

A GEOLOGICAL STUDY IN THE KARABURUN PENINSULA

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ABSTRACT. — The oldest formations in the Karaburun Peninsula exposed to the effects of the Hersinian and Alpine orogenies, are conglomerates, graywackes, arkoses, sandstones, schists, quartzites and limestones. Lack of fossils in the Devonian system made it impossible to go into distinguishing further subdivisions. Lower Carboniferous limestones containing fossils overlie Devonian series. Unlike in Sakız Island, where unconformities are occasionally observed, such is not the case in the Karaburun Peninsula.

The Mesozoic starts by a conglomerate base laid upon the Paleozoic formations and as a rule contains sandstones and limestones. Although a few Upper Triassic fossils are encountered in it, the well-defined ones belong to the Jurassic system.

Jurassic-Lower Cretaceous-Upper Cretaceous ensemble (including Turonian) presents a comprehensive series in the form of massive and plated limestones. The Upper Cretaceous (Maestrichtian) overlying this series also begins with a basal conglomerate and comprises pink limestones and sandstones overlain by grey and white compact schistose limestones showing good stratification. The youngest fossiliferous sediments in this area belong to the Miocene. Miocene systems composed of sandstones, clay, marls and limestones with intercalated tuff show that volcanism was on during the Neogene. In the course of this period rhyolitic, andesitic and basaltic lavas escaping from the cracks came up to cover older formations and a multitude of such cracks and faults came to be as a result of volcanic activities.

After this introduction, the following may be pointed out regarding the local paleogeography and tectonic history. Paleozoic formations which came up above sea level due to the Hersinian folding went down again during the Upper Triassic (possibly Jurassic) and the sea lasted till the end of the Turonian epoch. Then in the course of the sub-Hersinian phase the area emerged from under the sea but transgressions in the Maestrichtian time caused it to sink once more below the sea level. The upper layers of the Maestrichtian show strong folding and small synclines and anticlines, indicating that the Alpine orogeny took place during the Late Cretaceous or somewhat later and the Maestrichtian limestones were severely folded while they were not yet completely solidified. Folding, during the Mesozoic time, did not occur under unidirectional forces. Here, rather a set of multidirectional movements are observed.

The Neogene sediments overlie older formations beginning with a red layer of conglomerate at the bottom. In the eastern part of our district there exists a basal conglomerate between Miocene and Pliocene formations.

I. INTRODUCTION

The area under study is the 60 km long Karaburun Peninsula and the vicinity, extending N-S in the Western Anatolia, west of the vilayet of İzmir. The work was conducted to cover a total of 1600 square kilometres, equally divided between the map-sections No. 86/1 and 86/3. The area is roughly 50

km away from Izmir and only 15 km from the Island of Sakız. Examination of rock samples and subsequent determinations were taken up by Dr. P. de Wijkerslooth, Dr. C. Kieft and Dr. Klaus Markus. Fossils were identified by Miss Sevinç Başad, Dr. C. Öztür and Dr. Y. Ginkel. I feel indebted and owe many thanks to the gentlemen cited above,

and also to Dr. Cahit Erentöz for valuable suggestions and to Prof Dr. İhsan Ketin who helped me during my field work.

II. GEOGRAPHY

Although not much elevated, this district, with its suddenly rising hills right along the shore line, gives the impression of a mountainous country. In the Peninsula, surrounded by plains at sea level and tectonic troughs, there are valleys encircled by mountains of limestones and andesites. Highest peaks are Akdağ (1212 m), Bölmece (848 m) and Kırdağ (707 m).

While the northern part is dotted with hills, the Çeşme depression area forms a flat stretch of land. Morphologically four groups may be distinguished in the district : a) Devonian sandstones and limestones, b) Mesozoic limestones, c) Neogene sediments and d) andesites and basalts. Here we find high cliffs of the Alpine character, difficult to cross, in the Mesozoic limestones, as well as deep dry valleys and the like, in eroded limestone formations. Vast area of the Devonian age lying to the NW of the district has a monoclinical structure dipping west. The morphological structure is built of Neogene sediments and tuffs. In some places andesites form individual hills void of vegetation. The area is usually dry during the summer and wet during the winter. It is drained mainly by streams of water such as Örendere, Söğütdere flowing due south and due north and their tributaries.

