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The Geology Of İznik - Yenişehir (Bursa) Osmaneli (Bilecik) Area*

İznik-Yenişehir (Bursa)-Osmaneli (Bilecik) Yöresinin Jeolojisi

Simav BARGU**

ÖZ : İnceleme Yöresi, Marmara Bölgesinde, Bursa İline bağlı İznik ve Yenişehir İlçeleri ile Bilecik İline bağlı Osmaneli İlçesi dahilinde olup, İznik Gölü'nün E, SE ve NE sunda yer alır ve yaklaşık olarak 450 km2 lik bir alanı kapsar. Bu kesimde çok yüksek olmayan ve sahanın jeolojik yapısına uygun olan E-W ve N70-80E doğrultusundaki dağların gidişlerini belirleyen Derbent-Avdan Doruğu bulunur. Bölgede karstik şekiller, bazan fay düzlemini belirten sarp şevler ve heyelanlar kayda değerdir. Yer yer mermer ve travertende erime hunileri (dolinler) ve mağaralar bulunur.

1./25.000 ölçekli jeoloji haritası yapılmış olan yörede, kaya stratigrafi birimlerinden formasyon ve üyelerin litoloji özellikleri, kalınlıkları ile zaman stratigrafi birimleri, genelleştirilmiş stratigrafi kesitinde gösterilmiştir. Paleozoyikte Rejyonal metamorfik kayalardan oluşan Dereköy metamorfitleri ile İznik Mermeri (Permiyen öncesi), Sarmaşık formasyonu (Alt-Üst Permiyen), Yenişerefiye kireçtaşı (Üst Permiyen); Mesozoyikte Yardankaya kireçtaşı (Orta-Üst Jurastik), Karadin formasyonu (Santoniyen-Kampaniyen) ve Nushetiye formasyonu (Kampaniyen-Maestrichtiyen); Senozoyikte Yağhane kireçtaşı (Alt-Orta Paleosen), Aydoğru formasyonu (Üst Paleosan), Derbent formasyonu (Alt Eosen), Yenişehir formasyonu ve Çamlık kireçtaşı (Neojen-, İznik formasyonu (Pleistosen?) ve alüvyon (Holosen) ayırt edilmiştir. Bölgede, Orta-Üst Eosen yaşında olduğu düşünülen Piroksen andezit ve bunu kesen Bazaltik andezit, Dasit gibi volkan kayaları ile Lamprofir gibi damar kayası yeralmaktadır. Bunların Sedimanter kayalarla kontaktında bazan Pyrometamorfik kayalar bulunmaktadır.

İnceleme yöremizde, Kaledoniyen orojenezi ile Hersiniyen orojenezine ait Palatin, Alp orojenezine ait Vorgosau (Austrik), Osmaneli, İznik?, Anadolu, Attik, Valak, Pasadeniyen fazlarının etkisi sonucunda oluşan kıvrımlar, faylar, eklemler ve yapraklanmalar görülür.

Bölgede, yapıyı oluşturmada etkin Kuzey Anadolu transform fayının bir devamı olan İznik fayı (doğrultu atımlı sağ yönlü) ve bu fayla ilişkili olarak birbirine göre ters yönde gelişen Derbent ve Tınazkaya Ters fayları ve bazı düşey faylar bulunur.

Ayrıca, bölgede Permiyen öncesi yaşlı Dereköy metamorfitleriyle İznik mermerinde ve diğer kayalarda fay düzlemleri yanlarında "milonit" olarak adlanan, Kataklastik metamorfik kayalar bulunmaktadır.

Bu sahada miktarda ve çeşitte zengin ekonomik mineraller olduğu kadar endüstriyel materyaller de bulunmaktadır.

ABSTRACT: The investigation area, which is between the boundaries of İznik and Yenişehir districts within the territories of Bursa province and Osmaneli district within the territories of Bilecik province, is situated in E, SE and NE of the İznik Lake of the Marmara Region, and covers an area of approximately 450 km2. In this region, there liset he Derbent-Avdan Ridge, which shows the trend of the mountains, of moderate height and having a strike of E-W and N70-80E, confirming of the geological structure of the area.

It is important to note that there are karstic forms and high slopes and land slides which signify the fault plane. There are also dolines and caves in the travertine and marble in some places.

In the area, of which a 1/25000 scaled geological map is prepared, the lithological characteristics of the formation and the members of the lithostratigraphical units, their thickness and the chronostratigraphical units, are demonstrated in generalized stratigraphic section. In the Paleozoic, the Dereköy metamorphites and İznik marble which are formed by regional metamorphic rocks (Pre-Permian), Sarmaşık formation (Lower-Upper Permian), Yenişerefiye limestone (Upper Permian); in the Mesozoic, Yardankaya limestone (Middle-Upper Jurassic), Karadin formation (Santonian-Campanian) and Nushetiye Formation (Campanian-Maestrichtian); in the Senozoic, Yağhane limestone (Lower-Middle Paleocene), Aydoğdu formation (Upper Paleocene), Derbent formation (Lower Eocene), Yenişehir formation and Çamlık limestone (Neogene), İznik formation (Pleistocene?) and alluvium (Holocene) are distinguished. There are volcanic rocks such as pyroxene andesite, which is thought to be Middle - Upper Eocene, and basaltic andesite and dacite cutting the pyroxene andesite, and dyke rocks such as Lamprophyre. At the contacts of the above given rocks with the sedimentary rocks, there are pyrometamorphic rocks which are sometimes observed.

In the investigation area, with the effects of the Caledonian orogenesis, Palatinian phase belonging on the Hercynian orogenesis and Vorgosau (Austrian), Osmaneli, İznik? Anatolian, Attican, Wallachian and Pasadenian phases of Alpine Orogenesis, folds, faults, joints and cleavages are observed.

In the area, there is the İznik fault (right handed strike-slip fault)which is the continuation of the North Anatolian transform fault and has an important effect on the formation of the structure, and Derbent and Tınazkaya thrust faults which form in the opposite direction to each other inrelation to İznik fault, and some vertical faults.

There is also cataclastic metamorphic rocks which are called "mylonites" in Pre-Permian aged Dereköy metamorphites and İznik marble and in other rocks near the fault planes.

The area shows richness in the variety and quantity of the economic minerals as well as industrial materials.

* This is the summary of the Ph. D. thesis prepared by Simav BARGU under the authority of Prof. Dr. Mehmet AKARTUNA.
Simav BARGU tarafından, Prof. Dr. Mehmet AKARTUNA yönetiminde hazırlanmış doktora tezinin kısaltılmış şeklidir.

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INTRODUCTION

As most earth scientist know, the investigation area and its surrounding which is situated in the Anatolid tectonic belt, is an area with concentrated problems. Some of these problems have not been solved until the present time, and some have been englihtened by various speculations. The aim of this investigation and research is to englihten these problems as much as possible and approach to the solutions by field and laboratory work.

Preparing a 1/25000 scaled detailed geological map of the area for the first time, explaining its stratigraphy and finding the thickness of the related formations, their distributions, facies, depositional environments, relation between the lowest and highest layers; identifying the metamorphis rocks, explaining their origins, the type of metamorphism and conditions of pressure and temperature, identifying the volcanic rocks and their relations with themselves and with other side rocks, mapping the zones of hydrothermal alterations and especially the areas of caolinization, investigating the capacity of mineralization and other industrial raw materials, and especially, as some of the earth scientists have hypothesized before, proving with datas the existence of the İznik Fault which passed from the south of İznik Lake and which effected the formation of the lake; and in case of its formation, the type of the fault and its relation with North Anatolian fault, are problems which have mainly attracted our attention and have lead us for a research in the above mentioned area.

The survey covers 1/25000 scaled topographis maps of Bursa based on H_{23}-a_2, H_{23}-a_3, H_{33}-b_1, H_{23}-b_2, H_{23}-b_4.

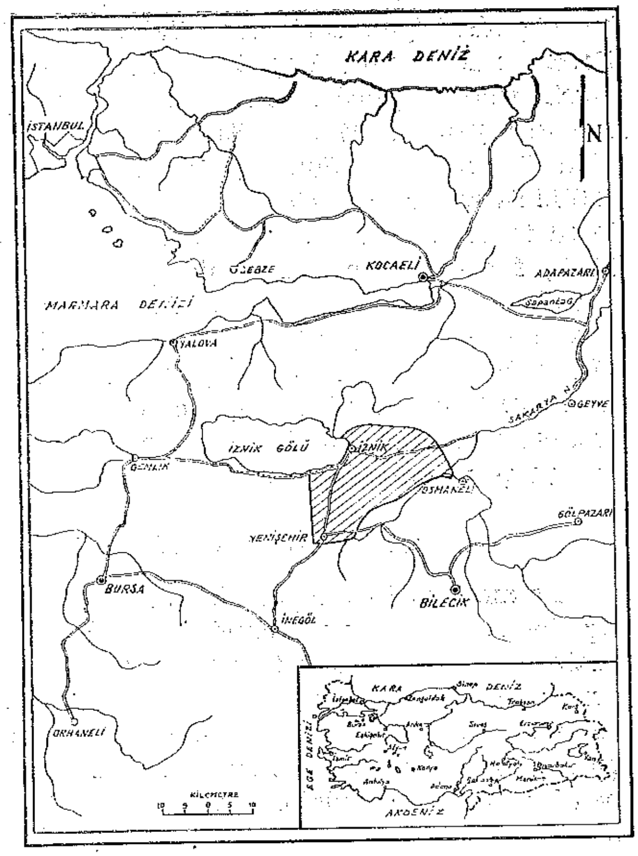
From the 1/25000 scaled geological map, which has been done based on the stratigraphic rock units, the structural map of the same scale together with the geological cross sections are aoquired; by using measured stratigraphical sections, a "generalized stratigraphic section" of the area is acquired; rose diagrams related to the formations between discordances and strikes and dips of the joints, and contour diagrams by using the polar equal distance projection net, and from the results of these contour diagrams, stereograms are prepared by using the equatoral equal distance projection net; and by correlating these with themselves, with the structural map and the geological cross sections, the structure of the investigation area and the relation of the dominant side pressures which make up the structure, are investigated.

The method of measurement of cross sections by the JACOB slide is applied while preparing the measured stratigraphic sections and making a practical, rapid and detailed study in the investigation area.

Abundance diagrams are prepared in order to determine the depositional environments, their conditions and facies of the Yardankaya limestone (Middle - Upper Jurassic) and Yağhane limestone (Lower-Upper Paleocene).

The metamorphic rocks are named as based on MIYASHIRO (1973), clastics from the sedimentary rocks based on TRAVIS (1970), limestones based on R.L. FOLK (1959), volcanic rocks and dyke rocks based on H. WILLIAMS, F.J. TURNER, C.M. GILBERT (1955).

In the clastic sedimentary rocks, grain size identifications are made as based on C.K. WENTWORTH (1922); roundness based on M.C. POWERS (1953); sorting and comparison chart hor sorting classes based on F.J.



ŞEKİL 1_ İNCELEME ALANININ MEVKİ HARİTASI

Figure 1_ Location map of the investigation area

PETTIJOHN, P.E. POTTER, R. SIEVER (1972) modified from R.L. FOLK (1968); the ideal textural maturity spectrum based on R.H. DOTT, Jr. (1964) modified from R.L. FOLK (1961); diagram for visual estimation of percentages of various components in rock thin sections based on SHVETSOV (1954), and TERRY and CHILINGAR (1955); the origin of quartz grains which are most frequently found in these clastics based on P.D. KRYNINE (1946 a); grain size and textural maturity in carbonate sedimentary rocks based on R.L. FOLK (1959).

The net arranged by myself for rose diagram of joints and beds in relation to tectonics; KAWRAISKI polar equal distance projection net and 1/100 scale point counter for the contour diagram; KAWRAISKI equatoral equal distance projection net for the Stereogram are used.

The investigation area, which is between the boundaries of İznik and Yenişehir districts within the territories of Bursa province and Osmaneli district within the territories of Bilecik province, is situated in E, SE and NE of the İznik Lake of the Marmara Region, and covers an area of approximately 450 km^2 (Fig. 1). In this region, there lies the Derbent-Avdan Ridge, which shows the trend of the mountains, of moderate height and having a strike of E-W and N70-80E, confirming to the geological structure of the area (Fig. 2).

It is important to note that there are karstic forms and high slopes and land slides which signify the fault plane. There are also dolines and caves in the travartine and marble in some places.

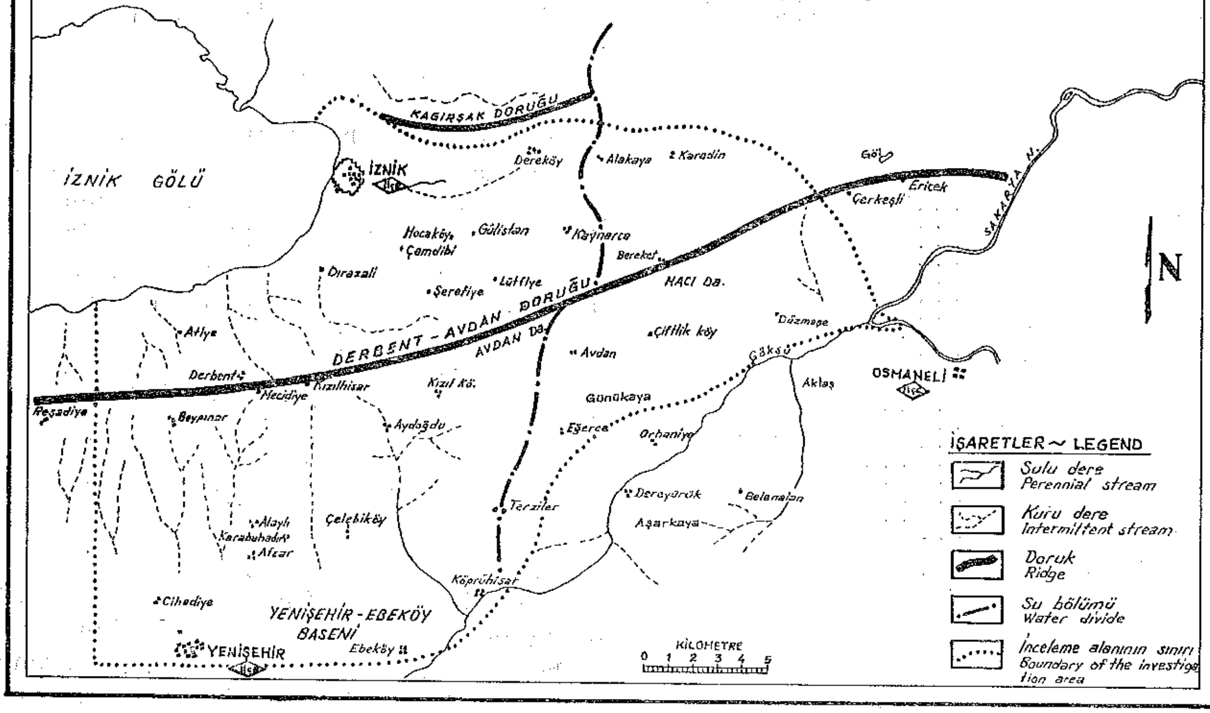
The climatic conditions of the region are found by using the THORNTHWAITE method (C_1B_2' sb') by means of the avarages computed by Iznik and Yenişehir Metereological Stations. In this short terminology, according to the humidity index, the symbols are: C_1 = dry subhumit, B_2' = secondary mesothermal, s= moderate summer water deficiency and moderate winter water surplus, b' = maritime climate. The avarage yearly temperature ise 14,46C°, the yearly total mean precipitation is 50,51 cm, yearly total potential evapotranspiration is 78,54 cm and the yearly total actual evapotranspiration is 41,58 cm (Fig. 3 and 4).

Generally thick soil is seen in the plains and thinner soil towards the mountaneous regions. Besides the Mediterranean vegetation, there are forests developped in some regions of the investigation area.

The 1/500000 and 1/100000 scaled maps of the area were acquired by previous works, but these can only give a general demonstration. Thus, there arises large differences between this survey and the previous ones.

The researchers who had worked in the investigation area are stated in chronological order as follows: P. de TCHIHATCHEFF (1867), K. Von FRITSCH (1882), A. PHILLIPPSON (1918), W. PENCK (1918), E. CHAPUT (1936), V. STCHEPINSKY (1941, 1942), E. ALTINLI (1965), M. AKARTUNA (1968), E. ALTINLI (1975a).

