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TECTONIC RELATIONS BETWEEN IZMIR-ANKARA ZONE AND KARABURUN BELT

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ABSTRACT.- In the Western Anatolia around Izmir region, three tectonic belts are located. These are from east to west, the Menderes massif, the Izmir-Ankara zone and the Karaburun belt. The Menderes massif is composed of metamorphic rocks, the uppermost section of which is Early Eocene in age. The Izmir-Ankara zone, which thrusted over the Menderes massif, is represented by a melange of Campanian-Danian age in a large region between Manisa and Seferihisar. This coatic unit which is named here as Bornova melange, is made up of matrix of sedimentary rocks of flysch facies and mafic volcanic intercalations and blocks of limestones more than 20 km in length in some areas. The limestone blocks and megablocks were incorporated during the sedimentation of the matrix and, as a result, various soft sediment deformations and chaotic contact relations were formed around them. The generalized stratigraphy of the megablocks, constructed from measured incomplete sections, is similar to the stratigraphy of the Karaburun carbonate succession. Besides that, lithological and paleontological correlations show that the blocks are broken parts of the Karaburun succession. In the Karaburun peninsula, the Upper Cretaceous lies with an angular unconformity, on the Triassic-Lower Cretaceous comprehensive carbonate succession, around Balıklıova village. Besides this, at two more locations, one near the villages of Karaburun and the other near Urla where the peninsula join Anatolia, caotic rocks similar to the Bornova melange are observed. At these last two locations, the contact relations between the Karaburun carbonate succession and those of the caotic rocks are similar to those seen around the megablocks of the Bornova melange, and can not be explained easily with normal stratigraphic concepts. It shows all the evidences indicative of the Karaburun succession had moved into the flysch depositing still soft sedimentary environment. Various data collected are all in agreement with the idea that the Karaburun carbonate succession was evolved as a platform of the Izmir-Ankara zone and it was tectonically transported during the flysch deposition as nappes. As the nappes moved into the Izmir-Ankara zone, broken large silices formed the megablocks, whereas, the Karaburun carbonate belt an allochthonous pack of nappes or the toe of the nappes itself.

INTRODUCTION

Three tectonic belts, trending in the NE—SW direction, are seperated in the paleotectonic structure of the Western Anatolia (Fig.l).The easternmost belt is the Menderes massif which is composed of metamorphic rock assemblages. The second belt is the Izmir-Ankara zone and, the third one, which lies to the farther west with a platform-type carbonate succession, is called the Karaburun belt, Şengör and Yılmaz (1981) have included this last belt into the continuation of the Sakarya continent in their classification of the cratonic realms of the Western Anatolia.

The east-west trending neotectonic structures, that started forming from Middle-Late Miocene and constructed the graben structures of the Western Anatolia, cut and dislocate these paleotectonic belts (Şengör,1980). Although the graben forming tectonics has not seperated the paleotectonic belts from each other to an unrecognizable extent, the sediment fillings in most places have covered and concealed their boundaries. Especially, the contact between the Karaburun belt and the Izmir-Ankara zone, except in a few places, is overlain by the Neogene sedimentary pile.

In the interpretation of the tectonic evolution of the Western Anatolia, the boundary relations of these paleotectonic belts will provide invaluable information. Various earlier workers have stated that the Izmir-Ankara zone thrust over the Menderes massif along low-angle faults in the southward direction (Dürr, 1975; Dürr et ah, 1978; Channel et al., 1979; Şengör and Yılmaz, 1981; Akdeniz et al., 1982; Akkök, 1983). It has also been put

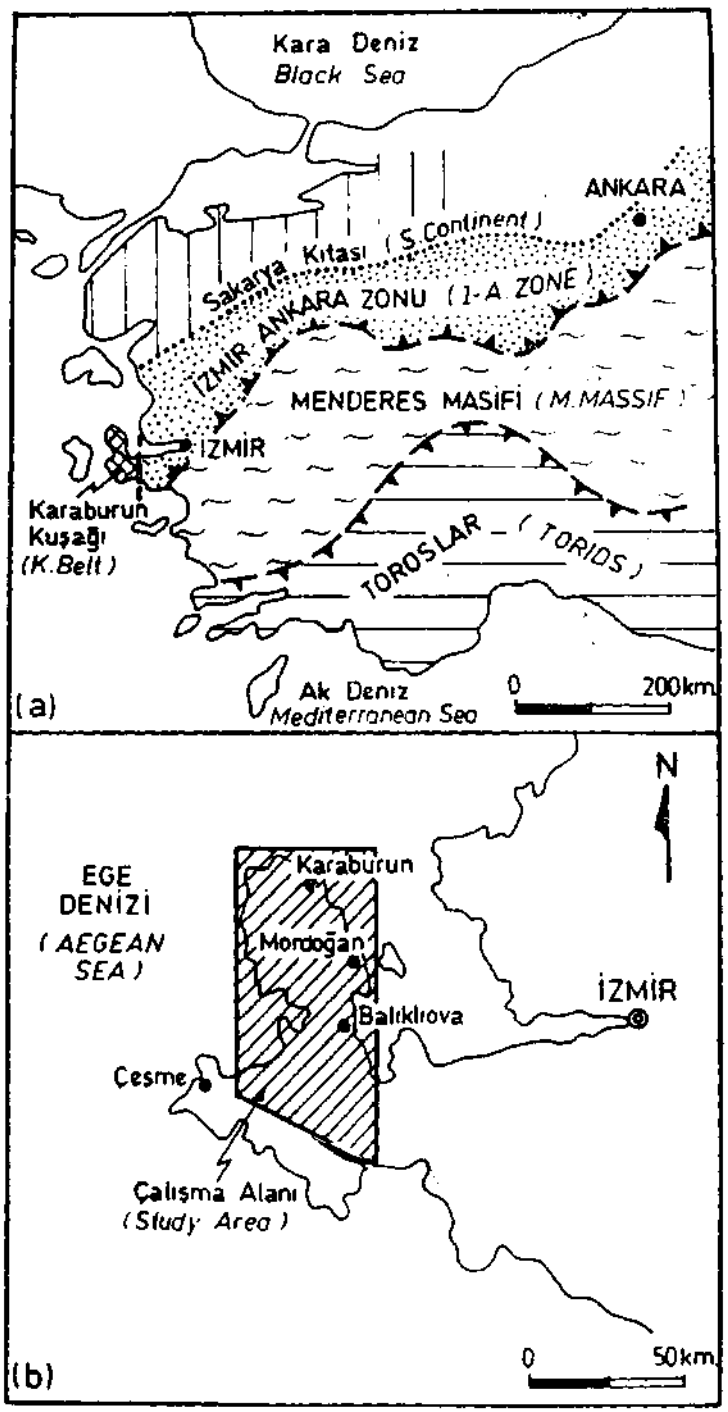

Fig.1— Paleotectonic belts of Western Anatolia; general trends of the Menderes massif, İzmir-Ankara zone and the Karaburun belt.

forward that, the displacement along these thrust faults reaches a continental scale and the roots of the Lycian nappes were located somewhere in the İzmir-Ankara zone and that they rode over the Menderes massif southward to take their present position (Dürr, 1975; Şengör and Yılmaz, 1981; Akkök et al., 1985).

