Further contribution to the early Miocene woody flora of Galatian Volcanic Province from Doğanyurt Village, Ankara (Turkey)

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AKKEMİK, ÜNAL; IAMANDEI, STANILA; and ÇELİK, HAKAN (2022) "Further contribution to the early Miocene woody flora of Galatian Volcanic Province from Doğanyurt Village, Ankara (Turkey)," Turkish Journal of Earth Sciences: Vol. 31: No. 2, Article 6. https://doi.org/10.55730/1300-0985.1763
Available at: https://journals.tubitak.gov.tr/earth/vol31/iss2/6

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Further contribution to the early Miocene woody flora of Galatian Volcanic Province from Doğanyurt Village, Ankara (Turkey)

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Received: 12.03.2021 • Accepted/Published Online: 08.01.2022 • Final Version: 29.03.2022

Abstract: The Galatian Volcanic Province (GVP) located in central-north Anatolia had a rich woody flora. The purpose of the present study is to contribute to the early Miocene woody flora of the GVP from two fossil sites from Doğanyurt Village of the city of Beypazarı in the Province of Ankara. The fossil sites, which are near to each other, have small pieces of fossil woods. Total 16 fossil woods were collected from two neighbour sites. Three thin sections as transversal, tangential and radial sections from each sample were taken, and they were identified microscopically. As a result, ten fossil species were identified, three of which are new (Cercioxylon mediterraneum Akkemik, Iamandei & Çelik sp. nov., Cryptocaryoxylon irregularis Akkemik, Iamandei & Çelik, sp. nov., and Myricoxylon doganyurtensis Akkemik, Iamandei & Çelik sp. nov.) and the rest fossil species (Glyptostroboxylon rudolphii Dolezych & van der Burgh, Taxiodoxylon gypsaceum (Göppert) Kräusel, Pinaxyl Gothan, Aceroxylon aceroides Akkemik, Pistacioxylon ufukii Akkemik, Salicoxylon galatianum Akkemik, and Ulmoxylon cf. carpinifolia Greguss) are found also in these two fossil sites. The fossil Myrica, identified for the first time in Turkey as a wood, has many leaf fossils from the early Miocene sites. The most common fossil trees in the Miocene time of GVP, which are G. rudolphii and T. gypsaceum, were also identified in these new sites. The fossil wood assemblage may indicate that the area had a subtropical climate in lowland, with riparian and swamp growth conditions.

Key words: GVP, Miocene petrified wood, new species, subtropical palaeoclimate.

1. Introduction

Turkey's land area functioned in the middle Eocene and later in Miocene, with common occurrences in the early Miocene (Okay et al., 2020). Fossil woods collected mainly from the lower Miocene of Turkey (e.g., Akkemik et al., 2009, 2016, 2019a, Acarca Bayam et al., 2018; Güngör et al., 2019; Akkemik, 2020a; Çevik Üner et al., 2020; Akkemik, 2021). However, several studies have revealed that there are also leaf imprints (e.g., Kasapligil, 1977; Denk et al., 2017, 2019; Güner et al., 2017) and pollen record (e.g., Kasapligil, 1977; Denk et al., 2017; Bılıktekin, 2017), nd land areas were occupied, generally, by lowland well-drained forests, swamp and riparian vegetation, living under subtropical climate conditions during the early-middle Miocene time, with possible drier conditions.

Many kinds of fossil wood have been collected and identified from the Miocene deposits of Turkey. They are fossil conifers Sequoioxylon egemenii Özgüven-Ertan (Özgüven-Ertan, 1971), Cupressinoxylon akdiki Özgüven-Ertan (Özgüven-Ertan, 1977), Sequoioxylon gypsaceum (Göppert) Greguss (Özgüven-Ertan, 1981, 1983), Taxiodoxylon gypsaceum (Göppert) Kräusel, Glyptostroboxylon rudolphii Dolezych & van der Burgh (Akkemik and Acarca Bayam, 2019), Cupressinoxylon pliocenica Akkemik (Akkemik, 2019), Leosbinoxylon kemalyensis Akkemik & Mantzouka (Akkemik et al., 2020), and Juniperoxylon acaracae Akkemik (Akkemik, 2021), and fossil angiosperms Laurinoxylon thomasii Akkemik, Mimosoxylon ceratoniae Akkemik, Pterocaryoxylon tuncayii Akkemik, Prunoidoxylon aytugii Akkemik (Akkemik et al., 2019b), Zelkovaoyxon yesimae Akkemik & I. Poole and Pistacioxylon ufukii Akkemik & I. Poole (Akkemik et al., 2018), Cerioxylon zeynepiae Akkemik (Akkemik, 2019), Actinodaphnoxylon zileensis Akkemik & Mantzouka (Akkemik et al., 2021), Liquidambaroxylon efeae Akkemik, Eucarpoxylon yaltirikii Akkemik, Ostryoxylon gokceadaense Akkemik, Quercinoxylon yaltirikii Akkemik, Cryptocaryoxylon grandolaeceum Akkemik, Fraxinoxylon beypazariense Akkemik, Prunoidoxylon prunoides Akkemik, Populoxylon sebenense Akkemik, Salicoxylon galatianum Akkemik, Aceroxylon aceroides Akkemik, Ulmoxylon kasapligilii Akkemik and Zelkoxylon crystalliferum Akkemik (Akkemik, 2021).

