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STRATIGRAPHY AND TECTONICS OF THE PULUR (BAYBURT) REGION IN THE EASTERN PONTIDES

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ABSTRACT.- The Pulur (Bayburt) region in the Eastern Pontides is a typical Alpide fold and thrust belt. In the region a relative autochthon and three north-vergent thrust sheets are differentiated, which are the Cebre relative autochthon, and the Hamurkesen, Aşutka and İmalıdağ thrusts sheets. When the thrust stack is palinspastically restored, the Jurassic-Lower Cretaceous sequences in the thrust sheets represent depositional settings that range from shelf in the north to oceanic crust in the south. The Cebre relative autochthon consists of Upper Carboniferous sedimentary rocks, neritic Jurassic limestones and Upper Cretaceous hemipelagic clastic and carbonate rocks. The Cebre relative autochthon is tectonically overlain by the Hamurkesen thrust sheet, which consists of Jurassic volcanoclastic rocks, uppermost Jurassic oolitic limestones, and a thick sequence of Lower Cretaceous pelagic micrites. The next overlying thrust sheet, the Aşutka sheet, comprises a crystalline basement of cordierite-sillimanite-schist, gneiss and amphibolite, which is unconformably overlain by Jurassic volcanoclastic rocks and Lower Cretaceous pelagic micrites. The Lower Cretaceous limestones are tectonically overlain by an ophiolitic melange, which is unconformably overlain by the Maastrichtian neritic limestones and a Paleocene-Lower Eocene flysch. The imalidag thrust sheet of Jurassic-Cretaceous pelagic micrites, lies tectonically over the Paleocene-Lower Eocene flysch. It forms a pop-up structure and rests in the south over the ultramafic rocks of the Ankara-Erzincan Neo-Tethyan suture.

During the Cenomanian-Turonian the ophiolitic melange was obducted northward over the south-facing passive continental margin of the Eastern Pontides. This obduction event was probably caused by the attempted subduction of the Eastern Pontide continental margin in a south-dipping intra-oceanic subduction zone. The polarity of the subduction changed after this event and the Tethyan ocean floor started to subduct northward under the Eastern Pontides. This led to the development of a major Senonian volcanic arc in the outer Eastern Pontides, while the inner Eastern Pontides including the area studied were in fore-arc position. The thrust and fold tectonics developed during the collision between the Eastern Pontides and the Anatolide-Tauride microplate, which took place in the Late Paleocene-Early Eocene. Post-collisional Middle Eocene marine limestones and sandstones overlie unconformably the various thrust sheets.

INTRODUCTION

The Pulur region contains the only autochthonous Carboniferous outcrops in the Eastern Pontides (Fig. 1). The Carboniferous outcrops, discovered by Ketin (1951), comprise coal and bituminous exploration (Akdeniz, 1988). Other important geological problems in this region are the relations of the Carboniferous sequence to the pre-Jurassic Pulur metamorphic rocks and to the Permo-Triassic Karakaya Complex. This paper comprises the results of the field work in the Pulur region during the summer months of 1992 with the aim of solving some of the above problems.

Because of the presence of the Carboniferous rocks, the Pulur region has attracted the attention of several geologists. After the initial study by Ketin (1951), the region was investigated by Ağar (1977), Akdeniz (1988), Tanyolu (1988) and Keskin et al., (1989).

TECTONIC FRAMEWORK OF THE PULUR REGION

The Pulur region lines in the internal part of the Eastern Pontides (Ketin, 1966). Tectonically this regions forms the easternmost part of the Sakarya Zone of the Pontides. The characteristic features of the Sakarya Zone are a Hercynian metamorphic basement of Carboniferous age, Permo- Triassic subduction-accretion units (Karakaya Complex), a widespread Liassic transgression and ubiquitous Upper Jurassic-Lower Cretaceous limestones (Okay, 1989; Okay et al., 1996). The region studied shows these typical features.

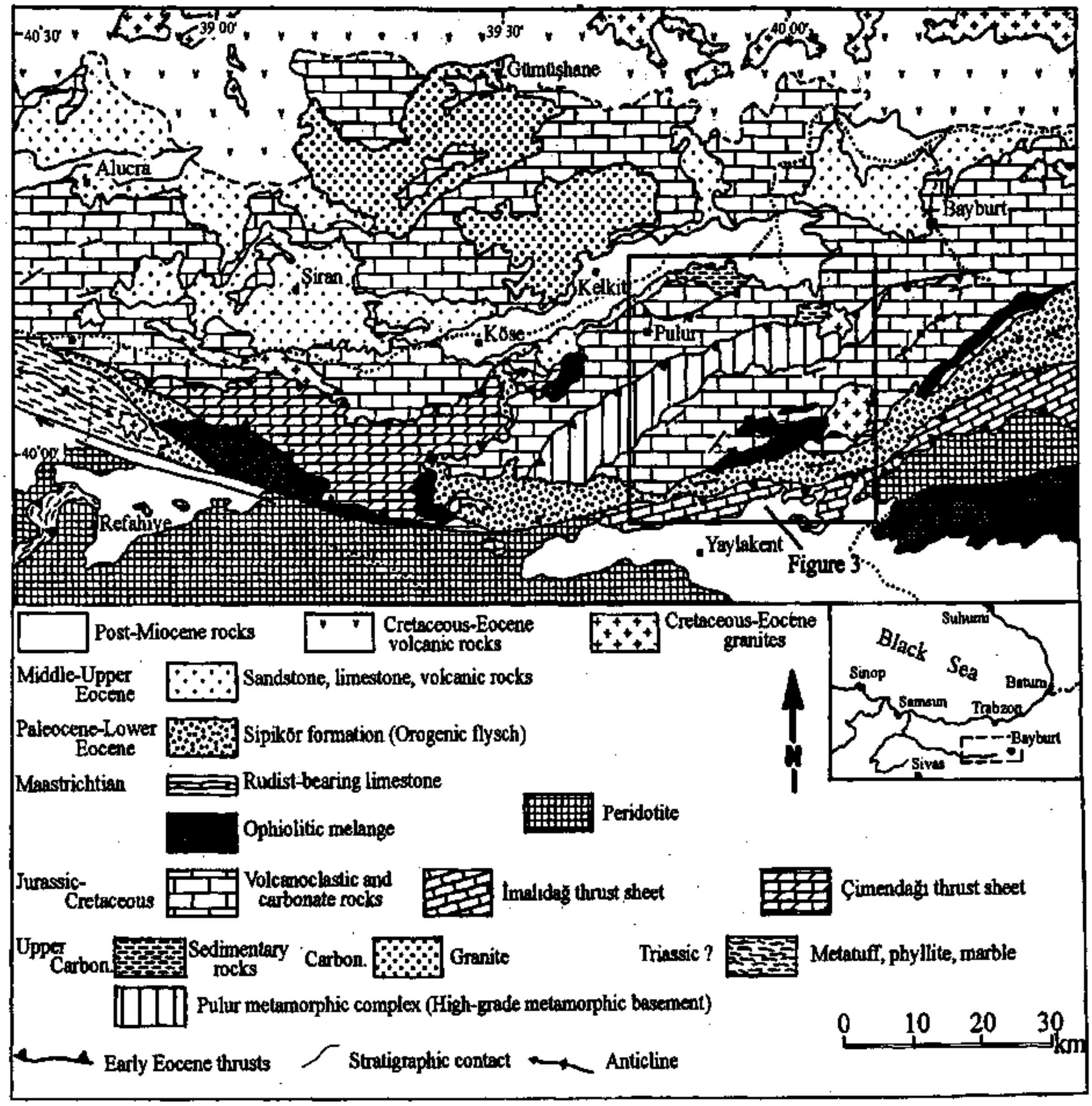

Fig. 1- Tectonic map of the southern part of the Eastern Pontides (modified from Yılmaz (1985) and Bergougnan (1987). The area studied and shown in Fig. 3 is outlined.

The internal parts of the Eastern Pontides formed a north-vergent thrust stack during the Early Tertiary continent-continent collison. In the Pulur region such thrusts were first recognised by Ketin (1951) and later shown on a geological cross-section by Akdeniz (1988). We have mapped a relative autochthon and three major thrusts sheets in the Pulur region, which were emplaced northward during the Late Paleocene - Early Eocene. These are named as the Cebre relative autochthon and going up and southward in the thrust stack the Hamurkesen, Aşutka and İmalidağ thrust sheets (Fig. 2). The pre-Jurassic basement is observed in the Cebre relative autochthon and in the Hamurkesen and Aşutka thrusts sheets, while the İmalidağ thrusts sheet is made up of Jurassic and

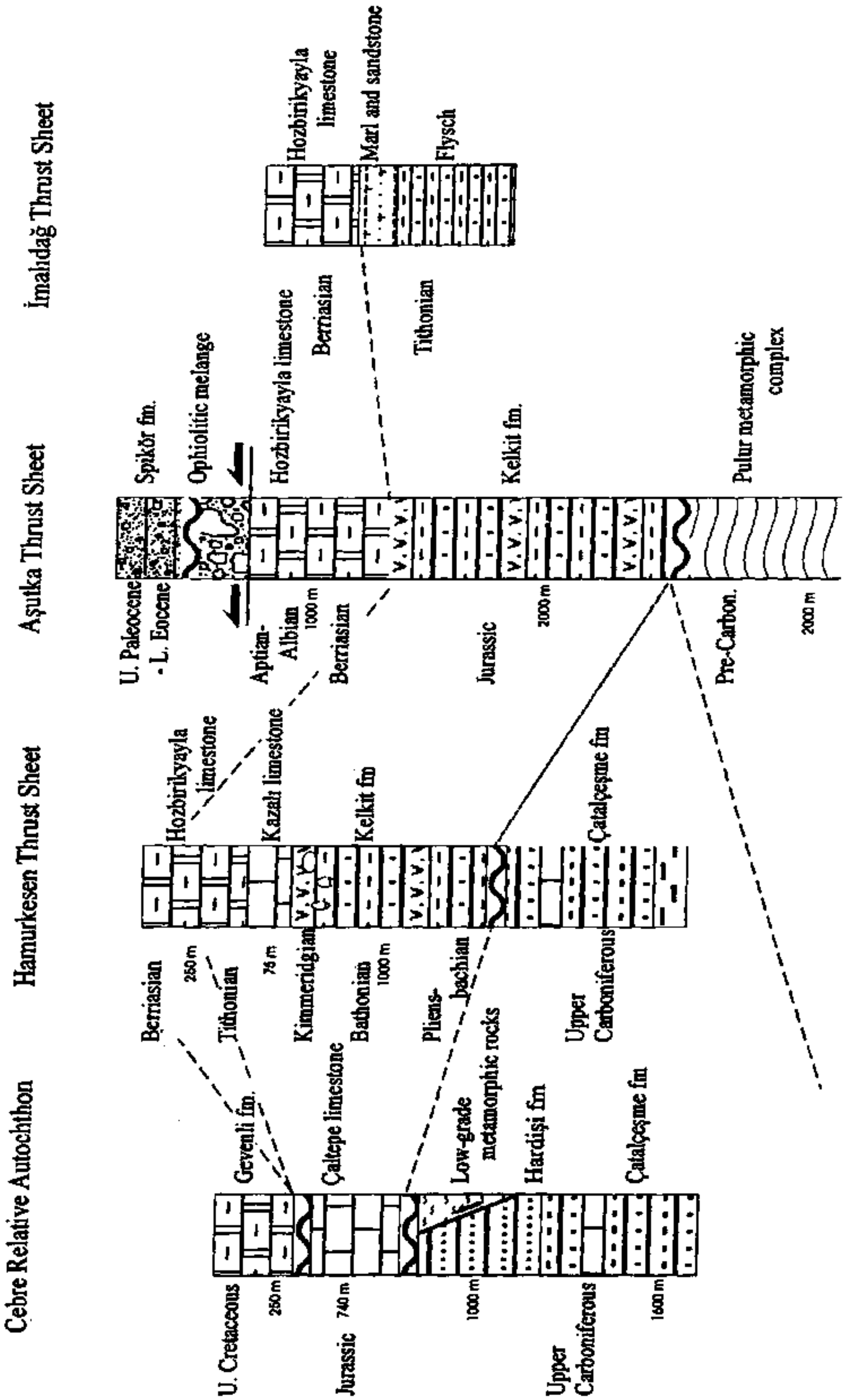

Fig. 2- Stratigraphy of the thrust sheets in the Pulur region

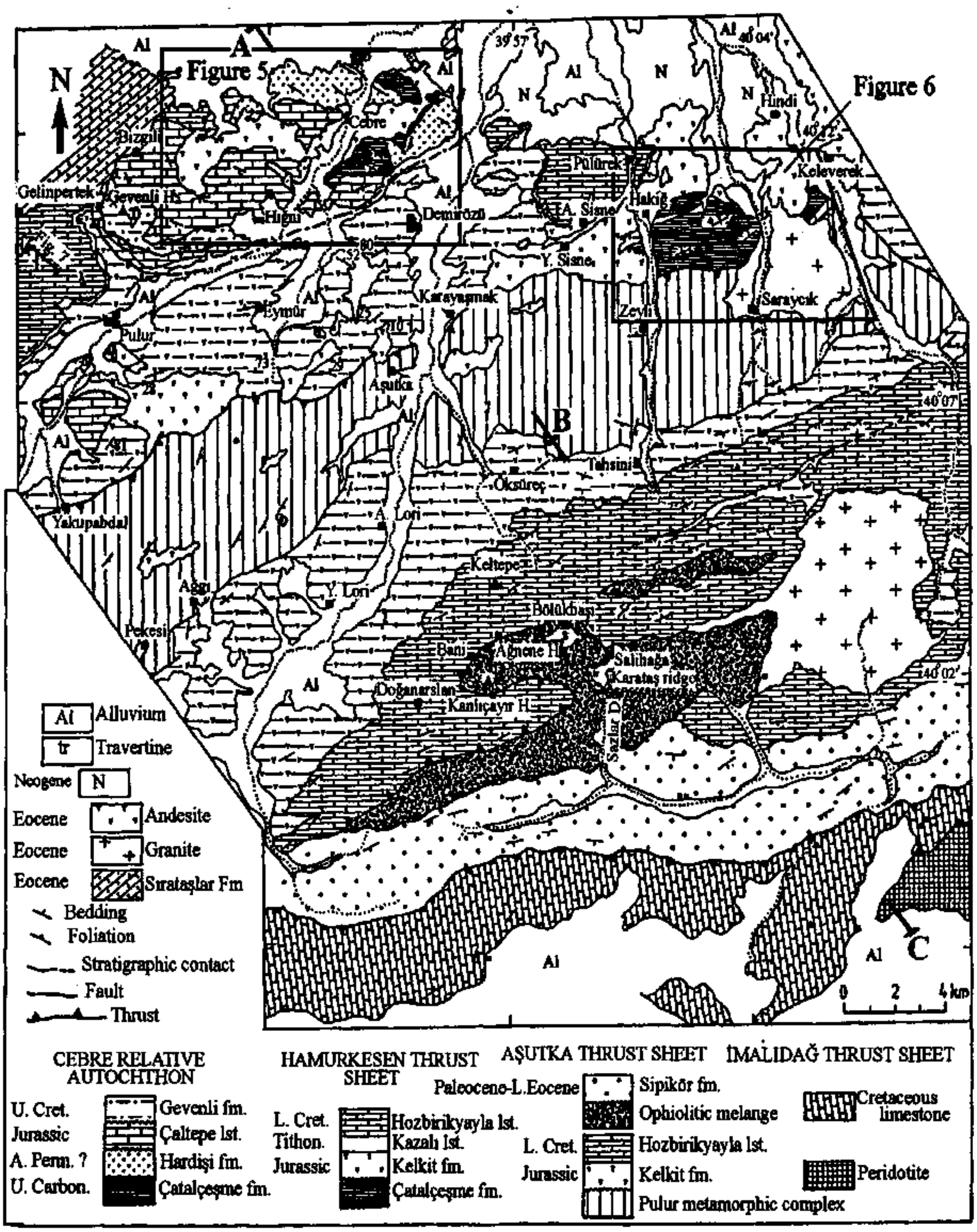

Fig. 3- Geological map of the Pulur region. For location see Figure 1.

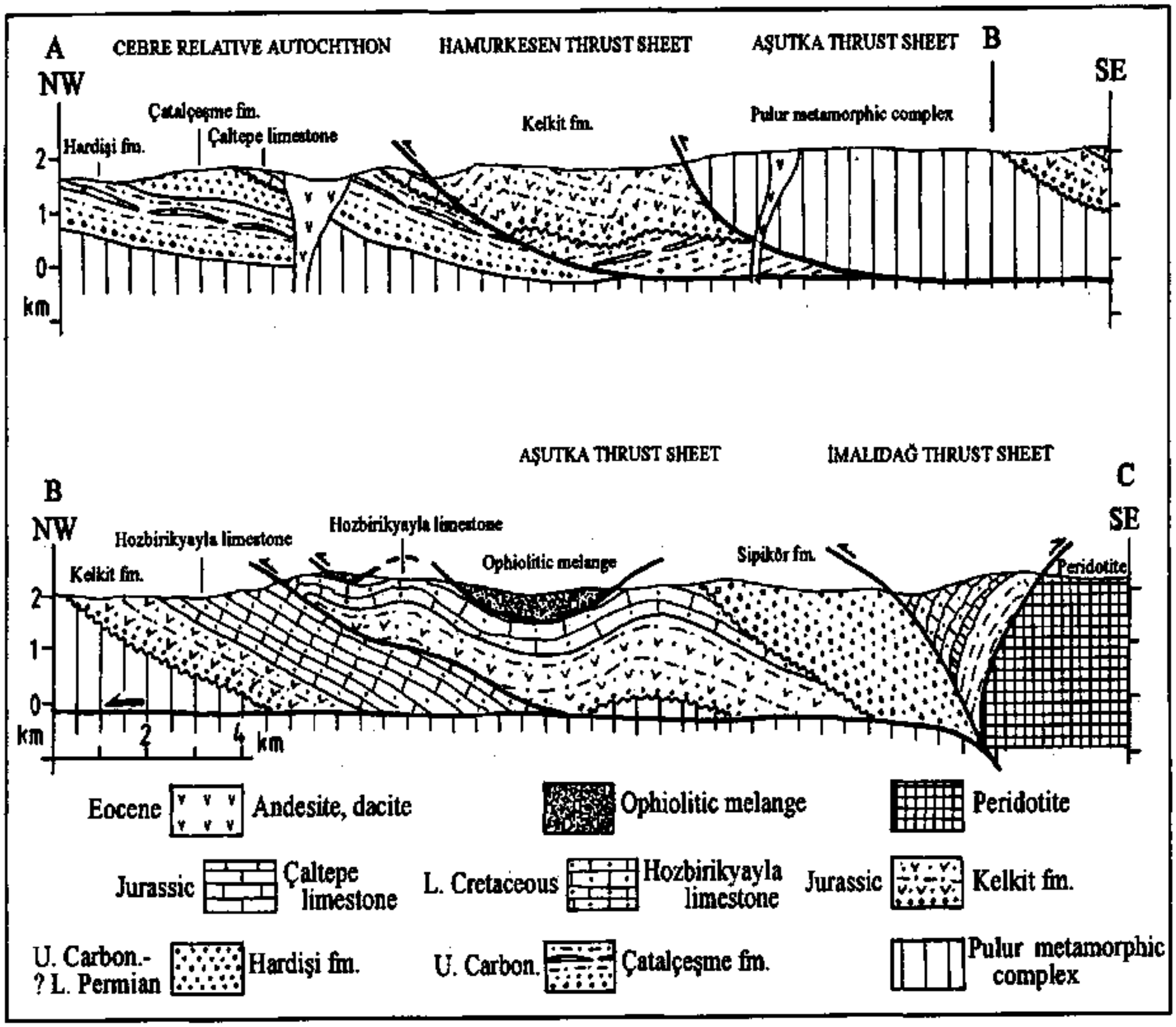

Fig. 4- Geological cross-section of the Pulur region. The section is along a single NW-SE trending line, the lower section continues from the upper one with some overlap around "B". For location see Fig. 3.

younger rocks. The bulk of the thrust sheets are constituted of Jurassic-Lower Cretaceous sedimentary rocks, which exhibit facies differences among the thrust sheets (Fig. 2). The Jurassic-Lower Cretaceous sequence of the Cebre relative autochthon was deposited in a shallow carbonate" platform in the north whereas the Lower cretaceous pelagic micrites of the İmalıdağ thrust sheet were deposited in the south-facing Tethyan continental margin. The ophiolitic melange in the Aşutka thrust sheet represents, the Mesozoic sedimentary and volcanic rocks of the Tethyan ocean floor. •

STRATIGRAPHY

Cebre relative autochthon

The relative autochthon was subdivided into four formations (Figs. 3 and 4). These are from bottom to top, Çatalçeşme formation, Hardişi formation, Çaltepe limestone and Gevenli formation (Fig. 2). Apart from these formations, low-grade metamorphic rocks of uncertain stratigraphic position outcrop in two small areas.

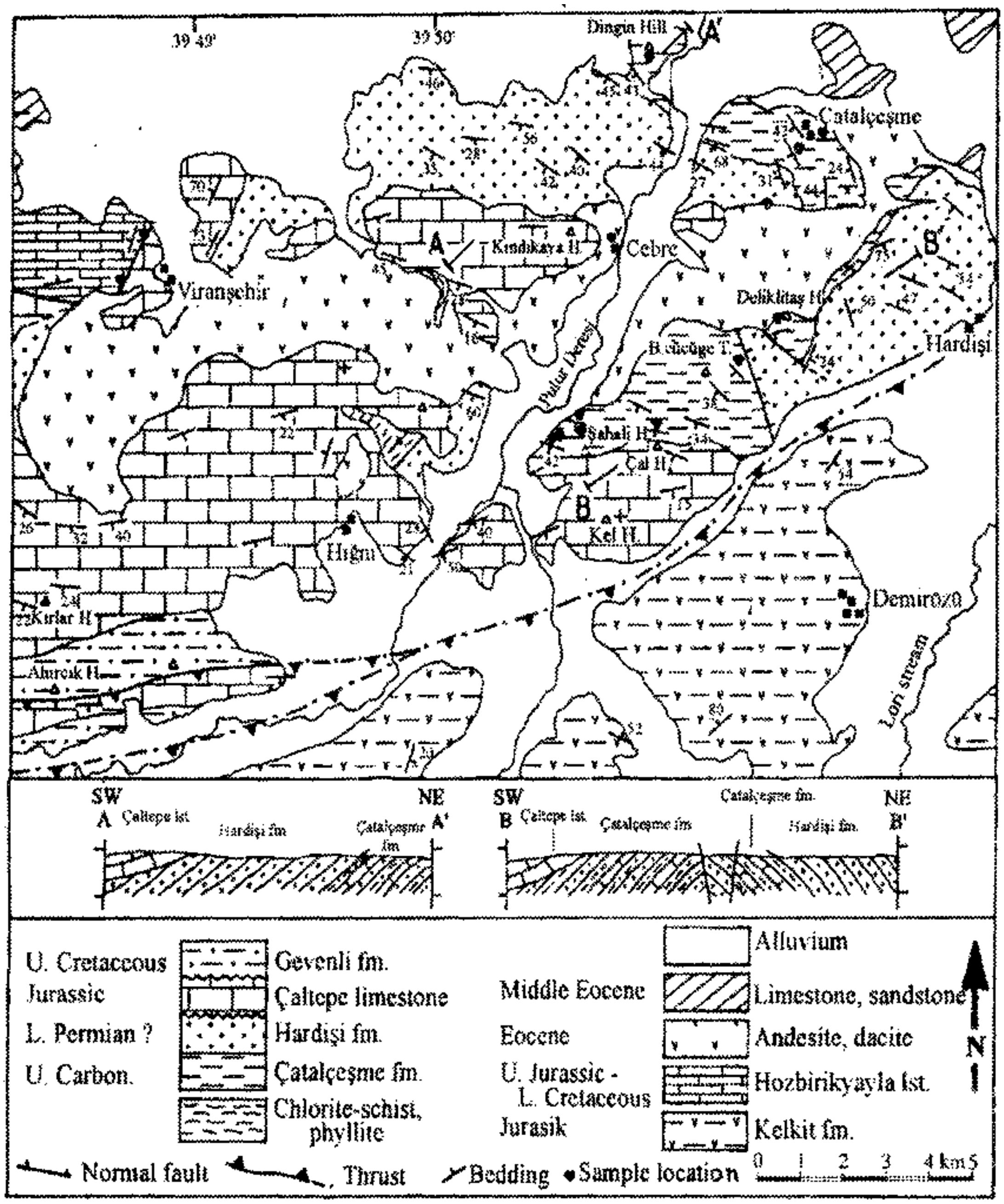

Fig. 5- Detailed geological map and cross-section of the Cebre-Demirözü region showing the Carboniferous outcrops (from Akdeniz (1988) and our own mapping). For location see Fig. 3.

Low-Grade Metamorphic Rocks.- These metamorphic rocks are represented by very fine-grained, greyish green, quartz-chlorite-schists and grey phyllites with a mylonitic foliation. They are cut by Tertiary andesites, and give poor outcrops north of the village of Hığnı and west of the Kındıkkaya hill (Fig. 5). North of the village of Hığnı, these rock are unconformably overlain by the Jurassic Çaltepe limestone. Akdeniz (1988), who first described these metamorphic rocks, places a probable angular unconformity between the metamorphic rock north of Hığnı, and the Hardişi Formation of Carboniferous age. The contact between these two units is covered in this region. However, the subvertical foliation in the metamorpihc rocks, and the attitude of the strike in the Hardişi formation, which is at right angles to the rock is much lower than that in the Pulur metamorphic complex, and resembles that in the Ağvanis Massif northwest of Refahiye (Okay, 1984; Fig. 1). The probable relation of the low-grade metamorpic rocks, which also outcrop in the Hamurkesen thrust sheet, to be Carboniferous sedimentary sequence and to the Pulur metamorphic rocks will be discussed in the final section of the paper.

