T.C.
DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

GEOLOGY AND OIL POSSIBILITIES OF THE ÇİÇEKDAĞ, AKÇAKENT (KIRŞEHİR) REGION

A Thesis Presented to
the Graduate School of Natural and Applied Sciences
Dokuz Eylül University

In Partial Fulfillment
of the Requirements for the Master Degree
in Geological Engineering

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February, 1994
Izmir

ABSTRACT

The Çankırı-Çorum Basin developed mainly as a detrital sedimentary basin during the Tertiary time. In this study, 8 sheets of 1/25000 scale map were geologically studied between Yerköy, Çiçekdağ and Akçakent which correspond to the southern margin of the Çankırı-Çorum Basin.

In the study area, the basement of the basin is composed of a magmatic belt which is considered as a part of the Kırşehir Massif. In this study, these basement units were named as the Çiçekdağ Belt which consists of two distinct rock associations. The older rocks are composed of mafic volcanics, pillow-lavas, massive diabases and submarine hyaloclastics which were named as the Çökelik volcanics. They include, as rare occurrences, thin lenses of cherty micrites which yield microfossils of the Turonian-Santonian age. The Çökelik volcanics are cut by the Yozgat magmatics which are composed of the granitic plutons and volcanic equivalents of the same plutonic rocks. Starting from the southernmost part of the study area and continuing further south away from the study area, the Çökelik volcanics become metamorphic and show distinct foliation.

The Yozgat magmatics vary from granite to diorite and their geochemical compositions range from granite, granodiorite, monzonite and to monzodiorite. Texturally, they considerably change in very short distances. Chemical compositions of the Yozgat magmatics suggest that, they are I-type and calc-alkaline in nature. They were probably formed above a subduction zone in the Santonian-Late Paleocene time.

The sedimentary succession of the Çankırı-Çorum Basin unconformably overlies the Çiçekdağ Belt and they range in age from the Late Paleocene to Late Eocene. Both marine and continental sediments interfinger with eachother laterally and vertically in

the Çankırı Basin and they also include andesitic to basaltic volcanic interlayers. The Tertiary sequence starts with the terrestrial sediments which consist of red conglomerates sandstones, siltstones and mudstones which are named as the İncik Formation in this study. The İncik interfingers with shallow marine deposits including dominantly fossiliferous shales and thin limestone lenses which are all named as the Yoncalı Formation. Thin limestone lenses in the Yoncalı Formation are named as the Kocaçay member. These units yield the Late Paleocene-Eocene fossils and have graditional boundaries with each other. The andesitic and basaltic lavas and tuffs of the Bayat Formation are present in these Late Paleocene-Eocene units as intercalations. They range in thickness from 10 to 500 m. These volcanics are mainly composed of andesite, andesitic basalt and trachyandesite. The chemical analyses indicate that, they are dominantly calc-alkaline in nature.

These Late Paleocene-Eocene rocks are unconformably overlain by the Miocene Kızılırmak Formation consisting of conglomerates, sandstones and shales. The Kızılırmak grades upward into the gypsiferous beds of the Bozkır Formation. The Pleistocene detrital sediments of the Değim Formation overlie the older units unconformably.

The southern margin of the Çankırı-Çorum Basin was a tectonically calm area during the Eocene period. On the contrary, along the northern margin tectonic slices of the Ankara Melange thrust into the Çankırı Basin during the Entire period of sedimentation. Along this margin coarse grained detrital rocks, submarine channel fills, olistostromal facies and olistolitic blocks are dominant.

The total thickness of the sedimentary sequence of the Çankırı-Çorum Basin is thinner along the southern margin compared to the northern edge and change laterally into the terrestrial deposits. In the study area these continental deposits directly overlie the rocks of the Çiçekdağ Belt. As the Tertiary succession changes into the continental deposits toward southern margin of the basin, they are no longer considered to be source rock for oil or natural gas. In addition to that, the volcanism played also a negative role in the oil potential of the Çankırı-Çorum Basin.

The basement units of the Çankırı-Çorum Basin were formed probably by convergence of the Sakarya and Kırşehir continents in the Late Cretaceous time. The Çiçekdağ Belt was considered to be formed in an arc environment of the Tethyan ocean and later upon collision with the Kırşehir continent, it thrust over the Kırşehir Platform. The metamorphism of the Kırşehir Massif occured by this collision. After this collision the Tethyan ocean subducted southward below the Kırşehir Massif and the Yozgat magmatics with granitic plutons and volcanic succession were formed. The Çankırı Basin is interpreted to be formed as an intermountain basin between the Kırşehir and Sakarya continents. As the convergence continued during the Eocene period ophiolitic melanges were formed along the southern margin of the Sakarya continent and thrust continiously into the basin along its northern margin.

ÖZ

Çankırı-Çorum Havzası Tersiyer boyunca kırıntılı bir tortul havza olarak gelişmiştir. Yerköy, Çiçekdağ ve Akçakent arasındaki bölgeyi kapsayan çalışma alanı havzanın güney kenarına karşılık gelir.

Çalışma alanında temeli Kırşehir Masifi'nin bir parçası olarak kabul edilen magmatik bir kuşak oluşturur. Bu çalışmada Çiçekdağ Kuşağı olarak adlandırılan bu kuşak birbirinden farklı iki kaya grubu içerir. Çiçekdağ kuşağı içinde altta Çökelik volkanitleri yer alır. Bu birim mafik volkanitler, yastık lavlar ve masif diabazlardan yapılıdır. Volkanik seri içinde ender olarak gözlenen ince mikrokristalin kireçtaşı merceklerinde Turoniyen-Santoniyen aralığını simgeleyen mikrofosiller saptanmıştır. Çökelik volkanikleri çalışma alanının güney bölümlerinde ve daha güneyde Kırşehir'e doğru metamorfiktirler ve belirgin foliasyon sunarlar. Bu volkanik seri Yozgat magmatikleri olarak adlandırılan granitik plütonlar ile bunların yarıderinlik ve yüzey eşdeğerleri tarafından kesilirler. Yozgat magmatitleri mineralojik ve kimyasal olarak granitten diyorite kadar değişirler ve granit, granodiyorit monzonit ve monzodiyorit türü kayalar içerirler. Bu farklı bileşimli kayalar dokusal olarak çok kısa mesafede belirgin farklılıklar sunarlar. Yozgat magmatikleri I. tipi, kalk-alkaline karakterlidirler ve olasılıkla bir dalma zonunun üzerinde Santoniyen-Geç Paleosen aralığında oluşmuşlardır.

Çiçekdağ Kuşağı, Çankırı-Çorum Havzası'nın Geç Paleosen-Eosen yaşlı tortul istifi tarafından açısal uyumsuz olarak üstlenir. Bu istif içinde denizel ve karasal tortullar yanal ve düşey yönde birbirlerine geçerler ve aynı zamanda andezitik, bazaltik bileşimli volkanik arakatkılar içerirler. Çalışma alanında Çankırı-Çorum Havzası'nın Tersiyer istifi kırmızı renkli çakıltaşları, kumtaşları, silttaşları ve

çamurtaşlarından yapılı İncik Formasyonu ile başlar. İncik Formasyonu yanal yönde sığ denizel, fosilli kireçtaşı ve şeyllerden yapılı Yoncalı Formasyonu'na geçer. Yoncalı Formasyonu içindeki kireçtaşı düzeyleri Kocaçay üyesi olarak adlanmıştır. Bu birimler içinden alınan en eski yaş Geç Paleosen ve en genç yaş ise Geç Eosendir. Bayat Formasyonu olarak adlanan andezitik, bazaltik lav ve tüfler Geç Paleosen-Eosen istifi içinde değişen kalınlıklara sahip düzeyler olarak gözlenir. Bayat Formasyonu andezit, andezitik bazalt ve trakiandezit türü kayalardan yapılıdır ve kalk-alkalin karekterlidir.

Geç Paleosen-Eosen yaşlı bu istif, Miyosen yaşlı Kızılırmak Formasyonu tarafından açısal uyumsuz olarak üstlenir. Kızılırmak Formasyonu karasal çakıltaşları, kumtaşları silttaşları ve çamurtaşlarından yapılıdır ve üste doğru kalın jips düzeyleri içeren çamurtaşlarından yapılı olan Bozkır Formasyonu'na geçer. Tüm bu birimler Pleyistosen yaşlı Değim Formasyonu tarafından açısal uyumsuz olarak üstlenirler.

Çankırı-Çorum Havzasının güney kenarı Eosen boyunca sakin bir tortullaşma alanı niteliğindedir. Buna karşın kuzey kenarda Ankara Melanjı'na ait tektonik dilimler tortullaşma ile eşzamanlı olarak havza içine doğru itilmişlerdir. Bu kenar boyunca havza tortulları içinde kaba dokulu kırıntılı tortullar, kanal dolguları, olistostromal oluşuklar ve olistolitik bloklar yaygın olarak gözlenir.

Havzadaki tortul istifin toplam kalınlığı kuzeyden güneye doğru azalır ve güney kenarda karasal tortullar baskınlık kazanır. Çalışma alanında bu karasal tortullar doğrudan temeli üstlerler. Bu fasiyes değişimi havzanın güney kenarının petrol ve gaz potansiyelini olumsuz yönde etkiler. Aynı zamanda Bayat volkanizması da bu bölgedeki petrol potansiyeli üzerinde olumsuz rol oynamıştır.

Çankırı-Çorum Havzasının temel birimleri olasılıkla, Sakarya ve Kırşehir kıtaları arasındaki yakınsama sonucunda gelişmiştir. Geç Kretasede, Tetis Okyanusunda bir ada yayının ürünü olarak gelişen Çökelik volkanikleri, sıkışma sonucunda Kırşehir Platformu üzerine itilmiştir. Bu çarpışmadan sonra Tetis kabuğu Kırşehir Masifinin altına dalmış ve Yozgat magmatikleri masifin içine yerleşmiştir. Çankırı-Çorum Havzası bu çarpışma zonu üzerinde bir dağarası havza olarak gelişmiştir ve devam eden sıkışma nedeniyle Sakarya Kıtasının güney kenarında gelişmiş olan ofiyolitik melanj havza tortullarının içine doğru itilmiştir.

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ACKNOWLEDGEMENTS

I would like to express my appreciation to Prof.Dr. Burhan Erdoğan for his kind supervision, valuable suggestions and discussions throughout this study.

I also want to express my gratitude to Dr. Funda Akgün for palynological definitions and to Yılmaz Gültekin, Nedim Tatari and Nalan Yılmazer for their assistance in geochemical studies.

This study was sponsored by the Turkish Petroleum Company (TPAO).I thank to Directory of the Exploration Group of the TPAO for sponsoring of this study.

It would be difficult to acknowledge each of the other contributors individually. Therefore, I am using this opporttunity to thank them collectively.

Bornova, 1994

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1. INTRODUCTION

The Tertiary Çankırı-Çorum Basin was developed as a dominantly detrital sedimentary basin which extends from Yozgat in the east, Yerköy and Çiçekdağ in the south, Kırıkkale in the west and to Çankırı and Merzifon in the north (Fig. 1).

In this study, an area, covering about 8 topographic sheets of 1/25000 scale is mapped. The stratigraphy of the Tertiary detrital deposits were examined and the rock units which were described in previous studies were redefined.

In the Tertiary basin, type sections from different units were measured and palynological studies were done on the samples collected from these measured sections.

The map area, is located among Yerköy, Çiçekdağ, Sekili, Akçakent, Boğazevci and Mahzenli which forms the southern border of the Çankırı-Çorum Basin. In this part of the basin, the relations between the Tertiary detrital sequences and the basement which is so called the Kırşehir Massif, form open outcrops, and can be examined in detail. The stratigraphy of the basement units were also studied and the rock units were petrographically and chemically examined.

In the study area two tectonostratigraphic association are seperated. The basement is dominantly consists of magmatic rocks of various kinds. This magmatic belt which is composed of the Turonian-Santonian mafic volcanics and the granitic plutons of the Paleocene age is called as the Çiçekdağ Belt in this study. In the Çiçekdağ Belt two different rock units are seperated and they are named as the Çökelik volcanics and the Yozgat magmatics.

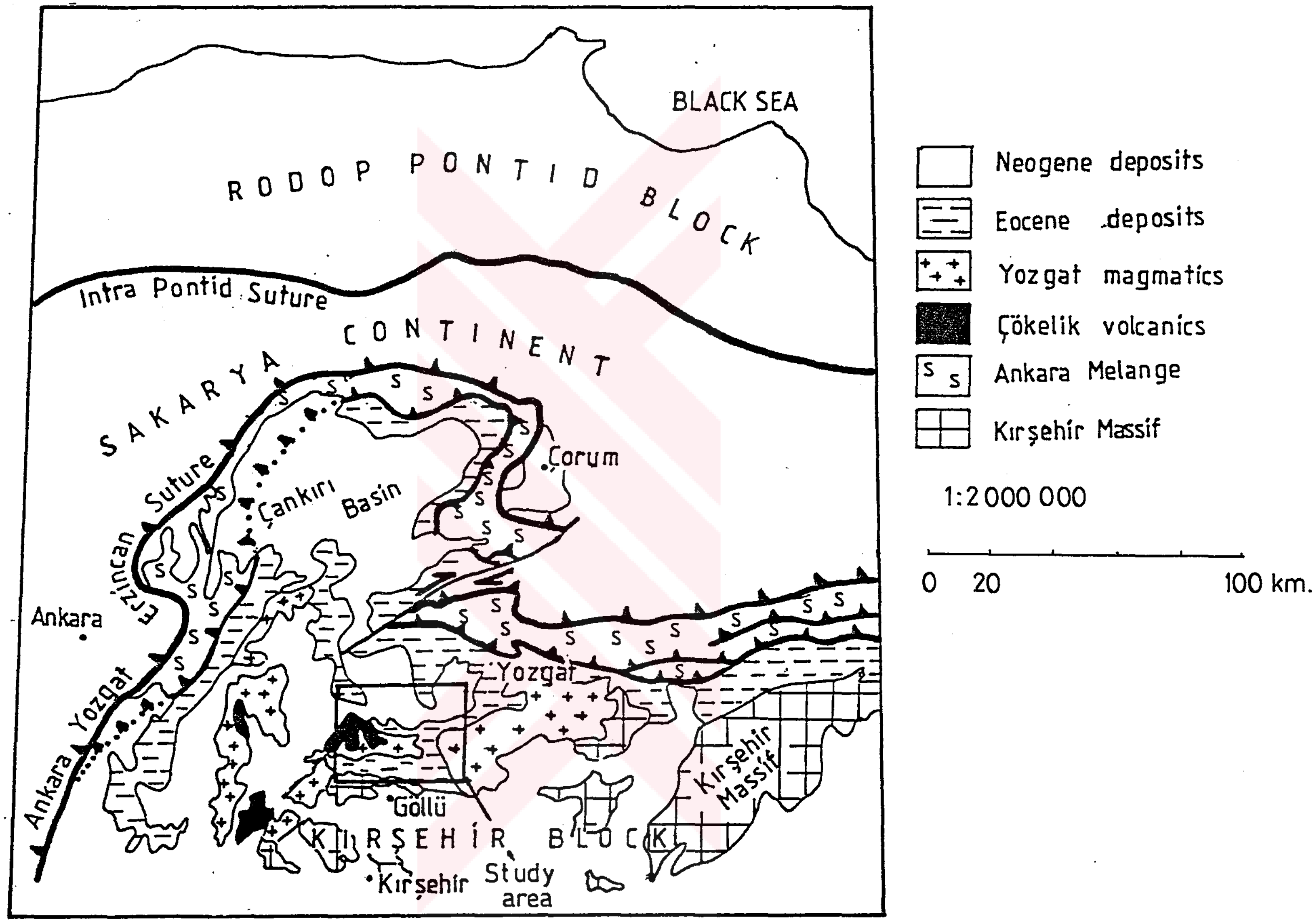


Fig. 1. Location map of the study area.

These basement rocks are unconformably overlain by the Tertiary sedimentary rocks. The oldest age obtained from these sedimentary rocks is the Late Paleocene and the youngest age from the uppermost part of the detrital sequence is the Late Eocene. This sedimentary sequence consists mainly of terrestrial and shallow marine deposits show graditional boundaries with andesitic-basaltic lavas and tuffs of the Eocene age.

For nearly last ten years, the Çankırı-Çorum Basin has been studied by geologists of the Turkis Petroleum Company (TPAO) and the Directory of Mineral Research and Exploration of Turkey (MTA), for the possibility of its potential for oil and natural gas.

In this study it was also aimed to distinquish the settlement and expansion of these possible source and reservoir rocks in the basin.

In the organization of this thesis, first the stratigraphy of the Çiçekdağ Belt will be presented and the petrological features of the various units will be examined in detail. It forms the basement for the Çankırı-Çorum Basin. In the following sections, the stratigraphy of the basin will be explained, and the evolution of the depositional environment will be discussed.

Later the structural characteristics of the region will be presented. Followed this section the oil and gas potential of the Çankırı-Çorum Basin will be evaluated.

In the final section, the tectonic evaluation and some limitations on the plate tectonic models put forward for the region will be discussed.

1.1. GEOGRAPHICAL AND MORPHOLOGICAL POSITION OF THE STUDY AREA

The study area covers 1/25000-scale sheets of Kırşehir I 32 c^1, c^2, c^3, c^4 and Kırşehir I 32 d^1, d^2, d^3, d^4 between Yerköy (YOZGAT), Çiçekdağ and Akçakent (KIRŞEHİR) regions.

In the study area, which extends from the west to the east, lithological differences of the basement and cover units are the main causes of the topographic differences. Çiçekdağ Belt, forming the basement, corresponds to the topographic higher regions and the Tertiary detrital units form topographically lowlands and peneplain areas.

Ankara-Yozgat highway cut the northern part of the study area from the west to the east. Minor roads from this highway make transportation easier where cover units crop out (Plate 1 A,B,C,D). Yerköy-Kırşehir highway is located in the eastern part of the study area and cut the area from the north to the south. By the end of this road it is accessible to the south and southeast parts of the area. For the accses to the central and southwest parts of the area, the Çiçekdağ-Akçakent highway and it's minor roads can be used.

The main country sites, in the study area, are Yerköy and Çiçekdağ townships in the east, Sekili and Boğazevci villages in the north and north west, Akçakent, Mahzenli and Kösefakılı villages in the central parts and Dulkadirli and Arabın mah. villages in the south (Plate 1 A,B,C,D).

1.2. METHODS USED

This study were sponsored by TPAO (Turkish Petroleum Company) and the field studies were carried out in the Yerköy camp of TPAO during the summer session of 1991.

The field studies were carried out on 1/25000-scale topographic maps and the stratigraphical relationships of the rocks which crop out in the study area were distinquished. In naming the stratigraphic units, previously given names were used as much as possible but they are redefined, wherever necessary, and stratigraphic relations were reconsidered.

Petrography of the various magmatic rock units were examined and for this about 150 thin sections were prepared.

Geochemical analyses of 30 samples from three different types of the magmatic rocks were done and the results were interpreted by related graphs. In the geochemical studies major and trace element analyses were made on 30 samples. Major element analyses were completed by atomic absorbtion and trace elements by X-Ray Fluoresencent method. For the atomic absorbtion analyses 0.25 gr. sample was mixed with 2 gr. lithium tetraborate and glassified at 1000 C^0 and dissoluted with HCl and finelly prepared solutions 1000 ppm. In the X-Ray fluorosencent studies 7 gr. sample was mixed with 2.8 gr. starch and made into a tablet in 25 ton presses. Then, samples were examined with (LIF 220 crystal in 2ϴ between 29^o-40^o) for Zr, Nb,Y, Rb, Sr under the conditions of 50 kV/30 mA; (LIF 200 crystal in 2ϴ between 86.5^o-$88,5^o$) for Ba and (LIF 200 crystal, 2ϴ between 38^o-40^o) for Ga under the conditions of 50 kV/50 mA. Peaks belonging to the elements of Nb, Zr, Y, Sr, Rb, Ba and Ga were faund and the amounts of these seven elements were obtained as ppm values by peak hights.

From different part of the detrital units of the Tertiary sedimentary succession, measured stratigraphic sections were made and they were sampled for the paleontological and palynological studies. The paleontological determinations of the samples were made in the paleontology section of TPAO and the palynological determinations by Dr. Funda Akgün of the Geology Department of the Dokuz

Eylul University.

1.3. PREVIOUS STUDIES

Çankırı-Çorum Basin has attracted attentions for it's importance on the tectonic evolution of the Anatolia and it's oil potential. Around the basin the first studies were carried out in 1950's.

Ketin (1955) who studied around the Yozgat, investigated the Kırşehir Massif which forms the basement of the basin and cover units. He indicates the Kırşehir Massif is composed of marbles and micaschists and crystalline rocks varying from asidic to basic. He noted these crystalline rocks crop out with their volcanic equivalents and consist of granite, quartz syenites, gabbros and diabases.

The author also observed that, units, with serpantinites, radiolarites and volcanics cropping out in the north of Yozgat, are Turonian-Campanian in age and have regular internal structure.

According to Ketin, (1955) the Early Eocene flysch-type rocks overlie the Late Cretaceous units unconformably with conglomerates at the base and Eocene detrital sequence includes basic volcanic intercalations in the upper parts.

Ayan (1963) Studied the petrography of the samples collected from Kaman and determined the age of the magmatic rocks cropping out in the area by the total Pb method.

This author noted the age of these rocks as 54 m.y. which corresponds to the Early Eocene time.

Ataman (1972) determined the age of Cefalıkdağ Pluton which is located near Kaman as 71 m.y. by ^{87}Rb-^{87}Sr method. This age corresponds to the Maastrichtian time.

Birgili et al.(1975) investigated detailed stratigraphy and oil possibilities of the Çankırı-Çorum Basin and observed nearly 10 km. thickness of sedimentary sequence in the basin. They indicated that this thick sedimentary sequence and large scale anticylinal structures are important for oil and gas.
According to these workers, the basement of the Çankırı-Çorum Basin is composed of ophiolites.
The workers noted the Tertiary sequence often transgressed

and regressed from the Maastrichtian to the end of Eocene. At the end of the Eocene, the area became completely terrestrial

Berent (1981) indicated that the ophiolitic melange cropping out in the north of Yozgat and consisting of serpantinites, pillow lavas and limestone blocks was Late Cretaceous in age and it included the Maastrichtian limestone levels on the top.

This melange is overlain by the Illerdian-Ypresian flysch-type deposits along an unconformity surfaces.
According to the author the age of the deformation was Oligoene or Miocene and directed from the north to the south.

Seymen (1981) studied the stratigraphy and metamorphism of the Kırşehir Massif. He pointed out that, the Kırşehir Massif was composed of the pre-Mesosoic marbles and schists, the ophiolitic rocks of the Ankara Melange, overthrusting the metamorphics, and the magmatic rocks, which cut all of this rock succession.
According to the author the Tertiary sedimentary rocks overlie the massif

unconformably.

Uygun (1981) studied the geology and oil possibilities of the Tuzgölü Basin and pointed out that the marine deposits were thick enough for the formation of oil. But according to the author, the marine formations often alternate with the continental sediments and this is a negative factor for the formation of oil.
He also noted that, the sedimentary sequence was often cut by faults and it made the stratigraphic correlation difficult.

Ünalan and Harput (1983) analized the Late Cretaceous-Early Tertiary source rocks in the western part of the Çankırı-Çorum Basin.

They indicated that, the source rocks were poor in organic material and existing organic material were suitable for reproduction of gas instead of oil. This is the reason, according to authors, well source rocks for oil are not observed in the area.

According to Seymen (1984) Kırşehir Metamorphics formed by metamorphism of sediments deposited in an Atlantic type passive margin.
He indicated that, the Ankara Melange was derived from an ocean in the north of Kırşehir Massif and became a melange, in a subduction zone at the pre-Maastrichtian time. He pointed out that this melange thrust over the Kırşehir Massif in Early Maastrichtian time along an obduction zone and were subjected high pressure/low temperature metamorphism. He also noted the rocks from calc-alkaline magmatism cut the older units and all of them were overlain by the Eocene deposits.

Görür et al (1985) devided the Tuzgölü Basin into two subbasin as the Haymana subbasin, and the Tuzgölü subbasin These authors indicated that the deepmarine sediments grade in to the shallow marine deposits in the basin margins laterally and

vertically.
According to the authors, inner Taurus ocean subducted under the Kırşehir Block from the south to the north and gave rise the arc magmatism which cut both the Kırşehir metamorphics and the ophiolitic nappes above.

Bayhan (1987) noted two different petrographic group in the Cefalıkdağ and Baranadağ Plutons which have features of the I and A types granitoids.
According to the author, these granitoids should be derived from the same initial magma by partial melting in two different cycle.

Önen and Unan (1988) studied on the petrography of the gabbros cropping out around Kaman and noted that, gabbros were subakaline to tholeitic in characters. According to these authors, the gabbros are a part of an ophiolitic suite.

Erler et al.(1989) wrote that the Kırşehir Massif consists of the Metamorphic rocks and felsic-medium magmatic rocks cutting the metamorphics. The authors noted that, these magmatic rocks, mineralogically varying from granite to nepheline syenite, are I-type granitoids and were derived from a magmatic arc formed by a subduction under the Kırşehir metamorphics.
The same workers pointed out that, around Yozgat, S-type plütonic rocks varying from granite to tonalite cropped out and these rocks were formed by partial melting of The Kırşehir metamorphics by collision of Pontid and Taurid blocks.

Korkmaz (1990) studied on the stratigraphy and organic and geochemical characteristics of the Sivas Basin which has similar properties with Çankırı-Çorum Basin.
He noted that the formations cropping out in the Sivas Basin is mature enough to form oil but poor in the organic material. For that reason, the basin will not be considered important for any occurences of oil.

Tüysüz and Dellaloğlu (1992) distinquished 6 tectonic units cropping out in the Çankırı-Çorum Basin as follows: Kırşehir Unit, Karakaya Unit, Sakarya Unit, Kalecit Unit, İskilip Unit and Çankırı Unit.

The İskilip and Çankırı Units correspond to the Tertiary cover units and the others correspond to the pre-Tertiary basement units.

The workers named the ophiolithic rocks, observed in the basin, as the Kalecik Unit and noted that these rocks were formed by subduction of Neo-Tethyan ocean and an ensimatic arc which developed simoultaneously under the Sakarya Block in the Senomanian time. Those authors pointed out that ophiolithic rocks of the Kalecik Unit tectonicaly overlie, the Kırşehir metamorphics and they all are cut by arc magmatics. This arc magmatism is supposed as the result of subduction of the Neo-Tethyan ocean under the Kırşehir Block.

Tüysüz and Dellaloğlu, (1992), also proposed nearly 7.5 km. thickness for Tertiary sedimentary sequence in the Çankırı-Çorum Basin.

Göncüoğlu (1993) devided the ophiolitic rocks of the Kırşehir terrane into three parts as follows:

The metamorphic ophiolites consisting of meta-serpantinites, meta-gabbros, meta-pyroxenites, meta-diabases, meta-basalts and meta-cherts that were formed and metamorphosed together with the central Anatolian Metamorphics.

The obducted ophiolites consisting of cumulate ultramafics and gabbros, diabase dikes, plagiogranites, pillow lavas and epiophiolitic sediments which have characteristics oceanic affinity.

These ophiolites thrust over the metamorphics along an obduction zone.

The monzogabbros and quartz-gabbros observed as minor outcropt in the Central Anatolian Crystalen Complex. These rocks are not yet studied in detail.

Güleç (1993) evaluated geochronological data from the Ağaçören granitoids which was located on the east of Tuzgölü and cut the ophiolitic rocks. She determined the age of the Ağaçören granitoid as 108 + 3 m.y. and suggested that the emplacement of the ophiolitic rocks would occur before this age that means before the Late Cretaceous.

Tüysüz (inprint) indicates that the basement of the Çankırı-Çorum Basin is composed of the Kırşehir Metamorphics, consisting of marbles and micaschists, ophiolithic rocks thrusting over the metamorphics and arc magmatics cutting them. These basement rocks are overlain by the Eocene-Oligocene transgressif-regressif sequences and the Neogene deposits.

He notes that the Kırşehir Block subducted under the Sakarya Block in the Campanian and the Çankırı-Çorum Basin was evolved as a molas basin on the collision zone of these blocks.

According to Tüysüz, the arc magmatism which cuts the Kırşehir metamorphics and ophiolitic rocks, is developed by subduction of the inner Taurus ocean under the Kırşehir Block from the south to the north.

2. STRATIGRAPHY

In the study area two main type of rock associations crop out. These are 1. The basement association which is called in this study as the Çiçekdağ Belt and, 2. the overlying succession of the Çankırı-Çorum sedimentary pile (Figs. 1,2).

The Çiçekdağ Belt, which crops out in the southern and central parts of the study area, extends nearly from the west to the east (Fig. 2, Plate 1 A,B,C,D). This belt forms the basement of the overlying Tertiary sequence and are composed dominantly of, mafic volcanic rocks and plutons of granitoids and their subvolcanic and volcanic equivalents. The granitic plutons are younger than the mafic volcanic rocks and cut them unconformably (Fig. 3).

The Çiçekdağ Belt is a part of the so called Mid-Anatolian Massif of Seymen (1984) or the Central Anatolian Crystalline Complex of Göncüoğlu (1993). According to Ketin (1955), this belt is the continuation of the Kırşehir Massif.

The Çankırı-Çorum sedimentary pile is the Late Paleocene-Miocene in age and overlies the Çiçekdağ Belt unconformably. This sequence is composed of shallow marine and terrestrial sediments with interval of andesitic lavas and tuffs.

2.1. ÇİÇEKDAĞ BELT

Çiçekdağ Belt crops out in a large area between Yozgat, Yerköy, Çiçekdağ and Akçakent and nearly extends from the west to the east (Fig.2, Plate 1A,B,C,D).

Ketin (1955) named the entire belt from Kırşehir to Yozgat as the Kırşehir Massif, so that the Çiçekdağ Belt of this study was considered as the northern continuation of the Kırşehir Massif.

