Yerbilimleri, 2017, 38 (1), 101-114
Hacettepe Üniversitesi Yerbilimleri Uygulama ve Araştırma Merkezi Bülteni
Bulletin of the Earth Sciences Application and Research Centre of Hacettepe University

Palaeovegetational and Palaeoclimatic Changes During the Early Miocene in Central Taurus, Turkey

Orta Toroslar'da Erken Miyosen de Paleovejetasyon ve Paleoiklim Değişimleri, Türkiye

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Geliş *(received)* : 9 Ocak (*January*) 2017
Kabul *(accepted)* : 14 Mart (*March*) 2017

ABSTRACT
This study presents palynological records from the Ermenek Basin during the Early Miocene to evaluate paleoenvironmental changes. The pollen spectra was dominated by coniferous trees during this time period. Especially, Cedrus was abundant in Ermenek flora and cedars occupied on the mountain areas with Abies and Picea, indicating cooler climate in the area. However, an increase in mega-mesothermic trees, mainly Taxodiaceae swamps show that the climate slightly turned to warmer and humid conditions at the uppermost part of the Ermenek section. The low occurrence of herbeceous taxa imply that the vegetation cover was mainly forest.

Keywords: Ermenek, flora, paleoclimate, paleoenvironment, pollen grains

ÖZ
Bu çalışma, Ermenek Havzası'nda Erken Miyosen'deki paleoortamsal değişimleri tayin etmek için palinolojik kayıtları sunmaktadır. Bu zaman aralığında polen dağılımı başlıca kozalaklı ağaçlardan oluşmaktadır. Özellikle Cedrus Ermenek florasında yaygın olarak bulunmuştur. Sedir ağaçları Abies ve Picea ile birlikte Erken Miyosen'de dağlık alanlarda yayılım göstermekte ve bölgede daha serin bir iklimin varlığına işaret etmektedir. Ancak, Ermenek kesitinin üst kısımlarında görülen Taxodiaceae bataklık ormanlarındaki artış iklimin hafifçe daha sıcak ve yağışlı koşullara geçtiğini göstermektedir. Otsul bitkilerin az miktarda bulunması vejetasyon örtüsünün başlıca ormanlardan oluştuğunu göstermektedir.

Anahtar Kelimeler: *Ermenek, flora, paleoiklim, paleoortam, polen taneleri,*

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INTRODUCTION

Our modern world was formed during the Miocene time (Potter and Szatmari, 2009), including important tectonic and climate events composing Neogene climate with the transition from greenhouse conditions of Paleogene to the icehouse conditions of Quaternary. East Antartic Ice Sheet (EAIS) started to expand at the oneset of the Neogene (Pagani et al., 1999; Zachos et al., 2001). This phenomena is also well-recorded at worldwide-scale with a temperature decrease and positive values in the oxygen isotope profile (Miller et al., 1991; Zachos et al., 2001). The oxygen isotope record of benthic foraminifers enable significant evidences for nine glacial events during the Miocene, four of these glacial cases established during the Early Miocene (Miller et al., 1991; Pagani et al., 1999). The outer wall of pollen grains are very resistant to the weathering conditions and strong acids. With this feature, pollen grains are well preserved in the sediments. Therefore, pollen analysis is a significant proxy in order to asses changes in past flora, vegetation and climate. In the recent years, several palynological studies have been made in the Mediterranean realm. This studies indicate that Anatolian flora experienced important changes in the context of climate (i.e. Suc, 1984; Akgün et al., 2007; Yavuz-Işık, 2007, 2008; Yavuz-Işık and Toprak, 2010; Akkiraz et al., 2011; Kayseri-Özer, 2014; Biltekin et al., 2015; Jiménez-Moreno et al., 2015; Üçbaş Durak and Akkiraz, 2016; Yavuz et al, 2017). Most of tropical and sub-tropical plants suffered and dissappeared from Europe and Mediterranean due to the decrease in global thermal gradient during the late Cenozoic (Suc and Popescu, 2005; Jiménez-Moreno et al., 2007). However, some meso-thermic deciduous trees such as, *Liquidambar orientalis* (Turkish sweetgum), *Parrotia* (ironwood), *Zelkova* (elm), *Pterocarya* (walnut), and meso-microthermic trees such as *Cedrus* (cedars) continued to persist in reduced areas of Anatolia (Quézel and Médail, 2003, Biltekin et al., 2015). Thus, today, Anatolia is one of the important refuge area for Neogene and Early Pleistocene Mediterranean flora (i.e. Becker-Platen et al., 1974, 1977; Akgün et al., 2007; Yavuz-Işık, 2007, 2008; Yavuz-Işık and Toprak, 2010; Akkiraz et al., 2011; Kayseri-Özer, 2014; Biltekin et al., 2015, Jiménez-Moreno et al., 2015; Üçbaş Durak and Akkiraz, 2016; Yavuz et al, 2017). To carry out the distribution of plants and climatic changes, more palynological studies are still needed. Therefore, Ermenek pollen data will contribute new insights to the future studies. In this research, pollen analysis has been done in the Early Miocene Ermenek Basin to reconstruct the paleoenvironmental changes through the studied time-window and determine climatic conditions in Central Taurus (Turkey).