The Permo-Carboniferous sequence of the Pulur region.- Ketin (1951), who first described the Permo-Carboniferous series in the Pulur region, divided the sequence into two lithostratigraphic units: At the base there were a monotonous series of thick, red sandstones, which were overlain by a heterogeneous series of intercalated fusulinid-bearing dark limestone, shale, quartzite and pebbly sandstone. Later Ağar (1977) stated, in our view correctly, that the red terrigeneous sandstones lay not below but above the heterogeneous series. Ağar (1977) placed an angular unconformity between the heterogeneous series, which he named the Çatalçeşme Formation, and the overlying terrigeneous sandstones, and suggested without any paleontological evidence, a Triassic age for the monotonous red sandstones. A third change in the Permo-Carboniferous stratigraphy of the region was introduced by Akdeniz (1988). Akdeniz (1988). who made a detailed geological map of the region, subdivided the Permo-Carboniferous sequence into three formations. At the base there was the Upper Carboniferous Çatalçeşme formation, overlain conformably-by the terrigeneous red sandstones, which in turn passed up into the Lower Permian Büyükcücüğe formation, which was lithologically very similar to the Çatalçeşme formation. In contrast to this, our study has shown that the Büyükcücüğe ad Çatalçeşme formations represent the same formation, which is repeated by faulting (Fig. 5), and both lie below the red sandstones. Moreover, our paleontological samples from "both formations" gave the same age range. Akdeniz (1988) correctly identified that the andesites, which were regarded by Ketin (1951) as part of the Permo-Carboniferous sequence, were in fact part of the Eocene volcanism, and were intrusive into the Permo-Carboniferous sequence. The British Petroleum geologists, who last studied the Pulur region (Robinson et al., 1995), suggested an Upper Paleozoic stratigraphy, which is not compatible with the field data and in fact with the lithologies in the Paleozoic sequence.

In our study, the Permo-Carboniferous sequence in the Pulur region is subdivided into two formations. At the base three is the Çatalçeşme formation of indercalated limestone, sandstone and shale, which is overlain by the red sandstones of the Hardişi formation. Although the Hardişi formation is referred to as Karakaya formation in previous studies (Ağar, 1977; Akdeniz, 1988), this name is not used as "Karakaya" is an already well-known lithostratigraphic name in the Pontides.

Çatalçeşme formation (Upper Carboniferous).- The Upper Carboniferous sequence of intercalated pebbly sandstone, limestone, conglomerate, quartzite and black shale with thin coal seams is named as the Çatalçeşme formation (Ağar, 1977). The Çatalçeşme formation used in this study encompasses the Çatalçeşme and Büyükcücüğe formations of Akdeniz (1988). Its type section, where its upper contact with the Hardişi formation is observed, is the unnamed valley, which runs parallel to the Demirözü-Cebre road, and climbs up to the Deliktaş hill (Fig. 5). Additional good section exist along the ridge from the Büyükcücüğe hill southwestard towards the Çal hill, and southeast of the Çatalçeşme village (Fig. 5).

The siratigcaphic base of the Çatalçeşme formation is not observed. The Çatalçeşme formation is overlain conformable by the Hardişi formation and unconformably by the Çaltepe limestone of Jurassic age. Ağar (1977) and Robinson et al. (1995) place an unconformity between the Çatalçeşme and Hardişi formations. However, as observed south of the Deliklitaş hill, an intercalation of limestofte, shale and pebbly sandstone of the Çatalçeşme formation passes upwards to the pebbly sandstones of the Hardişi formation with the gradual disappearance of limestones and shales in the sequence. The maximum observed thickness of the Çatalçeşme formation is about 1100 between the Büyükcücüğe and Şahali hills.

The Çatalçeşme formation has two main outcrop areas, one around the Çatalçeşme village and the other around the Büyükcücüğe hill (Fig. 5). In both of these outcrop areas the Çatalçeşme formation consists of sandstone, pebbly sandstone, dark limestone, siltstone, dark shale with coal seams, which are intercalated on a few to ten metre scale. The sandstones are medium to coarsa grained, beige, grey, yellowish pink and pink arkosic arenites with well-rounded pebbles. They are intercalated with dark grey, black, medium to thickly bedded limestones locally rich in brachiopods, corals, gastropods, algs and fusulinids. The thickness of the limestone horizons ranges from a few ten centimetres to few ten metres, and there are more than 20 limestone horizons ranges from a few ten centimetres to few ten metres, and there are more than 20 limestone horizons in the Çatalçeşme formation. Black, grey shales with thin, discontinuous coal seams, and yellowish brown, thinly bedded, strongly bioturbudited siltstones with plant fossils occur between the limestone beds and horizons. In the first outcrop area, around the village of Çatalçeşme, the Çatalçeşme formation passes up to the red sandstones of the Hardişi formation, as observed by Akdeniz (1988) (Fig. 5). Six limestones samples collected from around the village of Çatalçeşme contain the following fossils characteristic for Kasimovian-Gzelian (Upper Carboniferous): Syzran/a sp., *Eotuberiting* sp., *Palaeonubecularia* sp., *Palaonubecularia uniserialis* REITLINGER, *Palaeonubecularia fluxa* REITLINGER, *Tetrataxis* sp., *Tetrataxis linea* OZAWA, *Globivalvulina* sp., *Bradyinasp., Ozawainella sp., Staffellasp., Schubertella* sp., *Triticitessp., Pseudoenothyrasp., Hemigordius* sp., *Tubiphytes obscurus* MASLOW.

The sequence of sandstone, fusulinid limestones and shale in the second outcrop area, around the Büyükcücüğe hill was assigned by Akdeniz (1988) to the Büyükcücüğe formation, to which he gave an " early Permian age and placed above,he Hardişi formation. However, the contact of the Çatalçeşme and Hardişi formations to the east of the Büyükcücüğe hill is not stratigraphic but is consituted by a NNW trending normal fault (Fig. 5). Furthermore, fossils from eight limestone samples collected from around the Büyükcücüğe hill also give a Kasimovian-Gzelian (Late Carboniferous) age: Syzran/a sp., *Eotuberitina sp:, Palaeonubecularia* sp., Paleonubecularia uniserialis REITLINGER, *Deckeralla sp., Tetrataxis* sp., *Globivalvulina* sp., *Monotaxinoides* sp., *Ozawainella sp., Ozawainella angulata* (COLANI), *Staffella* sp., *Schubertella* sp., *Quasifusulina* sp., *Triticites sp., Tubiphytes sp., Girvanella* sp., *Beresella sp.*

Hardişi formation (Upper Carboniferous- ? Lower Permian).- The sequence of red, terrigeneous sandstones, which lies conformably over the Çatalçeşme formation is named after the Hardişi (Çiftetaş) village, around which it gives good exposures. The Hardişi formation is unconformably overlain by the Çaltepe limestones of Jurassic age (Figs, and 5). The type section of the Hardişi formation, where its lower and upper contacts are observed, is between the Kındıkkaya and Dingin hills (Fig. 5). In this section it has a thickness of about 1000 metres.

Hardişi formation consists of thickly bedded, pale pink, white, red feldspathic arkosic arenites and pebbly arenites. The poorly sorted and well rounded pebbles, generally 2 to 5 cm in diamater, are constituted of quartz and magmatic rocks, such as microgranite, microdiorite, rhyolite. These pebbles are most probably derived from Köse or Gümüşhane granodiorites of similar late Hercynian plutons, which outcrop north of the Pulur basin, and have given a 360±2 Ma (earliest Carboniferous) Rb/Sr whole rock isochron age (Bergoughan, 1987). No fossil has been found in the terrigeneous sandstones of the Hardişi formation. However, considering that it lies conformable on the Çatalçeşme formation of Kasimovian-Gzelian age, the Hardişi formation can be said to be of latest Carboniferous age and may possibly reach into the earliest Permian.

Çaltepe limestone (Jurassic).- The neritic carbonate sequence of Jurassic age, which lies unconformably over the Çatalçeşme and Hardişi formations, was named by Ağar (1977) as the Çaltepe limestone. It is striking that the Jurassic system in the Cebre relative authochthon is represented by neritic limestones and not the by widespread and typical volcanoclastic facies (Kelkit formation) of the Eastern Pontides. The best sections of the Çaltepe limestone is overlain unconformably by the Gevenli formation, as can be seen in the Kurtkoyağı Creek north of the Demirözü-Pulur road. The Çaltepe limestone has a thickness of 740 metres in the Kırlar hill section.

The Çaltepe limestone starts with sandstones with a carbonate matrix; these sandstones, which form a thin horizon at the base, pass up to medium to thickly bedded, dark grey, black, oolitic limestones. Above this oolitic limestones horizon there are thickly bedded, massive, grey and beige micrites with irregular black chert nodules and bands, which form the bulk of the Sequence. The lower part of the Çaltepe formation was assigned a Liassic (Pliensbachian) age by Akdeniz (1988) through microfossils and by Robinson et al. (1995) through Sr isotopic analyses. In contrast, our samples from the Çaltepe limestone have yielded microfossils with a wider age range of Jurassic-Early Cretaceous of Late Jurassic-Early Cretaceous: *Glomospira* sp., *Reophax* sp., *Textularia* sp., *Opthalmidium* sp., *Protopeneroplis?* Sp., *Trocholina* sp., *Lithocodium aggregatum* ELLIOT, *Bacinella irregularis* RADOICIC, *Saccocoma* sp., *Globochaete* sp. However, samples collected from the top of the sequence just below the Gevenli formation have yielded microfossils characteristic of Tithonian-Valanginian: *Pseudocylammina* spp., *Pseudocylammina lituus* YOKOYAMA, *Patellina* sp., *Neotrocholina* sp., *Cladocoropsis mirabilis* FELIX, *Tubiphytes morronens*/sCRESCENTI, *Opthalmidium sp.* Akdeniz (1988) also describes foraminifera of Late Jurassic-Berriasian age from the upper parts of the Çaltepe limestone. The available data indicate that the age range of the Çaltepe limestone includes the whole of the Jurassic and possibly passes into the earliest Cretaceous.

Gevenli formation (Upper Cretaceous).- The sequence of siltstone.-sandstone, shale, marl and pelagic limestones, which lies unconformably over the Çaltepe limestones has been named as the Gevenli formation. The name of the formation comes from the Gevenli hill between the Pulur and Bizgili villages. Gevenli formation corresponds to the upper part of the Çaltepe formation of Akdeniz (1988). The Gevenli formation is overlain with a low-angle thrust contact by the Jurassic Kelkit formation. It is also repeated by thrusting south of the Ahırcık hill (Fig. 5). The Gevenli formation has a minimum thickness of 250 metres.

The Gevenli formation outcrops widely to the south of the village of Pulur. Although its type section is along the road between the Pulur and Bizgili villages, the base of the Gevenli formation is best observed in the Kurtkoyağı creek. Here, the Gevenli formation starts above the Çaltepe limestone with a half a metre thick conglomerate with limestone clasts. The conglomerate is overlain by fine-grained, yellowish grey, yellow sandstone with bluish green tuff clasts; fine to medium bedded, yellowish silstone showing graded bedding; bluish grey marl and rare sandy limestone, the upper parts of the sequence is made up of brown, regularly and thinly bedded siltstone, shale and mudstone intercalation. It comprises limestone olistoliths derived from the Çaltepe limestone. The Gevenli formation is poorly fossiliferous. Only a single sample from the lowermost parts of the Gevenli formation has yielded *Hedbergella* sp. and undeterminable planktic foraminifera of the Globotruncanidae family indicating a Turoniyen-Maastrihtiyen age range. Akdeniz (1988) assignes a Valanginian age to the topmost part of the Çaltepe limestone, which in our scheme corresponds to the Gevenli formation. However, this age probably comes from the blocks of the Çaltepe limestone in the Gevenli elastics, and does not reflect the age of the Gevenli formation. Robinson et al. (1995) has obtained Late Cretaceous ages from the basal parts of the Gevenli formation and Santonian- ? Turonian ages from its middle parts. These data indicate a Senonian age range for the Gevenli formation.

Hamurkesen thrust sheet

The Cebre relative authochthon is technically overlain by the Hamurkesen thrust sheet. The Hamurkesen thrust, which forms the contact between the two units, can be followed for five kilometres north of the Pulur village between the Gevenli formation or the Çaltepe limestone below and Jurassic volcanoclastic rocks (Kelkit formation) above (Fig. 3). The thrust fault is represented by a few metres thick, sheared shale horizon and dips to the south at 50 degrees. Eastward the Hamurkesen thrust is covered by alluvium and follows the Pulur stream for 14 km. The non-recognition of the Hamurkesen thrust in the older studies has resulted in confusion. For example, in the map and section of Ağar (1977) the Gevenli formation of Cretaceous age is shown to lie strarigraphically below the Jurassic Kelkit formation. The Hamurkesen thrust corresponds to an important paleogeographic and sedimentological threshhold. In the Cebre relative authochthon below the thrust, the Jurassic system is represented by a carbonate facies, whereas above the thrust in the Hamurkesen and Aşutka thrust sheets the Jurassic is represented by volcanoclastic rock probably deposited in a depeer marine environment.

The Hamurkesen thrust sheet consists mainly of three formations (Fig. 2). At the base there is the Kelkit formation, a thick volcanoclastic sequence of Jurassic age, this is succeded by oolitic limestones of Kazalı limestone, and at the top there is the Hozbirikyayla limestone of thick radiolarian biomicrites of Lower Cretaceous age (Fig. 3). Apart from these formations, low-grade metamorphic rocks and Carboniferous sedimentary rocks outcrop in a restricted area.

Low-Grade metamorphic rocks.- These metamorphic rocks, which outcrop around the village of Hakiğ as a small tectonic slice, are made up of well foliated, grey phyllite and fine-grained green metatuffs (Fig. 6). Like in the Cebre relative autochthon, these rocks may be correlated with the Ağvanis metamorphic rocks or with a more metamorphic part of the Carboniferous sequence.

Çatalçeşme formation (Carboniferous).- The Çatalçeşme formation in the Hamurkesen thrust sheet (Keskin, 1987) is more recrystallised and more strongly deformed compared to that of the Cebre relative autochthon. It has undergone a very low-grade metamorphism, and the fine-grained clastic rocks, especially the shales, are well foliated and have been transformed into slates. The lower part of the Çatalçeşme formation outcrops north of the Sarigüney hill (Fig. 6). In this region slightly recrystallised black slates and siltstones form a sequence of over 500 m in thickness. These fine-grained clastic rocks, which are not observed in the Çatalçeşme formation of the Cebre relative authochthon, also contain rare beds of sandstone, metatuff and recrystallised limestone. These black slate series are conformabje overlain by a sequence of closely interclated sandstone, pebbly sandstone, dark limestone, siltstone and dark shale, very similar to that observed in the Çatalçeşme formation of the Cebre relative authochthon. Five limestone samples from the limestones of this sequence comprise foraminifera of Kasimovian-Gzelian age: *Syzrania* sp., *Eotuberitina* sp., *Paleonubecularia* sp., *Climacammina* sp. *Tetrataxis* sp., *Endothyranella* sp., *Bradyina* sp., *Monotaxinoides* sp., *Ozawainella* sp., *Schubertella* sp., Keskin (1987), who described However, the contact between the Çatalçeşme formation and the Pulur metamorphics in this region is not stratigraphic as claimed by Keskin (1987), but is a steep thrust fault (Fig. 6).

Kelkit formation (Jurassic).- It is made up of volcanogenic sandstone, siliceous shale, andesitic and basaltic tuff, agglomerate and rare sandy limestone, limestone, and grain and debris flows with volcanic material and up to a few kilometres largo block of Upper Jurassic limestone. This typical Jurassic formation of the Eastern Pontides is named by Bergougnan (1987). The Kelkit formation lies over the Gevenli formation of Upper Cretaceous age along the Hamurkesen thrust, and it is stratigraphically overlain by the oolitic limestones of the Kazalı formation and technically by the Pulur metamorphic complex (Figs. 3 and 4).

Reference section for the Kelkit formation in the region studied is the Hamurkesen valey north of the Pulur village. Kelkit formation has a thickness of over 1000 metres. No in situ fossils have been found in the Kelkit formation; however, the limestone olistoliths in the formation contain fossils of Kimmeridgian-Valanginian age: *Cladocoropsis mirabilis* FELIX, *Tubiphytes morronensis* CRESCENTI, *Protopeneroplis striata* WEYNSCHENCK, *Protopeneroplis trochoangulata* SEPTFONTAINE, *Bacinella irregularis* RADOICIC, *Koskinobullina*

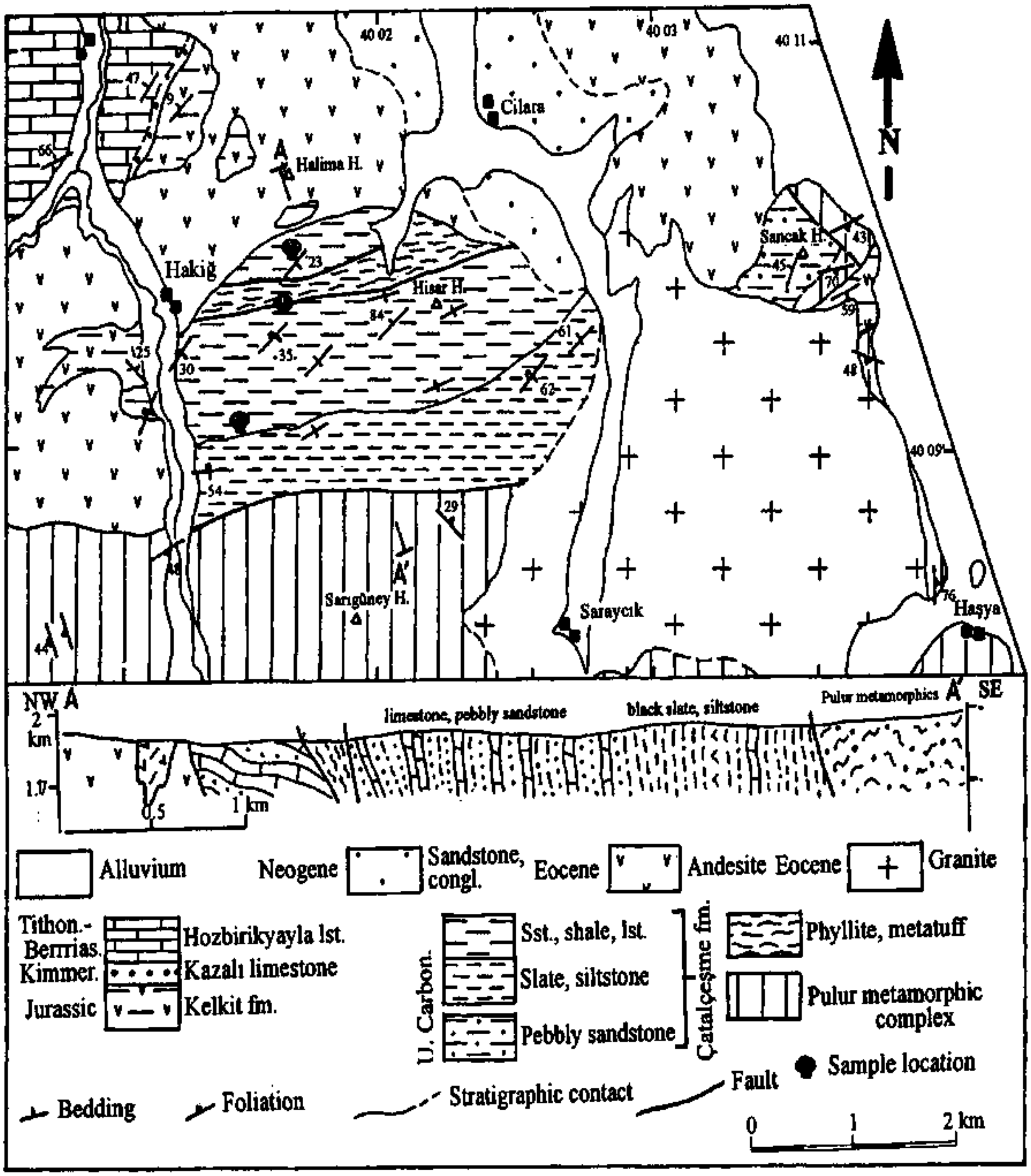

Fig. 6- Detalied geological map and cross-section of the Hakiğ (Çamdere) region showing the relation between the Carboniferous rocks and the Pulur memamorphic complex. For location see Fig. 3.

socialis CHERCI & SCHROEDER, *Reophax* sp., *Lenticulina* sp., *Patellina* sp., *Spirillina* sp: *Trocholina* sp. These age data and the age of the overlying Kazalı formation constrain the upper age limit of the Kelkit formation as Kimmeridgian. Data on the lower age limit of the Kelkit formation is provided by other workers. Robinson et al. (1995) have obtained dinoflagellates of Bathonian age from the middle parts of the Kelkit formation in the region studied. Özer (1984), who studied the eastward extension of the Kelkit formation to the south of Bayburt, describes a rich Lower Pliensbachian-Upper Toarcian ammonite fauna from the ammonitico rosso limestones rich Lower Pliensbachian-Upper Toarcian ammonite fauna from the ammonitico rosso limestones horizons in the Kelkit formation. Akdeniz (1988) describes Liassic fossils from the limestones blocks in the Kelkit formation. These data indicate that the age range of the Kelkit formation is from Late Pliensbachian to Kimmeridgian.

Kazalı limestone (Kimmeridgian). - The neritic limestones, which form a thin but laterally continuous stratigraphic horizon, above the Kelkit formation, is named as the Kazalı limestone. The Kazalı limestone corresponds to the lower parts of the Hozbirikyayla limestone of Ağar (1977) and Akdeniz (1988). The type section of the Kazalı limestone is the Kazalı valley west of the Pulur-Gelinpertek road, 2.5 km north of Pulur. The Kazalı limestone consists of thickly bedded, oolitic black limestones, and has a thickness of 50 to 100 metres (Fig. 2). Samples from the Kazalı limestone collected from north of the Pulur and Sisne villages contain a Kimmeridgian-Berriasian microfauna: *Nautiloculina* sp., *Protopeneroplis* sp., *Protopeneroplis trochoangulata* SEPTFONTAINE, *Conicospirillina basiliensis* MOHLER, *Trocholina alpina* (LEUPOLD), *Cayeuxina* sp., *Tubiphytes morronensis* CRESCENTI, *Bacinella irregularis* RADOICIC, *Siphovalvulina* sp., *Lenticulina* sp. Considering that the lower parts of the overlying Hozbirikyayla limestone is of Tithonian age, a Kimmeridgian age can be assigned to the Kazalı limestone.

Hozbirikyayla limestone (Tithonian-Berriasian) The Upper Jurassic-Lower Cretaceous radiolarian biomicrites, which overlie the Kazalı limestone, have been named as the Hozbirikyayla limestone (Ağar, 1977; Akdeniz, 1988). In the region studied the Hozbirikyayla limestone is intruded by magmatic rocks of probable Eocene age, and is unconformably overlain by Eocene and younger sedimentary rocks (Fig. 3). The Hozbirikyayla limestone is well exposed on the Pulur-Gelinpertek, road, and in the Karseçenin stream to the west of this road. The minimum thickness of the formation is 250 metres. The Hozbirikyayla limestone consists mainly of thinly to medium bedded, pink, grey, yellowish grey radiolarian micrite and marly micrite with intercalations of medium to thickly bedded calciturbidites with tuff clasts, reddish marly siltstones and pale green, fine-grained volcanogenic sandstones. A 280 metres thick section has been measured in the Kazalı limestone and Hozbirikyayla limestone in the Karseçenin stream (Fig. 7). In this section a sample from the top of the Kazalı limestone (sample no. 817) and a sample from the base of the Hozbirikyayla limestone (sample no. 816) contain Kimmeridgian faunas: *Trocholina* s., *Lenticulina* sp., *Spirillina* sp., *Tubiphytes morronensis* CRESCENTI (sample 817), and *Charantia* sp., *Nautiloculina* sp., *Mesoendothyra* cf. *izjumiana* DAIN (sample 816). Samples collected upwards in the sequence contain fauna of Kimmeridgian-Early Tithonian and Early Tithonian ages respectively: *Tubiphytes morronensis* CRESCENTI, *Charantia* sp., *Koskinobullina socialis* CHERCI & SCHROEDER (sample 815) and *Saccocoma* sp., *Cadosina* sp. (sampel 813). About 140 metres above the base of the Hozbirikyayla limestone, the rocks begin to comprise *Calpionella-bearing* faunas. Samples collected above 140 meters from the base contain faunas of Late Tithonian-Early Berriasian, Berriasian and Late Berriasian ages upwards in the sequence (Fig. 7): *Calpionella alpina* LORENZ, *Tintinopsella carpathica* (MURGEANU & FILIPESCU), *Crassirollaria parvula* REMANE (sample 812), *Calpionella alpina* LORENZ; *Tubiphytes* sp. (sample 811), and *Tintinopsella longa* (COLOM), *Cadosina* sp., *Calpinellopsis simplex* (COLOM) (sample 809). Apart from this section, samples of the Hozbirikyayla limestones collected from around the Pülürek villages, north of the Pulur village and north of the Sisne villages also contain fossils of Tithonian-Berriasian ages: *Calpionella alpina* LORENZ, *Calpionella elliptica* CADISH, *Calpionellopsis oblanga* (CADISH), *Calpionellopsis simplex* (COLOM), *Tintinopsella carpathica* (MURGEANU & PILIPESCU), *Tintinopsella longa* (COLOM), *Conicospirillina basiliensis* MOHLER, *Bacinella irregularis* RADOICIC, *Siphovalvulina* sp., *Sphaerostylus lanceola* (PARONA). All these data indicate a Tithonian-Berriasian age range for the Hozbirikyayla limestone. Similarly, Ağar (1977) indicates a Kimmeridgian-Berriasian, Akdeniz (1988) a Late Jurassic-Berriasian and Özer (1984) a Late Tithonian-Early Cretaceous age range for the Hozbirikyayla limestone.

