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The Late Miocene Mammal Faunas of the Mytilinii Basin, Samos Island, Greece: New Collection

3. Palynology

by

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Abstract

The present article is dealing with the study of the microfloristic assemblages of the Miocene deposits of the Mytilinii Basin, Samos Island. The deposits are divided in five formations (Basal Fm, Mavradzei Fm, Hora Fm, Mytilinii Fm and Kokkarion Fm) and correspond to the time interval from middle Miocene to Pliocene. New data obtained from palynological analysis and chronostratigraphic correlations based on field work and sampling in the Mytilinii Basin, were co-evaluated with already existing data concerning the litho-biostratigraphy of marine and continental deposits of Greece. The qualitative palynological results were complemented by quantitative pollen based on climatic reconstructions during Vallesian and Turolian.

Keywords: Late Miocene, Samos, Greece, Palynology, Palaeoclimatic Reconstruction.

Zusammenfassung

Die vorliegende Studie beschäftigt sich mit den Mikrofloren des miozänen Ablagerungen des Mytilinii Beckens der Insel Samos. Die Ablagerungen werden in fünf Formationen geteilt (die Basal, die Mavradzei-, die Hora-, die Mytilinii- und die Kokkarion Formation), die zeitlich vom mittleren Miozän bis zum Pliozän reichen. Die neuen Daten aus der palynologischen Analyse des Mytilinii-Becken werden verglichen mit den bereits existierenden Resultaten aus der Litho- und Biostratigraphie der marinen und kontinentalen Ablagerungen Griechenlands. Die qualitativen palynologischen Ergebnisse werden durch quantitative ergänzt, basierend auf klimatischen Rekonstruktionen des Vallesiums und Turoliums.

Schlüsselworte: Obermiozän, Samos, Griechenland, Palynologie, paläoklimatische Rekonstruktion.

1. Introduction

The Island of Samos is situated in the eastern Aegean Sea near the coast of Asia Minor and is well known for its late Miocene mammal faunas since the middle of the 19th century. The known fossiliferous sites are situated in the Neogene Mytilinii Basin, the palynological record of which is poorly known. Some palynological data from the lowest part of the Neogene deposits are given earlier (Ioakim & Solounias, 1985). The palynogological analysis of the deposits is important in order to get information about the palaeoenvironment and the climatic conditions during the Neogene. Although, there are several mammal fossil sites on Samos, their chronology and palaeoecological conditions are not clearly defined, as the collections are old and lack or have limited stratigraphic control. In 1993 a team of palaeontologists from the Laboratory of Geology and Palaeontology, University of Thessaloniki, led by G. K., started an extended study of the Neogene deposits of the Mytilinii Basin. The main goal of this research was to relocate the fossiliferous sites, to correlate them with the stratigraphy, to excavate for new fossils and to date the faunas. The palynological study of the Neogene deposits of the Mytilinii Basin was also included in this research. The analysis of the pollen samples was carried out in the laboratory of IGME (Institute of Geological and Mining Exploration) by C.I.

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2. Stratigraphy of the Mytilinii Basin

The stratigraphy of the Neogene deposits of the Mytilinii Basin has been studied by various authors and different approaches have been formulated. A synopsis of all views on the stratigraphy of the basin is given in Kostopoulos et al. (this volume, Fig. 1). According to them the lithostratigraphy of the Mytilinii Basin includes the following formations from bottom to the top:

Basal Formation: It overlies the basement unconformably and consists of red-brown sands and conglomerates with gravels and pebbles from the basement. Its age is estimated as middle Miocene.

Mavradzei Formation: The formation consists of fossiliferous limestones with intercalations of lignitic clays rich in Planorbiidae. In the upper part of the Mavradzei Fm there is a basalt flow and a series of lahar type volcanoclastic sediments. The age of the formation is middle Miocene-lowermost late Miocene.

Hora Formation: The formation consists of a series of thick-to-laminated, lacustrine limestones with intercalations of tuffaceous clays. It is dated to Vallesian.