REGIONAL SETTINGS

The study area is located in the central Taurus belt (Figure 1), covering southern regions of Turkey as a part of Alpine-Himalayan orogenic belt (Demirel, 2004), being Neogene intra-montane molasse basin which located at Taurus mountain belt (Özgül, 1976). The Ermenek Basin was formed by North-South crustal extension and strike-slip deformation (Ilgar and Nemec, 2005, Uchman et al, 2007). During the Early Miocene, two lakes phases turned to one clastic lake (Ilgar and Nemec, 2005) and towards to the end of the Early Miocene, the lakes was drowned by marine trangression. This issue induced the deposition of thick limestones during Burdigalian-Serravalian (Early-Middle Miocene). The Ermenek Basin is located on the Bozkır and Aladağ nappes (Özgül, 1976; Ilgar and Nemec, 2005). The basin is mainly constituted by Yenimahalle Formation with lacustrine sediments and Mut Formation with reefal carbonates (Middle Miocene). Bozkır and Aladağ nappes are overlain by Pamuklu Formation (lacustrine carbonates, Oligocene). The Lower Miocene sequence is represented by Yenimahalle Formation covered by upper Burdigalian marine deposits (Figure 1). The Yenimahalle Formation has a 300 m clastic lacustrine sediments (sandstones, claystones and conglomerates) (Ilgar and Nemec, 2005). The lower part of Yenimahalle Formation contains lignite levels (Ilgar and Nemec, 2005). The Lower Miocene sediments contain ostracod fauna such as *Cyprideis torosa*, *Candona candida*, *Candona recta*, and *Heterocypris salina* (Ilgar and Nemec, 2005, Uchman et al., 2007). These lacustrine sediments in the Ermenek Basin, formed close to the sea level, and have been uplifted (ca. 1000 m) since the Middle Miocene (Koç et al., 2012).

Present-day vegetation of Anatolia has a complexity and different phytogeographic regions represented by Mediterranean, Irano-Touranian, European and

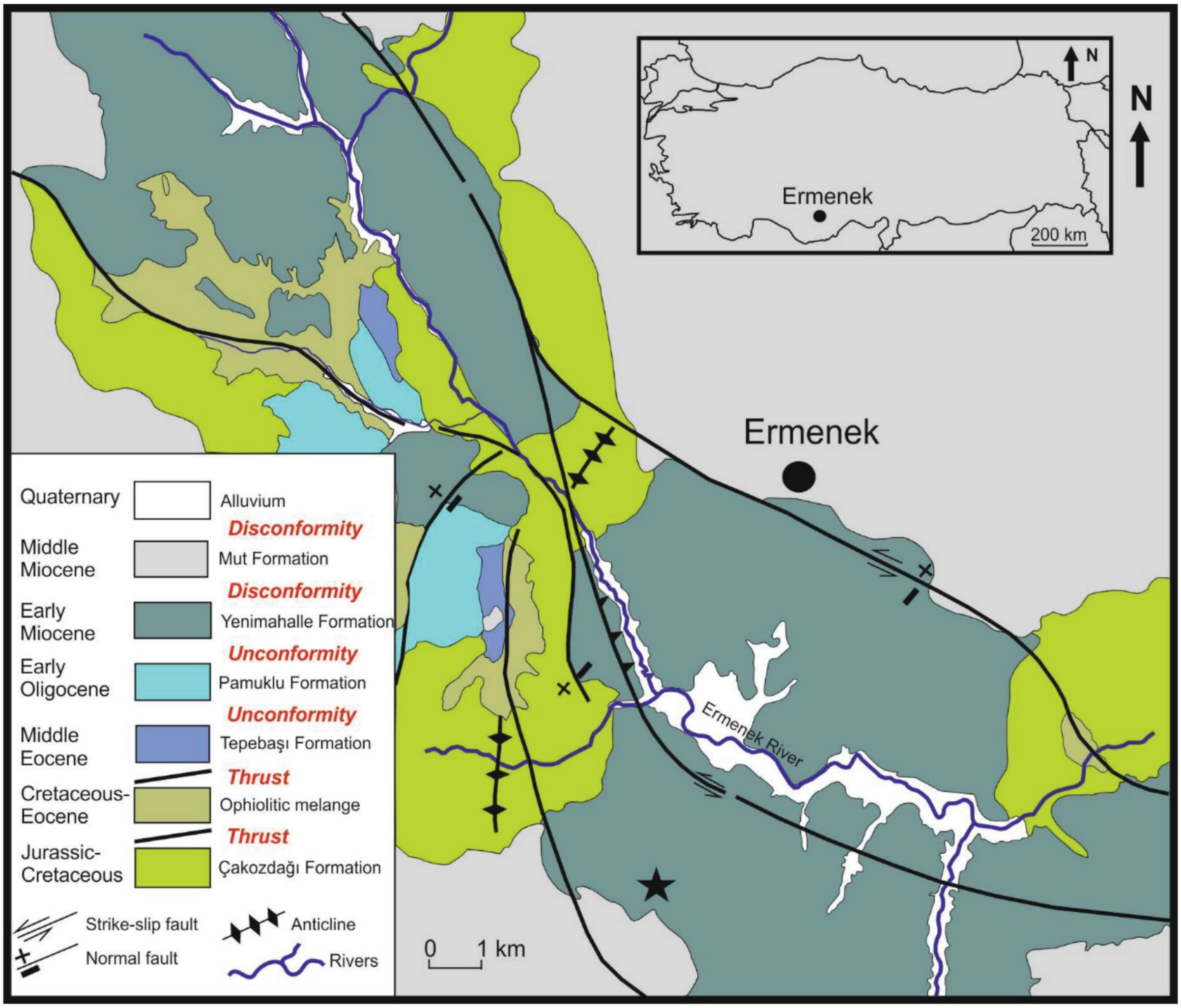

Figure 1. The simplified geological map of the Ermenek Basin (modified from Ilgar and Nemec, 2005; Uchman et al., 2007). The black star indicates outcrop section.

Şekil 1. Ermenek Havzası'nın sadeleştirilmiş jeoloji haritası (Ilgar ve Nemec, 2005; Uchman vd., 2007'den sadeleştirilerek). Siyah yıldız kesit yerini göstermektedir.

