Turk J Agric For
33 (2009) 89-97

doi:10.3906/tar-0807-17

Woods of a Miocene Petrified Forest near Ankara, Turkey

Ünal AKKEMİK[1,*], Necla TÜRKOĞLU[2], Imogen POOLE[3], İhsan ÇİÇEK[2], Nesibe KÖSE[1], Gürcan GÜRGEN[4]

[1]İstanbul University, Faculty of Forestry, Department of Forest Botany, 34473 Bahçeköy, İstanbul - TURKEY

[2]Ankara University, Faculty of Letters, Department of Geography, 06100 Sıhhiye, Ankara - TURKEY

[3]Wood Anatomy Section, National Herbarium of the Netherlands, University of Utrecht Branch, P.O. Box 80102, 3585 CS Utrecht, THE NETHERLANDS

[4]Ankara University, Faculty of Education, Cebeci, Ankara - TURKEY

Received: 16.07.2008

Abstract: The taxonomic composition of a recently discovered silicified fossil forest, preserved by volcanic activity 18.2-16.9 million years ago in Çamlıdere near Ankara (Turkey), is investigated. Many samples collected were divided into 2 groups as CAM1 and CAM2. Thin sections from transversal, radial, and tangential directions were cut to identify the woods. Wood identifications were performed using standard techniques and fossil wood features. The preserved wood indicates that the forest was composed almost exclusively of *Taxodium* (CAM1) and *Sequoia* (CAM2). These genera were extinct from Anatolia and Europe during late Miocene.

Key Words: Fossil forest, *Taxodium, Sequoia*, palaeobotany, Miocene, Çamlıdere

Ankara Yakınlarındaki Miyosen Dönemine Ait Silisleşmiş Ormanda Saptanan Ağaçlar

Özet: Bu çalışma ile, Ankara-Çamlıdere yakınlarında bulunan ve 18.2-16.9 milyon yıl öncesinde meydana gelen volkanik faaliyetler sonucu silisleşen, fosil ormanı oluşturan ağaçlar saptanmıştır. Toplanan çok sayıdaki örnek iki grup halinde, CAM1 ve CAM2 olarak kodlanmıştır. Örnekler üzerinde anatomik çalışmalar yapmak üzere enine, radyal ve teğet yönlerde ince kesitler alınmış, odun tanımada kullanılan standart yöntemler ve özellikle fosil odun özellikleri esas alınarak, teşhisler yapılmıştır. Silisleşmiş odunların *Taxodium* (CAM1) ve *Sequoia* (CAM2) cinslerine ait olduğu saptanmış olup, bu cinsler günümüzde Anadolu'da doğal yetişmeyen, Miyosen sonlarına doğru Anadolu ve Avrupa'dan yok olmuş ağaçlardır.

Anahtar Sözcükler: Fosil orman, *Taxodium, Sequoia*, paleobotanik, Miyosen, Çamlıdere

Introduction

Little is known about the palaeoecology of Turkey during the Tertiary since fossiliferous localities in both Thrace (European Turkey) and Anatolia (the Asian part of Turkey) have received few palaeobotanical investigations. Those studies have focused predominantly on evidence from macrofossils (Özgüven, 1971; Sayadi, 1973; Eroskay & Aytuğ, 1982; Şanlı, 1982; Selmeier, 1990; Gemici et al., 1991; Dernbach et al., 1996; Akkemik et al. 2005) rather than microfossils (Şanlı, 1982; Batı, 1996; Kayseri and Akgül, 2007).

In Thrace, to the northwest of İstanbul, the upper Oligocene Ağaçlı Lignite Quarry has yielded relatively abundant Tertiary fossil materials, indicating that the

* Correspondence to: uakkemik@istanbul.edu.tr

vegetation was diverse in that period. Petrified wood provides evidence for forests composed of *Pinus*, *Taxus*, *Juniperus*, *Juglans*, *Quercus*, *Salix* (Aytuğ and Şanlı, 1974), and *Sequoioixylon* (Akkemik et al., 2005). Upper Oligocene wood from the Northern Thrace Basin has revealed the presence of *Sequoioixylon* (*S. egemeni*) (Özgüven, 1971) and *Sequoiadendron giganteum* (Aras et al., 2003). Further evidence for a taxodiaceous element to the vegetation comes from fossil wood assemblages in Miocene deposits around Küçük Çekmece Lake (NW Turkey), which indicates the sustained presence of *Taxodium* in the vegetation along with *Taxus* and *Alnus* (Selmeier, 2001).