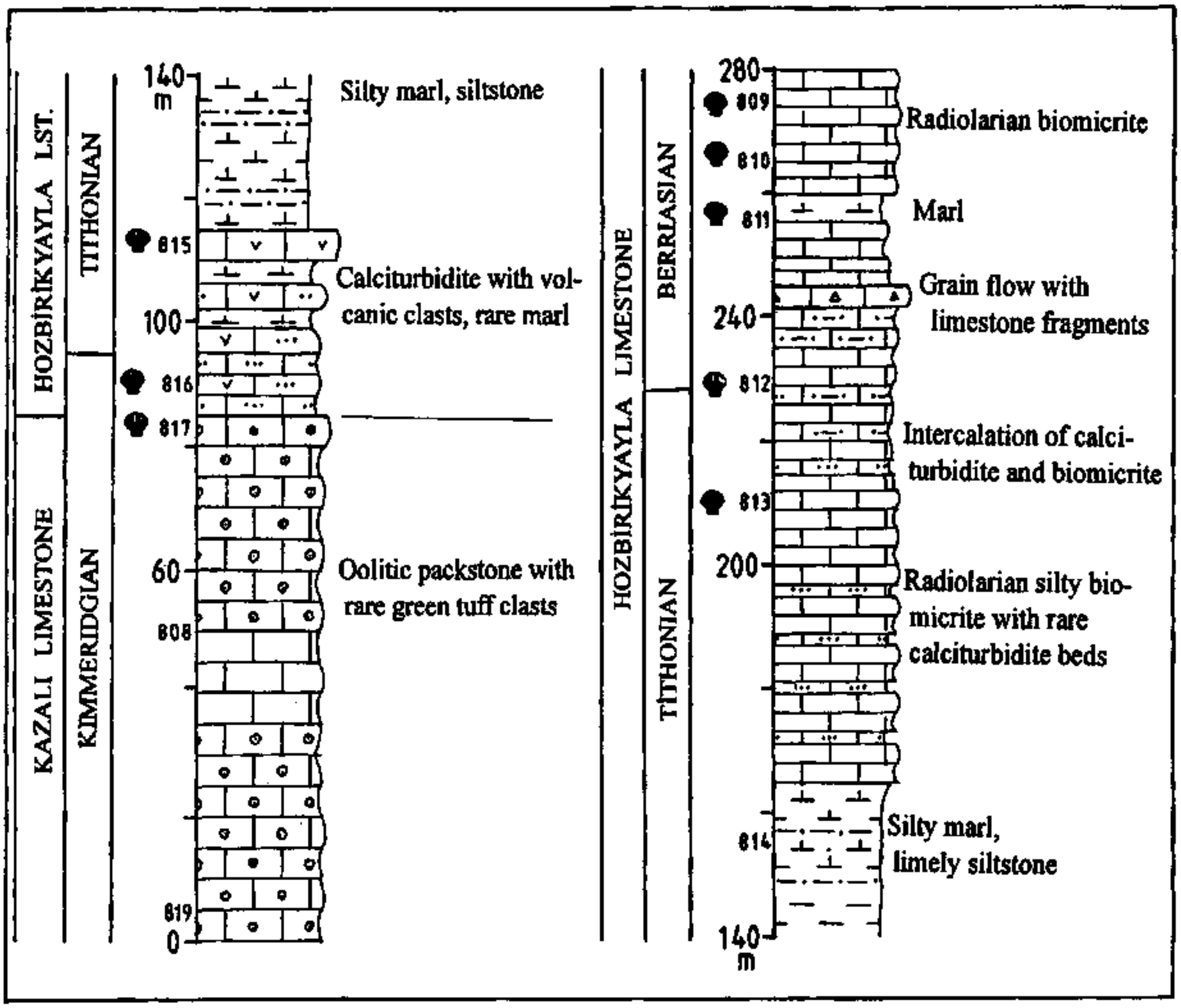

Fig. 7: Measured stratigraphic section of the Kazalı limestone and Hozbirikyayla limestone along the Karseçenin stream west of the Pulur-Gelinpertek road. For location see Fig. 3. Numbers starting with 8 to west of the columns indicate sample locations and numbers. For the microfossils in these samples see the text.

Aşutka thrust sheet

Hamurkesen sheet is tectonically overlain by the Aşutka thrust sheet along the Pulur thrust. The Pulur thrust, known since Ketin (1951) work, places the Pulur metamorphic complex over the Kelkit formation of Jurassic age. Due to the extensive andesite intrusions, it is difficult to determine the precise location and attitude of the Pulur thrust in the field. Nevertheless, a 20 m thick serpentinite lens outcrops along the Pulur thrust north of the village of Aşutka, in this region the thrust plane appears to be steep (>70°). East of the Karayaşmak village the Pulur thrust plane has also steep dips of 60-70°, in this area garnet-cordierite-micaschists lie over the Kelkit formation.

The Aşutka thrust sheet consists of a metamorphic basement (Pulur metamorphic complex), which is unconformably overlain by Jurassic-Cretaceous sedimentary and volcanic rocks (Kelkit formation and Hozbirikyayla limestones). Silices of ophiolitic melange lie with a thrust contact over the Cretaceous limestones, both are unconformably overlain by Maastrichtian rudist-bearing limestones outsidethearPaleocene-Lowereastudied,andby

Eocene flysch (Sipikör formation) in the region studied.

Pulur metamorphic complex (Pre~ Carboniferous) The basement of the Aşutka thrust sheet is made up of strongly tectonised micaschist, cordierite-sillimanite-garnet schist, amphibolite, gneiss, metagranite and very rare marble, which are intruded by Eocene or younger volcanic and subvolcanic rocks (Topuz and Sadıklar, 1994; Okay, 1996). The Pulur metamorphic complex lies tectonically over the Kelkit formation of the Hamurkesen thrust sheet along the Pulur thrust, and is also unconformably overlain by the Jurassic Kelkit formation (Figs. 3 and 4). The Pulur metamorphic complex has generally bad and discontinuous exposures, the best section is along the road between the Yakupaddal and Pekesi villages. Because of strong shearing and extensive magmatic intrusions, it has an irregular and disharmonious internal structure. The foliation in metamorphic rocks, although generally dipping to the south, changes over short distances.

Kelkit formation (Jurassic).-The Kelkit formation in the Aşutka thrust sheet consists of siltstone, tuff, shale and andesitic volcanic rocks, and has a thickness of between 1200 and 2500 metres. It lies unconformably over the Pulur metamorphic complex. This unconformity can be seen south of the Ağği village and west of the Öksüreç village (Fig. 3). The Kelkit formation passes upwards conformably to the Hozbirikyayla limestone. The Kelkit fomation starts on the metamorphic rocks with pebbly sandstones and microconglomerates. In this few ten metres thick basal horizon, there are thin and discontinuous coal horizons, for example to the south of the Aggi village. The bulk of the Kelkit formation consists of dark greenish brown, bluish grey shale, medium bedded dark greenish brown siltstone, bright bluish green, very fine grained, rare tuff beds, rare red soft shale and 1-2 m hick yellowish brown andesitic lavas with plagioclase phenocrysts. In comparison with the Kelkit formation in the Hamurkesen thrust sheet, the Kelkit formation in the Aşutka thrust sheet is on the whole finer grained and contains no large limestone olistoliths, suggesting a deeper and/or more pelagic depositional environment.

No age diagnostic fossils have been found in the Kelkit formation of the Aşutka thrust sheet. However, correlation with, the formation of the same name in the Hamurkesen thrust sheet, and the Berriasian age from the base of the overlying Hozbirikyayla limestone indicate a Jurassic age for the Kelkit formatio in the Aşutka thrust sheet.

Hozbirikyayla limestone (Lower Cretaceous) The pelagic biomicrites which lie conformably over the Kelkit formation are assigned to the Hozbirikyayla limestone. The conformable stratigraphic contact between the Kelkit formation and the Hozbirikyayla limestone can be clearly seen on the road continuing south from the Tahsini village (Fig. 3). Here, the fine-grained elastics of the Kelkit formation pass upwards to pelagic micrites through an interval of intercalated dark grey carbonate-rich mudstone, shale and black cherty limestone. In the Aşutka thrust sheet the Hozbirikyayla formation has a folded stucture and is stratigraphically overlain by the Sipikör formation and tectonically by the dphiolitic melange. It has a minimum thickness of 1000 metres.

The bulk of the Hozbirikyayla limestone in the Aşutka thrust sheet is made up of thinly to medium bedded, light beige, locally pink, radiolarian biomicrites. There are also rare intercalations of medium bedded calciturbidites within the biomicrites. Samples collected from the middle parts of the Hozbirikyayla limestone south of the Kel hill, contain a Beriasian fauna: *Calpionella alpine* LORENZ, *Calpionella elliptica* CADISCH, *Tintinopsella carpathica* (MURGEANU & FILIPESCU), *Trocholina sagittaria, Neotrocholina* sp., *Protopeneroplis trochoangulata* SEPTFONTAINE, Radiolaria. A sample from the topmost part of the section, just below the ophiolitic melange, contains Aptian-Albian fossils: *Hedbergella* cf. *gorbachikae* LONGARA, *Hedbergella planispira* (TAPPAN), *Planamalina?* sp. These data indicate a Berriasian to Aptian/Albian age range for the Hozbirikyayla limestone in the Aşutka thrust sheet.

Ophiolitic melange.- The ophiolitic melange is made up mainly of radiolarian chert, pelagic and neritic limestone, spilitised basalt, serpentinite, sandstone, shale and siltstone blocks and slices. The ophiolitic melange is thrust over the Hozbirikyayla limestone; a tear fault divide the thrust fault into two sections (Fig. 3). To the east of the tear fault, rocks of the ophiolitic melange lie with a low-angle thrust contact over the Hozbirikyayla limestone; in this region a long but narrow klip of ophiolitic melange also occurs above the limestones (Fig. 3). To the west of the tear fault, the thrust fault is overturned and the Hozbirikyayla limestone lies with a medium angle contact over the ophiolitic melange.

The ophiolitic melange is unconformably overlain by the Kapıkaya limestone or by the Sipikör formation (Figs. 2 and 3). The best outcrops of the ophiolitic melange are along the road following the Sazlar valley and continuing southward from the Bölükbaşı hamlet. Thinly to medium bedded red radiolarian chert, which forms an important part of the ophiolitic melange, make up the Büyük Karataş ridge south of the Salihağa hamlet. To the south of this large radiolarite outcrop, there are blocks of pillowed spilitised basalts intercalated with red pelagic limestones. Serpentinite is a rare lithology in the melange. Serpentinite bodies, 20-30 m large, occur 2.5 km southwest of the Bölükbaşı hamlet, in the Ağnene hill and in the Kanlıçayır hill, 3 km east of the Doğanarslan village. Blocks of radiolarian biomicrite, ilthologically similar to the Hozbirikyayla limestone, and neritic limestone blocks outcrop along the Otlukbeli stream.

A sample collected from a three metres large neritic limestone block in the Ovacık valley contains fossils of Oxfordian-Albian age: *Lithocodium aggregatum* ELLIOT, *Tubiphytes* sp. Blocks of red biomicrite in the thickly bedded, laminated, brownish grey sandstones along the road between the Bain and Bölükbaşı hamlets comprise *Hedbergella* species of Aptian-Albian age: *Hedbergella* spp., *Hedbergella trochoidea* (GANDOLFI), *Hedbergella gorbachikae* LONGARIA, *Hedbergella delrioensis* (CARSEY), *Hedbergella sigali* MOULLADE, *Hedbergella planispira* (TAPPAN). Another limestones sample collected again from this region has yielded a microfauna indicating an Aptian age: *Hedbergella* sp., *Hedbergella planispira* (TAPPAN), *Globigerinelloides blowi* (BOLLI), *Ticinella bejaouensis* SIGAL. These data indicates that the melange must have formed after the Aptian. The Upper Campanian-Maastrichtian age of the unconformably overlying Kapıkaya formation contrains the age of melange formation and emplacement to the Aptian-Upper Campanian interval. This indicates that the thrust fault between the ophiolitic melange and the underlying Lower Cretaceous Hozbirikyayla limestone is older than the Early Eocene Hamurkesen and Pulur thrusts.

Kapıkaya limestone (Maastrichtian).- This sequence of neritic limestone, which unconformably overlies the ophiolitic melange, outcrops outside and to the east of the area studied, along the main Bayburt-Erzurum road, and gives good outcrops two kilometres north of Maden. It was first described and mapped by Ketin (1951) and later named by Keskin et al. (1989). The Kapıkaya limestone continues westward from the main Bayburt-Erzurum road for 13 km forming a limestone cover of gradually decreasing thickness over the ophiolitic melange (Fig. 1). Farther west, the Kapıkaya limestone is totally eroded and, as in the area studied, the Sipikör formation lies unconformably over the ophiolitic melange.

The Kapıkaya limestone is made up of thickly bedded neritic limestones with abundant rudist. Bergougnan (1987) assigns a Late Campanian-Maastrichtian age, while Fenerci (1994) and Elmas (1994) give Maastrichtian ages to the rudists in the Kapıkaya limestone.

Sipikör formation (Upper Paleocene.- Lower Eocene)- The flysch-type clastic sequence of sandstone, conglomerate and shale, which lies unconformably over the ophiolitic melange and the Hozbirikyayla limestone in the southern part of the area studied, is assigned to the Sipikör formation of Bergougnan (1987). The sipikör formation also lies unconformably over the Maastrichtian Kapıkaya limestone in the east towards the Bayburt-Erzurum main road, and is tectonically overlain by the imalidag thrust sheet. It starts with a few hundred metres thick conglomerate with clasts of Jurassic-Lower Cretaceous limestone, spilitised basalt, serpentinite, metamorphic rock and sandstone, and passes upwards to siltstones and a turbidite sequence of sandstone and shale of over 1000m in thickness. The Spikör formation locally contains large olistoliths. Norman (1976) studied the sedimentary structures in the turbidites over a large region, and showed that the paleo-currents were largely parallel to the axis of the basin and were flowing from the southwest towards the northeast. The Sipikor formation, which has a thickness of about 1500 metres, represents a clastic wedge deposited in a foreland basin in front of the northward advancing İmalidağ thrust sheet. Paleontological data of Ketin (1951), Bergougnan (1976) and Norman (1975) indicate a Late Paleocene-Early Eocene age for the Sipikor formation.

İmalıdağ thrust sheet

To the north of the ultramafic rocks in the Ankara-Erzincan Neo-Tethyan suture zone, allochthonous Mesozoic carbonates outcrop along a 200 km long region between Ağvanis and Erzurum (Fig. 1). These allochthonous rocks were named by A. Yılmaz (1985) and Bergougnan (1987) as the Çimendağı nappe in the west and İmalıdağı nappe in the east. The main feature differentiating these two nappes is that the Jurassic-Lower Cretaceous sequence in the İmalıdağ thrust sheet has developed in a more pelagic facies that in the Çimendağı thrust sheet. Both thrust sheets lie tectonically over the Sipikör formation in the north and over the ultramafic rocks in the south. In the southern part of the region pelagic limestone of the İmalıdağı thrust sheet outcrop in a small area. In the section along the Kop stream the İmalıdağ thrust sheet consists of a sandstone-shale series at the base stratigraphically overlain by pelagic micrites of Tithonian-Berriasian age (Bergougnan, 1987). In the section in the Yeşirçöl Dağı there is a volcanoclastic sequence of Tithonian age with limestone intercalations at the base and a stratigraphically overlying Upper Tithonian-Hauterivian cherty biomictires (Bergougnan, 1987).

Post-collisional sequences

In the region studied rocks deposited after the Early Eocene tectonics can be subdivided into three formations: the Sirataslar formation of Eocene age made up of limestone, sandstone and conglomerate; Eocene of younger, intermediate magmatic rocks; and a Neogene sequence of terrigeneous, poorly consolidated, poorly sorted conglomerates with limestone pebbles, semi-consolidated sandstone and pinkish white tuffs. The first two formations will be described in more detail below.

Sırataşlar formation (Eocene).- The Sırataşlar formation (Ağar, 1977), which unconformably covers the thrust sheet in the region studied, and forms the base of the Bayburt-Pulur basin. It is made up mainly of limestone, conglomerate and sandstone. North of the village of Bizgili, the Sırataşlar formation starts above the Çaltepe limestone with thickly bedded conglomerates with 1 to 10 cm large, well rounded limestone clasts. The conglomerate beds are succeeded by pinkish white, thickly bedded, pebbly, nummulitic limestone, which pass up to terrgeneous red conglomerates and red sandstones. This outcrop of the Sırataşlar formation continues westward and covers the thrust contact between the Cebre relative authochthon and the Hamurkesen thrust sheet (Fig. 3). Around the village of Gelinpertek the nummulitic limestones of the Sırataşlar formation has a thickness of over 50 metres. The bedding in the Sırataşlar formation is subhorizontal.

Two limestone samples from the Sırataşlar formation collected from north of the Bizgili village contain the following Middle up Upper Eocene fossils. *Nummulites* sp., *Orbitolites* sp., *Turboratalia* sp., *Turboratalia cerroazulensis* COLE, *Globigerinatheka* sp. Apart from these Eocene fossils, the samples also contain *Calpionellid type* pelagic microfossils derived from the Mesozoic limestones. Samples taken from the thickly bedded nummulitic and sandy limestones from around the village of Gelinpertek and north of the Hardişi village also contain Eocene fossils: *Nummulites* sp., *Discocyclina* sp., *Rotalia* sp., *Sphaerogypsina* sp. These data indicates a Mid to Late Eocene age for the Sırataşlar formation. This age also provides an upper age limit for the main compressional tectonics in the region. Ağar (1977) assigns a Ypresian-Early Lutetian age to the Sırataşlar formation based on the foraminifera and echinodermata. In the Eastern Pontides the Middle Eocene rocks have generally a post-tectonic character and unconformably cover the older rocks. For example, in the Berdiga mountains in the Alucra region Middle Eocene limestone and volcanic rocks lie with an angular unconfomity over Jurassic clastic rocks (Nebert, 1961; Pelin, 1977).

Magmatic rocks.- In the region studied all pre-Eocene units are cut by intermediate subvolcanic rocks of andesite, dacite, diorite and diabase composition. These strongly altered magmatic rocks cover large areas in the region and with their irregular boundaries make geological mapping and determination of contract relation difficult. The contacts of the subvolcanic rocks rarely observed. However, rare andesite dykes are seen to cross-cut the Pulur metamorphic rocks. Apart from these subvolcanic rocks, a granitoid with a diameter of 3-4 km, occurs around the Saraycık village (Figs. 3 and 6). This pluton, which forms part of the same magmatic cycle as the subvolcanic rocks, has a granodiorite composition and intrudes the Pulur metamorphic complex, the Çatalçeşme and Kelkit formations. Another similar pluton occurs farther south (Fig. 3). The subvolcanic rocks cross-cut the thrust contact between the Hamurkesen and Aşutka thrust sheets, indicating a post-Early Eocene age for these shallow intrusions. Correlations with intermediate tuffs in the Middle Eocene sequence suggest a similar age for the subvolcanic rocks.

GEOLOGICAL EVOLUTION OF THE REGION

Pre-Jurassic evolution

The geological evolution of the region can be constructed by palinspastically restoring the thrust stack in the Pulur region. When this palinspastic restoration is done, the pre-Jurassic basement is represented by the Pulur metamorphic rocks in the south, and by the Upper Carboniferous- ? Lower Permian sedimentary rocks in the north. Although the surface contact between these two units is represented by a fault, it is probable that the Upper Paleozoic sequence was initially deposited unconformably over the Pulur metamorphic rocks. Outside the area studied, the pre-Jurassic basement of the Eastern Pontides is constituted by the earliest Carboniferous Köse and Gümüşhane granodiorites (360 ± 2 My; Yılmaz, 1976, Bergougnan, 1987) in the Gümüşhane region, and by the dacites and rhyolites in the Olur region (H. Yılmaz, 1985; Bozkuş, 1992).

The presence of minerals like cordierite and sillimanite in the Pulur metamorphic rocks indicates a high temperature and low pressure (HT/LP) regional metamorphism. It is probable that this HT/LP regional metamorphism was gnetically related to the magmatism producing the earliest Carboniferous granodiorites, and both may have formed at the basal levels of a Devonian-Carboniferous Andean-type magmatic arc. This implies a Devonian or earliest Carboniferous age for the regional metamorphism of the Pulur metamorphic complex. Following the regional metamorphism. the metamorphic and associated magmatic rocks were exhumed and were unconformably overlain during the Late Carboniferous by shallow marine and terrigeneous molasse-type sedimentary rocks (Fig. 8). Late Hercynian HT/LP metamorphic rocks and granodiorites, similar to the Pulur metamorphic complex and Köse-Gümüşhane granodiorites, have been described from the Greater and Lesser Caucasus (Khain, 1975; Adamia et al., 1982). As in the Pulur region, in the Caucasus these rocks are unconformably overlain by Upper Carboniferous molasse-type sedimentary rocks (Khain, 1975; Yılmaz, 1989). This remarkable similarity of the pre-Jurassic basements of the Eastern Pontides and the Caucasus (Yılmaz, 1989) indicates that the Eastern Pontides were situated during the Late Paleozoic along the southern margin of Laurasia.

In the region studied, and in the whole of the Eastern Pontides no Triassic sedimentary rocks are known. However, the metabasite-marble-phyllite association, which forms the Ağvanis Massif, 90 km west of the region studied, is lithologically very similar to the Permo-Triassic Nilüfer unit of the Karakaya Complex described from northwest Anatolia (Okay, 1984; Okay et al., 1991). Nilüfer unit is believed to have been deposited in a Permo-Triassic ensimatic fore-arc or intra-arc basin, and in the late Tnassic was thrust over a continental basement represented by the Kazdağ Group (Okay et al., 1991, 1996). The Pulur metamorphic complex, which is lithologically and metamorphically different from the Ağvanis Massif, can possibly be correlated with the Kazdağ Group of gneiss, marble and amphibolite. The latest geochronological studies in the gneisses of the Kazdağ Complex yielded zircon ages of 308 ±16 my (Okay et al., 1996). A similar tectonic relation can be envisaged for the Eastern Pontide basement (Fig. 8). In this context the low-grade metamorphic rocks in the region

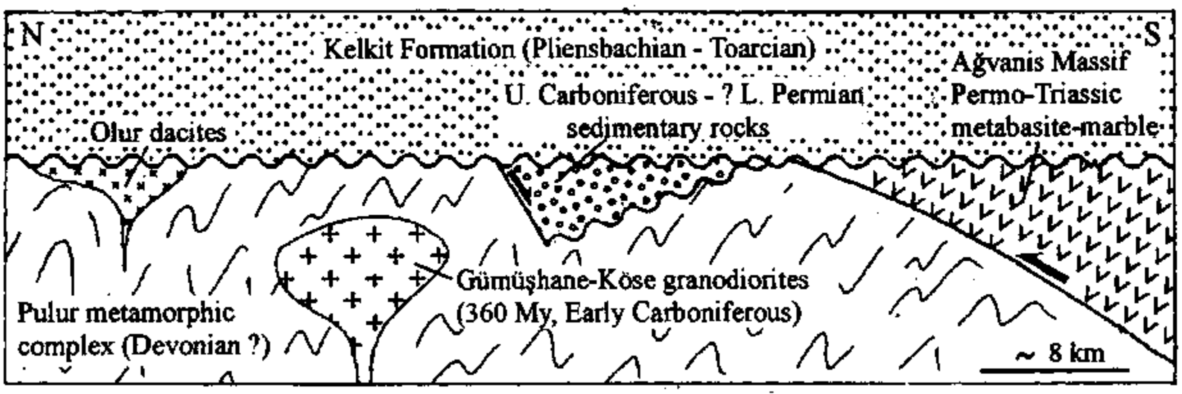

Fig. 8- Speculative section showing possible relations between the various pre-Jurassic units of the basement of the Eastern Pontides.

studied may represent relics of a thrust sheet over the Pulur metamorphic complex and over the Upper Paleozoic sedimentary sequence.

Jurassic - Early Cretaceous: Development of a passive continental margin

During the Lias (Pliensbachian) there was a major marine transgression from the south along the whole of the Sakarya Zone, and a large region including the Eastern Pontides were covered by the sea (Akın, 1978). In this newly formed basin, neritic carbonate rocks, represented by the Çaltepe limestone, were formed in high-standing areas possibly bounded by faults, while in the rest of the basin clastic rocks were deposited accompained by volcanic rocks related to rifting, represented by the Kelkit formation. Large limestone blocks slid into the basin from the high-standing areas. This sedimentation pattern in the Jurassic signifies rifting possibly related to the opening of the Neo-Tethys, as first claimed by Görür et al. (1983).

In the latest Jurassic and Early Cretaceous a transition from volcanoclastic to carbonate deposition took place in the whole of the basin. Carbonate deposition continued throughout the Early Cretaceous in the region studied and throughout the Eastern Pontides. However, a facies difference is noticable during the Early Cretaceous in the Eastern Pontides with neritic carbonate deposition in the north, an pelagic limestone and calciturbidite deposition in the south nearer to the Tethyan ocean. For example, in the Berdiga mountains the Upper Jurassic to Barremian sequence is represented by the shelf-type carbonates (Pelin, 1977), whereas in the Bayburt region and in the area studied pelagic limestones and calciturbidites (the Hozbirikyayla limestone) were deposited during this time interval (Burşuk, 1975; Özer, 1984). This situation indicates the development of a passive continental margin facing the Tethyan ocean in the Eastern Pontides during the early Cretaceous (Fig. 9).