All these results suggest a rich woody flora in the Miocene time in Turkey.

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The Galatian Volcanic Province (GVP), which had active volcanic centers in the early-middle and the late Miocene times (Türkecan et al., 1991), has rich wood fossils from early-middle Miocene (Akkemik et al., 2009, 2016, 2017; Acarca Bayam et al., 2018) and the late Miocene (Akkemik and Acarca Bayam, 2019). All results showed the presence of riparian and swamp forests together with lowland and upland well-drained forests. However, the GVP has many still unknown fossil sites, and new observations are needed. The new findings may reveal many other Miocene fossil species in this region. Thus, the present study aims to provide new insights into GVP knowledge by identifying early Miocene fossil woods from GVP.

2. Geological setting
Galatian Volcanic Province is one of the three widest Miocene volcanic areas of Turkey. Two active phases of volcanics and fossilizations occurred in early and late Miocene (Türkecan et al., 1991). The present fossil site is the early Miocene in age. Two fossil sites close to each other were found near to Doğanyurt village of Beypazarı, Ankara (Figure 1). These two sites fall into the early Miocene Hançili Formation. Detailed geology of the formation was given in the following references (e.g. Türkecan et al., 1991; Akbaş et al., 2002; Altun et al., 2002). The generalized stratigraphy of the region was given modifying from Akbaş et al. (2002). In the stratigraphy, the Gökçekaya Metamorphics including metaclastic and metavolcanites of the Permo-Triassic Karakaya Complex are located at the base of the region (Figure 2). The Mudurnu Formation consisting of Early-Middle Jurassic volcanics and fragments, Soğukçağ Formation consisting of Callovian-Aptian pelagic limestone and calciturbidites and Yenipazar Formation deposited in the Albian-Maastrichtian facies overlie the previous unit. The pelagic limestones in the lower parts of the Yenipazar Formation are differentiated as the Değirmenözü Member and the sandstone predominant part in the upper parts as the Taraklı Member. The Paleocene SelVIPinar Formation and the intrusive terrestrial Kızılçay Formation are conformable with the Yenipazar Formation and its lower sections are cut by the Paleocene Beypazarı Granitoid. Late Eocene-early Miocene Gemiciköy Formation, early-middle Miocene Hançili Formation and late Miocene lacustrine Uruş Formation unconformably overlie the older units. Pliocene Örencik Formation and Quaternary deposits constitute the youngest units of the area (Figure 2 and 3) (Akbaş et al., 2002).

The Hançili Formation, described by Akyürek et al. (1980) consists of alternations of sandstone, claystone, shale, tuff and limestone, and formed from intercalation of clayey limestone, marl, siltstone, sandstone, conglomerate and tuffite. In addition, intermediate levels of gypsum and bituminous shale are observed in the unit. Andesite sills are sometimes associated with these sedimentary units. Conglomerate and sandstones are yellowish-grey in color, little attached and bedding is unclear. The siltstones are gray colored, less fastened, thin bedded and parallel laminated. Clayey limestone and marls are white to yellowish-white in color and thin-medium bedded (Akbaş et al., 2002). The precipitation was accompanied by volcanic products in places. Regarding the age of the Hançili formation, different studies were performed (e.g.

Figure 1. The place of the study area, Doğanyurt Village-Beypazarı in the capital city of Turkey.
Akyürek et al., 1996; Türkecan et al., 1991). Akyürek et al. (1996) gave the Serravalian -Tortonian age based on the fossils of Candona steinheimensis Sierep, Candona convexa Livental, Candona sp. Türkecan et al. (1991) gave the lower Miocene age according to Mikrodyroyrs sp., Megaceritodon sp., Demeceritodon sp., Eumarian sp., Mirabella sp., Eucaritodon sp., Desmonodon sp., micro mammal fauna. Furthermore, several radiometric datings (e.g. Türkecan et al., 1991; Keller et al., 1992) revealed that the ages of the volcanoclastic rocks in the southwestern part of GVP are ranging from 24.83±2.01–21.79±4.93 Ma. Later, Akkemik et al. (2016) suggested 18.2±0.8 Ma (early-middle Burdigalian) from Seben, near the study area. Finally, we can suggest an age range of ca. 24.8–18 Ma for the fossil woods from Doğanyurt Village. Silicified wood samples were generally collected from the lower part of the Hançili Formation (Figure 3) in the present study and former (Akkemik et al., 2016; Acarca Bayam et al., 2018).