Euxino-Hyrcanian phytogeographic regions (Figure 3). Today, Anatolia is a refuge area for Neogene and Early Pleistocene Mediterranean flora. Among mesothermic trees such as *Pterocarya*, *Zelkova*, *Liquidambar*, *Parrotia* and *Cedrus* are still occurred in the Anatolia and Hyrcanian vegetation zone (Quézel and Médail, 2003). The study area is located in the Mediterranean vegetation belt with different vegetation types according to rainfall and altitude (Quézel and Médail, 2003). The thermo-Mediterranean belt composes of *Ceratonia siliqa*, *Pistacia lentiscus*, *Myrtus communis*, *Olea europaea* with *Quercus coccifera* and *Pinus brutia*. A meso-Mediterranean belt is dominated by sclerophyllous oaks, where *Quercus ilex* is very sparse (Quézel and Médail, 2003). The major extension of *Liquidambar orientalis* occurs in the southwestern Anatolia and in northeastern Antalya (Akman et al., 1993) and along the Oronte River (Hatay). In Mediterranean montane belt consists of the altitudinal conifers such as *Cedrus libani* occupying significant areas on the Taurus and Anti-Taurus massifs with oro-Mediterranean belt formed by meadows and steppes. The Irano-Touranian vegetation belt covers the Anatolian Plateau. In this

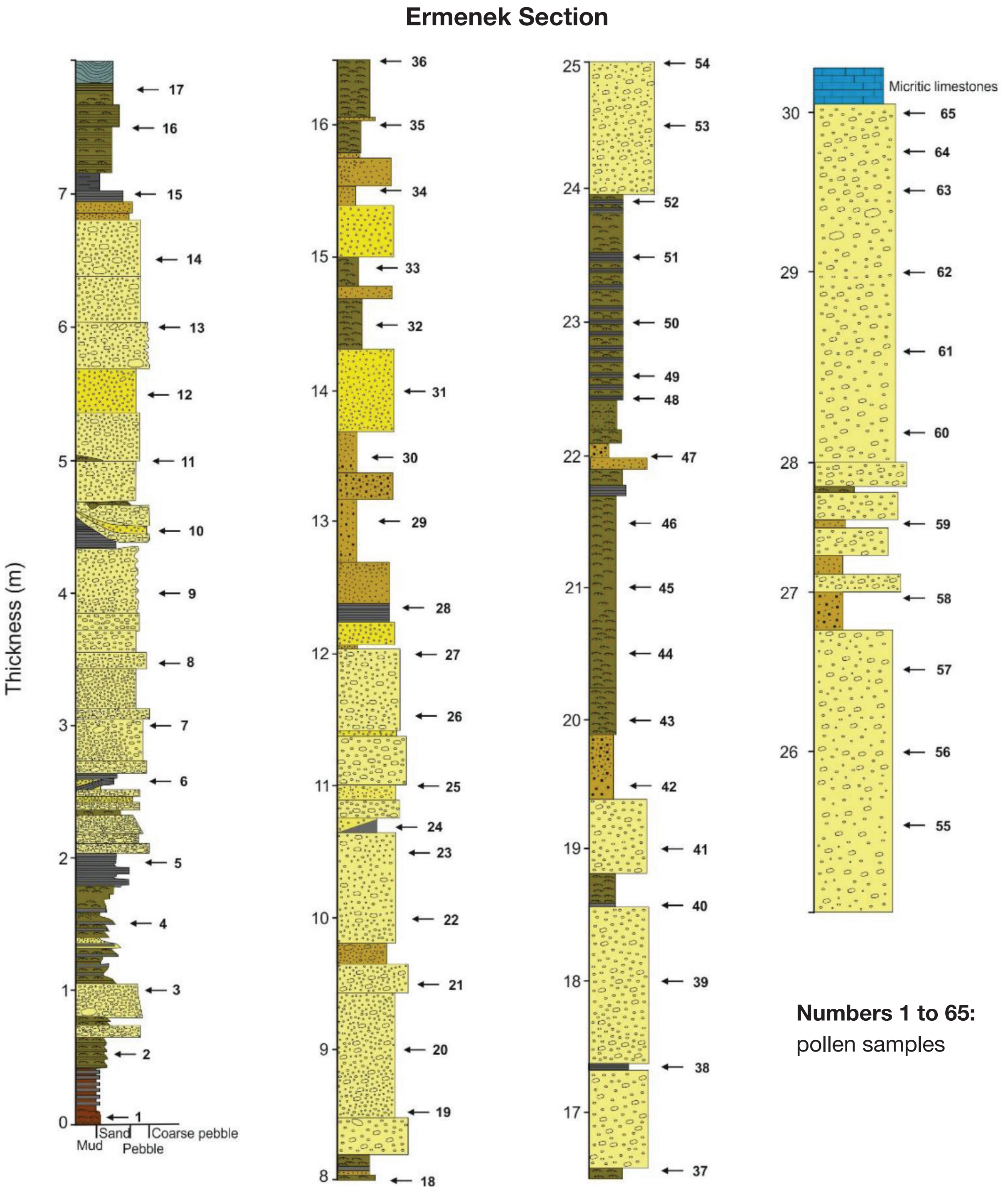

Figure 2. The lithological log of the Ermenek section with indicating the level of pollen samples (modified from Zigar and Nemec, 2005).

Şekil 2. Ermenek kesitinin litolojik logunda polen örnekleri seviyesi belirtilmiştir (Zigar ve Nemec, 2005'den sadeleştirilerek).