Cenomanian-Turonian: Uplift and erosion related to the obduction of ophiolitic melange

In several regions in the Eastern Pontides, all the Lower Cretaceous sequence is eroded and the Senonian rocks rest with an angular unconformity over the Jurassic or over the Kelkit formation (Nebert, 1961; Pelin, 1977; Özsayar et al., 1981). In the Gümüşhane region the Senonian sequence rests directly over the Carboniferous Gümüşhane granodiorite (Yılmaz, 1976). This major phase of uplift and erosion affecting the whole of the Eastern Pontides is caused by the obduction of an ophiolitic melange over the Eastern Pontide passive continental margin during the Cenomanian-Turonian. During this period ophiolite and ophiolitic melange were also emplaced from the south in the Lesser Caucasus (Knipper, 1980). Thus, during the Cenomanian-Turonian oceanic crust and/or oceanic accretionary complexes were thrust northward over the 100/ km long Eastern Pontides-Lesser Caucasus passive continental margin. Although the ophiolitic melange thrust slice in the Eastern

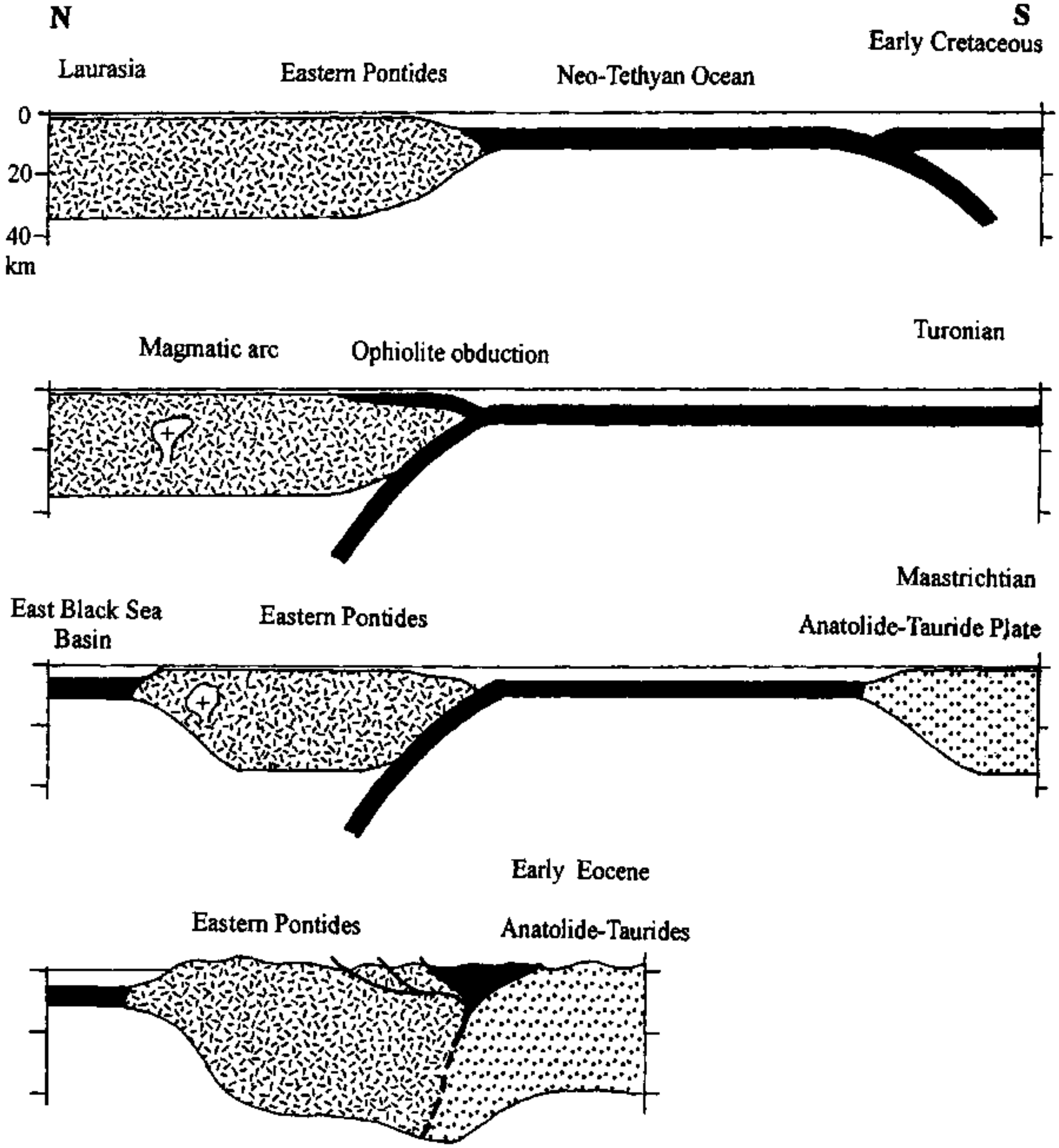

Fig. 9- Schematic and speculative sections illustrating Cretaceous-Early Tertiary plate tectonic evolution of the Eastern Pontides. In the Early Cretaceous the Eastern Pontides formed part of the south-facing passive continental margin of Laurasia. During the Cenomanian-Turoniah the southern part of the Eastern Pontides were partly subducted in an intra-oceanic subduction zone resulting in the obduction of the ophiolite and ophiolitic melange. Following this attempted subduction of the continental margin, the subduction zone changed its polarity and the Neo-Tethys ocean started to subduct northward under the Eastern Pontides. As a result of this northward subduction a major magmatic arc started to develop in the Turanian in the outer part of the Eastern Pontides. During the Maastrichtian this magmatic arc split and thereby creating in the north the East Black Sea basin as an oceanic back-arc basin. In the Late Paleocene-Early Eocene the Eastern Pontide magmatic arc collided with the Anatolide-Tauride plate resulting in the northward imbrication of the Eastern Pontide continental margin.

Pontides did not reach farther north than the Bayburt-Köse-Şiran line, this major obduction event showed itself farher north as a period of uplift and erosion.

It is not clear, why the ophiolitic melange was emplaced over the Eastern Pontide continental margin during the Cenomanian-Turonian. The subduction-related, extensive Senonian magmatism in the outer Eastern Pontides (e.g., Akın, 1978) shows that the Tethyan ocean was extant at the beginning of the Senonian, and thus no continent-continent collision could have occurred during the Cenomanian-Turonian. Elmas (1994) explains the obduction of the ophiolitic melange through the back-thrusting of an over-thickened Tethyan oceanic accretionary complex, developed above a northward-dipping subduction zone. However, there is no evidence for any, let alone a thick, accretionary complex during the Cenomanian-Turonian to the south of the Eastern Pontides. The ubiquitous Upper Jurassic-Lower Cretaceous carbonates show that subduction magmatism, and hence subduction, had not started by the Early Cretaceous under the Eastern Pontides. In the outer Eastern Pontides the first widespread by the Early Cretaceous under the Eastern Pontides. In the outer Eastern Pontides the fist widespread subduction-related magmatism starts in the Turanian (Özsayar, 1971; Taner and Zaninetti, 1978). A possible mechanism to explain the emplacement of the ophiolitic melange during the Cenomanian-Turonian is the partial subduction of the Eastern Pontide continental margin in an intra-oceanic subduction zone (Fig. 9). As it difficult to subduct the continental lithosphere because of its low density, the subduction polarity changed during the Turonian, and the Tethyan ocean started to subduct northward under the Eastern Pontides (Fig. 9). It is well known from the tectonics of the present day southeast Asia, that the intra-oceanic subduction zones can change their polarity (Hamilton, 1979). This model presented here, also explains why immediately following the obduction of the ophiolitic melange in the Turonian, the subduction-related magmatism started in the outer Eastern Pontides.

Senonian: development of the Eastern Porttide island-arc

A volcanic arc sequence mainly of andesitic and dacitic rocks, over 2000 metres thick, developed in the outer Eastern Pontides as a result of the Senonian subduction (Boccaletti et al., 1974; Akın, 1978; Eğin and Hirst, 1979; Gedikoğlu et al., 1979; Terlemez and Yılmaz, 1980, Şengör and Yılmaz, 1981). The East Black Sea basin started to form probably during the Maastrichtian as an oceanic back-arc basin a result of the splitting of this volcanic arc axis (Boccaletti et al., 1974, Robertson and Dixon, 1984; Zonenshain and Le Pichon, 1986; Görür, 1988; Okay et al. 1994, Robertson et al., 1996). As a result of the opening of the East Black Sea basin, the Eastern Pontides were transformed into an island arc, similar to the present day Japanase islands. During the Senonian the southern part of the Eastern Pontides, including the region studied, was in a fore-arc position. The volcanogenic sandstones, siltstones and marls in the Gevenli formation were deposited in a fore-arc environment. Subduction-related magmatism in the Eastern Pontides continued up to the end Maastrichtian and beginning of Paleocene (Korkmaz and Gedik, 1988; Korkmaz, 1993), and later the whole region was sliced, folded and uplifted as a result of the collision between the Anatolide-Tauride plate and the Eastern island arc.

Late Paleocene-Early Eocene: continent - island-arc collision

In the Late Paleocene - Early Eocene the continental margin of the Eastern Pontides were imbricated and formed a north-vergent thrust stack. The age of the thrusting is given by the age of the Sipikör formation, which was deposited in a foreland basin in front of the north-vergent İmalidağ thrust sheet. The north-vergent thrusting most probably did not reach farther north than the Bayburt-Pulur basin, although it was felt farther north as a phase of folding, uplift and erosion. For example, in the Berdiga mountains Middle Eocene nummulite and older formations (Pelin, 1977). The north-vergent imbrication of the Eastern Pontide continental margin is caused by the collision of the Eastern Pontide island arc with the Anatolide-

Tauride plate following the complete consummation of the Neo-Tethyan ocean in the region. The deformation ended by the Mid-Eocene, and nummulite-bearing limestones were deposited over a wide region in the Eastern Pontides over a folded and thrust-faulted basement. The ubiquitous Mid-Eocene magmatism observed in the region stutied and thoughout the Eastern Pontides is probably related to a post-collisional regional extension.

CONCLUSIONS

The main conclusions of the study are:

1/In a region of 1200 km^2 in the southern internal part of the Eastern Pontides a north-vergent Alpide thrust stack has been differentiated an mapped. There are important stratigraphic differences among the thrust sheets. When the thrust stack is palinspastically restored, the Jurassic-Lower Cretaceous sequences in the thrust sheets represent facies ranging from shelf in the north to continental margin and ocean floor in the south.

2/ The basement of the Cebre relative authochthon is constituted by an Upper Carboniferous sedimentary sequence. This Upper Carboniferous sequence consists of a lower formation of pebbly sandstone, limestone, quartzite and shale of Kasimovian-Gzelian age, which is conformably overlain by terrigeneous red sandstones and pebbly sandstones.

3/In the Cebre relative authochthon the Carboniferous is unconformably overlain by Jurassic carbonates. Upper Cretaceous siltstone, sandstone, shale, marl and pelagic limestone lie unconformably over the Jurassic carbonates.

4/ In the Hamurkesen thrust sheet, which lies tectonically over the Cebre relative authochthon, the Jurassic sequence consists dominantly of volcan--oclastic rocks and comprises Jurassic limestone blocks derived from the Cebre relative authochthon.

5/ The Asuka thrust sheet, which forms the next higher up thrust sheet, consist of fine-grained Jurassic clastic and volcanoclastic rocks, and-Lower Cretaceous pelagic carbonates. The Jurassic-Lower Cretaceous sequence was deposited in a deeper marine environment than the corresponding sequence in the Hamurkesen thrust sheet. In the Aşutka thrust sheet the Lower Cretaceous pelagic limestones are tectonically overlain by an ophiolitic melange. The ophiolitic melange was emplaced northward over the south-facing passive continental margin of the Eastern Pontides during the Cenomanian-Turonian. The absence of Upper Cretaceous rocks in the Hamurkesen andn Aşutka thrust sheet can be explained by uplift and erosion related to the tectonic emplacement of the ophiolitic melange.

6/An Upper Paleocene-Lower Eocene flysch lies uncorformably over the ophiolitic melange. This flysch was deposited in a foreland basin during the northward imbrication of the Eastern Pontide continental margin. This deformation event was caused by the collision of the Eastern Pontides with the Anatolide-Tauride plate. The Flysch is tectonically overlain by a rootless limestone nappe, which has provided detritus to the flysch. Middle Eocene rocks of post-collisional character lie unconformably over the various thrustsheets and cover the thrusts separating these sheets.

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Mineral Res. Expl. Bull., 119, 25-28, 1997

SİVASELLA GOEKCENİ, A NEW FORAMINIFER SPECIES OF MAASTRICHTIAN OF SOUTHWEST MALATYA (SE TÜRKİYE)

Engin MERİÇ* and Nurdan İNAN**

ABSTRACT-A new species called *Sivasella, Sivasella goekceni,* is described from sediments within the Maastrichtian levels of inekpman limestone overlying the Malatya (SE Türkiye). This new species can readily be distinguished from *Sivasella monolateralis* Sirel and Gündüz, 1978 by its thicker, longer test and much thinner filling material in the upper part of test.

INTRODUCTION

The basement rocks of southern Malatya sedimentary sequence consist of Permo-Carboniferous age Malatya Metamorphics (Fig. 1). Upper Cretaceous-Upper Eocene age sedimentary rocks are located on the top of the metamorphics. These units are called Upper Cretaceous age Gündüzbey group and Upper Eocene age Yeşilyurt group (Önal and Gözübol, 1992).

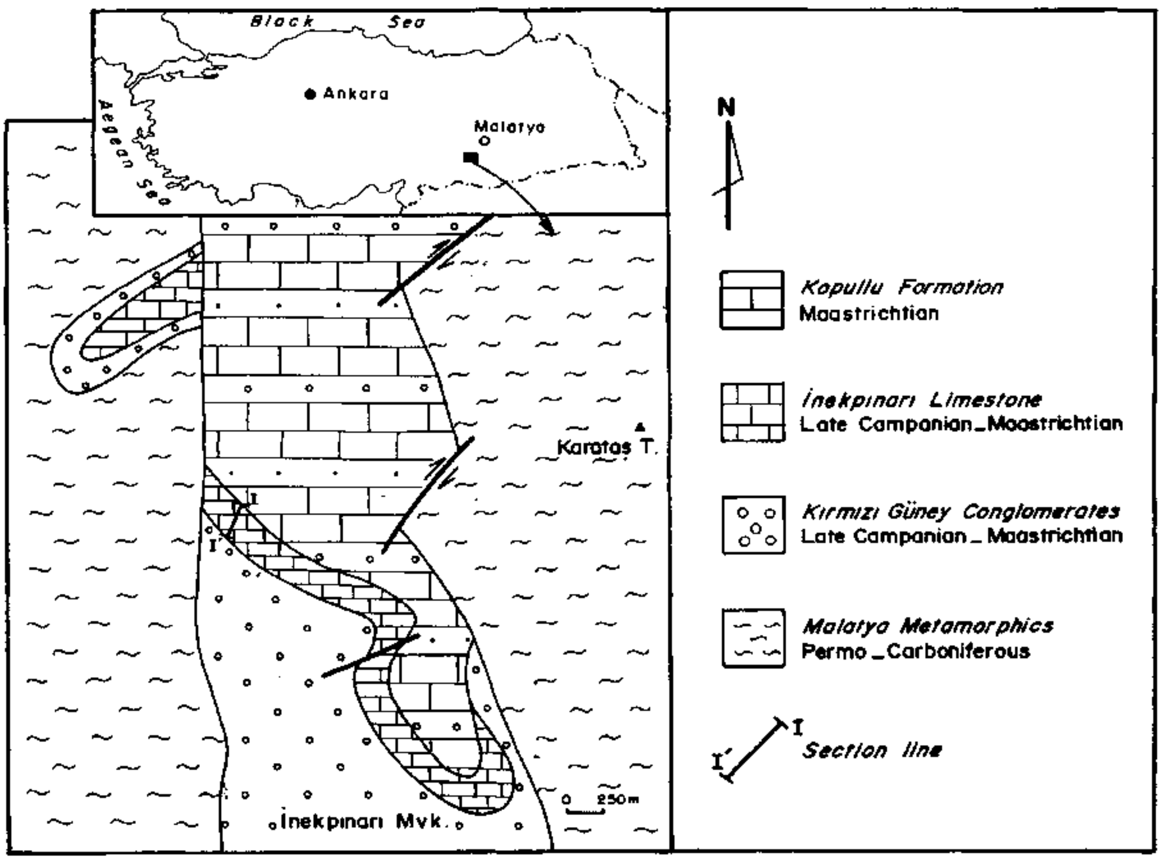

Fig. 1- Location and geological map of the study area (after Önal and Gözübol, 1992)

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In this study, on the Maastrichtian age level of Upper Campanian-Maastrichtian age İnekpınarı limestone, a new *Sivasella* species, *Sivasella goekceni* n. sp. has been found and described (Fig. 2).

Upper Campanian-Lower Maastrichtian age Tripolitze series in Greece (Zambetakis-Lekkas, 1987).

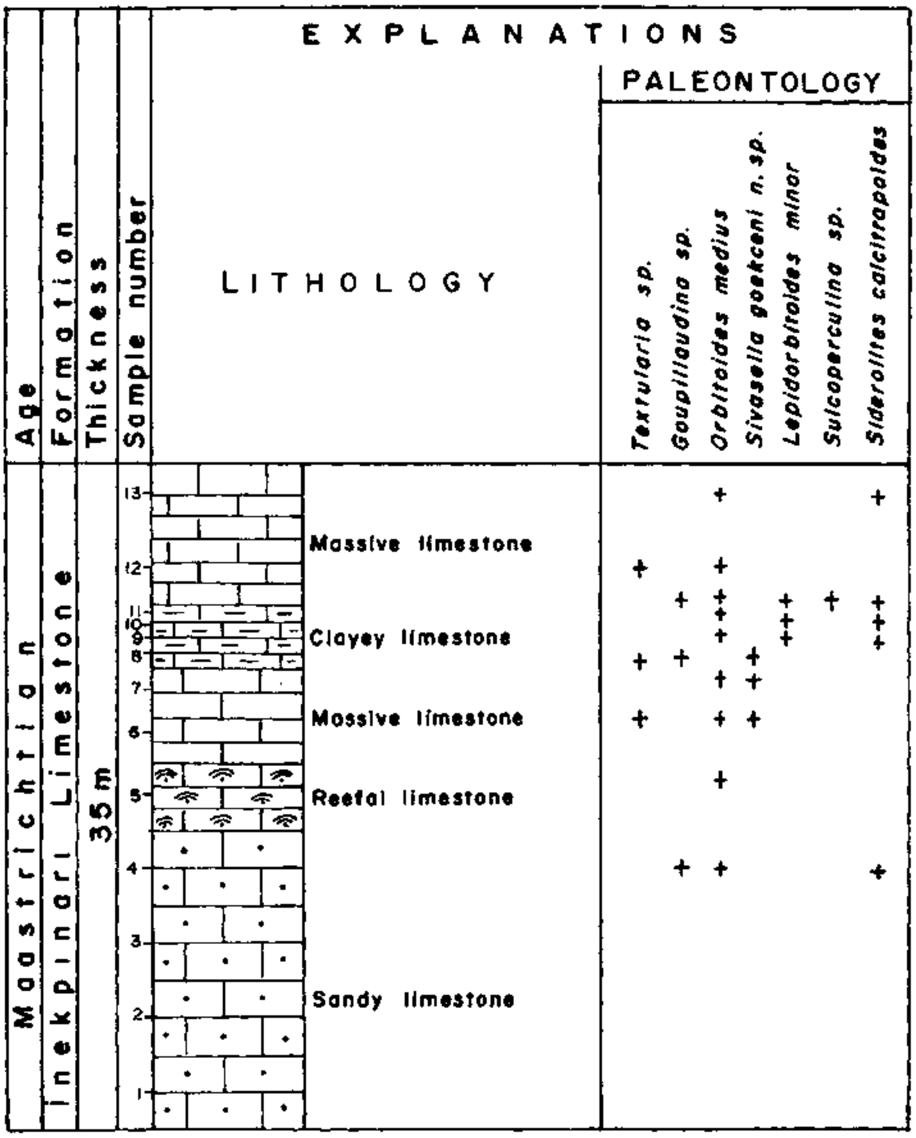

Fig. 2- The distribution of benthic foraminifera in the İnekpınarı section.

Sivasella genus were discovered by Sirel and Gündüz (1978) in Maastrichtian age sediments of southwest Sivas area (Sarkışla) and its type species was defined as *Sivasella monolateralis* Sirel and Gündüz was found in the Maastrichtian level of

SYSTEMATIC DESCRIPTION

Order	Foraminiferida Eichwald, 1830
Superfamily	Orbitoidacea Schwager, 1876
Family	Orbitoididae Schwager, 1876

Subfamily : Orbitoidinae Schwager, 1876
Genus : *Sivasella* Sirel and Gündüz, 1978
Types species : *Sivasella monolateralis* Sirel and Gündüz, 1978
Sivasella goekceni Meriç and inan, n. sp. (Plate I, Fig. 1-10)

Holotype : Axial section of microspheric, Plate I, fig. 3

Paratype : Axial section of macrospheric, Plate I, fig. 7 and 10

Type locality : İnekpınarı area (SW Malatya-SE Turkiye)

Type level : Maastrichtian

Derivation of name: This new species is named after Prof. Dr. L.Sungu Gökçen because of his valuable contribution to stratigraphy and sedimentology.
Deposition of types: Original material is kept at the Department of Geology, University of Cumhuriyet, in Sivas, Turkiye.

Tanımlama

The test is hyalin calcerous, its shape varies between concavo-convex, convex, conical and flabelliform.

The axial sections of the species is very characteristic. The arcuate shape of orbitoidal chamber series in on the equatorial plane. On one part of the lateral side of the test lie lateral chambers series and stolons which provide connection between lateral and and equatoral chambers. On the other part of the lateral side of the test, there is a slim calcerous filling material. The thicknees of this filling material decreases from center to periphery. Microspheric forms of this species are found more common than macrospheric forms (Fig. 3).

Association

This new species is discovered together with *Orbitoides medius* (d'Archiac), *Lepidorbitoides minor* Schlumberger, *Siderolites calcitrapoides* Lamarck, *Gaupillaudina* sp., *Sulcoperculina* sp., *Textularia* sp. group (Fig. 2).

Comparison

New species differs from *Sivasella monolateralis* Sirel and Gündüz, 1978 by its thicker and longer test, and much thinner filling material in one side of its test (Fig. 3). While the thickness of filling material in microspheric forms of new species is 13 or 16 of central thickness, in *monolateralis,* it is 6,6 or 1/4 of whole thickness. In macrospheric forms of new species; the thickness of filling material is 16 or 8,5 of central thickness. But, in *monolateralis,* it is measured as 3.3 or 1/2 of the whole thickness.

According to this comparison in filling parameters (Fig. 4), filling parameter of new species is 1/3 smaller than *monolateralis* parameters in average. New species can easily be identified by using this feature.

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	Sivasella goekceni n. sp.			*Sivasella monolateralis* Sirel _ Gündüz		
	Microspheric forms (B) Measurements mm					
	,in 21 specimens			,in 20 specimens(after Sirel _ Gündüz,1978)		
	min.	max.	average	min.	max.	average
Axial diameter (d)	0,925	2,625	1,775	0,87	1,62	1,19
Thickness of the filling material (f)	0,0125	0,07	0,047	0,036	0,084	0,054
Central thickness (h)	0,20	0,925	0,56	0,24	0,34	0,30
h / f	16,00	13,20	14,60	6,66	4,04	5,34
d / h	4,60	2,80	3,70	3,60	4,76	4,18
	Macrospheric forms (A) Measurements mm					
	,in 10 specimens			,in 20 specimens(after Sirel _ Gündüz,1978)		
	min.	max.	average	min.	max.	average
Axial diameter (d)	0,60	1,225	0,912	0,57	1,03	0,69
Thickness of the filling material (f)	0,0125	0,05	0,03	0,09	0,10	0,07
Central thickness (h)	0,20	0,425	0,31	0,18	0,33	0,26
h / f	16,00	8,50	12,25	3,30	2,00	2,65
d / h	3,00	2,80	2,90	3,10	2,70	2,90

Fig. 3- Comparison of the *Sivasella* species

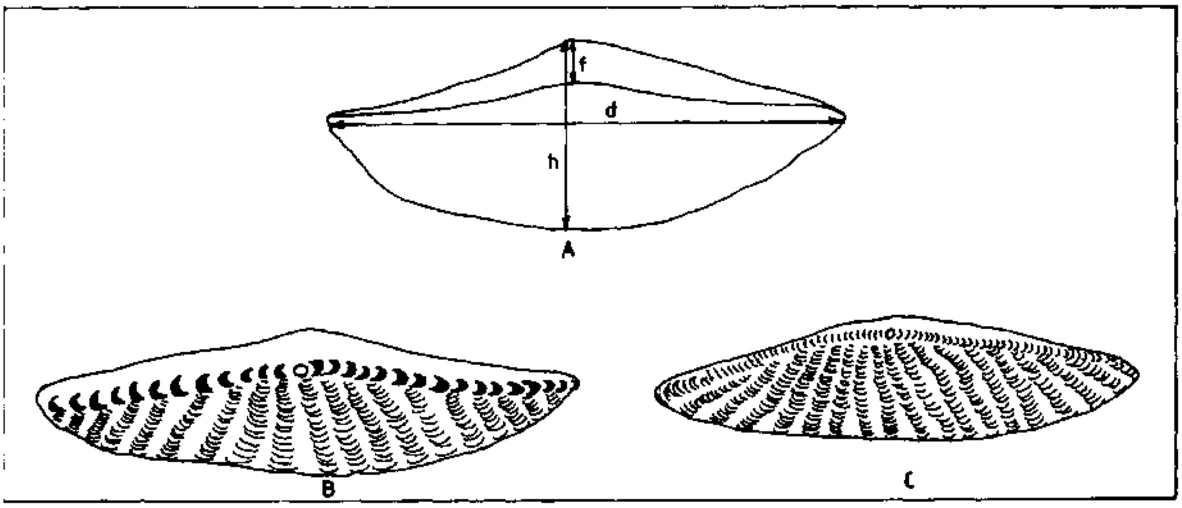


Fig. 4- Shematic axial sections showing the structural differences and test parametres of Sivasella genus.
(B)- *Sivasella monolateralis* Sirel and Gündüz, 1978, Plate I, fig. 8, Paratype, X91
(C)- *Sivasella goekceni* Meriç and İnan, n.sp., Plate I, fig.3, Holotype, X48.