3. Material and methods
One of the sites from Doğanyurt village was coded as DOGU (Figure 2), and nine specimens were collected from here. The second site was coded as DOGA (Figure 2), and seven specimens were collected. These samples, collected in 2020, were distributed in the field as small pieces. All samples and the reference fossil collection are housed at the Department of Forest Botany, Faculty of Forestry, Istanbul University-Cerrahpasa. Three thin sections, which has approximately 30 µm thickness, from transversal, tangential and radial sections of each specimen were taken, microscopically studied and described, and identified based on the related references (e.g., Wheeler, 2011; Akkemik and Yaman, 2012; Akkemik, 2020a; Iamandei et al., 2022, Iamandei and Iamandei, 2017; Mantzouka et al., 2016, 2018). Also, online databases, such as InsideWood for angiosperm wood (InsideWood, 2004-onwards).

The terminology of the IAWA Committee (1989) for hardwood identification and IAWA Committee (2004) for softwood identification was followed. In the identification of Glyptostroboxylon, cross-field pits were called as glyptostroboide (e.g. Teodoridis and Sakala, 2008; Dolezych, 2011). This type of cross-field pits is called as pinoid in the terminology of the IAWA Committee (2004).

4. Results and discussion
From the two fossil sites close to each other, three conifers and seven angiosperm species were identified. Three of them were the new fossil species (Table 1). The linear classification presented by Christenhusz et al. (2011) and that of the Angiosperm Phylogeny Group (2016), in which conifers were recognized as subclass Pinidæ and angiosperms as subclass Magnoliidæ, were preferred in this study.

Family CUPRESSACEAE Gray, 1822
Genus GLYPTOSTROBOXYLON Conwentz emend.
Dolezych & van der Burgh, 2004
Type species: Glyptostroboxylon tenerum (Kraus) Conwentz, 1884

Glyptostroboxylon rudolphii Dolezych & van der Burgh, 2004

Figure 4, Photos 1–7.
Formation: Hançili Formation. The detailed geology of the area was given by Acarca Bayam et al. (2018).
Age: Early Miocene.
Locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.
Sample code: DOGU4
Microscopic description: Microscopic description was given based on the wood features such as growth ring, tracheids, rays and axial parenchyma as follows.
Growth ring: Growth ring boundary slightly distinct, with 1–2 rows of flattened latewood tracheids. When late wood zone slightly visible, and transition from earlywood to latewood gradual. While late wood zone has 1–2 rows of flattened tracheids, the earlywood zone is distinctly wider than latewood zone. Resin canals absent (Figure 4.1).
Tracheids: Tracheids generally polygonal or hexagonal in outline in the transverse section (TS) (Figure 4: 1). Tangential and radial diameters of tracheids are 58 (34–82) µm and 76 (59–117) µm in earlywood, 52 (30–66) µm and 46 (34–57) µm in latewood, respectively. Tracheidal pitting on radial walls circular in outline, and 1–3 seriate, and because of poor fossilization crassulae formation could not be observed (Figure 4: 2).
Rays: Rays predominantly uniseriate, height of rays 2–6 (1–12) cells (Figure 4: 3–4). Ray number per mm 3 (2–5). Horizontal and tangential end walls of ray cells smooth (unpitted), and ray tracheids absent. Crossfield pits predominantly glyptostroboid (Figure 4: 5–6), rarely taxodioid, and number of pits 2–4 per crossfield. Horizontal diameters of pits 12.3 (11.5–14.1) µm and vertical diameters 7.6 (6.7–9.4) µm.
Axial parenchyma: Axial parenchyma few, diffuse, but not common. End walls of axial parenchyma thin and smooth (Figure 4: 7).

Coded descriptions following the IAWA Softwood List (IAWA Committee 2004): 40, 43, 45, 46, 54, 72, 73, 76, 80, 87, 91, 94, 98, 99, 102, 103, 107.

Discussion: Glyptostroboxylon type of wood is one of the most common fossil trees in the Miocene of Turkey. Due to having 1–3(–4) regular or irregular rows of tracheids pitting, smooth to moderately thick and pitted end walls of axial parenchyma, homogeneous rays and predominantly glyptostroboid, and also cupressoid or taxodioid type of crossfield pits, these types of wood were assigned as Glyptostroboxylon (Dolezych and van der Burgh, 2004).
HOC, KUZ, AGU, MEN, INL, INO and KAR are published fossil sites from GVP (Akkemik et al., 2016; Bayam et al., 2018) DOGU and DOGA in the box are the present fossil sites.