Mytilinii Formation: Fluvio-terrestrial deposits, consisting of reddish-brown volcanoclastic sediments, mainly sands, sandstones, tuffaceous sands, lenses of conglomerates, marly limestones and silty marls. All the known mammal fossiliferous sites of Samos Island are situated in the Mytilinii Fm. It is dated to Turolian.

Kokkarion Formation: The younger formation of the basin represents shallow lacustrine deposits. It consists of alternated beds of white-yellowish limestones, travertine limestones with green-brown clays and tuffaceous sands. The limestones are occasionally fossiliferous with plant remains, *Phragmites* and the gastropod *Brotia* cf. *graeca*. It is dated to latest Miocene-Pliocene.

A composite lithostratigraphic column of the Mytilinii Basin with the different formations and their age according to Kostopoulos et al. (this volume) is given in Fig. 1.

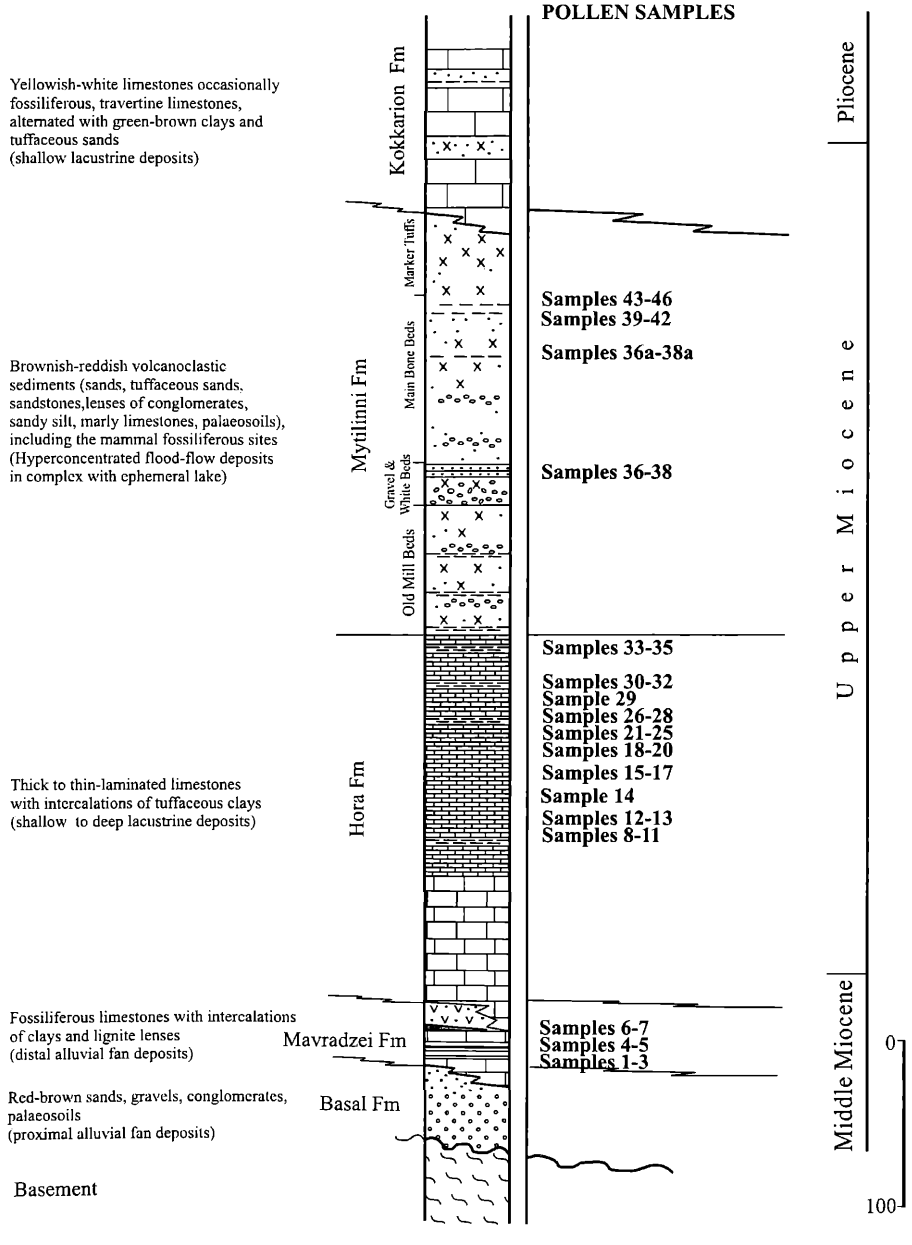

Figure 1: Synoptic stratigraphic column of the Mytilinii Basin with the lithology and age of the various formations, indicating the pollen sampling horizons. The stratigraphic column was taken from Kostopoulos et al. (this volume).

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3. Methodology

As a great number of the available sediments are not appropriate for the preservation of the pollen grains, the sampling of the pollen bearing sediments focus on the Vallesian and the Turolian deposits of the basin. Thus, 46 samples were collected along the Neogene sedimentary sequence (Fig. 1). The collected material was treated according to the standard palynological method with HCL and HF acides and sieved through a 6μm nylon mesh. Slides were prepared using glycerine jelly as a mounting medium. The palynomorphs were analysed per sample under a binocular transmission light Nikon microscope. They were processed according to standard procedures (Cour, 1974). For each sample at least 200 pollen grains were counted besides the dominant taxons, because the pollen concentrations were very low and 85 taxa were identified. The palynological results are presented as percentages in a synthetic diagram (Fig. 2). The pollen taxa were organized in ten groups on the basis of the ecological and climatic requirements of the present correlatives (Suc, 1984, 1989). The floral list is plotted in Table 1. In the pollen spectra the groups from left to right are:

- Megathermic(-tropical) elements: Mimosaceae, Rubiaceae, Euphorbiaceae (SUM A).
- Mega-mesothermic (subtropical) elements, requir-

