DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

OLIGO-MIOCENE PALYNOLOGY, PALAEOBOTANY, VERTEBRATE, MARINE FAUNAS, PALAEOCLIMATOLOGY AND PALAEOVEGETATION OF THE ÖREN BASIN (NORTH OF THE GÖKOVA GULF), WESTERN ANATOLIA

by

Mine Sezgül KAYSERI

March, 2010

IZMIR

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We have read the thesis entitled **"OLIGO-MIOCENE PALYNOLOGY, PALAEOBOTANY, VERTEBRATE, MARINE FAUNAS, PALAEOCLIMATOLOGY AND PALAEOVEGETATION OF THE ÖREN BASIN (NORTH OF THE GÖKOVA GULF), WESTERN ANATOLIA"** completed by **MİNE SEZGÜL KAYSERİ** under supervision of **PROF. DR. FUNDA AKGÜN** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy.

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ABSTRACT

This thesis explains the stratigraphical, palaeontological, palaeoenvironmental and palaeoclimatological significance of the Milas-Ören region. In this study, one formation (Kultak formation of the late Burdigalian-early Langhian age) and three members (Alakilise member of the Rupelian-Chattian; Hüsamlar and Belen members of late Burdigalian- Langhian age) are defined.

The basement in the Ören region is represented by limestones of the Lycian nappes. The basement rocks are unconformably overlaid by the Çambeleni formation. Çambeleni formation in the Rupelian time is lateral and vertical transitional contacts with Alakilise member composing of sandstones, mudstones alternation and coal. Deposition of the Çambeleni formation and Alakilise member continues in the Chattian time. The sediments of the Çambeleni formation are made of reefal limestones with foraminifers and these foraminifer fauna is defined in this thesis. The Alakilise member is represented by sandstones with gastropod and bivalvia fossils and including several lenses of lignite in the Chattian time and palynofloras and macro marine faunas of this time are defined. The Chattian–Aquitanian transition is conformably. The Aquitanian and early–middle Burdigalian sediments consist mainly of the sandstones with bivalvias, gastropods and reefal carbonates with coral, foraminifers, gastropods, bivalvias (the Çambeleni formation). According to these marine fossils, early–middle Burdigalian time is recorded. The Çambeleni formation is vertical and lateral transitional contact with Gökçeören formation including coarse conglomerates in the Akbük, Akyaka–Kuyucak regions. During the middle Burdigalian and Langhian, the unconformably overlaying Kultak formation is characterized by coarse conglomerates with mammalian fossils and sandstones alternation. This formation laterally and vertically passes the Belen member which is represented marine claystones, sandstones and limestones with gastropod, bivalvia and coral. In addition, the Kultak formation is lateral and vertical transitional contact with the Hüsamlar member which composes of marl with leaf fossils and coal alternation with mammalian and leaf fossils. The Hüsamlar and Belen members are unconformably overlain by Sekköy

and Yatagan formations which are dated as the late Astracian (the Sekköy formation) to Turolian (the Yatagan formation).

Palynoflora of the Rupelian time is represented by the *Momipites quietus, Plicapollis plicatus, Dicolpopollis kockelii, Plicapollis pseudoexcelsus, Cuphaniedites eucolptoides, Compositopollenites minitus, Compositoipollenites rhizophorus burghasungensis, Olaxipollis mathensis, Leiotriletes maxoides minoris, Bohlensipollis hohli, Mediocolpopollis compactus, Subtriporopollenites constans, Sparganiapollenites neogenicus, Pentapollenites pentangulus, Interpollis* sp., *Polygalacidites* sp., *Psilatricolporites crassus. Avicennia* sp., *Verrucatosporites alienus* and *Verrucatosporites favus* ssp. *favus*. Besides, in this thesis firstly pollen of the mangrove forest are observed in the Rupelian and during this time ?tropical-warm subtropical climatic condition is defined based on the palynofloras and numerical palaeoclimatic results.

The Chattian time is recorded foraminifer, gastropod, bivalvia and strontium isotope results of the Çambeleni formation and Alakilise member. The palynoflora of the Chattian time is characterized by the *Momipites quietus, Plicapollis plicatus, Dicolpopollis kockelii, Plicapollis pseudoexcelsus, Leiotriletes maxoides minoris, Interpollis* sp. and marine dinoflagellates species. According to the palynoflora brackish paleoenvironmental condition is observed. During the Chattian time, warm subtropical climatic condition continues based on the palynoflora. And also foraminifer, gastropod, bivalvia faunas of this time are defined and these fauna associations and oxygen and carbon isotopic analysis results support the palaeoenvironmental interpretation based on the palynoflora.

The late Early-early Middle Miocene time is recorded based on the palynofloras, leaf fossils, mammalian fossils, strontium isotope results in the Kultak formation, Belen and Hüsamlar members. Leaf flora of the Ören region firstly defined and this flora of late Early-early Middle Miocene time interval is represented by the *Acer integrilobum, Fagus gussonii, Quercus mediterranea, Quercus zorastri, Quercus rehenana, Pinus* sp., *Glyptostrobus europaeus, Carpinus grandis, Alnus cecroplifolia, Quercus sosnowskyi, Myrica lignitum, Nyssa bilinica, “Rhamnus” warthae, Populus populina, Zelkova zelkovifolia, Taxodium dubium, Acer angustilobul, Liquidambar europa, Berberis* sp., *Mahonia* sp., *Alnus julianaeformis, Alnus gaudinii, Alnus adscendens, Betula* sp., *Quercus kubinyii, Quercus* sp., *Hamamelis* sp., *Daphnogene polymorpha*. Palynoflora of this time is

characterized by the *Laevigatorsporites haardti*, *Pityosporites microalatus*, *Cupressacites cuspidateaformis*, *Monogemmites pseudosetarius*, *Quercopollenites robur*, *Tricoporopollenites densus*, *Dicolpopollis kalewensis*, *Subtriporopollenites anulatus nanus*, *Momipites punctatus*, *Momipites quietus*, *Periporopollenites multiporatus*, *Liriodendrioipollis semiverrucatus*, *Polygalacidites* sp., *Cichareacidites* sp. *liquiflora* type, *Tricoporopollenites* sp. (*tubuliflora* type), *Magnolipollis* sp. and *Avicennia* sp.. According to the palynoflora and numerical palaeoclimatic results using the coexistence approach CLAMP, LMA methods, warm subtropical climatic condition is observed in the Ören region. Besides, pollen of mangrove forest is firstly recorded for the late Early-early Middle Miocene time in Turkey. The mammalian fauna which includes *Anchitherium aurelianense hippoides* (Lartet), *Ancylotherium* (Metaschizotherium) *fraasi* (Koenigswald), *Tethytragus koehlerae* (Azanza & Morales) and *Gomphotherium* sp.. is determinated. This fauna of the MN5-6 boundary zone is the Langhian age and strontion isotope result is supported this age determination.

The Middle Miocene (the Serravallian) time is recorded by palynoflora which is represented by the *Laevigatosporites haartdi Baculatisporites primarius Pityosporites microalatus*, *Cathayapollis* spp., *Inaperturopollenites dubius*, *Cycadopites* spp., *Tricolpollenites densus*, *Quercopollenites robur* type, *Tricolporopollenites megaexactus exactus*, *Tricolporopollenites cingulum oviformis*, *Alnipollenites verus*, *Monogemmites pseudosetarius*, *Momipites punctatus*, *Triatriopollenites rurensis*, *Triporopopollenites coryloides*, *Oleoidearumpollenites microreticulatus*, *Caryapollenites simplex*, *Tricolpopollenites retiformis* (*Salix* type), *Ovoidites* spp., *Pityosporites labdacus*, *C. cuspidateaformis*, *Tricolporopollenites pseudocingulum*, *Leiotriletes maxoides minimus*, *Inaperturopollenites hiatus*, *Tetracolporopollenites sapatoides*, *Polyporopollenites undulosus*, *Periporopollenites multiporatus*, *Tricolporopollenites* sp. (*Tubulifloreae* type) and *Tricolporopollenites* sp. (*Liguliflоreae* type)). Palaeoclimate is temperate based on the palynoflora and numerical paleoclimatic results.

Keywords: Palynomorph, palaeobotany, foraminifera, gastropod, mammalian, palaeoclimate, palaeovegetation, Oligo-Miocene

ÖREN HAVASINA AIT OLIGO-MIYOSEN PALINOLOJI, PALEOBOTANIK, OMURGALI, DENIZEL FAUNALAR, PALEOIKLIM VE PALEOVEJATASYON (GÖKOVA KÖRFEZI KUZEYI), BATI ANADOLU

ÖZ

Bu tez kapsaminda, Milas-Ören bölgesin stratigrafik, paleontolojik, paleortamsal ve paleoiklimsel önemi açiklanmistir. Bu çalismada bir formayon (geç Burdigaliyen yasli Kulak formasyonu) ve üç üye (Rüpeliyen-Sattiyen yasli Alakiise üyesi ve geç Burdigaliyen-Langiyen yasli Hüsamlar ve Belen üyeleri) tanimlanmistir.

Ören bölgesine ait temel kayalari Likya naplarina ait kireçtaslari ile temsil edilmektedir. Temel kayalari uyumsuz olarak Çambeleni formayonu tarafindan üstlenir. Rüpeliyen zamaninda, Çambeleni formasyonu yanal ve düsey deçisli olarak Alakilise üyesine geçer ve bu üye kumtasi çamurtasi ardalanmasi ve kömürden olusmaktadir. Sattiyen zamaninda, Çambeleni formasyonu ve Alakilise üyesinin depolanmasi devam eder. Çambeleni formayonuna ait sedimentler foraminiferli resifal kireçtaslarindan olusmaktadir ve bu tez kapsaminda, derlenen foraminifer faunasi tanimlanmistir. Sattiyen zamaninda, Alakilise üyesi gastrapod ve bivalvia fosilli kumtaslarindan olusmaktadir ve üye birkaç linyit mercegi içermektedir. Bu zamana ait palinoflora ve makro denizel faunalar tanimlanmistir. Sattiyen-Akitaniyen geçisi uyumludur. Akitaniyen ve erken-orta Burdigaliyen yasli sedimentler, bivalvia, gastrapod fosilli kumtsalari ve mercan, foraminifer, gastrapod, bivalvia fosilli resifal kireçtaslarindan olusmaktadir (Çambeleni formasyonu). Denizel fosillere göre, erken-orta Burigaliyen tanimlanmistir. Çambeleni formasyonunun, Gökçeören formasyonuyla dokanak iliskisi yanal ve düsey geçislidir. Akbük, Akyaka-Kuyucak bölgelerinde, Gökçeören formasyonu kaba çakiltasindan olusmaktadir. Orta Burdigaliyen-Langiyen boyunca, Kultak formasyonu uyumsuz olarak gelmektedir ve bu formasyon memeli fosilli kaba çakiltasi ve kumtasi ardalanmasindan olusmaktadir. Bu formasyon yatay ve düsey geçisli olarak Belen üyesine geçer ve bu üye denizel kiltaslari, kumtaslari gastrapod, bivalvia ve mecran fosilli kireçtaslarindan temsil edilmektedir. Ek olarak, Kultak formasyonu yanal ve düsey geçisli olarak Hüsamlar üyesine geçer ve bu üye yaprak fosilli yaprak fosilli marn ve memeli fosilli kömür ardalanmasindan meydana gelmektedir. Hüsamlar ve Belen üyeleri uyumsuz olarak geç Astarasiye yasli Sekköy ve Turoliyen yasli Yatagan formasyonlari tarafindan üstlenir.

Rüpeliyen yasli palynoflora *Momipites quietus, Plicapollis plicatus, Dicolpopollis kockelii, Plicapollis pseudoexcelsus, Cuphaniedites eucolptoides, Compositopollenites minitus, Compositoipollenites rhizophorus burghasungensis, Olaxipollis mathensis, Leiotriletes maxoides minoris, Bohlensipollis hohli, Mediocolpopollis compactus, Subtriporopollenites constans, Sparganiapollenites neogenicus, Pentapollenites pentangulus, Interpollis* sp., *Polygalacidites* sp., *Psilatricolporites crassus. Avicennia* sp., *Verrucatosporites alienus* ve *Verrucatosporites favus* ssp. *favus* ile temsil edilmektedir. Ayrica, bu tez kapsamindan ilk kez Rüpeliyen zamanina ait mangrove ormanina ait polen tanimlanmistir. Bu zaman boyunca, palynoflora ve sayisal paleiklimsel degerler dayali olarak ?tropikal-ilik subtropikal iklim kosullari tanimlanmistir.

Sattiyen zamani Çambeleni formasyonu ve Alakilise üyesine ait kayalardan tanimlanan foraminifer, gastropod, bivalvia ve stronsiyum izotop sonuçlari ile kayit edilmistir. Sattiyen yasli palinoflora *Momipites quietus, Plicapollis plicatus, Dicolpopollis kockelii, Plicapollis pseudoexcelsus, Leiotriletes maxoides minoris, Interpollis* sp. ve denizel dinoflagellat türleri ile karakterizeedilmektedir. Palinofloraya göre acisu paleortam kosullari gözlenmistir. Palinofloraya dayali olarak, Sattiyen boyunca, ilik subtropical iklim kosullari devam etmektedir. Ve ayrica, bu zamana ait foraminifer, gastropod, bivalvia faunalari tanimlanmistir ve bu fauna topluluklari, oksijen ve karbon izotop analizi sonuçlarin, palinoflorayi temel alarak olusturulmus paleortamsal kosullari desteklemektedir.

Kultak formasyonu, Belen ve Hüsamlar üyelerine ait geç Erken-erken Orta Miyosen zamani palynoflora, yaprak fosilleri, memeli fosilleri, ve stronsiyum izotop analizi sonuçlari ile belirlenmistir. Ören bölgesine ait yaprak florasi ilk kez tanilanmis ve geç Erken-erken Orta Miyosen yasli bu flora *Acer integrilobum*, *Fagus gussonii, Quercus mediterranea, Quercus zorastri, Quercus rehenana, Pinus* sp., *Glyptostrobus europaeus, Carpinus grandis, Alnus cecroplifolia*, *Quercus sosnowskyi, Myrica lignitum, Nyssa bilinica, "Rhamnus" warthae, Populus populina, Zelkova zelkovifolia, Taxodium dubium, Acer angustilobul, Liquidambar europa, Berberis* sp., *Mahonia* sp., *Alnus julianaeformis, Alnus gaudinii*, *Alnus adscendens, Betula* sp., *Quercus kubinyii, Quercus* sp., *Hamamelis* sp. ve Daphnogene *polymorpha* ile temsil edilmektedir. Ayni bölge ve yasa ait palynoflora ise *Laevigatorsporites haardti*, *Pityosporites microalatus*, *Cupressacites cuspidateaformis, Monogemmites pseudosetarius, Quercopollenites robur*, *Tricoporopollenites densus,*

Dicolpopollis kalewensis, *Subtriporopollenites anulatus nanus*, *Momipites punctatus*, *Momipites quietus*, *Periporopollenites multiporatus*, *Liriodendrioipollis semiverrucatus*, *Polygalacidites* sp., *Cichareacidites* sp. *liquiflora* type, *Tricoporopollenites* sp. (*Tubuliflora* tip), *Magnolipollis* sp. ve *Avicennia* sp. ile characterize edilmektedir. Palinoflora ve coexistence approach CLAMP, LMA yöntemleri kullanilarak elde edilen sayisal paleoiklimsel sonuçlara gore Ören bölgesinde ilik subtropical iklim kosullari gözlenmektedir. Ayrica, Türkiye'de geç Erken-erken Orta Miyosen zamani için mangrove ormanina ait pollen ilkkez kayitedilmistir. *Anchitherium aurelianense hippoides* (Lartet), *Ancylotherium* (Metaschizotherium) *fraasi* (Koenigswald), *Tethytragus koehlerae* (Azanza & Morales) ve *Gomphotherium* sp. fosillerini içeren memeli faunasi tanimlanmistir. MN5-6 siniri zonunu temsil eden bu fauna Langiyen yaslidir ve stronsiyum izotop sonuçlari, memeli fosillerinden elde edilen yas yorumlamasini desteklemektedir.

Orta Miyosen (Seravaliyen) zamani palynoflora ile kayit edilmistir ve bu palinoflora *Laevigatosporites haartdi Baculatisporites primarius Pityosporites microalatus, Cathayapollis* spp., *Inaperturopollenites dubius, Cycadopites* spp., *Tricolpollenites densus, Quercopollenites robur* tip, *Tricolporopollenites megaexactus exactus, Tricolporopollenites cingulum oviformis, Alnipollenites verus, Monogemmites pseudosetarius, Momipites punctatus, Triatriopollenites rurensis, Triporopopollenites coryloides, Oleoidearumpollenites microreticulatus, Caryapollenites simplex, Tricolpopollenites retiformis* (*Salix* tip), *Ovoidites* spp., *Pityosporites labdacus, C. cuspidateaformis, Tricolporopollenites pseudocingulum, Leiotriletes maxoides minimus, Inaperturopollenites hiatus, Tetracolporopollenites sapatoides, Polyporopollenites undulosus, Periporopollenites multiporatus, Tricolporopollenites* sp. (*Tubulifloreae* tip) ve *Tricolporopollenites* sp. (*Ligulifloreae* tip) spor ve polenleri ile temsil edilmektedir.

Anahtar sözcükler: Palinomorf, paleobotanik, foraminifer, gastropod, memeliler, paleoiklim, paleovejetasyon, Oligo-Miyosen

CONTENTS

CHAPTER FIVE- PALYNOFLORA, FORAMINIFER, GASTRAPOD, BIVALVIA FAUNAS AND ISOTOP ANALYSIS RESULTS OF THE LATE OLIGOCENE-EARLY MIOCENE IN THE ÖREN BASIN (SW TURKEY): PALAEOCLIMATIC AND PALAEOVEGETATIONAL INTERPRETATION……………………………………………………………260

CHAPTER SEVEN – THE LATE BURDIGALIAN–LANGHIAN TIME INTERVAL IN THE ÖREN REGION (SOUTHWESTERN TURKEY)– PAYNOSTARTIGRAPHIC, PALAEOVEGETATIONAL, VERTABLATES VERTABLATES 441

CHAPTER ONE
INTRODUCTION

1.1 Study Area

The study area is located between Milas, Ören and Akyaka in northern part of Gökova Gulf (southwestern Turkey) and it is situated on the Lycian nappes (Fig. 1.1). These nappes are take places in southwest Turkey between the Menderes massif and Bey Daglari autochthon. The area extending from Milas to Akbük Bay, where includes ten 1/25.000–scale sheets of N19–b3, 4, N19–c1, 2, 3, 4, N20–d1, 2, 3, 4 (Fig. 1.1). Many of the sections were measured from the Tertiary sediments.

Along the roads connecting Milas, Çökertme, Ören and Akyaka it is accessible to different parts of the study area. The minor roads make easier to transport.

1.2 Regional Geological Setting

In the Gökova region, the basement is formed of the Mesozoic rocks of Lycian nappes and the associated Tertiary sediments (Görür et al., 1994; Yilmaz et al., 2000; Sözbilir, 2005). The Lycian nappes occupy a large area between the Menderes massif in the north and Bey Daglari autochthon in the east. The Ören basin is located in the Gökova region and this basin consists of the coal bearing terrestrial and marine sediments of the Tertiary (Görür et al., 1994; Yilmaz et al., 2000; Gürer & Yilmaz, 2002). These deposits persist from the Oligocene to Pliocene and are widespread in this region.

In the previous study, there are different opinions about the stratigraphy, age and the factor that what kind of tectonic regime of graben in western Anatolia caused development. According to opinions of some authors (i.e. Seyitoglu & Scott, 1991), the E–W grabens began to form throughout the Late Oligocene–Early Miocene and have been continuously evolving since that time. Other opinion is that the E–W grabens are younger tectonic features, and began to form in the Late Miocene

(McKenzie, 1972; Sengör & Yilmaz, 1981; Mercier et al., 1989; Paton, 1992; Yilmaz et al., 1997, 2000; Koçyigit et al., 1999; Bozkurt, 2000; Sarica, 2000). The Gökova graben is one of the major E–W trending grabens of western Anatolia (Fig. 1.1). The Ören area is located to north of the Gökova graben where there are Neogene outcrops. These Neogene sediments are commonly referred to as the Ören basin, which extends from the Gulf of Gökova in the south to Milas in the north. This basin is accepted as N–S trending basin and possibly developed in an E–W extension, N–S compression stress field according to Yilmaz & Polat (1998), Yilmaz et al. (2000), Robertson (2000) and Gürer & Yilmaz (2002). In the basin, sedimentary fill derived from the continental and shallow marine sediments (Gürer & Yilmaz, 2002). Additionally, in some places, sequences of the basin include reefal limestones.

1.3 Purpose and Scope

Many studies focusing on the Tertiary sedimentary sequence in western Anatolia have been carried out since beginning of this century. Most of studies have been concerned the general geology, stratigraphy and especially tectonic regime in western Anatolia (e.g. Nebert, 1957, 1961; Becker–Platen, 1970; Benda, 1971a, 1971b; Sengör & Yilmaz, 1981; Koçyigit, 1981, 1983, 1984, Sahbaz & Görmüs, 1992, 1993; Yagmurlu, 1994; Robertson, 1993; Yilmaz et al., 2000; Akgün & Sözbilir, 2001; Gürer & Yilmaz, 2002; Sözbilir, 2002, 2005) whereas detailed biostratigraphic studies are limited number in the Ören basin (Tchihatcheff, 1869; Philippson, 1915, 1918; Flügel & Metz, 1954; Nebert, 1956; 1957; Erentöz & Öztemür, 1964 and Kaya et al., 2001). In these studies, marine sediments of the Ören basin is aged persist from the ?Late Oligocene (Egerian) to the Early Miocene (the Aquitanian–Burdigalian).

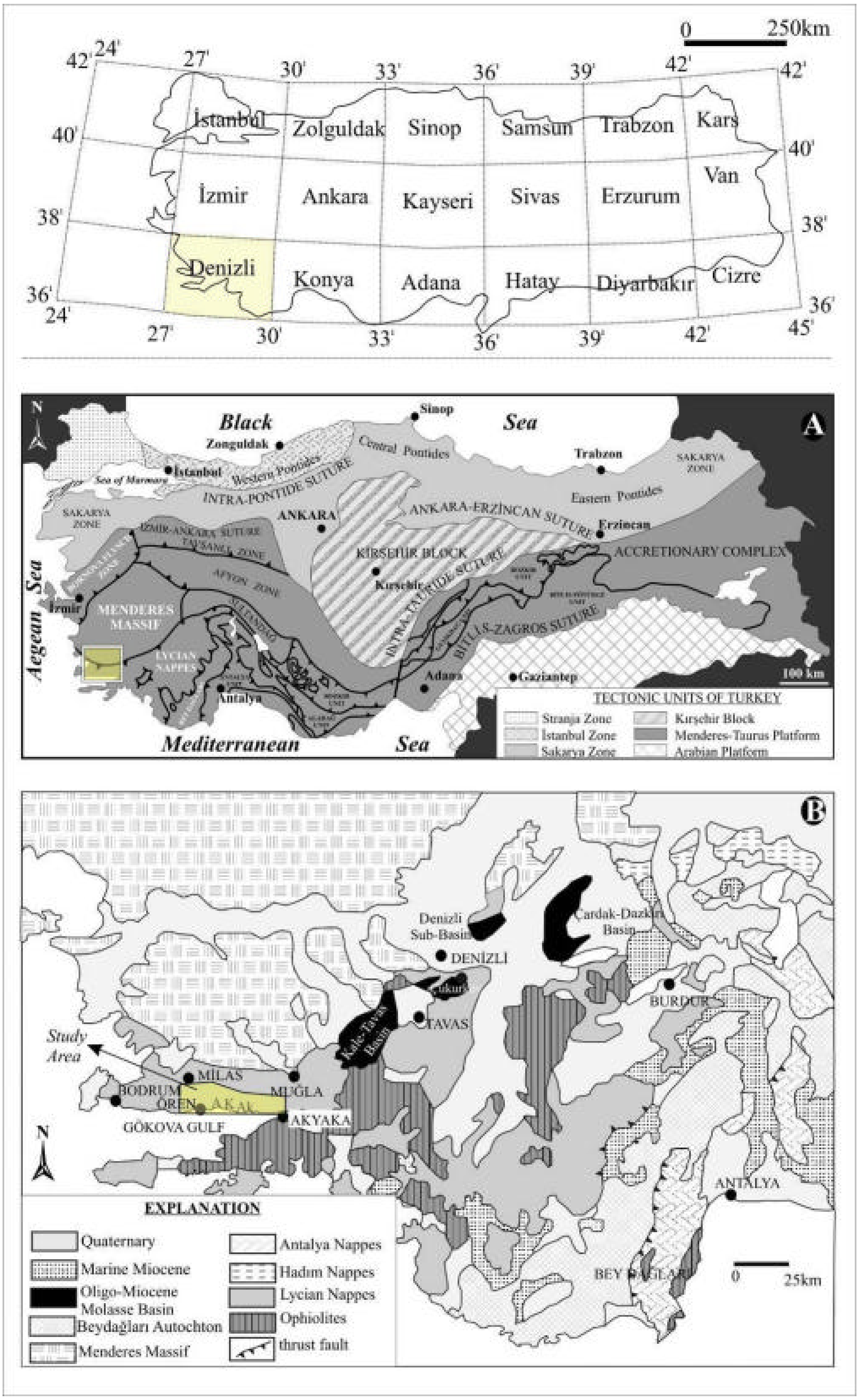


Figure 1.1 Map showing the location of the study area a) Main tectonic units of Turkey (after Görür & Tüysüz, 2001), b) Outline geological map of western Anatolia showing the major tectonic units and molasse basins in SW Turkey (simplified from Sari, 2006, Sözbilir, 2005 and Akgün & Sözbilir, 2001).

This study mainly deals with the detailed palynostratigraphic and biostratigraphic analysis of the palynoflora obtained from the Tertiary terrestrial sediments and foraminifers, gastropods, bivalves obtained from the neritic limestones, marl and sandstones of the Tertiary marine sediments in the Ören basin. Besides this study also concern the mammalian faunas and systematic palaeobotany of the terrestrial marl in Ören–Karacaagaç, Hüsamlar and Alakilise regions.

In order to make up the Tertiary evolution of the Ören basin, following aspects are the main aims of this thesis.

1. to establish the palynostratigraphy of coal bearing sediments in the Ören basin and to correlate to previous palynological records of Europe and Turkey,

2. to describe the leaf fossil association observed within marl of the Tertiary sediments in the Ören basin,

3. to establish mammalian faunas of the Miocene age in the coarse clastic rocks in the Ören basin,

4. to determine the foraminifer faunas, gastropod, bivalves of the neritic limestones,

5. to analyse the geochemically well preserved shells of gastropods (*Natica* sp.), micritic limestones with foraminifers and mammalian toots (*Gomphotherium angustidens*) for their $^{87}\mathrm{Sr}/^{86}\mathrm{Sr}$ to have numerical age. To correlate the numerical and biostratigraphical age,

6. to analyses the bulk of the neritic limestones for their oxygen ($^{18}\mathrm{O}$) and carbon ($^{13}\mathrm{C}$) isotope ratios in order to define palaeoenvironmental changes of the Ören basin during the Oligocene–Miocene,

7. to analyse $^{18}\mathrm{O}$ and $^{13}\mathrm{C}$ isotope ratio of *Gomphotherium angustidens* and also to support the palaeoenvironmentsl record based on the plant fossils,

8. to constitute palaeoclimatic evolution in the Ören basin. Additionally, to correlate the European palaeoclimatic record,

9. to determine palaeovegetational properties of the Ören basin for the Tertiary,

10. to approach the palaeogeography of southwestern Anatolia for the Oligocene–Miocene time interval.

1.4 Material and Methods

In this study, 19 stratigraphic sections are measured. 200 limestone (Alakilise=Alatepe, Kultak, Kumluca, Pinar, Türkevleri regions and north of Akbük Bay) and 503 lignite or claystone samples (Alakilise=Alatepe, Kultak, Hüsamlar, Ikizler, Sek regions) were collected systematically throughout these sections for the detailed biostratigraphic study. Besides lost of leaf (Karacaagaç, Hüsamlar and Alakilise regions), mammalian (Hüsamlar and Kultak regions), gastropod and bivalves (Kultak and Alakilise=Alatepe regions) fossils were collected in sections. Local geological mapping at 1/25.000 scale was carried out the locality where the section measured. The detail methods are applied for the palaeobotany, palynostratigraphy, foraminifer biostratigraphy, mammalian studies and Sr, C and O–isotopes stratigraphy.

1.5 Previous Studies

In this part, stratigraphic and paleontologic studies of southwestern Anatolia region are summarized under two headings.

1.5.1 Stratigraphic and Tectonic Studies

Many authors have studied Tertiary sediments in southwestern Anatolia (Nebert, 1956; 1957; 1961, Erentöz & Öztemür, 1964; Becker–Platen, 1970; Benda 1971a , b; Benda & Meunlenkamp, 1990; Atalay, 1980; Akgün & Sözbilir, 2001; Gökçen, 1982; Görür et al., 1994, 1995; Hakyemez & Örçen, 1982; Hakyemez, 1989; Robertson, 1993; Seyitoglu & Scott, 1991; 1992, Sözbilir, 2002; 2005, Sahbaz & Görmüs, 1992; 1993). These studies generally focused on the molasse basin which are Kale–Tavas, Çardak–Dazkiri and Denizli basins (Sözbilir, 2002, 2005) (Figs. 1.2, 1.3). However, fewer researchers were studied in the Ören basin (i.e. Nebert, 1957; Görür et al., 1994; Yilmaz et al., 2000; Kaya et al., 2001; Gürer & Yilmaz, 2002; Çemen et al., 2003; Seyitoglu et al., 2004). The stratigraphy of the molas basins is very imported for understanding of the geology of Ören basin. Because Kale–Tavas and Ören basins are accepted the parallel basins in southwestern Anatolia (Gürer & Yilmaz, 2002). Moreover other (i.e. Çardak–Dazkiri, Denizli, Kas–Kasaba basins and also Mut–Ermenek basin) and Ören basins are made up same time interval (Oligocene–Miocene) (Nebert, 1956; 1961, Erentöz & Öztemür, 1964; Becker–Platen, 1970; Benda 1971a , b; Benda & Meunlenkamp, 1990; Akgün & Sözbilir, 2001; Gökçen, 1982; Görür et al., 1994, 1995; Hakyemez & Örçen, 1982; Hakyemez, 1989; Robertson, 1993; Seyitoglu & Scott, 1991; 1992, Sözbilir, 2002; 2005, Sahbaz & Görmüs, 1992; 1993; Islamoglu, 2008; Islamoglu et al., 2006).

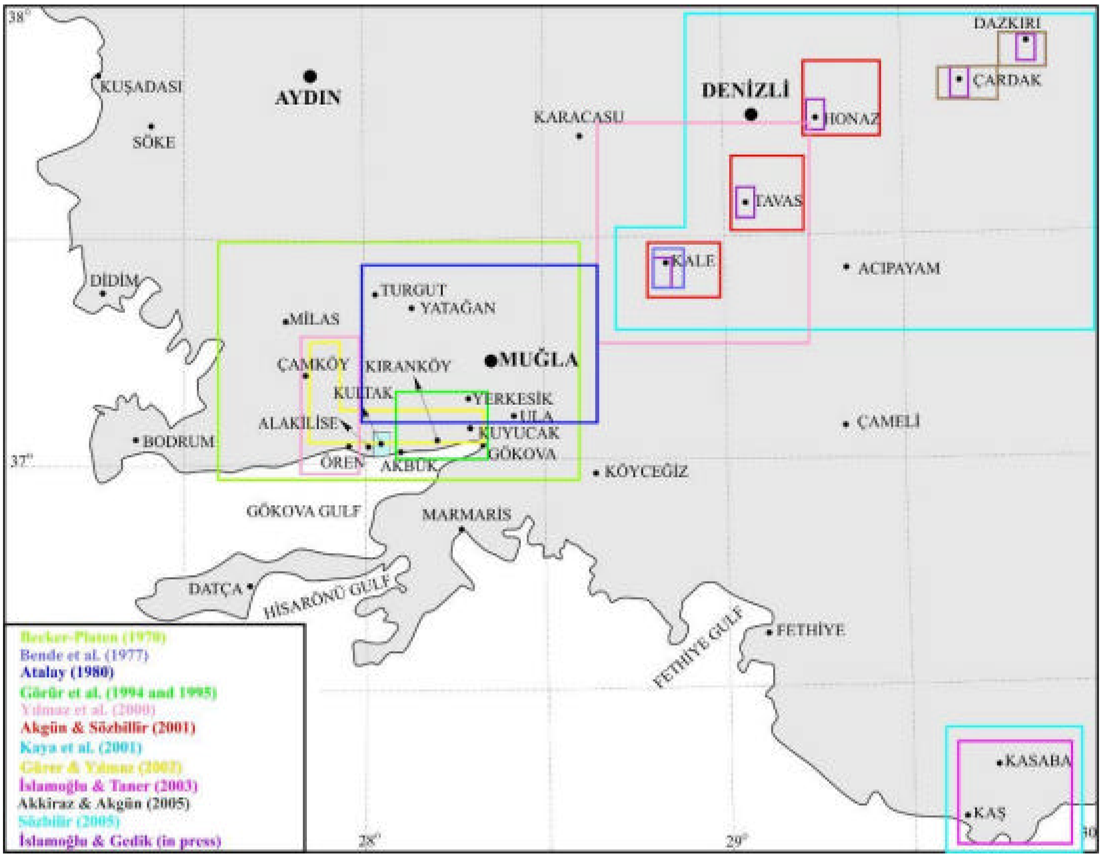


Figure 1.2 Location map showing areas corresponded studies in the SW Anatolia.

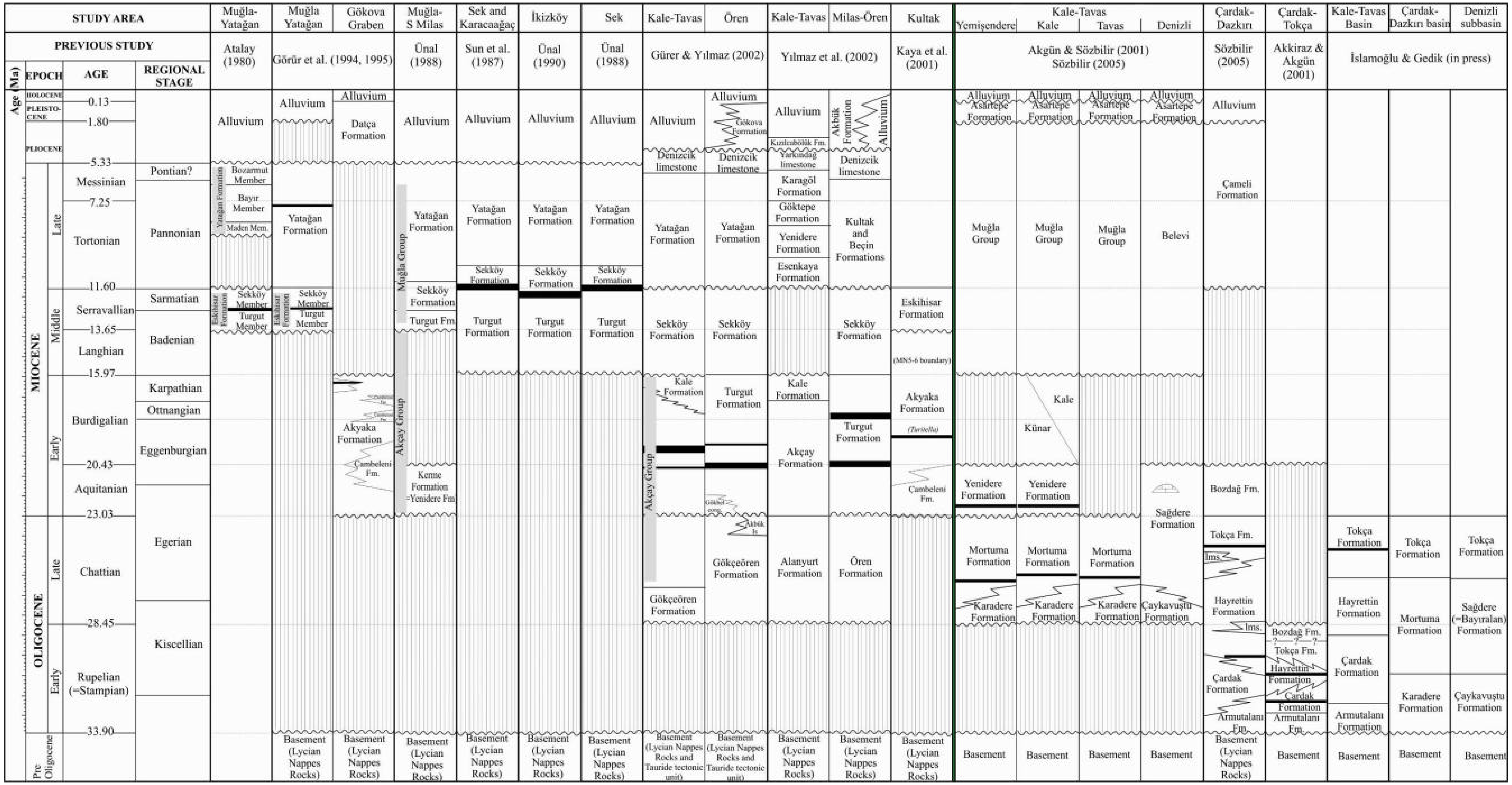


Figure 1.3 Chart showing the previous suggested Tertiary sequence of soutwestern Anatolia.

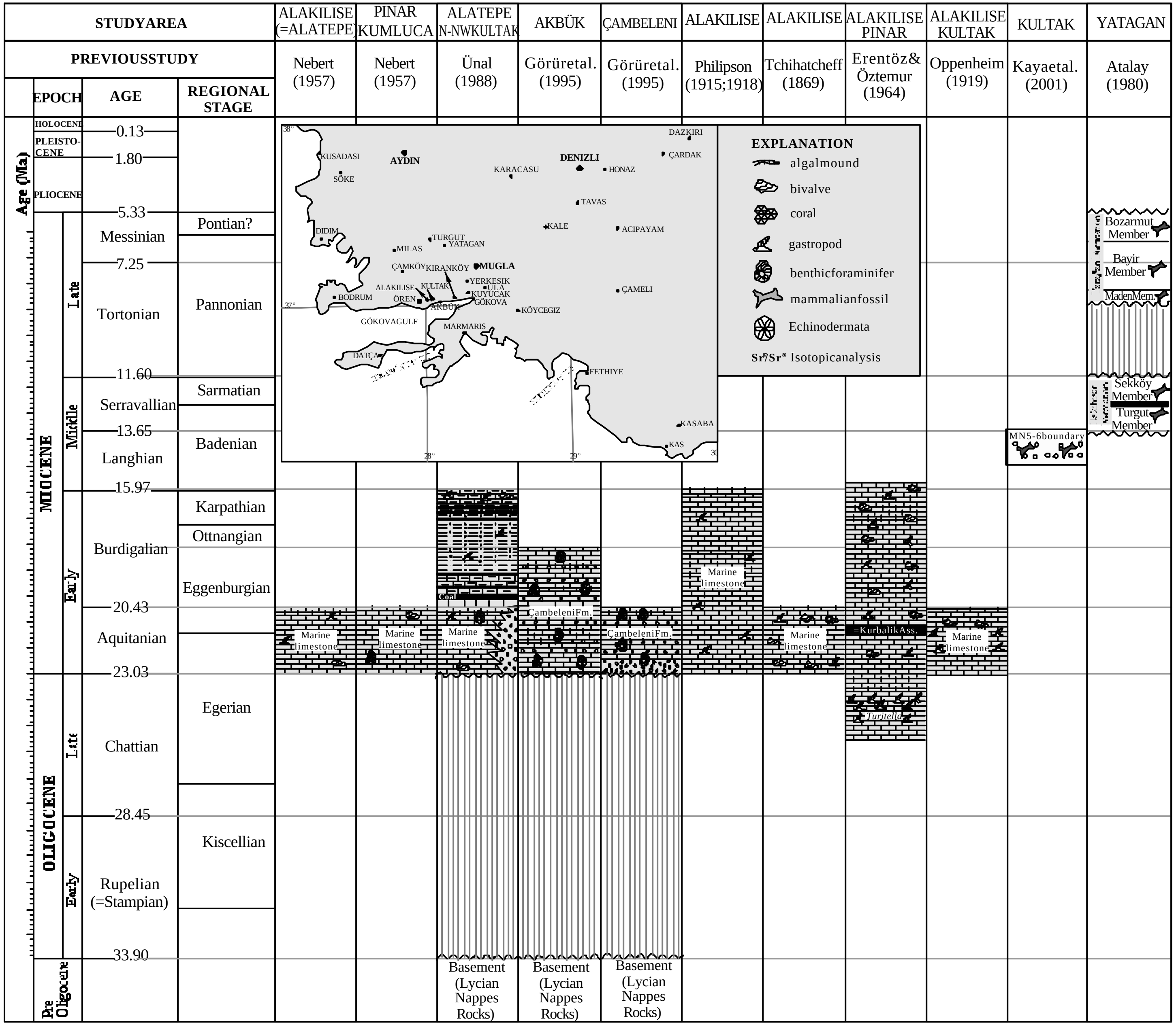


Figure 1.4 Chart showing the previous suggested Tertiary sequence of soutwestern Anatolia based on the paleontological data

Görür et al. (1994) defined two rift systems of different age and orientation in the Gökova region (southwestern Anatolia). The first system has a NW–SE trend with a Middle to Late Miocene infill, whereas the second system is orientated in an E–W direction a filled with Pliocene–Quaternary rocks. The first system was related to the palaeotectonic regime of southwestern Anatolia and is characterized by N–S compression, whereas the younger system is related to the neotectonic regime of the Gökova region and is represented by extension into the Late Miocene. According to authors, extensional tectonics and the related rift formation in the Aegean region commenced in the Early Miocene, with the alleged demise of the compressional palaeotectonics during the Late Oligocene. The Early Miocene sediments are represented by two interfingering facieses in the E–W grabens (Gökova graben) (Görür et al., 1994). These are Akkaya and Çambeleni formations. The first facies (the Akkaya formation) is a massive to poorly bedded and shorted conglomerate, containing well–rounded clasts recrystallized limestones, gneiss, schist, quartz and chert. The second facies (the Çambeleni formation) comprises sandstones with foraminifers and coral reefal limestones, passing up to conglomerate (Figs 1.1, 1.2).

Görür et al. (1995) suggested two rift systems of different ages and orientations. The first system is represented by northwest–southeast orientated rift and small grabens filled with Astaracian to Turolian (about 15 to 5 Ma) sedimentary rocks (Becker–Platen, 1970, as revised by Atalay, 1980). The second system cuts across the first one and is characterized by the large E–W trending Gökova Rift which was named Kerme Graben in the previous studies by Sengör et al. (1985) and Sengör (1987). The rifts and grabens of the first system have been the focus of continental sedimentation, whereas those of the second system have also been accumulating marine sediments since the late Pliocene. The Lower Miocene (from the Aquitanian to Burdigalian) sedimentary rocks are well exposed in the Gökova rift where they are intensively disrupted by dominantly east–west trending normal faults (Görür et al., 1995). According to authors, they are represented by two interfingering facies, corresponding with two formations (the Akyaka and Çambeleni formations), which rest with an angular unconformity mostly on the Mesozoic recrystallized limestone of the Köycegiz. The Akyaka formation is the first and type section of the formation was defined from the Sakartepe region in the district of Akyaka. This formation composed of the massive poorly–bedded and poorly–sorted yellowish–grey conglomerate, containing well–rounded clasts of the same recrystallized limestone of the substrate with subordinate gneiss, schist, quartz and chert. Above Akyaka is red clastic unit, which was named the Kizilagaç formation by Görür et al. (1995). The Akyaka formation angular unconformably is overlaid by the Kizilagaç formation which is the Pliocene age. The Akyaka formation is devoid of fossils. The second facies comprises white to yellow foraminiferal sandstone and yellowish–grey to white coralgal reefal limestone, passing up into an alternation of yellowish–grey microsparite and conglomerate. This formation is named the Çambeleni formation by the Görür et al. (1995) and *Bozorgniella gumiensis, Austrillina howchini, Archias kirkumensis, Peneroplis thomasi* from the Çambeleni region and *Archias kirkumensis, Peneroplis evolutus, Miogypsinoides* cf. *complanatus, Miogypsina irregularis, Miogypsina intermedia* are recorded from the Akbük region (Görür et al., 1995). According to these benthic foraminifer faunas, the Çambeleni formation is aged the Aquitanian in the Çambeleni region and the Aquitanian–Burdigalian in the Akbük region. Akyaka and Çambeleni formations include same lithology and similar stratigraphic position. Both formations have carbonate and clastic intervals, although authors had not discovered that so far any means of correlating them directly. Besides, in the Kultak region contemporaneous sedimentary rocks are composed conglomerates, gastropod and bivalve–bearing mudstone interbedded with marl, friable sandstone and coal seams. The faunal and sedimentary facies suggest that these coarse clastics formed a fan–delta, prograding into a gradually deepening environment, depositing sandstones and carbonates. The marine to paludal Kultak facies indicates the presence of paralic swamp by the sea during the Aquitanian and Burdigalian time intervals. Additionally, according to the Görür et al. (1995) the clastic sediments in the Kultak region were derived from the carbonate rocks of the Lycian Nappes exposed mainly in the North. The infill of the northwest–southeast rifts is represented by three distinct depositional sequences separated by regional disconformities. These sequences range in age from the

Middle to Late Miocene and can be divided into lower and upper parts (the Turgut and Sekköy members of the Eskihisar formation, respectively; Atalay, 1980).

Yilmaz et al. (2000) studied to solve a long–lasting controversy on timing and mechanism of generation of the western Anatolia. Authors emphasized that initially north–south trending graben basins were formed under an east–west extensional regime during the Early Miocene. Stratigraphies of the Bergama region, the Edremit graben, the Gediz region, southern and northern regions of the Demirci basin, Kale–Tavas region and Milas–Ören region are compared by Yilmaz et al. (2000). The north and south trending basins formed during the Early Miocene and Late Miocene times. The Ören and Yatagan basins are approximately north–northern–south–southeast trending subparallel basins, which display identical strata of the Early Miocene age. These basins units rest unconformably on slightly metamorphosed successions of the western Taurides, composed dominantly of Mesozoic platform carbonates and underlying older phyllitic rocks. In places, the lowermost clastics rocks rest unconformably on fossiliferous marine limestones of the Ören Formation, which possibly formed within the Kale–Tavas basin prior to development of the north–northwest–south–southeast trending basins. These basins were apparently controlled by an oblique fault system displaying major dip–slip and subordinate dextral strike slip components. The Lower Miocene units are disrupted by the east–west trending normal faults around the Gulf of Gökova, which opened the Gökova Graben. According to Yilmaz et al. (2000) The Ören and Yatagan basins infills consist mainly of two rock units. The lower unit is composed of clastic rocks, which beginning with coarse conglomerates. These are of debris flow and fluvial origin. Upper part of the succession the coarse conglomerates are replaced by sandstones. The upper unit (the Turgut Formation) is a shale–marl dominated and it has a number of lignite beds. The top of the sequence (the Sekköy Formation) is a white, marl and limestone unit (Atalay, 1980 and Yilmaz et al., 2000).

Gürer & Yilmaz (2002) studied the geology Ören basin and surrounding areas (Kale–Tavas and Yatagan basins) in southwestern Anatolia. According to authors, Neogene basins developed along two different trends in different periods on the Lycian nappes of southwestern Anatolia. The Ören and Yatagan basins are subparallel basins trending approximately NNW–SSE and these basins formed Early–Middle Miocene time interval. The Ören basin fill consists of two rock units. The lower unit is composed of clastic rocks the Gökbel conglomerate. This unit is massive to poorly bedded and poorly sorted grey, coarse conglomerate with well–rounded clasts derived from the Lycian nappes. Upward in the succession, the coarse conglomerates are replaced by sandstones of Turgut formation. The upper unit is characterized by the shale–marl and fine clastic succession having coals. The top of the sequence is a white marl and limestones unit (Sekköy formation) (Atalay, 1980; Gürer & Yilmaz, 2002) (Figs 1.2, 1.3). Authors emphasized that the NW–SE trending basin fills are composed generally of sediments deposited in a continental environment. The marine sediments of the Ören basin are corresponded to marine sequence of the Kale–Tavas basin. The marine beds in the Ören basin wedge out toward the north. The age of these marine rocks has been various assigned to the Aquitanian (Tchihatcheff, 1869), the Aquitanian–Burdigalian (Nebert, 1957), or the Oligocene–Lower Miocene (Erentöz & Öztemur, 1964). Authors are suggested that the N–S trending Ören basin formed slightly later during the Early Miocene time, under an E–W extension, N–S compression. The Ören and Kale–Tavas basins were interconnected (Gürer & Yilmaz, 2002).

Çemen et al. (2003) proposed that the N–dipping main breakaway fault is located on the south side of the Gökova Gulf and extension may have started with a large simple shear zone at depth. A listric normal fault and associated roll–over structure are observed according to the seismic reflection profiles in the Gulf of Gökova. The Ören basin is formed on the hanging wall of the main breakaway. Çemen et al. (2003) suggested that the Yatagan and Kale–Tavas basins are extensional basins located adjacent to the main breakaway. Based on the radiometric age determination, the north–northeast directed extension started in the Late Oligocene. Isostatic adjustment of the simple shear zone must have brought the lower plate rocks to the surface in the Early Miocene when the E–W trending grabens started to take from in a bivergent rolling hinge tectonic (Çemen et al., 2003).

Seyitoglu et al. (2004) studied the complete Tertiary exhumation history of the Menderes massif (western Anatolia). According to authors, the main exhumation of the massif occurred along an originally N–dipping Datça–Kale main breakaway fault that controlled depositions in the Kale and the Gökova basins throughout Oligo–Early Miocene time interval. The high–angle normal faults cut all of the previous structure after the Pliocene time.

Sözbilir (2005) established the Oligo–Miocene extension in the Lycian orogen and author defined the evidence from the Lycian molasse basin, SW Turkey. Besides, the occurrence of different clast types in the sedimentary succession of the Oligo–Miocene molasse and the progressive unroofing history of the Menderes Massif are correlated by Sözbilir (2005). Sözbilir (2002) emphasized that the southeastern fill of the molasse basin is ophiolite–fragment rich which are originated from the Lycian Nappes. The northwestern deposits were derived from the Menderes Massif core complex according to Sözbilir (2002) and Sözbilir (2005). Author suggested that the basin fill sediments of east basin become younger than the sediments of west basin. The basin of between Çardak and Dazkiri locates the east and this basin have a oldest age of molasse sediments (the Early Oligocene=Rupelian). The Kale–Tavas subbasin situates the west and oldest sediments of the subbasin are of the Chattian age. Sözbilir (2005) indicated at the eastern margin of the basin, deposition commenced during the Early Oligocene and shifted to the west over time until the Early Miocene based on palaeontological data. The Denizli subbasin comprised of the molasse sediments (the Early Miocene). This basin is a NE–SW trending extensional basin which is began to from the Menderes Massif. The unconformable, late–orogenic sedimentation of these hinterland areas was coeval with synorogenic deposition in front of the Lycian Nappes in the Kasaba–Kas basin.

In the Ören region (Hüsamlar, Sek village and Ekizköy regions), lost of reports are made by the Mineral Research of Exploration Institute (M.T.A.) (Gelincik 1986, Sun et al., 1987, Ünal 1988; 1990, Yigitel 1981, Sun & Karaca 2000 and Sun et al. 2001). Sun & Karaca (2000) emphasized presence of Akçay and Mugla groups in the Ören region. The Akçay group is widespread between the Mugla and Denizli (Kale–Kurbalik region) and this group deposited during the Late Oligocene and Early Miocene (Hakyemez, 1989). The Akçay group composed of the Karadere, Mortuma and Kerme formations from the lower to top. According to Sun & Karaca (2000) the Kerme formation prevalents in the Ören basin and this formation stratigraphically equivalents to the Yenidere formation which is determined by Hakyemez (1982). Based on the foraminifer, coral and bivalvia fossil which are collected from the Alakilise and Kultak regions, the Kerme formation is Aquitanian age. The Mugla group which includes the Turgut, Sekköy and Yatagan formations unconformably overlies the Kerme formation. Besides this stratigraphic section of the Ören basin are defined by the Ünal (1988 and 1990) and Yigitel (1981).

1.5.2 Palaeontologic Studies

Becker–Platen (1970) described the lithostratigraphy from the Oligocene to Lower Quaternary sediments in the southwestern Anatolia (i.e. Denizli, Mugla–Yatagan and Milas). Author defined the lithostratigraphy of the Alakilise–Gultak (Kultak), Pinar, Kumluca, Kizilca, Sek village, Ekizköy, Hüsamlar and Karacaagaç in the north of the Gökova Gulf used published studies (Nebert, 1956; 1957; Philippson, 1915; 1918, Flügel & Metz, 1954, Tchihatcheff, 1869, Erentöz & Öztemür, 1964).

Tchihatcheff (1869) defined tree facies from the Ören–Alakilise region which are grey limestones with *Pecten* and mollusk, yellowish marl and grey limestones with marine fossils and marl, limestone, sandstones. Author described the mollusk fauna of the marine sediments in the Ören–Alakilise region. The fauna is represented by the *Natica canrena* (Brocc.), *Cardita intermedia* (Brocc.), *Cardium multicostatus* (Brocc), *Lucina ornata* (Ag.), *Lucina subconcentrica* (D'orb.), *Lucina pomum* (Dujard.), *Venus subrudis* (Fisch.), *Fusus*, *Oliva*, *Voluta*, *Pecten*, *Tellina*, *Pecten* aff. *solarium* (*Pecten* ex aff. *Pecten burdigaliensis* (Bast.)). This fauna is interpreted the Burdigalian in age by Tchihatcheff, 1869.

Engelhardt is defined the leaf fossil in the Ören–Alakilise region in Philippson (1915) study. *Sequoia sternbergii* (Göpp.) and *Eucalyptus oceanica* (Ung.) are defined and leaf flora is aged the Oligocene–Miocene in this study.

Oppenheim (1919) defined the gastropod and bivalves faunas from the sandstones in the Gultak (Kultak) and Alakilise regions which correspond to sandstones with *Turitella* in Nebert study. *Ostrea* cf. *digitalina* ((Eichw.) Dub. De Montp.), *Arca philippsoni* (Oppenheim), *Corbula carinata* (Duj.), *Turitella* cf. *crossei* (Da Costa), *Arca* aff. *mytiloides* (Brocchi) and *Turitella* cf. *crossei* (Da Costa) and *Planorbis* sp. *Melania escheri* (Brongt.) are determinate. According to Oppenheim (1919), these faunas indicate the Burdigalian age.

Nebert (1957) studied the biostratigraphy of the marine sediments surround the Ören–Alakilise and Pinar regions. L. Erentöz and K. Turnovsky defined the gastropod and bivalvia faunas in the Nebert's study. *Monodonta* (*Osilinus*) cf. *elegans* (Faujas) "the Tongarien–Aquitanian", *Turitella crossei* (Da Costa) "the Burdigalian–Vindobonian), *Turitella* (*Haustator*) sp. aff. *Turitella* (*Haustator*) *asperulus* (Brong.) "Oligocene", *Turitella* sp., *Terrebralia bidentata* (Defrance) "the Aqutanian–Burdigalian", *Tympanotonus margaritaceus* (Brocchi) "from the Aquitanian to Vindobonian", *Potamides girondicus* (Mayer) "the Aquitanian–Burdigalian", *Cerithium* sp., *Rostellaria dentate* (Grateloup) "the Burdigalian–Vindobonian", *Galeodes lainei* (Basterot) "from the Aquitanian to Vindobonian", *Arca* (*Anadora*) cf. *montensis* (Mayer) var *elongate* (Schaffer) " the Burdigalian), *Arca* sp., *Cardita* sp., *Pirenella plicata* (Bruguiere) "Aquitanian–Burdigalian", *Terrebralia bidentata* (Defrance) var. *percingulata* (Coss. & Peyrot) "from the Aquitanian to Vindobonian", *Venericardiae*, *Lucinidae*, *Pecten* sp., *Natica* and *Conus* from the Alakilise region and *Flabellipecten* sp. (gr. *F. burdigaliensis*) "Burdigalian–Vindobonian" from the Pinar (=Pinarören) region are defined by the Erentöz in the Nebert (1957). Turnovsky described the foraminifer fauna of the limestones in the Alakilise region. This Early Miocene (Burdigalian) fauna is represented by the *Schwammrete*, *Miogypsina irregularis*, *Amphistegina*, ?*Spiroclypeus* sp., *Globigerina* sp., *Sigmailina* sp., *Textularia* sp., *Operculina* sp., *Rotalina beccarii*, *Cytheridae mülleri*, *Cytherella dilatata*, *Cytheria* sp., *Algenreste*, *Quinqueloculina* sp., *Lepidocyclina* sp., *Discorbis* sp., *Otolithen*, *Nonina* ex gr. *bovicenum*, *Cibicides* sp. and *Alles kleinwuchsig* (Nebert, 1957).

Erentöz & Öztemür (1964) defined the bivalvia and foraminifer faunas from the marine sandstones and limestones in the Ören–Alakilise and Pinar (=Pinarören) regions. The bivalvia association composes of *Pecten arculatus*, *Lucina* aff. *globulosa*, *Cardium* (*Ringicardium*) *bukkianum* and *Pholadomya puschi* is aged the Oligocene. Besides, the foraminifer association includes *Nonion tuberculatum*, *Nonion bouéanum*, *Cytheridae mülleri* and *Haplocytheridea* cf. *helvetica* and this association is the Aquitanian in age (Erentöz & Öztemür, 1964). *Aloides* (*Aloides*) *carniatus* and *Ampullina* (*Megatylotus*) *crassatina* var. *bourcarti* are defined from Alakilise region and according to these fossils the marine sediments in the Alakilise region is aged the Aquitanian.

Erentöz defined the macro and microfaunas from the lower layer of sediments in the Alakilise region (Becker–Platen, 1970). The macrofauna is represented by the *Monodonta* (*Osilinus*) *elegans* (Faujas), *Turitella* (*Peyrotis*) *asperulata* (Brongniart), *Turitella beyrichi* (Hofmann) var. *percarinata* (Roth V. Tel.), *Turitella beyrichi* (Hofmann) cf. var. *noda* (Noszky), *Cerithium* (*Gourmyia*) *tuberosum* (Grateloup), *Cerithium* (*Gourmyia*) Becker–Platen (1970), *Pirenella plicata* (Bruguiere), *Terebralia subcorrugata* var. *subinterruptum* (D'orbigny), *Rostellaria* (*Rostellaria*) *dentate* (Grateloup), *Ampullina* (Ampullinopsis) *crassatina* (Lamarck), *Gleodes lainei* (Basterot) and *Galeodes* sp. and this fauna is Oligocene in age. According to the microfauna which is characterized by the *Cytheridea* sp. cf. *peracuminata* (Koilimann) and *Ruggieria* sp., the marine sediments in the Alakilise region is the Miocene in age. Besides the lignite beds between the marine sediments in the Alakilise region are corresponded with the Kurbalik sporomorph association (Benda, 1968). Marine and brackish sediments in the Kiranköy and Çamköy regions (northwestern of the Akbük Bay) are aged Oligocene and Miocene by sporomorphs and macroflora. According to the Becker–Platen (1970), these sediments are correlated with the marine sediments in Alakilise, Gultak (=Kultak) and Kurbalik regions.

Benda (1971a) and Benda & Meulenkamp (1990) studied the palynology of the coal–bearing Neogene sediments in southwest Anatolia, and defined the seven palynological assemblages from bottom to top as Tokça, Kurbalik, Kale, Eskihisar, Yeni Eskihisar, Kizilhisar and Akça assemblages. Benda (1971a) defined the Tokça and Kurbalik sporomorph assemblages which are the Early Oligocene and the Chattian respectively.

Atalay (1980) recognized the two formations which are the Eskihisar and Yatagan formations from the Mugla–Yatagan region. *Anomalomys gatidryi*, *Mastodon* (*Zygolophodon*) *tapiroides* and *Anchitherium* sp. in the Turgut member of the Eskihisar formation from the Yatagan–Turgut, Eskihisar, Hacibayramlar, Kavaklidere, Çamyayla, Milas–Sariçay regions and *Dinotherium giganteum* and *Brachypotherium brachypus* in the Sekköy member of the Eskihisar formation from the Yatagan–Eskihisar, Yenieskihisar and Çatakbagyaka regions are founded. The Turgut member and Sekköy member are aged as the middle Astracian and late Astracian respectively. The Madenler (from the between the Milas–Karaagaç and Ulas regions), Bayir (from the Kemikalan and Karaagaç regions) and Bozarmut (from the Bozarmut region) members of the Yatagan formation are Turolian age according to *Hipparian mediterraneum* and *Gazella gaudryi*.

Benda et al. (1977) correlated the biostratigraphy in the Eastern Mediterranean Neogene basins (Denizli–Kale– Kutuköy and Dogubeyazit regions). Besides, authors determinated the Kurbalik palynomorph association of the Kutuköy/Göksun (Kahramanmaras) and Kale–Denizli regions. Based on the palynomorph and marine microfossils, the Late Oligocene–Early Miocene sediments are aged by Benda et al. (1977).

Gökçen (1982) defined the ostracoda and foraminifers faunas in the sediments from the Yenisehir–Kale region and these faunas indicate the N1 lithological zone (the middle Oligocene).

Hakyemez & Örçen (1982) and Hakyemez (1989) studied the sediments between Mugla and Denizli. Authors determined the age of the formation as the Late Oligocene based on the gastropods from the Mortuma Formation of the Kale–Tavas molasse Basin.

Akgün & Sözbilir (2001) studied the stratigraphy and palynostratigraphy from the Kale–Tavas and Denizli molasse basins in the southwest Anatolia. Deposits of the Kale–Tavas molasse crop out from the Yenidere and Çukurköy regions. The oldest Karadere formation consists of the alluvial fan deposits with coal lenses. This formation take place on the Lycian nappes and it is gradationally overlain by the Mortuma formation which is the Chattian in age based on the spores, pollen, foraminifer, gastropods and bivalvia fossil records. The Mortuma formation is uncornformably overlain by the Yenidere formation which has been dated on the Aquitanian age with respect to its gastropod, pelecypoda and palynomorph contents. These formations are uncorformabaly overlaid by the continental deposits of the Mugla group which was divided into three formations from bottom to top, Sekköy “Late Astracian”, Yatagan “Turolian” and Milet formations “Pliocene” (Akgün & Sözbilir, 2001). The Denizli molasse has been studied in detail by Sözbilir (1997). According to the author, transgressive sequence resting on the pre–Oligocene basement and it is unconformably overlain by the late Miocene sediments and Pliocene Belevi group. The name Acidere formation was applied to this sequence by

Nebert (1961) and Becker–Platen (1970). The basal part of the Acidere formation has been named as the Çaykavustu formation and it is unconformably overlied by the Sagdere formation (Sözbilir, 1997 and Akgün & Sözbilir, 2001). Akgün & Sözbilir (2001) defined two palynological assemblages. The first assemblage is the Late Oligocene and the second assemblage is the Early Miocene in age and it corresponds to Benda's Kurbalik assemblage. According to the authors, the molasse sedimentation in the Kale–Tavas and Denizli molasse basins took place in the Late Oligocene–Early Miocene time interval.

Kaya et al. (2001) studied in the Milas–Kultak region and defined mammalian fauna of the early Middle Miocene (the late Orleanian–early Astracian age = MN5–6 boundary). This fauna occurs at the top of marine to continental succession known to be Aquitanian and Burdigalian in age on the basis of marine faunal evidence (Nebert, 1957). The fauna includes *Anchitherium aurelianense hippoides* (Lartet), *Ancylotherium (Metaschizotherium) fraasi* (Koenigswald), *Tethytragus koehlerae* (Azanza & Morales) and *Gomphotherium* sp. These genera are known in Europe. *Anchitherium* and *Tethytragus* are common constituents of the Middle Miocene faunas of Turkey. *Ancylotherium (Metaschizotherium)* which is known in central Europe was the first recorded in Turkey by Kaya et al., 2001.

Akkiraz & Akgün (2005) defined the palynomorph assemblage of the coal bearing sediments in the Hayrettin and Tokça formations (the Çardak–Tokça basin). Palynofloras composed of 37 genera and 70 species are determinated. According to the *Bohlensipollis hohli*, *Slowakipollis hipophäeoides*, *Aglaoreidia cyclops*, *Dicolpopollis kockelii*, *Compositoipollenites rhizophorus* ssp. *burghasungensis*, *Pentapollenites pentangulus*, *Subtriporopollenites simplex* and *Intratriporopollenites instructus*, the Hayrettin and Tokça formations are aged the Early Oligocene (the Stamphian). Besides, the Armutalani, Çardak, Hayrettin, Tokça and Bozdag formations are deposited during the early Oligocene aged by Akkiraz & Akgün (2005).

According to Islamoglu et al. (2006), the Oligocene sediments in the “Acigöl” molasse basin start transgressive pebblestone–sandstone alternation (the Armutalani formation) and continue with shelf sediments forming by mudstone–sandstone (the Çardak formation). These sediments continue with reefal limestones and shallow marine to lagoonar–terrestrial facies become dominant in the Hayrettin formation. The upper parts of Oligocene deposits consist of shallow marine reefal and coal bearing terrestrial deposits (the Tokça formation). Besides, authors studied in the sediments with marine fossils in the “Denizli” basin. In this basin, while the coarse terrestrial sediments are called as the Karadere or Çaykavustu formation, the lagoonar–deltaic and shallow marine sediments are named the Bayiralan or Sagdere formation. Contemporaneous units having similar facies and stratigraphy in the “Kale–Tavas” basin are called as Karadere and Mortuma formations (Hakyemez, 1989 and Islamoglu et al., 2006). Based on the large benthonic foraminifers and nannoplanktons the Çardak formation is assigned as the middle–late Rupelian. In the Hayrettin formation shallow marine mollusca and large benthic faunas indicated the late Rupelian–early Chattian age. The Bayiralan formation in the Denizli basin and the Mortuma formation in the Kale–Tavas basin are middle Rupelian–early Chattian age based on the benthic foraminifers and coral fossils (Islamoglu et al., 2006). According to presence of the large benthic foraminifers, gastropod and coral fossils the age of the Tokça formation is assigned as early and late Chattian age. Besides, author emphasized that these basins have to be evaluated within the Mediterranean–Iranian province in the western Tethyan region.

Islamoglu (2008) defined the biostratigraphy of the Kale–Tavas subbasin. Author suggested the Sagdere and Mortuma formations as the late Rupelian–early Chattian age based on the benthic foraminiferal species. Besides, the late Rupelian–early Chattian mollusca fauna of the region displays strong similarities and could be correlated to the assemblage from the Mediterranean–Iranian province.

Islamoglu & Gedik (in press) interpreted the biostratigraphy, lithostratigraphy and palaeoecology of the Oligocene Denizli, Kale–Tavas and Çardak–Dazkiri (Acigöl) molasse basins in the southwestern, southeastern and north areas. According to the litho– and biostratigraphic data the ten sections divided into three different localities in the basin as six sections from the SW area, two from the SE area and two from the north area. During the Middle–Late Rupelian, the sediments of SE area represent shallow–deeper marine environments. During the late Middle Rupelian to Rupelian–Chattian transition, the sediments of SE area indicate both shallow marine, terrestrial and lagoonar elements. The sediments corresponds to Early–early Late Chattian are exposed to only NE part of the basin. Besides, authors defined four main transgression/regression cycles in these basins.

Sahbaz & Görmüs (1992) examined the stratigraphic and sedimentological properties of the conglomerates which are crop out in the Çardak–Tokça region. Authors recognized three different types of conglomerates belonging to the Eocene, Lower Oligocene and Oligocene age, respectively

CHAPTER TWO
STRATIGRAPHY

Tertiary rocks in the Ören region, the southernmost part of the Menderes Massif and the westernmost part of the Lycian Nappes crop out. Tertiary sediments overlaid the Lycian Nappes in the Milas–Ören region (Figs. 1.1 a, 2.1, 2.3, 2.4).

Stratigraphic sequence of the Ören region is defined in this chapter. Besides detail stratigraphic properties of this sequence in the Ören region during the geological time intervals which are the Rupelian, Chattian–Aquitanian, Burdigalian–Langhian and Serravallian are given in the related the chapters of this study (Fig. 2.2, 2.5).

2.1 The Milas–Ören Area

The Milas–Ören area is located in the north of the Gökova Gulf where there is large Tertiary outcrops (Fig. 1.1). Coal bearing Oligocene and Miocene sediments have been examined the scope of this thesis. According to Görür et al. (1995), between the Akbük and Akyaka regions, the earliest sedimentary fill composed of the two facies. The first facies represented reefal limestones which are named as the Çambeleni formation. These limestones includes the benthic foraminifers which were aged the Aquitanian-Burdigalian from Akbük, Alakilise and Çambeleni (near the Akyaka) regions. Besides, marine clastics widespread in Çambeleni, Akyaka regions and these clastics are named the Akyaka formation in these regions by Görür et al. (1995). The other detail study between the Ören–Akyaka regions is that Gürer & Yilmaz (2002) and authors are studied same regions with the Görür et al. (1995). The Akbük limestones which could be correspond to the Çambeleni formation are aged the Late Oligocene by Gürer & Yilmaz (2002). At the same time, the Gökçeören formation is deposited during the Late Oligocene according to the Gürer & Yilmaz (2002) and this formation is lateral and vertical transitional contacts with the overlying the Akbük limestone. For this reason the Gökçeören formation could be equaled the Akyaka formation which is represented by the coarse conglomerates and sandstones in the Akyaka and Akbük regions (Figs 2.1, 2.2).

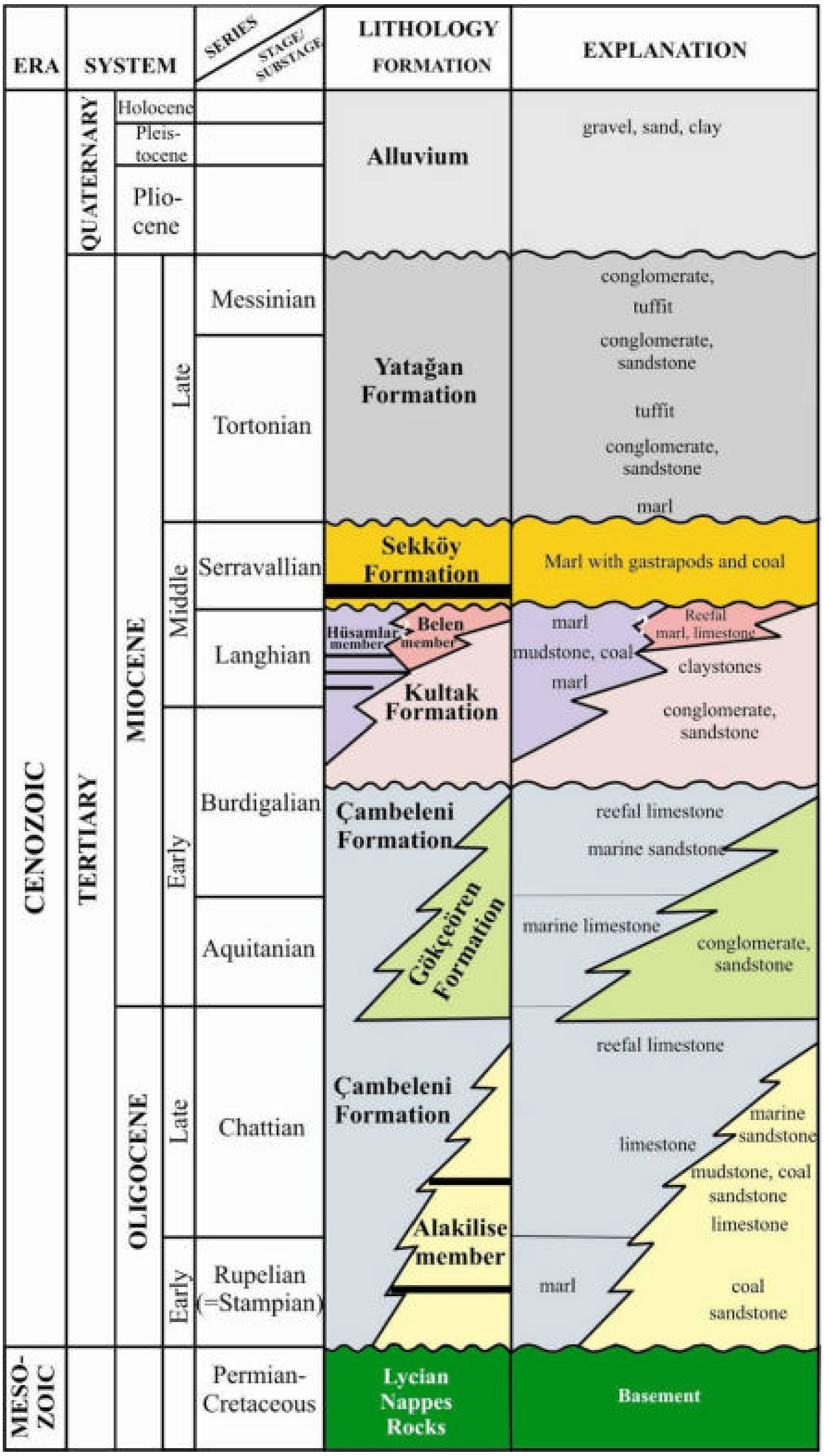


Figure 2.1 Generalized lithosratigraphic columnar section of the Ören region illustrating facies changes.

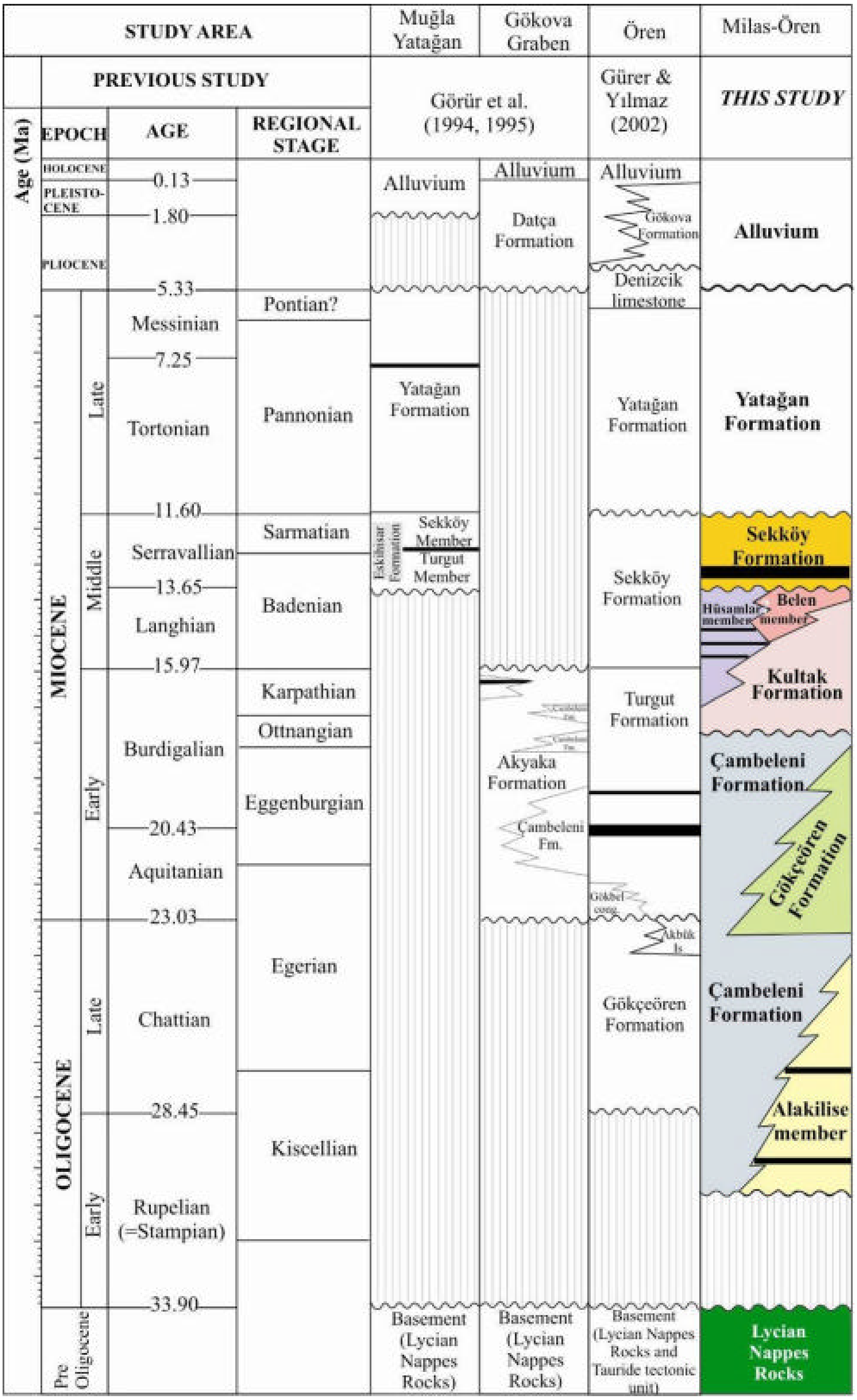


Figure 2.2 Generalized lithosratigraphic columnar sections of this study and correlation with the lithostratigraphy of Görür et al. (1994, 1995) and Gürer & Yilmaz (2002).

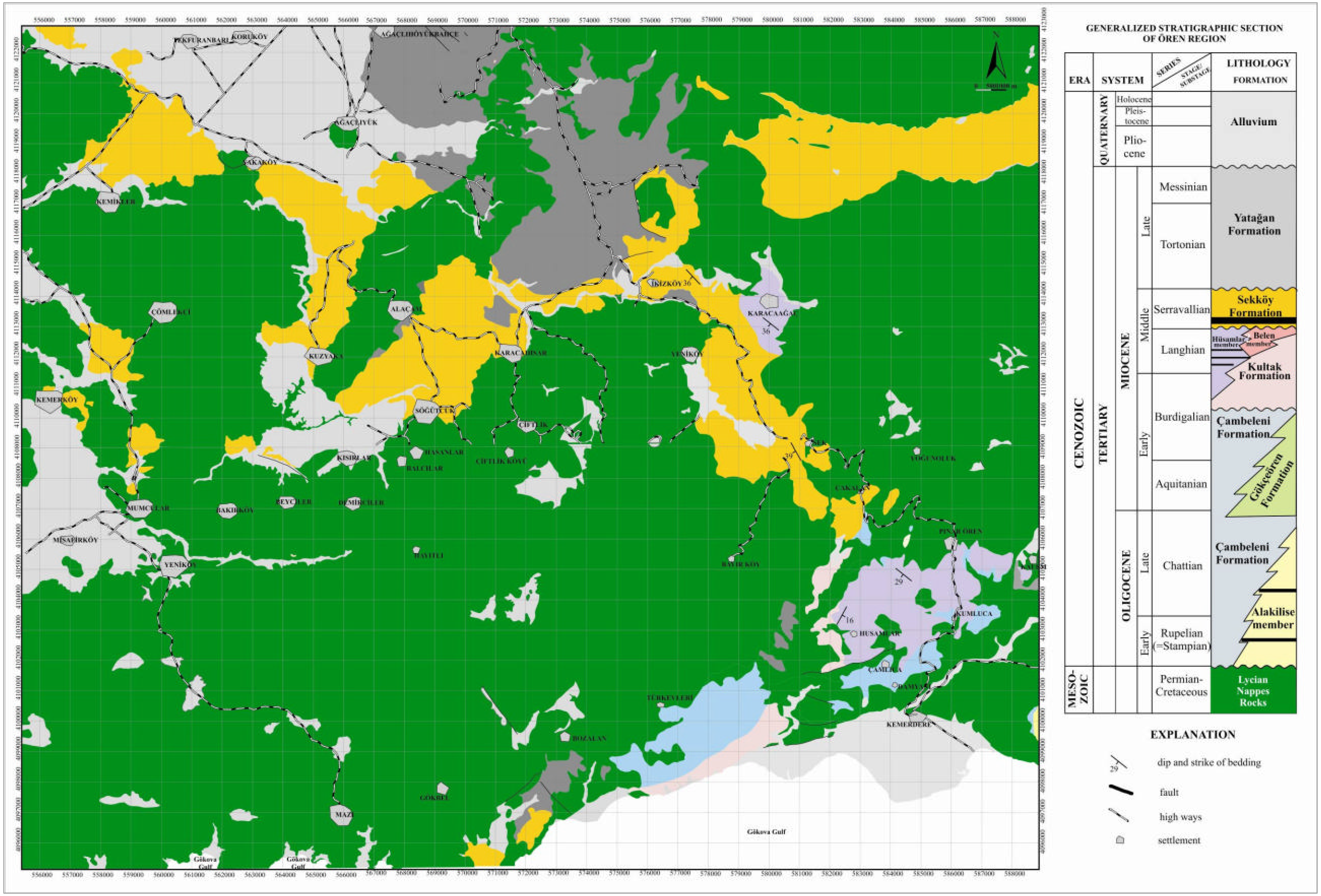


Figure 2.3 Geological map of the Ören region.

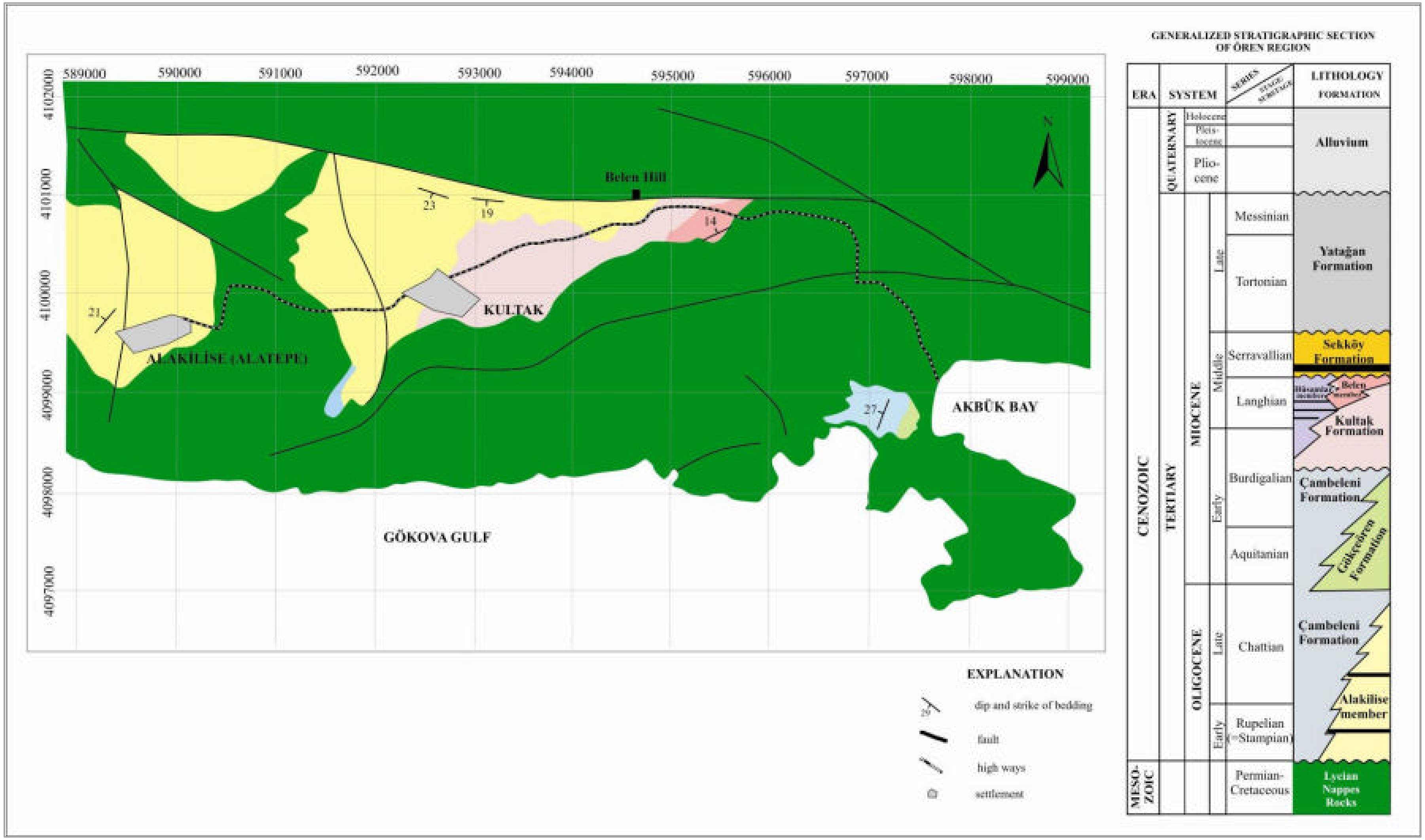


Figure 2.4 Geological map of the Alakilise, Kultak and Akbük regions.

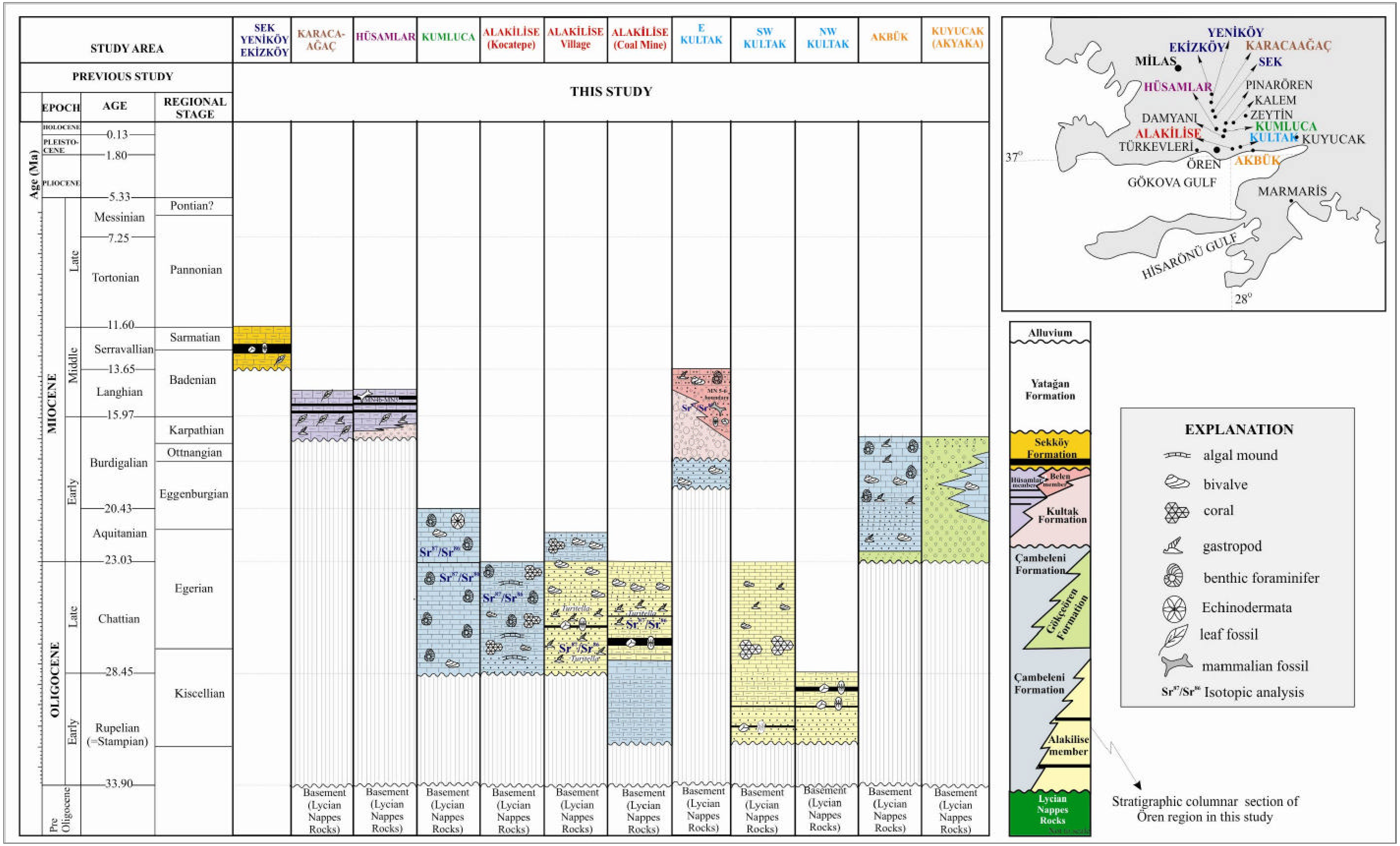


Figure 2.5 Measured stratigraphic sections of Ören region.

Take into consideration stratigraphic records of previous studies and stratigraphic, biostratigraphic data obtained in this thesis, below results are obtained. The marine sediments deposited during the Aquitanian and Burdigalian time interval form Alakilise, Kumluca, Akbük and Akyaka regions (the Çambeleni formation) overlies the conformably marine sediments which are observed during the Rupelian and Chattian time interval in the Ören region. For this reason, deposition age of the Çambeleni formation has been started as of the Oligocene age. In addition, the coarse conglomerates are observed in the Akbük and Akyaka regions and these sediments are named the Gökçeören formation in this thesis as the Gürer & Yilmaz (2002). Besides, coals bearing deltaic sediments are observed during the Rupelian–Chattian period and these sediments are named Alakilise member in this study. The Burdigalian and Langhian time interval in the Ören region is represented by marine and terrestrial sedimentary facies and these facies are firstly examined. Therefore Kultak formation is defined and this formation is lateral and vertical transitional contacts with the overlying the Hüsamlar and Belen members which are represented terrestrial and marine sediments respectively. Sekköy and Yatagan formations composing the terrestrial sediments are deposited during the late Middle Miocene and Late Miocene period as in the Mugla–Yatagan region (Atalay, 1980).

2.1.1 Revised Stratigraphy in the Milas–Ören Region

In the Akbük region, the pre–Oligocene basement consists of the Lycian Nappes is represented by red, claret red, purple, gray, green phyllites, metasandstones, metaconglomerates and limestones (Figs. 2.6–2.13). The Oligocene sedimentary fill of the Milas–Ören region can be divided into two periods (the Rupelian and Chattian) and during these periods marine condition is observed based on the palaeontological and sedimentological data. The Miocene sedimentary fill of this region composed of the marine Early Miocene and early Middle Miocene periods and terrestrial the late Early and Middle Miocene periods.

Figure 2.6 Picture indicating the Mesozoic limestones of the Lycian Nappes in the Kocatepe region (Alakilise village).

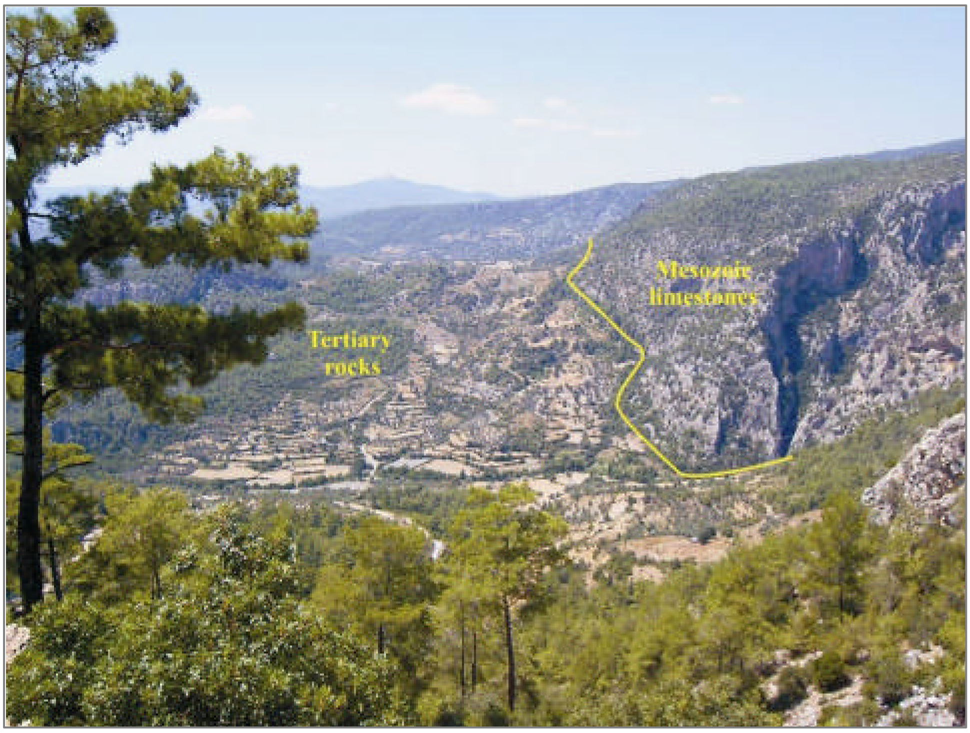


Figure 2.7 Picture showing of contact relationships between the Tertiary rock and Mesozoic limestones of the Lycian Nappes from Kalem to Kumluca village.

Figure 2.8 Picture showing the Mesozoic limestones of the Lycian Nappes from the north of the Ören.

Figure 2.9 Mesozoic limestones of the Lycian Nappes north of the Ören region.

Figure 2.10 These pictures showing of the Mesozoic limestone of the Lycian Nappes in the Ören region.

Figure 2.11 These pictures showing of the recrystallized, red, purple, bluish–gray shale, sandstone, conglomerate with quartz pebbles, quartzite of the Lycian Nappes (the Karaova Formation).

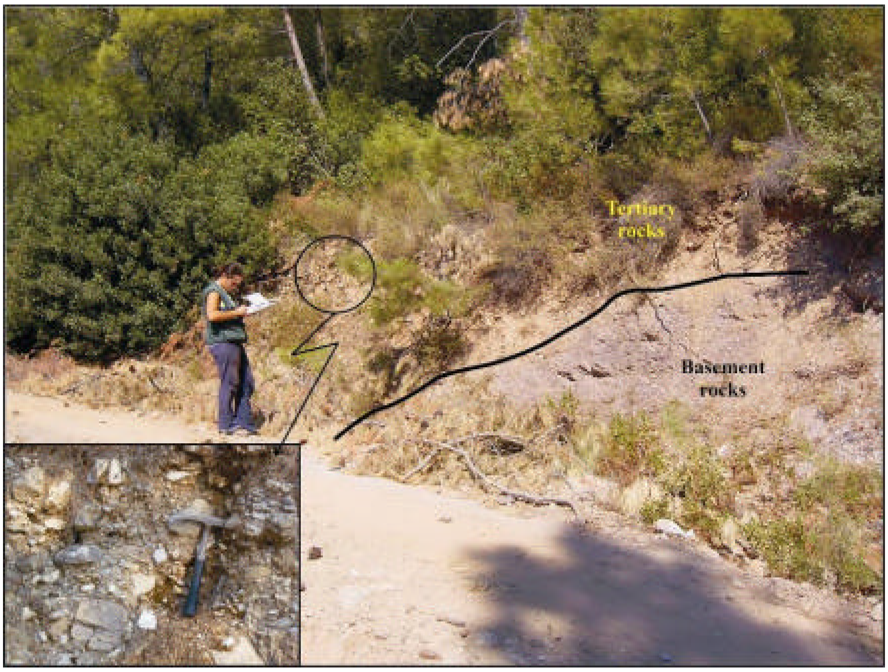


Figure 2.12 This picture showing of the purple, bluish–gray shale, sandstone and conglomerate of the Lycian Nappes in Çatak and Hüsamlar villages (the Karaova formation) and contact relationships between the Tertiary and basement rocks.

Figure 2.13 Picture showing of red and purple shales north of the Ören region.

The base of the stratigraphy in the Ören region is marked by limestones, marl in the Rupelian Çambeleni formation which is lateral and vertical transitional contacts with Alakilise member composing of sandstones, mudstones alternation and coal (see Chapter four). Deposition of the Çambeleni formation and Alakilise member continues during the Chattian period. The sediments of the Çambeleni formation are made of reefal limestones with foraminifers. The Alakilise member is represented by sandstones with gastropod and bivalvia fossils and including several lenses of lignite during the Chattian (in the SW Kultak and Kumluca regions) (see Chapter five). The Chattian–Aquitanian transition is conformably (Kumluca region). The Aquitanian and early–middle Burdigalian sediments consist mainly of the sandstones with bivalvias, gastropods and reefal carbonates with coral, foraminifers, gastropods, bivalvias in the Akbük, Akyaka–Kuyucak regions (the Çambeleni formation) (see Chapter six). The Çambeleni formation is vertical and lateral transitional contact with Gökçeören formation including coarse conglomerates in the Akbük, Akyaka–Kuyucak regions. During the middle Burdigalian and Langhian, the unconformably overlaying Kultak formation is characterized by coarse conglomerates with mammalian fossils and sandstones alternation. This formation laterally and vertically passes the Belen member which is represented marine claystones, sandstones and limestones with gastropod, bivalvia and coral (in the Kultak region). Besides the Kultak formation is lateral and vertical transitional contact with the Hüsamlar member which composes of marl and coal alternation with mammalian and leaf fossils (in the Hüsamlar and Karacaagaç regions) (see Chapters seven–nine). The Hüsamlar and Belen members are unconformably overlain by continental deposits of the Mugla group, dated as the late Astracian (Middle Miocene; the Sekköy formation) to Turolian (Late Miocene; the Yatagan formation) by Atalay (1980) (see Chapter ten).

2.1.1.1 The Çambeleni Formation

This formation was defined from the Akbük and Akyaka regions by Görür et al. (1994; 1995).

2.1.1.1.1 Lithology

The lower part of Çambeleni formation which is deposited during the Rupelian time composes of the parallel laminated yellow, gray marls and is nearly 50m thick. The marl deposit contains plant detritus and pyrites nodules (Figs. 2.14, 2.15).

Figure 2.14 Picture showing the marl of the Çambeleni formation (the Rupelian age) and sandstones of the Alakilise member from Alakilise coal mine.

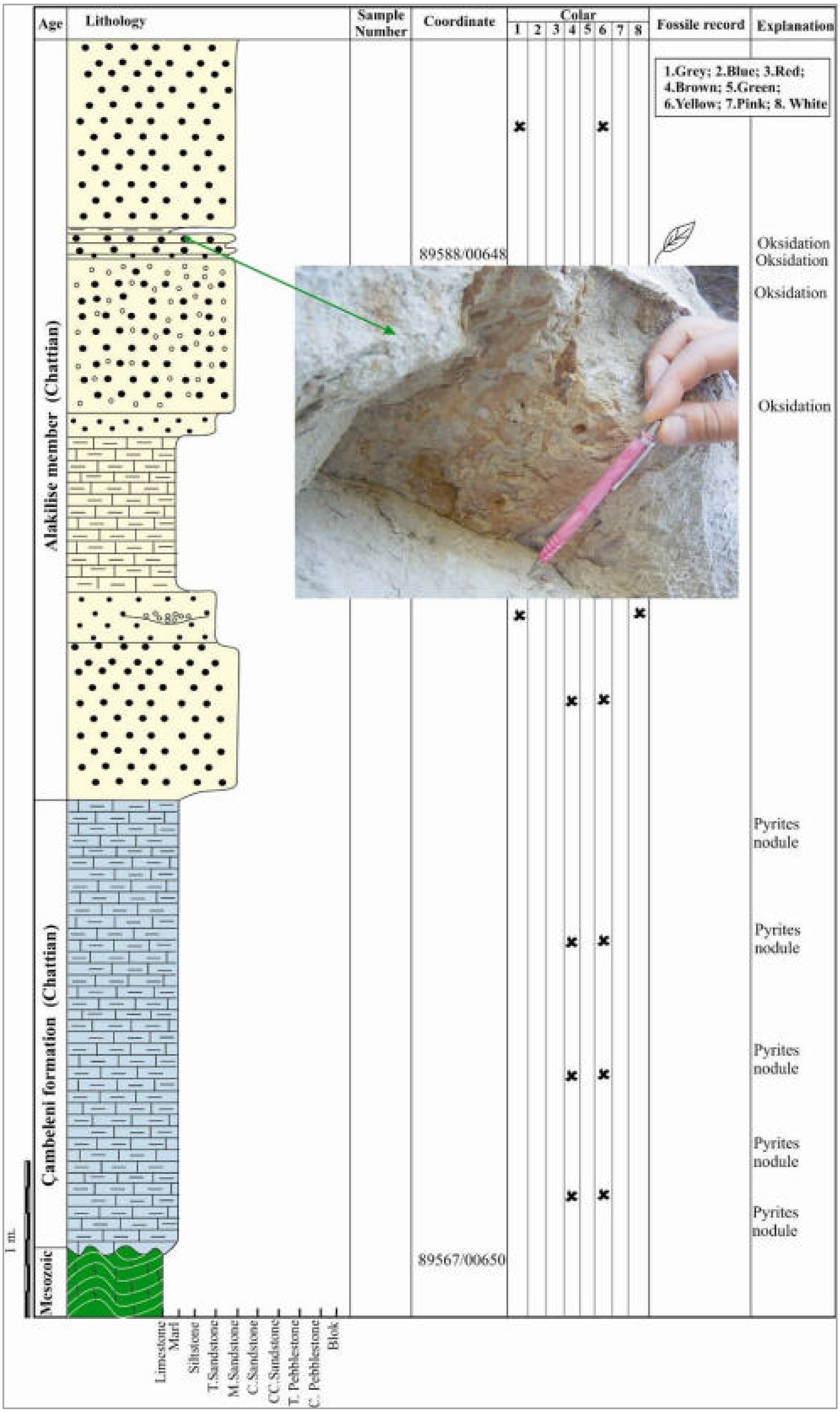


Figure 2.15 Measured stratigraphic section in the Alakilise coal mine from Ören-Alakilise region.

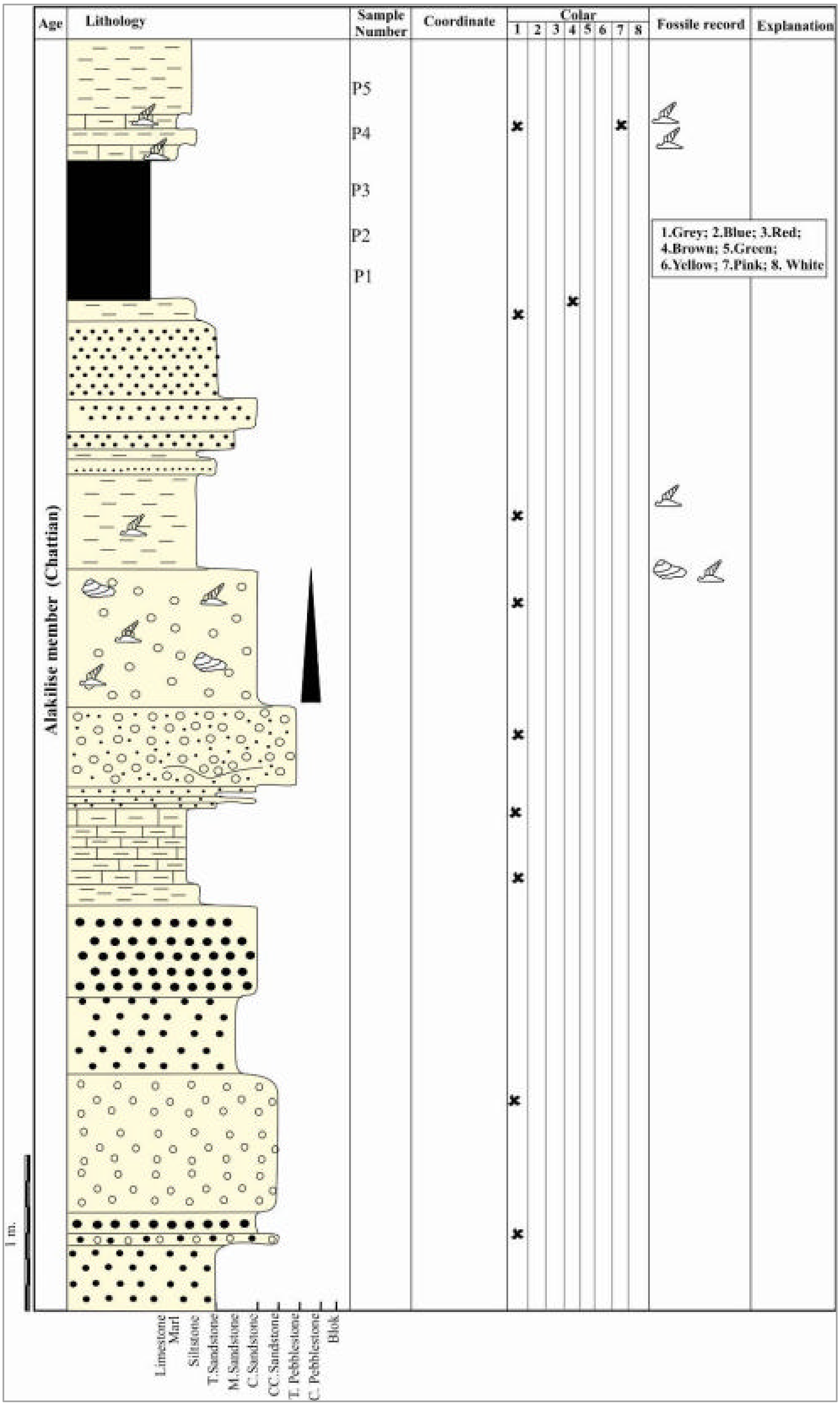


Figure 2.15 Alakilise coal mine section-continued.

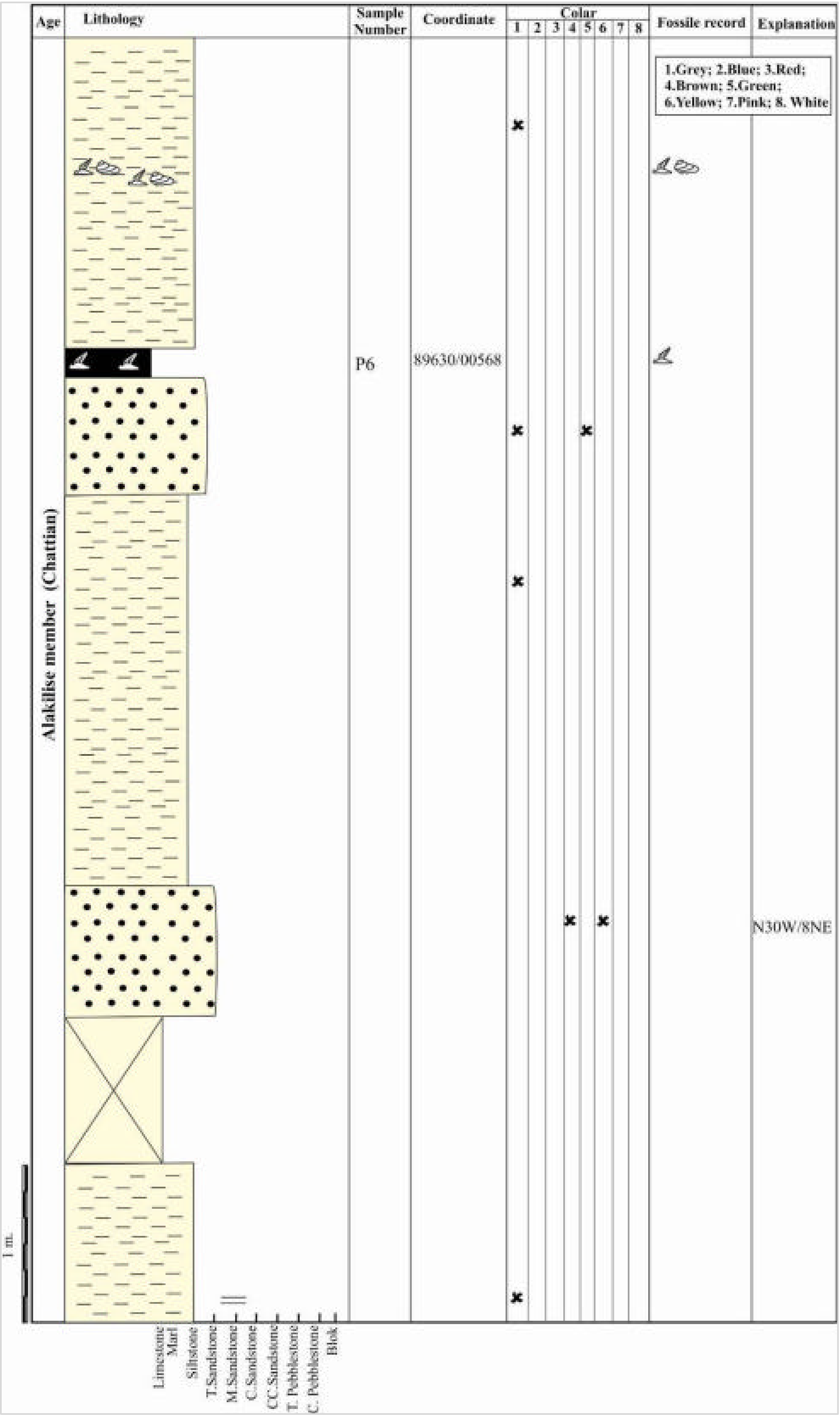


Figure 2.15 Alakilise coal mine section-continued.

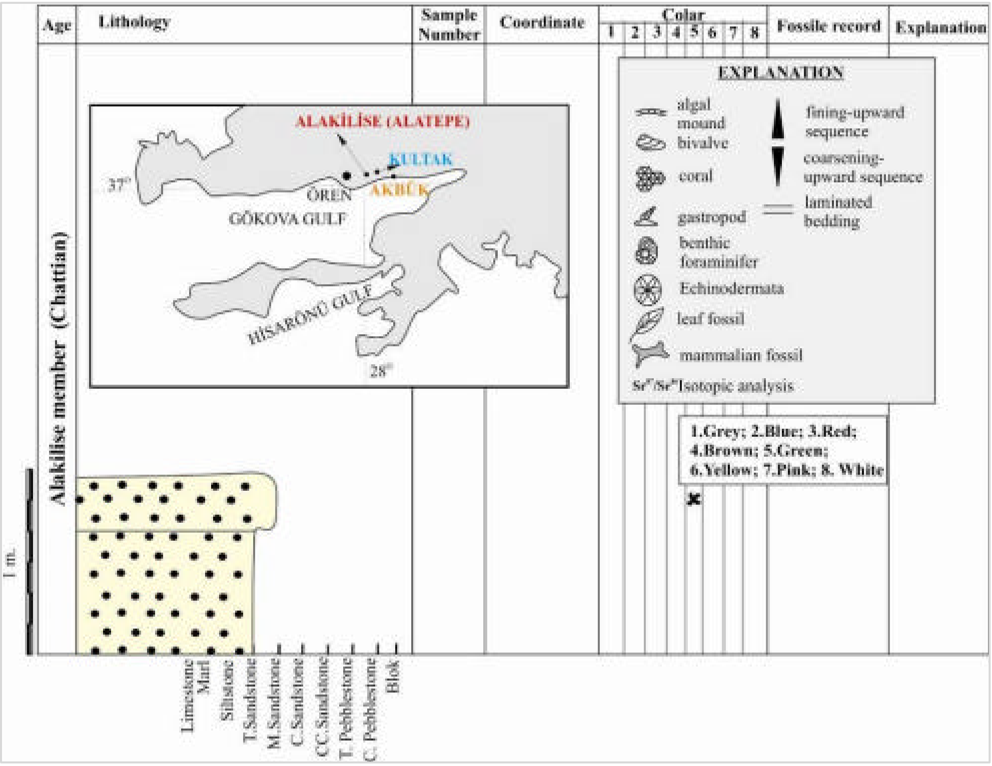


Figure 2.15 Alakilise coal mine section-continued.

During the Chattian-middle Burdigalian time interval, the Çambeleni formation is consist of the light yellow and gray limestone with bivalves, gastropods, foraminifers, coral and echinoderms. It is 50-70m thick (Figs. 2.16, 2.24). This formation is recorded in the Ören-Kumluca, Alakilise, Çamlica, Kocatepe, Kultak, Zetin, Türkevleri and Pinar regions.

2.1.1.1.2 Contact

The Lycian nappes are unconformably overlaid by the Çambeleni formation in the study area. During the middle Rupelian-Chattian this formation is lateral and vertical transitional contacts with the Alakilise member. During the late Chattian-middle Burdigalian, the Çambeleni formation is laterally and vertically passed the Gökçeören formation. The Kultak formation overlaid unconformably the Çambeleni formation.

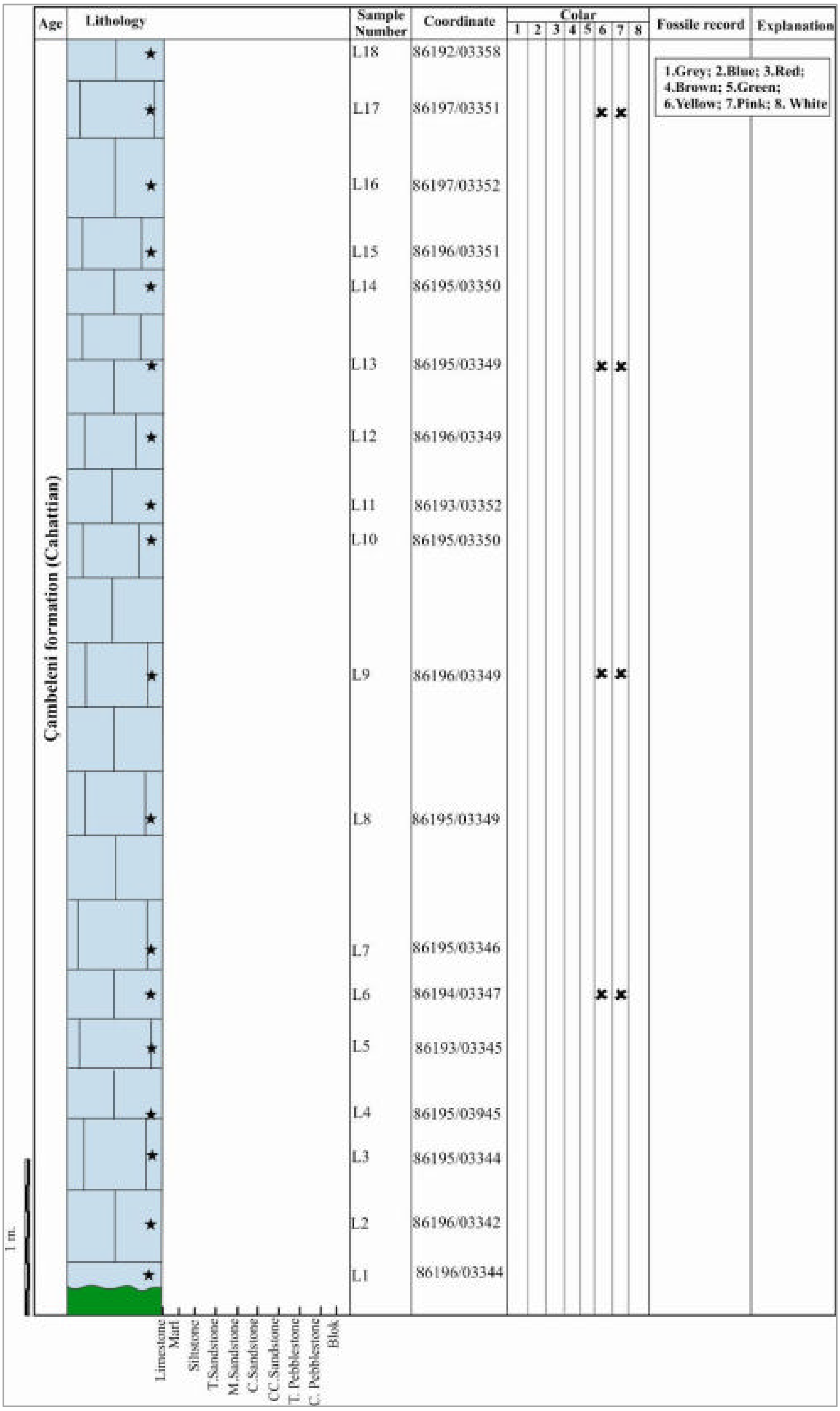


Figure 2.16 Measured stratigraphic section in the Ören-Kumluca region.

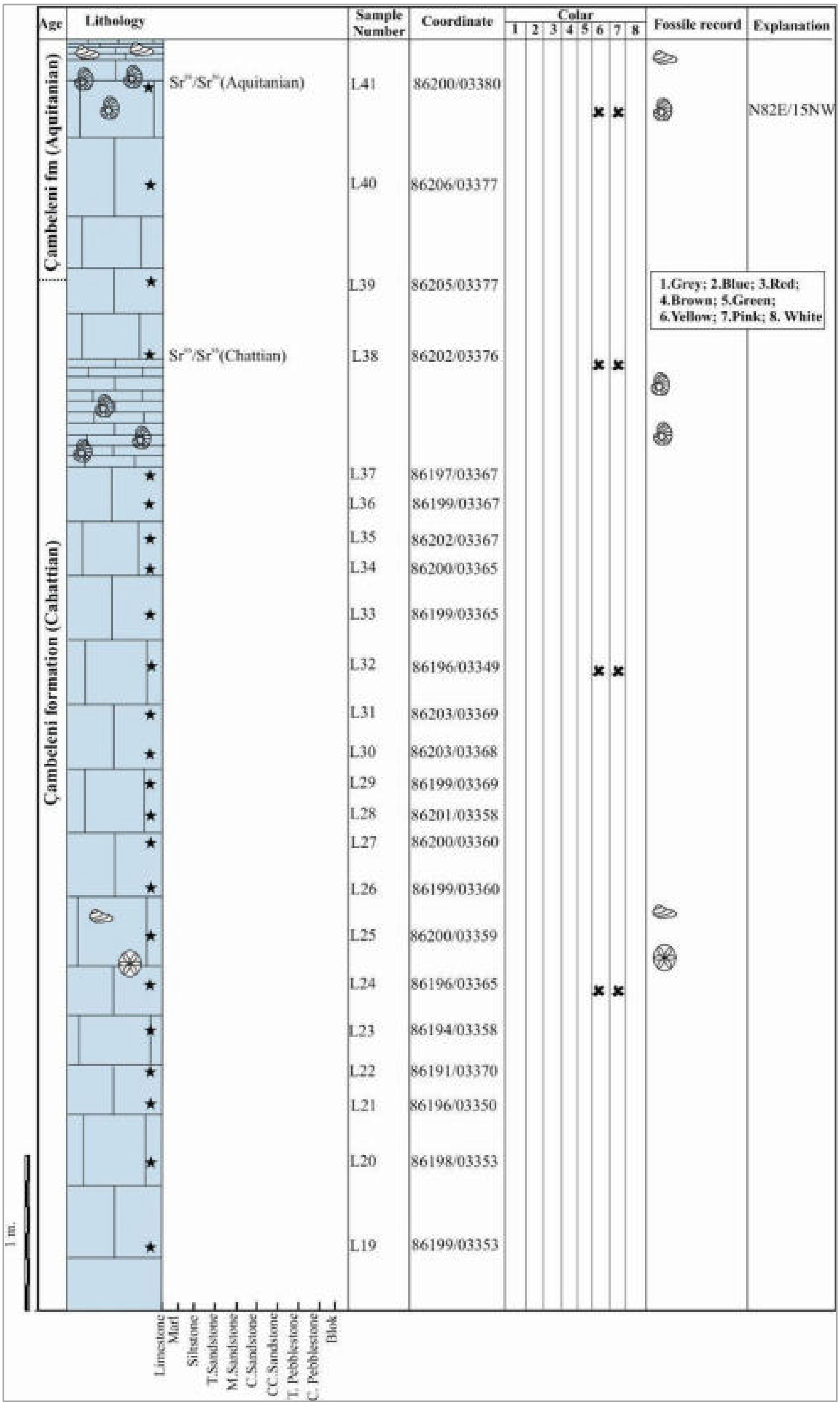


Figure 2.16 Ören-Kumluca section-continued.

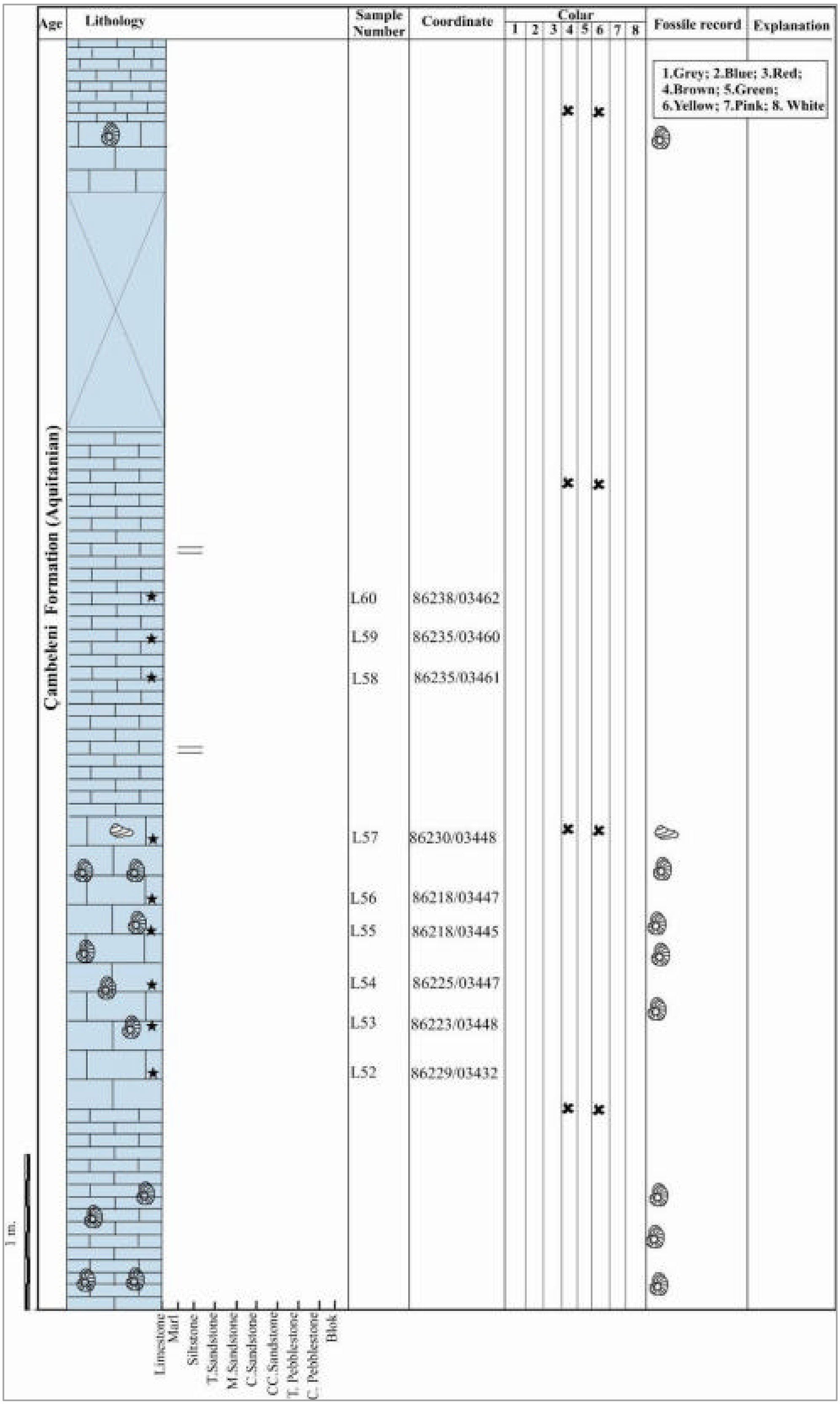


Figure 2.16 Ören-Kumluca section-continued.

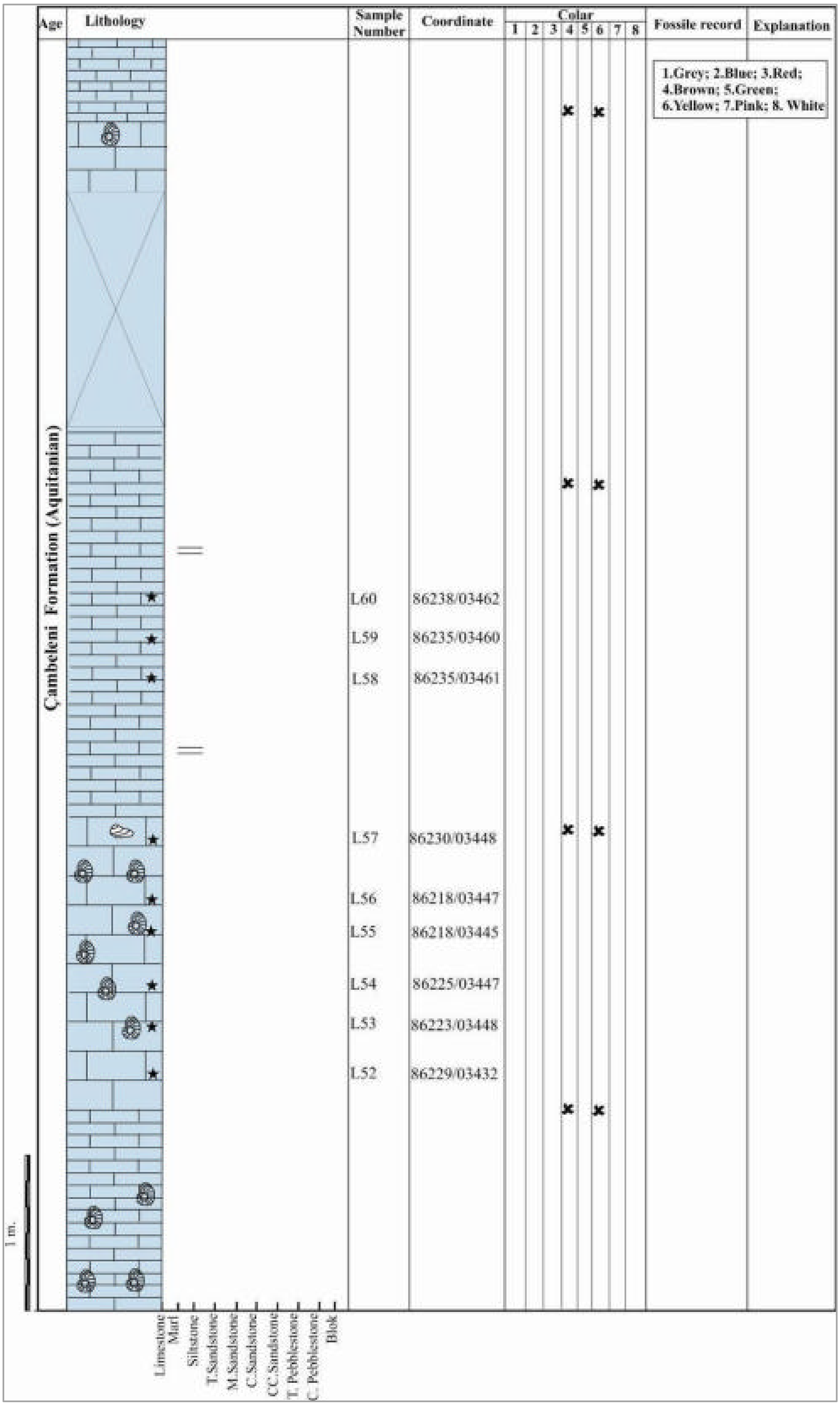


Figure 2.16 Ören-Kumluca section-continued.

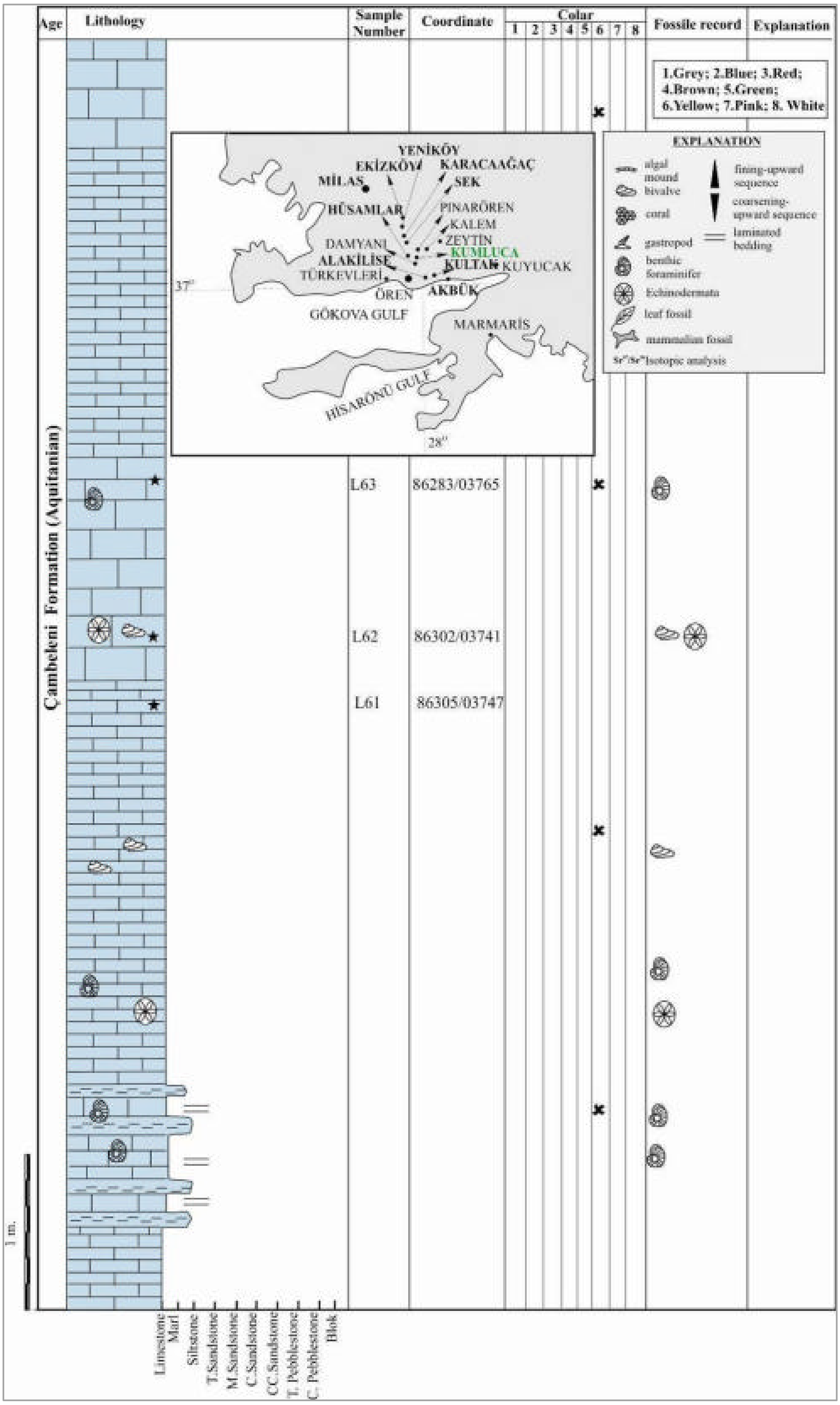


Figure 2.16 Ören-Kumluca section-continued.

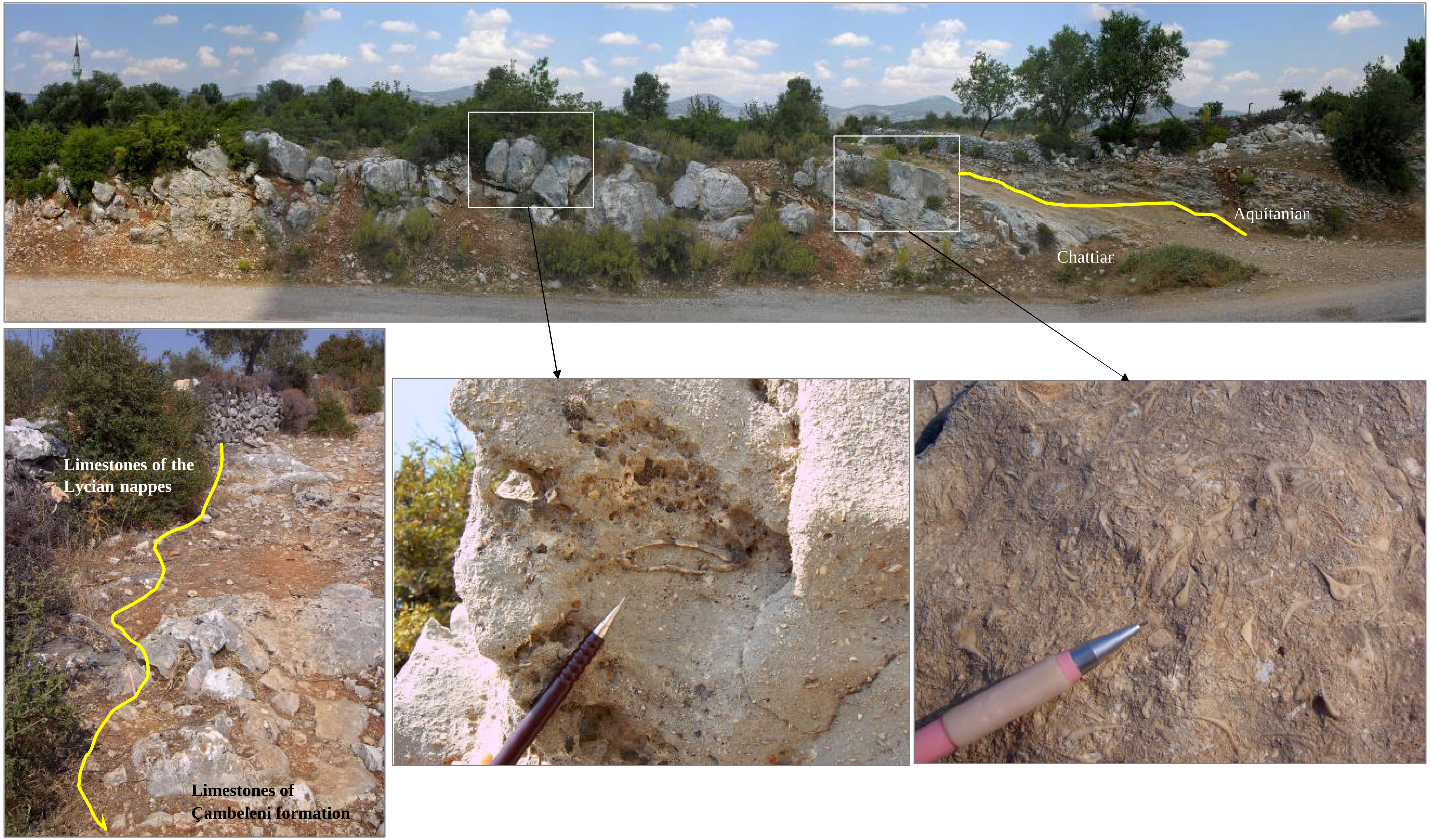


Figure 2.17 Limestones of the Chattian and Aquitanian ages in the Çambeleni formation from the Kumluca region.

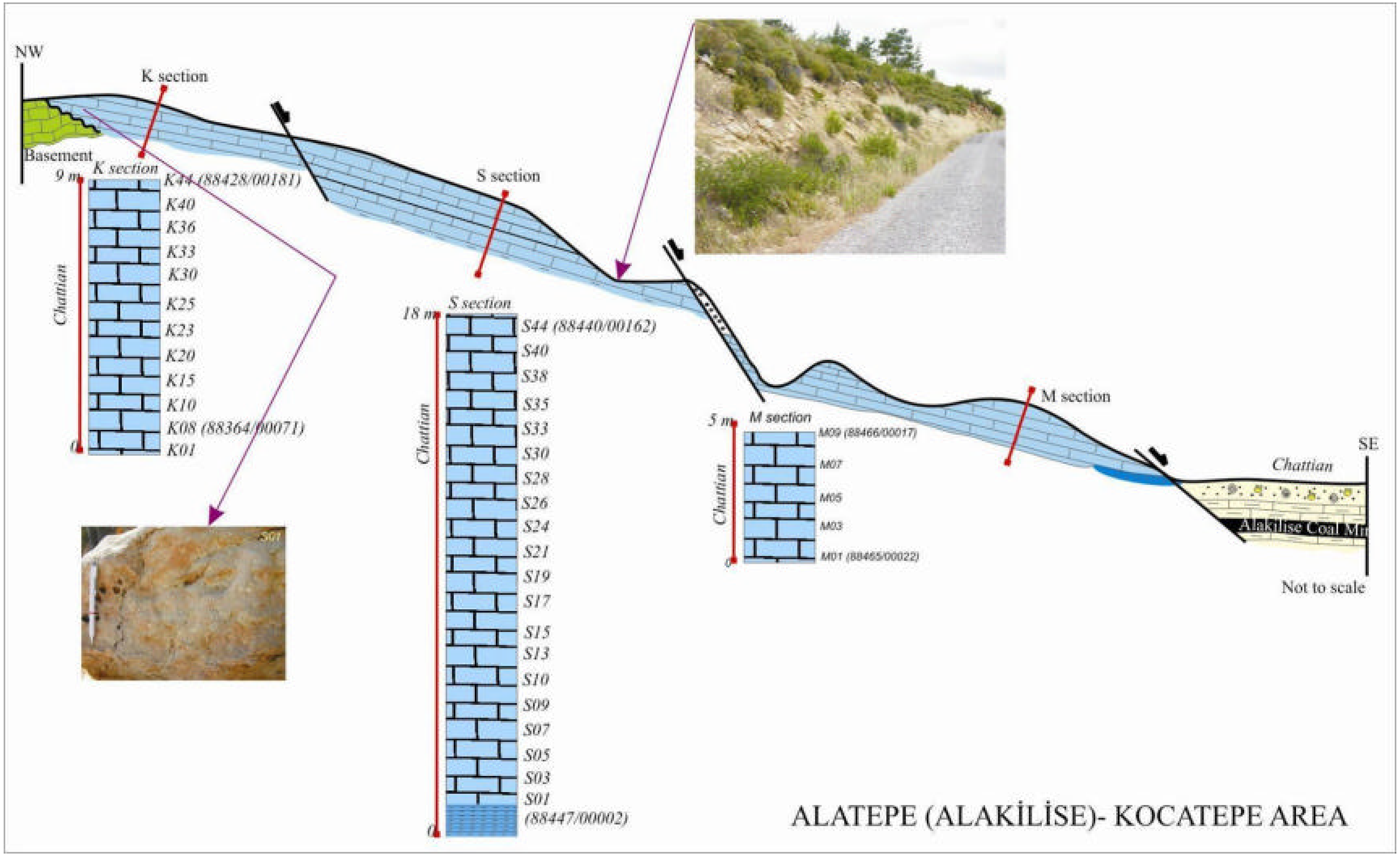


Figure 2.18 Limestones of the Chattian age in the Çambeleni formation from the Kocatepe-Alakilise region.

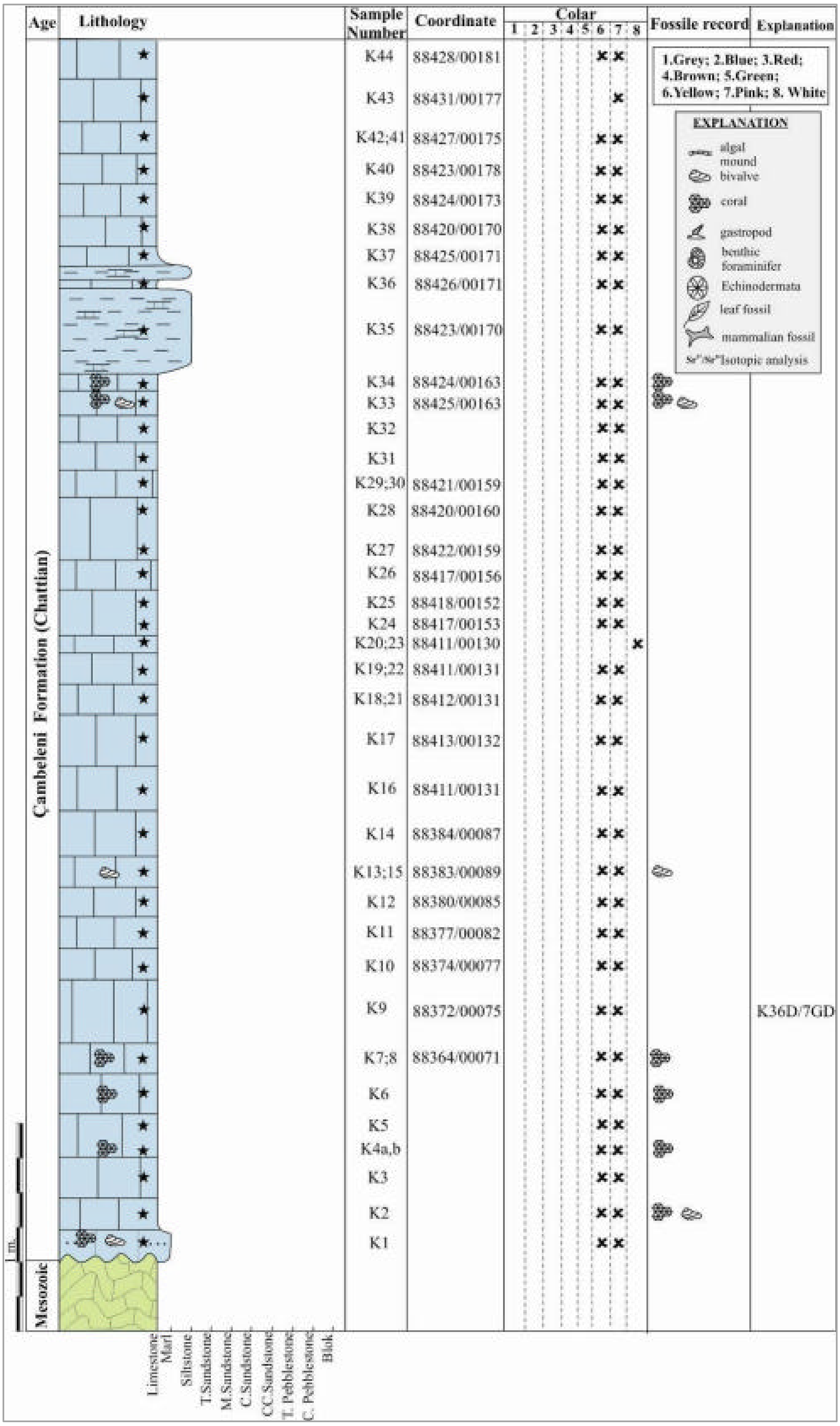


Figure 2.19 Limestones of the Chattian age in the Çambeleni formation from the Kocatepe-Alakilise region (K-section).

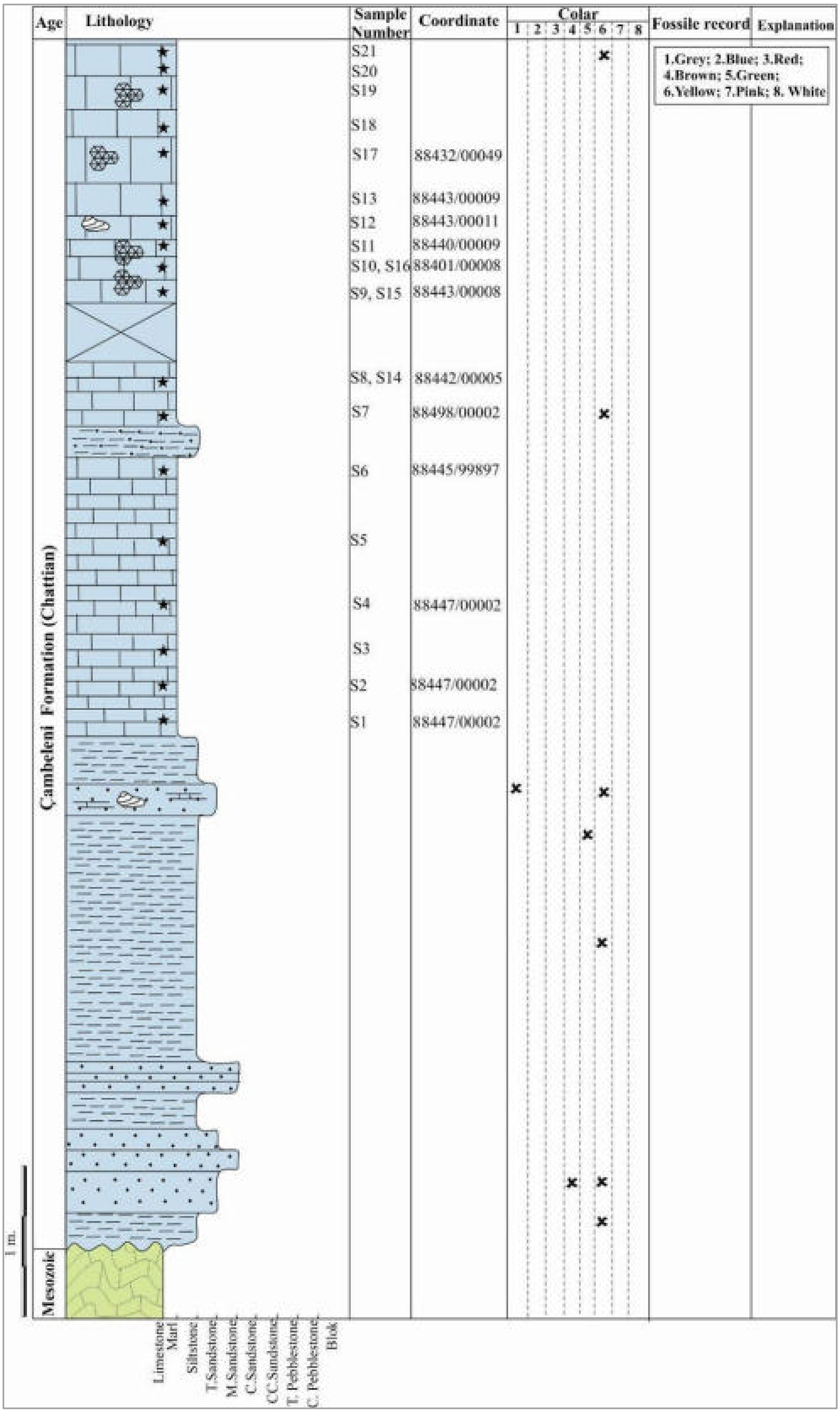


Figure 2.20 Limestones of the Chattian age in the Çambeleni formation from the Kocatepe-Alakilise region (S-section).

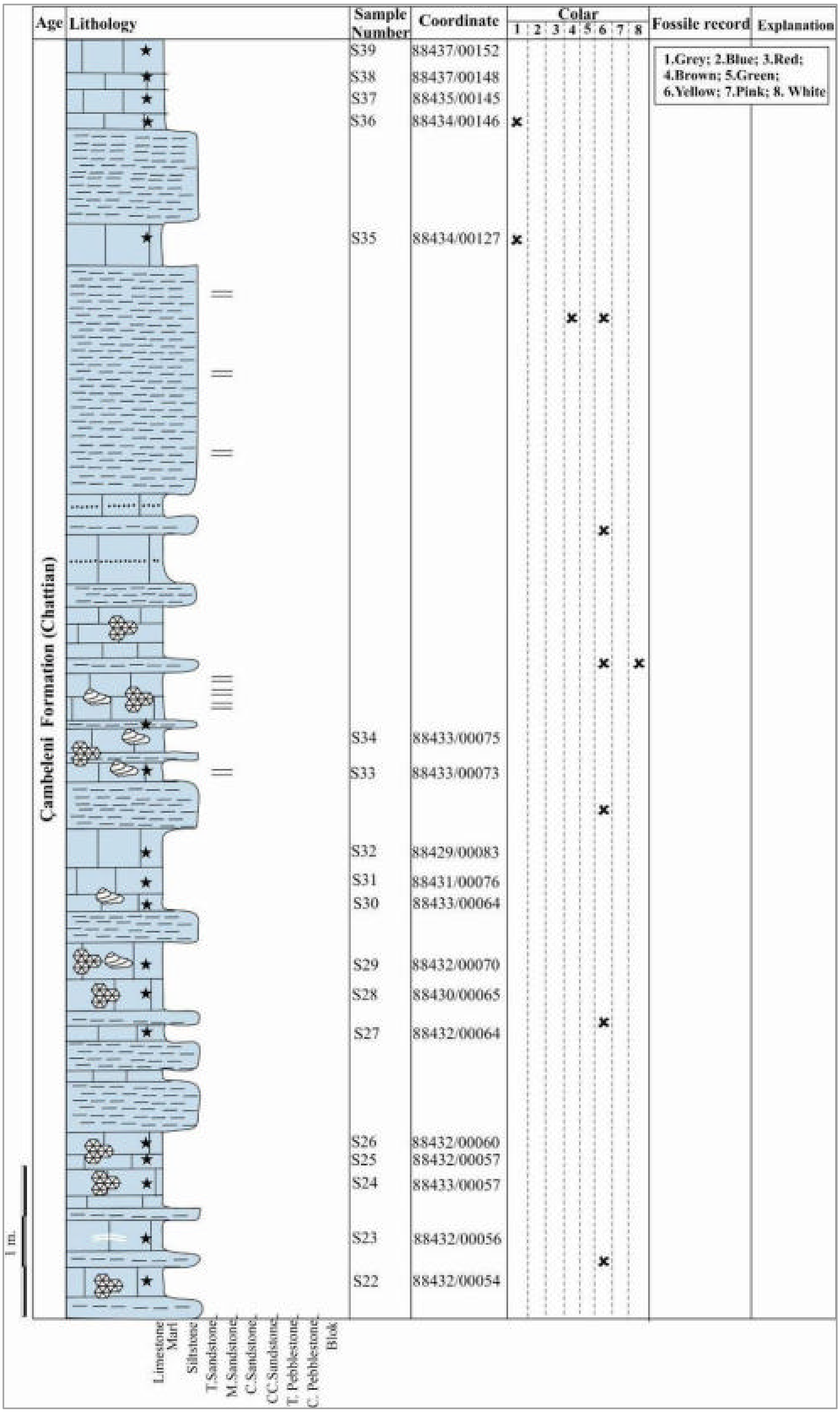


Figure 2.20 S-section-continued.

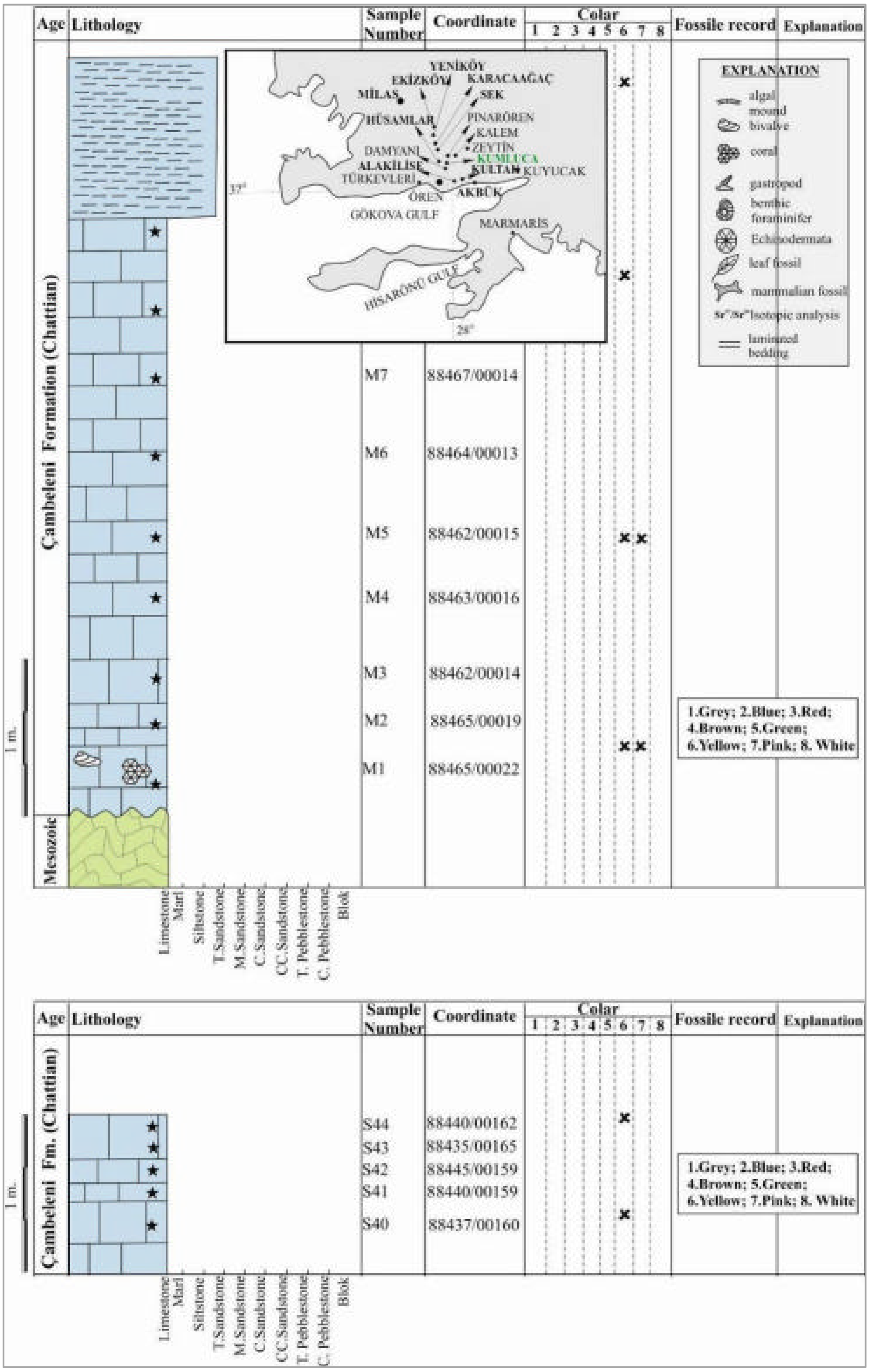


Figure 2.20 S-section-continued and M-section of the Çambeleni formation from the Kocatepe-Alakilise region

Figure 2.21 Pictures show limestone and marl of the Chattian age in the Çambeleni formation from the Alakilise-Kocatepe region (K, S and M sections).

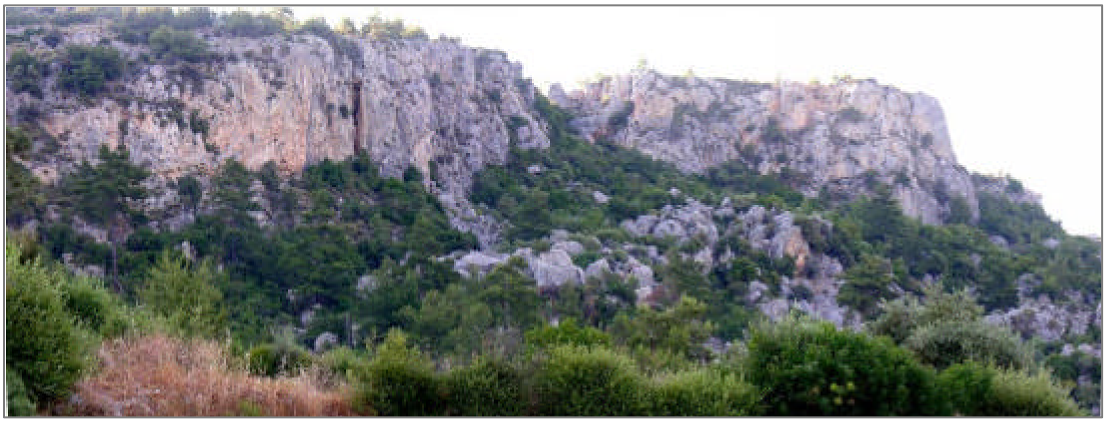


Figure 2.22 The Çambeleni formation from the Ören-Zeytin region.

Figure 2.23 The Çambeleni formation from the Ören-Pinar region.

Figure 2.24 The Çambeleni formation from the Ören-Türkevleri region.

Figure 2.24 Pictures show limestone and marl of the Chattian age in the Çambeleni formation from the Ören-Çamlica region.

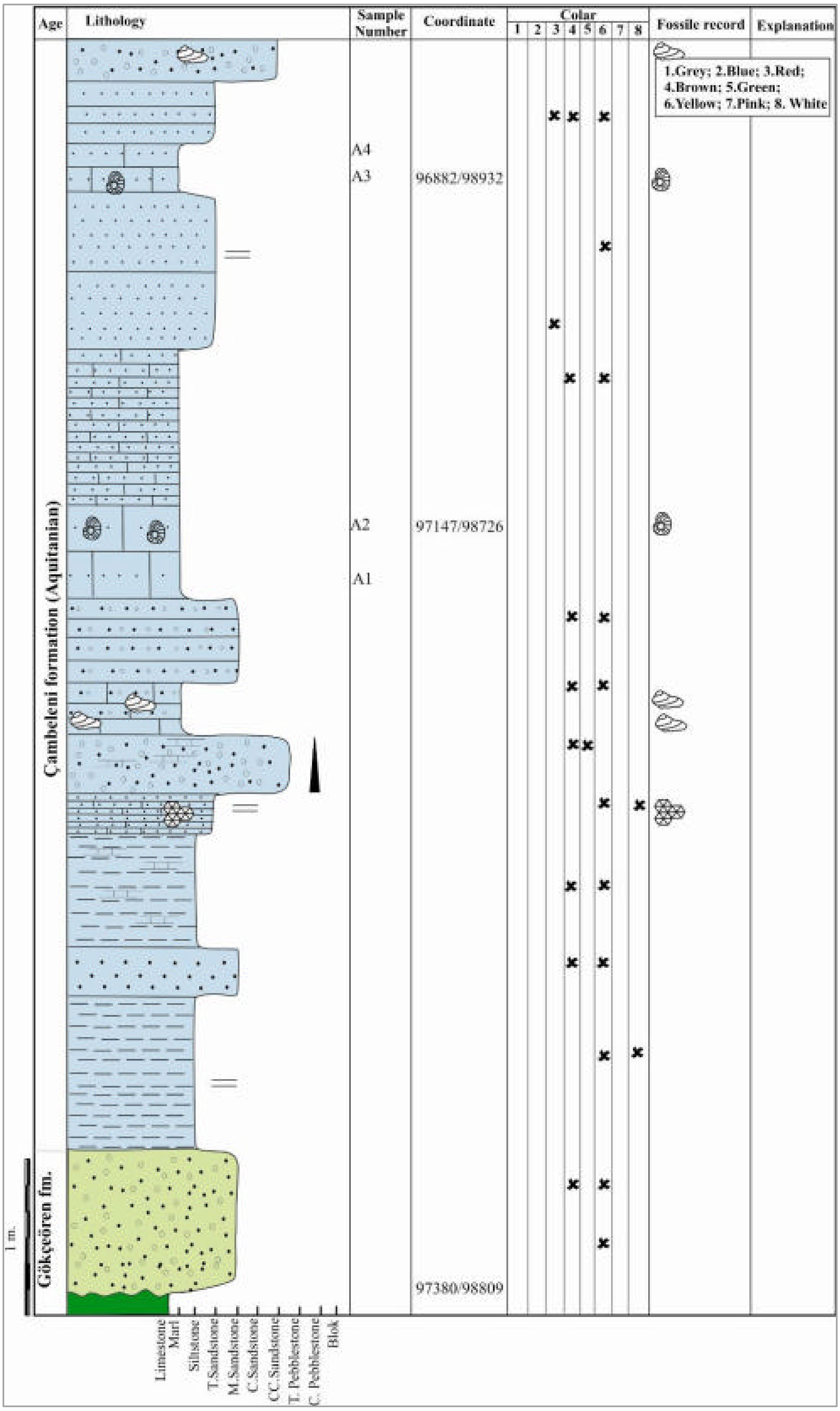


Figure 2.25 Akbük section in the Çambeleni formation from the Ören-Akbük region

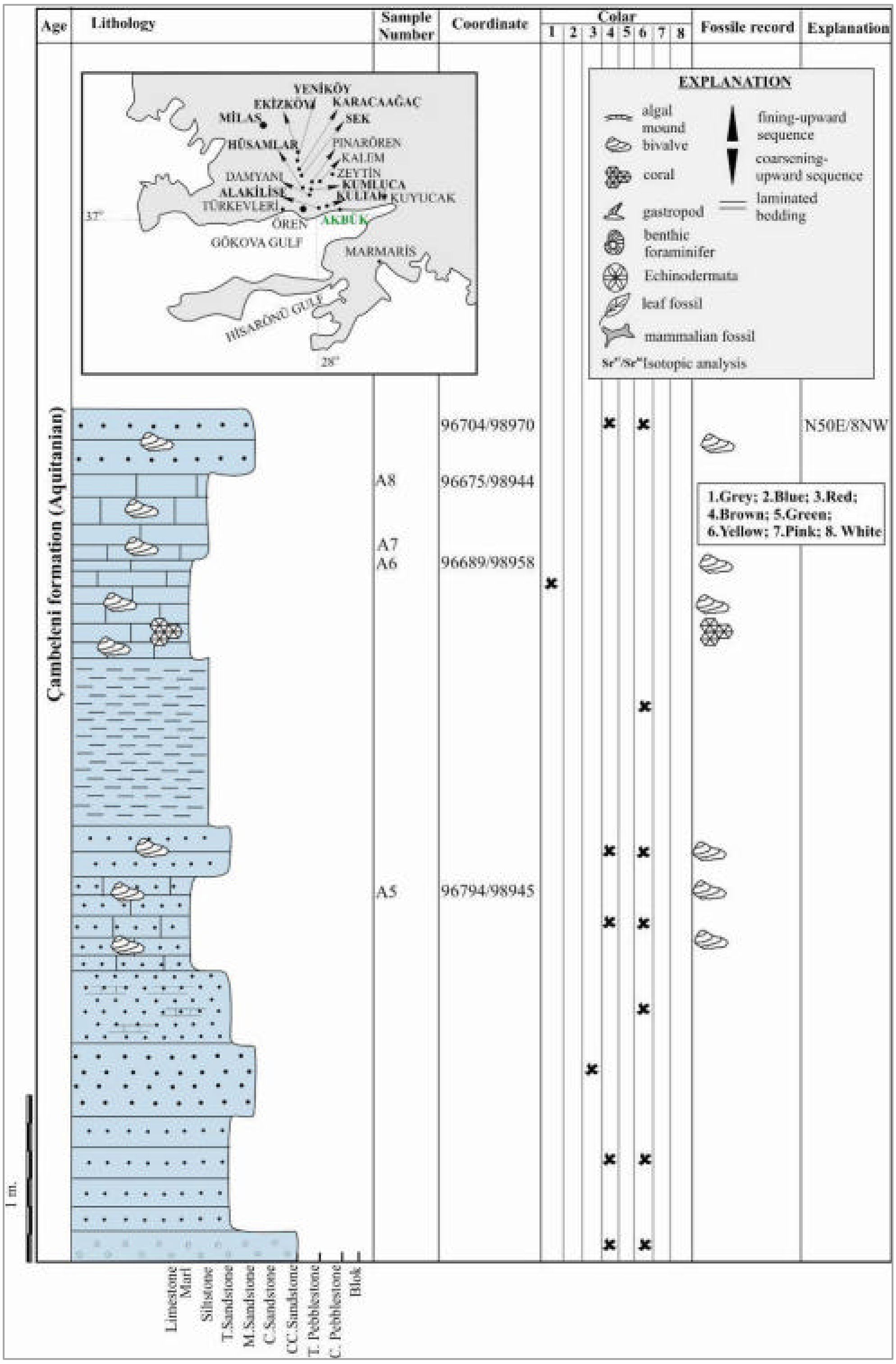


Figure 2.25 Akbük section-continued.

Figure 2.26 Pictures show the Akbük section in north of Akbük bay.

2.1.1.1.3 Age

The Çambeleni formation is deposited during the Rupelian-early Burdigalian time interval (Figs. 2.1, 2.5) based on the foraminifer, gastropod, bivalvia, spores, pollen and isotopic analysis results. See the related chapters for detail age determination of this formation (the chapters four and five).

2.1.1.2 The Alakilise member

This member is firstly defined in this study. The type localities are Ören-Alakilise and Kultak regions.

2.1.1.2.1 Lithology

The lower part of the Alakilise member which is deposited during the Rupelian time composes of the yellow, gray, reddish yellow thin thin pebblestone, sandstones, claystones, marls and coal seams in the Ören-Kultak region. Gastropod, bivalvias and corals are observed in these clastic sediments of the Alakilise member. The upper part of this member is deposited during the Chattian time. The sediments of this time are represented by sandstones, claystones and coal seams in the Ören-Alakilise region. These sandstones include rich gastropods and bivalvias faunas. The Alakilise member is nearly 45-60m thick (Figs. 2.27-2.31).

2.1.1.2.2Contact

The Lycian nappes are unconformably overlaid by the Alakilise member in the study area. This member is vertically and laterally passed the Çambeleni formation during the Rupelian-Chattian time interval. This contact relation is observed in the Ören-Alakilise region.

2.1.1.2.3 Age

The age of the Alakilise member is obtained from the palynoflora, gastropod, bivalvia and isotopic analysis results. See the related chapters for detail age determination of this formation (the chapters four and five).

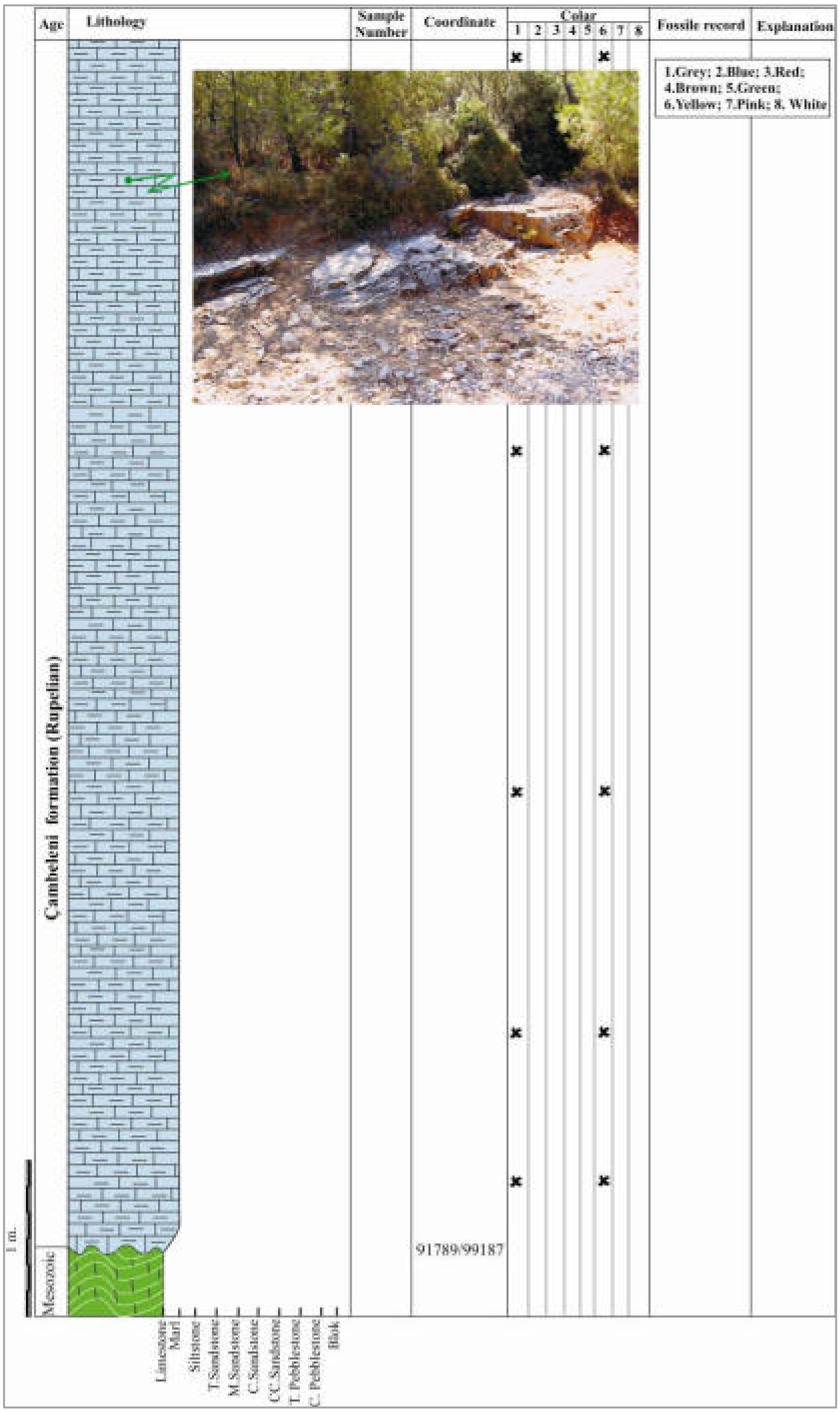


Figure 2.27 BP section in the Alakilise member from the Ören-SW Kultak region.

