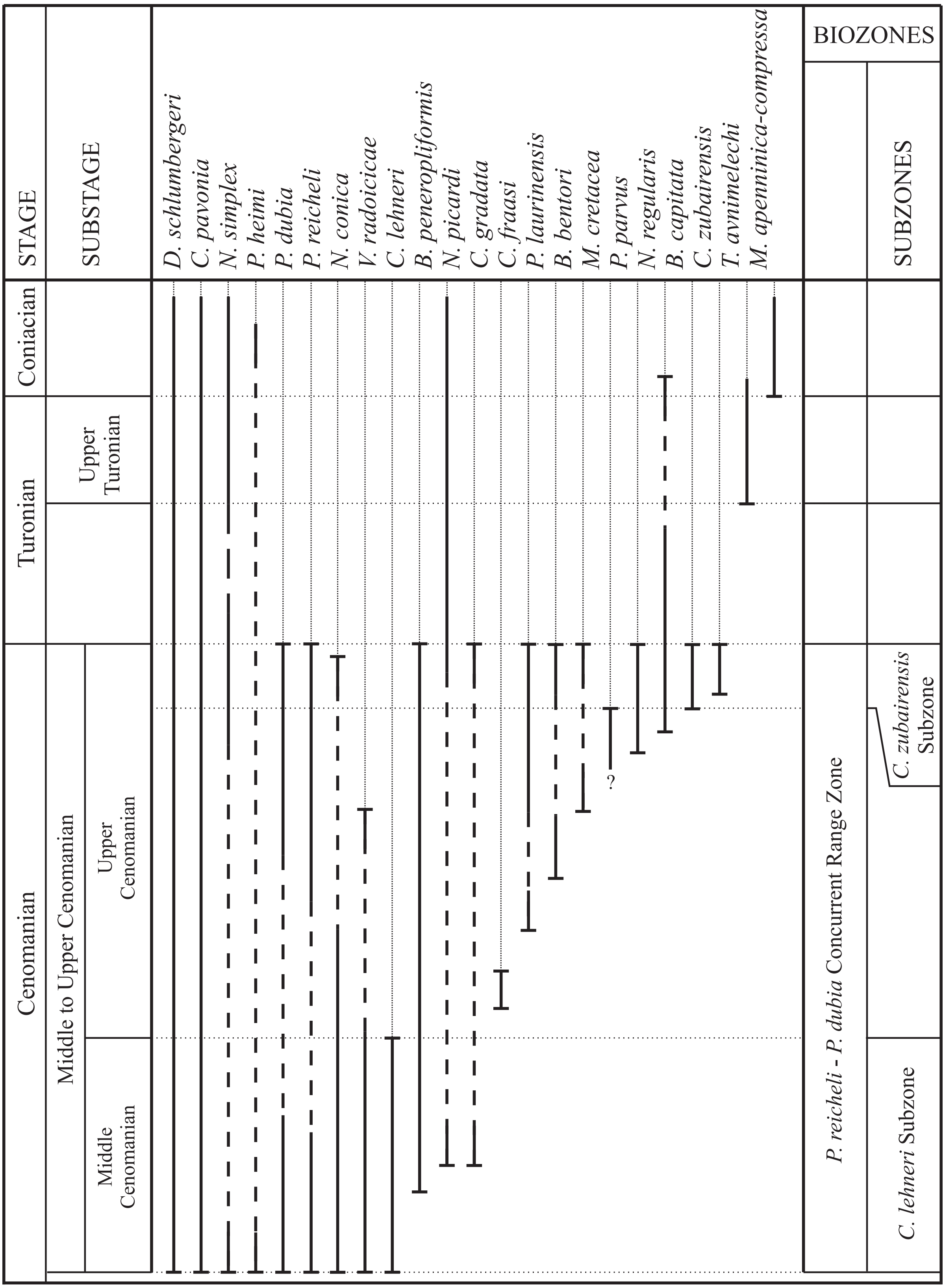

PLATE-1