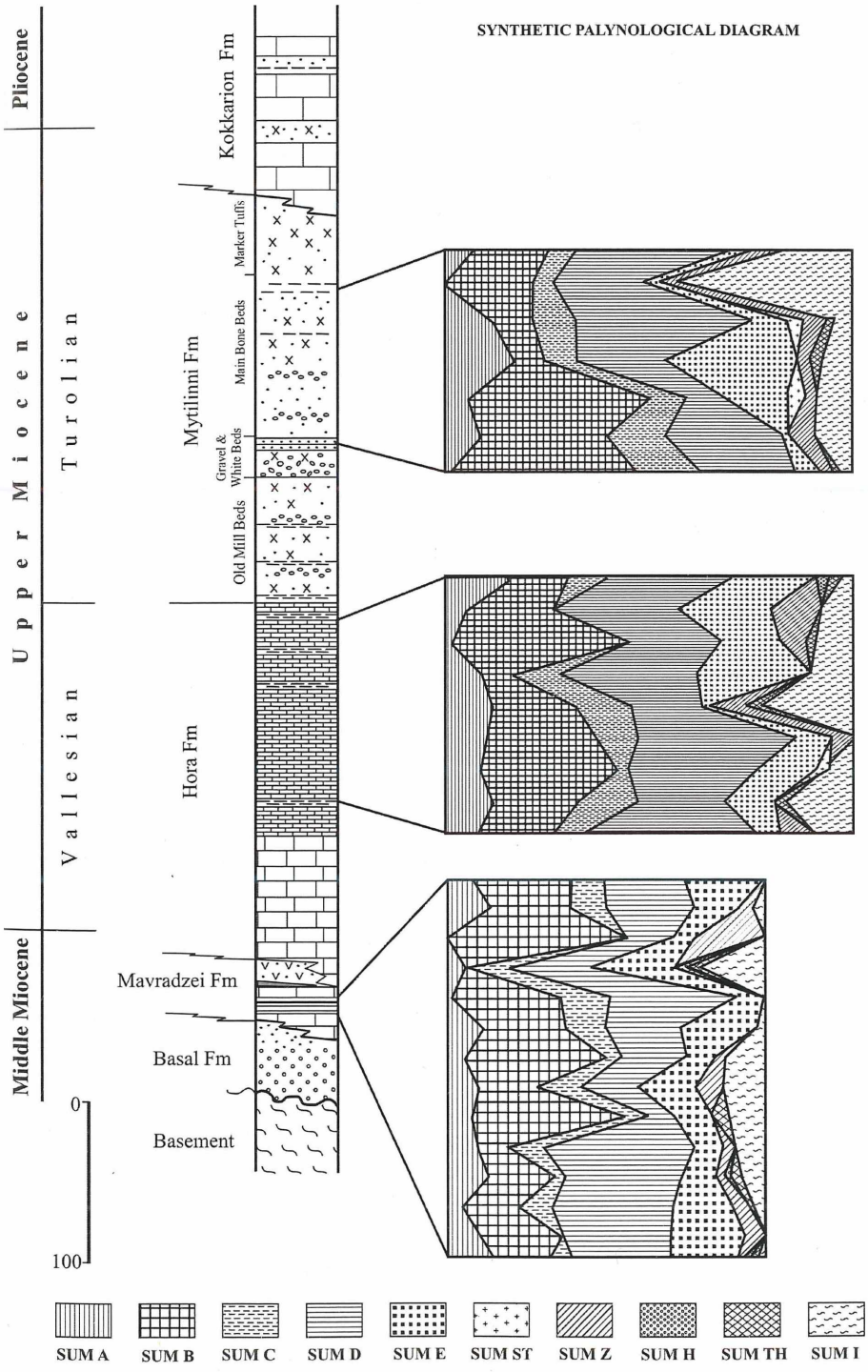

Figure 2: Synthetic Pollendiagrams of the Mytilinii Basin deposits correlated with the stratigraphy. The stratigraphic column was taken from Kostopoulos et al., this volume.

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Pinaceae	**Betulaceae**	**Juglandaceae**	**Plumbaginaceae**
Pinaceae sp.	*Betula*	Juglandaceae sp.	*Armeria*
Pinus	*Carpinus*	*Carya*	**Ranunculaceae**
P. haplostelle-type	*Alnus*	*Engelhardia*	Ranunculaceae sp.
Cathaya	*Ostrya*	*Juglans*	**Platanaceae**
Cedrus	**Buxaceae**	*Platycarya*	*Platanus*
Tsuga	*Buxus*	*Pterocarya*	**Polygonaceae**
Picea	**Caprifolliaceae**	**Liliaceae**	*Rumex*
Abies	*Lonicera*	Liliaceae sp.	**Rubiaceae**
Cupressaceae	**Caryophyllaceae**	**Loranthaceae**	Rubiaceae sp.
Cupressaceae sp.	Caryophyllaceae sp.	cf. Loranthaceae sp.	**Salicaceae**
Ephedraceae	**Chenopodiaceae - Amaranthaceae**	**Mimosaceae**	*Salix*
