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Upper Cretaceous Stratigraphy of the Bey Dağları Carbonate Platform, Korkuteli Area (Western Taurides, Turkey)

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Abstract: The Upper Cretaceous Korkuteli (Antalya) carbonate sequence of the Bey Dağları autochthonous unit (western Taurides) comprises two formations. The Cenomanian-Santonian Bey Dağları formation lies at the base of this sequence and can be divided into two parts. Neritic part is characterized by platform-type, peritidal limestones and comprises an approximately 600-m-thick sequence that contains two main rudistid horizons corresponding to Cenomanian and early Santonian. The neritic limestones pass gradually upward into the 15-m-thick, middle-upper Santonian massive hemipelagic limestones that form the upper part. The upper Campanian-middle Maastrichtian Akdağ formation consists totally of pelagic limestones that indicate basinal conditions and disconformably overlies different stratigraphic levels of the Bey Dağları formation. Palaeogene pelagic marls form the base of the Tertiary sequence and disconformably overlie different stratigraphic levels of the Upper Cretaceous sequence. The presence of two erosional phases in the Upper Cretaceous sequence is obvious. The autochthonous unit was subaerially exposed after post-Santonian and middle Maastrichtian regressions.

Key Words: Upper Cretaceous, Bey Dağları, carbonate platform, erosion, planktonic foraminifera

Bey Dağları Karbonat Platformunun Üst Kretase Stratigrafisi, Korkuteli Bölgesi (Batı Toroslar, Türkiye)

Özet: Bey Dağları otoktonunun (Batı Toroslar) Korkuteli (Antalya) bölgesindeki Üst Kretase karbonat istifi iki formasyon içerir. Senomaniyen-Santoniyen yaşlı Bey Dağları formasyonu istifin tabanında yer alır ve iki bölümden oluşur. Alttaki Senomaniyen-erken Santoniyen yaşlı neritik bölüm, gelgit ortamında çökelmiş, platform karbonatlarından oluşur ve yaklaşık 600 m kalınlığında bir istif oluşturur. Bu istif Senomaniyen ve erken Santoniyen'e karşılık gelen iki rudist resifi içerir. Senomaniyen rudist resifi radiolitid ve caprinid'lerden yapılıdır ve 10 m kalınlığa sahiptir. Yanal yönde sürekli olan alt Santoniyen rudist resifi ise hippuritid'lerden yapılıdır ve 20 m kalınlığa sahiptir. Senomaniyen yaşlı düzeylerde rudistlere eşlik eden bentonik foraminiferler çeşitlilik açısından fakir ancak birey sayısı bakımından zengindirler. Senomaniyenin üstündeki düzeylerde ise hem tür çeşitliliği hem de birey sayısı oldukça sınırlıdır.

Neritik kireçtaşları üste doğru dereceli olarak Bey Dağları formasyonunun üst bölümünü oluşturan 15 m kalınlığındaki, planktonik foraminifer içeren yarı pelajik massif kireçtaşlarına geçer.

Santoniyen sonrası regresyonu ve aşınmanın ardından, havza koşullarında çökelmiş, transgresif Akdağ formasyonu, Bey Dağları formasyonunun farklı stratigrafik düzeylerini belirgin bir erozyon yüzeyi ile, koşut uyumsuz olarak üstler. İnce katmanlı çörtlü kireçtaşlarında oluşan, 75 m kalınlığındaki formasyon, geç Kampaniyen-orta Maastrihtiyen yaşını veren zengin bir planktonik foraminifer faunası içerir.

Bölgedeki ikinci regresyon orta Maastrihtiyen sonunda gerçekleşmiştir ve Alt Kretase'ye ait karbonatlar büyük oranda aşınmışlardır. Planktonik foraminifer içeren Paleojen yaşlı transgresif marnlar, Üst Kretase istifinin farklı stratigrafik düzeylerini koşut uyumsuz olarak üstler.

Anahtar Sözcükler: Üst Kretase, Bey Dağları, karbonat platformu, aşınma, planktonik foraminifer

Introduction

The study area is located around the Korkuteli district of Antalya, southwestern Turkey (Figure 1). The area covers an area of ~25 km^2 between Korkuteli and Ulucak (formerly Simandır) on the northern flank of the Bey Dağları autochthonous unit that is bounded on the west by the Lycian nappes, and on the east by the Antalya nappes. The Upper Cretaceous carbonate sequence of the Korkuteli area contains facies variations and widespread stratigraphic gaps (Poisson 1967, 1977; Farinacci & Köylüoğlu 1982; Özyeğin *et al.* 1985; Farinacci & Yeniay 1986; Gültekin 1986; Köylüoğlu 1987; Özkan & Köylüoğlu 1988; Naz *et al.* 1992). In order to elucidate the precise age of the rocks beneath and above the disconformity surfaces, detailed (1/25,000 and 1/10,000 in scale) geological mapping was carried out and more than 40 closely spaced stratigraphic sections were measured. Five representative sections are presented in this paper (Figure 2). Field observations and thin-section study have yielded important stratigraphic and palaeontological data. Planktonic foraminifera and rudists have been the source of the main palaeontological data used in reappraising the age of the Upper Cretaceous carbonates.

Geological Setting

The Jurassic-Cretaceous Taurus sediments, that is, the autochthonous part of the Alpine Taurus belt, were deposited in shallow water on the unstable northern-northwestern palaeomargin of the Arabian-African plate. In Mesozoic times, this was part of the same sedimentary facies as the rest of Taurides and Zagrides to the east and the Hellenides and Dinarides to the west, as well as the other shelves of the northern African palaeomargin, such as the Apennines (Farinacci & Köylüoğlu 1982; Farinacci & Yeniay 1986).

The Bey Dağları is an important fragment rifted, with the Anatolian block (Taurus platforms) away from the northern margin of Gondwana in two steps: first, during the Permo-Triassic, there was a general break-up of the Gondwana margin, and then there was a second event during the Early Cretaceous opening of the eastern Mediterranean basin. This second event completely separated the Bey Dağları fragment from the mother plate (i.e., the Africa plate). Permo-Triassic rifting separated the Bey Dağları fragment from the Anatolian fragment but not completely from the Gondwana/Africa plate (Poisson 2001). Regional compression began in the latest Cretaceous (Maastrichtian), and the deep-water passive margins of the carbonate platforms were deformed and thrust-imbricated (Robertson 1993).

The Bey Dağları autochthonous unit oriented, NE-SW direction, is a segment of a Mesozoic Tethyan platform on which carbonate accumulation persisted until the Early Miocene. This segment was thrust over to the east by the Antalya nappes and to the northwest by the Lycian nappes, and is partially exposed in the Göcek windows (Naz *et al.* 1992) (Figure 1).

Many studies that have focused on the Bey Dağları carbonate platform have found that sequences are characterized by breaks in deposition and important facies variations in both neritic and pelagic carbonates (Poisson 1967, 1977; Özgül 1976, 1977; Gutnic *et al.*1979; Farinacci & Köylüoğlu 1982; Özyeğin *et al.* 1985; Farinacci & Yeniay 1986; Gültekin 1986; Köylüoğlu 1987; Özkan & Köylüoğlu 1988; Naz *et al.* 1992).

According to Günay *et al.* (1982), Triassic dolomites lie at the bottom of the carbonate sequence of the autochthonous unit and the Beydağı formation gradationally overlies the dolomites and forms a thick monotonous sequence (910 to 2500 m), extending from Lower Jurassic to Upper Cretaceous. The thickness of this monotonous carbonate sequence exceeds 3000 m in drill holes (André Poisson, personal communication 2001).

The Cenomanian deposits of the Bey Dağları are typically of the marine-open platform type (rudist accumulations and reefs) and the major part of the Bey Dağları (especially the northern part) subsided during the Turonian and were invaded by pelagic deposits. Pelagic sedimentation persisted there until the Oligocene (Poisson *et al.* 1983). These carbonates are typical of a shelf environment and contain a rich benthic foraminiferal and rudist fauna (Bignot & Poisson 1974; Poisson 1977; Farinacci & Köylüoğlu 1982; Özyeğin *et al.* 1985; Farinacci & Yeniay 1986; Gültekin 1986; Köylüoğlu 1987; Özkan & Köylüoğlu 1988; Özer 1988; Naz *et al.* 1992).

The presence of benthic foraminifera and calcispheres suggests a Cenomanian to- ? early Turonian age for the uppermost levels of the Bey Dağları formation (Özkan & Köylüoğlu 1988).

