GEOBIOS
MÉMOIRE SPÉCIAL N° 22
1998

QUATRIÈME CONGRÈS INTERNATIONAL SUR LES RUDISTES

Dédié à Henri DOUVILLÉ (1846-1937)

Marseille 9-15 septembre 1996

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Coordonnateurs

GEOBIOS - Mémoire spécial n° 22 - 1998

Édition de l'Université Claude-Bernard, Lyon 1
Avec le concours du Centre National de la Recherche Scientifique

RUDIST BEARING UPPER CRETACEOUS METAMORPHIC SEQUENCES OF THE MENDERES MASSIF (WESTERN TURKEY)

SACIT ÖZER

ÖZER S. 1998. Rudist bearing Upper Cretaceous metamorphic sequences of the Menderes Massif (Western Turkey). [Les séquences métamorphiques à rudistes du Crétacé supérieur du Massif du Menderes (Ouest de la Turquie)]. GEOBIOS, **M.S. n° 22**: 235-249.

ABSTRACT - The Menderes Metamorphic Massif is located between the Izmir-Ankara zone to the north, and the Lycian nappes and Bey Daglari platform to the south in the western part of Turkey. The massif consists of core rocks of Precambrian to Cambrian gneisses, schists, metagranites, and cover rocks of Paleozoic micaschists and marbles, Mesozoic thick bedded platform-type metacarbonates, and Lower Tertiary pelagic metacarbonates and flysch type rocks. Rudists were discovered locally from the southern sector of the Menderes Massif, around Milas area, and they were accepted as a very important paleontologic data indicating however only a Late Cretaceous age in the previous studies.The presence of several new localities showing a wide geographic distribution of the rudists in the southern and northern sectors of the massif is revealed, and presented in this study. The rudist-bearing metamorphic sequences are mainly represented by platform-type carbonates. However, sequences consisting of clastics and carbonates are also present. The Upper Cretaceous metamorphic sequences consist of, from base to top, emery-bearing marbles and marbles with rudists (Cenomanian), rudist-bearing marbles (Santonian-Campanian), and red-pinkish pelagic marbles (late Campanian-Maastrichtian). Flysch type rocks (Early Tertiary) overlie these sequences. Two rudist associations allowing precisely to establish the Upper Cretaceous stratigraphy in the massif, are distinguished. The first association is characterized by the abundance of rudists with canals such as *Neocaprina gigantea, Caprina schiosensis, Schiosia* cf. *schiosensis, Sphaerucaprina* cf. *forojuliensis, Ichthyosarcolites poljaki, Ichthyosarcolites rotundus, Ichthyosarcolites bicarinatus, Ichthyosarcolites* cf. *tricarinatus* indicating a middle-late Cenomanian age. This association also consists of *Eoradiolites* cf. *liratus, Durania* sp., *Apricardia* sp., *Chondrodonta* sp., and *Distefanella* close to *Distefanella bassani* and *Distefanella* cf. *montagnei* which are found for the first time in Turkey. The second association is represented mainly by hippuritids: and radiolitids such as *Vaccinites taburni, Vaccinites* cf. *sulcatus, Hippurites nabresinensis, Hippurites colliciatus, Sauvagesia* cf. *tenuicostata,* and *Durania* sp., indicating a Santonian-Campanian age.

KEYWORDS: UPPER CRETACEOUS, TURKEY, RUDISTS, BIVALVIA, MARBLES

RÉSUMÉ - Le massif métamorphique du Menderès qui se trouve dans la partie occidentale de la Turquie, se situe entre la zone d'Izmir-Ankara au Nord et les nappes lyciennes ainsi que la plate-forme de Bey Daglari au Sud. Le coeur du massif est constitué de gneiss, de schistes et de métagranites précambriens et cambriens. La couverture est composée par des micaschistes et des marbres paléozoiques, des métacarbonates massifs de type plate-forme du Mésozoïque, et des métacarbonates pélagiques et des flyschs tertiaires. Les rudistes découverts jusqu'ici, ponctuellement, au Sud du massif, dans le secteur de Milas, avaient permis de dater le Crétacé supérieur. Des prospections récentes ont conduit à la mise en évidence de nombreuses localités fossilifères, distribuées à la fois au Nord et au Sud du Massif du Menderès. Les séquences métamorphiques à rudistes sont essentiellement représentées par des carbonates de type plate-forme, associés à des dépôts clastiques. Les séquences du Crétacé supérieur présentent, de bas en haut, des marbres à émeris et à rudistes (Cénomanien), des marbres à rudistes (Santonien-Campanien), et des marbres pélagiques de couleur rouge-rosâtre (Campanien supérieur-Maestrichtien). Le flysch (Tertiaire inférieur) se trouve au-dessus de ces séquences. Deux associations de rudistes ont été reconnues, permettant précisément d'établir la stratigraphie du Crétacé supérieur dans le Massif du Menderès. La première caracterisée par l'abondance des formes à canaux comprend: *Neocaprina gigantea, Caprina schiosensis, Schiosia* cf. *schiosensis, Sphaerucaprina* cf. *forojuliensis, Ichthyosarcolites poljaki, Ichthyosarcolites rotundus, Ichthyosarcolites bicarinatus, Ichthyosarcolites* cf. *tricarinatus* qui datent du Cénomanien moyen et supérieur. Cette association contient également: *Eoradiolites* cf. *liratus, Durania* sp., *Apricardia* sp., et *Chondrodonta* sp. Notons la présence du genre *Distefanella bassani* et *Distefanella* cf. *montagnei,* qui est mentionnée pour la première fois en Turquie. La seconde association est dominée par des hippuritidés avec *Vaccinites taburni, Vaccinites* cf. *sulcatus, Hippurites nabresinensis* et *Hippurites colliciatus*; ces formes sont accompagnées des radiolitidés *Sauvagesia* cf. *tenuicostata* et *Durania* sp.; cette faune date du Santonien-Campanien.

MOT-CLÉS: CRÉTACÉ SUPÉRIEUR, RUDISTES, BIVALVES, TURQUIE, MARBRES

FIGURE 1 - Map showing the location of the Menderes Massif between the tectonic belts of Western Turkey. The main mass of the massif crops out over a large area, one of the sliver of the massif is also observed in the area extending from Kale- Tavas-Serinhisar, south of Denizli. The Serinhisar section is given in the Fig. 2. *Carte montrant la localisation du Massif du Menderes entre les unités tectoniques de Turquie occidentale. La masse essentielle du massif affleure largement, cependant un fragment du massif s'observe aussi aux environs du Kale-Tavas-Serinhisar (Sud de Denizli).La série stratigraphique de Serinhisar est donnée à la Fig. 2.*

INTRODUCTION

The Menderes metamorphic massif is located between the Izmir-Ankara Zone to the north and Lycian nappes to the south, in the western part of Turkey (Fig. 1). According to the long-established geological concepts, the massif consists of, in ascending order, the core series of Precambrian to Cambrian gneisses, schists, metagranites, migmatites and metagabbros, and cover series (or envelope association) of Lower Paleozoic micaschists, Permo-Carboniferous metaquartzites and meta-

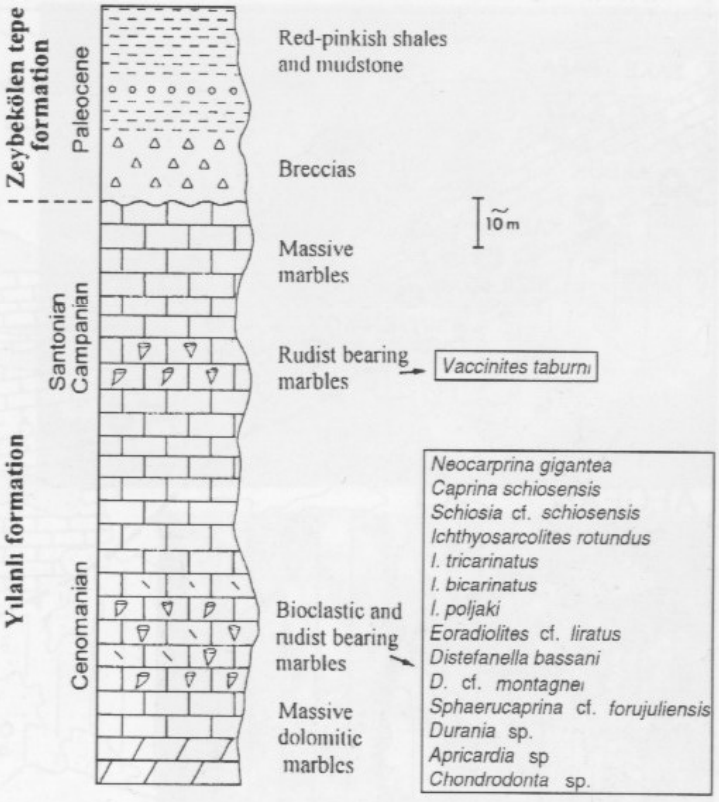


FIGURE 2 - Serinhisar stratigraphic columnar section (see Fig. 1 for the location). *Série stratigraphique de Serinhisar (voir Fig. 1 pour la localisation).*

carbonates, Mesozoic platform-type marbles, and Paleocene to Lower Eocene pelagic carbonates and flysch (Brinkmann 1967; de Graciansky 1968; Dürr 1975; Caglayan et al. 1980; Sengör et al. 1984; Konak et al. 1987; Okay 1989; Dora et al. 1990; Dürr et al. 1995).