Ephedra	**Cyperaceae**	Mimosaceae sp.	**Symplocaceae**
Taxodiaceae	Cyperaceae sp.	**Myricaceae**	*Symplocos*
Taxodium t.	**Cyrillaceae - Chlethraceae**	*Myrica*	**Tiliaceae**
Sequoia t.	Cyrillaceae - Chlethraceae sp.	**Nymphaeaceae**	*Tilia*
Aceraceae	**Ericaceae**	Nymphaeaceae sp.	**Typhaceae**
Acer	Ericaceae sp.	**Nyssaceae**	*Typha*
Araliaceae		*Nyssa*	
Araliaceae sp.			
Asteraceae - Asteroideae			
Artemisia			
Asteraceae - Cichoroideae			
Asteraceae - Cichoroideae sp.			
Euphorbiaceae			
Euphorbiaceae sp.			
Fagaceae			
Castanea			
Quercus			
Fagus			
Quercus ilex t.			
Hamamelidaceae			
Hamamelidaceae sp.			
Liquidambar			
Parrotia			
Oleaceae			
Olea			
Fraxinus			
Palmae			
Palmae sp.			
Platanginaceae			
Platango			
Ulmaceae			
Ulmus			
Celtis			
Vitaceae			
Vitis			
Osmundaceae			
Osmunda			
Polypodiaceae			
Polypodiaceae sp.			