Tmb: Bakacak volcanics
Tmd: Deveören volcanics
Tmı: Ilıcadere volcanics
Tmh: Hançili formation
Tmkı: Kirazdağı volcanics
Tmu: Uludere pyroclastics

Silicified woods found in mainly early-middle Miocene aged Hançili formation

Figure 2. Locations of the sampled fossil areas with code DOGA and DOGU in Doğanyurt village on the 1/100,000 geology map in Bolu - H27 sheet (Akbaş et al., 2002). The other sites KOZ and HOC (Akkemik et al., 2016) and KUZ, AGU, MEN, INO, INL, KAR (Acarca Bayam et al., 2018) were also given on the map. Red rhombs show the sampled points, which is from the early-middle Miocene Hançili Formation. The abbreviations on the figures: Tplö: Örencik Formation, Qym: Talus, Jks: Soğukçam Formation, Kye: Yenipazar Formation, Tpek: Kızılçay Formation, Qal: Alluvium, PTrg: Permian-Triassic. All the fossil sites are from the Hançili Formation with early-middle Miocene in Galatian Volcanic Province.

The common fossil species in Turkey is G. rudolphii from early to the late Miocene (Akkemik et al., 2017; Akkemik and Acarca Bayam, 2019). Furthermore, Kasapgil (1977) and Denk et al. (2017) identified leaf imprints of this fossil genus from the early Miocene deposits. Within three Glyptostroboxylon fossil species (G. microtracheidale Süss & Velitzelos, G. rudolphii and G. tenerum (Kraus) Conwentz) (see Dolezych & van der Burgh 2004; Süss and Velitzelos 1997; Iamandei et al. 2022), only G. rudolphii has been identified till now, in Turkey’s Miocene deposits. In the studied wood, the features belonging to G. rudolphii, such as radial pitting on tracheid walls up to three vertical rows, irregular and 1–4 predominantly glyptostroboid, but also taxodioid type crossfield pits were observed, and from these reasons, we have assigned it to the species Glyptostroboxylon rudolphii Dolezych & van der Burgh.

In fact, this genus is one of the most common members of swamp conditions. Denk et al. (2017) and Güner et al. (2017) indicated them as a member of VU3 (swamp forest) and VU4 (riparian forest). This new result also supports the marine and swamp subtropical conditions in the Miocene in the central area of Turkey. Genus TAXODIOXYLON Hartig emend. Gothan, 1905
Type species: Taxodioxylon goeppertii Hartig, 1848
Taxodioxylon gypsaceum (Göppert) Kräusel, 1949
Figure 5, Photos 1–8.

Formation: Hançili Formation. The detailed geology of the area was given by Acarca Bayam et al. (2018).
Age: Early Miocene.
Locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.
Sample code: DOGU7, DOGA1, DOGA3, DOGA6
Microscopic description: Microscopic description was given based on the wood features such as growth ring, tracheids, rays and axial parenchyma as follows.
Figure 3. Generalized stratigraphic section of the region covering the western parts of the Galatian Volcanic Province (simplified from Akbaş et al., 2002).

Table 1. The described fossil species from two close sites of Doğanyurt Village of Beypazarı in the province of Ankara.

<table>
<thead>
<tr>
<th>Fossil genus/species</th>
<th>Age</th>
<th>Formation</th>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyptostroboxylon rudolphii Dolezych &amp; van der Burgh</td>
<td>Early Miocene</td>
<td>Hançili Formation</td>
<td>DOGU4</td>
<td>-</td>
</tr>
<tr>
<td>Taxodioxylon gypsaceum (Göppert) Kräusel</td>
<td>Early Miocene</td>
<td>Hançili Formation</td>
<td>DOGU7</td>
<td>DOGA1</td>
</tr>
<tr>
<td>Pinuxylon Gothan</td>
<td>Early Miocene</td>
<td>Hançili Formation</td>
<td>DOGU6</td>
<td>DOGA2</td>
</tr>
<tr>
<td>Aceroxylon aceroides Akkemik</td>
<td>Early Miocene</td>
<td>Hançili Formation</td>
<td>DOGU9</td>
<td>DOGA5</td>
</tr>
<tr>
<td>Cercioxylon mediterraneum sp. nov.</td>
<td></td>
<td></td>
<td>DOGU2</td>
<td>DOGA7</td>
</tr>
<tr>
<td>Cryptocaryoxylon irregularis sp. nov.</td>
<td></td>
<td></td>
<td>DOGU8</td>
<td>-</td>
</tr>
<tr>
<td>Myricoxylon doganyurtensis sp. nov.</td>
<td></td>
<td></td>
<td>DOGU1</td>
<td>-</td>
</tr>
<tr>
<td>Pistaciaxylon ufukii Akkemik</td>
<td></td>
<td></td>
<td>DOGU3</td>
<td>-</td>
</tr>
<tr>
<td>Salicoxylon galatianum Akkemik</td>
<td></td>
<td></td>
<td>DOGU5</td>
<td>-</td>
</tr>
<tr>
<td>Ulmoxylon sp. carpinifolia Greguss</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Growth ring: Average width of growing rings is 0.3 (0.1–0.5) mm. Growth ring boundary distinct with 2–26 radially flattened latewood tracheids. Growth rings with variable extension, from narrow to wide rings (Figure 5: 1–2). The transition from earlywood to latewood mostly abrupt, and latewood zone clearly visible.