ŞEKİL 2 _ İNCELEME ALANININ DORUK VE AKARSU AĞI HARİTASI
Figure 2 _ Orographic and hydrographic map of the investigation area



İZNİK - YENİŞEHİR YÖRESİNİN MUKAYESELİ NEM BİLANÇOSU

Comparative Moisture Data of the İznik - Yenişehir Region

S. BARGU
1977

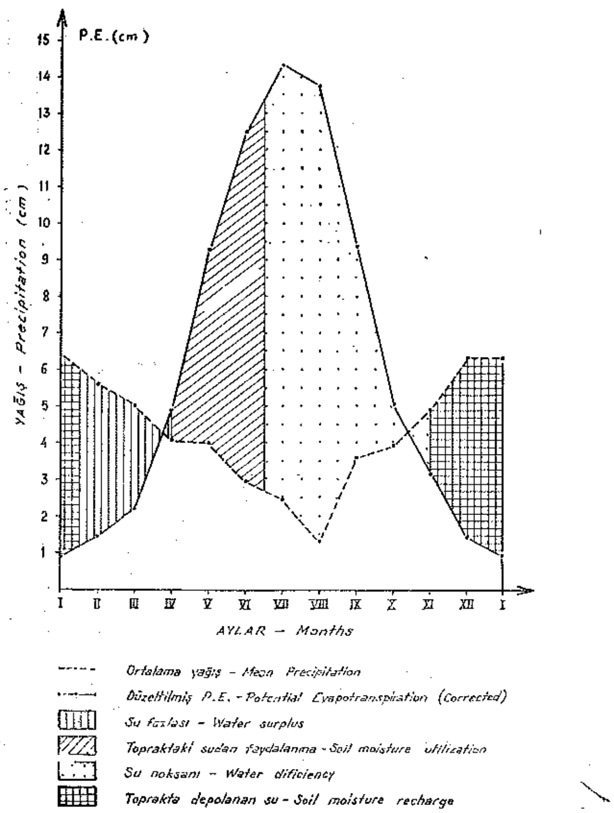
METEOROLOJİK ELEMANLAR Meteorologic elements	AYLAR - Months												YILLIK TOPLAM Yearly total
	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	
ORTALAMA SICAKLIK C° Mean temperature C°	14,3	11,6	7,3	5,2	7,2	8,4	12,7	17,6	22,0	23,4	23,8	20,1	14,46
SICAKLIK İNDİSİ Heat index	4,91	3,58	1,77	1,06	1,74	2,19	4,10	6,72	9,42	10,35	10,62	8,22	64,68
DÜZELTİLMEMİŞ P.E. Unadjusted Potential evapotr.	5,3	3,8	1,8	1,1	1,8	2,2	4,4	7,5	10,0	11,3	11,7	9,0	69,90
DÜZELTME KATSAYISI Correction factor	0,96	0,83	0,81	0,84	0,83	1,03	1,11	1,24	1,25	1,27	1,18	1,04	
DÜZELTİLMİŞ P.E. Potential evapotr.	5,08	3,15	1,45	0,92	1,49	2,26	4,88	9,30	12,50	14,35	13,80	9,36	78,54
ORTALAMA YAĞIŞ Mean precipitation	3,94	4,90	6,36	6,34	5,60	5,00	4,09	4,00	2,93	2,45	1,32	3,58	50,51
DEPO DEĞİŞİMİ Storage change	—	+1,75	+4,91	+5,42	—	—	-0,79	-5,30	-3,91	—	—	—	
DEPOLAMA Storage	—	1,75	6,66	10	10	10	9,21	3,91	—	—	—	—	
GERÇEK P.E. Actual evapotr.	3,94	3,15	1,45	0,92	1,49	2,26	4,88	9,30	6,84	2,45	1,32	3,58	41,58
SU NOKSANI Water deficiency	1,14	—	—	—	—	—	—	—	5,66	11,90	12,48	5,78	36,96
SU FAZLASI Water surplus	—	—	—	2,08	4,11	2,74	—	—	—	—	—	—	8,93
SELLENME Runoff	—	—	—	1,04	3,10	3,42	1,37	—	—	—	—	—	8,93

ŞEKİL. 3 - Figure. 3

İZNİK - YENİŞEHİR YÖRESİNİN YAĞIŞ VE POTANSİYEL BUHARLAŞMA TERLEME İLGİLERİNİ GÖSTERİR GRAF

Graph showing the relationships of Precipitation and potential Evapotranspiration of the İznik-Yenişehir region

S. BARGU
1977



Thornthwaite metoduna göre hazırlanmıştır. - Made according Thornthwaite's formula.
ŞEKİL. 4 - Figure. 4

STRATIGRAPHIC GEOLOGY

In the investigation area, there are Pre-permian regional melamorphic rocks, Paleozoic (Permian), Mesozoic (Jurassic, Cretaceous), Cenozoic (Paleocene, Eocene, Neogene, Quaternary) aged sedimentary rocks, magmatic rocks younger than Eocene, and pyrometamorphic rocks and cataclastic metamorphic rocks formed in relation to the faults.

The borders of the formations and members, their thickness and the symbols from the rock-stratigraphic units are displayed in the generalized stratigraphic section (Fig. 5).

P A L E O Z O I C

REGIONAL METAMORPHIC ROCKS

In the investigation area, the Pre- Permian regional metamorphic rocks which make the oldest basement, being in low pressure type green schist facies, are formed by Dereköy Metamorphites and İznik Marble.

DEREKÖY METAMORPHITES (Pzd)

The outcrops belonging to this unit are seen in the middle of our investigation area, in the S and N of İznik transform fault. The basement of the Dereköy Metamorphites can not be observed in the area. They are in graded contact and conformable with the İznik Marble. Dereköy Metamorphites are found unconformable with the overlapping sandstones of Sarmaşık formation (Lower-Upper Permian).

The classification and nomenclature of the metamorphic rocks are made according to A. MIYASHIRO (1973). The rock groups are identified taking the original composition of the pre-metamorphism of the metamorphic rocks into consideration. These rock groups have been subdivided to subclasses according to textural specifications. Within the metamorphic rock groups of the Dereköy Metamorphites, three members are also identified according to the law of stratigraphical nomenclature. The occasional repetition of these rock groups together with the members constitute Dereköy Metamorphites. These groups are identified as the following:

I. PELITIC METAMORPHIC ROCKS (METAPELITES)

A. Metasedimentites
   1. Metasandstones
      a) Metaarenites
      b) Metawackes
   2. Metasiltstones
   3. Metaclaystones
   4. Metacherts

B. Slate-phyllites

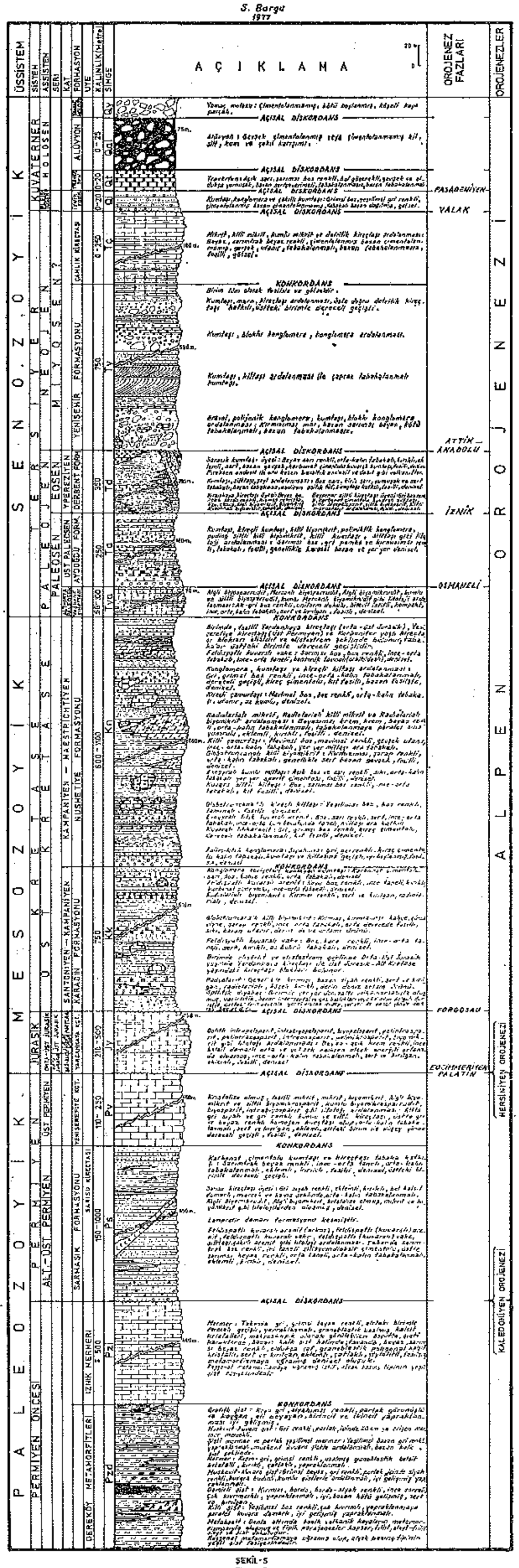
C. Phyllites

D. Schists
   1. Quvarts-Sericite schist

İZNİK - YENİŞEHİR (BURSA) - OSMANELİ (BİLECİK) YÖRESİNİN GENELLEŞTİRİLMİŞ STRATİGRAFİ KESİTİ

GENERALIZED STRATIGRAPHIC SECTION OF İZNİK - YENİŞEHİR (BURSA) - OSMANELİ (BİLECİK) AREA

S. Bargu 1977



ŞEKİL-5
Figure-5

2. Quartz-Muscovite schist
3. Muscovite-Quartz schist

II. METAMORPHIC ROCKS DERIVED FROM CALCEROUS SEDIMENTS
Marble

III. BASIC METAMORPHIC ROCKS (METABASITES)

A. Slates
B. Slate-phyllites
C. Phyllites
D. Schists

1. Epidote schist
2. Chlorite schist

Within the above stated rock groups, the following members are seen:

MARBLE MEMBER (Pzdm)
GRAPHITE SCHIST MEMBER (Pzdg)
IRON SCHIST MEMBER (Pzdd)

Pelitic Metamrophic rocks contain abundant AL_2O_3 and K_2O. The shistosity is significant when there is abundant mica and fine minerals. The increase in the pressure and temperature effect the new mineral reactions. The most abundant minerals are muscovite and chlorite. As it is in all metapelites, they are together with quartz.

The metamorphic rocks derived from calcerous sediments are seen in the form of marble. If the $CaCo_3$ percentage is high in the limestone which is the original rock, then pure marble is formed. If it contains SiO_2, clayey materials and rock fragments, then micaceous marble is formed, and thus, it makes the schistosity more significant.

The term 'metabasites' is offered by HACKMAN (1907) and is applied by MİYASHİRO (1973). These metabasites which are rich with Mg0, Fe0, Ca0 and Al_2O_3, contain minerals as epidotes, chlorites and actinolites, muscovites and biotites. These characterize the green schist facies having low temperature.

There are formations of mineral assemblages as muscovite - chlorite in the slate - phyllites and schist of metapelites; epidote-chlorite-muscovite in the slate-phyllite, phyllite and schists of the metabasites; epidote-chlorite-actinolite and epidote-calcite-actinolite in the schists of metabasites; and epidote-chlorite-calcite in some of the marbles, all belonging to Dereköy Metamorphites. According to the above mentioned mineral assemblages, it is understood that the Dereköy Metamorphites are formed in the low pressure type green schist facies.

In the orogenic belts, the sedimentary deposits together with the basaltic volcanites in between them have gone through metamorphism. Because of this reason, it is under possibility to observe the same mineral assemblages in the metasedimentites and the metabasites recrystallized under the same temperature and pressure.

İZNİK MARBLE (Pzi)

Outcrops of the İznik marble generally lies in the NE of the investigation area. It is graded contact and conformable with the Dereköy metamorphites. There is no sedimentary rock overlying the İznik marble in the investigation area. The Dereköy Metamorphites lying bleow are overlapped by the Lower-Upper Permian aged Sarmaşık formation and are unconformable with them.

According to the geological cross sections, its approximate thickness is 500 m. It is grey or grey-white at the bottom and its crystals are large enough to be seen through the microscope, has schistosity in general. Whereas on the levels close to the top, it is yellow-white or white in color and has smaller crystals, At the bottom, the calcite crystals in the marble are elongated granoblastics whereas at the top they are polygonal granoblastics. The rock is breakable and hard from top to bottom. The marble has the capacity of dividing parallel to the schistosity and the joint planes. The granoblastic calcite crystals become enlarged with the arising temperature. Crystallization develops together with the deformation and then is effected by the tectonical movements during regional metamorphism.

In some levels of the marble, stylolites are observed as parallel to the plane of elongation of oriented calcite crystals in relation with pressure. There are dolines and caves in the marble in some places. The following aspects in the calcite crystals of the İznik marble are identified: 1) elongation, 2) folding, 3) deformation lamellea, 4) deformation twinning, 5) reorganization of crystal structure.

Because of formation of the marbles of the investigation area under conditions of low P-T (pressure - temperature) the mineral as wollastonite which is seen in high temperature conditions, could not be observed. The marble is a product of the low pressure type green schist facies the regional metamorphism.

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

A. PENCK (1918), E. CHAPUT (1936), E. ALTINLI (1943), İ. KETİN (1946, 1947), H. PAMİR - F. BAYKAL (1947), M. BLUMENTHAL (1948), İ. KETİN (1951), M. AKARTUNA (1953), İ. KETİN (1955), Ş. ABDÜSSELAMOĞLU (1959), M. AKARTUNA (1962a, 1962b), E. ALTINLI (1965), E. ÇOĞULU- M. BLALOYE- R. CHESSEX (1965), M. AKARTUNA (1968), E. İZDAR (1969), E. BAŞARIR (1970), E. BİNGÖL (1971), Ö. DORA (1972), C. DEMİRKOL (1973), Ö. ÖZTUNALI (1973), E. ALTINLI (1975).

In the investigation area, Lower-Upper Permian aged fossiliferrous Sarmaşık Formation is discordant on the metamorphites. On the other hand, because of the fact of unmetamorphised Middle Carboniferous (Bashkırıan) limestone blocks being as olistolites in Nushetiye Formation aged Upper Cretaceous, we thing that these blocks which are not autochthonous in the area are carried from the near surroundings and believe the age of metamorphism as being Pre-Middle Carboniferous. Authors such as İ. KeTİN (1951), E. ÇOĞULU (1965), M. AKARTUNA (1968), E. BİNGÖL (1971) and C. DEMİRKOL agree with this concept with their research areas.

Ş. ABDÜSSELAMOĞLU (1959) who researched in areas close to this one, identified the age of crystallen rocks as being Pre-Devonian and taking these data into consideration ve accept that the age of İznik Marble and Dereköy Metamorphites is Pre-Devonian. M. BLUMENTHAL (1948) and M. AKARTUNA (1962a), agree with this concept according to the research made in their areas.

P E R M I A N

LOWER - UPPER PERMIAN SARMAŞIK FORMATION (Ps)

This is the oldest sedimentary rock which lies with a length of 30 km in E-W direction and width of 0,5-2 km in N-S direction, in a nearly rectangular shape and continues outside of the investigation area in the E. This formation is formed by grey, yellow-grey sandstones which cover the metamorphic rock particles and the Sarısu limestone member which is found within these sandstones in the shape of wedge, lense and beds. Because of overfolding of the unit, measured stratigraphical sections could not be obtained. According to the geological cross sections, its maximum thickness is measured as 1000 m. In the sandstones, there are lithologies such as feldispathic quartz arenite (arkose), feldispathic (quartz) arenite, feldispathic quartz wacke, feldispathic (quartz) wacke, wacke pebbled feldispathic quartz arenite, metaquartzite pebbled feldispathic quartz arenite, carbonate cemented quartz arenite; in the limestone beds and lenses which are situated in the sandstones and in the limestones which belong to Sarısu limestone member, there are crystallized micrite, crystallized biomicrite, crystallized fossiliferous micrite, algal biomicrudite, algal biomicrite. The age of this formation is Lower- Upper Permian which is determined according to carbonate sandstones situated in the upper layers and Fusulinidae and Algae which are discriminated in the Sarısu limestone member and the limestone layers of the formation. Within the cement of sandstones of Sarmaşık Formation, the below given fossils which are aged Artinskian (P_1^B) (Lower Permian)-Mourgapien (P^A_{11}) (Upper Permian) are identified:

Foraminifera Neoschwagerina sp.
Afghanella sp.
Climacammina sp.
Schwagerinidae
Algae Ungdarella sp.

Within the Sarısu Limestone member of Sarmaşık Formation the below given fossils which are aged Lower-Upper Permia are identified:

Foraminifera Glomospira sp.
Hemigordius sp.
Agathammina sp.
Pachyphloia sp.
Nankinella sp.
Neoschwagerina sp.
Afghanella sp.
Algae Pseudovermiporella sp.
Gymnocodium sp.
Dasycladaceae

The sequence is formed generally in shallow waters, and in a condition which is rather active but sometimes steady.

V. STCHEPINSKY (1942) and M. AKARTUNA (1968) have worked in areas close to the investigation area in similar units. This unit is misevaluated by STCHEPINSKY (1942) and was believed to have an age of Devonian, however the age of the Sarmaşık Formation is Lower - Upper Permian.

UPPER PERMIAN

YENİ ŞEREFİYE LİMESTONE (Py)

In the investigation area, Yenişerefiye limestone displays an outcrop in the form a belt with a width of 1 km generally lying in E-W direction. It lies as graded contact and conformable with the sandstones of Sarmaşık formation. It is formed by grey-black and grey colored sandy and silty limestone at the lower part and rather grey and white colored homogenous limestone at the upper layers. According to the measured stratigraphic section, its thickness is 110 m. In these limestones, there are lithology types such as crystallized fossiliferous micrite, crystallized biomicrite, fossiliferous sparite, crystallized algal biomicrite, sparite, sandy biomicrosparrudite, silty biomicrosparite, silty biomicrosparrudite, silty biomicrudite, biosparite, biosparrudite, intrabiosparite, fossiliferous sparite, biomicrite, biomicrudite. It contains a lot of Fusulinidae and Algae and the age is Upper Permian due to these factors. According to these lithologies and the fossils they cover, it is understood that the depositional environment is generally active and still shallow water and sometimes deep and still water.