PLATE

PLATE -I

Sivasella goekceni n.sp.
Maastrichtian
inekpman area-Southwest Malatya

Figure 1,2- Axial sections, Microspheric specimens, (7/I), X35

Figure 3- Axial section, Microspheric specimen, Holotype, (7/I), X48

Figure 4- Axial section, Macrospheric specimen, Paratype, (7/I), X10

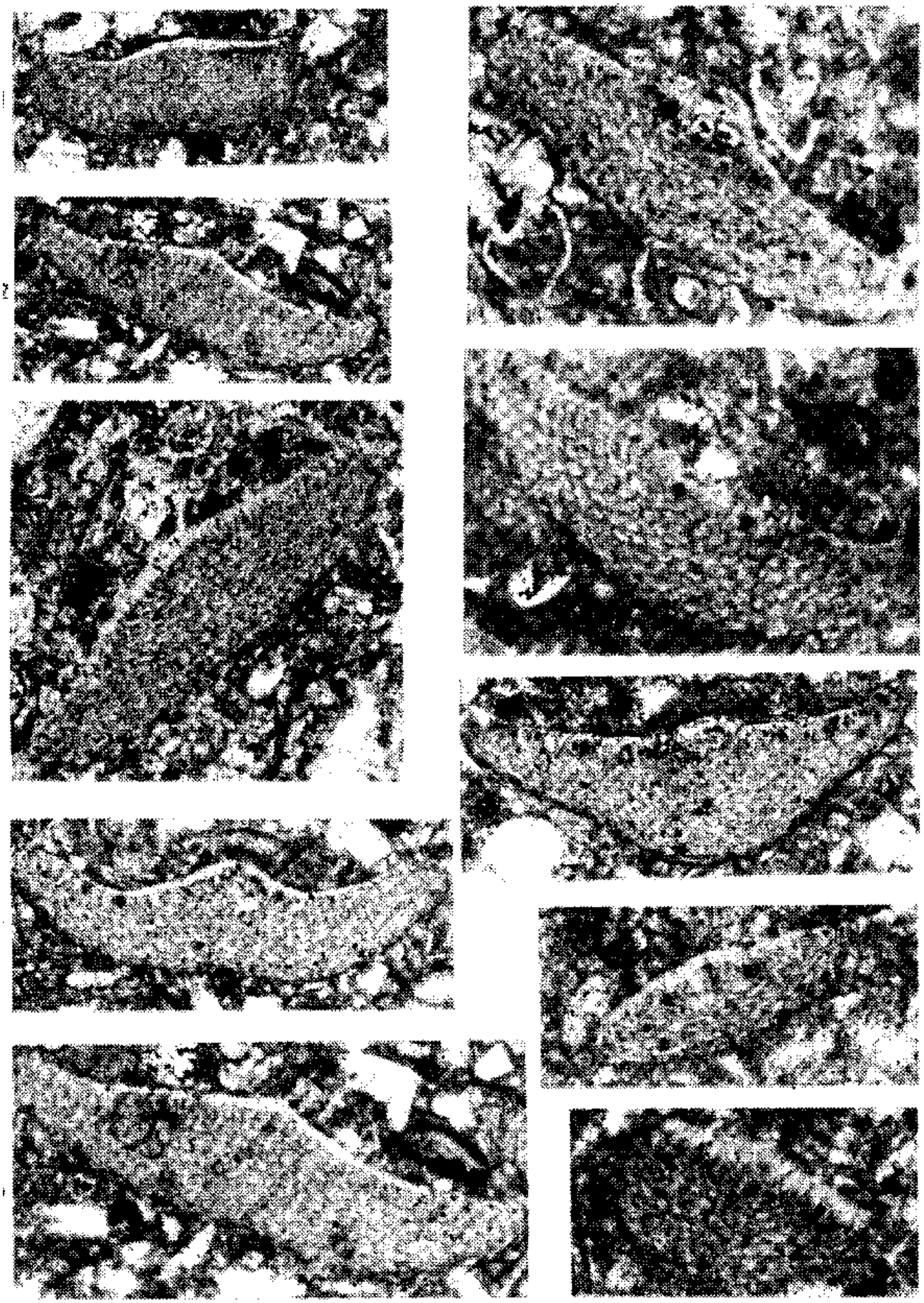
Figure 5- Axial section, Microspheric specimen, (7/I), X48

Figure 6,7- Axial sections, Microspheric specimens, (7/I), X74

Figure 8- Axial section, Macrospheric specimen, Paratype, (7/I), X46

Figure 9- Axial section, Microspheric specimen, (7/I), X74

Figure 10- Axial section, Microspheric specimen, (7/I), X78



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PALEOMAGNETIC CHARACTERISTICS OF THE CENOZOIC VOLCANICS AND TECTONIC EVOLUTION OF THRACE

M. Cengiz TAPIRDAMAZ* and Cenk YALTIRAK**

ABSTRACT.- The effects of three different tectonic regimes are seen in Eocene-Oligocene, Oligo-Miocene and Plio-Quaternary aged volcanics in Thrace. First of these is a 15° counter-clockwise rotation of Oligocene aged volcanic rocks. This rotation may be result of continent-continent collision which is closed of Rhodop-Pontide inner ocean in Oligo-Miocene period. Secondly, Thrace is situated between Thrace Wrench fault zone in the north Ganos fault system in the south in middle and late Miocene and was rotated 39° in anti-clockwise direction. End of this rotation right lateral motion is occurred Thrace Wrench faults. After this motion the Anatolian block is coverged to Thrace block with effect of the North Anatolian Fault. This event is compressed with sharing the Thrace with right lateral motion along a zone which is 40 km far away from the north of ghost Ganos fault. With the effect of this movement, 39° rotated basalts which are situated in the north along Hisarlıdağ-Tekirdağ line in Thrace are again rotated meanly 30° clockwise and it is approached to the original position. Furthermore, Gallipoli block which was rotated 39° counter-clockwise in Miocene was began to compressed by effect of the North Anatolian Fault and it is 20° more rotated in the same direction throughout Gulf of Saros for this reason, Saros block is escaped to the west in a period and it is produced a structure as Karlıova. In that period Gulf of Saroz is achived a structure as a present appearance and that region is entered to the extention regime which is characterized by oblic normal faults.

THE MARINE PLEISTOCENE SEDIMENTS ANDN PALEOGEOGRAPHY OF THE SOUTHERN THRACE COAST

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ABSTRACT.- During middle-late Pleistocene southern Thrace coast was imposed a transgression that caused the recession of the coast line with respect to the recent one. On this coast line that was developed as a result of the transgression which caused Paleo-Marmara sea to translate into an archipelago, shoreline elastics including *Ostrea edulis, Loripes lacteus* abudance zone and beach rock horizon deposited. The units which were deposited in the various paleodepositional areas were elevated by tectonic activity, thus gained a regressive character. Successively they were transported back into the sea. The deposits that are preserved up to recent, have different elevations due to their paleogeographical locations and tectonfcs influences. In the marine deposits having imprints of regional uplift, Marmara formation represented by shore line facies of Paleo-Marmara sea was deposited. The elevated Holocene deposits including *Cardium* sp. and *Murexsp.* above recent sea level indicate that comprasional regime is still active.

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ANATOMY OF AN EPITHERMAL MINERALIZATION: MUMCU (BALIKESİR-SINDIRGI), INNER-WESTERN ANATOLIA, TURKEY

Vedat OYGÜR*

ABSTRACT.- An epithermal mineralization at Mumcu has been developed on the "simple transfer faults" vertically cross-cutting the main breakaway of the Simav Graben, and between the metamorphics of Paleozoic (?) and Miocene andesitic volcanics. An argillic alteration composed of kaolinite, montmorillonite and cristobalite takes place around the mineralization, within both two types of the rocks. Silicification, brecciation, and opalisation are also observed along the fault which constitutes the boundary between the metamorphics and volcanics. Breccias partly have a matrix composed of black silica or limonite. Pervasive and intensive jasperoids occur at the west of the studied area. Epithermal mineralization which is situated in the opalite zone within the metamorphics is represented with cinnabar associated with arsenopyrite, electrum (?) and rare gold particles. The gold values determined both in the Hg-bearing opalite and pyrites are 500 and 340 ppb. respectively. Given these data, it is likely suggested that the Hg-bearing opalite represents the top of an epithermal gold mineralization which has not eroded yet. According to the genetic model designed for Mumcu epithermal mineralization, one could except a bonanza zone dominated by gold towards the deeper parts.

INTRODUCTION

The studied area is in the inner part of the Western Anatolia, between Sındırgı county of Balıkesir province and Simav county of Kütahya province (Fig. 1). The area is located in the northern bloc and at the western edge of the Simav Graben, next to the graben fault that is the most important tectonic feature of the region.

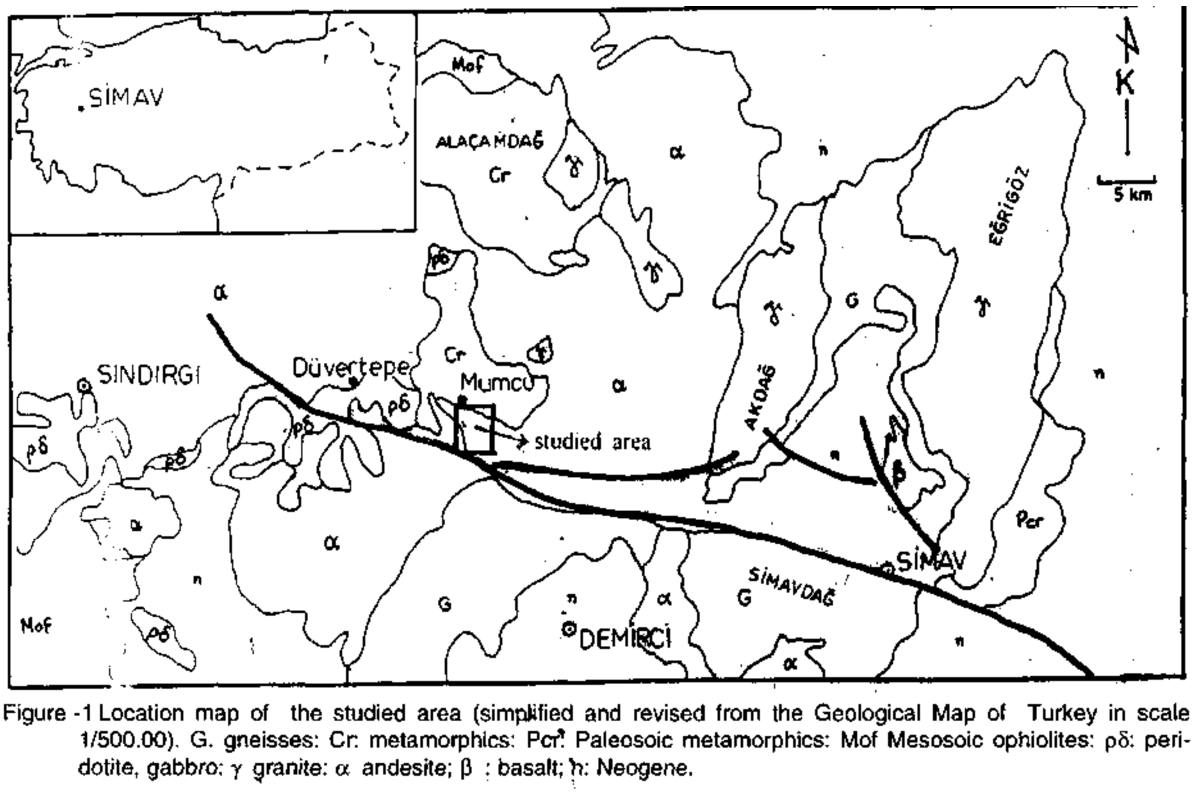

Figure -1 Location map of the studied area (simplified and revised from the Geological Map of Turkey in scale 1/500.00). G. gneisses: Cr: metamorphics: Pcr? Paleosoic metamorphics: Mof Mesosoic ophiolites: ρδ: peridotite, gabbro: γ granite: α andesite; β : basalt; ɳ: Neogene.

Geological researches on the metamorphic rocks of the region were made by Akdeniz and Konak (1979 *a, b)* and Konak (1982). Öztunalı (1973). Eğrigöz and Uz (1978) studied the granitoid massif of Akdağ, from the petrogenetic point of view. Ercan. et al. (1981/1982) investigated the chemical composition and origin of the volcanic rocks of Cenosoic age in the Simav region.

In this study, an epithermal gold mineralization which is located in the rocks as related with the faults of the Simav Graben will be determined and a genetic model associated with the characteristics of the mineralization will be constructed.

GEOLOGY OF THE STUDIED AREA

Kalkan Formation

It is located at the base of the lithological units within the studied area (Fig. 2). Kalkan Formation consists of biotite-bearing gneisses, and some marble lenses occur in the lower levels of the formation. The unid age as pre-Paleozoic by Konak (1982) constitutes the "Gneiss core", in terms of Şengör et al. (1984), with the underlying migmatites eastwards of the studied area. Gneisses are likely to be formed from pelitic sediments and shales (Akdeniz and Konak, 1979a) that metamorphosed in almandine-amphibolite fades.

Simav Metamorphics

Simav Metamorphics consisting of various schists were metamorphosed in the greenschist facies constitute the "schist envelope" with the formations of Sarıcasu and Arıkayası overlying them. According to Akdeniz and Konak (1979a) and Şengör et al. (1984). The schist envelope is unconformable over the gneiss core. However, it is clearly seen that these two units are in a tectonic relationship near Simav. By the crushed zone between the schists and gneisses.

The Simav metamorphics begin with quartz-muscovite schists, and continue with quartz-muscovite-biotite schists. Metamafic-metaultramafic levels named as Kulat Member (Akdeniz and Konak, 1979 *a, b)* are seen in the middle part of the unit. They were folded and metamorphosed with the muscovite-biotite schists. But, their initial relations, have not been resolved yet. Marble levels are observed in the upper parts of the metamorphics. Since (Konak, 1982). According to Uz (1985), they were derived from a volcano-sedimentary sequence where rhyolitic and basaltic lavas tuffs alternated with the clayey and carbonatic sediments.

Sarıcasu Formation

Sarıcasu Formation consists of quartz-, albite-, chlorite-, muscovite- and sericite-bearing schists representing lower grade metamorphic facies than the Simav Metamorphics. The alternating levels of quartz and albite with muscovite and sericite form a banded structure. Recrystallized gray limestone lenses with calcschist structure occur in the upper levels of the formation.

Arıkayası Formation

It has both lateral and vertical gradation to the Sarıcasu Formation, the unit is composed of limestone with granoblastic texture consisting of the calcite crystals that have equigranular dimensions and irregular boundaries. The rock comprises also muscovite and opaque minerals.

Budagan Limestone

Budoğan limestone unconformably overlies the metamorphics, starting with a conglomerate level including abundant and well rounded quartz pebbles. The bedding of the Budağan limestone which is dolomitized in the lower levels is not distinct. It has micritic, biomicritic, pelmicritic, and locally sparitic or pseudo-oolitic textures. Akdeniz and Konak (1979b) and Konak (1982) reported fossils giving a range of age from Rhaetian-Norian (upper Liassic) to Cenomanian (upper Cretaceous) to the formation, however according to Kaya (1972) who defined the formation for the first time the age of the unit is Maastrichtian.

Dağardı Melange

This formation comprises the unorderly mixture of the great masses of mudstone, radiolarite, limestone, tuffite and peridotite. It overlies all of the older by a tectonic contact, and the slabs of the Budağan limestone are tectonically emplaced into

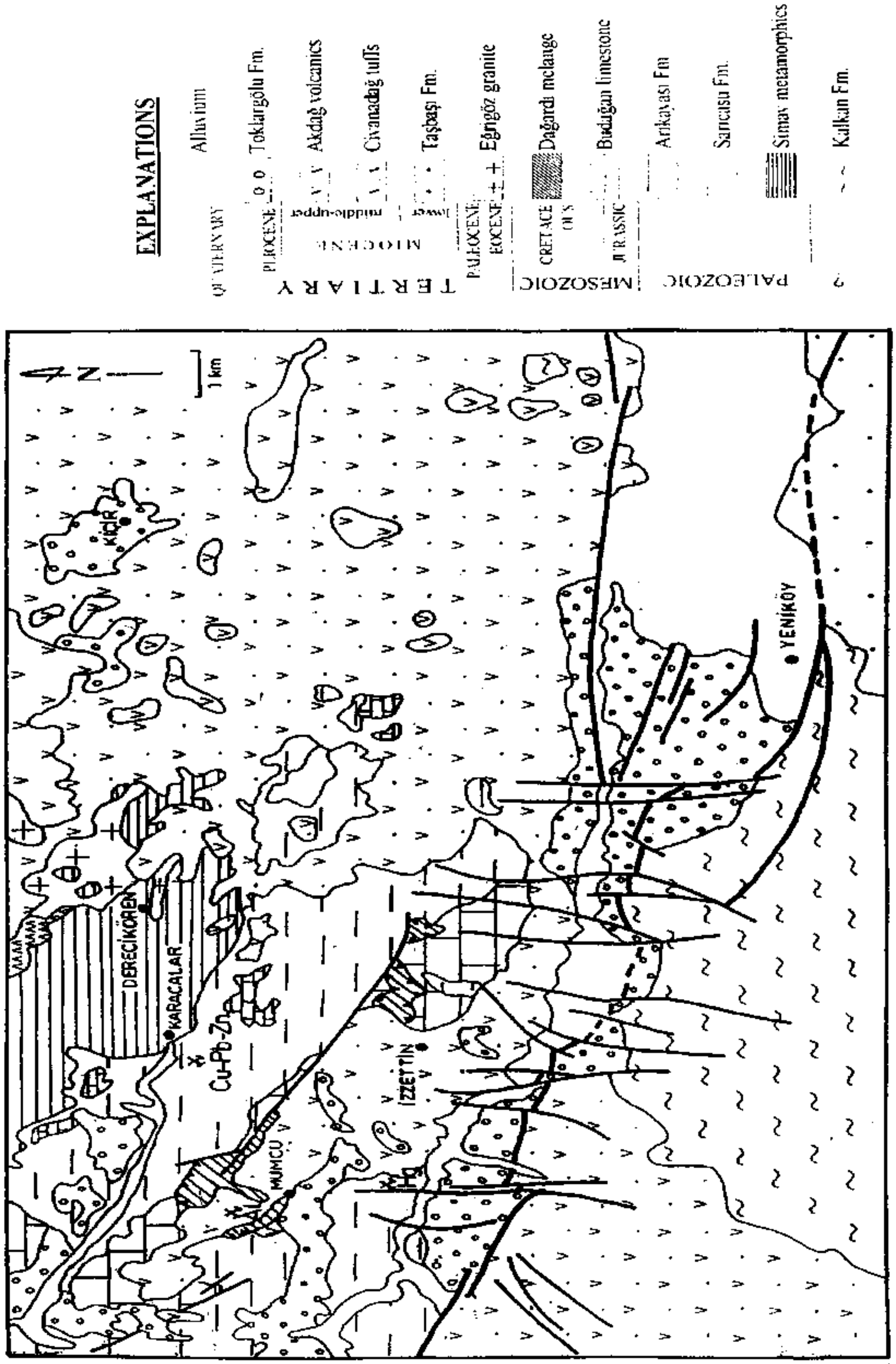

Fig. 2- Geological map of the studied area (revised from Akdeniz and Konak, 1979).

the melange (Konak, 1982). This formation includes Maastrichitan fossils near Dağardı where it is well described, and at the northern part of the Saphane Mountain (Akdeniz and Konak, 19796). Moreover, Dağardı Melange is unconformably overlain by the sediments of Eocene age around Duvertepe and Başlamış village of Akhisar county (Akdeniz, 1989; Akdeniz and Konak, 1979b).

Eğrigöz Granitoid

According to their modal compositions the pluton comprises monzogranite, tonalite and granodiorite, and is calc-alkaline in compositon. Bürküt (1966) suggested that the pluton reached it is composition by the differentiation and assimilation of the magmas a dioritic primary magma. However, Öztunalı (1973) defined the pluton as an anatexitic calc-alkaline granite, and suggested that the pluton started to form in the early Alpine phase (245 to 235 m.y.) and was emplaced in the principal Alpine phaset (78 to 58 m.y.). Uz (1973, 1978) suggested that the pluton consists of two different granite massifs. The first one surrounding the other is an older tectonised Hercynian granodiorite and formed by anatexis. The second cut post-tectonically the older one and is likely Jurassic in age. These young granites are magmatic in origin. According to Bingöl et al. (1982), the pluton that is syenomonzogranite in composition should be aged in late Oligocene-early Miocene (24,6 to 20,0 m.y.).

Simav granitoids intruded Budağan limestones and Dağardı melane, and are overlain by Taşbaşı Formation of the lower Miocene age (Akdeniz and Konak, 19796). Considering the field data, the emplacement age of the calc-alkaline granitoids should likely be Paleocene-Eocene.

Taşbaşı Formation

This unit is composed of loosely cemented conglomerate. The pebbles are angular, and the sorting of the unit is poor. The size of the grains get smaller towards the top, and locally, sandstone levels appear. Due to the pollens aged as middle-upper Miocene from the upper unit which is transitional to the Kızılbük Formation, Akdeniz and Konak (1979b) assigned lower Miocene age to the formation.

Civanadağ Tuffs

This unit consists of the tuffs which are rhyolitic, andesitic and dacitic in composition, and agglomerates in the upper levels. Marly, sand an clayey lenses occur locally. Agglomerate consists of volcanic fragments of various dimensions and the pebbles of metamorphics and ophiolitic melange. Civanadağ tuffs are laterally and vertically transitional to the Akdağ volcanics.

Akdağ Volcanics

The unit of the lavas of various compositions such as andesite, rhyolite, rhyodacite and dacite. According to Ercan et al. (1981/1982), Akdağ volcanics are subalkaline and have a calc-alkaline trend very close to the tholeitic series. According to their stratigraphical relations. Civanadağ Tuffs and Akdağ volcanics as middle to late Miocene in age (Akdeniz and Konak, 19796).

Toklargölü Formation

This unit is made up of unconsolidated coarse elastics. The grain size varies from sand to boulder. Alternations of silt, sand and pebble are observed in some places. Crossbedding is locally seen. Although no fossils are found. Gun et al. (1979) suggested that the formation is likely Plio-Quaternary in age.

SİMAV GRABEN

The most conspicuous tectonic feature of the region is the Simav Fault which trends nearly WNW-ESE for approximately 150 km. along the Simav river from Sındırgı at the west to Muratdağı at the east and which has a sinusoidal shape.

A depression plain bounded from south by the prominent escarpment of the Simav Mountain was occupied by Simav Lake which drained in 1950's. The fault is not a single fracture, instead in consists of several step faults parallel to the main fracture. The difference in altitude between the Civanadağ tuffs located in the northern and southern sides of the Simav Fault is 300 to 500 meters. Naşa basalts of Quaternary age and alkaline compositon (Ercan et al., 1981/1982) lie along the Simav Fault.

Konak (1982) depicted that the metamorphic zones in the northern block of the Simav Fault moved eastwards relative to the southern block. Therefore, the fault was a dextral strike-slip fault before the subsidence started the passive rifting. The lateral motion along a strike-slip fault before the subsidence started the passive rifting. The lateral motion of the fault surface (Crowell, 1974; Woodcock and Fischer, 1986; Sylvester, 1988). The planar normal fault at the surface transforms to a listric normal fault characterized by decreasing angle of dip with depth and a curved surface which is concave upward (Shelton, 1984). Therefore, Zeschke (1954), Akdeniz and Konak (1979b) and Koçyiğit (1984) defined the step faults on the surface of the footwall of Simav Graben as NE dipping gravity faults. Whereas, Dewey and Şengör (1979) pointed out that the bounding faults of the Simav Graben are listric faults that are rapidly flatten with depth.

A great number of faults trending N-S, perpendicular to the main fault at the western end of the graben, cut the Simav Fault. These cross-faults are referred by Gibbs (1984) as "transfer faults". According to Bosworth (1985), these structures are syn-rift features, although they may inherit a present zone of weakness. According to the Şengör's (1987) definition on the cross-faults observed in the western Anatolian graben, these cross faults cutting the Simav Graben are simple transfer faults. It means that the main breakaway fault of the graben is offset without rotation by strike-slip cross-faults.

Since the strike-slip movement of the Simav Fault caused shear fractures in- the Kızılbük Formation of the middle-upper Miocene age at the west of Simav, it is suggested that Simav strike-slip fault was still active during the late Miocene. Şengör et al. (1984) explained that the compressional tectonic regime, causing the movement of this fault, dominated the western Anatolia was transformed later to an extensional tectonic regime since the Cerravalian (upper Miocene). This new tectonic regime led to the formation of the grabens trending nearly east-west in the western Anatolia.

MUMCU EPITHERMAL MINERALIZATION

Mumcu epithermal mineralizations is situated on the Bağlar Hill, approximately 2 km south of the Mumcu village in the western end of the studied area and at the east of the well known Duvertepe kaolinite deposits (Fig. 2). The mineralization was emplaced in the fault zone formed by the transfer fault cross-cutting the Simav graben.

The schists of the Sarıcasu Formation of paleozoic age and the hyaloandesite tuffs of Civanadağ of middle-upper Miocene age are juxtaposed along these faults between Kızıl and Bağlar hills (Fig. 3). Both units are covered by the loosely cemented coarse detritics of the Toklargölü Formation of Plio-Quaternary age in the north.

The metamorphics of the Sarıcasu Formation consist of chlorite-quartz schists. The rocks has porphyroblastic texture and composed of quartz, calcite, and rare plagioclase, and has been subjected to the metamorpism in green-schist facies.

Hyaloandesitic tuffs with volcanic lava flows represent the Civanadağ tuffs in the studied area. Widespread zoned plagiociase (oligoclase-andesite) with polysynthetic lamella, corroded coarse quartz, partly opacitized biotite, and green amphibole phenocrysts that were transformed partly to biotite are seen in a devitrified matrix.

A little hyaloandesite blocks of the Akdağ volcanics crops out within the tuffs. It is composed of abundant zoned plagioclase with poylsynthetic lamellae, few biotite, and rare quartz phenocrysts within a glassy matrix. The cleavages of the biotite show local distortions.

Both tuffs and schists are strongly altered along the faults. Alteration is seen as a zone on 100 meters width in both rocks along the faults. The alteration products are determined as cristobalite, kaolinite, montmorillonite, tridimite and heulandite according to the XRD analysis. Döküş Hill kaolinite deposit that is located on the same faults at the northwest of the Mumcu village has alunite, dickite, cristobalite and quartz. An argillic alteration is discussed in the studied area on a account of the mineralogical assemblage. Due to the presence of montmorillonite, the alteration of the Kızıl hill is classified as intermediate argillic (Anderson and Eaton, 1990), and due to presence of alunite and dickite, the one of the Döküş hill as advanced argillic (Hemley and Jones, 1964).