Table 1: Stratigraphic comparison of previous studies complied in the Mytilinii Basin, Samos, Greece.

ing high (climatic or edaphic) humidity: Taxodiaceae (*Taxodium*- type and rare pollen grains of *Sequoia*-type) principally and subordinated *Nyssa*, Palmae, Sapotaceae, *Engelhardia*, *Myrica* (SUM B).

• *Cathaya* plus *Pinus* haplostelle type: *Cathaya* is an Asiatic gymnosperm tolerating low temperature but requiring high humidity during all the year (SUM C).

• Mesothermic elements (warm temperate): requiring a humid climate but tolerating seasonal contrast in humidity and temperature. The deciduous *Quercus* is the principal component with *Carya*, *Juglans*, *Platycarya*, *Pterocarya*, *Ulmus/Zelkova*, *Liquidambar*, *Carpinus*, *Castanea*, *Acer*, *Fraxinus*, Araliaceae etc. (SUM D).

• *Pinus* and indeterminable pollen grains of Pinaceae, characteristic of various and different ecological and climatic requirement (SUM E).

Meso-microthermic elements (i.e. mid to high altitude trees) *Tsuga*, *Cedrus* (SUM ST).

• The altitudinal elements *Abies* and *Picea* (SUM Z).

Cupressaceae and *Alnus*, *Salix* elements with local significance (SUM H).

• Mediterranean thermophyllous evergreen elements: *Olea*, *Quercus ilex*-type, *Cistus*, *Buxus* (SUM TH).

• Herbaceous elements (Amaranthaceae-Chenopodiaceae, Compositae, Graminae, Ericaceae, *Plantago*, Polygonaceae, Umbelliferae, Plumbaginaceae, Caryophyllaceae), including steppe elements (*Artemisia*, *Ephedra*, requiring an arid and sometimes a cooler period, and water depending plants (Typhaceae, Nympheaceae, etc.) (SUM I).

4. Pollen Flora: Vegetational and Climatic Inferences

The pollen flora is dominated by arboreal pollen grains (Fig. 2): Taxodiaceae (*Taxodium*-type) are principally followed by *Pinus*, sometimes *Abies*, *Tsuga* and *Cedrus*, also associated with the deciduous *Quercus* taxa, *Carya*, *Pterocarya* and the evergreen Mediterranean taxa (*Olea*, *Quercus ilex*-type etc). Herbs and shrubs (e.g. Poaceae,

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Amaranthacea, Chenopodiaceae, Gramineae, *Ephedra*, *Artemisia* and other Compositae) are constantly present but they show a major increase. The sclerophyllous *Quercus ilex*-type and the deciduous *Quercus*-type are used as climatic indicators, based on their climatic requirements. The first species (*Quercus ilex*-type) require substantial winter precipitation and low winter temperatures. On the contrary, the deciduous taxa of *Quercus*-type (*Quercus pubescens* or *Q. robur*) require higher soil water availability in summer and support also cold and dry winters. The Mytilinii Basin data set are divided in three pollen assemblages.

