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THE MOLLUSCAN FAUNA AND STRATIGRAPHY OF ANTALYA MIOCENE BASIN (WEST-CENTRAL TAURIDS, SW TURKEY)

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ABSTRACT.- This study has been carried out in Miocene units containing molluscan fauna, deposited in Antalya Miocene basin located at Western and Central Taurids. In the circumstances of this study, the eight stratigraphic sections were measured and the stratigraphy of the basin has been re-evaluated, based on the examination of the chronostratigraphic ranges of the collected samples belonging to the molluscan fauna. In this respect, the Lower Miocene Kepez travertine is the lowermost unit and unconformable with the basement, at the southeast of the basin. Succeded up, the Burdigalian Seving conglomerate of alluvial fan - fan delta character overlies this unit. The Upper Burdigalian - Langhian (Karpatian - Lower Badenian) Oymapınar limestone is composed of reefal - massive limestones and conformably overlies the Seving conglomerate. The Sevinc conglomerate and Oymapınar limestone are also unconformably overlying the basement rocks. The Oymapınar limestone is overlain by Çakallar formation (Upper Burdigalian - Lower Langhian) and Geceleme formation (Langhian). Geceleme formation is overlain by Serravalian - Tortonian levels of the Karpuzçay formation. It is the first in this study, that the units exposed in central and northern parts of the basin have been differentiated from the Aksu formation and defined as the Altınkaya formation. The Altınkaya formation is characterized by brackish water - marinal properties and contains Upper Burdigalian - Langhian (Ottnangian - Karpatian - Lower Burdigalian) molluscan fauna. It unconformably overlies the basement rock units and is overlain by Aksu formation. The Altınkaya formation is also laterally transitional with Upper Burdigalian - Langhian levels of the Karpuzçay formation. The Aksu formation widely cropped out widely at western and central parts of Antalya Miocene basin was dated as Lower Tortonian due to its molluscan fauna. However, the overall age of the formation was accepted as Serravalian - Tortonian.

INTRODUCTION

The Antalya Miocene basin is located at east of Western Taurids and west of Central Taurids in the area among Antalya, Alanya and Isparta provinces (Fig. 1). In this study, the Miocene units in the basin have been investigated and eight stratigraphic sections have been measured with compilation of samples collected from levels rich in molluscan fauna. The paleogeographic properties and taxonomies of molluscan fauna in measured sections were studied in detail (İslamoğlu, 2001).

The Miocene sediment fill in the region has been the subject of many studies since 1940's from the sedimentologic, paleontologic, stratigraphic and tectonic point of view and different ideas have been suggested (Altmli, 1945; Blumenthal, 1951; Özer at al., 1974; Öztümer, 1974; Dumont and Kerey, 1975a and *b;* Monod, 1977; Akbulut, 1980; Akoz, 1981; Akay and Uysal, 1984; Akay et al., 1985; Şenel et al., 1992, 1996 and 1998; Naz et al., 1991 and 1992; Tuzcu et al., 1994; Flecker et al., 1995; Erk et al., 1995; Karabıyıkoğlu et al., 1996 and 1997; Atabey, 1998; Karabıyıkoğlu et al., 2000).

Such a paleontological and stratigraphic study based on the molluscan fauna in the Antalya Miocene basin was firstly carried out and by using the obtained data, it is tried to make a contribution to the basin stratigraphy.

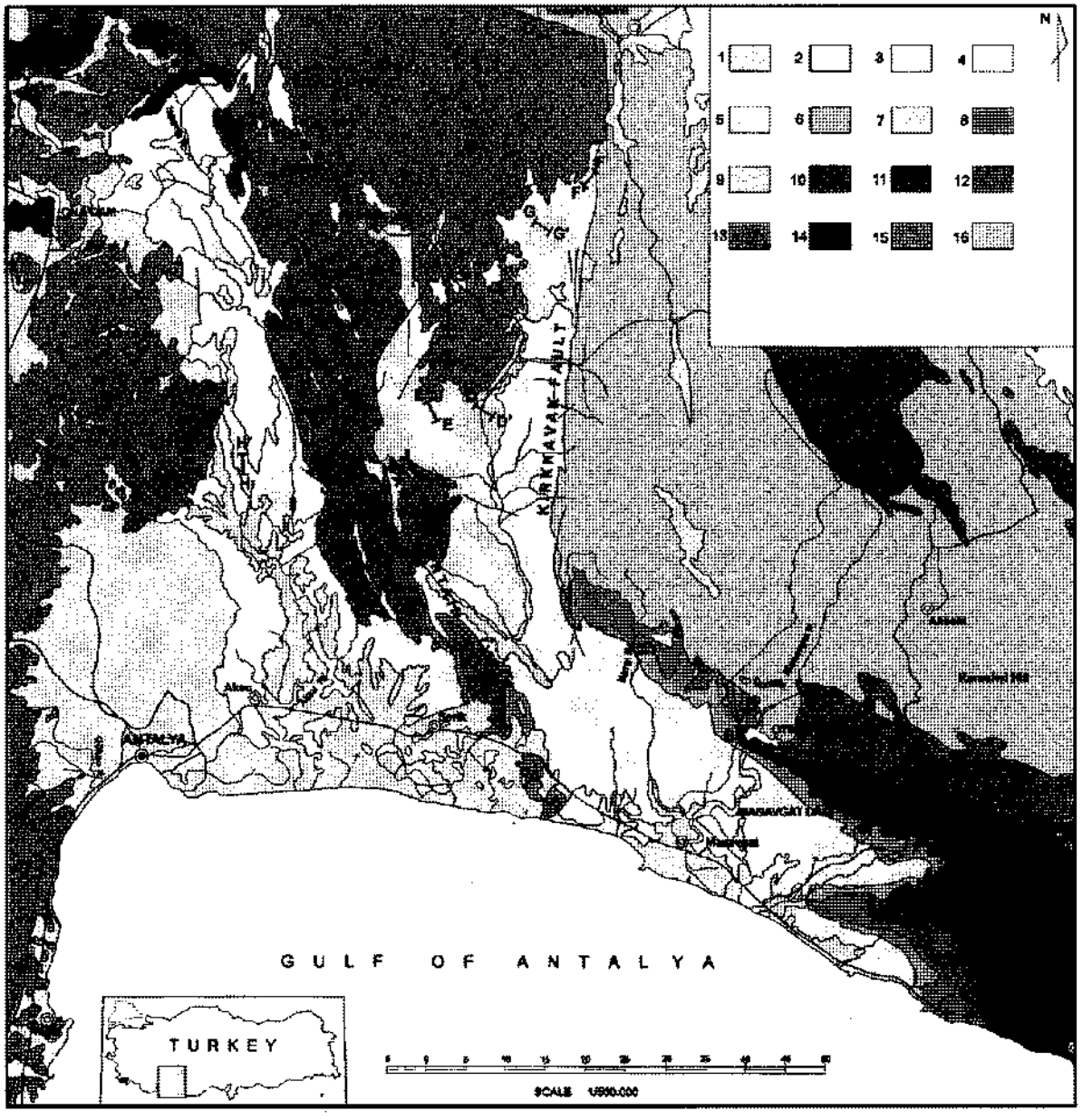


fig. 1- Geological map of the Antalya Miocene basin and surrounding area (modified by Şenel, 1997 *a,b,c*). 1- Quaternary, 2- Pliocene, 3- Taşlık formation, 4- Aksu formation, 5- Karpuzçay formation, 6- Oymapınar limestone, 7- Altınkaya formation, 8- Sevinç conglomerate, 9- Karabayır formation, + Karakuştepe formation, 10- Yeşilbarak nappe, 11- Lycian nappes, 12- Beyşehir-Hoyran-Hadim nappes, 13- Antalya nappes, 14- Alanya nappe, 15- Beydağları autochthone, 16- Anamas-Akseki autochthone. AA' Alarahan section, BB' Oymapınar section, CC' Radioring section, DD' Ballıbucak section, EE' Altınkaya section, FF' Aşağıyaylabel section, GG' Hocalarsırtı section, HH' Kargı section.

GEOLOGY OF THE BASEMENT ROCKS

The Neogene marinal deposits cover wide area in the region where the autochthonous and allocthonous rock units of Precambrian - Quaternary time interval are exposed.

In the region, the autochthonous rock units are Beydağları and Anamas - Akseki autochthone whereas the allocthonous were defined as Antalya nappe and Beysehir-Hoyran-Hadim nappes (Brunn et al., 1971, 1973; Dumont and Kerey, 1975a; Dumont, 1976; Monod, 1977; Poisson, 1977; Akbulut, 1977 and 1980; Waldron, 1982; Akay and Uysal, 1984; Akay et al., 1985; Şenel et al., 1992, 1996; Şenel, 1997a, *b).*

The Beydağları autochthone is located at west of Antalya Miocene basin and generally represented by Moesozoic platform carbonates. The Anamas-Akseki autochthone is observed at east and north of Antalya basin and consists of Mesozoic - Lower Tertiary carbonates with minor amount of clastic rocks. The Beydağları and Anamas-Akseki autochthones were combined and defined as Geyikdağ unit by Özgül (1976).

In the region, the Antalya nappes emplaced from the south, during Early Paleocene (Danian) and they include Upper Triassic platform, Jurassic - Cretaceous slope-basin type deposits of Çataltepe nappe, Permian-Lower Triassic platform, Middle Triassic-Upper Cretaceous basin type deposits with dominant basic volcanism of Alakırçay nappe-Tekirova ophiolite nappe and Tahtalıdağ nappe composed of Cambrian-Upper Cretaceous . platform type deposits (Brunn et al., 1971; Monod, 1977; Şenel et al., 1992; 1996). The Antalya nappes were also defined as "Antalya Unit" and "Antalya complex" by Özgül (1976) and Woodcock and Robertson (1977) respectively.

The Alanya nappe, overlying the Antalya nappes, includes Mahmutlar and Yumrudağ and Sugozu units undergone greenschist and blueschist facies metamorphism respectively (Özgül, 1984). Özgül (1976) defined the Alanya nappe as "Antalya unit".

Özgül (1976) distinguished three tectonic units namely; Aladağ unit, Bozkır unit and Bolkar unit based upon sequential between Lycian nappes and Beyşehir-Hoyran-Hadim nappes, Şenel (1997 *a,b,c)* classified the Lycian nappes into many structural units as Tavas nappe, Bodrum nappe, Marmaris ophiolite nappe, Domuzdağ nappe and Gülbahar nappe.

The Neogene deposits in the Antalya basin have been investigated by many researchers (Monod, 1977; Poisson, 1977; Dumont and Kerey, 1975a and *b;* Akay and Uysal, 1984; Akay et al., 1985; Şenel et al., 1991, 1992, 1996; Naz et al., 1991 and 1992; Flecker et al., 1995; Şenel and Bölükbaşı, 1997; Karabıyıkoğlu et al., 2000). The region has undergone the effect of Kırkkavak fault (Dumont and Kerey, 1975a) and Aksu thrust (Poisson, 1977) which are coeval with the sedimentation. For this reason, some of the researchers preferred to investigate the region under the three subbasin areas namely; N-S trending Aksu and Köprüçay subbasins and

NW-SE trending Manavgat subbasin (Flecker et al., 1995; Robertson et al., 1996).

Generally, at east and southeast of the basin, the Kepez travertine (Lower Miocene), the Seving conglomerate (Burdigalian), the Oymapınar limestone (Upper Burdigalian-Langhian), the Çakallar formation (Upper Burdigalian-Lower Langhian) and the Geceleme formation (Langhian) are cropped out. The Altınkaya formation (Upper Burdigalian-Lower Langhian) is exposed at central, northern and southern parts of the basin. The Karpuzçay formation (Upper Burdigalian-Tortonian) is observed in the whole basin, whereas the Aksu formation (Serravalian-Tortonian) is cropped out at central and western parts of it.

The other units in the region are the Lower Pliocene the Gebiz, the Eskiköy and the Yenimahalle formations, the Upper Pliocene Alakilise formation, the Pleistocene Belkıs conglomerate and the Quaternary Antalya travertine and alluvions (Poisson, 1977; Akay and Uysal, 1984; Akay et al., 1985).

There has been a compression - extention type tectonic regime prevailed since Miocene in the region. The products of the compressional regime are the empiacement of Lycian nappes from northwest to southeast, NE-SW trending Aksu thrust and Kırkkavak fault which is right-lateral strikeslip fault with reverse slip component (Dumont and Kerey, 1975a; Poisson, 1977; Akay and Uysal, 1988; Şenel et al., 1992). Antalya graben has developed by the E-W and later N-S trending compressions since Late Pliocene (Akay and Uysal, 1988).

LOCATIONS OF MEASURED STRATIGRAPHIC SECTIONS

In the region, the Miocene units containing molluscan fauna (Seving conglomerate, Oymapınar limestone, Altınkaya formation and Aksu formation) have been investigated in detail, and eight section were measured (Fig. 1). Measured sections and their locations are as follows.

The Alarahan measured stratigraphic section (Fig. 1, AA')

This section was measured in NE-SW direction at southeast of Antalya Miocene basin (Alanya 027d2 quadrangle) at eastern slope of the Alara stream. It has a 190 m total thickness, starting at X1 86400, Y1 62600 and finishing at X2 86350, Y2 62400 coordinates. Lower part of the section (170 m.) is represented by the Seving conglomerate, whereas the rest 20 m is the Oymapınar limestone (Fig. 2).

The Oymapınar measured section (Fig. 1, BB')

This section is located at O27a1 quadrangle and was measured along Manavgat stream toward southwest, at Oymapınar Dam and is situated approximately 3 km to the north of Oymapınar village. It is about 95 m thick and starting at X1 69150, Y1 85450 and finishing at X2 68950, Y2 85975 coordinates. Throughout the section, the basal 55 m part is belonging to Oymapınar limestone and the overlying 40 m thick upper part is represented by the Geceleme formation (Fig. 3).