In west central Anatolia, middle Miocene sediments around Kütahya have yielded abundant macro and microfossils. Over 70 species have been described from this region. Whereas *Glyptostrobus europeaus* was abundant in swamps, *Pinus* and *Quercus* formed a forest around the lake (Gemici et al., 1991). To the west, Suss and Velitzelos (1994a, 1994b) and Velitzelos (1996, 1997) described a petrified forest on Lesvos (Greece), which was composed of *Taxodioxylon*, *Pinoxylon*, *Quercus,* and *Alnus*. Studies of Miocene fossil wood from the Ergene Basin of Thrace provide evidence for the presence of *Carya* and *Juglans* (Eroskay and Aytuğ, 1982). Kayseri and Akgün (2007) identified vegetation composed of relatively abundant (5%-14%) *Pinus* (*silvestris*-type), Taxodiaceae, Nymphaeaceae, Myricaceae, *Ulmus, Quercus*, Cyrillaceae, and Chenopodiaceae along with rarer elements (1%–4%) such as *Engelhardtia*, Juglandaceae, *Platycarya, Carya, Salix, Quercus* (henrici-type), Fagaceae, *Castanea*, Oleaceae, Asteraceae (Tubulifloreae-type), *Gleichenia*, Sphagnaceae, *Podocarpus*, Cupressaceae, *Sequoia*, Ephedraceae, Sparganiaceae, *Tilia, Alnus*. Cycadaceae and Umbelliferae have also been identified from Miocene lignites of Çorum and Sivas provinces, located in the northern part of inner Anatolia (Kayseri and Akgül, 2007).

Further insights into the Late Tertiary palaeoecology can be gleaned from the discovery of 2 new petrified forests that have recently been uncovered (Ulrich Dernbach; personal communication). The forest studied in this work is located in Çamlıdere near Ankara in Central Anatolia and provides direct information regarding the biodiversity of the forests that grew near to what is now Ankara during the Miocene. To date only *Juniperus* and *Cupressus* wood materials have been found preserved in the vicinity of this forest (Akkemik et al., 2008; Ulrich Dernbach; personal communication).

At this time, Ankara was a volcanically active region and, as a result of one such volcanic eruption, a pyroclastic flow felled many of the trees that carpeted the vicinity typically displacing their trunks (cf. Kenrick and Davis, 2004) leaving only the stumps in life position. Along with clouds of fine ash, the forest was then (partially) buried and became entombed in life position (Türkecan et al., 1991, Koçyiğit et al., 2003). Akkemik et al. (2008) identified juniper, pine, and cypress woods from Çamlıdere, Beypazarı and Kızılcahamam deposits.

The Petrified Forest at Çamlıdere is very different from the other fossiliferous localities in Turkey, because it is characterized by dense silicified tree stems, branches, and roots covering the surface. The aim of this study therefore was to (i) identify tree species of the Petrified Forest at Çamlıdere, and (ii) to consider the palaeoecology according to the samples collected.

Geological Setting

The fossil forest is located 85 km northeast of Ankara, 10 km from the centre of Çamlıdere, and just south of the village of Pelitçik. The site is small, measuring ~400 m × ~250 m, and lies at 40°26'N 32°24'E, and at an altitude of 1100 m a.s.l. It is partially surrounded, on its southern and eastern sides, by the Çamlıdere Dam Lake (Figure 1). Numerous petrified trunks and stem material can be found lying on the surface (Figure 2).

During the Miocene, this forest grew on the Galatia volcanic mass (Yılmaz et al., 1981) at a palaeolatitude of 39°N (Meulenkamp and Sissingh, 2003). The prevailing climate was initially sub-tropical but gradually became more arid (Tankut et al., 1995). Tankut and co-workers studying the surrounding volcanics of the Çamlıdere fossil forest proposed an age range of 18.2-16.9 million years (Tankut et al., 1995).

Material and Methods

Silicified wood material, collected from the site, represent stem parts that had been felled by a volcanic eruption. They were all situated in close proximity to one another with the 2 specimens described herein lying next to each other. The preservation of the material collected was variable with some specimens being well-preserved, and others less so.