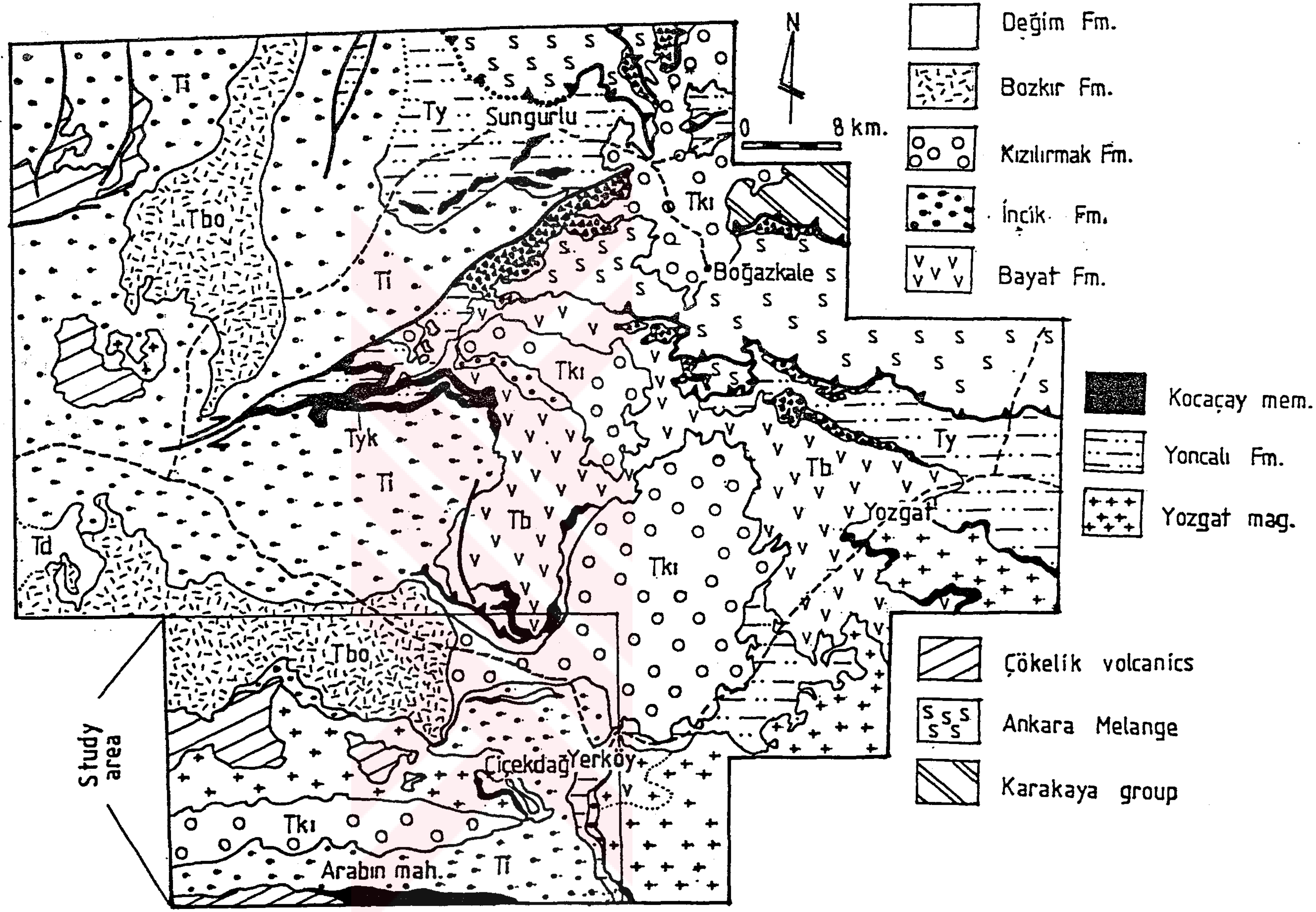
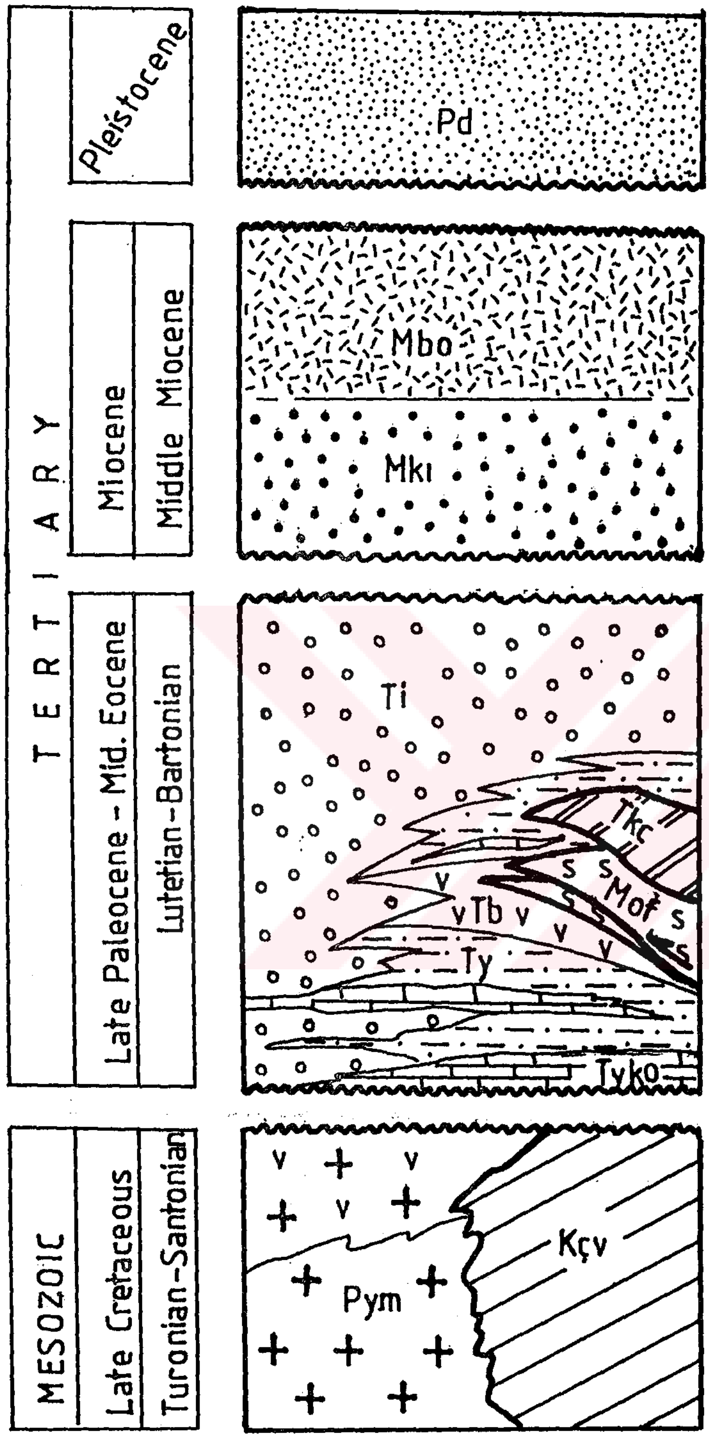


Fig. 2. Geological map of the Çankırı-Çorum Basin between Yozgat, Sungurlu and Yerköy (Prepared by B. Erdoğan, E. Akay and M.Ş. Uğur).



Pd: Değim Formation: Cross-bedded sandstones, conglomerates and siltstones.

Mbo: Bozkır Formation: Green shales with gypsiferous beds.

Mkı: Kızılırmak Formation: Gray, white, semi-consolidated sandstones, conglomerates and sand siltstones.

Ti: İncik Formation: Red conglomerates sandstones, siltstones and red, green shales.

Mof: Ankara Melange: Serpantinite and mafic volcanics-bearing ophiolitic rocks.

Tkc: Karakaya Complex

Ty: Yoncalı Formation: Nummulites-bearing, yellow, green shales and sandstones.

Tyko: Kocaçay member: Nummulites-bearing limestones and sandy limestones.

Tb: Bayat Formation::Andesitic, basaltic volcanic rocks.

Pym: Yozgat magmatics: Granitic, granodioritic plutons and their volcanic equivalents.

Kçv: Çökelik volcanics: Mafic volcanics with massive internal structure.

Fig. 3. Generalized stratigraphic section of the Çankırı-Çorum Basin between Yozgat, Sungurlu and Yerköy.

Tüysüz and Dellaloğlu (1992) and Tüysüz (in print) considered the same belt as Kırşehir continent and in this continent they seperated 1. The Kırşehir terrane as the Paleosoic-Mesosoic platform-type regionally metamorphosed micaschist and marble succession 2. Oceanic terrane that is composed of Upper Cretaceous ophiolites and 3. Arc terrane that consists of granitic plutons of Maastrichtian-Paleocene age.

In one of the latest work, Göncüoğlu et al. (1993) named the region as the Central Anatolian Crystalline Complex. In this complex they seperated three different ophiolitic rock groups, named as Metamorphic ophiolites, Obducted ophiolites and Monzogabbros and quartz-gabbros.

It is not definitive that, the Çiçekdağ Belt should be considered as the equivalent of the Oceanic terrane of Tüysüz (in print) or it would be the same tectonic belt as Göncüoğlu's obducted ophiolites.

As will be discussed in the following section, the Çiçekdağ Belt of our area consists of two rock associations. The lower and older one is dominated by mafic volkanic rocks and diabases. They are not typical rocks of oceanic association or ophiolitic material. In the area studied, they well may be interpreted as an İsland-arc succession as well. The internal part of this succession is not disrupted and serpantinite and equivalent rock types are not found although the unit forms very thick and extensive outcrop in the study area. These mafic rocks are cut by granitic plutons and their equivalent dasitic to rhyolitic volcanic assemblages. The granites and the related rhyolites and dacites are called together as the Yozgat magmatics. The underlying mafic assemblages are called the Çökelik volcanics. These two associations together are called in this study as the Çiçekdağ Belt. The Çiçekdağ Belt forms the basement of the Çankırı-Çorum Basin along it's southern margin. As the oldest age determined from the lowermost part of the Çankırı Basin is

Late Paleocene, the Çiçekdağ Belt would consist of rocks that are older than the Late Paleocene and probably would be the Upper Cretaceous in age.

2.1.1. Çökelik volcanics

2.1.1.1. Description

The mafic volcanics, consisting of darc green to black diabases, pillow-lavas and microgabbro masses are named as the Çökelik volcanics in this study. The Çökelik volcanics crop out between Çökelik village and Akçakent in the northwest part of the study area, around Alan village in the central part and at the southwest border of the study area (Plate 1A,B,C,D). In the 1/500000 scaled Geological map of Turkey (Ketin 1963), the mafic volcanics cropping out around Çiçekdağ were named as the ophiolitic melange and tought to be as a part of the Ankara Melange.

Seymen (1984), Tüysüz and Dellaloğlu (1992), Göncüoğlu (1993) and Tüysüz (in print) also considered these rocks as a part of an ophiolitic suite and named as "Ophiolitic rocks" or "Ophiolitic melange" which thrust over the Kırşehir metamorphics.

In the study area the internal structure of these mafic rocks is intact and no tectonic or sedimentary disruptions or chaotic mixings are observed on all scales from road cuts to 1/25000 map-scale. As seen on the geological map (Plate 1A,B,C,D) this unit forms an extensive outcrops of more than 20 km. in length. The thickness of the unit, although difficult to estimate precisely, reachs more than 5 km. Still no serpantinites or equivalent rock slices are found in the unit. Sediments are also very rare in the exposed area and they are estimated as not exceeding 5 percent of the entire region. Where present, they are mainly mafic tuffs and in only a few cases, red cherty limestone lenses are present. Where gabbros crop out, they are graditional to the mafic volcanic rocks and texturely they are dominantly microgabbros or coarse grained diabases. No banded gabbros or magmatics, with cumulate textures are seen. There is no distinct evidences or features suggesting that they are ophiolitic melange or slices of a former oceanic crust.

For this reason, we avoided to use genetic terms as ophiolites or ophiolitic melange for this unit and we prefered to give a new name for them. We have left the interpretation of the true tectonic setting of this unit for future studies which should also cover the boundary of this belt with the platform marbles and micaschists of the Kırşehir Massif. In a later section, though, we try to give a working hypothesis for the regional tectonic framework of the region.

2.1.1.2. Lithology

The Çökelik volcanics is composed of thick and massive diabases at the lower levels. These diabases can be followed along lateral direction and observed in open outcrops, between Alan and Halaçlı villages (Plate 1A,D). Green, darkgreen coloured, medium grained diabases are predominant. They are fine grained and in thin sections subophitic to ophitic textures are characteristic (Fig. 4). Plagioclase and amphibole crystals are present as phenocrystals in the matrix. Between Alan and Halaçlı villages and at the southwest of Safalı village (Plate 1B), microgabbro stocks are observed with diabases. These gabbros have fine grained holocrystalline texture and are composed mainly of plagioclase and pyroxene crystals (Fig.5). Amphiboles are less than pyroxenes and converted from pyroxenes by uralitization. A sharp contact between gabbros and diabases is not distinquished and commonly they are observed as having graditional boundaries. Around Çökelik village (Plate 1A), basalts with pillow structures about 40 cm. in size are present (Fig.6). Between these pillow lavas, in some levels, volcanics have clastic structures and tuffs and aglomerates are present as interlayers. The basalts have commonly porphiritic

Fig. 4. Photomicrograph of diabase from the Çökelik volcanics: Plagioclase and amphibole crytals are in crystalline matrix, (Plg): Plagioclase (Amp): Amphibole (Crossed nicols).

Fig. 5. Photomicrograph of gabbro from the çökelik volcanics Holocrystalline texture is clear. (Plg): Plagioclase, (Prx):Pyroxene (crossed nicols).

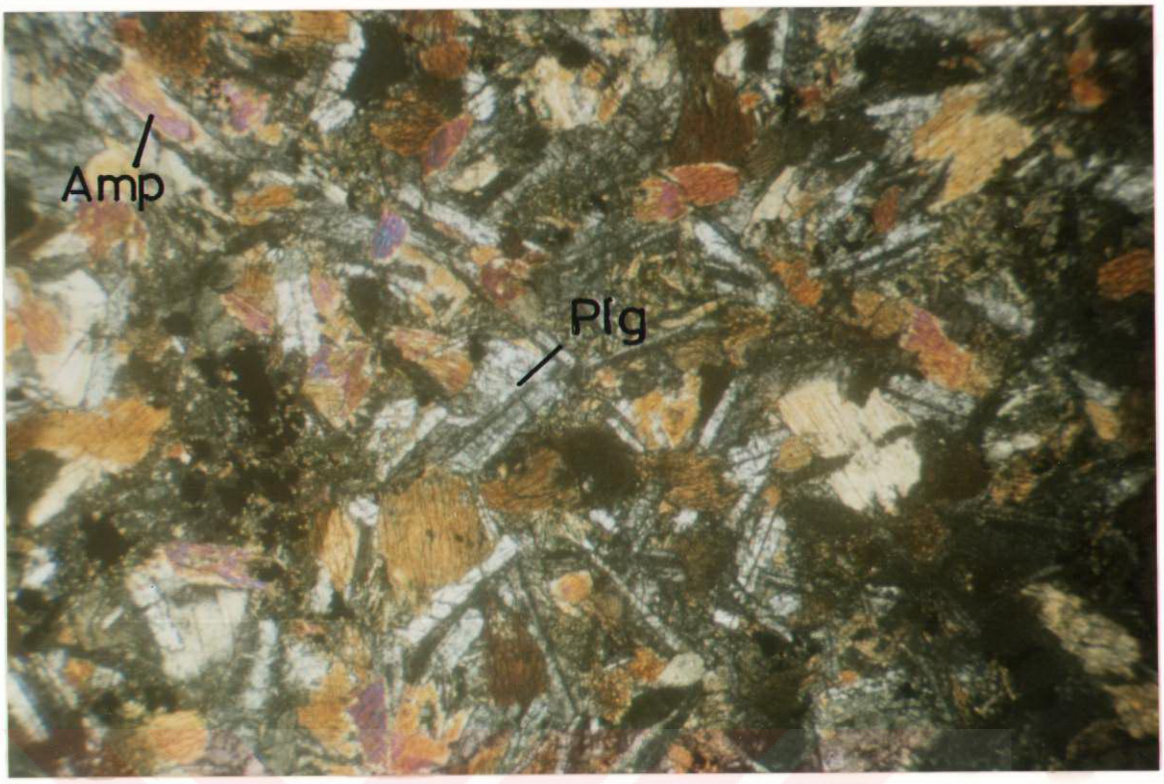


Fig. 4.

0 630 μ

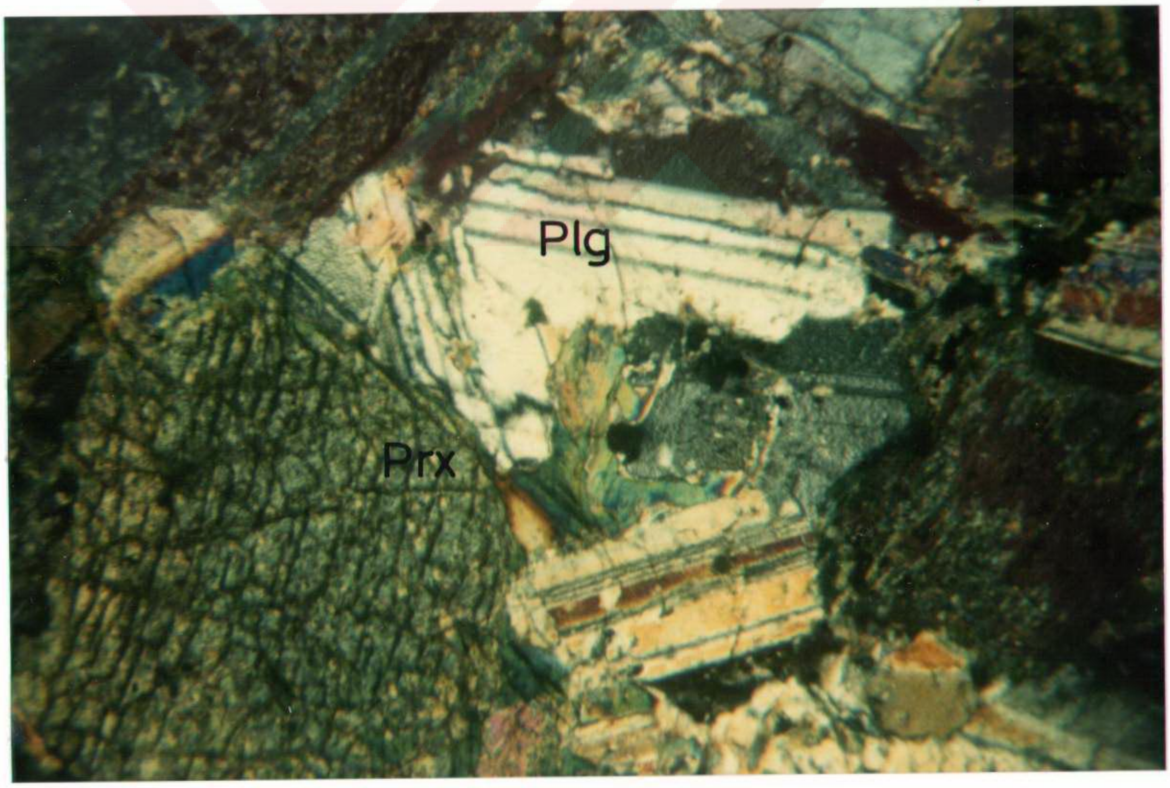


Fig. 5.

0 630 μ

Fig. 6. Pillow structures in basalts of the Çökelik volcanics (Near Çökelik village).

Fig. 6.

texture (Fig. 7). The matrix is commonly microlitic and sometimes glassy or cryptocrystalline. Plagioclase, pyroxene and rarely amphibole phenocrystals are present in this graundmass (Fig. 7). Olivine is not observed. All of these volcanic rocks, are deeply altered and chloritization in mafic minerals and sossurutization in plagioclase are common. Some amphibole crystals are completely converted into chlorite.

In the south, toward Kırşehir, near to Dulkadirli and Arabin mah. villages and between Boyalık and Pekmezci villages (Plate 1C,D), the Çökelik volcanics become slightly metamorphosed. This metamorphism has not completely errosed the primery texture of the volcanics and they only have slight schistosity. On the other hand to the south of Arabın mah. village, about 5 km. far from the southern border of the study area, along the Çiçekdağ-Kırşehir high-way, dark green-black amphibolites are observed. These rocks are formed by regional metamorphism of the Çökelik volcanics. Further south thin gray marble levels intercalating with the amphibolites are present.

Around Çökelik village on the western part of the study area and around Alan village on the central part (Plate 1A) red microcrystalline limestone lenses interfingering with mafic volcanics are observed (Fig. 8). These limestone lenses have maximum 1 m. thickness and can be followed 7-10 m in lateral direction. Although the Çökelik volcanics crop out in large areas these micritic limestone lenses are found only in three outcrops in the region studied.

2.1.1.3. Geochemistry

Geochemical analyses of 6 samples from mafic rocks of the Çökelik volcanics were made. Major and trace element compositions of these samples are given in Table 1. According to this table, SiO_2 ratios range from % 42 to % 52, Al_2O_3 from %

Fig. 7.A. Photomicrograph of basalt from the Çökelik volcanics. Plagioclase and pyroxene phenocrystals are in the glassy matrix. Porphyritic texture is clear. (Plg): Plagioclase- (Prx): Pyroxene (Crossed nicols).

Fig. 7.B. The same scene in uncrossed nicols. Pyroxene crystals are light green in color.

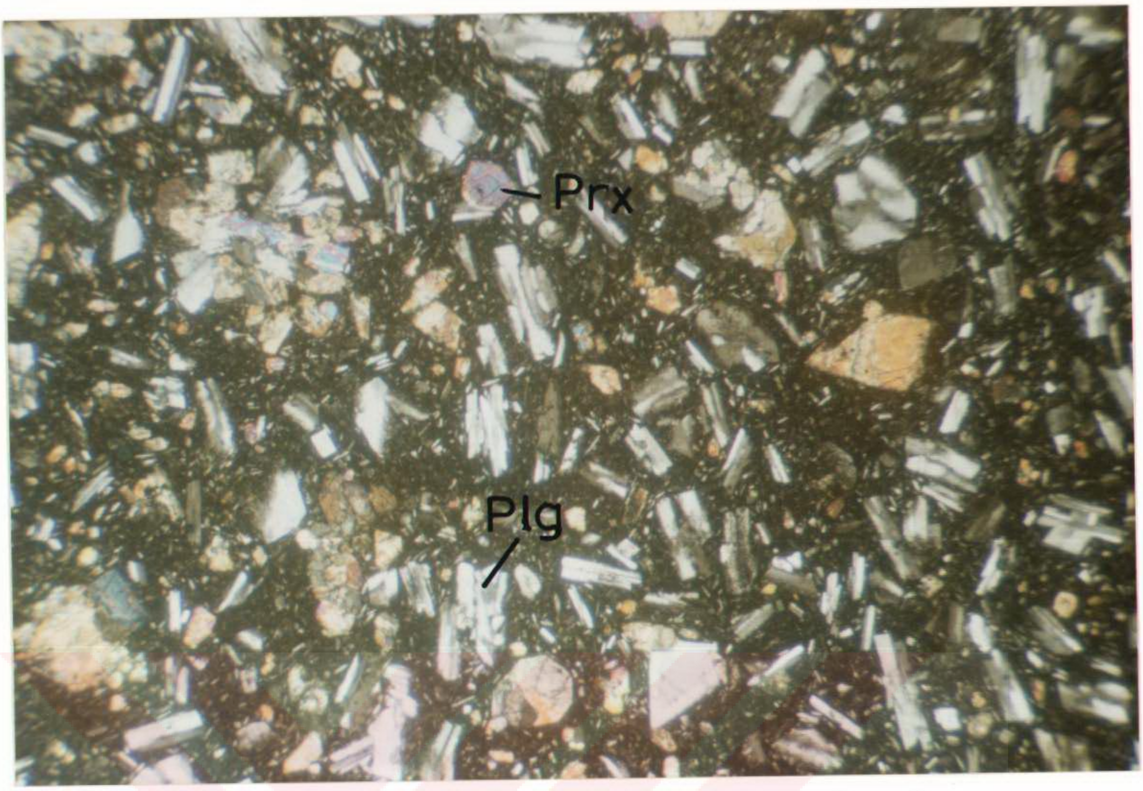


Fig. 7A.

0 630 μ

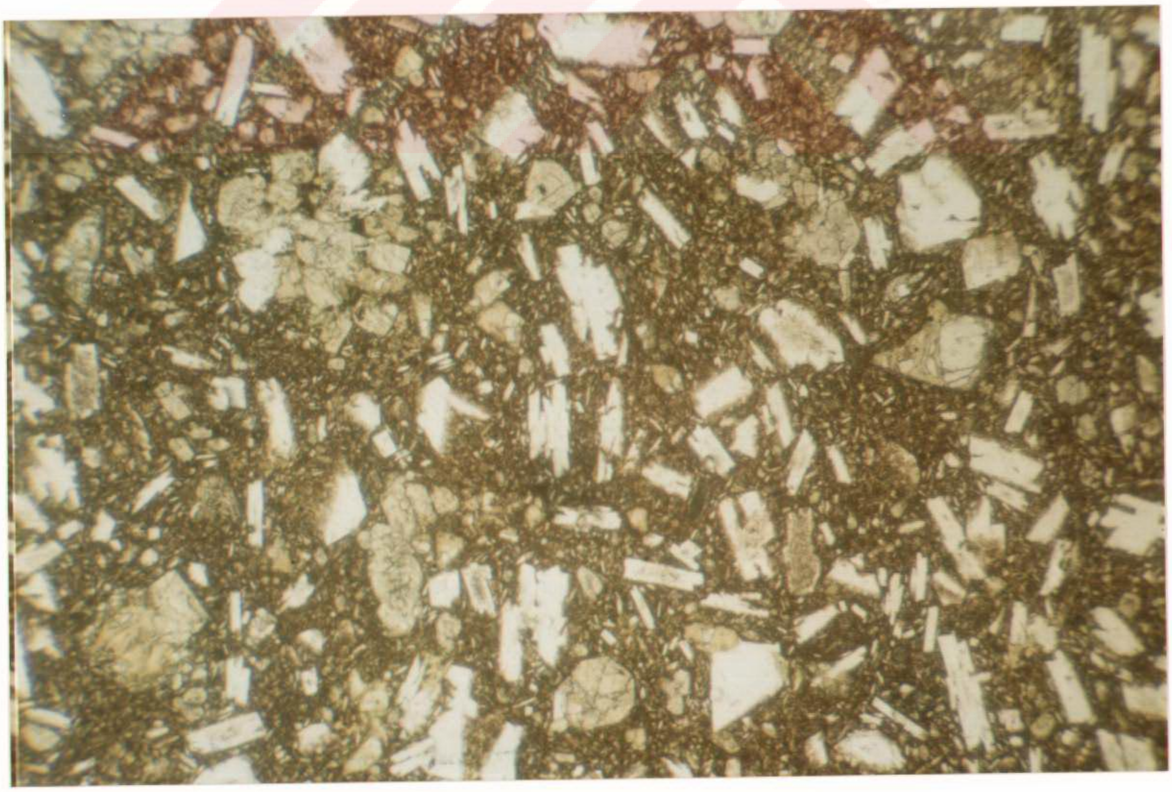


Fig. 7B.

0 630 μ

Fig. 8. Lense of microcrystalline limestone in the Çökelik volcanics. 1:Red microcrystalline limestone, 2: Mafic tuffs, 3: Basaltic lavas (On the Solakuşağı-Çökelik road, one km to the south of Çökelik village).

Fig. 8.

ELEMENT \ SAMPLE NO	35	38	39	40	41	44
SiO_2	52.16	47.72	41.87	42.77	55.60	50.19
TiO_2	0.67	0.53	0.74	1.18	0.37	1.17
Al_2O_3	14.05	15.67	14.64	15.79	16.70	14.97
FeO	7.63	9.72	9.52	15.34	2.89	11.52
MnO	0.17	0.09	0.10	0.12	0.16	0.14
MgO	6.45	2.06	6.49	3.71	0.42	5.41
CaO	5.75	5.42	9.60	7.38	5.46	3.88
Na_2O	4.74	1.25	6.36	4.00	6.52	6.87
K_2O	1.05	2.37	1.10	1.51	6.17	0.12
P_2O_5	0.14	0.14	0.23	0.27	0.12	0.21
H_2O	7.28	14.24	9.59	7.83	4.92	5.42
Rb	9	33	0	33	266	0
Ba	96	67	86	44	136	19
Sr	95	101	123	197	250	10
Ga	10	9	4	11	18	2
Nb	0	8	6	8	54	12
Zr	41	16	44	1	594	61
Y	3	13	9	7	36	14

Table 1. Majör and trace element composition of the Çökelik volcanics.

14 to % 16, total Fe_2O_3 from % 3 to % 11.5 and MgO from % 0.5 to % 6.5 As it was discussed above, the Çökelik volcanics are highly, altered in most of the outcrops. For this reason, results of geohemical analyses of samples from the Çökelik volcanics were not interpreted by graphs.

2.1.1.4. Age

On the 2.5 th km. of the Alan-Halaçlı road there is a micritic limestone lense in about 1.5 m. thickness and 5 m. in lateral length (03600/89200 in sheet of I 32 d_2, Plate 1A). In this lense laminated cherts are intercalated with micritic limestones. Another similar limestone lense is located on the Solakuşağı-Çökelik road (88900/88750 in sheet of I 32 d_1, Plate 1A). In four paleontological samples collected from these two lenses, the following microfossils of Turonian-Santonian were determined by paleontologists of TPAO.

Marginatruncana coronata
Marginatruncana pseudolinneniana
Hedbergella sp.
Globotruncanidae
Radiolaria

Although we can not found the exact time-span of the age of the Çökelik volcanics, we have at least determined that it is Turonian-Santonian in age.

2.1.1.5. Contacts

In most of the previous studies, the Çökelik volcanics were, considered as a part of an ophiolitic suite or the Ankara Melange and interpreted as slices above the Kırşehir Metamorphics (Ketin, 1955, 1963, Tüysüz and Dellaloğlu, 1992, Göncüoğlu, 1993). However in the study area this relationship is not observed, and it is not clear wheather the equivalent of the Çiçekdağ Belt can be found as nappes on the Kırşehir Metamorphics.

In Seymen (1984)'s description serpantinite-bearing melanges directly overlie the Kırşehir Marbles and they are not metamorphosed.

But in our area the Çiçekdağ Belt can not be considered as an ophiolitic melange and, in addition to that, toward the south near Kırşehir the Çiçekdağ succession becomes metamorphic with pronounced schistosity and regionally deformed penetrative cleavage. So, the rock succession of the Çiçekdağ Belt is not the same as those tectonic nappes described by Seymen (1984). Therefore, they may belong to a completely different tectonic terrane. The Çökelik volcanics are cut by granitic, granodioritic plutons and their volcanic, subvolcanic equivalents. This contact can be seen at the western edge of the study area and in the northwest of the Çökelik village (Fig.9, Plate 1A). In this locality basalts with pillow structures are cut by a granitic dyke which is fine-grained near the contact and coarse grained in the middle where K-Feldspar crystals about 1.5 cm. in size are present, indicating that the surrounding rocks were cold during the granite emplacement.

Both the granites and the Çökelik volcanics are overlain by Tertiary sediments of the Çankırı-Çorum Basin. At the south of Kilimli village (Plate 1A), the çökelik volcanics are unconformably overlain by the Miocene evaporites, mudstones and sandstones. At this contact nearly horizontal red sandstones and mudstones unconformably overlie the mafic volcanics and upward pass into mudstones with evaporite. Further west, yellow, yellowish white mudstones and evaporites directly overlie the çökelik volcanics.

Fig. 9. Subvolcanic granites cutting the Çökelik volcanics with pillow structures. (Gr): Granite dyke, (Pl): Pillow lavas (At the west border of the study area).

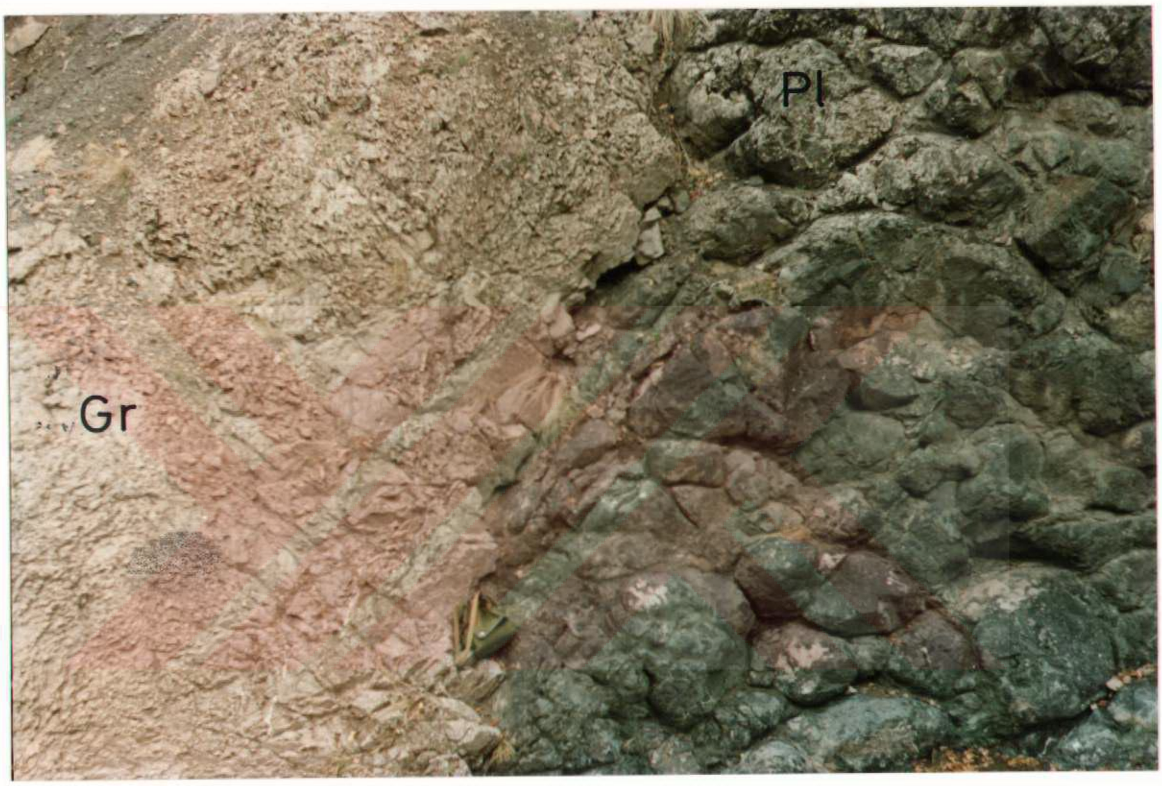


Fig. 9.

2.1.1.6. Discussion

Çökelik volcanics were named as ophiolitic melange and thought to be as a part of the Ankara Melange in the previous studies (Ketin, 1955, 1963, Seymen, 1984, Tüysüz and Dellaloğlu, 1992, Göncüoğlu, 1993). This unit has some lithological and chronological similarities with some rocks of the Ankara Melange that crops out around Yozgat, Sungurlu and Boğazkale (Figs. 1.2). However structurally, the Çökelik volcanics are rather different from the Ankara Melange. The Çökelik volcanics and the Ankara Melange are both Late Cretaceous in age and have mafic rocks, microgabbro stocks and microcrystalline limestone lenses. However the Çökelik volcanics have a regular internal structure. Thick and massive diabases and pillow lavas can be followed laterally. Contrary to this regular internal structure of the Çökelik volcanics, the Ankara Melange have a chaotic internal structure. It consists of ultramafic components such as serpantinites and pelagic sediments and these lithologies are at contact with each other along shear surfaces. However, the Çökelik volcanics are not melange and do not have typical properties of an ophiolitic suite. Whereas, according to Önen and Unan (1988), gabbros in the mafic rocks, cropping out around Kaman are a part of ophiolithic suite.