The fossils which are aged Upper Permian

(Mourgapien P^{A}_{11} - Pamirien P^{B}_{11}) are identified as follows:

Globivalvulina vonderschmitti REICHEL
Globivalvulina sp.
Schubertella sphaerica SULEJMANOV
Nankinella haymanensis (CIRY)
Nankinella sp.
Verbeekina verbeekii (GEINITZ)
Neoschwagerina craticulifera (SCHWAGER)
Neoschwagerina sp.
Hemigordius sp.
Hemigordiopsis sp.
Eotuberitina sp.
Neotuberitina sp.
Glomospira sp.
Glomospirella sp.
Pachyphloia sp.
Frondicularia sp.
Parafusulina sp.
Schwagerina sp.
Schwagerininae
Agathammina sp.
Kahlerina sp.
Nodosaria sp.
Tetrataksis sp.
Boultonia sp.
Afghanella sp.
Geinitzina sp.
Endothyra sp.
Paleotextularia sp.
Reichelina sp.
Rauserella sp.
Sphaerulina sp.
Climacammina sp.
Yangchienia sp.
Pseudofusulina sp.
Praesumatrina sp.
Cordioformis sp.
Cribrogenerina sp.
Fusiella sp.
Polydiexoidina sp.
Dunbarula sp.
Ostracoda
Coralla (Tetracoralla)
Brachiopoda
Crinoidea
Gastropoda
Bryozoa

Mizzia cornuta KOCHANSKY ve HERAK
Mizzia minuta JOHNSON ve DORR
Mizzia velebitana REZAK
Mizzia yabei KARPINSKY
Mizzia sp.
Stromatolite
Ungdarella sp.
Paleonubecularia sp.
Pseudoepimastopora sp.
Gymnocodium sp.
Girvanella sp.
Dasycladaceae
Tubiphytes sp.
Anthracoporella sp.
Petschoria sp.
Pseudovermiporella sp.
Velebitella sp.
Permocalculus sp.
Diplopora sp.
Komia sp.
Macroporella sp.
Cuneiphycus sp.
Pseudonumiporella sp.

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows :

E. CHAPUT (1936), V. STCHEPINSKY (1942), S. ERK (1942), Ş. ABDÜSSELAMOĞLU (1959), E. ALTINLI (1965), O. EROSKAY (1965), M. AKARTUNA (1968), E. ALTINLI (1975a).

Most of the above given authors accept the presence of Permian aged limestones. According to the results of our research, the similarity of the stratigraphical and lithological relations of the limestone unit aged Upper Permian in our investigation area to the research areas of S. ERK, M. AKARTUNA and O. EROSKAY is observed and it is understood that our concept agrees with their ideas.

There is no determination of a formation belonging to Triassic and Liassic in the investigation area.

M E S O Z O I C

J U R A S S İ C

MİDDLE - UPPER JURASSİC

YARDANKAYA LIMESTONE (Jy)

This unit which lies generally in the E of investigation area, has angular unconformity on the Upper Permian aged Yenişerefiye limestone and consists of white, cream-white limestone. The typical location is at Yardankaya. This location is used in the formation nomenclature. According to the measured stratigraphic section which is obtained from Yardankaya, its thickness is 218 m and the Bajocian- Bathonian, Callovian, Callovian-Oxfordian, Lucitanian-Kimmeridgian, Portlandian (Lower, Middle-Upper) stages which belong to Middle-Upper Jurassic, because of Trocholinidae, Tintinnidae and other fossils.

In the sequence, the follow ing levels with their fossil content and the characterizing ages are identified from bottom to the top:

a) Dogger (Bajocian - Bathonian), thickness 77 m
Protopeneroplis striata WEYNSCHENK
Trocholina conica SCHLUMBERGER
Bryozoa
Thaumatoporella parvovesiculifera (RAINERI)
Paleodasycladus sp. (mediterraneus group)
Dasycladaceae
Solenoporaceae

b) Callovian (Malm start), thickness 7 m
Girvanella sp.
Actinostromatophora sp.
Verneuillinidae
Textulariidae

c) Callovian - Oxfordian (Lower Malm, thickness 11 m
Trocholina sp. (alpina group)
Trocholina sp.
Lithocodium sp.
Girvanella sp.
Valvulinidae
Verneuillinidae
Myxophyte colonies

d) Lucitanian-Kimmeridgian (Middle Malm), thickness 19,5 m.
Cladorapsis mirabilis FELIX
Cayeuxia sp.
Valvulinidae
Verneuillinidae

e) Portlandian (Upper Malm), thickness 103,5 m
This level is divided to 3 substages:

e_1) Lower Portlandian, thickness 15,5 m.
Trocholina alpina (LEUPOLD)
Protopenoroplis striata WEYNSCHENK
Lenticulina sp.
Actinostromatophora sp.

e_2) Portlandian, thickness 53,5 m
Trocholina alpina (LEUPOLD)
Lenticulina sp.
Ophtalmidium sp.
Protoglobigerina sp.
Lithocodium sp.
Actinostromatophora sp.
Small Clypenid

e_3) Middle-Upper Portlandian, thickness 34,5 m.

Calpionella sp. (alpina group)
Clypeina Jurassica FAVRE

According to the fossils taken from all levels, the age of this unit is DOGGER (Bajocian-Bathonian) - MALM (Upper Portlandian).

In general, there is no observation of terrigenous components in the portion which lies outside of the 130-137th meter of the stratigraphical height. This fact shows that during deposition, there is no derivation of continental material to the depositional environment. This formation consists of lithology types as oolitic intrapelsparite, pelintrasparite, intrabiopelsparite, intrabiopelmicrosparite, biopelsparite, intrapelsparite, pelintraoosparite, oosparite, intraoosparite, intrapelmicrosparite, pelmicrosparite, algal intrasparite, Algal biosparite, Algal oosparite, fossiliferous oosparite, intrabiosparite, pelsparite, pelintrabiosparite, biomicrite, Tintinnidae bearing biomicrite, sparry micrite, sparry pelmicrite, sparry biomicrite, sparry fossiliferous micrite, and sandy intrabiomicrite. The abundance diagram related to the components of the limestones in the measured stratigraphic section is prepared and by using the depositional environment and the graded amount of energy in this environment with the facies of the sequence is explained. According to this explanation, there are first middle, then high and again middle degree energetic environments in which there are strong and weak periods formed. According to the lithologies within and out of the section, all of the formation has formed in generally active and still shallow water and sometimes in deep still water.

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

W. PENCK (1918), E. CHAPUT (1936), E. ALTINNLI (1943), S. ERK (1942), Ş. ABDÜSSELAMOĞLU (1959), E. ALTINLI (1965), O. EROSKAY (1965), M. AKARTUNA (1968), E. ALTINLI - C. YETİŞ (1972), V. TOKER (1973), E. ALTINLI (1975a).

According to the above explanations, most of the authors have identified the age of this formation as being Middle-Upper Jurassic. We support this concept by our data from this research. However, despite our belief of Upper Jurassic being in unconformity with the overlapping Upper Cretaceous, E. ALTINLI (1975a) suggests that there is an angular unconformity between Upper Jurassic (Bilecik Limestone) and Lower Cretaceous (Soğukçam Limestone) and Ş. ABDÜSSELAMOĞLU (1959) suggested that Upper Jurassic is in graded contact with the Lower Cretaceous.

In the investigation area, stratigraphically, although Lower Cretaceous does not lie over Upper Jurassic, because of the fact that there are limestones representing Upper Jurassic-Lower Cretaceous graded contact as olistolites in the Upper Cretaceous clastic sediments, and as Ş. ABDÜSSELAMOĞLU has suggested, we understand that there is a continuity of the sea in Upper Jurassic and Lower Cretaceous and no unconformity between them.

CRETACEOUS

The Lower Cretaceous which is not autochthonous in the investigation area, is found in forms of olistolites in the formations of Upper Cretaceous.

UPPER CRETACEOUS

Upper Cretaceous is represented by Santonian-Campanian aged Karadin Formation at the bottom and Campanian-Maestrichtian aged Nushetiye Formation lying over it which is vertical and in lateral graded contact and conformable with the Karadin Formation.

KARADİN FORMATION (Santonian-Campanian) (Kk)

This unit lies in the form of 2 belts, one with a width of 0,5-2 km between Kaynarca and Karadin villages, and the second having a width of 0,2-1 km in the S of İznik -Mekece highway, in the N of the investigation area. Karadin formation is shown as angular unconformable with the Middle-Upper Jurassic aged Yardankaya limestone on the generalized stratigraphic section, there is no direct contact seen on the map. This formation, generally being angular unconformable on Dereköy metamorphites (Pre- Permian) and sometimes on sandstones of Sarmaşık formation (Lower - Upper Permian), consists of grey, yellow grey, white grey, pink white, grey, dark green grey, olive, red, dark red conglomerate, pebbly sandstone, sandstone, siltstone, clayey siltstone, claystone, shale, marn, radiolarite, radiolarian marn, radiolarian limestone, clayey limestone and limestone alternation and Upper Jurassic-Lower Cretaceous, Middle -Upper Jurassic aged limestone blocks existing in the form of olistolite. Furthermore, there is spilitic diabase (variolitic diabase) which is generated by the under marine volcanism but coult not be plotted on the map because of their smallness in size. The Karadin formation, the age of which is identified as Santonian - Campanian due to the Globotruncanas, has been measured to have a thickness of 750 m according to the geological cross sections. The formation, according to the lithologies and the fossils it covers, is formed in an alternating shallow and deep water. Spilitic diabase and radiolarites are the most important proofs signifying the presence of deep water. There is the Nushetiye formation formed as having generally vertical and sometimes lateral graded contact and conformity on this particular formation. The boundary is sometimes unclear.

In the lithologies belonging to Karadin Formation, the following fossils have been identified:

Globotruncana coronata BOLLI
Globotruncana lapparenti BROTZEN
Globotruncana sp. (group lapparenti)
Nodosaria sp.
Lagena sp.
Heterostegina sp.
Rotaliidae
Textulariidae
Radiolaria sp.
Ostracoda
Mollusca test fragments

According to these fossils the age is Santonian- Campanian.

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

E. ALTINLI (1943), F. BAYKAL (1943b), M. BLUMENTHAL (1948), E. ALTINLI (1951), F. BAYKAL (1954), M. TOKAY (1954), Ş. ABDÜSSELAMOĞLU (1959), M. AKARTUNA (1962a), E. ALTINLI (1965), O. EROSKAY (1965), M. AKARTUNA (1968), E. ALTINLI - C. YETİŞ (1972), E. ALTINLI (1975a).

E. ALTINLI (1943, 1965, 1975a), F. BAYKAL (1943b, 1954), M. BLUMENTHAL (1948), M. TOKAY (1954), Ş. ABDÜSSELAMOĞLU (1959) have identified the corresponding units to the Santonian-Campanian aged Karadin Formation identified by us, to be in the limits of Upper Cretaceous or Cenonian.

The conditions of the graded contact and conformability of Santonian-Campanian aged Karadin Formation and Campanian-Maestrichtian aged Nushetiye Formation proved by us agrees with the research areas of F. BAYKAL (1943b), E. ALTINLI (1951), M. TOKAY (1954), Ş. ABDÜSSELAMOĞLU (1959), M. AKARTUNA (1962a, 1968), O EROSKAY (1965), E. ALTINLI - C. YETİŞ (1972).

The ages of both of the formations almost completely agree with the ages of the units that these authors have identified in their investigation areas.

NUSHETIYE FORMATION (Campanian - Maestrichtian) (Kn)

This unit which is in the form of two belts with a width of 3-4 km and length of 28-30 km in the N and S of Permian and Jurassic deposits located in the middle of the investigation area, continues outside of the area as well. Nushetiye formation has vertical and lateral graded contact and conformity with the Karadin Formation lying below. The boundary is sometimes unclear and over it, there is the Lower-Middle Paleocene aged Yağhane Limestone which has graded contact and conformity.

According to the measured stratigraphic section, the thickness of Nushetiye formation is 1100 m.

Nushetiye formation is formed by green grey, red grey, blue grey and grey colored sandstone (lithic arenite, quartz arenite) and claystone interbedded thick conglomerate level at the bottom, sandstone interbedded shale and claystone alternation, clayey limestone, marl, mudstone, conglomerate, sandstone and carbonate sandstone alternation, sandstone (lithic wacke, quartz wacke) calcerous sandstone and limestone interbedded calcerous sandstone with Orbitoides and Siderolites on the upper level. There are volcanic tuff, aglomerate and volcano clastics in some places of the layers close to the bottom of the formation. Also within this sequence, there are three limestone members distinguished in the Lower levels, Middle-Upper levels and Upper levels. The lithologies have from time to time lateral contact with each other.

The following fossils are identified within the Nushetiye Formation:

Praeglobotruncana sp.
Globotruncana coronata BOLLI
Globotruncana lapparenti BROTZEN
Globotruncana cf. lapparenti BROTZEN
Globotruncana subcircumnodifer GANDOLFI
Globotruncana arca (CUSHMAN)
Globotruncana cf. arca (CUSHMAN)
Globotruncana fornicata PLUMMER
Globotruncana cf. gansseri BOLLI
Globotruncana cf. ventricosa WHITE
Globotruncana bulloides VOGLER
Globotruncana cf. bulloides VOGLER
Globotruncana elevata (BROTZEN)
Globotruncana stuarti (DE LAPP.)
Globotruncana cf. stuarti (DE LAPP.)
Globotruncana contusa (CUSHMAN)
Globotruncana cf. linneiana (D'ORB.)
Globotruncana cf. conica WHITE
Globotruncana sp. (group arca)
Globotruncana sp. (group lapparenti)
Globotruncana sp. (group fornicata)
Globotruncana sp. (group stuarti)
Globotruncana sp. (group contusa)
Globotruncana sp. (group tricarinata)
Globotruncana sp. (group stuartiformis)
Globotruncana sp. (group linneiana)
Globotruncana sp. (group bulloides)
Globotruncana sp. (group elevata)
Globotruncana sp.
Globotruncanidae
Orbitoides apiculatus SCHLUMBERGER
Orbitoides spiculatus gruenbachensis PAPP
Orbitoides sp.
Siderolites calcitropoides LAMARCK
Siderolites sp.
Heterohelix sp.
Calcarata sp.
Quinqueloculina sp.
Miliola sp.
Miliolidae
Rugoglobigerina sp.
Hedbergella sp.
Pseudotextularia sp.
Textularia sp.
Textulariidae
Rotalia sp.
Rotaliidae
Valvulina sp.
Bolivina sp.
Lockhartia sp.
Marssonella sp.
Arnaudiella? sp.
Fissoelphidium sp.
Ammodiscus sp.
Robulus sp.
Gublerina sp.
Dorothia sp.
Stensioina? sp.
Bryozoa
Annelid section
Echinid plate section
Echinoidea spine section
Exogyra aff. owervegi BUCH
Exogyra conica SOWERBY
Exogyra sp.
Gryphaea sp.
Alectryonia sp.
Inoceramus sp.
Ostrea sp.
Janira sp.
Pelecypoda test fragments
Ostracoda
Melobesia sp.

According to these fossils, the age of the unit is Campanian-Maestrichtian.

We will go through the three limestone members which was identified with in the Nushetiye Formation seperately:

1. LİMESTONE MEMBER (Knk_1)

This limestone member is yellow white, pink-white, white colored, jointed and medium-thick bedded. It is in the form of a lens, sometimes wedge and somtimes beds in the layers belonging to Nushetiye Formation, especially in levels close to the bottom. Its thickness is almost upto 200 m. It consists of lithologies such as limestone, sandy limestone, clayey limestone and carbonate sandstone.

The following fossils within the unit are identified: Textularia sp., Textulariidae, Foraminifera, Radiolaria sp., Hexacoralla, Ostracoda, Echinoidea plate, Echinoidea spine.

The unit is formed in generally shallow and active, rarely shallow and inactive and sometimes deep waters, according to the lithologies and fossils.

2. LİMESTONE MEMBER (Knk_2)

This limestone member which is located in middle and upper but mostly upper levels of the Nushetiye Formation, is medium-thick calcite veined, fossiliferous and marinal.

According to the measured stratigraphic section, its thickness is 302,5 m. And it is generally formed by micritic stones. The following fossils are identified within the lithologies: Radiolaria sp., Sponge spicules, Ostracoda test fragments. Radiolarias resemble the Upper Cretaceous forms. Furthermore, because of the location of this unit in the fossiliferous Upper Cretaceous formation in a normal stratigraphic form, it should belong to Upper Cretaceous. The unit, according to the lithologies and fossils, has been formed in a generally deep inactive water and seldomly in a shallower portion of it.

3. LİMESTONE MEMBER (Knk_3)

This unit which represents the upper levels of the Nushetiye formation, is generally in the form of lens, sometimes in the form of wedge and sometimes a bed. It also shows as independent outcrops on the Santonian-Campanian aged Karadin Formation and Dereköy Metamorphites in the N of our investigation area. The thickness varies. Measured stratigraphical sections could not be obtained. According to the geological sections, the thickness is 75-100 m. It is generally grey, white grey colored, medium-thick bedded, jointed, irregular broken, calcite veined, bentonic fossiliferous, and marinal. The sequence consists of limestone, clayey limestone, sandy limestone, pebbled sandy limestone, pebbled limestone and carbonate sandstone. At the bottom of the limestone, sometimes a breccia texture is observed.

The following fossils are identified with this unit: Siderolites calcitropoides LAMARK, Sidorolıtes sp. Orbitoides medius D'ARCHIAS, Orbitoides sp. (apiculatus group), Orbitoides sp., Marssonella sp., Nodosaria sp., Heterostegina sp., Lagena sp., Lagenidae, Rotaliidae, Miliolidae, Miscellenidae, Peneroplidae, Bryozoa, Ostracoda, Mollusca test fragments, Echinoidea spine, Lithothamnium sp., Melobesia sp., Halimeda sp., Dasycladacea, Algae. According to these fossils, the age is Upper Maestrichtian. And the unit is formed in a generally shallow and active, rarely inactive waters, according to the lithologies and the fossils.

The sandstone intercalated shale, claystone and mudstone levels which are above conglomerate, a product of the shallow waters in the bottom of the Nushetiye Formation, is in the flysch facies has slump structure and turbidithic formations. Also traces of organism movements and organizm are observed.

