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DISTRIBUTION AND GENESIS OF NEOFORMED MINERALS IN KOYUNAĞILI (MIHALIÇÇIK-ESKİŞEHİR) AREA

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ABSTRACT.- The study area is located at the Southwest of Koyunağılı village situated in the south margin of the Beypazarı-Qayirhan basin which is in the Middle Sakarya Massif. The Neogene units in the investigated area are Çoraklar, Hırka, Karadoruk, Akpınar, Bozçayır, Acısu and Kırmızıtepe Formations. The mineralogic features of the clay minerals and tha host rock samples were studied by means of petrographic, XRD, DTA-TG, SEM-EDX and IR Spectra techniques. Various effects of pH values of the environment related to evaporation and feeding of the basin from several areas, cause the formation of different mineral paragenesis. The main mineral paragenesis are; loughlinite + analcime + calcite + dolomite + feldspar, sepiolite + analcime + dolomite + illite, sepiolite + analcime + dolomite + opal-CT + feldspar, montmorillonite + analcime + dolomit + illite + feldspar + quartz + opal-CT, montmorillonite + analcime + calcite + felspar + illite and montmorillonite + dolomite + calcite + analcime + quartz + Feldspar. Montmorillonite is formed at the margin of the basin, derived from freswater and detritic materials which contain Al and Mg. Aluminum ions are generally dominant in the shallow part of the basin facies of the Bozçayır and Acısu Formations. In the Akpınar Formation, sepiolite is formed at a non-acidic environment, which is rich in Mg and Si, but poor in Al. At the center of the area (around Ocak), loughlinite is formed in a way similar to that of sepiolite by combining of Na, originated from the alteration of tuff, to the Si and Mg. As a result of the alteration, especially after the formation of montmorillonite the proportion of (Na+K)/H increases and finally analcime and feldspar are formed. At the south of the area magnesite is formed at the bottom part of the Hırka Formation, due to the high Mg and pH and low Si values. To the north, some dolomite, depending on the decreasing of Mg content, is observed. At the north, dolomite and calcite are formed interbededly, due to changes in the pH conditions controlled by evaporation and freshwater participations. Sepiolite, loughlinite, analcime, feldspar, opal-CT and a small amount of quartz are formed authigenically, in and around the altered glass pores as a result of alteration of volcanic glasses.

1. INTRODUCTION

The study area is located in the southwest of the Koyanağılı village in the southern margin of the Beypazarı-Çayırhan of the Central of Sakarya Massive (Fig. 1).

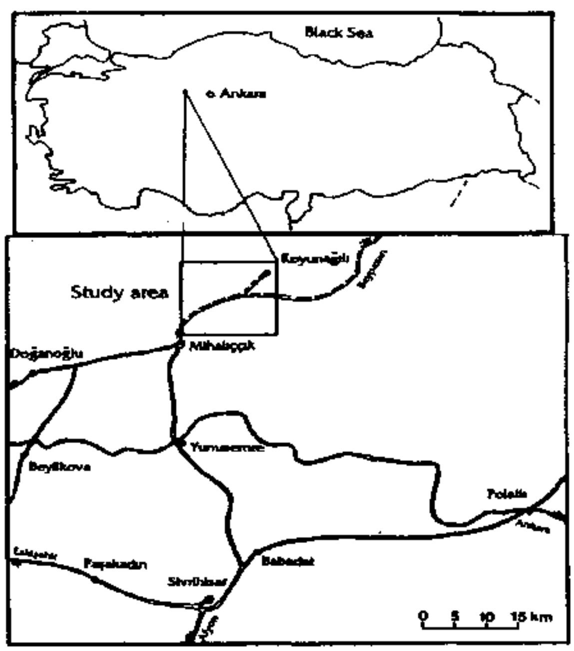

Fig. 1- Location map of study area.

Metamorphic rocks of Paleozoic age and Mesozoic serpantinites form the basement (Fig. 2). The unconformably overlying Middle-Upper Miocene units are spreaded widely and they comprise of the comformable units of the Çoraklar Formation (conglomerate, sandstone, mudstone, siltstone and tuff), the Hırka Formation (tuff), the Karadoruk Formation (dolomite), the Akpınar Formation (silicified tuff, crystal tuff and carbonate interbedded clay and claystone alternotions), the Bozçayır Formation (clay) and the Acısu Formation (claystone-limestone alternations) from the bottom to the top respectively. The Acısu Formation is uncomformably overlain by the Kırmızıtepe Formation (conglomerate, sandstone, mudstorre

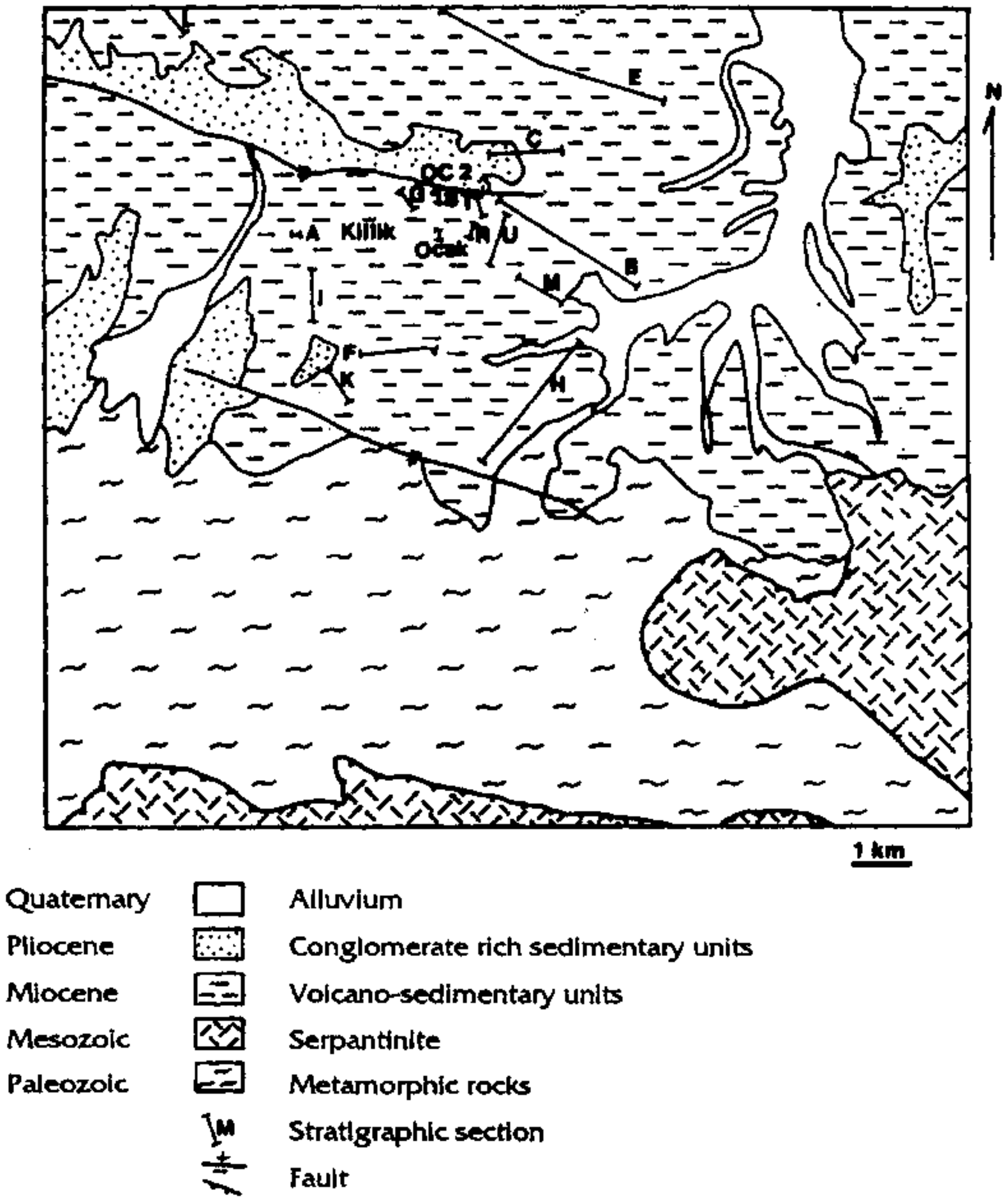

Fig. 2- Generalized stratigraphic section of study area.

