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LITHO-STRATIGRAPH1C UNITS IN THE DARENDE-BALABAN BASIN (MALATYA, ESE TURKEY) AND NEW KNOWLEDGE CONCERNING THE AGE OF GYPSIFEROUS FORMATIONS

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ABSTRACT.— Stratigraphic succession in the investigated area consists of Mesozoic, Cenozoic and Quaternary formations. In addition, ophiolithic rocks and pre-Lutetian and post-Lower Miocene (Burdigalian) volcanic rocks are present. Lithostratigraphic units are studied in a parallel way with time units, and rock units are named for the first time, according to the stratigraphic nomenclature.

The oldest formations of the Upper Jurassic - Lower Cretaceous limestones in the studied area form high zones both in northern and southern parts of the area. Younger sediments are deposited in the depression between these two high zones. The bordering of the region by peripheral faults, and of the northern and southern parts of the studied area by high zones, indicate basinal characteristics. Therefore, this area has been named by the author as the «Darende-Balaban Basin».

The age of the gypseous formations, which had been assumed to be Oligo-Miocene or Miocene in previous studies, has been proved by our work to be Upper Eocene (Bartonian). In the gypseous formations, which have been deposited in the basin, only limestone and gypsum were found, and no presence of the limestone-gypsum-salt type of sequence—which is seen in normal deposition of evaporites—was established. Hence, an orderly arrangement of series (cycle) in a normal evaporational basin had not been developed.

INTRODUCTION

The area to be examined covers the surroundings of the Darende and Balaban towns, which belong to the Malatya province (Fig. 1).

This paper represents a summary of new information obtained about the age of gypsiferous formations together with the lithostratigraphic units in the studied area, which constitutes a part of Ph. D. work (Mehmet F. Akkuş, 1969) that was done by the author in the Geological Institute of the Faculty of Science of the University of Istanbul. The present paper, however, does not discuss in detail the geologic and Stratigraphic features of the basin, which form the basis of the above-mentioned Doctorate work.

I present my thanks and gratitude to Prof. Dr. Fuat Baykal, who supervised and directed my work, and to Assoc. Prof. Dr. Sadrettin Alpan, the General Director of the Mineral Research and Exploration Institute, who provided me with every assistance and facilities, which enabled me to complete my work. In addition, I sincerely thank all the other persons involved, from whom I had assistance.

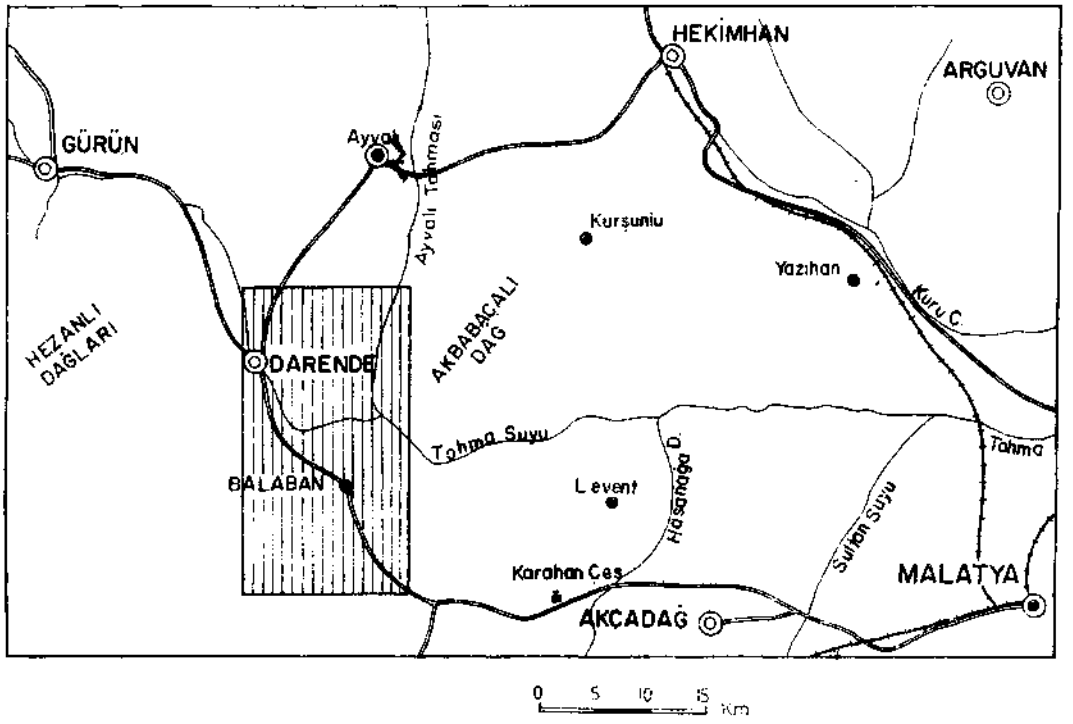

Fig. 1 - Geographical location map of the investigated area.

LITHO-STRATIGRAPHIC UNITS

The stratigraphic sequence in the investigated area consists of Mesozoic, Cenozoic and Quaternary formations (Fig. 2). The Upper Jurassic-Lower Cretaceous limestones constitute the oldest formation. These limestones outcrop only in the northern and southern parts of the investigated area and form two high zones. Middle Eocene (Lutetian), Upper Eocene (Bartonian) and Plio-Quaternary formations are deposited in the depression between these two high zones (Plate II). The bordering of the region by peripheral faults, and of the northern and southern parts of the studied area by high zones, indicate basinal characteristics. As the Darende and Balaban towns are situated within the area in question, this basin is named by the author the «Darende-Balaban Basin».

Formations in the investigated area are studied in a parallel way with time units, and formation names for the region are proposed for the first time, according to the stratigraphic nomenclature, as shown in Table 1.