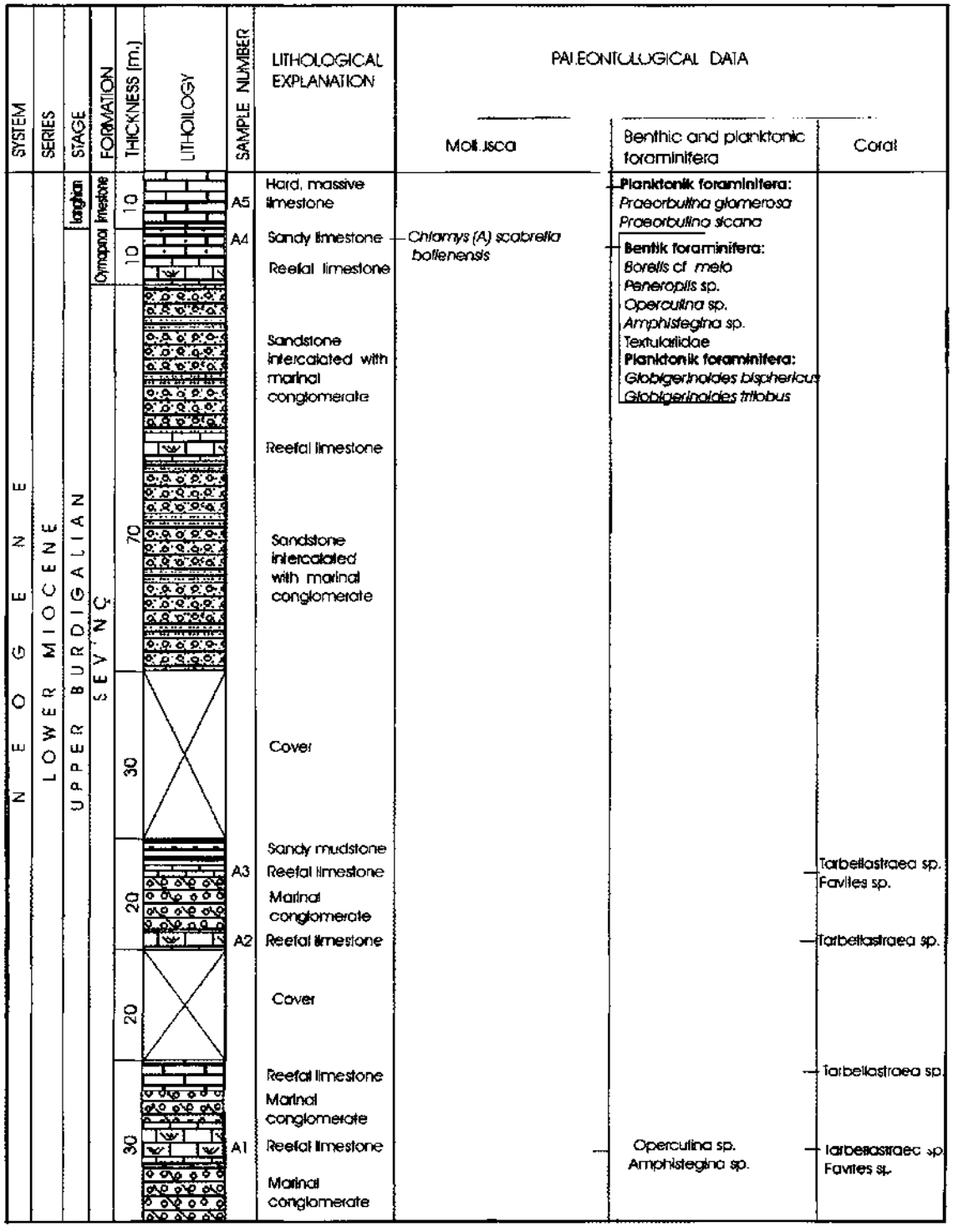


Fig. 2- The Alarahan stratigraphic section measured in the Seving conglomerate and the Oymapınar limestone (AA')

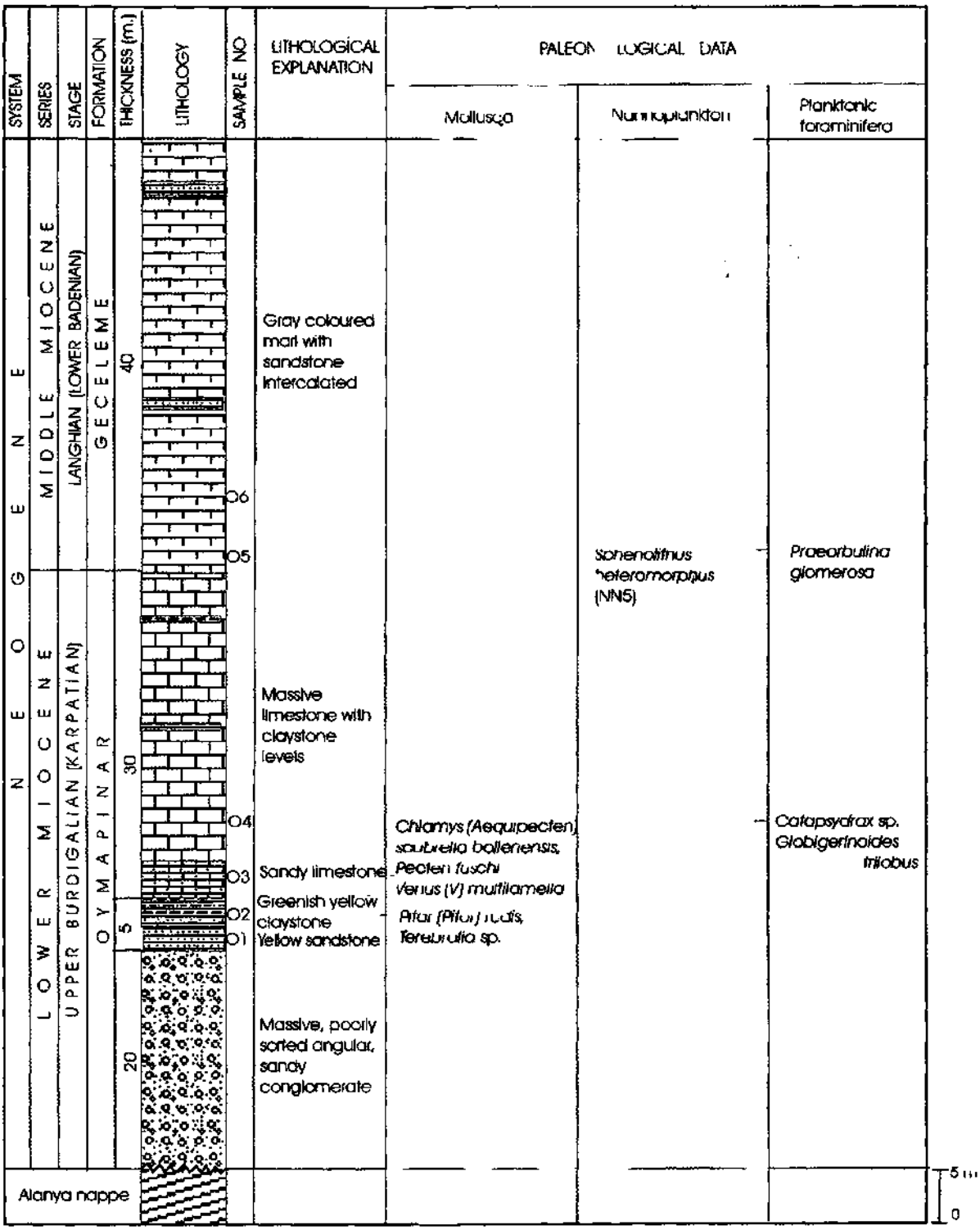


Fig. 3- The Oymapınar stratigraphic section measured in the teh Oymapınar limestone (BB')

The Radioring measured stratigraphic section (Fig. 1, CC')

This section is located at Antalya O26a2 quadrangle, 4.5 km northwest of Tasagil and 1 km south of Radioring station ancl was measured from southeast to northwest. The coordinates are starting at X1 40020, Y1 90020 and finishing at X2 40125, Y2 90000. It is only represented by 40 thick the Oymapınar limestone (Fig. 4)

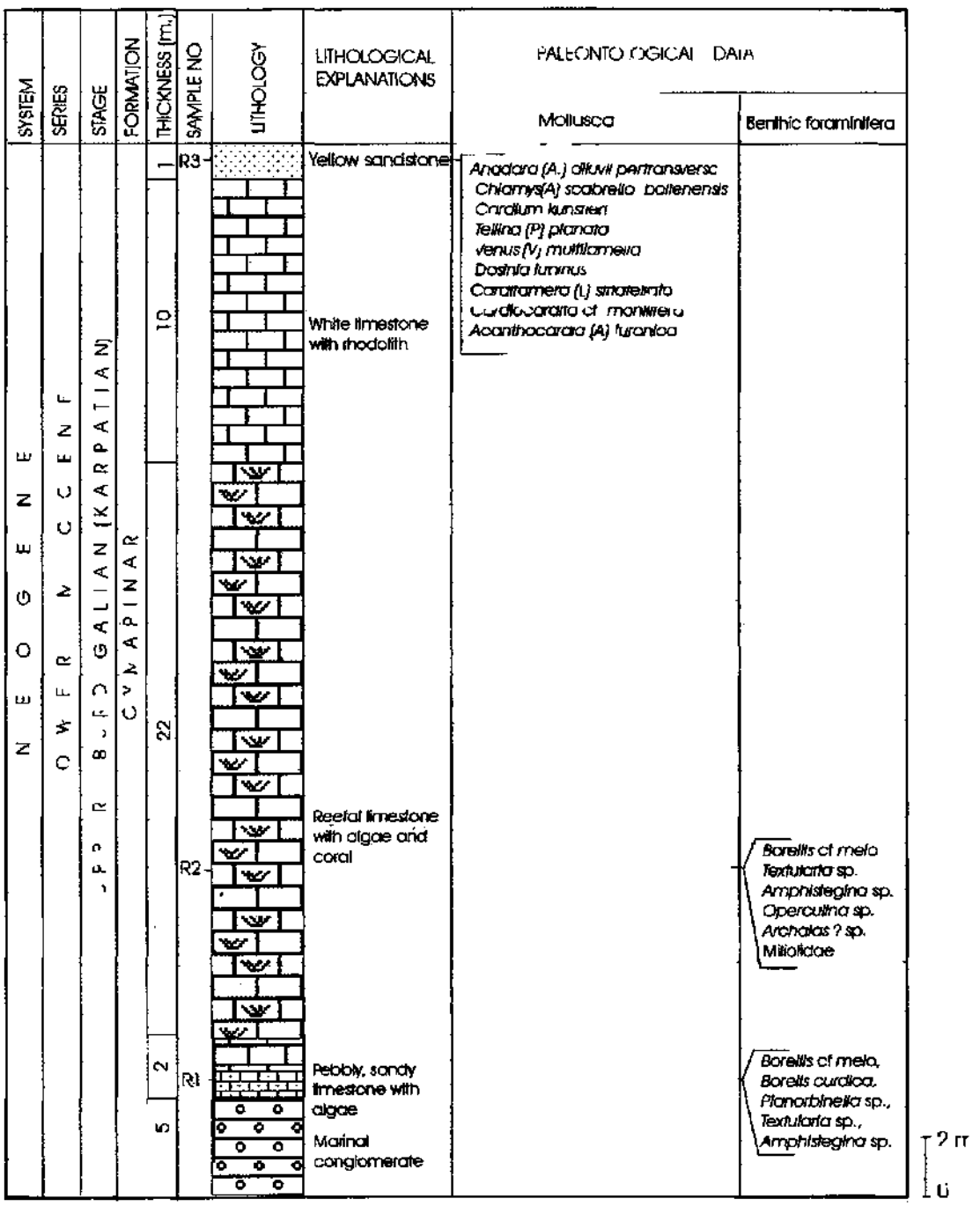


Fig. 4- The Radioring stratigraphic section measured in the Oymapınar limestone (CC')

The Ballıbucak measured stratigraphic section (Fig. 1, DD')

The section is located at Isparta N26a4 quadrangle, approximately 700 m to the southeast of Ballıbucak village and was measured in NW-SE direction. It starts at X1 33165, Y1 29425 and finishes at X2 33800, Y2 29000 coordinates. The basal 86 m part of 101m total thickness is characterized by the Oymapınar limestone. Unconformably overlying this is the 15 m thick conglomerates, probably belonging to Aksu formation (Fig. 5).

