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SOME STRAT1GRAPHIC AND TECTONIC CHARACTERISTICS OF THE AREA AROUND HINIS (SOUTHEAST OF ERZURUM)*

Ali YILMAZ**; İsmail TERLEMEZ** and Şükrü UYSAL**

ABSTRACT.— The study area is situated between Hınıs-Tekman and Karayazı southeast of Erzurum. The aim of this study was to investigate some geological characteristics of the region. The rock units constituting the lowermost sections of the study area consist of alternating gneiss, amphibolite, schist and marble, from bottom to top, are exposed beneath the ophiolitic complex, as a tectonic window. The ophiolitic complex consists essentially of diabase, gabbro, and locally of serpentinite and peridotite. The acidic intrusions cut both the metamorphics and ophiolitic complex. The rocks ranging from Maestrichtian to Pliocene in age are made up of regular alternations of transgressive and regressive sequences, and rest upon the older rocks, unconformably. The study area became a piece of land during the Middle(?) — Upper Miocene. The Oligocene sequence of the sedimentary cover contains thin intercalations of andesitic basalt. In the Miocene-Pliocene sequence of the cover, firstly, volcanic rocks varying from dacite to andesite in composition, and then, in turn, andesitic basalt and basaltic pyroclastic rocks and lavas took place. Overthrusts which are of pre-Maestrichtian and Late Eocene age were also defined in the study area. Along the Late Eocene overthrusts the ophiolitic complex has thrusted over the Eocene rocks which are situated to the south of the complex. Parallel and oblique fault zones which have NW-SE striking right lateral-slips and NE-SW striking left lateral-slips were developed, as well as approximately E-W trending folds and overthrusts under the control of compressional tectonic regime, during the Late and post-Miocene. In addition, some other structures have been also developed in the Plio-Quaternary formations lying within both of two fault zones, by the effects of approximately E-W trending compressional forces.

INTRODUCTION

The study area is situated approximately between Hınıs, Tekman and Karayazı, southeast of Erzurum (Fig.l). The aim of this study was to investigate some geological characteristics of the region. Particularly, the stratigraphic relationships of the study area are controversial.

The pioneer geological works in the region were carried out by Mercier (1948), Erentöz (1949, 1954 a, 6) and Altınlı (1963, 1964). As a result of these works, the significant rock units and stratigraphy of the region were defined, in general. Later, various studies were made in the region, on the basis of 1:25,000 scale mapping (Rathur, 1965, 1969; Tokel, 1979; Şenalp, 1966; İlker, 1966a, *b;* Yılmaz, 1967; Erdoğan, 1966,1967,1972; Sungurlu, 1967; Özcan, 1967; Tütüncü, 1967; Özocak, 1967; Tanrıverdi, 1971; Havur, 1972). The studies which were made by Soytürk (1973) and Erdoğan and Soytürk (1974), constitute a synthesis of above mentioned 1:25,000 scale studies. However, the controversial stratigraphic problems, in particular, started to be determined and to be cleared, step by step, by contribution of new data obtained from the recent studies. On the other hand, the important structural elements such as the metamorphics constituting the lowermost section of the region and ophiolitic complex and relationships between them were examined insufficiently. In this paper, the present writers present some new stratigraphic and tectonic data obtained from an extensive area, by examining the characteristics and positions of the rock units constituting the lowermost section also.

STRATIGRAPHY

In the study area, the pre-Maestrichtian rocks

* This paper was presented in the Geological Congress of Turkey in 1986.

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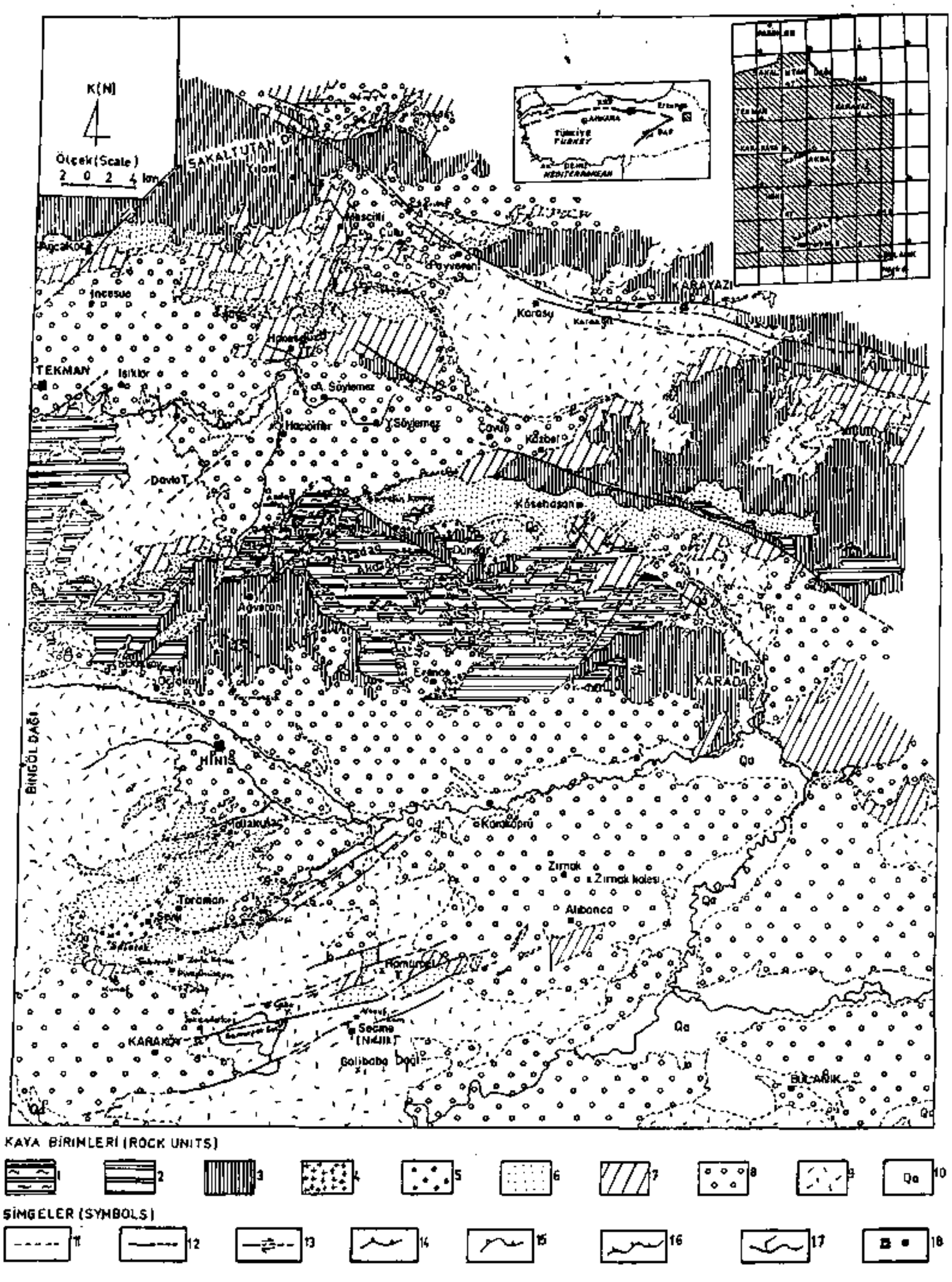

Fig.1— Location and geologic map of the study area (All previous studies were used for preparation of the map). Rock Units : 1,2 — Akdağ metamorphics (1- Gneiss amphibolite, schist; 2- Calcschist and marble), 3— Ağören complex and Sakaltutan group; 4— Tozlu yayla granitoids; 5— Maestrichtian - Paleocene rocks; 6— Eocene and Oligocene rocks; 7— Lower - Middle Miocene rocks; 8— Middle (?) - Upper Miocene - Pliocene terrigenous sediments; 9— Upper Miocene - Pliocene volcanics; 10— Quaternary deposits. Symbols : 11—Contact; 12—Fault, probable fault; 13—Strike - slip fault; 14—The Pre-Maestrichtian - Paleocene overthrust; 15— Late Eocene - Pre Miocene overthrust; 16— Late Miocene and subsequent overthrust; 17— Stream; 18— Human settlements.

and Maestrichtian-Pliocene rocks resting upon them, unconformably crop out.

Pre - Maestrichtian rocks

The rock units constituting the lowermost parts of the study area are subdivided into four units. These are the Akdağ metamorphics lying at the base, the Ağören complex which was thrusted over the metamorphics and the Sakaltutan group and the Tozlu Yayla granitoids.

Akdağ metamorphics — The metamorphic rocks which crop out in the central part of the study area and extend in E-W direction, are named "the Akdağ metamorphics" (Erdoğan, 1972). However, the rock units presenting the all levels of the metamorphics, are best exposed in the vicinity of Karadağ to the west of Akdağ and especially on the southwestern slopes of Karadağ mountain (Figs. 1 and 2).

