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ORIGINAL PAPER

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Stratigraphy of Upper Cretaceous–Palaeogene sequences in the southern and eastern Menderes Massif (western Turkey)

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Abstract The stratigraphy of the uppermost levels of the Menderes Massif is controversial and within its details lie vital constraints to the tectonic evolution of south-western Turkey. Our primary study was carried out in four reference areas along the southern and eastern Menderes Massif. These areas lie in the upper part of the Menderes metamorphic cover and have a clear stratigraphic relationship and contain datable fossils. The first one, in the Akbük–Milas area, is located south-east of Bafa Lake where the Milas, then Kızılağaç and Kazıklı formations are well exposed. There, the Milas formation grades upwards into the Kızılağaç formation. The contact between the Kızılağaç and the overlying Kazıklı formation is not clearly seen but is interpreted as an unconformity. The Milas and Kızılağaç formations are also found north of Muğla, in the region of Yatağan and Kavaklıdere. In these areas, the Milas formation consists of schists and conformably overlying platform-type, emery and rudist-bearing marbles. Rudists form the main palaeontological data from which a Santonian–Campanian age is indicated. The Kızılağaç formation is characterized by reddish–greyish pelagic marbles with marly-pelitic interlayers and coarsening up debris flow deposits. Pelagic marbles within the formation contain planktonic foraminifera and nanoplankton of late Campanian to late Maastrichtian age. The Kazıklı formation is of flysch type and includes carbonate blocks. Planktonic foraminifera of Middle Palaeocene age are present in carbonate lenses within the formation. In the Serinhisar–Tavas area, Mesozoic platform-type marbles (Yılanlı formation) belonging to the cover series of the Menderes Massif exhibit an imbricated internal structure. Two rudist levels can be distinguished in the uppermost part of the formation: the first indicates a middle-late Cenomanian age and the upper one is Santonian to Campanian in age. These marbles are unconformably covered by the Palaeocene–Early Eocene Zeybekölentepe formation with polygenetic breccias. In the Çal–Denizli area, the Menderes massif succession consists of cherty marbles and clastic rocks with metavolcanic lenses. The Lower–Middle Eocene Şalvan formation lies unconformably on this sequence and is interpreted as equivalent to the marble horizons at Serinhisar but with pelagic facies. The Şalvan formation consists of shale, mafic volcanic rock, lenses of limestone and blocks of recrystallized limestone. The Şalvan formation is dated here for the first time by Early–Middle Eocene foraminifera and nanoplankton from the matrix of the formation. An angular unconformity exists between the Upper Cretaceous and Lower Tertiary sequences, suggesting that a phase of deformation affected the southern and eastern part of the Menderes Massif at this time. This deformation may be caused by initial obduction of the Lycian ophiolite onto the passive margin to the north of the Menderes carbonate platform during the latest Cretaceous. Drowning of the platform led to termination of carbonate deposition and deposition of deep water flysch-like clastic sediments.

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Introduction

According to additional geological concepts, the Menderes Massif consists of a core series of Precambrian to Cambrian rocks and cover series of Lower Paleozoic to Lower Eocene rocks (Brinkmann 1967; Başarır 1970; Dürr 1975; Çağlayan et al. 1980; Şengör et al. 1984; Konak et al. 1987; Okay 1989; Dora et al. 1990; Dürr et al. 1995). Although, on a broad scale, this simple picture appears to hold true, recent studies have highlighted the presence of large thrusts within the Ring et al. 1999; Lips et al. this Volume) that imbricate the metamorphic rocks. After thrusting, the higher-grade rocks within the Menderes Massif were exhumed by bivergent extensional detachments (Bozkurt and Park 1994; Hetzel et al. 1995; Bozkurt 1996; Bozkurt and Park 1997; Lips et al. this Volume). Although the detailed kinematic evolution of the massif is controversial (e.g. Bozkurt and Park 1997; Collins and Robertson 1998; Hetzel et al. 1998), much evidence indicates that the entire southern Menderes Massif was overthrust by the Lycian thrust sheets during the Tertiary (Graciansky 1972; Okay 1989; Collins and Robertson 1997, 1998, 1999; Ring et al. 1999).

The Mesozoic sequence of the southern Menderes Massif mainly consists of massive platform-type neritic, marbles and forms a coherent, relatively undeformed stratigraphic package (Figs. 1, 2, and 3). The uppermost part of the Mesozoic sequence is characterized, from bottom to top, by emery-bearing marbles, rudist-bearing marbles, reddish pelagic marbles and flysch-like rocks. This sequence has been metamorphosed to greenschist-facies conditions and contains few datable fossils. However, rudists have been found locally around Milas and have been dated as Late Cretaceous (Dürr 1975) and the overlying detritic sequence as Palaeocene–Eocene age (Özkaya 1991). These rudists have recently been re-examined and many individual species have been determined (Özer 1993, 1998). The reddish pelagic marbles have yielded

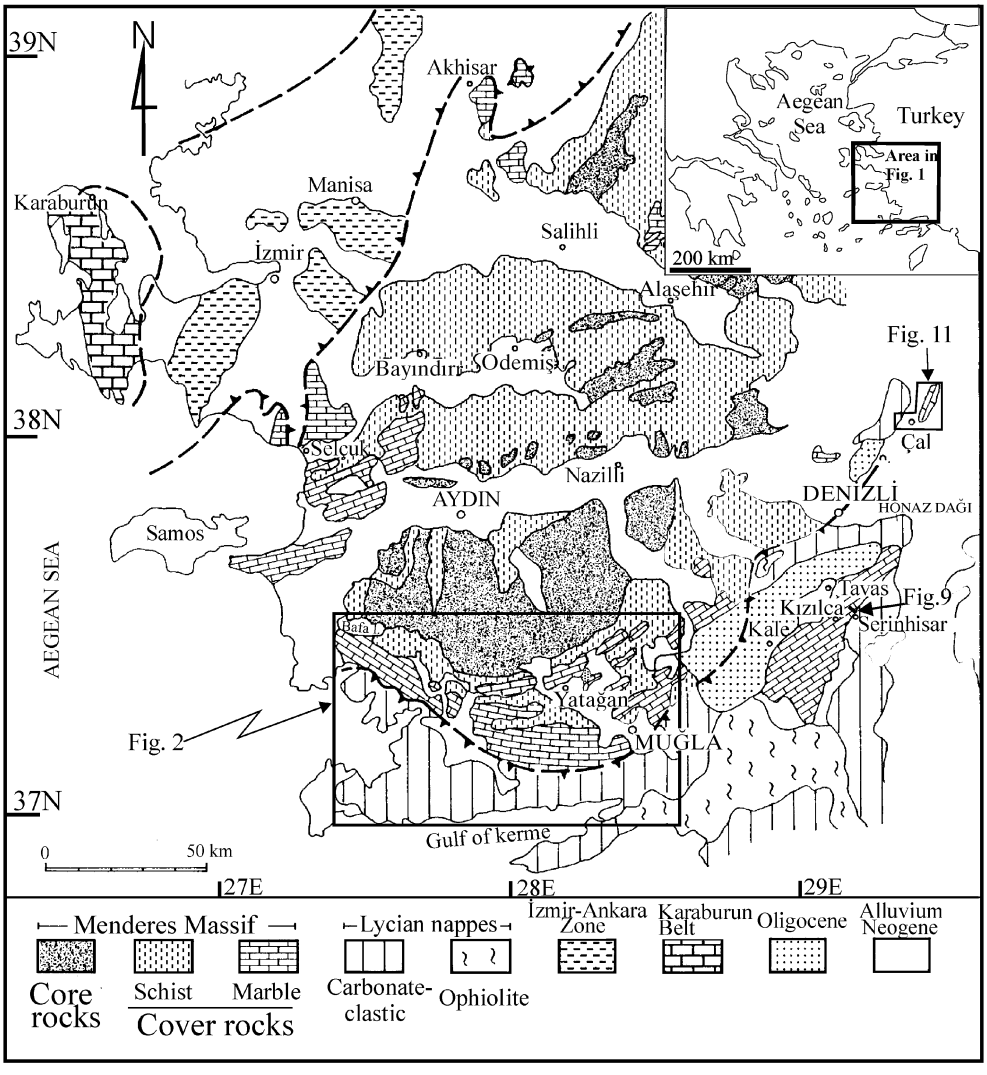


Fig. 1 Simplified geological map of western Turkey showing the location of the Menderes Massif between the tectonic belts of the İzmir–Ankara zone to the north and the Lycian thrust sheets to the south. The study areas are indicated