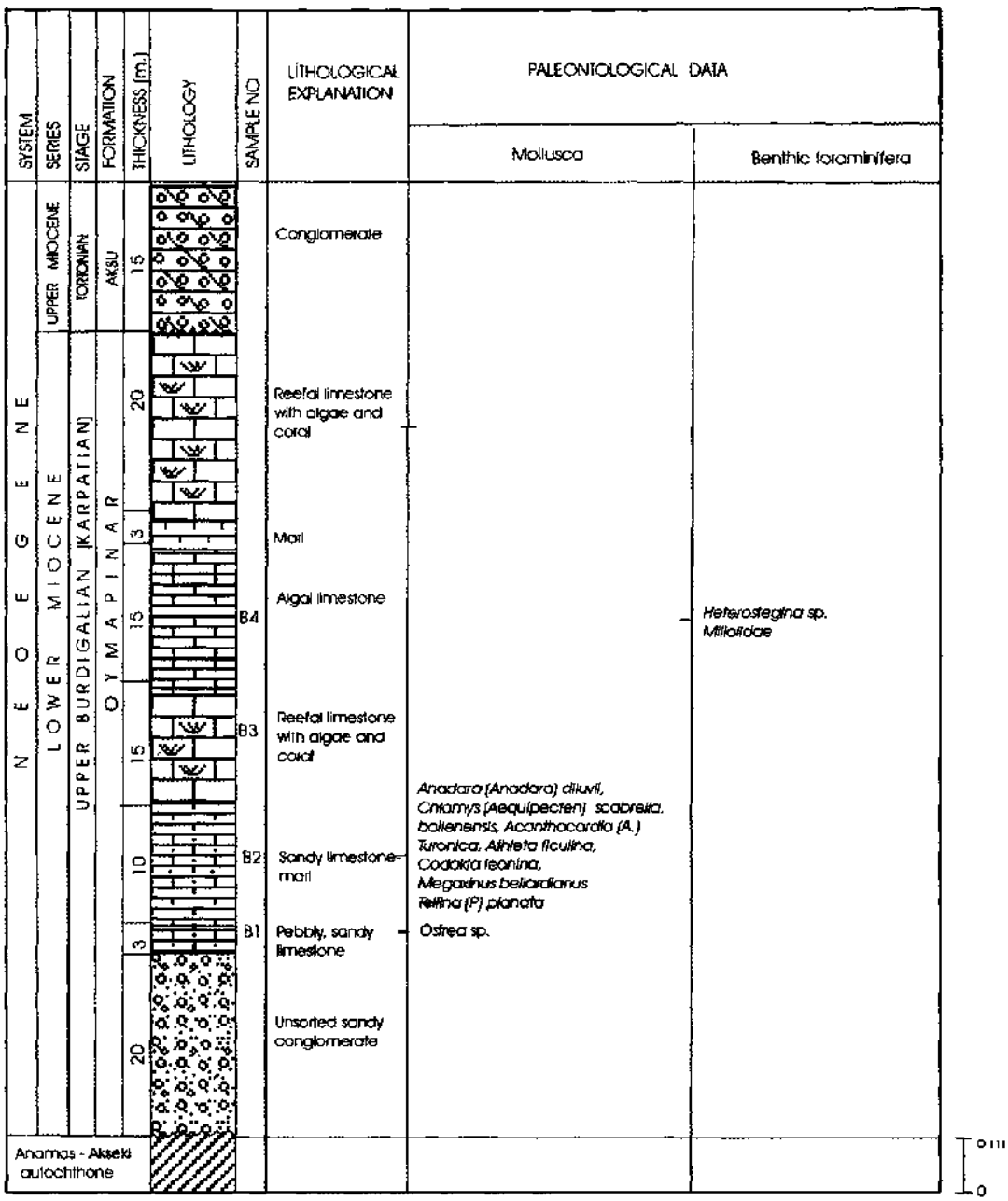


Fig. 5- The Ballıbucak stratigraphic section measured in the Oymapınar limestone and the Aksu formation (DD')

The Altınkaya measured stratigraphic section (Fig. 1, EE')

The Altınkaya measured section is located at Isparta N26d2 quadrangle. The section is 750 m in total thickness and was measured 2.5 km from north of Beşkonak village in northwest direction to the antique Zelga theatre (Altınkaya village). The section starts at X1 39250, Y1 15400 and finishes at X2 33825, Y2 22200 and it is completely represented by the Altınkaya formation (Fig. 6).

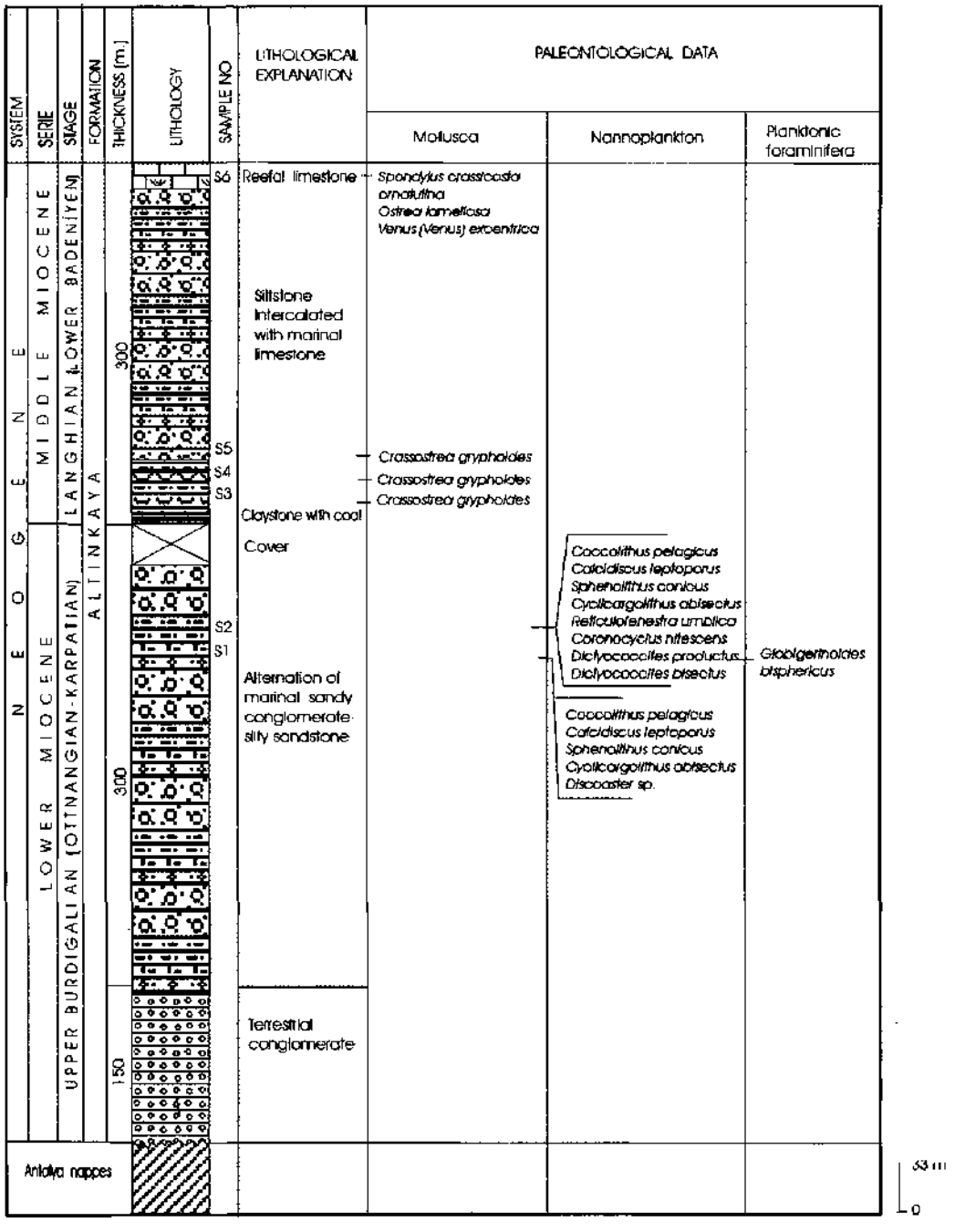


Fig. 6- The Altınkaya stratigraphic section measured in the Altınkaya formation (EE')

The Asağıyaylabel measured stratigraphic section (Fig. 1, FF')

This section is located at M26c4 quadrangle and was measured in northeast direction 1.5 km to the southwest Aşağıyaylabel province. It is approximately 54 m in thickness and starts at X1 49400, Y1 57175 and finishes at X2 49875, Y2 57275 coordinates. The whole section is characterized by the Altınkaya formation (Fig. 7).

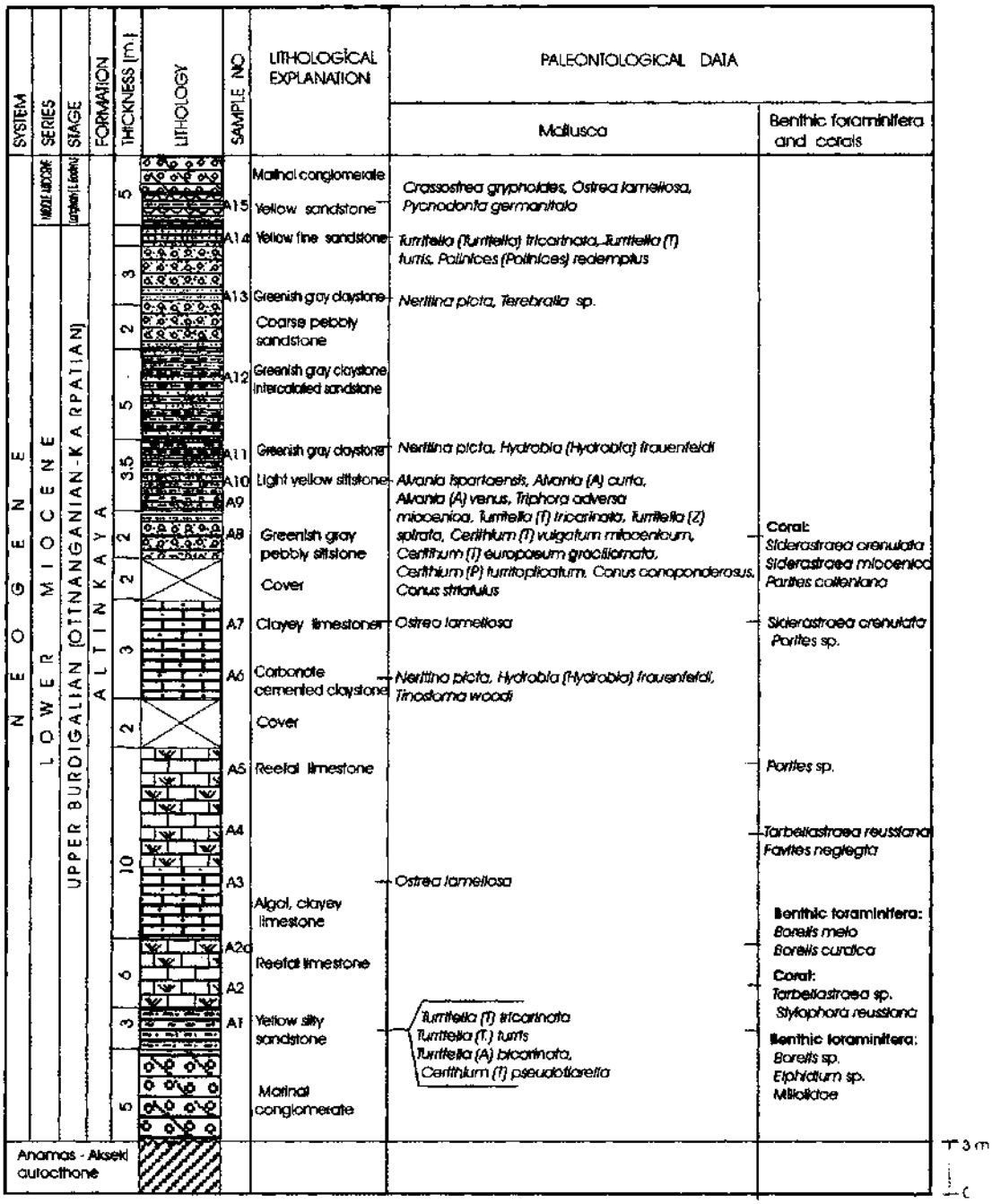


Fig. 7- The Aşağıyaylabel stratigraphic section measured in the Altınkaya formation (FF')

The Hocalarsırtı measured stratigraphic section (Fig. 1, GG')

This section is located at Isparta N26b2 quadrangle, approximately 1 km northwest of Hocalarsırtı and 1 km south of Karakaya province. The starting and finishing coordinates are X1 49250, Y1 45800 and X2 49750, Y2 45550 respectively. The thickness of the section is about 36 m and it belongs completely to the Altınkaya formation (Fig. 8).

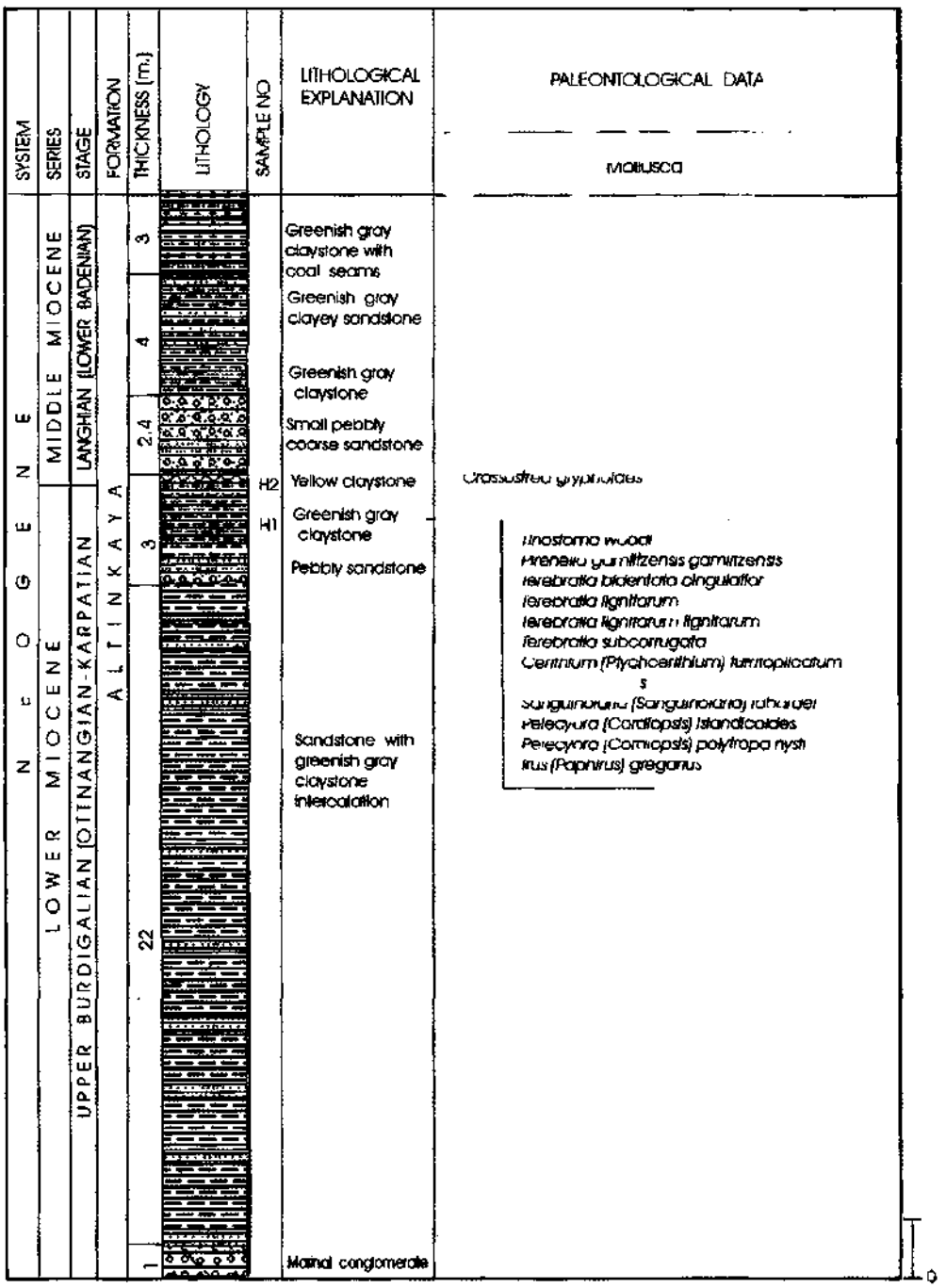


Fig. 8- The Hocalarsırtı stratigraphic section measured in the Altınkaya formation (GG')

The Kargı measured stratigraphic section (Fig. 1,HH')

This section is located at Isparta N25b4 quadrangle, 12 km to the south of Kargı and was measured from southwest to northeast around Kargı Tunnel. It is 56.5 m in total thickness and starting at X1 06150, Y1 27350 and finishing with X2 06275, Y2 27850 coordinates. The section was completely measured within Aksu formation (Fig. 9).