The metamorphics consisting of gneiss, amphibolite and mica-schist in the lowermost levels and marble and locally calc-schist in the uppermost levels, are generally well foliated and intensively folded. On the basis of petrographic determinations, some rocks such as amphibole-gneiss, amphibole-pyroxene gneiss, garnet-biotite gneiss, biotite-muscovite gneiss, cordierite-almandine-sillimanite-quartz gneiss, garnet - sillimanite - biotite gneiss, quartz - oligoclase-diopside - actinolite gneiss, amphibolite, garnet mica-schist, quartz - cordierite micaschist, calcschist and sugary textured marble were defined in the metamorphics. On the basis of index minerals contained in the metamorphics, it has been concluded that metamorphics lying within the study area underwent a predominantly medium to high grade metamorphism (under the conditions of approximately 500° - 600°C temperature and 4 - 5 kb pressure) in amphibolite facies, according to the criteria of Winkler (1976), or a metamorphism in Barrowian type sillimanite - almandine - orthoclase sub-facies, according to the criteria of Turner and Verhoogen (1960) and Winkler (1967).

The Akdağ metamorphics crop out as a tectonic window beneath the Ağören complex. Uncorifownity showing regional character was not observed, between the metamorphics. Nevertheless, an unconformity which has local character or coincides with a tectonic phenomena, is observed, to the south of Karadağ. The marble contains some pebbles and blocks derived from the underlying amphibolite and gneiss along this local unconformity. The marble which contains pebbles and blocks, conformably passes into the alternations of marble and schist, upwards.

The Akdağ metamorphics, have been probably produced by the high grade metamorphism of a sequence of volcanics?, quartz sandstone, claystone, siltstone and limestone, in ascending order.

It may be suggested that the Akdağ metamorphics show similarities to the section of the Central Anatolian massif, in the vicinity of Akdağmadeni-Yıldızeli(Yılmaz, 1980,1982; Özcan et al., 1980), on the basis of rock types, stratigraphic succession, degree of metamorphism and their relationships to the Ağören complex and the other rock units. For instance, it has been defined that both two sequences consist predominantlyof gneiss and schist in the lower levels and marble in the upper levels, and underwent a metamorphism in amphibolite facies and are covered by the Maestrichtian sediments, unconformably.

The Maestrichtian-Palaeocene formations rest upon the metamorphics and ophiolitic complex in the region with angular unconformities. On the basis of these observations the metamorphics may be the pre-Maestrichtian-Palaeocene in age, at least.

Ağören complex.— The Ağören complex rests upon the Akdağ metamorphics, tectonically and consists essentially of serpentinite, peridotite, gabbro and diabase. It is termed after Ağören village, where it is best cropped out. The rock units constituting this complex, were thrusted over each other, too.

Serpentinite and peridotite are found in small outcrops, gabbro is locally common and diabase is dominant rock unit.

Serpentinite and peridotite occur as small lenses. Peridotite consists of serpentinized olivine, clino-pyroxene, orthopyroxene and spinel, and has wehrlitic character. Gabbros are found as cumulates and have intersertal texture. Gabbro consists of olivine in lesser amounts, altered plagioclase (albitised), locally clinopyroxene, orthopyroxene in large amounts and rarely titanite and magnetite. Diabase has ophitic texture and contains hornblende and plagioclase (labradorite), both in the same proportions, with locally rutile in large amounts, titanite and opaque materal.

A dynamo metamorphism took place in some places where the ophiolitic complex had been thrusted over the metamorphics. In such places the units of ophiolitic assamblage may be called as metagabbro, metadiabase or metadolerite. The rock units belonging to the ophiolitic melange, i.e. gabbro and diabase were locally subjected to metamorphism, as mentioned above. For instance, amphiboles were altered to chlorites pyroxenes were uralitized, plagioclases were sericitized, fractures were filled with locally prehnite or iron-bearing formations.

Tozlu Yayla granitoids.— The acidic intrusions varying from granite to diorite in composition which cut both the Akdağ metamorphics and Ağören complex in the study area, and are of pre-Maestrichtian age, were named the Tozlu yayla granitoids (Fig. 1 and 2).

The acidic intrusions are found as small outcrops in the central part of the study area. The dykes and sills of the intrusions are very common in both the metamorphics and ophiolitic complex. The outcrops of the acidic rocks are distinguished from the adjacent rocks on the basis of yellowish colour, and cover an area of a few sq. km or less. The texture of granite is holocrystalline. It consists essentially of quartz, plagioclase, biotite and tourmaline. Granodiorite has holocrystalline porphyric texture and consists of quartz, orthoclase, plagioclase, biotite and muscovite; it has locally cataclastic texture and contains chloritized biotite, epidote, zircon, apatite and opaque material. The dioritic rocks which are generally called as quartz-diorite or monzodiorite have holocrystalline granular texture, and contain quartz, albite-oligoclase in large amounts, pyroxene (diopside-augite) and in places titanite.

The acidic intrusions constituted an extensive contact metamorphism at the contacts of the metamorphics and ophiolitic complex. In some sections, where the metamorphics were cut by the intrusions, calc-silicate fels and calcite-diopside fels were formed. In these zones, skarn rocks are characterized by banded structure and consist essentially of diopside, quartz and calcite. In addition, sericitized plagioclase, skapolite, muscovite, chlorite, datholite and titanite are observed in these zones. In the sections, where the rocks of the ophiolitic complex were cut by the acidic intrusions, the major minerals were undergone variations. For instance, plagioclases were sericitized, pyroxenes were altered to amphiboles. The edge parts of the acidic intrusions have porphyric texture.

The Tozlu yayla granitoids maybepre-Maestrichtian-Palaeocene in age as the Akdağ metamorphics and Ağören complex, probably Upper Cretaceous. The fact that the Maestrichtian - Palaeocene conglomerates and sandstones contain some fragments derived from the acid intrusive rocks, are in favor of this age.

Sakaltutan group.— The present writers have preferred to name the formations as the Sakaltutan group, been named firstly as the Sakaltutan ophiolites (Erdoğan and Soytürk, 1974), and then a part of them as the Anatolian ophiolitic melange (Koçyiğit, 1985), on the basis of the consideration that they have a heterogenous structure, and the ophiolites, melange, metamorphics and, the Upper Cretaceous pelagic limestones resting upon the melange as a cover may be differentiated from each other and named separately. The Sakaltutan group with its heterogeneous structure, were also differentiated from the Ağören complex consisting wholly of ophiolitic rock - units.

The Sakaltutan group consists essentially of serpentinite, peridotite gabbro, diabase, pillow structured volcanic rocks and pelagic limestone as well as metamorphics which underwent metamorphism in greenschist facies, marble and recrystallized limestone. The rock units corresponding to the ophiolitic sequence, were thrusted over one another and the other rocks. Additionally some olisthostromal levels are locally observed in this group. The matrix of these formations was derived from the volcanoclastic sandstone and claystone. The blocks of them were derived from the ophiolites or the other rock units constituting the group. The age of the limestone olistolithes ranges from Permian to Cenomanian, according to the determinations (Fig.2).

The Sakaltutan group constitutes the basement of the other rocks, to the north and further north of the study area, were thrusted over the Eocene olisthostromal rocks, in the south and north. The Oligocene red coloured terrigeneous and clastic rocks are the oldest formations resting upon this overthrust and complex, transgressively.

Maestrichtian and younger formations

In this chapter, the Maestrichtian - Palaeocene, Eocene - Oligocene, Lower - Middle Miocene and Upper Miocene - Pliocene units, in turn will be examined. The rocks which will be defined in turn, consist generally of regular alternations of transgressive and regressive sequences. The study area completely became a piece of land in the final regressive stage during the Middle? — Upper Miocene.

Maestrichtian - Palaeocene rocks

The Maestrichtian Dündar formation, Palaeocene Sevik formation and Merttepe formation will be defined in turn.

Diindar formation . — The Maestrichtian sequence consisting of conglomerate, sandstone and claystone alternations in the lowermost parts, sandstone, sandy-clayey limestone alternations in the central parts and clastic rocks with intercalations of rudistids-bearing limestone in the uppermost parts, are firstly named the Dündar formation by Erdoğan (1968), Erdoğan and Soytürk (1974).

The formation crops out typically to the south of Dündar village.

The grey-greenish coloured, thickly bedded polygenic conglomerate constituting the lowermost part of the formation, generally overlies the Ağören complex. The pebbles which were derived from" the rocks of the complex and metamorphics are well rounded and ill-sorted. By decreasing of grain size, gradually towards the central and uppermost levels, the alternations of sandstone and claystone, and intercalations of locally rudistids and algae bearing thick bedded limestone become predominate.

The Dündar formation rests upon the metamorphics and ophiolitic complex transgressively. It is represented by rudistids-bearing limestones, in the southwest and west of Ağören.

On the basis of palaeontological determinations (Fig.2), Maestrichtian age is assigned to the Dündar formation. It has probably deposited in a shallow-sea environment with high energy.

Sevik formation and Merttepe formation. — The rock units consisting of alternating Middle Palaeocene sandstone, limestone and marl in the lowermost levels, and the Upper Palaeocene rocks, mostly limestone in the uppermost levels, were named the Sevik formation and the Merttepe formation, respectively (Soytürk,1973).