Type localities and type sections of the formations are shown in Plate I.

MESOZOIC

Upper Jurassic - Lower Cretaceous

Geniz Limestone (J_G) - — These limestones can best be seen on Geniz Tepe which lies in the northern part of the investigated area. Therefore, this formation is named as «Geniz Limestone», according to its geographical location (Plate I,

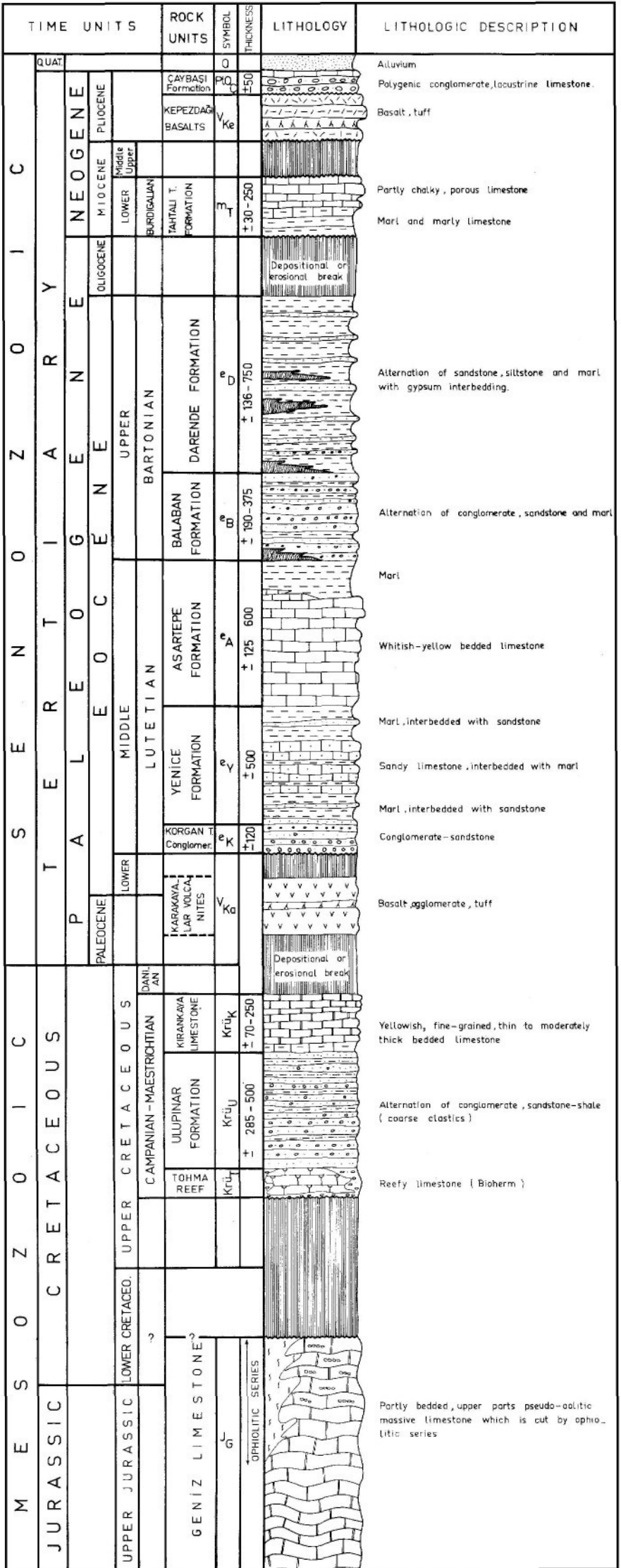

Fig. 2 - Composite stratigraphic section of the Darende - Balaban basin.

Table - 1

Litho-stratigraphic units in the Darende - Balaban Basin

Time units	*Rock units*	*Lithologic description*
	Sedimentites	
Plio-Quaternary	Çaybaşı Formation :	Polygenic conglomerate, in places lacustrine limestone.
	— — — — — Discordant	
Miocene (Lower Miocene -Burdigalian)	Tahtalı Tepe Formation :	Porous, partly chalky limestone, marl and marly limestone, sandstone.
	— — — — — Discordant	
Upper Eocene (Bartonian)	Darende Formation :	Alternation of sandstone, siltstone and marl with gypsum interbedding.
	Balaban Formation :	Alternation of conglomerate, sandstone and marl.
Middle Eocene (Lutetian)	Asar Tepe Formation :	Limestone, marl.
	Yenice Formation :	Marl, interbedded with sandstone and sandy limestone interbedded with marl.
	Korgan Tepe Conglomerate :	Conglomerate, sandstone.
	— — — — — Discordant	
Upper Cretaceous (Maestrichtian)	Kırankaya Limestone :	Yellowish, thin to moderately thick-layered limestone.
	Ulupınar Formation :	Alternation of conglomerate, sandstone and shale (coarse clastics).
	Tohma Reefs :	Reefy limestone (bioherm).
	— — — — — Discordant	
Upper Jurassic - Lower Cretaceous	Geniz Limestone :	Partly bedded, massive limestone.
	Intrusives	
Upper Cretaceous (Turonian ?)	Green Rocks :	Serpentine, gabbro, spilite, etc.
	Extrusives	
Post-Lower Miocene	Kepez Dağı Basalts :	Basalt, tuff.
Pre-Lutetian	Karakayalar Volcanites :	Basalt, agglomerate, tuff.

TS. 1). Besides Geniz Tepe, these limestones outcrop also around Oturak Tepe, Armutlu village and Gavur Kalesi, in the southern part of the studied area.