and claystone alternation) of Pliocene age. Quaternary alluvium deposits are the youngest units of the study area (Fig. 3). The clays of Akpınar Formation contain sepiolite, loughlinite (Na-sepiolite), analcime, montmorillonite, feldspar, dolomite, calcite, opal-CT and quartz minerals. Loughlinite deposit seems to be economic at the Ocak area. However, at the other areas, sepiolite is in mineral paragenesis of minerals such as dolomite, magnesite, calcite, montmorillonite, analcime, felspar, quartz and opal-CT within the tuffs.

In the study area, several geological studies were carried out for different purposes. Bituminous schists and trona investigations were studied by Siyako (1982, 1983), Şener (1981), Tenekeci et al. (1983), Kayakıran and Çelik (1986), Helvacı et al. (1988, 1989), Gündoğdu et al. (1985).

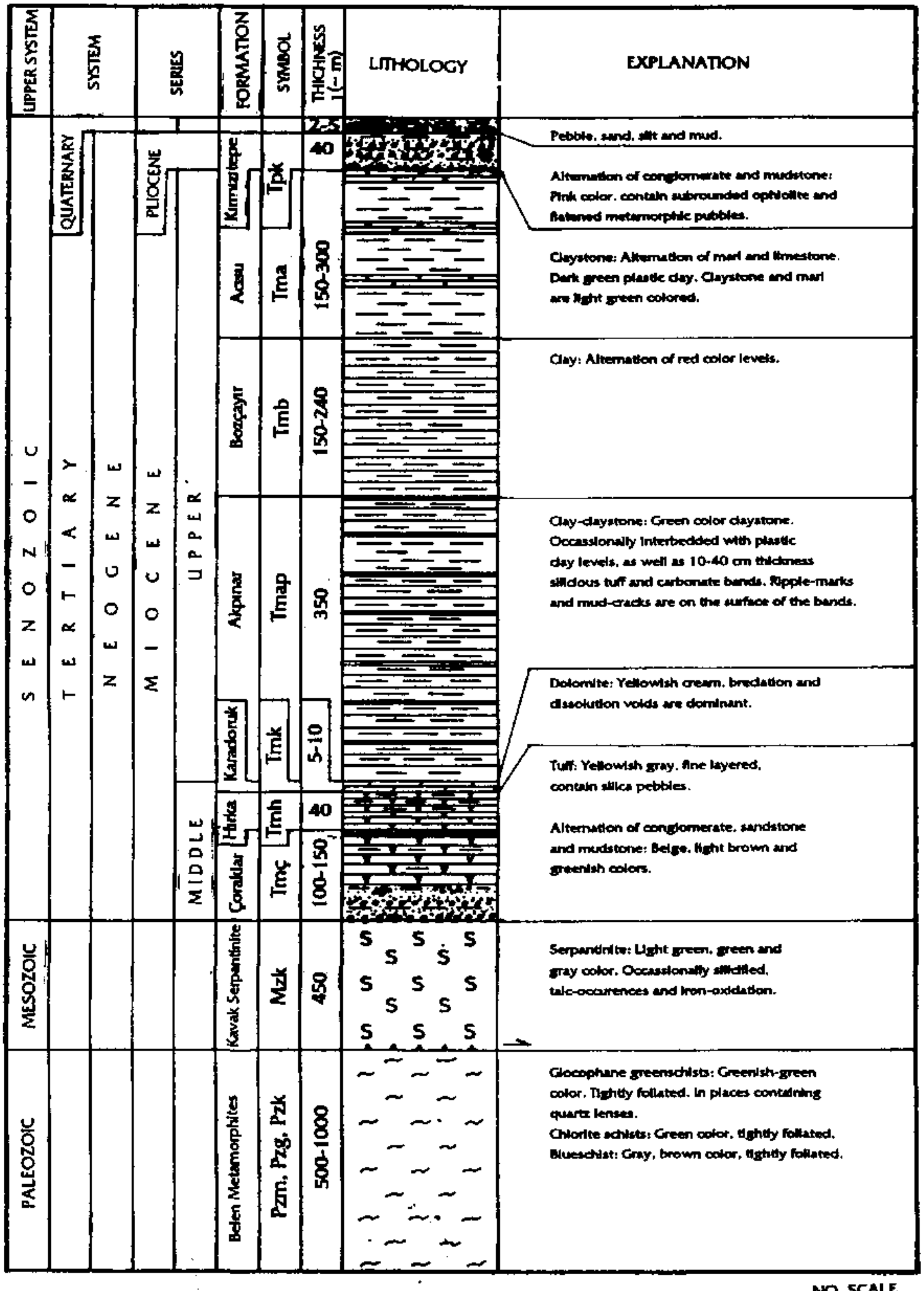

Fig. 3- Generalized geologic map of study area.

The mineralogical investigation was firstly performed by Echle (1967, 1974, 1978). He studied the sedimentology of the area as well as the formation of sepiolite-loughlinite and transformation of these minerals.

Ataman (1976) studies the Beypazarı basin, which contains analcime, dolomite, K-feldspar, searlesite, loughlinite, sepiolite, palygorskite and smectite minerals.

The purpose of this study is to determine the vertical and horizontal distribution of volcanic sepiolite-loughlinite bearing neoformed minerals in the Koyunağılı area.

2. MATERIAL AND METHODS

The mineralogy of the samples were determined by using of petrographic, XRD, DTA-TG, SEM-EDX and IR-spectrum techniques.

Petrographic, XRD, DTA-TG and SEM studies were performed in the laboratories of General Directorate of Mineral Research and Exploration of Turkey (MTA), EDX works were conducted in the General Directorate of Turkish Petroleum (TPAO).

During the field work, 20 stratigraphic sections were studied in detail and 310 samples were collected for mineralogical investigation These sections were named as A, B, C, E, F, G, H, I, L, M, R, Q, Ocak, R, S, T, U (Fig. 2). The distance between the stratigraphic sections at the center of the area is about 500-1000 m and the distance between the sections of the margin is about 1500 m.