Both formations crop out typically in the vicinity of Sevik village and in the eastern part of Seferek village.

The unit which consists predominantly of elastics, in the lowermost parts and predominantly of carbonates in the uppermost parts, is generally medium-thick bedded and regularly startified. Sole markings, gradation, parallel and convolute laminations are common in clastic rocks. The micritic carbonates contain abundant foraminiferas.

The base of the Sevik formation is not seen in the Hınıs basin. The levels of clastic rocks corresponding to the Upper Palaeocene-Lower Eocene rock units resting upon the Dündar formation conformably, are observed in the southern part of the Tekman - Karayazı basin. These levels may be equivalents to the Sevik formation. So, it may be suggested that the Sevik formation, conformably and passes into the overlying Merttepe formation, conformably.

On the basis of palaeontological determinations (Fig.2), the Palaeocene Sevik formation and Merttepe formation have been probably deposited in a shallow-sea environment, with low energy, in which the turbidity currents had predominated.

Eocene - Oligocene rocks

Here, the Toraman formation, the Sancaktar formation and the Kösehasan formation, the Ahlat formation and the Ağcakoca formation will be defined in turn. The sequence which started (as being) transgressive in the Maestrichtian, gained regressive character durirtg the end of Eocene and firstly transgressive and then regressive characters during the Oligocene (Fig.2).

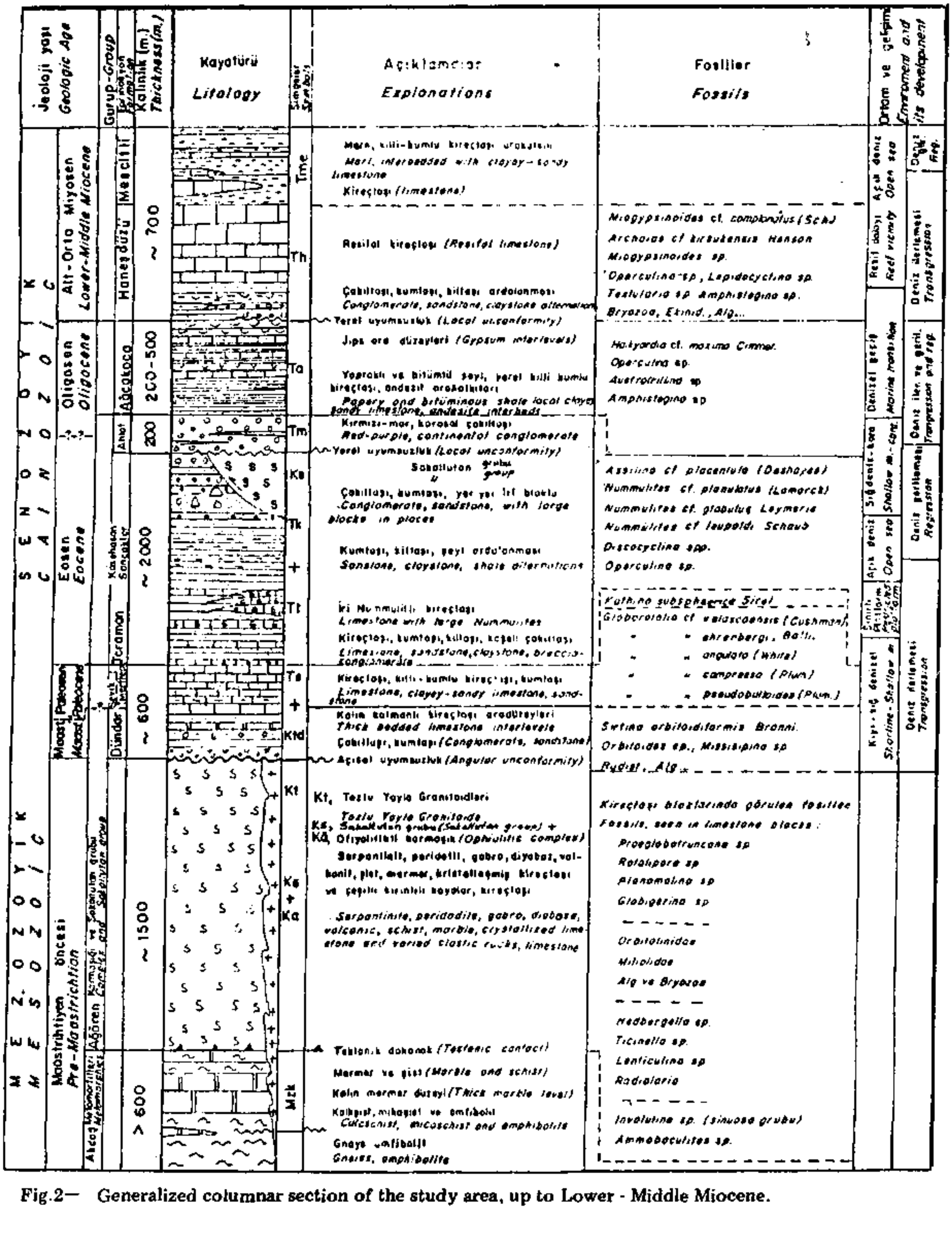

Fig.2— Generalized columnar section of the study area, up to Lower - Middle Miocene.

Toraman formation, —. The Eocene regular sequence consisting of alternating marine sandstone, claystone, marl and limestone was originally named the Toraman formation by Soytürk (1973) with its name of type location.

This unit consists of alternations of grey, greenish, yellowish coloured, thin to medium thick bedded and regularly stratified clayey limestone, claystone, sandstone, conglomerate and marl. The primary sedimentary structures such as sole structures and gradation, parallel and convolute laminations are clear in some sections where clastic rocks predominate.

The Toraman formation rests upon the Upper Palaeocene formations (Merttepe formations), conformably and transitionally, in the Hınıs basin (Soytürk, 1973). In the transition levels, some lenses of brecciated limestone lenses are found. The pebbles and matrix of the limestones were derived from the same carbonate. The above mentioned lenses may be regarded as products developed by high energy in the environment, during the transition from Palaeocene to Eocene.

On the basis of palaeontological determinations (Fig. 2), the Eocene Toraman formation has been probably deposited in *a!* shallow-sea environment, with low energy, in which the turbidy currents had predominated.

Sancaktar formation and Kösehasan formation.— The Eocene rocks consisting of regularly stratified clastic rocks and limestones in the lowermost levels, and coarse grained clastic rocks having olisthostromal and regressive characters in the uppermost levels in the Tekman-Karayazı basin were named the Sancaktar formation and the Kösehasan formation by Erdoğan and Soytürk(1974), on the basis of their type locations. However, the Eocene limestones are found as lenses in the section where the clastic rocks predominate, and locally correspond to a member.

Both of the formations crop out typically in the southern and western parts of Kösehasan village. These units consisting of alternating mostly sandstone, claystone, shale and locally conglomerate, contain some lenses of nummulites bearing bioclastic limestone, particulary in the sections where they rest upon the metamorphics, unconformably. The clastic rocks are grey, yellowish, greenish coloured, generally thin to medium thick bedded, whereas the limestones are generally thick bedded and regulary stratified. The unit having regular stratification in the lowermost part, show a blocky successions whose materials were derived from the complex, in the places where the Sakaltutan group was thrusted over it. This succession is observed to the western of Kösehasan village.

The Kösehasan formation overlies the Maestrichtian-Palaeocene clastic rocks, conformably. It overlies the basement which is constituted by the metamorphics and ophiolitic complex, with an angular unconformity. On the basis of palaeontological determinations (Fig. 2), it may be suggested that the Eocene units were deposited in a marine environment which had been shallow at the begining, became deepining and later became more shallow gradually towards the end of Eocene.

The lowermost parts of the Kösehasan formation resemble the Toraman formation, in terms of age, environment of deposition and rock types, but the middle and uppermost parts of the formation differ from the Toraman formation, on the basis of its blocky and regressive character.

Ahlat formation . — The terrigeneous unit consisting of alternating red coloured polygenic conglomerate, sandstone and locally siltstone, rests upon the Eocene rocks, was named the Ahlat conglomerate (Demirtaşlı and Pisoni, 1965), the Mollakulaç formation(Erdoğan, 1967 ; Özcan, 1967) and the Ahlat formation (Soytürk, 1973). Although it doesn't crop out typically in the vicinity of Ahlat, since it is the known and originally used name, the present writers preferred to use the geographic name as Ahlat for this formation. This formation crops out typically in the vicinity of Mollakulaç, village and southwestern part of it.

The reddish polygenic and blocky conglomerate as a product of terrestrial environment, is unbedded or thick bedded, its grains being unsorted, sub - rounded and poorly graded. The sandstone and siltstone are thin to medium thick bedded. Wedging and cross -

bedding are common in this unit. The coarse -grained materials show channel structure.

