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STRATIGRAPHY AND TECTONIC EVOLUTION OF THE NORTHERN MARGIN OF THE MENDERES MASSIF

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Four main tectonic belts are outlined in the Western Anatolia. These are the Sakarya Continent, Karaburun Belt, Izmir Ankara Zone and the Menderes Massif.

The Sakarya Continent consists of the Triassic Karakaya complex overlain unconformably by a Jurassic-Cretaceous carbonate succession. The Izmir-Ankara Zone is represented by an ophiolitic melange near Akhisar and the Bornova melange around İzmir. From the matrix of the Akhisar melange Lower Cretaceous age have been obtained but it is considered that its age goes as back as to the Upper Triassic. The matrix of the Bornova melange yields ages of Maastrichtian and Danian. The ophiolitic melange of Akhisar region and the Bornova melange of the Izmir area, merge into each other and were formed by a continious process in the İzmir-Ankara Zone.

The Karaburun Belt is underlain by a continious Mesozoic Succession. The oldest unit of this belt is the Carboniferous Alandere formation of shallow marine limestones. It is overlain by a very thick detrital Triassic unit consisting of mudstones, sandstones, black cherts and mafic volcanic lenses. The Lower Triassic detrital unit is more than 2 km thick and overlain gradationally by a continious platformal Carbonates of the Upper Triassic to Upper Cretaceous age. On top of the Karaburun succession a flysch unit of Maastrichtian age was deposited.

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The Menderes Massif in the Western Anatolia consists of regionally metamorphosed rocks. In the Selçuk-Bayındır region, the lowermost unit is composed of micaschists, named as the Bayındır formation. The Bayındır schists are overlain gradationally by marbles called as the Kayaaltı formation. The Kayaaltı formation is dominantly characterized by marbles and schist intercalations in its lower sections, whereas, the upper parts of the unit are represented by emery-bearing massive marbles. The marbles and schists intercalation have yielded a poorly-preservated coral fossil of Triassic or Jurassic age. In the uppermost parts of the massive marbles, rudist fragments are found. Thus, the age of the Kayaaltı formation is probably Late Triassic to Late Cretaceous. On top of the Kayaaltı marbles, there is a conformable micaschist unit with mafic metavolcanic and metatuff lenses. This unit, which is called the Selçuk formation, contains blocks of emery-bearing marbles and metaserpentinites. On top of Menderes metamorphics rests along a thrust fault, the nonmetamorphic Bornova melange.

In the Akhisar region, the stratigraphy starts again with thick micaschists of the Bayındır formation. In upper parts of the Bayındır schists, there is a thin lense of mafic metavolcanics and metaserpentinites which were probably formed by submarine volcanic eruptions. The Bayındır schists grade upward into marbles of Kayaaltı formation, the lower parts of which, yield fossils of Late Triassic and Jurassic age. The uppermost part of the Kayaaltı formation contains rudist fragments and farther up in the section, pelagic limestones with planktonic foraminifera are found. They yield an age of Late Campanian. The pelagic limestones are overlain by The Hasköy formation composed of sandstones, mudstones and lenses of limestones. The ophiolitic melange of the İzmir-Ankara Zone, overlies different units of Menderes metamorphics along a low-angle thrust fault.

Stratigraphy of Menderes metamorphics shows similarity to that of the Karaburun Belt. The micaschists and the mafic volcanics of the Bayındır formation might be equivalent of Lower Triassic detrital and mafic volcanic rocks of the Karaburun Belt. In both, the Karaburun and the Menderes sections, the detrital units are overlain conformably and gradationally by a thick platform-type carbonate successions. In both of the belts, also, the Campanian-Maastrichtian sections are in pelagic facies and they pass upward into flysch-type detrital assemblages.

The resemblance of the Karaburun and Menderes platforms suggests that they were once connected. To the north of this intact platform, the İzmir-Ankara Zone was probably opened in the Late Triassic. During Maastrichtian the Karaburun Belt was separated from Menderes platform

by a subordinate opening. After Danian, the İzmir-Ankara Zone started to close rapidly, and in the final period of the closing the Sakarya Continent collided with Menderes Massif and the melange unit were thrust over its northern edge.

INTRODUCTION

In the western Anatolia four main structural belts are defined (Fig. 1). These are the Sakarya Continent located in the northwest the İzmir-Ankara Zone and the Karaburun Belt in the middle, and Menderes Massif in the east.

The Sakarya Continent is underlain by the Lower Triassic Karakaya complex, which is composed of detrital rocks and mafic volcanics, which contains blocks of Permian limestones. This blocky unit is unconformably overlain by a carbonate succession of Jurassic to Upper Cretaceous age.

The İzmir-Ankara Zone is represented by tectonic melanges of ophiolitic rocks and flysch-type sediments. Near Manisa, this zone splits into two segments. One segment extends southward seperating the Karaburun belt from Menderes Massif, and the second segment passes to the north of Karaburun Peninsula and runs in the east-west direction (Fig. 1).

The Karaburun tectonic belt is surrounded from all sides with the melanges of the Izmir-Ankara Zone. In this belt a very-thick and continuous platformal carbonate succession of the Mesozoic age crops out, and along the whole stratigraphic section, presence of fossil-rich zones enable to date the whole succession (Erdoğan, 1990; Erdoğan et al., 1991).