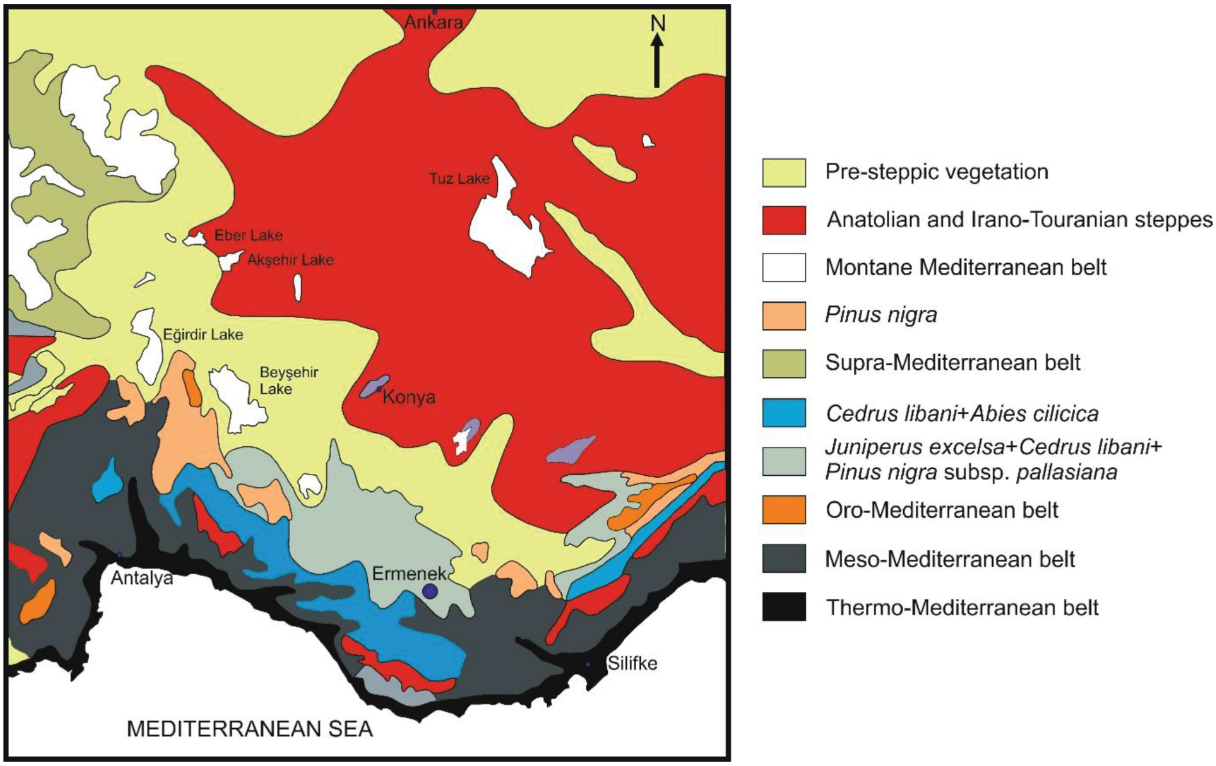

Figure 3. The present-day vegetation of Ermenek region (southern Turkey) (modified by Quézel, P., and Barbero, M., 1985)
Şekil 3. Ermenek bölgesinin (Türkiye'nin güneyi) günümüz vejetasyonu (Quézel, P., ve Barbero, M., 1985'den sadeleştirilerek)

phytogeographic region, annual precipitation does not exceed 200 mm and mostly includes steppe vegetation with *Artemisia* (Figure 3). Pre-steppic vegetation belt is characterized by *Quercus libani* and to eastward, *Quercus brantii* occurs on slopes while precipitation is high and to westward with *Pinus pallasiana* and *Juniperus excelsa* (Quézel and Médail, 2003).

METHODS AND MATERIALS

Sampling and Chemical Treatment

In this research, 65 sediment samples (mainly claystones, sandstones) were taken from the southern part of the Ermenek Basin belonging to the Early Miocene (Figure 2) and analysed in terms of pollen analysis. Among the pollen grains, the diagrams of Sapotaceae, *Engelhardia*, Taxodiaceae, *Cathaya*, *Carya*, *Tsuga*, *Zelkova*, *Pterocarya*, *Liquidambar orientalis* and *Cedrus* were shown in Biltekin et al (2015). This study covers the resting most of the other identified pollen grains in order to reconstruct the history of flora in the Ermenek Basin. For chemical treatment, the samples were processed according to the Cour's method (1974). Firstly, ca. 20-30 g of sediment was weighed. The samples were reacted with cold HCl (35%) and HF (70%) to remove carbonates and silicates respectively. For separation of the palynomophs from the sediments was used $ZnCl_2$ (density >2). The resting sediment was sieved with using a 200 μm sieve and then a 10 μm nylon mesh sieve. The pollen residue was mounted on slides with glycerine.

Counting and Identification

In order to identify and to count the palynomorphs, a transmitted light microscope was used with x40 and x100 magnifications (with immersion oil). The