- | | |
|---|------------------------|
| 1) Litri group : Schists, sandstones, (Uralian) | |
| 2) Litri group : Schists, conglomerates | } Middle Carboniferous |
| Yale group : Phthanites, schists, sandstones | |
| Basal conglomerate (?) - Lacune | |
| 3) Kayancık horizon : Limestones, schists (Middle Devonian) | |
| Denizgeren group : Schists, sandstones, graywackes (Lower Devonian) | |
| 4) Metamorphic system : Phyllites, sandy schists, quartzites. | |

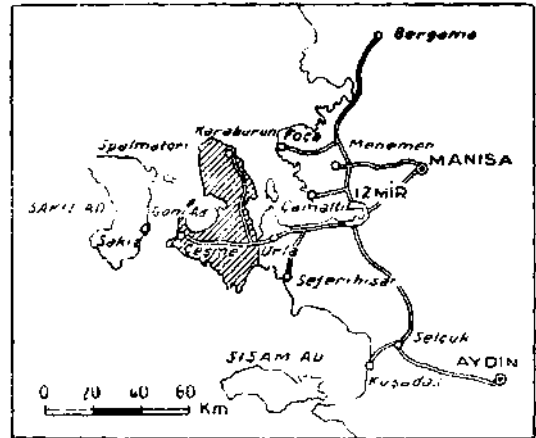


Fig. 1 - Geographic location of the district under study

III. PREVIOUS STUDIES

In 1911, A. Philippson (8) carried out the geologic survey of the entire Peninsula, drew a geologic map of it and correlated formations there with those of Greece and the Island of Sakız. According to Philippson, limestone formations covering the higher parts as well as wide flat are of Mesozoic age and represented in two facies : a) the massive limestone facies and b) the plated limestone facies, corresponding to the Olonese limestones in Greece (they contain secondary intercalated schists).

In 1921 Ktenas conducted a survey in northern section of the Peninsula to find the eastwardly continuation of the formations in Sakız and pointed out the following groups of the Paleozoic :

In 1939 Werner Paeckelmann (7) set the age of the limestones in the region of Çeşme as being Triassic.

Nuriye Pınar mentioned the existence of a great number of hot springs and mineral water sources within the depression area of Çeşme.

Mehmet Akartuna (1) claims that there is a discordance visible between the Miocene and Pliocene formations just east of the Peninsula.

IV. STRATIGRAPHY

A. Paleozoic

Devonian. — Devonian formations

outcrop in the northwestern part of the map-section 86/1 over a stretch of area 20 km long and 10 km wide, consisting mainly of schist, sandstone, arkose, conglomerate, graywacke, quartzite and grey limestone layers imbedded in schists and graywackes. This series is subdivided into several groups by Ktenas, ranging up to the Upper Carboniferous. We think this series should best be considered of the Devonian age, without going into further subdividing. Because, included into the Middle and Upper Carboniferous, it underlies the fossiliferous Lower Cretaceous limestones, indicating continuous sedimentation.

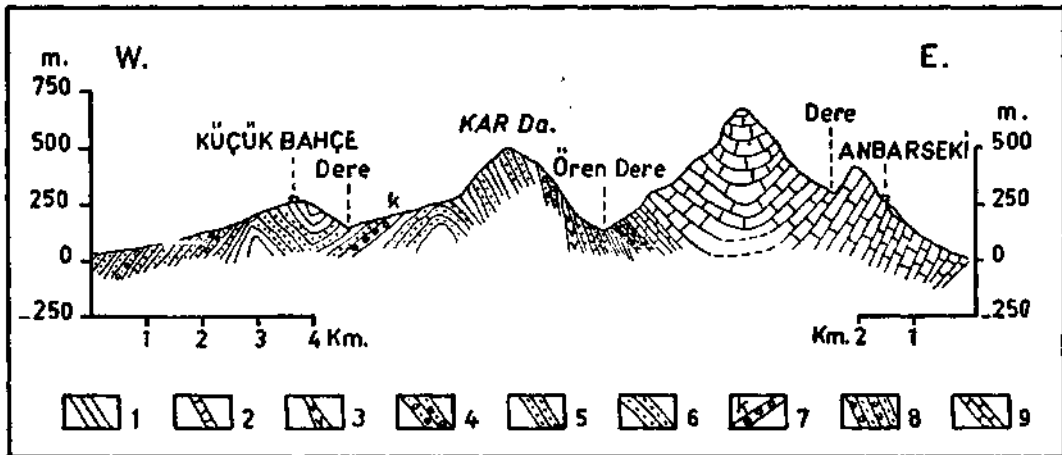


Fig. 2 - Section through Küçükbahçe - Anbarseki

Devonian: 1 - Schist (various colors); 2 - Black schistose limestone; 3 - Thick-layered quartzite (large grain); 4 - Arkose; 5 - Graywacke; 6 - Sandstone; 7 - Conglomerate. Mesozoic: 8 - Conglomerate, sandstone; 9 - Limestone.