Although various authors have discussed the boundary relations between the Izmir-Ankara zone and the Menderes massif, there is no detailed discussion on the contact relations between the Karaburun belt and the İzmir Ankara zone. In this study this boundary will be examined.

The Izmir-Ankara zone which was first defined by Brinkmann (1966, 1972 and 1976), is represented by flysch-type sedimentary rocks, various limestones, mafic volcanic and ultramafic rocks. There are differences in opinion among workers who Have constructed the generalized stratigraphic column of this zone around İzmir. Verdier (1963), Oğuz (1966), Marengwa (1968), Konuk (1977) and Akdeniz et al. (1982) have put forward that in the lower part there is a thick and continuous shallow-marine carbonate succession with age range from Early Triassic to Early Cretaceous. In the upper part of the stratigraphic column, they have seperated a flysch unit of the Late Cretaceous age. According to these authors, the present caotic internal structures and stratigraphy of the İzmir-Ankara zone were formed by the later tectonic deformations.

Yağmurlu (1980), however, has mapped three different flysch associations in the same area and considered several angular unconformities in the stratigraphic column of the Izmir-Ankara zone. One of is flysch associations lays below the shallow-marine carbonate succession and the other two are above this platform-type carbonate section.

The author of this paper has studied the stratigraphy of the Izmir-Ankara zone between Izmir and Manisa (Erdoğan, 1985) and, reached a different conclusion about the stratigraphic relations between the flysch and the carbonate section. It is found that the stratigraphic base of the flysch does not crop out in any place around Izmir and the carbonate sections are merely block up to 20 km in length and they float into the flysch matrix with an age of Campanian-Danian. The shallow-marine carbonate blocks of the Triassic-Upper Cretaceous age were incorporated into the flysch basin during the deposition in Maestrichtian and Danian (B.Erdoğan; D.Altıner and S.Özer, in preparation). As a result, below the limestone blocks structures of soft sediment deformation are common and the flysch matrix smears all sides of the blocks along very irregular surfaces. This blocky unit, which was formed in the Izmir-Ankara zone, is called the Bornova melange (Erdoğan, 1985,1988).

The stratigraphic data provide, presently, the only information to evaluate the tectonic evolution of the İzmir-Ankara zone (Özer and İrtem, 1982; Erdoğan, 1985,1988). However, because its caotic internal structures and the rootless nature of the carbonate masses, the stratigraphic tracks of this zone were considerably erased. Another area in which the tracks of the initiation of the opening of the Izmir-Ankara zone may be searched is the Menderes massif. However the massif is metamorphic up to the Eocene section (Boray et al., 1973; Dürr, 1975; Dürr et al., 1978; Gutnic et al., 1979) and so it does not appear to be a suitable area to look at the answer of this question. However, the stratigraphy of the uppermost part of the Karaburun peninsula, may provide a valuable information about the evolution of the Izmir-Ankara zone, because it has a continuous and fossil-rich carbonate section from lower Triassic to Upper Cretaceous.

In this study, the stratigraphic characteristics of the Upper Cretaceous that form the uppermost part of the Karaburun belt will be presented and their lower boundary with the underlying platform-type carbonate succession (Karaburun series) will be discussed. At the end of the paper the tectonic relation between the Karaburun belt and the İzmir-Ankara zone will be evaluated.

KARABURUN UPPER CRETACEOUS OUTCROPS

In the Karaburun peninsula, two different Upper Cretaceous with different internal stratigraphy are present and they crop out in three seperate areas (Fig.2). These areas, from the north to the south, are the Kalecik, Balık-