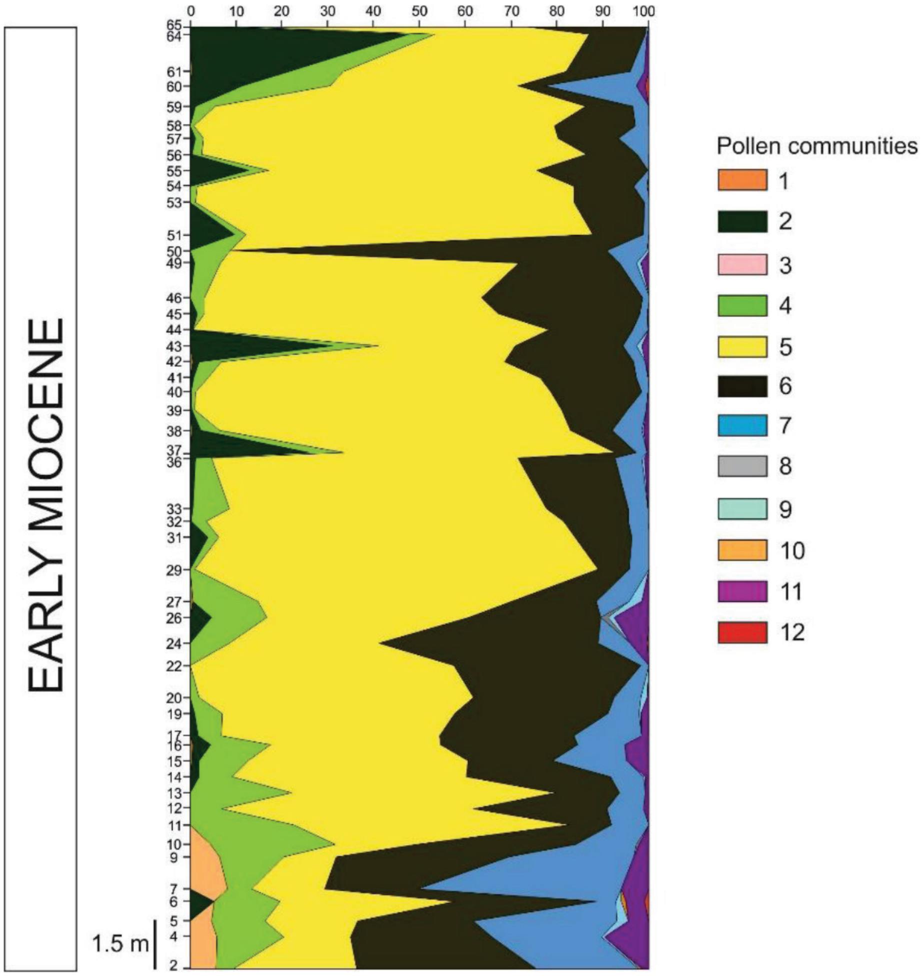

Figure 4. The synthetic pollen diagram of the Ermenek Basin. In the diagram, plants are grouped based on their ecological importance. Pollen communities: 1) Megathermic (tropical) elements: Euphorbiaceae, Rubiaceae, Sapotaceae; 2) Mega-mesothermic (sub-tropical) elements: Taxodiaceae, *Engelhardia*; 3) *Cathaya*; 4) Mesothermic (warm-temperate) elements: *Ilex*, *Alnus*, *Liquidambar orientalis*, Anacardiaceae, *Carya*, *Rhus*, *Ulmus*, *Corylus*, Oleaceae, *Zelkova*, *Pterocarya*, *Carpinus betulus*, *Quercus* deciduous type, *Parrotia cf. persica*, *Acer*, *Betula*, *Fraxinus*, *Carpinus orientalis*, Caprifoliaceae, *Juglans*, *Platanus*, *Salix*, *Tilia*, *Fagus*, *Buxus sempervirens*; 5) *Pinus*; 6) Meso-microthermic (mid-altitudinal trees) elements: *Tsuga*, *Cedrus*; 7) Microthermic (high altitudinal trees) elements: *Abies*, *Picea*; 8) Non-significant: Rosaceae, Ranunculaceae; 9) Cupressaceae; 10) Mediterranean xerophytes: *Olea*, *Quercus ilex-coccifera* type; 11) Herbs: Poaceae, Asteraceae-Asteroideae, *Geranium*, Ericaceae, Caryophyllaceae, Asteraceae-Cichorioideae, Amaranthaceae-Chenopodiaceae, *Myriophyllum*, Apiaceae, *Erodium*, *Phlomis*, *Rumex*, Cyperaceae with aquatic herbs such as *Potamogeton*, *Trapa natans*, *Typha*; 12) Steppes: *Ephedra*.

Şekil 4. Ermenek Havzası'nın sintetik polen diyagramı. Diyagramda bitkiler ekolojik önemlerine göre gruplandırılmıştır. Polen toplulukları: 1) Megatermik (tropikal) elementler: Euphorbiaceae, Rubiaceae, Sapotaceae; 2) Mega-mezotermik (yarı-tropikal) elementler: Taxodiaceae, Engelhardia; 3) Cathaya; 4) Mezotermik (sıcak-ılıman) elementler: Ilex, Alnus, Liquidambar orientalis, Anacardiaceae, Carya, Rhus, Ulmus, Corylus, Oleaceae, Zelkova, Pterocarya, Carpinus betulus, Quercus yaprağını döken türü, Parrotia cf. persica, Acer, Betula, Fraxinus, Carpinus orientalis, Caprifoliaceae, Juglans, Platanus, Salix, Tilia, Fagus, Buxus sempervirens; 5) Pinus; 6) Mezo-mikrotermik (orta-enlem ağaçlar) elementler: Tsuga, Cedrus; 7) Mikrotermik (yüksek enlem ağaçları) elementler: Abies, Picea; 8) Non-significant: Rosaceae, Ranunculaceae; 9) Cupressaceae; 10) Akdeniz kserofitleri: Olea, Quercus ilex-coccifera türü; 11) Otsul bitkiler: Poaceae, Asteraceae-Asteroideae, Geranium, Ericaceae, Caryophyllaceae, Asteraceae-Cichorioideae, Amaranthaceae-Chenopodiaceae, Myriophyllum, Apiaceae, Erodium, Phlomis, Rumex, Cyperaceae, sucul otsu bitkiler: Potamogeton, Trapa natans, Typha; 12) Stepler: Ephedra.

sediments are rich in pollen grains. Only four samples were barren and these samples were counted, but they were extracted from the pollen sum. The eight sampes were sterile. Spores have not been included due to their barely representation, but were counted. A special effort has been done with respect to botanical nomenclature. In the identification of pollen grains was used several pollen atlases from Mediterranean, China, Europe, etc. (Reille, 1992, 1995 and 1998; Huang, 1972) and pollen photographs. A minimum of 300 pollen grains was counted in each pollen slides except *Pinus* due to its over-representation in the sediments. A total of 59 taxa were identified. The standard synthetic pollen diagram (Suc, 1984) was plotted based on pollen results. In the synthetic pollen diagrams, pollen taxa have been grouped into 12 different groups (Nix, 1982) based on ecological criteria in order to reconstruct the past vegetation and diagram was made with using Matlab program (Figure 4):