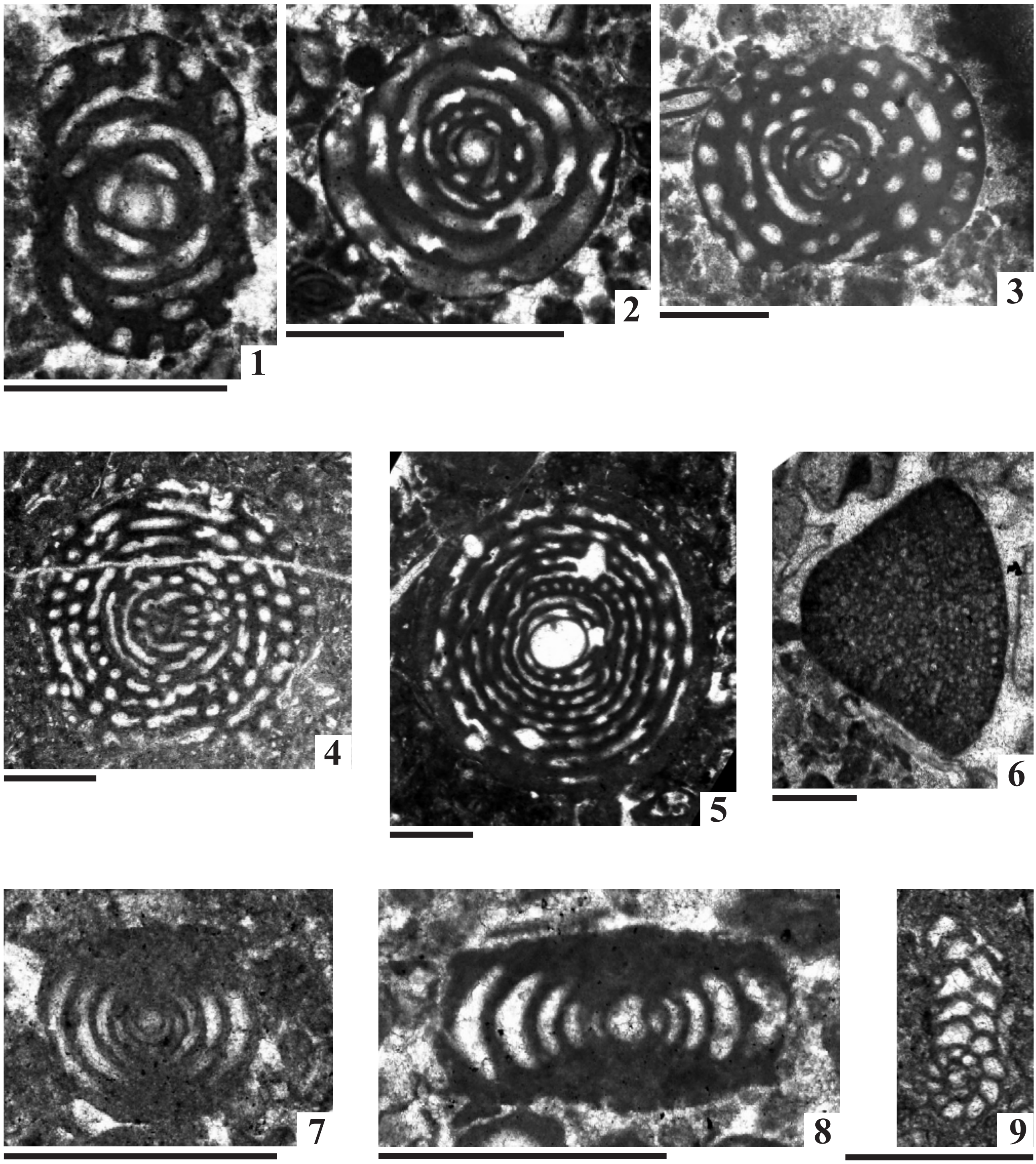

PLATE-2