According to all of this data, the lithologies which make up the Nushetiye Formation together with the three limestone members and the fossils they contain, show that the sea becomes shallow and deep continuously and submarine slumps and the turbidithic currents are effective. The presence of olistolites in this formation proves the effects of the gravity sliding in the depositional environment. However, Nushetiye Formation is formed in a generally shallow water, in a mostly active and rarely inactive period; and in some places in a deep water, generally inactive and sometimes in less currenty period.

Within the Karadin and Nushetiye formations, there are the limestone blocks aged Middle Carboniferous (Bashkırıan), Upper Permian, Middle-Upper Jurassic and Upper Jurassic-Lower Cretaceous in forms of olistolite having lengths for several hundred meters and generally lying very close to each other but sometimes lying apart, which are formed by gravity sliding and/or tectonic events in the Upper Cretaceous sedimentary basin.

The following fossils which are in the form of olistolite are identified as a result of microscopic analysis in the different colored and aged limestones in the Nushetiye Formation:

In the black colored Middle Carboniferous (Bashkırıan) aged limestones;

Pseudostaffella antiqua (DUTKEVIC)
Eostaffella sp.
Pseudoendothyra sp.
Palaeotextularia sp.
Samarella sp.
Petschoria sp.

In the grey-white, grey colored Upper Permain aged limestones;

Neoschwagerina sp.
Verbeekina sp.
Parafusulina sp.
Dunbarula sp.
Kahlerina sp.
Sphaerulina sp.
Afghanella sp.
Praesumatrina sp.
Mizzia velebitana REZAK
Petschoria sp.
Permocalculus sp.

In the white colored, Middle - Upper Jurassic and Upper Jurassic-Lower Cretaceous aged limestones:

Protopenoroplis trochangulata SEPTFONTAINE
Protopenoroplis striata WEYNSCHENK
Trocholina alpina (LEUPOLD)
Trocholina sp.
Trocholina sp. (group alpina)
Trocholina elongata (LEUPOLD)
Trocholina innominata BONET
Trocholina sp. (group elongata)
Neotrocholina sp.
Calpionella elliptica CADISCH
Calpionella undelloides COLOM
Calpionella alpina LORENZ
Calpionella sp. (group alpina)
Calpionella sp.
Calpionellites darderi (COLOM)
Calpionellites neocomiensis COLOM
Calpionellites sp.
Tintinnopsella longa (COLOM)
Tintinnopsella carpathica (MURG. - FILIP.)
Tintinnopsella batalleri COLOM
Amphorellina sp.
Remaniella cadischiana (COLOM)
Crassicollaria sp.
Crassicollaria parvula REMANE
Radiolaria sp.
Dorothia sp.
Reophax sp.
Paalzowella sp.
Spirillina sp.
Lenticulina sp.
Glomospira
Glomospirella sp.
Pseudocyclammina sp.
Nodosaria sp.
Nodosariinae
Rotaliidae
Miliolidae
Textulariidae
Verneuilinidae
Ophthalmidium sp.
Ophthalmidiidae
Nodophthalmidium sp.
Valvulinidae
Nautilocolina sp.
Labyrinthina sp.
Bryozoa
Sponge spicule
Ostracoda

Thaumatoporella parvovesiculifera (RAINERI)
Bacinella irregularis RADOICIC
Clypeina jurassica FAVRE
Girvanella sp.
Salpingoporella sp.
Actinostromatophora sp.
Palaeodasycladus sp.
Solenoporacea
Dasycladaceae

Nushetiye formation and the overlying Yağhane limestone have graded contact and conformity with each other. On the upper layers belonging to Nushetiye Formation, there lies Upper Maestrichtian beds containing Orbitoides and Siderolites, on these there are the characteristic fossilless carbonate sandstone and sandy limestone layers which contain Annelid, Bryozoa and Miliolidae, and the Montian beds with Laffitteina and Planorbulina on the previous ones. According to this determination, the age of the beds between Upper Maestrichtian and Montian and having conformity and graded contact with them, should be Danian. A. DİZER - E. MERİÇ (1972) have explained that the levels with Bryozoa and Miliolidae should be Danian. This concept agrees with our ideas and enforce their truthfullness.

As a result, it can be well understood that, according to the Lithological, Paleontological and Stratigraphical observations, the levels which could be Upper Maestrichtian (Upper Cretaceous) ard Danian (Lower Paleocene) and Montian (Middle Paleocene) have graded contact and conformity with each other.

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

E. ALTINLI (1943), F. BAYKAL (1943b), E. ALTINLI (1951), F. BAYKAL (1954), M. TOKAY (1954), Ş. ABDÜSSELAMOĞLU (1959), M. AKARTUNA (1962a), E. ALTINLI (1965), O. EROSKAY (1965), M. AKARTUNA (1968), A. DİZER (1971), A. DİZER - E. MERİÇ (1972), E. ALTINLI - C. YETİŞ (1972), E. ALTINLI (1975a, b)

From the above listed authors E. ALTINLI (1943, 1965), F. BAYKAL (1943b, 1954), M. TOKAY (1954), Ş. ABDÜSSELAMOĞLU (1959) have identified a wide range of age for the units corresponding to the Campanian-Maestrichtian aged Nushetiye Formation, and Santonian-Campanian aged Karadin Formation which is below, conformable and in graded contact with the Nushetihe Formation.

The contact situation and the ages of the Nushetiye Formation and the Karadin Formation agrees with the areas of E. ALTINLI (1951), M. AKARTUNA (1962a, 1968), O. EROSKAY (1965), E. ALTINLI - C. YETİŞ (1972). In our investigation area, the contact between the Nushetiye Formation and Lower- Middle Palocene aged Yağhane limestone which has graded contact and conformity over it, is similar to the investigation areas of E. ALTINLI (1943, 1951, 1965, 1975b), F. BAYKAL (1943b, 1954), M. AKARTUNA (1962a), A. DİZER (1971), A. DİZER - E. MERİÇ (1972).

S E N O Z O I C

T E R T I A R Y

PALEOCENE

Paleocene is represented by the Yağhane Limestone (Lower-Middle Paleocene) and the Aydoğdu formation (Upper Paleocene) in our investigation area.

LOWER-MIDDLE PALEOCENE

YAĞHANE LIMESTONE (Tya)

This unit which is not continuous in our investigation area, is placed in Güney Tepe, Kesenis Tepe, Alakaya Tepe and Kuz Tepe, NE of Eğerce Village in the E, and N and S of the Derbent Village in the W. It is typically observed in the Yağhane Dere and lies on the NW edge of Derbent Village. It is conformable and lies with graded contact on the Nushetiye formation aged Upper Cretaceous. And Aydoğdu formation (Upper Paleocene) lies unconformable over it. This position is seen clearly between the Kesenis Tepe and Güney Tepe.

Yağhane Limestone which lies uncontinuously as a marker bed, has the shape of a wedge.

Yağhane limestone is white grey and grey colored, uniform in texture, has monotonous sequence and is formed by lithologies as Algal biosparrudite, corall biosparrudite, Algal biomicrudite, corall biomicrudite, silty biosparrudite, sandy corall biomicrudite, silty Algal biosparrudite and silty corall biosparrudite. According to the measured stratigraphic section, the thickness of this formation is 66 m and its age is determined to be Lower-Middle Paleocene because of Planorbulina, Laffitteina and other fossils found on the lithologies. It is formed in a shallow water under the wave base and light ray. According to the abundance diagram prepared as to the components of limestones in measured stratigraphic section, it is understood that the secquence is formed in medium energy level from top to bottom.

In this environment there have been strong and weak periods. In the strong the quantity of sparicalcite has increased, and terrigenous quartz does not exist. Whereas in the weak period, the quantity of sparicalcite has been equal or nearly equal to the lime mud and sometimes terrigenous quartz exist.

There are no allochemes as intraclast, oölites and pellets. Generally Algae and Foraminifera are sometimes slightly crystallized and rather well preserved fossils. In the sequence, there is abundance of sometimes Corals, Algae, Bryozoa and sometimes Discorbidae. But the corals are not sufficient to form the reef. Planorbulinas sometimes exist and because they are in lithologies as biomicrite and biomicrudite they prove the presence of an inactive water.

The terrigenous quartz particles exist % 1-4 in the stratigraphical height of 0-14.5 m, % 2-12 in the heights of 28, 50-39, 25 m and 47,50 -66 m. There are no quartz particles between stratigraphical heights of 14,5-28,5 m and 39,25-47,50 m.

Out of the measured stratigraphical sections given above, the age of lithologies in the Kesenis Tepe and Güney Tepe in the E are thought to correspond to the lowest levels of the unit. These lithologies are the products of a high energy environment in the bottom and middle levels, and medium energy environment in the upper levels.

From the 90 thin sections from 30 samples obtained from the measured stratigraphic section and other point samples of the lithologies, the following fossils are identified:

Operculina heberti MUNIER-CHALMAS
Operculina cf. heberti MUNIER - CHALMAS
Discocyclina seunesi DOUVILLE
Discocyclina sp.
Valvulina triangularis D'ORBIGNY
Valvulina sp.
Valvulinidae
Assilina sp.
Rotalia sp.
Rotaliidae
Miliola sp.
Biloculina sp.
Triloculina sp.
Quinqueloculina sp.
Discorbidae
Lenticulina sp.
Textularia sp.
Textulariidae
Polfmorphinidae
Ophtalmidiidae
Marsonella sp.
Eorupertia sp.
Idalina sp.
Planorbulina cf. cretacea (MARSSON)
Planorbulina sp.
Lagenidae sp.
Verneuilinidae
Daviesina sp.
Pararotalia sp.
Ranikotalia sp.
Kathina sp.
Miscellanea sp.
Laffitteina sp.
Cuvillerina sp.
Gyroidina sp.
Annelid

Mercan
Faviidae
Bryozoa
Echinid spine
Gastropoda test fragment
Pelecypoda test fragments
Parachetetes asvapatii PIA
Distichoplax biserialis (DIETRICH)
Distichoplax sp.
Laginophora libernica STACHE
Melobesia
Achaeolithothamnium sp.

According to the above given fossils, the age is Lower-Middle Paleocene.

According to WELLS (from MOORE, 1967) the ecological distribution of the coralls, is effected by light, characteristics of the bottom, the depth of the water, its temperature, salt content, cleanliness and circulation, as it is with Algae.

It is known that coralls live in the waters with temperature generally hotter than 18°C, sometimes between 4,5°C and 10°C, salt content of % 27-40 and in generally depths lower than 50 m where there is the possibility of day light entrance. The most abundant development is in depths lower than 20 m. They also develop in environments where the bottom does not contain finely grained sand, silt and mud, where the sedimentation is slow and where there is enough circulation of water to enable to provide abundant zooplankton and oxygen. The most important factor which controls the development of the coralls is the heat and light powers which change with respect to the depth of the water.

JOHNSONN had suggested that the most of the Algae grows only in the mud and some of them prefer the sandy bottom. On the other hand, the coralls are understood to prefer generally environments without the finely grained sandy, silty and muddy bottoms. It is also observed that they live in colonies.

According to MOORE, Discocyclina, Daviesina, Operculina, Discorbidae and Rotalia which are bentonic foraminiferas, live in the Algal facies which signify the shallow waters.

Under the light of above given authors' research, the Yağhane Limestone, which contain the bentonic organisms as well as a small quantity of quartz silts and sands, is formed in a slightly weavy and sometimes inactive sea, which contains abundant Algae providing the connection of sediments and no thick tested microfora minifera, where there is no cross bedding, but on a stable shelf under the wave bottom, not very close to the shore.

In the investigation area and its surrourdings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

W. STCHEPINSKY (1941), F. BAYKAL (1943b), E. ALTINLI (1943), F. BAYKAL (1954), M. TOKAY (1954), A. DİZER (1957), Ş. ABDÜSSELAMOĞLU (1959), M. AKARTUNA (1962 a), E. ALTINLI (1965), O. EROSKAY (1965), M. AKARTUNA (1968), A. DİZER (1968, 1971), A. DİZER - E. MERİÇ (1972), E. ALTINLI - C. YETİŞ (1972), C. DEMİRKOL (1973), E. ALTINLI (1975 a, b)

All of the above given authors have accepted the presence of Paleocene. In our investigation area, the contact Lower-Middle Paleocene with the Upper Cretaceous agrees with the ideas of BAYKAL (1943b, 1954), ALTINLI (1943, 1965, 1975b), AKARTUUNA (1962a), A. DİZER (1968, 1971), A. DİZER - E. MERİÇ (1972); and the contact of Lower-Middle Paleocene with the Upper Paleocene agrees with the ideas of EROSKAY (1965), ALTINLI - YETİŞ (1972), ALTINLI (1975 a, b) for their research in their areas.

UPPER PALEOCENE
AYDOĞDU FORMATION (Ta)

This formation is observed in the SE and S of the investigation area.

Aydoğdu formation which has angular unconformity on Yağhane limestone, covers Orbitoides sp. and sandtone particles with Orbitoides and Globotruncana aged Upper

Cretaceous and Yağhane limestone pebbles which are fossiliferous and aged Lower - Upper Paleocene. This formation is overlied as unconformable by the Neogene aged Yenişehir formation. The sequence which is yellow grey, grey white, pink orange, red, sometimes grey green colored, is formed by alternations of sandstone, calcerous sandstone, clayey biomicrite, polymictic conglomerate, puding, silty clayey biomicrite, quartz arenite, quartz lithic arenite, siltstone, claystone and partially crystallized biomicrite. According to geological cross sections, its thickness is approximately 250 m. The formation is formed generally in a continental environment and is in molasse facies.

The roundness of the pebbles within the puding, the presence of concressions, and the dominant red colored conglomerates, sandstones, claystones and mudstones signify an environment of lake or lagune margin or river. Also, the unprotected macrofossils support the continental environment. Due to the Globorotalia and other fossils determined in marine layers which occur from time to time in between these continental formations, the age of Aydoğdu formation is determined as Upper Paleocene. And this continental environment had been sometimes covered by the sea.

Within the marinal levels of Aydoğdu formation, the below given fossils which are aged Upper Paleocene are identified:

Discorbis sp.
Discorbidae
Lenticulina sp.
Miscellanea sp.
Spiroplectammina sp.
Planorbulina sp.
Rotalia sp.
Globorotalia pseudomenardii BOLLI
Globorotalia cf. angulata (WHITE)
Globigerina cf. triloculinoides PLUMMER
Valvulina sp.
Robulus sp.
Cibicides sp.
Eponides sp.
Gyroidina sp.
Miliolidae
Bryozoa
Echinoidea spine
Echinid plate
Pattalophyllia cf. bilobata (MICH.)
Parachetetes asvapadii PIA
Melobesia sp.
Lithothamnium sp.
Archaeolithothamnium sp
Dasycladaceae

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

S. ERK (1942), E. ALTINLI (1943), F. BAYKAL (1943b), E. ALTINLI (1951), M. TOKAY (1954), Ş. ABDÜSSELAMOĞLU (1959), M. AKARTUNA (1962 a), O. EROSKAY (1965), M. AKARTUNA (1968), A. DİZER (1968, 1971), E. ALTINLI - C. YETİŞ (1972), E. ALTINLI (1975 a, b).

The above mentioned authors have believed in the presence of a unit aged Paleocene. We think that Sparnasian aged unit which was identified by Ş. ABDÜSSELAMOĞLU (1959) and O. EROSKAY (1965) in their investigation area, has a continuation in our area. Taking the facies into consideration, we accept and believe that the lagunar facies identified by ABDÜSSELAMOĞLU (1959) and Lacustr and fluvial facies identified by EROSKAY (1965) are similar to the molass facies in our area, but also accept that as a small difference from these ones, there is the presence of the sea levels in between this unit sometimes.

EOCENE

LOWER EOCENE

DERBENT FORMATION (Td)

The outcrops of this unit are situated in the E, in the villages of Hocaköy and Çamdibi, in the W in Derbent and Beypınar villages and in the areas surrounding these localities.

Derbent formation has angular unconformity on Campanian - Maestrichtian aged Nushetiye formation and Lower-Middle Paleocene aged Yağhane Limestone. In the generalized stratigraphic section, although this formation is shown as having angular unconformity with the Aydodu formation aged Upper Paleocene, there is no direct contact displayed on the map. And it is overlapped by the Neogene aged Yenişehir formation which is unconformable with it. The Derbent formation is cut by Pyroxene andesite.

The total thickness of Derbent formation is approximately 350 m. The formation is composed by the alternation of yellow grey, dark yellow, yellow white colored sandstone, claystone, siltstone and shale. There are volcanic tuffs which rarely contain quartz and generally contain alkali feldspars, plagioclase (albite-andesine) minerals and sometimes volcanic rock particles are asitic and with glassy ground mass, found locally and rarely in between the layers of this formation.

In the microscopic analysis of the thin sections and washed samples of the above mentioned clastic sediments, the following fossils aged Ypresian are identified:

Vaginulina sp.
Nummulites sp.
Asterocyclina sp.
Lenticulina sp.
Globulina sp.
Gryoidina sp.
Eponides sp.
Cibicides sp.
Nodosaria sp.
Lagenidae
Rotalia sp.
Rotaliidae
Robulus sp.
Dentalium sp.
Turritella sp.
Ostracoda
Aequacytheridea cf. perforata (ROEMER)
Aequacytheridea?
Echinocythereis cf. isabenana OERTLI
Echinocythereis sp.
Hermanites paijenborchiana KEIJ
Hermanites sp.
Cytheralla sp.
Crithe sp.
Krithe sp.
Bairdia sp.
Quadracythere sp.
Echinoidea plate
Echinid spine
Lamellibranchiata
Lucina sp.
Cardium sp.
Gastropoda
Plant traces

Within this formation, richly fossiliferous Beypınar silty limestone and Hırsızkaya limestone members at the bottom, and Saracık sandstone member at the top are distinguished.