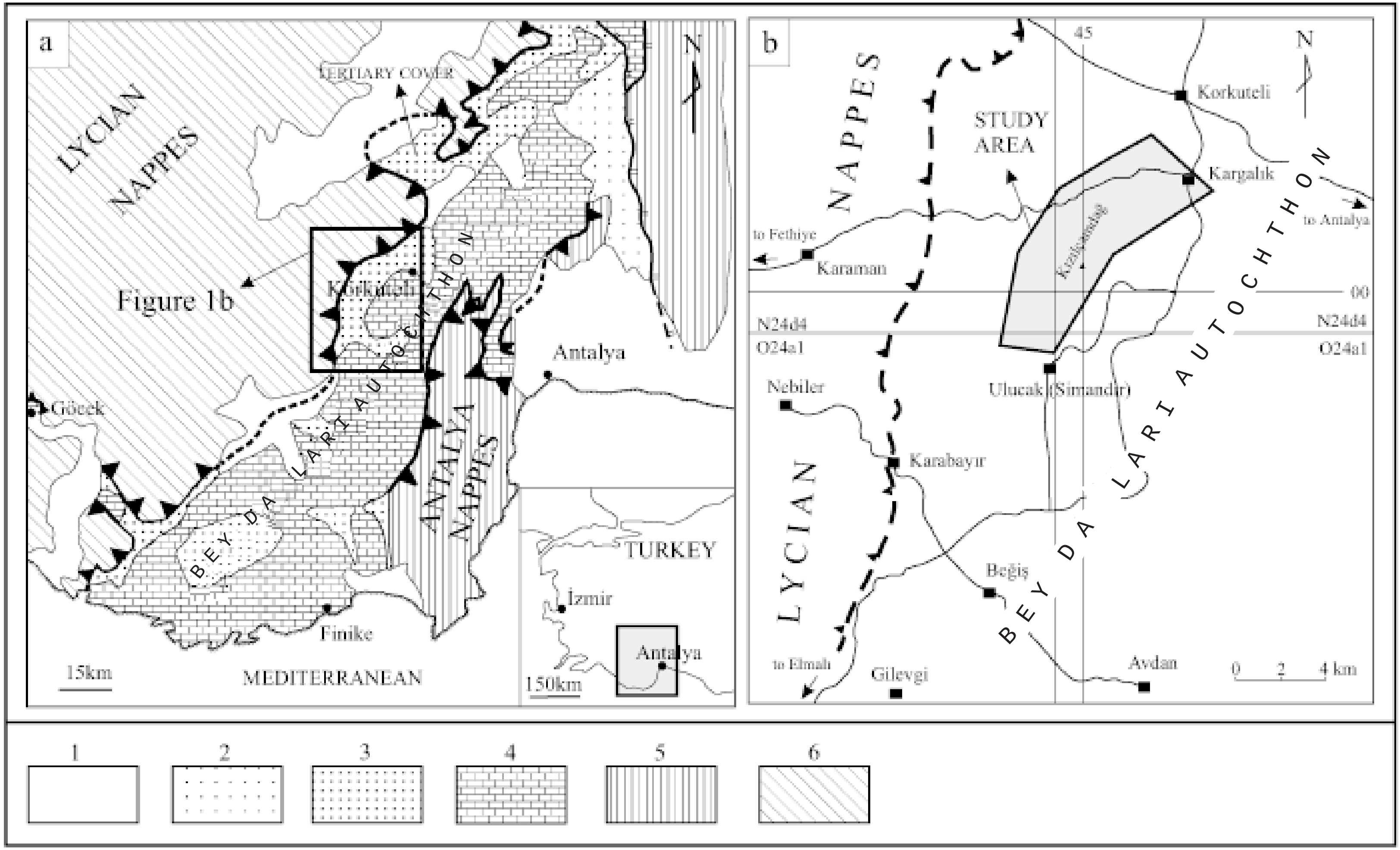

Figure 1. Maps showing **(a)** the main tectonic belts of the western Taurides (simplified from Poisson *et al.* 1983; see inset for location), and **(b)** the location of the study area. 1– Upper Miocene-Quaternary post-compressional tectonic formations, 2– Neogene formations preceeding the Aksu compressional event, 3– Lower and Middle Miocene of the Bey Dağları Autochthon, 4– Bey Dağları autochthon (Upper Triassic to Oligocene), 5– Antalya nappes, and 6– Lycian nappes.

The Akdağ formation of Coniacian-Maastrichtian age is represented by planktonic foraminifera-bearing, thin-bedded, clayey limestones with chert nodules, and disconformably overlies the Bey Dağları formation (Poisson 1977; Farinacci & Köylüoğlu 1982; Özyeğin *et al.* 1985; Farinacci & Yeniay 1986; Gültekin 1986; Köylüoğlu 1987; Özkan & Köylüoğlu 1988; Naz *et al.* 1992). The same authors state that the hiatus between the Bey Dağları and Akdağ formations corresponds to the early Turonian to Maastrichtian. Poisson (1967, 1977) is the only author to report the presence of Santonian-lower Campanian rudistid neritic limestones from the Korkuteli area.

The Tertiary is represented by various formations, of different lithologies and ages (Poisson 1977; Özyeğin *et al.* 1985; Özkan & Köylüoğlu 1988). Palaeogene pelagic marls form the base of the Tertiary sequence, and disconformably overlie different levels of the underlying two formations.

Stratigraphy

The Upper Cretaceous sequence of the Bey Dağları autochthonous unit comprises two formations in the Korkuteli area (Figures 2 & 3). The Cenomanian-Santonian Bey Dağları formation lies at the base and is disconformably overlain by the upper Campanian-middle Maastrichtian Akdağ formation along an erosional surface. As mentioned above, Palaeogene pelagic marls form the base of the Tertiary sequence and disconformably overlies different stratigraphic levels of two Upper Cretaceous formations.

Upper Cretaceous

Bey Dağları Formation

Description and Depositional Environment – Poisson (1977) named the Cenomanian rudistid limestones in the Katran Dağ as the Yağca Köy formation, however he did not name the Santonian rudistid limestones. Günay *et al.* (1982) described the neritic limestones ranging from Lower Jurassic to Upper Cretaceous, as the Beydağı formation and noted that the Beydağı formation gradationally overlies the Upper Triassic dolomites.

Later, some researchers used Beydağı formation (Erakman *et al.* 1982; Naz *et al.* 1992) and others used Bey Dağları formation (Özyeğin *et al.* 1985; Gültekin 1986; Özkan & Köylüoğlu 1988) for the Jurassic to Cenomanian neritic limestones.

In this study, because of their lithologic similarity, the Bey Dağları formation is used for the neritic limestones of Cenomanian-early Santonian age and the overlying hemipelagic limestones of middle-late Santonian age (Figures 2 & 3). The formation is recognizable by its typical prominent high relief and forms Kızılçamdağ that extends from SW to NE through the study area (Figure 2).

The Bey Dağları formation can be divided into two parts (Figures 2 & 3). Neritic limestones of Cenomanian-early Santonian age lie at the base and hemipelagic limestones of middle-late Santonian age at the top. The neritic part of the formation is approximately 600-m-thick and is generally made up of cream coloured, massive, mainly medium- to thickly but locally thinly bedded limestones.

In the neritic limestones, two main rudistid horizons have been identical, one of which is observed in the Cenomanian limestones and distinguished from underlying and overlying medium- to thickly bedded limestones by its massive structure (Figure 3). It is about 10-meters-thick and can be traced laterally for 70-80 m. The unique outcrop is in the Bozcalar Dere (Figure 2). The other horizon is observed within the Santonian limestones and is about 20-m-thick. This horizon is composed of thickly or massively bedded limestones and generally forms high relief in outcrop profile. These rudistid level is more widespread and distinctive as compared to the Cenomanian reefs, and is especially prevalent in the western part of Kargalıköy (NE part of the study area) (Figure 2).

Microfacies studies on the neritic limestones have determined five main microfacies and related microenvironments that are gradational, both laterally and vertically. These microfacies are: (1) laminated pelsparitic/pelmicritic and fenestral micritic microfacies, (2) an alternation of cryptalgal and pelsparite/pelmicrite lamina microfacies, (3) sparse benthonic foraminifera bearing pelsparitic/pelmicritic microfacies, (4) benthic foraminifera-bearing biomicritic microfacies, and (5) rudist fragment-bearing biosparitic/biomicritic microfacies. These microfacies are the result of deposition in supratidal, intertidal, tidal ponds, tidal channel, subtidal (lagoonal), and reef and fore-reef subenvironments (Wilson 1975; Sarı & Özer 2001).