Geniz Limestone is light grey or white-colored. Generally, it has crypto-crystalline texture. It has a fractured structure and these fractures are filled with

calcite. Its upper levels have pseudo-oolitic characteristics. It shows localized bedding in spite of its massive appearance.

In the examined area the base of Geniz Limestone cannot be seen. The thickness of this limestone is 500 m according to the observed outcrop. As to the drilling operations which were carried out by the Mineral Research and Exploration Institute in the west of the studied area, the drilling was advanced in the same limestone down to 1930 m, then stopped within it.

The upper boundary of the formation is limited by Upper Cretaceous Ulupınar Formation. Because Ulupınar Formation, which consists of coarse elastics, lies transgressively on Geniz Limestone, a discordance is present between Geniz Limestone and Ulupınar Formation.

In Geniz Limestone macrofossils could not be found. Microorganisms are also very poor. However, the following microfossils were identified by M. Serdaroğlu and E. Sirel:

Tintinnia
Pseudocyclammina sp.
Trocholina sp.
Valvulina sp.
Verneuilinidae
Lituolidae
Textularia
Radiolaria, etc.

According to the fossil content, we accept the age of Geniz Limestone as Upper Jurassic - Lower Cretaceous. However, in the above-mentioned drilling, the levels from Senonian to Lias have been determined. In this way, it is understood that Geniz Limestone, which is presented by Upper Jurassic - Lower Cretaceous in our area, descends down to Lower Jurassic (Lias). But no disconformity has been determined either at the surface or at the drilling, from Lower Cretaceous to Lower Jurassic. Therefore, Geniz Limestone has properties of comprehensive series which from the origin point of view had been deposited in a durable and shallow sea that continued from Lias to late Lower Cretaceous (Albian).

Morphologically Geniz Limestones constitute the highest hills. Karstic hollows are also common.

Upper Cretaceous

Tohma Reefs ($KrÜ_T$). — These are found as lenses in the valley east of Karahan Çeşmesi, which is on the Ayvalı road, in the northern part of the examined area, and at the bottom of the coarse elastics that constitute Ulupınar Formation to the north of Kara Tepe, in the southern part of the area (Plate I, T. S. 2). As seen at the localities which are in the south and north of the examined area, they give a typical section along Tohma River outside of our area. In relation to this place, in which typical reef examples are seen, the limestones are named as «Tohma Reefs».

Tohma Reefs are transgressive type of reefs that have organic or bioherm characteristics. They are formed especially by deposition of Rudists, Brachiopods,

Lamellibranchs and Foraminiferas. Bedding has been poorly developed and is generally absent.

In our area, the thickness of the reefs varies between 5 to 10 meters and their lengths range from 5 to 500 meters. Without being continuous, they appear as small lens intervals. Bioherms seen outside of our area, along Tohma River, whose name was given to the formation, have been better developed. The thickness of these bioherms varies between 25 to 50 meters, the lengths range from 40 to 1,500 meters.

The Tohma Reefs are usually found at the bottom of variegated, weakly cemented, coarse elastics. They are covered by coarse elastics and bedded limestones of the same age.

The organic content of the Tohma Reefs is considerably rich. Whether in our area or in the sourroundings, the exposures contain abundant amounts of the following fossils:

Hippurites (Vaccinites) ultimus Milovonoviç
Cyclolites
Actaeonella
Orbitoides apiculata Schlum.
Orbitoides media d'Arch.
Loftusia sp.

According to the available fossil association, the reefy limestones are Maestrichtian in age. These are shore-line reefs that had been developed in a warm sea.

Because the elastics overlying these reefs are weakly cemented and, thus, easily eroded, while the underlying limestones are more resistant, sharp-edged protuberances are formed, which constitute the characteristic topography of this area.

Ulupınar Formation (KrÜu). — This formation outcrops between Yukarı Ulupınar and Yenice villages, in the southern part of our area, and in the northern semi-area around Karahan Fountain that is situated on the way to Ayvalı. It is named «Ulupınar Formation» since it is observed best in the neighborhood of the Ulupınar village, through which Malatya road is passing.

Typical section of the formation can be seen in the Çakır valley between Kara Tepe and Asar Tepe, that are situated NNW of Yukarı Ulupınar village (Plate 1, TS. 2).

Ulupınar Formation generally consists of coarse elastics that constitute alternations of variegated conglomerate, sandstone, sandy marl and shale. The conglomerate and sandstone layers are so poorly cemented that they can be crumbled by hand. Conglomerates and sandstones contain grains of green rock and massive limestone. Variegated color of the formation also results from grains of green rock. It can be easily recognized in the field by its special color. The sandstones are medium (0.50-0.25 mm) and coarse (1.00-0.50 mm) grained. The grain size and thickness of the layers decrease gradually from the bottom to the top. The sorting and roundness of the grains have been fairly well developed.

In type section, the thickness of the formation is 285 meters. This value decreases or increases in various places.

The formation rests transgressively upon the ophiolitic series. The upper part of this formation gradually and concordantly passes to the Kırankaya Limestone of the same age. Hence, the bottom of the formation is discordantly bordered with ophiolites, while its top is bordered concordantly with Kırankaya Limestone.

The. fossil content of Ulupınar Formation is quite rich; it comprises microorganisms determined by E. Öztümer:

Globotruncana stuani de Lap.
Globotruncana rosetta Carsey
Globotruncana area Cushman
Gaudryina sp.
Clavulinoides trilatera Cushman
Marsonella oxycona Reuss
Robulus munsteri Roemer
Allomorphina sp.
Cibicides sp.

Ostracods, determined by N. Solak :

Cytherella sp.
Cythereis sp.

and macroorganisms, determined by N. Karacabey:

Hippurites (Vaccinites)
Gryphaea (Pycnodonta) vesicularis Lam.
Nerita sp.
Actaeonella sp.