3. RESULTS

Mineral paragenesis of each formation in the investigation area is as follows:

3.1. Hırka Formation: The Hırka Formation (M) is the oldest unit in the study area. The mineral distribution in the stratigraphic section H from relatively high to low amounts are: magnesite, dolomite, montmorillonite and illite (Fig. 4a). F sections contain montmorillonite, sepiolite, analcime and feldspar minerals (Fig. 4b). Towards the north, in the section M, dolomite and trace amount of kaolinite, illite, felspar and quartz are present. In section E, dolomite, illite, montmorillonite and analcime with a small amount of feldspar and calcite are present (Fig. 4c, 5). The southern margin of the area (section H), magnesite mineralization is relatively dominant because of high Mg and low Si and also of the short distance to the basement. Since the proportion of Mg and pH values are much lower towards the north, the dolomite becomes more dominant mineral, but montmorillonite and analcime seem to abundant at the presence of Al. Hırka Formation contains of green colored opal-CT nodules (3-10 cm).

3.2. Karadoruk Formation: This formation is generally composed of dolomite, quartz and small amount of feldspar.

3.3. Akpınar Formation: Akpınar Formation is cropped out in the most of the units within the stratigraphic section (Fig. 4a, b, c, 5, 6a, b, c, 7b). Sepiolite and montmorillonite are dominant in the Akpınar Formation. At the southern part of the area (section H), dolomite and sepiolite are dominant and small amount of analcime, illite, feldspar, amphibole, quartz and opal-CT are also present. At section F, montmorillonite, dolomite, illite and small amount of feldspar, talc and amphibole minerals were recognized. Dolomite and opal-CT were determined in section M. The bottom part of the section B is dominated by dolomite, montmorillonite, and illite, while its upper part is dominated by sepiolite, montmorillonite and analcime. Sepiolite, dolomite and analcime are dominant in the section E at the north. Loughlinitization is present in the Ocak section. Therefore, the mineral distribution of formations in the south close to the basement is montmorillonite, dolomite and sepiolite; towards the north, dolomite + opal-CT, dolomite + montmorillonite + sepiolite + analcime; sepiolite + dolomite + analcime become dominant minerals. This shows that sepiolite increases from south to north direction of the region.

The south, the west and center of the investigation area contain 0.5-1 m thick opal-CT beds and 3-10 cm opal-CT nodules.

3.4. Bozçayır Formation: Montmorillonite and mixed-layer clays (montmorillonite + sepiolite) are

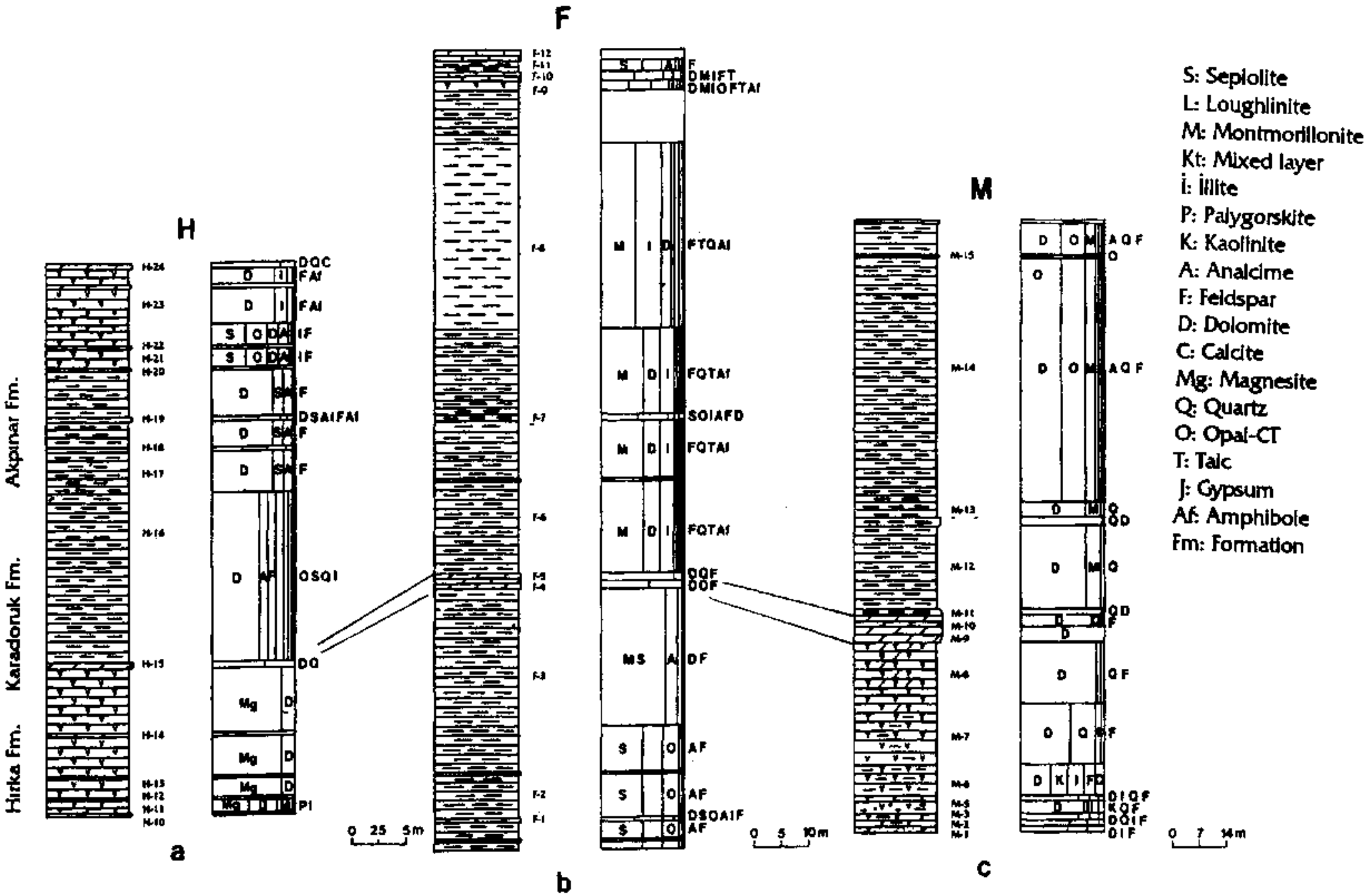

Fig. 4- Mineral distribution in Hırka, Karadoruk and Akpınar, Formations in the Southern part of the study area (See Fig. 2, for section locations and Fig. 4, for symbol explanations).