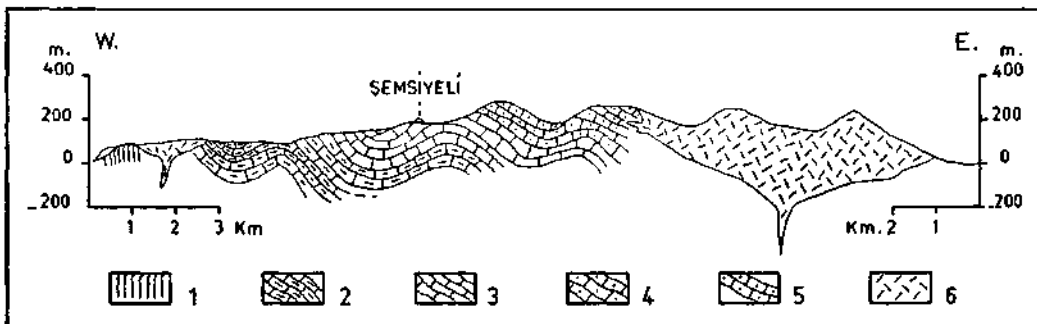


Fig. 3 - Section through Kermiyan Yalı - Çiftlik Village

1 - Lower Carboniferous; 2 - Jurassic; 3 - Lower Cretaceous; 4 - Upper Cretaceous; 5 - Neogene; 6 - Andesite.

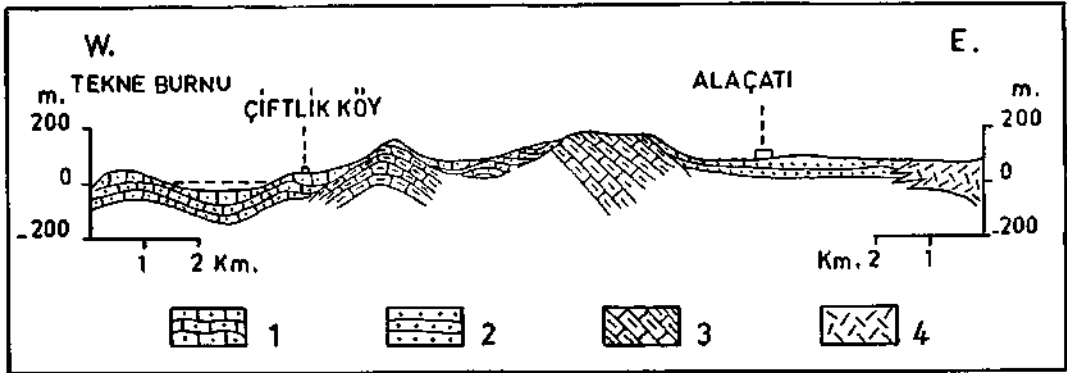


Fig. 4 - Section through Tekneburnu - Alaçati

1 - Neogene lake facies; 2 - Neogene volcanics; 3 - Jurassic; 4 - Andesite.

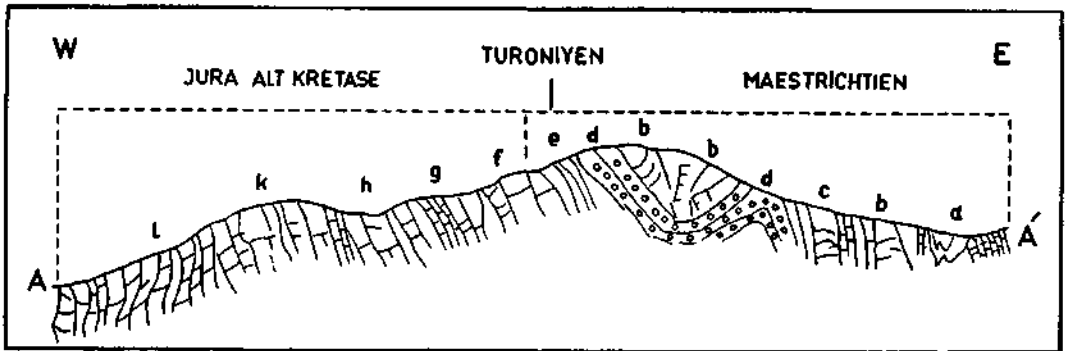


Fig. 5 - Section through Balıkhova İskelesi - Gerence. (A - A' = 7.5 km)