The Çökelik volcanics should be thought to be different from the Ankara Melange according to their properties which are observed in this area. Besides that, the Çiçekdağ Belt becomes metamorphic toward Kırşehir, suggesting that the Kırşehir marble association and this belt had close relation during the metamorphism of the Kırşehir Massif. However, as our study area is limited just to the northern continuation of this belt, we are not able to tell what was the exect relation of the Kırşehir Massif and the Çiçekdağ Belt during the main metamorphism.

2.1.2. Yozgat magmatics

2.1.2.1. Description

In this study granitoids cropping out around Çiçekdağ, Yerköy, Yozgat, Şefaatli, Solakuşağı, Armutlu and Kösefakılı (Fig. 2, Plate 1A,B,C,D) are named as the Yozgat magmatics. These rocks are composed of plutonic rocks of various composition and their volcanic and subvolcanic equivalents.

These kind of granitoids were named by local names as the Baranadağ Pluton and the Cefalıkdağ Pluton in the previous studies (Ayan, 1963, Ataman, 1972, Bayhan, 1987, Geven et al.,1993, Türeli et al.,1993, Güleç, 1993). These plutonic rocks were all named as the Central Anatolian Granitoids by Bayhan (1987) and Erler and Bayhan (1993). This definition includes all plutonic masses cropping out around Kaman, Yerköy, Çiçekdağ and Yozgat which cut the Kırşehir metamorphics and the ophiolithic rocks.

Birgili et al.(1975) named the plutonic rocks cropping out around Sulakyurt as the Sulakyurt Granite which have similar petrographic properties with the Yozgat magmatics.

However in all these studies, they do not mention any volcanic rock associated with the granitic plutons. In our study area very thick volcanic pile of andesite to rhyolite composition are intruded by granitic plutons of the same petrographic characteristics.

Ketin (1955) also noted a volcanic succession in close relation with the same kind of granitic plutons.

2.1.2.2. Lithology

The Yozgat magmatics are composed of chemically and mineralogically heterogenous plutonic rocks and their subvolcanic and volcanic equivalents. These rocks may also include different size of xenoliths from the Çökelik volcanics.

The Yozgat magmatics consist of granite, granodiorite, monzogranite, monzonite, monzodiorite, diorite type plutonic rocks and porphyries. They also include andesite, dacite, rhyodacite that amount to 2 km. in thickness.

The most typical properties of the plutonic rocks are abundance of pink K-Feldspar phenocrystals of up to 5 cm. in size (Fig. 10). Also they show variations of the chemical and mineralogical composition in very short distances laterally.

The volcanic rocks form crude bedding in some places and suggesting a very thick pile of lava was extruded first. The lava pile was intruded intensively by subvolcanic stocks, small scale porphyries and dykes. These subvolcanic stocks and smallscale intrusions intensively oblitirated the internal structure of the volcanic pile and so that, in most areas it is very difficult to recognize the lava succession. The lava flows are cut by subvolcanic stocks of the nearly same mineralogical composition, and in outcrops the lavas with glassy graundmass pass inperceptively into porphyries of the stocks. In the granites, this is also true that, in about 10 to 15 m. laterally the texture of the granite changes considerably.
On the Yozgat-Şefaatli road coarse grained pink granites and fine grained gray granites crop out. These different type granites also pass in to each other graditionally.

In plutonic types, texture is always holocrystalline (Fig. 11). In granites and granodiorites granophric texture is common (Fig. 12). In these samples myrmekitization and perthitization can be recognized clearly.

Fig. 10. Looking at the Granites in hand sample from the Yozgat magmatics K. Feldspar phenocrystals in about 2 cm. length are in crystalline matrix.

Fig. 11. Photomicrograph of granites from the Yozgat magmatics. Holocrystalline texture is clear. Plagioclase, K. Feldspare and Quartz crystals are seen in photo. (Plg): Plagioclase, (Q): Quartz, (KF): K. Feldspar (Crossed nicols).

Fig. 10.

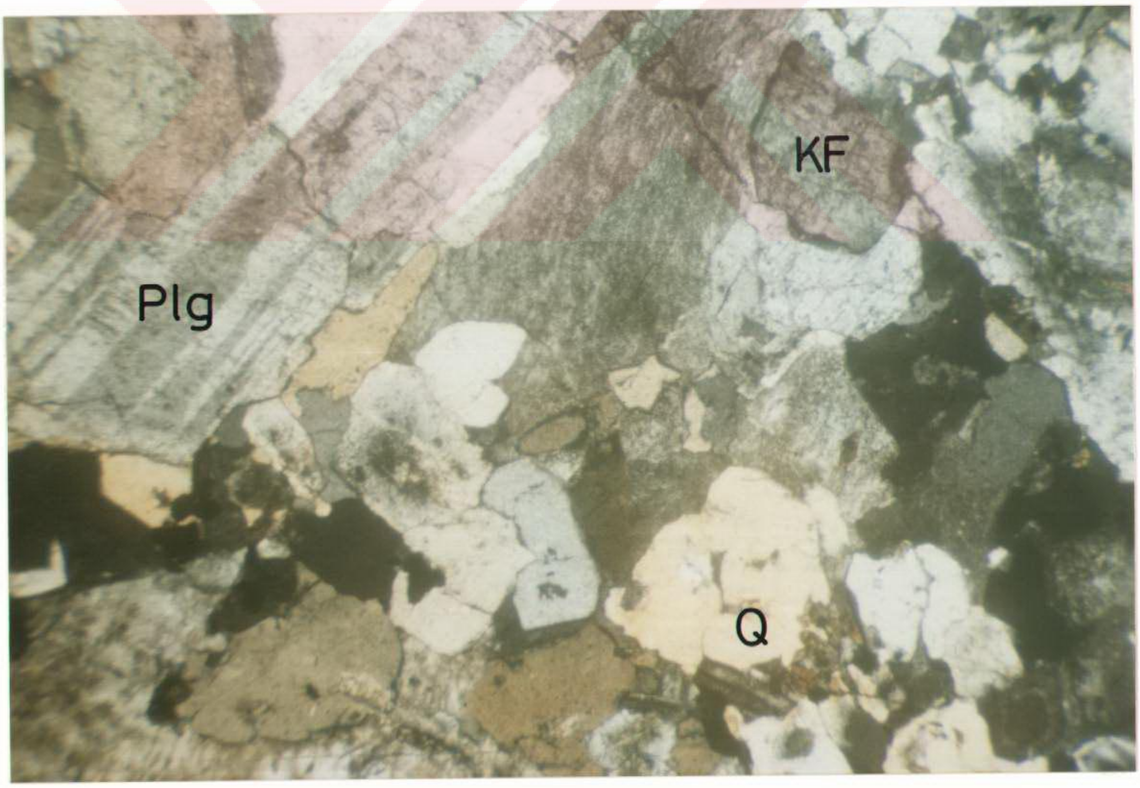


Fig. 11.

0 630 μ

Fig. 12. Photomicrograph of granites with granophyric texture. Radiate intergrowths of quartz and alcali feldspar can be recognized clearly (Crossed nicols).

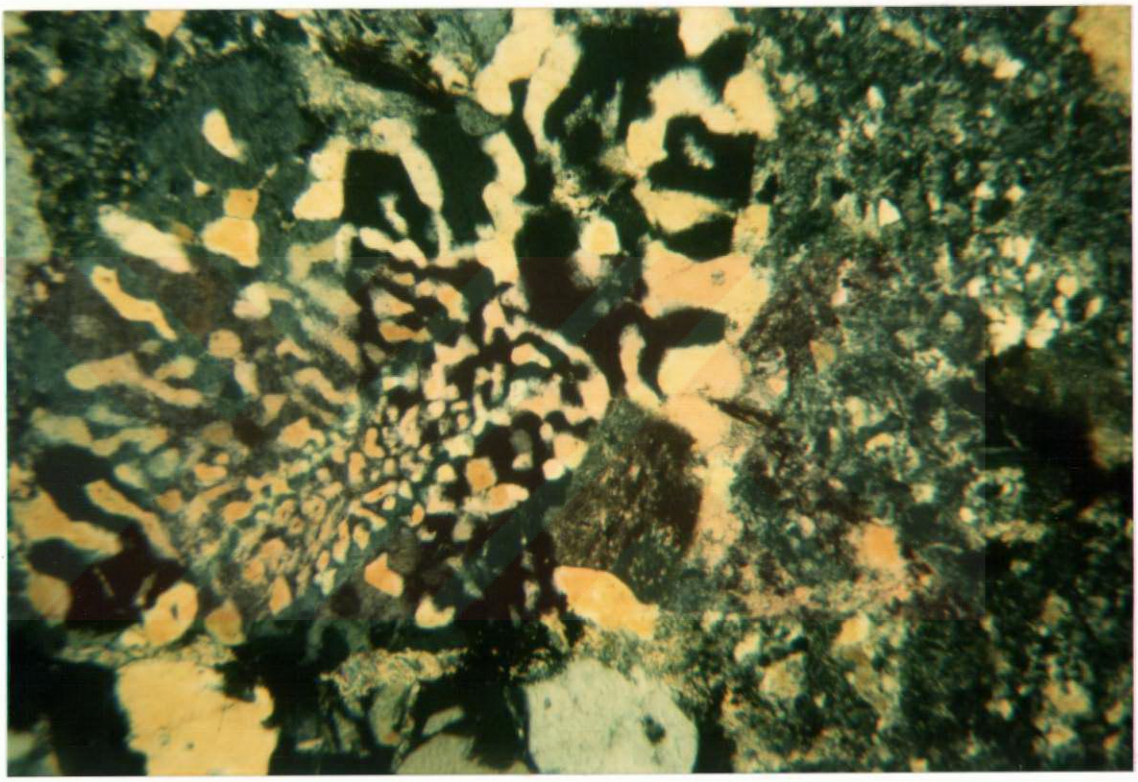


Fig. 12.

0 630 μ

The common mafic minerals are biotite and further more amphibole and felsic minerals are plagioclase, orthoclase and sanidine in varying abundance related to chemical composition. Convertion into chlorite and epidote in mafic minerals and sossuritization in felsic minerals are common. Abundance of quartz also depends on chemical composition. Granite or granodiorite-type rocks are rich in quartz contrary to monzonitic or dioritic types.

In the porphyritic types, especially K-Feldspar phenocrystals, 1-3 cm. in size, are observed in micro or medium granular graundmass (Fig. 10).

Around Yerköy and between Yerköy and Şefaatli (Fig.2, Plate 1B), volcanic equivalents of plutonic rocks, mentioned above, crop out. These volcanic sequence stars with mafic types of volcanic rocks as andesite at the lower parts and at the upper parts they become more asidic where dacite, rhyodacite and rhyolites are predominant. In the dacites and rhyolites porphyritic texture is common and can be observed clearly (Fig. 13,14,15). The graundmass is glassy or cryptocrystalline. In some samples in which glassy matrix are observed, devitrification and fluidal texture are present (Fig. 14,15). In the mafic types plagioclases as felsic mineral and biotites and amphiboles as mafic mineral are common in the matrix (Fig. 16). Quartz is common in the asidic types as idiomorph or embayed crystals (Fig. 17).

2.1.2.3. Geochemistry

Geological analyses of 13 samples from the granitic plutonic rocks of the Yozgat magmatics were made in this study. Major and trace element compositions of these samples are given in Table 2 and petrographic descriptions of hand samples and thin sections of each sample are given in Table 3. According to geochemical analyses, SiO_2 ratios range from % 59 to % 75, Al_2O_3 from % 12 to % 15 and total Fe_2O_3 from % 1 to % 7.

ELEMENT / SAMPLE NO	27	28	29	30	31	32	33	34	36	37	38	42	43
SiO_2	71.53	62.79	62.33	59.03	68.60	67.94	67.86	64.52	61.34	62.92	47.72	75.08	69.79
TiO_2	0.17	0.60	0.58	0.53	0.33	0.33	0.35	0.40	0.39	0.53	0.53	0.10	0.19
Al_2O_3	12.40	14.70	14.37	13.72	13.41	12.19	13.79	15.20	14.02	15.45	15.67	11.72	13.54
FeO	1.77	4.19	4.98	7.18	2.82	3.49	335	3.85	4.39	4.46	9.72	1.37	1.74
MnO	0.06	0.10	0.13	0.16	0.07	0.06	0.06	0.09	0.09	0.17	0.09	0.02	0.05
MgO	0.44	1.66	2.29	4.05	1.13	1.43	1.25	1.49	1.60	1.71	2.06	0.22	0.48
CaO	1.98	4.21	5.65	6.29	2.96	2.50	1.99	3.75	4.33	4.74	5.42	0.36	2.38
Na_2O	3.86	4.11	4.07	3.65	4.87	3.78	4.35	4.29	3.05	4.14	1.25	3.71	4.11
K_2O	5.68	4.55	4.83	3.23	4.51	5.18	4.86	4.67	4.49	4.56	2.37	5.27	5.37
P_2O_5	0.07	0.14	0.21	0.18	0.15	0.13	0.16	0.16	0.13	0.14	0.14	0.08	0.08
H_2O	1.50	2.83	0.69	2.21	1.03	3.05	1.96	1.51	5.19	0.80	14.24	1.22	1.39
Rb	273	147	158	59	151	185	--	184	178	204	33	346	227
Ba	201	479	621	1067	994	801	--	582	412	393	67	89	358
Sr	289	765	754	636	826	524	--	582	304	691	101	71	412
Ga	13	14	15	11	15	12	--	13	12	14	9	11	13
Nb	26	27	30	6	16	16	--	14	6	20	8	24	19
Zr	132	262	240	159	259	207	--	216	213	272	16	107	158
Y	32	34	35	18	21	32	--	31	38	32	13	44	31

Table 2. Majör and trace element composition of the Yozgat magmatics.

	QUARTZ	SANIDINE	PYROXENE	AMPHIBOL	ORTHOCLASE	PLAGIOCLASE	BIOTITE	MUSCOVITE	CALCITE	K-FELDSPAR	CHLORITE	SFEN
Sample No												
27	10	30	10	5	20	20	5					
28	5	15		13	17	30	1	1	10			
29	2			15		65	3			15		
30	2			15		55	8			15	5	
31	5	20		10	15	45	5					
32	8			18		27			9	38		
33	9			16		30			5	40		
34	7	28		15	23	25	1					1
36	20			10		35		2	10	25		
42	40	15		10	20	13		2				
43	5	30		10	30	15			10			

Table 3. Mineralogical composition of the Yozgat magmatics in thin sections.

Fig. 13. Photomicrograph of volcanic rocks with porphyritic texture from the Yozgat magmatics. Plagioclase, quartz and biotite phenocrystals are in the cryptocrystalline matrix. At the so southeast corner of the photo, a sossuritizated feldspar crystal is seen. (Plg): Plagioclase, (Q): Quartz, (B): Biotite (Crossed nicols).

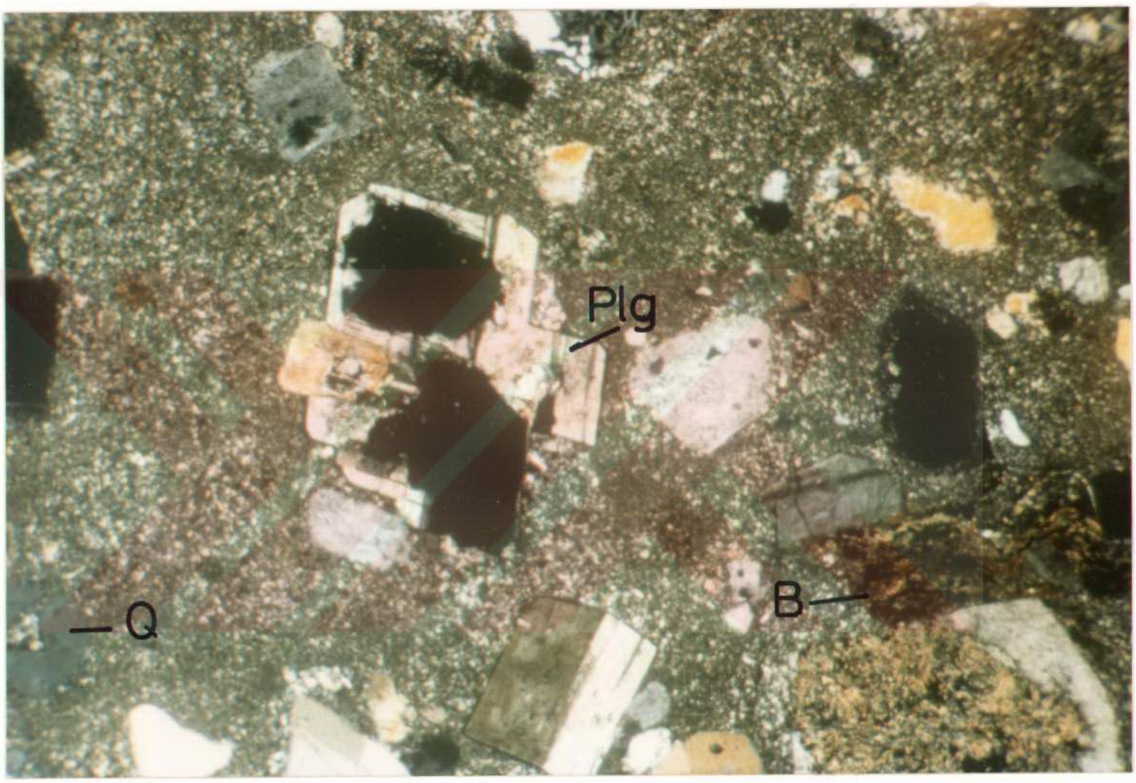


Fig. 13.

0 630 μ

Fig. 14.A. Photomicrograph of dacite with devitrificated glassy matrix (Crossed nicols).

Fig. 14.B. The similar scene in uncrossed nicols. Devitrification between phenocrystals are seen clearly.

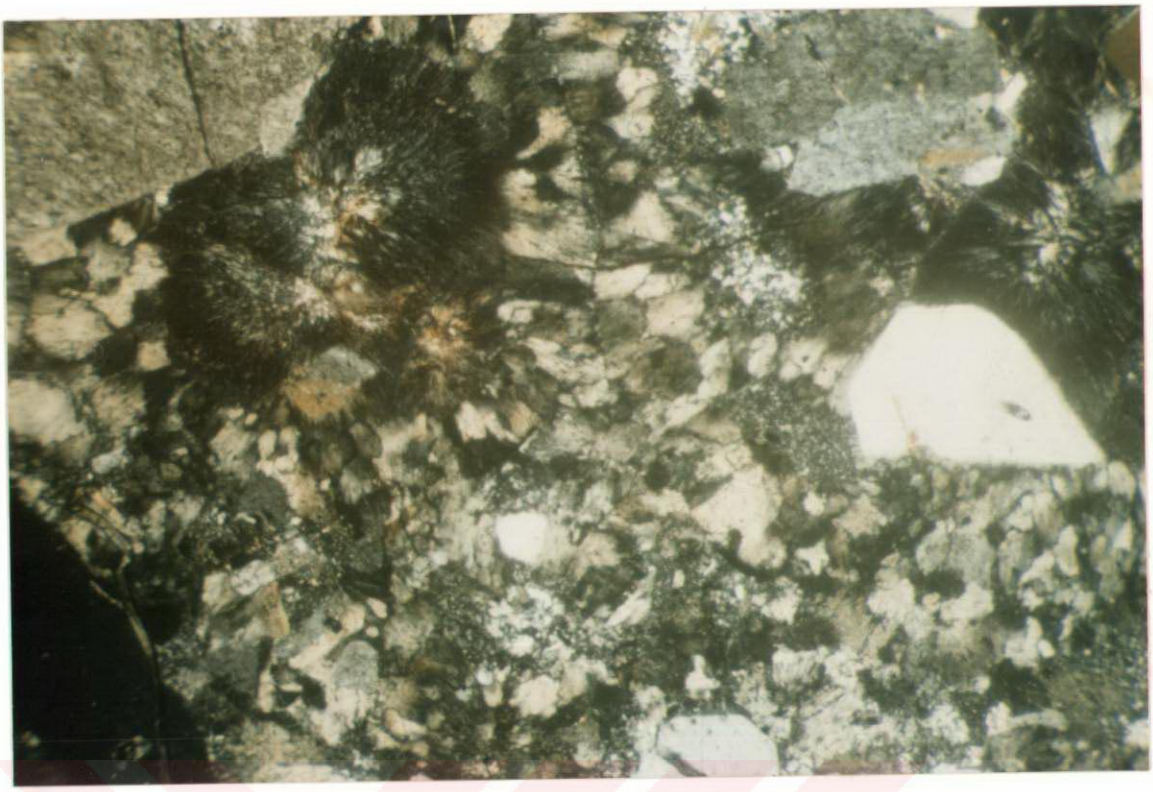


Fig. I4.A.

0 630 μ

Fig. I4.B.

0 630 μ

Fig. 15. Photomicrograph of rhyodacite from the Yozgat magmatics.Fluidal texture in matrix is clear. Euhedral quartz phenocrystal is sees in glassy matrix. (Q): Quartz,(uncrossed nicols).

Fig. 15.

0 630 μ

Fig. 16. Photomicrograph of andesite from the Yozgat magmatics.Porphyitic texture is clear. Plagioclas amphibole phenocrystals are seen in cryptocrystalline matrix. (Plg): Plagioclase, (Amp): Amphibole, (uncrossed nicols).

Fig. 17. Photomicrograph of rhyolite from the Yozgat magmatics. An embayed quartz phenocrystal is clear in matrix (Q): Quartz, (B): Biotite (crossed nicols)

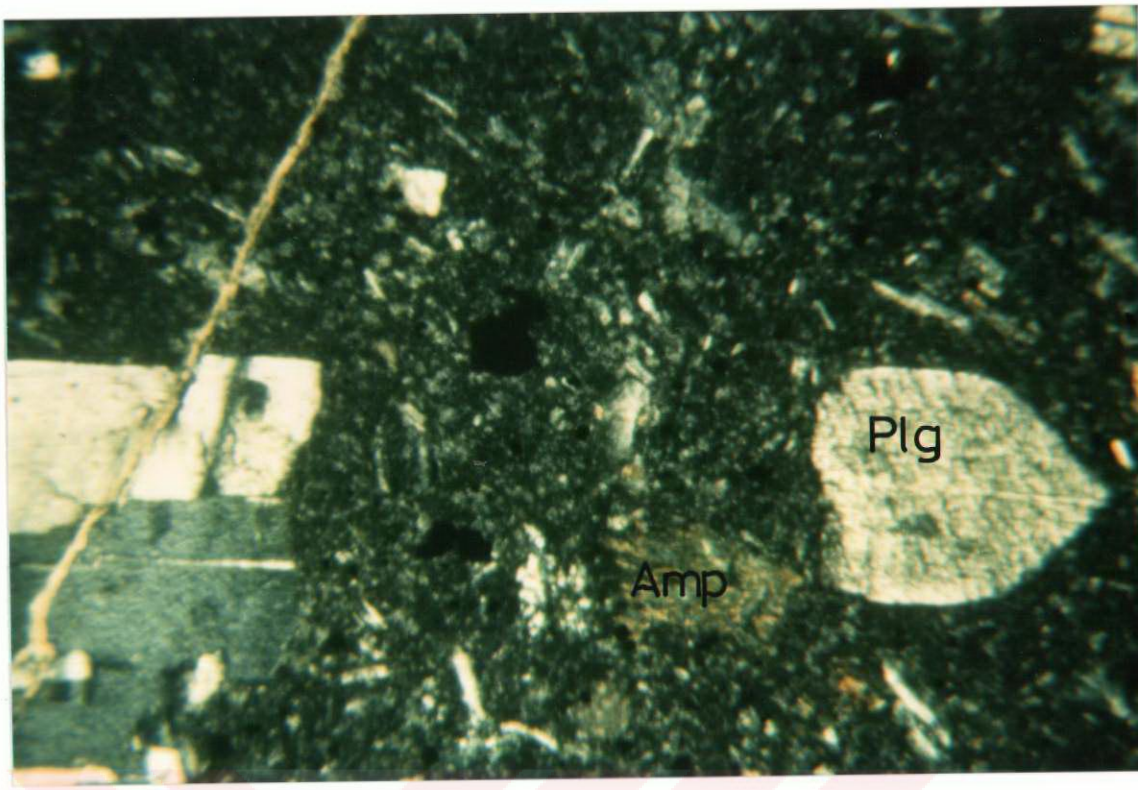


Fig. 16.

0 630 μ

Fig. 17.

0 630 μ

According to the (Na_2O + K_2O/SiO_2) diagram, constructed by Cox at al. (1979), the Yozgat magmatics gather in the field of granite (Fig. 18). In the same diagram there are also several samples located in the granodiorite and monzonite areas. In the Q/P diagram of Debon and Le Fort (1983), they are located in the fields of granite, granodiorite, monzodiorite, monzogranite and monzonite (Fig. 19) but they mostly cluster in the fields of adamellite and monzogranite. As these chemical analyses indicate, the plutonic rocks show a range of compositions, similar to the their appearance in the outcrops. In the outcrops, percantage of mafic minerals, pink K-Feldspar phenocrystals and quartz content change considerebly even in a few meters. The short changes of mineralogy and chemistry of the plutonic rocks are due to the their emplacement in a subvolcanic tectonic setting. Small subvolcanic stocks, dikes, apophyses from main plutons intrude into each other in a shallow crustal environment. This is probably one of the main reasons for the textural and mineralogical variations of the Yozgat magmatics. Another reason would be their low viscosity and high fluidity of the magma. High fluidity of the primery magma not only caused the textural and mineralogical variation but also caused the formation of large K-Feldspar pherocrystals, which is the pronounced characteristics of the Yozgat magmatics both in volcanic and also in plutonic settings.

According to A/B diagram of Debon and Le Fort (1983), the Yozgat magmatics are cafemic in character and located in the V.area (Fig. 20). The authors noted that, rocks placed in the V.area, are rich in amphiboles and biotites as mafic minerals. This is conformable with our petrographic data which were indicated above (Table 3).

In the SiO_2/MgO diagram of Miashiro (1974) and, FeO/Na_2O + K_2O/MgO triagle of Irvine and Baragar (1971), Yozgat magmatics are calc-alkaline in nature (Figs. 21,22).

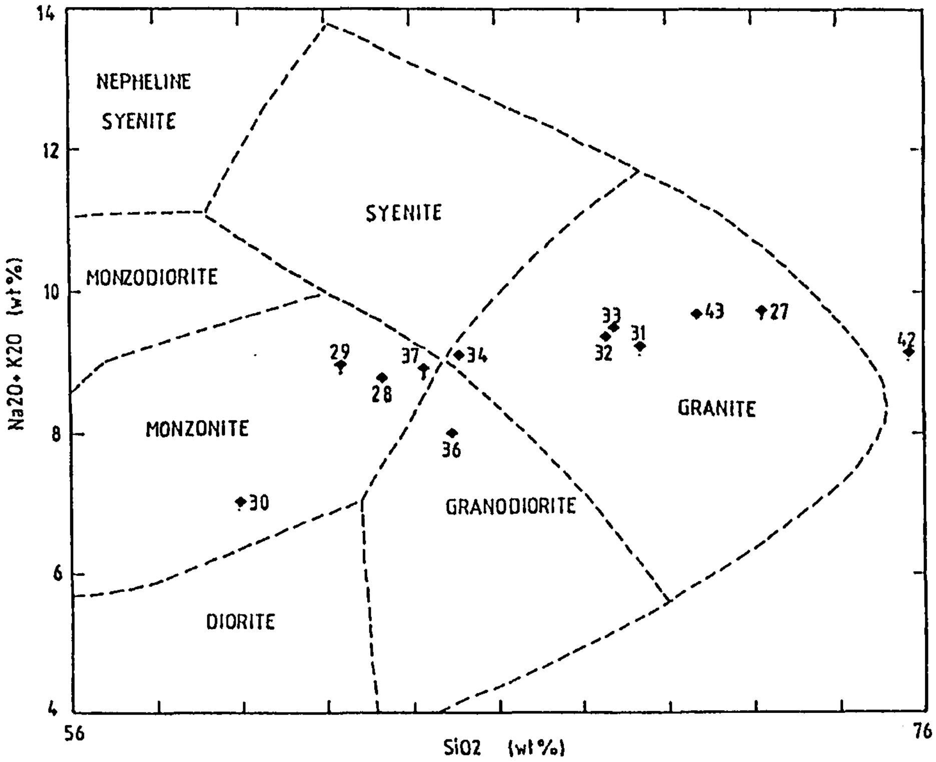


Fig. 18. (Na_2O+K_2O) versus SiO_2 variation of the Yozgat magmatics.

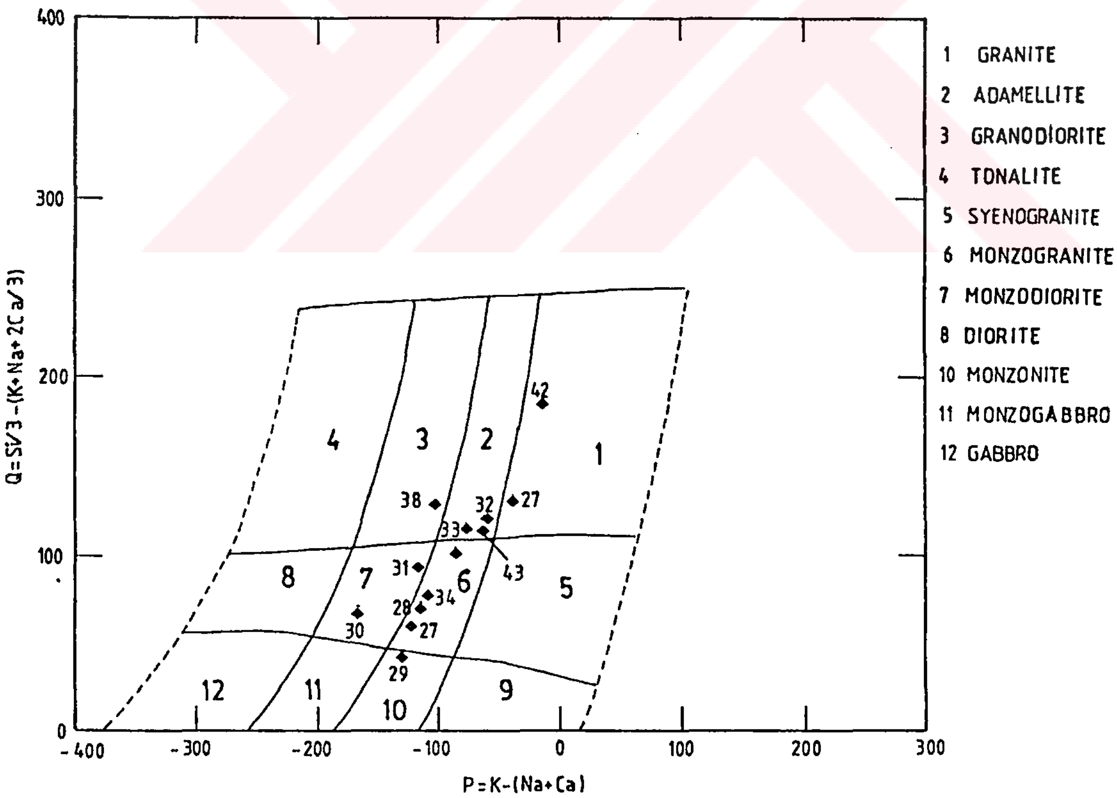


Fig. 19. Frequency of the Yozgat magmatics in Q/P diagram of Debon and Le Fort (1983).

