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THE GEOLOGICAL SETTING OF THE TECTONIC UNITS SITUATED ON THE SW ANATOLIA (TURKEY) AND THEIR GEODYNAMIC DEVELOPMENT

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ABSTRACT

At the present time, all the tectonic units, between Menderes Massif and Beydağları Carbonate platforms were emplaced onto foreland by multi-stage thrustings of major compressional regime. These tectonic units display different environmental characters from adjecent areas. Two different terranes are considered by the author to present these units to the north and the south of the Menderes Massif. The units which derived from areas to the north of the Menderes Massif are only the ophiolitic slices which were transported southward by the Upper Cretaceous-Middle Miocene thrustings. On the other hand, other units consisting mainly of carbonate nappes have been originated from a trough situated to the south of the Menderes Massif. The trough was rifted by continental extension forces during Upper Liassic time. The opening lasted until the continental approaching as a result of compression regime. During the closure stage, Late Senonian to Langhian clastics were deposited in submarine areas situated on the Taurid-Anatolid platform.

INTRODUCTION

It is commonly accepted that Western Taurides formed a north continuation of Gondwana Land (Şengör & Yılmaz, 1981). In the Taurid-Anatolid block has been observed the existence of the sussesive crustal thinning and shorting periods. The last crustal shorting in Upper Createaceous to Middle Miocene age was given rise the tectonic units emplaced onto the Beydağları foreland. These tectonic units are called the Western Taurus Nappes (Ersoy, 1989b) as you see in fig.1. They are also known as the Lycian Nappes (Brunn et.al., 1970) or the Bozkır Unit (Özgül, 1976; Şengör & Yılmaz, 1981). There are two controversial issues about their origin. First is that all of the tectonic units were derived from the north of the Menderes Massif (Dürr, 1975). This issue is also defended by Özgül (1976), Şengör & Yılmaz (1981), Erakman et. al (1986). According to second issue (Poisson, 1977, 1984; Poisson & Sarp, 1985 and Ersoy, 1989 a,b & 1990 a,b), most of these tectonic units were originated from the south of the Menderes Massif. Howerever, the author defends the second issue with some differences. According to his oppinion, the tectonic slices consisting mainly of carbonate nappes was derived from a trough between the Menderes and the Beydağları relatively autochthonous carbonate platforms, whereas the ophiolite nappes have been transported from the neotethys ocean which situated on the continuation of the north margin of the

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Taurid–Anatolid block. The tectonic emplacement movement of nappes follows the anticlockwise rotational path. For that reason, direction of the transport is not only from the north, but also from the east or the northeastern. In fact this situation appears as the result of direction of the tectonic transport changing in time. The anticlockwise rotation in the Western Anatolia is also recorded by earlier workers (Poisson, 1984; Kissel et. al., 1986; Kissel et. al.,1987. Therotational emplacement of nappes will explain.

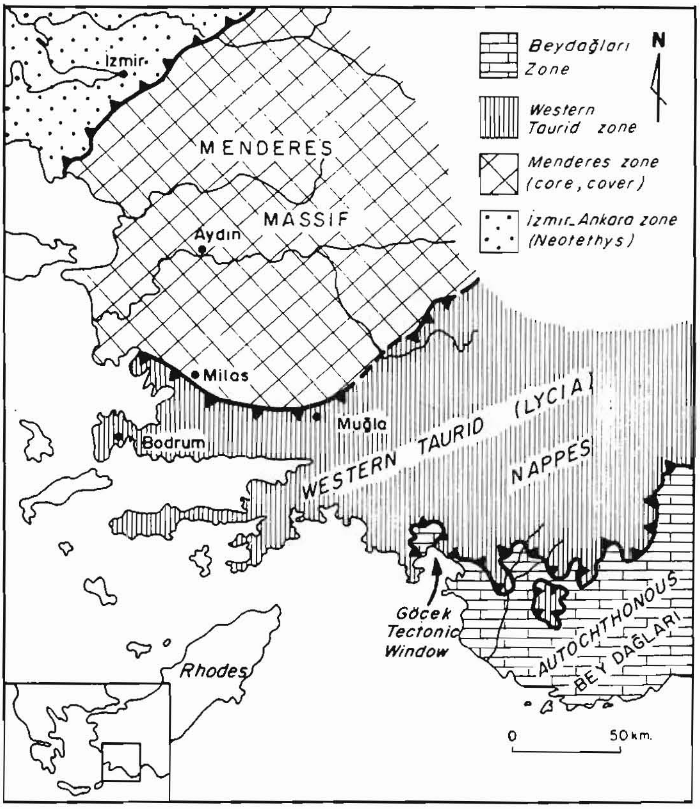


Figure-1. A Simplified Location map showing Western Taurid bappes and the paleogeographical Zones of the SW Anatolian.