a - Plated limy schist; b - Layered pink limestone, with Globotruncana; c - White crystalline limestone; d - Maestrichtian basal conglomerate; e - Cenomanian - Turonian limestone containing Trocholina cf. lenticularis; f - White limestone in thick layers; g - Plated limestone in thin layers; h - Brown limestone; k - White limestone, with silice, containing Crinoids, Brachiopods; l - Brown and pink semi-crystalline limestone, containing Pseudocyclammina.

Within this series, roughly 3000 m thick, neither fossils nor any sedimentation gaps are encountered. Its relation to the other Devonian formations may be summarized as follows: Although the under part of the Devonian sediments is not visible in the district, it is a known fact that the semi-metamorphic series of pre-Devonian age outcropping in the Island of Spalmatori, to the west of the Peninsula, here constitutes the lower parts of the Devonian deposition. The relation of this latter with the Lower Carboniferous limestones overlying it is not very clearly indicated. In the Island of Sakız Devonian is overlain by

Middle Carboniferous, showing angular unconformity. While, to the south of Yelkentaş, in the Peninsula of Karaburun graywackes and schists of the Devonian age underlie Lower Carboniferous limestone with fossils and without any sign of unconformity. At a typical section in the region of Örendere, of the northern part of the map-section 86/1, is seen a basal conglomerate of the Mesozoic age overlying the Devonian series. Limestone banks are encountered in the upper parts of this Devonian series and here, most probably, limestones and sandstones grade into one another. Limestones estimated to belong

to the Lower Carboniferous seem to be eroded out and presently non-existent. Whereas, a little to the south, portions of the limestones that escaped complete erosion are still visible.

Lower Carboniferous— The grey, compact, crystalline limestone beds seen between Yelkentaş and Gerence to the east of the locality known as Kermiyan Yalısı (map section 86/1) and those in Şifne Peninsula and to the south of it (map-section 86/3) belong to the Lower Carboniferous (Upper Visean to Lower Namurian). We are likely to place white crystalline limestones underlying the Devonian, north of the Kara Island, among the Lower Carboniferous formations.

The following fossils (determined by V. Ginkel) came from compact, crystalline limestones found in the east of Kermiyan Yalısı (map-section 86/1) :

Plectogyra
Eostaffella
Climacammina
Paramillerella (*Eostaffella*)
Endothyra
 Bryozoa
 Corals

All of the fossils named above are found in the white, compact semi-crystalline limestones of the Şifne Peninsula as well. The brown limestone beds overlying the white, compact limestones contained *Geinitzina* (*Lunucammina*) of the Paleozoic fossils, but a more exact determination could not be made as to its period by C. Öztemür who did the examination.

The following Lower Carboniferous fossils (determined by V. Ginkel) were found in the brown limestones stretching from Gerence to Yelkentaş which show no sign of crystallization and which are hard to tell from the Mesozoic limestones :

Glomospira
Tolypammina
Trepeilopsis
Hyperammina
Globivalvulina
Palaeotextularia
Endothyra
Plectogyra

Fusulinidae :

Eostaffella
Parastaffella

There exist other limestone areas in our district that we might include into the Carboniferous, besides, and in addition to, the Lower Carboniferous ones as determined through fossils listed above. However, we could not do so because a) No fossils were found and b) lithologic data alone is not sufficient for exact age determination. Upper parts of the Carboniferous are not represented in the Peninsula. And limestones formerly known to belong to the Paleozoic are now marked down as Mesozoic.

B. Mesozoic

Mesozoic rocks mainly occur in limestone facies. The subject matter in this district is the comprehensive series possibly beginning with the Upper Triassic and continuing up into the Upper Cretaceous (Coniacian). It covers wide areas in the map-sections 86/1 and 86/3, and stretches in the N-S direction forming a range of mountains marked with high hills. It contains fossils, has gone through various phases of the Alpine orogeny and is cut up by a multitude of tectonic lines, so that any distinction of levels does not seem possible.