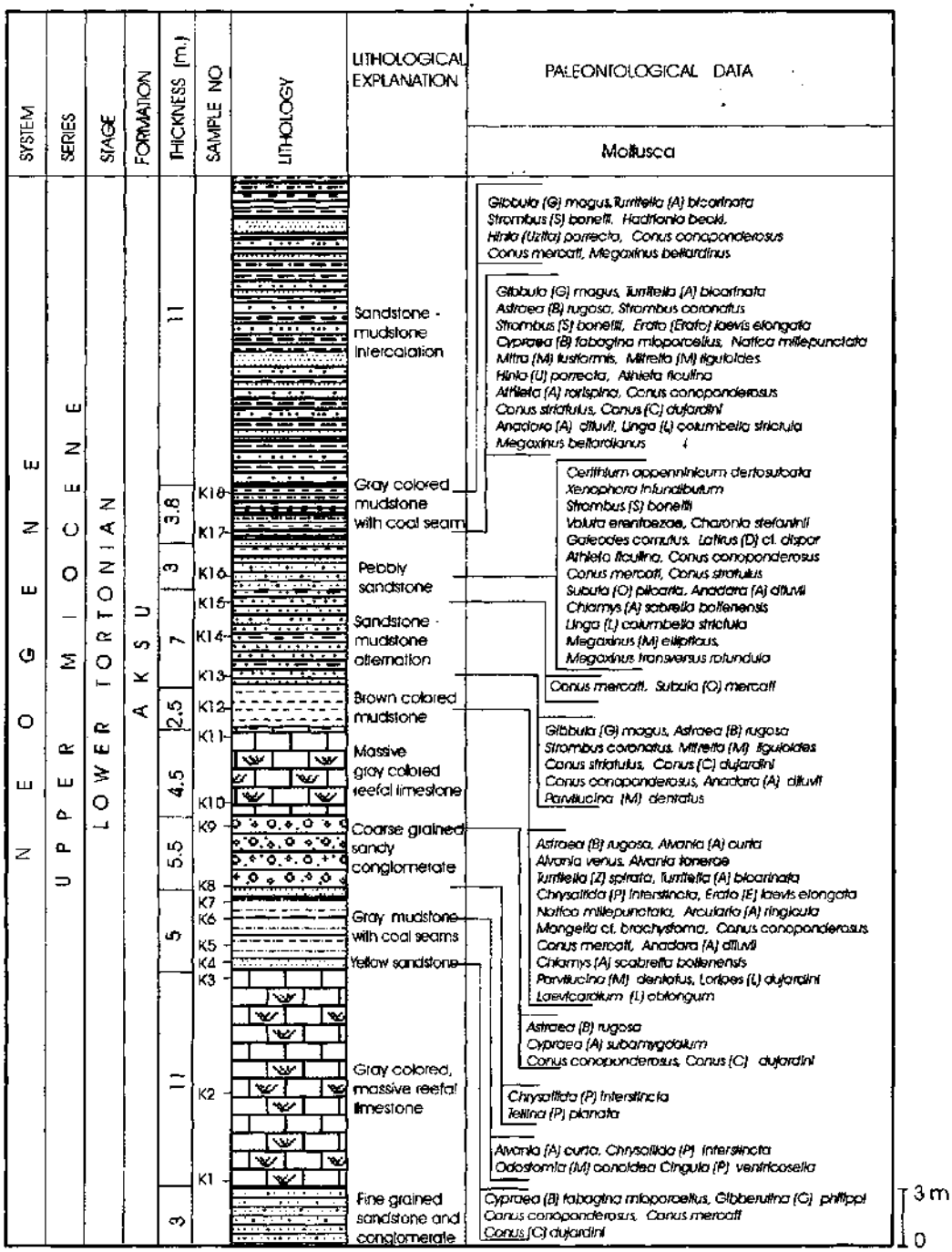


Fig. 9- The Kargı stratigraphic section measured in the Aksu formation (HH')

THE STRATIGRAPHY OF THE ANTALYA MIOCENE BASIN

For the better understanding the stratigraphic relationships in the basin, the other Miocene units in the region have been also investigated together with the studied formations. These units are Kepez Travertine, Seving conglomerate, Altınkaya formation, Oymapınar limestone, Çakallar formation, Geceleme formation, Karpuzçay formation and Aksu formation.

The Kepez travertine

Definition and nomenclature- It was firstly named by Monod (1977).

Type section locality.- It was defined at 300 m east of Kepez village (Antalya O27a1).

Lower-Upper boundary relations.- It unconformably overlies Alanya massif and is overlain by Upper Burdigalian deposits.

Lithology.- It is compposed of brown colored, massive calcium carbonate with solution cavity and plant fragments.

Thickness and distribution.- The unit is appoximately 20 m thick and pinches out laterally.

Fossil content and age.- It contains leave and plant fragments and rare green algae *(Charophyte)* (Monod, 1977). No age assignment was estimated these fossils. It is thought to be Lower Miocene based on stratigraphic relations.

Depositional environment.- It reflects a brackish water environment.

The Sevinç conglomerate

Definition and nomenclature.- Monod (1977) assigned the unit as Tepekli detritics. Later, Gutnic et al., (1979) defined it as Sevinç conglomerate in their geological map. Şenel et al., (1992, 1998) also adopted the name Sevinç conglomerate for the unit. Akay and Uysal (1984) and Akay et al., (1985) considered the unit together with Aksu formation.

Type section locality.- The type section is located around Sevinç village (Antalya O27a quadrangle).

Lower-Upper boundary relations.- The formation is observed at south and southeastern parts of the basin. It unconformably overlies the basement rock units and is conformably overlain by the Oymapınar limestone.

Lithology.- The formation is dominantly represented by unbedded or cross-lenticular stratified, continental and marinal conglomerates of different size. In some levels, it includes yellow, reddish brown colored sandstone and mudstone on small reefal limestone lenses. Sandstone and mudstone levels pinch out laterally. The marinal conglomerate is intercalated with reefal limestone in Alarahan section representing marine level of the formation.

Thickness and Distribution.- It is about 600 m thick (Şenel et al., 1992) and it pinches out laterally.

Fossil Content and age.- No fossil record was encountered to give an age data within terrestrial level of the formation. Late Burdigalian age has been suggested from the Alarahan section representing marine levels. It is concluded that due to unsuitable environmental conditions, the molluscan fauna could not find opportunity to develope in diversity. For this reason, only the *Chlamys (Aequipecten) scabrella bollenensis* (Mayer) and.Osfrea *lamellosa* Brocchi characterizing the Late Burdigalian were found and for this part of the formation this age has been accepted. Also in the same level, the presence of the benthic foraminfera such as *Borelis* cf. *melo* Fichtel and Moll, *Amphistegina* sp., *Peneroplis* sp., *Operculina* sp., Textulariidae (identified by

E. Sirel) and planktonic foraminifera *Globigerinoides trilobus* (Reuss) and *Globigerinoides Disphericus Todd* (identified by A. Hakyemez) confirm this ageassigment. The age of the formation has been accepted as Burdigalian.

Depositional Environment.- The continental parts of the formation indicate alluvial fan (Şenel et al., 1992, 1996), whereas the marinal levels reflect shallow marine environment. Karabıyıkoğlu et al., (1996, 1997, 2000) pointed out that, the deposits indicate facies characteristics of alluvial fan-fan delta environment.

Altınkaya formation

Definition an nomenclature.- The all basal conglomerates developed during different stages of Miocene in Antalya Miocene basin were considered under the name of Aksu formation and have been dated as Oligocene-Tortonian by Akay and Uysal (1984) and Akay et al., (1985). Şenel et al., (1992, 1997b, 1998) considered the continental conglomerates, developed at the base of Upper Burdigalian - Langhian units, as the Sevinç conglomerates and Tortonian conglomerates as the Aksu formation. They also named the conglomerates deposited during Late Burdigalian-Langhian time interval at northeastern part of the basin as Aksu formation. Dumont (1976) considered the same unit as the Kesme conglomerates. In this study, this unit not differentiated from Aksu formation will be considered as Altınkaya formation.

Type section locality.- It is not possible to observe the whole formation in one locality. The type section locality has been chosen along the road continues towards Altınkaya village (historical Selge city and theatre) located at northwest of Beşkonak.

Reference section localities.- These are Ute Asağıyaylabel section (Isparta M26c4) located 2.5 km to the northwest of Yaka village and Hocalarsırtı section (Isparta N26b1) situated at Hocalarsırtı ridge 1 km to the south of . Karakaya. The formation is also observed along the road continued from Ballıbucak village towards east (Köprüçay) (Isparta N26a4) and along the road between Kesme and Yeşilbağ village and north of Yeşilbağ village (Isparta M26c4).

Lower-Upper boundary relations.- The formation unconformably overlies the Antalya nappes, Beydağları-Karacahisar autochthone and Anamas-Akseki autochthone at northeastern parts of the basin. At central parts of the basin, it is laterally interfingering with turbiditic deposits of the Karpuzçay formation. This boundary relationship is best observed in Köprülü Canyon. The Aksu formation unconformably overlies the Altınkaya formation (Brunn etal, 1971).

Lithology.- The dominant lithology in the formation is the marinal conglomerates. In some levels, the sandstone, shale, claystone and sometimes reefal limestones are also present. The conglomerates are generally sandy conglomerate and pebbly sandstone in types and they are dark gray colored, welllithified, carbonate cemented and the pebbles are radiolarite, chert and limestone in origine. In Aşağıyaylabel section, the formation transgressively overlies the Anamas-Akseki autochthone and starts with marinal conglomerates at the base and succeded up by yellow colored silty fine-grained sandstones, transitional to reefs. Upwards, the marinal units with brackish water levels intercalate once more and the sequence ends regressively. The sequential development like Aşağıyaylabel section was also observed in Hocalarsırtı section. In this case, the thickness of coral reefs and intercalated underlying conglomerates can not be measured due to unsuitable topograp-

hic conditions. Also their boundary relation with basement rocks were not observed. The observable lowermost part of the section starts with 1 m thick marinal conglomerates, overlain by the 22 m thick sandstone, greenish gray colored claystone. The sandstone beds are 10-30 cm in thickness and become more thicker at upper part. The 80 cm thick, small pebbly fine-grained sandstone bed with scored base, overlies overlying this level. The sequence continues with 2 m thick greenish gray colored claystone. As it is explained below, the section is rich in molluscan fauna representing brackish water-marine conditions with nearly the same salinity of marine water.

The H1 sample is rich in molluscan fauna representing brackish water - marine environment in this unit. It yields *Tinostoma woodi* (Homes), *Pirenella gamlitzensis gamlitzensis* (Hilber), *Terebralia bidentata cingulatior* Sacco, *Terebralia lignitarum* (Eichwald), *Terebralia lignitarum lignitarum* (Eichwald), *Terebralia subcorrugata* d'Orbigny and *Cerithium (Ptychocerithium) turhtoplicatum* Sacco of class Gastropoda; *Gastrana fragilis* (Linne), *Sanguinolaria (Soletellina) labordei* (Basterot), *Pelecyora (Cordiopsis) islandicoides* Lamarck, *Pelecyora (Cordiopsis) polytropa suborbicularis* (Goldfuss) and *Irus (Paphirus) gregarius* Partsch from class Bivalvia. Based on these molluscan fauna, this part of the section represents the stage of Upper Burdigalian (Karpation) (Table 1a, 1c). The accumulation of thick and coarse shell fragments (20-35 cm) of *Crassostrea gryphoides* (Schlotheim) bearing fine-grained siltstones conformably overly this unit. With this level, the Langhian (Early Badenian) starts and it can be also correlated with A14 sample numoer of Aşağıyaylabel and S3-S4-S5 sample numbers of Altınkaya measured sections. This level is succeded up by 2-4 m thick fine-grained pebbly coarse sandstones. It continues upward with 80 cm thick greenish gray claystone, 40 cm thick matrix-supported conglomerates, 70 cm thick fine-grained sandstone with clay intercalation, 2.2 m thick green-blue colored fine grained clayey sandstone and 3 m thick green-blue colored claystones with thin coal seams. At uppermost part, the 2 m thick matrix-supported conglomerates were observed.