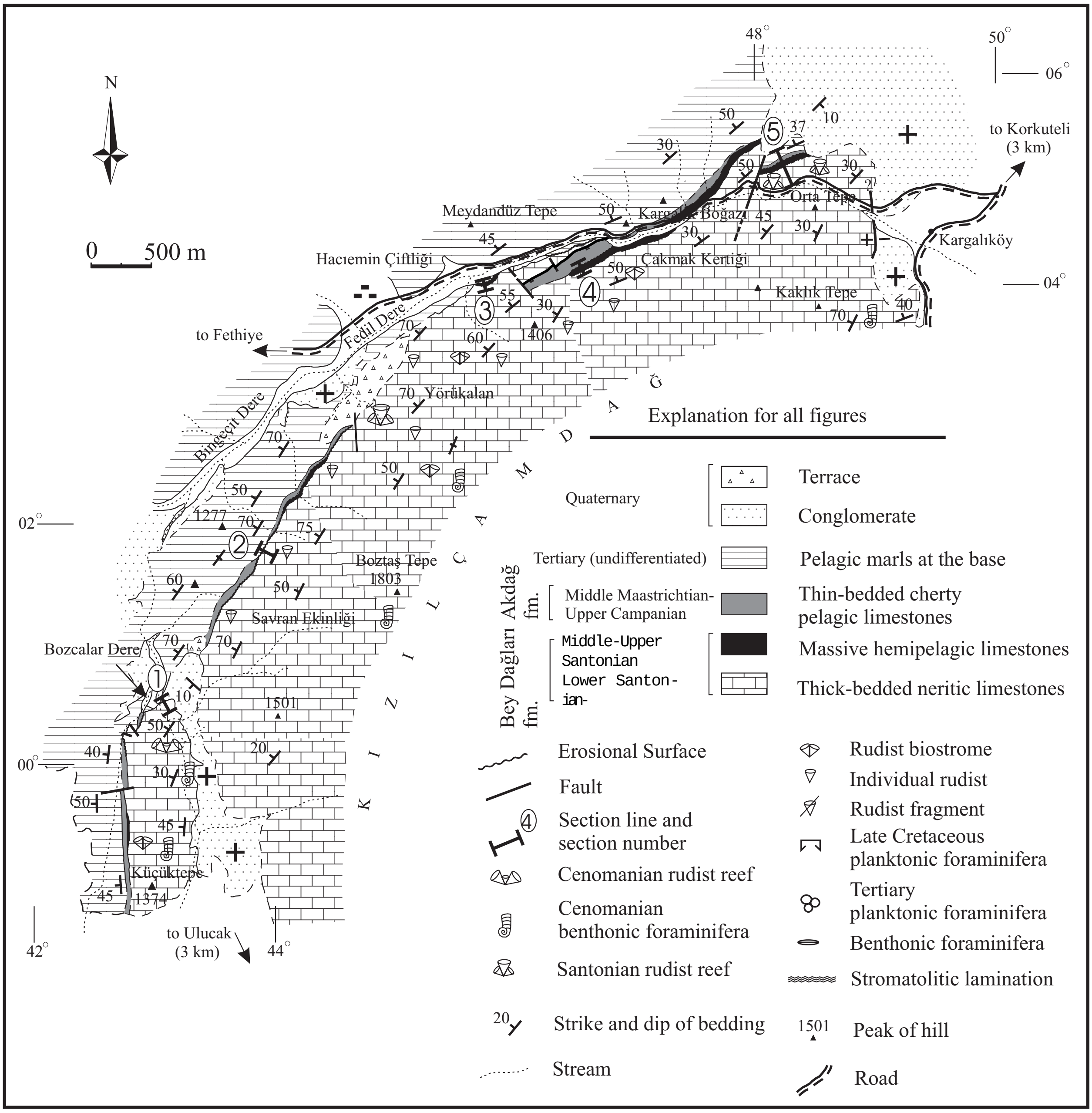

Figure 2. Geological map of the Korkuteli area (between Korkuteli and Ulucak). The Tertiary sequence is undifferentiated because of the scale. Palaeogene pelagic marls form the base of the Tertiary sequence.

The faunal turnover during the Santonian, from rudist and benthic foraminifera to planktonic foraminifera, and gradual facies change indicate a slight drowning of the platform which produced hemipelagic conditions on the platform until the end of the Santonian. The limestones deposited under hemipelagic conditions are massive, cream-coloured, fractured and contain sparse planktonic foraminifera and abundant spheroidal forms. The neritic and hemipelagic limestones are both massive and cream-coloured and nearly the same in appearance. In thin sections of samples coming from at and near the contact, benthic and planktonic fauna are found together (Figure 4a, b; samples 76, 30-32). The maximum thickness of the hemipelagic levels was measured at the Çakmak Kertiği locality as about 15 m (Figure 4b).

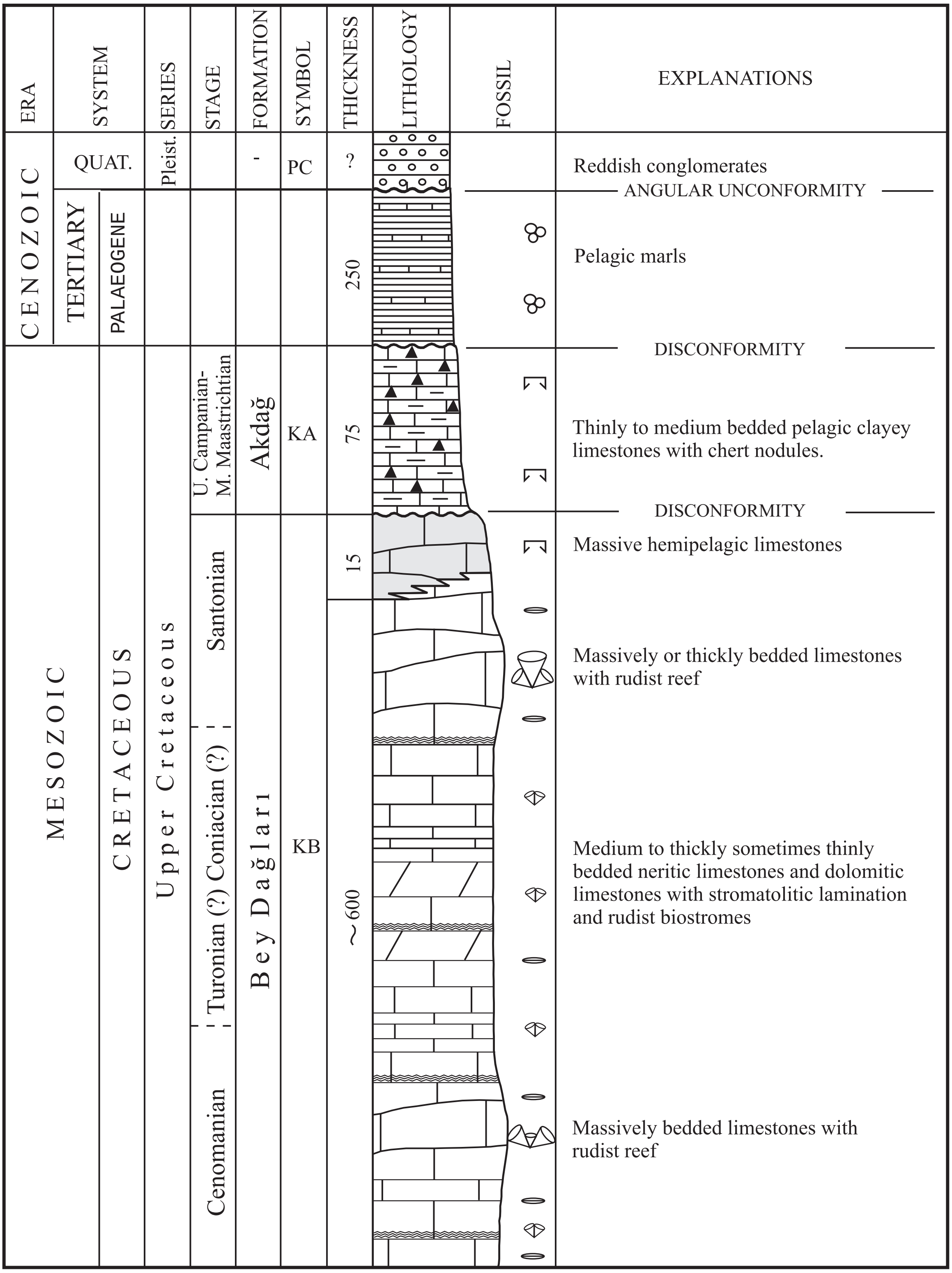

Figure 3. Generalized columnar section of the study area (see Figure 2 for explanation).