GENERAL FRAMEWORK OF THE SW ANATOLIA

The SW Anatolia might be divided into a few paleocographic zones; the İzmir–Ankara Zone (Brinkmann, 1966), the Menderes Massif (core and cover unit), the Western Taurid Zone (Ersoy, 1989 a,b), the Beydağları Zone (fig.1)

The Menderes and the Beydağları zones are made up by tectonically stable carbonate platforms concerning Mesozoic geodynamic development. The Menderes Massif sedimentary sequence, from bottom to top, consists mainly of gneiss of Precambrian age; micaschists of Lower Palezoic age, metaquartzites, black colored fillate and recystalised limestones of Permo-Carboniferous age; thick bedded, recrystallised rudist bearing neritic limestones of Mesozoic age, recrystallised pelagic limestone and flysch whose age extends to Lower Eocene age; ophiolite slices which tectonically emplaced onto blocky flysch of Middle Eocene age. The Beydağları platform exhibits almost continuous deposition probably Upper Triassic to Miocene. A thick part of the section is represented by neritic carbonates separated with the Upper Cretaceous–Lutetian and the Lutetian–Lower Miocene unconformities.

The latest stage of the deposition is represented by the Lower to Middle Miocene clastics. The boundary between the Miocene carbonates and clastics is transitional (Şenel et.al., 1987). The age of the autochthon squence was extended to the Lower Langhian by Şenel et.al.(1986). The area situated between the Menderes and the Beydağları platforms, which is called the Western Taurid zone by Ersoy (1989a), is covered by allochthonous and para-authochthonous tectonic units consisting of different facies from adjecent areas. The author here will firstly define to stratigraphic and tectonic situations of the nappes and later, interpret their paleogeographical sources and geological evolution.

STRATIGRAPHY AND TECTONIC SITUATION OF THE NAPPES

These tectonic units are divided into two groups, the para-authochthonous and allochthonous units (fig.2,3).

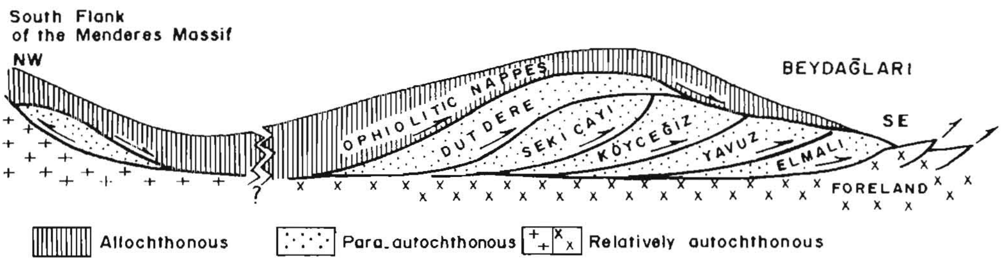


Figure-2. Schematic cross-section showing the present day position of the Western Taurid nappes.

The para-authochthonous units :

Elmalı Slice : This is structurally the lowest slice (fig. 2,3) and Lutetian-Lower Langhian age. This slice thrusts over the Beydağları foreland (relatively autochtonous). The sequence, consisting mainly of clastics, was formed by turbidity current. It was deposited in furrows situated infront of advancing nappes which is close to the Beydağları carbonate platform.

The Yavuz Slice : This slice structurally overlies the Elmalı Slice (fig.2,3). It was first defined by Poisson (1977) and is composed of blocky flysch, consisting mainly of thin-to medium-bedded, beige (rarely red) coloured claystone, siltstone, limestone and sand limestone. The lower part of the slice are mainly represented by carbonates, whereas the upper parts are represented by clastics. The sequence, which is Upper Lutetian-Priabonian in age, is mainly exposed around Korkuteli and Elmalı (Antalya). The blocky flysch (the İbrahimler Formation) around Altınyayla (Burdur) distinguished by Ersoy (1989a) consists mainly of neritic and pelagic limestone, volcanite, ophiolitic rock and various sandstone blocks in a pelitic and volcanic matrix. Morozovella cf. velascoensis, which is attributed to Paleocene, is found in the grey coloured, saccharoid textured limestone clast of the formation.