The main mass of the massif crops out mainly over a large area in the Western Anatolia, however one of the sliver is also observed in the area extending from Kale-Tavas to the south of Denizli (Fig. 1). The Mesozoic rock cover extends regularly and presents good outcrops in the southern sector of the massif (Fig. 4), while it shows a less regular extension in the northern part of the massif (Fig. 11).

Due to the metamorphism, the fossils are very sparse, and badly preserved in the Paleozoic and Mesozoic sequences. Previous studies suggested some foraminifers such as fusulinids for the Permo-Carboniferous, involutinids for the Triassic, and rare rudist fragments with a Late Cretaceous age (Dürr 1975; Çaglayan et al. 1980; Konak et al. 1987). The occurrence of Upper Cretaceous marbles in the massif, has been known since the first report of rudists from the Akbük-Milas area (Fig. 1, 4) by Dürr (1975). The rudists of this area have been recently reexamined and many species determined (Özer 1993).

The aim of this study is to provide an up to date overwiev on the Upper Cretaceous sequences with rudists from the southern and northern sector of the Menderes massif, and from the Kale-Tavas adjacent area.

STRATIGRAPHY

The Upper Cretaceous sequences with rudists were studied in four areas as follows.

KALE-TAVAS AREA

The metamorphic sedimentary rocks belonging to the cover series of the Menderes Massif crop out over a large area extending from southeast of Kale to Tavas and southeast of Denizli (Poisson 1977; Poisson & Sarp 1977; Poisson 1985; Okay 1989; Özkaya 1990). The relationship of these rocks with the main mass of the massif cannot be observed due to the Neogene sedimentary rocks (Fig. 1). In this area, the Paleozoic consists of slightly metamorphosed clastics and carbonate lenses with fusulinids (Okay 1989) and crops out to the south of Tavas, while the Mesozoic neritic, monotonous, platform-type marbles are observed in a major NE-SW striking mountain chain extending over a large area from southeast of Tavas to Denizli. This sequence has an imbricated internal structure (Poisson & Sarp 1977; Poisson 1985; Okay 1989; Özkaya 1990, 1991). Serinhisar (formerly Kizilhisar) was known from the previous studies as the single rudist locality in Tavas area, indicating a Late Cretaceous age (Çaglayan et al. 1980; Poisson & Sarp 1977; Okay 1989; Özkaya 1990, 1991), which is precisely described in this

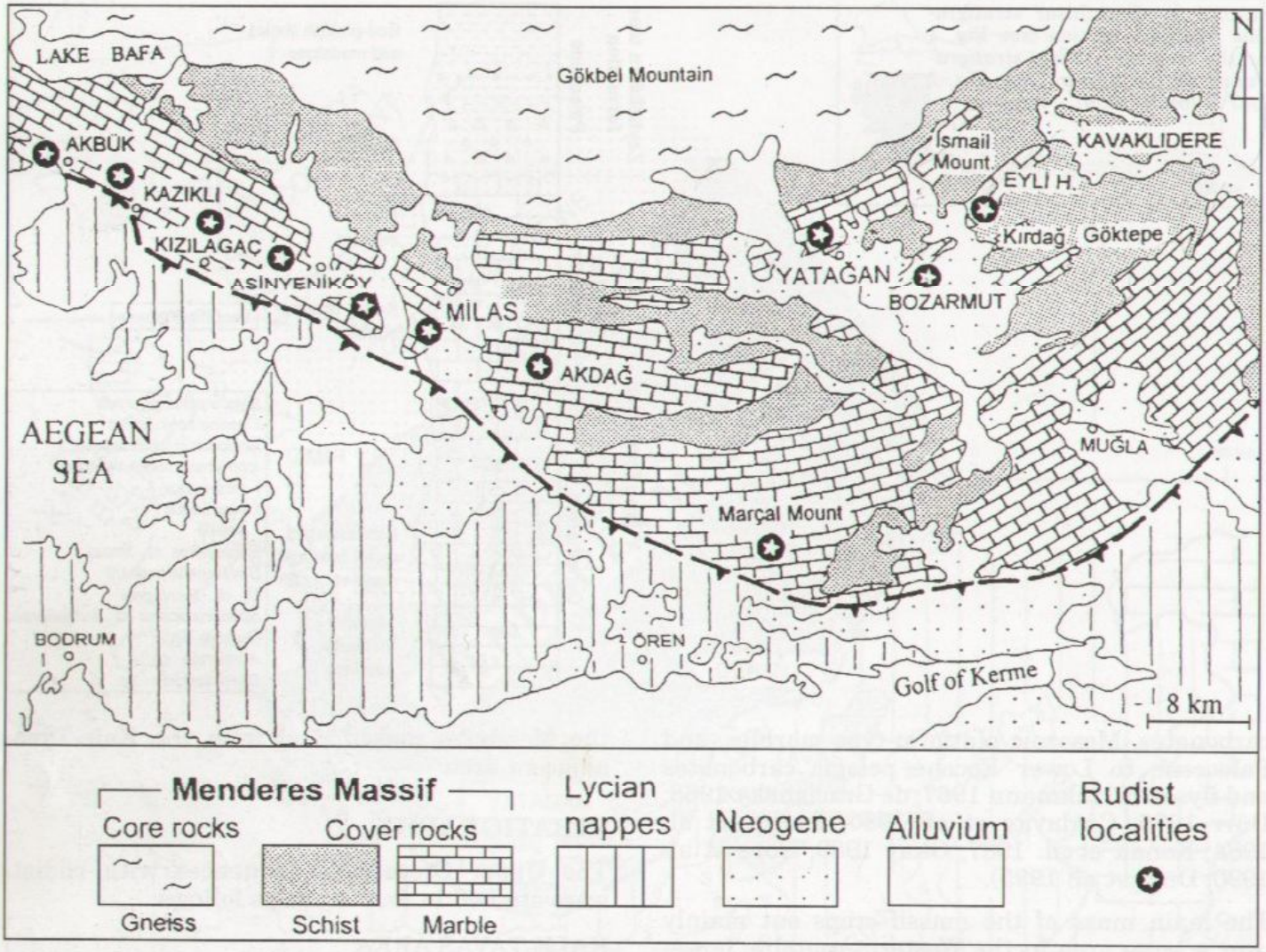
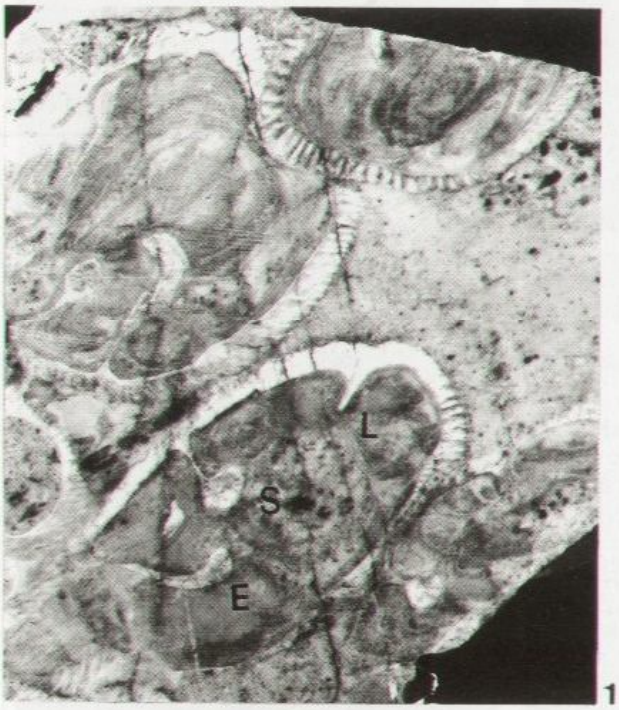


FIGURE 4 - Geological map of the southern sector of the Menderes Massif showing the distribution of the rudist localities (asteriks). (modified from Dürr 1975; Çaglayan et al. 1980; Konak et al. 1987). *Carte géologique du secteur sud du Massif du Menderes montrant la distribution (astérisques) des localités à rudistes (Dürr 1975; Çaglayan et al. 1980; Konak et al. 1987, modifié).*

study. In the Serinhisar locality, two formations named by Okay (1989) will be described (Fig. 2). Yilanli Formation. This formation is made up of mainly grey, massive, fine grained rudist-bearing platform-type marbles. Over the massive dolomitic marbles, intercalation of bioclastic and rudistid