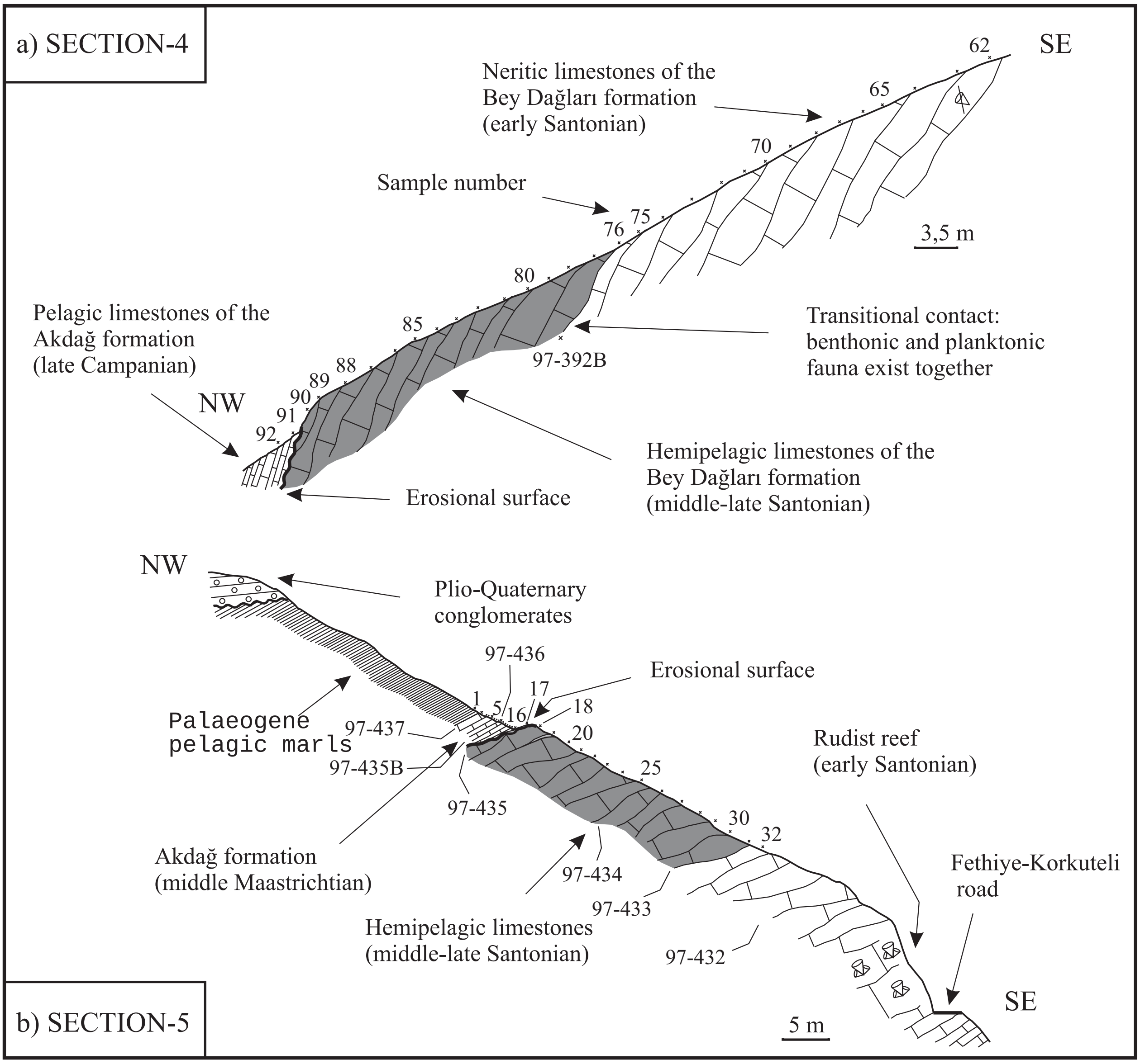

Figure 4. Contact relationship between the neritic and hemipelagic limestones of the Bey Dağları formation and the pelagic limestones of the Akdağ formation at the Çakmak Kertiği locality. The erosional surface, marked by bioturbation and reworked pebbles derived from the underlying hemipelagic limestones in Section 4, is characterized by flat surface, and shows intense silicification and iron oxidation in Section 5 (see Figure 2 for locations of the sections).

Age and Fossil Content – Benthic foraminifera and rudists are the unique fossil components to use in dating the neritic limestones of the Bey Dağları formation. The Cenomanian part of the formation is rich in benthic foraminifera, specifically, it is rich in number of individuals but poor in diversity because of the restricting environmental conditions. The following fauna indicating a Cenomanian age has been determined for the unit (Sarı 1999): *Pseudedomia viallii* (COLALONGO), *Chrysalidina gradata* d'ORBIGNY, *Pseudolituonella reicheli* MARIE, *Pseudorhapydionina dubia* (de CASTRO), P. cf. *laurinensis* (de CASTRO), *Nummoloculina* sp., *Nezzazata* sp. and *Cuneolina* sp. Similar benthic foraminifer associations were reported from the Cenomanian of the Korkuteli area (Çakmak Kertiği locality, west of Kargalıköy) by Poisson (1967, 1977) and Gutnic *et al.* (1979), and from the Yağca Köy formation (Cenomanian) of Katran Dağ (Sam Dağ) (30 km east of the study area) by Bignot & Poisson (1974) and Poisson (1977). Poisson (1977) recognized a succession of Early Jurassic to Cenomanian age in the Katran Dağ carbonate platform. The Cenomanian Yağca Köy formation has a rich benthic foraminiferal fauna that is associated with rudists (caprinids), algae, gastropoda and chondrodonta. Bignot & Poisson (1974) and Poisson (1977) distinguished two levels in the neritic carbonates of the Yağca Köy formation. The lower level containing *Pseudedomia viallii* (COLALONGO) corresponds to the middle Cenomanian and the upper level containing *Pseudorhapydionina laurinensis* (de CASTRO) corresponds to the late Cenomanian.

The upper part of the Lower Jurassic-Cenomanian succession along the eastern margin of the Katran Dağ carbonate platform was re-examined by Robertson (1993) with the aim of shedding light on the emplacement history of the Antalya complex. He proposed that the upper surface of the Cenomanian platform carbonates, occupied largely by rudist limestones, is fissured and karstic and then overlain by 40 m of medium-bedded micritic limestones, with abundant Late Cretaceous planktonic foraminifera (e.g, *Globotruncana*).

Farinacci & Yeniay (1986) noted that the Cenomanian layered carbonates of the Bey Dağları are typical of an open-shelf environment and contain a rich benthic foraminiferal fauna. They also stated that rudistid debris is rare and very localized, and became more abundant in the early Turonian, together with calcisphaeurulids and the first planktonic foraminifers to appear on this platform.

The rudist fauna is especially made up of caprinids and accompanies the benthic foraminiferal fauna. Bignot & Poisson (1974) recognized a rudist fauna, consisting especially of caprinids and radiolitids from the Cenomanian of Katran Dağ. Özer (1988) described this fauna in detail. The present forms resemble the fauna reported by Özer's (1988) that consists of *Neocaprina gigantea* PLENICAR, *Caprina schiosensis* BOEHM, *Caprina* cf. *carinata* (BOEHM) and *Ichthyosarcolites bicarinatus* (GEMMELLARO), indicating a middle-late Cenomanian age.

The Cenomanian rudistid limestones grade into medium- to thickly bedded limestones which have the same macroscopic and microscopic features as the underlying limestones, however, they do not include diagnostic foraminifera and rudist fossils. *Dicyclina* cf. *schlumbergeri* MUNIER-CHALMAS *Moncharmontia apenninica* (de CASTRO) and miliolids form the benthic foraminifera fauna. Small rudist biostromes (0.5- to 1.5-m-thick) constructed especially by the radiolitids (*Sauvagesia* sp. and *Durania* sp.) also occur throughout these limestones and are thought to be distributed patchily within the restricted platform. The thickness of the limestones in the Cenomanian and early Santonian interval is about 250 m and may arguably correspond to Turonian and Coniacian (Figure 3). Upward, these limestones pass into lower Santonian massive limestones with rudist reefs forming the uppermost part of the neritic carbonates (Figure 3). Poisson (1967) determined this rudist fauna in the Korkuteli area (Fedil Dere). The fauna of Poisson (1967) comprised *Vaccinites atheniensis* KTENAS, *Sauvagesia* cf. sharpie BAYLE, *Vaccinites* cf. *boehmi* DOUVILLE, *V.* cf. *sulcatus* DEFRANCE and *Hippurites* gr. *sulcatus* DOUVILLE, indicating a Santonian-early Campanian age.

The best outcrops of the rudist reefs can be seen at the Yörükalan locality and in the Korkuteli-Fethiye road cut, 1.5 km west of Kargalıköy (Figure 2). The reefs are chiefly made up of *Vaccinites taburni* (GUISCARDI), *Hippurites nabresinensis* FUTTERER and *H. colliciatus* WOODWARD. The fauna indicates a Santonian-Campanian age. Massive hemipelagic limestones forming the uppermost part of the formation include rare planktonic foraminifera and abundant spheroidal forms. At the boundary between the neritic and hemipelagic limestones, benthic and planktonic fauna are observed together (Figure 4a). The limestones, in which the planktonic foraminifera first appear, are considered to be a transitional zone between the neritic and hemipelagic facies. Rudist fragments, echinids, bryozoans and bivalvia accompany this foraminiferal fauna. A special microfacies is encountered in almost all measured stratigraphic sections. This microfacies lies just beneath the hemipelagic limestones, and generally has biomicritic, intramicritic, and intrasparitic texture and contains *Cuneolina* sp., rotalids, bryzoans, spheroidal forms and rudist fragments. *Dicarinella asymetrica* (SIGAL), *D. concavata* (BROTZEN), *Marginotruncana pseudolinneiana* PESSAGNO, *M. coronata* (BOLLI), *M.* cf. *sigali* (REICHEL), *Marginotruncana* sp., *Contusotruncana fornicata* (PLUMMER), *Heterohelix* sp., *Rotalina* sp., *Goupillaudina* sp., and *Hedbergella* sp. (Plate-I) make-up the planktonic foraminiferal association of the hemipelagic limestones, suggesting a Coniacian-Santonian age (Sarı 1999). The first appearance of the Globotruncanids, together with *D. concavata* in the transition zone between the neritic and the hemipelagic limestones, is accepted as the beginning of the zone. The first appearance of *D. asymetrica* characterizes the end of the zone. The *Dicarinella concavata* interval zone is the oldest planktonic foraminiferal zone identified in this study and corresponds to the lower part of the Santonian. The lower limit of this zone does not reach the Coniacian-Santonian boundary because these hemipelagic limestones grade into the rudistid neritic limestones to the base. Thus the age of the rudistid limestones cannot be younger than the early Santonian. The first and the last appearances of *D. asymetrica* characterize the *Dicarinella asymetrica* total range zone (Robaszynski *et al.* 1984; Caron 1985; Sliter 1989) and the interval corresponds to the middle and late Santonian (Figure 5).

