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Tertiary Terrestrial to Shallow Marine Deposition in Central Anatolia: A Palynological Approach

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Abstract: In central Turkey the Çankırı Basin developed between the Kırşehir and Sakarya continents as a collisional basin during the Tertiary. Along the southern border, between Yozgat and Yerköy, the basin fill predominantly comprises continental and shallow marine facies, and overlies the Late Cretaceous Kırşehir Block unconformably. The Yoncalı formation (shallow marine sandstones, shales and limestone lenses), the İncik formation (terrestrial conglomerates and sandstones) and the Bayat formation (subaerial lavas and pyroclastic rocks) are Middle to Late Eocene in age and grade laterally and vertically into each other. These units are unconformably overlain by a Middle Miocene continental sequence that is composed of terrestrial conglomerates, laminated shales and evaporites, called the "*cover series*". These dominantly continental sequences are generally devoid of fossils.

Coal and carbonaceus shale horizons of the Çankırı Basin fill and the "*cover series*" were sampled and their spore and pollen associations were examined to define the palynomorph content, and determine ages and palaeoclimatic and palaeoecological conditions of the Tertiary units in the Çankırı Basin. The palynologic determinations indicate that the Yoncalı and İncik formations are of Middle-Late Eocene age and the overlying cover units of the Kızılırmak and Bozkır formations are of Middle Miocene age. In addition to sedimentologic features, the palynomorph association, observed in the Yoncalı formation, indicates that the unit was deposited in swamps between the channels of a deltaic environment. The presence, in particular, of the tropical Gleicheniaceae, Schizeaceae, Icacinaceae, Palmae and the tropical-subtropical Cyrillaceae, Simaroubaceae, Anacardiaceae, and Sapotaceae indicate a moist tropical climate during deposition of the coals and shales of the Yoncalı formation. Cupressaceae, *Taxodium*, Oleaceae, *Nyssa, Carya, Engelhardtia*, Cyrillaceae, *Alnus, Ulmus* and *Pterocarya*, observed in the Kızılırmak and Bozkır formations, indicate that the units were deposited in a lacustrine environment under subtropical climatic conditions.

Key Words: Eocene, Middle Miocene, palynostratigraphy, palaeoecology, central Anatolia, Turkey

Orta Anadolu Tersiyer Karasal-Sığ Denizel Tortullaşması: Palinolojik Bir Yaklaşım

Özet: Orta Türkiye'de Çankırı Havzası, Tersiyer süresince, Kırşehir ve Sakarya kıtaları arasında yer alan bir çarpışma havzası olarak şekillenmiştir. Havzanın güney sınırı boyunca, Yozgat-Yerköy arasında, havza dolgusu egemen olarak karasal ve sığ denizel fasiyestedir ve Geç Kretase yaşlı Kırşehir Bloğu'nu uyumsuzlukla örter. Yoncalı formasyonu (sığ denizel kumtaşları, seyller ve kireçtaşı mercekleri), İncik formasyonu (karasal konglomeralar ve kumtaşları) ve Bayat formasyonu (karasal lavlar ve piroklastik kayalar) Orta-Geç Eosen yaşlıdır ve birbirleri ile yanal ve düşey geçişlidir. Bu birimler Örtü Serileri olarak adlanan, karasal konglomeralar, laminalı şeyller ve evaporitlerden yapılı, Orta Miyosen karasal istifi tarafından uyumsuzlukla üstlenir. Bu egemen karasal istif genellikle fosilsizdir.

Bu çalışmanın amacı Çankırı havzasında Tersiyer birimlerinin yaşlarını ve paleoklimatik ve paleoekolojik koşullarını saptamak ve palinomorf içeriğini tanımlamaktır. Bu amaca ulaşmak için, Çankırı Havza'sı tortul dolgusunun kömür ve karbonlu şeyl horizonları ve Örtü Serileri örneklenmiş ve onların spor ve pollen toplulukları incelenmiştir. Palinolojik incelemeler, Yoncalı ve İncik formasyonlarının Orta-Geç Eosen, üzerleyen Kızılırmak ve Bozkır formasyonları örtü birimlerinin ise Orta Miyosen yaşlı olduğunu belirtir. Sedimentolojik özelliklerin yanısıra, Yoncalı formasyonundan tanımlanmış olan palinomorf topluluğu, bu birimin bir delta ortamının kanalları arasıdaki bataklıklarda depolanmış olduğunu tanımlar. Özellikle tropical Gleicheniaceae, Schizeaceae, Icacinaceae, Palmae ve tropikal-subtropikal Cyrillaceae, Simaroubaceae, Anacardiaceae ve Sapotaceae'nin varlığı, Yoncalı formasyonu kömür ve şeyllerinin depolanması sırasında nemli tropical bir iklimin varlığını gösterir. Kızılırmak ve Bozkır formasyonlarında Cupressaceae, *Taxodium*, Oleaceae, *Nyssa, Carya, Engelhardtia*, Cyrillaceae, *Alnus, Ulmus* and *Pterocarya*'nın gözlenmesi, bu birimlerin subtropikal iklim koşulları altında ve gölsel ortamda depolandığını belirtir.

Anahtar Sözcükler: Orta Eosen, Orta Miyosen, palinostratigrafi, paleoekoloji, orta Anadolu, Türkiye

Introduction

Central Turkey is made up several continental fragments which were assembled during Late Cretaceous-Early Tertiary time interval by the closure of the Neotethys Ocean (Şengör & Yılmaz 1981). Complex deformations along the collisional zone are partially recorded in the sedimentary successions of remnant basins evolved along the suture zone (Erdoğan *et al.* 1996; Koçyiğit *et al.* 1995; Poisson *et al.* 1996). The Tuzgölü, Çankırı and Sivas basins are all situated along this complex collisional zone (Görür *et al.* 1985; Cater *et al.* 1991; Erdoğan *et al.* 1996; Poisson *et al.* 1996) (Figure 1). The Çankırı Basin, into which thick detrital sedimentary sequences and volcanic rocks of Eocene age were deposited, developed between the Kırşehir and Sakarya continents (Erdoğan *et al.* 1996; Tüysüz 1993) and unconformably overlain by evaporite-bearing Miocene continental successions.

At the northern margin of the Çankırı Basin, there was a relatively deep-marine environment and a tectonically active area during Eocene time. Ophiolitic mélange nappes of the suture zone complexes thrust southward into the basin along this border throughout the Eocene Period (Erdoğan *et al.* 1996).

The southern border of the basin was tectonically quiescent and the depositional sites were partly continental-deltaic and partly shallow marine. Red conglomerates, red sandstones, evaporite sequences and coal-bearing mudstones and sandstones formed along this border. They are generally fossil-poor and only the rare marine intercalations yield fossils suitable for age determinations. The overlying Miocene sequence also consists of predominantly continental successions of red sandstones, conglomerates and evaporite horizons.

In most areas, the continental deposits of the Eocene and Miocene successions are lithologically similar and

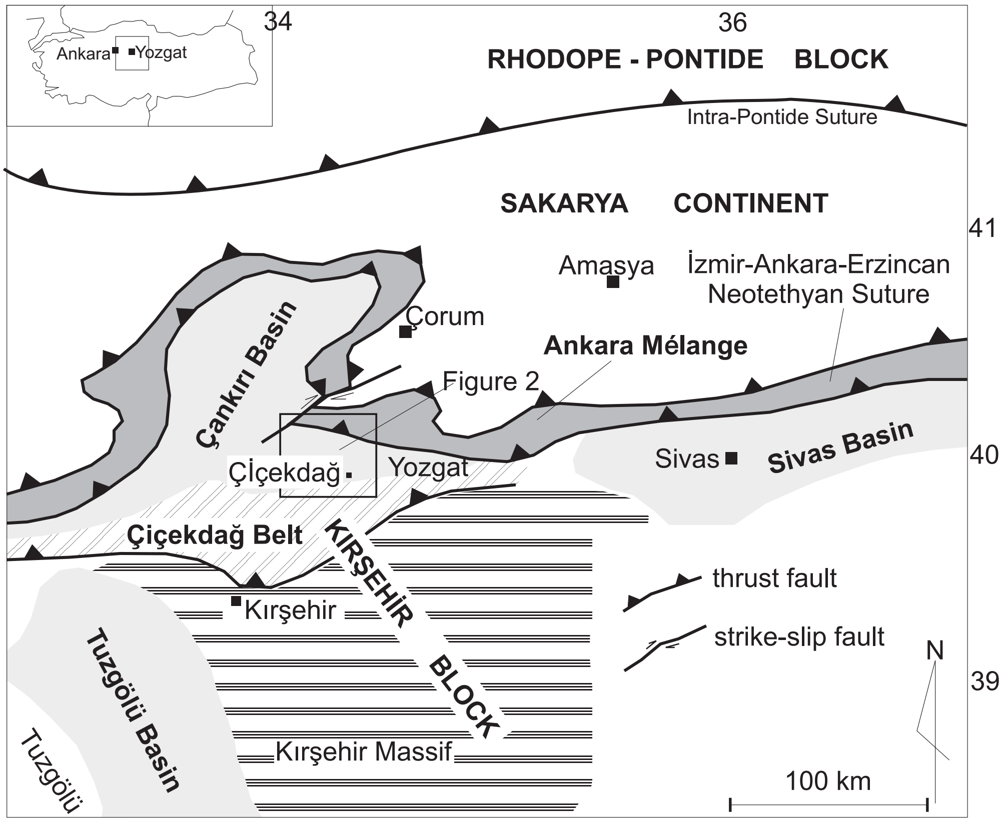


Figure 1. Main tectonic belts of central Anatolia and locations of the sedimentary basins developed along the collision zone between these belts. (Simplified after Tüysüz 1993).

their distinction is difficult. In previous studies, either a long time span was attributed to these rock units or, very often, their age has been assigned on the basis of underlying or overlying units, so that mistakes have been made in "reconstructing" the stratigraphy. The evaporite-bearing detrital rocks, coal seams, and carbonaceous-mudstone intervals yield, however, abundant palynomorph assemblages. The palynomorph assemblages of the complete stratigraphic section of the Çankırı Basin along its southern border have been examined in this study and the age of the continental sequences has been determined for the first time. Detailed definitions of the palynological associations allowed us to approach the palaeoecologic and palaeoclimatic conditions which reigned in the area during the Middle Eocene and the Middle Miocene.

All over the world, it is well known that the climate cooled through the latter part of the Eocene (e.g., Chateauneuf 1980; Wilkinson *et al.* 1980; Sarkar & Singh 1988; Martin 1990; Collinson 1992; Oboh *et al.* 1996). Wolf (1994) suggested that a major and rapid climatic detoriation occurred in the Oligocene, and, that a major climatic fluctuation probably occurred in the Late Eocene. In this study, the palaeoecological and palaeoclimatic conditions from the maximum tropical period to the cooling period are also emphasised.

Stratigraphy

Along the southern border of the Çankırı Basin, three units may be distinguished based on their tectonostratigraphic settings (Figures 2 & 3). These are (1) the Çiçekdağ belt that forms the basement; (2) Çankırı basin-fill; and (3) the cover series. The Çiçekdağ belt consists of mafic volcanic rocks and the cross-cutting Yozgat granitoids and rhyolitic volcanics (Erdoğan *et al.* 1996). The Çankırı Basin-fill is made up of detrital sedimentary rocks and intercalated volcanics. The "*cover series*" is dominated by red sandstones and conglomerates unconformably overlying the basement and the Çankırı Basin-fill.

Çiçekdağ Belt

The Çiçekdağ belt crops out over a large area between the towns of Yozgat (Figure 1) and Çiçekdağ (Figure 2). An entire region from Kırşehir to Yozgat has been named the Kırşehir Massif (Ketin 1955), and the study area has been considered to be the northern continuation of this massif. Şengör & Yılmaz (1981) and Tüysüz & Dellaloğlu (1992) interpreted the same belt as a part of the Kırşehir Continent and Göncüoğlu *et al.* (1993) named the region the Central Anatolian Crystalline Complex. Conversly, Erdoğan *et al.* (1996) recognized the Çiçekdağ belt as a separate thrust belt above the Kırşehir Massif along a major fault, and renamed the Kırşehir Massif and the Çiçekdağ belt together the Kırşehir Block (Figure 1), which was assembled before the formation of the Çankırı Basin and acted as an intact basement.

In the stratigraphically lower parts of the Çiçekdağ belt, a very thick sequence of volcanic rocks, diabases and rare microgabbro stocks crop out (Akay 1994; Erdoğan *et al.* 1996; Yalınız *et al.* 2000). The mafic volcanic rocks include rare crystallized limestone lenses and the total thickness of the volcanic succession reaches up to four km. This unit, which was first named the Çökelik volcanics by Akay (1994), has yielded an association of planktonic foraminifers including *Marginatruncana coronata, M. linneiena, Hedbergella* sp., Globotruncanidae and Radiolaria, indicating a Turonian-Santonian age. Erdoğan *et al.* (1996) noted that the Çiçekdağ belt formed as an ensimatic primitive island arc in the Neotethys Ocean that was later thrust onto the Kırşehir platform. After thrusting, both were cut by granitic plutons and their subvolcanic and volcanic equivalents of rhyolitic lavas, which together are termed the Yozgat magmatics (Figure 3). The sedimentary sequences of the Çankırı Basin were deposited on the deeply eroded surface of the Yozgat magmatics and the Çökelik volcanics as marked by a basal conglomerate.