FIGURE 3 - **1.** Transverse sections of a cluster of lower valves of *Vaccinites taburni* GUISCARDI. Sample n° S 92 02/ P, Serinhisar-Tavas, x 1.2. Ligamental ridge (L) is inclined towards the anterior side and cut at the end.The first pillar (S) is pedunculate and the second pillar (E) is reniform. **2.** *Neocaprina gigantea* PLENICAR. Transverse section of the lower valve. Sample n° S 92 01/M, Serinhisar-Tavas, x 0.6. Note the accessory cavities and canals (oma, omp and arrow). b, b': tooth sockets, ma, mp: myophores, CV: Central cavity, Vb: external carina. **3.** *Sphaerucaprina* cf. *forojuliensis* BOEHM. Transverse section of the upper valve. Sample n° S 92 01/B, Serinhisar-Tavas, x 1.7. Note the rectangular canals (big arrow) and fusiform canals (small arrow) separated by thin lamellae. CV: Central cavity, oma, omp: accessory cavities. **4.** Small build-ups constructed by *Eoradiolites* cf. *liratus* (CONRAD) associated with *Durania* sp. (D, above). Field photograph from Serinhisar-Tavas, x 0.8. **5.** *Durania* sp. Transverse sections of lower valves. Sample n° S 92 02/M, Serinhisar-Tavas, x 0.8. The outer shell layer is thick (arrows) and shows the characteristic prismatic structure. **6.** Fragment of *Caprina* sp. Note the fusiform canals arranged in a single row (arrow). Sample n° S 92 0.1/D, Serinhisar-Tavas, x 1.5. ***1.*** *Section transversale des valves inférieures d'un groupement de* Vaccinites taburni *GUISCARDI. L' arête ligamentaire (L) est courbée vers le côté antérieur et tronquée à son extrémité. Le premier pilier S est pédonculé et le second pilier E est réniforme.* **2.** Neocaprina gigantea *PLENICAR. Section transversale de la valve inférieure. Noter les cavités accessoires et les canaux (oma, omp et flèche). b, b': fossettes des dents, ma, mp: apophyses myophores, CV: cavité viscérale, Vb: carène externe.* **3.** Sphaerucaprina cf. forojuliensis *BOEHM. Section transversale de la valve supérieure. Noter les canaux rectangulaires (grande flèche) et les canaux fusiformes (petite flèche) séparés par de minces cloisons. CV: cavité centrale, oma, omp: cavités accessoires.* **4.** *Petit récif construit par* Eoradiolites *cf.* liratus *(CONRAD) associé à* Durania *sp. (D). Photographie de terrain, Serinhisar-Tavas.* **5.** Durania sp. *Sections transversales de valves inférieures. La couche externe est épaisse (flèche) et présente la structure prismatique caractéristique.* **6.** *Fragment de* Caprina *sp. Noter les canaux fusiformes diposés en une seule rangée (flèche).*



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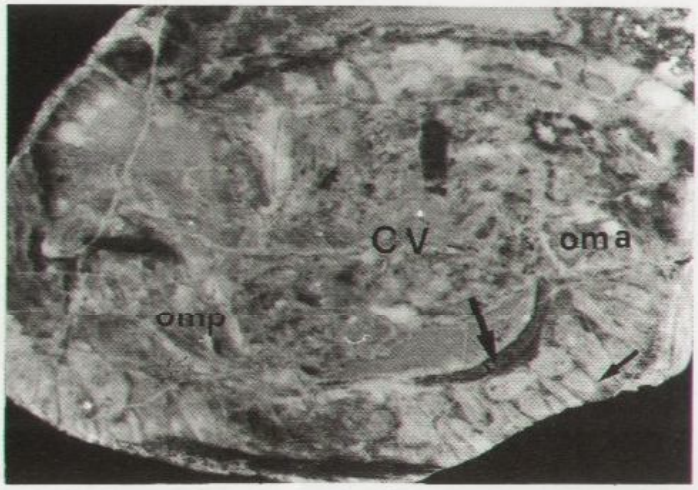

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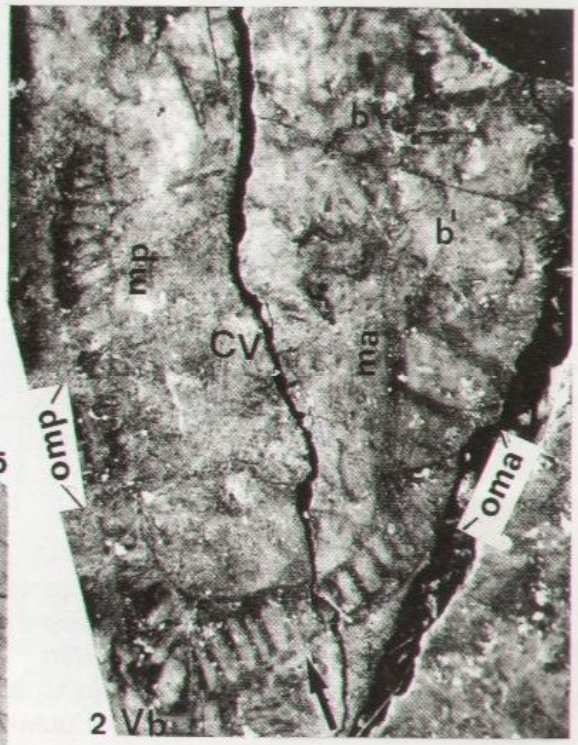

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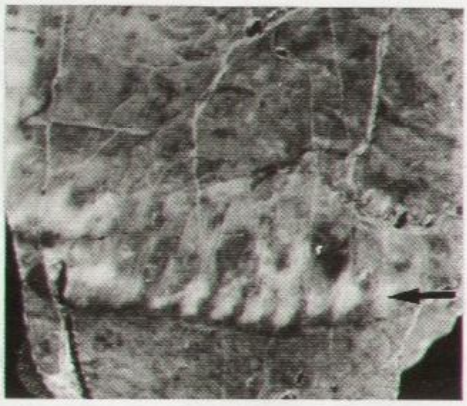
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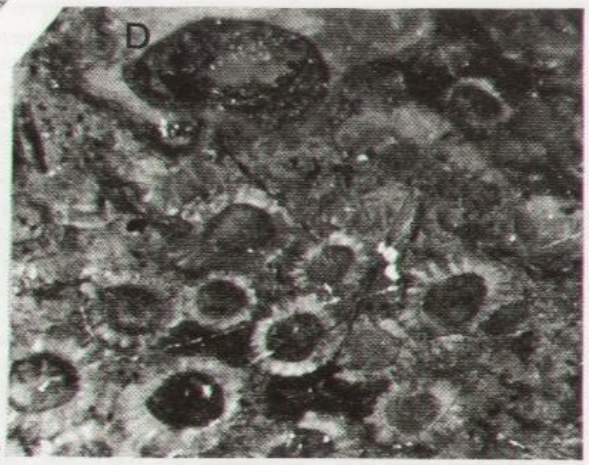

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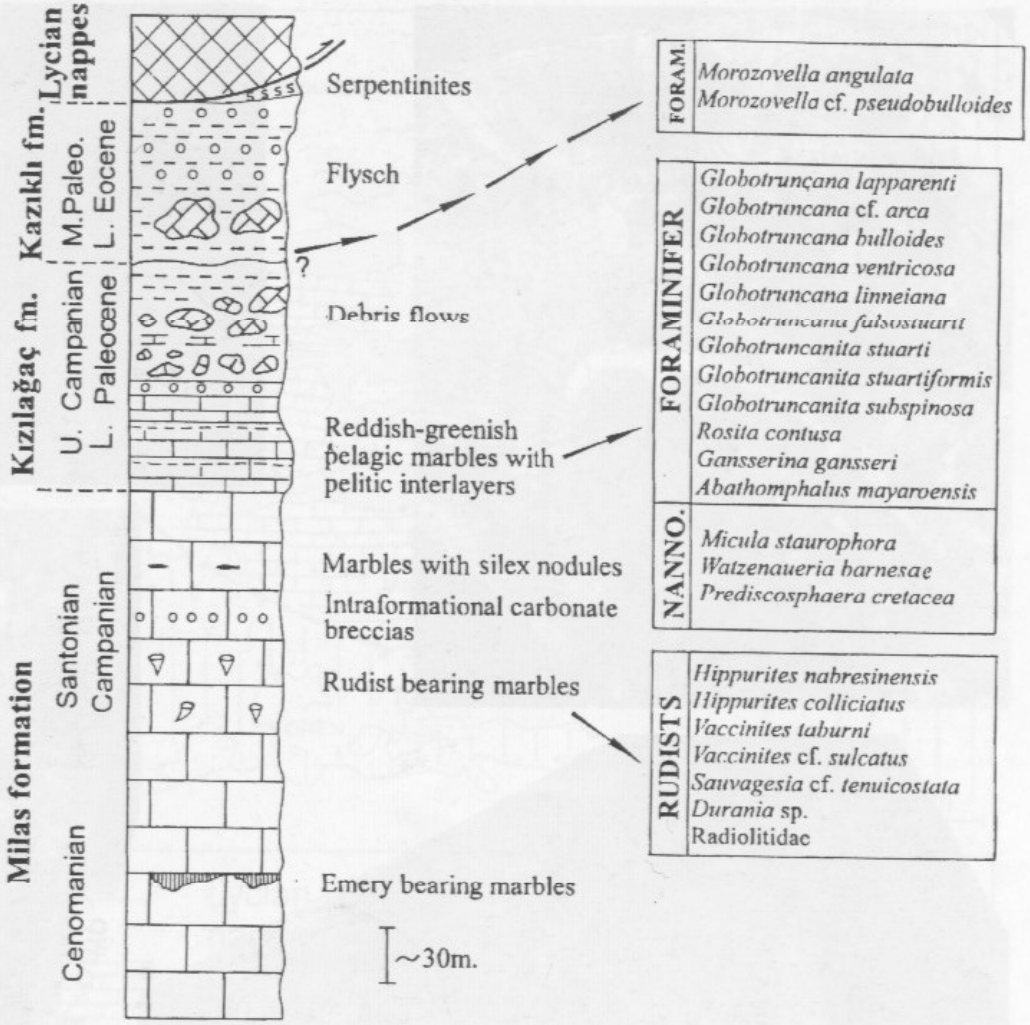
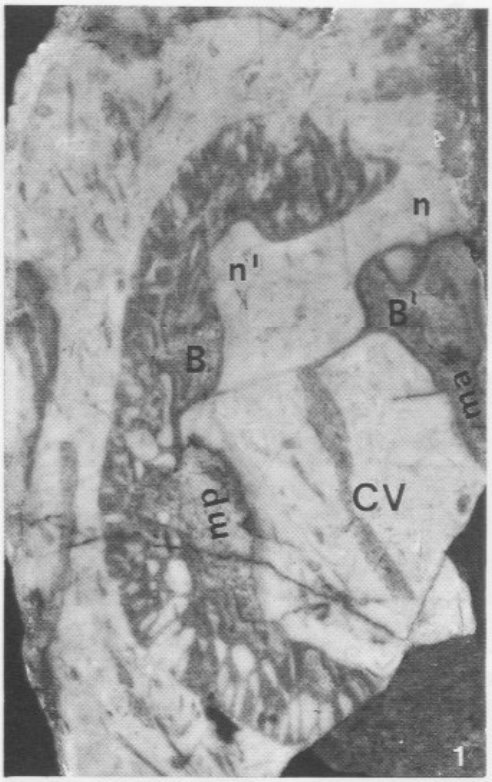


