GEOLOGY OF THE WESTERN PART OF ANTALYA BAY*

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ABSTRACT. — Studies carried out in this area indicate that the Permian-Mesozoic limestone series, which were previously named the *Comprehensive series,* show various facies. Detailed chrono-stratigraphic studies of the rock-stratigraphy units of the area were carried out, based on the fossil content of the formations of various ages.

Stratigraphic deposition in the area shows that the oldest rocks encountered are limestones and dolomites of Permian age. Triassic rhythmic series, which conformably overlie the Permian formations, show various lithological types. This series is represented by sandstone, radiolarites and platy limestones. Liassic, Dogger and Malm are represented by reef limestones, oolitic limestones, dolomites and bedded biomicrite limestones, respectively.

Cretaceous is divided into two sub-systems: namely, Lower Cretaceous and Upper Cretaceous. Lower Cretaceous formations are represented by white-colored reef limestones. Upper Cretaceous, on the other hand, consists of thick-bedded and crystallized limestones and dolomites. These formations, as a whole, show a marine facies.

Tertiary formations are characterized by Pliocene polymictic conglomerates and Quaternary coarse-grained conglomerates of the orthoconglomerate type, and by slope breccia, talus cones and alluvium. Igneous rocks occurring in the area under investigation consist of peridotite, gabbro, verlite, serpentinized harzburgite and serpentine contained within the Triassic ophiolitic series. These are ophiolites of alpine type found in the folded geosynclines. Triassic extrusives, on the other hand, mainly consist of pillow lavas, spilites, keratophyres, albite dolerites and diabases. The pillow lavas and the porphyritic lavas gave the beds their characteristic form. These rocks were deposited within the Triassic formations prior to the solidification of the Triassic deposits.

The tectonic structure of the area under investigation is characterized by numerous faults, upthrusts, overthrusts and imbricate structures. Tectonic units, namely anticlines and synclines which are found in a successive sequence, generally strike sub-parallelly to the western coast of the Antalya Bay. The deposition and facies of beds and the axis and strike of the folding indicate that the tectonic structure of the area is not complex; it is characterized by simple imbricate structures.

Based on the evaluation of the measured strike and dip of the beds on the Schmidt diagrams, it was found that the directions of the folding axes of the Permian, Triassic and Malm formations show a conformity. However a distinct deviation is observed in the Liassic formations. Lower Kimmeridgian, Austrian, Laramian and Wallachian orogenic phases are also found in the area.

INTRODUCTION

The area under investigation covers the 1:25,000-scale Antalya 024-b_3 and 024-a_4 sheets. The object of this paper is the clarification of the Stratigraphic deposition and tectonic structure of the area and was prepared as a doctorate thesis, under the supervision of Prof. Dr. Fuat Baykal, Director of the Geology Department, University of Istanbul. Initial work on the preparation of this study was carried out in the period between 1964-1965. Interesting features of the stratigraphy and tectonics of the area and the encouragement and assistance extended by Prof. Dr. Fuat Baykal, led the author of this text to continue his works in 1971 and 1972.

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I. GEOGRAPHY, MORPHOLOGY AND HYDROGRAPHY

The area under investigation, which covers approximately 280 km^2, is situated in the western part of the Antalya Bay in Southern Anatolia. It is a mountainous region lying between 36°45'00"-36°52'30" mer. and 30°22'33"-30°37'30" par. The area is bordered by the Mediterranean Sea in the east; Alakır Çay Valley and Bakırlı Dağ in the west; alluvial areas in the vicinity of the Çakırlar township, Geyik Bayır village-Doyran Stream in the north; and Çamdağ, Sarıçınar Dağ and Göl Stream in the south. This area covers the 1:25,000-scale', 0 24-b_3 and 0 25-a_4 sheets. It is located west of the Antalya Bay and is characterized by steep peaks along the coastline. High mountain ranges and deep valleys, resembling alpine scenery, form the morphological structure of the area, which is quite inaccessible. Sharp morphological forms and limestone escarpments caused by imbricate structures and faulting give the area a very wild and peculiar appearance. The important mountains located within the area, from west to east, are given below: Ziyaret Tepe (2422 m), Bereket Dag (2648 m), Karadağ (1959 m), Çürük Tepe (1640 m), Sivri Dağ (1834 m), İncegeriş Tepe (1630 m), Girevit Dag (911 m), Sivridağ Tepe (1413 m), Şalbalı Dağ (1651 m), Tastaratacağı Tepe (1568 m), and along the coastline Tümek Tepe (618 m), Karıncalı Dağ (1321 m) and Yumrucak Tepe (452 m).

The high limestone mountains located in the area are cut by deep valleys which caused the formation of individual peaks; erosion is very recent. Due to faulting, mountains which are mostly covered with massive, thick-bedded limestone formed escarpments several hundred meters high. These mountains are very steep and were strongly eroded forming «minaret»-shaped structures. In some places the mountains, which start sharply along the coastline, reach as much as 1300 m in height. Deep valleys are found between the mountain ranges, extending in the NE-SW direction. Valleys located between the mountains, which are covered with sub-reef limestone, are overlain by detritic series and ophiolitic facies.

To the west of the area plateaus located some 1500-2000 m above the sea level are observed. Underlying them, layers of easily eroded detritic facies are found. The plateaus are surrounded by high ridges. Karstic forms, such as caverns, dead caves, clints, poljes and dolines, are observed in the limestone strata. The area is highly accidental and the limestone hills form the main topographic feature of the area. Limestone beds cover the steep cliffs; Triassic rhythmic formations, on the other hand, occur on the gently dipping slopes. These rocks form high plateaus such as Fesligen Yaylası, some 1800-1900 m above the sea level. Valleys located within the limestone and serpentine are V-shaped. No upfolding was observed in the area along the Çandır Çayı; the tributaries are connected vertically.

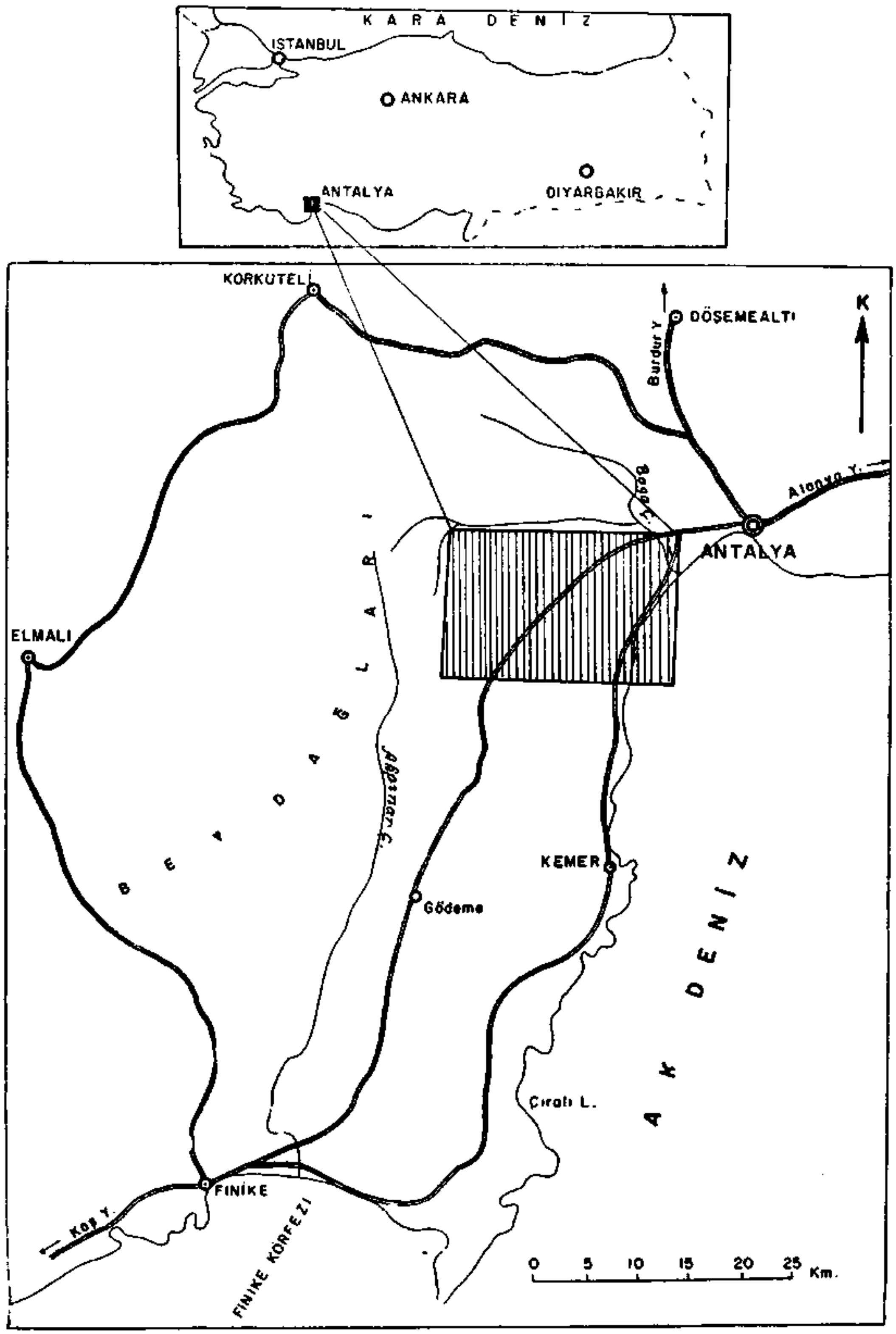

Fig. 1 - Geographic location map of the investigated area.

The hydrographic network of the area under investigation consists of Boğa Çayı, which flows into the sea in the northeastern part of the area (22A), as well as numerous minor streams, springs and brooks that are dry in summer. Most of the streams flow parallelly to the strike of the morphology of the mountain ranges. Due to its great load Boğa Çayı forms a dendritic drainage pattern at its mouth. Çandır Çay (13E), which is a tributary of the Boğa Çayı, flows in the SW-NE direction across the entire area. There are numerous waterfalls along the course of the Çandır Çay which contains water in all seasons. This stream flows through a narrow valley and its source is located in the vicinity of Dört Çam Gediği in the southern part of the area. The tributaries of the Bayır Dere and the Sinan Değirmeni Dere flow into Çandır Çay and take the name of Boğa Çayı. Çandır Çayı pours into the sea from an elevation of 700 m; the flow rate of this stream is very high. It flows through a narrow gorge in the Köprücü Ağzı locality (9H). The stream forms buried meanders in this area. Terraces located in the valley are strongly eroded. Due to the fact that the bed of the,Çandır Çay is deeply seated, the tributaries of this river are suspended at Köprücü Gorge. Frequent uplifting took place during Quaternary; at the same time the beds of major streams were deeply cut during this period. The original beds of the tributaries pass through the alluvial land. This alluvium shows recent dissection. Backward erosion caused by the trunk stream or its branches is not observed in the area.

The network of valleys is very dense in the area where the coarse-grained Quaternary conglomerates occur. The steep flanks of valleys were strongly eroded and as a result an old limestone surface was exposed. Terraces are observed at the bottom of the wide valleys.

Inaccessible steep valleys cut vertically the morphological strike of the mountains. These are: Koyun Çukuru (14M) and Yarma Gorge; in addition numerous streams, such as Acısu Deresi (17H), Belama Deresi, Gökçevik Boğaz Deresi and Karadeniz Boğaz Deresi are observed along the coastline. These rivers cut the structural lines vertically. Gökdere Çay flows through the central part of the 0-25-a_4 sheet and is fed by resurgent waters (sources vauclusiennes) coming from the limestone strata. The springs located in the Karıncalı Dağ and Sivridağ Tepe limestones of Upper Jurassic and Upper Cretaceous age have a high discharge of water. The catchment area of this river is located 1400 m above the sea level. The Çalbalı Deresi (8A), which is located north of the area, and whose catchment basin is situated in the area between Sivridağ and Karadağ, flows in the W-E direction, after passing through Çağlarca Mahallesi, and then joins Çandır Çayı in the vicinity of Körler Mahallesi (15B); the river flows in all seasons.

II. PREVIOUS INVESTIGATIONS

This region was geologically investigated since many years ago. However these studies were mainly dedicated to the general features of the area.

It was first investigated by Spratt and Forbes (1847). In 1869 Tchihatcheff described the general geology of the area in his work entitled «Asie Mineure». Tietze (1885) prepared the geological map of the Lycia region (SW Turkey).

During the following years the area was investigated by Philippson (1912-1918), Penck (1913) and later by Taşman (1930), Maxson (1937) and Mankiewicz (1946).

More detailed study of the area was made during the recent years by the following authors: E. Altınlı (1944), H. Colin (1955), H. Holzer (1955) and H. Flügel (1961). Altınlı, in his work on the northern part of the area, describes the difficulties to be faced in distinguishing the stratigraphical units. According to Altınlı, this is due to facies similarities. The author assigned Cenomanian age to the fine-grained, gray-colored and slightly bituminous limestones overlying the unit, which consists of sandstone, limestone, radiolarite, silicified schist, and quartzite. Altınlı called this unit—which is more than 1000 meters thick—the «Flysch-like series». He indicates that there does not exist any unconformity between Senonian limestones, which contain Globotruncana, and the underlying limestone stratum, which is 500 meters thick. According to the author, Eocene beds overlie these formations with an unconformity. In his opinion, the Alpine paroxysm movements took place probably during the Pyrenean phase. He reports further that the Hercynian folds strike NW-SE, while alpine folds strike in the NW-SE and NE-SW directions in the eastern and western parts of the Antalya Bay.

H. Colin (1955), in his work on the area under investigation, described the presence of two separate Mesozoic series, which he called *Elmalı series* and *Lycia series* (Littoral series). He assigned Cretaceous age to the Lycia series, based on the fact that this series, which consists of reef limestones, shows horizontal transition into the cherty limestone series, cherts and sandstones; furthermore, this theory is supported by the presence of interbedded basic extrusives.

H. Holzer (1955), who investigated the western and southwestern parts of the area, indicates that the reef limestone series which form the coastal ranges are massive and were in part slightly recrystallized; endogenic syngenetic breccia were also observed locally by the author. Based on the presence of abundant hornstein in this area, he named this flysch-like series the *Hornstein series.* According to this author, the lateral transition between this series and the massif limestone series was observed here, and it is highly possible that these two series are of the same age.

H. Flügel (1961), who investigated the area located in the vicinity of Elmalı, changed the name assigned to the gray-green-colored and partly flysch-like rocks—which were previously called the «Schist-Hornstein Series,*—and called them *Dirmil schists* based on his idea that the mother rock in the area does not consist entirely of hornstein. Flügel also indicates that the dolomites, occurring along the Korkuteli road, belong tho the flysch-like series and were intermixed with other rocks by tectonic movements.

Following these studies and until 1964 no new geological investigations were carried out in the Antalya region. In 1964, work on the preparation of the 1:25,000-scale geological map of the Antalya region was initiated by the M.T.A. Institute. The age of this formation—which was previously named by various geologists who investigated the areas as the «Flysch-like series», «Schist-hornstein series», «Hornstein series or «Dirmil series («Triassic rhythmic series», according to the author of the present paper)—was thought to be Liassic, Lower Cretaceous or Upper Cretaceous, and it was accepted that this series shows lateral transition with the limestone strata occurring along the coastline (Holzer, Colin, Flügel).

M. Blumenthal (1963) assumed that the «schisto-radiolaritic formations, and the reef limestones of the coastal ranges are of Upper Cretaceous age, and it was established that these rocks are autochthonous. Based on the recent studies, the following conclusions were reached:

1. Rhythmic Triassic formations, which were assigned different ages and names, start with a sandstone facies in ttye lower part; the middle part of the formation is represented by radiolarite-bearing cherts; and the upper part consists of limestones showing pelagic facies. There does not exist any similarity between the formation in question and the flysch facies; therefore terms such as «Schist-hornstein series or «Dirmil schists» are not appropriate.

2. Based on the macro and microfossils identified in various levels, Ladinian and Carnian age was attributed to this formation. Neither Jurassic nor Upper Cretaceous can be assigned to this rhythmic series.

3. The assumption that the rhythmic Triassic formations and the massive limestones show lateral transition is not correct. In fact, the massive limestones (not entirely massive: in particular the Upper Jurassic formations are well-bedded) are Liassic, Dogger, Malm, Lower Cretaceous and Upper Cretaceous in age and overlie the Triassic beds with an unconformity.

Recent investigations: Since 1964 French geologists, who worked on the preparation of 1:25,000-scale geological map of the surrounding area—namely the lakes located to the north; Kumluca and Finike to the south; and Alakırçay-Beydağları and Korkuteli to the west of our area—publish from time to time the results of their studies. In these publications', R. Lefevre (1967), and J. Marco and R. Lefevre (1970) indicated that the Triassic rhythmical formations formed a nappe structure upon the Upper Cretaceous formations of Beydağları (Lower Antalya Nappe); the limestone formations occurring at the coastal ranges, on the other hand, form a second nappe structure (Upper Antalya Nappe) upon the Triassic formations.

These authors claim that the roots of the nappes are located towards the sea, based on the fact that the Beydağları Upper Cretaceous formations are autochthonous, while the other formations, Triassic-Jurassic and Cretaceous, are allochthonous. Furthermore, they assumed that the Permian limestones of the Upper Antalya Nappe were thrust over the Triassic formations.

Our opinion on this subject is as follows: Triassic rhythmic formations, occurring within the area under investigation, do not overlie the Cretaceous. These formations overlie the serpentines transgressively, and, although the same beds rest upon the Permian limestones along the coastline with a conformity, they still show a transgressive character. The lower parts of the Permian formations, several hundred meters thick, can be clearly seen on the Pamu9ak Plateau, located just south of our area. The formation extends as far as the Devonian. The Permian formations are overlain by Triassic beds and are not considered to be a separate allochthonous series—that is, they are not a part of the limestone series included in the Upper Antalya Nappe. The imbricate structures and the abnormal position between the massive limestones and Triassic formations observed in some parts of the area cannot be considered to be a nappe structure. It will be more logical to describe these abnormal tectonic structures as due to thrust faulting, upthrusting and imbrexes.

The presence of Senonian (Upper Cretaceous) limestones, overlying the Cenomanian formations, to the north of the area in question, indicates that reef limestone beds of Cenomanian age, which rest upon the Triassic formations, cannot form a nappe structure. Senonian formations show the same facies character and age as the Beydağları limestones. Thus, it may be clearly understood that the stratigraphical sequence observed in the area is normal. It is also very interesting that the microfaunal content of the Mezosoic limestones occurring in the vicinity of Akseki, Anamas Dağ and Isparta, NE of our area, and the microfaunal content of the Mezosoic limestones in question are similar. Since the Mesozoic formations found in these regions are assumed to be autochthonous, the Mesozoic formations located within our area and showing the same biofacies must also be autochthonous. That is, these formations were deposited at the Tethys geosyncline; the facies changes observed locally are due to the distance between the coast and the deposition environment and the type of material transported. Apart from these there does not exist any evidence indicating a nappe structure in the area. Actually, the «surface tectonics» is the dominant feature of the entire Antalya region—deep and wide deformations were not formed at the bottom. Only the younger formations were displaced in the form of imbricate structure.

III. HISTORICAL GEOLOGY

Stratigraphical deposition in the area under investigation consists of Paleozoic (Permian), Mesozoic (Triassic, Jurassic, Cretaceous), Tertiary (Pliocene) and Quaternary formations (Ann. I, II, III).

A. PALEOZOIC

Paleozoic formations occurring in this area are represented by Permian limestones and dolomites.

Permian

The oldest formations in the area are Permian limestones. These consist of schistose limestones in the lower part, sandy limestones in the middle part, and dolomites in the upper part. The basement of the Permian formations is not visible, the upper part, on the other hand, grades into Triassic sandstones. The Permian formations occurring in the area are divided into two formations, namely: 1) Dinek limestones and 2) Fesliğen dolomites.

1. Dinek limestones. — They are best seen in the vicinity of Dinek Çeşme (20G) and are called after this locality. Outcrops are exposed in the following localities: in the west, in the area between Erendağ and Fesliğen Plateau and Karadağ, and between Keş Dağ (6D) and Sivridağ (8D); in the east, between Sivridağ Tepe (13İ) and Kanncalı Tepe(15İ); and in the Dinek Çeşmesi locality situated along the coastline. The outcrops occupy an area approximately 5 km^2 From a distance Dinek limestones have the appearence of dark-colored well-stratified beds. Outcrops are generally located on the flanks of the mountains. On the western flank of Sivridağ they form characteristic humps (Pl. IX, photo 26). At a close distance it may be observed that the color of the formation varies between black to gray. The formation has fine-crystalline texture and its surface is very smooth. The thickness of the layers varies between 5 to 25 cm. Cleavage is observed in the form of thick plates. Well-preserved fossils were not encountered.

Permian limestones are underlain by quartzites in the southern part of the area. This formation attains a total thickness of over 1000 meters, of which 200 meters are visible in the surveyed area. Dolomites overlie the formation conformably. In the vicinity of Dinek Çeşme and along the coastline (20G), the formation starts with schistose limestones in the lower part and upwards passes into well-bedded, fossiliferous limestones. The limestone strata, which dips N 25°E, 25°NW, is overlain by gray-colored Fesliğen dolomites striking in the same direction. In the uppermost part the Triassic limonitic sandstones containing plant remnants are observed. The contacts between the formations are conformable (Fig. 2).

The following microfossils were collected from an outcrop in Dinek Çeşme:

Geinitzina sp.
Robuloides sp.
Hemigordius sp.
Frpndicularia sp.
Lingulina sp.
Ammodiscus sp.
Mizzia velebitana Schubert

Based on this microfauna, Middle Permian age was assigned to these limestones.

In another sample the following Middle Permian microfauna was identified:

Nodosaridae
Embergerella sp.
Glomospirella sp.
Gymnocodium sp.
Ostracoda

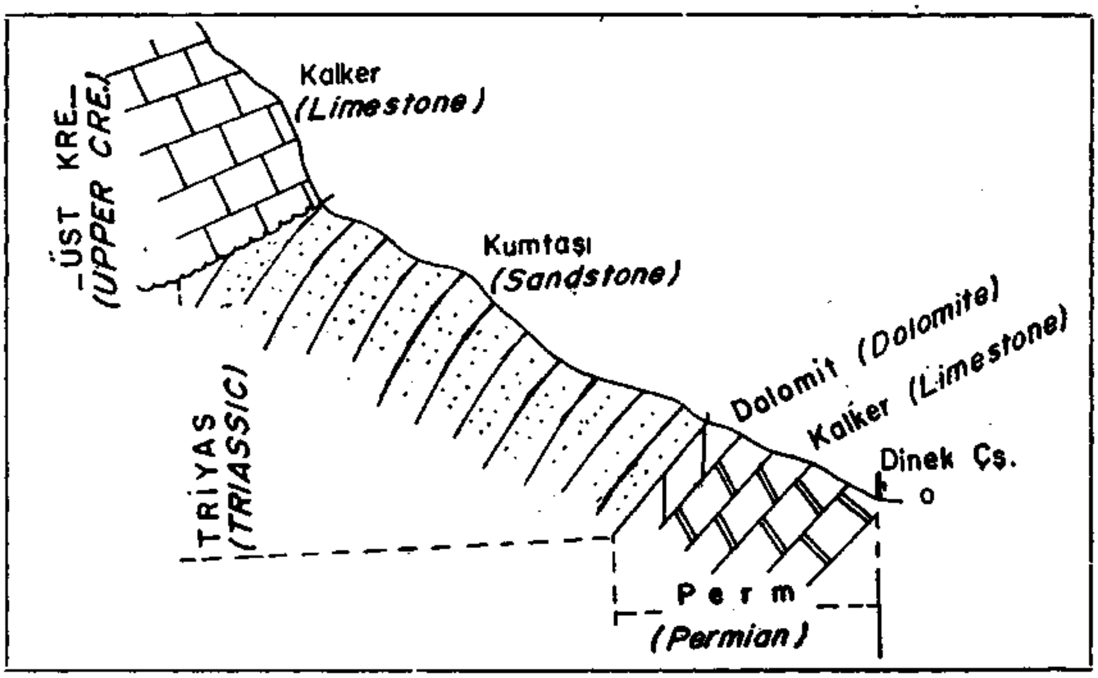

Fig. 2 - Schematic cross section showing relationship between the Permian, Triassic and Upper Cretaceous formations in the west of Dinek Çeşmesi.

Some more fossils taken from the upper levels of these beds were identified by E. Çatal, who assigned an Upper Permian age to this formation:

Paleotextnlaria sp.
Pachyphloia sp.
Staffella sp.
Climacammina sp.
Gymnocodium sp.

Based on these studies Middle-Upper Permian age was assigned to the limestone strata of the Dinek Çeşmesi. The contacts between the Dinek limestones, located along the coastline, and the Upper Jurassic dolomites, are faulted. Both of the limestones are mylonitized along the contacts. The Permian limestones in the form of wedges intruded the Malm dolomites (Pl. IX, photo 24).

The results obtained from the sedimentological studies of the thin sections of the samples collected from the exposures located in this area are given below:

The rock is mainly biomicrite. Small shell fragments and allochems of Bryozoa and Foraminifera are also observed. The inner parts of the Brachiopoda are filled with secondary calcite. Furthermore, secondary iron oxide staining is also noticed. Stylolitic limits can be seen. Facies was developed in a stable environment.

The second exposure of this formation is located in the area between Sivridağ (13İ) and Kanncali Dag (15J), situated south of Gedeller Mahallesi. The exposures are lithologically similar. The lower levels of the fine- to medium-grained, black-colored limestone strata cannot be seen, it is overlain by Fesliğen dolomites. The Permian formations are generally overlain by Triassic detritic formations in the west, and by the Malm Karınçalı formation in the eastern part of the area. limestones, which in this area form the core of the anticline, are overlain by a thin layer of dolomites. The top of the anticline is eroded, whereas the flanks are overlain by the Triassic detritic formations in the west, and the Malm dolomites and limestones in the east. The micropaleontological study of the samples collected from this area revealed the presence of the following microfauna:

Pachyphloia sp.
Globivalvulina sp.
Nodosaria sp.
Geinitzina sp.
Staffella sp.
Climacammina sp.
Paleotextularia sp.
Embergerella sp.
Glomospirella sp.
Permocalculus anatoliensis Güvenç
Gymnocodium sp.
Ostracoda

E. Çatal, who studied these microfossils, assigned an Upper Permian age to this formations.

The microfacies is represented here by dark-colored biomicrites. Dinek limestones are the oldest rocks of the area and they occupy the lowermost parts of the geological sequence. In other terms, these limestones were not deposited as a result of any tectonic disturbance, while other Permian limestones encountered in this area were uplifted to the surface due to tectonic movements — for example, an imbrex of Permian age observed to the west of Sivridağ (9D). These black-colored, well-bedded limestones, some 3 to 30 cm thick, are intercalated between the Triassic extrusives and the Liassic Girevit limestones. The limestone beds, which dip N 10°-40°E and 40°-60°SE were thrust over the Girevit limestones along the NE-SW-striking fault. An other example of an abnormal contact was observed between the Triassic extrusives and the Dinek limestones which overlie them (Fig. 3).

Some samples were taken from the lower levels of these limestones, at a depth of 150 m. According to the microfauna encountered in these samples a Middle-Upper Permian age (probably Upper Permian) was assigned to the above beds. The following fossils were identified:

Schwagerina sp.
Polydiexodina sp.
Climacammina sp.
Ammodiscus sp.
Lingulina sp.

Some 20 meters higher above these beds, the following microfauna was collected and determinations made:

Polydiexodina sp.
Parafnsulina sp.
Monodiexodina sp.
Codonofusiella sp.
Globivalvulina sp.

Based on these microfossils, an Upper Permian age was assigned to the lower levels of the formation. Microfacies is represented by biomicrites (PL. I, photo 1, 2).

The following microfauna were identified in the samples taken from the higher levels, to which an Upper Permian age was assigned:

Pachyphloia sp.
Globivalvulina sp.
Globivalvulina vonderschmidti Reichel
Glomospirella sp.
Staffellininae
Hemigordiopsis sp.
Agathammina sp.
Nodosaria sp.
Permocalculus sp.

Microfacies is represented by black-colored biomicrites.

Another exposure of the Dinek limestones is observed west of Erendağ (2E) (Ann. I, II). In this area, Dinek limestones and the overlying Fesliğen dolomites are interbedded in the Triassic and Liassic formations. The limestones, which are well-bedded and black-colored, contain abundant Fusulinids; they overlie the Triassic for a distance of 5 km. Dinek limestones strike NE-SW and dip 25°-30°NW along a N-S-striking thrust line; this thrusting was directed from NW. The upper part of the limestone strata changes its color gradually and grades into Fesliğen dolomites, which are unconformably overlain by the Liassic Girevit limestones (Fig. 3).