The Köyceğiz Slice : The slice, which is Paleozoic (Carboniferous)-Early Eocene in age, has the oldest rocks of the Western Taurid Nappes (fig.3). The Paleozoic section of the slice is characterised by sediments deposited in a low energy and shallow water environment. According to Graciansky (1968), there are two Paleozoic series, namely the Karadağ (Carboniferous-Middle Triassic) and Tekedere (Permian) which underlie the Upper Trisassic to Lower Eocene Haticeana dağ Series (Graciansky, 1968). Karadağ series consist of bioclastic and pelitic carbonates intercalated with quartzite. In contrast, the Teke dere Series begin with alternations of dolomite and limestone and later, upwards, are overlain by pillow lavas (including sinerite and radiolarite) and greenish coloured arkoze intercalated with small spilitic flows. The Karadağ Series was tectonically overlain by the Tekedere Series. The overthrusting is pre-Upper Triassic in age. Both series are unconformably overlain by basal clastics belonging to Mesozoic series.

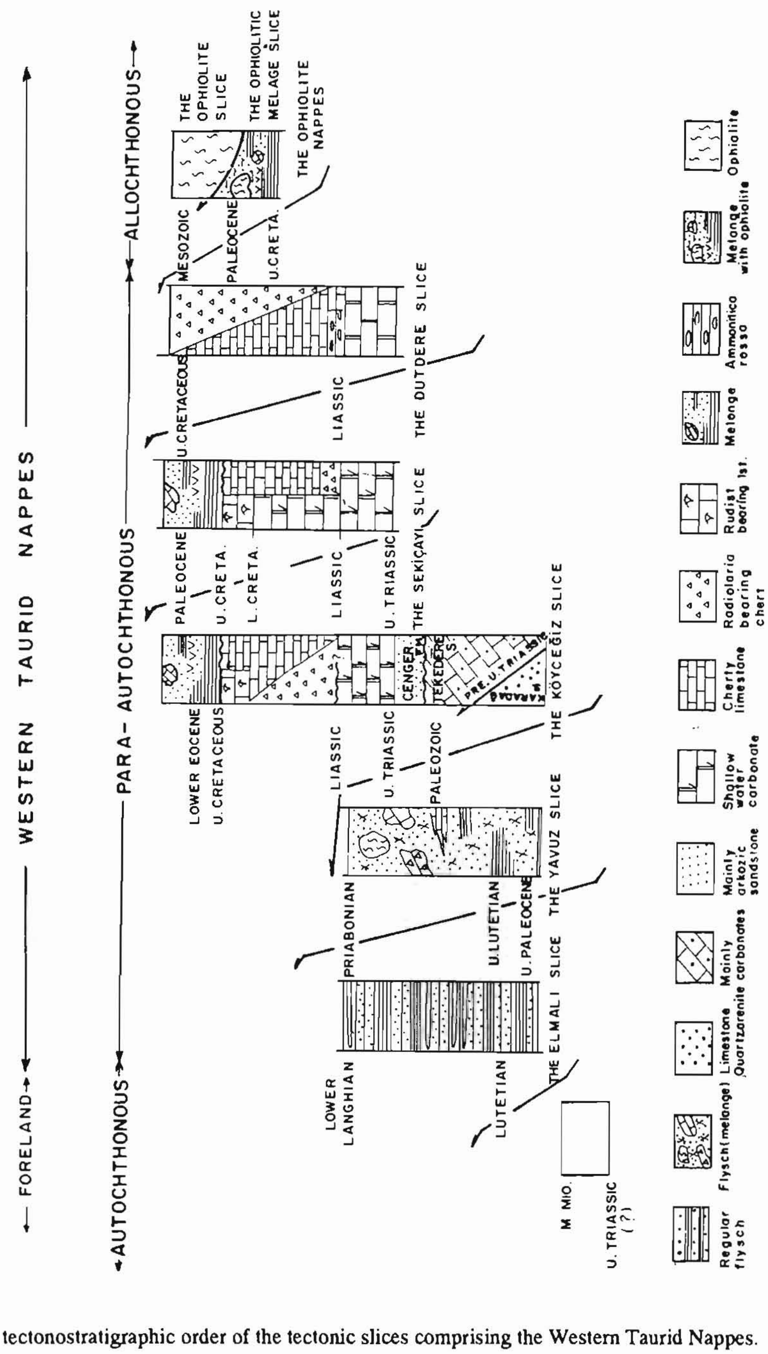


Figure-3. The tectonostratigraphic order of the tectonic slices comprising the Western Taurid Nappes.

The Mesozoic section of the slice begins with the clastics of the Upper Triassic age, which are situated at the base of the Haticeana dağ Series, and rests unconformably on the Paleozoic units. This unit consist of reddish, violet-colored conglomerates and arkosic sandstones and is conformably overlain by the upper units with a transitional zone. The upper parts of the slice consist of shallow water carbonates of Upper Triassic-Liassic age, cherty limestone, radiolaria-bearing cherts of Upper Liassic (or Dogger)- Upper Cretaceous (to Late Senonian) age (rarely rudist-bearing limestones of Upper Cretaceous age) and blocky flysch of Maastrictian- Lower Eocene age. There is probably an unconformity between the shallow and deep water carbonates. On the other hand, the contact relationship between cherty limestones and clastics is both transitional and unconformable.