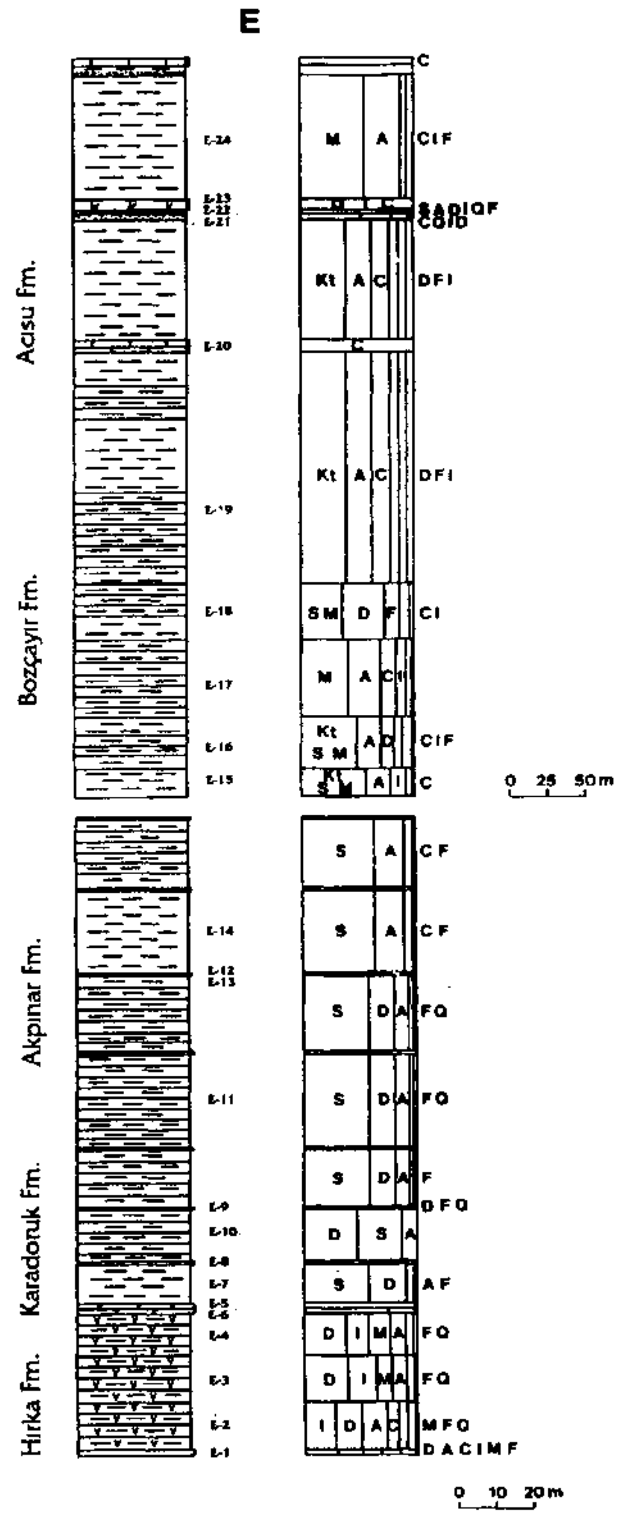

Fig. 5- Mineral distribution in Hırka, Karadoruk, Akpınar, Bozçayır and Acısu Formations in the northern part of the study area (See Fig. 2, for section locations and Fig. 4, for symbol explanations).

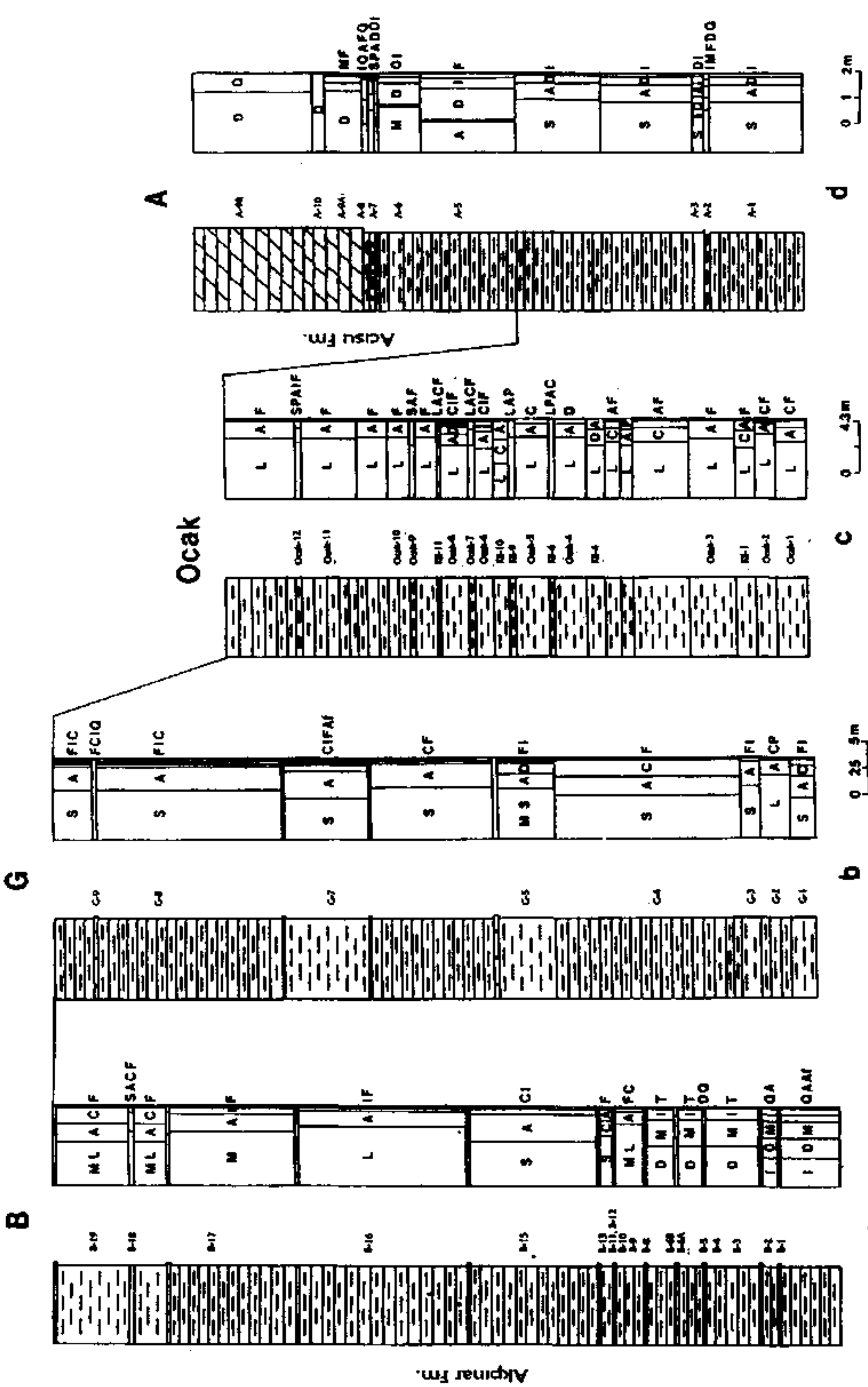

Fig. 6- Mineral distribution in Akpınar and Acısu Formations in the center of the study area (See Fig. 2, for section locations and Fig. 4, for symbol explanations).