According to the above fossil content, Ulupınar Formation is Maestrichtian in age.

Kırankaya Limestone (KrÜK).— Coarse elastics that form Ulupınar Formation pass vertically and gradually to a limestone facies. The Upper Cretaceous deposits also terminate with these limestones. The formation received its name from the hill which is formed by this limestone, outcropping just to the north of the Yenice Şugul village, SW of our area (Plate I, TS. 3).

Kırankaya Limestone extends as a belt with short intervals over the Ulupınar Formation, between Yukarı Ulupınar and Yenice villages. It also forms Keloğlanyurdu and Kırmızı hills, NW of our area.

It generally consists of thin (5-10 cm) and moderately thick (10-30 m) limestone beds. They are light yellow or dirty white in color. At the bottom, the formation begins with marly limestones, and subsequently passes to hard and very fine-grained limestones. The upper horizons show porous, lacustrine limestone characteristics.

In type section, the thickness of the formation is 70 m, but this thickness changes in places; to the northwest it reaches up to 250 meters.

The base of Kırankaya Limestone is limited concordantly by Ulupınar Formation and its top is limited discordantly by Eocene (Lutetian) formations.

Whether in the investigated area or in its surroundings, the organic content of the limestones that match with the Kırankaya Limestone is very poor. In the

outcrops that occur in the southern semi-area, only algal fragments can be seen. To the north, the exposures contain some microorganisms, such as *Orbitoides media* d'Arch., *Globigerina* sp., *Textularia* sp., which represent Maestrichtian age. Sometimes it is very difficult to distinguish these limestones from the Jurassic-Lower Cretaceous Geniz Limestones.

Morphologically they always create high mountains and hills.

CENOZOIC

Eocene (Lutetian)

Korgan Tepe Conglomerate (eK). — It is observed at Korgan Tepe, İncebel Tepe, Sersi Tepe and east of Kantaruz Gorge, that all stretch in the northeast of the investigated area. In the south of our area it can be also observed in places at the base of Lutetian formations. The formation took its name from Korgan Tepe, which gives a typical section that can be best observed in that locality (Plate I, TS. 4).

The Korgan Tepe Conglomerate consists of dark green, poorly cemented conglomerate, fine to medium-grained sandstone (sand) and sandy marl layers that all occur at Korgan Tepe and its surroundings. The conglomerates contain partly silicified limestone gravels together with abundant volcanic pebbles. Volcanics which form the base of this conglomerate consist of basalt, hyalo-basalt, pyroxene basalt and tuffs. Likewise, a great portion of the material, that produces sandstone and sandy marl beds, consists of basal volcanics. Due to the content of this material, the formation gained a dark greenish color.

In the soutb of our area, at the base of Lutetian formations, the Korgan Tepe Conglomerate is also present. In places, it is best observed at the bottom of Lutetian formations that extend from south of Asar Tepe towards northwest. This conglomerate generally contains the pebbles of crystalline limestone, ophiolitic rock and Ulupınar Formation.

The maximum thickness of Korgan Tepe Conglomerate attains 120 meters at Korgan Tepe, which has given the type section. This thickness changes in places and at its southern outcrops it is between 4-10 m.

The lower limits of the formation are bordered by Geniz Limestone, Ulupınar Formation, Kırankaya Limestone and pre-Lutetian Karakayalar Volcanites, over which it rests discordantly. Asar Tepe Formation (in the northern semi-area) and Yenice Formation (in the southern semi-area), which belong to the same age, concordantly constitute its upper limits.

The fossil content of the Korgan Tepe Conglomerate is not rich at its northern exposures. In the poorly cemented sandstones, the inner moulds of *Athleta* and of poorly preserved *Lucina* are found.

As to its southern outcrops, they contain such fossils as:

Nummulites laevigatus Brug.
Nummulites atacicus Leym.
Assilina exponens Sow.
Nummulites cf. *irregularis* Des.

Nummulites lucasi d'Arch.
Nummulites cf. *perforatus* Denys de Montfort
Assilina cf. *douvillei* Abrard & Fabre
Nummulites uroniensis A. Heim

that have been determined by Y. N. Pekmen and E. Sirel. According to the above fossil association, the age of the Korgan Tepe Conglomerate is Lutetian.

Yenice Formation (e_Y).— This formation outcrops only in the southern half of the studied area. Typical section of the formation can be observed around the Yenice village situated in a valley SW of our area (Plate I, TS.5). This formation is named for the Yenice village where its outcrops are best observed. The Yenice Formation does not give any exposures in the northern part of our area. From south to north it passes laterally to Asar Tepe Formation.

The Yenice Formation consists of fine to medium-grained, 5-10 cm thick sandstone interbedded with marl and 5-10 cm thick, thin marl interbedded with sandy limestones. As a whole, the formation is light grey in color. Sandstone and sandy limestone beds generally contain grains of hyalo-basalt, andesite, quartz, hornblende and serpentine.

The thickness of the formation is 500 m to the west of the Yenice village and 90 m in section to the south of Asar Tepe.

The base of Yenice Formation is limited concordantly by the Korgan Tepe Conglomerate, of the same age, and its upper limit is again bordered concordantly by the Asar Tepe Formation which belongs to the same age.

The fossil content of the formation is fairly rich. The sandy limestones with marl intercalations contain such microorganisms as :

Nummulites sp.
Operculina sp.
Textularia spp.
Miliolidae
Lagenidae
Rotalidae
Globorotalia sp.
Acarinina sp.

that have been determined by S. de Civrieux, while marls contain the following microorganisms, determined by E. Öztümer:

Hantkenina alabamensis Cush.
Buliminella cf. *longicamerata* Bandy
Globorotalia crasssata Cush.
Globorotalia centralis Cush. & Bermudez
Halkyardia ovata Heron & Allen
Uvigerina cocaoensis Cush.
Bulimina jacksonensis Cush.