The Ahlat formation overlies the Toraman formations, conformably in the Hınıs basin, according to Özcan (1967). Soytürk (1973) and, Erdoğan and Soytürk (1974) suggested that the Ahlat formations contains some fragments of Lower - Upper Eocene, and underlies the Oligocene rocks, may be Upper Eocene in age. According to the observations, the relationship between the Ahlat formation and the Eocene rocks is unconformable in the Hınıs basin and conformable, in the vicinity of Ağcakoca situated within the Tekman - Karayazı basin. On the basis of available data the age of the Ahlat formation probably ranges from Upper Eocene to Lower Oligocene. The relationship of the formation to the underlying Lower-Middle Eocene formations, may be only a local unconformity ofa regional phenomenan.

Ağcakoca formation — Various names were used for the Oligocene rocks consisting essentially of pebbly sandstone, marl, foliated shale and limestone and gypsum - bearing levels in upwards. It has been named the Mollakulaç, Dere formation by Erdoğan (1967) and Özcan (1967), the Çığılgan formation by Rathur (1965), İlker (1966a), Erdoğan (1966, 1972) and Havur (1972), the Ağcakoca formation by Aziz (1971), the Gümüşali formation by Erdoğan and Soytürk (1974). Since it crops out typically in the vicinity of Ağcakoca village, in the northwestern part of the study area and hence, the lower - upper contact relations are best seen there, the name Ağcakoca formation (Aziz, 1971) was preferred. The name of Çığılgan formation wasn't preferred since the landslide made the section measurement impossible, in the vicinity of Çığılgan. Whereas Ağcakoca village and neighbouring areas are the most typical locations, where the all characteristics of the formation are best examined.

The formation consists predominantly of shale, claystone and marl, in places, levels of pebbly sandstone and beds of clayey - sandy limestone. The uppermost parts of the formation, contains gypsum bearing intercalations, in places. The Ağcakoca formation is generally greenish-bluish coloured and thin to medium-thick bedded. The levels of pebbly sandstone are thick-bedded. Sole structures, gradation, parallel and convolute laminations, and sand - concretions are common in this, unit. The Ağcakoca formation contains locally remnants" of plant and abundant macro or microfossils. Andesitic basalt interlayers are observed rarely.

' All the earlier workers of the region, suggested that this formations rests upon the underlying terrigeneous formations, conformably and transitively. Oligocene age is assigned to the uppermost part of this formation by ilker (1966a) and Lower Miocene by Havur (1972) in the northern part of the Tekman-Karayazı basin. The lowermost and uppermost levels of the formation were deposited in a shallow - sea environment, whereas the central levels were deposited in a relatively deep - sea environment. On the basis of its fossil content, the Ağcakoca formation is probably of Oligocene age.

Lower - Middle Miocene rocks

The Haneşdüzü formation and the Mescitli formation will be defined, in turn, here. The sequence which had continued its development, regressively, towards the end of Oligocene, gained a transgressive character, at the begining of the Lower Miocene and regressive character again during the Middle Miocene. The study area became a piece of land, as a whole, as a result of development of final regressive sequence (Fig.2).

Haneşdüzü formation.— This formation, occurring very widespread in Eastern Anatolia and consisting predominantly of platform type of carbonates was named the Adilcevaz calcareous by Demirtaşlı and Pisoni (1965), the Haneşdüzü formation by Rathur (1957), İlker (1966a), Erdoğan (1966) and Koçyiğit (1985), the Alibonca formation by Soytürk (1973) and the Güzelbaba formation by İlker (1966b). The outcrops and lower and upper contacts of the formation which is of Lower Miocene and consists predominantly of limestone, are best seen near Haneşdüzü hill and in its eastern part inside the study area (Fig.l).

The unit, starting with alternation of fine - grained conglomerate, sandstone and claystone, passes into the reef carbonates, conformably. The uppermost levels of this formation is locally represented by reef carbonates. The clastic rocks lying within the lowermost levels are greenish, yellowish coloured, and mostly, thin to medium - thick and cross-bedded.The carbonates are grey, whitish and yellowish coloured, very thick bedded, and contain abundant macro or microfossils. The sequence of bioclastic limestone generally containing fragments of reef - forming organisms, in places has oolithic texture and contains intraclasts.

According to Rathur (1965) and Soytürk (1973), an unconformity exists between this formations and the Oligocene formations. On the basis of variations and characteristics of rocks lying at the lower contact, it may be suggested that the sea had become rather shallow toward the end of Oligocene and become terrestrial, locally. However the contact relation doesn't point out a significant regional unconformity. This evidence reflects that a regressive sequence which had developed at the end of Oligocene, probably gained a transgressive character during the Lower Miocene.

On the basis of palaeontological determinations (Fig. 2), the Haneşdüzü formation, Aquitanian — Burdigalian in age, was deposited in a shallow - sea environment, which was neritic and the development of reefs was continuing in.

Mescitli formation.— The sequence which crops out typically within a limited area in Eastern Anatolia and particulary in the vicinity of Mescitli, consists predominantly of marl and rests upon the Lower Miocene carbonates, conformably and transitionally, was named the Mescitli formation. It corresponds to the marl series of the Mescitli formation of Rathur (1969), and the Mescitli member of Erdoğan and Soytürk (1974). İlker (1966a), Tanrıverdi(1971), Erdoğan (1972) and Havur (1972) named the same unit as the Mescitli formation.

All the characteristics and lower-upper contacts of the formation are best seen in the vicinity of Mescitli.

Marl is the dominant rock. It consists of limestone, in the lowermost levels, claystone and clayey limestone in the middle levels, and interlayers of light coloured dacitic and andesitic pyroclastic and epiclastic rocks and lavas in the uppermost levels. In general, it is light grey, whitish beige coloured and thin to medium - thick bedded and regularly stratified. The thick beds are common in lower and uppermost levels. Gradation and lamination are observed in some levels of the wackestone and packstone. Pelagic formations are seen in the middle levels gastropoda and lamellibranchiata fossils in the uppermost levels.

It has been accepted that the Mescitli formation rests upon the Haneşdüzlü formation, conformably and transitively (İlker, 1966a; Rathur, 1966). On the basis of palaeontological determinations (Fig. 2 and 3), it may be suggested that the Mescitli formation, Lower - Middle? Miocene in age was deposited in a marine environment which had been shallow at the beginning, deep and pelagic later and, subsequently become more shallow again.

Upper Miocene - Pliocene rocks

The Middle - Upper Miocene - Pliocene formations show some remarkable differences in places, in terms of their settings, terrestrial facies and relationships to the synchronized volcanics. For this reason, separate columnar sections were prepared for each location (Fig. 3, 4 and 5). Soytürk (1973), Erdoğan and Soytürk (1974) named this deposits as the Zırnak formation and subdivided it into several members. The Pliocene terrigenous units were mapped separately and defined that the units were rested upon the Zırnak formation, unconformably, in this study. However, some relationships which were mentioned above to be unconformable, were observed to be conformable. The Middle?—Upper Miocene—Pliocene sequence was regarded as separately for different places. In this chapter, Mescitli area, the area between Hınıs and Tekman, and Hamurpetdağı area will be defined, in turn.

Mescitli area .— The Mescitli formation is underlain by the Çullu formation, conformably in the vicinity of Mescitli. The İncesu formation and Karayazı volcanics follow the Çullu formation, respectively (Fig.3).