The slice is exposed of around Köyceğiz situated at most western side of the Western Taurides and tectonically overlain by the Sekiçayı Slice.

The Sekiçayı Slice : The slice, extending up to the Paleocene, is tectonically situated on top of the Köyceğiz Slice (fig.2). The typical outcrops of this slice are mainly found around the Sekiçayı creek, north of Fethiye (Muğla). According to Ersoy (1989a), the Sekiçayı Slice, from base upwards, is composed of platform carbonates of Upper Triassic-Liassic age, mainly cherts and cherty limestones of Dogger-Upper Cretaceous age and blocky flysch of Upper Cretaceous-Paleocene age (fig.3).

Platform carbonates consist of yellowish, grey, dark grey, dirty white colored, thick-bedded, dolomite, dolomitic limestone and recrystallised limestone which include shallow water fossils such as gastropoda, algae, coelenterata, bryozoa. These carbonates, as indicated by Çağlayan et.al.(1980), include fossils characteristic for the Upper Triassic, such as Maendrospira sp., Glomospirella sp. and Duostominidae. The upper parts of the formation contain Paleodacycladus mediterraneus (Pia), characteristic for the Liassic, which is widespread in the Mediterranean region.

Regionally, there are some sections of the neritic facies that extend up to the Lower Cretaceous (fig.3,4). The Neritic section at the Eren tepe around Anltınyayla (Gölhisar, Burdur), is such as an example. The Lower Cretaceous in the Eren tepe is defined by Trocholina alpina (Leupold), T. cf. palatiniensis (Menson), T. elongata (Leupold) and T. cf. conica (Schlumberger), which are found in the samples of blackish biomicrite. According to the present author, this section is interpreted as being deposited in the north of the Western Taurid Trough (it will be explained in the Paleocography and Geological Evolution chapter) close to Menderes Massif or as a neritic carbonate platform, whose margins have been cut by normal faults.

The platform carbonates pass upwards to pelagic and hemipelagic sediments. The boundary between the two units is conformable with a sharp transition. The deep marine sequence, at the bottom, begins with thin to medium-bedded, green, beige-colored, 30-40 meter thick, radiolaria-bearing cherts, resting on 5-10 meter thick a intercalation of dolomite and cherty limestone. The unit upwards passes into cherty limestone. The topmost level of the unit consists of rudist-bearing limestones of the Upper Cretaceous age (Colin, 1962; Brinkmann, 1966; Graciansky, 1968; Erakman et.al., 1986; Ersoy, 1989a). However, these are poorly exposed. This sequence includes badly preserved radiolaria Mirifusus mediodilatus (Oksfordian-Hauterivian), Arceodicyomitra aspidrum (Kimmerian-Barremian), Praeconaryomamma magnimamma (Kimmerian-Tithonian) as determined by Monstler, H. and forams Marginotruancana marginata (Reuss), Helvetoglobotruncana helvetica (Bolli) as determined by Tansel, İ., which are characteristic for Upper Cretaceous (Türonian-Senonian). Hence, according to the paleontological data, the age of the unit is the Dogger-Senoian in age.

Cherts and cherty limestones is overlain either unconformably or conformably by blocky flysch, which is divided into three units, from bottom to top, called the regular flysch, olistostrome and tectonic melange. The sedimentary and tectonic melanges show a great variation in lithological and paleontological aspects. The blocks of Permian, Triassic, Upper Jurassic-Lower Cretaceous and Upper Cretaceous age, display a pelagic and neritic characters. The unit consists of conglomerate (including chert), basalt, ophiolite pebble, pelagic limestone, sandstone, volcanite, microcoquina, pisolitic limestone, sandy limestone and marl. The age of the blocky flysch, deposited since the Late Senonian time, extends up to the Early Eocene in the Datça peninsula (SW Turkey) and even up to the Oligocene on the Island of Crete (Bonneau et.al., 1977; Hall et.al.,1984).

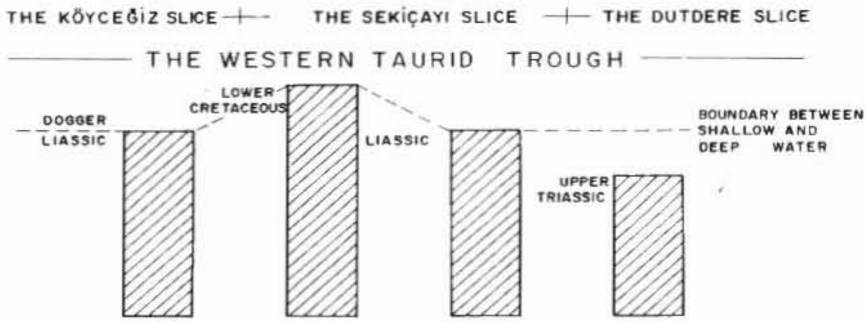


Figure-4. Schematic columnar section displaying the environmental variation of neritic facies between the units. The age gets older eastwards.