According to the above fauna, the age of the formation is Lutetian.

Those parts of the formation in which marl is predominant form valleys, while the sandy limestone horizons interbedded with marl form hills and ridges.

Asar Tepe Formation (e_A). — It can be clearly observed around Asar Tepe, which is situated to the west of the Malatya road, between the Yukarı Ulupınar and Aşağı Ulupınar villages, south of our area. This formation is given the name of the place at which it is best seen. It also occurs along the Darende-Ayvalı road in the northern parts of our area.

In the associated type section at Asar Tepe, the formation consists of limestones at the bottom and light grey, greenish colored marls overlying it (Plate I, TS. 6). The limestones generally have a whitish yellow-colored, finely crystalline, compact structure. The stratification has developed regularly in 25-50-cm-thick layers. The upper levels of limestones gradually alter to marly limestones and marls.

Although the thickness in measured section of the formation is 125 m, it changes in various places. The thickness of marls above also changes between 25-100 m.

In type section, the lower limit of the formation is bordered concordantly by the Yenice Formation, of Lutetian age, and its upper limit is also concordantly bordered by the Darende and Balaban formations of the Upper Eocene (Bartonian) age, while in the northern section, in some places, the formation rests discordantly on Geniz Limestone and Kırankaya Limestone.

The lower horizon of the limestone of the Asar Tepe Formation contains the following microorganisms, determined by E. Sirel :

Nummulites lucasi d'Arch.
Nummulites sp. (N.*irregularis* group)
Nummulites helveticus Kauf.
Alveolina cf. *oblonga* d'Orb.
Chapmanina gassiemis Silv.
Rhapydionina sp.
Rotalia trochidiformis Lam.
Eorupertia incrassata Uhlig
Asterigerina totula Kauf., etc.

while the top marls contain such microorganisms as :

Clavulinoides szaboi Hantken
Pararotalia armata Terquen
Cibicides alleni Plummer
Robulus cf. *limbosus* Reuss
Marsonella cf. *oxycona* Reuss
Bolivina aff. *cookei* Cush.
Reusella terquemi Cush.
Gyroidina girardana Reuss, etc.

that have been determined by E. Öztümer.

Beside the above microfauna, the formation contains the following Lamellibranchs :

Lucina corbaricus Leym.
Lucina immanis Opp.
Spondylus

Campanile giganteum Lam.
Pleurotomaria
Ostrea

determined by A. Nazlı-Güngör, and some Echinoids, such as :

Echinolampas sp.
Leiopneustes antiquus (Agassis) Cott.

that have been determined by M. Türkünal.

Both micro and macroorganism contents show that the age of Asar Tepe Formation covers the period from Lower Lutetian to Upper Lutetian.

Upper Eocene (Bartonian)

Darende Formation (e_D) — It is widespread around the town of Darende and in the central part of our area. The formation has been named with reference to this town. The type sections of the formation can be best observed on the Darende - Ayvalı road, along the contact of the Asar Tepe Formation (Plate I, TS. 7). In addition, this formation can be clearly seen along the Malatya road that crosses the basin.

The Darende Formation is generally composed of alternations of light grey-colored sandstone-siltstone-marl interbedded with gypsum. Around the town of Balaban the formation displays a reddish color. The sandstone is generally made up of fine to medium-grained, subrounded and subangular feldspar, quartz, hornblende, chlorite, and serpentine minerals together with fragmental magmatic rock, hornstone and limestone. These mineral rock fragments, that form the sandstones, are being binded by calcite and the cementation is fairly well developed. In various places, from bottom to the top, the formation contains gypsum layers.

As seen on the road between Darende and Ayvalı, the lower boundary of the Darende Formation is concordantly bordered by Asar Tepe Formation, when it rests over the Asar Tepe Formation, or again is concordantly bordered by the Balaban Formation of the same age.

The upper part of the formation is discordantly covered by the horizontal Plio-Quaternary Çaybaşı Formation.

The measured thickness of the formation in typical sections between Ayvalı road - Alidede Tepe is 136 - 380 m. This thickness increases toward the center of the basin.

Information about the fossil content and the age of the formation will be given at the end of the Balaban Formation section.

Balaban Formation (e_B)-— The outcrops in this area are observed between Aşağı Ulupınar and Yukarı Ulupınar villages that are situated on the Malatya highway, southeast of the studied area, as well as in a small area at the starting point of the Darende - Ayvalı road, in the north (Plate I, TS. 8). This rock unit, which is well seen beginning south of the Ulupınar village along the Malatya highway up to the town of Balaban, is named as «Balaban Formation».

Balaban Formation generally consists of greenish, light-grey-colored conglomerates which contain thin-bedded sandstone and marl layers. The conglomerates

are made up of well and moderately rounded Jurassic - Cretaceous, Upper Cretaceous and Lutetian pebbles, together with green rock pebbles. The size of long axes of the pebbles is between 0.50-20 cm. Conglomerates are represented by 50-80-cm-thick beds; sandstone layers consist of 20-30 cm moderately thick layers, while marls occur in 5-10-cm-thin layers.

In the northern semi-area, in typical section the measured thickness of the formation is 190 m, while in the southern semi-area its thickness is 375 m.

The Asar Tepe Formation concordantly constitutes the lower boundary of the formation. Its upper boundary is again concordantly bordered by the Darende Formation of the same age. Only at the southeast of the studied area, basalts of Kepez Mountain cover Balaban Formation horizontally.