BEYPINAR SILTY LIMESTONE MEMBER (Tdb)

This unit lies having angular unconformity over the Karadin formation and Nushetiye Formation (Upper Cretaceous). According to the measured stratigraphic sections, the total thickness of the unit is 283 m. The sequence consists of grey, yellowish grey, yellow colored, richly fossiliferous, sometimes having sandy and pebbly limestone levels, and rather monotonous lithologies.

There is abundant Alveolina, Nummulites and Opertorbitolites at the bottom of the sequence. Then going to the top, Discocyclinas and Ranicotalias exist and then levels which have fewer fossils follow, the lithology changes and red-brown color becomes dominant. Over this level, there is a level of abundant fossils and then the sequence ends with few fossils. Within this unit, the following fossils aged Ypresian are identified:

Nummulites planulatus LAMARCK (Aform)
Nummulites globulus LEYMERIE (A ve B form)
Nummulites cf. umbilicata CIZANCOURT
Nummulites sp. (group planulatus)

Nummulites sp. (group irregularis)
Nummulites sp. (group nitidus)
Nummulites sp.
Operculina sp.
Assilina sp.
Opertorbitolites sp.
Orbitolites sp.
Glomalveolina sp. (group primaeva)
Alveolina sp. (group ellipsoidalis)
Alveolina sp. (group subpyrenaica)
Alveolina ellipsoidalis SCHWAGER
Discocyclina seunesi DOUVILLE
Discocyclina sp. (archiaci group)
Discocyclina sp.
Ranikotalia cf. sahnii DAVIES
Ranikotalia sp.
Rotalia sp.
Rotaliidae
Miscellanea sp.
Textularia sp.
Nodosaria sp.
Biloculina sp.
Triloculina sp.
Valvulina sp.
Verneuillinidae
Calcarinidae
Bryozoa
Pelecypoda test fragments

Gastropoda
Dasycladaceae

HIRSIZKAYA LIMESTONE MEMBER (Tdh)

Hırsızkaya Limestone member lies as unconformeble on the Nushetiye Formation (Upper Cretaceous), and does not have any other formation over it. It is cut by Pyroxene andesite. This formation which represents the bottom of Derbent Formation, is dark red colored and has abundant calcite veins. It is observed as white dotted red because of the fossils it contains. According to measured stratigraphic section total thickness is 74 m. The sequence is formed by richly fossiliferous monotonous limestones. According to the microscope analysis, it covers the following lithologies: Algal biomicrite, Biomicrite with alveolina, crystallized fossiliferous micrite.

In this unit, the following fossils are identified:

Orbitolites cf. complanatus LAMARCK
Orbitolites sp.
Opertorbitolites sp.
Alveolina rutimeyeri HOTTINGER

Alveolina sp. (group rutimeyeri)
Alveolina aff. agrigentina SORRENTINO
Alveolina aff. frumentiformis SCHWAGER
Alveolina sp. (group frumentiformis)
Alveolina sp. (group subpyrenacia)
Alveolina sp. (elongated form from the fusiform type)

Lockhartia conditi (NUTTALL)
Rotalia sp.
Rotaliidae
Miliola sp.
Biloculina sp.
Triloculina sp.

Quinqueloculina sp.
Gaudryina sp.
Nummulites sp. (group planulatus)
Nummulites sp.
Amphistegina sp.
Spiroloculina sp.
Linderina sp.
Valvulinidae
Verneuillinidae
Textulariidae
Echinoidea spine fragments
Mollusca test fragments
Pelecypoda test fragments
Dasycladaceae
Algae

Because of too much recrystallization of the rock samples and difficulty of obtaining dimentional sections, characteristic type identifications could not be made, however, according to the fossils obtained, the age of Hırsızkaya member is Ypresian. There is very few fossils at the bottom of the sequence. And these are generally Algae, Nummulites, Alveolinas and few Miliolidae. Going to the top, Alveolina, Nummulites and Miliolidae becomes abundant. Sometimes Alveolinas become the most abundant in between these organisms. Sometimes Alveolina and Nummulites ratio becomes equal with Algae between them occasionally. In the sequence, there is rarely a decrease in the abundant fossils. The size of Alveolina and Nummulites vary all through the sequence. The large or the medium sized organisms can occur together at different levels as well as in the same level.

SARACIK SANDSTONE MEMBER (Tds)

This formation represents the upper levels of the Derbent formation and is in vertical contact with the lower levels of this formation. It does not contain any formations at the top. It is cut by Pyroxene andesite. According to the measured stratigraphic section, the total thickness of the unit is 56.5 m.

The unit is formed by white-yellow, richly micro lossiliferous, carbonate cemented, rather monotonous sandstone which has an abundance of quartz. Also, limestone blocks aged Jurassic having a length of upto 10-15 m and identified as intrasparite and bıcintrasparite are observed.

The following fossils aged Ypresian are determined in the Saracık sandstone member:

Nummulites sp. (group planulatus)
Nummulites sp.
Operculina sp.
Assilina sp.
Opertorbitolites sp.
Orbitolites sp.
Glomalveolina sp.
Alveolina sp. (group subpyrenaica)
Alveolina aff. sicula (STEFAN)
Alveolina sp.
Rotalia sp.
Discocyclina sp.
Textularia sp.
Lockhartia sp.
Ranikotalia sp.
Gaudryina sp.
Echinoidea spine fragment
Pelecypoda test fragment
Gastropoda test fragment

According to the above given fossils the age is Ypresian. The fossils are abundant at the top levels and decrease towards the bottom. At the bottom levels, Nummulites, Discocyclina, plant traces and Alveolina, in the middle levels Assilina, Nummulites, Discocyclina, Alveolina and in the Upper levels Alveolina, Nummulites and Assilina exist and they are listed in abundance order. It is determined that the fossils at the top levels are larger in size in comparison to the lower ones.

The lithologies in the Derbent formation show that the depositional environment is shallow and sometimes deep. Lithologies as sandstone and siltstone are deposited in the places close to the sea shore whereas claystone, shale, silty limestone and limestoneare deposited in the areas away from the sea shore. During deposition clastics whose quantities increase sometimes are carried to the depositional environment and volcanic activities are formed which make up the tuffs. But there is no observation of the pillow lavas. The sandstones of the Derbent Formation and Saracık sandstone member are formed in the shallow places where there is a lot of carriage of the clastics, and the claystone and shale of Derbent formation and Beypınar silty limestone are formed in the deep places. Within the limestone, the carried fragments are generally in the size of the silts, and rarely are in the size of coarse sand or pebbles.

The age of Derbent formation and its members, with respect to the Alveolina, Nummulites and other fossils that the lithologies of the formation cover, is Lower Eocene (Ypresian). It is formed generally in shallow but sometimes in rather deep water near the shore, Beypınar silty limestone member at the bottom being close to shore, Hırsızkaya limestone member being in shallow water away from the shore and Saracık sandstone member at the top being in a very shallow water.

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

K. Von FRITSCH (1882), A. PHILLIPPSON (1918), W. PENCK (1918), S. ERK (1942), F. BAYKAL (1943 a, b), E. ALTINLI (1951), F. BAYKAL (1954), A. DİZER (1956), Ş. ABDÜSSELAMOĞLU (1959), M. AKARTUNA (1962), O. EROSKAY (1965), M. AKARTUNA (1968), A. DİZER (1968), E. ALTINLI (1975a).

Most of the above given authors have believed the presence of Ypresian. The concepts of AKARTUNA (1968) and ALTINLI (1975 a) as a result of their research which is the unconformity of Ypresian with Upper Cretaceous agrees with the results of our investigation. However, because there is no determination of Lutesian in the investigation area, a relation between the Ypresian and Lutesian could not be predicted.

NEOGENE

In the investigation area, Neogene is represented by the Yenişehir Formation at the bottom and the Çamlık Limestone at the top.

MIOCENE?

YENİŞEHİR FORMATION (Ty)

Yenişehir formation is located in the S and SE of the investigation area. It has angular unconformity with the Cretaceous, Paleocene, Eocene aged deposits and Middle-Upper Eocene aged volcanites and has graded contact and conformity with the Çamlık Limestone lying over it. Yenişehir formation is formed by medium, medium - thick bedded, roughly bedded, unbedded, cross bedded, red violet and sometimes yellow white colored blocked conglomerate, blocked sandstone, polygenic conglomerate, gravel, sandstone, mudstone, marl, detritic limestone alternations. According to geological cross sections, its thickness is nearly 750 m. The formation is formed generally in the shallow parts of fresh lake water, the debth of which changes occasionally. The presence of cross bedding with blocks carried by streams and flows shows that these are the channel filling of the marginal facies.

No fossils could be identified to determine the age of the Yenişehir Formation. However, the presence of Eocene aged limestone with Discocylina and Nummulites and volcanite pebbles and blocks belonging to Middle - Upper Eocene, shows that the Formation is younger than Eocene. Moreover, the correlation of some insignificant fossils identified by ourselves in the Çamlık Limestone with the surrounding environment (ALTINLI, 1975 a) shows that there is a possibility of the age of this formation to be older than Upper Miocene.

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the following authors have studied:

E. CHAPUT (1936), V. STCHEPINSKY (1941), M. AKARTUNA (1953), E. ALTINLI (1965), O. EROSKAY (1965), M. AKARTUNA (1968), E. ALTINLI (1975 a).

The above given authors have identified the age of the formations as Neogene. However, our observations agree with the ones of

M. AKARTUNA (1968) and E. ALTINLI (1975 a).

ÇAMLIK LIMESTONE (Tç)

Çamlık limestone is observed typically in Çamlık Tepe, 9 km E of Yenişehir district and is generally white and sometimes yellow-white in color.

Çamlık limestone which has graded contact and conformity on Yenişehir formation, is formed by alternation of detritic limestone and white, yellow white, porous micrite, clayey micrite, and sandy micrite. According to geological cross sections, its maximum thickness is 250 m. Planorbis, Serpula, Ostracoda and Gastrapoda are observed in the unit which generally lacks fossils. It is formed in the middle of a deep lake which is sometimes slightly active but generally inactive. The rock samples which we have obtained from the porous Çamlık limestone are generally expressed with teh term IIFCIO. II expresses the type of texture which is finely grained smaller than 0,05 mm, calcerous and with maximum porosity of % 15 (According to V. CHILLINGER, W. MANNON, H. RIEKE, 1972). F shows that the size of the grains are 0,0625-0,125 mm, and C gives the size of the pores as 0,1-1 mm and finally 10 gives the % ratio of the pores to the total volume of the rock (According to ARCHIE, from the works of the above given authors.)

The structure of the pore space is sometimes Tip I (type with wide and narrowchannel) and sometimes Tip VI (Composite type with pores and fissures). (According to TEODOROWICH, from the works of the above given authors).

In the investigation area and its surroundings on this formation or on the units which are thought to be continuing this formation, the following authors have studied:

V. STCHEPINSKY (1941), O. EROSKAY (1965), M. AKARTUNA (1968), E. ALTINLI (1975 a).

It is observed that from the above given authors the concepts and ideas of M. AKARTUNA (1968) and E. ALTINLI (1975 a) agree with the conditions in our investigation area.

QUATERNARY

Quaternary is identified by İznik Formation (Pleistocene?), travertine, alluvium, terrace and slope waste (Holocene).

PLEİSTOCENE?

İZNİK FORMATION (Qi)

This formation is represented by beddings which have dipping towards the lake and is located in the S and SE of the İznik lake, on the margin of the İznik lake in the investigation area.

İznik formation (Pleistocene?) is transgressive overlying the pyroxene andesite. Although it is displayed as having angular unconformity on the generalized stratigraphic section, this formation and Neogene aged Çamlık Limestone, do not have a direct contact on the map. Over this formation, there is alluvium having angular unconformity. The unit, which is formed by lithologies as conglomerate, pebbly sandstone, and sandstone, formed in a shallow lake bigger than İznik lake, has a thickness of 15-20 m. This unit is formed in the Pleistocene aged lake probably after the faults formed in the Wallachian phase of the Alpine orogenesis. E. CHAPUT (1936), had suggested that the İznik lake was formed by the vertical tectonic movements and identified that the marls and the sands which are slightly dipping to the lake, at the 30-40 m higher level than the present one, are formed in a larger lake than the İznik lake, which is probably Quaternary aged, between Orhangazi-Gedelek.

HOLOCENE

TRAVERTINE (Qt) is generally formed by waters with Ca $(HCO_3)_2$ coming out of fissures of carbonate rocks leaving $CaCO_3$.

ALLUVIUM (Qal) are observed through the rivers. The most important of them are in İznik and Yenişehir planes.

TERRACE (Qta) is observed generally in several heights in Neogene areas.

SLOPE WASTE (Qy) is formed by rock

fractures which come down from the hills where the physical alteration is dominant.

MAGMATIC ROCKS

In this region, there are volcanic and dyke rocks, forming the magmatic rocks.

VOLCANIC ROCKS

In the investigation area, there are pyroxene andesite, and basaltic andesite and dacite which cut the pyroxene andesite. Because there is no contact identified between the last two, it is impossible to say whichever is younger.

PYROXENE ANDESITE (α)

The pyroxene andesite is the most common one within the above given magmatic rocks. The unit lies in the E-W direction of the S of İznik Lake, narrowing from W to E and ends at 1 km W of Kaynarca Village .It is believed that the augite andesites which are located in the NW and W of Mekece outside of the E of our investigation area (AKARTUNA, 1968), is a continuation of the ones in our area. At the contacts of pyroxene andesite, the very narrow skarns and hornfels are formed which could not be plotted on the 1/25.000 scaled geological map, in relation to the neighbor rock composition.

Because pyroxene andesite cuts the Lower Eocene aged formations, it is younger than Lower Eocene, and because its blocks, pebbles and sands are found in Neogene aged Yenişehir formation, it is older than Neogene. With reference to the investigations (AKARTUNA 1968) made on the augite andesite, W of Dırazali Village in the investigation area, pyroxene andesite at the Naldöken Dağı on Armutlu Peninsula close to our area, and the rocks resembling pyroxene andesite in locations as N of Mekece, S of Çınarcık, S of Bahçecik District, Ayvaşa Mt. and pyroxene andesite is thought to have formed in the period of MIDDLE-UPPER EOCENE.

The rock, the outside surface of which has a color range from yellow white to red yellow due to the decomposition rate, and the inside has a color greygreen-dark green, sometimes violet, is medium, fine and rarely coarse grained, hard and breakable, jointed, irregular broken, red and white colored thin opal and quartz veined and has spherical decomposition. It has a porphyritic texture made of a groundmass formed by plagioclase microlites mostly and of glass which has irregularly distributed plagioclase and pyroxene phenocrystals. According to the microscope analysis, there are also minerals as sphene (titanite) and opaque. Referring to the analysis of the thin sections, the following were identified:

Plagioclase

It consists of phenocrystal and microlites in the form of bars. The prismatic phenocrystals several mm long are in the composition of andesine and the microlites which form the groundmass are in oligoclase-andesine composition. They are generally idiomorphic, normal zoned, albitpericlined, polysynthetic twinned, and have their extinction angles between 19°-23°, indices of refraction larger than Canada Balsam and optically positive. They have undergone cataclazm and strong deformations, under the tectonic effects. The mineral is caolinized due to decomposition through cleavages and fissures. Where the decomposition is strong, the calcite formed as secondary replaced the plagioclase.

Pyroxene

This mineral is formed by the fine grains with in the groundmass components and the idiomorphic phenocrystals in the shape of prisms of several mm of size. According to the optical features it has augite composition, has yellow color, well developped cleavage and lamellae twins. The decomposition is generally in the form of chlorite.

Sphene (Titanite)

Generally the crystals are in the shape of rhombic, idiomorphic, cleavaged (100) and lamellae twinned. Because of decomposition the surroundings of the crystal becomes opaque.

Opaque minerals

These are formed by inclusions in the pyroxenes and distributed, rare small magnetite crystals in the ground mass. These are generally in the from of idiomorphic crystals with the corners partially corroded. There are also pyrite crystals with epigenetical formations. At the result of decomposition, most of the opaque minerals take the form of iron-oxyhydroxites.

Groundmass

It varies from cryptocrystallines to glass. It is formed by mainly oligoclase microlites, small augite crystals, and glass. The fact that the indices of refraction is close to Canada Balsam, shows that the groundmass is formed from a nearly neutral magma. The groundmass is generally glassy at the edges of the mass of pyroxene andesite. And due to this reason, these rocks can be called hyaloandesite. The following results are obtained after the field research and microscope analysis:

There is a difference between the side zones and the common mass of pyroxene andesite. This difference is observed in the groundmass, phenocrystals and the full texture of the rock. In the common parts, the groundmass is cryptocrystalline with large phenocrystals and partially of current structure. In the side zones it is glassy, in the form of small phenocrystals and has a breccia texture and in tuff appearance. At the edge zones, there are older sandstone and limestone blocks as inclusions that the lavas could not destroy completely. At the contacts of pyroxene andesite with sandstones, opal is formed and at the contacts of limestones, amethyst, chessylite and malachite are formed. Near the fractures, the features of the rock changed due to effects of hydrothermal solutions. As a result, the feldspars are caolinized, pyroxenes are chloritized and opaque minerals are hydratized. Some materials within the hydrothermal solutions have accumulated in this zone and as a result of this chalcopyrite, pyrite, galena and little zincblende is formed.

In the investigation area and its surroundings on this formation, or on the units which are thought to be continuing this formation, the chronological order of the authors who have studied are as follows:

K. von FRITSCH (1882), W. PENCK (1918), E. CHAPUT (1936), V. STCHEPINSKY (1941), S. ERK (1942), E. ALTINLI (1943), A. ARDEL (1949), Ş. ABDÜSSELAMOĞLU (1959), E. ALTINLI (1965), M. AKARTUNA (1968), E. ALTINLI (1975a).