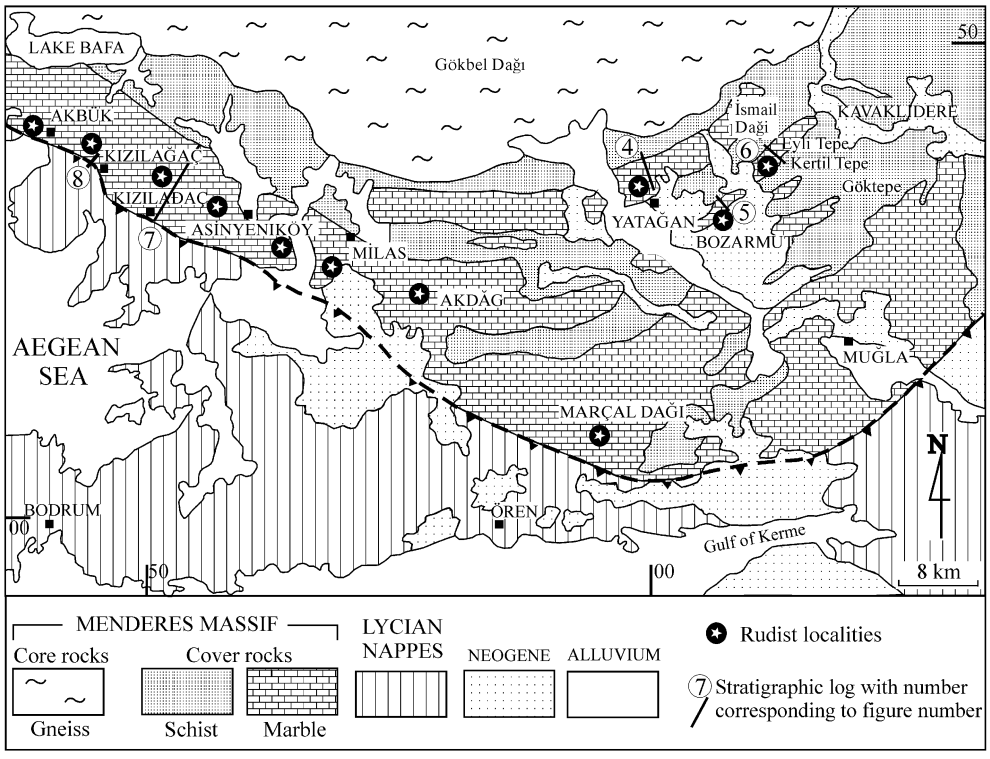


Fig. 2 Geological map of the southern sector of the Menderes Massif showing the location of the measured stratigraphic sections (*4*-Yatağan section; *5* Bozarmut section; *6* Kertil Tepe section; *7* Akbük-Milas section) and also the distribution of the rudist localities (map modified after Dürr 1975; Çağlayan et al. 1980; Konak et al. 1987). Map grid relates to Turkish National Grid

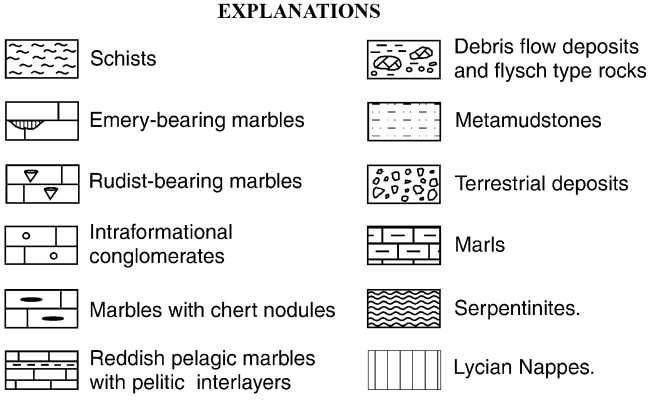


Fig. 3 Key for stratigraphic logs

some globotruncanids (Dürr 1975; Çağlayan et al. 1980; Konak et al. 1987) which support a Late Cretaceous age of deposition. The detritic formation was deposited in the Kızılca/Alakaya basin, which extended during Palaeocene–Middle Eocene times between the Menderes Massif to the north and the Beydağlari carbonate platform to the south (Poisson and Sarp 1977; Poisson 1985; Özkaya 1991). According to previous studies (Şengör et al. 1985; Konak et al. 1987; Dora et al. 1990; Oberhansli et al. 1998), the main Menderes metamorphism took place during the Late Eocene, just after the ophiolitic melange was emplaced onto it, and buried the Kızılca/Alakaya basin (Özkaya 1990). For that reason, the Palaeocene–Eocene detrital rocks of the Alakaya basin are accepted as the uppermost part of the Menderes sequence.

The aim of this study was to provide an up-to-date overview of the Upper Cretaceous–Lower Tertiary sequence of the southern and eastern sector of the Menderes Massif. This study is based on rudists, planktonic foraminifera and nanoplankton data from many measured stratigraphic sections. Five examples are presented in Figs. 4, 5, 6, 10and 13, and Fig. 8 summarizes 24 sections from the Akbük–Milas area. For the first time, new palaeontological data from the metamorphosed detritic sequence are determined in the Çal–Denizli and Serinhisar–Tavas areas. A detailed geological map of the Çal–Denizli area (Fig. 14), previously unreported in the referred literature, represents a tectonic window into the eastern Menderes sequence beneath the Lycian nappes.

Stratigraphy

The Upper Cretaceous-Palaeogene successions of the southern and eastern sector of the Menderes Massif are studied in the Yatağan-Kavaklıdere, Akbük–Milas, Serinhisar–Tavas and Çal–Denizli areas (Fig. 1).

Yatağan-Kavaklıdere area

Micaschists and emery-bearing marbles outcrop in this area (Fig. 2). According to previous studies (Dürr 1975; Çağlayan et al. 1980; Konak et al. 1987; Konak 1994), the contact between the Palaeozoic mica schists

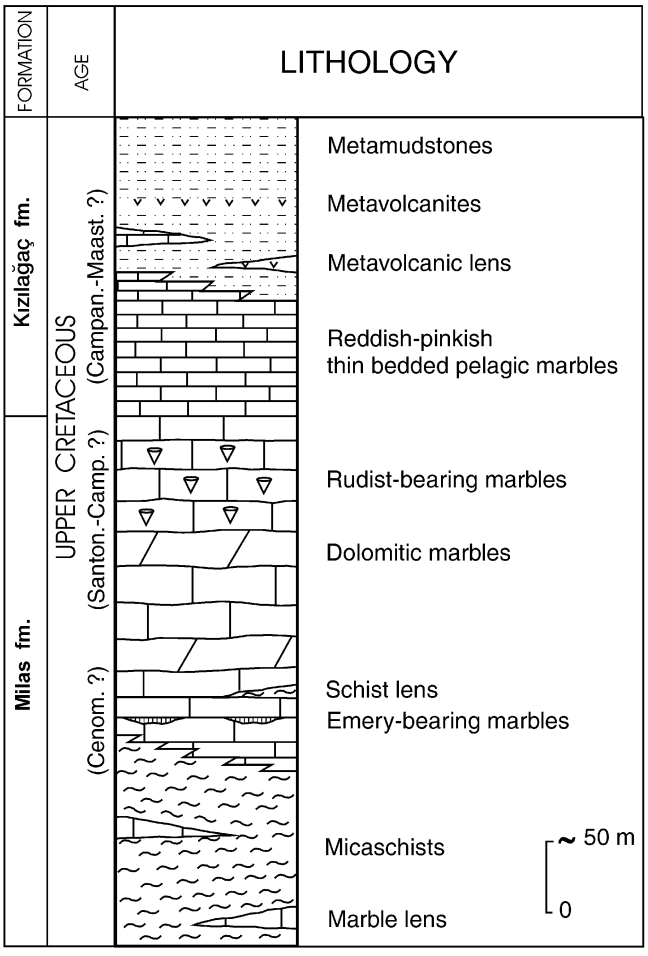


Fig. 4 Yatağan measured stratigraphic section. See Fig. 2 for location and Fig. 3 for key

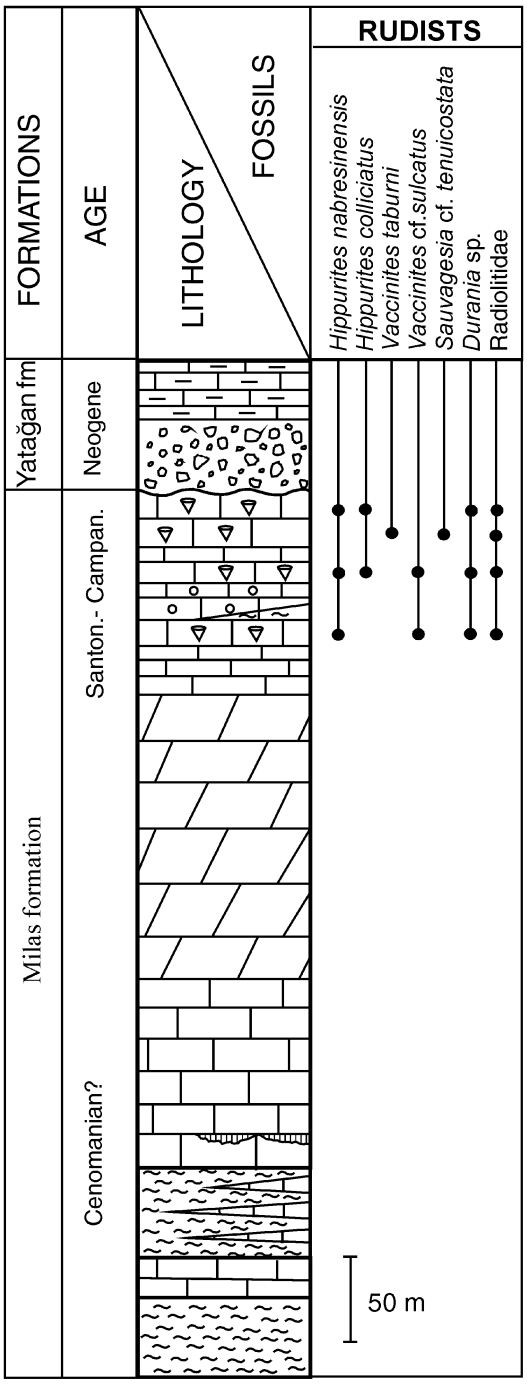


Fig. 5 Bozarmut measured stratigraphic section. See Fig. 2 for location and Fig. 3 for key

and Mesozoic emery-bearing platform-type marbles is characterized by a clear unconformity. Our work, however, contrasts with this interpretation and shows that this contact is conformable (Figs. 4, 5, 6). The main observations in this area are detailed below:

Milas formation

The Milas formation is well seen in the Yatağan (Fig. 4), Bozarmut (Fig. 5) and Kertil Tepe (Fig. 6) sections. It consists of, from bottom to top, mica schists, emery-bearing marbles, dolomitic marbles and rudist-bearing marbles with nearly vertical dip. The mica schists contain 1- to 3-m-thick and 5- to 100-m-long marble lenses. A gradational transition between the mica schists and emery-bearing marbles is clearly observed (Figs. 4, 5, 6). In the marble succession, mica-schist lenses and intraformational metaconglomerates are present. The emery-bearing marbles grade upwards into massive dolomitic marbles and rudist-bearing marbles. The rudist fauna (from both Bozarmut and Kertil Tepe) indicates a Santonian–Campanian age and consists of: *Hippurites nabresinensis* Futterer, *Hippurites colliciatus* Woodward, *Vaccinites* cf. *sulcatus* Defrance and *Sauvagesia* cf. *tenuicostata* Polsak (Fig. 7, nos. 1, 5 and 7). The rudist-bearing marbles also contain rare coral sections. These levels grade upwards into thick, grey marbles and then, at Yatağan and Kertil Tepe, pass into the Kızılağaç for-

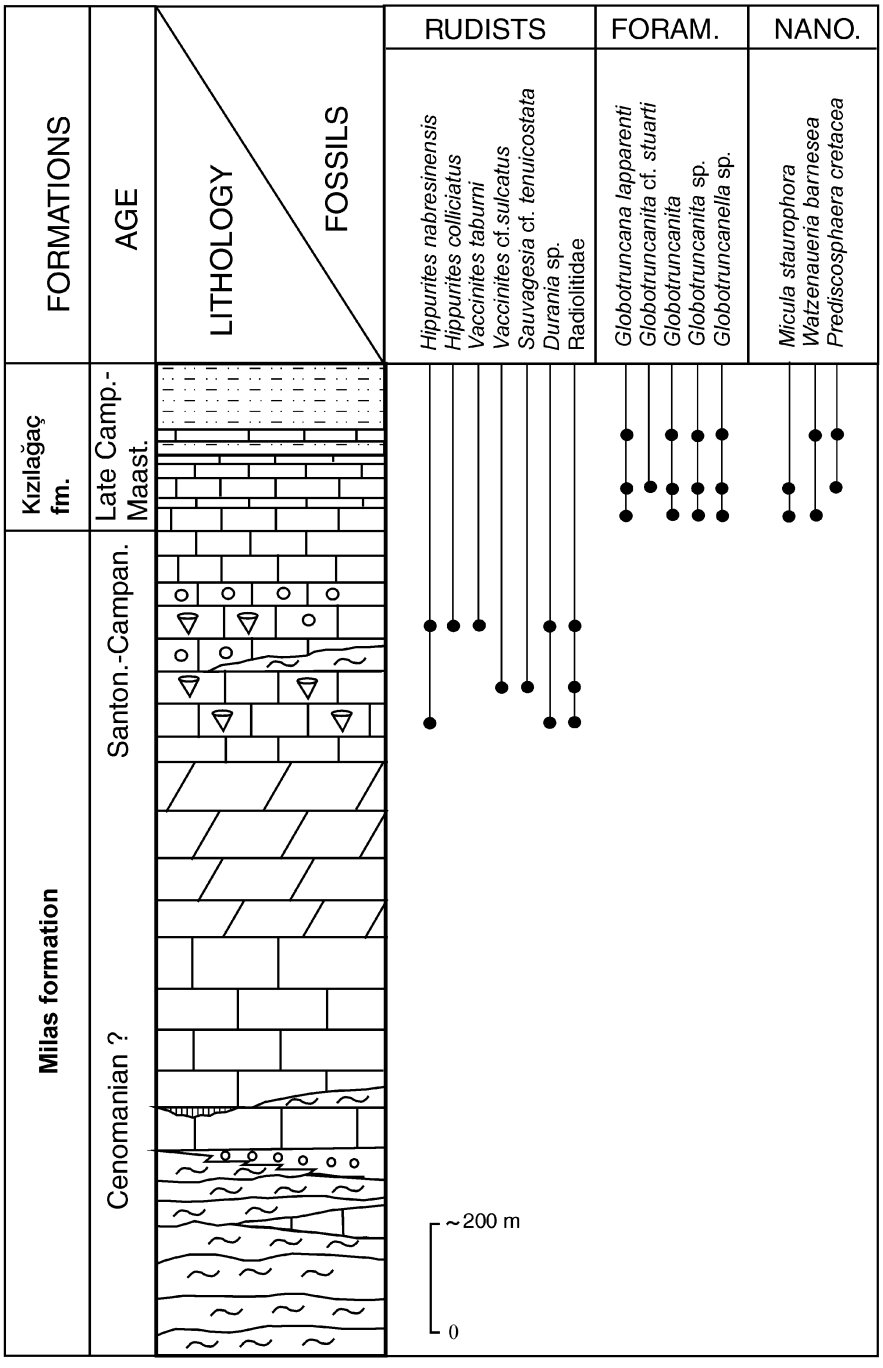


Fig. 6 Kertil Tepe (SW of Eyli Tepe) measured stratigraphic section. See Fig. 2 for location and Fig. 3 for key

mation (Figs. 4 and 6). At Bozarmut, the Milas formation is unconformably overlain by the Neogene Yatağan formation.

Kızılağaç formation

The Kızılağaç formation was logged at Yatağan and Kertil Tepe where it conformably overlies the Milas formation. This formation is made up of reddish–pinkish pelagic metacarbonates and metamudstones with carbonate lenses. Planktonic foraminifera such as *Globotruncana lapparenti* Brotzen, *Globotruncanita* cf. *stuarti* (De Lapparent), *Globotruncanita* sp., *Globotruncana* sp. and also nanoplankton such as *Micula staurophora* (Garted), *Watznaueria barnesae* (Black) and *Prediscosphaera cretacea* (Arkhangelsky) indicate a late Campanian–Maastrichtian age. These pelagic fossils are observed only around Magara village–Kertil Tepe (Figs. 2 and 6). At Yatağan, the Kızılağaç formation contains only very poorly preserved pelagic fossils (probably globotruncanids).