FIGURE 5 - Generalized stratigraphic section of the Akbük- Milas area (modified from Dürr 1975; Çaglayan et al., 1980). *Série stratigraphique de la région d'Akbük-Milas (Dürr 1975; Çaglayan et al. 1980, modifié).*

marbles are observed. These levels are approximately 25-30 m thick, and mainly composed of rudists with canals: *Neocaprina gigantea* PLENICAR, *Caprina schiosensis* BOEHM, *Schiosia* cf. *schiosensis* BOEHM, *Ichthyosarcolites rotundus* POLSAK, *I. tricarinatus* PARONA, *I. bicarinatus* (GEMMELLARO), *I. poljaki* POLSAK, *Sphaerucaprina* cf. *forojuliensis* BOEHM with a middle-late Cenomanian age (Figs 3.2,3,6; 6.1,2,4,5,6,7,11). The genus *Distefanella* PARONA, documented for the first time in Turkey, is also

FIGURE 6 - **1.** *Schiosia* cf. *schiosensis* BOEHM. Transverse section of the upper valve. Sample n° S 92 02/G, Serinhisar-Tavas, x 1.3. B,B': teeth, ma, mp: myophores, n: socket of the N tooth, n': secondary cavity, CV: Central cavity. **2.** *Sphaerucaprina* cf. *forojuliensis* BOEHM. Transverse section of the upper valve. Sample n° S 92 02/L, Serinhisar-Tavas, x 1.3. Note the rectangular, polygonal and fusiform canals (arrows). **3.** *Apricardia* sp. Sample n° S 92 01/L, Serinhisar-Tavas, x 1. **4.** *Ichthyosarcolites poljaki* POLSAK. Transverse section of the lower valve, field photo from the area of Serinhisar-Tavas,x 0.6. The ridges (1.2, and 3) are well-developed. Note the small round or oval canals (arrows). **5.** *Ichthyosarcolites bicarinatus* (GEMMELLARO). Transverse section of the lower valve. Sample n° S 92 02/I, Serinhisar-Tavas, x 1.8. Note two ridges (1 and 2) and the canal (arrow). **6.** *Ichthyosarcolites cf. tricarinatus* PARONA. Transverse section of the lower valve. Sample n° S 92 01/H, Serinhisar-Tavas, x 1.2. The central cavity (CV) is subquadrangular. **7.** *Ichthyosarcolites rotundus* POLSAK. Transverse section of the lower valve. Sample n° S 92 02/K, Serinhisar-Tavas, x 0.5. **8.** *Distefanella* cf. *montagnei* SLISKOVIC. Transverse section of the lower valve. Sample n° S 92 01/G, Serinhisar-Tavas, x 0.6. Siphonal bands (S, E) are strongly concave. Note the very convex interband (I). **9,10.** *Distefanella bassani* PARONA. Transverse sections of lower valves. Field photo taken from the area of Serinhisar-Tavas, x 0.5. Siphonal bands (S, E) are flat. **11.** *Schiosia* cf. *schiosensis* BOEHM. Transverse section of the upper valve. Sample n° S 92 02/J, Serinhisar-Tavas, x 1.6. Note the rounded or fusiform small canals (arrows). *1.* Schiosia *cf.* schiosensis *BOEHM. Section transversale de la valve supérieure. B, B': dents, ma, mp: apophyses myophores, n: fossette de la dent N, n': cavité secondaire, CV: cavité viscérale.* **2.** Sphaerucaprina *cf.* forojuliensis *BOEHM. Section transversale de la valve supérieure. Noter les canaux rectangulaires, polygonaux et fusiformes (flèches).* **3.** Apricardia *sp. Echantillon n° S9201L, Serinhisar-Tavas, x 1.* **4.** Ichthyosarcolites poljaki *POLSAK. Section transversale de la valve inférieure. Photographie de terrain. Les arêtes (1, 2 et 3) sont bien développées. Noter les petits canaux ronds ou ovales (flèches).* **5.** *Section transversale de la valve inférieure. Noter deux arêtes (1 et 2) et aussi les canaux (flèche).* **6.** *Section transversale de la valve inférieure. La cavité centrale (CV) est subquadranqulaire.* **7.** *Section transversale de la valve inférieure.* **8.** *Section transversale de la valve inférieure. Les bandes siphonales (S, E) sont fortement concaves. Noter l' interbande (I) fortement convex.* **9,10.** *Section transversale de la valve inférieure. Photographie de terrain. Les bandes siphonales (S, E) sont planes.* **11.** *Section transversale de la valve supérieure. Noter les petits canaux ronds ou fusiformes (flèches).*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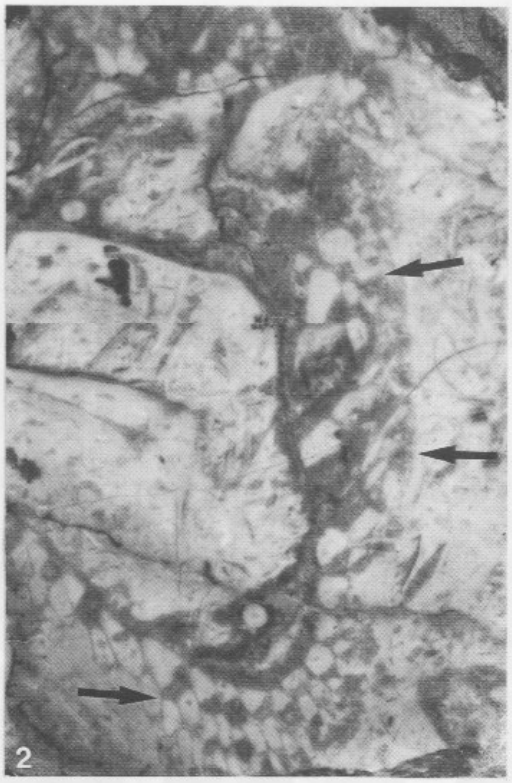
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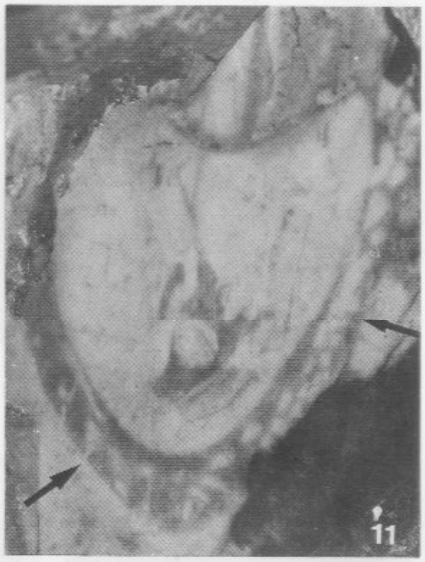
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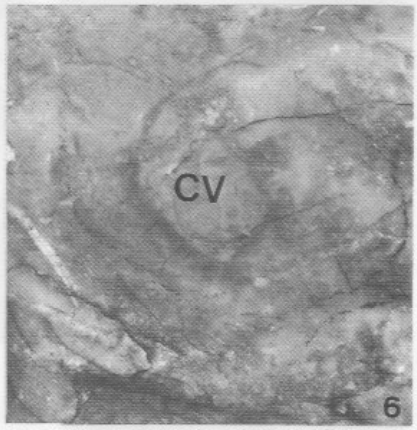
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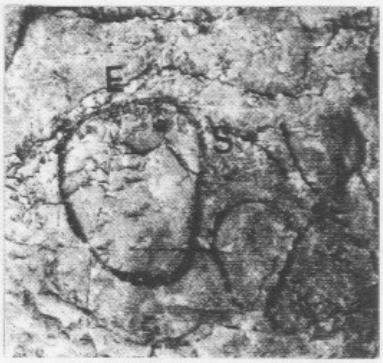
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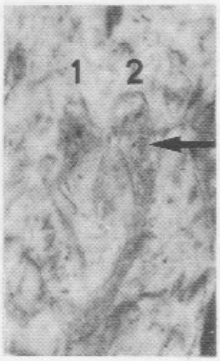
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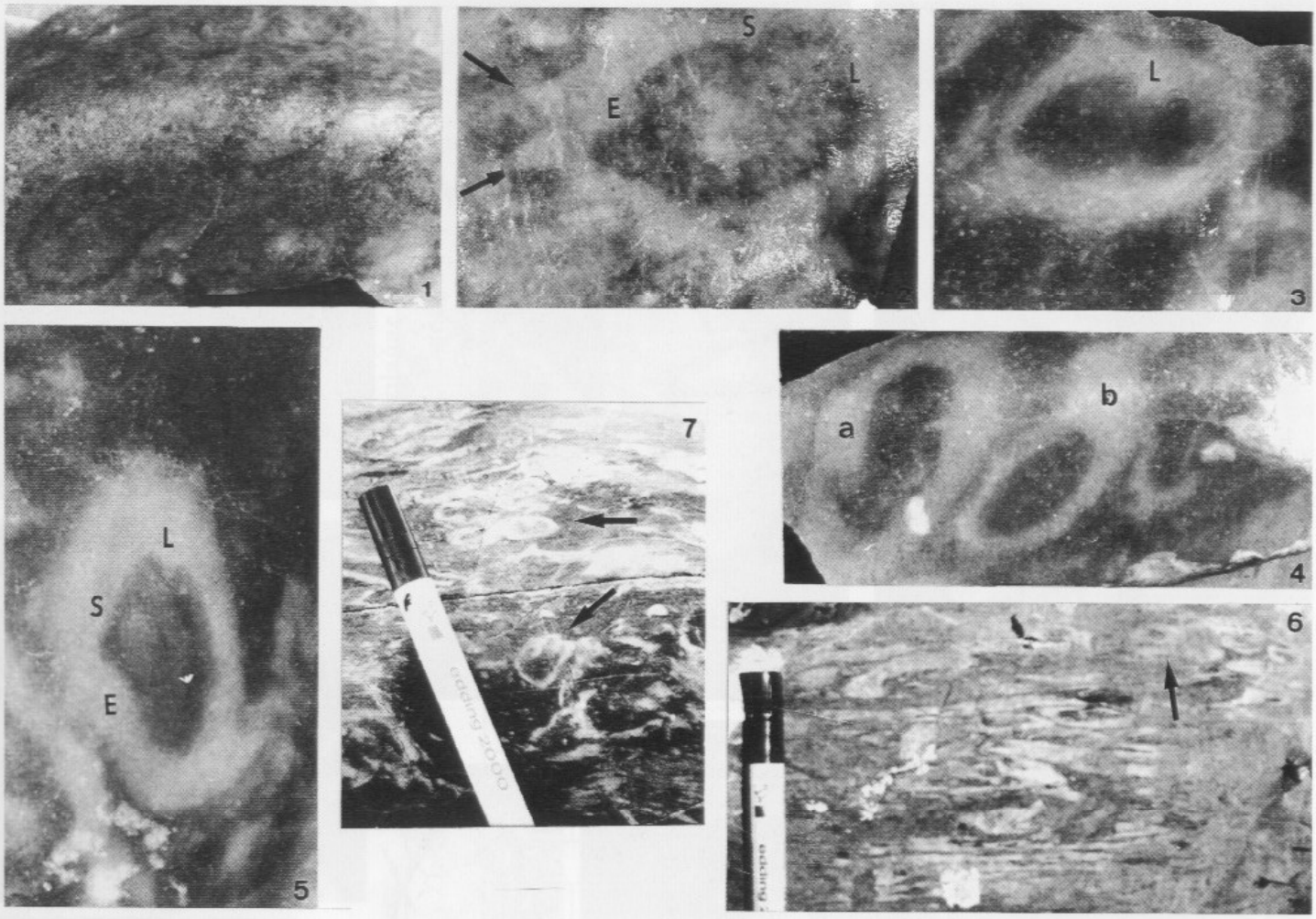