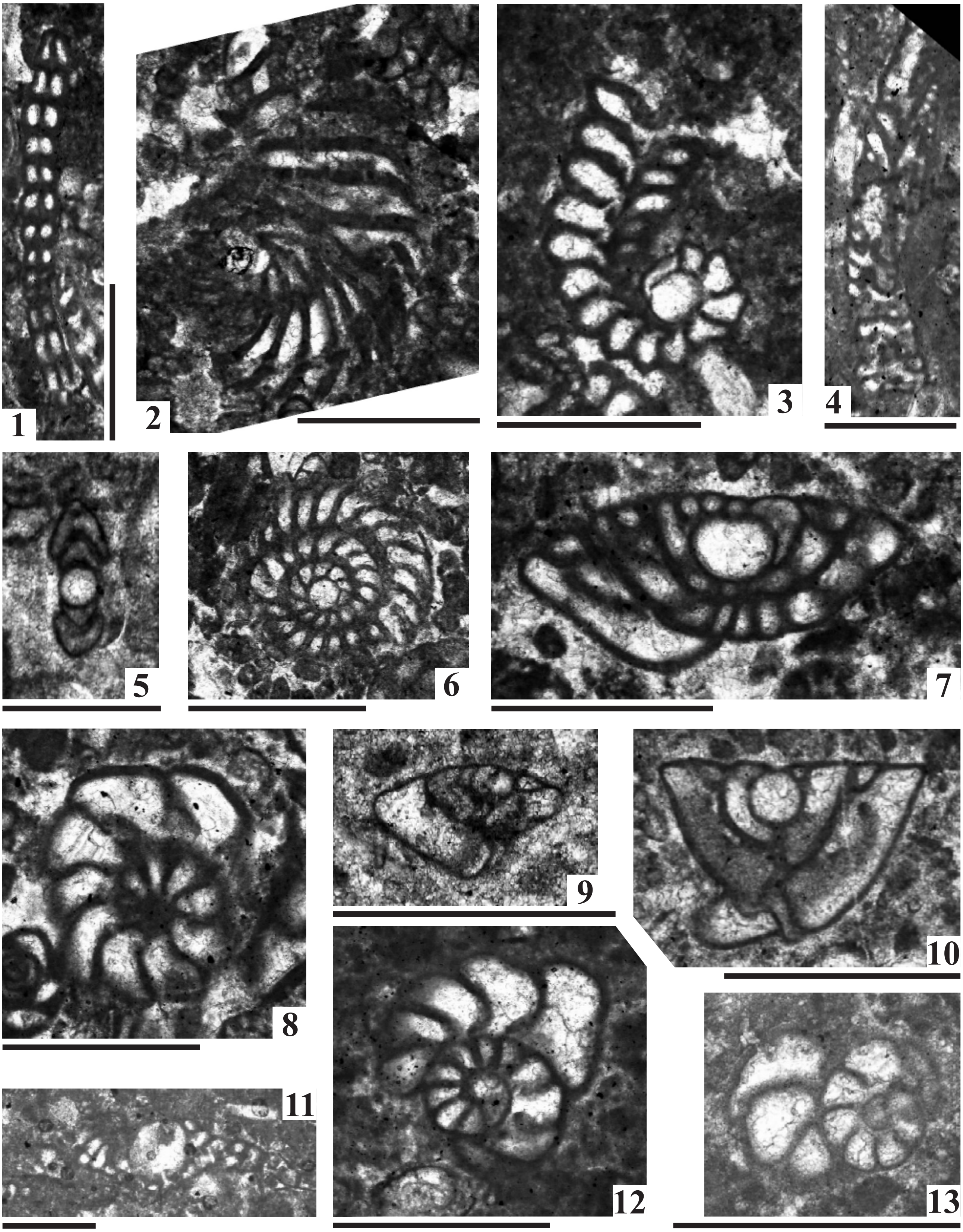

PLATE-3