Çankırı Basin Fill

Along the southern border of the basin, the sedimentary fill is dominantly of continental and shallow-marine character (Figure 3). The Yoncalı formation is composed of green shales and sandstones and includes fossiliferous reefal limestone lenses at various levels which are termed the Kocaçay member (Figure 3). In places, the Yoncalı formation overlies the basement with a basal conglomerate 5- to 10-m thick (Figures 4 & 5). The conglomerates are coarse and poorly sorted with particles

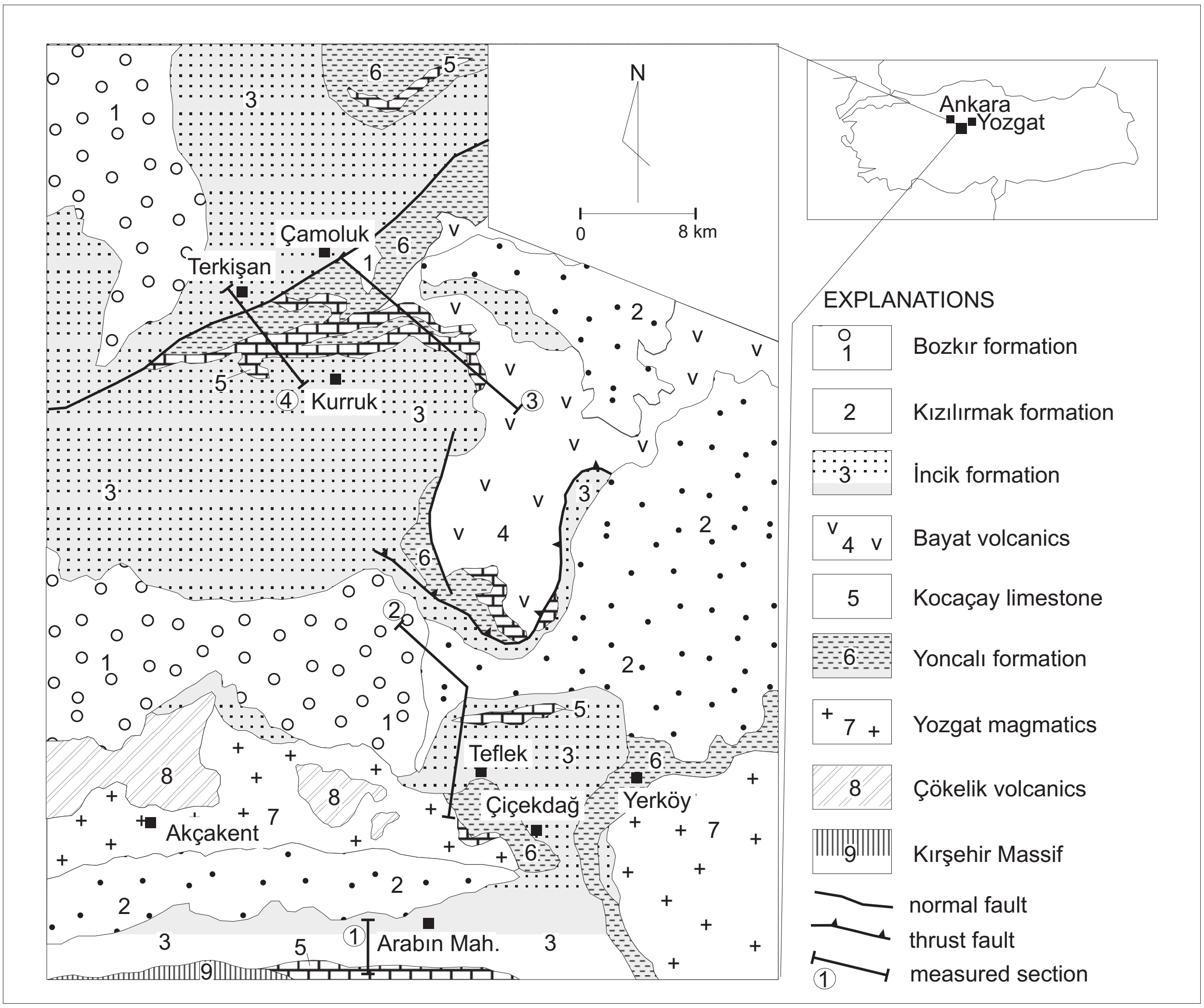


Figure 2. Generalized geological map of the study area (After Erdoğan et al. 1996). Partially measured sections, which are presented in Figures 4, 5, 6 and 7, are shown on this map.

and boulders derived from the Yozgat magmatics and Çökelik volcanics. In places, such as around Arabın Mahallesi, carbonaceous shales and a coal seam also occur within the sandstone intervals as lenses (Figure 4). Thin coal seams (20-30-cm thick) occur in the lowermost 20-30 m of this unit in various places and are characterized by sandstone and mudstone intercalations. Erdoğan *et al.* (1996) suggested an Early (?) to Middle Eocene age based on the foraminifera and nannoplankton content of the Yoncalı formation.

The Yoncalı formation laterally and vertically interfingers with red conglomerates, red sandstones and evaporite-bearing red shales of the İncik formation. This unit resembles the Kartal formation of the Tuzgölü Basin (Uygun 1981; Görür *et al.* 1985). The İncik formation was first named by Birgili *et al.* (1975). In their study area, it was described as overlying the Yoncalı formation and thus considered as Oligocene in age based only on this stratigraphic relationship. The İncik formation resembles the Miocene succession, and its lower boundary was probably confused with that of the younger Kızılırmak formation by Birgili *et al.* (1975) and, therefore, interpreted as an unconformity surface. In our study area, the İncik formation laterally and vertically interfingers with the Yoncalı formation and therefore represents the continental equivalent of this unit (Figures 3 & 5).

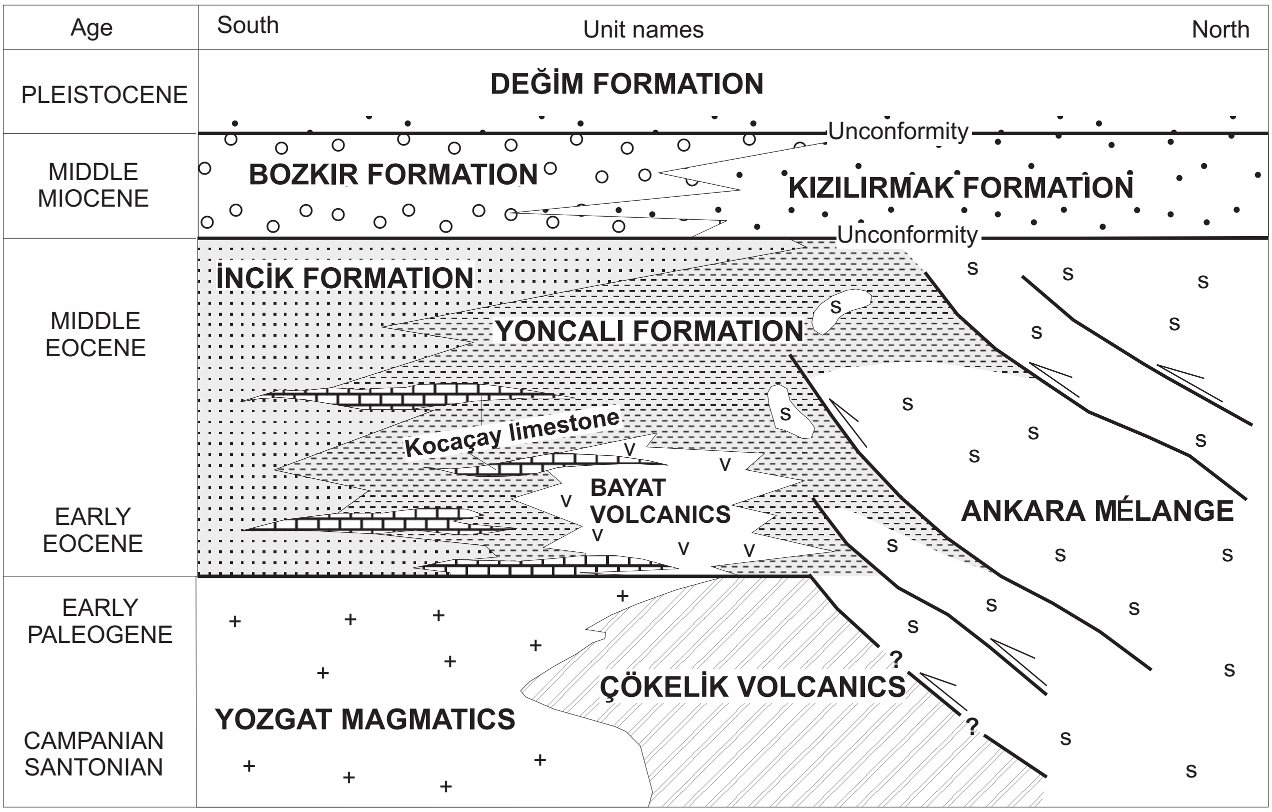


Figure 3. Generalized stratigraphic columnar section showing the rock units of both the southern and northern margins of the Çankırı Basin (Modified after Erdoğan et al. 1996)

Thick-bedded conglomerate intervals with large-scale trough cross-stratification dominate the İncik formation. The lower erosional boundary of the conglomerate intervals is cut into underlying sandstones suggesting their deposition as channel-fill. Interlayering sandstone intervals show planar bedding and include small-scale ripple cross-stratification. They are interbedded with red and green mudstones of overbank facies which contain laminated gypsum horizons 1-2 cm in thickness.

In the Çankırı Basin-fill, basaltic-andesite lava flows and palagonite breccias and tuffs interfinger with both the Yoncalı and İncik formations (Figures 2 & 3). These mafic rocks have been termed the Bayat volcanics (Birgili *et al.* 1975; Erdoğan *et al.* 1996) and are found as extensive outcrops around Yozgat, reaching up to 500 m in thickness. The subaqueous tuff horizons of the Bayat volcanics are found interdigitating with the shales and fossiliferous limestones of the Yoncalı formation and are, stratigraphically, the submarine equivalents of the terrestrial İncik formation. The Bayat volcanics are slightly alkaline and are interpreted to have formed in an extensional zone of the Çankırı Basin (Erdoğan *et al.* 1996).

The Yoncalı, Bayat and the İncik formations grade laterally and vertically into each other along the southern border of the Çankırı Basin as observed in partially measured sections (Figures 4, 5, 6 & 7). Along the Arabın Mahallesi section (Figure 4), the Yoncalı formation directly overlies the basement. There is a conglomerate at its base and it grades upward into mudstones and fossiliferous limestones (Kocaçay member) of the Yoncalı formation. In this section there is a 1-m-thick coal seam. Along the Teflek section (Figure 5), the İncik formation directly overlies the basement and reaches up to 750 m in thickness. In the lower and middle parts of the İncik formation, two marine limestone lenses of the Yoncalı

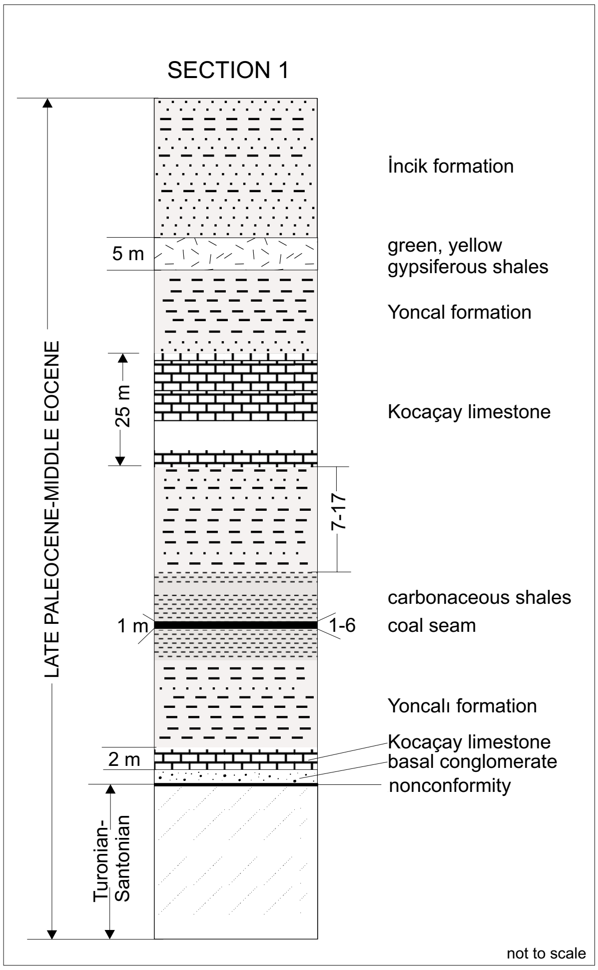


Figure 4. Columnar section partially measured in the vicinity of Arabın Mahallesi (see Figure 2 for location). Sample numbers were best examined are shown on the right hand side of the section.

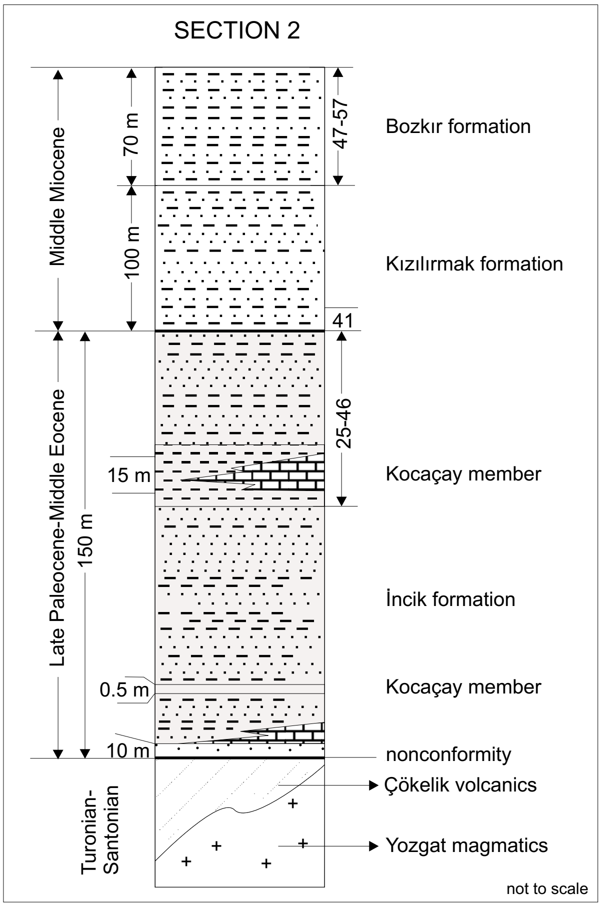


Figure 5. Columnar section partially measured in the vicinity of Teflek village (See Figure 2 for location). Sample numbers are shown on section.

formation occur. Along section 3 (Figure 6), which was measured around the village of Çamoluk, the Bayat volcanics are present, and along the Kurruk-Terkisan section (Figure 7) the Yoncalı formation is dominant.

Cover Series

In the Çankırı area, continental sequences of the Miocene and younger units unconformably overlie older rocks. Based on their stratigraphic positions, a Miocene age for the Kızılırmak and Bozkır formations and a Pleistocene age for the Degim formation were proposed by Birgili *et al.* (1975). Akay (1994) and Erdoğan *et al.* (1996) suggested based on both stratigraphic and palynological data, that the cover units are Middle Miocene in age. A Middle Miocene age was also recently mentioned also by Kaymakçı *et al.* (2000).

The Kızılırmak and Bozkır formations laterally grade into each other. The Kızılırmak formation consists of red and grey conglomerates with intercalated gypsum horizons. The conglomerates are thickly bedded including large-scale trough cross-stratification. They are characteristic of fluvial facies and consist entirely of channell fill sequences that cut into each other. This unit includes several 20- to 25-m thick gypsum horizons which are laterally continuous in the central and southern parts of the basin. The Kızılırmak formation becomes fine-grained in the stratigraphically upper parts and red to green shales with laminated gypsum beds become dominant rock types. These fine-grained shales have been

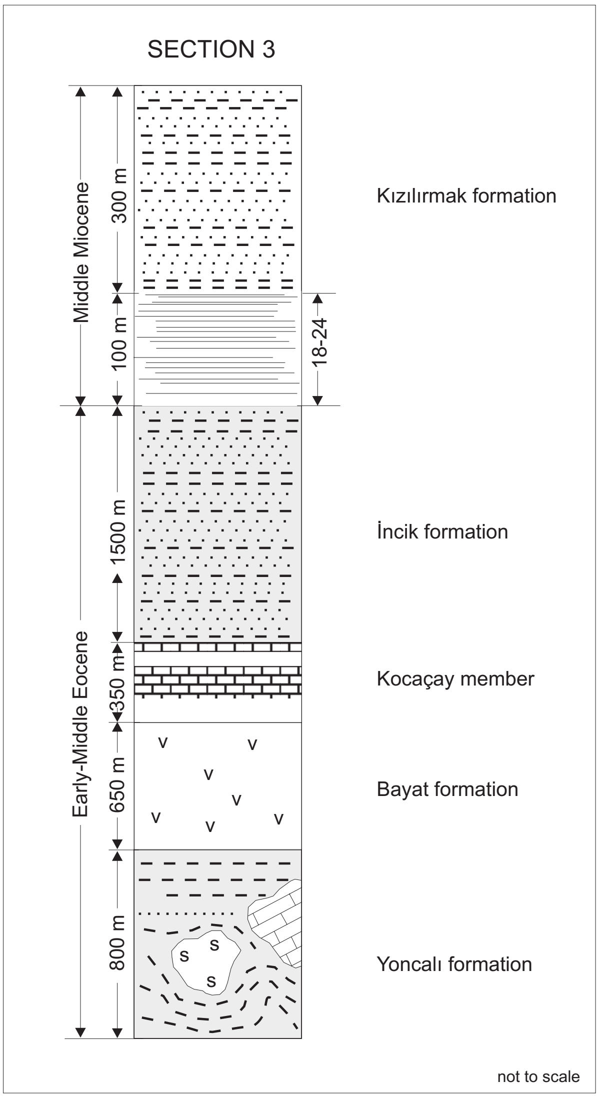


Figure 6. Columnar section partially measured in the vicinity of Çamoluk village (see Figure 2 for location). Sample numbers are shown on the right hand side of the section.