FIGURE 7 - **1.** *Hippurites nabresinensis* FUTTERER. Sample n° MK 12, Kömürburnu-Akbük(Milas), x 1. **2.** *Hippurites colliciatus* WOODWARD. Sample n° MA 9, Asinyeniköy-Milas, x 1.2. Note the preservation of the ligamental ridge (L), the siphonal pillars (S, E), and the well pronounced costae (arrow). **3.** *Sauvagesia* sp. Sample n° MY 6, Yeniköy-Milas, x 1. L: Ligamental ridge. **4.** Radiolitid sections. a, *Sauvagesia* sp., b, *Durania* sp. Sample n° MS 36, Sapliada-Akbük (Milas), x 1. **5.** *Sauvagesia* cf. *tenuicostata* POLSAK. Sample n° MS 36, Sapliada-Akbük (Milas), x 1. **6.** Rudist-bearing marbles. Bozarmut village-Yatagan, scale is 12 cm.Note the strongly deformed shells; however some sections (arrow) belonging to Radiolitidae can be observed. **7.** Rudist-bearing marbles. Bozarmut village-Yatagan, scale is 12 cm. Note the section of *Hippurites nabresinensis* (arrows). ***1.*** Hippurites nabresinensis *FUTTERER. Sample n° MK 12, Kömürburnu-Akbük(Milas), x 1. Noter les deux piliers siphonaux (S, E).* **2.** Hippurites colliciatus *WOODWARD. Sample n° MA 9, Asinyeniköy-Milas, x 1.2. Noter la préservation de l'arête ligamentaire (L), les deux piliers (S, E) et aussi les côtes bien développées (flèches).* **3.** Sauvagesia *sp. Sample n° MY 6, Yeniköy-Milas, x 1. L: arête ligamentaire.* **4.** *Sections de radiolitidés. a,* Sauvagesia *sp., b,* Durania *sp.* 5. Sauvagesia *cf.* tenuicostata *POLSAK. Sample n° MS 36, Sapliada-Akbük (Milas), x 1.* **6.** *Marbres à rudistes. Le crayon a approximativement 12 cm. Noter les valves très déformées; cependant quelques sections appartenant aux radiolitidés (flèches) peuvent être observées.* **7.** *Marbres à rudistes. Le crayon mesure environ de 12 cm. Noter la section de* Hippurites nabresinensis *(flèches).*

found in these levels *Distefanella bassani* PARONA and *Distefanella* cf. *montagnei* SLISKOVIC are also present (Fig. 6.8-10). *Durania* sp., *Eoradiolites* cf. *liratus* (CONRAD), *Chondrodonta* sp. and *Apricardia* sp., are also associated to this fauna (Figs 3.4,5; 6.3). These levels pass upward to 30-35 m thick, grey, massive marbles, and then to rudist-bearing, 10-15 m thick, grey marbles. The rudistid marbles are mainly composed of *Vaccinites taburni* GUISCARDI with a Santonian-Campanian age. Some small build-ups of this species are observed (Fig. 3.1). The uppermost part of the formation is made up of massive, grey marbles. Zeybekölen tepe Formation. This formation consists of breccias, and red-pinkish shales and mudstones. According to Poisson and Sarp (1977), Okay (1989) and Özkaya (1990), the age of the formation is Paleocene-Early Eocene.

MILAS AREA

The region is located between the Bafa Lake and Mugla, where the main features of the cover rocks

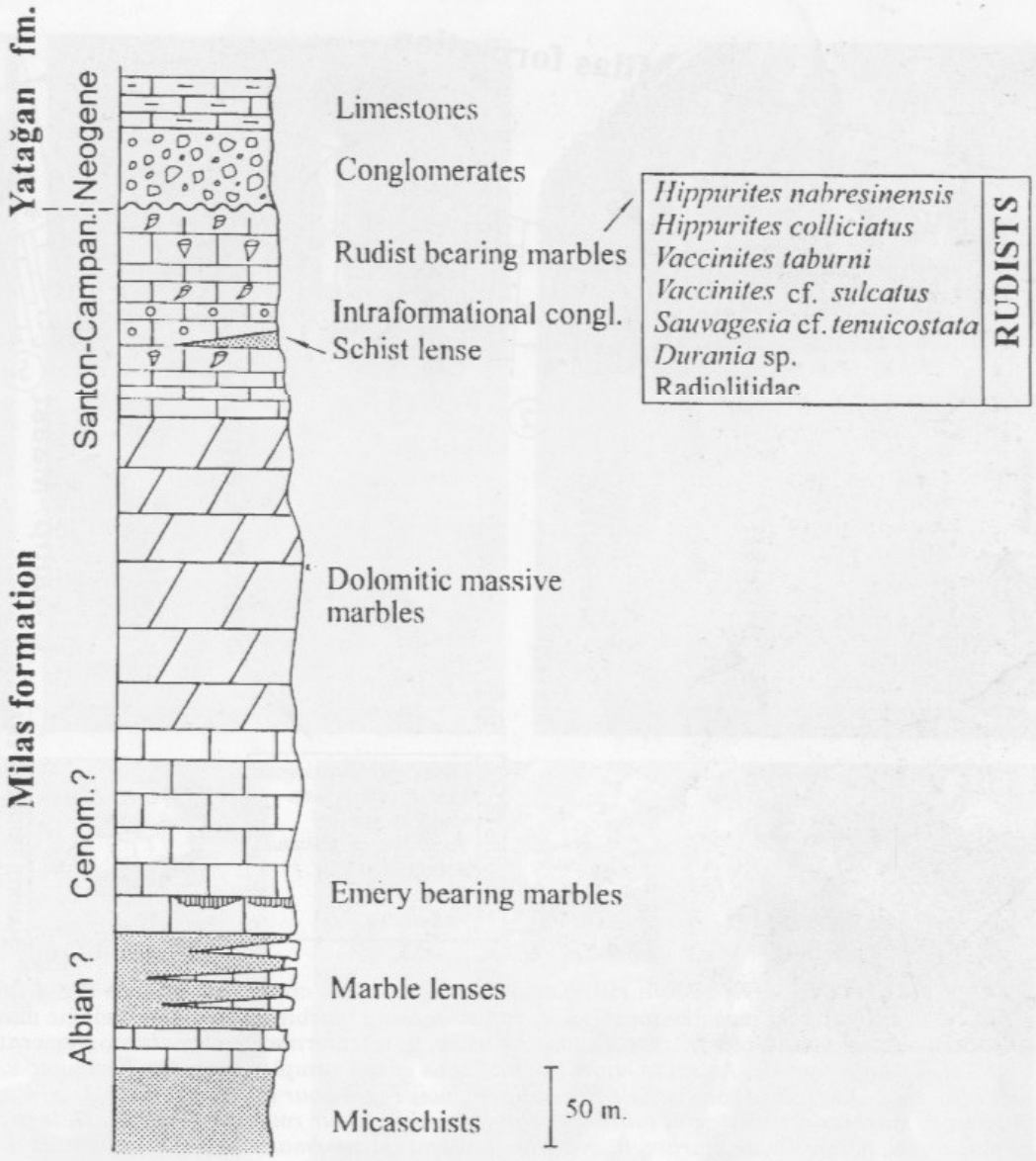

FIGURE 8 - Bozarmut (SE of Yatagan) measured stratigraphic section (see Fig. 3 for location). *Section stratigraphique mesurée dans le village de Bozarmut, Sud-Est de Yatagan (voir Fig. 3 pour la localisation).*

are well exposed (Fig. 4). Three formations are distinguished (Fig. 5).