The thin coal seams developed within the formation are similar to the levels in the Altınkaya and Hocalarsırtı sections.

Thickness and distribution.- It is about 600 m, although the thickness changes laterally.

Fossil content and age.- The moluscan fauna, found within sections measured from different localities of Altınkaya formation, indicate generally Upper Burdigalian - Langhian (Ottnangian-Karpatian-Lower Badenian) age also supported by the other faunas.

The molluscan fauna hasn't been found at lowermost part of Altınkaya section. However, in the sandstone-marl intercalations of this level, the nannoplankton flora such as *Coccolithus pelagicus* (Wallich), *Sphenolithus conicus* Bukry, *Cyclicargolithus abisectus* (Muller), *Calcidiscus leptoporus* (Murray-Blackman), *Dictyococcites productus* (Kamptner), *Dictyococcites bisectus* (Hay-Mohler-Wade), *Reticuloenestra umblica* (Levin) and *Coronocyclus nitescens* (Kamptner) were detected. This flora indicate and give the Lower Miocene age (identified by H. Karakullukçu). In the same unit, rare planktonic foraminifera was found such as *Globigerinoides bispherícus* Todd which is known to be appeared in Early Burdigalian (identified by A. Hakyemez). For this part of the section mentioned above, althought there is no presence of the molluscan fauna, considering its stratigraphic position and the presence of nannoplankton assemblage and planktonic foraminifer fauna,

its age was accepted as Upper Burdigalian (Ottnangian-Karpatian). After a 5 m thick covered interval, 50 cm thick ctaystones with thin coal seams were observed. Upward, yellow colored, silty fine grained sandstone (S3) containing 70-80 cm thick accumulations of the Crassostrea gryphoides (Schlotheim) of class Bivalvia are present. For this level, the age of the sequence was accepted as Langnian (Lower Badenian) based on the presence of the *Crassostrea gryphoides* (Schlotheim). Overlying this level, the section continues with nearly 280 m thick marine conglomerates and ends with 6 m thick coral reefs observed around antique theatre. Within the S6 sample number of coral reefs as *Ostrea lamellosa* Brocchi, *Spondylus crassicosta ornatulina* Sacco and *Venus (Venus) excentrica* Agassız were identified. This fauna also indicate the Langhian (Lower Badenian) age. At the lowermost part of the Aşağıyaylabel section, the identified Gastropods are *Turritella (Turhtella) rricarinata* (Brocchi), *Turritella (Archimediella) bicarinata* Eichwald, *Chrysallida (Parthenina) mterstincta* (Montagu) and *Cerithium (Tiaracerithium) pseudotiarella* D'Orbigny which the last one became extinct at the end of Burdigalian. This unit also includes benthic foraminifera as *Borelis* sp., *Elphidium* sp., Miliolidae (identified by E. Sirel) and ostracoda as *Aurila) cicatricosa* (Reuss) survived in neritic environment and widely distributed in Middle-Upper Miocene (identified by M. Duru). The yellow colored silty sandstones are transitional to 6 m thick and 40 m wide reefal limestones. Sample A2 collected from this level contains *Heliastraea* sp., *Stylophora reussina* (Montarano-Galitelli) like coral fauna (identified by S. Babayiğit). Also in sample A2a, the benthic foraminifera (A3) as *Borelis melo* (Fichtel and Moll) and *Borelis curdica* (Reichel) (identified by E. Sirel), indicate the Upper Burdigalian-Tortonian age and marine environment with low salinity. In the overlying reefal limestones (sample A4), the *Tarbellastraea reussiana* (Milne Edwards and J. Haime) and *Favites neglegta* (Michelotti) corals were found (identified by S. Babayiğit). The sequence continues with 60 cm thick clayey limestone and 5 m thick limestone including Porites sp fragments. In this level a sample as A6 many Gastropoda representing low-salinity marine environment as *Neritine picta* (Ferussac), *Hydrobia (Hydrobia) frauenfeldi frauenfeldi* (Hoernes) and *Tinostoma woodi* (Hoernes) were found. In the sample A7 taken from 3 m thick clayey limestone, Bivalvia as *Ostrea lamellosa* Brocchi, corals as *Siderastraea crenulata* (Goldfuss) *Porites* sp. (identified by S. Babayiğit) and ostracoda as *Bairdia* sp. (identified by M. Duru) were found.

After 2 m thick cover, light greenish gray colored, 2 m thick fine grained pebbly, silty clay overlies the unferlying levels. In the sample A8, the corals as *Siderastraea crenulata* (Goldfuss), *Sedirastraea miocenica* (Osasco) and *Porites collegniana* (Michelin) were found (identified by S. Babayiğit). The level of sample A9 taken for nannoplankton is 70 cm thic and is composed of greenish gray colored, parallel laminated clay stone containing no nannoplanktons. The section continues with light yellow colored, 60 cm thick clayey siltstone. Sample A10 taken from this level yielded following marine Gastropod fauna are *Alvania ispartaensis* n.sp., *Alvania (Alvania) curta* (Dujardin), *Alvania (Alvania) venus* d'Orbigny), *Triphora adversa miocenica* Cossmann ve Peyrot, *Turritella (Turritella) tricarinata* (Brocchi), *Turritella (Zaria) spirata* (Brocchi), *Cerithium (Thericium) vulgatum miocenicum* (Vignal), *Cerithium (Thericium) europaeum graciliornata* (Sacco), *Cerithium (Ptychocerithium) turritoplicatum* Sacco, *Conus conoponderosus* (Sacco) and *Conus striatulus* Brocchi. The sample A11 taken from greenish gray colored 1.6 m thick clays with

thin clayey limestone intercalation also yielded Gastropoda as *Neritina picta* (Ferussac), *Hydrobia (Hydrobia) frauenfeldi frauenfeldi* (Hoernes) characterizing brackish water-marine environment. No fauna was found in yellowish colored 10 cm thick carbonate cemented sandstone (A12 sample).

Towards the upper part of the section is represented by greenish gray colored, 1.1 m thick, thin laminated claystones and continues with yellow colored, 10 cm thick, carbonate cemented sandstone. The greenish gray colored 4 m thick claystones with increasing sandstone intercalations are succeded up by yellow colored, parallel lamimated 2.5 m thick coarse-grained pebbly sandstones with scored bases. Within the 1 m thick greenish gray claystone the identified Gastropods are *Neritina picta* (Ferussac), *Terebralia* sp. and *Valvata* sp. (sample A13) which also characterizing the low salinity marine conditions. The section continues with yellow colored, carbonated, sandy siltstone. In thp 1 m interval of yellow colored silty sandstone, the Gastropoda fauna as *Turritella (Turritella) thcarinata tricarinata* (Brocchi), *Turritella (Turritella) turris* Basterot and *Polinices (Polinices) redemptus* (Michelotti) indicating the marinal conditions were found (A14). This part of the section was dated as Upper Burdigalian (Ottnangian-Karpatian) based on this fauna (Table 1).

From this level upward, the sequence includes Bivalvia as *Crassostrea giyphoides* (Schlotheim) which can survive in very low salinity environments. The other species are the *Ostrea lamellosa* Brocchi and *Pycnodonte germanitala* (De Gregoria) which their shell fragments accumulated in 70 cm thick siltstone and adopted themselves to salinity changes in environment. Uppermost part of the sequence is characterized by 5 m thick marinal conglomerates. The age of this part of the section has been accepted as Langhian (Lower Badenian) based on the molluscan fauna.

The sample H1 in Hocalarsırtı section is rich in moluscan fauna which represents the low salinity marine environment. The identified Gastropods are *Tinostoma woodi* (Hornes), *Pirenella gamlitzensis gamlitzensis* (Hilber), *Terebralia bidentata cingulatior* Sacco, *Terebralia lignitarum* (Eichwald), *Terebralia lignitarum lignutarum* (Eichwald), *Terebralia subcorrugata* d'Orbigny and *Cerithium (Ptychocerithium) turritoplicatum* Sacco. The Bivalves are *Gastrana fragilis* (Linne), *Sanguinolaria (Soletellina) labordei* (Basterot), *Pelecyora (Cordiopsis) islandicoides* Lamarck, *Pelecyora (Cordiopsis) polytropa suborbicularis* (Goldfuss) and *Irus (Paphirus) gregahus* Partsch. Based on the mentioned molluscan fauna, the age of the section at this level was assigned as Upper Burdigalian (Karpatian) (Table 1a-b-c). The Langhian (Lower Badenian) starts with the *Crassostrea giyphoides* (Schlotheim) found as accumulation of thick and coarse shell fragments (20-35 cm) overlying the basal level. This level can be correlated with other measured sections in the basin, such as, sample A14 of Aşağıyaylabel and sample S3, S4 and S5 of Altınkaya measured stratigraphic sections.

Depositional environment.- The Altınkaya formation contains molluscan fauna which generally indicates the low salinity brackish water-marine environments. Especially, in Hocalarsırtı and Aşağıyaylabel sections the euryhaline mollusc species survive in low salinity environment were detected in greenish gray colored claystones. In this sections, also in the Altınkaya section, the accumulation of shell fragments of the *Crassostrea giyphoides* (Schlotheim) were detected which developed in much lower salinity environments (Cox et al., 1969). These levels are intercala-

ted with marinal units. The intercalations of molluscan fauna representing low salinity marine environment and small-scale coral reefs indicate tidal changes in sea level throughout the time. This change is especially well-observed in Aşağıyaylabel section. The benthic foraminifera encountered within sandy limestones of this section are *Borelis melo* Fichtel and Moll and Miliofidae representing back reef-lagoon environmental conditions (identified by E. Sirel).

In the formation, similar to the Altınkaya section, the nannoplanktons and planktonic foraminifera implying the deeper and more saline environmental conditions were found. As it is seen from the Altınkaya and Aşağıyaylabel sections the presences of algae and small patchy reefs indicates the marine environment.

The geochemical analyses were carried out on shell fragments of molluscs found in Hocalarsırtı, Aşağıyaylabel and Altınkaya sections to interprete the paleoecological conditons. These analyses also imply the presence of cold and low saline marine water conditions (İslamoğlu, 2001). The faunal data from the formation also support this idea. Although the euryhaline molluscs are abundant, the stenohaline nannoplanktons and planktonic foraminifera are not abundant and diverse in the section (Flecker et al. 1995 and Hakyemez, 2001, personal communication). It is observed that, the types and number of diversity are less and the wall structures of the planktonic foraminifera were destroyed (Hakyemez, personal communication). This is interpreted that, the environmental salinity and temperature conditions were not suitable for the surviving of planktonic foraminifera.

The Oymapınar limestone

Definition and nomenclature.- Oymapınar limestone as a formation was first given by Monod (1977). It was previously named as Burdigalian limestone by Altınlı (1943) and Miocene limestone facies by Blumenthal (1951). Later, Derman (1977) and Aköz (1981) used the name as Sakseydi limestone and Naz et al., (1992) considered it under the name of Oymapınar formation. Akay and Uysal (1984), Akay et al. (1985) and Şenel et al., (1992, 1996) adopted and used the same name as Oymapınar limestone.

Type-section locality.- It is located at slope of Manavgat stream, 3 km north of Oymapınar.

Reference sections.- Two reference sections sections are observed; one is located at 4.5 km northwest of Taşağıl, the Radioring and the other is situated about 700 m southeast of Ballıbucak village, the Ballıbucak section.

Lower-Upper boundary relations.- This unit unconformably overlies the Alanya nappe, Antalya nappes and Anamas-Akseki autochthone and conformable over the Sevinç conglomerate. The Oymapınar limestone is conformably overlain by the Çakallar formation at southeast of the basin and Geceleme formation in Oymapınar section. It is unconformably overlain by the Aksu formation in Ballıbucak section.

Lithology.- The Oymapınar limestone is composed of medium-thick bedded, polygenic base conglomerate, sandstone, white-gray colored hard, sandy limestone, algal limestone, massive limestone, coral-algae reefal limestone and mudstone. It sometimes starts with conglomerate or sandstones and continues with reefal limestone and with massive limestones. The sequence in Oymapınar section transgressively overlies the Alanya nappes and it starts at the base with 20 m thick, red colored poorly sorted and angular conglomerates (Fig. 3). The limestone brecci-

as are exposed following the conglomerates at the slope face to measured section locality. These breccias indicate the tectonic activity which is known to be developed at the beginning of the Miocene in the region (Akay et al., 1985; Şenel et al., 1992, 1996). The terrestrial conglomerates are followed by greenish yellow colored, small pebbly 1.55 m thick sandstones. These are succeded up by green colored, 60 cm thick claystones and greenish yellow, 1.8 m thick, semi-lithified siltstones.

In Alarahan section, the topmost 10 m is represented by white-gray colored very hard, massive, algae limestones which are the Oymapınar limestone (Fig. 2).

In Radioring section, the Oymapınar limestone overlies conformably the 5 m thick marinal conglomerates and continues with 2 m thick, algae, distributed pebbly, sandy limestone (Fig. 4).

In Ballıbucak section, the sequence again starts transgressively and at the base it contains thick, massive, sandy, poorly sorted, grain-supported conglomerates. It continues with 3 m thick, small pebbly, bioclastic limestone containing coral and mollusc fragments. In sample B1 of this level, the *Ostrea* sp. was found. Upward, the sequence continues with 10 m thick sandy limestone and marl alternation.

Thickness and distribution.- Although the thickness is changeable, it reaches up to 100 m.