Mavradzei Assemblage: The palynological associations are included in five dark clay horizons sampled from an outcrop that is located very close to the village of Mavradzei. The thickness of each clay horizon ranges from 1 - 2 cm and they are intercalated by grey-brown marly beds, which are rich in fresh-water gastropods (mainly Planorbiidae) and sandy layers with amorphous leaf impressions (Fig. 1). The total thickness of the sampled section is about 12 m, from where seven samples were collected for pollen analysis. The megathermic elements, living under moist or dry conditions, such as the pollen grains of Mimosaceae are abundant, while the Euphorbiaceae, Rubiaceae are very rare. The mega-mesothermic and mesothermic elements requiring high (climatic or edaphic) humidity, like Taxodiaceae (*Taxodium*-type) in particular, *Engelhardia*, *Myrica* are well represented. The taxa demanding a warm temperate climate and relatively high humidity, like the deciduous *Quercus*, *Carya*, *Eucommia*, *Ulmus/Zelkova*, *Juglans* are also well expressed. The Pinaceae, *Pinus*, *Abies* and *Tsuga* are abundant. The altitudinal elements are very poor, while pollen grains of the riparian plants, like *Alnus*, *Salix* and Cupressaceae are also recorded. On the contrary, most of the thermophilous evergreen taxa (*Buxus*, *Quercus ilex*-type, *Cistus*) are rare. The herb assemblages are dominated by Amaranthaceae-Chenopodiaceae, Gramineae, Compositae. Other common elements are those of water depended plants, such as Nymphaeaceae and Typhaceae, while some fern spores are also recorded. The presence of this microflora in the Mavradzei Fm suggests warm and humid climatic conditions during middle Miocene. Equivalent warm and humid conditions are also assumed for the Mediterranean during middle Miocene with the development of mixed mesophytic forests (Agustí et al., 2003).

Hora Assemblage: The overlying Hora Fm consists of lacustrine limestones intercalated by tuffaceous clays in the upper part. Twenty eight samples were collected from the type section of the Hora Fm, across the road from Hora to Mytilinii, from the clayey intercalations covering a thickness of about 120 m (Fig. 1).

The pollen assemblage obtained from this section reveals a homogeneous vegetation of a more or less widespread forest consisted mainly of mega-mesothermic *Engelhardia*, Taxodiaceae (*Taxodium*-type principally and sporadically *Sequoia*-type), Hamamelidaceae, *Nyssa*, *Myrica*, Sapotaceae etc.) and mesothermic *Carya*, *Pterocarya*, *Cathaya*, *Ulmus/Zelkova*, *Acer*, *Carpinus*, *Symplocos*, Betulaceae, Fagaceae (*Quercus*, *Castanea*, *Fagus*) elements. The altitudinal belts are characterized by enrichment of mesothermic trees (*Cedrus*, *Abies*, *Tsuga*), (Fig. 2). Herbs occur in lower frequencies with respect to the previous palynological assemblages.

Mytilinii Assemblage: The general lithologic features of the Mytilinii Fm correspond to volcanoclastic fluviolacustrine sediments which are not favorable for the preservation of pollen grains. The total thickness of the formation is ~230 m but only a short part of it (~30 m) was sampled. This part covers the main mammal fossiliferous horizons (Fig. 1) from which 14 samples were collected from the most profitable clayey horizons.

The pollen spectra is characterized by the presence of *Calligonum*, *Lygeum*, as well as the high abundance of more thermophilic and xerophytic elements like *Olea*, *Cistus*, *Quercus ilex*-type. Moreover, it includes a high percentage of open vegetation plants, like Compositae, Amaranthaceae-Chenopodiaceae, as well as steppe elements like *Artemisia* and *Ephedra*. The absence of aquatic plants is characteristic (Fig. 2), indicating drier conditions in comparison to the previous assemblages. This pollen flora suggests an open vegetation rich in herbs, growing under dry / warm-temperate climatic conditions. The presence of these taxa is characteristic of southern Mediterranean vegetation and they are found today in Southern Spain, Southern Italy, Sicily, Crete and North Africa

Moreover, during the beginning of late Miocene, the conditions changed, becoming more and more arid. According to Agustí et al., 1999, 2003; Agustí & Antón, 2002; Bonis et al., 1992; Koufos, 2006a) this aridity was gradually extended to the Western Mediterranean regions.