Mesozoic (Akdağ series). — As no fossils were encountered in compact, crystalline limestones which covered the Akdağ mountains in the north of the district and displayed distinct layering at places, it has not been easy to tell sections belonging to Jurassic

from those belonging to Cretaceous. So, for the time being, we mark these Akdağ formations only as Mesozoic, of which there is no doubt.

Triassic. — It is thought that the lowermost layers of the Mesozoic limestones in the Karaburun Peninsula belong to the Upper Triassic. *Trocholina multispira*, possibly of Upper Triassic, and some algae, again of Triassic age, are found in our district.

Dolomitic limestones (Triassic) seen in the Island of Sakız and the Bodrum Peninsula, also occur in this district, but the lack of fossils forbids calling them Triassic for certain. Accordingly, we can not plot them on the map as Triassic formations and, what is more, limestones near Çeşme formerly marked down as Triassic, now are known to belong to the Jurassic.

Jurassic. — Fossiliferous limestones of the Jurassic are widespread in our district. The fossils listed below, and determined by C. Öztemür, come from white crystalline limestones, pink limestones and dolomitic limestones occurring SW of Çeşme (strike N 40° E, dip 41° SE).

Coskinolinopsis a.ff.primaveus Henson
Orbitopsella sp.
Spirocyclina sp.
Textularia
 Miliolidae

Mrs. Utarit Bilgütay detected *Pseudovermiporella* in the white compact limestones and also in the brown stratified limestones that occur in the Köste Peninsula, north of Çeşme.

In a formation of dark-grey limestones striking N 20° E and dipping 44° NW, east of Boş Island, C. Öztemür determined the following fossils :

Pseudocyclarnmina
Lituola
 Dasycladacea

To the southeast of Gerence, limestones with dark - grey, hard crystalline calcite veins, conformably underlying fossiliferous limestone beds, are found to contain :

Textularia
Nodosaria
Oligostegina
Radiolaria
 Ostracoda

and placed in the Jurassic, which goes to show the existence of Jurassic limestones stretching from Gerence to Narlıca in a N-S direction.

Cretaceous. — Compact Cretaceous limestones, white, grey, brown and pink in color, conformably overlie Jurassic limestones indicating that the comprehensive series which probably begins in the Upper Triassic continues to the end of the Turonian. This latter, in turn, is overlain by the Maestrichtian limestones beginning with a basal conglomerate.

Lower Cretaceous. — It is hard to distinguish the Jurassic formations from the white, brown, compact (also stratified) Lower Cretaceous limestones they conformably overlie. These Lower Cretaceous beds dipping east cover wide areas in the district and are often fossiliferous. They are conformably overlain by the Cenonian deposits. The limestones, grey outside and light - grey inside, occasionally creamy, striking N 30°W and dipping 54° SW form high, pointed hills west of Çatalkaya (map-section 86/1) and contain the following fossils, determined by V. Ginkel:

Verneulinidae : (cf. *Dukhanio*)
 Miliolidae:
 Orbitolinidae:
 Lituolidae or Orbitolinidae : *Hauarani?*
 (*Coskinolinoides*)
 Lituolidae : *Haplophragmium*
 Lagenidae : *Robulus* or *Lenticulina*
 Ammodiscidae : *Glomospira*, *Turritella*

Same fossils are encountered between the Jurassic and Upper Cretaceous sediments in several places within the district, making it possible to outline the area (if only probably) occupied, by the Lower Cretaceous deposits.

Upper Cretaceous. — Upper Cretaceous begins with the Cenomanian and conformably overlies the Lower Cretaceous. Cenomanian-Turonian limestones, containing *Trocholina* cf. *lenticularis*, are widespread in the district. The Maestrichtian comes above these, on a basal conglomerate.

Cenomanian-Turonian. — Cenomanian - Turonian conformably overlies Lower Cretaceous and appears in limestone facies. From a wide area, separated from the andesites by a fault line running N-S in the east of the map-section 86/3, several rock samples showed *Trocholina* cf. *lenticularis*, indicative of Turonian age.