E. (Çatal identified the following microfossils in the samples takerf from the lower levels of the limestone strata located in Erendağ:

Schwagerina sp.
Paleotextularia sp.
Climacammina sp.
Lingulina sp.

This microfacies is represented by recrystallized biomicrite.

Towards the upper parts of the formation the following microfauna was collected from the light-colored limestones to which Upper Permian age was assigned (Pl. IV, photo 10):

Staffellininae
Hemigordiopsis sp.
Agathammina sp.
Nodosaria sp.
Staffella sp.
Parafusulina sp.
Climacammina sp.
Polydioexodina sp.
Verbeekina sp.
Mizzia cornuta Kochansky & Herak
Permocalculus anatoliensis Güvenç

This microfacies is represented by biomicrites which contain Ostracoda, shell fragments and Foraminifera (Pl. I, photo 3).

Chronostratigraphically, the Dinek limestones are classified as Middle-Upper Permian. Although characteristic Lower Permian fossils are locally observed in the area under investigation, the Lower Permian strata are essentially located in the Pamuçak Plateau, just south of the area. In this locality the Permian formations attain a thickness of more than 1000 meters and consist of quartzites, shales and coal seams (1 m thick).

2. *Fesligen dolomites.* — Gray-colored, crystalline dolomites overlying the Dinek limestones are well seen in the Fesligen Plateau and are named the *Fesligen dolomites.*

Exposures of Fesligen dolomites are located south of Gedeller, east of the area under investigation; between Karıncalı Dağ and Sivridağ Tepe; and west of Dinek Çesmesi (20G). From a distance it is hard to distinguish the Fesliğen dolomites from the Dinek limestones, but due to their light color and thick beds they are easily distinguished when observed more closely. The dark-colored Dinek limestones occurring in the Fesliğen Plateau gradually change their color and become dark gray and finally light gray towards the surface.

The change of color is best seen in the area between Fesliğen Plateau and Erendağ, Dark- to light-gray-colored lithology is represented by dolomites. These dolomites are mostly crystalline and unfossiliferous; occassionally they contain remnants of Crinoids and crystallized *Mizzia* sp. The thickness of the Fesliğen dolomites is about 250 meters; their strike and dip are conformable with those of the underlying Dinek limestones (Fig. 3). In the Erendağ area, the Fesliğen dolomites are disconformably overlain by Liassic limestones (Girevit limestone) and by Upper Jurassic dolomites and limestones in the southern part of Gedeller.

Along the eastern coastline, in the vicinity of Dinek Çeşmesi, the thickness of the dolomites is only 20 meters. These dolomites are conformable with the underlying Dinek limestones and are overlain by detritic formations of Triassic age. Study of thin sections staken from the Fesliğen showed that these dolomites are of diagenetic origin; the presence of the original deposition texture and organic remnants led to this conclusion.

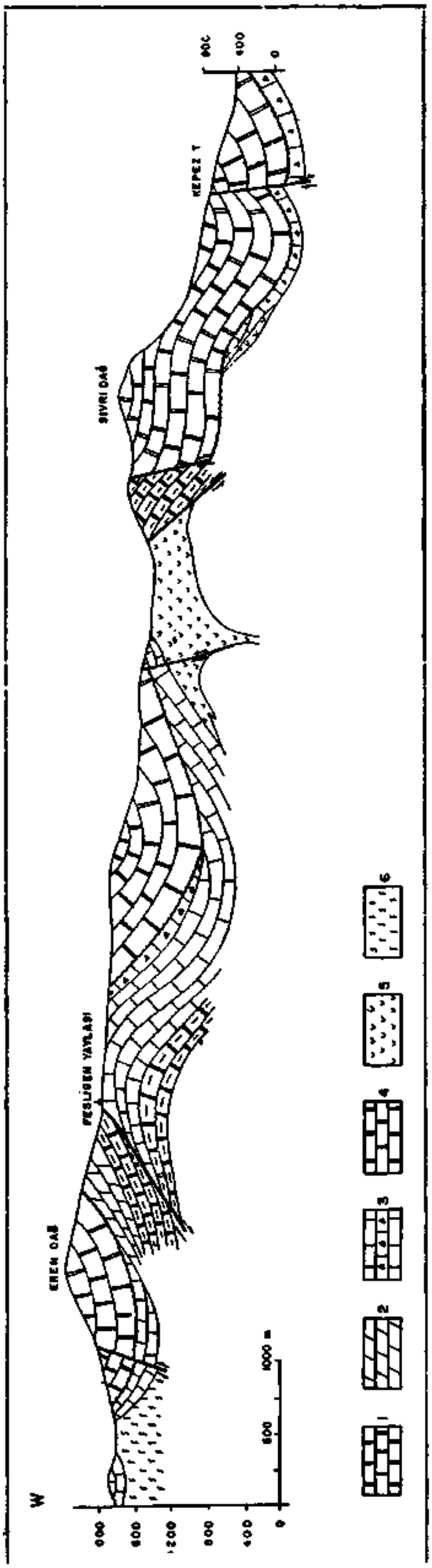

Fig. 3 - Geologic cross section between Erendağ and Sivridağ.

1 - Permian limestone; 2 - Permian dolomite; 3 - Triassic limestone, radiolarite; 4 - Liassic limestone; 5 - Alpine ophiolite extrusives; 6 - Serpentinite peridotite.

Extension of Permian formations in the neighboring areas

Exposures of Permian formations cover large" areas in the Pamuçak Plateau (west of Kemer), just south of the area under investigation. The thickness of the formation is approximately 1000 meters. Quartzites, shales, graywackes and coal seams, which constitute the lower levels of the Dinek limestones, are observed in this area. Another outcrop of the Dinek limestones can be seen at the Tahtalı Mountain, situated also in the south of our area.

S. Türkünal (1969), who studied the area between Beyşehir and Oymapınar in the Taurus Range, reported that the undifferentiated Permo-Carboniferous formations in this region were represented by rhythmic series composed of interbedded quartzite, shale, chert and sandstone bands.

Further to the east, in the Alanya massif, the Permian formations rest transgressively upon the metamorphic series. In the lower part these formations consist of well-bedded, gray to black-colored limestones containing *Mizzia velebitana,* closely resembling Dinek limestones, while in the upper part they are represented by gray-colored dolomites and dolomitic bauxite deposits, occurring in the form of large lenses. Studies carried out recently show that the white-colored limestones observed in the Alanya Kalesi are of Permian age. Permian formations (allochthonous) are also present in the limestone facies located further to the east in the area between Hadım and Bozkır. Going further to the east, in the area between Anamur and Ovacık, it may be observed that the Middle-Upper Permian formations, showing terrigenous and limestone facies, overlie the Devonian formation transgressively.

Detailed study of the Permian formations located in the western part of the area under investigation was carried out by P. de Graciansky (1967). The same formation was studied by the author who also visited this region. Permian formations exposed in the area between Karadağ, Nif and Kıloluk, north of Fethiye, consist mainly of limestone, sandstone, spilite, tuff, diabase, and red-colored breccia containing arkose fragments, and, in the upper layers, partly dolomitized limestones. This series is represented by a complex lithofacies and rests disconformably upon the Carboniferous.

From the descriptions above it may be noticed that the Permian formations are generally widespread in the Western Taurus Range and that they are of shallow-marine facies and display various lithological facies. The general transgressive character of Permian is not seen in our area. However, the fact that in many places in the Taurus Range the Permian starts with sandstones and quartzites (for instance on the Pamuçak Plateau, in the southern part of our area, where it overlies discordantly the Devonian formation), and then passes into a true marine facies, indicates that at the beginning of the Permian epoch an abrupt subsidence and an extensive transgression took place in the Taurus region. This facies indicates existence of a characteristic Middle Permian.

B. MESOZOIC

Triassic, Liassic, Dogger, Malm, Lower Cretaceous, and Upper Cretaceous formations are encountered in the area under investigation. These formations (including Permian), which were previously called the «Comprehensive series», are represented by a thick and monotonous limestone facies (excluding Triassic detritics and platy limestones). Although in places this series contains dolomites, it is difficult to distinguish lithologically. Only based on the identification of fossils and the results obtained from the study of the thin section of these rocks, the chronostratigraphy of the area was established and the litostratigraphical units were determined, taking as a basis the dolomites and brecciated layers occurring in various levels of this formation.

1. Triassic

The Triassic rhythmic formations occurring within the area are divided into three units; from base to top; a) Çandır formation; b) Tesbihli formation; and c) Gökdere formation. These formations are conformable with each other, show gradual horizontal or vertical transitions and cover an area of 70 km^2.

These Triassic rhythmic formations are widespread in the area under investigation; they were previously called by various authors as «Flysch-like series», «Schisto-radiolarite series» or «Dirmil schists». M. Blumenthal (1963), H.J. Colin (1962) and H. Holzer (1955) attributed an Upper Cretaceous age to these Triassic rhythmic series and to the reef limestones of the coastal range and called them the «Schisto-radiolarite series». However, in 1964 for the first time Halobia and Daonella were discovered by the present author in the chert lithosome encountered within the formation, and a Triassic age was assigned to this series.

The formation is very complex. Tectonic movements, which took place following the sedimentation, destroyed the original features of the formation. Due to the scarcity of the fossils contained in these rocks stratigraphical sequence is difficult to establish. The Triassic rhythmic series occur either in the form of symmetrical or asymmetrical rhythmic series. In general, Triassic series which show horizontal or vertical transition are divided into three lithosomes. These are from base to top: a) Sandstone lithosome; b) Radiolarite lithosome; c) Platy limestone lithosome.

Beds which constitute the formation, both lithologically and technically, show facies changes (Fig. 6, 7, 8, 9). These lithologic facies, which are repeatedly encountered at various levels, are classified in three units, as shown above. Triassic formations are mostly observed along the strike of anticlines and at the bottom of the valleys. Less rigid beds, which were affected by tectonic movements, are strongly folded and fractured. Most of the folds are asymmetrical and disharmonic. Although rare, recumbent folds and even imbricate structures are observed. Normal stratigraphical sequence is not encountered everywhere. In some places sandstone, radiolarite and limestone beds alternate with marls, sandstone, limestone and conglomerates; in other localities, sandstone and limestone occur in the form of an individual unit attaining a thickness of several hundred meters.

a. Çandır formation. — The Çandır formation covers an area of about 27 km^2 As it is best observed in the northern part of the Çandır Çay and on both of its banks (13E), the formation is named after this locality. Going from the west, exposures of this formation are also observed at the northern and western flanks of Erendağ, in the vicinity of Çandır Mahallesi, between Çınarcık and Armutçuk, north of Menekişler (10İ), east and west of Girevit Dağ (15E), in Gedeller Mahallesi, north of Sivridağ, west of Tahtacı and Körler Mahallesi (15A), and on the coastline west of Dinek Çeşme (20G).

Çandır formation overlies conformably the Permian limestones and is overlain, in turn, by a radiolarite-bearing chert formation. No fossils were found in the Çandır formation; it contains numerous sills of extrusive submarine lavas (PI. X, photo 29). Although plant remains were encountered in some of the layers they could not be determined. -

The formation is generally thick-bedded (PI. XI, photo 31) and grades into sandy limestone beds. In some localities, this formation alternates with radiolarite beds, while in the upper parts it gradually alternates with platy limestone beds. It occurs in the lower part of the thick Triassic rhythmic series, and its thickness varies between 300-600 meters. In the middle part of the formation alternations of marls and limestones are observed.

Çandır formation, which generally occurs on the flanks of the hills, consists of sandstone, sandy limestones and marls. Sandstone, which is dominant, occurs in the form of beds attaining some 100 cm in thickness. However it is thin-bedded when occurring in alternation with green-colored marls and silicified layers. The beds are generally yellowish, brown or sometimes gray-colored. They strike NE-SW and dip 20°-60°SE or NW. Microscopic investigation of the sandstones shows that they are predominantly graywacke or subgraywacke.

The sandstone layers, which overlie the Permian limestones and dolomites west of Dinek Çeşme (20G) along the coastline, are hard,-yellowish in color, and contain plant remnants; ripple marks are also observed. Sandstone layers are conformable with the Permian dolomites and are overlain by Cretaceous limestones. Microscopical examination of the rocks gave the following results (determination by Dr. S. Gökçen):

Cementing material: Ferruginous carbonate cement containing abundant clay.

Rock fragments: Very rare; they were not identified.

Minerals: (in order of abundance) quartz, feldspar-mica group; heavy minerals of the hornblende and epidote group; and ferruginous opaque minerals.

Sorting: Well-sorted.

Grains: Subrounded to rounded.

Rock type: Siltstone.

Sandstones observed south of Gedeller Mahallesi (14H) are also found in the valley between Sivridağ and Karıncalı Dağ, but contact with the Permian layers is not normally observed due to thrusting. Further to the west, in the Sivridağ area, they are thrust over the Upper Cretaceous limestones (Ann. II, P-IV). The boundary between the two formations is faulted.

Petrographical examination of the samples collected from this area gave the following results: The rock is a calcareous graywacke cemented by detritic fragments of serpentine, quartz, radiolarite, spilite and diallage.

In the area between the Çandır Çay and Girevit Dağ (15E) the Çandır formation (13E) is very thick and the outcrops are seen to continue on the eastern flank of the mountain. The lower part of the sandstone formation cannot be seen in this area; it strikes in the SW direction where it overlies the serpentines. Well-bedded sandstones strike NE-SW, and dip SE (25-50°). Thin layers of green-colored marls and limestones, sandy limestones, thin radiolarite layers and conglomerates are intercalated in the sandstones. Sandstone represents the dominant lithological feature. Extrusives in the form of sills (spilite and keratophyre) are widespread in the upper layers (Fig. 4).

Microscopic examination of a sample taken from the eastern part of the Girevit Mountain gave the following results: The rock is a graywacke; it consists of medium to fine-grained quartz, feldspar, schists, quartzite, hornstein, as well as fragments of magmatic rocks and garnet. These are cemented by sericite and quartz grains. Sandstones are interbedded with radiolarites, pink to whitish-colored marly limestones and extrusive submarine lavas (Fig. 5). These rocks strike in the NE-SW direction and show a distinct conformity with the general strike of the area. They are overlain with an angular unconformity by the Liassic reef limestones, but basal conglomerates are not observed between the two formations. In this area *Myophoria wohrmanni* Bitther are found in the lumachelle and sandy limestones. N. Karacabey, who determined this fossil, assigned a Lower Ladinian age to this formation. Due to the fact that Triassic stage begins with a sandstone facies, it may be presumed that a rapid transgression took place in the area. Furthermore the presence of angular grains in the sandstone facies indicates a rapid deposition. The presence of plant imprints and ripple marks, as well as the uufossiliferons nature of this formation, show that the Triassic stage started with a shallow-sea deposition.

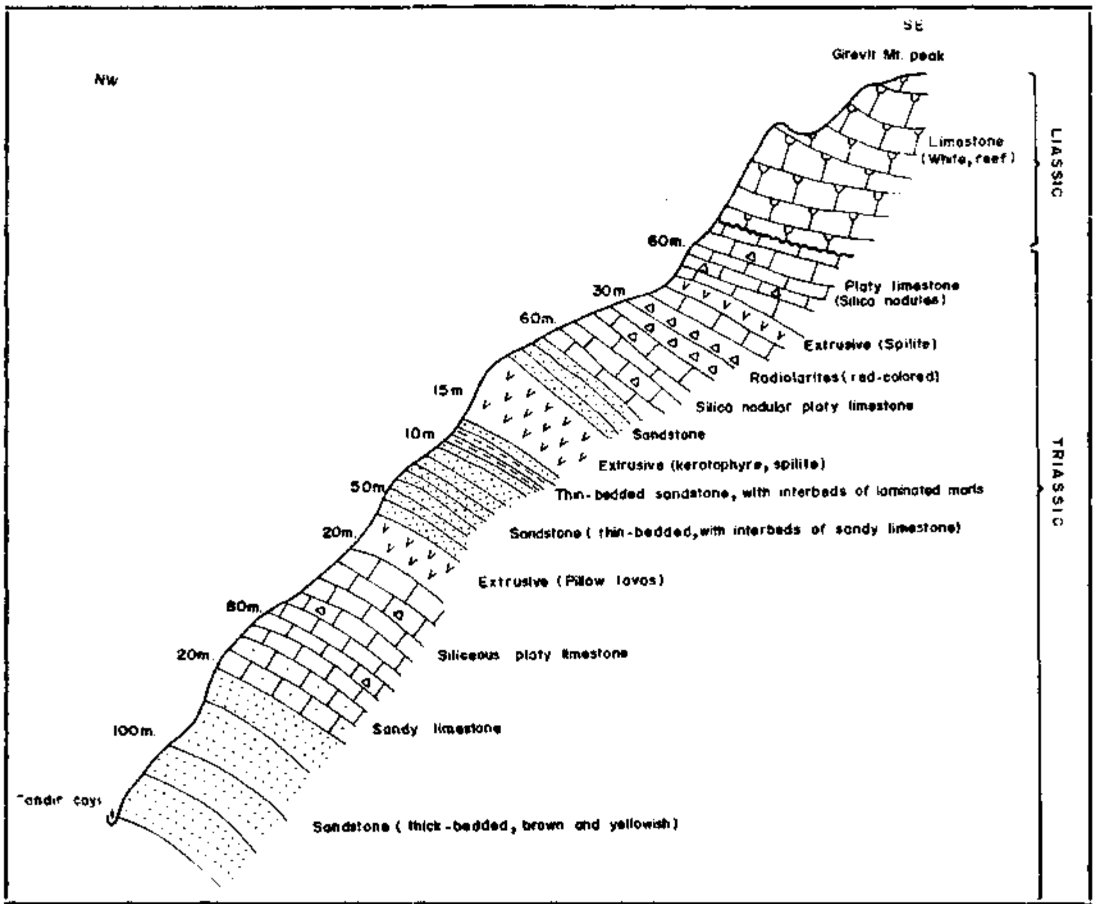

Fig. 4 - Schematic profile from the NW side of Girevit Dağ.

In the lower levels of the Çandır formation, radiolarite and limestone layers, as well as crystallized limestone blocks, 20-30 meters in length, are observed in places; these do not show continuity and grade horizontally into the sandstones.

Stratigraphical column and schematical sections of this formation are given in Figures 6, 7, 8 and 9.

b. Tesbihli formation. — This formation occupies an area of approximately 8 km^2. It is named *Tesbihli formation* because it is best observed in the neighborhood of Tesbihli Tepe (11İ). It is encountered in many places in various levels of the Triassic rhythmic series, but its greatest thickness occurs in the middle part of the Triassic. Exposures of this formation are observed in the following localities: On both sides of Sinan Değirmeni located north of the area (1A); in the area between Erendağ and Karadağ (5C); in the Çukurardıç locality (5D); south of Çalbalı Dere (8A); in the area between Akadamlar (14A)-K6rler Mahallesi (15A) and Sekli Tepe (13A); to the south of the studied area, between Çınarcık (6L)-Filler Mahallesi, and between Akçaisa (9K)-Armut9uk (7E); between Palaz Mevki (9N)-Şalbalı Dağ (13K) (in thin bands); east and west of Girevit Dağ (15E); and south of Gökdere (17F). In these areas the formation grades vertically or laterally into sandstones and limestones. The formation is mainly red-colored; in places, green, gray or black color can also be observed (Fig. 8 and 9).

The Tesbihli formation concordantly and gradually passes into the Çandır and Gökdere formations in the lower and upper parts, respectively. Its lithology is represented by cherts, radiolarites,

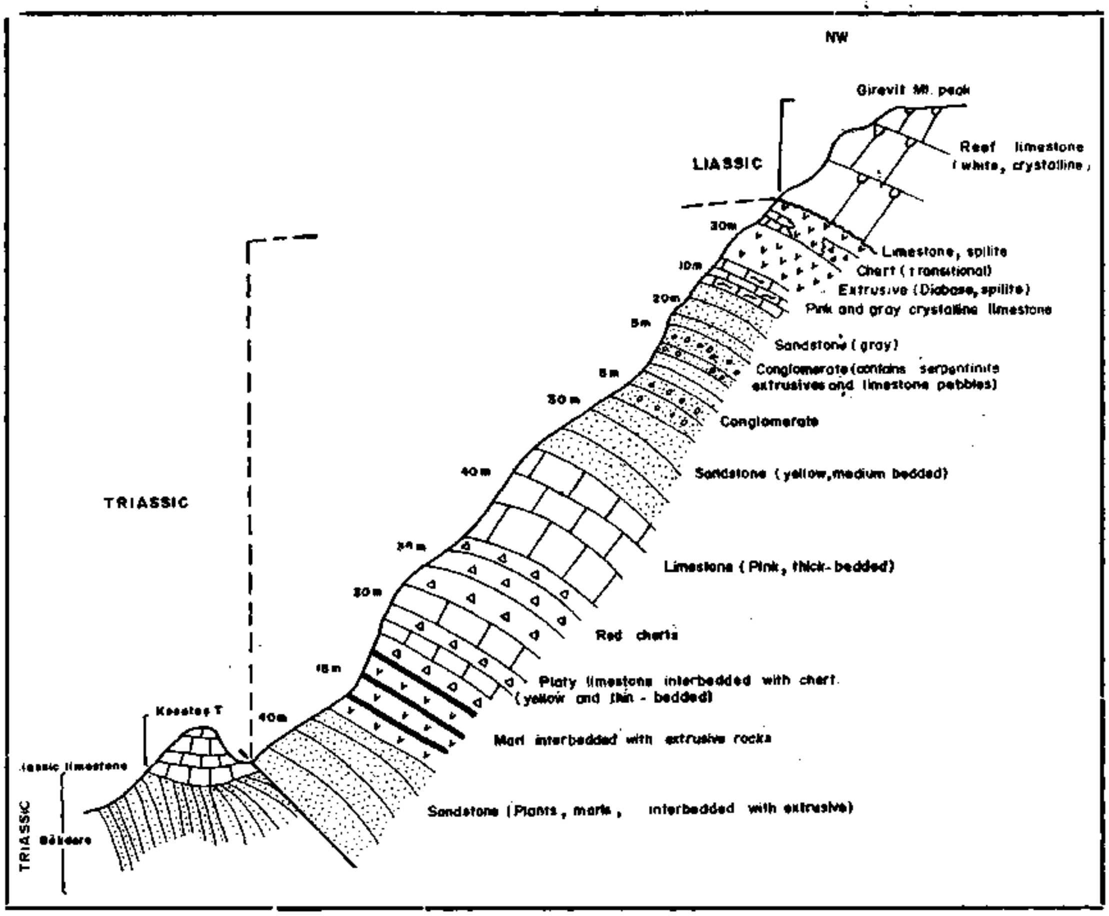

Fig. 5 - Schematic profile from the SE side of Girevit Dağ.

radiolarite-bearing cherts, green and brown-colored, thin bedded marls and clays, pink-colored and thin-bedded limestone, as well as grayish marly limestones.

The thickness of radiolarites varies between 40 to 60 meters. Total thickness of the formation including other rocks encountered in the area amounts to appr. 200 meters. However, thickness of the formation shows some local changes. Abundant Daonella and Halobia are found in various parts of the area under investigation. Particularly rich in fossils are the following localities: Deveboynu (16G)-Çınarcık Mahallesi (6L), Palamut Gediği (12K) and southern part of Tesbihli Tepe (10İ). Fossils collected from the strongly folded and fractured red radiolarites, located south of Tesbihli Tepe, were identified by Mrs. Suzanne Freneix from the Paleontological Institute of France, who attributed this formation to Ladinian, based on the presence in these beds of *Daonella indica* Bittner (Pl. IV, photo 11).

The following results were obtained from the study of thin sections of the radiolarites located in this area:

The rock is mainly radiolarite-bearing chert writh ground matrix consisting of silica and limonite; silicified material contains fine-grained quartz and chalcedony. The rock contains abundant radiolaria.

The Tesbihli formation within the Triassic rhythmic series is tectonically the most affected formation in the area; in places it is fractured, folded and strongly deformed (Pl. X, photo 28). The formation is not represented by continuous beds but is in the form of lenses, which attain sometimes 1 to 3 km in length. The general strike is in the NE-SW direction. Within this formation bituminous horizons and manganese ore beds are encountered.

c. Gökdere formation. — This formation occupies an area of 35 km^2. It is named *Gökdere formation* because it is best observed in the vicinity of Gökdere Boğazı (17F) where abundant fossils were found.

In many parts of the area the formation occurs in the uppermost levels of the Triassic rhythmic series and is exposed in the following localities: to the west and north of Ermelik Çukuru (1G), which is located NE of the area under investigation; between eastern part of Erendağ (2E) and Karadağ, and southwest of the Bereket Mountain (1S); in the large area between Şalbalı Mountain (13K) and Ak9aisa (9K); some outcrops are also observed between the Sivridağ and Çandır Çay and in the vicinity of Aktepe.

The formation consists of platy limestones containing silica nodules (Pl. X, photo 27). Thickness of the formation is between 400-600 m. Limestones, which are whitish to milky-white-colored or pinkish to gray-colored, contain silica lenses; in places radiolarite layers can be observed within these limestones. This formation—which horizontally or vertically grades into radiolarites in the lower part—shows gradual transition into sandy limestones in the Körler Mahallesi (15A), situated in the north of the area (Fig. 6). In the eastern part of the area, in the vicinity of Gökdere, Deveboynu Geçidi (16G), platy limestones which show lateral transition and are interbedded with radiolarites were observed. The beds strike N45°E and dip 56°NW (Fig. 7). The radiolarites contain abundant Halobia, Daonella and small Ammonites and are overlain by marly limestones and sediments with plant remains; the contact is abnormal since the formation is thrust here over the Upper Cretaceous and limestone beds (Ann. II, P-II).

Thin sections of fine-grained limestones with silica nodules were examined and the presence of the following fossils was established: *Nodosaria* sp., *Glomospira* sp., Duostominidae (Diplotremina?), *Radiolaria* sp., spicules, and pelagic lamellibranch fragments. Erol Öngüç, who determined these fossils, assigned them to a Triassic age. Macrofossils, such as Halobia, Daonella, and Ammonites *(Ceratites* sp.), were also found.

Sedimentological study of the thin sections of some samples showed that the rock is biocalcilutite (or aphanitic limestone). Biomicrite is generally well sorted and contains Radiolaria, Nodosaria and other small, deep-sea Foraminifera scattered in an orthochem consisting of thick calcareous ooze. Dolomitization is very slight and secondary calcite mosaic and stylolite structures, which do not change the original texture of the rocks, are also observed. Study of the rocks shows that calm marine conditions predominated in this area. One of the localities, where the Gökdere formation is best observed, is the southern part of Bereket Dag (1J). Here the formation starts with the underlying Triassic extrusives, towards the upper part pink-colored Triassic limestones are observed, while higher up come radiolarites. The thickness of the well-bedded, gray dolomitic limestones overlying the radiolarites is up to 5-40 cm; they are, in turn, overlain by layers of sandy or clayey limestones containing silica nodules. These limestones are gray or white'in color. The thickness of these limestone beds shows local changes between 5 to 20 cm; they have a NW-SE strike and 30-45°NE dip. The formation contains *Opthalmidium* sp., *Nodosaria* sp., *Radiolaria* sp., *Ammobacnlites* sp., spicules and lamellibranch fragments. Based on this fossil determination it is assumed that this formation belongs to a typical pelagic facies of Triassic age. The platy limestone beds containing silica nodules are overlain by fine-grained light gray limestones. While-colored massive crystalline limestones of Liassic age overly discordantly these series. No silica beds or lenses are observed in the limestones (Fig. 10).