The Dutdere Slice : This slice, named by Ersoy (1989a), is considered to be transported from far a way with respect to the Köyceğiz and the Sekiçayı Slice and is tectonically overlain by the ophiolitic nappes (fig.2). The sequence of the Dutdere Slice is very similar with the Sekiçayı and the Köyceğiz sequences concerning lithology and chronology. This slice, at the base, comprises shallow water carbonates (of the Upper Triassic age) which overlain by deep marine carbonates of the Liassic-Upper Cetaceous age. The boundary relationship between the platform carbonates and overlying deeper lithologies is concordant. The platform carbonates consist of clayey, sandy, rarely pebbly biomicrites, which are white, grey, rustly yellow colored and poorly bedded. The biomicrites contain neritic fossils such as Megalodont sp., gastopoda, algae, corals. The deep marine sediments begin with red coloured, ammonite-bearing nodular clayey limestone (the Ammonitico Rosso facies) of the Liassic age and cherty limestones, which pass upwards into cherts. The uppermost section of this slice includes the products of the rift volcanism. The age of deep water sediments extends to the Middle Maastrihtian with pelagic fossils Globotruncana lapparenti (Brotzen) (fig.3). The outcrops of the Dutdere Slice extend to the areas, northwards of Fethiye (Muğla). No outcrops were observed in the Köyceğiz, Datça, Bozburun (Muğla) regions. In addition, we could not observed the outcrops of this slice on the Menderes Massif. For these reasons, this tectonic sequence, excluding clastic facies, is interpreted by the author as having been transporting form the south of the Menderes Massif and the east or northeastern side of the Western Taurid Trough (WTT). Although the Dutdere slice is very similar to the Sekiçayı and Köyceğiz, there is a little different among them concerning transition from shallow water to deep marine deposition. In the Köyceğiz and the Sekiçayı slices, transition mentioned above is Upper Liassic in age, while it is of Early Liassic age in the Dutdere (fig.4). As Poisson (1977) said, this is the evidence of the rifting propogating westwards.

The allochthonous units :

The ophiolite nappes : These units are divided into two subordinate slices, namely the ophiolitic melange slice and the ophiolite slice (fig.3).

The Ophiolitic Melange Slice : This unit is widespread in the Western Taurid belt and on the Menderes Massif. The blocks of the melange show a great variation in lithology and size. Its matrix is clayey or rarely ophiolitic. The unit, from base upwards, is divided into three units; the flysch sequence, the sedimentary melange sequence and tectonic melange sequence. The melange comprises mainly basic volcanics including red colored claystones, radiolaria bearing cherts, pelagic and neritic limestones, shales, sandstone and spilitic basalts. The unit includes the Paleocene foraminifera such as Heterahelicidae; the Triassic conodonts such as Neohindeodella triassica, Metapolygnathus communsti, Ozarkodina, sp., Xanignathus sp. and Gondollelidae; the Paleozoic foraminifera such as Schwagerina sp., radiolaria and fishteeth. Based on the paleontological data, the melange is of Upper Cretaceous–Paleocene age.

This units weakly metamorphosed during its multi–stages thrustings over the Taurid–Anatolide platform between the Late Cretaceous and the Late Eocene.

The Ophiolite Slice : This slice is widespread in the Western Taurid belt, and is variously called : e.g. the Peridotite Nappe (Graciansky, 1968), the Bozkır unit (Özgül, 1976) and the Fethiye Peridotite (Özkaya, 1982). Although, this is usually the uppermost slice, it may also be tectonically placed between the Yavuz and the Köyceğiz or between the Köyceğiz and the Sekiçayı Slices. The unit is built up mainly of peridotite and gabbro cut by dolerite dikes. The peridotites are commonly serpentinised and composed of dunite and harzburgite. The thickness of the ophiolite slice is sometimes greater than 1000 m. (personal communication with Mr.Erakman, B.). According to the present author and to some previous workers (Özgül, 1976; Ricou and Marcoux 1980; Şengör and Yılmaz, 1981), the ophiolite masses in the Western Taurid Complex (except for the Antalya nappes) are possibly relics of the oceanic crust located along the northern margin of the Menderes Massif. This is called the İzmir–Ankara Zone by Brinkmann (1966).