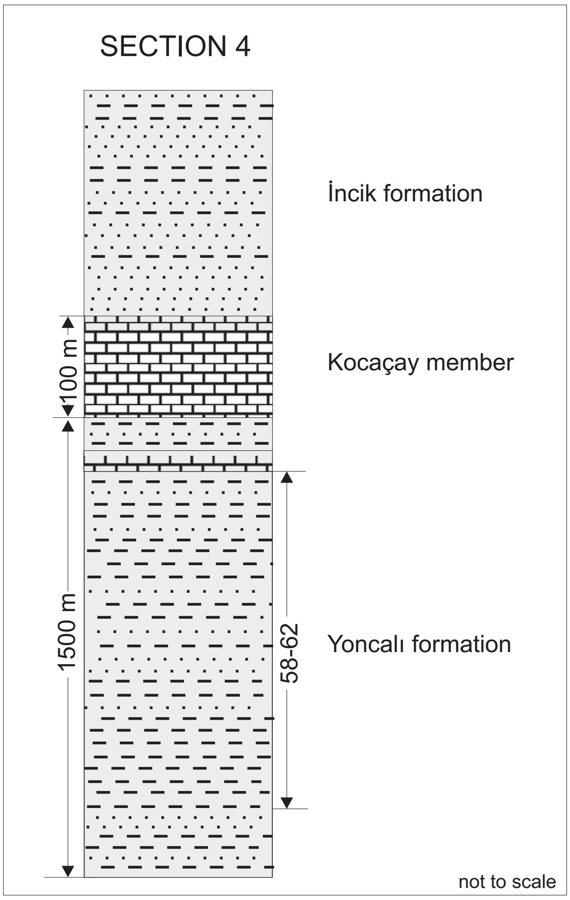


Figure 7. Columnar section partially measured between Kurruk and Terkişan villages (see Figure 2 for location). Sample numbers are shown on the right hand side of the section.

named the Bozkır formation (Birgili *et al.* 1975; Erdoğan *et al.* 1996). The boundary of the Bozkır formation with the Kızılırmak is arbitrarly defined from the first appearance of the cyclic repetition of shales and laminated gypsum horizons. The total thickness of the Bozkır unit reaches up to 500 m. It directly overlies the basement rocks in the southern and western parts of the Çankırı Basin.

The youngest unit of the Çankırı Basin is the Değim formation, made up of coarse-grained and partly consolidated conglomerates. No fossils have been found in this unit and based on stratigraphic setting, a Pleistocene age has been assigned (Birgili *et al.* 1975).

Palynostratigraphy

Localities Sampled and Methodology

In this study, 62 samples, collected along four partially measured sections from the Çankırı Basin-fill and from the overlying Kızılırmak and Bozkır formations (Figure 2), were examined. Seventeen samples were taken from coals and shales of the Yoncalı formation in the Arabın Mahallesi section (Figure 4). One sample from the coal and seven samples from the shales were found suitable for qualitative and quantitative pollen analysis. The other nine samples were determined to contain only a few pollen and spores and have not been included in the

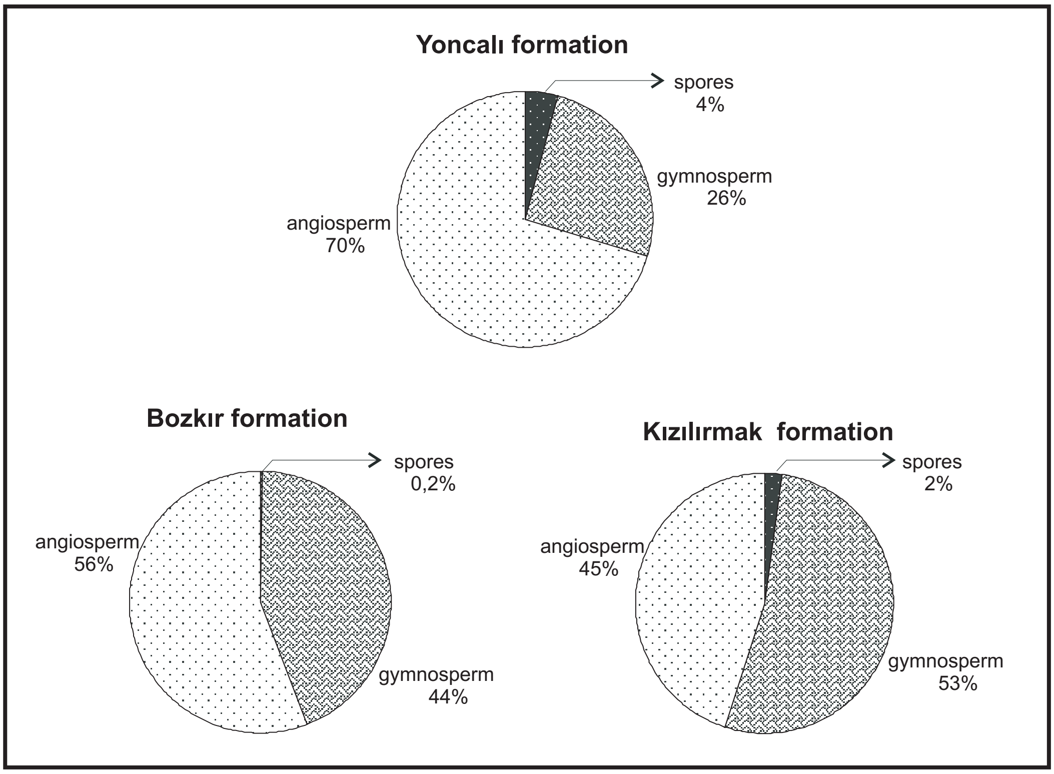


Figure 8. Diagrams showing the relative abundances of the main sporomorph groups in the Yoncalı, Kızılırmak and Bozkır formations.

palynological diagrams because they are not appropriate for statistical evaluation. Twelve samples, which were taken from the İncik formation, and one sample from the Kızılırmak formation, along the Teflek section (Figure 5), are devoid of palynomorphs. Five samples taken from shales of the Yoncalı formation in the Kurruk-Terkişan section (Figure 7) are also devoid of palynomorphs. Only four samples out of seven, taken from the Bozkır formation in the Teflek section, and only four samples out of six, taken from the Kızılırmak formation in the Çamoluk section (Figure 6), were suitable for statistical evaluation.

Palynological Assemblages

Spores and pollen belonging to 35 taxa, consisting of seven pteridophytic spores, five gymnosperm and 23 angiosperm pollen taxa, were encountered in the samples of the Yoncalı formation. Sixteen different genera and 13 species of spores, 17 genera and 61 species of pollen, and 16 genera and six species of dinoflagellate cysts were recognized in this study (Table 1).

The palynomorph diagram of the Yoncalı formation depicts the relative frequency of taxa (Table 1). Quantitative analysis of the Yoncalı formation shows that angiosperm elements (70%) dominate more than gymnosperm elements (26%). The pteridophytic spores (except *L. haardti*) make up 4% of the total population (Figure 8). In this diagram, *Inaperturopollenites concedipites* has a high frequency. Representatives of *Inaperturopollenites emmaensis*, *Triatriopollenites excelsus*, and *Tricolporopollenites margaritatus* occur almost uniformly in small amounts. *Tricolpopollenites densus* and *Tricolporopollenites cingulum* have low frequencies but they are not observed in all samples. The relative frequencies of *Verrucatosporites* cf. *alienus*, *V. favus*, *Leiotriletes microadriennis*, *Polypodiaceoisporites marxheimensis*, *Ephedripites claricristatus*, *Spinizonocolpites species*, *Subtriporopollenites constans*, *S. intraconstans*, and *Caryapollenites circulus* fluctuate from absence to 0 to 3%. *Concavisporites arugulatus*, *Trilites solidus*, *Polypodiaceoisporites saxonicus*,

Table 1. Palynomorph diagram showing the relative % frequency of taxa in the Yoncalı, Kızılırmak and Bozkır formations.

FORMATIONS	YONCALI								KIZILIRMAK				BOZKIR					
SAMPLE NUMBERS	3	8	10	12	13	14	15	17	18	19	24	41	48	50	52	53	54	55
Pteridophytes																		
Laevigatosporites haardti (R.POT. & VENITZ.) TH. & PF. (Polypodiaceae)	3	7		2	8				17	2			1		1	2		
Verrucatosporites cf. *alienus* (R.POT.) TH. & PF. (Polypodiaceae :*Polypodium*)				2				*										
Verrucatosporites favus (R.POT.) TH. & PF.	3				1	*												
Leiotriletes microadriennis KRUTZS. (Schizeaceae:*Lygodium*)		3	3			*				1		1				*		*
Leiotriletes seidewitzesis (KRUTZS.) NAKM.																	*	
Concavisporites arugulatus PF. *in* TH. & PF. (?Gleicheniaceae)								*										
Concavisporites sp.						1												
Trilites solidus KRUTZS. (Lygodiaceae)				1		*												
Baculatisporites primarius (WOLFF) TH. & PF. (Osmundaceae:*Osmunda*)			1	3	1		4	*	1									
Cicatricosisporites regularis NAKM. (? Schizaeceae)						*												
Polypodiaceoisporites marxheimensis (MURR. & PF.) KRUTZS. (*? Lycopodium*)							1	4	3				*		1			
Polypodiaceoisporites saxonicus KRUTZS. (Polypodiaceae/Cycatheaceae/Selaginellaceae)			*															
Polpodiaceoisporites cf. *verruspeciosus* KRUTZS.	1							*										
Gleicheniidites simplex PACLT. & SIMONS. (Gleicheniaceae)						1												
Gleicheniidites sp.				1		1				1		1						
Verrucosisporites cf. *rariverrucosus* NAKM. (?Polypodiaceae)						*												
GYMNOSPERM																		
Pityosporites microalatus (R.POT.) TH. & PF. (*Pinus haploxylon*- type)	2		2	2	3	9	4	6	14	59	53	45	44	40	59	29	44	15
Pityosporites labdacus (R.POT.) TH. & PF. (*Pinus silvetris*- type)										2		2						
Pityosporites libellus (R.POT.) NAKM. (*Podocarpus*)										1	*							*
Inaperturopollenites magnus (R.POT.) TH. & PF. (*?Pseudostuga / Larix*)			1	1			*	*										
Inaperturopollenites concedipites (WODEH.) KRUTZS. (Taxodiaceae:*Taxodium,Glyptostrobus*)	1	25	1	5	19	17	23	16	3			16	2		4		6	26
Inaperturopollenites hiatus (R.POT.) TH. & PF. (Taxodiaceae)	1		1		*				1	1	1	1	1			1		*
Inaperturopollenites polyformosus (THIERG.) TH. & PF. (*Sequoia*)														1		1		1
Inaperturopollenites emmaensis (MURR. & PF.) TH. & PF. (?Cupressaceae)	1	15	3	4	5	5	13											
Cupressacites cuspidataeformis (ZANKL.) KRUTZS. (Cupressaceae*: Taxus*)									*	*						1		
Ephedripites claricristatatus (SHAKHM.) KRUTZS. (Ephedraceae)	3			2			7	*					*					1
Ephedripites hungaricus NAGY				*			*											
Ephedripites eosenipites (WODE.) KRUTZS.	1																	
Ephedripites sp.						3						3	*	*		4	1	*
ANGIOSPERM																		
Monocotyledon																		
Monogemmites pseudostarius (WEYL. & PF.) KRUTZS. (Palmae)	1			1				1										
Monoporopollenites gramineoides MEYER (Gramineae)									1				2		1	*	1	
Sparganiapollenites neogenicus KRUTZS. (Sparganiaceae)																		4
Spinizonocolpites cf. *baculatus* MULLER								1										
Spinizonocolpites prominatus (MACINTYRE) STOVER & EVANS (*Nypa*- Palmae)				1		1		2										
Spinizonocolpites bulbospinosus SINGH					2	1												
Spinizonocolpites spp.			*			*												
Dicotyledon																		
Triatriopollenites exelsus (R.POT.) TH. & PF. (Myricaceae)	7	5	11	7	4	2	5	3										
Triatriopollenites pseudorurensis PF. *in* TH. & PF.			1			2												
Triatriopollenites rurensis PF. & TH. *in* TH. & PF. (Myricaceae: *Myrica*)	3	2	4	2	2	1		3		8	2	2	1		1		1	3
Triatriopollenites rurobituitus PF. *in* TH. & PF.								1										
Triatriopollenites bituitus (R.POT.) TH. & PF. (Myricaceae: *Myrica*)			4			*							2			*		
Triatriopollenites sp.	*					1			3									
Momipites punctatus (R.POT.) NAGY (*Engelhardtia*)	1	2	1						2	8		6	2	4	3	4	1	5
Momipites quietus (R.POT.) NICH.				*														
Platycaryapollenites miocaenicus NAGY (*Platycarya*)			2															
Platycaryapollenites platycaryoides (ROCHE) KEDVES						*												
Triporopollenites spackmanii (TRAV.) KEDVES (Corylaceae)		*	3			4		*										
Triporopollenites simpliformis PF. & TH. *in* TH. & PF.									2		*	3	2				3	5
Subtriporopollenites palaeogenicus KEDVES			3			1												
Subtirporopollenites anulatus PF. & TH. *in* TH. & PF. (? Juglandaceae)	1		2	4	4		4	*										
Subtriporopollenites constans PF. *in* TH. & PF. (?Juglandaceae)	2		1	1		1												
Caryapollenites circulus (PF.) KRUTZS. (*Carya*)		1	1					4										
Caryapollenites simplex (R.POT.) R.POT.									2	5	1		2	1		*	1	1
Subtriporopollenites intraconstans PF. *in* TH. & PF.	1		4					*										
Subtriporopollenites intrastructurus KRUTZS. & VANH. (Ulmaceae/*Celtis*)			*		1			*										
Subtriporopollenites spp.			*							1			*					
Compositoipollenites rhizophorus (R.POT.) R.POT. (Icacinaceae)		*	*					*										
Intratriporopollenites magnoporatus PF. & TH. *in* TH. & PF. (Juglandaceae)							1											
Intratriporopollenites indubitabilis (R.POT.) TH. & PF.	*						*											
Intratriporopollenites instructus (R.POT. & VENITZ.) TH. & PF. (Tiliaceae:*Tilia*)	1		*								1					*		*
Reevesiapollis sp. (Reevesia)																*		
Polyvestibulopollenites verus (R.POT.) TH. & PF. (*Alnus*)									*									*
Myrtaceidites sp. (Myrtaceae)	*																	
Polyporopollenites stellatus (R.POT. & VENITZ.) TH. & PF. (*Pterocarya*)									8	2		9	5	30	16	45	22	16
Polyporopollenites undulosus (R.POT.) TH.& PF. (*Ulmus/Zelkova*)	3						2	1	20	7	30	2	19	5	10	4	1	1
Porocolpopollenites rotundus (R.POT.) TH. & PF. (Symplocaceae)	*		1	1		1												
Porocolpopollenites cf. *rotundus* (R.POT.) TH. & PF.				1														
Porocolpopollenites stereoformis PF. *in* TH. & PF.			2			1												
Porocolpopollenites vestibulum (R.POT.) TH.& PF.			2										*					
Porocolpopollenites sp.						1	1			*								*