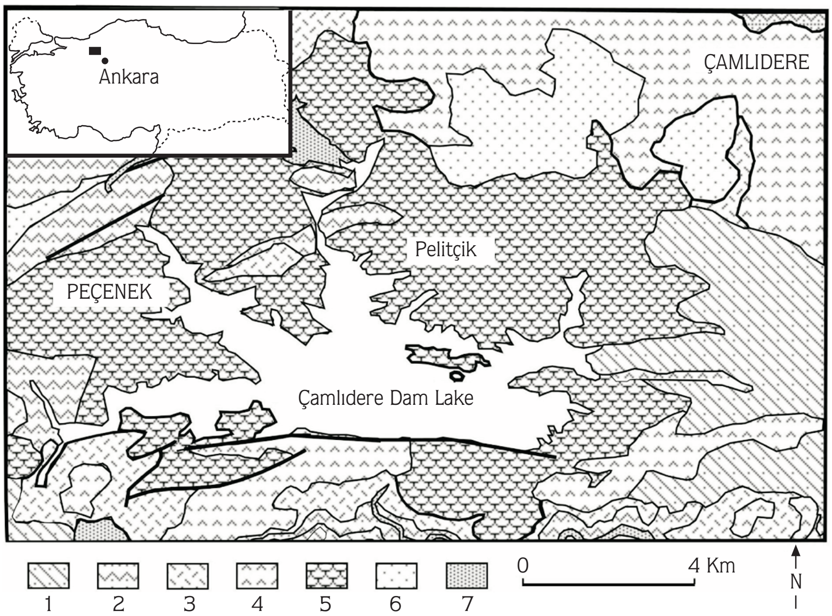

Figure 1. Location and geologic map of Peçenek Basin 1- Lower-Middle Miocene sandstone, claystone, clayey limestone, diatomite, chert, tuffite, conglomerate; 2- Lower-Middle Miocene andesite, basalt, pyroclastic rock; 3- Lower-Middle Miocene dacite, andesite, pyroclastic rock; 4-Lower-Middle Miocene andesite, dacite, pyroclastic rock; 5- Upper Miocene conglomerate, sandstone, mudstone; 6-Pliocene loosely consolidated conglomerate, sanstone, claystone; 7-Alluvium (after Altun et al., 2002).

Figure 2. A general view of the area showing abundant petrified wood material.

Two specimens (CAM1-01 and CAM2-01) are representative of the 2 taxa (CAM1 and CAM2) present in this assemblage. They were thin sectioned along 3 planes, transverse section (TS), radial longitudinal section (RLS), and tangential longitudinal section (TLS), and were studied using a transmitted light microscope. Descriptions follow the terminology of the IAWA Committee (2004) wherever possible. Identifications were made following reference to well-described extant wood, preferably voucher specimens, housed in the Forest Botany Department, Faculty of Forestry, İstanbul University, and the University Utrecht Branch of the National Herbarium of the Netherlands along with comparisons with the literature (e.g. Jacquiot, 1955; Greguss, 1955; Greguss, 1967; Eliçin, 1977; Barefoot and Hankins, 1982; Fahn et al., 1986; Schweingruber, 1990, 1993; Tidwell, 1998). The fossil material described has been referred, rather than assigned, to modern taxa at this stage. More specimens need to be sectioned to validate identification as fossil conifer wood morphospecies are usually ill-defined (cf. Wheeler and Baas, 1998; Falcon-Lang and Cantrill, 2000) and both quantitative and qualitative anatomical characters can vary greatly throughout one tree.

Results

The descriptions are based on the anatomical characteristics of 2 pieces of silicified wood that represent the 2 taxa (CAM Types 1 and 2) present at this site. Their anatomical characters are summarised in Table 1 and illustrated in Figures 3 and 4.

Cupressaceae

'Taxodium' sp.

Representative specimen: CAM1-01

This specimen measures 8 cm diameter by 11 cm in length and displays ~30 growth rings.

Table 1. Wood features and identifications of representatives of the 2 taxa present (CAM Type1 and CAM Type 2). LW: Latewood, EW: Earlywood, TS: Transversal Section, TLS: Tangential Section, RLS: Radial Section

Taxon	**CAM Type 1**	**CAM Type 2**
Specimen	CAM1-01	CAM2-01
Location	from region within the site of abundant fallen material	from the same area with CAM1-01
Preservation	silicified with good contrast locally	silicified with locally good contrast
TS:		
Growth ring boundary	indistinct	distinct
EW to LW transition	gradual with narrow zone (1-2 rows) of LW.	abrupt with wide zone (>10 rows) of LW.
Resin ducts	absent	absent
Axial parenchyma	solitary and rare	diffuse to tangentially zonate
Intercellular canals	absent	absent
TLS:		
Ray width (cells)	uniseriate (part biseriate)	uniseriate
Ray height (cells)	1-4(-10)	5-33
Helical thickenings	absent	absent
Axial parenchyma end walls	none observed	seemingly smooth
RLS:		
Tracheidal pit arrangement	1-2(3), opposite	1-3(4), opposite
Cross field pitting	taxodioid horizontally, randomly arranged	cupressoid-taxodioid, horizontally arranged
No. pits per cross field	2-7	1-6
Indentures	absent	absent
Ray cells walls: end	smooth	smooth
horizontal	smooth	smooth
Ray tracheids	absent	absent