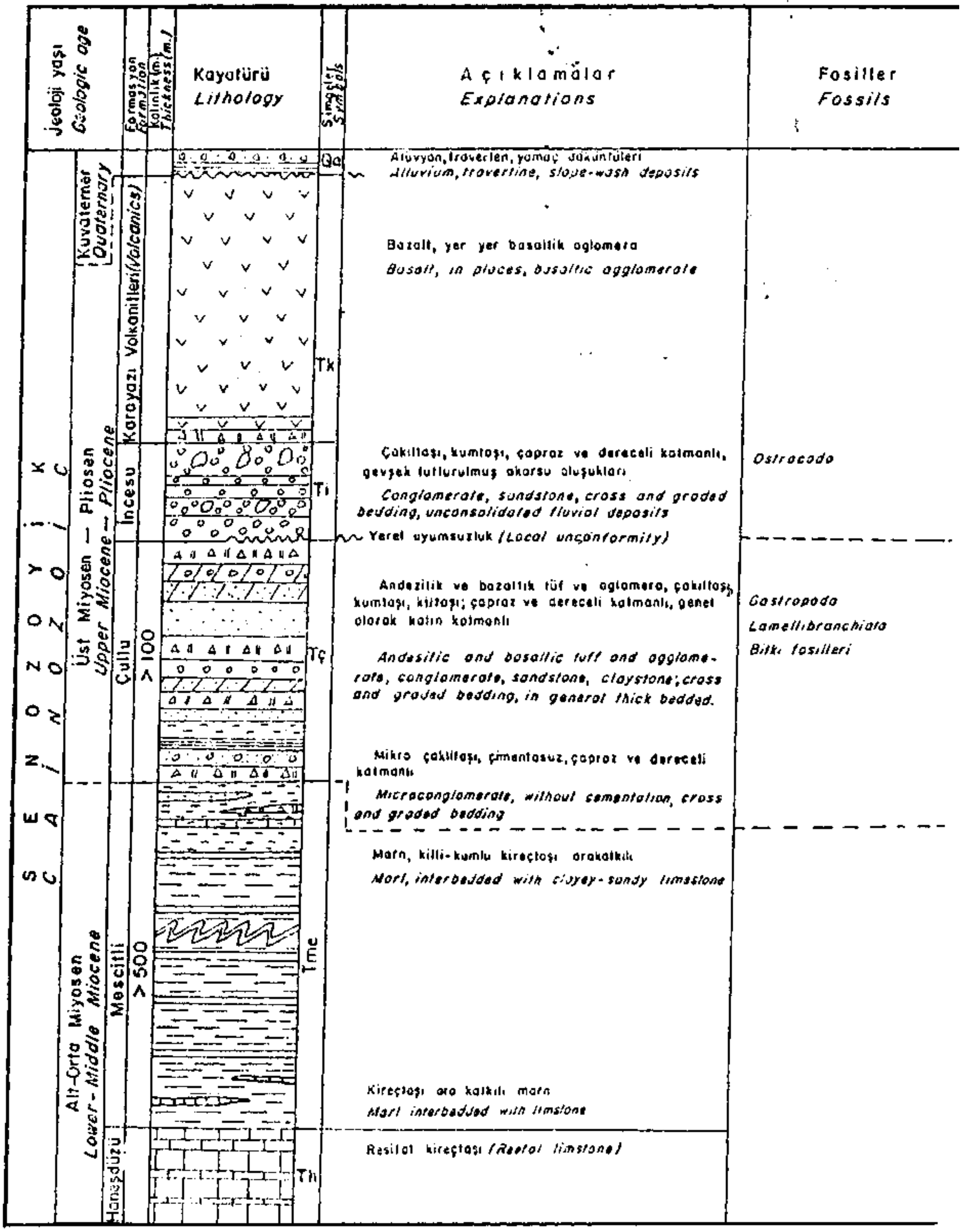

Fig.3— Columnar section of the Mescitli area.

Çullu formation: The rock units, which had been named the agglomerate series of the Mescitli formation by Rathur (1969) and the Çullu agglomerates by Erdoğan and Soytürk (1974), were named the Çullu formation, on the basis of the fact that they consist of alternations of terrigenous sedimentary deposits and pyroclastic rocks, Koçyiğit (1985) named the terrigenous sedimentary rocks as the Payveren formation, and the pyroclastic rocks as the Çilligöl formation in the eastern part of Çullu village. The Çullu formation probably corresponds to the lateral transitive sections of these two formations.

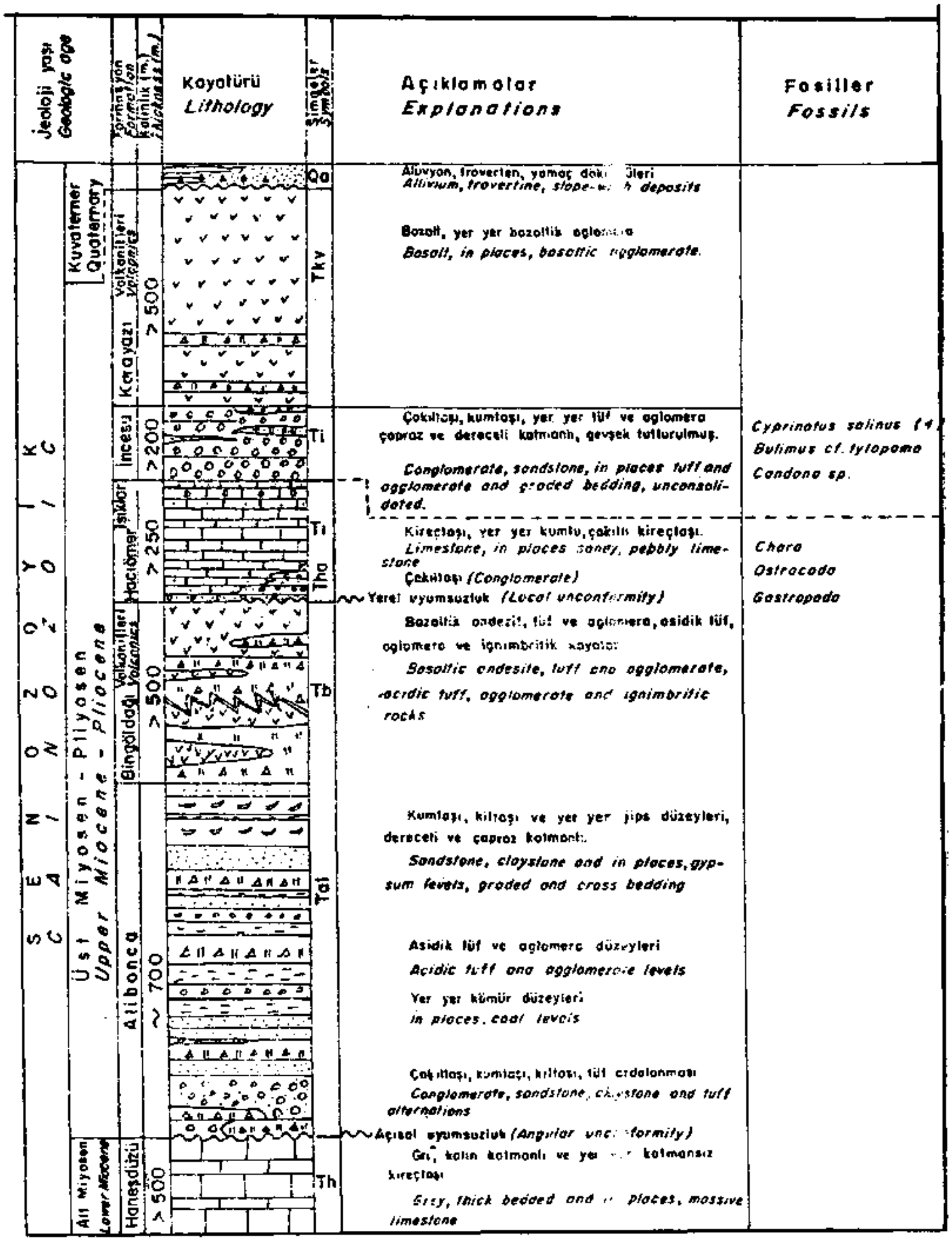

Fig.4— Columnar section of the Hınıs - Tekman area, (1) after Erdoğan and Soytürk (1974).

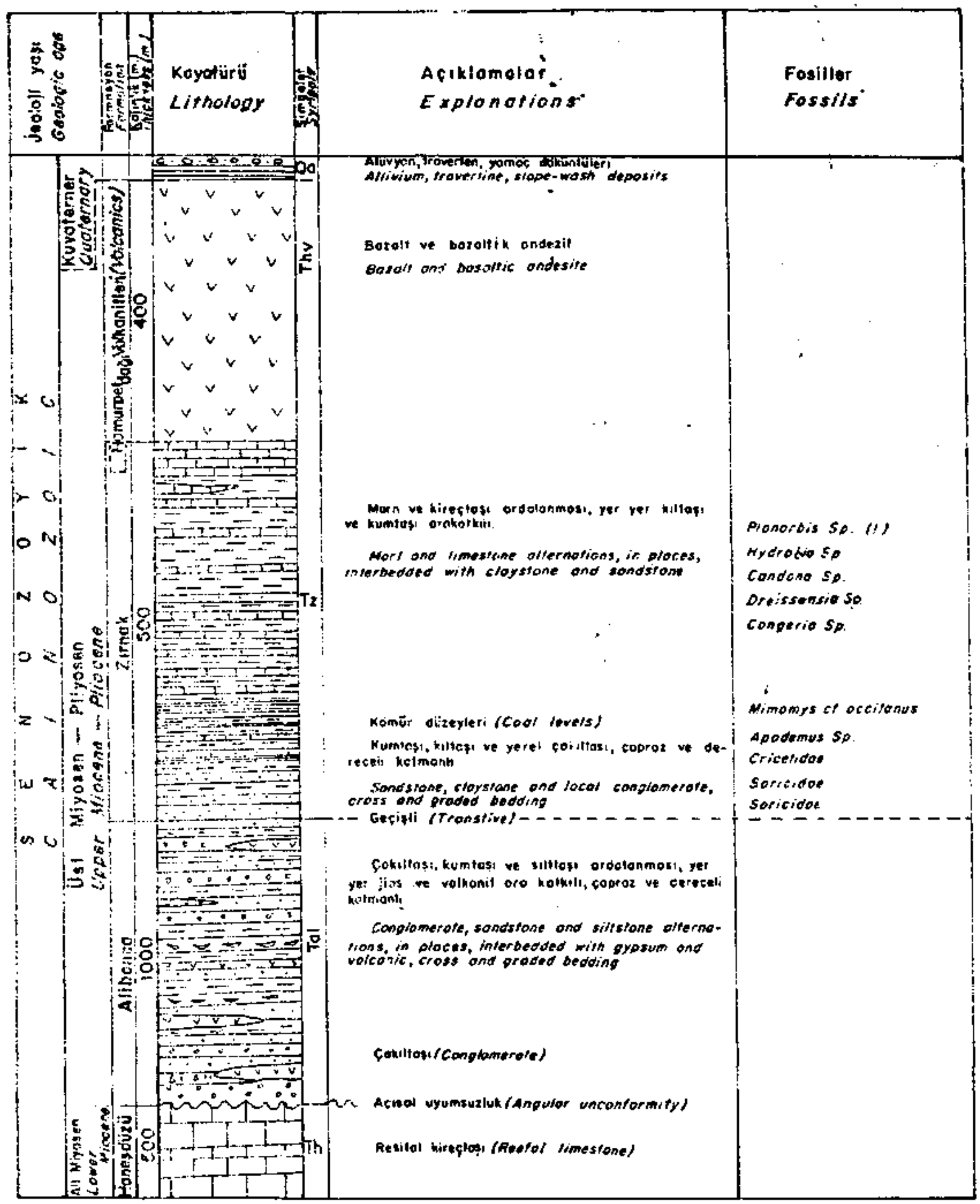

Fig.5— Columnar section of the Hamurpet dağı area, (1) after Sungurlu (1967).