(1) Megathermic (tropical) elements: Euphorbiaceae, Rubiaceae, Sapotaceae

(2) Mega-mesothermic (sub-tropical) elements: Taxodiaceae, Engelhardia

(3) Cathaya

(4) Mesothermic (warm-temperate) elements: *Ilex*, *Alnus*, *Liquidambar orientalis*, Anacardiaceae, *Carya*, *Rhus*, *Ulmus*, *Corylus*, Oleaceae, *Zelkova*, *Pterocarya*, *Carpinus betulus*, *Quercus* deciduous type, *Parrotia cf. persica*, *Acer*, *Betula*, *Fraxinus*, *Carpinus orientalis*, Caprifoliaceae, *Juglans*, *Platanus*, *Salix*, *Tilia*, *Fagus*, *Buxus sempervirens*

(5) Pinus

(6) Meso-microthermic (mid-altitudinal trees) elements: *Tsuga*, *Cedrus*

(7) Microthermic (high altitudinal trees) elements: *Abies*, *Picea*

(8) Non-significant: widely distributed cosmopolitan plants such as Rosaceae, Ranunculaceae

(9) Cupressaceae

(10) Mediterranean xerophytes: *Olea*, *Quercus ilex-coccifera* type

(11) Herbs: Poaceae, Asteraceae-Asteroideae, *Geranium*, Ericaceae, Caryophyllaceae, Asteraceae-Cichorioideae, Amaranthaceae-Chenopodiaceae, *Myriophyllum*, Apiaceae, *Erodium*, *Phlomis*, *Rumex*, Cyperaceae with aquatic herbs such as *Potamogeton*, *Trapa natans*, *Typha*.

(12) Steppes: *Ephedra*

RESULTS AND DISCUSSION

Pollen Analysis

Pollen record covers the Early Miocene sediments from Ermenek (central Taurus, Turkey). Counting results were performed by using TILIA program developed by Grimm (1994), excluding the aquatics (i.e., Cyperaceae). A cluster analysis stratigraphically constrained with using a square root transformation was performed by CONISS (constrained incremental sum-of-squares cluster analysis). The pollen diagram is divided into three local pollen zones and two subzones based on major changes in pollen species as *Pinus*, *Cedrus*, *Abies* and cluster analysis of pollen record performed by CONISS program (Grimm, 1987).

Pollen zone Er-1 (0.5-4.4 m)

Er1 pollen zone is characterized by coniferous trees. In this forest assemblages, microthermic trees such as *Abies* and *Picea* and among meso-microthermic trees, *Cedrus* are abundant in this zone with *Cathaya* (4.5-7.8%). Additionally, *Pinus* is also frequent in the zone and reaches up 88 % towards to upper part of this pollen zone. Among the other forest communities, *Liquidambar orientalis*, deciduous *Quercus*, *Ulmus* and *Rhus* are prominent in the sediments (Figure 5). The resting pollen spectra comprises of Cupressaceae and herb communities. Cupressaceae reach up to 2.6% at 2 m at the lower part of the Ermenek section (Figure 5). Herbaceous assemblages are represented by Poaceae, Asteraceae-Asteroideae, *Potamogeton*, *Geranium*, Ericaceae, Caryophyllaceae, Asteraceae-Cichorioideae, Amaranthaceae- Chenopodiaceae, *Myriophyllum*, *Trapa natans*, Apiaceae, *Erodium*, *Typha*, *Phlomis*, *Rumex* and Cyperaceae. In these assemblages, Poaceae are prominent and vary between 1.2 and 7% in this zone (Figure 5).