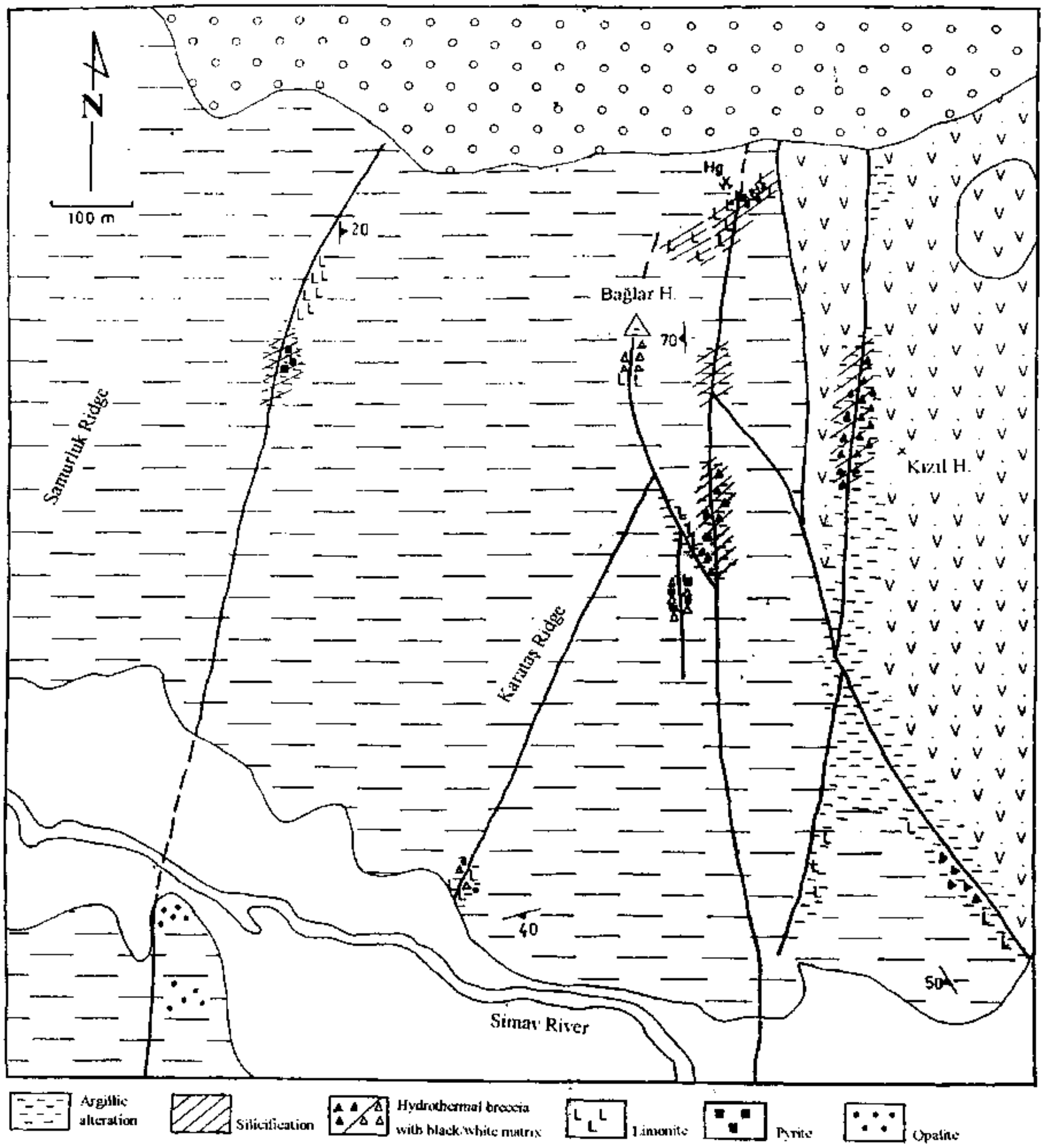

Fig. 3- Geological map of the Mumcu epithermal mineralisation. Explanations of the rocks in Figure 2.

White opaline coatings are observed on the fissure surfaces of the tuffs along the strongly argillized fault forming the boundary between the tuffs and metamorphics. In addition, the rocks in this part are also intensively silicified and brecciated. The breccia at the tuff side is formed by angular volcanic fragments in a silica matrix also some black silica veinlets. However, it is cemented by limonite and crossed by fine quartz veinlets at the schists side. The matrix of the breccia is white at Bağlar Hill and Karataş Ridge.

Pyrites are widespread, and quartz with drusy texture which is characteristics for an epithermal mineralization is observed along the faults at Samurluk and Karataş ridges. Idiomorphic honey-colored quartz crystals developed on the walls of the drusy cavities. Kaolinization and limonization are observed near the Simav river where these faults cut the Toklargölü Formation.

Strong limonization ad pyritization along the fault and bleaching in the host rock are observed at the west of the Bağlar Hill. Vuggy texture is developed in the limonitized parts. Intensive opalization is seen on the continuation of this fault at the south of the Simv river.

Intensive and pervasive jasperoid formation related to the marble levels in the schists of the Sarıcasu Formation is seen on the Kadiruçtu and Ballık hills, at the west of the mineralization area. Colored opal is partly observed in the rock and on the fissure surfaces. Colloform pyrite as black bands, and fine veinlets of limenite-hematite are dominant at the some parts of the rock.

Opalite occurs in an intensively limonitized part of the schists, on the northward continuation of the tectonic zone, at the northern slope of the Bağlar Hill. Opalite in various tones of black, green mineralization was formed in opalite, and spread along the fissures within the rock. Arsenopyrite and electrum (?) are associated with the cinnabar. A gold silver with the length of 5-7 micron and the width of 2-3 micron is seen in this part. The gold content of the Bağlar Hill opalite is 50 ppb. and of the pyrite zone, at the west. 340 ppb. The geochemical analyses of the mineralization is given in Table 1.

By considering all of these data, the mercury-bearing opalite represents the top most uneroded level of an epithermal gold mineralization (Clarke and Govett, 1990: Rytuba and Heropoulos. 1992). According to the mineralogical zoning seen in art epithermal system, it is quite possible that the bonanza zone dominated by gold is situated in the deeper levels.

DISCUSSION

A genetic model constructed to explain the Mumcu epithermal system is illustrated in Fig. 4, It was accepted that the mechanism of the system is comparable to the model proposed by Henley (1985).

The field evidence of the buried porphyry stock, which was the engine of the epithermal system to provide the heat to drive the hydrothermal circulation cell as stated by Henley and Ellis (1983) is the Derecikören granite at the north of the studied area. Skarns including base metals occur on the borders of this granitoid and a pophyry with pyrite, limonite and stockwork quartz veins crop outs at the north of the village. The presence of a hydrothermal quartz vein rich in Au (3.8 gr/t) and Ag (270 gr/t) within the schists, located Karacalar between the Derecikören granite and the Mumcu epithermal system may be evidence for an ore-bearing system. Some mineralized porphyry systems occur also along the Simav Graben fault at the east of the studied area and at the southeast of Gediz town.

The hot, acidic, low-density fluids rich in magmatic volatiles were produced related to the late phases during the cooling of a granitic stock (Sillitoe and Lorson, 1994). The ascended and condensed, and mixed with meteroic water at the shallower epithermal levels to generate the highly reactive and corrosive fluids involved in the generation of the gold-and silver-bearing and sulfide replacement bodies and the overlying quartz-alunite alteration (Henley, 1985). Chromite and magnetite observed within the opalite suggest that these solutions silicified metaultramafic/mafic bands within the schists.

These acidic fluids moved along the transfer faults to the parts suitable for the deposition and started to boil at the shallower levels where the pressure was between hydrostatic and lithostatic (Reed and Spycher, 1985). Thus, the decrease in the temperature of the fluid and the increase in pH resulted in the formation of the epithermal mineralization. On account of the low-contents of Sb.As.Ag and Au in cinnabar, it is suggested that the mercury can be transported in a vapor phase and deposited as cinnabar at the surface or near-surface environment, below the ground-water table (Rytuba and Heropoulos, 1992).

The water vapor and acidic gases (H_2S, SO_2, HCl) liberated during the boiling process con-

Table 1. Geochemical analyses of the Mumcu mineralization (values are in ppm: in % if bold).

LOCATION	Cu	Pb	Zn	As	Sb	Au	Hg	Mo	Ag
Bağlar Hill	49	23	10	20	>600	0.5	200	-	-
Samurluk Ridge	45	26	25	100	<4	0.34	0.2	20	-
Samurluk Ridge				<2	7	0.04	0.1	3	-
Karataş Ridge				<2	5	0.04	2.0	3	-
Bağlar Hill	68	44	84	275	<4	0.60		10	1.0
Karacalar vein	>1000	116	1000	>1000	>600	3			270
" "	%1.82	%8.58	%11.90	%0.16	%0.11	2.95			392

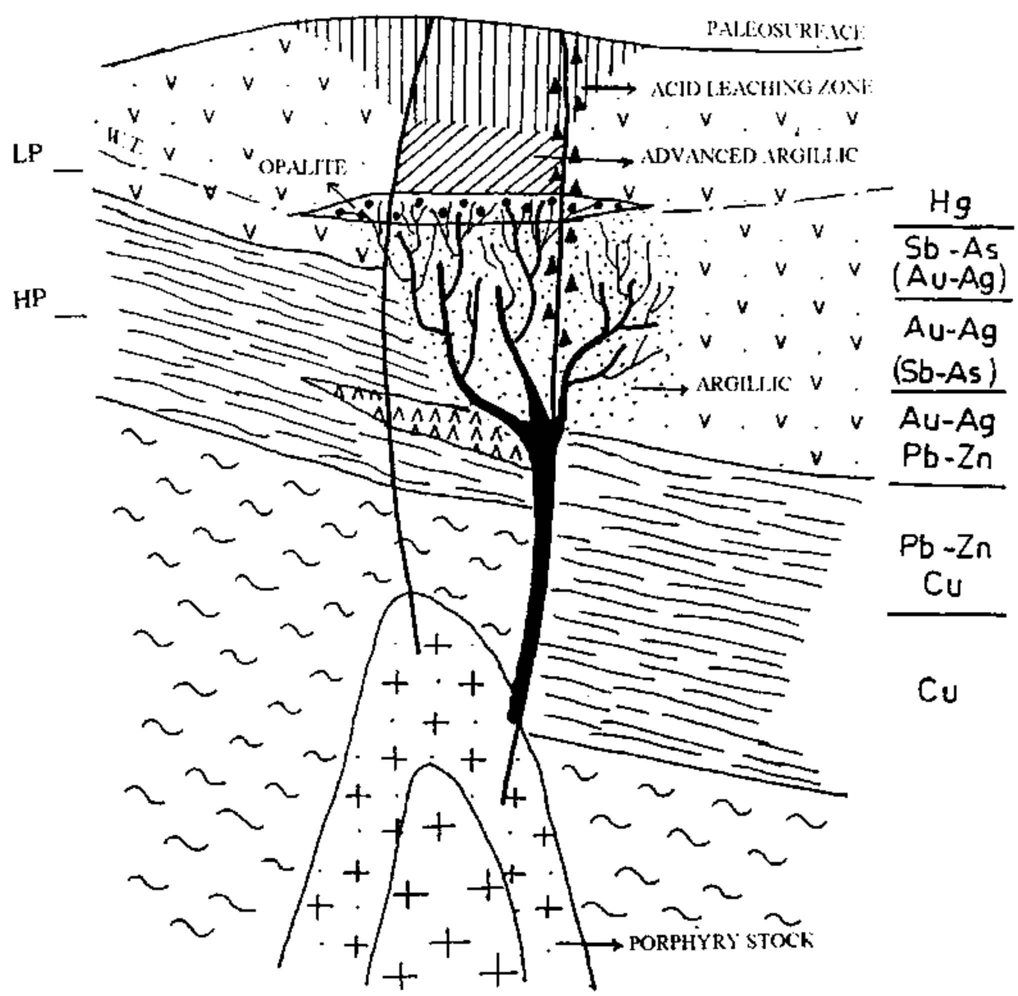

Figure 4- Genetic model of the Mumcu epithermal system.

densed into the cold water below the ground-water table, and formed argillic alteration (Henley, 1985). Alunite-, dickite- and cristobalite-bearing kaolins at the Döküş Hill represent the quartz-alunite and acid-leaching zones of advanced argillic alteration which have been eroded at the Bağlar. Cristobalite and opal indicate the surfical zone of such an alteration (Sillitoe and Lorson, 1994). The quartz-alunite zone was formed along the faults below the acid-leached cap.

The temperature of the hydrothermal solutions rapidly decreased by mixing with the cold meteoric water and opal precipitated instead of quartz (Fournier, 1985a). The lateral flow of the fluids due to the enhanced permeability of the host-rock, formed roughly stratabound opalite horizons. Hg-bearing opalite covers gold-bearing quartz sulfide veins.

The step-like, narrow, fault-localized, chalcedonic quartz ledges are supposed to be the feeders for the quartz sulfide bodies. The hydrothermal breccias with black silica veinlets at these parts are likely the upward projections of such feeders. It is suggested that the vuggy chalcedonic quartz was produced by hypogene leaching of all principal rock components, except for part of the silica, under highly acidic (pH<2) (Stoffregen, 1987).

Overpressure on the hydrothermal fluids, as a result of their accumulation beneath impermeable silicified tuff caused hydraulic fracturing and explosions forming the hydrothermal breccias (Hedenquist and Henley, 1985). The black matrix-should have been emplaced with or after the ore deposition (Sillitoe and Lorson, 1994). In contrast, white matrix breccia is believed to have been emplaced before most of the metals were deposited.

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GEOLOGY OF THE İDİŞ DAĞI - AVANOS AREA (NEVŞEHİR - CENTRAL ANATOLIA)

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ABSTRACT.-İdiş Dağı-Avanos area is located on the northeast of Nevşehir, and is a part of the Central Anatolian Crystalline Complex.

The basement rocks of the study area constitue? Mesozoic aged Aşıgediği Metamorphics, that represent the uppermost unit of the Central Anatolian Metamorphics and consist of platform type meta-carbonates. İdiş Dağı Syenitoid, composed of quartz syenite, alkali feldspar quartz syenite and quartz monzonite intruded the Aşıgediği Metamorphics, and generated contact metamorphic zones. Karahıdır Volcanics are found as dykes cutting the İdiş Dağı Syenitoids and as blocks in the Göynük Volcaniclastic Olistostrome.

Göynük Volcaniclastic Olistostrome unconformably covers the basement rocks. It is formed within a fault-controlled extansional basin in Uppermost Cretaceous-Lower Paleocene period, and includes the olistoliths of the Karahıdır Volcanics and İdiş Dağı Syenitoids.

The late Lower Paleocene-Upper Paleocene Yeşilöz Formation consists of the Saytepe Conglomerate Member and the Asaftepe Member and represents the terrestrial and lacustrine depositional environment. Middle Eocene Mucur Formation characterising shallow marine (reefal) deposition transgressively overlies the basement rocks. It is suggested that in the Early Miocene, a compressional system effected the İdiş Dağı Area, and the basement rocks were thrusted over the Tertiary cover units.

The neotectonic period started in Late Miocene in the study area. In this period a new tensional system became effective, Ürgüp and Asarcık Formations are deposited within the basins which are controlled by the Central Kızılırmak Fault Zone. The Quaternary aged travertine occurrences and talus deposits are also related to this fault zone. The Karataş Volcanics and Kızılırmak River terraces of Quaternary of age are mainly controlled by the Central Kızılırmak Fault Zone.

INTRODUCTION

The study area is located to the northeast of Nevşehir (Fig. 1) in the Kırşehir Massif which is included in Central Anatolian Crystalline Complex (CACC) (Fig. 2), which comprises three large sub-massifs; Akdağmadeni to the east, Kırşehir to the west and Niğde to the south (Göncüoğlu et al., 1991).

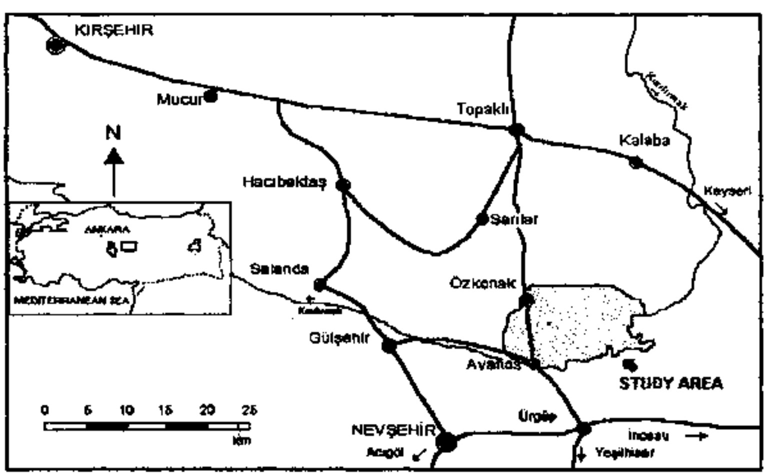


Fig. 1- Location map of the study area.

The metamorphic rocks in the CACC are defined as "Central Anatolian Metamorphics" comprising Gümüşler, Kaleboynu and Aşıgediği Metamorphics by Göncüoğlu (1977) and Göncüoğlu et al. (1991, 1992, 1993). These metamorphics were obducted by ophiolitic units which are named as "Central Anatolian Ophiolites" and both are intruded by plutonic rocks named generally as Central Anatolian Granitoids.

In the earliest work on the geology of the study area Pisoni (1961) suggests that the Paleozoic-Mesozoic aged marbles intruded

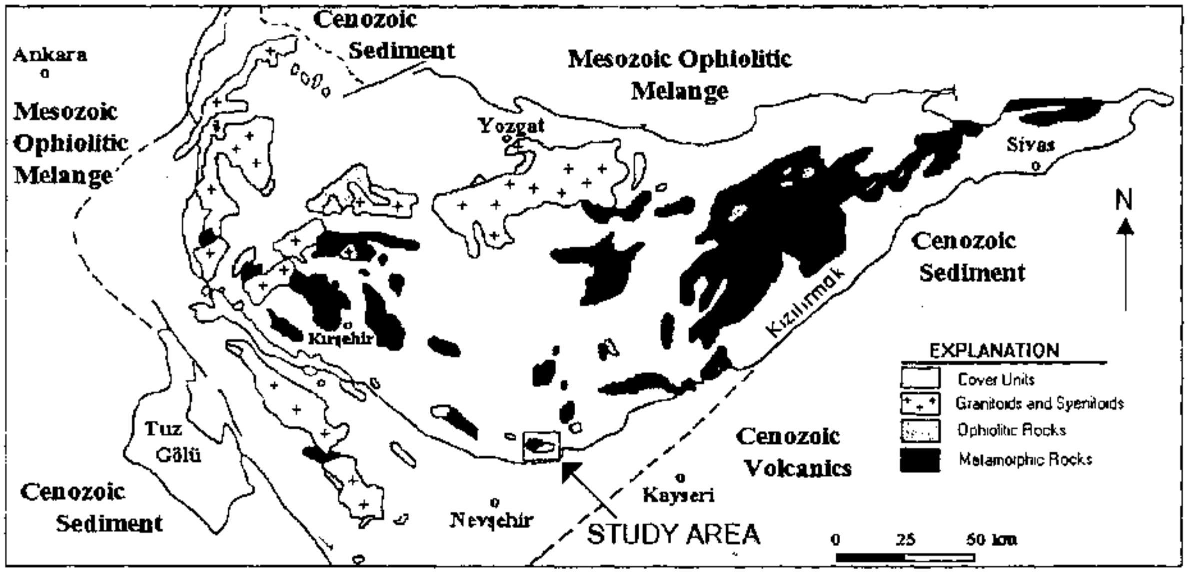


Fig. 2- Distribution of the main rock-units in the Central Anatolian Crystalline Complex (simplified from Bingöl, 1989).

by granitoids and/or syenitoids form the basement. They are covered by graywackes, marls and Nummulitic limestones of Eocene, graywackes, conglomerates and marls of Oligocene, and tuffs of Neogene age.

Aydın (1985) worked in the Gümüşkent (Nevşehir) area which is on the west of Avanos, and described alkaline plutonic rocks in the area. According to her, in the area the metamorphic rocks such as marbles, gneissic rocks and amphibolites are intruded by granitoids and syenitoids at a nearly shallow depth, and the volcanic rock types in the area were created from almost the same magma.

Atabey et al (1988) and Atabey (1989), studied the geology of the area around Avanos which also comprises the İdiş Dağı region, and mapped the area at 1/25 000 scale. According to him, in the İdiş Dağı area, the basement is Tamadağ and Bozçaldağ formations which belong to the Pre-Mesozoic aged Kaman Group of Seymen (1981). The basement is intruded by Pre-Campanian aged granitoids, The metamorphic and magmatic rocks of İdiş Dağı area are nonconformably covered by Saytepe and Lalelik members of Pre-Lutetian aged Ayhan Formation which is followed by Upper Miocene-Pliocene aged Tuzköy and Yüksekli Formations, Kavak Member of Ürgüp Formation and Quaternary cover units.

According to Göncüoğlu et al. (1993), Paleozoic-Mesozoic aged Central Anatolian Metamorphics which mainly consist of Gümüşler, Kaleboynu and Aşıgediği Metamorphics are the basement units in the Avanos area. Central Anatolian Metamorphics are intruded by Upper Cretaceous aged İdiş Dağı Syenitoid which is cut by Karahıdır Volcanics. These units are covered by Latest Cretaceous-Early Paleocene Göynük Formation, which can be defined as a volcaniclastic olistostrome followed by Middle-Late Paleocene Saytepe and Asaftepe members of Yeşilöz Formation. Mucur Formation is Early-Middle Eocene in age, and includes four members as Göbekli, Ayhan, Sarılar and Keklicek members. The Lower Miocene rocks (Akgün et al., 1995) in the surrounding region which are called as Gümüşyazi Group are not observed in the Avanos area. The Mio-Pliocene Kızılırmak Group rocks are deposited in the terrestrial basins which were formed in the neotectonic period, and composed of four contemporary and laterally transitional formations as Ürgüp (Pasquare, 1968), Asarcık, Seyfe and Akbayır.

Lulu (1993) described that in the Hırka Dağı (Gülşehir-Nevşehir) area, there are Paleozoic-Mesozoic Central Anatolian Metamorphic rocks, Cenomanian Üçkapılı Granodiorite which intruded the metamorphics, and Tertiary Elmadere Olistostrome, which corresponds to the Göynük Formation and the younger cover units.

Toprak (1994), defined the fault set in İdiş Dağı area as one of the major fault sets which belong to the Central Kızılırmak fault zone. İdiş Dağı fault represents the northern margin of the Hırka Dağı-İdiş Dağı horst and southern margin of the depositional environment of the Asarcık Formation. According to Toprak (1994), Central Kızılırmak fault zone constitutes the northern margin of the Central Anatolian Volcanic Province which includes the several volcaniclastics intercalated with lacustrine to fluvial deposits.

In spite of these numerous geological works in Central Anatolia, there are still problematic points about the geological evolution of Central Anatolia and surrounding regions. The present research is aimed towards an understanding of the geological and petrological characteristics of the İdiş Dağı-Avanos area, considering this as one of the key regions of Central Anatolia.

Three very critical problems can be investigated in İdiş Dağı area in detail. The first important problem in the study area is the structural relationship of the rocks of Central Anatolian Crystalline Complex (CACC) with the Tertiary cover units. Secondly, the geological and petrological features of a volcaniclastic olistostrome which is one of the most important units in CACC, could be properly studied in the area. Besides these aspects, the geological and geochemical properties of the plutonic and volcanic rocks in the area are very criticai to understand the evolution of the Central Anatolian Crystalline Complex.

This work is mainly focused on the general geological aspects of the study area, to give the regional geological framework and thus an introduction for further work on petrology of the plutonic rocks (Göncüoğlu et al., 1995) of the study area.

ROCK UNITS OF THE BASEMENT

The basement rock units exposed in the study area can be divided into three main groups: 1) Central Anatolian. Metamorphics, 2) Central Anatolian Plutonic Rocks, and 3) Karahıdır Volcanics. The geological map and the stratigraphic columnar section of the study area are given in Fig. 3 and 4.

Central Anatolian Metamorphics

In the study area, the Central Anatolian Metamorphics are represented by an incomplete sequence of Aşıgediği Metamorphics.