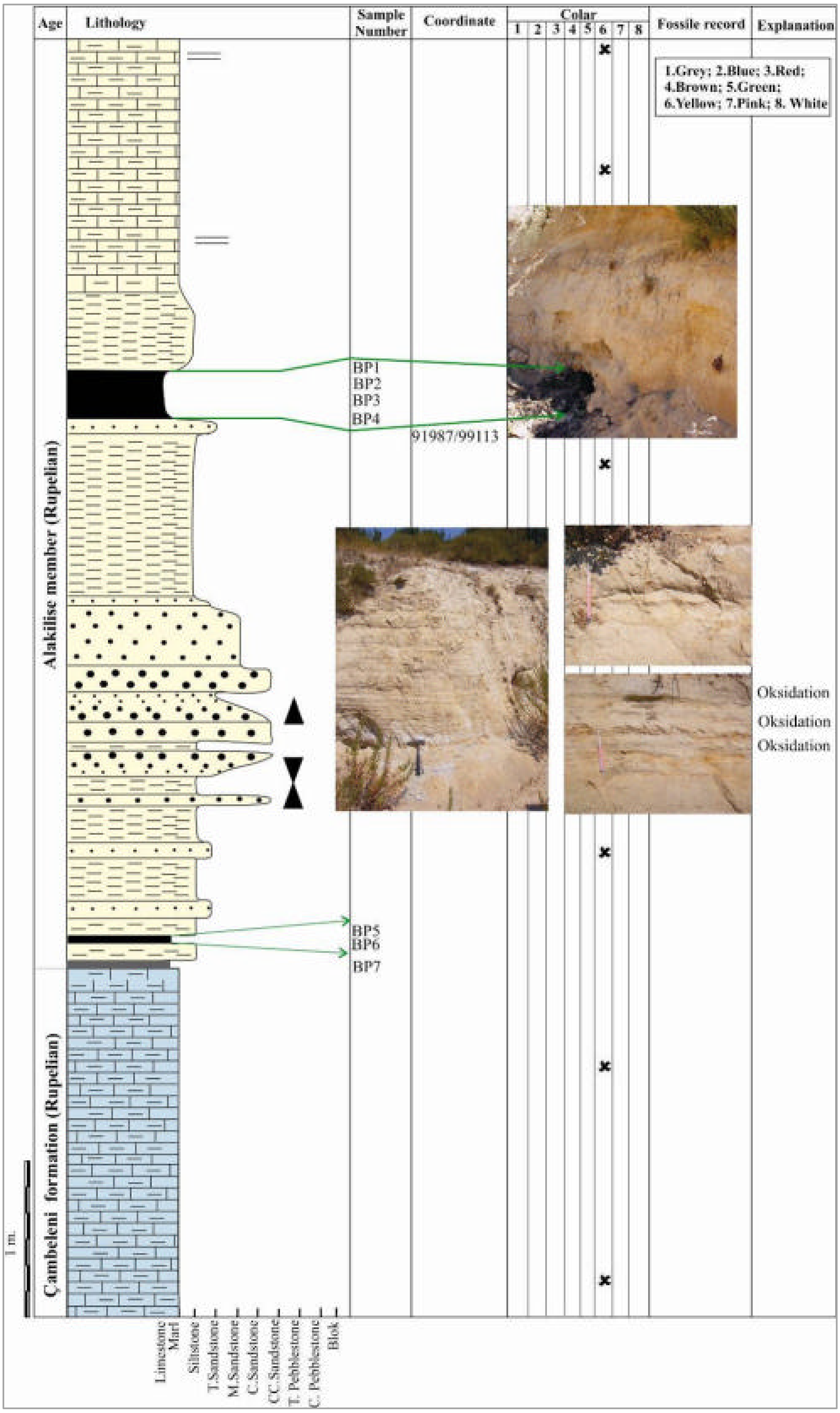


Figure 2.27 BP section-continued.

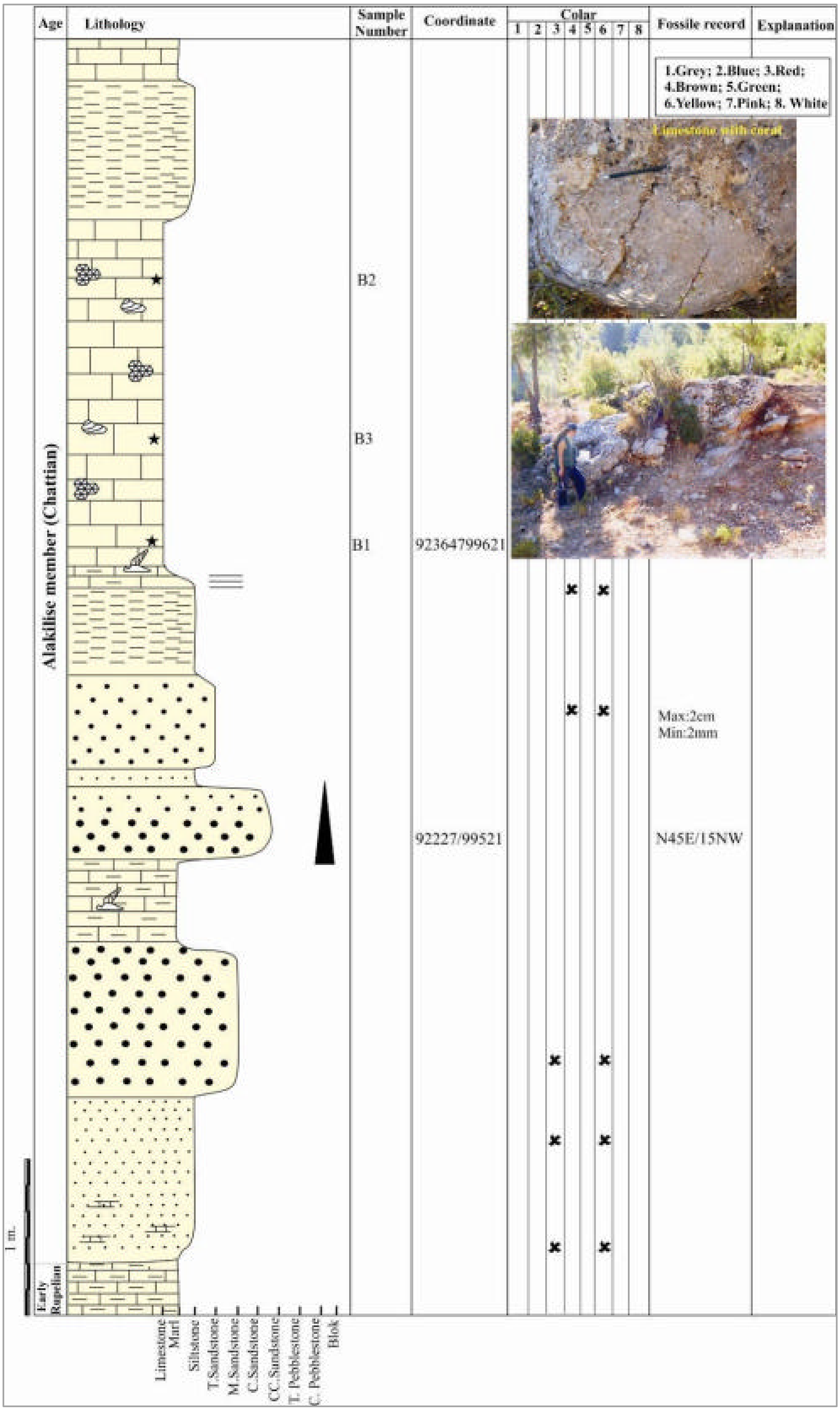


Figure 2.27 BP section-continued.

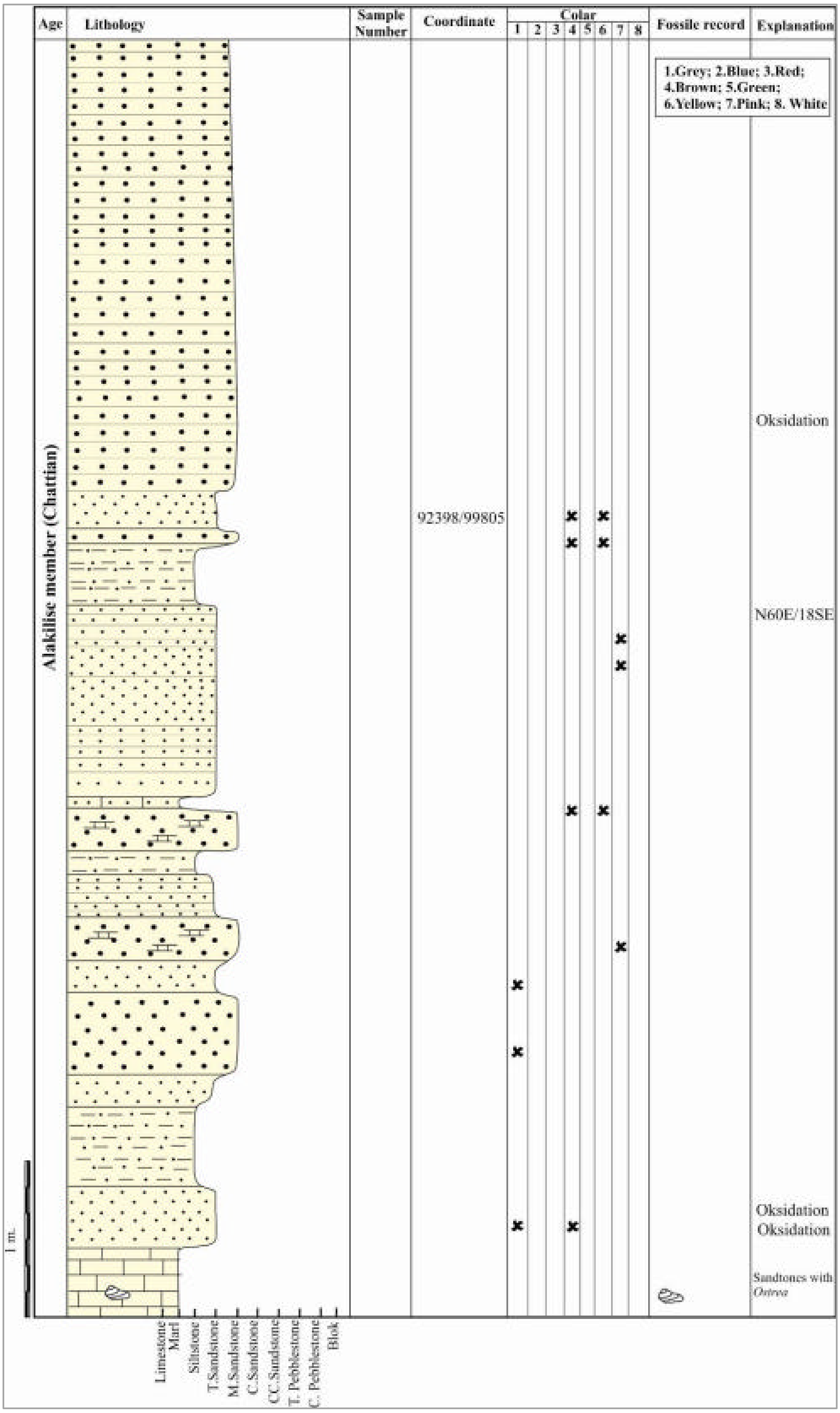


Figure 2.27 BP section-continued.

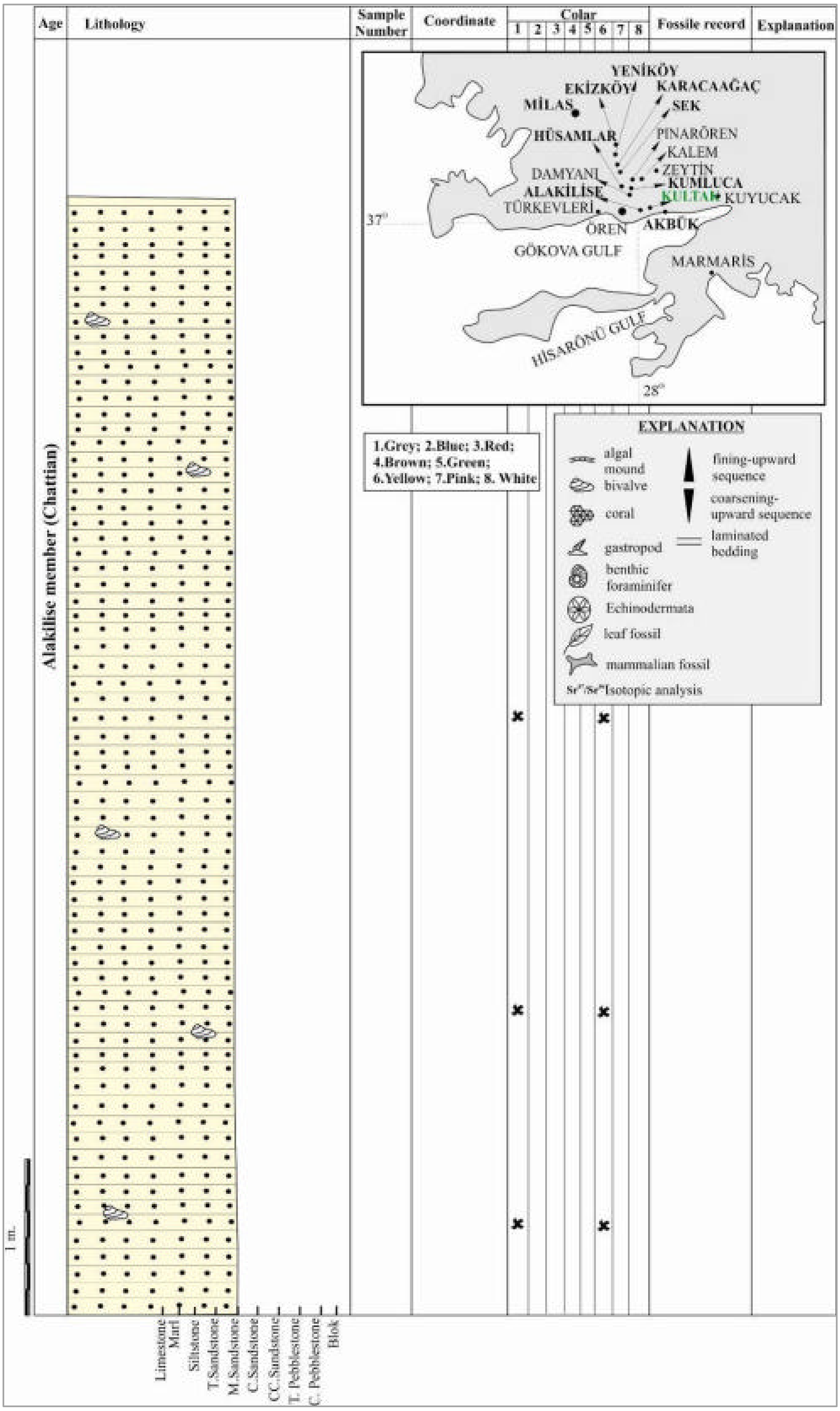


Figure 2.27 BP section-continued.

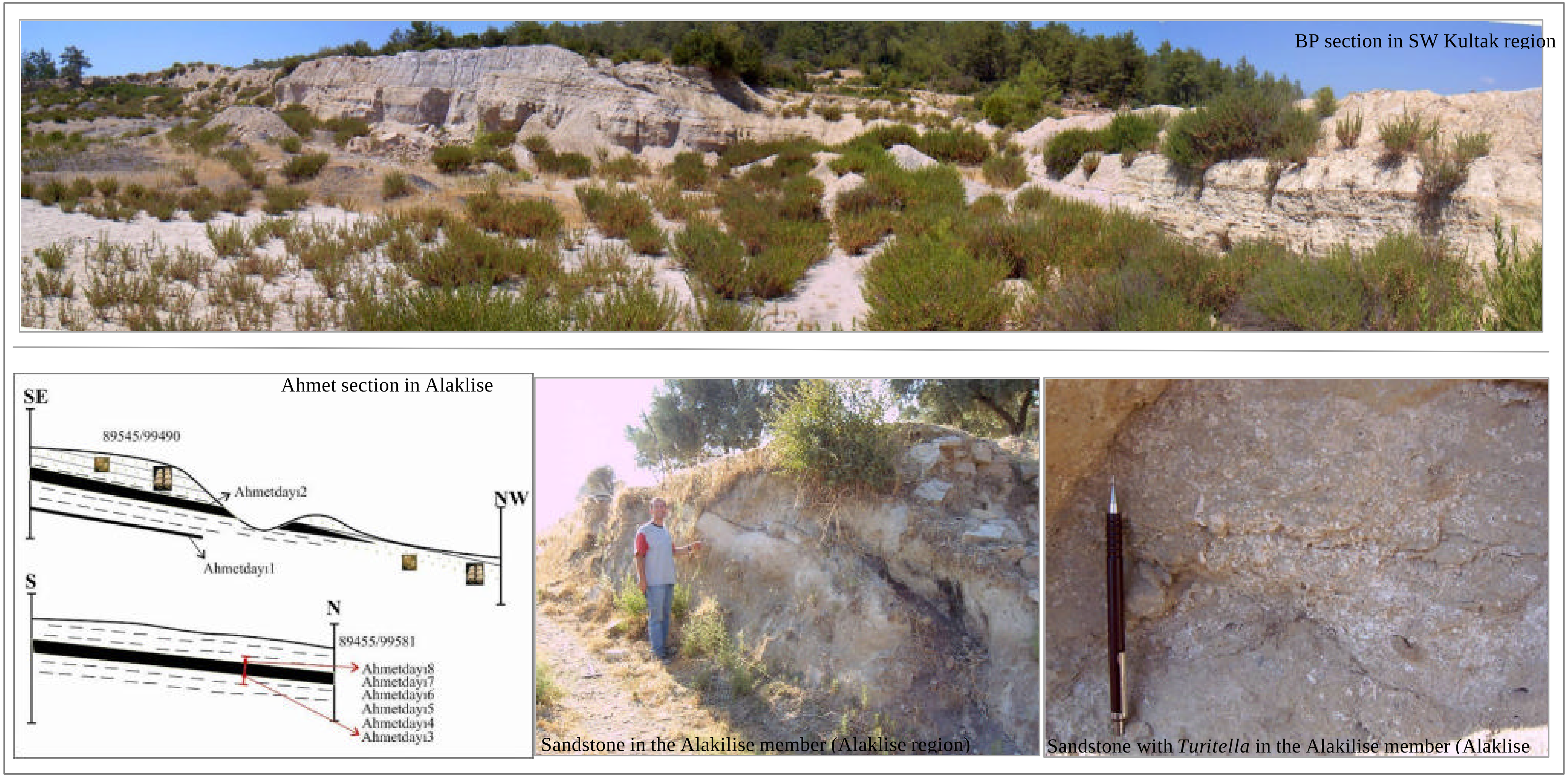


Figure 2.28 BP section in the Alakilise member from the SW Kultak region and Ahmet section in the Alakilise region.

Alakilise member in Alakilise coal mine

Sandstone with bivalvia in the Alakilise member

Sandstones and claystone alternation, and coal seam in the Alakilise member (Alakilise coal

Sandstones in the Alakilise member (Alakilise coal

Sandstones and conglomera alternation in the Alakilise member (Alakilise coal mine)

Coal mine in Alakilise member (Alakilise coal mine)

Sandstone with gastrapods in the Alakilise member

Sandstones and conglomera alternation in the Alakilise member (Alakilise coal mine)

Figure 2.29 The Alakilise member from the Alakilise coal mine in the Alakilise region.

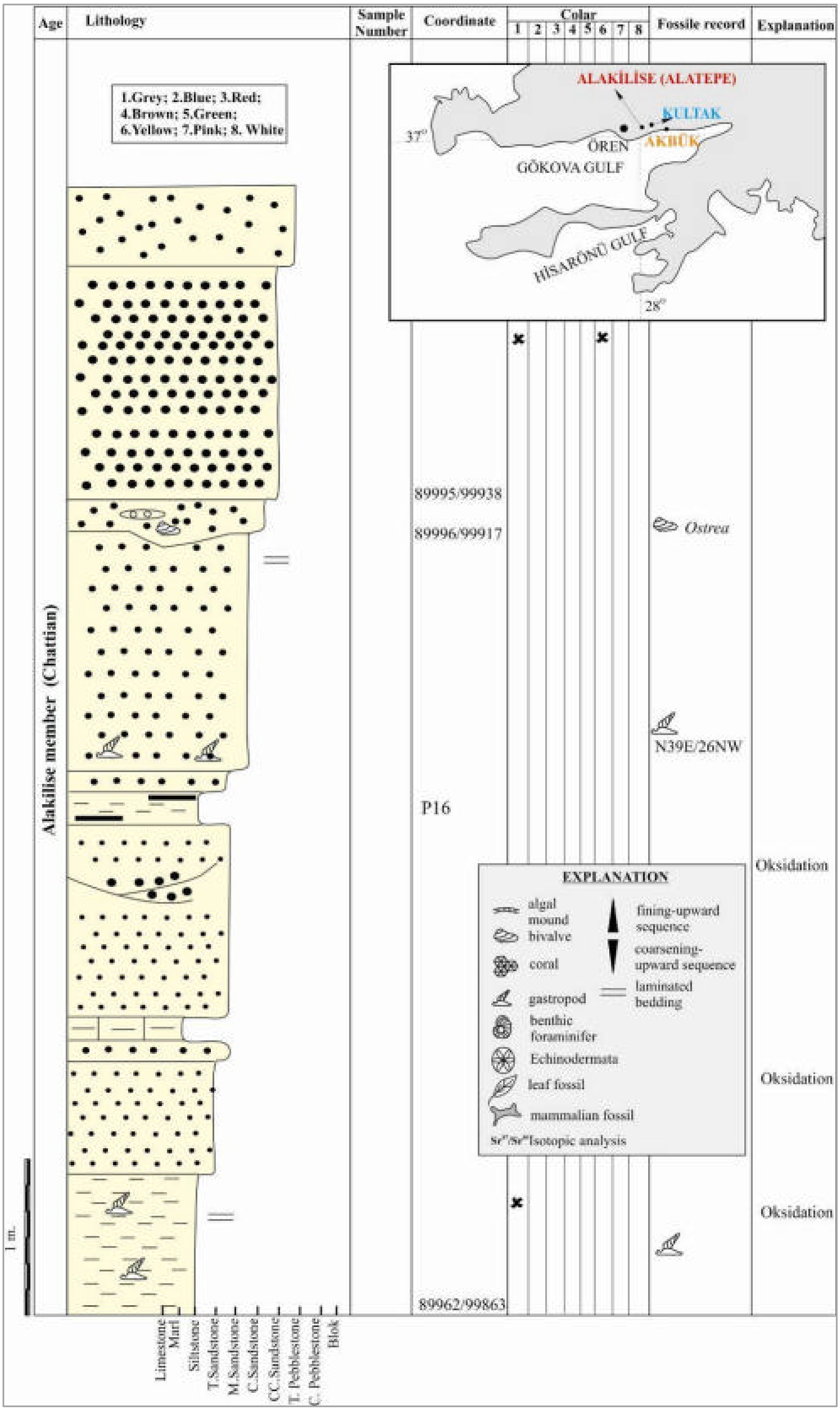


Figure 2.30 Alakilise-II section in the Alakilise member from the Ören-SW Kultak region.

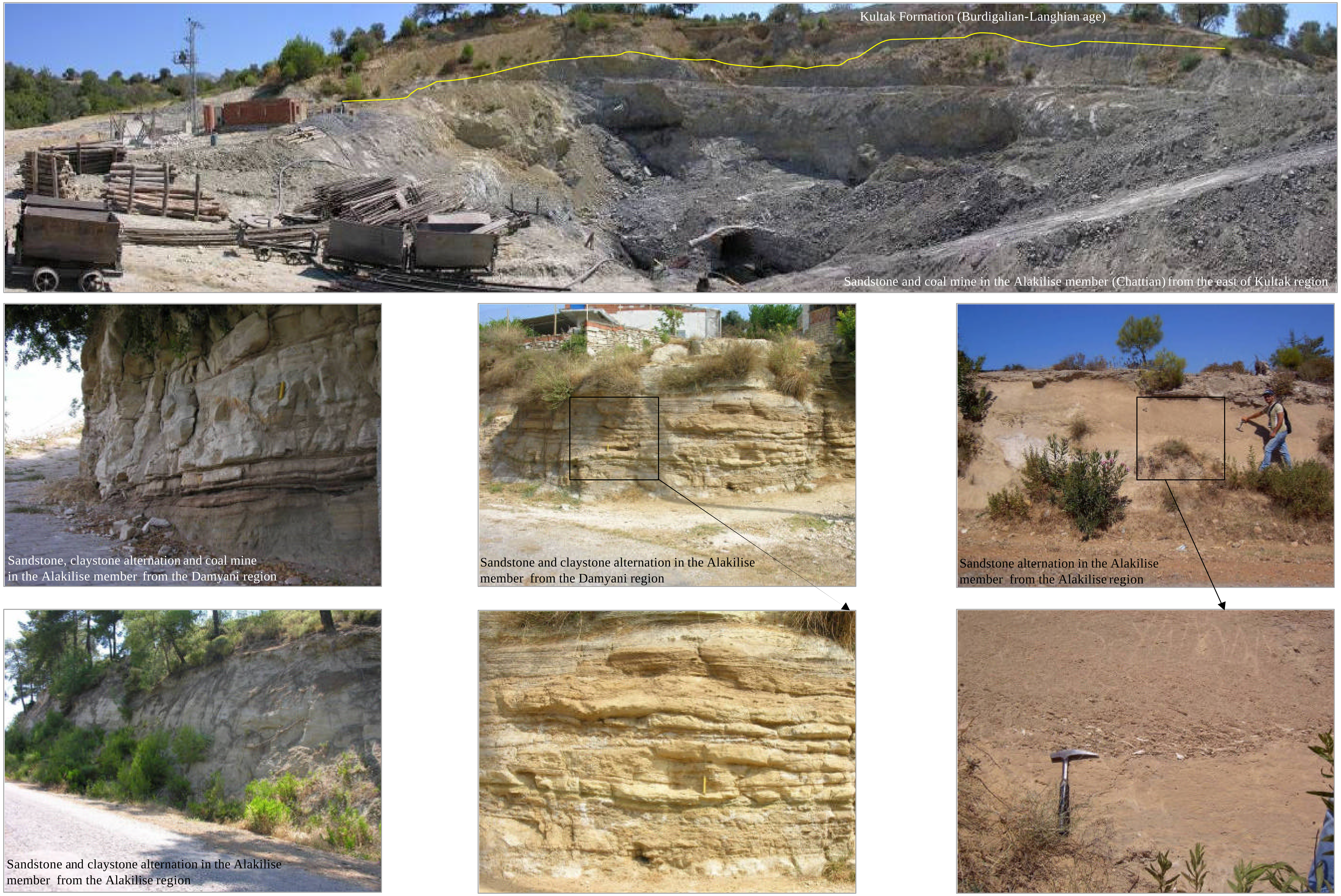


Figure 2.31 Picture show the Alakilise member from the Ören-Alakilise, Damyani and Kultak regions.

2.1.1.3 The Gökçeören Formation

This formation was defined by the Gürer and Yilmaz (2002) from the Kiranköy, Akbük and Kuyucak regions.

2.1.1.3.1 Lithology

This formation is observed between Akbük and Akyaka regions. In the Akbük region the formation has a minimum thickness (nearly 2m). Besides, this formation in the Akyaka region has a maximum thickness (nearly 1500m). This formation composed of the coarse conglomerates and sandstones alternation which are derived from the Lycian nappes (Fig. 2.32). Matrix includes sand, silt and mud.

2.1.1.3.2 Contact

The Çambeleni formation is unconformably overlaid by the Gökçeören formation in the study area. This formation is vertically and laterally passed the Çambeleni formation during the late Oligocene and Burdigalian time interval.

2.1.1.3.3 Age

Fossil is not observed in the Gökçeören formation. However, contact relationship between the Gökçeören and Çambeleni formations and conglomerates of the Gökçeören formation is observed in the below of limestones in the Akbük region of the Aquitanian-Burdigalian age indicate the Gökçeören formation is older than the Aquitanian age.

Figure 2.32 Picture show the Gökçeören formation from the Ören-E Akbük, Kuyucak and Akyaka regions.

2.1.1.4 The Kultak Formation

This formation is firstly defined in this study. The type locality is Ören-Kultak region.

2.1.1.4.1 Lithology

The lower part of the Kultak formation composes of the yellow, gray and brown block, coarse conglomerate, sandstone alternation. Matrix includes the sand and mud. Conglomerates are derived from the limestones of Çambeleni formation, sandstone of the Alakilise member, conglomerate of Gökçeören formation. Besides the upper part of the Kultak formation includes the sandstone with gastropod and bivalvia (Figs. 2.33-2.35). The Kultak formation is nearly 30-40m thick.

2.1.1.4.2 Contact

The Çambeleni formation is unconformably overlaid by the Kultak formation in the study area. This formation is vertically and laterally passed the Belen member in the Belen hill.

2.1.1.4.3 Age

The age of the Kultak formation is obtained from the palynoflora, mammalian fauna, isotopic data and isotopic analysis results. See the related chapters for detail age determination of this formation (the chapters seven and eight).

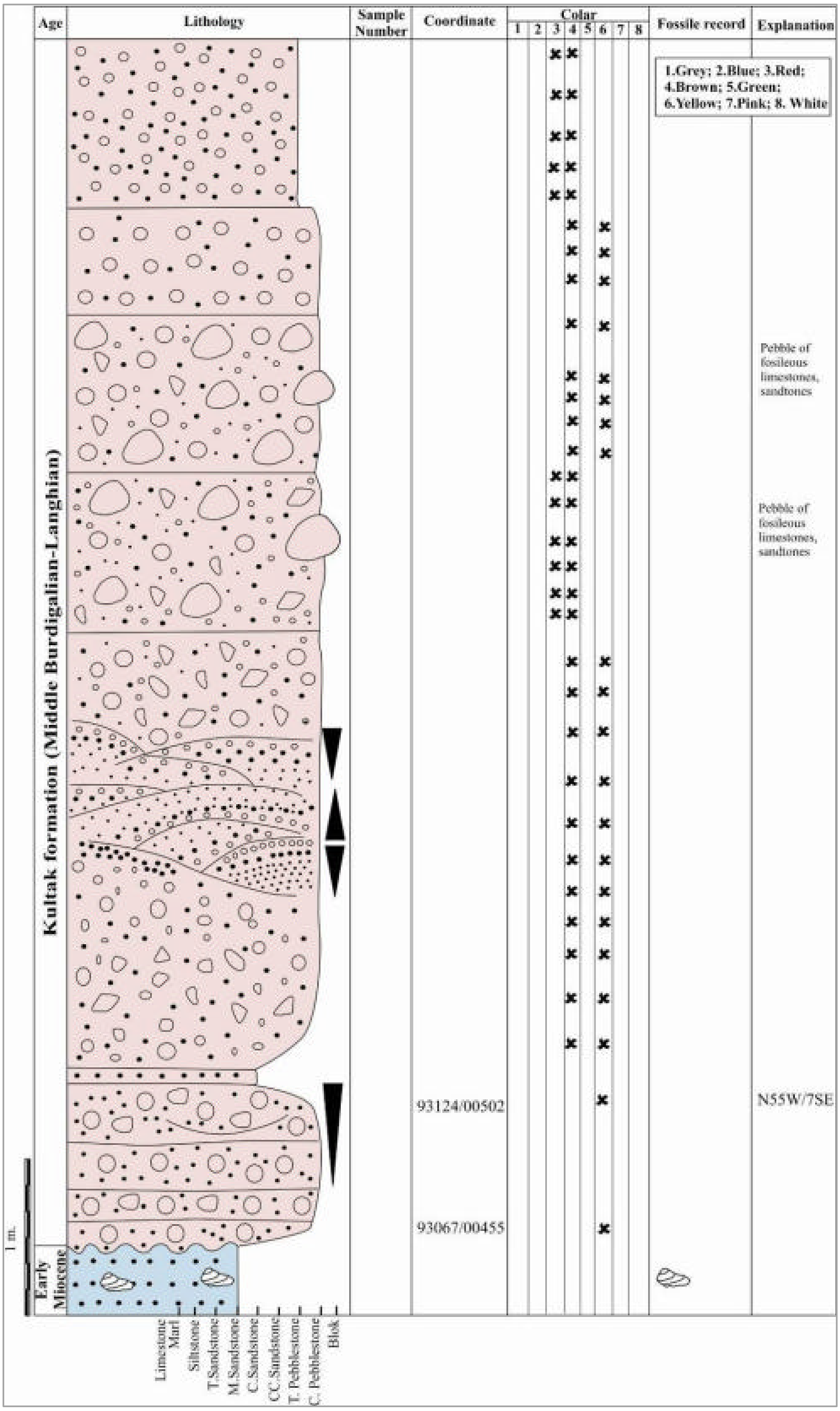


Figure 2.33 Kultak section in the Kultak formation from the Ören-E Kultak region.

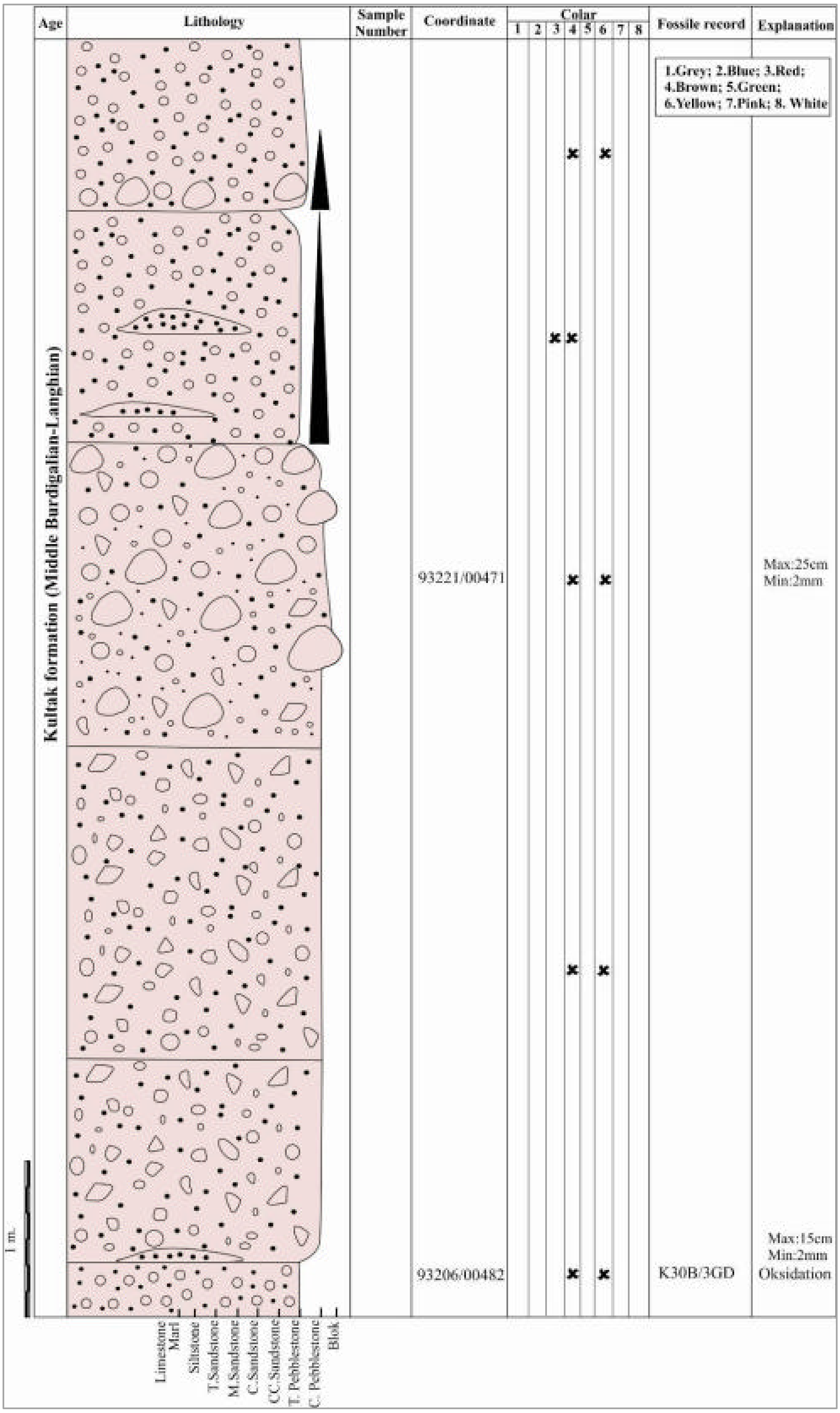


Figure 2.33 Kultak section-continued.

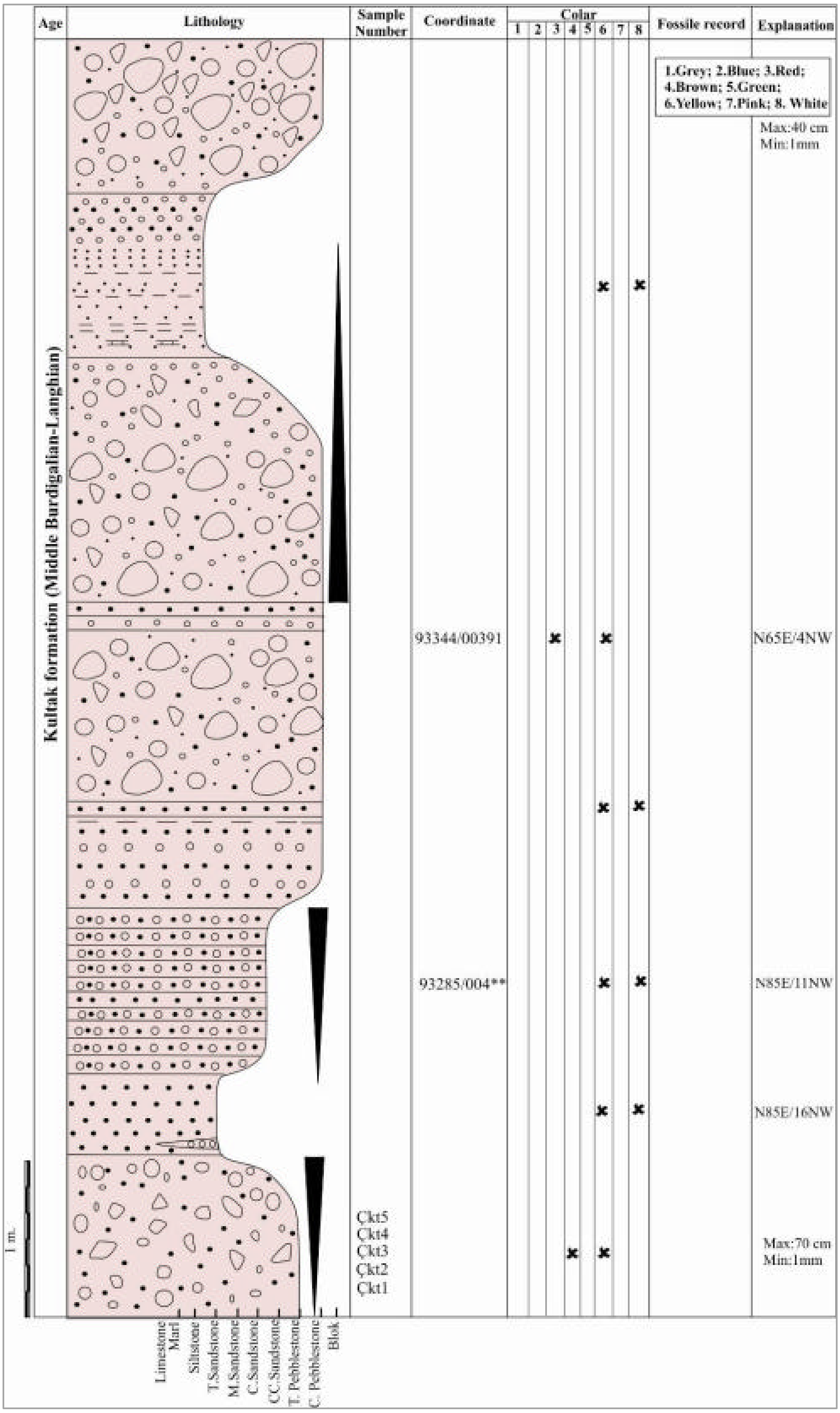


Figure 2.33 Kultak section-continued.

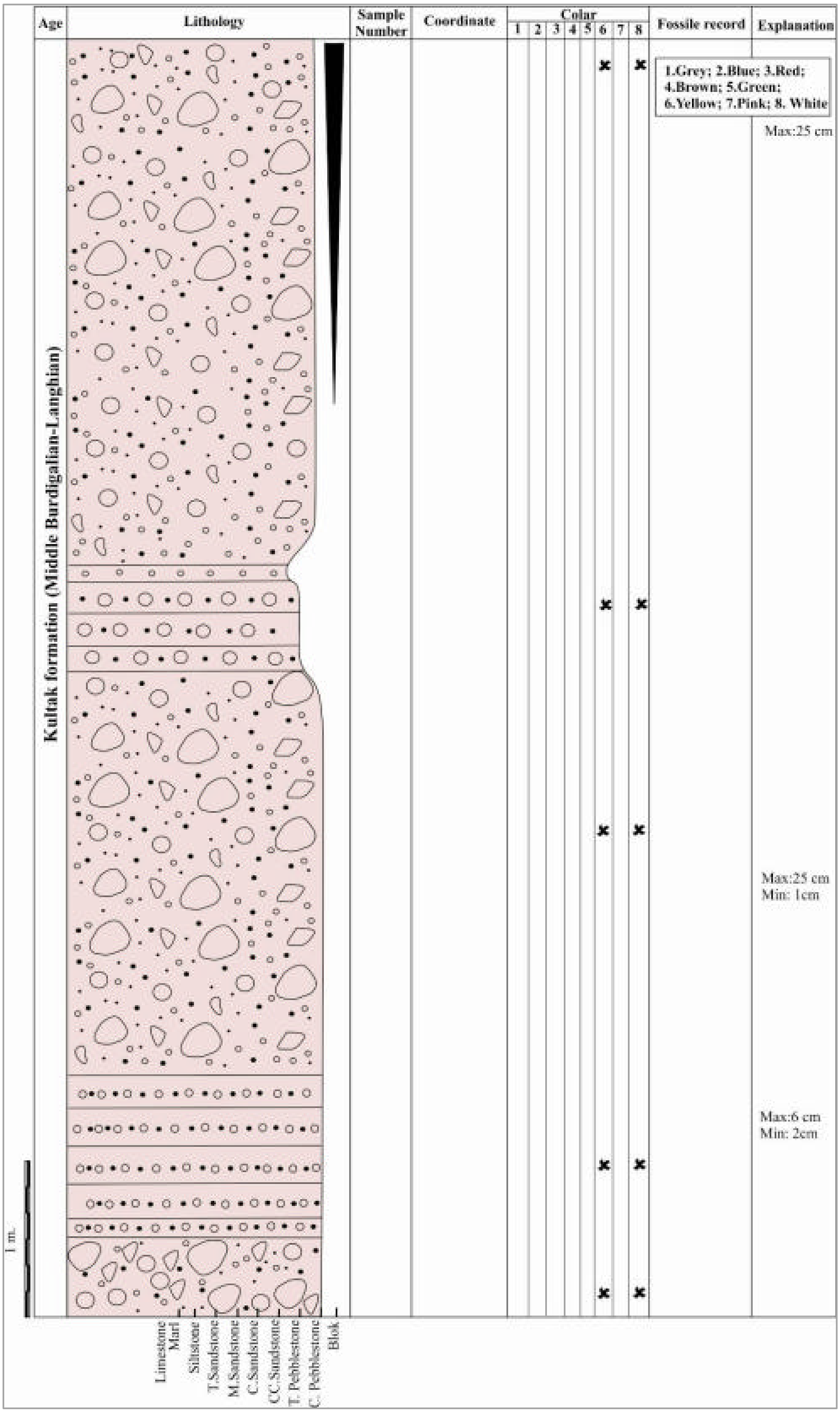


Figure 2.33 Kultak section-continued.

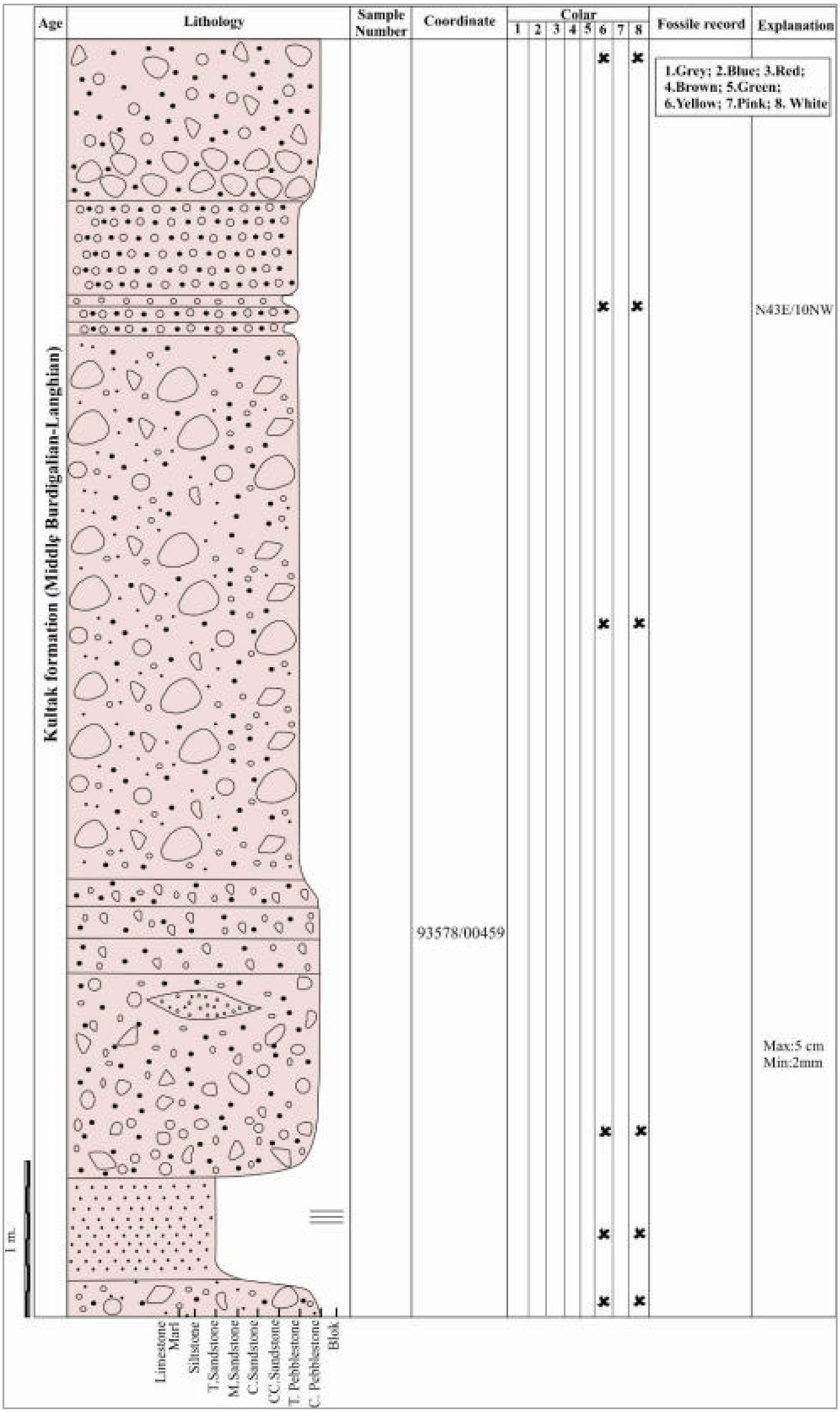


Figure 2.33 Kultak section-continued.

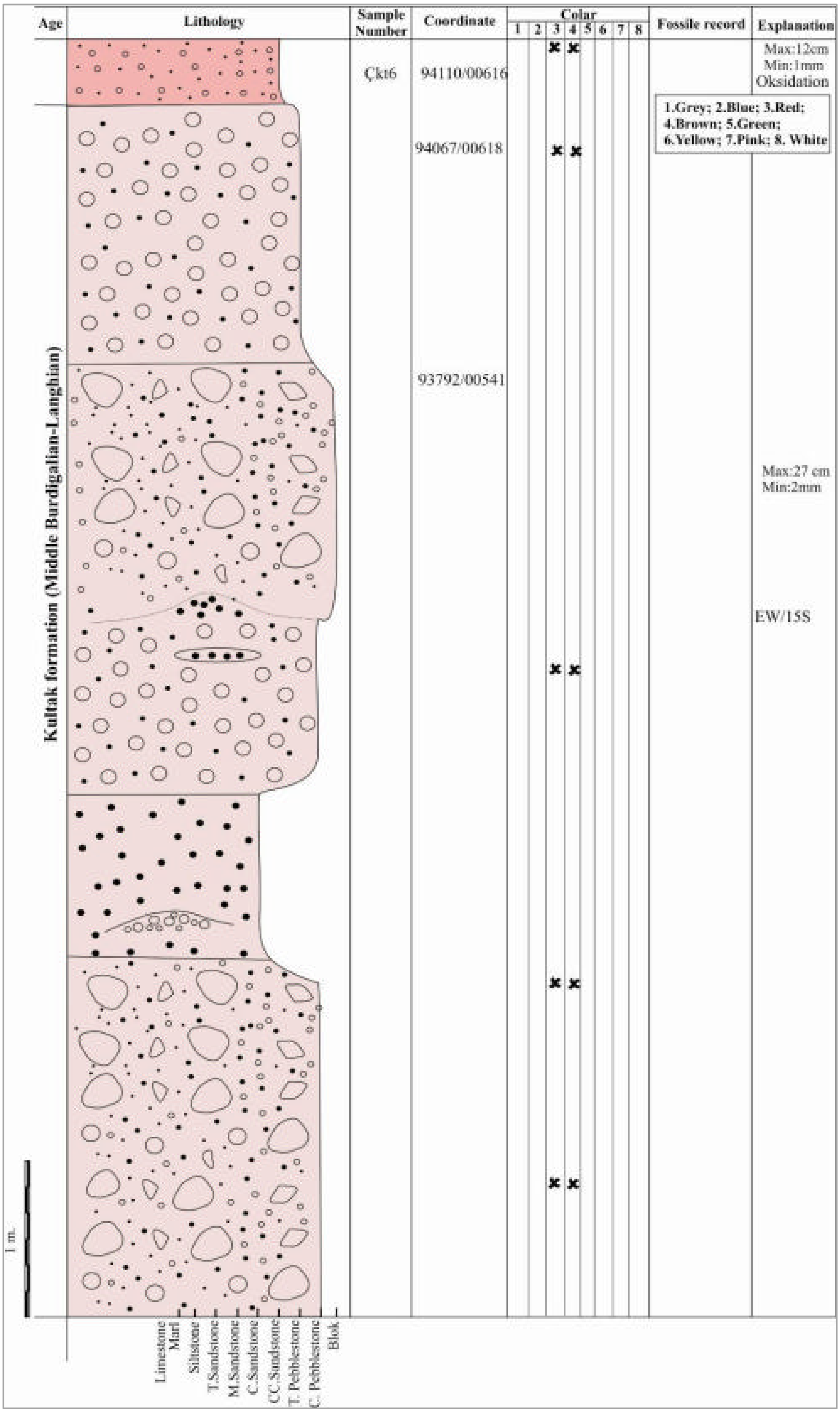


Figure 2.33 Kultak section-continued.

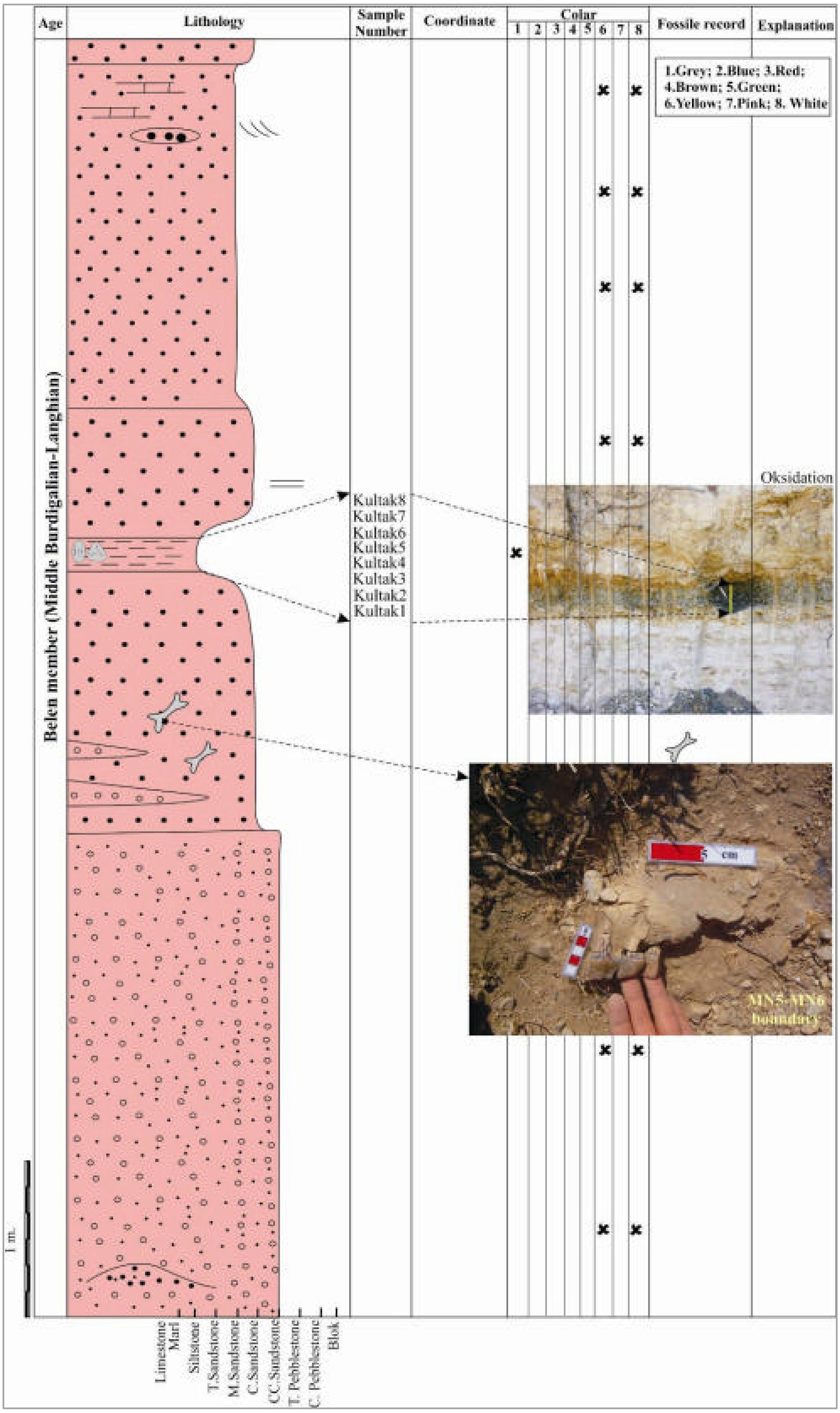


Figure 2.33 Kultak section-continued.

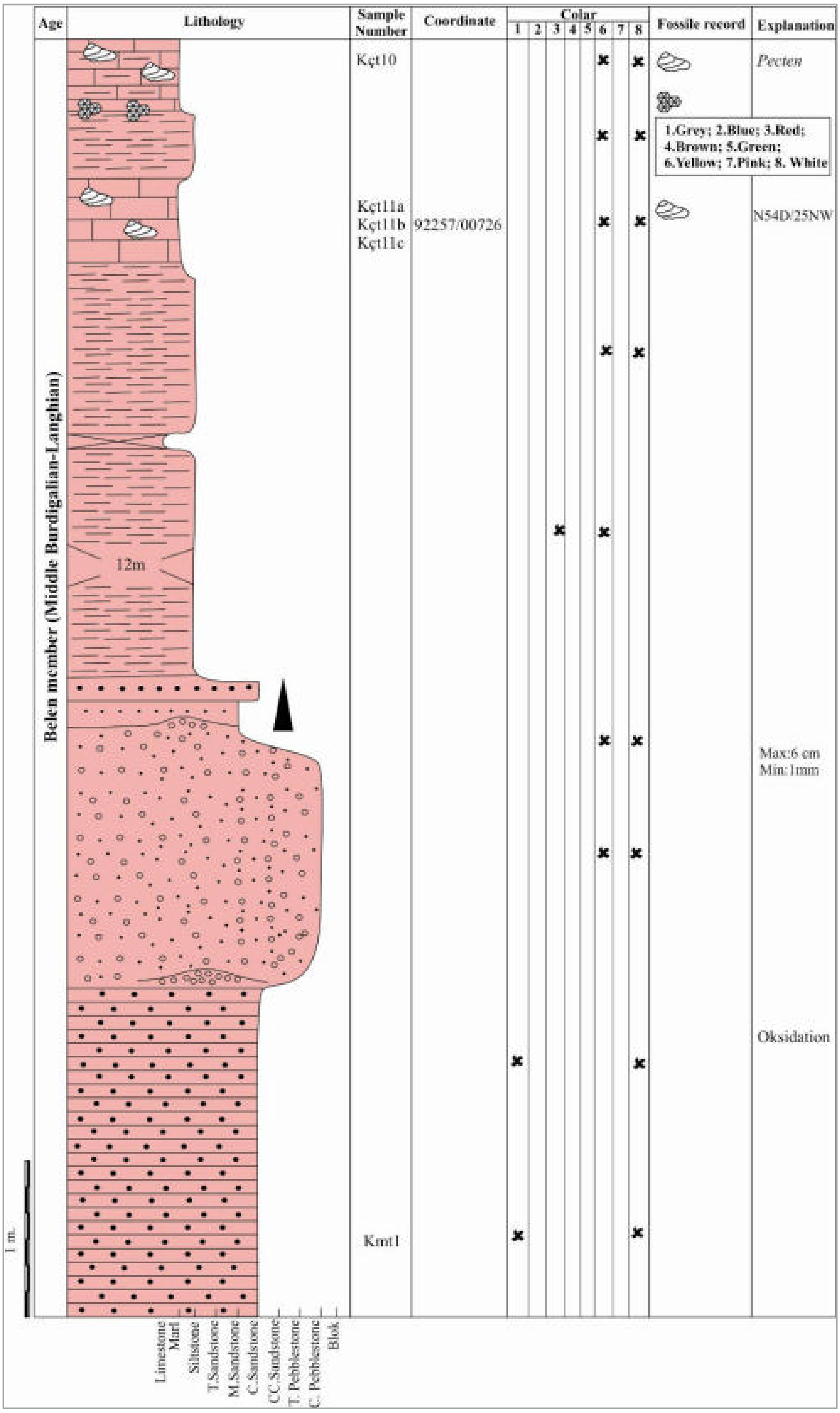


Figure 2.33 Kultak section-continued.

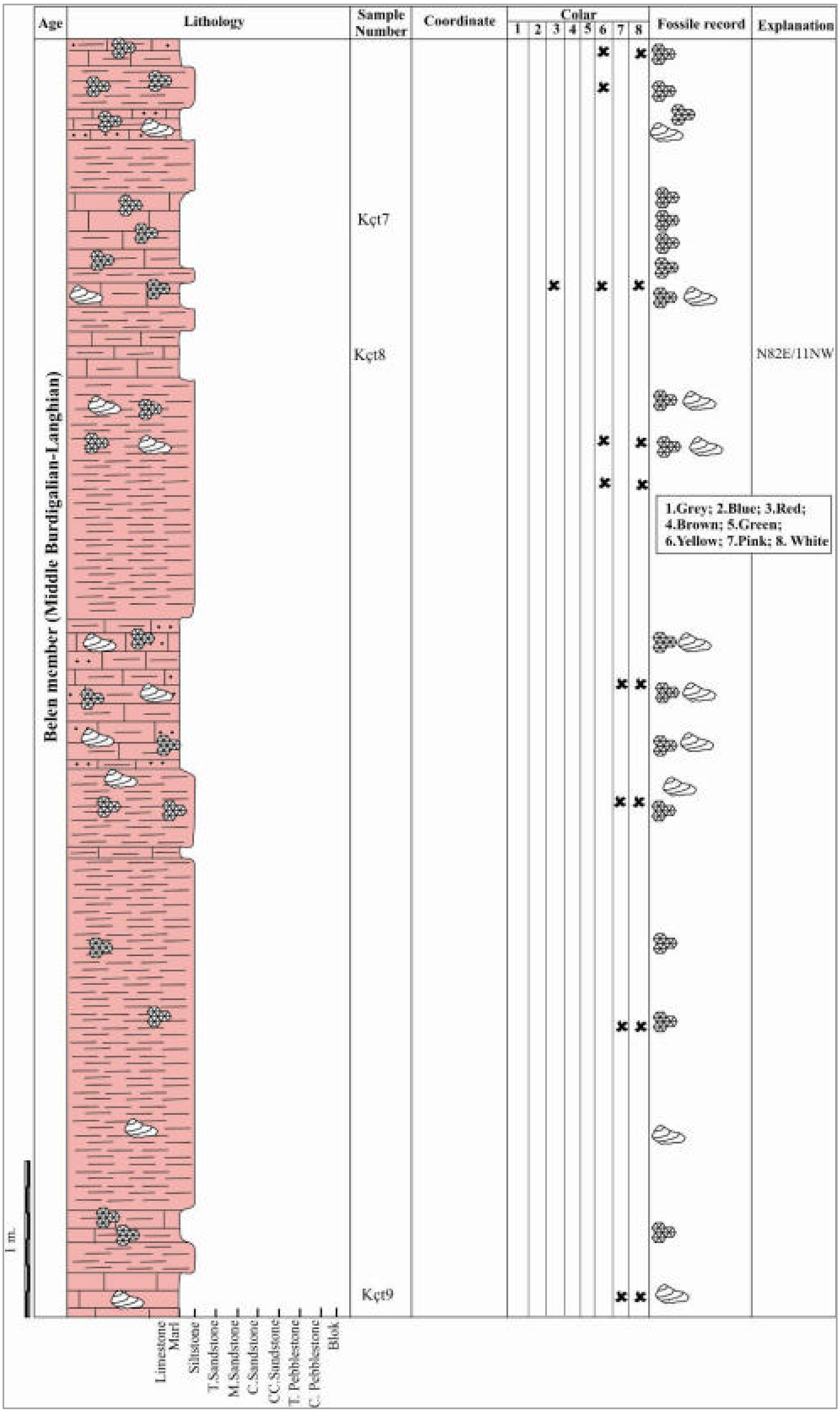


Figure 2.33 Kultak section-continued.

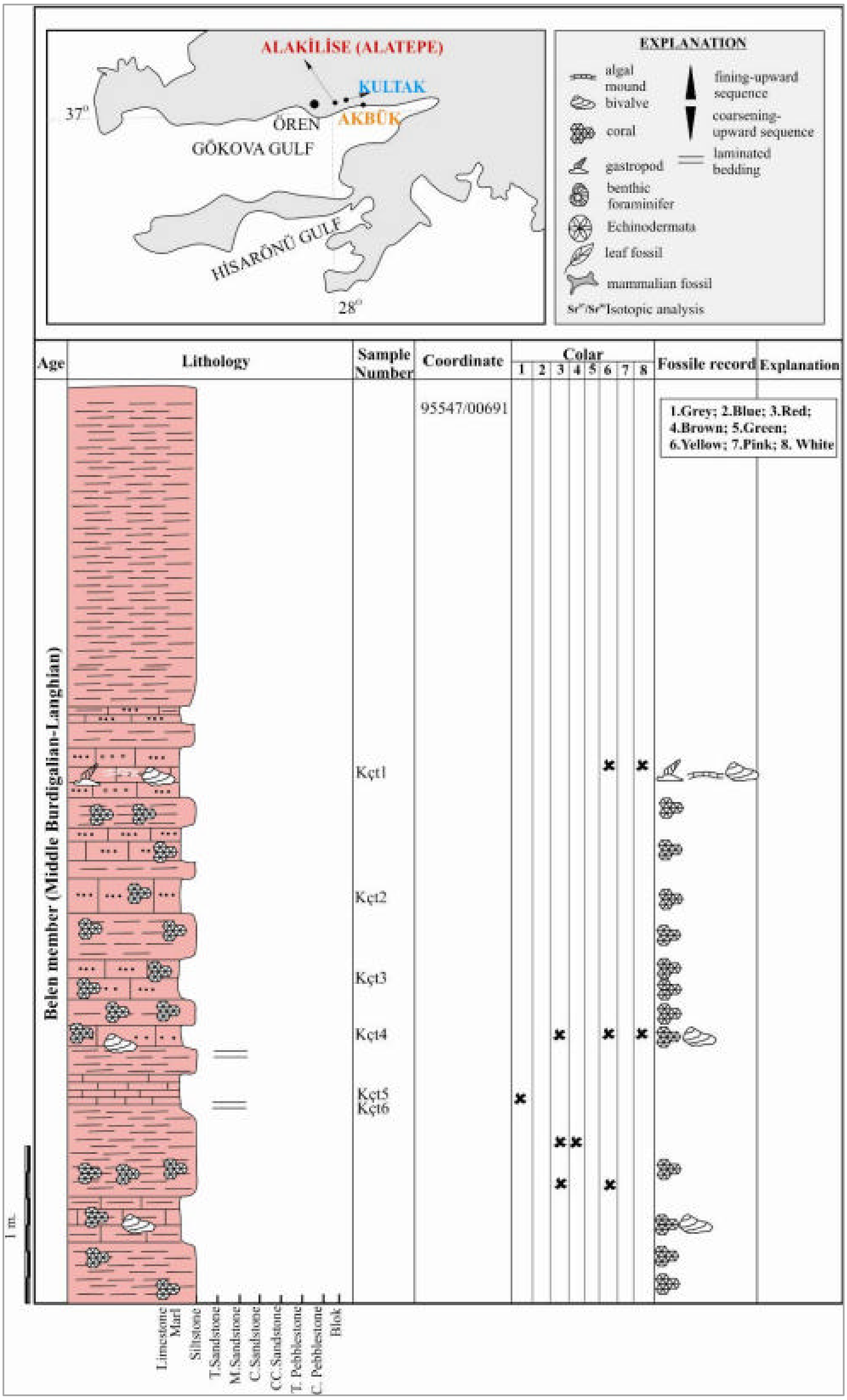


Figure 2.33 Kultak section-continued.

Figure 2.34 Pictures show the Kultak formation from the Ören-Kultak region.

Figure 2.35 Pictures show the Gökçeören formation from the Ören-E Akbük, Kuyucak and Akyaka regions.

2.1.1.5 The Belen member

This member is firstly defined in this study. The type locality is the Ören-Kultak region.

2.1.1.5.1 Lithology

The Belen member composes of the yellow, gray and brown sandstone, siltstone and claystone alternation. The upper part of the Belen member is passed the marl with gastropod, bivalvia and coral (Fig. 2.35). This member is nearly 10m thick.

Figure 2.35 Picture shows the Belen member from the Ören-East Kultak region.

2.1.1.5.2 Contact

The Kultak formation is vertically and laterally passed the Belen member and this member is overlaid by the Sekköy formation.

2.1.1.5.3 Age

The age of the Belen member is obtained from the palynoflora, mammalian fauna, foraminifera and isotopic analysis results. See the related chapters for detail age determination of this formation (the chapters seven and eight).

2.1.1.6.1 The Hüsamlar member

This member is firstly defined in this study. The type locality is Ören-Hüsamlar and Karacaagaç regions.

2.1.1.6.2 Lithology

The Hüsamlar member composes of the white, yellow, gray and brown siltstone, claystone, marl with leaf fossils (Karacaagaç and Hüsamlar) and coal alternation (Fig. 2.36).This member is nearly 70-80m thick. Mammalian fossils are collected in the coal seam from the Hüsamlar region.

2.1.1.6.3 Contact

The Kultak formation is vertically and laterally passed the Hüsamlar member and this member is overlaid by the Sekköy formation. However, contact relationship between the Belen and Hüsamlar members is not observed in the study area. But both members are deposited during the same time interval (middle Burdigalian-Langhian).

2.1.1.6.4 Age

The age of the Hüsamlar member is obtained from the palynoflora, mammalian fauna, leaf floras and isotopic analysis results. See the related chapters for detail age determination of this formation (the chapter six).

2.1.1.7 The Sekköy Formation

The Sekköy formation is defined from the Mugla-Yatagan region by the Atalay (1980).

Figure 2.36 Pictures show the Hüsamlar member from the Ören-Hüsamlar region.

2.1.1.7.1 Lithology

The Sekköy formation of the white, yellow and gray claystone, marl with leaf fossils (Sek, Ikiler and Ekizköy regions) alternation and thick coal seam (Fig. 2.37).This formation is nearly 80m thick.

2.1.1.7.2 Contact

The Hüsamlar and Belen members are unconformably overlaid by the Sekköy Formation and this formation unconformably passed the Yatagan formation.

2.1.1.7.3 Age

The age of the Sekköy formation is obtained from the palynoflora. See the related chapters for detail age determination of this formation (the chapter nine). Besides, this formation is aged Middle Miocene based on the mammalian fossil in the Mugla-Yatagan region (Atalay, 1980).

2.1.1.8 The Yatagan Formation

The Yatagan formation is defined from the Mugla-Yatagan region by the Atalay (1980).

2.1.1.8.1 Lithology

The Yatagan formation of the red, yellow and gray conglomerate, claystone, marl and volcano clastic sediments (tüffite) alternation (Fig. 2.38). This formation is nearly 80m thick.

2.1.1.8.2 Contact

This formation conformably overlaid the Sekköy formation in the Ören region.

2.1.1.8.3 Age

The late Middle Miocene-Late Miocene is used for the age of the Yatagan formation (Atalay, 1980).

2.1.1.9 Alluvium

Alluvium unconformably overlaid all sediments in the Ören region.

Figure 2.37 Pictures show the Sekköy formation from the Ören-Sek and Ikizler regions.

Figure 2.38 Pictures show the Yatagan formation from the Ören-Ekizköy region.

CHAPTER THREE
PALYNOLOGY

3.1 Material and Method

Following techniques processed 503 samples for quantitative counting. Firstly the samples were dried and crushed after that about 10mg of sediment were shredded and placed in a plastic pot.

Palynological preparations were made from collected samples by using standard HCL and HF treatments followed by oxidation with Schulze's solution and KOH. The samples were treated by using concentrated 30 milliliters of 32 % HCL for one day to remove carbonates and disaggregate clay. After the material was washed four times in a centrifuge, the residue was processed with concentrated 30 milliliters of 38–40 % HF for two days. After the solution centrifuged three times, the material was prepared by using the Schulze's solution. The samples mixed with 5 gr $KCLO_3$ and then 30 milliliters of 65 % nitric acid were added. The material was kept in the laboratory until it flushed. The solution was often controlled on the microscope whether it was prepared or not. When the samples were prepared, they were ashed three or five times until the water was reasonably cleaned. The residue was put into a glass tube and added small amount of water. The solution was heated until 70^0C. 2 grams of KOH were added into the solution and then it was immediately centrifuged three times. The residue was placed into a small bottle and small amount of water mixed with it. Then 4–5 drops alcohol was added into the bottle.

Some of the slides were sterile and at least 100 identified pollen and spores from the others had been counted. Selected palynomorphs were photomicrographed with the help of Olympus microscope. A full list of the slides examined was present in the Appendix.

3.2 Systematics

This chapter includes the palynological study of one hundered thirty microscopic slides from coal, claystone and mudstone. The genera and species showed here are arranged alphabetically under the broad of trilete and monolete spores, gymnospermous pollen, angiospermous pollen, algae, fungal spore. Thomson & Pflug (1953)'s classification were dominantly used and also the publications of Stuchlik et al. (2001), Thiele–Pfeiffer (1980, 1988) and Krutzsch (1957, 1958, 1959a; b, 1960, 1961, 1962a; 1962b, 1966, 1967a; b, 1968, 1970a; b and 1971) to determine the spores. Additionally, taxonomy of dinoflagellate cysts and *Pediastrum* was also given on the following part. Basic terms of the spores and pollen are used for the palynomophs identification (Figs. 3.1-3.10).

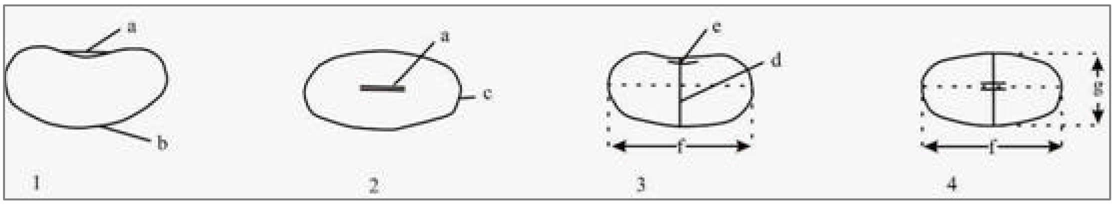


Figure 3.1 Monolete spores: 1, 3-equatorial view, bean shaped: 2, 4-polar view, amb elliptical. Details: a-proximal pole: b-distal pole: c-equatorial outline (amb): d-polar axe: e-single leasure; f-longer equatorial axe (length): g-shorter equatorial axe (width) (Stuchlik et al., 2001).

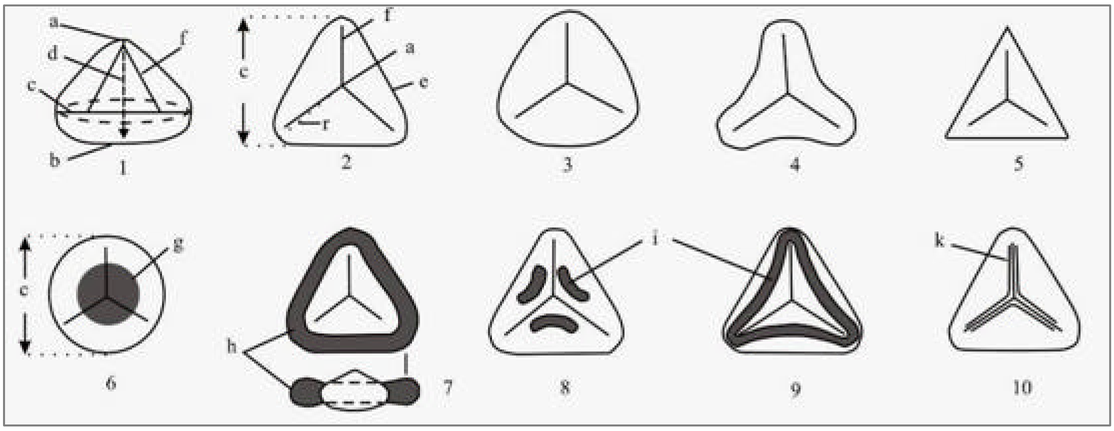


Figure 3.2 Trilete spores: 1-outline in equatorial view: 2-5-outline in polar view- triangular: 2-with straight sides: 3-with convex sides: 4- with concave sides: 5-with acute apex: 6-outline in polar view-circular: 7-10-structural features. Details: a-proximal pole: b-distal pole: c-equatorial diameter (dimension): d-polar axe: e-equatorial outline (amb): f-leasure arm: r- radius: g-contact area: h-cingulum: i- torus: k- labrum(Stuchlik et al., 2001).

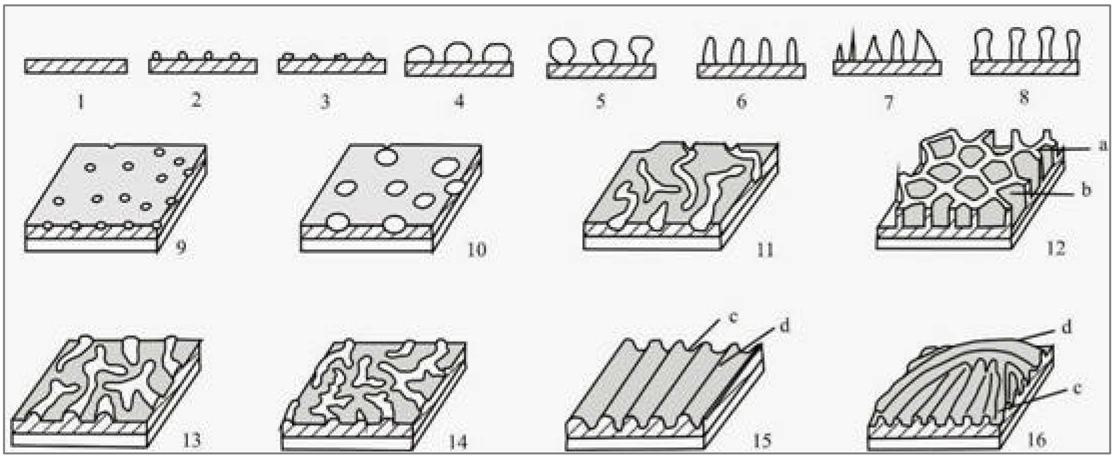


Figure 3.3 Sculpture elements: 1-psilate: 2-granulate, Ø<1μm: 3-scabrate, Ø>1μm: 4-verrucate, Ø>1μm: 5-gemmate: 6-baculate: 7-echinate, spines height>1μm, microspines height<1μm: 8-clavate: 9-punctate, Ø<1μm: 10-foveolate, Ø>1μm: 11-fossulate, lenght>1μm: 12-reticulate, a-lumen, b-murus: 13-rugulate,lenght>1μm: 14-hamulate, lenght>1μm: 15,16-striate, c-stria, d-ridge.

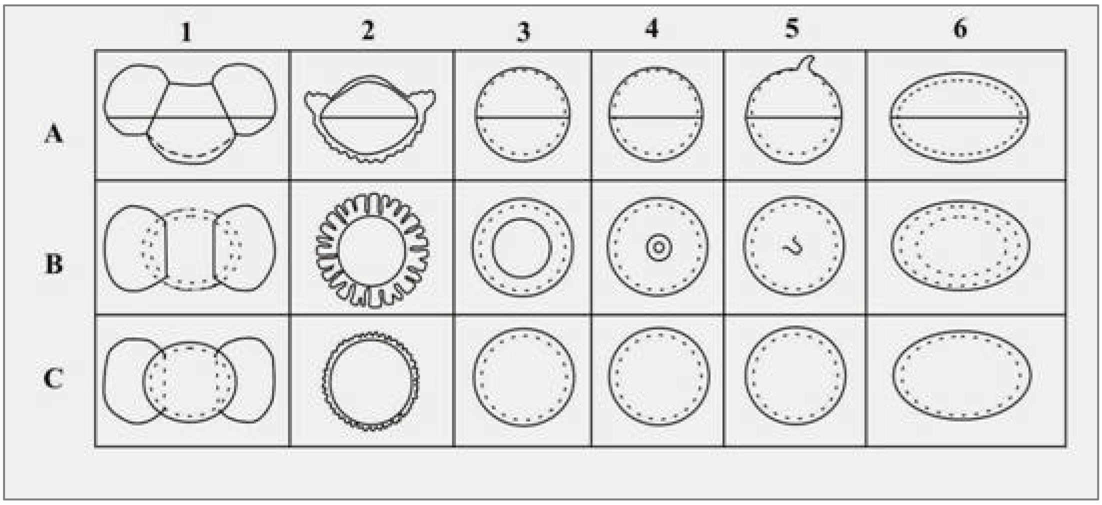


Figure 3.4 Pollen morphology of gymnosperms (Stuchlik et al., 2002). A-equatorial view; B-polar view, distal face; C-polar view, proximal face. 1-bisaccate pollen grains; 2-pollen grains with equatorial collar; 3-inaperturate pollen grains with leptoma; 4-pollen grains with small aperture in the leptoma center; 5-pollen grains with papilla; 6-monosulcate pollen grains.

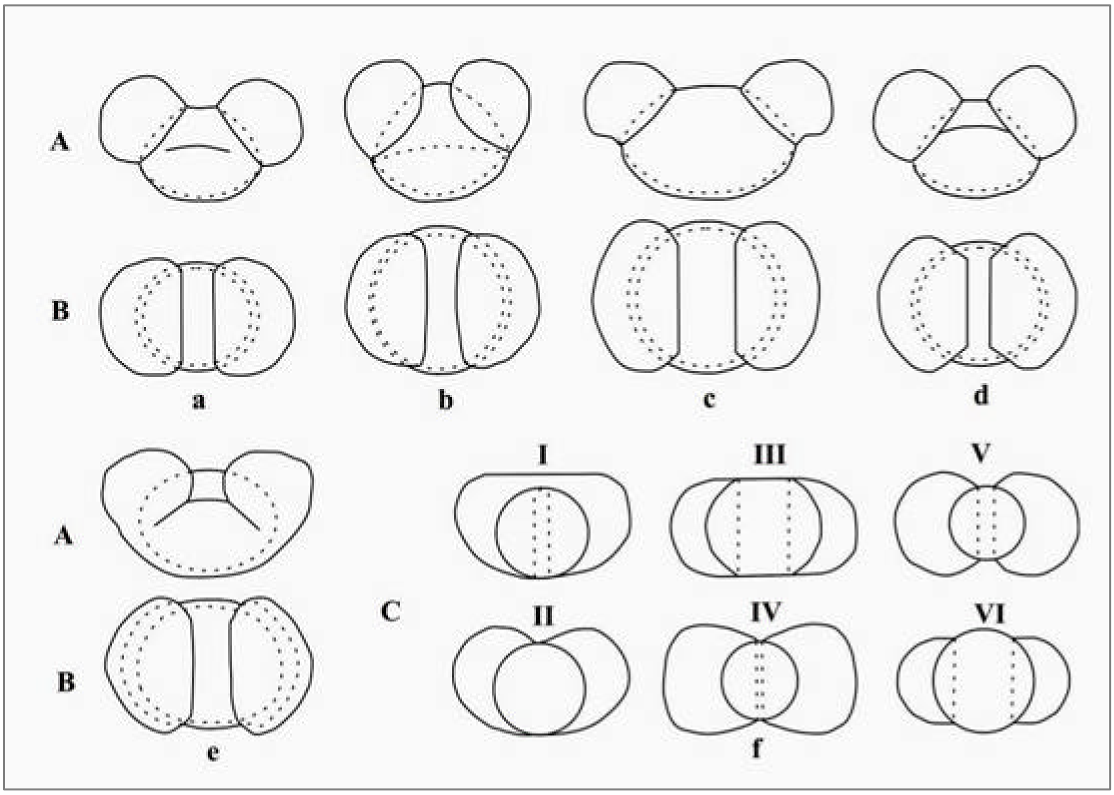


Figure 3.5 Sacci position in bisaccate pollen grains (Stuchlik et al., 2002). A-equatorial view. B-polar view, distal face; a, b-*Pinuspollenites*, *Piceapollenites*, *Piceapollis*, *Abietineaepollenites*, *Pinus*- type *hoploxylon* after Rudolph (1935); c, d-*Pinuspollenites*, *Abiespollenites*, *Keteleeriapollenites*, *Podocarpidites*, *Pinus*–type *silvestris* after Rudolph (1935); e-*Cedripites;* C-polar view, proximal face, f-*Cathayapollis;* I-VI schematic drawings of sacci position after Sivak (1976).

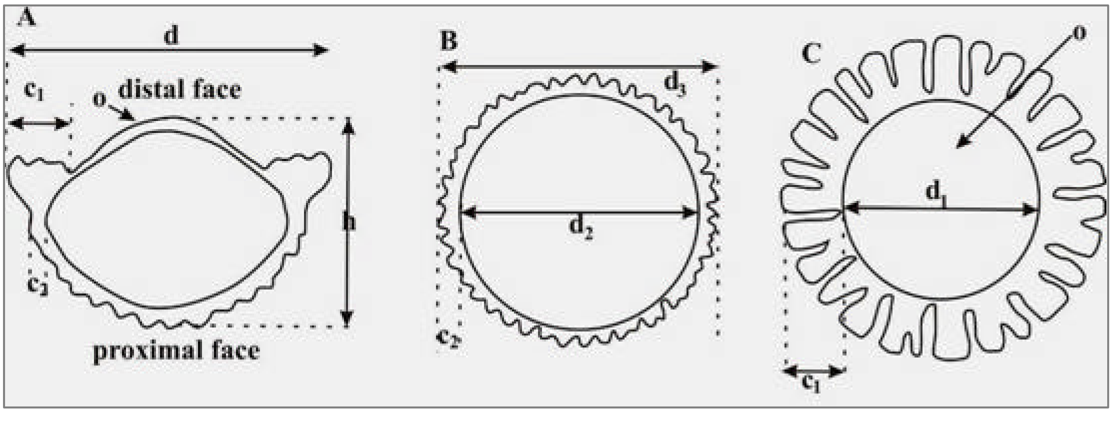


Figure 3.6 Measurements of morphological details in pollen grains with equatorial collar. A.Equatorial (lateral) view: d-total diameter; h- height of pollen grain (=lenght of polar axis): c_1-breadth of collar; o-operculum. B.Polar view, proximal face: d_2-inner diameter (without collar): d_3-outer diameter (with collar): c_2-breadth of collar. C.Polar view, distal face: o-operculum: d_1-diameter of operculum: c_1-breadth of collar (Stuchlik et al., 2002).

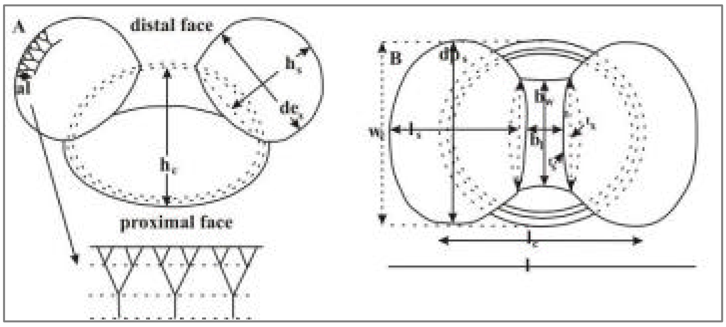


Figure 3.7 Measurements of morphological details in pollen grains: l-total lenght, l_c-lenght of corpus (equatorial diameter). A. Equatorial view: h_c-height of corpus (=lenght of polar axis). h_s:height of saccus; de_s-diameter of saccus: al-thickness of alveolar layer. B. Polar view, distal face: w_c- breadth of corpus: l_s-length of saccus: dp_s-breadth of saccus: t-attachment area (=area of the saccus/corpus fastening); t_x-attachment axis (=longer axis of the attachment area); t_s-attachment line (=line of saccus/corpus fastening): b_l-length of leptoma: b_w-braedth of leptoma (Stuchlik et al., 2002).

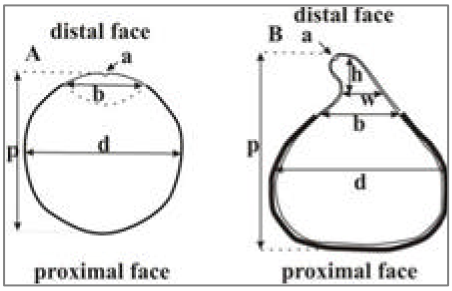


Figure 3.8 Measurements of morphological details in ‘inaperturate’ pollen grains–equatorial view. A. Pollen grain with leptoma: d-equatorial diameter: p-length of polar axis: b-breadth of leptoma: a-aperture. B. Pollen grain with papilla: d-equatorial diameter: p-length of polar axis: b-breadth of leptoma: w-breadth of papilla: h-heigth of papilla: a-aperture (Stuchlik et al., 2002).

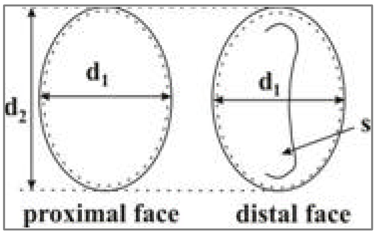


Figure 3.9 Measurements of morphological details of monosulcate pollen grains–polar view: d_1, d_2-equatorial diameters: s-sulcus.

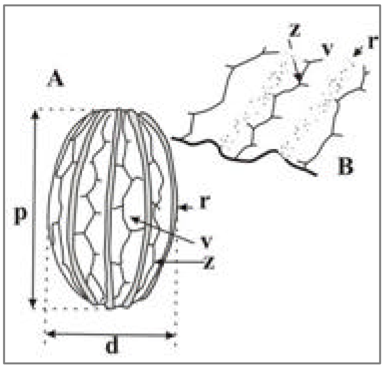


Figure 3.10 Morphological details and measurements of polyplicate pollen grains. A. Equatorial view: p - length of polar axis: d-equatorial diameter: v-valley: r-plica (ridge); z-zig-zag line on the bottom of valley. B. Part of surface v-valley: r-plica (ridge); z-zig-zag line on the bottom of valley (Stuchlik et al., 2002).

The stratigraphic ranges of the species have been given on the basis of previous Turkish, European and also other countries' literatures. Photos of palynomorphs for the Rupelian, Chattian, Burdigalian–Langhian and Serravallian times given in relate chapter.

3.2.1 Systematics of Palynomorphs

Sporites POTONIÉ 1893

Triletes (REINSCH 1881) IBRAHIM 1933

Azonotrilete Microspores

Genus: *Leiotriletes* (NAUMOVA 1937) POTONIÉ & KREMP 1954

(1) *Leiotriletes maxoides* KRUTZSCH 1962a ssp. *maximus*
(PGLUG *in* THOMSON & PFLUG 1953) KRUTZSCH 1962a
pl. (Atici Section) 1, fig. 3
pl. (Plant-Kultak) 7.1, figs. 9-15

1952	*Triradiato–sporites adriennis* (POTONIÉ) *maximus* PGLUG cf. *Lygodium*–MURRIGER & PFLUG, p. 57, 64, pl. 11, fig. 7.
1953	*Divisisporites maximus* (PGLUG) THOMSON & PFLUG, p. 52, pl. 1, figs. 57, 58.
1959	*Leiotriletes maximus* (PFLUG) KRUTZSCH, p. 57.
1962a	*Leiotriletes maxoides* (KRUTZSCH) *maximus* (PGLUG) KRUTZSCH, p. 20, pl. 3, figs. 1–4.

Size: 73–90µm.

Description: Trilete spores, in polar view triangular with convex sides and widely rounded corners, exine more than 3µm thick. Arms of leasura straight, reaching 2/3 of radius. Labrum indistinct.

Botanical Affinity: Family Lygodiaceae, the fossil spores are morphologically similar to spores of *Lygodium?*

General Occurrence*:* The species occurred from the Sparnacien to Miocene of the Dorog Basin (France) (Kedves, 1961). In Germany, late Egerian (Krutzsch, 1962a). Nakoman (1966a) also recorded the presence of species from the Eocene sediments of Yozgat–Sorgun area in Central Anatolia. The range of the species is from the Eocene to Miocene of the Thrace Basin (Nakoman, 1966b). Akyol (1971) reported its occurrence from the Early Oligocene of Sile–Istanbul. According to Ziembinska–Tworzydlo (1974), this psecies was recorded from the Late Oligocene and Early Miocene sediments of western Poland. Akyol (1980) mentions the species disappears after the upper most of "Middle" Oligocene in the Çorum–Bayat lignites. The species occurs in the Early Eocene and Early Miocene of the Upper Rhine Graben (Nickel, 1996a). Stuchlik et al. (2001) recorded from the Oligocene and Miocene sediments of Poland. Akgün (2002) reported the species from the Middle–?Late Eocene sediments of Çankiri and Çorum–Amasya areas. The species was also recorded from the Early–"Middle" Oligocene Tokça Formation by Akkiraz & Akgün (2005).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

(2) *Leiotriletes maxoides* KRUTZSCH 1962a ssp. *maxoides* KRUTZSCH 1962a
pl. (Atici Section) 1, figs. 4–11
pl. (Alakilise Section) 1, fig. 6

1953	*Lygodium– sporites adriennis* (POTONIÉ & GELLETICH) HUNGER, p. 10, pl. 1, fig 21.
1953	*Laevigatosporites pseudomaximus* (PFLUG & THOMSON) THOMSON & PFLUG, p. 54, pl. 2, fig. 21.
1961	*Leiotriletes dorogensis* (KEDVES) pl. 4, fig. 14.
1962a	*Leiotriletes maxoides maxoides* KRUTZSCH p. 18, pl. 2, figs. 1–5.

Size: 55–72µm.

Description: Spores trilete, amb triangular to rounded–triangular with broadly rounded apices. The trilete mark is in most cases clearly recognizable. Exine up to 1.5µm thick, arms of leasura straight reaching 2/3 of radius. Labrum distinct.

Botanical Affinity: Family Schizaeaceae; Genus probably *Lygodium*?

***General Occurrence**:* According to Krutzsch (1962a), this species occurs in the Middle and Late Oligocene and randomly in the Middle Miocene of Germany. According to Lenz (2000), range of this species is from the Middle Eocene to Miocene at Helmstedt in northern Germany. Nagy (1985) recorded from the Early and Middle Miocene sediments in Hungary. It was reported from the Middle–Late Oligocene of western Poland by Ziembinska–Tworzydlo (1974). The species found in the Ottnangian and Karpathian (the Early Miocene) and disappears in the younger sediments of Slovakia (Planderová, 1991). Stuchlik et al. (2001) recorded from the Middle Eocene to Middle Miocene of Poland.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(3) *Leiotriletes maxoides* KRUTZSCH 1962a ssp. *minoris* KRUTZSCH 1962a
pl. (Atici Section) 1, fig. 12
pl. (Alakilise Section) 1, figs. 4, 5
pl. (Karacaagaç Section) 6.19, fig. 16

1962a *Leiotriletes maxoides* KRUTZSCH ssp. *minoris* KRUTZSCH, p. 16, pl. 1, figs. 1–8.

Size: 45–55µm.

Description: Spores trilete, amb triangular to rounded–triangular with broadly rounded apices. The exine smooth. Arms of leasura reaching 2/3–4/5 of radius. Spore surface smooth or psilate.

Botanical Affinity: Family Schizaeaceae; Genus probably *Lygodium*?

General Occurrence*:* Krutzsch (1962a) found abundantly in the Late Oligocene and Early Miocene coal deposits of Germany. This species was described in the Egerian and Sarmatian (Oligocene–Miocene) of Hungary (Nagy, 1985). Stuchlik et al. (2001) recorded from the Late Oligocene to Pliocene of Poland.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation. Middle Miocene Sekköy formation.

(4) *Leiotriletes microadriennis* KRUTZSCH 1959a

1959 *Leiotriletes microadriennis* KRUTZSCH, p. 61, pl. 1, figs. 3–7.

Size: 30–40µm.

Description: Trilete spore with a triangular to roundish figure. Arms of leasura straight, reaching 2/3 to 4/5 of radius. Exine is about 1µm thick. Laevigate.

Botanical rank: Family Schizaeaceae; Genus probably *Lygodium*?

General occurrence: Sittler (1965) recorded it from Early–"Middle" Oligocene of France. Nakoman (1966a) recorded the species in Eocene sediments of Yozgat–Sorgun area. Nakoman (1966b) mentions the occurrences of species may be observed up to Oligocene of the Thrace Basin. According to Krutzsch & Vanhoorne (1977), it occurs from Late Palaeocene to Late Eocene in Belgium. Nickel (1996a) mentions occurrences in the Rhine Graben from Late Palaeocene to Late Eocene. It was also recorded from Middle Miocene sediments of the Büyük Menderes Graben by Akgün & Akyol (1999). Akgün et al. (2000) illustrated the species from the Late Miocene Incesu Formation of Central Anatolia. Akgün & Sözbilir (2001) reported it from the Oligocene sediments of western Anatolian molasse basins (Kale–Tavas). Akgün (2002) and Akgün et al. (2002) indicate the presence of the species from Middle–?Late Eocene sediments in the Çankiri Basin.

Occurrence in Ören Basin: Early–Middle Miocene Belen member in the Kultak formation.

Palaeofloristical element: Cosmopolitan

(5) *Leiotriletes triangulus* (MURRIGER & PFLUG 1952 ex KRUTZSCH 1959A) KRUTZSCH 1962a

pl. 2, figs. 5–7
pl. (Plant-Kultak) 7.1, fig. 16

1952	*Triradiato-sporites neddeni* POTONIÉ ssp. *triangulus* (PFLUG) MURRIGER & PFLUG, p. 57,pl. 2, fig. 5.
1953	*Concavisporites obtusangulus* POTONIÉ *minor* (PFLUG) THOMSON & PFLUG, pl. 1, fig. 40.

1959	*Toroisporis* (*Toroisporis*) *triangulus* MURRIGER & PFLUG ex KRUTZSCH, p. 91, 92.
1962a	*Leiotriletes triangulus* (MURRIGER & PFLUG ex KRUTZSCH) n. comb. KRUTZSCH, p. 24, pl. 5, figs. 11–17.

Size: 26–40µm.

Description: Spores trilete, amb triangular with slightly convex sides, exine thicker than 1µm. Leasure arms reaching nearly a half of radius.

Botanical Affinity: Family Schizaeaceae; Genus probably *Lygodium*?

General Occurrence: The species occurs in the Early–Middle Miocene and ?Pliocene sediments of Germany (Krutzsch, 1962a). It was recorded from the "Middle" Oligocene sediments of western Poland by Ziembinska–Tworzydlo (1974). According to Nickel (1996a), it ranges from the "Middle" Oligocene to Miocene of the Upper Rhine Graben. It was also observed from the Middle Eocene of Messel (Thiele–Pfeiffer, 1988).

Palaeofloristical Element: Cosmopolitan

Occurrence in Ören Basin: Early–Middle Miocene Belen member in the Kultak formation.

(6) *Leiotriletes* sp. 1

pl. (Atici Section) 1, fig. 13
pl. (Plant-Kultak) 7.1, figs. 7, 8

Size: 33µm.

Description: Spores trilete, amb triangular with strongly concave sides and rounded apices. Leasura arms straight, reaching 3/4 length of spore radius.

Remarks: Only a few grains have been found and are similar to *Leiotriletes maxoides minoris* Krutzsch 1962a, but seem to differ in having trilet mark thickening located in the vicinity.

Botanical Affinity: ?Schizaeaceae

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

Genus: *Polypodiaceoisporites* POTONIÉ 1951 ex POTONIÉ 1956
Generotype: *Polypodiaceoisporites specious* POTONIÉ 1934 ex POTONIÉ 1956

(7) *Polypodiaceoisporites corrutoratus* NAGY 1985
pl. (K–Section) 1, fig. 11

1985	*Polypodiaceoisporites corrutoratus* NAGY, p. 96, pl. 27, figs. 14–16, pl. 28, figs. 1–6.
1990	*Polypodiaceoisporites corrutoratus* NAGY ssp. *corrutoratus* PLANDEROVÁ, p. 29, pl. 18, figs. 6, 7.
1996	*Pteridacidites variabilis* STUCHLIK, p. 18, 19, pl. 11, fig. 2.
1998	*Cingulisporis corrutoratus* (NAGY) WAZYNSKA; SLODKOWSKA, pl. 5, fig. 12.

Size: 37–55µm.

Description: Spores trilete, amb triangular with straight or slightly concave sides and rounded apices. Cingulum nearly of uniform breadth, up to 6µm wide, with slightly undulate margin, occasionally narrowing at the apices. Exine about 1µm thick (without sculpture elements). Laesura arms up to 4/5 length of the spore radius, accompanied by rugulae forming a scalloped border along them. On the distal face the rugulae are almost flat, forming a rugulate pattern. Surface of the cingulum psilate.

Botanical Affinity: Pteridaceae. Morphologicallay, these fossil spores are similar to spores of the recent *Pteris*.

General Occurrence: Nagy (1995) sporodicaly recorded in the Late Oligocene and Early Miocene (south–western Poland). Stuchlik et. al. (2001) reported in the Oligocene–Early Miocene.

Palaeofloristical Element: Palaeotropical/Arctotertiary (warm–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Neogenisporis* KRUTZSCH 1962a

Generotype : *Neogenisporis neogenicus* KRUTZSCH 1962a

(8) *Neogenisporis plicatoides* KRUTZSCH 1962a

pl. (K–Section) 1, fig. 11

1962a *Neogenisporis plicatoides* KRUTZSCH. p. 90, pl. 38. figs, 6-10.

1993 *Neogenisporis plicatoides* (KRUTZSCH) KOHLMAN-ADAMSKA, p. 104, pl. 5, fig. 2.

Size: 35-45µm.

Decription: Spores trilete, amb triangular with concave sides and sharply angled ovigal apices. Exine composed of two layers. 4.5µm thick on the sides, thinner (up to 2. 5µm) on the apiccs, surface psilate. Laesura arms straight reaching the equator. On the side well developes torus-like structure with exine folds reaching to the apices.

Botanical Affinity: Gleicheniaceae**.**

General Occurrence: Stuchlik et al. (2001) mention occurrences from the Miocene to Pliocene in Northern and northwestern Poland.

Palaeofloristical Element: Paleotropical (tropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Punctatisporites* IBRAHIM, 1933

Type Species: *Punctatisporites crassiexinus* KRUTZSCH, 1962a

(9) *Punctatisporites* sp.

Size: 68–72µm.

Description: A trilete spore of round shape. The ornamentation of exine is dense fine–punctate. The Y–mark extends to2/3, 3/4 of the spore.

Botanical Affinity: Pteridaceae–*Pteridophyta*

General Occurrence: Krutzsch (1967a) mentions occurrences of the species in Eocene of Germany. Ashraf & Mosbrugger (1995) reported the species in the early Middle Miocene. Akgün & Akyol (1999) recorded from the Middle Miocene sediments in western Anatolia.

Palaeofloristical Element: Palaeotropical/Arctotertiary (warm–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Baculatisporites* THOMSON & PFLUG 1953

Generotype: *Baculatisporites primarius* (WOLFF 1934) THOMSON & PFLUG 1953

(10) *Baculatisporites primarius* (WOLFF 1934) THOMSON & PFLUG 1953

pl. (K–Section) 1, figs. 13–17
pl. (Alakilise Section) 1, fig. 9
pl. (Karacaagaç Section) 6.19, figs. 1–5
pl. (Plant-Kultak) 7.1, fig. 17

1934	*Sporites primarius* WOLFF, p. 66, pl. 5, fig. 8.
1953	*Baculatisporites primarius* (WOLFF) PFLUG & THOMSON in THOMSON & PFLUG, p. 56, pl. 2, fig. 51.
1954a	*Sporites primarius* WOLFF, p. 49, figs. 36–39.
1959a	*Baculatisporites nanus* (WOLFF) KRUTZSCH, p.140.
1964	*Osmunda claytoniana* STUCHLIK, p. 15, figs 2–4. non figs 5, 6.
1967	*Baculatisporites primarius* (WOLFF) THOMSON & PFLUG; KRUTZSCH, p. 54.
1967	*Baculatisporites primarius primarius* KRUTZSCH, p. 54, pl. 9, figs. 1–12.
1967	*Baculatisporites primarius crassiprimarius* KRUTZSCH, p. 58, pl. 11, figs. 1–7.

1967	*Baculatisporites primarius oligocaenicus* KRUTZSCH, p. 60, pl. 13, figs. 7–12.
1967	*Baculatisporites primarius semiprimarius* KRUTZSCH, p. 60, pl. 13, figs. 1–12.
1985	*Osmundacidites primarius* (WOLFF) NAGY *primarius* NAGY, p. 74, pl. 12, figs. 5, 6.
1994	*Osmundacidites primarius* (WOLFF) NAGY; ZIEMBINSKA–TWORZYDLO et al., pl. 4, fig. 7.

Size: 40–70µm.

Description: Spores trilete, amb nearly circular. Exine (without sculpture elements) less than 1µm thick. Laesura arms straight, thin, reaching ½ of the spore radius. Surface baculate, bacula of varius shape and size (up to 2µm high and diameter 1.5–2.5µm at base). Dense spaced, sharp or flat on their tops.

Botanical Affinity: Osmundaceae/*Osmunda*.

General Occurrence: Krutzsch (1967a) mentions occurrences from the Miocene to Upper Pliocene in Germany. Planderová (1991) mentions occurrences of the species in the Ottnangian–Karpatian (the Early Miocene) of Slovak, Central Paratethys. Ashraf & Mosbrugger (1995) and Mohr (1984) reported the species from the Eocene to Pliocene. Thiele–Pfeiffer (1980) mentions occurrences of the Late Eocene–Pliocene.

Palaeofloristical Element: Palaeotropical and Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

(11) *Baculatisporites primarius* (WOLFF 1934) THOMSON & PFLUG 1953 ssp. *oligocaenicus* KRUTZSCH 1967a

pl. (K–Section) 1, figs. 18–24

1934	*Sporites primarius* WOLFF, p. 66, pl. 5, fig. 8.
1953	*Baculatisporites primarius* (WOLFF) THOMSON & PFLUG, p. 56, pl. 2, figs. 49–53.
1955	*Baculatisporites primarius* (WOLFF) MURRIGER & PFLANZL, pl. 6, fig. 19.
1967	*Baculatisporites primarius oligocaenicus* KRUTZSCH, p. 60, pl. 13, figs. 7–12.

Size: 65–70µm.

Description: Spores trilete, amb nearly circular. Leasura arms straight, reaching 1/2of the spore radius, bacula of various shape and size (up to 2µm high), densely placed.

Botanical Affinity: Family Osmundaceae; Genus *Osmunda*.

General Occurrence: Krutzsch (1967a) reported the species from the Late Eocene to Early Miocene in Germany. Hochuli (1978) found in the Oligocene sediments from the Western Paratethys. According to Stuchlik et al. (2001), the range of species is between the Late Oligocene and Pliocene in Poland. Akgün (2002) defined this species from the Middle–?Late Eocene sediments of Çorum–Amasya area.

Palaeofloristical Element: Palaeotropical–Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(12) *Baculatisporites nanus* (WOLFE 1934) KRUTZSCH 1959a

pl. (K–Section) 1, figs. 9–10

1934 *Sporites nanus* WOLFF, p. 66–67, pl. 5, fig. 9.
1959 *Baculatisporites nanus* (WOLFF) KRUTZSCH, p. 140.

Size: 30–42µm.

Description: Spores trilete, amb circular. Leasura arms straight. Surface covered by densely placed bacula up to 1.5µm high and 1.5µm at their bases.

Botanical Affinity: Family Osmundaceae; Genus *Osmunda*.

General Occurrence: In Germany, the species occurs from the "Middle" Oligocene to Pliocene (Krutzsch, 1967a). In the Carpathians the species occurs in the entire Miocene and Pliocene (Planderová, 1991). According to Ashraf & Mosbrugger (1995), the species was recorded from the "Middle" Oligocene and Pliocene sediments of Lower Rhine Embayment. Stratigraphic distribution of species was accepted from the Late Oligocene to Pliocene by Stuchlik et al. (2001).

Palaeofloristical Element: Palaeotropical–Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(13) *Baculatisporites* sp.
pl. (K–Section) 1, fig. 12

Size: 41µm.

Description: Spore trilete, amb circular. Leasura arms straight. Spore surface densely placed bacula up to 2µm high.

Remarks: The specimen differs from the *Baculatisporites nanus* Krutzsch 1967a in having scarce ornaments.

Botanical Affinity: Family probably Osmundaceae?

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus*:* *Laevigatosporites* IBRAHIM, 1933
Type Species: *Laevigatosporites vulgaris* (IBRAHIM, 1932) IBRAHIM, 1933

(14) *Laevigatosporites gracilis* WILSON & WEBSTER 1946

1946 *Laevigato-sporites gracilis* WILSON & WEBSTER, p. 273–274, fig. 4.

Size: 22–30 X 18–20µm.

Description: Spores monolete, outline in equatorial view bean shaped. Amb almost ellipsoidal. Leasura about 15µm. Spore surface psilate.

Botanical rank: Family Polypodiaceae

General occurrence: The range of species is between the Early Oligocene to Early Pleistocene of Middle Europe (Krutzsch, 1967a). According to Planderová (1991), the species frequently occurred in the Miocene sediments. The range of species is accepted between the Early Oligocene and Pliocene by Stuchlik et al. (2001). It was recorded from the Late Oligocene–Early Miocene sediments of southwest Anatolian molasse deposits by Akgün & Sözbilir (2001). Akgün (2002) also determined the species from Middle–Late Eocene sediments of Çorum–Amasya area.

Occurrence in Ören Basin: Early–Middle Miocene Kultak member in the Kultak formation

Palaeofloristical element: Arctotertiary

(15) *Laevigatosporites haardti* (POTONIÉ & VENITZ 1934)
THOMSON & PFLUG 1953
pl. (K–Seciton) 1, fig. 8,
pl. (Kultak Seciton) 1, figs. 1–6
pl. (Alakilise Section) 1, fig. 1.
pl. (Karacaagaç Section) 6.19, figs. 6–15
pl. (Plant-Kultak) 7.1, figs. 1–4

1934	*Sporites haardti* POTONIÉ & VENITZ, p. 13, pl. 1, fig 13.
1953	*Laevigatosporites haardti* (POTONIÉ & VENITZ) THOMSON & PFLUG, p. 59, pl. 3, figs. 27–38.

Size: 32–41X 21–26µm.

Description: Spores monolete, outline in equatorial view bean shaped. Amb nearly ellipsoidal. Leasura about 23–25µm. Spore surface psilate or laevigate.

Botanical Affinity: Family Polypodiaceae.

General Occurrence: Ashraf & Mosbrugger (1995) mention occurrences from the Paleocene to Pliocene. Thiele–Pfeiffer (1980), Krutzsch (1967a) and Mohr (1984) mention occurrence of the species in the Tertiary. Thomson & Pflug (1953) mention that the species is observed from the Paleocene to Miocene of Germany. According to Nakoman (1966a) the species may be present from the Lower Lias to Tertiary of Thrace Basin. Nakoman (1966b) found the species in the Eocene of Yozgat (Sorgun) area. The species was recorded from the Eocene, Oligocene and Miocene sediments of Turkey (e.g. Nakoman, 1964; Akyol, 1980; Akgün & Akyol, 1999; Akgün & Sözbilir 2001; Akgün 2002; Sancay et al., 2006, Kayseri & Akgün, 2008)

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation. Middle Miocene Sekköy formation.

Genus: *Verrucatosporites* THOMSON & PFLUG 1953
Generotype: *Verrucatosporites alienus* (POTONIÉ 1931d)
THOMSON & PFLUG 1953

(16) *Verrucatosporites favus* (POTONIÉ 1931c) THOMSON & PFLUG 1953
pl. (Atici Section) 1, figs. 1, 2
pl. (K–Section) 1, figs. 3–5.
pl. (Alakilise Section) 1, figs. 2, 3
pl. (Plant-Kultak) 7.1, figs. 5, 6

1931c	*Polypodii(?) sporonites favus* POTONIÉ, p. 556, fig. 3.
1953	*Verrucatosporites* (*Polypodiispor.*) *favus* (POTONIÉ) THOMSON & PFLUG, p. 60, pl. 3, figs.52–55; pl. 4, figs. 1–4.

Size: 41–58 X 25–30µm.

Description: Spores monolete, outline in equatorial view bean shaped. Amb nearly ellipsoidal. Exine 2.5µm thick. Leasura up to 35–40µm. Spore surface spaced by flat verrucae about 3–5µm in diameter and about 3µm high.

Botanical Affinity: Family Dennstaedtiaceae; Genus *Paesia*.

General Occurrence: Nakoman (1966a) recorded the species in the Eocene sediments of Sorgun lignites. Krutzsch (1967a) mentions occurrences of the species in the Middle

Eocene–Pliocene of Middle Europe. Akyol (1971) found the species in the Early Oligocene sediments of Sile–Istanbul (Turkey). Akyol (1980) also mentions that the species may be observed in the Early Miocene sediments of Bayat lignites. Akgün (2002) and Akgün et al. (2002) indicate the presence of species from the Middle–?Late Eocene sediments of the Çankiri Basin. The species was also determined in the Late Oligocene and Miocene sediments of southwest Anatolian mollase basins by Akgün & Sözbilir (2001).

Palaeofloristical Element: Palaeotropical–Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

(17) *Verrucatosporites alienus* (POTONIÉ 1931c) THOMSON & PFLUG 1953
pl. (K–Section) 1, figs. 5, 6.

1931c	*Sporites alienus* POTONIÉ, p. 556
1953	*Verrucatosporites alienus* (POTONIÉ) THOMSON & PFLUG, p.60, pl. 3, figs. 47–48.

Size: 42–57 X 30–33 µm.

Description: Spores monolete, outline in equatorial view bean shaped. Amb nearly ellipsoidal. Exine about 2µm. Spore surface covered with verrucae about 5–6µm in diameter and 3–4µm high.

Botanical Affinity: Family Davalliaceae.

General Occurrence: Nakoman (1966a) reported the species in the Eocene of Sorgun lignites. According to Nakoman (1996b), the species is present from the Middle Eocene to Early Miocene in the Thrace Basin. Krutzsch (1967a) determines the presence of species from the Late Eocene to Miocene of Europe. Akyol (1971) indicates the presence of species in the Early Oligocene of Istanbul–Sile. Akgün et al. (2002) recorded the species from the Middle–?Late Eocene sediments of the Çankiri Basin.

Palaeofloristical Element: Palaeotropical (subtropical)

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(18) *Verrucatosporites* sp.
pl. (K–Section) 1, fig. 1.

Size: 38µm.

Description: Small monolete spore. Spore surface covered with small verrucae but not dense.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Pollenites POTONIÉ 1931c
Saccites ERDTMAN 1947
Genus: *Podocarpidites* COOKSON 1947 ex COUPER 1953
Generotype: *Podocarpidites ellipticus* COOKSON 1947

(19) *Podocarpidites libellus* (POTONIÉ 1931c) KRUTZSCH 1971
pl. (Karacaagaç Section) 6.20, fig. 10

1931c	*Pinispollenites libellus* POTONIÉ, p. 5, text figure 33.
1971	*Podocarpidites libellus* (POTONIÉ) KRUTZSCH, p. 128, text figure 1–22.

Size: Length: 45µm and width: 30µm.

Description: Pollen grains bisaccate, corpus nearly circular. Sacci nearly circular in outline, double as big as corpus. Surface of sacci smooth, exine infrastucture alveolate.

Botanical Affinity: Family Podocarpaceae, Genus *Podocarpus*.

General Occurrence: Nakoman (1966a) mentions the occurrences of the species in the Tertiary of Thrace Basin. Krutzsch (1971) observed that the species from the Middle

Oligocene to Miocene of the Middle Europe. In the Early Miocene and sporadical in the Late Miocene (Nagy, 1985). In the Slovakia, the species occurred in the Middle and Late Miocene and Pliocene (Planderová, 1991). According to Stuchlik et al. (2002), the range of species is between the Palaeogene and Middle Miocene of Poland. The species was described from the Middle Miocene sediments of the Büyük Menderes Graben by Akgün & Akyol (1999).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

Genus: *Piceapollis* KRUTZSCH 1971

Generotype: *Piceapollis praemarianus* KRUTZSCH 1971

(20) *Piceapollis planoides* (KRUTZSCH 1971) ex HOCHULI 1978

1949	*Picea:* KREMP, p. 61, pl. 4, fig, 18
1956a	*Picea:* DOKTOROWICZ-HREBNICKA, p. 97, pl. 15, figs, 2, 5.
1971	*Piceapollis planoides* (=? *Picea planoides* n. sp) KRUTZSCH, p. 110, 111, pl. 25, figs 1-4
1978	*Piceapollis planoides* (KRUTZSCH) HOCHULI p. 67, pl. 8, fig. 2.

Size: 92-113µm.

Description: Pollen grains bisaccate. In polar view amb nearly even, corpus, ellipsoidal to circular. The attachment line of sacci straight or slightly concave, axis 45-47µm long. Leeptoma 12µm long and 40µm broad. In equatorial view outline of pollen grains uniform, corpus fan-shaped with slightly convex proximal face, 78-82µm long and 50-60µm high. Proximal surface smooth, exine up to 2 µm thick, infrabaculate. Sacci obliquely arranged, semicircular in outline, 47-53µm in diameter and 34-37µm high. Surface sacci nearly smooth, exine structure alveolar. Alveolate at the marginal part densely spaced, 1µm in diameter, in deeper part polygonal, mostly closed up to 3µm in diameter.

General Occurrence: According to Stuchick et al. (2002) this species recorded all over the Poland (Early Miocene–Early Pliocene).

Botanical Affinity: *Picea*

Palaeofloristical Element: Arctotertiary (warm–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(21) *Piceapollis tobolicus* (PANOVA 1966) KRUTZSCH 1971

pl. (Atici Section) 1, figs. 16, 17

1961	*Picea:* ROMANOWICZ, p. 337, pl. 8, fig, 53b
1964	*Picea* forma *miranda* p. 37, 38, pl. 31, fig. 194.
1964	*Picea* sp., *Pityosporites alatus* (POTONIÉ) THOMSON & PFLUG: STUCHLIK, p. 25, 26, pl. 9, figs. 1,2.
1966	*Picea tobolica* PANOVA, p. 220, pl. 105, fig. 5.
1969	*Piceapollenites neogenicus* NAGY, p.147, pl. 32, fig. 1.
1971	*Piceapollis tobolicus* (PANOVA) (= *Picea tobolica* PANOVA) KRUTZCSH, p. 104, pl. 22, figs 1–3, tab. 5/28.
1974	*Abiespollenites maximus* (KRUTZSCH) ZIEMBINSKA–TWORZYDLO, p. 349, pl. 11, fig. 2.
1984	*Picea;* SADOWSKA in JAHN et al., pl. 6, figs. 14, 15.
1985	*Piceapollis tobolicus* (PANOVA) 70, fig. 1.
1994	*Piceapollis tobolicus* (PANOVA) KRUTZSCH; ZIEMBINSKA–TWORZYDLO et al., pl. 7, fig. 2.
1996	*Piceapollis tobolicus* (PANOVA) KRUTZSCH; ZIEMBINSKA–TWORZYDLO, p. 822, pl. 273, fig. 1.
1998	*Piceapollis tobolicus* (PANOVA) KRUTZSCH; SLODKOWSKA, pl. 13, fig. 19.

Size: 120–176µm.

Description: In polar view amb uniform, ellipsoidal and corpus ellipsoidal. In equatorial view outline of pollen grain nearly uniform. Corpus ellipsoidal, 90–100µm high. Proximal surface nearly smooth. Exine up to 3µm thick, infrabaculate. Sacci semicircular in outline. 90–180µm in diameter and 50–65µm high. The attachment line often arcuate, axis 76–100µm long, mostly shorter than the diameter of sacci. Surface of sacci smooth, exine infrastructure alveolate. Alveolar layer up to 3µm thick. Alveolae at the marginal part of saccus samaller, irregularly polygonal, not always closed, densely spaced, in deeper part bigger, polygonal and radially elongate up to 6µm long.

General Occurrence: According to Stuchick et al. (2002) this species recorded all over the Poland (Early Miocene–Pliocene).

Botanical Affinity: *Picea*

Palaeofloristical Element: Arctotertiary (cool–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(22) *Piceapollenites alatus* (POTONIÉ 1931 ex POTONIÉ 1958)
pl. (Atici Section) 2, figs. 3, 4.

1931a	*Piceae–pollenites alatus* POTONIÉ, p. 27, pl. 2, fig. v 70a.
1949	*Pinus hoploxylon* (RUDOLPH) KREMP, p. 60, pl. 4, fig. 21.
1953	*Pityosporites alatus* (POTONIÉ) THOMSON & PFLUG, p. 68.
1956b	*Pinus hoploxylon*–type RUDOLPH (*Picea*?–*Pollenites alatus* POTONIÉ) pl. 27, fig. 3.
1956c	*Picea–Pollenites alatus* (POTONIÉ) pl. 29, fig. 8.
1958	*Piceapollenites alatus* (POTONIÉ) POTONIÉ, p. 64, pl. 8. figs. 80, 81.
1964	*Pinus hoploxylon* RUDOLPH type, *Pityosporites microalatus* (POTONIÉ) THOMSON & PFLUG f. major (POTONIÉ) THOMSON & PFLUG; STUCHLICK, p. 27, pl. 9, figs. 12, 13.
1971	*Pityosporites alatus* (POTONIÉ) THOMSON & PFLUG; KRUTZSCH, p. 51, pl. 6, figs. 1–10.

1985 *Piceapollenites alatus* (POTONIÉ) THIERGART: NAGY, p. 137, pl. 68, fig. 3.
1990 *Pinuspollenites* cf. *alatus* (THOMSON & PFLUG) PLANDEROVÁ p. 43, pl. 34, figs. 7, 8.

Size: 70–80µm.

Description: In polar view amb more or less uniform. Corpus ellipsoidal to broadly ellipsoidal 32–65µm long and 50–55µm broad. Proximal surface smooth, slightly undulate, exine 2.5 thick, infrabaculate. Outline of sacci semicircular. 50–55 broad, equal or somewhat greater than the breadth of the corpus. The attachment line striaght. Occasionally slightly concave. Axis 45–50µm long always shorter than the breadth of corpus in the attachment area. Leptoma 10µm long, Smooth surface of sacci smooth, exine infrastructure alveolate. Alveolar layer up to 4µm thick. Alveolae at the marginal part densely spaced up to 1µm in diameter, in the area of attachment alveolae smaller muri up to 1µm thick.

General Occurrence: Thomson & Pflug (1953) recorded the species in the Miocene–Pliocene. Planderová (1991) mentions occurrences in the Miocene of Slovakia. Stuchlik et al. (2002) recorded all over the coal bearing sediments in Poland (Miocene).

Botanical Affinity: Pinaceae.

Palaeofloristical Element: Palaeotropical and Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Middle Miocene Sekköy formation.

Genus : *Pityosporites* SEWARD 1914
Generotype : *Pityosporites antarcticus* SEWARD 1914

(23) *Pityosporites microalatus* (POTONIÉ 1931b) THOMSON & PFLUG 1953
pl. (K–Section) 2, figs. 6–9
pl. (Kultak Seciton) 1, figs. 8, 10
pl. (Karacaagaç Section) 6.20, figs. 8, 9
pl. (Plant-Kultak) 7.1, figs. 19-21

1931b *Piceaepollenites microalatus* POTONIÉ, p. 5, text figure 34.pp

1953 *Pityosporites microalatus* (POTONIÉ) THOMSON & PFLUG, p. 67, pl. 5, figs. 47, 49, 51,57.

Size: Length: 50–82µm and width: 42–54µm.

Description: Pollen grains bisaccate, corpus rounded rhomboid in outline. Sacci nearly circular in outline. Surface of sacci reticulate.

Botanical Affinity: Family Pinaceae; Genus *Pinus* "haploxylon" type.

General Occurrence: Thomson & Pflug (1953); Hochuli (1978); Mohr (1984); the species occurs from the Eocene to Pliocene of the Middle–East Europe. Nakoman (1966b) indicates that the species occurs from the lower Lias to all Tertiary of Thrace Basin. Akyol (1971) reported the species in the Early Oligocene of Sile–Istanbul. Frederiksen (1980) recorded the species in the Eocene of North America. Chateauneuf, (1980) mentions that the species was located in the Late Eocene–Middle Oligocene of France. According to Stuchlik et al. (2002), the species takes place from the Cretaceous to Pliocene of Poland. The species was determined from the Eocene, Oligocene and Miocene basins of Turkey (e.g. Bati, 1996; Akgün & Akyol, 1999; Akgün & Sözbilir, 2001; Akgün, 2002; Akgün et al., 2002; Sancay et al., 2006, Kayseri & Akgün, 2008).

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation.

(24) *Pityosporites labdacus* (POTONIÉ 1931c) THOMSON & PFLUG 1953

pl. (Atici Section) 2, fig. 5,
pl. (K–Section) 2, fig. 5
pl. (Karacaagaç Section) 6.20, figs. 2–5
pl. (Plant-Kultak) 7.1, figs. 22-27

1931c *Pollenites labdacus* POTONIÉ, p. 3, text figure 32.

1953 *Pityosporites labdacus* (POTONIÉ) THOMSON & PFLUG, p. 68, pl. 5, figs. 60–61.

Size: Length 57–85µm and width: 22–44µm.

Description: Pollen grains bisaccate, corpus in outline ellipsoidal, sometimes more circular. In equatorial view outline of pollen grain tripartite with convex proximal face. Sacci nearly circular in outline and somewhat narrower than the breadth of corpus.

Botanical Affinity: Family Pinaceae; Genus *Pinus* "sylvestris" type.

General Occurrence: Thomson & Pflug (1953) mention the species from Eocene to Pleistocene of the Middle Europe. According to Krutzsch (1971) the species mentions occurrences in the Miocene–Pliocene. The species was recorded from the Oligocene and Miocene in all profiles, sometimes rich by Ziembinska–Tworzydlo (1974). Hochuli (1978) reported the species in the Late Oligocene sediments of Germany. The species was recorded from the Middle Miocene sediments of the Büyük Menderes Graben (Akgün & Akyol, 1999). According to Stuchlik et al. (2002), the species is present all Tertiary of Poland. The species was described from the Oligocene and Miocene sediments of the Kars–Erzurum–Mus sub–basins by Sancay et al. (2006).

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation.

(25) *Pinuspollenites macroinsignis* (KRUTZSCH 1971 ex OLLIVIER–PIERRE 1980)
PLANDEROVÁ 1991
pl. (Atici Section) 2, fig. 2
pl. (K–Section) 2, fig. 4
pl. (Kultak Seciton) 1, fig. 9
pl. (Alakilise Section) 1, figs. 10–15
pl. (Karacaagaç Section) 6.20, fig. 6

1953	*Pinus insignis* (NAUMOVA) (=*Oedemosaccus insignis* NAUMOVA ex BOLKHOVITINA), p. 85, pl. 13, figs. 1–3.
1971	*Pityosporites macroinsignis* (= *Pinus macroinsignis* n. sp.) KRUTZSCH, p. 62, pl. 6, figs 7–13.
1980	*Pinuspollenites macroinsignis* (KRUTZCH) OLLIVIER–PIERRE, pl. 10, fig.6.
1990	*Pinuspollenites macroinsignis* (KRUTZCH) PLANDEROVÁ, p. 44, pl. 35, figs. 1–5.

Size: 53–75µm.

Description: In polar view amb tripartite, corpus ellipsoidal 45–51µm long and 40–48µm borad. Surface of the proximal face verucate. Verrucae often fused together, exine 1.5–2.0µm thick. Infrabaculate. Sacci semicircular in outline, 35–42µm in diameter. Smaller than the breadth of the corpus. The attachment line straight, axis 22–28µm long. Leptoma smooth, exine infrastructure alveolate, alveolar layer about 4µm thick. Alveolae at the marginal part small. Densely spaced, in deeper part polygonal, up to 3µm in diameter. Diminishing towards the attachment of the sacci. Muri straight.

General Occurrence: Stuchlik et al. (2002) recorded from the Cretaceous–Pliocene sediments in Europe. The species was described from the Oligocene and Miocene sediments in Turkey (Sancay et al., 2006 and Kayseri & Akgün, 2008).

Botanical Affinity: *Pinus*.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation.

(26) *Pityosporites* spp.
pl. (K–Section) 2, figs. 11–13, pl. (K–Section) 3, figs. 1–3,
pl. (Kultak Seciton) 1, fig. 7
pl. (Atici Section) 2, fig. 1
pl. (Alakilise Section) 1, figs. 16–18, pl. (Alakilise Section) 2, figs 2–5

pl. 6.19 (Karacaagaç Section), figs. 22–30

Size: Length: 50–62µm and width: 30–45µm.

Description: Pollen grains bisaccate, in equatorial and polar view outline of pollen grains ellipsoidal. Surface of exine covered by densely spaced granulate and verrucate.

Remarks: The specimens obtained belong to morphologically to the genus *Pityosporites*, but are not described this specific epithet.

Botanical Affinity: Family probably Pinaceae?

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation.

Genus: *Keteleeriapollenites* NAGY 1969

Generotype: *Keteleeriapollenites komloënsis* NAGY 1969

(27) *Keteleeriapollenites dubius* (KHLONOVA 1960) SLODKOWSKA in
ZIEMBINSKA–TWORZYDLO et al. 1994
pl. (Atici Section) 1, fig. 14

1957a	*Keteleeria*, p. 98, pl. 17, figs 1, 3.
1960	*Keteleeria dubia* KHLONOVA, p. 59, pl. 9, fig. 5.
1964	*Pinus silvestris*– type Rudloph forma *gracilis similis*, p. 32, 33, pl. 19, fig. 115.
1964	*Abies* forma *alta*, p. 36, 37, pl. 25, fig. 166.
1971	*Abiespollenites dubius* (KHLONOVA) (= ? *Keteleeria dubia* KHLONOVA) KRUTZSCH, p. 98, pl. 21, figs. 1–10.
1974	*Abiespollenites dubius* (KHLONOVA) KRUTZSCH; ZIEMBINSKA–TWORZYDLO, p. 349, 350, pl. 10. fig. 2.
1993	*Keteleeria* Carr.–type, *Abiespollenites dubius* (KHLONOVA) KRUTZSCH; KOHLMAN–ADAMSKA, p. 111, pl. 8, fig. 2.

1994	*Keteleeriapollenites dubius* (KHLONOVA) SLODKOWSKA; ZIEMBINSKA–TWORZYDLO et al., p. 14, pl. 7, fig. 4
1996	*Keteleeriapollenites dubius* (KHLONOVA) SLODKOWSKA; ZIEMBINSKA–TWORZYDLO, p. 882, pl. 274, fig. 3.

Size: 120–170µm.

Description: In polar view amb three–parted to uniform, corpus ellipsoidal to circular, 75–90µm long and 76–85µm broad. Proximal surface nearly smooth, exine 2–3 thick, infrabaculate. Sacci approximately semicircular or slightly more in outline, not as broad as the breadth of corpus, 42–44µm long and 71–78µm broad. The attachment line straight or slightly arcuate, axis 40–44µm long. Leptoma finely granulate, 29–32µm long and about 64µm broad. Surface of sacci smooth, exine infrastructure alveolate. Alveolar layer up to 4µm thick, alveolae in marginal part irregular and smaller than 1µm in diameter, in deeper part six–angular to polygonali mostly closed, 3–5 in diameter, sometimes elongate up to 7µm. Muri up to 1µm thick.

General Occurrence: Stuchlik et al. (2002) recorded the Early Miocene–Pliocene.

Botanical Affinity: Morphologically, these fossil pollen grains are similar to pollen of the recent *Keteleeria* Carr.

Palaeofloristical Element: Arctotertiary (warm–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Middle Miocene Sekköy formation.

(28) cf. *Keteleeriapollenites* sp.

pl. (Atici Section) 1, fig. 15

Size: 134µm long and 86µm broad.

Remarks: Corpus ellipsoidal. Sacci approximately semicircular. The breadth of corpus, 70µm long and 60µm broad.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Zonolapollenites* (PFLUG) *in* THOMSON & PFLUG 1953
Generotype: *Zonolapollenites igniculus* (POTONIÉ 1931c) PFLUG
in THOMSON & PFLUG 1953

(29) *Zonalapollenites verrucatus* KRUTZSCH 1971
ex ZIEMBINSKA–TWORZYDLO 1974
pl. (Atici Section) 2, figs. 6, 7
pl. (Alakilise Section) 2, figs. 6, 6a
pl. (Plant-Kultak) 7.1, fig. 18

1954	*Tsuga canadensis* RUDOLPH, p. 53–54, fig. 63.
1956b	*Tsuga canadensis* RUDOLPH, p. 170, pl. 27, fig. 5, pl. 28, fig. 14.
1960	*Tsuga canadensis* RUDOLPH *crispa*, p. 28, 200, pl. 5, fig. 31.
1964	*Tsuga canadensis* RUDOLPH *crispa*, p. 39, pl. 18, fig. 104; pl. 26, fig. 168; pl. 29, fig. 186.
1964	*Tsuga canadensis* RUDOLPH *delicata*, p. 39, pl. 20, fig. 120; pl. 26, fig. 169.
1971	*Zonalapollenites verrucatus* KRTUZSCH, p. 144, pl. 39, figs. 1–10.
1974	*Zonalapollenites verrucatus* (KRTUZSCH) ZIEMBINSKA–TWORZYDLO, p.353, pl. 12, fig. 4.
1977	*Tsuga canadensis*: OSAZST & STUCHLIK, pl. 4, figs, 3, 4.
1985	*Tsugapollenites verrucatus* (KRTUZSCH) NAGY, p. 137, pl. 67, figs. 3, 4.

Size: 45–70µm.

Description: Pollen grains in polar view circular in outline, in lateral view ellipsoidal. In equatorial area exist a 4–5µm broad collar. Somewhat overlapping the distal face, built of ectexine elements. Ectexine on the proximal face and in the area of equator loosely connected with endexine, on the distal face in the area of operculum both layers of exine more compactly United. Proximal face covered by irregularly shaped, solid verrucae of more regular shape. 1.0–1.5µm in diameter. Surface of verrucae.

General Occurrence: Stuchlik et al. (2002) recorded all over the Poland during the Oligocene–Pliocene.

Botanical Affinity: Pinaceae–*Tsuga*.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

Genus: *Cathayapollis* RAATZ 1937 ex POTONIÉ 1958
Generotype : *Cathayapollis potoniei* SEWARD 1914

(30) *Cathayapollis vancampoae* (SIVAK 1976) ZIEMBINSKA–TWORZYDLO 1996
pl. (Alakilise Section) 2, fig. 1.
pl. (Karacaagaç Section) 6.20, fig. 12

1973	*Pinus hoplxylon* (RUDOLPH) STACHURSKA et al., pl. 3, fig. 3.
1976	*Cathaya van–campoae* SIVAK, p. 264, 266, pl.7, figs1–5, pl.8, figs.1–7.
1977	*Pinus* type *hoplxylon* OSAZST & STUCHLIK, pl. 3, fig. 3
1990	*Pinuspollenites hoplxylon* STUCHLIK, et al., pl. 1, figs. 1, 2.
1990	*Cathayapollis van campoae* (SIVAK) PLANDEROVA, p. 42, pl. 31, figs. 1–5.
1996	*Pinuspollenite alatus* (POTONIE) PLANDEROVA; ZIEMBINSKA–TWORZYDLO, p. 822, 823, pl. 274, fig. 2.

Size: 73–80µm.

Description: pollen grains bisaccate. In polar view amb asymmetric in proportion to the longer, equatorial axis. Corpus nearly circular, 40–45µm in diameter. Surface psilate. Exine on the proximal face about 2µm thick, infrabaculate. Sacci semicircular in outline, up to 58µm broad. Distally attached to the corpus by a straight line, close each to the other. Leptoma smooth, up to 10µm long. Sacci surface smooth or sometimes with indistinct microgranules. Exine infrastructure alveolate, alveolar layer 2µm thick, in the marginal part alveolae closed and very small, up to 1 mikron in diameter, with solid muri.

General Occurrence: Stuchlik et al. (2002) recorded in the Miocene sediments.

Botanical Affinity: *Cathaya.*

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

(31) *Cathayapollis* sp.
pl. (K–Section) 2, fig. 10
pl. (Karacaagaç Section) 6.20, fig. 11

Size: Length: 85µm and width: 53µm.

Description: Pollen grains bisaccate. In polar view amb nearly uniform, corpus sircular. Sacci semicircular in outline. Surface of sacci smooth, exine alveolate.

Remarks: The specimens obtained belong to morphologically to the genus *Cathayapollis*, but are not described this specific epithet.

Botanical Affinity: Genus probably *Cathaya*?

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Cedripites* WODEHOUSE 1933
Generotype: *Cedripites eocenicus* WODEHOUSE 1933

(32) *Cedripites miocaenicus* KRUTZSCH 1971
pl. (Karacaagaç) 6.19, figs. 17–21

1960	*Pityosporites* cf. *cedroides* THOMSON – cf. *Cedrus* sp.; PACLTOVA, S. 155, Pl. 14, Fig. 2, 3; Pl. 16, Fig. 4, 5
1971	*Cedripites miocaenicus* (KRUTZSCH) S. 120, Pl. 29, Fig. 1–8
1974	*Cedripites miocaenicus* (KRUTZSCH) ZIEMBINSKA–TWORZYDLO, S. 350/351, Pl. 11, Fig. 3
1994	*Cedripites miocaenicus* (KRUTZSCH) ZIEMBINSKA–TWORZYDLO, Pl. 7, Fig. 3
1996	*Cedripites miocaenicus* (KRUTZSCH) ZIEMBINSKA–TWORZYDLO, S. 821/822, Pl. 273, Fig. 3
2002	*Cedripites miocaenicus* (KRUTZSCH) STUCHLIK et al. S. 21, Pl. 22, Fig. 1–8

Size: 45–50x75–85µm.

Description: Pollen grains bisaccate. In equatorial outline nearly uniform, corpus ellipsoidal 50–72µm long and 40–50µm high, with strongly convex proximal face. Proximal surface rough. Exine 2.5µm thick, infrabaculate. Sacci obliquely orientate to the corpus. 50–72µm high and 30–48µm in diameter, considerably shorter than the height of corpus. The attachment line often in distinct. Leptoma 10–15µm long and more than 50µm broad. Surface of sacci smooth, exine infrastructure alveolate, alveolae of irregular shape, mostly closed.

Botanical Affinity: Genus *Cedrus*.

General Occurrence: According to the Stuchlik et al. (2002), this species recorded from the Early Miocene–Pliocene sediments in Europe. This species rare in the Middle Miocene–Pliocene sedimentens (south–western Poland).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Abiespollenites* THIERGART 1937 ex POTONIÉ 1958

(33) *Abiespollenites* sp.

pl. (K–Section) 2, figs. 1–3

pl. (Alakilise Section) 1, figs. 7, 8
pl. (Karacaagaç Section) 6.20, fig. 1

Size: Length: 86–96µm and width: 60–70µm.

Description: Pollen grains bisaccate. In polar view amb uniform Corpus ellipsoidal. Sacci nearly circular in outline. Surface of sacci and corpus smooth exine infrastructure alveolate.

Remarks: The specimen obtained is similar to genus the *Abiespollenites*, but are not described it specific epithet.

Botanical Affinity: Genus probably *Abies*?

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

Inaperturates THOMSON & PFLUG 1953
Genus: *Inaperturopollenites* THOMSON & PFLUG 1953

Generotype: *Inaperturopollenites dubius* (POTONIÉ & VENITZ 1934)
PFLUG &THOMSON *in* THOMSON & PFLUG 1953

(34) *Inaperturopollenites dubius* (POTONIÉ & VENITZ 1934)
THOMSON & PFLUG 1953
pl. (K–Section) 3, figs. 4–15, pl. (K–Section) 4, figs. 1–6,
pl. (Kultak Seciton) 1, figs. 30–33, pl. (Kultak Seciton) 2, fig. 1
pl. (Alakilise Section) 2, fig. 7
pl. 7.1 (Plant-Kultak), figs. 36, 37

1934	*Pollenites magnus dubius* POTONIÉ & VENITZ, p. 17, pl. 2, fig. 20–21.
1953	*Inaperturopollenites dubius* (POTONIÉ & VENITZ) THOMSON & PFLUG, p. 64, pl. 4, fig. 89 and pl. 5, figs. 1–13.

Size: 25–40µm.

Description: In equatorial and polar view outline of pollen grains circular. On the distal face at the center of leptoma and sometimes small papilla. Exine about 2µm thick.

Botanical Affinity: Family Taxodiaceae.

General Occurrence: It is generally considered to range from the Paleocene to Upper Pliocene of the Middle Europe (Thomson & Pflug 1953). Nakoman (1966a) indicated the species in the Eocene sediments of Sorgun area. According to Nakoman (1966b), the species may be present all the Tertiary of the Thrace Basin. Meon–Vilan (1970) indicates that the species had been present between the Miocene and Pliocene in the France. Akyol (1971) reported the species in thr Early Oligocene sediments of Sile–Istanbul. Akyol (1980) recorded the species from the Middle–Late Eocene Bayat (Çorum) lignites. Mohr (1984) indicates the species from the Lower Tertiary to Pliocene of the Central Europe. Akgün & Akyol (1992); Akgün et al. (1986); Akgün et al. (2000) and Akgün & Akyol (1999) mention occurrences the Middle Miocene of Turkey. Akkiraz & Akgün (2005) recorded fossil pollen grains from the Early–"Middle" Oligocene Tokça Formation. The species was described from Late Oligocene sediments of the Kars–Erzurum–Mus sub–basins by Sancay et al. (2006).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

(35) *Inaperturopollenites hiatus* (POTONIÉ 1931b) PFLUG & THOMSON *in* THOMSON & PFLUG 1953

pl. (Kultak Section) 1, figs. 24–29

1931b	*Pollenites hiatus* POTONIÉ, p. 3, fig. 27.
1953	*Inaperturopollenites hiatus* (POTONIÉ) PFLUG & THOMSON *in* THOMSON & PFLUG, p. 65, pl. 5, figs. 14–20.

Size: 25–40µm.

Description: Pollen grains round, generally cleaved “V” shape. The sculpture is smooth, fine–chagranate.

Botanical Affinity: Family Taxodiaceae.

General Occurrence: Akyol (1971) found the species in the Early Oligocene sediments of Sile–Istanbul. According to Snopková (1983), the species occurs in the Middle Eocene and frequently in the Rupelian of Carpatians. Mohr (1984) mentioned the species from the Eocene to Pliocene of Germany. According to Nakoman (1966a) the species is present all the Tertiary of Thrace Basin. Moreover Nakoman (1966b) recorded the species in the Eocene sediments of Sorgun lignites. The species was described from the Eocene, Oligocene and Miocene basins of Turkey (e.g. Akgün & Akyol, 1999; Akgün, 2002; Akgün et al., 2002; Akkiraz & Akgün, 2005; Sancay et al., 2006).

Palaeofloristical Element: Palaeotropical and Arctotertiary (subtropical to warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Middle Miocene Sekköy formation.

(36) *Inaperturopollenites magnus* (POTONIÉ 1934) THOMSON & PFLUG 1953
pl. (Atici Section) 2, fig. 9,
pl. (K–Section) 3, figs. 18, 19
pl. (Karacaagaç) 6.20, fig. 27

1934	*Pollenites magnus* POTONIÉ, p. 69, pl. 5, fig. 4.
1953	*Inaperturopollenites magnus* (POTONIÉ) THOMSON & PFLUG, p. 64, pl. 4, figs. 83–88.

Size: 51–75µm.

Description: Pollen grains large, round and spherical with mostly secondarily folded. Exine about 1µm. Surface of pollen exine microgranulate smooth, chagrenat and without suggestion of a germinal aperture.

Botanical Affinity: Genus probably *Pseudotsuga/Larix*.

General Occurrence: Thomson & Pflug (1953) recorded occurrences of the species from the Paleocene to Upper Pliocene of the Middle Europe. Nakoman (1966a) recorded the species in all the Tertiary of Thrace Basin. The species may be observed in the Early Oligocene of Sile–Istanbul coals (Akyol, 1971). The species was described from the Miocene basins of Turkey (e.g. Akgün & Akyol, 1999; Akgün & Sözbilir, 2001; Akgün et al., 2002, Kayseri & Akgün 2008).

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

(37) *Inaperturopollenites laevigatus* TAKAHASHI 1957
pl. (Karacaagaç) 6.20, figs. 16–19

1957	*Inaperturopollenites laevigatus* TAKAHASHI, p. 216–217, pl. 38, fig. 18, pl. 39, fig. 16.
1961	*Inaperturopollenites laevigatus* TAKAHASHI, p. 295, pl. 17, figs. 12–13.
1982	*Inaperturopollenites laevigatus* (TAKAHASHI) TAKAHASHI & JUX, p. 37, pl. 4, figs. 7, 8.

Size: 20–30µm.

Description: Pollen grains round inaperturat pollen. Exine smooth.

Botanical Affinity: Family Taxodiaceae–Cupressaceae.

General Occurrence: Takahashi & Jux (1986) recorded from the late Oligocene sediments in Germany. Takahashi & Jux (1991) defined from the Early–Middle Miocene sediments in Soma Basin.

Palaeofloristical Element: Palaeotropical and Arctotertiary (subtropical to warm temperate).

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

(38) *Inaperturopollenites parvus* TAKAHASHI 1963
pl. (Karacaagaç) 6.20, figs. 20–22

1963 *Inaperturopollenites parvus* TAKAHASHI, p. 134–135, pl. 7, figs. 10, 11.

1979 *Inaperturopollenites parvus* (TAKAHASHI) TAKAHASHI & KIM, p. 33, pl. 8, figs. 9–14.

Size: 14–22µm.

Description: Pollen grains round inaperturat pollen. Exine chagranate.

Botanical Affinity: Family Taxodiaceae–Cupressaceae.

General Occurrence: Takahashi & Jux (1986) recorded from the Oligocene–Miocene sediments in Korea. Takahashi & Jux (1991) defined from the Early–Middle Miocene sediments in Soma Basin.

Palaeofloristical Element: Palaeotropical and Arctotertiary (subtropical to warm temperate).

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

(39) *Inaperturopollenites verrupapillatus* (TREVISAN, 1967)
THOMSON & PFLUG, 1998

1967 *Inaperturopollenites verrupapillatus* TREVISAN, p. 15, pl. 6, figs. 9-12.

1998 *Inaperturopollenites verrupapillatus* (TREVISAN) SLODKOWSKA, pl. 10, fig.5.

Size: 30–35µm.

Description: It is inaperturate pollen grains and circular pollen, hiatus existence and usually with a ligula. Wall one-layered. Exine is punctate.

Botanical Affinity: Taxodiaceae.

General Occurrence: Krutzsch (1971) determined that the species was present since the Oligocene of the Central Europe. Planderová (1991) recorded the species in the Middle Oligocene, mainly in the Middle Miocene of the Western Europe.

Palaeofloristical Element: Palaeotropical and Arctotertiary (subtropical to warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(40) *Inaperturopollenites* spp.
pl. (Karacaagaç) 6.20, figs. 23–24

Size: 35–50µm.

Description: In equatorial and polar view outline of pollen grains circular.

Remarks: Even the microscopic features point directly to the *Inaperturopollenites*, but identification down to species level is yet not possible because of bad preservation.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Sequoiapollenites* THIERGART 1937
Generotype: *Sequoiapollenites polymorfosus* THIERGART 1937

(41) *Sequoiapollenites polymorfosus* THIERGART 1937
pl. (Karacaagaç) 6.20, fig. 25

1937	*Sequoia–pollenites polyformosus* THIERGART, p. 301–302, pl. 23, figs. 5–11.
1953	*Inaperturopollenites polyformosus* (THIERGART) THOMSON & PFLUG, p. 65, pl. 5, figs. 21–25.

1971 *Sequoiapollenites polyformosus* (THIERGART) KRUTZSCH, p. 212, pl. 68, figs. 1–40, text–figure 13/86, tab. 13/86.

Size: 22–31µm.

Description: Pollen grain ellipsoidal. On the distal face leptoma smooth, circular in outline, with curved papilla, 2.5 µm long and 3.5 µm at the basis.

Botanical rank: Family Taxodiaceae; Genus *Sequoia*

General Occurrence: Nakoman (1966b) mentions that the species is mainly present from Oligocene to Pliocene of the Thrace Basin. Meon-Vilan (1970) mentions that the species was located in the Miocene-Pliocene of France. In the German Upper Oligocene-Pliocene (Krutzsch, 1971). Miocene–Pliocene (Stuchlik et al., 2002). Akgün & Akyol (1999) recorded the species from Middle Miocene sediments of the Büyük Menderes Graben. Nagy (1985) mentions that the species is observed in the Egerian. Akgün & Akyol (1999) mentions occurrences in the Middle Miocene of the Western Anatolia. Moreover Akgün et al. (2000) recorded the species in the Upper Miocene of the Central Anatolia (Sivas). Akgün (2002) defined the species from Middle–?Upper Eocene sediments of Çorum–Amasya area. It was also described from Upper Oligocene sediments of the Kars–Erzurum–Mus sub–basins by Sancay et al. (2006).

Palaeofloristical Element: Arctotertiary (warm temperate)

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

Genus: *Cupressacites* BOLKHOVITINA 1956 ex KRUTZSCH 1971 emended KOHLMAN–ADAMSKA

Generotype: *Cupressacites russeus* BOLKHOVITINA ex KRUTZSCH 1971

(42) *Cupressacites insulipapillatus* (TREVISAN 1967) KRUTZSCH 1971

pl. (Atici Section) 2, fig. 10

1959	*Pollenites polyformosus* THIERGART. cf. *Taxodium distichum* forma *parva*; DOKTOROWICZ–HREBNICKA, pl. 1, fig. 11
1961	*Pollenites magnus dubius* POTONIÉ, p. 207, 208, 291, pl. 8, fig. 75
1967	*Inaperturopollenites insulipapillatus* TREVISAN, p. 16, pl. 7, fig. 1
1971	*Cupressacites insulipapillatus* (TREVISAN) KRUTZSCH, p. 196, pl. 62, figs 1–6, text–fig. 11/75. tab. 11/75.
1974	*Inaperturopollenites dubius* (POTONIÉ) THOMSON & PFLUG, p. 59, pl. 7, figs, 18, 19.
1998	*Inaperturopollenites dubius* (POTONIÉ & VENITZ) THOMSON & PFLUG: SLODKOWSKA, pl. 6, fig. 13, pl. 13, fig. 6.

Size: 35–50µm.

Description: On the distal face a leptoma in form of a big, polygonal area of thin exine, without papilla. Exine composed of two, mostly not compressed layers, often crumpled. 1,5µm thick. Pollen grains rarely split. Surface of ectexine distinctly microgranulate.

General Occurrence: Krutzsch (1971) mentions that the species was located from the Middle Eocene to Miocene of Germany.

Botanical Affinity: Morphological these fossil pollen grains are similar to pollen of the recent *Cupressus* L., *Thuja* L. and *Libocedrus* Endl.

Palaeofloristical Element: Palaeotropical and Arctotertiary (subtropical to warm–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(43) *Cupressacites bockwitzensis* KRUTZSCH 1971

pl. (K–Section) 3, fig. 16,
pl. (Kultak Section) 1, figs. 16–21
pl. (Alakilise Section) 2, fig. 9

1960	*Glyptostrobus* sp. OSZAST, p. 21, pl. 3, figs. 13, 16.
1964	*Glyptostrobus* cf. *europaeus* (BRONGN) HEER: STUCHLIK, p.28, pl.10, fig.7.

1964 *Pollenites magnus dubius* POTONIÉ & VENITZ, p. 43, pl. 20, fig. 125.
1971 *Cupressacites bockwitzensis* KRUTZSCH, p. 196, 197, pl. 62, figs. 19–25.

Size: Polar axis 44–55µm and equatorial diameter 20–30µm.

Description: Along the polar axis a deep split, with secondary folds of exine running parallel to both sides of the split. Exine composed of two not compressed layers, about 1µm thick. Surface of exine covered by microgranulate–like elements.

General Occurrence: This species recorded in the Early–Middle Miocene sediments in Poland (Stuchlik et al., 2002).

Botanical Affinity: Cupressaceae–*Cupressus*.

Palaeofloristical Element: Arctotertiary (warm–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(44) *Cupressacites cuspidataeformis* (ZAKLINSKAYA 1957) KRUTZSCH 1971

pl. (K–Section) 4, figs. 7, 8,
pl. (Kultak Section) 1, figs. 22, 23
pl. (Alakilise Section) 2, fig. 8
pl. (Karacaagaç) 6.20, fig. 26
pl. (Plant-Kultak) 7.1, figs. 29-35

1957 *Taxus cuspidataeformis* ZAKLINSKAYA, p. 96, pl. 1, figs. 17, 18.
1971 *Cupressacites cuspidataeformis* (ZAKLINSKAYA) KRUTZSCH, p. 196, pl. 62, figs. 9–17.

Size: 20–25µm.

Description: Uniformly without split. Exine consists of two compressed layers. 1.5–2.0µm thick, often secondarily folded. Surface of exine covered by densely spaced micrograules.

General Occurrence: This species recorded in the Early–Middle Miocene sediments in Poland (Stuchlik et al., 2002).

Botanical Affinity: Taxaceae. Morphologically these fossil pollen grains grains are smilar to pollen of the recent *Taxus* L. and *Torreya* Arn.

Palaeofloristical Element: Arctotertiary (warm–temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation. Middle Miocene Sekköy formation.

(45) *Cupressacites* sp1.

pl. (K–Section) 3, fig. 17; pl. (K–Section) 4, fig. 9

Size: 56µm.

Description: Rounded pollen with secondary folds. Surface of exine covered by microgranulate–like elements.

Remarks: Even the microscopic features point directly to the *Cupressacites,* but identification down to species level is yet not possible.

Botanical Affinity: Probably ?Taxodiaceae or ?Cupressaceae.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(46) *Cupressacites* sp2.

pl. (K–Section) 3, fig. 17; pl. (K–Section) 4, fig. 9

Size: 55µm.

Description: Rounded pollen with secondary folds. Surface of exine covered by small microgranulate–like elements.

Remarks: Even the microscopic features point directly to the *Cupressacites,* but identification down to species level is yet not possible.

Botanical Affinity: Probably ?Taxodiaceae or ?Cupressaceae.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Cyperaceaepollis* KRUTZSCH 1970a

(47) *Cyperaceaepollis* sp.

Size: 35µm.

Description: Large pollen form. Surface of exine covered by punctate–like elements. Pore round and large (nearly 8 µm).

Remarks: Even the microscopic features point directly to the *Cyperaceaepollis,* but identification down to species level is yet not possible.

Botanical Affinity: Cyperaceae

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Middle Miocene Belen member in the Kultak formation.

Genus: *Graminidites* COOKSON 1947

Generotype: *Graminidites media* COOKSON 1947

(48) *Graminidites laevigatus* KRUTZSCH 1970a

pl. 7.1 (Plant-Kultak), fig. 28

1970a *Graminidites laevigatus* KRUTZSCH, p. 60, pl. 5. figs. 1–12.

Size: 28–30µm.

Description: Spheroidal in equatorial outline. Pore round, about 2–2.5µm with a very distinct annulus about 2–2.5µm wide. Pollen surface laevigate to chagrenate.

Botanical rank: Family possibly Gramineae? (=Poaceae)

General Occurrence: Krutzsch (1970a) described the species from Middle Miocene sediments of Middle Europe. The species was recorded from late Early Miocene–Middle Miocene of Karpathians (Planderová, 1991). It was also reported from Middle Miocene sediments of the Soma Basin (western Anatolia) by Takahashi & Jux (1991). Ashraf & Mosbrugger (1995) mention occurrences in the Miocene. In Slovakia the species occurs in the Late Karpatian–Early Badenian. Akgün et al. (2000) and Kayseri & Akgün (2008) recorded from the species in the Middle–Late Miocene sediments in Central Anatolia.

Palaeofloristical Element: Arctotertiary

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

Monoporates NAUMOVA 1937 ex POTONIÉ 1960
Genus: *Sparganiaceaepollenites* THIERGART 1937
Generotype: *Sparganiaceaepollenites convexus* THIERGART 1937

(49) *Sparganiaceaepollenites neogenicus* KRUTZSCH 1970a
pl. (Atici Section) 2, fig. 86
pl. (Karacaagaç) 6.20, figs. 28, 29

1970a *Sparganiaceaepollenites neogenicus* KRUTZSCH, p. 82, pl. 13, figs. 1–6.

Size: 27–29µm.

Description: Rounded in outline. Pores roundish, 3–4µm in diameter, without an annulus. Pollen surface having reticulate forming by dense baculate processes.

Botanical Affinity: Family Sparganiaceae/*Sparganium*; Typhaceae, Gattung *Typha.*

General Occurrence: Krutzsch (1970a) indicates that the species occurred from the Oligocene to Pleistocene of Middle Europe. Ziembinska–Tworzydlo (1974) recorded the species from various horizons in the Neogene of western Poland. Akgün et al. (2000) mentions that the species disappeared in the Late Miocene of Sivas (Central Anatolia). Akgün (2002) recorded its presence from the Middle–Late Eocene sediments of Çorum–Amasya area. Akgün & Akyol (1999) mentions that the species were present in the Middle Miocene of Western Anatolia (Büyük Menderes Graben). Akkiraz & Akgün (2005) indicate the presence of species from the Early–“Middle” Oligocene sediments of the Çardak–Tokça Basin.

Palaeofloristical Element: Arctotertiary (temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

(50) *Sparganiaceaepollenites sparganoides* (MEYER, 1956) KRUTZSCH, 1970a

1952	*Sparganioidites* MEYER, p.36, pl. 3, fig. 53
1956	*Monoporopollenites sparganioides* MEYER, p. 111, 128, pl. 4, fig. 28
1970a	*Sparganiaceaepollenites sparganioides* (MEYER) KRUTZSCH, p. 19/20, pl. 12, fig. 1–35

Size: 22µm.

Description: Monoporate pollen. Sculptural elements surround the pole. Sculpture finely reticulates.

Botanical Affinity: Family Sparganiaceae/*Sparganium*; Typhaceae, Gattung *Typha.*

General Occurrence: Krutzsch (1970a) indicates that the species occurred from the Oligocene to Pleistocene of Middle Europe. Thiele–Pfeiffer (1980) recorded the species from the Middle Oligocene to Pliocene. Ashraf & Mosbrugger (1995) mention occurrences from the Middle Oligocene to Pliocene. Akgün & Akyol (1999) indicate the species in the Middle Miocene of Western Anatolia (Büyük Menderes Graben).

Palaeofloristical Element: Arctotertiary (temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Cycadopites* WODEHOUSE ex WILSON & WEBSTER 1946
Generotype: *Cycadopites follicularis* WILSON & WEBSTER 1946

(51) *Cycadopites minimus* (COOKSON 1947) KRUTZSCH 1970a

1970a *Cycadopites minimus* (COOKSON) KRUTZSCH, p. 95, pl. 18, figs 13, 14.

Size: Length: 18–21µm and width: 12–13µm.

Description: Small monosulcate pollen grains, in polar view amb roundish ellipsoidal. Sulcus on the distal face in the pole area about 2µm broad. Exine psilate or laevigate.

Botanical rank: Family Cycadaceae; Genus *Cycas*

General Occurrence*:* Krutzsch (1970a) reported the species from Upper Oligocene and Middle Miocene sediments of Germany. Planderová (1991) documented it in the Egerian of west Carpatians.

Palaeofloristical Element: Palaeotropical

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(52) *Cycadopites* sp.

pl. (K–Section) 4, fig. 10
pl. (Kultak Seciton) 1, figs. 11–15
pl. (Karacaagaç Seciton) 6.21, figs. 1–6

Size: Length: 36–50µm and width: 18–25µm.

Description: Pollen grains monosulcate, in polar view amb varied from strongly ellipsoidal to roundish. Sulcus on the distal face in the pole area about 1–3µm broad.

Remarks: The specimens obtained are small sized and similar to *Cycadopites* but are not described.

Botanical Affinity: Family probably Cycadaceae?

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

Genus: *Monocolpopollenites* THOMSON & PFLUG 1953
Generotype: *Monocolpopollenites tranquillus* (R. POTONIÉ 1934)
THOMSON & PFLUG 1953

(53) *Monocolpopollenites tranquillus* (R. POTONIÉ 1934)
THOMSON & PFLUG 1953
pl. (Karacaagaç) 6.21, figs. 7–8a

1934	*Pollenites tranquillus* (POTONIÉ), p. 51 und pl. 2, figs. 3, 8.
1953	*Monocolpopollenites tranquillus* (R. POTONIÉ) THOMSON & PFLUG, p. 62, pl. 4, figs. 24–47.

Size: 20–40µm.

Description: Pollen grains monosulcate pollen. In polar view amb varied from strongly ellipsoidal.

Botanical Affinity: Palmae–*Phoenix*.

Palaeofloristical Element: Palaeotropical.

General Occurrence: Thomson & Pflug 1953, Krutzsch 1970a, Hochuli 1978 and Thiele–Pfeiffer 1988 reported the species from the Eocene and Early Miocene sediments in Europe. In Turkey, it is defined from the Eocene–Early Miocene sediments (Ediger, 1999; Akgün & Sözbilir 2001; Akgün 2002).

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Arecipites* WODEHOUSE 1933
Generotype: *Arecipites punctatus* WODEHOUSE 1933

(54) *Arecipites* sp.

Size: 30µm.

Description: Monocolpate pollen grain, amb perprolate with rounded corners in polar view. Colpus distinct, reaching both corners.

Remarks: The specimens obtained are small sized and similar to *Arecipites*, but are not described because of poor preservation.

Botanical rank: Family Arecoideae?, Palmae?

Palaeofloristical Element: Unknown

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Liliacidites* COUPER 1953

Generotype: *Liliacidites kaitangataensis* COUPER 1953

(55) *Liliacidites geiseltalensis* (KRUTZSCH 1970a)

pl. (Atici Section) 4, figs. 1–7

1970a	*Liliacidites geiseltalensis* KRUTZSCH

Size: 30–52µm.

Description: Sulcate pollen grain and reticulate sculpture.

Botanical Affinity: Liliaceae.

General Occurrence: This species recorded from the Middle Eocene sediments in the Germany (Krutzsch 1970a).

Palaeofloristical Element: Cosmopolitan.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(56) *Liliacidites* sp.

pl. (Atici Section) 3, figs. 60, 60a, pl. (Atici Section) 4, fig. 8

Size: 76µm.

Description: Sulcate pollen grain and reticulate sculpture.

Remarks: The specimens obtained are small sized and similar to *Liliacidites* but are not described.

Botanical Affinity: Probably Liliaceae.

Palaeofloristical Element: Unknown

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Magnoliaepollenites* NAGY 1969

Generotype: *Magnoliaepollenites simplex* NAGY 1969

(57) *Manoliapollis* sp.

pl. (Karacaagaç Section) 6.21, figs. 15, 16.

Size: 51–62µm.

Description: Pollen grains monosulcate, in polar view amb varied from strongly ellipsoidal. Exine granulate like ornamentation.

Remarks: The specimens obtained are small sized and similar to *Magnoliapollis,* but are not described.

Botanical Affinity: Family probably Magnoliacea.

Palaeofloristical Element: Palaeotropical–Arctotertiary.

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

Generotype: *Liriodendrio ipollis semiverrucatus* KRUTZSCH 1970a

(58) *Liriodendrioipollis semiverrucatus* KRUTZSCH 1970a
pl. (Karacaagaç Seciton) 6.21, figs. 9–14

1970a	*Liriodendrioipollis semiverrucatus* KRUTZSCH, p. 138, pl. 18, figs 13, 14.

Size: 65–85µm.

Description: Pollen grains ovate monosulcate, exine baculate or verrucate.

Botanical Affinity: Magnoliacea–*Liriodendron.*

Palaeofloristical Element: Palaeotropical–Arctotertiary.

General Occurrence*:* Krutzsch (1970a) and Nagy (1985) recorded the species from Miocene sediments of Germany and Hungary.

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Monogemmites* KRUTZSCH 1970a
Generotype: *Monogemmites gemmatus* (COUPER 1960) KRUTZSCH 1970a

(59) *Monogemmites pseudosetarius* (WEYLAND & PFLUG 1957) KRUTZSCH 1970a
pl. (Karacaagaç) 6.21, figs. 20–30.

1957	*Inaperturopollenites pseudosetarius* WEYLAND & PFLUG, p. 103, pl. 22, fig. 29–31.
1970a	*Monogemmites pseudosetarius* (WEYLAND & PFLUG) KRUTZSCH, p. 146, pl. 39, figs. 21–25.

Size: 20–32µm.

Description: Pollen grains oval to roundish in outline and having monosulcate bursting. Loosely settled spinae like ornaments occupied all pollen body.

Botanical Affinity: Nymphaceae.

General Occurrence: Nakoman (1966a) mentions that an occurrence of the species was restricted in the Sannoisian (the lowest part of Oligocene) of the Thrace Basin. Krutzsch (1970a) reports occurrences in the Miocene of central Europe and mainly in the Pliocene, mostly in freshwater sediments. Thiele–Pfeiffer (1980) mentions occurrence in the Middle Miocene. Akgün & Akyol (1999) mention that the species is observed in the Middle Miocene of Western Anatolia (Büyük Menderes Graben). Akgün et al. (2000) indicates that it was present in the Late Miocene of Sivas (Central Anatolia). Akgün et al. (2002) recorded the species from the Middle–?Late Eocene sediments of the Çankiri–Çorum Basin.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

(60) *Nymphaepollis minor* NAGY 1985

pl. (Karacaagaç) 6.21, figs. 17–19.

1985 *Nymphaepollis minor* NAGY, p. 157, pl. XC, figs. 1–3; 5–11.

Size: 21µm.

Description: Rounded, zonisulcate, spiny pollen grains with thin exine. The echini are relatively thin and regularly spaced.

Botanical Affinity: Nymphaceae.

General Occurrence: Nagy (1985) recorded from the Miocene sediments from the Hungary.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

Monocolpates IVERSEN & TROELS–SMITH 1950

Genus: *Longapertites* VAN HOEKEN KLINKENBERG 1964

Generotype: *Longapertites marginatus* VAN HOEKEN KLINKENBERG 1964

(61) *Longapertites punctatus* FREDERIKSEN 1994

pl. (Atici) 4, fig. 9

1994 *Longapertites punctatus* FREDERIKSEN, p. 122, pl. 3, figs. 7, 11–13.

Size: Length: 34–47µm, Width: 21–38µm.

Description: Proximal face straight to gently arched, distal face strongly arched. Pollen surface distinctly punctate. Monosulcate, sulcus extends the full length of the distal face.

Botanical rank: Family probably Arecaceae? Lepidocaryoidae?

General occurrence: It was described from the Middle–Late Palaeocene of Pakistan (Frederiksen, 1994). The species was recorded from the Middle–Late Eocene sediments of central Anatolia by Akgün (2002) (Yoncali Formation).

***Palaeofloristical element**:* Palaeotropical

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(62) *Longapertites retipilatus* KAR 1985

pl. (Atici) 4, fig. 10

1985 *Longapertites retipilatus* KAR, p.120, pl. 22, fig. 9.

Size: Length: 49–51 and width: 34–36µm.

Description: In equatorial view, proximal face straightto gently arched, distal face tough arched. Monosulcate, sulcus extends the full lenght of distal face. Exine designed by retipilate sculpture.

Botanical affinity: Family probably Arecaceae?, Lepidocaryoidae?

General occurrence: It was recorded from Middle–Upper Palaeocene of Pakistan by Frederiksan (1994). It was also reported from? Middle and Upper Eocene of southwestern India (Kar 1985).

Palaeofloristical element: Unkown

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Dicolpates ERDTMAN 1947
Genus: *Dicolpopollis* PFLANZL 1956
Generotype : *Dicolpopollis kockelii* PFLANZL 1956

(63) *Dicolpopollis kockelii* PFLANZL 1956
pl. (Atici Section) 3, figs. 55–59,
pl. (K–Section) 4, figs. 18–24,
pl. (Kultak Section) 2, figs. 64, 65
pl. (Plant-Kultak) 7.2, fig. 45

1956 *Dicolpopollis kockelii* PFLANZL, p. 241, pl. 16, figs. 9–12.

Size: 18–26µm.

Description: Small dicolpate pollen grain with prominent reticulate sculpture. Amb irregularly elliptical or trapezoidal. Sulci are usually parallel to each other and sometimes converge or even touch to each other.

Botanical Affinity: Family Palmae; Genus *Calamus*.

General Occurrence: Nakoman (1966a) recorded the species in the Late Oligocene sediments of the Thrace Basin. It is generally considered to range from the Middle Eocene to “Middle” Oligocene of Germany (Krutzsch, 1967b). Akyol (1971) reported the species in the Early Oligocene of Sile–Istanbul (Turkey). According to Wilkinson et al. (1980), the species although not restricted to Oligocene, occurs only in northwest European Oligocene deposits. Chateauneuf et al. (1988) studied the Paleogene sediments of the Paris Basin (France). They mention occurrences of the species from the Late

Eocene to lower "Middle" Oligocene. Olliver–Pierre (1988) recorded the species from Early Oligocene to "Middle" Oligocene of the Armorican Massif (France). Schuler (1988) indicates that the species occurrence from the "Middle" Oligocene to Late Oligocene of the Rhine Graben. According to Roche (1988), it is characteristic species of the "Middle" Oligocene in Belgium. Ediger et al. (1990) studied the *Calamus*–like disulcate pollen grains and indicated the stratigraphic distribution of *Dicolpopollis kockelii*. According to authors, stratigraphic distribution of *Dicolpopollis kockelii* is low frequencies in the Late Eocene. It is represented by abundantly in the Late Oligocene and reduces to the Miocene. Akgün & Sözbilir (2001) reported the species in the Late Oligocene of southwest Anatolian molasse basins (Kale–Tavas and Denizli).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

Polyplicates ERDTMAN 1952

Genus: *Ephedripites* BOLCHOVITINA 1953

Generotype: *Ephedrepites mediolobatus* BOLCHOVITINA 1953

(64) *Ephedripites* sp. 1

pl. (Karacaagaç Section) 6.20, figs. 30–35,

Size: 39–55x12–17µm.

Description: Polyplicate pollen grain. In equatorial view outline ellipsoidal with tapering pole areas. 8–10 plicae about 2–2.5µm running meridionally reaching the poles.

Remarks: Although the specimens obtained are similar to the species *Ephedripites (Distachyapites) bernheidensis* Krutzsch 1961 with respect to size and morphology, it is not possible to describe it because of poor preservation.

Botanical Affinity: Family probably Ephedraceae?

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Triatriopollenites* PFLUG *in* THOMSON & PFLUG 1953
Generotype : *Triatriopollenites rurensis* PFLUG & THOMSON
in THOMSON & PFLUG 1953

(65) *Triatriopollenites rurensis* THOMSON & PFLUG 1953
pl. (Atici Section) 3, figs. 27–29
pl. (Alakilise Section) 3, fig. 3
pl. (Karacaagaç Section) 6.21, fig. 31
pl. (Plant-Kultak) 7.2, fig. 2

1953 *Triatriopollenites rurensis* THOMSON & PFLUG, p. 79, pl. 7, figs. 81–109.

Size: 20–27µm.
Description: Triatrioporate pollen grains. Amb triangular with straight or slightly convex sides and rounded apices. Three pores situated on each corner with atrium, labrum and small annulus.
Botanical Affinity: Family Myricaceae; Genus *Myrica*
General Occurrence*:* Thomson & Pflug (1953) mention occurrences of the species from the Eocene to Pliocene of Middle Europe. Thiele–Pfeiffer (1980); Mohr (1984); Kirchner (1984); Thomson & Pflug (1953) indicate the species from the Eocene to Pliocene of the Middle Europe. According to Akgün et al. (2000) it occurs in the Late Miocene of Sivas (Central Anatolia). Nakoman (1966b) recorded the species in the Eocene sediments of Sorgun lignites. Akgün et al. (1986) mentions occurrences in the Middle Miocene of Soma (Western Anatolia). Akgün & Akyol (1999) reports the species in the Middle Miocene of the Büyük Menders Graben (Western Anatolia).
Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation. Middle Miocene Sekköy formation.