The pyroxene andesite is within the age limits that E. ALTINLI (1943), A. ARDEL (1949), Ş. ABDÜSSELAMOĞLU (1959), have identified. However, authors as E. CHAPUT (1936), S. ERK (1942), and M. AKARTUNA (1968) have explained that they are formed in Eocene. According to this, the last three authors' concepts agree with our investigation area.

As a result of the data from our investigation area, it can be predicted that, pyroxene andesite is younger than Lower Eocene due to the fact that it cuts Lower Eocene aged formation, and older than Neogene due to its block, pebble and sandcontent in the Neogene aged formations. Referring to AKARTUNA (1938) who predicted that volcanic rocks sometimes contain fossiliferous limestone lenses, and is placed sometimes in between continuous beds and sometimes over them, we may predict that the age of the volcanic rocks can be Middle-Upper Eocene.

BASALTIC ANDESITE (β)

In the investigation area, these are seen as small and independent. They are in the form of a dyke which come out of the fractures of pyroxene andesite. The rock is black colored, compact, hard and breakable, jointed and irregular broken. Because it cuts the pyroxene andesite, it is younger than it.

These andesites represent a product of transitional phase because they contain abundant basic plagioclase (labradorite) and resemble basalt macroscopically. This is why they are called basaltic andesite. With respect to the microscopic analysis, the rock has hyalopilitic texture, has partially glassy matrix and plagioclase and augite phenocrystals in it.

Plagioclase

It shows various compositions. The phenocrystals are in the composition of labradorite and zone structured andesine. Around these, there is an albite frame surrounding due to sodium metasomatose formed after the crystallization. The feldspar of the groundmass is a composition of andesine-oligoclase. Although the phenocrystals are idiomorphic, the plagioclase of the groundmass are formed by sometimes thin, needle shaped microlites, and sometimes very small sized Xenomorphic crystals which is in graded contact with the groundmass. It is ordinary to observe albite and pericline type polysynthetic twinning in all plagioclase. In some of the feldspars, poiklitic texture formed by plagioclase-pyroxene assemblages, is observed. As a result of the decomposition of the plagioclase, caolinization and slight sericitization is observed.

Pyroxene

They are light green colored, idiomorphic, short prysmatic formed.Pheir most important features are two directioned perpendicular cleavages, lamellae twinning, (—) optical character, and extinction angle of 44°. Besides the monoclinic pyroxenes, there are the orthorhombic pyroxenes which are totally chloritized, but they could not be identified.

Groundmass

They are formed by generally light basic glass and cryptocrystalline plagioclase and finely grained opaque minerals in smaller quantities.

In the investigation area and its surroundings on this formation, or on the units which are thought to be continuing this formation the following authors have studied:

E. ALTINLI (1943), Ş. ABDÜSSELAMOĞLU (1959), E. ALTINLI (1965, 1975a).

As a result, it can be concluded that because the basaltic andesite cuts the pyroxene andesite aged Middle-Upper Eocene, it is accepted to be younger than Middle-Upper Eocene, and because its blocks, pebbles and sands are in Neogene aged Yenişehir formation, it is older than the Neogene.

The age and formation of basaltic andesite in our investigation area, is similar to the investigation area of Ş. ABDÜSSELAMOĞLU (1959).

DACITE (D)

Dacite is seen as veins cutting the pyroxene andesite, its outcrops are small and independent. It lies generally in E-W and sometimes in N-S direction. It is thought to have formed in the pyroxene andesite after the extinguishment of the lavas from small fractures. The rock which is grey, grey white and brownish yellow, includes feldspars seen macroscopically, has fractures and joints and is composed of plagioclase, quartz phenocrysts and a groundmass generally made of glass or crypto-microcrystalline, and has a porphyritic texture. It is characteristic that it contains no mafic minerals except opaque minerals. The edge zones have a brecchic texture, generally become cataclized due to tentonic effects, and sometimes caolinized due to decomposition. As a result of the microscopic analysis, the below given minerals are observed:

Plagioclase

It is in the form of microlites which are located in the groundmass composition and phenocrystals of several mm large. The phenocrystals are corroded at the corners, Carlsbad and albite and pericline type twinning, and have normal or oscillation zones. Especially, the core part of the crystals are labradorite, and have andesine-oligoclase towards outside, and is surrounded by pertite on the outside. The plagioclase microlites are more sodic in comparison to the phenocrystals in the groundmass. Some of the phenocrystals seem like a sponge due to the gas it contains, and in some others, apatite inclusions can be observed. The decomposition of the plagioclase is as caolinization and sericitization.

Quartz

It covers more than 10 % of the volume of the rock, and is formed by idiomorphic phenocrykstals bordered by pyramid surfaces and micro and cryptocrystals which are the components of the groundmass. The phenocrystals are generally undergone corrosion and irregular development and the cavities of corrosion are filled with the groundmass. Due to corrosion, some of the quartz becomes round in shape. Especially the minerals taken from locations close to fracture zones, it is distinguished that the mineral has undergone cataclasms due to tectonic effects and undulatory extinction.

Subsidiary minerals

These are apatite, zircon and opaque. Apatite has bar like crystals in the form of bars. Zircon has generally undergone corrosion, has high double refraction, relieved, and is finely grained. Opaque minerals are formed by very small magnetite and pyrite and are few in quantity. Hydration is observed in most of them due to alteration. Within the dacite, chalcedony and calcite are observed besides these subsidiary minerals.

Groundmass

The groundmass which is made of glass and crystals, are generally felsic, and are formed by sodic plagioclase, quartz and doubtedly ortoclase. It is acitic because the refraction indices of glass is smaller than the Canada Balsam. The ratio of the phenocrystals to the groundmass is not more than 1/4 in volume in the samples which contain glass.

Due to the effects of the hydrothermal solution circulations at the fractures and locations near the fractures, the feldspars are caolinized, the silisified parts are developped and pyrite, galenite and zinc blende are formed.

The age of Dacite in our investigation area is believed to be within the periods of post Cretaceous and Pre-Neogene as E. ALTINLI (1954) have distinguished. E. CHAPUT (1936) had predicted the age of dacite as Eocene. As a result, it can be concluded that the age of dacite in our investigation area is younger than Middle-Upper Eocene and older than Neogene.

DYKE ROCKS

In the investigation area, Lamprophyre is observed as a dyke rock, its age being younger than Upper Permian.

LAMPROPHYRE (L)

Lamprophyre, which gives independent outcrop at S of Sarısu Dere in the S of Nushetiye village, cuts only the Sarmaşık Formation aged Lower-Upper Permian. It can be predicted that it is younger than the Upper Permian. The rock, being grey, and dark greenish grey, is medium-fine grained and is formed by plagioclase and mafic minerals. Because of too much alteration, the feldspars are caolinized and the dark colored minerals are totally chloritized. Because of this reason, the detailed nomenclature could not be obtained.

M. AKARTUNA (1968) determined the presence of albite diabase spessartite close to Çerkeşler Village outside of the E border of our investigation area, and olivined augite spessartite in Lower and Upper Kocadere and Katırlı Villages in the W of Çınarcık, and explained the total volcanic rock complex as being over, under and in between the Paleocene-Eocene formations. As a result, although we can identify the Lamprophyre in our area to be younger than Permian for it only cuts the Upper Permian, we can think that as basaltic andesite and dacite, it is formed after Middle-Upper Eocene and before Neogene.

PYROMETAMORPHIC ROCKS

They are formed as xenolith fragments within the volcanic rocks, at contacts of volcanic rocks with sedimentary rocks, at the contacts of small intrusions due to high temperature recrystallization. Because it gives outcrops rarely, it could not be plotted on the map. These rocks have a formation between sedimentaries and metamorphites, on them partial melting traces can be observed and they are formed during transition to metamorphism. In our area, these rocks do not give a distinctive structure, are called Buchite and are formed by partial melting of shale and sandstone.

STRUCTURAL GEOLOGY

In the investigation area, several orogenic movements had been effective. These orogenic movements which formed the folds, faults, land slides, joints and foliations can be analised under three sections:

A — PRE-HERCYNIAN MOVEMENTS,

B — HERCYNIAN MOVEMENTS,

C — ALPINE MOVEMENTS.

By means of the Rose and Contour Diagrams which are prepared in relation with dips and the strikes of the folded beds and joints and foliations, and the Stereograms which are obtained from the Contour diagrams, the dominant strikes and dips and the dominant side pressures which form them are identified in detail, and their effects on the trends of the tectonic evolution of the investigation area is comprehended.

A — PRE-HERCYNIAN MOVEMENTS PRE-PERMIAN

Metamorphic rocks, which represent the oldest basement of our investigation area, is divided into two formations: Dereköy Metamorphites at the bottom and the İznik Marble at the top. These are conformable and have graded contact with each other. These formations had taken their present forms due to several orogenic movements. Generally, the large structures are effected by the latest Alpine movements and suitable to the trend of this orogenesis. There is the fossiliferous sandstones of Lower-Upper Permian aged Sarmaşık formation which lies unconformable over the Metomorphic rocks.

Referring to the field observations, it is understood that the metamorphic rocks have undergone several plastic deformations. There was not a trace of a relation between these deformation phases and the foldings. The metamorphites which were effected by the deformation phases have primary and secondary foliations.

There are several foliations showing different strikes and dips in Dereköy metamorphites and İznik marble with the effect of Pre-Hercynian movements. According to the rose diagram, the avarage dominant strike and dip of 117 foliations are N60E and average dip is 51° in N30W(NW) direction and 49°,5 in S30E(SE) direction. The side pressures that form these are equally effective from N30W-S30E. According to the contour diagram, the average strikes and dips are N55E 53NW, N52E, 52SE. The side pressures which form them are equally effective from N38W(NW) and S35E (SE) directions. The axes of the anticline and synclines are 4 km N60E, 4 km N80E, 2 km N70E from E to W, and the side pressures are developped from N30W-S30E, NIOW-S10E and N20W-S20E.

B — HERCYNIAN MOVEMENTS PERMIAN

Sarmaşık formation (Lower-Upper Permian) and Yenişerefiye limestone (Upper Permian) layers have several strikes and dips due to Hercynian movements and especially Palatinian orogenic phase. According to the rose diagrams of 168 beddings, the dominant limit strike is N70-80E and their average dips are 44°,6 in N10-20W(NW) and 45°,7 in S10-20E(SE) direction. The side pressures are developped equally from N10-20W(NW) and S10-20E(SE). According to the contour diagram, the dominant average strikes and dips are N78E 47 SE and N79E 45 NW. The side pressures has effected nearly in equal strength, same direction from N12 W and S11E directions, however have developped a little bit stronger from N12W. The axes of anticlines and synclines are from E to W, 2 km N60E, 8 km N80-90E, 2 km N80E, 5 km N60-70E, 8 km N75-85E, 2 km N70E and the side pressures are from N30W-S30E, (NO-10W) - (SO-10E), N10W-S10E, (N20-30W) - (S20-30E), (N5-15W) - (S5-15E), N20W-S20E.

C — ALPINE MOVEMENTS

The investigation area, in the period starting from the end of Paleozoic upto the present time, had been under the effect of the several phases of the Alpine orogenesis and took its present structure and morphology. The effects of the Alpine orogenesis on the several beddings will be analised in detail:

MIDDLE-UPPER JURASSIC

Yardankaya limestone (Middle-Upper Jurassic) layers have several strikes and dips due to Vorgosau (Austrian) Orogenic phase of the Alpine movements. According to the rose diagrams of 144 beddings, the average dips related to dominant limit strikes of N70-80E are 34°,3 in N10-20W(NW), 35°,3 in S10-20E(SE); the average dip related to N80-90W are 38° in NO-10E(NE) direction, and 36°,9 in SO-10W (SW). The side pressures which make up the N70-80E limit strikes are from N10-20W(NW) and S10-20E(SE), the ones from S10-20E(SE) being more effective; the side pressures which form N30-90W limit strikes are from NO-10E(NE) and SO-10W (SW), the ones from NO-10E(NE) being more effective. According to the contour diagram, the dominant average strikes and dips are N78E 28NW and N82W 36SW. The side pressures are from S12E and N8E, ones from S12 W being more effective. The axes of the anticlines and synclines are 9 km N85-90E, 2 km N70E in E to W direction and the side pressures are (NO-5W) - (SO-5E), N20W-S20E.

In Yardankaya limestone (Middle-Upper Jurassic), there are joint sets due to the effects of Vorgosau or the other orogenic phases following it. According to the rose diagram (Fig. 6) prepared by 80 joint strikes and dips, the ones having limit strike of NO-10E are Dip or Transversal joints according to Geometric classification; and Extention joints according to Genetic classification. The ones having the limit-strike as N80-90W are Strike or Longitudinal joints according to Geometric classification and Release joints according to Genetic classification. The ones with limit strikes of N20-30E and N40-50W and N50-60W are Diagonal or Oblique joints according to Geometric classification and Shear joints according to Genetic classification. There is an approximate 60° difference between the last two joints and N20-30E. The compressive forces which make up the three joint sets are effective from (N0-10E) - (N0-10W) and (S0-10W) - (S0-10E).

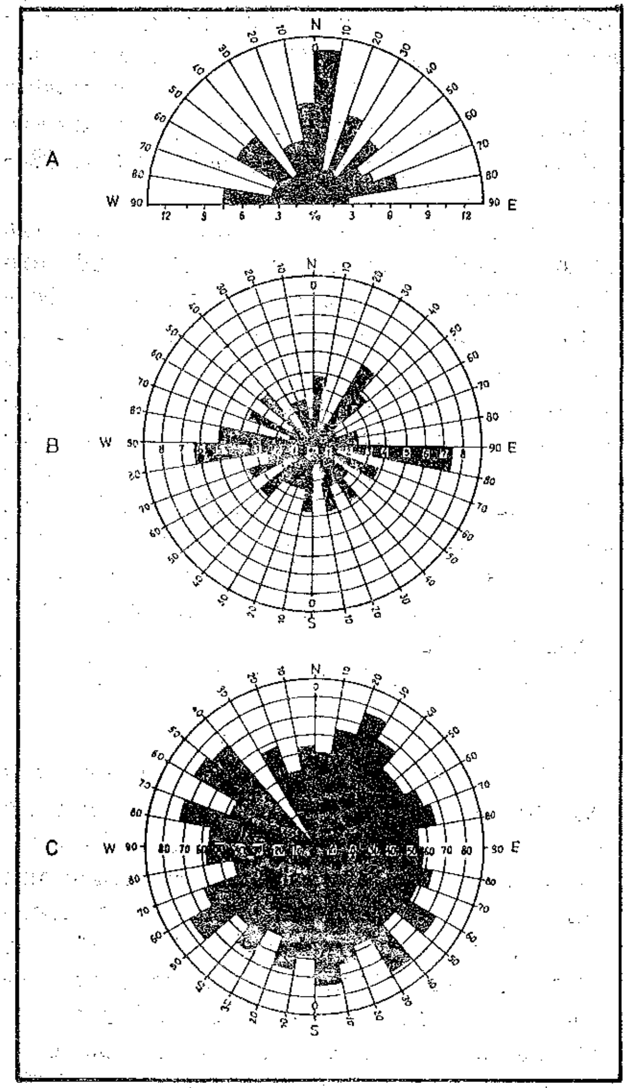
From the contour diagram (Fig. 7), the limit strikes which are from N10W-N5E are Dip or Transversal joints according to Geometric classification and Extension joints according to Genetic classification. The ones which are from N50-81W are Strike or Longitudinal Joints according to Geometric classification and Release Joints according to Genetic classification. The ones from N45-51E and N39-53W are Diagonal or Oblique joints according to geometric classification and Shear joints according to Genetic classification. The compressive forces forming the three joint sets are effective from (N10W-N5E) and (S10 E-S5W).

The dominant average strikes and dips attained from the contour diagram which are N-S 46W, N-S 57E are Dip or Transversal joints according to Geometric classification and Extension joints according to Genetic classification. The ones which are N67W 58SW are Strike or Longitudinal joints according to Geometric classification and Release joints according to Genetic classification. The ones which are N48E 89NW, N48E 89SE and N48W 55NE are Diagonal or Oblique joints according to Geometric classification and Shear joints according to Genetic classification (Fig. 8): The compressive forces making up the three joint sets are effectiv efrom N and S.

They are formed either simultaneously with folding with the compressive forces at the same strike, or after folding again with the effective forces at the same strike.

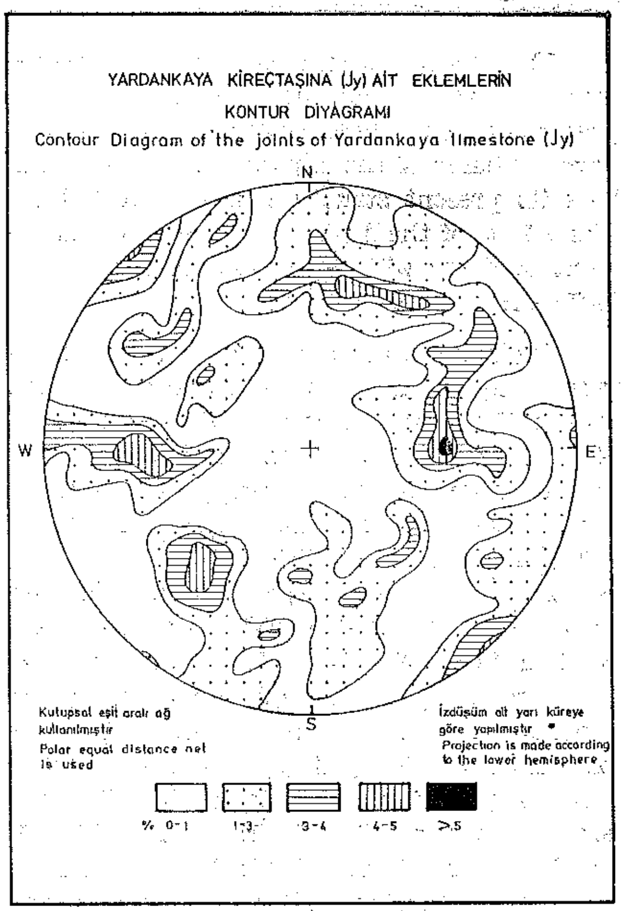
UPPER CRETACEOUS and LOWER-MIDDLE PALEOCENE

Karadin and Nushetiye formations (Upper Cretaceous) and Yağhane limestone (Lower-Middle Paleocene) beds have several strikes and dips due to the Osmaneli orogenic phase. According to the rose diagram of 530



Şekil. 6- Yardankaya kireçtaşına (Jy) ait eklemlerin Gül Diyagramı. A. Doğrultu Diyagramı. B. ve C. Eğim Diyagramı (B. Eğim yönü-Yüzde Diyagramı, C. Eğim yönü-Ortalama eğim Diyagramı).