Fossil content and age.- The molluscan fauna identified in the Oymapınar limestone indicate generally Upper Burdigalian-Langhian (Karpatian-Lower Badenian) age (Table 1). The Bivalve as *Pitar (Pitar) rudis* (Poli) and Gastropod as *Terebralia* sp. found in sample O2 reveal the shallow marine environment. The sequence continuing with green colored, 50 cm thick clays with coal seams, is later transitional to light colored, 3 m thick massive sandy limestones. The sample O3 from this level contains *Pecten fuschi* Fontannes, *Chlamys (Aequipecten) scabrella bollenensis* (Mayer). *Venus (Ventricoloidea) multilamella* (Lamarck) characterizing also marine environment. Overlying this level, is the 27 m thick, sometimes claystone intercalated with hard, massive algal limestones. Sample O4 in this unit includes planktonic foraminifera *Catapsydrax* sp., *Globigerinoides trilobus* (Reuss) representing Burdigalian age (identified by A. Hakyemez). Based on these data, it is accepted that this part of the sequence represents the Upper Burdigalian (Karpatian) stage (Table 1).

At the locality of Oymapınar section, the olistoliths derived from coral reefs of the Oymapınar limestone are found in Geceleme formation. The thin sections prepared from the samples of this olistolits indicate Upper Burdigalian - Tortonian age based on the benthic foraminifera suchs as *Borelis melo* (Fichtel and Moll), *Borelis* cf. *curdica* (Reichel), *Amphisteginasp., Planorbulinella* sp., *Lepidocyclina* sp., *Operculina* sp., Miliolidae, Rotaliidae, Victoriellidae (identified by E. Sirel). The fauna also confirms the Upper Burdigalian (Karpatian-Lower Badenian) age formation the Oymapınar limestone in this section.

In Alarahan section, the uppermost parts of the formation were dated as Langhian based on planktonic foraminifera. These levels indicate that the environment was deeper Gastropod and Bivalve fauna were not detected there. However, there was abundance of planktonic foraminifera, the sample A5 includes *Praeorbulina glomerosa glomerosa* (Blow), *Praeorbulina glomerosa curva* (Blow)

and *Praeorbulina sicana* de Stefani which characterizing the transition to Langhian (identified A. Hakyemez). The *Praeorbulina* sp. appeared at the beginning of the Middle Miocene and indicates a great distribution both Mediterranean Tethys Langhian and Central Paratethys Lower Badenian (Steininger and Rogl, 1984; Rogl, 1998). Although it was not found in Alarahan section, the presence of turbiditic deposits of Serravalian and Tortonian in the region has been determined in the other studies (Öztümer, 1974; Akay ve Uysal, 1984; Akay ve dig., 1985; Naz ve diğerleri, 1991, 1992; Şenel, 1996). The sample R1 in Radioring section is taken from 2 m thick algae pebbly, sandy limestone and benthie foraminifera assigning to Upper Burdigalian-Tortonian age were found in this level. These are *Borelis* cf. *melo* (Fichtel and Moll). *Borelis curdica* (Reichel), *Planorbulinella* sp., *Textularia* sp., *Amphistegina* sp. (identified by E. Sirel). 22 m Thick coral and algae reefal limestone overlies this level. The sample R2 also includes benthic foraminfera as *Borelis* cf. *melo* (Fichtel and Moll), *Amphistegina* sp., *Textularia* sp., *Operculina* sp., *Archaias* ? sp., Miliolidae (identified by E. Sirel) Later, it is 10 m thick, white colored limestone with rodolithes (identified by. N. Atabey) and the section ends with 1 m thick yellow colored sandstone. In sample R3 of this level, the following molluscan fauna were found; *Anadara (Anadara) diluvii pertransversa* Sacco, *Chlamys (Aequipecten) scabrella bollenensis* (Mayer), *Tellina (Peronaea) planata* Linne, *Venus (Ventricoloidea) multilamella* (Lamarck), *Carditamera (Lazariella) striatellata* (Sacco), *Cardiocardita* cf. *monilifera* (Dujardin), *Acanthocardia (Acarthocardia) turonica* (Mayer), *Cardium kunstleri* Cossmann ve Peyrot, *Tellina (Peronidia) planata* Linne, *Venus (Ventricoloidea) multilamella* (Lamarck), *Dosinia lupinus* (Linne). These fauna represent marine environment and indicate Upper Burdigalian (Karpatian) age. They include both Mediteranean Tethys and Central Paratethys species. For this reason, the age of the section was estimated as Upper Burdigalian (Karpatian) based on the molluscan fauna (Table 1).

In Ballıbucak section, within sample B2, the Bivalves and Gastropods characterizing marine environment were found. The Bivalves are *Anadara (Anadara) diluvii* (Lamarck), *Chlamys (Aequipecten) scabrella bollenensis* (Mayer), *Codakia leonina* (Basterot), *Acanthocardia (Acanthocardia) turonica* (Mayer), *Tellina (Peronaea) planata* Linne, *Megaxinus bellardianus* (Mayer) whereas the Gastropod is-*Athleta ficulina* (Lamarck). At the basal part of the 15 m thick massive algae-coral reefal limestone Miliolidae was obtained (Sample B3). After this level, again at the lower part of the 15m thick limestones, the *Heterostegina* sp., Miliolidae type benthic foraminifera were obtained and algal abundance increase towards up the section. The sequence foraminifera were obtained and algal abundance increase towards up the section. The sequence continues with 3 m thick marls and 20 m thick reefal limestone where the algae and corals become abundant. The age of the this part of the section was accepted as Upper Burdigalian (Karpatian) based on the molluscan fauna (Table 1). The 15 m thick conglomerates unconformably overlie the limestone levels. These conglomerates are conglomerate could be suggested as Tortonian due to its stratigraphical position. It can be assumed that this formation formed in transgressive and reefal conditions.

Depositional environment.- The formation is generally reflecting transgressive and reefal characteristics.

Table 1 a- Ranges of the molluscan fauna determined in the Antalya Miocene basin

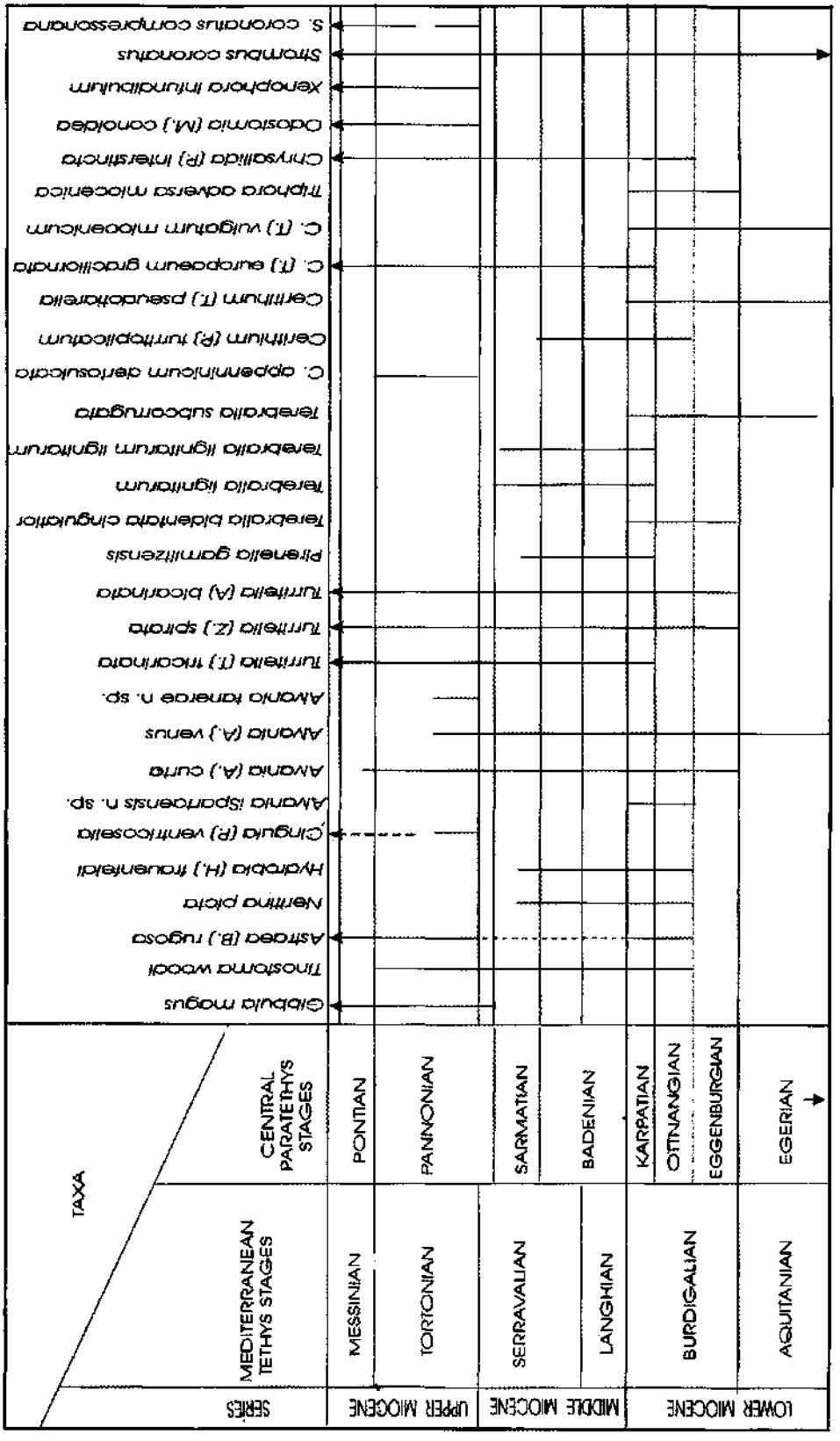


Table 1 b-

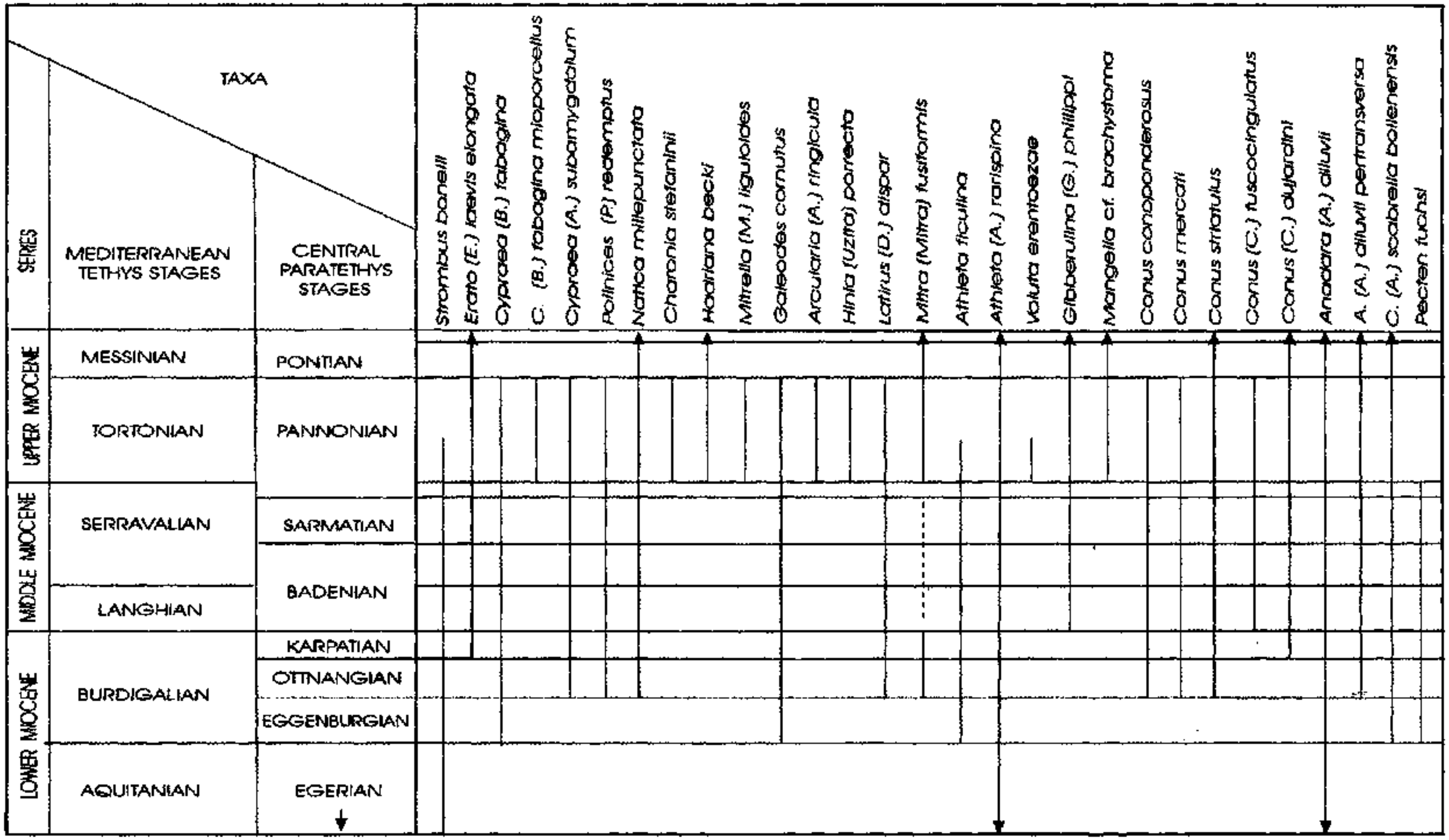
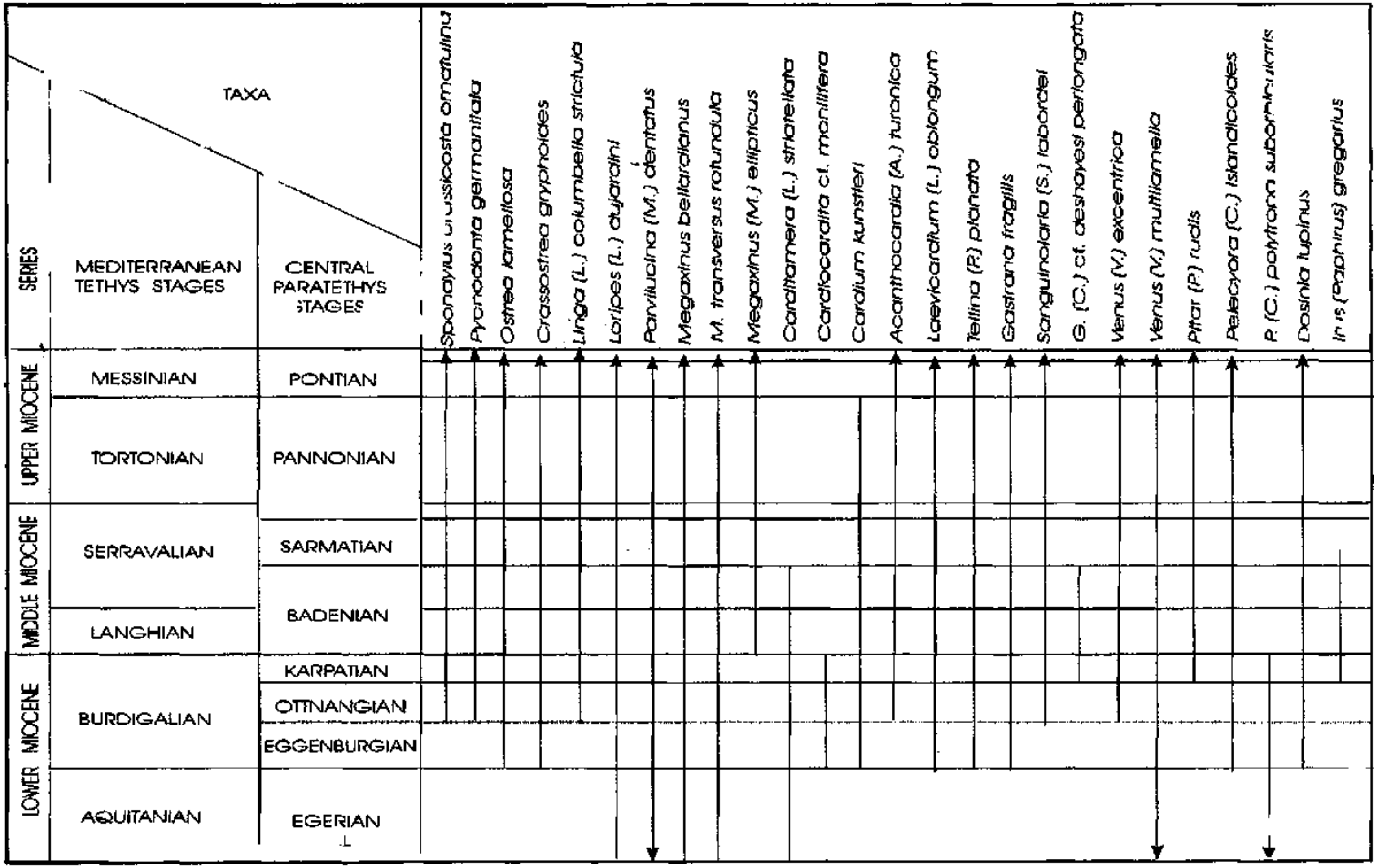