(66) *Triatriopollenites bituitus* (POTONIÉ 1931a) THOMSON & PFLUG 1953

1931a	*Pollenites bituitus* POTONIÉ, p. 332, pl. 11, fig. 17.
1953	*Triatriopollenites bituitus* (POTONIÉ) THOMSON & PFLUG, p. 79, pl. 7, figs. 116–134.

Size: 18–28µm.

Description: Triatrioporate pollen grains. Amb triangular with straight or slightly convex sides. Three pores situated on each corner with atrium and labrum.

Botanical Affinity: Family Myricaceae; Genus *Myrica*.

General Occurrence: According to Thiele-Pfeiffer (1980); Mohr (1984); Kirchner (1984) and Thomson & Pflug the species can be observed from the Eocene to Pliocene of Central Europe. Planderová (1991) indicates the species in Miocene of Southern Slovakia. It is generally considered ranging from the Eocene to Pliocene of Germany (Ashraf & Mosbrugger, 1996). Akgün et al (2000) indicates that the species may be observed in the Late Miocene of Sivas (Central Anatolia). Akgün et al. (1986) mentioned the species in the Middle Miocene of Soma (Western Anatolia). Akgün & Akyol (1999) mention that the species was located in the Middle Miocene of Büyük Menderes Graben (Western Anatolia).

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(67) *Triatriopollenites coryphaeus* (R. POTONIÉ, 1931a) THOMSON & PFLUG, 1953

1931a	*Pollenites bituitus* POTONIÉ, p. 329, pl. 2, figs. 7, 11, 13, 15.

1953 *Triatriopollenites bituitus* (POTONIÉ) THOMSON & PFLUG, pl. 8, figs. 15–37.

Size: 10–25µm.

Description: Triatrioporate pollen grains. Exine is smooth to chagrenatte, rigid, only with insignificant secondary folds. Outline is triangular. Pores have a large atrium and labrum. The exine is smooth with many folds.

Botanical Affinity: Myricaceae/*Engelhardtia*

General Occurrence: Akyol (1971) found it in the Lower Oligocene of Sile – Istanbul. Akgün & Sözbilir (2000) recorded the species in the Upper Oligocene of SW Anatolian Molasse Basin. Thomson & Pflug (1953) the species can be observed in the Miocene of Central Europe.

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

(68) *Triatriopollenites myricoides* (KREMP 1949) THOMSON & PFLUG 1953
pl. (K–Section) 4, figs. 47–49

1949 *Pollenites myricoides* KREMP, p. 64 and pl. 6, fig. 63

1953 *Triatriopollenites myricoides* (KREMP) THOMSON & PFLUG, p. 80, pl. 8, figs. 1–14.

Size: 38–40µm.

Description: Triatrioporate pollen grains. Amb triangular with straight or slightly concave sides. Three pores situated on each corner with a prominent atrium and small labrum. Exine is chagrenate.

Botanical Affinity: Family Myricaceae.

General Occurrence: Thomson & Pflug (1953) mention that the species is observed in Miocene of Germany. This species was founded from Hungarian the Oligocene (Rákosi

1973), in Miocene (the lower Ottnangian–Sarmatian) by Nagy (1969). It was recorded from the Late Eocene and Oligocene of Carpathians by Snopková (1980). According to Hochuli (1978), the species occurs in the Paleogene. Akgün & Akyol (1999) report the species in the Miocene of Büyük Menderes Graben (Western Anatolia). Akgün & Sözbilir (2001) illustrated the species from the Late Oligocene and Early Miocene sediments of southwest Anatolian molasse basins.

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(69) *Triatriopollenites* spp.
pl. (Atici Section) 3, figs. 30, 31

Size: 19–20µm.

Description: Triatrioporate pollen grains. Amb triangular with straight or slightly concave sides. Three pores situated on each corner with a prominent atrium and small labrum. Exine is microgranulate like ornamentation.

Remarks: Even the microsrobic features point directly to the *Triatriopollenites*, but identification down to species level is yet not possible.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Braveaxones PFLUG *in* THOMSON & PFLUG 1953
Genus: *Plicapollis* PFLUG *in* THOMSON & PFLUG 1953
Generotype: *Plicapollis serta* PFLUG *in* THOMSON & PFLUG 1953

(70) *Plicapollis pseudoexcelsus* (KRUTZSCH 1957) KRUTZSCH 1961
pl. (Alakilise Section) 2, figs. 28–29a

1953	*Triatriopollenites excelsus* (POTONIÉ) ssp. *turgidus* PFLUG *in* THOMSON & PFLUG, p. 77, pl. 7, figs. 36–46.
1957	*Triatriopollenites pseudoexcelsus* KRUTZSCH, p. 519, pl. VIII, figs. 31–37.
1961	*Plicapollis pseudoexcelsus* (KRUTZSCH 1957) KRUTZSCH, p. 304.

Size: 16–20µm.

Description: Triporate pollen grains with drop–shaped annulus. Annulus develops abruptly from the thin exine and show a small appendix from outline. Exine is smooth and plica is characteristic.

Botanical Affinity: Family probably Juglandaceae?

General Occurrence: This form species occurs in the Palaeocene and Late Eocene and possibly in “Middle” Oligocene (Krutzsch, 1957; Góczán et al., 1967; Krutzsch & Vanhoorne, 1977; Hochuli, 1978; Thiele–Pfeiffer, 1988; Nickel, 1996a, 1996b; Lenz, 2001). Akgün (2002) recorded the species from the Middle–?Late Eocene sediments of Çorum–Amasya area.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(71) *Plicapollis* sp. 1

pl. (K–Seciton) 4, fig. 57

Size: 20µm.

Description: Triporate pollen grains. Three pores situated on each corner with annulus, labrum.

Remarks: Even the microsrobic features point directly to the *Plicapollis*, but identification down to species level is yet not possible.

Botanical Affinity: Family probably Juglandaceae?

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Plicatopollis* KRUTZSCH 1962b

Generotype : *Plicatopollis plicatus* (POTONIÉ 1934) KRUTZSCH 1962b

(72) *Plicatopollis plicatus* (POTONIÉ 1934) KRUTZSCH 1962b
pl. (Atici Section) 3, figs. 41, 42
pl. (K–Section) 4, figs. 50–56
pl. (Kultak Seciton) 2, figs. 45, 46
pl. (Alakilise Section) 2, fig. 27

1934	*Pollenites plicatus* POTONIÉ, p. 55, pl. 2, fig. 19.
1953	*Triatriopollenites plicatus* (POTONIÉ) THOMSON & PFLUG, p. 81, pl. 8, figs. 85–108.
1962b	*Plicatopollis plicatus* (POTONIÉ) KRUTZSCH, p. 277, text figure 6.

Size: 18–23µm.

Description: The species having a clear Endoplica. Annulus slightly developed or (in most cases) not visibly. Exine smooth and psilate.

Botanical Affinity: Family Juglandaceae.

General Occurrence: The species occurred mostly in the Eocene sediments of Europe (Thomson & Pflug, 1953; Krutzsch, 1957, 1970a, b; Nickel 1996a, 1996b). The species is most frequent in the Middle Eocene sediments of Messel (Thilele–Pfeiffer, 1988). According to Knobloh et al. (1996), the species predominantly occurs in the Eocene, reduces in the Oligocene and Miocene of middle Europe. Akgün (2002) determined the species from the Middle–?Late Eocene sediments of Çorum–Amasya area.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Momipites* WODEHOUSE 1933

Generotype: *Momipites coryloidites* WODEHOUSE 1933

(73) *Momipites punctatus* (POTONIÉ 1931a) NAGY 1969
pl. (Atici Section) 3, figs. 33–40
pl. (K–Section) 4, figs. 37–44
pl. (Kultak Seciton) 2, figs. 13–44a
pl. (Alakilise Section) 2, figs. 30–42; pl. (Alakilise Section) 3, figs. 1, 2
pl. (Karacaagaç Section) 6.21, figs. 33–36
pl. (Plant-Kultak) 7.2, figs. 3-17

1931a	*Pollenites coryphaeus punctatus* POTONIÉ, p. 329, 332, pl. 2, figs. 7 and 11.
1969	*Momipites punctatus* (POTONIÉ) NAGY, p. 478, pl. LIV, figs. 9, 10.

Size: 16–25µm.

Description: Triporate pollen grains. Triangular in equatorial view with convex sides. Three small pores arranged angularly with a small atrium. Exine finely punctate.

Botanical Affinity: Family Juglandaceae; Genus *Engelhardia*.

General Occurrence: Most authors report occurrences in the Paleogene and mainly the Early and Middle Miocene (Konzálová, 1976a) of the Central Europe. It was reported from the "Middle" Oligocene to Early Miocene of the Western Paratethys (Hochuli, 1978). According to Thiele–Pfeiffer (1980), Mohr (1984), Ashraf & Mosbrugger (1996), Kirchner (1984) the species occur from the Eocene to Pliocene. Snopková (1983) mentions sporadically occurrences in the Late Eocene and Oligocene of the Inner–Carpathian depressions. In Central Paratethys the species was the most frequent in the Middle Miocene (Planderová, 1991). Nickel (1996a) reported the species from the Early Eocene to Late Miocene of the Upper Rhine Graben. Akgün & Sözbilir (2000) recorded the species in the Late Oligocene of SW Anatolian Molasse Basin. It was recorded from the Middle–?Late Eocene sediments of Çorum–Amasya area by Akgün (2002).

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation. Middle Miocene Sekköy formation.

(74) *Momipites quietus* (POTONIÉ 1931c) NICHOLS 1973

pl. (Atici Section) 3, figs. 32
pl. (Kultak Seciton) 2, figs. 11, 12
pl. (Plant-Kultak) 7.2, figs. 18-40

1931c	*Pollenites quietus* POTONIÉ, p. 556, text figure 13.
1953	*Triatriopollenites coryphaeus* ssp. *microcoryphaeus* (POTONIÉ) THOMSON & PFLUG, p. 81, pl. 8, figs. 40?, 47, 48, 49, 56?
1973	*Momipites quietus* (POTONIÉ) NICHOLS, p. 107.

Size: 12–15µm.

Description: Small triporate pollen grains. Triangular in equatorial view. Three small pores arranged angularly with a small atrium. It is easy to recognize due to characteristic form species.

Botanical Affinity: Family Juglandaceae; Genus *Engelhardia*.

General Occurrence: According to Hochuli (1978), the species can be observed from Lower Palaeocene to Early Miocene of Central and Western Paratethys. It was reorded from Lower Palaeocene to “Middle” Oligocene of the Upper Rhine Graben (Nickel, 1996a).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

Genus: *Triporopollenites* THOMSON & PFLUG 1953

Generotype: *Triporopollenites coryloides* PFLUG & THOMSON
in THOMSON & PFLUG 1953

(75) *Triporopollenites coryloides*
pl. (Atici Section) 3, figs. 6–11

1953 *Triporopollenites coryloides* (PFLUG) *in* THOMSON & PFLUG, Palaeontogr. 94. B. p. 84, Pl. 9, figs. 20–24.

Size: 22–25µm.

Description: It is triporate pollen grains and relatively rigid triangular pollen with week convex pages. Ornamentation is scabrate finely. Pores may be having labrum.

Botanical Affinity: Betulaceae/*Corylus*.

General Occurrence: According to Thomson & Pflug (1953); Mohr (1984) the species occurs particularly in the Pliocene very frequently. Akgün & Akyol (1999) recorded the species in the Middle Miocene of Büyük Menderes Graben (Western Anatolia).

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(76) *Triporopollenites simpliformis* PFLUG & THOMSON, 1953 *in* THOMSON & PFLUG, 1953
pl. (Alakilise Section) 2, figs. 23–26

1953 *Triporopollenites simpliformis* (PFLUG) *in* THOMSON & PFLUG, Palaeontogr. 94. B. p. 84, Pl. 9, figs. 14–17.

Size: 25–40µm.

Description: Exine completely smooth outline approximate roundish to triangular triporate pollen. A pores frequently subaequatorial small circular pores.

Botanical Affinity: Juglandaceae.

General Occurrence: Thomson & Pflug (1953) suggested the species in the Middle Miocene of Germany. It is observed in the Middle Miocene of Büyük Menders Graben – Western Anatolia (Akgün & Akyol, 1999). Akgün & Akyol (1992) mentioned the species in the Middle Miocene of Isparta (Southern Anatolia).

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(77) *Triporopollenites megagranifer* (POTONIÉ 1931a) THOMSON & PFLUG 1953

pl. (Atici Section) 3, figs. 4, 5

1931a	*Pollenites coryphaeus megagranifer* POTONIÉ, p. 328, pl. 1, fig. 22.
1953	*Triporopollenites megagranifer* (POTONIÉ) THOMSON & PFLUG, p. 82, pl. 8, figs. 153–158.

Size: 25–30µm.

Description: Triporate pollen grains. Amb triangular with convex sides. Three simple pores without annulus situated on each corner. Exine intragranulate structure.

Botanical Affinity: Family probably Betulaceae.

General Occurrence: Thomson & Pflug (1953) indicate the species from the Palaeocene to Late Miocene of the Middle Europe. From the Palaeocene to Early Oligocene of the Thrace Basin (Nakoman, 1966b). It was determined from the Middle–?Late Eocene sediments of Çorum–Amasya area by Akgün (2002).

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(78) *Triporopollenites robustus* (MURRIGER & PFLUG 1951)
PFLUG *in* THOMSON & PFLUG 1953

pl. (Atici Section) 3, figs. 12–17

1951 *Pollenites granifer robustus* MURRIGER & PFLUG, p. 93, pl. 6, fig. 41.

1953 *Triporopollenites robustus* (MURRIGER & PFLUG) (PFLUG) THOMSON & PFLUG, p. 82, pl. 8, figs. 109–149.

Size: 25–36µm.

Description: Triporate pollen grains. Amb triangular with slightly convex or rounded sides. Three pores situated on each corner arranged angularly, sometimes subequatorially. Pores round, annulus indistinct.

Botanical Affinity: Unknown.

General Occurrence: It occurs commonly from Palaeocene to Late Eocene and rarely in Miocene of the Middle Europe (Thomson & Pflug, 1953; Krutzsch & Vanhoorne, 1977). According to Nakoman (1966b), the species occurs in Lower Tertiary of the Thrace Basin. Ollivier–Pierre (1980) defined from the Eocene–Oligocene sediments in France. Akgün (2002) recorded the species from the Middle–?Late Eocene of Çorum–Amasya area.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(79) *Triporopollenites* cf. *robustus* (MURRIGER & PFLUG 1951)
PFLUG *in* THOMSON & PFLUG 1953

pl. (K–Section) 4, fig. 45

Size: 26µm.

Description: Triporate pollen grains. Amb triangular with slightly convex. Three pores situated on each corner arranged angularly, sometimes subequatorially.

Remarks: Even the microsrobic features point directly to the *Triporopollenites robustus*, but annulus not observed.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Generotype: *Triporopollenites minimus* KEDVES 1974

(80) *Triporopollenites minimus* KEDVES
pl. (Atici Section) 3, figs. 3, 3a

1974 *Triporopollenites minimus* KEDVES p. 34, pl. XIII, 4–6; fig. 13.

Size: 14–20µm.

Description: Equatorial outline triangular, with slightly rounded sides. Pores 0.6 to 0.8µm in diameter. Exine about 0.7µm thick. Viewed under optical microscope, it consists only of an ectexine which is three–layered, each being subequally thick. Surface finely granulate, with frequently anastomosing ornamental elements. Hence the partially rugulate pattern of the ornamentation.The ornamental elements are usually 0.5 to 0.7µm wide.

Botanical Affinity: cf. Juglandaceae.

General Occurrence: Kedves (1974) recorded the species from Paleogene of the Bakony mountains.

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(81) *Triporopollenites* cf. *constatus* TAKAHASHI 1961
pl. (Atici Section) 2, figs. 36, 37; pl. (Atici Section) 3, fig. 26

1961 *Triporopollenites constatus* TAKAHASHI

Size: 20–25µm.

Description: Convex triangle triporat pollen grain. Exine smooth.

Botanical Affinity: Corylaceae.

Remarks: Even the microsrobic features point directly to the *Triporopollenites constatus*, but exine fine granulate like ornamentation.

General Occurrence: Kedves (1970) is defined in the Eocene sediments in France. Ollivier–Pierre (1980) recorded from the Eocene–Oligocene sediments in France.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(82) *Triporopollenites spackmanii* (TRAVERSE) KEDVES 1970
pl. (Atici Section) 2, figs. 38–40

1970a *Triporopollenites spackmanii* (TRAVERSE) KEDVES

Size: 23–30µm.

Description: Triporat convex triangle pollen. Simple pore.

Botanical Affinity: Corylaceae.

General Occurrence: Kedves (1970) is defined in the Eocene (Sparnacian) sediments in France.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(83) *Triporopollenites rugulatus* KEDVES 1965
pl. (Atici Section) 3, fig. 2

1965 *Triporopollenites rugulatus* KEDVES

Size: 17µm.

Description: Small triporate pollen, convex triangulate and rugulate sculpture pollen grain.

Botanical Affinity: Ulmaceae.

General Occurrence: This species is recorded from the Eocene sediments (Kedves, 1965; Rákosi, 1968)

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(84) *Triporopollenites* cf. *undulatus* (PFLUG) THOMSON & PFLUG 1953

pl. (K–Section) 4, fig. 46.

1953 *Triporopollenites undulatus* (PFLUG) THOMSON & PFLUG, p. 83, pl. 9, figs. 5–13.

Size: 20–40µm.

Description: Triangular triporate pollen grains. Exine is rugulate. Their pores have a vestibulum or atrium. Exine is two–layered (2–3µ).

Botanical Affinity: Ulmaceae.

Remarks: Even the microsrobic features point directly to the *Triporopollenites robustus*, but anulus not observed.

General Occurrence: According to Thomson & Pflug (1953) the species occur from the Paleocene to Eocene. Pflug (1950) recorded the species in the Eocene–Oligocene. Nakoman (1966b) found the species in the Oligocene of the Thrace Basin. Ollivier–Pierre (1980) recorded from the Eocene–Oligocene sediments in France.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(85) *Triporopollenites* spp.
pl. (Atici Section) 3, figs. 18–25
pl. (K–Section) 5, figs. 3–5
pl. (Alakilise Section) 2, fig. 21
pl. (Plant-Kultak) 7.2, figs. 41-44

Size: 16–21µm.

Description: Triporate pollen grains. Triangular with strongly convex sides. Exine is punctuate. Three pores situated on each corner arranged angularly, sometimes subequatorially.

Remarks: The specimens obtained belong to morphologically to the genus *Triporopollenites*, but are not described this specific epithet.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Belen member in the Kultak formation.

Genus: *Olaxipollis* KRUTZSCH 1962b
Generotype : *Olaxipollis matthesi* KRUTZSCH 1962b

(86) *Olaxipollis matthesi* KRUTZSCH 1962b
pl. (Kultak Section) 2, figs. 50–63

1962b *Olaxipollis matthesi* KRUTZSCH, p. 277, pl. V, figs. 7–14.

Size: 15–20µm.

Description: Triporate pollen grains with convex triangular in polar view. Pores without annulus, projecting and arranged angularly. Exine psilate.

Botanical Affinity: Family Olacaceae, Genus probably *Olax*?

General Occurrence: From Middle Eocene to Middle Miocene of Middle and East Europe (Krutzsch, 1962b; Ollivier–Pierre, 1980; Thiele–Pfeiffer, 1980).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Trivestibulopollenites* PFLUG *in* THOMSON & PFLUG 1953

Generotype: *Trivestibulopollenites betuloides* PFLUG *in* THOMSON & PFLUG 1953

(87) *Trivestibulopollenites betuloides* PFLUG *in* THOMSON & PFLUG 1953

pl. (Atici Section) 3, figs. 46–50

1953 *Trivestibulopollenites betuloides* (PFLUG) THOMSON & PFLUG, p. 85, pl. 9, figs. 25–34.

Size: 18–25µm.

Description: Triangular or rounded in equatorial outline. Three pores arranged angularly, having a vestibulum. Exine smooth.

Botanical Affinity: Family Betulaceae; Genus *Betula.*

General Occurrence: In Miocene and Pliocene of Middle Europe (Thomson & Pflug, 1953). Krutzsch (1958) indicates the presence of species in Middle Oligocene of Middle Europe. According to Nakoman (1966b), the species occurs all Tertiary of the Thrace Basin.

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Caryapollenites* POTONIÉ 1960 ex RAATZ 1937 emend. KRUTZSCH 1961

Generotype: *Caryapollenites simplex* POTONIÉ 1960 ex RAATZ 1937 emend. KRUTZSCH 1961

(88) *Caryapollenites simplex* (POTONIÉ 1931b) RAATZ ex POTONIÉ 1960

pl. (Atici Section) 2, figs. 33–35, pl. (Atici Section) 3, fig. 1,
pl. (Kultak Seciton) 2, figs. 2–8
pl. (Alakilise Section) 2, figs. 17–20
pl. (Karacaagaç Section) 6.21, figs. 37–39
pl. (Plant-Kultak) 7.1, figs. 41-45

1931b	*Pollenites simplex* POTONIÉ, p. 3, fig. 4.
1937	*Carya–pollenites simplex* (POTONIÉ) RAATZ, p. 19,pl. 1, fig. 6.
1960	*Caryapollenites simplex* (RAATZ) POTONIÉ, p. 123, pl. 7, fig. 162.

Size: 30–45µm.

Description: Pollen grains of a typical round shape, usually having three simple subequatorial pores. The sculpture is microgranulate distributed regularly. Pores round and with 4–5µm in diameter.

Botanical Affinity: Family Juglandaceae; Genus *Carya*.

General Occurrence: Sporadical occurrences were recorded from Early Miocene of North Bohemian coal basins by Konzálová (1976a). Hochuli (1978) mentions occurrences of the species from Early Oligocene to Early Miocene of Central and Western Paratethys. Chateauneuf (1980) reported the species from Early Oligocene to Middle Oligocene of the Paris Basin (France). Kirchner (1984) and Krutzsch (1957) reported the species from Eocene to Pliocene. It is abundant in the Karpathian and Badenian of Hungarian Paratethys (Nagy, 1985). Its occurrences were reported from Early Oligocene to Miocene of Belgium (Roche, 1988). Planderová (1991) indicates that the species had been present between the Oligocene and Sarmatian in the Southern Slovakia. Nickel (1996a) recorded the species from Early Oligocene to Pliocene of the Upper Rhine Graben. In Turkey, the species occurs in Oligocene and Miocene deposits (e.g. Nakoman,1966b; Akyol; 1971; Bati, 1996; Akgün & Akyol, 1999; Karayigit et al., 1999; Akgün et al., 2000; Akgün & Sözbilir, 2001; Akgün, 2002; Sancay et al., 2006).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation. Middle Miocene Sekköy formation.

Genus: *Subtriporopollenites* THOMSON & PFLUG 1953
Generotype: *Subtriporopollenites anulatus* PFLUG & THOMSON
in THOMSON & PFLUG 1953

(89) *Subtriporopollenites anulatus* THOMSON & PFLUG 1953 ssp. *nanus*
THOMSON & PFLUG 1953
pl. (Atici Section) 2, figs. 12–14
pl. (Alakilise Section) 2, figs. 15–16
pl. (Karacaagaç Section) 6.21, fig. 40
pl. 7.2 (Plant-Kultak), fig. 1

1953 *Subtriporopollenites anulatus* (THOMSON & PFLUG) *nanus* (THOMSON & PFLUG) THOMSON & PFLUG, p. 86, pl. 9, fig. 54–55.

Size: 18–23µm.

Description: Triporate pollen grains with nearly circular in outline and usually subequatorial pores. Exine smooth.

Botanical Affinity: Family Juglandaceae; Genus probably *Carya*?

General Occurrence: Thomson & Pflug (1953) and Krutzsch & Vanhoorne (1977) indicate the species from Upper Palaeocene to Late Eocene of Europe. Akyol (1980) recorded the species from Middle–Late Eocene sediments of Bayat lignites. Akgün & Sözbilir (2001) recorded the species from Late Oligocene sediments of southwest Anatolian molasse basins. Akgün (2002) and Akgün et al. (2002) determined the species from Middle–?Late Eocene sediments of the Çankiri Basin.

Palaeofloristical Element: Subtropical–warm temperate.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation.

(90) *Subtriporopollenites constans* PFLUG *in* THOMSON & PFLUG 1953

pl. (Atici Section) 2, figs. 29, 30

1953 *Subtriporopollenites constans* (PFLUG) THOMSON & PFLUG, p. 87, pl. 9, figs. 78–89.

Size: 22–29µm.

Description: Triporate pollen grains with nearly circular in outline and usually subequatorial pores. Exine rugulate or intrabaculate sculpture.

Botanical Affinity: Unknown.

General Occurrence: Thomson & Pflug (1953) recorded the species from Palaeocene to Early Oligocene of Middle Europe. Nakoman (1966b) mentions that the species occurred up to Oligocene. According to the Kedves (1970), the species occurs in Early Eocene sediments of France. According to Akyol (1980), the species disappears after Late Eocene. However, the author also indicates that the species can be observed in Early Oligocene of the Thrace Basin. Akgün (2002) and Akgün et al. (2002) indicate the presence of species from Middle–?Late Eocene sediments of the Çankiri Basin.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(91) *Subtriporopollenites constans* PFLUG *in* THOMSON & PFLUG 1953 *magnus* KRUTZSCH 1961

pl. (Atici Section) 2, figs. 31, 32

1961d	*Subtriporopollenites constans* PFLUG *magnus* KRUTZSCH 1958a, Pl. VII, Fig. 36
1965	*Triporopollenites vadosus* (PFLUG) ROCHE, S. 434, Pl. III, Fig. 3.

Size: 30–45µm.

Description: Morphological description similar to *S. constans*. Size is bigger than the *S. constans*. Wartier sculpture. Pores subequatorial.

Botanical Affinity: Juglandaceae.

General Occurrence: This species is recorded from the Eocene–Oligocene sediments (Rákosi, 1968). Gruas–Cavagnetto (1968) recorded in the Eocene sediments in France. According to the Kedves (1974), this species is defined in the Eocene sediments. Ollivier–Pierre (1980) recorded from the Eocene–Oligocene sediments in France. Krutzsch & Vanhoorne (1977) reported from the Eocene sediments in Belgium. Thiele–Pfeiffer (1988) defined from the Middle Eocene sediments in Germany.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(92) *Subtriporopollenites intraconstans* PFLUG in THOMSON & PFLUG

pl. (Atici Section) 2, figs. 20–27

1953	*Subtriporopollenites intraconstans* PFLUG in THOMSON & PFLUG

Size: 18–35µm.

Description: Subtriporat round pollen. Pores subequatorial. Rugulate sculupture.

Botanical Affinity: Juglandaceae.

General Occurrence: According to Thomson & Pflug (1953), this species recorded in the Early Tertiary sediments in Germany.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(93) *Subtriporopollenites facilis* (BOTSCHARNIKOVA 1960) KEDVES 1970
pl. (K–Section) 4, figs. 25–27

1970 *Subtriporopollenites facilis* (BOTSCHARNIKOVA 1960) KEDVES

Size: 16–20µm.

Description: Small subtriporat round pollen. Pores subequatorial. Exine smooth or thin granulate.

Botanical Affinity: Juglandaceae.

General Occurrence: According to the Kedves (1970), the species occurs in Early Eocene sediments of France.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(94) *Subtriporopollenites* spp.
pl. (Atici Section) 2, fig. 28
pl. (K–Section) 4, figs. 28–33
pl. (Alakilise Section) 2, figs. 14–14a., pl. (Alakilise Section) 2, figs. 22,22a.

Size: 20–25µm.

Description: Subtriporat round pollen. Pores subequatorial with secondarily folded. Exine smooth or thin granulate.

Remarks: The specimens obtained belong to morphologically to the genus *Subtriporopollenites,* but are not described this specific epithet.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus *Intratriporopollenites* THOMSON & PFLUG 1953

Type Species: *Intratriporopollenites instructus* (POTONIÉ 1931c) THOMSON & PFLUG 1953

(95) *Intratriporopollenites instructus* (POTONIÉ 1931c) THOMSON & PFLUG 1953

1931c	*Tiliae-pollenites instructus* POTONIÉ, p. 556, text figure 9.
1953	*Intratriporopollenites instructus* (POTONIÉ & VENITZ) THOMSON & PFLUG, p. 89, pl. 10, figs 16, 18–22.

Size: 35–38 µm.

Description: Pollen grains having a typical shape with triangular in outline. They have large pores with annulus. The outer part of exine extends around pores and forms a postvestibulum. Ectoexine with a reticulate sculpture composing of muri type processes about 0.5–1 µm in diameter.

Botanical Affinity: Family Tiliaceae; Genus *Tilia*

Palaeofloristical Element: Arctotertiary (cool temperate)

General Occurrences: The species occurs during Tertiary of Middle Europe (Thomson & Pflug, 1953). The species is observed in Lower Tertiary of the Thrace Basin (Nakoman, 1966b). According to Planderová (1972), the species was more frequent in Lower–Middle Miocene than Sarmatian–Pliocene in Carpathians. Akgün & Akyol (1999) recorded the species from Middle Miocene sediments of the Büyük Menderes Graben. It was determined from Upper Miocene sediments of Sivas area by Akgün et al. (2000). Akkiraz & Akgün (2005) reported the presence of species from Lower–"Middle" Oligocene sediments of the Çardak–Tokça Basin.

Occurrence in Ören Basin: Middle Miocene Sekköy formation.

Genus: *Compositoipollenites* POTONIÉ 1960

Generotype : *Compositoipollenites rhizophorus* (POTONIÉ 1934) POTONIÉ 1960

(96) *Compositoipollenites rhizophorus* (POTONIÉ 1934) POTONIÉ 1960 ssp. *burghasungensis* (MURRIGER & PFLUG 1952) MURRIGER & PFLUG *in* THOMSON & PFLUG 1953

pl. (K–Section) 4, figs. 34, 35; pl. (K–Section) 5, figs. 1, 2a
pl. (Kultak Seciton) 2, figs. 9, 10

1934	*Pollenites rhizophorus* POTONIÉ, p. 94, pl. 6, fig. 32 and pl. 5, figs. 25, 26.
1952	*Triporato–pollenites burghasungensis* MURRIGER & PFLUG, p. 60.
1953	*Intratriporopollenites rhizophorus* (POTONIÉ) *burghasungensis* (MURRIGER & PFLUG) THOMSON & PFLUG, p. 88, pl. 9, figs. 126–132 and pl. 10, figs. 1–6.
1960	*Compositoipollenites rhizophorus* (POTONIÉ) POTONIÉ, p. 105, pl. 6, fig. 123.

Size: 24µm.

Description: Pollen grains triporate. However, pores are not clearly recognized. Amb triangular with slightly convex sides and rounded apices. Exine having loosely situated spinae like ornament about 2µm base and 2.5µm high in diameter.

Botanical Affinity: Family Icacinaceae.

General Occurrence: Thomson & Pflug (1953) recorded the species from Upper Palaeocene to Late Eocene of the Middle Europe. Gruas–Cavagnetto (1968) mentioned the species from Early Eocene to Late Eocene of the Paris Basin. Kedves (1970) reported the species from Upper Palaeocene to Early Eocene of Paris region. Nickel (1996a) mentions the occurrences from Upper Palaeocene to Late Eocene of the Upper Rhine Graben. Akgün (2002) indicate the presence of species from Middle–?Late Eocene sediments of the Çankiri Basin.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(97) *Compositoipollenites minimus* KRUTZSCH & VANHOORN (1977)
pl. (K–Section) 4, fig. 36

1977 *Compositoipollenites minimus* KRUTZSCH & VANHOORN

Size: 16–20µm.

Description: Pollen grains triporate. Amb triangular with slightly convex sides and rounded apices. Exine echinate.

Botanical Affinity: Family Icacinaceae.

Krutzsch & Vanhoorne (1977) reported from the Eocene sediments in Belgium.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Polyporopollenites* PFLUG *in* THOMSON & PFLUG 1953
Generotype: *Polyporopollenites undulosus* (WOLFF 1934)
THOMSON & PFLUG 1953

(98) *Polyporopollenites undulosus* (WOLFF 1934) THOMSON & PFLUG 1953
pl. (K–Section) 4, figs. 14, 15
pl. (Kultak Section) 3, figs. 2–5
pl. (Alakilise Section) 2, figs. 11–13
pl. (Karacaagaç Section) 6.21, fig. 53
pl. 7.1 (Plant-Kultak), fig. 38

1934 *Ulmipollenites undulosus* WOLFF, p. 75, pl. 5, fig. 25.

1953 *Polyporopollenites undulosus* (WOLFF) THOMSON & PFLUG, p. 91, pl. 10, figs. 52–58.

Size: 30–38µm.

Description: Four to five porates pollen grain. Amb roundish. Exine having strongly rugulate sculpture.

Botanical Affinity: Family Ulmaceae; Genus *Ulmus*?, *Zelkova*?

General Occurrence: According to Thomson & Pflug (1953); Thiele–Pfeiffer (1980); Mohr (1984); Ashraf & Mosbrugger (1996); Kirchner (1984) the species occur from the Eocene to Pliocene of the Middle–East Europe. Krutzsch (1957) mentions occurrences of the species from Upper Palaeocene to recent of Middle Europe. From uppermost Middle Eocene to "Middle" Oligocene of the Paris Basin (Chateauneuf, 1980). Akyol (1971) recorded the species in the Early Oligocene sediments of Sile–Istanbul. Akgün & Akyol (1999) mention that the species in the Middle Miocene of Büyük Menderes Graben (Western Anatolia). Akgün et al. (2000) mentioned about the species in the Late Miocene of Sivas (Central Anatolia).

Palaeofloristical Element: Arctotertiary (warm temperate)

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Early–Middle Miocene Belen member in the Kultak formation. Middle Miocene Sekköy formation.

(99) *Polyporopollenites* spp.

pl. (K–Section) 4, figs. 16, 17
pl. (Alakilise Section) 3, figs. 3, 3a

Size: 20–24µm.

Description: Polyporate pollen grains angularly straight sides in outline, having five pores lain equatorially with simple. Exine smooth.

Remarks: Even the microsrobic features point directly to the *Polyporopollenites*, but identification down to species level is yet not possible.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Pterocaryapollenites* THIERGART 1937 ex POTONIÉ 1960
Generotype : *Pterocaryapollenites stellatus* (POTONIÉ 1931d) THIERGART 1937

(100) *Pterocaryapollenites stellatus* (POTONIÉ 1931d) THIERGART 1937
pl. (Atici Section) 2, figs. 11
pl. (K–Section) 4, fig. 13
pl. (Kultak Section) 3, figs. 1, 1a
pl. (Alakilise Section) 2, fig. 10
pl. 7.1 (Plant-Kultak), figs. 39,40

1931d	*Pollenites stellatus* POTONIÉ, p. 28, pl. 2, fig. 47b.
1937	*Pterocaryapollenites stellatus* (POTONIÉ) THIERGART, p. 311, pl. 24, fig. 19.

Size: 30–38µm.

Description: Polyporate pollen grains angularly straight sides in outline, usually having five pores lain equatorially with weak annulus. Exine chagrenate to punctate.

Botanical Affinity: Family Juglandaceae; Genus *Pterocarya.*

General Occurrence: Thomson & Pflug (1953) mention the occurrences of the species from Middle Eocene to Pleistocene of Middle Europe. Hochuli (1978) reported the species in “Middle” Oligocene of Central and Western Paratethys. According to Mohr (1984); Kirchner (1984); Thiele–Pfeiffer (1980); Ashraf & Mosbrugger (1996) the species is present from the Middle Eocene to Pleistocene of the Middle Europe. According to Nakoman (1966a) the species occur from the Eocene to Pliocene of Thrace

Basin. Akgün & Akyol (1999) mention that the species is observed in the Middle Miocene of Büyük Menderes Graben (Western Anatolia).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Middle Miocene Sekköy formation.

(101) *Polygalacidites* sp.
pl. (Atici Section) 5, fig. 19
pl. (K–Section) 6, fig. 44
pl. (Kultak Section) 3, fig. 58
pl. (Karacaagaç Section) 6.22, fig. 22

Size: 25–40µm.

Description: Polycolporat pollen. Exine smooth or granulate like ornamentation.

Remarks: The specimens obtained belong to morphologically to the genus *Polycolporopollenites,* but are not described this specific epithet.

Botanical Affinity: Polygalaceae.

Palaeofloristical Element: Cosmopolitan.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Corsinipollenites* NAKOMAN, 1965
Type Species: *Corsinipollenites oculis noctis* (THIERGART 1940) NAKOMAN 1965

(102) *Corsinipollenites oculis noctis* (THIERGART 1940) NAKOMAN 1965

1940	*Pollenites oculus noctis* THIERGART, p. 47, pl.. 7, fig. 1
1965	*Corsinipollenites oculus noctis* (THIERGART 1940) NAKOMAN, p. 156, pl. 8, Fig. 1–5

Size: 35–80µm.

Description: Triporate pollen grains; equator rounded triangular; shape lenticular; pores approximately, equatorial. Pores are pseudo–oculoid (strongly anulate).

Botanical Affinity: Onagraceae.

Palaeofloristical Element: Cosmopolitan.

General Occurrence: According to Krutzsch (1968) the species may be present from the Middle Eocene to Pliocene of Europe. Akyol (1971) mentions that the species was located in the Lower Oligocene of Sile–Istanbul. Ashraf & Mosbrugger (1996) and Mohr (1984) mention that the species is observed from Eocene to Pliocene. Nakoman (1966a) indicates the species in the Tertiary of Thrace Basin.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Polyvestibulopollenites* PFLUG *in* THOMSON & PFLUG 1953
Generotype : *Polyvestibulopollenites verus* ((POTONIÉ 1931a)
THOMSON & PFLUG 1953

(103) *Polyvestibulopollenites verus* (POTONIÉ 1931a) THOMSON & PFLUG 1953
pl. (K–Section) 4, figs. 11, 12
pl. (Karacaagaç Section) 6.21, figs. 41–52

1931a	*Pollenites verus* POTONIÉ, p. 329, pl. 2, fig. 40.
1934	*Alnipollenites verus* POTONIÉ–POTONIÉ, p. 58, pl. II, figs. 13, 17, 18, 25, 26.
1953	*Polyvestibulopollenites verus* (POTONIÉ) THOMSON & PFLUG, p. 90, pl. 10, figs. 62–76.

Size: 25–30µm.

Description: Pollen having generally five, rarely four pores, characteristic arcus connected pores. Exine smooth.

Botanical Affinity: Family Betulaceae; Genus *Alnus*.

General Occurrence: In the Paratethys of Slovakia, Planderová (1991) recorded the species since the Egerian till the end of the Pliocene. Thomson & Pflug (1953) mention that the species generally is present from the Eocene to Pliocene of the Middle Europe. Akgün & Akyol (1999) indicate the species in the Middle Miocene of the Büyük Menderes Graben (Western Anatolia). Akgün et al. (2000) mentions that occurrences of the species in the Late Miocene of the Sivas–Hafik (Central Anatolia).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

Genus: *Pentapollenites* KRUTZSCH 1957
Generotype: *Pentapollenites pentangulus* (PFLUG *in* THOMSON & PFLUG 1953)
KRUTZSCH, 1958

(104) *Pentapollenites pentangulus* (PFLUG *in* THOMSON & PFLUG 1953)
KRUTZSCH 1957
pl. (Atici Section) 3, figs. 51–54
pl. (Kultak Section) 3, figs. 6–11
pl. (K–Section) 6, fig. 37

1953	*Periporopollenites pentangulus* (PFLUG) THOMSON & PFLUG, p. 112, pl. 15, figs. 62–64.
1957	*Pentapollenites pentangulus* (PFLUG) KRUTZSCH, p. 520, pl. X, figs. 5–7.

Size: 18–20µm.

Description: Form of the *Pentapollenites* with more or less punctate structure. Outlinen convex triangular to concave rhombically.

Botanical Affinity: Family Elaeagnaceae? Simarubaceae?

General Occurrence: From Middle Eocene to Early Oligocene of the Paris Basin (Chateauneuf, 1980). Nagy (1985) mentions occurrences in the Egerian, Ottnangian and lower Badenian of Hungary. According to Nickel (1996a), the species occurred from Palaeocene to "Middle" Oligocene of the Upper Rhine Graben.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Cupaniëidites* COOKSON & PIKE 1954

Generotype: *Cupaniëidites major* COOKSON & PIKE 1954

(105) *Cupaniëïdites eucalyptoides* KRUTZSCH 1962b

1962b *Cupaneïdites eucalyptoides* KRUTZSCH, p.271, pl. 3, figs. 11–17.

Size: 18–24µm.

Description: Pollen grains triangular in outline with strongly concave sides. Syncolporate pollen with "Y" mark strongly clear. Exine micropunctate or psilate sculpture.

Botanical Affinity: Myrtaceae?, Sapindaceae?

General Occurrence: Cookson & Pike (1954) reported the species in Eocene sediments of Australia. Krutzsch (1962b) mentions occurrences of the species in "Middle" Oligocene of Germany. According to Konzalová (1976, 1981), the species occurs during Tertiary. It is rarely observed in Late Eocene sediments of the Paris Basin (Chateauneuf, 1980).

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Myrtaceidites* COOKSON & PIKE 1954

Generotype: *Myrtaceidites mesonesus* COOKSON & PIKE 1954

(106) *Myrtaceidites mesonesus* COOKSON & PIKE 1954

1954 *Myrtaceidites mesonesus* COOKSON & PIKE, p. 205/6, pl. 1, figs. 32–36.

Size: 15–20µm.

Description: Pollen grains small to medium. Amb triangular to subtriangular, straight or slightly convex or concave sides. Parasyncolporate. Straight or curved, narrow or wide colpi with arci, enclosing developed polar area, called polar island, clearly or poorly definite. Exine psilate.

Botanical rank: Family Myrtaceae

General occurrence*:* Cookson & Pike (1954) indicate the species from Eocene to Pliocene of Australia.

Palaeofloristical element: Unknown

Occurrence in Ören Basin: Early–Middle Miocene Belen member in the Kultak formation.

Genus: *Boehlensipollis* KRUTZSCH 1962b

Generotype : *Boehlensipollis hohli* KRUTZSCH 1962b

(107) *Boehlensipollis hohli* KRUTZSCH 1962b

pl. (Kultak Seciton) 2, figs. 47, 47a

1962b *Boehlensipollis hohli* KRUTZSCH, p. 272, pl. 3, figs. 18–20.

Size: 41µm.

Description: Pollen grain heterosyncolporate, angulaperturate, amb triangular strongly concave sides, corner narrowly rounded. Pollen having a sinuous exocolpi. Exine punctate or chagrenate sculpture.

Botanical Affinity: Family Elaeagnaceae.

General Occurrence: Hochuli (1978) recorded the species from Lower and “Middle” Oligocene of Central and Western Paratethys. According to Wilkinson et al. (1980), the species was restricted to Oligocene sediments of the Lough Neagh Clays. Frederiksen (1980) reported the species from Middle Eocene to Early Oligocene of South Carolina (America). Gorin (1975), Chateauneuf (1980) and Olliver–Pierre (1988) studied palynology in France. They mention occurrences of the species from Lower to “Middle” Oligocene. According to Schuler (1988), the species is characteristic for “Middle” Oligocene of the Rhine Graben. Roche (1988) mentions that the species is characteristic form for the “Middle” Oligocene of Belgium. From Early Oligocene to “Middle” Oligocene of the Upper Rhine Graben (Nickel, 1996a). Schalke (1988) recorded the species in “Middle” Oligocene of Netherlands. It was also described from Early Oligocene sediments of Çorum–Amasya area by Akgün (2002).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Slowakipollis* KRUTZSCH 1962b

Generotype: *Slowakipollis cechovici* (PACLTOVA 1958) KRUTZSCH 1962b

(108) *Slowakipollis hippophäeoides* KRUTZSCH 1962b

pl. (Atici Section) 3, figs. 43, 44

pl. (Kultak Seciton) 2, figs. 48, 48a

1962b	*Slowakipollis hipophäeoides* KRUTZSCH, p. 273, pl.4, figs. 1–15.
1972	*Slowakipollis hipophäeoides* (KRUTZSCH) PLANDEROVA, p. 249, pl. 31, figs.10–13.

1978 *Slowakipollis hipophäeoides* (KRUTZSCH) HOCHULI, p. 74, pl. 10, fig. 22a,b.

1980 *Slowakipollis hipophäeoides* (KRUTZSCH) CHATEAUNEUF, p. 125, pl. 16, fig.11.

1984 *Slowakipollis hipophäeoides* (KRUTZSCH) KIRCHNER, p. 115, pl. 6, fig 7a,b.

Size: 30µm.

Description: Pollen grain syncolporate, angulaperturate, amb triangular more or less concave sides, corner narrowly rounded. Pores having drop–shaped annulus. Exine psilate.

Botanical Affinity: Family Elaeagnaceae; Genus *Hippophäe*.

General Occurrence: According to Hochuli (1978), the species occurred from “Middle” Oligocene to Early Miocene of the Central and Western Paratethys. Kirchner (1984) recorded the species from Late Oligocene to Pliocene of Southern Bavarian. Roche (1988) recorded the species in “Middle” Oligocene of Belgium. It is observed in “Middle” Oligocene sediments of Netherlands (Schalke, 1988). According to Schuler (1988), it occurred Lower and “Middle” Oligocene of the Rhine Graben. Hottenrott (2002) indicates its presence from the Early Oligocene sediments of the Eisenberg Basin. Sancay et al. (2006) recorded the species from Early Oligocene sediments of the Kars–Erzurum–Mus sub–basins.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Gothanipollis* KRUTZSCH 1959a

Generotype: *Gothanipollis gothani* KRUTZSCH 1959a

(109) *Gothanipollis* sp.

Size: 23–30µm.

Description: Syncol(or)ate pollen triangular amb. Exine smooth.

Remarks: The specimens obtained belong to morphologically to the genus *Gothanipollis*, but are not described this specific epithet.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Interpollis* KRUTZSCH 1961

Generotype: *Interpollis supplingensis* (PFLUG 1953) KRUTZSCH 1961

(110) *Interpollis* sp.

pl. (Kultak Seciton) 2, fig. 49

Size: 20µm.

Description: Concave triangle pollen, Exine chagrinate or granulat.

Remarks: The specimens obtained belong to morphologically to the genus *Interpollis*, but are not described this specific epithet.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Longaxones PFLUG *in* THOMSON & PFLUG

Genus: *Tricolpopollenites* THOMSON & PFLUG 1953

Generotype : *Tricolpopollenites parmularius* (POTONIÉ 1934)
THOMSON &PFLUG 1953

(111) *Tricolpopollenites henrici* (POTONIÉ 1931a) THOMSON & PFLUG 1953

pl. (Karacaagaç Section) 6.22, figs. 18, 19

1931a	*Pollenites henrici* POTONIÉ, p.332, pl. 2, fig. 19.
1952	*Quercoidites henrici* POTONIÉ–MEYER, p. 41, pl. Pl. 3, fig. 19.
1953	*Tricolpopollenites microhenrici* (POTONIÉ) THOMSON & PFLUG, p. 95, pl. 11, figs. 62–110.

Size: Polar axis: 30–50µm and equatorial axis: 18–25.

Description: Large tricolpate pollen grains. Outline elliptical or prolate to subprolate in equatorial view. Three colpi run from pole to pole.

Botanical Affinity: Family Fagaceae; Genus *Quercus*.

General Occurrence: Mohr (1984) and Thiele–Pfeiffer (1980) mention abundant occurrences from the Eocene to Pliocene. Kirchner (1984) reports the species in the Middle Tertiary. The species is abundant in the Paleogene, mainly in the Oligocene and infrequently in the Early and Middle Miocene (Thomson & Pflug, 1953). According to Akgün & Akyol (1999) the species can be observed in the Middle Miocene of Büyük Menderes Graben (Western Anatolia).

Palaeofloristical Element: Subtropical–warm temperate.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

(112) *Quercopollenites robur* type NAGY 1969

pl. (Atici Section) 4, figs. 16–18
pl. (K–Section) 5, figs. 16–18
pl. (Kultak Section) 3, figs. 14–17
pl. (Alakilise Section) 3, figs. 22–26
pl. (Karacaagaç Section) 6.21, figs. 61, 62; pl. (Karacaagaç Section) 6.22, figs. 1–8
pl. (Plant-Kultak) 7.2, figs. 50,51

1969	*Quercopollenites robur* type – NAGY, pp. 223 (465), pl. LIII, fig. 10.
1985	*Quercopollenites robur* type – NAGY, pp. 201, pl. CXIV, figs. 10–14.
1990	*Quercopollenites robur* type– (NAGY) PLANDEROVA, pp. 68, pl. LXVII, fig. 33–36.

Size: 24–30µm.

Description: Tricolporoidate pollen grains in lateral position. Prolate or subprolate conture. Colpi convergant and taper toward the poles. Exine fine granulate. The shape of pollen grain is the important character to distinguish this taxon from other *Quercus* types.

Botanical Affinity: Familiy Fagaceae, *Quercus robur* L.

General Occurrence: Quercoide–forms occur throughout the Tertiary (THOMSON & PFLUG 1953). In Paratethys the species was found in the Badenian, in the Sarmatian (Planderová, 1991). Nagy (1985) found the species since the Egerian till the Early Pannonian.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

(113) *Quercopollenites petrea* NAGY

pl. (Atici Section) 4, figs. 19–28a
pl. (Alakilise Section) 3, figs. 12–21

1969	*Quercopollenites petrea* type–NAGY, pp. 234 (466), pl. LIII, fig. 18.
1985	*Quercopollenites petrea* typus–NAGY, pp. 201, pl. CXIV, figs. 7–9.
1990	*Quercopollenites petrea* type (NAGY) PLANDEROVA, pp. 68, pl. LXVII, figs. 24–32.

Size: 28–31 and 21–24µm.

Description: Tricolporoidate pollen grains with wide and straight colpi, tapering towards but not reaching to the poles. Fine granulate exine.

Botanical Affinity: Familiy Fagaceae, Genus *Quercus* L.. Recent species *Quercus petrea*.

General Occurrence: Quercoide–forms occur throughout the Tertiary (THOMSON & PFLUG 1953).

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(114) *Quercopollenites granulatus* NAGY 1969

pl. (Atici Section) 4, figs. 29–34

pl. (K–Section) 5, figs. 11–15

pl. (Kultak Section) 3, figs. 18, 19

1969	*Quercopollenites granulates* NAGY, pp. 233 (465), pl. LII, fig. 21.
1985	*Quercopollenites granulatus* (NAGY) NAGY, pp. 201, pl. CXIV, figs. 4–6

Size: 22–33µm.

Description: Prolate tricolporoidate pollen grain in lateral position. Colpi straight, parallel andslightly tapering towards the poles. Exine coarsely granulate. Different with *Quercopollenites petrea* type in its straight colpi.

Botanical Affinity: Familiy Fagaceae, Genus *Quercus* L., Species *Q. robur* (Nagy 1969).

General Occurrence*:* Quercoide–forms occur throughout the Tertiary (Thomson & Pflug 1953).

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(115) *Tricolpopollenites densus* PFLUG *in* THOMSON & PFLUG 1953

pl. (K–Section) 5, fig. 10

pl. (Karacaagaç Section) 6.22, figs. 9–12

1953 *Tricolpopollenites densus* (PFLUG) THOMSON & PFLUG, p. 96, pl. 11, figs. 55–58.

Size: Polar axis: 20–26µm and equatorial axis: 15–20.

Description: Tricolpate pollen grains. Outline elliptical or prolate spheroidal in equatorial view. Three colpi run from pole to pole. Exine psilate or finely granulate.

Botanical Affinity: Family Fagaceae; Genus *Quercus*.

General Occurrence: Thomson & Pflug (1953) reported the species from Eocene to Miocene. Chateauneuf (1980) recorded the species from upper most Eocene to Lower–"Middle" Oligocene of the Paris Basin. Akgün et al. (2000) mentions that the species in the Late Miocene of Sivas (Central Anatolia). Akgün & Akyol (1999) recorded it in the Middle Miocene of Büyük Menderes Graben (Western Anatolia). The species occurs all Tertiary period of Turkey (e.g. Nakoman, 1966b; Akyol, 1971; Akgün & Sözbilir, 2001).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

(116) *Tricolpopollenites liblarensis* (THOMSON *in* POTONIÉ, THOMSON & THIERGART 1950) THOMSON & PFLUG 1953 ssp. *fallax* (POTONIÉ 1934) THOMSON & PFLUG 1953

pl. (Kultak Section) 3, figs. 12, 13

1934 *Pollenites fallax* POTONIÉ, p. 70, pl. 3, fig. 10.

1953 *Tricolporopollenites liblarensis* (THOMSON) *fallax* (THOMSON) THOMSON & PFLUG, p. 97, pl. 11, figs. 133–151.

Size: Polar axis: 10–18µm and equatorial axis: 5–13µm.

Description: Small tricolpate pollen grains. Amb perprolate in equatorial view. Three colpi run from pole to pole. Exine psilate.

Botanical Affinity: Family probably Fagaceae?

General Occurrence: Thomson & Pflug (1953) report occurrences of the species from Eocene to Miocene of Middle Europe. The species occurs all Tertiary period of Turkey (e.g. Nakoman, 1966b; Akyol, 1971; Akyol, 1980; Akgün & Akyol, 1999; Akgün & Sözbilir, 2001).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(117) *Tricolpopollenites liblarensis* (THOMSON *in* POTONIÉ, THOMSON & THIERGART 1950) THOMSON & PFLUG 1953 ssp. *liblarensis* (THOMSON *in* POTONIÉ, THOMSON & THIERGART 1950) THOMSON & PFLUG 1953

pl. (Alakilise Section) 3, fig. 4
pl. (Plant-Kultak) 7.2, figs. 46-49

1950	*Cupuliferoidae–poll. liblarensis* THOMSON *in* POTONIÉ, THOMSON & THIERGART, p. 55, pl. B, figs. 26, 27.
1953	*Tricolporopollenites liblarensis* (THOMSON) subsp. *liblarensis* (THOMSON) THOMSON & PFLUG, p. 96, pl. 11, figs. 111–132.

Size: Polar axis: 18–25µm and equatorial axis: 10–14µm.

Descriptions: Tricolpate pollen grains. Amb long–elliptical or perprolate in equatorial view. Three colpi run from pole to pole. Exine psilate.

Botanical rank: Family probably Fagaceae?

General Occurrence: See under (115) *Tricolpopollenites liblarensis* ssp. *fallax*.

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(118) *Tricolpopollenites microhenrici* (POTONIÉ 1931d) THOMSON & PFLUG 1953

pl. (Atici Section) 4, figs. 11–15,
pl. (K–Section) 5, figs. 6–9,
pl. (Kultak Section) 3, fig. 20
pl. (Alakilise Section) 3, figs. 5–11
pl. (Karacaagaç Section) 6.21, figs. 54–60
pl. (Plant-Kultak) 7.2, figs. 52-55

1931d	*Pollenites microhenrici* POTONIÉ, p. 26, pl. 1, V 19c.
1953	*Tricolpopollenites microhenrici* (POTONIÉ) THOMSON & PFLUG, p. 96, pl. 11, figs. 62–110.

Size: Polar axis: 20–29µm and equatorial axis: 18–20µm.

Description: Tricolpate pollen grains. Amb elliptical or prolate in equatorial view. Three colpi strong, running almost paralel toward to apices and converging to the poles. Exine psilate or fine granulate.

Botanical Affinity: Family Fagaceae; Genus *Quercus*.

General Occurrence: Nagy (1985) reports most occurrences in the Lower and Middle Miocene of the Hungarian Paratethys. Thiele–Pfeiffer (1980); Mohr (1984); Kirchner (1984) indicate the species from the Eocene to Pliocene. Akgün & Akyol (1999) suggested the species in the Middle Miocene of Büyük Menderes Graben (Western Anatolia). Akgün et al. (2000) mentions that occurrences of the species could be observed in the Late Miocene of Sivas (Central Anatolia). Akyol (1971) recorded the species in the Early Oligocene sediments of Sile–Istanbul.

Palaeofloristical Element: Palaeotropical–Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

(119) *Tricolpopollenites asper* THOMSON & PFLUG 1953

1953 *Tricolpopollenites asper* (PFLUG &THOMSON) THOMSON & PFLUG, p. 96, pl. 11, figs. 43–49.

Size: Polar axis: 25–35µm and equatorial axis: 15–20µm.

Description: Tricolpate pollen grains. Amb oval in equatorial view. Three colpi running paralel toward to apices. Exine chagrenate.

Botanical Affinity: Family Fagaceae; Genus *Quercus*.

General Occurrence: Thomson & Pflug (1953) indicates that the species in the Tertiary of Germany. According to Akgün & Akyol (1999) the species can be observed in the Middle Miocene of Büyük Menderes Graben (Western Anatolia).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(120) *Tricolpopollenites retiformis* THOMSON & PFLUG 1953

pl. (K–Section) 5, figs. 23–37,
pl. (Kultak Section) 3, figs. 21–28
pl. (Plant-Kultak) 7.2, figs. 56-61

1953 *Tricolpopollenites retiformis* THOMSON & PFLUG, p. 97, pl. 11, figs. 59–61.

Size: Polar axis: 14–22µm and equatorial axis: 7–14µm.

Description: Small tricolpate pollen grains. Amb elliptical or prolate in equatorial view. Three colpi run from pole to pole. Lumina of reticulum about 1µm, muri baculate about 1µm high.

Botanical Affinity: Family Saliaceae; Genus *Salix/Platanus*.

General Occurrence: According to Thomson & Pflug (1953) the species is present from Upper Paleocene to Pleistocene of the Middle Europe. Thiele–Pfeiffer (1980) mentions that the species is observed from the Miocene to Pliocene. The species was recorded from Tertiary sediments of Turkey (e.g. Nakoman, 1966b; Akyol, 1980; Akgün & Akyol, 1999; Karayigit et al., 1999; Akgün & Sözbilir, 2001; Akgün, 2002; Akgün et al., 2002, Kayseri & Akgün 2008).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Middle Miocene Sekköy formation.

(121) *Tricolpopollenites pudicus* (POTONIÉ 1931a) THOMSON & PFLUG 1953
pl. (Atici Section) 4, fig. 35

1953 *Tricolpopollenites pudicus* (POTONIÉ) THOMSON & PFLUG, pl 11, figs. 27–29.

Size: 50–70µm.

Description: Large tricolpate pollen grains. Outline elliptical or prolate to subprolate in equatorial view. Exine intrabaculat.

Botanical Affinity: ?*Cupulifere*

General Occurrence*:* This species recorded in the Eocene–Miocene sediments in Turkey and Europe (Thomson & Pflug 1953; Akgün & Akyol, 1999; Akgün & Sözbilir, 2001).

Palaeofloristical Element: Palaeotropical

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Aceripollenites* NAGY 1969
Generotype: *Aceripollenites rotundus* NAGY 1969

(121) *Aceripollenites striatus* (PFLUG 1959) THIELE–PFEIFFER 1980
pl. (Atici Section) 4, figs. 36–40

pl. (K–Section) 5, figs. 19, 20
pl. (Plant-Kultak) 7.2, figs. 64,65

1959 *Tricolpo–pollenites striatus* PFLUG, p. 155, pl. 16, figs. 13–14.
1980 *Aceripollenites striatus* (PFLUG) THIELE–PFEIFFER, p. 115, pl. 11, figs. 22–25.

Size: 28x22µm.

Description: Tricolpate pollen grain. Amb prolate or prolate spheroidal in equatorial view. Three colpi strong, running from pole to pole. Exine having striate ornamentation.

Botanical Affinity: Family Aceraceae; Genus *Acer.*

General Occurrence: According to Thiele–Pfeiffer, (1980) it is recorded in all Tertiary.

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(122) *Aceripollenites reticulatus* NAGY 1969
pl. (Atici Section) 4, figs. 41, 41a

1969 *Aceripollenites reticulatus* NAGY, p. 182, pl. XLIII, figs. 10–11.

Size: 27–44µm.

Description: Tricolporate pollen grain. Lisse or granulate ornaments. Narrow lopes and fine reticulate–striate structure.

Botanical Affinity: Family Aceraceae; Genus *Acer.*

General Occurrence*:* The species occurs from Late Oligocene–Middle Miocene (Nagy 1969 and 1985).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(123) *Aceripollenites* sp.

pl. (Atici Section) 4, fig. 42

Size: 25µm.

Description: Tricolpate pollen grain. Lisse ornaments. Narrow lopes and fine reticulate–striate structure.

Remarks: The specimens obtained belong to morphologically to the genus *Aceripollenites*, but are not described this specific epithet.

Botanical Affinity: Probably Aceraceae–*Acer*.

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Tricolporopollenites* THOMSON & PFLUG 1953

Generotype: *Tricolporopollenites dolium* (POTONIÉ 1931d)
THOMSON & PFLUG 1953

(124) *Tricolporopollenites euphorii* (POTONIÉ 1931a) THOMSON & PFLUG 1953

1931a	*Pollenites euphorii* POTONIÉ, p. 328, pl. 1, figs. 12, 28.
1953	*Tricolporopollenites euphorii* (POTONIÉ) THOMSON & PFLUG, p. 102, pl. 12, figs. 133–140.

Size: Polar axis: 25–28µm and equatorial axis: 18–20µm.

Description: Tricolporate pollen grains. Amb rounded–oval or prolate in equatorial view. Three colpi running almost towards the apices. Equatorial pores roundish. Exine psilate.

Botanical Affinity: Family Araliaceae.

General Occurrence: Thomson & Pflug (1953) mention occurrences of the species from the Early Eocene to Pliocene of the Middle Europe. Akgün & Akyol (1999) indicate that the species in the Middle Miocene of Büyük Menderes Graben (Western Anatolia). Akgün & Akyol (1992) reported the species in the Middle Miocene of Isparta (Southern Anatolia).

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(125) *Tricolporopollenites cingulum* (POTONIÉ 1931d) THOMSON & PFLUG 1953
ssp. *fusus* (POTONIÉ 1931a) THOMSON & PFLUG 1953
pl. (Kultak Section) 3, figs. 33, 34
pl. (Alakilise Section) 3, fig. 27

1931d	*Pollenites cingulum* POTONIÉ, p. 26, pl. I, V 60d, V 61c, V 60a and V48b.
1931a	*Pollenites fusus* POTONIÉ, p. 4 and 8, pl. 1, fig. 13.
1953	*Tricolporopollenites cingulum* (POTONIÉ) *fusus* (POTONIÉ) THOMSON & PFLUG, p. 100, pl. 12, figs. 15–27.

Size: Polar axis: 22–28µm and equatorial axis: 9–17µm.

Description: Tricolporate pollen grains. Amb long elliptical or perprolate in equatorial view. Three colpi running towards the apices. Equatorial pores roundish or lalongate.

Botanical Affinity: Family Fagaceae; Genus *Castanea*, *Castanopsis*, *Lithocarpus*, *Pasania*.

General Occurrence: Thomson & Pflug (1953) mention that the species is observed in the Late Miocene of Germany. Nagy (1985) reports occurrences in the Egerian–Middle Miocene of the Hungarian Paratethys. The species was recorded from Tertiary sediments of Turkey (e.g. Nakoman, 1966a, 1966b; Akyol, 1971; Akgün & Akyol, 1999; Karayigit et al., 1999; Akgün et al., 2000; Akgün, 2002; Akgün et al., 2002).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Middle Miocene Sekköy formation.

(126) *Tricolporopollenites cingulum* (POTONIÉ 1931d) THOMSON & PFLUG 1953 ssp. *pusillus* (POTONIÉ 1934) THOMSON & PFLUG 1953

pl. (Kultak Section) 3, figs. 35–45

1931d	*Pollenites cingulum* POTONIÉ, p. 26, pls. I, V 46c, V 46b and V 46a.
1934	*Pollenites quisqualis pusillus* POTONIÉ, p. 71, p. 3, fig. 21.
1953	*Tricolporopollenites cingulum* (POTONIÉ) *pusillus* (POTONIÉ) THOMSON & PFLUG, p. 100, pl. 12, figs. 28–41.

Size: Polar axis: 18–22µm and equatorial axis: 10–16µm.

Description: Tricolporate pollen grains. Amb long elliptical or perprolate in equatorial view. Three colpi running towards the apices. Equatorial pores roundish or lalongate.

Botanical Affinity: Family Fagaceae; Genus *Castanea*, *Castanopsis*, *Lithocarpus*, *Pasania*.

General Occurrence: See under (126) *Tricolporopollenites cingulum* ssp. *fusus*.

Palaeofloristical Element: Palaeotropical (Subtropical) Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(127) *Tricolporopollenites cingulum* (POTONIÉ 1931d) THOMSON & PFLUG 1953 ssp. *oviformis* (POTONIÉ 1931a) THOMSON & PFLUG 1953

pl. (Atici Section) 5, fig. 11
pl. (K–Section) 5, figs. 38–51
pl. (Alakilise Section) 3, figs. 28, 29
pl. 7.2 (Plant-Kultak), figs. 66-76

1931d	*Pollenites cingulum* POTONIÉ, p. 26, pl. 1, figs. V 46a–V 46c.
1931a	*Pollenites oviformis* POTONIÉ, p. 328 and 332, pl. 1, fig. 20.
1953	*Tricolporopollenites cingulum* (POTONIÉ.) *oviformis* (POTONIÉ) THOMSON & PFLUG, p. 100, pl. 12, figs. 42–49.

Size: Polar axis: 7–18µm and equatorial axis: 5–14µm.

Description: Small tricolporate pollen grains. Amb prolate or prolate spheroidal in equatorial view. Three strong colpi run from pole to pole. Equatorial pores roundish. Exine psilate.

Botanical Affinity: Family Fagaceae; Genus *Castanea*, *Castanopsis*, *Lithocarpus, Pasania*.

General Occurrence: See under (126) *Tricolporopollenites cingulum* ssp. *fusus*.

Palaeofloristical Element: Palaeotropical (Subtropical) Arctotertiary (warm temperate)

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(128) *Tricolporopollenites megaexactus* (POTONIÉ 1931d) THOMSON & PFLUG 1953 ssp. *brühlensis* (THOMSON *in* POTONIÉ, THOMSON & THIERGART 1950) THOMSON & PFLUG 1953

pl. (Atici Section) 5, figs. 12, 13
pl. (K–Section) 6, figs. 1–6
pl. (Kultak Section) 3, figs. 29–31
pl. (Karacaagaç Section) 6.22, figs. 14, 15

1931d	*Pollenites megaexactus* POTONIÉ, p. 26, pl. 1, V 42b.
1950	*Pollenites cingulum brühlensis* THOMSON *in* POTONIÉ, THOMSON & THIERGART, p. 56, pl. B, figs. 32 and 33.
1953	*Tricolporopollenites megaexactus* (POTONIÉ) *brühlensis* (THOMSON) THOMSON & PFLUG, p. 100 and 101, pl. 12, figs. 50–57 and figs. 65–80.

Size: Polar axis: 16–23µm and equatorial axis: 10–18µm.

Description: Pollen grains tricolporate, widely subprolate in equatorial view. Three colpi radially symmetrical and converging at the apices. Pores oval. Exine psilate.

Botanical Affinity: Family Cyrillaceae.

General Occurrence: Ashraf & Mosbrugger (1996) mentions that the species can be observed from the Eocene to Pliocene. Mohr (1984) suggested the species from the Paleocene to Pliocene. Thiele–Pfeiffer (1980) indicates that the species may be observed from Early Eocene to Pliocene of Germany. The species occurs all Tertiary period of Turkey (e.g. Nakoman, 1966b; Akyol, 1971; Akyol, 1980; Akgün & Akyol, 1999; Karayigit et al., 1999; Akgün et al., 2000; Akgün, 2002; Akgün et al., 2002).

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

(129) *Tricolporopollenites megaexactus* (POTONIÉ 1931d) THOMSON & PFLUG 1953 ssp. *exactus* (POTONIÉ 1931d) THOMSON & PFLUG 1953
pl. (K–Section) 6, figs. 8, 9, pl. (Kultak Section) 3, fig. 32
pl. (Karacaagaç Section) 6.22, fig. 13
pl. (Plant-Kultak) 7.2, figs. 77-80

1931d	*Pollenites megaexactus* POTONIÉ, p. 26, pl. 1, fig. V 42b.
1931d	*Pollenites exactus* POTONIÉ, p. 26, pl. 1, fig. V 49b.
1953	*Tricolporopollenites megaexactus* (POTONIÉ) *exactus* (POTONIÉ) THOMSON & PFLUG, p. 100–101, pl. 12, figs. 87–92.

Size: Polar axis: 8–16µm and equatorial axis: 7–17µm.

Description: Small tricolporate pollen grains. Amb subprolate. Three distinct colpi radially symmetrical. Pores roundish. Exine psilate.

Botanical Affinity: Family Cyrillaceae.

General Occurrence: Thiele–Pfeiffer (1980) and Mohr (1984) mention that the species generally is present from Middle Eocene to Pliocene of Middle Europe. Ashraf & Mosbrugger (1995) indicates that the species had been present between the Middle Eocene and Pliocene in the Lower Rhine Embayment (NW Germany).

Palaeofloristical Element: Palaeotropical (Subtropical) Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

(130) *Tricolporopollenites steinensis* PFLUG *in* THOMSON & PFLUG, 1953

1953	*Tricolporopollenites steinensis* (PFLUG) *exactus* THOMSON & PFLUG, p. 101, pl. 12, figs. 93–95.

Size: 15–26µm.

Remarks: Elliptical tricolporate pollen grains. Exine is baculate.

Palaeofloristical Element: Palaeotropical (Subtropical) Arctotertiary (warm temperate).

Botanical Affinity: Unknown.

General Occurrence: Akgün & Akyol (1999) indicate the species in the Middle Miocene of the Büyük Menderes Graben (Western Anatolia). Thomson & Pflug (1953) mention occurrences in the Tertiary of Germany. Nakoman (1966a) reports the species in the Tertiary of the Thrace Basin.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(131) *Tricolporopollenites pseudocingulum* (POTONIÉ 1931a) THOMSON & PFLUG 1953

1931a	*Pollenites pseudocingulum* POTONIÉ, p. 332, 328, pl. 1, figs. 2–4, 19, 24, 26, 27.
1953	*Tricolporopollenites pseudocingulum* (POTONIÉ) THOMSON & PFLUG, p. 99, pl. 12, figs. 96–111.

Size: Polar axis: 25–30µm and equatorial axis: 20–28µm.

Description: Tricolporate pollen grains. Amb widely subprolate in equatorial view. Three colpi strong, radially symmetrical and converging at the apices. Pores oval, elongate meridionally. Exine psilate and granulate.

Botanical Affinity: Family Anacardiaceae; Genus *Rhus.*

General Occurrence: Thomson & Pflug (1953) suggested its ranges from Palaeocene to Pliocene of Middle Europe. The species occurs all Tertiary period of Turkey (Nakoman, 1966b; Bati, 1996; Akgün & Akyol, 1999; Akgün et al., 2002).

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(132) *Tricolporopollenites edmundii* (POTONIÉ 1931d) THOMSON & PFLUG 1953
pl. (Atici Section) 4, fig. 48
pl. 7.2 (Plant-Kultak), figs. 81-85

1931d	*Pollenites edmundi* POTONIÉ, p. 26, pl. 1, V53e, V52a, V53a.
1953	*Tricolporopollenites edmundii* (POTONIÉ) THOMSON & PFLUG, p. 101, pl. 12, figs. 125–132.

Size: Polar axis: 38–39µm and equatorial axis: 20–30µm.

Description: Tricolporate pollen grains. Amb prolate or subprolate in equatorial view. Three thick colpi having large and vigorous fastigium. Exine intrabaculate sculpture.

Botanical Affinity: Family Mastixiaceae.

General Occurrence: Nagy (1985) reported occurrences in the Eggenburgian and lower Pannonian of Hungary. Late Oligocene to Middle Miocene (Thomson & Pflug 1953; Krutzsch, 1957). According to Nakoman (1966b), the species occurs in Tertiary sediments of Turkey. It was recorded from Middle Miocene sediments of Akhisar (Çitak) lignites by Akgün & Akyol (1987).

Palaeofloristical Element: Palaeotropical (subtropical).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(133) *Tricolporopollenites pacatus* PFLUG *in* THOMSON & PFLUG 1953

pl. (K–Section) 5, figs. 52, 53

1953	*Tricolporopollenites pacatus* (PFLUG) THOMSON & PFLUG, p. 99, pl. 12, figs. 118–121.

Size: Polar axis: 25–32µm and equatorial axis: 15–19µm.

Description: Tricolporate pollen grains. Amb subprolate in equatorial view. Three thick colpi run from pole to pole. Exine psilate.

Botanical Affinity: Family Simarubaceae.

General Occurrence: According to Kedves (1963), occurrences of the species from Early Eocene to Late Eocene of Hungary. Akgün & Akyol (1999) suggested it in the Middle Miocene of the Büyük Menderes Graben (Western Anatolia). Thomson & Pflug (1953) indicates that the species in the Tertiary of Germany. From the Late Eocene to Late Oligocene of Thrace Basin (Nakoman, 1966a).

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(134) *Tricolporopollenites villensis* (THOMSON *in* POTONIÉ, THOMSON & THIERGART 1950) THOMSON & PFLUG 1953

pl. (K–Section) 6, fig. 7

1950	*Tricolporopollenites cingulum* ssp. *villensis* POTONIÉ, THOMSON & THIERGART, p. 55, pl. B, figs. 28–29.
1953	*Tricolporopollenites villensis* (POTONIÉ, THOMSON & THIERGART) THOMSON & PFLUG, p. 99, pl. 12, figs. 5–14.

Size: Polar axis: 25–28µm and equatorial axis: 16–20µm.

Description: Tricolporate pollen grains. Amb prolate in equatorial view. Three colpi strong, running almost toward to apices. Exine psilate.

Botanical Affinity: Family Cupuliferae.

General Occurrence: Thomson & Pflug (1953) reported the species in Middle Eocene and Miocene sediments of Middle Europe. Akgün & Akyol (1999) mentioned the species in the Middle Miocene of Büyük Menderes Graben (Western Anatolia).The species occurs in Tertiary sediments of Turkey (Akyol, 1980; Karayigit et al., 1999; Akgün, 2002).

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus : *Oleoidearumpollenites* NAGY 1969
Generotype: *Oleoidearumpollenites reticulatus* NAGY 1969

(135) *Oleoidearumpollenites microreticulatus* (THOMSON & PFLUG 1953)
ZIEMBINSKA–TWORZYDLO 1974
pl. (Atici Section) 4, figs. 45–47,
pl. (K–Section) 6, figs. 10–29; pl. (K–Section) 3, figs. 46, 47
pl. (Karacaagaç Section) 6.22, fig. 16
pl. (Plant-Kultak) 7.2, figs. 62, 63; pl. (Plant-Kultak) 7.2, figs. 97-100

1953 *Tricolporopollenites microreticulatus* THOMSON & PFLUG, p. 106, pl. 14, figs. 27–42.

1980 *Tricolporopollenites microreticulatus* THOMSON & PFLUG; THIELE-PFEIFFER, p. 154–156, pl. 13, figs. 1–11.

1984 *Tricolporopollenites microreticulatus* THOMSON & PFLUG; MOHR, p. 89, pl. 16, figs. 11, 12.1, 12.2

1989 *Tricolporopollenites microreticulatus* THOMSON & PFLUG; THIELE-PFEIFFER, p. 44, pl. 12, figs. 8–14.

1974 *Oleoidearumpollenites microreticulatus* (THOMSON & PFLUG) ZIEMBINSKA-TWORZYDLO;ZIEMBINSKA-TWORZYDLO in ZIEMBINSKA-TWORZYDLO et al., p. 25, pl. 14, figs. 18a-c.

Size: Polar axis: 18–30µm and equatorial axis: 17–22µm.

Description: Small tricolporate pollen grains. Amb prolate or perprolate**.** Three colpi conspicuous, running almost parallel towards the apices and converging to the poles. Exine densely reticulate. Muri baculate. Lumina of reticulum less than 1µm.

Botanical Affinity: Family Oleaceae; Genus *Olea*, *Fraxinus*, *Ligustrum*.

General Occurrence: Meon–Vilan (1970) mention occurrences of the species in the Miocene of France. Thiele–Pfeiffer (1980); Mohr (1984); Ashraf & Mosbrugger (1996); Kirchner (1984) indicate the species from the Eocene to Pliocene. Thomson & Pflug (1953) record the species from the Paleocene to Pliocene of the Middle–East Europe. The species occurs all Tertiary sediments of Turkey (e.g. Nakoman, 1966b; Akyol, 1980; Akgün & Akyol, 1999 Karayigit et al., 1999; Akgün et al., 2000; Akgün & Sözbilir, 2001; Akgün et al., 2002).

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation. Middle Miocene Sekköy formation.

(136) *Tricolporopollenites oleoides* KRUTZSCH & VANHOORNE 1977

1977 *Tricolporopollenites oleoides* KRUTZSCH & VANHOORNE, p. 79, pl. 33, figs. 21–25.

Size: 26 X 23µm

Description: Tricolporate pollen grains. Amb subprolate in equatorial view. Three large colpi run from pole to pole. Exine densely coarse reticulate. Muri baculate. Strong reticulum about 2–2.5µm in diameter.

Botanical rank: Family Oleaceae

General occurrence: It was reported from Middle–Upper Eocene of the Paris Basin by Chateauneuf (1980). It was also recorded from Middle–?Upper Eocene Yoncali Formation in central Anatolia (Akgün 2002).

Palaeofloristical element: Unknown

Occurrence in Ören Basin: Middle Miocene Sekköy formation.

(137) *Avicennia* sp.
pl. (K–Section) 6, figs. 34–36
pl. (Plant-Kultak) 7.2, fig. 101

Size: 25µm.

Description: Tricolporat circular pollen, The aperture is elongate and pore ofen rounded. The exine wit two layers cosists of regular and reticulate ectexine with regular network, psilate tectum and distinct columella.

Remarks: The specimens obtained belong to morphologically to the genus *Avicennia*, but are not described this specific epithet.

Botanical Affinity: Probably *Avicennia*.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Caprifoliipites* WODEHOUSE 1933
Generotype: *Caprifoliipites viridi–fluminis* WODEHOUSE 1922

(138) *Caprifoliipites sambucoides* NAGY, 1969
pl. (K–Section) 6, figs. 30–33

1969	*Caprifoliipites sambucoides* NAGY

Size: Polar axis 24 to 28µm long and equator 26 to 28µm in diameter.

Description: Subspheroid in equatorial view. Exine about 2µm thick with large, polygonal meshes. Ectotexine distinctly columellar. Endoexine thin (about 0.5µm) without a distinct structure. Furrows narrow, bent near equator, reaching poles. Pores round, about 1.5µm in diameter.

Botanical Affinity: Familiy Caprifoliaceae, the genus *Viburnum***.**

General Occurrence: This species is recorded from the Early–Middle Miocene sediments in Hungary.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(139) *Tricolporopollenites* sp. (Phillrea–type)
pl. (Atici Section) 4, figs. 43, 44

Size: 30µm.

Description: Tricolporate pollen. Shape round. Exine densely reticulate. Muri baculate.

Remarks: The specimens obtained belong to morphologically to the Oleaceae–*Phillrea* type.

Botanical Affinity: Oleaceae

Palaeofloristical Element: Arctotertiary (warm temperate).

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(140) *Tricolporopollenites* sp. (Compositae–Tubulifloreae type).
pl. (Atici Section) 5, fig. 14

Size: 30µm.

Description: The species is oblate–spheroidal, sometimes sub–oblate, exine fairly thick and echinolophate. Sexine thicker than nexine composed of dense columella structure.

Remarks: The specimens obtained belong to morphologically to Compositae (Tubulifloreae–type), but are not described this specific epithet.

Botanical Affinity: Compositae =Asteraceae (Tubulifloreae=Asteroideae type).

General Occurrence: Akgün & Akyol (1999) indicate that the species is rarely in the Middle Miocene, more abundant in the Late Miocene of Büyük Menderes Graben (Western Anatolia). Akgün et al (2000) mentions that the species occur abundant in the Late Miocene of Sivas (Central Anatolia).

Palaeofloristical Element: Cosmopolitan.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(141) *Tricolporopollenites* sp. (Compositae–Liguliflorae type).
pl. (Karacaagaç Section) 6.22, fig. 17

Size: 18μm.

Description: The species is oblate–spheroidal. Exine is coarse reticulate.

Remarks: The specimens obtained belong to morphologically to Compositae (Liguliflorae type), but are not described this specific epithet.

Botanical Affinity: Compositae =Asteraceae (Liguliflorae=Cichorioideae type).

General Occurrence: Akgün et al (2000) and Kayseri & Akgün (2008) mentions that the species occur abundant in the Late Miocene of Sivas (Central Anatolia).

Palaeofloristical Element: Cosmopolitan.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

(142) *Tricolporopollenites* sp1.
pl. (Atici Section) 5, figs. 15, 16
pl. (Plant-Kultak) 7.2, figs. 86-95

Size: 22–26μm.

Description:

Remarks: The specimens obtained belong to morphologically to the genus *Tricolporopollenites*, but are not described this specific epithet.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(143) *Tricolporopollenites* sp2.
pl. (K–Section) 6, figs. 38–43
pl. (Kultak Section) 4, fig. 48

Size: 22–29µm.

Description: Tricolporate pollen. Exine smooth or microreticulate.

Remarks: The specimens obtained belong to morphologically to the genus *Tricolporopollenites* but are not described this specific epithet.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(144) *Tricolporopollenites* sp3 (Compositae–Umbelliferae type)..
pl. (K–Section) 6, figs. 38–43
pl. (Kultak Section) 4, fig. 48

Size: 20-48 µm.

Description: Tricolporate pollen grains. The species is oblate-spheroidal, sometimes sub-oblate, exine fairly thick and echinolophate. Sexine thicker than nexine composed of dense columella structure.

General Occurrence: Akgün & Akyol (1999) indicate that the species is rarely in the Middle Miocene, more abundant in the Upper Miocene of Büyük Menderes Graben (Western Anatolia). Akgün et al (2000) mentions that the species occur abundant in the Upper Miocene of Sivas (Central Anatolia).

Botanical Affinity: Umbellifereae

Palaeofloristical Element: Actotertiary

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(145) *Stephanoporopollenites* sp.
pl. (Kultak Section) 4, figs. 1, 1a

Size: 25µm.

Description: Polyporate pollen grains angularly straight sides in outline, having four pores lain subequatorially with simple. Exine smooth.

Remarks: The specimens obtained belong to morphologically to the genus *Stephanoporopollenites*, but are not described this specific epithet.

Botanical Affinity: Unknown.

Palaeofloristical Element: Unknown.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Faguspollenites* RAATZ 1937 ex R. POTONIÉ
Generotype: *Faguspollenites* verus RAATZ 1937

(146) *Faguspollenites* verus RAATZ 1937
pl. (K–Section) 5, fig. 22

1937	*Fagus–pollenites verus* RAATZ, pp. 23, pl. 1, fig. 17
1980	*Faguspollenites verus* (RAATZ) THIELE–PFEIFFER, pp. 161, pl. 15, figs. 4, 5

1985	*Faguspollenites verus* (RAATZ) NAGY, pp. 200, pl. CXIII, figs. 15–16
1987	*Faguspollenites verus* (RAATZ) SEITNER, pp. 184, pl. 19, figs. 1, 2
1996	*Faguspollenites verus* (RAATZ) ASRAF & MOSBRUGGER, pp. 47, pl. 7, figs. 21–22.

Size: 37–39µm.

Description: Round tricolporate pollen grain with fine granulates sculpture. Round pores, narrow colpi.

Botanical Affinity: Familiy Fagaceae. According to Raatz (1937), the slightly coarse granulate form is close to that seen in the extant species *Fagus silvatica* and *Fagus ferruginea* while the coarsely granulate form is close to *Fagus orientalis*.

General Occurrence: Form Late Oligocene to recent in Middle and Eastern Europe (Thomson & Pflug 1953; Krutzsch 1957).

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Psilatricolporites* VAN DER HAMMEN 1956 ex VAN DER HAMMEN & WYMSTRA 1964

Generotype: *Psilatricolporites inornatus* (VAN DER HAMMEN 1954) PIERCE 1961

(147) *Psilatricolporites crassus* VAN DER HAMMEN & WYMSTRA 1964
pl. (Atici Section) 5, figs. 1–10
pl. (K–Section) 5, fig. 21

1931d	*Pollenites megaexactus* POTONIÉ, p. 26, pl. 1, fig. V 42b.
1964	*Psilatricolporites crassus* VAN DER HAMMEN & WYMSTRA, p. 237, pl. 1, figs. 1–4.

Size: Polar axis: 30–45µm and equatorial axis: 35–55µm.

Description: Large tricolporate pollen grains, colpi medium sized, pole elongate, sculpturing and thickness of the wall extremely variable.

Botanical Affinity: Genus *Pelliciera*.

General Occurrence: Van Der Hammen & Wymstra (1964) reported the presence of *Psilatricolporites crassus* in Oligocene and Miocene sediments of Guyana. The species has also been found in Oligocene and Miocene sediments of Chiapas, Mexico (Langenheim et al., 1967), in Eocene sediments of Jamaica and Panama (Graham, 1977). Akgün (2002) suggested the presence of *Psilatricolporites crassus* from the Middle–?Late Eocene Yoncali Formation (central Anatolia)

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Mediocolpopollis* Krutzsch 1959ab

Generotype: *Mediocolpopollis compactus* Krutzsch 1959ab

(148) *Mediocolpopollis compactus* Krutzsch 1959 spp. *ellenhaunensis* KRUTZSCH 1970a

pl. (K–Section) 6, figs. 45, 46

pl. (Kultak Section) 3, figs. 49–50

Size: 25–35µm.

Description: Tricolporate pollen. Having symmetrical fold. Pore ovate or round. Caverna observed.

Botanical Affinity: Santalaceae.

General Occurrence: Hochuli (1978) mentions occurences of the species from the Late Eocene to Early Oligocene of the Central and Western Paratethys. Nickel (1996a) indicates the species in the Late Eocene of the Upper Rhine Graben.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Lonicerapollis* KRUTZSCH, 1962a

Type Species: *Lonicerapollis gallwitzi* KRUTZSCH, 1962a

(149) *Lonicerapollis* sp.

pl. (Karacaagaç Section) 6.22, figs. 20, 20a

Size: 37µm.

Description: Pollen body weakly oblate to spherical. Colpo is short (10–12µ) and narrow. Multilevel wall. Exine small baculate.

Remarks: The specimens obtained belong to morphologically to the genus *Lonicerapollis*, but are not described this specific epithet.

Botanical Affinity: Caprifoliaceae/*Lonicera.*

General Occurrence*:* Thiele–Pfeiffer (1980) recorded the species from the Middle Oligocene to Pliocene. Hochuli (1978) mentions occurrences from the Miocene to Pliocene of the Zentralen and Westlichen Paratethys.

Palaeofloristical Element: Arctotertiary.

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

Genus: *Tetracolporopollenites* THOMSON & PFLUG 1953

Generotype: *Tetracolporopollenites sapatoides* PFLUG & THOMSON
in THOMSON & PFLUG 1953

(150) *Tetracolporopollenites sapotoides* PFLUG & THOMSON
in THOMSON & PFLUG 1953

pl. (Kultak Section) 3, figs. 53–56

1953 *Tetracolporopollenites sapotoides* (PFLUG & THOMSON) THOMSON & PFLUG, p. 108, pl. 15, figs. 6, 7.

Size: Polar axis: 33µm and equatorial axis: 22µm.

Description: Tetracolporate pollen grains. Amb prolate and rounded apices in equatorial view. Large pores about 4–5 µm and lalongate. Exine psilate.

Botanical Affinity: Family Sapotaceae.

General Occurrence: The range of species is from Eocene to Miocene of Middle Europe (Thomson & Pflug, 1953). The species occurs in Tertiary sediments of Turkey (Nakoman, 1966b; Akgün et al., 1986; Bati, 1996; Akgün et al., 2002).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(151) *Tetracolporopollenites biconus* PFLUG *in* THOMSON & PFLUG 1953

1953 *Tetracolporopollenites biconus* n. sp. (PFLUG) – THOMSON & PFLUG, p. 109, pl. 15, figs. 1–3.

Size: Polar axis: 18–20µm, Equatorial axis: 12–14µm, (n = 2)

Description: Small tetracolporate pollen grains. Amp prolate in equatorial view. Colpi distinct run from pole to pole and converging the apices. Pores lalongate. Exine psilate.

Botanical rank: Family Sapotaceae

Previously recorded occurrence: Nagy (1969) mentions occurrences in the Egerian and lower Badenian of Hungary. The species was recorded from the Eocene, Oligocene and Miocene basins of Turkey (Akyol, 1980; Akgün & Sözbilir, 2001; Akgün et al., 2002).

Occurrence in Ören Basin: Lower–“Middle” Oligocene Incesu Formation; Lower Miocene Aksu Formation.

Palaeofloristical element: Palaeotropical

(152) *Tetracolporopollenites obscurus* PFLUG & THOMSON *in* THOMSON & PFLUG 1953

pl. (Kultak Section) 3, figs. 53–56

1953 *Tetracolporopollenites obscurus* (PFLUG & THOMSON) THOMSON & PFLUG, p. 108, pl. 14, figs. 86–99 and 102–108.

Size: Polar axis: 25–28µm and equatorial axis: 18–23µm.

Description: Tetracolporate pollen grains. Amb prolate and rounded apices in equatorial view. Colpi strong run parallel from pole to pole. Pores are small about 2µm. Exine psilate and fine granulate.

Botanical Affinity: Family Sapotaceae.

General Occurrence: According to Thomson & Pflug (1953), the species occurs in Lower–Middle Tertiary of Middle Europe. The species has been found in Tertiary sediments of Turkey (Bati, 1996; Akgün & Akyol, 1999; Akgün & Sözbilir, 2001; Akgün et al., 2002).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Lower–“Middle” Oligocene Incesu Formation; Early Miocene Aksu Formation.

(153) *Tetracolporopollenites microrhombus* PFLUG *in* THOMSON & PFLUG 1953

pl. (Kultak Section) 3, figs. 51, 52

1953 *Tetracolporopollenites microrhombus* (PFLUG) THOMSON & PFLUG, p. 109, pl. 15, figs. 22–25.

Size: Polar axis: 20–23µm and equatorial axis: 16–19µm.

Description: Tetracolporate pollen grains. Amb prolate in equatorial view. Colpi distinct run from pole to pole and converging the apices. Exine psilate.

Botanical Affinity: Family Sapotaceae.

General Occurrence*:* In Paleogene of Middle Europe (Thomson & Pflug, 1953). The species occurs in Tertiary sediments of Turkey (e.g. Akyol, 1980; Akgün & Akyol, 1999; Akgün & Sözbilir, 2001).

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(154) *Tetracolporopollenites* sp1.
pl. (Atici Section) 5, fig. 18
pl. (Karacaagaç Section) 6.22, fig. 21

Size: 34µm.

Description: Tetracolporate pollen grains. Colpi distinct run from pole to pole. Exine psilate.

Remarks: The specimens obtained belong to morphologically to the genus *Tetracolporopollenites,* but are not described this specific epithet.

Botanical Affinity: Probably Sapotaceae.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

(155) *Tetracolporopollenites* sp2.
pl. (Kultak Section) 3, fig. 57

Size: 51µm.

Description: Round tetracolporat pollen and pores simple. Exine microgranulate like ornamentation.

Remarks: The specimens obtained belong to morphologically to the genus *Tetracolporopollenites,* but are not described this specific epithet.

Botanical Affinity: Probably Sapotaceae.

Palaeofloristical Element: Palaeotropical.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Periporates POTONIÉ 1970a

Genus: *Periporopollenites* PFLUG & THOMSON *in* THOMSON & PFLUG 1953
Generotype: *Periporopollenites stigmosus* (POTONIÉ 1931a)
THOMSON & PFLUG 1953

(156) *Periporopollenites stigmosus* (R. POTONIÉ, 1931a) THOMSON & PFLUG, 1953
pl. (Karacaagaç Section) 6.22, fig. 25

Size: 32–46µm.

Description: Multiporate pollen grains. Exine is reticulate. Pores are round or oval (5–8µ).

Botanical Affinity: Altingiaceae/*Liquidambar*

General Occurrence: Kirchner (1984) mentions occurrences from the Eocene to Pliocene of the Southern Bavarian Pitch Coal Mine. Thiele–Pfeiffer (1980) and Ashraf & Mosbrugger (1996) report the species from the Oligocene to Pliocene of Germany Hochuli (1978) recorded this species in the Middle Oligocene of the Zentralen and Westlichen Paratethys. Thomson & Pflug (1953) described the species in the Middle and Upper Oligocene sediments of the Middle Europe. According to Chateauneuf (1980) it occurs from the Upper most Middle Eocene to Upper Eocene of the Paris Basin. Akgün & Akyol (1999) mention that the species in the Middle Miocene of Büyük Menderes Graben (Western Anatolia).

Palaeofloristical Element: Arctotertiary

Occurrence in Ören Basin: Early–Middle Miocene Hüsamlar member in the Kultak formation.

(157) *Periporopollenites multiporatus* PFLUG & THOMSON
in THOMSON & PFLUG 1953

pl. (Atici Section) 5, fig. 20
pl. (Kultak Seciton) 4, figs. 2, 2a
pl. (Karacaagaç Section) 6.22, figs. 23, 24

1953 *Periporopollenites multiporatus* (PFLUG & THOMSON) THOMSON & PFLUG, p.111, pl. 15, fig. 17.

Size: 22µm.

Description: Periporate pollen grains in round shape. Many openings situated on pollen surface. The openings are round about 1.5µm in diameter.

Botanical Affinity: Family Chenopodiaceae.

General Occurrence: Thomson & Pflug (1953) indicate the species in the Miocene of the Germany. The species is observed in the Late Miocene of Hafik–Sivas, Central Anatolia (Akgün et al., 2000). The species has mainly been determined from Miocene sediments of Turkey (Akgün et al., 1986; Akgün & Akyol, 1987; Akyol & Akgün, 1990; Akgün & Akyol, 1999; Sancay et al., 2006).

Palaeofloristical Element: Cosmopolitan.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

Organic Walled Green Algae

Division Clorophyta PASHER 1914
Class Chlorophyceae KÜTZING 1849
Genus: *Botryococcus* KÜTZING 1849

(158) *Botryococcus braunii* KÜTZING 1849

1849 *Botryococcus braunii* KÜTZING, p. 892.

Size: 50–100µm.

Description: Most diverse cauliflower–like cell colonies irregular shape and variable size composed of aggregates of ellipsoidal and spherical cells arranged radially.

Botanical Affinity: Family Botryococcaceae.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(159) Microforemineral lignin
pl. 7.2 (Plant-Kultak), fig. 104

Division Dinoflagellata (BÜTSCHLI 1885) FENSOME et al. 1993
Class Dinophyceae FRITSCH 1929
Genus *Cleistopheridium* DAVEY, DOWNIE, SARJEANT & WILLIAMS 1966
Generotype: *Cleistopheridium diversispinosum* DAVEY et al. 1966

(160) *Cleistopheridium* sp.
pl. (Alakilise Section) 3, figs. 32–34

Size: 73–84µm.

Description: The body is oval. The processes relatively long, hollow, erect. The number of processes present is more than thirty. The surface of central body and processes is smooth.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Cordosphaeridium* (KLUMP 1953) MORGENROTH 1968
Generotype: *Cordosphaeridium inodes* (KLUMP 1953) MORGENROTH 1968

(161) *Cordosphaeridium* sp.

pl. (Alakilise Section) 3, figs. 35, 36

Size**:** 57µm (lenght of processes about 26µm).

Description **:** The central body is spherical. The processes are simple, tubular expanded and open distally serrate margin. The surface of central body and processes is smooth.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

(162) Dinoflagellate sp.

pl. (K–Section) 6, figs. 51, 52

Size: 58µm.

Description: The central body is spherical. Having a kyst and central body in this kyst. The surface of central body and processes is smooth.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation.

Genus: *Ovoidites* (R. POTONIÉ, 1951) W. KRUTZSCH, 1959

Type Species: *Ovoidites ligneolus* (R. POTONIÉ, 1931a) R. POTONIÉ, 1951

(163) *Ovoidites* spp.

pl. (Atici Section) 5, figs. 22, 23

pl. (K–Section) 4, fig. 50

pl. (Kultak Section) 4, figs. 7–13

pl. (Karacaagaç Section) 6.22, fig. 40

Explanation: This group forms are fresh water elements.

Occurrence in Ören Basin: Early–Late Oligocene Alakilise member in the Çambeleni formation. Early–Middle Miocene Hüsamlar member in the Kultak formation.

CHAPTER FOUR

PALYNOFLORA OF THE EARLY OLIGOCENE IN THE ÖREN BASIN (SW TURKEY): PALAEOCLIMATIC AND PALAEOVEGETATIONAL ESTIMATES

4.1 Introduction

The Oligocene sediments in Turkey are widespread (i.e. Thrace region, Istanbul–Sile region, Çankiri–Çorum basin, Sivas basin, Mus basin) and these sediments include the rich fossil groups which are composed of foraminifers, bivalvias, gastrapods, mammalian and palynomorphs (Rükert–Ülkümen, 1960; Nakoman, 1968; Benda, 1971a,b; Akyol, 1971; Lüttig & Steffens, 1976; Ünay–Bayraktar, 1989; Bati, 1996; Taner, 1996; Akgün & Sözbilir, 2001; Akgün, 2002; Saraç, 2003; Akkiraz & Akgün, 2005; Sancay, 2006; Islamoglu et al., 2008). In the SW Anatolia, the Oligocene sediments was deposited in terrestrial condition under marine influences and these sediments are observed in the Çardak–Tokça basin, Kale–Tavas basin, Denizli basin, Antalya–Kas basin. The paleontological studies in these basins have increased recently. However these studies focus on the marine fossil groups (Tchihatchef, 1869; Nebert, 1956; Becker–Platen, 1970; Lutting & Steffens, 1976; Gökçen, 1982; Hakyemez & Örçen, 1982; Göktas et al., 1989; Hakyemez, 1989; Sahbaz & Görmüs, 1992; Akgün & Sözbilir, 2001; Gürer & Yilmaz, 2001). The first detailed palynological record was obtained by the Benda (1971) in SW Anatolia and authors defined palynomorph association from bottom to top Tokça, Kurbalik, Kale, Eskihisar, Yeni Eskihisar, Kizilhisar and Akça. The palynomorph association of the Oligocene was recorded from the coal bearing sediments in the Kale–Tavas region. Akgün & Sözbilir (2001) studied in the same region with Benda (1971) and authors defined the palynomorph associations which are 1. Palynological association of the Late Oligocene (Chattian) and 2. Palynological association of the Early Miocene (Aquitanian). Other palynological study is from the Çardak–Tokça basin and Akkiraz & Akgün (2005) defined the Early Oligocene (Stamphian) palynomorph association.

The sediments in the Ören region (Kultak regions) deposited in terrestrial condition and these sediments affected marine influence in the Early Oligocene time. In this chapter, palynofloras of the Early Oligocene (Rupelian) in Ören region is produced based on the palynomorph associations. Besides, Ören palynomorph association is correlated with the Oligocene palynomorph associations in Turkey (i.e. Çardak–Tokça, Mus basin, Istanbul-Sile, Çankiri–Çorum basin, Burdur-Incesu) and Europe.

Detail palaeoclimatic and palaeovegetational interpretations of the Early Oligocene palynoflora in the Ören region and published palynofloras of Turkey are obtained using the palaeoclimate and paleoecologic preferences of the plants and coexistence approach methods. Additionally, obtaining palaeoclimatic constitutions of the Early Oligocene time are corresponded with the palaeoclimatic evolution in Europe.

4.2 Geological Setting of Ören–Kultak Region

Pre–Oligocene basement comprises Lycian nappes in the Kultak region (Fig. 4.1) and the basement is unconformably overlain by the Çambeleni formation. The Early Miocene age was suggested Görür et al., (1994; 1995) based on the benthic foraminifer fauna in the Akbük region. In this study, lithostratigraphy and fossil contents of the Çambeleni formation in the Kultak region are studied detail. Deposition of the Çambeleni formation continues during the Rupelian–Aquitanian period. This formation vertically and laterally passes the Alakilise member during the Rupelian–Chattian time interval which is defined in this study (see chapter two). Palynofloras are determinated from the coal bearing sediments in this member. The Çambeleni formation is unconformably overlain by the late Middle–early Middle Miocene rocks. These rocks unconformably pass the Middle–Late Miocene rocks in the study area (Fig. 4.1).

4.3 Material and Methods

Two stratigraphic sections are measured from the Çambeleni formation and Alakilise member in the Alakilise and southeast of the Kultak regions. Additionally coal samples are collected from throughout measured stratigraphic section in southeast of the Kultak region (Atici section) and coal mine in the northwest of the Kultak region (Alakilise member) (Figs. 4.2, 4.3). Totally, twelve coal samples are collected. There is no fossil record from marl in the Çambeleni formation.

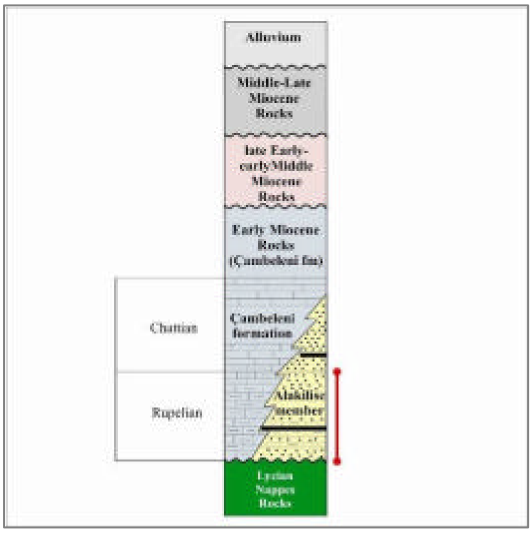


Figure 4.1 Generalized stratigraphic columnar section of the Kultak region. Red line indicates investigated period.

Figure 4.2 this picture shows the coal seam and sandstones in the Atici section (south of Kultak region).

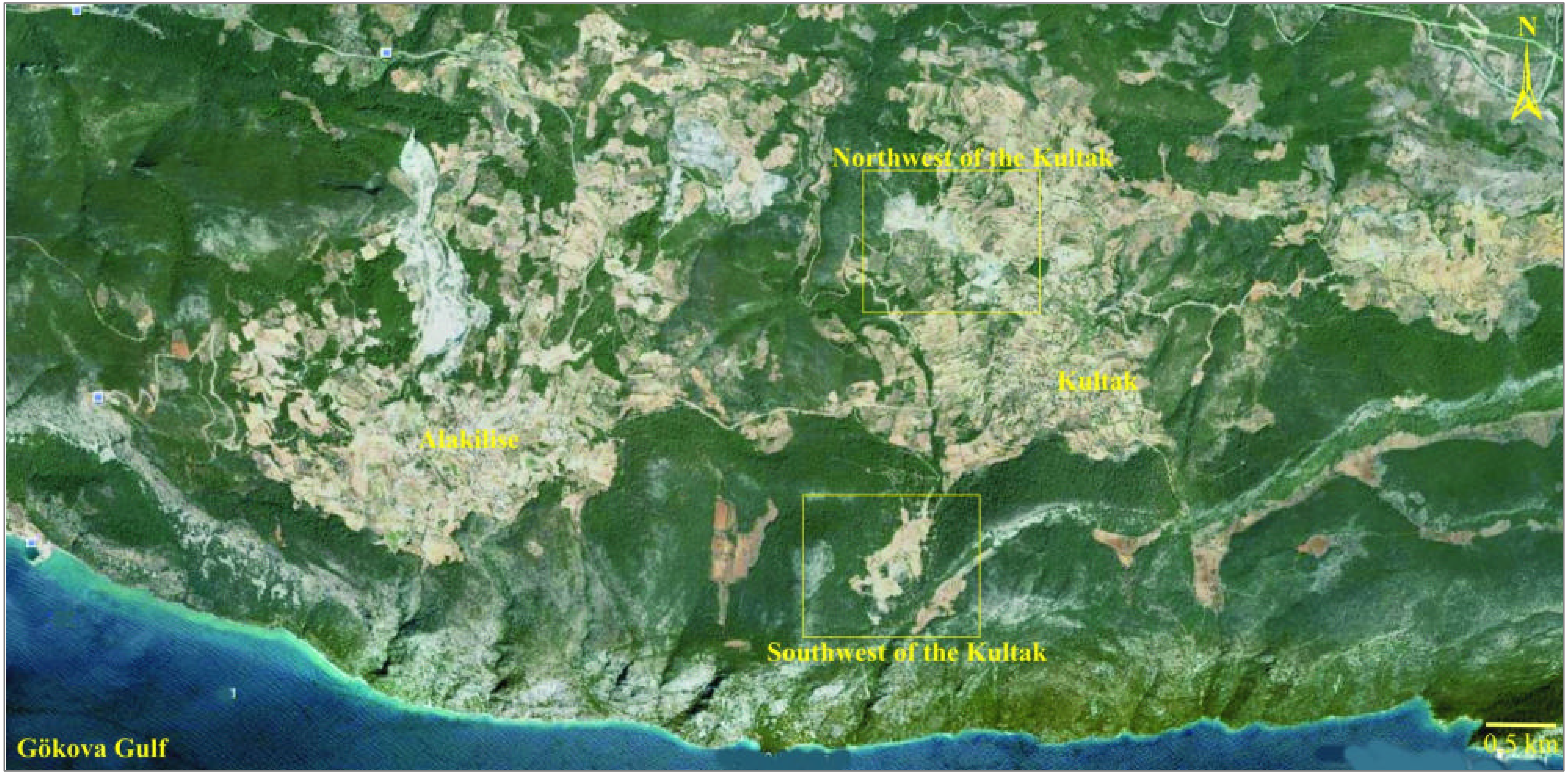


Figure 4.3 Satellite image shows the study area near the Kultak regions.

4.4 Composition of the Rupelian Microflora in the Kultak Region

Palynological interpretations are obtained from the coal bearing sediments in the Alakilise member. All samples contain well preserved marine and terrestrial palynomorphs although there are a small number of samples.

4.4.1 Palynoflora of the Southwest Kultak Region

The first palynoflora is defined from six samples which are collected during the Atici section in the southwest Kultak region (Figs. 4.2, 4.3). This palynoflora is represented by more abundantly (>15%) *Laevigatosporites haartdi, Inaperturopollenites dubius, Momipites punctatus, Triatriopollenites rurensis, Triporopopollenites coryloides* and *Oleoidearumpollenites microreticulatus,* abundantly (10–15%) *Pityosporites microalatus, Tricolporopollenites cingulum, Tricolporopollenites megaexactus exactus, Quercopollenites robur* type, *Q. granulatus, Q. petrea, Caryapollenites simplex, Subtriporopollenites constans constans, S. anulatus nanus, Tricolpopollenites retiformis* (*Salix* type), *Sparganiapollenites neogenicus, Psilatricolporites crassus* and *Ovoidites* spp. (Fig. 4.5), less abundantly (5–10%) *Verrucatosporites favus, Leiotriletes maxoides maxoides, Pityosporites labdacus, Inaperturopollenites magnus, Cupressacites insulipapillatus, C. cuspidateaformis, Arecipites* spp. *Plicapollis plicatus, Momipites quietus, Tricolporopollenites megaexactus brühlensis, Tricolporopollenites pseudocingulum, Tricolpopollenites pudicus, Aceripollenites sitriatus, A. reticulatus, Dicolpopollis kockelii, Slowakipollis hippophäeoides, Triporopollenites robustus, Monogemmites pseudosetarius, Pentapollenites pentangulus, Liliacidites geiseltalensis, Pterocaryapollenites stellatus, Tricolpopollenites retiformis* (*Platanus* type), *Sparganiapollenites sparganioides, Triatriopollenites myricoides* and *Tricolporopollenites kruschi* (Fig. 4.5). Some species (*Leiotriletes maxoides maximus, L. maxoides minimus, Leiotriletes* spp., *Piceapollis tobolicus, Piceapollenites alatus, Piceapollis* sp. *Keteleeriapollenites dubius, Pinuspollenites macroinsignis, Inaperturopollenites hiatus, Tetracolporopollenites sapatoides, Cycadopites minimus, Cycadopites* spp., *Aceripollenites* sp., *Trivestibulopollenites betuloides, Gothanipillis* sp., *Longapertites retipilatus, Longapertites punctatus,* *Triporopollenites undulatus, Corsinipollenites occulis noctis, Subtriporopollenites constans magnus, S. intraconstans, Subtriporopollenites* spp., *Triporopollenites simpliformis, Triporopollenites robustus minor, Triporopollenites megagranifer, Triporopollenites minimus, Triporopollenites* cf. *constatus, Triporopollenites spackmanii, Triporopollenites rugulatus, Triporopollenites* spp., *Periporopollenites stigmosus, Polyporopollenites undulosus, Periporopollenites multiporatus, Tricolporopollenites* sp. (*Tubulifloreae* type) and Dinoflagellat species) are recorded rarely or sporadically (Fig. 4.5, Plates 4.1–4.5).

4.4.2 Palynoflora of the Northwest Kultak Region

Two palynofloras are defined from samples of the lower (Kultak–1a and Kultak–1b) and upper coal (K–2a, K–2b and K–2c) seams in the northwest Kultak region (Figs. 4.3, 4.5).

Palynoflora of the lower coal seam is represented by more abundantly (>15%), *Laevigatosporites haartdi, Momipites punctatus, Momipites quietus, Tricolporopollenites cingulum,* abundantly (10–15%) *Inaperturopollenites hiatus, Cupressacites cuspidateaformis, Cupressacites bockwitzensis, Inaperturopollenites dubius, I.* spp., *Plicapollis plicatus, Dicolpopollis kockelii, Plicapollis pseudoexcelsus, Cuphaniedites eucolptoides, Tricolpopollenites microhenrici, Compositopollenites minitus, Olaxipollis mathensis* and *Tetracolporopollenites* sp. (Fig. 4.5, Plates 4.6–4.9). *Punctatisporites* sp., *Pityosporites microalatus, Pityosporites macroinsignis, Pityosporites labdacus, Oleoidearumpollenites microreticulatus, Triporopollenites* spp., *Polyporopollenites undulosus, Tricolpopollenites retiformis* (*Salix* type) and *Compositoipollenites rhizophorus burghasungensis* are recorded less abundantly (5–10%) in this palynoflora. Same species (*Baculatisporites* sp., *Leiotriletes maxoides minoris, Leiotriletes* sp., *Tricolporopollenites megaexactus, Inaperturopollenites magnus, Cycadopites* spp., *Tricolpopollenites henrici, Bohlensipollis hohli, Mediocolpopollis compactus, Subtriporopollenites constans, Sparganiapollenites neogenicus, Pentapollenites pentangulus, Interpollis* sp. and *Polygalacidites* sp.) are rarely observed.

Palynoflora of the upper the coal seam is characterized by more abundantly (>15%) *Oleoidearumpollenites microreticulatus* and abundantly (10–15%) *Pityosporites microalatus, Inaperturopollenites hiatus, Cupressacites cuspidateaformis, Dicolpopollis kockelii, Tricolporopollenites cingulum, Tricolporopollenites megaexactus, Aceripollenites striatus, Caryapollenites simplex, Triporopollenites* cf. *robustus* and *Psilatricolporites crassus. Laevigatosporites haartdi, Baculatisporites primarius primarius, Baculatisporites primarius oligocaenicus, Baculatisporites nanus, Baculatisporites* spp., *Pityosporites labdacus, Pityosporites* spp., *Cathayapollis* sp., *Abiespollenites* sp., *Cupressacites bockwitzensis, C. insulipapillatus, Inaperturopollenites dubius, I* spp., *Plicapollis pseudoexcelsus, Cuphaniedites eucolptoides, Momipites punctatus, Tricolpopollenites henrici, Compositopollenites minitus, Subtriporopollenites anulatus* ssp. *nanus* , *Subtriporopollenites facilis, Avicennia* sp., *Tricolporopollenites pacatus, Tricolporopollenites steinensis* and *Polyvestibulopollenites verus* are less abundantly (5–10%) observed in this palynoflora. Besides, certain species which are represented by *Verrucatosporites alienus, Verrucatosporites favus* ssp. *favus, Triletes* sp., *Leiotriletes maxoides minoris, Polypodiaceoisporites corrutoratus, Podocarpidites libellus, Piceapollis planoides, Momipites quietus, Inaperturopollenites magnus, Cycadopites* spp., *Tricolpopollenites microhenrici, Tricolpopollenites densus, Tricolporopollenites villensis, Mediocolpopollis compactus, Polyporopollenites undulosus, Tricolpopollenites retiformis* (*Platanus* type), *Compositoipollenites rhizophorus burghasungensis, Triatriopollenites rurensis, T. myricoides* and *Gothanipillis* sp. are recorded rarely or sporadically (Fig. 4.5; Plates 4.10-4.15).

4.5 Comparison with the Early Oligocene Palynoflora of Turkey

There are lost of the palaeontologic studies of the Oligocene sediments in Turkey (i.e. Rükert–Ülkümen, 1960; Lüttig & Steffens, 1976; Ünay–Bayraktar, 1989; Taner, 1996; Saraç, 2003). However, palynological studies of that time especially for the Early Oligocene are limited in Turkey (i.e Nakoman, 1968; Benda, 1971a,b; Akyol, 1971; Bati, 1996; Akgün & Sözbilir, 2001; Akgün, 2002; Akkiraz & Akgün, 2005; Sancay et al., 2006; Islamoglu et al., 2008) (Fig. 4.4).

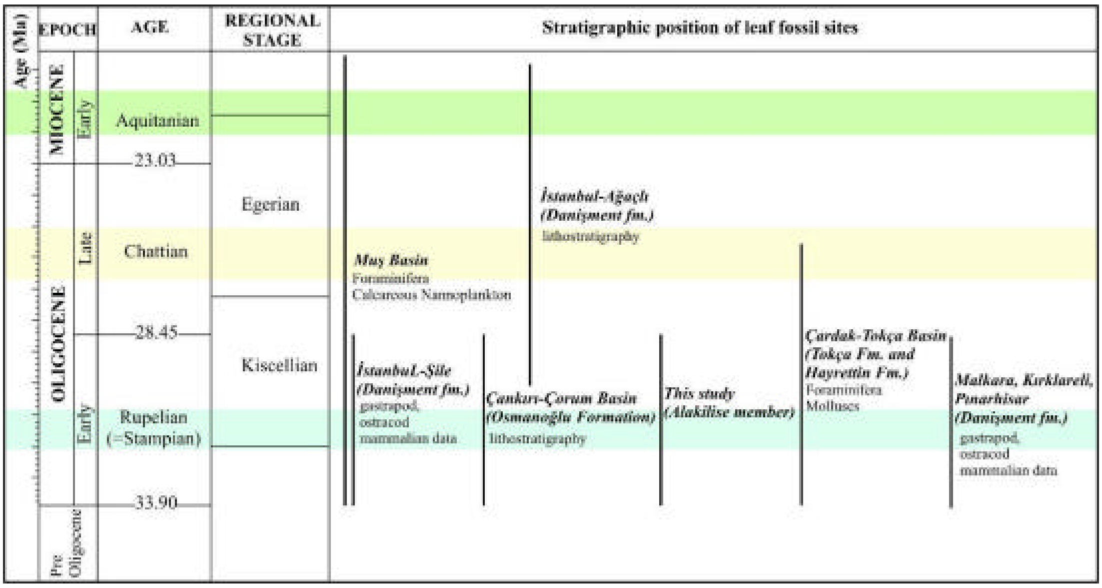
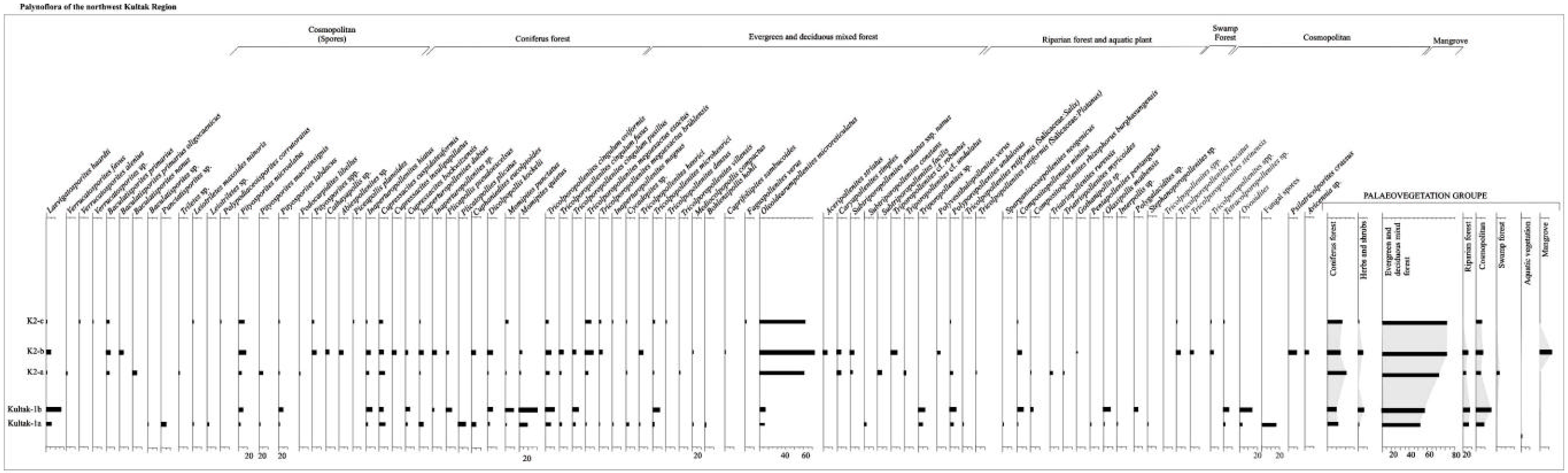


Figure 4.4 Stratigraphic ranges of previous Oligocene palynoflora involved in this chapter (Stratigraphic column Harzhauser & Piller, 2007).

One of the oldest studies is recorded by Nakoman (1968) and author defined the Early Oligocene sporomorph assemblage in the Agaçli (Istanbul) region. This age determination is supported by the gastrapod, ostracod and mammalian fossils in this region (i.e. Kemper, 1961; Ozansoy, 1962; Lebküchner, 1974; Umut et al., 1983, 1984; Sümengen et al., 1987; Kasar & Eren, 1986; Saraç, 1987; Gerhard & Alisan, 1987). 33 taxa most of belong to pollen were defined in the samples of Agaçli. Nakoman (1968) recorded the *Verrucatosporites favus, Trivestibulopollenites betuloides*, *Tricolporopollenites megaexactus*, *Dicolpopollis kalewensis* and author emphasized that *Subtriporopollenites simplex* appeared for the first time in the Early Oligocene, *Inaperturopollenites hiatus* in the “Middle” Oligocene. Besides *Monocolpopollenites tranquillus, Monoporopollenites areolatus, Polycolporopollenites vestibulum, Triatriopollenites rurobituitus* are not appeared in the Late Miocene. Nakoman (1968) concluded that coal bearing sediments in the Agaçli (Istanbul) region are of the latest Oligocene–Early Miocene in age. Taxa of Nakoman’s palynoflora are also present in palynofloras in Ören–Kultak region.


Palynoflora of the northwest Kultak Region

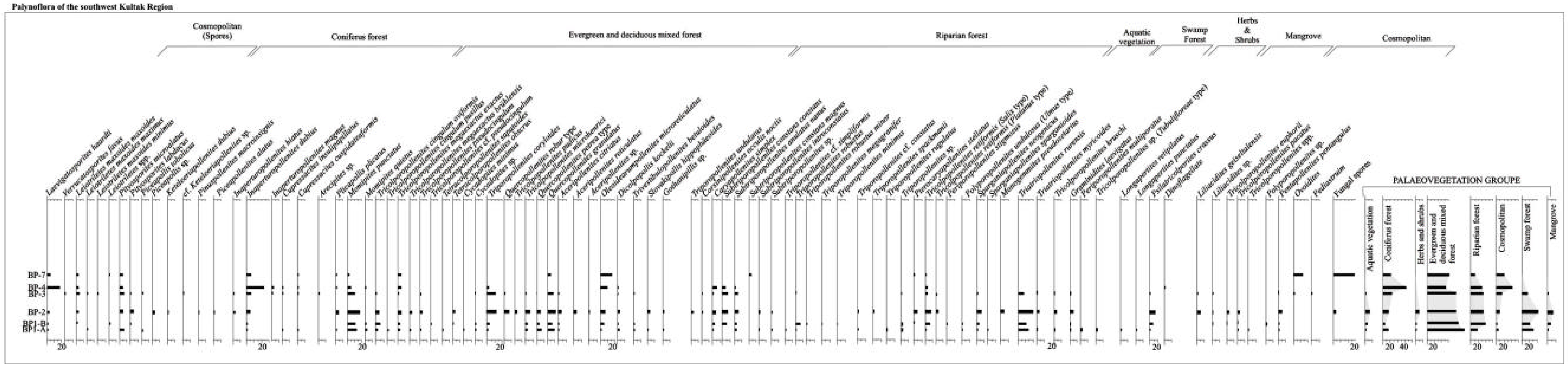

Palynoflora of the southwest Kultak Region

Figure 4.5 Detailed microfloras diagram of the studied part of the stratigraphic section in the southwest and northwest of Kultak region. Black dots indicate percentage lower than %1.

Mediocolpopollis compactus, Compositoipollenites rhizophorus burghasungensis, C. minitus, Gothanipillis sp., *Cuphaniedites eucolptoides, Plicapollis pseudoexcelsus, Subtriporopollenites anulatus* ssp. *nanus, S. facilis, Avicennia* sp., *Psilatricolporites crassus, Olaxipollis mathensis, Interpollis* sp., *Pentapollenites pentangulus, Plicapollis plicatus, Bohlensipollis hohli, Slowakipollis hippophäeoides, Longapertites retipilatus* and *L. punctatus* are not observed in the Agaçli palynoflora (Nakoman 1968). This result indicates that, although there is a close similarity in the palynomorph assemblages, the Agaçli lignites are younger than the coal studied in this chapter.

Akyol (1971) recorded the palynoflora of the coal bearing sediments in the Sile–Istanbul region. Author has defined abundantly *Verrucatosporites favus, Leiotriletes dorogensis, Pityosporites microalatus, Triatriopollenites coryphaeus, T. rurensis, Dicolpopollenites kalewensis, Tricolpopollenites liblarensis, Tricolporopollenites cingulum* and *Extratriporopollenites pompeckji.* Istanbul–Sile palynoflora is aged the Early Oligocene based on presence of the *Extratriporopollenites pompeckji* (Akyol 1971). This age determination is also recorded other fossil groups (i.e. Kemper, 1961; Ozansoy, 1962; Lebküchner, 1974; Umut et al., 1983, 1984; Sümengen et al., 1987; Kasar & Eren, 1986; Saraç, 1987; Gerhard & Alisan, 1987). These taxa are frequently recorded in our palynoflora like Akyol’s palynoflora. However in Kultak palynofloras, *Extratriporopollenites pompeckji* which is recorded in the assemblage of Eocene–Early Oligocene time interval in Europe is not founded whereas other taxa of our palynoflora (*Mediocolpopollis compactus, Compositoipollenites rhizophorus burghasungensis, C. minitus, Gothanipillis* sp., *Cuphaniedites eucolptoides, Interpollis* sp., *Pentapollenites pentangulus, Plicapollis plicatus, Bohlensipollis hohli, Slowakipollis hippophäeoides, Longapertites retipilatus* and *L. punctatus*) are frequently recorded. Based on these results, although both palynofloras include different spores and pollen, Kultak and Istanbul–Sile palynofloras are same age.

Benda (1971) defined the Early–Middle Oligocene Tokça assemblage. Kultak palynofloras resemble to the Benda’s palynoflora. *Pityosporites microalatus, Tricolpopollenites microhenrici, Tricolporopollenites microreticulatus, T. cingulum* and *T. megaexactus* frequently observed in both palynofloras. Certain species which are represented by *Mediocolpopollis compactus, Compositoipollenites rhizophorus burghasungensis, C. minitus, Gothanipillis* sp., *Cuphaniedites eucolptoides, Plicapollis pseudoexcelsus, Subtriporopollenites anulatus* ssp. *nanus, S. facilis, Avicennia* sp., *Psilatricolporites crassus, Olaxipollis mathensis, Interpollis* sp., *Pentapollenites pentangulus, Plicapollis plicatus, Slowakipollis hippophäeoides, Longapertites retipilatus* and *L. punctatus* are absent in the Tokça sporomorph assemblage. Besides *Triatriopollenites excelsus* is recorded abundantly in Tokça palynoflora whereas this species is not observed in our palynoflora. According to these results our palynoflora could be older than the Benda's palynoflora.

Akkiraz & Akgün (2005) defined the Early Oligocene palynofloras of the Tokça and Hayrettin formations. Tokça palynoflora is represented by *Leiotriletes adriennis, L. dorogensis, Laevigatosporites haartdi, Pityosporites microalatus, Inaperturopollenites hiatus, I. dubius, Sparganiapolenites polygonalis, S. neogenicus, Aglaoreidia cyclops, Dicolpopollis kockeli, Momipites punctatus, M. quietus, Olaxipollis matthesi, Subtriporopollenites anulatus nanus, Subtriporopollenites simplex, Compositoipollenites rhizophorus burghasungensis, Polyporopollenites undulosus, Aceripollenites* cf. *reticulatus, Tricolpopolenites densus, T. microhenrici, Tricolporopollenites cingulum, T. megaexactus, T. microreticulatus, Slowakipollis hippophäeoides* and *Mediacolpopollis compactus ellenhausensis.* Hayrettin palynoflora is characterized by the *Leiotriletes microadriennis, L. dorogensis, Laevigatosporites haartdi, Dicolpopollis kockeli, Momipites punctatus, Intratriporopollenites instructus, Tricolporopollenites macrodurensis, T. porasper* and *Bohlensispollis hohli.* Although the characteristic forms for the Oligocene time (*Aglaoreidia cyclops, Compositoipollenites rhizophorus burghasungensis, Bohlensispollis hohli, Slowakipollis hippophäeoides* and *Pentapollenites pentangulus*) are defined sporadically in the both palynofloras, authors suggested the Early (Middle) Oligocene age for the Tokça and Hayrettin palynofloras. Percentages of these forms and other old Tertiary pollen of Kultak palynoflora are higher than the Tokça and Hayrettin palynofloras. For this reason, age of the Tokça and Hayrettin palynofloras could be younger than our palynoflora of Kultan regions.

Akgün (2002) defined the early Oligocene palynomorph association of the Osmanoglu formation in the Çankiri–Çorum basin. *Intratriporopollenites instructus, Caryapollenites simplex, Gothanipollis* sp. *Bohlensipollsi hohli* are recorded sporadically in Osmanoglu palnoflora and according to the Akgün (2002) these pollens appear in the Early Oligocene. Besides *Plicapollis pseudoexcelsus, Plicatopollis lunatus* and *Triporopollenites robustus* are characteristic Paleocene–Eocene age and these are barely recorded in this palynoflora. The Osmanoglu palynoflora resemble to the Kultak palynofloras and both palynofloras are same age, although old Tertiary sporomorphs in the Kultak palynoflora varies and abundant than the Osmanoglu palynoflora.

Sancay et al. (2006) defined the palynomorph, foraminifera and calcareous nannoplankton biostartigraphy of the Oligocene–Miocene sediments in the Mus basin (eastern Anatolia). Early Oligocene palynoflora is composed of Compositae type pollen, *Inaperturopollenites hiatus*, *Magnastriatites howardi*, *Periporopollenites multiporatus*, *Pityosporites* spp. and Umbelliferae small types. The species of *Leiotriletes adriennis*, *Trilites multivallatus*, *Verrucatosporites favus*, *Reticulatisporites* sp., *Saxosporis* sp., *Echinatisporis* sp., *Cingulatisporites macrospecious*, *Cicatricosisporites* sp. *Podocarpidites libellus*, *Caryapollenites simplex*, *Dicolpopollis kockelii*, *Slowakipollis hippophaëoides*, *Triatriopollenites* sp., *Polyporopollenites undulosus*, *Mediocolpopollis compactus*, *Intratriporopollenites instructus* and *Ephedripites* sp. recorded in Mus palynoflora. Besides various marine dinoflagelates species are defined. Characteristic pollen of the Oligocene age are defined both palynofloras of Kultak and Mus regions. However herb species such as Compositae, *Ephedripites* sp. and Umbelliferae is only observed in the Mus palynoflora (Sancay et al., 2006).

Islamoglu et al. (2008) defined the gastrapod, bivalvia faunas and palynoflora of the Danisment formation in the Thrace basin and authors constituted palaeoenvironmental, palaeoecologic and palaeobiogeographic approaches based on these fossils. Islamoglu et al. (2008) determinated four resemble palynofloras in the Danisment formation. Palynoflora of Tozakli (Chattian age) is represented by the rich thermophilous plants such as *Taxodium* type, *Myrica* or *Engelhardia*. The abundance of hygrophilous riparian taxa (mainly *Taxodium* type, *Myrica*, *Carya* and *Alnus*) are observed in this palynoflora and these taxa are accompanied by aquatic herbs (*Sparganium–Typha*, *Potomogeton* etc.) in this pollen spectrum. Other palynoflora recorded from the Pullukcu region. Palynoflora of Pullukcu (the Rupelian age) is rich in thermophilous plants such as *Taxodium* type, *Myrica* or *Engelhardia* as the Tozakli palnoflora. *Avicennia*, a mangrove plant, is founded in Pullukcu palynoflora and this result indicated the coastal area during the Oligocene time. Presence of the indeterminate marine dinoflagellate cysts is also supported this palaeoenvironmental results. Besides hygrophilous–riparian taxa (*Taxodium* type, *Myrica*, *Carya* and *Alnus*) and aquatic herbs such as *Sparganium–Typha*, Liliaceae are abundantly observed. Both palynofloras of Tozakli and Pullukcu resemble to Kultak palynoflora. Besides mangrove paleoenvironment is represented by *Avicennia* and dinoflagellate species in the Pullukcu region during the Rupelian time, while this paleoenvironment is characterized by the *Avicennia*, *Pelliciera*, Arecaceae and marine dinoflagellate species in the Kultak palynoflora.

4.6 Comparison with the Early Oligocene Palynoflora of Europe

Conversely in Turkey, a lot of palynological studies of the Oligocene in Europe are recorded by many workers (i.e. Gorin, 1975; Hochuli, 1978; Nickel, 1996 a,b; Rákosi, 1968; Chateauneuf, 1969; Boulter & Craig, 1979; Wilkinson & Boulter, 1980; Wilkinson et al., 1980; Kirchner, 1984; Gruas–Cavagnetto & Barbin, 1989; Ollivier–Pierre, 1980; Schuler, 1990; Ollivier–Pierre et al., 1993; Cavagnetto & Anadón, 1996; Cavagnetto, 2002). Some of them are summarized below.

Chateauneuf (1969) recorded the Oligocene palynoflora of the Marseilles basin in France. Four ones are defined by author which are zone 1 (Upper Eocene), zone 2 (Lower Oligocene), zone 3 (Lower–Middle Oligocene) and zone 4 (Upper Oligocene). Chateauneuf (1969) emphasized presences of *Slowakipollis hippophäeoides* in all zones. Besides *Bohlensispollis hohli* is only recorded zone 1 and zone 2. This palynological finding Chateauneuf's Oligocene palynoflora resemble to Kultak palynoflora.

Gorin (1975) determinated the sporomorph association of Grande Limagne (Massif Central, France). Author emphasized presences of *Bohlensispollis hohli* which is the most imported for the Oligocene age. Besides, while *Bohlensispollis hohli* is recorded in the Early–Middle Oligocene, species of *Slowakipollis hippophäeoides* is observed in the Late Oligocene. Presences of the both species indicate the Early–Middle Oligocene age according to Gorin (1975). Additionally, *Plicapollis plicatus*, that is postnormapole pollen, is recorded abundantly Late Eocene time and is disappeared rapidly in Stampian. This species is reported in palynoflora of the Early–Middle Oligocene age with *Bohlensispollis hohli*, *Slowakipollis hippophäeoides. Bohlensispollis hohli* and other old Tertiary pollen and spores is defined in Kultak palynoflora and our palynomorph content indicates the similarity with Gorin's Early–Middle Oligocene palynoflora.

Hochuli (1978) defined the seven palynofloras which belong to the late Eocene, Early Oligocene, early and late Middle Oligocene, Late Oligocene, early and late Early Miocene age. Palynofloras of the Early and Middle Oligocene are represented by the *Bohlensispollis hohli, Cicatricosisporites dorogensis, Mediacolpopollis compactus, Cupaniedites* sp., *Aglaoreidia cyclops, Plicapollis pseudoexelsus, Caryapollenites simplex, Momipites punctatus* and *M. quietus.* These species are observed in our palynoflora and also *Slowakipollis hippophäeoides, Mediacolpopollis compactus ellenhausensis, Subtriporopollenites anulatus nanus, S. constans, Triporopollenites robustus, Compositopollenites minitus, Olaxipollis mathensis, Cuphaniedites eucolptoides, Compositoipollenites rhizophorus burghasungensis, Pentapollenites pentangulus* and *Interpollis* sp. accompanied with these species.

Boulter & Craig (1979) defined the Middle Oligocene palynoflora of the Stanley Bank Basin in the Bristol Channel. Authors recorded the 49 genera which are represented *Leiotriletes, Laevigatosporites, Baculatisporites, Pityosporites, Inaperturopollenites, Arecipites, Cycadopites, Nyssapollenites, Tricolpopollenites, Tricolporopollenites, Polyvestibulopollenites* and etc. Boulter & Craig (1979) suggested the importance of some species for the Oligocene time which are *Monocolpopollenites, Arecipites, Bohlensispollis, Dicolpopollis* and *Gothanipollis.* Some of them are recorded in the Kultak palynoflora and both palynofloras are similar. However, *Plicapollis* *plicatus, Slowakipollis hippophäeoides, Mediacolpopollis compactus ellenhausensis, Subtriporopollenites anulatus nanus, S. constans, Triporopollenites robustus, Compositopollenites minitus, Olaxipollis mathensis, Cuphaniedites eucolptoides, Compositoipollenites rhizophorus burghasungensis, Pentapollenites pentangulus* and *Interpollis* sp. are recorded in our palynoflora.

Wilkinson & Boulter (1980) defined the spores and pollen species of the Oligocene age of from the boreholes through the Bovey basin in British Isles. Authors suggested that species of *Trilites, Cicatricosisporites, Camazonosporites, Verrucingulatisporites, Muerrigerisporitesi, Echinosporis, Corrusporis, Arecipites, Dicolpopollis, Tiliaepollenites, Nyssapollenites, Mediacolpopollis, Porocolpopollenites, Polyatriporopollenites* and *Bohlensispollis* more or less restricted for Oligocene age in Europe and British Isles. Content of the spore species does not resemble to Kultak palynoflora while presence of the pollen species is similar in both palynofloras.

Schuler (1990) reconstructed the Paleogene environments and climates based on the palynological study of Eocene and early Oligocene formation of basins located along the west Europe Rift. 80 species of pollen and spores identified. According to author, three distinct climatic periods recorded during the Oligocene. The start of Oligocene time was characterized by slight cooling and increased humidity which means that climate remained subtropical with more temperate influence. The Early Oligocene palynoflora is represented by *Slowakipollis hippophäeoides, Bohlensispollis hohli, Plicapollis plicatus, Caryapollenites simplex, Pterocaryapollenites stellatus, Subtriporopollenites constans, Dicolpollenites kockelii* and *Trivestibulopollenites betuloides.* This palynomorph content resemble to our palynoflora of Kultak region.

Olivier–Pierre et al. (1993) defined the sporomorph assemblage of the Middle Oligocene age from Bretagne coals (France). Spore species is various and abundant. Pinaceae is always rich. Restionaceae and Psarganaiceae are observed abundantly and regularly in palynospectra of Middle Oligocene age. Angiosperm species which are Fagaceae, Ulmaceae, Betulaceae, Thymelaeaceae, Cyrillaceae, Ebenaceae, Oleaceae, Theaceae, Euphorbiaceae, Araliceae, Sapotaceae, Aquifoliaceae, Rubiaceae, Ericaceae and Eleagnaceae are observed sporadically. *Bohlensispollis hohli, Aglaoeridia cyclops* and *Dicolpopollis kockelii* is important for the Oligocene and these are recorded in the upper Rupelian age (Olivier–Pierre et al., 1993; Olivier–Pierre, 1980). Characteristic species of the Oligocene is also recorded in Kultak palynoflora. However, diversity angiosperm species is not observed in our palynoflora.

Cavagnetto (2002) recorded the palynofloras of the Rupelian–Stampian, Stampian and Aquitanian age. The Rupelian–Stampian palynoflora is represented by the i.e. *Leiotriletes adriennis, L. maxoides minoris, L. wolffi wolffi, Verructosporites alienus, V. favus, Inaperturopollenites hiatus, Milfordia minima, Sparganiapollenites* spp., *Dicolpopollis kockelii, Bohlensispollis hohli, Slowakipollis hippophäeoides, S. elaeagnoides, Momipites punctatus* and *Plicapollis plicatus*. Cavagnetto's palynoflora resemble to the Kultak palynoflora. Besides, in our palynoflora *Mediacolpopollis compactus ellenhausensis, Subtriporopollenites anulatus nanus, S. constans, Triporopollenites robustus, Compositopollenites minitus, Olaxipollis mathensis, Cuphaniedites eucolptoides, Compositoipollenites rhizophorus burghasungensis, Pentapollenites pentangulus* and *Interpollis* sp. are also recorded.

4.7 Age of Palynofloras of Alakilise Member in Kultak Region.

According to all palynological studies of Eocene and Oligocene in Turkey and Europe, the range of palynostratigraphically important species (i.e. *Caryapollenites simplex*, *Plicatopollis plicatus*, *Boehlensipollis hohli, Slowakipollis hippophaëoides* summarized in below) (Table 4.1).

- *Pentapollenites pentangulus* was recorded in the Middle Eocene–Early Oligocene of the Paris Basin by Chateauneuf (1980), Krutzsch (1970). This species has found in the Palaeocene to "Middle" Oligocene sediments from the Upper Rhine Graben (Nickel, 1996a).

- *Slowakipollis hippophäeoides* is recorded generally in the Oligocene sediments (Gorin, 1975; Chateauneuf, 1980; Cavagnetto, 2002; Schuler, 1990).

- *Compositoipollenites rhizophorus* spp. *burghasungensis* is defined from the Late Eocene sediments in Europe (Thomson & Pflug, 1953; Gruas–Cavagnetto, 1968; Kedves, 1970; Nickel, 1996a). However it is also define in the Late Eocene and Early Oligocene sediments in Turkey (Akgün, 2002; Akkiraz & Akgün; 2005).

- *Mediocolpopollis compactus* ssp. *ellenhausensis* is defined from the Late Eocene in the Upper Rhine Graben (Nickel, 1996a). It is also recorded from the Late Eocene–Early Oligocene in central and western Paratethys by Hochuli (1978). This is reported in the Late Oligocene sediments in western part of the British Isles (Wilkinson & Boulter, 1980). Boulter & Craig (1979) is defined in the "Middle" Oligocene sediments from the Bristol Channel.

- *Boehlensipollis hohli* is used for a palynostratigraphic marker during the Early–"Middle" Oligocene time in France (Gorin, 1975; Chateauneuf, 1972, 1980; Ollivier–Pierre et al., 1993). This species has also similar range in central and western Paratethys (Hochuli, 1978). It has been recorded in the "Middle" Oligocene sediments from Belgium (Roche, 1988) and in Netherlands (Schalke, 1988). *Boehlensipollis hohli* has defined in the "Middle" Oligocene sediments in the Bristol Channel (Boulter & Craig, 1979). In Turkey, this species has been found from Early Oligocene of the Osmanoglu formation in the Çankiri–Çorum Basin by Akgün (2002).

- *Gothanipollis* sp. is recorded in the Eocene and Oligocene sediments in Europe (Fairchild & Elsik, 1969; Tschudy, 1973; Boulter & Craig, 1979; Wilkinson & Boulter, 1980; Wilkinson et al., 1980). It is defined in the Eocene–Miocene sediments by Krutzsch (1970).

- *Plicapollis plicatus* is recorded in the Eocene–"middle" Oligocene sediments in Europe (Krutzsch, 1970). It is also found in the Eocene sediments in Çankiri–Çorum basin.

✍ *Subtriporopollenites constans* defined from the Early Tertiary sediments in Europe (Thomson & Pflug, 1953). This species recorded frequently in the Palaeocene and Lower Eocene sediments of Europe (Krutzsch, 1970c; Krutzsch & Vanhoorne, 1977; Kedves, 1982). It also occurs in Late Eocene and possibly “Middle” Oligocene (Krutzsch, 1957; 1961; 1970c). According to Lenz (2000), the range of species is between Palaeocene and “Middle” Oligocene. Akgün (2002) and Akgün et al. (2002) indicate the presence of species from Middle–?Upper Eocene sediments of the Çankiri Basin. Akkiraz & Akgün (2005) determined the species from Lower–“Middle” Oligocene sediments of the Çardak–Tokça Area.

✍ *Dicolpopollis kockelii* is generally found in the Oligocene sediments in Turkey (Pflanz, 1956). According to Nakoman (1966a), the species observed in the Early Tertiary sediments in the Thrace Basin. Akyol (1971) recorded the species from the Early Oligocene of Sile (Istanbul). Ediger et al. (1990) suggested that, although *Dicolpopollis* is frequently found in the Eocene–Oligocene rocks all over the world, this forms an acme zone in the Upper Oligocene (Chattian) rocks in the northern Thrace Basin. Akgün & Sözbilir (2001) observed in the Late Oligocene and Early Miocene sediments of southwest Anatolian molasse basins. The genus *Dicolpopollis* is not restricted to the Oligocene time, because it is recorded in the palynoflora of Oligocene and Early Miocene age in Europe (Boulter & Craig, 1979; Wilkinson et al., 1980 and Planderova, 1991).

✍ *Intratriporopollenites instructus* and *Caryapollenites simplex* are generally found in Tertiary sediments in Europe and Turkey (i.e. Nakoman, 1968; Hochuli, 1968; Chateauneuf, 1980; Wilkinson & Boulter, 1980; Gruas–Cavagnetto, 1988; Roche, 1988; Schuler, 1988; Nickel, 1996a; Akgün & Akyol, 1999; Akgün, 2002; Akgün & Sözbilir, 2002; Kayseri & Akgün, 2008).

✍ *Olaxipollis mathesii* is defined in the Oligocene–Miocene sediments in Europe (Krutzsch, 1970). It is also recorded in “middle” Oligocene sediments in Çardak–Tokça basin (Akkiraz & Akgün, 2005).

The species of *S. hippophaëoides*, *C. rhizophorus* ssp. *burghasungensis*, *C. minimus*, *P. pentangulus*, *P. plicatus*, *O. mathesii*, *Gothanipollis* sp. and *M. compactus* ssp. *ellenhausensis* are recorded in the Atici, Kultak and K sections of the Alakilise member from the Kultak region. Besides, *Leiotriletes maxoides maximus*, *Verrucatosporites favus*, *V. alienus* and *Polypodiaceoisporites* are determinated in our palynofloras. Hence, the present state of knowledge on the basis of palynomorph states that the sedimentation of the Alakilise member in Çambeleni formation began in the Early Oligocene (Rupelian) age.

4.8 Palaeovegetation

Palaeovegetations of the southwest and northwest of Kultak regions are reconstructed in this part. For the palaeovegetation interpretation, botanical affinity of spores and pollen and environmental preferences of these plants are used.

4.8.1 Palaeovegetation of Northwest Kultak region

In the Rupelian time, the evergreen and deciduous mixed forest elements are observed more abundantly in samples of the lower coal seam (Fig. 4.5). The coniferous and riparian forests elements are recorded abundantly in Kultak1a and 1b samples. The swamp and Mangrove forests elements are not observed in this palynospectra. Predominated palaeovegetation type is evergreen and deciduous mixed forest and coniferous forest elements in the samples of the upper coal seam. Riparian and swamp forest elements are defined less abundantly. Besides, the mangrove forest elements are determinated in upper coal seam samples (K2a, K2b, K2c). Herb and shrub species are less abundant in both coal seams (Figs. 4.5, 4.6). According to this palaeovegetational data, deposition of the lower coal seam could be mentioned the terrestrial condition. And presence of the mangrove forest indicates the marine influence in the Rupelian time. This results could be interpreted the transgression during the Early Oligocene.

Table 4.1 Age determinations of some forms found in the Oligocene basins.

Intratriporopollenites instructus	Early Oligocene – Late Oligocene	Schuler (1988); Roche (1988)
	Early Oligocene – Miocene	Wilkinson & Boulter (1980)
	Late Oligocene	Von Der Brelie (1988)
	Miocene	Kayseri & Akgün (2008, 2010); Akgün & Akyol (1999)
Caryapollenites simplex	Early – "Middle" Oligocene	Chateauneuf (1980)
	Early Oligocene – Miocene	Hochuli (1978); Roche (1988); Schuler (1988); Nickel (1996a)
	Miocene	Akgün & Sözbilir (2002); Kayseri & Akgün (2008, 2010); Akgün & Akyol (1999)
	Tertiary	Krutzsch (1970)
Dicolpopollis kockelii	Early Tertiary	Nakoman (1966a)
	Late Eocene – Early Oligocene	Chateauneuf (1980),
	Early Oligocene	Akyol (1971); Ollivier – Pierre (1980)
	Early – "Middle" Oligocene	Roche (1988)
	Late Oligocene	Von Der Brelie (1988)
	Early Miocene, early Middle Miocene	Sözbilir & Akgün (2002); Kayseri & Akgün (2010), Planderova (1992)
Slowakipollis hippophaëoides	Oligocene	Gorin (1975), Cavagnetto (2002), Schuler (1990)
	Early – "Middle" Oligocene	Chateauneuf (1980)
Boehlensipolis hohli	Early – "Middle" Oligocene	Gorin (1975); Chateauneuf (1980); Ollivier – Pierre et al. (1993); Hochuli (1978)
	"Middle" Oligocene	Schalke (1988); Roche (1988); Boulter & Craig (1979), Krutzsch (1970)
Pentapollenites pentangulus	Paleocene – "Middle" Oligocene	Nickel (1996a)
	Middle Eocene – "Middle" Oligocene	Chateauneuf (1980); Krutzsch (1970)
	Middle*Late Eocene	Akgün (2002)
Gothanipollis sp.	Middle Eocene	Fairchild & Elsik (1969)
	Early Eocene – Early Oligocene	Tschudy (1973)
	Oligocene	Boulter & Craig (1979); Wilkinson & Boulter (1980); Wilkinson et al. (1980)
	Eocene–Miocene	Krutzsch (1970)
Olaxipollis mathesii	Oligocene–Miocene	Krutzsch (1970)
Plicapollsi plicatus	Late Eocene – "Middle" Oligocene	Krutzsch (1970), Akgün (2002)
Subtriporopollenites constans	Early Tertiary	Thomson & Pflug (1953)
	Paleocene–Eocene	Krutzsch (1970c); Kurtzsch & Van Hoorn (1977)
	Late Eocene–"Middle"Oligocene	Krutzsch (1957; 1961; 1970c)
Compositoipollenites rhizophorus ssp. *burghasungensis*	Late Eocene	Thomson and Pflug (1953); Gruas –Cavagnetto (1968); Kedves (1970); Nickel (1996a)
	Oligocene	Akkiraz & Akgün (2005), Akgün (2002)
Mediocolpopollis compactus ssp. *ellenhausensis*	Late Eocene–Early Oligocene	Hochuli (1978)
	Late Eocene – "Middle" Oligocene	Nickel (1996a)
	"Middle" Oligocene	Boulter & Craig (1979)
	Late Oligocene	Krutzsch (1959)

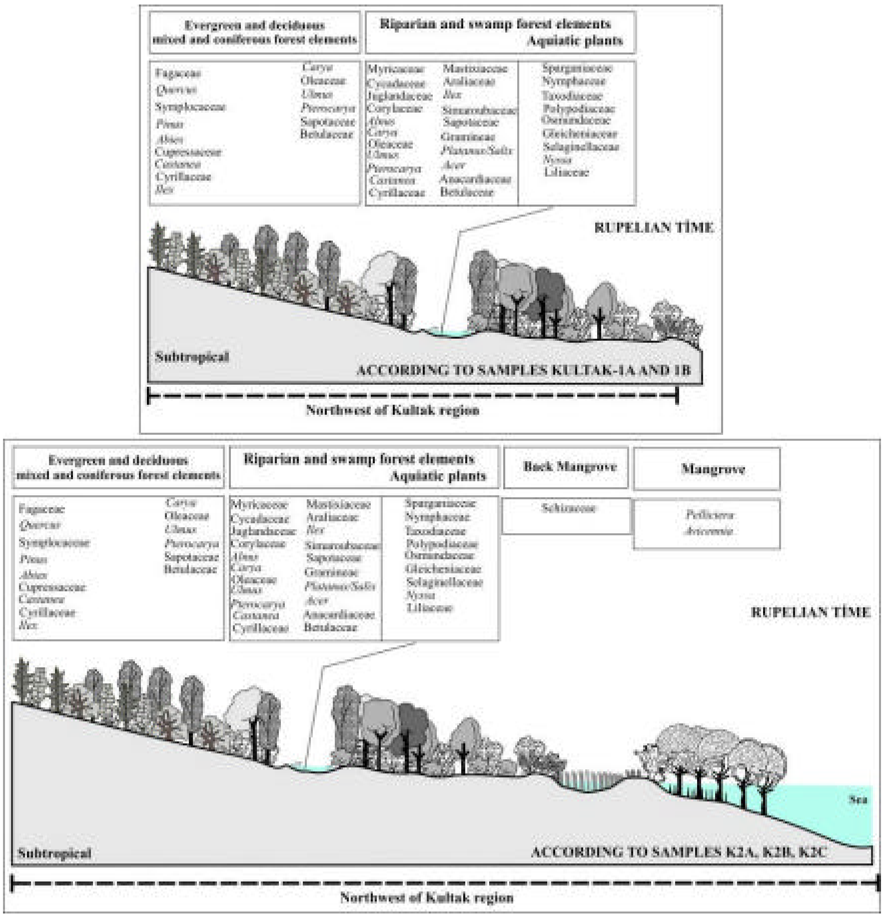


Figure 4.6 Palaeoenvironmental reconstruction of northwest of Kultak region during the deposition of coal bearing Rupelian Alakilise member.

4.8.2 *Palaeovegetation of southwest Kultak region*

The palaeovegetation is represented predominantly evergreen and deciduous mixed and coniferous forests as the palaeovegetation of southwest Kultak region during the Rupelian time. Distinctly differences, mangrove forest elements are defined in all samples and marine dinoflagellate species are accompanied less abundantly to these forest elements in this region. Besides the swamp forest and aquatic vegetation plants are recorded in samples of the southwest Kultak region. During the Rupelian time, the riparian forest elements southwest region high percentage than the riparian forest elements northwest region. Herb and shrub vegetation plants are recorded less abundantly (Figs. 4.5, 4.7). Besides, decreasing of the percentage of mangrove species from lower to upper samples and presence of the dinoflagellate species in the upper sample indicates the marine influence in the Rupelian time as in the northwest of Kultak region. This results could be indicated the transgression during the Early Oligocene.

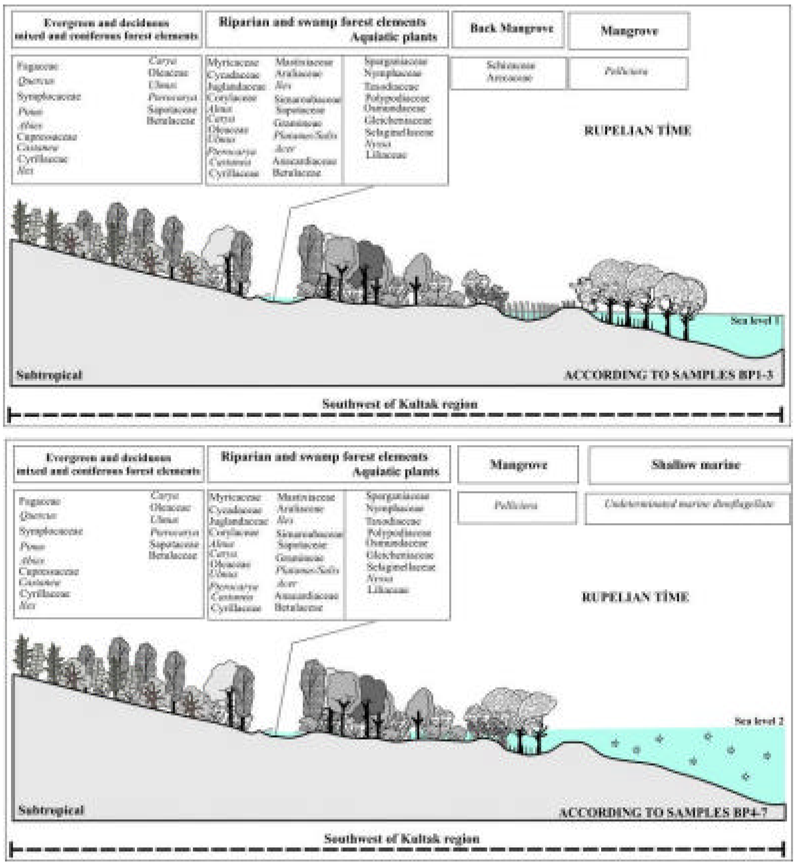


Figure 4.7 Palaeoenvironmental reconstruction of southwest of Kultak region during the deposition of coal bearing Rupelian Alakilise member.

Level of “BP” samples in the southwest region can be correlated with the level of “K2” samples in the northwest region. Besides, presence of marine dinoflagellates species and various mangrove vegetation elements indicate the marine conditions in southwest region, however this condition of northwest region is more affected than condition of the southwest region during the Rupelian time (Figs. 4.6, 4.7).

4.9 Palaeoclimate

The palaeoclimate records are obtained from the application of the coexistence approach to the palynofloras of the Rupelian sediments in the southwest and northwest of Kultak regions. Besides, numerical palaeoclimatic results of Istanbul–Sile and Çorum–Osmanoglu are calculated using coexistence approach method and results of Tokça and Incesu regions are obtained from published study (Akkiraz et al., 2005). Climatic variables for the seven palynoflora levels of the Rupelian (Early Oligocene) are obtained and the MAT, CMT, WMT, MAP, MAP_{WET}, MAP_{DRY} and MAP_{WARM} variables are used for the palaeoclimatic interpretation in this chapter.

The climatic reconstruction of samples (BP) of Atici section in the northeast of Kultak region relies on a total of 22 taxa with known NLRs (Fig. 4.8; Table 4.2). Reconstructed climatic estimates of the BP samples are MAT 16.5–21.3°C, CMT 7.7–13.3°C, WMT 27.3–28.1°C, MAP 1122–1520mm, MAP_{WET} 204–227mm and 115–180mm, MAP_{DRY} 19.0–43.0mm and MAP_{WARM} 118.0–125.0mm. The palaeoclimatic reconstruction of the lower coal seam (samples Kultak1) in the southwest Kultak region is based on 19 taxa. The values are 17.2 to 18.8^{o}C for the MAT, 5.5 to 13.1^{o}C for the CMT, 27.3 to 27.7^{o}C for the WMT and 1217–1520mm for the MAP, 204–227mm for MAP_{WET}, 19–54mm for MAP_{DRY} and 118–125mm for MAP_{WARM} (Fig. 4.9; Table 4.2). The temperature values of the of the upper coal seam (samples K2) in the southwest Kultak region are MAT 17.2–18.8^{o}C, CMT 6.2–13.1^{o}C for, WMT 27.3–28.1^{o}C and MAP 1217–1322mm, MAP_{WET} 225–227mm, MAP_{DRY} 19–32mm and MAP_{WARM} 118–125mm (Fig. 4.9; Table 4.2).

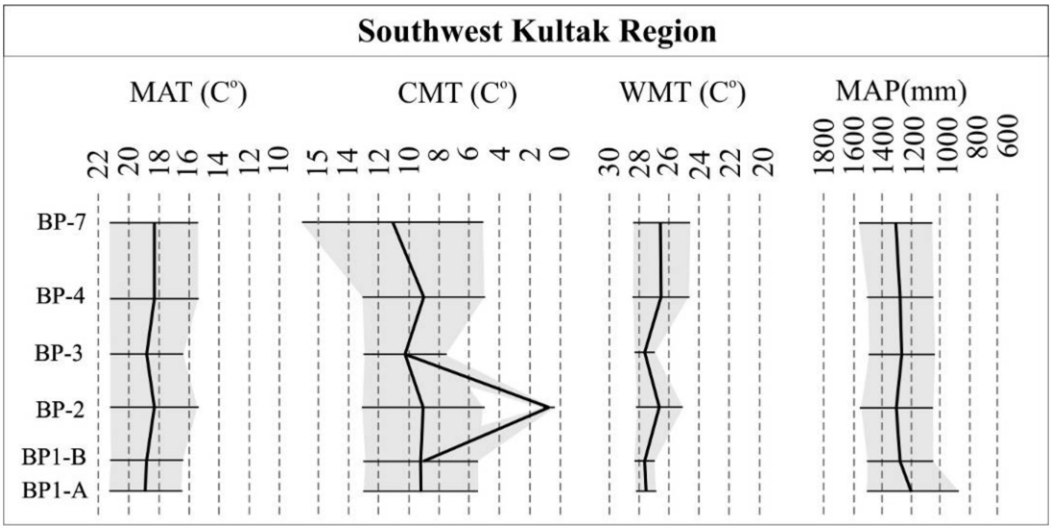


Figure 4.8 Application of the Coexistence Approach to the palynoflora of southwest Kultak region (MAT: mean annual temperature, CMT: mean temperature of coldest month, WMT: mean temperature of warmest month and MAP: mean annual precipitation).

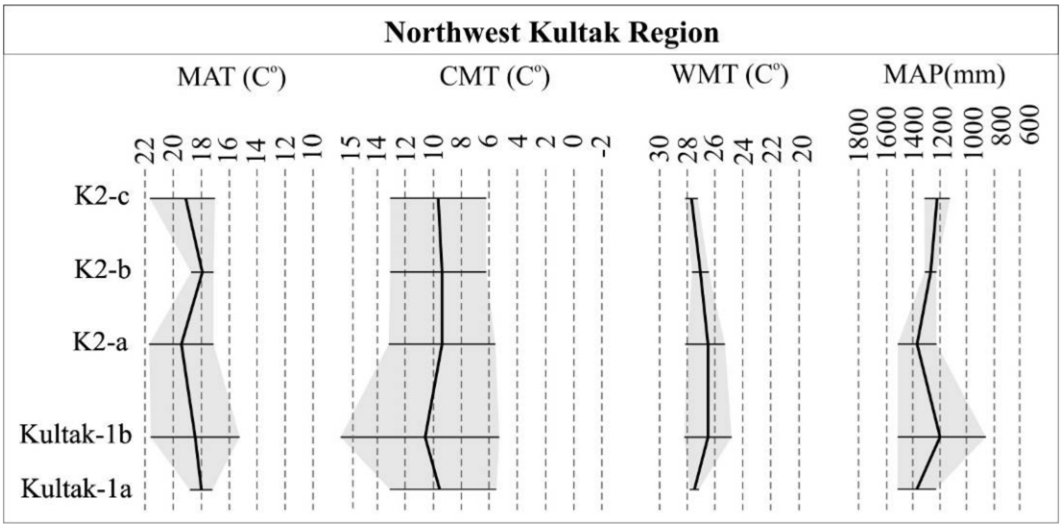


Figure 4.9 Application of the Coexistence Approach to the palynoflora of northwest Kultak region (MAT: mean annual temperature, CMT: mean temperature of coldest month, WMT: mean temperature of warmest month and MAP: mean annual precipitation).

According to these coexistence results and palynoflora, the palaeoclimate could be subtropical under high rainfall in the southwest and northwest Kultak regions during the Rupelian time. The average of the MAT and WMT values are generally between the 18–20^{o}C and 25–28^{o}C. Besides the MAP results are distinctly high and 1000–1500mm. The average of the CMT values are between 9–11^{o}C in the southwest Kultak region during the Rupelian time (Fig. 4.8).

In the northwest Kultak region during the Rupelian time, the average of the MAT, WMT and MAP values resemble to the values of the southwest region of Kultak. The average of the CMT value is generally 10^{o}C and this result is similar to the CMT value of other Kultak region (Fig. 4.9).

According to Mosbrugger et al. (2005), the changing of the WMT, MAT and MAP values do not observed during the Eocene and Late Miocene time interval. However, the CMT values have variations during that period. These variations indicate the curve from the Eocene to Pliocene. Zachos et al. (2001) defined the palaeoclimatic evolution during the Eocene and Quaternary period based on the oxygen and carbon isotopes analysis. The curve of the CMT values is corrected with the Zachos's curve of oxygen analysis results by Mosbrugger et al. (2005). Both curves indicated the similar changes and these have "temperature optimum" periods in the Middle Eocene, Late Oligocene and Middle Miocene time.

Table 4.2 Temperature values of the CA$_{palynoflora}$ for the Early Oligocene time (Atici section in northwest Kultak region and lower and upper coal seams in the southwest Kultak region).

Location		**MAT (^{o}C)**	**CMT (^{o}C)**	**WMT (^{o}C)**	**MAP (mm)**	**MAP$_{wet}$ (mm)**	**MAP$_{dry}$ (mm)**	**MAP$_{warm}$ (mm)**	**MART(^{o}C)**
THIS STUDY	Atici section (Samples BP)	**16.5–21.3** (20taxa) Cycadaceae– *Carya cordiformis*	**7.7–13.3** (20 taxa) *Arecoideae* sp – *Carya cordiformis*	**27.3–28.1** (20 taxa) Cycadaceae – Cupressaceae	**1122.0–1520.0** (21 taxa) *Lygodium* sp – *Taxodiaceae*	**115.0–180.0** (21 taxa) *Lygodium* sp. – *Carya cordiformis* **204.0–227.0** (21 taxa) *Engelhardtia* sp. – *Pinus sylvestris*	**19.0–49.0** (22 taxa) *Lygodium* sp. – Cupressaceae	**79.0–125.0** (21 taxa) *Engelhardtia* sp. – *Pinus sylvestris*	**17.2**
	(Samples of lower coal seam)	**17.2–18.8** (16 taxa) *Trigonobalanus* sp. – *Armeria* sp.	**5.5–13.1** (18 taxa) Cycadaceae – *Armeria* sp.	**27.3–27.7** (18 taxa) Cycadaceae – *Armeria* sp.	**1217.0–1520.0** (19 taxa) *Trigonobalanus sp* – Taxodiaceae	**204.0–227.0** (18 taxa) *Engelhardtia* sp. – *Pinus sylvestris*	**19.0–54.0** (19taxa) *Lygodium* sp. – *Pinus sylvestris*	**118.0–125.0** (19 taxa) *Trigonobalanus* sp – *Pinus sylvestris*	**18.2**
	(Samples of upper coal seam)	**17.2–18.8** (16 taxa) *Trigonobalanus* sp. – *Armeria* sp.	**6.2–13.1** (16 taxa) *Cathaya* sp. – *Armeria* sp.	**27.3–28.1** (16 taxa) *Cycadaceae* – *Cycadaceae*	**1217.0–1322.0** (16 taxa) *Trigonobalanus sp* .– *Cathaya sp*	**225.0–227.0** (13 taxa) *Cathaya* sp. .– *Pinus sylvestris*	**19.0–32.0** (13 taxa) Lygodium sp. – Cathaya sp.	**118.0–125.0** (17 taxa) Trigonobalanus sp. – Pinus sylvestris	**18.1**
Istanbul–Sile		**17.2–18.8** (23 taxa) *Reevesia* sp. – *Armeria* sp.	**5.5–13.1** (23 taxa) Cycadaceae – *Armeria* sp.	**27.3–27.7** (23 taxa) Cycadaceae.– *Armeria* sp.	**1187.0–1355.0** (19 taxa) *Reevesia* sp. – *Carpinus*	**204.0–236.0** (23 taxa) *Tilia* sp..– Taxodiaceae	**9.0–67.0** (23 taxa) *Tilia* sp. – Taxodiaceae	**118.0–141.0** (23 taxa) *Reevesia* sp. – *Armeria* sp.	**18.2**
Çorum–Osmanoglu fm.		**16.5–18.8** (19 taxa) *Sabal* sp. – *Armeria* sp.	**4.8–13.1** (19 taxa) *Sabal* sp. – *Armeria* sp.	**26.0–27.7** (19 taxa) *Sabal* sp.– *Armeria* sp.	**1183.0–1520.0** (19 taxa) *Gleichenia sp* .– *Taxodiaceae*	**134.0–180.0** (18 taxa) *Sabal* sp.– *Carya cordiform is* **205.0–241.0** *Gleichenia* sp. *Sabal* sp.	**19.0–43.0** (19 taxa) *Lygodium* sp. – Cupressaceae	**85.0–141.0** (28 taxa) *Gleichenia* sp.– *Armeria* sp.	**17.9**
Çardak–Tokça (Akkiraz et al. 2005)		**17.2–17.4** (35 taxa)	**5.5–8.3**	**27.3–27.9**	**1217–1355**	–	–	–	**20.7**
Burdur–Incesu (Akkiraz et al. 2005)		**17.2–20.8**	**9.6–13.3**	**27.3–27.9**	**1217–1520**	–	–	–	**16.2**

In figure 4.10, the CMT values of Çorum–Osmanoglu formation, Istanbul–Sile, Çardak–Tokça, Burdur–Incesu, Ören–upper and lower coal seams and Ören–Atici section are correlated between each other and continental temperature values of the CMT in the central Europe (Mosbrugger et al., 2005). Besides, the CMT values of the Eocene (Yozgat–Çiçekdag, Yozgat–Sorgun regions and Çorum–Çektek, Çorum–Armutlu formations) in Turkey are used for the correlation. Thus palaeoclimate Turkey could be observed changing from the Eocene to Early Oligocene (Fig. 4.10).

In the Eocene time the CMT values are generally high and some regions have two coexistence intervals for the CMT. This time is characterized the mangrove palaeovegetation in the central Anatolia which is represented by the *Nypa*, *Avicennia*, Arecaceae, *Pelliciera*, Restionaceae, Verbenanaceae and marine various dinoflagellate species because of the tropical climate (Akgün, 2002; Akkiraz et al. 2008). From Eocene to Early Oligocene, the CMT values distinctly decrease and this decline could be indicated the palaeoclimatic changes from tropical to subtropical (Fig. 4.10).

Additionally, the lower CMT value is recorded from the Çardak–Tokça region whereas the highest CMT value is observed from the Burdur–Incesu region. The MART value of the Çardak–Tokça region is 20.70°C and this result indicates the terrestrial condition which could be represented by the high palaeotopography. The lower CMT values could be explained high palaeotopographic condition. Besides, the MART value of Burdur–Incesu region is 16.15°C and presence of the low palaeotopography in this region and high CMT value is strengthened presence of low palaeotopographic condition. The CMT values of the Ören region is lower than the value of Burdur–Incesu region although presence of the mangrove vegetation. This could be indicated presence of terrestrial and marine conditions in the Ören region during the Rupelian time (Figs. 4.6, 4.7, 4.10). The MART values of Ören, Sile and Çorum regions resemble and this could be interpreted similar palaeotopographic condition (Fig. 4.11). These results are supported by the palaeogeographic map of Popov et al. (2004). Besides, in the Ören region, land-sea border could be located north of the Gökova Gulf (Fig. 4.11).

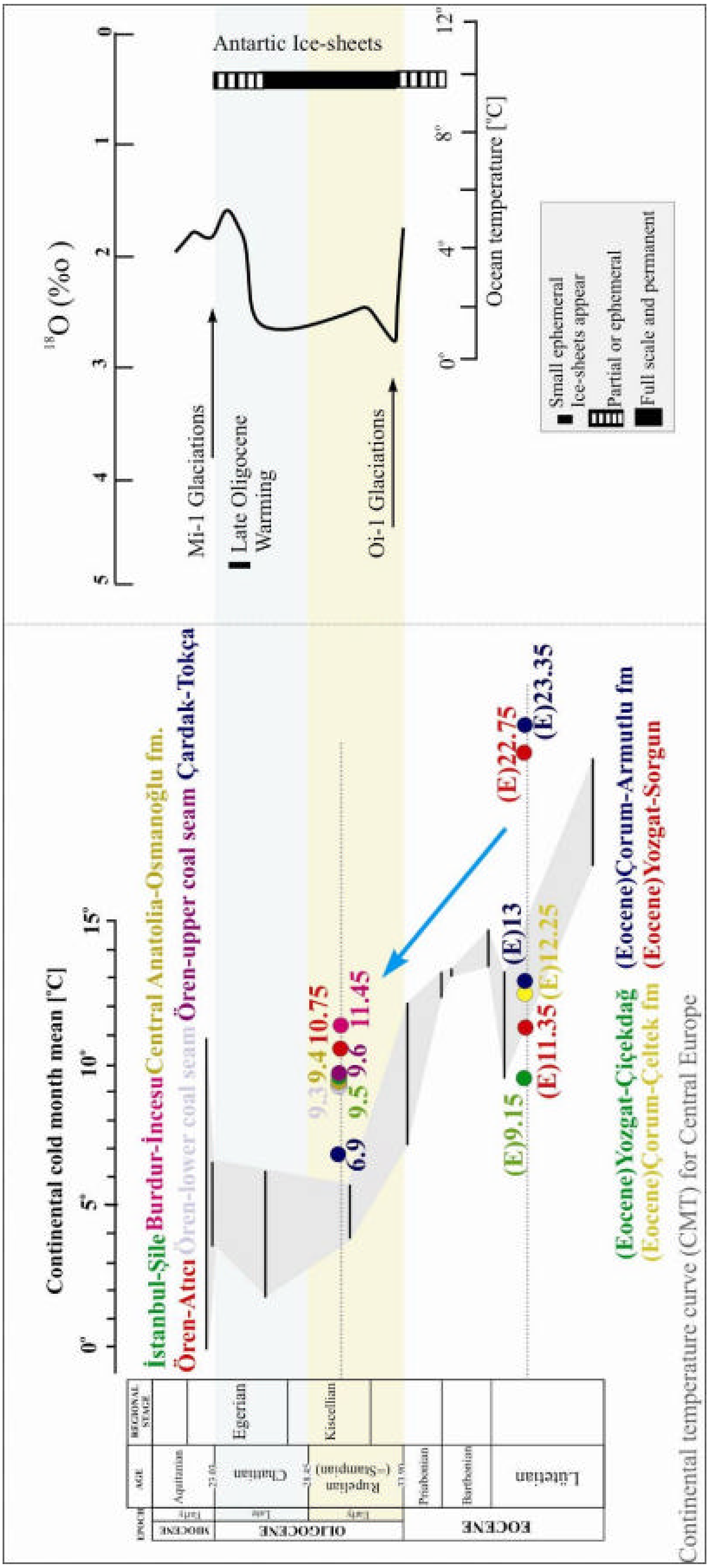


Figure 4.10 Coexistence intervals and isotopic data derived from the samples between Middle Eocene and Early Oligocene (data from Zachos et al., 2001; Akgün, 2002; Akgün et al., 2002; Akkiraz et al., 2008 and here with study).