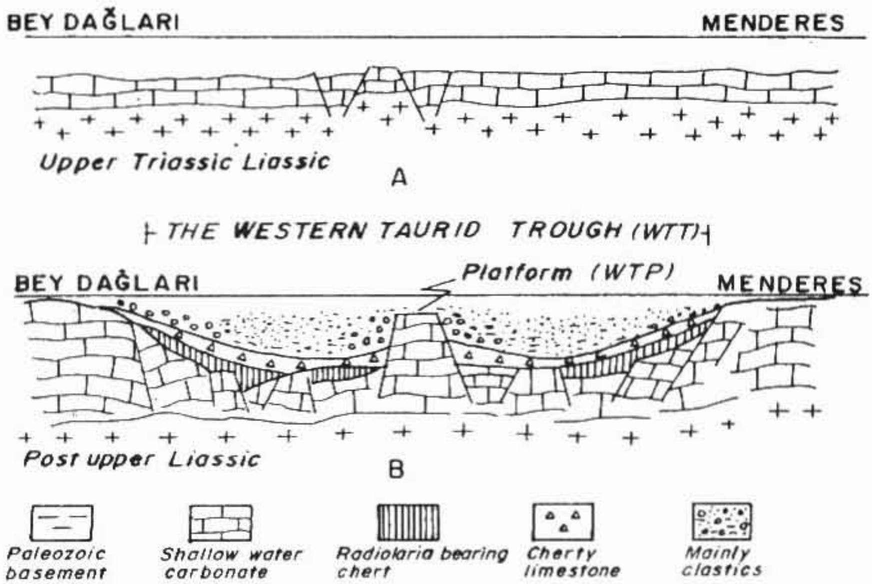
PALEOGEOGRAPHY AND GEOLOGICAL EVOLUTION

It is commonly accepted that all the authochthonous and allochthonous units from Cambrian to Recent, situated in Western Taurid Belt are the northern continuation of the Gondwana Land (Şengör & Yılmaz, 1981). The oldest rocks belonging to the Western Taurid nappes formed in the Paleozoic (Carboniferous) time. During this period, the environment was generally of low energy, and shallow. After the uplift of the region, the environment was tectonically instable and after that, the Paleozoic sediments were uncorformably overlain by the Upper Triassic Çenger Formation (Graciansky, 1968) consisting mainly of red coloured conglomerates, sandstones, sandstones and claystones (fig.3). The pre–Upper Triassic uplift in the Taurides was recorded by Monod (1977).

At the same time (in the Middle–Upper Triassic), in the southern branch of the Neotethys, block faulting started (Marcoux,1978) and prograded westwards (Poisson, 1977, 1984; Poisson & Sarp, 1985). According to Poisson (1984), the Kızılca Trough (defined by him) and the Antalya basin interconnected with each other around Barla dağları, the site of deposition of the Kasımlar shale and Çayır clastics. This interconnection occurred in the Middle Triassic and contiuned troughout the Mesozoic. In the west, the similar flysch deposits which have been found in Barla Dağları, Beydağları and Kızılca trough, are the evidence of an interconnection in Paleocene (Dumont et.al.,1980). The crust in the Kızılca Trough have not reached to the oceanic crust genesis, while it has been created in the Antalya Basin. According to Thuizat et. al.(1981), in the Taurides ophiolites are of Creaceous age. The ophiolites in the Antalya Complex yield a wider range of ages, tending to cluster between the Upper Cretaceous and the Tertiary boundary, but also show a dispersion back towards the Middle Cretaceous (Yılmaz, 1984). In addition to these, the age of the ophiolites are reported by Whitechurch et. al.(1984), to be around 104 ma. in the Lycian nappes. The present author prefer use of the name the Western Taurid Trough (Ersoy, 1989a), shortened to the WTT, instead of the Kızılca or the Kızılca – Çorak göl Trough (Poisson, 1977; Poisson & Sarp, 1985) due to in broad sence. This is limited by the Menderes Massif to the north and Beydağları to the south (fig.5). The Western Taurid Trough was rifted apprently from east to west, being Early Liassic in the east and Upper Liassic (or Dogger) in the west.

The Elmalı, the Yavuz, the Köyceğiz, the Sekiçayı and the Dutdere slices are orginal rocks of the WTT.