Tracheids: In crosssection, tracheid cells mostly polygonal and sometimes rounded (Figure 5: 1–2). Radial and tangential diameters of tracheids are 41 (17–49) µm and 50 (29–74) µm in earlywood, 18 (12–31) µm and 30 (13–46) µm in latewood respectively. Tracheidal radial pitting 1–4 (mostly 2–3) seriate, opposite, and crassulae common (Figure 5: 3 and 6).

Rays: Ray width predominantly uniseriate, rarely partly biseriate, ray height 11–26 (1–71) cells (Figure 5: 4). Rays homogenous, composed of only ray cells; horizontal and end walls of ray cells smooth (Figure 5: 4–5), crossfield pits clearly taxodioid, 2–5 pits per crossfields (Figure 5: 7). Ray number per mm 6–9, horizontal and vertical diameters of crossfield pits 11.8 (7.8–14.6) µm and 7.6 (6.3–8.1) µm, respectively.

Axial parenchyma: Axial parenchyma appears diffuse and zonate. Intercellular resin canals absent. End walls of axial parenchyma smooth or slightly nodular (Figure 5: 8).

Coded descriptions following the IAW A Softwood List (IAW A Committee 2004): 40, 42, 43, 45, 46, 55, 72, 73, 75, 76, 80, 87, 94, 98, 99, 104, 107.

**Microscopic description:** Microscopic description was given based on the wood features such as growth ring, tracheids, rays and axial parenchyma as follows. The sample of fossil wood shows a poorly preserved structure.

**Discussion:** In the studied specimens, we observed distinct growth rings, angular tracheids in crosssection, wide tracheids in earlywood, 1–3 seriate of radial wall pits with 15–20 µm diameter, abundant crassula formation and axial parenchyma with smooth horizontal walls, uniseriate and partly biseriate rays up to 35 cells in height, and predominantly taxodioid of crossfield pits, and details similarly described by Koutecký and Sakala (2015). In this type of wood, a gradual to the abrupt transition from earlywood to latewood appears, with a clear latewood zone, composed of flattened latewood tracheids. Also, the 1–3 vertical rows of tracheid pits, the smooth transverse walls of axial parenchyma cells, crassula formation and the up to three taxodioid pits in one horizontal row in the crossfield (or six pits in two rows in taller fields) are the main xylotomical characteristics (e.g., Özgüven-Ertan, 1971, 1981 (1983); Iamandei et al., 2011, 2022; Koutecký et al., 2009, 2019a; Akkemik, 2019, 2020a; Acarca Bayam et al., 2018; Güngör et al., 2019; Polat et al., 2019) and up to Pliocene fossil site (Akkemik, 2019). The presence of this type of wood indicates an environmental continuity from the late Oligocene to Pliocene (Akkemik, 2019) in Turkey and reveals its abundance.

Family PINACEAE Gray, 1822
Genus PINUXYLON Gothan, 1905
**Pinuxylon** sp.

Figure 6, Photos 1–7.

**Formation:** Hançili Formation. The detailed geology of the area was given by Acaoca Bayam et al. (2018).

**Age:** Early Miocene.

**Locality:** Doğanyurt Village at the city of Beypažar in the province of Ankara.

**Sample code:** DOGA4

The presence of the possible tiny denticles suggested in the ray tracheids (Figure 3, photos 6, 7) may lead us to pine of *Diploxylon*-type (see Iamandei et al., 2022). The studied wood has probably such type idioblast-like cells in rays but is poorly preserved. Because of this, we prefer to identify it as *Pinuxylon* sp., as a wood of pine that lived in the early Miocene in Turkey. This type of wood is common in the Galatian Volcanic Basin (Akkemik et al., 2016; Acaoca Bayam et al., 2018), in west Anatolia
(Akkemik et al., 2019a), and east Anatolia (Akkemik et al., 2020). With this identification, one more site was added to its distribution area. Thus, it is possible that our Pinus xylonsp. would be a form of Diploxylon type: close to the pines living today in the Mediterranean area, as for example (subgenus Pinus): Pinus halepensis, P. brutia, P. pinaster, P. pinea, P. canariensis, P. nigra, P. sylvestris, P. heidrichii, P. uncinata (see Gernandt et al., 2005; Earle, 2020). Because this fossil wood was poorly fossilized, it could not be used as an indicator in the ecological evaluation and species description.

Family SAPINDACEAE Jussieu 1789
Genus ACEROXYLON Hofmann, 1939
Type species Aceroxylon campestre Hofmann, 1939

Aceroxylon aceroides Akkemik 2021
Figure 7, Photos 1–8.

Formation: Hançlıli Formation. The detailed geology of the area was given by Acarca Bayam et al. (2018).