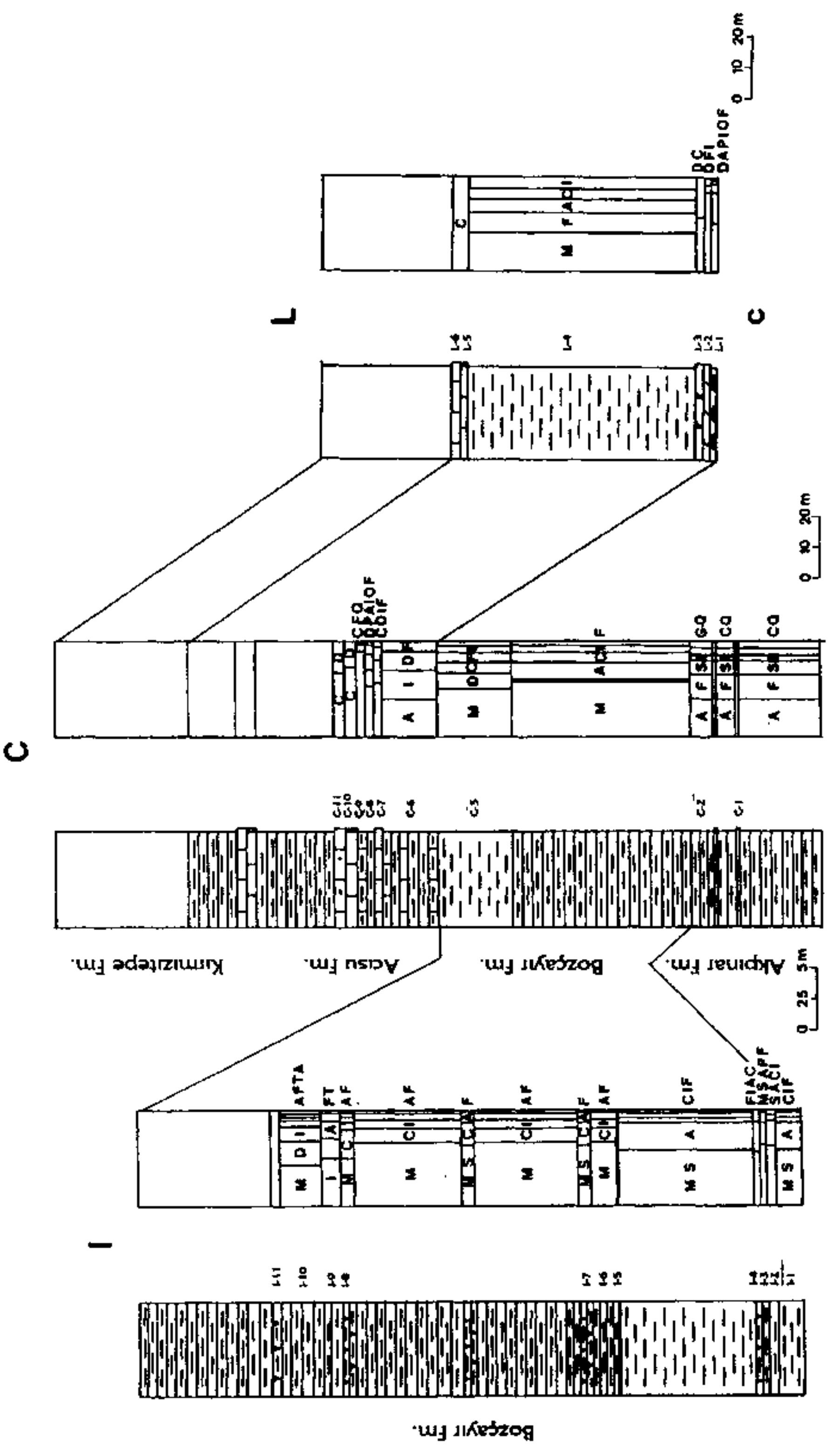

Fig. 7- Mineral distribution in Akpınar, Bozçayır, Acısu and Kırmızıtepe Formations (See Fig. 2, for section locations and Fig. 4, for symbol explanations).

dominant and a small amount of analcime, dolomite, calcite, felspar and illite are also determined (Fig. 5, 7a, b).

3.5. Acısu Formation: Montmorillonite, mixed-layer clays and analcime are dominant in this formation.

4. DISCUSSION

Sepiolite forms in basic environments (pH 8-9) when SiO_2 and MgO proportions are high (Caillere, 1951, Milton and Eugster, 1959; İsphording, 1973; Starkey and Blackmon, 1979; Singer and Galan, 1984; Velde, 1985; Weaver and Beck, 1977). The formation of sepiolite was examined experimentally by many workers. Mumpton and Roy (1958) prepared composition of 38.1 % MgO, 59.6% SiO_2, 2.3% Al_2O_3 and observed that montmorillonite, talc, silica and chlorite phases were formed rather than sepiolite at different heat and water vapor pressures. Hast (1956), Wollast et al. (1968), Mumpton and Roy (1958) formed sepiolite without adding Al_2O_3 to the mixture. This shows that Al_2O_3 seems to prevent the formation of sepiolite.

Wollast et al. (1968) found out that the reaction of sea water with the silica had caused the formation of hydro-magnesium silicate. The composition and structure of this formation is similar to that of sepiolite. These authors state that sepiolite is precipitated in environments which the pH value is higher than 8, high MgO and low or zero Al_2O_3. When pH value is less than 8, sepiolite does not form but the environment becomes saturated with amorph silica. Sepiolite does not form if the silica concentration is high and pH as well as magnesium values are low.

The fault, dip and strikes of the beddings show that the center of investigation area seem to be a depression zone. The source of MgO of the formation of sepiolite is probably derived from the alteration of basic, ultrabasic and metamormophic rocks which are cropped out at the south and east of the investigation area. Sepiolite-dolomite, sepiolite-montmorillonite-talc, magnesite-dolomite, magnesite-dolomite-montmorillonite-illite mineral paragenesis support the idea of the source of magnesium (Fig. 8). In addition; smecite (montmorillonite) and montmorillonide-sepiolite mineral paragenesis in Hırka and Akpınar formations were determined (Fig. 8). Generally mixed-layer montmorillonite are formed at the environment which comprise of high amount of fresh water influx (Fig. 9).

Starkey and Blackmon (1979, 1984) found that the reaction of aluminum with silica and magnesium in a pH > 9 environment forms montmorillonite, chlorite and talc rather than sepiolite.

Cheminal analyses show that sepiolite contain high MgO and low Al_2O_3 (Fig. 10). The proportion of Al_2O_3/MgO decreases from the margin toward the center of the investigated area (Killik). This means that the amount of the aluminum in the horizontally distributed minerals of the same formation decreases from the margin towards the center (Fig. 10). At the south, low Mg causes the formation of dioctahedral smectite (montmorillonite) and at the central area, that is more stable, high Mg and Si and low Al content cause to form the sepiolite minerals. The mineral distribution of the study area is agree with in the mineral distribution of that of Northwest African Lake which tends to contain montmorillonite-illite-chlorite-kaolinite, montmorillonite-palygorskite, palygorskite-sepiolite, sepiolite paragenesis from the margins towards the center (Millot, 1964). The region is devoid of palygorskite mineral in nature, probably due to the most of the aluminum being used in the occurrence of aluminum silicate and zeolite.

illite is very low in the studied area because of the mobility of K in the solution. The same condition was mentioned by Fontes et al. (1967), Galan and Ferro(1982).

Vertical mineral distribution of the investigated area is as follows; montmorillonite, in Hırka Formation, sepiolite, in Akpınar Formation, montmorillonite and mixed-layer clay (montmorillonite dominant) in Bozçayır and Acısu Formations and the upper part of the Akpınar Formation at the center of the investigated area (around Ocak).