Table 1. (Continued)

Tricolpopollenites pudicus (R.POT.) TH.& PF. (Fagaceae:*?Quercus*)			*															
Tricolpopollenites henrici (R.POT.) TH.& PF. (Fagaceae:?*Quercus*)			1								1							*
Tricolpopollenites asper PF. & TH. *in* TH. & PF. (Fagaceae:?*Quercus*)								1										
Tricolpopollenites densus PF. *in* TH. & PF. (?Fagaceae:?*Quercus*)	4	12	4	3					1	*		2	*				2	6
Tricolpopollenites retiformis PF. & TH. *in* TH. & PF. (Salicaceae:*Salix/Platanus*)		1	1		1			1	1			1					3	2
Tricolpopollenites microhenrici (R.POT.) TH.& PF. (?Fagaceae)	3		1	2		1		1	1			1		2			5	4
Tricolpopollenites liblarensis (TH. *in* R.POT.,TH. & THIERG.)TH. & PF. (Fagaceae)		1	2						1			1	1		1			1
Tricolpopollenites sp.		1	*	2														
Pistilipollenites mcgregorii ROUSE (Gentianaceae)					1			1										
Tricolporopollenites villensis (TH.) TH. & PF. (?Anacardiaceae/*Rhus*)			*			1												*
Tricolporopollenites cingulum (R.POT.) TH. & PF. (Fagaceae:*Castanea,Castanopsis*)	19		6		*	*	1		5	1	1	2	4	10	2	6	6	3
Tricolporopollenites megaexactus (R.POT.) TH. & PF. (Cyrillaceae)	6	2	6	2	7	3	2	7	10	*	5		5	4			2	5
Tricolporopollenites steinensis PF. *in* TH. & PF.					1			*								2		
Tricolporopollenites pseudocingulum (R.POT.) TH. & PF. (Anacardiaceae)	*		*			1												
Tricoporopollenites cf. *pacatus* PF. *in* TH. & PF. (Simaroubaceae)	*		6			1		1				1	1				1	1
Tricolporopollenites cf. kruschi (R.POT.) TH. & PF. (Nyssaceae:*Nyssa*)	1		3						1				*			*		*
Tricolporopollenites baculoferus PF. *in* Th. & PF.			*			1												
Tricolporopollenites porasper PF. *in* TH. & PF.								1			2							*
Tricolporopollenites microreticulatus PF. & TH. *in* TH. & PF. (Oleaceae:*Olea,Fraxinus*)	4		5		2	1		5	1	1	1	1	3					
Tricolporopollenites margaritatus (R.POT.) TH. & PF. (Aquifoliaceae:*Ilex*)	26	4	3	4	3	6	11	4						3		1		
Tricolporopollenites sp.	1		1		1	1	1				1		1					
Tricolporopollenites sp. (*tubuliflorae* type) (Compositae)											*		*					*
Tetracolporopollenites obscurus PF. & TH. *in* TH. & PF. (Sapotaceae)			1			1			1		*		*			*		
Tetracolporopollenites abditus PF. *in* TH. & PF.			2	6	1	3	2	1										
Tetracolporopollenites microellipsus PF. *in* TH. & PF.			2			1												
Tetracolporopollenites sapotoides PF. & TH. *in* TH. & PF.			*															
Tetracolporopollenites manifestus (R.POT.) TH. & PF.			2			1												1
Tetracolporopollenites cf. *oblongus* PF. & TH. *in* TH. & PF.																		*
Tetracolporopollenites sp.								*	1									1
Periporopollenites multiporatus PF. & TH. *in* TH. & PF. (Chenopodiaceae)											1		2		1			
DINOFLAGELLATE																		
Areosphaerdium arcuatum EATON					2													
Batiacasphaera sp.				1	2		1											
Cleistosphaeridium sp.				2		*		2										
Cordosphaeridium inodes (KLUMPP) EISENACK				2		*		*										
Cordosphaeridium sp.						*												
Homotryblium sp.				2				1										
Impagidinium sp.								5										
Impletosphaeridium sp.				7	21	*	1	10										
Melitaspheridium sp.				2		8	7											
Operculodinium microtriainum KLUMPP			*	3				2										
Pentadinium sp.				1		2												
Phthanoperidinium amoenum EATON				1				3										
Polysphaeridium sp.				2	1			3										
Samlandia sp.						1												
Spiniferites ramosus (EHRENBERG) MANTELL				5	3		1											
Spiniferites sp.				7	1	2	5	8										
Wetzeliella lunaris GOCHT			*			3												
Wilsonidium echinosuturatum (WILSON) LENTIN & WILLIAMS					*													
Wilsonidium cf. *tabulatum* (WILSON) LENTIN & WILLIAMS					1													
Wilsonidium sp.					2	1	1											
Dinoflagellate		19		5		7	2	1										

Compositoipollenites rhizophorus, and *Pistilipollenites mcgregorii* are extremely scarce or observed only sporadically. Of the dinoflagellate cysts, only a few taxa such as *Impletosphaeridium* sp., *Spiniferites* sp., *Spiniferites ramosus*, *Melitaspheridium* sp. and some fragments, which could not be identified, play an important role in the quantitative composition of some samples (Table 1, Plate1-6).

Ten samples from the Kızılırmak and Bozkır formations include four pteridophytic spores, seven gymnosperm and 17 angiosperm pollen taxa. Five genera and six species of spores and 29 genera and 47 species of pollen were identified from these formations (Table 1, Plate 7). The Bozkır and Kızılırmak palynological assemblages reflect a predominance of angiosperm pollen (45-56%). The percentages of the gymnosperm pollen vary between 44% and 53%. The pteridophytic spores (except *L. haardti*) are quite scarce (0.2-2%) (Figure 8). The most typical features of the palynomorph assemblages of these two formations are as follows:

1. Notably high percentages of *Pityosporites microalatus*, *Polyporopollenites undulosus* are abundant in the Kızılırmak samples, and *Polyporopollenites stellatus* is abundant in the Bozkır samples.

2. The abundances of *Laevigatosporites haardti*, *Inaperturopollenites concedipites*, *Triatriopollenites*

rurensis, *Momipites punctatus*, *Tricolporopollenites megaexactus*, *T. cingulum*, *T. microreticulatus*, and *Caryapollenites simplex* are represented in low but irregularly varying percentages.

3. Spores such as *Leiotriletes microadriennis*, *Polypodiaceoisporites marxheimensis* and pollen species such as *Monoporopollenites gramineoides*, *Tricolporopollenites henrici*, *Tricolporopollenites* sp. (*tubuliflorae* type) and *Periporopollenites multiporatus* are scarce or only sporadic in their occurence.

Age Interpretation Based on Palynological Data

The palynological assemblages of the Tertiary coal deposits of Turkey have been described in many studies (Akyol 1964, 1971, 1980; Arslan 1979; Benda 1971a, b; Benda *et al.* 1974; Ediger 1981, 1990; Nakoman 1964, 1966a, b, 1968a, b; Corsin & Nakoman 1967; Akgün *et al.* 1986; Akgün & Akyol 1987, 1992; Akyol & Akgün 1990; Akgün 1993). The distribution and relative percentages of the Çankırı Basin samples show similarity with those described in these earlier studies (Table 1, Plates 1-7). The pollen and spore species found in the Çankırı area, as a whole, indicate a long time span covering the whole Tertiary Period. They show, with certainty, that the sampled rock units are not older than Tertiary. The following list of species, on the other hand, appear predominantly in the Palaeogene period, except for *Cicatricosisporites* species, which have been present since the Early Cretaceous.

all *Cicatricosisporites* species,

all *Subtriporopollenites* species except *S. simplex*,

Verrucatosporites favus,

Concavisporites arugulatus,

Trilites solidus,

Baculatisporites gemmatus,

Verrucosisporites cf. *rariverrucosus*,

Inaperturopollenites emmaensis,

Ephedripites hungaricus,

Spinizonocolpites species,

Triporopollenites constatus,

Intratriporopollenites indubitabilis,

Pistilipollenites mcgregorii

In addition, the vertical distribution of dinoflagellate cyst genera and species in the Çankırı samples covers the entire Tertiary Period, whereas a few dinoflagellate species characterize only the Palaeogene Period (see Table 1, Plates 4-6).

On the other hand, the following species generally appear in the Neogene and especially in the Middle-Late Miocene and Pliocene units of Turkey (e.g., Akyol 1978; Akyol & Akgün 1990; Batı 1996; Ediger *et al.* 1996) (see Table 1, Plate 7):

Monoporopollenites gramineoides,

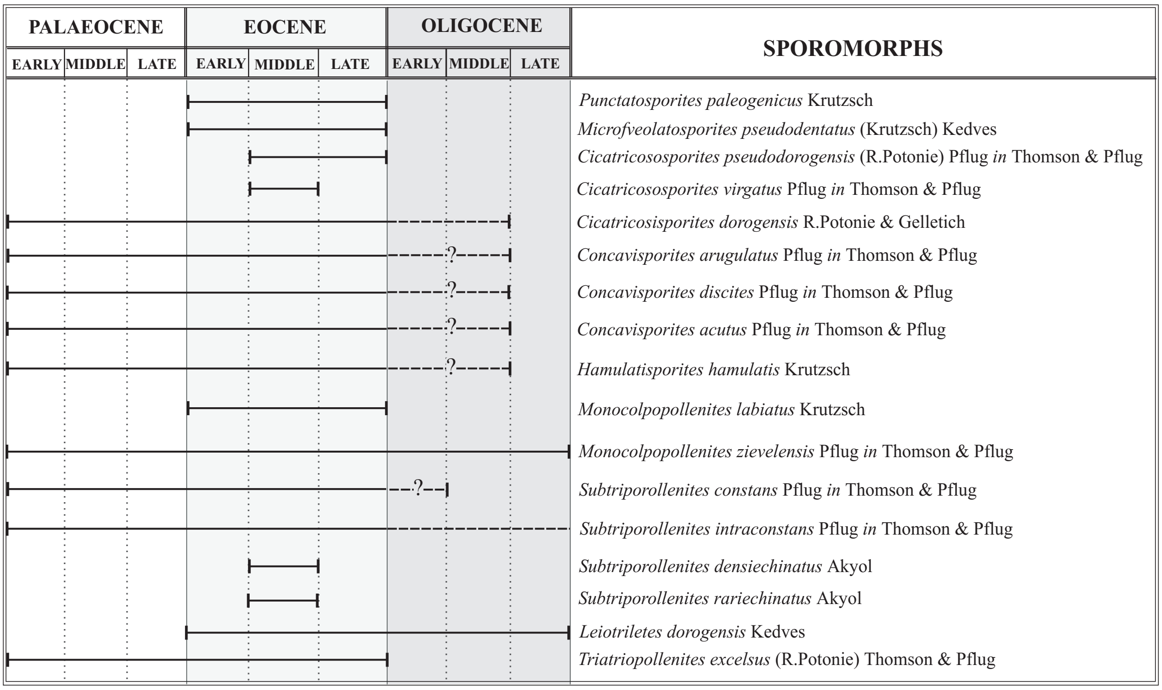
Periporopollenites multiporatus and

Tricolporopollenites sp. (Compositae)

The examination of Table 1 and Plates 1-7 indicate that the Yoncalı formation is Palaeogene and the Kızılırmak and Bozkır units are Neogene in age.

In Turkey, continental Eocene and Oligocene sedimentary successions are much richer in the number of characteristic genera and species than the Miocene sediments. Norris (1986) reported that the variety of spore and pollen associations decreases dramatically after the Eocene and toward the upper parts of the Tertiary. Akyol (1978) defined the Eocene (Lutetian and Priabonian) in Turkey by the species shown in Table 2. The genus *Extratriporopollenites*, which has some diversity in the Palaeocene and Eocene periods may be represented just by *E. pompekji* (R. POTONIE) THOMSON & PFLUG in Early Oligocene time. Middle Oligocene sedimentary sequences are rich in laevigate and verrucate monolete spores. In the Late Oligocene, however, the Middle Oligocene forms disappear and Miocene species generally accompany the Middle Oligocene forms. In addition to that, it is known that species of the genus *Dicolpopollis* is generally observed in Eocene and especially in Oligocene sediments all over the world including Turkey and Germany (Nakoman 1966b; Akyol 1971; Ediger *et al.* 1990; Takahashi & Jux 1991). Some pollen species found in the Yoncalı formation have been reported in the literature as species characteristic of the Palaeocene and Eocene periods (Table 3). Comparison of Table 1 with Tables 2 and 3 also indicates that the age of the Yoncalı formation is Eocene.

Table 2. The characteristic Middle-Late Eocene sporomorph association suggested by Akyol (1978).



In the pollen diagram for samples from the Yoncalı formation, some dinoflagellate cyst genera and species are observed along with spores and pollen. Most of the determined species have wide stratigraphical ranges and are seen from the Cretaceous to Holocene. There are no dinoflagellate cyst species in the list which are characteristic of the Palaeocene. *Areosphaeridium arcuatum, Phthanoperidinium amoenum, Samlandia* sp., and *Wilsonidium* sp. are Early or Middle Eocene-Early Oligocene in age and *Wetzeliella lunaris, Wilsonidium echinosuturatum* and *W. tabulatum* are Early-Middle Eocene and Late Eocene in age (Mellina 1979; Chateauneuf 1980; Ioannides 1986; Norris 1986; Heilmann-Clausen 1988; Schalke & Meyer 1988; Costa *et al.* 1988; Gruas-Cavagnetto *et al.* 1988; Gruas-Cavagnetto & Barbin 1989; El-Beialy 1990; Ertuğ *et al.* 1990; Köthe 1990). On the basis of these considerations, the palynomorph association of the Yoncalı formation is Middle-Late Eocene in age.

Some of the characteristically Lower Eocene taxa of Normapolles, such as *Basapollis, Interpollis, Urkutipollenites*, are poorly represented in the Lower Eocene and are absent in the Middle Eocene of Hungarian localities (Kedves 1986). These pollen have never been recorded in the Yoncalı samples.

Nickel (1996) studied the microflora of the Palaeocene Pechelbronn Beds of the northern part of the Upper Rhine Graben and defined 182 taxa. Based on the stratigraphic distribution and relative abundance of those taxa, mentioned in that study, the Pechelbronn Beds were divided into three major parts which characterize the Upper Eocene, and Lower-Middle Oligocene. Nickel (1996) noted that the abundant presence of *Leiotriletes regularis* (PFLUG) KRUTZSCH, *Caryapollenites triangulus/circulus* (PFLUG) KRUTZSCH, *Triatriopollenites excelsus, Plicatopollis hungaricus* KEDVES, *Catinipollis geiseltalensis* KRUTZSCH, and *Cupanieïdites minimus* KRUTZSCH is characteristic for the Upper Eocene. Nickel (1996) suggested the Early and Middle Oligocene ages based on the presence, scarce occurence, or abundance of *Boehlensipollis hohli* KRUTZSCH which is suggested as the index species for Middle Oligocene by the author, *Caryapollenites simplex, Chenopodipollis multiplex* (synonym *Periporopollenites multiporatus*) and *Verrucatosporites histiopteroides* KRUTZSCH, first seen in Oligocene, *Ischyosporites*

Table 3. Previous age determinations of some forms found in the Yoncalı samples.