Age: Early Miocene.
Locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.
Sample code: DOGU6

Microscopic description: Microscopic description was given based on the wood features such as growth ring, vessels, rays, axial parenchyma and (if it was seen) fibers as follows.

Growth ring: Growth ring boundaries visible and marked by 1–3 rows of flattened fibers and marginal axial parenchyma cells (Figure 7: 1–2).

Vessels: Wood diffuse-porous, diameter and frequency of vessels slightly lower at the end of latewood zone. Solitary vessels generally circular, and angular in radial multiples; solitary (60%–70%) or mainly in radial multiples of 2–3 or rarely 4 vessels (Figure 7: 1–2). Mean radial and tangential diameter of vessels 78 (21–102) μm and 53 (26–72) μm in earlywood, 49 (18–80) μm and 43 (26–65) μm in latewood, respectively, and their frequency 44–63 vessels per square mm. Intervessel pits alternate, 8.6 (7.0–10.2) μm in horizontal diameter and 6.2 (4.6–7.9) μm in vertical diameter (Figure 7: 3). Perforation plates simple (Figure 7: 4). Helical thickenings present in vessels (Figure 7: 5).

Rays: Rays of two distinct sizes, wider rays commonly 4–5 seriate, sometimes 1–2 (3) seriate (Figure 7: 6). Rays are homocellular and composed of procumbent ray cells (Figure 7: 7). Ray number per mm 4–6.

Axial parenchyma: Axial parenchyma is both apotracheal diffuse and marginal. Prismatic crystals commonly present in chambered axial parenchyma cells (Figure 7: 8).

Fibers: Fibers generally thin walled, and septate fibers present.

Coded descriptions following the IAWA Hardwood List (IAWA Committee 1989): 1, 5, 7, 13, 22, 26, 36, 41, 49, 61, 65, 69, 76, 89, 97, 98, 103, 104, 115, 142.

Discussion: This fossil species was determined from a near locality (18 km far from the new site) at the same geological unit by Acarca Bayam et al. (2018) as genus and later by Akkemik (2021) as fossil species, Aceroxylon aceroides Akkemik. Considering the above mentioned microscopic description and the similarity up to identity to the extant species just cited (Acer monspessulanum L.), regarding the arrangement of vessels in crosssection, their alternate pitting, helical thickenings and their simple perforations, the septate fibers and chambered crystalliferous parenchyma, diffuse and marginal, and also the aspect of rays, 4–5 seriate, support the proposal for the species that we identified Aceroxylon aceroides Akkemik. Acarca Bayam et al. (2018) stated that the present fossil species is very similar to modern Acer monspessulanum L., (see Akkemik & Yaman, 2012), which is a Mediterranean species living also in the riparian forest (VU4), well-drained lowland (VU5) and upland (VU6) (see Denk et al., 2017; Güner et al., 2017).

Family FABACEAE Lindl., 1836
Subfamily CERCIDIOIDEAE LPWG, 2017
Genus CERCIOXYLON Akkemik, 2019
Type species Cercoxylon zeynepiae Akkemik, 2020
Species Cercioxyylon mediterraneum sp. nov. Figure 8, Photos 1–10.

Holotype: DOGU5
Repository: Department of Forest Botany, Faculty of Forestry, İstanbul University-Cerrahpaşa, İstanbul, Turkey.

Plant fossil registry number: PFN002411

Etymology: The name “mediterraneum” is derived from the name of the Mediterranean region, which have a wide distribution area of the modern representative species Cercis siliquastrum L.

Type locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.

Age: Early Miocene

Type horizon: Hançlıli Formation.

Diagnosis: Wood ring porous. Vessels solitary or in small radial groups in earlywood, and grouped in short radial multiples or in clusters with net-like large diagonal axial parenchyma bands in latewood., sometimes in dendritic pattern. Tangential diameter of vessels 118 (55–174) μm, and their frequency 11–24 vessels in earlywood per square mm; 41 (18–69) μm in latewood and their frequency 23–49 vessels per square mm. Pits on vessels alternate and opposite. Some vestured pits present in vessel elements. Perforation plates simple. Rays 2–4 (1–5) seriate, up to 53 cells high, homocellular, vessel-ray pits of 5–7 μm in diameter. Fibers thin- to thick walled. Axial parenchyma paratracheal to vasicentric, and organized in tangentially and largely diagonally banded to confluent. Storied axial
Figure 4. Wood characteristics of *Glyptostroboxylon rudolphii*. 1) Transversal section (TS) with slightly distinct growth ring boundary, 2) Up to triseriate of bordered pits (arrow) on radial surfaces of tracheids in radial longitudinal section (RLS), 3) Tangential longitudinal section (TLS) with uniseriate rays, 4) The longest ray, 5–6) Glyptostroboid type crossfield pits (arrows), 7) Axial parenchyma cells with smooth end wall.
Figure 5. Wood characteristics of *Taxodioxylon gypsaceum*. 1) Transversal section (TS) with distinct growth ring boundary, 2) The widest latewood zone up to 26 cells (arrow), 3) Biseriate bordered pits and crassulae formation (arrow) in RLS, 4–5) Tangential longitudinal section (TLS) with uniseriate rays, 6) Up to tetraseriate of bordered pits on radial surfaces of tracheids (arrow) in RLS, 7) Taxodioid type of crossfield pits in RLS (arrow), 8) Axial parenchyma with smooth end walls (arrows).
parenchyma present and 2–4 cells per parenchyma strand. Microscopic description: The fossil wood sample is relatively well preserved. Microscopic description was given based on the wood features such as growth ring, vessels, rays and axial parenchyma as follows.