The source of silica for the formation of sepiolite is probably the alteration of volcanic tuff and/or Si^{+4} of the sorrounding litnologies. Amorphous material and opal-CT were also determined in the

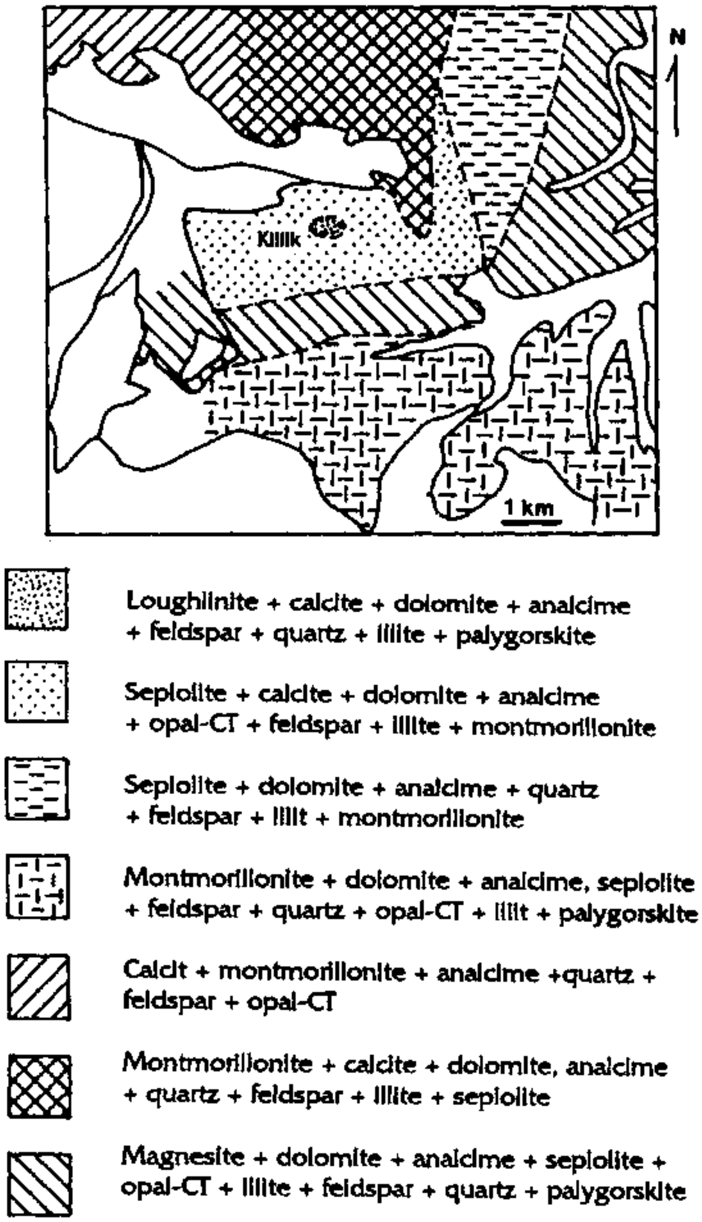

Fig. 8. Neoformed mineral distributions in the Neogene age units.

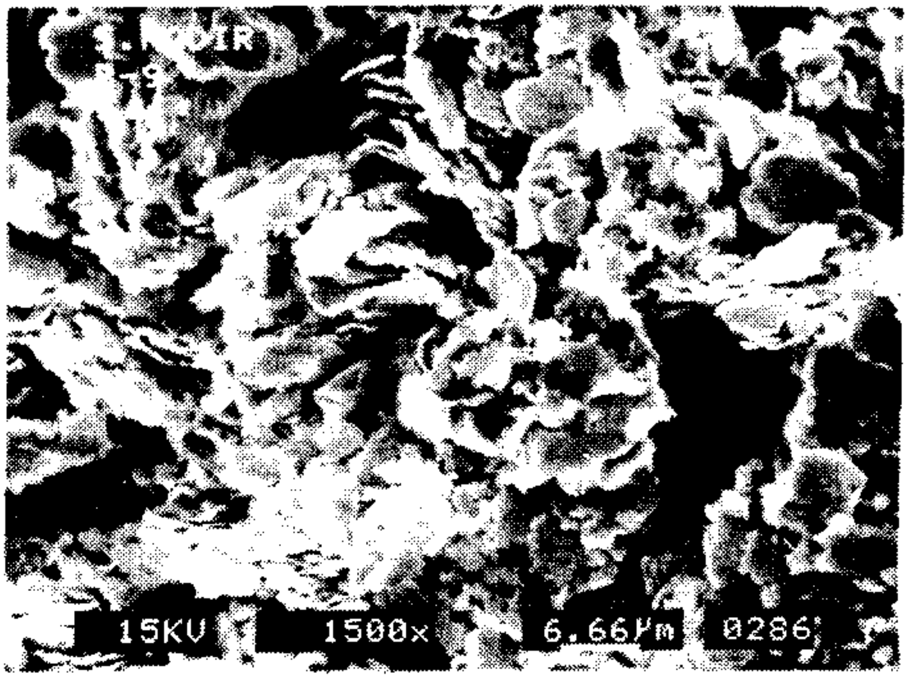

Figure 9. SEM view of authigenic montmorillonite showing cornflakes structure.

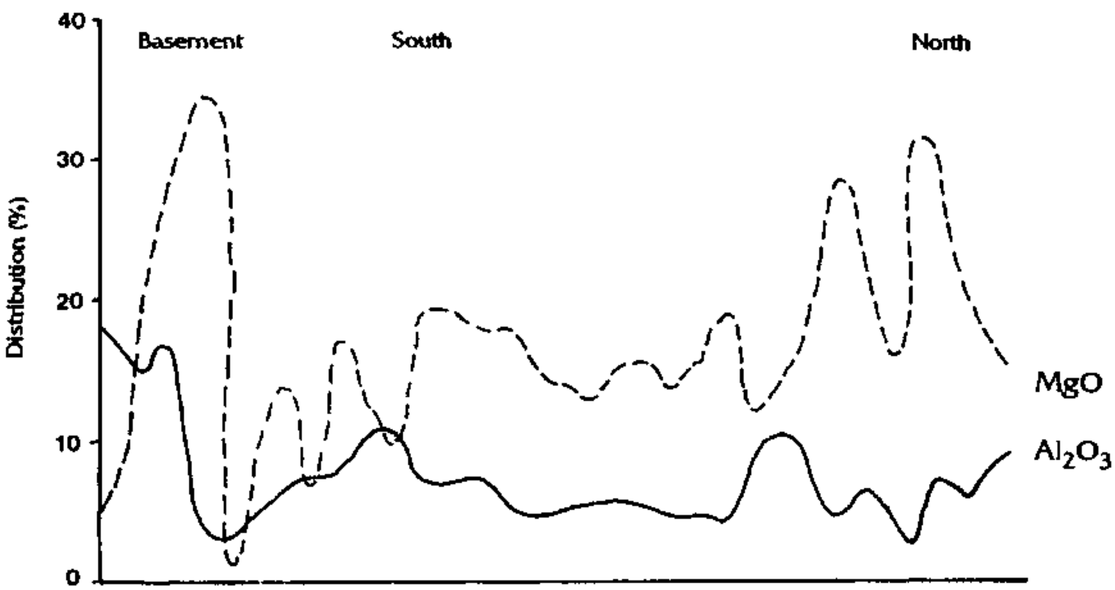

Fig. 10- MgO and Al_2O_3 distribution curves of the investigation area (From south to north).

taken samples of the region (Kadir and Baş, 1995). It was observed that (001) peak of the clay minerals are relatively sharp and strong. This shows that the alteration is very strong (Jones, 1986). The argilization degree of the area is controlled by pH value and the diagenesis period (Hardie et al., 1978). Scanning Electron Microscope studies showed that sepiolite and loughlinite fibrous were formed authigenically in and around the altered pores as a result of alteration of the volcanic glass (Fig. 11) (Kadir and Baş,1995).