The Çullu formation, consisting essentially of alternating polygenic conglomerate, sandstone, claystone, andesitic, pyroclastic and epiclastic rocks is grey - dark grey, in places, brown and greenish coloured and medium - thick to thick bedded and in some places very thick bedded. Coal fragments, plant fossils and well elutriated sandstones are common in some levels, especially in the lowermost levels. Cross and graded bedding, channel and load structures, sliding deposits synchronized with deposition, oblique-slip faults are often observed. The size and quantity of pebbles belonging to the conglomerates gradually increase from the lowermost levels to uppermost levels. The rock units mostly show lateral and vertical transitions.

The above mentioned rocks rest upon the Mescitli formations, conformably, according to Rathur (1965) and Koçyiğit (1985), unconformably, according to Erdoğan and Soytürk(1974). On the basis of the observations, this unit rests upon the Mescitli formation, both conformably and transitively. The transitive relationship represents the phenomena that the study area changed as a whole from the marine environment to a piece of land as a result of the last regressive development which started during the Middle? Miocene.

Since this unit which was formed in various terrestrial environments such as deltaic, fluvial and lacustrine environments, rests conformably, on to the Middle Miocene Mescitli formations, the Çullu formation may be Middle? — Upper Miocene in age.

İncesu formation: The terrigenous deposits consisting of conglomerate and locally sandstone and claystone, was named the İncesu formation (Aziz, 1971; Tanrıverdi, 1971; Erdoğan, 1972; Havur, 1972; Erdoğan and Soytürk, 1974).

The unit, consisting of alternating poorly - bedded conglomerate, sandstone, mudstone and claystone is generally orange, grey - brown coloured, uncemented or weakly cemented, its grains being well - rounded and unsorted In the some places, blocks are seen as much as 1m in size.Cross and graded bedding have been developed rather well. The unit rarely contains interlayers of vitric - crystalline pyroclastic rocks.

On the basis of the above mentioned preliminary studies, the unit which is of Pliocene age, overlies all the formations unconformably. On the basis of the observations, in the vicinity of Tekman, the İncesu formation rests upon the Işıklar formation which was formed in a lacustrine environment, conformably and transitionally. Nevertheless the relationship regarded as an unconformity must be a local unconformity.

Karayazı volcanics: The rocks" consisting predominantly of olivine basalts and, in places, andesitic rocks were named as the Karayazı volcanics, on the basis of the fact that they crop out typically in the vicinity of Karayazı. They partly correspond to the Karasu basalt and Kaletepe andesite of Koçyiğit (1985). The volcanics varying from andesite to basalt in composition, are regarded as different products of the same phenomena. It may be suggested that andesitic lavas solidified in higher places whereas basaltic lavas solidified in lower places, since basaltic lavas have much lower viscosity.

The lavas which are dark - black and brown coloured and with abundant vesicles and columnar joints, have porphyric or intersertal texture with flow structure. Olivine, hornblende, augite, plagioclase varying from andesine to labradorite in composition and opaque minerals are found in a groundmass composed of plagioclase microlites. These volcanics are with abundant greenish lichens.

The Karayazı volcanics overlie the older units, approximately horizontal. They are probably of Pliocene or Plio - Quaternary age.

The area between Hınıs and Tekman — The above mentioned Haneşdüzü formation is overlain by the Upper - Miocene Alibonca formations which is a terrigenous volcanosedimentary unit, with an angular unconformity, to the northwest of Hınıs. The Alibonca formation is followed by the Bingöldağı volcanics, Hacıömer formation, Işıklar formation and the İncesu formation which crops out in the vicinity of Mescitli, to the north of the study area, and the Karayazı volcanics, respectively (Fig.4)

Alibonca formation: The Upper Miocene terrigenous volcanosedimentary unit consisting of alternating conglomerate, sandstone, mudstone, marl, clayey limestone, gypsum, pyroclastic rocks and lavas, was named as the Alibonca formation (İlker, 1966b; Sungurlu, 1967). This formation corresponds to the lowermost levels of the Zırnak formation of Soytürk (1973).

The unit is orange, locally grey and greenish coloured, thin, medium-thick and thick bedded and contains coaliferous levels and fragments of plants. Cross and graded bedding, channel and load structures, sliding formations synchronized with deposition, oblique-slip faults are common in this unit. This unit contains more volcanic intercalations, in the eastern part of Bingöldağı, than those near Alibonca village.

The Alibonca formation resting upon the Haneşdüzü formation with angular unconformity, was deposited in a terrestrial environment between fluvial and lacustrine, in which a volcanic activity took place.

Bingöldağı volcanics: The volcanics, a part of which was named as the Tekman basalt (Erdoğan and Soytürk, 1974), are mostly of Upper Miocene age and varying from andesite to andesitic basalt in composition, originated from Bingöldağı caldera. So, these volcanics were named as Bingöldağı volcanics.

They crop out typically in the vicinity of Bingöldağı, particularly near Ortaköy - Başköy, on the eastern slope of the Bingöldağı mountain.

The volcanics, which are grey, blackish grey, generally thin medium-thick, in places thick bedded, and contain a large number of regular and parallel joints, greenish lichens in some places, and have concentric flow structure, and parasitic cones, consists generally of alternating andesitic basalt lavas, ignimbrite, tuff and agglomerate. In thin sections, flow texture is prominent. Andesine laths and opacitized hornblende phenocrysts showing parallel arrangement are found in a groundmass composed of plagioclase microlites. In some places, iron - oxide compounds were exposed. As a result of this, the volcanics became reddish.

The Bingöldağı volcanics rest upon the Lower Miocene carbonates with an angular unconformity, in the northwest of Hınıs, but the Alibonca formation conformably and transitionally. The lowermost part of the Bingöldağı volcanics alternates with the terrigenous formation. The Bingöldağı volcanics are overlain by the Pliocene lacustrine formations with angular unconformity. On the basis of these data, the volcanics are most probably of Upper Miocene in age.

Hacıömer formation: The terrigenous formations consisting predominantly of mottled and orange-gray coloured conglomerate were named the Hacıömer formation (Erdoğan, 1966; İlker 1966a). It was regarded as the Kırmızıtuzla member of the Zırnak formation by Erdoğan and Soytürk (1974).

The formation crops out typically in the southern part of Hacıömer village and in the vicinity of Şertefin komu.

The unit consists mostly of polygenic conglomerate and passes into the alternation of conglomerate, sandstone, claystone and mudstone, upwards. The pebbles of conglomerate are well-rounded ill-sorted and poorly-consolidated. The transitions as lateral wedges are observed in this formation as well as poorly, thin-medium thick-thick bedding, gradation changing laterally and vertically and cross-bedding. The gypsum beds are seen in some levels.

According to Erdoğan and Soytürk(1974), the Hacıömer formation which rests upon the Lower Miocene marine carbonates with angular unconformity, shows conformable relationship to the Bingöldağı volcanics. On the basis of the observations, the unit rests upon the volcanics with an angular unconformity, to the west of Hacıömer.

The Hacıömer formation was deposited in fluvial environment. It is of Upper Miocene (Erdoğan and Soytürk, 1974) or Upper Miocene - Pliocene in age (Erdoğan, 1966).

Işıklar formation: The unit, consisting mostly of lacustrine carbonates, crops out typically, in the eastern part of Tekman and in the vicinity of Işıklar village. This unit was named the Işıklar limestone member by Erdoğan and Soytürk (1974). However, since it contains, in places, clastic-pyroclastic rock levels, it was regarded as a formation.

The lacustrine carbonates are dominant rock unit in this formation. The carbonates are yellowish, white and beige coloured, and thin to medium-thick, in places thick bedded. They contain a large number of pores. Cross and graded bedding are common. The unit contains, in places, intercalations of conglomerate, and travertine in the lowermost levels, and intercalations of pebbly and sandy limestone, conglomerate and pyroclastic rocks in the uppermost levels.