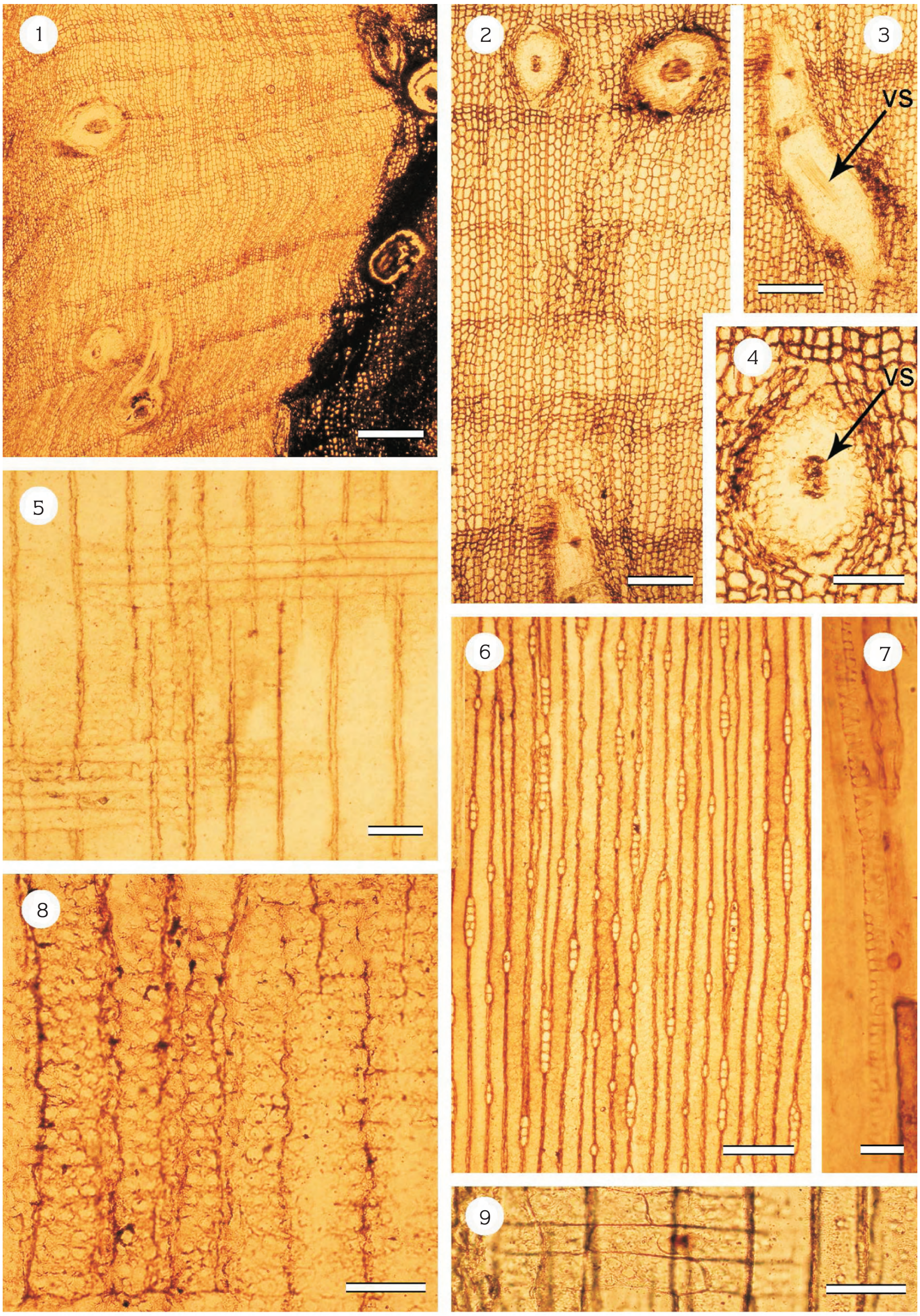

Figure 3. CAM01-01 '*Taxodium*'. 1. TS showing narrow growth rings with indistinct boundaries. Scale bar 1 mm. 2. Narrow latewood zone and 3 vascular traces, TS; scale bar 1mm. 3. Vascular trace running at ~45º to the main axis showing vascular strand (vs), TS; scale bar 1 mm. 4. Vascular trace running parallel to the main axis showing vascular strand and surrounding parenchymatous cells, TS; scale bar 250 µm. 5. RLS of 2 short rays; scale bar, 100 µm 6. TLS of short rays; scale bar, 250 µm. 7. Vascular strand in TLS showing spiral thickening; scale bar, 25 µm. 8. RLS showing biseriate and opposite tracheidal pitting; scale bar, 100 µm. 9. RLS showing cross field pitting; scale bar, 100 µm.