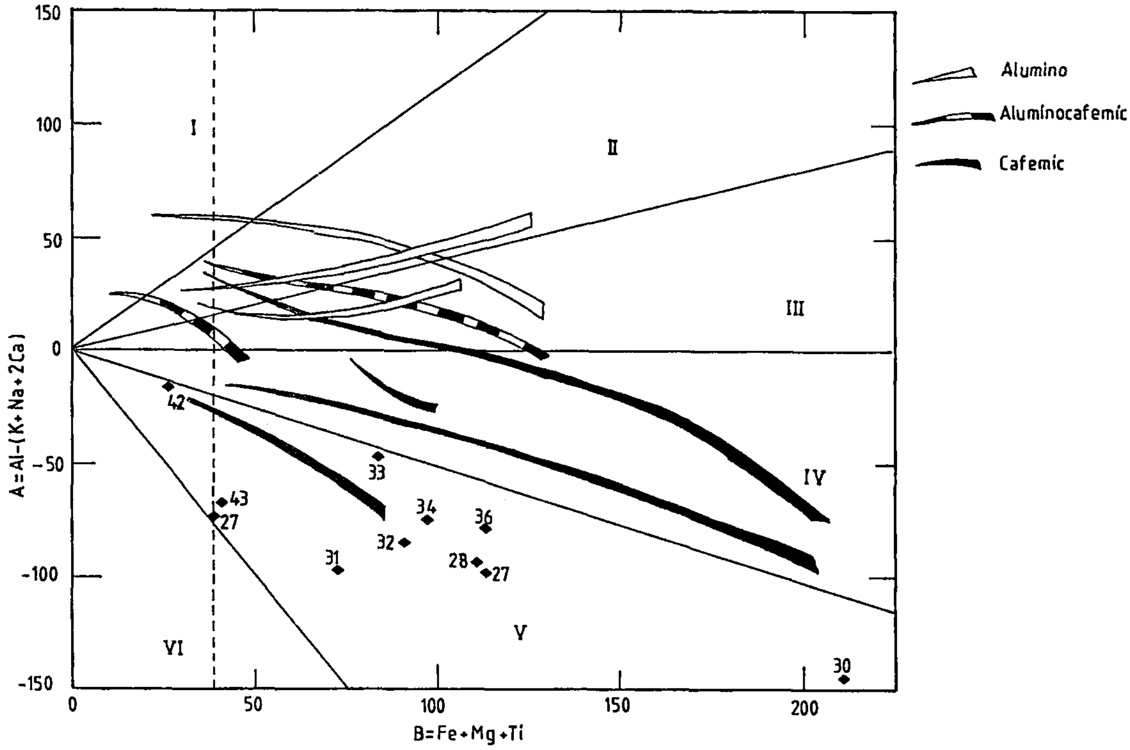


Fig. 20. Frequency of the Yozgat magmatics in A/B diagram of Debon and Le Fort (1983).

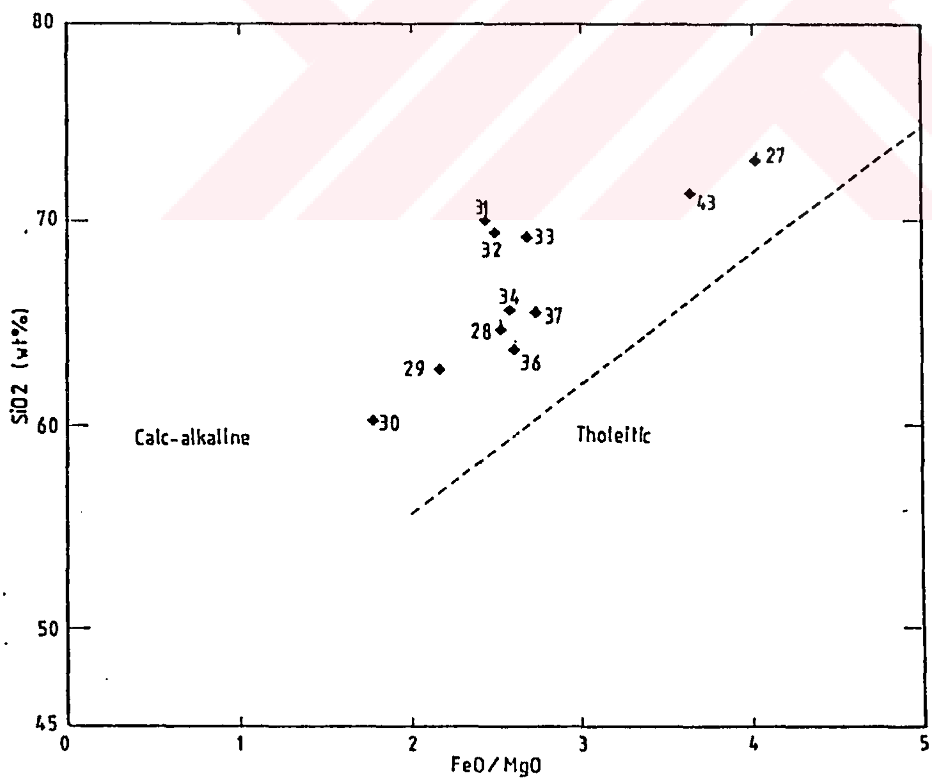


Fig. 21. SiO_2 versus (FeO/MgO) variation of the Yozgat magmatics.

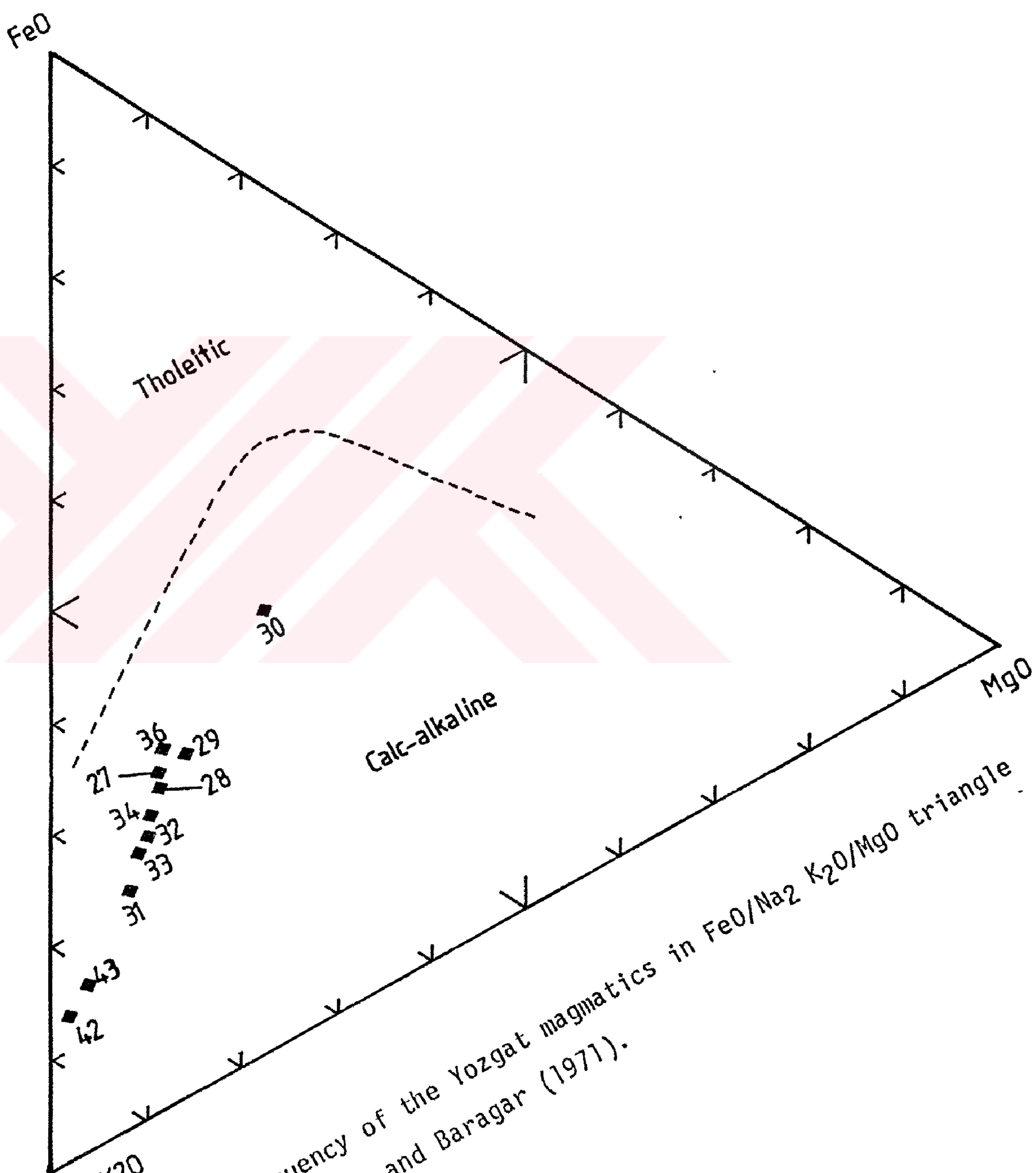


Fig. 22. Frequency of the Yozgat magmatics in FeO/Na_2 K_2O/MgO triangle of Irvine and Baragar (1971).

Results of the trace element analyses were transfered to some diagrams in order to approach the source of granitoids. According to Y/SiO_2 and Ga/Al_2O_3 diagrams of Collins et al.(1982), the Yozgat magmatics are I-type granitoids (Figs. 22,24). In the Rb/Y+Nb and Nb/Y diagrams of Pearce at al.(1984), the magmatics are placed in the areas of Volcanic Arc Granitoids and Within Plate Granitoids (Figs. 25,26). The authors classified these kind of granitoids as Collisional Granitoids.

2.1.2.4. Age

There are several radiometric age determinations on the plutonic masses cropping out around Kaman. Ayan, (1963) determined the age of the Cefalıkdağ Pluton as 54 m.y suggesting the Early Eocene time and Ataman (1972) as 71 m.y. indicating the Maastrichtian time. Güleç (1993) determined the age of the Ağaçören granitoid as 108 m.y. which indicates Albian or Late Early Cretaceous.

The Yozgat magmatics cut the Çökelik volcanics which are Turonian - Santonian in age and unconformably overlain by Late Paleocene deposits. So that stratigraphic relationships in the study area, give more pricise age than the radiometric ages given above. For example 108 m.y. age is too old compared with our stratigraphic age and also 54 m.y is too young because we obtained Late Paleocene age from the sediments overlying the granites with angular unconformity. The basal conglomerate of the overlying rocks are composed of dominantly clasts from the granitic rocks. This indicates clearly that the Yozgat magmatism would developed between the Santonian and the Late Paleocene.

2.1.2.5. Contacts

Yozgat magmatics cut the Çökelik volcanics. This relationship can be observed at the western edge of the study area (Fig.9). Around Harmanpınarı village in the

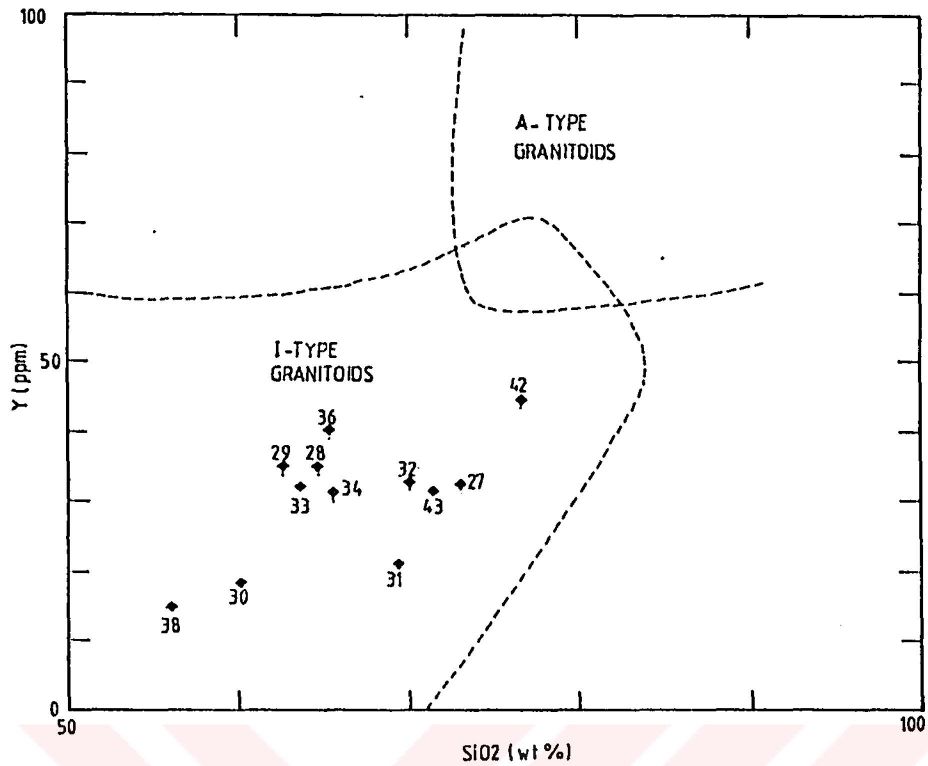


Fig. 23. Y versus SiO_2 variation of the Yozgat magmatics.

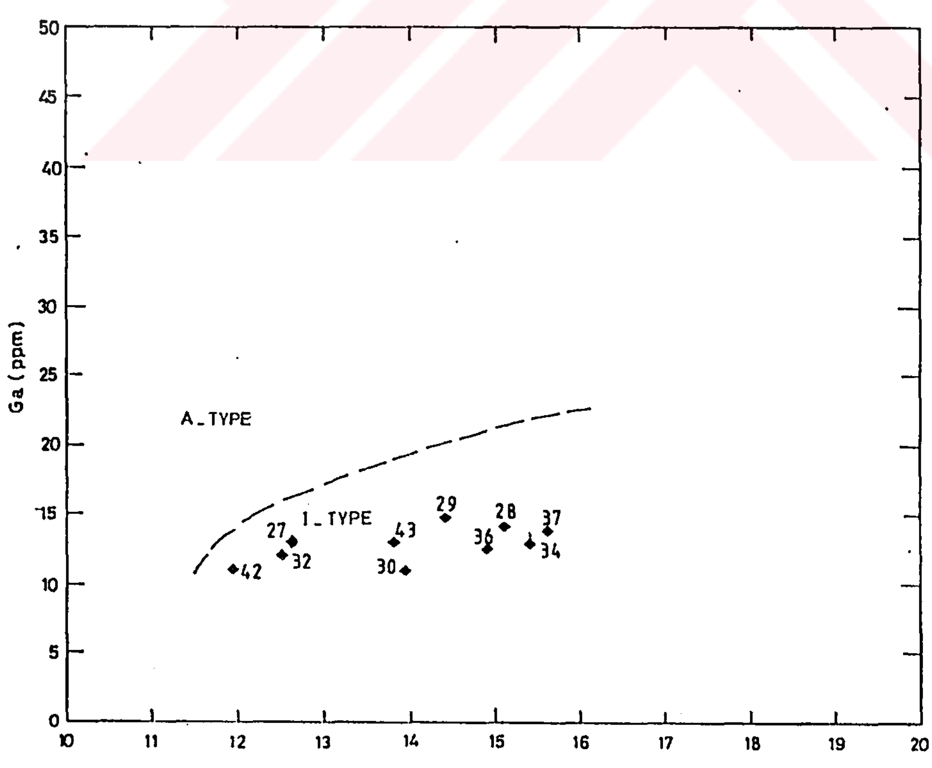


Fig. 24. Ga versus Al_2O_3 variation of the Yozgat magmatics.

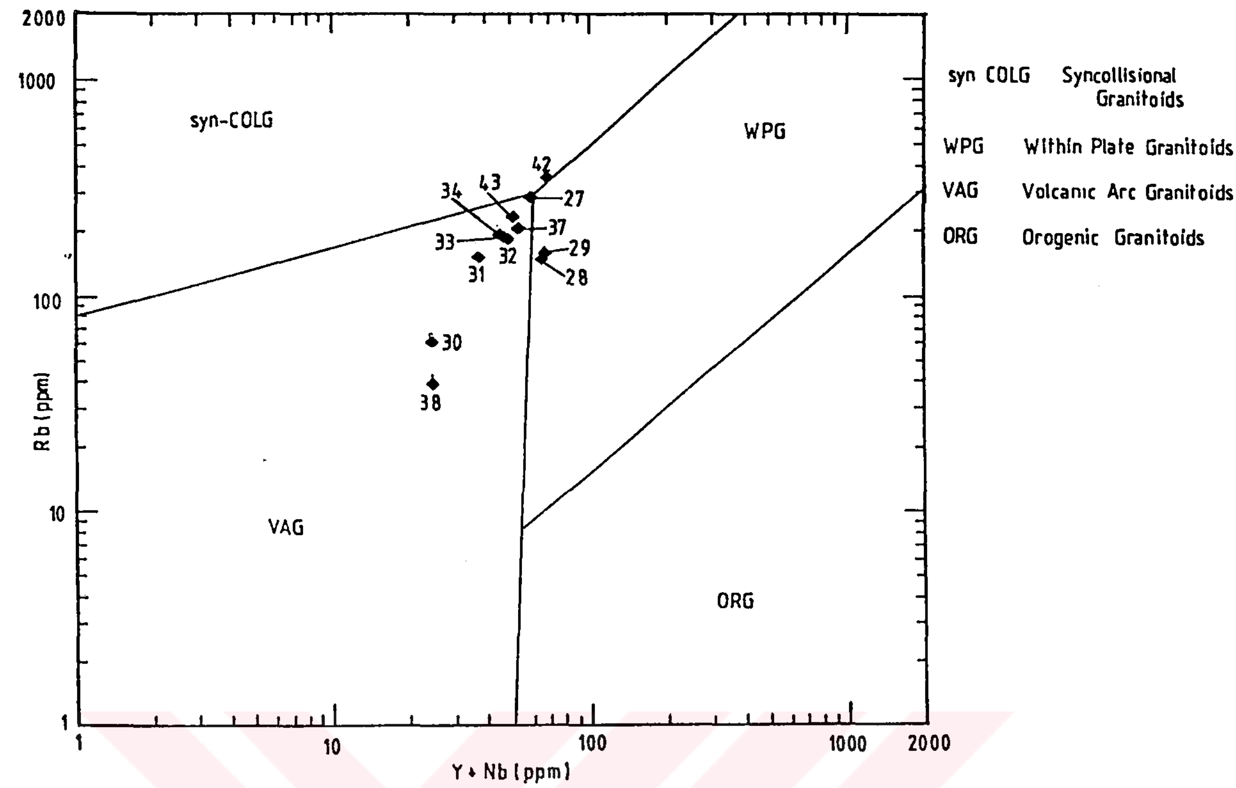


Fig. 25. Rb versus (Y+Nb) variation of the Yozgat magmatics.

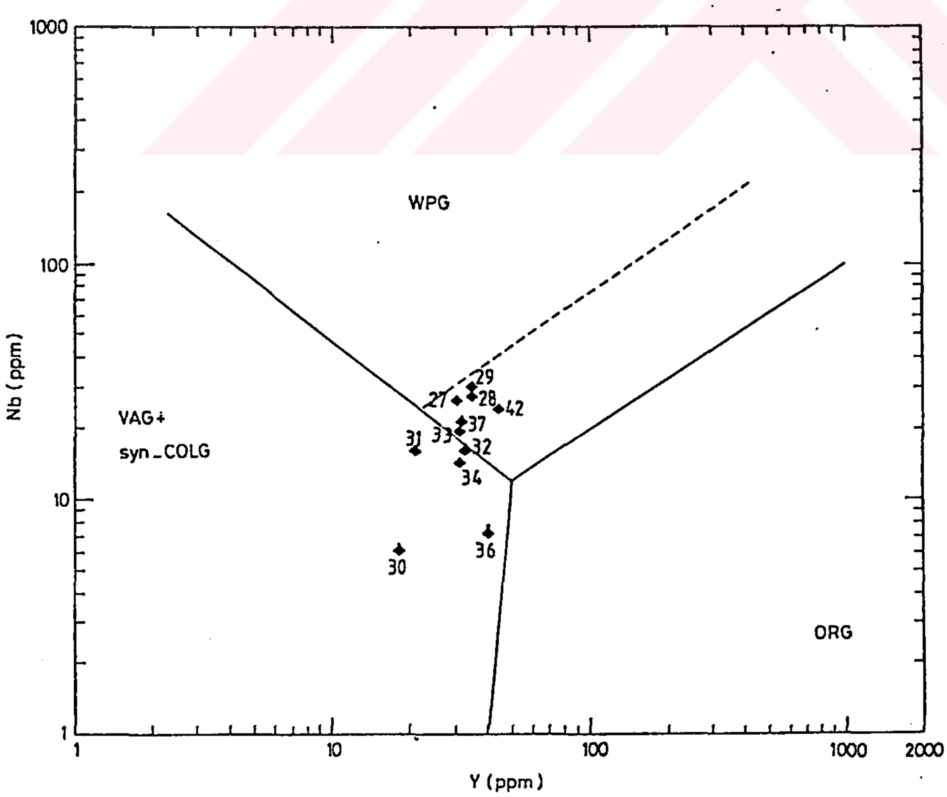


Fig. 26. Nb versus Y variation of the Yozgat magmatics.

west of Çiçekdağ, around Yozgat, on the Yerköy-Yozgat highway and in Arabın mah. village (Plate 1B,C) Yozgat magmatics are overlain by Late Paleocene-Eocene limestones and sandy limestones of Çankırı-Çorum Basin. In these contacts, the Early Tertiary sediments always start with coarse grained basal conglomerates or blockstones (Fig. 27). In these blockstones, particles and pebbles derived from the Yozgat magmatics are found in sandy or carbonate matrix.

In the south of Yerköy, around Hamam Hill, volcanic rocks of Yozgat magmatics are unconformably overlain by red conglomerates of İncik Formation and at the southeast corner of the study area by volcanics of Bayat Formation (Plate 1C). In this locality the Bayat Formation stars with a basal conglomerate of about 5 m. thickness and pass into the basaltic lavas with massive internal structure.

In the Yozgat magmatics, granitoids with different mineralogical and chemical compositions, pass into each other graditionally and sharp contacts between plutonic rocks and their volcanic equivalents are also not seen. Between Yerköy and Şefaatli this contact is often cut by subvolcanic porphyries of granitoids indicating subvolcanic, shallow crustal environment of intrusion. The volcanic pile would be extruded first and followed by stocks, dykes, and apophyses of the plutonic rocks that partly injected into lower parts of the volcanic pile.

2.1.2.6. Discussion

Tüysüz and Dellaloğlu (1992) and Tüysüz (in print) interpreted the magmatic rocks, cutting the Kırşehir metamorphics and ophiolitic rocks, as arc magmatics which were formed in a subduction zone. And some other authors (Türeli et al., 1993, Geven et al.,1993) considered the derivation of the Yozgat magmatics by partial melting of the Kırşehir metamorphics in the collision zone of the Taurid and Pontid Blocks.

Fig. 27. Looking at the contact between the Yozgat magmatics and the Kocaçay member on the Yerköy-Yozgat highway. Blocks from the Yozgat magmatics are connected by sandy or carbonate matrix and these basal conglomerates are overlain by the Kocaçay member in the upper part of the photo (On the Yerköy-Yozgat highway, about three km. to southwest of Yozgat).

Fig. 27.

Erler et al.(1989) and Erlerand Bayhan (1993) indicated the plutons in the Kaman region as derived from in an arc-environment which were formed by a subduction zone under the Kırşehir Massif. Thus, the plutons in the Yozgat region were formed by partial melting of the metamorphics in the collision zone of the Pontid and Taurid Blocks.

Boztuğ (1989), indicates that the cafemic, calc-alkaline, I-type granitoids are crystalized from a hylorid magma derived from both mantle and crustal material and tey characterize the arc-type magmatism.

The geochemical and regional data of the Yozgat magmatics indicate that these rocks were formed in an arc setting and emplaced into the Çökelik volcanics between the Santonian and the Late Paleocene. Volcanic equivalents of the plutonic rocks reach more than 2 km. in thickness and the Yozgat magmatics form extensive outcrops between Yerköy and Şefaatli. These all suggest that the magmatism was not a local phenomena but rather great amount of magma generation occured. It appears that, local cratonic melting by loading of thrusts can not explain this kind of large volume of magma generation.

2.2. STRATIGRAPHY of the ÇANKIRI-ÇORUM BASİN

All the units mentioned above, form the basement in the study area and are overlain by sedimentary and volcanic rocks of the Çankırı-Çorum Basin which are Late Paleocene to Pleistocene in age. In this sequence 6 formations are distinquished. They are the Yoncalı Formation, Bayat Formation, İncik Formation, Kızılırmak Formation, Bozkır Formation and Değim Formation. The Yoncalı, Bayat and Incik are the Late Paleocene-Eocene, the Kızılırmak and Bozkır are the Miocene and the Değim is the Pleistocene in age. In the Yoncalı Formation, the Kocaçay member consisting of fossiliferous limestones and sandy limestones is seperated. In the Paleocene-Eocene succession the rock units grade into each other laterally and vertically. The Miocene units lay unconformably above the Paleocene-Eocene succession and the Değim also unconformably overlies the all other units.

2.2.1. Yoncalı Formation

2.2.1.1. Description

In this study the Yoncalı Formation is used for shallow marine and terrestrial sediments which consist of fossiliferous sandstones, shales and carbonates. As will be mention, these carbonates and sandy carbonates are distinquished as the Kocaçay member. The Yoncalı Formation was first used by Birgili et al.(1975) for lithologically similar units which are observed in the northern part of the Çankırı-Çorum Basin. This formation corresponds to flysch-type rocks which crop out in the northern parts of the Çankırı-Çorum Basin and include turbiditic sequences.

Tüysüz and Dellaloğlu (1992) and Tüysüz (in print) considered these turbiditic rocks as a part of İskilip Unit.

Görür et al.(1985) interpreted these türbiditic rocks as deep-sea deposits and named as the Eski Polatlı Formation. Şenalp (1980) named the turbiditic rocks, cropping out around Sungurlu as the Cevherli Formation which includes sandstone shale alternation and olistostromal conglomerates in it.

The Yoncalı Formation crops out around Yerköy and Çiçekdağ, in the north of Büyük Teflek village, around Karacaahmetli village (Plate 1B), between Yerköy and Yozgat and around Sungurlu (Fig. 2).

2.2.1.2. Lithology

The Yoncalı Formation is mainly composed of fossiliferous sandstones and shales. The Sandstones are yellow and greenish yellow in colour and have regular bedding. The thickness of beds varies from 10 to 50 cm. Grains are medium rounded and well sorted. The fine-medium grained sand stones are well consodilated. Feldspar and quartz grains are dominant. Mafic components from Çökelik volcanics are present in lesser amount then feldspar and quartz. These grains are connected by clayey matrix.

The shales which are predominant in the Yozgat Formation, brown, green in colour and mostly laminated. In the southern part of Arabın mah. village (Plate 1C), these shales include a coal seam of about 1 m. in thickness (Figs. 28,29). At this locality the coal seam is in carbonaceous shales, dark brown-black in colour, and these shales pass into mudstones of the Yoncalı Formation in the upper and lower parts (Figs. 28,29).

In the study area the Yoncalı is dominantly composed of mudstones with very rare thin and regularly bedded siltstone lenses. Typical flysch facies with alterating Bauma sequences are not found. Sporadically the green shales of the Yoncalı include Nummulites-rich limestone lenses become carbonate rich shales that contain abundant Nummulites fossils. It was formed shallow to relatively calm marine environment.

2.2.1.3. Age

In the Yoncalı Formation shales and claystones include large amounts of foraminifera fossils.

In the samples, collected from the shales including coal seam in Arabın mah. village (18950/73600 in the sheet of I 32 c_3, Plate 1C) following fossil assemblages were determined by paleontologists of the paleontology section of TPAO.

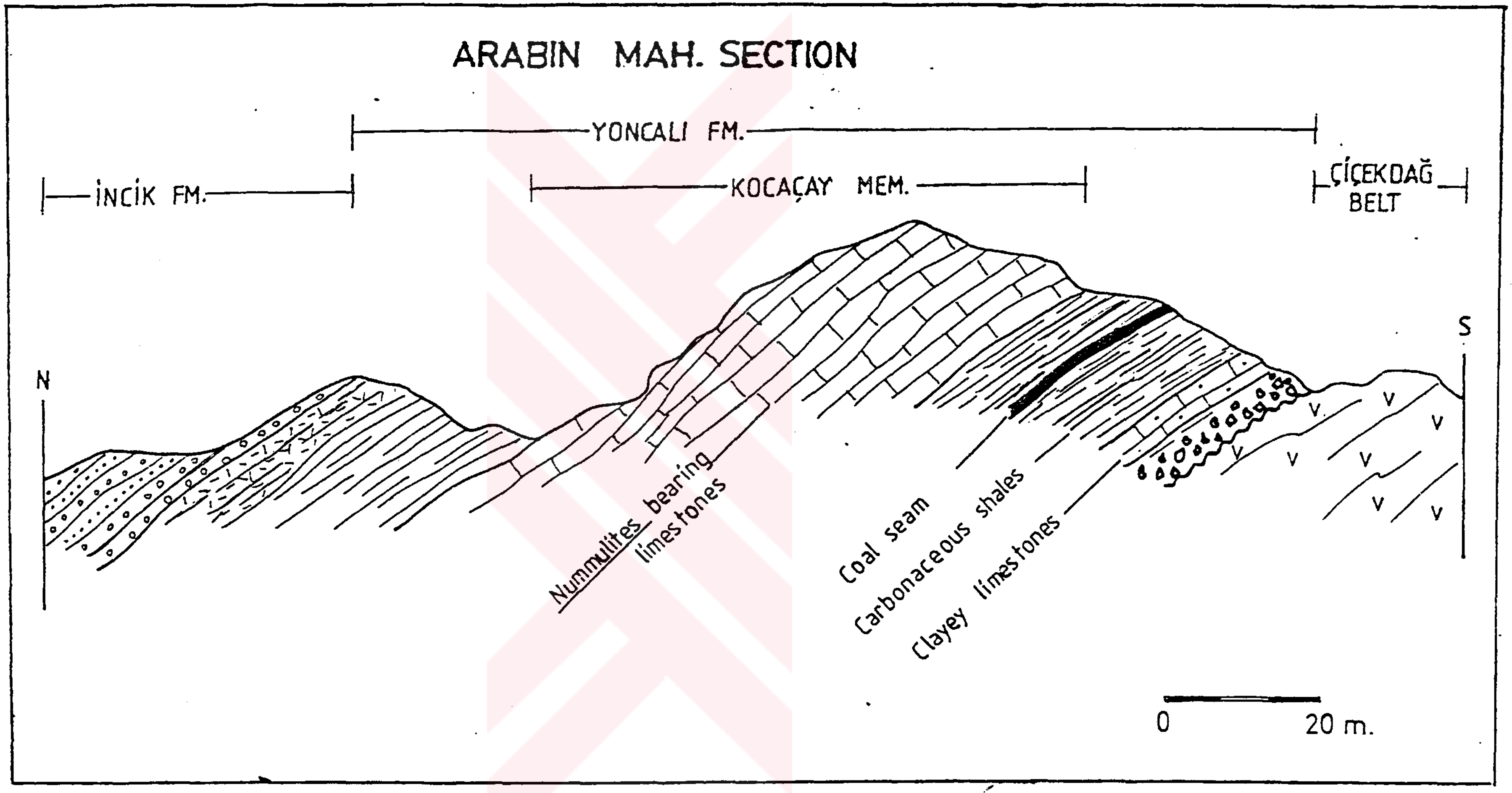


Fig. 28. Cross section showing the relationship of the basement and the Yoncalı and İncik Formations in Arabın Mahallesi village.

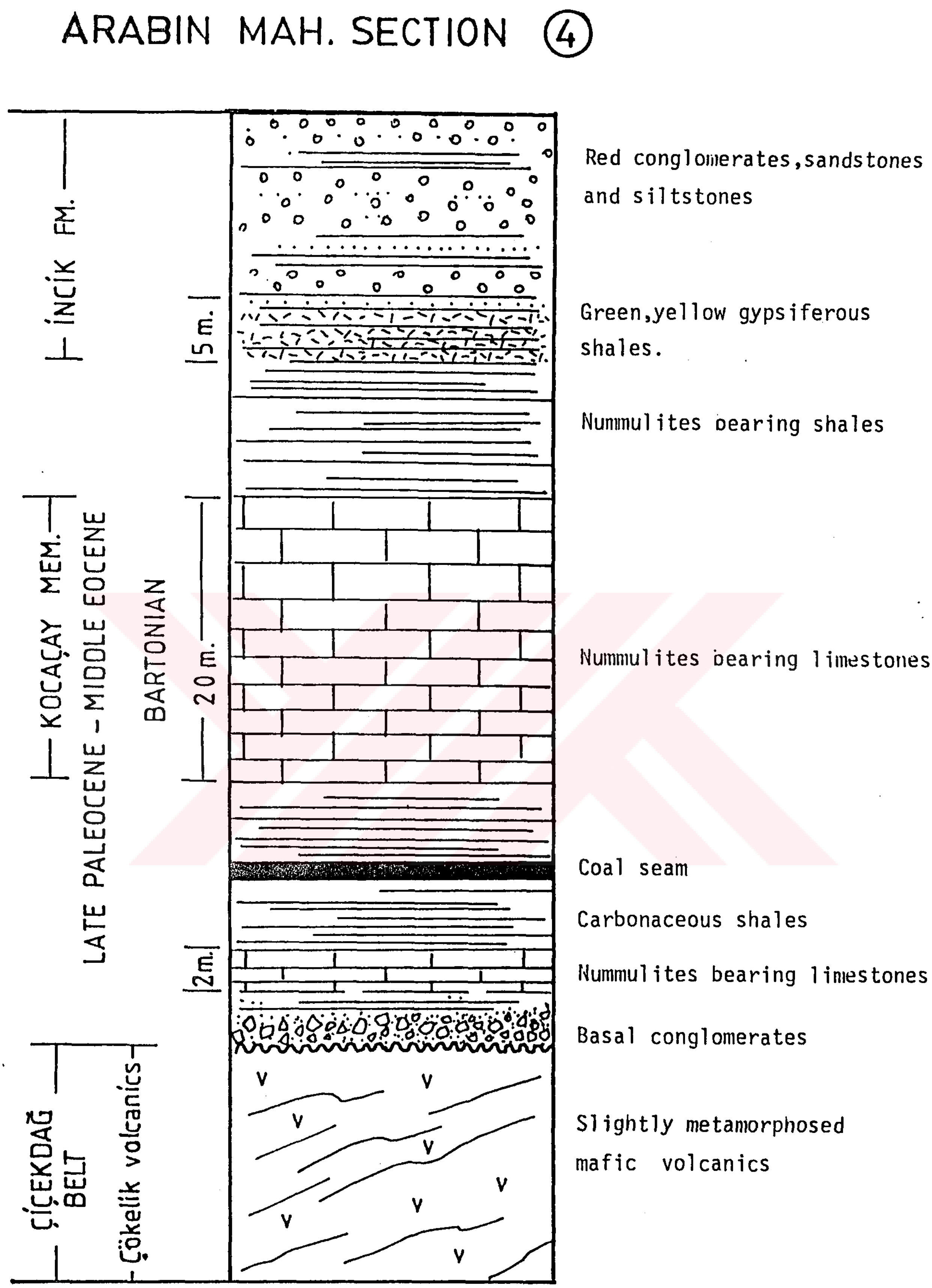


Fig. 29. Measured stratigraphic section in Arabın Mahallesi village

Morozovella pseudobulloides

Morozovella quetra

Globigerina triloculinoides

Vulvulina sp.