Milas formation. This formation is characterized by platform-type carbonates. The massive, grey, emery-bearing marbles are probably of Cenomanian age, then grade upwards to massive marbles and 30 to 40 m thick rudist-bearing marbles. The rudist fauna consists of *Hippurites nabresinensis* FUTTERER, *Hippurites colliciatus* WOODWARD, *Vaccinites taburni* GUISCARDI, *Vaccinites* cf. *sulcatus* DEFRANCE, *Sauvagesia* cf. *tenuicostata* POLSAK, *Durania* sp., and Radiolitid fragments (Fig. 7.1-5) indicative of a Santonian-Campanian age (Özer 1993). The rudist horizon is clearly visible between Akbük-Kazikli-Kizilagaç and Asinyeniköy (Fig. 4). Rudist sections are also observed around Akdag and Marçaldag. In Akbük and Asinyeniköy localities, small rudist build-ups constructed by *Hippurites nabresinensis* FUTTERER are found (Fig. 7.1). The rudist beds grade laterally and verticallly to intraformational carbonate breccias. The uppermost part of the Milas formation is made up of grey, massive marbles, with some silex nodules, and passes gradually upwards to the pelagic marbles of the Kizilagaç Formation.

Kizilagaç Formation. This formation (25 to 30 m thick) is characterized by thin to medium bedded, reddish, greenish and light grey pelagic marbles with marly-pelitic interlayers. Upwards appear debris flows with coarsening upward clasts. The formation crops out around Kazikli and Kizilagaç village together with the overlying Kazikli formation.

Nannofossils like *Micula staurophora* (GARTED), *Watznaueria barnesae* (BLACK) and *Praediscosphaera cretacea* (ARKHANGELSKY) and planktonic foraminifers such as *Globotruncana lapparenti* BROTZEN, *Gl.* cf. *arca* (CUSHMAN), *Gl. bulloides* VOGLER, *Gl. ventricosa* WHITE, *Gl. linneiana* (D'ORBIGNY), *Gl. falsostuarti* SIGAL, *Globotruncanita stuarti* (DE LAPPARENT), *Glb. stuartiformis* (DALBIEZ), *Glb. subspinosa* (PESSAGNO), *Rosita contusa* (CUSHMAN),

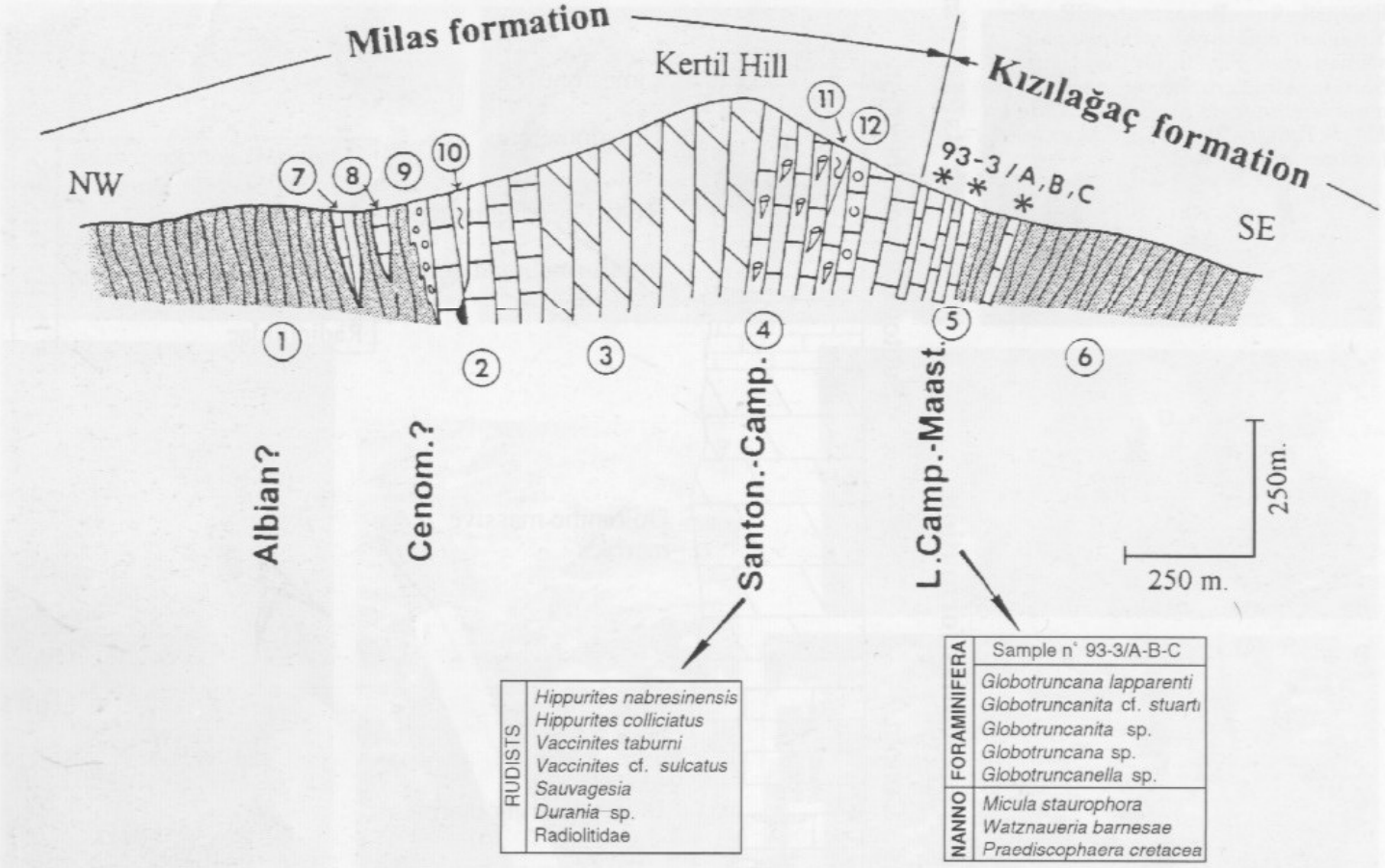

FIGURE 9 - Kertil Hill, SW of Eyli Hill-Kavaklidere geological cross- section (see Fig. 4 for location). **1**, schists, **2,** emery-bearing marbles, **3,** dolomitized massive marbles, **4,** rudist-bearing marbles, **5,** reddish pelagic marbles, **6,** phyllites, **7,** marble lense with intraformational metaconglomerate, **8,** marble lense, **9,** intraformational metaconglomerate, **10,11,** schist lenses, **12,** intraformational metaconglomerate. Asteriks show the locations of the samples from the Kizilagaç formation. *Profil géologique de la colline de Kertil, Sud-Ouest de la colline Eyli-Kavaklidere (voir Fig. 4 pour la localisation).* ***1,*** *schistes,* ***2,*** *marbres à émeris,* ***3,*** *marbres dolomitisés,* ***4,*** *marbres à rudistes,* ***5,*** *marbres pélagiques de couleur rouge,* ***6,*** *phyllites,* ***7,*** *lentille de marbre à métaconglomérat intraformationnel,* ***8,*** *lentille de marbre,* ***9,*** *métaconglomérat intraformationnel,* ***10,11,*** *lentille de schiste,* ***12,*** *métaconglomérat intraformationnel. Les astérisques montrent la localisation des échantillons récoltés de la formation de Kizilagaç.*

Gansserina gansseri (BOLLI), *Abathomphalus mayaroensis* (BOLLI), *Globotruncanella* sp., *Racemiguembelina* sp., *Archaeoglobigerina* sp. and *Globigerinelloides* sp. have been identified and document a late Campanian-late Maastrichtian age (Fig. 5). According to Dürr (1975) and Çaglayan et al. (1980), the age of the formation extends to the Early Paleocene.

Kazikli Formation. The formation is made up of flysch type rocks consisting of schists, phylites with carbonate lenses and carbonate blocks. Some foraminifers such as *Morozovella angulata* (WHITE), *Morozóvella* cf. *pseudobulloides* (PLUMMER), *Morozovella* sp. and *Globigerina* sp. indicating a middle Paleocene age are present; however Dürr (1975) and Çaglayan et al. (1980) suggest only an Early Eocene age for the formation.

The Lycian nappes consisting of siliciclastics, dolomites, and limestones of Upper Triassic-Liassic thrust over the cover rocks. In some areas, the serpentinite lenses marking the basal thrust plane of the Lycian nappes (de Graciansky 1966; Dürr 1975; Çaglayan et al. 1980) are observed (Fig. 5).