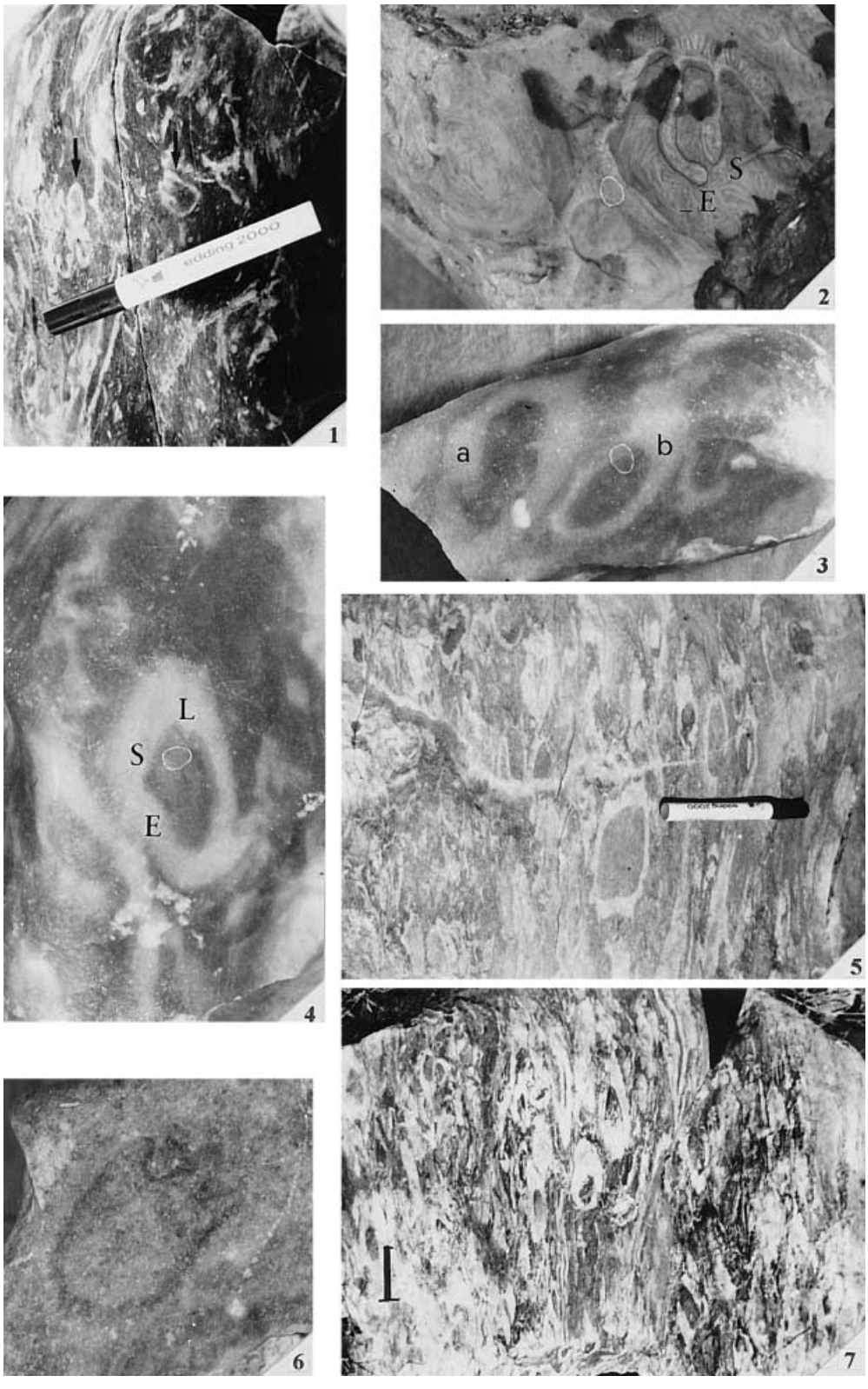


Fig. 7 The rudists from the marbles of the Milas Formation. *1 Hippurites nabresinensis* Futterer (*arrows*) from Bozarmut village–Yatağan (scale is 12 cm). *2 Vaccinites taburni* Guiscardi from Akdağ (*scale bar* is 10 mm) (*S* and *E* pillars). *3* Radiolitid sections from Sapliada–Akbük (Milas) *a Sauvagesia* sp., *b Durania* sp. (*scale bar* is 10 mm). *4 Sauvagesia tenuicostata* Polsak from Sapliada–Akbük (Milas) (*scale bar* is 10 mm). *L* Ligamental ridge; *S* and *E* siphonal bands. *5* Hippuritid and Radiolitid sections from west of Eyli Tepe–Kavaklıdere (scale is 14 cm). *6 Hippurites nabresinensis* Futterer from Kömürburnu–Akbük (Milas), *scale bar* is 10 mm. *7* Radiolitid sections from west of Eyli Tepe, Kavaklıdere (*scale bar* is 5 cm). Note the elongation of the valves caused by deformation

Akbük–Milas area

The Mesozoic to Palaeogene rocks are exposed in the Akbük–Milas area where 24 stratigraphic sections were measured. The palaeontological and lithological characteristics of these sections are summarized in Fig. 8. Three formations are distinguished in this area as follows.

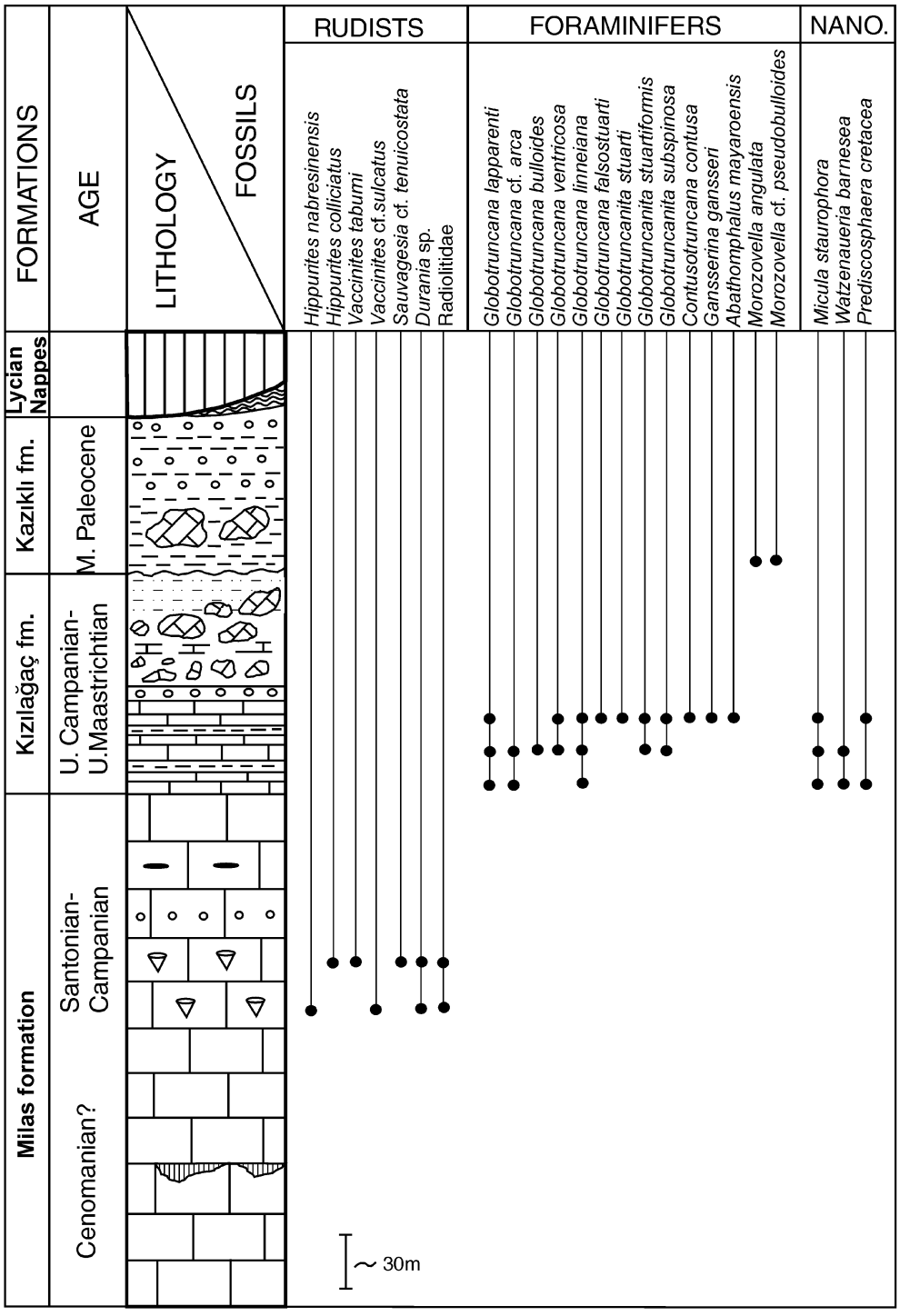


Fig. 8 Generalized stratigraphic section of the Akbük–Milas area (see Fig. 2 for location and Fig. 3 for key). The section is summarized from 24 detailed logs and the coordinates, using the Turkish grid, are listed as follows: (39,100/39,750–40,000/39,500), (40,775/39,675–40,950/39,925), (39,950/34,450–40,050/39,100), (43,625/35,800–43,725/36,075), (44,050/34,825–44,200/35,200), (44,500/34,200–44,750/34,600), (42,225/38,250–42,450/38,525), (41,250/40,600–41,175/39,025), (43,050/37,300–43,175/37,625), (43,300/36,975–43,500/37,125), (47,625/32,875–48,450/34,300), (50,200/32,650–50,600/33,575), (42,300/38,175–42,700/38,400), (42,850/37,700–42,950/38,000), (34,950/40,575–35,500/42,275), (35,575/41,000–37,175/43,500), (50,000/31,250–52,750/33,650), (51,650/29,925–54,925/32,675), (56,300/28,000–60,000/32,000), (62,800/29,250–61,000/27,000), (Sapliada section), (48,350/32,700–49,275/34,300), (42,350/37,800–43,000/38,250), (57,250/28,000–59,000/29,600)

Milas formation

This formation (250–300 m thick) is mainly made up of platform-type massive carbonates and, from bottom to top, consists of emery-bearing marbles, rudist-bearing marbles, intraformational carbonate breccias and marbles with cherts (Fig. 8). Rudists form the main palaeontological database in this formation. The rudist fauna (Fig. 7, nos. 2–4 and 6) consists of *Hippurites nabresinensis* Futterer, *Hippurites colliciatus* Woodward, *Vaccinites taburni* Guiscardi, *Vaccinites* cf. *sulcatus* Defrance, *Sauvagesia* cf. *tenuicostata* Polsak, *Durania* sp., and radiolitid fragments indicative of a Santonian–Campanian age (Özer 1993, 1998). The rudist-bearing massive marbles are 30 to 40 m thick and grade laterally and vertically into intraformational carbonate breccias. The uppermost part of the formation is made up of massive marbles with chert nodules, and passes gradually upwards into the reddish-pelagic marbles of the Kızılağaç formation.

Rudist sections are observed around Kömürburnu and Saplıada localities (NE of Akbük), Kazıklı, Kızılağaç and Asinyeniköy villages and also Akdağ and Marçal Dağ (Fig. 2). In Kömürburnu and Asinyeniköy small rudist buildups are found that were constructed by hippuritids.