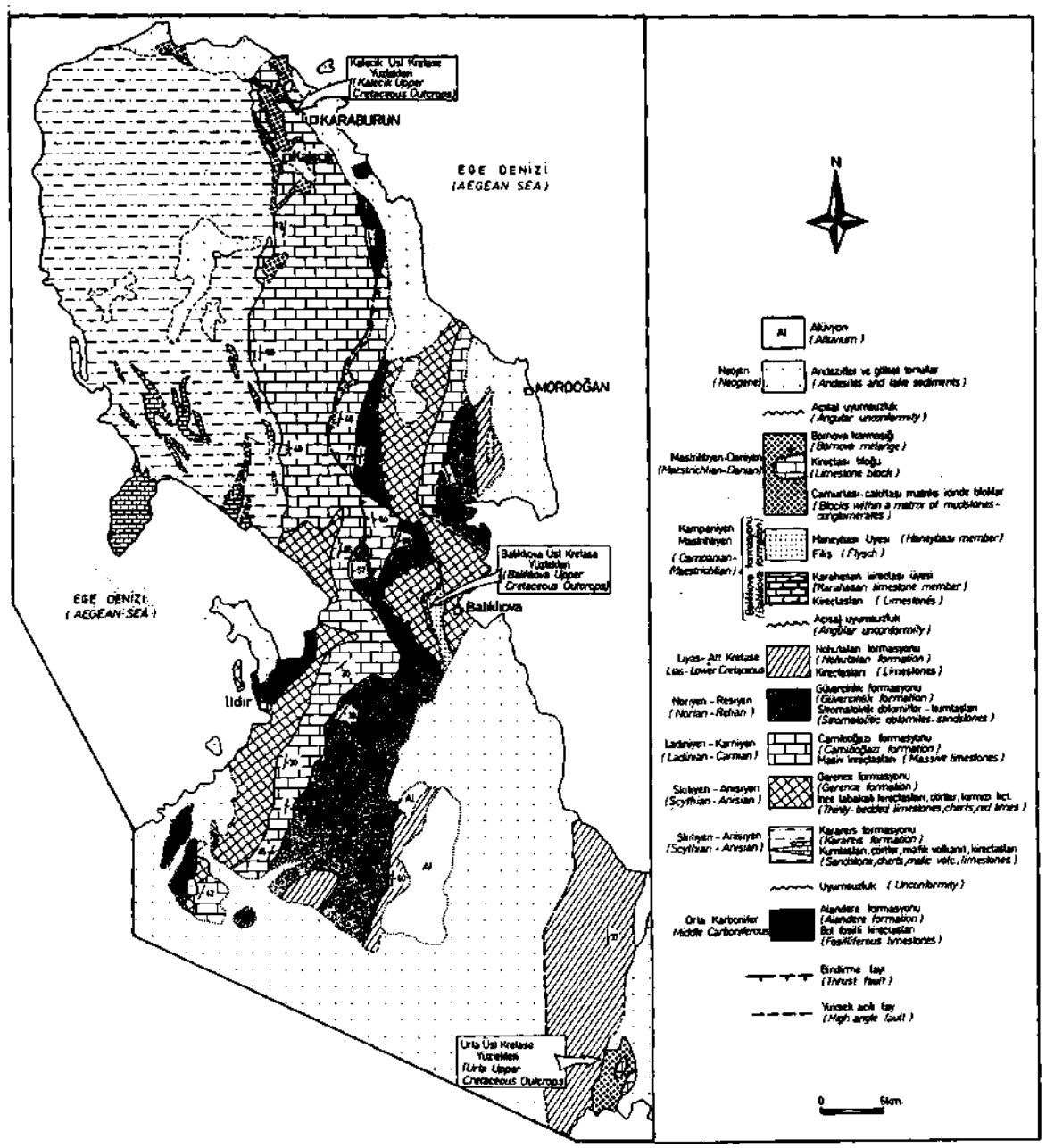

Fig.2-- Simplified geological map of the Karaburun peninsula showing the locations of the Upper Cretaceous outcrops discussed in the text.

liova and the Urla outcrops. The Upper Cretaceous in the Kalecik and Urla outcrops resembles to each other on the basis of internal stratigraphy and contact relations with the underlaying platform succession (Karaburun series). In the following section these two areas will be presented together. The Upper Cretaceous in the Balıklıova area, however, is different and will be discussed under a seperate heading.

The Balıklıova Upper Cretaceous lies above the Karaburun series with a continious stratigraphic boundary. At the lower part, it starts with a shallow-marine carbonates above an unconformity surface and passes upward into detrital sedimentary rocks of flysch-facies. So the Balıklıova Cretaceous is unique among others cropping out

in a large region covering İzmir, Manisa and Seferihisar. It is the only area in which the flysch unit is stratigraphically connected to the underlaying continuous carbonate succession. In other areas around Izmir, however, the Upper Cretaceous flysch forms the matrix and the carbonate masses are blocks into it, which are all together called the Bornova melange (Erdoğan, 1985, 1988).

The Kalecik and Urla outcrops are different from the Balıklıova ones and the Upper Cretaceous in these last two areas resembles to the Bornova melange. The lower contacts of the Upper Cretaceous with the Karaburun series in the Kalecik and Urla areas, are also like the flysch matrix and the limestone blocks in the İzmir-Ankara zone, and this unit with a similar way spreads over a very irregular paleotopography.

Balıklıova Upper Cretaceous outcrops

Around the Balıklıova village, the Upper Cretaceous forms the uppermost part of the Karaburun series (Fig.3). Open outcrops are also seen near the Çatalkaya village and Mersincik tepe location. In these areas the Upper Cretaceous starts at the base with a shallow-marine carbonates and passes upward first into pelagic limestones and finally into a flysch. In this study, the carbonates and the flysch are together called the Balıklıova formation; the lower carbonate section is called the Karahasan limestone member and the upper flysch is the Haneybaşı member.

The Karahasan limestone member is 90 m in thickness as measured at the type locality near Balıklıova village. The lower 29 m-thick section of the member is composed of massive limestones which contain abundant rudist particles, echinoderm plates and algae. Above the massive limestones there is a 29 m-thick bioclastic limestones and sandy limestones which are gray in the lower part but become pink in color in the upper half. The detrital limestones pass upward into layers of cherts-or nodule-bearing limestones that are about 36 m in thickness. At the uppermost part of the Karahasan limestone member there are red micritic limestones which are thinly bedded and measure up to 4 m in total thickness at the type locality.

The lower half of the Karahasan limestone member is poorly fossiliferous; the middle and upper parts contain *Globotruncana stuarti, G. lapparenti, G. bulloides, G. arca, G. fornicata, G. coronata, G.* cf. *mazyoni, G. linneiana, Praeglobotruncana* sp., *Globoratalites* sp., *Bolivina* sp., *Oualveolina* sp. and *Rotalia* sp. which indicate a Campanian age. Supporting the above age assignment, Brinkmann et al. (1977) have stated the middle and upper parts of the same limestones as Campanian and Early Campanian.

The uppermost red pelagic limestones of the Karaburun limestone member yield foraminifera *Globotruncana stuarti, G. tricarinata, G. stuartiforrriis, G. falsostuarti, G. linneiana, G.* cf. *mazyoni, G.* cf. *sentricosa, G.* cf. *gansseri, G. elevata, G. area, G. calcarata, G.* cf. *gagnebini, Praeglobotruncana* sp. and *Ruglobigerina* sp. indicating a Maestrichtian age'. Accordingly, Brinkmann et al. (1977) have assigned a Maestrichtian age for the same levels of the Upper Cretaceous limestones.

The lower parts of the Karahasan limestone member, which are light gray in color, show thick and massive bedding, and contain abundant benthic fossil fragments, indicating a high-energy shallow marine or a slope environment of deposition. As the presence of cljert lenses and nodules in the upper part of the member implies the depositional site gradually become deeper and probably an open sea environment, and finally during the deposition of the uppermost red micritic limestones a pelagic condition prevailed.

The Karahasan limestone member which up to 90 in thickness near Balıklıova village, thins along the strike in short distance and around the Mersincik tepe location becomes 20 m and near Çatalkaya measures only 2-4 m.