To the east and southeast of the İzmir-Ankara Zone, the Menderes Massif underlies an extensive area in the Western Anatolia, and it is represented by regionally metamorphosed micaschist and marbles (Boray et al., 1975; Çağlayan, et al., 1980 ; Dürr, 1975 ; Dürr, et al., 1978).

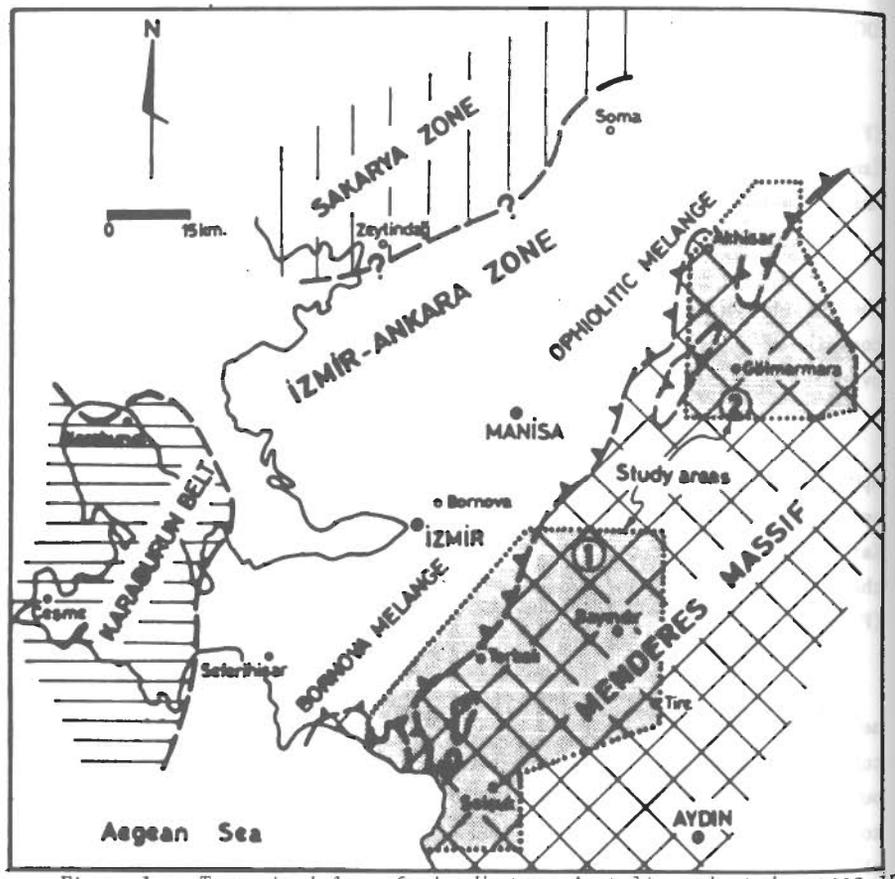

Figure 1 : Tectonic belts of the Western Anatolia and study areas in the Menderes Massif. 1- Selçuk-Bayındır area, 2- Akhisar area.

In the following sections first, the stratigraphy of the Karaburun Belt and the İzmir - Ankara Zone will be summarized. Second, the stratigraphy of the northern edge of the Menderes Massif will be presented in two areas (Fig. 1). The Selçuk-Bayındır areas is located in the south, and the Akhisar area in the north of the Western Anatolia. In the final part of the paper, stratigraphic correlation between the Karaburun and the Menderes platforms will be discussed and the tectonic evolution of the region will be evaluated.

STRATIGRAPHY OF THE KARABURUN BELT

In the Karaburun Peninsula, more than 4 km thick sedimentary rock succession with an age range of the Lower Carboniferous up to the Maastrichtian crops out (Fig. 2). In the tectonic and stratigraphic synthesis of the Western Anatolia, the stratigraphy of Karaburun Peninsula has a pronounced importance, because the equivalent units are metamorphic and poor in fossils in the nearby Menderes platform.

The oldest unit of the Karaburun succession is the Lower-Middle Carboniferous Alandere formation (Fig. 2), which is represented by fossilliferous neritic limestones. Upper Carboniferous and Permian sections are missing and the Lower Triassic units directly overlay the Alandere formation (Erdoğan et al., 1991). The Lower Triassic units are included in the Denizgiren group composed of the Gerence and Karareis formations. The Gerence formation is limestone-rich and the Karareis detrital-rich units that grade each other laterally and yield ages from the Scythian to the Upper Anisian (Erdoğan et al., 1991). The Karareis formation is more than 2 km thick and composed dominantly of graywackes and mudstones with subordinate amount of black cherts, pelagic limestones and blocks of older limestones. In the upper part of the Karareis formation mafic volcanic interlayers are found. Above the Lower Triassic Units, along a gradational boundary, there is thick neritic carbonate succession. This platform-type carbonates form a stratigraphically uninterrupted section from the Ladinian to the Maastrichtian. In the uppermost part of the succession, bauxite lenses are found, that are overlain, by rudist-bearing limestones. In the