Vaginulina sp.

Bulimina sp.

Rotalia sp.

Eponides sp.

Robulus sp.

This fossil assemblage characterizes the Late Paleocene-Early Eocene time.

The fossil contents of samples, collected from Çorak Hill, around Çiçekdağ (21900/85300 in the sheet of I32 c_3, Plate 1B) are as fallows:

Morozovella spinulosa

Acarinina bullbroaki

Morozovella subbotinae

Morozovella quetra

Globigerina triloculinoides

Globigerina senni

Globigerina linaperta

Planulina sp.

Eponides sp.

This assemblage characterizes the Early Eocene age. In the south of Yerköy following fossil assemblages of the Middle Eocene were determined in the shale samples 21900/85300 in the sheet of I32 c_3, Plate 1C).

Globigerina eocaena

G. linaperta

G. pseudoeocaena

G. apertuna

G. infflata

G. frontosa

Truncorotalides topilensis

Globigerinoides higginsi

Morozovella spinuloso

Acarinina pseudotopilensis

Acarinina broedermanni

The palynological contents of shale and coal samples collected from Arabın mah. village are given in Tables 4 and 5. These palynological contents characterizes the Middle Eocene age.

According to the all these determinations, it is obvious that,the earliest age of the Tertiary sequence of Çankırı-Çorum Basin is the Late Paleocene in age but from the middle and upper part of the unit ages of the Middle-Early Eocene are obtained.

2.2.1.4. Contacts

In the south of Yerköy, around Çiçekdağ and further south, around Dulkadirli village (Plate 1B,C,D) the Yoncalı Formation overlies the rock units of the Çiçekdağ Belt unconformably. In these contacts Yoncalı Formation starts with a basal conglomerates at the base and upward passes into the shales and limestones of the Kocaçay member (Figs. 28,29,30). The basal conglomerates may have thickness varying from 1 m. to 5 m. In the south of Yerköy, shales and claystones of the Yoncalı Formation overlie a thick, red conglomerate interval graditionally

FORMATIONS	YONCALI							
SAMPLE NUMBERS	434	429	428	427	108	109	110	111
SPORES								
Laevigatosporites haardti	3	7			2	7		
Verrucatosporites cf. alienus				+	2			
Verrucatosporites favus	3					1	+	
Leiotritriletes microadriennis		3	3				+	
Concavisporites arugulatus				+				
Concavisporites sp.							1	
Trilites solidus					1		+	
Baculatisporites primarius			1	+	3	1		4
Cicatricosisporites sp.							+	
Cingulatisporites macrospeciosus				4				1
Cingulatisporites gracicingulis			+					
Cingulatisporites cf. verruspeciosus	1			+				
Gleicheniidites simplex							1	
Gleicheniidites sp.					1		1	
Verrucosisporites cf. rariverrucosus							+	
POLLEN								
Gymnospermae								
Pityosporites microalatus	2		2	6	3	3	9	4
Pityosporites labdacus								
Pityosporites libellus								
Inaperturopollenites magnus			1	+	1			+
Inaperturopollenites dubius	1	25	1	16	5	18	17	23
Inaperturopollenites hiatus	1		1			+		
Inaperturopollenites polyformosus								
Inaperturopollenites incertus								
Inaperturopollenites emmaensis	1	15	3		4	5	5	13
Ephedra claricristata	3			+	2			7
Ephedra hungarica								
Ephedra eosenipites	1							
Ephedra sp.							3	
Angiospermae								
Monocotyledoneae								
Monocolpopollenites tracycarpoides	1			1	1			
Monoporopollenites gramineoides								
Monoporopollenites rarispinosus								
Couperipollis robustus				1				
Spinomonosulcites cf. varispinosus			+				+	
Spinomonosulcites cf. achinatus						2	1	
Acanthotricolpites intermedius				+	1		1	
Acanthotricolpites kutchensis				1				
Acanthotricolpites bulbospinosus				1		+		
Dicotyledonae								
Inaperturopollenites granulosus								
Triatriopollenites excelsus	6	5	10	3	7	3	2	5
Triatriopollenites pseudorurensis			1				2	
Triatriopollenites rurensis	3	2	4	3	2	2	1	
Triatriopollenites rurobituitus				1				
Triatriopollenites bituitus			4				+	
Triatriopollenites plicatus			2					
Triatriopollenites coryphaeus	1	2	1					
Triatriopollenites sp.	+						1	

Table 4. Sporomorph contents of the Arabın mah. shales and coal seam.

Triatriopollenites sp.	+						1	
Triporopollenites labraferus			3				+	
Triporopollenites simpliformis		+	3	+			4	
Triporopollenites constatus	1		1			1		
Subtriporopollenites anulatus	1		2	+	4	4		4
Subtriporopollenites simplex		1	1	4				
Subtriporopollenites constans	2		1		1		1	
Subtriporopollenites intraconstans	1		4	+				
Subtriporopollenites rariechinatus		+	+	+				
Subtriporopollenites intrastructus			+	+		1		
Subtriporopollenites sp.			+					
Intratriporopollenites magnoporatus								1
Intratriporopollenites indubitabilis	+							+
Intratriporopollenites instructus	1		+					
Intratriporopollenites sp.								
Polyvestibulopollenites verus								
Polyporopollenites carpinoides								
Polyporopollenites undulosus	3			1				2
Porocolpopollenites rotundus	+		1		1		1	
Porocolpopollenites cf. rotundus					1			
Porocolpopollenites stereoformis			2				1	
Porocolpopollenites vestibulum			2					
Porocolpopollenites sp.							1	1
Tricolpopollenites pudicus			+					
Tricolpopollenites cf. pudicus								
Tricolpopollenites henrici			1					
Tricolpopollenites asper				1				
Tricolpopollenites densus	4	12	4		3			
Tricolpopollenites retiformis		1	1	1		1		
Tricolpopollenites microhenrici	3		1	1	2		1	
Tricolpopollenites liblarensis		1	2					
Tricolpopollenites sp.		1	+		2			
Pistillipollenites mcgregorii				1		1		
Tricolporopollenites villensis			+				1	
Tricolporopollenites cingulum	19		6			+	+	1
Tricolporopollenites megaexactus	6	2	6	7	2	7	3	2
Tricolporopollenites steinensis				+		1		
Tricolporopollenites pseudocingulum	+		+				1	
Tricolporopollenites pacatus	+		6	1			1	
Tricolporopollenites cf. kruschi	1		3					
Tricolporopollenites baculoferus			+				1	
Tricolporopollenites porasper				1				
Tricolporopollenites microreticulatus	4		5	5		3	1	
Tricolporopollenites margaritatus	26	4	3	4	4	3	5	11
Tricolporopollenites sp.	1		1			1	1	1
Tricolporopollenites sp. (tubuliflorae type)								
Tetracolporopollenites obscurus			1				1	
Tetracolporopollenites abditus			2	1	6	1	3	2
Tetracolporopollenites microellipsus			2				1	
Tetracolporopollenites sapotoides								
Tetracolporopollenites manifestus			2				1	
Tetracolporopollenites cf.oblongus								
Tetracolporopollenites sp.				+				
Periporopollenites multiporatus								

Table 4. (Continued).

FORMATION	YONCALI							
SAMPLE NUMBERS	434	429	428	427	108	109	110	111
Areosphaeridium sp.						2		
Batiacasphaera sp.					1	2		1
Cleistosphaeridium sp.				2	2		+	
Cordosphaeridium inodes				+	2		+	
Hemicystodinium sp.				2				
Homotriblium sp.				1	2			
Impagidinium sp.				5			+	1
Impletosphaeridium sp.				10	7	20	8	7
Melitasphaeridium sp.					2			
Operculodinium sp.			+	2	3	2	2	
Pentadinium sp.					1			
Phthanoperidinium sp				3	1			
Polysphaeridium sp.				1	2	1	1	
Samlandia sp.								1
Spiniferites ramosus					5	3	2	5
Sipiniferites sp.				8	7	1	3	
Wetzeliella cf. symmetrica			+					
Wilsonidium echinosuturatum							1	
Wilsonidium cf. tabulatum						1		
Wilsonidium sp.						2	1	1
Didoflagellate sp.		19		1	5		7	2

Table 5. Dynoflagellate contents of the Arabın mah. shales.

YERKÖY SECTION ②

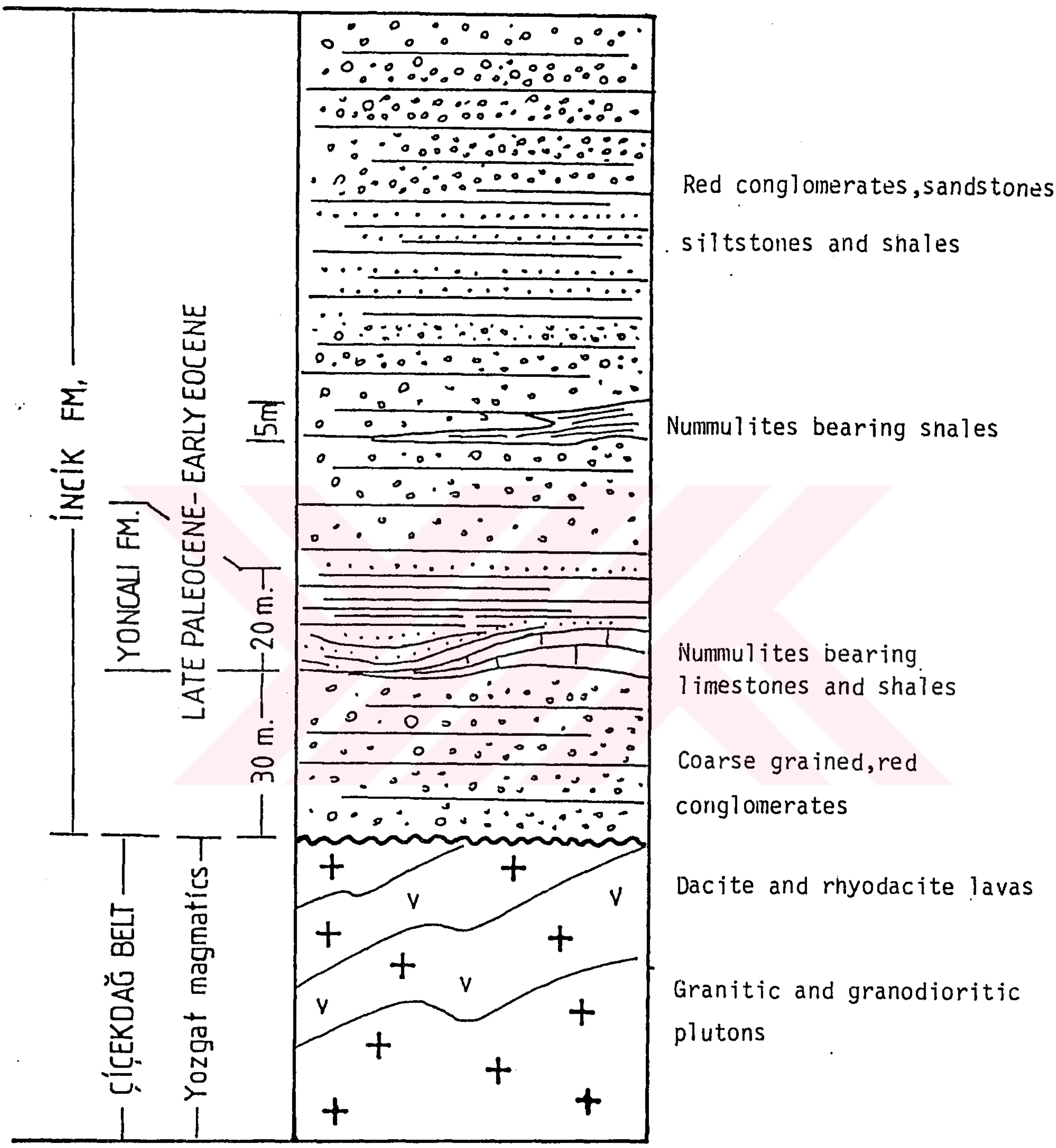


Fig. 30. Measured stratigraphic section of the lower part of the Tertiary succession around Yerköy.

and at the southeast corner of the study area, they overlie the lavas of the Bayat Formation (Fig. 30, Plate 1B,C).

In an area, 2,5 km. to the south of Çiçekdağ, shales of the Yoncalı Formation are overlain by the İncik Formation (Plate 1C). Along the same contact toward the south, the Yoncalı interfingers with the red conglomerates of the İncik.

To the north of Büyük Teflek village the shales of the Yoncalı are present as lenses within the İncik (Fig.31). At this locality the Nummulites-bearing shallow marine carbonate lenses of the Kocaçay member also incorporate into the interdigitating shales and red clastics (Plate 1 A,B,C,D, Figs.31,32).

The Yoncalı has graditional boundaries with the Bayat Formation. This contact can be seen on the Çiçekdağ-Kırşehir and Yerköy-Yozgat highways (Fig. 33, Plate 1C), the Bayat Formation overlies the Yoncalı and Kocaçay member and upward, it is overlain by them along a graditional contact (Figs.34,35). In Arabın mah. village fossiliferous shales of the Yoncalı are overlain by the İncik. At this contact shales grade into the clastics of İncik through gypsiferous levels (Figs. 28,29).

2.2.1.5. Discussion

Age determinations of the Yoncalı indicate that, in the southern margin of the Çankırı-Çorum Basin, sedimentation started during the Late Paleocene and continued in the Early and Middle Eocene time.
According to the fossil content and internal stratigraphy, the Yoncalı were deposited in a very shallow marine environment. From time to time this shallow sea was converted into the terrestrial environment and the coal seam and carbonaceous shales were formed.

Fig. 3I. Looking at the lenseof the Yoncalı Formation interfingering with the thick red clastics of the İncik Formation. Ty: Yoncalı Formation, Ti: İncik Formation.

Fig. 31.

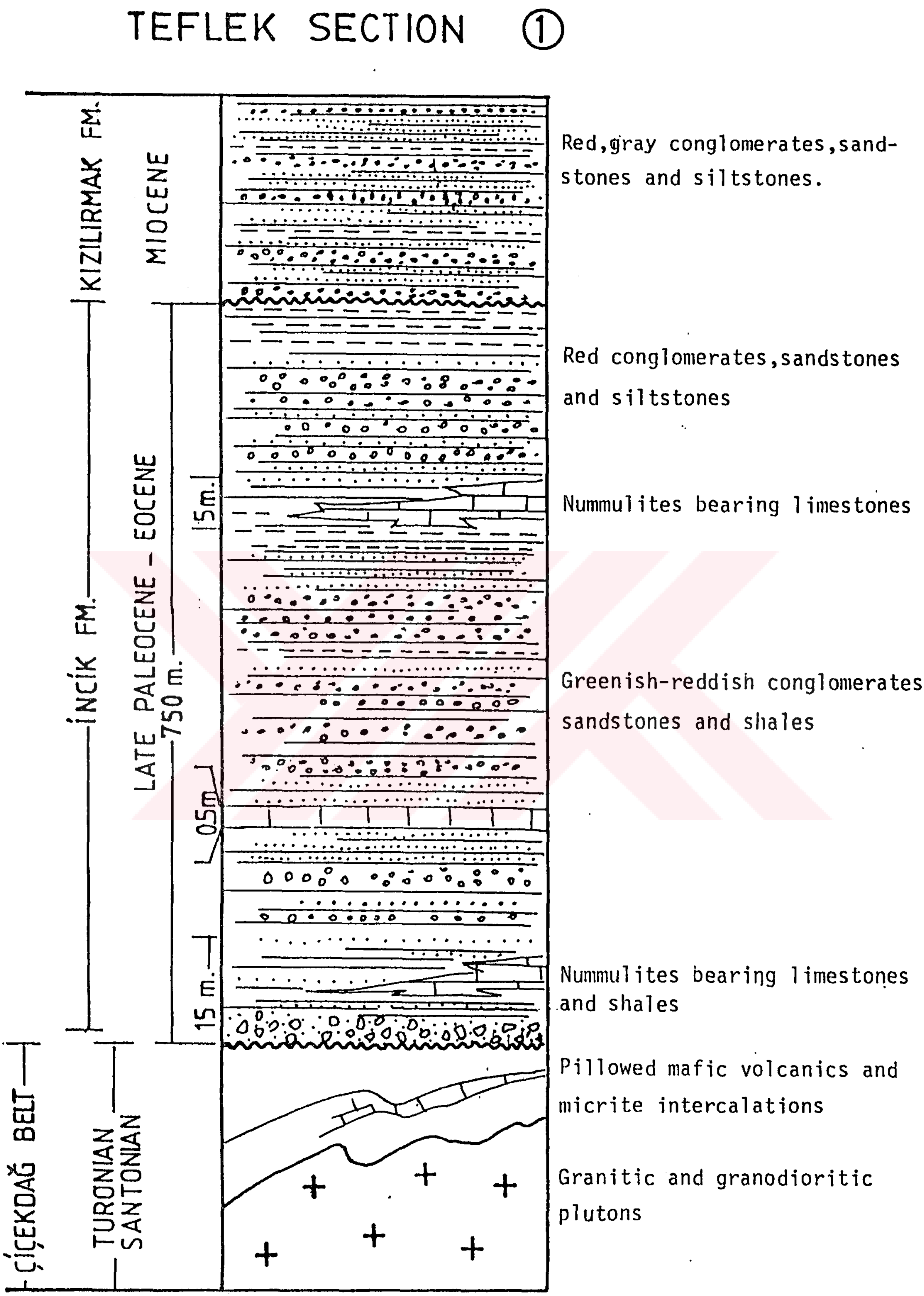


Fig. 32. Measured stratigraphic section of the Tertiary succession around Büyük Teflek village.

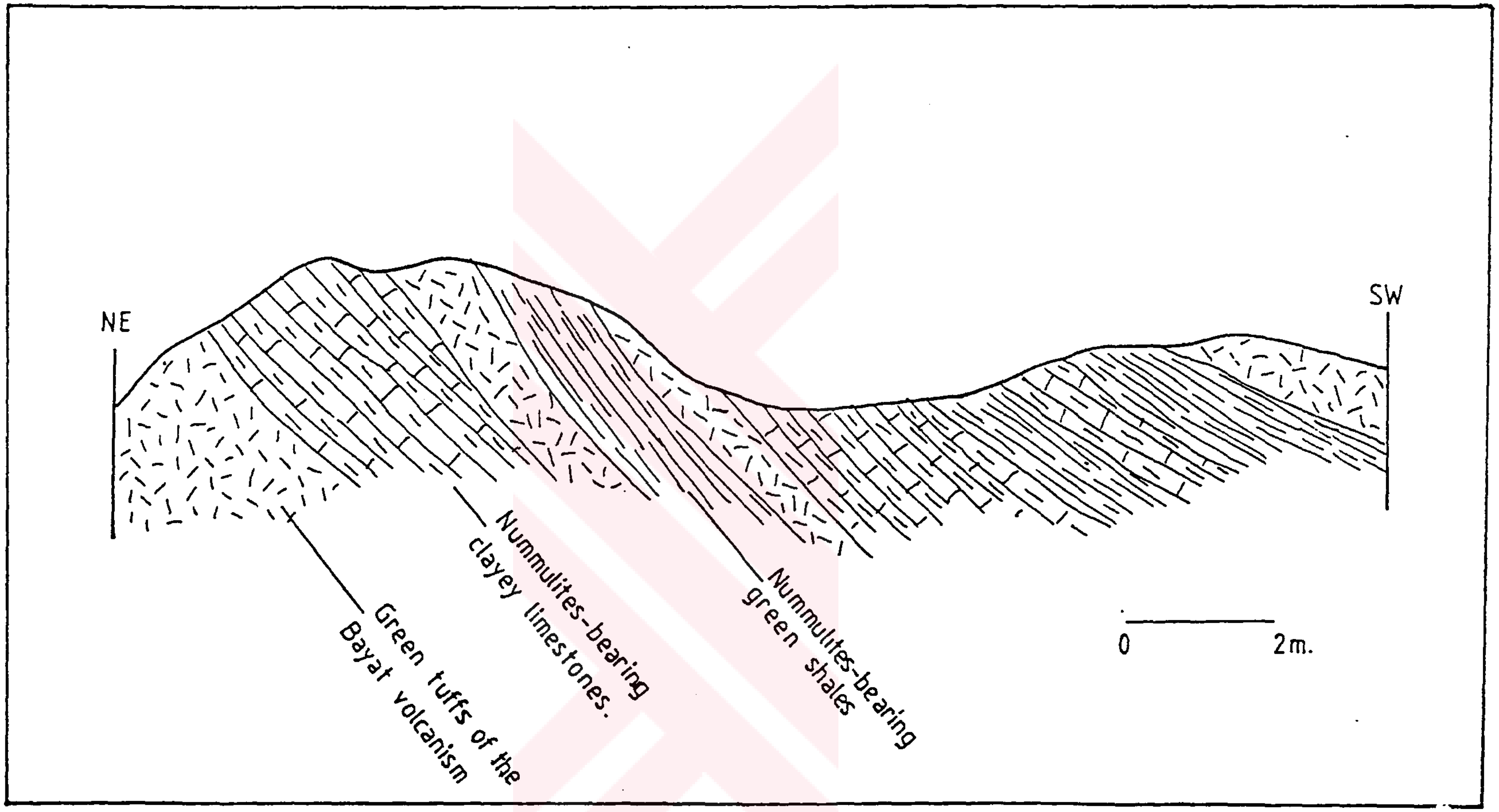


Fig. 33. Cross section showing the relationship between the Yoncalı and Bayat Formations on the Çiçekdağ-Kırşehir highway.

ÇİÇEKDAĞ SECTION ③

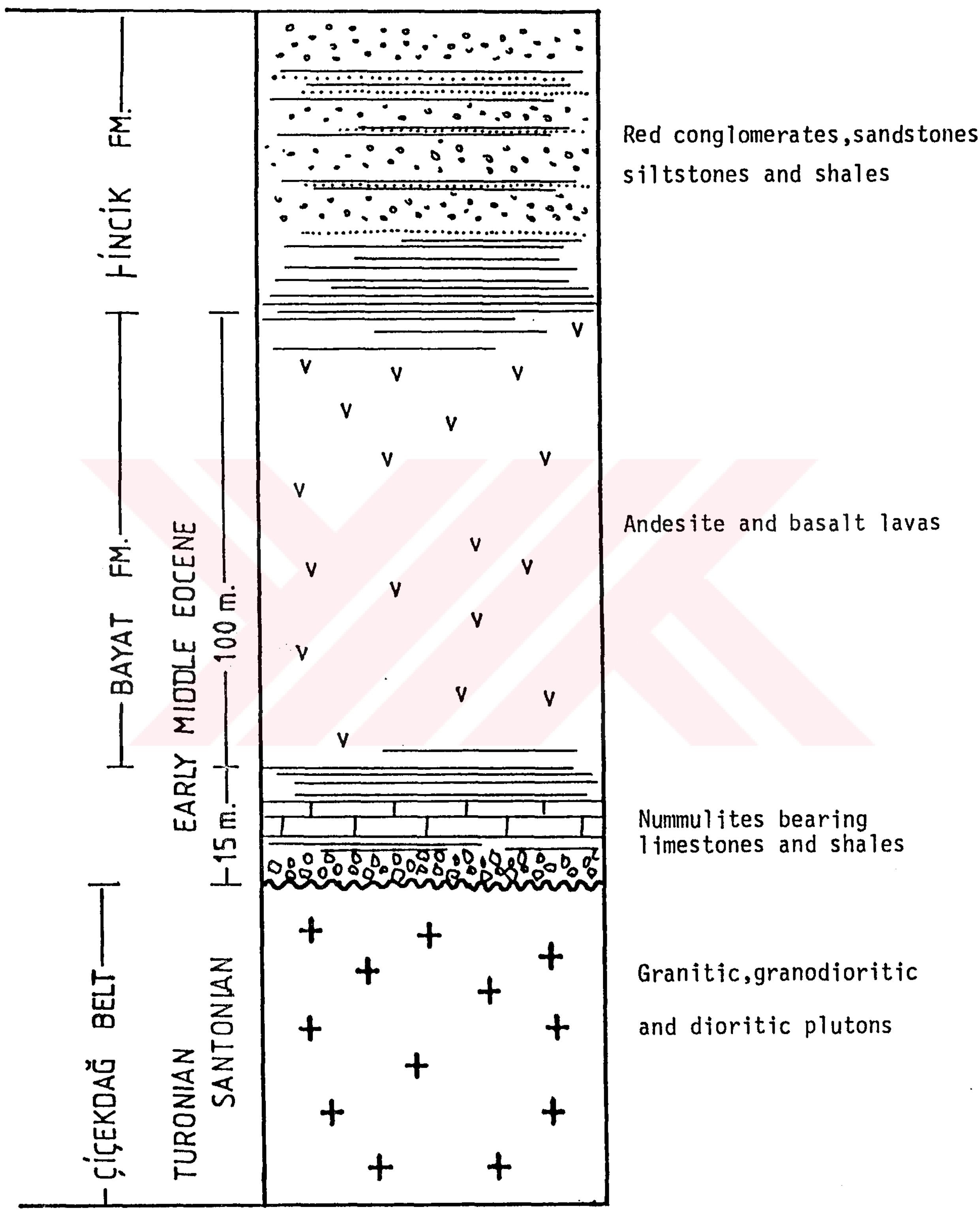


Fig. 34. Measured stratigraphic section of the sedimentary and volcanic pile of the Çankırı-Çorum Basin around Çiçekdağ.

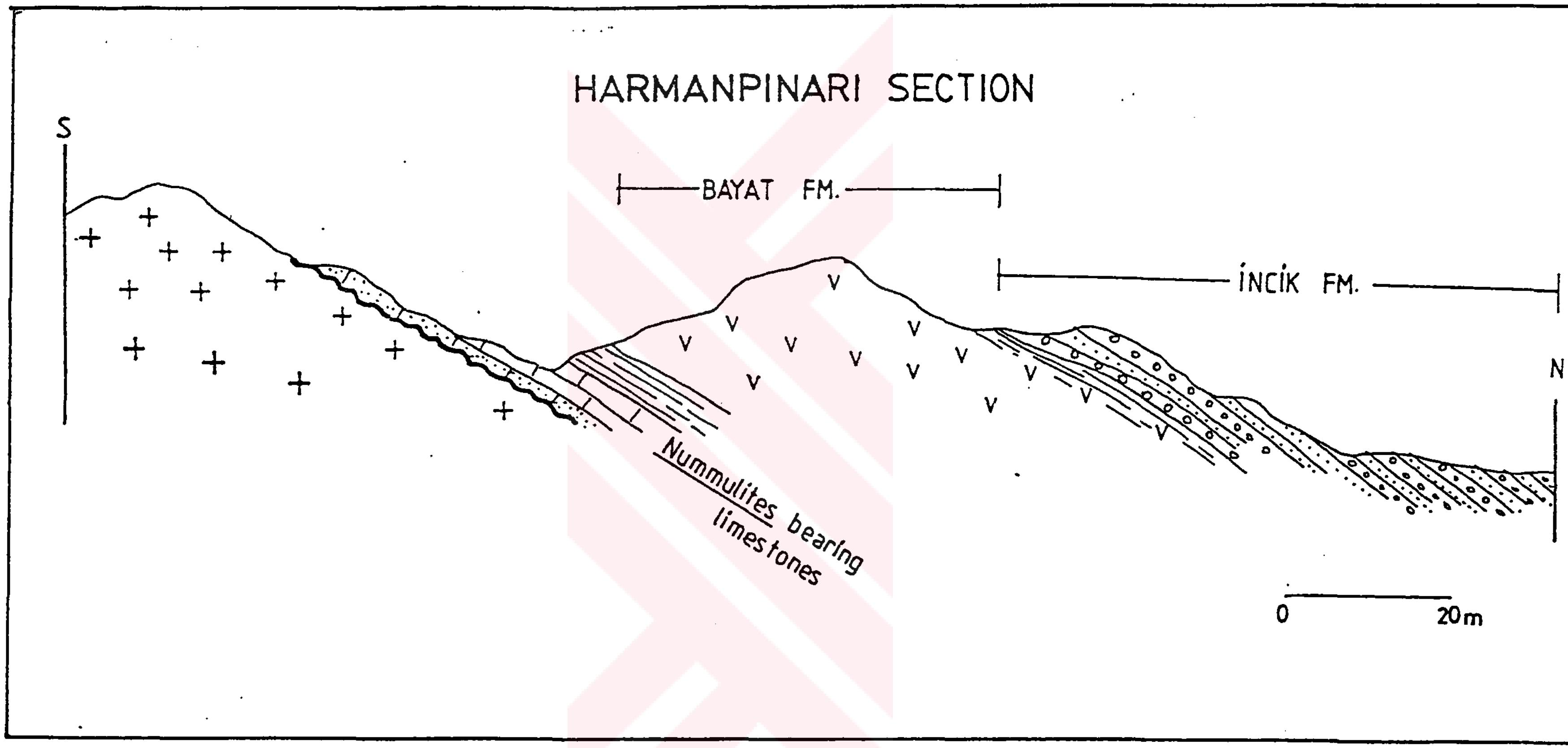


Fig. 35. Cross section showing the relation between the Çiçekdağ Belt, the Yoncalı Formation and the İncik Formation.

The graditional contact relationship between the Yoncalı and Bayat Formations indicates, in these shallow marine and terrestrial environment, andesitic-basaltic volcanic eruption took place sporadically.

2.2.1.a Kocaçay member

2.2.1.a.1 Description

The Yoncalı Formation includes lenses of shallow marine limestones in different stratigraphic levels and in various localities. In this study, these limestone lenses are named as the Kocaçay member, and where these lenses are thick enough, they are shown on the 1/25000 scale geological map (Plate 1).

Birgili et al.(1975) distinquished these limestones as a formation and named as the Kocaçay Formation. However, in this study, the same unit is named as a member because it appears in different levels in the Yoncalı as very thin or thick lenses. Some of the thick lenses can be followed long distances along their strikes but most of then pinches out in short distances or appear in different levels.

2.2.1.a.2 Lithology

The Kocaçay consists of limestones and sandy or clayey limestones of mainly yellow or yellowish white in colours. The limestones in places show regular bedding. Thickness of the bedding varies from 20 to 50 cm. The Kocaçay is quite rich in nummulites and lamellibranch fossils in all localities.

Around Dulkadirli village the Kocaçay includes shale and claystone intercalations of the Yoncalı (Fig. 36). These kind of intercalations can be observed in Arabın mah. village (Figs. 29,30) and around Şefaatli (Fig. 2).