The fossils below (determined by V. Ginkel) occurred in brown, grey and white calcite veins lying south of the Urla mineral water springs :

Verneulinidae

Cornuspiridae : *Trocholina* (*Aulotortus*)
cf. *lenticularis*

Ellipsoidinidae

Further to the north, the following fossils of the Lower Cretaceous were found in black limestone beds dipping NE :

Verneulinidae

Lagenidae

Pithonella cf. *ovalis*

Glomospiridae : *Glomospira*

Trocholina cf. *lenticularis* was reported from a number of deposits and the corresponding areas were marked down as Cenomanian-Turonian. These deposits are the well-stratified grey limestones near the village of Nohutalan;

the brown and white limestones lying east of the village of Tatarçeşme; the beige-colored limestones at the village of Yağcılar north of Zeytineli village; the grey oolitic limestones at the village of Kovanlık and the grey, finely brecciated, limestones west of Oynatan.

Maestrichtian- — Pink-colored sandstones and limestones overlie a basal conglomerate of the same color, north of the Balıklıova village (map-section 86/1). The fossils (determined by V. Ginkel) that came from these deposits were :

Globotruncana cf. *linnei*

Globigerinella

Verneulinidae

Buliminidae

Overlying these pink limestones with *Globotruncana*, are white and brown beds and, still further up, marly-limy schists. Maestrichtian flysch covers these series to the east of our district. Within the district proper the flysch is not sufficiently pronounced to be mapped separately. Either no appreciable amount of it was deposited, in the first place, or the greater portion is already eroded out.

C. Neogene

Neogene begins with a pink-colored conglomerate overlying older rocks and continues upward with limestone, clay, marl, sand and sandstone layers intercalated with tuff horizons. They usually strike NW-SE in the map-section 86/1 and dip 5° to 10° NE. Their strike is not definable in the map-section 86/3 because of various fault lines cutting through that region. Besides the tuff beds intercalated in the Neogene sediments, siliceous layers and concretions are also observed. That these concretions must have to do with Neogene time volcanism is beyond doubt.

The fossils below were picked up in the vicinity of the town Karaburun by M. Akartuna and the corresponding area was mapped as Dacian. A number of them found also by us, could not be determined close enough for a definite age setting. So the area was simply marked down as Neogene.

Bulimus cf. *tentaculatus* L.

Melanopsis (*Canthidomus*) sp. (aff. ?
hybostoma Neum.)

Melania (*Melanoides*) *tuberculata*
Mull.

Lymnea (*Stagnicola*) sp. aff. *palustris*
corvus Gmel.

Planorbirius thiollierei Mich.

Alluviums

Within our district, areas covered by alluviums consist of the flat stretches near the sea shore. Balıklıova İskelesi, Çiftlikvillage, vicinity of Ilca are among them.

V. VOLCANISM

Volcanic rocks are common throughout the district and include mainly andesites, basalts and tuffs, Andesites begin at the coastal region, along the eastern side of the map-section 86/1, reach out to cover high hills, such as Velidağ and Kocadağ. In map-section 86/3 they again cover wide areas and high spots such as Ermeğan Mountain. They occur in all colors but generally dark. Most common varieties are hypersthene, hornblende and biotite andesites. These rocks show stratification in several places. with strikes in the direction of NNE. A typical example of flow layering, running NNE, is visible on the high andesite hills to the north of Kılıç creek. Basalts, in the map-section 86/1 occur over the wide stretch between the villages of Küçükbahçe and Yayla. Küçükbahçe village and vicinity is covered with basalts-containing olivine. Ground mass (a light flow structure) : plagioclase, glass and

augite. Phenocrysts : olivine (altered, serpentinized, calcitized) and minerals opaque under the microscope (as determined by K. Markus). Lath - shaped plagioclase cemented with augite makes the bulk of the compact basalt deposits near the village of Yayla. Individual, small size, ore veins or dikes cut through the main body. Basalt dikes near Kalecik show mercury ore mineralization. Basalt intrusions took place along the contact zones such as limestone-schist or limestone-graywacke, etc.

Tuffs generally occupy a large stretch of area in map-section 86/3 between Ilca in the west and Alaçatı part in the south, alternating in some places with Neogene sediments. In map-section 86/1 they lie between Kumburnu and Mordoğan.

Serpentine. — We can not definitely tell the age of the serpentines in the district. Serpentine veins are seen to cut through Cretaceous formations and are found associated with radiolarite. They occur dark - green to black and fractured. We assume that the magmatic activities responsible for the creation of these serpentines took place during the Cretaceous folding or the period immediately following it. It is most likely that they belong to the Upper Cretaceous.