The uppermost red micritic limestones of the Karahasan limestone member grade upward into mudstones

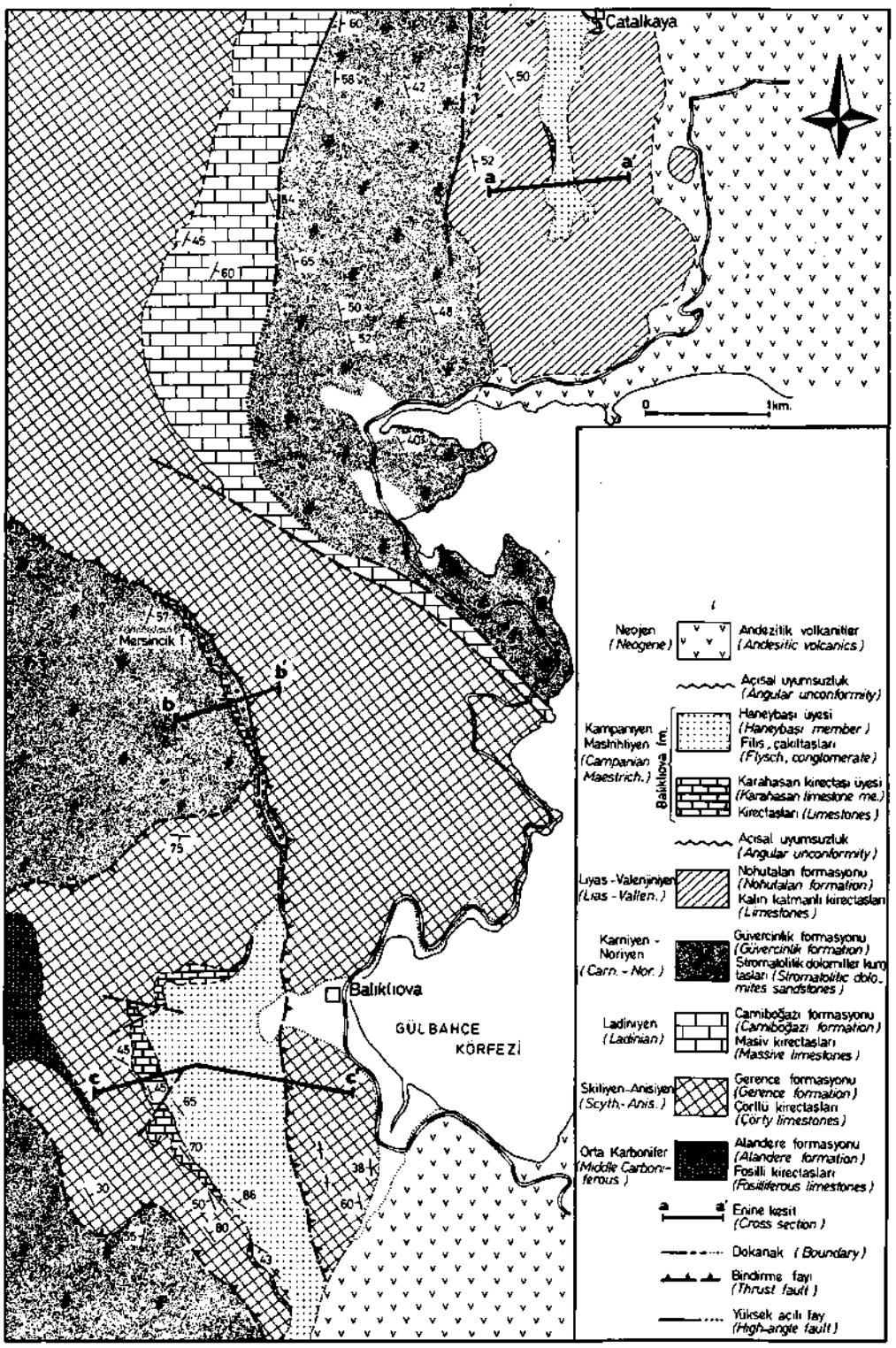

Fig.3– Geological map of the Balıklıova area.

and intercalations of mudstones and sandstones. This detrital sedimentary rocks of the Balıklıova formation is called the Haneybaşı member (Fig.3). In the lower part of the Haneybaşı member, mudstones dominate and in upper parts sandstone and mudstone intercalations give the member a flysch-type appearance. Around the Mersincik tepe there are conglomerate intervals the particles of which are entirely derived from various limestones of the Karaburun series. These conglomerates with matrix-supported angular blocks show all kinds of gradation laterally and vertically to the flysch-type detrital sedimentary rocks.

The maximum thickness of the Haneybaşı member reaches 200 m at the type locality of the Balıklıova formation, but the upper contact is a low-angle thrust fault (Fig. 3,4), so that the true thickness must be more than this.

The Balıklıova formation lies above various formations of the Karaburun series along an unconformity surface. Around the Balıklıova village the unit overlies the Gerence formation of Early-Middle Triassic, around Mersincik tepe it directly lays above the Güvercinlik formation of Late Triassic, and farther north near Çatalkaya village it is above the Nohutalan formation of Liassic-Early Cretaceous (Fig. 3,4). In this last location, the carbonate member of the Balıklıova formation is very thin and the unit overlies the irregular topography of the Nohut-

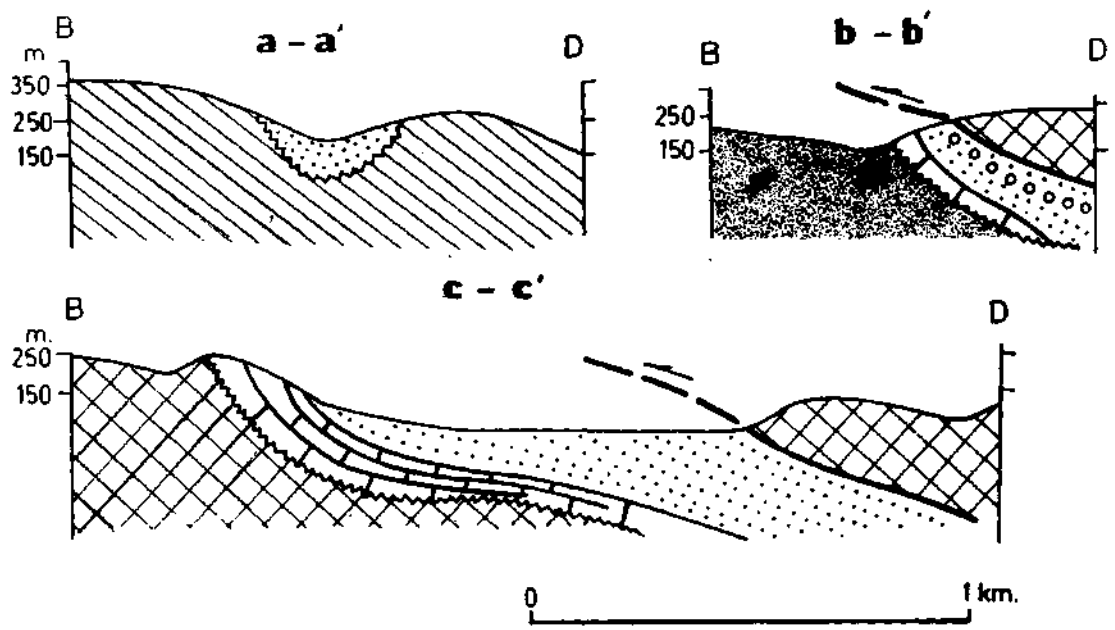

Fig.4– Geological cross-sections of the Balıklıova area; locations of the sections are shown on Figure 3.