Fossil	Age	References
Concavisporites arugulatus	Middle Eocene Eocene-Early Oligocene	Nakoman (1966a); Akyol (1978); Akyol (1980)
Ephedripites eosenipites	Middle Eocene-Early Oligocene	Gruas-Cavagnetto & Barbin (1989)
Ephedripites hungaricus	Eocene	Chateauneuf (1980); Frederiksen (1980a)
Spinizonocolpites Group	Eocene Middle Eocene-Early Oligocene	Vinken (1988) Elsik (1974); Frederiksen (1973)
Triatriopollenites excelsus	Palaeocene-Late Eocene	Thomson & Pflug (1953); Kedves (1969, 1982); Gruas-Cavagnetto (1978); Nickel (1996)
Triporopollenites constatus	Late Palaeocene-Middle Eocene	Kedves (1970)
Triporopollenites spackmanii	Middle Eocene	Kedves (1970)
Compositoipollenites rhizophorus ssp. *minimus*	Middle Palaeocene-Middle Eocene	Kedves (1970, 1982); Krutzsch & Vanhoorne (1977); Thiele-Pfeifer (1988); Nickel (1996)
Subtriporopollenites anulatus ssp. *nanus*	Late Palaeocene-Late Eocene	Thomson & Pflug (1953); Krutzsch (1957,1970); Krutzsch & Vanhoorne (1977)
Subtriporopollenites anulatus ssp. *notus*	Middle Eocene	Thomson & Pflug (1953)
Subtriporopollenites constans	Palaeocene-Early Eocene Middle Eocene Middle Eocene-Middle Oligocene Palaeocene-Early Oligocene	Kedves (1970); Krutzsch & Vanhoorne (1977) Thiele-Pfeifer (1988) Krutzsch (1970) Gruas-Cavagnetto (1978); Kedves (1985)
Caryapollenites circulus	Palaeocene-Late Eocene Latest Palaeocene-Eocene	Thomson & Pflug (1953); Kedves (1970); Krutzsch & Vanhoorne (1977); Thiele-Pfeifer (1988); Krutzsch (1992) Meyer in Vinken (1988)
Porocolpopollenites vestibulum- Group	Middle Eocene-Pliocene	Thomson & Pflug (1953); Krutzsch & Vanhoorne (1977); Chateauneuf (1980); Roche & Schuler (1976,1980); Ollivier-Pierre (1980); Roche (1982)
Intratiriporopollenites magnoporatus	Early Tertiary Early Eocene	Thomson & Pflug (1953) Kedves (1970)
Pistilipollenites mcgregorii	Middle Eocene-early Late Eocene (?) Late Palaeocene-Early Eocene	Elsik (1974); Frederiksen (1984); Norris (1986); McIntyre (1991) Krutzsch & Vanhoorne (1977)

asolidus (KRUTZSCH) KRUTZSCH which is first seen in Eocene, and *Trivestibulopollenites betuloides* PFLUG *in* THOMSON & PFLUG, *Polyvestibulopollenites verus* which are seen during Tertiary time. The absence of *Boehlensipollis hohli* and *Verrucatosporites histiopteroides* in our samples, the presence of *Caryapollenites simplex* and *Chenopodipollis multiplex* only in the Kızılırmak and Bozkır samples and *Caryapollenites triangulus/circulus, Triatriopollenites excelsus* in the Yoncalı samples confirm our Middle-Late Eocene and Middle Miocene determination and indicate the absence of the Oligocene as well. The typical Eocene species of the Pechelbronn Beds were not identified in this study probably because of local ecological differences between the two regions.

Gulinck (1969) and Roche & Schuler (1976, 1980) studied the Palaeogene microflora of Belgium and suggested that *Baculatisporites guintus* (THOMSON & PFLUG) KRUTZSCH ssp. *eocaenicus, Caryapollenites triangulus / circulus, Plicatopollis plicatus* (R.POTONIE) KRUTZSCH, and *Intratriporopollenites instructus* are the typical taxa for Late Eocene time. These authors also pointed out that this relatively species-poor assemblage is accompanied by *Pityosporites, Laevigatosporites, Inaperturopollenites concedipites,* and *Tricolporopollenites cingulum*. In the latest Late Eocene and Early Oligocene beds, on the other hand, *Boehlensipollis hohli* and *Trivestibulopollenites betuloides* are scarce contrary to the predominance of Late Tertiary forms such as *Triatriopollenites rurensis / bituitus*, *Momipites, Caryapollenites simplex*, and *Polyporopollenites undulosus*. The general features of the Palaeogene microflora of Belgium as defined by Gulinck (1969) and Roche & Schuler (1976, 1980) support the Middle-Late Eocene age of the Yoncalı formation as determined in this study.

The stratigraphic distribution of most of the palynomorphs making-up the palynological spectra of the Kızılırmak and Bozkır formations is quite wide. Angiosperm pollen comprise 65% of this assemblage. *Tricolporopollenites cingulum, T. megaexactus, Polyporopollenites undulosus* and *P. stellatus* dominate this assemblage.

Previous studies noted that these forms were observed in the Neogene and also in the Upper Palaeogene units of Turkey (Benda 1971a, b; Benda *et al.* 1974; Nakoman 1966a, 1967a, b, c, 1968a, b; Arslan 1979; Akgün 1993; Akgün & Akyol 1987, 1992; Akyol & Akgün 1990). Coniferous pollen comprise 20% of the species mentioned in Table 1. In this diagram, *haploxylon*-type *Pinus* and Cupressaceae pollen are most frequent, and *silvestris*-type *Pinus* pollen occurs only sporadically observed. The abundance of both of these *Pinus* morphotypes was used in a biostratigraphic classification of the Neogene palynomorph associations of Turkey, Greece, Spain and Italy (Baltenuille *et al.* 1992; Benda 1971a, b; Benda & Meulenkamp 1990; Van de Weerd 1983). In these studies, *haploxylon*-type *Pinus* is considered to have appeared from Mesozoic time, but which lost its dominance upward. The ratio between the *Pinus silvestris* and *Pinus haploxylon* types begins at 1:10 in the late Middle Miocene and *Pinus silvestris* type increase in dominance from the Late Miocene to the Pliocene. In the samples from the Kızılırmak and Bozkır formations, pollen taxa such as Gramineae, Compositae, and Chenopodiaceae occur in low numbers (Table 1). Abundance of these forms is very low in Middle Miocene time (2-3% max), increasing to 10% in the Late Miocene and 20% in the Pliocene period (Akgün 1993; Akgün & Akyol 1987, 1999). In the Kızılırmak and Bozkır samples, spores of *Leiotriletes* sp., *Cingulatisporites* sp., and *Gleicheniidites* sp. are scarce and only sporadically observed. Spore genera and species are of a wide variety in the Lower Tertiary samples and a number of genera and species decrease toward the Late Tertiary (e.g., Thomson & Pflug 1953; Corsin & Nakoman 1967; Hochuli 1978; Benda & Meulenkamp 1990; Akgün & Akyol 1999).

According to these observations, the palynological association determined from the Kızılırmak and Bozkır formations is Middle Miocene in age.

Palaeoclimate and Palaeogeography

As a result of these palynological studies, it is possible to speculate about the palaeoclimatic and palaeoecologic conditions of the area during the deposition of the Yoncalı, İncik, Kızılırmak and Bozkır formations. The first step in this kind of interpretation is to determine the botanical relationships of the parent plants or plant assemblages from which the pollen and spores of the fossil association may have been derived. A necessary assumption is that these plants had the same ecological adaptations as their extant relatives. This is mainly true for Tertiary plants although some taxa may have had different ecological requirements. Another assumption is that the relative abundances of spores and pollen in a sample reflect the abundance of the respective plants in the area and/or closeness of their habitat to the depositional site. This assumption is not always true because of the different pollen/spore productivities of different taxa.

In order to reduce possible misinterpretations to a minimum, taxa should be grouped into growth assemblages. However, it should be emphasized that many samples from several stratigraphic sections should be studied. This is the only way to distinguish local, facies-related, or allochthonous elements of the palynofloras.

The palynospectrum of a coal bed is not solely derived from plants growing within the peat swamp. Allochthonous elements may be found that were incorporated along with the autochthonous material. Therefore some of the taxa that are thought to be allochthonous in a specific coal horizon may have originated in adjacent environments.

It is possible to draw some conclusions regarding sedimentary environment of the Yoncalı formation from dinoflagellates, spores, and pollen. Scull *et al.* (1966) stated that dinoflagellate cyst forms with many conspicuous processes, such as *Cleistosphaeridium*, appear in restricted brackish water, and forms with forked processes such as *Spiniferites*, are indicative of a shallow-marine environment. The presence of *Wetzeliella* is believed to be related to lagoonal, estuarine, or brackish-water environments (Downie *et al.* 1971; Ioannides 1986; Köthe 1990). Dinoflagellate cyst associations including *Wetzeliella* with *Cordospheridium* which characterize marine Tertiary deposits, indicate a restricted marine, possibly hyposaline, prodeltaic environment of deposition (Norris 1986). Brinkhuis (1994) and Köthe (1990) noted that representatives of *Homotryblium* and *Areosphaeridium* might be linked to nearshore, restricted marine waters, possibly hypersaline lagoons. Frederiksen (1985) noted that an abundance of marine dinoflagellate cysts indicates that the sea was near the depositional site, or that the depositional area was under pronounced influence of the sea. The genera and species identified in the Yoncalı formation (Table 1, Plates 1-6) are present in low percentages in the samples. However, *Impletosphaeridium*, which has short processes, and dinoflagellates, which have no processes, reach abundances of 10% in two samples indicating a hyposaline, brackish depositional site. Dinoflagellate cyst genera and species indicating brackish, shallow-water conditions are present in the shales just above the coal seam (Figure 4). *I. emmaensis*, indicative of brackish water, was also observed in these shales. However, in the coal samples, the presence of a palynomorph association indicating brackish water plants is not clear. Therefore, the flora which contributed pollen and spores to the coal and shales of the Yoncalı formation may have been as follows: Osmundaceae, Schizeaceae, Pteridaceae, Cupressaceae, Taxodiaceae, Gentianaceae, *Platycarya*, and *Nyssa* in the swamps of channel-margin systems, were incorporated into the sediments probably after short-distance transport. Gentianaceae locally accompanied the other plants. *Nyssa* may have been transported from the topographic highlands at the back of the swamp (Frederiksen 1985). In our samples, the low frequency of *Nyssa* suggests that they were transported from far away and/or that they were scarce. *Alnus, Carya,* Juglandaceae, *Engelhartdia*, Cyrillaceae, *Myrica*, and Anacardiaceae were transported from lowlands, close to the swamp areas. *Alnus* (locally) and pteridophyte spores reflect the levee vegetation (Farley 1990). The upland forest association, including *Pinus, Tilia, Castanea, Quercus, Ulmus/Zelkova,* Sapotaceae, Icacinaceae, Palmae and Fagaceae were also transported from well-drained upland environments. Low frequency of Ephedraceae indicates the presence of distinct dry areas away from the site of deposition. Frederiksen (1985) suggested that Ephedraceae and Myricaceae might have been occupying shallow-marine environments, or at least brackish swamps, in Palaeogene times as distinct from today. Representatives of *Nypa*, which form a part of recent Indo-Pacific mangroves, are present in the shales of Yoncalı, supporting the proposal of hyposaline brackish deposition, as indicated by the dinoflagellate cyst species. Because shales from the Yoncalı formation laterally grade into the shallow-marine limestones of the Kocaçay member and also the deltaic deposits of the İncik formation (Figures 4 & 5), the coal seams and carbonaceous shales of the Yoncalı formation are interpreted to have been deposited in swamps between the channels of a deltaic environment. Lateral gradition from these kinds of shales into shallow-marine shales and limestones can be anticipated, as indicated in this study by the dinoflagellate cyst content of the palynomorph assemblage.

Akgün (2000), defines a Middle-? Late Eocene palynoflora in the Armutlu formation that crops out in the Çorum-Amasya area (NE part of the Çankırı Basin). The botanical affinities of the studied palynoflora from the Armutlu formation suggest that the Middle-? Late Eocene vegetation of this area comprised: a mangrove association with *Nypa*-like palms, Verbenaceae, Theaceae; a freshwater aquatic habitat with Nymphaceae, Sparganiaceae, Typhaceae; and an arborescent vegetation with Juglandaceae, Sapotaceae, Oleaceae, Fabaceae, Icacinaceae and other palms (Aracaceae). The Restionaceae, represented by *Milfordia* pollen, occurs mainly in coastal plain to brackish-water palaeoenvironments. The Middle Eocene mangrove record of the Çorum-Amasya area, which comprises the typical elements of the present Atlantik mangrove (*Pelliciera*) and the elements of the present Indo-Pacific mangrove (*Nypa*, *Avicennia* type *marina, Avicennia* type *alba*), have not been previously reported as fossils in Turkey. The sediments were deposited in a marginal-marine environment under terrestrial influence, as indicated by the presence of very rare dinocysts. The overall vegetational community supports the presence of tidal swamps near the area of deposition. The diversity of the angiosperm palynoflora, which forms the bulk of the assemblages, is thought to indicate a dense lowland vegetation cover. The Yoncalı samples of this study palynologically resemble the Armutlu formation, indicating a deposition in a brackish-water coastal environment during Middle-? Late Eocene time.

The general composition of the Yoncalı microflora also indicates that most of the microfosils might have been terrestrial. A perusal of different families present in the assemblage shows that out of the 35 families and genera, 20 are confined to present-day tropical-subtropical regions while 15 are cosmopolitan in their distribution. The presence, in particular, of the tropical Gleicheniaceae, Schizeaceae, Icacinaceae, Palmae and the tropical-subtropical Cyrillaceae, Simaroubaceae, Anacardiaceae, and Sapotaceae indicate a hot-humid (tropical) climate during deposition of the coals and shales of the Yoncalı formation. A low percentage for the representatives of *Engelhartdia* in the Yoncalı formation indicates that the climate occasionally changed into a winter-dry tropical climate.

A climate of distinctly tropical tendency in the Lutetian gives way, from the Bartonian onward, to a sub-tropical climate with more marked seasons in England, Belgium and France (Krutzsch & Vanhoorne 1977; Chateauneuf 1980; Olliver-Pierre 1980; Boulter & Hubbard 1982; Hubbard & Boulter 1983). Our data shows us that the Middle Eocene must have been the time of greatest expansion of the palaeotropical flora in the Northern Hemisphere. The climate of the Gulf Coast apparently was more or less uniform from the Middle Eocene until nearly the end of the Eocene. Then, very rapidly, the climate probably became cooler and perhaps drier, persisting until the Early Oligocene (Wolfe & Hopkins 1967; Dilcher 1973; Elsik 1974; Wolfe 1975; Frederiksen 1980; Kirchner 1984). In the Amasya area, which is located in the northern part of the studied basin, new palynological findings indicate clearly that warm-subtropical climatic conditions were prevalent in Early Oligocene time (Akgün *et al.* 2000). This kind of a cooling period affected the area, corresponding to the global cooling cycle that has been documented all around the world.