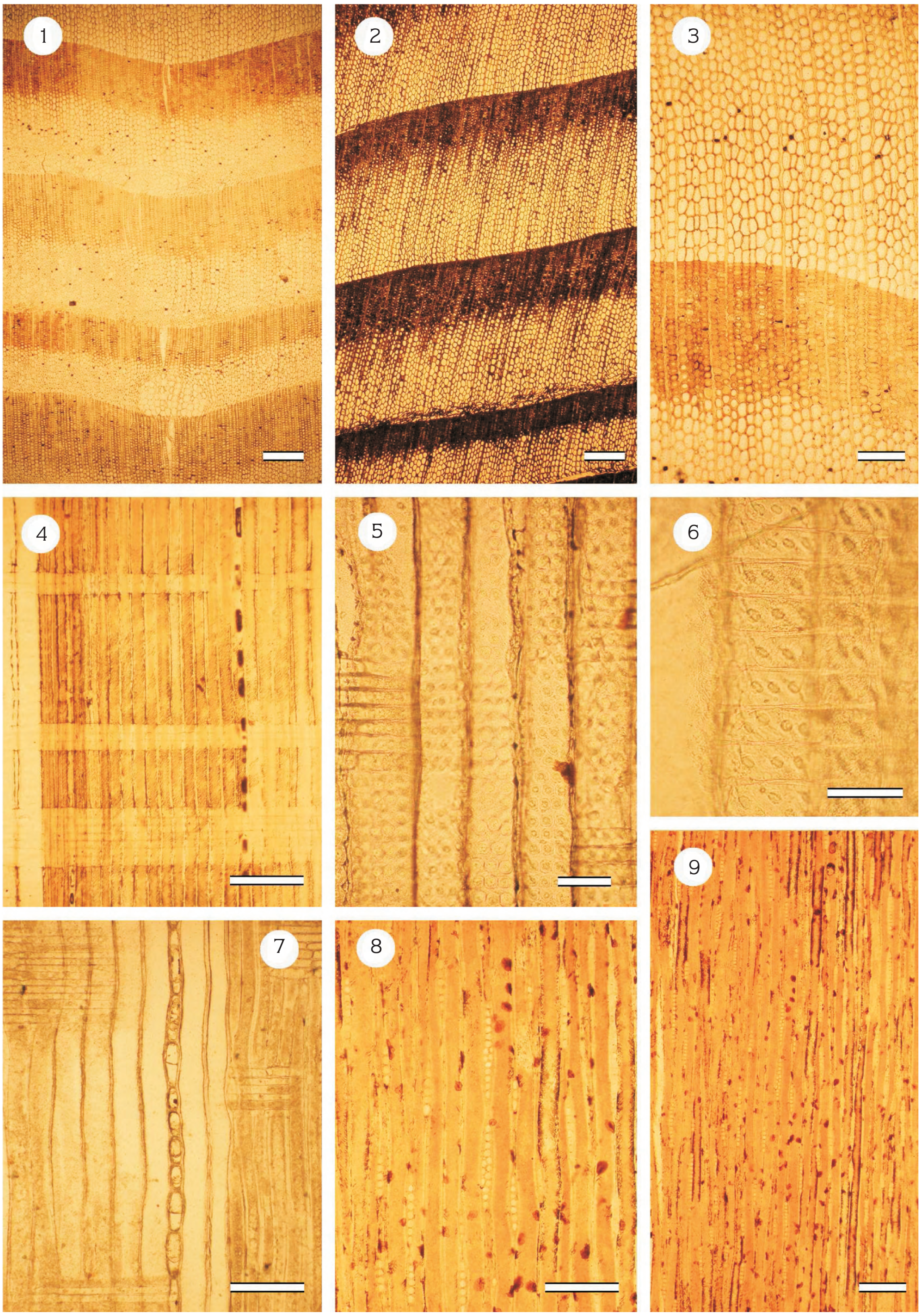

Figure 4. CAM02-01 '*Sequoia*'. 1 and 2. TS showing wide growth rings with distinct boundaries; scale bar, 1 mm. 3. TS showing wide zone of thick walled late wood tracheids with reduced radial diameters; scale bar 250 µm. 4. Rays and axial parenchyma, RLS; scale bar 100 µm. 5. Biseriate and triseriate tracheidal pitting, RLS; scale bar 100 µm. 6. Horizontally aligned cross field pits, RLS; scale bar 50 µm. 7. Axial parenchyma, RLS; scale bar 100 µm. 8. Short, part-biseriate rays, TLS; scale bar 100 µm. 9. TLS showing uniseriate ray size and distribution scale bar 250 µm.

Transverse section: Growth ring boundaries indistinct (Figure 3.1). Transition from earlywood to latewood gradual with narrow zone (1-3, rarely more) of thin walled, latewood tracheids (Figure 3.1-3.2). Axial parenchyma diffuse and rare. Resin canals absent. About 20 vascular traces (probably leaf traces) present (Figure 3.1-3.4), in no obvious arrangement, with a central vascular strand (Figure 3.2-3.4), surrounded by parenchymatous tissue, running parallel to the longitudinal axis (Figure 3.2-3.4) or at an angle (e.g. 45°; Figure 3.2-3.3) or running perpendicular to the axis (not shown) and passing through at least 2 growth rings.

Tangential section: Rays uniseriate and very low (1-4 cells) to rarely medium (up to 10 cells) in height (Figure 3.6). Tracheidal pitting rare, uniseriate and non-contiguous or biseriate and contiguous. Helical thickening absent. Vascular traces composed of elongated cells with wall ornamentation and/or spiral thickening (Figure 3.7).

Radial section: Tracheid pitting uniseriate or biseriate (rarely triseriate) and opposite (Figure 3.8). Rays low (Figure 3.5). Three to seven seemingly taxodioid pits per cross field both horizontally and randomly (Figure 3.9). Ray tracheids absent. Ray parenchyma walls smooth.

Cupressaceae

'Sequoia' sp.

Representative specimen: CAM2-01

This specimen measures 5 cm diameter by 14 cm in length and displays ~20 growth rings.

Transverse section: Growth ring boundaries distinct (Figure 4.1-4.3). Transition from earlywood to latewood abrupt with a thick zone (>10 cells) of latewood tracheids with reduced radial diameters (Figure 4.1-4.3). Axial parenchyma diffuse to tangentially zonate (Figure 4.1, 4.3). Resin canals absent. Vascular traces absent. Crushing of the early wood tracheids present in some growth rings.