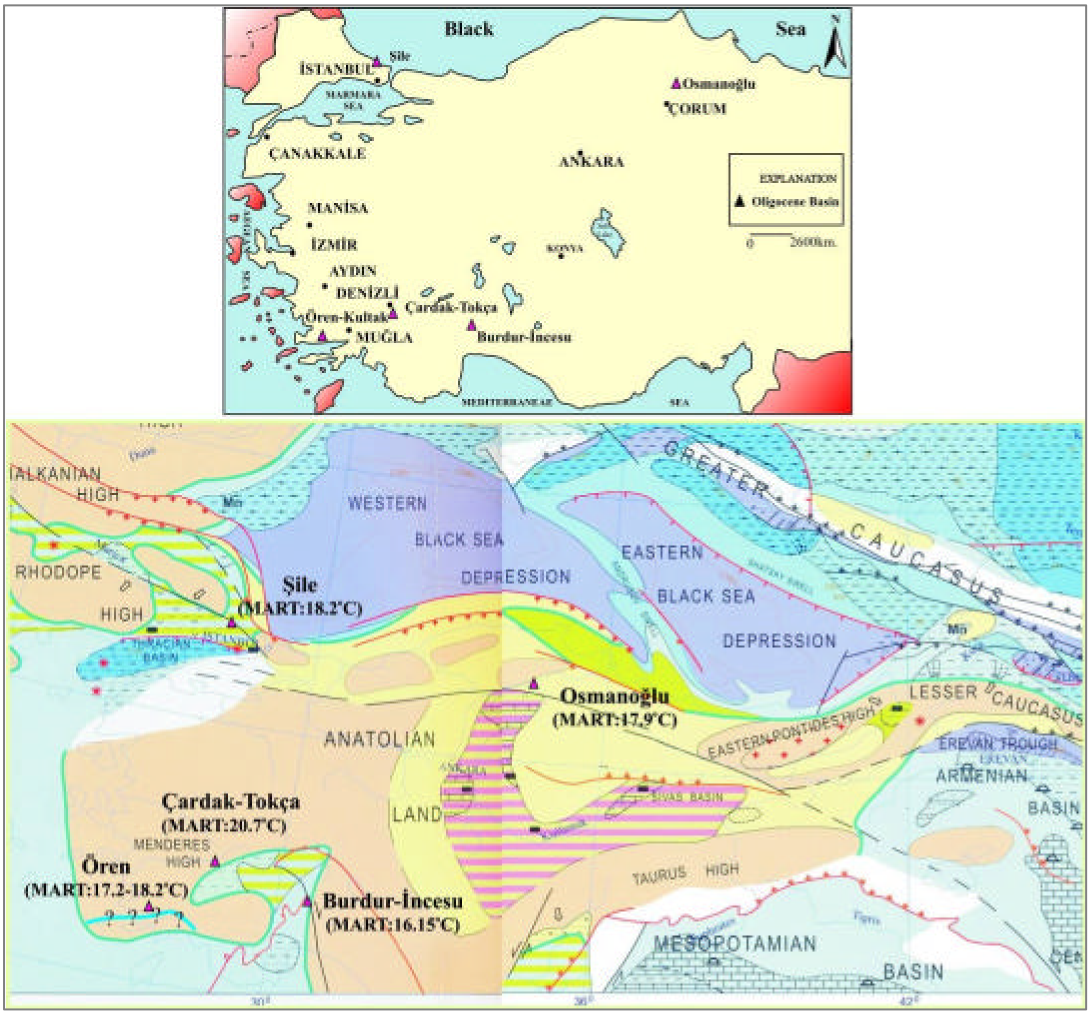


Figure 4.11 The Oligocene localities and the MART values of these localities on the palaeogeographic map of the Early Oligocene time (Popov et al., 2004).

PLATE 4.1 (Atici Section in southwest Kultak)

1, 2.	*Verrucatosporites favus* (Potonié) Thomson & Pflug
3.	*Leiotriletes maxoides* Krutzsch ssp. *maximus* (Pglug *in* Thomson & Pflug) Krutzsch
4–11.	*Leiotriletes maxoides* Krutzsch ssp. *maxoides* Krutzsch
12.	*Leiotriletes maxoides* Krutzsch ssp. *minoris* Krutzsch
13.	*Leiotriletes* sp.
14.	*Keteleeriapollenites dubius* (Chlonova) Slodkowska
15.	cf. *Keteleeriapollenites* sp.
16–17.	*Piceapollis tobolicus* (Panova) Krutzsch

PLATE 4.2 (Atici Section in southwest Kultak)

1.	*Pityosporites* sp.
2.	*Pinuspollenites macroinsignis* (Krutzsch ex Ollivier–Pierre) Planderova
3, 4.	*Piceapollenites alatus* (Potonié ex Potonié)
5.	*Pityosporites labdacus* (Potonié) Thomson & Pflug
6, 7.	*Zonolapollenites verrucatus* Krutzsch ex Ziembinska–Tworzydlo
8.	*Sparganiaceaepollenites neogenicus* Krutzsch
9.	*Inaperturopollenites magnus* (Potonié) Thomson & Pflug
10.	*Cupressacites insulipapillatus* (Trevisan) Krutzsch
11.	*Pterocaryapollenites stellatus* (Potonié) Thiergart
12–19.	*Subtriporopollenites anulatus* Thomson & Pflug ssp. *nanus* Thomson & Pflug
20–27.	*Subtriporopollenites intraconstans* Pflug in Thomson & Pflug
28.	*Subtriporopollenites* sp.
29–30.	*Subtriporopollenites constans* Pflug *in* Thomson & Pflug
31, 32.	*Subtriporopollenites constans* Pflug in Thomson & Pflug *magnus* Krutzsch
33–35.	*Caryapollenites simplex* (Potonié) Raatz ex Potonié
36, 37.	*Triporopollenites* cf. *constatus* Takahashi
38–40.	*Triporopollenites spackmanii* (Traverse) Kedves

PLATE 4.3 (Atici Section in southwest Kultak)

1.	*Caryapollenites simplex* (Potonié) Raatz ex Potonié
2.	*Triporopollenites rugulatus* Kedves
3, 3a.	*Triporopollenites minimus* Kedves
4, 5	*Triporopollenites megagranifer* (Potonié) Thomson & Pflug
6–11.	*Triporopollenites coryloides* Pflug & Thomson *in* Thomson & Pflug
12–17.	*Triporopollenites robustus* (Mürriger & Pflug) Pflug *in* Thomson & Pflug
18–25.	*Triporopollenite* spp.
26.	*Triporopollenites* cf. *constatus* Takahashi
27–29.	*Triatriopollenites rurensis* Thomson & Pflug
30, 31.	*Triatriopollenites* spp.

32.	*Momipites quietus* (Potonié) Nichols
33–40.	*Momipites punctatus* (Potonié) Nagy
41, 42.	*Plicatopollis plicatus* (Potonié) Krutzsch
43, 44.	*Slowakipollis hippophäeoides* Krutzsch
45.	*Gothanipillis* sp.
46–50.	*Trivestibulopollenites betuloides* Pflug *in* Thomson & Pflug
51–54.	*Pentapollenites pentangulus* (Pflug) Krutzsch
55–59.	*Dicolpopollis kockelii* Pflanzl
60, 60a.	*Liliacidites* sp.

PLATE 4.4 (Atici Section in southwest Kultak)

1–7	*Liliacidites geiseltalensis* Krutzsch
8.	*Liliacidites* sp.
9.	*Longapertites punctatus* Frederiksen
10.	*Longapertites retipilatus* Kar
11–15.	*Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
16–18.	*Quercopollenites robur* type Nagy
19–28a	*Quercopollenites petrea* Nagy
29–34.	*Quercopollenites granulatus* Nagy
35.	*Tricolpopollenites pudicus* (Potonié) Thomson & Pflug
36–40.	*Aceripollenites striatus* (Pflug) Thiele–Pfeifer
41, 41a.	*Aceripollenites reticulatus* Nagy
42.	*Aceripollenites* sp.
43, 44.	*Tricolporopollenites* sp. (Phillrea–type)
45–47.	*Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
48.	*Tricolporopollenites edmundii* (Potonié) Thomson & Pflug

PLATE 4.5 (Atici Section in southwest Kultak)

1–10.	*Psilatricolporites crassus* Van Der Hammen & Wymstra
11.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *oviformis* (Potonié) Thomson & Pflug
12, 13.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *brühlensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
14.	*Tricolporopollenites* sp. (Compositae–Tubulifloreae type)
15, 16.	*Tricolporopollenites* sp1.
17.	*Tricolporopollenites* sp2.
18.	*Tetracolporopollenites* sp1.
19.	*Polygalacidites* sp.
20.	*Periporopollenites multiporatus* Pflug & Thomson *in* Thomson & Pflug
21	Indeterminated form
22, 23.	*Ovoidites* spp.
24.	Cuticle

PLATE 4.1 (Atici Section in southwest Kultak)

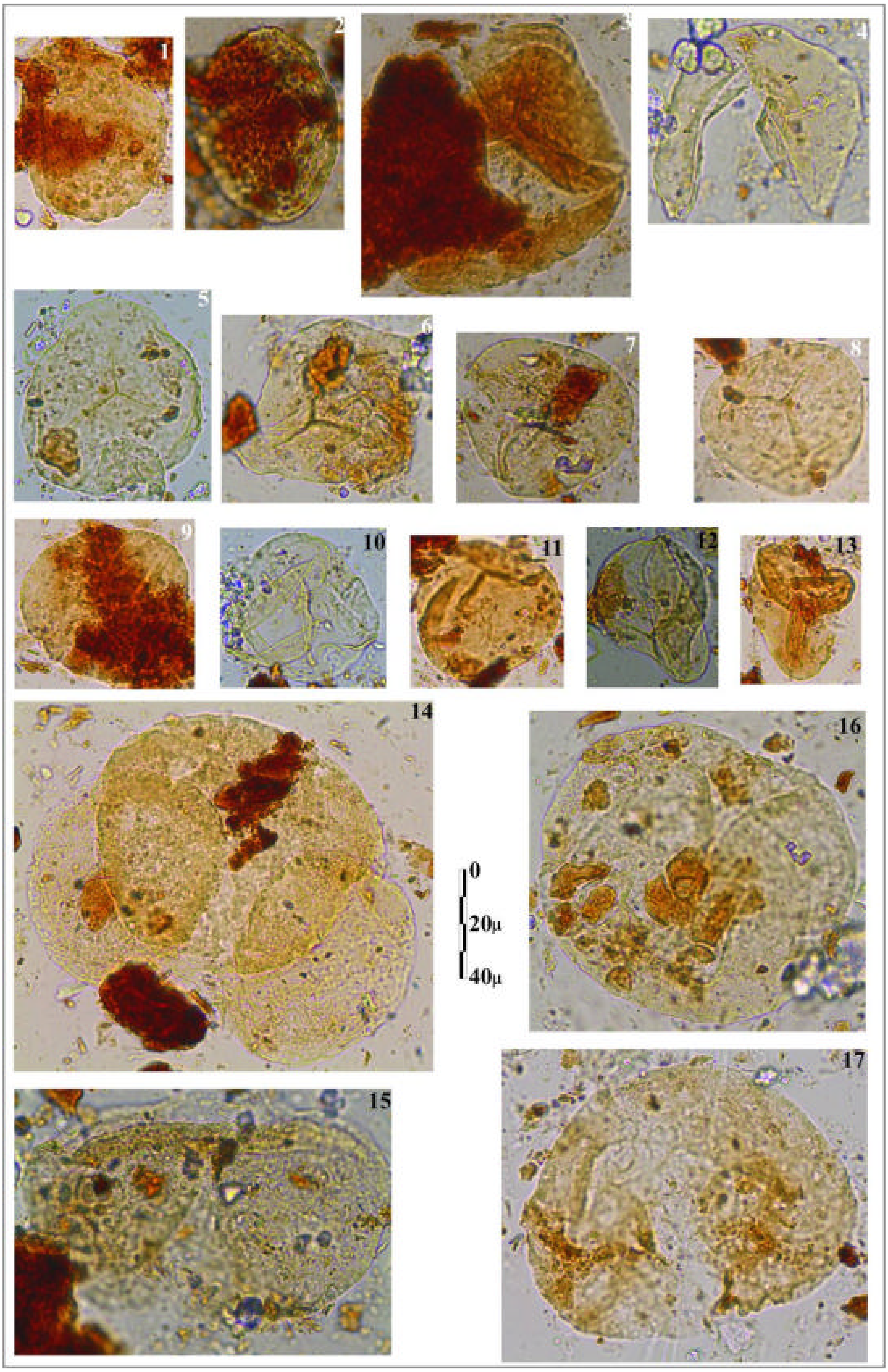


PLATE 4.2 (Atici Section in southwest Kultak)

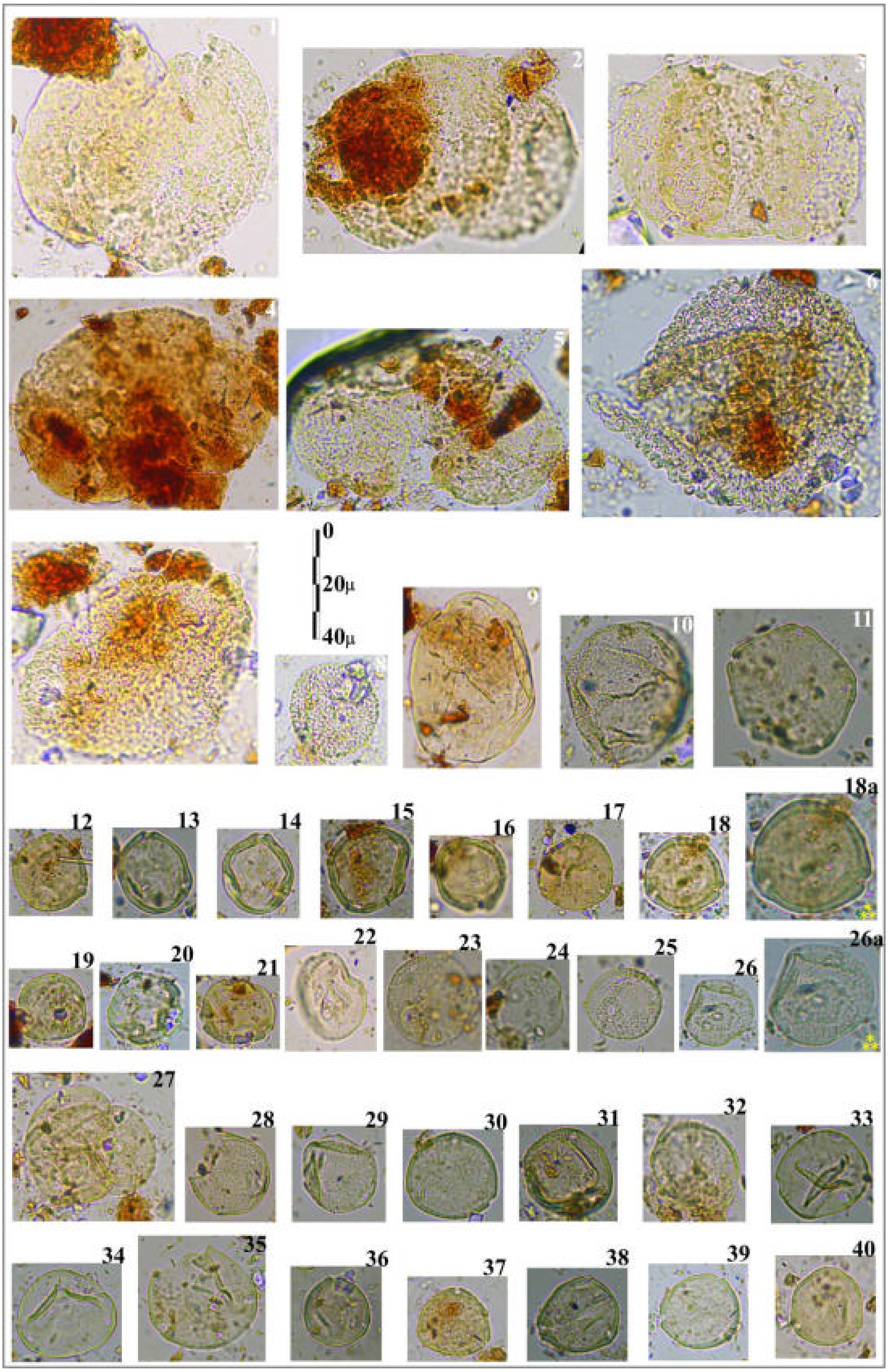


PLATE 4.3 (Atici Section in southwest Kultak)

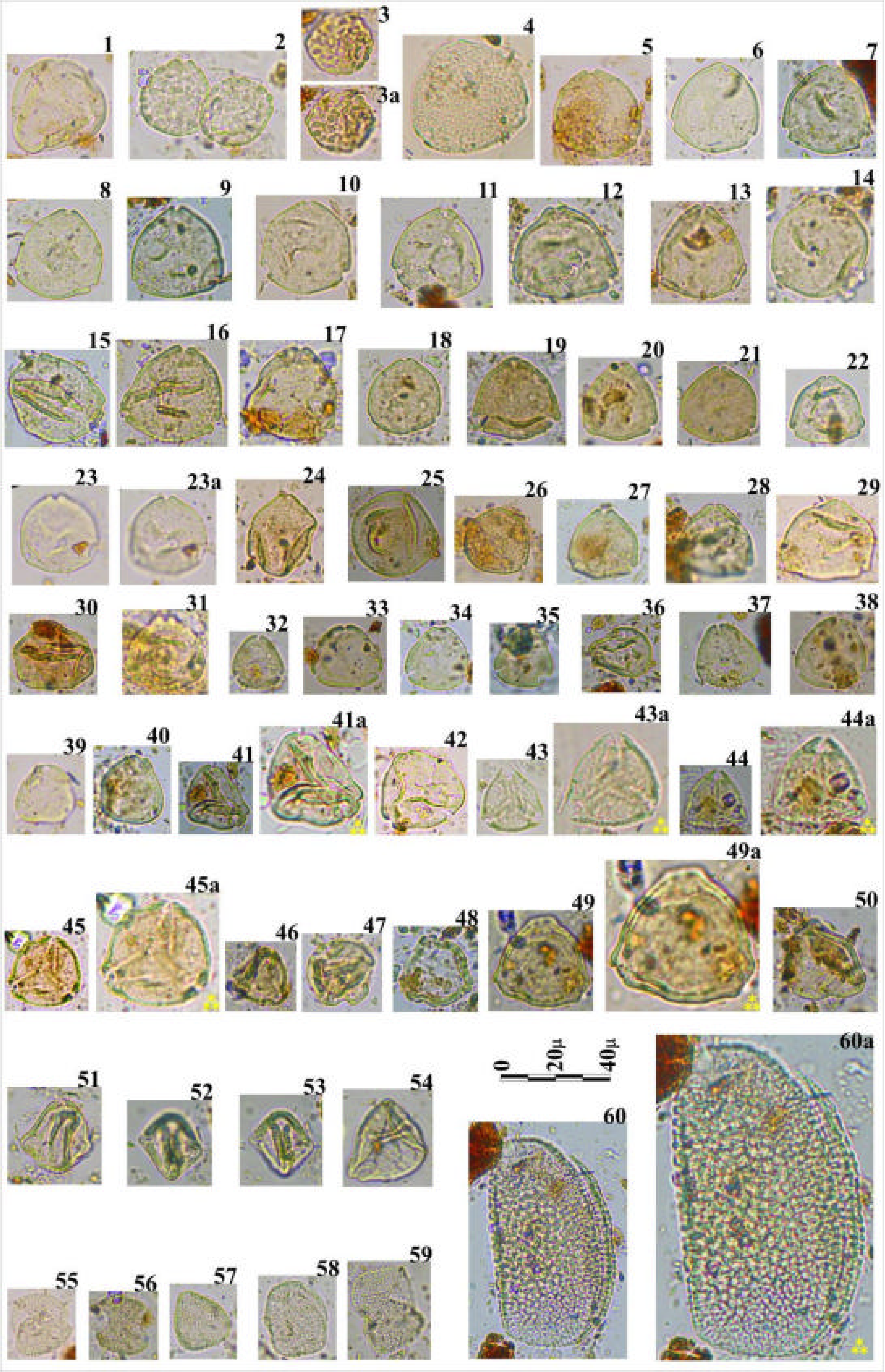


PLATE 4.4 (Atici Section in southwest Kultak)

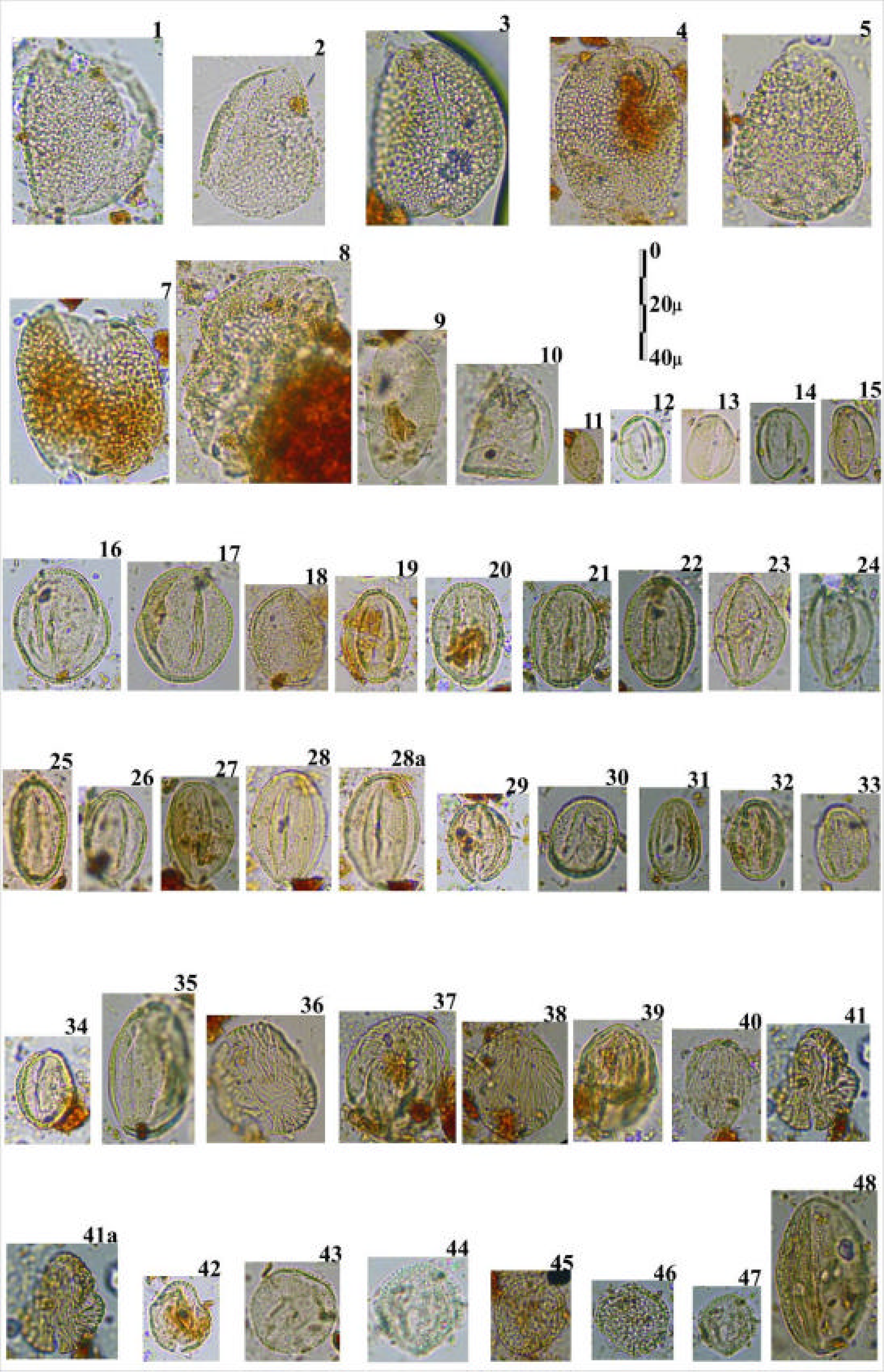


PLATE 4.5 (Atici Section in southwest Kultak)

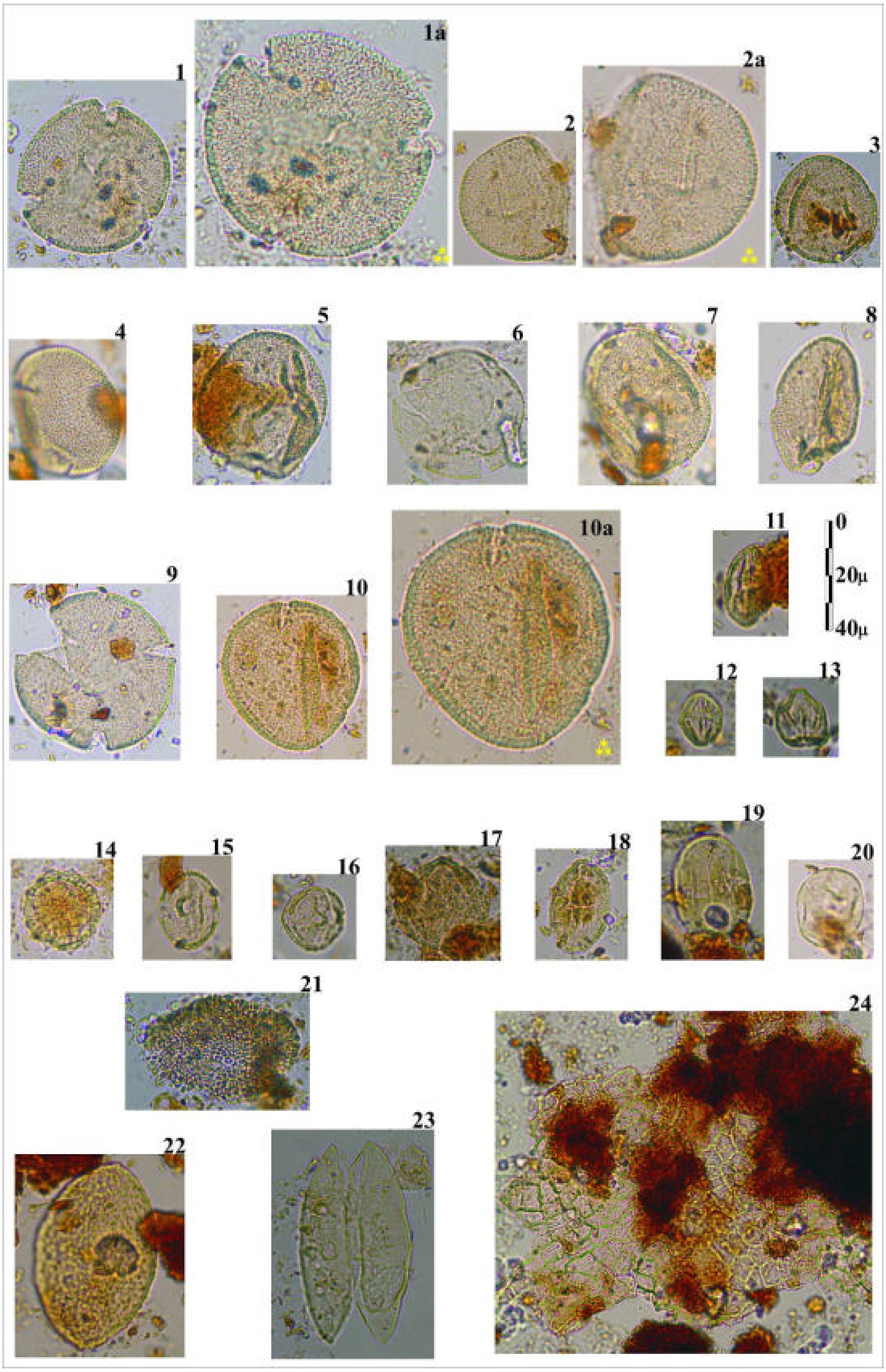


PLATE 4.6 (K–Section in northwest Kultak)

1.	*Verrucatosporites* sp.
3–5.	*Verrucatosporites favus* (Potonié) Thomson & Pflug
5, 6.	*Verrucatosporites alienus* (Potonie)
8.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
9–10.	*Baculatisporites nanus* (Wolfe) Krutzsch
11.	*Polypodiaceoisporites corrutoratus* Nagy
12.	*Baculatisporites* sp.
13–17.	*Baculatisporites primarius* (Wolff) Thomson & Pflug
18–24.	*Baculatisporites primarius* (Wolff) Thomson & Pflug ssp. o*ligocaenicus* Krutzsch

PLATE 4.7 (K–Section in northwest Kultak)

1–3.	*Abiespollenites* sp.
4.	*Pinuspollenites macroinsignis* (Krutzsch ex Ollivier–Pierre) Planderova
5.	*Pityosporites labdacus* (Potonié) Thomson & Pflug
6–9.	*Pityosporites microalatus* (Potonié) Thomson & Pflug
10.	*Cathayapollis* sp.
11–13.	*Pityosporites* spp.

PLATE 4.8 (K–Section in northwest Kultak)

1–3.	*Pityosporites* spp.
4–15.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
16.	*Cupressacites bockwitzensis* Krutzsch
17.	*Cupressacites* sp1.
18, 19.	*Inaperturopollenites magnus* (Potonié) Thomson & Pflug

PLATE 4.9 (K–Section in northwest Kultak)

1–6.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
7–8.	*Cupressacites cuspidataeformis* (Zaklinskaya) Krutzsch
9.	*Cupressacites* sp2.
10.	*Cycadopites* sp.
11–12.	*Polyvestibulopollenites verus* (Potonié) Thomson & Pflug
13.	*Pterocaryapollenites stellatus* (Potonié) Thiergart
14, 15.	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
16, 17	*Polyporopollenites* spp.
18–24.	*Dicolpopollis kockelii* Pflanzl
25–27.	*Subtriporopollenites facilis* (Botscharnikova) Kedves
28–33.	*Subtriporopollenites* spp.
34, 35.	*Compositoipollenites rhizophorus* (Potonié) Potonié ssp. *burghasungensis* (Mürriger & Pflug) Mürriger & Pflug *in* Thomson & Pflug

36. *Compositoipollenites minimus* Krutzsch & Vanhoorne
37–44. *Momipites punctatus* (Potonié) Nagy
45. *Triporopollenites* cf. *robustus* (Mürriger & Pflug) Pflug *in* Thomson & Pflug
46. *Triporopollenites* cf. *undulatus* (Kedves)
47–49. *Triatriopollenites myricoides* (Kremp) Thomson & Pflug
50–56. *Plicatopollis plicatus* (Potonié) Krutzsch
57. *Plicapollis* sp.

PLATE 4.10 (K–Section in northwest Kultak)

1–2a *Compositoipollenites rhizophorus* (Potonié) Potonié ssp. *burghasungensis* Mürriger & Pflug *in* Thomson & Pflug
3–5. *Triporopollenites* spp.
6–9. *Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
10. *Tricolpopollenites densus* (Pflug) Thomson & Pflug
11–15. *Quercopollenites granulatus* Nagy
16–18. *Quercopollenites robur* type Nagy
19–20. *Aceripollenites striatus* (Pflug) Thiele–Pfeifer
21. *Psilatricolporites crassus* Van Der Hammen & Wymstra
22. *Faguspollenites verus* Raatz
23–36. *Tricolpopollenites retiformis* (*Salix* type) Thomson & Pflug
37. *Tricolpopollenites retiformis* (*Platanus* type) Thomson & Pflug
38–51. *Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *oviformis* (Potonié) Thomson & Pflug
52, 53. *Tricolporopollenites pacatus* PFLUG *in* THOMSON & PFLUG

PLATE 4.11 (K–Section in northwest Kultak)

1–6. *Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *brühlensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
7. *Tricolporopollenites villensis* (Thomson) Thomson & Pflug
8, 9. *Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *exactus* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
10–29. *Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
30–33. *Caprifoliipites sambucoides* Nagy
34–36. *Avicennia* sp.
37 *Pentapollenites pentangulus* (Pflug) Krutzsch
38–43 *Tricolporopollenites* sp2.
44. *Polygalacidites* sp.
45, 46. *Mediocolpopollis compactus* Krutzsch spp. *ellenhaunensis* Krutzsch
47–49. Fungal spore
50. *Ovoidites* spp.
51, 52. Dinoflagellate spp.

PLATE 4.6 (K–Section in northwest Kultak)

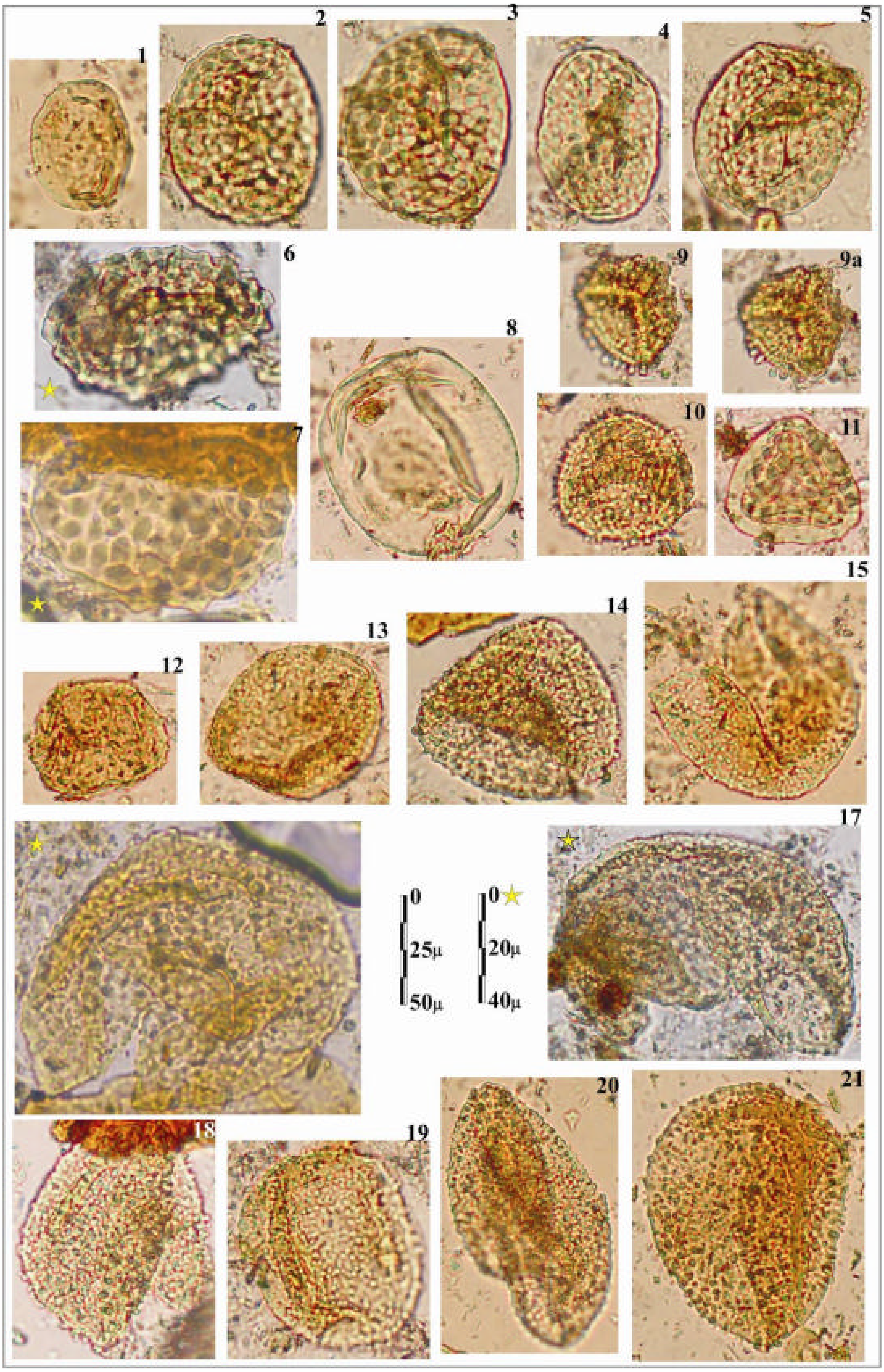


PLATE 4.7 (K–Section in northwest Kultak)

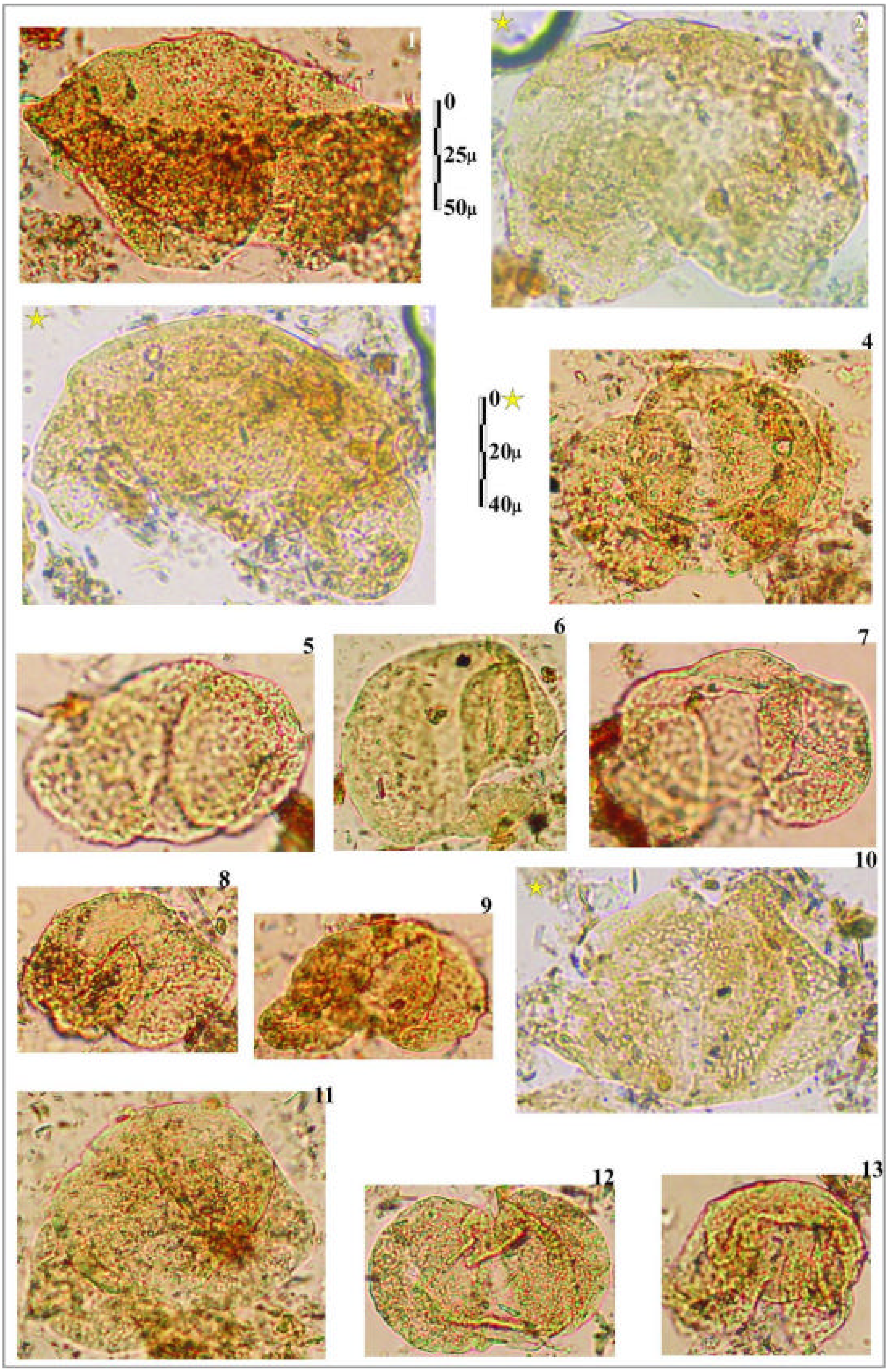


PLATE 4.8 (K–Section in northwest Kultak)

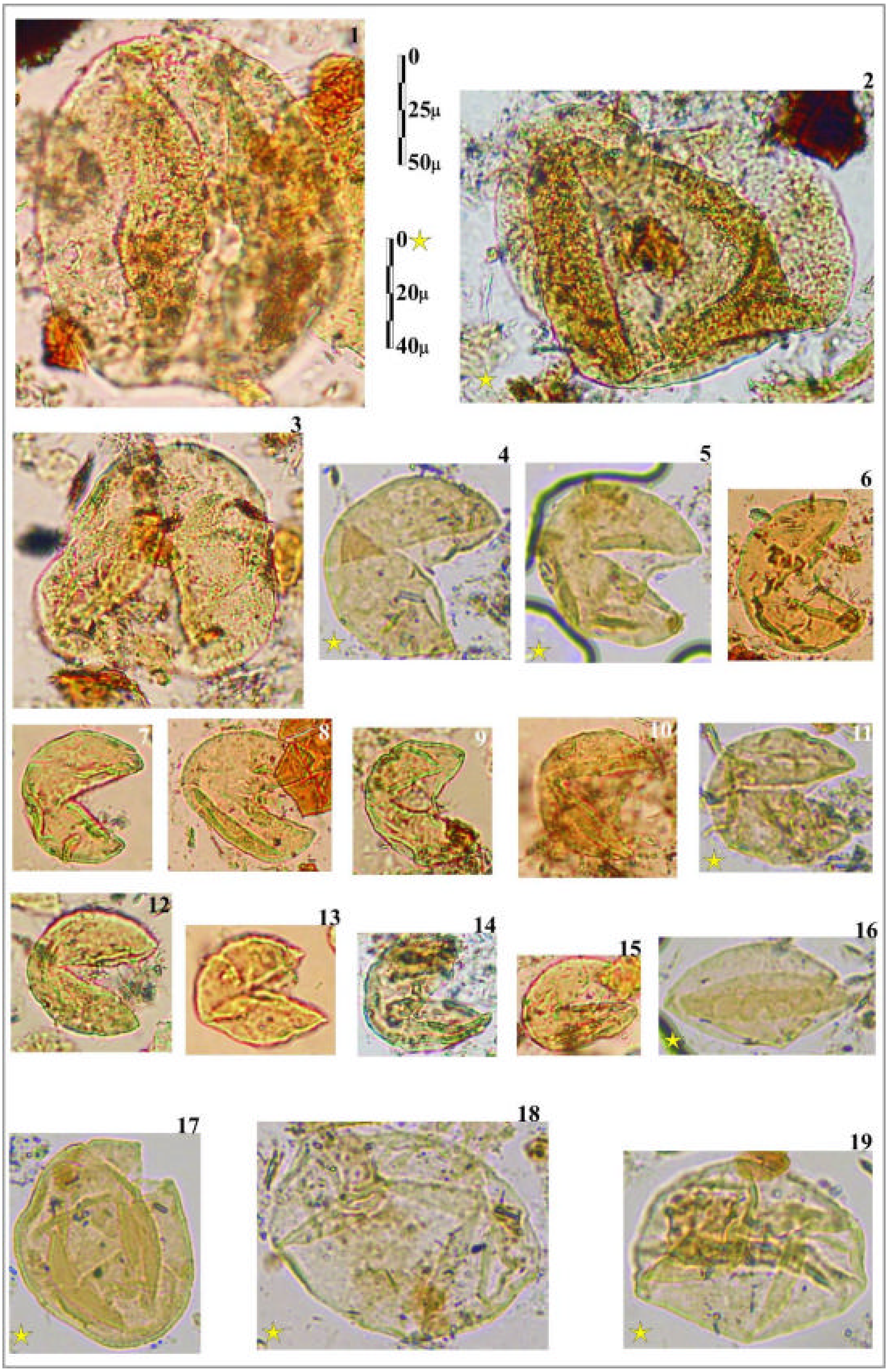


PLATE 4.9 (K–Section in northwest Kultak)

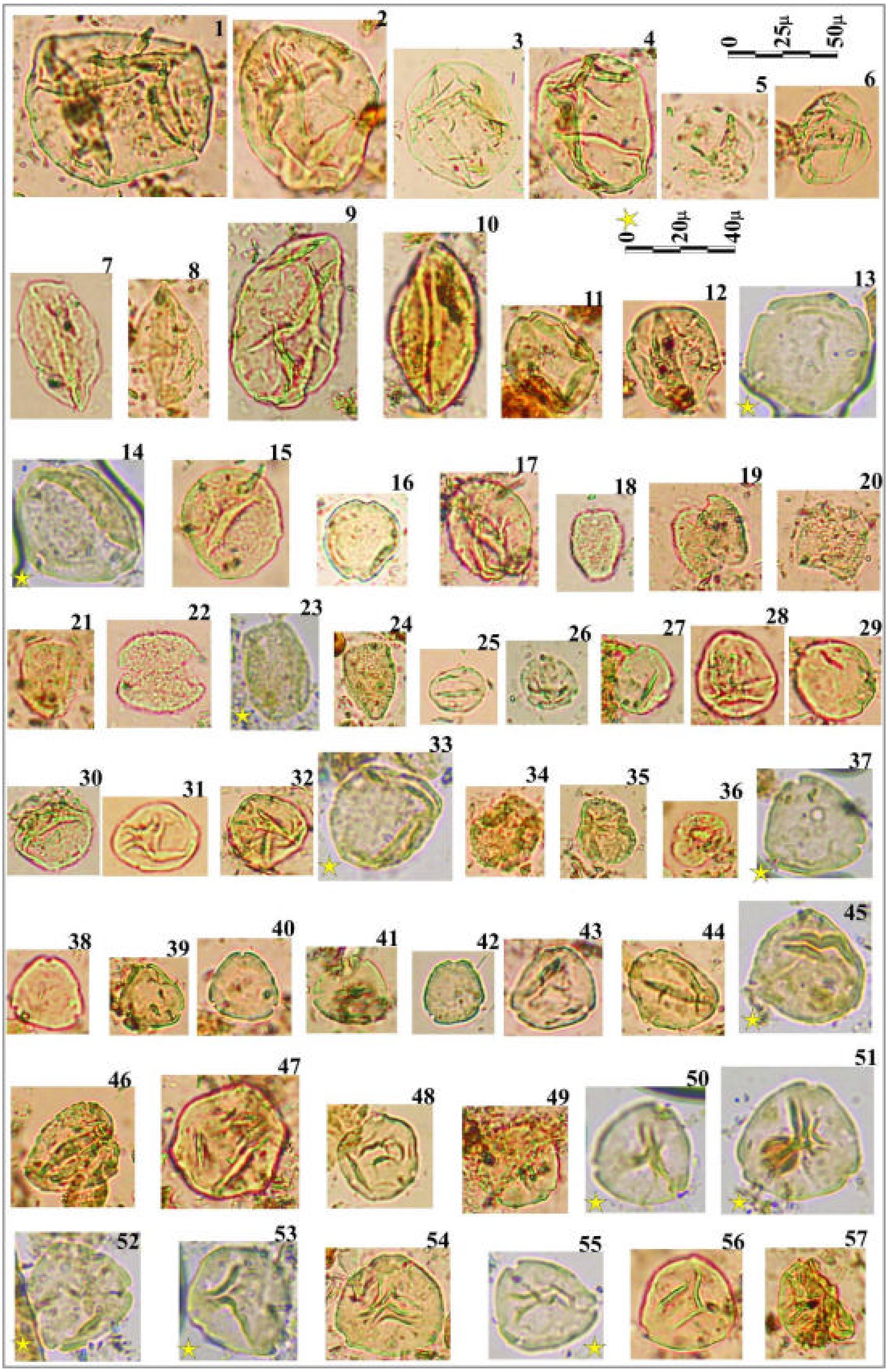


PLATE 4.10 (K–Section in northwest Kultak)

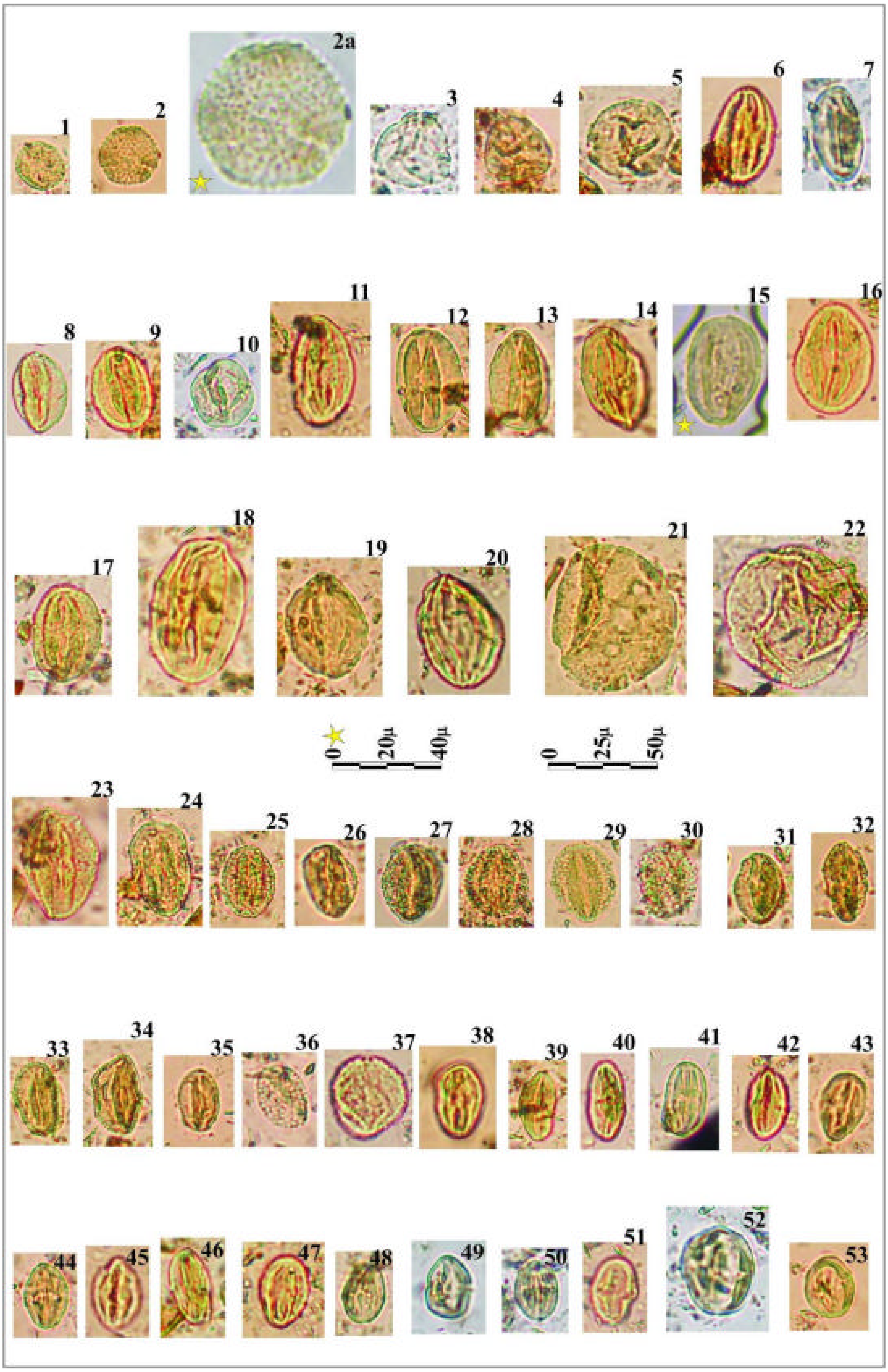


PLATE 4.11 (K–Section in northwest Kultak)

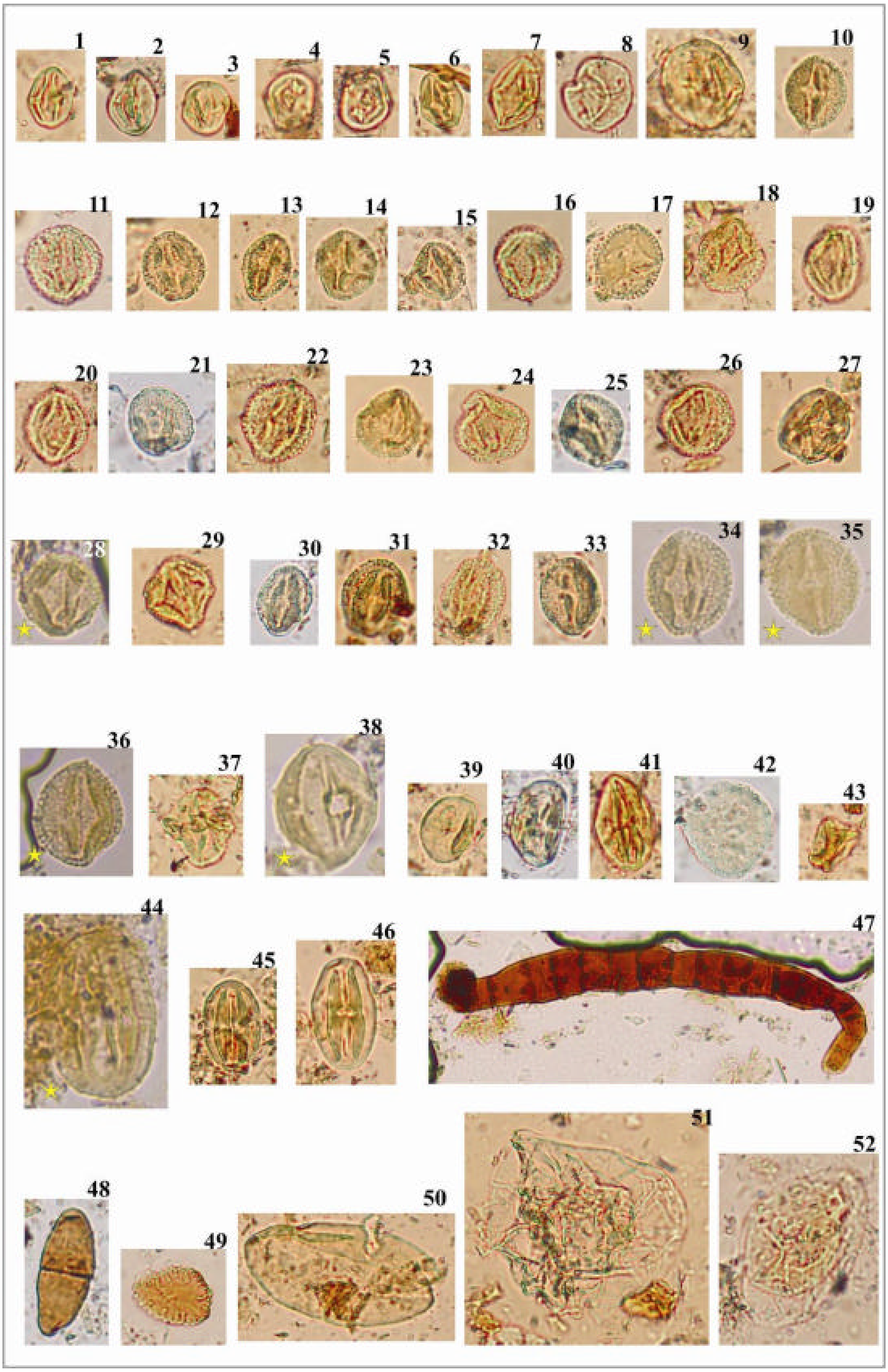


PLATE 4.12 (Kultak Section in northwest Kultak)

1–6.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
7.	*Pityosporites* sp.
8, 10.	*Pityosporites microalatus* (Potonié) Thomson & Pflug
9.	*Pinuspollenites macroinsignis* (Krutzsch ex Ollivier–Pierre) Planderova
11–15.	*Cycadopites* spp.
16–21.	*Cupressacites bockwitzensis* Krutzsch
22, 23.	*Cupressacites cuspidateaformis* Krutzsch
24–29.	*Inaperturopollenites hiatus* (Potonié) Pflug & Thomson *in* Thomson & Pflug
30–33.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug

PLATE 4.13 (Kultak Section in northwest Kultak)

1.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
2–8	*Caryapollenites simplex* (Potonié) Raatz ex Potonié
9, 10.	*Compositoipollenites rhizophorus* (Potonié) Potonié ssp. *burghasungensis* (Mürriger & Pflug) Mürriger & Pflug *in* Thomson & Pflug
11, 12.	*Momipites quietus* (Potonié) Nichols
13–44a.	*Momipites punctatus* (Potonié) Nagy
45–46.	*Plicatopollis plicatus* (Potonié) Krutzsch
47, 47a.	*Boehlensipollis hohli* Krutzsch
48, 48a	*Slowakipollis hippophäeoides* Krutzsch
49.	*Interpollis* sp.
50–63.	*Olaxipollis matthesi* Krutzsch
64, 65.	*Dicolpopollis kockelii* Pflanzl

PLATE 4.14 (Kultak Section in northwest Kultak)

1, 1a.	*Pterocaryapollenites stellatus* (Potonié) Thiergart
2–5	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
6–11.	*Pentapollenites pentangulus* (Pflug) Krutzsch
12, 13.	*Tricolpopollenites liblarensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug ssp. *liblarensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
14–17.	*Quercopollenites robur* type Nagy
18, 19.	*Quercopollenites granulatus* Nagy
20.	*Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
21–25.	*Tricolpopollenites retiformis* (*Platanus* type) Thomson & Pflug
26–28.	*Tricolpopollenites retiformis* (*Salix* type) Thomson & Pflug
29–31.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *brühlensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug

32. *Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *exactus* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
33, 34. *Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *fusus* (Potonié) Thomson & Pflug
35–45. *Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *pusillus* (Potonié) Thomson & Pflug
46, 47. *Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
48. *Tricolporopollenites* sp2.
49, 50. *Mediocolpopollis compactus* Krutzsch spp. *ellenhaunensis* Krutzsch
51, 52. *Tetracolporopollenites microrhombus* Pflug *in* Thomson & Pflug
53–56. *Tetracolporopollenites obscurus* Thomson & Pflug
57. *Tetracolporopollenites* sp2.
58. *Polygalacidites* sp.

PLATE 4.15 (Kultak Section in northwest Kultak)

1–1a. *Stephanoporopollenites* sp.
2–2a. *Periporopollenites multiporatus* Pflug & Thomson *in* Thomson & Pflug
3–6. Indeterminated forms
7–13 *Ovoidites* spp.
14. Fungal spore

PLATE 4.12 (Kultak Section in northwest Kultak)

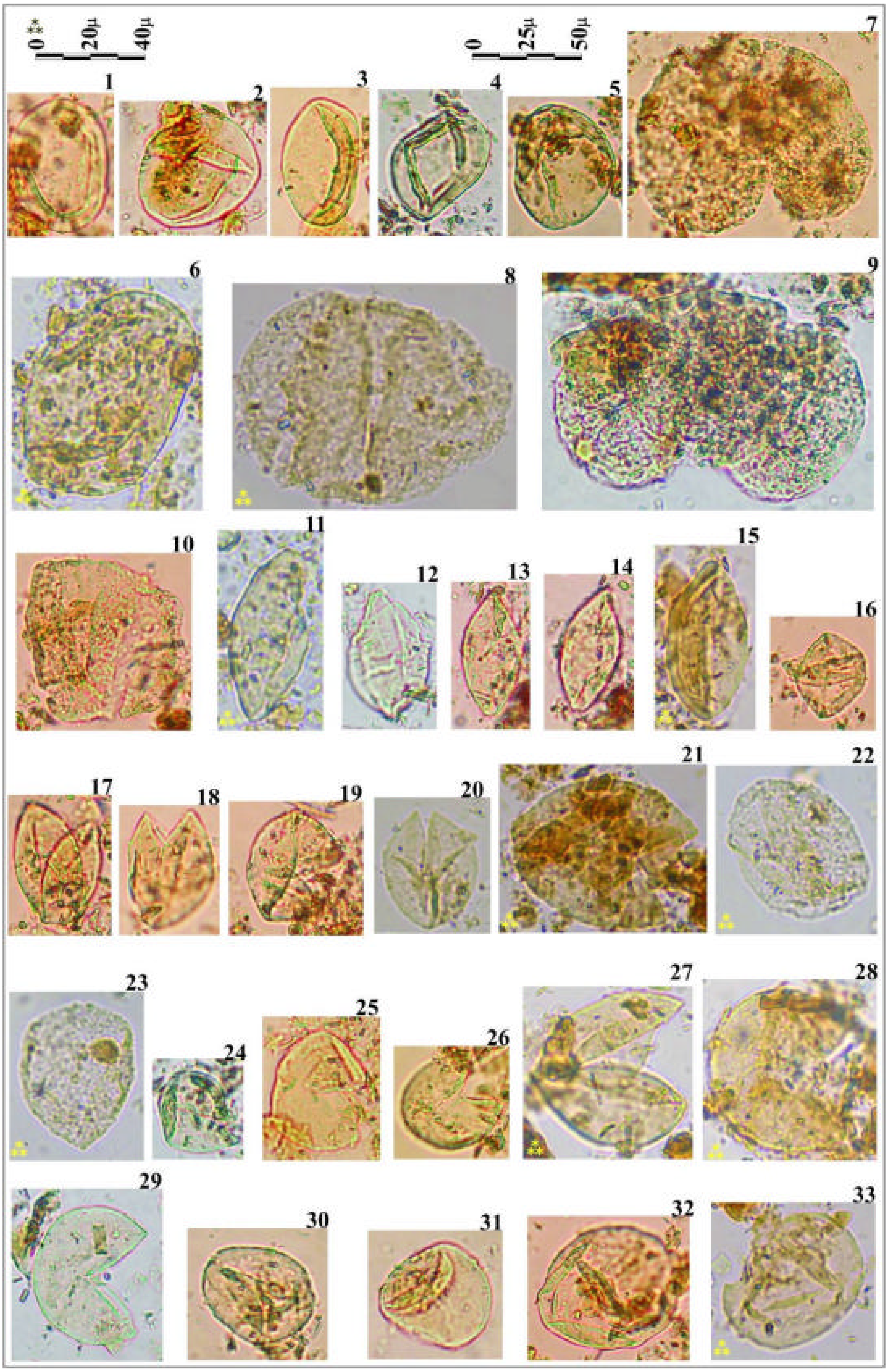


PLATE 4.13 (Kultak Section in northwest Kultak)

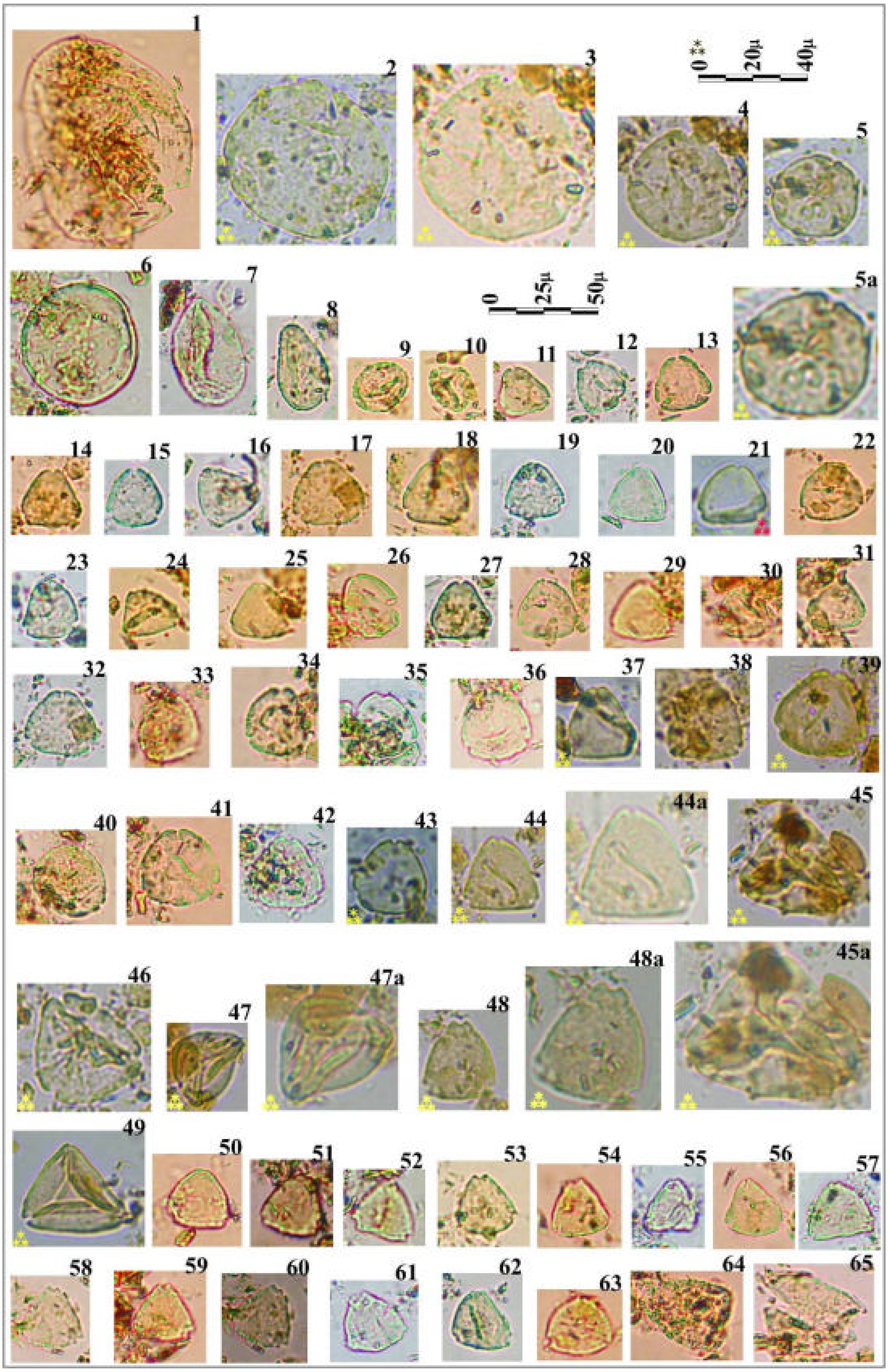


PLATE 4.14 (Kultak Section in northwest Kultak)

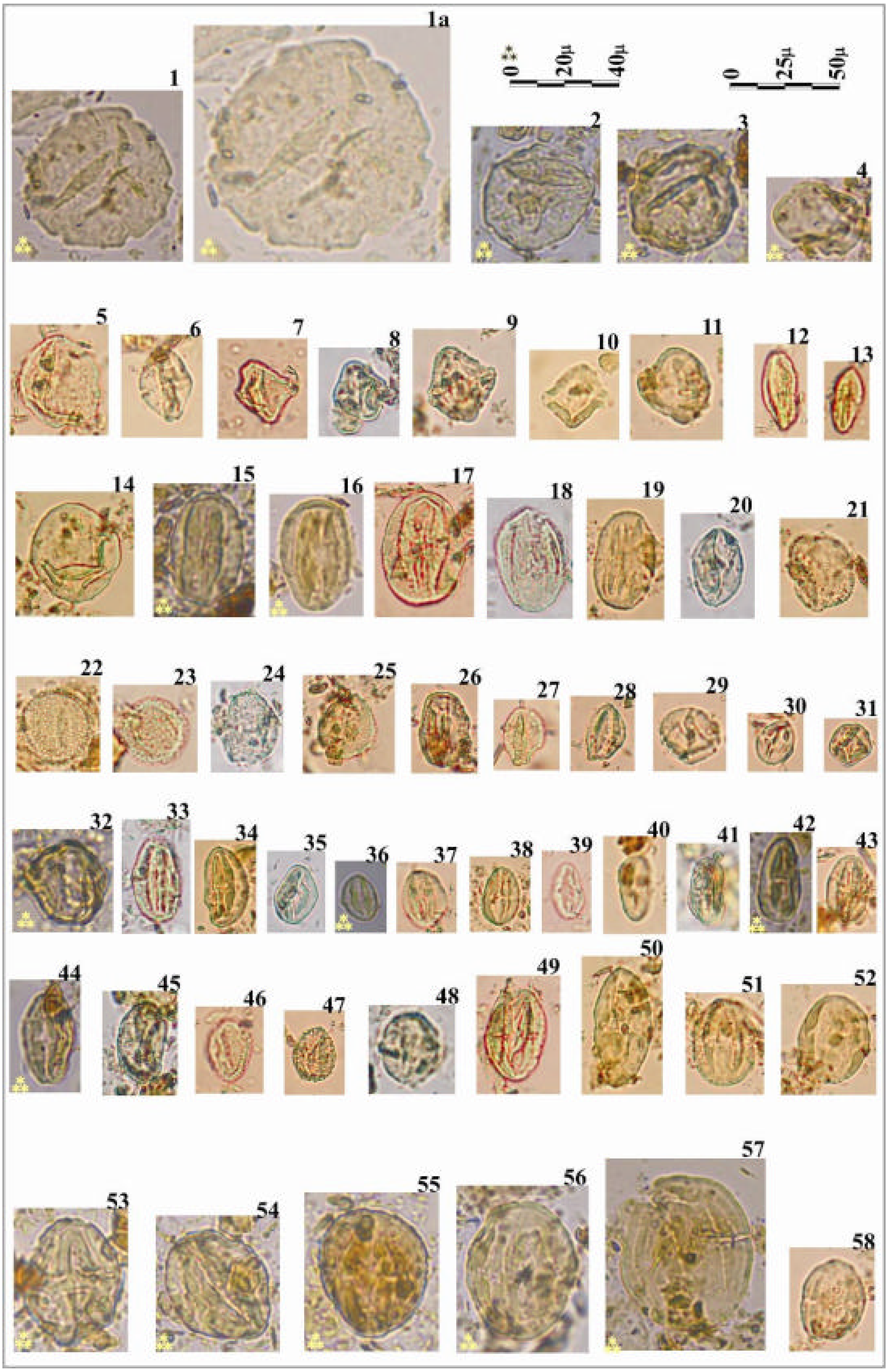
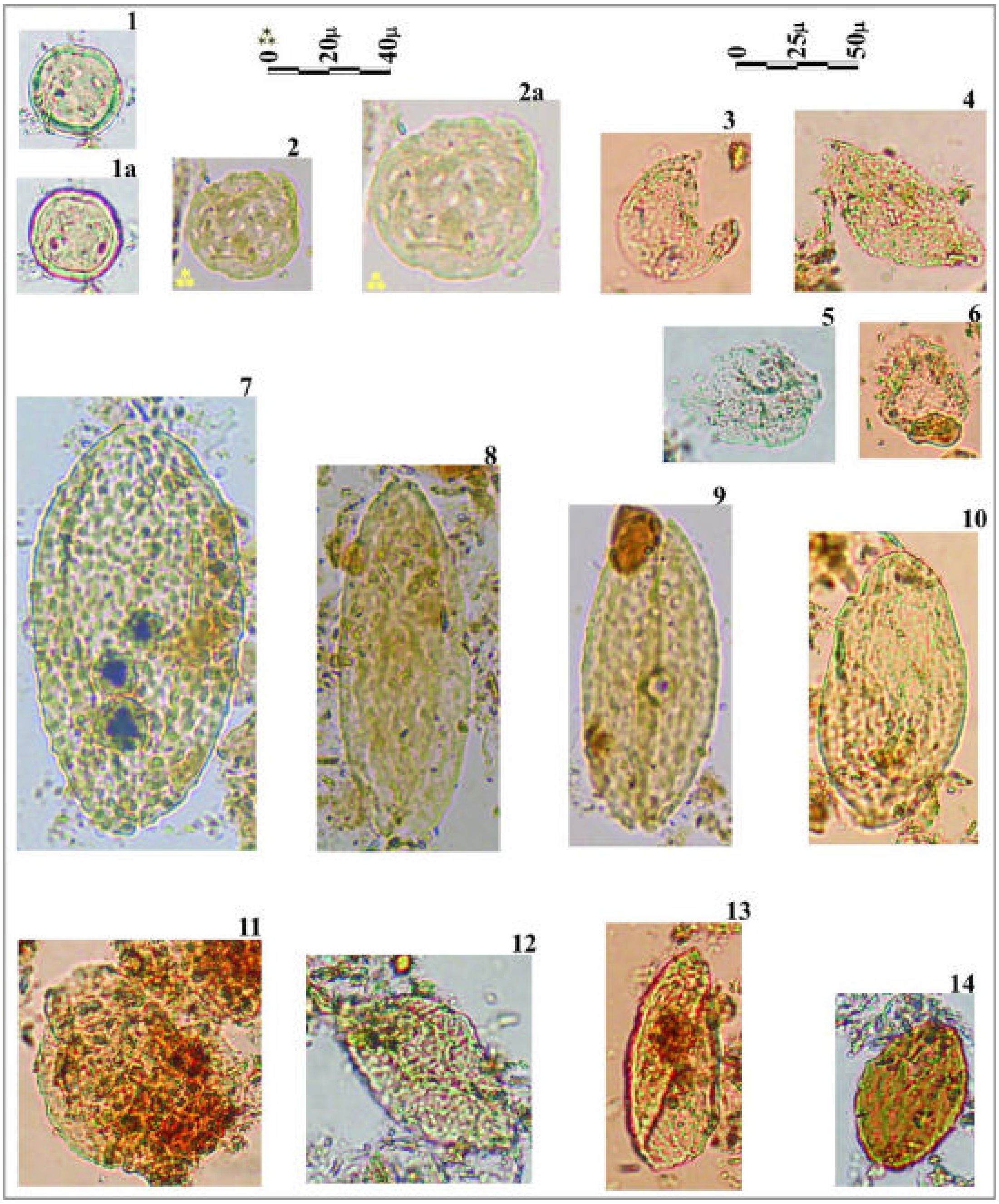


PLATE 4.15 (Kultak Section in northwest Kultak)



CHAPTER FIVE

PALYNOFLORA, FORAMINIFER, GASTRAPOD, BIVALVIA FAUNAS AND ISOTOP ANALYSIS RESULTS OF THE LATE OLIGOCENE-EARLY MIOCENE IN THE ÖREN BASIN (SW TURKEY): PALAEOCLIMATIC AND PALAEOVEGETATIONAL INTERPRETATIONS

5.1 Introduction

The Chat-Aquitanian sediments in the southwestern were deposited in a terrestrial under marine influences (i.e. Kale-Tavas, Çardak-Tokça, Denizli basins). The Tertiary marine sediments in the Ören region are deposited during the same time interval (Chattian and Aquitanian time interval) (Gürer & Yilmaz, 2001). Besides, various fossil groups (foraminifers, bivalvias, gastropods and palynomorphs) are recorded in these Chat-Aquitanian basins (i.e. Becker–Platen, 1970; Akgün & Sözbilir, 2000; Akkiraz & Akgün, 2005; Sözbilir, 2005; Islamoglu et al., 2008). These groups are studied a lot of workers and generalized stratigraphy of the Kale-Tavas, Çardak-Tokça, Denizli basins are made up based on the lithostratigraphic properties and age determination of marine fossil groups. Paleontological data of the marine sediments in the Ören region studied various workers (Nebert, 1956; 1957; Philippson, 1915; 1918, Flügel & Metz, 1954, Tchihatcheff, 1869, Erentöz & Öztemür, 1964) and these data are compiled by the Becker–Platen (1970). According to these fossil groups marine sediments in the Ören region are deposited during the Aquitanian-Burdigalian time interval. In addition, the palynofloras of Kale-Tavas and Çardak-Tokça basins are defined (Benda, 1971; Akgün & Sözbilir, 2001; Akkiraz & Akgün, 2005) but palynoflora of the Ören region is not recorded in previous studies.

The sediments in the Ören region (Alakilise and Kultak regions) deposited in terrestrial condition and these sediments affected marine influence at times. In this chapter, the age determination of the Ören region is produced based on the the Sr^{87}/Sr^{86} isotop analysis, foraminifers, gastropods, bivalvias and palynomorph association. Besides, palynomorph association of the Ören region is correlated with the Chat-Aquitanian palynomorph associations in Turkey (Çardak–Tokça, Mus basin, Kale–Tavas basin) and Europe.

Detail palaeoclimatic and palaoenvironmental interpretations of the Chat-Aquitanian palynoflora in the Ören region and published palynofloras of Turkey are obtained using the palaeoclimate and paleoecological preferences of the plants and coexistence approach methods. Additionally, obtaining palaeoclimatic data of the Chattian time are corresponded with the palaeoclimatic evolution in Europe. In this chapter, defining age determinations based on gastropod, bivalvia and foraminifer fossils groups are corroborated the palynostratigraphic data of the Ören region. Besides, the O^{18} and C^{13} isotopes results are obtained for palaeoclimatic and palaeoenvironmental interpretations.

5.2 Geological Setting of Ören–Kultak Region

Pre–Oligocene basement of the Lycian nappes in the Alakilise and Kultak regions is unconformably overlain by the Çambeleni formation (Fig. 5.1). Deposition of the Çambeleni formation continues during the late Rupelian–Aquitanian period. This formation vertically and laterally passes the Alakilise member during the Rupelian–Chattian time interval which is defined in this study (see chapter two and chapter four). The Çambeleni formation is unconformably overlain by the late Middle–early Middle Miocene rocks. These rocks unconformably pass the Middle–Late Miocene rocks in the study area (Fig. 5.1).

5.3 Material and Methods

Three stratigraphic sections are measured from the Çambeleni formation and Alakilise member in the Alakilise, Kultak, Kumluca and Damyani regions. Additionally coal samples are collected from throughout measured stratigraphic sections in these regions. Twelve coal samples are collected from the palynological study. Gastrapods and bvalvia fossils are collected from the clastic sediments in the Alakilise member. 200 limestone samples with foraminifer are collected from the

Çambeleni formation during stratigraphic sections. Isotopic analysis records are obtained to limestones, gastropods and bivalvia shells.

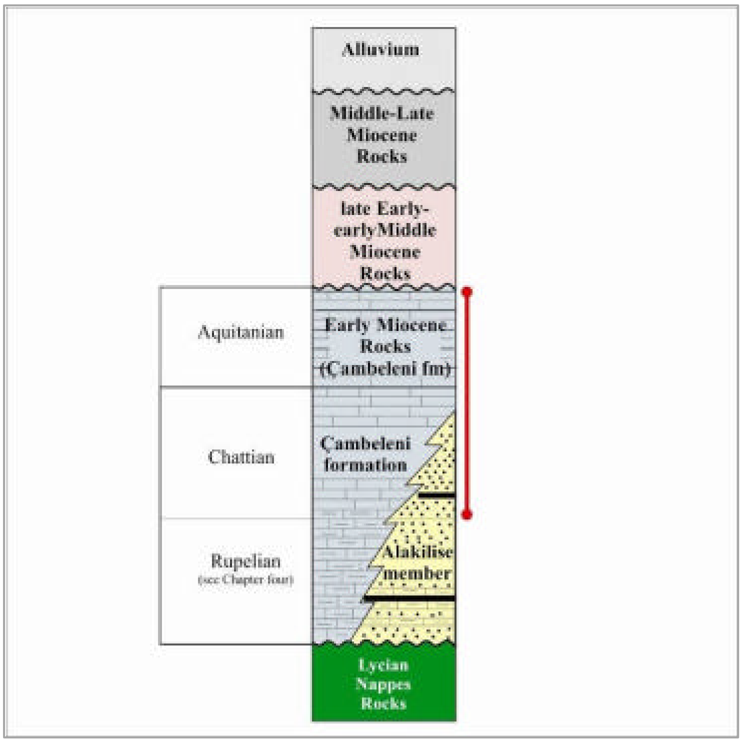


Figure 5.1 Generalized stratigraphic columnar section of the Kultak and Alakilise regions. Red line indicates investigated period.

5.4 Palynoflora of Late Oligocene (Chattian) in the Ören Region

Two palynofloras are defined from samples of the Alakilise member in the Ahmet section and coal seams in the Alakilise region (Fig. 5.2).

Palynoflora of the Ahmet section is represented by the *Laevigatosporites haardti, Verrucatosporites favus, Leiotriletes maxoides minoris, Abiespollenites* sp., *Baculatisporites primarius, Pinuspollenites macroinsignis, Pityosporites* spp., *Cathayapollis vanampoae, Zonolapollenites verrucatus, Inaperturopollenites dubius, Cupressacites cuspidataeformis, Cupressacites bockwitzensis, Pterocaryapollenites stellatus, Polyporopollenites undulosus, Subtriporopollenites anulatus nanus, Caryapollenites simplex, Triporopollenites simpliformis, Plicatopollis plicatus, Plicapollis pseudoexcelsus, Momipites punctatus, Triatriopollenites rurensis, Tricolpopollenites liblarensis, Tricolpopollenites microhenrici, Quercopollenites* *petrea*, *Quercopollenites robur* type, *Tricolporopollenites cingulum fusus, Tricolporopollenites cingulum oviformis* and same dinoflagellate species (*Cleistosphaeridium* sp. and *Cordosphaeridium* sp.) (Fig. 5.2).

Palynoflora of the Alakilise coal mine section is caharterized by the *Laevigatosporites haardti, Verrucatosporites favus, Leiotriletes maxoides maximus Leiotriletes maxoides maximus, Leiotriletes maxoides minoris, Baculatisporites primarius* o*ligocaenicus*, *Inaperturopollenites dubius, Cupressacites bockwitzensis, Cycadopites* sp., *Caryapollenites simplex*, *Subtriporopollenites anulatus nanus, Intratriporopollenites supplingensis, Momipites punctatus, Triatriopollenites excelsus, Interpollis* sp., *Plicatopollis plicatus, Tricolpopollenites densus*, *Quercopollenites robur* type, *Tricolporopollenites cingulum pusillus, Tricolporopollenites megaexactus brühlensis, Oleoidearumpollenites microreticulatus*, *Pinuspollenites macroinsignis*, *Zonolapollenites verrucatus, Inaperturopollenites hiatus, Polyporopollenites undulosus*, *Compositoipollenites rhizophorus burghasungensis, Triatriopollenites excelsus, Tricolpopollenites microhenrici, Tricolpopollenites densus, Tricolpopollenites retiformis* (*Salix* type) and Microforaminiferal astar (Fig. 5.2).

Presences of the *Subtriporopollenites anulatus nanus, Plicapollis pseudoexcelsus, Verrucatosporites favus, Leiotriletes maxoides maximus Leiotriletes maxoides maximus, Leiotriletes maxoides minoris, Interpollis* sp., *Plicatopollis plicatus* and *Triatriopollenites excelsus* is represented the Late Oligocene (the Chattian) time interval. And also species of the *Bohlensipollis hohli, Mediocolpopollis compactus* and *Slowakipollis hippophäeoides* which are recorded in palynofloras of the Rupelian time in Turkey and Europe are notdefine in the samples of the Ahmet section and Alakilise coal mine. This also supported the the Late Oligocene age determination.

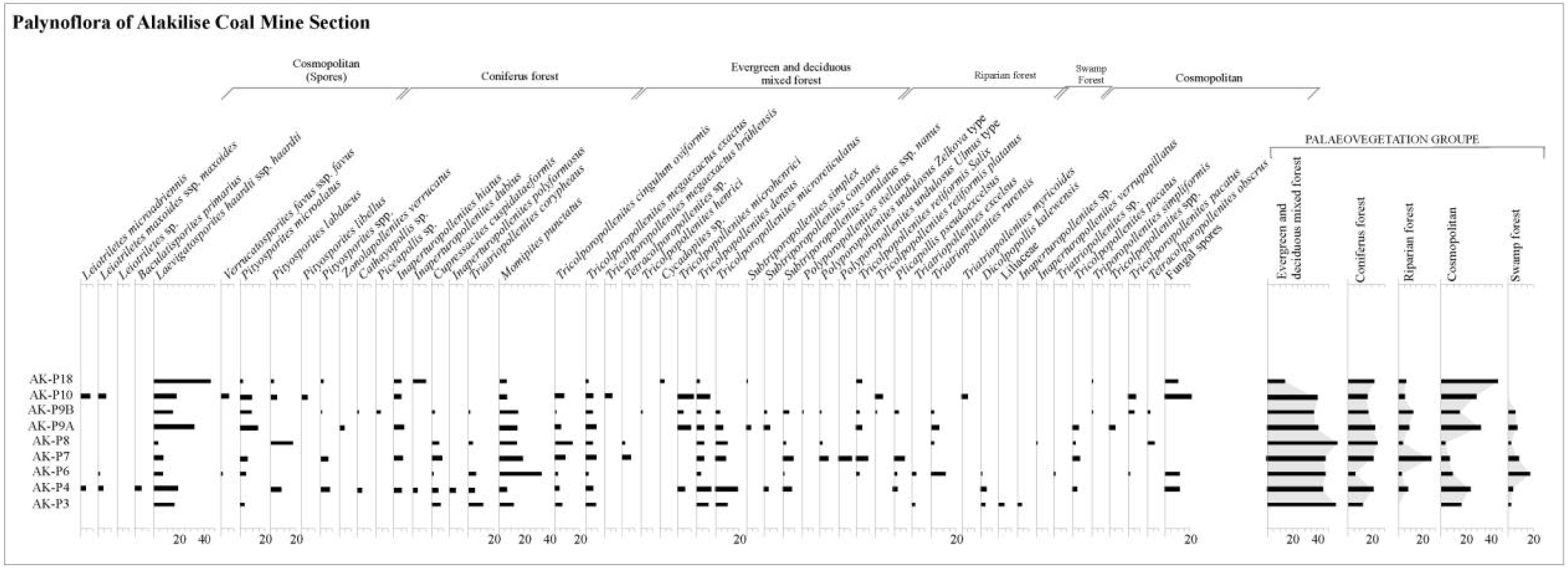
5.4.1 Palaeovegetation

For the palaeovegetation interpretation, botanical affinity of spores and pollen and environmental preferences of these plants are used.

The palaeovegetation is represented predominantly evergreen and deciduous mixed and coniferous forests as the palaeovegetation of southwest Kultak and Alakilise regions during the Chattian time. Distinctly differences from the Rupelian time, dinoflagellates species and microforaminiferal astar are defined in samples and mangrove forest elements are not observed in the Cahattian samples. Besides the swamp forest and aquatic vegetation plants are less abundantly recorded in samples of the southwest Kultak and Alakilise regions. During the Chattian time, the riparian forest elements are high. Herb and shrub vegetation plants are recorded less abundantly in the Chattian palynospectra. Besides, in Chattian time absences of the mangrove species which are defined abundantly Rupelian time in the Ören region and presence of the dinoflagellate species which are not recorded in the Rupelian time indicates the marine influence from the Rupelian to Chattain in the northwest of Kultak region. This results could be indicated the transgression in transition of Rupelian-Chattian time.

5.4.2 Palaeoclimate

Climatic variables for the two palynoflora of the Chattian time (Late Oligocene) are obtained and the MAT, CMT, WMT, MAP, MAP_{WET}, MAP_{DRY} and MAP_{WARM} variables are used for the palaeoclimatic interpretation in this chapter. According to the numerical palaeoclimatic results and palynoflora in the Ören region, could be said that presence of the warm subtropical climatic condition in the Chattian time.



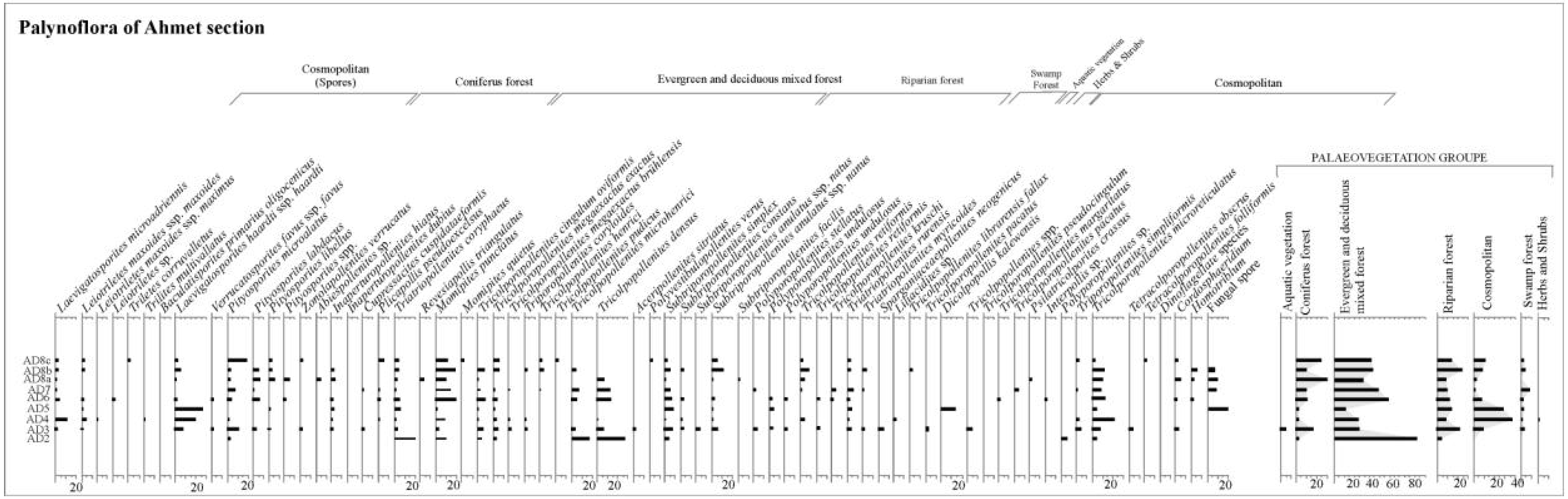


Figure 5.2 Detailed microfloras diagram of the studied part of the stratigraphic section in the Ahmet and Alakilise coal mine sections (Alakilise region). Black dots indicate percentage lower than %1.

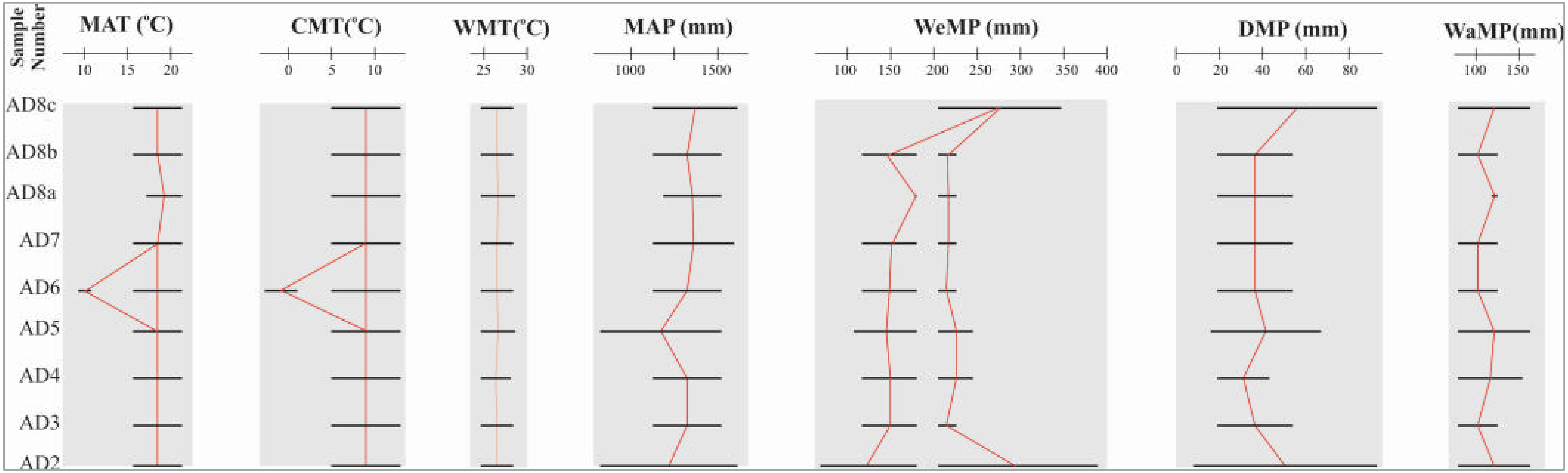


Figure 5.3 Application of the Coexistence Approach to the palynoflora of Ahmet section (MAT: mean annual temperature, CMT: mean temperature of coldest month, WMT: mean temperature of warmest month and MAP: mean annual precipitation, precipitation in the warmest month (WeMP), the driest month (DMP_y), and warmest month (WaMP).

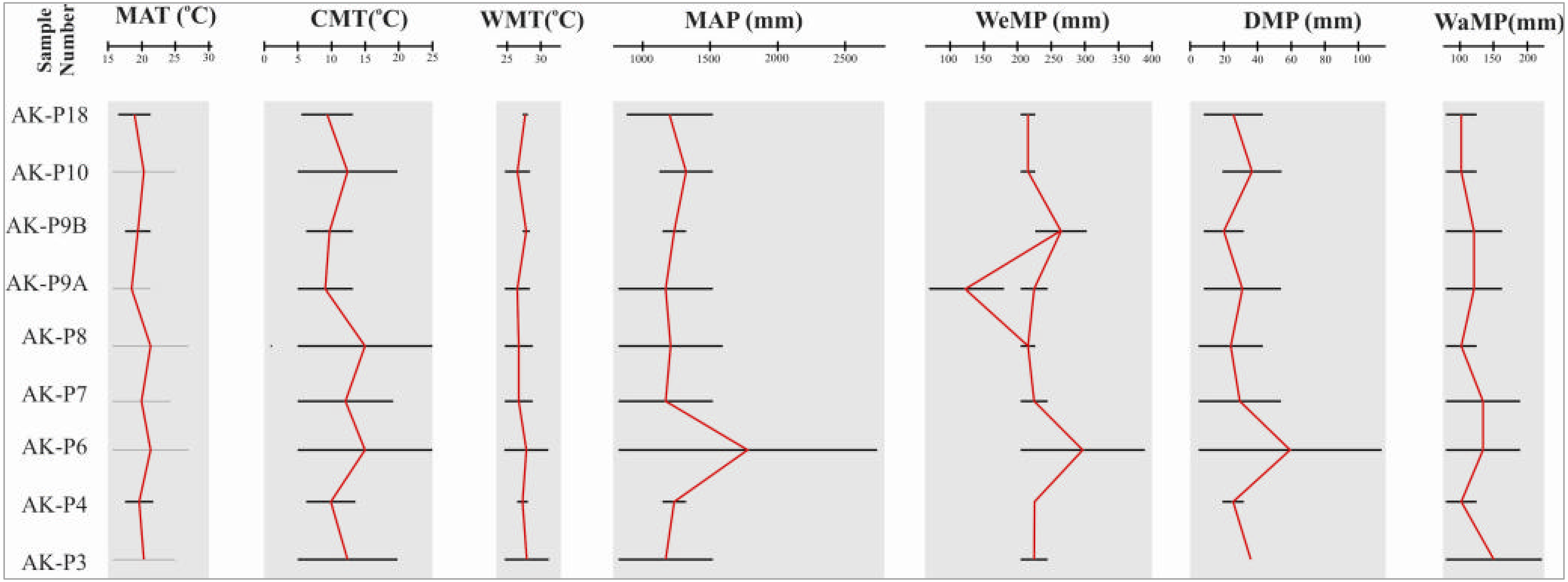


Figure 5.4 Application of the Coexistence Approach to the palynoflora of Alakilise coal mine section (MAT: mean annual temperature, CMT: mean temperature of coldest month, WMT: mean temperature of warmest month and MAP: mean annual precipitation, precipitation in the warmest month (WeMP), the driest month (DMP$_y$), and warmest month (WaMP).

PLATE 5.1 (Ahmet Section)

1.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
2, 3.	*Verrucatosporites favus* (Potonié) Thomson & Pflug
4, 5.	*Leiotriletes maxoides* Krutzsch ssp. *minoris* Krutzsch
6.	*Leiotriletes maxoides* Krutzsch ssp. *maxoides* Krutzsch
7, 8.	*Abiespollenites* sp.
9.	*Baculatisporites primarius* (Wolff) Thomson & Pflug
10–15.	*Pinuspollenites macroinsignis* (Krutzsch ex Ollivier–Pierre) Planderova
16–18.	*Pityosporites* spp.

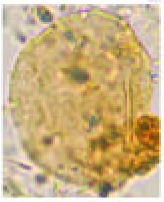
PLATE 5.2 (Ahmet Section)

1.	*Cathayapollis vanampoae* (Sivak)Ziembinska–Tworzydlo
2–5.	*Pityosporites* spp.
6, 6a.	*Zonolapollenites verrucatus* Krutzsch ex Ziembinska–Tworzydlo
7.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
8.	*Cupressacites cuspidataeformis* (Zaklinskaya) Krutzsch
9.	*Cupressacites bockwitzensis* Krutzsch
10.	*Pterocaryapollenites stellatus* (Potonié) Thiergart
11–13.	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
14, 22.	*Subtriporopollenites* spp.
15, 16.	*Subtriporopollenites anulatus nanus* Thomson & Pflug
17–20.	*Caryapollenites simplex* (Potonié) Raatz ex Potonié
21.	*Triporopollenites* sp.
23–26.	*Triporopollenites simpliformis* Thomson & Pflug
27.	*Plicatopollis plicatus* (Potonié) Krutzsch
28–29a	*Plicapollis pseudoexcelsus* (Krutzsch 1957) Krutzsch 1961
30–42.	*Momipites punctatus* (Potonié) Nagy

PLATE 5.3 (Ahmet Section)

1, 2.	*Momipites punctatus* (Potonié) Nagy
3.	*Triatriopollenites rurensis* Thomson & Pflug
3, 3a.	*Polyporopollenites* sp.
4.	*Tricolpopollenites liblarensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug ssp. *liblarensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
5–11.	*Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
12–21.	*Quercopollenites petrea* Nagy
22–26.	*Quercopollenites robur* type Nagy
27.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *fusus* (Potonié) Thomson & Pflug
28, 29.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *oviformis* (Potonié) Thomson & Pflug
32–34.	*Cleistosphaeridium* sp.
35, 36.	*Cordosphaeridium* sp.

PLATE 5.1 (AhmetSection)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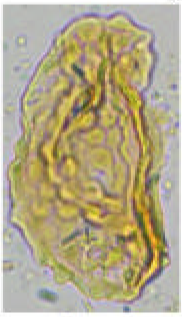
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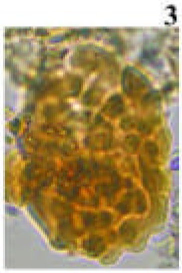
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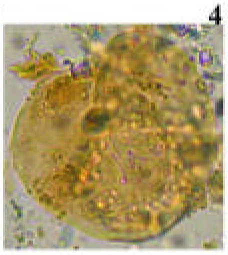
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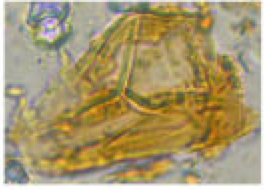
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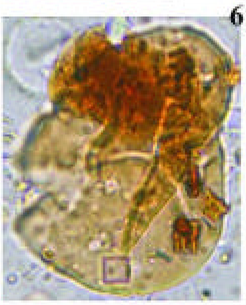
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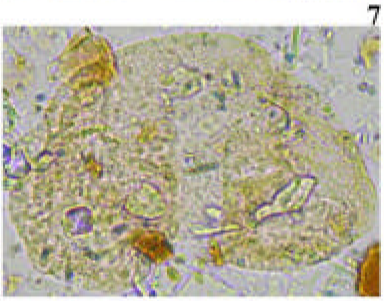
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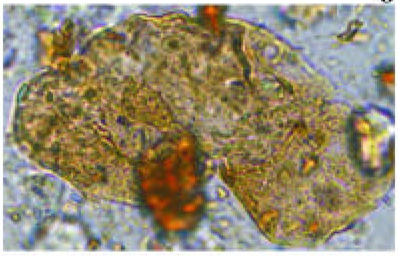
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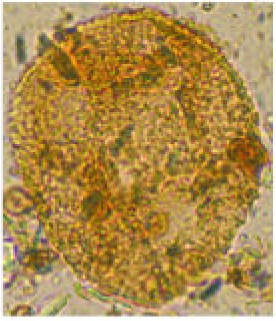
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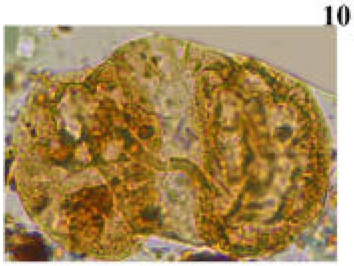
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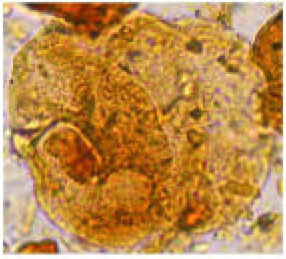
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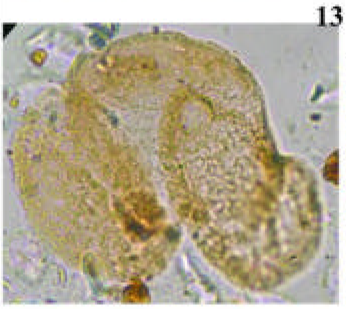
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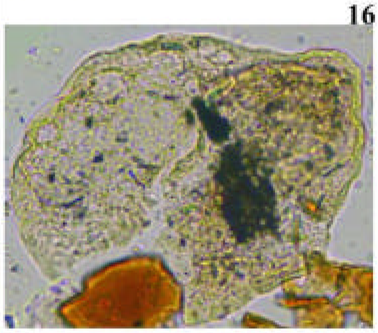
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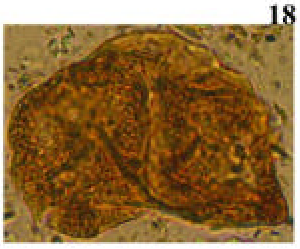
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PLATE 5.2 (Ahmet Section)

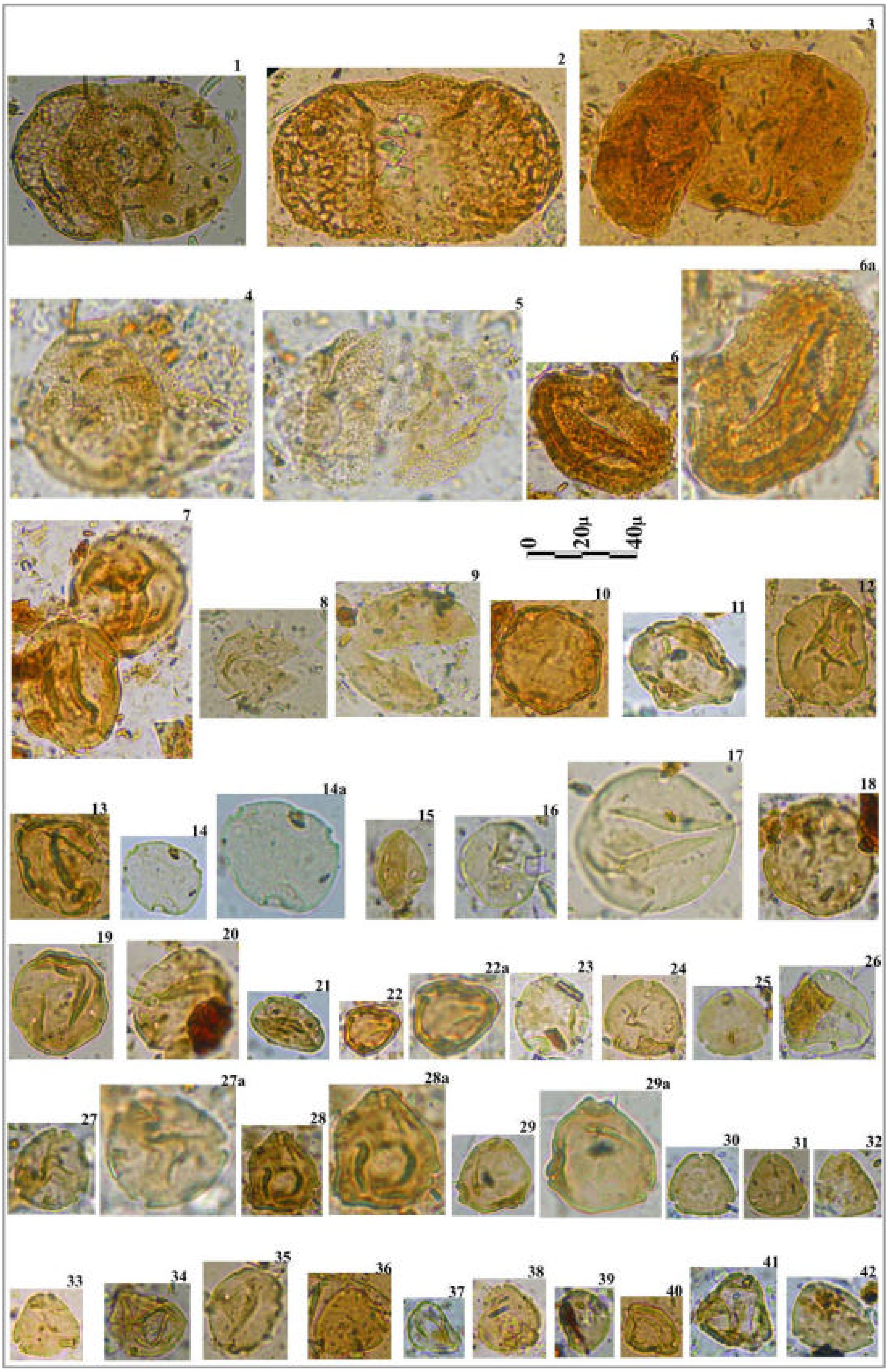


PLATE 5.3 (Ahmet Section)

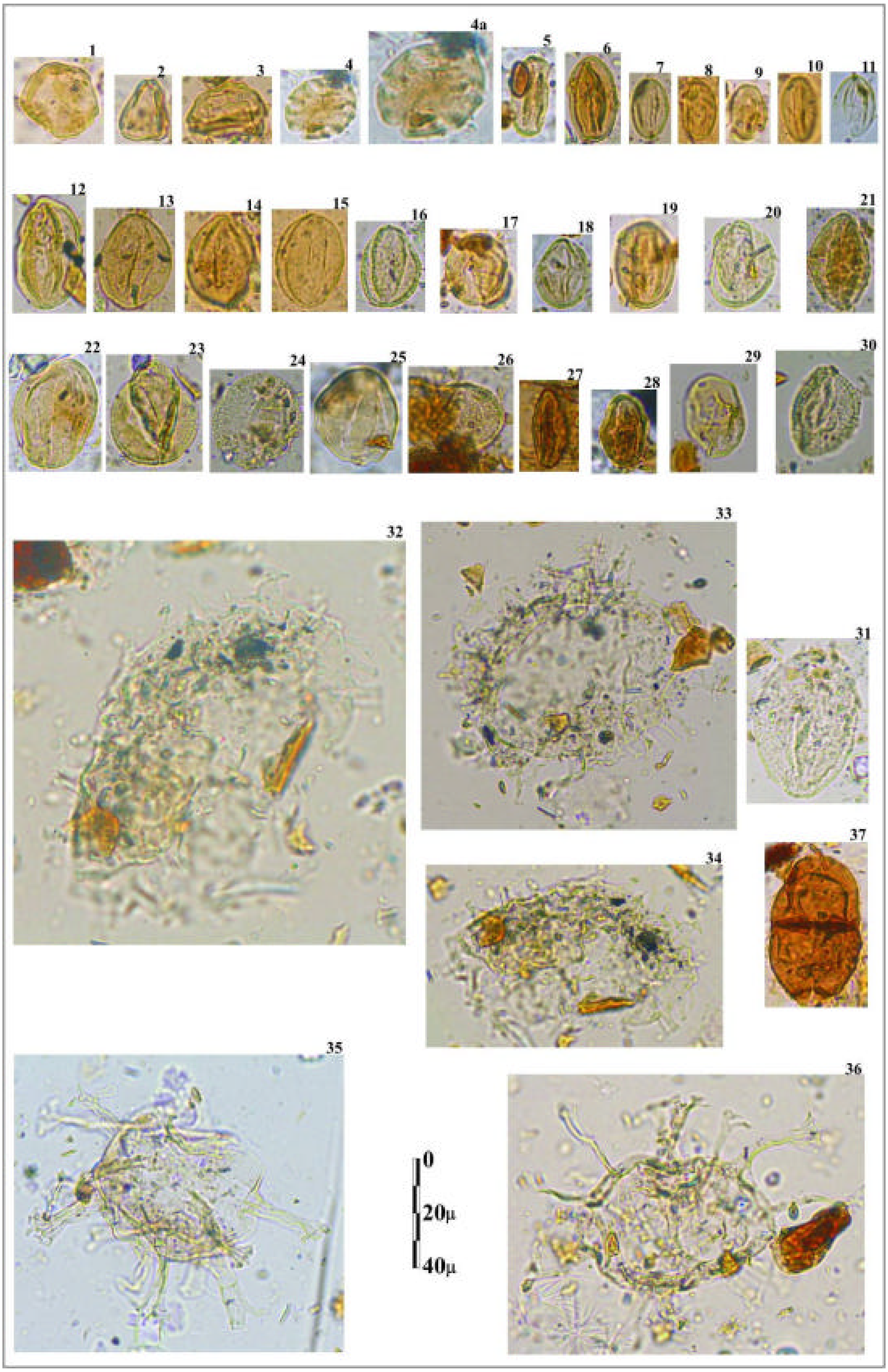


PLATE 5.4 (Alakilise Coal Mine)

1–2.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
3–6.	*Verrucatosporites favus* (Potonié) Thomson & Pflug
7.	*Verrucatosporites* sp.
8.	*Leiotriletes maxoides* Krutzsch *maximus* (Pglug *in* Thomson & Pflug) Krutzsch
9.	*Leiotriletes maxoides* Krutzsch *maximus* (Pglug *in* Thomson & Pflug) Krutzsch
10.	*Leiotriletes maxoides* Krutzsch *minoris* Krutzsch
11, 12.	*Baculatisporites primarius* (Wolff) Thomson & Pflug *oligocaenicus* Krutzsch
13.	*Pityosporites* spp.
14, 15.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
16.	*Cupressacites bockwitzensis* Krutzsch
17, 18a.	*Cycadopites* sp.
19–22.	*Subtriporopollenites anulatus* (Thomson & Pflug) *nanus* Thomson & Pflug
23, 24.	*Intratriporopollenites supplingensis* (Pflug) Thomson & Pflug
25–37.	*Momipites punctatus* (Potonié) Nagy
38, 38a.	*Triatriopollenites excelsus* (Potonié) Thomson & Pflug
39, 39a.	*Interpollis* sp.
40–43.	*Plicatopollis plicatus* (Potonié) Krutzsch
44, 45.	*Tricolpopollenites densus* (Pflug) Thomson & Pflug
46–48.	*Quercopollenites robur* type Nagy
49, 50.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *pusillus* (Potonié) Thomson & Pflug
51.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *brühlensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
52.	*Tricolporopollenites* sp.
53–56.	*Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
57.	Indeterminate form

PLATE 5.5 (Alakilise Coal Mine)

1–2.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
3	*Leiotriletes maxoides* Krutzsch *minoris* Krutzsch
4, 9, 10.	*Pityosporites* spp.
6, 7.	*Pinuspollenites macroinsignis* (Krutzsch ex Ollivier–Pierre) Planderova
8.	*Zonolapollenites verrucatus* Krutzsch ex Ziembinska–Tworzydlo
11,12.	*Cupressacites bockwitzensis* Krutzsch
13, 13a.	*Inaperturopollenites hiatus* (Potonié) Pflug & Thomson *in* Thomson & Pflug
14.	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
15–17.	*Caryapollenites simplex* (Potonié) Raatz ex Potonié

18. *Subtriporopollenites anulatus* (Thomson & Pflug) *nanus* Thomson & Pflug
19–20. *Compositoipollenites rhizophorus* (Potonié) Potonié ssp. *burghasungensis* (Mürriger & Pflug) Mürriger & Pflug *in* Thomson & Pflug
21–23. *Momipites punctatus* (Potonié) Nagy

PLATE 5.6 (Alakilise Coal Mine)

1–4. *Momipites punctatus* (Potonié) Nagy
5–8. *Plicatopollis plicatus* (Potonié) Krutzsch
9, 10. *Triatriopollenites excelsus* (Potonié) Thomson & Pflug
11. *Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
12–15. *Tricolpopollenites densus* (Pflug) Thomson & Pflug
16–20a. *Quercopollenites robur* type Nagy
21. *Tricolpopollenites retiformis* (*Salix* type) Thomson & Pflug
22–24. *Quercopollenites petrea* Nagy
25, 26. *Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *exactus* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
27, 28. *Oleoidearumpollenites microreticulatus* (Thomson & Pflug)
29. Indeterminate form
30. Microforaminiferal astar

PLATE 5.4 (Alakilise Coal Mine)

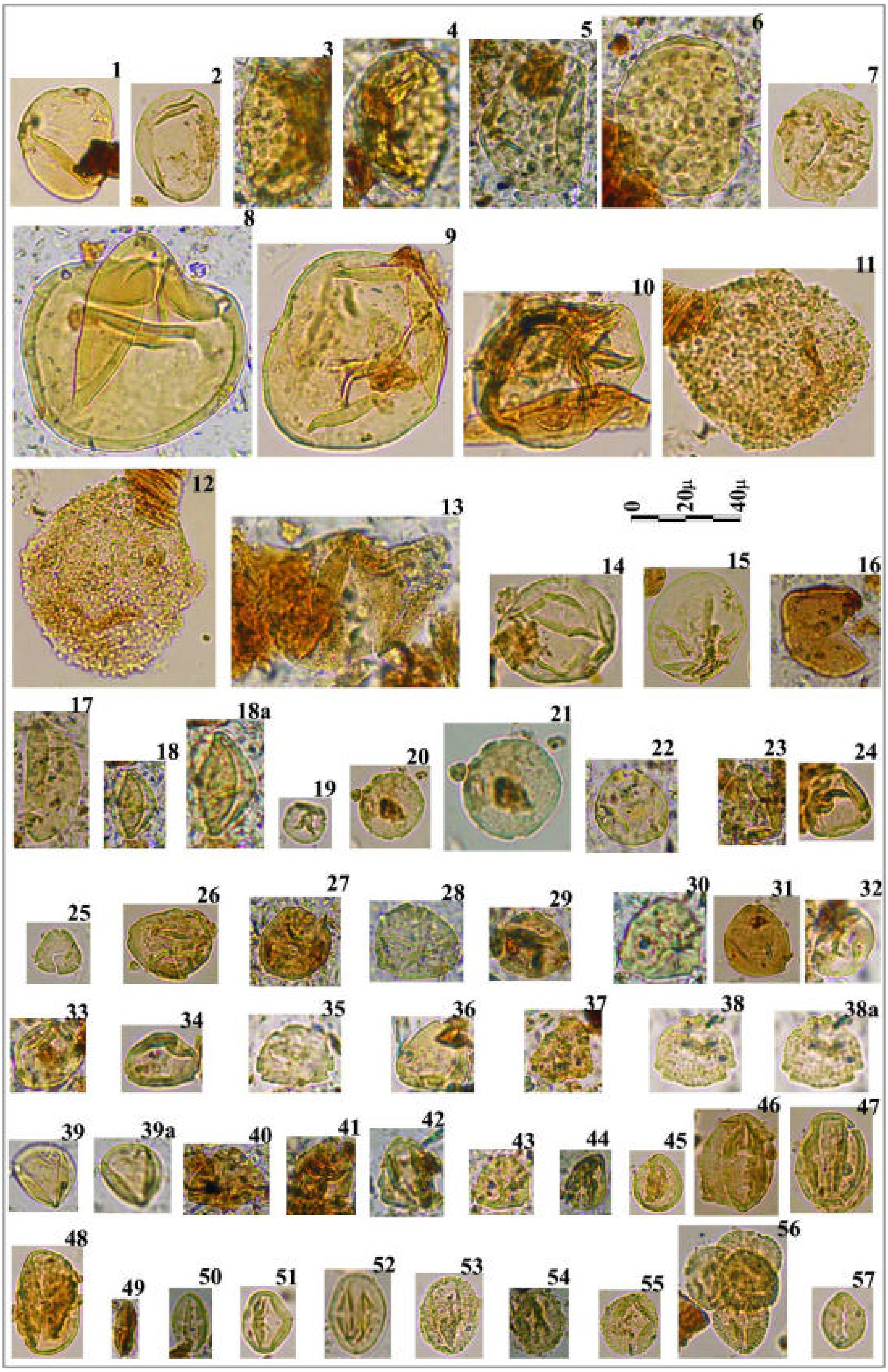


PLATE 5.5 (Alakilise Coal Mine)

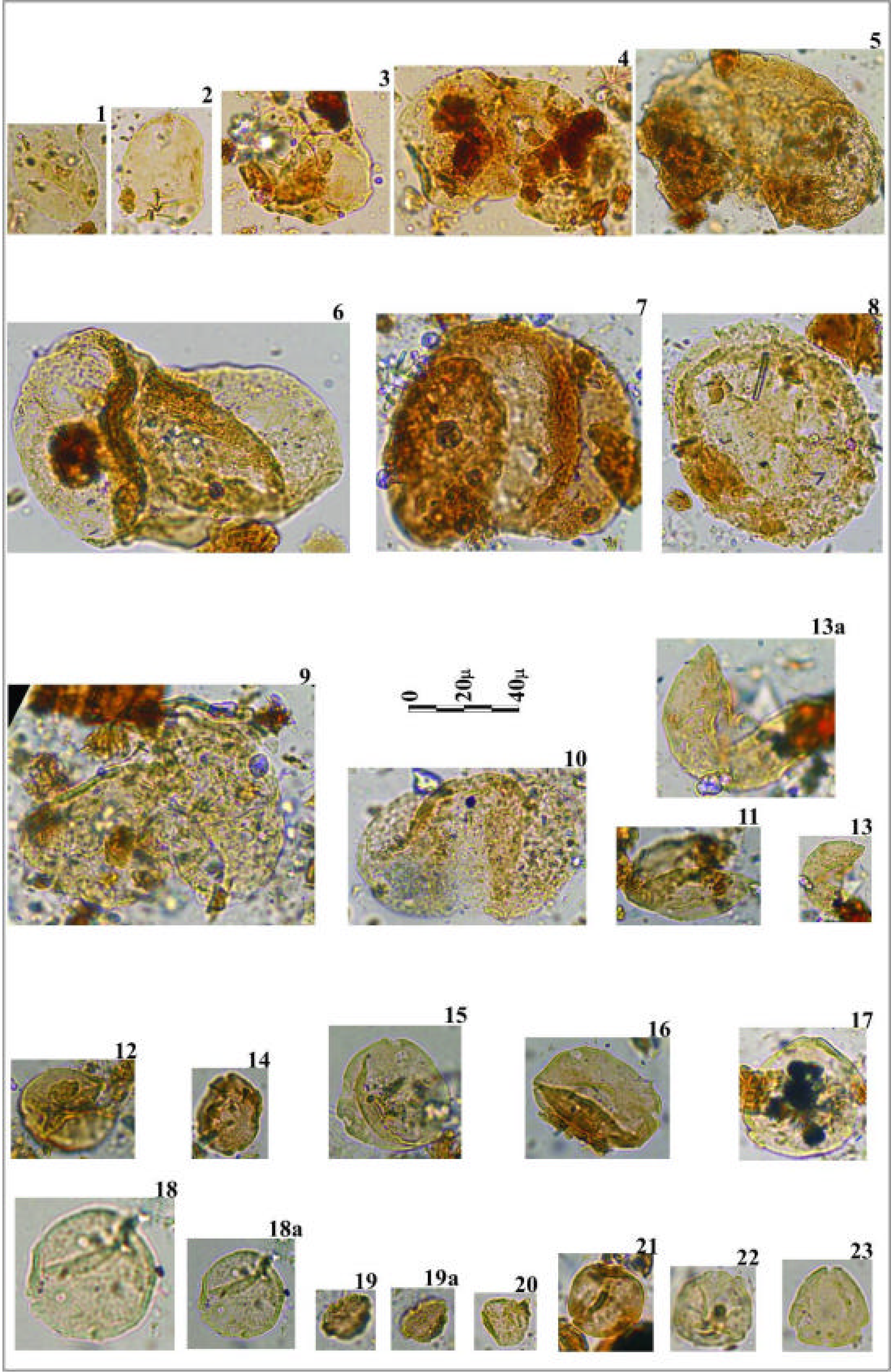
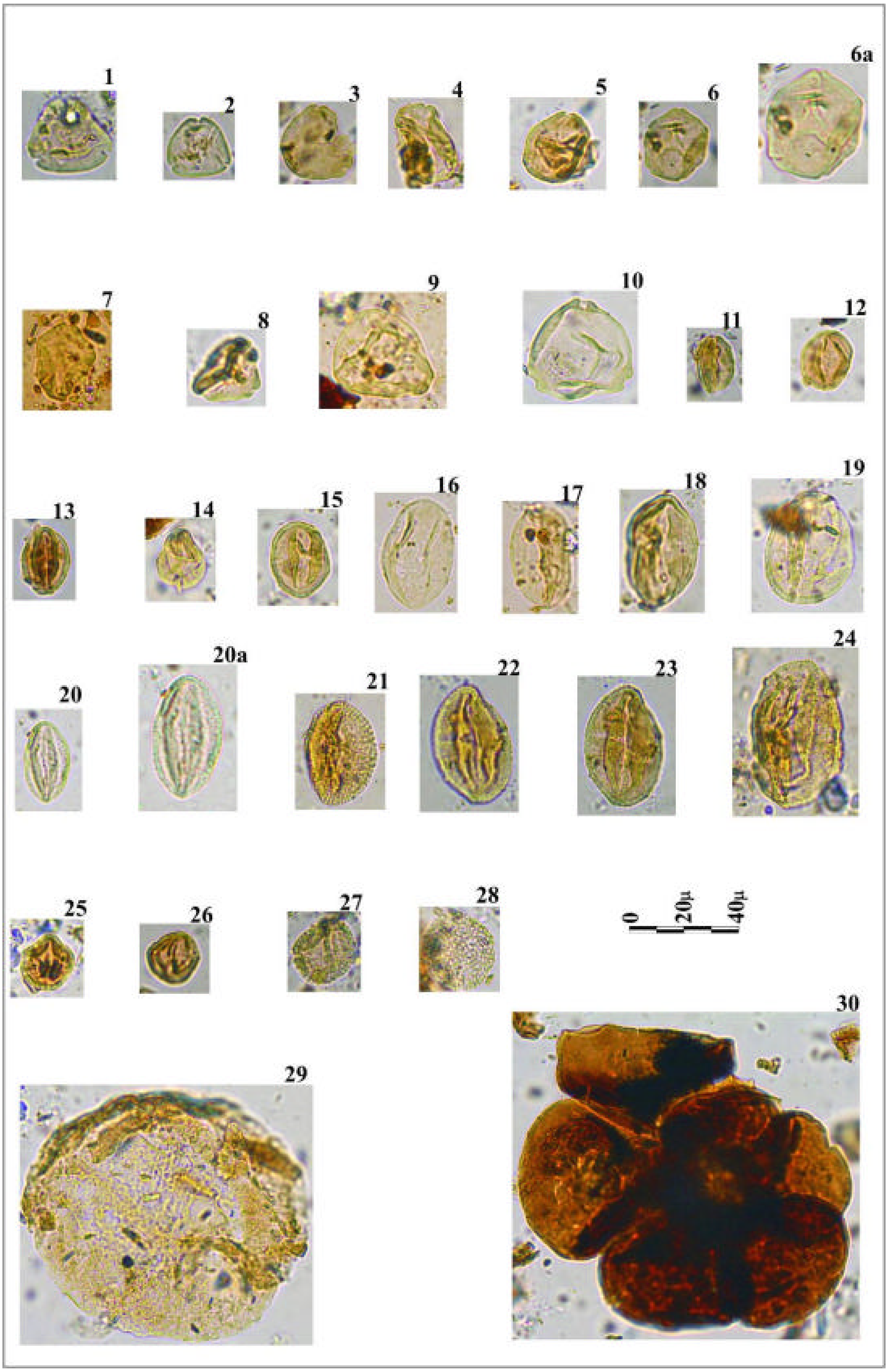


PLATE 5.6 (Alakilise Coal Mine)



5.5 Gastropod and Bivalvia Faunas of Late Oligocene in the Ören Region

Gastrapods and bivalvias fossils are collected from the Alakilise member in Alkilise and Kultak regions. These fossils are represented by the *Calliostoma elegantulum hegeduesi* Baldi, *Turritella beyrichi percarinata* Telegdi–Roth, *Turritella venus margarethae* Gaal, *Granulabium plicata* (Bruguiere), *Tympanotonus (T.) labyrintum labyrintum* (Nyst), *Polinices josephinia olla* De Serres, *Natica millepunctata tigrina* Defrance, *Globularia gibberosa sanctistephani* Cossmann et. Peyrot, *Chicoreus (Foveomurex) trigonalis* (Gabor), *Galeodes semseyiana* Erdös, *Turricula* regularis Koninck, *Arca* sp., *Anadara diluvii* Lamarck, *Anadara* sp., *Ostrea cyathula* Lamarck , *Ostrea* sp., *Cardita* sp. and *Panopea* sp.. These fossils are generally are observed in sediments of the Chattian and Aquitanian (Fig. 5.5). Strontium analysis result is obtained from the *Natica millepunctata tigrina.* According to this result, the Late Oligocene age are recorded in sediments of the Alakilise member. Besides, this result is supported the paleontological age determination (Fig. 5.6).

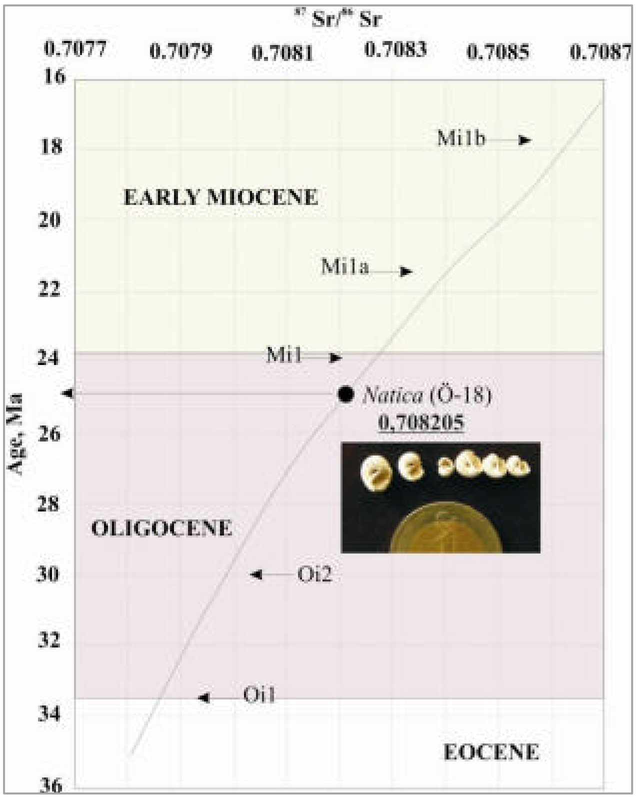
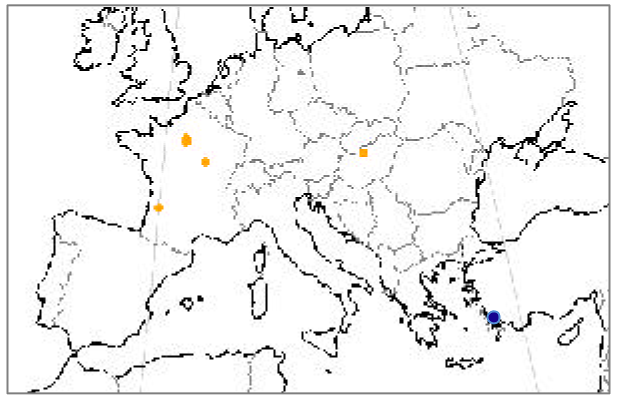


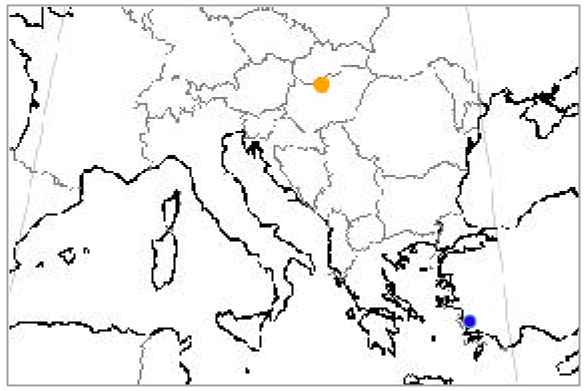
Figure 5.6. Strontium analysis result of the *Natica* sp..

Ostrea cyathula LAMARCK



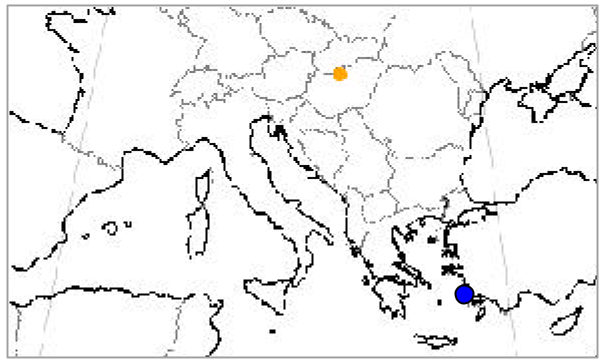
Age	Location	Species
Oligocene	France (Essonne)	*Ostrea cyathula*
Early Oligocene	France (Essonne)	*Ostrea cyathula*
Rupelian	France (Region Aquitaine)	*Ostrea cyathula*
Late Oligocene	Hungary	*Ostrea cyathula*
Chattian	Hungary	*Ostrea cyathula*

Polinicies josephinia DE SERRES



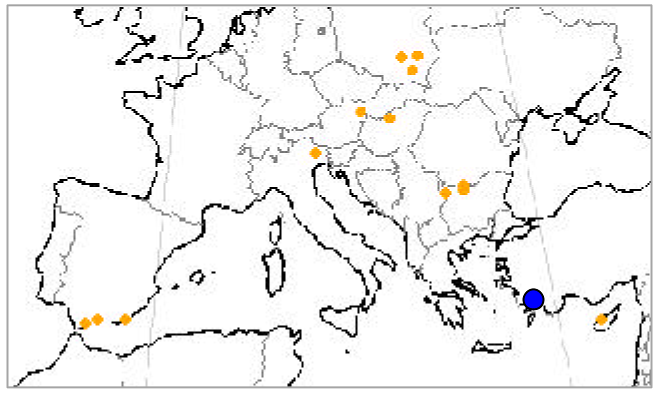
Age	Location	Species
Late Oligocene	Hungary	*Polinicies josephinia*
Chattian	Hungary	*Polinicies josephinia*

Calliostoma elegantulum hegeduesi BALDI



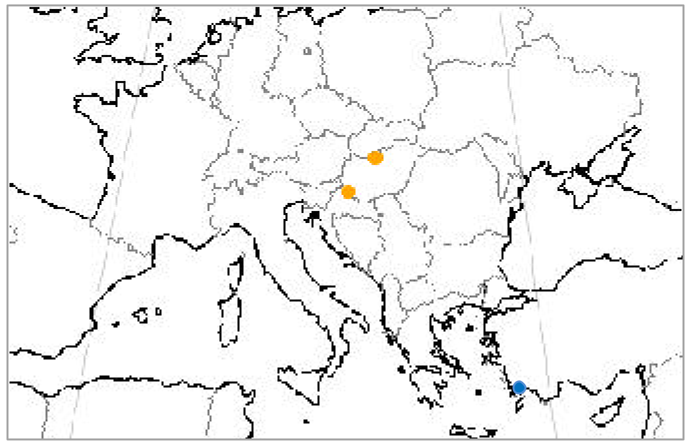
Age	Location	Species
Chattian	Hungary	*Calliostoma elegantulum*

Anadara diluvii LAMARCK



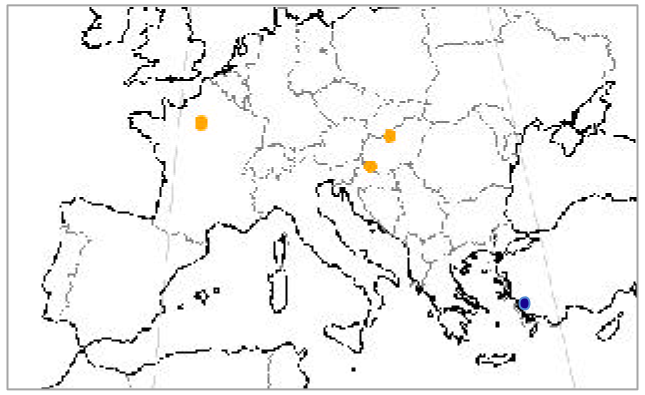
Age	Location	Species
Late Oligocene	Hungary	*Anadara diluvii*
Chattian	Hungary	*Anadara diluvii*
Middle Miocene	Bulgaria	*Anadara diluvii*
Middle Miocene	Poland	*Anadara diluvii*
Langhian	Italy (Pordenone)	*Anadara diluvii*
Serravallian	Italy (Pordenone)	*Anadara diluvii*
Badenian	Slovakia	*Anadara diluvii*
Tortonian-Messinian	Spain	*Anadara diluvii*
Tortonian	Cyprus	*Anadara diluvii*
Tortonian	Italy (Pordenone)	*Anadara diluvii*
Pliocene	Cyprus	*Anadara diluvii*
Pliocene	Spain	*Anadara diluvii*

Turritella beyrichi percarinata GAAL



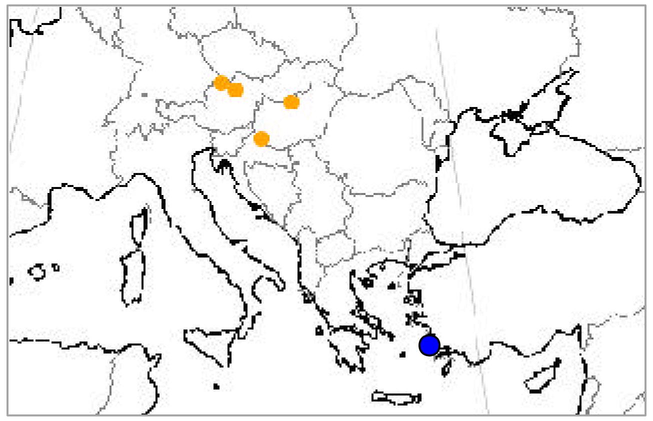
Age	Location	Species
Late Oligocene	Hungary	*Turritella beyrichi*
Chattian	Hungary	*Turritella beyrichi*

Turricula regularis KONINCK



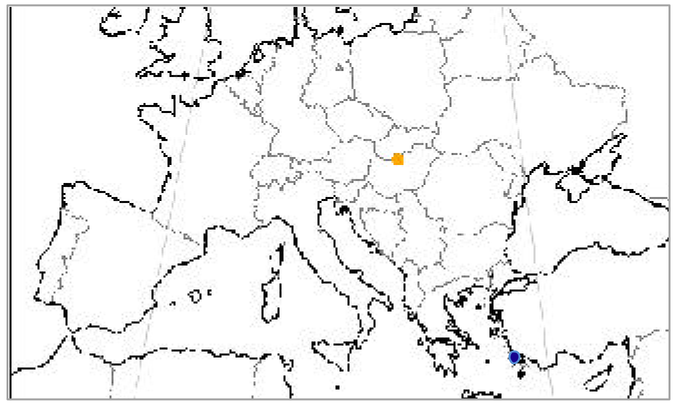
Age	Location	Species
Oligocene	France (Essonne)	*Turricula regularis*
Early Oligocene	France (Essonne)	*Turricula regularis*
Late Oligocene	Hungary	*Turricula regularis*
Chattian	Hungary	*Turricula regularis*

Turritella beyrichi percarinata TELEGDI & ROTH



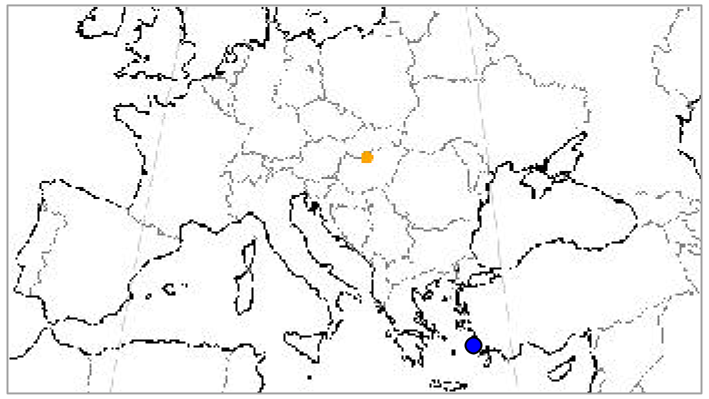
Age	Location	Species
Late Oligocene	Hungary	Turritella venus
Chattian	Austria (Lower Austria)	Turritella venus
Chattian	Austria (Upper Austria)	Turritella venus
Chattian	Hungary	Turritella venus

Galeodes semseyiana Erdös



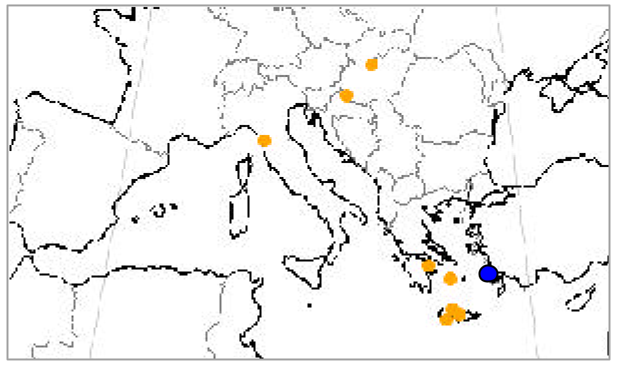
Age	Location	Species
Chattian	Hungary	*Galeodes semseyiana*

Globularia gibberosa sanctistephani COSSMANN ET. PEYROT



Age	Location	Species
Late Oligocene	Hungary	*Globularia gibberosa*
Chattian	Hungary	*Globularia gibberosa*

Natica millepunctata tigrina DEFRANCE



Zaman Araligi	Lokasyon	Cins ve tür adi
Late/Upper Oligocene	Hungary	*Natica millepunctata*
Serravallian	Greece	*Natica millepunctata*
Tortonian	Greece	*Natica millepunctata*
Pliocene	Italy	*Natica millepunctata*

Figure 5.5 Gastrapod and bivalvia fossils distribution in Europe and Turkey.

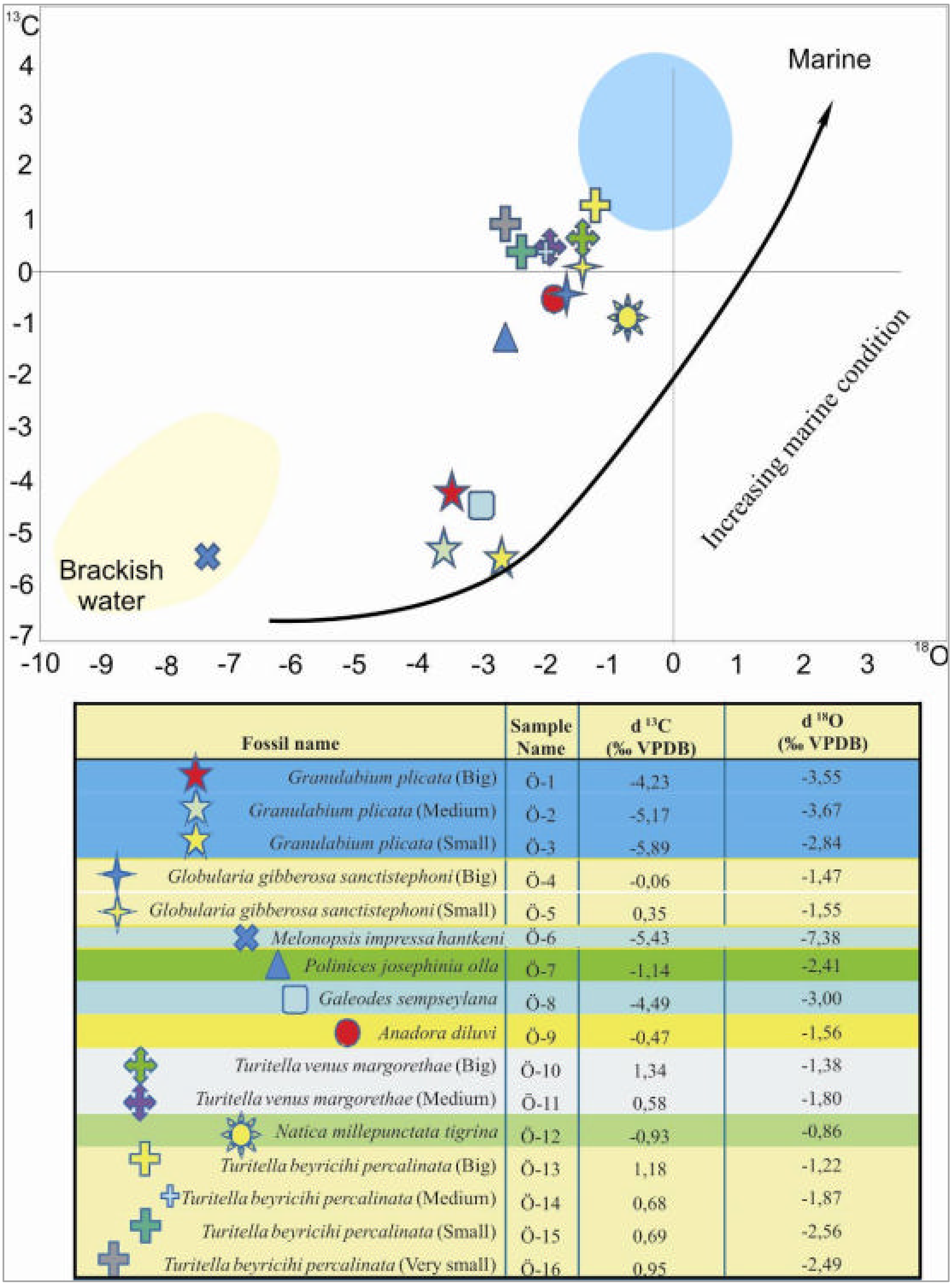
5.6 Oxygen, Carbon (dO^{18} and dC^{13}) Isotopes Analysis results of Marine Sediments for the Chattian-Aquitanian in the Ören Region

The ^{13}C and ^{18}O isotopic analysis results are calculated from the 16 gastrapod and bivalvia fossils (Ö1-16) (Table 5.1; Fig. 5.7). Negative ^{13}C and ^{18}O isotop values are indicate the brackish condition. However, positive ^{13}C and ^{18}O isotop values are interpretated distict marine condition. The ^{13}C and ^{18}O isotop values of the Ören region indicate the brackish and marine condition (deltaic condition) because of the negative and positive values of ^{13}C and ^{18}O. This palaeoenvironmental interpretation is supported the palaeoenvironmental evaluation based on the palynology (Fig. 5.8).

Table 5.1. Oxygen and carbon isotop analysis results of the gastropods and bialvia fossils

Sample Name	d ^{13}C (‰ VPDB)	d ^{18}O (‰ VPDB)
Ö-1	-4,23	-3,55
Ö-2	-5,17	-3,67
Ö-3	-5,89	-2,84
Ö-4	-0,06	-1,47
Ö-5	0,35	-1,55
Ö-6	-5,43	-7,38
Ö-7	-1,14	-2,41
Ö-8	-4,49	-3,00
Ö-9	-0,47	-1,56
Ö-10	1,34	-1,38
Ö-11	0,58	-1,80
Ö-12	-0,93	-0,86
Ö-13	1,18	-1,22
Ö-14	0,68	-1,87
Ö-15	0,69	-2,56
Ö-16	0,95	-2,49

Figure 5.7 Strontium analysis result of the *Natica* sp..



Fossil name	Sample Name	d ^{13}C (‰ VPDB)	d ^{18}O (‰ VPDB)
★ *Granulabium plicata* (Big)	Ö-1	-4,23	-3,55
☆ *Granulabium plicata* (Medium)	Ö-2	-5,17	-3,67
★ *Granulabium plicata* (Small)	Ö-3	-5,89	-2,84
✦ *Globularia gibberosa sanctistephoni* (Big)	Ö-4	-0,06	-1,47
✧ *Globularia gibberosa sanctistephoni* (Small)	Ö-5	0,35	-1,55
✖ *Melonopsis impressa hantkeni*	Ö-6	-5,43	-7,38
▲ *Polinices josephinia olla*	Ö-7	-1,14	-2,41
□ *Galeodes sempseylana*	Ö-8	-4,49	-3,00
● *Anadora diluvi*	Ö-9	-0,47	-1,56
✚ *Turitella venus margorethae* (Big)	Ö-10	1,34	-1,38
✚ *Turitella venus margorethae* (Medium)	Ö-11	0,58	-1,80
✹ *Natica millepunctata tigrina*	Ö-12	-0,93	-0,86
✚ *Turitella beyricihi percalinata* (Big)	Ö-13	1,18	-1,22
✚ *Turitella beyricihi percalinata* (Medium)	Ö-14	0,68	-1,87
✚ *Turitella beyricihi percalinata* (Small)	Ö-15	0,69	-2,56
✚ *Turitella beyricihi percalinata* (Very small)	Ö-16	0,95	-2,49

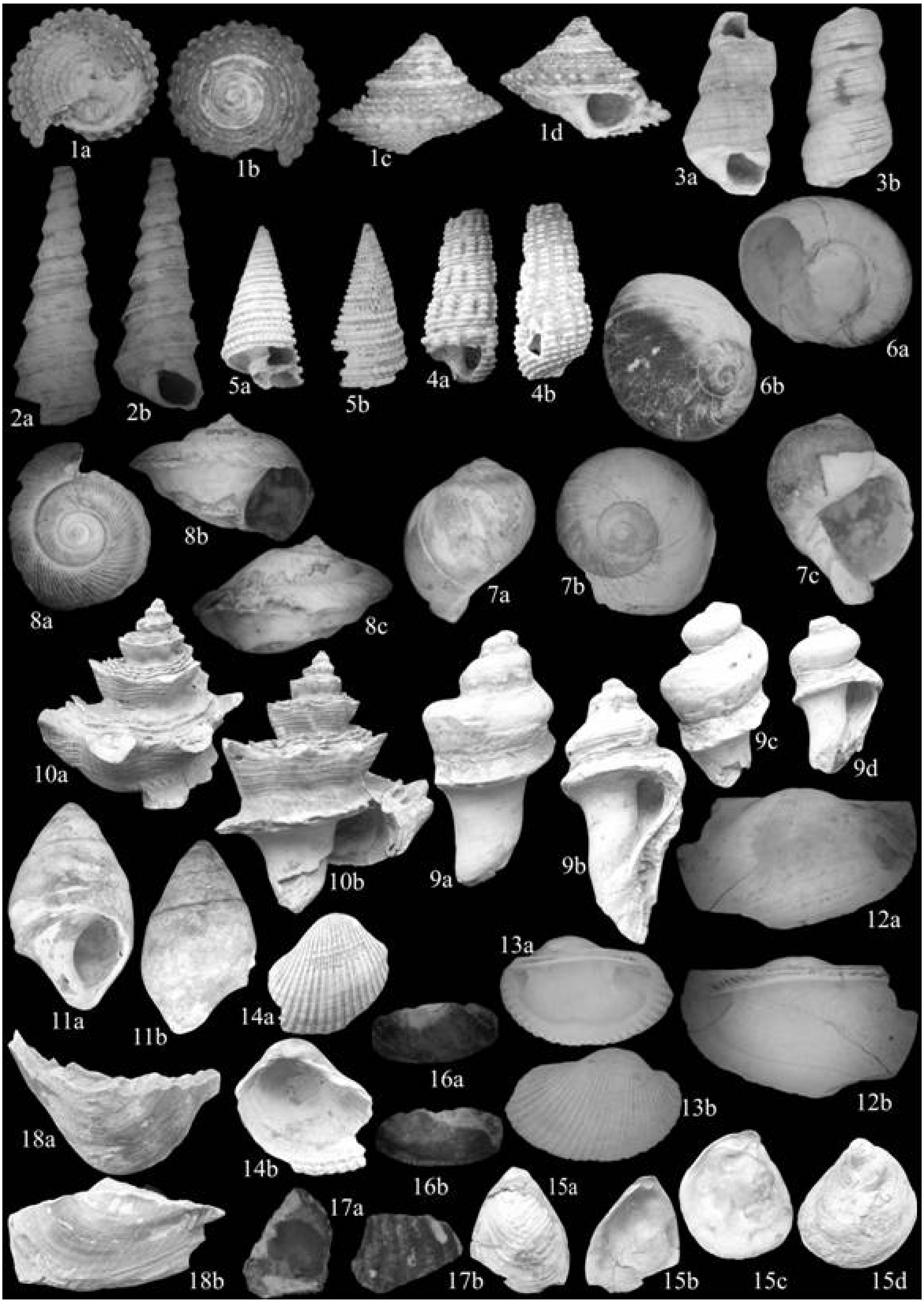
Figure 5.8. ^{13}C and ^{18}O isotop values of the samples of Ören region and ^{13}C and ^{18}O isotop graphic indicates the palaenvironment.

PLATE 5.7 (Gastrapod and Bivalvia fossils)

(Figure 1, 4, 5, 6, 7, 8, 12, 13, 17 “X2” and Figure 2, 3, 9, 10, 11, 14, 15, 16, 18 “X1” magnified used)

Figure	
1a, 1b,1c, 1d	*Calliostoma elegantulum hegeduesi* (Baldi)
2a, 2b	*Turritella beyrichi percarinata* (Telegdi & Roth)
3a, 3b	*Turritella venus margarethae* (Gaal)
4a,4b	*Granulabium plicata* (Bruguiere)
5a, 5b	*Tympanotonus (T.) labyrintum labyrintum* (Nyst)
6a, 6b	*Polinices josephinia olla* (De Serres)
7a,7b,7c	*Natica millepunctata tigrina* (Defrance)
8a, 8b, 8c	*Globularia gibberosa sanctistephani* (Cossmann et. Peyrot)
9a, 9b, 9c, 9d	*Chicoreus (Foveomurex) trigonalis* (Gabor)
10a, 10b	*Galeodes semseyiana* (Erdös)
11a, 11b	*Turricula regularis* (Koninck)
12a, 12b	*Arca* sp.
13a, 13b	*Anadara diluvii* (Lamarck)
14a, 14b	*Anadara* sp.
15a, 15b, 15c, 15d	*Ostrea cyathula* (Lamarck)
16a, 16b	*Ostrea* sp.
17a, 17b	*Cardita* sp.
18a, 18b	*Panopea* sp.

PLATE 5.7


1a
1b
1c
1d
3a
3b
2a
2b
5a
5b
4a
4b
6a
6b
8a
8b
8c
7a
7b
7c
10a
10b
9a
9b
9c
9d
11a
11b
14a
12a
13a
16a
12b
13b
18a
14b
16b
15a
17a
18b
17b
15b
15c
15d

5.7 Foraminifer fauna of Chattian-Aquitanian in the Ören Region

5.7.1 “L” Section

63 samples were taken from the stratigraphic section located to Ören-Kumluca region. Presences of the *Lepidocyclina dilatata d’Archiac*, *Miogypsinoides* and *Miogypsina* indicate the Aquitanian age. Abundance of *Miogypsinoides*, *Miogypsina*, *Lepidocyclina* indicates the open sea towards the front of reef carbonate shelf environment. Samples of the Kumluca region are aged by the Sr^{87}/Sr^{86} isotopic analysis. L-25 sample is the late Chattian age and L-42 sample is the Aquitanian age. Age determination based on the Sr^{87}/Sr^{86} is supported the palaeontological results. However, more detail data are obtained from the isotopic analysis (Fig. 5.9).

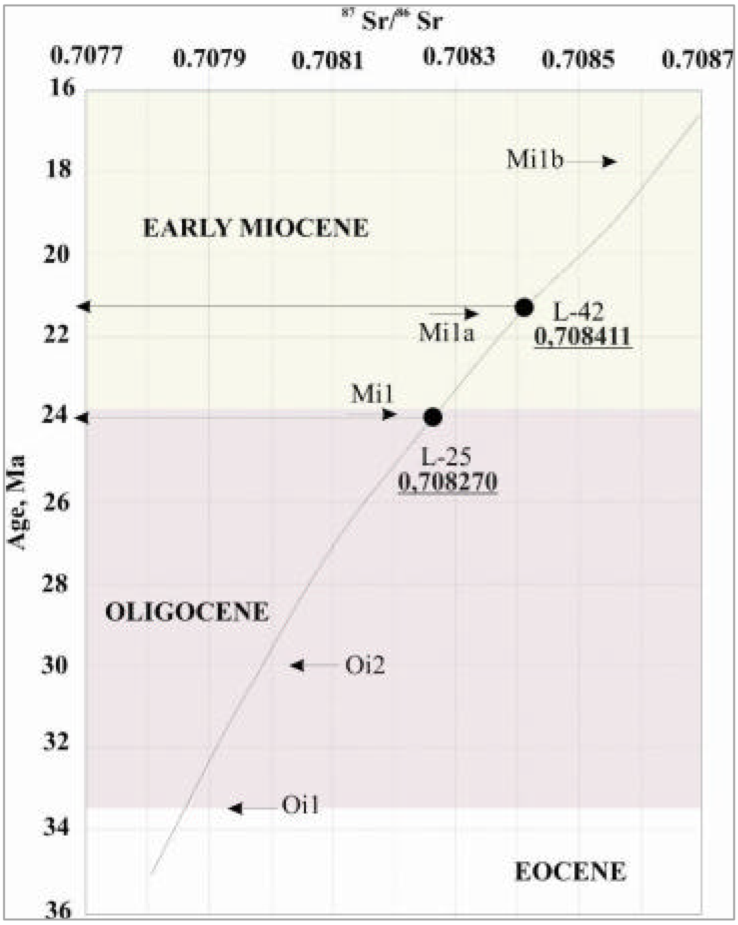


Figure5.9 Sr^{87}/Sr^{86} isotope analysis results of the “L” section in the Kumluca region.

Content of "L" section are given below:

? L-1. (Bioclastic Limestone) *Miogypsina* sp., *Operculina* sp., *Lepidocyclina* sp., *Amphistegina* sp., *Lepidocyclina (Eulepidina)* sp., Haurenidae, Rotaliidae, Textulariidae, red algae (abundant), bryozoa and annelida.

? L-2. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina*? sp., *Operculina* sp., *Lepidocyclina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, Pelesipod, red algae (abundant), bryozoa and annelida.

? L-3. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Amphistegina* sp., *Gypsina* sp., pelesipod, red algae (abundant) and bryozoa.

? L-4. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina*? sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, red algae (more abundant) and bryozoa.

? L-5. (Bioclastic Limestone) *Lepidocyclina* cf. *dilatata* d'Archiac, *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., Hauerinidae, Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, red algae and bryozoa.

? L-6 (Bioclastic Limestone) *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Ditrupa* sp., pelesipod, red algae (abundant), bryozoa and gastrapod.

? L-7. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Elphidium* sp., Ditrupa sp., Acervuliniidae, Hauerinidae, Anomalinidae, Rotaliidae, Textulariidae, Acervuliniidae, Globigeriniidae, pelesipod, red algae (abundant), bryozoa and .

? L-8. (Bioclastic Limestone) *Lepidocyclina* cf. *dilatata* d'Archiac, *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Elphidium* sp., *Mississippina* sp., Acervuliniidae, Hauerinidae, pelesipod, red algae (abundant) and bryozoa.

? L-9. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., Textulariidae, pelesipod, red algae (abundant), and bryozoa.

? L-10. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp. (abundant), *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., Textulariidae, Acervuliniidae, Hauerinidae, pelesipod, red algae (more abundant), gastropoda, and bryozoa.

? L-11. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Ditrupa* sp., Rotaliidae, Textulariidae, Pelesipod, red algae (more abundant), Annelida, gastropoda and bryozoa.

? L-12. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp. (abundant), *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., Textulariidae, pelesipod, red algae (abundant) and bryozoa.

? L-13. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp. (abundant), *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, Pelesipod, red algae (abundant), Ekinit dikeni and Bryozoa.

? L-14. (Bioclastic Limestone) *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Ditrupa* sp., Acervuliniidae, Rotaliidae, Textulariidae, pelesipod, red algae and bryozoa.

? L-15. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, pelesipod, red algae (more abundant), and bryozoa.

? L-16. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp. (abundant), *Lepidocyclina (Nephrolepidina)* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, pelesipod, red algae (more abundant) and bryozoa.

? L-17. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp. (abundant), *Lepidocyclina (Eulepidina)* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, pelesipod, red algae (more abundant) and bryozoa.

? L-18. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp. (abundant), *Lepidocyclina* sp., *Quinqueloculina* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, pelesipod, red algae (more abundant), bryozoa and annelida.

? L-19. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Elphidium* sp., *Quinqueloculina* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Hauerinidae, Textulariidae, pelesipod, red algae (more abundant), bryozoa and annelida.

? L-20. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Quinqueloculina* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Lageniidae, Acervuliniidae, Textulariidae, pelesipod, red algae (more abundant), bryozoa and annelida.

? L-21. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp. (abundant), *Operculina* sp., *Amphistegina* sp., *Ditrupa* sp., Acervuliniidae, Textulariidae, pelesipod, red algae (more abundant) and bryozoa.

? L-22. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp. (more abundant), *Operculina* sp., *Amphistegina* sp., *Ditrupa* sp., Acervuliniidae, Textulariidae, pelesipod, red algae (abundant) and bryozoa.

? L-23. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp. (abundant), *Operculina* sp., *Amphistegina* sp., Acervuliniidae, Textulariidae, pelesipod, red algae (abundant) and bryozoa.

? L-25. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Ditrupa* sp. Acervuliniidae, pelesipod, red algae (abundant) and bryozoa.

? L-27. Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp. (abundant), *Amphistegina* sp., *Ditrupa* sp. Rotaliidae, Acervuliniidae, pelesipod, red algae (more abundant) and bryozoa.

? L-28. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp. (abundant), *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Gypsina* sp., *Ditrupa* sp., Rotaliidae, pelesipod, red algae (more abundant) and bryozoa.

? L-29. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Gypsina* sp., *Ditrupa* sp., Rotaliidae, pelesipod, red algae (more abundant) and bryozoa.

? L-30. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Gypsina* sp., *Ditrupa* sp., Rotaliidae, Textulariidae, pelesipod, red algae (more abundant) and bryozoa.

? L-31. (Bioclastic Limestone) *Miogypsinoides* sp. (abundant), *Miogypsina* sp., *Lepidocyclina* sp. (more abundant), *Operculina* sp., *Amphistegina* sp., Acervuliniidae, pelesipod, red algae (more abundant) and bryozoa.

? L-32. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., Textulariidae, Acervuliniidae, pelesipod, red algae (more abundant) and bryozoa.

? L-33. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., Textulariidae, Acervuliniidae, pelesipod, red algae (more abundant) and bryozoa.

? L-34. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Gypsina* sp., Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, red algae (more abundant) and bryozoa.

? L-35. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Gypsina* sp., Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, gastropoda, red algae (more abundant) and bryozoa.

? L-36. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Mississippina* sp., Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, gastropoda, red algae (more abundant) and bryozoa.

? L-37. (Bioclastic Limestone) *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., Textulariidae, Acervuliniidae, pelesipod, gastropoda, red algae (more abundant) and bryozoa.

? L-38. (Bioclastic Limestone) *Lepidocyclina* sp. (abundantluk zonu), *Lepidocyclina* (*Eulepidina)* sp., *Lepidocyclina* cf. *dilatata* d'Archiac, *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, gastropoda, annelida, red algae (abundant) and bryozoa.

? L-39. (Bioclastic Limestone) *Lepidocyclina* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Pyrgo* sp., *Elphidium* sp., Hauerinidae, Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, gastropoda, annelida, , red algae (more abundant) and bryozoa.

? L-40. (Bioclastic Limestone) *Lepidocyclina* sp., *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Gypsina* sp.., *Pyrgo* sp., *Elphidium* sp., Hauerinidae, Rotaliidae, Textulariidae, Acervuliniidae, pelesipod, gastropoda, annelida, red algae (abundant) and bryozoa.

? L-41. (Bioclastic Limestone) *Lepidocyclina* cf. *dilatata* d'Archiac (abundant), *Lepidocyclina* sp., *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Elphidium* sp., Textulariidae, pelesipod, gastropoda, annelida, , red algae (abundant) and bryozoa.

? L-42. (Bioclastic Limestone) *Lepidocyclina* cf. *dilatata* d'Archiac (abundant), *Lepidocyclina* sp., *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Elphidium* sp., Textulariidae, Rotaliidae, pelesipod, gastropoda, annelida, red algae (abundant) and bryozoa.

? L-44. (Bioclastic Limestone) *Lepidocyclina* sp., *Miogypsinoides* sp., *Miogypsina* sp., *Amphistegina* sp., *Elphidium* sp., Textulariidae, Hauerinidae, Acervuliniidae Rotaliidae, pelesipod, gastropoda, annelida, red algae (more abundant) and bryozoa.

? L45. (Bioclastic Limestone) *Lepidocyclina* cf. *dilatata* d'Archiac (abundant), *Lepidocyclina* sp., *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., Acervuliniidae, Rotaliidae, pelesipod, red algae (more abundant) and bryozoa.

? L-46. (Bioclastic Limestone) *Lepidocyclina* sp., *Miogypsinoides* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Mississippina* sp., Acervuliniidae, Textulariidae, Hauerinidae, pelesipod, red algae (more abundant) and bryozoa.

? L-47. (Bioclastic Limestone) *Lepidocyclina* cf. *dilatata* d'Archiac (abundant), *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Elphidium* sp., Acervuliniidae, Textulariidae, pelesipod, red algae (more abundant) and bryozoa.

? L-48. (Bioclastic Limestone) *Lepidocyclina* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., Rotaliidae, Textulariidae, pelesipod, red algae (more abundant) and bryozoa.

? L-49. (Bioclastic Limestone) *Lepidocyclina* sp., *Miogypsina* sp., *Operculina* sp., *Amphistegina* sp., *Mississippina* sp., Rotaliidae, Textulariidae, Globigeriniidae, pelesipod, red algae (more abundant) and bryozoa.

? L-51. (Bioclastic Limestone) *Lepidocyclina* sp., *Miogypsina* sp., *Amphistegina* sp., *Mississippina* sp., Rotaliidae, Globigeriniidae, Textulariidae, Rotaliidae, pelesipod, gastropoda, red algae (more abundant) and Bryozoa.

? L-52. (Bioclastic Limestone) *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Amphistegina* sp., *Operculina* sp. *Mississippina* sp., Rotaliidae, Textulariidae, Hauerinidae, pelesipod, red algae (more abundant) and bryozoa.

? L-54. (Bioclastic Limestone) *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Miogypsinoides* sp., *Amphistegina* sp., *Mississippina* sp., *Operculina* sp., Rotaliidae, Acervuliniidae, Textulariidae, pelesipod, gastropoda, red algae (more abundant) and bryozoa.

? L-55. (Bioclastic Limestone) *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Miogypsinoides* sp., *Amphistegina* sp., *Mississippina* sp., *Operculina* sp., Rotaliidae, Acervuliniidae, Textulariidae, pelesipod, gastropoda, red algae (more abundant) and bryozoa.

? L-56. (Bioclastic Limestone) *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Miogypsinoides* sp., *Amphistegina* sp., *Mississippina* sp., *Operculina* sp., Rotaliidae, Acervuliniidae, Textulariidae, pelesipod, gastropoda, annelida, red algae (more abundant) and bryozoa.

? L-57. (Bioclastic Limestone) *Lepidocyclina* cf. *dilatata* d'Archiac (abundant), *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Amphistegina* sp., *Operculina* sp., Rotaliidae, Textulariidae, pelesipod (abundant), red algae (more abundant) and bryozoa.

? L-58. (Bioclastic Limestone) *Lepidocyclina dilatata* d'Archiac, *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Amphistegina* sp., *Globigeriniidae,* Rotaliidae, Textulariidae, gastropoda, pelesipod, red algae and bryozoa.

? L-59. (Bioclastic Limestone) *Lepidocyclina dilatata* d'Archiac (abundantluk zonu), *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Amphistegina* sp., *Operculina* sp., Textulariidae, annelida, pelesipod, red algae (abundant) and bryozoa.

? L-59b. (Bioclastic Limestone) *Lepidocyclina dilatata* d'Archiac, *Lepidocyclina* sp. (abundant), *Miogypsina* sp., *Amphistegina* sp., pelesipod, red algae (abundant) and bryozoa.

? L-60. (Bioclastic Limestone) *Lepidocyclina* sp., *Lepidocyclina dilatata* d'Archiac, *Lepidocyclina (Eulepidina)* sp., *Operculina* sp., *Amphistegina* sp., *Miogypsina* sp., Textulariidae, Rotaliidae, red algae (abundant), pelesipod and bryozoa.

? L-61. (Bioclastic Limestone) *Lepidocyclina* sp., *Operculina* sp., *Amphistegina* sp., *Miogypsina* sp., Acervuliniidae (abundant), Textulariidae, Rotaliidae, red algae (abundant), pelesipod and bryozoa.

? L-63. (Bioclastic Limestone) *Lepidocyclina* sp. (abundant), *Operculina* sp., *Amphistegina* sp., *Miogypsina* sp., *Ditrupa* sp., Acervuliniidae (abundant), Lageniidae, Rotaliidae, red algae (abundant), pelesipod and bryozoa.

5.7.2 “S” Section

“S” section is represented by the abundant *Heterostegina* and *Amphistegina.* *Quinqueloculina* sp., *Austrotrillina*? sp., *Operculina* sp., *Austrotrillina* sp., Soritidae, Textulariidae, Rotaliidae, Hauerinidae, coral, red algae, bryozoa, gastropoda and pelesipods also recorded in limestone samples of the Alakilise member. According to foraminifer fauna and strotium isotopic analysis results samples of this section are late Chattian age (Fig. 5.10).

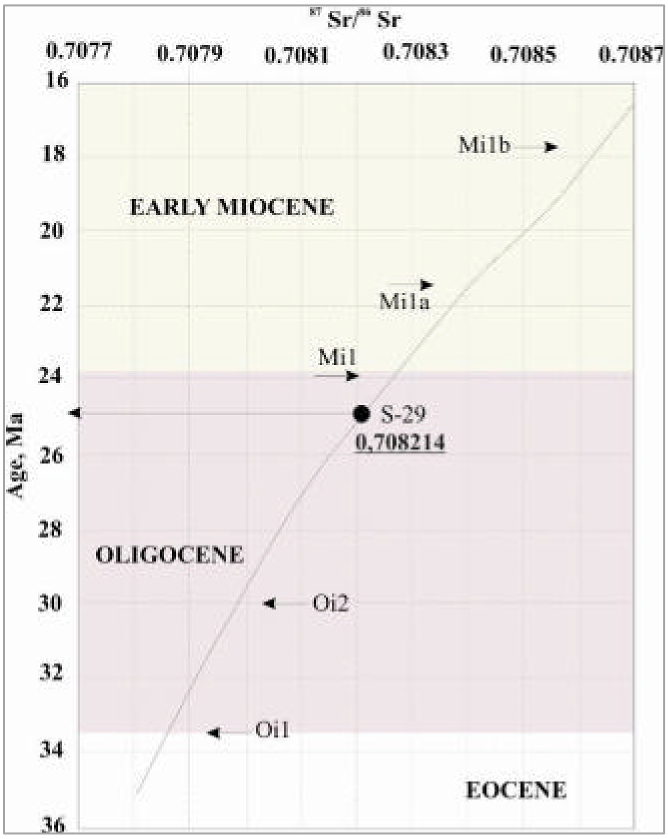


Figure5.10 Sr^{87}/Sr^{86} isotope analysis results of the “S” section in the Kumluca region.

Contents of the “S” section are given below:

? S-1. (Bioclastic Limestone) *Amphistegina* sp., *Heterostegina* sp. (abundant), *Quinqueloculina* sp., red algae, bryozoa, pelesipod (abundant), annelida and Foraminifera.

? S-2. (Bioclastic Limestone) *Amphistegina* sp. (abundant), *Heterostegina* sp. (abundant), *Quinqueloculina* sp., Rotaliidae, Hauerinidae, coral, red algae, bryozoa, gastropoda, ostracoda, pelesipod (abundant) and foraminifera.

? S-3. (Bioclastic Limestone) *Amphistegina* sp., *Heterostegina* sp., Rotaliidae, Hauerinidae, coral, red algae, bryozoa, gastropoda, pelesipod and foraminifera.