alan formation directly with sandstone and mudstone intercalations (Fig.4, section a-a')

The upper contact of the Balıklıova formation is a structural surface and the Gerence formation of Early-Middle Triassic thrust over this unit along a low-angle fault (Fig. 3,4, section c-c'). Near the Mersincik tepe without any cataclastic or mylonitic zone the Lower Triassic Unit overlays the conglomeratic intervals of the Haneybas.l member. Along the southward continuation df the same fault near Balıklıova village mudstones of the Haneybas.l member intrude, upward along the hanging-wall of the thrust fault and soft sediment deformational structures like load-casts are common.

The Karaburun platform uplifted before the deposition of the Balıklıova formation. During Campanian a shallow sea invaded the area and the Karahasan limestone member was deposited. During Maestrichtian the platform subsided rapidly to form a deep marine environment in which at the beginning the pelagic limestones and later the flysch-type detrital sedimentary rocks were formed. A compressif deformation effected the platform during Maestrichtian and, the N—S trending and eastwardly dipping thrust faults were formed, at the bases of which the flvsch was deformed in a viscous condition. The conglomeratic intervals within the Maestrihtian flysch

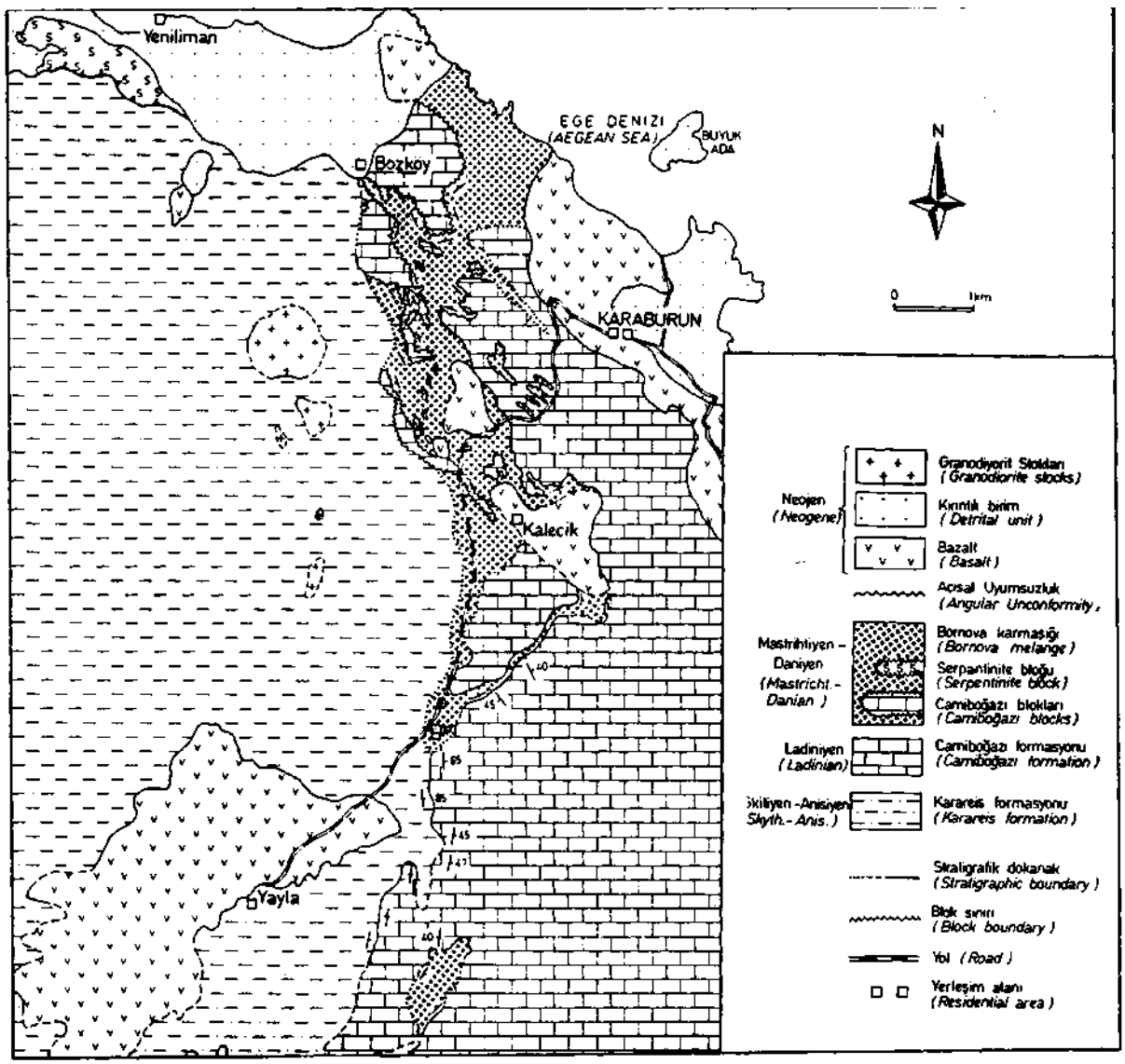

Fig.5– Geological map of the Kalecik area.

and soft sediment deformations along the base of the thrusts indicate that the deformation was active during the deposition.

Kalecik and Urla Upper Cretaceous outcrops

In the north of the Karaburun peninsula near Kalecik village and in the south near Urla, a melange with caotic internal structure crops out (Fig. 2,5). The melange at these two locations, include blocks of various limestones, serpentinites and mafic volcanic rocks set in a matrix of sandstones and mudstones.