At Killik area, loughlinite seems to be a small lens inside of the sepiolite zone (Fig. 8). Loughlinite is formed in the same way with that of sepiolite by combining of Na, probably originated from the alterated tuffs to the Si and Mg.

The formation of montmorillonite causes the concentration of alkaline ions in the rest material which is suitable to form zeolite minerals (Sheppard and Gude, 1969, Moiola, 1970). By the hydrolization of volcanic glasses, pH value increases and the concentration of alkaline ion causes to form montmorillonite (Hay, 1963). The (Na+K)/H activity ratio of pore waters increases and the environment become suitable for the zeolite to form.

In the study area the evolution of more saline alkaline pore waters becomes a favoured environment for the precipitation of analcime. The geochemical change in pore-water is thought to be influenced by probably;

1. Mineralogy and geochemistry of tuffs, igneous, metamorphic and ophiolitic sorunding rocks.
2. The climatic condition of the evaporates.
3. The accumulation of the sediments within a closed hydrographic basin.
4. A higher than normal geothermal gradient due to the magnetic activity.

However, the diagenesis of tuff of the area seems very complicated. Due to the mineralization period of analcime, carbonate and small amount of feldspar neoformed with the clay minerals.

Preburial diagenesis of the tuff under an oxidation regime at near neutral pH, conditions favour the precipitation of quartz and K-felspar (Walker et al., 1978). Evaporation of pore-water causes to increase of pH value, the alteration of felspars probably provide a source of Na^+ and Al^{+3} for analcime precipitation.

$$NaAlSi_3O_8 + 6H_2O + 2H^+ \text{Ş} \; 3Si(OH)_4 + Na^+ + Al(OH)^+_2$$

$$CaAl_2Si_2O_8 + 4H_2O \; \text{Ş} \; 2Si(OH)_4 + Ca^+ + Al(OH)^+_2$$

Following the above alteration, interstratal solutions would evolve the saline, alkaline brines and increase the amount of the fluid, basinward. With further concentration and temperature increase (due to burial) calcite would be precipitated as following;

$$Ca+^2 + HCO_3 \, \text{ÜŞ} \, CaCO_3 + H^+$$

Calcite

As a result when conditions were sufficient with alkaline, analcime would be precipitated (below 100°C) as in the following reaction:

$$2Si(OH)_4 + Na^+ + Al(OH)^+_2 \; \text{Ş} \; NaAlSiO_6.H_2O + 3H_2O + 2H^+$$

Analcime

In the studied area some small amount of albite and sanidine were found to be associated with zeolite. Hay (1966), İijima and Hay (1968), Sheppard and Gude (1968, 1969, 1973), Hay (1970), Eugster (1970), Surdam and Parker (1972), Surdam (1981) reported that there is a relationship between the authigenic mineralizetoin and the deposition. In high saline and alkaline environment, the volcanic glasses dissolve and analcime neoforms and analcime is transformed to feldspars as showed in the following reactions:

$$NaAlSi_2O_6.H_2O + SiO_2 + K+ \text{Ş} \; KAlSi_3O_8 + H_2O + Na$$

Analcime K-feldspar

$$NaAlSi_2O_6.H_2O + SiO_2 \; \text{Ş} \; NaAlSi_3O_8 + H_2O$$

Analcime Albite

The presence of loughlinite and Na-feldspar in the Killik area indicates the Na enrichement. SEM investigation shows that analcime, albite and sani-

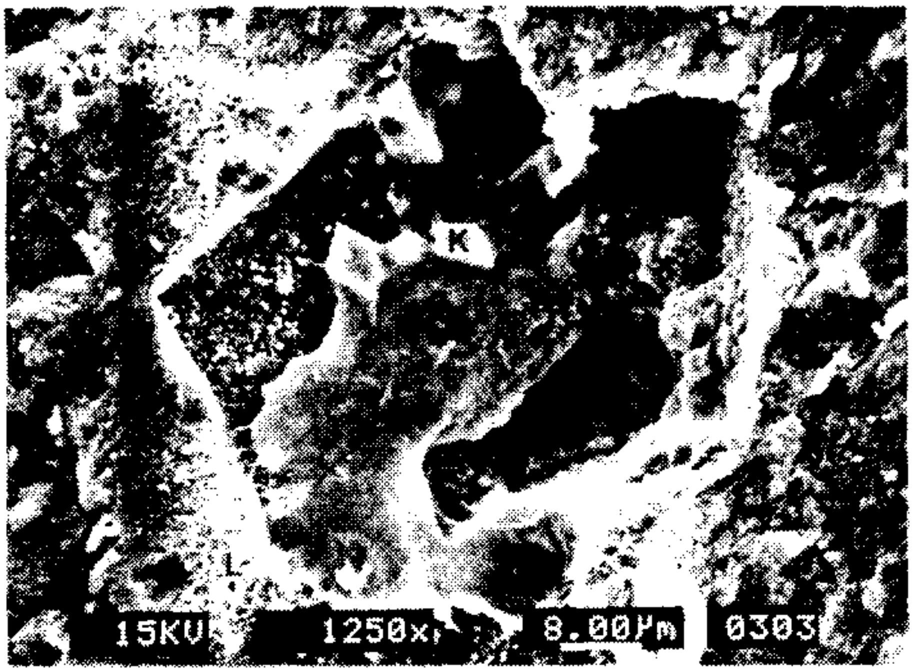

Fig.11- Neoformation of loughlinite and feldspar in and around of dissolution voids of altered volcanic glasses in Sample Ocak-10.
C: Volcanic glass, L. Loughlinite, K: K-feldspar, A: Analcime.

dine minerals authigenically to be neoformed and seem to own automorphic crystal structures.

Generally amorphous materials, authigenic opal-CT and small amount of quartz were determined in the study area. The amount of silica decreases as feldspar forms from the silicious analcime. Very small amount of silica left behind, is crystallized as quartz. Therefore, the amount of quartz is expected very low. Similar condition could be seen in the Green River formation where small amount of silica is also found together with the analcime and K-feldspar (Ijima and Hay, 1968).

Mineralogic and geochemical studies showed that magnesite + dolomite, dolomite, dolomite + calcite and calcite mineral zones were determined vertically and horizontally (Fig. 8).

Magnesite formation in the Hırka formation at the south and the bottom part of Akpınar at the Killik area show that Mg and pH values are considerably high and probably indicate the lowest level of the stratigraphic section of the study area. Following the formation of magnesite, the amount of Mg decreases and with the presence of Ca, dolomite precipitated. At the north, the change of Mg and Ca proportions cause the precipitation of dolomites and calcites.

5. RESULTS

1. The study area is comprised of the Middle-Upper Miocene aged volcano-sedimentary rocks which are composed of 6 main formations (Çoraklar, Hırka, Karadoruk, Akpınar, Bozçayır and Acısu Formations).

2. Sepiolite, loughlinite, analcime, montmorillonite, feldspar, magnesite, dolomite, calcite, illite, quartz and opal-CT are neoformed minerals and they are discerned within these formations.