? S-4. (Bioclastic Limestone) *Amphistegina* sp., *Heterostegina* sp. (abundant), *Austrotrillina*? sp., Soritidae, Textulariidae, Rotaliidae, Hauerinidae, coral, red algae, bryozoa, gastropoda, pelesipod and foraminifera.

? S-5. (Bioclastic Limestone) *Amphistegina* sp., *Heterostegina* spp. (more abundant), *Ouinqueloculina* sp., Soritidae, Textulariidae, Rotaliidae, Hauerinidae, coral, red algae, bryozoa, gastropoda, pelesipod and foraminifer.

? S-6. (Bioclastic Limestone) *Amphistegina* sp. (abundant), *Heterostegina* sp. (more abundant), Textulariidae, Hauerinidae, pelesipod, bryozoa, gastropoda and coral.

? S-7. (Bioclastic Limestone) *Amphistegina* sp. (abundant), *Heterostegina* sp., Rotaliidae, Textulariidae, Hauerinidae, pelesipod, bryozoa, gastropoda and red algae.

? S-8. (Bioclastic Limestone) *Amphistegina* sp., *Heterostegina* sp., *Ouinqueloculina* sp., *Operculina* sp., Soritidae, Hauerinidae, annelida, pelesipod, bryozoa, gastropoda and red algae.

? S-9. (Bioclastic Limestone) *Heterostegina* spp. (abundant), *Amphistegina* sp. (abundant), Hauerinidae, bryozoa, pelesipod, gastropoda, coral and red algae.

? S-10. (Bioclastic Limestone) *Heterostegina* spp. (abundant), *Amphistegina* sp. (abundant), Hauerinidae, Bryozoa, pelesipod, gastropoda, coral and red algae.

? S-11. (Bioclastic Limestone) *Heterostegina* sp. (more abundant), *Amphistegina* sp., Hauerinidae, Soritidae, bryozoa, pelesipod, gastropoda, coral and red algae.

? S-12. (Bioclastic Limestone) *Heterostegina* spp. (more abundant), *Amphistegina* sp., Hauerinidae, Textulariidae, Soritidae, bryozoa, pelesipod, gastropoda and red algae.

? S-13. (Bioclastic Limestone) *Heterostegina* spp. (abundant), *Amphistegina* sp., *Anomalina* sp., Hauerinidae, bryozoa, pelesipod, gastropoda and red algae.

? S-14. (Bioclastic Limestone) *Heterostegina* spp., *Amphistegina* sp., *Operculina* sp., *Austrotrillina* sp., Hauerinidae, Textulariidae, bryozoa, pelesipod, gastropoda and red algae.

? S-15. (Bioclastic Limestone) *Heterostegina* spp (more abundant), *Amphistegina* sp., *Operculina* sp., *Austrotrillina* sp., Hauerinidae, Rotaliidae, Textulariidae, bryozoa, pelesipod, annelida, gastropoda and red algae.

? S-16. (Bioclastic Limestone) *Heterostegina* sp (more abundant), *Amphistegina* sp. (abundant), *Operculina* sp., bryozoa, pelesipod, gastropoda and red algae.

? S-16a. (Bioclastic Limestone) *Sphaerogypsina globulus* Reuss, *Heterostegina* sp (more abundant), *Amphistegina* sp. (abundant), *Operculina* sp., bryozoa, pelesipod, gastropoda and red algae.

? S-17. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Operculina* sp., Hauerinidae, Rotaliidae, Textulariidae, Acervuliniidae, Discorbiidae, bryozoa (abundant), pelesipod, coral, gastropoda and red algae.

? S-18. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Acervuliniidae, Discorbiidae, coral (abundant), bryozoa, pelesipod and red algae.

? S-19. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Operculina* sp., Hauerinidae, Rotaliidae, Discorbiidae, bryozoa (abundant), pelesipod, coral, gastropoda and red algae.

? S-19a (Bioclastic Limestone) *Heterostegina* sp., Acervuliiniidae, Discorbiidae, coral, pelesipod, bryozoa and annelida.

? S-19b (Bioclastic Limestone) *Heterostegina* sp., Acervuliiniidae, Discorbiidae, mercan, pelesipod, bryozoa and annelida.

? S-20. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Operculina* sp., Hauerinidae, Discorbiidae, bryozoa (abundant), Pelesipod, coral and red algae.

? S-21. (Bioclastic Limestone) Discorbiidae, coral (abundant), bryozoa, red algae, pelesipod and gastropoda.

? S-22. (Bioclastic Limestone) *Amphistegina* sp., Acervuliniidae, Hauerinidae, coral (abundant), red algae, pelesipod, bryozoa and gastropoda.

? S-23. (Bioclastic Limestone) *Heterostegina* sp., Discorbiidae, coral (abundant), bryozoa, red algae, pelesipod and gastropoda.

? S-24. (Bioclastic Limestone) *Heterostegina* sp., (abundant), *Amphistegina* sp., *Operculina* sp., Acervuliniidae, Rotaliidae, Hauerinidae, coral (abundant), red algae, bryozoa, pelesipod, and annelida.

? S-26. (Bioclastic Limestone) *Heterostegina* sp., (abundant), *Amphistegina* sp., Acervuliniidae, Rotaliidae, Hauerinidae, coral (abundant), red algae, bryozoa, gastropoda and pelesipod.

? S-27. (Bioclastic Limestone) *Heterostegina* sp., (abundant), *Amphistegina* sp., *Quinqueloculina* sp., Acervuliniidae, Rotaliidae, Hauerinidae, Discorbidae, coral (abundant), red algae, bryozoa, pelesipod (abundant) and ostracoda.

? S-28. (Bioclastic Limestone) *Heterostegina* sp., (abundant), *Amphistegina* sp., *Quinqueloculina* sp., Acervuliniidae, Rotaliidae, Hauerinidae, coral (abundant), red algae, bryozoa and pelesipod (abundant).

? S-29. (Bioclastic Limestone) *Amphistegina* sp., *Quinqueloculina* sp., Hauerinidae, coral, red algae, annelida, bryozoa, ostracoda, gastropoda and pelesipod (abundant).

? S-30. (Bioclastic Limestone) Discorbidae, coral, red algae, annelida, bryozoa (abundant), ostracoda, gastropoda and pelesipod.

? S-31a. (Bioclastic Limestone) *Amphistegina* sp., Discorbidae, Acervuliniidae, coral, red algae, annelida, bryozoa ostracoda, gastropoda, pelesipod.

? S-31b. (Bioclastic Limestone) *Amphistegina* sp., *Sphaerogypsina globulus Reus*, Textulariidae, Discorbidae, Hauerinidae, coral, red algae, annelida, bryozoa ostracoda, gastropoda and pelesipod.

? S-31c. (Bioclastic Limestone) *Amphistegina* sp., *Sphaerogypsina globulus Reus*, Textulariidae, Discorbidae, Hauerinidae, Acervuliniidae, coral, red algae, annelida, bryozoa ostracoda, gastropoda, pelesipod.

? S-32. (Bioclastic Limestone) *Amphistegina* sp., Acervuliniidae (abundant), Rotaliidae, coral, red algae, bryozoa, pelesipod and annelid.

? S-33a. (Bioclastic Limestone) *Amphistegina* sp., Acervuliniidae, Hauerinidae, Discorbidae, coral (abundant), red algae, bryozoa, pelesipod (abundant), gastropoda.

? S-33b. (Bioclastic Limestone) *Amphistegina* sp., Acervuliniidae, Discorbidae, coral (abundant), red algae, annelida, bryozoa and pelesipod.

? S-34. (Bioclastic Limestone) *Amphistegina* sp.(abundant), *Quinqueloculina* sp., Rotaliidae, Textulariidae, Discorbidae, Valvulinidae, Hauerinidae, Acervuliniidae, Gypsinidae, coral (abundant), red algae, annelida, bryozoa gastropoda and pelesipod.

? S-35. (Bioclastic Limestone) *Amphistegina* sp.(abundant), *Heterostegina* sp. (abundant), *Operculina* sp., *Quinqueloculina* sp., Rotaliidae, Textulariidae, Discorbidae, Hauerinidae, Gypsinidae, coral (abundant), red algae, annelida, bryozoa gastropoda, pelesipod and Foraminifera.

? S-36. (Bioclastic Limestone) *Amphistegina* sp. (abundant), *Heterostegina* sp. *Quinqueloculina* sp., Rotaliidae, Hauerinidae, coral, red algae, annelida, bryozoa, pelesipod and foraminifera.

? S-37. (Bioclastic Limestone) *Amphistegina* sp.(abundant), *Heterostegina* sp. (abundant), Rotaliidae, Hauerinidae, Gypsinidae, coral, red algae, annelida, bryozoa gastropoda, pelesipod and Foraminifera.

? S-38. (Bioclastic Limestone) *Amphistegina* sp.(abundant), *Heterostegina* sp. (abundant), Hauerinidae, Textulariidae, coral, red algae, annelida, bryozoa gastropoda, pelesipod and foraminifera.

? S-39. (Bioclastic Limestone) *Heterostegina* sp. (abundant), *Amphistegina* sp., Discorbiidae, coral (abundant), pelesipod, bryozoa and annelida.

? S-40. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Discorbiidae, coral, pelesipod, bryozoa and annelida.

? S-41a. (Bioclastic Limestone) *Amphistegina* sp.(abundant), *Heterostegina* sp. (abundant), *Quinqueloculina* sp., Acervuliniidae, coral, red algae, annelida, bryozoa, pelesipod and foraminifera.

? S-41b. (Bioclastic Limestone) *Amphistegina* sp., *Heterostegina* sp. (abundant), *Quinqueloculina* sp., Acervuliniidae, coral, red algae, bryozoa, pelesipod, annelid and foraminifera.

? S-42. (Bioclastic Limestone) *Amphistegina* sp., *Heterostegina* sp. (abundant), *Quinqueloculina* sp., Acervuliniidae, Textulariidae, coral, red algae, annelida, bryozoa, gastropoda, pelesipod (abundant) and foraminifer.

? S-43. (Bioclastic Limestone) *Amphistegina* sp. (more abundant), *Heterostegina* sp. (more abundant), corel, red algae, bryozoa, gastropoda, pelesipod, annelid and foraminifera.

? S-44. (Bioclastic Limestone) *Amphistegina* sp. (abundant), *Heterostegina* sp. (more abundant), *Quinqueloculina* sp., coral, red algae, bryozoa, gastropoda, pelesipod, annelid and foraminifera.

5.7.3 "K" Section

"K" section is characterized by the *Heterostegina* sp., *Amphistegina* sp., *Austrotrillina* sp., *Quinqueloculina* sp., Hauerinidae, Textulariidae, Acervuliniidae, Red algae, Pelesipod, Gastropoda and Bryozoa. According to foraminifer fauna and strotium isotopic analysis results samples of this section are late Chattian age (Figs. 5.11; 5.12).

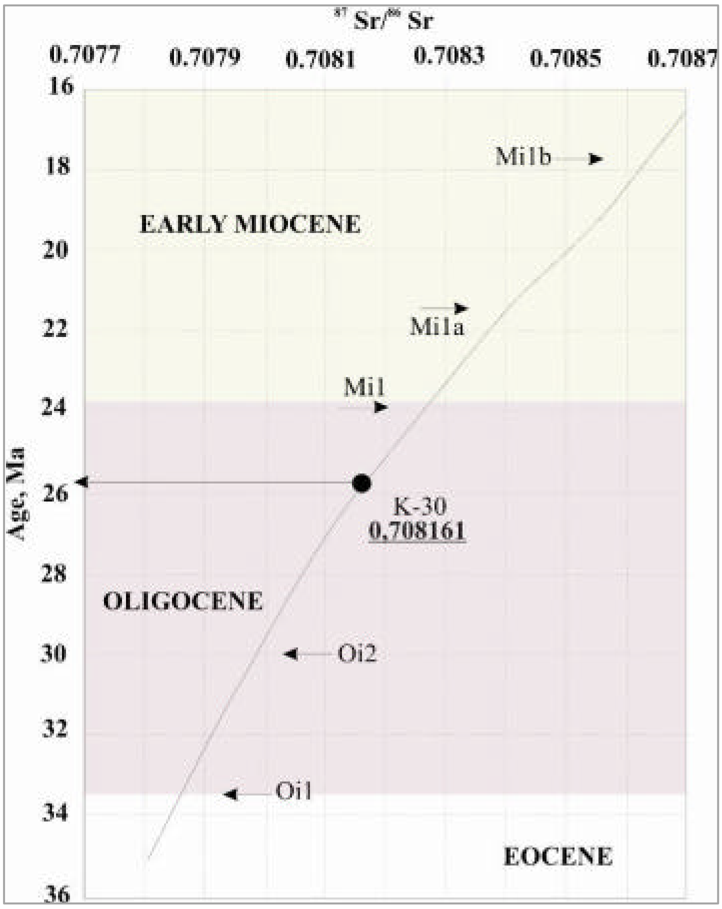


Figure5.11Sr^{87}/Sr^{86} isotope analysis results of the "S" section in the Kumluca region.

Contents of the "K" section are given below (Fig. 5.13):

? K-1. (Bioclastic Limestone) *Heterostegina* sp. (abundant), *Amphistegina* sp. (abundant), Hauerinidae, Textulariidae, Red algae, Pelesipod and Bryozoa.

? K-2. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Acervuiliniidae, Textulariidae (abundant), Red algae, Pelesipod and Bryozoa.

? K-3. (Bioclastic Limestone) *Heterostegina* sp. (more abundant), *Amphistegina* sp., Textulariidae, Red algae, Pelesipod and Bryozoa.

? K-4a. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Coral (abundant), Gastropoda, Pelesipod and Bryozoa.

? K-4b. (Bioclastic Limestone) *Amphistegina* sp., Hauerinidae, Pelesipod, Red algae, Coral (more abundant) and Bryozoa.

? K-5. (Bioclastic Limestone) Coral (more abundant) and Red algae.

? K-6. (Bioclastic Limestone) *Amphistegina* sp., Acervuliniidae, Red algae and Pelesipod (abundant).

? K-7. (Bioclastic Limestone) Coral (abundant), Pelesipdod and Bryozoa.

? K-8. (Bioclastic Limestone) Hauerinidae, Coral, Pelesipdod, Gastropoda and Bryozoa.

? K-9. (Bioclastic Limestone) *Heterostegina* sp. (abundant), *Amphistegina* sp., *Archaias* sp., *Quinqueloculina* sp., Hauerinidae, Textulariidae, Red algae, Pelesipod and Bryozoa.

? K-10. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Archaias* sp., *Quinqueloculina* sp., Hauerinidae, Red algae, Pelesipod and Bryozoa.

? K-11. (Bioclastic Limestone) *Heterostegina* sp. (abundant), *Amphistegina* sp., Hauerinidae, Textulariidae, Red algae, Pelesipod and Bryozoa.

? K-12. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Austrotrillina* sp., *Quinqueloculina* sp., Hauerinidae, Textulariidae, Acervuliniidae, Red algae, Pelesipod, Gastropoda and Bryozoa.

? K-13. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Textulariidae, Red algae, Pelesipod, Coral and Bryozoa.

? K-14. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Textulariidae, Hauerinidae, Red algae, Pelesipod and Bryozoa.

? K-15. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Textulariidae, Hauerinidae, Red algae, Gastropoda, Pelesipod, Coral and Bryozoa.

? K-16. (Bioclastic Limestone) *Heterostegina* sp., Textulariidae, Hauerinidae, Red algae, Gastropoda, Pelesipod (abundant), Coral, Annelida and Bryozoa.

? K-17. (Bioclastic Limestone) *Heterostegina* sp., Textulariidae, Rotaliidae, Hauerinidae, Red algae, Gastropoda, Pelesipod (abundant), Coral and Bryozoa.

? K-19. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Textulariidae, Soritiidae, Hauerinidae, Red algae, Pelesipod (abundant), Coral and Bryozoa.

? K-20. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Textulariidae, Soritiidae, Hauerinidae, Red algae, Pelesipod (abundant), Coral and Bryozoa.

? K-21. (Bioclastic Limestone) *Heterostegina* sp. (more abundant), *Amphistegina* sp., Textulariidae, Soritiidae, Hauerinidae, Red algae, Pelesipod, Coral and Bryozoa.

? K-23. (Bioclastic Limestone) *Heterostegina* sp. (more abundant), *Amphistegina* sp., Hauerinidae, Red algae, Pelesipod (abundant), Coral and Bryozoa.

? K-24. (Bioclastic Limestone) *Heterostegina* sp. (more abundant), *Amphistegina* sp., Soritiidae, Rotaliidae, Red algae, Pelesipod, Coral, Annelida and Bryozoa.

? K-25. (Bioclastic Limestone) *Heterostegina* sp. (abundant), *Amphistegina* sp. (abundant), Hauerinidae, Gastropoda, Red algae, Pelesipod (abundant), Bryozoa.

? K-26. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Hauerinidae, Gastropoda, Red algae, Pelesipod, Coral and Bryozoa.

? K-27. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Pyrgo* sp., Hauerinidae, Red algae, Pelesipod and Bryozoa.

? K-28. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Archaias?* sp., Red algae, Pelesipod (abundant), Coral and Bryozoa.

? K-29. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Red algae, Pelesipod (abundant), Gastropoda, Coral and Bryozoa.

? K-30. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Rotaliidae, Soritiidae, Red algae, Pelesipod (abundant), Gastropoda, Coral, Annelida, Dasycladacea and Bryozoa.

? K-31. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Gypsina* sp., Rotaliidae, Hauerinidae, Red algae (abundant), Pelesipod (abundant), Gastropoda, Coral, Dasycladacea and Bryozoa.

? K-32. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Soritiidae, Red algae (abundant), Pelesipod (abundant), Gastropoda, Coral, Dasycladacea and Bryozoa.

? K-33. Bioclastic Limestone) *Amphistegina* sp., Red algae, Pelesipod (more abundant), Coral (more abundant).

? K-36. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Red algae, Pelesipod (abundant), Gastropoda (abundant) and Coral.

? K-37. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Red algae, Pelesipod (abundantluk), Gastropoda and Bryozoa.

? K-38. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Textulariidae, Hauerinidae, Red algae (abundant), Pelesipod (abundant) and Gastropoda.

? K-39. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), *Gypsina* sp., Hauerinidae, Dasycladacea, Red algae, Pelesipod (abundant), Coral, Gastropoda and Bryozoa.

? K-40. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Quinqueyloculina* sp., *Gypsina* sp., Textulariidae, Hauerinidae, Peneropliidae, Red algae, Pelesipod (abundant), Coral, Annelida, Gastropoda and Bryozoa.

? K-41. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., Hauerinidae, Red algae, Pelesipod (abundant), Annelida and Bryozoa.

? K-41a. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp., *Operculina* sp., Hauerinidae, Peneropliidae, Red algae, Pelesipod (abundant) and Bryozoa.

? K-42. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Hauerinidae, Peneropliidae, Red algae, Pelesipod (abundant) and Bryozoa.

? K-43. (Bioclastic Limestone) *Heterostegina* sp., *Amphistegina* sp. (abundant), Rotaliidae, Textulariidae, Hauerinidae, Peneropliidae, Red algae, Pelesipod (abundant) and Bryozoa.

? K-44. (Bioclastic Limestone) *Heterostegina* sp. (abundant), *Amphistegina* sp. (abundant), *Gypsina* sp., Textulariidae, Hauerinidae, Peneropliidae, Red algae, Pelesipod, Coral and Bryozoa.

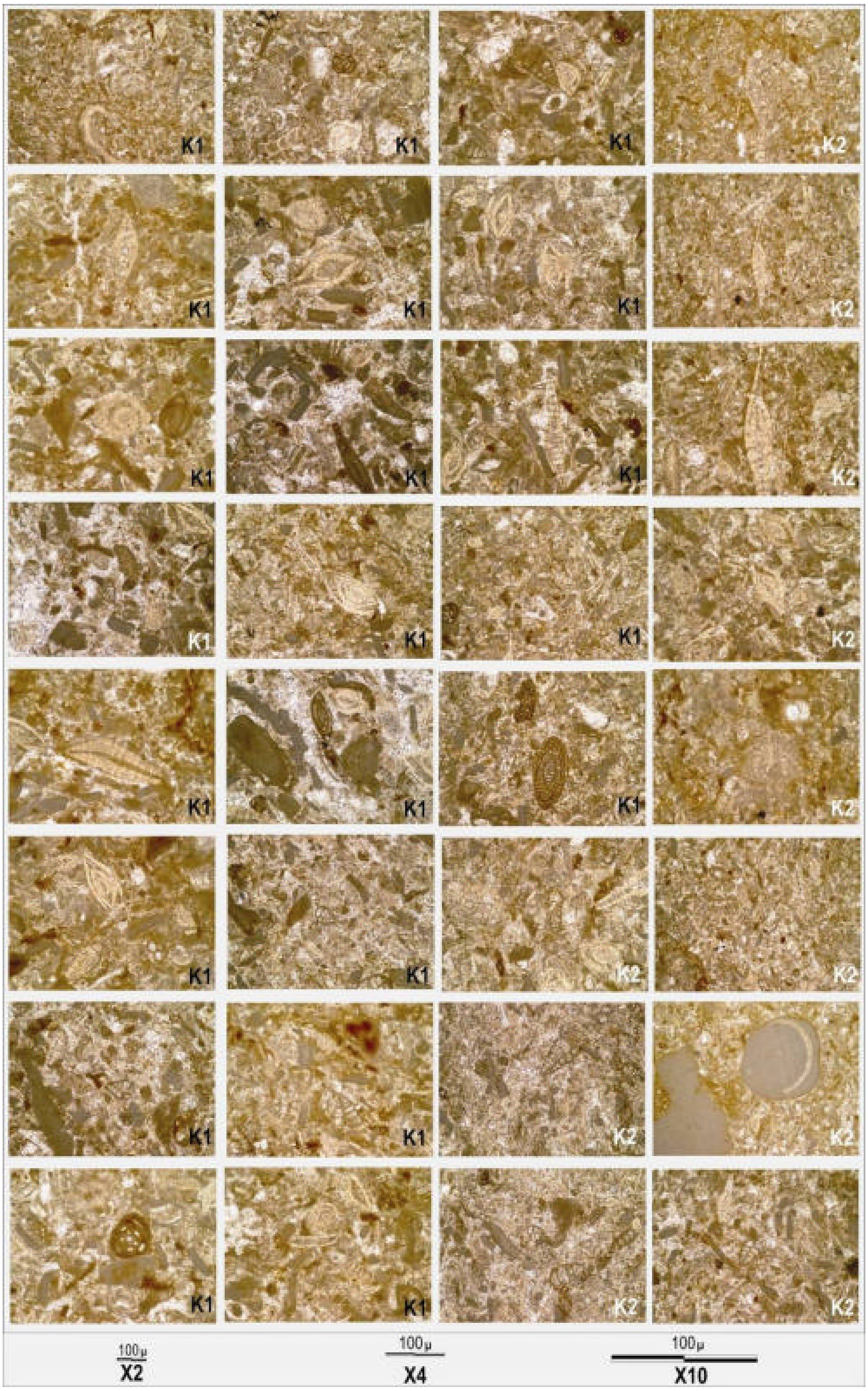


Figure 5.12 Photos show the microscopic images of the limestone samples in the K section.

Figure 5.12 Continiued.

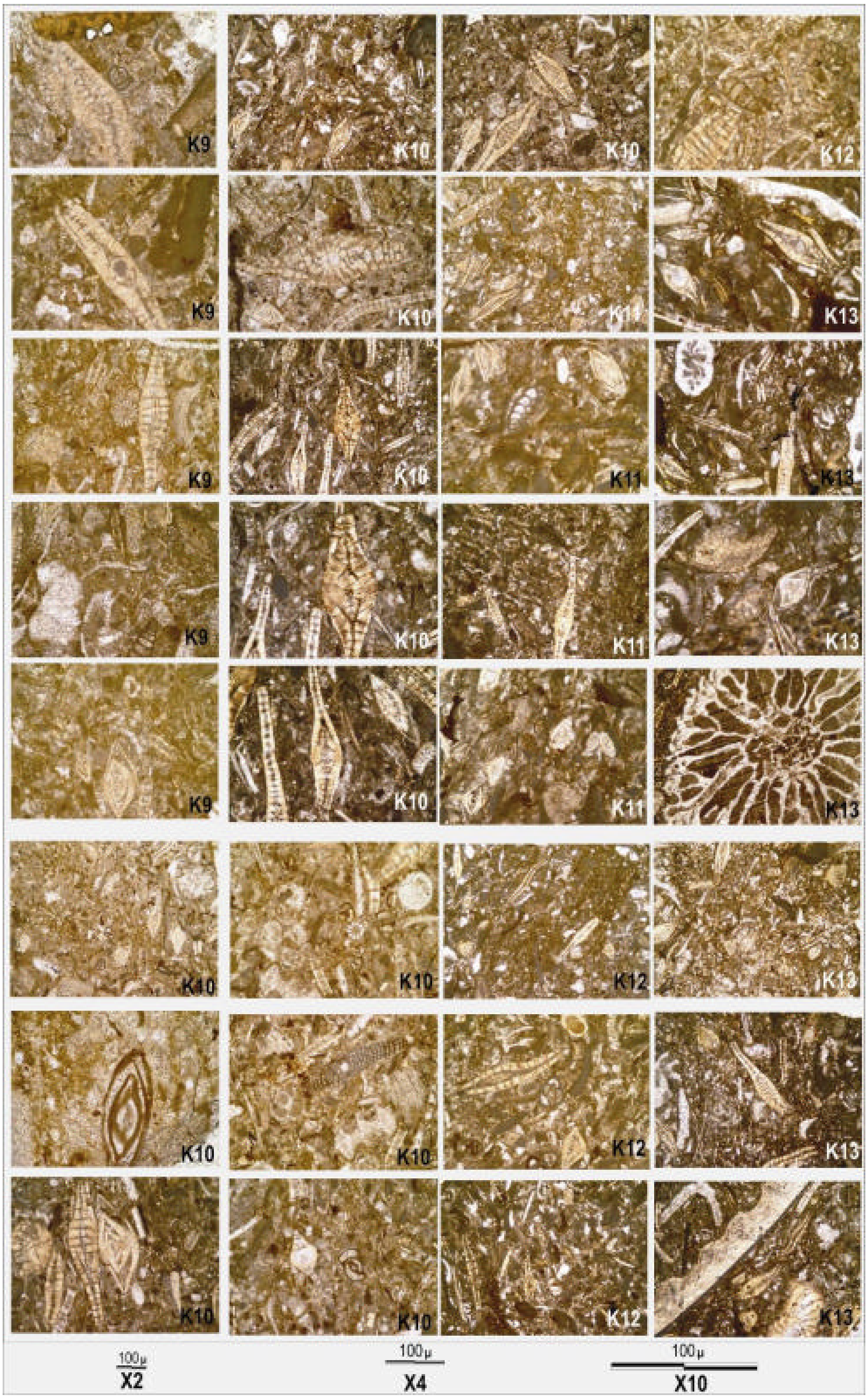


Figure 5.12 Continiued.

5.7.4 “M” Section

This sectin have poor fossils. However, *Heterostegina* sp. and *Amphistegina* sp. are abserved in the “M” section of the Alakilise member. According to the strontium isotopic analysis result and foraminifer fauna, samples of the “M” section is the late Chattian age (Figs. 5.13, 5.14).

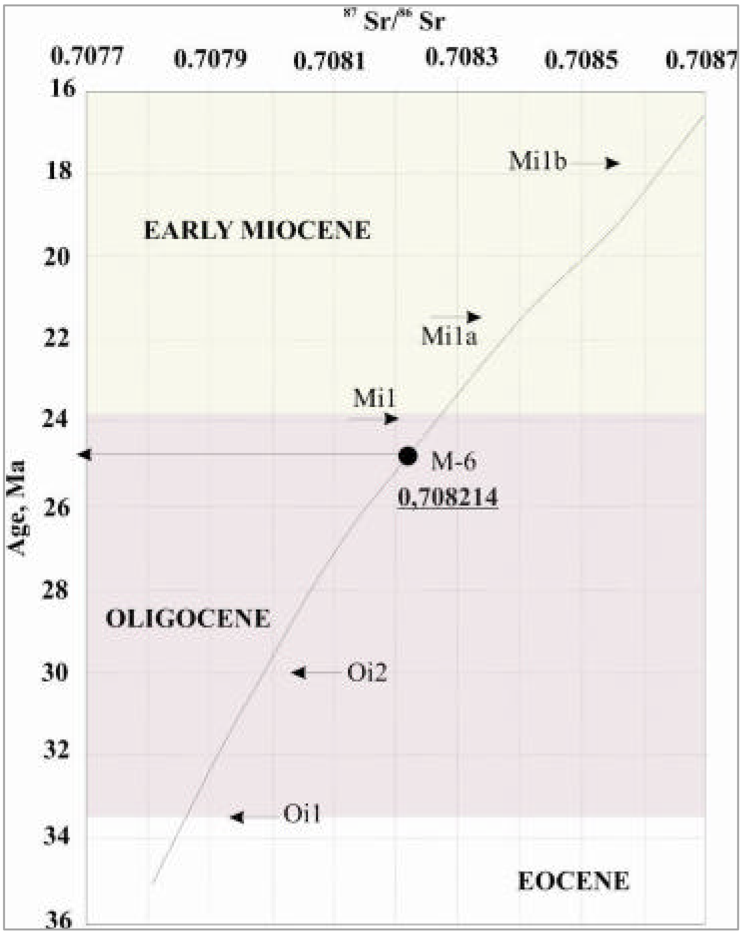


Figure5.13 Sr^{87}/Sr^{86} isotope analysis results of the “S” section in the Kumluca region.

Contents of the “M” section are given below (Fig. 5.14):

? M-0. *Amphistegina* sp., *Operculina* sp., *Heterostegina* sp., Hauerinidae, Soritiidae?, Coral, Red algae, Gastropoda, Bryozoa and Pelesipod.

? M-1. Coral (abundant), Red algae and Gastropoda?

? M-2. Acervuliniidae, Hauerinidae, Pelesipod, Bryozoa, Gastropoda, Coral and Red algae.

? M-4b. *Amphistegina* sp., Acervuliniidae, Coral, Red algae, Annelida, Pelesipod and Bryozoa.

? M-5a. Acervuliniidae, Elphidiidae, Discorbiidae, Coral, Red algae, Pelesipod and Gastropoda.

? M-5b. *Amphistegina* sp., Acervuliniidae, Coral, Red algae and Bryozoa.

? M-6. *Amphistegina* sp. (abundant), *Heterostegina* sp., Acervuliniidae, Discorbiidae, Coral, Red algae, Pelesipod and Bryozoa.

? M-7. *Amphistegina* sp., Discorbiidae, Anomaliniidae, Red algae, Pelesipod, Coral and Bryozoa.

? M-8a. There is no fossil.

? M-8b. Ostracoda?

? M-8c. There is no fossil.

? M-9. There is no fossil.

5.7.5 “B” Section

Foraminifer fauna of the “B” section resemble to the foraminifer faunas of the “M”, “K” and “S” sections. According to the foraminifer fauna of the “B” section, limestone of the Alakilse member is the late Chattian age.

Contents of the “B” section are given below (Fig. 5.15):

B-1. *Amphistegina* sp., *Heterostegina* sp., Hauerinidae (abundant), Pelesipod (abundant) and Gastropoda.

B-2. Hauerinidae, Textulariidae, Pelesipod (abundant) and Gastropoda

B-3. Acervuliniidae, Pelesipod, Bryozoa and Gastropoda.

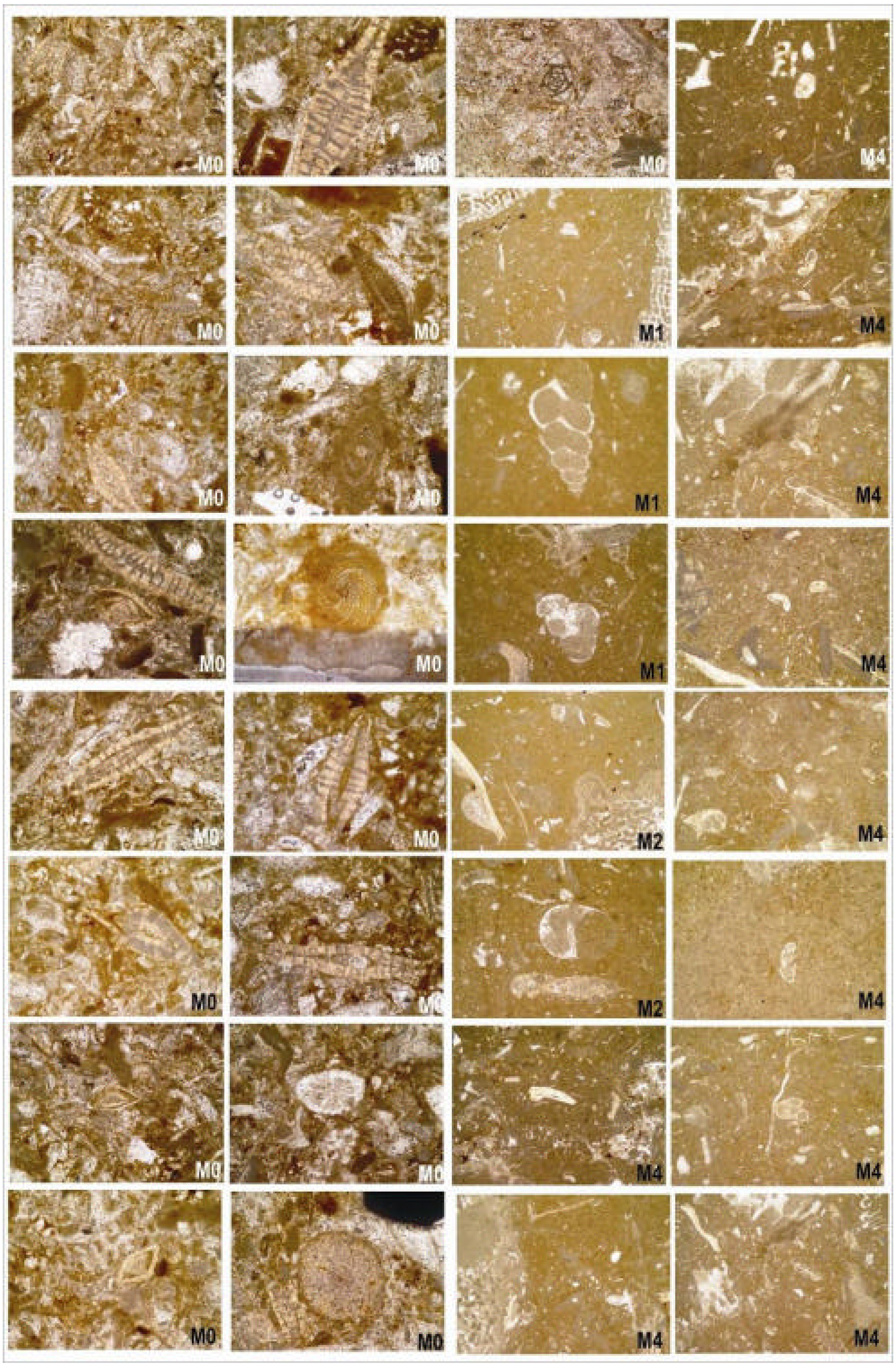


Figure 5.14 Photos show the microscopic images of the limestone samples in the M section.

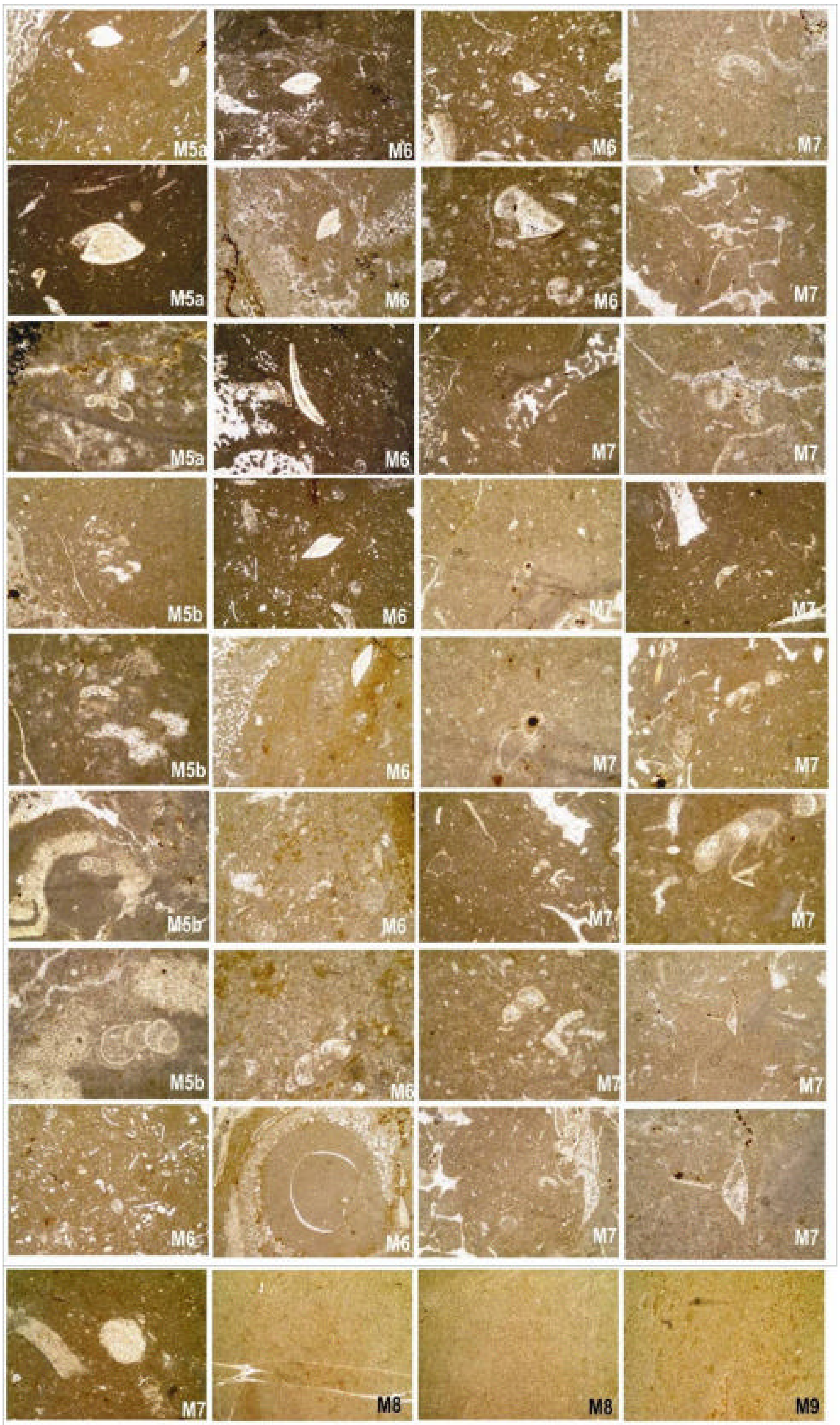


Figure 5.14 Continiued.

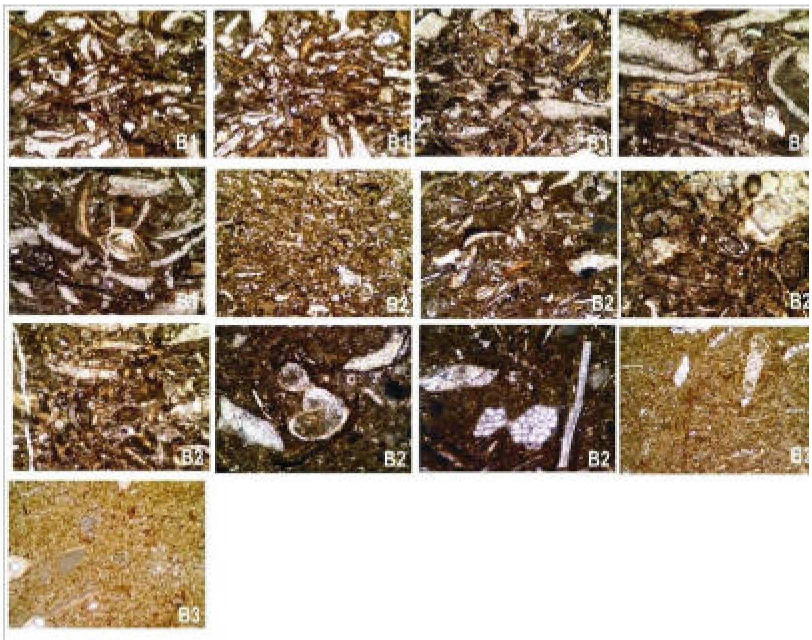


Figure 5.15 Photos show the microscopic images of the limestone samples in the B section.

5.7.6 "A" Section

Miogypsinoides sp., *Lepidocyclina* sp., *Heterostegina* sp., *Amphistegina* sp., Rotaliidae and Textulariidae defined in the limestones of the "A" section in the Akbük region. According to the foraminifer fauna, this section is the late Aquitanian-Burdigalian age. This age determination resemble to the age determination of the Gürer et al. (1995).

Contents of the "A" section are given below (Fig. 5.16):

? A-1. (Sandstone) *Amphistegina* sp., Rotaliidae and Textulariidae.

? A-2. (Sandstone) Textulariidae, Rotaliidae and Pelesipod.

? A-3. There is no fossil.

? A-4. (Sandstone) *Miogypsinoides?* sp. and Rotaliidae?

? A-5. (Sandstone) *Miogypsinoides* sp., Textulariidae, Rotaliidae, Hauerinidae and Pelesipod.

? A-6. (Bioclastic Limestone) *Lepidocyclina* sp., *Heterostegina* sp., *Amphistegina* sp., Hauerinidae (abundant), Rotaliidae, Soritiidae, Red algae, Bryozoa, Pelesipod and Gastropoda.

? A-7. (Bioclastic Limestone) Hauerinidae (abundant), Soritiidae, Red algae (abundant), Pelesipod (abundant), Gastropoda and Bryozoa.

? A-8. (Bioclastic Limestone) *Austrotrillina* sp., Hauerinidae, Soritiidae, Textulariidae, Peneropliidae, Red algae and Gastropodra.

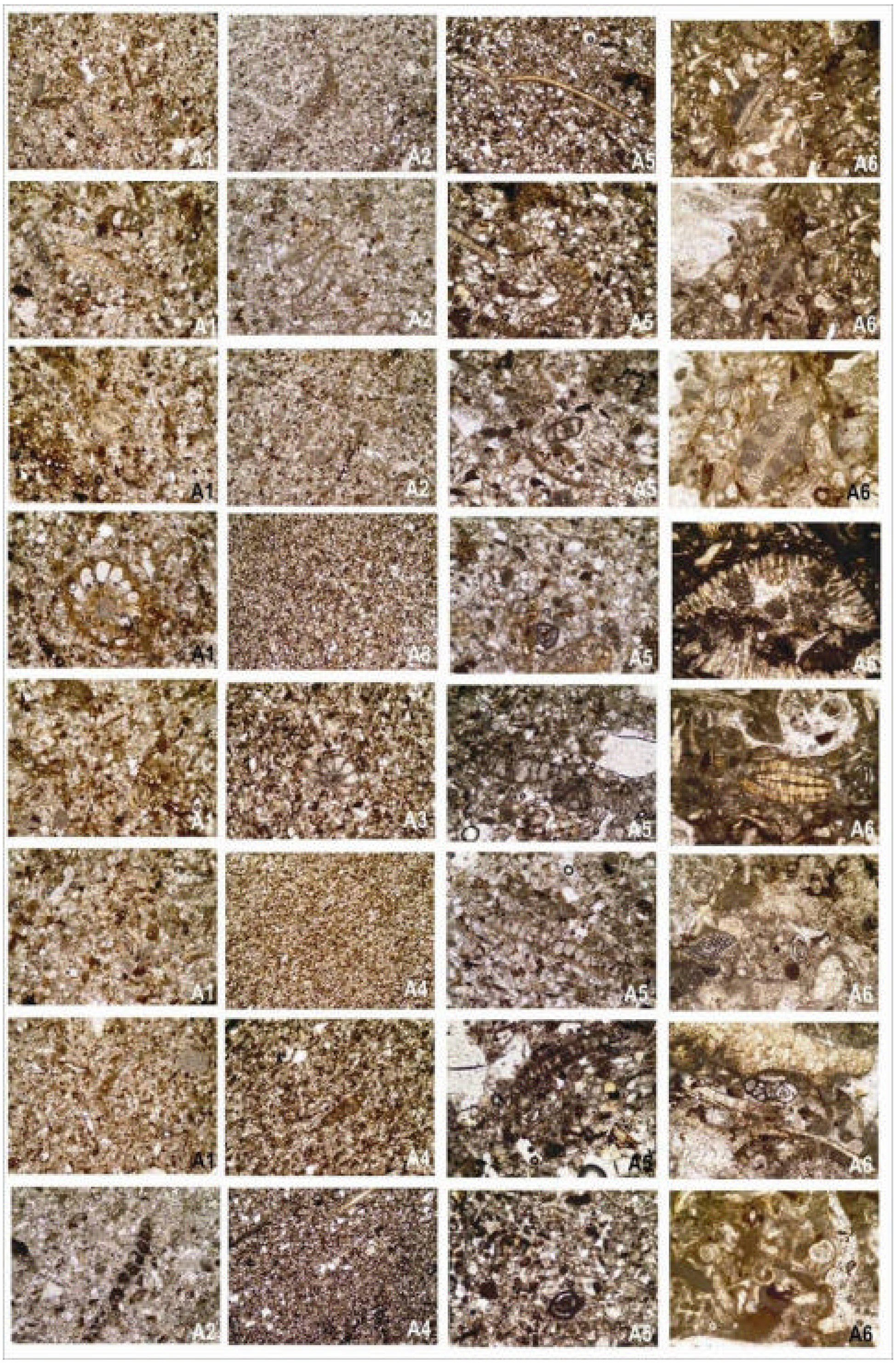


Figure 5.16 Photos show the microscopic images of the limestone samples in the A section.

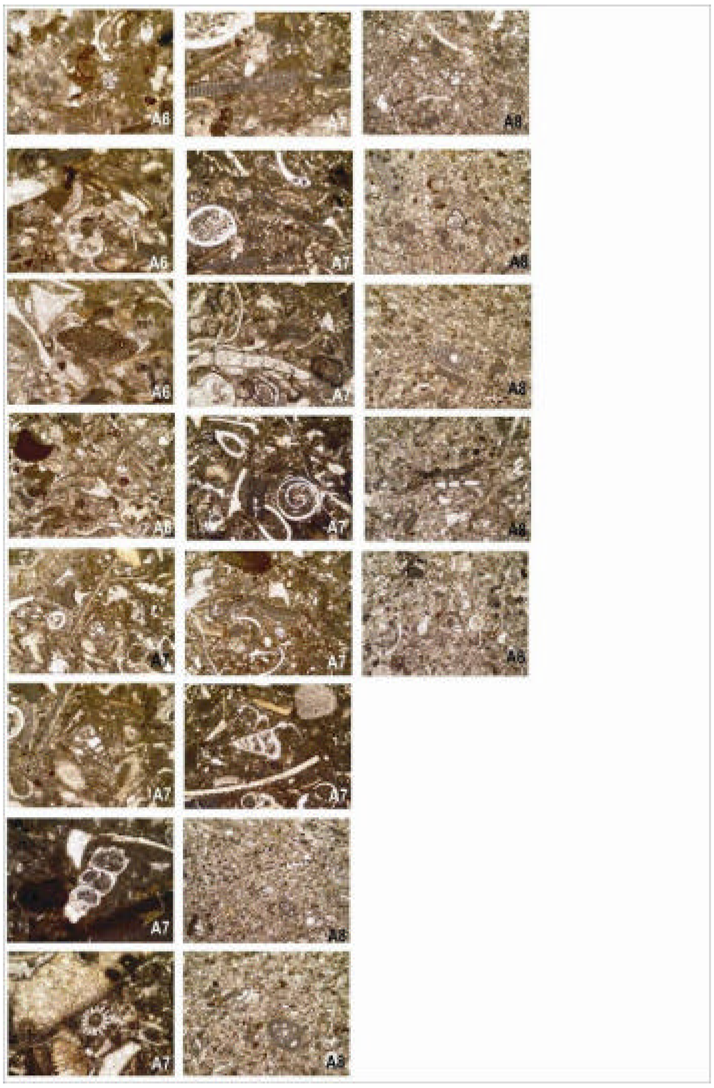


Figure 5.16 Continiued.

5.8 Oxygen and Carbon (dO^{18} and dC^{13}) Analysis results of Marine Sediments for the Chattian-Aquitanian in the Ören Region

The ^{13}C and ^{18}O isotopic analysis results of the late Cahattian-early Aquitanaian period obtained from the same samples of the “K”, “S”, “M” and “L” sections in the Çambeleni formation (Figs. 5.9, 5.10). ^{13}C and ^{18}O isotop values of samples in the “K”, “S”, “M” and “L” sections (the late Chattian- early Aquitanaian age) are negative values and these negative values indicate the brackish and shallow marine conditions. This palaeoenvironmental interpretation resemble to the the palaeoenvironmental evaluation based on the palynology, faunas of gastrapos and bivalvias (Fig. 5.17).

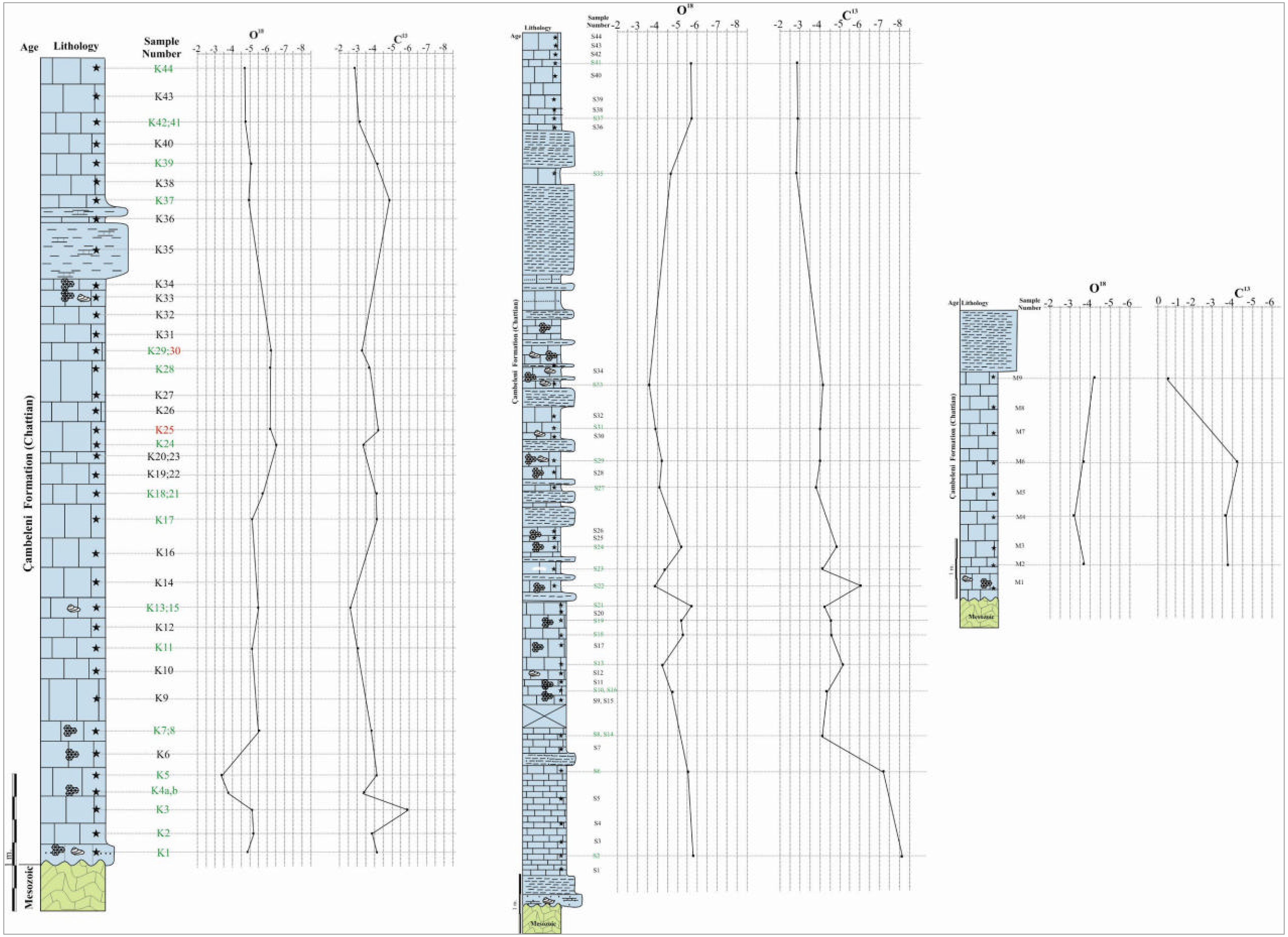


Figure 5.17 Oxygen and corbon isotop analysis results of the “K”, “S” and “M” sections in the Alakilise-Kocatepe region.

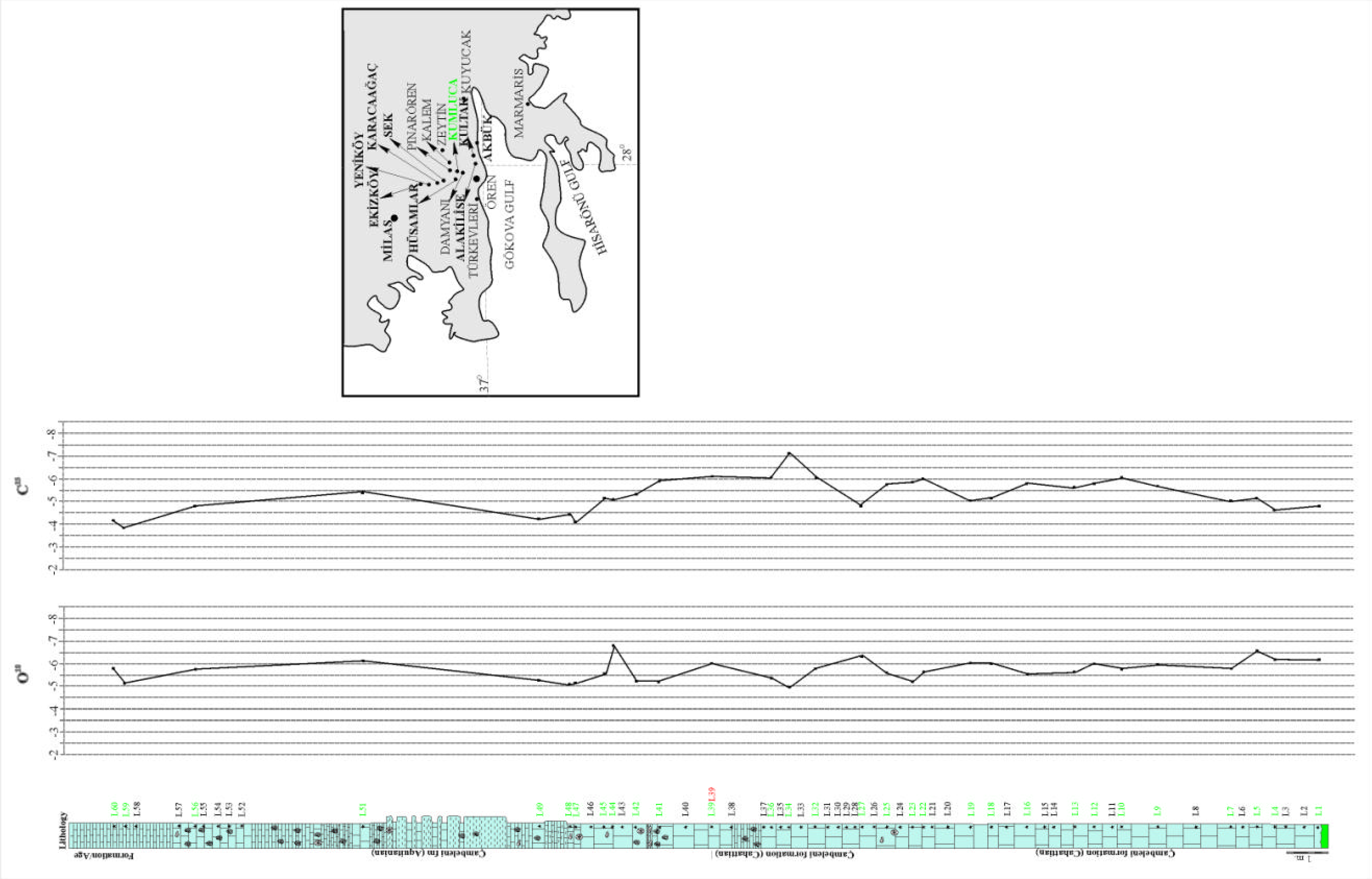


Figure 5.18 Oxygen and corbon isotop analysis results of the "L" section in the Kumluca region.

CHAPTER SIX

MACRO AND MICRO FLORAS OF THE LATE EARLY-EARLY MIDDLE MIOCENE IN THE ÖREN BASIN (HÜSAMLAR AND KARACAAGAÇ REGIONS): QUANTITATIVE PALAEOCLIMATE AND PALAEOVEGETATION ESTIMATES

6.1 Introduction

In Turkey, there are a lot of coal basins in which leaf fossils are found. However, some leaf floras (Manisa–Soma, Aydin–Sahinali, Izmir–Akçasehir–Tire areas in the western Anatolia and Ankara–Beskonak and Güvem areas in the central Anatolia) was used in this chapter (Paicheler & Blanc, 1978; Mädler & Steffens, 1979; Gemici et al., 1991, 1992, 1993; Kasapligil, 1976 and Yavuz–Isik, 2008). Leaf floras of Milas–Ören–Karacaagaç, Hüsamlar and Alakilise in western Anatolia are determinated in this chapter and this study has been importance because of pioneering palaeobotanical studies in Turkey recently. Besides paleovegetational and palaeoclimatic interpretations were derived from the macrofloras and correlated with the palaeovegetation and palaeoclimate of the European macrofloras data (Erdei, 1995; Kovar–Eder et al., 1995; Walther, 1995; Erdei & Kvacek, 1997, Hably, 2001, 2002; Kvacek et al., 2002; Worobeic, 2003; Erdei et al., 2007 and Utescher et al., 2007).

Sedimentary rocks of Ören–Karacaagaç and Hüsamlar region are represented by lacustrine sequences and leaf fossils are collected from the marl in these sequence. Additionally, palynofloras of the Karacaagaç and Hüsamlar regions are defined. Palaeovegetational and palaeoclimatic estimates are obtained based the palynofloras and corresponded with the results of the leaf floras for the Karacaagaç and Hüsamlar regions. Thus for the late Early and Early Middle Miocene time, the most accurate reconstruction of the palaeovegetation and palaeoclimatic are carried out.

Leaf morphology approaches which are the Leaf Margin Analysis (LMA; e.g. Wolfe, 1971) and Climate Leaf Analysis Multivariate Program (CLAMP; Wolfe,

1993) and the Coexistence Approach based on the leaf floras (CoA–leaf) are applied on the defined floras in this study and published floras (Manisa–Soma, Aydin–Sahinali, Izmir–Akçasehir–Tire and Ankara–Beskonak and Güvem areas).

6.2 Geological Setting of Ören–Karacaagaç and Hüsamlar Regions

There are numerous works treating the stratigraphy and tectonic evolution of the western Anatolia (Nebert, 1956; 1957; 1961, Erentöz & Öztemür, 1964; Becker–Platen, 1970; Benda, 1971a , b; Benda & Meunlenkamp, 1990; Atalay, 1980; Akgün & Sözbilir, 2001; Gökçen, 1982; Görür et al., 1994, 1995; Hakyemez & Örçen, 1982; Hakyemez, 1989; Robertson, 1993; Seyitoglu & Scott, 1991; 1992, Kaya et al., 2001; Yilmaz et al., 2000; Gürer & Yilmaz, 2002; Sözbilir, 2002; 2005, Çemen et al., 2003; Sahbaz & Görmüs, 1992; 1993). The Lycian nappes are basement rocks in the Karacaagaç and Hüsamlar regions (Fig. 6.1). The basement unconformably overlies the Oligocene–Early Miocene rocks. Kultak formation deposited during the late Early–early Middle Miocene period and upper part of this formation laterally and vertically passes the Hüsamlar and Belen members. These members are overlaid by the Middle–Late Miocene rocks in the study area. The leaf fossils of Hüsamlar and Karacaagaç region are collected from the Hüsamlar member (Figs. 6.2, 6.3).

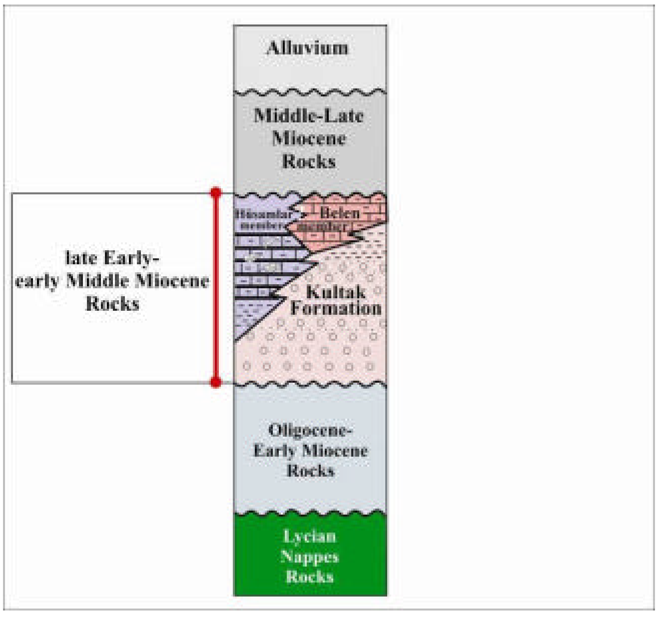


Figure 6.1 Generalized stratigraphic columnar section of between the Kultak and Karacaagaç regions.

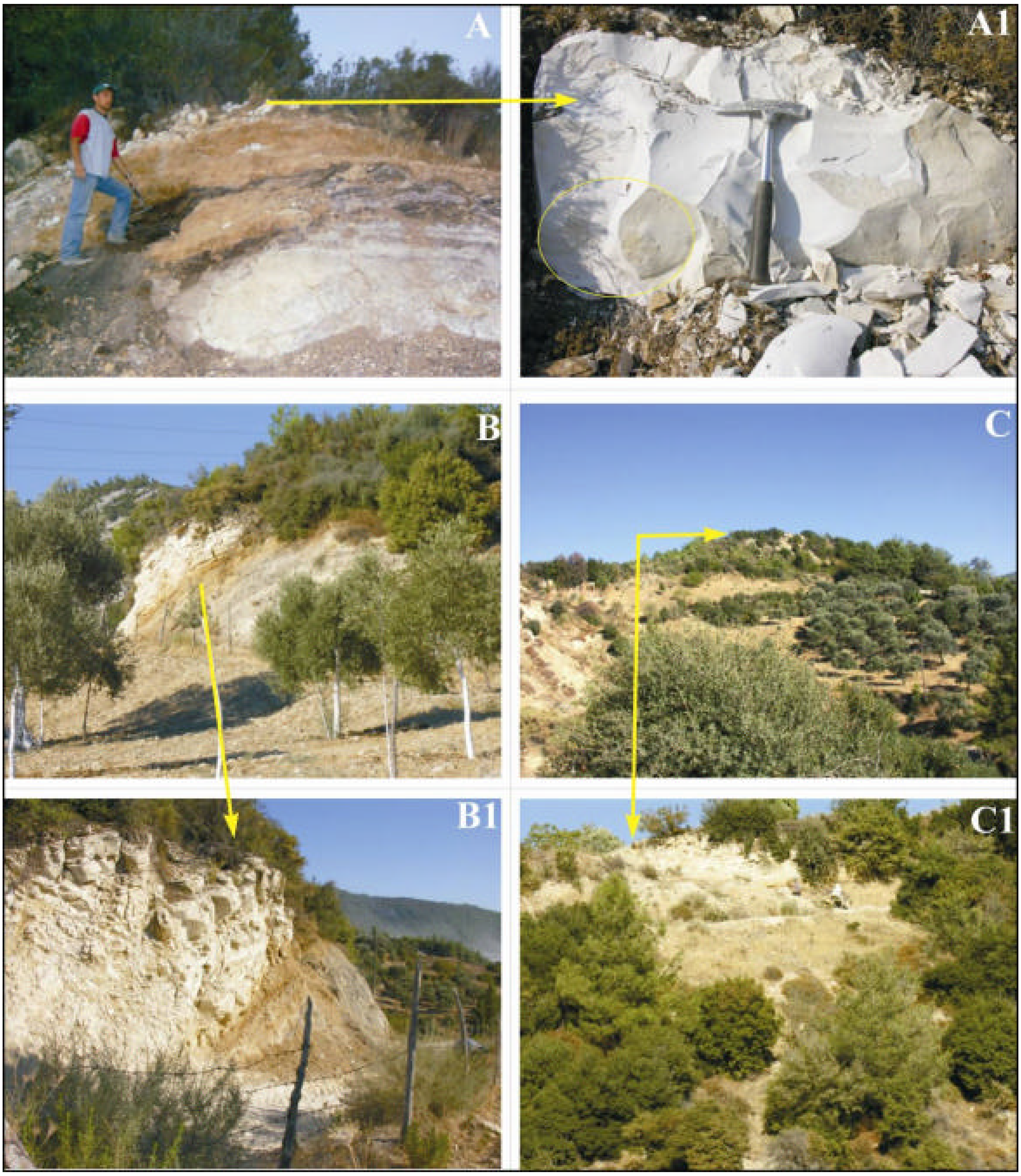


Figure 6.2 Locality of the collecting leaf fossils (A–C) and coal bearing sediments in the Karacaagaç region.

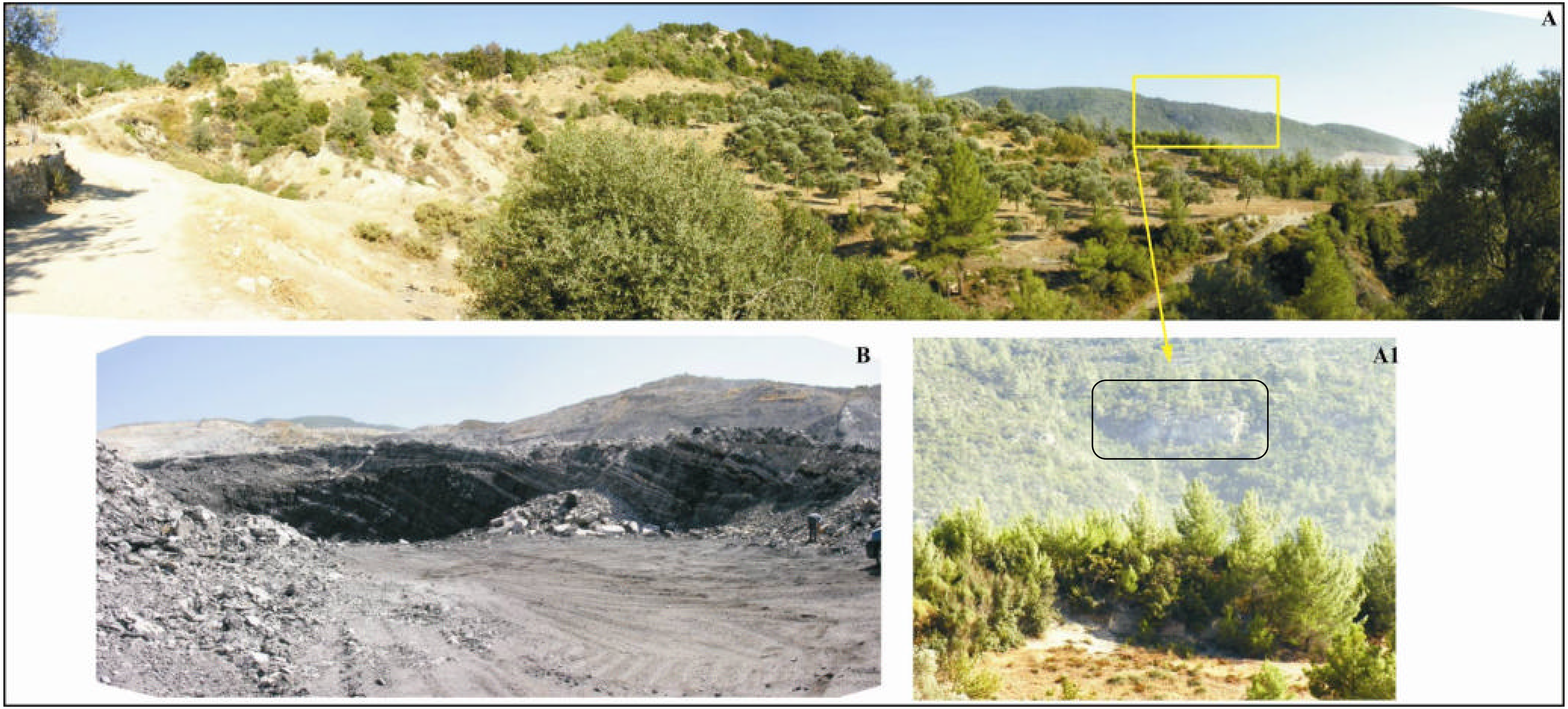


Figure 6.3 Locality of the collecting leaf fossils and coal bearing sediments (A and B) in the Karacaagaç region. A1 shows the Early Miocene marine limestones.

6.3 Age of the Fossil Floras Karacaagaç, Hüsamlar, Alakilise and Other Regions in Turkey

The age determination of the Karacaagaç, Hüsamlar and Alakilise fossil floras from Ören region is obtained. Dating based exclusively on mammalian fossils and Sr^{87}/Sr^{86} isotopic data was possible for the macrofloras of Hüsamlar area. According to the mammalian fossils which are founded from the coal bearing sediments are characterized by MN4e–MN5 boundary (the late Burdigalian). Additionally, Sr^{87}/Sr^{86} isotopic analysis result for the age determination is obtained from the primitive *Gomphitherium* sp. fossil indicates the middle Burdigalian age (Sr^{87}/Sr^{86} results: 0.708575 and dSr(2s): 8; 18.80Ma) (Plates 6.1). The coal bearing sediments in the Karacaagaç area are same lithostratigraphic position in the Ören region. Besides palynostratigraphic evidences of the Karacaagaç area is supported the age interpretation. Defining leaf fossils from the Alakilise area which are poorly preserved are collected from sandstones with gastropod fossils (*Turitella* spp.). This sandstones level are aged the Chattian (late Oligocene) in this study (see Chapter five). Concluding from these considerations, the flora of Hüsamlar and Karacaagaç areas are late Early–early Middle Miocene (middle Burdigalian and Langhian) in age.

The age of the leaf flora in the Çanakkale–Çan–Demirci region is the late Serravallian (Late Miocene) age according to the mammalian data (Mädler & Steffens, 1979). Coal bearing sediments in the Aydin–Sahinali region includes the leaf fossils and this flora was accepted the early–middle Serravallian age based on the lithostratigraphic data by Gemici et al. (1993). The late Early and Middle Miocene Soma flora was defined by the Gemici et al. (1991). This flora was aged by mollusk fossil and palynostratigraphic data (Gemici et al., 1991 and Nebert, 1978). The leaf flora of the Usak–Ilyasli region was defined from the Küçükderbent formation in study of Ercan et al. (1978). Authors suggested the late Miocene age based on the ostracod, fish fossil and mammalian data (Mädler & Steffens, 1979). However Seyitoglu (1997) is used the early Middle Miocene age based on the lithostratigraphic correlation with neighbouring regions. Izmir–Tire–Akçasehir flora was grown during the late Early and Middle Miocene period and age determination of this flora based on mammalian data (MN4–MN5) (Gemici et al., 1991). Ankara–Güvem and Beskonak floras were defined in Paicheler & Blanc, 1978, Kasapligil, 1976 and Yavuz–Isik, 2008 and age of these floras was late Early Miocene age (radiometric record, 17.9–17.8 Ma) (Fig. 6.4).

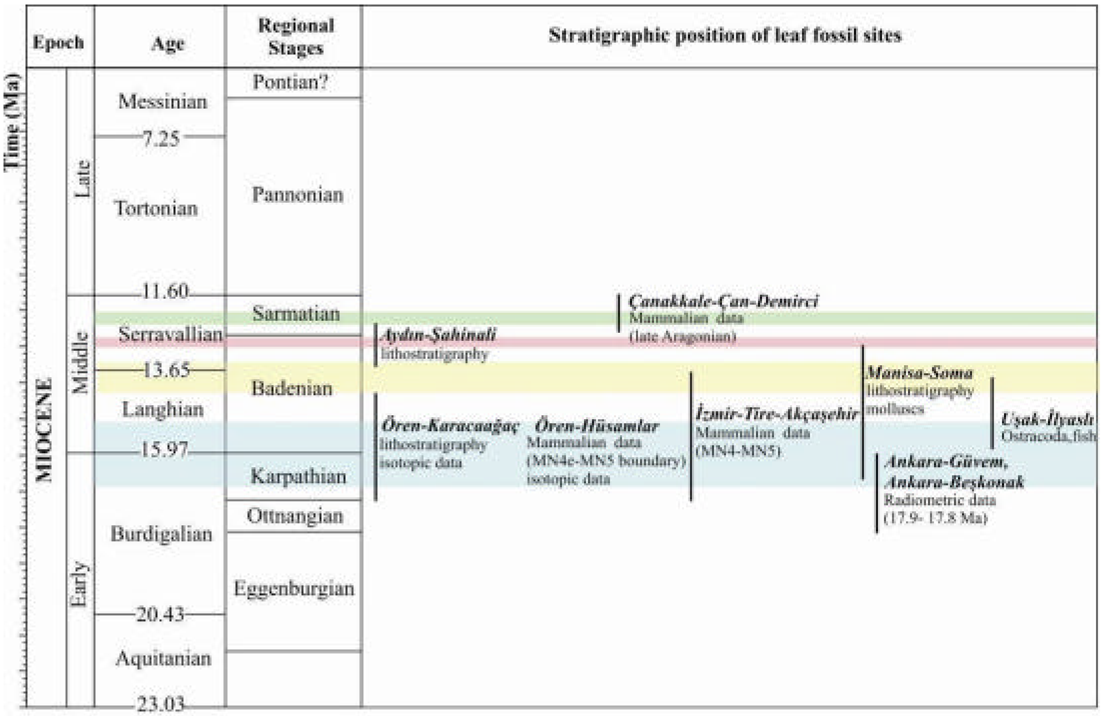


Figure 6.4 Stratigraphic ranges of leaf fossil sites involved in this chapter (Stratigraphic column Harzhauser & Piller, 2007).

6.4 Methods

Two new approaches have improved in the last half of the twentieth century. The first has been to study multiple organs, including leaves, thought to represent the same plant species, either because they are preserved in attachment or because they occur together at many localities. This approach allows traditional characters of flowers and fruits to be used in defining extinct taxa and determining their relationships (e.g., Manchester, 1986). Studying characters of multiple organs of the same plant allows fossil taxa to be described more comprehensively and systematic relationships to be established with greater certainty than can be gained from leaves alone. However, there are many types of fossil leaves that have not been found attached to or consistently associated with other organs. The second approach has been to identify systematically informative leaf features that allow species to be recognized on the basis of dispersed leaves; these features may also permit the fossil to be assigned to a family or higher taxonomic category (Hickey & Wolfe, 1975, Wolfe 1989, Hickey & Taylor, 1991). This approach has been used principally in dicotyledonous angiosperms with complex vein systems.

Identify a plant based on its leaves, it is helpful to recognize the diversity of leaf types and know the terminology for different leaf patterns, shapes and arrangements. Following features to identify fossil leaves were used in this study (Dilcher, 1974 and Wing et al., 1999).

6.4.1 Basic Terminology

Apex : usually the upper ~25% of the lamina (Figs. 6.5a, 6.5b).
Base : usually the lower ~25% of the lamina (Figs. 6.5a, 6.5b).
Concave : curving toward the center of the lamina or tooth (Fig. 6.7).
Convex : curving away from the center of the lamina or tooth (Fig. 6.7).
Costal vein: primary and secondary veins that extend from the base of the leaf or from a primary toward the leaf margin.
Lamina (blade): the expanded, flat part of a leaf or leaflet (Figs. 6.5a, 6.5b).
Margin : the edge of the lamina (Fig. 6.5a).
Midvein : medial primary, in pinnate leaves this is the only primary (Figs. 6.5a, 6.5b).
Node : the place where a leaf is (or was) attached to the axis (stem) (Fig. 6.5a).
Petiole : the stalk of the leaf (Figs. 6.5a, 6.5b).
Petiolule : the stalk of a leaflet in a compound leaf (Fig. 6.6).
Primary vein: the widest vein of the leaf and any others of like width and/or course primaries usually originate at or just above the petiole. Symbolized 1^o (Figs. 6.5a, 6.5b).
Secondary vein: the next narrower class of veins after the primary, originating from the primary or primaries. Symbolized 2^o (Fig. 6.5b).

Sessile : a leaf or leaflet that is lacking a petiole or petiolule.

Vein course: the path of the vein.

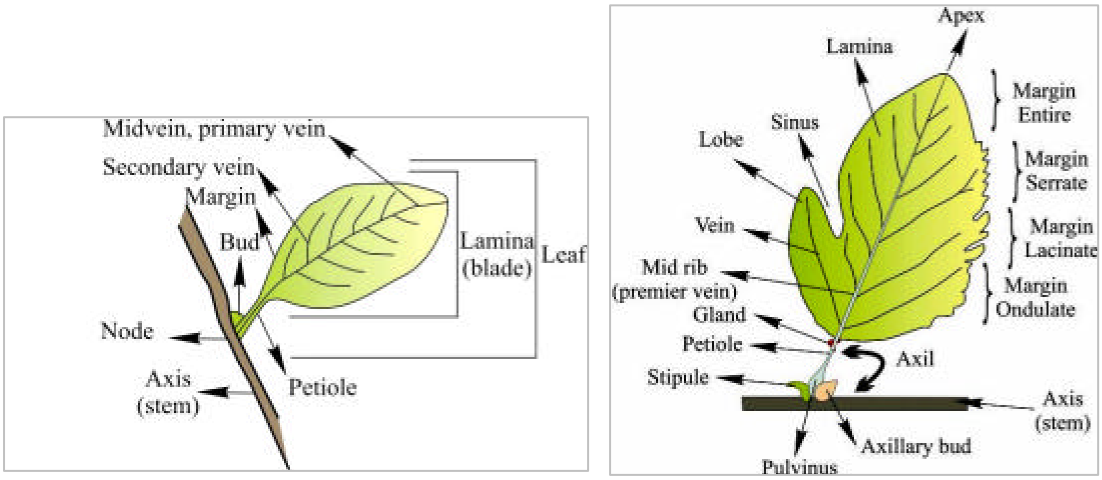


Figure 6.5 Simple leaf classifications (Wing et al., 1999).

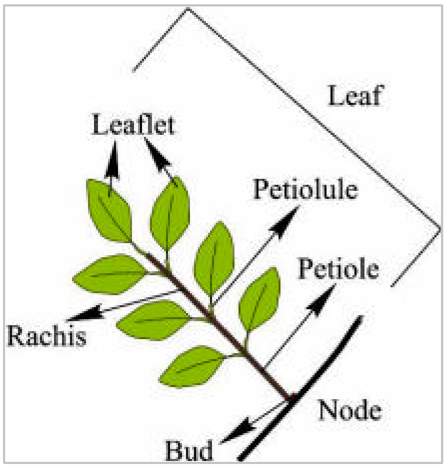


Figure 6.6 Pinnately compound leaf (Wing et al., 1999).

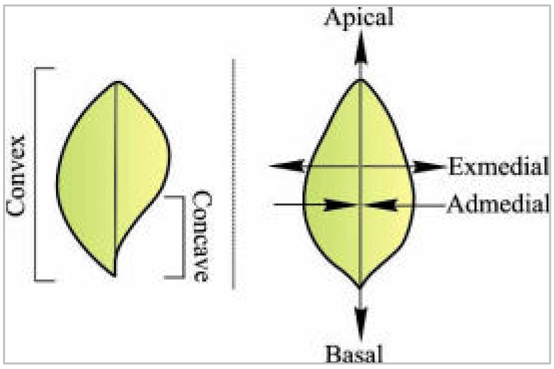


Figure 6.7 Basic leaf shape (Wing et al., 1999).

6.4.2 Leaf Attachment

Alternate : One leaf at each node (Fig. 6.8 A).

Opposite : Two leaves at each node (Fig. 6.8 B).

Whorled : Three or more leaves at each node (Fig. 6.8 C).

Decussate : Each leaf attached at 90^{o}C from those above and below (can be opposite, as shown, or alternate) (Fig. 6.8 D).

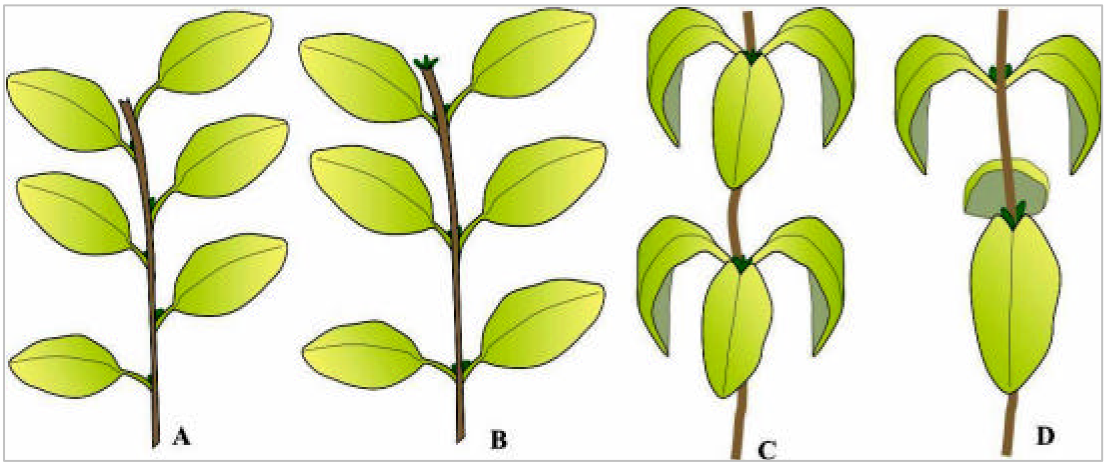


Figure 6.8 Leaf attachment A: alternate; B: opposite; C: whorled and D: decussate (Wing et al., 1999).

6.4.3 Leaf Organization

Simple : Consisting of single lamina (Fig. 6.9A).

Palmately compound : A leaf with separate subunits (leaflets) attached at the apex of petiole (Figs. 6.9B, 6.9C).

Ternate (trifoliate): A compound leaf with three leaflets (Fig. 6.9D).

Pinnately Compound: A leaf with leaflets arranged along a rachis (Figs. 6.9E, 6.9F).There are two types, odd–pinnately and even–pinnate

Bipinnate (twice pinnately compound): Compound leaf dissected twice with leaflets arranged along rachillae that are attached to the rachis (Fig. 6.9G).

Tripinnate (thrice pinnately compound): a compound leaf with leaflets attached to secondary rachillae that are in turn attached to rachillae, which are borne on the rachis (Fig. 6.9H).

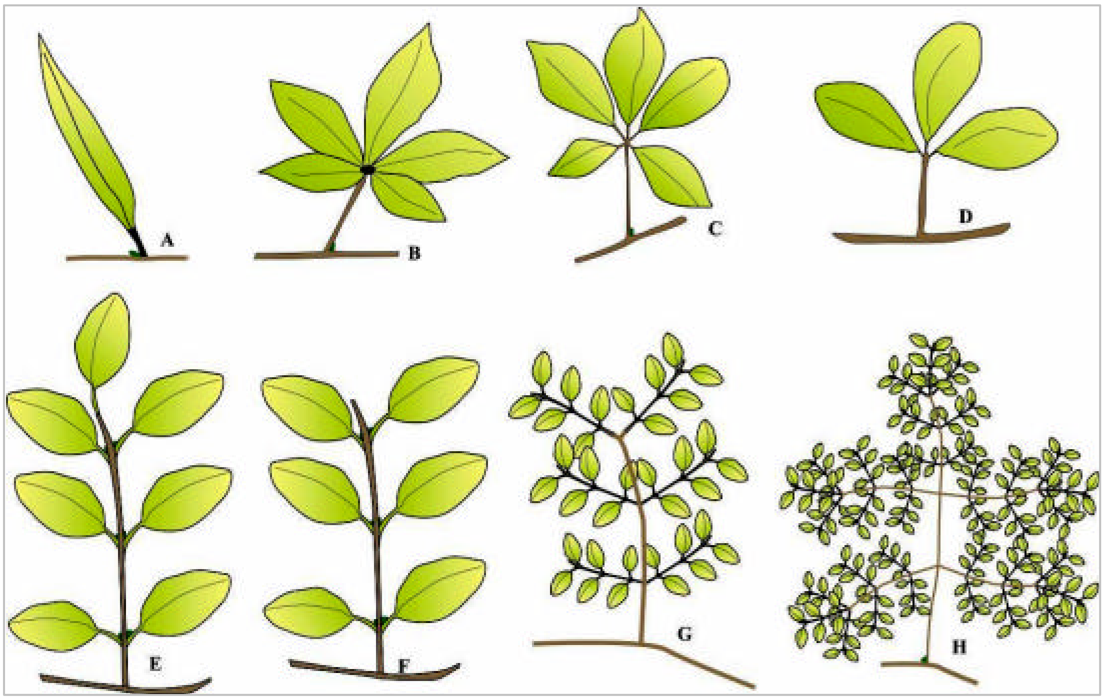


Figure 6.9 Leaf organization A: Simple; B and C: palmately compound; D: Ternate (trifoliate); E: odd–pinnately; F: even–pinnate; G: bipinnate (twice pinnately compound) and D: tripinnate (thrice pinnately compound) (Wing et al., 1999).

6.4.4 Petiole Features

A petiole is the stalk or stem that connects the leaf to the plant. There is a distinctive feature of the petiole (e.g., width, length, base swollen, base inflated, sessile or other) (Figs. 6.10A, 6.10B).

Base Swollen: Petiole thickens at the base where it attaches to the node (Fig. 6.10A).

Pulvinate : Having an abruptly swollen portion near the node around which the leaf can flex (e.g. legumes) (Fig. 6.10B).

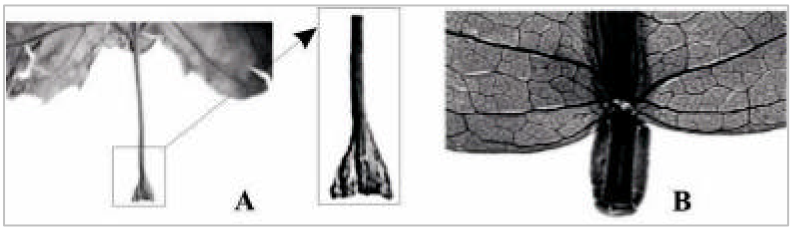


Figure 6.10 Petiole features, A) base swollen and B) pulvinate (Wing et al., 1999).

6.4.5 Laminar Size

The laminar size is determined by measuring the area of the leaf. An approximation can be made by measuring the length and width of the leaf in millimeters and multiplying the length X width (Fig. 6.11). Besides, Table 6.1 shows the ranges of areas for the different leaf classes (Webb, 1955).

Table 6.1 The chart indicates laminar size and morphotype of the leaf (Wing et al., 1999).

Blade class	**Area of leaf in mm^2**
Leptophyll	< 25
Nanophyll	25–225
Microphyll	225–2,025
Notophyll	2,025–4,500
Mesophyll	4,500–18,225
Macrophyll	18,225–164,025
Megaphyll	>164,025

6.4.6 Laminar L:W Ratio

Measure the length of the lamina (Fig. 6.12) and divide this number by the width of the lamina. Report the full range of ratios (e.g. 3:1–6:1). Midvein length, l_m = distance from proximal most to the distal most point of the midvein (Figs. 6.12A, 6.12B, 6.12C, 6.12D). Apical extension length, l_a = distance on a perpendicular from the distal most point of the midvein to the distal most extension of leaf tissue (Figs. 6.12A, 6.12D). Can equal zero (Figs. 6.12A, 6.12B). Basal extension length, l_b = distance on a perpendicular from the proximal most point of the midvein to the proximal most extension of leaf tissue (Figs. 6.12B, 6.12D). Can equal zero (Figs. 6.12A, 6.12C). Mucronate, apex terminating in a sharp point that is the continuation of the midvein. Character goes in diagnostic features field if observed. Leaf Length, $L = l_m + l_a + l_b$

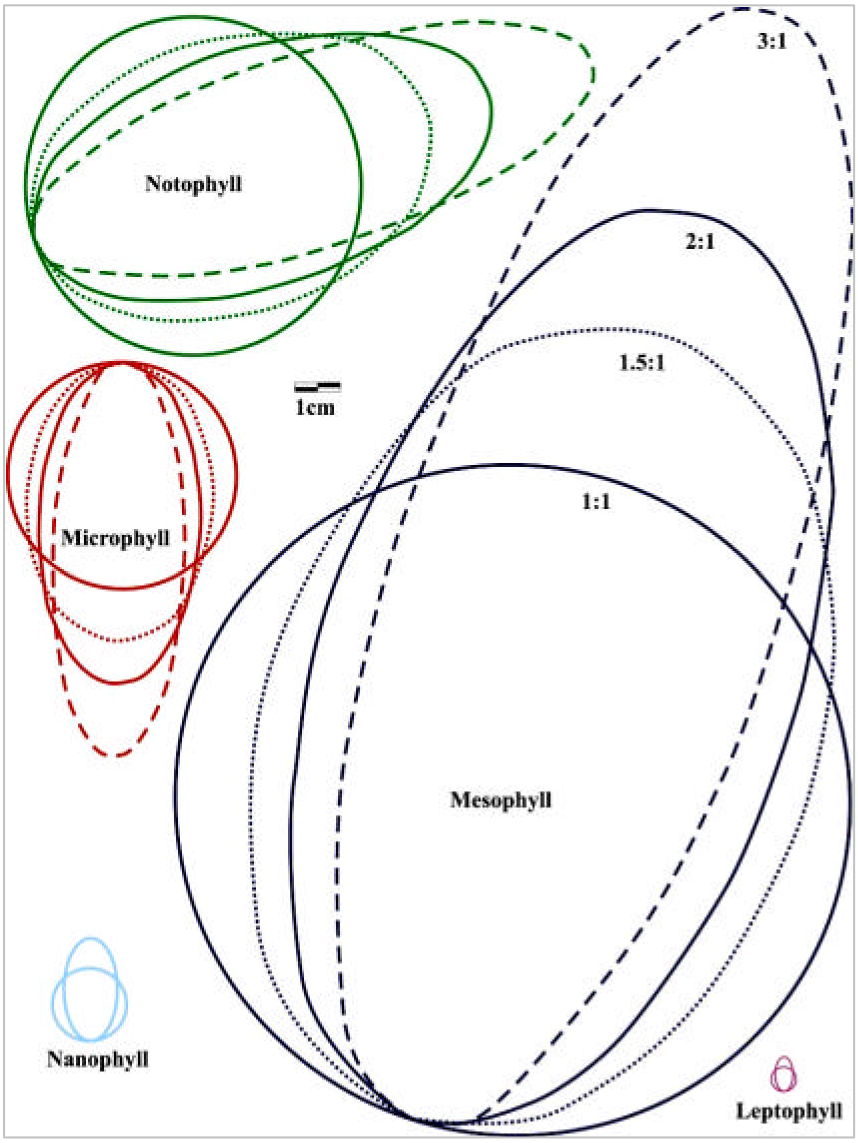


Figure 6.11 Laminar size and morphotype of the leaf (Wing et al., 1999).

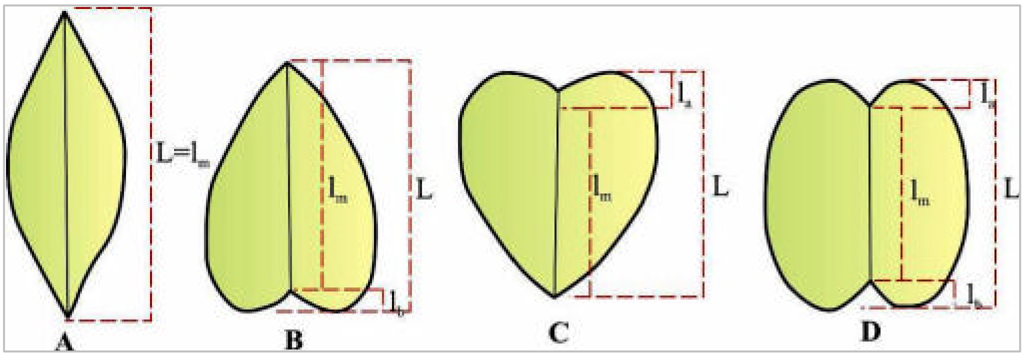


Figure 6.12 Defination of the laminar L:W Ratio (Wing et al., 1999).

6.4.7 Laminar Shape

The simplest way to describe the overall shape of the lamina is to locate the axis or, in some cases, the zone of greatest width that lies perpendicular to the axis of greatest length (long axis). Five laminar shapes are defined (elliptic, obovate, ovate, oblong and special). Each shape is divided into subgroups (e.g. norrow elliptic, wide ovate, narrow oblong or orbiculate).

Elliptic : The widest part of leaf is on an axis in the middle fifth of the long axis of the leaf (Fig. 6.13).
Obovate : The widest part of leaf is on an axis in the apical 2/5 of the leaf (Fig. 6.14).
Ovate : The widest part of leaf is on an axis in the basal 2/5 of the leaf (Fig. 6.15).
Oblong : The widest part of leaf is a zone in the middle 1/3 of the long axis where the opposite margins are roughly parallel (Fig. 6.16).
Special : Leaf is not described by any of the shapes illustrated.

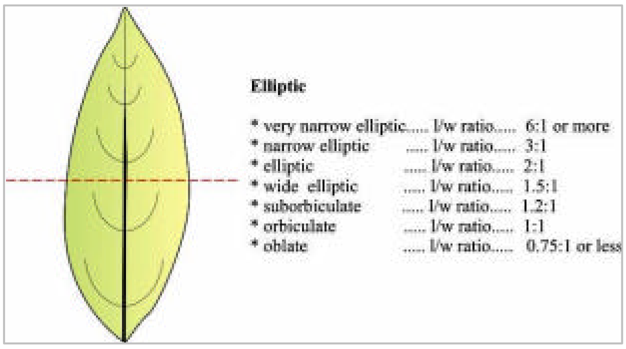


Figure 6.13 Elliptic shape of the leaf and subgroups (Dilcher, 1974 and Wing et al., 1999).

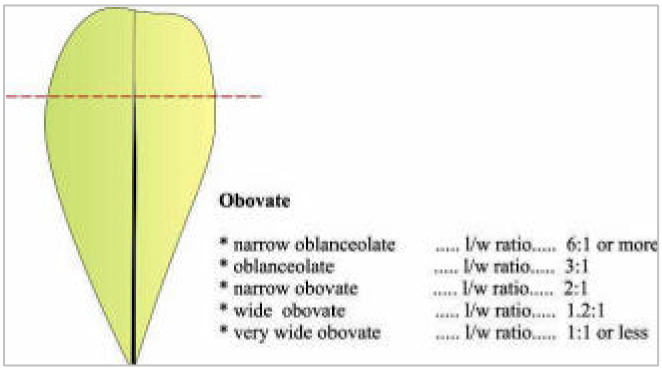


Figure 6.14 Obovate shape of the leaf and subgroups (Dilcher, 1974 and Wing et al., 1999).

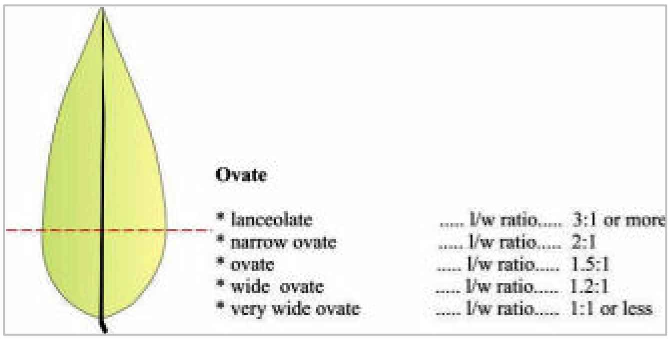


Figure 6.15 Elliptic shape of the leaf and subgroups (Dilcher, 1974 and Wing et al., 1999).

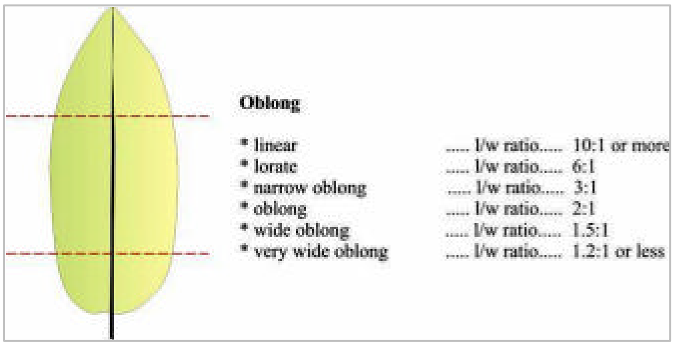


Figure 6.16 Oblong shape of the leaf and subgroups (Dilcher, 1974 and Wing et al., 1999).

6.4.8 Laminar and Base Symmetry

Symmetrical lamina is approximately the same shape on either side of the midvein. Asymmetrical lamina is different size or shape on either side of the midvein. Besides, base symmetrical is base of the lamina of about same shape on either side of the midvein and base asymmetrical is base of lamina of markedly different shape either side of the midvein (Figs. 6.17 A, B and C).

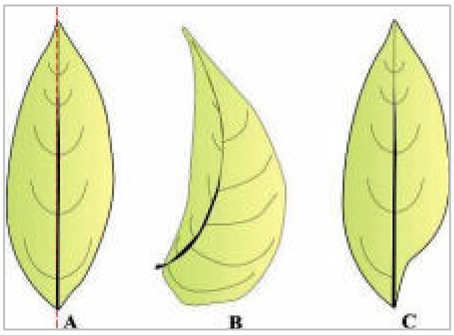


Figure 6.17 Laminar symmetry A) symmetrical base and laminar shape; B) asymmetrical laminar shape and C) asymmetrical base shape.

6.4.9 Base Angle andSshapes

The vertex of the base angle lies in the center of the petiole at the point where the basal most laminar tissue touches the petiole. Base angle is the angle from the vertex to the points where a line perpendicular to the midvein at $0.25l\ m$ from the base intersects the margin (Fig. 6.18A, 6.18B). In leaves with a basal extension $(l_b > 0)$, the base angle should be measured from the same vertex point to the basal most points of the leaf on each side (Fig. 6.18). The base angle is always measured on the apical side of the rays even in leaves where the angle is greater than 180°. Peltate leaves are defined as having a circular angle.

Acute : base angle <90 (Fig. 6.18A)

Obtuse : base angle >90 (Fig. 6.18B)

Wide obtuse: a special case of obtuse such that the base angle is >180 (Fig. 6.18C).

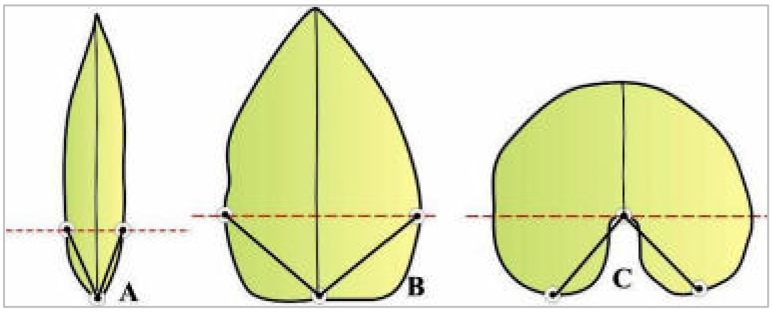


Figure 6.14 Base angle A) acute; B) obtuse and C) wide obtuse (Wing et al., 1999).

Cunate (straight): The margin between the base and 0.25L has no significant curvature ($lb = 0$) (Fig. 6.19A).

Convex : The margin between the base and 0.25L curves away from the center of the leaf ($lb= 0$) (Fig. 6.19B).

Rounded : Subtype of convex in which the margin forms a smooth arc across the base ($lb= 0$) (Fig. 6.19C).

Truncate : Subtype of convex in which the base terminates abruptly as if cut, with margin perpendicular to the midvein or nearly so ($lb = 0$) (Fig. 6.19D).

Concave : The margin between the base and 0.25L curves toward the center of the leaf ($lb = 0$) (Fig. 6.19E).

Concave–convex: The margin between the base and 0.25L is concave basally and convex apically (*lb* = 0) (Fig. 6.19H).

Decurrent : subtype of either concave or concavo–convex in which the laminar tissue extends basally along the petiole at a gradually decreasing angle (*lb* = 0) (Fig. 6.19F).

Complex : there are more than two inflection points in the curve of the margin between the base and 0.25L (*lb* = 0) (Fig. 6.19L).

Cordate : the leaf base is embayed in a sinus with straight or convex sides (*lb* > 0) (Fig. 6.19I).

Lobate : rounded projections with inner margins (those towards the petiole) concave in part (*lb* > 0) (Fig. 6.19J).

Sagittate : narrow pointed lobes with apices directed basally, i.e. at an angle 125° or greater from the leaf axis (*lb* > 0) (Fig. 6.19G).

Hastate : two narrow pointed lobes that have apices directed exmedially, i.e. at 90°–125° from the leaf axis (*lb* ~ 0) (Fig. 6.19H).

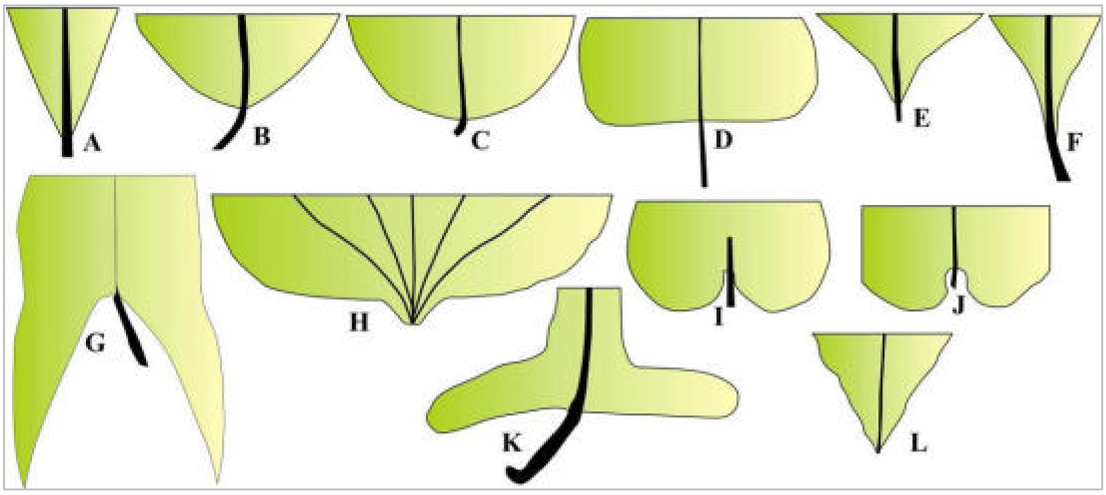


Figure 6.19 Base shapes A) cunate; B) convex; C) rounded; D) truncate; E) concave; F) decurrent; G) sagittate; H) concave–convex; I) cordate; J) lobate; K) hastate and L) complex (Wing et al., 1999).

6.4.10 Apex Angle and Shapes

Apex angle is the angle from the apical termination of the midvein to the pair of points where a line perpendicular to the midvein and 0.75l_m from the base intersects the margin (Fig. 6.20). In leaves with an odd number of lobes, measure the apex angle as in unlobed leaves (Fig. 6.20). In leaves with an apical extension (l_a>0) the apex angle should be measured using the termination of the midvein as the vertex, and the apices of the lobes on either side (Fig. 6.20). The apical angle is always measured on the basal side of the rays, even in leaves where the angle is greater than 180°.

Acute : Apex angle < 90° (Fig. 6.20A).

Obtuse : Apex angle 90–180° (Fig. 6.20B).

Wide obtuse: A special case of obtuse such that the apex angle is >180° (Fig. 6.20E).

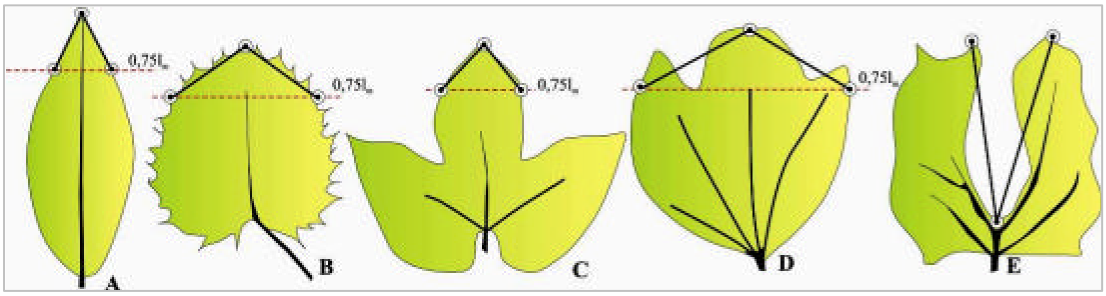


Figure 6.20 Apex angle A) acute; B) obtuse; C) odd–lobed acute; D) odd–lobed obtuse and E) wide obtuse (Wing et al., 1999).

Cuneate (straight): The margin between the base and 0.25L has no significant curvature (l_b = 0).

Convex : The margin between the base and 0.25L curves away from the center of the leaf (l_b= 0).

Rounded : Subtype of convex in which the margin forms a smooth arc across the base (l_b= 0).

Truncate : Subtype of convex in which the base terminates abruptly as if cut, with margin perpendicular to the midvein or nearly so (l_b = 0).

Concave : The margin between the base and 0.25L curves toward the center of the leaf (l_b = 0).

Concavo–convex: The margin between the base and 0.25L is concave basally and convex apically (l_b = 0).

Decurrent : Subtype of either concave or concavo–convex in which the laminar tissue extends basally along the petiole at a gradually decreasing angle (l_b = 0).

Complex : There are more than two inflection points in the curve of the margin between the base and 0.25L ($l_b = 0$).

Cordate : The leaf base is embayed in a sinus with straight or convex sides ($l_b > 0$).

Lobate : Rounded projections with inner margins (those towards the petiole) concave in part ($l_b > 0$) (Fig. 6.21I).

Sagittate : Narrow pointed lobes with apices directed basally, i.e. at an angle 125^{o} or greater from the leaf axis ($l_b > 0$).

Hastate : Two narrow pointed lobes that have apices directed exmedially, i.e. at 90^{o}–125^{o} from the leaf axis ($l_b \sim 0$).

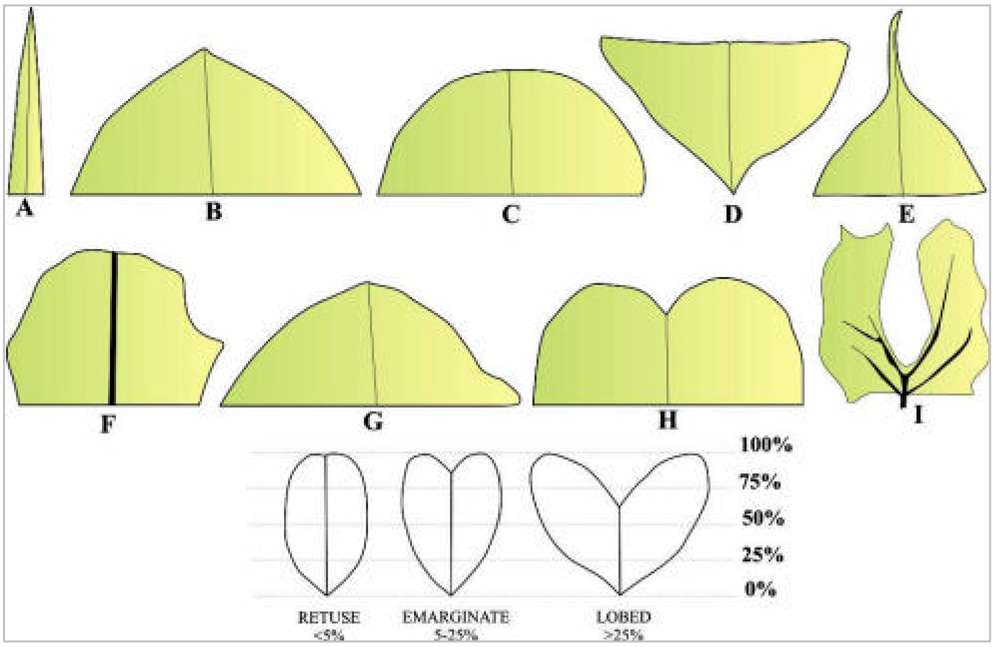


Figure 6.21 Apex shapes A) straight; B) convex; C) rounded; D) truncate; E) acuminate; F) complex; G) retuse; H) emarginated and I) lobed (Wing et al., 1999).

6.4.11 Position of Petiolar Attachment

There are three position of petiolar attachment which are marginal, peltate central and peltate eccentric (Fig. 6.22).

Marginal : Petiolar insertion at the margin of the leaf (Fig. 6.22).

Peltate central	: Petiole attached within the boundaries of the leaf margin and near the center of the leaf (l_b>0) (Fig. 6.22B).
Peltate eccentric	: Petiole attached near the edge but inside the boundaries of the leaf margin (l_b>0) (Fig. 6.22C).

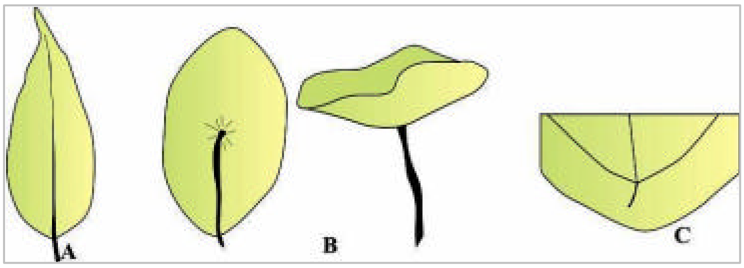


Figure 6.22 Position of the petiolar attachment A) marginal; B) peltate central and C) peltate eccentric (Wing et al., 1999).

6.4.12 Margin Type and Lobation

Margin type is most important for the leaf definition. Teeth are marginal projections with sinuses indented less than 1/4 of the distance to the midvein or long axis of the leaf. Teeth can be either, dentate, serrate or crenate (Fig. 6.23). Besides, if there is a single tooth of any size, the leaf is considered to be toothed.

Dentate	: Teeth pointed with their axes perpendicular to the trend of the leaf margin.
Serrate	: Teeth pointed with their axes inclined to the trend of the leaf margin.
Crenate	: Teeth smoothly rounded without a pointed apex.
Entire	: Margin is smooth, without teeth.
Revolute	: Margins are turned under or rolled up like a scroll
Erose	: Margins are irregular as if chewed.

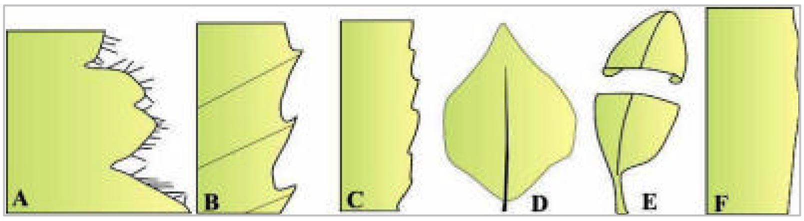


Figure 6.23 Margin types A) dentate; B) serrate; C) crenate; D) entire; E) revolute and F) erose (Wing et al., 1999).

Lobes are marginal indentations that reach 1/4 or more of the distance to the midvein, measured parallel to the axis of symmetry of the lobe (Fig. 6.24).

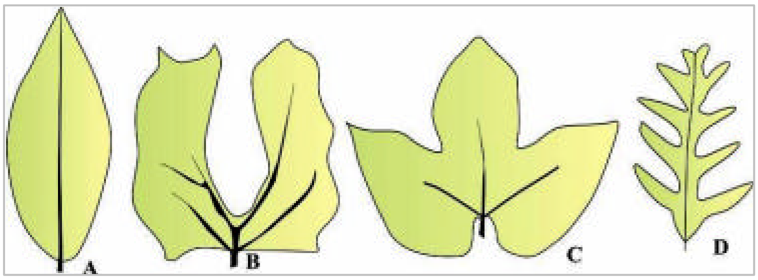


Figure 6.24 Lobation types A) unlobed; B) bilobed; C) palmately lobed and D) pinnately lobed (Wing et al., 1999).

6.4.13 Teeth,Teeth Shapes and (Tooth) Apex

Sinus is an incision between marginal projections of any sort (lobes, dentations, serrations, crenations) and may be angular or rounded. Tooth apex is the tip of a tooth. Apical side is the side of the tooth that is toward the apex of the lamina. Basal side is the side of the tooth that is toward the base of the lamina.

If the teeth can be separated into different size groups, they are called compound (1°, 2° or 3°) (Figs. 6.25A, 6.25B, 6.25C). The number of teeth/cm is in the middle 50% of the leaf (Fig. 6.25D). This refers to the interval between corresponding points on the teeth or crenations (Figs. 6.25E, 6.25F).

Tooth shape is described in terms of the shape of the apical side and the basal side. The possible combinations are shown in the chart below. In the database, the following abbreviations are used: **cv** (convex), **st** (straight), **cc** (concave), **fl** (flexuous=basally convex and apically concave), **rt** (retroflexed=apically convex and basally concave). The apical shape is listed first. For example, cc/fl would be concave on the apical side and flexuous on the basal side of the tooth. Note that a given leaf can exhibit more than one tooth shape (Fig. 6.26). The sinus is the shape of the tooth (Figs. 6.26A, 6.26B).

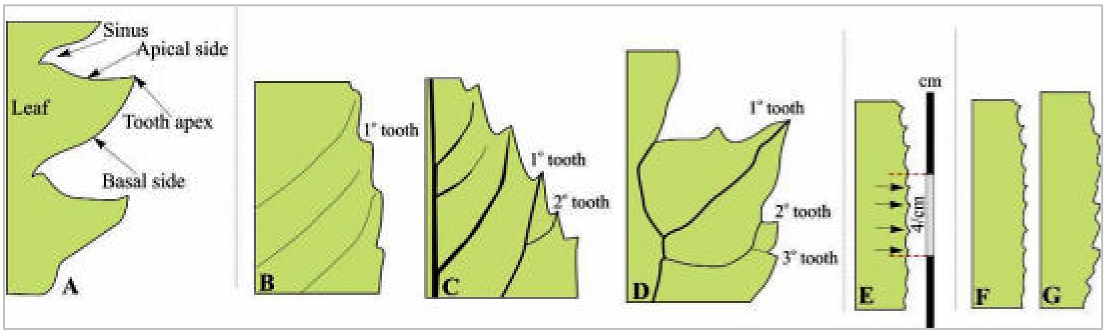


Figure 6.25 Teeth structure; A) Parts of teeth; B) orders of teeth (1 order); C) orders of teeth (2 order); D) orders of teeth (3 order); E) teeth/cm; F) tooth spacing (regular) and G) tooth spacing (irregular) (Wing et al., 1999).

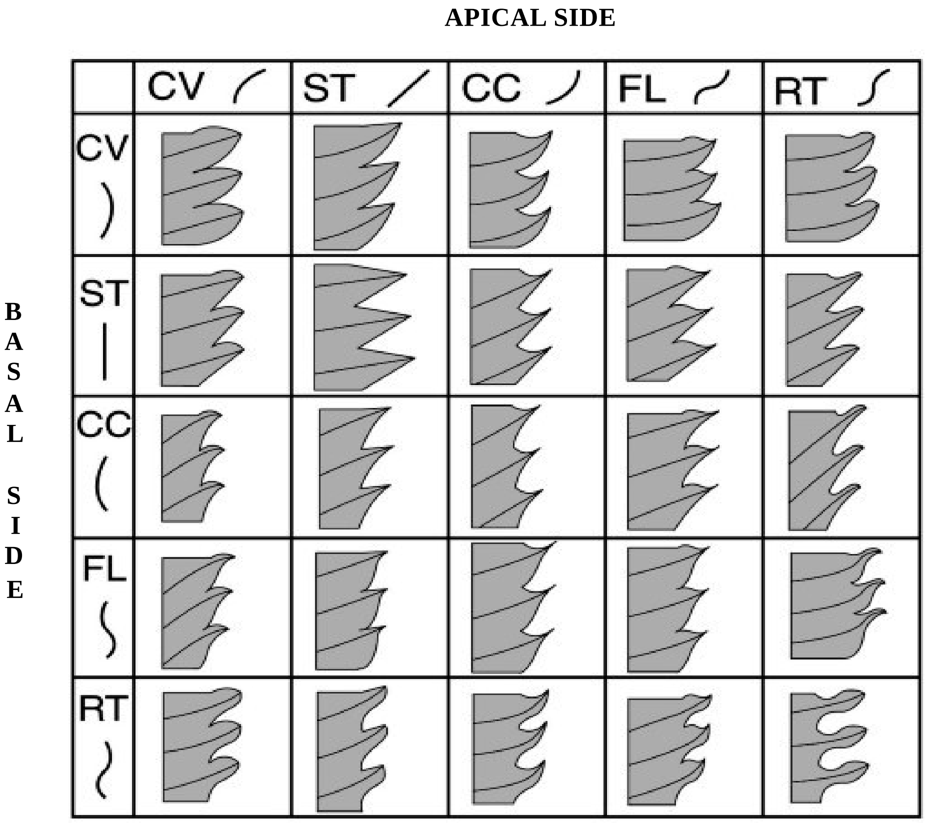


Figure 6.26 Tooth shapes (Wing et al., 1999).

There are three major types of tooth apex: simple, spinose, and glandular. In living leaves and some fossils, it may be possible to distinguish the following subsets of glandular: spherulate, papillate, foraminate, mucronate, and setaceous. For situations in which a more specific identification is not possible, use non–specific glandular (Figs. 6.27C–6.27J).

Simple : Tooth apex formed by the change in direction of the leaf margin without additional elements (Fig. 6.27C).

Non–specific glandular: In fossils, it may be impossible to distinguish between the different subtypes of glandular teeth. This character state is reserved for the description of fossil teeth with a visible concentration of material on the tooth apex (Fig. 6.27D).

Spinose : Principal vein of tooth projecting beyond the apex (Fig. 6.27E).

Spherulate : Having a spherical callosity fused to the apex (Fig. 6.27F).

Papillate : Having a clear, nipple–shaped, glandular apical termination (Fig. 6.27G).

Foraminate: With an apical cavity or foramen that broadens from the termination of the principal vein toward the exterior (Fig. 6.27H).

Mucronate : With an opaque or non–deciduous cap or mucro fused to the tooth (Fig. 6.27I).

Setaceous : An opaque, deciduous bristle or cap thickened proximally and not fused firmly with the remaining tooth substance (Fig. 6.27J).

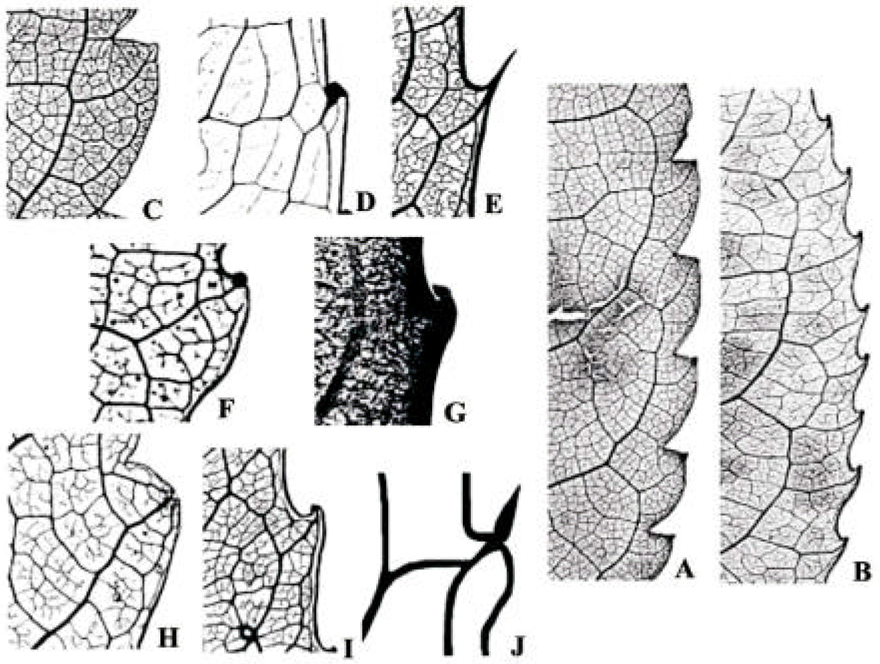


Figure 6.27 Sinus type and shapes of tooth apex; A) angular; B) rounded; C) simple; D) non–specific glandular; E) spinose; F) spherulate; G) papillate; H) foraminate; I) mucronate and J) setaceous (Wing et al., 1999).

6.4.14 Vein Orders and 1^o, 2^o, 3^o Vein Categories

The first step in describing the pattern of venation in a leaf is to recognize discrete categories or orders of veins that have similar widths and courses. Most angiosperm leaves have between four and seven orders of venation (Fig. 6.28). Firstly, describing venation is to recognize the first three orders of veins. In general, the primary and secondary veins are the major structural veins of the leaf, while the tertiary veins are the largest veins that fill the field of the leaf. The primary vein or veins are somewhat analogous to the main trunk or trunks of a tree. They are the widest veins, they usually taper along their length, and they generally run from at, or near, the base of the leaf to the margin. Secondary veins are analogous to the major limbs of a tree. They are the next set in width after the primary(s), they also usually taper along their course, and they ordinarily run from either the base of the leaf or from a primary vein toward the margin. For tertiary and higher order veins the analogy with the branching system of a tree breaks down. Tertiary veins are usually considerably narrower than the secondary set and have courses that connect primary and secondary veins to one another in a similar fashion throughout the leaf. Tertiaries are usually the widest veins that form a more or less organized "field" over the great majority of the leaf area. Generally it is fairly easy to recognize the primaries and tertiaries, but sometimes the secondaries consist of several subsets with different widths and courses. Nevertheless, all the subsets of veins between the primaries and the tertiaries are considered to be secondaries.

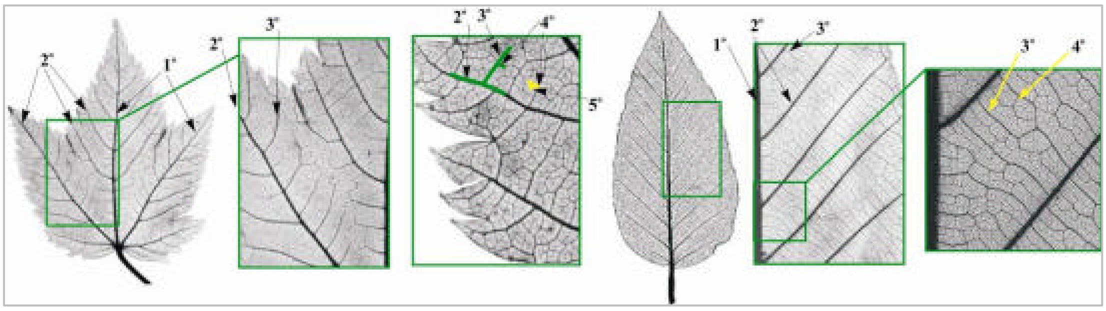


Figure 6.28 Vein orders and types (Wing et al., 1999).

The 1^{o} vein categories are below:

Pinnate: With a single primary vein (Fig. 6.29A).

Actinodromous: Three or more primary veins diverging radially from a single point (Figs. 6.29B “basal”, 6.29C “suprabasal”).

Palinactinodromous: Primaries diverging in a series of dichotomous branchings, either closely or more distantly spaced (Fig. 6.29D).

Flabellate: Several to many equally fine basal veins diverge radially at low angles and branch apically (Fig. 6.29E).

Acrodromous: Three or more primaries running in convergent arches toward the leaf apex (Figs. 6.29F “basal”, 6.29G “suprabasal”).

Parallelodromous: 2 or more parallel primary veins originate beside each other at the leaf base and converge apically (Fig. 6.29H).

Campylodromous: Several primary veins or their branches, originating at or near a single point and running in strongly recurved arches that converge apically (Fig. 6.29I).

The 2^{o} vein categories are below:

Brochidodromous: Secondaries joined together in a series of prominent arches (Fig. 6.30J).

Weak brochidodromous: Secondaries joined together in a series of arches (Fig. 6.30K).

Eucamptodromous: Secondaries upturned and gradually diminishing apically inside the margin, connected to the superadjacent secondaries by a series of 3° cross veins without forming any 2° marginal loops (Fig. 6.30L).

Festooned brochidodromous: Having one or more additional sets of loops outside of the main brochidodromous loop (Fig. 6.30M).

Cladodromous: Secondaries freely branching toward the magrin (Fig. 6.30N).

Reticulodromous: Secondaries branching into a reticulum toward the magrin (Fig. 6.30O).

Craspedodromous: Secondaries terminating at the margin (ordinarily in toothed leaves) (Fig. 6.30Ö).

Semicraspedodromous: Secondary veins branching just within the margin, one of the branches terminating at the margin and the other join (Fig. 6.30P).

Festooned semicraspedodromous: Semicraspedodromous venation with one or more additional sets of loops outside the branch that joins the superadjacent 2° (ordinarily in toothed leaves). The superadjacent secondary (ordinarily in toothed leaves) (Fig. 6.30R).

Intramarginal vein: Secondaries end in a strong vein closely paralleling the leaf margin (Fig. 6.30S).

Interior : 2° crossing between primary veins or 2° veins that do not reach the margin – typically arched or straight (Fig. 6.30T).

Acrodromous: Two or more secondaries running in convergent arches toward the leaf apex (Figs. 6.30U "basal", 6.30V "suprabasal").

The Agrophic vein is a comb–like complex of veins comprised of a lateral 1° or 2° backbone with 2 or more exmedial 2° veins that travel roughly parallel courses towards the margin. These veins may be straight or looped. There are two types of the Agrophic vein which are simple agrophic and compound agrophic (Figs. 6.31A, 6.31B). For the basal veins, the number of 1°, 2°, and 3° veins originating at or near the base of the leaf/top of the petiole (Fig. 6.31C).

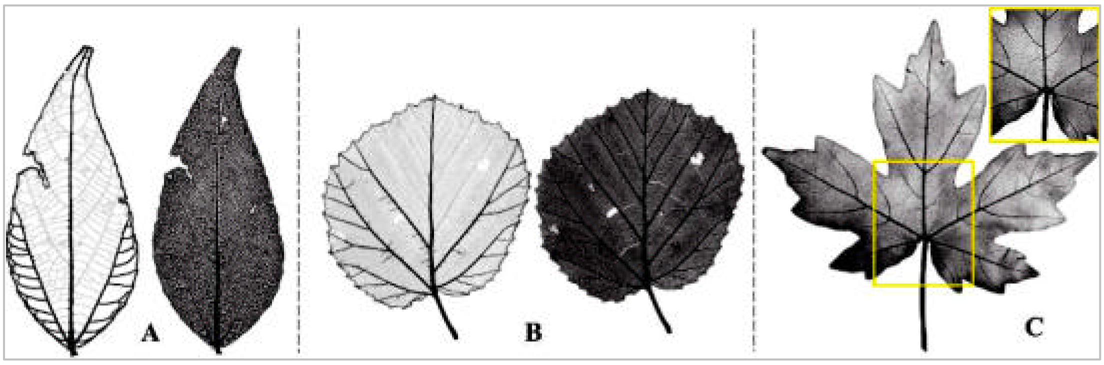


Figure 6.31 Simple agrophic, B) Compound agrophic and C) Basal vein (Wing et al., 1999).

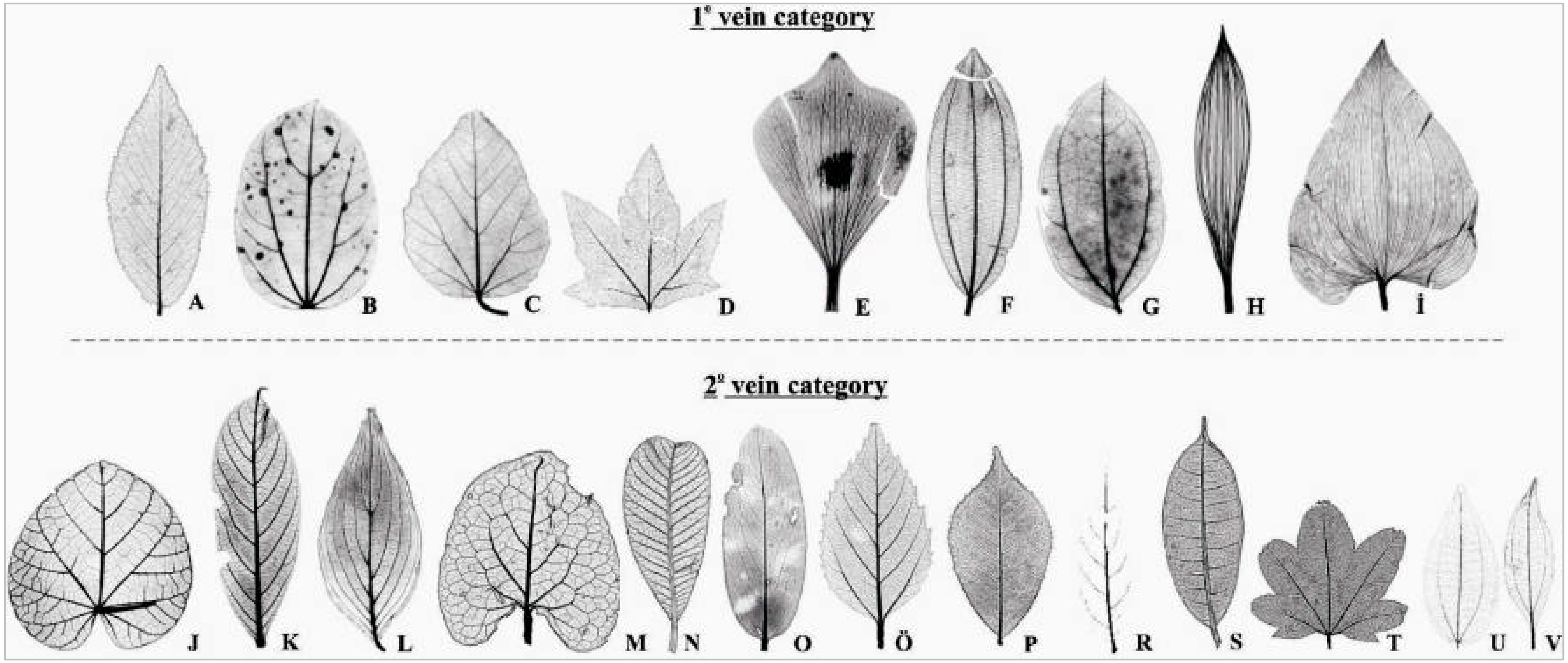


Figure 6.30 Vein orders and types, A)Pinnate, B) Actinodromous “basal”, C) Actinodromous “subrabasal”, D) Palinactinodromous, E) Flabellate, F) Acrodromous “basal”, G) Acrodromous “subrabasal”, H) parallelodroum, I) Campylodromous, J) Brochidodromous, K) Weak brochidodromous, L) Eucamptodromous, M) festooned brochidodromous, N) Cladodromous, O) reticulodromous, Ö)Craspedodromous, P) Semicraspedodromous, R) Festooned semicraspedodromous, S) Intramarginal vein, T) Interior, U) Acrodromous “basal” and V) Acrodromous “subrabasal”

6.4.15 2^o Vein Spacing, Angle and Inter 2^o Veins

There are four 2^o vein spacing types which are uniform, irregular, decreasing toward base and increasing toward base (Figs. 6.32A–6.32D). Besides, there are six 2^o vein angle types which are uniform, one pair acute basal secondaries, two pair acute basal secondaries, smoothly increasing toward base, smoothly decreasing toward base and abruptly increasing toward base (Figs. 6.32E–6.32J). Inter secondary veins have a width and course similar to the 2°s, but they are usually thinner than the costal 2°s and do not reach the margin (Figs. 6.32K–6.32M).

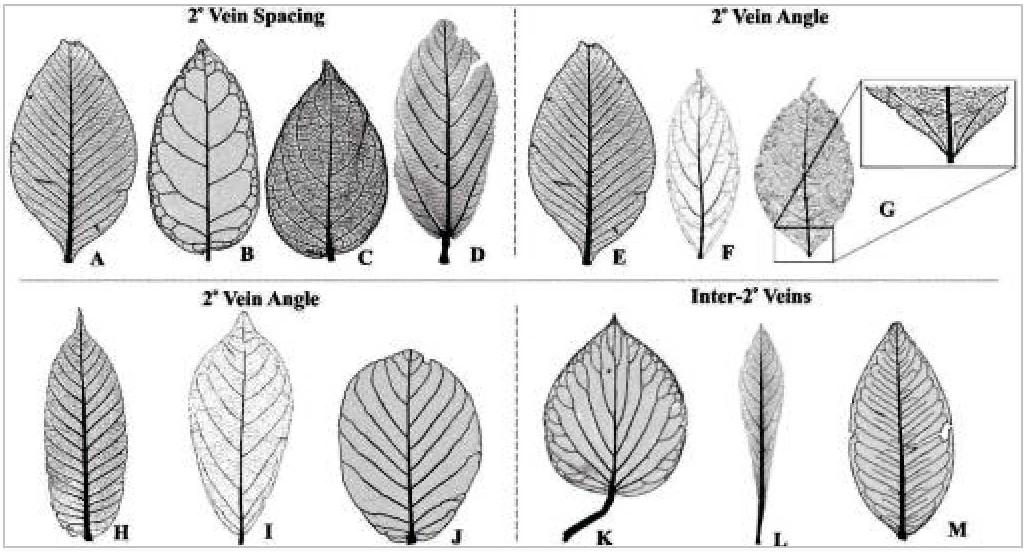


Figure 6.32 A) Uniform, B) Irregular, C) Decreasing toward base, D) increasing toward base, E) Uniform, F) One pair acute basal secondaries, G) Two pair acute basal secondaries, H) Smoothly increasing toward base, I) Smoothly decreasing toward base, J) Abruptly increasing toward base, K) absent intersecondaries, L) weak intersecondaries and M) strong intersecondarieS (Wing et al., 1999).

6.4.16 3^o Vein Category, Course, 3^o Vein Angle to1^o and 3^o Vein Angle Variability

There are six 3^o vein category types which are opposite percurrent, alternate percurrent, mixed opp/alt, random reticulate, dichotomizing, regular polygonal reticulate (Fig. 6.33).

Opposite percurrent : Tertiaries cross between adjacent second aries in parallel paths without branching (Fig. 6.33A).

Alternate percurrent : Tertiaries cross between secondaries with an offset (an abrupt angular discontinuity) (Fig. 6.33B).

Mixed opp/alt : Tertiaries have both opposite percurrent and alternate percurrent courses (Fig. 6.33C).

Random reticulate : Tertiaries anastomose (rejoin) with other 3° veins or 2° veins at random angles (Fig. 6.33D).

Dichotomizing : Tertiaries branch freely (Fig. 6.33E).

Regular polygonal reticulate: Tertiaries anastomose with other 3° veins to form polygons of similar size and shape (Fig. 6.33F).

There are five 3^{o} vein course types which are straight, convex, sinuous, admedial ramified and exmedially ramified.

Straight : Passing across the intercostal area without a noticeable change in course (Fig. 6.34G).

Convex : Middle portion of the vein curving away from the center of the leaf (Fig. 6.34H).

Sinuous : Changing direction of curvature (Fig. 6.34I).

Ramified : Tertiary veins branch into higher orders without rejoining secondaries (Figs. 6.34J, 6.34K).

Admedially ramified : Branching oriented toward the primary or midline (Fig. 6.34J).

Exmedially ramified: Branching oriented toward the leaf margin (Fig. 6.34K).

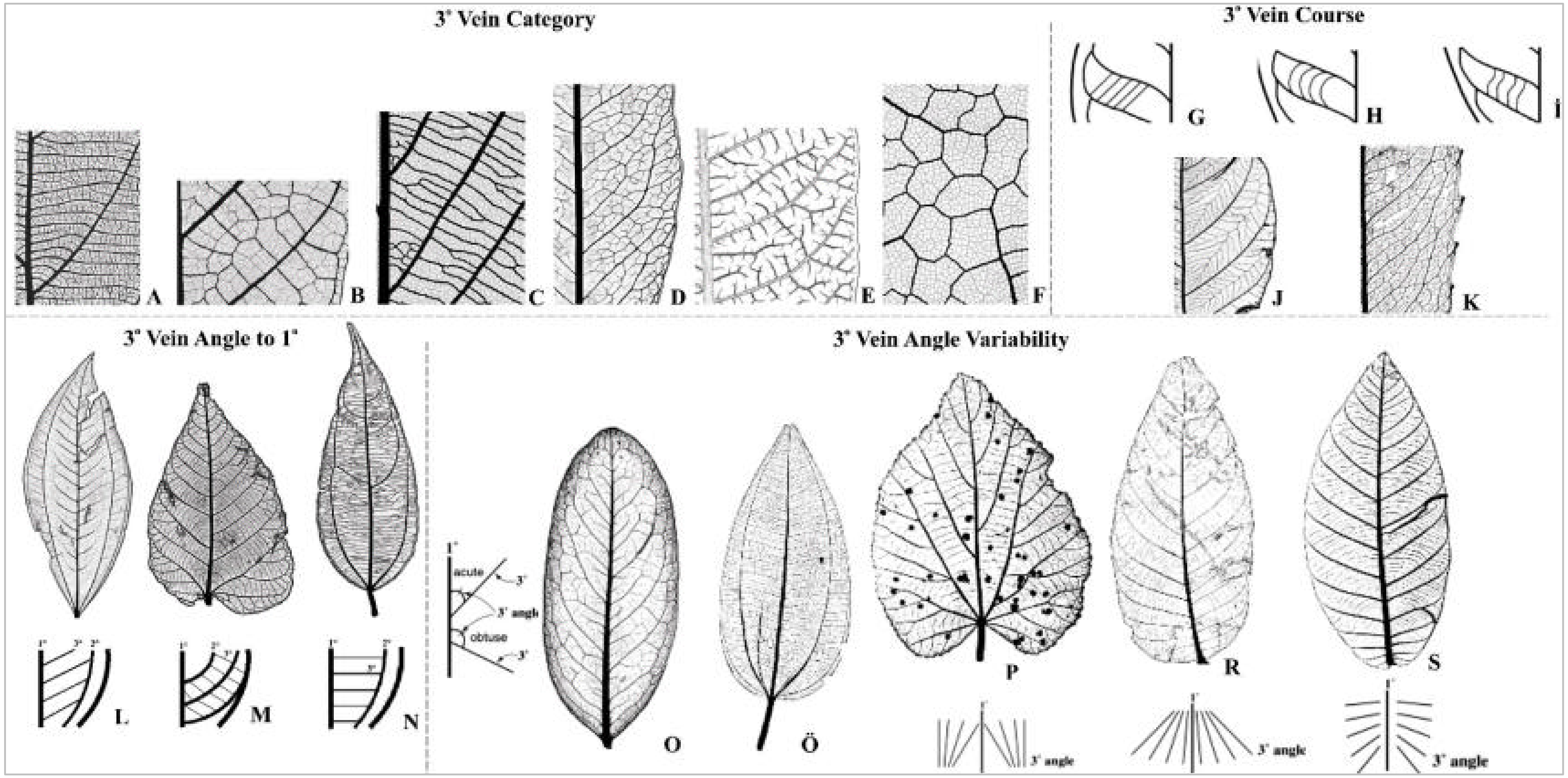


Figure 34. 3^o Vein Category, Course, 3^o Vein Angle to1^o and 3^o Vein Angle Variability, A) Opposite percurrent, B) Alternate percurrent, C) Mixed opp/alt, D) Random reticulate, E) Dichotomizing, F) Regular polygonal reticulate, G) Straight, H) Convex, I) Sinuous, J) Admedially remified, K) exmedial ramified, L) Acute, M) Obtuse, N) Perpendicular, O) Inconsistent, Ö) Uniform, P) Increasing exmedial, R) Decreasing exmedial and S) Increasing basal.

The tertiary angle is measured with respect to the primary vein.

Inconsistent: Angle of the tertiaries varies randomly over the lamina (Fig. 6.34O).

Uniform: Angles of the tertiaries do not vary over the surface of the lamina (Fig. 6.34Ö).

Increasing exmedially: The angles of the tertiaries become more obtuse away from the axis of symmetry (Fig. 6.34P).

Decreasing exmedially: The angles of the tertiaries become more acute away from the axis of symmetry (Fig. 6.34R).

Increasing basally: The tertiary angles become more obtuse toward the base of the lamina (Fig. 6.34S).

6.4.17 4^o and 5^o Veins Category

Fourth and higher order venational characters should be scored in the portion of the leaf that is roughly half way between the base and the apex unless the area is lacking.

4° Vein Category

Alternate percurrent: 4°s cross between adjacent tertiaries with an offset (an abrupt angular discontinuity) (Fig. 6.35A).

Opposite percurrent: 4°s cross between adjacent 3°s in paralel paths without branching (Fig. 6.35B).

Regular polygonal reticulate : 4°s anastomose with other veins to form polygons of similar size and shape (Fig. 6.35C).

Dichotomizing: 4°s branch freely and are the finest vein orders the leaf exhibits (Fig. 6.35D).

5° Vein Category

Regular polygonal reticulate	Veins anastomose with other veins to form polygons of similar size and shape (Fig. 6.35E).
Dichotomizing	5°s branch and are the finest vein class that the leaf exhibits (Fig. 6.35F).

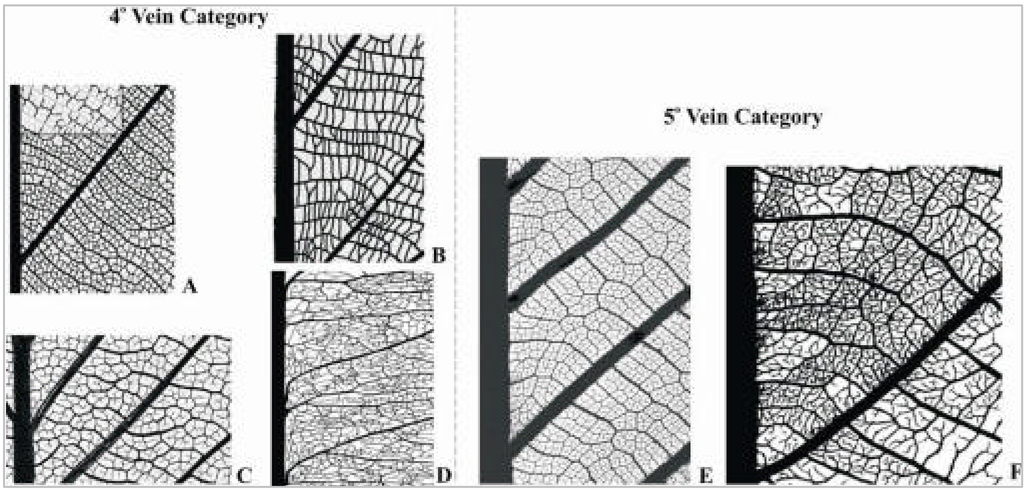


Figure 6.35 A) Alternate percurrent, B) Opposite percurrent, C) Regular polygonal reticulate, D) Dichotomizing, E) Regular polygonal reticulate and F) Dichotomizing (Wing et al., 1999).

6.4.18 CLAMP Analysis Method

Climate Leaf Analysis Multivariate Program (CLAMP) is a multivariate statistical technique that decodes the climatic signal inherent in the physiognomy of leaves of woody dicotyledonous plants (Wolfe, 1990, 1993; Kovack & Spicer, 1995; Wolfe & Spicer, 1999 and Spicer, 1999). CLAMP was developed as an evolutionarily robust, accurate, and precise tool for direct atmospheric palaeoclimate determinations over land. It calibrates the numerical relations between leaf physiognomy of the woody dicotyledons and meteorological parameters in modern terrestrial environments. Using this calibration, past climatic data are potentially determinable from leaf fossil assemblages provided that the calibration is robust over time and that the sampling of the fossil assemblage represents well the characteristics of the living source vegetation. CLAMP has been applied effectively to fossil floras up to 100 million years old (Herman &Spicer, 1996), but is an even more powerful and reliable tool for late Tertiary (Wolfe, 1995; Spicer, 1999) and Quaternary assemblages. A typical CLAMP analysis consists of six stages which are given below.

After collecting the fossil sample for analysis you will have to divide the specimens up into morphotypes. In an ideal world these are equivalent to biological species but, as with all fossil material, this is an ideal rarely achieved. The criteria used for this taxonomic partitioning should include characters not used in the CLAMP analysis. In most cases venation characters should be used in addition to shape and margin features. It is not necessary to identify (i.e. name or establish relationships to published taxa) the morphotypes. At least 20 morphotypes of leaves woody dicotyledonous plants are required for each fossil assemblage.

Lobed: A species receives a score of: "0" or if no leaves are lobed, a score of "0.5" if some leaves are lobed and some are unlobed, and a score of "1" if all leaves are lobed (Fig. 6.36).

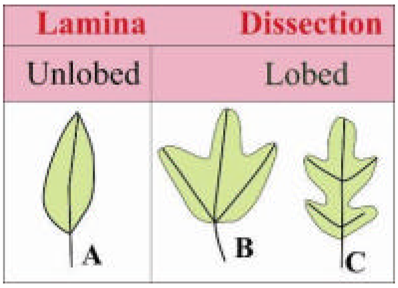


Figure 6.36. Lobed group for the CLAMP analysis method; A) Untoothed leaf, B) Palmately leaf and C) Pinnately lobed untoothed leaf.

Teeth: No teeth species receives a score of "0" if teeth are present on all leaves, a score of "0.5" if some leaves are toothed and some are not, and a score of "1" if no leaves are toothed; the scores, when converted to percentages, for no teeth, teeth rounded and (or) appressed, and teeth acute will total approximately 100 for a single sample (Fig. 6.37). The no teeth character state is basically that of the entire margin as proposed by Bailey & Sinnott (1915, 1916); a major difference, however, is that spinose leaves are included in the no teeth category. This is because spinose teeth are primarily an adaptation to deter browsing and therefore not related to climate.

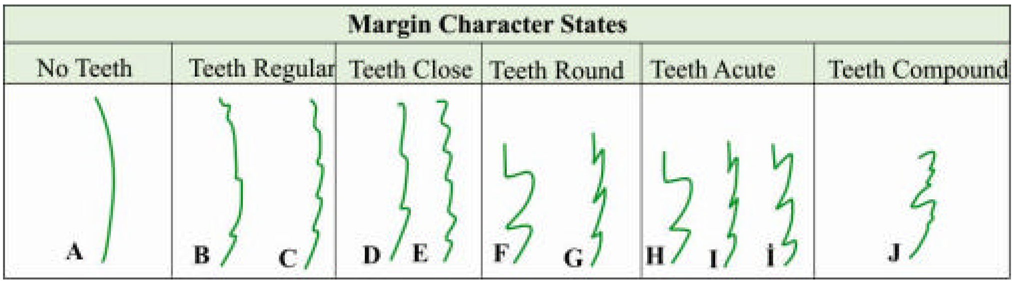


Figure 6.37 Margin character states A) No teeth; B) Irregular spaced; C) Regular spaced; D) Distantly spaced; E) Regular spaced; F) Rounded; G) Appressed; H) Rounded; I) Appressed and J) Compound

Regularity of tooth spacing (teeth regular): A species receives a score of "0" if no teeth are present, a score of "0.25" if the teeth are both regular and irregular and some leaves have teeth and others do not, a score of "0.5" if the teeth are only regular and some leaves have teeth and others do not, a score of "0.5" if the teeth are both regular and irregular and all leaves are toothed, and a score of "1" if all teeth are regular and all leaves are toothed. Teeth are considered to be regularly spaced if the length of the basal flanks of two adjacent teeth differs by less than one–third (Figs. 6.37B, 6.37C).

Closeness of teeth (teeth close): A species receives a score of "0" if no teeth are present, a score of "0.25" if the teeth are both close and distant and some leaves have teeth and others do not, a score of "0.5" if the teeth are only close and some leaves have teeth and others do not, a score of "0.5" if the teeth are both close and distant at all leaves are toothed, a score of "1" if all teeth are close and all leaves of toothed. Teeth are considered to be closely spaced if the basal flanks of the teeth are no longer than three times the apical flanks (Figs. 6.37D, 6.37E).

Teeth rounded and (or) appressed: A species receives a score of "0" if no teeth are present, a score of "0.25" if the teeth and both rounded (or appressed) and acute (Fig.6.37I), and some leaves have teeth and others do not, a score of "0.5" if the teeth are only rounded (or appressed) and some leaves have teeth and others do not, a score of "0.5" if the teeth are both rounded (or appressed) and acute and all leaves are toothed, and a score of "1" if all teeth are rounded (or appressed) and all leaves are toothed. Teeth are rounded if they have convex apical and basal flanks and the convexity extends to the tip of the tooth (Figs. 6.37F, 6.37G). Teeth are appressed if the apical flank is concave, the base of flank is convex, and the tooth is curved toward the lamina (Fig. 6.37G); such teeth are typically glandular. The two states of rounded teeth and appressed teeth were scored and run separately, but combining the two states produced both higher values and percent variance.

Teeth acute: A species receives a score of “0” if no teeth present, a score of “0.25” if the teeth are both rounded (or appressed) and acute and some leaves have teeth and others do not, a score of “0.5” if the teeth are only acute and some leaves have teeth and others do not, a score of “0.5” if the teeth are both rounded (or appressed) and acute and all leaves are toothed, and a score of “1” if all teeth are acute and all leaves are toothed. Teeth are acute if the apical and basal flanks of the teeth form a sharp point (Figs. 6.37H–6.37I).

Teeth compound: Species that have at least 50 percent teeth that are compound receive a score of “1”, species that have some, but less than 50 percent, teeth that are compound receive a score of “0.5”, and species that have no compound teeth receive a score of “0”. A compound tooth is a tooth that has smaller teeth on (typically) its basal flank (Fig. 6.37J).

Leaf Size: A species is scored for its full range of variation in leaf size. A species that has leaves of only one size category receives a score of “1” in that category. If a species ranges through two categories, it receives a score of “0.5” in both categories, if it ranges through three categories it receives a score of “0.33” in each category, and so forth. If a lobed leaf is dissected more than half the distance from the apex of the lobe to the base of the lamina or to the midrib, the unit area scored is an individual lobe (Fig. 6.38).

Apex emarginated: A species receives a score of “1” if some leaves are emarginate and a score of “0” if no leaves are emarginate (Fig. 6.39A). Insect related damage can cause a somewhat similar notched apex that tends to have irregular sides and is excluded from the emarginate category.

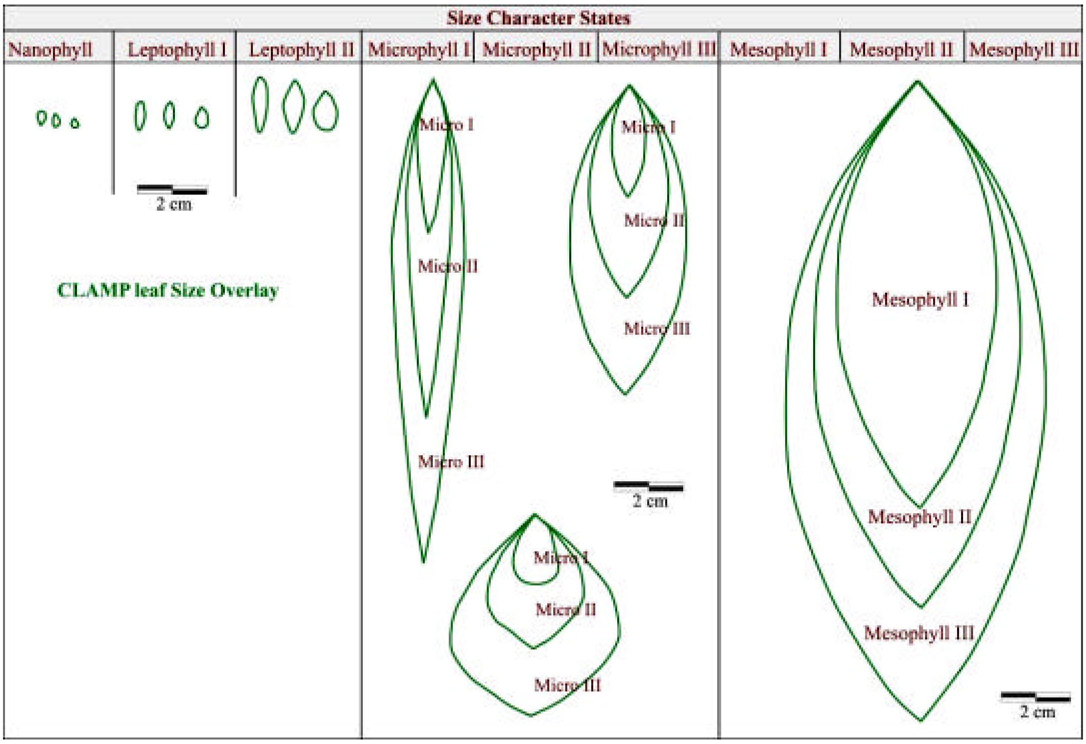


Figure 6.38 Leaf size for the CLAMP analysis.

Apex round: This and the two following categories (attenuate and acute) have a total score of one for each species. A species can have a score of "0.33" in each category if each category is represented, a score of "0.5" in two categories if two categories are represented, and a score of "1" in one category if only one category is represented (Figs. 6.39B–6.39D).

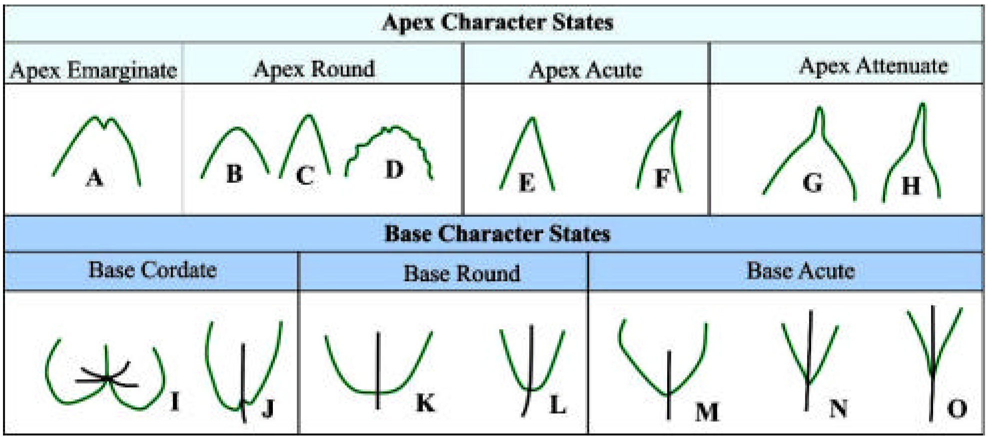


Figure 6.39 A) Apex emarginated; B, C, D) Apex round; E, F) Apex acute; G, H) Apex Attenuate; I, J) Base cordate; K, L) Base round and M, N, O) Base acute

Apex acute: This and the two adjacent categories have a total score of 1 for each species. A species can have a score of “0.33” in each category if each category is represented, a score of “0.5” in two categories if two categories are represented, and a score of “1” in one category if only one category is represented. An apex is acute if the most apical forth of the lamina has a margin that is straight and the two sides form a point (Figs. 6.39E, 6.39F). Note that this definition of acute does not depend on the angle formed by the lamina sides.

Apex attenuate: This and the two preceding (Acute and round) categories have a total score of 1 for each species. A species can have a score of “0.33” in each category if each category is represented, a score of “0.5” in two categories if two categories are represented, and a score of “1” in one category if only one category is represented. An apex is attenuate if, in the most apical forth of the lamina, the margin on both sides changes from a linear or convex margin to a concave margin and the concave margin extends for a distance of at least one centimeter (Figs. 6.39G, 6.39H). The necessity in the attenuate category for both sides to change curvature thus excludes many falcate laminae, which typically have a change of curvature on only one side (Fig. 6.39F) and are considered to have acute apices.

Base cordate: This and the two following categories have a total score of 1 for each species. A species can have a score of “0.33” in each category if each category is represented, a score of “0.5” in two categories if two categories are represented, and a score of “1” in one category if only one category is represented. A base is cordate if the basal parts of the lamina extend basally (below) beyond the juncture of the petiole and the lamina (Figs.6.39I, 6.39J).

Base round: This and the two adjacent (cordate and acute) categories have a total score of 1 for each species. A species can have a score of “0.33” in each category if each category is represented, and a score of “0.5” in two categories of two categories are represented, and a score of “1” in one category if only one category is represented. A base is round if the most basal forth of the lamina has a convex margin (Figs. 6.39K, 6.39L).

Base acute: This and the two preceding categories have a total score of 1 for each species. As species can have a score of “0.33” in each category if each category is represented, a score of “0.5” in two categories of two categories are represented, and the score of “1” in one category of only one category is represented. A base is acute if the most basal forth of the lamina has a straight or concave margin (Figs. 6.39M, 6.39N, 6.39O).

Length to width ratio: The five categories of length to width have a total score of 1 for each species. A species is scored for his full range of variation in length to width. A species that has leaves of only one length to width category receives a score of 1 in that category. If a species ranges through two categories, it receives a score of 0.5 in each category; if it ranges through three categories it receives a score of 0.33 in each category, and so forth (Fig. 6.40).

Shape obovate: This and the two following categories have a total score of 1 for each species. A species can have a score of “0.33” in each category if each category is represented, a score of “0.5” in two categories if two categories are represented, and a score of “1” in one category if only one category is represented. The leaf is obovate if it is widest in the most typical third of the lamina (Fig. 6.40A).

Shape elliptic: This and the two adjacent categories have a total score of 1 for each species. A species can have a score of “0.33” in each category if each category is represented, a score of “0.5” in two categories if two categories are represented, and a score of “1” in one category if only one category is represented. A leaf is elliptic if it is widest in the medial third of the lamina (Fig. 6.40B).

Shape ovate: This and the two preceding categories have a total score of 1 for each species. A species can have a score of “0.33” in each category if each category is represented, a score of ‘0.5” in two categories if two categories are represented, and a score of “1” in one category if only one category is represented. At leaf is ovate if it is widest in the most basal third of the lamina (Fig. 6.40C).

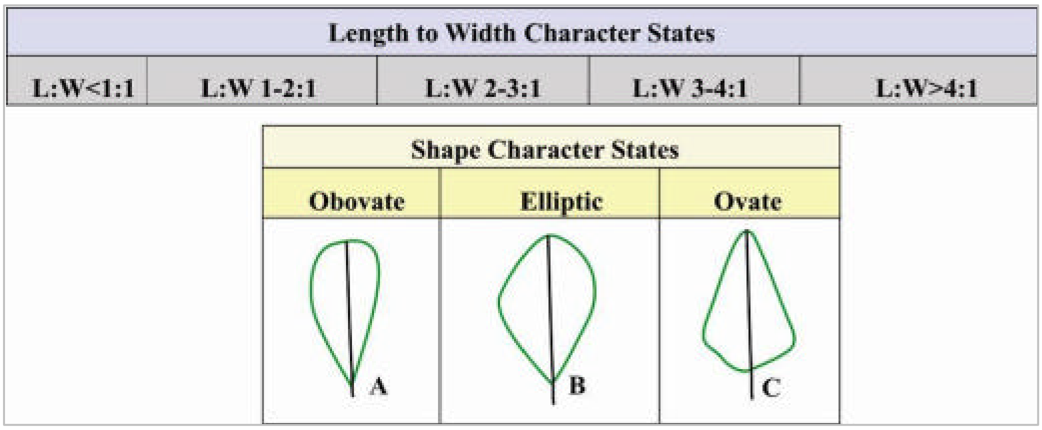
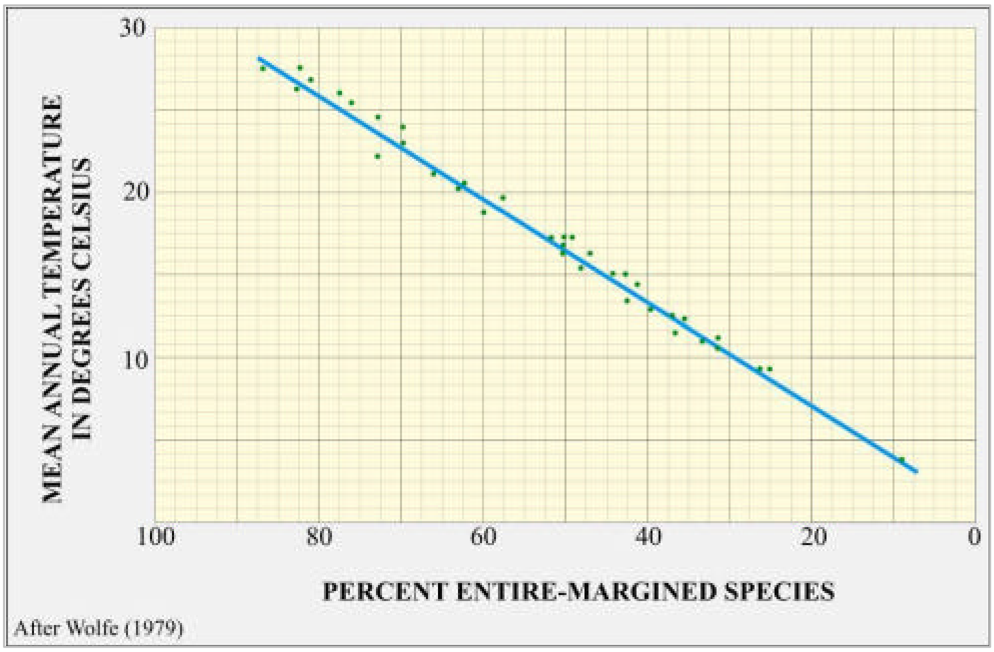


Figure 6.40 Length to width character and shape character States; A) Obovate; B) Elliptic and C) Ovate

Next you need appropriate data derived from modern vegetation growing under known climatic conditions. These data are made up by Jack A Wolfe. CANOCO program calculates the numerical palaeoclimatic values based on these data. Having entered the fossil scores on the end of the vegetation dataset it is now time to do the analysis. This is most easily accomplished using version 4.0 of CANOCO. The program automatically calculates the climate variable predictions using the inbuilt calibrations of the climate vectors. By using the calibration score sheet and definitions provided on the CLAMP website, 31 leaf characters for all the woody dicot fossils were scored. The PHYSG3BR/ Physg3br dataset, containing144 meteorological and leaf physiognomic data from the CLAMP website was chosen for our analysis. Twelve climatic parameters were calculated, i.e., MAT, WMT, CMT, MAP, GRS, GSP, MMGSP, 3–WET, 3–DRY, RH, SH and Enthalpy.

6.4.19 Leaf Margin Analysis Method

LMA is based on the established positive relationship between the percentage of woody species in a given flora with entire–margined leaves and temperature (Bailey & Sinnott, 1915, 1916; Wolfe, 1979; Wing & Greenwood, 1993; Wilf, 1997; Greenwood, 2005, 2007). The following regression equation, mainly based on the mesic (moist) vegetation of East Asia (Wolfe, 1979), was used to calculate MAT of the Xiaolongtan megaflora (Fig. 6.41):



After Wolfe (1979)

Figure 6.41 Correlation between the percentage of species in a local floras with entire margineted leaves and mean annual temperature (MAT) (Wolfe, 1979 and Wilf, 1997).

Calculating of the temperature value based on the LMA is below:

MAT = 30.6 (=c) x P (Percentage of species with entire leaf margins) + 1.14

Teeth are defined as leaf margin sinuses less than 1/4 of the distance to the midvein or long axis of the leaf (Ash et al., 1999). A fossil species was scored “1” if all leaves were entire, “0.5” if only some leaves were entire and “0” when all leaves were toothed. The MAT error was calculated using the equation of Wilf (1997) (Fig. 6.42):

$$\delta MAT = c\sqrt{\frac{P(1 - P)}{r}}$$

Figure 6.42 The formula used to calculate the temperature value.

where “c” is the slope of the equation of the MAT regression (= 30.6),
where “P” is defined as above, and “r” is the number of total woody dicots.

6.4.20 Coexistence Approach (CA) Macro and Micro Analysis Methods

The CA which was developed by Mosbrugger & Utescher (1997), following the principle of the classic Nearest Living Relative (NLR) method (Mosbrugger, 1999). It is based on the assumption that the climatic requirements of fossil species (spore, pollen and leaf fossil) are similar to those of their NLRs (e.g. Mosbrugger & Utescher, 1997 and Mosbrugger, 1999). This method reconstructs the palaeoclimatic parameters for a given fossil flora using climatic intervals in which all of the NLRs of the fossil flora could coexist (Mosbrugger & Utescher, 1997; Mosbrugger, 1999). To facilitate the quantitative analysis, Utescher & Mosbrugger (1997–2006) have developed a database, PALAEOFLORA, which contains more than 4000 Cenozoic plant taxa. Climatic intervals were calculated by the ClimStat program, provided by T. Utescher.

6.5 Systematic of Leaf Fossils

The descriptions of the entities follow the alphabetical order for practical use. In Table 6.2 the arrangement expresses their general systematic position (Plates 6.2–6.19).

Gymnospermae
Pinaceae
Pinus L.
Pinus sp.
Plate 6.8; figs. 1–5

Taxodiaceae
Glyptostrobus sensu lato
Glyptostrobus europaeus (BRANGNIART) UNGER
pl 6.8; fig. 13
Taxodium dubium (STERNBERG) HEER
pl 6.8; fig. 11

Angiospermae

Sapindaceae

Acer L.

Acer angustilobum HEER

pl 6.3, figs. 3–12; pl 6.4, fig.1-6; pl. 6.5, figs. 1-3; pl. 6.6, figs. 1-7; pl. 6.7, 1-12

1859	*Acer angustilobum* HEER, p.57, pl.117, fig. 25a, pl. 118, figs 4–9
1972	*Acer angustilobum* HEER, p. 40, pl. 3–5, pl.6, figs1–5, pl. 31–35 text–figs 9, 10a, b
1975	*Acer dasycarpoides* HEER forma *angustilobum* PROCHÁZKA et BUŽEK, p. 37, pl. 21, figs1–5, pl. 6–10, text–figs 14–15.

Morphological Description: Leaves petiolate, petiole 15mm long, blade trilobite, 81mm long and 61mm wide, with narrow lobes, medial lobe slightly narrowing towards the base with low irregular blunt teeth.

Material: Ka 1-47

Acer integrilobum WEBER

pl 6.3, figs. 1, 2

1852	*Acer integrilobum* WEBER, p.196, pl. 22, figs. 22a–c.
1967	*Acer loclense* HANTKE, p. 266, pl. 5, figs. 1–2
1972	*Acer integrilobum* WEBER, p. 101, pl. 25, figs 1,3, 2, 4, 6, 5, 7–10, pl.26, figs1–3, 5, 4, 6, pl 55, figs, 1, 3, 2, 10, 4, 5, 6,7–9, pl. 56, figs. 6–7.
1975	*Acer pseudomonspessulanum* UNGER, p. 61, pro parte, text–fig. 21.
1994	*Acer pseudomonspessulanum* UNGER, p. 67, pl 1, fig. 3.
1995	*Acer* cf. *decipiens* A. BRAUN, p. 29, pl 10, fig. 2.

Morphological Description: Leaves long petiolate, petiole 65mm long, blade trilobite, 80mm long and 75mm wide, entire margin or with only small irregular teeth occasionally on the medial lobe as well as on the side lobes, base rounded to sub–cordate.

Material: Ka1, 2

Altingiaceae

Liquidambar L.

Liquidambar europa A. BRAUN

pl 6.8, fig. 6

1836	*Liquidambar europa* A. BRAUN, p. 513.
1847	*Acer parschlugianum* UNGER, p.132, pl.43, fig. 5.
1847	*Liquidambar europaeum* A. BRAUN–UNGER, p. 120, pl. 35, figs. 1–5.
1850a	*Liquidambar protensum* UNGER, p.415.
1851a	*Liquidambar europaem* A. BRAUN–ETTINGSHAUSEN, p. 15, pl.2, figs. 20,22.
1852	*Liquidambar protensum* UNGER–UNGER, p.116, pl. 43, fig. 27.
1852	*Liquidambar acerifolium* UNGER–UNGER, p.116, pl. 43, fig. 26.
1878b	*Liquidambar europaem* A. BRAUN–ETTINGSHAUSEN, p. 86, pl.2, figs. 3, 4, pl. 3., fig 7,4.

Morphological Description: Leaf palmately 5–lobed with finely serrate margins, 4–6 cm in breadth and truncate base. The midvein, running through the middle of the particular lobes, branch out from one place near the base of the blade. The angle included between the nerves of the middle and of the neighbouring lobes is 30°–50° and that between the nerves of the middle and the lowest lobes ~70°.

Material: K281.

Berberiaceae

Berberis sp.

pl 6.8, fig. 12

Morphological Description: Leaves obovate, short petiole and denser secondaries, semicrospedodromous venation. 28mm long and 16mm wide. Base cunate and apex slightly rounded. Entire margin (Fig. 6.44).

Material: K66.