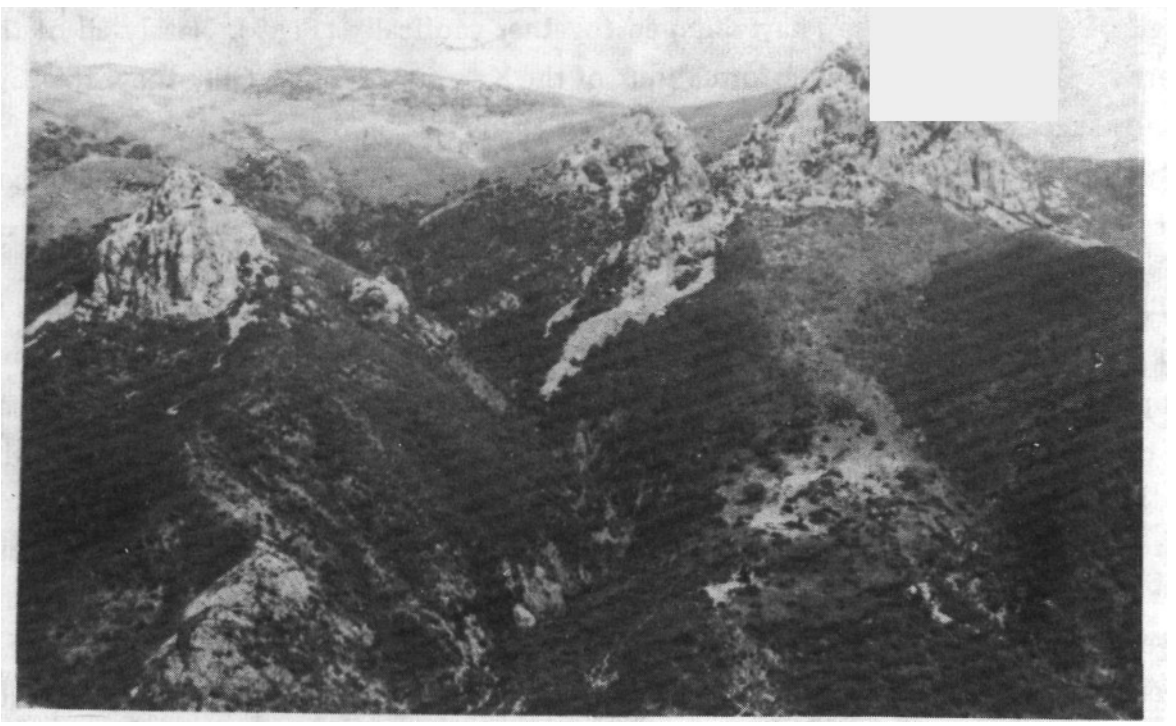

Fig.6— General view of the Upper Cretaceous melange in the Kalecik area. Areas with a gentle topography are underlain by the matrix with sandstone and mudstone intercalation. Blocks of the Camiboğazı limestone are floating within a matrix of the melange.

Near Kalecik village the blocks of the melange are generally massive limestones up to 2 km in length with a shallow-marine facies (Fig.6). These massive limestone blocks, which are Ladinian in age, belong to the Camiboğazı formation of the Karaburun series and so they are shown by the same hatching on the geological maps but with a *zigzag* boundary.

Beside the large blocks, around Kalecik, there are small masses of red pelagic limestones with thin-shelled lamellibranch-fossils that give an Early Triassic age, black cherts of the same age and blocks of mafic volcanics and

Fig.7– Olistostromal materials exposed at the base of the melange unit and also inside the massive limestones of the Camiboğazı formation. Angular limestone fragments are cemented by mudstones with matrix-supported texture.

serpentinites of unknown ages. These small angular blocks range from centimeter to hundreds of meter across without any sign of errosion and they have lumped together caotically (Fig.7). Nearly all of the large and small blocks were derived from the underlying formations of the Karaburun series. Only the serpentines do not belong to the Karaburun succession and the probable origin of them will be discussed in the following section on the conclusions. The matrix of the blocky unit is composed of mudstones and sandstones and it comprises 10 to 15 volume-percent of the melange.

The youngest age that give the closest age of the blocky unit has been obtained from a red micritic limestone outcroping approximately 2 km to the southeast of Bozköy (Fig.5). At this location the micritic limestones form an outcrop 20 m in length but it is not defmately determined whether it is a small block set into the matrix of the melange or it is the matrix itself. The samples collected from the micrites have been examined by Ercüment Sirel and with the following list of the microfossils Campanian age has been determined. These are *Globotruncana area, G. linneiana, G.* cf. *rozetta,* and *G. elevata*. Therefore, the melange in the Kalecik area must be Campanian and/or younger in age. The melange of the Kalecik area closely resembles to the Bornova melange of the Campanian-Danian age that crops out in a extensive region between Manisa and Seferihisar in the İzmir-Ankara zone. The only noticeable difference between the two units is the percentage of their matrixes; while it comprises 40-50 percent of the Bornova melange, the matrix is about 10-15 percent in the Kalecik area.

The lower contact of the melange in the Kalecik area with the Karaburun series is so complicated that can not be explained easily with normal stratigraphic concepts. On the geological map (Fig.5) the melange outcrops form caps above the units of the Karuburun series and patches of them overlay the older unit with widely different angular relations. The formational boundaries of the Karaburun series trend in the N—S direction and dip with high angles. The contacts of the melange, on the other hand, overly stratigraphically various levels of the underlaying series. As it is seen on the geological map, this unit in places starts directly with mudstones at the base, or in other areas with olistostromes that are composed of angular, particles derived from nearby areas (Fig.8). These olistostromal materials with mudstone matrix cover an irregular paleotopography or crop out within the Camiboğazı formation in narrow zones nearly 300 m topographically lower than their drown contact on the geo-