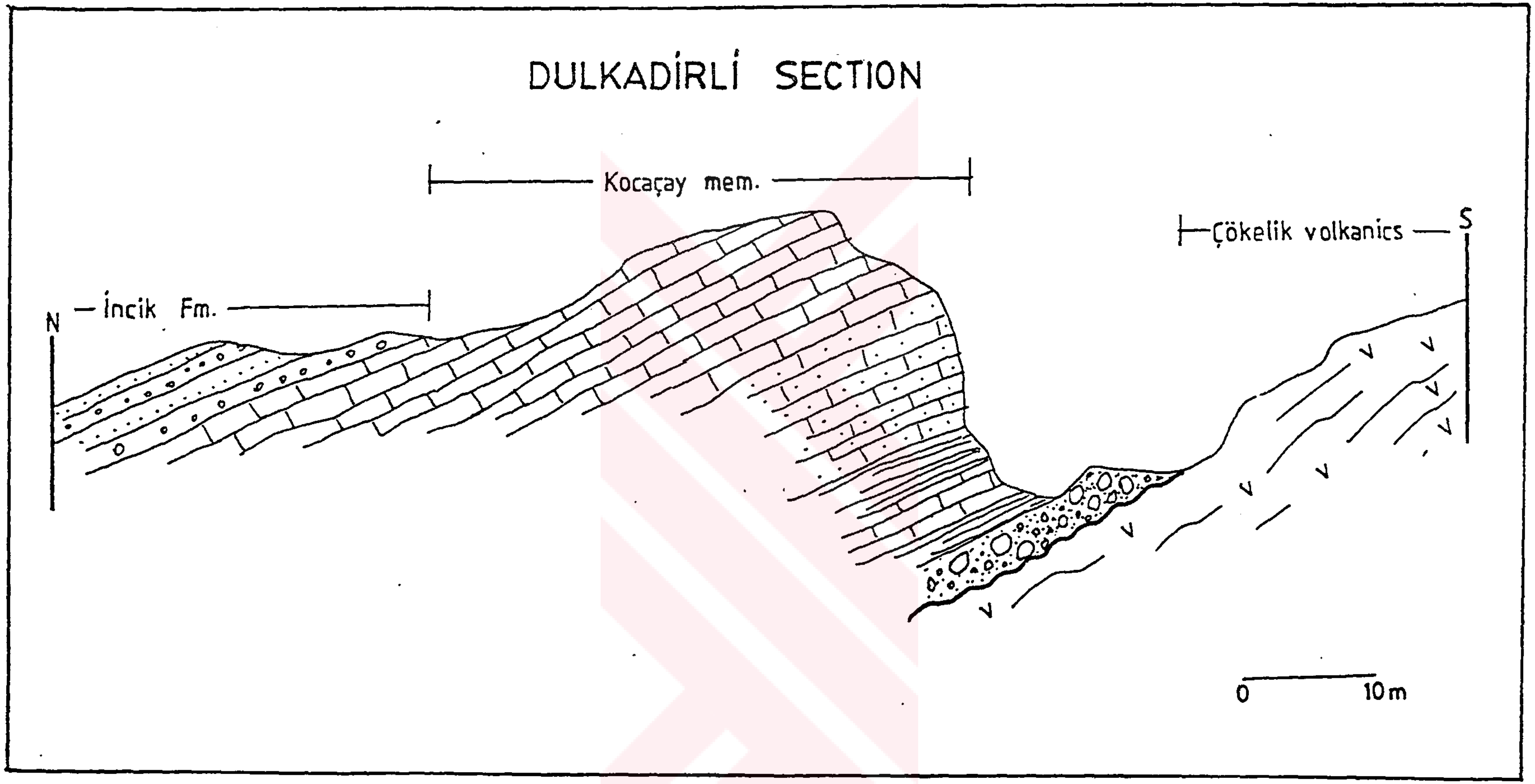


Fig. 36. Cross section showing the relation between the Çökelik volcanics, the Kocaçay member and the İncik Formation in Dulkadirli village.

2..2.1.a.3. Age

In the north of Büyük Teflek village (Plate 1B) the Kocaçay includes the following fossils of Late Paleocene-Early Eocene age.

Alveolina sp.
Nummulites sp.
Orbitolites sp.
Opthalmidium sp.
Dissocladella sp.
Miliolidae

In the samples collected from shales cropping out in the south of Yerköy (25200/81700 in the sheet of I32 c_3, Plate 1C).

Nummulites sp.
Biloculina
Quinqueloculina
Alveolina sp.
Glomospirella sp.
Miliolidae
Rotalidae
Alaxophragminidae

This assemblage suggests the Late Paleocene-Early Eocene age.
In the southern part of the study area, around Arabın mah. village, the Kocaçay limestone yields following fossil assemblages.

Vulvulina sp.

Silvestriella sp.

Globigerina sp.

Globirotalia sp.

Acarinina cf. bullbroaki

Nummulites spp.

Assilina sp.

Alveolina sp.

Discocyclina spp.

Asterocyclina

Actinocyclina

Caprinidae

Rotalidae

This assemblage characterizes the Bartonian age.

2.2.1.a.4. Contacts

The Kocaçay member is present in the Yoncalı Formation as lenses and intercalations. The limestones and the shales have graditional contact with each other. This relationship can be observed around Harmanpınarı village (Plate 1C, Fig.35) and Dulkadirli village (Plate 1D, Fig.36).

In the south of Yerköy, the Kocaçay conformably overlies a thick red conglomerate interval (Figs. 30,37). At the southeast corner of the study area, the Kocaçay conformably overlies and grades into tuffs of the Bayat Formation (Fig. 38). The same relationship is observed around Karacaahmetli village (Plate 1B). Near Harmanpınarı village (Plate 1C) the limestones of the Kocaçay unconformably overlie the Çiçekdağ Belt. At this contact, the Kocaçay starts with coarse-grained sandstones and conglomerates at the base and becomes sandy and conglomeratic

Fig. 37. Looking at the relation between the Kocaçay member and the İncik Formation in the south of Yerköy. Limestones of the Kocaçay member conformably overlie the red clastics of the İncik Formation. Tyko: Kocaçay member, Ti: İncik Formation.

Fig. 37.

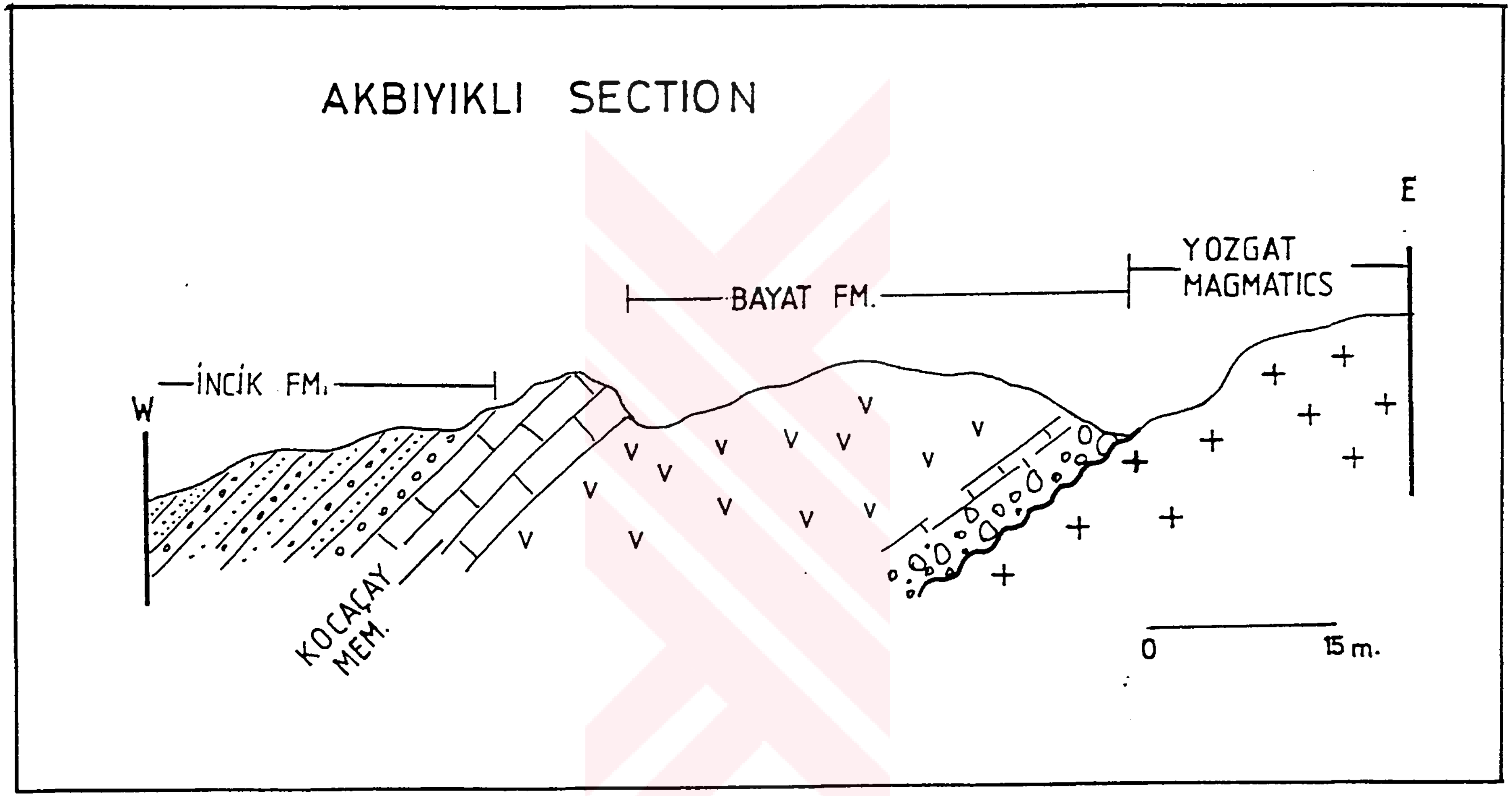


Fig. 38. Cross section showing the relation between the Yozgat magmatics, the Bayat and İncik Formations and the Kocaçay member.

limestones and passes upward into green shales of the Yoncalı (Fig.35). Similar relationship between Kocaçay member and the underlying basement is observed on the Yerköy-Yozgat highway, a few km. away from Yozgat (Fig. 27). At this contact, blocks and pebbles derived from the Yozgat magmatics, are in a carbonate or sandy matrix and overlying limestones are quite rich in fossil.

At the southeast corner of the study area limestones of the Kocaçay overlie the basement and upward they grade into the volcanics of the Bayat Formation (Fig. 38).

Around Arabın mah. village the Kocaçay member overlies the slightly metamorphosed Çökelik volcanics unconformably with a basal conglomerate. Above the conglomerates, limestone levels are observed in varying thickness in the shales of the Yoncalı Formation (Figs. 28,29).

In Dulkadirli village, at the southeast corner of the study area and around Karacaahmetli village the Kocaçay is conformably overlain by sandstones and conglomerates of İncik Formation (Figs.36,38), Plate 1 B,C,D). The same relationship is observed in the north of Büyük Teflek village (Fig. 32, Plate 1B).

2.2.1.a.5. Discussion

Fossil content and stratigraphic relationships of the Kocaçay member with the Yoncalı Formation indicate that, these limestones were deposited in very shallow marine or lagoonal environment. When this shallow sea passed into completely a lagoon or a terrestrial environment coal and carbonaceous shales were deposited together with red continental clastics.

In the palynological studies some marine dynoflagellatecysts were determined in the samples collected within the coal seam (Table 5). That indicates the sea flooded on the land or delta plain occasionally, when the coal seam forming.

In the northern part of the Çankırı-Çorum Basin, Yoncalı Formation shows relatively deeper marine facies than the south. In those areas, the unit contains sandstone-shale alternations with turbiditic sequences and olistostromal conglomerates (Şenalp, 1980, Görür et al., 1985, Tüysüz and Dellaloğlu, 1992). These data suggest that, the Çankırı-Çorum Basin becomes shallower from the north to the south and along the southern margin of the basin interfingering shallow marine-terrestrial facies were dominant from the Late Paleocene to the Early-Middle Eocene time.

2.2.2. Bayat Formation

2.2.2.1. Description

In this study, andesitic-basaltic lavas and tuffs, cropping out around Çiçekdağ and Karacaahmetli village, were named as the Bayat Formation (Plate 1 B,C). These volcanics are found as thin lenses and intercalations in the Yoncalı Formation. However along the Yerköy-Yozgat highway, the Bayat Formation becomes thicker and it forms extensive outcrops (Fig.2). The name of this formation was first used by Birgili et al.(1975) for volcanic rocks intercalated with detrital sedimentary rocks of the Eocene age.

2.2.2.2. Lithology

In the study area the Bayat is rich in basaltic lavas. In addition to lavas aglomerates and tuffs can be observed. Between Çiçekdağ and Harmanpınarı villages (Plate 1C) aglomerates are intercalated with the basaltic lavas. In the same place, well rounded pebbles of volcanic rocks are formed in tuff intervals. Similar aglomerates are observed along the Yozgat-Sungurlu road.

Around Karacaahmetli village (Plate 1B) the Bayat is made of tuff and lava alternations.

The basaltic lavas have well-developed columnar joints, around Çiçekdağ and on the Yerköy-Yozgat highway (Plate 1C, Fig. 39) indicating that, due to piling of extrusive lavas, some parts of the shallow sea become filled completely and emerged above the sea level. So that, the lava flowed in these submerged areas and columnar joints were formed upon coiling.

Between Yozgat and Sungurlu (Fig.2), palagonite tuffs alternating with andesites and basalts, are observed. These palagonite tuffs are composed entirely of very angular volcanic clasts set in a green altered volcanic matrix. The outer boundaries of every volcanic clast are surrounded by green alteration zones. The same green palagonitic alteration is seen more intensily in the matrix of the rocks (Fig.40). These properties were caused by the extrusion of the volcanic activity within the shallow sea environment. So that upon getting contact with sea water the lavas brecciated strongly and the particles and the matrix finely altered. The intensity of alteration was high around the brecciated clasts and finely surrounded green rims of alteration of the clasts were resulted in.

The Bayat Formation is characterized by it's trachitic texture. In thin sections trachitic and porphyritic texture is always clear (Fig.41). The matrix is commonly microlitic and pyroxene and amphibole crystals are present in this matrix as mafic phenocrystals. Biotite is rare and as felsic mineral plagioclases are present. In plagioclases sossurutization, and in mafic minerals chloritization and epidotization are common alteration types. In the Bayat, petrographic examinations indicate that, andesites, trachiandesites and basalts are common.

In the basalts, matrix is always microlitic and elongation in these microlites are

Fig. 39. Looking at the columnar joints in the Bayat Formation on the Yozgat-Yerköy highway

Fig. 40. Palagonite tuffs on the Yozgat-Sungurlu highway. Angular particles of the Bayat volcanics are seen in altered matrix derive from the same volcanism indicating the very shallow marine volcanism

Fig. 39.

Fig. 40.

Fig. 41. Photomicrograph of basalt from the Bayat Formation. Porphyritic texture is clear. Plagioclase and amphibole phenocrystals are seen in slightly elongated microlitic matrix. (Plg): Plagioclase- (Amp): Amphibole (crossed nicols)

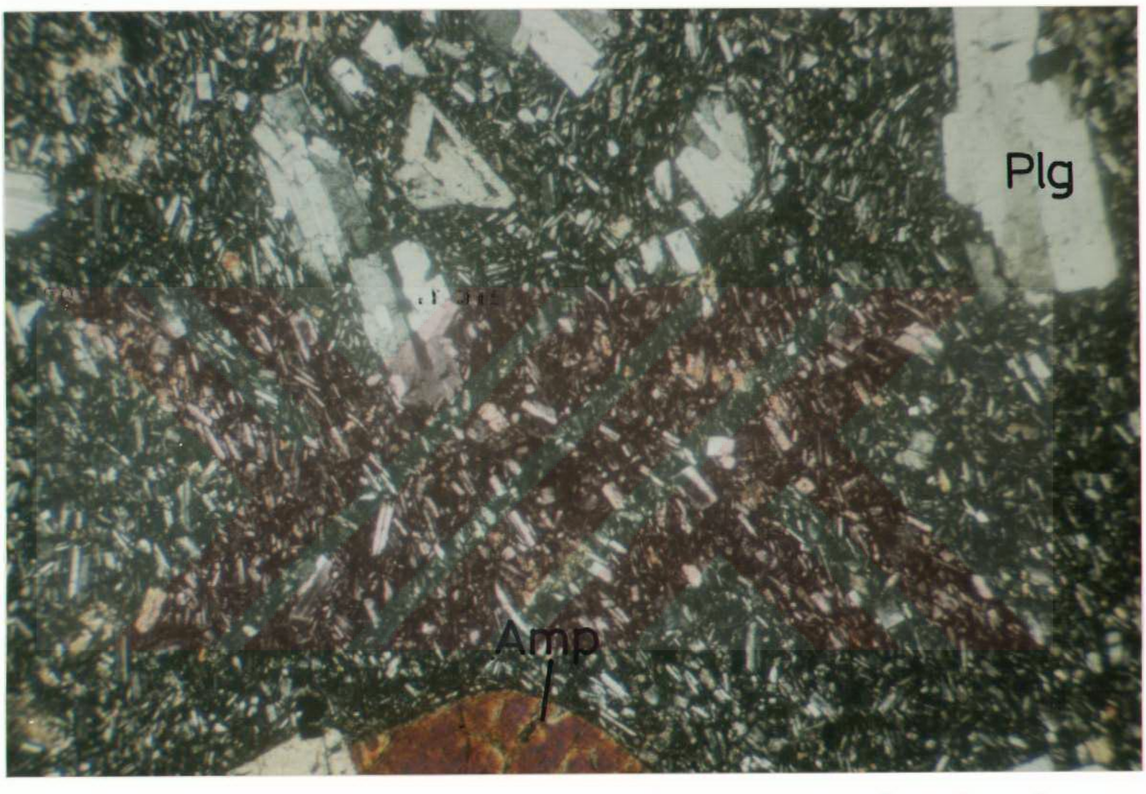


Fig. 41.

common (Fig. 42). Mostly pyroxene and plagioclase, rarely amphibole phenocrystals are present in this matrix.

Andesites are rich in amphibole and plagioclase as phenocrystal. Matrix is commonly microlitic but elongation in these microlites is not clear. However in trachyandesite types fluidal texture in matrix is characteristic (Fig. 42).

2.2.2.3. Geochemistry

Geochemical analyses of 12 samples collected along the Yerköy-Yozgat highway and around Çiçekdağ, were analysed. Major and trace element compositions of these samples are given in Table 6. SiO_2 content of the Bayat Formation varies from % 53 to % 65 indicating that, they range from basalt to andesite in composition. Al_2O_3 ratios vary from % 13 to % 16 and total Fe_2O_3, from % 2 to % 7 (Table 6).

According to the Na_2O+K_2O/SiO_2 diagram of Le Maitre (1989), the Bayat volcanics consist of trachyte, trachyandesite, andesite, basaltictrachyandesite type rocks (Fig. 43). But they gather in the fields of trachyte and trachyandesite. According to the Zr/Ti02/Nb/Y diagram, constructed by Winchester and Floyd (1977), the volcanics include trachyandesite, alkali basalt, andesite and dacite type rocks. But most of the samples cluster in the fields of trachyandesite and alkali basalt (Fig. 44). K20/Si02 ratios of the Bayat ploted on the K20/Si02 diagram of Peccerillo and Taylor (1976) and they cluster in the andesite area. In addition to this, several samples are located in the fields of High K andesite and dacite (Fig. 45).

According to the $FeO/Na_2O+K_2O/MgO$ triagle of Irvine and Baragar (1971) and $SiO_2/FeO/MgO$ diagram of Miyashiro (1974), the Bayat volcanics are calc-alkaline

Fig. 42. Photomicrograph of the basalt from the Bayat Formation. Elongation in microlitic matrix is clear (crossed nicols)

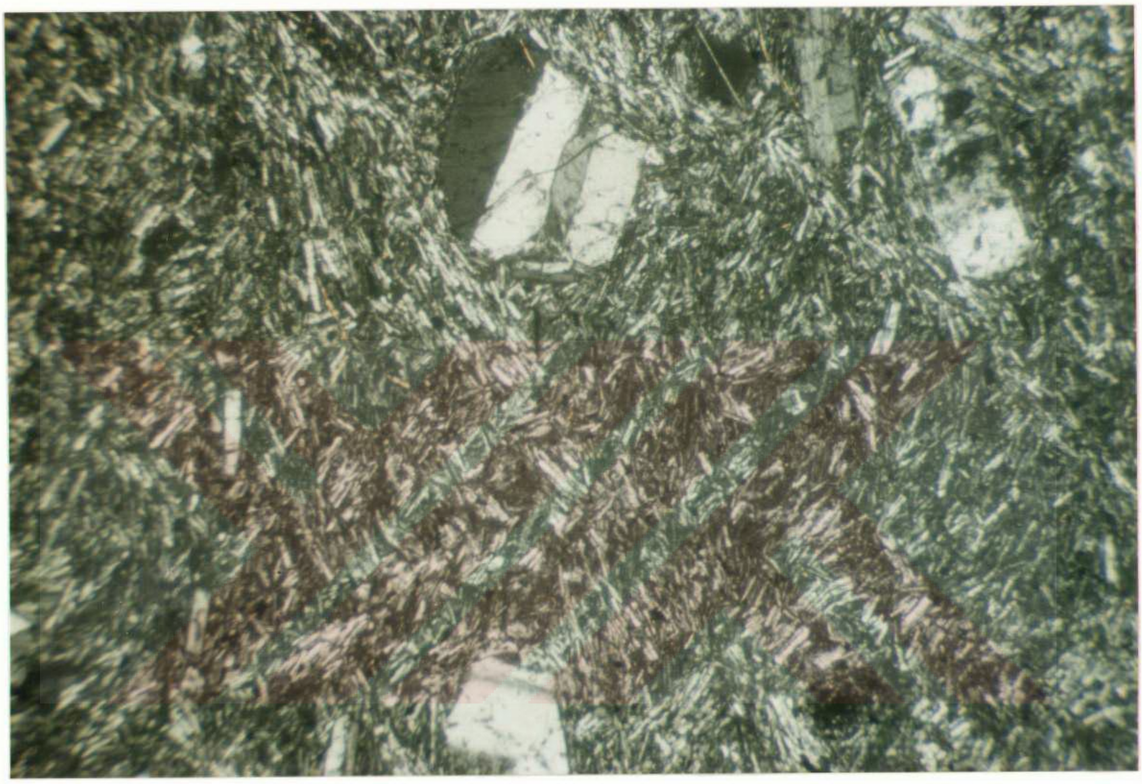


Fig. 42.

0 630 μ

ELEMENT / SAMPLE NO	15	16	17	18	19	20	21	22	23	24	25	26
SiO_2	59.85	63.72	62.65	64.99	68.32	61.01	54.83	56.76	55.24	55.64	55.38	53.47
TiO_2	0.50	0.52	0.52	0.60	0.56	0.47	0.92	0.91	0.77	0.66	0.83	0.84
Al_2O_3	13.59	14.44	14.10	14.10	13.42	14.63	14.18	14.10	13.76	14.61	14.88	15.79
FeO	3.83	2.88	3.45	2.88	2.38	3.52	5.85	5.20	6.65	6.84	5.59	7.18
MnO	0.09	0.04	0.04	0.08	0.05	0.07	0.11	0.13	0.14	0.14	0.12	0.11
MgO	6.08	2.91	3.73	1.60	0.74	4.80	8.27	6.08	6.88	5.65	6.95	6.43
CaO	5.97	5.39	5.32	5.17	4.95	5.63	7.51	7.85	8.51	8.14	7.52	6.33
Na_2O	4.95	4.87	4.60	5.57	5.10	5.05	4.57	4.48	4.48	3.98	4.50	4.82
K_2O	1.48	2.65	2.87	3.03	2.97	1.67	1.92	2.41	1.61	1.52	1.59	2.42
P_2O_5	0.21	0.17	0.18	0.19	0.21	0.17	0.22	0.24	0.26	0.21	0.23	0.24
H_2O	2.80	1.67	1.82	1.15	1.02	2.42	1.35	2.07	1.77	2.86	2.47	2.00
Rb	42	77	110	45	85	90	44	68	43	43	50	39
Ba	11	442	442	399	1137	419	392	270	472	292	316	419
Sr	574	514	485	467	532	534	613	509	510	755	522	502
Ga	0	11	11	12	12	12	10	11	14	12	11	12
Nb	4	11	4	21	13	9	0	19	14	3	21	0
Zr	192	193	193	314	209	183	132	158	150	157	175	138
Y	7	17	17	24	17	14	20	19	12	17	20	8

Table 6. Majör and trace element composition of the Bayat Formation

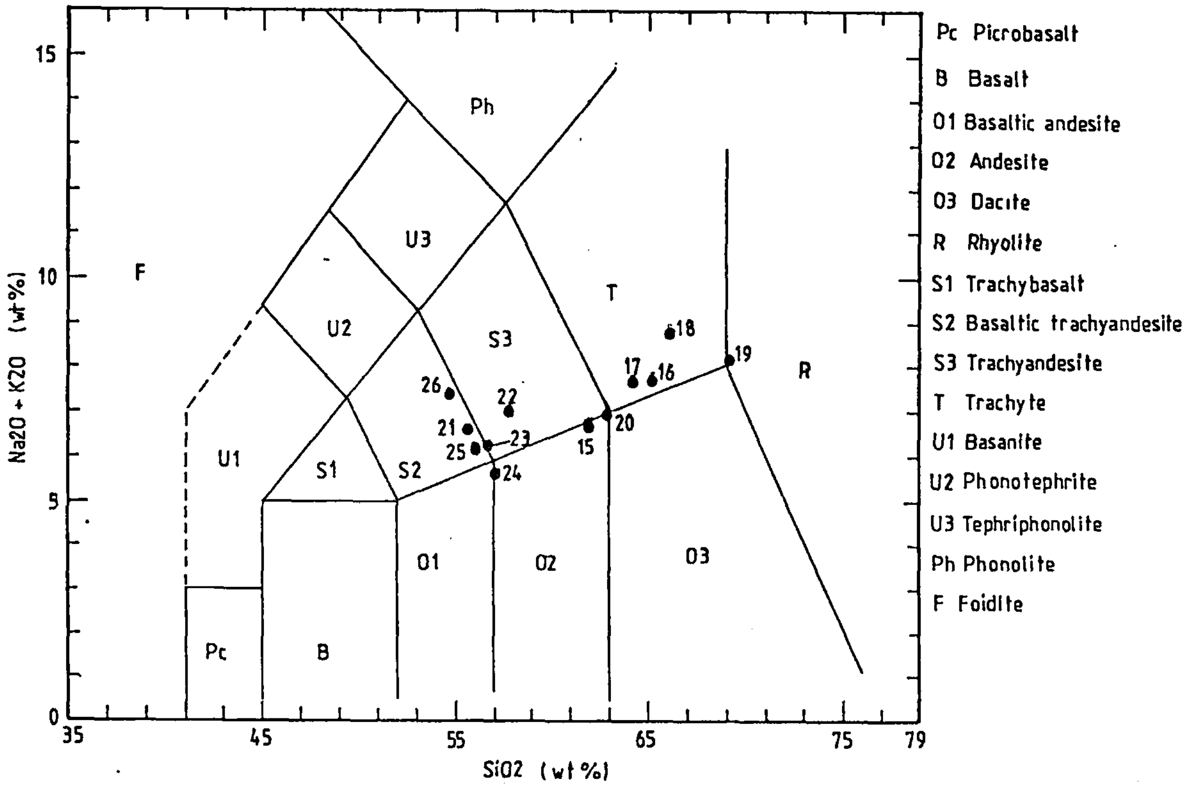


Fig. 43. (Na_2O+K_2O) versus SiO_2 variations of rocks of the Bayat Formation.

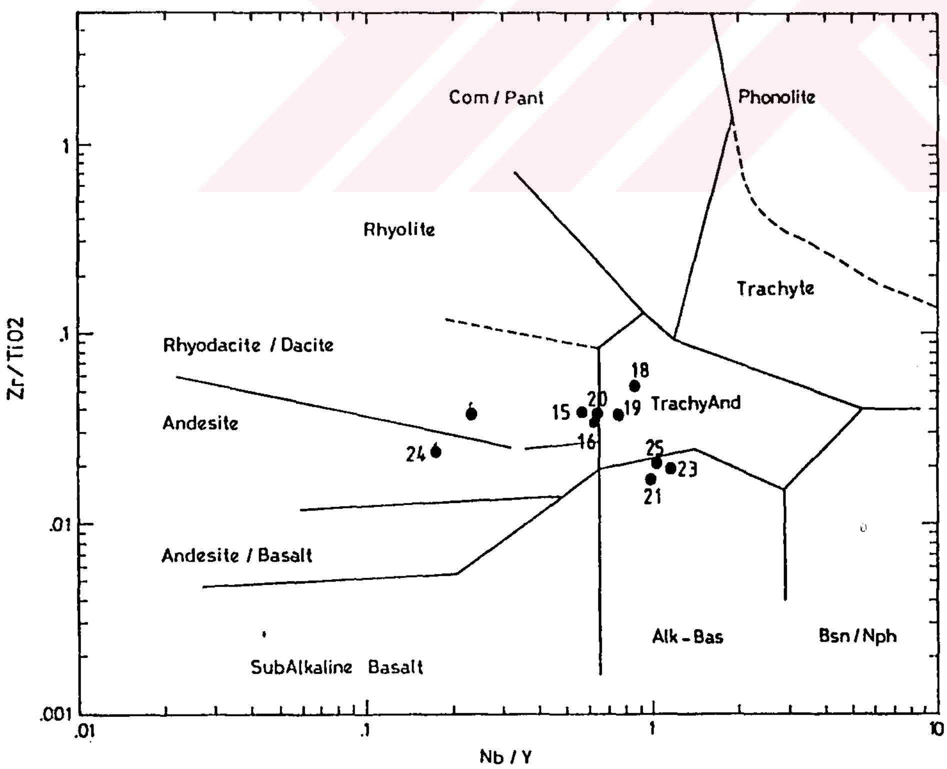


Fig. 44. (Zr/TiO_2) versus (Nb/Y) variations of rocks of the Bayat Formation.

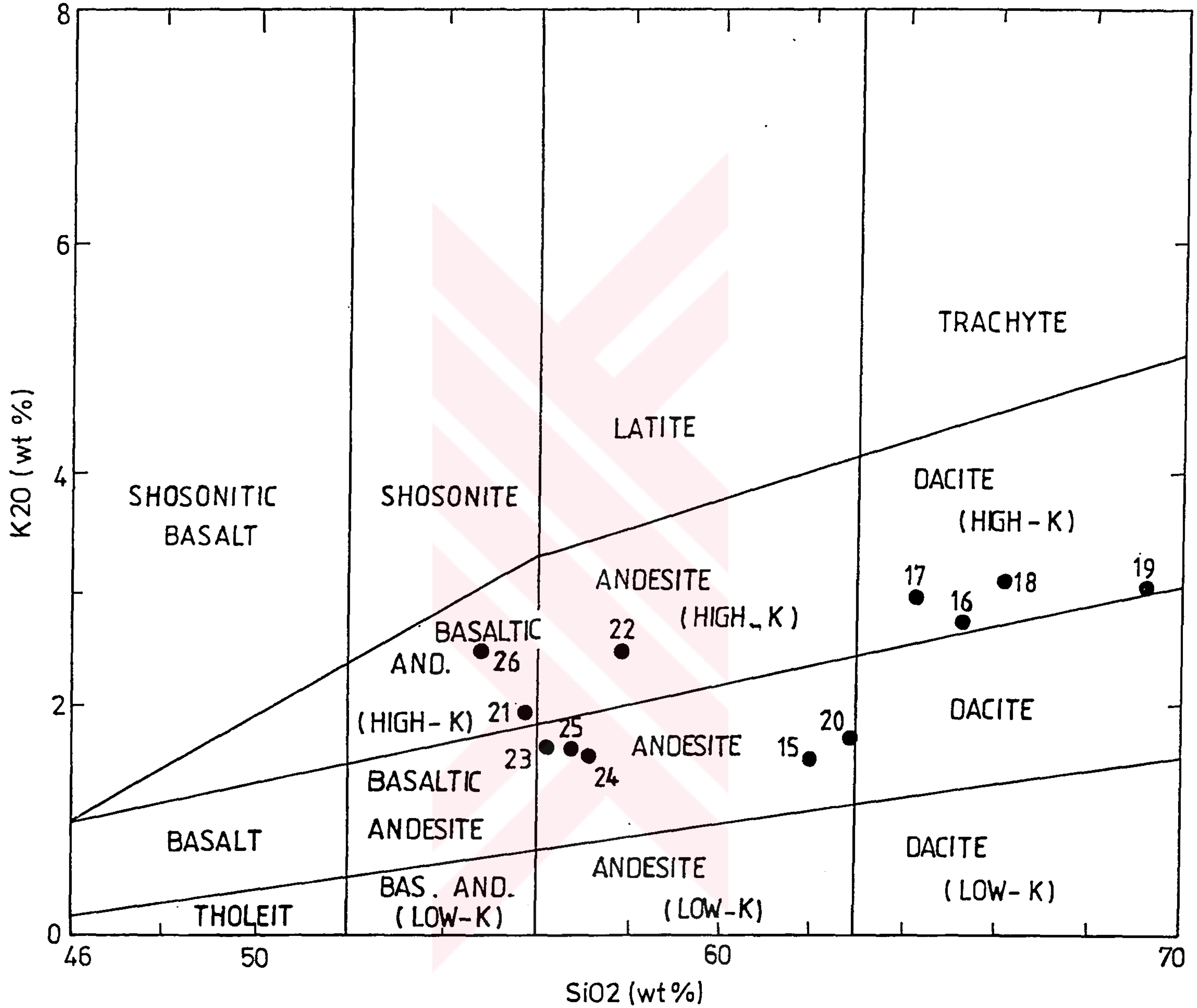


Fig. 45. Na_2O versus SiO_2 variations of the Bayat volcanics.

in nature (Fig. 46,47).