3. Sepiolite is formed in the condition of basic pH value, which is rich in Mg and Si and poor in Al

at the center and northern parts of the study area within the Akpınar Formation.

4. At the center of study area (Killik), loughlinite is formed by combining of Si and Mg and Na originated from the alteration of tuffs.

5. Montmorillonite is formed within shallow margin facies at high pH conditions and in the presence of Al.

6. After montmorillonite forms, the analcime is formed from the remnant Na.

7. Magnesite and dolomite are dominant in the lower part of the sequence (Hırka Formation), while dolomite, calcite or the repitition of these minerals are dominant at the upper part (Akpınar, Bozçayır and Acısu Formation).

8. The source of Mg for the neoformation of the minerals seem to be basic, ultrabasic and ophiolitic rocks which are cropped out at the south and the east of the investigated area. Na and K were probably derived from tuffs. On the other hand Si and Al were probably derived from the both sources.

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ABSTRACTS OF THE PAPERS PUBLISHED ONLY IN THE TURKISH EDITION OF THIS BULLETIN

MICROPALEONTOLOGICAL INVESTIGATION AND ENVIRONMENTAL INTERPRETATION (OSTRACODA) OF THE PLIOCENE SEQUENCE OF BURDUR BASIN

Cemal TUNOĞLU* and Emel BAYHAN*

ABSTRACT.- In this study, micropaleontological studies based on ostracods are carried out on units belonging to Pliocene aged sedimentary units in Burdur basin in SW Anatolia and environmental assesments are made through other macro and micro level data (lithostratigraphic and mineralogic). As a result of investigations ten different ostracoda species are determined in 4 different ostracoda genus belonging to fresh water environment and these fauna are found in 8 samples from 5 measured stratigraphic sections. Existing of Heterocypris, Candona, Ilyocypris and Limnocythere species and their known living environments conform with the volcanic, sedimentologic, tectonic and hydrothermal processes in that period and support each other. Clay mineralogy, geochemistry and ostracoda fauna of this environment reflect all characteristics of lake facies which are fed from the continent. It has been demonstrated that, the present Burdur lake gained its actuel setting through a regressive sedimentation towards NW, and the ostracoda findings show a regular increase on the fresh water characteristics.

MINERALOGY AND GENESIS OF THE ZINC-LEAD DEPOTISTS OF THE YAHYALI (KAYSERİ)-DEMİRKAZIK (NiĞDE-ÇAMARDI) REGION

İbrahim ÇOPUROĞLU**

ABSTRACT.- The area under study is situated in region, north east of Middle Toros, where faults, thrust faults, fracture zones are commanly present. Many zinc-lead deposits, small-big occurrences in the form of vein, lode, fault and karst fillings along the Yahyalı-Demirkazık region, were deposited in the vanious carbonate rocks of Permian-Jurassic age. Ore minerals of the deposits are sphalerite, galena, smitsonite, anglesite and cerussite. The primary mineral parageneses are composed of pyrite, chalcopyrite, arsenopyrite, pyrhotite, magnetite, molibdenite, bravoite, fahlore (tetraedrite, freibergite), nativ Ag, argentite and nativ gold ore. While gothite, lepidocrosite, malachite, azurite, covelline, hemimorphite and hidrozincite from the secondary minerals, the gangue minerals are made up calcite, dolomite, quartz and barite. These minerals assemblage parageneses, indicate high temperature formations. In addition to this, sphalerite and galene contain Fe, Cu, Mn, Al, Mg, ni, V, W, Co, Cd, Ir, Ge, Ag, and Au moreover, the content or Sr is 2,13 %, a very high value. All these proofs point out that the orebodies are probably hydrothermal. According to the plate tectonic model calc alkali magma splits in to two grats due to gravitation before intrusion. One part of these, calc alkali magma, formed granitoid rocks which along Bolkar mountains and the other areas under investigation, the other has no significant mineralizations part of magma was rich in metal ions both parts were in placed in the weak zones of limestones, fractures and faults. Karstification process is continuing even today. The effect of the atmospheric conditions and underground hot water allows the ore in the area to remobilize, and provides it for sedimentation.

MORPHOLOGICAL FEATURES, AGES AND NEOTECTONIC SIGNIFICANCE OF PAMUKKALE TRAVERTINES

Erhan ALTUNEL***

ABSTRACT.- The Pamukkale travertines in the northern margin of the Denizli basin can be classified into five categories based on their morphology. These are: (1) terraced-mound travertines, (2) fissure-ridge travertines, (3) range-front travertines, (4) self-built channel travertines, and (5) eroded-sheet travertines. Three of these classes, range-front travertines, self-built channel travertines and fissure-ridge travertines are of special tectonic significance because they contain syndepositional and postdepositional tectonic structures. Uranyum series dating method has been applied to the Pamukkale travertines and showed that travertine deposition has continued for at least the last 400 000 in different localities. Extensional fissures, that supply water to the travertines, have been dilating at average rates between 0.02 and 0.1 mm/yr, and propagating laterally at about 20 mm/yr. The time averaged rates of extension of the plateau as a whole having been between 0.23 and 0.6 mm/yr during the last 200 000 years.

STRATIGRAPHY OF THE AUTOCHTHONOUS AND ALLOCHTHONOUS UNITS AT THE EASTERN PART OF THE ISPARTA ANGEL, WESTERN TAURIDES-TURKEY

Mustafa ŞENEL*; İbrahim GEDİK*; Halil DALKILIÇ*; Mualla SERDAROĞLU*; Ali Zafer BİLGİN*; M. Fuat UĞUZ;
A. Sait BÖLÜKBAŞI; Metin KORUCU** and Necdet ÖZGÜL*"

ABSTRACT.- The investigation area which located at the eastern part of "Isparta Angle" of Taurus mountain, includes Beydağları-Karacahisar autochthonous, Anamas-Akseki autochthonous and Antalya nappes. Beydağları-Karacahisar autochthonous which is cropped out below the Antalya nappes as tectonic windows is represented by from bottom to top Precambrian, Cambrian, Carboniferous and Middle Triassic-Danian sedimentary deposits. Anamas-Akseki autochthonous represented by Upper Triassic-Middle Eosen rock units is over thrusted to Antalya nappes and Beydağları-Karacahisar autochthonous at the north and is seperated from Beydağları-Karacahisar autochthonous by Kırkkavak fault at the eastern part of the investigation area. During the Mesozoic period Anamas-Akseki and Beydağları-Karacahisar autochthonouses were developed as different platforms. In the Antalya nappe which composed of offshore platforms, slope, basin and fragments of oceanic crust, from bottom to top Çaltepe, Alakırçay, Tahtalıdağ and Tekirova ophiolitic nappes are distinguished on the basis of their structural and stratigraphical properties. Çaltepe nappe includes Şeyhdere, Sofular, Zindan, Yaka, Yılanlı and Kocaoluk sequences, Alakırçay nappe, Alakırçay, Koçular, Sülekler sequences, Tahtalıdağ nappe, Yumaklar, Erenler, Dutdibi, Ovacık, Güme and Dulup sequences. Akpınar sequence which is composed of Middle-Upper Triassic basic volcanic and through the upper part Jurassic-Cretaceous platform carbonates structurally conformable to Alakırçay nappe. Also, Tekirova ophiolitic nappe is composed of Ayvalı peridotite and Kırkdirek melange.

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