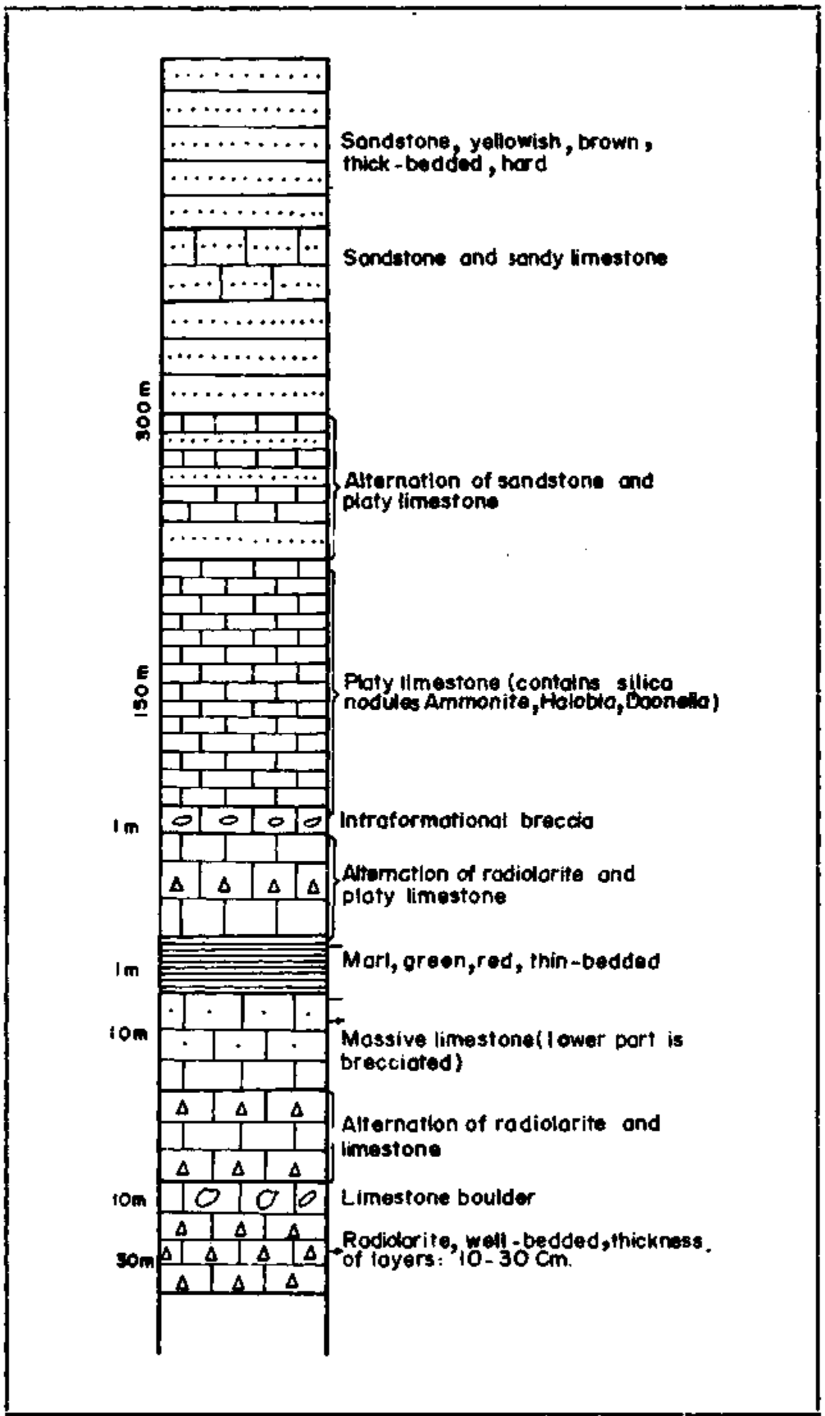

Fig. 6 - Triassic columnar section of Körler Mahallesi.

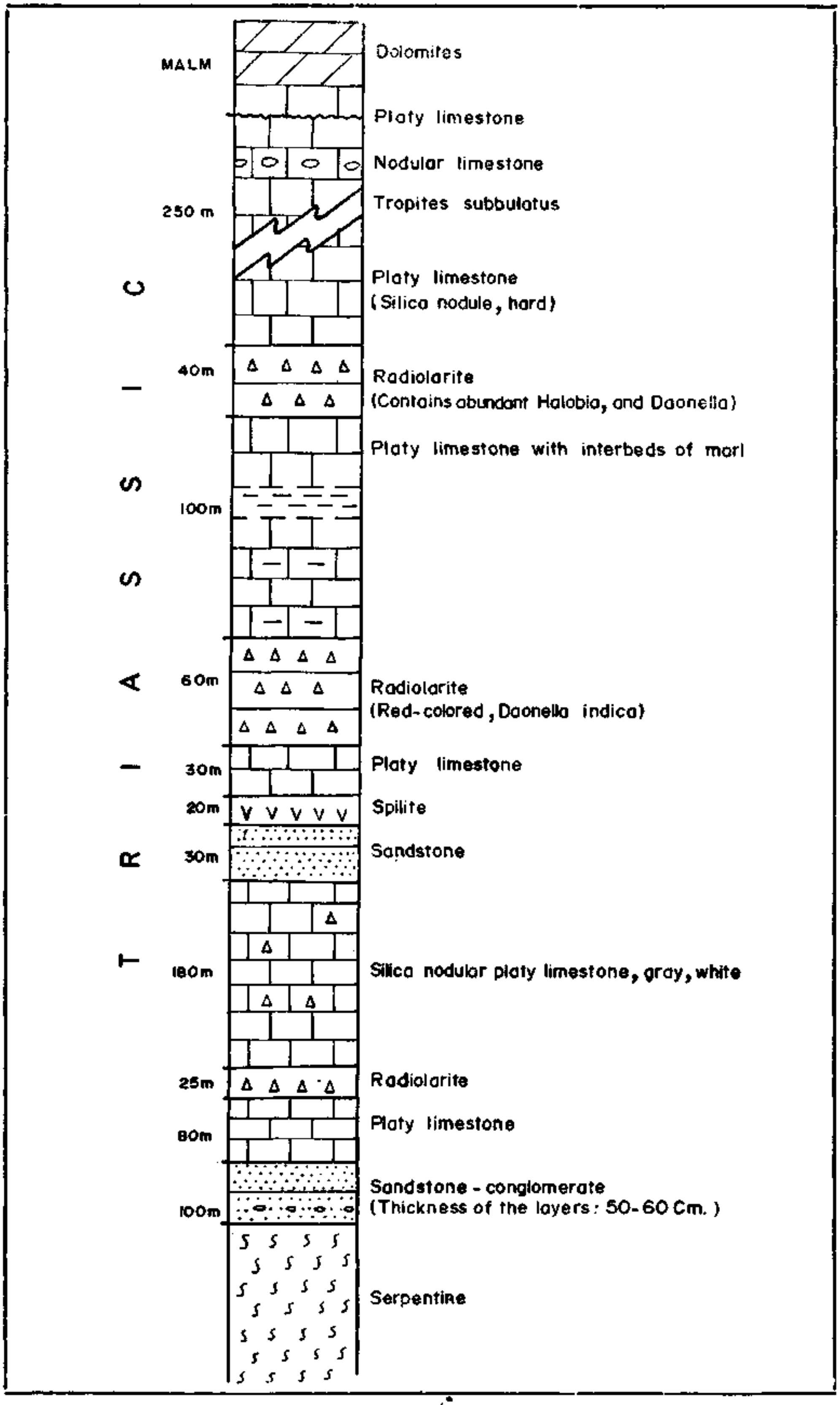

Fig. 7 - Columnar section of Triassic between north of Menekiş and Şalbalı Dağ.

To the north of the area, between Erendağ (2E) and Karadağ (5C), the formation contains Halobia and Daonella fossils. Here, it is very difficult to differentiate the Triassic rhythmic series and facies changes are frequently observed. Therefore, whichever lithology was predominant in the area, the name of the formation was given based on the kind of rock predominant in that particular locality.

Alternations of thin limestone, radiolarite and sandstone beds reach sometimes several hundred meters of thickness. The Gökdere formation appears here as an anticline which is overlain by the white-colored and semicrystalline Karadağ limestones; the contact between the two formations is slightly faulted.

The outcrop of the Gökdere formation on the western slope of the Şalbalı Mountain (13K), located in the central part of the region, is composed of platy limestones containing typical silica nodules. In the lower part, red-colored radiolarites containing abundant Halobia and Daonella of Ladinian age are observed. In the upper levels, the unit forms minor anticlines and synclines with strikes in NW-SE or NE-SW directions; the dip is towards NE and SE. The limestone strata contain silica lenses and nodular limestone beds. The formation is unconformably overlain by the dolomites of Malm age. Dogger and Liassic formations are not represented in this area. The following Triassic microfossils, showing a pelagic facies, were identified in the samples collected from this limestone strata: *Frondicularia* sp., *Radiolaria* sp, spicules and lamellibranch fragments. The rock is mainly biomicrite; pelsparite divided by stylolitic boundaries is also observed. Ammonites collected in this area were determined by Dr. L. Krystyn as *Tropiles mbbullatus* Hauer, who assigned them to Middle-Upper Carnian age. An other exposure Of the Gökdere formation, observed in the area between Tahtacı (14C)-Aktepe-Körler Mahallesi (15A) east of Sivridağ, is somewhat different (Fig. 8 and 9). In this area, radiolarites occurring in the lower part show vertical and horizontal transition into the platy limestones toward the upper portion of the formation; limestone blocks are found between the two units. Limestones contain abundant Halobia, Ammonites and Daonella. Going upward the boundary between the sandstone facies and the limestones is characterized by a

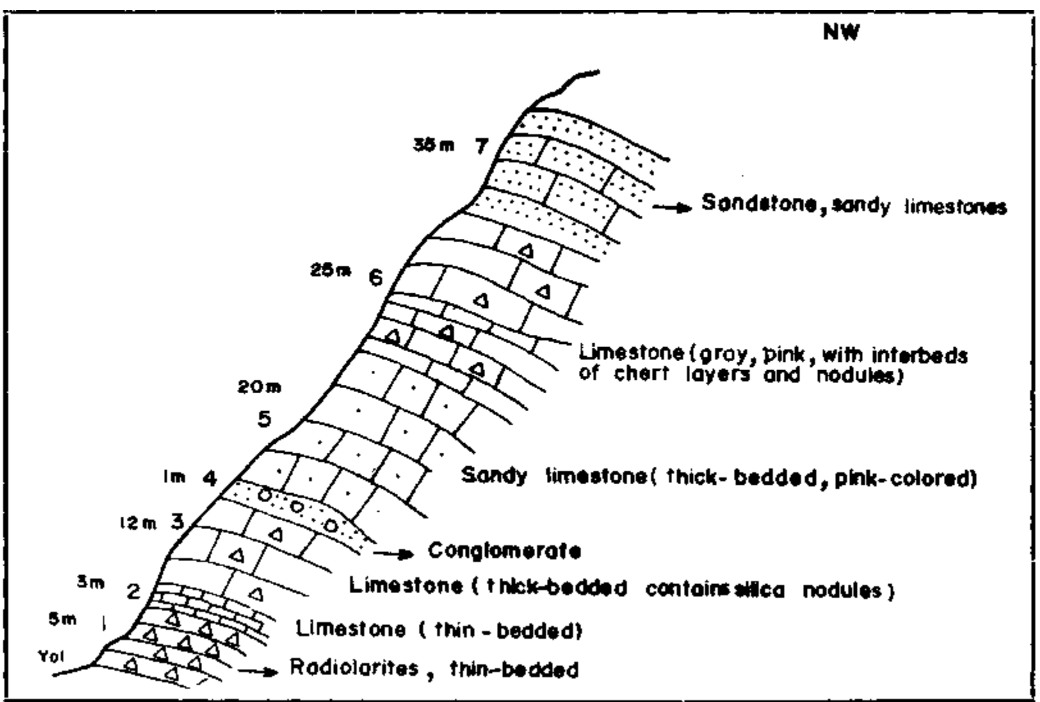

Fig. 8 - Triassic section along the road cut on the way to the south of Tahtacı.

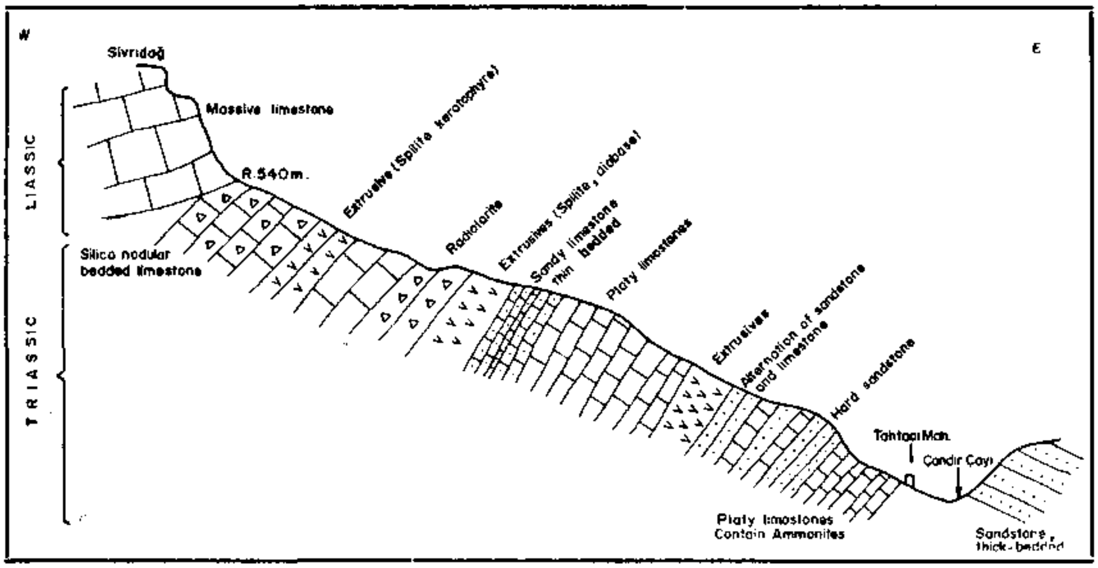

Fig. 9 - Schematic section of Triassic rhythmic formation between east of Sivridağ and Çandır Çay.

gradual transition. This is a somewhat different form of rhythmic series. The area is characterized by numerous minor faults. In the limestone blocks, occurring within the lower portion of the limestone strata, silicified and brecciated parts are observed. Sedimentological study of the thin sections showed that the rock is mainly unconsolidated biomicrite containing radiolaria and pelagic lamellibranch fragments. Irregular calcite veins of various thicknesses are encountered in this formation.

Ammonites collected from the pelagic limestones, located west of Tahtacı Mahallesi (14C), were determined by Dr. Ülker Özdemir, who attributed this series to Upper Ladinian-Carnian. This determination was made based on the presence in this area of *Megaphytes* sp. and *Longobardites zsigmondyi* Boeck. Microscopic study of the samples showed that the rocks are mainly of biomicrite microfacies and contain abundant radiolaria; partial dolomitization was observed (PL II, photo 4).

The geologists who have studied previously this region did not differentiate the Triassic rhythmic series of the area into various formations. However, the presence of Jurassic, Lower and Upper Cretaceous series was mentioned.

It may be concluded that the Triassic rhythmic series observed in this area are represented by alternations of various rocks, beds and lenses overlying each other. Although sandstones, radiolarites and platy limestones showing various rock facies occur in different levels, they appear as separate units. For this reason, the Triassic rhythmic series encountered here were divided into three separate formations and were plotted on the map separately. They were considered to be a part of the formation in association with other rocks, such as sandy limestone, marl, clay, brecciated limestone and minor extrusive sills.

Unfortunately the species determination of Ammonites, Daonella, Halobia and other lamellibranches, found within the Triassic formations, tould not be made in Turkey and, consequently, it was impossible to subdivide this series. Only the age of the middle level containing radiolarites could be established as Ladinian, because of a fossil specimen identified in France as *Daonella indica* Bittner. Accordingly, it is very probable that the age of the underlying sandstone formation (Çandır formation) may be of Lower-Middle Triassic, while an Upper Triassic age may be assigned to the overlying platy limestones (Gökdere formation) based on the Ammonites determined as *Tropites subbullatus* and *Megaphyllites* sp.

In many localities Triassic formation begins with a sandstone level overlying serpentines; this fact supports the theory that a transgression may have taken place here. On the other hand, at the contact of Triassic with Permian a concordant bedding of limestone-dolomite and hard sandstone sequence is observed.

The upper part of the Triassic contact is overlain by Liassic limestones that form here an angular disconformity and although there is no basal conglomerate between the two formations it is to be assumed that an uplifting process took place following the Triassic stage.

Triassic formations in the neighboring areas

The rhythmic Triassic formations, that extend in the northern, southern and western parts of the area under investigation, show almost similar lithological sequence. French geologists, who studied the western and northern parts of the region, suggested an Upper Triassic age for the rhythmic series located in these areas and called them the I*sparta (Çay formation* and the *Alakır (Çay unit,* respectively. However, T. Juteau (1968), who studied the southern part of the area (Kumluca-Tekir-ova), claimed that the rhythmic series, which are called the Alakır Çay series, show pelagic sedimentation, and assigned a Malm-Lower Cretaceous age to this unit.

A. Poisson (1970), who studied the NW part of the area (Korkuteli), reports that the gray to whitish-colored limestones occurring in the form of massive bands in places show a brecciated character and are of Triassic age. Further to the west, in the Fethiye area, İ. Yılmaz reported the presence *in situ* of a *Gyroporella vesiculifera* Gümbel. This form of Algae is very widespread in the Norian levels of the Southern Alps and Dinarids. P. de Graciarisky, who investigated the Köyceğiz area, notes that the Triassic formations begin with arkosic conglomerates and rest unconformably upon the Permian dolomites. The arkose conglomerates are overlain by limestones and dolomites. In the Karadağ area, north of Fethiye, Triassic quartzites overlie conformably the Permian formations. In the eastern part of the region, in the area between Beyşehir Lake and Manavgat, Triassic formations show an Alpine facies and are of a geosynclinal character. The Triassic formations occurring in this area overlie disconformably the Ordovician formations. Here blue and black-colored limestones interbedded with shales occur in the lowermost part; in the middle part gray to green-colored schists containing sandstone, chert and conglomerates—as much as 50-60 meters thick—are observed; the uppermost part of the formation is represented by black-colored limestones attaining a thickness of some 20-30 meters. These contain *Trachyceras acanthica* of Carnian age. Further to the east, bauxite deposits and dolomites overlying the Permian formations of the Alanya area are assigned an Upper Triassic age (Peyronnet, 1970). In this area a disconformity between the Triassic and Permian formations was observed.

Further to the north, in the Seydişehir area, Triassic begins with basal conglomerates. Shales overlying the conglomerates contain *Myophoria vulgaris* and are assigned an Anisian age. These beds are overlain by the Taraşçı limestones of Ladinian age; these limestones are up to 300 m thick. Detritic materials which are observed in places upon the Taraşçı limestones are of Upper Triassic. In the northern and southeastern parts of the region, dolomites and shales of Triassic age were discovered (O. Monod, 1967).

Triassic formations occurring in the area under investigation belong to two facies: (1) rhythmic series and (2) massive dolomite and massive dolomitic limestone facies.

The rhythmic series is very thick; in some places it attains a thickness of about 1,500 m, while the thickness of the dolomite and massive limestone series varies between 300 to 500 m. The relation between the two facies cannot be observed in this area. In this part of the Taurus Mountains, in the western portion of our area of study (between west of Beydağlan and Fethiye) and in the east (in the neighborhood of Seydişehir-Alanya) massive dolomitic limestones and dolomites predominate, while the rhythmic series are located in the central part of the area. This situation suggests that various formations were formed in the area during the Triassic period. In the east and in the west the sea was more shallow and rocks of neritic facies, comprising coral limestones and algal limestones, as well as dolomites, were deposited in those parts, while in the central area sandstones are accumulated in the lower level and are overlain successively by radiolarite of pelagic facies, pelagic limestone, limestone containing chert, and platy limestones with Ammonites, Halobia and Daonella.

On Cyprus similar rhythmic formations of Triassic age, known as *Mamonia series,* occur on the southern flanks of the Troodos pluto-volcanic massif, located in the southern part of the island. In this area, Triassic is composed of sandstone with plant remains, chert, radiolarite, and platy limestone; within these series pillow lavas are also observed. Comparison of numerous sections reveals that although the lithological sequence of this formation is somewhat different from that in our area, in general, both formations resemble each other, the only difference being that in the case of the Mamonia series the serpantines occur in the upper part of the rhythmic series while extrusives are found underneath that formation. H. Lapierre (1968) who identified Halobia within the platy limestones assigned them to a Norian-Karnian age.

2. Jurassic

Jurassic outcrops located in the area under investigation were studied in four different groups: a) Liassic: Girevit limestones; b) Dogger: Hayıtlı limestones; c) Malm: 1. Kaplan dolomites and 2. Karıncalı limestones.

a. Liassic is represented by *Girevit limestones.* This formation occupies an area of 70 km^2. The lowermost part of the Mesozoic comprehensive series in this area is composed of generally massive, in places thick- to medium-bedded reef limestones of Liassic age; these limestones have a characteristic mottled appearance. Since they are best seen in the Girevit Dağ area (15E), they are called the *Girevit limestones.*

These limestones are widespread in our area; they generally form the high limestone mountains and are easily differentiated as they contain abundant microfossils. On the other hand, the determination of numerous Corals and Gastropods encountered within these beds could not be made because they were crystallized. The limestone exposures are mainly located at the Girevit Mountain, in the northeastern part of the region; at Yumrucak Tepe (18K) and to the north of this hill, along the coastline; in the central part of the area, at Sivridağ (9D) and—with interruptions—in the area between Akçaisa (9K) and Şalbalı Mountain (13K); at Karadağ, Erendağ and Bereket Dag, located in the western part; and also in the wide area between Karadağ (5C) and Çitdibi (6J) in the southern part of the area. The thickness of these beds varies between 300 to 600 m.

Girevit limestones overlie unconformably the Triassic rhythmic formations and are overlain by the Dogger formations at Bereket Mountain. They were formed in a neritic environment. These beds are also rich in Coral and Gastropod fossils. The sedimentation of thick and monotonous limestone strata during the Liassic period shows that no important changes took place during this deposition. The Girevit Mountain (15E) is located in the northeastern part of the area; it consists of a succession of hills extending in the NE-SW direction and composed of reef, massive, crystallized limestones. The Girevit Mountain exhibits a typical structure due to the presence of echelon faults (PI. IX, photo 25); here the white-colored limestones rest disconformably upon the Triassic formations (Fig. 4 and 5) The determination of the Corals, Sponges and Gastropods found in these reef limestones could not be made since the limestones were crystallized. The following microfossils which characterize the Liassic were identified in the samples taken from various parts of the Girevit Mountain: *Vidalina martana* Farinacci, *Involutina* sp., Ophthalmidiidae, *Radiolariasp. and Nodosaria* sp. A sedimentological study of the samples revealed the following characteristics: The rocks show an intrabiosparite microfacies with radiolaria observed in intraclasts. The rock also contains fragments of algae, various microfossils and sponge fragments (PL II, photo 5). Another thin section showed that the rock is a fine- to coarse-grained (biocalcilutite and biocalcarenite) and poorly sorted biomicrite. Sometimes allochems consisting of Corals and Foraminifera, irregularly distributed in the limestone matrix, are observed. A mosaic of secondary calcite is developed in the micrire, and stylolitic boundaries are observed between the grains. Evidence of diagnesis and recrystallization is observed, and the microfacies usually indicates to a coastal environment. The original texture of the rock was changed as a result of strong recrystallization:

Liassic formations rich in fossils are encountered in the vicinity of Ak9aisa Mahallesi (9K). The formation is usually massive, sometimes medium- to thick-bedded; within the white-colored reef limestones dark spots are observed which give them a mottled appearance, in places a characteristic intraformational brecciated structure is seen. This formation is rich in macrofossil Corals, such as *Montlivanltia* sp., *Thecosmilia* sp., *Thamnasteria* sp and abundant Gastropods. The paleontological study of the microfauna, collected from the Liassic limestones in the vicinity of Akçaisa and determined by E. Öngüç, gave the following results (PL V, photo 12, 13, 14; PL VI, photo 15):

Involutina turgida Kristan
Involntina liassica Jones
Involutina cf. *tumida* Kristan-Tolman
Involutina cf. *communis* Kristan
Involutina sinuosa sinuosa Weynschenk
Involutina tennis Kristan
Involutina cf. *eomesozoica* Oberhauser
Trocholina permodiscoides Oberhauser
Hemigordius sp.
Ophthalmidiidae
Glomospira sp.
Algae (Solenoporacea)

Based on the above microfossils it is clearly understood that the Involutina-bearing biomicrites represent the most widespread microfacies. They are also observed in the microbreccia deposits; these are mainly intraclastic microbreccia cemented by micritic or sparitic material.

In the vicinity of Akçaisa the contact between the Girevit limestones and the Triassic rhytmic formations is characterized by a disconformity. These limestones cover various formations of the rhythmic series. The southern boundary of the limestone strata is faulted by Triassic formations; the northern boundary of the limestones, which is covered by forests, could not be properly studied; however no lateral transition can be expected here. In the İncegeriş Tepe (11M) area these limestones are overlain by the Karıncalı formation.

Sedimentological examination of the thin sections taken from this unit showed that the rock is a recrystallized fossiliferous intrapelimicrite. It was mainly formed in a stable deep-sea environment, at a certain distance from the shore.

The white-colored limestone beds with black-colored specks, showing a brecciated facies, are exposed in the northwestern part of the Karadağ area; they are lithologically similar to the limestone strata located in the vicinity of Ak9aisa. This limestone strata overlies discordantly the Triassic Gökdere formation; the contact between the two formations is slightly faulted. A slight subsidence is observed in the Liassic limestones. In this part of the area the Girevit limestones are bedded.

The beds, which strike N 40°W and dip 30°-60° NE and SW, form numerous small anticlines and synclines (Ann. I). An abrupt fault in the north caused a sudden change in the elevation of the area from 1960 m to 1300 m, thus forming an extensive plain where several dolines were observed.

The following microfossils were identified from the samples collected in various parts of the Karadağ formation:

Vidalina martana Farinacci
Involutina sp.
Ophthalmidiidae
Algae (Solenoporacea)

Fragments of Sponges, Corals and Gastropods are also observed in the thin sections. The above microfossils indicate that the Karadağ limestones belong to the Lower-Middle Liassic stages. Towards the upper levels these limestones show a brecciated texture and black specks of various sizes are observed in the rock. These are most probably the lithoclasts of the Permian limestones transported to this area.

A sedimentological study of the Karadağ Liassic limestones showed that this limestone is a recrystallized biomicrite containing Algae; a great part of the rocks consists of allochems. Corals and Foraminifera occur in association with the Algae. The rock shows a cataclastic texture.

In the eastern part of the area, in the Yumrucak Tepe (18K) and its vicinity, white-colored, crystallized Liassic limestones are exposed that rarely show bedding. These limestones, which were thrust over the Malm limestones along the coastline, are normally overlain by the Malm (Dogger?) formations in the western area, in the vicinity of Kötekli Tepe.

Typical Liassic microfauna are also found in this area. The following microfossils were identified by Mualla Serdaroğlu, who assigned Lower Liassic age to this formation:

Aulotortus sinuosus Weyns.
Triasina yberhauseri Zaninetti & Bronnimann
Involutina liassica Jones .
Vidalina martana Farinacci
Nodosaria sp.
Ophthalmidiidae
Frondicularia sp.
Trocholina sp.
Aeolisaccus sp.

The Sivridağ (9D) limestones, which cover large areas in the central part of the region, are white-colored, crystallized and massive. The western border of Sivridağ is faulted and Permian limestones are revealed here (Fig. 3), while the eastern contact rests disconformably upon the Triassic formation. Bedding is riot clear. The following microfossils were identified in the massive, strongly fractured limestones:

Lituosepta recoarensis Cati
Haurania amiji Henson
Valvulinidae
Glomospira sp.
Paleodasycladus mediterraneus Pia

In the western part of the region another Liassic exposure is located in the area south of Bereket Dağ (1J) and Erendağ (2E).

White-colored, crystallized Liassic limestones, which rest upon the Permian dolomites in the eastern part of Erendağ, overlie the serpentines and Triassic formation at the western side of the mountain. In places, *Vidalina* sp., *Involutina* sp., Ophthalmidiidae, *Nodosaria* sp., Corals (such as *Thecosmilia* sp.) and Mollusc shell fragments characterizing Liassic are encountered in the dolomitic and strongly fractured limestones. Bedding is not clear. Liassic limestones occurring in the eastern part of Erendağ cover the eastern flank of the Triassic anticline located in the Fesliğen Plateau. White-colored reef limestones, striking NW-SE and dipping NE along the Şarlangıç Dere (14E), contain abundant Corals and Gastropods. Such microfossils as *Vidalina martana* Farinacci, Ophthalmidiidae, *Involutina* sp. *Nodosaria* sp., *Radiolaria* sp. and *Glomospira* sp., characterizing Liassic, are also identified in the Kadran Gediği area.

The Liassic limestones located south of Bereket Dağ start with an abrupt change of facies where they overlie the Triassic formation; near the peak of the mountain the silicified, platy limestones of pelagic facies are replaced by the crystallized reef limestones containing Corals. Characteristic Liassic fossils are also encountered here:

Lituosepta recoarensis Cati
Frondicularia woodwardi Howch.

Microfacies is represented by fossiliferous intrapelmicrite (Fig. 10; P1. VI, photo 16).

Liassic formations of the neighboring areas. — The extension of Liassic formations is not definitely known, since the massive reef limestones occupying the southern part of the area were not yet studied in full detail. J. Marcoux (1970) reports that the fine-grained silicified limestones overlying the Carnian limestones in the vicinity of Tahtalı Dağ are of Triassic-Liassic age.

The presence of Liassic formations was proved during recent studies carried out by A. Poisson (1970) in the Korkuteli area, northwest of Antalya.