YATAGAN AREA

The Yatagan-Kavaklidere area (Fig. 4) was known as a reference section showing a clear stratigraphic organization, such as an unconformity between the Paleozoic micaschists and the Mesozoic emery-bearing platform-type marbles (Dürr 1975; Çaglayan et al. 1980; Konak et al. 1987; Konak 1994). However, Özer (*in* Dürr et al. 1995) first demonstrated the presence of a Cretaceous sequence ascribed to the Milas and Kizilagaç formations in the Yatagan-Kavaklidere area suggesting important new data when compared with the previous studies.

Milas Formation. The best sections of the formation were examined in the Bozarmut village-SE of Yatagan and between Söben and Magara villages-SW of Eyli Hill (Fig. 4). The formation comprises,

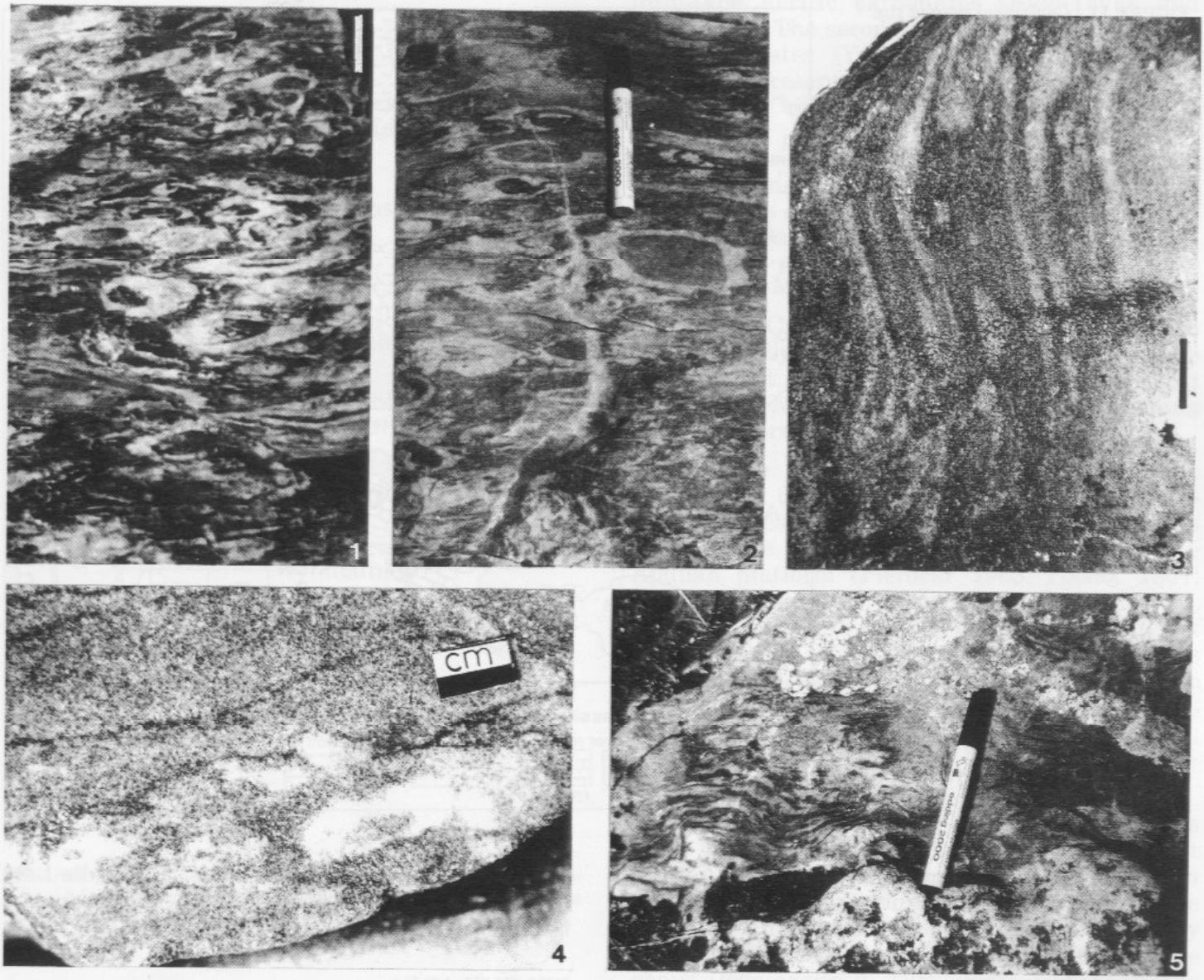

FIGURE 10 - **1.** Rudist-bearing marbles. Kertil Hill-Kavaklidere, scale bar is 5 cm. Note the deformation of the shells and also the preservation of the sections belonging probably to radiolitids. **2.** Hippuritid and Radiolitid sections. Kertil Hill-Kavaklidere. Note the elongation of the valves in the same direction. The position of the scale (pen: 14cm) is orthogonal to the elongation of the valves. **3.** Longitudinal sections of rudists from the marbles of Kursak village-Selçuk, scale bar is 1 cm. **4.** Rudist sections (probably radiolitids) from the marbles of the south of Selçuk. Scale is 1 cm. **5.** Marbles presenting strongly deformed rudist shells from the west of Söke. Compare this deformation with 1 and 2 of this figure and also 6 and 7 of the figure 7. The scale (pen: 14 cm) shows the vertical position to the elongation of the shells. ***1.*** *Marbres à rudistes. Colline de Kertie-Kavaklidere. Noter la déformation des valves et aussi la préservation des sections appartenant probablement à des radiolitidés. Le barre d'échelle est de 5 cm.* ***2.*** *Colline de Kertil-Kavaklidere. Section d'hippuritidés et de radiolitidés. Noter l'allongement des sections de toutes les valves dans la même direction. La position de l'échelle (crayon mesurant de 14 cm) est perpendiculaire à la direction de cet allongement.* ***3.*** *Sections longitudinales des rudistes dans les marbres du village de Kursak-Selçuk. Le barre d'échelle est de 1 cm.* ***4.*** *Sections de rudistes (probablement radiolitidés) dans les marbres du Sud de Selçuk. L'échelle est de 1 cm.* ***5.*** *Marbres à l'Ouest de Söke contenant des valves de rudistes très déformées. Comparer cette déformation avec 1 et 2 de cette figure et aussi 6 et 7 de la figure 7. L'échelle (crayon mesurant de 14 cm) est en position perpendiculaire à la direction d'allongement*

from bottom to top, micaschists with marble lenses, emery-bearing marbles, dolomitic marbles and rudist-bearing marbles showing a nearly vertical bedding (Figs 8, 9). A gradational transition between the micashists and the emery-bearing marbles are clearly observed in the lowermost section. Micaschist lenses and intraformational metaconglomerates are present in the formation.

Rudists are abundant upsection. The rudist fauna consist of hippuritid and radiolitid species with a Santonian-Campanian age: *Hippurites nabresinensis* FUTTERER, *Hippurites colliciatus* WOODWARD, *Vaccinites* cf. *sulcatus* DEFRANCE and *Sauvagesia* cf. *tenuicostata* POLSAK (Fig. 7.6,7; 10.1,2). Some corals are also observed in the rudist beds.