Figure. 6 - Rose Diagram of the joints of Yardankaya limestone (Jy) A. Strike, B and C. Dip Diagrams (B. Dip direction - % Diagram, C. Dip direction - Average dip Diagram).



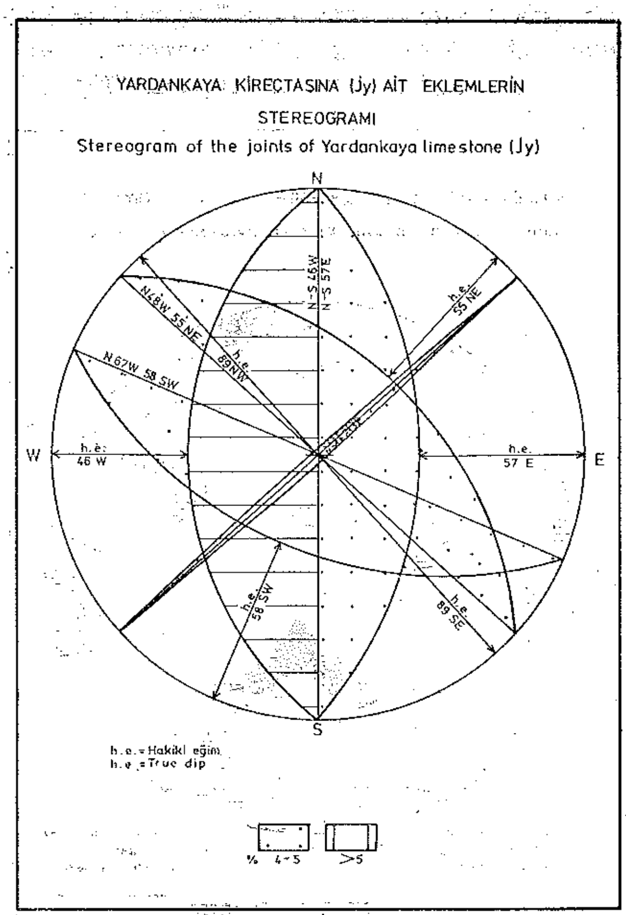
ŞEKİL - 7
Figure - 7

beddings, the dominant limit strike is N70-80E, and the average dips are 50° in N10-20W (NW) 48°,5 in S10-20E(SE) direction and the side pressures are nearly equally developped in N10-20W(NW) and S10-20E(SE), the ones from N10-20W(NW) being more effective. According to the contour diagram, the dominant average strikes and dips are N79E 58SE and N72E 48NW. The side pressures are equal from N11W(NW) and S18E(SE), the ones from N11W(NW) being more effective.

The direction of the fold axis from E to W formed in these units are 1 km N60E, 2 km N80E, 3 km N60E, 3 km N70E, in N of İznik fault; 1,5 km N60E, 7 km N80-90E, 1,5 km N70E, 2 km N30-50E, 12 km N60-80E, 1,5 km N40E in between İznik fault and Tınazkaya fault; 2 km N80-90W, 6 km N70-80E, 3 km N60-70E, 5 km N80-90E, 2 km N80-90W, 4 km N80-90E, 6 km N70-80E in S of Derbent fault.

UPPER PALEOCENE

The beds belonging to Upper Paleocene aged Aydoğdu Formation have strikes and dips due to İznik? orogenic phase. According to the rose diagram prepared by 23 bedding strikes and dips, the average dip of the N70-80E dominant limit strikes is 42°,4 in N10-20E(SE). The side pressures are through N10-20W(NW). According to the contour diagram, dominant average strikes and dips are N77E 28SE, N53W 30 NE and N82W 35NE. The strongest of the side pressures is from N13W (NW). The other pressures are from N37W (NW) and S8W(SW). The most important folding is an asymmetrical syncline without any plunge, and is in N80E direction. The side



ŞEKİL-8
Figure-8

pressures forming it are from N10W(NW) and S10E(SE).

LOWER EOCENE

The beds of Lower Eocene aged Derbent formation have their strikes and dips formed by Anatolian orogenic phase. According to rose diagram prepared by 30 strikes and dips, the average dips of dominant limit strikes of N70-80W are 37°,5 in N10-20E(NE) and 45° in S10-20W(SW). The average dips of dominant limit strikes of N30-40E are 17° in N50-60W pressures forming the N70-80W dominant li- (NW), 38° in S50-60E(SE) direction. The side mit strike have developped from N10-20E(NE) and S10-20W(SW) and the ones from S10-20W(SW) being more effective. The side pressures forming the N30-40E dominant limit strike are from N50-60W(NW) and S50-60E (SE), the ones from N50-60W (NW) being more effective. According to the contour diagram, the dominant average strikes and dips are N30E 30SE, N78W 28NE. The side pressures are from N60W(NW) and S12W(SW). The axis of the Derbent syncline from E to W, identified in Lower Eocene as important, has strike of 0,5 km in N70E, 1 km in N75W and 0,5 km in N70E. The side pressures for the fold axis are from N20W-S20E, N15E-S15W and N20W-S20E.

NEOGENE

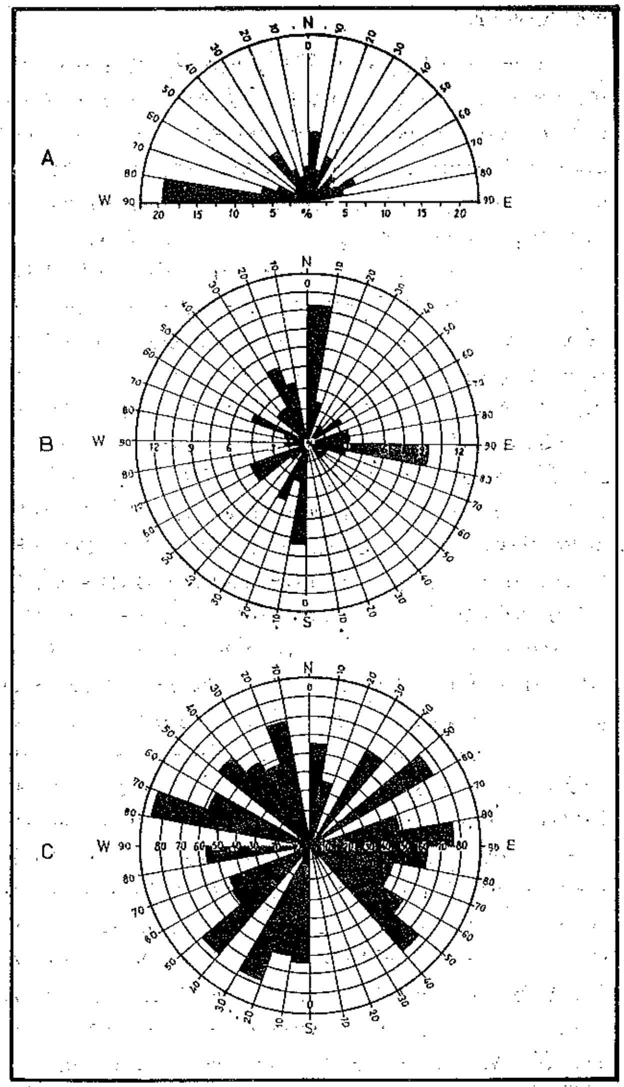
The beddings of Neogene aged Yenişehir formation and Çamlık limestone have several strikes and dips effected by Attican? or most possibly Wallachian orogenic phase. According to the rose diagram prepared by 28 strikes and dips, the average dips of N60-70W dominant limit strikes are 49° in N20-30E(NE), 14°,4 in S20-30W(SW); average strikes of N80-90W dominant limit strikes are 17° in N0-10E(NE) and 19° in S0-10W(SW). The dips of N60E dominant average strikes are 24° in N30W(NW) and 27° in S30E(SE). The side pressures which form N60-70W dominant limit strike are from N20-30E(NE) and S20-30W(SW) and the ones from N20-30E(NE) being more effective. The side pressures which form N80-90W dominant limit strike are from N0-10E(NE) and S0-10W(SW), the ones from N0-10E(NE) being more effective. The side pressure which form N60E dominant average limit strike is from N30W (NW) and S30E (SE), the ones from S30E(SE) being more effective. The anticlines and synclines which are formed in Neogene beds are 3-4 km N65E, 1 km E-W, 7-8 km N80W, 1 km E-W and 1 km N65W directions from E to W. The side pressures are from N25W-S25E, N-S, N10E-S10W, N25E-S25W. According to the contour diagram, the dominant average strike and dips are N68W 12SW, N88W 30NE, and N55E 25 NW. The side pressures are from N22E(NE) S2W(SW) and S35E(SE).

QUATERNARY (PLEISTOCENE)

The beds of Pleistocene aged İznik formation have gained a slight dip effected by the Post-Tyrrhenian movements (Pasadenian orogenic phase).

MIDDLE-UPPER EOCENE
VOLCANIC ROCKS

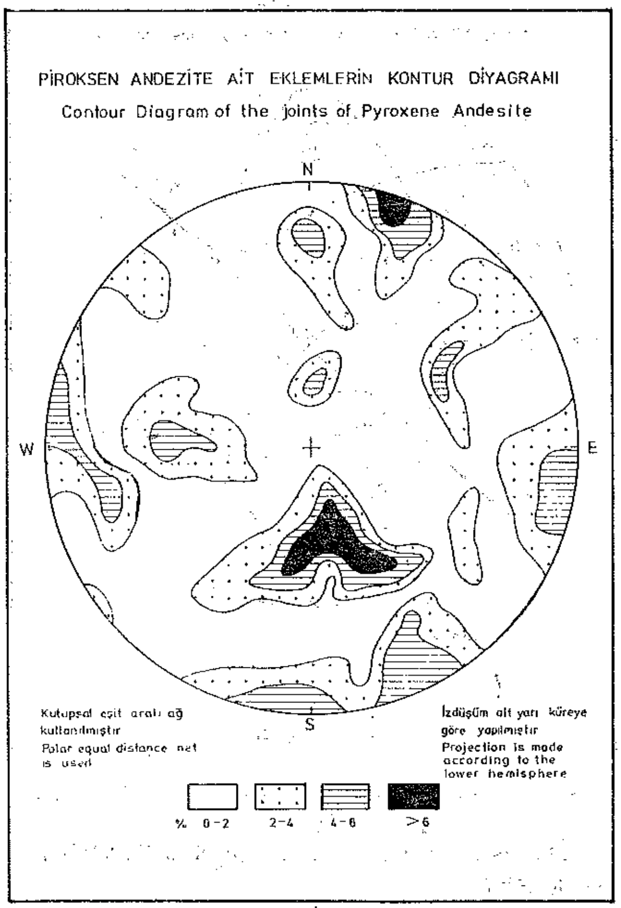
In the Middle-Upper Eocene volcanites, there are joint sets in several strike and dips formed by Anatolian orogenic phase or the other orogenic phases following it. Rose and Contour diagrams are prepared in relation to 60 joint strikes and dips. From the rose diagram (Fig. 9), the limit strikes of N80-90W be-



Şekil. 9 - Piroksen andezite ait eklemlerin Gül Diyagramı. A. Doğrultu Diyagramı. B. ve C. Eğim Diyagramı (B. Eğim yönü_Yüzde Diyagramı, C. Eğim yönü_Ortalama eğim Diyagramı).

Figure. 9 - Rose Diagram of the joints of Pyroxene andesite. A. Strike, B. and C. Dip. diagrams. (B. Dip direction - % Diagram, C. Dip direction - Avarage dip Diagram.).

ing parallel or nearly parallel to the position of the volcanic mass, are Longitudinal joints according to the geometric classification; the ones of N0-10E, being perpendicular or nearly perpendicular to the position of the volcanic mass are Transversal joints; and the ones of N30-40W, N20-30E and N60-70E, unfitting the position of the mass are Diagonal or Oblique joints. According to the geometric classification from the contour diagram (Fig. 10),

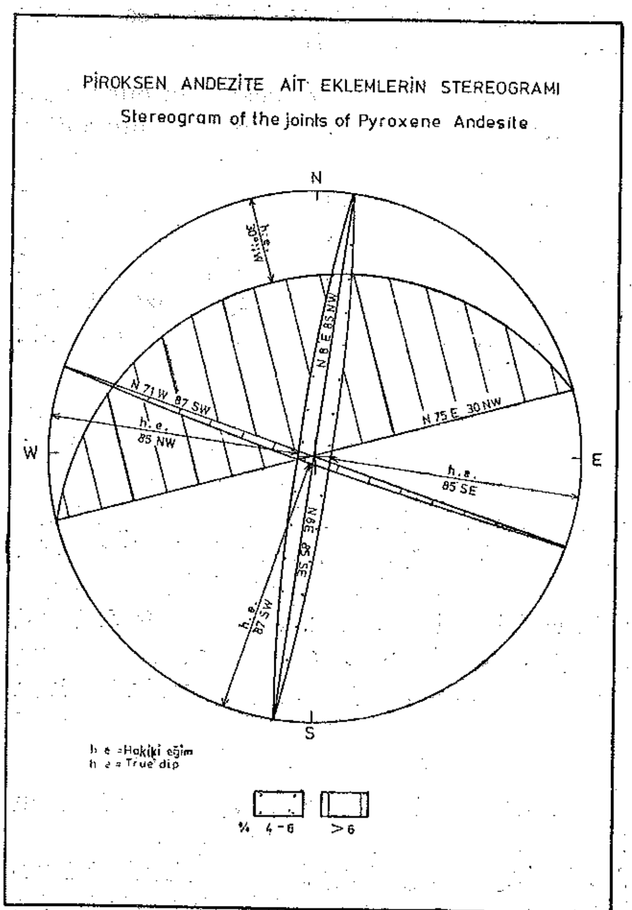


ŞEKİL-10
Figure-10

the dominant average strike and dips of N71W 87SW are longitudinal joints; N8E 85NW and N8E 85SE are Transversal joints, and N75E 30NW are Diagonal joints, or Oblique joints (Fig. 11).

FAULTS

The investigation area, which had been effected by various orogenesis had the role of the faults on the present morphology. These are vertical slip, dip slip (normal, reverse) and strike slip faults. Some of them continue for long distances. The most important ones are generally in the E-W direction, the ones in N-S direction are of secondary importance. In the classification according to fault axis and strike of the bed, the ones in E-W direction are Longitudinal and the ones in N-S direction are transversal faults. AKARTUNA



ŞEKİL- 11
Figure- 11

(1968) explained that the formation of the faults in the area are by the effect of Alpine movements, Post Pliocene and especially by the Wallachian orogenic phase and continued to be active with the post - Tyrrhenian movements. There are proofs for this concept in the investigation area. One of them is the Pleistocene conglomerate, sandstone and pebbly sandstone (İznik Formation) beddings which have a strike of 6°-7° with the latest movements.

The most important fault and fault zones of the area as follows:

İZNİK FAULT : This is the most important fault which effected the formation of the İznik Lake. It is 29 km long and lies outside of the area in the E and W. AKARTUNA (1968) distinguished that the faults becomes 77 km long between Mekece train station and guif of Gemlik and is vertical. Referring to our research, the fault is identified to have generally N70E and sometimes N80E strike, generally vertical or close to vertical dip, and with a slip close to 75-100 m. This fault which is identified as a strike slip (right handed) fault is a continuation of the North Anatolian transform fault.

DERBENT FAULT: It is 14 km long, and the first part 10 km long is a reverse fault, and the 4km long second part is a vertical fault, from W to E. In the vertical part from W to E, the N block in the first 2 km portion went down and the portion in the S block went upwards. At the next 2 km portion the N block went upwards and S block went down. This is rotational movements. At the reverse fault featured portions of the Derbent fault, the fault plane has 65°-70° N dips and the hanging wall moved from N to S. The net slip could not be identified. The fault plane can be seen clearly where it is vertical. Where the fault is reverse, the beddings of the Upper cretaceous formations subduct under the Permian beds. Milonitized zones and recrystallization are observed at the Permian and Jurassic limestones through the fault plane.

TINAZKAYA FAULT: It is nearly 9 km long, has a dip of 35°-40° S and is reverse. It has formed after the Upper Paleocene, and although the fault plane can not be observed clearly, through this plane, the Upper Cretaceous and Upper Paleocene beds subduct under the Middle-Upper Jurassic beds. Milonitization and recrystallization are observed in the Jurassic limestones through the fault. The hanging wall at the S of the fault plane, has moved from S to N. It is impossible to predict net slip. The hanging wall makes up the high portions of the region.

AKÇAPINAR FAULT: It is a vertical fault which cuts the reverse Tınazkaya Fault and is 3,5-4 km long. The fault plane can be seen sometimes through this fault which is formed in the Jurassic limestone. Sometimes milonitized portions are observed. The net slip value is approximately 100 m.

ARAPUÇTU FAULT: It is a vertical fault with length about 3 km. This fault, which was formed between the sanstones of Permian aged Sarmaşık Formation at the N block and the Middle-Upper Jurassic aged Yardankaya limestone at the S block, can be observed clearly in the area.