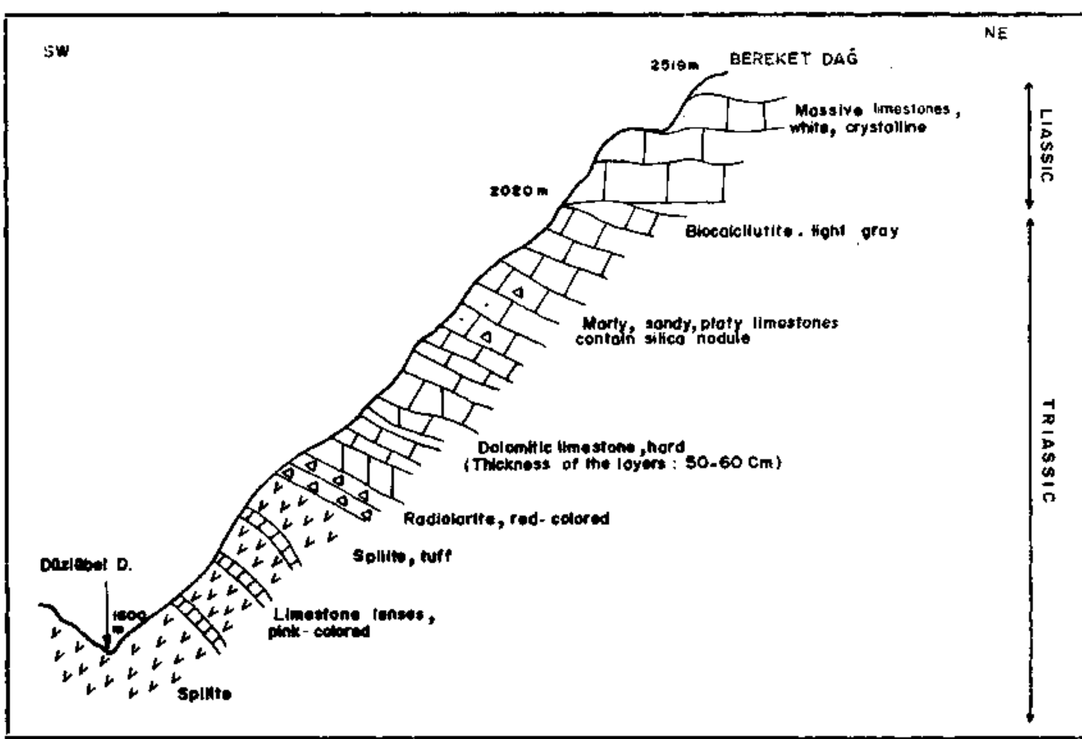

Fig. 10 - Schematic profile from the SW side of Bereket Dağ.

Liassic formations located in this area are divided into two levels: In the lower level, at the contact between Liassic and Triassic, are found thin beds of crinoidal limestones which are overlain by limestones with calcite veins showing microbreccia characteristics. Microfacies represented by oolitic limestones is very frequently observed. The presence of a discontinuity with the Triassic formation is assumed, based on the abrupt change of Foraminiferal content. Overlying this lower layer are found pink-colored, fine-grained limestones of various thicknesses which contain abundant *Vidalina* sp.

To the north of the area, between Beyşehir and Eğridir Lakes, red-colored detritic formations and dolomites—overlying the Upper Triassic dolomites—contain *Orbilopsella* sp., which indicate a Liassic age. The oolitic algal limestones overlying the Barla Dağ dolomites (Upper Triassic), located west of Eğridir Lake, contain Lower-Middle Liassic microfauna. Liassic limestones and dolomites are also found to the south of Beyşehir. From the above description it appears that the Liassic limestones in our area of study—that extend in the southern, western, northern and northwestern directions and reach as far as the Eğridir Lake—are nearly of the same facies and contain the same microfauna.

The Liassic dolomites and brecciated limestones in the western part of the area, in the vicinity of Fethiye, contain Algae *(Palaeodasydadus mediterraneus)*. Detailed study of neighboring areas will certainly show that the lower levels of the thick monotonous limestone series also belong to Liassic.

b. Dogger. — The Dogger in this area is represented by *Hayıtlı limestones.* They are exposed in a relatively small area. Because of the scarcity of fossils in the outcrops of this formation, no determinations were made. The fact that the Dogger formation can hardly be found in this area, while thick and fossiliferous Liassic and Malm formations are widespread, shows that the major part of the area was not invaded by sea during this sub-system. In the southeastern part of the area the Dogger beds are exposed at the surface in the vicinity of Hayıtlı Göl (17); they can be observed in the normal fault scarp within the Jurassic limestones. *Protopeneroplis striata* Weyn. were identified in the cream-colored oolitic limestones occurring in this locality (PL VII, photo 18). The sedimentological study of thin sections showed that the rock is mainly oosparite; the oolites are well developed; shell fragments constitute the core; a large intraclast is also observed. The oolites preserved their primary structure (PL II, photo 6). Another Dogger exposure is located in the western part of the area, in the vicinity of Bereket Dag (1J) (PL XII, photo 33). The strata forming the lower part of Bereket Dağ are Liassic; north of this mountain Liassic limestones grade conformably into Dogger. F. Armağan determined the following microfossils within the gray-colored, partly oolitic limestones (PL VI, photo 17):

Meyendorffina bathonica Aurouze & Bijon

Valvulinidae

Textularia

Haurahia

Taking into consideration that oolitic limestones occurring in the vicinity of Asar Tepe (7K), located east of Akçaisa Mahallesi, contain *Protopeneoroplis striata* Weyn., it is highly possible that these white-colored reef limestones belong to Dogger; however, they were not plotted on the map since they occupy only a small area in the region, which is mostly covered with Liassic formations.

Dogger formations occurring in the neighboring areas. — The Dogger is characterized by massive, reef limestones attaining a thickness of approximately 500 meters in the south of our area, at Tahtalı Dağ. In places the Protopeneroplis encountered within the oolitic limestones represents this formation.

In the northwestern part of the area, in the vicinity of Çatal Tepe, a part of massive limestones of oolitic and brecciated facies are known to belong to Dogger. Likewise, further to the north, south of Senirkent, in the vicinity of Barla Dağ, oolitic limestones containing Protopeneroplis and Meyendorffina were also attributed to Dogger.

Dogger was encountered also in the areas south of the Beyşehir Lake and west of the Eğridir Lake, within the limestones with Meyendorffina which underlie the Malm beds.

c. Malm. — Malm consists of two formations in the area under investigation: 1) Kaplan dolomites and 2) Karıncalı formation.

1) Kaplan dolomites: The Kaplan dolomites occur mainly in the eastern part of the region under investigation and cover an area of some 7.5 km^2. This formation, extends from the NATO Harbor Site towards the west, along the Acısu River (17H), and then turns towards the south, between Karıncalı and Şalbalı Mountains (13K). It forms an anticline which extends beyond the boundaries of our area. The formation was named the *Kaplan dolomites,* because it can be best observed in the Kaplan Gediği (14K) area.

The Kaplan dolomites are generally light-cream to gray in color; sometimes they are of whitish color, fractured and brittle. In our area they overlie disconformably the Triassic and Permian formations. The upper limit of this sequence grades into the Malm (Karıncalı limestone) formations. Its total thickness is 300 m.

Along the coast line, to the south of Tümek Tepe (19F), compact and brittle Cenomanian limestones with beds striking NE-SW and dipping 20°-40°NW, overlie discordantly the crinoidal dolomites (Pl. XI, photo 32). Further to the south, in the vicinity of Karaanlı Tepe (19H), dolomites pass into the Malm limestones in the form of horizontal and vertical transitions. In the upper part only the Malm limestones are observed.

The upper layers of dolomites are eroded in the Kaplan Kapanı Gediği area (14K); the anticlinal bend here displays dark to gray-colored, well-bedded (thickness of the beds varies between 20 to 60 cm) dolomites. On both flanks of this anticline the dolomites are overlain by the Karıncalı formation (Ann. II, P. V). The following microfossils were identified in the samples collected from the cream-colored and slightly dolomitized limestones (determined by E. Öngüç):

Clypeina jurassica Favre

Pseudocyclammina jaccardi Schrod.

Valvulinidae

Kilianina sp.

Based on the above microfossils, the upper levels of the dolomites were assigned an Upper Jurassic (Malm) age. The age of the lower levels of the dolomites, however, is not known definitely.

Another exposure of the Kaplan dolomites is located to the west of Şalbalı Dağ (13K), between the pelagic limestones of Triassic age and the Upper Cretaceous limestones (PL III, photo 7). Well-bedded, creamy-colored dolomites, striking NE-SW and dipping approx. 28°SE are observed here; they overly the Triassic, Ammonite-bearing, platy limestones containing silica nodules. The contact of these beds with Triassic shows a distinct parallelism; their contact with the overlying limestones is also concordant. Here a disconformity is observed. The eastern flank of the NE-SW striking anticline is covered with the Karıncalı limestones, while in some parts of the western flank, that is partially eroded, limestones of the Upper Cretaceous are encountered. Triassic formations located along the axis of the anticline are sometimes exposed at the surface along the faults.

The sedimentological study of a thin section obtained from the samples collected from the Kaplan Kapanı Gediği showed that the original texture of the rock was biocalcilutite and biomicrite. These can be observed as small patches within the strongly dolomitized rocks. This secondary dolomitization is widespread and followed the diagenesis processes that took place in the area. However, after this dolomitization, cavities that have been formed probably as a result of melting, were completely filled with calcite crystals among which stylolites are observed.

2. Karıncalı formation: This formation occupies some 21 km^2 of the investigated area. Since it is best observed in the vicinity of Karıncalı Dağ (15J), where rich fossil fauna was collected, it was given the name of *Karıncalı formation* (Pl. XII, photo 33).

The Karıncalı limestones are exposed in the following localities: In the west, on the northern slopes of Bereket Dağı (1J); as thin bands in the south, to the east and west of Dünek Tepe (9N); in the vicinity of İncegeriş Tepe (11M); and also very extensively on the Karıncalı Mountain.

This formation consists of well-bedded, compact limestones of various colors, including creamy, beige, gray, pink and white hues, but it is predominantly cream-colored. In the lower levels intercalations of dolomites are also observed.

In the eastern part of the region, the Karıncalı formation forms a syncline in the Karıncalı Dağ (15J) area and then extends as far as the coastline. The bedding is conformable with the underlying gray and cream-colored dolomites; gradual transition between the two units is observed. The formation is discordantly overlain by the Upper Cretaceous limestones. They are well-bedded with thicknesses varying between 25 cm to 1 m. The general strike of these beds is NE-SW, the dips are 30°-50°SE and NW. The following microfossils were determined in the paleontological examination of the samples collected from various parts of the mountain (Pl. VII, photo 19 and 20):

Pfenderina sp.
Kilianina blancheti Pfender
Kurnubia jurassica Henson
Pseudocyclammina lituus Yokoyama
Pseudocyclammina jaccardi Schrod.
Clypeina jurassica Favre
and Corals *(Cladocoropsis mirabilis* Felix)

The study of the limestones in thin sections showed that the rock sample was collected from a beige-colored compact series which is interbedded with pinkish layers. This examination showed that the rock is a biomicrite containing abundant Foraminifera. Development of a secondary calcite mosaic was observed. Allochems are fossiliferous; some stylolites are encountered; the boundaries of stylolites contain FeO concentrations; calcite veins are intersected by micrites and stylolites.

To the east of Karıncalı Mountain, along the coastline, south of Kargacık, gray and cream-colored, bedded limestones are observed; they strike N 75°E, dip 25°NW,and are between 10 to 30 cm thick. The following microfauna was determined in this formation:

Kurnubia sp.
Valvulina sp.
Pseudocyclammina sp.
Pfenderininae
Algae (Thaumatoporella)'

The limestones, which most probably belong to Malm, are overlain by white-colored, crystallized and massive limestone strata. These are Liassic Jimestories which are here thrust over the Malm limestones. The sedimentological study of the thin sections showed that the microfacies is represented by biomicrite; sparitization is observed in places and crystallized organic fragments are also found (Pl. III, photo 7). Anather exposure of the Karıncalı formation is located on the Dünek Tepe. Here also, on the eastern flank of the mountain, gray-colored and sandy Triassic limestones are observed overlain by white-colored, bedded oolitic limestones which strike N 15°E and dip 20°NW; they contain the following fossils (determined by F. Armağan):

Calpionella alpina Lor.
Calpionella elliptica Cad.
Pseudocyclammina sp.
Textularia

Tithonian-Valanginian age is assigned to these limestones. In the upper part these limestones grade into thick-bedded limestones containing Corals of Lower Cretaceous age.

Another exposure of the Karıncalı formation is observed on the İncegeriş Dağ (11M). Here, the fossiliferous Gökdere limestones of Triassic age are overlain by a thin bed of dolomites which are covered concordantly wiht cream-colored limestones. The following mirofauna was collected from İncegeriş Dağ:

Pseudocyclammina lituus Yokoyama .
Trocholina sp.
Nautiloculina sp.

The microfacies is represented by biomicrite.

It is highly probable that the thick dolomites underlying the Karıncalı limestones are of Dogger age. However, since these beds are unfossiliferous and are closely related to the Kaplan dolomites, we included this series in the Upper Jurassic. The strike of the Upper Jurassic dolomites and limestones is in conformity with the general structure of the area. In general, the dolomites form anticlines, whereas the limestones constitute synclines. The age of the upper layers of the dolomites, which form an anticline, reach up to the Kimmeridgian-Portlandian; based on the microfossils contained, it may be assumed that they were formed in a shallow-sea (neritic) environment.

Geologists, who investigated the area in the preceding years, assigned a Cretaceous age to the Malm formations occurring in this region. These formations were shown as a part of the Comprehensive series on the 1:500.000-scale Geological Map of Turkey. Furthermore, lithostratigraphical units, such as dolomites and limestones, were not indicated as a separate unit.

Upper Jurassic in the neighboring areas

The Upper Jurassic sequence extends in the south of the investigated area. J. Marcoux, who surveyed this region, observed cream-colored, massive limestones with Pfenderina fossils, which he attributed to Dogger-Malm, while he assigned an Upper Jurassic-Lower Cretaceous age to the upper beds of beige-colored, massive limestones containing Clypeina.

T. Juteau, who studied the area between Tekirova and Kumluca, in the southern part of the area, gathered all the limestones encountered here under the name of the *Coastal limestone ranges* and assigned to these massive, brecciated limestones a Lower Cretaceous age. This is erroneous. Actually, as these limestones differ from the point of view of fossil content as well as their lithologic structure, we were able to differentiate them into Liassic, Dogger, Malm, Lower and Upper Cretaceous formations.

P. de Graciansky, M. Lemoine, M. Lys and J. Sigal (1967), who had visited the western part of this region and studied the area around Fethiye, report that they observed black-colored limestones of Dogger age overlain by light-colored, microcrystalline, slightly undulated limestones containing silica layers. These calcareous beds, of pelagic facies are between 5 to 20 cm thick and contain *Calpionella alpina* fossils. Therefore these workers have assigned an uppermost Upper Jurassic age to this formation. Although these beds—which we had also personally observed—have a different facies from the Malm limestones of our area, they show a resemblance with the limestones of the Dünek Tepe, which also contain Calpionella.

S. Türkünal (1969) has studied the eastern part of the area between Beyşehir Lake and Manavgat. He describes a rhythmic series, which was formed here in a warm and shallow sea, overlain by some 40-50-m thick, stratified, gray-colored and rather clayey limestones, upon which come massive, gray to black-colored dolomitic limestones. Because of the fossil content of these series he attributes them to the Upper Jurassic. According to Türkünal, the Upper Jurassic cannot be differentiated from the Lower Cretaceous.

South of the surveyed area, on the Tahtalı Mountain, were observed massive reef limestones; they were attributed to Dogger because of the Protopeneroplis fossils encountered in these beds. Overlying this formation a sequence of cream-colored limestones which contain *Pfenderina* sp. were assigned a Malm age. The upper parts of these limestones are characterized by well-bedded limestones and dolomites of the Upper Cretaceous age.

The Kaplan dolomites, which represent the lower parts of the Upper Jurassic, were not observed as yet in any part of our area of study. Therefore we were unable to compare the Kaplan dolomites with those observed in the neighboring areas.

3. Cretaceous

Cretaceous in our area is divided into two sub-systems: a) Lower Cretaceous; b) Upper Cretaceous. The Upper Cretaceous is further subdivided into two formations: 1) İnburnu formation, 2) Tümek dolomites.

a. Lower Cretaceous. — It is represented by Dünek limestones and covers an area of about 1 km^2. Because the Lower Cretaceous limestones are best observed on Dünek Tepe (9N) they are called the *Dünek limestones.*

The thick-layered or massive limestones encountered here, which overly the white-colored, thin or thick bedded limestones containing *Calpionella alpina* of Kimmeridgian age, form a concordant contact with Malm formations.

These white-colored limestones, with a thickness not exceeding 100 m, contain abundant Corals and Gastropods and show a reef facies. The paleontological study of the samples showed the following microfauna (Pl. VIII, photo 21):

OrbitoUna sp.
Neotrocholina sp.
Ophthalmidiidae
Miliolidae

Microfacies is generally composed of biomicrites.

Lower Cretaceous in the neighboring areas. — The well-bedded and partly dolomitized limestone$ that overly the cream-colored, massive Upper Jurassic limestones on the Tahtalı Mountain, in the southern part of our area, contain *Hensonella* sp. and are Lower Cretaceous in age. They are found at the top of the mountain. The limestones lying between Tekirova and Kumluca, further to the south, were determined as Lower Cretaceous in age by T. Juteau (1968).

The Lower Cretaceous formations of a shallow-sea facies, with a thickness of some 1000 m, are widespread to the northeast of our area, south of Beyşehir Lake. North of Beyşehir Lake, the upper parts of a monotonous limestone facies are likewise of Lower Cretaceous age.

In the north, the Malm limestones, containing a benthonic microfauna and overlain by Lower Cretaceous with a planktonic microfauna, are observed around Balçıkhisar and Homa, Akdağ. Further to the north, massive limestones observed on the Barla Mountain, near Senirkent, were found to contain Lower Cretaceous fossils.

The Lower Cretaceous limestones of reef facies, and in places also of dolomitic facies, can be observed in the entire region under investigation and in the neighboring areas. Within these Lower Cretaceous series, ranging from Malm to Cenomanian, limestones which are generally of a monotonous aspect and a shallow-sea facies were observed.

The brecciated limestones containing Rudists are encountered in the northwestern part of the area, in the vicinity of Korkuteli. These limestones are also of Lower Cretaceous age. They are found within the Cataltepe unit.

To the west, the lower parts of the Beydağları in all probability may be also attributed to Lower Cretaceous. Going farther to the west, north of Fethiye, Lower Cretaceous limestones of brecciated facies are encountered on the Çal and Haticeana Mountains.

b. Upper Cretaceous. — The Upper Cretaceous in the surveyed area was studied in two formations: 1) İnburnu formation; 2) Tümek dolomites.

1. İnburnu formation: This formation covers an area of about 8.5 km^2. Because the Upper Cretaceous series are best observed in the vicinity of İnburnu (20E) this sequence is called the *İnburnu formation.*

This formation is best observed in the following locations: along the eastern coast of the area; in the north, in the vicinity of Alakaya Tepe and İnburnu; to the north of Kocaçaltıcık (18J) and between Şalbalı Mountain (13K) and Gedeller (14H); around Tastaratacağı Tepe (12L); in the southwestern part of the area, in the neighborhood of Kavşık Tepe (3M) and the surrounding hills. In the lower parts the İnburnu formation lies uncorformably over the Malm dolomites, while higher up there is a gradual transition between the İnburnu formation and the overlying Upper Cretaceous dolomites (Tümek dolomites). These beds were formed in a neritic environment and have a thickness varying between 200 and 400 m. Lithologically they are mainly composed of crystallized and dolomitic limestones. The İnburnu formation characterizes generally the lower parts of the Upper Cretaceous (Cenomanian), while in the upper parts, which contain a Dicyclina sp., it reaches up to the lower layers of Senonian. The uppermost parts of the Upper Cretaceous do not exist in our area of study; they are found in the west, on the Beydağlan.

The white-colored, crystalline, reef limestones extending along the coastline in a NE-SW direction and observed in İnburnu (20E), Tümek Tepe (19F) and Dipsiz Mağarası (18H) contain in places dolomitic rocks; they overlie discordantly the dolomites of the Malm age in their lower parts. Towards the upper parts these limestones lose their amorphous structure and grade into crystalline dolomitic limestones (Tümek dolomites). The change in facies here can be explained by the sea water which is rich in magnesium because of an abundant Algae content at the bottom of the sea, this kind of environment being favorable for algal life. In the vicinity of İnburnu, overlying the Upper Jurassic limestones, massive, rarely thick-bedded limestones, striking N 30°E and dipping 50°NW, can also be observed. On the surface these limestones contain Algae, Corals and Gastropods; fragments of Rudists, Actaeonella and Nerinea are also abundant. Thin section of these limestone samples showed the following benthonic microfauna (P. VIII, photo 22, 23):

Dicyclina cf. *schlumbergeri* Münier-Chal.
Cuneolina pavonia Henson
Nautiloculina sp.
Pseudolituonella cf. *reicheli* Marie
Ophthalmidium sp.
Valvulammina sp.
Pseudocyclina sp.
Triloculina sp.
Miliolidae
Orbitolina sp. (a fragment)

E. Sirel, who studied these fossils, attributed them to Cenomanian. The microfacies is an ill-sorted, recrystallized biointrasparite containing Foraminifera and Algae. Based on the grain size they may be determined as biocalcarenites. The white-colored, thick-layered limestones lying south of Tümek Tepe (19F), 2 km SW of İnburnu and striking N20°E and dipping 24°NW contain a benthonic microfauna, such as *Cuneolina pavonia* Henson and *Dicyclina* sp., of Cenomanian age. The sedimentological studies of the thin sections of the samples showed that this rock is of biomicritic microfacies and contains abundant Algae and microorganisms (Pl. III, photo 8). Approximately 2 km further to the southwest, in the vicinity of Dipsiz Mağarası (18H), limestones of biomicritic facies, containing fragments of Rudists and *Dicyclina* sp.—which can also be attributed to Cenomanian—were encountered.

Some samples of limestones containing Rudists collected south of Gedeller, on the Sivridağ Tepe, have yielded the following microfauna:

Cuneolina pavonia parva d'Orbigny
Martiguesia cyclamminiformis Maync
Dicyclina sp.
Miliolidae
Ophthalmidiidae

E. Öngüç, who studied these fossils, assigned them a Cenomanian-Lower Senonian age. Further to the south, the same limestones are observed in the neighborhood of Tastaratacağı Tepe (12L) and extend outside the limits of our area.

The white-colored limestones found at Kavşık Tepe (3M) and İkiağaç Arası Gediği (3N), SW of our area, overly the Triassic formations and serpentines; along the western border of this area, faults, due to volcanic activity that took place during Triassic, were observed. The crystallized limestones in biomicrite .microfacies, which were deposited here, were found to contain the following microfauna: .

Pithonella ovalis Kauffman
Praeglobotruncana sp.
Stomosphaera sp.

The uppermost layers of the Upper Cretaceous encountered in this area are found to the northwest of Yumrucak Tepe (18K) at the 143 R Tepe. These are cream-colored to white, bedded limestones striking N 15°E and dipping 40°NW. Their paleontological study revealed the following microfauna:

Stomosphaera sphaerica Kauf.
Globotruncana concavata Brot.
Globotruncana lapparenti angusticarinata Gandolfi
Globotruncana fornicata Plummer
Pithonella ovalis Kauf.

M. Serdaroğlu who determined these fossils attributed them to a Santonian-Coniacian age.

Sedimentological studies of the thin sections of limestones taken from the İnburnu formation are summarized below:

The original texture of the the rock is biocalcilutite or biomicrite. Secondary dolomitization has taken place in some parts of the rock. Some isolated calcite crystals and styldjites can be observed. The allochems are formed by fragments of Rudists, Gastropods and Corals. The predominant microfacies is biomicrite containing Cuneolina. The rock was formed in a shallow and warm-sea environment. Some samples contain recrystallized biomicrite (biocalcarenite) with pellets, Mollusks and Foraminifera.

2. Tümek dolomites: This formation covers an area of more than 2 km^2. It outcrops only east of our area, between Gökdere (17F) and Tümek Tepe (19F), and because it is best observed around Tümek Tepe (19F) it is called the *Tümek dolomites.*

Tümek dolomites overly the Cenomanian limestones; there is a transition between these two formations. As observed in the vicinity of İnburnu (20E), the İnburnu limestones lose their amorphous shape and change into crystalline dolomitic limestones. Going upward, the change in facies becomes more apparent and here dark-colored dolomites are observed. These dolomites are well-stratified and have a monoclinal structure; their strike is NE-SW and dip is 40-45°NW.

The Tümek dolomites differ from other Permian and Malm dolomites of the area by their very dark color. The exposure, covering an area of 4 km long and 1-0.5 km wide, is overlain by the Gökdere formation of Triassic age. The contact is abnormal; a movement from the west caused the thrust of the Gökdere formation over the Tümek dolomites (Ann. II, P-II).

The lower parts of the Tümek dolomites can be seen within İnburnu formation. Therefore they are certainly Upper Cretaceous in age. The medium to thick-layered Tümek dolomites contain no fossils; some parts are so strongly dolomitized that they are not affected by acid and look like silica. The sedimentological studies of thin sections that were carried out on rock samples taken from this locality revealed that the structure of original deposition could be observed only in one instance and that only traces of unidentified fossils were present in the rock. This leads to the assumption that the Tümek limestones are of diagenetic origin. The main texture of the rock is biomicrite. This original texture can be seen in the thin section. On the other hand, dolomite crystals are of diagenetic origin and they entirely cover a large part of the rock (Pl. III, photo 9). It is clear that dolomite intrudes the limestone by replacing it; since it is in relation with the limestone it does not indicate a different environment. Only an increase in heat and pressure is necessary for the replacement of calcite by magnesium. Dolomitization takes place in shallow and cool submarine environment.

Upper Cretaceous in the neighboring areas. — The Upper Cretaceous is widespread in the regions surrounding the area under investigation. The upper parts of the high limestone mountains situated in the southern portion of our area are composed generally of dolomitized limestone, reef limestone and dolomites. In the north Amanas Dağ and Davras Dağ occupy a large part of the area; in the east Seylan Dag (northern part of the Alanya massif); in the west, Beydağları and their northern extension consisting of partly massive, fine-grained, shallow-marine limestones, are attributed to Cenomanian-Turonian-Coniacian and represent the lower parts of the thick Upper Cretaceous formations. This limestone series reaches up to Paleocene. Since the thick Upper Cretaceous formations found in different facies were not studied in detail, their orogenic phases are not yet determined. Only the Cenomanian of the Hadım-Bozkır area, in the east, is known to overly the older formations with a basal conglomerate.

C. TERTIARY

Pliocene

Kötekli conglomerates. — Since this formation, which covers about 1 km^2 of our area, is best exposed around Kötekli Tepe (17M) it was called the *Kötekli conglomerates.* These conglomerates, outcropping also north of Yumrucak Tepe (18K) and in the valley west of Bobasdağ Tepe (4H), can be easily distinguished from the younger, coarse-grained limestone conglomerates. Within these conglomerates limestone gravels, radiolarites, serpentines and extrusive rock fragments are encountered; these gravels are well-cemented.

These conglomerates outcrop in the area between Karıncalı Mountain (15J) and Kötekli Tepe (17M), southeast of the area; the beds are nearly horizontal and overly the Upper Cretaceous limestones. Since Oligocene and Miocene formations were not observed in the surveyed area, there is no criterion to determine the age of these conglomerates; the Miocene and Oligocene formations are widespread to the west and east of our area. Following the uplifting of marine Micoene, some younger formations were formed in the depressed areas. According to H. Colin, these rocks are of Pliocene age and the uppermost part of the formation is composed of polimictic conglomerates. Because these formations closely resemble each other, we have also accepted a Pliocene age for the Kötekli limestones. The fact that conglomerates of our area were observed overlying the Miocene formations on the highway between Elmalı and Kaş also confirms this assumption.

D. QUATERNARY

The Quaternary formations in the surveyed area are composed of the Bayır conglomerates, terraces, young alluvium, slope breccia and alluvial cones.

Bayır conglomerates

Because these conglomerates are best observed near Bayır village they were named as *Bayır conglomerates.* They belong to the orthoconglomerate group and are in the form of oligomictic conglomerates. These coarse-grained conglomerates are found along the coastline and on the slopes of the valleys apart frorn the slope breccia and alluvial cones, and contain very large blocks. They are sometimes well-cemented and sometimes loose, which points to the fact that very young movements have taken place in the area.