NEW KNOWLEDGE ABOUT THE AGE OF DARENDE AND BALABAN FORMATIONS THAT CONSTITUTE GYPSIFEROUS FORMATIONS

In the previous studies, the deposits that were not differentiated into rock units but rather only named as «gypsiferous series», were investigated by the author and distinguished into lithostratigraphic units whose properties were given above. Likewise, the age of these formations had been proposed as Oligocene or Oligo-Miocene. Presumably, this opinion is not based on any fossil studies, but rather is reached by presupposing a resemblance of this formation to the Oligo-Miocene gypseous deposits occurring in other regions. In our studies, due to the fact that for the first time the fossiliferous horizons of this formation were determined, we were able to obtain more favorable results about the age of this formation.

The sandstone beds in the exposure of the Balaban Formation, that occurs in the northern semi-area, contain the following microorganisms that have been determined by E. Sirel:

Nummulites fabianii Prever
Nummulites incrassatus de la Harpe
Nummulites sp. (of the Globulus group)
Fabiania cassis Opp.
Discocyclina sp.
Acervulina sp.
Gypsina sp.
Operciluna sp.
Triloculina, etc.

The presence of *N. fabianii* in the above fossil association shows that the age of the formation rises up to Upper Eocene (Bartonian).

Besides the microfossils that have been determined in the Balaban Formation, some species of Cardium, that are representative of Bartonian in Italy and Greece, have been found for the first time by us in the marly horizons of the Darende Formation :

Cardium cf. *granconense* Opp.
Cardium sp. aff. *rouyanum* d'Orb.
Cardium cf. *bonelli* Bellardi

In addition, beside these fossils, some characteristic Upper Lutetian-Bartonian Ostracods were found, which have been determined by N. Solak:

Krithe papillosa Bosquet
Krithe bartonensi Jones
Krithe rutoti Keij
Cytherella gamardensis Dentel
Cytheropteron sp.
Trachyleberis sp., etc.

According to the above fossil content, we have proved the age of Darende and Balaban formations, that constitute the gypseous series, as Upper Lutetian-Bartonian.

In the gypseous formations a deposition of limestone-gypsum-salt-type sequence, which is seen from bottom to top in normal evaporite basins, is not present. Only limestone and gypsum are deposited. Hence, the regular cycle in a normal evaporite basin has not been developed.

Miocene

Tahtalı Tepe Formation (mT). — It outcrops in a narrow area in the Dangış Tepe locality to the north of Kepez Mountain, that is situated southeast of the studied area. To the east, outside of our area, this formation is widespread. The name of the formation has been given in connection with the Tahtalı Mountain that shows a typical section in the vicinity of the town of Kurşunlu, which is outside of our area.

In a typical section on the Tahtalı Mountain, whose name it bears, the formation consists (from bottom to top) of sandy limestone - argillaceous limestone - shale, sandstone - sandy limestone, argillaceous limestone, shale - argillaceous limestone, porous limestones (T. Ayan & C. Bulut, 1964). Its outcrop in our area consists of bluish-colored marl - marly limestone at the base and moderately thick - layered, white-colored, partly chalky, porous limestones at the top (Plate I, TS. 9).

In our area the thickness of the Tahtalı Tepe Formation is around 30 m. Outside of our area this thickness increases up to 300 m.

The lower boundary of the Tahtalı Tepe Formation is discordantly limited by the Asar Tepe Formation and its upper boundary is covered by horizontal volcanites of the Kepez Mountain.

The formation contains the following microorganisms, that have been determined by C. Öztemür :

Miogypsina irregularis Mich.
Miogypsina sp.
Miolepidocyclina burdigalensis Gümbel
Lepidocyclina sp.
Amphistegina radiata Fichtel & Moll
Miliolidae

Beside these microorganisms, Lamellibranch shell fragments are also present in the formation. The outcrops outside of our area contain the following macrofossils (T. Ayan & C. Bulut, 1964):

Lucina globulosa Deshayes
Lucina fragilis Philippi
Chlamys multistriatus Poli
Pecten aff. *corsicanus* Deperet & Roman

According to the above-listed micro and macrofauna, the age of the Tahtalı Tepe Formation is Lower Miocene (Burdigalian).

Plio-Quaternary

Çaybaşı Formation (P1-$Q_Ç$). — This formation covers horizontally all other formations. It can be well observed on the hills that are situated along the east and west sides of the Malatya highway that crosses our area. The formation received its name from the Çaybaşı locality, which gives a typical section west of the Balaban town (Plate I, TS. 10).

Çaybaşı Formation is generally made up of polygenic conglomerates. It contains Jurassic-Cretaceous, Upper Cretaceous, Eocene, ophiolitic series and post-Burdigalian basalt pebbles. The pebbles are very poorly rounded and bound by limestone cement. The cementation has been moderately developed. Because the cement usually becomes loosened, the pebbles have been set free. Although the formation is generally made up of conglomerates, white-colored lacustrine limestones are present in its upper parts, as seen in the Çaybaşı locality, where it gives a type section.

The maximum thickness of the formation is 25 m.

Çaybaşı Formation covers other formations horizontally. Therefore, it forms a very good angular discordance with the underlying formations.

Within the formation no fossils have been found. Therefore it is not possible to give an age based on fossils. However, according to stratigraphical position of the formation, its age has been accepted as Plio-Quaternary.

MAGMATITES

A. Intrusives

Green Rocks (ophiolites). — These rocks cover the area between Yukarı Ulupınar and Yenice Şuğul villages, which extends in the NW-SE direction in the southern part of the investigated area (Plate 1, TS. 11). It generally consists of ultrabasic rocks such as serpentine, gabbro, spilite, etc.