Growth ring: It shows a ring porous structure and growth ring boundary distinct (Figure 8: 1–2).

Vessels: Vessels in earlywood, solitary or in small radial groups, and smaller in late wood, grouped in short radial multiples and in clusters with net-like large axial parenchyma bands, sometimes in dendritic pattern (Figure 8: 1–3). Mean radial and tangential diameters of vessels 174 (43–245) μm and 118 (55–174) μm and their frequency 11–24 vessels in earlywood per square mm; they are 30 (14–45) μm and 41 (18–69) μm and their frequency per square mm 23–49 in late wood. Intervessel pits alternate and opposite, 6 (4–7.3) μm (Figure 8: 4). Some vestured pits present in vessel elements (Figure 8: 4). Helical thickening presents on vessel walls (Figure 8: 5). Perforation plates simple (Figure 8: 6).

Rays: Rays homocellular, 1–5 seriate (usually 2–4 seriate), the multiseriate ray height have 15–35 (max. 53) cells, the uniseriate ray height have 2–10 cells. Rays commonly 2–5 seriate, uniseriate rays scarce, ray cells all procumbent, and vessel-ray pits of 5–7 μm in diameter, and ovate-ellipsoid. Ray number per mm 4–6 rays (Figure 8: 7–9).

Axial parenchyma: Axial parenchyma scanty paratracheal to vasicentric, and organized in tangentially and largely diagonally banded, to confluent (Figure 8: 13). The axial parenchyma storied, 2–4 cells per parenchyma strand (Figure 8: 10).

Fibers: Fibers thin- to thick walled (Figure 8: 1–3).

Coded descriptions following the IAWA Hardwood List (IAWA Committee 1989): 1, 3, 7, 8, 13, 21, 22, 25, 36, 42, 48, 61, 66, 69, 78, 79, 83, 85, 92, 97, 98, 104, 115, 120, 142.

### Table 2. Comparison of Cercioxylon described species and the studied wood.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>(Akkemik and Yaman, 2012)</td>
<td>Distinct</td>
<td>Distinct</td>
<td></td>
</tr>
<tr>
<td>(Akkemik, 2019)</td>
<td>Cercioxylon zeypieae Akkemik</td>
<td>The present wood</td>
<td>Vessel semiring to ring porous</td>
</tr>
<tr>
<td>Helical thickening</td>
<td>Present</td>
<td>Not observed</td>
<td>Present</td>
</tr>
<tr>
<td>Vessel tangential diameter</td>
<td>50–110 μm</td>
<td>84 (52–132) μm</td>
<td>118 (55–174) μm</td>
</tr>
<tr>
<td>Vessel arrangement</td>
<td>Vessel in diagonal pattern and tangential bands, and in radial pattern up to 8 vessels</td>
<td>Vessels in short radial pattern up to 6 cells</td>
<td>Vessel in diagonal pattern and tangential bands, and in radial pattern up to 3 vessels</td>
</tr>
<tr>
<td>Perforation Figure</td>
<td>Simple</td>
<td>Simple</td>
<td>Simple</td>
</tr>
<tr>
<td>Vestured pits</td>
<td>Common</td>
<td>Common</td>
<td>Present</td>
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<tr>
<td>Fibers</td>
<td>Fibers thin- to thick-walled.</td>
<td>Fibers thin- to thick-walled.</td>
<td>Fibers thin- to thick-walled.</td>
</tr>
<tr>
<td>Axial parenchyma</td>
<td>Axial parenchyma scanty paratracheal to vasicentric and confluent, banded, and in tangential to net-like groups with vessels</td>
<td>Axial parenchyma predominantly aliform and confluent</td>
<td>Axial parenchyma predominantly in large tangential bands, and confluent</td>
</tr>
<tr>
<td>Ray height</td>
<td>Multiseriate ray height generally 20–40 cells (max 71 cells)</td>
<td>Multiserate ray height generally 18–27 (max. 56) cells in larger rays, and 5–15 cells in uniseriate rays</td>
<td>Multiserate ray height generally 15–35 (max. 53) cells, the uniseriate ray height have 2–10 cells.</td>
</tr>
<tr>
<td>Ray type</td>
<td>All rays procumbent</td>
<td>Body ray cells procumbent with 1–4 of square marginal cells</td>
<td>All rays procumbent.</td>
</tr>
<tr>
<td>Storied structures</td>
<td>In axial parenchyma and vessel elements</td>
<td>In axial parenchyma</td>
<td>In axial parenchyma and vessel elements.</td>
</tr>
<tr>
<td>Mineral inclusions</td>
<td>Crystals present in axial parenchyma cells and marginal ray cells</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>
Discussion: This type of wood was described from the Pliocene of central Anatolia by Akkemik (2019), and most of the features observed are very similar to those of the here studied specimen (see Table 2). These are the typical xylotomical characters of *Cercioxylon*: ring to semi-ring-porous structure in cross-section, the tangential diameter of the vessels in earlywood of 50–150 μm, perforation plates simple, vested pits present on vessels, axial parenchyma in large bands and dendritic and diagonal tangential bands, confluent, ray-cells all procumbent 1–4 rows of square marginal cells present (Akkemik, 2019).