Terraces

Terraces are observed along the Çandır Stream (13E); in the vicinity of Kum (10G), between Kepez Tepe (10E) and Kadir Tepe (10F), situated some 10 m from the present bed of the stream and also along both banks of the stream. These terraces were formed along the old bed of the Çandır stream and are composed of gravel and sand deposits which are partly cemented. The gravels contain limestone, radiolarite and green rocks.

IV. IGNEOUS ACTIVITY

The igneous rocks of the area are represented by the intrusives and extrusives of the ophiolitic series and are particularly widespread in the zone of submarine volcanism.

A. INTRUSIVES

Intrusives, which cover an area of some 18 km^2, are found within the ophiolitic series and contain peridotite, harzburgite, verlite, gabbro, and serpentinite.

Serpentines and serpentinized harzburgites cover large areas, while gabbros occur in the form of gangue minerals and lenses within the serpentines or sometimes in large masses. The ophiolites of the area are of the Alpine type observed in folded eugeosynclines. As is known, they represent the axes of the folded mountain ranges and are found in association with geosynclinal sediments and spilites.

An important fact observed here is that the ophiolitic intrusions which pass through the entire region along the Çandır Stream (13E) are not related with radiolarites and schists of the area. This does not conform to the situation in the whole of the Mediterranean basin and the Alpine Ranges, where ophiolitic rocks are always found in association with the radiolarites and both vertical and lateral transitions can be observed in various horizons. It is known that ophiolites are affected by very strong orogenic movements; this causes the serpentines to form mobile surfaces along numerous fractured zones and resulted in an increase in their mobility. Although the ophiolites in our area are Triassic in age, in some places they were thrown over the Upper Mesozoic formations or formed tectonic contacts with them.

Serpentinites

Serpentinites are found along the (Çandır Stream (13E), west of Erendağ (2E), and in the vicinity of Çandır (4M).

A great part of the ophiolite rocks in the area are serpentinized. They are generally greenish in color, with polished surfaces, and are strongly fractured. During the field work we observed that these serpentinized rocks were always affected by strong orogenic movements and fractured into fragments of various sizes. Sometimes these rocks have a brecciated structure. The fissures are filled with white magnesite and silica. The serpentinization generally begins in the outer parts of the rock and gradually progresses inwards. This phenomenon can be clearly observed in the field. The core is usually found to maintain its original properties.

Serpentinized harzburgites and verlites

The peridotites observed in places within the great serpentine massif are exposed in small outcrops; they have been subjected to serpentinizalion.

In the vicinity of Çıtdibi (6J) was observed an exposure of a serpentinized harzburgite, some 30-40 m wide and surrounded by serpentines. A microscopic examination of a sample from this locality showed that a great part of the rock was serpentinized, in addition, bastite, pseudomorphic olivine (partly cryzotilized) and in smaller proportion some chromites were also identified.

Verlite is found within the serpentines observed south of Kum; the rock is composed of olivine and augite; it contains also some chromite and picotite grains; numerous fissures are filled by serpentine.

Gabbro. — Gabbros are the basic rocks frequently found in the area. They extend between Kavşık Tepe (3M) and Çandırlar (4M) in the south; in the area between Asar Tepe (6N) and Çandır Stream; and in the north, south of Kum (10G), on both banks of the stream. These rocks are also found in small dikes which cut the serpentines. They are compact, generally greenish and sometimes brown in color. A microscopic examination of a sample taken from Harnuplu Tepe (30G), south of Sivridağ (9D), showed that the rock has a hypidiomorphic granular texture and contains hypidiomorphic labradorite and augite. An other sample shows a zeolitized and albitized gabbro and hypidiomorphic plagioclase; presence of uralite, zeolite and chlorite was also observed. Gabbroid gangue rocks were found within the serpentines on both banks of the Çandır Stream and north of Bobasdağ (4H). They are 10-15 m long and 3-4 m thick. Very often these gangue minerals cut the previously hardened parts of the massive; and they are the final products of hardening of the ophiolitic mass.

An exposure of gabbro is also found north of Çınarcık (6L) located south of the Çandır Stream. This gabbro is also of a hypidiomorphic granular texture and contains hypidiomorphic labradorite (partly albitized) and augite (partly chloritized and uralitized).

Around Harnuplu Tepe, further to the north of the Çandır Stream, at Kum, another outcrop of gabbro was encountered. Here again a hypidiomorphic granular structure of the rock, which is composed of labradorite and augite, is observed; the rock displays the beginning of uralitization process. Petrographical examination of numerous samples taken from the same locality showed that this rock contains hypidiomorphic labradorite and diallage.

A sample taken from serpentines west of Erendağ (2E) contains hornblende gabbro. This rock again has a hypidiomorphic granular texture and contains hypidiomorphic labradorite and augite (partly uralitized and partly chloritized), and rarely magnetite.

B. EXTRUSIVES

The ophiolitic extrusives covering an area of 15 km^2 consist mainly of pillow lava, spilite, keratophyre, diabase, albite, dolerite and augite basalts. The structure of rocks is in the form of pillow lava and amorphous porphyritic lava with a flow texture. These submarine lavas of the basalt family settled within the Triassic formations prior to the hardening process of the Triassic sediments; they are synchronous with sedimentation. Although these rocks are mostly found in the lower layers of the formation, they can be also observed outcropping in the various levels (Çandır, Tesbihli and Gökdere formations) in the form of sills. Only diabase dikes cut the Triassic sandstone beds to the north of Gedeller (14H). These rocks are probably intrusive diabases; they have a pillow structure. The pillow lavas are found west of Erendağ, next to our area, in the western and northwestern sections of the area, and to the west and northwest of Bereket Dag. These pillow forms overlie each other and in between contain crystallized limestone fragments. Or, to be more precise, each unit of pillow lava is encircled with limestone and overlies the serpentines.

In some places these pillow lavas are brecciated, crushed and fractured by tectonic movements. The spilitic rocks of the area are in close relationship with radiolarites and cherts. In places, manganese deposits are observed within these cherts and around spilites. This situation is considered in the light of the present hypothesis, which maintains that the submarine extrusive rocks were formed by the silica, iron and manganese brought along with the magma from the upper part of the mantle.

Spilitic type

Spilitic lavas are poor in CaO and rich in Na. They are mostly brown or grayish-colored, and are found in the form of veins in various levels of the Triassic formations. This type of lavas is the most common in the area.

The extrusives found within Triassic formations south of Girevit Mountain show an exfoliation structure (PI. X, photo 29). Though these recks resemble pillow lavas and pillow balls, they have a different structure. The microscopic examination of a sample taken from the area showed that the rock is an amygdaloidal natron-keratophyre spilite. It has a hemicrystalline-porphyric texture. Grain crystals of albite lie in a vitreous groundmass, which is composed of albite and ore grains; large calcite veins are observed here. The groundmass contains a number of amygdaloidal vesicles which are filled by calcite, zeolite and chlorite.

An other sample taken from a locality north of Gedeller (14H) showed a calcitized amygdaloidal natron-keratophyre-spilite with partly calcitized groundmass. It contains albite grains.

Diabasic type

Outcrops of diabases are observed around Gökdere (17F); NE of Gedeller (14H), NW of Balaban Mezarlığı; and north of Arapuçtu and south of Çağlarca (8B). These rocks are greenish to brown-colored, hard and fresh. They are in the form of dikes. The dikes are about 20-30 cm long and from 1 to 2 m thick. The diabases of Gökdere contain augite (titano-augite, showing a strong serpentinization and chloritization) and, in lesser proportion, plagioclase (labradorite) miciophenocrysts. The groundmass is composed of microscopic rods of plagioclase and entirely decomposed augite microlites. In addition, the sample contains scattered magnetite microlites. The rock has an intersertal texture.

A sample collected NE of Gedeller (14H) shows albite diabase (albite dolerite); it contains phenocrysts of plagioclase (albite produced by albitization) and pyroxene (titano-augite shows serpentinization and calcitization). The groundmass is composed of plagioclase (albite), microscopic rods, pyroxene (completely serpentinized), microlites; the sample contains also natrolite and magnetite microlites. Other exposures of diabase are the albite diabases found north of Balaban Mezarlığı and west of Tahtacı; the pyroxene is completely chloritized and serpentinized. The rock is massive and has a porphyritic appearance.

Basaltic type

This type of lavas cover large areas especially west of Sivridağ (9D) and south of Bereket Mountain. They have an intersertal texture and are of augite-olivine basalt type. The groundmass contains labradorite phenocrysts, calcite pseudomorphs and olivines. The cavities are filled by augite. Accessory material is magnetite grains.

The basalts lying south of Bereket Mountain (1J) are amygdaloidal and zeolitized augite-basalts. The groundmass contains zeolitized plagioclase phenocrysts; augite and, in a lesser amount, ilmenite are also found in the groundmass. The numerous cavities of the rock are filled by calcite.

Agglomerates and tuffs

These rocks are in relation with the extrusives of the area. The spilites and basalts south of Erendağ (2E) sometimes contain green tuffs (tuffite) and volcano-clastic levels (volcanic breccia).

In conclusion it may be stated that Triassic is characterized by a geosynclinal diabasic and spilitic volcanism. Triassic formations contain abundant natron-keratophyre spilite, basalts and diabases, generally as sills and rarely in the form of dikes. They are certainly of Triassic age.

The age of ophiolitic series

The age of the ophiolitic rocks found in the area is known for certain only for extrusives. The age of intrusive ophiolites (serpentine, peridotite, gabbro), on the other hand, is uncertain, although based on our field observations we consider it most probably as Triassic.

First, it should be accepted that the ophiolitic magma is always formed in mechanically weak marginal zones, during the initial formation phase of a geosyncline; then it penetrates between the old and more or less metamorphic beds and the young geosynclinal sediments. It is always affected by high orogenic tectonics. This condition is essential for the age determination of ophiolites.

Secondly, the age determination should be based on the relationship between the rocks of the large and thick ophiolitic series and the marginal rocks. The relationship between lenticular or small ophiolite outcrops and the neighboring rocks should not be taken into consideration, because in our area the serpentines are found in relation with the Cretaceous limestones. This relationship is the result of the tectonic movements. The intrusion that took place at the beginning of the geosynclinal phase, was certainly affected by these orogenic movements, together with geosynclinal sedimentation. Therefore, the old and young formations with subsequent folding and scales lost their original place. Because of such tectonic complexity, the older basal and the younger formations can be confused with serpentines.

Although the serpentines are widespread in our area, it is very difficult to form an opinion about their age. Their base is not visible anywhere and there is no contact between these rocks and the Permian limestones, which represent the oldest formation in this region. The only way to determine the age of these serpentines is by comparing them with the overlying Triassic sandstones and conglomerates, observed to the north and west of Menekişler, which contain some serpentine grains.

However, the base of serpentines can be observed to the northwest of our area of study. Here, in the vicinity of Belkis, a crystalline substratum of Paleozoic age underlies the serpentines. Most probably the border between the old crystalline mass and the metamorphic Paleozoic rocks forms the zones of ophiolite intrusions (according to H. Borchert, 1958).

The second hypothesis is that the ophiolites probably emerged from the weak zones between the Permian and Triassic sandstones.

Some geologists, who carried out surveys in this area and in the neighboring regions, have expressed their opinion on the age of these ophiolites: H. Colin (1962) in his studies, which include also our area, described the ophiolites as belonging to Cretaceous age. This opinion was also shared by H. Holzer (1955) and A. Helke. This important error arised from the fact that the fossiliferous Triassic rhythmic formations, according to these workers, were of the Upper Cretaceous age, and consequently they inferred that the age of the interbedded extrusive rocks is also Cretaceous. Starting from this point of view and considering the intrusives as equivalents of extrusives, they attributed these rocks to the Upper Cretaceous. However, since we discovered abundant Halobia and Daonella fossils in the Triassic beds, the hypothesis of an Upper Cretaceous age should be abandoned.

T. Juteau (1968), who studied the southern part of our area, stated that the intrusives and extrusives of the ophiolitic series were closely connected with each other and assigned to them an age between Aptian and Maestrichtian. Because no fossils were found in this area, the. Triassic formations, under the name of schisto-radiolarites or Alakır Çayı formation, were hypothethically accepted as being Cretaceous in age. Although, in a way, this claim seems to support the theory of H. Colin, T. Juteau differs from H. Colin in advancing that these intrusive and extrusive rocks belong to the same pluto-volcanic origin, while Colin and Holzer attribute the effusives to Lower Cretaceous, and the extrusives to Upper Cretaceous, stating that these rocks were deposited separately at different periods. We accept the theory of a difference in the time of deposition of these formations. However, in our opinion, first the intrusives and then the extrusives were deposited in our area of study. Even if we accept that a very close relationship exists between the spilites, diabases and tuffs, they certainly had been deposited at different times. The ophiolite extrusives are slightly younger. If we accept the age of ophiolites as Cretaceous, we would be obliged to adopt the theory that Lias, Dogger, Malm, and Cretaceous, overlying the Triassic formations (intercalated with intrusives), form a nappe covering the ophiolites, which is completely erroneous.

The age of the ophiolitic extrusives has been definitely established. The fact that these rocks in the form of sills are interbedded at numerous horizons with the Triassic formation proves that they are of Triassic age.

Thus, the extrusives of the area are Triassic, while the intrusives belong to lower horizons of the Triassic. However, this does not prove that the ophiolites of the entire Taurus region are of the same age. An other intrusion of ophiolite magma has. certainly taken place between Triassic and Upper Cretaceous and even during Paleocene. In conclusion, the basic and ultrabasic rocks of the area under investigation can not be younger than Triassic, taking into consideration the close relationship between Triassic formations and these rocks.

Settling of ophiolite intrusions and field observations

1. The rocks with ophiolite phenocrysts encountered in our area are composed of peridotite, serpentinite, verlite, serpentinized harzburgite and gabbro.

2. In the center of the area peridotites and serpentines extend in a NE-SW direction; they constitute a single massive.

3. No close relationship between peridotites and serpentinites with radiolarites and basic extrusive rocks was observed in the area.

4. Basic rocks such as gabbros are found within the ultrabasic rocks.

5. Peridotites and serpentinites have not metamorphosed the country rock.

6. Ultrabasic rocks did not cut the country rock even tectonically.

7. The existence of gabbros points to an upward injection.

8. The lower border of serpentinites is not visible. In the upper parts they are directly overlain by Triassic and Liassic formations.

9. Ultrabasic rocks do not contain any foreign blocks.

10. The strike of the ultrabasic massif in the surveyed area, which extends in the NE-SW directions, corresponds to the directions of overthrusting, imbrexes and folding system.

11. Gradual transition from ultramafites into gabbros-dolerites and pillow lavas was not observed in the area.

If we try to solve the problems of the origin of peridotites and serpentinites and the mode of their settling by accepting hypothesis of the presence of ultrabasic rocks in this area, and if we study the conditions of formation of these rocks, we cannot arrive at any satisfactory conclusions. Because a great number of objections and unresolved questions will arise. Had the ultramafites in solid state been deposited during the tectonic intrusions, or are they an evidence of a magma flow which spread out on the deep-sea floor? What is the relation between the diabases and spilites of the true ophiolites? What is the origin of the ultrabasic magma? If we accept the hypothesis that it is derived from the upper layer of the mantle, did it appear in a fluid or consolidated state? Or had the ultrabasic magma undergone a secondary structure; that is to say, is that state due to differentiation processes from the basaltic magma? If the differentiated magma is ultrabasic, how the volcanics have been formed?.

At present, we lack sufficient evidence and means to give positive answers to these questions. For this reason we shall try to present ideas based only on our field observations. There is some evidence to show that ophiolites are a tectonic lens which settled in the upper part of the earth crust during orogenic movements. The ultrabasics are aligned in NNE-SSW directions; this trend corresponds to the direction of upthrusts, imbrexes and overthrusts. Although the upthrusts and the formation of imbrexes took place much later than the settling of ophiolites, we may accept a theory that these ophiolites were deposited during the first stages of deformation of geosyncline. Of course, this theory cannot be considered as a proven actual fact, but it is possible that the Tethys sea had undergone a deformation prior to the Upper Triassic and the deposition of ophiolites might have taken place during that period. Another hypothesis can be that the ophiolites issued from the tectonically weak zones during the initial phases of geosynclines. In that case it may be assumed that the ophiolites had settled during the Lower Triassic when the Mesozoic sea was in its initial phase. This assumption is supported by the evidence of a close relationship between the Triassic rhythmic series and the ophiolites, especially the extrusive series.

As for volcanic rocks—although in recent years the theory that there is no relationship between volcanic rocks and the ultramafites had been greatly strengthened—it has been observed that everywhere in Turkey the ophiolitic grained rocks were always associated with the submarine volcanic rocks which were, however, always younger. This interval in age is usually unimportant, but amounts sometimes to a change in stage. After studying the existing hypotheses on the origin of volcanics, the theory suggested by W.P. de Roever (1957) may be accepted. According to this author, a probable decrease of pressure during the geosynclinal phase caused a partial melting of the mantle and, thus, a basaltic magma consisting of diabases and pillow lavas was formed. In this manner, although solidified during different pefiods, the ultramafites and mafites may have the same origin.

V. STRUCTURAL GEOLOGY

A. GENERAL STRUCTURE

The surveyed area, extending between the high mountain range of Beydağları in the west and the Gulf of Antalya in the east, includes all the formations from Permian to Upper Cretaceous. This area emerged from the sea during repeated orogenic phases, and, thus, new transgressions were formed here.

The general structure of the area is characterized by anticlines and synclines extending in a NE-SW direction. Within these structures imbrexes, upthrusts, and probably unimportant overthrusts and young faults, that cut them vertically, took place. The formations of the area disappear under the Upper Cretaceous of the Beydağları Range, and are bordered in the east by the great fault of the Antalya Bay, trending in a N-S direction.

The axes of the folds trend in a NNE-SSW direction, the pressure forces being mostly from NW. West of the. Antalya Bay, along the high slopes and the parallel fault lines extending inland, reef limestones of different ages and forming isolated peaks are observed. This structure is very interesting. According to H. Colin (1962), the coastal limestone ranges are crossed by numerous faults dividing these series into isolated imbricate structures, the eastern parts of which are thrust upon the western sections. Although this theory is correct partly, in our opinion the thrust is not from east to west, but on the contrary from west to east (Ann. I) Numerous examples confirming this statement can be encountered in our area; sometimes, as a result of thrust movements, the limestone units have been displaced and upthrust faults have been formed between the beds. These thrusts sometimes were very violent as observed, for instance, at Erendağ (2E), where the Permian limestones and dolomites have been thrown to the surface and thus covered the Triassic formations. Another interesting feature of the region is that the folding and faulting, which reveal the general structure of the area, run parallel to the Antalya Bay. This factor together with the information based on field observations shows that the present structure of the area was formed by the thrust movements coming from NNW-SSE. According to M. Blumenthal (1963), the tectonic movements that took place in the Taurus Mountain Range, east of the Antalya region, have come to an end before the Oligocene; that is to say, the folding and imbricate structures have been formed prior to Oligocene.

In the western part of the studied area, in Korkuteli, to the east of Beydağları and in the neighborhood of Fethiye, the tangential tectonic movements took place between Lower Miocene and Plio-Quaternary. P. Graciansky stated that the units which have undergone overthrusts were always thrown upon the detritic Miocene formations. We were unable to verify these statements since no Eocene, Oligocene or Miocene formations were encountered in our area of study.

The tectonic structure in the surveyed area is generally in relation with the tectonic structure of the Alpine region. There are numerous normal and reverse faults, thrusts and imbrexes. Particularly interesting are small overthrusts and—if the presence of nappes should be accepted—only small fragments of nappes of the Western Taurus Range produced by these important tectonic movements may have affected the structure of the beds in our area of study. Whether this theory is correct, or, as has been claimed, no nappe structures exist in our area, is an open question. We had an opportunity, during our field trips, to observe in the neighboring areas (Elmalı-Korkuteli, Burdur) numerous overthrusts and upthrusts as well as evidence of an imbricate structure, but nowhere in the studied area were encountered Triassic formations that would show a similarity in facies. As concerns formations similar to limestones of Liassic and Malm age, they have been thrust over Eocene and Miocene. The surveyed area stayed in the middle of SE and SW vergence thrusts which border it on two sides; here Triassic formation overlies the ophiolitic series and Permian formations. In order to consider this Triassic series as a nappe it must have been thrust with Permian or ophiolites over a younger formation, but no evidence of such thrusts was encountered either in our area or in the neighboring regions.

The Permian formation in the area described is encountered mostly in the form of imbricate structure and is intercalated between the Triassic and Liassic formations and within the Upper Jurassic dolomites (Ann. II).

The Triassic rhythmic series occupy mostly the depressed parts of our area; they are found interbedded and folded together with basic extrusives (pillow lavas) and tuffs and show an imbricate structure. Because of constant change of facies and absence of fossils within the Triassic formations, determination of orogenic phases was not attempted. Local fractures, recumbent folds and overthrusts are predominant features within this series.

Liassic, Dogger and Cretaceous limestones and dolomites are mostly fractured by tectonic movements. The folding pattern of these series is not distinct because these limestones are thick and massive in structure; only in some places the folds within the limestones and dolomites of the Malm age, and the Liassic limestones of Karadağ in the NE part of the area are encountered.

In the east and west of our area two structures can be observed which extend in the NE-SW directions. They are represented by limestone series, generally of massive texture, forming the higher parts of the area. These two limestone units are found along the Çandır Valley; they are separated by the Triassic rhythmic series and the intercalated ophiolitic extrusives. Thus there are two predominant units in this area. One of these units consists mainly of massive reef limestones; the second unit is represented by a Triassic rhythmic series containing sandstones, radiolarites and platy limestones. These two units reveal a fold structure which runs in a NE-SW direction.

B. STRIKES AND DIPS

The exposures of Permian formations (Dinek limestones, Fesliğen dolomites), which represent the oldest beds in our area of study, have two major trends: 40 % of beds strike N 10°-30°E, while 15 % of the series are in a N 10°-20°E direction (Fig. 11a).

The average dip of the beds striking N 20°-30°E and N 10°-20°E is measured to be 45° and 30° in beds dipping in the SE and NW directions, respectively. Based on the fact that a distinct similarity exists in the strike-and-dip character of the formations (Çandır, Tesbihli, Gökdere), included in the Triassic rhythmic series, they are shown on a single diagram. 23 % of the sandstone, radiolarite and platy limestone beds, which constitute the Triassic formation, strike N 30°-40°E; 18 % of these beds strike N 10°-20°E, and 14 % of the beds strike N 50°-60°E (Fig. 11b).

The average dip of the beds striking N 30°-40°E is measured to be 34° and 33° for beds dipping in the NW and SE directions, respectively.

Liassic beds generally show a massive structure; only the Girevit limestones in the vicinity of Karadağ are well-bedded. Based on the measurements taken, it was noted that 42 % of the Liassic limestones located in this area strike N 30°-40°W; whereas the 24% strike N 10°-20°W; and the 12 % of the beds strike N 60°-70°W (Fig. 11c). The average dip of the beds striking N 30°-40°W and N 10°-20°W is 65°NE and 50°SW. The structure of the Dogger beds being massive, it was impossible to measure their strike and dip. The Upper Jurassic formations (Kaplan dolomites, Karıncalı limestones) generally strike NE-SW and the beds dip 30°-60°NW and SE. The average dip of the beds dipping NW and SE and striking N 40°-50°E is 44° and 47°, respectively (Fig. 11d). The Lower Cretaceous beds dip N15°E and 10°-15°NW and SE. The Upper Cretaceous limestones are massive or thick-bedded; the Tümek dolomites, on the other hand, are characterized by medium to thick beds and are well-bedded.

C. FAULTS AND IMBRICATE STRUCTURES

The study of the present-day morphology of the studied area reveals numerous dislocation zones, as evidenced by various faults, upthrusts and imbricate structures. The trend of these zones is generally in the NNE-SSW direction and corresponds to the main trend of the dislocation zones west of our area. Sometimes these dislocation zones are cut on the bias by secondary fractures.

After the main structure of the area has been established, some younger orogenic movements have caused fractures, which are observed particularly in the massive limestone mountains.

Imbrexes of Erendağ

In the western part of the area, along the high (2422 m) Erendağ (2E) Range, the Permian limestones and dolomites are overlain by the Girevit limestones and underlain by the Triassic rhythmic series; the position of the Permian series among these formations is abnormal. Here, the Triassic, Permian and Liassic formations have almost the same strike and dip. The Permian limestones and dolomites, observed on the western flank of the Fesliğen anticline which was formed during the

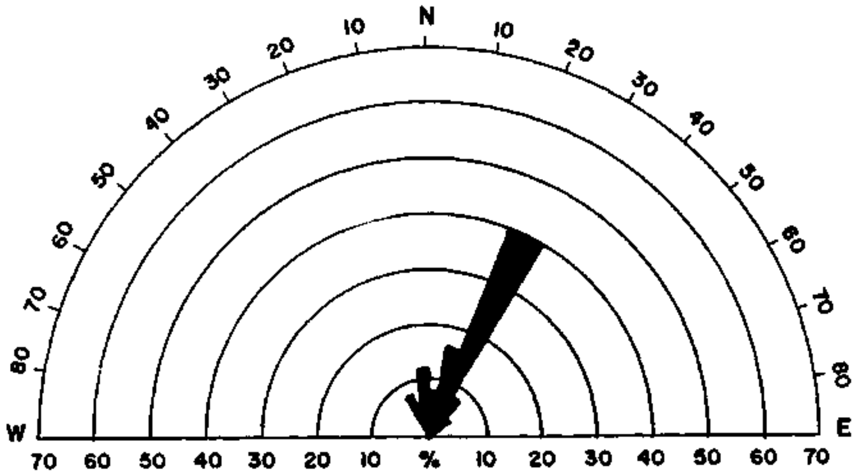

Fig. 11*a* - Strike diagram of Permian limestone and dolomite beds.

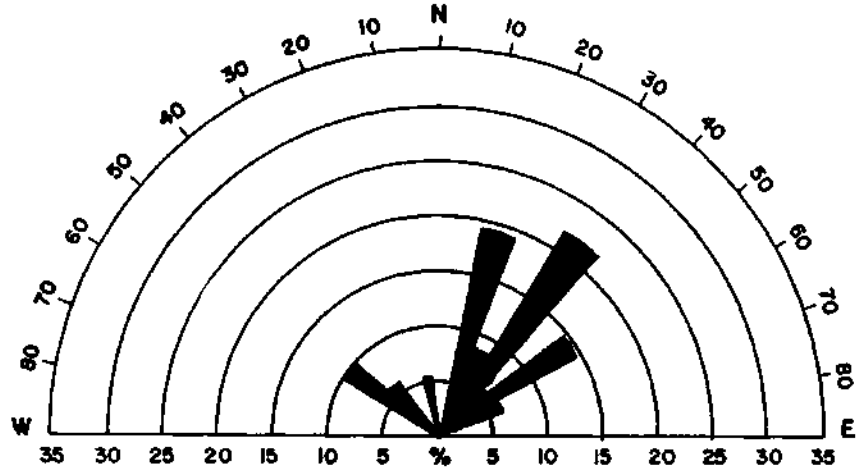

Fig. 11*b* - Strike diagram of Triassic rhythmic series.

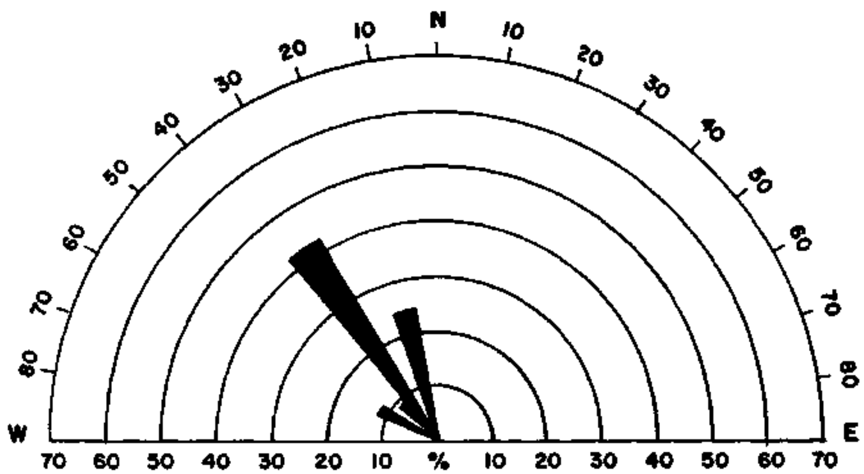

Fig. 11*c* - Strike diagram of Liassic (Girevit formation) beds.