The geochemical data indicates that, the Bayat includes compositionally heterogeneous volcanic rocks, but trachyandesites and alcali basalts are predominant and trachytes, andesites, and dacites are relatively rare.

2.2.2.4. Age

Berent (1981) studied on the north of Yozgat and determined the age of the volcanics, cropping around the Yozgat, by K/Ar method. He indicates the 43+5 m.y. age for andesitic-basaltic volcanics. This age corresponds to the Lutetian-Bartonian time.

In this study age of the Bayat volcanics were determined from the interfingering shale and limestone levels. Along the, Çiçekdağ-Kırşehir and Yerköy-Yozgat highways, Bayat Formation interfingers with fossiliferous shales and claystones of the Yoncalı Formation (Fig. 33). These shales contain abundant nummulites fossils. In most of the places in the map area the Bayat volcanics interfinger within different levels of the Yoncalı Formation. So, it's age is clearly Late Paleacene to Middle Eocene.

At the southeast corner of the study area, the shales of the Yoncalı Formation overlie the Bayat volcanics (Plate 1C). This relationship indicates that, Bayat volcanism started in Late Paleocene and during sedimentation reactived in different stratigraphic levels untill the end of the Early Tertiary sedimentation.

2.2.2.5. Contacts

In the most parts of the study area Bayat volcanics interdigitate with the Yoncalı Formation in varying thickness (Plate 1B,C). Especially around Çiçekdağ, basaltic

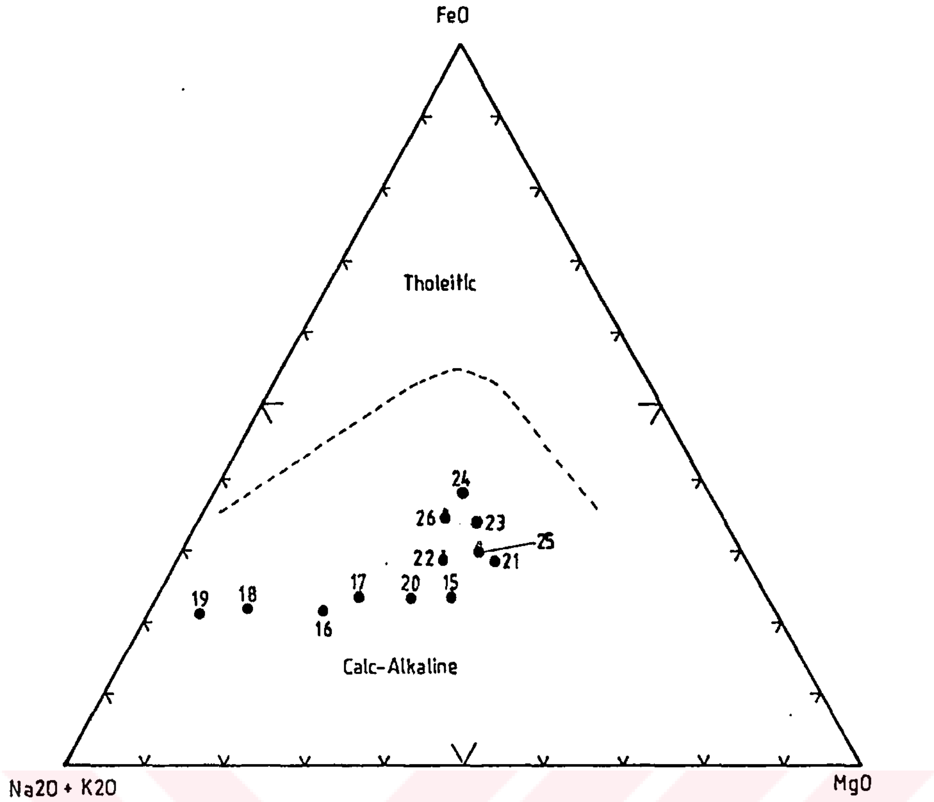


Fig. 46. Frequency of the Bayat volcanics in the FeO/Na_2O+K_2O/MgO triangle of Irvine and Baragar (1971).

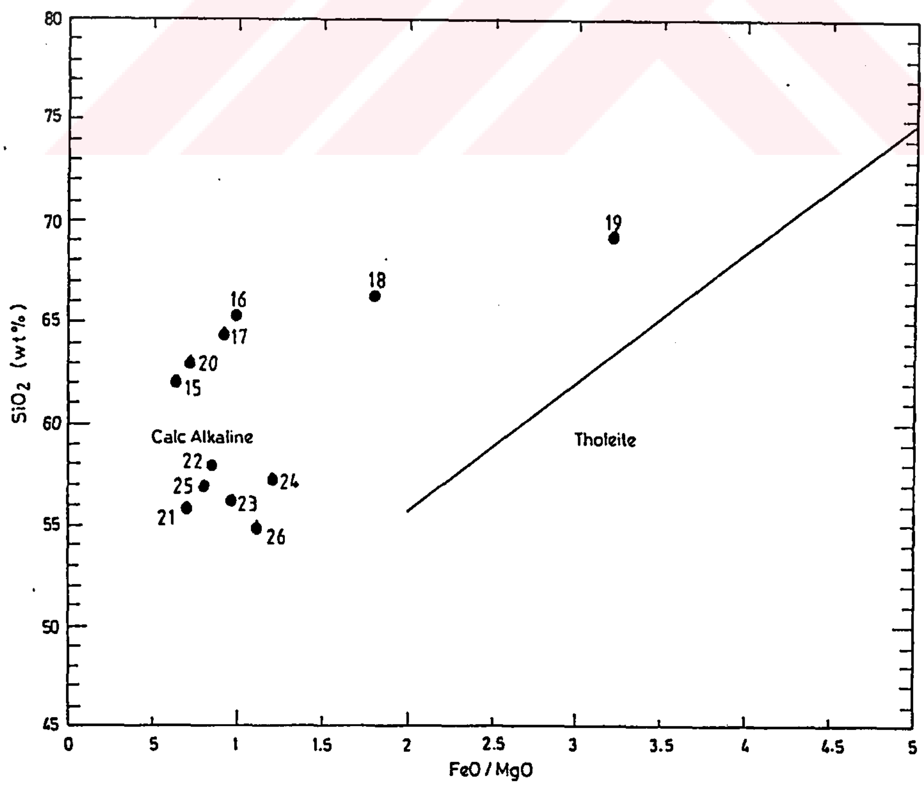


Fig. 47. Si_2O versus (FeO/MgO) variations of the Bayat volcanics.

lavas are observed in shales and claystones as lenses (Figs.34,35). In these lenses lower and upper contacts with Yoncalı Formation is graditional through tuff intervals. At the southeast corner of the study area the Bayat directly overlies the Yozgat magmatics. At the bottom, there is a 5-6 m. thick basal conglomerate which passes upward into tuffs and basaltic volcanics of the Bayat.

Berent (1981) indicates the volcanics cropping out at the north of Yozgat, unconformably overlie the flysch-type sediments. However in this study this kind of relationship is nowhere observed but rather in all open outcrops they are formed in interdigitation relationships.

2.2.2.6. Discussion

Stratigraphic relationships of the Bayat Formation indicate the Tertiary volcanism started in Late Paleocene-Early Eocene, in a very shallow marine environment of the Yoncalı Basin. Palagonite tuffs and alternating with marine shales and claystones indicate this shallow marine volcanism.

However on the Yozgat-Yerköy highway, the Bayat volcanics show the well-developed columnar joints (Fig. 39). In addition to that, around Çiçekdağ some aglomerate lenses within the Bayat include well rounded clasts of the same volcanic material indicating abrasion within a terrestrial area or in a shore land.

These shallow marine and terrestrial features of the Bayat volcanics indicate that, the Bayat extruded into the shallow sea as interfingering with the shales and limestones of the Yoncalı. Due to the piling of lavas the sea filled completely and in this mewly, local terrestrial areas columnar-joints were formed by lava flowing. These lava flowing also caused the abrasion on the surface of the lava pile and aglomerates with well-rounded clasts, were formed as intercalations in the lavas.

2.2.3. İncik Formation

2.2.3.1. Description

Red, reddish-brown conglomerates, sandtones, siltstones, shales and green shales which have large outcrops in the study area and all over the Çankırı-Çorum Basin are named as the İncik Formation in this study. This name was first used by Birgili et al. in 1975 for detrital sediments with similar lithological properties cropping out in the northern part of the Çankırı-Çorum Basin. But they considered the İncik Formation as the Oligocene age. They did not find any fossils but based on stratigraphic relations, so they assigned this age. In our area, the red clastics of the İncik Formation forms interdigitate with the Yoncalı Formation. Especially along the southern border of the Çankırı-Çorum Basin the red clastics become dominant and the lower part of the Çankırı-Çorum Basin become marine and Yoncalı Formation was formed. These two continental and marine deposits laterelly grade into each other. In the upper parts, the basin becomes filled completely and, the terrestrial clastics of the İncik Formation becomes predominant again.

In the study area, the İncik crops out around Yerköy, Çiçekdağ townships and Arabın mah. and Teflek villages (Plate 1 B,C). The formation also have large outcrops in the central part of the Çankırı-Çorum Basin and in the west and south of Sungurlu (Fig. 2).

2.2.3.2. Lithology

At the lower part, the İncik Formation is formed by as alternation of dominantly red conglomerates, sandstones and shales. The well-packed detrital sediments have usually regular bedding. The thickness of beds vary in the range of 10-50 cm. Ill sorted and well rounded grains are supported by silty and muddy matrix. Grains which include diabases, basalts and reddish micritic limestones, are all derived from the Çökelik volcanics.

The İncik becomes poorer in conglomerates and richer in siltstones and shales in the upper parts where shale horizons intercalating with sandstones become thicker.

In the north of Büyük Teflek village, in sandstones trough cross beddings are common (Fig. 48). Between these cross bedded sandstones, shales with planar lamination are present(Fig. 49). Around the Küçük and Büyük Teflek villages, thin tuff, limestone and clayey limestone levels are intercalated with the sandstones.

2.2.3.3. Age

The İncik Formation is quite poor in fossils because of it is dominantly coarse grained clastic sediments. In the southern part of the Büyük Teflek village (15900/89000 in the sheet of I32 c_1, Plate 1B) a thin carbonate level is found within the red clastics of the İncik Formation. This carbonate level yields the following fossil assemblage and give an age of the Middle Eocene.

Globigerina bulloides

- G. triloculinoides
- G. eocaena
- G. inaquerpira
- G. senni
- G. cf. apertura
- G. hagni
- G. higginsi
- Cassidulinidae
- Anomalinidae

Fig. 48. Looking at through cross beddings in sandstones of the İncik Formation.

Fig. 49. Looking at the planar lamination in shales of the İncik Formation. These indicate that, deposition in the flood basins of the rivers.

Fig. 48.

Fig. 49.

In the north of Büyük Teflek village (Plate 1B) a carbonate lense of the Kocaçay member is found within the red clastics of the İncik Formation yielding the Early Eocene age. The fossil content of this sample is given in the age section of the Kocaçay member. In addition to these age determinations, in the south of Yerköy (Plate 1C) the İncik Formation laterally interfingers with shales of the Yoncalı Formation.

So, the age of the İncik Formation is Late Paleocene and Early-Middle Eocene and it is the continental equivalent of the Yoncalı.

2.2.3.4. Contacts

The İncik interfingers with the Yoncalı in lateral and vertical direction. Where the Yoncalı is represented with the green shales, the red conglomerates of the İncik interfinger with them. In some areas, the İncik also digitates with the carbonates of the Kocaçay member.

Around Yerköy, Pekmezci village and at the south of Tepecik village (Plate 1 A,B,C,D) the İncik directly lies upon the rocks of the Çiçekdağ Belt. In these areas, the unit starts with thick bedded conglomerates and upward it passes into conglomerate, sandstone, siltstone and shale alternations (Fig. 30).

Around Yerköy, the İncik is conformably and graditionally overlain by the Kocaçay member and shales of the Yoncalı (Figs. 30,37, Plate 1 C). However around Çiçekdağ, about 5 km. away from Yerköy and at the southeast corner of the study area, the İncik lies upon shales of the Yoncalı (Plate 1C) or the Kocaçay member (Fig. 38) where these units overlie directly the basement. Similarly around Hacıoğlu village (Plate 1C) the İncik and the Yoncalı interfinger with each other laterally.

To the north of Büyük Teflek village, a lense of shales of the Yoncalı and carbonates of the Kocaçay member are present in the red clastics of the İncik Formation (Figs. 31,32, Plate 1B). In the lower contact of this lense the İncik is rich in red and green shales and grades into shales with a 10 m. in thickness (Fig. 50). In the upper contact, the İncik graditionally overlies the fossiliferous limestones and shales of the Yoncalı (Fig. 50).

These relationships between the İncik and Yoncalı Formations indicate a lateral and vertical graditions with each other on a regional bases.

If directly overlain by the younger Kızılırmak Formation, the İncik is not differantiated easily and the contact may be confused. These formations resemble each other. In places though, the İncik Formaiton attains dips of 70 to 80 degrees, for example at the east of Beşikli villae even vertical dips are measured. The Kızılırmak Formation of the Miocene age on the other hand is nearly flat lying above the İncik.

2.2.3.5. Discussion

The İncik Formation characterizes a fluvial environment by it's coarse grained texture and trough cross beddings. However some shallow marine intercalations and lateral and vertical graditions with marine sedimentary intervals indicate that this fluvial environment has connection with a sea. Cross beds, in various size and directions, characterize the various energy levels and supplying directions. In addition, planar laminated shales, intercalating the cross beddings, should be formed in the flood basins of the rivers.

These lithological properties, can occur in a deltaic area. So, it can be suggested that, the İncik Formation were formed in a deltaic area by process of rivers and

Fig. 50. Looking at the lower contact of the Yoncalı lense in the İncik Formation. Ty: Yoncalı Formation, Tyko: Kocaçay member,Ti: İncik Formation.

Fig. 50.

the flood basins of them in Late Paleocene-Early-Middle Eocene time. From time to time the sea flooded over the delta and by movements of the sea shallow marine intercalations were formed.

According to the stratigraphic relationships and age determinations of Early Tertiary deposits, in the Late Paleocene-Eocen time there must was a shallow marine environment in the southern margin of the Çankırı-Çorum Basin. However the Tertiary shallow sea passed into deltaic environment. In such kind of marine delta facies, Early Tertiary sediments and volcanics were formed as graditionally with each other laterally and vertically.
In most of previous studies, the İncik Formation stated to be the Oligocene in age (Birgili et al.,1975, Tüysüz and Dellaloğlu, 1992). However we have not found any fossil indicating the Oligocene but with all stratigraphic and paleontological relationships were determined indicate that, it interfingers and grades laterally into the Late Paleocene-Eocene units.

This shallow marine environment becomes deeper toward the north of the Çankırı-Çorum Basin where flysch-type Sediments deposited.

In the Tuzgölü Basin the Late Cretaceous-Early Paleocene red conglomerates were named as Kartal Formation (Görür, 1981, Uygun, 1981, Görür et al., 1985). Uygun (1981) also indicated that all terrestrial equivalents of Maastrichtian-Lutetian marine formations should be named as the Kartal Formation. It is clear in our area that the continental and shallow marine sedimentary rocks of the Çankırı-Çorum Basin laterally grade into each other. So that, the İncik is the continental equivalent of the Çankırı-Çorum Basin whereas the Yoncalı and Kocaçay are the shallow marine equivalent of the same succession.

2.2.4. Kızılırmak Formation

2.2.4.1. Description

The Late Paleocene-Eocene deposits of the Çankırı-Çorum Basin are unconformably overlain by the Miocene terrestrial sediments of red, reddish-gray and gray conglomerates, sandstones and shales. In this study, for the name of these sedimentary rocks, Kızılırmak Formation is given. This name was first used by Birgili et al.(1975) for terrestrial deposits of similar lithologies of the Miocene age. The Kızılırmak crops out in large areas in the study area and all over the Çankırı-Çorum Basin. In the study area, at the north of Büyük Teflek village and around Yakuplu, Mahzenli, Topalali villages (Fig. 2, Plate 1 B.D).

2.2.4.2. Lithology

The Kızılırmak is characterized by the regular bedded alternations of conglomerates, sandstones, siltstones and shales. Their clasts are derived from the Yozgat magmatics. In the area examined these beds are commonly horizontal or low angle. At the north of Büyük Teflek village sandstones and shales of the Kızılırmak have deeps of 20-30 degrees. In generally, poorly sorted conglomerates and sandstones consist of well rounded clasts in sandy or muddy matrix.

This unit includes trough cross beddings in different size and direction.

The Kızılırmak is represented completely by the conglomerate, sandstone and shale alternation in the south of the area studied. However in the north of Büyük Teflek village (Plate 1B), green and red shales become predominant and sandstones, and siltstones intercalate these shales. In this area the thickness of the shale levels vary from 0.5 to 2 m. Around Beşikli and Mahzenli villages the Kızılırmak is represented by semiconsolidated clastic deposits.

2.2.4.3. Age

No fossils have been mentioned from the Kızılırmak in the previous studies and the unit was considered as Miocene by stratigraphic relationships. In this study, some paynological data were obtained from the Kızılırmak. The fossil content of shales, collected from the north of Büyük Teflek village (Plate 1B), is given in Table 7. According to these fossil contents, the Kızılırmak Formation is the Middle Miocene in age.

2.2.4.4. Contacts

The Kızılırmak unconformably overlies the Early Tertiary units and the older rocks. Unconformity between the İncik and Kızılırmak Formations is generally not clearly seen. At the north of Büyük Teflek village and around Topalali and Kavakliöz villages (Plate 1C), the contact between the İncik and the Kızılırmak is seen as conformable.

On the Çiçekdağ-Kırşehir highway, regular bedded, horizantal conglomerates and sandstones overlie the steeply dipped, fossiliferous shales. The Kızılırmak Formation becomes richer in the red and green shales upward and grades into the Bozkır Formation (Fig. 51). This contact is clear around Kilimli1 village (Plate 1A).

2.2.4.5. Discussion

The Kızılırmak resembles lithologically to the rocks of the İncik Formation. In places where it overlie the İncik, the boundary can not seen clearly and the both would be confused.
The unit was deposited in a terrestrial environment and in places formed in a playa

FORMATIONS	KIZILIRMAK				BOZKIR					
SAMPLE NUMBERS	445	439	440	9	450	449	513	446	447	514
SPORES										
Laevigatosporites haardti		2	16		1			1	2	
Leiotritriletes microadriennis		1		1					+	+
Baculatisporites primarius			1							
Cingulatisporites macrospeciosus			3		+			1		
Gleicheniidites sp.		1		1						
POLLEN										
Gymnospermae										
Pityosporites microalatus	53	59	13	45	44	40	45	59	29	13
Pityosporites labdacus		2		2						
Pityosporites libellus	+	1								+
Inaperturopollenites dubius			2	16	2		6	4		26
Inaperturopollenites hiatus	1	1	1	1	1				1	+
Inaperturopollenites polyformosus						1			1	1
Inaperturopollenites emmaensis		+	+						1	
Ephedra claricristata					+					
Ephedra hungarica				3						1
Ephedra eosenipites	+								4	
Ephedra sp.					+	+	1			+
Angiospermae										
Monocotyledoneae										
Monoporopollenites gramineoides			1		2		1	1	+	
Dicotyledonae										
Inaperturopollenites granulosus										4
Triatriopollenites rurensis	2	8		2	1		1	1		3
Triatriopollenites bituitus					2				+	
Triatriopollenites coryphaeus		2	1	6	2	4		3	4	4
Triatriopollenites sp.			3							
Triporopollenites labraferus	+		2	3	2		3			5
Triporopollenites simpliformis		5	1				1			1
Subtriporopollenites anulatus					+					
Subtriporopollenites simplex	1	5	2		2	1	1		+	1
Subtriporopollenites sp.		1			+					
Intratriporopollenites indubitabilis									+	
Intratriporopollenites instructus	1								+	+
Intratriporopollenites sp.									+	
Polyvestibulopollenites verus			+							+
Polyporopollenites carpinoides		2	7	9	5	30	22	16	45	16
Polyporopollenites undulosus	30	7	20	1	19	5	1	10	4	1
Porocolpopollenites vestibulum					+					
Porocolpopollenites sp.		+								+
Tricolpopollenites henrici	1									+
Tricolpopollenites densus		+	1	2	+		2			6
Tricolpopollenites retiformis			1	1			3			2
Tricolpopollenites microhenrici			1	1		2	5			4
Tricolpopollenites liblarensis			1	1				1		1
Pistilipollenites mcgregorii					1					
Tricolporopollenites villensis										+
Tricolporopollenites cingulum	1	1	5	2	4	10	6	2	6	3
Tricolporopollenites megaexactus	5	+	10		5	4	2			5
Tricolporopollenites steinensis									2	
Tricolporopollenites pacatus				1	1		1			1
Tricolporopollenites cf. kruschi			1		+				+	+
Tricolporopollenites porasper	2									+
Tricolporopollenites microreticulatus	1	1	1	1	3					
Tricolporopollenites margaritatus						3			1	
Tricolporopollenites sp.	1				1					
Tricolporopollenites sp. (tubuliflorae type)	+				+					+
Tetracolporopollenites obscurus	+		1		+				+	
Tetracolporopollenites manifestus										1
Tetracolporopollenites cf.oblongus										+
Tetracolporopollenites sp.			1							1
Periporopollenites multiporatus	1		+		2			1		

Table 7. Sporomorph contents of the Kızılırmak and Bozkır Formations.

Fig. 5I. Looking at the graditional contact between the Kızılırmak and Bozkır Formations(From the south-west of Kilimli village,in the sheet of I32 dI). Mkı: Kızılırmak Formation,Mbo: Bozkır Formation.

Fig. 51.

lakes with high detrital influx.

Trough cross beddings were formed by processes of the rivers and planar lamination in shales intercalating with conglomerates and sandstones in lake or delta plain environment. Gypsiferous lenses in places were formed by evaporation by small playa lakes of the basin.

2.2.5. Bozkır Formation

2.2.5.1. Description

The Kızılırmak becomes richer in shales upward and grades into finely laminated gypsiferous beds alternating with shales. These horizontal gypsiferous unit is named as the Bozkır Formation. This name was first given by Birgili et al.(1975) for the Miocene laminated red clastics and gypsium bearing shales.

The Bozkır mainly crops out in the western parts of the study area, around Kilimli, Ayvalı, Kabaklı and Tepecik villages (Plate 1A).

2.2.5.2. Lithology

The Bozkır Formation mainly consists of an alternation of gray shales and laminated gypsiferous beds. The unit is rich in sandstones and siltstones in the lower part. These levels are mainly reddish in colours, and resemble to the Kızılırmak Formation. The fine grained sandstones are ill sorted and composed of well rounded clasts derived from the Çiçekdağ Belt. Shales intercalating with sandstones are yellowish green in colour and include thin gypsium levels as laminas and nodules (Fig. 52).

Upward, the Bozkır becomes richer in shales and gypsium. In this part gypsium beds, 30-40 cm. in thickness, are intercalated with shales. The unit is yellow, yellowish white in colours in this part and have commonly horizontal or slightly

Fig. 52. Gypsium laminas and nodules in the Bozkır Formation (from the west of Kaleevci village- in the sheet of I32 d1)

Fig. 52.

dipped beds.

In the northern part of the area studied, around Aşağı Sekili village, the Bozkır includes thick salt beds in reddish shales.

2.2.5.3. Age

Birgili et al.(1975) gave the age of the Bozkır Formation as the Miocene based on stratigraphic relationships.
In this study a section was measured at the northwest of Büyük Teflek village and a series of samples were collected for palynological investigation. The samples were examined by Dr. Funda Akgün and the list of the fossils is given in Table 7. The palynological assemblages from the Bozkır Formation yield an age of the Miocene.

2.2.5.4. Contacts

The Bozkır graditionally overlies the Kızılırmak Formation at the north and northwest of Büyük Teflek village and around the Kilimli village (Plate 1 A,B). Around Kızılcalı village, the Bozkır progrades overthe basement and unconformably overlies directly the Çiçekdağ Belt (Plate 1 A). At this boundary the unit is dominantly coarse grained and represented by red conglomerates and sandstones.

2.2.5.5. Discussion

The Bozkır characterizes the lagoonal and terrestrial cycles of the Miocene sedimentation in the Çankırı-Çorum Basin. In fact similar sedimentary environments are observed during all the Tertiary. Gypsiferous beds which are observed in the contact of the Yoncalı and İncik Formations in Arabın mah.

village and terrestrial sequence in Eocene indicates that, the terrestrial and lagoonal environment were predominant in the Çankırı-Çorum Basin during the entire Tertiary time.

2.2.6. Değim Formation

2.2.6.1. Description

Birgili et al.(1975) named the unconsolidated, coarse grained, red conglomerates and sandstones cropping out at the northern part of the Çankırı-Çorum Basin as Değim Formation. In this study, the Değim Formation is given for gray and white conglomerates and sandstones which overlay the Bozkır and the older formations. The Formation crops out around the Tuztepe, in the northeast part of Kızılcalı village and around Kızıltepe, on the northern border of the study area (Plate 1 A).

2.2.6.2. Lithology

The Değim Formation is composed mainly of conglomerates and sandstones in the study area. Shales intercalate the sandstones as thin beds.

Coarse grained conglomerates are ill sorted and have well rounded clasts derived mainly from the Çiçekdağ Belt. Detrital materials are bounded by sandy or clayey matrix.
Gray-white fine grained sandstones include trough cross beddings in varying size. Conglomerates and sandstones consist of thin shale intercalations in greenish gray in colour.

2.2.6.3. Age

There is no paleontological determination from Değim Formation. Birgili et al.(1975), considered the age of the

Değim Formation as the Pleistocene by it's stratigraphic setting.

In the study area the Değim unconformably overlies the Bozkır Formation. By this relationship, the Pleistocene age is also accepted in this study for the Değim Formation.

2.2.6.4. Contacts

The Değim unconformably overlies the Bozkır Formation. This relationship is observed in the Tuztepe, in the north of Kızılcalı village (Plate 1 A). Here, horizontal beds of Değim Formation lay above the shales of Bozkır Formation with a dip of 20-30 degrees. The contact is irregular and does not form open outerops.

The same relationship is observed in the Peycan Hill, at the west of Aşağı Sekili village (Plate 1 A).

2.2.7.5. Discussion

The Değim Formation have similar lithological and environmental properties with the Kızılırmak. Deposition of the such fluvial sediments in Pleistocene indicates terrestrial conditions were repeated during the Tertiary time and in the Pleistocene time detrital sediments were deposited by processes of rivers.

3. STRATIGRAPHIC EVOLUTION OF THE ÇANKIRI-ÇORUM BASIN

The Tertiary Çankırı-Çorum Basin was a dominantly detrital sedimentary basin in the region studied. The study area corresponds to the southern margin of the basin and the earliest age obtained from the sedimentary succession is the Late Paleocene. The northern margin of the Çankırı-Çorum Basin are observed between Yozgat and Sungurlu. In this area slices of the Maastrichtian-Campanian Ankara Melange thrust into the basin from the north to the south during the Eocene time simoultaneously with the sedimentation.

As mentioned in the section of stratifraphy, the Late Paleocene and Early-Middle Eocene shallow marine deposits, andesitic-basaltic volcanics and terrestrial deposits interfinger with the each other. Near Büyük Teflek village lenses of shallow marine limestones and shales are present in a thick section of terrestrial conglomerates and sandstones of the İncik Formation. Besides that, around Arabın mah. village, a coal seam and carbonaceous shales intercalate with each other (Figs. 28,29). These carbonaceous shales that underlie and overlie the coal seam contain marine fauna (Table 5) indicating that shallow marine depositional site passed into swamp areas laterally. In the southern part of the study area, about 5 km. far from Çiçekdağ, the terrestrial conglomerates of the İncik interfinger with the marine deposits. In the near areas, the basaltic volcanics which directly overlie the basement alternate with the terrestrial conglomerates and in the south of Yerköy these red conglomerates directly overlie the basement (Plate 1C). These two different rock types grade upward into shallow marine sediments.

All of these data indicate that, in the southern margin of the basin shallow marine rocks and terrestrial conglomerates were formed interdigitating laterally into each other. The depositional site was a shallaw marine and a delta in places during the Late Paleocene time (Fig. 53A).

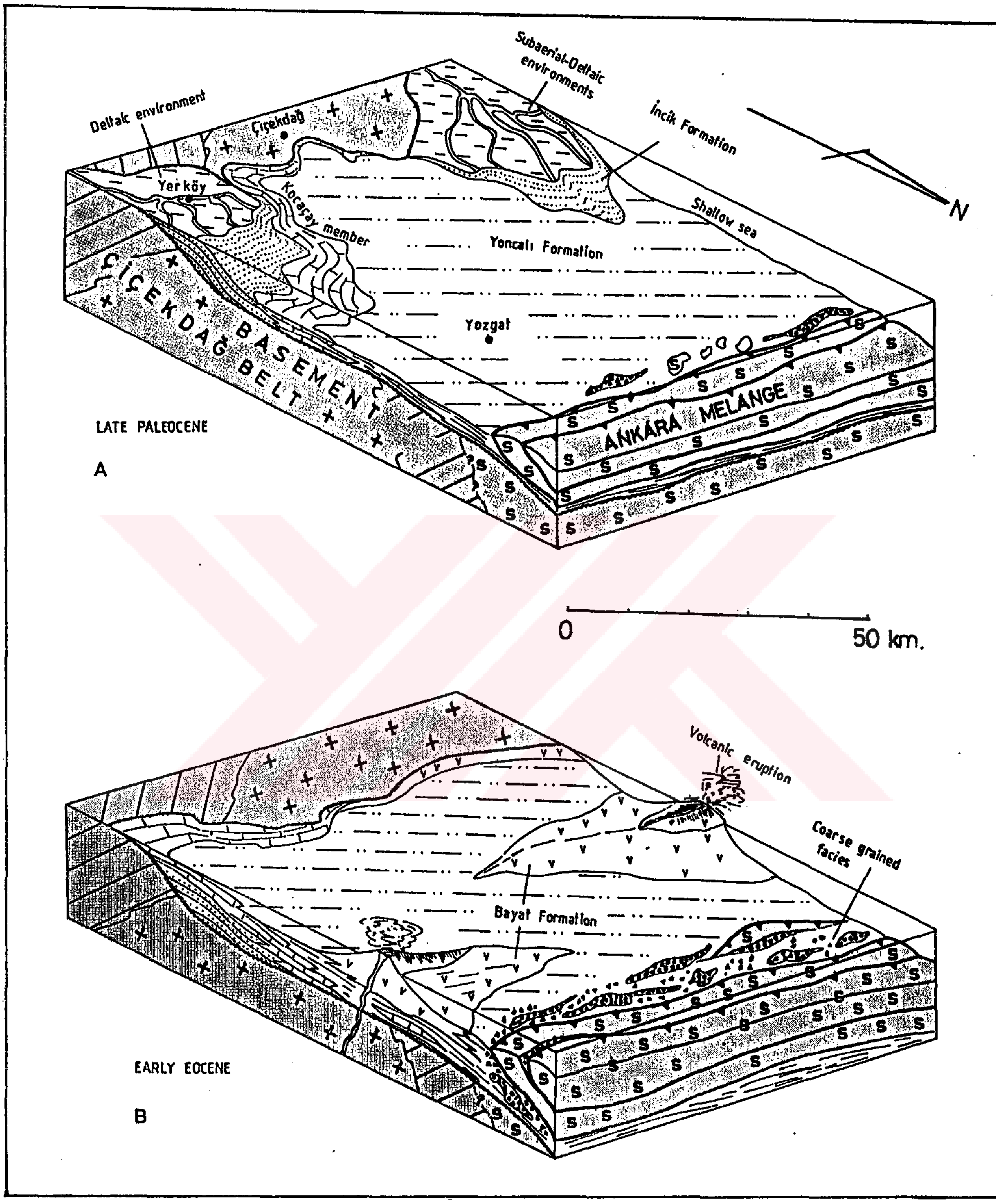
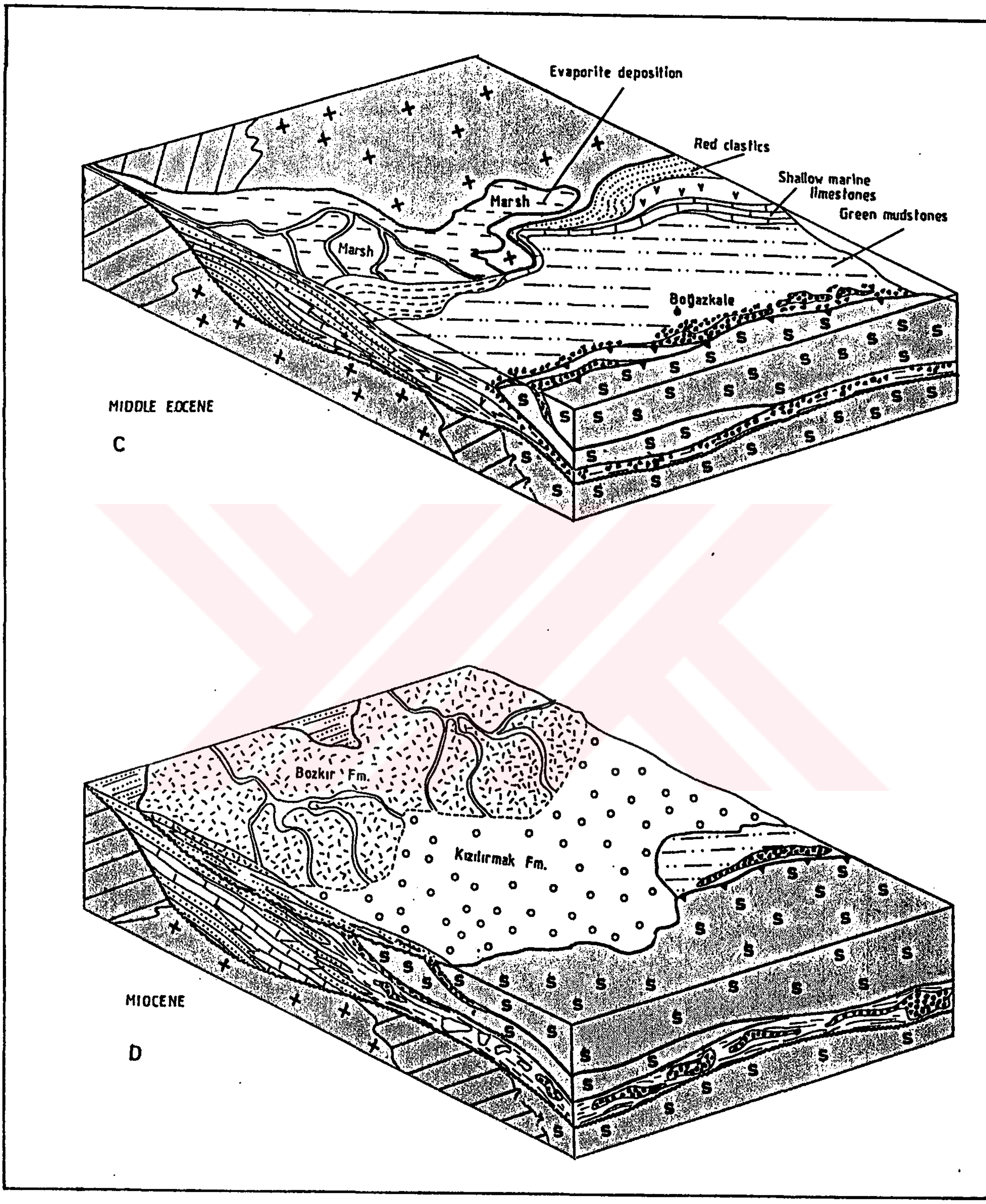


Fig. 53A,B,C,D. Stratigraphic evolution of the Çankırı-Çorum Basin.