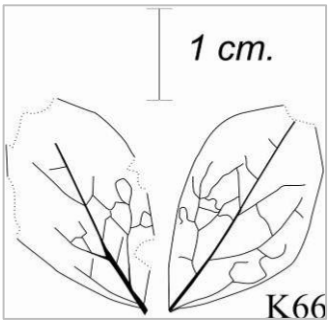


Figure 6.44 Text figures of *Berberis* sp.

Mahonia sp.

pl 6.19, fig. 2

Morphological Description: Leaf 55mm long and 10mm wide, tapering above to a long very sharp attenuated apex, the base not observed, secondaries numerous and thin, tertiaries irregular. Irregular spin margin (Fig. 6.45).

Material: K25.

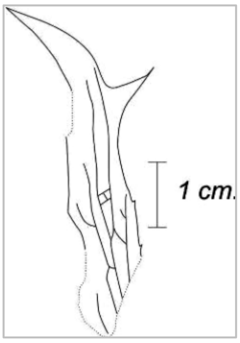


Figure 6.45 Text figures of *Mahonia* sp.

Betulaceae

Carpinus L.

Carpinus grandis UNGER emend. HEER

pl 6.2, fig. 1; pl 6.8, figs. 7–10

1852	*Carpinus grandis* UNGER, p.11, pl.10, figs.4–5 (non figs 2–3).
1853	*Carpinus grandis* UNGER, prochazka, p. 24, pl. 4, fig. 2a.

1854 *Carpinus grandis* UNGER, MAI & WALTER, p.69, pl. 7, figs 5–11, pl.11, fig. 5, pl. 29, figs 1–12.

1856 *Carpinus grandis* UNGER emend. HEER, p. 40, pars Pl. 72, Figs 2–11, 14, 16–24 (non Figs 12–13, 15 = *Carpinus* sp. fruct.); Pl. 73, Figs 2–4.

Morphological Description: Twings with alternate leaves, leaves simple, typically shortly petiolate, petiole 2–11 mm long, blade narrow oblong, oblong–ovate to ovate, 17–110 (typically 34) mm long, 12–45 (typically 33) mm wide, apex acute to shortly acuminate, rarely attenuate, base rarely cuneate, mostly rounded, subcordate to cordate, margin indistinctly double serrate, main teeth slightly longer, rarely more prominent, secondary teeth fine, venetation craspedodromous, midrib thick secondaries dense, in 8–17 (typically 14) pairs, sub–alternate to alternate, straight, at low angles running in to the main teeth sending to margin abmedial veinlets into secondary teeth, intersecondaries lacking, tertiaries percurrent, rarely forked perpendicular to slightly oblique to secondaries (Fig. 6.46).

Material: K1, K2, K3, K4 and H1.

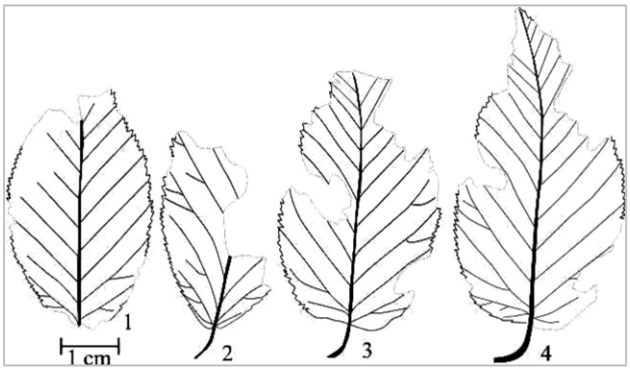


Figure 6.46 Text figures of *Carpinus grandis* UNGER emend. HEER

Alnus Mill

Alnus julianaeformis (STERNBERG) KVACEK & HOLÝ

pl 6.9, fig. 1

1823 *Phlyllites julianaeformis* STERNBERG, K.STERNBERG, p37, 39, pl.36, fig. 2.

1845	*Alnus gracilis* UNGER, p.116, pl. 33, figs. 5–7.
1949	*Alnus feraniae* (UNGER) NEMEJC, p.47, pl. 1, figs. 6–11, pl. 2, fig. 11, pl. 3, fig. 1, pl. 7, figs. 1–2.
1974	*Alnus julianaeformis* (STERNBERG) KVACEK & HOLÝ, p.367, text fig. 1, pl. 1–3, pl.4, fig. 1.

Morphological Description: Leaves petiolate 32mm wide and 42mm long, ovate, indistinctly double serrate, apex and base are not seen, venetation craspedodromous, midvein straight, prominent. Petiole 15mm long (Fig. 6.47).

Remarks: *Alnus julianaeformis* have *a* simetrical base, venetation craspedodromous and teeth irregular. But, *Alnus gaudinii* have asymmetrical base and semicraspedromous venetation.

Material: K46.

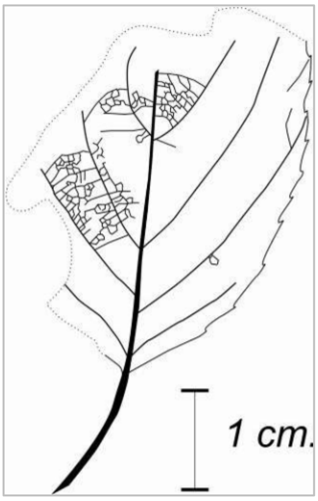


Figure 6.47 Text figures of *Alnus julianaeformis* (STERNBERG) KVACEK & HOLÝ

Alnus gaudinii (HEER) KNOBLOCK et KVACEK

pl 6.9, figs. 4a, 4b

1856	*Rhamnus gaudinii* HEER, O. HEER, p.79, pl. 124.
1954	*Rhamnus gaudinii* HEER, J. RANIECKA–BOBROWSKA, p. 20, pl. 9,

1976 *Alnus gaudinii* (HEER) KNOBLOCK & KVACEK, E. KNOBLOCK & Z. KVACEK, p.33, pl. 6, figs. 1, 3, pl. 7, figs. 1–5, pl. 13, fig. 4, pl. 15, figs. 1–4, 7, 8, 10, 11, 13, 15, 17, pl. 16, figs 1–5, pl. 19, fig 15, pl. 20, fig. 10, text figs 11, 12.

1988 *Alnus gaudinii* (HEER) KNOBLOCK & KVACEK, D. H. MAI & H. WALTHER, p. 65, pl. 34, figs 5–7, text fig. 5/11.

Morphological Description: Leaves narrow–ovate, to about 65mm long and 32mm wide. Venetation semicraspedodromous. Apex and base not observed. Simple sharply serrate (teeth irregular). The secondary veins run slightly curved towards the margin, where they form loops (Fig. 6.48).

Material: K6.

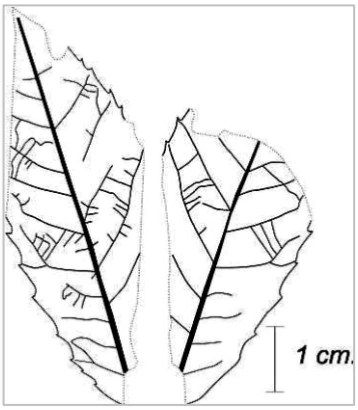


Figure 6.48 Text figures of *Alnus gaudinii* (HEER) KNOBLOCK et KVACEK

Alnus cecroplifolia (ETTINGSHAUSEN) BERGER

pl 6.2, fig. 6; pl 6.9, fig. 2

1851 *Artocarpidium cecropiaefolium* ETTINGSHAUSEN, C.V. ETTINGSHAUSEN, p.15, pl. 2, figs. 3–4.

1955 *Alnus cecropiaefolium* (ETTINGSHAUSEN) BERGER, W. BERGER, p. 87, fig. 30. p.15, pl. 2, figs. 3–4.

Morphological Description: Leaf simple, petiolate, nearly orbiculate, 50mm wide and 66mm long, serrate, widely cunate rounded to truncate at the base, apex not observed, venation craspedodromous, midvein straight, secondaries almst straight (Fig. 6.49).

Material: K55

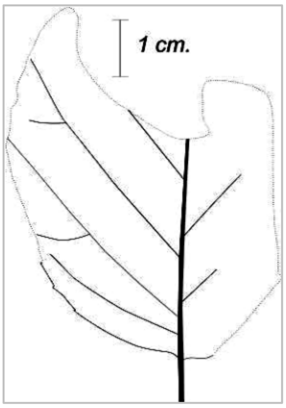


Figure 6.49 Text figures of *Alnus cecroplifolia* (ETTINGSHAUSEN) BERGER

Alnus adscendens (GOEPPERT) ZASTAWNIAK & WALTHER

pl 6.9, figs. 5, 6a, 6b

1852	*Carpinus betuloides* UNGER, p.43, fig. 6.
1855	*Betula dryadum* BRONGN., H.R. GOEPPERT, p. 10, pl. 3, fig. 1.
1855	*Betula crenata* GOEPPERT, H. R. GOEPPERT, p. 11, pl. 3, figs. 7, 6.
1855	*Betula subovalis* GOEPPERT, H. R. GOEPPERT, p. 12, pl. 3, fig. 17.
1855	*Alnus pseudoglutinosa* GOEPPERT, H. R. GOEPPERT, p. 12, pl. 4, fig. 1.
1855	*Alnus rotundata* GOEPPERT, H. R. GOEPPERT, p. 12, pl. 4, fig. 4.
1855	*Quercus ovata* GOEPPERT, H. R. GOEPPERT, p. 17, pl. 8, fig. 6.
1996	*Alnus adscendes* (GOEPPERT) ZASTAWNIAK et WALTHER, p. 875, pl. 290, figs. 5, 7.
1998	*Alnus adscendes* ZASTAWNIAK et WALTHER, p. 88, pl. 1, figs. 1–5, pl. 290, figs 5,7, pl. 3, figs. 4–10, pl. 4, figs 1–9, text figs. 1/1–16, 2/1–7, 9–10, 13–16a, 3/1–4, 7, 9–13, 15–17, 411–2, 4,6,8–9, 11, 14, 18/14, 19/8, 10.

Morphological Description: Leaves short petiolate, lamina 28 mm wide and 35 mm long, oval to broadly oval, irregular serrate, rounded to truncate at the base, rounded at the apex, venation craspedodromous, midvein straight, secondaries in 5 pair, the tertiary veins loin the secondaries nearly at right angles (Fig. 6.50).

Material: K56

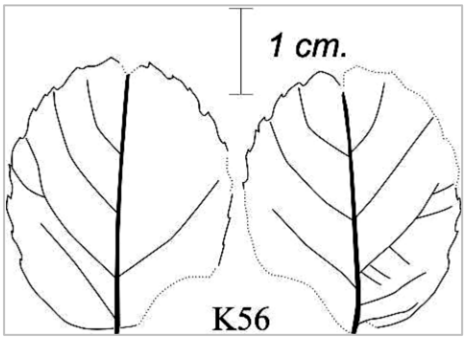


Figure 6.50 Text figures of *Alnus adscendens* (GOEPPERT) ZASTAWNIAK & WALTHER

Betula sp.

pl 6.9, fig. 3

Morphological Description: Leaves simple, 35mm wide and 51mm long, shape, broadly ovate to subtriangular, acumuminate at the apex, broadly rounded to truncate at the base, serrate. Venation crospededromous and midvein straight (Fig. 6.51).

Material: K24.

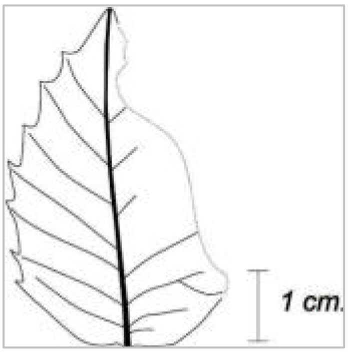


Figure 6.51 Text figures of *Betula* sp.

Fagaceae

Fagus L.

Fagus gussonii MASSALONGO emend. KNOBLOCH & VELITZELOS

pl 6.2, fig. 2; pl 6.15, figs. 1-5b

1859	*Fagus gussonii* MASSALONGO in MASSALONGO & SCARABELLI, 202, p.25, figs 2, 5.
1954	*Fagus gussonii* KNOBLOCH & VELITZELOS, p. 9, pl. 2, figs. 2–4, 6–8, pl.5, fig. 11, pl. 6, fig. 5.
1999	*Fagus gussonii* VELITZELOS & KVACEK, p.420, pl.1, fig.1.

Morphological Description: Leaves narrow to wide oval, petiolate, blade typically 36–44 wide and 75–100mm long, partly undulate or simple dentate, with teeth small, usually blunt and indistinct, venation craspedodromous, secondaries regularly spaced, directed towards the teeth (Fig. 6.52).

Material: K2

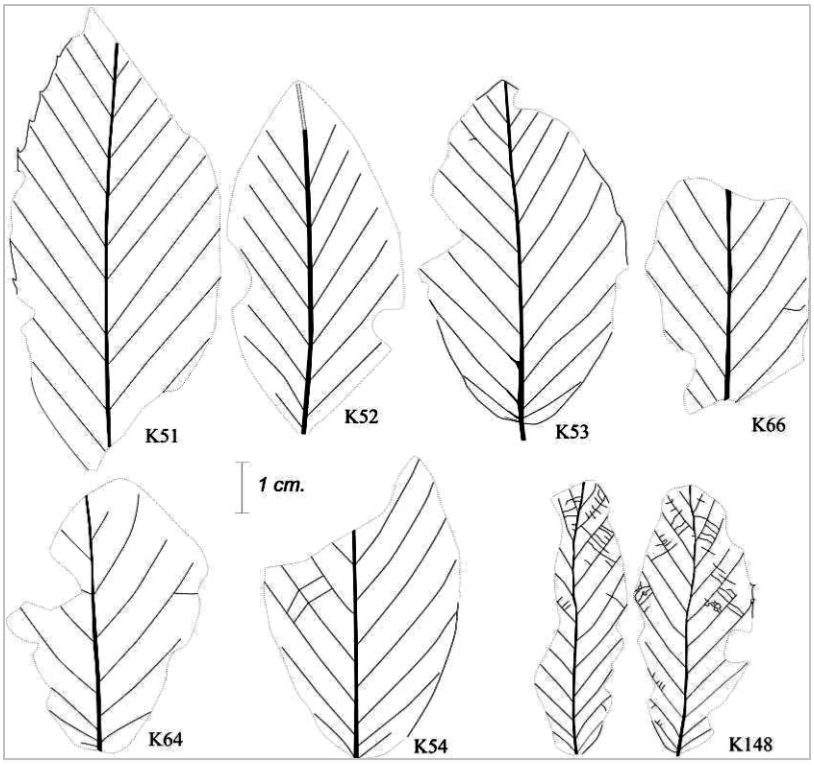


Figure 6.52 Text figures of *Fagus gussonii* MASSALONGO emend. KNOBLOCH & VELITZELOS

Quercus L.

Quercus kubinyii (KOVÁTS ex ETTINGSHAUSEN) CZECZOTT

pl 6.19, fig. 1

1851	*Castanea kubinyii* KOVÁTS, p.178, nomen nudum.
1852	*Castanea kubinyii* (KOVÁTS ex ETTINGSHAUSEN), p. 6, Pl. 1, fig. 12.
1951	*Quercus kubinyii* (KOVÁTS) CZECZOTT, p. 392, fig. 7.
1976	*Castanea kubinyii* (KOVÁTS ex ETTINGSHAUSEN) KNOBLOCH & KVACEK, p. 35–38, fig. 13, 14, Pl. 16, figs 7–9, Pl. 18, figs 1, 4–10, Pl. 23, figs 4, 6, 8–11, Pl. 31, fig. 7.
1996	*Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) CZECZOTT; KNOBLOCH & KVACEK, p. 51–52, fig. 1, 2, Pl. 7, figs 3, 6, Pl. 8, figs 1, 2.

Morphological Description: Leaves petiolate and leaves narrow–elliptic to lanceolate, blade 22–45 mm wide and 40 to more than 105 mm long, elongate, narrow acute at apex, cunate to rounded at the base, sharply simple dentate with teeth mucronate, triangulate to reduced to form wavy margin, lower part of the lamina entire; venation craspedodromous, midvein straight, thick, secondaries simple, straight, regularly disposed, typically in 12 and more pairs, tertiaries oblique, mostly percurrent, higher order venation not preserved (Fig. 6.53).

Material: K7.

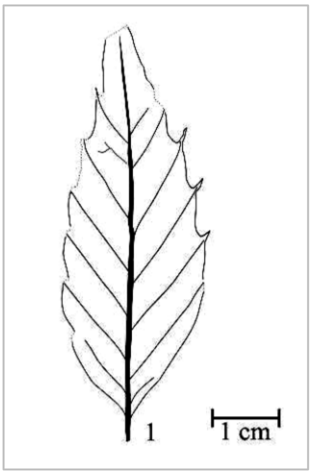


Figure 6.53 Text figures of *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) CZECZOTT

Quercus mediterranea UNGER

pl 6.2, fig. 5; pl 6.10, figs. 1-15

1847	*Quercus mediterranea* UNGER, p. 114, pl.32, figs. 5–6.
1850	*Quercus mediterranea* UNGER–UNGER, p.400.
1852	*Quercus mediterranea* UNGER–UNGER, p.35, pl. 18, figs. 1–6.

Morphological Description: Leaves simple, petiolate, 20 to 35mm wide and 25–50mm long. Shape broadly obovate, ovate to oval. Base acute or rounded, rarely cordate and apex slightly emergine. Mostly finely widely serrate at least in the upper half of the lamina. Venation craspedodromous, midvein stout, upper part more slender. Secondary veins distinct, in 5 to 9 pairs, running straight or bent towards the leaf margin entering the teeth Fig. 6.54).

Material: K11–23, K26, K28–30 and K41.

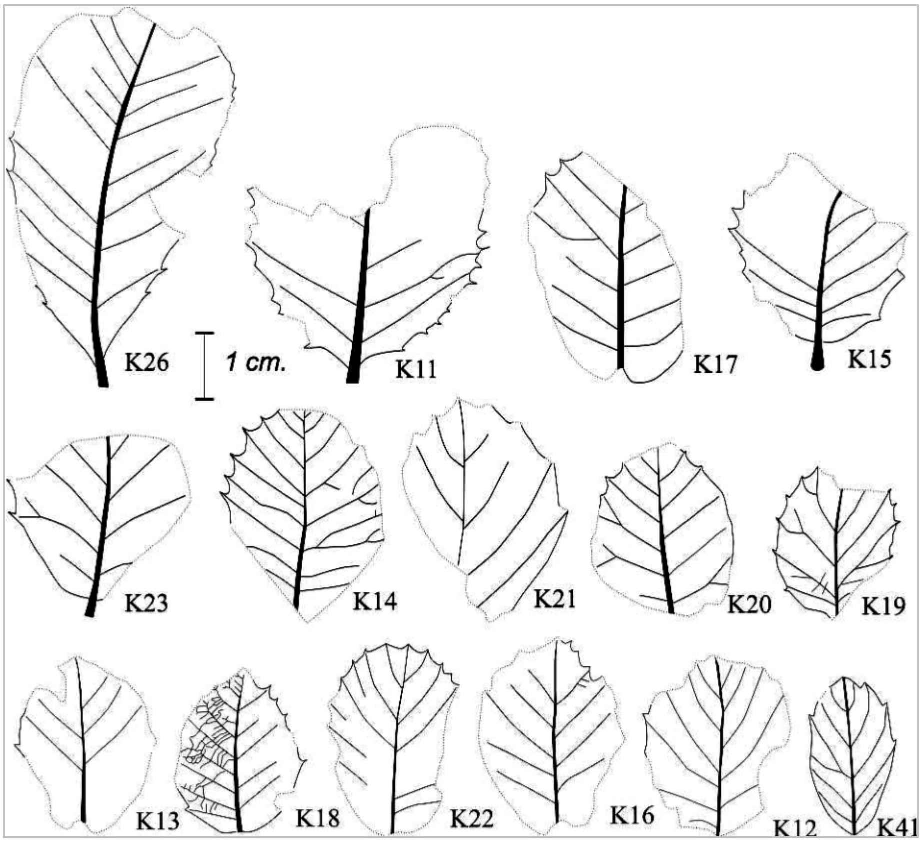


Figure 6.54 Text figures of *Quercus mediterranea* UNGER

Quercus sosnowskyi KOLAKOVSKII

pl 6.11, figs. 11, 16, 17

1955	*Quercus sosnowskyi* KOLAKOVSKII, p. 247, pro porte, pl.8, figs. 3–4, 6–7, pl. 20, fig 1, 3, 5, pl. 21, fig2, pl. 22, figs. 1–3.
1964	*Quercus sosnowskyi* KOLAKOVSKII, p. 89, pl. 25, figs. 3–11, pl. 26, figs. 2–4, pl. 27, fig. 3, pl. 31, figs 2–7, pl. 32, figs. 1–10, pl. 33, figs. 1–5, pl. 34, figs. 1–5, pl. 35, figs. 1–10.
1955	*Quercus alienaeformis* KOLAKOVSKII, p. 240, pl. 9, fig. 1.
1955	*Quercus semiacutidentata* KOLAKOVSKII, p. 246, pl. 7, fig. 3.
1957	*Cyclobalonopsis palaeoacuta* KOLAKOVSKII, p. 263, pl. 26, fig. 2–4.
1957	*Quercus parodoxa* KOLAKOVSKII, p. 266, pl. 22, fig. 4.

Morphological Description: Leaves short petiolate (max. 10mm), lamina variable in size 15–26mm and 30–55mm long, broadly to narrowly oval–ovate, oblongate, highly variable in shape, blunt or acute at the apex, rounded to cunate at the base, margin antire in the lower leaf part, rarely higher, and dentate mostly in the apex area, corresponding to the secondaries or their branches, venation craspedodromous, midvein very prominent, straight, secondaries regularly spaced, sub–opposite or alternate, tertiaries usually distinct, percurrent or once forked (Fig. 6.55).

Material: K31, K34, K36 and K46.

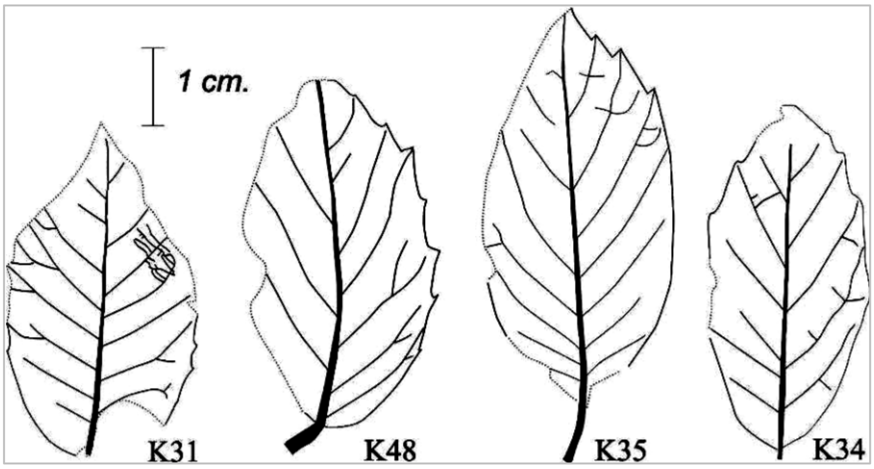


Figure 6.55 Text figures of *Quercus sosnowskyi* KOLAKOVSKII.

Quercus zorastri UNGER

pl 6.11, figs. 1-10, 12-15

1850a	*Quercus zoroastri* UNGER, p. 401 pro porte.
1850b	*Juglans hydrophila* UNGER, p. 196 pro porte, pl. 53, fig. 6.
1852	*Quercus zoroastri* UNGER–UNGER, p. 36, pro porte, pl. 18, figs. 7, 6.

Morphological Description: Leaves broad elliptic to ovate, oblongate, petiolate, cunate to rounded rarely cordate at the base, lamina size variable in size, 15–33mm. and 35–60mm long, venation craspedodromous, secondaries straight to slightly bent, dense, never forked, entering regular. Tertiary veins inconspicuous (Fig. 6.56).

Material: K28, K49–51, K32, K33, K35, K37–40, K42–52.

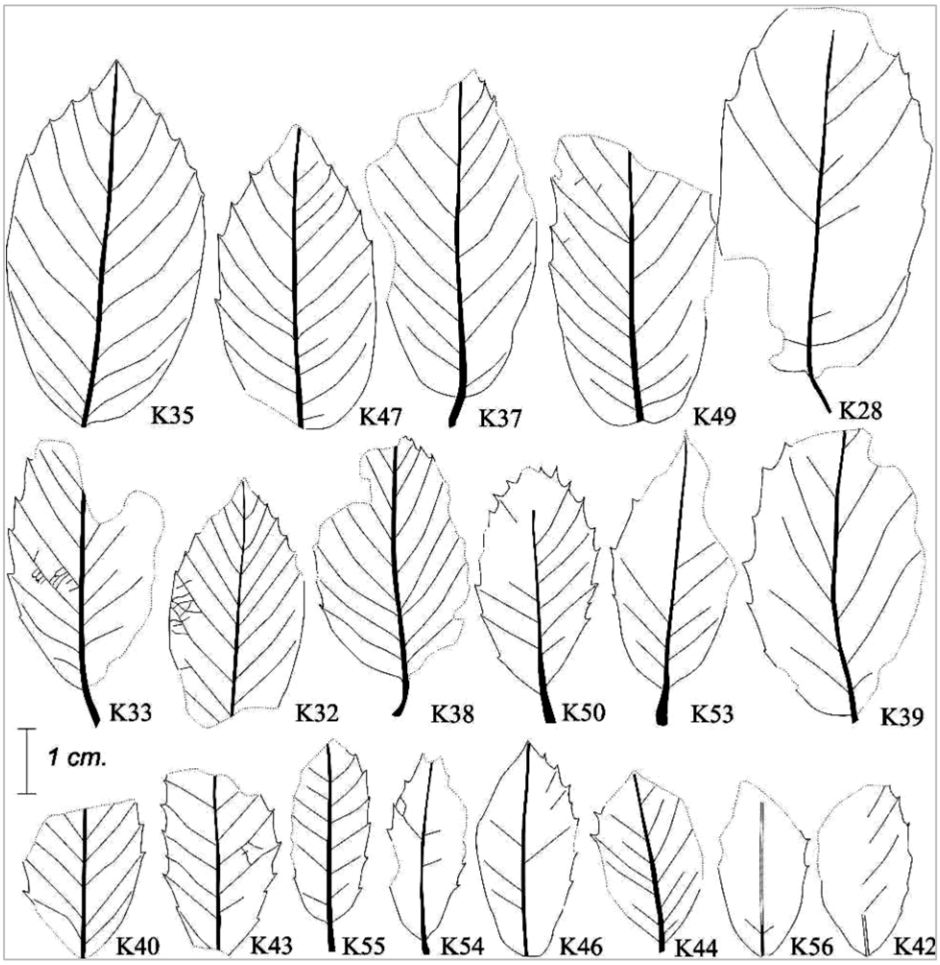


Figure 6.56 Text figures of *Quercus zorastri* UNGER

Quercus rehenana (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK

pl 6.12, figs. 1-15; pl 6.13, figs. 1-12; pl 6.14, figs. 1-11

1950	*Illicum rhenanus* KRÄUSEL et WEYLAND, p. 50, pl. 9, figs. 5–7, pl. 10, figs 1–2, pl. 11, fig. 8, text–fig 14.
1966	*Quercus lusatica* JÄHNICHEN, p.478, pl.1–4, 8,14, pl.21–22, text–figs1,3–4.
1976	*Quercus rhenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK, p. 41, pl. 17, fig. 6,8,14, pl. 21, figs. 5–6, pl. 24, fig. 10.
1981	*Laurus primigenia* VELENOVSKÝ, p. 30, pl. 5, figs. 1–5.

Morphological Description: Leaves elongate, entire margined with cunate (widened in the lower part) decurrent base. Leaf apex rounded to acute, up to 40mm long and 14–31mm wide, most probably narrow elliptic or lanceolate or obovate. Venetation brochidodromous. Primary vein straight, stout. Secondary veins curve upward. Close to the leaf margin secondaries interconnected in loops (Fig. 6.57).

Material: K107–146.

Quercus sp.

pl 6.15, fig. 7

Morphological Description: Leaf asymetrical narrow obovate, coarsely lobate–dentate. Base decurrent, apex not observed, midrib straight (Fig. 6.58).

Material: K96.

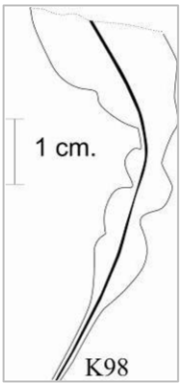


Figure 6.58 Text figures of *Quercus* sp.

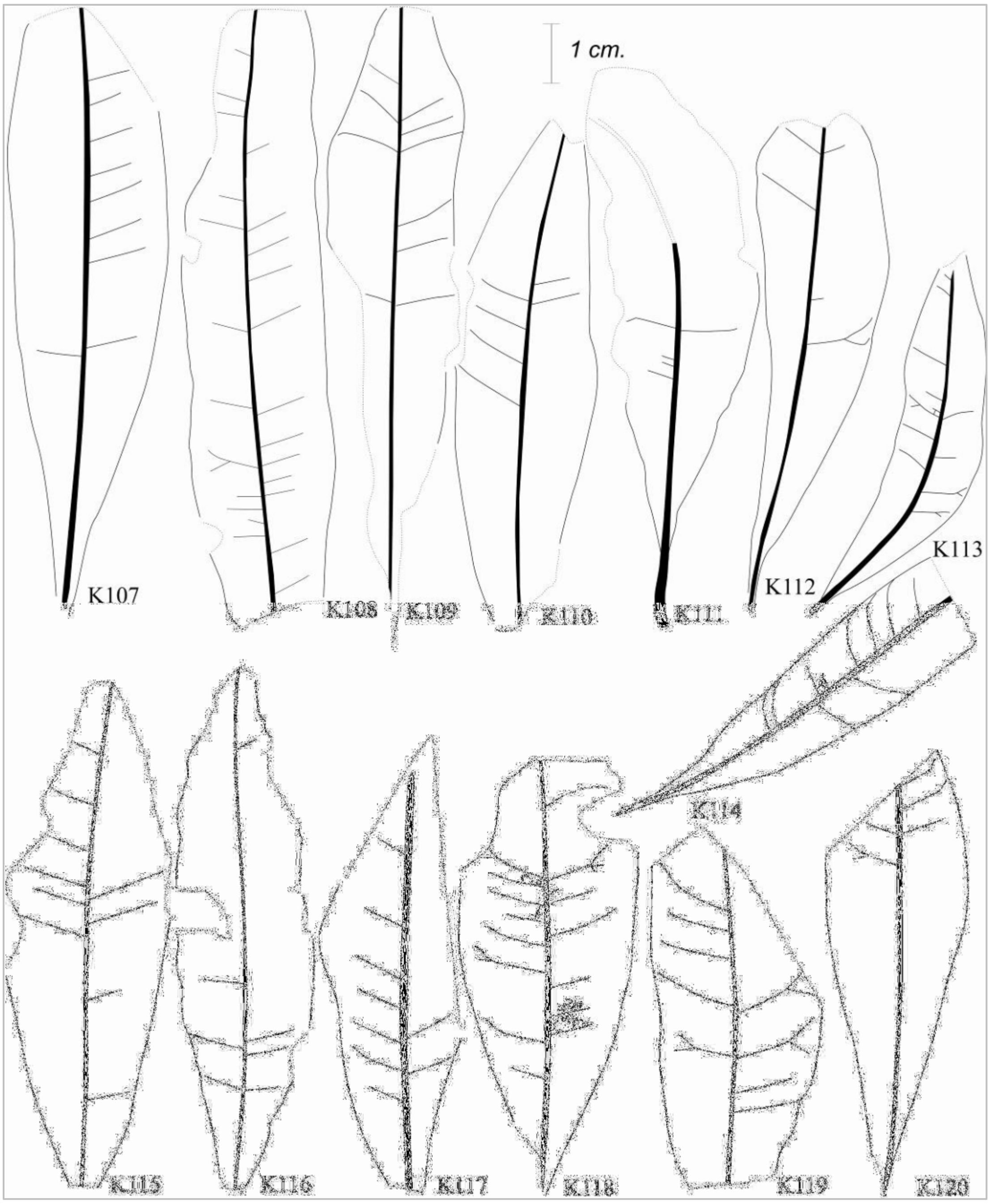


Figure 6.57a Text figures of *Quercus rehenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK

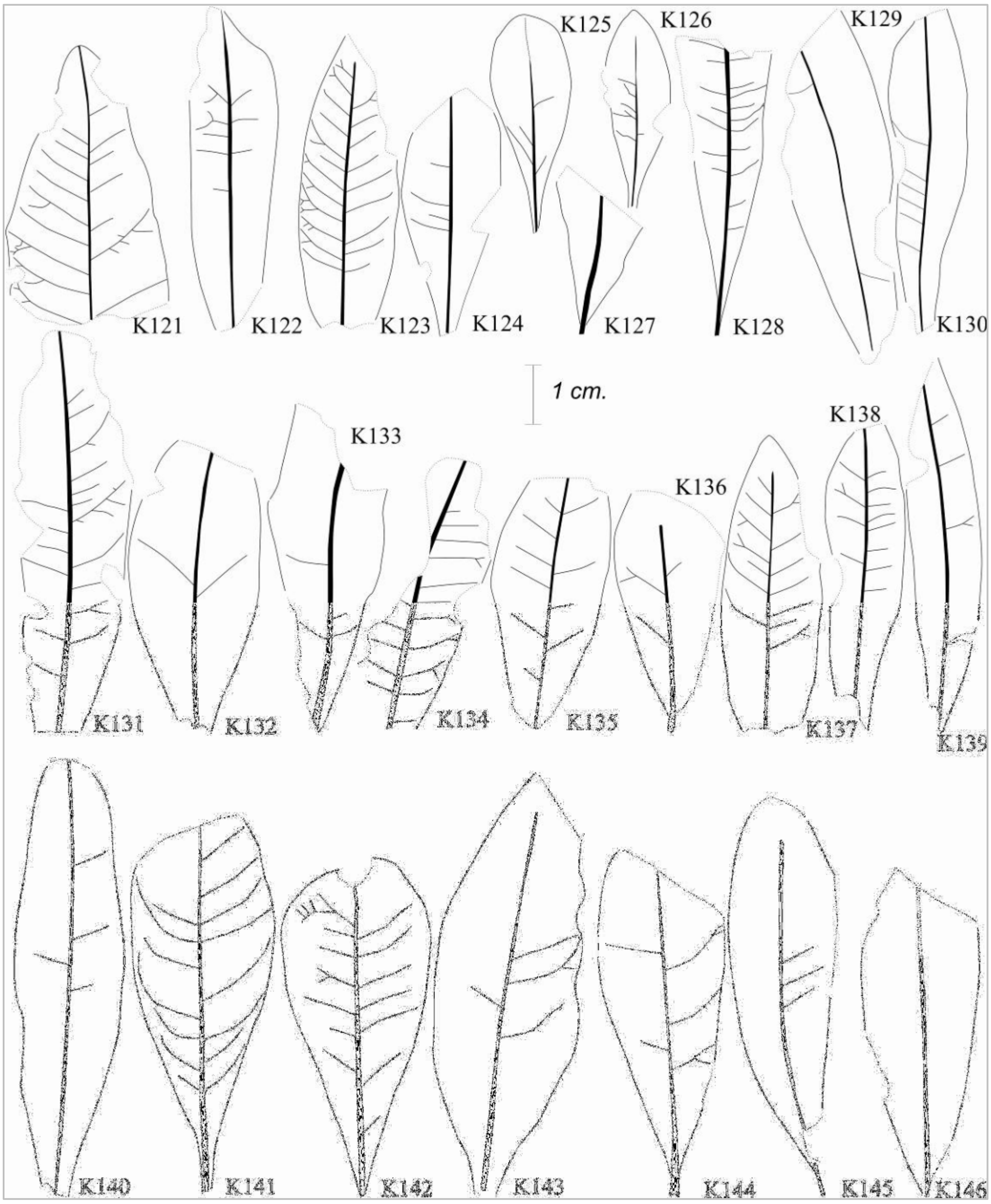


Figure 6.57b Text figures of *Quercus rehenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK

Hamamelidaceae

Hamamelis sp.

pl 6.9, fig. 7

Morphological Description: Leaf suborbiculate, 51mm wide, 67mm long, apex acuminate, base convex, simple sharply serrate, teeths are irregular, short petiolate, venation craspedromous, midrib straight, secondaries in 8 pairs. The secondaries slightly curved toward the margin (Fig. 6.59).

Material: K101

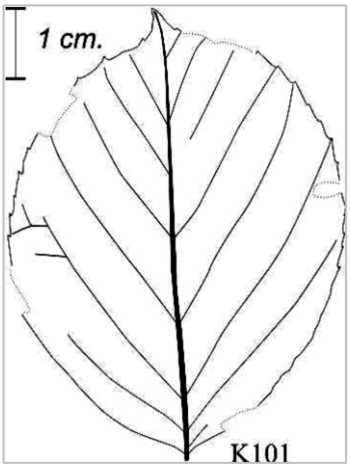


Figure 6.59 Text figures of *Hamamelis* sp.

Lauraceae

Daphnogene UNGER

Daphnogene polymorpha (AL. BRAUN) ETTINGSHAUSEN

pl 6.2, fig. 3, 3a; pl 6.16, fig. 9

1845	*Ceanothus polymorphus* (AL. BRAUN), p. 171.
1851	*Daphnogene polymorpha* (AL. BRAUN) ETTINGSHAUSEN p.16, Pl.2, fig. 23–25.

Morphological Description: Frangmentary leaves, entire margin. Apex not seen, base acute. 35mm long and 10mm wide. Midvein straight.

Material: K151

Myricaceae

Myrica L.

Myrica lignitum (UNGER) SAPORTA

pl 6.2, fig. 4; pl 6.17, fig. 1-4a

1847	*Quercus lignitum* UNGER, p. 113, pl. 31, figs. 5–7
1850	*Quercus lignitum* UNGER–UNGER p. 402.
1850	*Quercus lignitum* UNGER, p. 34, pro porte, pl. 17, figs. 1–7.
1852	*Quercus commutata* UNGER, p. 35, pl. 17, figs. 8–10.
1865	*Myrica lignitum* (UNGER) SAPORTA, p. 102.

Morphological Description: Leaves simple, elongate, 15–18mm wide, 80–100mm long, partly coarsely to finely bluntly toothed, partly entire marginated, apex acute, base cunate to decurrent, venation crospedodromous midrib thick, secondaries dense, looping within the lamina (Fig. 6.60).

Material: K94–96, K100

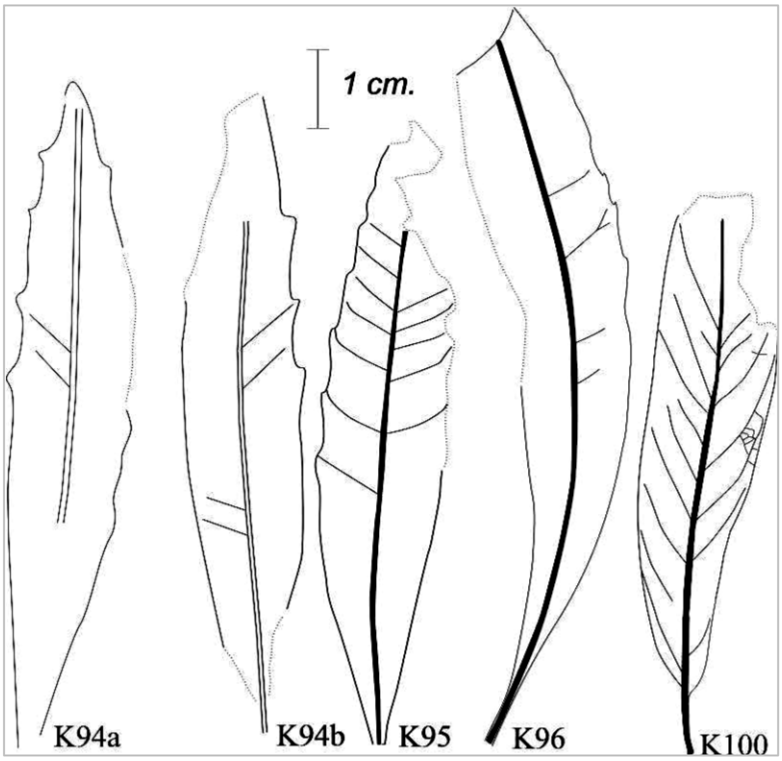


Figure 6.60 Text figures of *Myrica lignitum* (UNGER) SAPORTA

Nyssaceae

Nyssa bilinica (UNGER) KVACEK

pl 6.16, figs. 1-8

1866	*Laurus bilinica* UNGER, Pl. 25:75, Pl. 22, fig. 16.
1868	*Apocynophyllum cinanchum* UNGER, p. 217, pl. 36, fig. 16.
1972	*Nyssa haidingeri* (ETTINGSHAUSEN) Z. KVACEK & BUŽEK, P. 373, Pl. 1, figs 1–2, 5, Pl. 2, figs 1–2, pl.3, figs 1,3, Pl. 4, figs 1–5, text–fig. 1.
1992	*Nyssa haidingeri* (ETTINGSHAUSEN) Z. KVACEK & BUŽEK; Bužek et al., p. 125, pl. 3, fig. 8, text–fig. 4–6.
2000	*Nyssa haidingeri* (ETTINGSHAUSEN) Z. KVACEK & BUŽEK; KVACEK, p. 18, pl. 8, fig. 1, text–fig 1.3. 3, 16.

Morphological Description: Leaves petiolate, rather large, cunate at the base, apex not observed, leaf entire, venation brachidodromous, midrib thick and prominent, slightly bent, secondaries more than 9, alternate to sub–oposite, partly forked, at angles of 90^o in the lower part (Fig. 6.61).

Material: K57–65.

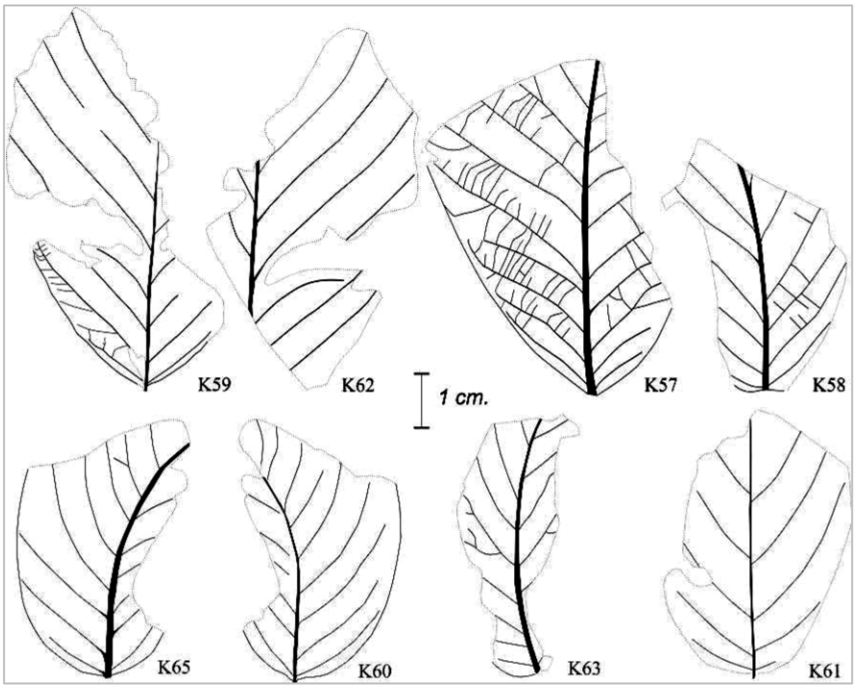


Figure 6.61 Text figures of *Nyssa bilinica* (UNGER) KVACEK

Rhamnaceae

“Rhamnus” warthae HEER

pl 6.16, figs. 10-15

1872	*Rhamnus warthae* HEER, p. 23, Pl. 5, figs 2, 3, 4a, Pl. 6, figs. 3–5.
1887	*Rhamnus warthae* HEER, STAUB, p. 360, Pl.38, figs. 1–2.
1991	*“Rhamnus” warthae* HEER, KVACEK & HABLY, p. 64, Pl. 12, figs. 1,4.
1996	*Rhamnus warthae* HEER, GIVULESCU, p70, pl. 4, fig. 6, pl.10, fig. 1.

Morphological Description: Leaves simple. Lamina 11–21mm wide and 32–60mm long. Shape of lamina ovate to lanceolate. Apex acute and base cunate. Venation comptodromous–brachidodromous. Midvein, secondaries and also the tertiaries are strong, well observed. Secondaries as well as the tertiaries form compound loops are very characteristic of species. Margin tooted and teeth irregular very thin and small (Fig. 6.62).

Material: K27, K57–58, K92–93.

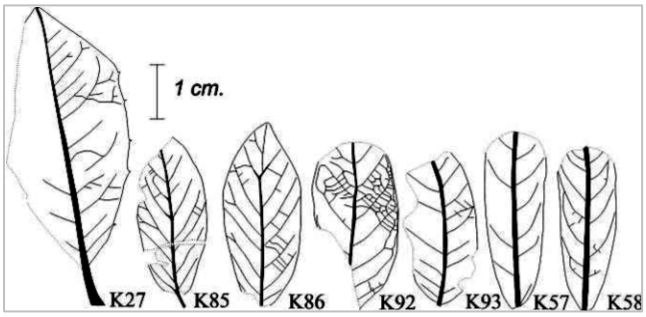


Figure 6.62 Text figures of *“Rhamnus” warthae* HEER

Salicaceae

Populus L.

Populus populina (BRONGNIART) KNOBLACH

pl 6.16, fig. 16

1822	*Phyllites populina* BRONGNIART, p. 237, Pl. 14, fig. 4.
1836	*Populus latior* A. BRAUN, p. 512
1852	*Populus latior* A. BRAUN–UNGER, p.45, Pl. 21, figs 3–5.
1964	*Populus populina* (BRONGNIART) KNOBLACH, p. 601.

Morphological Description: Leaves petiolate, lamina transversally obovate, 35–65mm wide and 35 to 70mm long, roundish to broadly oval, bluntly widely acute to rounded at the apex, widely cunete to rounded at the base, coarsely or finely toothed–undulate on margin with teeth blunt and rounded on tips, glandular; venation 3–palmately veined, semicraspedodromous, primaries straight, admedially slightly bent, lateral sending off dense subparallel side veinlets looping along the margin, secondaries, particular the first pair from the lamina base, widely spaced, in 2–3 pairs, slightly bent and looping together with the lateral primaries, interspaced with one to several intersecondaries, reaching hardly half way the lamina with and merged with meshes of tertiaries, these rarely percurrent, mostly forked even several times, perpendicular to secondaries and primaries, forming irregular meshes of higher–order venetation (Fig. 6.63).

Material: K103; Ka 103a

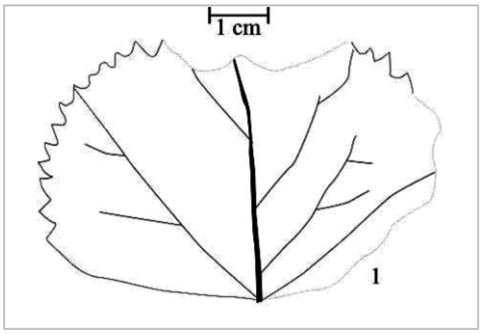


Figure 6.63 Text figures of *Populus populina* (BRONGNIART) KNOBLACH

Ulmaceae

Zelkova (SPACH)

Zelkova zelkovifolia (UNGER) BUŽEK et KOTLABA

pl 6.19, fig. 3-5

1843	*Zelkova zelkovifolia* UNGER, p.24, figs. 9–13.
1845	*Zelkova zelkovifolia* UNGER, p.26, fig. 7.
1847	*Zelkova zelkovifolia* UNGER, p.94.
1963	*Zelkova zelkovifolia* (UNGER) BUŽEK et KOTLABA, in KOTLABA p.59, pl.3, figs. 7–6.

Morphological Description: Leaves ovate, shortly petiolate, 27–70mm long and 15–78mm wide, base subcordate to wide cunate, sometimes slightly to strongly asymmetrical, apex acute, partly extremely long, when teeth extreme coarse, margine simple coarsely serrate, teeth slightly convex or straight on admedial side, in rare cases teeth extremely convex/concave or slightly convex to straight with more or less long acute apices. Venetation craspedodromous, midrib thick, secondaries typically in 6–9 pairs, thin slightly bent, entering marginal teeth. In subcordate leaves the first basal secondary vein bifurcates into two branches which turn into the teeth. Tertiaries mostly not observed (Fig. 6.64).

Material: K5 and K6.

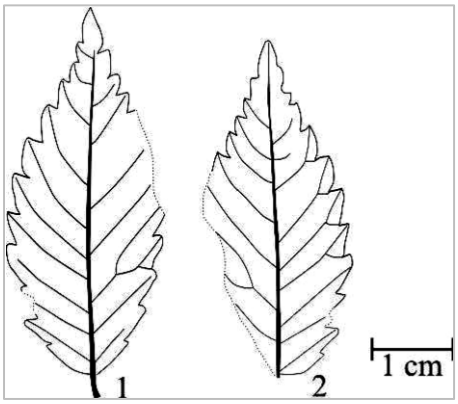


Figure 6.64 Text figures of *Zelkova zelkovifolia* (UNGER) BUŽEK et KOTLABA

Dicotylophyllum sp. 1

pl 6.18, fig. 1

Morphological Description: One fragmentary leaves with ovate outline, 48mm long (perhaps more) and 30 mm wide. Petiolate and it is 0.5mm long. Base of lamina rounded and apex not seen. Entire margin. Midvein straight (Fig. 6.65).

Material: K68

Dicotylophyllum sp. 2

pl 6.18, figs. 2, 3

Morphological Description: Two complete leaves, petiolate, 7mm long leaves with elliptic or ovate. Lamina 48–58mm long and 14–20mm wide. Base rounded or cunate, apex acute. Entire margin. Midvein straight. Secondaries in 7–10 pairs, tertiaries usually distinct (Fig. 6.66).

Material: K69, K70

Dicotylophyllum sp. 3

pl 6.18, fig. 4

Morphological Description: Leaves long petiolate (petiole 14mm long), obovate, 70mm long, 43mm wide, toothed margin, teeths are irregular and seen the apex area. Midvein very prominent, secondaries straight. Base convex, apex not seen (probably rounded) (Fig 6.67).

Material: K104

Dicotylophyllum sp. 4

pl 6.18, figs. 5-14

Morphological Description: Leafs petiolate, 9mm long. Leaves with elliptic. 58–30mm long and 27–16mm wide. Base rounded or slightly cunate. Apex acute. Entire margin. Midvein straight. Secondaries alternate and in 7 pairs. Secondaries forked near the margin. These leaves resemble to Lauraceae family (Fig. 6.68).

Material: K71–86

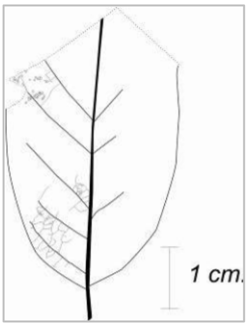


Figure 6.65 Text figures of *Dicotylophyllum* sp.1

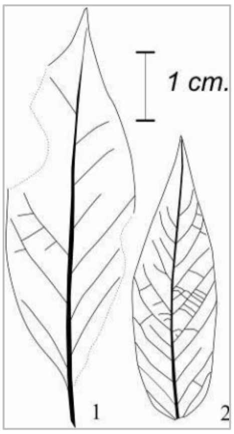


Figure 6.66 Text figures of *Dicotylophyllum* sp.2

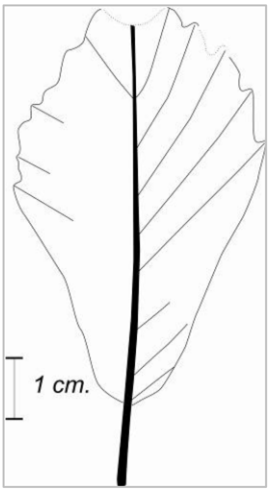


Figure 6.67 Text figures of *Dicotylophyllum* sp. 3

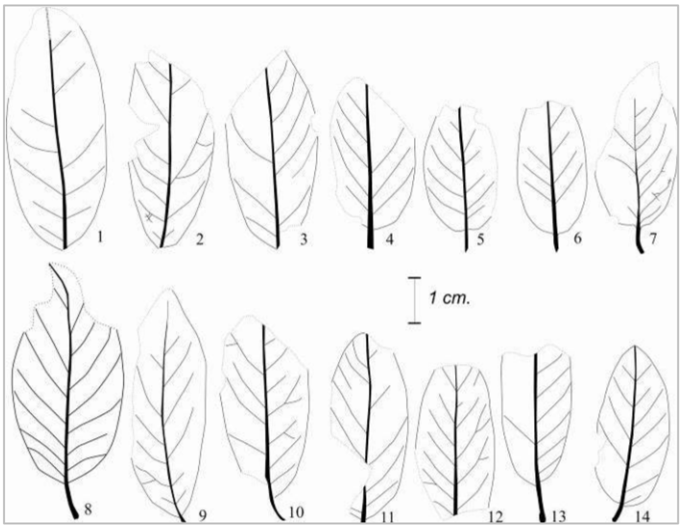


Figure 6.68 Text figures of *Dicotylophyllum* sp. 4

Dicotylophyllum sp. 5

pl 6.18, fig. 15

Morphological Description: One fragmentary leaves, 55mm long (perhaps more) and 50mm wide. Base not preserved, apex obtuse. Entire margin. Midvein straight. Secondaries more than 7 and partly forked near the margin (Fig. 6.69).

Material: K106a and b

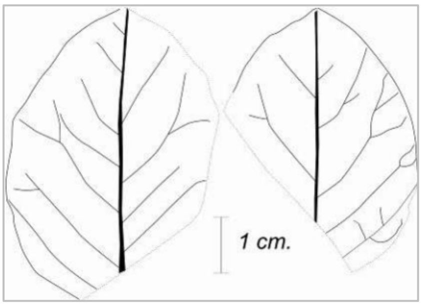


Figure 6.69 Text figures of *Dicotylophyllum* sp. 5

Dicotylophyllum sp.6

pl 6.18, figs. 16, 17

Morphological Description: Four fragmentary leaves, 64–35mm long and 31–28mm wide. Leaves elliptic, base rounded, apex not observed. Midvein straight and secondaries opposite. Tertiary rare preserved (Fig. 6.70).

Material: K83, K84, K91 and K105

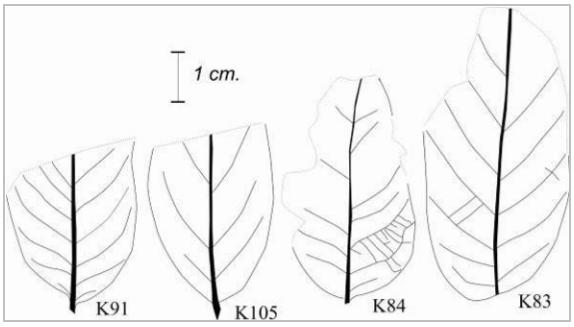


Figure 6.70 Text figures of *Dicotylophyllum* sp. 6

Figure 6.71 indicates the undeterminated dicotyledone species in the Karacaagaç macroflora.

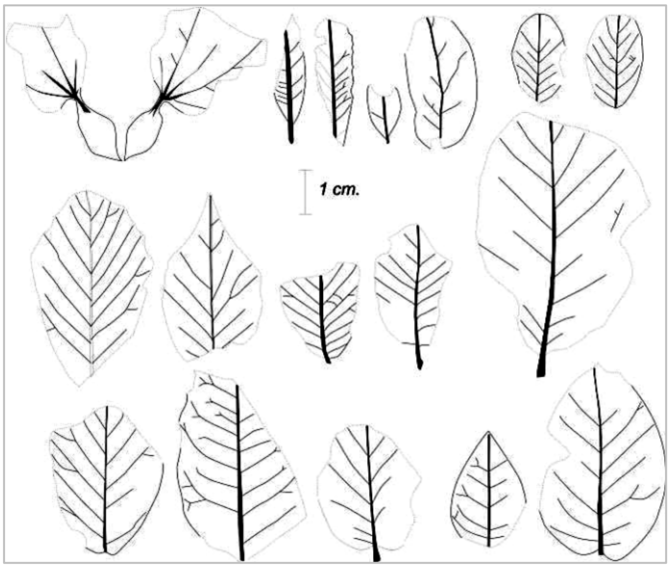


Figure 6.71 Text figures of undeterminated dicotyledone (Plate 6.15 and Fig.6).

6.6 Composition of the Macrofloras in the Ören Region

Totally 276 leaf fossils have yielded in the investigated areas (Karacaagaç, Hüsamlar and Alakilise regions). These fossils compose of the 3 gymnospermae and 33 angiospermae (including 7 taxa with uncertain systematic position). Karacaagaç flora is characterized by the dominance of *Acer integrilobum, Fagus gussonii, Quercus mediterranea, Quercus zorastri* and *Quercus rehenana,* commonly of *Pinus* sp., *Glyptostrobus europaeus, Carpinus grandis, Alnus cecroplifolia, Quercus sosnowskyi, Myrica lignitum, Nyssa bilinica, "Rhamnus" warthae, Populus populina* and *Zelkova zelkovifolia*, rare of *Taxodium dubium, Acer angustilobul, Liquidambar europa, Berberis* sp., *Mahonia* sp., *Alnus julianaeformis, Alnus gaudinii, Alnus adscendens, Betula* sp., *Quercus kubinyii, Quercus* sp., *Hamamelis* sp. and *Daphnogene polymorpha* (Tables 6.2, 6.3). Hüsamlar flora is represented by the abundantly *Daphnogene polymorpha,* commonly *Fagus gussonii* and rare *Carpinus grandis, Alnus cecroplifolia, Quercus mediterranea* and *Myrica lignitum*. Leaf fossils in Alakilise region are poorly preserved and palaeoflora of this region is only characterized by the *Pinus* sp., *Glyptostrobus europaeus* and *Myrica lignitum.*

Table 6.2 Floral list of the Karacaagaç, Hüsamlar and Alakilise floras of the Early Miocene (symbols of approximate abundance: D– dominant, C– common, R– rare or single).

Family and Genus	**Locations**		
GYMNOSPERMAE	**Karacaagaç**	**Hüsamlar**	**Alakilise**
Pinaceae			
Pinus sp.	C		R
Taxodiaceae			
Glyptostrobus europaeus (BRANGNIART) UNGER	C		R
Taxodium dubium (STERNBERG) HEER	R		
ANGIOSPERMAE			
***Acer* L.**			
Acer angustilobul HEER	R		
Acer integrilobum WEBER	D		
Altingiaceae			
Liquidambar europa A. BRAUN	R		
Berberiaceae			
Berberis sp.	R		
Mahonia sp.	R		
Betulaceae			
Carpinus L.			
Carpinus grandis UNGER emend. HEER	C	R	
***Alnus* Mill**			
Alnus julianaeformis (STERNBERG) KVACEK & HOLÝ	R		
Alnus gaudinii (HEER) KNOBLOCK et KVACEK	R		
Alnus cecroplifolia (ETTINGSHAUSEN) BERGER	C	R	
Alnus adscendens (GOEPPERT) ZASTAWNIAK & WALTHER	R		
Betula sp.	R		
Fagaceae			
***Fagus* L.**			
Fagus gussonii MASSALONGO emend. KNOBLOCH & VELITZELOS	D	C	
***Quercus* L.**			
Quercus kubinyii (KOVÁTS ex ETTINGSHAUSEN) CZECZOTT	R		
Quercus mediterranea UNGER	D	R	
Quercus sosnowskyi KOLAKOVSKII	C		
Quercus zorastri UNGER	D		
Quercus rehenana (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK	D		
Quercus sp.	R		
Hamamelidaceae			
Hamamelis sp.	R		
Lauraceae			
***Daphnogene* UNGER**			
Daphnogene polymorpha (AL. BRAUN) ETTINGSHAUSEN	R	D	
Myricaceae			
***Myrica* L.**			
Myrica lignitum (UNGER) SAPORTA	C	R	R
Nyssaceae			
Nyssa bilinica (UNGER) KVACEK	C		
Rahamnaceae			
“Rhamnus” warthae HEER	C		
Salicaceae			
***Populus* L.**			
Populus populina (BRONGNIART) KNOBLACH	C		
Ulmaceae			
***Zelkova* (SPACH)**			
Zelkova zelkovifolia (UNGER) BUŽEK et KOTLABA	C		
Dicotylophyllum sp.1	R		
Dicotylophyllum sp.2	C		
Dicotylophyllum sp.3	R		
Dicotylophyllum sp.4	D	R	
Dicotylophyllum sp.5	C		
Dicotylophyllum sp.6	C		
Undeterminated dicotyledone	C	C	

Table 6.3 Floral list of the Karacaagaç, Hüsamlar and Alakilise floras of the Early–Middle Miocene and Nearest Living Relative, Palaeoclimatic Data and Area, Inferred vegetation storey and ecology.

Family and Genus	Fossil Taxon	Nearest Living Relative	Palaeoclimatic Data and Area	Inferred vegetation storey and ecology
Pinaceae	*Pinus* sp.	*Pinus* spp.	subtropical and temperate	evergreen, mesic/ evergreen conifer tree
Taxodiaceae	*Glyptostrobus europaeus*	*Glyptostrobus pensilis*	para–subtropical (SE China)	semi–evergreen, hygrophyllic
Taxodiaceae	*Taxodium dubium*	*Taxodium distichum, mucronatum*	subtropical and warm–temperate (SE USA, Mexico to Guatemala)	deciduous, hygrophilic
Sapindaceae/ *Acer*	*Acer angustilobul*	*Acer trautv. Pseudoplatanus*	subtropical and warm temperate central Europe and southwestern Asia, from France east to Poland, and south in mountains to northern Spain, northern Turkey, and the Caucasus	deciduous
Sapindaceae/ *Acer*	*Acer integrilobum*	*Acer monspessulanum* vel *cappadocicum* group	subtropical and warm temperate (Mediterranean)	deciduous, mesic
Altingiaceae	*Liquidambar europa*	*Liquidambar styracif*	warm temperate (north America)	deciduous
Berberiaceae	*Berberis* sp.	*Berberis* spp.	temperate and subtropical regions (Europe, Asia, Africa, North America and South America)	deciduous and evergreen, shrub
Berberiaceae	*Mahonia* sp.	*Mahonia* spp.	temperate and subtropical regions (eastern Asia, the Himalaya, North America and Central America)	evergreen shrub
Betulaceae/*Carpinus*	*Carpinus grandis*	*Carpinus* spp.	subtropical and temperate	deciduous, mesic/ deciduous broad–leaved
Betulaceae/*Alnus*	*Alnus julianaeformis*	? *Alnus trabeculosa*	subtropical and temperate (SC China, Japan)	deciduous, hygrophilic
Betulaceae/*Alnus*	*Alnus gaudinii*	? *Alnus nitidia*	subtropical (Himalayas)	deciduous, hygrophilic/deciduous broad–leaved tree
Betulaceae/*Alnus*	*Alnus cecroplifolia*	? *Alnus glutinosa* var. *barbata*	warm temperate (Caucasus, Persia)	deciduous, hygrophilic
Betulaceae/*Alnus*	*Alnus adscendens*	*Alnus* spp.	?	deciduous, ? mesic
Betulaceae	*Betula* sp.	*Betula* spp.	?	deciduous
Fagaceae/*Fagus*	*Fagus gussonii*	*Fagus orientalis*	warm temperate (SE Europe, Near East)	deciduous, mesic
Fagaceae/*Quercus*	*Quercus kubinyii*	? *Quercus variabilis* group	warm temperate (E Asia)	deciduous, mesic

Table 6.3.Continued

Fagaceae/*Quercus*	*Quercus mediterranea*	*Quercus coccifera* group	subtropical (Mediterranean)	sclerophyll, mesic–xeric
Fagaceae/*Quercus*	*Quercus sosnowskyi*	? *Quercus alnifolia*	subtropical (Cyprus)	sclerophyll, mesic
Fagaceae/*Quercus*	*Quercus zorastri*	?	subtropical (Cyprus)	sclerophyll, mesic
Fagaceae/*Quercus*	*Quercus rehenana*	*Quercus flagerifera* Trel., *Quercus imbricaria* michx. *Quercus laurifolia* michx., *Quercus viryiniana* Mill.	subtropical	deciduous or semi – evergreen swamp, riparian and mesophytic forest
Fagaceae/*Quercus*	*Quercus* sp.	*Quercus* spp.	?	deciduous
Hamamelidaceae	*Hamamelis* sp.	*Hamamelis* spp.	?	deciduous, shrub
Lauraceae/*Daphnogene*	*Daphnogene polymorpha*	?	?	evergreen
Myricaceae/*Myrica*	*Myrica lignitum*	*Myrica* spp.	?	evergreen broad–leaved tree or shrub
Nyssaceae/*Nyssa*	*Nyssa bilinica*	?	?	evergreen, swamp
Rhamnaceae	*“Rhamnus” warthae*	?	?	swamp
Salicaceae/*Populus*	*Populus populina*	*Populus alba* group	warm temperate and teperate (Eurasia)	deciduous, mesic
Ulmaceae/*Zelkova*	*Zelkova zelkovifolia*	*Z. carpinifolia, abelicea*	subtropical and warm temperate (Caucasus, Crete)	deciduous, mesic
Dicotylophyllum sp.1	*Dicotylophyllum* sp.1	?	?	? Evergreen broad–leaved
Dicotylophyllum sp.2	*Dicotylophyllum* sp.2	?	?	? Evergreen broad–leaved
Dicotylophyllum sp.3	*Dicotylophyllum* sp.3	?	?	? Deciduous broad–leaved
Dicotylophyllum sp.4	*Dicotylophyllum* sp.4	?	?	? Lauraceae/ Evergreen broad–leaved
Dicotylophyllum sp.5	*Dicotylophyllum* sp.5	?	?	? Evergreen broad–leaved
Dicotylophyllum sp.6	*Dicotylophyllum* sp.6	?	?	? Evergreen broad–leaved

6.7 Composition of the Microfloras in the Ören Region

Samples of the Karacaagaç and Hüsamlar regions are studied palynological. Although both palynofloras preserves poor palynomorphs, these palynofloras resemble with each other (Figs. 6.72a, 6.72b; Plates 6.20–6.23). Hüsamlar microflora is represented by the abundantly *Laevigatorsporites haardti*, *Pityosporites microalatus*, *Pityosporites* spp., *Cupressacites cuspidateaformis*, *Monogemmites pseudosetarius*, *Quercopollenites robur*, *Tricoporopollenites densus*, *Tricolporopollenites microhenrici*, *Tricolporopollenites cingulum oviformis*, *Sparganiapollenites neogenicus*, *Inaperturopollenites laevigatus*, barely *Pityosporites labdacus*, *Cathaya* spp., *Graminidites gramineoides*, *Inaperturopollenites dubius*, *Tricolporopollenites megaexactus exactus*, *Tricolporopollenites microreticulatus*, *Polyvestibulopollenites verus* and rarely *Dicolpopollis kalewensis*, *Subtriporopollenites anulatus nanus*, *Momipites punctatus*, *Momipites quietus*, *Lonicerapollis* sp., *Polyporopollenites undulosus*, *Tricoporopollenites kruschi*, *Subtriporopollenites simplex*. Karacaagaç palynoflora is characterized by abundantly *Laevigatorsporites haardti*, *Pityosporites microalatus*, *Pityosporites* spp., *Inaperturopollenites dubius*, *Cupressacites cuspidateaformis*, *Monogemmites pseudosetarius*, *Polyvestibulopollenites verus*, scarcely or rarely *Baculatisporites primarius*, *Leiotriletes* sp., *Pityosporites labdacus*, *Podocarpidites libellus*, *Pityosporites macroinsignis*, *Cathaya* sp., *Cedripites miocenicus*, *Ephedripites* spp., *Graminidites gramineoides*, *Betulapollenites betuloides*, *Quercopollenites robur*, *Tricoporopollenites densus*, *Tricolporopollenites microhenrici*, *Cycadopites* spp. *Arecipites* sp., *Polyporopollenites undulosus*, *Triatriopollenites rurensis*, *Triatriopollenites coryphaeus*, *Triporopolenites simpliformis*, *Momipites punctatus*, *Momipites quietus*, *Lonicerapollis* sp., *Tricolporopollenites megaexactus exactus*, *Tricolporopollenites megaexactus brühlensis*, *Polycolporopollenites* sp., *Inaperturopollenits laevigatus*, *Periporopollenites multiporatus*, *Liriodendrioipollis semiverrucatus*, *Polygalacidites* sp., *Cichareacidites* sp. *liquiflora* type, *Tricoporopollenites* sp. (*tubuliflora* type) and *Magnolipollis* sp. (Figs. 6.72a, 6.72b).

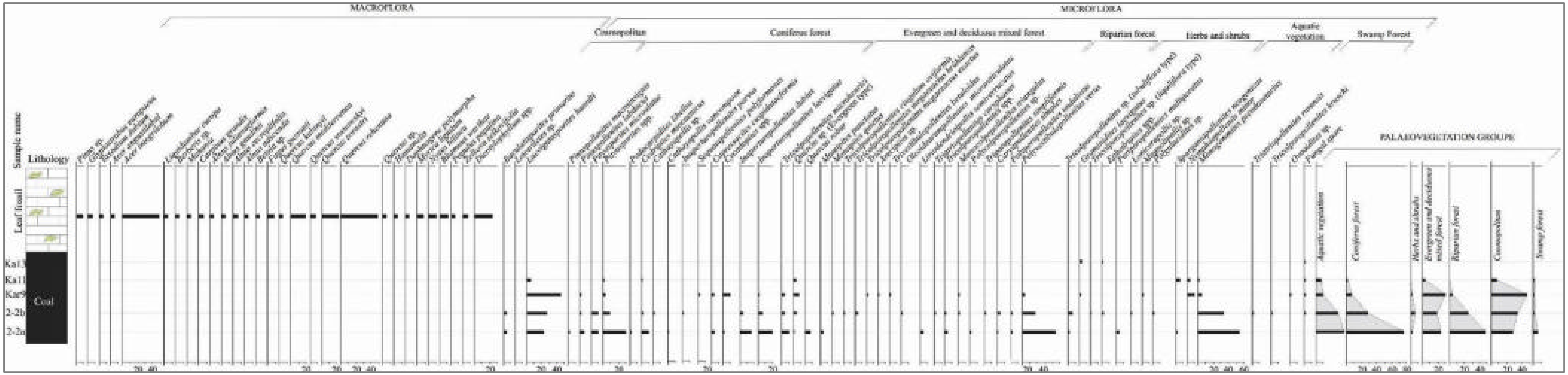


Figure 6.72a Detailed macro and micro floras diagram of the studied part of the stratigraphic section in the Karacaagaç region. Black dots indicate percentagee lower than %1.

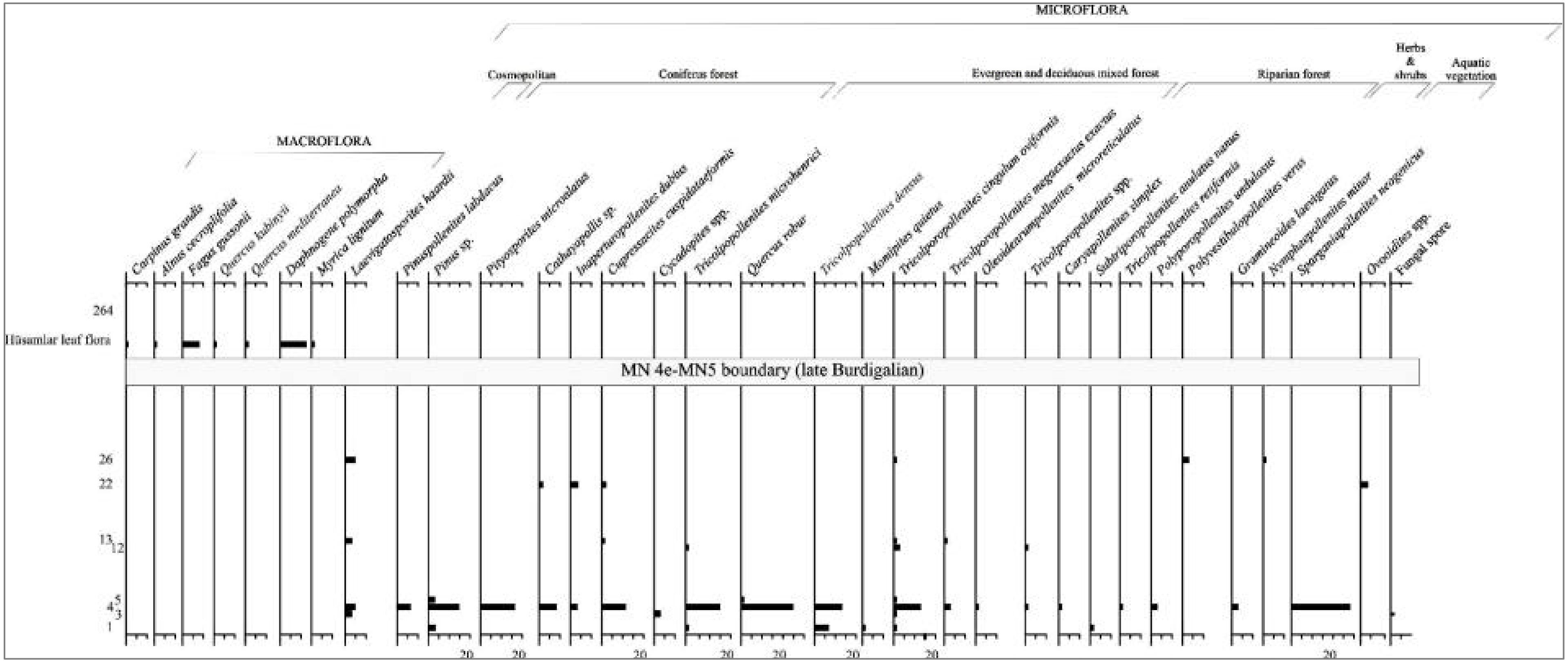


Figure 6.72 b Detailed macro and micro floras diagram of the studied part of the stratigraphic section in the Hüsamlar region. Black dots indicate percentagee lower than %1 and mammalian data level in the Hüsamlar section.

Table 6.4 Ecological requirement and climatic character of extant taxa represented by sporomorphs of the Ören-Karacaağaç and Hüsamlar regions i.e. KovarEder 1987; Planderová 1991; Nagy 1990; 1999, 1992; Akgün & Akyol 1999).

TAXA		**PREFERABLE HABİTAT**	**CLIMATIC DISTRIBUTION**	**Deciduous/Evergreen/ Sclerophyllous Trees**
Spores				
Schizaeaceae/*Lygodium*	*Leiotriletes* sp.	Cosmopolitan	Subtropical to Tropical	Fern
Polypodiaceae /*Pteridoidreae*	*Laevigatosporites haardti*	Cosmopolitan	Cosmopolitan	Fern
Osmundaceae/*Osmunda*	*Baculatisporites primarius*	Cosmopolitan	Cosmopolitan	Fern
Pollen				
Gymnosperm				
Pinus (*haploxylon*–type)	*Pinuspollenites microalatus,* *Pinuspollenites macroinsignis*	Conifer forest	Warm Temperate	Evergreen
Pinus (*silvestris*–type)	*Pinuspollenites labdacus*	Conifer forest	Temperate	Evergreen
Pinus	*Pityosporites* spp.	Conifer forest	Temperate	Evergreen
Podocarpaceae / *Podocarpus*	*Podacarpidites libellus*	Conifer forest	Subtropical to Tropical	Evergreen
Cedrus	*Cedripites miocaenicus*	Conifer forest		Evergreen
Cathaya	*Cathayapollis* sp.	Conifer forest		Evergreen
Taxodiaceae/Cupressaceae	*Cupressacites cuspidataeformis* *Inaperturopollenites dubius*	Conifer forest	Warm Temperate to Temperate	Evergreen/Deciduous
Taxodiaceae	*Inaperturopollenites laevigatus*	Swamp Forest	Warm Temperate to Temperate	Evergreen/Deciduous
Ephedraceae-*Ephedra*	*Ephedripites* sp.	Herbs & Shrubs	Temperate	Shrub
Angiosperm				
Monocotyledoneae Pollen				
Poaceae (=Gramineae)	*Graminidites gramineoides*	Herbs & Shrubs	Cosmopolitan	Shrub
Sparganiaceae/*Sparganium*	*Sparganiapollenites neogenicus*	Aquatic Vegetation	Temperate	Aquatic plant
Nymphaeaceae	*Nymphaepollenites minor,* *Monogemmites pseudosetarius*	Aquatic Vegetation	Cosmopolitan	Aquatic plant
Cycadaceae-*Cycas*	*Cycadopites* spp.	Conifer Forest	Subtropical to Tropical	Evergreen
Arecaceae-*Palmea*	*Monocolpopollenites triangulus*	Evergreen and Deciduous Mixed Forest	Subtropical to Tropical	Evergreen
Arecaceae	*Arecipites* sp.	Evergreen and Deciduous Mixed Forest	Subtropical to Tropical	Evergreen
Magnoliaceae-*Magnolia*	*Magnolipollis* sp.	Herbs & Shrubs	Subtropical to Tropical	?Evergreen
Magnoliaceae-*Liriodendron*	*Liriodendron semiverrucatus*	Evergreen and Deciduous Mixed Forest	Subtropical to Tropical	?Evergreen

Dicotyledoneae Pollen				
Myricaceae/ *Myrica*	*Triatriopollenites rurensis*	Swamp Forest	Warm Temperate	Evergreen
Juglandaceae/ *Engelhardtia*	*Momipites punctatus* , *Momipites quietus* , *Triatriopollenites coryphaeus*	Evergreen and Deciduous Mixed Forest	Subtropical to Tropical	Evergreen
Betulaceae	*Betulapollenites betuloides*	Evergreen and Deciduous Mixed Forest	Temperate	Deciduous
Carya	*Subtriporopollenites simplex* , *Subtriporopollenites anulatus nanus*	Riparian Forest	Temperate	Deciduous
Onagraceae		? Swamp Vegetation	Temperate	Shrub
Betulaceae/ *Alnus*	*Polyvestibulopollenites verus*	Riparian Forest	Temperate	Deciduous
Ulmaceae, *Ulmus*	*Polyporopollenites undulosus*	Riparian Forest	Temperate	Deciduous
Fagaceae/ *Quercus*	*Tricolpopollenites microhenrici* *Quercus robur* *Tricolpopollenites densus* *Quercus* sp. (Evergreen type)	Evergreen and Deciduous Mixed Forest	Warm Temperate to Temperate	Deciduous/ Evergreen
Platanus	*Tricolporopollenites retiformis*	Riparian Forest	Temperate	Deciduous
Castanea	*Tricolporopollenites cingulum oviformis*	Evergreen and Deciduous Mixed Forest	Warm Temperate	Deciduous
Cyrillaceae	*Tricolporopollenites megaexactus exactus,* *Tricolporopollenites megaexactus brühlensis*	Evergreen and Deciduous Mixed Forest	Subtropical to Tropical	Evergreen
Nyssaceae (=Cornaceae) /*Nyssa*	*Tricolporopollenites kruschi*	Swamp Forest	Subtropical to Tropical	Cosmopolitan tree
Oleaceae/ Olea	*Tricolporopollenites microreticulatus*	Evergreen and Deciduous Mixed Forest	Subtropical to Tropical	Deciduous/ Evergreen
Lonicera	*Lonicerapollis* sp.	Herbs & Shrubs	Temperate to Tropical	Sclerophyllous
Compositae	*Tricolporopollenites* spp. *tubuliflora* / *Liguliflora* types	Herbs & shrubs	Cosmopolitan	Shrub
Polygalaceae	*Polygalacidites* sp.	Herbs & Shrubs	Cosmopolitan	Cosmopolitan tree/shrub/herb
Amaranthaceae -Chenopodioideae	*Periporopollenites multiporatus*	Herbs & Shrubs	Cosmopolitan	Cosmopolitan shrub/herb

6.8 Comparison with Neogene Leaf Flora of Europe and Turkey

In this part the taxonomic composition of the Karacaagaç and Hüsamlar floras, with other Neogene leaf floras from Europe and Turkey are compared.

The Late Burdigalian–early Serravallian flora in the western Turkey (Gemici et al., 1991; Nebert, 1978) is defined from Manisa–Soma region and it is commonly represented by *Glyptostrobus europaeus*, *Pinus* sp. and *Quercus* spp.. cf. *Fonlinalis, Seguoia langsdorfii, Taxodium dubiium* cf. *Thuja ocddentalis*, *Magnolia,* cf. *lllicium rhenanum,* cf. *Liriodendron, Cinnamophyllum polymorphum, Cinnamophyllum scheuchzeri*, *Clematis* cf. *vitalba*, *Laurophyllum primigenium*, *Percea* cf. *indica, Mahonia* spp., *Buxus sempervirens*, *Pistacia lentiscus*, *Acer* cf. *decipens*, *Acer trilobatum*, *Sapindus falciifolius*, *Ziziphus ziziphoides,* cf. *Frangula alnus, Zelkova ungeri, Ficus lanceolata,* cf. *Cassia*, *Cercis* sp., *Colutea salteri*, *Cornus* sp., *Populus* cf. *balsamoides, Salbcangusta* sp., *Myrica lignutum, Myrica pseudologniium,* cf. *Carpinus miocenica, Castanea* cf. *sativa, Castanea, Fagus* cf. *attenuata, Quercus drymeja, Quercus ilex, Quercus* cf. *infectoria, Quercus kubinyii, Quercus mediterranea, Quercus* cf. *trojana, Carya* cf. *minör, Carya serraefolia, Vaccmium, Palmae*, *Comptonia* sp. and *Apocyanophyllum* are less abundantly preserved in this flora (Table 6.5). Karacaagaç and Hüsamlar macrofloras generally resemble to Soma flora. However, Palmae, *Comptonia* sp., *Carya serraefolia, Castanea* cf. *sativa, Buxus sempervirens*, *Cinnamophyllum* spp., *Sapindus falciifolius* are only defined in the Soma flora.

Late Early Miocene Ankara–Güvem and Beskonak floras (Paicheler & Blanc 1978; Kasapligil, 1976 and Yavuz–Isik, 2008) are *Glyptostrobus europoeus* and other common species of gymnosperms composing *Sequoia langsdorfii*, *Pinus pinaster, P. canariensis*, *P. massoniana*, *P. morrisonicala*, *Picea* sp. and *Ephedra* aff. *major*. The oaks are the dominant (*Quercus sderophyllina*, *Q. drymeja*, *Q. heidingeri*, *Q. kubinyi, Q.* cf. *semecarpifolia*, *Q. seyfriedii* and *Q. stranjensis*). Other broad–leaved deciduous trees of the Güvem flora are *Zelkova ungeri, Ulmus, Acer angustilobum, A. trilobatum, Alnus, Astronium, Betula, Carpinus miocenica,* *Cercidiphyllum trenatum*, *Cercis*, *Comptonia*, *Diospyros* aff. *miokaki*, *Ilex gracilis*, *Magnolia sprengeri*, *Meninspermum*, *Myrica banksiaefolia*, *Perseca indica fossilis*, *Platanus*, *Populus tremula*, *Platcarya miocenica*, *Pterocarya pterocarpa*, *Salix*, *Smilax aspera*, *Sorbus* aff. *aucuparia*, *Sophora* aff. *miojaponica*, *Tilia* aff. *platyphyllos*, *Cryptogramma* aff. *crispa*, *Salvinia*, *Berberis* aff. *chinensis*, *Liquidambar europaeum*, *Ailanthus* aff. *altissima*. Aquatic plants which are characterized *Potamogeton*, *Typha* and *Egeria* aff. *densa* recorded in this flora. Dominant plants in the Ören–Karacaagaç, Ankara–Güvem and Beskonak macrofloras includes similar species. However, *Pinus* species is not variously and abundantly observed Karacaagaç macroflora (Table 6.5).

The Late Early–Middle Miocene Izmir–Tire–Akçasehir macroflora (Gemici et al., 1992) is represented by the *Fraxinus* sp., *Pinus* sp., *Populus latior*, *Cornus* sp., *Buxus* cf. *sempervirens*, *Acer trilobatum*, cf. *Cassia* sp., *Sapindus falciifolius*, *Salix* sp., cf. *Quercus goepperti*, cf. *Quercus neriifolia*, *Quercus* sp., *Typha* sp., *Sophora* sp. and *Leguminosae*. Species of the flora are different from the species of Karacaagaç and Hüsamlar floras. This discrepancy could be related to palaeoclimatic and palaeoenvironmental differences (Table 6.5).

The early–middle Serravallian Aydin–Sahinali macroflora (Gemici et al., 1993) is characterized by the *Acer* sp., *Alnus phocaensis*, *Betula subpubescens*, *Glyptostrobus europaeus*, *Diospyros* cf. *anceps*, *Diospyros* sp., *Cercis antique*, *Castanopsis* sp., cf. *Fagus attenuate*, *Fagus orientalis*, *Quercus drymeja*, *Quercus goepperti*, *Quercus kubinyii*, *Quercus mediterranea*, *Quercus neriifolia*, *Tilia* sp., cf. *Symplocos* sp., *Sapindus falciifolius*, *Populus* sp., *Populus* cf. *latior*, *Populus balsamoides*, *Pinus pinastroides*, *Pinus* sp., *Fraxinus* sp., *Myrica pseudolignitum*, *Myrica lignitum*, *Magnolia* sp., *Cinnamophyllum polymorphum*, *Cinnamophyllum scheuchzeri*, *Laurophyllum primigenium* and *Carya serraefolia*. This floral composition is generally similar to the Karacaagaç flora, but *Diospyros* cf. *anceps*, *Diospyros* sp., *Cercis antique*, *Castanopsis* sp., *Tilia* sp., cf. *Symplocos* sp., *Sapindus falciifolius*, *Magnolia* sp., *Cinnamophyllum polymorphum* and *Carya serraefolia* are not recorded in the Karacaagaç flora (Table 6.5).

Table 6.5. List of the taxa of macrofloras indentified from the previous studies in Turkey (Paicheler & Blanc 1978; Gemici et al. 1991, 1992, 1993; Kasapligil, 1976; Yavuz–Isik, 2008).

Age	late Early and Middle Miocene	late Early and Middle Miocene	early-middle Serravallian	late Early Miocene	
Location	Manisa-Soma	Izmir-Tire-Akçasehir	Aydin-Sahinali	Ankara-Güvem	Ankara-Beskonak
Family and Genus					
ACERACEAE					
Acer augustilobum				x	
Acer camppestre					x
Acer dasycarpoides					x
Acer integerrimum					x
Acer opalus					x
Acer palaeosaccharinum					x
Acer pseudomonspessulanum					x
Acer tricuspidatum					x
Acer trilobatum	x	x		x	
Acer cf. *decipens*	x				
Acer sp.			x		x
ANACARDIACEAE					
Pistacia lentiscus	x				
Astronium truncatum				x	
Astronium sp.				x	x
Rhus sp.					x
AQUIFOLIACEAE					
Ilex gracilis				x	
APOCYANACEAE					
Apocyanophyllum sp.	x				
ARALIACEAE					
Aralia sp.					x
Hedera sp.					x
ASCLEPIADACEAE					x
BERBERIDACEAE					
Mahonia sp.	x				x
Berberis aff. *chinensis*				x	
BETULACEAE					
Alnus phocaensis			x		
Alnus rottensis					x
Alnus sp.				x	
Betulus alba					x
Betula aff. *luminifera*				x	
Betula subpubescens			x		
Carpinus miocenica				x	
cf. Carpinus miocenica	x				
BURCERACEAE					
Bursera serrulata					x
BUXACEAE					
Buxus sempervirens	x				
Buxus cf. *sempervirens*		x			
CANNABACEAE					
Celtis sp.					x
CAESALPINIOIDES					
Gymnocladus sp.					x
CERATOPHYLLACEAE					
Ceratophyllum submersum					x
CERCIDIPHYLLACEAE					
Cercidiphyllum crenatum				x	
Cercidiphyllum sp.					x
CRYPTOGRAMMACEAE					
Cryptogramma aff. *crispa*				x	
CORNACEAE					
Cornus sp.	x	x			
CUPRESSACEAE					
Glyptostrobus europaeus	x		x	x	x
Glyptostrobus lineatus				x	
cf. *Thuja occidentalis*	x				
CYPERACEAE					
Cyperacites lacustris					x
DRYOPTERIDACEAE					
Dryopteris sp.					x
EBENACEAE					
Diospyros cf. *anceps*			x		
Diospyros aff. *miokaki*				x	
Diospyros sp.			x		
EPHEDRACEAE					
Ephedra aff. *major*				x	
ERICACEAE					
Vaccinium sp.					x
cf. Vaccinium sp.	x				
EUPHORBIACEAE					x
EQUISETACEAE					
Equisetum sp.					x
FABACEAE					
Calpurnia europaea					x
Cassia hyperborea					x
cf. Cassia sp.	x	x			
Cercis antiqua			x		
Cercis sp.	x			x	
Colutea salteri	x				
Sophora europaea					x
Sophora aff. *miojaponica*				x	
Sophora sp.		x			
Leguminosae		x			
Platycarya miocenica				x	
FAGACEAE					
Castanea	x				
Castanea cf. *sativa*	x				
Castanea sp.			x		
Castanopsis sp.			x		x
Fagus cf. *attenuata*	x				
cf. *Fagus attenuata*			x		
Fagus orientalis			x		
Fagus pristina					x
Fagus sp.	x				
Quercus coccifera				x	
Quercus drymeja	x		x	x	x
Quercus cf. *drymeja*			x		
Quercus goepperti			x		
cf. Quercus goepperti		x			
Quercus haidingeri				x	
Quercus ilex	x				
Quercus infectoria					x
Quercus cf. *infectoria*	x				
Quercus kubinyii	x		x	x	
Quercus aff. *lonchitis*				x	
Quercus lusitanica					x
Quercus mediterranea	x		x		x
Quercus nerifolia			x		x
cf. Quercus nerifolia		x			
Quercus aff. *polycarpa*				x	
Quercus polymorpha					x
Quercus sclerophyllina				x	
Quercus cf. *semecarpifolia*				x	
Quercus seyfriedii				x	
Quercus sosnowskii				x	
Quercus strangensis				x	
Quercus trojana				x	
Quercus cf. *trojana*	x				
Quercus aff. *trojana*				x	
Quercus urophylla					x
Quercus sp.		x			x
FONTINALACEAE					
cf. Fontinalis L.	x				
GRAMINEAE					
Gramineae	x				
Phragmites cf. *oeningensis*	x				
Phragmites sp.		x			
HAMMAMELIDEAE					
Liquidambar europaeum				x	
HYDROCHARITACEAE					
Egeria aff. *densa*				x	
Stratiotes thalictroides					x
HYMENOPHYLLACEAE					
Hymenophyllum dilatatum					x
HYSTERIACEAE					
Hysterium sp.					x
JUGLANDACEAE					
Carya cf. *minor*	x				
Carya serraefolia	x		x		
Juglans acuminata	x				x
Juglans altissima					x
Juglans sp.					x
Pterocarya pterocarpa				x	
LAURACEAE					
Cinnamophyllum polymorphum	x		x		x
Cinnamophyllum scheuchzeri	x		x		
Laurophyllum primigenium	x		x		
Laurus princeps					x
Laurus sp.			x		
Percea indica				x	
Persea princeps					x
Percea cf. *indica*	x				
Ocotea heeri					x
MAGNOLIACEAE					
Magnolia sp. (Type 1)	x				
Magnolia sp. (Type 2)	x				
Magnolia sprengeri				x	
Magnolia sturii					x
Magnolia sp.			x		
cf. *Illicium rhenanum*	x				
cf. *Liriodendron* sp.	x				
MENISPERMACEAE					
Menispermum sp.				x	
MORACEAE					
Ficus lanceolata	x				
Ficus sp.				x	
MYRICACEAE					
Comptonia sp.	x			x	
Comptonia acutiloba					x
Myrica acuminata					x
Myrica banksiafolia				x	x
Myrica lignitum	x		x		x
Myrica pseudolignitum	x		x		
Myrica sp.					x
OLEACEAE					
Fraxinus excelsifolia					
Fraxinus sp.		x	x		x
PALMAE					
cf. *Chamaedorea*	x				
PINACEAE					
Cedrus sp.					x
Pinus canariensis				x	
Pinus leucodermis					x
Pinus massoniana				x	
Pinus aff. *morrisonicola*				x	
Pinus pinaster				x	
Pinus pinastroides			x		
Pinus sp.	x	x	x		x
Picea sp.				x	x
Sequoia langsdorfii	x			x	x
Tsuga sp.				x	
Taxodium dubium	x				
Taxodium sp.					x
PLATANACEAE					
Platanus orientalis					x
Platanus sp.				x	
PODOCARPACEAE					
Saxegothaea conspicua					x
POTAMOGETONACEAE					
Zannichellia palustris					x
Potamogeton sp.				x	x
RANUNCULACEAE					
Clematis cf. *vitalba*	x				
RHAMNACEAE					
Rhamnus sp.					x
cf. Frangula alnus	x				
Paliurus sp.					x
Ziziphus ziziphoides	x				
Ziziphus sp.	x				
ROSACEAE					x
Crataegus sp.					x
Sorbus aucuparia					x
Sorbus aff. *aucuparia*				x	
Spiraea sp.					x
RUTACEAE					
Ptelea sp.					x
SALICACEAE					
Populus balsamoides			x		
Populus cf. balsamoides	x				
Populus euphratica					x
Populus latior		x			
Populus cf. latior			x		
Populus mutabilis					x
Populus populina					x
Populus tremula				x	x
Populus sp.			x		x
Salix angusta	x				
Salix haidingeri					x
Salix longa					
Salix sp.		x		x	x
SALVINIACEAE					
Salvinia natans					x
SAPINDACEAE					
Sapindus falcifolius	x	x	x		x
SAPOTACEAE					
Bumelia florissanti					x
Bumelia sp.					x
SIMAROUBACEAE					
Ailanthus aff. *altissima*				x	
SMILACACEAE					
Smilax aspera				x	
SYMPLOCACEAE					
cf. Symplocos sp.			x		
TILIACEAE					
Tilia platyphyllos					x
Tilia aff. *platyphyllos*				x	
Tilia sp.			x		
TYPHACEAE					
Typha sp.		x		x	x
ULMACEAE					
Ulmus sp.				x	x
Zelkova ungeri	x			x	x
Zelkova sp.					
VITACEAE					
Vitis teutonica					x
Monocotyledons *indeterminae*					x
Antholithes					x
Gleditschia wesseli					x
Nuts				x	
Periploca sp.					x
Phoenicites sp.					x
Salinia				x	

Mädler & Steffens (1979) defined the macrofloras from the western and central Anatolia (Manisa–Soma, Manisa–Akhisar, Denizli–Kurbalik–Acidere–Çukurköy, Aydin–Çavdar, Aydin–Sahinali, Usak–Ilyasli, Afyon–Dumlupinar–Ikizdere, Kütahya–Tunçbilek–Tavsanli–Alabarda, Balikesir–Kavacik, Çanakkale–Çan–Demirci, Ankara–Beynam and Kizilcahamam regions). Leaf fossils in the certain regions are not rich (Table 6.6). In this study Usak–Ilyasli and Çanakkale–Çan–Demirci floras are used for the palaeovegetation and palaeoclimate interpretations because of the including rich leaf fossils.

The common species in the early Middle Miocene Usak–Ilyasli macroflora which was defined by Mädler & Steffens (1979) are *Acer dasycarpoides* and *Glyptostrobus europaeus. Acer trilobatum, Alnus* sp. *Taxodium dubium, Quercus mediterranea, Myrica* cf. *pseudolignitum, Myrica* cf. *salicina, Myrica serotina, Pteris parschlugiana* and *Potamogeton* sp. are rare defined in the Ilyasli macroflora. The other early Middle Miocene macroflora in the Usak–Ilyasli region are defined from the coal bearing sediments (Ercan et al., 1978). This flora composes of *Acer trilobatum*, *Acer* sp., *Cinnamomophyllum* cf. *polymorphum*, *Cinnamomophyllum* cf. *scheuehzeri*, *Cinnamomophyllum* cf. *laneeolatum*, *Osmunda* cf. *lignitum*, *Myrica* cf. *lignitum*, *Metasequoia* cf *occidentalis*, *Glyptostrobus europaeus*, *Taxodium miocenicum*, *Taxodium distichum*, *Rhamiuis* cf. *decheni* and *Salix* sp. Karacaagaç macroflora is less resemble to the Ilyasli flora excepted for presences of *Glyptostrobus europaeus, Taxodium dubium* and *Quercus mediterranea* (Table 6.6).

The other late Middle Miocene macroflora is defined from the Çanakkale–Çan–Demirci region and this macroflora is abundantly represented by the *Glyptostrobus europaeus*, *Diospyros brachysepala, Liquidambar europaeum, Ulmus carpinoides* and *Ulmus longifolia.* Rare elements are *Acer dasycarpoides,* cf. *Rhus* sp., cf. *Ampelopsis* sp., *Cercidiphyllum crenatum,* cf. *Cornus* sp., *Taxodium dubium, Quercus mediterranea,* cf. *Quercus neriifolia, Quercus* sp., *Persea princeps, Myrica acutiloba*, *Myrica* sp. and *Sapindus falcifolius* (Mädler & Steffens, 1979). Composition and abundancy of this floral is not similar to the Karacaagaç flora (Table 6.6).

Table 6.6. List of the taxa indentified of Turkey macrofloras from the previous study (Mädler & Steffens, 1979).

Age	Early-Middle Miocene		Middle Miocene	Early Miocene	Oligocene	Middle Miocene (early-middle Serravallian)	late Middle Miocene	Middle Miocene (Langhian-early Serravallian)	Middle Miocene (early-middle Serravallian)	late Middle Miocene	late Middle Miocene	late Middle Miocene	late Middle Miocene	Late Miocene	
Location	Manisa-Soma-Denis 1 and 2		Manisa Akhisar	Acidere, Kurbalik, Çukurköy	Aydin-Çavdar	Aydin-Sahinali	Usak-Ilyasli	Afyon-Dumlupinar and Ikiz Dere	Kütahya-Tunçbilek	Kütahya-Tavsanli	Kütahya-Alabarda	Balikesir-Kavacik	Çanakkale-Çan-Demirci	Ankara-Beynam	Ankara-Kizilcahamam
Family and Genus															
ACERACEAE															
Acer dasycarpoides							15						1	3	
Acer trilobatum	x						2							7	
Acer sp.							1								
ALISMATACEAE															
Sagittaria sp.	x														
ANACARDIACEAE															
cf. *Rhus* sp.													1		
APOCYANACEAE															
Apocyanophyllum sp.											x				
Nerium sp.											x				
AQUIFOLIACEAE															
Ilex sp.	x														
BETULACEAE															
Alnus phocaeensis						20									
Alnus sp.							2								
cf. *Ampelopsis* sp.													1		
Betula subpubescens						1									
Carpinus sp.		1													
Carya serrafolia		1													
Carya cf. *serrafolia*						2						1			
BERBERIDACEAE															
? Berberidaceae		1													
BUXACEAE															
Buxus cf. *sempervirens*								6							
CERCIDIPHYLLACEAE															
Cercidiphyllum crenatum				3									5		
CORNACEAE															
cf. *Cornus* sp.													1		
CUPRESSACEAE															
Glyptostrobus europaeus	x	7				1	4			x			10		
Glyptostrobus sp.	x														
Taxodium distichum										x	x				
Taxodium dubium		2			1		3		11				1		
Taxodium sp.										x					
EBENACEAE															
Diospyros brachysepala									1				6		
cf. *Diospyros brachysepala*												1			
EQUISETACEAE															
Equisetum sp.								1						x	
ERICACEAE															
Vaccinium sp.		1													
FABACEAE															
Sophora miojaponica												1			
cf. *Sophora miojaponica*															
Sophora sp.				4											
FAGACEAE															
Castanopsis furcinervis		1													
Castanopsis sp.						2									
cf. *Castanea kubinyi*						1								7	
Fagus attenuata								11	1						
Fagus ferrugeinea	x														
Fagus sp.	x														
Quercus goepperti						1									
Quercus mediterranea		2				2	1						3		
Quercus cf. *mediterranea*	x					1									
cf. *Quercus neriifolia*	x												2		
cf. *Quercus drymeja*			x			4									
Quercus sp.													1		
GRAMINEAE															
Phragmites sp.										x					
cf. *Phragmites*											x				
HAMAMELIDACEAE															
Liquidambar europaea													4		
ILLICIACEAE															
cf. *Illicium* [illegible]		4													
JUGLANDACEAE															
Juglans acuminata		7													
LAURACEAE															
Cinnamomum polymorphum		10				5						3			
Cinnamomum scheuchzeri	x														
Laurus phoeboides				1	18										
Laurophyllum primigenium		2		14		6			1						
cf. *Laurophyllum*	x														
Laurophyllum sp.	x	1													
Persea princeps													2		
LEGUMINOSAE															
Cercis antiqua						1									
Leguminosites sp.								2						1	
MAGNOLIACEAE															
Magnolia ludwigii	x														
Magnoliaephyllum sp.				1											
MYRICACEAE															
Myrica [illegible]													2		
Myrica lignitum	x					3					x				
Myrica cf. *pseudolignitum*						6	1	4							
Myrica cf. *salicina*							1								
Myrica serrulata							7								
Myrica sp.	x												1		
PALMAE															
? *Palmae*					1										
PINACEAE															
Pinus palaeostrobus	x									x					
Pinus pinastroides						1									
Pinus sp.	x							6				x			
cf. *Pseudotsuga*								1							
PLATANACEAE															
Platanus [illegible]							1								
POTAMOGETONACEAE															
Potamogeton sp.							1							1	
ROSACEAE															
? *Rosaceae*		1													
SALICACEAE															
Populus balsamoides		1				1									
Salix angusta		1													
Salix varians	x														
Salix longa		1													
Salix sp.	x														
SAPINDACEAE															
Sapindus falcifolius				1		1							2		
Sapindus sp.	x														
SAPOTACEAE															
Sideroxylon sp.	x														
[illegible]															
[illegible] cf. [illegible]														10	
[illegible] sp.						1									
STAPHYLEACEAE															
[illegible]									1						
SYMPLOCACEAE															
cf. *Symplocos* sp.						1									
TILIACEAE															
[illegible]		1													
ULMACEAE															
Ulmus [illegible]													17		
Ulmus longifolia								1				1	22		
Zelkova ungeri		1													7
Incertae sedis								4							
Phyllites sp.														1	

The Early Miocene flora of the Cypris Shale in western Bohemia is dominated by thermophilic (paleotropic) elements of humid subtropical climate which are represented by *Tetraclinis salicornioides*, diverse Lauraceae, Theaceae, Symplocaceae, *Trigonobalonopsis*, *Plantanus neptuni* and *Engelhardia* (Bužek et al., 1996). Deciduous (arctotertiary) elements are less abundantly present which are characterized by *Myrica lignitum*, *M. oehningensis*, *Acer integrilobum*, *Liquidambar*, *Podocarpium*, *Craigia*, *Tilia*, *Ulmus*, *Zelkova*, *Cedrelospermum*, *Fraxinus*, *Populus populina*, *Ailanthus* and Betulaceae. Thermophilic elements in the Karacaagaç flora (*Daphnogene polymorpha* and *Laurophyllum* spp.) are less abundant different from the Early Miocene flora of the Cypris Shale. However, in the Hüsamlar flora thermophilic elements are abundantly represented by *Daphnogene polymorpha*. Besides, deciduous elements of the Karacaagaç are abundantly than the flora Cypris Shale.

The Sarmatian flora in the Hungary (Erdei et al., 2007) is defined from Felsotárkány area and it is commonly represented by *Osmunda parschlugiana*, *Pteris palaeoaurita*, *Glyptostrobus europaeus*, *Byttneriophyllum tiliifolium*, *Cercidiphyllum crenatum*, *Quercus pontica miocenica*, *Alnus cecropiifolia*, *Salix* sp. and *Acer* div. sp. *Ulmus* div. sp., *Quercus kubinyii*, *Populus populina* and *Musophyllum tárkányense* are rare elements. The other Sarmatian flora from the Sopron–Piusz puszta and Erdobénye–Tállya in Hungary (Pannonian basin) (Erdei et al., 2007) are abundantly represented by *Pinus* sp., *Picea* sp., Lauraceae, *Toddalia* sp. *Buxus* sp., *Glyptostrobus europaeus*, *Quercus drymeja*/*Q. mediterranea*, *Q. kubinyii*, *Podocarpium podocarpum*, *Zelkova zelkovifolia*, *Carpinus* div. sp., *Pinus* div. sp., *Ulmus braunii*, Juglandaceae, *Alnus* sp., *Populus populina*, *Acer* div. sp. and *Parrotia* sp.. Lauraceae, *Pistacia* sp., *Ilex* sp., *Fagus* sp., *Rosa* sp., *Smilax* sp. and *Liquidambar* sp. are found rarely. The Langhian flora from the Hungary is recorded from the Nógrádszakál area (Erdei et al., 2007) and it is represented by the dominant and frequent elements including *Equisetum* sp., *Parrotia pristina*, *Ulmus* div.sp., *Populus* sp., *Acer* div. sp., *Quercus* div. sp., (*Q. kubinyii*), *Alnus* sp., Cornaceae, *Daphnogene* sp., *Carya* sp. and *Salix* sp.. *Platanus* sp., *Vitis* sp., Juglandaceae, *Leguminosae*, *Zelkova zelkovifolia* and *Palmae* are observed rarely in the

Nógrádszakál flora (Erdei et al., 2007). The Late Burdigalian flora from the Hungary is represented Magyaregregy area. It is characterized by the commonly *Glyptostrobus europaeus*, Lauraceae, *Zizyphus paradisiacus*, *Cedrelospermum* sp., *Myrica lignitum*, *Podocarpium podocarpum*, *Zelkova zelkovifolia*, *Ulmus* sp., *Ailanthus* sp., *Engelhardia orsbergensis*, *Carya* sp. and *Celastrus* sp. *Quercus kubinyii*, *Fagus* sp., *Rosa* sp., *Acer* sp., *Nyssa* sp. and Salicaceae are recorded scarcely in this flora. The Sarmatian flora in the Hungary generally resembles to late Early Miocene–early Middle Miocene flora in the Karacaagaç region. But *Osmunda parschlugiana*, *Pteris palaeoaurita*, *Byttneriophyllum tiliifolium*, *Cercidiphyllum crenatum*, *Quercus pontica miocenica* are not defined in the Karacaagaç and Hüsamlar floras. Additionally *Salix* sp., *Picea* sp., *Podocarpium podocarpum*, *Ulmus braunii*, *Equisetum* sp. and *Parrotia pristina* in the late Burdigalian and Langhian floras in Hungary are not seen in Karacaagaç and Hüsamlar floras. However *Zelkova zelkovifolia*, *Myrica lignitum*, *Glyptostrobus europaeus*, Lauraceae, *Q. kubinyii* and *Alnus* sp., are defined in the both floras.

There are numerous Sarmatian floras of Hungary from the areas of Tokaj Mountains (Erdobénye, Talya and Ligetmajor) (Erdei 1995, Hably, 2001; 2002 and Erdei et al., 2007). Taken together, they include a higher number of common elements (*Fagus*, *Quercus mediterraneae*, *Q. drymeja*, Betulaceae, Ulmaceae and Celtidaceae, *Engelhardia*, *Acer*, *Platanus leucophylla*, *Ailanthus* and some *Leguminosae* including *Podocarpium*. The Langhian and late Burdigalian floras are represented by *Equisetum* sp., *Parrotia pristina*, *Ulmus* sp., *Populus* sp., *Acer* sp., *Quercus* sp., (*Q. kubinyii*), *Alnus* sp., Cornaceae, *Daphnogene* sp., *Carya* sp., *Salix* sp., *Ulmus* sp., *Zelkova zelkovifolia*, *Glyptostrobus europaeus*, Lauraceae, *Zizyphus paradisiacus*, *Cedrelospermum* sp., *Myrica lignitum*, *Podocarpium podocarpum*, *Ailanthus* sp., *Engelhardia orsbergensis*. Contrary to Hungary, some species (*Fagus*, *Quercus mediterraneae*, *Acer*, *Zelkova* and Betulaceae) are recorded in Karacaagaç and Hüsamlar areas in the Late–Middle Miocene because of probably for palaeoclimate or palaeogeographic position.

In the area of southern Europe, the flora Kymi and Evia in Greece (Erdei & Kvacek, 1997, Kvacek et al., 2002) are Early Miocene age (Burdigalian). *Pinus* sp., *Glyptostrobus europaeus*, *Myrica lignitum*, *M. vindobonensis*, *Daphnogene polymorpha*, *Laurophyllum* sp., *Diospyros rugosa*, *Quercus mediterraneae, Q. drymeja*, *Q. neriifolia*, *Alnus gaudinii* and *A. cycladum* are observed in the flora Kymi (Erdei & Kvacek, 1997). This flora resemble to the Karacaagaç and Hüsamlar floras except for presences of the *Diospyros rugosa*, *M. vindobonensis*, *Q. neriifolia* and *A. cycladum.*

In the Early Miocene, the fossil taxa *Laurophyllum pseudoprinaceps* and *Daphnogene polymorpha* are abundantly present in the fossil floras of central Europe. Besides, these species are found in the Late Miocene sediments from Poland (Belz & Mosbrugger, 1994 and Kovar–Eder et al., 1995). *Quercus rhenana* is characterized by a narrower stratigraphic range (Walther, 1995 and Worobeic, 2003). Because this species is recorded mainly from the Early Miocene in central Europe and it disappears in the Middle Miocene. In the central Europe, "*Castane*" *kubinyii* (*Quercus kubinyii*) appears in the upper part of the Early Miocene, but its peak development occurs in the younger Neogene (Kobloch & Kvacek, 1996). According to stratigraphic range of species in Table 6.7 Karacaagaç and Hüsamlar macrofloras resemble to the Early–Middle Miocene macrofloras in Europe (i.e. Greece, Bohemia, Bulgaria and Austria) and the late Burdigalian–Sarmatian macrofloras of Pannonian basin (Hungary). Differences in the floral composition in Europe, Hungary and Turkey during the same time interval could be related to the palaeoclimatic evolution and longitude and latitude of Turkey during the Neogene.

Table 6.7 Stratigraphic range of species found in fossil floras Hüsamlar and Karacaagaç (Ören region) in Neogene (Walther, 1995; Worobeic, 2003).

Taxon	**Karacaagaç**	**Hüsamlar**	**Stratigraphical Range**
Quercus kubinyii	+		Early Miocene
Quercus rehenana,	+		Early Miocene
Acer integrilobum	+		Early Miocene
Daphnogene polymorpha	+	+	Early–Middle Miocene
Alnus julianaeformis	+		Early Miocene–Early Pliocene
Alnus gaudinii	+		Early Miocene–Late Miocene
Taxodium dubium	+		Early Miocene–Pliocene
Myrica lignitum	+	+	Early Miocene–Pliocene
Glyptostrobus europaeus	+		Early Miocene–Early Pliocene
Fagus gussonii	+		Late Oligocene–late Miocene
Carpinus grandis	+	+	Middle–Late Miocene
Alnus cecroplifolia	+	+	Late Miocene
Hamamelidaceae	+		Oligocene–Miocene

6.1 Palaeovegetation of Ören–Karacaagaç and Hüsamlar Macrofloras

The presence of two groups of vegetation has been defined in Karacaagaç and Hüsamlar fossil floras. The first group comprises azonal vegetation characterized by swamp and riparian forests (*Glyptostrobus europaeus*, *Myrica lignitum*, *Liquidambar europa* and *Alnus julianaeformis*) which surrounded a water reservoir, probably lake with swamp shores. Zonal vegetation is represented by taxa characteristic of mesophytic forest (*Fagus*, *Betula*, *Zelkova* and *Acer*) which probably over grew the nearby elevations.

The reconstruction of the vegetation profile in the Karacaagaç area during the Early–Middle Miocene is based on the autecology of single taxa, their abundance and the whole association. Leaf fossils of aquatic plants are not observed whereas pollens of aquatic plants are observed in samples of Karacaagaç region. The swamp forest stand was included coniferous *Glyptostrobus europaeus*, *Taxodium dubium* and deciduous *Liquidambar europa*, *Nyssa bilinica*, *Quercus rhenana* and *Alnus julianiformis*. This swamp forest was inundated that locally it could be classed as bog forest. Slightly drier areas were inundated only periodically and the riparian forest formed of *Acer integrilobum*, *Liquidambar europaea*, *Populus populina*, *Zelkova zelkovifolia*, *Alnus julianiformis*, *A. goudinii*, *A. cecroplifolia* and *A. adscendens* were overgrown. *Quercus kubinyii* rare in the fossil flora of the Karacaagaç area, may have grow in the riparian forest or may have been a component of mesophytic forest vegetation. Pines (*Pinus*), were dispersed or mixed with oaks. Mesophytic forest components are composed of *Daphnogene polymorpha*, *Fagus gussonii*, *Carpinus grandis*, *Acer integrilobum*, *A. angustilobum* and *Laurophyllum* spp.. Evergreen oaks (*Quercus mediterraneae*, *Q. sosnowskyi* and *Q. zoroastri*) are abundant and also *Pinus* sp. present. These oaks and gymnosperm species formed scrub–like sclerophyllous woodland on drier substrates. More extensive were probably subhumid forest composed of sclerophyllous oaks in the canopy and plants of similar physiognomic character in the shrub vegetation, including *Berberis* sp. and *Mohonia* sp..

6.2 Zonal Palaeovegetation during the late Early and Middle Miocene Period

A new method for evaluating the plant record was introduced by Kovar–Eder & Kvacek (2003). This method firstly applied to the plant record of the time interval the latest Miocene to Early Pliocene. After Kovar–Eder (2004), this method was used for the late Burdigalian–Langhian HR3 and late Serravallian (HR2) and middle Tortonian (HR1) times. Thus authors constituted the maps of characterization of the large zonal vegetation. Basic taxonomic–physiognomic and autecologic factors were established by Kovar–Eder & Kvacek (2003) and Kovar–Eder (2008). In this study, taxonomic, physiognomic components in table 6.8 are calculated and used for the zonal palaeovegetational interpretation for floras of Miocene time in Turkey.

Table 6.8 Taxonomic, physiognomic and autecology grouping of floral components.

Taxonomic, physiognomic components	Autecology
Conifers (CON)	extrazonal and zonal
Broad–leaved deciduous (BLD)	zonal
Broad–leaved evergreen (BLE)	zonal
Sclerophyllous (SCL)	zonal
Legume–like (LEG)	zonal
Palms (PALM)	zonal
Angiosperm herbs (MEH – DRH)	zonal
Ferns (FERN)	azonal and zonal
Azonal woody (AZW)	azonal
Azonal herbs (helophytes) (AZH)	azonal
Aquatic plants (AQU)	azonal

Definitions of basic taxonomic–physiognomic grouping which are established by Kovar–Eder & Kvacek, 2003 and Kovar–Eder et al., 2008 are given below. The conifer component (CON): zonal and extrazonal conifers, for example, *Cunninghamia* (zonal) and *Abies, Picea* and *Tsuga* (extrazonal). The broad–leaved deciduous component (BLD): leaf–size class microphyll (2.25–20.25cm^2), notophyll (20.25–45cm^2), or mesophyll (45–182.2cm^2; Webb, 1955), texture thin, usually not entire margined. The broad–leaved evergreen component (BLE): leaf–size class microphyll, notophyll, or mesophyll, texture coriaceous, usually entire margined, revolute, erose, or inconspicuously (often sparsely) toothed. According to Kovar–Eder et al., 2008, the resolution of the BLE component is higher in floras with leaf cuticle preserved, which allows for differentiation of the Lauraceae to the specific level. For this reason, without preserved cuticle, the resolution of this component is less accurate. The sclerophyllous component (SCL): leaf–size class nanophyll to microphyll (0.25–2.25cm^2; lower end of leaf size range); texture thick, toothed, or entire margined; teeth apex often spinose. The legume–type component (LEG): leaf–size class (of leaflets) leptophyll (0.25cm^2) or nanophyll, that is, the lower end of microphyllsize range; mostly entire margined or inconspicuously toothed. The palm component (PALM): The zonal palms. The mesophytic herbaceous component (MEH) and dry herbaceous component (DRH): previously, the angiosperm zonal herb component was not subdivided (Kovar–Eder & Kvacek, 2003; Jechorek & Kovar–Eder, 2004 and Kovar–Eder et al., 2006), however Kovar–Eder et al. (2008) separated two components which are the herbaceous plants characteristic of mesophytic forest understory (MEH) and open woodlands and grasslands (DRH). The fern component (FERN): includes both zonal and azonal ferns, owing to a lack of taxonomic resolution of these plants in fossil assemblages. The azonal woody component (AZW): azonal conifers (e.g., *Taxodium* and *Glyptostrobus*) and azonal woody angiosperms (e.g., *Salix*, *Populus*, *Avicennia* and *calamus daemonorops*). The azonal herbaceous component (AZH): reeds, sedges, and other helophytes, for example, *Cladium*, *Cladiocarya* (Cyperaceae), and *Decodon* (Lythraceae). The aquatic component (AQU): hydrophytes (Table 6.7).

Definitions of vegetation types which are defined by Kovar–Eder et al. (2008) are given below (Table 6.9):

Type no.1 (Zonal, temperate to warm–temperate broad–leaved deciduous forests "broad–leaved deciduous forests and vegetation"): the BLD component is =80% of the zonal woody angiosperms and the zonal herb component is mostly =30%. Characteristic taxa include *Carpinus*, *Fagus*, *Parrotia*, and *Tilia*.

Type no. 2 (Zonal warm–temperate to subtropical mixed mesophytic forests "mixed mesophytic forests and vegetation"): BLD <80%; BLE <30%; SCL+LEG <20% of zonal woody angiosperms. Zonal herbs constitute <30%.

Type no. 3 (Zonal subtropical broad–leaved evergreen forests "broad–leaved evergreen forests and vegetation"): BLE =80% of zonal woody angiosperms and (SCL + LEG) < BLE. Zonal herbs are <25%. Essential taxa include evergreen members of Fagaceae, Lauraceae, Mastixiaceae, Sapotaceae, Symplocaceae, Theaceae, etc. This type includes the Younger Mastixioid Floras *sensu* Mai (1964).

Type no. 4 (zonal subtropical, subhumid sclerophyllous or microphyllous forests "subhumid sclerophyllous forests and vegetation"): SCL+LEG=20% of zonal woody angiosperms, and zonal herbs (MEH+DRH) 30% of zonal taxa. Characteristic taxa include *Quercus mediterranea* and *Podocarpium podocarpum*.

Type no. 5 (Zonal xeric open woodlands "open woodlands and vegetation": SCL+LEG=20%, MEH+DRH nearly 30%–40% of all zonal taxa, and MEH>DRH up to a maximum of 10% of all zonal herbs.

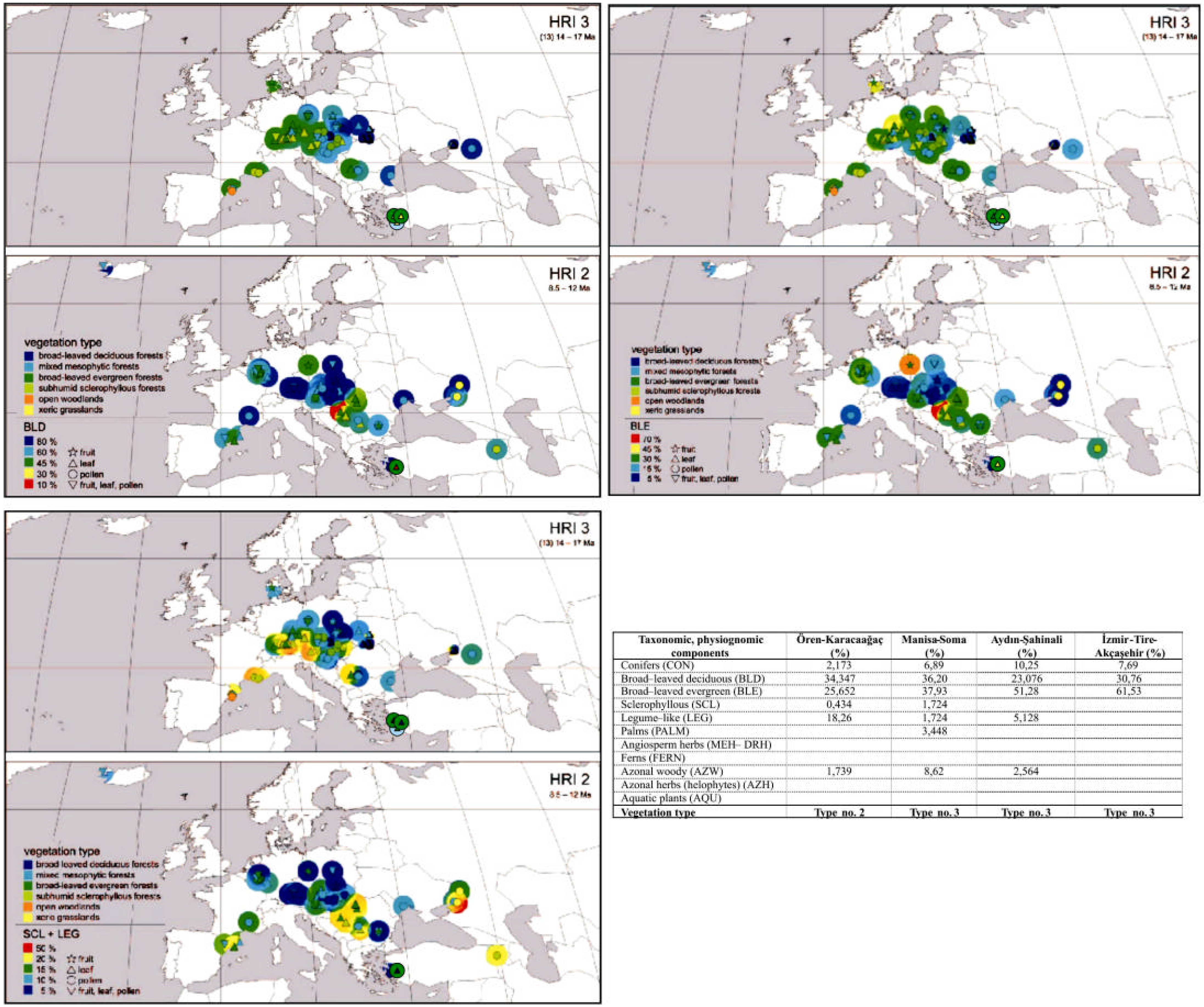
Type no. 6 (Zonal xeric grasslands or steppe "xeric grasslands and vegetation"): MEH +DRH=40% of all zonal taxa. The presence of *Artemisia*, Chenopodiaceae, and Poaceae (Gramineae) is characteristic.

Table 6.9 Zonal vegetation types, as defined by percent of various components of angiosperm taxa (Kovar–Eder et al., 2008).

Vegetation type		**Woody taxa**			**Herbaceous taxa**
	No	**BLD**	**BLE**	**SCL + LEG**	**MEH + DRH**
Broad–leaved deciduous forests	1	**=80%**			mostly =30%
Mixed mesophytic forests	2	**<80%**	**<30%**	**<20%**	<30%
Broad–leaved evergreen forests	3		**=80%**	**(SCL + LEG) < BLE**	<25%
Subhumid sclerophyllous forests	4			**=20%**	
Xeric open woodlands mostly	5		mostly =30%	**=20%**	**30–40%;** **MEH > DRH up to 10% of all zonal herbs**
Xeric grasslands or steppe	6				**=40%**

Utescher et al. (2007) published Miocene mega and microfloral records in western Eurasia and analyzed with respect to diversity of different plant functional types for the Langhian, Serravallian and Tortonian times. Zonally arranged patterns of these times are obtained by authors. Broadleaved deciduous forests are most important in the higher latitudes while mixed mesophytic forest dominate the mid–latitudes in western Eurasia. Broadleaved evergreen forests are of minor importance in the region.

According to Kovar–Eder & Kvacek (2003) the BLD components corresponds to the humid temperate component, the BLE components represents humid subtropical component and the SCL, LEG components characterizes the subhumid subtropical component. Later than Kovar–Eder et al (2008) established the zonal vegetation (HRI3 "late Burdigalian–Langhian, 14–17Ma", HRI2 "middle Serravallian–Tortonian, 6.5–12Ma" and HRI1 "Messinian–early Pliocene, 4–7Ma") from the Langhian to early Pliocene (Fig. 6.73). During the late Early–early Middle Miocene (HRI3) the high values of LEG components in Hungary, Serbia, Austria and southern Germany are especially remarkable. Comparing the components indicating humid condition the percentage of the BLE components is considerably high in west than east. The western area shows clearly higher rates of SCL and LEG components. During the late Burdigalian–Langhian (HRI3) broad–leaved evergreen and subhumid sclerophyllous forests were the dominant vegetation types in the western part of the central Paratethys region. Toward the southwest, subhumid sclerophyllous forest have been recorded from southern France and open woodlands are known from north Spain. Further east mixed mesophytic forest common according to the Kovar–Eder et al. (2008).



Taxonomic, physiognomic components	Ören-Karacaağaç (%)	Manisa-Soma (%)	Aydın-Şahinali (%)	İzmir-Tire-Akçaşehir (%)
Conifers (CON)	2,173	6,89	10,25	7,69
Broad–leaved deciduous (BLD)	34,347	36,20	23,076	30,76
Broad–leaved evergreen (BLE)	25,652	37,93	51,28	61,53
Sclerophyllous (SCL)	0,434	1,724		
Legume–like (LEG)	18,26	1,724	5,128	
Palms (PALM)		3,448		
Angiosperm herbs (MEH– DRH)				
Ferns (FERN)				
Azonal woody (AZW)	1,739	8,62	2,564	
Azonal herbs (helophytes) (AZH)				
Aquatic plants (AQU)				
Vegetation type	**Type no. 2**	**Type no. 3**	**Type no. 3**	**Type no. 3**

Figure 6.73 Maps showing vegetation types (colored symbols) and percentage of BLD, BLE and SCL+LEG components in the colored area surrounding each symbol; HRI3 also includes the late Burdigalian–Langhian and HRI2 also includes middle Serravallian–Tortonian (European vegetational results taken Kovar–Eder et al (2008) and added the vegetational results of western Turkey).

Kovar–Eder (2004) emphasized that in Europe, during the late Early–early Middle Miocene higher percentages of sclerophyllous oaks, *Ziziphus* and lower numbers of evergreen broad–leaved taxa indicate the existence of sclerophyllous subhumid forest that physiognomically resemble modern natural Mediterranean vegetation.

In this study, taxonomic, physiognomic components of the Ören–Karacaagaç, Manisa–Soma, Aydin–Sahinali and Izmir–Tire–Akçasehir floras are calculated (Table 6.6) and also zonal vegetation types are determined based on the leaf fossil flora. According to the percentage of these components Ören–Karacaagaç flora represents the warm–temperate to subtropical mixed mesophytic forests "mixed mesophytic forests and vegetation" during the late Burdigalian–Langhian period. Manisa–Soma and Izmir–Tire–Akçasehir floras characterizes the subtropical broad–leaved evergreen forests "broad–leaved evergreen forests and vegetation" during the late Burdigalian–Langhian time interval. Additionally, early–middle Serravallian Aydin–Sahinali flora is represented by the subtropical broad–leaved evergreen forests "broad–leaved evergreen forests and vegetation" as the Manisa–Soma and Izmir–Tire–Akçasehir floras (Table 6.10 and Fig. 6.73).

Table 6.10 Percentage of taxonomic and physiognomic of Ören–Karacaagaç, Manisa–Soma, Aydin–Sahinali and Izmir–Tire–Akçasehir floral components.

Taxonomic, physiognomic components	**Ören–Karacaagaç (%)**	**Manisa–Soma (%)**	**Aydin–Sahinali (%)**	**Izmir–Tire–Akçasehir (%)**
Conifers (CON)	2,173	6,89	10,25	7,69
Broad–leaved deciduous (BLD)	34,347	36,20	23,076	30,76
Broad–leaved evergreen (BLE)	25,652	37,93	51,28	61,53
Sclerophyllous (SCL)	0,434	1,724		
Legume–like (LEG)	18,26	1,724	5,128	
Palms (PALM)		3,448		
Angiosperm herbs (MEH – DRH)				
Ferns (FERN)				
Azonal woody (AZW)	1,739	8,62	2,564	
Azonal herbs (helophytes) (AZH)				
Aquatic plants (AQU)				
Vegetation type	**Type no. 2**	**Type no. 3**	**Type no. 3**	**Type no. 3**

During the late Burdigalian–Langhian period, BLD zonal vegetation type in western Turkey is resemble to the central Europe vegetation types. In addition, percentage of the BLD component in the Pannonian basin is higher than percentage of the BLD in the central Europe and western Turkey (Fig. 6.73). Percentage of the BLE forest component of western Turkey is similar to percentage of central Europe.

Percentage of the SCL+LEG component is low values in the western Anatolia as the values of the central Europe. However, vegetation type in central Europe excepted for the southwestern part of Europe is represented by the BLD forest. Western Turkey is characterized by the mixed mesophytic and evergreen forests vegetation types. During the early–middle Serravallian, palaeovegetation in central and northern Europe is represented by the BLD whereas in western Turkey is characterized by the BLE. The SCL+LEG component is low percentage in western Turkey, however in the western part of the Pannonian basin this component is high percentage. According to zonal vegetation results, could be said that palaeoclimate in western Turkey more humid than European climate.

6.11 Palaeovegetation of Ören–Karacaagaç and Hüsamlar Microfloras

The aquatic palaeovegetation is represented by *Sparganiapollenites neogenicus*, *Nymphaepollenites minor*, *Monogemmites pseudosetarius* and abundantly observation of these species indicates the presence of the shallow lake from the Ören–Karacaagaç and Hüsamlar area. The plants of the swamp (*Inaperturopollenites dubius*, *Inaperturopollenites laevigatus*, *Triatriopollenites rurensis* and *Tricoporopollenites kruschi*) and riparian forests (*Polyvestibulopollenites verus*, *Polyporopollenites undulosus* and *Subtriporopollenites simplex*) are less abundantly defined in the both palynospectras. Coniferous forest elements are recorded abundantly in the microflora and evergreen–deciduous mixed mesophytic forest elements accompanied with this coniferous forest. This result indicates the presence of middle elevation area around the lake. Although percentage of the herb and shrubs species (i.e. *Ephedripites* spp., *Graminidites gramineoides*, *Periporopollenites multiporatus*, *Cichorioidites* sp. *liquiflora* type, *Tricoporopollenites* sp. (*tubuliflora* type)) in the Hüsamlar and Karacaagaç palynospectras is low, these species are varied in all samples (Fig. 6.72). This results thinks that presences of the open vegetational areas in the Karacaagaç and Hüsamlar regions during the middle Burdigalian–Langhian time.

During the measured stratigraphic section of the Karacaagaç region two floras are defined in this chapter. Palynoflora is defined from the lower part of the section which is represented by coal deposits and the macroflora of Karacaagaç region is recognized from the upper part of this section which is characterized by the marl during the middle Burdigalian-Langhian time (Fig. 6.72). Palaeovegetation of the lower part of the stratigraphic section is represented by aquatic vegetation, riparian forest and coniferous, evergreen–deciduous mixed forests. Open vegetation elements accompanied to these forest elements. Palaeovegetation of the upper part of this section is characterized by the especially riparian and swamp forest elements and sclerophyllous and mixed mesophytic forest plants are observed abundantly. Both floras are defined swamp and mixed mesophytic forests plants and this result indicates the widespread swamp area and there are middle elevation areas surround the marsh area.

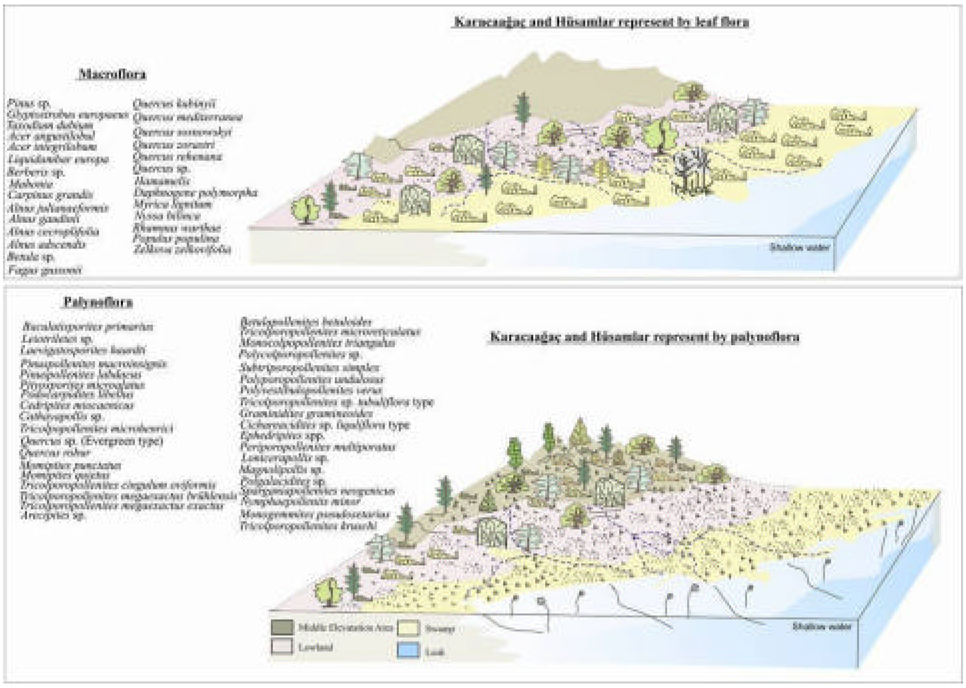


Figure 6.74 Reconstructed vegetation of the Karacaagaç and Hüsamlar regions.

6.12 Palaeoclimate

Three quantitative approaches were used to reconstruct the palaeoclimatic conditions of macro and microfloras for the Karacaagaç and Hüsamlar regions. The assumptions of these approaches and their procedures are outlined below. In addition, published macrofloras of the Turkey from the Manisa–Soma, Ankara–Beskonak, Ankara–Güvem, Aydin–Sahinali, Usak–Ilyasli, Çanakkale–Çan–Demirci and Izmir–Tire–Akçasehir regions are used for the palaeoclimatic correlation with the palaeoclimate of Karacaagaç and Hüsamlar region during the middle Burdigalian-Langhian period. Besides palaeoclimatic evolution is tried to establish based on the CA results of these regions.

6.12.1 Coexistence Approach (CA_{macro})

The climatic variables for the nine macroflora levels of the middle Burdigalian and late Serravallian time interval are obtained. Besides MAT, CMT, WMT, MAP, MAP_{WET}, MAP_{DRY} and MAP_{WARM} variables are used for the palaeoclimatic interpretation in this study. Reconstructed climatic estimates of the Ören–Karacaagaç using CA are MAT 13.9–13.9°C, CMT 2.7–7.0°C, WMT 25.7–26.1°C, MAP 1036–1046mm, MAP_{WET} 124–141mm, MAP_{DRY} 43–59mm and MAP_{WARM} 90.0–93.0mm and the ranges of the climatic parameters were determined by several climate–limiting species (Fig. 6.75; Table 6.11). The CA_{macro} intervals of the Ören–Hüsamlar macroflora are MAT 13.9–13.9°C, CMT 2.7–9.7°C, WMT 25.7–26.1°C, MAP 1036–1046mm, MAP_{WET} 124–159mm, MAP_{DRY} 43–63mm and MAP_{WARM} 90.0–116.0mm (Table 6.11). Results of the CA_{macro} for the Ankara–Beskonak macroflora are MAT 14.4–15.4°C, CMT 3.7–3.7°C, WMT 21.7–22.0°C or 26.5–26.7°C, MAP 1122–1171mm, MAP_{WET} 131–135mm, MAP_{DRY} 32.0–41.0mm or 43.0–49.0mm and MAP_{WARM} 108.0–113.0mm and for the Ankara–Güvem macroflora MAT 13.8–15.6°C, CMT 1.8–4.4°C, WMT 21.7–24.8°C or 25.7–26.8°C, MAP 897–1297mm, MAP_{WET} 125–153mm, MAP_{DRY} 29.0–37.0mm and MAP_{WARM} 84.0–84.0mm or 89.0–93.0mm. The CA_{macro} intervals of Manisa–Soma macroflora are represented by MAT 13.9–13.9°C or 15.3–15.6°C, CMT 2.7–2.7°C, WMT 25.7–25.7°C, MAP 1136–1237mm, MAP_{WET} 124–159mm, MAP_{DRY} 43.0–43.0mm and MAP_{WARM} 90.0–94.0mm (Table 6.11).

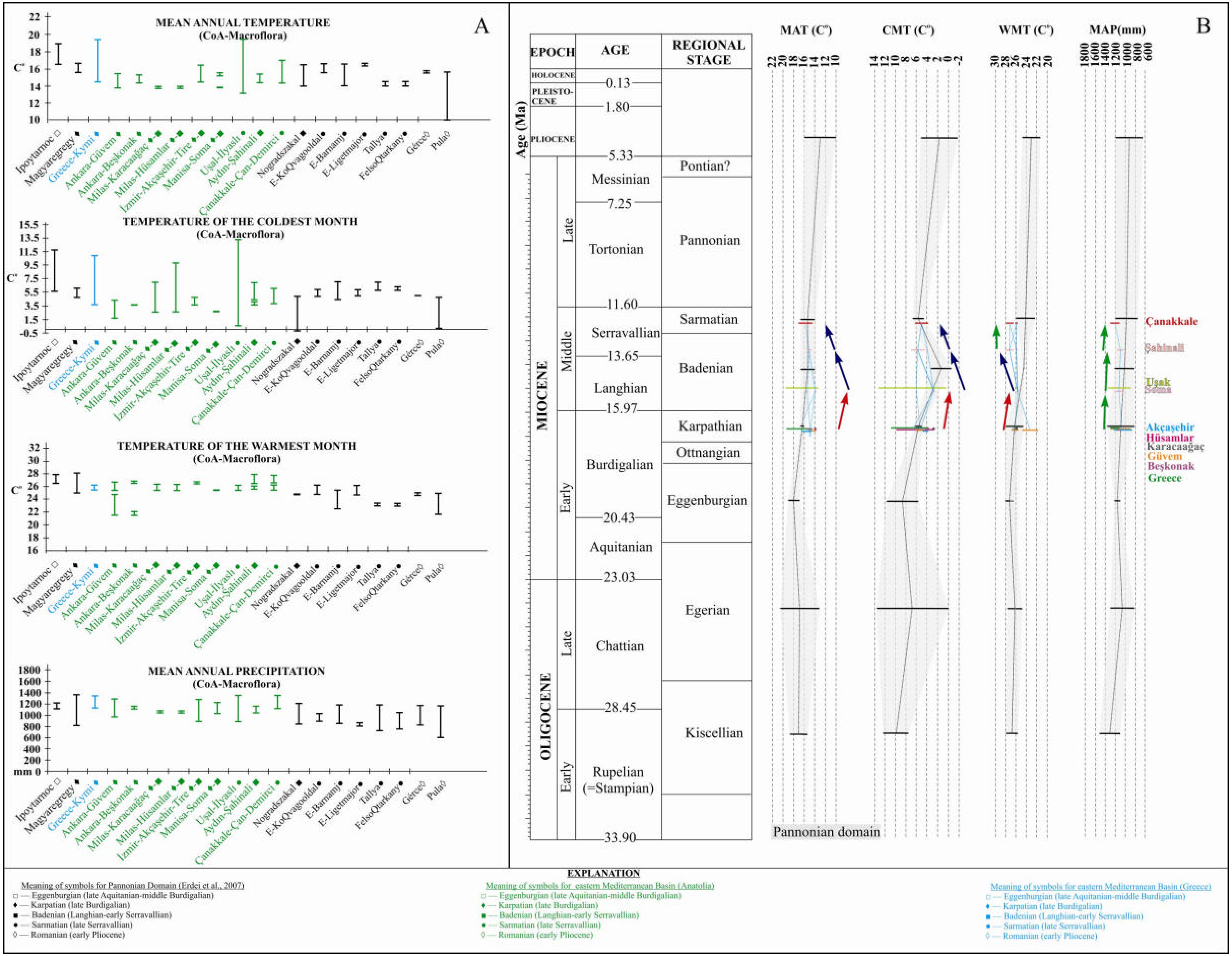


Figure 6.75 A) Intervals for MAT, CMT, WMT, MAP through the Neogene adopting the coexistence approach to fossil plant assemblages, B) trend of climatic variables the MAT, CMT, WMT and MAP during the late Burdigalian and late Serravallian times; correlation with the Pannonian domain (Erdei et al., 2007 and Akgün et al., 2007).

Table 6.11 Temperature values of the CA_{macro} for Ören–Karacaagaç, Ören–Hüsamlar, Manisa–Soma, Ankara–Beskonak, Ankara–Güvem, Aydin–Sahinali, Usak–Ilyasli, Çanakkale–Çan–Demirci and Izmir–Tire–Akçasehir regions.

	CA_{macro}							
Location	**MAT (°C)**	**CMT (°C)**	**WMT (°C)**	**MAP (mm)**	**MAP_{wet}**	**MAP_{dry}**	**MAP_{warm}**	**MART(°C)**
Ören–Karacaagaç	**13.9–13.9** (19 taxa) *Myrica cerifera*–*Myrica cerifera*	**2.7–7.0** (19 taxa) *Myrica cerifera*–*Zelkova carpinif*	**25.7–26.1** (19 taxa) *Myrica cerifera*–*Quercus ilex*	**1036.0–1046.0** (19 taxa) *Myrica cerifera*–*Alnus sibir*	**124.0–141.0** (19 taxa) *Myrica cerifera*–*Quercus*	**43.0–59.0** (19 taxa) *Myrica cerifera*–*Quercus*	**90.0–93.0** (19 taxa) *Myrica cerifera* *Acer trautv* **105.0–116.0** *Alnus trabec.* *Quercus ilex*	**21.05**
Ören–Hüsamlar	**13.9–13.9** (7 taxa) *Myrica cerifer*–*Myrica cerifera*	**2.7–9.7** (4 taxa) *Myrica cerifera*–*Carpinus betulus*	**25.7–26.1** (4 taxa) *Myrica cerifera*–*Quercus ilex coccif*	**1036.0–1046.0** (4 taxa) *Myrica cerifera*–*Alnus sibir oblongi*	**124.0–159.0** (4 taxa) *Myrica cerifera*–*Quercus ilex coccif*	**43.0–63.0** (4 taxa) *Myrica cerifera*–*Myrica cerifera*	**90.0–116.0** (4 taxa) *Myrica cerifera*–*Quercus ilex coccif*	**19.7**
Ankara–Beskonak	**14.4–15.4** (46 taxa) *Persea* sp.–*Castanopsis chrysoph*	**3.7–3.7** (47 taxa) *Persea* sp.–*Stratiotes (aloides)*	**21.7–22.0** (44 taxa) *Cercidiphyllum japon*–*Castanopsis chrysoph* **26.5–26.7** *Cassia* sp–*Juglans regia*	**1122.0–1171.0** (49 taxa) *Persea* sp.–*Castanopsis chrysoph*	**131.0–135.0** (49 taxa) *Persea* sp.–*Populus euphratica*	**32.0–41.0** (46 taxa) *Sapindus* sp.–*Cedrus sp.* **43.0–49.0** *Myrica cerifera*–*Populus tremula*	**108.0–113.0** (47 taxa) *Paliurus* sp.–*Juglans regia*	**18.15** **22.9**
Ankara–Güvem	**13.8–15.6** (32 taxa) *Ficus* sp.–*Comptonia peregrina.*	**1.8–4.4** (32 taxa) *Ficus* sp.–*Comptonia peregrina.*	**21.7–24.8** (31 taxa) *Zelkova* sp.–*Sorbus aucuparia L* **25.7–26.8** *Ficus* sp.–*Comptonia peregrina.*	**897.0–1297.0** (32 taxa) *Liquidambar styracif*–*Populus tremula*	**125.0–153.0** (32 taxa) *Ficus* sp.–*Comptonia peregrina*	**29.0–37.0** (32 taxa) *Acer sacharinum*–*Platycarya* sp.	**84.0–84.0** (28 taxa) *Liquidambar styracif*–*Zelkova carpinif* **89.0–93.0** *Cercidiphyllum japon*–*Acer trautv.pseudopl*	**20.15** **23.15**
Manisa–Soma	**13.9–13.9** (32 taxa) *Myrica cerifera*–*Thuja occidentalis* **15.3–15.6** *Ziziphus sinica*–*Comptonia peregrina*	**2.7–2.7** (32 taxa) *Myrica cerifera*–*Thuja occidentalis*	**25.7–25.7** (32 taxa) *Myrica cerifera*–*Thuja occidentalis*	**1136.0–1237.0** (34 taxa) *Myrica cerifera*–*Populus balsamifera*	**124.0–159.0** (33 taxa) *Ficus* sp.–*Populus balsamifera*	**43.0–43.0** (34 taxa) *Myrica cerifera*–*Pistacia lentiscus*	**90.0–94.0** (31 taxa) *Myrica cerifera*–*Populus balsamifera*	**23**
Usak–Ilyasli	**13.9–19.5** (9 taxa) *Taxodium distichum*–*Quercus ilex. coccif*	**0.4–13.3** (9 taxa) *Quercus ilex*–*Acer sacharinum*	**25.6–26.1** (9 taxa) *Taxodium distichum*–*Quercus ilex*	**897.0–1355.0** (9 taxa) *Taxodium distichum*–*Acer sacharinum*	**106.0–159.0** (9 taxa) *Taxodium distichum*–*Quercus ilex*	**42.0–70.0** (9 taxa) *Taxodium distichum*–*Acer sacharinum*	**84.0–116.0** (9 taxa) *Taxodium distichum*–*Quercus ilex*	**18.5**
Usak–Ilyasli 2	**13.9–20.8** (7 taxa) *Myrica cerifera*–*Acer sacharinum*	**2.7–13.3** (7 taxa) *Myrica cerifera*–*Acer sacharinum*	**25.7–28.4** (7 taxa) *Myrica cerifera*–Lauraceae	**1036.0–1355.0** (7 taxa) *Myrica cerifera*–*Acer sacharinum*	**160.0–195.0** (7 taxa) *Cinnamomum* sp.–*Acer sacharinum*	**43.0–59.0** (7 taxa) *Myrica cerifera*–*Plenasium* sp.	**90.0–177.0** (7 taxa) *Myrica cerifera*–*Taxodium distichum*	**19.85**
Izmir–Tire–Akçasehir	**14.4–16.5** (9 taxa) *Quercus incana*–*Populus balsamifera*	**3.7–4.8** (9 taxa) *Quercus incana*–*Populus balsamifera*	**26.5–26.7** (10 taxa) *Cassia* sp. *Buxus sempervirens*	**867.0–1237.0** (10 taxa) *Sapindus* sp. *Populus balsamifera.*	**116.0–134.0** (10 taxa) *Sapindus* sp. *Populus balsamifera*	**32.0–70.0** (10 taxa) *Sapindus* sp. *Acer sacharinum*	**81.0–86.0** (10 taxa) *Sapindus* sp. *Buxus sempervirens*	**22.35**
Aydin–Sahinali	**14.4–15.4** (23 taxa) *Quercus incana*–*Castanopsis chrysoph*	**3.7–4.1** (23 taxa) *Quercus incana*–*Betula pubescens* **4.5–7.0** *Sektion pinast*–*Fagus orientalis*	**25.6–26.1** (21 taxa) *Myrica cerifera*–*Quercus ilex coccif* **26.4–28.0** *Sapindus* sp.–*Fagus orientalis*	**1136.0–1171.0** (23 taxa) *Myrica cerifera*–*Castanopsis chrysoph*	**124.0–159.0** (23 taxa) *Myrica cerifera*–*Quercus ilex. coccif*	**43.0–59.0** (22 taxa) *Myrica cerifera*–*Quercus sekt Cerris*	**90.0–116.0** *Myrica cerifera*–*Quercus ilex. coccif*	**21.45** **21.45**
Çanakkale–Çan–Demirci	**14.4–17.0** (16 taxa) *Persea* sp *Cercidiphyllum japon*	**3.7–6.2** (16 taxa) *Persea* sp *Cercidiphyllum japon*	**25.7–26.1** (15 taxa) *Ulmus alata* *Quercus ilex* **26.4–27.9** *Sapindus* sp *Cercidiphyllum japon*	**1122.0–1355.0** (16 taxa) *Persea* sp *Acer sacharinum*	**131.0–159.0** (16 taxa) *Persea* sp *Quercus ilex*	**42.0–63.0** (16 taxa) *Taxodium distichum* *Ulmus a lata*	**90.0–116.0** (16 taxa) *Persea* sp *Quercus ilex*	**22.2**

Results of the CA_{macro} for the Izmir–Tire–Akçasehir macroflora are MAT 14.4–16.5°C, CMT 3.7–4.8°C, WMT 26.5–26.7°C, MAP 867–1237mm, MAP_{WET} 116–134mm, MAP_{DRY} 32.0–70.0mm and MAP_{WARM} 81.0–86.0mm and for the Aydin–Sahinali macroflora MAT 14.4–15.4°C, CMT 3.7–4.1°C, WMT 25.6–26.1°C or 26.4–28.0°C, MAP 1136–1171mm, MAP_{WET} 124–159mm, MAP_{DRY} 43.0–59.0mm and MAP_{WARM} 90.0–116.0mm (Table 6.11).The CA_{macro} intervals of the Usak–Ilyasli macroflora are MAT 13.9–19.5°C, CMT 0.4–13.3°C, WMT 25.6–26.1°C, MAP 897–1355mm, MAP_{WET} 106–159mm, MAP_{DRY} 42–70mm and MAP_{WARM} 84.0–116.0mm (Table 6.11). Çanakkale–Çan–Demirci macroflora are represented by MAT 14.4–17.0°C, CMT 3.7–6.2°C, WMT 25.7–26.1°C or 26.4–27.9°C, MAP 1122–1355mm, MAP_{WET} 131–159mm, MAP_{DRY} 42.0–63.0mm and MAP_{WARM} 90.0–94.0mm (Table 6.11) (Fig. 6.75).

The coexistence approach intervals of the Akçasehir, Hüsamlar, Karacaagaç, Güvem and Beskonak macrofloras during the late Burdigalian–late Serravallian period generally resemble with each other. Temperature values based on the macrofloras of western and central Turkey indicates that increasing from late Burdigalian to Langhian. From the Langhian to Serravallian, the palaeoclimatic trend indicates the slightly cooling related to the decreasing of temperature values. This decreasing continues during the Serravallian period. MAP values have minor fluctuations. The straight increasing of the temperature is observed CMT values and this warm climatic condition could be corresponded with the Middle Miocene Climatic Optimum period which is recorded during the late Burdigalian–Langhian time interval (Zachos et al., 2001).

In this study precipitation records are obtained based on the Turkey macrofloras. The MAP, MAP_{wet}, MAP_{dry} and MAP_{warm} records slightly increase from the Burdigalian to Langhian (Fig. 6.76). This increasing precipitation rates can be interrelated with warm climatic period which is recorded during the late Burdigalian–Langhian time interval. During the Serravallian period, MAP_{dry}, MAP_{wet} and MAP_{warm} values are not observed changing except for the MAP value. Observing the different precipitation values during the same time interval could be explained the seasonality.

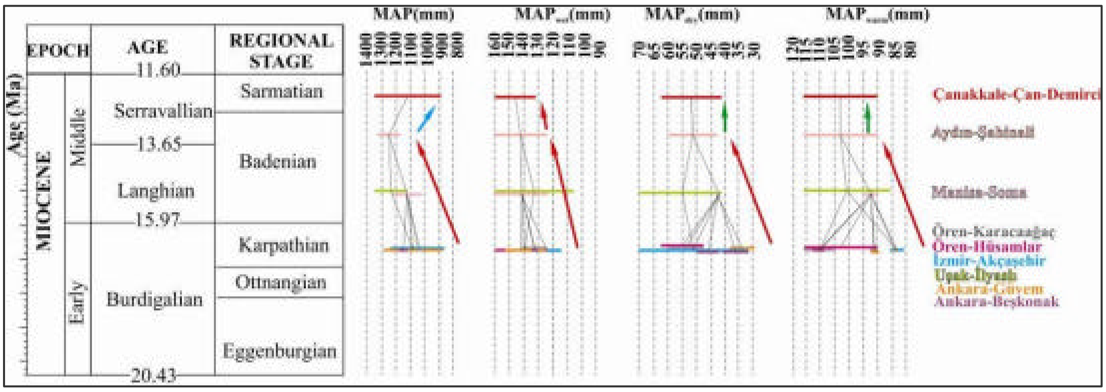


Figure 6.76 Coexistence intervals for mean annual precipitation rates (MAP), precipitation in the warmest month (MAP_{warm}), the driest month (MAP_{dry}), and warmest month (MAP_{wet}) of Turkey macrofloras. The solid curves are tentatively plotted about connecting interval means.

Palaeoclimatic evolution of the Pannonian domain (Erdei et al., 2007) from the Karpathian to Sarmatian is represented by firstly warming and that cooling. This palaeoclimatic trend resembles to Turkey's palaeoclimatic trend. However, Turkey's CA_{macro} values of the late Burdigalian (=Karpathian) time higher than the values of Pannonian domain whereas during the late Langhian and early–middle Serravallian period temperature values of Turkey lower than the values of Pannonian domain. For the late Serravallian time the results of the Turkey's CA_{macro} similar to results of Pannonian domain. The CA_{macro} results of Greece only obtained for the late Burdigalian time and the values of Greece are generally lower than the values of Turkey (Fig. 6.75A, 6.75B). The MAP values of Turkey during the late Burdigalian–late Serravallian period higher than the MAP values of Pannonian domain. Hence the warmer climatic condition in Turkey during this period explains that widespreading BLE forest vegetation.

6.12.2 Coexistence Approach (CA_{micro})

The climatic variables for the Karacaagaç and Hüsamlar microfloras of the middle Burdigalian and Langhian time interval are calculated. Range of the temperature for the MAT, CMT, WMT and MAP climatic variables are obtained. The CA results of the Ören–Karacaagaç microflora are MAT 17.0–18.4°C (*Cathaya* sp.–*Cedrus* sp.), CMT 6.2–12.5°C (*Cathaya* sp.–*Cedrus* sp.), WMT 26.5–28.1°C (*Cathaya* sp.–Cupressaceae), MAP 1146–1322mm (*Cathaya* sp.–*Cathaya* sp.), MAP$_{\text{WET}}$ 225–227mm (*Cathaya* sp.–*Pinus sylvestris*), MAP$_{\text{DRY}}$ 7–32mm (*Cathaya* sp.–*Cathaya* sp.) and MAP$_{\text{WARM}}$ 79.0–125.0mm (*Engelhardtia* sp.–*Pinus sylvestris*) and the ranges of the climatic parameters were determined by several climate–limiting species (Table 6.13). The CA$_{\text{micro}}$ intervals of the Ören–Hüsamlar microflora are MAT 17.0–21.3°C (*Carya cordiformis*–*Pinus sylvestris*), CMT 6.2–13.3°C (*Cathaya* sp.–*Pinus sylvestris*), WMT 27.3–28.1°C (Cycadaceae–Cupressaceae), MAP 1146–1322mm (*Cathaya* sp.–*Cathaya* sp.), MAP$_{\text{WET}}$ 225–227mm (*Cathaya* sp.–*Pinus sylvestris*), MAP$_{\text{DRY}}$ 8–32mm (Cycadaceae–*Cathaya* sp.) and MAP$_{\text{WARM}}$ 79.0–125.0mm (*Engelhardtia* sp.–*Pinus sylvestris*) (Table 6.12).

Table 6.12 Predicted climate parameters for fossil sites in this study.

	CLAMP	**LMA**	**CA$_{\text{macro}}$**	**CA$_{\text{micro}}$**	**CA$_{\text{micro}}$**
Climate Parameters	**Karacaagaç**				**Hüsamlar**
MAT (°C)	13,36	14.25±1.17	13.9–13.9	17.0–18.4	17.0–21.3
CMT(°C)/ CMMT (°C)	4,47		2.7–7.0	6.2–12.5	6.2–13.3
WMT(°C)/ WMMT (°C)	23,35		25.7–26.1	26.5–28.1	27.3–28.1
MAP (mm)			1036.0–1046.0	1146.0–1322.0	1146.0–1322.0
MAP$_{\text{wet}}$ (mm) / 3–WET (mm)	56,03		124.0–141.0	225.0–227.0	225.0–227.0
MAP$_{\text{dry}}$ (mm) / 3–DRY (mm)	26,98		43.0–59.0	7.0–32.0	8.0–32.0
MAP$_{\text{warm}}$ (mm)			90.0–93.0 or 105.0–116.0	79.0–125.0	79.0–125.0
MGSP (mm)	108,49				
MMGSP (mm)	13,80				
RH (%)	67,65				
SH (%)	7,09				
ENTHAL	30,53				

6.12.3 Results of Climate Leaf Analysis Multivariate Program (CLAMP) and Leaf Margin Analysis (LMA) Analysis Methods for Karacaagaç flora.

In CLAMP, 31 physiognomic character states that encompass lobing, margin geometry, apex and base shape, and lamina size and shape are used (Table 6.13). Typically, 11 climate variables (MAT; warm month mean temperature, WMMT; cold month mean temperature, CMMT; length of the growing season, LGS; mean growing season precipitation, MGSP; mean monthly growing season precipitation, MMGSP; precipitation during the three wettest months, 3–WET; precipitation during the three driest months, 3–DRY; specific humidity, SH; relative humidity, RH; and Enthalpy) are correlated with the foliar physiognomic data using canonical correspondence analysis (Ter Braak, 1986) in the form of the program CANOCO v. 4. For the CLAMP analysis of Karacaagaç macroflora, PHYSG3BR data set, the default values in CANOCO 4.0 are used, and placed the results in a spreadsheet appropriate to PHYSG3BR as available from the CLAMP website (see the CLAMP website for details: http://www.open.ac.uk/earth–research/spicer/CLAMP/Clampset1.html; 05.02.2010; 15:44).

Table 6.13 The statistics of the leaf scorings for CLAMP on the Karacaagaç macroflora.

Leaf Character	Percentage	Leaf Character	Percentage
Lobed	6	Emarginate apex	4
No teeth	43=42.9	Round apex	72
Regular teeth	43	Acute apex	13
Close teeth	31	Attenuate apex	10
Round teeth	16	Cordate base	15
Acute teeth	41	Round base	59
Compound teeth	14	Acute base	25
Nanophyll	0	L:Wb1:1	4
Leptophyll 1	0	L:W 1–2:1	59
Leptophyll 2	3	L:W 2–3:1	24
Microphyll 1	12	L:W 3–4:1	4
Microphyll 2	58	L:WN4:1	10
Microphyll 3	26	Shape obovate	6
Mesophyll 1	1	Shape elliptic	89
Mesophyll 2	0	Shape ovate	6
Mesophyll 3	0		

There are two physiognomic techniques in common usage. The first of these is simple LMA first introduced by Bailey & Sinnott (1915, 1916) and it is recently revisited by Wolfe (1979), Wing & Greenwood (1993), and Wilf (1997). LMA relies on the correlation that exists between the proportion of nontoothed (entire) woody dicotyledone leaves in a given patch of stable (nonpioneer) vegetation and the mean annual temperature. In humid to mesic vegetation, the relationship is essentially a straight line, the slope and intercept of which differ between the northern and southern hemispheres. The percentage of entire margined species (PEMS) was employed to predict MAT from the relationship shown by the following equation for the northern hemisphere based on southeastern Asia data:

MAT = 30.6 P + 1.14 as shown by Wolfe (1979) and Wing & Greenwood (1993). The MAT errors are calculated by Wilf's (1997) sample error equation:

$$\mathrm{dMAT} = c \times \sqrt{\frac{P(1-P)}{r}}$$

c = 30.6 and is the slope of the MAT vs. leaf margin regression (Wilf, 1997);

"r" is the total species number (Wilf, 1997);

"p" ($0 < p < 1$) is the fraction (Wilf, 1997);

"r" species that have entire margins (Wilf, 1997).

Calculation of MAT values based on the LMA is below;

MAT = 30.6 P + 1.14 (P = 0.429 % for the Karacaagaç macroflora)

MAT = 30.6 x 0.429 + 1.14= 14.27°C

$$\mathrm{dMAT} = 30.6 \times \sqrt{\frac{0.429\,(1-0.429)}{167}}$$

dMAT= ±1.17

MAT = 14.27±1.17°C (Fig. 6.77)

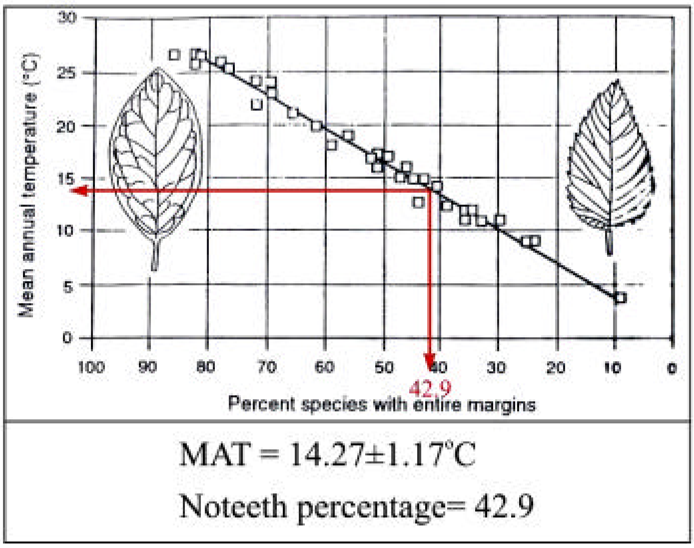


Figure 6.77 Correlation between the percentage of species in a local floras with entire margineted leaves and mean annual temperature (MAT) of Karacaagaç macroflora

The temperature values of Ören–Karacaagaç micro and macrofloras are correlated with CLAMP, LMA, CA_{macro} and CA_{micro} and the temperature values of Ören–Hüsamlar microflora is estimated using the CA_{micro} method (Table 6.12). Generally, temperature values of macroflora are similar with each other. However, least MAT value is obtained from CLAMP analysis method (Table 6.12). Highest value of the MAT is seen LMA method. The CMT and WMT values of the CA_{macro} are slightly higher than the CLAMP method. The all temperature CA results of the microflora are straightly higher that CA macroflora's results. This difference could be related to the showing the different floral composition of the macro and microfloras. For instance, the Karacaagaç microflora includes the herb species (Poaceae, Ephedraceae and Asteraceae), abundantly aquatic plants (Sparganiaceae and Nymphaceae) whereas these species not observed in macroflora of Karacaagaç region.

According to all methods, the middle Burdigalian-Langhian Karacaagaç and Hüsamlar floras are growing subtropical climatic condition in western Turkey based on macro and microfloras. And also this warm climatic condition can be corresponded the Middle Miocene Climatic Optimum period which is recorded in Europe (Zachos et al., 2001)

Using the temperature values is obtained the plant formation based on the difference methods (Wolfe, 1985; Kloetzli, 1988; Song, 1983, 1988) (Figs 6.78–6.79). In figures 6.78 and 6.79, the macrofloras of Turkey are located in area of the broadleaved evergreen. Additionally, Song (1983) and (1988) constituted the temperature parameters of vegetation zones used the Chinese flora. The late Early–late Middle Miocene macrofloras in Turkey is located in the area transitional subtropical temperate zone in figure 6.80. Besides, the late Middle Miocene floras of Turkey are located in the same area with the late Early–late Middle Miocene macrofloras according to temperature parameters of Chinese vegetation zones of Song (1983) and (1988).

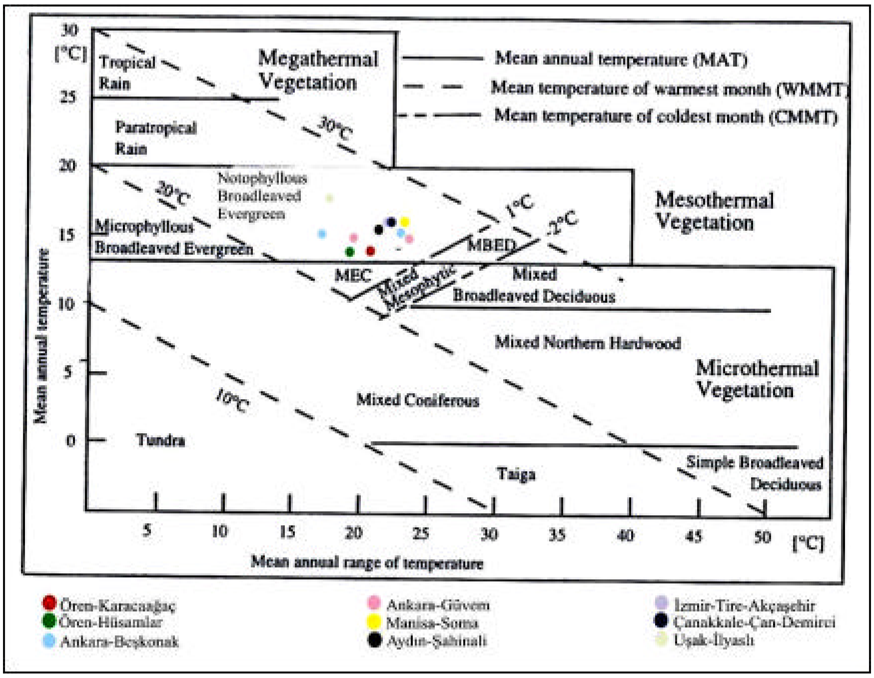


Figure 6.78 Climatic characterization of plant formation after Wolfe (1985). MEC: Mixed Evergreen and Coniferous. MBED: Mixed Broadleaved Evergreen and Deciduous. Colored circles symbolize the macroflora of Ören–Karacaagaç, Ören–Hüsamlar, Ankara–Beskonak, Ankara–Güvem, Manisa–Soma, Aydin–Sahinali, Izmir–Tire–Akçasehir, Çanakkale–Demirci–Çan and Usak–Ilyasli.

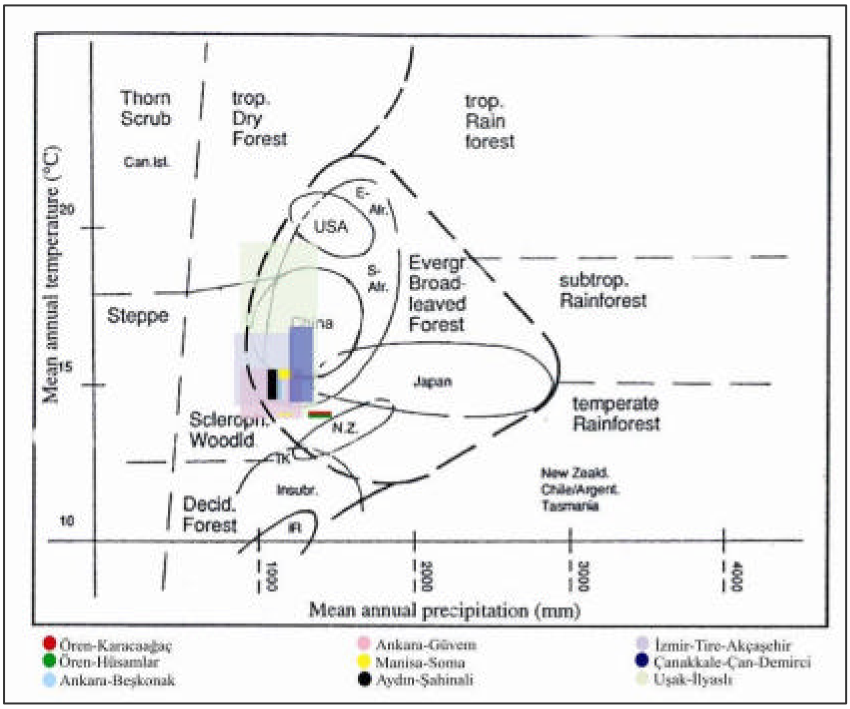
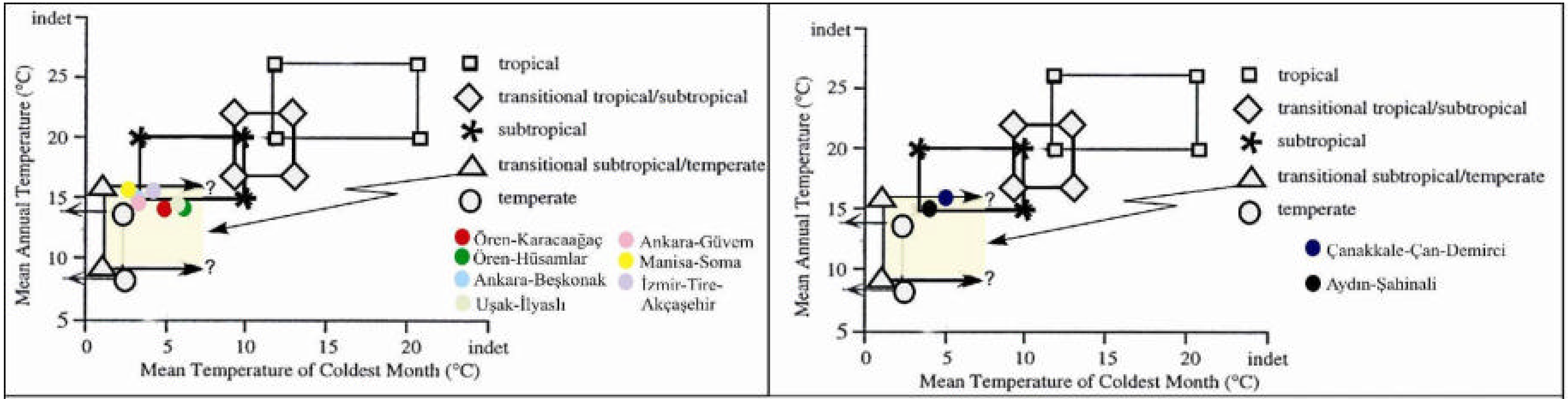


Figure 6.79 The mean annual temperature and mean annual precipitation of the worldwide distribution of evergreen broad–leaved forests (=laurophyllous) and adjacent plant formation after Kloetzli (1988). Colored areas symbolize the macroflora of Ören–Karacaagaç, Ören–Hüsamlar, Ankara–Beskonak, Ankara–Güvem, Manisa–Soma, Aydin–Sahinali, Izmir–Tire–Akçasehir, Çanakkale–Demirci–Çan and Usak–Ilyasli.



vegetation zone	climate parameters	vegetation zone^b	formation	zonobiome^a
tropical ◻	MAT 20 - 26 °C. CMMT: 12 - 21 °C, no frost	tropical	semideciduous laurophyllous forest	zonoecotone I-II
tropical-subtropical transition ◇	MAT 17 - 22 °C. CMMT 9 - 13 °C, occasional frost	tropical-meridional	Monsoon laurophyllous forest and dry sclerophyllous forest	zonoecotone V-II
subtropical *	MAT 15 - 20 °C. CMMT: 3 - 10 °C, extreme minima > -10 °C, 25-55 days frost.	meridional (boreosubtropical to meridional)	laurophyllous (humid), and sklerophyllous (semihumid) forest	zonobiome V
subtropical-temperate transition △	MAT 14 - 16 °C, CMMT > 1 °C, or MAT 9 - 14 °C, extreme minima -10 - -20 °C, 115 - 165 days frost	northern subtropical (northern meridional)	mixed mesophytic forests	zonoecotone V-VI
temperate ○	MAT 8 - 14 °C, CMMT -15 - 2 °C), Regularly occuring frosts.	nemoral, (sub-meridional, temperat)	deciduous forests	zonobiome VI

Figure 6.80 The graphic indicates temperature parameters of Chinese vegetation zones defined by Song (1983, 1988). The table (lower part of the figure) indicates the characterization of recent climatic vegetation zones sensu Song (1983, 1988). Colored circles symbolize the macroflora of Ören–Karacaagaç, Ören–Hüsamlar, Ankara–Beskonak, Ankara–Güvem, Manisa–Soma, Aydin–Sahinali, Izmir–Tire–Akçasehir, Çanakkale–Demirci–Çan and Usak–Ilyasli.