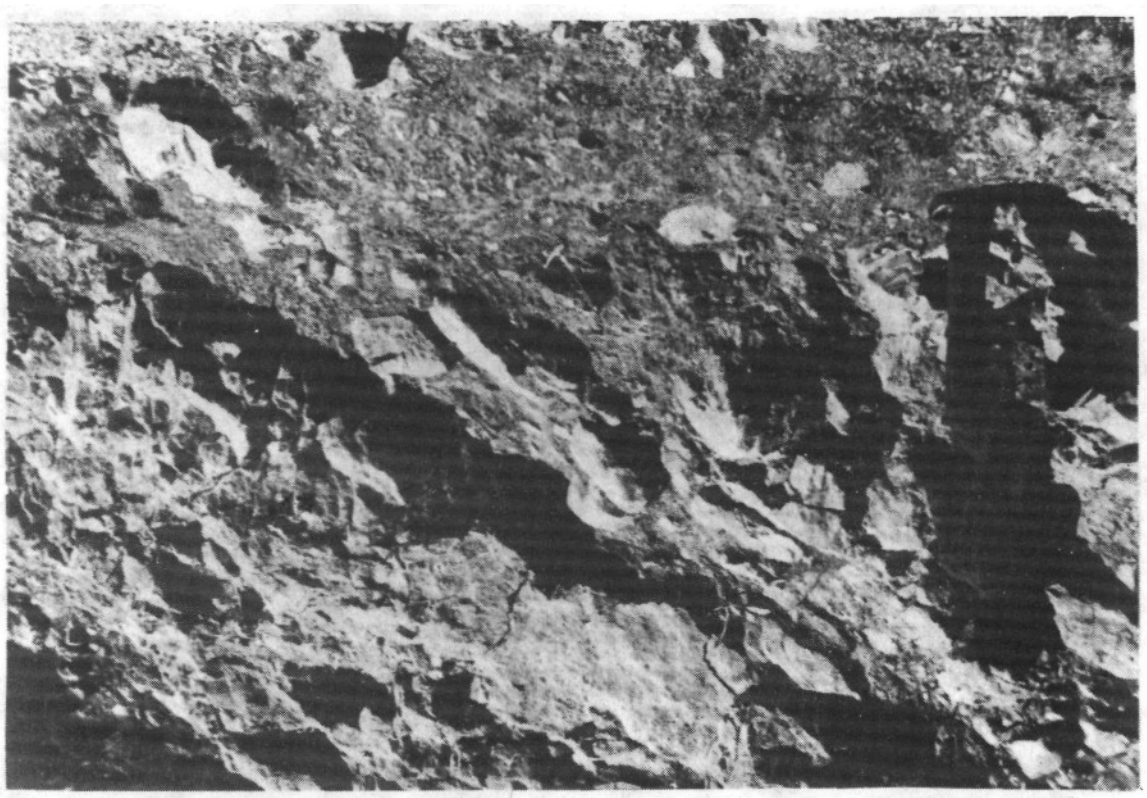

Fig.8— Along road-cuts between Karaburun and Kalecik, inside the limestones of the Camiboğazı formation flysch outcrops of the melange unit are seen along irregular zones.

logical map. The road connecting the Karaburun district to the Kalecik village (Fig.9) cuts the massive limestones of the Camiboğazı formation along a level topographically 300 m below the lower contact of the melange. Along the road cut, however, inside the Camiboğazı limestones the mudstones of the melange unit are seen along irregular zones (Fig.7). In these zones angular particles of the Camiboğazı limestones are found cemented by the mudstones (Fig.8). These caotic materials with flysch matrix are found along 4 large zones as shown on the geological map (Fig.5).

The same kind of structures are common around the limestone blocks of the Bornova melange. Near İzmir in the Bornova district, there are numerous quarries opened in the limestone megablocks of the Bornova melange, along the high excavation scarps of which the flysch matrix crops out in irregular zones. The flysch matrix, that is composed of sandstones and mudstones, cements broken irregular particles of the limestones.

In the Karaburun peninsula, around Kalecik village the size of the limestone blocks in the melange unit reaches up to 2 km in length, and at the bases of them in places olistostromes are found. The mudstone matrix of these olistostromes is seen injected 4-5 meter upward into the base of the blocks (Fig.9), showing clearly that

Fig.9– Soft sediment deformations are common below large limestone blocks of the melange unit in the Kalecik area. In the photograph, upward injection of mud is seen below a broken base of a limestone block.

it was in a soft state when the blocks were carried above the melange unit.

The various data described above are all in accord with the interpretation that the Karaburun belt is an allochthonous masse that had been displaced as a nappe or a toe of a nappe into the melange unit during its deposition. The structural relation between the caotic unit of the Kalecik area, which is considered to the continuation of the Bornova melange, and that of the Karaburun belt is shown schematically in Figure 10.

The melange unit of the Kalecik area also crops out, with the same lower contact relations, near Urla (Fig. 2), where it overlies the various levels of the Nohutalan formation of the Liassic-Early Cretaceous age. The blocks of the melange in this last location are cherty limestones of Early Triassic, massive limestones of Ladinian that are together belong to the Karaburun series, and serpentinites. They range in size from a small particle to a block up to 1 km in length 500 m in thickness. The base and the internal structure of the unit are observed along cliffs of