Their pollen and spore assemblages may also infer certain palaeogeographic conditions for the Bozkır and Kızılırmak formations: high percentages of *Pinus* and *Quercus* characterize the topographic highlands close to the depositional site. Arboreal plants, including *Castanea, Quercus*, Fagaceae, *Engelhardtia, Carya*, Cupressaceae, *Reevesia, Tilia, Ilex* and Oleaceae covered the slopes and lowlands. A typical Mediterranean element, Myrtaceae, is also present. Shrubby forms of the Myricaceae family accompanied this association as undergrowth. The presence of aquatic gymnosperm, such as *Taxodium*, and angiosperms such as *Pterocarya, Nyssa, Salix, Alnus, Ulmus* and Cyrillaceae indicates that the forests in these areas were interspersed with shallow lakes, or a high water table. The scarce presence of *Ephedra* and Compositae forms indicates the presence of seasonally dry areas away from the depositional site, and the rest of the palynomorph association must have been transported from nearby areas since they fit the climatic environment and have high abundances. High percentages of the tropical-subtropical element Cyrillaceae and temperate-subtropical elements *Pterocarya, Castanea*, and the presence of the tropical-subtropical *Engelhardtia, Carya*, Oleaceae, and the warm-temperate *Reevesia, Quercus, Ilex, Nyssa*, Myricaceae, *Rhus, Tilia* pollen, indicate the presence of a warm-subtropical climate. Tropical plants represented in Yoncalı samples are not present in the Kızılırmak and Bozkır samples, and indicate a change in climate from tropical to subtropical.

Conclusions and Discussion

In previous studies, the age of the continental succession of the Çankırı Basin was based solely on the stratigraphic relations of individual units in local areas. However, in the southern part of the basin, the rock units grade vertically and laterally into each other, obscuring stratigraphic relations from place to place. In this study, a total of 49 palynofossil genera and 80 species assignable to dinoflagellate cysts, pteridophytic spores, gymnosperm and angiosperm pollen grains from the coal bearing horizons, carbonaceous shales and laminated shales of the Yoncalı formation and interdigitating İncik formation, have been examined and indicate a Middle-Late Eocene age. This age is also in accord with ages based on foraminifera collected from limestone lenses of the Kocaçay member of the Yoncalı formation (Erdoğan *et al.* 1996), in which a fossil content indicating an Early Eocene age has been described from the stratigraphically lowermost limestone lenses, close to the base of Yoncalı formation. A Middle Eocene age has been determined for the upper parts of the same unit. Our age determination of the Middle-Late Eocene from the carbonaceus shales, based on abundant pollen fossils, closely matches this age.

In Europe, the most pronounced feature of the vertical distribution of spores and pollen in the Tertiary period is the presence of Normapolle pollen in Palaeocene and Early Eocene time as a characteristic group, although it first appeared in the Cretaceous. It is known that several genera of Normapolles pollen appeared until the beginning of the Oligocene (Akyol 1980; Hochuli 1984). In the previous studies, carried out on the Tertiary of Turkey (Akyol 1980; Nakoman 1966b), Normapolles pollen have never been documented. Additionally, we have not yet observed Normapolles pollen in more than 100 samples collected from the other coal-bearing Eocene basins of central Anatolia. Based on the sporadic occurrence of Normapolles pollen in Late Cretaceous and Palaeocene rocks of Pakistan, Frederiksen (1994) suggested filtered migrations between Eurasia and the Indo-Pakistan Island before the collision of these two continents in the Middle Eocene. The absence of Normapolles pollen in the Yoncalı samples might indicate that they are younger than Middle Eocene or older than Eocene but, because of limited migration as suggested by Frederiksen (1994), their population in our samples is quite limited. However, since our other data show that the Yoncalı formation is Middle-Late Eocene, the first point of view is deemed more acceptable.

Coal seams and carbonaceous shales of the Yoncalı formation contain both terrestrial and brackish/marine palynomorphs which is interpreted, additionally to the sedimentologic features, as the coal seams of Yoncalı formation were most probably deposited in shallow fresh waters close to a shoreline. Vegetational pattern of carbonaceous shales of Yoncalı formation indicates that coastal brackish swamps were adjacent to the depositional area in moist tropical climatic conditions. Through the end of the Eocene the climatic conditions were nearly uniform and from the beginning of the Oligocene time, like all around the world, there was a prominent cooling in the basin.

In this study, the Kızılırmak and Bozkır formations have been dated palaeontologically for the first time as Middle Miocene. From these formations, 34 genera and 53 species were determined. Qualitative and quantitative analyses of the palynoflora indicate that the units were deposited in mires adjacent to lakes and/or in flood plains, surrounded by topographic highs covered by forests.

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Plate I
(Yoncalı formation)
(All photomicrographs x 500)

Figure 1, 2 : *Verrucatosporites* cf. *alienus* (R.POTONIE) THOMSON & PFLUG
3-5 : *Verrucatosporites favus* (R.POTONIE) THOMSON & PFLUG
6-8 : *Leiotrilites microadriensis* KRUTZSCH
9 : *Concavisporites arugulatus* PFLUG in THOMSON & PFLUG
10 : *Concavisporites* sp.
11 : *Trilites solidus* KRUTZSCH
12 : *Trilites* cf. *solidus* KRUTZSCH
13-15 : *Baculatisporites primarius* (WOLFF) THOMSON & PFLUG
16, 17 : *Cicatricosisporites regularis* NAKOMAN
18-20 : *Polypodiaceoisporites marxheimensis* (MÜRRIGER & PFLUG) KRUTZSCH
21 : *Polypodiaceoisporites saxonicus* KRUTZSCH
22 : *Polypodiaceoisporites verruspeciosus* KRUTZSCH
23 : *Gleicheniidites simplex* PACLTOVA & SIMONCSICS
24, 25 : *Gleicheniidites* sp.
26 : *Verrucosisporites* cf. *rariverrucosus* NAKOMAN
27-30 : *Pityosporites microalatus* f. *major* (R.POTONIE) THOMSON & PFLUG
31, 32 : *Pityosporites microalatus* f. *minor* (R.POTONIE) THOMSON & PFLUG
33 : *Inaperturopollenites magnus* (R.POTONIE) THOMSON & PFLUG

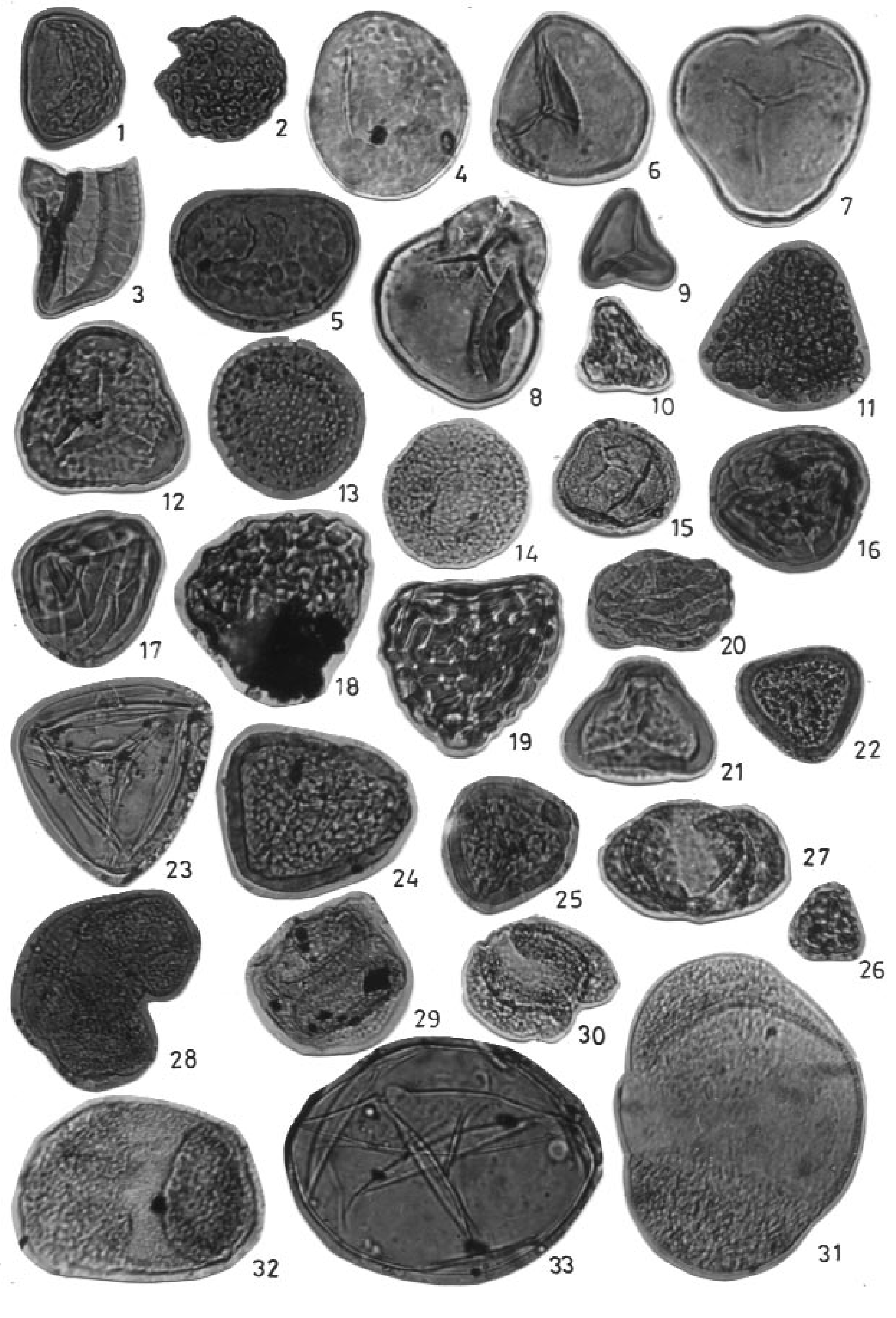
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Plate II
(Yoncalı formation)
(All photomicrographs x 500)

Figure 1-3 : *Inaperturopollenites magnus* (R.POTONIE) THOMSON & PFLUG
4-7 : *Inaperturopollenites concedipites* (WODEHOUSE) KRUTZSCH
8, 9 : *Inaperturopollenites hiatus* (R.POTONIE) THOMSON & PFLUG
10-13 : *Inaperturopollenites emmaensis* (MURRIGER & PFLUG) THOMSON & PFLUG
14-17 : *Ephedripites claricristatus* (SHAKHMUNDES) KRUTZSCH
18 : *Ephedripites eosenipites* (WODEHOUSE) KRUTZSCH
19-21 : *Monogemmites pseudosetarius* (WEYLAND & PFLUG) KRUTZSCH
22, 36 : *Spinizonocolpites bulbospinosus Singh*
23, 27-32 : *Spinizonocolpites prominatus* (MacIntyre) Stover & Evans
24 : *Spinizonocolpites* cf. *baculatus* Muller
25, 26, 33-35 : *Spinizonocolpites* spp.
37-40 : *Triatriopollenites excelsus* (R.POTONIE) THOMSON & PFLUG ssp. *minor* (R.POTONIE) THOMSON & PFLUG
41, 42 : *Triatriopollenites excelsus* (R.POTONIE) THOMSON & PFLUG ssp. *turgitus* (R.POTONIE) THOMSON & PFLUG
43 : *Triatriopollenites excelsus* (R.POTONIE) THOMSON & PFLUG ssp. *semiturgitus* (R.POTONIE) THOMSON & PFLUG
44 : *Triatriopollenites excelsus* (R.POTONIE) THOMSON & PFLUG ssp. *microturgitus* (R.POTONIE) THOMSON & PFLUG
45-47 : *Triatriopollenites pseudorurensis* PFLUG *in* THOMSON & PFLUG
48, 49 : *Triatriopollenites rurensis* PFLUG & THOMSON *in* THOMSON & PFLUG
50 : *Triatriopollenites rurobituitus* PFLUG *in* THOMSON & PFLUG
51, 52 : *Triatriopollenites bituitus* (R.POTONIE) THOMSON & PFLUG
53 : *Momipites quietus* (R.POTONIE) NICHOLS
54-56 : *Momipites punctatus* (R.POTONIE) NAGY
57 : *Momipites* sp.
58 : *Platycaryapollenites platycaryoides* (ROCHE) KEDVES
59 : *Platycaryapollenites miocaenicus* NAGY
60 : *Triporopollenites spackmanii* (TRAVISAN) KEDVES
61-64 : *Subtriporopollenites palaeogenicus* KEDVES
65, 66 : *Subtriporopollenites* cf. *anulatus* PFLUG & THOMSON *in* THOMSON & PFLUG

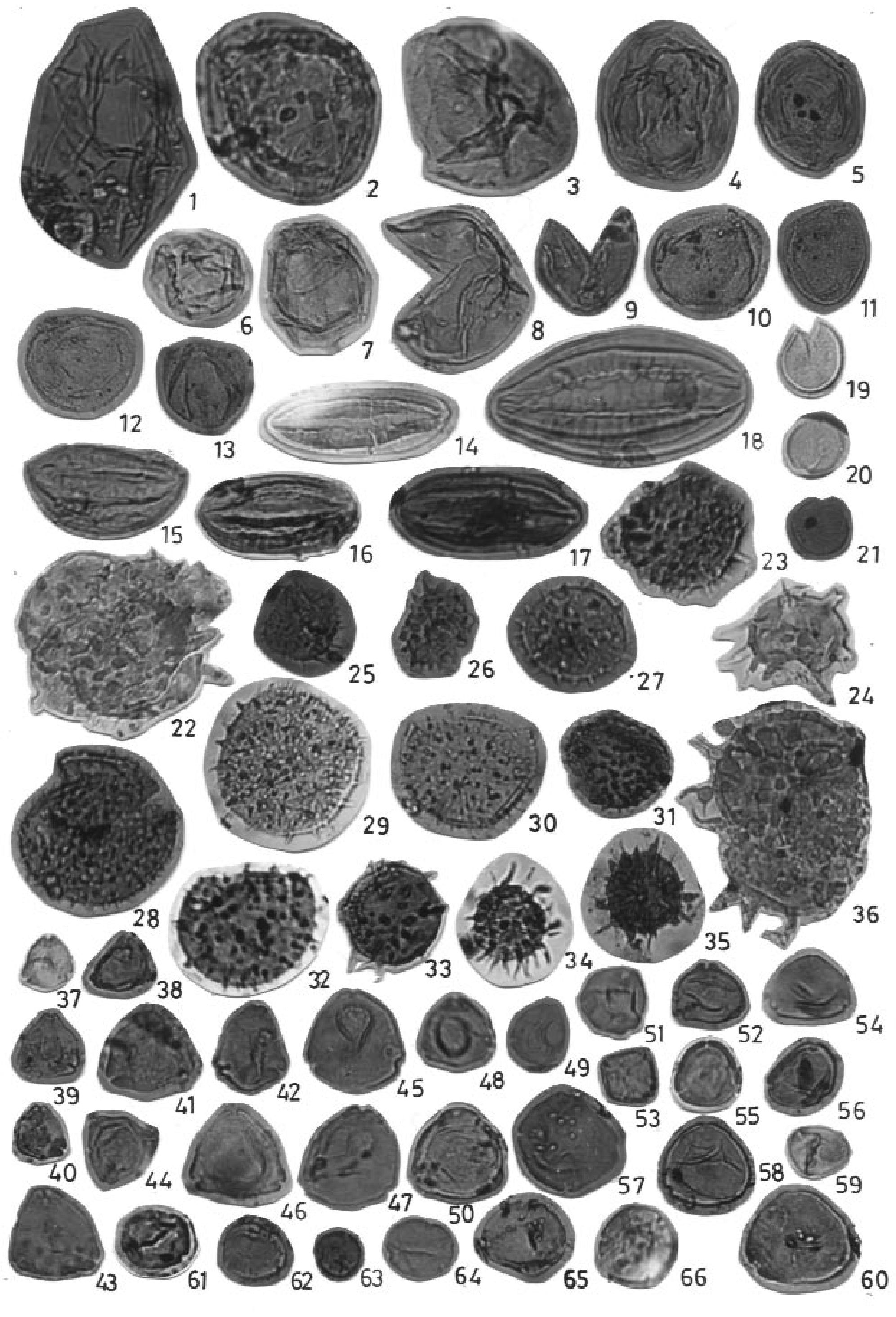

Plate III
(Yoncalı formation)
(All photomicrographs x 500)