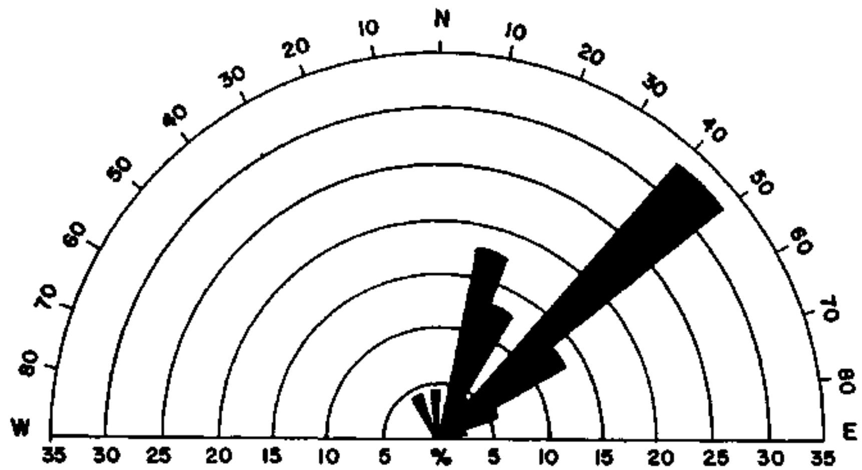

Fig. 11*d* - Strike diagram of Upper Jurassic (Karıncalı formation) beds.

Triassic period, were probably pushed to the surface by a strong orogenic movement and formed an imbricate structure between the Liassic and Triassic formations. The trend of the abnormal contact line is generally from north to south; however, this is not a straight line but shows a concave shape (Fig. 3 and Ann. I).

Similar imbricate structures are observed in several other places of the surveyed area; but these imbrexes are much smaller and are probably fragments of a major nappe structure which was displaced from another area.

Imbrexes and faults of Sivridağ

The Sivridağ imbricate structure can be followed along the western slope of this mountain in a NE-SW direction; its length is 4.5 km. Here Permian limestones were thrusted to the surface as a result of a strong orogenic movement; they intruded between the Triassic extrusives and the Liassic limestones. These beds strike N15°E and dip 40°SE.

On the eastern and western flanks of the mountain, NE-SW trending thrust faults are also observed in the Sivridağ limestones of Liassic age (Ann. I).

Fault-line of Bereket Mountain

There is a 2-km-long fault-line east of Bereket Mountain (1J). It is observed between the Upper Jurassic limestones and the serpentines. The fault strikes N-S in the south, but after 1 km it takes a NW-SE direction and continues between the Tertiary conglomerates and the limestones. It is a young fault and has a 50 m-high fault scarp.

Faults of Karadağ

There are three 500-m-long faults west of Karadağ (5C). They extend within the Liassic limestones and are reverse fults. The major fault, extending north and east of the mountain, is a gravity fault; the northern block is downthrown. The fault extends in a NW-SE direction and takes a N-S trend in the vicinity of Sarıeşik.

Faults of the Girevit Mountain

Normal faults are found within the Liassic limestones, south and north of Girevit Mountain (15E); they extend in a NE-SW direction. This trend corresponds to the strike of the mountain, which is also NE-SW. Along the 3.5 km of the fault-line, in the southern part of the area, exposures of Triassic radiolarites and extrusives can be observed (Ann. I and II).

Fault (upthrust) of Gökdere

The platy limestones interbedded with the Triassic radiolarites, observed in the eastern part of the Gökdere Valley (17F), are thrust over the Upper Cretaceous dolomites and limestones. A reverse fault extending in a NE-SW direction represents an abnormal structure. The regularly bedded limestones, trending NE-SW and dipping 25°-40°NW were thrown over dolomites by a stress coming from NW; these beds show almost the same strike and dip (Ann. I and II).

In addition to the faults and imbrexes described above, there are numerous normal and reverse faults in our area of study. The complexity of the tectonics in this part of the area can be evidenced especially by the Liassic limestones found along the coast south of Akyar Mevkii (18L) and on the Yumrucak Tepe, where these limestones are thrust over the bedded Upper Jurassic limestones. Likewise, along the coast, in the vicinity of Dinek Çeşme, the black-colored Permian limestones are observed intruding between the Upper Jurassic dolomites.

D. FOLDS

The folds in the studied area are mostly observed within the Permian, Triassic, Liassic and Malm formations. The other formations, such as Dogger, Lower Cretaceous, Upper Cretaceous and Tertiary, do not show any folding. These formations show a monoclinal structure, since they are usually massive in character or—in the case of upthrusts—the flanks of the folds are not visible. The formations of different lithologic character form folds of various types because they underwent different orogenic movements. Most of the faults are asymmetrical.

The folds observed in this area were produced during various times by orogenic forces pushing from NW-SW; thus, numerous anticlines and synclines, as well as overturned and recumbent folds, were formed within these formations.

The general trend of the fold axes is NNE-SSW; a NW-SE direction was only observed in the Liassic limestones on Karadağ (5C).

When the strikes and dips of the beds, observed in the studied area, were checked with the Schmidt diagram, differences were noticed in connection with the axial direction and plunging of these formations (Fig. 12).

The Permian limestones and dolomites, which are the oldest formations in the area, were folded together. South of Gedeller (14L), in the area between Sivridağ Tepe (13İ) and Karıncalı Dağ (15J), folding structure present in the core of the limestones in the Kaplangediği anticline was not observed in any of the other exposures of these series. The strikes and dips of the Permian formations were measured and compared with the Schmidt diagram (Fig. 13A), axes of folding being about N 12°E and a plunge of 4°NE. Because they were folded together the Triassic rhythmic formations (Çınarcık fm., Tesbihli fm., Gökdere fm.) have similar characteristics. The anticlines and synclines formed by these Triassic beds are mostly assymetric and are frequently overlain by younger beds. Within the inner Triassic structure a great number of small folds are found.

Measured strikes and dips of the Triassic formation are found to have axes of folding about N 35°E and plunge of 4°NE in the evaluation of Schmidt diagrams (Fig. 13B). The Fesliğen anticline, Çandır Çayı anticline and Girevit syncline, from west to east, are the main anticlines and synclines formed by the Triassic formations.

The Liassic Girevit limestones are generally massive and thick-bedded. They overlie the Triassic formations in the form of wide synclines or have monoclinal structures. These series are well-bedded only on Karadağ Mountain where they form anticlines and synclines. Liassic beds are found to have a folding axis extending N 40°W according to the Schmidt diagram (Fig. 13C).

Because of the scarcity of measurements on the Dogger beds they could not be shown on a diagram.

The Malm beds (Kaplan dolomites, Karıncalı limestones) were folded together. They formed a large anticline of Kaplan Gediği in the east of the surveyed area and the Karıncalı Dağ syncline cutting through the Karıncalı Mountain.

The Malm beds were found to have an approximate fold axis extending N 48°E and a dip of 6°NE, according to the Schmidt diagram (Fig. 13D).

The Lower Cretaceous beds have exposures only on Dünek Tepe (9N) where they form an open fold.

To the west of Tümek Tepe the Upper Cretaceous limestones and dolomites are partly covered by an upthrust of Triassic beds. The Upper Cretaceous beds show here a monoclinal structure. In the southern part of the area these Upper Cretaceous limestones are not folded.

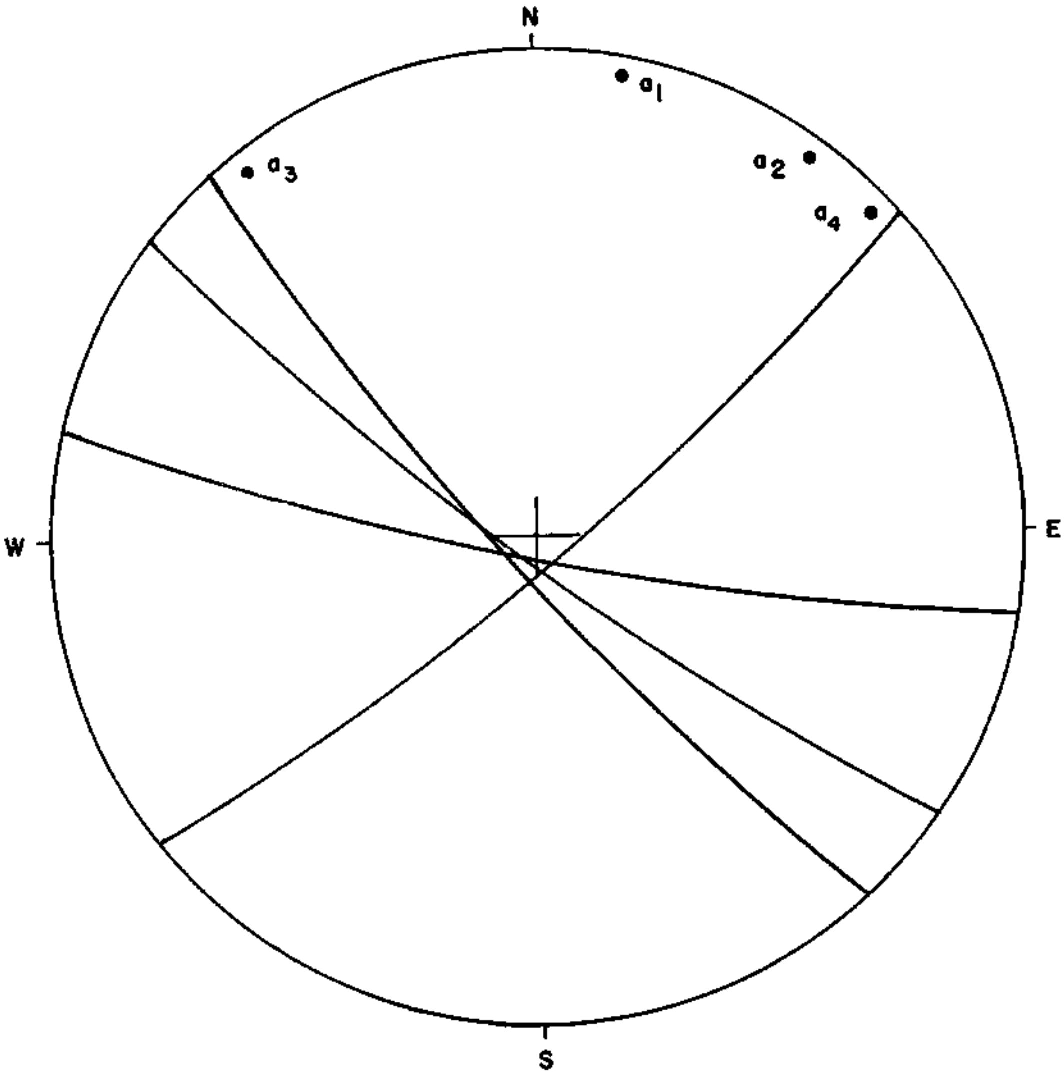

Fig. 12 - Schmidt diagram showing average fold axes and plunges of various formations.
a_1 - Permian; a_2 - Triassic; a_3 - Liassic; a_4 - Malm.

The Pliocene conglomerates and the coarse-grained conglomerates of Quaternary age, as well as alluvium beds and the underlying travertines, do not show any folding.

Anticlines and synclines

The Fesliğen anticline. — It extends between Erendağ (2E) and Karadağ (5C) in the west, and in the vicinity of Çürük Tepe (5H) in the southern part of the studied area. Because the Liassic limestones are eroded, the Triassic formation can be observed on the surface. The anticline shows Triassic at its base and Liassic limestones in its upper parts. These Liassic limestones can be seen only on the flanks of the anticline, being eroded in the axial part of this structure. As a result of a thrust in the western flank of the anticline, the Permian limestones intruded between Triassic and Liassic formations. The western flank of the anticline plunges under the Erendağ with a dip of some 30 degrees, while the eastern flank dips between 25° to 40° and disappears under the Liassic limestones of Karadağ and Çürük Tepe. The southern part of the anticline is covered by the

Middle Jurassic limestones in the vicinity of Bereket Dag. The northern part of this anticline is partially fractured and finally plunges under the Karadağ Liassic limestones. The axis of the anticline trends NE-SW in the south, and extends in a NW-SE direction in the north; it is 6-7 km long.

Çandır Çayı anticline. — This anticline is situated to the north of the Çandır Stream. The upper parts of the anticlinal axis are eroded and a valley is formed here along the axis. The part of the anticline extending within the Triassic rhythmic series, with an axis trending in a NE-SW direction, disappears under Sivridağ at an angle of 30°-40°. The SE flank of this anticline plunges under the Girevit Mountain with a dip of 35°-50°.

Kaplangediği anticline. — It is the longest anticline in the area and is situated between Karincali Mountain, Şalbalı Mountain and Tastaracağı Tepe (12L); it trends in a NNW-SSE direction. Its main part lies within the Malm dolomites and its northern extension can be observed in exposures of the Permian limestones overlain by dolomites. The total length of this anticline is 7-8 km. The upper parts are eroded and cut in the north by the western flank of the Gedeller fault. In places, along the axis of the anticline, some breaks are observed; this is due to the subsequent orogenic movements.

Girevit syncline. — This great syncline, which runs along the entire length of the Girevit Mountain in a NE-SW direction, is found within the Triassic formations, and probably continues also in the overlying Liassic limestones. The syncline starts in the northeast, in a large area lying between Gökdere and Çandır Çayı; its upper parts are overlain by Liassic limestones. Both flanks of this syncline can be observed on either side of the mountain. Although, because of thick forests that cover this part of the area, it was not possible to follow the trend of this syncline, it may be assumed that it continues in a SW direction, where it joins the Karain and Dünek Tepe synclines.

Karıncalı Dağ syncline. — This syncline passes through the entire length of the Karıncalı Mountain. To the south, its axis, trending in a NW-SE direction, makes a curve in the middle of the mountain and then turns to the NE-SW. Both flanks of the syncline which lies within the Malm limestones dip between 30° and 50°. The eastern flank of this syncline is cut by a large fault.

Karadağ synclines and anticlines. — Two anticlines and two synclines are observed within the Karadağ Liassic limestones in the northwestern part of the surveyed area. They are about 1-2 km in length and extend in a NW-SE direction. These folds have a rather fractured structure and follow each other within the massive Liassic limestones; they are not found in any other place of the area. The trend of their axes does not correspond to the axial direction of any other fold in this region.

E. UNCONFORMITY AND OROGENIC PHASES

In the vicinity of Dinek Çeşme the Permian limestones and dolomites are transgressively overlain by Triassic sandstones. Although no unconformity was observed between these two formations, it was noted that the Triassic series are of a transgressive character. Likewise, to the west of Menekşeler Mahallesi, Triassic sandstones and conglomerates overly discordantly the serpentines. This fact proves that some Hercynian movements, although probably not very strong, have taken place in this area. Though no evidence of Hercynian orogenic movements was found in the Taurus tectonic unit, it was observed during recent survey trips that even some instances of a Triassic series overlying Paleozoic formation with an angular unconformity existed in the vicinity of Seydişehir. In spite of this evidence, the presence of Hercynian in our area is not definitely accepted.

The Liassic limestones in this area overlie the Triassic formations with an angular unconformity. Although the basal conglomerates are not visible at the base of the Liassic, the strike and dip of the beds—when compared with the Schmidt diagram—showed that there is a great difference between the two formations, and the fact that Liassic limestones overly the folded Triassic formation with a slight dip indicate that Lower Kimmerian orogenic phase that followed the Triassic took place in this region.

It may be assumed that after the Liassic period many parts of this area emerged above the sea level. Because Dogger was observed only in one place, a stratigraphical hiatus is evident starting from Liassic up to Malm. This shows that the Girevit limestones and partly the Hayıtlı limestones were affected by the Adige phase of the Alpine orogenesis. The Lower Cretaceous is not noticeably differentiated from the Malm and their bedding is conformable. On the other hand, Cenomanian overlies Malm and other older formations with an angular unconformity. It shows that the Malm and Lower Cretaceous beds were affected by the Austric phase of the Alpine orogenesis. Among other orogenic phases that caused the folding of the Upper Cretaceous beds are the Laramian and the young Wallachian phases.

VI. PALEOGEOGRAPHY

Our area of study is situated within the Taurus tectonic unit which represents a part of the Alpine geosynclinal structure. However, if we consider the fact that outside of our region, in the east and west, large tracts are covered by metamorphics, while within our area Liassic-Malm-Upper Cretaceous formations are transgressive, leads us to assume that—though probably only for short periods of time—a withdrawal of the sea must have taken place here and that the surveyed area does not represent the central part of this geosyncline. This shows that in the beginning the Permian formation was deposited in a shallow sea, and as this sea deepened this phase came to an end with dolomites of a neritic facies. Towards the end of the Permian, the area—even if for a short period of time —emerged to the surface of the sea and a transgressive phase of limestones and conglomerates has taken place again, and this environment was of a very active and turbulent character, which is evidenced by the roundness of the sandstone grains. Initially during the Triassic period, the sea was shallow and then gradually deepened towards the Ladinian stage, when hundreds of meters of siliceous and platy limestones and radiolarites were deposited in this area. Moreover, the vertical and lateral facies changes, observed within the Triassic formations, show that the marine environment underwent frequent changes due to perpendicular movements.

The presence of pelagic limestones containing Radiolaria, radiolarites, as well as limestones and radiolarites with Daonella and Halobia in the upper parts of the Triassic formation, show that the sea of the area has gradually deepened during that period. The extrusives of ophiolitic facies which are found in the Triassic sandstones—especially within the sandstones of terrigenous facies—indicate that these extrusives poured out from a fracture near the land. Actually these Triassic formations were formed in a typical eugeosyncline resulting from a strong submarine volcanic action of basaltic origin.

Brecciated limestone blocks observed in the pelagic limestones were probably formed by strong currents or by displacement and slipping of the neritic sediments which settled in the depth. These breccia are sometimes found also as microbreccia; they are homogenous and consist of sediments of the same age. These units were mainly formed by submarine slumping and then transported by turbidity currents. As to heterogenous breccia, observed within the Triassic formations, these are related to terrigenous sediments which originated in the zones that emerged on the surface of the water, and then were washed from the land and carried by swift turbidity currents towards sedimentary basins.

The radiolarites found within the Triassic represent a characteristic feature of geosynclines—particularly eugeosynclines—and were deposited in the deep seas. The fact that these deposits contain abundant Radiolaria, and there is still a radiolarian ooze at the bottom of the oceans as deep as 4000 meters, as well as the absence of shallow-sea Foraminifera, indicate that these radiolarites are deep-sea deposits.

There is no evidence of any volcanic activity after Triassic.

In the area of study the thick-shelled Lamellibranches, such as Myophoria, inhabited the shallow-sea areas (Germanic-type areas), while the thin-shelled and fine-ornamented Lamellibranches, such as Daonella and Halobia, were found in the open-sea areas (i.e. in the Alpine-type regions). The fact that both of these types of fossils were found in the Triassic formations of our area shows that the Triassic sea here was first shallow and then has gradually deepened. In conclusion it can be said that the surveyed area is characterized by the facies of pre-flysch period of geosynclinal evolution during the Triassic. That is, it is a basin containing thin-grained pelagic sediments, siliceous rocks (radiolarite, chert), and basic lavas.

Study of the Liassic limestones revealed the presence of abundant Corals, and, as microfacies, pelsparite or intrasparite texture was observed in thin sections. This evidence indicates that the formation was deposited near the shoreline in a relatively shallow sea.

Microbreccia and breccia were observed in the Liassic formations.

These limestones contain abundant Algae—which are benthonic plants that lived in shallow water penetrated by light—that gives us at least partial knowledge of the environment in which Liassic limestones of this area were deposited.

Furthermore, no Ammonites are encountered in the Liassic formations. Mostly these semi-crystalline, white limestones contain abundant Corals, Algae and Gastropods, which indicates that these limestones were deposited in a shallow-sea environment. The breccia found within the Liassic formations points to the existence of cordillera. The pebbles of Permian age, which constitute this breccia, indicate that following the Permian the sea withdrew for a certain time and the Permian limestones thus exposed were eroded and then transported into the Liassic sea, which is evidenced by the presence of Permian fragments in the form of lithoclasts within the Liassic breccia.

In some parts of the area the Liassic sea continued also during Dogger. But there is no doubt that many parts of the region by that time have emerged above the sea surface. This is evidenced by the fact that in many places Malm is observed directly overlying the Permian, Triassic or Liassic formations. Moreover, the presence of oolitic limestones is another proof that the sea in this area was mostly shallow. During the Malm the region was covered for a long time by calm waters which enabled deposition of a thick layer of limestones and dolomites. The Lower Cretaceous limestones containing Orbitolina are rarely encountered in this area, but their presence again is another evidence of a shallow, neritic environment.

The Upper Cretaceous sea also points to a transgression that occurred in this area. The littoral facies here is represented by fossils, such as Rudists, Nerinea and Actaeonella of Cenomanian age. There is no doubt that the Upper Cretaceous sea covered the entire region and, according to fossils collected in our area of study, it continued up to Senonian. It may be assumed that other parts have been eroded. At the end of Laramian orogenic phase the sea withdrew from this area and no further evidence of a marine facies was encountered in these formations. It is known that Eocene was transgressive and covered an eroded area. It was characterized by warm, neritic and epicontinental environment. Following the Oligocene and Miocene periods the entire region was uplifted, the younger sediments being deposited in the lower parts of the area. According to H. Colin, these are formations

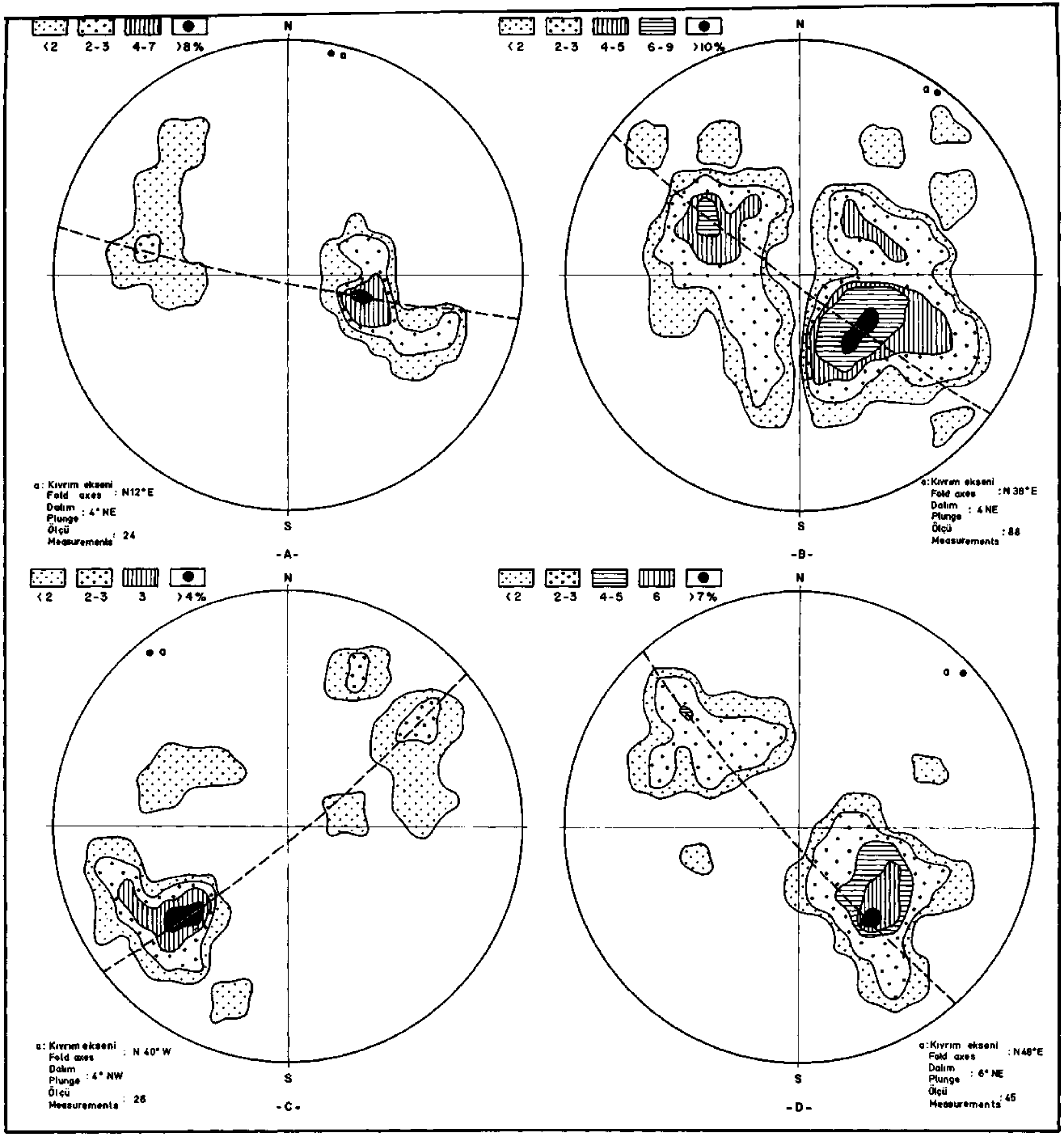

Fig. 13 - SCHMIDT diagrams showing average fold axes and plunges of the formations.
A - Permian limestones and dolomites; B - Triassic rhythmic series; C - Girevit formation (Liassic);
D - Karıncalı formation (Malm).

of Pliocene age; the upper parts of these formations, as seen in our area, are represented by conglomerates consisting of pebbles which are mostly limestone, serpentine and radiolarite. After the Neogene, during the Wallachian phase, the region was affected by strong vertical tectonic movements which were followed—particularly in the neighborhood of Antalya—by deposition of coarse-grained, calcareous conglomerates. These formations are of Pleistocene age and show that they were affected by violent tectonic movements. Then this phase was followed by peneplanation processes which produced a new relief of the area, while streams formed the travertines of today.

VII. ECONOMIC GEOLOGY

There are no mineral deposits of great economic value in the surveyed area. Some unimportant chromite beds exist within the peridotite-serpentine massif which lies in the central part of the region.

— Manganese ore in association with radiolarites is observed in the form of small veins within the Triassic rhythmic series. These veins were formed by the extrusives of ophiolitic series. Their value can only be determined after detailed studies.

— Along the shoreline of the area a number of quarries can be observed from which limestone is extracted. This limestone is used both for manufacture of lime and as building stones.

— There are two kinds of marble that may be of some interest: the pink-colored Triassic limestones and the black-colored limestones of Permian age. These limestones can be easily cut into blocks for commercial use.

— The bituminous beds of this area do not represent any particular economic value. These are the bituminous schists known since a long time in the Antalya region. They can be observed in our area exposed mostly in the form of thin black films within the radiolarite beds.

VIII. CONCLUSIONS

The geological studies carried out in the surveyed area with regard to the stratigraphy and tectonics of this region can be summarized as follows:

1. Detailed geologic map of the area on the 1:25,000 scale has been compiled for the first time.

2. Lithostratigraphic units of the area were identified and studied in detail; names were given to various formations and their positions indicated on the map.

3. Permian—the oldest formation of'the region—has been subdivided as two rock units: limestones and dolomites.

4. Flysch-like series prevalent in the area—which had been variously assigned Jurassic, Lower Cretaceous and Upper Cretaceous ages by different geologists who had previously studied this region—has been determined as Triassic in age (Triassic fossils, such as Halobia and Daonella, were first encountered in 1964 by the present author in the Antalya region) and subdivided into three lithosomes.

5. Liassic was found to overlie the Triassic formations with an angular unconformity.

6. Jurassic formations were studied in detail and divided into Liassic, Dogger and Malm. The facies characteristics and fossil content of these sub-systems were determined and the orogenic phases that affected these formations were established.

7. The Austrian orogenic phase between the Lower and the Upper. Cretaceous formations was established. The Upper Cretaceous was found to be of reef facies. '

8. By the discovery of the primary texture in thin sections it has been proved that dolomites overlying the Upper Cretaceous were gradually transitional and dolomitization was of diagenetic character. These dolomites were named as Tümek dolomites and shown om the map.

9. The area was found to be affected by the Lower Kimmerian, Adige, Austric and Laramian orogenic phases.

10. A number of faults and fault zones were found in the area and the Bereket Mountain, the Sivridağ and the Gökdere imbricated structures and overthrusts were observed.

11. A large fault was found west of the Antalya Bay.

12. It was established that the area does not contain any nappes, as previously claimed. Instead tectonic units, that is synclines and anticlines, extending in the NE-SW direction, were observed. The structure of the area is composed of imbrexes, upthrusts and overthrusts.

13. It was established that the intrusives ofthe ophiolinc series (peridotite, gabbro, serpentine) were Triassic in age; while extrusives of ophiolitic series (pillow lava, spilite, diabase and basalt), although also Triassic in age, were younger than the intrusives.

14. A great number of anticlines and synclines (Karıncalı Dağ syncline, Kaplan Gediği anticline, Girevit Dağ syncline and Çandır Çayı syncline) were found in the surveyed area.

15. A previous suggestion that the Triassic formations ofthe area; overly the Upper Cretaceous formations of the Beydağları in the form of nappes could not be confirmed.