Tangential section: Rays uniseriate and (low) medium to high (5-33 cells) (Figure 4.9), rarely part-biseriate (Figure 4.8). Tracheidal pitting rare, non-contiguous uniseriate, and loosely biseriate and opposite. Helical thickening absent. Axial parenchyma in strands with brown contents present in each cell and smooth horizontal end walls.

Radial section: Tracheid pitting generally uniseriate in the latewood and bi- and triseriate, and opposite in the earlywood (Figure 4.5). Ray (low) medium to high (Figure 4.4). One to six cupressoid-taxodioid pits per cross field, horizontally arranged (Figure 4.6). Ray tracheids absent. Ray parenchyma walls smooth. Axial parenchyma cells with (brown) contents (Figure 4.4, 4.7).

The 2 specimens are characterised by the lack of resin ducts, generally uniseriate rays, uniseriate and multiseriate opposite tracheidal pitting, axial parenchyma with smooth end walls (when observable), taxodioid-cupressoid cross field pitting, smooth tangential walls of the ray cells, which are characteristic of the taxodiaceous genera of the Cupressaceae. Taxodiaceous woods generally lack true resin canals, lack indentures in the horizontal walls of the ray parenchyma, and have taxodioid type cross-field pits (Visscher et al. 2003) – a character combination also observed in the fossil CAM1-01 specimens. These CAM1 specimens can be distinguished from the CAM2 specimens, represented by CAM2-01 by the presence of distinct growth rings with abrupt transition from late- to earlywood, seemingly tangentially zonate parenchyma and the presence of high rays, which are absent in CAM1-01, and the presence of vascular strands in CAM1-01. In comparisons with taxodiaceous woods, CAM1-01 exhibits closest similarity to modern *Taxodium* and CAM2-01 to modern *Sequoia* and have thus been referred to these modern genera.

Discussion

Today Turkey is a meeting point of 3 phytogeographical regions, namely the Euro-Siberian, Mediterranean, and Irano-Turanian regions, which reflects differences in climate, geology, topography, soils, and floristic diversity (Çolak and Rotherham, 2006). The Euro-Siberian region is characterised by deciduous forests growing under a relatively humid climate. The Mediterranean vegetation is predominantly sclerophyllous with maquis dominated by evergreen shrubs covering much of the land below 1200 m that gives way to coniferous forests at higher elevations. The vegetation of the Irano-Turanian phytogeographic region is less well known; however, over the Anatolia plateau, oak scrub dominates, giving way to pine forests in the north, west, and south. Today the native forests found in this region are composed of *Quercus pubescens* and *Juniperus* at lower elevations (700-1000 m), *Pinus nigra* at mid-elevations (1000-1400 m), and *Pinus sylvestris* and *Abies* *bornmuelleriana* at elevations above 1400 m - a taxa combination commonly found in other arid parts of Turkey. The prevailing climate is continental with 565 mm annual precipitation and a mean annual temperature of 9.9 °C. According to the Thornthwaite Method (Çepel, 1988), the climate is generally humid with a summer dry period and a very cold winter season.

The Petrified Forest of Çamlıdere of west Central Anatolia lay at a palaeolatitude of 39°N during the Lower Miocene (Meulenkamp and Sissingh, 2003). Bruch et al. (2006) describes a mean annual temperature of between 16 and 17 °C with a cold month mean of 5-7 °C and a warm month mean of 26-27 °C, and a total annual precipitation of 500-1000 mm. Although these climate parameters can not be applied directly to Turkey, as it lies outside the area of data cover (Bruch et al., 2006), it can provide a general idea of conditions in this part of Europe during the later Miocene.

Taxodiaceous conifers (Cupressaceae) were an important component of the vegetation of this region for several million years during the Palaeogene. Evidence for this comes from deposits ranging from Eocene to late Miocene in age (Özgüven, 1971; Gemici et al., 1991; Suss and Velitzelos 1994a, 1994b; Kayacık et al., 1995; Batı, 1996; Selmeier 2001; Aras et al., 2003; Akkemik et al., 2005; Kayseri and Akgün, 2007). This is not surprising since both *Taxodium* and *Sequoia* have a long fossil history and were common elements in the forests of Europe, Asia, and America forming a subcosmopolitan distribution up to about 5 million years ago. Interestingly, the monospecific *Sequoia*, which today is restricted to a narrow range along the Pacific coast, is one of the few conifers that can vegetatively reproduce. Following a major environmental disturbance (e.g. fire), regeneration can occur from the stump, or even roots, and thus allowing it to survive and maintain dominance in an ecologically dynamic habitat. This ability may explain the dominance of *Sequoia* in the volcanic environment of Çamlıdere. *Taxodium*, restricted to the southern part of North America, occupies flood prone areas and its presence in the Miocene Petrified Forest of Çamlıdere may indicate that inundated regions were present in an otherwise *Sequoia*-dominated forest.