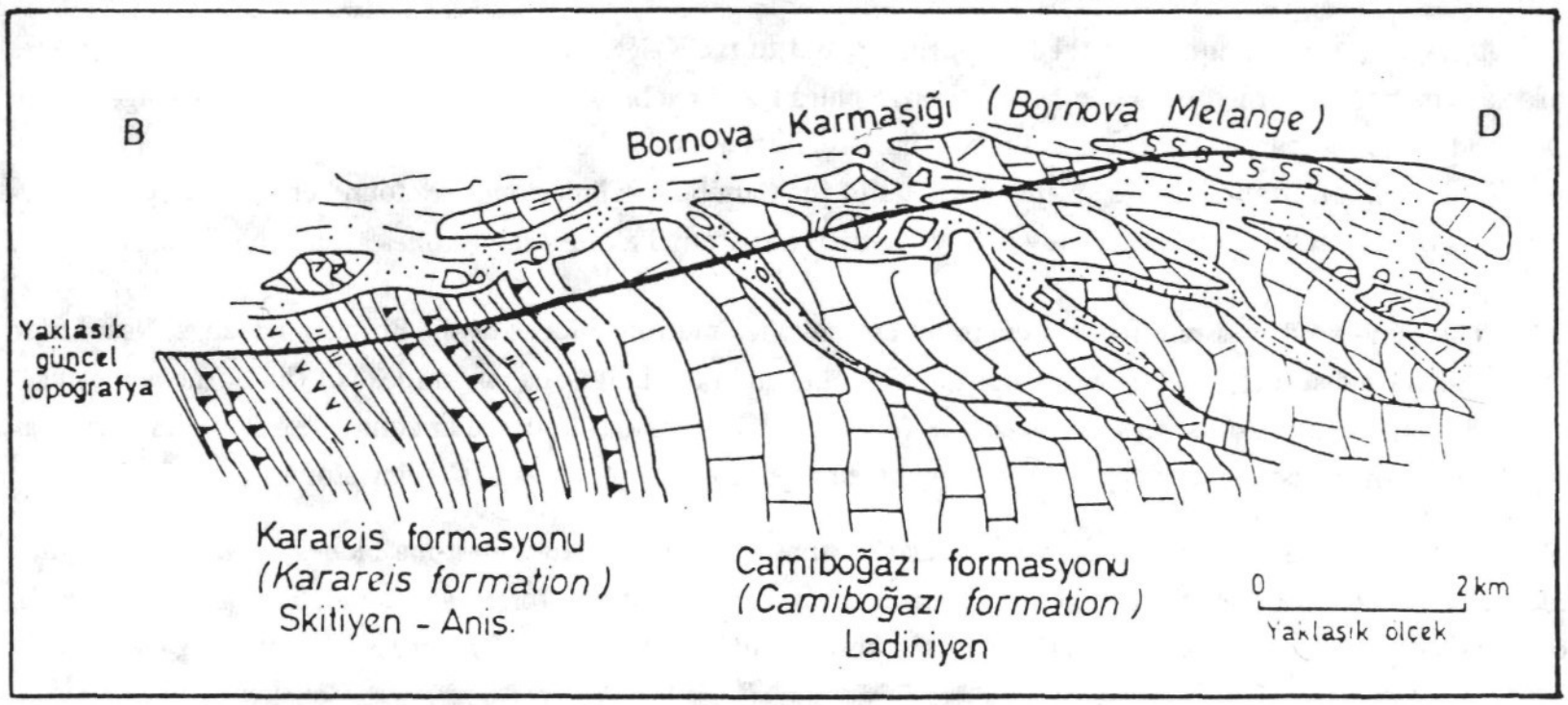

Fig.10– A schematic cross section showing the relations between the Karaburun series and the melange unit, in the Kalecik area.

the seashore, in the Urla area (Fig.2). At the base, there is a blockstone interval that is 50-60 m in thickness with a caotic internal structure (Fig.10). The blockstones probably formed as a submarine fan deposit, are not continuous laterally and pinch out within 100 m. The melange with blocks and olistostromal intercalations, that can be traced 4 to 5 km along the shore, forms a thickness more than 1-2 km and lays below Neogene deposits along an unconformity (Fig.2).

If lateral extents of the Kalecik and Urla outcrops are considered together, the blocky unit does not appear to be a local in origin rather surrounds the entire Karaburun peninsula. It is apparently the continuation of the Bornova melange that characterizes the İzmir-Ankara zone in Western Anatolia and hence on the geological maps and cross sections it is shown with the same name.

Fig.11 – Blockstones in the melange unit of the Urla area. Very angular blocks set in a flysch matrix. Probably submarine fan deposits.

DISCUSSIONS AND CONCLUSIONS

A platform-type shallow marine carbonate successions with an age range from Early Triassic to Aptian-Albian crops out in the Karaburun peninsula (Brinkmann et al., 1972; Erdoğan et al., 1988). Above this succession around Balıklıova the Campanian limestones were deposited. During Maestrichtian the Karaburun platform subsided rapidly and a basin was formed in which first pelagic limestones and later sedimentary rocks with flysch facies were deposited. These Upper Cretaeeous rocks with a continuous section from the platform and with a relatively orderly internal stratigraphy are collectively named here the Balıklıova formation. As a result of the Maestrichtian subsidance, the flysch section encroached upon the different levels of the platform and overlaid the older units along an unconformity.

The Izmir-Ankara zone, that was evolved nearby to the Karaburun platform, was a basin in which flysch-type sedimentary rocks and spilitic volcanics were formed. Limestone blocks of the Karaburun succession measured up to 20 km in length, were carried into the Izmir-Ankara basin and a blocky unit with caotic internal structure, that is named here the Bornova melange, was formed from Campanian to Danian.

Mapping of a large area in the Karaburun peninsula shown that the platform is imbricated by N—S trending and eastward dipping thrust faults (Fig. 2,3,5). The thrusting took place during the deposition of the flysch section of the Balıklıova formation and later the whole platform was carried as a nappe into the İzmir-Ankara basin. As a result of this deformation, the Upper Cretaceous melange outcropping near the Kalecik and Urla areas was formed, which is considered here to be the continuation of the Bornova melange. Hence, the boundary between the Karaburun belt and the Izmir-Ankara zone shows all kinds of gradation although it is concealed in most places by an overlaying Neogene sedimentary pile.

In the Kalecik and Urla outcrops, the melange contains serpentinite blocks that are entirely foreign to the Karaburun series (Brinkmann et al., 1972; Erdoğan et al., 1988). They may belong to broken parts of the oceanic crust of the İzmir-Ankara zone, as the study carried out by us in an extensive area in the Western Anatolia suggests. The presence of slices of oceanic crust of the Izmir-Ankara zone in the melange above the Karaburun belt, may imply a complicated mechanism incorporating overthrusting of the oceanic crust in the tectonic transportation of the nappes of the Karaburun platform.

The initial age of the opening of the İzmir-Ankara zone has a critical importance in the tectonic evolution of the Western Anatolia. The stratigraphic record of the Karaburun series indicate an uninterrupted platform condition from Middle Triassic to Aptian-Albian, which is the youngest age obtained from the uppermost part of the platform succession (Erdoğan et al., 1988). A subaerial condition had intervened between Albian and Campanian as the unconformity below the Balıklıova formation implies. During Campanian a shallow marine carbonate deposition took place which gave way, by a rapid subsidance in Maestrichtian, to a deep basin in which a flysch was formed. The stratigraphic record of the Karaburun platform indicate, therefore that the first opening of the Izmir-Ankara zone took place after Albian and most probably during Campanian and Maestrichtian. Stratigraphic and paleontologic data derived from the limestone blocks within the İzmir-Ankara zone also suggest a platform condition dominating from Late Triassic to Santonian, and a basin was formed during the Campanian-Danian interval (B.Erdoğan; D.Altıner and S. Özer, in preparation).

The various data presented above are all in accord with the interpretation that the Izmir-Ankara zone had opened in a relatively short time interval and that its closing initiated in Maestrichtian was completed in Middle Eocene by thrusting entirely above the Menderes massif. Therefore, it is implied that, in the Western Anatolia there had never been an extensive ocean named,as the İzmir-Ankara zone and a large oceanic crust had never been produced. This interpretation necessitates a critical reconsideration of the roots of the large ophiolite slices of the Lycian nappes that heve been suggested to come from the north of the Menderes massif somewhere around the İzmir-Ankarazone.

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