5. Conclusions

The palynological study of the Neogene deposits from Mytilinii Basin allows the recognition of different vegetational environments corresponding to the climatic evolution of the wider Samos area during Miocene. In the Middle Miocene the main vegetational features are characterized by mixed mesophytic forests. This view fits quite well with the known palaeoenvironmental conditions of the Mediterranean during middle Miocene (Agustí et al., 2003). During Vallesian, the pollen flora of the Mytilinii Basin was developed near a deep lacustrine environment under warm-temperate climatic conditions. The formation of thin-laminated marly limestones depends on the water depth and suggests that the sedimentary sequence of the Hora Fm was deposited in a deeper lacustrine environment, followed by the clastic sediments of the Mytilinii Fm during Turolian. This means a desiccation of the Vallesian lake of the Mytilinii Basin. In fact, during the beginning of Vallesian, the conditions in Eastern Mediterranean started to change, being more arid, as is indicated from the study of the mammal faunas (Bonis et al., 1992; Koufos; 2006a). In spite of the relatively drier conditions, the lacustrine environment of the Mytilinii Basin seems to be preserved till the end of Vallesian. However, in the wider Eastern Mediterranean

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the Vallesian mammal assemblages suggest a relatively open environment with bushes, shrubs and grass (Bonis et al., 1992, 1999; Bonis & Koufos, 1994; Merceron et al., 2005, 2007; Koufos, 2006a).

The Mytilinii Fm corresponds to the Turolian time-interval and its palynological composition (low abundance of Taxodiaceae and *Pinus*, high percentage of herbaceous plants, including steppe elements and the fairly continuous presence of the Mediterranean sclerophyllous plants), indicates a warm-temperate climate, where an open vegetation was developed. Similar conditions were also proposed from the study of the dental wear and the analysis of the mammal fauna found in the Mytilinii Fm, suggesting an open bushland with rich grass floor (Koufos et al., this volume-a). Similar conditions were recorded in the Turolian of Axios Valley, Macedonia, Greece (Bonis et al., 1992; Merceron et al., 2005, Koufos, 2006b), as well as in the Turolian of Thessaly, Greece (Koufos et al., 2006). The Turolian palynological record of the Serres Basin (Macedonia, Greece) indicates the existence of sub-tropical vegetational development associated with well represented Poaceae. The latter suggests a more open environment growing under sub-tropical climate with moderately moist to dry conditions (Broussoulis et al., 1990; Karistineos & Ioakim, 1989). According to Bonis et al. (1994), also in Turkey an open environment under arid climatic conditions existed during the Turolian period. More precisely, the study of the Turolian mammal faunal assemblages of Asia Minor indicate that there is a trend to more open and arid conditions than those of Continental Greece from Early Turolian (MN 11) to the end of Middle Turolian, MN 12 (Koufos et al., this volume-a). The study of the phytolith assemblages from the Samos mammal fossiliferous horizons confirms the open character of the landscape during Turolian (Strömberg et al., 2008)

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PLATE 1

Fig. 1. *Pinus* diplostelle-type

Fig. 2. *Pinus* haplostelle-type

Fig. 3. *Tsuga diversifolia*

Fig. 4. *Ulmus/Zelkova*

Fig. 5. *Taxodium* sp.

Fig. 6. *Alnus* sp.

Fig. 7. *Alnus* sp.

Fig. 8. *Corylus* sp.

Fig. 9. *Alnus* sp.

Fig. 10 *Betula* sp., *Myrica* sp.

Fig. 11. *Quercus pubescens*

Fig. 12. *Betula* sp.