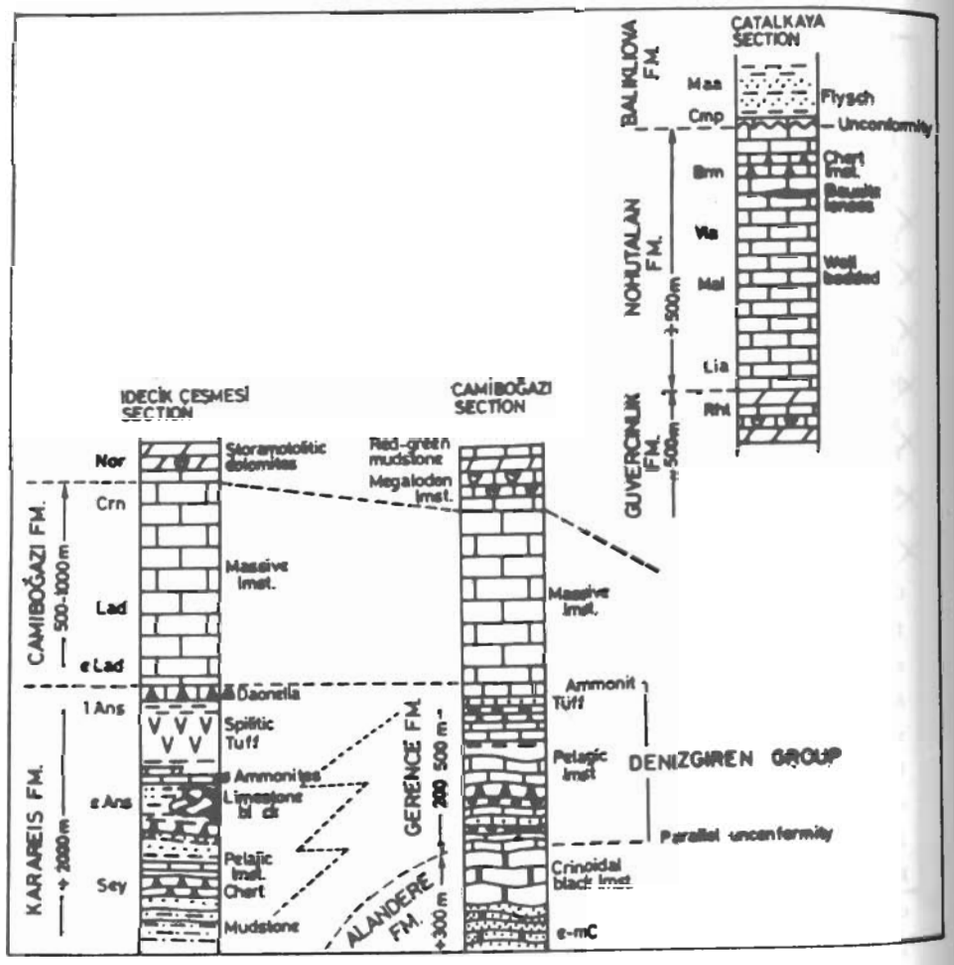

Figure 2 : Generalized stratigraphic section of the Karaburun belt (Erdogan et al. 1991). Thickness of the units are also shown.

uppermost part of the Karaburun Section, pelagic limestones overlain by the flysch-type detrital sediments of the Maastrichtian age are present (Fig. 2).

STRATIGRAPHY OF THE IZMIR-ANKARA ZONE

The Izmir-Ankara Zone is characterized by tectonic melanges in the Western Anatolia, which are separated into two units based on dominant lithology, internal structures and upper and lower age limits of their matrix (Fig. 1) (Erdoğan, 1991).

The Bornova melange is composed of a matrix of flyschoidal sedimentary rocks and mafic volcanics with an age range of Maastrichtian to Danian (Erdoğan, 1991). Incorporated into the matrix as blocks of up to 20 km in length, are neritic limestones which represent broken parts of the Karaburun succession. The Bornova melange is strongly sheared and the internal sedimentary boundaries of its matrix are completely destroyed by brittle deformation. The Bornova melange, crops out between Manisa and Seferihisar (Fig. 1).

In the north, near Akhisar area (Fig. 1) there is an ophiolitic melange composed of ophiolite, radiolarite and pelagic limestone slices. In the Akhisar ophiolitic melange unit, slices of oceanic crustal material are predominant and the lower age limit of the pelagic matrix of this melange is relatively older namely Aptian to Albian. Both melange units merge gradually into each other and were pushed over the Menderes metamorphics along low-angle thrust faults (Fig. 3,5).