VI. TECTONICS AND PALEOGEOGRAPHY

The oldest rocks belonging to the Devonian period, which were exposed to the Hersinian and Alpine orogenies, include various argillaceous schists, arkoses, graywackes, sandstones, conglomerates, quartzites and limestones. Conglomerates laid down in schists, must be deposited during the time when seas Became shallow. Same may be assumed in the case of arkoses. Limestones and argillaceous schists indicate periodic

deepening of the Devonian sea. The vertical fluctuation of the sea bottom must have been the cause of alternate layering noticed in these deposits. All the Devonian strata show perfect conformity among them, with gradual change, while passing from one into another. Lack of conformity was never observed in these Devonian sediments.

Differences of elasticity in different layers is the reason behind their somewhat dissimilar response to folding action. Devonian formations strike NNE and dip 30° to 60° . The Lower Carboniferous limestones overlying the Devonian strata bear witness both to stability and depth of the seas at the time of deposition. All of these series are unconformably overlain by the Mesozoic and the Mesozoic sea lasted till the end of the Turonian epoch, when it finally receded. The sea invaded the area once again during the Maestrichtian to drain out by the close of Late Cretaceous. Conformable Lower Carboniferous and Devonian strata were folded during the Hersinian orogeny, with folds running NNE.

Alpine movements. — Mesozoic and Neogene formations showing effects of the Alpine orogeny exist in the district. These sedimentary series were folded from time to time and came up from under the sea during the sub-Hersinian, Laramian and Rhodanian orogenic phases.

Local tectonics of the district may be summarized as follows : Old Paleozoic formations which the Hersinian folding brought out of the sea sank down again during the Late Triassic (possibly Jurassic).

At a locality called Örendere, in the northeast of the map-section 86/1, basal conglomerate of the Mesozoic may be seen overlying the Paleozoic. Till the

end of Turonian epoch this area must have been covered by the sea which subsequently receded to let the land emerge from the water in the course of the sub-Hersinian orogenic phase. A new transgression covered the region during the Maestrichtian. Upper layers of the Maestrichtian sediments were exposed to strong folding which gave birth to a number of small-size synclines and anticlines. This implies that the Alpine orogeny had taken place during the Late Cretaceous or a little later, while the rocks were still sufficiently soft and the Maestrichtian limestones could undergo such strong folding.

Forces acting during the Mesozoic folding in the Karaburun Peninsula were not unidirectional. Instead, they were localized and in most any direction. Some of folds showed NE and NW directions.

Neogene begins on older rocks with a red conglomerate overlain by marl, limestone, sandstone, clay and siliceous layers with intercalations of tuff. Although the Neogene formations should have a general northwesterly trend, because of all the tectonic movements during this period, coupled with physical characteristics of these rocks, namely their susceptibility to folding, no such trend in any one given direction could subsequently be observed. While the contrary prevailed, dipping changed from 10° - 25° .