Evaporite deposition
Red clastics
Shallow marine limestones
Green mudstones
Marsh
Marsh
Boğazkale
MIDDLE EOCENE
C
Bozkır Fm.
Kızılırmak Fm.
MIOCENE
D

In the delta areas red clastics and coal seams were formed. Wheras in nearby, shallow sea shales of the Yoncalı Formation and the limestones of the Kocaçay were deposited.
Farther to the north near, Sungurlu the deltaic to shallow marine facies gradually become relatively deep marine (Şenalp, 1981) close to the northern margin of the basin.

During the same period, the northern margin of the Çankırı-Çorum Basin was affected by compressive tectonic regime and nappes of the Ankara Melange thrust into the basin. Between Yozgat and Sungurlu blocks of the ophiolites are found in the Yoncalı Formation and the matrix is represented by very coarse grained detrital rocks with olistostromal facies (Fig. 53 A).

In the Early Eocene, marine deposits became dominant in the southern margin due to the southward invasion of the Yoncalı sea. Because of this invasion, the Çiçekdağ Belt is seen directly overlain by the Shallow marine formations in some places. During the same time, the Bayat volcanism was active in various places of the Yoncalı sea and andesitic to basaltic lavas were formed alternating with shales of the Yoncalı Formation (Fig. 53 B).

The lavas and tuffs of the same volcanism directly overlay the Çiçekdağ Belt in some areas and volcanoclastic rocks alternate with limestones of the Kocaçay member (Fig. 53 B).

The Bayat volcanism was intensively occured in some local places and lavas piled up and emerged above the sea level (Fig. 53 B). In this newly formed volcanic islands, lavas extruded subaerially and upon coiling well developed columnar joints were formed. During the same period, along the northern border of the Çankırı-Çorum Basin, movements of the nappes continued into the basin. Since these movements and the sedimentation were formed simoultaneously, slices of the Ankara Melange are found overlain by the basin sediments and also by the coarse grained conglomerates (Fig. 53 C).

In the Middle Eocene time, along the southern margin of the basin, terrestrial conditions became predominant and lagoons and marshs were formed above the Çiçekdağ Belt (Fig. 53 C). At the same period in deltaic environment, cross bedded sandstones and siltstones were formed by the processes of rivers and in the flood basins of these rivers laminated shales were deposited intercalating with the sandstones (Fig. 53 C).
In the northern margin of the basin, extensive thrust sheets of the Ankara Melange moved over the sediments and overlay their coarse grained facies (Fig. 53 C). Before the Miocene, the area affected by a compression and folds with long wave length was formed followed by a regional errosion.

During the Miocene time, in the region continental conditions became dominant and in closed lakes evaporitic conditions were prevalent. In this period, the Kızılırmak Formation were formed with laminated evaporites (Fig. 53 D).

In the southern margin, due to the active tectonism, these formations were folded together with the Early Tertiary units. After the deposition of the Bozkır Formation, there was an unconformity again in the region. Probably in the Pleistocene time poorly induruted conglomerates and sandstones of the Değim Formation were deposited.

4. STRUCTURAL GEOLOGY OF THE REGİON

4.1. Deformation of the Basement

In the area studied the most pronounced unconformity is between the Tertiary Çankırı-Çorum sedimentary succession and the Çiçekdağ Belt. The basal conglomerates of the Çankırı-Çorum Basin with well rounded pebbles and cobbles of various rocks of the Çiçekdağ Belt, including the granites of the Yozgat magmatics, overlays the deeply eroded surface of the Çiçekdağ Belt.

The oldest age obtained above this unconformity is the Late Paleocene-Early Eocene. It indicates that before the invasion of the sea of the Çankırı-Çorum Basin the Çiçekdağ Belt deformed and intruded by the Yozgat magmatics, and later a deep erosion took place.

The Çiçekdağ Belt, as discussed in the stratigraphy section, consists of the mafic rocks of the Çökelik volcanics and the granites dacites of the Yozgat magmatics. The Çökelik volcanics with pillow structures, gradually become metamorphic further south, near Kırşehir, and the regionally metamorphosed rocks show marked penetratic cleavage. Just at the southern border of the study area, near Arabın mah. village (Plate 1 C), the Çökelik volcanics are represented by foliated metavolcanics with low-grade greenschist facies metamorphism. This deformation and low-grade metamorphism took place before the emplacement of the Yozgat magmatics. To the south of the study area, we made an excursion toward Kırşehir. Along the Çiçekdağ-Kırşehir highway, after passing Göllü township, it is turned toward Akçakent, and along this road near Beşler village, metavolcanics, amphibole-quartz schists, red marbles of the Çökelik unit are cut by pink microgranite stocks of the Yozgat magmatics. It is clearly doserved at this location that, the Çökelik volcanics were metamorphosed and obtained distinct schistosity and later they were intruded by the post metamorphic granites.

The age of the Çökelik volcanics is obtained from the study area as the Turonian-Santonian. Therefore, the deformation and the metamorphism took place after the Santonian.

After this deformation, the Çiçekdağ Belt was cut by the granites of the Yozgat magmatics. The age of the Yozgat magmatism, with granitic intrusions and dacitic to andesitic lava eruptions, was between the Santonian and Late Paleocene-Early Eocene. This last age is the oldest age determined from the sedimentary rocks of the Çankırı-Çorum Basin.

4.2. Deformation of the Succession of the Çankırı-Çorum Basin

During the Tertiary, the northern boundary of the Çankırı-Çorum Basin was a compressive area. However affects of these compressive forces were felt lesser in the south than in the north. As a result, folds with large wave-length and faults with small slip were formed as main structures in the study area.

In the study area, the second unconformity is between the Late Paleocene-Eocene sequence and the Miocene detrital deposits. Along this unconformity, the flatlying Kızılırmak Formation overlays the slightly deformed İncik and Yoncalı Formations.

The youngest age, obtained from the Early Tertiary units, is the Late Eocene and the oldest age obtained from the overlying detrital sequence is the Middle Miocene. That indicates, the main deformation of the Early Tertiary succession took place before the Middle Miocene time and after the Late Eocene.

During the Early Tertiary time, the Çankırı-Çorum Basin was affected by the synsedimentary compressional forces. These forces caused thrusting of the of the Ankara Melange into the basin from the north (Fig. 2). Between Boğazkale and Sungurlu, the nappes of the Ankara Melange are directly overlain by the flatlaying detrital sedimentary rocks of the Middle Miocene. So, in this region, the main deformation was affective during also the Miocene time. As the Miocene and Early Tertiary units were deformed together and due to the lithological similarities where the Kızılırmak directly overlies the İncik, this unconformity can not be recognized easily. The İncik and the Kızılırmak have large outcrops all over the Çankırı-Çorum Basin. However the unconformity surface between these two formations can be recognized just in very district localities. However on the Çiçekdağ-Kırşehir highway, 1 km. away from the Çiçekdağ, nearly horizontal sandstones and conglomerates of the Kızılırmak, unconformably overlie the shales of the Yoncalı.

At the southern border of the Çankırı-Çorum Basin the Tertiary succession was folded rather than faulted. These folds are commonly symmetrical and the flanks of them dip in the range of about 15 to 30 degrees.

In the area studied the third unconformity surface is between the Miocene and the Pleistocene units. The horizontal Değim Formation of the Pleistocene age, unconformably overlies the slightly tilted Bozkır Formation in the Tuztepe and in the north of Kızılcalı village (Plate 1 A), that indicates the Miocene formations were deformed before in Pleistocene time and after the Pleistocene time there was no pronounced deformation at least in the study area.

5. OIL POTENTIAL OF THE ÇANKIRI-ÇORUM BASIN

The oil potential of the Çankırı-Çorum Basin was first studied by Birgili et al. (1975). The authors indicated that, the basin was important for oil in point of the structures and the thickness and the maturity of the sedimentary sequence.
The workers suggested especially the Yoncalı Formation as the main source rock and the Kocaçay member as the main reservoir rock. They also suggested some big anticlines as possible drilling site.

It is necessary to examine the oil potential of the study area and the neighbouring region in several sections as follows :

1. Existance of source, reservoir and cap rocks.
2. Stratigraphic features of these units
3. Structural properties of the region
4. Geochemical data.

5.1. The source, reservoir and the cap rocks

5.1.1. The source rocks

In the Çankırı-Çorum Basin, between Yozgat, Sungurlu and Yerköy the main source rock is the bituminous shales of the Yoncalı Formation. The Yoncalı have large outcrops in the study area and between Yozgat and Sungurlu. In the study area, the Yoncalı is dominantly rich in the shales. In this shales, rare sandstone beds are present intercalating with shales.

In the north of the Çankırı-Çorum Basin, between Yozgat and Sungurlu, the Yoncalı also crops out in the large areas. However in these areas the Yoncalı poorer in the shales and richer in the sandstones than the southern margin of the basin. There, the Yoncalı is generally an alternation of the sandstones and shales.

5.1.2. The reservoir rocks

In the Early Tertiary succession of the area studied, the most important unit to reserve oil or gas is the Kocaçay member. The Kocaçay is composed of the fossil-rich limestones and sandy limestones. This unit is porous enough to reserve oil, and crops out all over the Çankırı-Çorum Basin in different localities and stratigraphic levels.

The largest outcrop of the Kocaçay in the study area is located at the southern border of the area, among Dulkadirli and Arabın mah. villages. In these areas the Kocaçay is about 20 m. in thickness and extends about 16 km. laterally (Plate 1 C,D). The other outcrops, are generally as thin and local lenses in the Yoncalı Formation.

Further north, toward Sungurlu and Boğazkale, the Kocaçay is also present in the shales of the Yoncalı as thin lenses.

5.1.3. The cap rocks

In the study area and the Çankırı-Çorum Basin, between Yozgat and Sungurlu, the most suitable cap rocks are also the shales of the Yoncalı Formation overlying the Kocaçay member.

5.2. Stratigraphic features of the source and reservoir rocks

As discussed before, the total thickness of the Tertiary succession in the Çankırı-Çorum Basin become thinner from the north to the south. In the north of the area studied, between Yozgat and Sungurlu the Tertiary succession is mainly characterized by the relatively deeper marine shales and sandstones of the Yoncalı

and they are thick enough to produce oil in these areas.
On the contrary, in the study area, which is the southern part of the Çankırı-Çorum Basin, the Tertiary marine sequence is thinner than the north. In this area, the thickness of the Yoncalı Formation is quite thin, however the shales are dominant in the unit. In addition to that, as discussed in the stratigraphy section in the southern margin of the basin, the marine deposits laterally grade in to the continental clastic deposits and these terrestrial deposits become dominant in this region. For this reason, the bituminous shales of the Yoncalı are not thick enough to produce oil economically.

In the southern margin of the Çankırı-Çorum Basin the Early Tertiary sedimentary succession is interdigidated by the andesitic and basaltic lavas of the Bayat Formation. This volcanism developed mainly in this margin of the basin, between Yozgat and Yerköy and lavas and tuffs of the volcanism are formed in the marine and terrestrial units. As mentioned before, this volcanism is the Late Paleocene-Eocene in age. During the volcanism, the shallow Yoncalı sea became a land time by time due to the piling of the volcanic material and in the newly terrestrial area extrusive volcanism developed. These features of the Bayat volcanics indicate a very dynamic deposition area during the Eocene time. So, this dynamic environment which is caused by the volcanic activity, also played a negative role on the oil formation. The Çankırı-Çorum Basin have an another handicap for oil potential in point of the reservoir rock. The Kocaçay which is the most probable reservoir rock of the basin, generally interfingers with the shales of the Yoncalı as thin lenses. These lenses do also not have lateral continuity to reserve oil economically.

In the north of the Çankırı-Çorum Basin a bore-holl was drilled in about 3 km. depth by TPAO. According to the previous stratigraphic sequence which were suggested by Birgili et al. (1975), Tüysüz and Dellaloğlu (1992), after the terrestrial units, the thick marine formations, which are rich in shales, were expected in this bore-holl. However the terrestrial units and several thin marine intercalations were cut and the boreholl ended in the basement units. That indicates, lateral marine land gradition which prevented the oil formation, can be observed all over the Çankırı-Çorum Basin.

5.3. Structural properties of the region

The Çankırı-Çorum Basin have different structural properties in it's northern and southern margin. The northern margin is a tectonically active depositional site during the Early Tertiary time Because of this tectonic activity, the slices of the Ankara Melange were thrust into the basin along this margin, during the deposition. This tectonic activity prevented the oil formation in the shales of the Yoncalı.

Due to these thrusts, the tight folds were formed in the Early Tertiary units and these folds were considered as the suitable drilling sites by Birgili et al. (1975). However the Early Tertiary units are unconformably overlain by the Miocene units. So, these anticline structures eroded from the Eocene till the Miocene and this erosion affected the oil reservation negatively.

As discussed in the Structural Geology section, the southern part of the Çankırı-Çorum Basin was not affected the pronounced compresive tectonism during the Early Tertiary time. For this reason in the study area, there are just several folds with large wave-length are observed. The dips of the flanks vary in the range of 15-25 degrees. Because of these structural features of the folds, mentioned above, this region does not seem very convinient for the reservation of oil.

5.4. Geochemical data

In the last 10 years, some workers analysed chemically, the possible source rocks of the Çankırı-Çorum Basin or the neighbouring basins (Uygun, 1981, Ünalan and Harput, 1983, Korkmaz, 1990). They all indicated that, these basins do not include the source rocks which are rich in the organic material to form oil. Ünalan and Harput (1983) also pointed out that, the existing organic material in the Çankırı-Çorum Basin were derived from the terrestrial flora so, they are suitable for the reproduction of gas instaed of oil. The results of these chemical analyses emphasize our stratigraphic data on the oil potential of the Çankırı-Çorum Basin. As discussed before due to the tectonic activity shales are poor in the organic material in the north. On the other hand, toward the study area, because of the sea-land graditions, the organic materials were mostly derived from the terrestrial flora and these organic materials can just from the natural gas.

As a result, it is possible to summarize the factors, controlling the oil and gas potential of the Çankırı-Çorum Basin between Yozgat, Sungurlu, Boğazkale and Yerköy, as follows:

- In the Çankırı-Çorum Basin the main source rock is the shales of the Yoncalı Formation and the main reservoir rock is the Kocaçay member.
- In the northern margin of the basin thick enough to produce oil. However due to the tectonic activity it does not include enough organic material.
- In the southern margin of the basin, the Yoncalı become thinner and laterally grade into the terrestrial conglomerates of the İncik Formation. In this area the existing organic material in the Yoncalı Formation was derived from the terrestrial flora and they tend to produce gas instead of oil.
- The Bayat volcanism which developed simoultaneously with the deposition also a negative factor in the southern margin of the basin.
- In the Çankırı-Çorum Basin the Kocaçay, which is the main reservoir rock for oil is present in the Yoncalı Formation as thin and district lateral continued lenses.
- In the southern margin of the Çankırı-Çorum Basin the main Tertiary structures

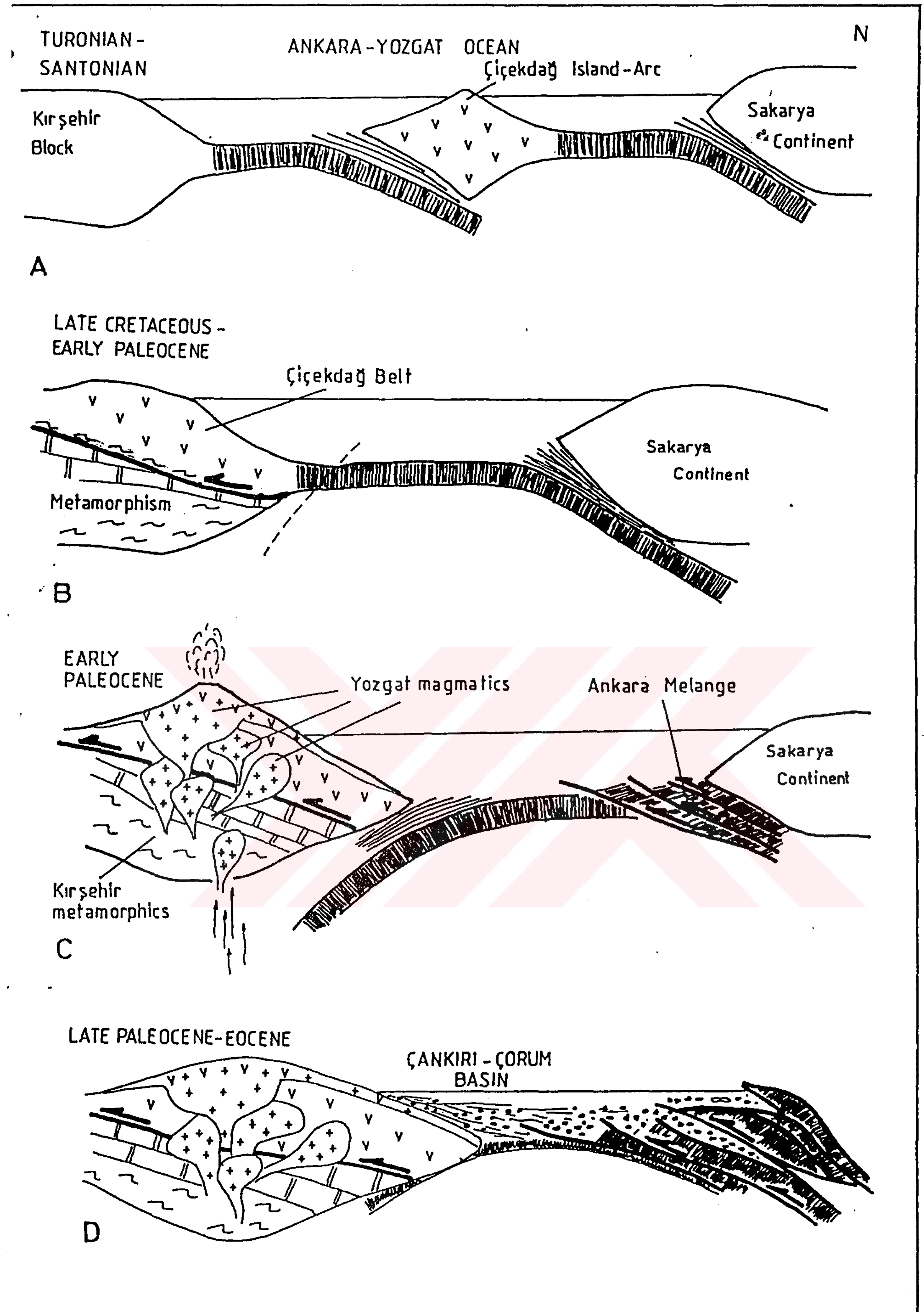
are the large folds and these folds are not important to reserve oil.

According to the all stratigraphic and tectonic features of the study area, and chemical analyses of the organic materials which were carried out previously, it is concluded that, the study area and the surrounding region is not economic for oil in point of both the stratigraphy and geochemistry.

6. TECTONIC EVOLUTION OF THE STUDY AREA AND THE SURROUNDING REGION

The Tertiary Çankırı-Çorum Basin developed on the Çiçekdağ Belt in it's southern margin between Yozgat, Yerköy and Çiçekdağ. The Çiçekdağ Belt which forms the basement in the study area, is composed of two different rock associations as the Çökelik volcanics and the Yozgat magmatics.

The Çökelik volcanics were defined as a part of an ophiolitic suite by most of the previous authors (Ketin, 1955, Görür et al. 1985, Tüysüz and Dellaloğlu, 1992, Göncüoğlu et al., 1993, Tüysüz, in print). However these volcanics have a regular internal structure in the study area and include massive diabases and pillow lavas. They do not include pelagic and ultrabasic components of the ophiolitic suite and no serpantinites are seen in our area. So that, it does not have typical ophiolitic features. Göncüoğlu et al. (1993) indicate that, this rock association include also ultrabasic rocks near Kırşehir and they tectonically overlie the Kırşehir metamorphics. For this reason they may not be certainly a part of an ophiolitic suite. Lithological features of these volcanics may indicate an arc-type magmatism that was developed in the north of the Kırşehir platform (Fig. 54 A). Then these arc volcanics should have been thrust over the Kırşehir platform (Fig. 54 B). As discussed in the Stratigraphy and the Structural Geology sections, the Çökelik volcanics are slightly metamorphosed in the south of the study area near Kırşehir. This may indicate the thick carbonate platform of the Kırşehir Block were metamorphosed due to the loading of the Çiçekdağ Island Arc during the Late Cretaceous time (Fig. 54 B). However, to define the relationship between the metamorphism and the thrusting of the arc volcanics more precisely, the boundary of the Çökelik volcanics and the Kırşehir metamorphics should be studied in detail.



ig. 54 A, B, C, D. Tectonic evolution of the basement units of the Çankırı-Çorum Basin.

The second unit which forms the Çiçekdağ Belt, is the Yozgat magmatics which are composed of the granitic, granodioritic plutons and their subvolcanic, volcanic equivalents. These rocks show the chemical and mineralogical features of the arc-type magmatism. They may formed by the subduction of the Ankara-Yozgat Ocean under the Kırşehir Block in the Paleocene time (Fig. 54 C).

Görür et al. (1985) indicates that, these rocks were derived from the inner Taurid Ocean which subducted under the Kırşehir Block from the south to the north. According to these authors the plutons cut both the Kırşehir metamorphics and the ophiolitic rocks, tectonically overlying the metamorphics.

Türeli et al. (1993) and Geven et al. (1993) indicate that, the granitoids in the Central Anatolian Crystalline Complex were derived from the partially melted Kırşehir metamorphics, which were caused by the loading of the tectonically overlying ophiolitic rocks.
It is expected that, magma which formed by the melting of a continental crust under another crustal mass, crystalize as relatively small, homogenous stock. Whereas, near Yerköy, in the Yozgat magmatics, granitic plutons are present and their subvolcanic and volcanic equivalents reach about 2 km. thickness. Besides that, they show mineralogical and textural heterogeneties in very short distances. All these evidences indicate that, the Yozgat magmatics should have been derived from the high amount of magma generation. Such a large amount of magma generation may be formed by a subduction instead of partial melting of a crustal material.

The Yozgat magmatics cut the Turonian-Santonian Çökelik volcanics and they are all unconformably overlain by the Late Paleocene-Eocene rocks of the Çankırı-Çorum Basin. For this reason the magmatism which formed the Yozgat magmatics should have been developed between the Santonian and Late Paleocene time.

According to the all of these data, after the thrusting of the Çökelik volcanics over the Kırşehir Massif and the metamorphism of this block, the Ankara-Yozgat Ocean might subducted under the Kırşehir Block along a collision zone. This subduction developed between the Santonian Late Cretaceous and Late Paleocene time.

According to Tüysüz and Dellaloğlu (1992) and Tüysüz (in print) Ankara-Yozgat Ocean subducted under the Sakarya Continent during the Campanian time. This subduction caused the formation of the Ankara-Melange in the north.

The subduction of the Ankara-Yozgat Ocean caused the generation of the high amount of magma and the Yozgat magmatics which cut the Kırşehir metamorphics and the Çökelik volcanics, were formed (Fig. 54 C). In the Late Paleocene and Eocene time, the Çiçekdağ Belt which is formed by the Çökelik volcanics and the Yozgat magmatics formed the basement of the Çankırı-Çorum Basin in the south, and in the north the Ankara Melange which were formed previously thrust into the Çankırı-Çorum Basin simoultaneously with the deposition (Fig. 54 D).

7. CONCLUSIONS

In this study 8 1/25000 topographic sheets were mapped between Yerköy, Çiçekdağ and Akçakent which are located in the southern margin of the Çankırı-Çorum Basin. In the study area, the Çankırı-Çorum Basin was developed on the Çiçekdağ Belt as a detrital sedimentary basin in the Tertiary time. The andesitic and basaltic Bayat volcanics interdigitate with this Tertiary succession between Yerköy and Yozgat.

In the study area, the Çiçekdağ Belt consist of two distinct rock association, the older and lower one is the Çökelik volcanics and the younger one is the Yozgat magmatics. The Çökelik volcanics are dominantly composed of thick, massive diabases and pillow lavas. The unit crops out in large areas in the study area, however there are no serpentinites and ultramafic rocks or any disruptions in lithologies in these outcrops. So, although the Çökelik volcanics were defined as ophiolitic rocks by the previous workers, it does not appear to be an ophiolitic suite at least in the study area. The Çökelik volcanics include rare thin red micrite lenses intercalating with the mafic volcanics. These micrite lenses yield microfossils of the Turonian-Santonian age.

Textural and mineralogical features of the Çökelik volcanics indicate that, the unit may be formed in an arc environment which developed in the north of the Kırşehir Block during the Turonian-Santonian interval and these arc volcanics were thrust over the Kırşehir Block between the Santonian and Late Paleocene time Toward the south, near Kırşehir, the Çökelik volcanics become metamorphic and amphibolites and thin red marbles showing distinct foliation are observed. However, the exect relation between this unit and the Kırşehir metamorphics can not be recognized in the study area.

The Çökelik volcanics are cut by the Yozgat magmatics including granitic, granodioritic plutons and their volcanic and subvolcanic equivalents. The Yozgat magmatics mineralogically and chemically vary from the granite to monzonite and show textural heterogeneties in very short distances.

In the southeast part of Yerköy, plutonic rocks are overlain by their volcanic equivalents in about 2 km. thickness. These volcanics are andesitic in composition in the lower part and dacitic, rhyodacitic in the upper part. This volcanic succession is often cut by the subvolcanic porphyries of the same magmatism.

Petrographical and chemical features of the Yozgat magmatics indicate that, they are I-type, calc-alkaline in nature and probably formed above a subduction zone at the northern border of the Kırşehir Block.

The Çiçekdağ Belt is unconformably overlain by the Çankırı-Çorum sedimentary succession. The oldest age obtained from this succession is the Late Paleocene. This succession is seperated into three parts by two distinct unconformity surfaces.

In the southern margin of the basin the Early Tertiary şequence is composed of the shallow marine shales and sandstones of the Yoncalı Formation, shallow marine limestones of the Kocaçay member, continental conglomerates, sandstones and mudstones of the İncik Formation and andesitic, basaltic lavas and tuffs of the Bayat Formation interfingering with each others. The sedimentary rocks, in this succession grades into each others laterally and vertically and they are all Late Paleocene to Eocene in age.

This Early Tertiary succession is unconformably overlain by the Miocene continental detritals and evaporites. The Kızılırmak Formation consists of conglomerates, sandstones and shales and forms the lower part of the Miocene succession. Upward it grades into the evaporite bearing shales and thick gypsiferous beds of the Bozkır Formation.

Another unconformity surface in the Çankırı-Çorum succession seperates the Miocene Kızılırmak and Bozkır Formations and the Pleistocene Değim Formation The Değim is formed of the terrestrial conglomerates, sandstones and mudstones including trough cross beddings.

The Çankırı-Çorum Basin was evaluated as mainly a detrital sedimentary basin during the Tertiary time. In this basin terrestrial clastics and shallow marine shales and limestones were deposited graditionally in lateral and vertical directions. Contrary to the northern margin of the basin in the study area continental deposits become predominant and directly overlie the basement units. However, because of the invasion of the shallow Yoncalı sea, the marine deposits overlie the Çiçekdağ Belt in some stratigraphic levels.

During the sedimentation the andesitic, basaltic Bayat volcanism developed in the shallow sea and lavas of this volcanism took place in the basin sediments as intercalations. Because of the piling of lavas, the sea was emerged and in this newly formed volcanic islands lavas with the columnar joints and agglomerate lenses in lavas were formed.

At the same time in the northern margin, slices of the Ankara Melange were moved into the basin simoultaneously with the deposition and this movement gave rise the formation of coarse grained facies in the Early Tertiary sediments and in this coarse grained detrital rocks with olistostromal facies blocks of the ophidites are found.

After the Eocene time, the Yoncalı sea closed and the Miocene succession which is characterized by the continental clastics of the Kızılırmak and evaporites of the

Bozkır, formed in a fluvial environment. This continental sequence unconformably overlies the underlying Early Tertiary succession.

The Pleistocene Değim Formation including the terrestrial conglomerates, sandstones and siltstones with trough cross beddings, unconformably overlies the older units and characterize a fluvial environment.

In the Çankırı-Çorum Basin the Early Tertiary units have importance as the source and reservoir rocks for oil or natural gas. In this study oil potential of the basin was studied and some new approachs were presented about the oil potential of the basin. In the Çankırı-Çorum Basin the most probable source rocks are shales of the Yoncalı Formation and the reservoir rocks are limestones of the Kocaçay member. These shales are quite thick in the northern margin of the basin. However along this margin movement of the Ankara Melange into the basin caused a tectonically active depositional site and this tectonic activity prevented the oil formation in the northern margin.

Toward south, the Yoncalı shales grade into the continental clastics laterally and in the study area, detritals of the İncik become predominant. In these areas, the Yoncalı shales are poor in the organic material and the existing organic materials were derived from the terrestrial organisms so, in the study area, the Yoncalı shales are not suitable for oil production. In the same area, the Bayat volcanism which developed simoultaneously with the sedimentation resulted in the active depositional site and this volcanic activity also played a negative role on the oil formation.

In this study a possible tectonic evolution model was suggested for the region. According to this model, the Çiçekdağ Belt which forms the basement of the basin, developed in the north of the Kırşehir continent during the Late

Cretaceous-Paleocene time. In the Late Cretaceous time an island arc developed between the Kırşehir and Sakarya Continents and this arc was thrust over the Kırşehir Block in the Late Cretaceous time. This thrusting may be cause of the metamorphism of the Kırşehir Block.Emplacement of the Yozgat magmatics in the Kırşehir metamorphics and the Çiçekdağ volcanics is the Eerly Paleocene in age and follows the thrusting of the Çiçekdağ Island Arc over the Kırşehir Block. This magmatic emplacement was caused by the subduction of the oceanic crust under the Kırşehir Block from the north to the south. In the same time, this oceanic crust also subducted under the Sakarya Continent in the north and in this subduction zone the Ankara Melange melange was formed.

The Çankırı-Çorum Basin was developed on the Çiçekdağ Belt in its southern margin and on the nappes of the Ankara Melange in its northern margin after the closing of the Ankara-Yozgat Ocean.

Continuoing compressional forces during the evolution of the basin caused the movements of the nappes into the basin sediments, simoultaneously with the deposition.

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