The unit rests upon the Bingöldağı volcanics with angular unconformity but the Hacıömer formation conformably. The lower and uppermost levels of the formation reflect the conditions of fluvial environment, whereas the middle levels typically reflect the conditions of lacustrine environment. The formation is of Pliocene in age (Erdoğan and Soytürk, 1974).

The Işıklar formation is overlain by the incesu formation and Karayazı volcanics conformably.

Hamurpet dağı area.— The Alibonca formation which is a terrigenous volcano-sedimentary unit,overlies the Lower Miocene Haneşdüzü formation with angular unconformity, in the vicinity of Hamurpet dağı and near Hınıs-Tekman. The Alibonca formation is overlain by the Zırnak formation and Hamurpet dağı volcanics (Fig. 5).

Z ı r n a k f o r m a t i o n : The coaliferous terrigenous formations resting upon the Alibonca formation which has terrestrial character and consists generally of sandstone, claystone and predominantly limestones upwards, were name as the Zımak formation (İlker, 1966b). Soytürk (1973) preferred to use the same name for the Upper Miocene terrigenous formations and named the Pliocene terrigenous clastic rocks as the Bulanık formation and the volcanic terrigenous rocks as the Elmakaya formation. As a result of the observations, the name given by İlker (19666) was preferred for this formation.

The formation crops out typically in the vicinity of Zırnak village and on the slopes of Hamurpet dağı mountain.

Some levels of the formation which is grey, yellowish coloured and consists of sandstone, claystone, marl in the lowermost levels and limestone in the uppermost levels, contain pyroclastic interlayers- and coaliferous formations. The rocks is thin to medium-thick bedded. Locally well developed graded and cross-bedding, oblique sliding structures are the same age with deposition are common in the lowermost levels. The limestones which are dominant in the uppermost levels, contain ooliths and abundant lacustrine macrofossils in some places.

İlker(1966b) and Tütüncü (1967) claimed that this formation rests upon the Alibonca formation, unconformably, whereas Sungurlu (1967) proposed a paraconformity between them. The same relationship was examined again near Zırnak and Alibonca villages and it was concluded that the existing relationship may be a local unconformity, only.

According to Erdoğan (1966) and Sungurlu (1967) and on the basis of mammalian fauna determined, Pliocene age is assigned to this formation (Fig. 5). The formation was deposited in a lacustrine environment.

H a m u r p e t d a ğ ı v o l c a n i c s : The volcanics which consist mostly of basalt and crop out near Hamurpet mountain, were named as the Hamurpet dağı volcanics.

They crop out typically on the northern and southern slopes of Hamurpet dağı mountain.

They are dark-grey and blackish coloured, unbedded, locally thick bedded and contain locally greenish lichens and a great number of joints intersecting each other. The joints were affected by the movements of the oblique faults. Basalts having prominent flow structure, contain large plagioclase laths (varying from andesine to labradorite) and hornblende and in places pyroxene and olivine.

The Hamurpet dağı volcanics rest upon the Zırnak formation and were probably formed after the formation had been deposited during the Pliocene or Plio - Quaternary.

Correlation of Middle ? — Upper Miocene — Pliocene rocks

The examination and correlation of the units which are exposed in the vicinity of Mescitli, in the area between Hınıs and Tekman, and near Hamurpet dag area, will lead to the following conclusions : The Çullu formation cropping out in the vicinity of Mescitli, probably corresponds to the Alibonca formation cropping out in the area between Hınıs and Tekman. Both formations are terrigenous volcano-sedimentary sequences and probably of Upper Miocene age, and represent the lowermost levels of the younger formations. The Bingöldağı volcanics rest upon these formations, locally and show lateral transitions also.

The Pliocene Işıklar and incesu formations which show conformable relationships to each other, rest upon the Upper Miocene formations,unconformably, in the Tekman-Karayazı basin, whereas the Pliocene Zırnak formation rests upon the Upper Miocene formations, conformably, near Hamurpet dağı area. However, the Pliocene Işıklar formation rests upon the Hacıömer formation ranging from Upper Miocene to Pliocene in age, conformably in the northern basin. Therefore, unless any remarkable deformational and erosional features are recognized, the relationship between the Upper Miocene and Pliocene formations must be regarded as a local unconformity.

The Pliocene Işıklar and incesu formations cropping out in the Tekman-Karayazı basin can be correlated with the Pliocene Zırnak formation cropping out near Hamurpet dağı mountain. For example, while the lacustrine carbonates were dominant at the beginning and fluvial deposits later, in the northern basin, lacustrine conditions prevailed, wholly and lacustrine carbonates predominated towards the end of this deposition, in the southern basin.

The Pliocene formations are overlain by the basaltic Karayazı volcanics in the northern basin, and basaltic Hamurpet dağı volcanics in the southern basin. These basaltic volcanics whose relationships are not seen, directly are probably products of the same phenomena.

Consequently, two significant volcanic stages were differentiated, one being of Upper Miocene age (Bingöldağı volcanics) and one being of Pliocene - Plio - Quaternary age (Karayazı and Hamurpet dağı volcanics).

The above mentioned differences are possibly related to the phenomena that the study area which was developed as a unique basin during the Maestrichtian - Lower Miocene time interval, were subdivided into several basins during the Middle - Upper Miocene - Pliocene.

TECTONIC CHARACTERISTICS OF THE REGION

In the study area, three significant tectonic stages were differentiated, in turn, pre-Maestrichtian-Palaeocene, Late Eocene-pre-Miocene and one that from Middle? - Upper Miocene to the present day in age," and the structures related to these stages were mapped (Fig. 1).

Pre — Maestrichtian — Palaeocene stage

The Akdağ metamorphics constituting the basement, are exposed beneath the Agoren complex as a tectonic window. The ophiolitic complex rests upon the metamorphics, at an angle varying between 30° and 80°. The angle of overthrusting is higher, in the southern part of the metamorphics. But, the metamorphics rest upon the ophiolitic complex, as being bounded by the oblique - slip faults only. The Maestrichtian - Palaeocene sediments rest upon the two units which show tectonic relationships to each other, unconformably. The sedimentary unit contains well rounded pebbles of the formations belonging to the basement. In other words, a definite erosive stage took place during the pre-Maestrichtian. On the basis of these data, it may be concluded that the ophiolitic complex and hence the ophiolites were emplaced in their secondary position, during the pre-Maestrichtian.

Late Eocene stage

In this stage, the Sakaltutan group was thrusted over the Eocene Kösehasan formation, in the southern part of the group. The olisthostromal levels of the Eocene units may be suggested that overthrusting took place during the Eocene. The continuations of the overthrust are covered by the Lower Miocene marine carbonates, in the northern part of Kösehasan and in the southwestern part of Sakaltutan mountain (Fig.l). For this reason, this stage differs from the recent tectonic stage which began during the Middle? — Upper Miocene.

New tectonic stage ranging from Middle - Upper Miocene to the recent

It has been proposed that the Eastern Anatolia is being controlled by compressional regime, from the

Middle? — Upper Miocene to the recent and as a result of this, a crustal thickening took place (Saroğlu et al., 1980; Şaroğlu, 1980). On the other hand, it has been claimed that the compressional and extensional regimes followed each other in the same area (Barka, 1984) or a tectonic regime which took place as compression-narrowing during the Upper Miocene and compression . extending during the Pliocene (Koçyiğit et al.,1985).

The relationships between the Middle? — Upper Miocene terrigenous formations and Lower - Middle Miocene marine formations were examined again. For instance, the Lower Miocene carbonates pass into the Lower? — Middle Miocene Mescitli formation, conformably in the vicinity of Mescitli and the Mescitli formation passes into the Çullu formation, conformably. Nevertheless, the Upper Miocene formations rest upon the Lower Miocene marine carbonates with angular unconformity near Hınıs and Hamurpet dağı area. On the basis of this, the study area was affected by the compressional regime, at least, during the Middle? — Upper Miocene. Extensional forces have probably affected the study area at right angle to compressional forces. It may be concluded that angular unconformity is seen in the areas uplifted under the compressional regime, whereas local conformities are observed in the extensional part of the areas.

In new tectonic stage, the study area was affected by an appoximately N-S striking compression, as in the other parts of Eastern Anatolia (Şaroğlu and Yılmaz, 1984; Şaroğlu, 1986) and as a result of this, approximately NW-SE striking right lateral-slip and NE-SW striking left lateral-slip oblique fault zones took place, as well as E-W trending folds and overthrusts (Fig.l). Along these zones, the northern or southern blocks were uplifted, in places. Therefore, in addition to strike-slip, vertical-slip has occured, also. The fault planes which were developed in the Miocene and older rocks, confirm the oblique character of these faults. The fault traces which were developed on fault planes, make an angle varying between 20° and 45° with a horizontal plane. Some characteristics of the oblique fault zones are presented below.