Aşıgediği Metamorphics

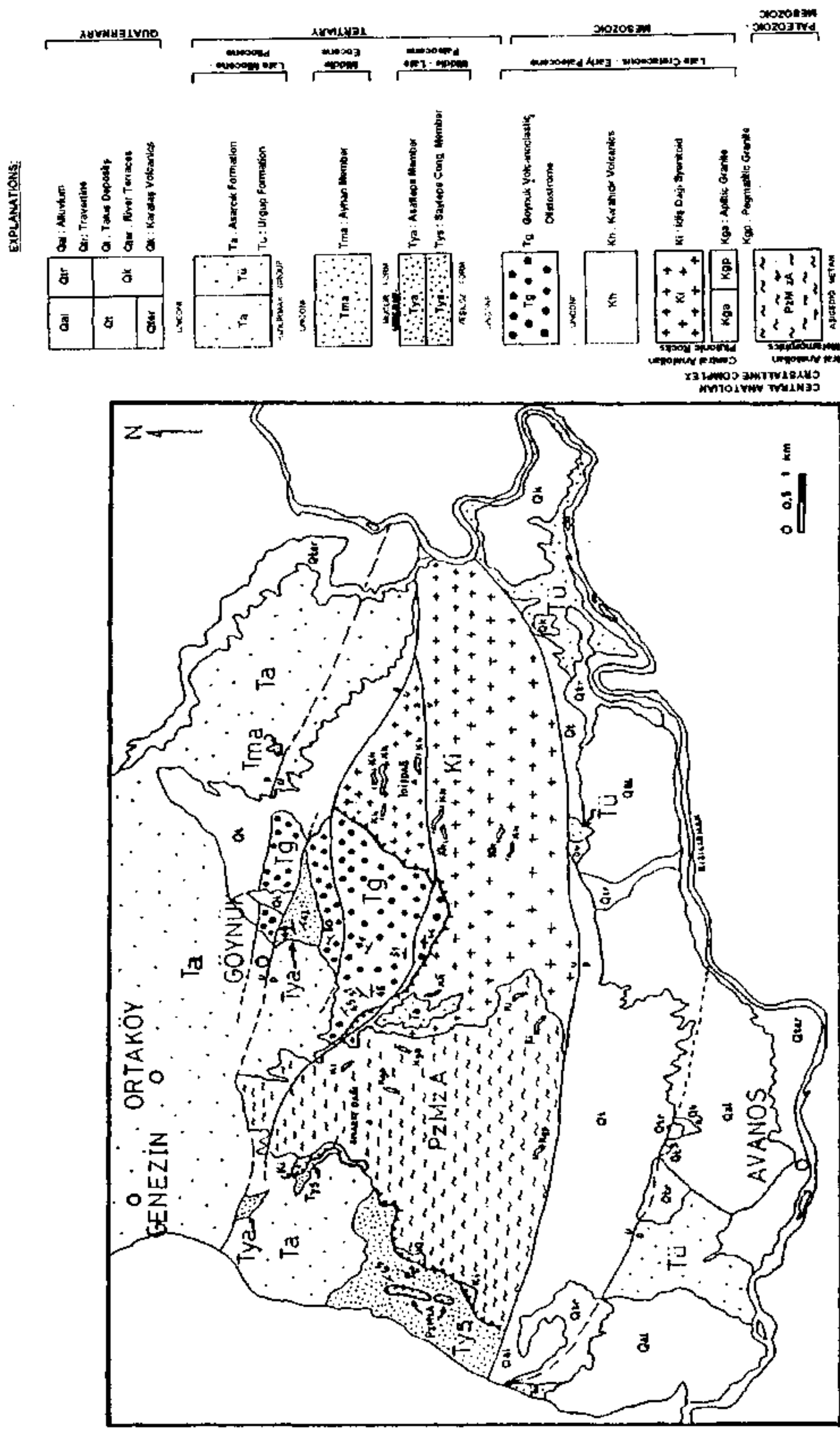
In the İdiş Dağı area, Aşıgediği Metamorphics are characterized by massive marbles with amphibolite intercalations. Aşıgediği Metamorphics are observed as roof pendants on the plutonic rocks. It has a thrust fault contact with Paleocene-Eocene sedimentary cover. Miocene-Quaternary cover units uncorformably overlay this formation. To the south and north Aşıgediği Metamorphics is delineated by faults. In the study area, the marbles, amphibolites and some contact metamorphic rocks are observed.

Marbles

Marbles in the Avanos region are observed at the Ziyaret Tepe, and are also observed in Göynük Formation on the Lalelik Tepe as blocks.

Marbles are white colored and form topographically smoothed hills. Marbles are composed of micro and macrocrystalline calcite grains and characterized by massive structure. Along the thrust fault contact, to the northwest of the study area, marbles are cataclastically deformed.

Marbles are composed of interlocking calcite grains and show granoblastic texture. Two types of Marbles of Aşıgediği Metamorphics are differentiated according to their grain sizes macrocrystalline marbles with grain size of 0.3-2 cm and microcrystalline marbles with grain size of 0.1-0.3 cm. In the study area, marbles are generally formed from calcite, but minor amounts (upto 5 %) of quartz, K-feldspar and opaque minerals are also present. Calcite minerals are twinned. The effects of post-metamorphic deformation are detected microscopically. In the highly deformed samples, quartz and



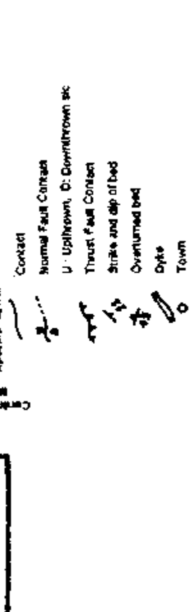


Fig. 3- Geological map of İdiş Dağı area (simplified from Köksal, 1996).

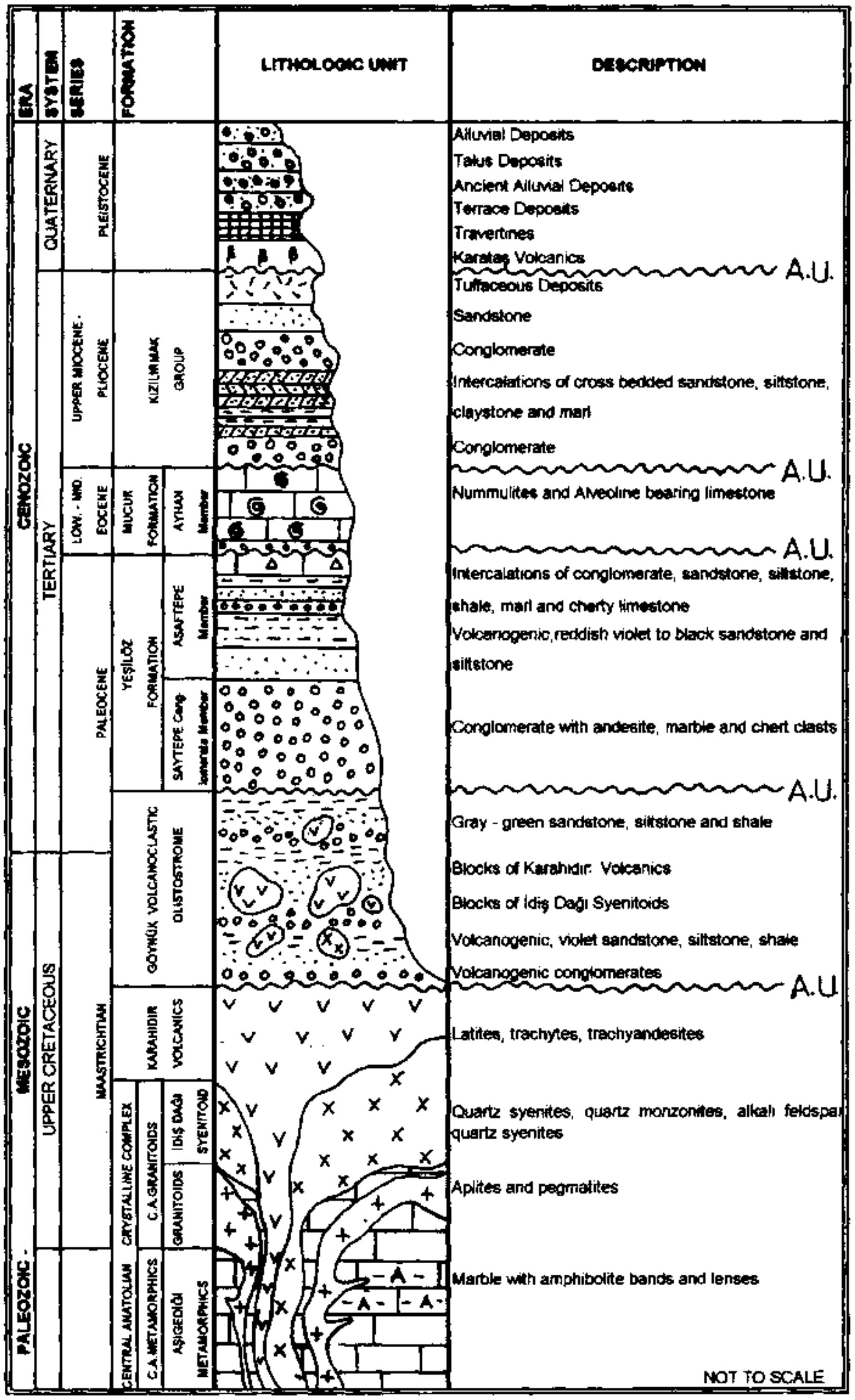


Fig. 4- Generalized colomnar section of the study area.

quartzo-calcitic lenses are observed between foliated calc-schist bands. The protolith of marbles in the area may be suggested as pure or slightly impure limestone.

Marbles are surrounded by the İdiş Dağı Syenitoids, and they are roof pendants on that body. Dykes of the İdiş Dağı Syenitoids, pegmatitic and aplitic granites are found in marbles. Along their contacts, marbles are macrocrystalline and highly silicified. At some parts contact metamorphic aeroles, between marbles and syenitoids, are also observed. At these contact metamorphic zones, hornblende-garnet hornfelses are found between syenitoid intrusions and coarse grained silica-bearing marbles. These hornfelses exhibit fine grained granoblastic texture. Amphibole-garnet hornfelses are composed of ~ 45 % Ca-garnet", ~ 42 % amphibole, ~ 10 % calcite, ~ 2 % quartz and ~ 1 % opaque minerals. Garnets are brown in color and of calcium type. Ca-garnets are idioblastic crystals, with about 0.5 mm diameter. They show anormous zoning due to the anomalous extinction. Amphiboles occur as smaller xenoblastic crystals, smaller than Ca- garnets. They show pleochroism from dark to light green or bluish green to green. Quartz and opaques are found as minor grains. Main paragenesis in these hornfelses is Ca- garnet+amphibole+calcite+quartz assamblage, which represent the medium grade contact metamorphic conditions (Winkler, 1979). At more northern contact zones vesuvianite and wollastonite minerals are also observed. In these samples vesuvianite + K-feldspar and wollastonite + K-feldspar + amphibole paragenesis are detected.

Amphibolites

Amphibolites and amphibole schists in the study area are found as interlayers confined in marbles. Amphibolite bands are found on the southern parts of the Ziyaret Tepe. Amphibolite bands are conformable with marbles, and intruded by alkaline dykes on the southeastern and by pegmatitic dykes on the southern part of the Ziyaret Tepe. In the hand specimen, amphibolites are dark grayish colored and contain hornblende, plagioclase and biotite. They are generally fine grained, but grains are larger at the contacts with dykes. The thickness of amphibolite bands changes from 5 to 70 cm.

In the study area, amphibolites have generally fine grained nematoblastic texture. The modal compositions of amphibolites are given in Table 1. Amphiboles are of hornblende type and are xenoblastic, with < 2 mm diameter, and interlocking minerals having well developed cleavages. They are pleochroic from light green to greenish brown. Plagioclases are xenoblastic and exhibit polysynthetic twinning. Sericitization is present on plagioclases. Biotites are characterized by fine grained xenoblasts and are pleochroic from light green or brown to dark brown.

They are distributed in distinct zones, and partly chldritized. Epidotes are also characterized by fine grained xenoblasts and are pleochroic from yellowish green to green. Andalusite occurs as colorless to reddish idioblasts in only one biotite-rich sample and is nearly idiomorphic.

Table 1 - Modal composition of amphibolite

Minerals Abundances	SK-78	SK-96
Hornblende	40	40
Plagioclase	35	20
Biotite	15	20
Quartz	3	5
Andalusite	-	10
Epidote	4.5	-
Chlorite	-	5
Zircon	0.5	-
Opaque	2	-

Paragenesis in amphibolites are,

Plagioclase (Labradorite) + hornblende + biotite + epidote + quartz

Plagioclase (Anorthite) + hornblende + biotite + andalusite + quartz

According to Winkler (1979), the Low grade-medium grade metamorphism boundary of mafic rocks is indicated by An 17 + Hb isograde. Since the plagioclases of the plagioclase + hornblende pair in the study area are labradorite and anorthite in composition, temperature must be of higher parts of medium grade. In addition andalusite which is observed in some amphibol-rich rocks is the typical mineral for medium grade metamorphism. Thus, the metamorphism conditions of amphibolites are medium grade. The protolith of the amphibolites may be a marly sediment containing a mixture of clays and carbonate material.

Central Anatolian Plutonic Rocks

The plutonic rocks in the İdiş Dağı area can be classified into two main groups as syenitoids and granitoids.

İdiş Dağı Syenitoid

In the İdiş Dağı area, plutonic rocks with little amount of quartz, are defined generally as syenitoids. These rocks form the basement units together with the Aşıgediği Metamorphics in the study area. Göncüoğlu et al (1993) named these rocks as İdiş Dağı Syenitoids because of their typical and extensive occurrence in this area. İdiş Dağı Syenitoid is a large stock which form Ötedikme Tepe and the eastern part of Ziyaret Tepe. It also crops out in the western side of the Ziyaret Tepe. Dykes of İdiş Dağı Syenitoid are found in Aşıgediği Metamorphics.

İdiş Dağı Syenitoid is generally in yellowish-pinkish color. Around the Ziyaret Tepe, white-gray colored samples are found. In the hand specimen large crystals of alkali feldspars (up to 3 cm) with well developed tabular appearance and in minor amounts and in smaller grain size quartz, plagioclase, and biotite minerals are detected.

İdiş Dağı Syenitoid is considerably altered in most parts of the study area. As a result of weathering, syenitoids seem to have been disintegrated to yield syenitic soil which covers considerabJe areas in the field. Thus, these areas are accepted and mapped as syenitoid areas.

At the contacts With metamorphics, syenitoids are highly altered. Also olistoliths of syenitoids are found in volcano-clastic olistostrome. Dykes of Karahıdır Volcanics are observed within the İdiş Dağı Syenitoid. İdiş Dağı Syenitoid cut and uplifted the Aşıgediği Metamorphics as roof pendants. It has also thrust fault contact with both Göynük volcano-clastic olistostrome unit rocks and Paleocene-Eocene sedimentary rocks. Miocene-Quaternary sedimentary units covered this unit, İdiş Dağı Syenitoids are faulted in the northern and southern parts. Also there are faults within the syenitoid body.

İdiş Dağı Syenitoids are defined by Göncüoğlu et al. (1993) as post collisional intrusions. The plutonic rocks around Kırşehir (Seymen, 1981; Lunel, 1985; Bayhan 1987, 1988; Bayhan and Tolluoğlu, 1987; Erler et al., 1991; Tolluoğlu, 1993, Akıman, and Boztuğ, 1993), Ankara (Bayhan, 1989), Nevşehir (Aydın, 1985), Kayseri (Özkan and Erkan, 1994), and Ulukışla (Çevikbaş et a1.,1995) have some similar and different characteristics, and their spatial and temporal relations with İdiş Dağı Syenitoids has been discussed properly in Göncüoğlu et al. (1995a).

Granitoids

Granitic rocks observed within the Aşıgediği Metamorphics are mainly aplitic and pegmatitic dykes.

The aplitic dykes were observed in the southeastern part of the Ziyaret Tepe intruding marbles of Aşıgediği Metamorphics. They are fine grained, granular rocks white in color, Almost no mafic mineral is seen on the hand specimen while quartz, K-feldspar and plagioclase are detected. These aplitic dykes are about 1 m. in width and almost 10 m. in length.

Pegmatitic granites are found in the southeastern part of the Ziyaret Tepe both as dykes and sills. They are intruding both amphibolites and marbles of Aşıgediği Metamorphics. Amphibolite enclaves are observable within the pegmatitic dykes. Pegmatitic granites are coarse grained (more than 1 cm. in length) and white in color. They are almost totally formed from quartz and K-feldspar crysts as detected on the hand specimen, These dykes are about 1 m. in width and few meters in length.

Aplitic and pegmatitic granites are not observed in contact with İdiş Dağı Syenitoids in the study area. Göncüoğlu et al. (1992), however report that granitic rocks in CACC have been commonly intruded by syenitoids. Since they intrude the Mesozoic Aşıgediği Metamorphies and nonconformably covered by Latest Cretaceous elastics they must be at least Upper Cretaceous in age as İdiş Dağı Syenitoids.

Karahıdır Volcanics

In the İdiş Dağı area volcanic rocks are found as blocks within the Göynük Volcaniclastic Olistostrome and dykes cutting İdiş Dağı Syenitoids. These volcanic rocks are classified as Karahıdır Volcanics by Göncüoğlu et al. (1993). This name was first used by Kara and Dönmez (1990) by considering their wide exposure around Karahıdır Village to the north of Kırşehir.

Karahıdır Volcanics in İdiş Dağı area are both cutting the İdiş Dağı Syenitoids especially around Ötedikme Tepe and observed as olistoliths in Göynük Volcaniclastic Olistostrome in the center of the study area. Huge olistoliths of these volcanics formed the Köydikmeni, Gedikkasi and Gözenekli Tepe within the Göynük Volcaniclastic Olistostrome (Fig. 5). Also lot of volcanic blocks are found in Göynük Volcaniclastic Olistostrome in variable scales reaching up to tens of meters.

Karahıdır Volcanics in the study area can be differentiated into trachytic, latitic and andesitic types according to their field occurences. Trachytes are pink-violet or violet colored and trachytic texture is recognizable with the lineation of about 1 cm long, white-pink feldspar crystals. Also biotite, and minor amounts of quartz and pyroxene are observed. Trachytes are observed both as blocks in the Göynük Volcaniclastic Olistostrome and as dykes cutting İdiş Dağı Syenitoids. In these dykes effective chloritization is observable.

Latites are gray-violet colored and fine grained. Minerals are not recognizible except few altered feldspar and small biotite grains. They are mainly jointed (joint spacing from 5 cm to 10 cm) and porphyritic. Latites are generally observed as large blocks in the Göynük Volcaniclastic Olistostrome. Argillization is very effective in latitic rocks.

Andesites are fine grained and dark violet in color. Porphyritic texture is observable with feldspar grains (upto 0.5 cm) in some samples. Andesites are generally found as blocks in the Göynük Volcaniclastic Olistostrome, but there are some andesitic dykes cutting İdiş Dağı Syenitoids also.

Depending on the contact relationships Maastrichtian-Lower Paleocene age interval is suggested for Karahıdır Volcanics (Göncüoğlu et al., 1993).

The occurrences of Karahıdır Volcanics in Sarıkaya-Karahıdır, Karaova and Karaburna are reported by Göncüoğlu et al. (1993). Köksal (1996) studied the petrographical and geochemical characteristics of the unit. Kötüdağ Volcanite (Seymen, 1981; Tolluoğlu, 1993) and volcanic rocks in Salanda area (Aydın,1985) reflects similar characteristics with Karahıdır Volcanics.

STRATIGRAPHY OF THE SEDIMENTARY COVER

The nonmetamorphic units unconformably covering the basement rocks in the study area are represented by Göynük Volcaniclastic Olistostrome (latest Cretaceous-Paleogene), Yeşilöz Formation (Paleogene) and Ayhan Member of Mucur Formation (Middle Eocene) which are unconformably covered by Kızılırmak Group of Upper Miocene-Pliocene age and Quaternary sediments.

Göynük Volcaniclastic Olistostrome

In the İdiş Dağı area, on the east and south of Göynük Village there is a blocky Volcaniclastic Olistostrome. This unit is defined as Göynük Formation by Göncüoğlu et al. (1993) because of its type locality and section around Göynük Village which is in the northeast of the study area. The unit is renamed as Göynük Volcaniclastic Olistostrome in this study (Fig. 4).

Göynük Volcaniclastic Olistostrome covers about 7 km^2 in the center of the study area, between Ziyaret and Ötedikme Tepes. Göynük Volcaniclastic Olistostrome can be defined generally as a volcano-sedimentary sequence with blocks of the basement rocks.

Göynük Volcaniclastic Olistostrome starts with massive conglomerates which dip towards south, under the syenitoid body due to the later thrusting (Fig. 5). Towards the north the conglomerates are followed by cross-bedded sandstone and siltstone layers. Beds of elastics are deformed and folded along Mesenin Stream Valley. In this area, there are syenitic and volcanic rocks which are surrounded by a matrix of conglomerate, sandstone, siltstone, and shale. The size of these ellipsoidal shaped blocks varies between 10-50 m.

volcanic block which formed Koydikmeni Tepe is about 2.5 km in length and is placed on top of the southern clastic series. On that block, to the north there are volcanic sandstone layers and smaller volcanic rocks.

The volcaniclastic rocks in the Göynük Volcaniclastic Olistostrome can be characterized as sequences of conglomerate-sandstone-siltstone-shale series. These rocks are composed of volcanic material derived from the underlying vol-

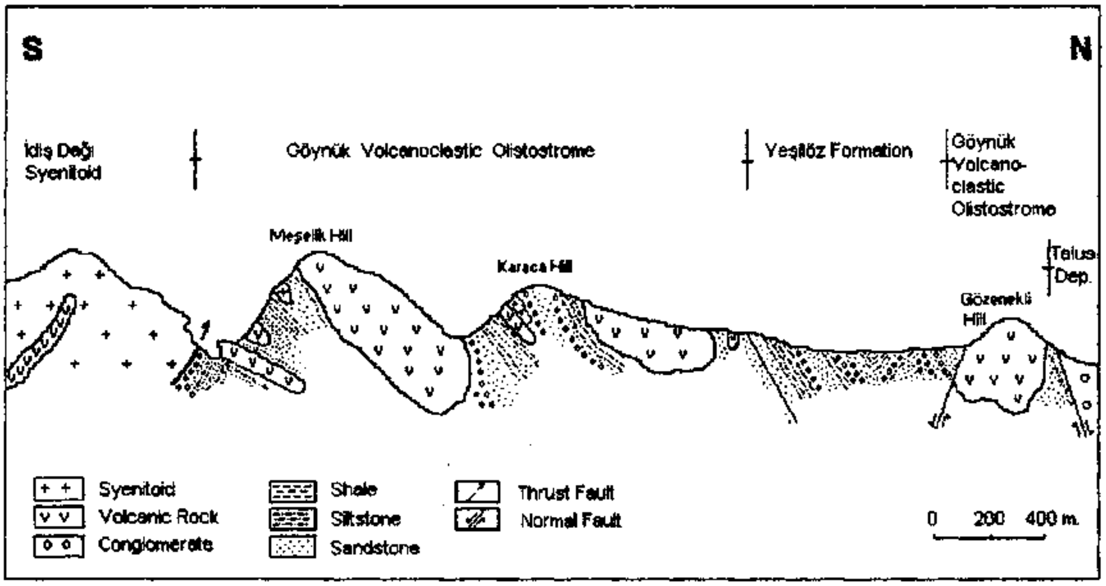


Fig. 5- Simplified cross-section from the study area showing the contact relationships of the Göynük Volcaniclastic Olistostrome.

The sandstones in the lower part of the unit are often violet or violet-gray colored and thin bedded. The conglomerates however, are massive to thick bedded, violet in color and contain rounded to subrounded, volcanic, syenitic and consolidated shale pebbles. The pebbles are generally grain supported and their sizes are up to 15 cm. The large volcanic olistolith on the Meşelik Tepe, is covered at the northern slope of the Meşelik Tepe, by an alternation of conglomerate, sandstone and siltstone. Towards the north, green colored flyschoidal sandstone and siltstones are observed. Another cycle of olistostromes with smaller syenitic and andesitic blocks is emplaced between the green flyschoidal elastics and volcanjclastics. The ellipsoidal shaped

canic blocks. Conglomerates are formed from trachyte, latite, andesite, syenite and chert clasts within a volcanogenic groundmass. In sandstones, siltstones and shales main minerals are K-feldspar, quartz and plagioclase. There are also lesser amounts of biotite, muscovite, chlorite, calcite, opaque and trace amounts of zircon exist.

K-feldspar in volcaniclastic rocks is of sanidine type and highly sericitized and argillized. It is generally represented by large subhedral crystals. Corroded and rounded quartz crystals with anhedral grain boundaries are observed. Biotites are pleochroic from yellowish green to dark green, and reddish brown to dark brown. Chloritization is effective on biotites in some samples. Plagioclases are found as sericitized subhedral grains. On some grains 10° (indicating to a oligoclase composition) and 20° (indicating to an andesine composition) albite twinning angles are determined. Biotite and plagioclase can be detected as small grains in the groundmass in lesser amounts. Calcite is observed in veins and fractures. Zircon is present on some quartz, K-feldspar and plagioclase minerals as tiny inclusions.

There are no fossils observed in volcanosedimentary rocks. At its northern part Göynük Volcaniclastic Olistostrome unconformably overlain by the Yeşilöz Formation. Towards north, a south dipping normal fault juxtaposes Yeşilöz Formation and the Olistostrome. The part of Göynük Volcaniclastic Olistostrome observed at the north of this fault is in the same character with that in southern part. The volcanic block similar to that of Koydikmeni Tepe is observed on the Gözenekli Tepe and smaller blocks of similar lithologies are found on the Gedikkaşı Tepe. On the northern slope of Gözenekli Tepe elastics are dominant. Violet-gray and green sandstone, siltstone and shale layers and trachytic and latitic volcanics are found. On the north of Gözenekli Tepe the formation is cut by a fault which is named as İdiş Dağı Fault by Toprak (1994), after which only talus deposits are observable (Fig. 5).

Göynük Volcaniclastic Olistostrome is thrusted by İdiş Dağı Syenitoids at its southern part, and overlain by Paleocene-Eocene sedimentary rocks at its northern part. The thrusting of Aşıgediği Metamorphics to Paleocene-Eocene sedimentary rocks in the western part of the study area suggests that the Aşıgediği Metamorphics and İdiş Dağı Syenitoids together thrusted to Göynük Volcaniclastic Olistostrome. The thrust fault contact between syenitoids and Olistostrome is well detected in the Meşelik and Kurudere Valleys. Near to these contacts the bottom beds of the Olistostrome are overturned and dip beneath the syenitoid body, and this thrusting caused anticlinal folding at the southern parts of the Göynük Volcaniclastic Olistostrome. There are tear-faults which cut and displaced the thrust fault contact. At the east of the Göynük Village, on the north of Paleocene-Eocene sedimentary rocks, the volcanic rocks and clastic rocks of the Göynük Volcaniclastic Olistostrome are observed again. Thickness of the formation reaches up to 250 m. Clastic, members of Göynük Volcaniclastic Olistostrome suggest a fluvial environment. This formation is defined as underwater canyon deposits by Göncüoğlu et al. (1993).