STRATIGRAPHY OF THE MENDERES MASSIF

In the Selçuk-Bayındır area, micaschists of more than 2 km in thickness called here as the Bayındır formation, constitute the lower part of the stratigraphy (Fig. 3,4). The Bayındır formation is composed mainly of biotite-muscovite-quartz schists, rare marble lenses and subordinate amounts mafic metavolcanic interlayers. The micaschists are overlain with a gradational boundary by a thick marble unit called the Kayaaltı formation. These two formations grade also laterally into each other

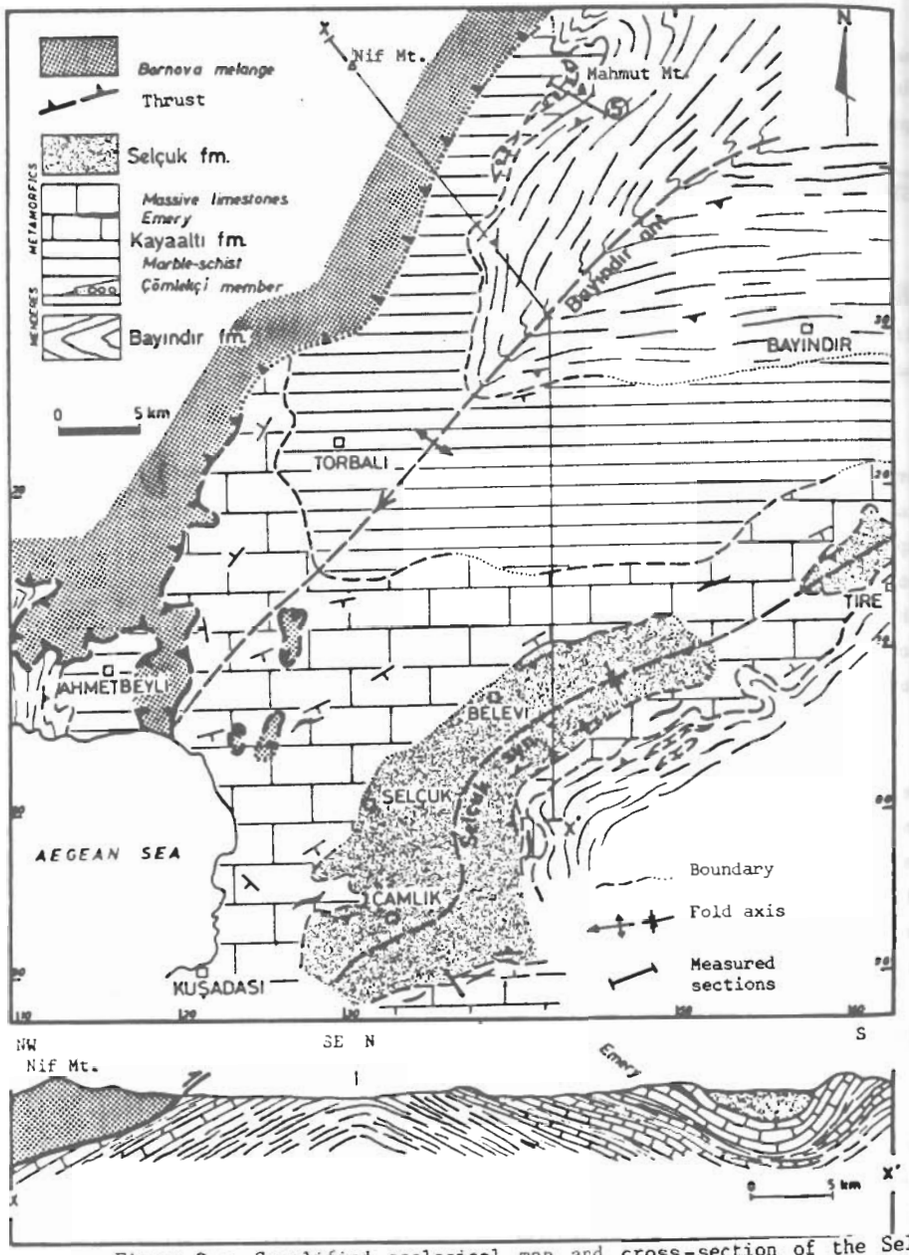

Figure 3 : Symplified geological map and cross-section of the Selçuk-Bayındır area.