PLATE CAPTIONS (HÜSAMLAR AND KARACAAGAÇ REGIONS)

PLATE 6.1 (Hüsamlar)

1-2.	Primitive *Gomphitherium* sp.

PLATE 6.2 (Hüsamlar)

1.	*Carpinus grandis* UNGER emend. HEER
2.	*Fagus gussonii* MASSALONGO emend. KNOBLOCH & VELITZELOS
3, 3a.	*Daphnogene polymorpha* (AL. BRAUN) ETTINGSHAUSEN
4.	*Myrica lignitum* (UNGER) SAPORTA
5.	*Quercus mediterranea* UNGER
6.	*Alnus cecroplifolia* (ETTINGSHAUSEN) BERGER

PLATE 6.3 (Karacaagaç)

1, 2	*Acer integrilobum* WEBER
3–12	*Acer angustilobum* HEER

PLATE 6.4 (Karacaagaç)

1–6	*Acer angustilobum* HEER

PLATE 6.5 (Karacaagaç)

1–3	*Acer angustilobum* HEER

PLATE 6.6 (Karacaagaç)

1–7	*Acer angustilobum* HEER

PLATE 6.7 (Karacaagaç)

1–12	*Acer angustilobum* HEER

PLATE 6.8 (Karacaagaç)

1–5.	*Pinus* sp.
6.	*Liquidambar europa* A. BRAUN
7-10.	*Carpinus grandis* UNGER emend. HEER
11.	*Taxodium dubium* (STERNBERG) HEER
12.	*Berberis* sp.
13.	*Glyptostrobus europaeus* (BRANGNIART) UNGER

PLATE 6.9 (Karacaagaç)

1.	*Alnus julianaeformis* (STERNBERG) KVACEK & HOLÝ
2.	*Alnus cecroplifolia* (ETTINGSHAUSEN) BERGER
3.	*Betula* sp.
4a, 4b.	*Alnus gaudinii* (HEER) KNOBLOCK et KVACEK
5-6b.	*Alnus adscendens* (GOEPPERT) ZASTAWNIAK & WALTHER
7.	*Hamamelis* sp.

PLATE 6.10 (Karacaagaç)

1-15. *Quercus mediterranea* UNGER

PLATE 6.11 (Karacaagaç)

1-10, 12-15. *Quercus zorastri* UNGER
11, 16, 17. *Quercus sosnowskyi* KOLAKOVSKII

PLATE 6.12 (Karacaagaç)

1-15. *Quercus rehenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK

PLATE 6.13 (Karacaagaç)

1-12. *Quercus rehenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK

PLATE 6.14 (Karacaagaç)

1-11. *Quercus rehenana* (KRÄUSEL et WEYLAND) KNOBLOCH et Z. KVACEK

PLATE 6.15 (Karacaagaç)

1-5b. *Fagus gussonii* MASSALONGO emend. KNOBLOCH & VELITZELOS
7. *Quercus* sp.

PLATE 6.16 (Karacaagaç)

1-8. *Nyssa bilinica* (UNGER) KVACEK
9. *Daphnogene polymorpha* (AL. BRAUN) ETTINGSHAUSEN
10-15. *“Rhamnus” warthae* HEER
16. *Populus populina* (BRONGNIART) KNOBLACH

PLATE 6.17 (Karacaagaç)

1-4a. *Myrica lignitum* (UNGER) SAPORTA

PLATE 6.18 (Karacaagaç)

1. *Dicotylophyllum* sp. 1
2, 3. *Dicotylophyllum* sp. 2
4. *Dicotylophyllum* sp. 3
5-18. *Dicotylophyllum* sp. 4
15. *Dicotylophyllum* sp. 5
16, 17. *Dicotylophyllum* sp.6

PLATE 6.19 (Karacaagaç)

1. *Quercus kubinyii* (KOVÁTS ex ETTINGSHAUSEN) CZECZOTT
2. *Mahonia* sp.
3, 4. *Zelkova zelkovifolia* (UNGER) BUŽ EK et KOTLABA

PLATE 6.1 (Hüsamlar)

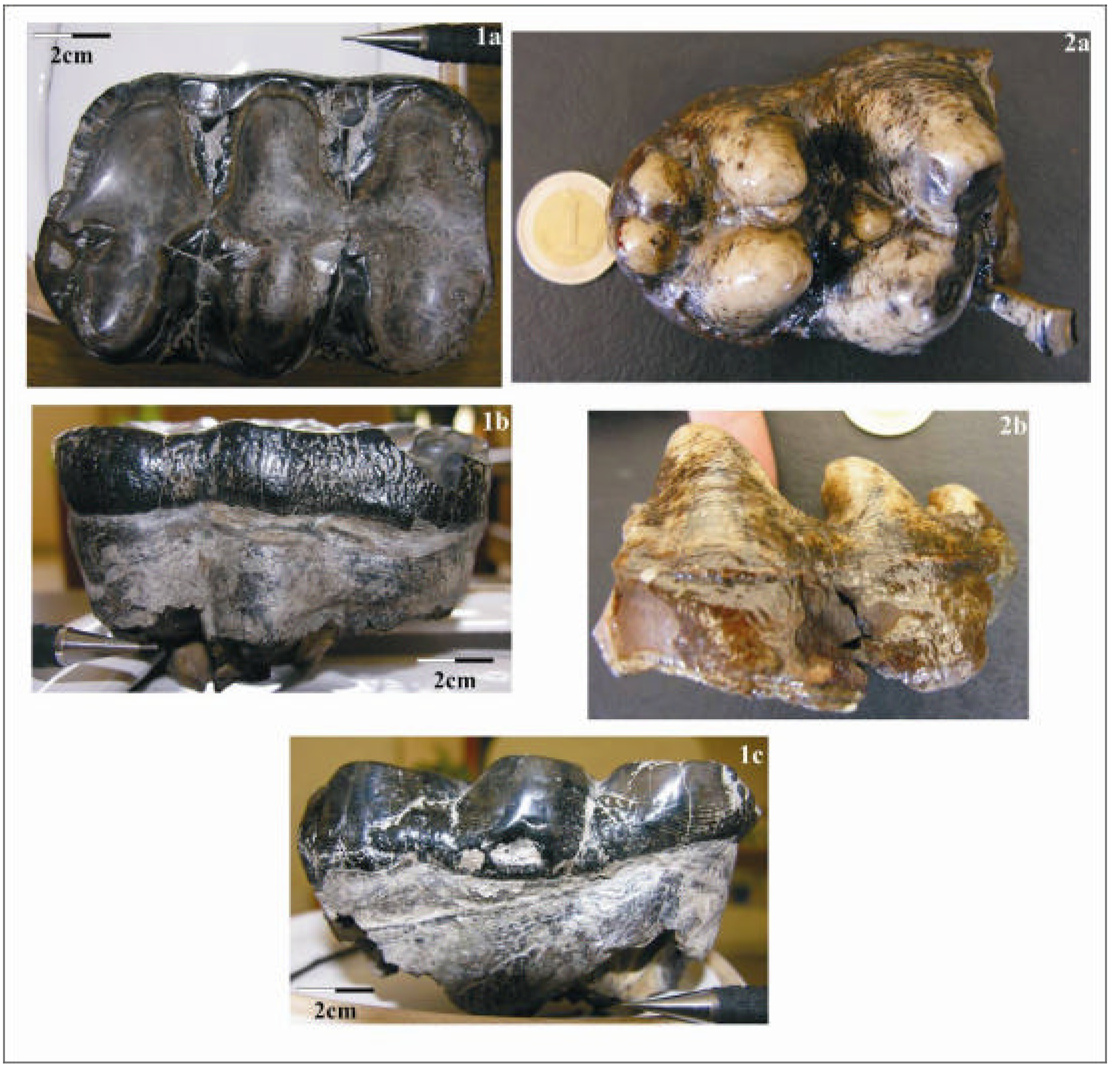


PLATE 6.2 (Hüsamlar)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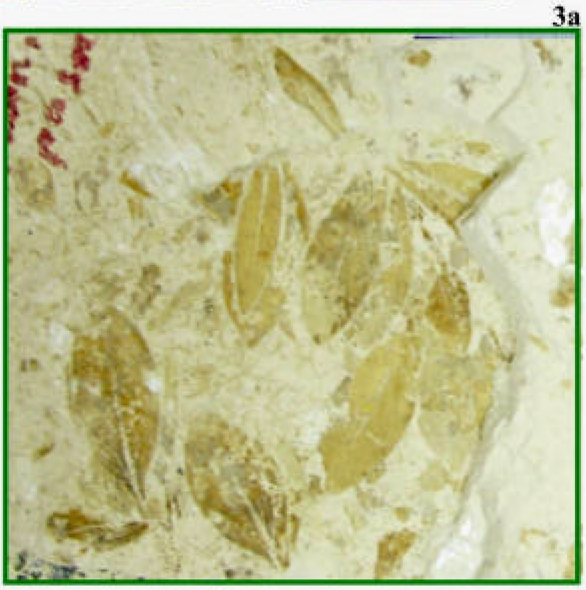
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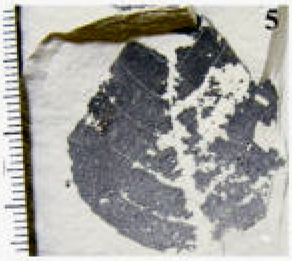
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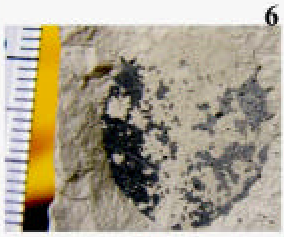
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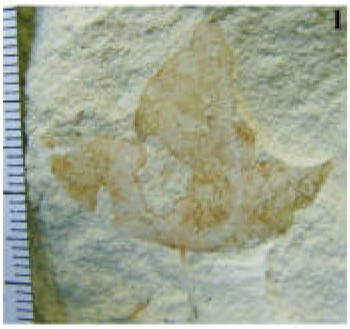
PLATE 6.3 (Karacaagaç)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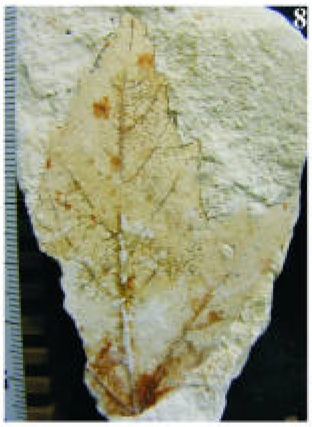
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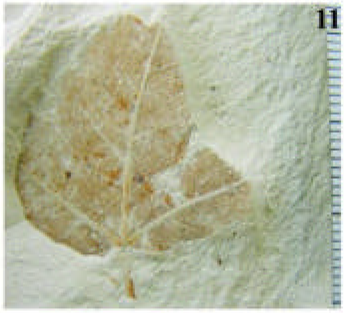
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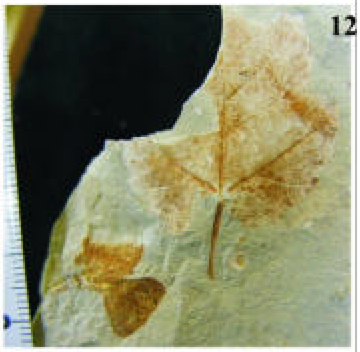
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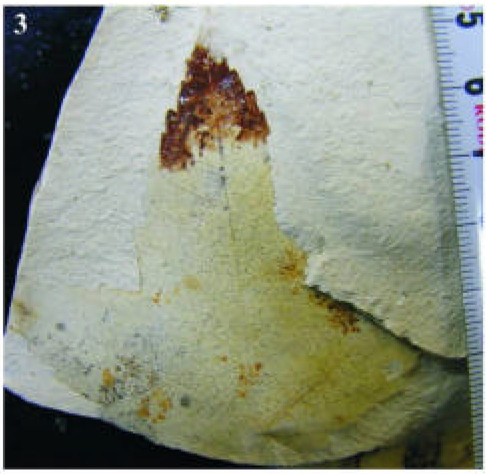

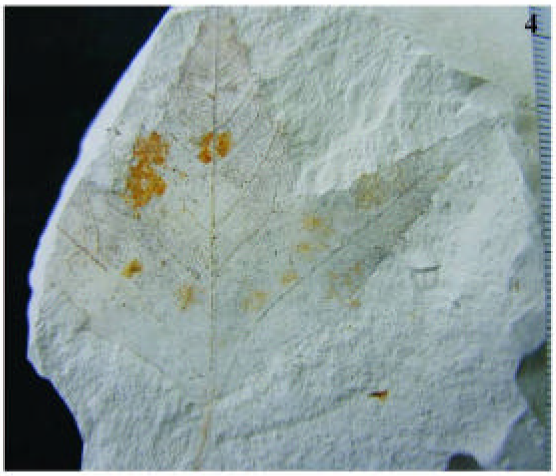

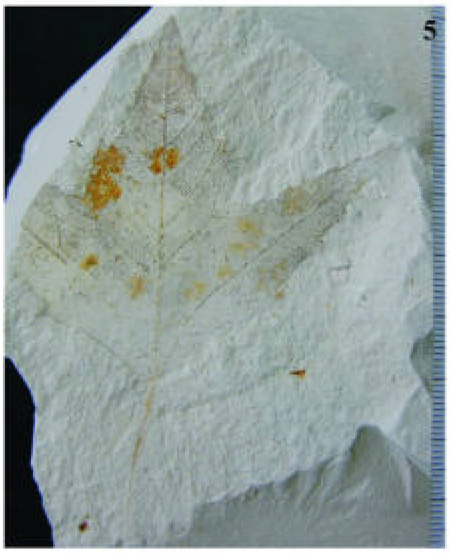

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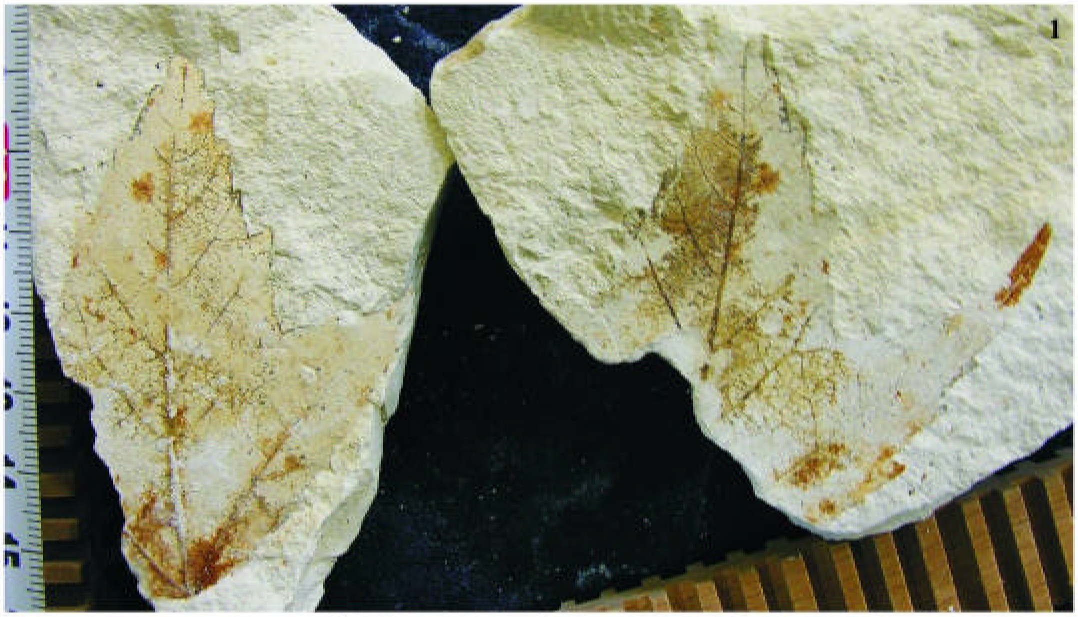
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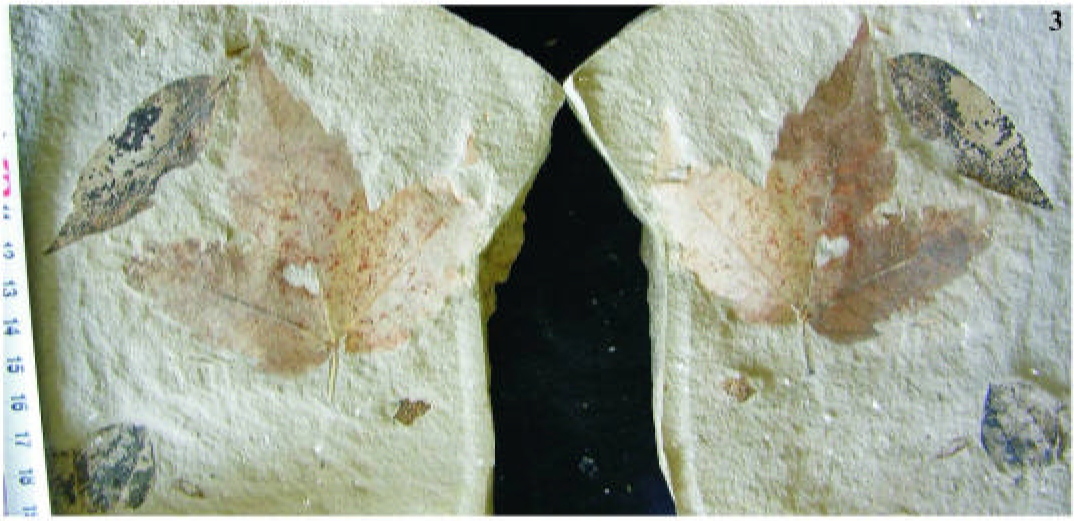
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PLATE 6.6 (Karacaagaç)


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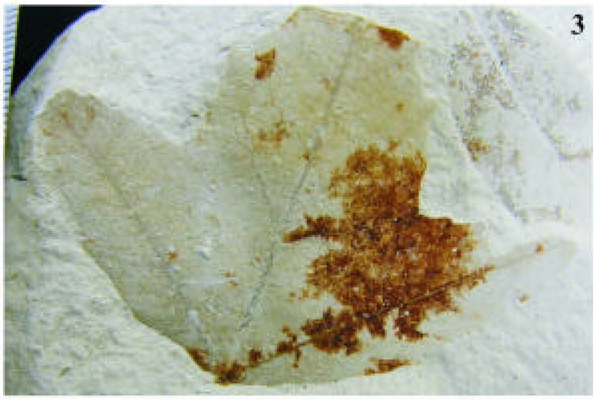
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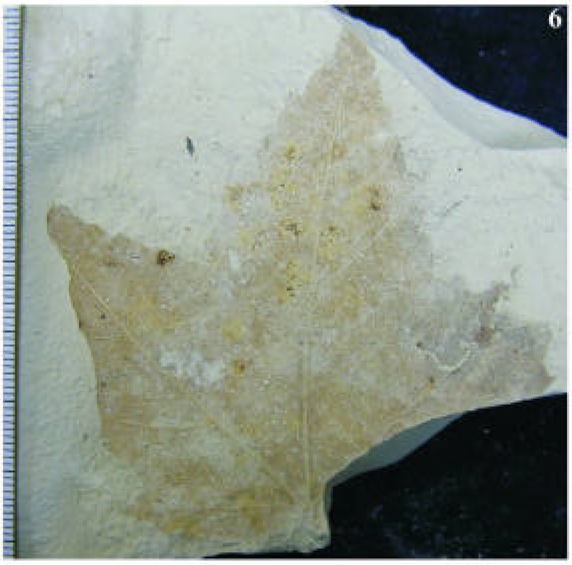
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PLATE 6.7 (Karacaagaç)


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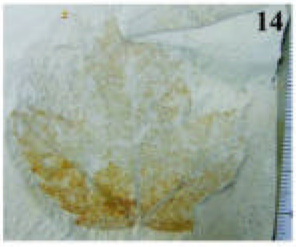
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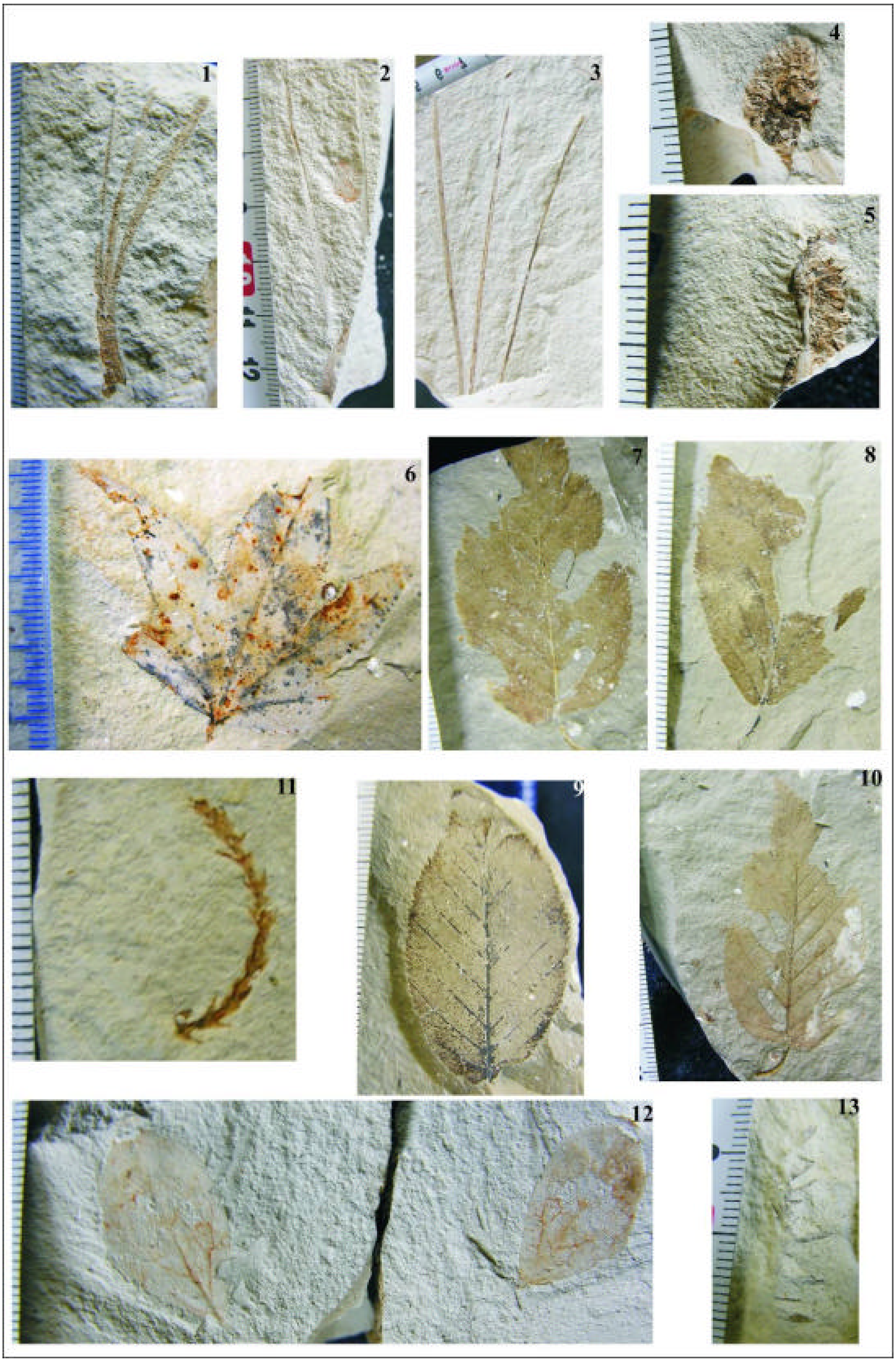

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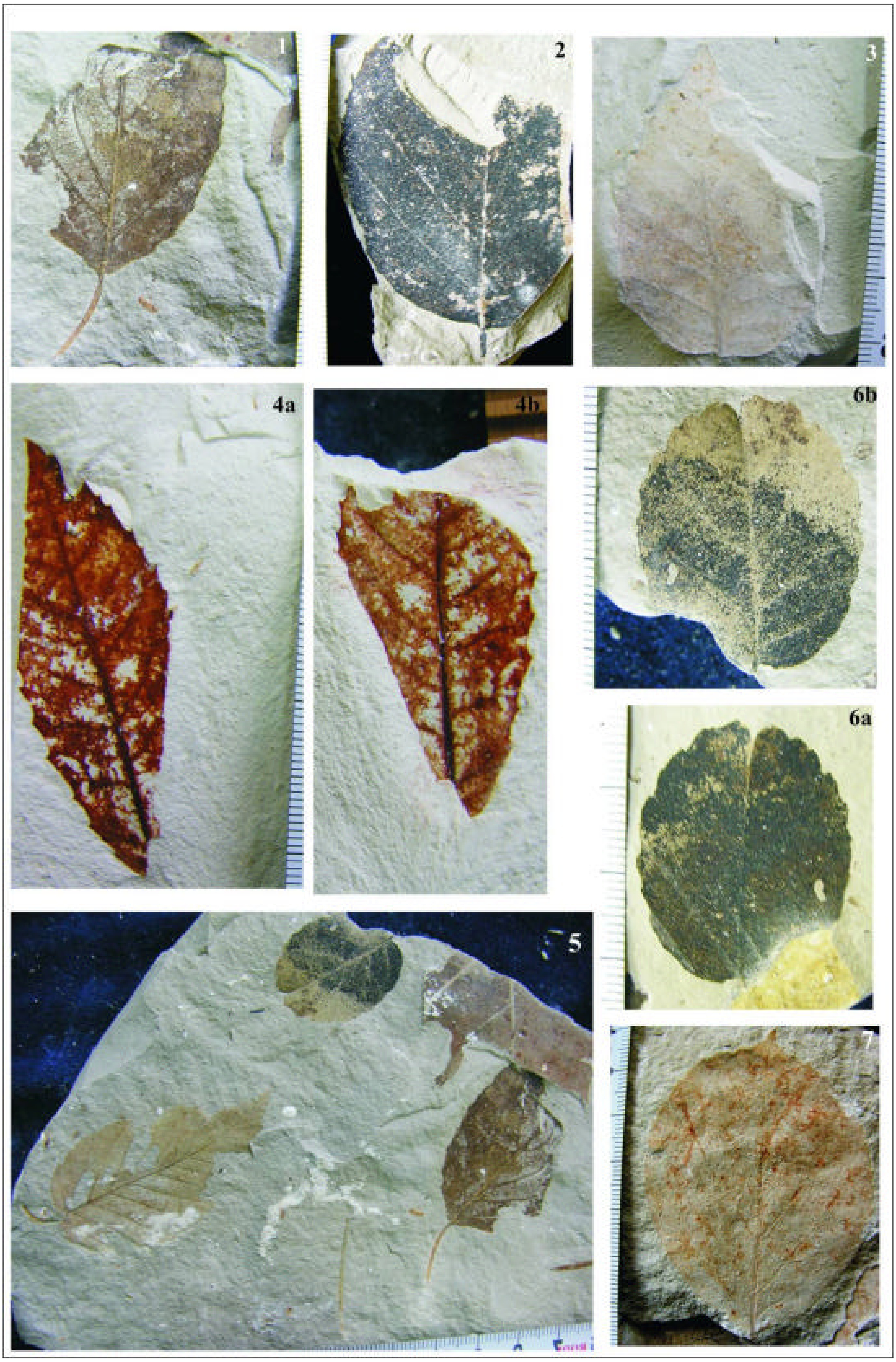

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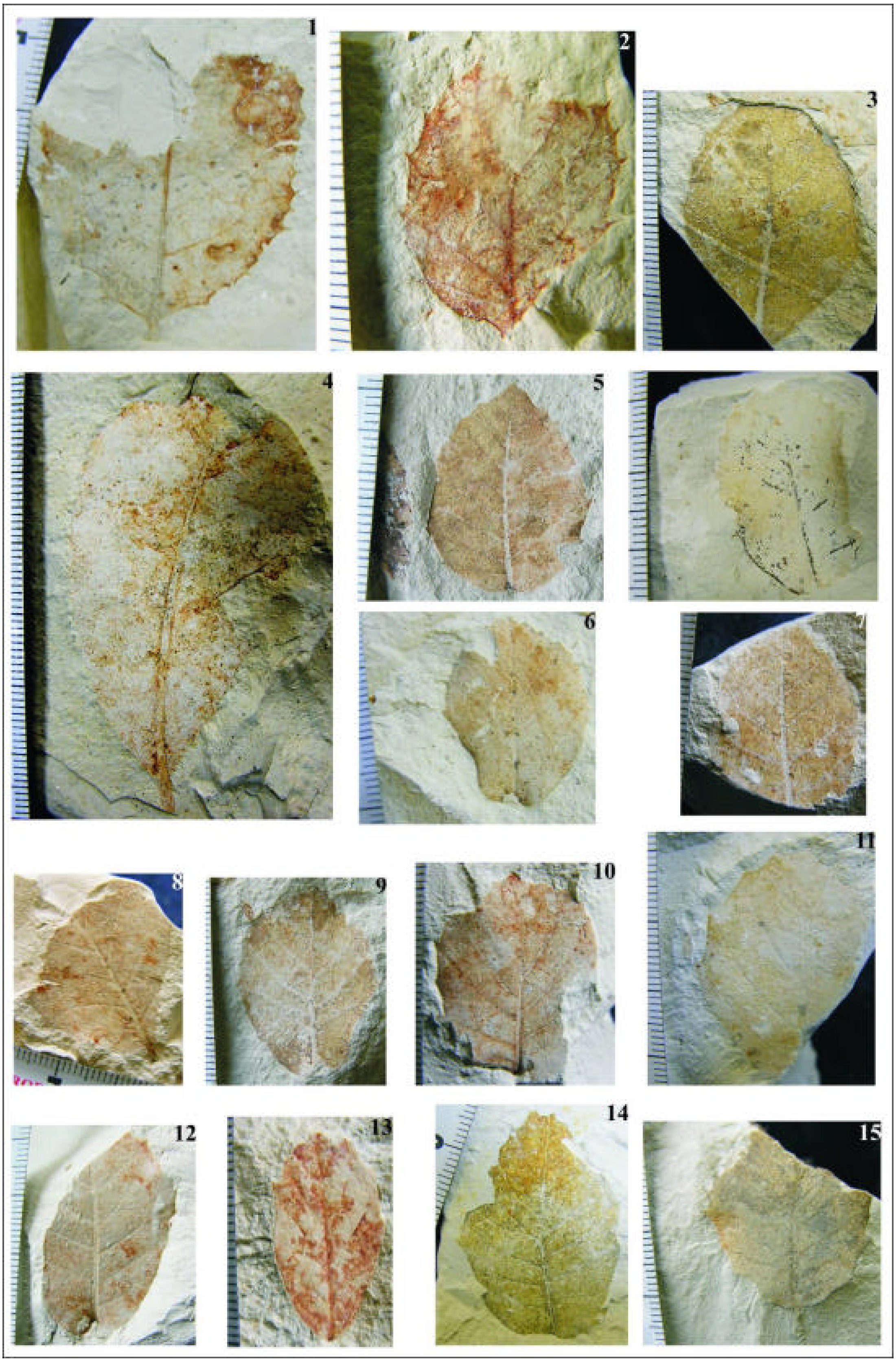

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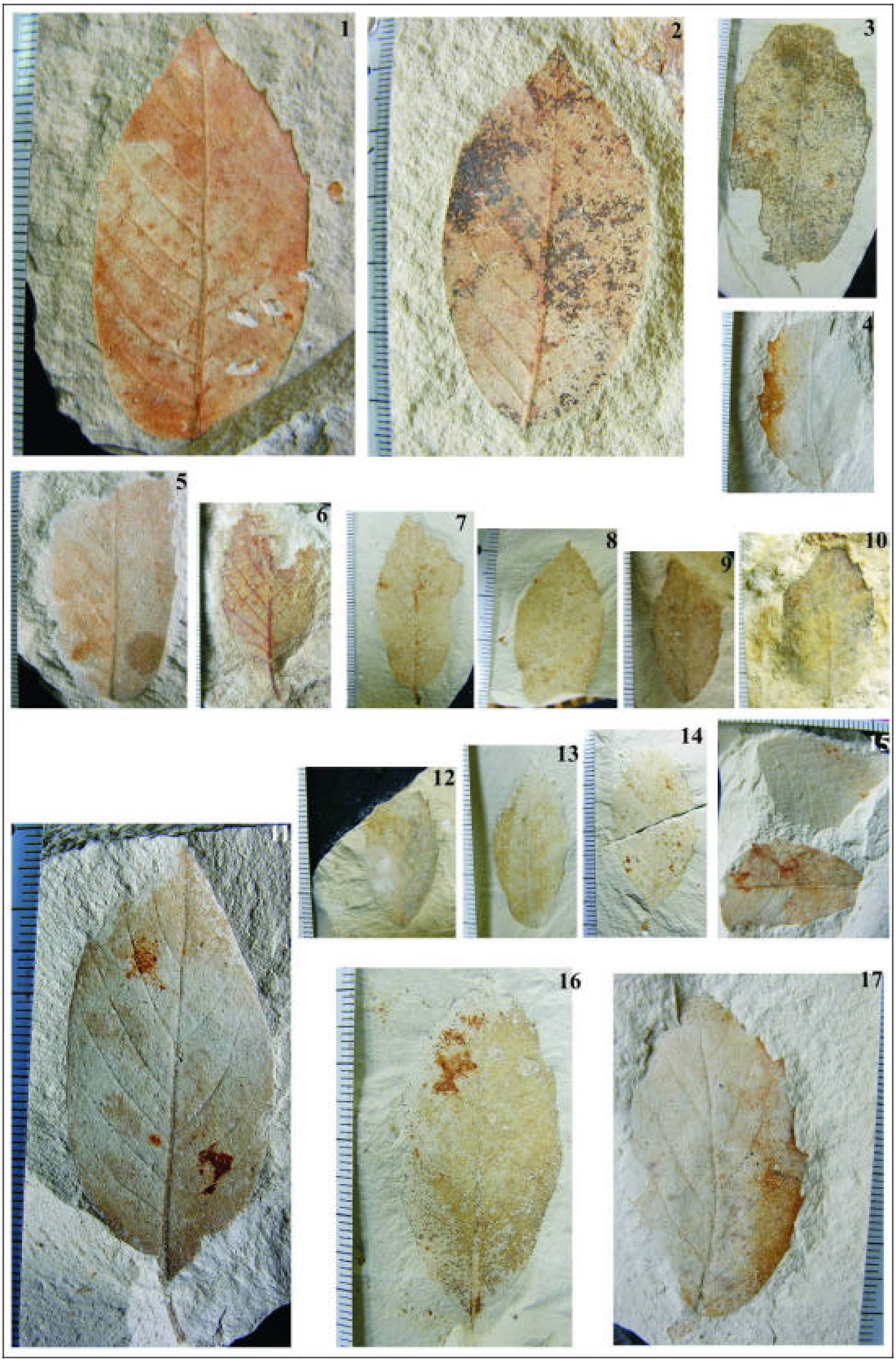

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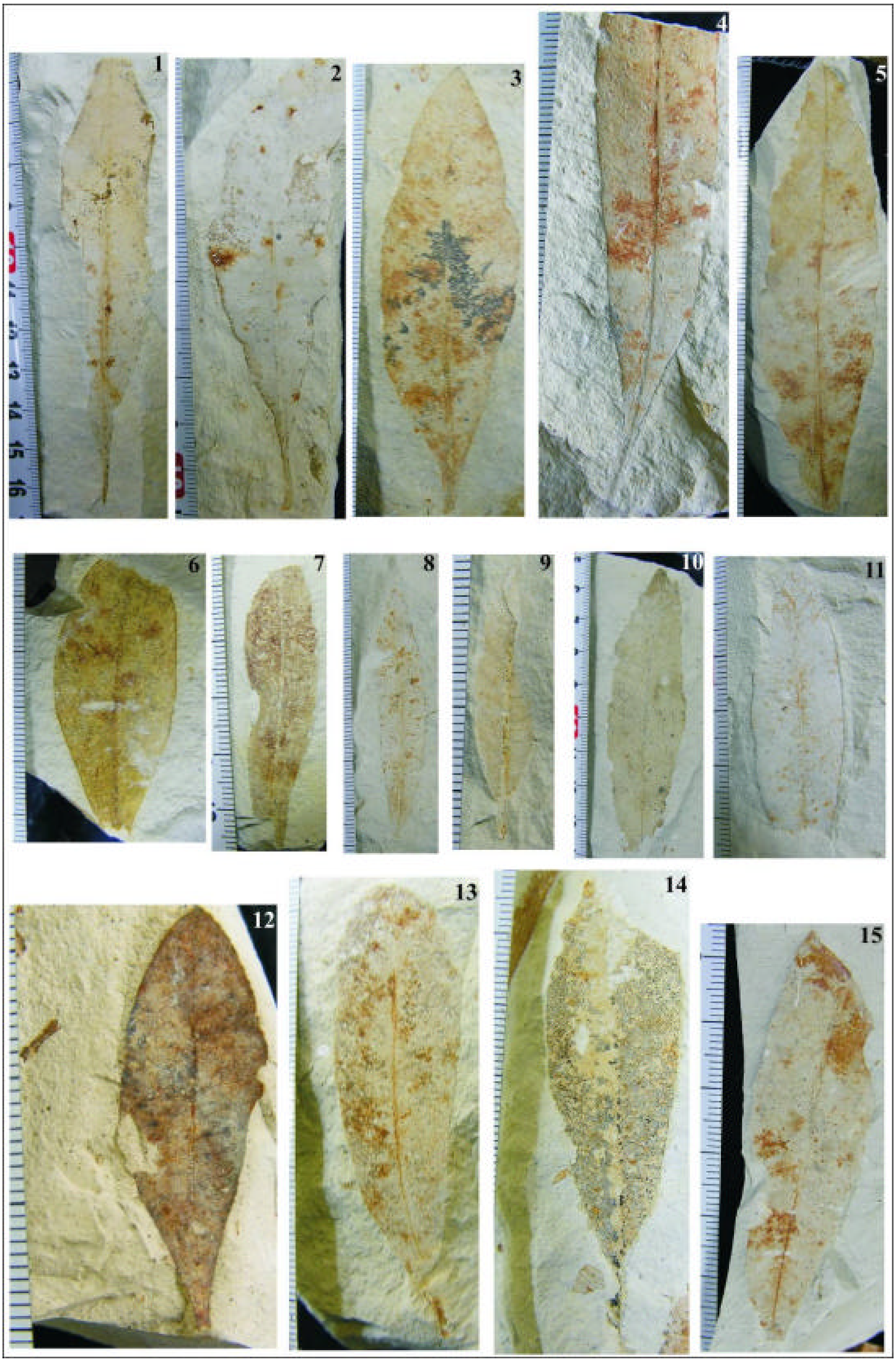

PLATE 6.13 (Karacaagaç)


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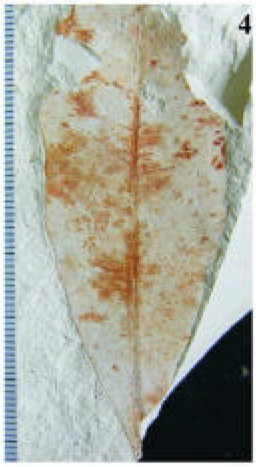
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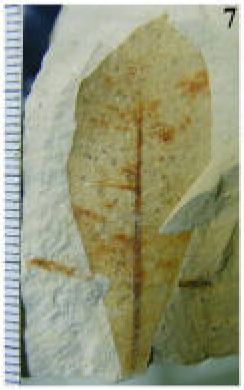
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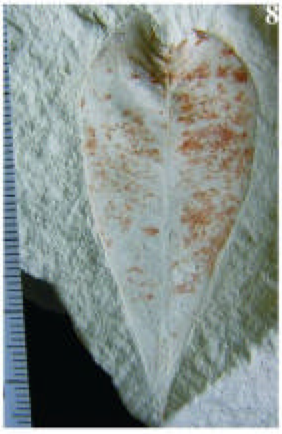
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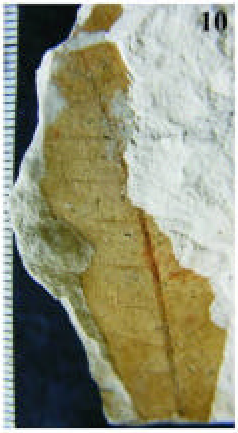
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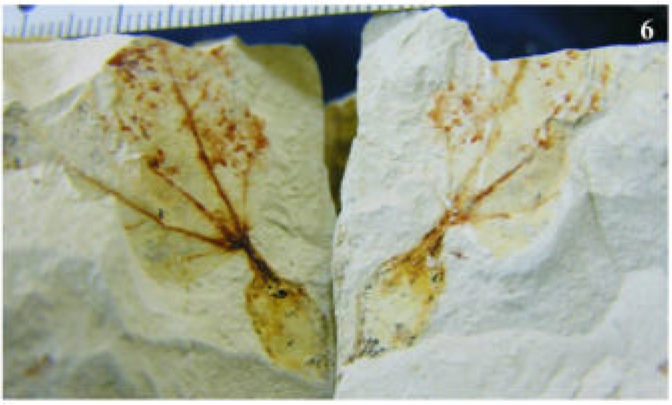
PLATE 6.14 (Karacaagaç)

PLATE 6.15 (Karacaagaç)



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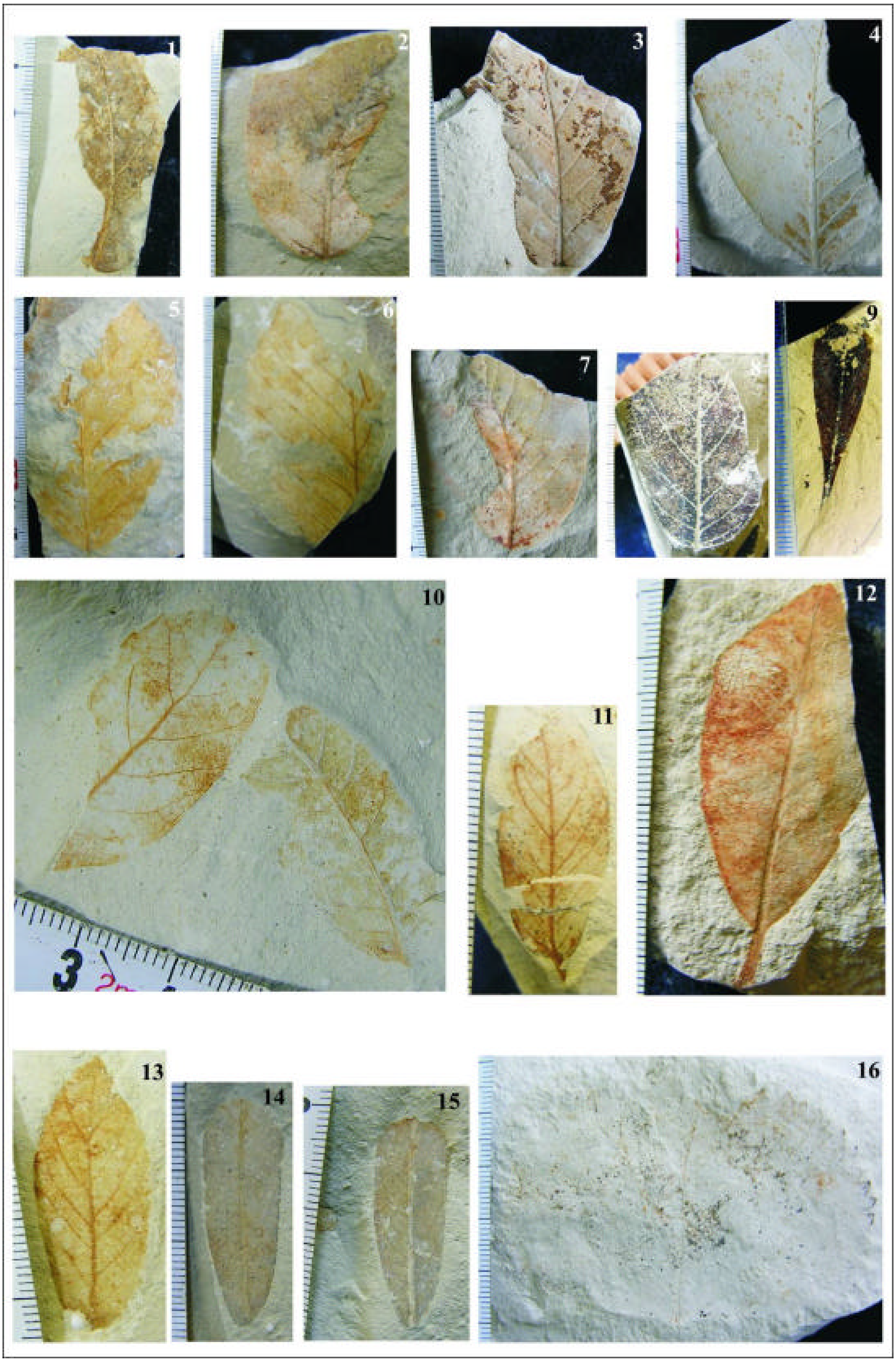

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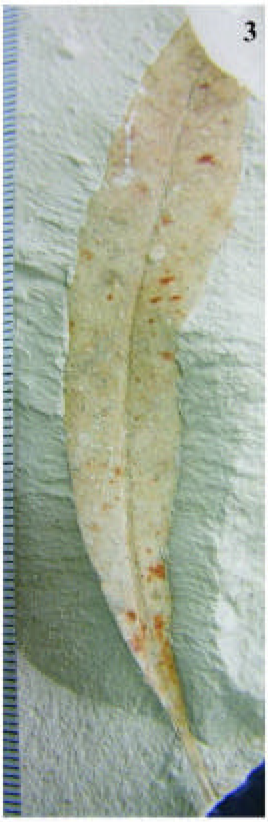


PLATE 6.18 (Karacaagaç)

PLATE 6.19 (Karacaagaç)

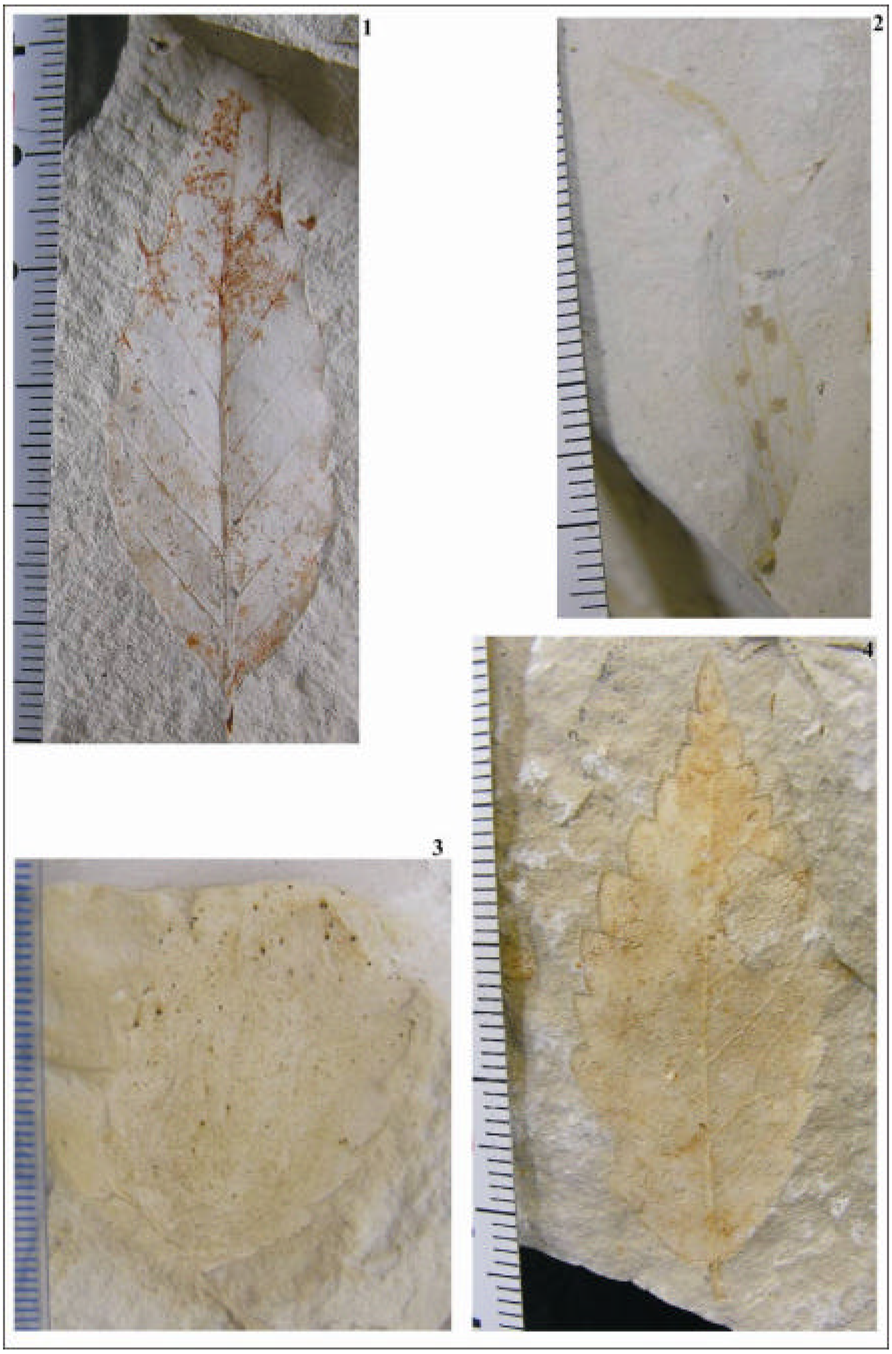


PLATE 6.20 (Karacaagaç)

1–5.	*Baculatisporites primarius* (Wolff) Thomson & Pflug
6–15.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
16.	*Leiotriletes maxoides* Krutzsch ssp. *minoris* Krutzsch
17–21.	*Cedripites miocaenicus* Krutzsch
22–30.	*Pityosporites* zpp.

PLATE 6.21 (Karacaagaç)

1.	*Abiespollenites* sp.
2–5.	*Pityosporites labdacus* (Potonié) Thomson & Pflug
6.	*Pinuspollenites macroinsignis* (Krutzsch ex Ollivier–Pierre) Planderova
7–9.	*Pityosporites microalatus* (Potonié) Thomson & Pflug
10.	*Podocarpidites libellus* (Potonié) Krutzsch
11.	*Cathayapollis* sp.
12.	*Cathayapollis vanampoae* (Sivak) Ziembinska–Tworzydlo
13–15.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
16–19.	*Inaperturopollenites laevigatus* Takahashi
20–22.	*Inaperturopollenites parvus* Takahashi
23, 24.	*Inaperturopollenites* spp.
25.	*Sequoiapollenites polymorfosus* Thiergart
26.	*Cupressacites cuspidataeformis* (Zaklinskaya) Krutzsch
27.	*Inaperturopollenites magnus* (Potonié) Thomson & Pflug
28, 29.	*Sparganiaceaepollenites neogenicus* Krutzsch
30–35.	*Ephedripites* spp.

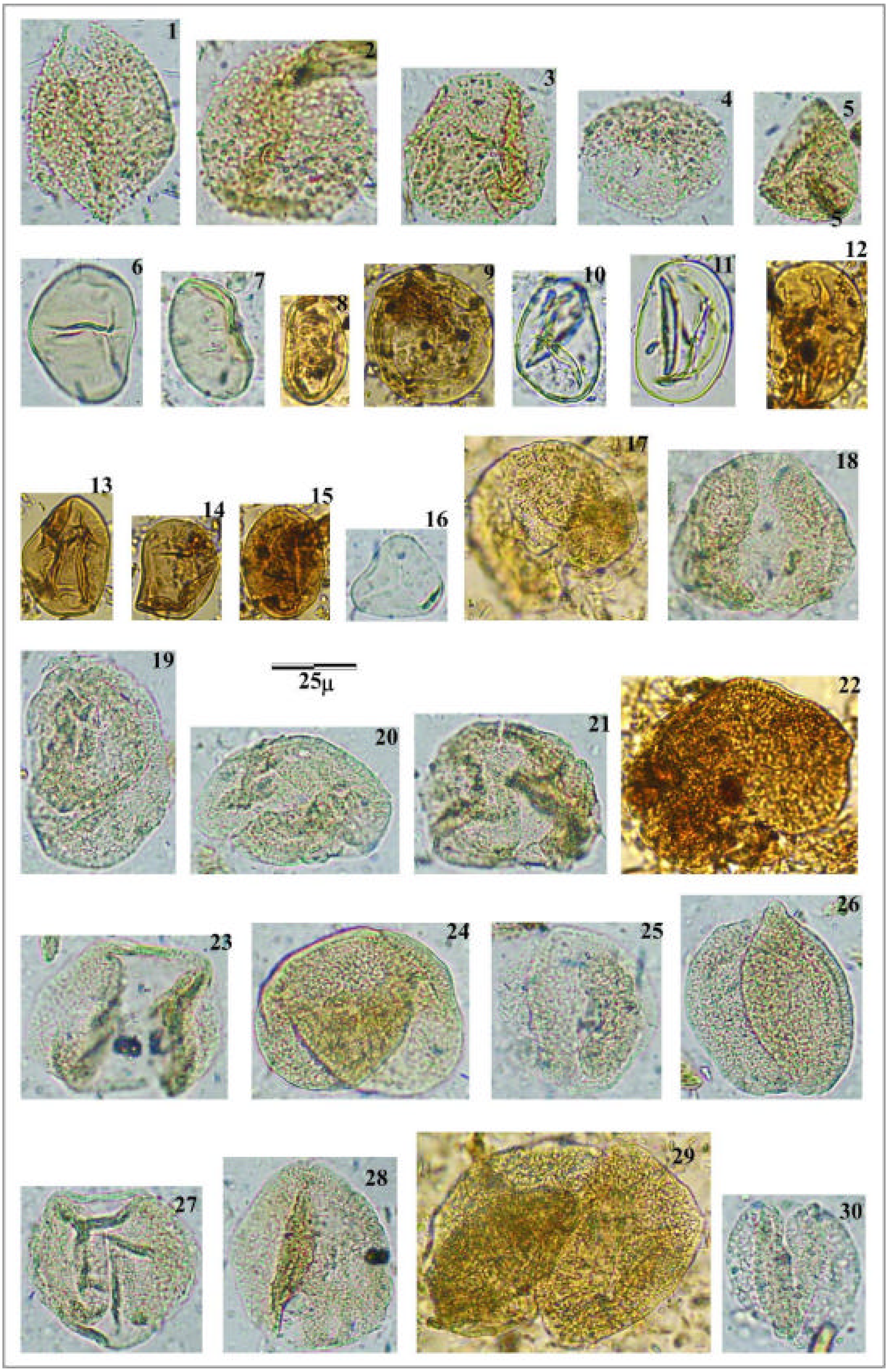
PLATE 6.22 (Karacaagaç)

1–6.	*Cycadopites* sp.
7–8a.	*Monocolpopollenites tranquillus* (Potonié) Thomson & Pflug
9–14.	*Liriodendrioipollis semiverrucatus* Krutzsch
15, 16.	*Manoliapollis* sp.
17–19.	*Nymphaepollis minor* Nagy
23–30.	*Monogemmites pseudosetarius* (Weyland & Pflug) Krutzsch
31.	*Triatriopollenites rurensis* Thomson & Pflug
32.	*Triporopollenites coryloides* Pflug & Thomson *in* Thomson & Pflug
33–36.	*Momipites punctatus* (Potonié) Nagy
37–39	*Caryapollenites simplex* (Potonié) Raatz ex Potonié
40.	*Subtriporopollenites anulatus* Thomson & Pflug ssp. *nanus* Thomson & Pflug
41–52.	*Polyvestibulopollenites verus* (Potonié) Thomson & Pflug
53	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
54–60.	*Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
61, 62.	*Quercopollenites robur* type Nagy

PLATE 6.23 (Karacaagaç)

1–8.	*Quercopollenites robur* type Nagy
9–12.	*Tricolpopollenites densus* (Pflug) Thomson & Pflug
13.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *exactus* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
14, 15.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *brühlensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
16.	*Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
17.	*Tricolporopollenites* sp. (Compositae–Liguliflorae type)
18, 19.	*Tricolpopollenites henrici* (Potonié) Thomson & Pflug
20, 20a.	*Lonicerapollis* sp.
21.	*Tetracolporopollenites* sp.
22.	*Polygalacidites* sp.
23, 24.	*Periporopollenites multiporatus* Pflug & Thomson *in* Thomson & Pflug
25.	*Periporopollenites stigmosus* (Potonié) Thomson & Pflug
40.	*Ovoidites* sp.
26-30. 46.	Fungal spores
31-45.	Indeterminated forms

PLATE 6.20 (Karacaagaç)



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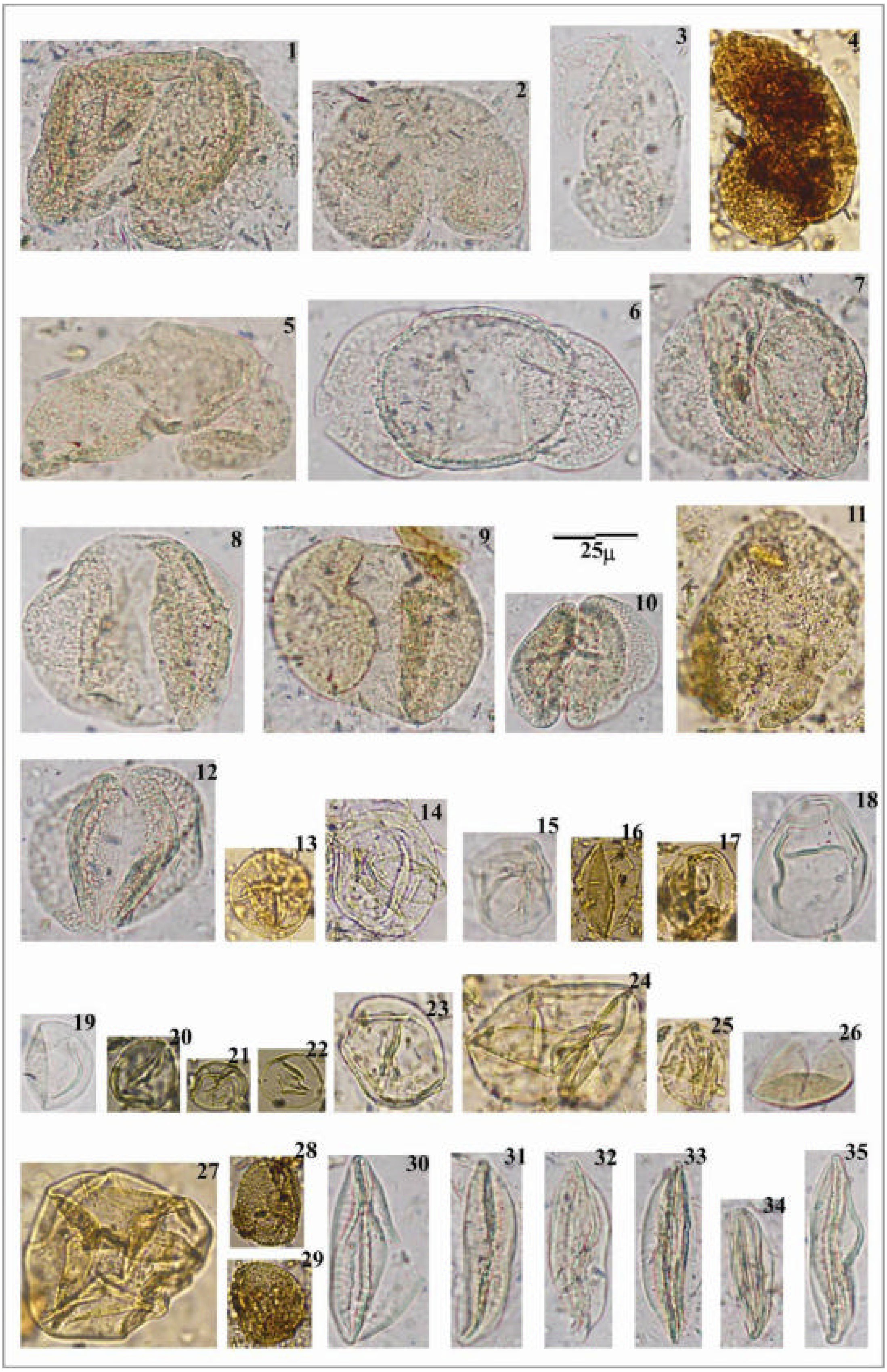

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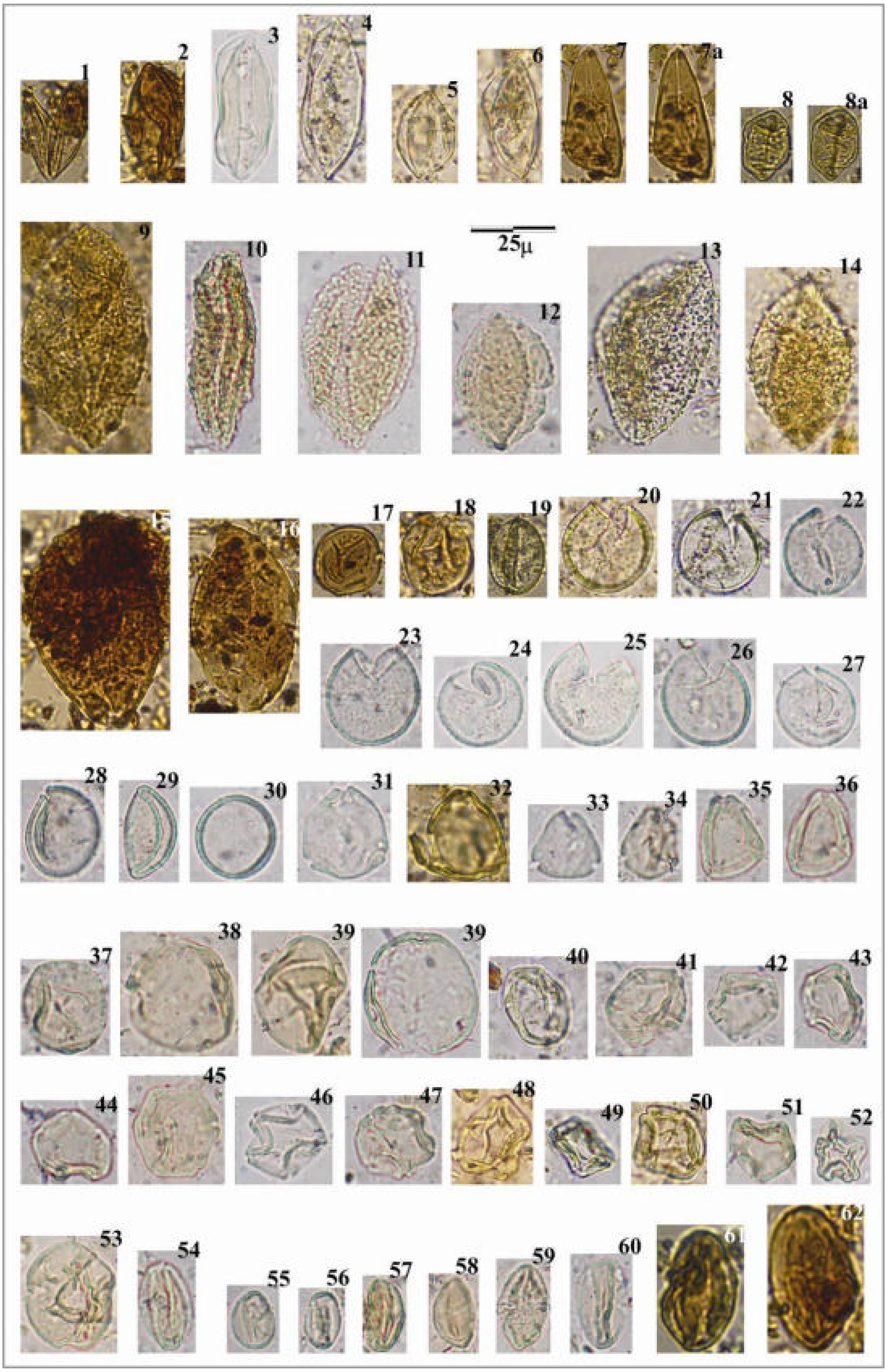

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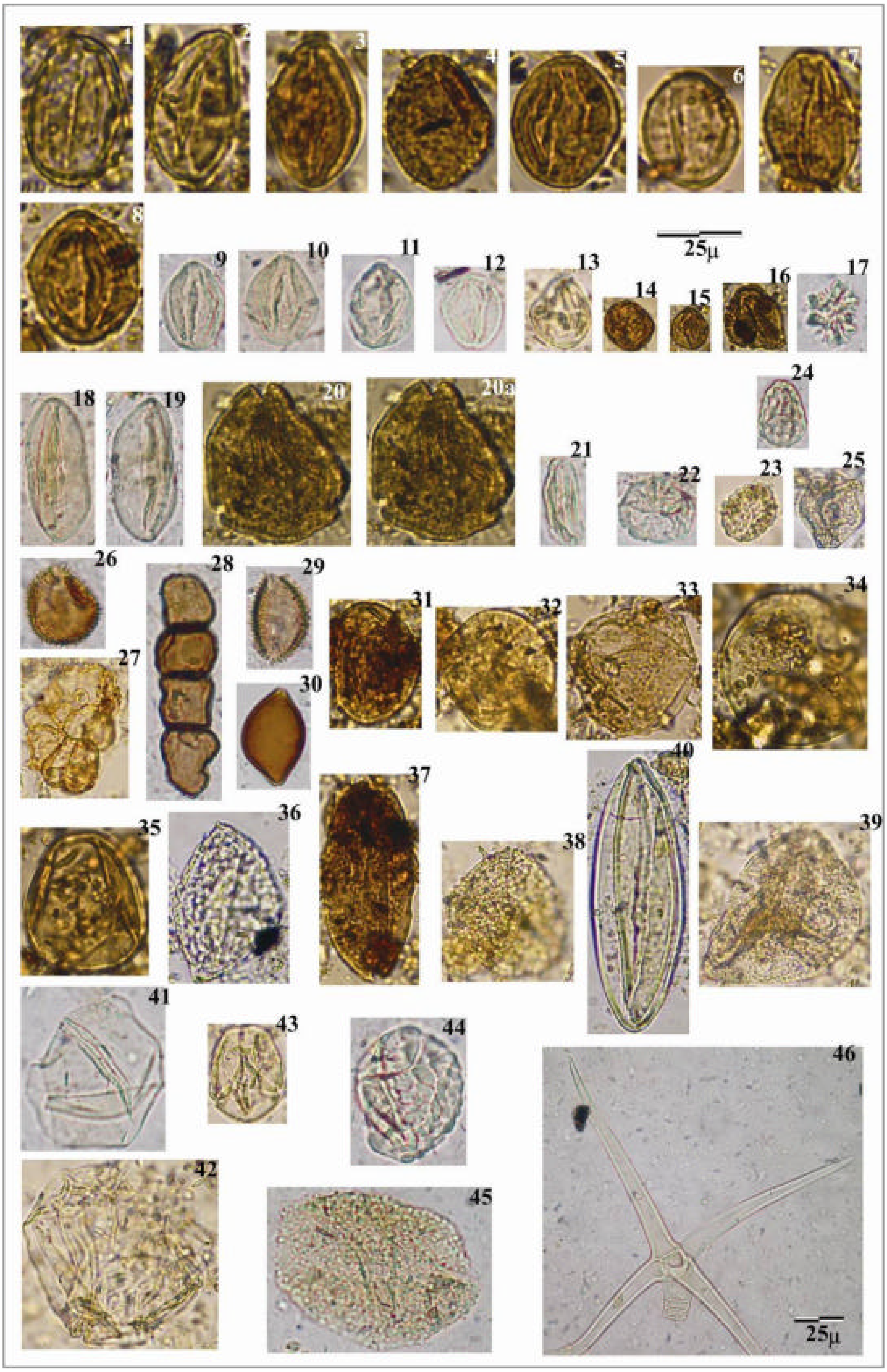

CHAPTER SEVEN

THE LATE BURDIGALIAN–LANGHIAN TIME INTERVAL IN THE ÖREN REGION (SOUTHWESTERN TURKEY)–PAYNOSTARTIGRAPHIC, PALAEOVEGETATIONAL, VERTEBRATES

This chapter was inpressed to the Geological Bulletin of Turkey edited by Cemal Tunoglu,
as; Mine Sezgül Kayseri and Funda Akgün
Late Burdigalian–Langhian Time Interval in Turkey and Palaeoenvironment and Palaeoclimatic
Implications and Correlation of Europe and Turkey: late Burdigalian–Langhian Palynofloras and
Palaeoclimatic properties of the Mugla –Milas (Kultak)

7.1 Introduction

From northeast to southwest, there are the Oligo–Miocene aged Çardak–Tokça, Denizli and Kale–Tavas basins (Gürer & Yilmaz, 2002; Görür et al., 1994, 1995; Özerdem et al., 2002; Sözbilir, 2005) and Ören basin is one of these basins (Gürer & Yilmaz, 2002; Özerdem et al., 2002). The stratigraphy of the Ören region is constituted lithostratigraphic correlation with neighbor regions and there are a few palaeontological studies in this region (i.e. Nebert, 1957; Kaya et al., 2001). Generally the Burdigalian time is represented by marine sediments in the Akbük region based on the previous studies (i.e. Görür et al., 1994, 1995). In addition, the late Langhian time (MN5–6 boundary) is revealed based on the mammalian fossil records by Kaya et al. (2001). However terrestrial (see chapter six) and marine conditions during the late Burdigalian–Langhian time interval are firstly established in this thesis.

During the late Burdigalian–Langhian, sedimentary rocks of Ören–Kultak region are characterized by clastic sediments which are deposited in the delta environment (Görür et al., 1994, 1995). The mammalian fossils of this time interval are collected from these sediments and are defined in this chapter. Besides result of strontium analysis is obtained from tooth of mammalian fossil and it is used to support the age determination. Additionally, palaeoenvironmental data is reinforced based on oxygen and carbon analysis results which are obtained applying on the teeth of mammalian fossil. And also, Kultak palynoflora of this period is recognized and it is correlated with the palynofloras of the Burdigalian and Langhian ages in Turkey and Europe.

The vegetation and climate history of Turkey during the Burdigalian and Langhian time interval is revealed from the palynofloras of Ören–Kultak, Karacaagaç, Hüsamlar; Ankara–Beypazari "latest Burdigalian"; Çanakkale–Çan and Balikesir–Gönen "latest Burdigalian–?Serravallian" (Ediger, 1990); Aydin–Basçayir and Kulogullari "Langhian" (Akgün & Akyol, 1999), Izmir–Sabuncubeli "latest Burdigalian". Additionally, numerical palaeoclimatic results of Greece–Spanokhorion, Evia "latest Burdigalian" and Kolivata "Langhian" are obtained (Benda et al., 1982). Take in to consideration palaeogeography of Burdigalian and Langhian time interval, palaeoclimatic records of Europe are correlated with palaeoclimatic results of Turkey.

7.2 Geological Setting

The basement rocks (the Lycian nappes) are unconformably overlain by the Oligocene–Early Miocene rocks between the Ören and Kultak regions. The Kultak formation unconformably overlies these rocks observed during the Oligocene–Early Miocene. The Kultak formation laterally and vertically passes the Hüsamlar and Belen members and this formation is deposited during the late Early–early Middle Miocene period. The Belen member is characterized by the fossiliferous marine sediments in the Kultak region. The rocks of the early Middle Miocene are uncorformably overlie marl and coal bearing sediments were formed lacustrine sedimentary sequence in the Middle–Late Miocene (Figs. 7.1, 7.2). Alluvium is covered on the all sediments in the Kultak region. The palynological data are obtained from the claystones upper part of the Kultak formation and mammalian fossils are collected from the clastic rocks in this formation and these fossils are determinated in this chapter. Besides, the Belen member is aged based on the foraminifer fauna (Fig. 7.1).

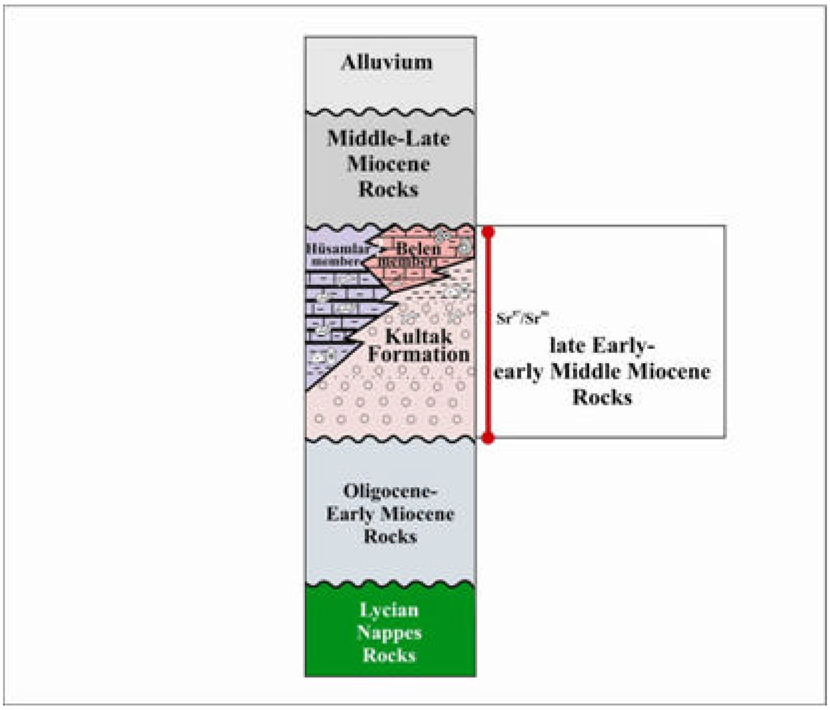

Figure 7.1 Generalized stratigraphic columnar section of between the Kultak and Karacaagaç regions. Red line indicates investigated period.

7.3 Material and Methods

This study is based on sporomorphs extracted from the measured stratigraphic section of the Ören–Kultak region and this section is approximately 78 meter. All samples were processed at the Dokuz Eylül University in Turkey and Senckenberg Museum in Frankfurt using standard paynological preparation techniques including treatment with HCl, HF and HNO_3. Separation of the spores and pollen from the rest of the residue was carried out using $ZnCl_2$. Ten samples were collected from the green claystones and mudstones in the measured stratigraphic section of Ören–Kultak region and only four samples were found suitable for quantitative pollen analysis. Changing of the palynomorph abundance is demonstrated by the TILIA (2.0.2.) program. Besides, mammalian fossils are collected from the sandstones and thin conglomerates. These fossils are defined by Prof. Dr. Tanju KAYA and Dr. Serdar MAYDA.

Figure 7.2 Satellite image shows mammalian fossil locality and samples of claystones in the west of Kultak village.

The use of multivariate analytical methods in palaeontologic studies has become more widespread in the last twenty years (Spicer & Hill, 1979; Kovach, 1988, 1989). The choice of methods depends on the type of data and the specific problems being solved (Kovach, 1989). To interpret the fauna similarities, the statistical analyses were done using the UPGMA (unweighted pair group method with arithmetic mean) cluster algorithm method. The Jaccard's similarity index of the PAST program has been chosen in this study for identify groups of mammalian fossil locality characterizing MN5 and MN6. Additionally, in this chapter, the isotopic results of oxygen and carbon are obtained from the first lower molar *Gomphotherium* sp.. Thus these results are used to support the palaeovegetational investigations and these are associated with the temperature and precipitation results.

The coexistence approach (CA) method which is developed by Mosburgger & Utescher (1997) is used to obtain numerical palaeoclimatic results in different parts of

Turkey and Greece during the late Early and early Middle Miocene period. In this thesis, a totally of 12 microfloras (Ören–Kultak, Karacaagaç, Hüsamlar; Samsun–Havza, Ankara–Beypazari, Çanakkale–Çan, Balikesir–Gönen, Aydin–Basçayir, Kulogullari, Izmir–Sabuncubeli, Greece–Spanokhorion, Evia and Kolivata) is analyzed with respect to 7 climate variables. These are mean annual temperature (MAT), cold month mean (CMT), warm month mean (WMT), mean annual precipitation (MAP), mean annual range of temperature (MART=WMT–CMT) and precipitation in the warmest month (MAP_{WARM}), precipitation of the driest month (MAP_{DRY}) and precipitation of the wettest month (MAP_{WET}).

7.4 Palynoflora of the Belen Member in Ören–Kultak Region (Turkey)

Palynoflora is determined in the Ören–Kultak region. A total of 52 species and 35 genera were identified in the claystone and mudstones samples studied. Eight species and four genera belong to spores and the other species to pollen (Fig. 7.3). The Kultak microflora includes *Laevigatosporites haardti, L. gracilis* (Polypodiaceae) and *Pityosporites microalatus* (*Pinus haploxylon*–type) more abundantly, *Cupressacites cuspidateaformis* (Cupressaceae), *Momipites punctatus* (*Engelhardia*), *M.quietus* (*Engelhardia*), *Polyporopollenites undulosus* (*Ulmus*), *Caryapollenites simplex* (*Carya*), *Subtriporopollenites anulatus nanus* (*Carya*), *Tricolpolpollenites densus, T. microhenrici* (*Quercus* evergreen–type), *Tricolporopollenites cingulum* (*Castanea*), *T. megaexactus* (Cyrillaceae) abundantly, *Baculatisporites primarius* (Osmundaceae), *Inaperturopollenites dubius* (Taxodiaceae), *Cycadopites* spp. (Cycadaceae), *Pityosporites labdacus* (*Pinus–diploxylon* type), *Pityosporites macroinsignis*, *Graminidites gramineoides* (Poaceae), *Pterocaryapollenites stellatus* (Pterocarya), *Triatriopollenites rurensis* (Myricaceae), *Tricolpollenites retiformis* (*Salix*), *Tricolporopollenites pacatus* (Simaraubaceae), *Oleoidearumpollenites microreticulatus* (Oleaceae) scarcely and *Verrucatosporites favus* (Davaliaceae), *Leiotriletes maxoides minoris, L. maxoides maxoides* (Schizaceae), *L. traquillus* (Schizaceae), *Dicolpopollis kockelii* (*Calamus*–Calamoid palm), *Zonalapollenites verrucatus* (*Tsuga*), *Inaperturopollenites polyformosus* (*Sequoia*), *Plicapollis plicatus* (Juglandaceae), *Quercopollenites robur* (*Quercus* deciduous–type), *Umbelliferaepollenites* sp. (Umbelliferae), *Tricolpopollenites librarensis librarensis*, *T. librarensis fallax* (Fagaceae), *Tetracolporopollenites* spp. (Sapotaceae) and *Tricolporopollenites* sp. (*Avicennia*) rarely or sporadically recorded (Fig. 7.3; Plates 7.1, 7.2).

7.5 Comparison with the Burdigalian–Langhian Palynoflora of Turkey and Greece

In this part, previous palynological studies of the Burdigalian and Langhian time interval (Samsun–Havza, Ankara–Beypazari, Çanakkale–Çan, Balikesir–Gönen, Balikesir–Bigadiç, Aydin–Basçayir and Kulogullari, Izmir–Sabuncubeli and Greece–Spanokhorion, Evia, Kolivata) are summarized and palynomorph contents of these regions are correlated with the Kultak palynoflora of the Belen member (Fig. 7.4).

Palynofloras of Çanakkale–Çan and Balikesir–Gönen regions are aged the late Burdigalian–? Serravalian by Ediger (1990) and these palynofloras are characterized by different palaeovegetation groups although observing warm subtropical climatic condition in both regions. Gymnosperms in palynospectra of the Çan and Gönen regions are observed high percentage. The riparian forest elements (*Alnus*) are abundantly accompanied with gymnosperm pollen in the Çan region. The swamp forest elements (*Leoitriletes microadriennis, Monogemmites pseudosetarius, Inaperturopollenites hiatus, I. dubius* and diversity fungal spore species) are observed predominantly in palynoflora of the Gönen region. The mixed mesophytic forest elements recorded less abundantly and low diversity in palynospectras of two regions. Author stated that spores and pollen in samples of the Çanakkale–Çan and Gönen regions suggested a more temperate to subtropical climate during the late Burdigalian–?Serravallian time interval in the Biga Penninsula. Besides according to Ediger (1990), the Neogene volcanism apparently affected the palaeovegetation and palaeoclimate in these regions.

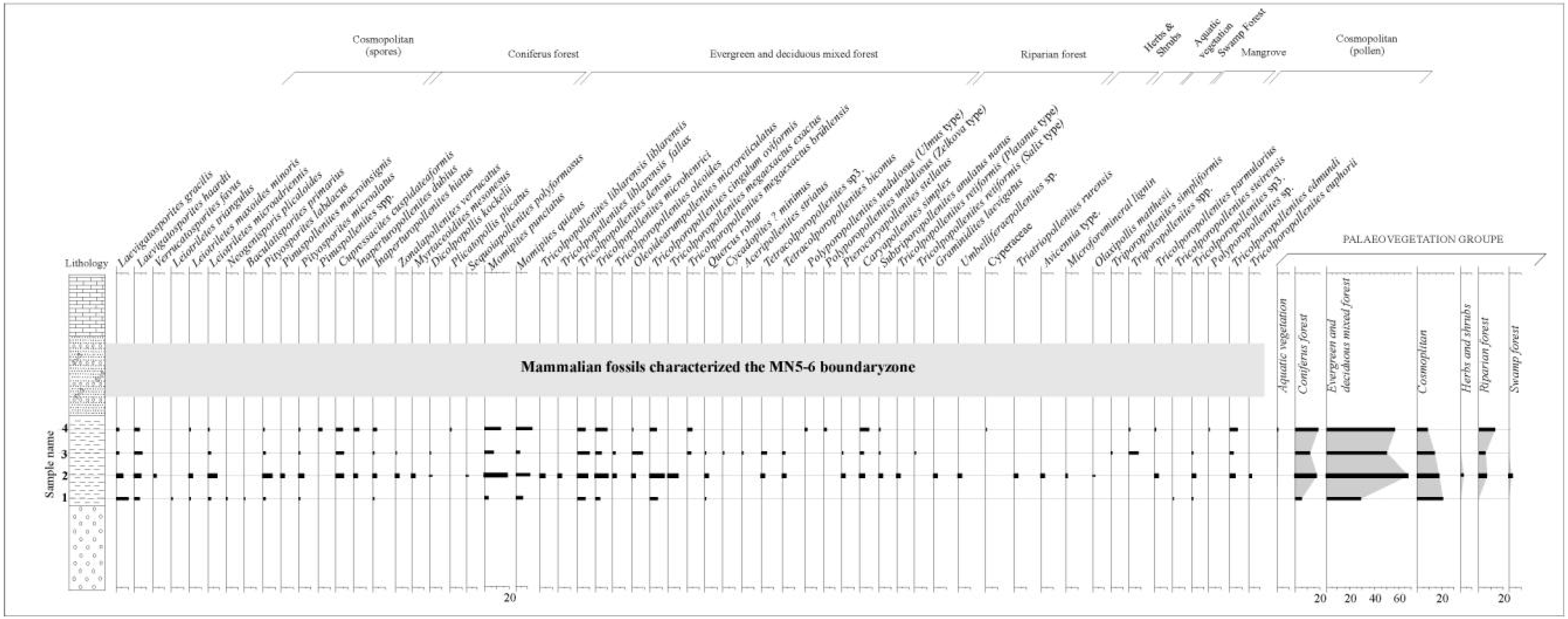

Figure 7.3 Detailed microfloras diagram of the studied part of the stratigraphic section in the west of Kultak region. Black dots indicate percentage lower than %1.

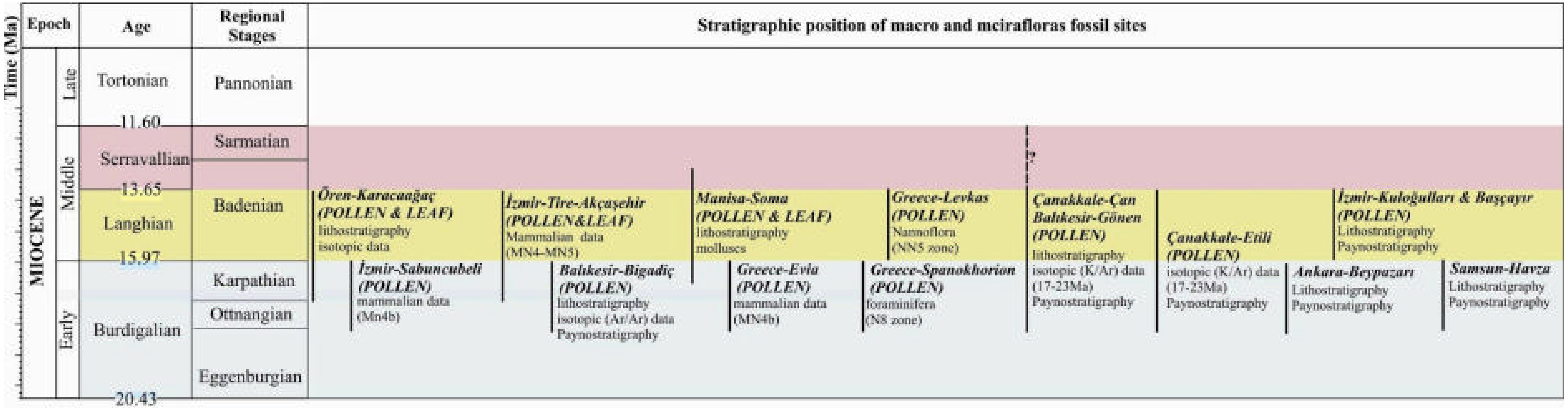

Figure 7.4 Stratigraphic ranges of previous Burdigalian and Langhian palynofloras involved in this chapter (Stratigraphic column Harzhauser & Piller, 2007).

Samples of the upper lignite seams from the Çoraklar formation in the Ankara–Beypazari (Çayirhan) region (Central Anatolia) was studied palynological by the Güngör (1991) and the latest Burdigalian palynoflora is defined. Palynoflora of the upper lignite seam were characterized by generally thermophil spores and pollen (*Palmae*, Schizaceae, *Engelhardia*, Sapotaceae and Cyrillaceae). Besides, palaeovegetation in the Çayirhan region during the latest Burdigalian is represented by the swamp (*Nyssa*, Myricaceae, Nymphaeaceae and Polypodiaceae) and riparian (*Alnus, Platanus* and *Salix*) forests. Palynoflora of the lower lignite seam in the Ankara–Beypazari region is defined by the Whateley & Tuncali (1995). This palynoflora is represented by the thermophil species (Schizaceae, *Engelhardia*, Sapotaceae and Cyrillaceae) as the palynoflora of upper lignite seam. Both palynofloras of upper and lower lignite seams indicate the warm subtropical climatic condition during the latest Burdigalian time according to Güngör (1991) and Whateley & Tuncali (1995).

Akgün & Akyol (1999) defined sporomorph assemblage of the Langhian time in the Aydin–Kulogullari and Basçayir regions in Büyük Menderes basin (western Anatolia) and warm subtropical palaeoclimatic condition is observed in these regions based on the palynoflora. Palaeovegetation of the Basçayir region is represented by the swamp forest (i.e. Taxodiaceae, Myricaceae), mixed mesophytic and mountain forests (i.e. *Pinus haploxylon, Quercus*). Besides, species of open vegetation (Compositae, Chenopodiaceae and Poaceae) are observed low percentage in this palynoflora. The palaeovegetation of the Kulogullari region is characterized by the riparian forest (*Alnus* and Simaroubaceae), mountain and mixed mesophytic forests.

Akgün et al. (2007) interpreted the paleoclimatic and palaeovegetational properties of the western and central Anatolia during the Miocene time. Besides, authors summarized the palaeovegetation and palaeoclimate of the Bigadiç, Emet, Kirka and Kestelek regions (western Anatolia) in the latest Burdigalian time. Palaeovegetation of these regions is characterized by the swamp (*Nyssa,* Taxodiaceae–*Taxodium* and Myricaceae) and mixed mesophytic forests (i.e. *Quercus, Ulmus* and *Carya*). The open vegetation plants (Chenopodiaceae and Poaceae) are abundantly accompanied with these forests. Additionally, borate deposits in the Bigadiç region occur in carbonate rich facies, which is suggestive of a period high evaporation, salinity and low alkaline perennial lake levels (Helvaci, 1995). During the latest Burdigalian period, this palaeovegetational property caused that species of Chenopodiaceae abundantly observed different from the palaeovegetation of the other locality in Anatolia (Akgün et al., 2007).

The latest Burdigalian palynoflora in the Samsun–Havza region is defined by Kayseri & Akgün (2008). The palaeovegetation of this region is represented by swamp forest, consisted mostly of *Nyssa*, Myricaceae and Taxodiaceae, with numerous ferns (Polypodiaceae, Osmundaceae, Schizaceae) in undergrowth, coniferous (*Pinus*, *Podacarpus*) and mixed mesophytic forest (*Quercus*, *Tilia*, *Ulmus*, *Carpinus* and Juglandaceae–*Carya*). Palaeoclimate in this region during the latest Burdigalian time is suggested warm subtropical according to Kayseri & Akgün (2008).

During the Late Burdigalian period Izmir–Sabuncubeli region was covered by swamp forest that is characterized by the Sparganiaceae, Schizaceae, Myricaceae and this forest accompanied the lowland forest elements (*Castanea*, Cyrillaceae, *Carya*, *Quercus* and *Ulmus*). Besides, abundant *Pinus* species in the Izmir–Sabuncubeli samples indicate a high palaeotopography surrounding the swamp areas. Besides, this region was aged Ottnangian (MN3a mammalian zone) based on the mammalian fossils (Kayseri et al. 2007). According to authors, percentage of the subtropical and tropical elements (Cyrillaceae, *Engelhardtia*, Schizaceae) in the Izmir–Sabuncubeli palynoflora higher than the temperate elements (*Pinus, Quercus, Castane, Carya, Ulmus*) and in this region presence of the warm subtropical climatic condition has been suggested.

The Akçasehir–Tire palynoflora is represented by the Polypodiaceae, Taxodiaceae, Juglandaceae, Myricaceae, *Quercus, Castanea, Salix, Platanus, Alnus,* Cyrillaceae, Chenopodiaceae and this palynoflora is aged the latest Burdigalian by Gemici et al. (1992).

The late Early and Middle Miocene palynoflora of Soma region is characterized by the Polypodiaceae, *Pinus*, *Pseudotsuga*, Taxodiaceae, *Ulmus*, *Zelkova*, Chenopodiaceae, *Nyssa*, *Salix*, Myricaceae, *Carpinus*, *Castanea*, *Quercus*, *Carya*, *Pterocarya* and Sparganiaceae (Gemici et al., 1991).

The late Early and early Middle Miocene palynological assemblage of Çanakkale–Etili region is represented by high percentage *Pinus*, Juglandaceae, *Quercus, Castanea, Alnus* and Fagaceae. Besides, *Baculatisporites nanus, Trilites microvallatus*, *Verrucatosporites megafavus, Polypodiaceoisporites gracillimus, Verrucingulatisporites rugosus, Leiotriletes maxoides maxoides* and also some pollen species like *Liriodendronpollenites semiverrucatus*, *Myricipites myricoides*, *Plicatopollis plicatus*, *Platycaryapollenites miocaenicus*, *Momipites punctatus*, *M. quietus*, *Subtriporopollenites anulatus nanus*, *Tricolpopollenites liblarensis fallax* and *Tricolporopollenites cingulum fusus* are also recorded low percentages in the Etili assemblage and authors emphasized that these palynomorphs are recorded generally in the Oligocene–Miocene sediments. This assemblage is aged by the palynoflora by Akgün et al. (2008) based on the lithostratigraphy and palynostratigraphy.

Planktonic foraminiferal association of the Kolivata–Spanokhorion region (lower part of N8 zone) is the latest Burdigalian age and palynological results of Kolivata–Spanokhorion region support this age interpretation (Benda et al., 1982). Playnoflora of Spanokhorion is represented by the abundantly mixed mesophytic and coniferous forests elements (i.e. *Pinus* spp. *Pinus haploxylon*–group and rarely *Pinus silversteris*–group, *Quercus*, Castaneae). The swamp forest is also well developed in Kolivata–Spanokhorion region during the latest Burdigalian time which is characterized by the Taxodiaceae, *Nyssa* and Myricaceae. Besides, open area representing the herb and shrubs species such as Poaceae, Compositae, Cyperaceae and Chenopodiaceae is recorded in palynospectra of the Kolivata–Spanokhorion region. Langhian microflora and nannofloras (NN5 zone) of Kolivata–Levkas region are defined (Benda et al., 1982). Palynoflora of Kolivata–Levkas region is characterized by the abundantly mega–

mesothermic elements such as *Tricolporopollenites megaexactus–exactus, Engelhardia microcorpheause–punctatus, Inaperturopollenites magnus–dubius* and mesothermic element (*Pinus, Quercus*). The herb and shrubs of palaeovegetation in the Kolivata–Levkas region, which rarely reach more than %2, are represented by Poaceae, Cyperaceae and Chenopodiaceae.

Reigel et al. (1989) recorded the late Burdigalian palynoflora of Marmarenia formation in the southern part of the Aliveri basin in the Evia region, Greece. This palynoflora is equivalent to mammalian zone of the MN4a. Marmarenia microflora is characterized by the termophilous elements (*Engelhardia*, Sapotaceae, *Platycarya* and *Palmae*). Palaeovegetation is represented by the swamp forest which is consisted of the *Ovoidites*, Taxodiaceae, *Sequoia*, Glyptostrobus and Nymphaeaceae.

All palynological studies in Turkey indicate that termophilous plants (*Engelhardia*, Sapotaceae, *Cyrillaceae* and *Palmae*) are abundantly observed in the Burdigalian–Langhian time interval. Besides, other angiosperm pollen (i.e. *Pinus, Quercus, Ulmus, Carya, Nyssa*, Taxodiaceae, Myricaceae, *Alnus, Platanus* and *Salix*) accompany with these plants. Milas–Kultak palynoflora resemble to other palynofloras of Turkey. Additionally, herb species are recorded less abundantly in Kultak and other palynofloras in Turkey and Greece (Fig. 7.3).

7.6 Age Determination

Kayseri & Akgün (2008) summarized the palynological contents of the Early, Middle and Late Miocene times based on the previous palynostratigraphic studies of Turkey and Europe. According to the authors, *Leiotriletes microadriennis, L. maxoides maximus, L. maxoides maxoides, Verrucatosporites scutulum, V. alenius, V. favus* were observed to be rare in the Early Miocene (Burdigalian), occurring with *Baculatisporites, Cingulatisporites* and *Stereisporites*. *Laevigatosporites haardti* species is extremely numerous but stratigraphically unimportant. *Plicapollis plicatus, Dicolpopollis kockelii,* *Compositoipollenites minimus, Subtriporopollenites anulatus* and *Momipites quietus* are low percentage in the Early Miocene (Burdigalian). Gymnosperm and angiosperm plants including Taxodiaceae, *Pinus* (*haploxylon*–type), Myricaceae, *Carya*, *Alnus*, *Ulmus*, Fagaceae, *Quercus, Castanea,* Cyrillaceae and Oleaceae reach their highest relative abundance in the Middle Miocene (Langhian–Serravallian) and these taxa are also observed during Tertiary. In the late Middle Miocene (Sarmatian), herbaceous angiosperms consisting of Poaceae, Asteraceae–Asteroideae and Asteraceae–Cichorieae accompanied other angiosperm pollen less abundantly. Especially palynofloras of the late Burdigalian–Langhian period in Turkey and Greece are characterized by oldest pollen species which are thermophil elements such as *Momipites punctatus* (%5–15; *Engelhardia*), *M. quietus* (%1–2; *Engelhardia*), *Plicapollis plicatus* (%>1–1; Myricaceae) and *Monocolpopollenites tranquillus* (%>1–1) (Table 7.1). Additionally *Tetracolporopollenites* spp. (%5; Sapotaceae) accompany to this palynoflora.

Based on these age interpretations, palynoflora of Ören–Kultak region which is represented by less abundantly *Leiotriletes maxoides minoris, L. maxoides maxoides, Momipites punctatus, M. quietus, Plicapollis plicatus, Tetracolporopollenites* sp. *Dicolpopollis kockelii*, abundantly *Tricolporopollenites cingulum, Tricolpopollenites densus, T. microhenrici,* species of Taxodiaceae could be aged the late Middle and early Middle Miocene (the late Burdigalian–Langhian).

7.7 Comparison with the Burdigalian–Langhian Palynoflora of Europe and Palaeoclimatic Records

In this part palynoflora of Bulgaria, Serbia, Hungary, Poland, Ukraine, Germany, Spain and France are summarized and numerical palaeoclimatic results based on the macro and microfloras are given.

Table 7.1 Palynostratigraphical used spores and pollen of palynofloras in Turkey and Greece for the late Burdigalian–Langhian time interval.

Spores and Pollen		***GREECE***			***TURKEY***								
		Evia	***Spanokhorion***	***Levkas***	***Çanakkale Çan–Etili***	***Çanakkale Çan***	***Balikesir Gönen***	***Ankara Beypazari***	***Samsun Havza***	***Balikesri Bigadiç***	***Aydin Basçayir***	***Aydin Kulogullari***	***Mugla Milas–Kultak***
		Riegel et al. (1989)	Benda et al. (1982)		Akgün et al. (2008)	Ediger (1990)		Güngör (1991)	Kayseri (2002) Kayseri & Akgün (2008)	Akyol & Akgün (1990) Akgün et al. (2007)	Akgün & Akyol (1999)		**This study**
Momipites punctatus	*Engelhardia*	7,0	2,5	4,0	low percentage				3,0	2,5			**11,4**
Momipites quietus	*Engelhardia*				low percentage								**0,3**
Engelhardia						2,0	1,2	3,0	0,1		1,0	2,0	
Monocolpopollenites tranquillus	*Palmae*	0,1					0,5						
Tetracolporopollenis spp.	Sapotaceae	0,2				0,1	0,6	1,0	1,5	3,0	1,0	0,5	**2,6**
Plicapollis plicatus	Myricaceae				low percentage			0,5	0,5			0,04	**0,3**
Subtriporopollenites annulatus nanus	*Carya*				low percentage								
Laeitriletes maxoides maxmimus	Schizaceae												
Laeitriletes maxoides maxoides	Schizaceae				low percentage								
Laeitriletes maxoides minoris	Schizaceae												
Verrucatosporites favus/m egafavus	Davaliaceae				low percentage								
AGE		**late Burdigalian**	**late Burdigalian**	**Langhian**	**late Burdigalian–?early Serravaliyen**			**late Burdigalian**	**late Burdigalian**	**late Burdigalian**	**Langhian**	**Langhian**	**Langhian**

Palynoflora of the Langhian period in northeast Bulgaria was studied by Ivanov et al. (2007). During the Tarkhanian time (Langhian) mixed mesophytic forests appear to have been widespread in the lowlands and mid–altitude uplands surrounding the Pannonian basin in Bulgaria. *Quercus* and *Ulmus* defined abundantly in these forests, accompanied by C*astanea, Carya, Pterocarya, Juglans, Ilex, Eucommia, Betula, Carpinus* and *Corylus* etc. Elements of the thermophilous plants such as *Platycarya, Engelhardia, Symplocos, Reevesia*, Sapotaceae, Araliaceae and Arecaceae are also present in the pollen spectra (Ivanov et al., 2007). Additionally, authors obtained the numerical climatic results using the coexistence approach analysis of the whole time the MAT 9–21^{o}C (15^{o}C), the CMT 2–13^{o}C (7,5^{o}C), the WMT 22–29^{o}C (25,5^{o}C), the MAP 700–1300mm and the MART 18^{o}C. According to Meulenkamp & Sissingh (2003) and Ivanov et al. (2007), a tectonic controlled reorganization in the latest Early to earliest Middle Miocene in the Eastern Paratethys resulted in the emergence of the Greater Caucasian archipelago, flowed by a transgression in the territories west of the Black Sea. Tropical and subtropical water which came by way of transgression from the Black Sea effected on the climate of the terrestrial area in Bulgaria and termophilous elements abundantly recorded in the palynospectra of the Tarkhanian time. Additionally, upland areas (Balkan Peninsula) in northeast Bulgaria are known since the Early Miocene time and these highland areas can be caused the mixed mesophytic forest. Besides, the Balkan Peninsula apparently played a significant role in the origin, evolution, and migration of the Mediterranean vegetation during the Miocene, for it situated between the Tethyan and Paratethys basins (Palamarev, 1989; Rögl, 1998 and Ivanov et al., 2007). Our palynoflora shows similarities in presences of some thermophilous species (i.e. *Engelhardia*, Sapotaceae). Besides, *Avicennia*, *Calamus*, *Acer* and Myrtaceae are also recorded in our palynosectra.

Macroflora (Popovac, Slanci and Misaca floras) of lower part of the Badenian in Serbia was recorded by Utesher et al., (2007). Popovac palynoflora is represented by the deciduous plants (i.e. *Acer, Rhamnus*) and presences of these plants indicated the highland area in the Serbis during the Badenian time. Authors emphasize that in the Slanci palynoflora species of Lauraceae family are important. Typical temperate, deciduous taxa, such as *Salix, Alnus, Populus* and *Acer,* but also *Engelhardia, Zelkova* and conifers reach minor percentages in Slanci palynoflora. In the Misaca palynoflora, *Acer, Ulmus* and *Carpinus* of the arctotertiary element are more important. According to Utesher et al., (2007) these taxa migrated to Serbia across the higher altitudes of the rising Carpathian mountain range. Additionally authors stated that, deciduous and arctotertiary taxa played a more important role during the Badenian time in the mixed mesophytic vegetation of Central Europe (Mai, 1995; Utescher et al., 2007). Palaeoclimatic data of Serbia were calculated by the coexistence approach (Utesher et al., 2007). Resulting coexistence intervals of the Popovac flora are for the MAT 14.4–21.3^{o}C, CMT 3.7–13.3^{o}C (8,5^{o}C), WMT 27.2–28.1^{o}C (27,65^{o}C) and MART 19.15^{o}C. Coexistence intervals of the Slanci flora are the MAT ranges from the 15.6–16.5^{o}C, the CMT 7–7^{o}C, the WMT 25.6–27^{o}C, the MART 19^{o}C and the MAP 823–1237mm. The values of the Misaca flora obtained are 14.4 to 16.6^{o}C for the MAT, 5.6 to 11.7^{o}C (8.65^{o}C) for the CMT, 25.7 to 28.1^{o}C for the WMT, 18.25^{o}C for the MART and 867 to 1018mm for the MAP. Authors suggested that these coexistence intervals of the Popovac, Misaca and Slanci floras indicate higher that the palynoflora of the Eggenburgian time and this high values pointed the Mid–Miocene climatic optimum (Zachos et al, 2001 and Utescher et al., 2007). Our palaeovegetation groups indicate the similarities in terms of presences of deciduous and evergreen plants. However, elements of the riparian forest and mangrove vegetation are recorded in our palynoflora and presences of these elements could be indicated slightly differences.

Langhian period in Polish Lowland recorded mostly studies (Wazynska, 1998; Slodkowska, 2004; Planderova, 1991). These studies indicate that *Tricolpopollenites henrici* (*Quercus*) and *Tricolporopollenites pseudocingulum* recorded abundantly. Additionally both species were typical of the subtropical element (P2) and they were accompanied by the representatives of the palaeotropical elements (P1), palm pollen inclusively (Wazynska, 1998). The subtropical elements (P2) was abundantly represented and taxonomically varied. The warm temperate (A2) and cool temperate (A1) elements were represented less commonly in the palynoflora of Polish. Early Middle Miocene period in Polish is characterized by the marshy palaeocommunities, the pollen of *Nyssa* and Taxodiaceae (representing the swamp forest), and the pollen of Cyrillaceae, Myricaceae and Clethraceae (representing wet shrubs and brushwood peatbog). Furthermore, Wazynska (1998) recorded that the more arid areas in the Polish during the early Middle Miocene period were covered by mixed mesophytic forest and the palaeoclimate in this period was humid and very warm within the warm–temperate conditions. Langhian sediments in Poland deposited in the Pannonian basin and intramountain basins and the Carpathian foredeep in the Central Paratethys were covered by tropical and subtropical waters. Additionally, during the Langhian in the Paratethys (i.e. the Northeastern Mediterranean) coral reefs existed in Southern Poland and Hungary (Müller, 1984; Suc et al., 1992) where *Avicennia* pollen grains were also recorded (Nagy & Kókay, 1991; Jiménez–Moreno, 2006). Palaeovegetation of the late Burdigalian and Langhian times were dominated by thermophilous elements rich in evergreen trees (*Engelhardia*). This kind of vegetation points to a subtropical climate for the Pannonian basin during that times. In additional Jiménez–Moreno (2006) suggested that this palaeoclimatic condition in Paratethys basin has been correlated to warmest period during the Miocene: the Mid–Miocene climatic optimum. All palynological results show that palaeoclimate of the Langhian time is subtropical and tropical and this palaeoclimatic condition caused the mangrove palaeocommunities in some part of the Paratethys basin (Hungary) or the swamp palaeocommunities (Poland). Content of the Kultak palynoflora in our study for the late Burdigalian–Langhian time resemble to palynofloras of the Hungary and Poland.

Paleovegetation types and palaeoclimatic interpretations in Langhian time were defined separately for the Ukrainian Carpathian region and Ukraine Plain based on the macroflora. Badenian in the Carpathian Basin characterized transgressive cycle according to Venglinsky (1975) and Syabryaj et al. (2007). Authors emphasized that an existing seaway between the Central Paratethys and Tethys, warm oceanic waters stimulated the presences of thermophilous ferns. Expanding board–leaved forest includes *Ulmus*, Castaneae and *Engelhardia*. Palaeovegetation of the elevated and slope areas in the Ukrainian Carpathian region, which is characterized by *Picea* and *Ulmus* differences from the palaeovegetation of the inner zone of the Ukrainian

Carpathians during the Langhian time. Additionally thermophilous species disappeared in the Ukrainian Carpathian region and cooler palaeoclimatic conditions observed in this region. The coexistence approach results of the Ukrainian Carpathian region, the MAT values are between 15.6 and 18.4^{o}C, the CMT from 6.6 to 12.5^{o}C (9.55^{o}C), the WMT from 25.4 to 27.9^{o}C, the MART 17.1^{o}C and MAP between 1122 and 1213mm (Syabryaj et al. 2007). In the early Middle Miocene time of the Ukrainian Plain was characterized by regressive phase. Continental areas of this region were represented by the pine forests (*Keteleeria, Tsuga, Cedrus, Picea, Ginkgo* and *Podocarpus*). The swamp forest with *Taxodium* occurred in the most humid continental areas of the Ukrainian Plain. The broad–leaved forest was characterized by *Quercus, Ulmus, Zelkova*, Castaneae, *Liquidambar, Fagus, Pterocarya, Juglans, Carpinus* and *Betula*. In the undergrowth of this forest, *Corylus, Erica,* Lauraceae, *Buxus, Ilex, Palmae* and Theaceae occurred and this plant community pointed to the subtropical climatic conditions in the Ukrainian Plain. *Salix* and *Alnus* cloaked the river valleys and lakes. Additionally, lost of herb species were recorded in samples of Ukrainian Plain. Resulting coexistence intervals of the Ukraine Plain are calculated by Syabryaj et al. (2007) and results are the MAT ranges from the 17–17.1^{o}C, the CMT 6.6–7.1^{o}C (6.85^{o}C), the WMT 24.7–25.9^{o}C, the MART 18.45^{o}C and the MAP 1146–1322mm. In our palynoflora evergreen and deciduous plants are observed abundantly as the Ukraine Carpathian and Plain region. However presence of *Avicennia* species indicates the marine influence in the Ören–Kultak region during the Burdigalian–Langhian time interval different from the Ukraine region.

Jiménez–Moreno & Suc (2007) recorded detail palaeovegetational properties of the Western Europe (France and Spain) using the palynofloras for the Miocene time. Authors defined the four flora–vegetation domains of the Langhian and Serravallian time from south to north. In the southern Spain, species of herb and shrubs (Poaceae, Amaranhaceae–Chenopodiaceae, Plumbaginaceae and Caryophyllaceae) are dominant in the palynoflora. Additionally the pollen spectra were characterized by abundance subdesertic elements since Langhian time. Thermophilous elements such as *Taxodium* type, *Engelhardia*, Sapotaceae, *Myrica*, Rutaceae, *Avicennia* and mesothermic elements (*Quercus* deciduous type, *Carya*, *Zelkova* etc.) contributed to pollen spectra of the Southern Spain. Mid and high–altitudes elements (*Cedrus, Tsuga, Abies* and *Picea*) were recorded (Jiménez–Moreno & Suc, 2007). In the northeast Spain and Corsica, palaeovegetation of these regions is characterized herbs and shrubs species and *Avicennia* still played a very imported role. More imported differences of these areas, subdesertic elements were not recorded. Mid and high–altitude elements were very scarce in pollen spectra of northeast Spain and Corsica regions during the Langhian time. Palynoflora of the southern France was characterized by the dominance of thermophilous elements (Sapotaceae, *Myrica*, *Engelhardia*, *Taxodium*, Hamamelidaceae, Simarubaceae, *Avicennia*, etc.) as well as mesothermic elements such as *Carya, Buxus, Zelkova*, *Quercus* deciduous type, Oleaceae, *Liquidambar*, etc. Herb species in pollen spectra of southern France were not imported. In the eastern–central part of France, a pollen spectrum of this domain was characterized by high abundance of thermophilous elements and predominantly by *Taxodium* type and *Engelhardia*. Additionally, high percentages of mesothermic elements mainly made up *Quercus* deciduous type. *Avicennia* has not been recorded and herbs and shrubs are very low (Jiménez–Moreno & Suc, 2007). The Western Mediterranean Sea effected on the changing of palaeoclimate and palaeovegetation during the Langhian time in the Spain and France. Coastal areas in western Mediterranean basin observed and this deposition system caused the impoverished mangrove forest in these areas. Highland areas existed in the central part of this basin and *Cedrus, Tsuga, Abies* and *Picea* grow on these areas during the Langhian time. Our palynoflora of Ören–Kultak region during the Burdigalian–Langhian time interval resemble to palynospectras of France and Spain.

7.8 The Burdigalian and Langhian Palaeobiogeography of Turkey Based on the Vertebrates

Although the Middle Miocene fossil localities known from Turkey are limited unlike the numerous Late Miocene deposits, thanks to well organized predecessor studies dating back to early sixties, almost most of them were studied thoroughly (Gaziry, 1976; Köhler, 1987; Gentry, 1990; Geraads et al., 1995; Kaya et al., 2001;

Geraads, 2003; Mayda et al., 2006; Saraç, 2003; Sickenberg et al., 1975). The rich collections of Bursa–Pasalar, Ankara–Çandir and Ankara–Inönü localities as well as remarkable Izmir–Mordogan, Çanakkale–Nebisuyu and Milas–Kultak collections were subjected of detailed systematic studies on many paleontological papers. The Kultak faunal assemblage, previously described in this level by Kaya et al. (2001) includes: *Anchitherium aurelianense hippoides* (Lartet), *Ancylotherium* (Metaschizotherium) *fraasi* (Koenigswald), *Tethytragus koehlerae* (Azanza & Morales) and *Gomphotherium* sp.. Recent field work in Ören–Kultak region has led to the discovery of additional fossils and isotopic a result of the mammalian tood is discussed (Plates 7.3; 7.4).

The proboscidean remains, collected from the former studies were previously allocated to *Gomphotherium* sp. (Kaya et al., 2001). The rich proboscidean remains recovered from the latest studies are now identified as *Gomphotherium angustidens* (Cuvier). *G. angustidens* (Cuvier), has been found from various the Early and Middle Miocene localities of Eurasia, mainly from: Spain “Bunol” and “Corcoles” (MN4); Portugal “Quinta Grande” (MN4b); Sansan (France) (MN6) and Germany “Steinheim” (MN7–8) and Saudi Arabia “Al Jadidah (MN6) (Göhlich, 1999). This species is also found from the Middle Miocene localities of Anatolia mainly from: Bursa–Pasalar, Mugla–Milas–Sariçay and Çatakbagyaka; and from an Early Miocene locality: Ankara–Kalecik–Hancili (Gaziry, 1976; Mayda et al., 2006; Saraç, 2003; Sickenberg et al., 1975). Well preserved rhinocerotid remains that have been unearthed from Kultak for the first time were identified as, *Brachypotherium brachypus* (Lartet). *B. brachypus* (Lartet) is a common element of Middle Miocene localities of Europe, such as: France, Simorre (MN 7) and La Grive (MN 7); Germany, Thannhausen (MN 6) and Massenhausen (MN 8) (Heissig, 1999). This species was found in the Middle Miocene localities of Turkey: Ankara–Çandir, Inönü–I and Tüney; Mugla–Yenieskihisar and Çatakbagyaka; Kütahya–Sofça; Edirne–Pismanköy; Bursa–Pasalar and Orhaneli (Saraç, 2003) (Fig. 7.5). *B. brachypus* is a short–legged rhino of hippo–like proportion which adapted subtropical forested habitats and nearby lakes and rivers (Fortelius, 1990). It is a brachydont form, indicates the soft diet. However, the wear patterns of teeth are indicated intermediate between the browser and grasser (Fortelius, 1990). Comparing with the other Turkish and European samples, *Brachypotherium* material appeared to be slightly larger. This feature shows that our sample is more advanced in terms of evolution. *G. angustidens* from Kultak samples are morphologically identical with the Turkish and European Middle Miocene samples and distinguished from the Early Miocene forms by its relatively simple molar pattern and more advanced accessory tubercles. Additional fossil materials of *Tethytragus koehlerae* were also found from Kultak fauna which was previously identified by Kaya et al., (2001). This species is a typical the Middle Miocene form and it has previously been known from Bursa–Pasalar, Mugla–Sariçay, and Ankara–Çandir and Inönü localities (Köhler, 1987; Gentry, 1990; Geraads et al., 1995; Geraads, 2003) (Fig. 7.5).

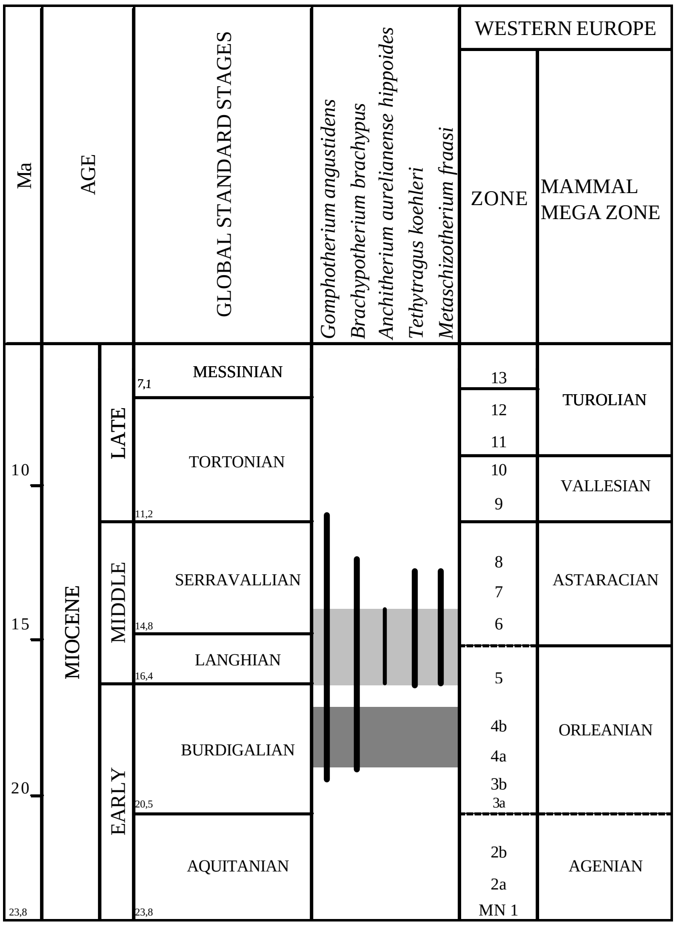

Figure 7.5 Faunal list and stratigraphic occurrences of Kultak vertebrate assemblage.

Besides the systematic and taxonomic part, we have focused on the faunal similarity across regarding Middle Miocene localities which were performed, at genus level only, using the UPGMA (unweighted pair group method with arithmetic mean) cluster algorithm method on similarity indices based on presence/absence data (Hair et al., 1998). Over 50 taxa from the following mammalian faunas are analyzed by the Jaccard Index (Jaccard, 1908) as a distance measure to examine paleocommunity integrity and the only sites with at least ten specimens (except Çanakkale–Nebisuyu locality) were retained for this analysis: Izmir–Mordogan (MN 5–6, Western Anatolia); Nebisuyu (MN6–7/8, NW Anatolia); Ankara–Çandir (MN 5, Central Anatolia), Mugla–Çatakbagyaka (MN 6–7/8, SW Anatolia); Bursa–Pasalar (MN6, NW Anatolia); Ankara–Inönü (MN6, Central Anatolia); Mugla–Kultak (MN6; SW Anatolia); Chios (MN5, Greece); Thymiana (MN5, Greece) (Fig. 7.6A, 7.6B).

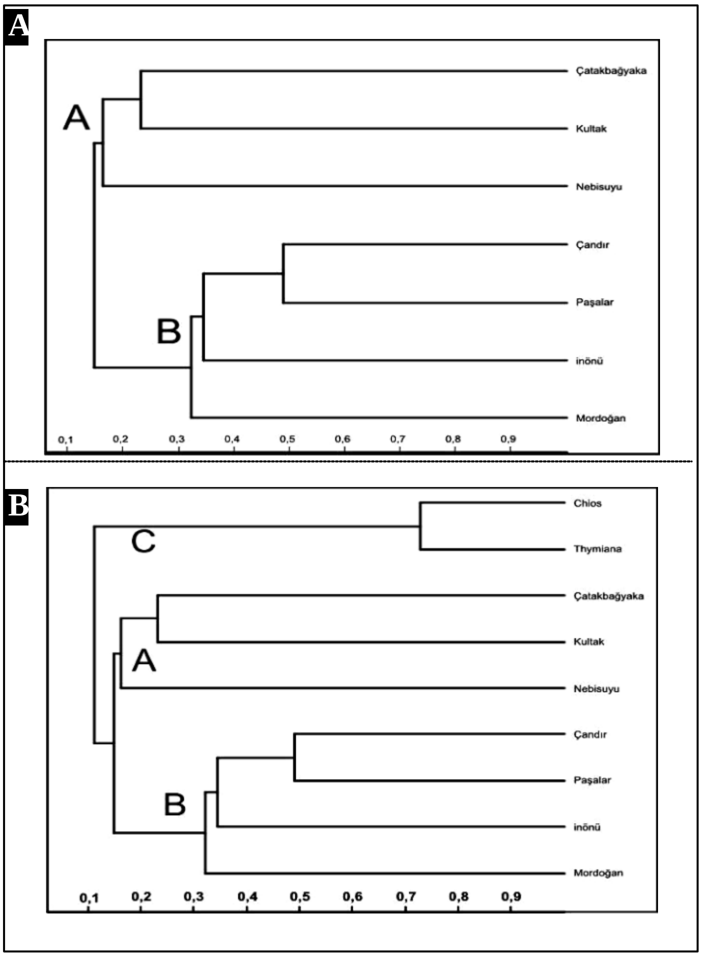

Figure 7.6 A. Cluster Analysis on presence/absence data at the genus level, using Jaccard's similarity index on Turkish and B. Greek and Turkish Middle Miocene sites.

Figures 7.6A and 7.6B summarize the result of the analysis carried out on the Middle Miocene taxa. Considering figure 7.6A, the dendrogram based on the Jaccard index has grouped two major clusters: (1) the Central Anatolian localities (Bursa–Pasalar, Ankara–Çandir, Inönü) and (2) SW Anatolian localities. First group clearly seperated from the second group except for the Izmir–Mordogan site, which seems to close to Ankara–Inönü and Çandir respectively. Moreover, there is a clear separation between the faunas correlated with MN5, MN5–6, MN6–7/8 and Greek faunas that don't cluster with Turkish faunas and form an independent cluster. Bursa–Pasalar and Ankara–Çandir localities match together as a result of high faunal similarity and Ankara–Inönü and Izmir–Mordogan localities follow this conclusion. This arrangement of the localities in subcluster B also marks a higher bovid diversity than subcluster A, which points out a more open environment was dominant during the Middle Miocene in Central Anatolia.

Andrews (2007) suggests a subtropical woodland or forest environment in middle Miocene times at Bursa–Pasalar with abundant ground vegetation and incorporating open areas. Geraads et al., (2003), proposed a relatively dry, seasonal subtropical woodland habitat for Ankara–Çandir and Bursa–Pasalar and emphasized that Ankara–Çandir had a more open, dominant open country biotope and Ankara–Inönü had an even more open environment comparative to the former sites. This type of environment which was lately documented at Izmir–Mordogan (Geraads et al., 2002) indicates the mixture of woodland and grassland habitats were widespread in the western part of Anatolia. Çanakkale–Nebisuyu differs significantly from the former localities by the absence of open environment elements, such as bovids (Made et al., in prep.). *Chalicotherium* and *Anchitherium* are regarded as being moist forest inhabitants. This is also consistent with the existence of the more or less the same taxa for Kultak and Catakbagyaka. Besides, the new Kultak rhino record, Brachypus, which is a short–legged brachydont rhino of hippo–like proportion usually assumed to adapted subtropical forested habitats and nearby lakes and rivers (Fortelius, 1990). Therefore, the conclusion justified the existence of humid palaeoclimates around SW and NW Anatolia. On the contrary, Central Anatolia was under the influence of dry phase throughout Langhian.

7.9 Palaeoclimate

The Burdigalian–Langhian palynoflora of the Ören–Kultak region is obtained for the palaeoclimatic interpretation using the coexistence approach analysis method. Obtained numeral climatic variables are correlated with the variables of Turkey, Greece and central European countries (i.e. Serbia, Bulgaria, Germany, Ukraina).

During the Burdigalian–Langhian period, thermophilous species (*Engelhardia*, Sapotaceae, Cyrillaceae, *Avicennia*, Arecaceae, *Palmae* etc.) are recorded abundantly in palynospectra of coal bearing sediments in Turkey. Abundance of these species could be interpreted the warm climatic condition during that period by many workers in Turkey and this warm climate was related to Middle Miocene climatic optimum period (i.e. Akgün et al., 2007; Kayseri & Akgün, 2008, 2009) (Fig. 7.7). The Middle Miocene climatic optimum period recorded in the Burdigalian–Langhian interval from Europe caused warming of the subtropical climate. Thus certain regions are observed the mangrove vegetation (i.e. France, Spain, Turkey), recorded the abundantly herb species (southern Spain) and also evergreen plants are observed (north of Europe) (Nagy & Kókay, 1991; Utescher et al., 2007; Jiménez–Moreno & Suc, 2007; Syabryaj et al., 2007; Jiménez–Moreno, 2006).

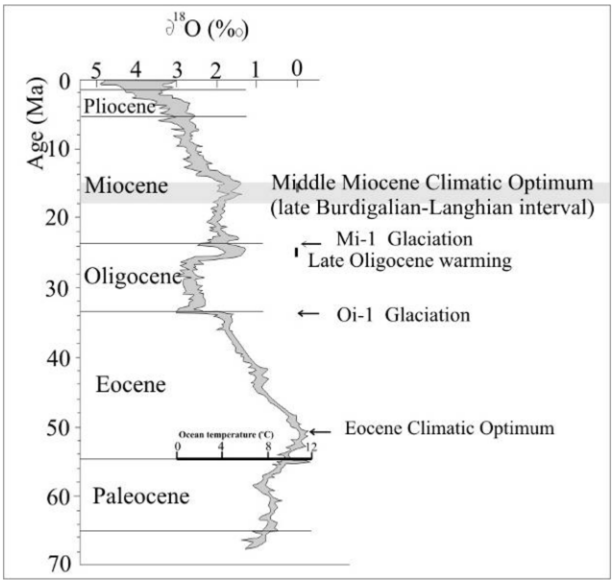

Figure 7.7 Palaeoclimatic changes observed during the geological time based on the oxygen isotopic results (Zachos et al., 2001).

7.9.1 Coexistence Approach Results of Ören–Kultak Region

According to the data obtained from the late Burdigalian–Langhian sediments in the Ören–Kultak region display a relatively subtropical climate based on palynoflora. Palaeovegetation of the region grown under this climatic condition is represented by palaeotropical elements (*Engelhardia*, Schizaceae, Sapotaceae, *Avicennia* and Cyrillaceae). The MAT coexistence intervals of Ören–Kultak region range between 15.7 and 18.8°C, the CMT is between 9.6 and 13.1°C, the WMT between 24.7 and 27.7°C, the MAP 1122.0 and 1520.0mm, MAP_{WET} 204 and 227mm, MAP_{DRY} 19 and 43mm MAP_{WARM} 79 and 125mm and the MART 13.5°C (Table 7.2).

Table 7.2 $CA_{palynoflora}$ results (MAT, CMT, WMT and MAP) of the Burdigalian–Langhian time interval in Turkey and Greece ("*" symbolized the palynoflora of the Langhian time).

Location		**MAT (°C)**	**CMT (°C)**	**WMT (°C)**	**MART(°C) (WMT-CMT)**	**MAP (mm)**
THIS STUDY	Ören–Karacaagaç	17.0–18.4	6.2–12.5	26.5–28.1	1146–1322	17.95
	Ören–Hüsamlar	17.0–21.3	6.2–13.3	27.3–28.1	1146–1322	17.95
	Ören–Kultak	15.7–8.8	9.6–13.1	24.7–27.7	1122–1520	13.5
Ankara–Çayirhan (upper coal seam)		16.5–20.8	4.8–13.3 or 0.9–1.1	26.0–27.9	17.9 or 25.95	735–1520
Ankara–Çayirhan (lower coal seam)		17.0–21.3	7.7–13.3	27.3–28.1	17.2	1146–1322
Samsun–Havza		17.2 –20.8	6.2–13.3	27.3–27.9	17.45	1217–1322
Çanakkale–Çan		15.7–21.3	9.6–13.3	22.8–28.1	14	735–1520
Çanakkale–Etili		17.2–18.4	6.2–7.4	27.3–27.9	20.8	1146–1151
Balikesir–Gönen		15.7–21.3	9.6–13.3	22.8–28.1	14	437–1520
Balikesir–Bigadiç		17.2–21.3	6.2–13.3	26.5–27.9	17.45	1217–1322
Manisa–Soma		16.5–21.3	4.8–13.3	26–27.9	17.9	629–1520
Izmir–Sabuncubeli		16.3–21.3	5.5–13.3	27.3–28.1	18.3	887–1520
* Aydin–Kulogullari		13.5–21.3	1.8–13.3	25.4–28.1	19.2	1183–1520
* Aydin–Başçayir		12.9–21.7	0.9–15.6	23.6–28.1	17.6	735–1574
Grecee–Spanokhorion		9.1–10.8 or 15.6–21.3	(–2.7)–1.1 or 5.0–13.3	24.7–43.0	34.65 or 24.7	823–1520
Grecee–Evia		17.0–18.4	6.2–12.5	26.5–32.0	19.9	1146–1322
* Grecee– Kolivata		15.6–21.7	5.0–15.6	24.7–27.9	16	823–1520

7.9.2 Coexistence Approach Results of Palynoflora in Other Region from Turkey and Greece

In the latest Burdigalian, temperature increased and the succeeding warm time span persisted through late Burdigalian and early Serravalian time interval. This time of high temperature corresponds to the Middle Miocene climatic optimum which is also globally observed based on the isotopic, palynologic and palaeobotanical data (Zachos et al., 2001 and Mosbrugger et al., 2005). This important palaeoclimatic event of the Miocene time in Turkey and Greece (Ören–Karacaagaç "late Burdigalian–Langhian" (see chapter six); Ankara–Beypazari "latest Burdigalian"; Balikesir–Bigadiç "latest Burdigalian", Izmir–Sabuncubeli "latest Burdigalian"; Akçasehir–Tire "latest Burdigalian"; Manisa–Soma "late Burdigalian–Langhian"; Çanakkale–Etili "late Burdigalian–Langhian", Çanakkale–Çan and Balikesir–Gönen "latest Burdigalian–?Serravallian"; Milas–Kultak "middle Burdigalian–Langhian", Aydin–Basçayir and Kulogullari "Langhian"; Greece–Spanokhorion and Evia "latest Burdigalian", Greece–Kolivata "Langhian") could be evaluated using the coexistence approach method.

Numerical palaeoclimatic values of palynofloras from the Ören–Karacaagaç and Hüsamlar regions are calculated in this thesis (see chapter six). The coexistence intervals of the Ören–Karacaagaç are MAT 17.0–18.4°C, CMT 6.2–12.5°C, WMT 26.5–28.1°C, MAP 1146–1322mm, MAP_{WET} 225–227mm, MAP_{DRY} 7–32mm, MAP_{WARM} 79.0–125.0mm, MART 17.95°C and the ranges of the climatic parameters were determined by several climate–limiting species. The intervals of the Ören–Hüsamlar are MAT 17.0–21.3°C, CMT 6.2–13.3°C, WMT 27.3–28.1°C, MAP 1146–1322mm, MAP_{WET} 225–227mm, MAP_{DRY} 8–32mm, MAP_{WARM} 79.0–125.0mm and MART 17.95°C (Fig. 7.8).

Coexistence results of two coal seams in Ankara–Çayirhan region are calculated. Results of upper coal seam in Ankara–Beypazari (Çayirhan) region for the latest Burdigalian time (Güngör, 1991) are the MAT 16.5–20.8°C, the CMT 4.8–13.3°C (9.05°C) and 0.9–1.1°C (1°C), the WMT 26.0–27.9°C (26.95°C), the MAP 735.0–1520.0 mm and the MART 17.9°C or 25.95°C. These values support the warm subtropical climatic condition during the latest Burdigalian time. Coexistence intervals of the lower coal seam are the MAT 17.0–21.3°C, CMT 7.7–13.3°C (10.5°C), WMT 27.3–28.1°C (27.7°C) and MART 17.2°C'dir.

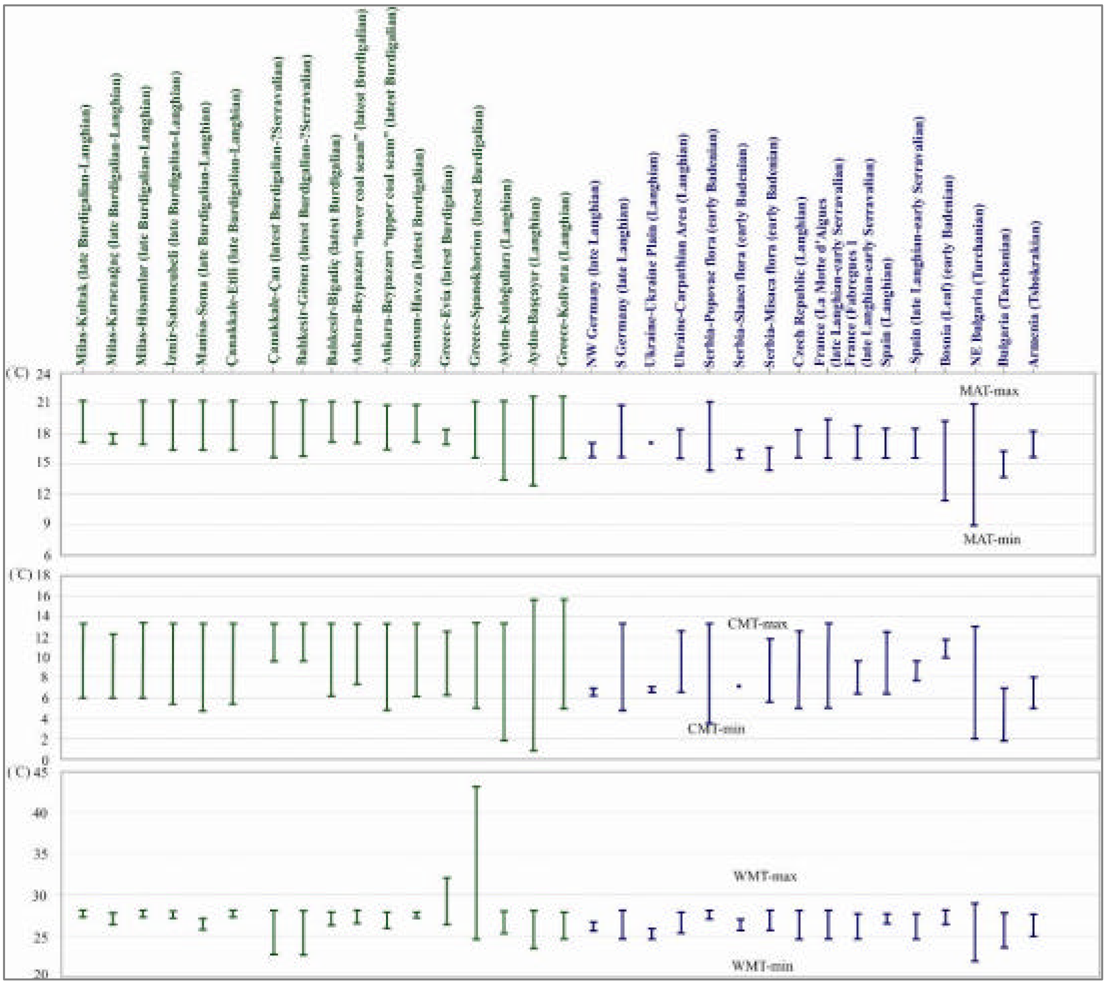

Figure 7.8 Intervals of the MAT, CMT and WMT of Turkey and European countries for the Burdigalian–Langhian time interval.

Palynofloras of the Çanakkale–Çan and Balikesir–Gönen regions were recorded by Ediger (1990), which indicate the latest Burdigalian–?Serravalian time. Author emphasized that the more temperate to subtropical climate observed in Çanakkale–Çan and Balikesir–Gönen regions but numerical climatic values of these regions were not calculated. The coexistence approach results of the Çanakkale–Çan region are obtained in this chapter which are the MAT 15.7–21.3°C, the CMT 9.6–13.3°C (11.45°C), the WMT 22.8–28.1°C (22.45°C), the MAP 735.0–1520.0 mm and the MART 14°C. The results of Balikesir–Gönen region are the MAT 15.7–21.3°C, the CMT 9.6–13.3°C (11.45°C), the WMT 22.8–28.1°C (22.45°C), the MAP 437.0–1520.0mm and the MART 14°C.

Palynoflora and palaeoclimatic interpretation of Balikesir–Bigadiç region were defined by the Akyol and Akgün (1990) and Akgün et al. (2007). Warm subtropical climatic condition observed based on palynoflora which is characterized by the *Engelhardia*, Cyrillaceae and Sapotaceae. Coexistence intervals of the Balikesir–Bigadiç region for the latest Burdigalian palynoflora were calculated by Akgün et al. (2007) and there are the MAT of 17.2–21.3°C, the CMT and WMT of 6.2–13.3°C (9.75°C) and 26.5–27.9°C, the MAP 1117–1322mm, and the MART 17.45°C.

Palynological record of the Samsun–Havza region was obtained by the Kayseri (2002) and Kayseri & Akgün (2008). Numerical palaeoclimatic records were calculated in these studies which are 17.2 to 20.8°C for the MAT, 6.2 to 13.3°C (9.75°C) for the CMT, 27.3 to 27.9°C for the WMT and 1217 to 1322mm for the MAP and 17.45°C for the MART. These results of the latest Burdigalian time support the warm subtropical palaeoclimatic condition.

The coexistence approach results of the Izmir–Sabuncubeli region are the mean annual temperature 16.3–21.3°C, the mean annual coldest mound 5.5–13.3°C, the mean annual warmest mound 27.3–28.1°C and mean annual precipitation 887–1520mm respectively (Kayseri et al., 2007).

The palynoflora of the samples collected from the Soma basin includes 30 taxa (Akgün et al., 2007). The palaeoclimatic parameters are based on the 10 taxa. The calculations are 16.5 to 21.3°C for MAT, 4.8 to 13.3°C for the CMT, 26 to 27.9°C for WMT and 629 to 1520 mm for the MAP respectively.

The palynological assemblage of Çanakkale–Etili region has also been applied to the Coexistence Approach method for the climate analysis (Akgün et al., 2008). Quantitative results indicate values of mean annual temperature (MAT) of 17.2–18.4°C, with winter temperatures (CMT) of 6.2–7.4°C, summer temperatures (WMT) of 27.3–27.9°C, the mean annual precipitation (MAP) ranging between 1146 and 1151 mm and the MART of 20.8°C.

The other regions of the early Middle Miocene (Langhian) time are Aydin–Kulogullari and Basçayir (Akgün & Akyol, 1999). The coexistence approach results of the Aydin–Kulogullari region (southeast of Aydin) are the MAT 13.5–21.3°C, the CMT 1.8–13.3°C (7.55°C), the WMT 25.4–28.1°C (26.75°C), the MAP 1183.0–1520.0mm and the MART 19.2°C. Coexistence intervals of the Aydin–Basçayir (northeast of Aydin) region for the Langhian palynoflora the MAT of 12.9–21.7°C, the CMT and WMT of 0.9–15.6°C (8.25°C) and 23.6–28.1°C (25.85°C), the MAP 735.0–1574.0 mm and the MART 17.6°C. Palaeotropical elements (Cyrillaceae, Sapotaceae, *Engelhardia* and Schizaceae) are recorded in samples of the Langhian time and these elements indicate the warm subtropical palaeoclimate.

For the latest Burdigalian time, palynological record of Spanokhorion region in Greece is published by Benda (1982) and palynoflora of this region is characterized by the thermophilous elements (Cyrillaceae and *Engelhardia*). Using this palynoflora obtained the numerical climatic values of Spanokhorion region in Greece which are the MAT 9.1–10.8°C or 15.6–21.3°C, the CMT (–2.7)–1.1°C (–0.8°C) or 5.0–13.3°C (9.15°C), the WMT 24.7–43.0°C (33.85°C), the MAP 823.0–1520.0mm and the MART 34.65°C or 24.7°C. Two intervals of the MAT, CMT and MART obtained. And also the WMT interval is fairly wide.

Reigel et al. (1989) recorded the late Burdigalian palynoflora of southern part of the Aliveri basin on the isle of Evia region (Greece). This flora is characterized by the thermophilous elements (*Engelhardia*, Sapotaceae, *Platycarya* and *Palmae*). Coexistence intervals of the Greece–Evia region for the late Burdigalian palynoflora calculated in this study and there are the MAT of 17.0–18.4°C, the CMT and WMT of 6.2–12.5°C (9.35°C) and 26.5–32.0°C, the MAP 1146–1322mm, and the MART 19.9°C.

Detail palynological records for the Miocene of Greece were obtained by Benda (1971) and Benda et al. (1982). The warm subtropical palaeoclimatic conditions observed from the latest Burdigalian and Langhian time interval (Benda et al., 1982) based on the palynoflora characterizing the thermophilous elements (Cyrillaceae and

Engelhardia). However, numerical climatic data of Langhian time of Greece have not obtained until now and in this chapter, the data of Langhian time are calculated based on the Benda's (1982) palynofloras. Results of Kolivata (west of Greece) for the Langhian time are the MAT 15.6–21.7°C, the CMT 5.0–15.6°C (10.3°C), the WMT 24.7–27.9°C (26.3°C), the MAP 823.0–1520.0mm, the MART 16°C and these values support the Benda's palaeoclimatic records.

Mosbrugger et al. (2005) recorded the palaeoclimatic evolution during the Eocene–Pliocene time interval based on the macro and microfloras of Germany and central Europe. And also climatic curves of central Europe (Mosbrugger et al., 2005) are correlated with the climatic curves of oxygen and carbon isotopes (Zachos et al., 2002). For MAT and WMT, similar values are obtained from the floras of different Cenozoic basins during that time. Authors observed the peak in the curve of CMT values (9–13°C) and this increasing of temperature is related to the warm climatic period in the Burdigalian–Langhian period by Mosbrugger et al. (2005). Besides, authors emphasized that regional differences of climatic values are probably caused by paleogeographic settings. For example, the Lower Rhine and the Weisselster–Lausitz Basins are close to the Cenozoic North Sea, moderating the climate during the cold season. In the case of the Molasse Basin, orographic movements in the nearby area might be reflected by palaeoclimate. The onset of the Miocene cooling seems to be between 13.0 and 14.0 my when considering all of the different records and climate variables analyzed. In the Molasse Basin, CMT decreased more rapidly than in other regions at the end of the middle Miocene. The CMT dropped below 4°C.

In the Burdigalian time, the CMT values of the Ören–Kultak region higher than the other regions in Turkey. This indicates the palaeoclimatic condition in this region warmer than the palaeoclimatic condition of the other regions. Additionally, MART value of Ören–Kultak region is lower than the other regions in Turkey for the Burdigalian time. This could be interpreted the presence of the low palaeotopographic condition in the Ören–Kultak region during the middle Burdigalian–Langhian time interval. Besides, the CMT and MART values of Ören–

Karacaagaç and Hüsamlar regions are similar. For the middle Burdigalian–Langhian time interval, the CMT values of these regions are lower than the CMT values of Ören–Kultak region and also the MART values of Ören–Karacaagaç and Hüsamlar region are higher than the MART values of Ören–Kultak region. This different CMT and MART values could be interpreted the distinct palaeotopographic condition in the Ören–Karacaagaç, Hüsamlar and Kultak regions. Palaeotopography of the Ören–Kultak region is lower than the palaeotopography of Ören–Karacaagaç and Hüsamlar regions. Palynoflora of Ören–Kultak region supports this palaeoenvironmental evident according to presence of plants growing in mangrove environment (*Avicennia*) (see chapter eight). In Europe, a small number of palaeoclimatic values were observed for the Burdigalian time (Utescher et al., 2007; Syabryaj et al., 2007). The CMT values of Europe are lower than the CMT values of Turkey. Besides, the CMT values of Turkey during the Langhian time are generally between the 7–8°C. In Europe these values are generally between 8 and 13°C. Temperature difference of the Burdigalian and Langhian times could be explained the palaeogeographic position in these times although the MART values of Turkey and central Europe indicates similarities (Fig.7.9).

7.10 Stable isotope analysis (^{13}C and ^{18}O) and Precipitation Records of Turkey and Europe

The carbon isotopic composition of carbonate in biogenic apatites and in most soil is dependent upon the local carbon isotopic composition of the local vegetation. C_3 plants include nearly all trees, most shrubs and herbs, and grasses that favor cool growing seasons. Regions receiving dominantly winter rains, such as the modern Mediterranean, are vegetated largely by C_3 plants (Papanstasis, 1981). Modern C_3 plants average –27±5‰ for ^{13}C. The ^{13}C value of C_4 plants averages about –13±3‰. C_4 plants include grasses that favor warm growing seasons, as well as a few desert shrubs and herbs. C_4 grasses common in tropical, subtropical and temperate climates dominated by warm summer rainfall (Quade et al., 1995).

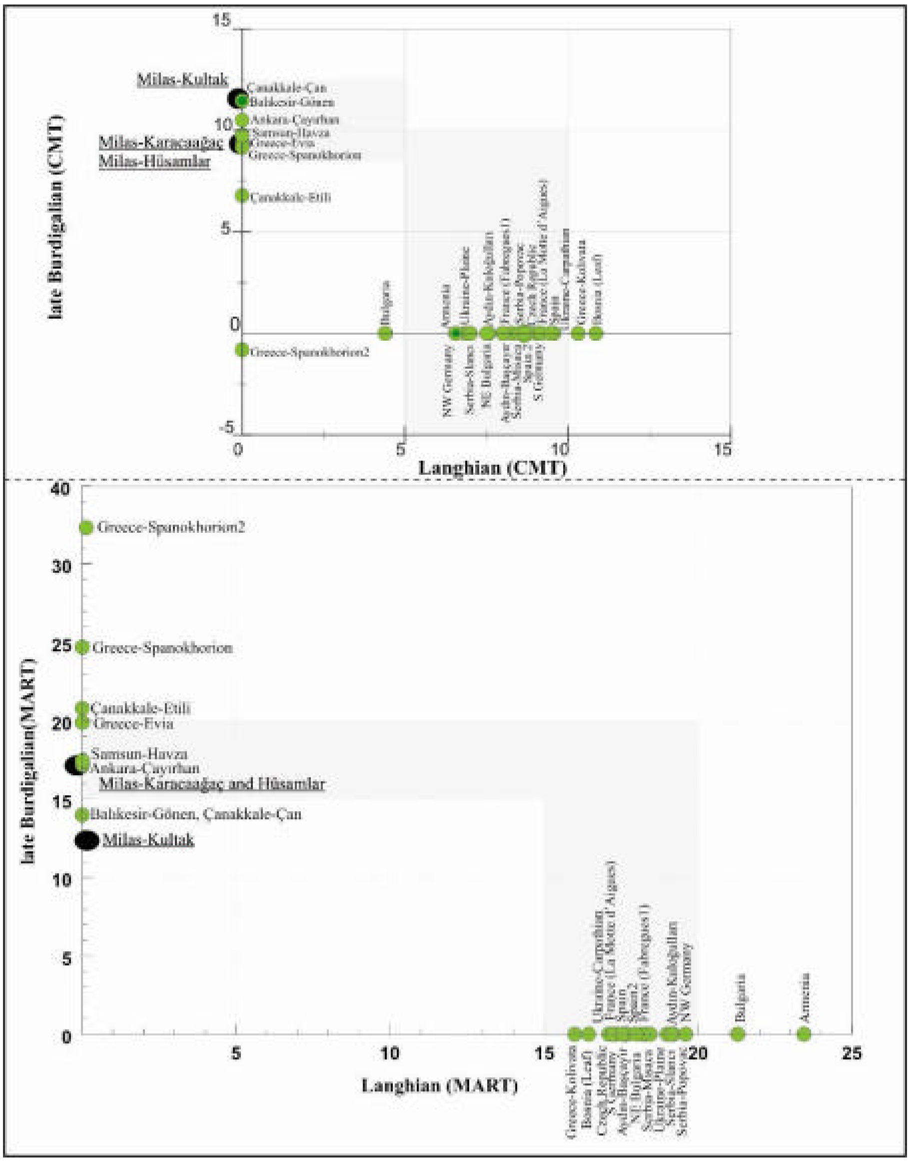

Figure 7.9 Correlation of the CMT and MART values of the late Burdigalian and Langhian times for Turkey and Europe.

The ^{13}C value of fossil tooth enamel at Kultak is –8.32‰ (Table 7.3). This value indicates that mammals at Kultak consumed mainly C_3 plants as the Bursa–Pasalar region.

Table 7.3 Stable carbon and oxygen value of Ören–Kultak fossil site.

Sample	**CO3–content (%CaCO3)**	**d ^{13}C (‰ VPDB)**	**^{18}O (‰ VPDB)**	
Gomphotherium sp.	12.4	–8.,32	–7.75	**This Study (MN4–5 boundary)**
Gomphotherium sp.	–	(–10) and (–12)	(–5) and (–8)	**Bursa–Pasalar (15Ma)**

The oxygen isotopic composition of bone phosphate is largely determinated by ^{18}O value of environmental water, and metabolic processes which vary from species to species (Luz & Kolodny, 1995; Quade et al., 1995). Of the two, the ^{18}O value of environment water has been shown to be the most important, and this is controlled by the ^{18}O value of local precipitation and by the extent to which rainfall is later modified by evaporation. Leafs can be strongly enriched in ^{18}O due to evaporation from a leaf surface, the more so in an unshaded setting like a clearing or high in a forest canopy (Quade et al., 1995). Sternberg et al. (1989) documented systematic enrichment in ^{18}O of foliage upward through a tropical forest. This isotopic stratification appears to be reflected in the ^{18}O value of mammals consuming such vegetation. The ^{18}O value of the *Gomphotherium* sp. is low (Table 7.3). This result could be indicated eating plants shielded from sunlight, as in a shaded forest setting (Fig. 7.10). Carbon and oxygen values of the Kultak and Bursa–Pasalar regions are located in the C_3 plants are in figure 7.10. This indicates the same ecological condition during the Burdigalian–Langhian time. This isotopic result and high MAP_{DRY} value are in Ören–Kultak region supported with ecological interpretation of mammalian fossils. However, according to isotopic results Ören–Kultak region is high shaded than the Bursa–Pasalar region. Negative ^{18}O values could be displayed less humidity in the Kultak region (Table 7.4).

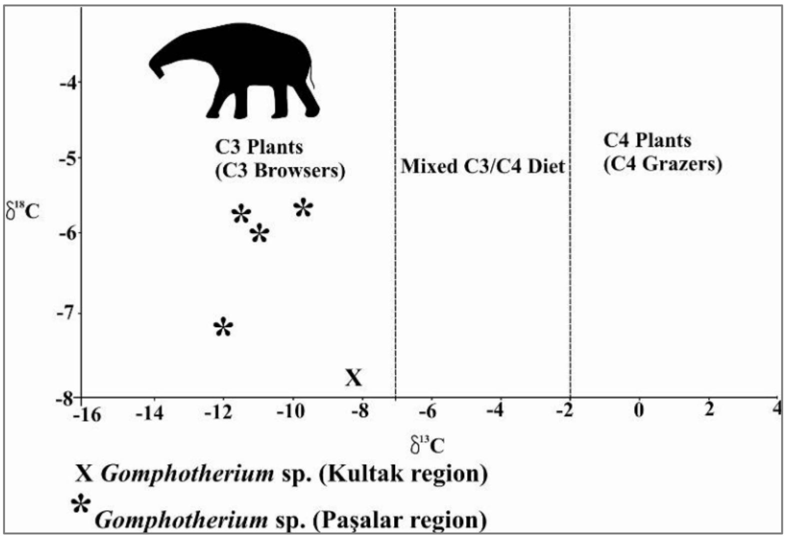

Figure 7.10 Stable carbon and oxygen isotope values of Kultak and Pasalar region (Quade et al., 1995).

Table 7.4 $CA_{PALYNOFLORA}$ results (MAP, MAP_{WET}, MAP_{DRY} and MAP_{WARM}) of the Burdigalian–Langhian time interval in Turkey and Greece ("*" symbolized the palynoflora of the Langhian time).

Location		**MAP (mm)**	**MAP_{WET} (mm)**	**MAP_{DRY} (mm)**	**MAP_{WARM} (mm)**	**MART(°C)**
THIS STUDY	Ören–Karacaagaç	1146–1322	225–227	7–32	79–125	17.95
	Ören–Hüsamlar	1146–1322	225–227	8–32	79–125	17.95
	Ören–Kultak	1122–1520	204–227	→ 19–43	79–125	13.5
CENTRAL ANATOLIA	Ankara–Çayirhan (upper coal seam)	735–1520	134–180	→ 26–27.9	55–125	17.9 or 25.95
	Ankara–Çayirhan (lower coal seam)	1146–1322	225–245	→ 19–32	79–154	17.2
	Samsun–Havza	1217–1322	236–255	→ 19–32	118–125	17.45
NORTHWEST ANATOLIA	Çanakkale–Çan	735–1520	175–180	8–43	45–163	14
	Çanakkale–Etili	1146–1151	–	–	–	20.8
	Balikesir–Gönen	437–1520	175–180	8–43	45–61	14
	Balikesir–Bigadiç	1217–1322	109–180 or 204–227	→ 16–43	118–125	17.45
WESTERN ANATOLIA	Manisa–Soma	629–1520	134–180	8–43	51–63	17.9
	Izmir–Sabuncubeli	887–1520	–	–	–	18.3
	* Aydin–Kulogullari	1183–1520	107–180 or 205–245	8–43	85–163	19.2
	* Aydin–Basçayir	735–1574	107–323	5–43	51–180	17.6
GRECEE	Spanokhorion	823–1520	204–227	8–43	79–125	34.65 or 24.7
	Evia	1146–1322	225–227	8–32	79–125	19.9
	* Kolivata	823–1520	107–180 or 204–227	8–43	79–125	16

The MAP, MAP_{WET} and MAP_{WARM} values of the Ören-Karacaagaç, Hüsamlar and Kultak regions resemble each other. However, the MAP_{DRY} values of these regions indicate differences. This value of the Ören-Kultak region is distinctly higher than the MAP_{DRY} values of other Ören regions. This could be indicated presences of the drier areas in the Ören-Karacaagaç and Hüsamlar regions. Ören-Kultak region have a moist areas during the middle Burdigalian-Langhian time interval according to the high MAP_{DRY} value.

Wide MAP values of central, northwest and western Anatolia are observed during the Burdigalian-Langhian time interval. The lower limits of MAP values of certain regions are low (Table 7.4). This decreasing precipitation values could be interpreted as the existence of quite dry period occasionally. The MAP_{WET} and MAP_{WARM} values of these regions do not observed distinctly differences. However, there are noticeably changes in the MAP_{DRY} values. The MAP_{DRY} values of the central Anatolia and Balikesir-Bigadiç region in western Anatolia are higher than the MAP_{DRY} values of other regions. This could be indicated the more rainfall in the central Anatolia during the Burdigalian-Langhian time interval. The middle Miocene climatic optimum period was recorded in this time interval. The CMT values of Anatolia are generally high and this high temperature values can be related to this climatic optimum period. This warm climatic time interval can be caused the decreasing the MAP_{DRY} values of Anatolia. However the higher MAP_{DRY} values central Anatolia and Balikesir-Bigadiç region can be commented presences of different palaeotopography during the Burdigalian-Langhian period.

PLATE 7.1 (Palynology–Kultak)

1–4.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
5, 6.	*Verrucatosporites favus* (Potonié) Thomson & Pflug
7, 8.	*Leiotriletes* sp.
9–15.	*Leiotriletes maxoides* Krutzsch ssp. *maximus* (Pglug *in* Thomson & Pflug) Krutzsch
16.	*Leiotriletes triangulus* (Mürrüger & Pflug) Krutzsch
17.	*Baculatisporites primarius* (Wolff) Thomson & Pflug
18.	*Zonolapollenites verrucatus* Krutzsch ex Ziembinska–Tworzydlo
9–21.	*Pityosporites microalatus* (Potonié) Thomson & Pflug
22–27.	*Pityosporites labdacus* (Potonié) Thomson & Pflug
28.	*Graminidites laevigatus* Krutzsch
29–35.	*Cupressacites cuspidataeformis* (Zaklinskaya) Krutzsch
36, 37.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
38.	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
39, 40.	*Pterocaryapollenites stellatus* (Potonié) Thiergart
41–45.	*Caryapollenites simplex* (Potonié) Raatz ex Potonié

PLATE 7.2 (Palynology–Kultak)

1.	*Subtriporopollenites anulatus* Thomson & Pflug ssp. *nanus* Thomson & Pflug
2.	*Triatriopollenites rurensis* Thomson & Pflug
3–17.	*Momipites punctatus* (Potonié) Nagy
18–40.	*Momipites quietus* (Potonié) Nichols
41–44.	*Triporopollenites* spp.
45.	*Dicolpopollis kockelii* Pflanzl
46–49.	*Tricolpopollenites liblarensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug ssp. *liblarensis* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
50, 51.	*Quercopollenites robur* type Nagy
52–55.	*Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
56–59.	*Tricolpopollenites retiformis* (*Salix* type) Thomson & Pflug
60, 61.	*Tricolpopollenites retiformis* (*Platanus* type) Thomson & Pflug
62, 63.	*Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
64, 65.	*Aceripollenites striatus* (Pflug) Thiele–Pfeifer
66–76.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *oviformis* (Potonié) Thomson & Pflug
77–80.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug ssp. *exactus* (Thomson *in* Potonié, Thomson & Thiergart) Thomson & Pflug
81–85.	*Tricolporopollenites edmundii* (Potonié) Thomson & Pflug
86–95	*Tricolporopollenites* sp1.
96.	*Tricolpopollenites* sp.
97–100.	*Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
101.	*Avicennia* sp.

102, 103.	*Tetracolporopollenites* sp3.
104.	Microforamiferal lignin
105.	Wood

PLATE 7.3 (Vertebrate–Kultak)

1. Lower right m1 – *Gomphotherium angustidens* (lingual view)
2. Labial view–*Gomphotherium angustidens*
3. occlusal view
b: Lower right m2 – *Gomphotherium* sp. (oclusal view)
c: Lower left m3 – *Gomphotherium* sp. (oclusal view)
d: Lower left m3 – *Gomphotherium angustidens* (oclusal view)
4. Lower right molar serie: *Brachypotherium brachypus* (oclusal view)

PLATE 7.4 (Vertebrate–Kultak)

1-6 *Gomphotherium angustidens*

PLATE 7.1 (Palynology–Kultak)

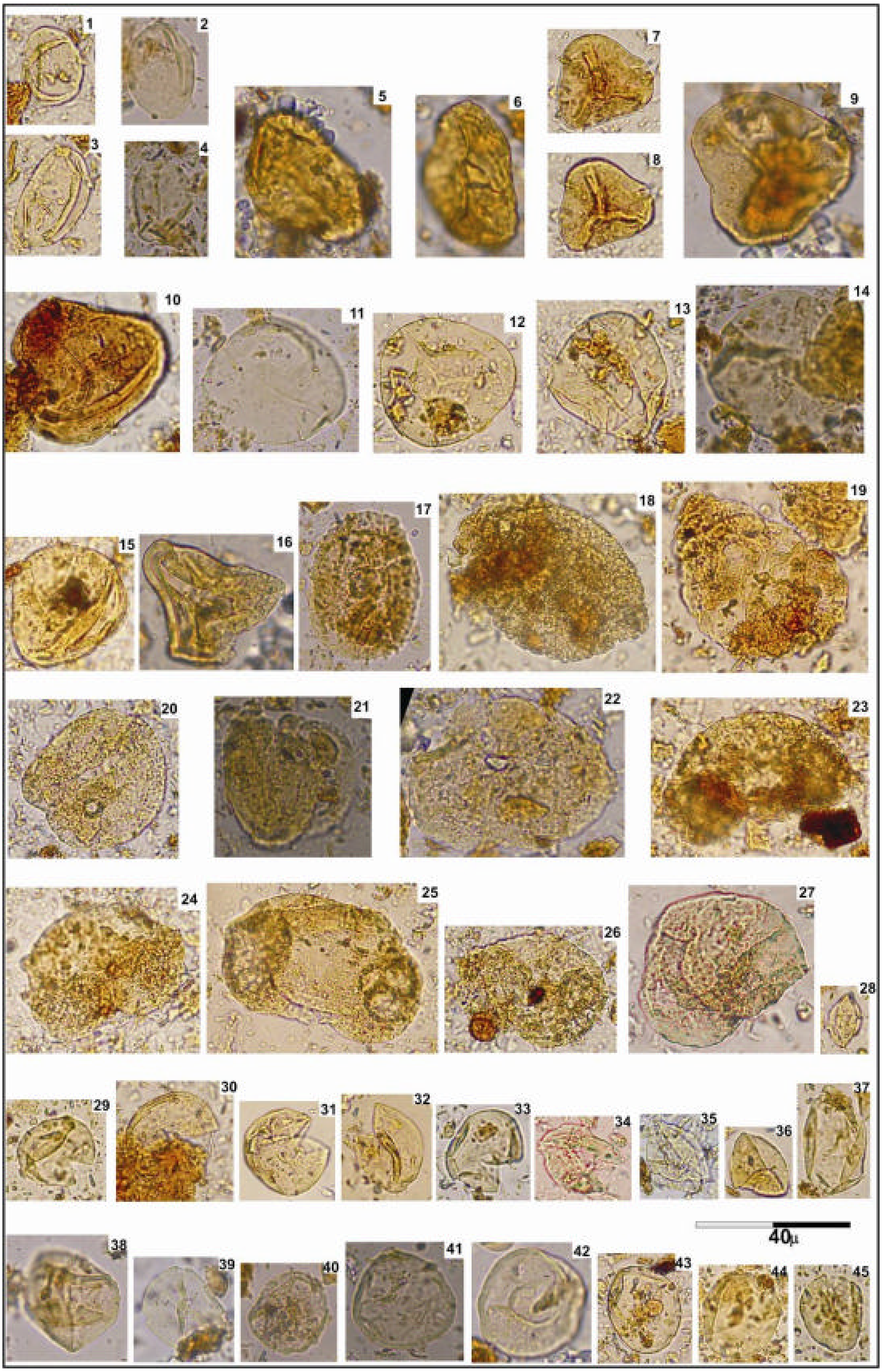

PLATE 7.2 (Palynology–Kultak)

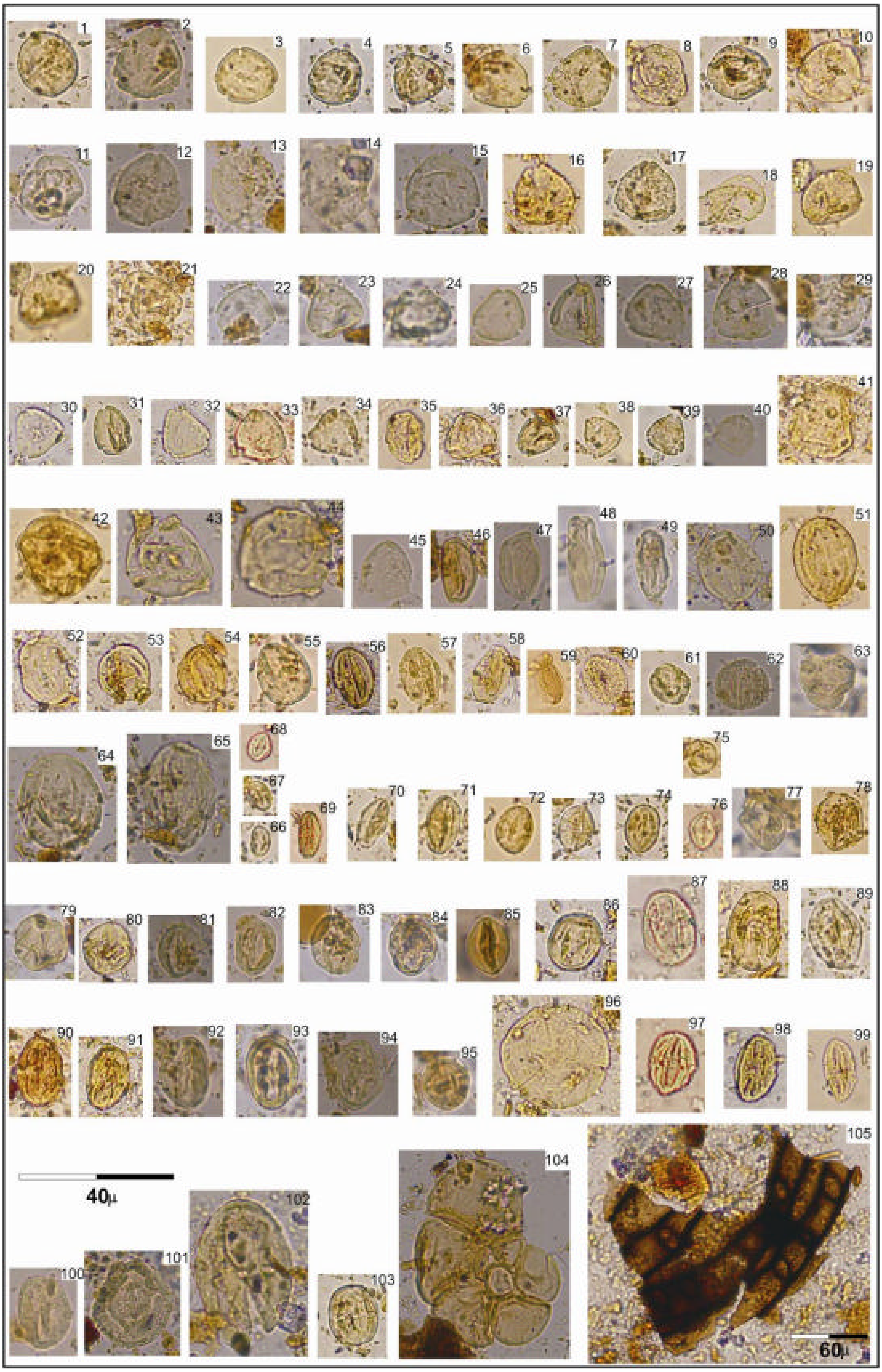

PLATE 7.3 (Vertebrate–Kultak)

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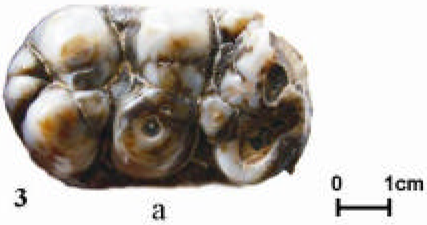

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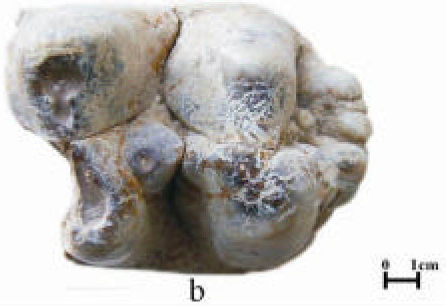

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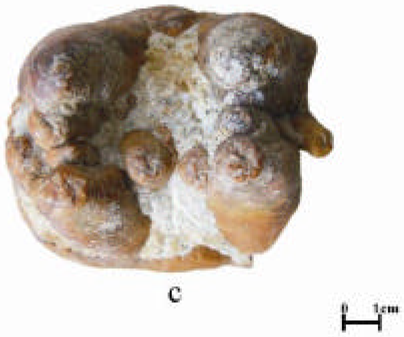

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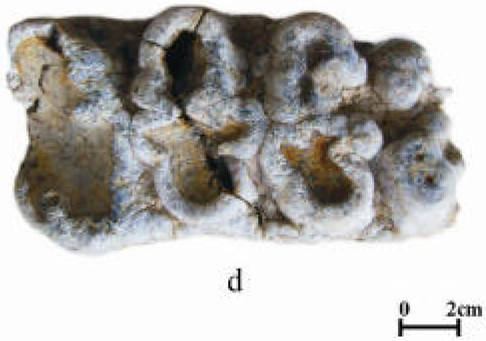

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PLATE 7.4 (Vertebrate–Kultak)

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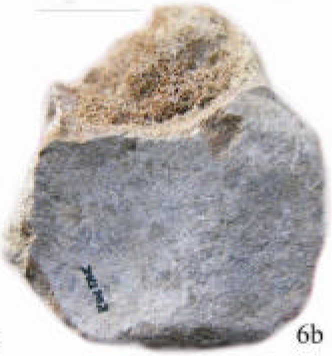
5a

5

6a



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7b

CHAPTER EIGHT

MARINE CONDITION AND PRESENCE OF AN AVICENNA MANGROVE IN THE BURDIGALIAN-LANGHIAN TIME INTERVAL OF THE ÖREN REGION (SW TURKEY): PALAEOCLIMATIC INTERPRETATION

8.1 Introduction

An *Avicennia* mangrove developed around the western Mediterranean basins such as Châteauredon in France and northern Spain during the Late Oligocene-Miocene (i.e. Châteauneuf et al., 2006; Jiménez-Moreno, 2006 and Bessedik, 1981). This mangrove reached its maximum developed the late Burdigalian-Langhian time interval in these basins (especially in France). It constitutes a palaeoclimatic as well as stratigraphic indicator for the Middle Miocene time in the western Mediterranean basins. Up to now *Avicennia* mangrove is not recorded for the Burdigalian and Langhian time in Turkey where located in the eastern Mediterranean province. Here *Avicennia* finding of the late Early and early Middle Miocene series in Kultak-Ören area (southwestern Turkey) and palaeoclimatic assessments are established.