Göynük Volcaniclastic Olistosrome is assumed to be formed in Upper Cretaceous-Early Paleocene period (Göncüoğlu et al., 4993) based on its similarity to Elmadere Olistostrome which is named and dated as pre-Danian by Göncüoğlu et al. (1991) in the south of Niğde. Lulu (1993) reported similar rocks in tectonic windows to the east of Hırkadağ, a few kilometers to the west of the study area, and described them as Elmadere Formation.

Tertiary Sedimentary Rocks

In the study area, large parts are covered by Tertiary sedimentary rocks. In the central part, on the north of Köydikmeni Tepe, these rocks start unconformably over the Göynük Volcaniclastic Olistostrome while in the western part around Lalelik Tepe, they are found as thrusted directly by the basement rocks. These rocks are defined as Yeşilöz Formation by Göncüoğlu et al. (1993). On the north, there is a fossilliferous limestone patch, which is defined as Mucur Formation by Göncüoğlu et al. (1993). Moreover, in the further northern and southern parts there are rocks defined as Kızılırmak Group. All these three different rock groups are Tertiary in age (Göncüoğlu et al. 1993). The same nomenclature will be used in this study.

Yeşilöz Formation

Yeşilöz Formation is represented by debris or mud flow consisting of volcanic and metamorphic clasts at the lower, and shallow marine and terrestrial rocks at the upper parts. Yeşilöz Formation is named depending on its type locality around Yeşilöz Village (Göncüoğlu et al. 1993), The formation covers about 4-5 km° in the western and central part of the study area.

Yeşilöz Formation is differentiated into two members as Saytepe Conglomerate Member and Asaftepe Member. Saytepe Conglomerate Member can be defined as the thick conglomeratic parts, and Asaftepe Member as the overlying conglomerate, sandstone, siltstone, shale, marl and cherty limestone intercalations in the Yeşilöz Formation.

Saytepe Conglomerate Member

The thick conglomeratic part of the Yeşilöz Formation is named as Saytepe Conglomerate Member (Göncüoğlu et al., 1993, 1994a). Saytepe Conglomerate Member is observed in the middle part of the İdiş Dağı area on the north of Köydikmeni and Karaca Tepe, and also in the western part of the study area on the east of Lalelik Tepe. The base of this formation is observable in the central part of the study area on the Göynük Formation as the conglomeratic level having volcanic and chert clasts. This level comprises interlayers of thin layered dark grayish violet to black colored voleanogenic sandstone and siltstone through the upper parts. Saytepe Conglomerate Member is thicker on the western part of the study area. In that part, beds are nearly vertical and reverse graded because of overturning by the thrusting of İdiş Dağı Syenitoids and Aşıgediği Metamorphics. Marble clasts are observable in conglomerates in that part also. Conglomerates of the Saytepe Conglomerate Member are poorly sorted and rounded to subrounded, ranging from small (1 cm) to large (up to 20-30 cm) in size, Matrix is formed by alteration of dominating voleanogenic clasts violet to violet-red in color. Sandstones and siltstones are also volcanic in origin and reflect the same colors with the conglomerates.

Saytepe Conglomerate Member conformably overlies the Göynük Volcaniclastic Olistostrome and conformably overlain by the Asaftepe Member of the Yeşilöz Formation. The thickness of the Saytepe Conglomerate Member in the study area is about 20 m. Features of the member suggest that Saytepe Conglomerate Member is formed as debris flow, and the clasts are from the underlying formations abundantly from the Karıhıdır Volcanics.

Asaftepe Member

The conglomerate-sandstone-siltstone-shale^ marl intercalations with cherty limestone interlayers overlay the Saytepe Conglomerate Member in the study area. This unit is defined as the Asaftepe Member of the Yeşilöz Formation by Göncüoğlu et al. (1993).

In the central part of study area, Asaftepe Member starts with thin layered green-gray colored voleanogenic sandstone. It contains conglomeratic interlayers which contains clasts up to 30 cm in size. After a thin conglomeratic level, violet-gray colored conglomerate-sandstone- siltstone and shale intercalations start. More than five repetitions of these intercalations are detected. In most of them, transitional levels as conglomeratic sandstone, sandy siltstone and shale are abundant. Lithic tuff layers are present in few parts. The unit is generally thin layered, but in some parts thick layers (up to 20 cm) exist. Through the upper levels green-gray colored sandstone- siltstone layers are observable. Conglomerates are formed from subrounded volcanic clasts supported by a fine grained sandy to silty matrix. Cross-bedding is observable on sandstone layers. Small scale faulting and folding exist in beds of Asaftepe Member. Slickensides, calcite veins and mud cracks are observed on these beds. Recumbent foids and small scale slumps are detected in Asaftepe Member.

In the western part of the study area around Lalelik Tepe, beds of Asaftepe Member are observable over the conglomeratic sandstone layers of Saytepe Conglomerate Member. Thick bedded (about 20 cm) violet siltstone with thin fissile shale interlayers are the first observable beds of Asaftepe Member in that part. There are gray, algea-bearing clayey limestone lenses of few meters in size within these beds. On top of these beds, brownish shale, green siltstone-marl and violet siltstone layers exist alternatively. There are lenses of pink-gray colored algeal limestone with chert bands. These lenses reach up to 30 meters in thickness and are conformable with underlying and overlying beds. Overlying beds are gray colored, thick bedded (about 30 cm) sandstone and violet colored conglomeratic sandstone. Conglomerates are unsorted and from mm size to 15 cm in diameter. Conglomerates are mainly volcanic in character.

In the northwestern part of the study area, in the Kireçlik Valley pinkish sandstone-siltstone and pink-gray clayey limestone beds are observed. These beds belong to Asaftepe Member and represent the upper parts of this member in the study area. On the Lalelik Tepe, on top of the rocks of Asaftepe Member there are klippen of marbles of Aşıgediği Metamorphics (Fig. 6). Intensive brecciation and slickensides and are detected on siltstone beds of Asaftepe Member formed during the overthrusting of the basement rocks onto the Yeşilöz Formation. Along the contacts of the klippen with the elastics of the Asaftepe Member, the underlying sandstones are squeezed and crushed, and the pebbles of the conglomerates are polished and broken.

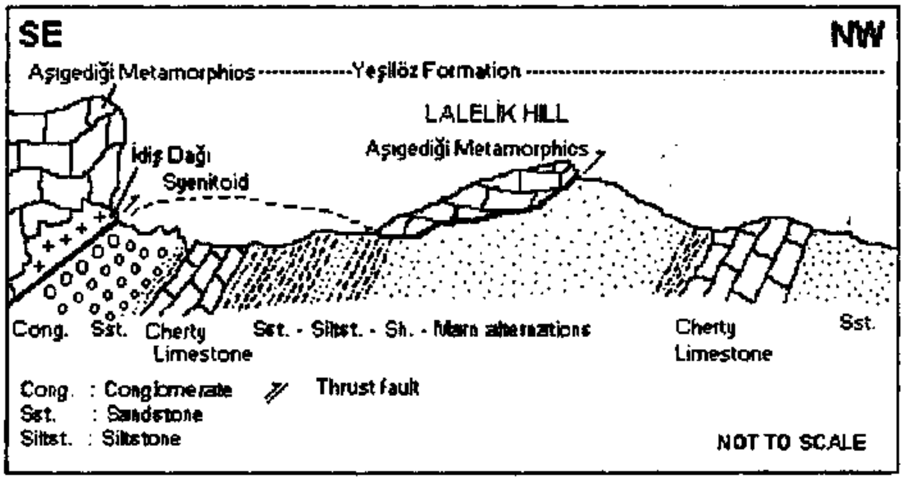


Fig. 6- The structural relationships of Yeşilöz formation and the basement rocks in the NW of the study area.

Detailed petrographical work carried out on the sandstones, siltstones and shales of this unit shows that the rocks fragments are composed mainly of Karahichr Volcanics with some clasts of ophiolithic rocks. The main minerals in these rocks are K-feldspar and quartz. There are also lesser amounts of biotite, muscovite, plagioclase, chlorite, calcite, epidote and opaque and trace amounts of zircon and apatite exist. In fine grained samples the same mineralogical composition but turbiditic character is determined. In lithic tuffs, grains are somewhat larger, but matrix is almost unrecognizable. K-feldspar, plagioclase, quartz, biotite and opaques are observed in lithic tuffs. Chlorite is the secondary mineral in lithic tuffs.

No microfossils are recognized in these rocks.

The thickness of the Asaftepe Member in the study area is determined approximately as 150 m. Asaftepe Member represents the lacustine to shallow marine rocks deposited in a basin of which filled by the fluvial Saytepe Conglomerate at the lower levels.

The depositional age of Asaftepe Member is accepted as Late Lower Paleocene- Early Upper Paleocene, depending on its lithologic similarities and stratigraphic position with the fossiliferous (Algea and Ataxophragmidae; det: E. Sirel in: Göncüoğlu et al., 1991) Karataş Limestone Member of Eskiburç Formation to the south of the study area.

Mucur Formation

In the İdiş Dağı area, on the north of Dalak Tepe there are massive limestones which contain Alveolines and Nummulites fossils. On the west of study area around Ayhan village, the units with the same character are defined as Ayhan Member of Mucur Formation by Göncüoğlu et al. (1993).

Mucur Formation uncorformably overlies Yeşilöz Formation, and transgressivly covers the basement rocks of the Central Anatolian Crystalline Complex. Mucur Formation is Early-Middle Eocene in age, and consists of four members: Göbekli Conglomerate Member (shallow marine), Ayhan Limestone Member (reefal), Sanlar Flysch Member (deep marine) and Keklicek Limestone (shallow marine-lacustrine) (Göncüoğlu et al., 1993).

Limestones of Ayhan Member in the study area are clayey, white gray in color, brittle and having macrofossils of 1.5-2 cm in diameter. Fusiform and cylindrical Nummulites and Alveolina fossils are recognizible. In the fossiliferous limestones of the Mucur Formation, *Alveolina* sp. and *Nummulites* sp. fossils are dominant. There are also *Assilina* sp. fossils observed in these rocks. There are pellets and peloids observed in fine-medium grained matrix which is fonned from calcite. These limestones can be classified as bio-pelsparite.

Ayhan Member is unconformably overlain by the rocks of Kızılırmak Group. The thickness of the member is about 30 m in the study area.

By the paleontological works, the age of Ayhan Member is found as Middle Eocene (Lutetian) (Göncüoğlu et al., 1993). It can be compared with the Lutetian aged Boztepe Member of Altınpınar Formation of Atabey et al, (1988).

Kızılırmak Group

The younger terrestrial units unconformably covering the Paleogene sediments in the study area are named as Kızılırmak Group and defined as Mio-Pliocene in age (Göncüoğlu et al., 1993).

Although the units of Kızılırmak Group are concurrent, the differences in depositional environment give way to distinguishing of different formations which are transitional laterally. Two of these formations are observable in the Avanos area: Ürgüp and Asarcık Formations. (Pasquare, 1968; Göncüoğlu et al., 1993, Toprak, 1994).

Ürgüp Formation

The volcano-sedimentary deposits on the southern side of İdiş Dağı belong to the Ürgüp Formation, which is named by Pasquare (1968). These are formed from several pyroclastic levels intercalated with sandstone and claystone bearing, tuffaceous fluvial-lacustrine sediments. Intercalations of cross bedded sandstone, thin bedded siltstone, laminated claystone and marl are detected in the Ürgüp Formation. The sediments are generally gray in color, but in some parts reddish sandstone-siltstone-claystone alternations transitional with grayish sandtone-siltstone- clay stone-marl alternations, are observed.

Temel (1992), worked in the region which is on the south of the İdiş Dağı Area. He differentiated the Kavak, Zelve and Çökek Members of the Ürgüp Formation along the southern bank of the Kızılırmak River. The continuation of these members are observed in the study area. Kavak Member is observed in the southwestern, Zelve Member is observed in the southern and Çökek is observed in the southeastern part. Kavak and Zelve Members are ignimbritic in character, and Çökek Member is formed from intercalation of clayey-carbonaceous units and tuffites.

The bottom part of Ürgüp Formation is not observed in the study area, but the contact along the Salanda Fault (Toprak, 1994) with İdiş Dağı Syenitoids is present in the eastern parts. Salanda Fault is generally east-west elongated, and dip of the fault plane changes from 58°-84° S. The other faults in the İdiş Dağı area, are synthetic or antithetic with the Salanda Fault. Ürgüp Formation is unconformably overlain by the Karataş Volcanics, river terraces, alluviums and talus deposits. Its thickness is about 120 m in the study area.

Ürgüp Formation is deposited in a basin bounded by the Central Kızılırmak Fault Zone (especially Salanda Fault) at the north. The depositional environments are fluvial and lacustrine. According to radiometric age datings (Innocenti et al., 1975), Ürgüp Formation is 10 ± 3 ma (Late Miocene-Pliocene) in age.

Asarcık Formation

Asarcık Formation (Göncüoğlu et al., 1993, Toprak, 1994), covers large areas on the northern part of the study area. It consists of pyroclastic and epiclastic levels. The thick tuffaceous layers are the most characteristic features in Asarcık Formation. Also white-gray colored, medium- fine grained sandstone and conglomerate levels are observed.

In the Avanos area, Asarcık Formation unconformably overlies the units of Eocene and older age. There are restricted outcrops of tuffs of Asarcık Formation in the central part of the study area. Asarcık Formation is unconformably covered by Quaternary river terraces, alluviums and talus deposits. Its thickness in the area is about 70 m.

Asarcık Formation represents the lacustrine and fluvial environments. It is accepted as concurrent with Ürgüp Formation (Upper Miocene-Pliocene in age) by comparison of some tuff layers with the Ürgüp Formation (Göncüoğlu et al., 1993).

Quaternary Units

The units unconformably overlying the Mio-Pliocene and older units in the study area are defined as Quaternary Cover Units. These are basalts of Karataş Volcanics, travertines formed in the vicinity of active faults, terraces near Kızılırmak River, alluviums and talus deposits.

Karataş Volcanics

The basaltic lavas in the southeast of the idis Dağı area are named as Karataş Volcanics (Göncüoğlu et al., 1993).

The basalts of the Karataş Volcanics cover 2.5-3 km^2 in the study area. They are brownish black in color. These are hard and massive basalts with cooling joints.

On the hand specimen, large plagioclase, pyroxene and amphibole minerals are seen. Trachytic texture is also observable. These volcanic rocks are named as olivine basalt according to their mineralogical composition. These rocks are composed of plagioclase, clinopyroxene, hornblend, olivine and opaque minerals. Plagioclase is the dominant mineral in the olivine basalt of Karataş Volcanics. Plagioclases occur both as phenocrystals and as small grains. They generally exhibit euhedral crystal outlines and typical polysynthetic twinning. The maximum extinction angle in albite twins varies between 44° to 53°, representing bytownite and anorthite composition. Clinopyroxene occurs as subhedral crystals green in color. Clinopyroxenes reflect oblique extinction with about 27 suggesting a pigeonite type. Amphiboles occur as smaller crystals and are generally green in color. Epidotes are secondary minerals, found as small grains as amphiboles. Olivines are observed as subhedral to anhedral crystals and are replaced and surrounded by yellowish green iddingsite.

The basalts of the Karataş Volcanics unconformably and horizontally overlay the ignimbrites of the Ürgüp Formation. Thickness of the Karataş Volcanics reaches up to 10 m in some parts of the study area. The Karataş Volcanics reflects similar characteristics with the Kızıldağ Basalts of Atabey etal. (1988).

Travertines

In the Avanos area, especially along the Central Kızılırmak Fault Zone and along small scale active faults cogenetfc with the Central Kızılırmak Fault Zone, there are large travertine occurences (Göncüoğlu et al., 1993, Toprak, 1994).

GEOLOGICAL EVOLUTION OF AVANOS-İDİŞ DAĞIAREA

The İdiş Dağı-Avanos area represents the main geological characteristics of CACC with its complexity in petrographidal, mineralogical and structural features.

In the study area, the basement rocks are the Aşıgediği Metamorphics which belong to Central Anatolian Metamorphic Rocks, and granitoids and İdiş Dağı Syenitoids which belong to Central Anatolian Plutonic Rocks.

The Aşıgediği Metamorphics is found as an incomplete sequence. The massive marbles, are the parts of the metacarbonates of the Aşıgediği Metamorphics, and represent the platform type carbonates of Mesozoic age according to Göncüoğlu (1977) and Göncüoğlu et al (1993).

In the İdiş Dağı Area, the Aşıgediği Metamorphics are roof pendant on the plutonic rocks and also intruded by them. The plutonic rocks are generally named as Central Anatolian Plutonic Rocks, and differentiated into the granitoids and İdiş Dağı Syenitoids. Granitoids are the pegmatite and aplitic granites, and are found as intrusions in the Aşıgediği Metamorphics.

The formation of the Göynük Volcaniclastic Olistostrome is very probably related to a fault-controlled basin formed during Late Maastrichtian-Early Paleocene. In the Göynük Volcaniclastic

Olistostrome, large blocks of İdiş Dağı Syenitoids and Karahıdır Volcanics are observed. These blocks might have been broken away from the sides of the basin by the tensional faults during the basen formation. At the edges of these blocks the effects of the cataclastic deformation and relict parts of the trachytic-latitic volcanics are observable.

In the study area, Göynük Volcaniclastic Olistostrome is unconformably covered by the Yeşilöz Formation which represents the late Lower Paleocene-Upper Paleocene period. The Yeşilöz Formation is overthrusted by the basement units in the western part of the area. Areal distribution, contact relations and field characteristics suggest that the basement rocks were originally covered transgressively by Yeşilöz Formation which reflects fluvial deposition in its lower part and lacustrine depositional environment. The dominance of alluvial fan-apron type elastics and turbidites in Yeşilöz Formation indicates to a continental deposition in a technically subsiding intra-mountain basin.

The Ayhan Member of the Mucur Formation characterizes the Middle Eocene period in the study area. The limestone in, this member is reefal in character, but the contact relationship with older units could not be detected. However, in other,parts of CACC, Mucur Formation is observed to overly the Yeşilöz Formation with an angular unconformity (Fig. 3).

According to Göncüoğlu et al. (1993, 1994a, 1994b), in the Middle Eocene period, a compressional regime was effective in the Central Kızılırmak Basin which is just to the north of the study area. According to them, in this period transgression occurred and a new northward dipping basin was formed. Olistostromes and huge basement olistoliths placed from south into this basin in which deep turbidites were deposited. Since the deposits containing these olistoliths are Middle Eocene in age, this event must have been occurred in Middle Eocene. The south-north directed compression was continued during Early Miocene period, and asymmetric basins filled by Gümüşyazı Group were formed in the region (Göncüoğlu et al. 1993,1994a,1994b; Akgün at al., 1995) The rocks, of this period are not observed in the İdiş Dağı area.

The thrusting of the Aşıgediği Metamorphics together with the İdiş Dağı Syenitoids to the Tertiary Cover Units in the mapped area, is probably related to the terminal period of this compressional regime. Along the thrust contact, rocks are cataclastically deformed. The klippen of the marbles of the Aşıgediği Metamorphics on the Eocene Units in the western part of the study area is a result of this compression. The overturned basal units of the Göynük Volcaniclastic Olistostrome in Meşeliğin Dere as well as the folds observed in the Göynük Volcaniclastic Olistostrome and Yeşilöz Formation show that the compression is directed from south to north. Regarding the position of the klippen in Lalelik Tepe, the amount of the basement thrusting is at least 350 meters.

In the study area, in the Upper Miocene, the neotectonic period started. The rocks of the Kızılırmak Group (Ürgüp and Asarcık Formations in the study area) were deposited within the basins developed by the west-east trending grabens unconformably over the folded and deformed older units. The faults forming that horst-graben system are oblique in character and belong to Central Kızılırmak Fault Zone (Dirik and Göncüoğlu, 199S). The extrusion of the Karataş Volcanics is very probably related to the main fault of this fault system. Some of the splays of the fault zone are covered by the Plio-Quaternary rocks in the study area.

The presence of active travertine occurences shows that the faults of the Central Kızılırmak Fault Zone are still active. Quaternary age talus deposits and alluvial fans were also formed due to these faults.

CONCLUSIONS

İdiş Dağı-Avanos region is a critical area to study the characteristics of the Tertiary cover units and their relationship to the basement rocks of the Central Anatolian Crystalline Complex.

The basement rocks in the study area consist of Aşıgediği Metamorphics constituting the upper part of the Central Anatolian Metamorpics which is intruded by granitoids, İdis Dağı Siyenitoids and Karahıdır Volcanics of the Central Anatolian Plutonics, respectively.

The basement units are unconformably overlain by Göynük Volcaniclastic Olistostrome which consists of olistostromes with basement blocks of variing size. It is suggested that this unit has been deposited during Late Maastrichtian-Early Paleocene period in one of the numerous fault- controlled extansional basins in central Anatolia (Göncüoğlu et al., 19936, 1994a, 1994b, 1995b), indicating that the region was effected by tansional or trans-tansional regime. The presence of late- stage monzonitic-syenitic products of the Uppper Cretaceos Central Anatolian Plutonism with obvious geochemical fingerprints of a tectonic setting related to post-collisional extension (Göncüoğlu et al., 1994a, 1995a, Erler and Göncüoğlu, 1995).is a further support for our suggestion.

Alluvial fan-apron-type elastics and turbidites of the late Lower Paleocene-Upper Paleocene Yeşilöz Formation indicate to continental deposition on a regionally uplifting basement. Ayhan Member of the Middle Eocene Mucur Formation is represented by reefal limestones. This member transgressively overlies all the preexisting units and indicates to a transition from continental to marine depositional environment.

The İdiş Dağı basement rocks are thrusted at the end of Middle Miocene onto the Tertiary sediments which is ascribed to the compressional tectonics in the study arae that started already during Middle Eocene and reached its peak in late Middle Miocene. The overthrusting in the Avanos area is directed from south to north where the Aşıgediği Metamorphics are transported as a thrust-sheet at least 350 ms onto the Yeşilöz Formation.

Rock units of the Upper Miocene-Pliocene Kızılırmak Group unconformably cover the thrust contacts and have been deposited in small, east-west trending graben-type fluvio-lacustrine basins. The fault system generating the grabens and the İdiş Dağı horst is part of the Central Kızılırmak Fault Zone of Toprak (1994). The main fault to the south of İdiş Dağı is still active and is related to the extrusion of Quaternary Karataş Volcanics.

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ENVIRONMENTAL INTERPRETATION OF THE OSTRACODA FAUNA FROM THE UPPER MIOCENE-PLIOCENE SEQUENCE IN THE KARAMAN REGION

Ümit Şafak**

ABSTRACT.- In this study the ostracoda fauna of the Upper Miocene-Pliocene sedimentary units have been considered aspects. According to ostracoda fauna-the Neogene sequence of the region has been deposited in different environments ranging gradually from shallow marine through littoral and Lagoon to lacustrine within short intervals resulting from continuous lowering of the sea-level.

INTERPRETATION OF THE NEW RADIOMETRIC AGE DETERMINATIONS FROM THE TERTIARY AND QUATERNARY VOLCANIC ROCKS IN WESTERN ANATOLIA.

Tuncay ERCAN*; Muharrem SATIR" Dilek SEViN*** and Ahmet TÜRKECAN*

ABSTRACT: In order to evaluate the extensive problems concerning the age of the Tettiary to Quaternary volcanic rocks exposed in the Western Anatolia, 17 samples were collected and aated in terms of K/Ar and Rb/Sr dating methods and new geochemical data that would contribute towards the understanding of the volcanism in a regional context have been obtained. The oldest age measured is of 18,0±0,2 Ma and belongs to the Selendi volcanics of calcalkaline andesites whereas the youngest age is of 100.000 - 200.000 B.P. and is obtained from alkaline basaltic type Kula volcanics.

STRATIGRAPHY OF THE TECTONOSTRATIGRAPHIC UNITS AROUND HADIM-BOZKIR-TAŞKENT REGION (NORTHERN PART OF THE CENTRAL TAURIDES, TURKEY)

Necdet ÖZGÜL****

ABSTRACT.- The region studied shows the typical geological features of the Central Taurides and includes several tectonic units with distinctive stratigraphic, structural and metamorphic feature. These units are from base upward the Geyik Dağı, Aladağ, Bolkar dağı and Bozkır units. The Geyik Dağı Unit, which lies tectonically at the base of all the other units, and hence forms relative autochthonous, is constituted of Lower Paleozoc carbonate and clastic rocks, Upper Mesozoic-Lower Tertiary shelf type carbonate and an olistostromal flysch of Lutetian age. The Aladağ and Bolkar Dağı units comprise Upper Devonian-Upper Cretaceous carbonates and clastic rocks and Senonian olistostromal flysch. Although these two units have some apparent similarities, they also exhibit distinct differences in the stratigraphy, lithology and depositional environment. Both the Aladağ and Bolkar Dağı units form flat-lying nappes over the Lutetian flysch of the Geyik Dağı unit. The Bozkır Unit is a large-melange constituted of blocks and slices of Triassic-Cretaceous basinal, continental margin and minor platform deposits, basic submarine volcanic rocks, diabase, serpentinite etc. It includes blocks of a single lithology as large tectonic slices made up of several rock-stratigraphic units reflecting basinal deposition over an extensive period. It is believed that during the Late Maastrichtian- Illerdian (Late Paleocene-Early Eocene) a narrow oceanic basin, represented by the Dipsiz G6l Ophiolitic Melange of ophiolite cherty pelagic limestone with basic volcanic intercalations and calsiturbidites, existed between the Geyik dağı and Aladağ units. Dipsiz G6l Ophiolitic Melange occurs as tectonic slices of various thicknesses above the chaotic Lutetian flysch of the Geyik dağı unit and above the allochthonous Aladağ and Bolkar dağı units. A palinspastic reconstruction for the Early Triassic-Senonian period, based on the tectonic and stratigraphic relations between the different units, would place the Geyik dağı Unit in the south and Aladağ, Bolkar Dağı and Bozkır units gradually northward. Such a reconstruction would range from a platform in the south to an oceanic basin in the north. Following the closure of this oceanic basin during the Late Senonian, which may be called as the North Tethyan Ocean, the Bozkır Unit internally sliced and was emplaced over the Bolkar Dağı units was closed during the Lutetian. Following this closure, the Bolkar Dağı and Aladağ units with their tectonic cover of the Bozkır unit were emplaced over the Geyik Dağı unit.