The planktonic foraminiferal zonation of Robaszynski *et al.* (1984) and Caron (1985) is followed in this paper. Robaszynski & Caron (1995) calibrated the vertical distribution of some zone marker planktonic foraminifera

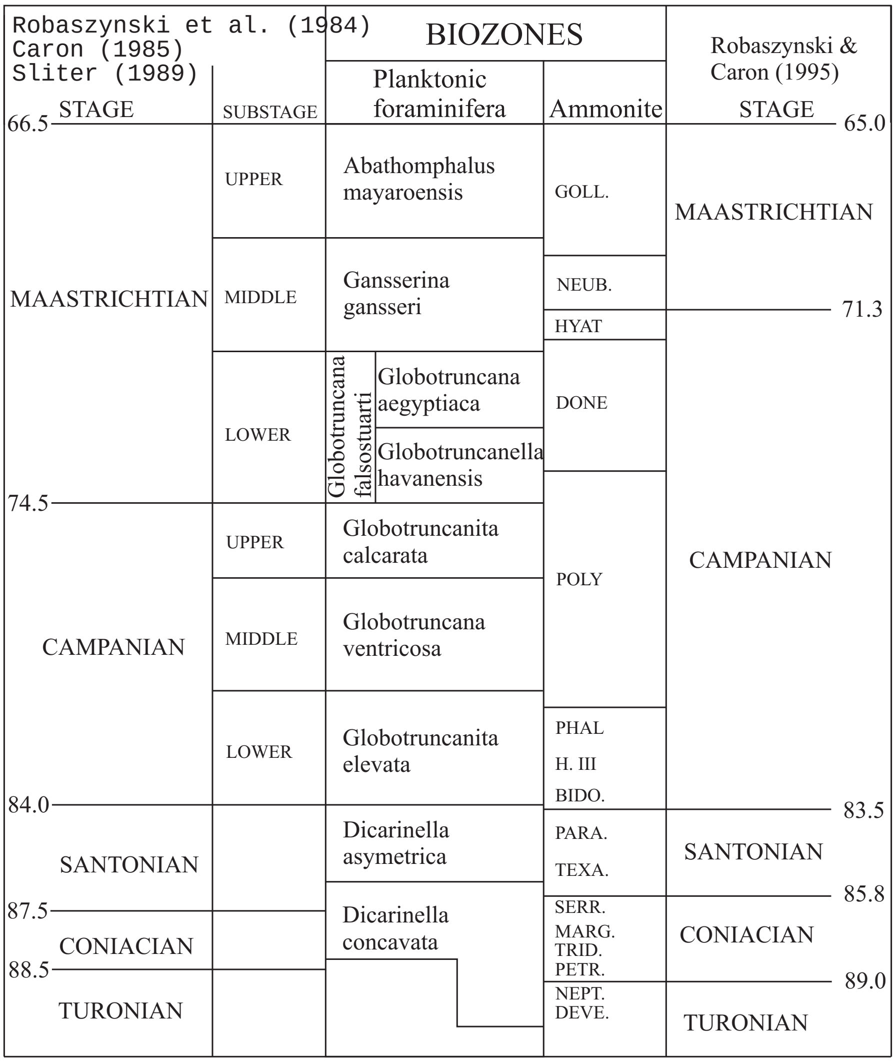

Figure 5. Chart showing the planktonic foraminifera and ammonite zonations and the shifted Campanian-Maastrichtian boundary.

and the ranges of some biozones with another important fossil group (ammonites) and palaeomagnetic reversals (Figure 5).

Contact – The lower contact of the Bey Dağları formation has not been observed in the study area because of faults and young cover, but it was stated by Günay *et al.* (1982) that the contact was vertically transitional into Upper Triassic dolomites. The Akdağ formation disconformably overlies the different stratigraphic levels of the Bey Dağları formation (Figures 4 & 6). In these sections, strikes and dips of the carbonates of the Bey Dağları and Akdağ formations are nearly the same.

Akdağ Formation

Description and Depositional Environment – The Akdağ formation was first named by Günay *et al.* (1978 in Özyeğin *et al.* 1985). Since then, many researchers have used this name for the Coniacian-Maastrichtian pelagic limestones (Özyeğin *et al.* 1985; Gültekin 1986; Köylüoğlu 1987; Özkan & Köylüoğlu 1988; Naz *et al.* 1992).

In this study, the Akdağ formation is used for the upper Campanian-middle Maastrichtian planktonic foraminifera-bearing thinly bedded cherty–clayey limestones ('scaglia' of Italian authors; Farinacci & Yeniay 1986). They are distinguished from the middle-upper Santonian hemipelagic limestones by their distinctive thin bedding. The middle-upper Santonian hemipelagic limestones are massive and have high relief in outcrop profile (Figures 3, 4 & 7).

The Akdağ formation is composed of thinly to medium bedded (8-10 cm), planktonic foraminifera-bearing dirty-white to cream-coloured, cherty–clayey limestones. The formation has a 75 m maximum thickness that varies laterally. These limestones are distinctly bedded and rather strong at the base of the formation. They include brown iron-oxide spots that gradually disappear upward. The middle and upper parts of the formation have no clear bedding because of the fractured nature of the limestones, especially at the Çakmak Kertiği locality. Brown and gray chert nodules are abundant in these levels. These nodules are irregular in shape, their diameters range from 3 to 20 cm and even reach 120 cm near the Savran Ekinliği locality. These nodules are sometimes coated with white coloured chalk. The limestones of the Akdağ formation have planktonic foraminifera-bearing biomicritic texture which is indicative of basinal depositional conditions (cf. Wilson 1975).

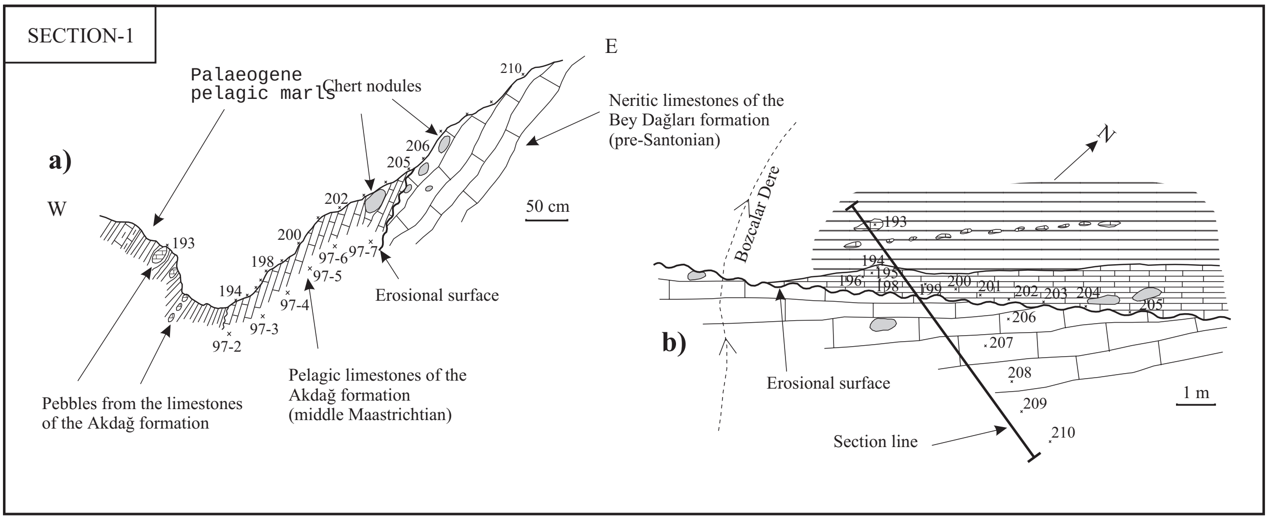

Figure 6. Contact relationship between the Bey Dağları and Akdağ formations and Palaeogene pelagic marls in the Bozcalar Dere. Pelagic limestones of the Akdağ formation disconformably overlie the neritic limestones of the Bey Dağları formation. The hemipelagic limestones of the Bey Dağları formation were completely eroded. The erosional surface is rather distinct. The thickness of the pelagic limestones of the Akdağ formation is 1.5 m, and the age of this level is middle Maastrichtian. The Palaeogene marls disconformably overlie the Akdağ formation and include pebbles derived from the Akdağ formation. **(a)** cross section, **(b)** sketch map (see Figure 2 for the location).

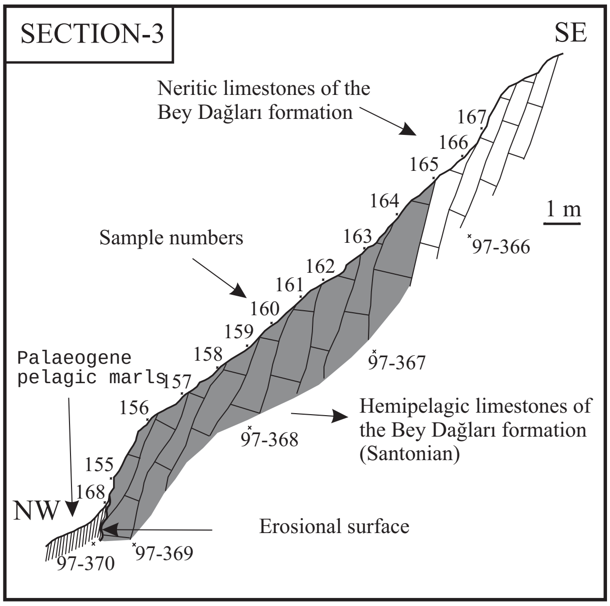

Figure 7. Contact between the hemipelagic limestones of the Bey Dağları formation and the pelagic marls of the Palaeogene (See Figure 2 for location of the section).