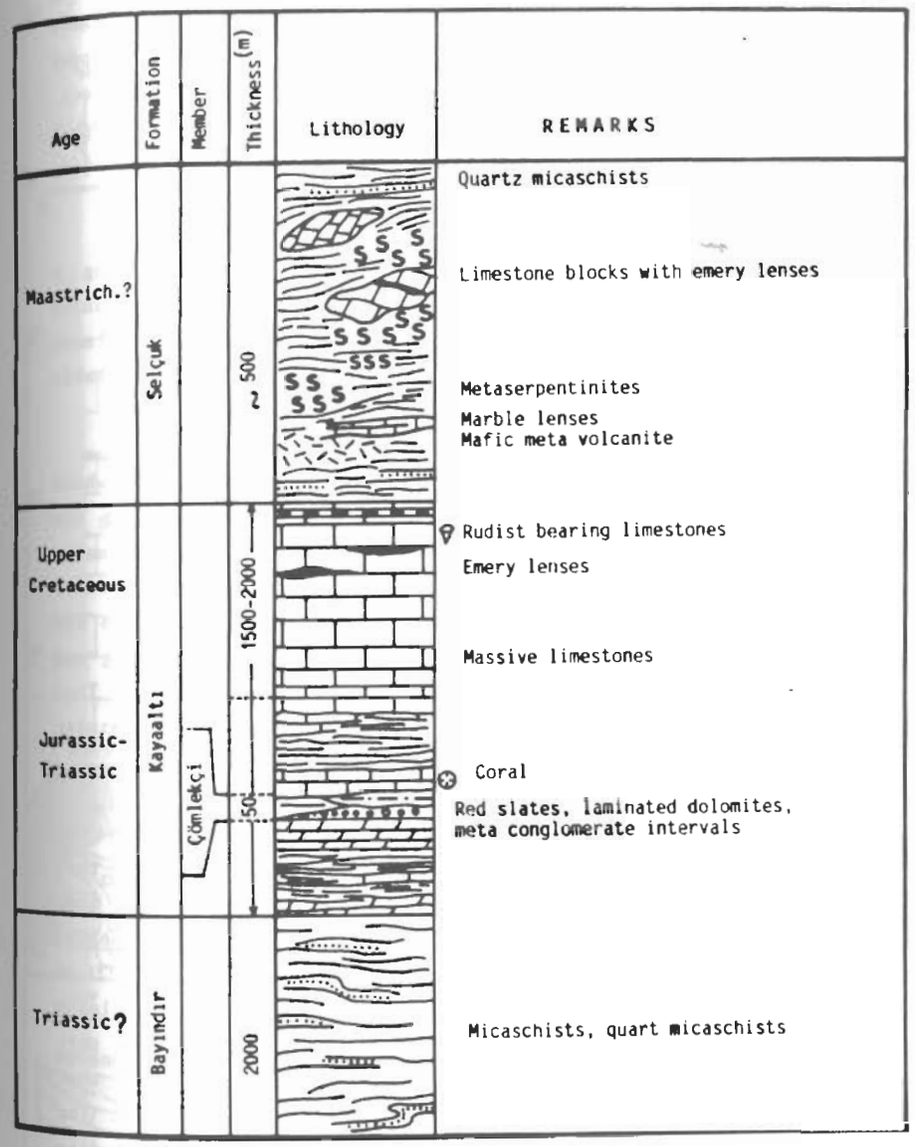

Figure 4 : Generalized stratigraphic section of the Menderes metamorphics in the Selçuk-Bayındır area.

as their map pattern suggests (Fig. 3). In the lower levels of the marbles, a poorly-preservated coral fossil of Upper Triassic-Jurassic age is found. The Kayaaltı formation contains emery lenses in the upper parts, above which, massive limestones with rudist fragments crop out. Thus, the age of this unit is probably Upper Triassic to Upper Cretacesus. The underlying Bayındır schists is presumably Lower-Middle Triassic in age.

The Selçuk formation overlays the Kayaaltı formation along a gradational boundary and is composed of micaschists, mafic metavolcanics and blocks of metaserpentinite and marble (Fig. 4). It is the uppermost unit of the Menderes metamorphics in this area and its age is probably Maastrichtian and younger.

The Second area studied is the Akhisar region (Fig. 1, 5, 6), where the Menderes metamorphics start again with thick micaschists of the Bayındır formation. In the upper part of this unit, lenses of mafic metavolcanics and metaserpentinites with ophicalcite layers are found. These mafic lenses are confined to certain stratigraphic horizons and in all scales they passes through metatuff zones into underlaying and overlaying schists and laminated marble-schist intercalations. They are certainly formed by submarine volcanism in the basin of Bayındır formation.

Overlain the micaschists with gradational contact, marbles and crystallized limestones of the Kayaaltı formation crops out, that carries fossils through its whole thickness. In the gradational zone with Bayındır formation the limestones contain Aulotortus sinosus, characterizing Upper Triassic (Norian-Rhetian). In the lower half of the unit, Taumatoporella parvovesiculifera and Paleodacycladus mediterraneus are found indicating Liassic, and in the middle part Clypeina Jurassica and Protopeneroplis striata are determined that prove Dogger and Upper Malm-Lower Cretaceous ages respectively. The uppermost part of Kayaaltı formation contains limestones with rudist fragments, that gradually passes upward into the pelagic limestones. With the following list of fossils Upper Santonian-Campanian has been proved. These are Pseudosiderolites vidali, Pseudosiderolites