Figure 1 : *Subtriporopollenites anulatus* PFLUG & THOMSON *in* THOMSON & PFLUG ssp. *notus* PFLUG & THOMSON *in* THOMSON & PFLUG
2-6 : *Subtriporopollenites anulatus* PFLUG & THOMSON *in* THOMSON & PFLUG ssp. *nanus* PFLUG & THOMSON *in* THOMSON & PFLUG
7-9 : *Caryapollenites circulus* (PFLUG) KRUTZSCH
10-13 : *Subtriporopollenites constans* PFLUG *in* THOMSON & PFLUG
14 : *Subtriporopollenites intraconstans* PFLUG *in* THOMSON & PFLUG
15 : *Compositoipollenites rhizophorus* (R.POTONIE) R.POTONIE ssp. *minimus* ROCHE
16-19 : *Subtriporopollenites intrastructurus* KRUTZSCH & VANHOORNE
20 : *Intratriporopollenites magnoporatus* PFLUG & THOMSON *in* THOMSON & PFLUG
21-24 : *Intratriporopollenites indubitabilis* (R.POTONIE) THOMSON & PFLUG
25, 26 : *Intratriporopollenites instructus* (R.POTONIE & VENITZ) THOMSON & PFLUG
27 : *Reevesiapollis* sp.
28, 30 : *Porocolpopollenites rotundus* f. *rotundus* (R.POTONIE) THOMSON & PFLUG
29 : *Myrtaceidites* sp.
31, 32 : *Porocolpopollenites* cf. *rotundus* (R.POTONIE) THOMSON & PFLUG
33, 34 : *Porocolpopollenites stereoformis* PFLUG *in* THOMSON & PFLUG
35 : *Tricolpopollenites pudicus* (R.POTONIE) THOMSON & PFLUG
36 : *Tricolpopollenites henrici* (R.POTONIE) THOMSON & PFLUG
37, 38 : *Tricolpopollenites asper* PFLUG & THOMSON *in* THOMSON & PFLUG
39, 40 : *Tricolpopollenites densus* PFLUG *in* THOMSON & PFLUG
41, 42 : *Tricolpopollenites retiformis* PFLUG & THOMSON *in* THOMSON & PFLUG
43, 44 : *Tricolpopollenites microhenrici* (R.POTONIE) THOMSON & PFLUG
45 : *Tricolpopollenites liblarensis* (THOMSON *in* R.POTONIE, THOMSON & THIERGART) THOMSON & PFLUG
46 : *Pistilipollenites mcgregorii* ROUSE
47-50 : *Tricolporopollenites villensis* (THOMSON *in* R.POTONIE, THOMSON & THIERGART) THOMSON & PFLUG
51, 52 : *Tricolporopollenites cingulum* (R.POTONIE) THOMSON & PFLUG ssp. f*usus* (R.POTONIE) THOMSON & PFLUG
53-56 : *Tricolporopollenites cingulum* (R.POTONIE) THOMSON & PFLUG ssp. *pusillus* (R.POTONIE) THOMSON & PFLUG
57-61 : *Tricolporopollenites cingulum* (R.POTONIE) THOMSON & PFLUG ssp. *oviformis* (R.POTONIE) THOMSON & PFLUG
62-65 : *Tricolporopollenites megaexactus* (R.POTONIE) THOMSON & PFLUG ssp. *brühlensis* THOMSON *in* R.POTONIE, THOMSON & THIERGART
66 : *Tricolporopollenites megaexactus* (R.POTONIE) THOMSON & PFLUG ssp. *exactus* (R.POTONIE) THOMSON & PFLUG
67, 68 : *Tricolporopollenites steinensis* PFLUG *in* THOMSON & PFLUG
69 : *Tricolporopollenites pseudocingulum* (R.POTONIE) THOMSON & PFLUG
70, 71 : *Tricolporopollenites* cf. *pacatus* PFLUG *in* THOMSON & PFLUG
72, 73 : *Tricolporopollenites* cf. *kruschi* (R.POTONIE) THOMSON & PFLUG
74-77 : *Tricolporopollenites baculoferus* PFLUG *in* THOMSON & PFLUG
78 : *Tricolporopollenites porasper* PFLUG *in* THOMSON & PFLUG
79-81 : *Tricolporopollenites microreticulatus* PFLUG & THOMSON *in* THOMSON & PFLUG
82-84 : *Tricolporopollenites margaritatus* (R.POTONIE) THOMSON & PFLUG
85-91 : *Tricolporopollenites margaritatus* (R.POTONIE) THOMSON & PFLUG *f. medius* PFLUG & THOMSON *in* THOMSON & PFLUG
92 : *Tricolporopollenites* sp.
93-95 : *Tetracolpoporopollenites obscurus* PFLUG & THOMSON *in* THOMSON & PFLUG
96-102 : *Tetracolpoporopollenites abditus* PFLUG *in* THOMSON & PFLUG
103 : *Tetracolpoporopollenites microellipsus* PFLUG in THOMSON & PFLUG
104 : *Tetracolpoporopollenites sapotoides* PFLUG & THOMSON *in* THOMSON & PFLUG
105-107 : *Tetracolpoporopollenites manifestus* (R.POTONIE) THOMSON & PFLUG
108 : *Tetracolpoporopollenites* sp.

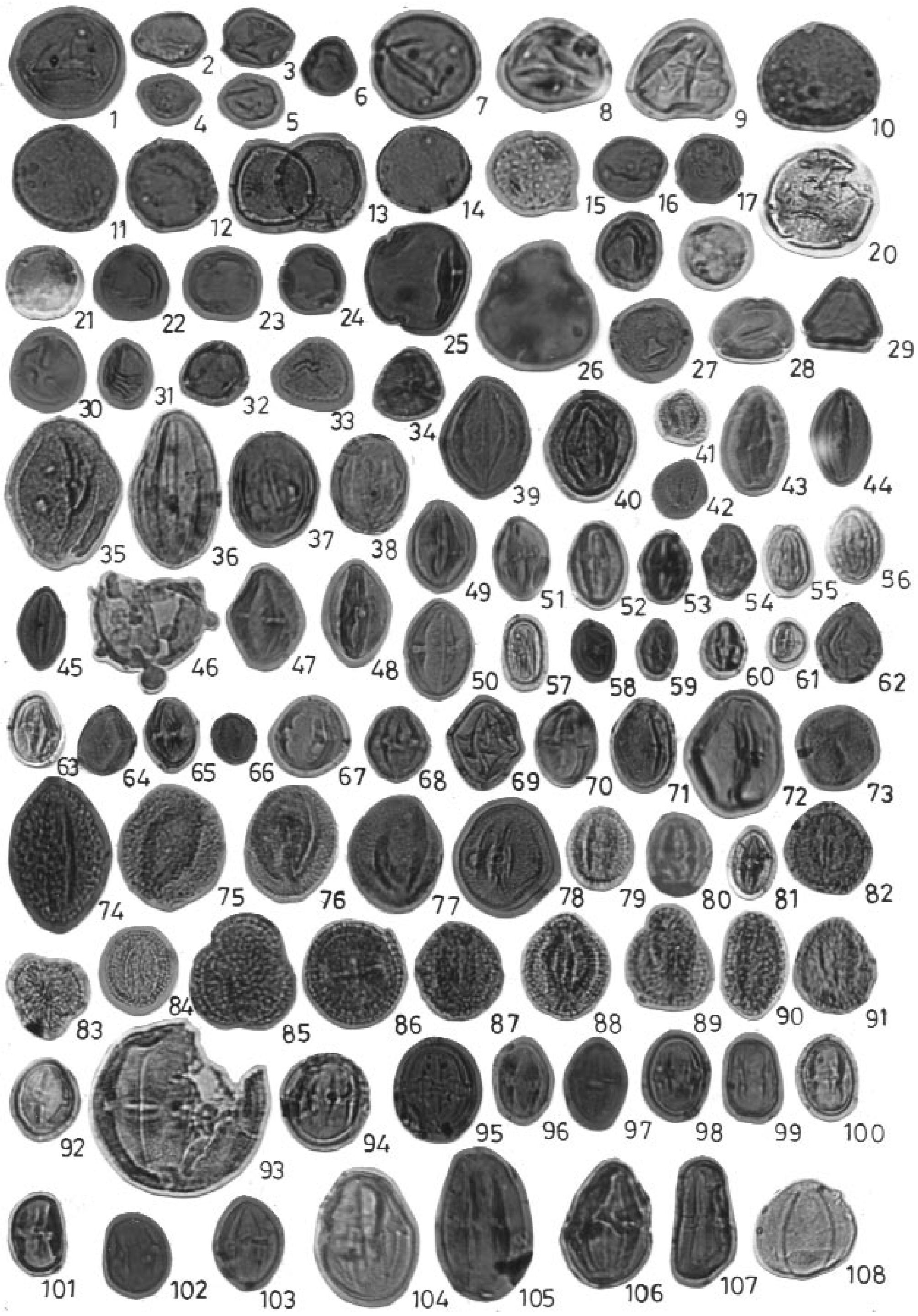
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Plate IV
(Yoncalı formation)
(All photomicrographs x 500)

Figure 1-3 : *Areosphaeridum arcuatum* EATON
4, 5 : *Batiacasphaera* sp.
6, 7 : *Cleistosphaeridum* sp.
8, 9 : *Cordosphaeridum* sp.
10 : *Polysphaeridium* sp
11 : *Homotryblium* sp.
12 : *Homotryblium vallum* STOVER
13-15 : *Impagidinium* sp.
16-19 : *Impletosphaeridum* sp.
20, 21 : *Melitasphaeridum* cf. *simpulum* ISLAM
22 : *Pentadinium* sp

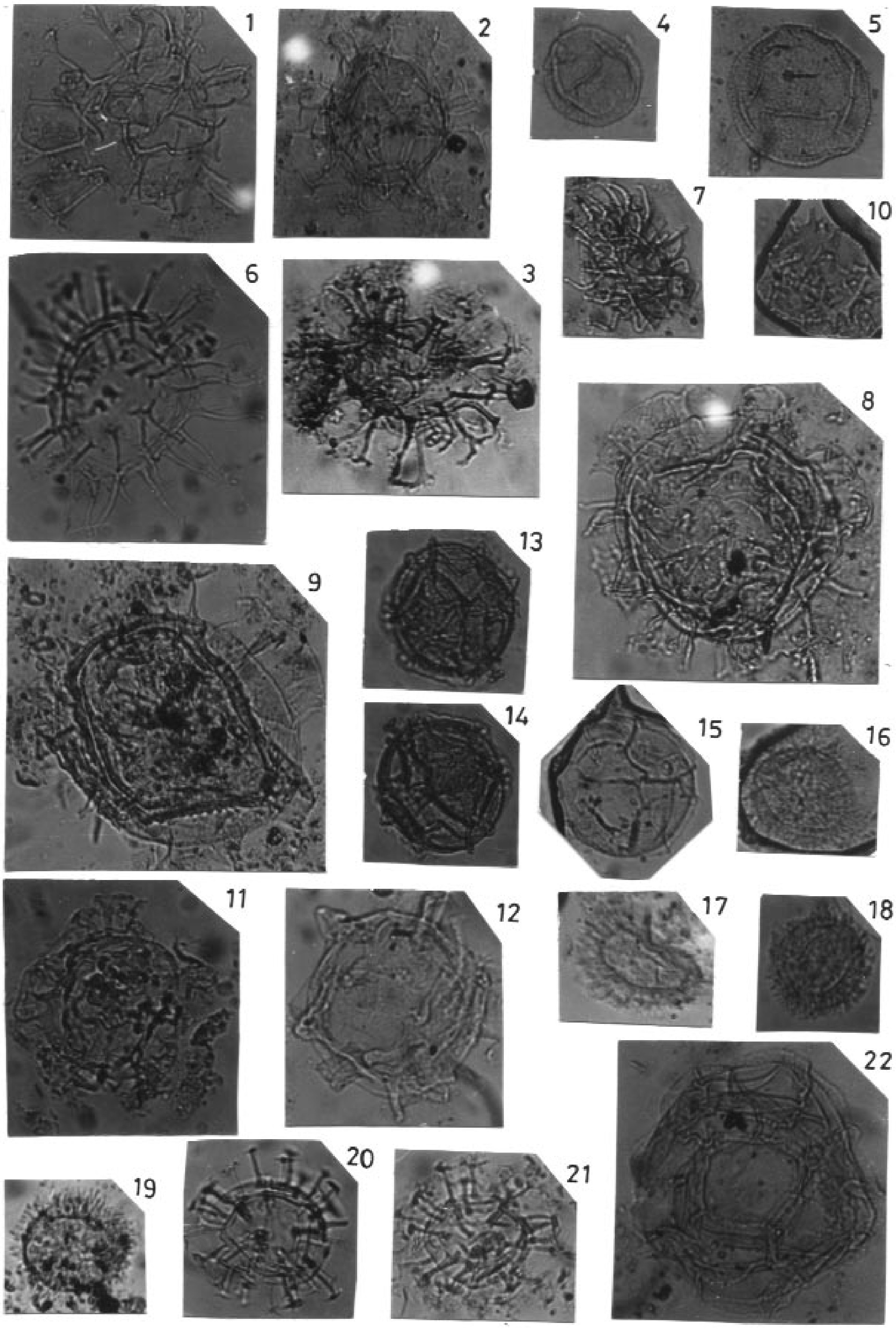
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Plate V
(Yoncalı formation)
(All photomicrographs x 500)

Figure 1,10 : *Operculodinium* sp.
2 : *Operculodinium microtriainum* KLUMPP
3-5 : *Cordosphaeridum inodes* (KLUMPP) EISENACK
6, 7 : *Polysphaeridium* sp.
8 : *Operculodinium centrocarpum* (DEFLANDRE & COOKSON) WALL
9 : *Phthanoperidinium amoenum* EATON
11 : *Samlandia* sp.