Age and Fossil Content – The Akdağ formation has a rich planktonic foraminiferal fauna: *Globotruncana arca* (CUSHMAN), *G. bulloides* VOGLER, G.(?) *insignis* GANDOLFI, *G. linneiana* (d'ORBIGNY), *G. mariei* BANNER & BLOW, *G. orientalis* EL NAGGAR, *G. rosetta* (CARSEY), *G. ventricosa* WHITE, *Globotruncanita atlantica* (CARON), *Gt. calcarata* (CUSHMAN), *Gt. elevata* (BROTZEN), *Gt. stuartiformis* (DALBIEZ), *Gt. subspinosa* (PESSAGNO), *Contusotruncana fornicata* (PLUMMER), *Archaeglobigerina* sp., *Rugoglobigerina* sp. and *Heterohelix* sp. (Plate-I) make up the late Campanian assemblage (Sarı 1999). The *Globotruncanita calcarata* total range zone is characterized by the first and last appearance of *Gt. calcarata* (CUSHMAN), and corresponds to the late Campanian (Robaszynski *et al.* 1984; Caron 1985; Sliter 1989). The Campanian-Maastrichtian boundary is marked by the disappearance of *Gt. calcarata* (CUSHMAN) as determined by many researchers (Robaszynski *et al.* 1984; Caron 1985; Almogi-Labin *et al.* 1986; Sliter 1989). Robaszynski & Caron (1995) shifted the Campanian-Maastrichtian boundary from 74.3 Ma to 71.3 Ma (Figure 5).

Globotruncana aegyptiaca NAKKADY, *G. arca* (CUSHMAN), *G. bulloides* VOGLER, *G. dupeublei* CARON et al., *G. esnehensis* NAKKADY, *G. falsostuarti* SIGAL, *G. linneiana* (d'ORBIGNY), *G. mariei* BANNER & BLOW, *G. orientalis* EL NAGGAR, *G. rosetta* (CARSEY), *G. ventricosa* WHITE, *Globotruncanita angulata* (TILEV), *Gt. conica* WHITE, *Gt. pettersi* (GANDOLFI), *Gt. stuarti* (de LAPPARENT), *Gt. stuartiformis* (DALBIEZ), *Gt. subspinosa* (PESSAGNO), *Contusotruncana contusa* (CUSHMAN), *C. fornicata* (PLUMMER), *Gasserina gansseri* (BOLLI), *G. wiedenmayeri* (GANDOLFI), *Archaeglobigerina* sp., *Rugoglobigerina rugosa* (PLUMMER), *Heterohelix* sp., and *Racemiguembelina* sp. (Plate-II) make up the early-middle Maastrichtian assemblage (Sarı 1999). The lower-middle Maastrichtian has two planktonic foraminiferal zones. The *Globotruncana falsostuarti* partial range zone is characterized by the last appearance of *Gt. calcarata* (CUSHMAN) and the first appearance of *G. gansseri* (BOLLI) and corresponds to the early Maastrichtian. The first appearance of *G. gansseri* (BOLLI), is used to draw the early-middle Maastrichtian boundary, as reported by many researchers (Robaszynski *et al.* 1984; Caron 1985; Almogi-Labin *et al.* 1986; Sliter 1989). The *G. gansseri* interval zone is characterized by the first appearance of the *G. gansseri* (BOLLI) and the last appearance of the nominal species together with whole Late Cretaceous planktonic foraminifera around the lower part of the middle Maastrichtian. According to the zonation of Robaszynski & Caron (1995), the *Globotruncana falsostuarti* partial range zone and the lower part of the *Gansserina gansseri* interval zone correspond to the upper part of the Campanian (Figure 5).

Contact – The Akdağ formation disconformably overlies different stratigraphic levels of the Bey Dağları formation along a prominent erosional surface. Distinctly bedded pelagic limestones (upper Campanian) of the Akdağ formation overlie the massive hemipelagic limestones (Santonian) of the Bey Dağları formation at the Çakmak Kertiği locality (Figures 2 & 4a, b). The erosional surface at this locality is characterized by iron oxidation, silicification and bioturbation, indicative of a later period of low rates of sedimentation due to relative starvation (Rosales *et al.* 1994). At the Bozcalar Dere locality, thinly bedded pelagic limestones (middle Maastrichtian) of the Akdağ formation disconformably overlie the neritic limestones (? pre-Santonian) of the Bey Dağları formation (Figure 6).

Palaeogene

The Palaeogene is represented by various lithologies and formations that show lateral and vertical facies variations throughout the Bey Dağları autochthonous unit; hence many names have been used for these formations. Because it is beyond the scope of this study, the Palaeogene is not described in detail.

Planktonic foraminifera-bearing thin-bedded, light greenish to cream-coloured marls form the base of the Tertiary sequence. These marls disconformably overlie the different stratigraphic levels of the Upper Cretaceous Bey Dağları and Akdağ formations. The thickness of these marls is about 250 m.

Contact – The pelagic marls of the Palaeogene disconformably overlie pelagic limestones of the Akdağ formation at the Çakmak Kertiği locality (Figure 4a, b) and Bozcalar Dere locality (Figure 6). Blocks and big pebbles of the Akdağ formation are seen at the base of the Palaeogene at this locality. At the Meydandüz Tepe locality, the Palaeogene disconformably overlies the hemipelagic levels of the Bey Dağları formation (Figure 2, section 3; Figure 7).

A rather extreme case is encountered in section 2 at which the Palaeogene lies directly on neritic limestones of the Bey Dağları formation (Figure 8). Hemipelagic limestones of the Bey Dağları formation and the Akdağ formation are totally absent. The Palaeogene begins with

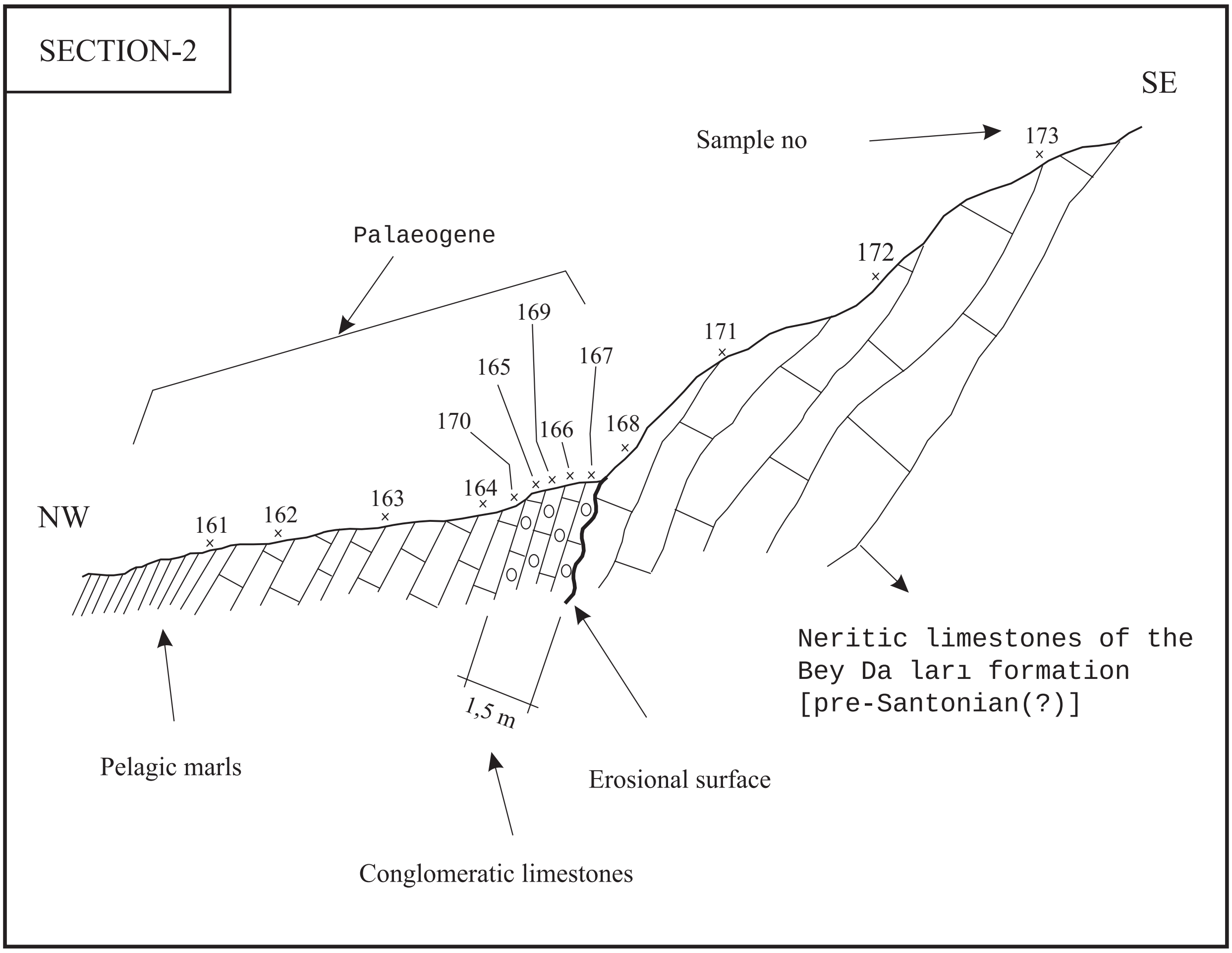

Figure 8. Section showing the contact between the neritic limestones of the Bey Dağları formation (? pre-Santonian) and the pelagic conglomeratic limestones of the Palaeogene. Pebbles are embedded in a lime-mud matrix with planktonic foraminifera. Note the total absence of hemipelagic limestones of the Bey Dağları formation and pelagic limestones of the Akdağ formation.

a 1.5-m-thick conglomeratic level composed of pebbles embedded in abundant planktonic- foraminifera and scarce benthic-foraminifera-bearing, pelagic lime mud matrix. The pebbles are mostly derived from the pelagic, hemipelagic and neritic limestones of the Upper Cretaceous formations. Rudistid fragments are also observed.