NW—SE striking right lateral-slip oblique faults.— The Karayazı faults which are observed, in the northwestern part of the study area, and the Kazbel faults and Akdağ faults which are seen in the south of the Karayazı faults, respectively are the most significant faults. A part of the Karayazı fault was originally defined and mapped by Koçyiğit (1985). On the basis of the observations, it has been determined that this fault was separated into a great number of small faults which are disconnected from each other, but following one another, the northern of southern blocks were uplifted and the faults have rather small displacements. The maximum visible lateral displacement of the Kazbel fault which is observed further to tire south, is 4.5 - 5 km (Fig.l). In other words, the rock units lying on both sides of these faults don't show significant differences. So, in the studies of these fault belts, it is not necessary to seperate the rock units as northern or southern blocks of the faults, always.

NE—SW *striking left lateral-slip oblique faults.—* The conjugated faults of the above mentioned faults are observed in the eastern part of Ağcakoca village to the southwest of Sakaltutan mountain, in the western part of Karadağ, around Hamurpet hill, particularly in the northern or southwestern part of the hill(Fig.l).

The fact that some lakes and swamps are arranged in parallel, some streams were displaced, the significant morphological lines are observed and the younger formations are found as being bounded along these faults, may suggest that these faults are active at present and may be moved as a result of energy discharge.

Examination of the relationships between the oblique faults and younger terrigenous formations (Fig.l) and folds and overthrusts which were formed in these formations, may show that both the Hınıs basin and Tekman-Karayazı basin were developed under the control of movements of oblique faults which predominantly have strike slips, as a result of compression, during the Upper Miocene-Pliocene. However, some fault planes and displacements of the faults which are incongruous to the general strike, have been determined in the Lower Miocene marine carbonates and particularly Plio-Quaternary formations and travertines, within some fault zones (Fig. 6A and B). Two small outcrops of travertine which are found.

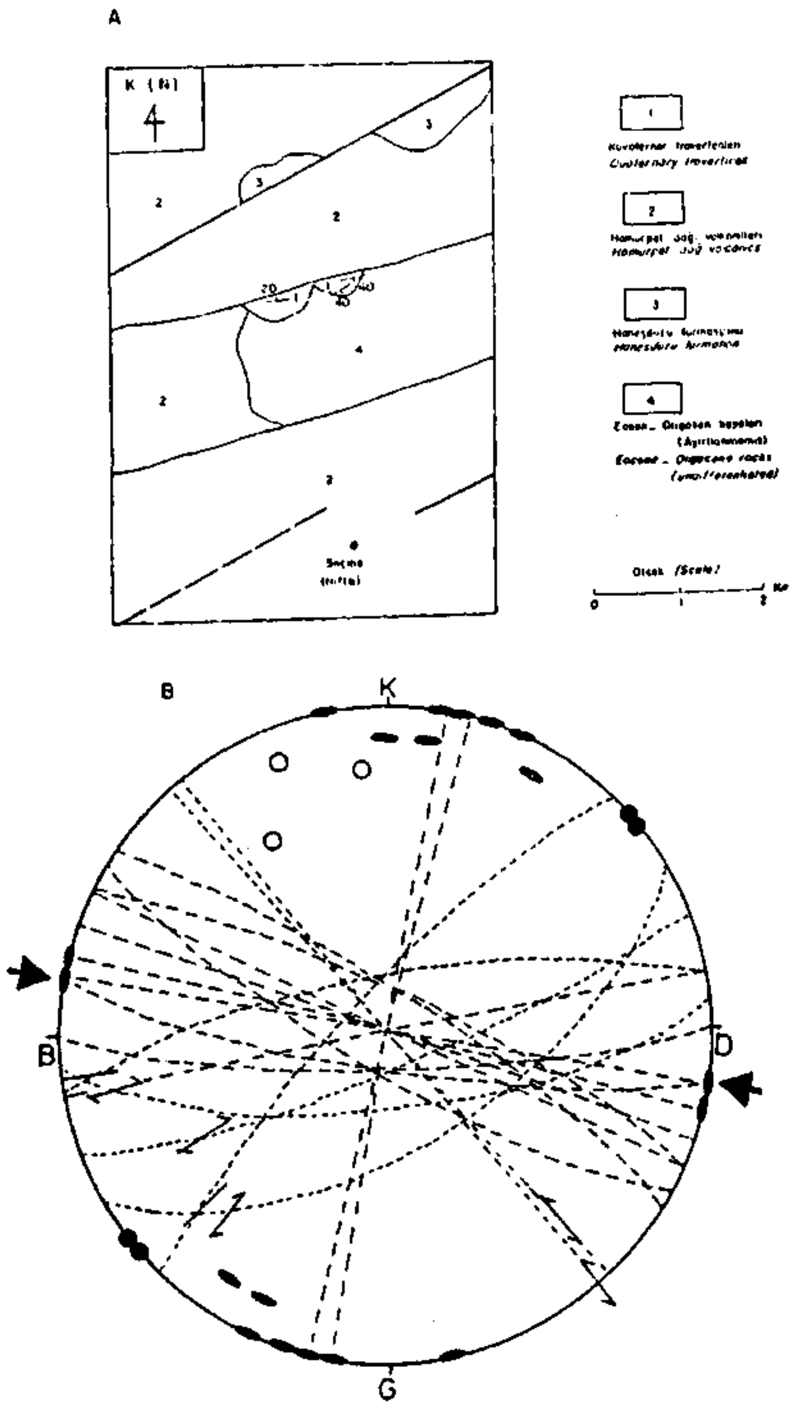

Fig.6— The direction of compression and Schmidt diagram (B) of measured fractures in travertine, to the north (A) of Seçme (Niftik), (18 micro strike-slip faults and cracks have been evaluated).

3 km north of Seçme (Niftik) village, were mapped, one in the east (striking of dip, 140° - 180° and dipping 40°) and another in the west (striking of dip, 350° and dipping 40°), However, evaluation of 18 micro-scale strike-slip faults and cracks in the same outcrops, point out an approximately E-W striking compression (Fig.6B). On the diagram, the short lines represent faults, the long ones cracks, the closed circles left lateral-slip oblique faults, the open ones right lateral-slip oblique faults and the lens-like symbols poles of cracks. In addition, the E-W striking micro-scale normal faults, which have oblique slips also, have been determined in lacustrine carbonates of probably Plio-Ouaternary in age, in Cako upland, 1 km north of Hamurpet lake. These structures are products of E-W striking compression.

Consequently, examination of positions of faults and their relations to the basins, suggests that both the Tekman-Karayazı basin and Hınıs basin were developed under the control of particularly oblique-slip faults and some incongrous structures were formed in the youngest deposits.

CONCLUSIONS

As a result of the studies, the geological map of the area was simplified and made again. The conclusions obtained from these studies are as follows :

The general stratigraphic sequence of the metamorphics in the region, has been determined. In addition, it has been emphasized that the metamorphics had undergone a metamorphism in amphibolite facies and resemble the Central Anatolian massifs (Yılmaz, 1980, 1982; Özcan et al., 1980) on the basis of rock type, the sequence and degree of metamorphism. Furthermore, it has been concluded the metamorphics are exposed beneath the ophiolitic complex as a tectonic window and the both units were cut by acidic intrusions and subjected to contact metamorphism.

The Maestrichtia'n-Pliocene cover, which rests unconformably upon the basement consisting of the metamorphics and ophiolitic complex, is composed essentially of regular transgressive and regressive sequences. This cover started to gain a terrestrial character, as a result of development of final regression during the Middle? — Upper Miocene. Additionally, some data related to the fact that the Ağören complex and hence ophiolites were emplaced in the study area during pre-Maestrichtian, and the transitions between the Maestrichtian-Palaeocene and Oligocene-Miocene rocks, are presented in this paper, for the first time.

The Oligocene levels of the sedimentary cover contain thin interlayersofandesiticbasalt. Additionally, some levels of dacitic and andesitic pyroclastic and epiclastic rocks, and lavas are found in the Middle Miocene formations. The lowermost levels of the Upper Miocene-Pliocene sequence consist of andesite, andesitic basalt and pyroclastics (Bingöldağı volcanics), whereas the uppermost levels consist of andesitic basalt, olivine basalt and pyroclastics (Karayazı and Hamurpet dağı volcanics). So, the Middle-Upper Miocene-Pliocene volcanics varies from dacitic - andesitic volcanics to olivine basalts.

The pre-Maestrichtian overthrusts and Late Eocene-pre-Miocene overthrusts were defined in the study area also.

The NW-SE striking right lateral-slip oblique faults and NE-SW striking left lateral-slip oblique faults were defined as well as the E-W trending folds and overthrusts. These structures were formed as a result of compressional tectonic, during the Late and post-Miocene. The Tekman-Karayazı basin and Hınıs basin were a single basin until the Lower Miocene. The last compressional tectonic regime caused this basin to be separated into two parts during the Middle? — Upper Miocene. Both basins were developed under the control of oblique faults. In addition, some structures were developed locally in the Miocene and Plio-Ouaternary rocks by the effects of the approximately E-W striking compressional forces.

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