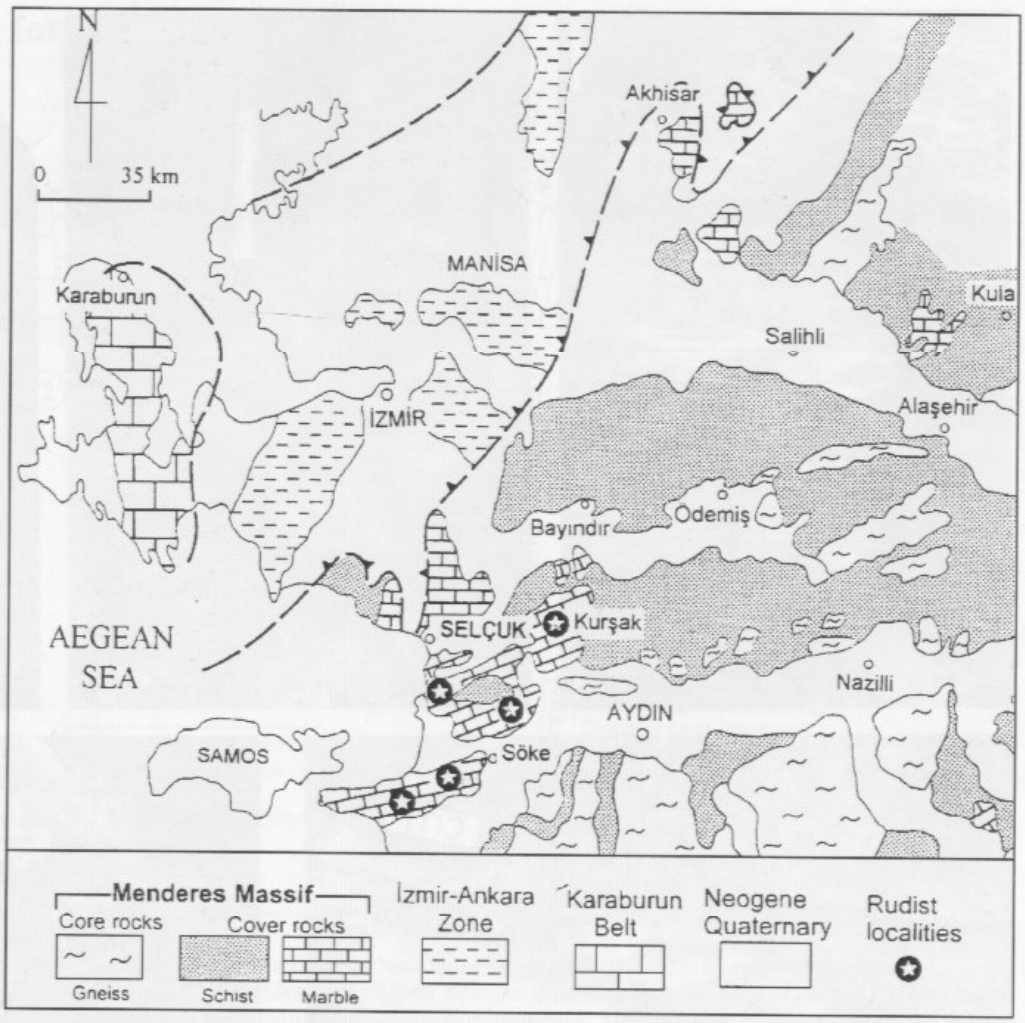

FIGURE 11 - Geological map of the northern sector of the Menderes Massif showing the distribution of the rudist localities (asteriks) (simplified from Dürr 1975). *Carte géologique du secteur nord du Massif du Menderes montrant la distribution (astérisques) des localités à rudistes (d'après Dürr 1975, simplifié).*

The marble successions in the north of Yatagan and around Kirdag locality (Fig. 4), display also rudist sections. The rudist bearing marbles grade upward to thick, grey marbles, and pass to the Kizilagaç formation.

Kizilagaç Formation. This formation is observed only around Kertil Hill-SW of Eyli Hill, Kavaklydere (Fig. 4,9), and is made up of reddish-pinkish pelagic metacarbonates down section and phyllites with carbonate lenses upsection. The pelagic carbonates yield planktonic foraminifers such as *Globotruncana lapparenti* BROTZEN, *Globotruncanita* cf. *stuarti* (DE LAPPARENT), *Globotruncanita* sp., *Globotruncana* sp. and *Globotruncanella* sp., and also nannoplanktons like *Micula staurophora* (GARTED), *Watznaueria barnesae* (BLACK) and *Prediscosphaera cretacea* (ARKHANGELSKY) indicative of a late Campanian-Maastrichtian age.

Yatagan Formation. This formation overlies the units of the Menderes Massif with an angular unconformity and consists of, from bottom to top, conglomerates composed mainly by marble clasts and lacustrine type carbonates (Fig. 4,8). According to the ostracods, vertebrates (Perissodactyla) and palynologic determinations a Middle-Late Miocene age have been suggested for the formation (Gökçen 1982; Gemici et al. 1990; Kaya 1991).

SELÇUK AREA

In the northern sector of the Menderes Massif, the Mesozoic sequences crop out only around Selçuk (Fig. 11), where two formations were distinguished by Erdogan and Güngör (1992).

Kayaalty Formation. This formation is represented by micaschists and platform-type marbles. In the eastern part of Selçuk, around the village of Kursgak a gradational transition characterises the marble lenses between the micaschist and emery-bearing massive marbles (Fig. 12). Upsection are found grey, rudist-bearing massive marbles. Fragments of rudists are not well preserved; however, some sections of radiolitids belonging probably to genus *Sauvagesia* and /or *Durania* have been determined (Fig. 10.3). The rudist sections are also found south of Selçuk and in the western part of Söke (around Tuzburgaz and Gülbahçe) (Fig. 10.4,5, 11). The uppermost

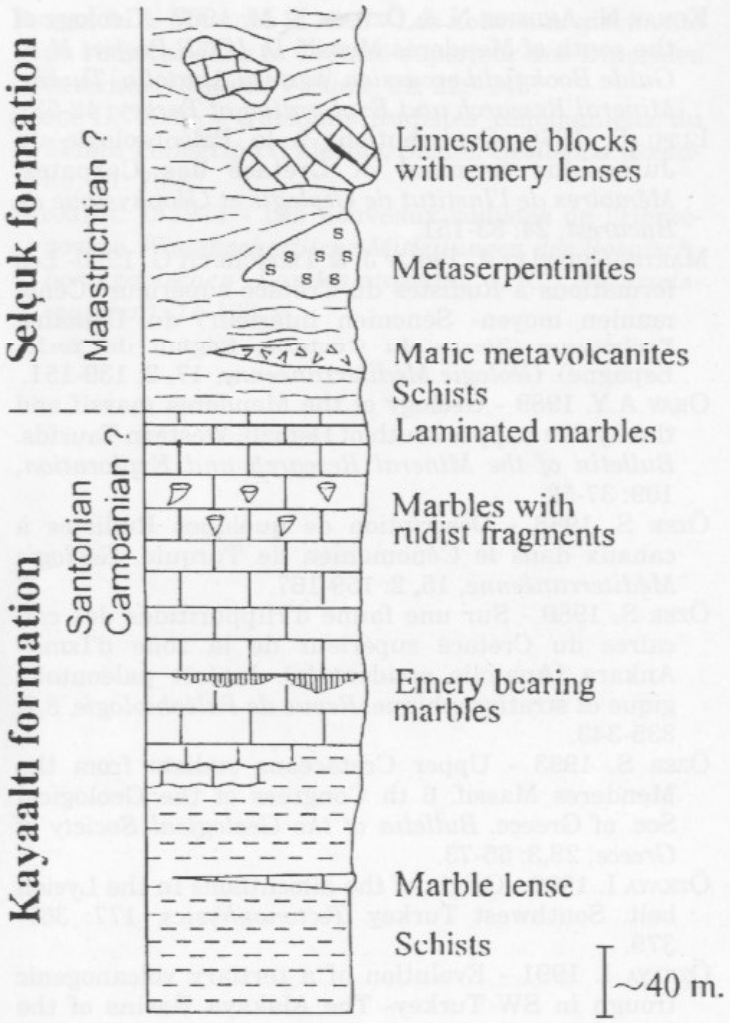

FIGURE 12 - Kursak (east of Selçuk) stratigraphic section (see Fig. 11 for location). *Section stratigraphique de Kursak, Est de Selçuk (voir Fig. 11 pour la localisation).*

part of the formation consists of laminated, grey marbles. The top of the Kayaalti formation is capped by observes the Selçuk formation.

Selçuk Formation. The formation is composed of dark green-gray micaschists with mafic metavolcanics. Blocks of metaserpentinite, metagabbro, and marble with emery lenses are also observed. Due to its stratigraphic position, the age of the formation has been accepted as Maastrichtian by Erdogan and Güngör (1992).

CONCLUSION

The main stratigraphic features of the Upper Cretaceous sequences with rudists of the Menderes Massif are listed below.

Two types of Cretaceous sequences are distinguished. The first sequence is characterized by platform-type neritic carbonates (Kale-Tavas and Milas area). The second is represented by clastics and carbonates (Yatagan-Selçuk areas). These sequences present three levels which are important for the Cretaceous stratigraphy, from base to top:

- emery-bearing marbles and / or marbles with rudists having canals of Cenomanian age,
- hippuritids dominant rudist-bearing marbles of Santonian-Campanian age,
- finally red-pinkish pelagic marbles for the late Campanian-Maastrichtian.

The Upper Cretaceous sequence of the massif is dominated by platform-type rocks; however the development of pelagic carbonates in the latest Campanian-Maastrichtian indicate the drowning of the platform.

Despite the metamorphism effects, two rudist associations can be distinguished. The first association represented mainly by rudists with canals (middle-late Cenomanian) is typical of the Apulian platform (Plenicar 1963; Polsak 1967; Carbone et al. 1971; Sirna 1982; Camoin 1983), and is also found in the Bey Daglari carbonates of Turkey (Özer 1988). The second association is characterized by hippuritids described from the Santonian-Campanian of the Mediterranean province (Douvillé 1910; Parona 1926; Polsak 1967; Lupu 1976), and limestone blocks of the Izmir-Ankara zone, around Izmir (Özer 1989).

The Upper Cretaceous sequence of the Kale-Tavas area, which is precisely described for the first time in this study, comprises both Cenomanian and Santonian-Campanian rudist faunas. The Cenomanian of this area is characterized by rudists with canals, and the first mention of the genus *Distefanella* in Turkey. The species of this genus are generally described from late Turonian (Polsak & Mamuzic 1969; Sliskovic 1971; Accordi et al. 1982). However, the presence of *Distefanella* in the late Cenomanian of the Domaine Prébétique (Spain) has been reported by Martin-Chivelet et al. (1990). The discovery of this genus in the Cenomanian beds in western Turkey, reveals a wide geographic and stratigraphic distribution of *Distefanella* in the Mediterranean province.

Acknowledgements - The author would like to thank Dr. J.P. Platel (BRGM-Aquitaine), Dr. M. Plenicar (Univ. of. Ljubljana), Dr. J.P. Masse (Univ. of Provence) for reviewing the manuscript and Prof. Dr. V. Toker (Univ. of Ankara) for determination of nannoplanktons, Prof. Dr. I. Tansel (Univ. of Istanbul) for foraminifers, and Prof. Dr. A. Poisson (Univ. of Sud-Orsay) for his valuable helps in the studies of the Kale-Tavas area. The author also thank M. Gürle (DEU-Izmir) for drawing of the figures, E. Sanli (DEU-Izmir) for the photos and M. Fenerci (DEU-Izmir) for typing of manuscript.

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