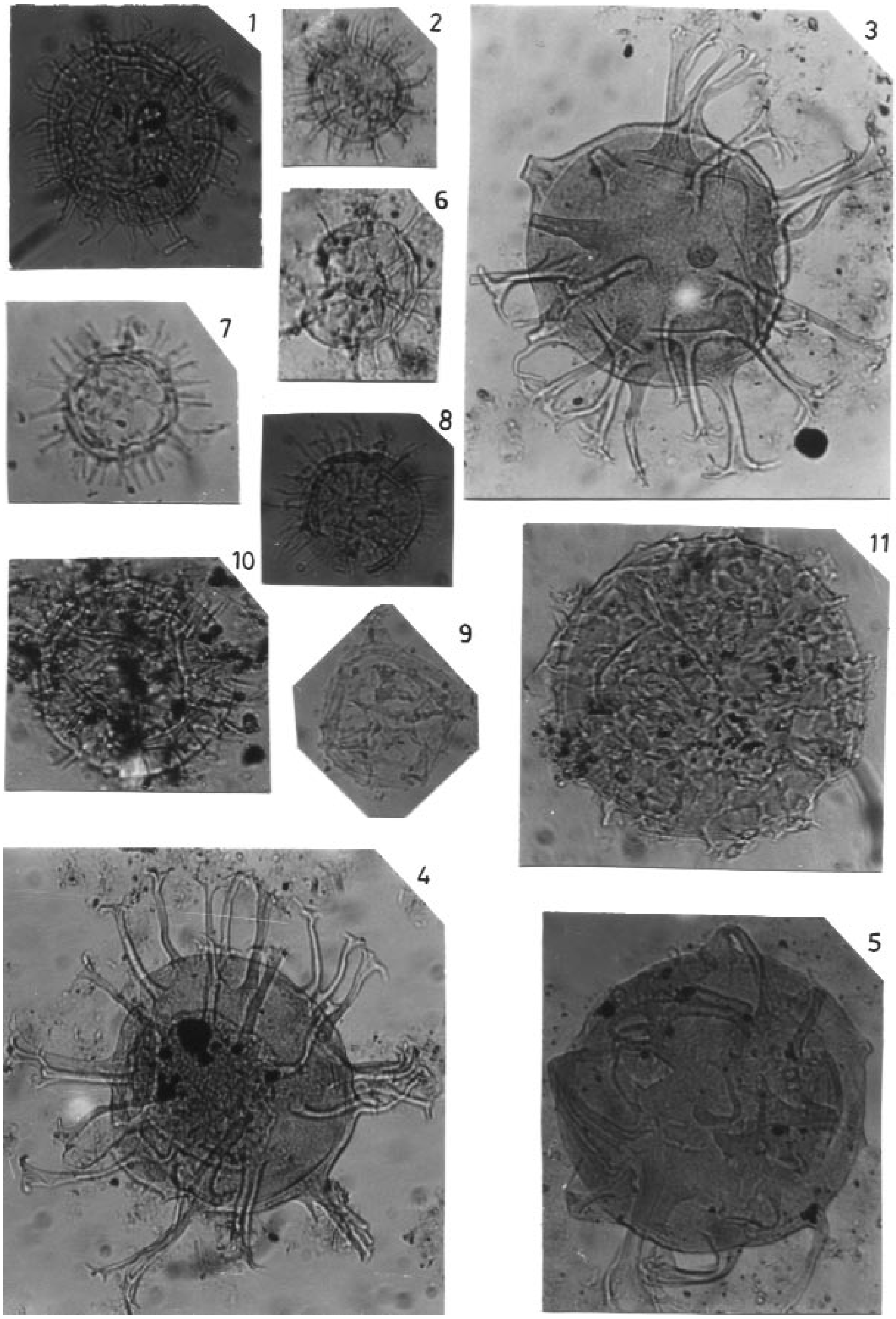
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Plate VI
(Yoncalı formation)
(All photomicrographs x 500)

Figure 1 : *Phthanoperidinium amoenum* EATON
2-4 : *Spiniferites ramosus* (EHRENBERG) MANTELL
5, 6 : *Spiniferites* sp.
7 : *Wetzeliella lunaris* GOCHT
8 : *Wilsonidium echinosuturatum* (WILSON) LENTIN & WILLIAMS
9 : *Wilsonidium* cf. *tabulatum* (WILSON) LENTIN & WILLIAMS
10, 11 : *Wilsonidium* sp.

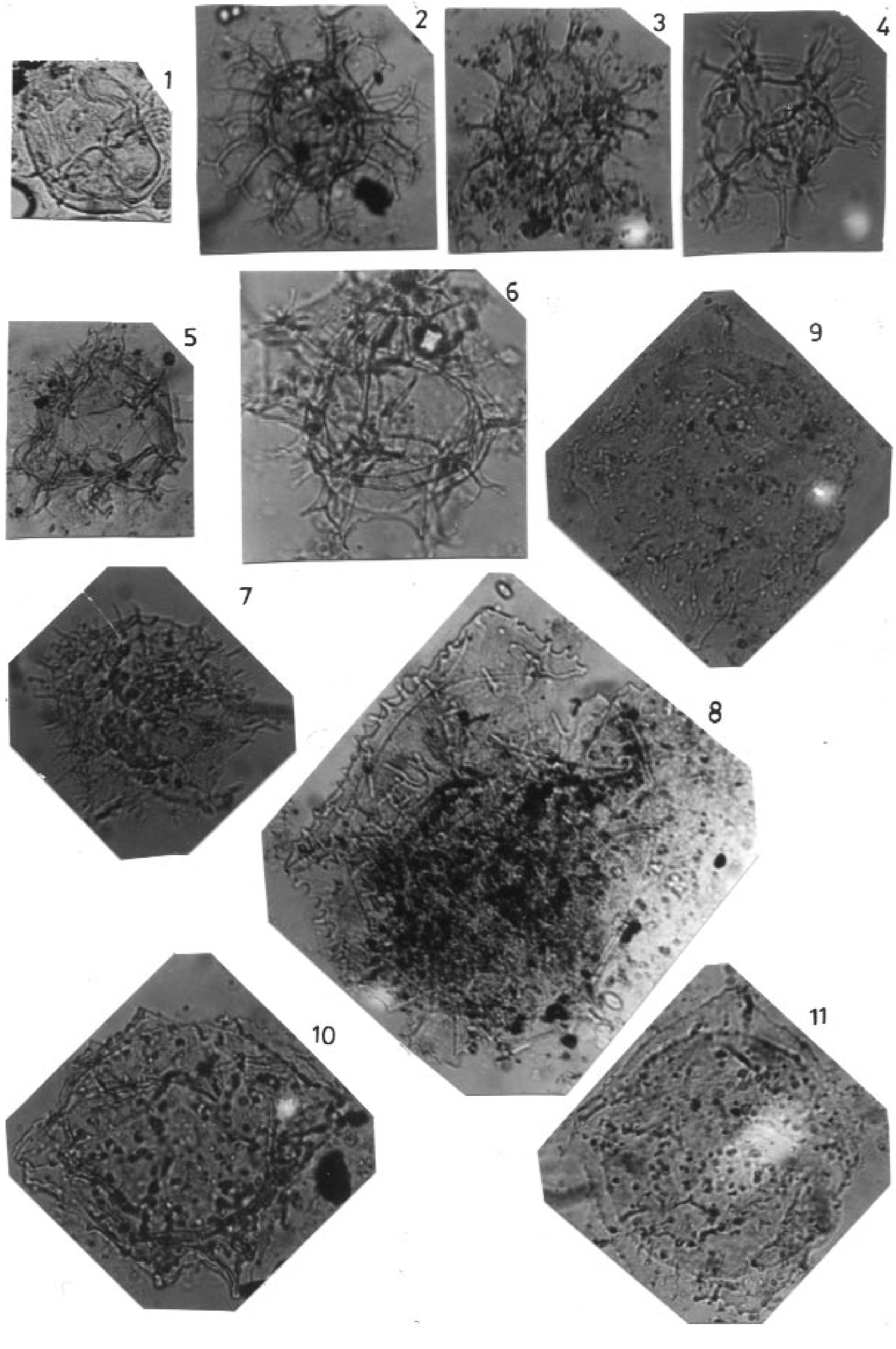
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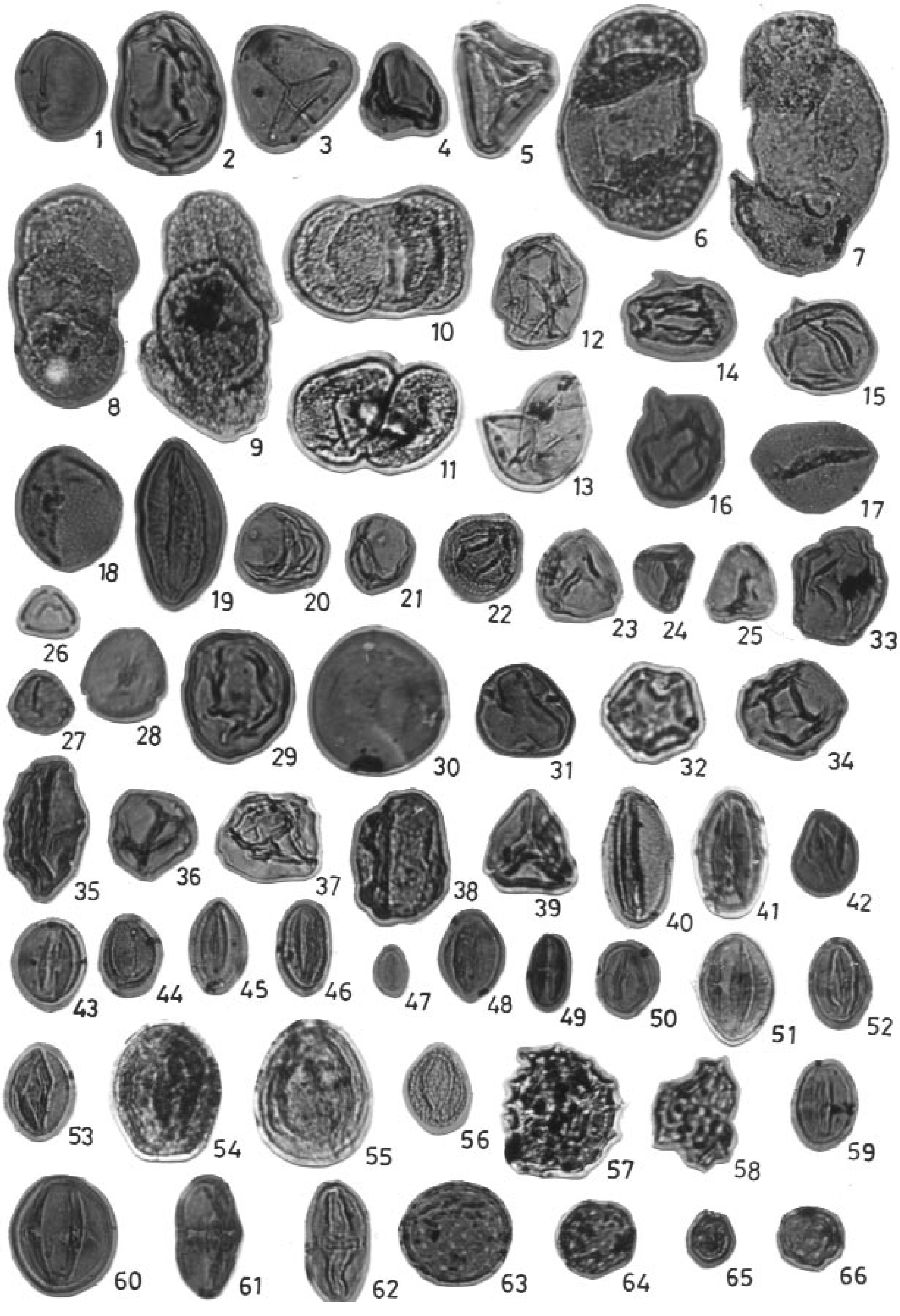
Plate VII
(Kızılırmak and Bozkır formations)
(All photomicrographs x 500)

Figure 1, 2 : *Laevigatosporites haardti* (R. POTONIE & VENITZ.) THOMSON & PFLUG
3 : *Leiotriletes microadriennis* KRUTZSCH
4 : *Leiotriletes seidewitzennis* (KRUTZSCH) NAKOMAN
5 : *Gleicheniidites* sp.
6 : *Pityosporites microalatus* (R.POTONIE) THOMSON & PFLUG
7 : *Pityosporites labdacus* (R.POTONIE) THOMSON & PFLUG
8-11 : *Pityosporites libellus* (R.POTONIE) NAKOMAN
12 : *Inaperturopollenites concedipites* (WODEHOUSE) KRUTZSCH
13 : *Inaperturopollenites hiatus* (R.POTONIE) THOMSON & PFLUG
14-16 : *Inaperturopollenites polyformosus* (THIERGART) THOMSON & PFLUG
17, 18 : *Cupressacites cuspidataeformis* (ZANKLINSKAJA) KRUTZSCH
19 : *Ephedripites claricristatus* (SHAKMUNDES) KRUTZSCH
20, 21 : *Monoporopollenites gramineoides* MEYER
22 : *Inaperturopollenites granulatus* NAKOMAN
23 : *Triatriopollenites runensis* PFLUG & THOMSON *in* THOMSON & PFLUG
24 : *Triatriopollenites bituitus* (R.POTONIE) THOMSON & PFLUG
25, 26 : *Triatriopollenites coryphaeus* (R.POTONIE) THOMSON & PFLUG
27 : *Momipites punctatus* (R.POTONIE) NAGY
28 : *Triporopollenites simpliformis* PFLUG & THOMSON *in* THOMSON & PFLUG
29, 30 : *Caryapollenites simplex* (R.POTONIE) RAATZ
31 : *Intratriporopollenites instructus* (R.POTONIE & VENITZ) THOMSON & PFLUG
32 : *Polyvestubulopollenites verus* (R.POTONIE) THOMSON & PFLUG
33-37 : *Polyporopollenites stellatus* (R.POTONIE & VENITZ) THOMSON & PFLUG
38 : *Polyporopollenites undulosus* (WOLFF) THOMSON & PFLUG
39 : *Porocolpopollenites vestibulum* (R.POTONIE) THOMSON & PFLUG
40, 41 : *Tricolpopollenites henrici* (R.POTONIE) THOMSON & PFLUG
42, 43 : *Tricolpopollenites densus* PFLUG in THOMSON & PFLUG
44 : *Tricolpopollenites retiformis* PFLUG & THOMSON *in* THOMSON & PFLUG
45, 46 : *Tricolpopollenites microhenrici* (R.POTONIE) THOMSON & PFLUG
47 : *Tricolpopollenites liblarensis* (THOMSON *in* R.POTONIE, THOMSON & THIERGART.) THOMSON & PFLUG
48 : *Tricolporopollenites villensis* (THOMSON.) THOMSON & PFLUG
49 : *Tricolporopollenites cingulum* (R.POTONIE) THOMSON & PFLUG ssp. *fusus* (R.POTONIE) THOMSON & PFLUG
50 : *Tricolporopollenites megaexactus* (R.POTONIE) THOMSON & PFLUG
51-53 : *Tricolporopollenites pacatus* PFLUG *in* THOMSON & PFLUG
54, 55 : *Tricolporopollenites porasper* PFLUG *in* THOMSON & PFLUG
56 : *Tricolporopollenites margaritatus* (R.POTONIE) THOMSON & PFLUG
57, 58 : *Tricolporopollenites* sp. (tubuliflorae-type)
59 : *Tetracolporopollenites abditus* PFLUG *in* THOMSON & PFLUG
60 : *Tetracolporopollenites obscurus* PFLUG & THOMSON *in* THOMSON & PFLUG
61 : *Tetracolporopollenites* cf. *oblongus* PFLUG & THOMSON *in* THOMSON & PFLUG
62 : *Tetracolporopollenites* sp.
63, 64 : *Periporopollenites multiporatus* PF. & TH. *in* TH. & PF.
65, 66 : *Periporopollenites periporatus* NAKOMAN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