There are two more faults at the S of Arapuçtu fault, approximately 1,5 km long and unite with each other after 1 km. These are normal faults. The dip of the fault planes are opproximately 80°-85° S and the net slip is 30-40 m. There is another fault at the NE of İznik district which is 2 km long and vertical. The fault, which is formed in between the marbles at the N block and the Dereköy metamorphites at the S block, has a net slip of 125-150 m. There has been milonitization at the sides of the fault planes of the above mentioned faults.

In the investigation area and its surroundings, the following authors have researched on the İznik fault: C. RISCH (1909), W. PENCK (1918), A. PHILLIPSON (1918), M. AKARTUNA (1968). The concepts and results of our research on the investigation area agrees with the ideas of M. AKARTUNA (1968) who made the most detailed research from among the above given authors.

KATACLASTIC METAMORPHIC ROCKS

MYLONITE

They are formed with the cataclastic effects of several rock groups, and are younger than regional metamorphism. There is milonitization and crystallization due to mechanical effects, generally at low temperatures with the increasing pressure. The detailed research about these cataclastic rocks are done by READ (1964) and HIGGINS (1971) as MIYASHIRO (1973) distinguished. HIGGINS (1971) explained the presence of milonitization where there is excess cataclastic deformation in a fault zone or a fault plane. MIYASHIRO (1973) expressed that the tectonic brecchia formed with weak cataclasm, and with increasing cataclasm, the rate of finely grained material increases and forms the aphanitic rocks.

The mylonites are formed at regions close to or within the faults, the rate of fine graning depends on the movement strength of the fault, the distance to the area under effect and the type of the lithology.

The rocks which are located in our investigation area are in the forms of mylonites and have foliation. The effects of cataclasm and deformation can be seen clearly on the rocks which contain quartz and mica. The quartz are elongated, folded, broken and distributed. The mica are recrystallized, folded and are divided into thin planes (N of İznik Fault, Kurbanlık Bayırı).

The samples which are obtained from 100-200 m close to Arapuçtu fault are mylonitized. The metasedimentites (metaarenites and metawackes) are fractured into particles of different sizes, because of cataclistis effects. These effects can be seen on the veins of quartz which cut the rock. Veins got folded and finely grained. The effects of fracturing, crushing and getting finely grained in the iron schist in the forms of mylonite, are observed in the Doruklar Hill, N of İznik Fault.

A brecchic texture at Tavşan Sırtı-Devren Region in the S of İznik Fault, over folding, fracturing and getting finely grained at Kurbanlık Bayı at 1 km N of İznik Fault in the Metacherts; fractures and fissures and secondary growths in the quartz inside them in the Phillites at S of Deliktaş Tepe in the N of İznik District; fractures, brecchic textures and some recrystallization in the Marbles and Limestones are observed due to cataclastic effects.

LAND SLIDES

In the investigation area, there are land slides with N-S strike and in the shape of arc on the map, generally developing in the Neogene aged Yenişehir formation. The sliding planes have either vertical or nearly vertical dip. The land slides develop generally in the places of slightly consolidated rocks where the underground waters are effective, due to the gravity forces.

ECONOMIC GEOLOGY

The area shows richness in the variety and quantity of the economic minerals as well as industrial materials.

These are: Galena, zincblende, chessylite, malachite, bornite, pyrite, hematite, manganite, amethyst opal, quartz feldspar, kaolinite, gypsum, aragonite, marble, limestone, travertine, sand and pebble, spring waters.

PLATE I

N70E S70W

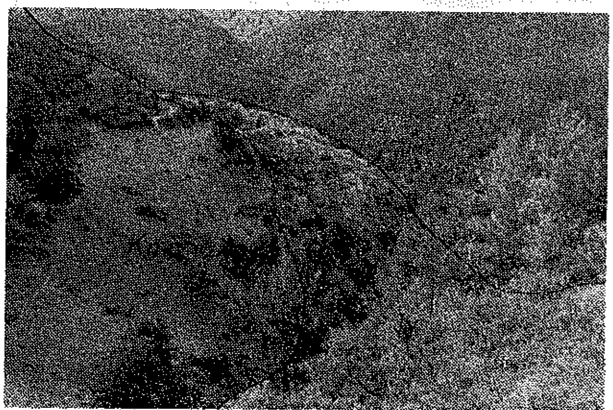


Photo 1 — SE view of Yardankaya limestone (Middle-Upper Jurassic) (Jy) which lies with angular unconformity over the sandstone of Sarmaşık Formation (Lower-Upper Permian) (Ps), and the shale and mudstones of Nushetiye formation (Campanian-Maestrichtian) (Kn) which overlappes transgressively over the Yardankaya limestone at the river in SW of Kırdoruk Tepe of The Şerefiye Village.

N50W S50E

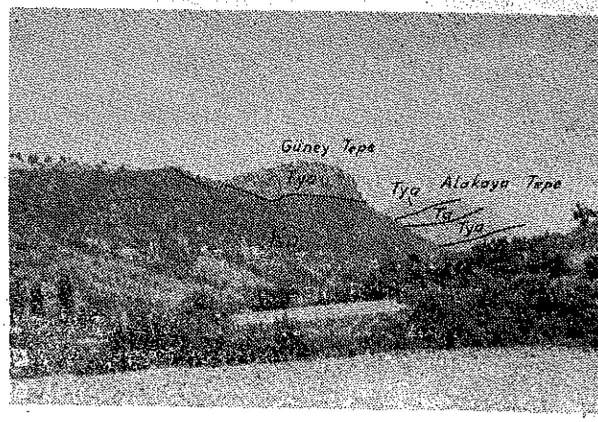


Photo 2 — NE view of the Yağhane limestone (Lower-Middle Paleocene) (Tya) which lies in graded contact and conformable on the alternation of sandstone and shale of the Nushetiye formation (Campanian-Maestrichtian) (Kn), and the Aydoğdu formation (Upper Paleocene) (Ta) which lies as angular unconformity over it, from the Aşağı Dere in the NE of Eğerce Village. Yağhane limestone beds form a syncline.

S10W N10E

Photo 3 — NW view of the structural terrace at the sandstone interbedded marl beds which belongs to the Nushetiye Formation (Campanian - Maestrichtian) (Kn) on the road of İznik - Osmaneli in the location of W slope of Kurterenler Dere.

S60E N60W

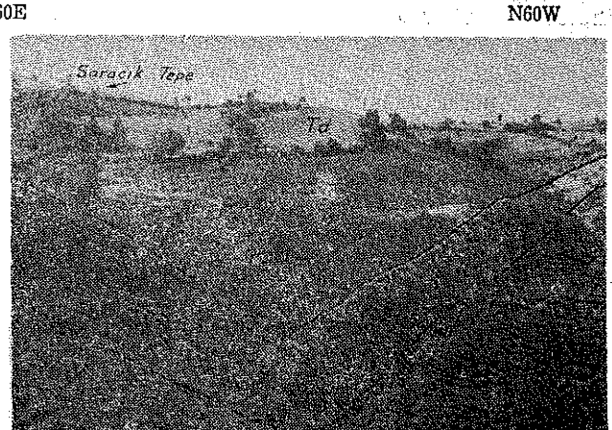


Photo 4 — SW view of sandstone, marl and claystone of Derbent Formation (Ypresian) (Td) which lies unconformable on the Yağhane limestone (Lower - Middle Paleocene) (Tya) beds which have a dip of 42°SE and lies unconformable on the sandstone of Sarmaşık Formation (Lower - Upper Permian) (Ps) from the E slope of Yağhane Dere in the W of Derbent Village.

PLATE II

N30W S30E

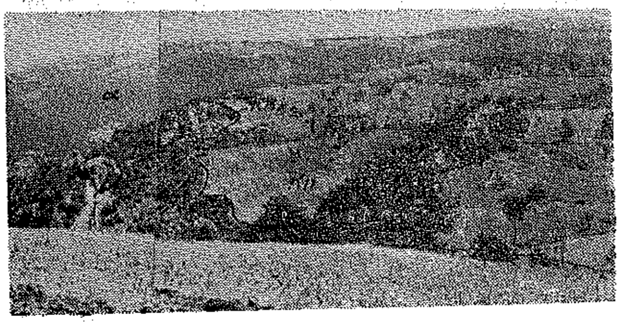


Photo 1 — NE View of Pyroxene andesite (α) and Middle - Upper Jurassic limestone inclusion (I) inside it, limestone member (Knk_n) of the Nushetiye formation (Campanian - Maestrichtian) (Kn) and the Yardankaya limestone blocks (Jy) in the form of olistolite aged Middle - Upper Jurassic within this formation from N of Akkaya Tepe which is located S of Atiye Village.

N S

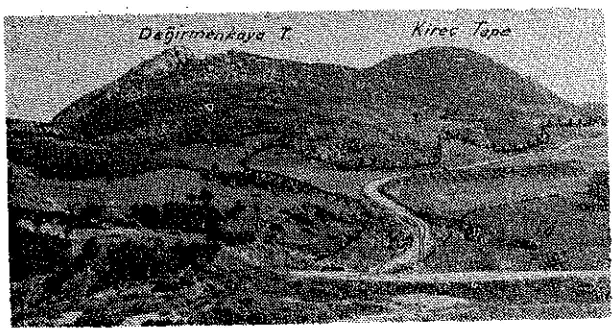


Photo 2 — E view from the SW of the Değirmenbayırı Tepe to Derbent fault which are in between the Yenişerefiye limestone (Upper Permian) (Py) and Nushetiye Formation (Campanian - Maestrichtian) (Kn), and Derbent formation (Td). The barbs show the upthrown block over the fault plane. The movement direction was from N to S.

Photo 3 — Pyroxene Andesite. Andesine (Pl_1), Oligoclase - Andesine (Pl_2), Pyroxene (Pr). Porphyritic texture, Xnicols, (X50).

S25E N25W

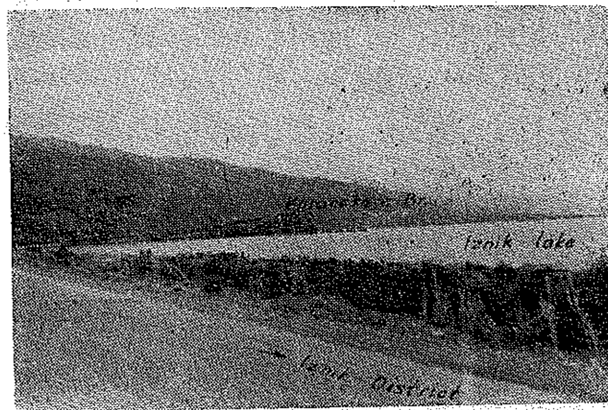


Photo 4 — SW view of the İznik fault which divides into two branches in the S of İznik lake, in the W of the investigation area.

PLATE III

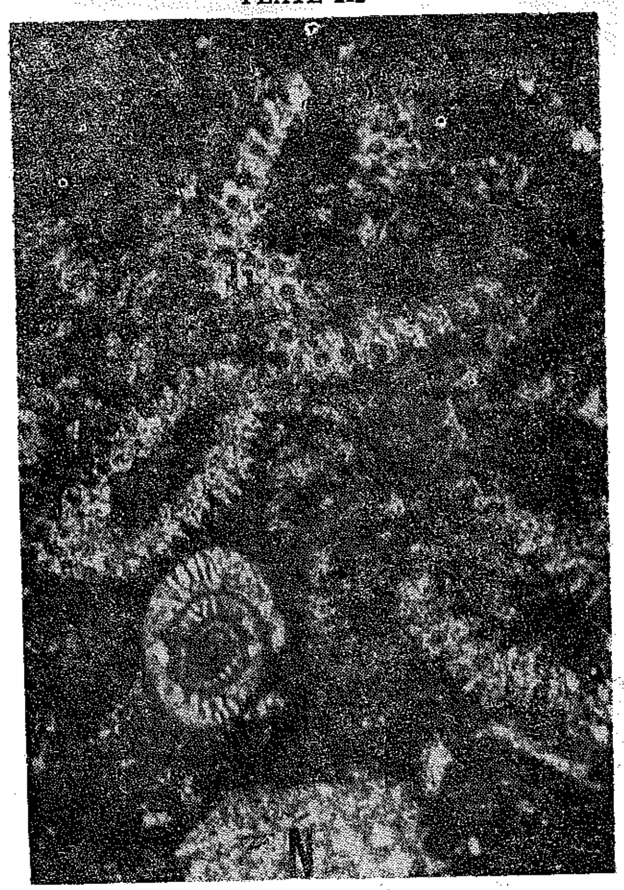


Photo 1 — Algal biomicrudite. Gymnocodium spp. (G), Nankinella (N), Sarısu limestone member of the Sarmaşık Formation, LOWER PERMIAN (Artinskien) (P_I^B) - UPPER PERMIAN (Mourgapien) (P_{II}^A), Ordinary illumination, (X50)

PLATE III

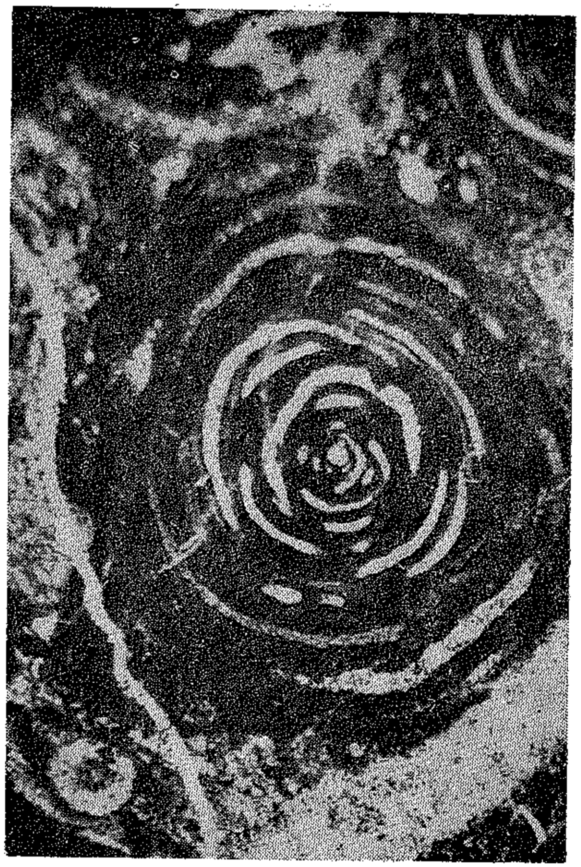


Photo 2 —
Biosparrudite. Hemigordiopsis renzi REICHEL, Yenişerefiye limestone. UPPER PERMIAN, Mourgapien (P_{II}^{A}) - Pamirien (P_{II}^{B}), Ordinary illumination, (X100)

Photo 3 —
Biomicrudite. Verbeekina verbeekii (GEINITZ), Yenişerefiye Limestone, UPPER PERMIAN (PII), Ordinary illumination, (X50)

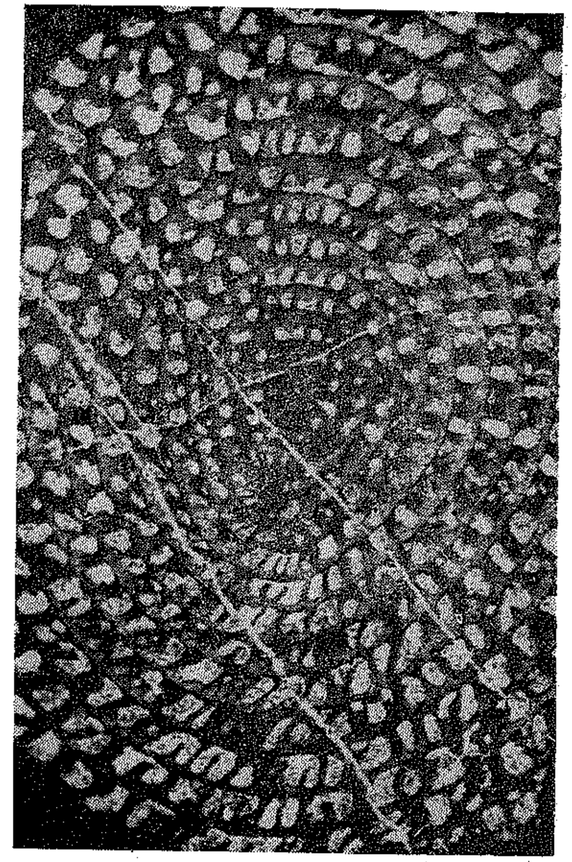


Photo 4 —
Biosparrudite. Neoschwagerina craticulifera (SCHWAGER), Yenişerefiye limestone, UPPER PERMIAN, Lower Mourgapien (P_{II}) - Lower Pamirien (P_{II}^{B}), Ordinary illumination, (X50)

PLATE IV

Photo 1 —
Oosparite. At top portion composite oölites are observed. Yardankaya limestone. UPPER JURASSIC (Portlandian), Ordinary illumination, (X50)

Photo 2 —
Globotruncana lapparenti BROTZEN Clayey biomicrite. Nushetiye Formation. UPPER CRETACEOUS (Santonian - Lower Campanian), Ordinary illumination, (X100)

Photo 3 —
Laffitenia sp. Biointramicrite. Yağhane limestone. LOWER - MIDDLE PALEOCENE, Ordinary illumination, (X50)

PLATE IV

Photo 4 — Nummulites sp. Silty biomicrite. Beypınar silty limestone member of the Derbent formation, EOCENE (Ypresian), Ordinary illumination, (X50)

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Due to a publishing error the lines between 28-29 on the left column of the page 205 from the top should be added and read a sfollows: «bedded, white, cream, sometimes grey white colored, irregular broken, juinted, filled with silex parallel to the bedding and juints, thin".