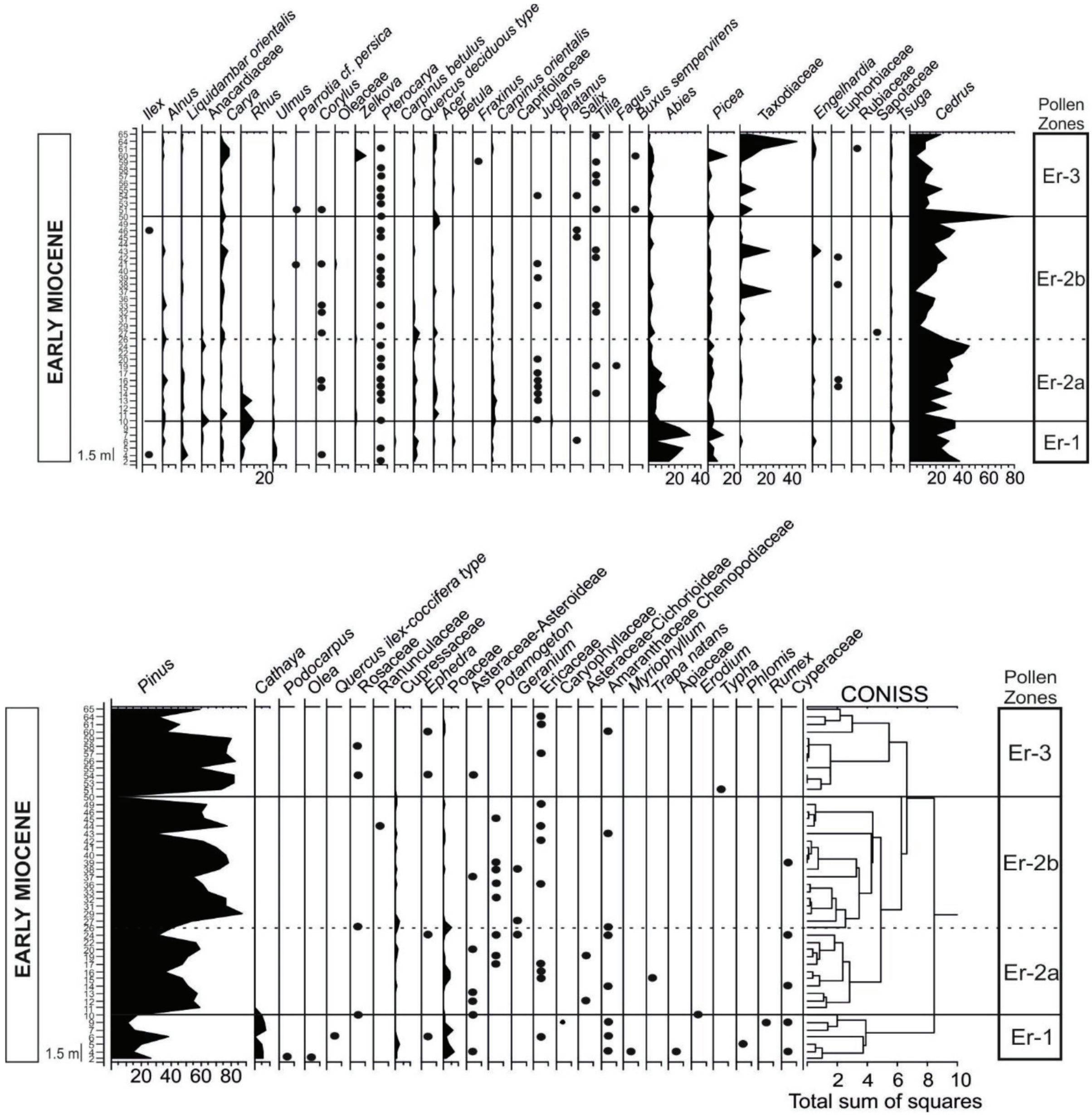

Figure 5. Detailed pollen diagram of the Ermenek Basin. Cyperaceae were excluded, but calculated according to total pollen sum. Pollen zones were done using CONISS in Tilia program (Grimm, 1987). The black dots indicate values are <1%.

Şekil 5. Ermenek Havzası'nın detaylı polen diyagramı. Cyperaceae hariç tutulmuş fakat toplam polen dağılımına göre yüzdesi hesaplanmıştır. Polen zonları Tilia programında CONISS kullanılarak belirlenmiştir (Grimm, 1987). Siyah noktalar değerlerin <% 1'den küçük olduğunu göstermektedir.

Pollen zone Er-2 (4.4-23 m)

This zone is represented by *Cedrus*, Taxodiaceae and *Pinus*. The pollen zone Er-2 is divided by two sub zones which are labeled as Er-2a (4.4-11.5 m) and Er-2b (11.5-23 m). *Alnus* is observed frequently. Anacardiaceae are abundant at the begining of the subzone Er-2a at 4.4 m (Figure 5). *Carya* increases in this zone, especially in subzone Er-2b. *Rhus* continues to increase in bottom of the subzone Er-2a, but in subzone Er-2b starts to decrease and its last appearance is recorded at 14.5 m. *Acer* increases and varies between 0.1 and 4.5%. *Abies* decreases in the zone with *Picea*, but is still prominent in the sediments. Taxodiaceae are abundant and occur over 20% at 20 m and 16.65 m. *Cedrus* increases at 23 m up to 78.9% in the upper level of the zone (Figure 5). *Cathaya* is only recorded at 4.4 m in the subzone Er-2a. *Pinus* increases and reaches up to 88% at 13 m. Among herb communities, Poaceae are still detected in the most of the samples, but in minor quantities (Figure 5).

Pollen zone Er-3 (23-30 m)

Pollen zone Er-3 is dominated by Taxodiaceae and pine trees such as *Pinus* (Figure 5). *Cedrus* slightly declines but is still prominent in the sediments. *Pinus* is very abundant and increases according to previous zone. While *Abies* continues to decrease in this zone, *Picea* makes a peak at 28.15 m, but in the resting sediments of this zone, it has low values. Beside coniferous trees, Taxodiaceae forest are also abundant and reach up about 43% at 29.75 m in the zone. *Acer* is still prominent in this zone mesothermic trees are well recorded as well. They are constituted by *Liquidambar orientalis*, Anacardiaceae, *Rhus*, *Corylus*, Oleaceae, *Pterocarya*, *Carpinus betulus*, *Quercus* deciduous type, *Acer*, *Betula*, Caprifoliaceae, *Juglans*, *Platanus*, *Tilia*, *Fagus* and *Buxus sempervirens* with some riparian trees such as *Alnus*, *Salix*, *Fraxinus*, *Carpinus orientalis*, *Carya*, *Zelkova* and *Ulmus*, etc.