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PLATES

PLATE - I

Photo 1 - Biomicrite with Schwagerininae (Sc). Dinek limestone (Permian).

Photo 2 - Biomicrite with Polydiexodina (Pd). Dinek limestone (Permian).

Photo 3 - Biomicrite with algae (Alg). Dinek limestone (Permian).

PLATE - II

Photo 4 - Biomicrite containing abundant Radiolaria. (*) Partial dolomitization is observed. Euhedral dolomite rhombs (\). Gökdere formation (Triassic).

Photo 5 - Intrabiosparite. Intraclasts containing Radiolaria (•). There are fragments of algae and sponges *(/)* and microorganisms. Girevit formation (Liassic).

Photo 6 - Oosparite containing a large intraclast (in). Note the crushed zone to the right of the photo. Oolites are fractured and the fissures filled with calcite. Hayıtlı limestone (Dogger).

PLATE - III

Photo 7 - The microfacies is micrite; in places nests of spars are observed. Fissures are filled with spari-calcite. (Sp). Karıncalı formation (Malm).

Photo 8 - Biomicrite containing abundant algae (Alg) and microorganisms (F). İnburnu formation (Upper Cretaceous).

Photo 9 - The rock is strongly dolomitized. Euhedral crystals of dolomite are well developed (|-|). Tümek dolomites (Upper Cretaceous).

PLATE - IV

Photo 10 - Algae: *Permocalculus anatoliensis* Güvenç, X 14. Thin section shows barren and fertile branches. The arrow (\) shows sporangia. 1 - Barren branch; 2- Fertile branch.

Photo 11 - *Doanella indica* Bittner, X 2. *Daonella indica* Bittner, x 1.

PLATE - V

Photo 12 - *Involutina sinuosa sinuosa* Kristan, x 50 (Norian-Hettangian).

Photo 13 - *Involutina sinuosa sinuosa* Weynschenk, X 50 (Norian-Hettangian).

Photo 14 - *Involutina* cf. *communis* Kristan, x 50 (Norian-Hettangian).

PLATE - VI

Photo 15 - *Involutina liassica* Jones, x 48 (Norian-Hettangian).

Photo 16 - *Lituosepta recoarensis* Cati, X 42. Girevit formation.

Photo 17 - *Meyendorffina bathonica* Aurouze & Bijon. Hayıtlı limestones (Dogger).

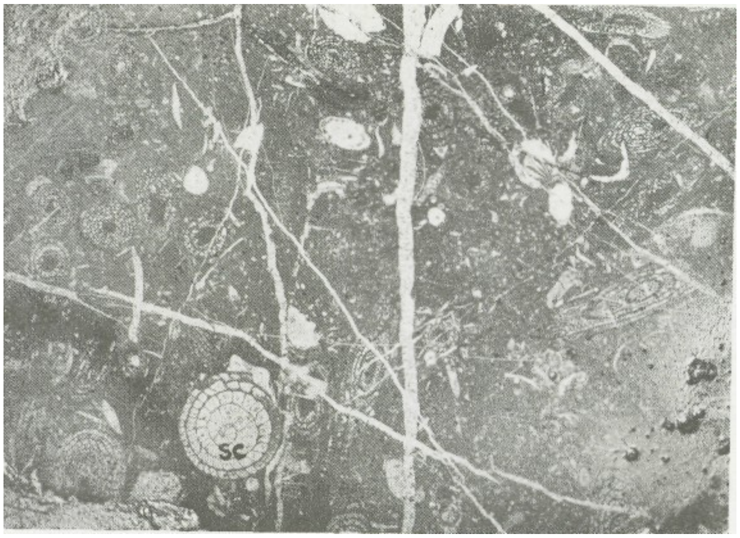
PLATE - VII

Photo 18 - *Protopeneroplis striata* Weyn., x 34. Hayıtlı limestone (Dogger).

Photo 19 - *Kilianina blancheti* Pfender, x 30. Karıncalı limestone (Malm).

Photo 20 - *Kurnibia jurassica* Her on, x *25* (Malm).

PLATE - I



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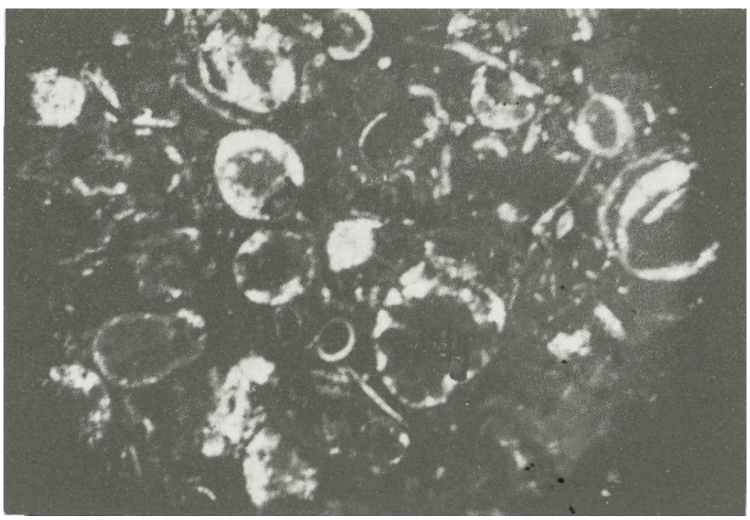


Photo 3

PLATE - VIII

Photo 21 - *Orbitolina* sp., X 30 (Lower Cretaceous).

Photo 22 - *Dicyctina cf. schlumbergeri* Munier-Chal. İnburnu limestone (Upper Cretaceous).

Photo 23 - *Cuneolina pavonia* Henson. İnburnu limestone (Upper Cretaceous).

PLATE - IX

Photo 24 - Malm dolomites (b) in the vicinity of Dinek Çeşmesi and wedge-shaped Permian limestones (a) intruding into the dolomites.

Photo 25 - View of Girevit Mountain; Liassic limestones and faults, a - Liassic (Girevit limestone); b - Triassic (Çandır formation); c - Fault lines.

Photo 26 - View of the western flank of Sivridağ Mountain, a - Permian limestones; b - Liassic limestones; c-Ophiolitic extrusives; d - Overthrusting line; e- Quaternary conglomerates.

PLATE - X

Photo 27 - Folded structure of the Triassic platy limestones. (Photo taken from the side of Sinandeğirmeni Stream.)

Photo 28 - View of the folded structure of Triassic age, north of Bobas Mountain.

Photo 29 - Exfoliation features observed in the lavas within the Triassic formations SW of Girevit Mountain.

PLATE - XI

Photo 30 - Sivridağ Tepe. a- Upper Cretaceous limestones; b- Malm dolomites; c- Triassic sandstones.

Photo 31 - Triassic sandstones at the banks of the Çandır Stream. Çandır formation.

Photo 32 - Relationship between Triassic, Malm and Upper Cretaceous formations in the vicinity of İnburnu. a - Malm dolomites; b - Upper Cretaceous limestones; c - Upper Cretaceous dolomites; d - Triassic platy limestones; e - Line of overthrusts.

PLATE - XII

Photo 33 - Panoramic view of Bereket Mountain, Bobas Mountain and the southern part of Sivridağ Mountain as seen from Ak9aisa. a - Serpentinite; b - Liassic limestones; c - Dogger limestones; d - Fault-scarp.

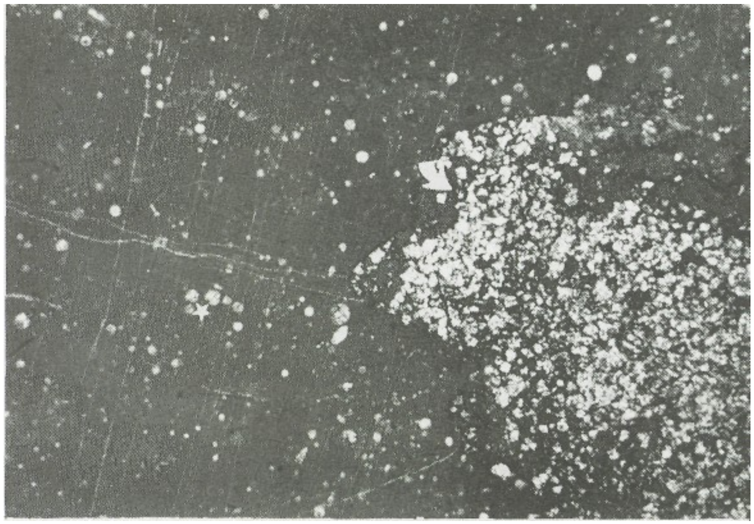
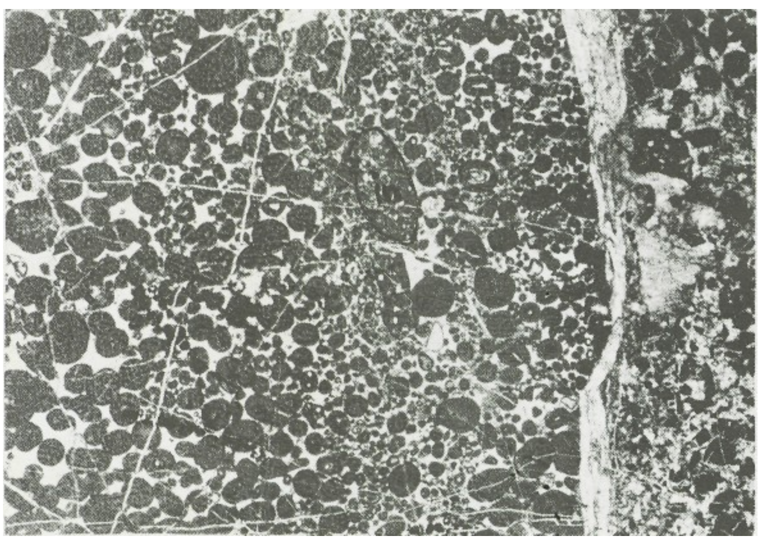


Photo 4

Photo 5



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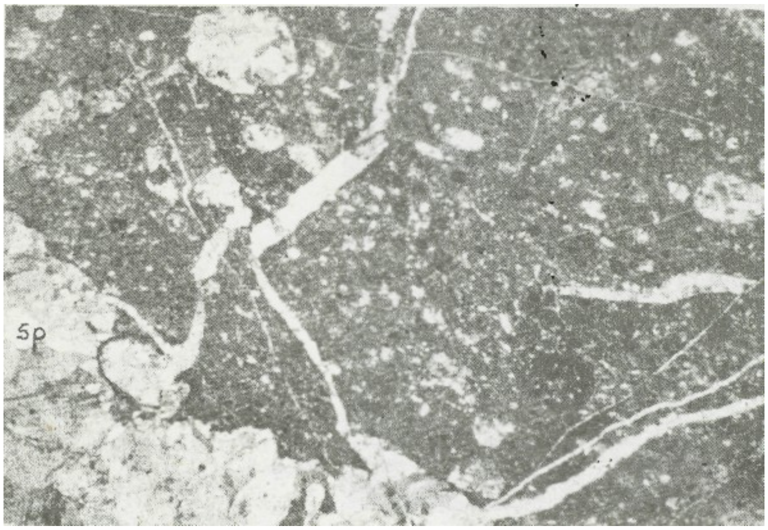

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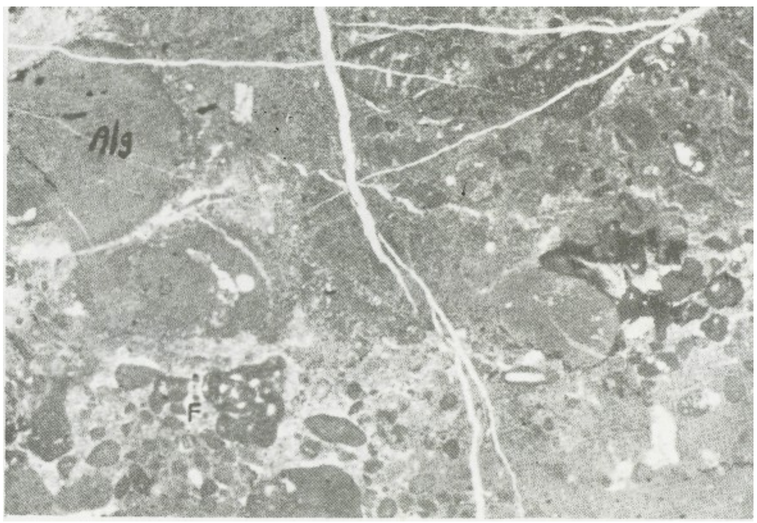

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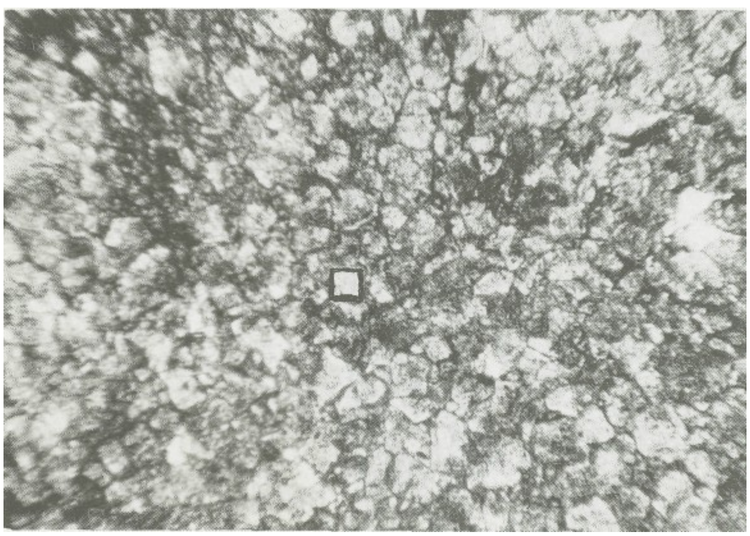


Photo 9

Photo 10

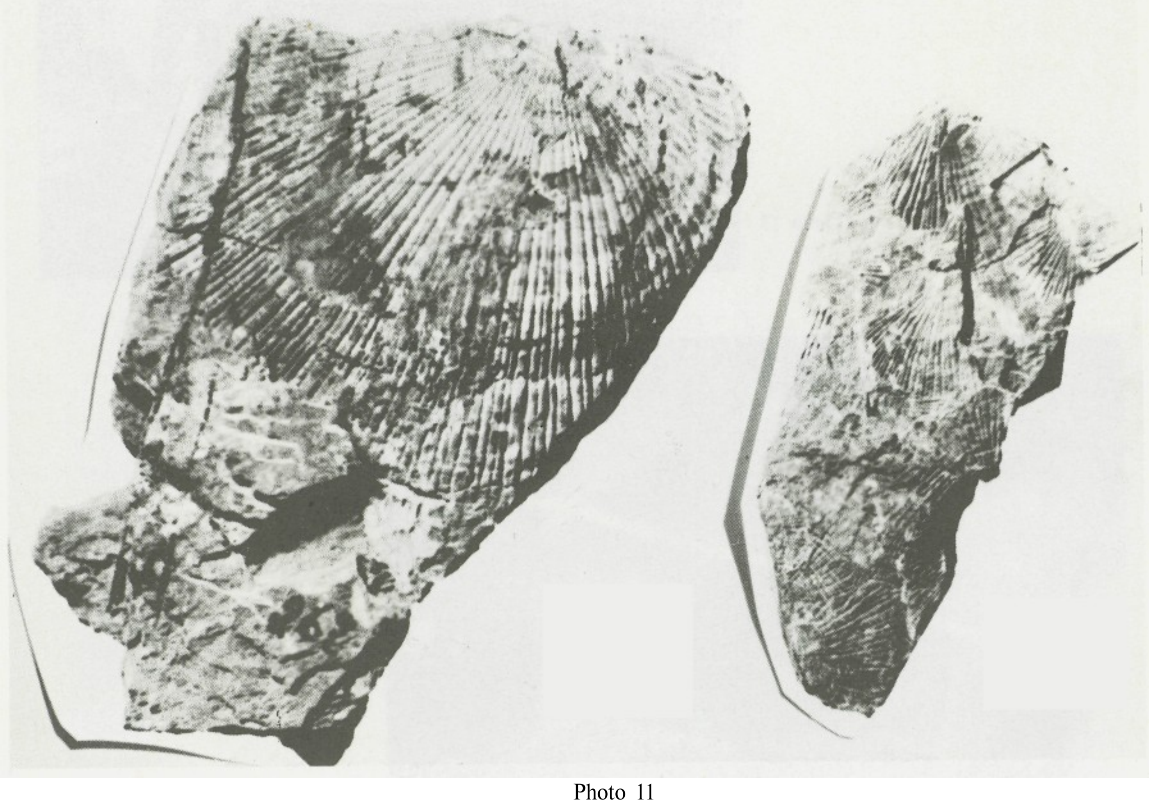
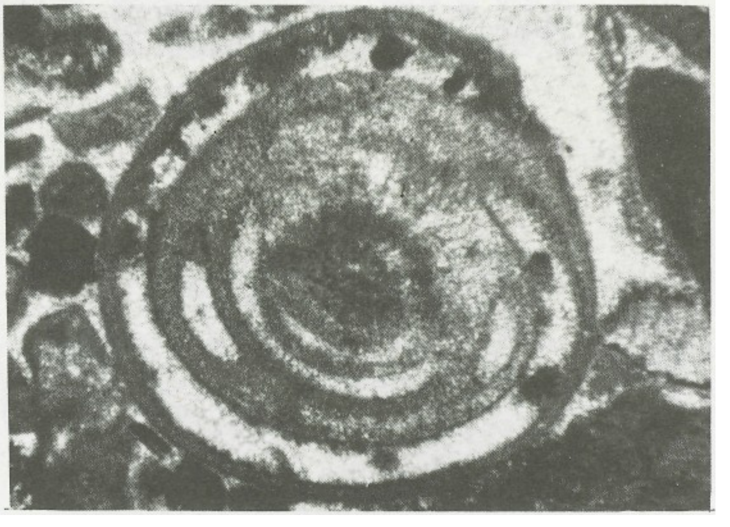


Photo 11


Photo 12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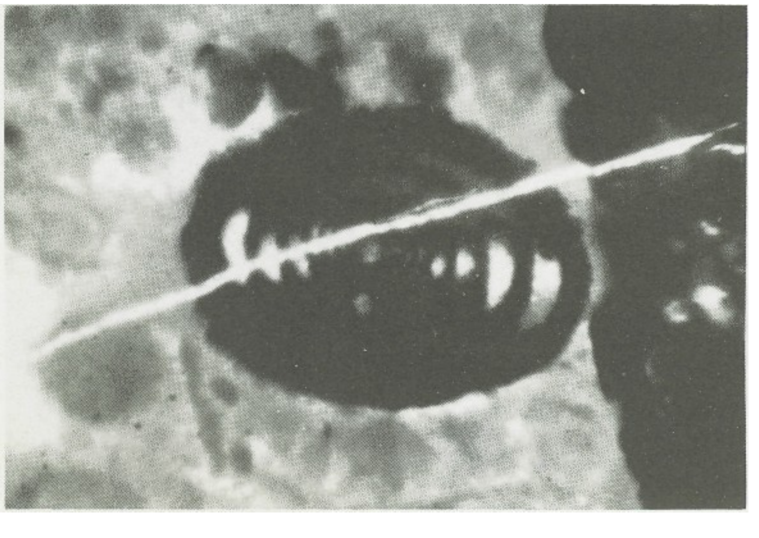
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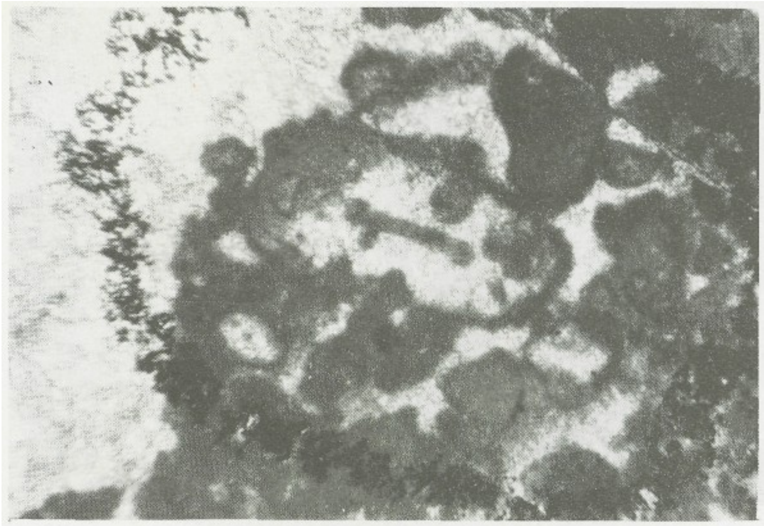

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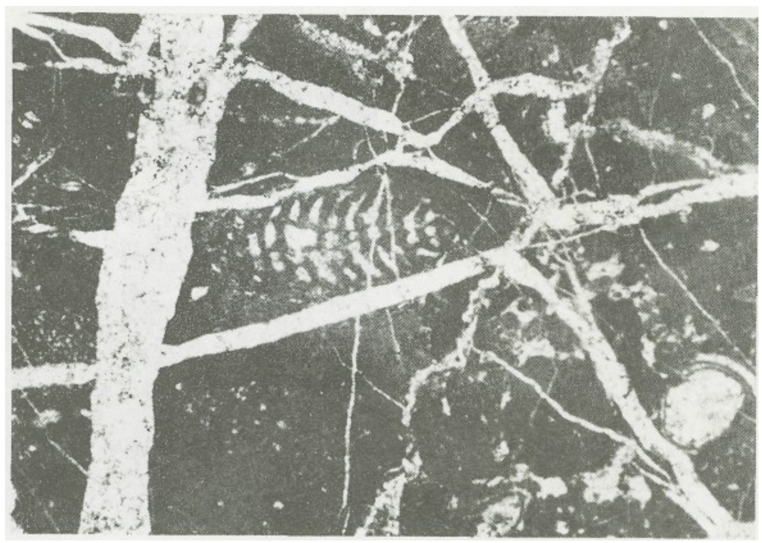

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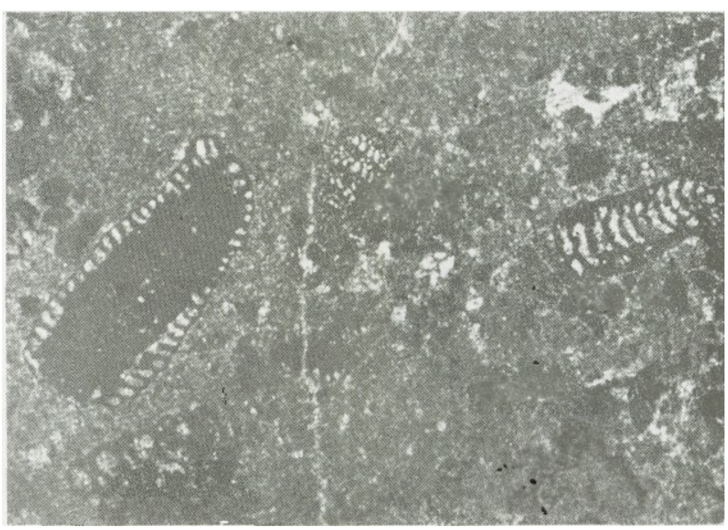

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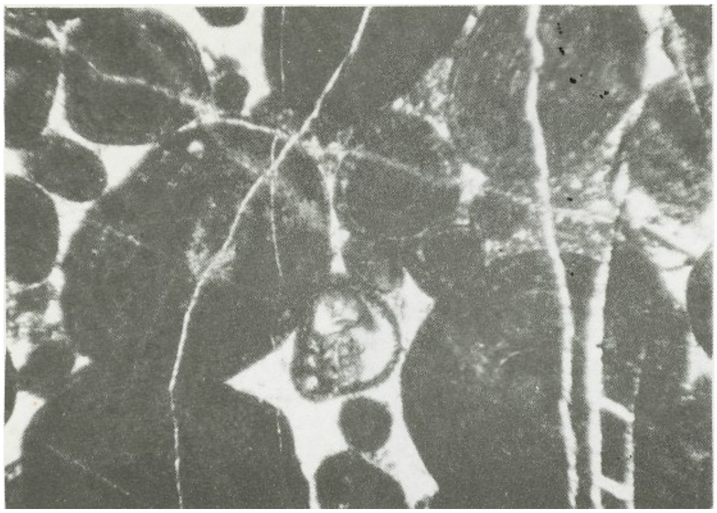

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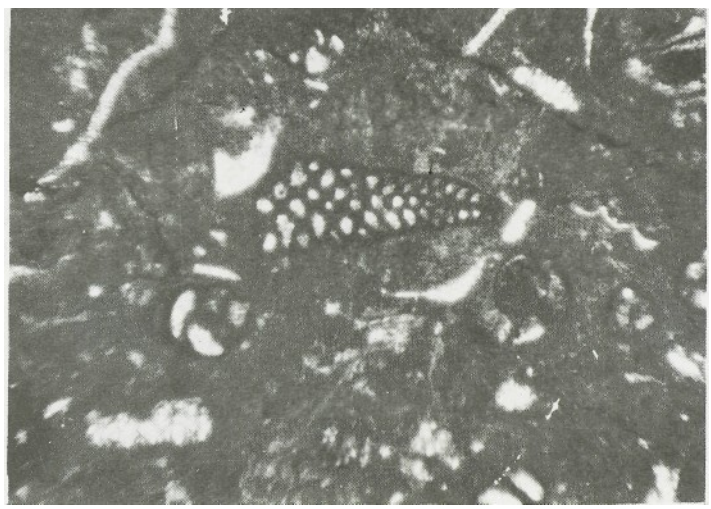

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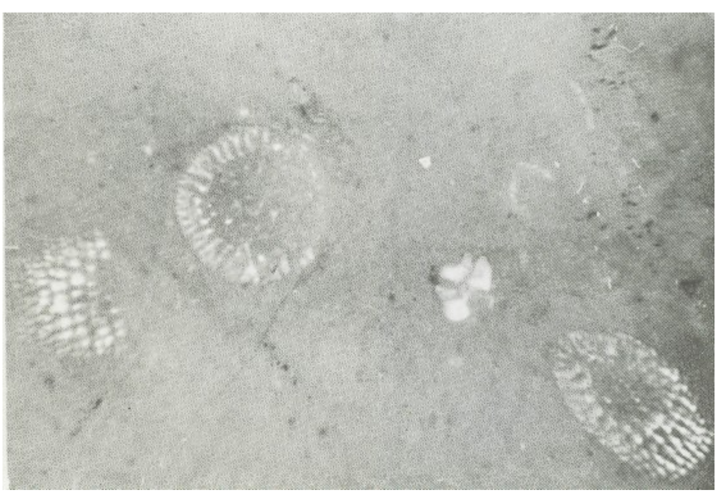

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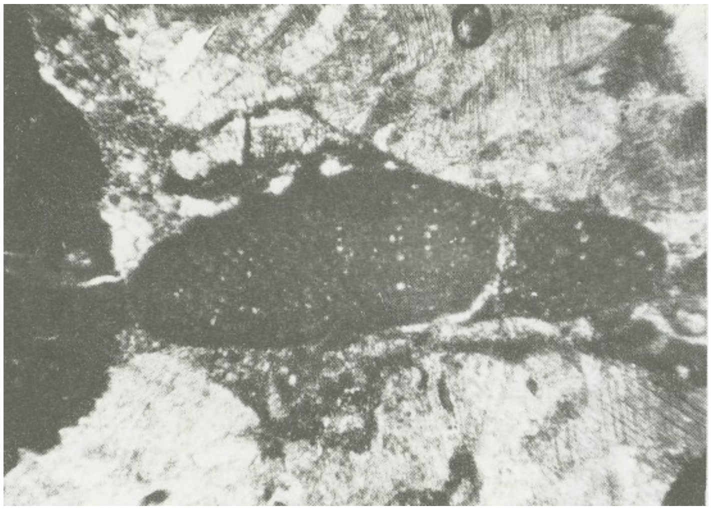

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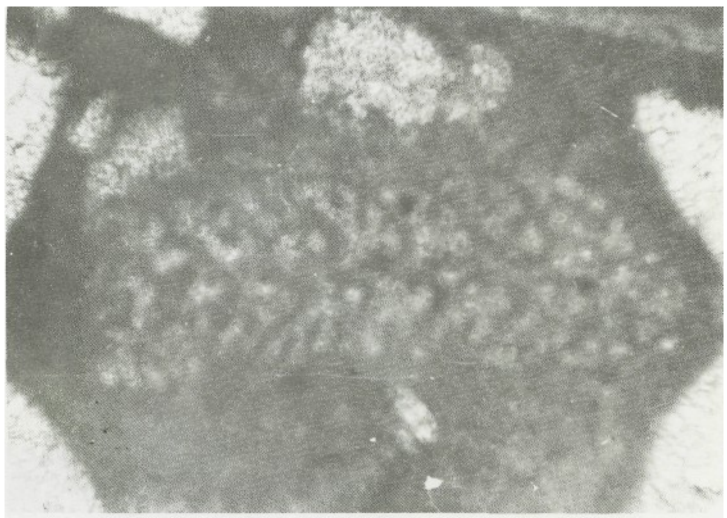