Kızılağaç formation

This formation is characterized by thin- to medium-bedded, reddish, greenish and grey pelagic marbles with marly-pelitic interlayers in the lower part (25–30 m thick). In the upper 40–50 m, coarsening up debris-flow deposits are found. The reddish pelagic marbles have yielded planktonic foraminifera such as *Globotruncana lapparenti* Brotzen, *G.* cf. *arca* (Cushman), *G. bulloides* Vogler, *G. ventricosa* White, *G. linneiana* (Dlate Maastrichtian age.

The formation crops out around Kazıklı and Kızılağaç villages together with the overlying Kazıklı formation. In this area, the reddish, pinkish marbles of the formation are 25–30 m thick; however, in the Kalınagil locality (west of Akdağ), they are 100–150 m thick. The contact between the Kızılağaç and Kazıklı formations is interpreted as an unconformity (Figs. 8 and 9).

Fig. 9 Detailed stratigraphic cross section of the upper Menderes sequence showing the contact relationships of the Cretaceous–Palaeocene units and their fossil contents. This cross section is measured from north of Canavar Tepe, 2 km north-west of Kazıklı, between the coordinates of (42,300/38,175) and (42,700/38,400) taken from the Turkish grid. See Fig. 2 for location of the cross section and Fig. 3 for explanation

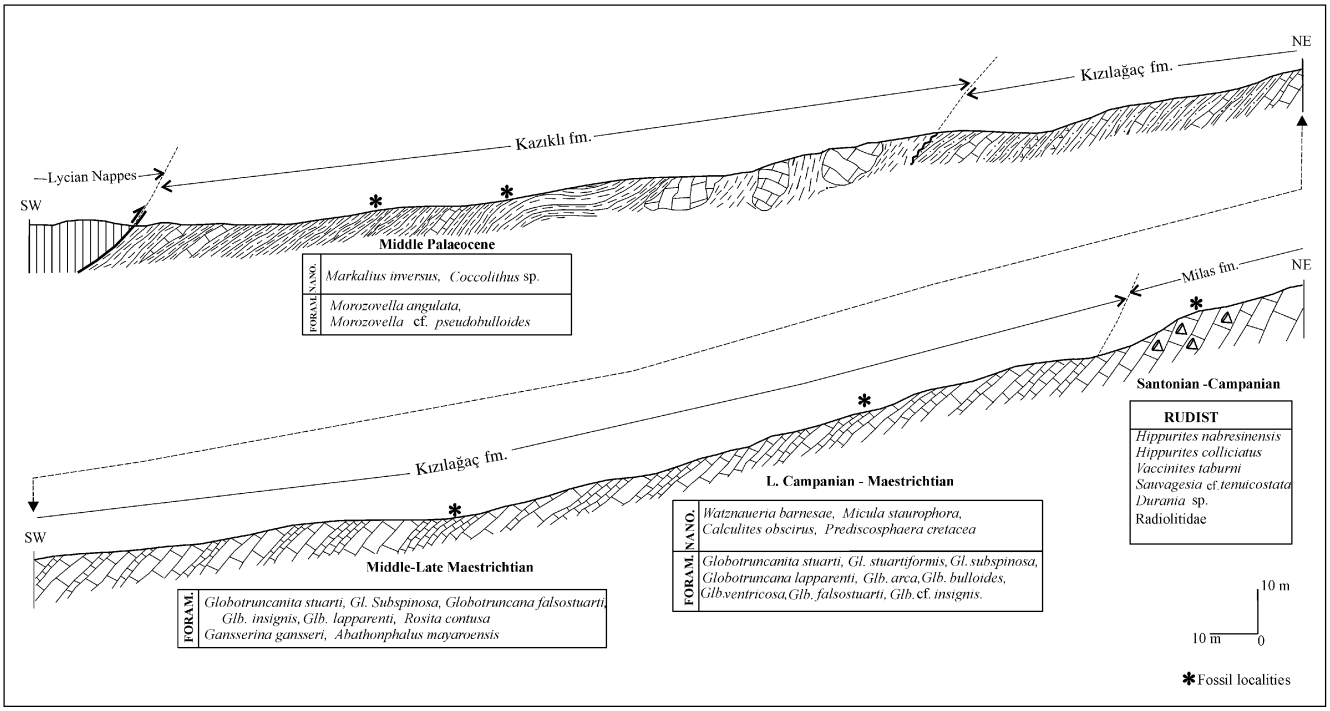
Kazıklı formation

This formation consists of fine-grained clastic rocks with carbonate lenses and carbonate blocks (Fig. 9). In the carbonate lenses planktonic foraminifera such as *Morozovella angulata* (White), *Morozovella* cf. *pseudobulloides* (Plummer), *Morozovella* sp. and *Globigerina* sp. have been determined, which indicate a Middle Palaeocene age. As these microfossils have been extracted from the matrix of the formation and not from exotic blocks, the Middle Palaeocene age is interpreted as an actual, rather than a maximum, deposition age.

Tavas–Serinhisar area

The cover rocks of the Menderes Massif crop out over a large area extending from south of Kale to Tavas and south-east of Denizli (Fig. 1). In this area, the metamorphic rocks of the massif have an imbricated internal structure (Poisson 1977, 1985; Poisson and Sarp 1977; Okay 1989; Özkaya 1990, 1991; Collins and Robertson 1999). Late Palaeozoic, slightly metamorphosed, clastic rocks outcrop south of Tavas. These rocks contain carbonate lenses with fusulinid foraminifera. Overlying Mesozoic monotonous, platform-type neritic marbles are observed in a major NE–SW striking mountain chain extending south-east of Tavas to Denizli.

Previous studies (Poisson and Sarp 1977; Çağlayan et al. 1980; Okay 1989; Özkaya 1990, 1991) recognized that rudists formed the major component of the mar-



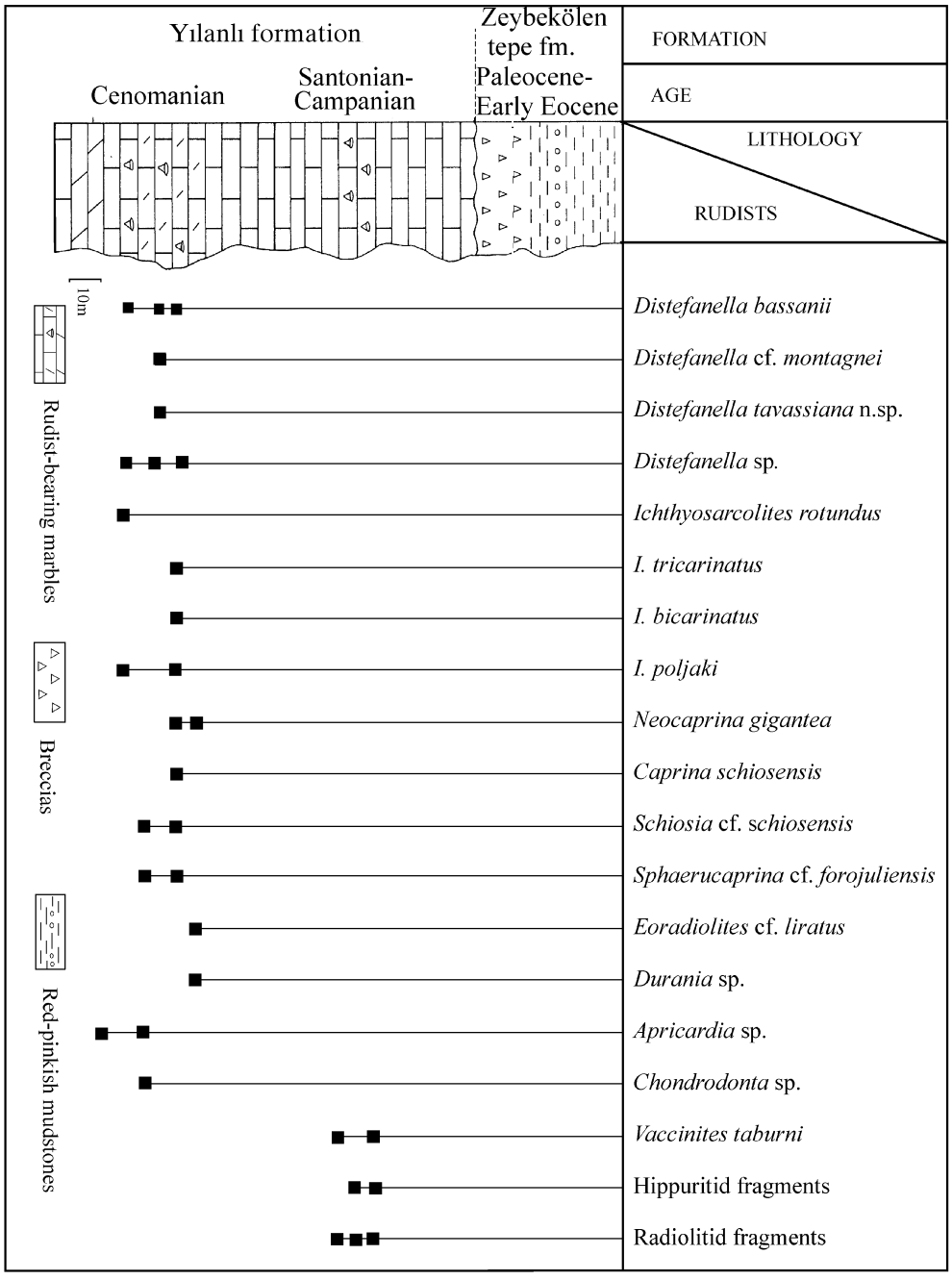


Fig. 10 Serinhisar (Kızılhisar) stratigraphic columnar section showing the rudist distributions in the Serinhisar–Tavas area. This section is measured from Sarp Dere, 1 km north of Serinhisar between the coordinates of (99,500/63,750) and (00,250/63,550) from the Turkish grid

bles at Serinhisar (formerly Kızılhisarhisar). The rudists are collected from the Yılanlı formation along Sarp Dere, 1 km north of Serinhisar. Two lithological formations have been identified and are correlated with units first described by Okay (1989) from Honaz Dağı, 20 km to the north. These units are outlined below (Fig. 10).