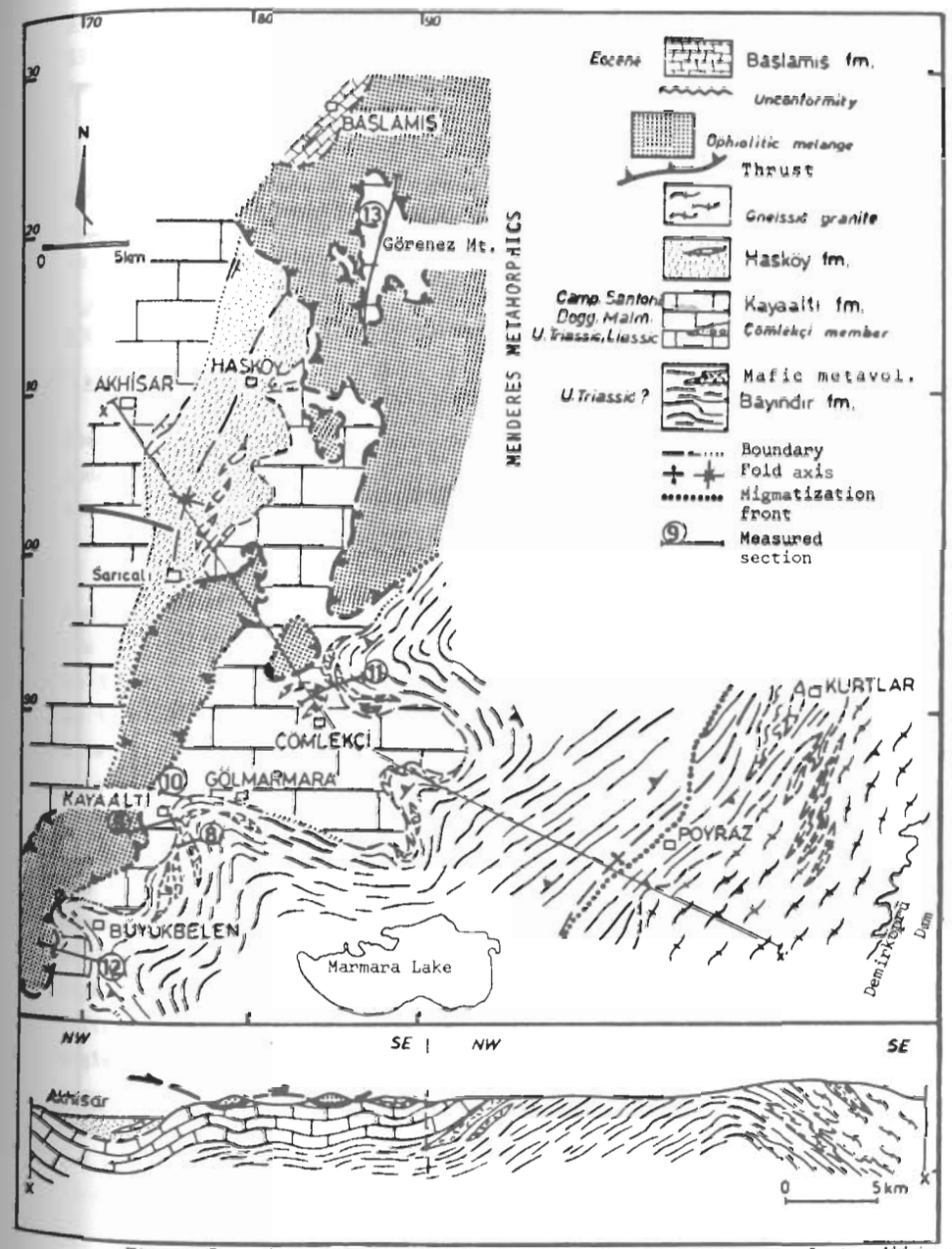

Figure 5 : Symplified geological map and cross section of the Akhisar area.

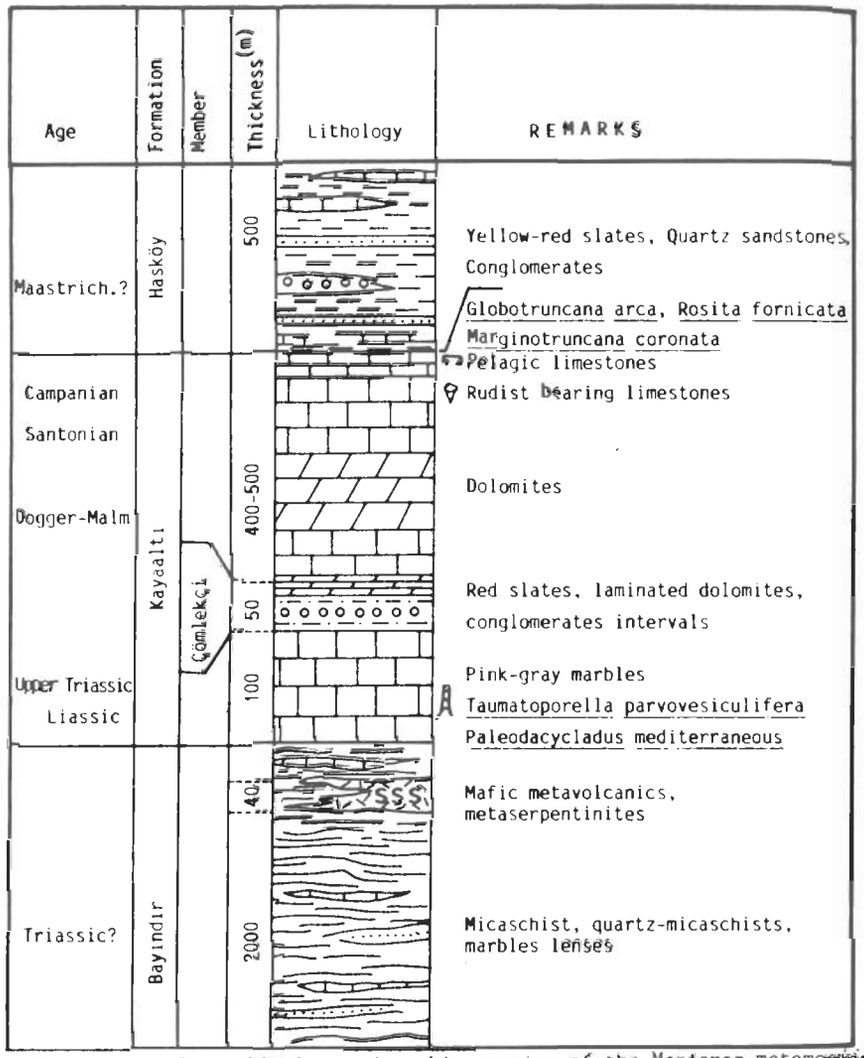

Figure 6 : Generalized stratigraphic section of the Menderes metamorphics in the Akhisar area.