Conclusion

This study aims to highlight the excellent preservation of a newly discovered petrified forest from Çamlıdere in Central Anatolia (Turkey). The trees are preserved as a result of volcanic activity that took place during the lower Miocene. Preliminary studies indicate that the forest was composed predominantly of *Taxodium* with few *Sequoias*. *Juniperus* has also been found from the same area (Akkemik et al., 2008) along with *Cupressus* and more evidence for *Juniperus* from neighbouring areas (Ulrich Dernbach: personal communication). With further studies of the site and fossils found in the region, both here and at other localities around Ankara, a more complete reconstruction of ecology of this region will be possible.

Acknowledgement

This study was supported by the Research Fund of İstanbul University. Project number is BYP-690.

References

Akkemik, Ü., N. Köse and I. Poole. 2005. Sequoioiodae (Cupressaceae) woods from the upper Oligocene of European Turkey (Thrace). Phytologia Balcanica, 11: 119-131.

Akkemik, Ü., N. Köse and N. Türkoğlu. 2008. Ankara civarının Tersiyer Florasındaki bazı odunsu bitkiler. II. Doğa Tarihi Kongresi, 3-4 Kasım 2006, Ankara. pp: 107-120.

Altun, E.İ, G. Kadınkız and A. Aksay. 2002. 1/100.000 Ölçekli Jeoloji Haritaları. Bolu H28 Paftası. M.T.A Gn. Müd., Ankara.

Aras, A., N. Aksoy, Z. Batı, M. Sakınç and M. Erdoğan. 2003. Yaşayan fosil *Sequoiadendron giganteum* (Ağaçlı Linyitleri): Ksiloloji, Palinoloji ve Yaşı Türkiye Kuvaterner Çalıştayı. TURQUA IV, pp: 187-195.

Aytuğ, B. and İ. Şanlı. 1974. Forêt de la fin du Tertiaire aux environs du Bosphore. I. Ü. Orman Fakültesi Dergisi. 24: 64-78.

Batı, Z. 1996. Palynostratigraphy and Coal Petrography of the Upper Oligocene Lignites of the Northern Thrace Basin, NW Turkey. Ph.D., Middle East Technical University, Ankara, Turkey.

Barefoot, A.C. and F. W. Hankins. 1982. Identification of Modern and Tertiary Woods. Clarendon Press, Oxford.

Bruch, A. A., T. Utescher, V. I. Mosbrugger, I. Gabrielyan and D. A. Ivanov. 2006. Late Miocene climate in the circum-Alpine realm—a quantitative analysis of terrestrial palaeofloras. Palaeogeography Palaeoclimatology Palaeoecology. 238: 270-280.

Çepel, N. 1988. Orman Ekolojisi. İ.Ü.Orman Fakültesi Yayın no: 3518/399, İstanbul.

Çolak, A.H. and I. D. Rotherdam. 2006. A review of the forest vegetation of Turkey: its status past and present and its future conservation. Biology and Environment: Proceedings of the Royal Irish Academy. 106 B: 343-354.

Dernbach, U., R. Herbst, W. Jung, F. Schaarschmidt, A. Selmeier and E. Velitzelos. 1996. Versteinerte Wälder. –188 S.; Heppenheim (D'Oro).

Eliçin, G. 1977. Türkiye'de Doğal Ardıç (*Juniperus* L) Taksonlarının Yayılışı ile Önemli Morfolojik ve Anatomik Özellikleri Üzerine Araştırmalar. İ. Ü. Orman Fakütesi Yayın No: 2327/ 232.

Eroskay, O. and B. Aytug. 1982. Bois petrifiés du Bassin d'Ergene oriental. I. Ü. Orman Fakültesi Dergisi. 32: 7-21.

Fahn, A., E. Werker and P. Baas. 1986. Wood Anatomy and Identification of Trees and Schrubs from Israel and Adjacent Regions. The Israel Academy of Science and Humanities Publication, pp. 221.

Falcon-Lang, H.J. and D. J. Cantrill. 2000. Cretaceous (Late Albian) Coniferales of Alexander Island, Antarctica. 1. Wood taxonomy. Review of Palaeobotany and Palynology 111: 1-17.

Gemici, Y., E. Akyol, F. Akgün and Ö. Seçmen. 1991. Soma kömür havzası fosil makro ve mikroflorası. MTA Journal 112: 161-178.

Greguss, P. 1955. Xylotomische Bestimmung der Heute Lebenden Gymnospermen, Academia Kiado, Budapest.

Greguss, P. 1967. Fossil Gymnosperm Woods in Hungary, From Permian to Pliocene. Academia Kiado, Budapest.

IAWA Committee. 2004. IAWA list of microscopic features for softwood identification. IAWA J. 25: 1-70.

Jacquiot, C. 1955. Atlas d'anatomie des bois des conifères, Press of Centre Technique du bois et du Fonds Forestier National, Paris, France.

Kayacık, H., B. Aytuğ, F. Yaltırık, İ. Şanlı, A. Efe, Ü. Akkemik and M. İnan. 1995. Tersiyerin Sonunda İstanbul'un Çok Yakınında Yaşamış Olan Mamut Ağaçları, İ.Ü. Orman Fakültesi Dergisi. 45:15-22.