Yılanlı formation

This formation consists of massive, grey, rudist-bearing platform-type marbles ~60 m thick. The rudist-bearing facies are ~25–30 m thick and are intercalated with bioclastic facies.

The rudist fauna of these marbles consists mainly of rudists with canals, indicating a middle-late Cenomanian age: *Neocaprina gigantea* Plenicar, *Caprina schiosensis* Boehm, *Ichthyosarcolites tricarinatus* Parona, *I. bicarinatus* (Gemmellaro), *I. rotundus* Polsak, *I. poljaki* Polsak, *Sphaerucaprina* cf. *forojuliensis* Boehm (Fig. 11, nos. 1, 3 and 4). These species are found in the Cenomanian (middle-upper) beds of the Apulian platform in Italy, former Yugoslavia and Greece (Plenicar 1965; Sliskovic 1965; Polsak 1967; Carbone et al. 1971; Praturlon and Sirna 1976; Combes et al. 1981;

Sirna 1982; Camoin 1983), and also in the Beydagları carbonate platform, in Turkey (Özer 1988). *Distefanella bassanii* Parona, *Distefanella* cf. *montagnei* Sliscovic, *Distefanella tavassiana* Özer, *Distefanella* sp. and *Eoradiolites* cf. *liratus* (Conrad), *Durania* spp., *Chondrodonta* sp. and *Apricardia* sp. (Fig. 11, nos. 2 and 5; Fig. 12, nos. 1–6) are also associated with this fauna at Serinhisar (Özer 1998, 1999).

The rudist-bearing marbles pass conformably upward to 30- to 35-m-thick, massive, grey marbles and are followed by 10- to 15-m-thick, grey rudistid and bioclastic marbles. These levels are mainly composed of *Vaccinites taburni* Guiscardi, indicating a Santonian–Campanian age. The uppermost part of the formation is made up of massive, grey marbles without fossils.

Zeybekölentepe formation

The Zeybekölentepe formation unconformably overlies the Yılanlı formation and consists of serpentinite breccias and red–pinkish mudstones. The formation yields no fossils. However, the age of the formation

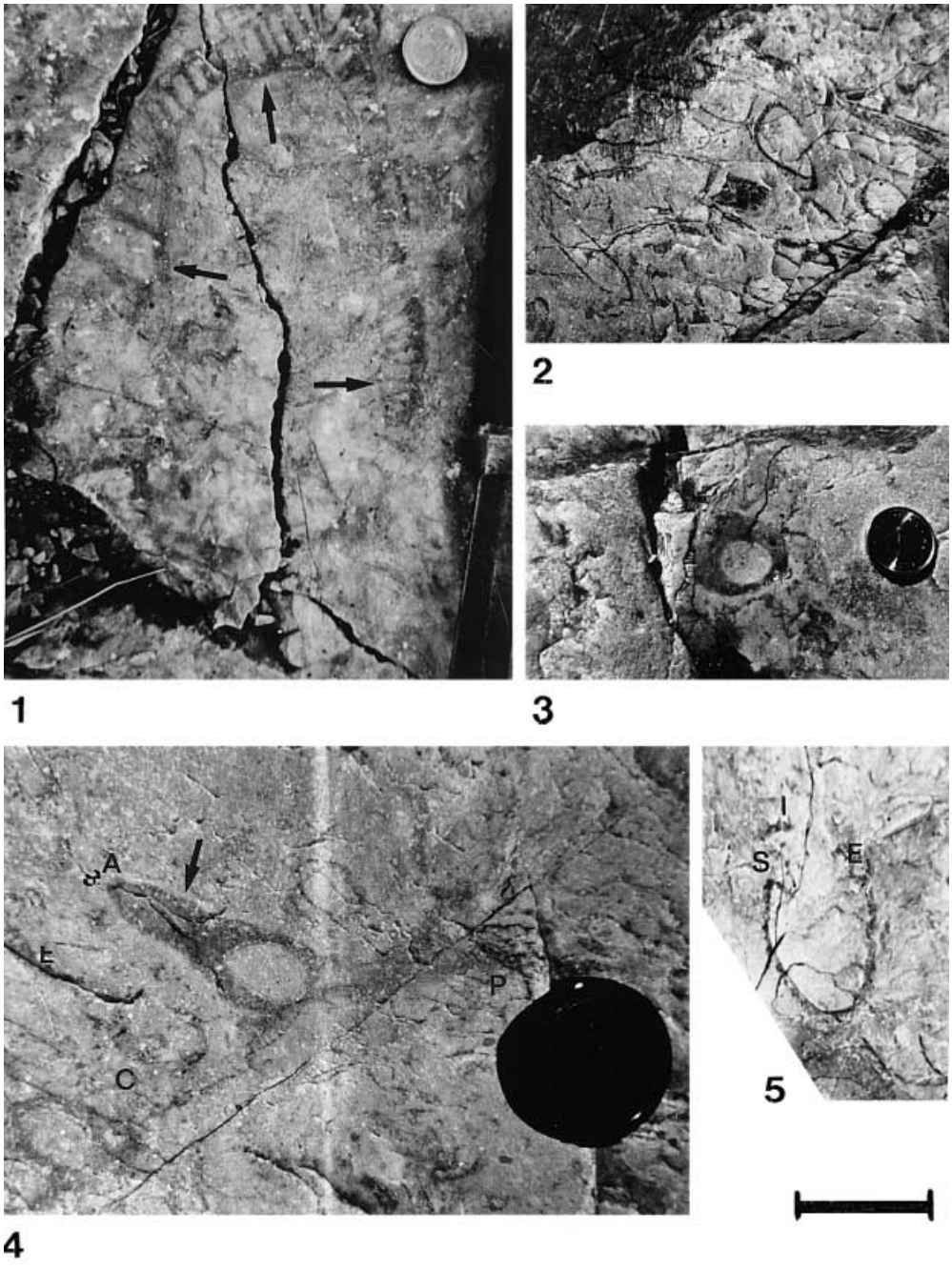


Fig. 11 The rudists of Serinhisar-Tavas area. *1 Neocaprina gigantea* Plenicar. Transverse section of the lower valve. Note the canals (*arrows*), sample no S 92.01/M. *2* Field photo showing the transverse sections of lower valves of *Distefanella bassani* Futterer. *3 Ichthyosarcolites rotundus* Polsak. Transverse section of the lower valve, field photo. *4 Ichthyosarcolites poljaki* Polsak. Transverse section of the lower valve showing the ridges (*A*, *P* and *C*) and the small round or oval canals (*arrows*), field photo. *5 Distefanella* cf. *montagnei* Slickovic. Transverse section of the lower valve. Note strongly concave siphonal bands (*S*,*E*) and very convex interband (*I*), sample no S 92.01/G. The 10 mm of the *scale bar* in the *lower right corner* is valid for all sections