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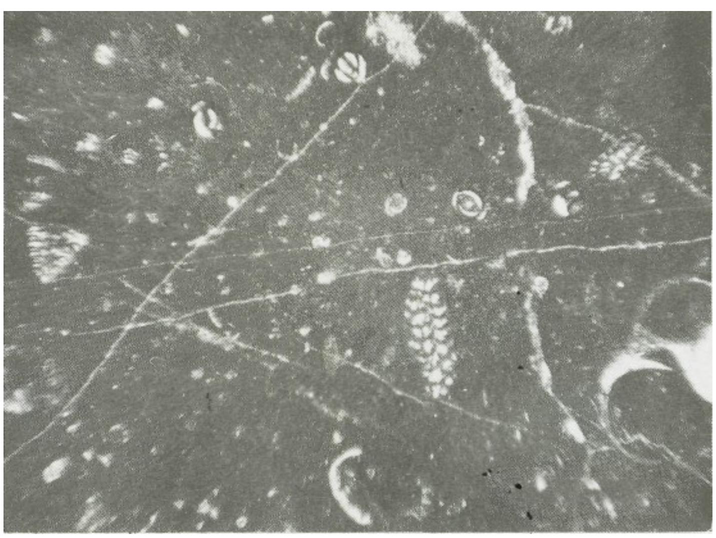

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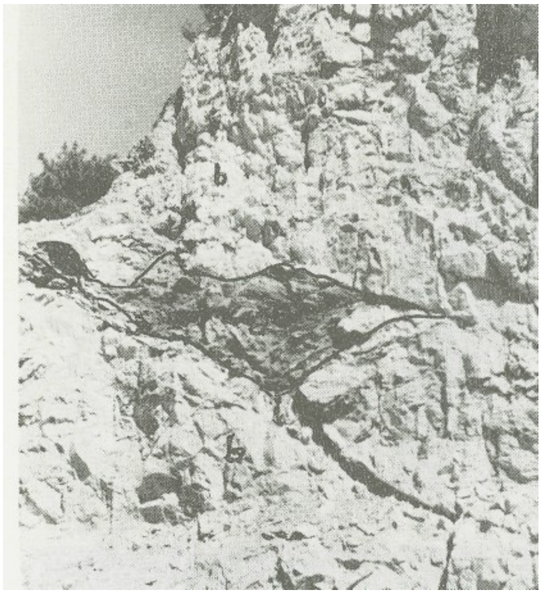

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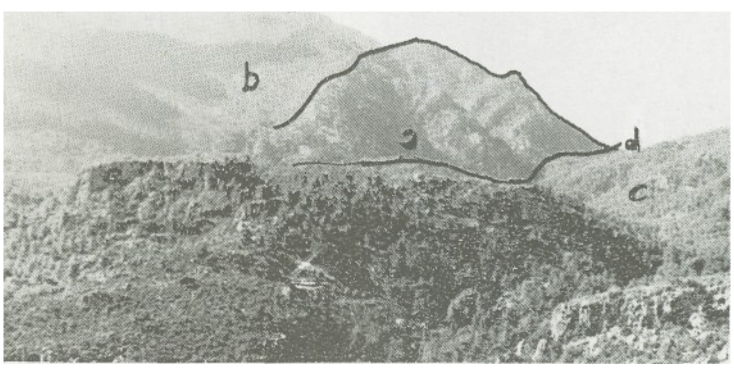

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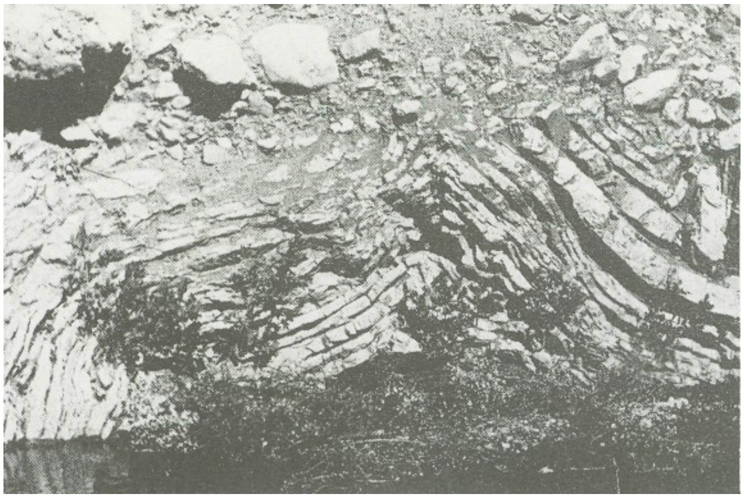

Photo 27

Photo 28

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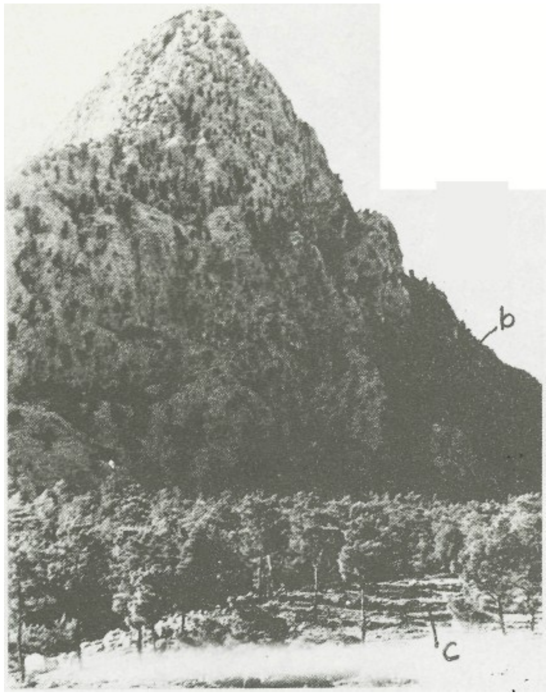
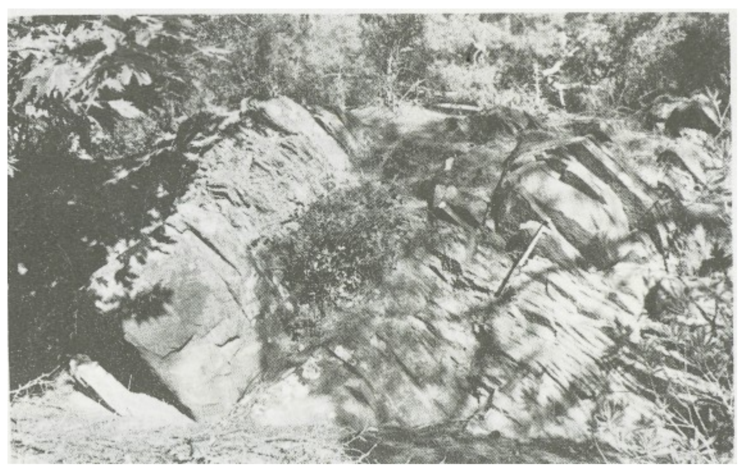
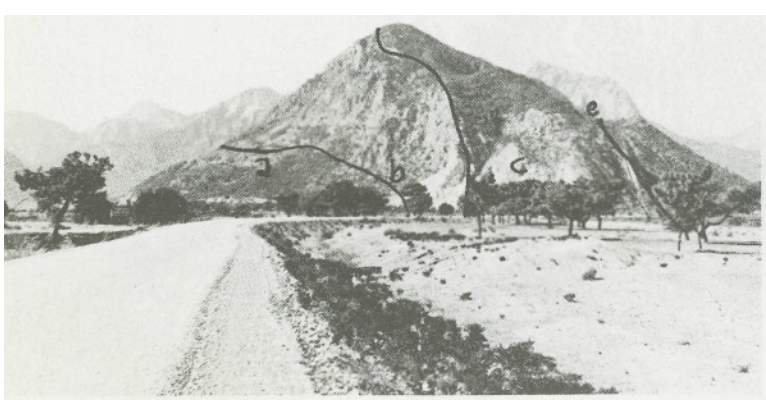


Photo 30

Photo 31





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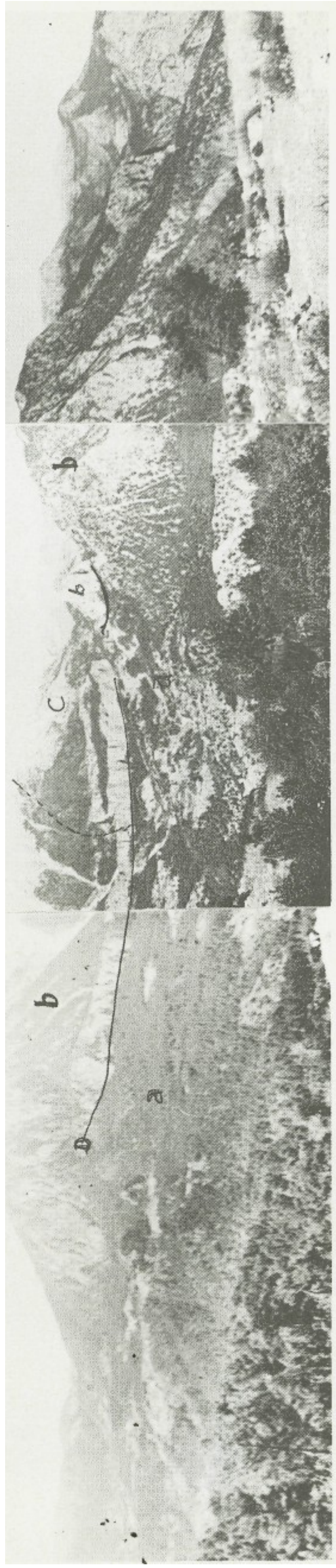

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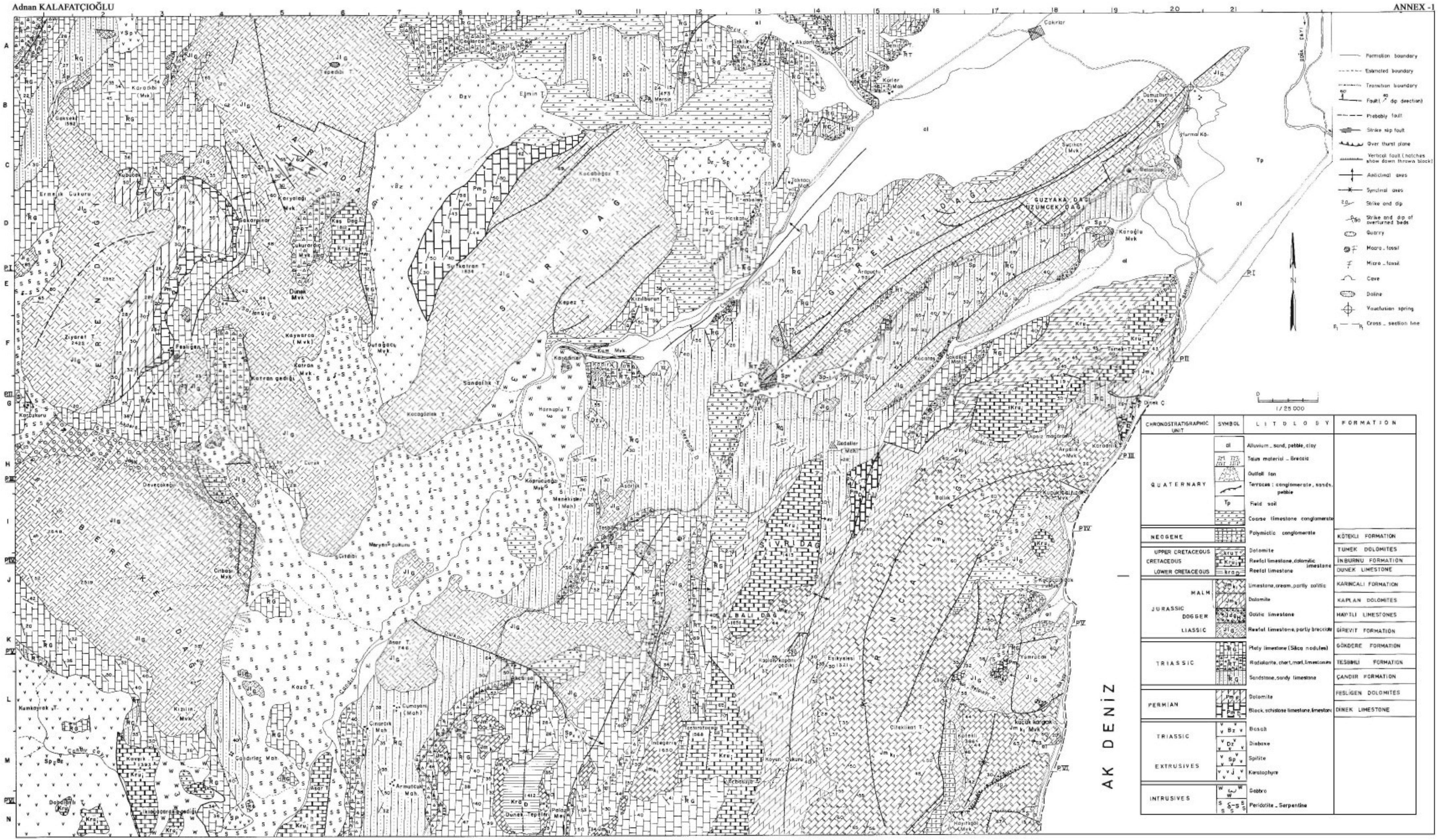
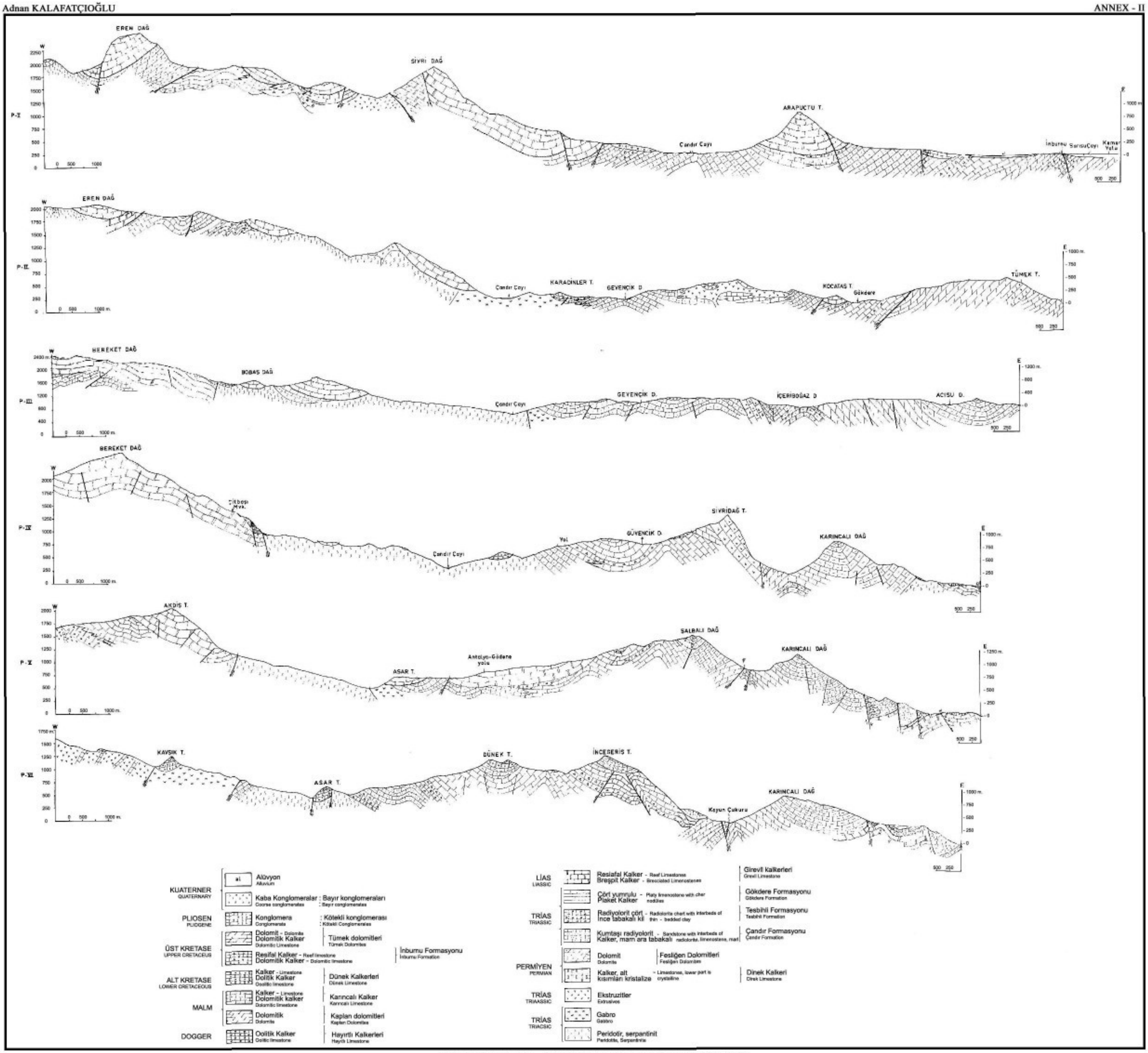
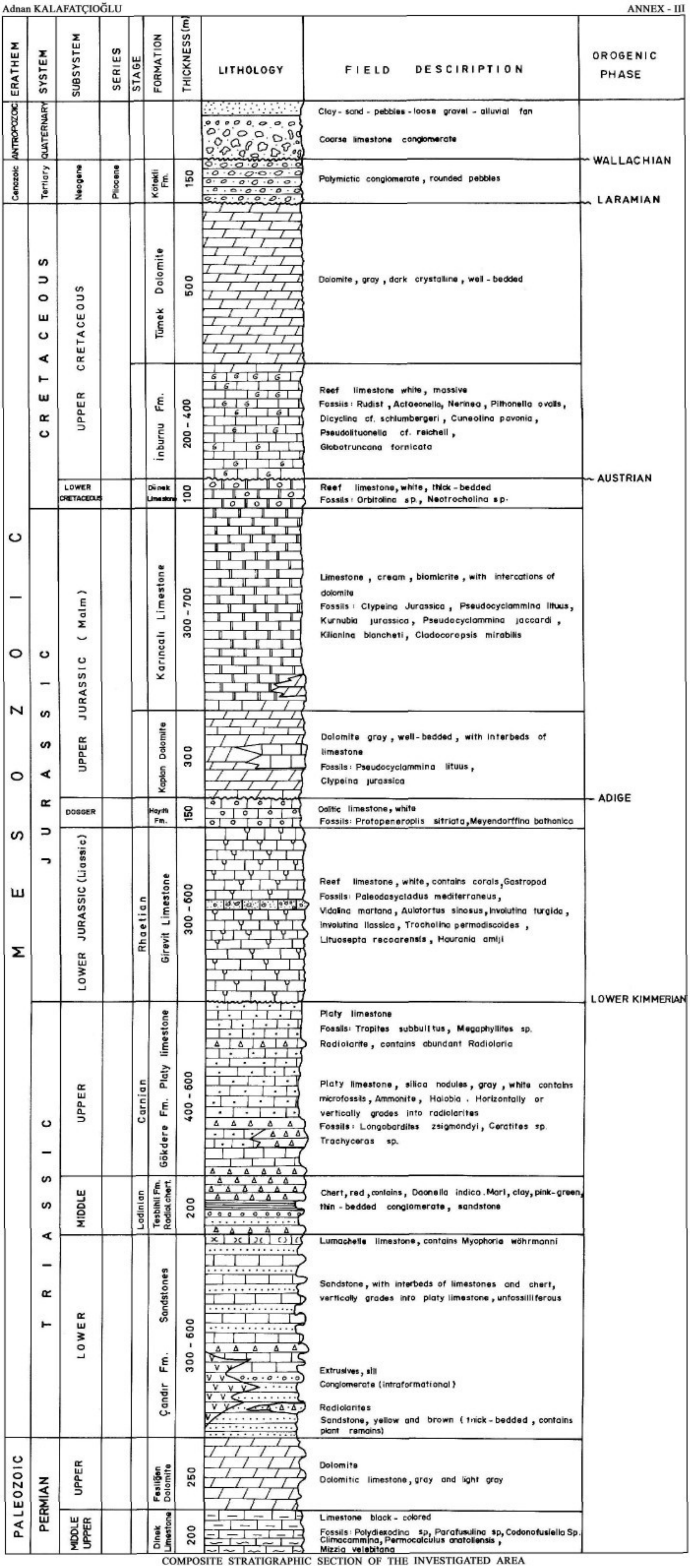


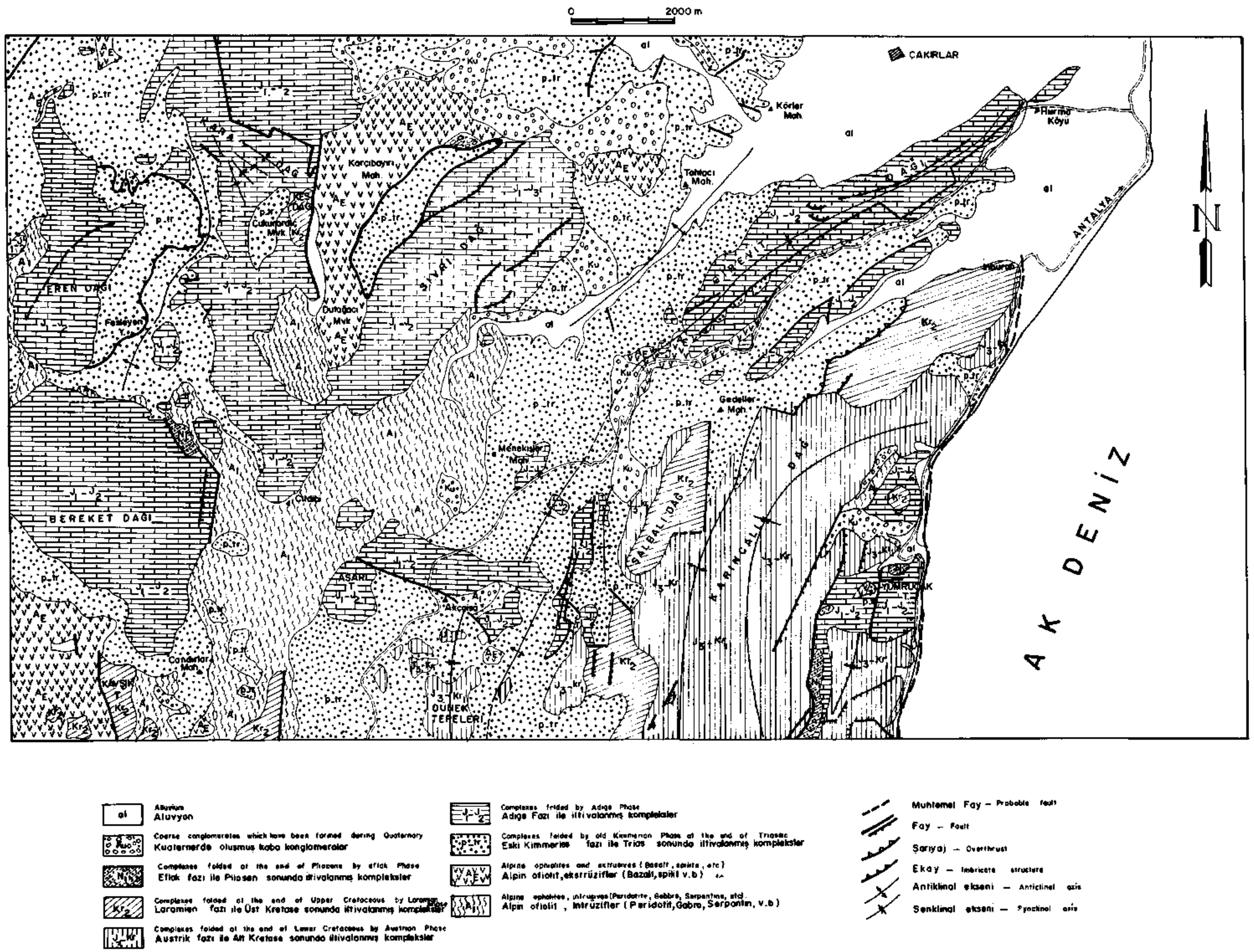
GEOLOGIC MAP OF THE WESTERN PART OF THE ANTALYA BAY



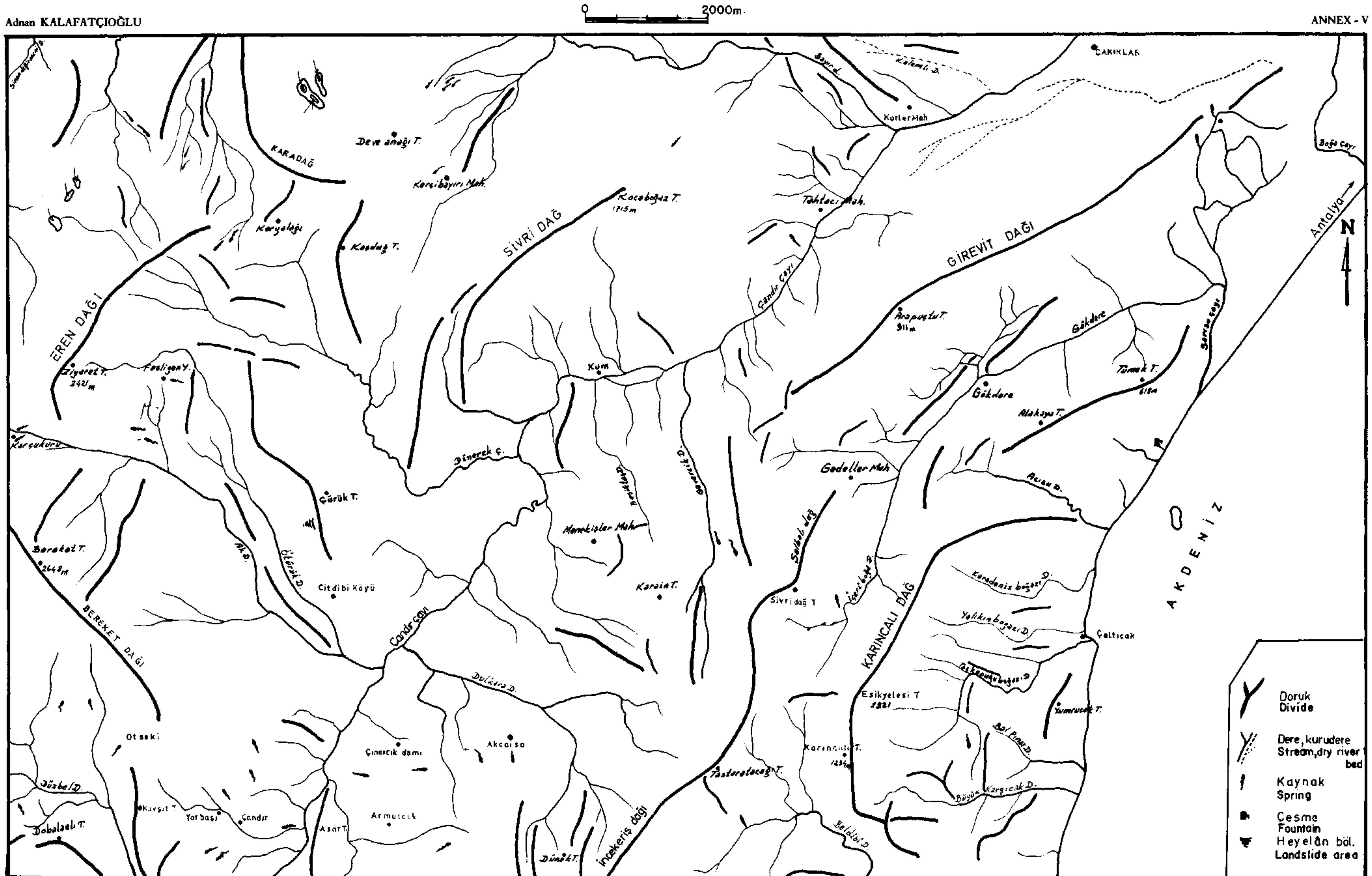
GEOLOGIC CROSS - SECTIONS OF THE INVERSTIGATED AREA



COMPOSITE STRATIGRAPHIC SECTION OF THE INVESTIGATED AREA



TECTONIC MAP OF THE INVESTIGATED AREA



THE ORO-HYDROGRAPHIC MAP OF THE INVESTIGATED AREA