Evolution of the Carbonate Platform

Peritidal conditions persisted from the Cenomanian to the early Santonian in the Bey Dağları autochthonous unit. Slight drowning of the Korkuteli part of the platform at the end of the early Santonian produced a hemipelagic environment that would persist until the end of the Santonian.

The major part of the Bey Dağları carbonate platform (especially the northern part) subsided during the Turonian and was invaded by pelagic deposits (Bignot & Poisson 1974; Poisson 1977; Gutnic *et al.* 1979; Farinacci & Köylüoğlu 1982; Poisson *et al.* 1983; Özyeğin *et al.* 1985; Farinacci & Yeniay 1986; Gültekin 1986; Köylüoğlu 1987; Özkan & Köylüoğlu 1988; Naz *et al.* 1992; Robertson 1993).

Poisson *et al.* (1983) reported that three main extensional events are well documented in the western Taurides during Middle and Late Triassic, at the Jurassic-Cretaceous boundary and during the Turonian-early Senonian. Robertson (1993) proposed that subduction of old, dense (Late Triassic ?) oceanic crust and mantle could have led to regional crustal extension, and this may have been the driving force for subsidence of the carbonate platforms after Cenomanian time. The extensional tectonics may have been the cause of subsidence of the Bey Dağları carbonate platform during Turonian; alternatively short-term major sea-level fall in the late Turonian (90 Ma) as proposed by Haq *et al.* (1987), may have been the main control. The Korkuteli part of the platform retained its neritic character until the early Santonian. Deepening began in the middle Santonian and short term major sea-level fall in the middle Santonian (85 Ma) (Haq *et al.* 1987) or Turonian extension (Poisson *et al.* 1983) may have been the major control.

The lower and middle Campanian, the upper part of the middle Maastrichtian and the upper Maastrichtian are absent in all sections. The absence of the lower and middle Campanian may have been related to the discontinuity of pelagic sedimentation at the Santonian-Campanian boundary and nondeposition during post-Santonian subaerial exposure. The absence of the upper part of the middle Maastrichtian and the upper Maastrichtian should have been related to another break in pelagic deposition at the Cretaceous-Tertiary boundary. Measured stratigraphic sections show that the platform was subaerially exposed after the Santonian and during the middle Maastrichtian. Discontinuity may have been related to nondeposition during these times of subaerial exposure.

Farinacci & Yeniay (1986) suggested that the basin in which the Upper Cretaceous pelagic carbonates were deposited was not so deep, and facies variations (e.g., presence of cherts) and gaps in the pelagic sequence of the Bey Dağları was caused by sub-marine volcanic eruptions, represented now by an ophiolitic complex that crops out immediately north. They also noted that eustatic variations and tectonic pulses are also important events that change environment. The large platform of the Arabo-African palaeomargin divided into numerous basins; a large part of that palaeomargin, the Bey Dağları area, was subaerially exposed for short periods of time, between which there were long periods of drowning (Farinacci & Yeniay 1986).

The last transgression of the Mesozoic was Campanian in age and ceased in the Early Palaeocene when a new regression took place (Farinacci & Köylüoğlu 1982). The Maastrichtian was the closure time for the Arabo-African and Eurasiatic plates in this particularly critical area of Tethys (Farinacci & Yeniay 1986). It was also the time of the onset of collision (Poisson *et al.* 1983) and the initial stages of emplacement time of the Antalya Complex in the Katran Dağ area (Robertson 1993).

The hiatus at the end of the Late Cretaceous (after middle Maastrichtian), and subaerial exposure and erosion, may have been caused by the aforementioned tectonic events and/or short-term major sea-level fall during the middle Maastrichtian (68 Ma) (Haq *et al.* 1987).

Discussion

The age of the neritic limestones of the Bey Dağları formation extends from Cenomanian to the early Santonian. The uppermost level of the neritic part is characterized by massive lower Santonian rudistid limestones (Figure 4b). In the study area, the platform retained its shallow character until the end of the early Santonian, on contrary to the general agreement that establishment of the pelagic facies began in the Turonian throughout the major parts of the Bey Dağları autochthonous unit.

Slight drowning of the platform at the end of the early Santonian produced a hemipelagic environment that would persist until the end of the Santonian. This hemipelagic level was included in the Akdağ formation in most previous studies (Farinacci & Köylüoğlu 1982; Özyeğin *et al.* 1985; Farinacci & Yeniay 1986; Gültekin 1986; Köylüoğlu 1987; Özkan & Köylüoğlu 1988; Naz *et al.* 1992) due to its hemipelagic character (Figure 9), but the present authors propose that it should be included in the Bey Dağları formation because of its transitional contact with the neritic limestones, its massive structure, and the presence of a prominent erosional surface between the hemipelagic limestones of the Bey Dağları formation and the pelagic limestones of the Akdağ formation.

Figure 212 of Poisson (1977) clearly shows the lateral and vertical facies changes in the neritic and pelagic carbonates of the Upper Cretaceous Bey Dağları carbonate sequence. Subsidence of the platform, thus initiation of the pelagic facies is diachronous throughout the platform. Poisson (1977) separated the lower Senonian and upper Senonian carbonates along a surface which corresponded to a gap 'discontinuité de sedimentation en régime pélagique'.

Farinacci & Yeniay (1986) reported upper Coniacian-Santonian pelagic limestones over lower Turonian neritic deposits, interposing sedimentary gap between them in some sections. They proposed that the early-middle Senonian foraminiferal assemblage might be considered a transitional benthic neritic facies and a planktonic marine assemblage. They also reported a hiatus between Santonian and Campanian pelagic limestones.

Gültekin (1986) and Naz *et al.* (1992) mentioned the presence of the late Maastrichtian in their generalized columnar sections (Figure 9) but did not give the fossil association. Poisson (1977) and Farinacci & Yeniay (1986) reported the presence of the late Maastrichtian from the Korkuteli area (Figure 9). The planktonic foraminiferal assemblage given by Poisson (1977) in the Bozcalar Dere (Ulucak) section (table 6 in Poisson 1977) does not indicate the late Maastrichtian according to recent planktonic foraminiferal zonations (Robaszynski *et al.* 1984; Caron 1985; Robaszynski & Caron 1995). Farinacci & Yeniay (1986) also suggested the presence of the pelagic upper Maastrichtian in their Taraklı and Küçüktepe sections (Figure 9). Photomicrographs of upper Maastrichtian samples in plates 7 and 8 of their paper are very similar to our observations in the Küçüktepe sequence, but the planktonic foraminiferal association given in their paper does not indicate late Maastrichtian. In the absence of zone marker *Abathomphalus mayaroensis* (BOLLI), it is very difficult to determine the late Maastrichtian.

Conclusions

1- The Upper Cretaceous Korkuteli sequence comprises two formations. The Cenomanian-Santonian Bey Dağları formation lies at the base of the sequence and is disconformably overlain by the upper Campanian-middle Maastrichtian Akdağ formation. Palaeogene pelagic marls form the lowermost part of the Tertiary section and disconformably overlie the different stratigraphic levels of the Upper Cretaceous sequence.

2- The Bey Dağları formation can be divided into two parts. The 600-m-thick Cenomanian-lower Santonian neritic peritidal carbonates form the basal part and are gradationally overlain by the 15-m-thick, middle-upper Santonian hemipelagic limestones that form the upper part.

3- The neritic part is characterized by two rudistid horizons, corresponding to the Cenomanian and early Santonian. Massive hemipelagic limestones are easily distinguished due to their high relief.

4- The Akdağ formation disconformably overlies different stratigraphic levels of the Bey Dağları formation with a prominent erosional surface formed during a nondepositional and/or an erosional event in the early Campanian to early Maastrichtian. The lower and middle Campanian is totally missing.

5- The Upper Cretaceous sequence was truncated by an erosional surface. The upper part of the middle Maastrichtian and the upper Maastrichtian are totally absent in all sections.