TAXA
SERIES
MEDITERRANEAN TETHYS STAGES
CENTRAL PARATETHYS STAGES
UPPER MIOCENE
MIDDLE MIOCENE
LOWER MIOCENE
MESSINIAN
TORTONIAN
SERRAVALIAN
LANGHIAN
BURDIGALIAN
AQUITANIAN
PONTIAN
PANNONIAN
SARMATIAN
BADENIAN
KARPATIAN
OTTNANGIAN
EGGENBURGIAN
EGERIAN
Strombus bonelli
Erato (E.) laevis elongata
Cypraea (B.) fabagina
C. (B.) fabagina miopporcellus
Cypraea (A.) subamygdalum
Polinices (P.) redemptus
Natica millepunctata
Charonia stefaninii
Hadriana becki
Mitrella (M.) liguloides
Galeodes cornutus
Arcularia (A.) ringicula
Hinia (Uzita) porrecta
Latirus (D.) dispar
Mitra (Mitra) fusiformis
Athleta ficulina
Athleta (A.) rarispina
Voluta erentoezae
Gibberulina (G.) philippi
Mangelia cf. brachystoma
Conus conoponderosus
Conus mercati
Conus striatulus
Conus (C.) fuscocingulatus
Conus (C.) dujardini
Anadara (A.) diluvii
A. (A.) diluvii pertransversa
C. (A.) scabrella bollenensis
Pecten fuchsi

Table 1 c-


TAXA
SERIES
MEDITERRANEAN TETHYS STAGES
CENTRAL PARATETHYS STAGES
UPPER MIOCENE
MIDDLE MIOCENE
LOWER MIOCENE
MESSINIAN
TORTONIAN
SERRAVALIAN
LANGHIAN
BURDIGALIAN
AQUITANIAN
PONTIAN
PANNONIAN
SARMATIAN
BADENIAN
KARPATIAN
OTTNANGIAN
EGGENBURGIAN
EGERIAN
Pycnodonta germanitala
Ostrea lamellosa
Crassostrea gryphoides
Linga (L.) columbella stricta
Loripes (L.) dujardini
Parvilucina (M.) dentatus
Megaxinus bellardianus
M. transversus rotundula
Megaxinus (M.) ellipticus
Carditamera (L.) striatellata
Cardiocardita cf. monilifera
Cardium kunstleri
Acanthocardia (A.) turonica
Laevicardium (L.) oblongum
Tellina (R.) planata
Gastrana fragilis
Sanguinolaria (S.) labordei
G. (C.) cf. deshayesi perlongata
Venus (V.) excentrica
Venus (V.) multilamella
Pitar (P.) rudis
Pelecyora (C.) islandicoides
Dosinia lupinus

The Çakallar formation

Definition and nomenclature.- Akay and Uysal (1984) and Akay et al., (1985) defined this unit which is composed of breccia limestone. It is onlyobserved at southeast part of Antalya Miocene basin.

Type section locality.- This unit is cropped out at eastern part of the basin and its type locality is at the eastern slope of Alara stream to the west of Çakallar.

Lower-Upper boundary relations.- It conformably overlies Oymapınar limestone with a sharp contact relation.

Lithology.- It is brecciated and represented by beige-dirty yellow colored, clayey limestone-limestone alternations.

Thickness and distribution.- The unit is about 80 m thick and displays a lenticular geometry.

Fossil content and age.- No age data has been found in the unit. Since it is overlying the Upper Burdigalian Oymapınar limestone and underlying the Geceleme formation, its age was accepted as Upper Burdigalian-Lower Langhian.

Depositional environment.- It reflects the slope environmental conditions.

The Geceleme formation

Definition and nomenclature.- The unit was firstly named as Geceleme marls by Blumenthal (1951), Monod (1977), Akay and Uysal, (1984); Akay et al., (1985); Şenel et al., (1992); Naz et al., (1992) adopted the same name.

Type section locality.- The type locality of the unit is located at 1 km north of Gençler village.

Reference section.- It is partly observed in Oymapınar section.

Lower-Upper boundary relations.- Geceleme formation crops out only in the southeast part of the basin and it lies conformably between Oymapınar limestone and çarpuzcay formation. At southeast of the basin, it is transitionally overlying the Çakallar formation.

Lithology.- The formation is generally composed of marls and clayey limestones. The thinmedium bedded, light gray, greenish gray, green, dark colored clayey - sandy limestone, claystone and siltstone levels are also observed. In the Oymapınar section, the Geceleme formation is represented by 1.3 m thick, light gray colored marls and continues with 30 m thick, sandstone intercalated marl. It also contains limestone blocks derived from Oymapınar limestone.

Thickness and distribution.- The thickness of the unit was measured as 410 m by Akay etal., (1985).

Fossil content and age.- The identified fossils are the Bivalves and Gastropods. The age of the formation was accepted as Langhian based on the microfossil assemblage. In Oymapınar section, the sample O5 yields *Helicosphaera kamptneri* Hay-Mohler, *Cyclicargolithus abisectus* (Muller), *Calcidiscus leptoporus* (Murray-Blackman), *Dictyococites productus* (Kamptner), *Dictyococites bisectus* (Hay-Mohler-Wade), *Sphenolithus heteromorphus* Deflandre, *Coccolithus pelagicus* (Wallich) and *Pontosphaera* sp. like nannoplanktons of biozones NN5 (Langhian-Lower Serravalian) (identified by H. Karakullukçu and E. Erkan) and planktonic foraminifera *Praeorbulina glomerosa glomerosa* (Blow) characterizing Langhian age (identified by A. Hakyemez). After 1.2 m thick sandstone level, the 2 m thick marls are observed. In this level, again *Helicosphaera kamptneri* Hay-Mohler, *Sphenolithus heteromorphus* Deflandre, *Sphenolithus conicus* Bukry, *Sphenolithus compactus* Backman, *Dictyococites produc-*

tus (Kamptner), *Dictyococcites antarcticus* Haq, *Coccolithus pelagicus* (Wallich7, *Braarudosphaera bigelowi* (Gran-Braarud). *Dis*coasfersp. corresponding to NN5 biozone of nannoplankton flora are present (Langhian-Lower Serravalian) (identified by H. Karakullukçu, E. Erkan). Based on these data of the age was accepted as Langhian.

Depositional environment.- The presence of abundant planktonic foraminifera and nannoplankton flora, reveals relatively deep marine environment.

The Karpuzçay formation

Definition and nomenclature.- Previously defined units such as flysch and conglomerate (Altınlı, 1943), partly Beşkonak formation (Eroskay, 1968), Manavgat molasse (Monod, 1977) Kargı molasse (Poisson, 1977) have been combined under the name Karpuzçay formation by Akay and Uysal (1984), Akay et al., (1985) which is best observed along the Karpuzçay stream.

Type section locality.- The type section of the formation strats at 2 km west of Gençler village and continues along the ridge located between two branches of Karpuzçay stream.

Lower-Upper boundary relations.- The unit is widely cropped out in all parts, of the basin. It conformably overlies Oymapınar limestone and Geceleme formation at central and southeastern part of the basin respectively. At the west of the basin, it is overlain by Aksu formation, in other parts it is, either unconfortnably overlain by Pliocene rock units or exposed as recent erosional surface.

Lithology.- It is cdmposed of gray, green greenish gray, beige, dirty yellow colored, thinmedium-thick-bedded sandstone, conglomerate, siltstone, claystone and detritic limestones.

Thickness and distribution.- It has a variable thickness throughout the basin. It was measured as 2050 m between Kızıldağ-Karabekir.

Fossil content and age.- It was not studied in detail because of absence of molluscan fauna. Based on its planktonic foraminifera and nannoplankton contents, its age was accepted as Upper Burdigalian-Tortonian.

Depositional environment.- The presence of synsedimentary fold and slump structures implies turbiditic characteristics.

The Aksu formation

Definition and nomenclature.- In the region, the Tortonian molassic conglomerates has been considered as Aksu conglomerate by Poisson (1977) and Aksuçayı formation by Akbulut (1977). Akay and Uysal (1984) and Akay et al. (1985) defined the unit as Aksu formation, since they mapped the conglomerates over and under the unconformity plane below Langhian age. However, they were unable to separate these conglomerates. Naz et al., (1992) defined this unit as the Aksu member of Karpuzçay formation. Şenel et al., (1992, 19976, 1997c) mapped and defined the Tortonian rock units as Aksu formation. In this study based on the Poisson (1977) and Akbulut (1977) definitions, the name Aksu formation is adopted, since the type section of molassic deposits is located along Aksu stream. Due to stratigraphic and faunal environmental differences of the unit, the "Aksu formation" definition applied for whole basin by Akay and Uysal (1984) and Akay et al., (1985) should be separated and the "Aksu formation" definition must be used for Serravalian-Tortonian molassic deposits which are exposed at west of the basin.

Type section locality.- The type section of the formation is best observed at junction of Sinne stream with Aksu stream in Eskiköy village (Akay et al., 1985).

Reference section.- It is also observed in Kargı section.

Lower-Upper boundary relations.- The Aksu formation unconformably overlies the basement at the locality 5 km to the southwest of Kargı tunnel. It is conformably overlying the Karpuzçay formation. Its relation with Altınkaya formation has not been differentiated yet. In the region, the presence of a unconformity is known between Lower-Middle Miocene and Tortonian (Brunn et al., 1971).

Lithology.- It is generally composed of alternations of red, reddish brown, yellowish green colored, thick bedded, molassic sandstone and conglomerates. At some levels, the dark gray, brown colored marls and sandstones, gray colored limestones, algae and coral reef limestones and locally very thin coal seams are also present.

The reddish brown colored conglomerate-sandstone alternation forming the lower part of the formation is considerably thick and observed along the road arrived Kargı. It was not measured as no fossil record was obtained in this unit.

The Kargı section starts at the base with 3 m thick altenations of conglomerate, sandstone and mudstone. No fossils was observed from this level (sample K1). Over this level, me 11 m thick, massive, gray colored, algae and coral reefal limestone succeds. The sample K2 taken from this unit yields Tortonian age based on the Molluscan fauna as *Pontes lobatosepta* (Chevalier), *Tarbellastraea siciliae* (Chevalier), *Tarbellastraea reussiana* (Milne-Edwards and J. Haime), *Siderastraea crenulata* (Goldfuss), *Tarbellastraea* sp., *Aquitanastraea* sp. and in the K3 sample taken from uppermost of reefal limestone, continues with 30 cm thick yellow colored sandstone. In the sample K4 of this level, the Gastropods are represented by *Cypraea (Bernaya) fabagina* (Lamarck), *Gibberulina (Gibberulina) , philippi* (Monterosato), *Conus conoponderoSus* (Sacco), *Conus mercati* Brocchi, *Conus (Conolithus) dujardini* Deshayes and *Terebralia* sp., *Cerithium* sp. The following level is the 64 cm thick gray colored mudstone in which *Cerithium* sp. was obtained (K5).