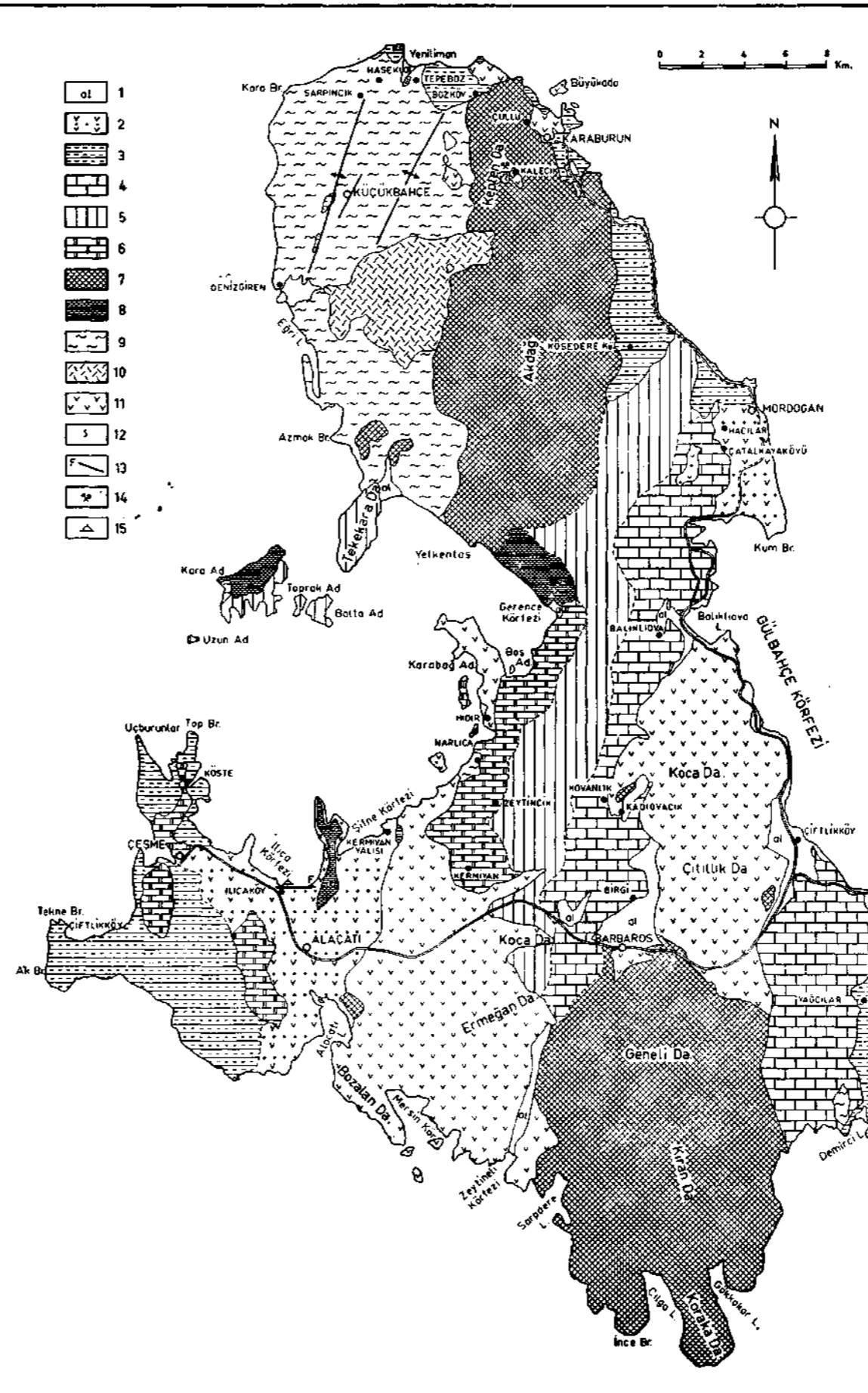
Neogene tuffs and limestones occur on both sides of the existing bays in the Karaburun Peninsula. These bays may be said to have taken shape during the Neogene or later.

M. Akartuna who worked in the eastern part of our district stated that the Pliocene and Miocene were unconformably superposed showing effects of the Alpine orogeny, effects more speci-

Geologic Map of the Karaburun Peninsula

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- 1 - Alluvium.
- 2 - Neogene volcanics.
- 3 - Continental Neogene sediments : Sandstone, marl, clay, limestone, siliceous concretions.
- 4 - Upper Cretaceous : Limy schist, compact, layered limestone.
- 5 - Lower Cretaceous : Brown layered limestone, white compact limestone.
- 6 - Jurassic : Pink compact limestone, layered limestone, dolomitic limestone.
- 7 - Mesozoic : Akdağ Series.
- 8 - Lower Carboniferous : White crystalline, compact limestone, layered brown limestone.
- 9 - Devonian : Conglomerate, graywacke, arkose, sandstone, schist, quartzite, limestone.
- 10 - Basalt.
- 11 - Andesite.
- 12 - Serpentine.
- 13 - Fault line.
- 14 - Mercury mine.
- 15 - Hot spring or mineral water spring.



fically pertaining to the Rhodanian phase.

Faults. — In map-section 86/1, a couple of fault lines lie E-W in the Mesozoic formations, south of Keplen Mountain. Another fault line, 2 km long, reaches south of Karaburun town, showing a hanging-wall, again in the Meso-

zoic formations. Limestones form a high hanging-wall on the andesite-limestone contact, east of Tatarçeşme, lying N-S in the map-section 86/3. Several of the faults were formed in the Neogene. Fault and shore lines coincide at İlica and in the Şifne Bay.

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