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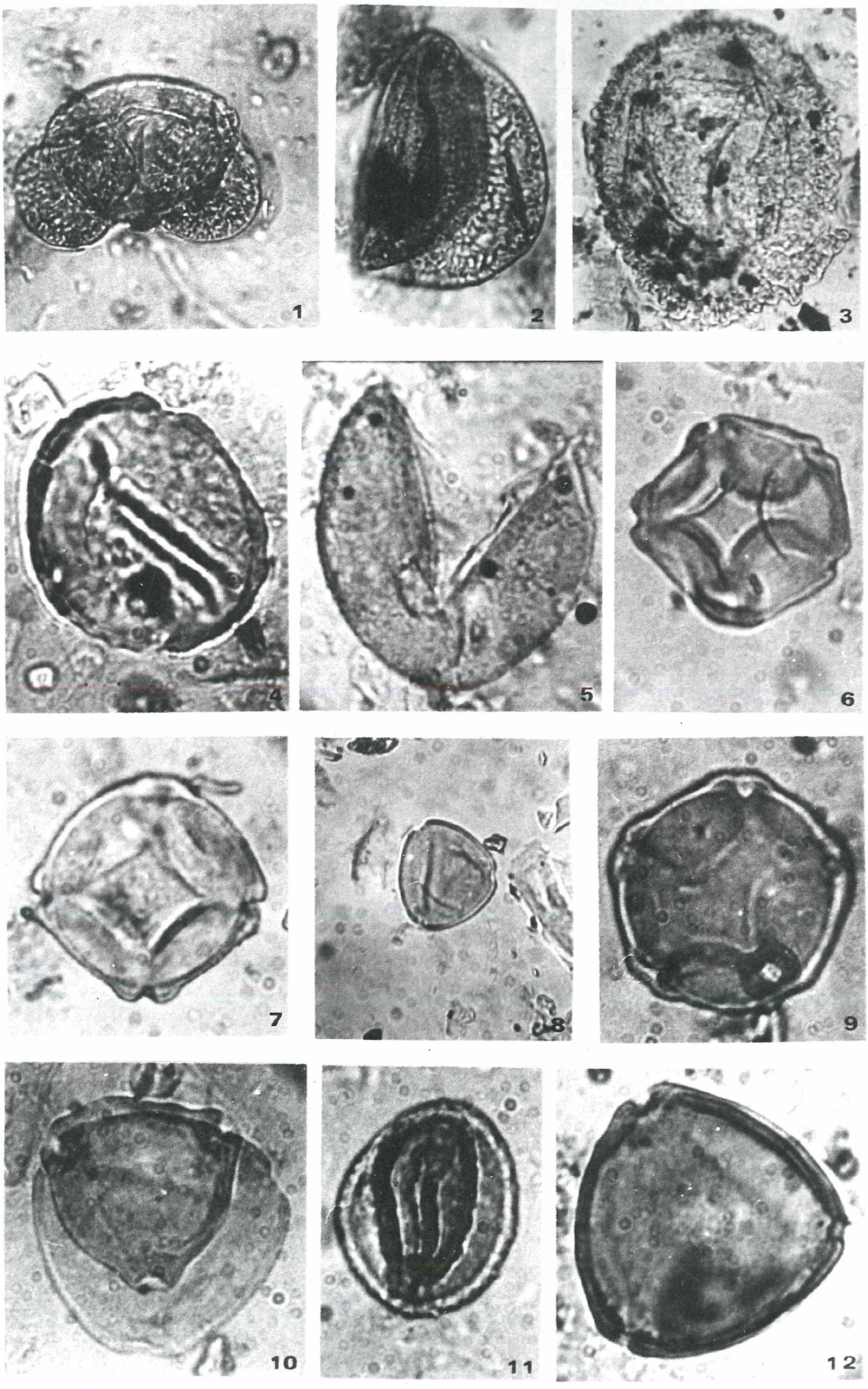
PLATE 1



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Zoologisch-Botanische Datenbank/Zoological-Botanical Database

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