The Upper Jurassic - Lower Cretaceous limestones (Geniz Limestones) in this region have been cut by the ophiolitic series. In spite of this, the Upper Cretaceous (Maestrichtian) Ulupınar Formation contains gravels of ophiolitic rocks. According to our observations, whether in our area or in the neighboring areas, ophiolitic rocks were formed after the deposition of Jurassic - Lower Cretaceous comprehensive limestones and before the deposition of the Ulupınar Formation. Due to this stratigraphic position, the ophiolitic magma activities have occurred after Lower Cretaceous and before Campanian-Maestrichtian.

B. Extrusives

Karakayalar Volcanites (V_{Ka})- — These volcanites outcrop in the northeastern corner of our area. Since the locality where these rocks are found is called Karakayalar, this rock unit has been named «Karakayalar Volcanites» (Plate I, TS. 12).

When seen from a distance, the Karakayalar Volcanites look like serpentines, because of their light-greenish color. They generally consist of pyroxene basalt, pyroxene hyalo-basalt, olivine-pyroxene basalt, basalt, agglomerates and tuffs. Due to alteration of olivines and chlorites within the basalts, they have a color which resembles that of serpentines. It is probable that owing to their greenish color they were defined as serpentines in previous studies.

The Korgan Tepe Conglomerates of the Lutetian age rest discordantly on Karakayalar Volcanites. The Korgan Tepe Conglomerates contain well-rounded pebbles of Karakayalar Volcanites. This stratigraphic position shows that Karakayalar Volcanites were formed before Lutetian.

Basalts of Kepez Mountain (V_{Ke}) — These basalts form wide plains and plateaus which are widespread to the south and southeast of the investigated area. The rock unit received its name from Kepez Mountain, which is formed by these basalts and is situated to the east of the Ulupınar village (Plate I, TS. 13).

The basalts of Kepez Mountain cover large areas spreading to the east and south, outside of our area. They are very well observed along the Malatya highway as far as Akçadağ.

Basalts of Kepez Mountain are petrographically made up of basalts with olivine, and andesite basalts with pyroxene. In addition, between these basalts two tuff horizons have been found. From the manner of this basalt and tuff alternation, we understand that at least two volcanic activities had occurred in the region.

Basalts of Kepez Mountain cover the Lower Miocene (Burdigalian) and older formations horizontally. According to this stratigraphic position, the volcanic activity had occurred after Burdigalian.

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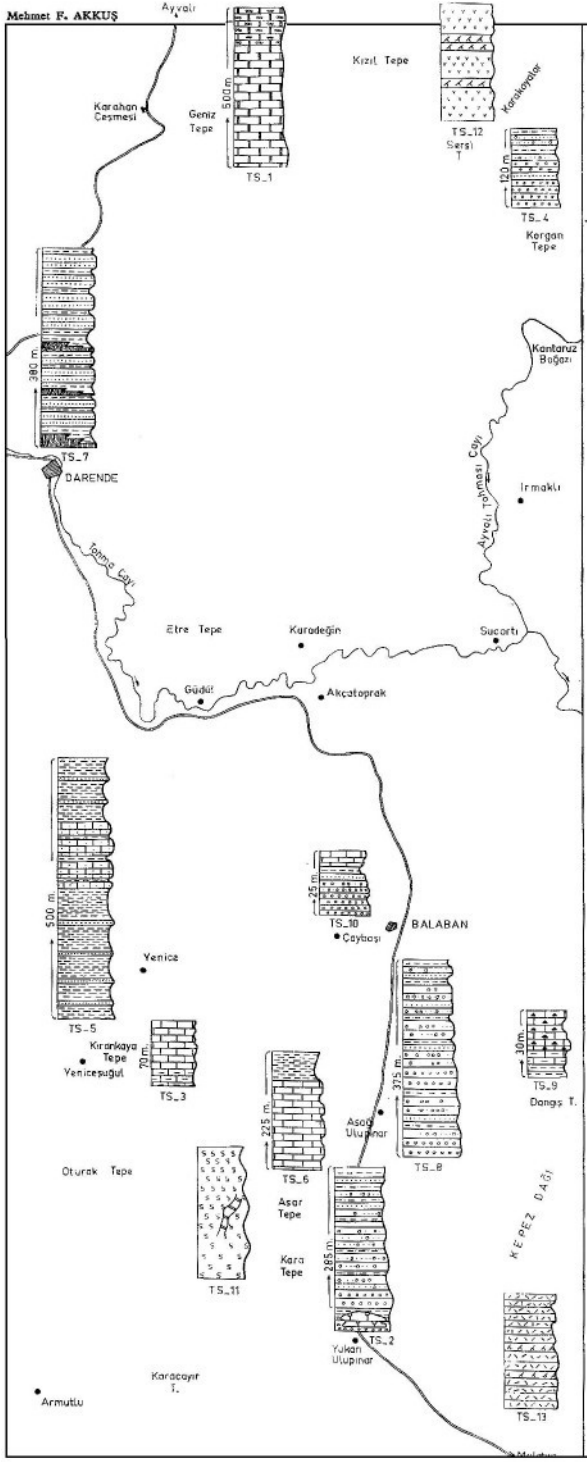
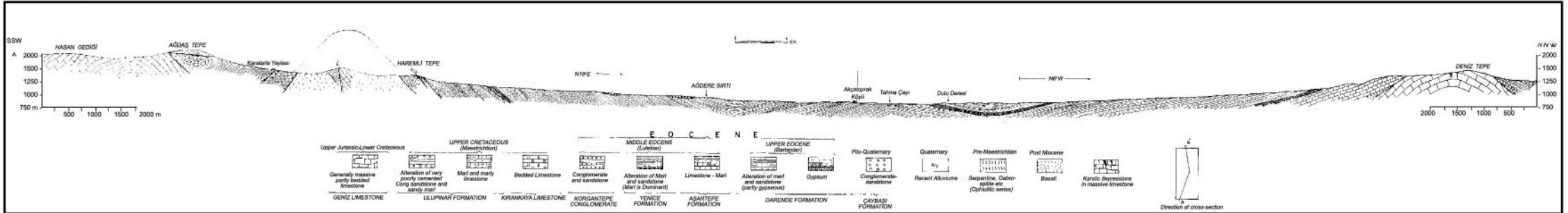