dordoniensis, Globotroncana arca, Globotruncana linnea and Marginotruncana coronata. The Kayaaltı formation, therefore, is Upper Triassic to Uppermost Cretaceous in the Akhisar area.

The pelagic limestones pass upward gradually into a detrital unit composed dominantly of sandstones, conglomerates with minor amount of limestones. This unit is called the Hasköy formation, and its age is probably Maastrichtian.

BOUNDARY RELATIONS OF THE TECTONIC BELTS

The boundary between the Sakarya continent and the Izmir-Ankara Zone has not been studied in detail, but in various plate tectonic models of the region it was considered as a sture zone and shown as nortward dipping thrust faults. (Şengör and Yılmaz, 1981; Okay, 1984).

The boundary between the Karaburun belt and the Izmir-Ankara Zone was studied by the first author (Erdoğan, 1990) and it was shown that, the Karaburun platform was broken and slid into the Izmir-Ankara Zone as blocks of up to nappe size. This occured during the sedimentation so that the contacts are irregular and block-boundaries, olistostromal materials and soft-sediment injections are common characteristics of this zone.

The contact between the Izmir-Ankara Zone and the Menderes Massif can be observed both in the Selçuk and Akhisar areas (Fig. 3,5). The nonmetamorphic, brittly deformed and strongly sheared tectonic melanges of Izmir-Ankara Zone, overlay directly, along low-angle thrust faults, high-grade metamorphic rocks of the massif. The thrust surfaces overlay different units of the Menderes metamorphics (Fig. 3,4) and this low-angle fault zones are not conformable with the fold axis and structural trends of the underlaying units. It is concluded therefore that, the deformation and metamorphism of the Menderes metamorphics occured before and independently with the thrusting.

STRATIGRAPHIC CORRELATION BETWEEN THE MENDERES AND KARABURUN PLATFORMS AND TECTONIC EVOLUTION OF THE REGION

The stratigraphy of Karaburun Belt and the Menderes Massif can be closely correlated (Fig. 2,4,6). The lower Triassic detrital-rich Karareis formation with mafic volcanic lenses is correlatable with the Bayındır schists. The Bayındır schists similarly contain mafic volcanic lenses in its upper parts. These very thick detrital units, are overlain along a gradationally boundary by uninterrupted platformal carbonate successions. These neritic limestone sections yield ages ranging from the Upper Triassic to Upper Cretaceous in both of the belts (Fig. 2,6). The bauxite lenses of the Karaburun succession are correlatable with emery lenses in the Menderes sections. In both belts, neritic carbonates are overlain, through a pelagic limestone zone, by detrital units of the Maastrichtian and younger age.

However, the tectonic setting of the Selçuk formation presents a problem this unit could be the metamorphosed equivalent of the Izmir-Ankara Zone. It is also possible that it was formed along the continuation of a separate trough located to the south of the Menderes Massif, called in the literature as the Alakaya basin (Özkaya, 1991).

The tectonic evolution of the Western Anatolia from the Triassic to the Middle Eocene is shown in Figure 7. It is considered that the Karaburun and Menderes belts were connected to each other and to the north of this intact platform, the Izmir-Ankara Ocean was formed, which produced the oceanic slices of the Akhisar ophiolitic melange (Fig. 7.a,b). During Maastrichtian, the Karaburun belt was separated from the main Menderes platform and the Bornova basin with flysch deposits was formed (Fig. 7c). After Danian, this ocean and its branch closed rapidly and during this short interval the Menderes platform was metamorphosed (Fig. 7d). At the final phase of the ocean closing, the Sakarya continent and the Menderes Massif collided and the melanges of İzmir-Ankara Ocean were thrust over already metamorphosed Menderes platform (Fig. 7e).