The dolomitic and recrystallised limestones, which include algae, corals and oolites characteristic for shallow water, are attributed to the Upper Triassic–Liassic. However, in some areas (e.g. north of Gölhisar, Burdur), the age of neritic deposits extends to the Lower Cretaceous. Such shallowness indicates a large horst block within the trough where margins are probably limited by gravity faults. Subsequently, pelagics and hemipelagics such as cherts and cherty limestone, indicating the development of the WTT, began to be deposited into the trough after than the Upper Liassic. There is a transition between the shallow water carbonates and pelagics, evidence for which includes occasional radiolarian fossils in the upper part of the shallow water carbonates. The Upper Cretaaceous is a period of predominatly pelagic facies. However, in some areas (e.g. around the north of Fethiye), neritic facies, which are represented by rudist bearing limestones (Colin, 1962; Graciansky, 1968; Ersoy, 1989a), are found.



Figure–5. A simplified cross section of the Western Taurid Trough situated between the Menderes Massif and the Beydağları (not to scale). **A**. Neritic Period developed during the Upper Triassic–the Liassic on the Taurid–Anatolid Platform. **B**. From the Upper Liassic (or Dogger), deeper water sedimentation in the trough. But, in some areas, platform facies extends to the Lower Cretaceous.

The ophiolites, emplaced by the multi–stage compressional phases onto the para-autochthonous, are the real foreign units of the Western Taurid Nappes and are derived from the Neotethys oceanic crust located on the northern margin of the Taurid–Anatolid platform (Graciansky, 1968; Poisson, 1977; Ricou & Marcoux, 1980; Şengör & Yılmaz, 1981). After a possible initial collision in the Upper Cretaceous (Campanian–Maastrihtian), the nappes were apprently driven southwards over the Menderes Massif until the Late Eocene, giving rise to slicing and progressive metamorphism of the complex (Akkök et. al., 1984) and poorly understood unit below, which includes metacarbonates, metaschists, metaclastics and serpentine (Dürr, 1975; Ricou et. al., 1975; Özgül, 1976; Özgül et.al., 1978; Şengör & Yılmaz, 1981). In the Upper Eocene, these were transported into the WTT by gravity sliding, and were overlain uncormably by the Kale–Tavas