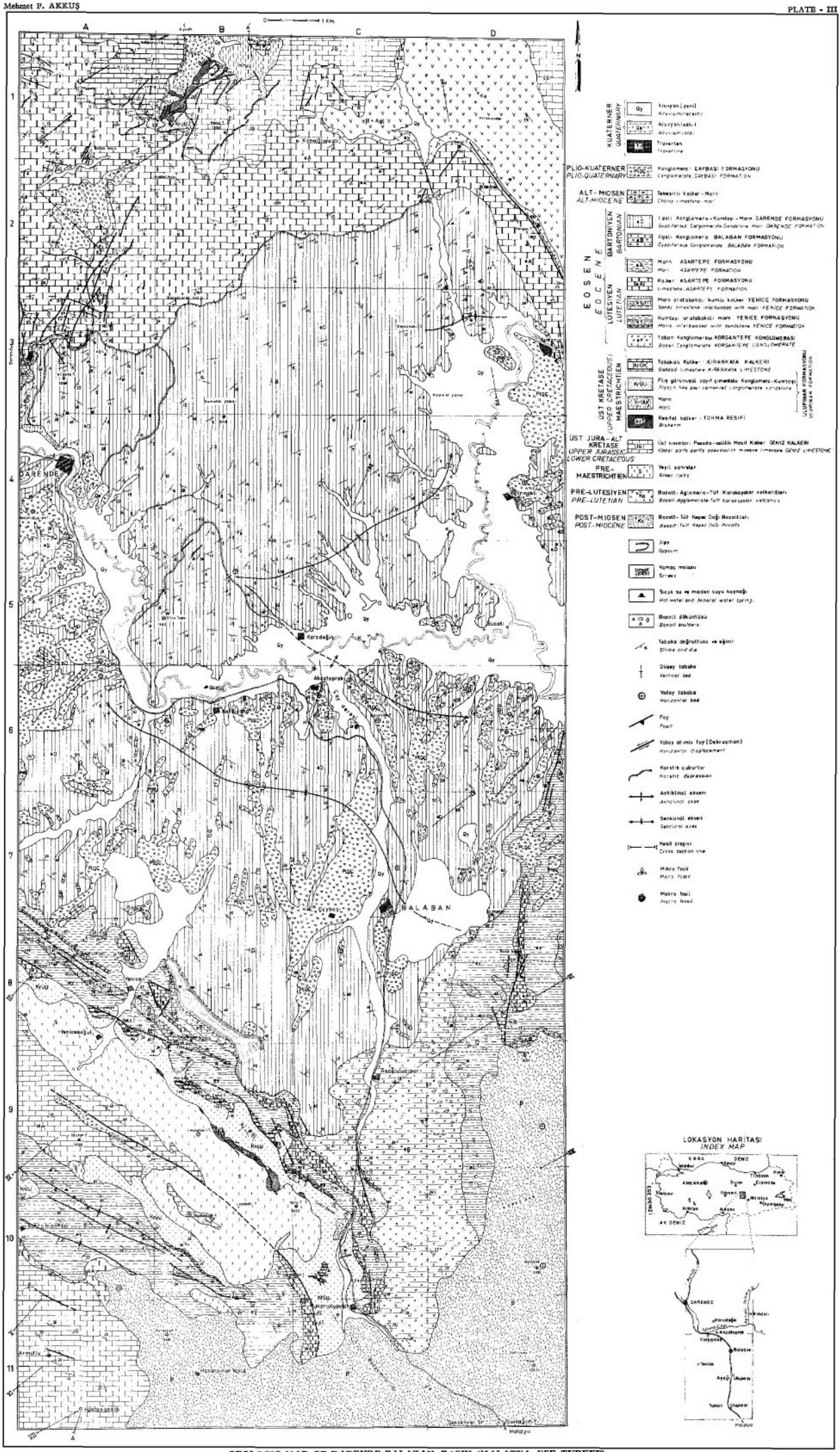
MAP SHOWING TYPE LOCALITIES AND TYPE SECTIONS OF THE LITHOSTRATIGRAPHIC UNITS IN THE DARENDE-BALABAN BASIN

T.Section: 0 100 m.

TS_1	Type section of Geniz Limestone. (Upper Jurassic-Lower Cretaceous)
TS_2	Type section of Tohma Reefs and Ulupınar Formation. (Upper Cretaceous , Maestrichtian)
TS_3	Type section of Kırankaya Limestone. (Maestrichtian)
TS_4	Type section of Kergan Tepe Conglomerate. (Lutetian)
TS_5	Type section of Yenice Formation. (Lutetian)
TS_6	Type section of Asar Tepe Formation. (Lutetian)
TS_7	Type section of Darende Formation. (Upper Eocene -Bartonian)
TS_8	Type section of Balaban Formation. (Upper Eocene-Bartonian)
TS_9	Type section of Tahtalı Tepe Formation. (Lower Miocene)
TS_10	Type section of Çaybaşı Formation. (Plio-Quaternary)
TS_11	Green rocks. (Turonian)
TS_12	Karakoyalar volcanites. (Pre-Lutetian)
TS_13	Kepez Dağı basalts. (Post-Lower Miocene "Burdigalian")



GEOLOGIC CROSS-SECTION OF THE INVESTIGATED AREA.



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