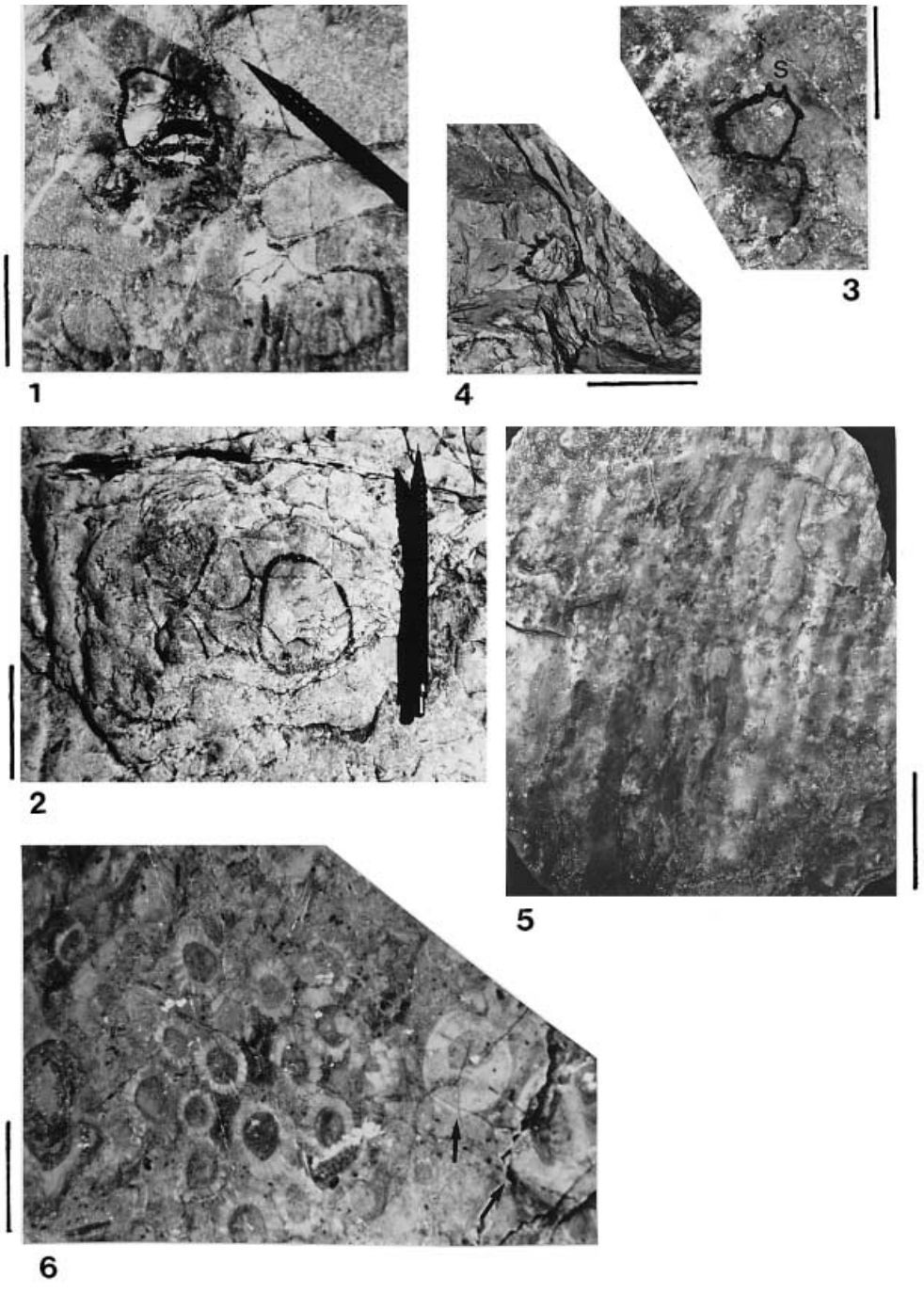


Fig. 12 The rudists of Serinhisar-Tavas area. *1* and *2 Distefanella bassani* Parona. Transverse sections of the lower valves. Siphonal bands are flat, field photo. The *scale bar* is 10 mm. *3* and *4 Distefanella tavassiana* Özer. Transverse sections of the lower valves. The siphonal band *S* is very concave, field photo. The *scale bar* is 10 mm. *5 Chondrodonta* sp. Note the very intense costates. Sample no S 92.01/A. The *scale bar* is 16 mm *6* Small construction of *Eoradiolites* cf. *liratus* (Conrad) associated with *Durania* spp. (*arrows*), field photo. The *scale bar* is 16 mm

was speculated as Palaeocene–Early Eocene by Poisson and Sarp (1977), Okay (1989) and Özkaya (1990).

According to Okay (1989), the contact between the Yılanlı formation and the overlying Zeybekölentepe formation is conformable. Our work, however, contrasts with this interpretation and considers this contact to be an unconformity. Evidence for the presence of this unconformity are (1) the basal part of the Zeybekölentepe formation rests on the different levels of the Yılanlı formation, and (2) there is no transition from the carbonate-dominated Yılanlı formation to the overlying coarse detritic deposits of the Zeybekölentepe formation.

Çal–Denizli area

In the Çal area (Figs. 1, 13and 14), the stratigraphy of the Menderes Massif has been established from the Jurassic–Cretaceous Bükrüce formation. It is conformably overlain by the Upper Cretaceous Gömce formation and the Palaeogene Şalvan formation (Konak 1993; Çakmakoglu 1995). This sequence is tectonically

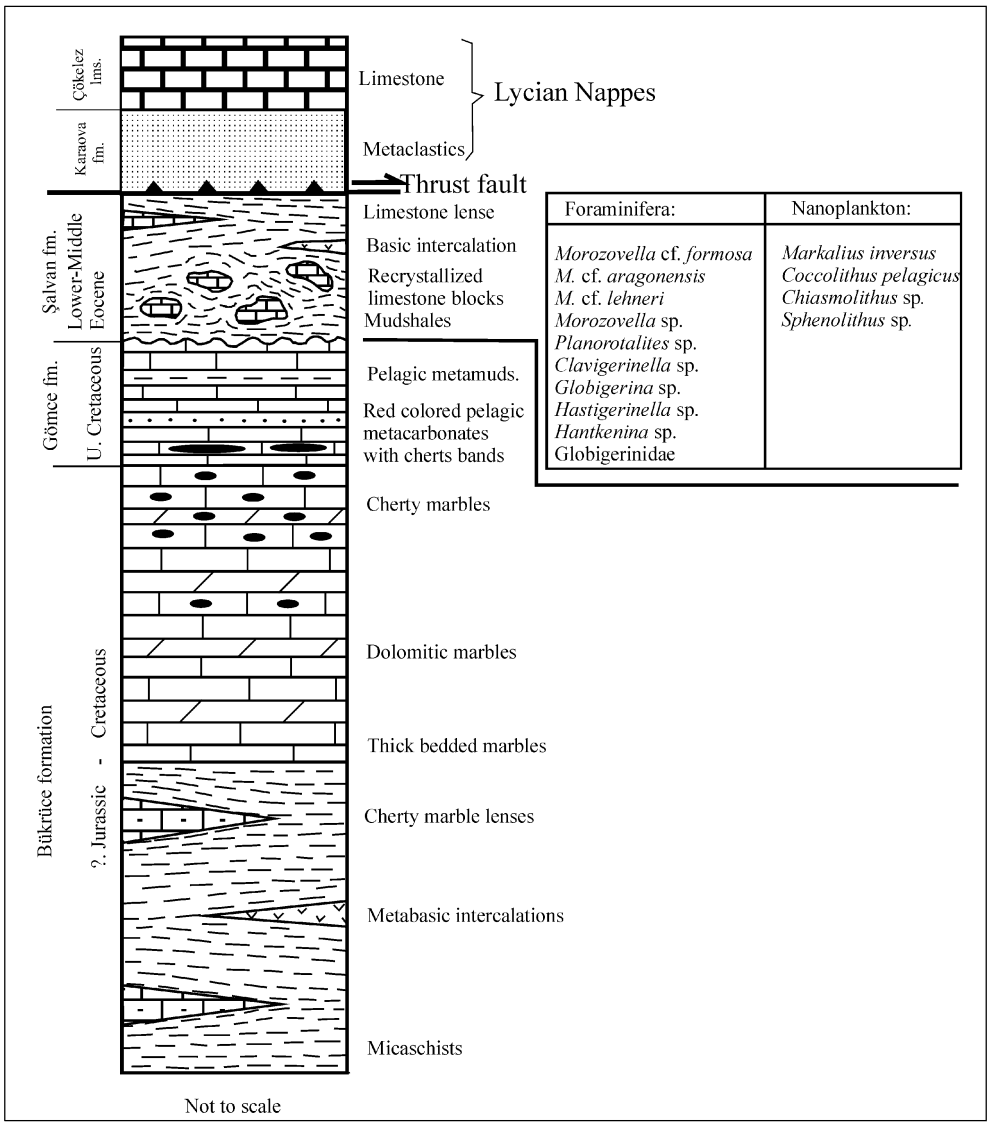


Fig. 13 Generalized stratigraphical columnar section showing the cover series of the Menderes Massif and the fossil content of the unconformably overlying Şalvan formation in the Çal–Denizli area

overthrust by the Lycian nappes (Konak 1993; Özer and Sözbilir 1995), with a nearly horizontal thrust contact (Fig. 14).

Bükrüce formation

The low-grade metamorphic schists containing marble lenses and local metabasic intercalations are called the Bükrüce formation. Similar formations in the Menderes Massif were described by Dürr (1975) and Çağlayan et al. (1980) in the southern part of the Menderes Massif.

Good exposures of the formation are observed south of Sarıkaya Tepe (Fig. 14). Here, the formation consists of green–reddish brown calc-schists, chlorite schists, tremolite–actinolite schists containing metabasic intercalations, and marbles towards the top. The marbles are light grey, thick bedded, locally dolomitic and include chert bands at the top. The metabasic rocks are green to dark green, massive and crudely foliated lenses, and are found as intercalations in schists.

The lower contact of the Bükrüce formation is not visible in the study area. There is no published age data for the Bükrüce formation. Öztürk (1981) interpreted it as Palaeozoic, whereas Konak (1993) thought it might be Jurassic–Cretaceous. However, new observations on the age of schists (Erdoğan and Güngör 1992) and presence of the metabasic volcanic intercalations in equivalent units in the western Menderes Massif suggest an upper Mesozoic age, probably Cretaceous (Erdoğan and Güngör 1992; Özer 1993, 1998). The Bükrüce formation is conformably overlain by the Gömce formation.