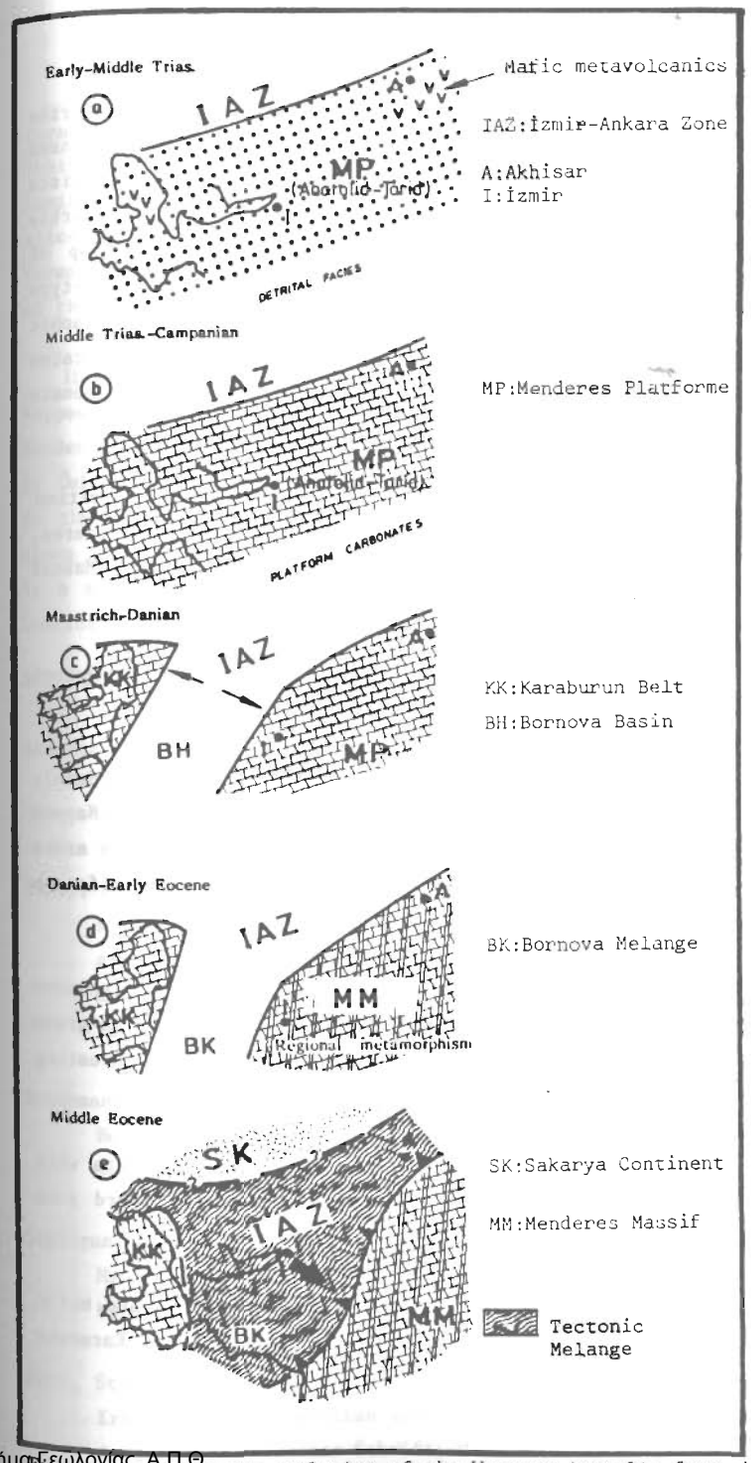

Figure 7 : Tectonic evolution of the Western Anatolia from the Triassic to the Middle Eocene.

Stratigraphy of the southern margin of the massif has been describe by Dürr et al. (1978). They separated a core complex of paragneisses and an envelope of micaschists and marbles. The age of the micaschists is considered to be Paleozoic and even Lower Triassic and the marble envelope to be Upper Triassic and Uppermost Cretaceous. On top of marbles, along a transitional zone of red marbles, a flysch-type sequences have been described. The resemblance of their stratigraphic column with that of the northern margin is pronounced. This indicates that the Menderes platform was a site of uninterrupted carbonate buildup during the entire Mesozoic era.

Dürr et al. (1978) have considered that the paleogeographic position of the Lycien Nappes was along the northern margin of the Menderes, and they thrust southward overriding and metamorphosing the Massif due to the tectonic loading.

The following geological data from study area, however, are not in agreement with this wiew.

1. The Akhisar region, which would have been buried more deeply by thrust packs and metamorphosed most intensivly, if the Lycien Nappes were originated from the northern margin, are among the very rare areas in the Massif with lowest-grade metamophism and preserved fossilliferous units.

2. In the study areas, unmetamorphosed but tectonically sheared melanges of the İzmır-Ankara Zone, directly overlay high-grade metamorphic units of Menderes Massif indicating that the thrusting was after the regional metamorphism and unrelated with it.

3. The second lowest thrust slice of the Lycien Nappes starts with red clastics of the Triassic Karaova formation and passes upward into platform carbonates (Brınkmann, 1967; Dürr, 1975).

The equivalent unit in the Akhisar region is micaschists and mafic volcanics of Bayındır formation, and in Karaburun Belt it is Karareis

formation with pelagic facies. To the north of the Karaburun Belt and Akhisar area, it could have passed into more pelagic facies of the İzmir-Ankara Ocean. Therefore it is unlikely that one of lowest thrust slices of the Lycien Nappes with the continental red clastics of Karaova formation could be paleogeographically placed to the northern margin of the Menderes platform.

It is most probable that the paleogeographic position of the Lycien Nappes were in the south margin and located somewhere between the Menderes platform and Beydağları autocthone, as recently suggested by Özkaya (1991). The Menderes Massif was probably metamorphosed due to the both tectonic load of the Lycien Nappes that thrust nortward along the southern margin, and regionally compression that was caused by a subduction in the northern margin along a zone with the Sakarya Continent.

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