6- The presence of two erosional phases has been obviously observed. During post-Santonian

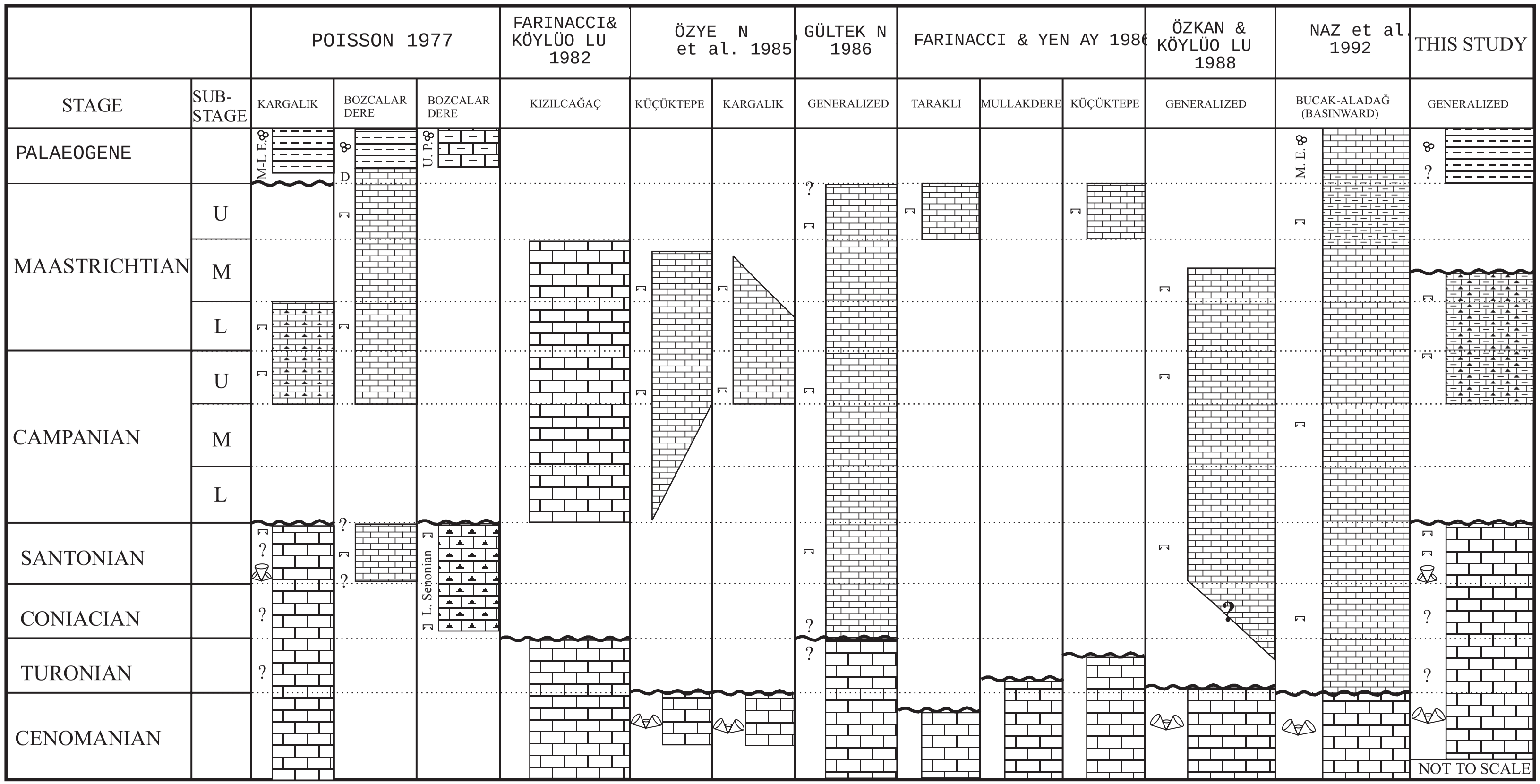

Figure 9. Chart showing sequences previously suggested by researchers who have studied the Bey Dağları autochtonous unit, and comparison with the present study. D– Danian, U.P.– Upper Palaeocene, M.E.– Middle Eocene.

regression, hemipelagic limestones of the Bey Dağları formation were partially or totally eroded and a prominent erosional surface was formed. The middle Maastrichtian erosional phase was more profound. Erosion reached the neritic limestones of the Bey Dağları formation. These data demonstrate that conditions were rather changeable on the platform during the Late Cretaceous, especially from the Santonian to the Palaeogene. These important variations correspond to regional and local tectonic movements and also short-term major drops in sea level.

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PLATE-I

Figure 1. *Globotruncana arca* (CUSHMAN); sample no: 97-393A; *Globotruncanita calcarata* total range zone; Upper Campanian

Figure 2. *Dicarinella* cf. *asymetrica* (SIGAL); sample no: 97-390A; *Dicarinella asymetrica* total range zone; Upper Santonian.

Figure 3. *Dicarinella concavata* (BROTZEN); sample no: 97-434; *Dicarinella asymetrica* total range zone; Upper Santonian.

Figure 4. *Globotruncanita elevata* (BROTZEN); sample no: 96-44; *Globotruncanita calcarata* total range zone; Upper Campanian.

Figure 5. *Globotruncana bulloides* VOGLER; sample no: 97-457; *Globotruncanita calcarata* total range zone; Upper Campanian.

Figure 6. *Globotruncanita calcarata* (CUSHMAN); sample no: 97-392A; *Globotruncanita calcarata* total range zone; Upper Campanian.

Figure 7. *Globotruncana* linneiana (d'ORBIGNY); sample no: 97-4; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 8. *Globotruncanita* subspinosa (PESSAGNO); sample no: 97-4; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 9. *Globotruncana ventricosa* WHITE; sample no: 97-102; *Gansserina gansseri* interval zone; Middle Maastrichtian.

PLATE-I

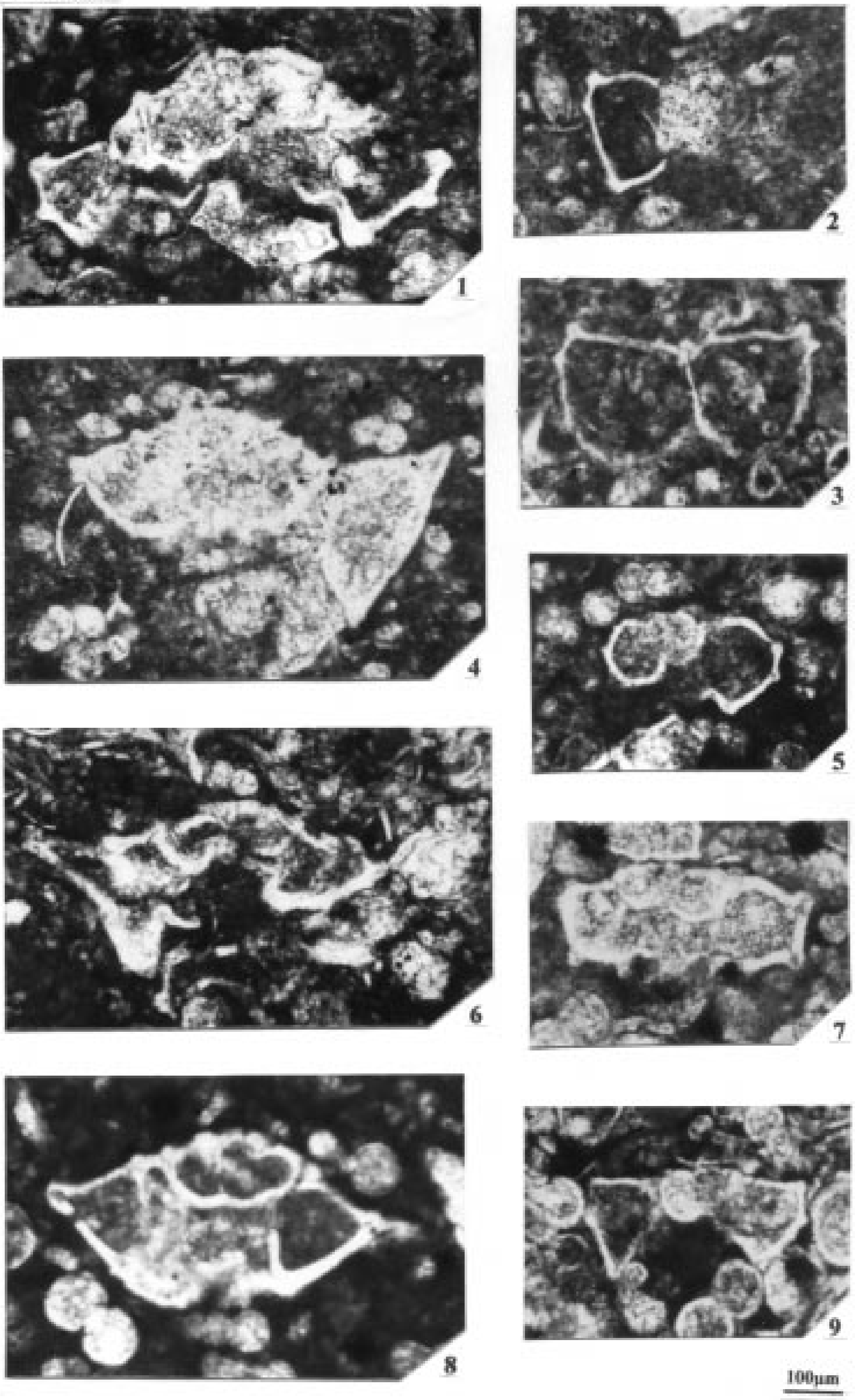

PLATE-II

Figure 1. *Globotruncana aegyptiaca* NAKKADY; sample no: 97-436; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 2. *Globotruncana esnehensis* NAKKADY; sample no: 97-101; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 3. *Globotruncana falsostuarti* SIGAL; sample no: 97-5; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 4. *Globotruncanita angulata* (TILEV); sample no: 97-102; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 5. *Globotruncanita conica* (WHITE); sample no: 97-103; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 6. *Globotruncanita pettersi* (GANDOLFI); sample no: 97-101; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 7. *Globotruncanita stuarti* (de'LAPPARENT); sample no: 97-102; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 8. *Contusotruncana contusa* (CUSHMAN); sample no: 97-5; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 9. *Gansserina gansseri* (GANDOLFI); sample no: 97-102; *Gansserina gansseri* interval zone; Middle Maastrichtian.

Figure 10. *Gansserina wiedenmayeri* (GANDOLFI); sample no: 97-102; *Gansserina gansseri* interval zone; Middle Maastrichtian.

PLATE-II