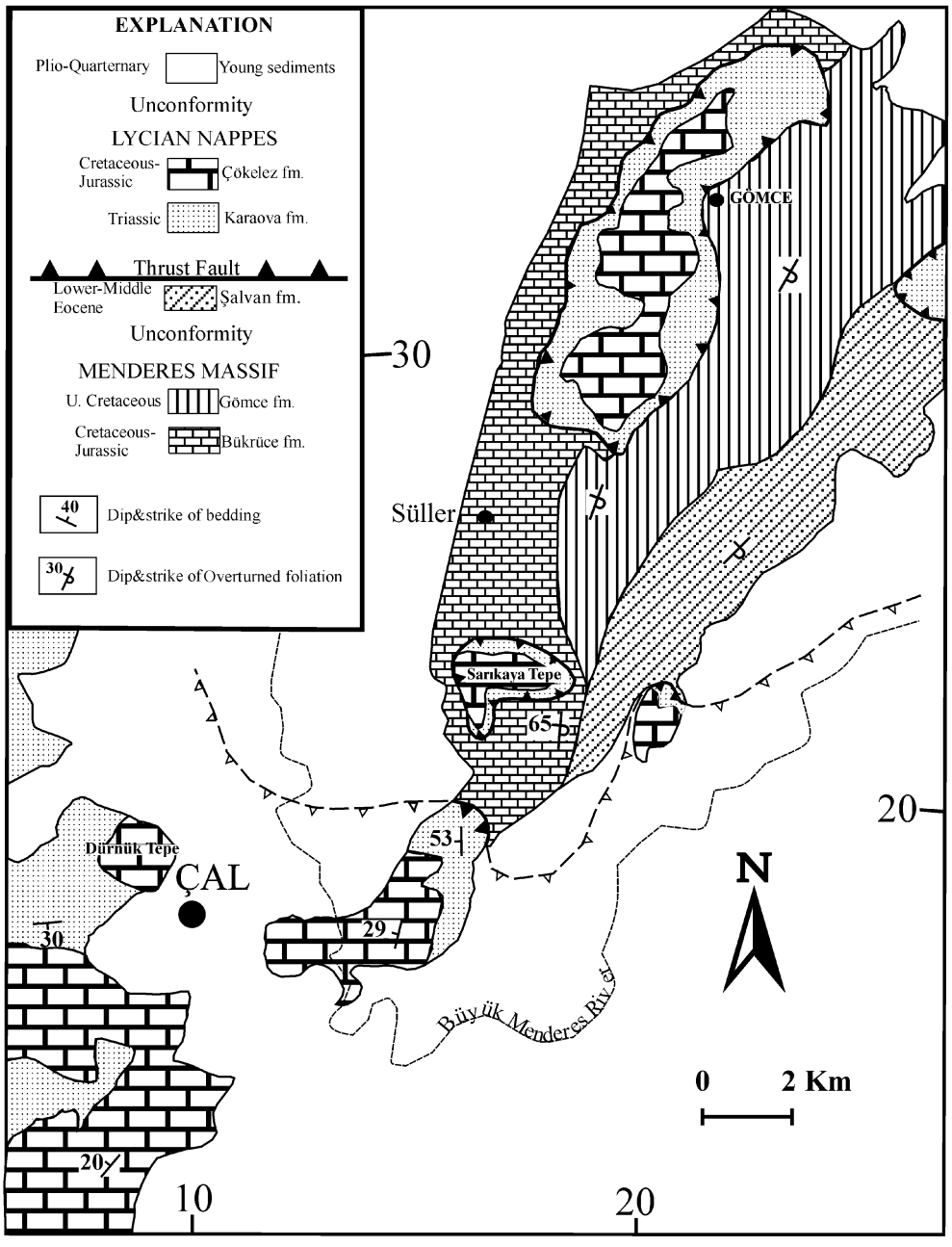


Fig. 14 Detailed geological map of the Çal–Denizli area. The upper part of the map, NE of Sarıkaya Tepe, modified from Çakmakoglu (1995), and lower part of the map, SW of Sarıkaya Tepe, studied by Sözbilir (1997). Note the allochthonous units of the Lycian nappes sitting above different formations of the carbonate cover of the Menderes Massif and the Şalvan formation as well. Map grid relates to Turkish National Grid. See Fig. 1 for location

Gömce formation

The name Gömce formation is applied to a sequence of banded chert and recrystallized limestone. There is a transitional zone between the Bükrüce formation and the Gömce formation where pinkish–reddish and greenish, thin bedded recrystallized limestone with chert bands become dominant (Fig. 13). The chert bands are 2–10 cm thick and can be followed for several metres. To the east of Süller Village (Fig. 14), kink folds are well observed in the cherty levels of the Gömce formation. The Gömce formation yields no fossils; however, we correlated it with the Kızılağaç formation cropping out in the southern Menderes Massif owing to its lithological resemblance (Dürr 1975; Çağlayan et al. 1980; Konak et al. 1987; Özer 1998).

Şalvan formation

The Şalvan formation lies unconformably on both the Bükrüce and Gömce formations (Figs. 13and 14). The Şalvan formation consists of blocks of cherty marbles and metavolcanic lenses surrounded by a matrix of pelagic meta-mudstones. The formation resembles a slightly metamorphosed flysch.

Foraminifera (*Morozovella* cf. *formosa*, cf. *M. aragonensis*, cf. *M. lehneri, Morozovella* sp., *Planorotalites*

sp., *Clavigerinella* sp., *Globigerina* sp., *Hastigerina* sp., *Hantkenina* sp.) and nanoplanktons (*Markalius inversus*, *Coccolithus pelagicus*, *Chiasmolithus* sp., *Sphenolithus* sp.), which indicate an Early–Middle Eocene age, have been found in the matrix of the Şalvan formation.

Discussion and conclusions

This study forms the first detailed biostratigraphic study of the southern and eastern Menderes Massif. New Cretaceous sequences with rudists and pelagic marbles are described from the area of Yatağan-Kavaklıdere, and throughout the region many new occurrences of rudists, planktonic foraminifera and nanoplankton are recorded. The main stratigraphic results of the Upper Cretaceous–Palaeogene successions from the southern and eastern Menderes Massif are listed below.

The region of southern Menderes Massif can be lithologically divided into four units, from base to top these are emery-bearing marbles (probably Cenomanian); rudist-bearing marbles of Santonian–Campanian age (both form the Milas formation); red–pinkish pelagic marbles of Late Campanian–Maastrichtian age (the Kızılağaç formation); and flysch-like sediments of Middle Palaeocene age (the Kazıklı formation).

The contact between the underlying mica schists and the overlying emery-bearing marbles is interpreted as gradational. The evidence of a previously postulated unconformity (Dürr 1975; Çağlayan et al. 1980; Konak et al. 1987) has not been confirmed.

Palaeontological data indicate that sedimentation lasted at least until the Middle Palaeocene in the southern Menderes Massif. Evidence for Eocene deposition is lacking in our work (cf. Konak et al. 1987, who reported an Eocene foraminifera fauna from the Kazıklı formation). Collins and Robertson (1998, 1999) stated that the southern Menderes Massif was overthrust by the Lycian thrust sheets in the Late Eocene. Our data suggest that this thrusting may have started earlier, probably in the middle Palaeocene when deposition of the Kazıklı debris flows occurred.

The carbonate sequence of the Menderes Massif ends abruptly at the end of Cretaceous in the Çal and Tavas areas. In the Tavas area, the uppermost section of this sequence is Santonian–Campanian in age and unconformably overlain by the Palaeocene–Early Eocene Zeybekölentepe formation. In the Çal area, a similar Cretaceous carbonate sequence is unconformably covered by the Lower–Middle Eocene Şalvan formation. However, at Honaz Dağı, between these two study areas, the lateral equivalent units of the late Cretaceous–Lower Tertiary sequence are represented by a continuous sequence (Okay 1989). The main difference in the Upper Cretaceous sequence between these three carbonate sequences is the facies, which is shallow marine in the Tavas section but pelagic in the Çal and Honaz Dağı. Poisson and Sarp (1977) reported similar deep water Upper Cretaceous rocks from Kızılca, south of Tavas area (Fig. 1). They suggested that these rocks were deposited within a basin that lay along the eastern margin of the Menderes massif. They called this basin the Kızılca-Çorakgöl trough. Rocks in our Tavas section may have been deposited on a basement high within this Late Cretaceous intra-platform basin.

The Upper Cretaceous sequence of the Menderes Massif is dominated by platform-type carbonates. The development of pelagic carbonates in the latest Campanian–Maastrichtian indicates a drowning of this platform. Deposition on the south and south-east Menderes margin continued without a break until the Maastrichtian. Between Çal and Milas, no deposition occurred between the latest Cretaceous and the middle Palaeocene. This break is interpreted to mark the initial obduction of the Lycian ophiolite onto the Menderes carbonate platform.

Final overthrusting of the Lycian nappes over the southern Menderes Massif occurred in Late Palaeocene times. Deposition continued until Early to Middle Eocene times at Tavas and Çal demonstrating the progressive south-eastward movement of the Lycian nappes throughout the Palaeocene.

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