The Evaluation of Vegetation Cover and Climate

The paleoecological data from lacustrine basin in Ermenek, reflect that the Early Miocene vegetation has a mosaic of vegetation types. The Ermenek flora is dominated by coniferous woodland. In this forest assemblages, *Cedrus* is regularly abundant, with other coniferous trees such as *Cathaya*, *Tsuga*, *Abies* and *Picea* (Biltekin et al., 2015). *Cedrus* needs to be mentioned due to abundance and their morphological characters in Ermenek area (Figure 4 and Figure 5). Today, *Cedrus* is distributed in the Eastern Mediterranean, in the Northern Africa and in the Western Himalaya today (Quézel and Médail, 2003). Cedar trees includes four species consisting of *Cedrus deodara*, *Cedrus atlantica*, *Cedrus libani* and *Cedrus brevifolia*. According to genetic studies on *Cedrus*, firstly *Cedrus deodara* (Himalayan cedar) diverged and then *Cedrus atlantica* (North African cedar) separated from its ancestor of *Cedrus libani* and *Cedrus brevifolia* (Qiao et al. 2007). The molecular clock estimates display that separation between *C. atlantica* and Eastern Mediterranean species took place at 23.49±3.55 to 18.81±1.25 Ma. The divergence occurs between *C. libani* and *C. brevifolia* at 7.83±2.79 to 6.56±1.20 Ma (Qiao et al., 2007). The earliest fossil wood record of *Cedrus* was found in Kamchatka (Russia) (Blokhina et al., 1998, 2005, 2007). The coming of *Cedrus* to Himalaya would not have been before the Miocene, and to North Africa during the late Cenozoic (Qiao et al., 2007). According to palynological analysis from Anatolia (Biltekin et al., 2015), it may be considered that *Cedrus* in Ermenek area may belong to the couple *C. Libani*-*C. brevifolia*. The earlier existence of *Cedrus* goes back to the late Oligocene (Akgün and Sözbilir, 2001; Üçbaş Durak and Akkiraz, 2016). Palynological records from Denizli region (Akgün and Sözbilir, 2001) and in Danişment from Kalkım-Gönen Basin (Üçbaş Durak and Akkiraz, 2016) during the late Oligocene (Chattian) indicate that *Cedrus* existed in Anatolian flora for along time. In these regions, while *Cedrus* occurs with minor amounts in Kalkım-Gönen Basin, it is found with *Pinus* and Fagaceae as a ca. %15 in Denizli. However, the main development of Cedar trees ocurred in Central Taurus, in Ermenek during the Early Miocene. During this time, *Cedrus* is recorded abundantly. These pollen records show that *Cedrus* survived in Anatolia since late Oligocene (Akgün and Sözbilir, 2001; Üçbaş Durak and Akkiraz, 2016) and from early miocene to present (Biltekin et al., 2015) with changing amount. The long time presence of Cedar trees in ancient Anatolian flora indicates that coniferous forest occupied in the nearby mountain range with cooler climate. *Cathaya*, is a gymnosperm in Pinaceae family, today it is living in the tropical southern China between 900 and 1900 m (Liu et al., 1997). *Cathaya* is only observed in the lowermost part of the section with prominent values. Deciduous-evergreen mixed forest developed at higher altitude, with comprising of *Engelhardia*, *Carpinus orientalis*, *Carpinus betulus*, *Fagus*, *Acer*. In this forest community, riparian plants also formed such as *Alnus*, *Salix*, *Fraxinus*, *Zelkova*, etc., and shrub associations were composed of Caprifoliaceae, *Ilex*, Rosaceae and Ericaceae.

Rhus is a warm-temperate tree, belongs to Anacardiaceae family and abundant with *Cathaya* at the lowerpart of the Ermenek section (Figure 5). *Rhus* was extensively scattered in Eastern Asia, Europe and North America during the Eocene and Miocene (Yi et al., 2004). *Rhus*, probably, developed on well-drained slopes around paleolake in Ermenek during the Early Miocene. Sub-tropical trees, particularly, such as Taxodiaceae give a peak in the upper part of the section (Figure 4). This suggests that climate started to turn warm and humid while high and middle altitudinal trees decline. This swamp forest generally requires very humid conditions during all the year (Wang, 1961). Herb assemblages are characterized by Poaceae, Asteraceae Asteroideae, Asteraceae Cichorioideae, Amaranthaceae-Chenopodiaceae, *Potamogeton*, Ericaceae, etc. with low percentages in the section. In herb communities, only, Poaceae are prominent in the pollen spectra. The low representation of herbaceous and steppe plants indicate that the climate was not arid in the lake environment during the Early Miocene and land cover was mostly forest. Non-significant plants are generally preserved poorly. While some of them are cosmopolitan, the others are widely distributed plants such as Ranunculaceae and Rosaceae (Figure 5). Palynological studies belonging to the Early Miocene from another localities in Turkey indicate that climate was warm and humid by the occurrence of tropical and sub-tropical trees (Akgün et al., 2007; Yavuz-Işık et al., 2010; Yavuz-Işık, 2008). However, vegetation cover has a different history in Ermenek region, chiefly constituted of coniferous trees signing cooler climate during the Early Miocene. The similar trend was observed by Üçbaş Durak and Akkiraz (2016) in Kalkım-Gönen Basin. Here, the pollen record of Danişment section exhibits that presence of coniferous forest suggesting cooler climate in that region in the late Oligocene (Chattian) (Üçbaş Durak and Akkiraz, 2016). The oxygen isotope record of deep sea benthic foraminiferal data ($\delta^{18}O$) shows an increase, corresponding to first Early Miocene glaciations (Miller et al., 1991; Billups et al., 2002). Moreover, climatical variations from the late Oligocene to the earliest Miocene was associated with orbital forcing (Zachos et al., 2001). This is followed by warmth during the late Early Miocene. These global signals are also well associated with Ermenek pollen data. While coniferous trees reflect cooler climate in the most of Ermenek section, towards to the upper part of section, an increase in subtropical and warm-temperate trees suggest that climate slightly turned to the warmer conditions in the region.

CONCLUSION

The palynological analysis of the Ermenek Basin enable us to visualize paleovegetation and paleoclimate during the Early Miocene. The pollen record indicates that Ermenek flora comprises of mainly middle- and high-altitudinal trees. In these tree community, Cedar trees (*Cedrus*) are abundantly detected in the sediments with *Abies* (Firs) and *Picea* (Spruce). *Cathaya*, is a coniferous (pine) tree, is living southern tropical China today. *Cathaya* is prominent at the lowermost part of the Ermenek section. However, it decreases towards to up in the section. The abundance of coniferous trees shows that the climate was cool during the deposition of sediments in the most of the Ermenek section. In contrast to this, sub-tropical trees (mega-mesothermic plants) increase at the upper most parts of the Ermenek section with warm-temperate trees. This may be occurred by changing climate conditions turning to warmer and humid climate in the region. The low presence of herbaceous taxa imply that vegetation was constitued by mainly forests in Ermenek during the Early Miocene. Another noteworthy result, the common appearance of *Cedrus* remarks that cedar trees can be ancient element in Anatolian flora since 23 Ma.

ACKNOWLEDGEMENTS

I would like to thank to C. Messina and the late D. Joly, for providing samples from Ermenek. I would like to thank Funda Akgün and Mehmet Serkan Akkiraz for their valuable comments on the manuscript, which greatly improved the article.

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