Kayseri, M. S. and F. Akgün. 2007. Palynostratigraphic, Palaeovegetational and Palaeoclimatic Investigations on the Miocene Deposits in Central Anatolia (Çorum Region and Sivas Basin). Turkish J. Earth Sci. 17: 361–403.

Kenrick, P. and P. Davis. 2004. Fossil Plants. Smithsonian Books, Washington.

Koçyiğit, A., J. A. Winchester, E. Bozkurt and G. Holland. 2003. Saraçköy Volcanic Suite: implications for the subductional phase of arc evolution in Galatean Arc Complex, Ankara, Turkey. Geol. J. 38: 1-14.

Meulenkamp, J. E, and W. Sissingh. 2003. Tertiary palaeogeography and tectonostratigraphic evolution of the Northern and Southern Peri-Tethys platforms and the intermediate domains of the African –Eurasian convergent plate boundary zone. Palaeogeography, Palaeoclimatology, Palaeoecology. 196: 209-228.

Özgüven, K. 1971. Sur un bois fossile de Taxodiaceae dans la flore Neogene d'Istanbul (Turquie d'Europe): Sequoioxylon egemeni n.sp., Rev. Fac. Sci. l'Université d'Istanbul, Series B. 36: 89-114.

Şanlı, İ. 1982. Récherches xylologiques sur la flore du Tertiaire de la Thrace Turque. I. Ü. Orman Fakültesi Dergisi. 32: 84-138.

Sayadi, S. 1973. Contribution a l'etude de la flore miocène de la Turquie. –Thèse 3e cycle Paléontologie (Paléobotanique), Paris IV, pp. 81.

Schweingruber, F. H. 1990. Anatomy of European Woods. Verlag Paul Haupt, Bern and Stuttgart.

Schweingruber, F. H. 1993. Trees and Wood in Dendrochronology. Springer-Verlag pp. 402; Berlin Heidelberg.

Selmeier, A. 1990. Dichrostachyoxlon zirkelii (Felix), Mimosoideae, a silicified wood from Miocene sediments of Küçük Çekmece Lake (Turkey). Mitt. Bayer. Staatsslg. Paläont. Hist.Geol. 30: 121-135.

Selmeier, A. 2001. Silicified Miocene woods from the North Bohemian Basin (Czech Republic) and from Kuzuluk, district Adapazari (Turkey). Mitt. Bayer. Staatsslg. Paläont. Hist.Geol. 41: 111-144.

Suss, H. and E. Velitzelos. 1994a. Ein neues fossiles Koniferenholz, Taxoceoxylon biseriatum sp. nov., aus tertiaren Schichten der Insel Lesbos, Griechenland. Feddes Repertorium, 105. 5-6: 257-269.

Suss, H. and E. Velitzelos. 1994b. Zwei neue tertia re Holzer der Gattung Pinoxylon KNOWLTON emend. READ aus dem Versteinerten Wald von Lesbos, Griechenland. Feddes Repertorium, Berlin. 105: 7 - 8, 403-423.

Tankut, A., M. Satır, N. Güleç and V. Toprak. 1995. Galatya volkaniklerinin petrojenezi, Ankara, TÜBİTAK, Project No. YBAG-0059.

Tidwell, W.D. 1998. Common fossil plants of Western North America. Smithsonian Institution Press. pp. 299. Washington and London.

Türkecan A., N. Hepşen, I. Papuk, B. Akbuş, A. Dinçel, S. Karataş, İ. Özgür, E. Akay, Y. Bedi, M. Sevin, G. Mutlu, D. Sevin, E. Ünay and G. Saraç. 1991. Seban-Gerede (Bolu)-Güdül-Beypazarı (Ankara) ve Çerkeş-Orta-Kurşunlu (Çankırı) Yörelerinin (Köroğlu Dağları) Jeoloji ve Volkanik Kayaçların Petrolojisi. MTA rap. no: 9193.

Velitzelos, E. 1996. The petrified forest of Lesvos, a rare natural and geological monument (in Greek). Proc.1st Symposium on the Petrified Forest of Lesvos: pp. 35-42, Mytilene.

Velitzelos, E. 1997. The petrified forest of Lesvos – Protected Natural Monument. Proc. Internat. Sympos. On Engineering Geology and the Environment, Athens, p. 3037-3043, Athens.

Visscher, G.E. and R. Jagels. 2003. Separation of Metasequoia and Glyptostrobus (Cupressaceae) based on wood anatomy, IAWA J. 24: 439-450.

Wheeler, E. A. and P. Baas. 1998. Wood identification: a review. IAWA Journal. 19: 241-264.

Yılmaz, Y., A. M. Gözübol, O. Tüysüz and E. Yiğitbaş. 1981. Abant (Bolu)-Dokurcun (Sakarya) arasında kalan Kuzey Anadolu Fay zonunun kuzey ve güneyinde kalan birliklerin jeolojik evrimi. MTA derleme, rapor no: 7085.