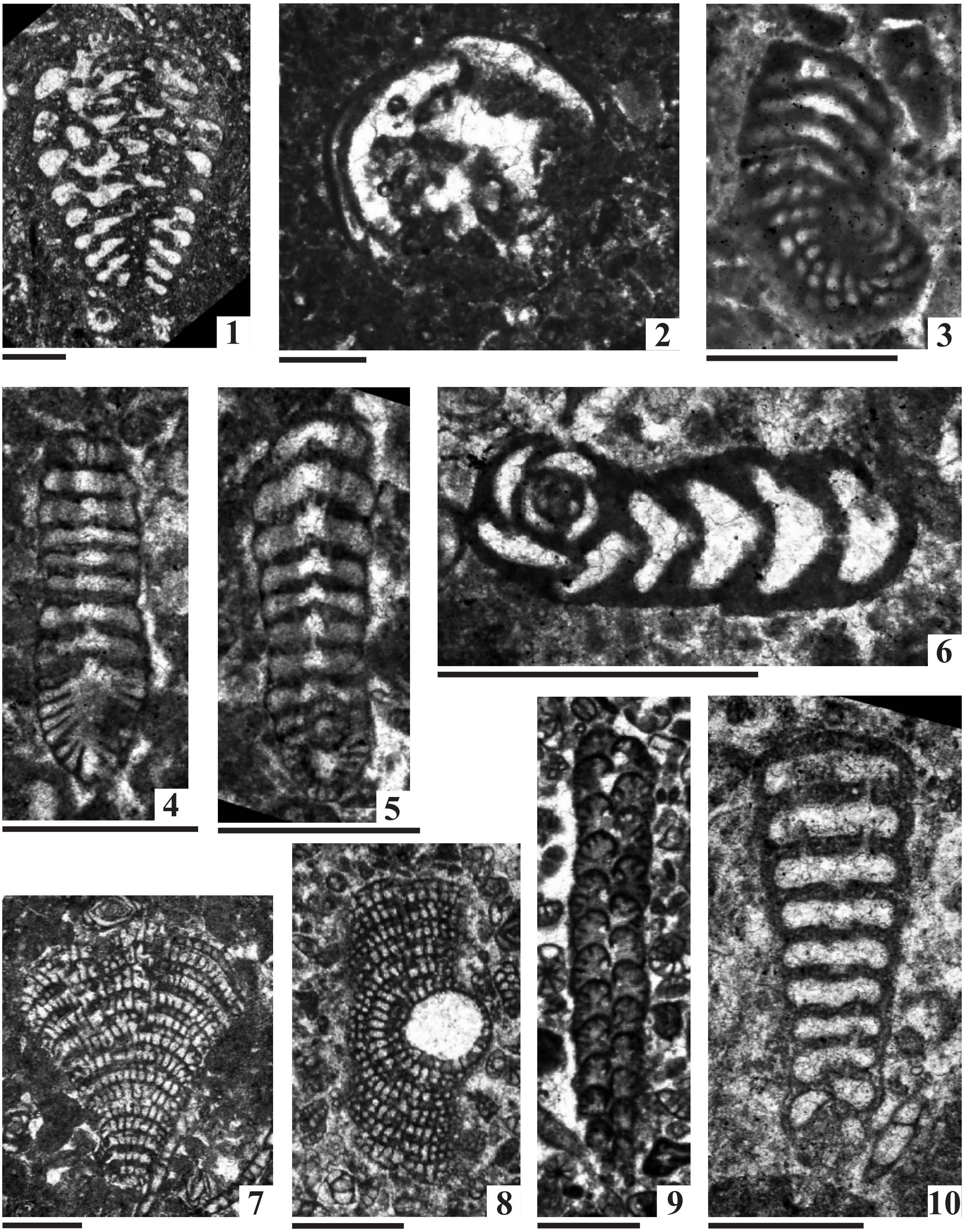

PLATE-4