Overlying this level is the gray colored. 17 cm thick mudstone with, laminated coal seam. In this level (sample K6), Gastropods as *Alvania (Alvania) curta* (Dujardin), *Chrysallida (Parthenina) interstincta* (Montagu), *Odostomia (Megastomia) conoidea* (Brocchi), *Valvata* sp., *Cerithium* sp. *Alvania (Alvania) curta* (Dujardin), *Chrysallida (Parthenina) interstincta* (Montagu), *Odostomia (Megastomia) conoidea* (Brocchi), *Valvata* sp., and *Cerithium* sp. were determined.

After 7 cm thick, white colored clay level, the *Cerithium* sp.was found (K7) within 60 cm thick, gray colored mudstones with coal seam. In the overlying 30 cm thick fine-grained sandstone, the *Chrysallida (Parthenina) interstincta* (Montagu), *Cerithium* sp. of class Gastropoda and *Tellina (Peronaea) planata* Linne of class Bivalvia were identified (K8).

The sample K9 was taken from the level which is represented by 4 cm thick, white colored lenticular claystone followed by 5.5 m thick, coarse grained pebbly sandstones. The (K9) sample yields *Astraea (Bolma) rugosa* (Linne), *Cypraea (Adusta) subamygdalum* d'Orbigny, *Conus conoponderosus* (Sacco), *Conus (Conolithus) dujardini* Deshayes of class Gastropoda and *Tellina (Peronaea) planata* Linne of class Bivalvia. The gray colored, massive, algae and coral reefal limestones 4.5 m thickness overly the conglomerates. The sample K10 and K11 were collected from this level and they contain the corals, as *Porites lobatosepta* (Chevalier), *Tarbellastraea siciliae* (Chevalier), *Favites neglegta* (Michelotti), *Aquinastraea* sp., *Porites* sp. implying Tortonian age (determined by S. Babayiğit).

The brown-colored, 2.5 m thick mudstone overlies the reefal limestone. Many gastropods and bivalvia were obtained from sample K12 taken from mudstone level. Gastropods are *Astraea (Bolma) rugosa* (Linne). *Tinostoma woodi* (Homes), *Alvania (Alvania) curia* (Dujardin), *Alvania (Alvania) venus* (d'Orbigny), *Alvania tanerae* n. sp., *Turritella (Zaria) spirata* (Brocchi), *Turritella (Archimedielrdi bicarinata* (Eichwald), *Chrysallida (Parthenina) interstincta* (Montagu), *Erato (Erato) laevis elongata* Sacco, *Natica millepunctata* Lamarck, *Arcularia (Arcularia) ringicula* (Bellardi), *Mangelia brachystoma* (Philippi), *Conus conoponderosus* (Sacco), *Conus mercati* Brocchi and *Cerithium appenninicum dertosulcata* Sacco whereas. The Bivalves are *Anadara (Anadara) diluvii* (Lamarck), *Cniamys (Aequipecten) scabrella bollenensis* (Mayer), *Parvilucina (Microloripes) dentatus (* Defrance), *Loripes (Lonpes) dujardini* (Deshayes) and *Laevicardium (Laevicardium) oblongum* (Chemnitz) (Table 1),. Also in the same level (K12), the Rotaliidae type benchic foraminifera (determined by. E. Sirel) and Ostracoda as *Bairdia* sp. were determined (identified by M. Duru).

Above this level, the brown-colored, 2.5 m thick, fine sadstone intercalated mudstone is present. In the 12 cm thick mudstone level, the sample K13 includes Gastropoda as *Gibbula (Gibbula) magus* (Linne), *Astraea (Bolma) rugosa* (Linne), *Cerithium appenninicum dertosulcata* Sacco. *Strombus (Strombus)* bone//iiBrongniart *Strombus cononatus* Defrance, *Mitiella (Mitrella) liguloides* (Doderlein), *Conus conoponderosus* (Sacco), *Conus striatulus* Brocchi. *Conus striatulus* Brocchi. *Conus (Conolithus) dujardini* Deshayes and Bivaivia as *Anadara (Anadara) diluvii* (Lamarck)-- and *Parvilucina (Microlonpes) dentaius* (Defrance).

The section upward with increasing bed thickness of 2 m thick sandstone - mudstone intercalations. This level is overlain by yellow colored 15 cm thick, pebbly coarse-grained sandstone, gray colored 15 cm thick, fine-grained sandstone and 8 cm claystone. The sample K 15 from the mudstone of 7 m thick sandstone-mudstone alternation includes Gastropoda as *Conus mercati* Brocchi ve *Subula (Oxymeris) plicaria* (Basterot). The 20 cm thick sandstone and 2 m thick pebbly coarse-grained thick sandstone overlies the former level. The sample K16 collected from pebbly sandstone contains *Xenophora infundibulum* Brocchi, *Strombus (Strombus) bonel-* /ii Brongniart, *Strombus coronatus* Defrance, *Galeodes cornutus* (Agassız), *Latirus (Dolicholatirus) dispar (Peyrot), Mitra (Mitra) fusiformis* (Brocchi), *Athleta ficulina* (Limarcks), *Conus conoponderosus* (Sacco), *Conus striatulus* Brocchi and *Cerithium appenninicum dertosulcata* Sacco of class Gastropoda and *Anadara (Anadara) diluvii* (Lamarck), *Linga (Linga) columbella* (Lamarck), *Megaxinus bellardianus* (Mayer), *Megaxinus (Megaxinus) ellipticus* (Borson), *Megaxinus (Megaxinus) transversus* (Bronn) and *Nemocardium spondyloides* (Hauer) of class Bivalvia.

The level of sample K 17 is represented by the 50 cm thick gray colored mudstone and rich in molluscan fauna. In this sample, gastropods ane *Gibbula (Gibbula) magus* (Linne), *Astraea (Bolma) rugosa* (Linne), *Turritella (Archimediella) bicarinata* (Eichwald), *Cerithium appenninicum dertosulcata* Sacco, *Strombus coronatus* Defrance, *Strombus coronatus compressonana* Sacco, *Strombus (Strombus) bonelli* Brongniart, *Erato (Erato) laevis elongata* Sacco, *Cypraea (Bernaya) fabagina mioporcellus* Sacco, *Natica millepunctata* Lamarck, *Charonia stefaninii* (Montarano), *Mitrella (Mitrella) liguloides* (Doderlein), *Hinia*

(Uzita) porrecta (Bellardi), *Athleta ficulina* (Lamarck), *Voluta erentoezae* n. sp., *Conus conoponderosus* (Sacco), *Conus (Chelyconus) fuscocingulatus* Bronn, *Conus mercati turricula* Brocchi, *Conus striatulus* Brocchi, *Conus (Conolithus) dujardini* Deshayes. Within this sample some Bivalvia as *Anadara (Anadara) diluvii* (Lamarck), *Linga (Linga) columbella* (Lamarck), *Parvilucina (Microloripes) dentatus* (Defrance), *Megaxinus bellardianus* (Mayer) and *Megaxinus (Megaxinus) ellipticus* (Borson) were also determined.

The sequence continues upward whith gray colored, 30 cm thick sandstone and dark gray colored, 3.8 m mudstone with coal seam. In the sample K18 taken from this level, the *Strombus coronatus* Defrance, *Strombus (Strombus) bonellii* Brongniart, *Murex (Pseudomurex) becki* Michelotti, *Hinia (Uzita) porrecta* (Bellardi), *Conus conoponderosus* (Sacco), *Conus mercati* Brocchi belonging to class Gastropoda were identified. At the uppermost part, the section is represented by 75 cm thick conglomerate, gray colored, mudstone intercalated, thick bedded. 4 m thick sandstone, brown colored 3 m thick mudstone. 30 cm thick sandstone and 4 m thick mudstone. The section is laterally transitional to sandstones and conglomerates towards the northwest part.

Thickness and distribution.- The total thickness of the formation was not measured. However, it is known to be reached up to 450 m in thickness (Akay et al., 1985).

Fossil content and age.- In the formation, the molluscan fauna reveals Lower Tortonian age and implies marine suptropic environment. The previously identified nannoplankton flora submitted by Akay et al., (1985) is also confirmed this age assignment.

In this unit, the molluscan fauna *Gibberuhna (Gibberulina) philippi* (Monterosato), *Odostomia (Megastomia) conoidea* (Brocchi), *Arcularia (Arcularia) ringicula* (Bellardi), *Mangelia brachystoma* (Philippi), *Cerithium appenninicum dertosulcata* Sacco, *Gibbula (Gibbula) magus* (Linne) and *Charonia stefaninii* (Montarano) indicate the Tortonian age. However, the typical molluscan fauna representing Upper Tortonian (Robba, 1970) which are *Parvamussium (Parvamussium) duodecimlamellatum* (Bronn), *Polinices (Lunatia) catena helicina* (Brocchi), *Amycyclina semistriata dertonensis* (Bellardi), *Hinia (Hinia) turbinella turbinella* (Brocchi), *Turricula (Knefastia) bellardii bellardi* (Desmoulins), *Gemmusa (Gemmula) rotata rotata* (Brocchi) and *Gemmula (Gemmula) rotata coronata* (Münster in Goldfus) have not been found in this unit. For this reason, the levels containing mollusc fauna in Kargı section of the Aksu formation was accepted as Lower Tortonian.

Corals as *Porites lobatosepta* (Chevalier), *Favites neglegta* (Michelotti), *Tarbellastraea siciliae* (Chevalier) *Tarbellastraea reussiana* (Milne-Edwards ve J. Haime) and *Siderastraea crenulata* (Goldfuss) (determined by by S. Babayiğit) obtained from Kargı section also confirm the Tortonian age.

Based on this idea, the age of the hundred meter thick conglomerates underlying conformably the Kargı section of the Aksu formation should be stratigraphically Serrevalian in age. For this reason, overall age of the formation was accepted as Serravalian - Tortonian.

Depositional environment.- The formation represents the continental and shallow marine environments. The marine environment indicates shallow shelf-deep shelf repetition and the great abundance of molluscan fauna was present in shallow shelf implying warm and normal salinity marine environment (suptropic climate). Coral reefs were developed during deepening of environment. This

environmental change can be observed in Kargı section (Fig. 9).

CONCLUSION AND DISCUSSION

The stratigraphical study related to the molluscan fauna in the Antalya Miocene basin was firstly established in this study. The stratigraphy of the basin has re-evaluated by using all fossil records.

The oldest unit in the basin is the Kepez travertine. It stratigraphically underlies the Upper Burdigalian rock units (the Sevinç conglomerate and the Oymapınar limestone). Since the unit is terrestrial in origine and has no reliable age data, the stage name was not used and its age was fixed as Lower Miocene.

Another unit in the basin is the Sevinç conglomerate cropping out at south and southeastern parts of the basin. This unit was considered as Tepekli conglomerates by Monod (1977). later it was mapped and defined as Sevinç conglomerate by Gutnic et al. (1979). As it is pointed out by Şenel et al. (1992, 1998), this unit is not only in continental characteristics, but also includes marine levels. This evidence is also confirmed by other researchers such as Monod (1977), Akay and Uysal (1984), Akay et al. (1985), Karabıyıkoğlu et al. (1996, 1997. 2000). The marine levels of the Sevinç conglomerate was dated as Upper Burdigalian. By considering the continental levels of the formation, as a whole, its age was accepted as Burdigalian.

The Aksu formation was previously generallized to the whole basin by Akay and Uysal (1984) and Akay et al. (1985). In this case, clue to stratigraphic, faunal and environmental differences, it has been thought that, it should oe differentiated. For this reason, the units exposed at central and northern parts of the basin and Upper Burdigalian-Langhian (Ottnangıan-Karpatian-Lower Badenian) and containing brackish water-marine molluscan fauna-was firstly named as the Altınkaya formation in this study. The Altınkaya formation unconformably overlies the basement units. It is also interfingering with turbiditic deposits of Karpuzçay formation outcropping at central parts. It is unconformably overlain by Aksu formation. This unit was previously investigated under the name Aksu formation. The previous researchers assigned Upper Burdigalian - Langhian age which also support the age data obtained during this study (Akay and Uysal, 1984; Akay et al., 1985 and Tuzcu et al., 1994).

The other investigated unit in the basin is the Oymapınar limestone. Its age was previously claimed to be Lower Langhian (Akay and Uysal, 1984; Akay et al., 1985; Şenel et al., 1992. 1996). This age has been modified as Upper Burdigalian - Langhian (Karpatian-Lower Badenian). The identified benthic and planktonic foraminifera and corals also confirm this age assignment.

The planktonic foraminifera and nannoplankton obtained from the Geceleme formation which conformably overlies the Upper Burdigalian levels of the Oymapınar limestone, also confirmed with age evidences of Öztümer (1974), Akay and Uysal (1984), Akay et al. (1985), Nazetal. (1991, 1992), Seneletal. (1991, 1992, 1996, 1998) and Karabıyıkoğlu et al. (2000).

The Çakallar formation conformably overlies the Oymapınar limestone and underlies the Geceleme formation and is observed only at southeastern part of the basin. Althought it is brecciated and has no fossil record, its age was accepted as Upper Burdigalian-Lower Langhian.

In this study, no detailed study was carried out in widely exposed at west of the basin and the previously suggested Aksu formation for the whole basin by Akay et Uysal (1984)

and Akay et al. (1985) has been modified. The levels of the formation containing molluscan fauna was dated as Lower Tortonian. The lower parts composed of alternations of thick conglomerate and sandstone levels are thought to be Serravalian in age. Based on this data, the age of the Aksu formation was accepted as Serravalian- Tortonian but not Tortonian as the previous investigators suggested (Akbulut, 1977: 1980; Şenel et al., 1997 *a,b,c; Ş*enel et al.. 1991, 1992, 1996. 1998).

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