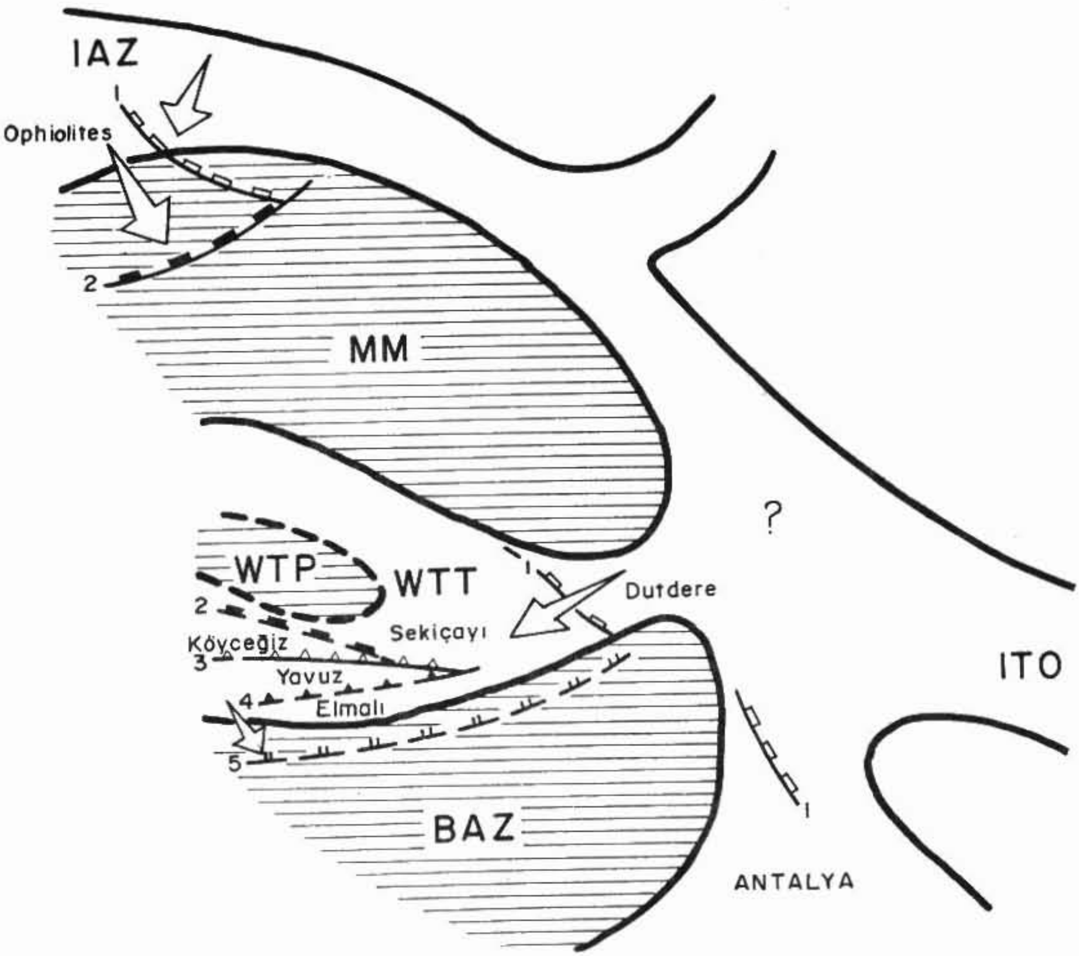


Figure-6. Paleocographical setting of the tectonic units belonging to the Western Taurid Nappes. IAZ= the İzmir-Ankara Zone, MM= the Menderes Massif, WTT= the Western Taurid Trough, WTP=the Western Taurid Platform, BAZ= the Beydağları Autochthonous Zone, ITO=the Inner Taurid Ocean, Horizontal lines represent neritic platforms, Arrows indicate tectonic progression directions. In contrast, the order of the tectonic emplacement has been given by numbers; (1), oldest, (5) youngest. The nappe movements follows the anticlockwise rotational orbit.

mollase of Oligocene age (Gutnic et.al., 1979). On the other hand, during same period or shortly after (possibly in the Late Upper Cretaceous), the Dutdere Slice, formed in the eastern side of the WTT, started to be thrusted westwards onto the Sekiçayı unit. As a result of the nappe progression, clastics sedimentation started in furrows infront of the nappes. This sedimentation contiuned until the Lower Langhian. Finally, following succesive major thrusts, all of the thrust slices were emplaced onto the Beydağları foreland in the Late Langhian, and were overlain by Tortonian conglomerates (Altınlı, 1945; Delaune-Mayere et.al.1977). This tectonic emplacement, which follows the anticlockwise path, is illustrated on fig.6,7. This anticlockwise rotation of the nappes in history gives rise two different tectonic sides and is suggested by a variation in age of the olistostromes situated on the top of the tectonic units. The age of olistostromes in the Western Taurid nappes gets younger from the east to the west and from the north to the south. On the other hand, it is an evidence that the Dutdere Slice doesn't expose around western side of the Western Taurides. The final mollase sedimentation indicates the initial extensional phase of the Neotectonic period and end of the succesive compressional phases of the paleotectonic period.

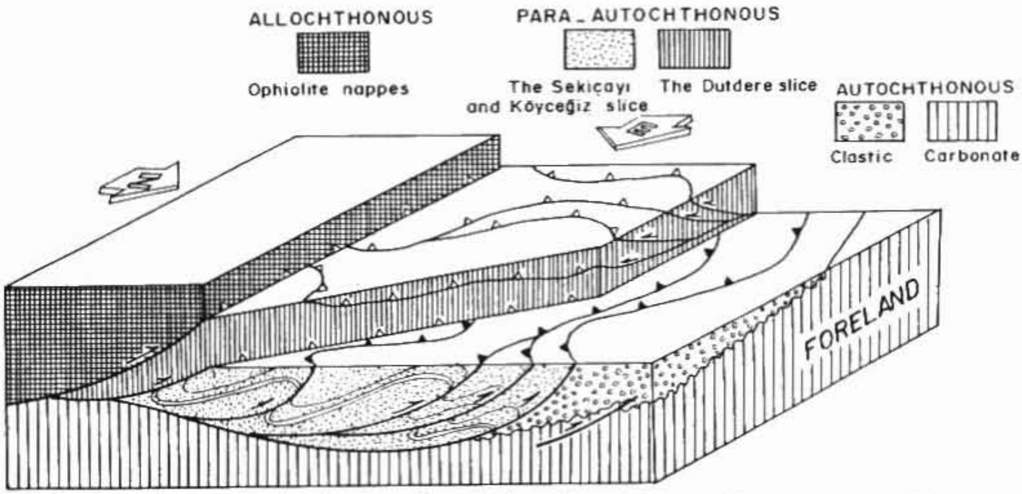


Figure-7. Block diagram showing the three dimensional position of the autochthonous, para-autochthonous and allochthonous units. Arrows show tectonic movement directions.

CONCLUSIONS

The Western Taurid Nappes, which have been emplaced onto the Beydağları foreland by successive multi-stage thrustings of the Late Cretaceous - Middle Miocene compressional phases, have been derived from two different paleogeographical zones; the north of the Menderes Massif and the south of the Menderes Massif. The ophiolitic nappes have been transported from north of the Menderes Massif, whereas the others have been transported from south of the Menderes Massif.

The far-travelled nappes mentioned above have been traced the anticlock wise path during tectonic emplacement. This situation causes two different thrusting directions as illustrated in fig.7.

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