8.2 Geological Setting

The sediments of the Langhian time are located at the Kultak area (Fig. 7.1, 7.2). They are composed of deltaic sediments. The lower part of these sediments includes continental episodes and upper part of these sediments comprises marine deposits (Fig. 8.1). Sampling has been carried out in grey claystone level present in lower part of the sediments. Dating of these sediments is based on mammalian faunas, palynological data and ^{86}Sr-^{87}Sr isotope analysis result (Kayseri & Akgün, 2010; Kayseri et al., 2007; Kayseri et al., 2006). The stratigraphic interval of the Kultak area extends from the middle Burdigalian to Langhian.

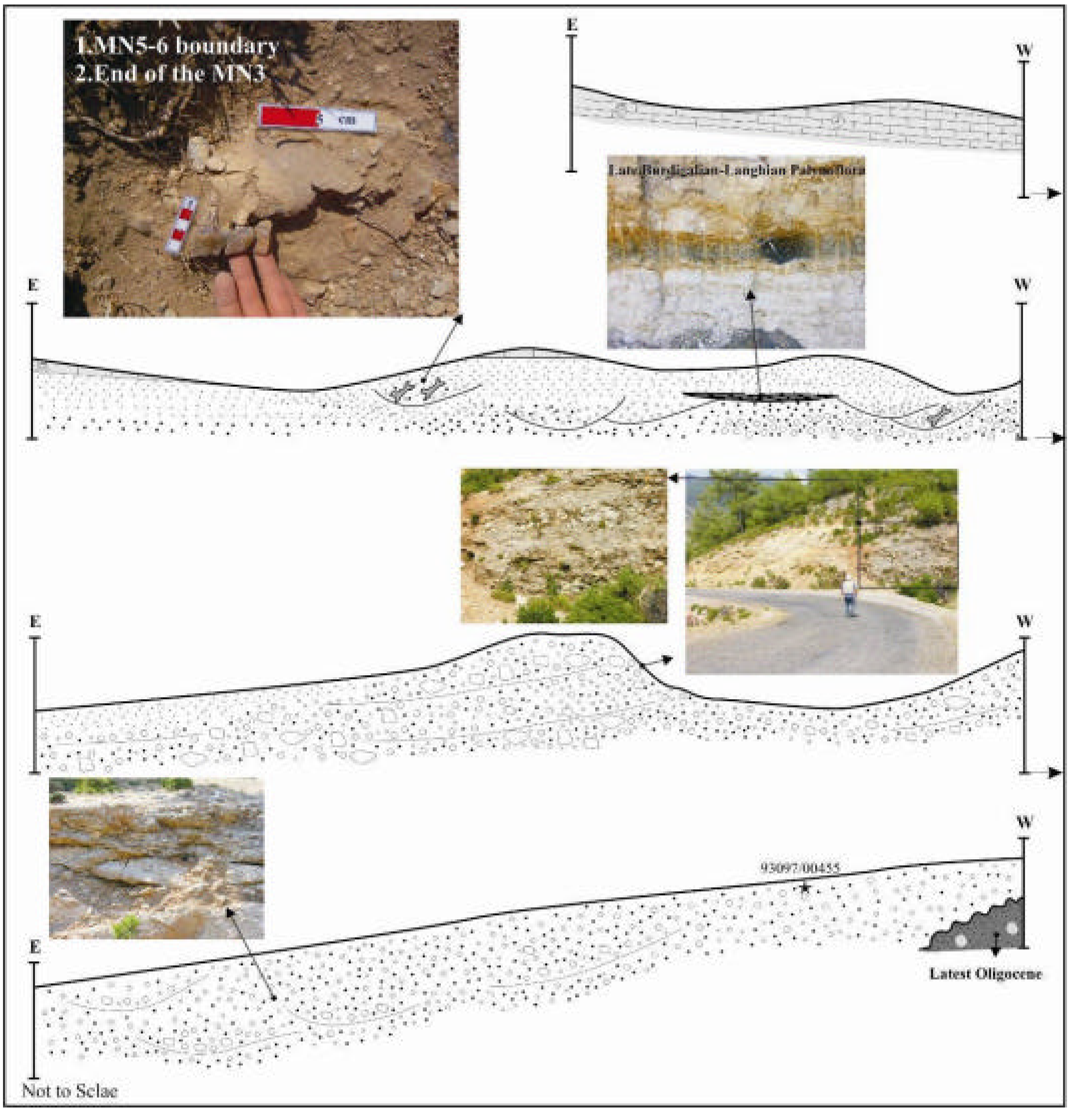


Figure 8.1. Geological cross section showing the sediments of the Burdigalian-Langhian time interval in the Kultak area.

8.3 Palynological Study

Only one section is measured from the Kultak area in the Ören basin. Additionally the middle Burdigalian and Langhian period with *Avicennia* recorded in this study. Palynological record obtained from the claystone end of the lower part of the section. Mammalian fossils are collected clastic sediments in the lower part of the section and these faunas correspond with the MN4-5 (the late Burdigalian-early Langhian) and MN 5-6 (the Langhian) boundaries (Kayseri et al., 2007) (see chapter seven). Besides ^{86}Sr-^{87}Sr isotope value which is applied on the *Gomphotherium* sp. indicated the late Burdigalian time. End of this section passed the marine sediments composed of limestones with rich coral, bivalvia and gastropod fossils (Figs. 8.2 A, B, C, D, E, F, H and 8.3).

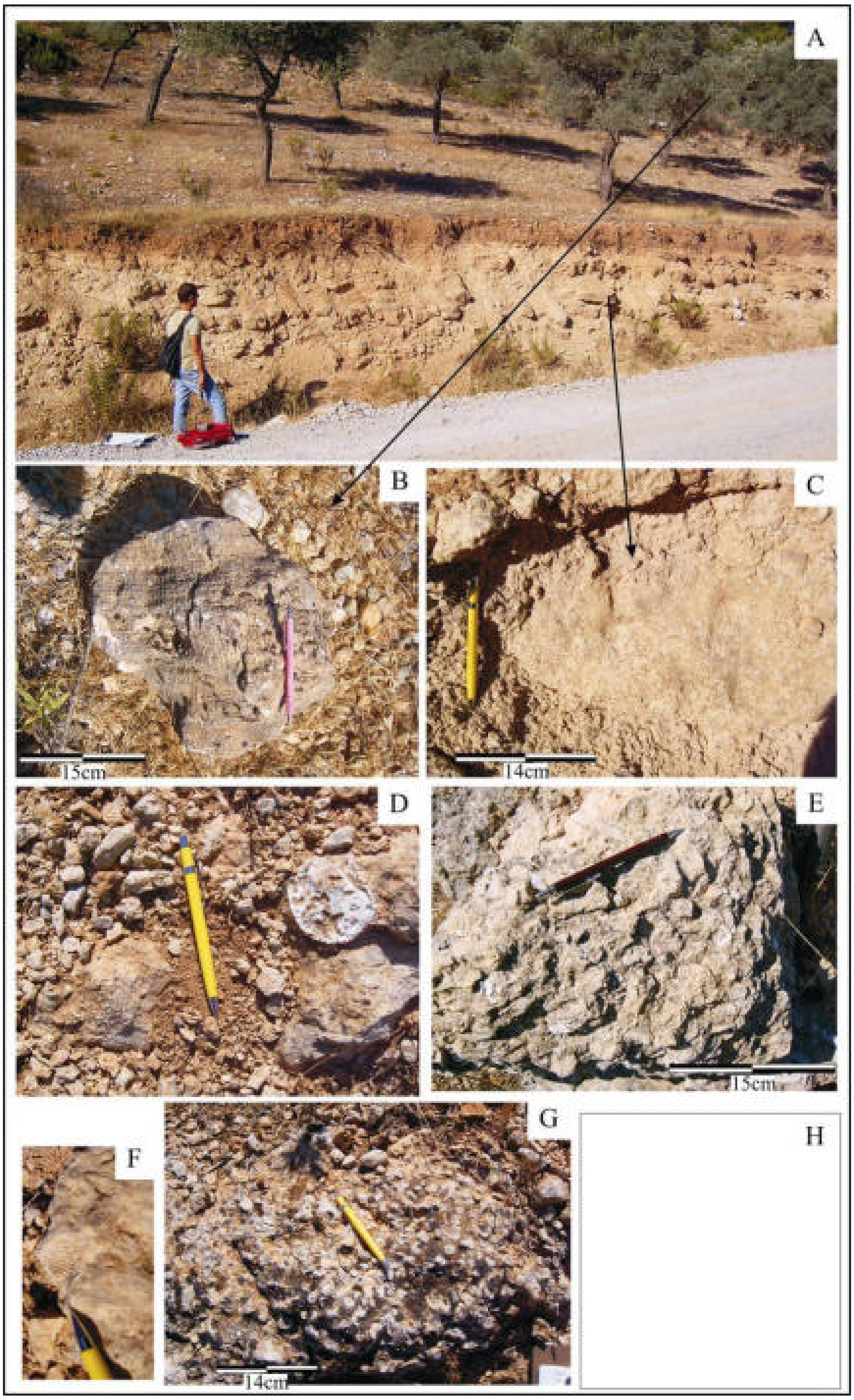


Figure 8.2 A) Marl deposited marine condition in the end of the Kultak section, B; C; D; E; F and G Outcrop photographs showing main characteristics of the Kultak section.

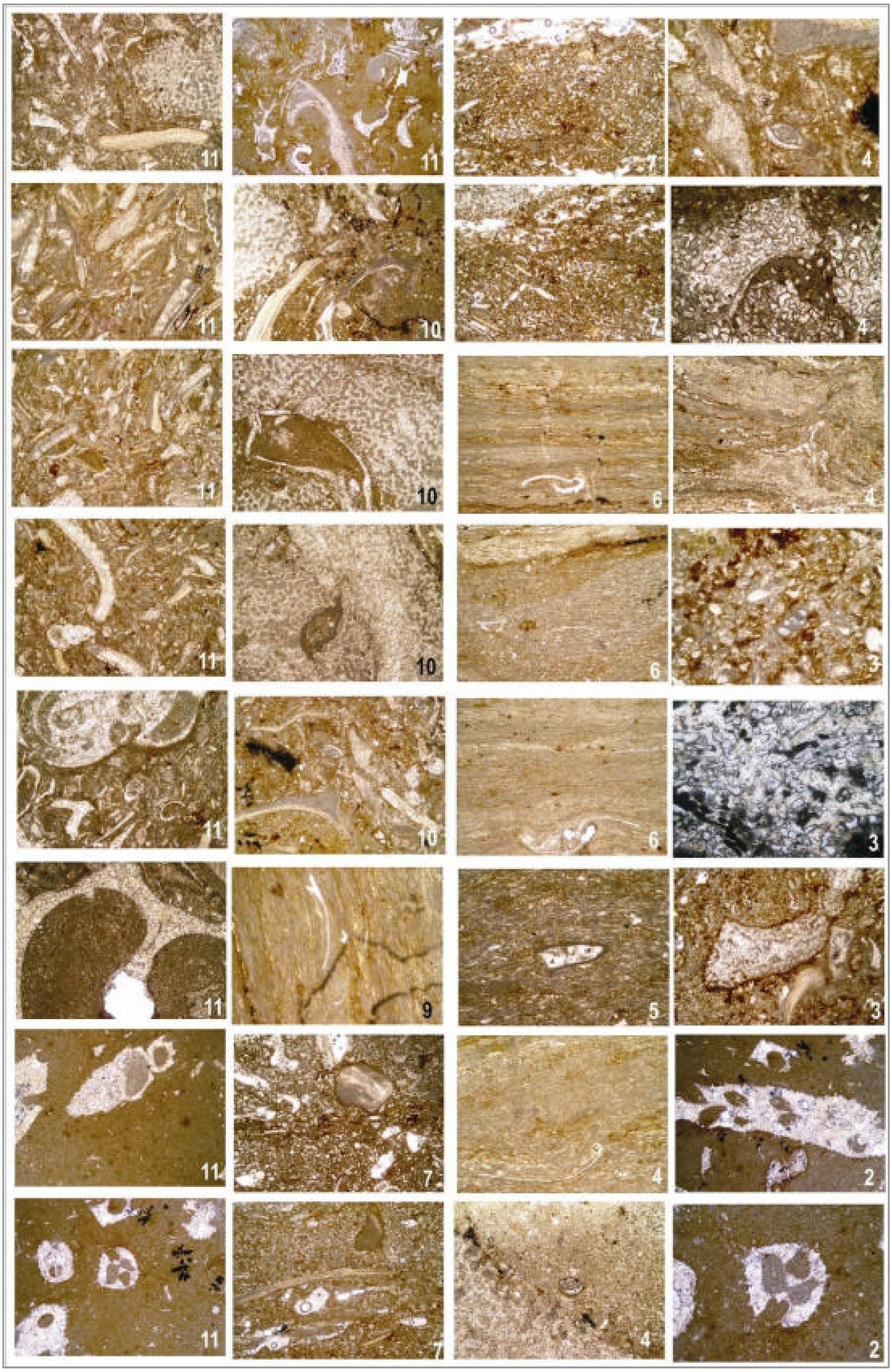


Figure 8.3 Microfacies photographs of marl in the Kultak section.

8.3.1 Sporomorph Associations

39 genus and 27 species are defined in the claystone samples of the Kultak area. Polypodiaceae and *Pinus haploxylon*-type more abundantly, Cupressaceae, *Engelhardtia, Ulmus, Carya, Quercus* evergreen-type, *Castanea,* Cyrillaceae abundantly, Osmundaceae, Taxodiaceae, Cycadaceae, *Picea, Pinus-diploxylon* type, Poaceae, Pterocarya, Myricaceae, *Salix,* Simaraubaceae, Oleaceae scarcely and Schizaceae, *Abies, Calamus* (Calamoid palm) Sphagnaceae, *Sequoia,* Juglandaceae, *Quercus* deciduous-type, Umbelliferae, Fagaceae, Sapotaceae and *Avicennia* rarely or sporadically recorded (see chapter seven for detail). In addition, microforaminiferal lignin found infrequently (Kayseri & Akgün, 2010).

8.3.2 Palaeovegetation

Spores and pollen grains can be grouped into ecologically different environments:

1) Mangrove and coastal swamp forest represented by *Avicennia*,
2) Swamp environment characterized by the *Sequoia*, Taxodiaceae, Polypodiaceae, Davaliaceae, Gleicheniaceae, Osmundaceae, Schizaceae and Myricaceae,
3) Board leaved evergreen forest, from sea level to around 700m altitude characterized by *Myrica,* Cyrillaceae, Sapotaceae, *Castanea,* Maxtixiaceae and *Engelhardia* (Jimenez-Moreno et al., 2007),
4) Deciduous and evergreen mixed forests, above 700m altitude; composed mainly of *Quercus* deciduous and evergreen types, *Pterocarya*, Betulaceae, *Engelhardia,* Aceraceae/*Acer*, Fagaceae, *Castanea*, Cyrillaceae, Oleaceae/*Olea* and Sapotaceae with in this vegetation belt, a riparian plant association has been identified with *Salix*, *Platanus*, *Zelkova*, Ulmaceae/*Ulmus*, Juglandaceae/*Carya* (Jimenez-Moreno et al., 2007),
5) Mid-altitude forest characterized by gymnosperms, such as *Pinus* sylvesteris/haploxylon types and *Tsuga*,
6) Open land areas are represented by Poaceae and Umbelliferae.

An impoverished *Avicennia* mangrove grows the coastal marine environment. In the hinterland, lowland was populated by a broad-leaved evergreen forest, characterized by *Myrica,* Cyrillaceae, Sapotaceae, *Castanea*, *Engelhardia*, Schizaceae, Gleicheniaceae. Within this vegetation belt, swamp forests were also well developed during this period. Its components, such as *Sequoia*, Taxodiaceae, Polypodiaceae, Davaliaceae, Gleicheniaceae, Osmundaceae, Schizaceae and Myricaceae, show comparatively high values in the pollen spectra. Low elevation palaeotopography and very humid climatic conditions at that time in the Kultak area favored the wide distribution of swamp forests and of ecologically related riparian forests with *Platanus*, *Salix*, *Zelkova*, Ulmaceae-*Ulmus*, Juglandaceae-*Carya* and *Pterocarya*. The evergreen and deciduous mixed forests mainly composed of *Quercus* deciduous and evergreen types, *Pterocarya*, Betulaceae, *Engelhardia*, Aceraceae/*Acer*, Fagaceae, *Castanea*, Cyrillaceae, Oleaceae/*Olea* and Sapotaceae. Conifer pollen, mainly *Pinus* and indeterminate Pinaceae are defined less abundantly, presumably because of the capacity of saccate pollen for long-distance transport (Heusser, 1988; Suc & Drivaliari 1991; Cambon et al., 1997; Beaudouin, 2003). Additionally, mid- and high altitude elements are represented by *Pinus* sylvesteris/haploxylon types and *Tsuga*.

8.3.3 Distribution of Avicennia

Châteauneuf et al. (2006) recorded the *Avicennia* mangrove in the Middle Miocene from SE France (Châteauredon area) and defined "*Avicennia* peak" during the late Burdigalian and Langhian time interval (15.8-16.5 Ma). According to authors, this interval corresponds with TB 2.3 cycle (the sequence limits Bur5/Lan1 and Lan2/Ser1 on the Berggren Timescale). Châteauredon area locates in 42^{o}N latitude in the Middle Miocene (Châteauneuf et al., 2006). During the same time interval, a mangrove palaeocommunities had also been determinated at similar latitude in Hungary and Japan (Itoigawa, 1989; Nagy & Kókay, 1991; Plaziat, 1995) (Fig. 8.4). Jimenez-Moreno et al. (2007) published pollen analysis of Miocene and Pliocene sediments from the southeastern Europe and northeastern Mediterranean and authors emphasized *Avicennia* mangrove impoverished in the coastal marine environment from Hungary. Jimenez-Moreno et al. (2006) and (2007) recorded the palynoflora of Spain, France, Arboran Sea and Switzerland. Besides, palynofloras of Spain and France include *Avicennia*.

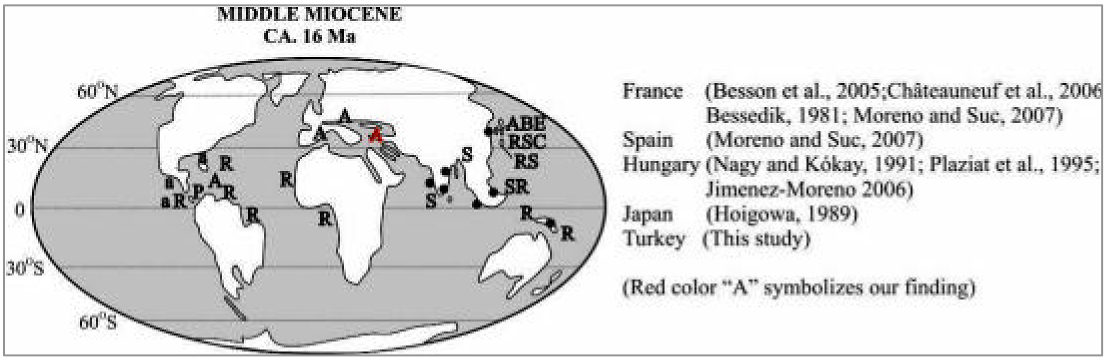


Figure 84 Plants distribution in the mangrove palaeocommunity and presence of *Avicennia* sp. (Plaziat et al., 2001).

8.4.4 Palaeoclimatic Results

During the late Burdigalian, the Eastern Mediterranean seaway closed, and a landbridge open between Anatolia and Arabian/African Plates enabling a remarkable faunal exchange. The eastern Paratethys become entirely isolated with reduced salinity and endemic faunas. The Mediterranean communicated with the Atlantic Ocean and fed the western and central Paratethys. The renewed seaway in the Alpin Foredeep was again connected to the North Sea by the Rhine graben. Throughout the Langhian time, Indo Pacific reoccurred. The Mediterranean-Indo Pacific seaway reopened around the Early- Middle Miocene boundary. From Eastern Anatolia a new transgression flooded the Paratethys. The intromountain basins and the Carpathian foredeep in the Central Paratethys were covered by tropical-subtropical waters. A connection is proposed a long the Rhodopes and Pontides, south of the Black Sea – Plate. The Eastern Paratethys stayed in reduced communication (Rögh, 1999).

Avicennia type pollen are recorded from the Kultak area in the western Anatolia and found from the Iskilip region (Çankiri-Çorum basin) in the central Anatolia (Kayseri & Akgün, 2008).

Kayseri & Akgün (2010) record temperature values of Kultak area using the Climstat program of the coexistence approach analysis. Numerical temperature values of the Milas-Kultak area for the middle Burdigalian-Langhian time are 15.7–18.8°C MAT, 9.6–13.1°C CMT, 24.7–27.7°C WMT and 1122-1520mm MAP (see chapter seven). Kayseri & Akgün (2008) obtained the coexistence approach intervals of the Iskilip area in the central Anatolia and these intervals are 18.9°C MAT, 9.4°C CMT, 27.7°C WMT and 1122-1520mm. Both values of the Milas-Kultak and Iskilip areas are similar. The coldest month temperatures are also very high (9.4°C) and annual rainfalls are estimated between 887 and 1520mm. These palaeo-temperatures and precipitations are consistent with present day impoverishes mangrove distribution.

Palaeogeographic reconstructions place the Châteauredon area by 42°N latitude during the Middle Miocene. During same period, a mangrove had also been identified at similar latitude in Japan and Hungary because of the Middle Miocene Climatic Optimum period. Anatolia located about same latitude but Anatolia places southeast than the France and Spain. Besides *Avicennia* more abundantly recorded from palynoflora of France and Spain, it is sporadically recorded during the late Early and early Middle Miocene period in Anatolia. This difference could be related to palaeotopographic condition because during this period tectonic activities have been affected in the Anatolia. Additionally high temperature values and marine condition could support growing the mangrove forest. The presence of *Avicennia* type pollen grains in the Kultak area is of both palaeogeographic and palaeoclimatic interest. Using independent stratigraphic data, the Kultak palynoflora with *Avicennia* is given an age late Burdigalian-Langhian. Numerical temperature values imply a subtropical climate in Anatolia during that time. This palaeoclimatic condition could cause that growing Mangrove palaeocommunities in the Kultak area. End of the Langhian sediments are characterized by sandstones with lamellibranches and marl with coral, gastropod and lamellibranches. According to this data, terrestrial condition is finished by marine influence in Kultak area. This marine influence could coincide with transgression, which is global observed during late Burdigalian-Langhian time interval.

CHAPTER NINE

PALYNOFLORA OF THE MIDDLE MIOCENE IN THE ÖREN BASIN (SW TURKEY): PALAEOCLIMATIC AND PALAEOVEGETATIONAL INTERPRETATION

9.1 Introduction

The Miocene sediments which include the rich fossil groups (foraminifers, bivalvias, gastrapods, mammalian and palynomorphs) in Turkey are widespread. Palynofloras of the coal bearing these sediments are studied a lot of authors (….).

The Middle Miocene sediments in the Ören region (Sekköy, Ekizköy and Ikizköy) deposited in terrestrial condition. In this chapter, palynofloras of the Middle Miocene (Serravallian) in Ören region is firstly produced based on the palynomorph associations. Besides, Ören palynomorph association is correlated with the Miocene palynomorph associations in Turkey (i.e. Manisa-Soma, Balikesir-Bigadiç, Büyük Menderes Graben, Konya-Ilgin).

Detail palaeoclimatic and palaeovegetational interpretations of the Middle Miocene palynoflora in the Ören region and published palynofloras of Turkey are obtained using the palaeoclimate and paleoecologic preferences of the plants and coexistence approach methods. In addition, obtaining palaeoclimatic constitutions of the Middle Miocene are correlated with the palaeoclimatic evolution in Europe.

9.2 Geological Setting of Ören–Kultak Region

The basement rocks (Lycian nappes) are unconformably overlain by the Çambeleni formation. Kultak formation (the middle Burdigalian-Langhian) unconformably overlay the Çambeleni formation. Kultak formation vertically and laterally passes the Belen and Hüsamlar members during late Burdigalian-Langhian time interval. These members unconformably pass the Sekköy formation (Middle–

Late Miocene) and palynofloras are defined from the coal bearing sediments in this formation (Fig. 9.1).

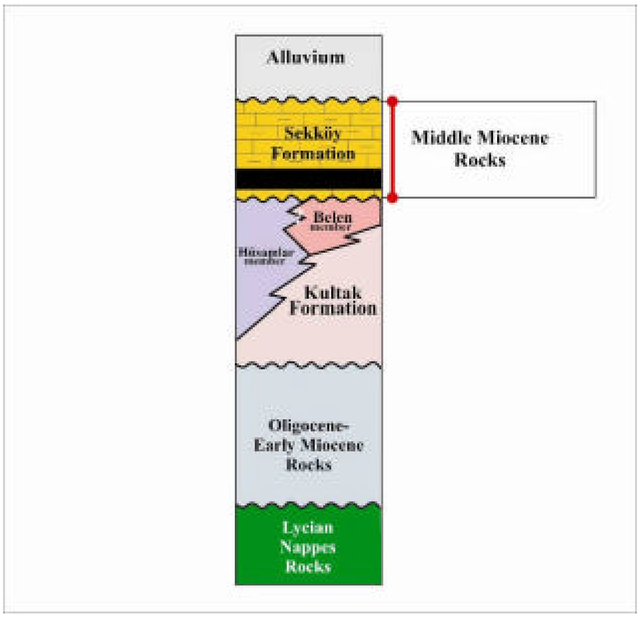


Figure 9.1 Generalized stratigraphic columnar section of between the Sekköy and Milas regions. Red line indicates investigated period.

9.3 Material and Methods

Three stratigraphic sections are measured from the Sekköy formation. Additionally coal samples are collected from throughout measured stratigraphic section in north of the Ören region (Sekköy I, II, Ikizler I and II sections) (see chapter two). Totally, seventy coal samples from Ikizler region and ninety-nine coal samples from Sekköy region are collected. There is no fossil record from marl in the Sekköy formation.

9.4 Composition of the Middle Miocene Microflora in the Ikizler and Sekköy Region

The Ikizler palynoflora is defined from twenty samples which are collected during the Ikizler I and II sections in the Ikizler region (Fig. 9.2). This palynoflora is represented by more abundantly (>15%) *Laevigatosporites haartdi Baculatisporites primarius Pityosporites microalatus*, *Cathayapollis* spp., *Inaperturopollenites dubius*, *Cycadopites* spp., *Tricolpollenites densus, Quercopollenites robur* type, *Tricolporopollenites megaexactus exactus, Tricolporopollenites cingulum oviformis, Alnipollenites verus* and *Monogemmites pseudosetarius,* abundantly (10–15%) *Momipites punctatus, Triatriopollenites rurensis, Triporopopollenites coryloides* and *Oleoidearumpollenites microreticulatus,* less abundantly (5–10%) *Caryapollenites simplex, Tricolpopollenites retiformis* (*Salix* type), *Ovoidites* spp., *Pityosporites labdacus, C. cuspidateaformis, Tricolporopollenites pseudocingulum, Leiotriletes maxoides minimus, Inaperturopollenites hiatus, Tetracolporopollenites sapatoides, Polyporopollenites undulosus, Periporopollenites multiporatus, Tricolporopollenites* sp. (*Tubulifloreae* type) and *Tricolporopollenites* sp. (*Liguliflorea*e type)) are recorded rarely or sporadically (Fig. 9.2, Plates 9.1–9.5).

Palynoflora of the Sekköy I and II section is represented by more abundantly (>15%), *Laevigatosporites haartdi, Inaperturopollenites dubius, Tricolpopollenites microhenrici, Polyvestibulopollenites verus,* abundantly (10–15%) *Tricolporopollenites cingulum, Inaperturopollenites hiatus, Cupressacites cuspidateaformis, Pityosporites microalatus, Tricolpopollenites densus,* and *Pityosporites labdacus, Oleoidearumpollenites microreticulatus, Triporopollenites* spp., *Polyporopollenites undulosus, Tricolpopollenites retiformis* (*Salix* type), *Tricolporopollenites megaexactus, Caryapollenites simplex* and are recorded less abundantly (5–10%) in this palynoflora (Fig. 9.3, Plates 9.6–9.10).

9.5 Comparison with the Miocene Palynofloras of Turkey

Defining Ikizler and Sekköy palynofloras are correlated with the previous Miocene palynoflora of Büyük Menderes Graben, Manisa-Soma, Aydin-Sahinali, Akhisar-Çitak, Bigadiç, Kestelek, Emet, Kirka, Isparta-Yukarikasikara and Yarikkaya, Konya-Ilgin, Kirsehir, Ankara-Beypazari, Northwest Turkey and Alasehir-Turgutlu area in the Gediz Graben (Gillet et al. 1978; Akgün et al. 1986, 1995; Yagmurlu et al. 1988; Akyol & Akgün, 1990; Akgün & Akyol 1992, 1999; Akgün 1992; Gemici et al. 1991; Karayigit et al. 1999).

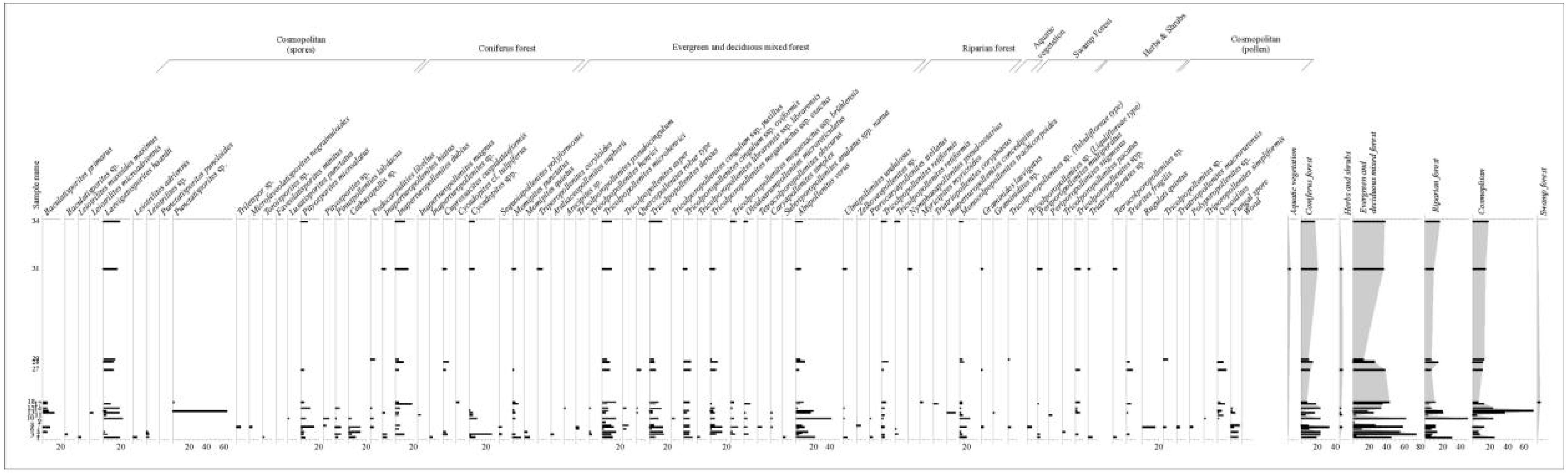


Figure 9.2 Detailed microfloras diagram of the studied part of the stratigraphic section in the İkizler region. Black dots indicate percentage lower than %1.

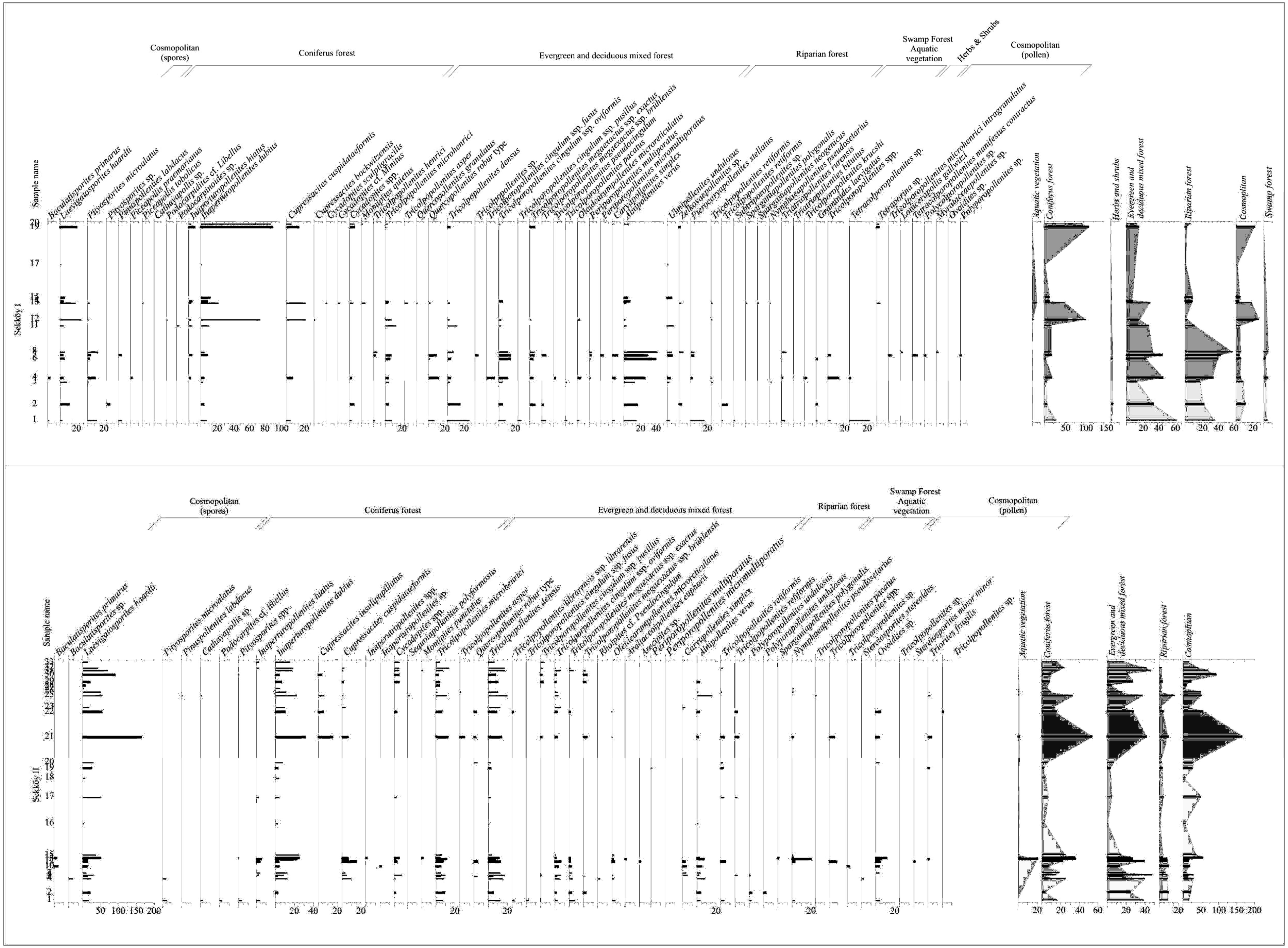


Figure 9.3 Detailed microfloras diagram of the studied part of the stratigraphic section in the Sekköy region. Black dots indicate percentage lower than %1.

Akgün & Akyol (1999) defined palynoflora of the Middle Miocene in the Neogene in Büyük Menderes Graben (western Anatolia, Turkey). This palynoflora is recognized in Söke, Sahinali, Kulogullari, Kösk-Basçayir coal horizons, and the Aydin-Incirliova, Kösk-Kizilcayer, Nazilli-Hasköy lower coal horizons. It contains distinctly high percentage of *Pityosporites microalatus* (*haploxylon* type). In some samples *Laevigatosporites haardti, Sparganiapollenites neogenicus, Triatriopollenites rurensis, Tricolpopollenites densus* and *Polyvestibulopollenites verus* are abundant. Representatives of *Inaperturopollenites dubius, Tricolporopollenites cingulum* and *Tricolporopollenites megaexactus* occur almost uniformly in small amounts. Abundance of *Triatriopollenites coryphaeus, Triporopollenites simpliformis* and *Subtriporopollenites simplex* irregularly vary and are present in low percentages. *Pityosporites labdacus* (*silvestris* type), *Monoporopollenites gramineoides*, *Echigraminidites moravicus, Tricolporopollenites* sp. (Compositae) and *Periporopollenites multiporatus* are sporadically represented. The sporadical existence of *Cingulatisporites* sp., *Leiotriletes* sp., *Punctatisporites* sp., *Verrucosisporites* sp., *Stereisporites* sp. and *Lusatisporites* sp. is only present in the Söke, Sahinali, Kulogullari, Kösk-Basçayir coal horizon, and the Aydin-Incirliova, Kösk-Kizilcayer and Nazilli-Hasköy lower coal horizons.

Akgün et al. (1986) and Akgün (1992) studied in the coal bearing sediments in the Manisa-Soma region. Authors distinguished two palynoflora. The first palynoflora is present in the Soma formation (k1 and k2). The second palynoflora is demonstrated as a Denis formation (k3). The age of the first assemblage is indicated as an the early Serravalian (the Middle Miocene) by the authors due to the high percentages of *Tricolpopollenites microhenrici, T. densus, Laevigatosporites haardti, Pityosporites microalatus*, *Inaperturopollenites dubius, Tricolporopollenites cingulum* and rare existence of *Inaperturopollenites hiatus, Triporopollenites simpliformis, T. labraferus, Triatriopollenites coryphaeus, Tricolpopollenites liblarensis, Tricolporopollenites megaexactus* and sporadically occurrences of *Monoporopollenites solaris* and *Tricolporopollenites* sp. (*Tubulifloreae* and *Liguliflorea*e types). Relative frequencies of *Pityosporites labdacus,* *Inaperturopollenites magnus, Polyporopollenites magnus, Polyporopollenites undulosus, P. stellatus, Subtriporopollenites simplex, Triatriopollenites bituitus, T. rurensis, Polyvestibulopollenites verus* and *Triporopollenites retiformis* fluctuate in amount. The second palynoflora, which includes high percentages of *Tricolpopollenites henrici, T. densus, Inaperturopollenites hiatus, I. dubius, I. hiatus, Polyvestibulopollenites verus, Tricolpopollenites retiformis* and sparsely existence of *Pityosporites microalatus, Triporopollenites simpliformis, T. coryphaeus, Tricolpopollenites liblarensis*, *Tricolporopollenites megaexactus* and sporadically occurrence of *Pityosporites labdacus, Monoporopollenites gramineoides, Periporopollenites multiporatus* and *Tricolporopollenites* sp. (Compositae) indicated the middle Serravallian (the late Badenian) age.

Gemici et al. (1991) investigated the macro and microflora of the Sahinali (Aydin) and recorded 33 spore and pollen taxa. The taxa are characterized by abundant *Triatriopollenites bituitus, T. coryphaeus, Subtriporopollenites simplex, Polyvestibulopollenites verus, Polyporopollenites undulosus, Tricolpopollenites densus, T. microhenrici, Tricolporopollenites cingulum, T. megaexactus, T. pacatus, Tetracolporopollenites manifestus, Tetradopollenites ericius* and *Pityosporites microalatus*.

Akgün & Akyol (1987) studied the sporomorph assemblage of the Middle Miocene from the Akhisar-Çitak region. The author recorded 71 sporomorphs: 9 spores and 63 pollen. The assemblage comprises some spores that are *Laevigatosporites haardti, Baculatisporites primarius, Leitriletes microadriennis, Gleicheniidites* sp., *Cingulatsporites vitiosus, Verrucatosporites favus, Punctatisporites ellipsoids* and some pollen, which are *Inaperturopollenites hiatus, I. polyformosus, Monoporopollenites gramineoides, Pityosporites microalatus, P. libellus, Triatriopollenites rurensis, T. bituitus, T. simpliformis, Subtriporopollenites simplex, Polyporopollenites undulosus, Tricolpopollenites densus, T. microhenrici, Tricolporopollenites cingulum, T. megaexactus, T. microreticulatus* and

Periporopollenites multiporatus. The authors suggest that the age of the Akhisar-Çitak lignites is in the Middle Miocene.

Akyol & Akgün (1990) were defined two palynofloras in the coal beraing sediments from the Balikesir-Bigadiç, Kestelek, Emet and Kirka regions. The lower sporomorph association is characterized by abundant *Laevigatosporites haardti, Polyvestibulopollenites verus, Tricolporopollenites cingulum, T. megaexactus, Pityosporites microalatus* and less abundance of *Triatriopollenites coryphaeus, T. rurensis, T. bituitus, Inaperturopollenites dubius, I. hiatus, Triporopollenites simpliformis, Pityosporites libellus, Polyporopollenites undulosus, Subtriporopollenites simplex* and sporadically *Cingulatisporites* sp. and *Gleicheniidites* sp.. The lower sporomorph association is in the middle Miocene (the late Badenian-early Serravalian) age. The upper sporomorph association is recognized by high percentages of *Laevigatosporites haardti, Monoporopollenites gramineoides, Pityosporites microalatus, P. labdacus* and *Tricolpopollenites densus. Periporopollenites multiporatus, Tricolporopollenites megaexactus, T. microreticulatus* and *Tricolporopollenites* sp. (Compositae) occurs in a small amount. The upper sporomorph association is in the Late Miocene age.

Akgün & Akyol (1992) examined the sporomorph assemblage in the Isparta-Yukarikasikara and Yarikkaya. The authors have identified 32 spore and pollen taxa. Some spores (*Pityosporites microalatus, Polyvestibulopollenites verus* and *Laevigatosporites haardti*) are abundant in their samples and pollen such as *Inaperturopollenites hiatus, Tricolpopollenites retiformis, T. densus, Tricolporopollenites megaexactus, T. cingulum, Subtriporopollenites simplex, Triatriopollenites coryphaeus, T. rurensis,* and *T. bituitus* also occur sparsely in the samples. The age of the Isparta-Yukarikasikara and Yarikkaya lignites are indicated as the Middle Miocene by the authors.

Karayigit et al. (1999) investigated the coal petrography, rank and sporomorph assemblage of the Ilgin (Konya) and recorded 32 spore and pollen taxa. These taxa are characterized by abundant *Tricolpopollenites densus, T. microhenrici* and *Polyvestibulopollenites verus*. The species *Pityosporites microalatus, Inaperturopollenites dubius, Triatriopollenites coryphaeus, Tricolporopollenites cingulum* are sparsely present. *Laevigatosporites haardti, Baculatisporites primarius, Cingulatisporites macrospeciosus, Cycadopites* sp. *Pityosporites absolidus, P. libellus, Inaperturopollenites polyformosus, Monoporopollenites gramineoides, T. rurensis, T. bituitus, Subtriporopollenites simplex Polyporopollenites undulosus, Tricolpopollenites retiformis, Tricolporopollenites megaexactus, T. kruschi, Tetracolporopollenites abditus, T. manifestus, T. microellipsus* and Ericaceae are sporadically in Ilgin sporomorph associations. According to authors, this association is the middle Middle Miocene (equivalent of the middle Badenian) age.

Akgün et al. (1995) defined the Middle Miocene palynoflora from the Kirsehir region (Kizilöz, Tuzköy and Avciköy). Authors defined three palynofloras and *Pityosporites microalatus, Inaperturopollenites dubius, Tricolpopollenites densus, Laevigatosporites haardti, Polyporopollenites undulosus* and *P. carpinoides* are most abundant spore and pollen taxa in these palynofloras. On the other hand *Triatriopollenites rurensis, T. coryphaeus, Tricolpopollenites henrici, T. asper, T. microhenrici, Tricolporopollenites cingulum, T. megaexactus, Tricolporopollenites* sp. (*tubulifloreae* type) and *Periporopollenites multiporatus* are the sparsely and rare pollen taxa. Besides, *Leiotriletes microadriennis, Gleicheniidites* sp. and *Cingulatisporites macrospeciosus* occur in sporadically in the palynofloras.

Yagmurlu et al. (1988) investigated the stratigraphy of the Ankara-Beypazari basin. Sporomorph association determined from the lower lignite seam from the Çoraklar formation is characterized by *Pityosporites microalatus, Laevigatosporites haardti, Polyvestibulopollenites verus, Tricolpopollenites densus, T. microhenrici* and *Subtriporopollenites simplex* which is Middle Miocene age.

Gillet et al. (1978) have studied the spores and pollen, which they believed to belong to the Kizilhisar association from Northwest Turkey (Gelibolu and

Karamürsel). Gelibolu and Karamürsel sporomorph associations are characterized by *Pinus-haploxylon* and *silvestris* types, *Picea, Cedrus, Tsuga, Sequoiapollenites polyformosus, Taxodiaceae hiatus, Quercoidites microhenrici, Tricolpopollenites parmularius, Triporopollenites coryloides, Triatriopollenites myricoides, T. rurensis, Ulmipollenites undulosus, Liquidambar, Intratriporopollenites instructus, Subtriporopollenites simplex, Pterocarya, Alnipollenites verus, Trivetibulopollenites betuloides, Tricolporopollenites cingulum oviformis/pusillus, Cyrillaceae megaexactus, Caprifoliaceae microreticulatus,* Gramineae, Nymphaeaceae, Umbelliferae, Chenopodiaceae, Compositae, Caryophyllaceae, Osmundaceae, Polypodiaceae. These sporomorph associations are in the Upper? Vallensiyen-Turolian age (the Late Miocene).

The Ikizler and Sekköy palynofloras resemble to the other Middle Miocene palynofloras in Turkey. However, differences of the palynofloras are observed in palynospectras of Turkey. This differs could be related to the palaeotopographic differences.

9.6 Palaeoclimate

Numerical palaeoclimatic values are obtained from the palynofloras of Ikizler and Sekköy using the coexistence approach analysis method (Figs. 9.5-9.7). Averages of the CMT value are between 3 and 9°C for the Ikizler and Sekköy regions. These values are lower than values of the Langhian time in the Ören region. This temperature decrease could be related to the palaeoclimatic changes. From the Langhian to Serravallian time in Europe, the palaeoclimate changes from warm subtropical to temperate. This change could be also observed in the palaeoclimatic condition of Turkey. Besides, MAP values are general high. However, DMP values lower than the values of the Langhian time. According to these coexistence approach results in the Ören region, palaeoclimate is temperate and precipitation is low.

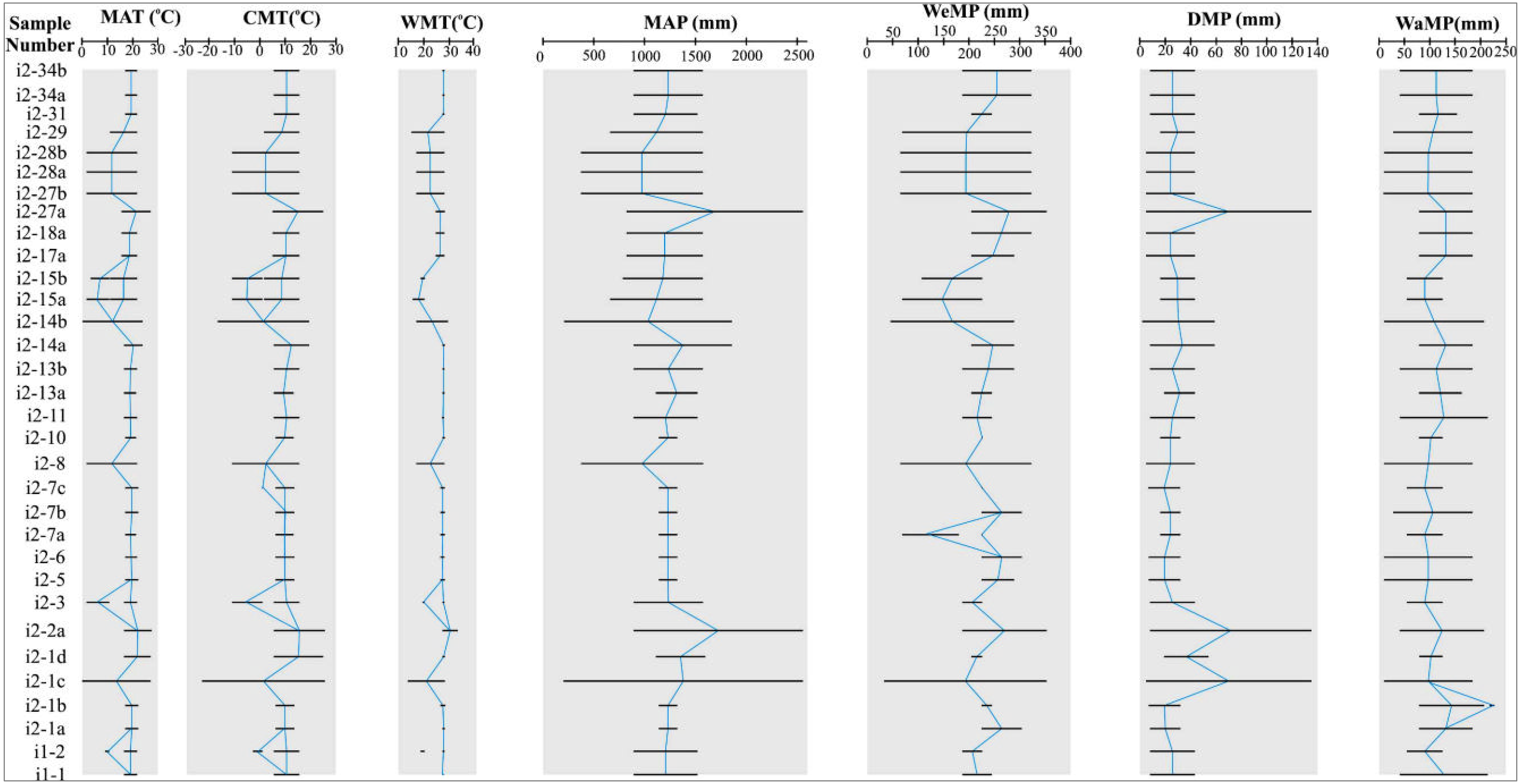


Figure 9.5 Application of the Coexistence Approach to the palynoflora of Ikizler region (MAT: mean annual temperature, CMT: mean temperature of coldest month, WMT: mean temperature of warmest month and MAP: mean annual precipitation, precipitation in the warmest month (WeMP), the driest month (DMP$_y$), and warmest month (WaMP).

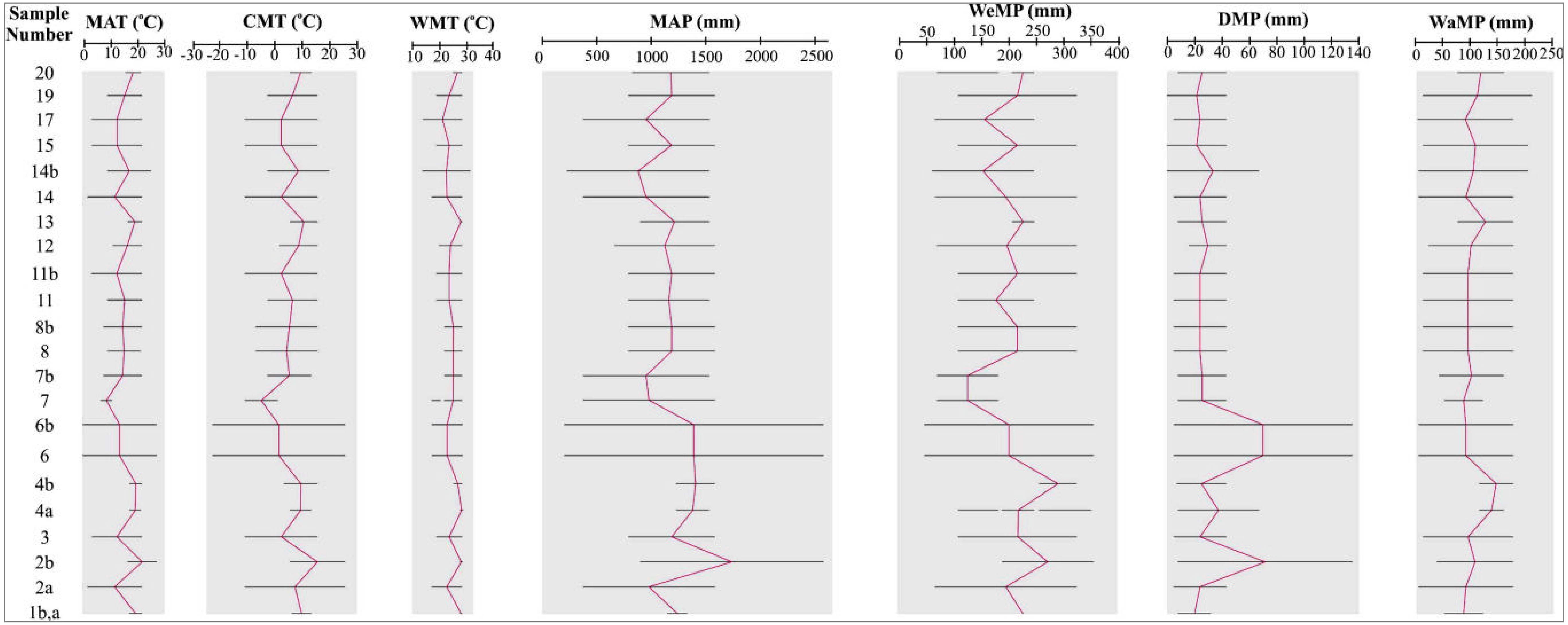


Figure 9.6 Application of the Coexistence Approach to the palynoflora of Sekköy I section (MAT: mean annual temperature, CMT: mean temperature of coldest month, WMT: mean temperature of warmest month and MAP: mean annual precipitation, precipitation in the warmest month (WeMP), the driest month (DMP_y), and warmest month (WaMP).

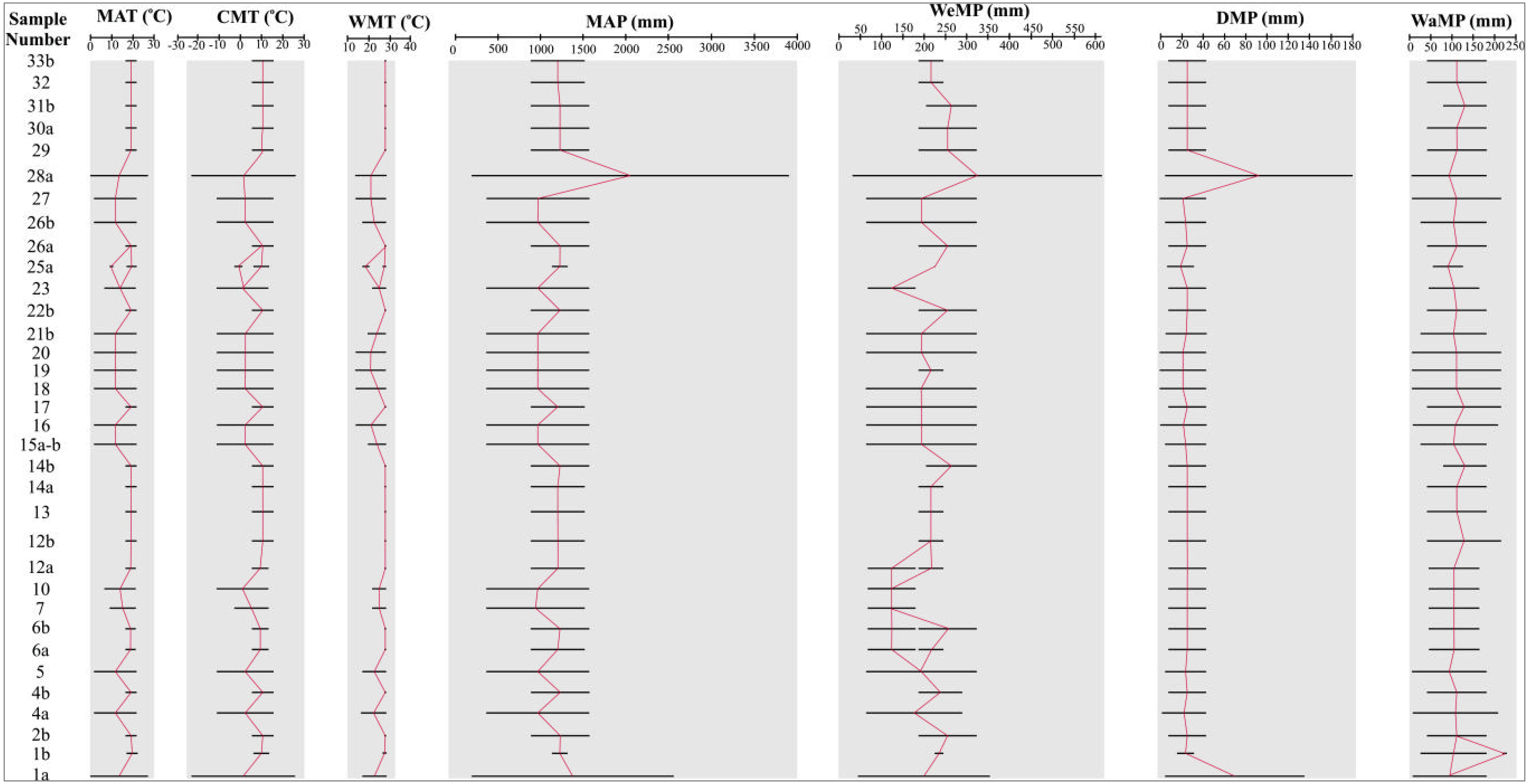


Figure 9.7 Application of the Coexistence Approach to the palynoflora of Sekköy I section (MAT: mean annual temperature, CMT: mean temperature of coldest month, WMT: mean temperature of warmest month and MAP: mean annual precipitation, precipitation in the warmest month (WeMP), the driest month (DMP_y), and warmest month (WaMP).

PLATE 9.1 (Ikizler Section)

1,2.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
3; 12.	*Leiotriletes maxoides* Krutzsch ssp. *minoris* Krutzsch
6-8.	*Leiotriletes* sp.
9; 13-35.	*Punctatisporites* spp.

PLATE 9.2 (Ikizler Section)

1-3.	*Punctatisporites* spp.
4-9.	*Pityosporites* sp.
10-14.	*Podocarpidites libellus* (Potonié) Krutzsch
15-29.	*Pityosporites microalatus* (Potonié) Thomson & Pflug
30-33.	*Monogemmites pseudosetarius* (Weyland & Pflug) Krutzsch

PLATE 9.3 (Ikizler Section)

1-5.	*Monogemmites pseudosetarius* (Weyland & Pflug) Krutzsch
6-14.	*Cycadopites* spp.
15.	*Pterocaryapollenites stellatus* (Potonié) Thiergart
16–39.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
40-42.	*Inaperturopollenites hiatus* (Potonié) Pflug & Thomson
43-47.	*Cupressacites cuspidataeformis* (Zaklinskaya) Krutzsch
48-52.	*Sequoiapollenites polymorfosus* Thiergart
53-65.	*Polyvestibulopollenites verus* (Potonié) Thomson & Pflug

PLATE 9.4 (Ikizler Section)

1-20.	*Polyvestibulopollenites verus* (Potonié) Thomson & Pflug
21.	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
22-24.	*Pterocaryapollenites stellatus* (Potonié) Thiergart
25-30.	*Polyporopollenites fragilis* Nakoman
31-34.	*Caryapollenites simplex* (Potonié) Raatz ex Potonié
35, 36.	*Triatriopollenites rurensis* Thomson & Pflug
37-40.	*Triatriopollenites* spp.
41-63.	*Tricolpopollenites densus* (Pflug) Thomson & Pflug
64-69.	*Quercopollenites robur* type Nagy
70-80.	*Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug

PLATE 9.5 (Ikizler Section)

1-8.	*Tricolpopollenites microhenrici* (Potonié) Thomson & Pflug
9-21.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *oviformis* (Potonié) Thomson & Pflug
22, 32-53.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug
23-27.	*Oleoidearumpollenites microreticulatus* (Thomson & Pflug) Ziembinska–Tworzydlo
28, 29,54-60.	*Tricolporopollenites* spp.
61-63.	*Tricolporopollenites* sp. (Compositae–Tubulifloreae type)
64, 66, 67.	*Periporopollenites multiporatus* Pflug & Thomson
65.	*Umbelliferaepollenites* sp.
68, 69.	*Periporopollenites stigmosus* (Potonié) Thomson & Pflug
70, 71.	*Faguspollenites verus* Raatz

72, 73.	*Ovoidites* spp.

PLATE 9.6 (Sekköy1 Section)

1-4.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
5-12.	*Pityosporites microalatus* (Potonié) Thomson & Pflug
13-24.	*Cycadopites* spp.
25.	*Monogemmites pseudosetarius* (Weyland & Pflug) Krutzsch
26-35.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug

PLATE 9.7 (Sekköy1 Section)

1-20.	*Cycadopites* spp.
21-24.	*Polyporopollenites fragilis* Nakoman
25-37.	*Polyvestibulopollenites verus* (Potonié) Thomson & Pflug
38.	*Caryapollenites simplex* (Potonié) Raatz ex Potonié
39.	*Inaperturopollenites* sp.
40-61.	*Tricolpopollenites densus* (Pflug) Thomson & Pflug
62.	*Tricolporopollenites* sp.
63, 64.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *oviformis* (Potonié) Thomson & Pflug
65-67.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug

PLATE 9.8 (Sekköy1 Section)

1,2	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug
3.	*Periporopollenites multiporatus* Pflug & Thomson
4-6	Fungal spores
7-9	Indeterminated form
8.	Wood

PLATE 9.9 (Sekköy2 Section)

1.	*Laevigatosporites haardti* (Potonié & Venitz) Thomson & Pflug
2-8.	*Pityosporites microalatus* (Potonié) Thomson & Pflug
9-15.	*Cycadopites* spp.
16-24.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug

PLATE 9.10 (Sekköy2 Section)

1-6.	*Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug
7-13.	*Polyvestibulopollenites verus* (Potonié) Thomson & Pflug
14.	*Polyporopollenites undulosus* (Wolff) Thomson & Pflug
15.	*Faguspollenites verus* Raatz
16, 17.	*Tricolporopollenites cingulum* (Potonié) Thomson & Pflug ssp. *oviformis* (Potonié) Thomson & Pflug
18-22; 31, 32.	*Tricolporopollenites* spp.
23-27.	*Tricolporopollenites megaexactus* (Potonié) Thomson & Pflug
28, 29.	*Tricolporopollenites* sp. (Compositae–Tubulifloreae type)
33-35.	*Umbelliferaepollenites* sp.
30.	Cuticle

PLATE 9.1 (Ikizler Section)

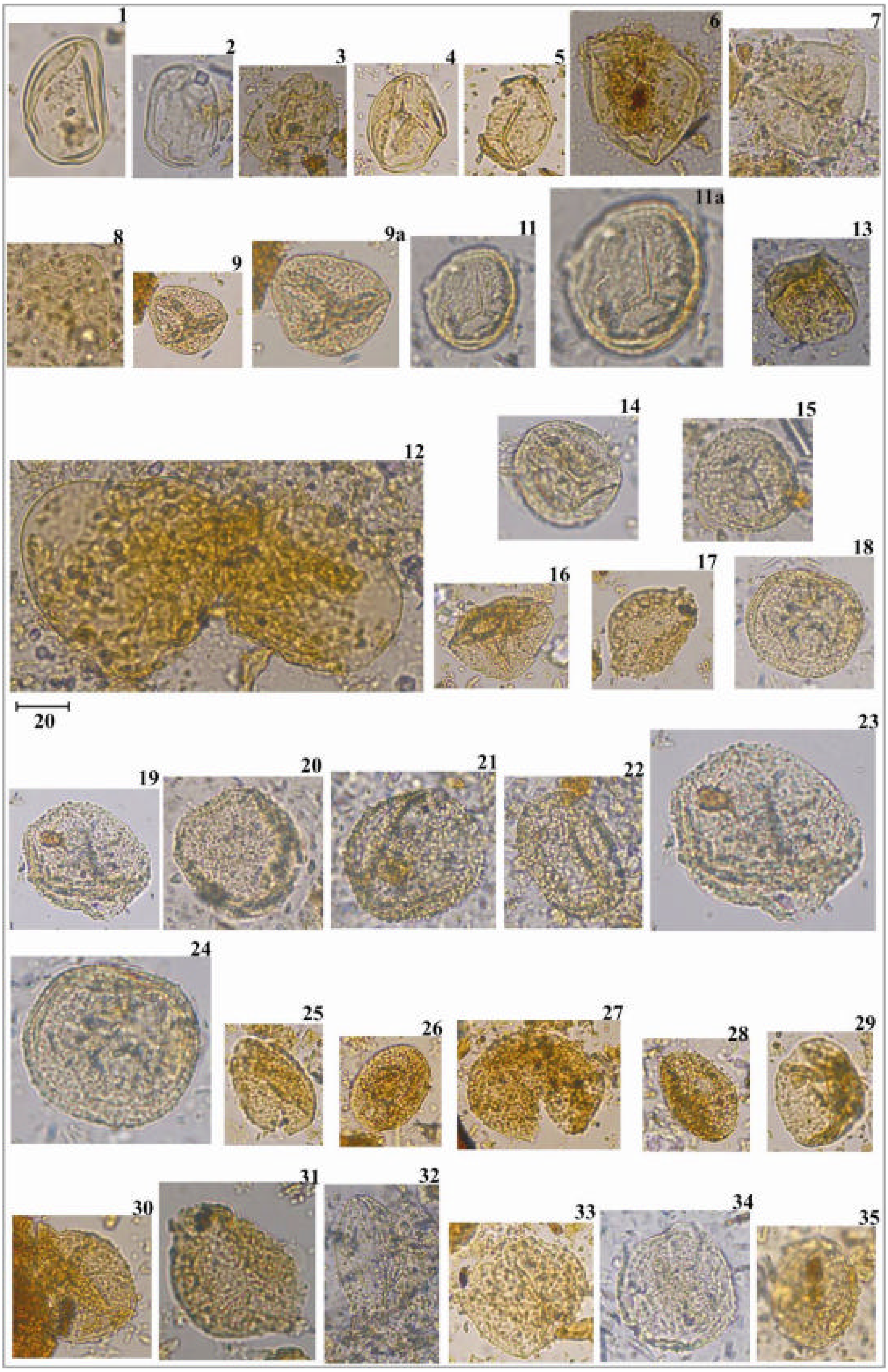
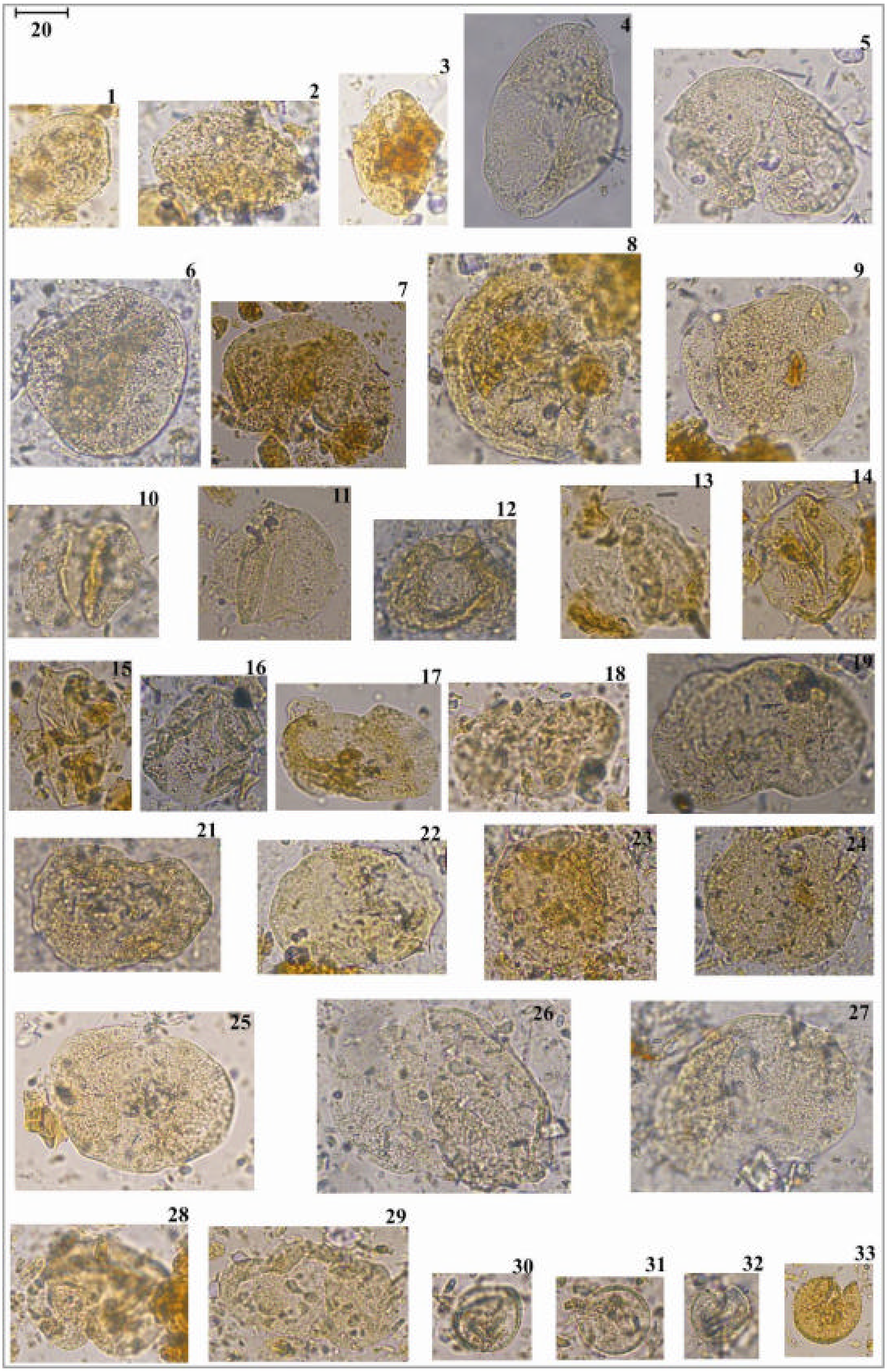


PLATE 9.2 (Ikizler Section)



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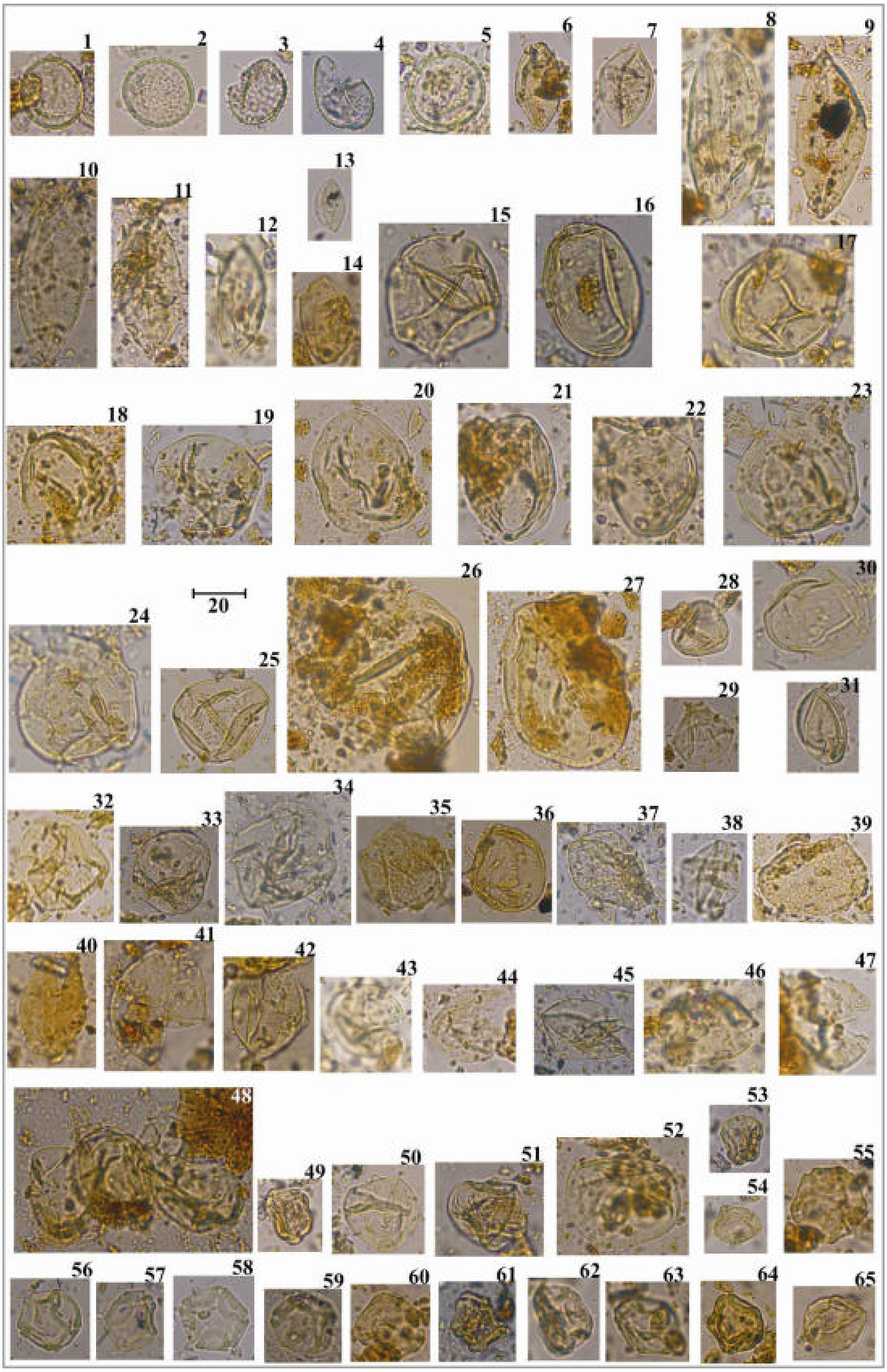

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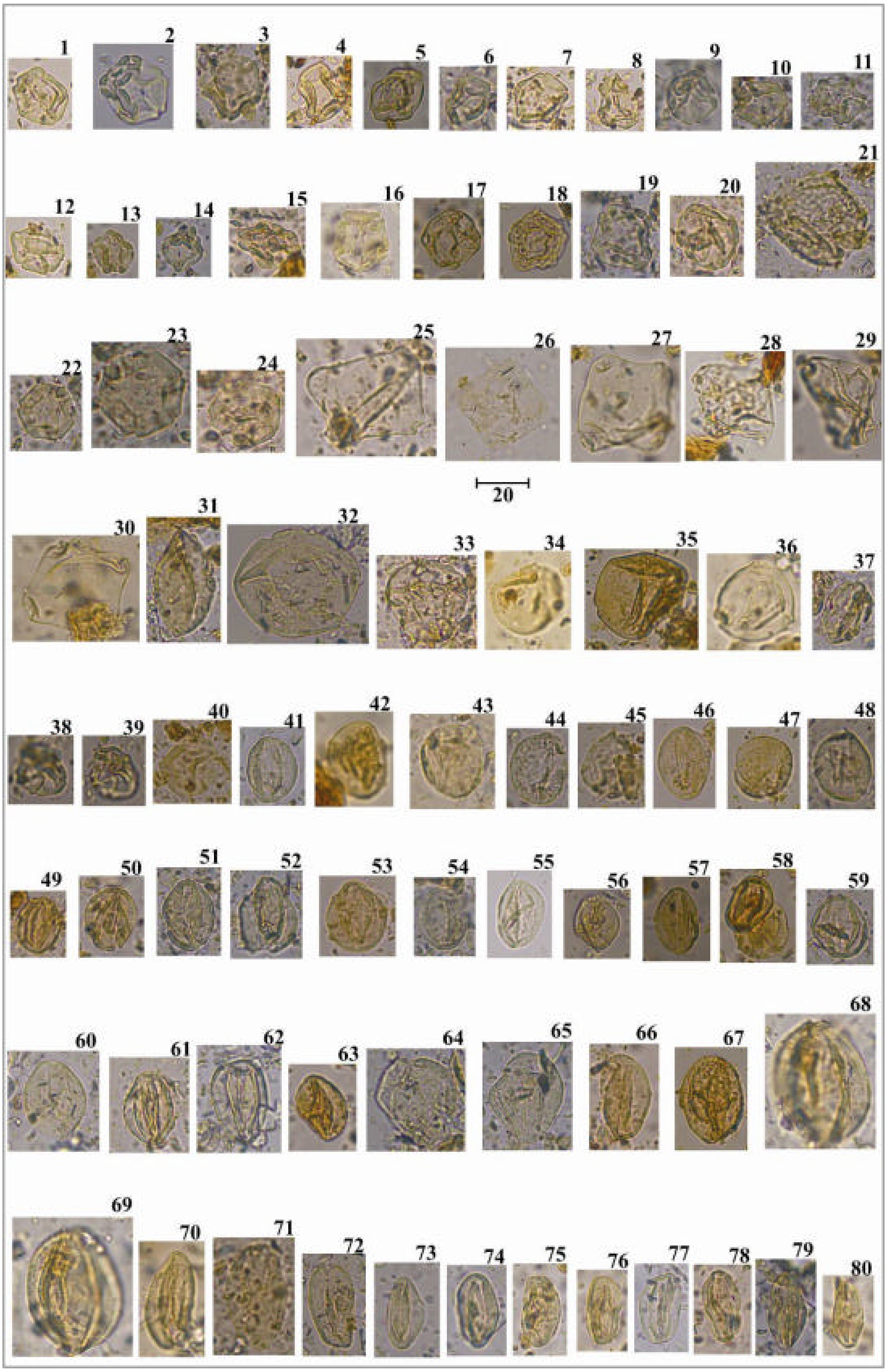

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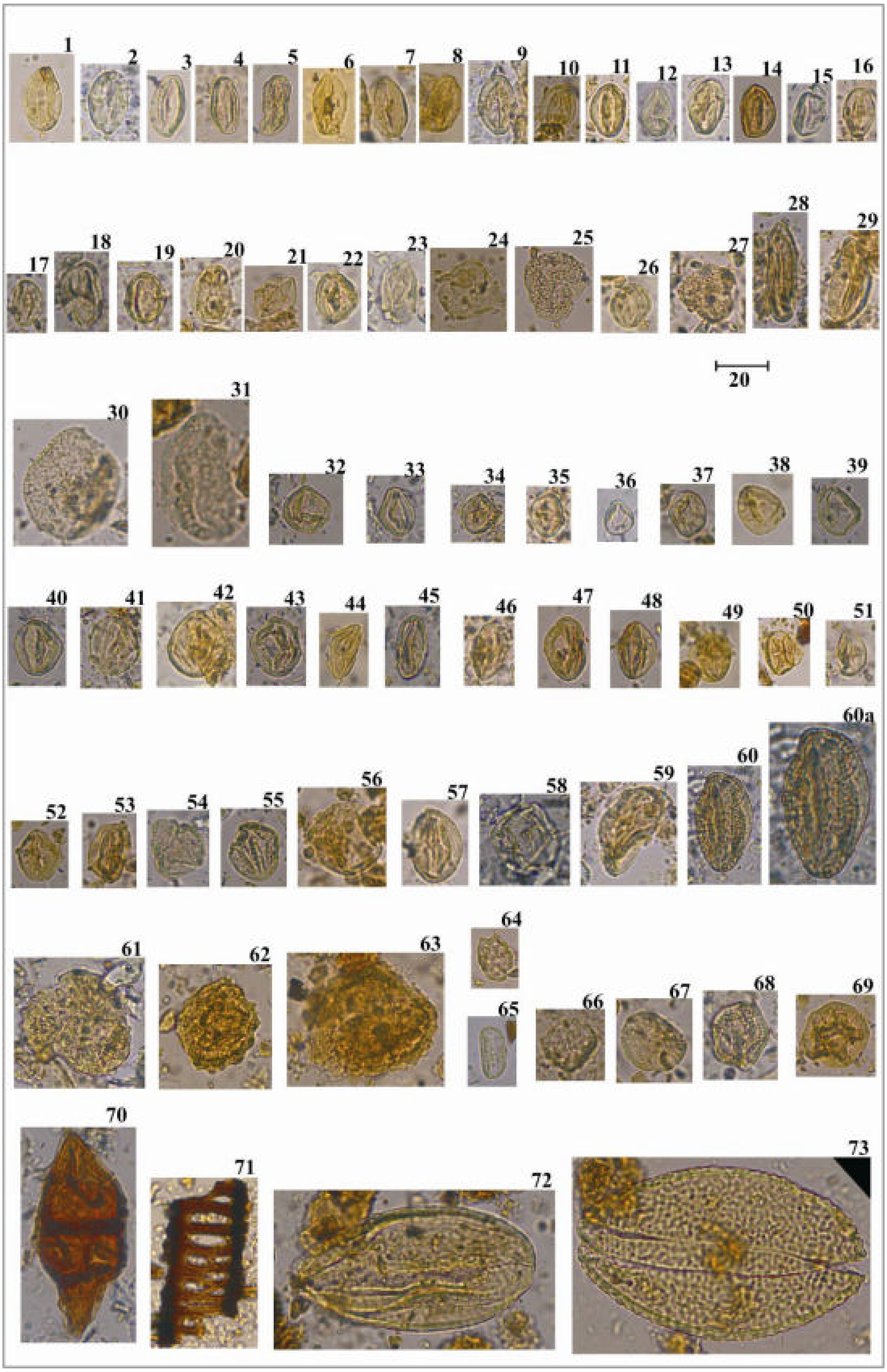


PLATE 9.6 (Sekköy1 Section)

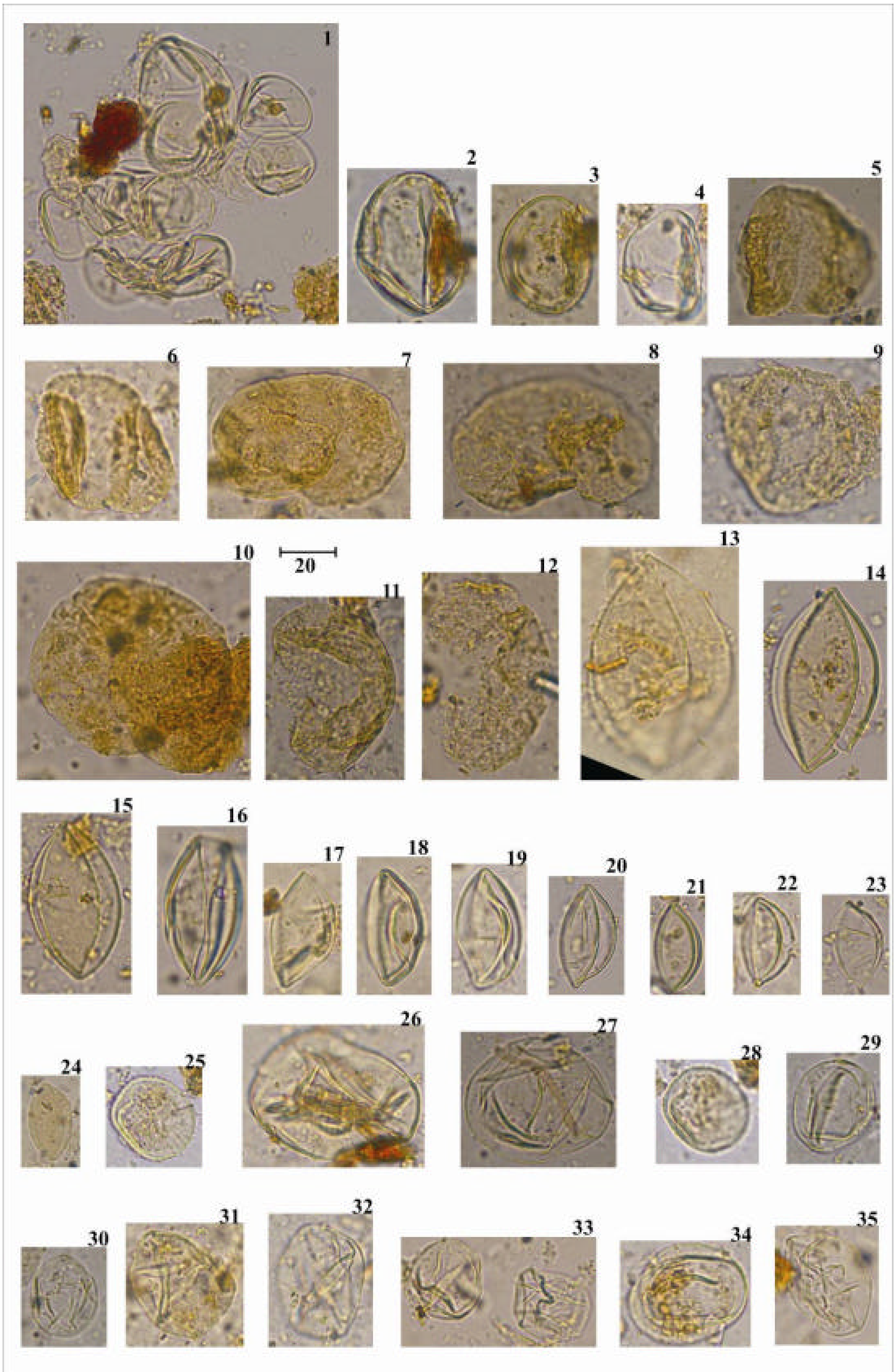


PLATE 9.7 (Sekköy1 Section)

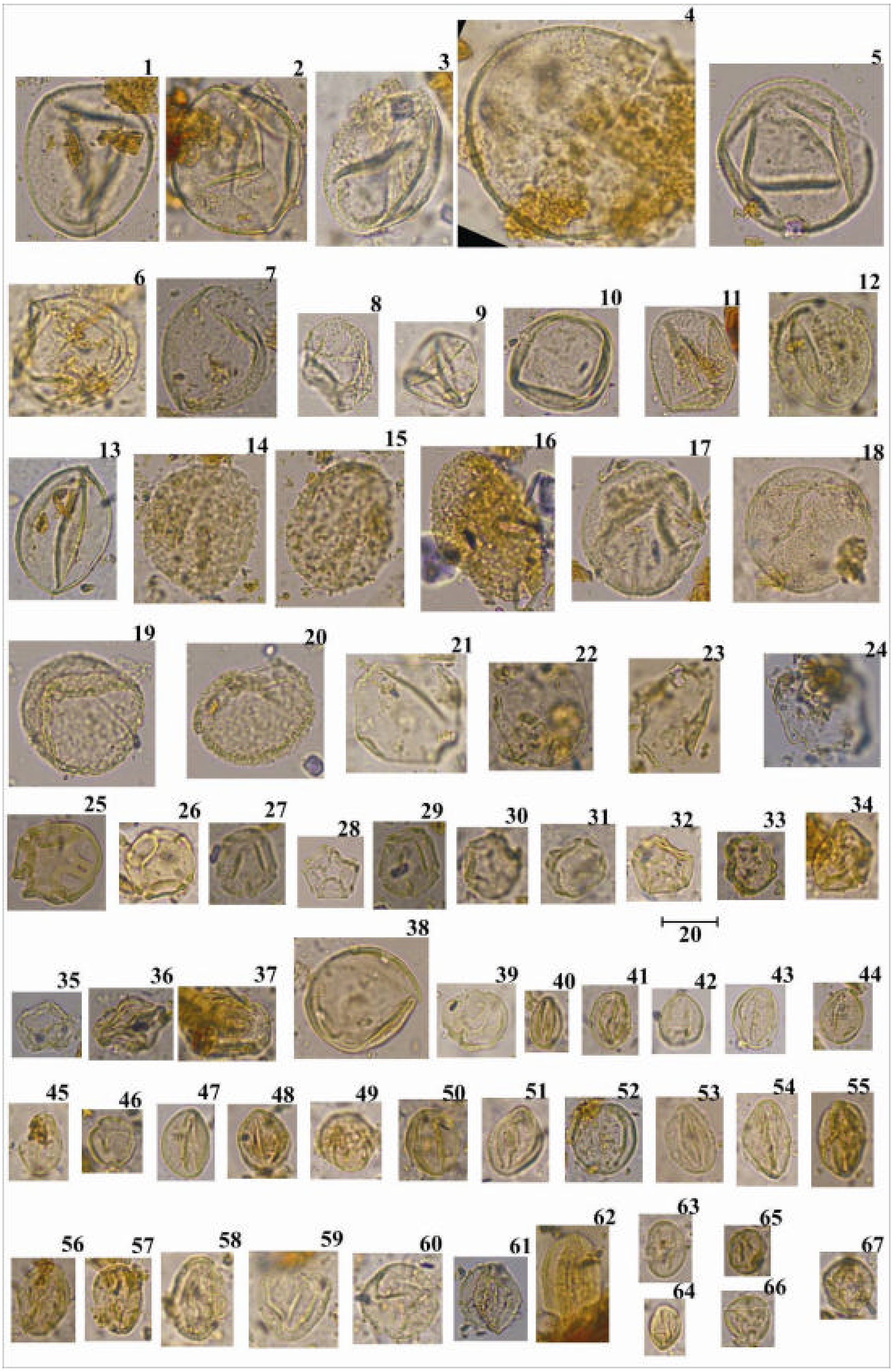


PLATE 9.8 (Sekköy1 Section)

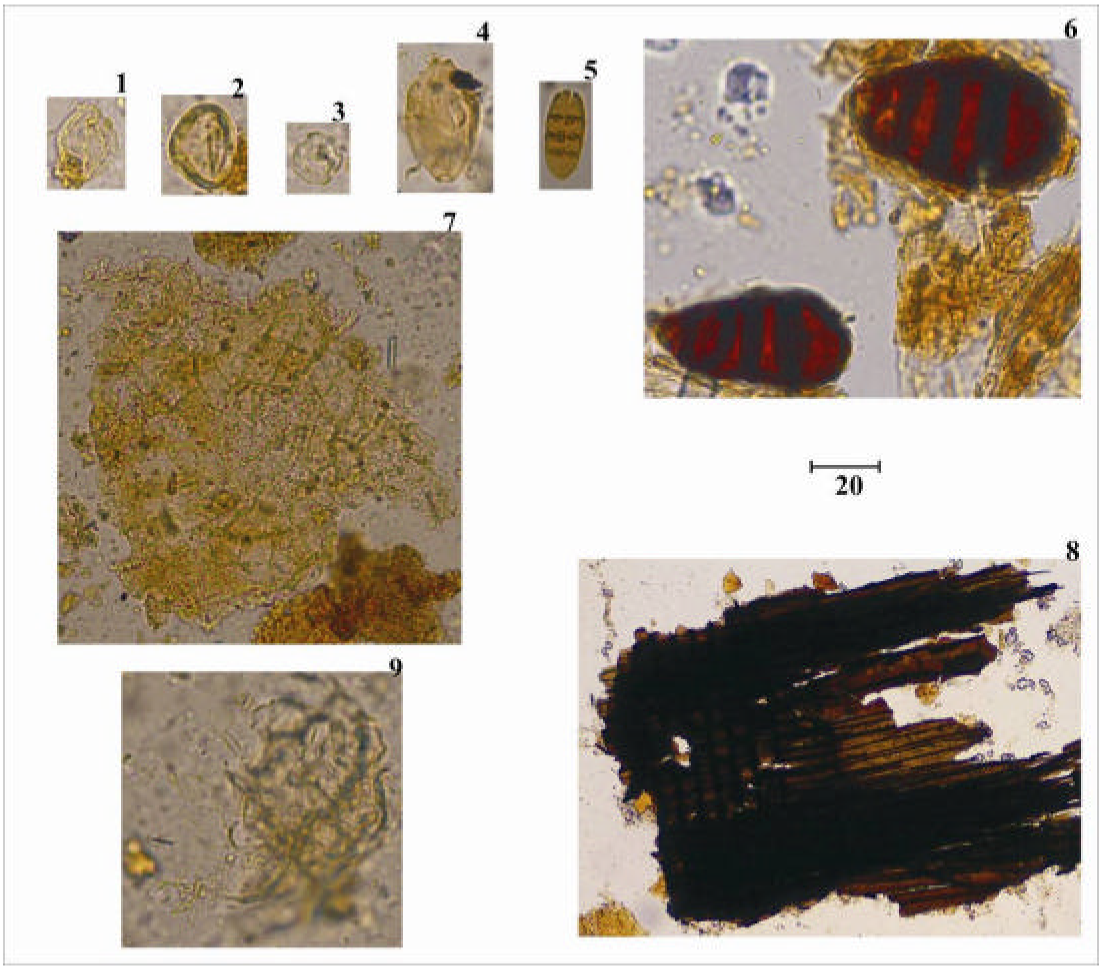


PLATE 9.9 (Sekköy2 Section)

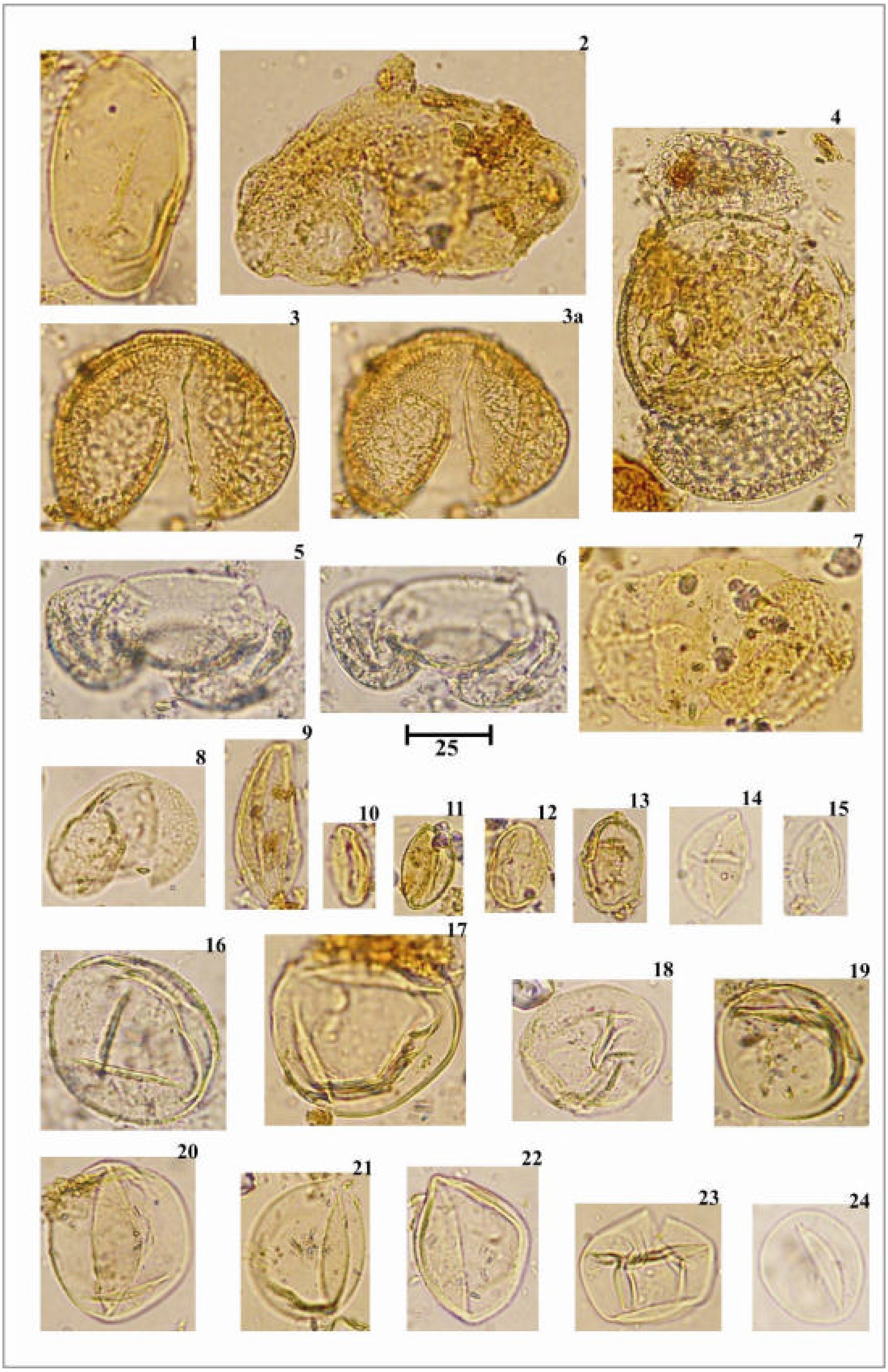
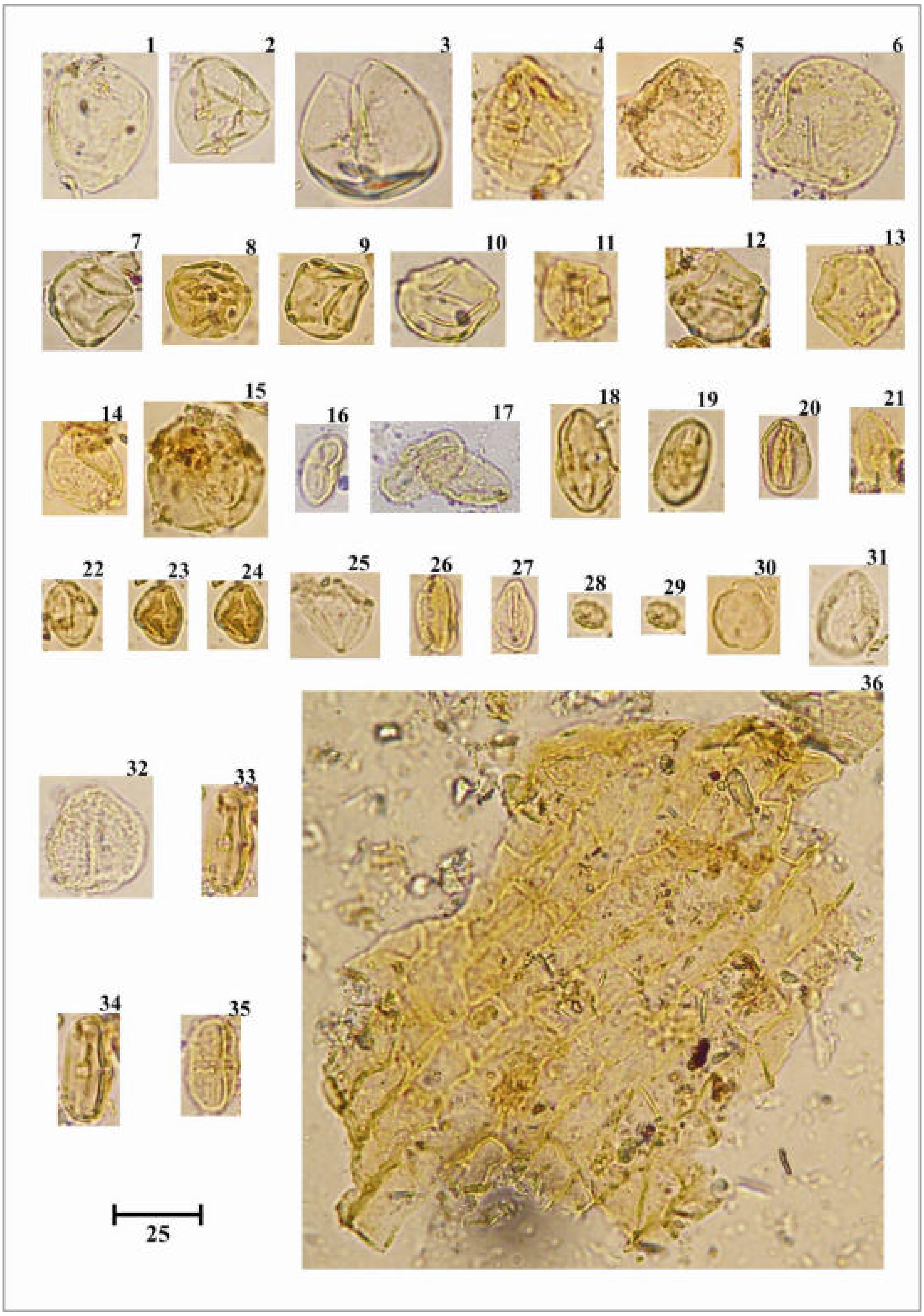


PLATE 9.10 (Sekköy2 Section)



CHAPTER TEN

CONCLUSIONS

Study area is located from the southwestern Anatolia where include the Ören basin of the Tertiary time. This thesis emphasized the stratigraphical, palaeontological, palaeoenvironmental and palaeoclimatological significance of the Milas-Ören region.

In this study, stratigraphy of the Ören region is revised based on the new evidences of thesis. In the Ören region one formation (Kultak formation of the late Burdigalian-early Langhian age) and three members (Alakilise member of the Rupelian-Chattian; Hüsamlar and Belen members of late Burdigalian- Langhian age) are determinate different from the previous workers. Besides, age of the deposited is started the Early Oligocene time (Rüpelian) according to the palaeontological and isotopic analysis results.

Limestones of the Lycian nappes are basement in the Ören region and the basement rocks are unconformably overlaid by the Çambeleni formation. The base of the stratigraphy in the Ören region is marked by limestones, marl in the Rupelian Çambeleni formation which is lateral and vertical transitional contacts with Alakilise member composing of sandstones, mudstones alternation and coal. Deposition of the Çambeleni formation and Alakilise member continues during the Chattian period. The sediments of the Çambeleni formation are made of reefal limestones with foraminifers. The Alakilise member is represented by sandstones with gastropod and bivalvia fossils and including several lenses of lignite during the Chattian (in the SW Kultak and Kumluca regions). The Chattian–Aquitanian transition is conformably (Kumluca region). The Aquitanian and early–middle Burdigalian sediments consist mainly of the sandstones with bivalvias, gastropods and reefal carbonates with coral, foraminifers, gastropods, bivalvias in the Akbük, Akyaka–Kuyucak regions (the Çambeleni formation). The Çambeleni formation is vertical and lateral transitional contact with Gökçeören formation including coarse conglomerates in the Akbük, Akyaka–Kuyucak regions. During the middle Burdigalian and Langhian, the unconformably overlaying Kultak formation is characterized by coarse conglomerates with mammalian fossils and sandstones alternation. This formation laterally and vertically passes the Belen member which is represented marine claystones, sandstones and limestones with gastropod, bivalvia and coral (in the Kultak region). Besides the Kultak formation is lateral and vertical transitional contact with the Hüsamlar member which composes of marl and coal alternation with mammalian and leaf fossils (in the Hüsamlar and Karacaagaç regions). The Hüsamlar and Belen members are unconformably overlain by continental deposits of the Mugla group, dated as the late Astracian (Middle Miocene; the Sekköy formation) to Turolian (Late Miocene; the Yatagan formation).

Palynoflora of the Rupelian time is represented by the *Momipites quietus, Plicapollis plicatus, Dicolpopollis kockelii, Plicapollis pseudoexcelsus, Cuphaniedites eucolptoides, Compositopollenites minitus, Compositoipollenites rhizophorus burghasungensis, Olaxipollis mathensis, Leiotriletes maxoides minoris, Bohlensipollis hohli, Mediocolpopollis compactus, Subtriporopollenites constans, Sparganiapollenites neogenicus, Pentapollenites pentangulus, Interpollis* sp., *Polygalacidites* sp., *Psilatricolporites crassus. Avicennia* sp., *Verrucatosporites alienus* and *Verrucatosporites favus* ssp. *favus*. Besides, in this thesis firstly pollen of the mangrove forest are observed in the Rupelian and during this time ?tropical-warm subtropical climatic condition is defined based on the palynofloras and numerical palaeoclimatic results. Reconstructed climatic estimates of the Rupelian time in the the northeast of Kultak region are MAT 16.5–21.3°C, CMT 7.7–13.3°C, WMT 27.3–28.1°C, MAP 1122–1520mm, MAP_{WET} 204–227mm and 115–180mm, MAP_{DRY} 19.0–43.0mm and MAP_{WARM} 118.0–125.0mm. The palaeoclimatic reconstruction in the southwest Kultak region is based on 19 taxa. The values are 17.2 to 18.8^{o}C for the MAT, 5.5 to 13.1^{o}C for the CMT, 27.3 to 27.7^{o}C for the WMT and 1217–1520mm for the MAP, 204–227mm for MAP_{WET}, 19–54mm for MAP_{DRY} and 118–125mm for MAP_{WARM}. The temperature values of the of the upper coal seam in the southwest Kultak region are MAT 17.2–18.8^{o}C, CMT 6.2–13.1^{o}C for, WMT 27.3–28.1^{o}C and MAP 1217–1322mm, MAP_{WET} 225–227mm, MAP_{DRY} 19–32mm and MAP_{WARM} 118–125mm.

The Chattian time is recorded foraminifer, gastropod, bivalvia and strontium isotope results of the Çambeleni formation and Alakilise member. The palynoflora of the Chattian time is characterized by the *Momipites quietus, Plicapollis plicatus, Dicolpopollis kockelii, Plicapollis pseudoexcelsus, Leiotriletes maxoides minoris, Interpollis* sp. and marine dinoflagellates species. According to the palynoflora brackish paleoenvironmental condition is observed. During the Chattian time, warm subtropical climatic condition continues based on the palynoflora. The coexistence approach results of the Chattian time in the Ören region MAT 16.5–21.3°C, CMT 5–13.3°C, WMT 24.7–28.1°C, MAP 1187–1520mm, MAP_{WET} 115–180mm and 204–227mm, MAP_{DRY} 19.0–54.0mm and MAP_{WARM} 118.0–125.0mm. And also foraminifer, gastropod, bivalvia faunas of this time are defined and these fauna associations and oxygen and carbon isotopic analysis results support the palaeoenvironmental interpretation based on the palynoflora.

The late Early-early Middle Miocene time is recorded based on the palynofloras, leaf fossils, mammalian fossils, strontium isotope results in the Kultak formation, Belen and Hüsamlar members. Leaf flora of the Ören region firstly defined and this flora of late Early-early Middle Miocene time interval is represented by the *Acer integrilobum, Fagus gussonii, Quercus mediterranea, Quercus zorastri, Quercus rehenana, Pinus* sp., *Glyptostrobus europaeus, Carpinus grandis, Alnus cecroplifolia, Quercus sosnowskyi, Myrica lignitum, Nyssa bilinica, "Rhamnus" warthae, Populus populina, Zelkova zelkovifolia, Taxodium dubium, Acer angustilobul, Liquidambar europa, Berberis* sp., *Mahonia* sp., *Alnus julianaeformis, Alnus gaudinii, Alnus adscendens, Betula* sp., *Quercus kubinyii, Quercus* sp., *Hamamelis* sp., *Daphnogene polymorpha*. For the late Early-early Middle Miocene time, reconstructed climatic estimates of the leaf flora (Karacaagaç) using coexistance approach method are MAT 13.9–13.9°C, CMT 2.7–7.0°C, WMT 25.7–26.1°C, MAP 1036–1046mm, MAP_{WET} 124–141mm, MAP_{DRY} 43–59mm and MAP_{WARM} 90.0–93.0mm. The CA_{macro} intervals of the Ören–Hüsamlar macroflora are MAT 13.9–13.9°C, CMT 2.7–9.7°C, WMT 25.7–26.1°C, MAP 1036–1046mm, MAP_{WET} 124–159mm, MAP_{DRY} 43–63mm and MAP_{WARM} 90.0–116.0mm. Palynoflora of this time is characterized by the *Laevigatorsporites haardti,* *Pityosporites microalatus*, *Cupressacites cuspidateaformis*, *Monogemmites pseudosetarius*, *Quercopollenites robur*, *Tricoporopollenites densus, Dicolpopollis kalewensis*, *Subtriporopollenites anulatus nanus*, *Momipites punctatus*, *Momipites quietus*, *Periporopollenites multiporatus*, *Liriodendrioipollis semiverrucatus, Polygalacidites* sp., *Cichareacidites* sp. *liquiflora* type, *Tricoporopollenites* sp. (*tubuliflora* type), *Magnolipollis* sp. and *Avicennia* sp.. Numerical palaeoclimatic values of palynofloras from the Ören–Karacaagaç and Hüsamlar regions are calculated in this thesis. The coexistence intervals of the Ören–Karacaagaç in the late Early-early Middle Miocene time are MAT 17.0–18.4°C, CMT 6.2–12.5°C, WMT 26.5–28.1°C, MAP 1146–1322mm, MAP_{WET} 225–227mm, MAP_{DRY} 7–32mm, MAP_{WARM} 79.0–125.0mm, MART 17.95°C. The intervals of the Ören–Hüsamlar are MAT 17.0–21.3°C, CMT 6.2–13.3°C, WMT 27.3–28.1°C, MAP 1146–1322mm, MAP_{WET} 225–227mm, MAP_{DRY} 8–32mm, MAP_{WARM} 79.0–125.0mm and MART 17.95°C. The MAT coexistence intervals of Ören–Kultak region in the late Early-early Middle Miocene time range between 15.7 and 18.8°C, the CMT is between 9.6 and 13.1°C, the WMT between 24.7 and 27.7°C, the MAP 1122.0 and 1520.0mm, MAP_{WET} 204 and 227mm, MAP_{DRY} 19 and 43mm MAP_{WARM} 79 and 125mm and the MART 13.5°C. According to the palynoflora and numerical palaeoclimatic results using the coexistence approach CLAMP, LMA methods, warm subtropical climatic condition is observed in the Ören region. Besides, pollen of mangrove forest is firstly recorded for the late Early-early Middle Miocene time in Turkey. The mammalian fauna which includes *Anchitherium aurelianense hippoides* (Lartet), *Ancylotherium* (Metaschizotherium) *fraasi* (Koenigswald), *Tethytragus koehlerae* (Azanza & Morales) and *Gomphotherium* sp.. is determinated. This fauna of the MN5-6 boundary zone is the Langhian age and strontium isotope result is supported this age determination.

The Middle Miocene (the Serravallian) time is recorded by palynoflora which is represented by the *Laevigatosporites haartdi Baculatisporites primarius Pityosporites microalatus, Cathayapollis* spp., *Inaperturopollenites dubius, Cycadopites* spp., *Tricolpollenites densus, Quercopollenites robur* type, *Tricolporopollenites megaexactus exactus, Tricolporopollenites cingulum oviformis,* *Alnipollenites verus, Monogemmites pseudosetarius, Momipites punctatus, Triatriopollenites rurensis, Triporopopollenites coryloides, Oleoidearumpollenites microreticulatus, Caryapollenites simplex, Tricolpopollenites retiformis* (*Salix* type), *Ovoidites* spp., *Pityosporites labdacus, C. cuspidateaformis, Tricolporopollenites pseudocingulum, Leiotriletes maxoides minimus, Inaperturopollenites hiatus, Tetracolporopollenites sapatoides, Polyporopollenites undulosus, Periporopollenites multiporatus, Tricolporopollenites* sp. (*Tubulifloreae* type) and *Tricolporopollenites* sp. (*Liguliflorеae* type)). Averages of the CMT value of the Middle Miocene time are between 3 and 9^{o}C (Ikizler and Sekköy regions). These values are lower than values of the Langhian time in the Ören region. This temperature decrease could be related to the palaeoclimatic changes and palaeoclimate is temperate in the Middle Miocene time.

Yatagan formation which is defined in the Mugla region overlie the Middle Miocene period. This formation is characterized by the marl, conglomerate and volcanic rocks. In the study area, faults systems active and this activate caused the alluvial fan.

REFERENCES

Akgün, F. (2002). Stratigraphic and paleoenvironmental significance of Eocene palynomorphs of the Çorum–Amasya area in the central Anatolia, Turkey. *Acta Palaeontologica Sinica, 41*, 576–591.

Akgün, F., & Akyol, E. (1987). Palynological investigations of Akhisar (Çitak) lignite. *Geological Society of Turkey Bulletin*, *30*, 35–50.

Akgün, F., & Akyol, E. (1999). Palynostratigraphy of the coal–bearing Neogene deposits Graben in Büyük Menderes Western Anatolia. *Geobios*, *32*(3), 367–383.

Akgün, F., & Sözbilir, H. (2001). A Palynostratigraphic approach to the SW Anatolian Molasse Basin: Kale–Tavas and Denizli Molasse. Geodinamica Acta 14, 71–93.

Akgün, F., Alisan, C., & Akyol, E. (1986). A palynological approach to the Neogene stratigraphy of Soma area. *Geological Society of Turkey Bulletin*, *29,* 13–25.

Akgün, F. & Akyol, E. (1992). Palynostratigraphy of the coal bearing Neogene deposits in Büyük Menderes Graben, Western Anatolia. *1 st. International symposium on Eastern Mediterranean Geology, Adana-Turkey, Proceedings and Abstracts*, p. 309.

Akgün, F., Akay, E., & Erdogan, B. (2002). Terrestrial to shallow marine deposition in central Anatolia: a palynological approach. *Turkish Journal of Earth Sciences*, *11*, 1–7.

Akgün, F., Kayseri, M. S., & Akkiraz, M. S. (2007). Palaeoclimatic evolution and vegetational changes during the Late Oligocene–Miocene period inWestern and Central Anatolia (Turkey). *Palaeogeography, Palaeoclimatology, Palaeoecology, 253*, 56–90.

Akgün, F., Kaya, T., Forsten, A., & Atalay, Z. (2000). Biostratigraphic data (Mammalia and Palynology) from the Upper Miocene Incesu Formation at Düzyayla (Hafik Sivas, Central Anataloia). *Turkish Journal of Earth Sciences*, *9,* 57-67.

Akkiraz, M. S., & Akgün, F. (2005). Palynology and age of the Early Oligocene units in Çardak–Tokça basin, southwest Anatolia: paleoecological implications. *Geobios, 38*, 283–299.

Akyol, E. (1971). Microflore de l'Oigocene infériur récoltée dans un sondage pres d' Avcikoru, Sile–Istanbul. *Pollen et Spores, 13* (1), 117–133.

Akyol, E. (1980). Etude palynologique de l'Eocene de Bayat (Çorum–Turquie) et essai de correlation entre Karakaya et Emirsah. *Mineral Research and Exploration Institute of Turkey (MTA) Bulletin*, *91*, 39–53

Ash, A., Ellis, B., Hickey, L.J., Johnson, K., Wilf, P., & Wing, S. (1999). Manual of Leaf Architecture: Morphological Description of Dicotyledonous and Net–veined Monocotyledonous Angiosperms. Smithsonian Institution, Washington, D.C.. Privately published and distributed.

Ashraf, A. R., & Mosbrugger, V. (1995). Palynologie und Palynostratigraphie des Neogens der Niederrheinischen Bucht. *Palaeontographica Abteilung B Ionnides, 235* (1–6), 61–173.

Atalay, Z. (1980). Mugla Yatagan ve Yakini Dolayi Karasal Neojen'inin Stratigrafik Arastirilmasi: Türk. Jeo. Kur. Bült. 23, 1, 93–99.

Bailey, I.W., & Sinnott, E.W. (1915). A botanical index of Cretaceous and Tertiary climates. Science 41 (1066), 831–834.

Bailey, I.W., & Sinnott, E.W. (1916). The climatic distribution of certain types of angiosperm leaves. Am. J. Bot. 3 (1), 24–39.

Barrón, E., & Diéguez, C. (1994). Neogene species of the genus Fagus L. From La Cerdaña (Lérida, Spain). Taxonomic conclusions and phylogenetic considerations, Anales Jard. Bot. Madrid, 52(1), 21–32.

Bati, Z. (1996). Palynostratigraphy and Coal Petrography of the Upper Oligocene Lignites of the Northern Thrace Basin, NW Turkey. PhD Thesis, Middle East Technical University, Ankara, Turkey [unpublished].

Becker–Platen, J. D. (1970). Lithostratigraphische Untersuchungen im Känozoikum Südwest –Anatoliens (Türkei): Beih. Geol. Jb., 97: 244 p.

Belz, G. & Mosbrugger, V. (1994): Systematisch-paläoökologische und paläoklimatische Analyse von Blattfloren im Mio-/Pliozän der Niederrheinischen Bucht (NW-Deutsch-land). *Palaeontographica, B*, 233: 19 – 156.

Benda, L. (1968). Wichtige biostratigraphische Einzelergebnisse: Sporomorphen. In: Gold, O., Abschlußbericht Türkei, 1, Untersuchung auf Braunkohle, 2, Geologie, S. 457–466, Köln.

Benda, L. (1971a). Grundzüge einer pollenanalytischen Gliederung des türkischen Jungtertiärs (Känozoikum und Braunkohle der türkei. 4. *Beihhefte zum Geologischen Jahrbuch*, *113,* 1–46.

Benda, L. (1971b). Principles of the palynologic subdivision of the Turkish (Kanozoikum und Braunkohlen der Turkei–3.) *Newsletter Stratigraphy, 1,* 23–26.

Benda, L., Meunlenkamp, J. E., Schmidt, R. R., Steffens, P., & Zachariasse, J. W. (1977). Biostratigraphic correlations in the Eastern Mediterranean Neogene. 2. Correlation between sporomorph Associations and marine microfossils from the Upper Oligocene–Lower Miocene of Turkey.– Newsl. Stratigr., 6(1):1–22, 1 Abb., 3 Tab.; Berlin– Stuttgart.

Benda, L., & Meunlenkamp, J. E. (1990). Biostratigraphic correlations in the Eastern Mediterranean Neogene 9. Sporomorph associations and event stratigraphy the Eastern Mediterranean. *Newsletter Stratigraphy, 2*3, 1–10.

Bolkhovitina, A.R. (1956). Atlas spor i pyl'tsy iz yurskikh i niznemelovykh otlozheny Viluyskoy vpadiny (Atlas of spore and pollen complexes from the Jurassic and Lower Cretaceous deposits of the Viluain hollov). Trudy Inst. Geol. Nauk SSSR, 2: 1–87. (in Russian).

Bozkurt, E. (2000). Timing of Extension on the Büyük Menderes Graben, Western Turkey and its tectonic implications. *In*: Bozkurt, E., Winchester, J.A. & Piper, J.D.A. (eds) Tectonics and Magmatism in Turkey and the Surrounding Area. *Geological Society, London, Special Publications 173,* 385-403.

Bužek, C., Holy, F., & Kvacek, Z. (1996). Early Miocene Flora of the Cypris shale (Western Bohemia). Acta Musei Natioanlis Pragae, Series B, Historia Naturalis 52, 1–72.

Cavagnetto, C. (2002). La palynoflore du Bassin d'As Pontes en Galice dans le Nord Ouest de l'Espagne á la limite Rupélien–Chattien(Oligocéne). Palaeontographic Abt. B 263, Lfg. 1–6. 161–204.

Chateauneuf, J. J. (1980). Palynostratigraphie et Paléoclimatologie de L' Eocene Supérieur et de L' Oligocene du Bassin de Paris. *Mémorie du Bureau de Recherches Géologiques et Minières, 116* , 1–360.

Chateauneuf, J. J., Cavagnetto, C., Meyer, K. J., Sittler, C., & Pierre. O. (1988). Pollen and Spores (Compilation). In R. Vinken, (Ed.). The Northwest European Tertiary Basin. *Geologisches Jahrbuch*, *100*, 288–320.

Dilcher, D.L. (1974). Approaches to the Identification of Angioperm Leaf Remaine, Bot. Rev., 40, 1, 1–156.

Ediger, V. S., Bati, Z., & Alisan, C. (1990). Paleopalynology and Paleoecology of *Calamus* like Disulcate Pollen Grains. *Review of Paleobotany and Palynology*, *62*, 97–105.

Ercan, T., Dinçel, A., Metin, S., Türkecan, A., & Güney, E. (1978). Usak Yöresindeki Neojen Havzalarinin Jeolojisi, Türkiye Jeoloji Kurumu Bülteni, c–21, 97–106, Agustos.

Erdei, B. (1995). The Sarmatian flora from Erdobenye–Ligetmajor, NE Hungary. Annales Histrico–Naturales Musei Nationalis Hungarici, 87: 11–33.

Erdei, B., & Kvacek, Z. (1997). A newly recovered collection of the Early Miocene flora of Kymi (Greece) previously misinterpreted as the Upper Miocene flora of allya (NE Hungary). Annales Histrico–Naturales Musei Nationalis Hungarici, 89:5–10.

Erdei, B., & Wilde, V. (2004). An Oligocene leaf assemblage from Csalnak, Dorog Basin, N. Hungary, Revue de Paléobiologie, 23(1), 117–138.

Erdei, B., Hably, L., Kázmér, M., Utescher, T., & Bruch, A. A. (2007). Neogene flora and vegetation development of the Pannonian domain in relation to palaeoclimate and palaeogeography, Palaeogeography, Palaeoclimatology, Palaeoecology 253 (2007) 115–140.

Erdtman, G. (1947). Suggestions for the Classifikation of Fossil and Recent Pollen Grains and Spores. *Svensk. Bot. Tidskr., 41*, 104–114.

Erentöz, L., & Öztemür, C. (1964). Aperçu général sur la stratigraphie du Néogéne de la Turguie et observations sur ses limites inférieures et supérieures, Institute ‘Lucas Maldada’ C.S.I.C. (Espana) Cursilles Conferencies, Madrid 9, 259–266.

Ferguson, D. K. (1989). A survey of the Liquidambaroideae (Hamamelidaceae) with a view to elucidating its fossil record, Systematics Association Special Volume No. 40A, pp. 249–272.

Ferguson, D. K., Pingen, M., Zetter, R., & Hofmann, C. C. (1998). Advances in our knowledge of the Miocene plant assemblage from Kreuzau, Germany, Review of Palaeobotany and Palynology, 101, 147–177.

Fernández–Marbón, M. T., & Hably, L. (2005). A new Miocene plant assemblage from Parla, Madrid basin, Spain, Revue de Paléobiologie, Genéve, 24(2), 647–656.

Flügel, N. & Metz, K. (1954), Bodrum-Mugla yöresinde yapilan jeolojik harita hakkinda rapor : *M.T.A. Rap. No. 2789*, (unpublished)

Frederiksen, N. O. (1980). Sporomorphs from the Jackson Group (Upper Eocene) and Adjacent Strata of Mississipi and Western Alabama. *Geological Survey Professional Paper*, *1084*, 1–75.

Frederiksen, N. O. (1994). Middle and Late Palaeocene angiosperm polen from Pakistan. *Palynology, 18*, 91–137.

Gaziry, A. W. (1976). Jungtertiäre Mastodonten aus Anatolien (Türkei). *Geologisches Jahrbuc* 22:3-145.

Gelincik, Y. (1986). Mugla–Milas kömürlü Neojeni Hüsamlar (Çakiralan) Sektörü Jeolojik Raporu, Kö:47.

Gemici, Y., Akyol, E., Seçmen, O., & Akgün, F. (1991). Soma Kömür Havzasi Fosil Makro ve Mikroflorasi. *Maden Tetkik Arama Enst. Dergisi*, 112, 161–178.

Gemici, Y., Akgün, F., & Yilmazer, Ç. (1992). Akçasehir (Tire–Izmir) Neojen Havzasi Fosil Makro ve Mikroflorasi, Doga, Türk Botanik D., 16:383–393.

Gemici, Y., Akyol, E., & Akgün, F. (1993). Sahinali (Aydin) Neojen Havzasinin Fosil Makro ve Mikroflorasi, Doga, Türk Botanik D., 17:91–106.

Gorin, G., (1975). Étude palynostratigraphique des sédiments paléogènes de la Grande Limagne. Bulletin Bureau *Recherches Géologiques et Minières*, *3*, 147–181.

Gökçen, N. (1982). Denizli ve Mugla çevresi Neojen istifinin Ostrakod biyostratigrafisi. *Yerbilimleri*, *9*, 111–131.

Görür, N., Sengör, A.M.C., Sakinç, M., Tüysüz, O., Akkök, R., Yigitbas, E., Oktay, F.Y., Barka, A.A., Sarica, N., Ecevitoglu, B., Demirbag, E., & Akyol, A. (1994). Cross–cutting rift systems of the Gökova Region, SW Anatolia: Implications for the formation of the aegean Sea, Bull. Tech. Univ. , 47 (1), 275–292.

Görür, N., Sengör, A.M.C., Sakinç, M., Tüysüz, O., Akkök, R., Yigitbas, E., Oktay, F.Y., Barka, A.A., Sarica, N., Ecevitoglu, B., Demirbag, E., Ersoy, S., Algan, O., Güneysu, C., & Akyol, A. (1995). Rift formation in the Gökova region, soutwest Anatolia:imlications for the opening of the Aegean Sea, Geolgical Magazine, 132, p. 637–650.

Görür, N. & Tüysüz, O. (2001). Cretaceous to Miocene palaeogeographic evolution of Turkey: Implications for hydrocarbon potential. *Journal of Petroleum Geology, 24(2)*, 119-146

Graham, A. (1977). New records of *Pelliciera* (Theaceae/Pelliceriaceae) in the Tertiary of the Caribbean. *Biotropica, 9*, 48–52.

Gruas–Cavagnetto, C. (1968). Étude palynologique des divers gisements du Sparnacien du Bassin de Paris. *Mémoire de la Société Géologique de France, 110*, 1–144.

Greenwood, D.R. (2005). Leaf form and the reconstruction of past climates. New Phytol. 166, 355–357.

Greenwood, D.R. (2007). Fossil angiosperm leaves and climate: fromWolfe and Dilcher to Burnham and Wilf. Cour. Forsch. Inst. Senckenberg 258, 95–108.

Gürer, Ö. F., & Yilmaz, F. (2002). Geology of the Ören and surrounding regions, SW Turkey, *Turkish Journal of Earth Science, 11*, 2–18.

Hably, L. (1990). Egerian plant fossils from Vértesszolos, NW Hungary, Studia Botanica Hungarica, XXII., p. 3–78.

Hably, L., & Kvacek, Z. (1998). Pliocene mesphytic forests surrounding crater lakes in western Hungary, Rewiev of Palaeobotany and Palynology, 101, 257–269.

Hably, L., Kvacek, Z., & Manchester, R. (2000). Sharad Taxa of Land Plants in the Oligocene of Europe and North America in context of Phtogeography, Acta Universitatis Carolinae–Geologica, 44(1), 59–74.

Hably, L. (2001). 'Rhamnus' warthae HEER, on important element of central paratethyon region during the Egerian, Studia Botanica Hungarica, 32, p.5–12.

Hably, L., & Zastawniak, E. (2001). Distribution, Taphonomy and Palaeoecology of Ulmus L. in the Hungarian Egerian, Studia Botanica Hungarica, 32, 13–32.

Hably, L., Erdei, B., & Kvacek, Z. (2001). *19th Century's Palaeobotanical types and Originals of the Hungarian Natural History Museum,* (first edition), Hungarian Natural History Museum, Bedapest, p. 235.

Hably, L., & Thiébaut,M. (2002). Revision of Cedrelospermum (Ulmaceae) fruits and leaves from the Tertiary of Hungary and France. Palaeontographica Abteilung B Paläophytologie 262 (1–4), 71–90.

Hakyemez, H.Y., & Örçen, S. (1982). Mugla Denizli arasindaki (GB Anadolu) Senozoyik yasli çökel kayalarin sedimentolojik ve biyostratigrafik incelenmesi. *Mineral Research Exploration Institute*, (7311).

Hakyemez, H. Y. (1989). Kale–Kurbalik (GB Denizli) Bölgesindeki Senozoyik yasli Çökel Kayalarin Jeolojisi ve Stratigrafisi. *Bulletin Mineral Research Exploration Institute, 109,* 9–21.

Harzhauser, M., & Piller, W. (2007). Benchmark data of a changing sea: Palaeogeography, Palaeoclimatology, Palaeoecology, 253:8–31.

Heissig, K. (1999). Family Rhinocerotidae. In The Miocene land mammals of Europe, *eds. Rössner, G.E., and K. Heissig*, 175–188.

Helvaci, C., 1995. Stratigraphy, mineralogy and genesis of the Bigadiç borate deposits, Western Turkey. *Economic Geology* 90, 1237-1260

Herman, A.B., & Spicer, R.A. (1996). Palaeobotanical evidence for a warm Cretaceous Arctic Ocean. Nature 380, 330–333.

Hickey, L. J., & J. A. Wolfe. (1975). The bases of angiosperm phylogeny: vegetative morphology. *Annals of the Missouri Botanical Garden 62:* 538–589.

Hickey, L.J. &Taylor, D.W. (1991). The leaf architecture of Ticondendron and the application of foliar characters in discerning its relationships. *Annual Missouri Bot Gard, v 78*, 105-130.

Hochuli, P. A. (1978). Palynologische untersuchungen im Oligosen der zentralen und westlichen Paratethys. *Beitrräge Paläontologie*, *Österreich*, *4*, 1–132.

Hottenrott, M. (2002). Age Determinations of Palynological Assemblages from Lower Tertiary of the Eisenberg Basin (Northern Palatinat, Germany). *Acta Palaeontologica Sinica, 4*1(4), 565–575.

Iversen, J., & Troels–Smith, J. (1950). Pollenmorphologische Definitionen und Typen. *Danmarks Geologiske Undersøgelse*, *4* (8), 1–53.

Ivanov, A.R. Ashraf & V. Mosbrugger, (2007). Late Oligocene and Miocene climate and vegetation in the Eastern Paratethys area (northeast Bulgaria), based on pollen data, *Palaeogeography, Palaeoclimatology, Palaeoecology 255*, pp. 342–360.

Islamoglu, Y. (2008). Middle Pleistocene bivalves of the Iznik lake basin (Eastern Marmara, NW Turkey) and a new paleobiogeographical approach. Int J Earth Sci (Geol Rundsch).

Islamoglu, Y., Gedik, F., Aydin, A., Atay, G., Hakyemez, A. & Babayigit, S. (2006). Denizli bölgesindeki lagüner ve denizel çökellerin Oligosen biyostratigrafisi (GB Türkiye) [Oligocene biostratigraphy of lagoonal and marine deposits in Denizli region], *Geological Congress of Turkey, Ankara, Abstracts,* 245-249.

Jechorek, H., & Kovar–Eder, J. (2004). Vegetational Characteristics in Europe around the Late Early to Early Middle Miocene Based on the Plant Macro Record. Cour. Forsch. Inst. Senckenberg, 249:53–62.

Kancucka–Srodoniowa, M., & Zastwniak, E. (1997). The Middle–Miocene flora of wieliczka Revision of Jan Zabtocki’s Collection, Acta Palaeobotanica, 37(1), 17–49.

Kar, R. K. (1985). The fossil flora of Kachchh –IV. Tertiary palynostratigraphy. *Palaeobotanist*, *34*, 1–280.

Karayigit, A. I., Akgün, F., Gayer , R. A., & Temel, A. (1999). Quality, Palynology, and Palaeoenvironmental Interpretation of the Ilgin Lignite, Turkey. *International Journal of Coal Geology*, *38*, 219–236.

Kasapligil, B. (1976). Ankara, Kizilcahamam Yakinindaki Güvem Köyü Civarinda Bulunan Son Tersiyer Kozalakli–Yesil Yaprakli Ormani. Mills Koleji, Bijoloji Fakültesi, Oakland, Kaliforniya. 94–102.

Kaya, T., Tuna, V. & Geraads, D. (2001). A new Late Orleanian/early astaraccian Mammalian Fauna from Kultak (Milas–Mugla), Southwestern Turkey, Geobios 34 (6), 673–680.

Kedves, M. (1961). Etudes palynologiques dans le bassin de Dorog. II. *Pollen et Spores*, *3(*1), 101–153.

Kedves, M. (1963). Stratigraphie palynologique des couches Eocènes de Hongrie. *Pollen et Spores*, *1*, 149–159.

Kedves, M. (1971). Presence de types sporomorphes importants dans les sediments pre-quaternaires Egyptiens. *Acta botanica Academiae Scientiarum Hungaricae 17,* 371–378

Kedves, M. (1970). Etudes palynologiques des couches du Tertraire inferieur de la region Parisienne. *Pollen et Spores, 12*, 83–97.

Kedves, M. (1974). Paleogene Fossil Sporomorphs of the Bakony Mountains. II. *Studia Biologica Hungarica*, *13*, 1–124.

Kemper, E. (1961). The Kirklareli limestone (Upper Eocene) of the northern basin rim. *Geological report T 27.*

Khlonova, A. F. (1960). Vidovoy sostav pyl'tsy i spor v otlozheniyakh vierkhnevo mela Chulimo–Eniseyskoy vpadiny (The specific composition of pollen and spore complexes in the Upper Cretaceous deposits of the Tschulimo–Yeniseian hollow). Trudy *Inst. Geol. Geofiz. Sibir. 3*: 1–104. (in Russian).

Kirchner, M. (1984). Die Oberoligozäne Mikroflora des Südbayerischen Pechkohlenreviers. *Palaeontographica Abteilung B Ionnides, 192*, 85–162.

Klaus, W. (1984). Zur Mikroflora des Unter–Sarmatam Alpen–Südostrand. Beiträge zur Paläontologie von Österreich. 11:289–419.

Knobloch, E., & Kvacek, Z. (1996). Miozane Floren der südböhmischen Becken. Sbornik geologickych ved Paleontologie, 33:39–77.

Knobloch, E., Konzálová, M., & Kvacek, Z. (1996). Die Obereozäne Flora der Staré Sedlo–Schichtenfolge in Böhmen (Mitteleuropa). *Rozpravy Ceského Geologického ústavu, svacek*, *49*, 260 pp.

Koçyigit, A. (1981). Isparta Büklümünde (Bati Toroslar) Toros karbonat platformunun evrimi. *Türkiye Jeoloji Kurumu Bülteni, 24* (2), 15–23.

Koçyigit, A. (1983). Hoyran Gölü (Isparta Büklümü) dolayinin tektonigi. *Türkiye Jeoloji Kurumu Bülteni, 26* (1), 1–10.

Koçyigit, A. (1984). Tectono–stratigraphic characteristics of Hoyran Lake region (Isparta Bend). In O. Tekeli, & C. Göncüoglu, (Eds.). *Geology of the Taurus belt*. 53–67.

Koçyigit, A., Yusufoglu, H. & Bozkurt, E. (1999). Evidence from the Gediz Graben for episodic two-stage extension in western Turkey. *Journal of the Geological Society, London 156*, 605–616.

Konzalová, M. (1976a). Micropaleontological Research of the Lower Miocene of Northern Bohemia. *Rozpravy CSAV, Rada mat. a prirod, 12*, 1–75.

Kovach, W.L., & Spicer, R.A., (1995) Canonical Correspondence Analysis of Leaf Physiognomy: a Contribution to the Development of a New palaeoclimatological Tool. *Palaeoclimates*, 1: 125-138.

Kovack, B.E. (1989), "Successful derailment", *Organizational Dynamics*, Autumn, Vol. 18 No. 2.

Kovar, J. B. (1982). Eine Blätter–Flora des Egerien (Ober–Oligozän) aus marinen Sedimenten der Zentralen Paratethys Im Linzer Raum (Osterreich), Beitr. Paläont. Osterr., (Beitrag zur Palaontologien Osterreich), 9:1–209.

Kovar, J. B. (1987). Pannonian (Upper Miocene) vegetational character and climatic inferences in the Central Paratethys area. Annalen des Naturhistorschen Museums in Wien **88**, A, 117-129.

Kovar–Eder, J. (1996). Eine bemerkenswerte Blätter– Vergesellschaftung aus dem Tagebau Oberdorf bei Köflach, Steiermark (Unter–Miozän), Mitt. Abt. Geol. und Paläont. Landesmuseum Joanneum, 54, 147–171.

Kovar–Eder, J. (1997). Die adv–gestützte erfassung der in õsterreichischen Kollektionen Befindlichen Paläontologishen typen und originale, Geol. Paläont. Mitt. Innsbruck. 22, 123–127.

Kovar–Eder, J. (1998). Leaf Assemblages from the Early Miocene Lignite Opencast Mine Oberdorf (N. Voitsberg, Styria, Austria), Jahrbuch Der Geologischen Bunde sonstalt, 140(4), 447–452.

Kovar–Eder, J., Meller, B., & Zetter, R. (1998). Comperative investigations on the basal fossiliferous layers at the opencast mine Oberdorf (Köflach–Voitsberg lignite deposits, Styria, Austria, Early Miocene), Review of Palaeobotany and Palynology, 101, 125–145.

Kovar–Eder, J., & Wójcicki, J. J. (2001). A late Miocene (Pannonian) flora from Hinter schlagen, Hausruck lignite area, Upper Austria, Acta Palaeobotanica, 41(2), 221–251.

Kovar–Eder, J., Kvacek, Z., & Meller, B. (2001). Comparing Early to Middle Miocene floras and probable vegetation types of Oberdorf N. Voitsberg (Austria), Bohemia (Czech Republic), and wackersdorf (Germany), 114, 83–125.

Kovar–Eder, J., Schwarz, J., & Wójcicki, J. (2002). The predominantly aquatic flora from Pellendorf, Lower Austria, Late Miocene, Pannonian– a systematic study, Acta Palaeobotanica, 42(2), 125–151.

Kovar–Eder, J., & Kvacek, Z. (2003). Towards vegetation mapping based on the fossil plant record, in Kvacek, Z., ed., Neogene Vegetation and Climate Reconstructions: Acta Universitatis Carolinae, Geologica, v. 46, p. 7–13.

Kovar–Eder, J. (2004). Die Adv–Gestützte Erfassung der in Österreichischen Kollektionen Befindlichen Palaontologischen Typen Und Originale. Geol. Palaont. Mitt. Innsbruck, 123–127.

Kovar–Eder, J., Kvacek, Z., & Strobitzer–Hermann, M. (2004). The Miocene flora of Parschlug (Styria, Autria)–Revision and Synthesis, Ann. Naturhist. Mus. Wien, 105A, 45–159.

Kovar–Eder, J., Kvacek, Z., Martinetto, E., & Roiron, P. (2006). Vegetation of Southern Europe around the Miocene/Pliocene boundary (7–4Ma– The High Resolution Interval I) as reflected in the macrofossil record, in Agusti, J., Oms, O., and Meulenkamp, J.E., eds., Late Miocene to Early Pliocene Environment and Climate Change in the Mediterranean Area: Palaeogeography, Palaeoclimatology, Palaeoecology, 238, 321–339.

Kovar–Eder, J., Jechorek, H., Kvacek, Z., & Parashiv, V. (2008). The Integrated Plant Record: An Essential Tool for Reconstructing Neogene Zonal Vegetation in Europe. *Palaios, 23:* 97–111.

Kremp, G. (1949). Pollenanalytische Untersuchung des miozänen Braunkohlenlagers von Konin an der Warthe. *Palaeontographica Abteilung B Ionnides*, *90,* 53–93.

Krutzsch, W. (1957). Sporen–und Pollengruppen aus der Oberkreide und dem Tertiär Mitteleuropas und ihre stratigraphische Verteilung. *Zeitschrift für Angewandte Geologie, 3,* 509–548.

Krutzsch, W. (1958). Sporen und Pollengruppen aus der Oberkreide und dem Tertiär Mitteleuropas und ihre stratigraphische Verteilung. *Zeitschrift für angewandte Geologie, 3*(11/*12*), 509–548.

Krutzsch, W. (1959). Mikropaläontologie (sporenpaläontologische) Untersuchungen in der Braunkohle des Geiseltasles. I. Die Sporen und die Sporenartigen sowie die ehemals zu Sporites gestellten Formeinheiten der Sporae dispersae der mitteeozänen Braunkohle des mittleren Geiseltales (Tagebau Neumark–West i. w. S.), unter Berücksichtigung und Revision weiterer Sporenformen aus der bisherigen Literatur. *Geologie, 21/22*, 1–425.

Krutzsch, W. (1959c). Einige neue Formattungen und arten von Sporenund Pollen aus der mitteleuropäischen Oberkreide und dem Tertiär. – Palaeontographica 105, B., Lief. 5–6, 125–157, 18 Abb., 5 Taf., Stuttgart, Mai.

Krutzsch, W. (1960). Beitrag zur Sporenpaläontologie der präoberoligozänen kontinentalen und marinen Te rtiärablagerungen Brandenburgs. *Ber. geol. Ges. DDR, 5* (4), 290–343.

Krutzsch, W. (1962a). Atlas der mittel–und jungtertiären dispersen Sporen–und Pollen–sowie der Mikroplanktonformen des nördlichen Mitteleuropas. I. VEB Deutscher Verlag der Wissenchaften, Berlin.

Krutzsch, W. (1962b). Stratigraphisch bzw. botanisch wichtige neue Sporen und Pollenformen aus dem deutschen Tertiär. *Geologie, 11*(3), 263–307.

Krutzsch, W. (1966). Zur Kenntnis der präquartären periporaten Pollenformen. *Geologie, 15* (55), 16–71.

Krutzsch, W. (1967a). Atlas der mittel– und jungtertiären dispersen Sporen– und Pollen– sowie der Mikroplanktonformen des nördlichen Mitteleuropas. IV–V. VEB Gustav Fischer Verlag. Jena.

Krutzsch, W. (1967b). Die stratigraphisch verwertbaren Sporen und Pollenformen des mitteleuropäischen Alttertiärs. *Geologisches Jahrbuch, 3,* 309–379.

Krutzsch, W. (1970a). Atlas der mittel–und jungtertiären dispersen Sporen–und Pollen sowie der Mikroplanktonformen des nördlichen Mitteleuropas. Lieferung VII: Monoporate,monolcolpate, longicolpate, und ephedroide (polyplicate) Pollenformen. 175pp.

Krutzsch, W. (1970b). Die stratigraphisch verwertbaren Sporen–und Pollenformen des mitteleuropäischen Alttertiärs. *Jb. Geol., 3,* 309–379.

Krutzsch, W. (1971). Atlas der mittel– und jungtertiären dispersen Sporen– und Pollensowie der Mikroplanktonformen des nördlichen Mitteleuropas. Leferung VI. Coniferenpollen (Saccites und „Inaperturates”). 1–234.

Krutzsch, W., & Vanhoorne, R. (1977). Die Pollenflora von Epinois und Loksbergen in Belgien. *Palaeontographica Abteilung B Ionnides*, *163,* 1–110.

Kayseri, M.S. & Akgün, F. (2008), Late Burdigalian-Langhian time interval in Turkey-palaeoenvironment and palaeoclimatologic implications and correlation of Europe and Turkey, *Terra Nostra 2008/2, IPC-XII/IOPC-VIII,* p 138.

Kvacek, Z. (1998). Bilina: a window on Early Miocene marshland environments, Review of Palaeobotany and Palynology, 101, 111–123.

Kvacek, Z., & Hurnik, S. (2000). Revision of Early Miocene Plants preserved in Baked Roks in the North Bohemien Tertiary, Acta Musei Nationalis Pragae, Series B, 56(1–2), 1–48.

Kvacek, Z., Velitzelos, D., & Velitzelos, E. (2002). *Late Miocene Flora of Vegora Macedonia N. Greece*, (first edition) Korali publication, Greece, p. 175.

Kvacek, Z. (2004). Revisions to the Early Oligocene flora of Flörsheim (Mainz Basin, Germany) based on epidermal anatomy, Senckenbergiona lethaea, 84(1/2), 1–73.

Kvacek, Z., & Walther, H. (2004). Oligocene flora of bechlejovice at Decín From the Neovolcaic area of the Ceské Stredohorí mountains, Chech Republic, Acta Musei Natioanlis Pragae, Series B, 60(1–2):9–60.

Kvacek, Z., Böhme, M., Dvorák, Z., Konzalová, M., Mach, K., Prokop, J., & Rajchl, M., (2004). Early Miocene freshwater and swamp ecosystems of the Most Basin (northern Bohemia) with particular reference to the Bilina Mine section, Journal of the Czech Geological Society, 49(1–2), 1–40.

Kvacek, Z., & Teodoridis, V. (2007). Tertiary macrofloras of the Bohemian Massif: a review within Boreal and Central Europe, Bulletin of Geosciences, 82(4), 383–408.

Langenheim, J.H., Hackner, B.L., & Bartlett, A. (1967). Mangrove pollen at the depositional site of Oligo−Miocene amber from Chiapas, Mexico. *Harvard University Botanical Museum Leaflets*, *21*, 289–324.

Lenz, O. (2000). Paläoökologie eines Küstenmoores aus dem Eozän Mitteleuropas am Beispiel der Wulfersdorfer Flöze und deren Begleitschichten (Helmstedter Oberflözgruppe, Tagebau Helmstedt). *Doctoratal dissertation*, 228 pp.

Mädler, K., & Steffens, P. (1979). Neue Blattflaren aus dem Oligozän, Neogen und Pleistozän der Türkei. Geologisches Jahrbuch, 33:3–33.

Mai, D.H. (1964). Die MastixioideenFloren im Tertiar der Oberlausitz. *Palaeontographica Abteilung B,* II, 1:1–192.

Manchester, S.R. (1986). Vegetative and reproductive morphology of an extinct plane tree (Platanaceae) from the Eocene of western North America. *Bot Gaz 147,* 200–226

Marinetto, E. (1996), Leaves of terrestrial plants from the Pliocene shallow marine and transitional deposits of Asti (Piedmant, NW Italy), *Bollettino della Societá Paleontologica Italiana*, 42(1–2), p. 75–111.

Meon–Vilain, H. (1970). Palynologie des Formations Miocenes superieures et Pliocenes du Bassin du Rhone (France). *Docum. Lab. Geol. Fac. Sci.,* 38, p. 167.

Mohr, B. A. R. (1984). Die Mikroflora der Obermiozänen bis unterpliozänen Deckschichten der rheinischen Braunkohle. *Palaeontographica Abteilung B Ioannides,* 191, 29–133.

Mosbrugger, V., & Utescher, T. (1997). The coexistence approach a method for quantitative reconstructions of Tertiary terrestrial palaeoclimate data using plant fossils. *Palaeogeogr., Palaeoclimatol., Palaeoecol.* 134, 61–86.

Mosbrugger, V. (1999). The nearest living relative method. In: Jones, T.P., Rowe, N.P. (Eds.), Fossil Plants and Spores Modern Techniques. The Geological Society, London, pp. 261–265.

Mürriger, F., & Pflug, H., (1951). Über die Altersstellung der Braunkohle von Burghasungen, Bezirk Kassl, auf Grund pollenanalytischer Untersuchungen und Verleiche mit anderen Braunkohlenvorkommen. *Notizblatt des Hessiches Landesamtes für Bodenforschung zu Wiesbaden, 6*, 87–97.

Mürriger, F., & Pflug, H., (1952). Über eine palynologische Untersuchung des Braunkohlenlagers der Grubbe Emma bei Marxheim (Untermaingebiet). *Notizblatt des Hessiches Landesamtes für Bodenforschung zu Wiesbaden, 6* (3), 56–66.

Nagy, E. (1969). Palynological Elaborations of the Miocene Layers of the Mecsek Mountains. *Annales Instituti Geologici Publici Hungarici, 52* (2), 237–650.

Nagy, E. (1985). Sporomorphs of the Neogene in Hungary. *Geologica Hungarica Seria Palaeontologica, 47,* 1–470.

Nagy, E. (1990). Palynological correlation of the Neogene of the Central Paratethys. *Geological Institute of Hungary*, 1–126.

Nagy, E. (1992). Magyarorszag Neogen sporomorphainak ertekelese, *Geol. Hung.* 53, pp. 1–379.

Nagy, E. (1999).

Nakoman, E. (1964). Etude palynologiqe de quelques échantillons de lignite provenant du Bassin de Thrace (Turquie). *Annales de la Société Géologique du Nord*, *74*, 289–303.

Nakoman, E. (1966a) Eosen yasli Sorgun linyitlerinin sporopollinik etüdü. *Maden Tetkik ve Arama Enstitüsü Dergisi*, *67*, 69–88.

Nakoman, E. (1966b). Contribution á I’étude palynologique des formations tertiaires du bassin de Thrace. I. Etude qualitative. *Annales de la Société Géologique du Nord, 86*, 65–107.

Nebert, K. (1956). Denizli–Acigöl merkezinin Jeolojisi, 1/100,000 ölçekli Denizli 105/1, 105/2 ve Isparta 106/1 paftalarinin sahasi içinde yapilan jeolojik harita çalismalari hakkinda rapor.*Maden Tetkik Arama Raporu,* (2509).

Nebert, K. (1957). Die braunkohlenvorkommen von Oeren. Mineral Research and Exploration Institute of Turkey (MTA) Rapor no 3011, 21p (unpublished).

Nebert, K. (1961). Kale–Tavas bölgesine ait yeni müsahedeler. *Bulletin Mineral Research Exploration Institution, 57,* 57–64.

Nebert, K. (1978), Linyit içeren Soma Neojen bölgesi,. Bati Anadolu: *Maden Tetkik Arama Enst. Derg.*. 90, 20-70.

Nichols, D. J. (1973). North American and European Species of *Momipites* („*Engelhardtia*“) and related Genera. *Geoscience and Man, 7,* 103–117.

Nickel, B. (1996a). Palynofazies und Palynostratigraphie der Pechelbronner Schichten im nördlichen Oberrheintalgraben. *Palaeontographica Abteilung B Ionnides, 240,* 1–151.

Nickel, B. (1996b) Die mitteleozäne Mikroflora von Eckfeld bei Manderscheid/Eifel. *Mainzer Naturw Archiv, 18,* 1–121.

Ollivier–Pierre, M. F. (1980). Étude palynologique (spores et pollens) de gisements paléogènes du Massif Amoricain. Stratigraphie et paléogéographie. *Mém. Soc. géol. minéral. Bretagne, 25,* 1–239.

Ollivier–Pierre, M. F. (1988). Pollen and spores (compilation). In. R. Vinken, (Ed.). The Northwest European Tertiary Basin. *Geologisches Jahrbuch, 100,* 288–320.

Oppenheim, P. (1919). Das Neogene in Kleinasien. I. Teii. Z. Deutsch. Geol. Ges., 70.

Paicheler, J.C., & Blanc, C. (1978). La Flore Du Bassin Lacustre Miocene de Bes–Konak (Anatolie septentrionale, Turquie).

Pacltova B. L. (1958). Palynologicky vyzkum kridovych, tretihormch a kvarternfch hornin v jihooeskych panvich v roce 1956. *V stmk G XXXIII*, 330-339.

Palamarev, E., & Mai, D. H. (1998). Die Paläogenen Fagaceae in europa: Artenvielfalt und Leitlinien ihrer entwicklungsgeschichte, Acta Palaeobotanica, 38(2), 227–299.

Palamarev, E., & Bozukov, V. (2004). The macroflora of Neogene sediments in the Elhova Formation (South Bulgaria), Phytologia Balcanica, 10(2–3), 131–146.

Palamarev, E., Bozukov, V., Uzunova, K., Petkova, A., & Kitanov, G. (2005). Catalogue of the Cenozoic plants of Bulgaria (Eocene to Pliocene), Phytologia Balanica, 11(3), 215–364.

Panova, L. A. (1966). Spory i phy’tsa iz neogenovykh otlozheny (Spores and polen from Neogene deposits) Paleopalinologia III, Trudy WSEGEI NS, 141: 228–257. (in Russian).

Paton, S. (1992). Active normal faulting, drainage patterns and sedimentation in southwestern Turkey. *Journal of the Geological Society, London 149,* 1031-1044

Pflanz, G. (1956). Das Alter der Braunkohlen des Meißners, der Flöze 2 und 3 des Hirschbergs und eines benachbarten Kohlenlagers bei Laudenbach. *Notizblatt des Hessiches Landesamtes für Bodenforschung zu Wiesbaden, 84,* 232–244.

Pflug, H. (1959). Beiträge zur Klimageschichte Islands. VIII. Sporenbilder aus Island und ihre stratigraphische Deutung. *Neues Jahrbuch für Geologie und Paläontologie*, *107,* 141–172.

Pierce, R. L. (1961). Lower Upper Cretaceous Plant Microfossils from Minnesota. *Üniv. of Minnesota. Geological Survey Bulletin, 42,* 86 pp.

Planderová, E. (1991). Miocene microflora of Slovak Central Paratethys and its biostratigraphical significance. *Dioniz Stur Institute of Geology*, Bratislawa, 144 pp.

Potonié, R. (1931). Zur Mikroskopie der Braunkohle. Tertiäre Blüntenstaubformen. IV. *Braunkohle*, *27:* 554–556.

Potonié, R. (1931 a). Zur Mikroskopie der Braunkohle. Tertiäre Blüntenstaubformen. *Braunkohle, 30* (16), 325–333.

Potonié, R. (1931b). Pollenformen aus tertiären Braunkohlen. *3. Jahrbuch der Preussischen Geologischen Landesanstalat*, *52,* 1–7.

Potonié, R. (1931c). Zur Mikroskopie der Braunkohlen. Tertiäre Sporen–und Blütenstaubformen. (4. Mitteilung). *Zeitschrift Braunkohle*, *30* (27), 554–556.

Potonié, R. (1931d). Pollenformen der miocänen Braunkohle (2. Mitteilung). *Sitz. Ber. Ges. Naturf. Fr.*, *1–3,* 24–29.

Potonié, R. (1934). Zur Mikrobotanik des eozänen Humodils des Geiseltales. *Arbeiten aus dem Institut für Paläobotanik und Petrographie der Brennsteine*, *4,* 25–125.

Potonié, R., & Venitz, H. (1934). Zur Mikrobotanik des miozänen Humodils der niederrheinischen Bucht. *Arbeiten aus dem Institut für Paläobotanik und Petrographie der Brennsteine, 5*, 5–58.

Potonié, R. (1951). Revision stratigraphisch wichtiger Sporo–morphen des mittel europäischen Tertiärs. *Palaeontographica Abteilung B Ionnides, 91*(5–6), 131–151.

Potonié, R. (1956). Synopsis der Gattungen der Sporae dispersae. I. Teil: Sporites. *Beihefte zum geologischen Jahrbuch*, *23*, 103pp.

Potonié, R. (1958). Synopsisder Gattungen der Sporae dispersae. II. Teil: Sporites (Nachträge), Saccites, Aletes, Praecolpates, Polyplicates, Monocolpates. *II. Beihefte zum Geologischen Jahrbuch, 31***,** 1–114.

Potonié, R. (1960). Synopsis der Gattungen der Sporae dispersae. III Teil: Nachträge Sporites, Fortsetzung Pollenites. *Beihhefte zum Geologischen Jahrbuch*, 39, 1–189.

Potonie, R., Thomson, P. W., & Thiergart, F. (1950). - Zur Nomenklatur und Klassifikation der neogenen Sporo- morphae (Pollen und Sporen). *Geol. Jahrb.*, 65, pp. 35-70

Raatz, G. V. (1937). Mikrabotanisch–stratigraphische Untersuchung der Braunkohle des Muskauer Bogens. *Abhadlungen der Preussischen Geologischen Landesanstalt Neue Folge, 183*, 3–48.

Rákosi, L. (1973). A dorogi–medence paleogén kèpzödményeinek palinologiaja. *Annales Instituti Geologici Publici Hungarici, 55*(3), 497–575.

Robertson, A. H. F. (1993). Mesozoic–tertiary sediments and tectonic evolution of Neotethyan carbonate platforms, margins and small oceanic basins in the Antalya Complex, southwest Turkey. *Spec. Publ. Int. Ass. Sediment*, *20*, 415–465.

Robertson, A.H.F. 2000. Mesozoic-Tertiary tectonic-sedimentary evolution of a south Tethyan oceanic basin and its margins in southern Turkey. *In*: Bozkurt, E., Winchester, J.A. & Piper, J.D.A. (eds) Tectonics and Magmatism in Turkey and the Surrounding Area. *Geological Society, London, Special Publications 173,* 353- 384.

Roche, E. (1988). Pollen and Spores (Compilation). In. R. Vinken (Ed), The Northwest European Tertiary Basin. *Geologisches Jahrbuch*, *100*, 288–320.

Rull, V. (1998a). Middle Eocene mangroves and vegetation changes in the Maracibo Basin. *Palaios*, *13*, 287–296.

Sachse, M. (19979. *Die makrilia flora (Kreta–Griechenland)–Ein Beitrag zur Neogenen Klima–und vegetationsgeschichte Des ostlichen mittelmeergebietes*, Geologe, Universität Göttingen, p.hd thesis, p. 311.

Sakala, J. (2000). Flora and vegetation of the roof of the main lignite seam in the bilina mine (most Basin, Lower Miocene), Acta Musei Nationalis Pragae, Series B, 56(1–2), 49–84.

Sancay, R. H., Bati, Z., Isik, U., Kirici, S., & Akça N. (2006). Palynomorph, Foraminifera, and Calcareous Nanoplankton Biostratigraphy of Oligo–Miocene Sediments in the Mus basin, Eastern Anatolia, Turkey. *Turkish Journal of Earth Sciences*, *15*, 259–319.

Sari, B. (2006). Foraminifera-Rudist Biostratigraphy, Sr-C-Isotope Stratigraphy and Microfacies Analysis of the Upper Cretaceous Sequences of the Bey Daglari Autochthon (Western Taurides, Turkey). *Dokuz Eylül University,* 436 pp.

Sarica, N. (2000). The Plio-Pleistocene age of Büyük Menderes and Gediz grabens and their tectonic significance on N-S extensional tectonics in West Anatolia: mammalian evidence from the continental deposists. *Geological Journal 35,* 1-24

Schalke, H. J. W. (1988). Pollen and Spores (Compilation). In R. Vinken (Ed), The Northwest European Tertiary Basin. *Geologisches Jahrbuch*, *100*, 288–320.

Schuler, M. C. (1988). Pollen and spores (compilation). In R. Vinken, (Ed.). The Northwest European Tertiary Basin. *Geologisches Jahrbuch*, 100, 288–320.

Schuler, M. (1990). Palynologie et biostratigraphie de l'Eocéne et de l'Oligocéne inférieur dans les fossés rhénan, rhodanien et de Hesse. Environnements et Paléoclimats Paléogénes. 3–513.

Seyitoglu, G., & Scott, B. (1991). late Cenozoic crustal extenension and basin Formation in west Turkey, Geological Magazine, 128, 155–166.

Seyitoglu, G., & Scott, B. (1992). The age of Büyük Menderes Graben (west Turkey) and its tectonic implications. Geological Magazine, 129, 239–242.

Seyitoglu, G., Isik, V. & Çemen, I. (2004) Complete Tertiary exhumation history of the Menderes massif, western Turkey: an alternative working hypothesis. *Terra Nova* 16, 358-364.

Slodkowska, B. (2004). Palynological Studies of the Paleogene and Neogene Deposits From the Pomeranian Lakeland Area (NW Poland). *Polis Geological Institute Special Papers, 14.* 1–116.

Snopková, P. (1983). Indexové fosilie paleogénu Západných Karpát Clastk. záver. správa. *Archiv Geol. Úst. D. Sturá*, 1–182.

Sözbilir, H. (1997). Stratigraphy and sedimentology of the Tertiary sequences in the northeastern Denizli province (southwest Turkey): Dokuz Eylül University, Graduate School of Natural and Applied Sciences, Ph.D. Thesis, 195 p., 4 sheet, Izmir.

Sözbilir, H. (2002). Revised stratigraphy and facies analysis of the Palaeocene–Eocene supra–allochthonous sediments and their tectonic significance (Denizli, SW Turkey), *Turkish Journal of Earth Sciences, 11*, 1–27.

Sözbilir, H. (2005). Oligocene–Miocene extension in the Lycian orogen: evidence from the Lycian molasse basin, SW Turkey. *Geodinamica Acta*, *18,* 255–282.

Strobitzer, M. (1999). Die fosilsen Blattvergesellschaftungen von Lintsching (Tamsweger, Salzburg, Miozän), Beiträge zur paläontologie, Nummer 24, p. 91–153.

Stuchlik, L. (1994). Neogene Pollen Flora of Central Europe. Part 1, Acta Palaeobotanica, 5–56.

Stuchlik, L., Ziembinska–Tworzydlo, M., Kohlman–Adamska, A., Grabowska, I., Wazynska, H., Slodkowska, B., & Sadowska, A. (2001). Atlas of pollen and spores of Polish Neogene. *W. Szafer Institute of Botany, Polish Academy Sciences, 1,* 1–69.

Stuchlik, L., Ziembinska–Tworzydlo, M., Kohlman–Adamska, A., Grabowska, I., Wazynska, H., & Sadowska, A. (2002). Atlas of pollen and spores of Polish Neogene. *W. Szafer Institute of Botany, Polish Academy Sciences*, *2*, 1–237.

Sun, S., Gelincik, Y. & Ünal, D. (1987). Mugla–Milas–Sekköy–Karaagaç Linyit sektörü 1986 yili çalisma raporu, MTA raporu.

Sun, H.E., Sun, R.S. & Karaca, K. (2001). Mugla–Milas–Ekizköy–Hüsamlar Sektörlerinin Jeoloji ve Fizibilite ve Jeofizik, MTA Raporu Kö: 172.

Sahbaz, A., & Görmüs¸ S. (1992). Çardak (Denizli) kuzeyindeki Eosen ve Oligosen yasli konglomeralarin stratigrafik ve sedimantolojik incelenmesi. *Ninth Petroleum Congress of Turkey*, *2*, 62–74.

Sahbaz, A., & Görmüs¸ S. (1993). Çardak (Denizli) Kuzeyindeki Eosen ve Oligosen yasli kumtaslarinin kaynak kaya türleri ve provenansi. *Yerbilimleri*, *16*, 43–53.

Sengör, A. M. C. &Yilmaz, Y., 1981, Tethyan evolution of Turkey: a plate tectonic approach, Tectonophysics, 75, 181–241.

Sengör, A.M.C., Görür, N. & Saroglu, F. (1985) Strike-slip faulting and related basin formation in zones of tectonic escape; Turkey as a case study. *Society of Economic Paleontologists and Minerologists, Spec. Pub. 37. Research Symposium, strike-slip Deformation, Basin Formation and Sedimentation. San Antonio, Texas*, 227-264

Sengör, A.M.C. 1987, Cross-faultsand differential streching of hanging walls in regions of low-angle normal faulting: examples from western Turkey. *In*:Coward M.P., Dewey J.F., Hancock, P.L.(Eds.), *Continental Extensional Tectonics, Geological Society Special Publication no.28, Geological Society, London*, pp.575-589

Tchihatcheff, M.P. (1869). Asie Mineure Description Physique de cette contrée, 8, Geologie, Paris.

Teodoridis, V. (2003). Tertiary flora and vegetation of the locality záhori near Ž atec (Most Basin, Czech Republic), Bulletin of Geosciences, Vol. 78(3), 261–276.

Teodoridis, V., & Kvacek, Z. (2006). Palaeobotanical research of the Early Miocene deposits overlying the main coal seam (Libkovice and Lom members) in the Most Basin (Czech Rebuplic), Bulletin of Geosciences, 81(2), 93–113.

Thiele–Pfeiffer, H. (1980). Die Miozäne Mikroflora aus dem Braunkohlentagebau Ode bei Wackersdorf / Oberpfalz. *Palaeontographica Abteilung B Ionnides*, *174*, 95–224.

Thiele–Pfeiffer, H. (1988). Die Mikroflora aus dem mittelozänen Ölschiefers von Messel bei Darmstadt. *Palaeontographica Abteilung B Ionnides, 211*, 1–86.

Thiergart, F. (1937). Die Pollenflora der Niederlausitzer Braunkohle, besonders im Profil der grube Marga bei Senftenberg. *Jahrbuch der Preusissischen Geologischen Landesanstalt*, *58*, 282–351.

Thomson, P. W., & Pflug, H. (1953). Pollen und sporen des mitteleurp.ischen Tertiärs. *Palaeontographica Abteilung B Ioannides*, *94*, 1–138.

Trevisan, L. (1967). Pollini fosilsi del Miocene superiore nei Tripoli del Gabro (Toscania). Palaeontographia Italica, 62, n. ser. 32: 1–73.

Utescher, T., & Mosbrugger, V.P. (1997–2006). Palaeoflora Database. (http://www. geologie.uni–bonn.de/Palaeoflora).

Utescher, T., Erdei, B., Francois, L., & Mosbrugger,V. (2007). Tree diversity in the Miocene forests of Western Eurasia. Palaeogeography, Palaeoclimatology, Palaeoecology 253, 226–250.

Ünal, D. (1988 a). Mugla–Milas–Ören–Alatepe kömür sahasi jeolojisi, MTA raporu, Kö. 86.

Ünal, D. (1988 b). Mugla–Milas–Sekköy Linyit sahasi jeolojisi, MTA raporu.

Ünal, D. (1990). Mugla–Milas–Sekköy–Ikizköy linyit sektörü jeolojisi, MTA raporu.

Van der Hammen, T. (1954). El desarrollo de la Flora colombiana en los periodos Geologicos 1. Maestrichtiano Hasta Terciaria mas Inferior. *Boletin Geological (Bogotá)*, *11*(1), 49–106.

Van der Hammen, T. (1956). Description of some genera and species of fossil pollen and spores. *Boletin Geological (Bogotá)*, *4*, 103–109.

Van der Hammen, T., & Wymstra, T. A. (1964). Apalynological study on the Tertiary and Upper Cretaceous of British Guayana. *Leidse Geologische Mededelingen*, *30*, 183–241.

Van Hoeken–Klinkenberg, P. M. J. (1964). A palynological investigation of some Upper Cretaceous sediments in Nigeria. *Pollen et Spores*, *6*, 209–231.

Wazynska, H. (1998). Palynology and Palaeogeography of the Neogene in the Polish Lowlands. *Prace Panstwowego Instytutu Geologicznego,* CLX. 5–42.

Webb, L.J. (1955). A physiognomic classification of Australian rain forests: Journal of Ecology, 47:551–570.

Wilf, P. (1997). When are leaves good thermometers? A new case for leaf margin analysis. Palaeobiology 23, 373–390.

Wilkonson, G. C., Bazley, R. A. B., & Boulter, M. C. (1980). The geology and palynology of the Oligocene Lough Neagh Clays, Northern Ireland. *Journal of Geological Society*, *137*, 65–75.

Wing, S. L., & Greenwood, D. R. (1993). Fossils and fossil climate: the case for equable continental interiors in the Eocene. Phil. Trans. Biol. Sci. 341, 243–252.

Wodehouse, R. P. (1933). Tertiary Pollen II. The Oil Shales of the Eocene Green River Formation. *Bulletin of the Torrey Botanical Club, 60*, 479–524.

Wolfe, J. A. (1979). Temperature parameters of the humid to mesic forests of eastern Asia and their relation to forests of other regions of the Northern Hemisphere and Australasia. United States Geological Survey Professional Paper 1106: 1–37.

Wolfe, J.A. (1993). Method of obtaining climatic parameters from leaf assemblages. U.S.Gel. Surv. Bull. 2040, 1–71.

Wolfe, J.A. (1995). Paleoclimatic estimates from Tertiary leaf assemblages. Annu Rev Earth Planet Sci 23: 119–142.

Wolfe, J.A., & Spicer, R.A. (1999). Fossil leaf character states: multivariate analysis. In: Jones, T.P., Rowe, N.P. (Eds.), Fossil Plants and Spores: Modern Techniques. Geological Society, London, pp. 233–239.

Wolff, H. (1934). Microfossilien des pliozänen Humodils der Grube Freigericht bei Dettingen a. M. Und Vergleich mit älteren Schichten des Tertiärs sowie posttertiären Ablagerungen. *Arbeiten aus dem Institut für Paläobotanik und Petrographie der Brennsteine*, *5*, 55–88.

Worobiec, G. (1995). Preliminary report on the Lower Miocene Leaf Flora from the Brown Coal Mine ‘BetCHATÓW’ (Central Poland), Acta Palaeobotanica, 35(2), 243–251.

Worobiec, G. (2003). New fossil floras from Neogene deposits in the Betchatów Lignite Mine, Acta Palaeobotanica, 3,3–133.

Worobiec, G., & Szynkiewicz, A. (2007). Betulaceae leaves in Miocene deposits of the Betchatów Lignite Mine (Central Poland), Rewiev of Palaeobotany and Palynology, 147, 28–59.

Yagmurlu, F. (1994). Isparta Kuzeyinde Yeralan Oligosen Yasli Molas Tipi Kirintili Tortullarin Tektono–Sedimenter Özellikleri. Çukurova Üniversitesi, *15. Yil sempozyumu*, 241–252.

Yilmaz, Y., Genç, S. C., Gürer, F., Bozcu, M., Yilmaz, K., Karacik, Z., Altunkaynak, S., & Elmas, A. (2000). When did the western Anatolian Grabens begin to develop? In E. Bozkurt, J. A. Winchester, & J.A.D. Piper, (Eds.) Tectonics and

Magmatism in Turkey and the Surrounding Area, vol. 173, *Geological Society, London, Special Publications*, *173*, 131–162.

Zachos, J., Pagani, M., Sloan, L., Thomas, E., & Billups, K. (2001). Trends, rhythms, and aberrations in Global Climate 65 Ma to present. *Science*, *292*, 686–693.

Zaklinskaya, E. D. (1957). Stratigraficheskoye znachenie pyl’tsy golosemiannykh kaynozoyskikh otlozheny Pavlodarskovo Priirtysa i severnovo Priaralya. (Stratigraphic significance of pollen grains of gymnosperms of the Cainozoic deposits of the Irish Basin and of the northern Aral Basin). *Trudy Geologicheskovo Instituta Akademii Nauk SSSR*, *2*(6), 1–220.

Zastawniak, E. (1972). Pliocene leaf flora from Dománski wierch near czarny Dunajec (Western Carpathians, Poland), Acta Palaeobotanica, 13(1), 1–73.

Zastwniak, E. (1995). New Data About Plant Macrofossils ,n the Middle Miocene Limestones at MLYNY Near Chmielnik (Central Poland), Acta Palaeobotanica, 35(2), 237–242.

Zastwniak, E., & Walter, H. (1998). Betulaceae from Sosnica near Wractaw (Poland)– A revision of Goeppert’s original materials and a study of more recent collections, Acta Palaeobotanica, 38(1), 87–145.

Zidianakis, G., Mohr, B. A. R., & Fassoulas, C. (2007). A late Miocene leaf assemblage from Vrysses, westerm Crete, Greece and its paleoenvironmental and palaeoclimatic interpretation, Geodiversitas, 29(3), 351–377.

Ziembinska–Tworzydlo, M. (1974). Palynological characteristics of the Neogene of Western Poland. *Acta Palaeontologica Polonica*, *19* (3), 309–342.

Ziembinska–Tworzydlo, M., Grabowska, I., Kohlman–Adamska, A., Skawinska, K., Slodkowska, B., Stuchlik, L., Sadowska, A., & Wazynska, H. (1994).

Taxonomical revision of selected pollen and spores taxa from Neogene deposits. In L. Stucklik, (Ed.). Neogene pollen flora of central Europe. *Acta Palaeobotanica*, *1*, 5–30.