The nearest fossil genus is *Mimosoxyylon* Müller-Stoll et Mädel (1967). It differs from *Cercioxylon* in having large and diffuse-porous of the wood, indistinct, fairly visible or distinct boundary of growth rings, mainly paratracheal vasicentric, aliform and confluent axial parenchyma, procumbent body ray-cells with one to four rows of upright and/or marginal square cells (heterocellular type), and prismatic crystals present in squared marginal ray-cells (see Müller-Stoll & Mädel, 1967; Akkemik et al., 2019b).

Based on this discussion the present wood was identified as *Cercioxylon* Akkemik. The differences and similarities of the current wood with the type species *Cercioxylon zeynepiae* Akkemik (Akkemik, 2019) and the extended Mediterranean species *Cercis siliquastrum* L. (Akkemik and Yaman, 2012) are given in the following identification key and, respectively, in Table 2:

1A. All rays procumbent; wood ring porous; Vessel within the tangentially banded axial parenchyma; vessels also in radial pattern up to 3 vessels; helical thickening presents in vessels; axial parenchyma predominantly in large tangential bands, and confluent > *Cercioxylon mediterraneum* sp. nov.

1B. Body ray cells procumbent with one to four square marginal cells; wood semiring to ring porous; Vessels in short radial pattern up to 6 cells, helical thickening absent; axial parenchyma predominantly aliform, and confluent > *Cercioxylon zeynepiae* Akkemik 2019

Considering the above discussion and the comparison table, we observe a considerable similarity with the species *Cercioxylon zeynepiae* Akkemik, but up to identity, to the species *Cercis siliquastrum* given in Akkemik and Yaman (2012), and we attribute the studied specimen. Thus, our studied specimen will be named *Cercioxylon mediterraneum* sp. nov., as a new species similar to the extant species *Cercis siliquastrum* L., commonly known as the Judas tree, a small deciduous tree which live now in Southern Europe and Western Asia [and also identical with the fossils species described with the same Linnean name (Akkemik and Yaman, 2012)]. This species grows under the lowland well-drained Mediterranean conditions in the region. This identification also supports the presence of lowland well-drained conditions in the early Miocene of the Anatolian area.

Family LAURACEAE Juss. 1789
Genus CRYPTOCARYOXYLON Leisman, 1986
Type species *Cryptocaryoxylon gippslandicum* Leisman, 1986

Cryptocaryoxylon irregularis Akkemik, Iamandei & Çelik sp. nov.

Figure 9, Photos 1–9.

Holotype: DOGA7
Repository: Department of Forest Botany, Faculty of Forestry, Istanbul University-Cerrahpaşa, Istanbul, Turkey.

Plant fossil registry number: PFN002412

Etymology: The name “irregularis” is derived from ray features. Ray cell widths are irregular, wider or narrower depending on presence/absence of oil and mucilage cells.

Type locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.

Age: Early Miocene

Type horizon: Hançili Formation.

Diagnosis: Growth ring boundaries distinct and marginal axial parenchyma cells 1–3 seriate. Vessels diffuse porous and generally in radial multiples of 2–3 and 4 or more, rarely solitary. Mean radial and tangential diameters of vessels 66 (34–129) μm and 79 (44–112) μm and their frequency 42–65 vessels per square mm. Perforation plates simple. Intervessel pits alternate, small and medium sized. Shape of the alternate pits mostly ellipsoid. Ray width of 1–3 cells and up to 37 cells high, 7–12 rays per mm. In tangential section marginal cells of rays longer, irregular, wider or narrower. All rays procumbent, 1–4 rows of irregularly enlarged procumbent cells contain oil and mucilage materials. Oil and mucilage within the enlarged ray cells, but typical marginal oil and mucilage cells not observed. Some enlarged procumbent ray cells contain oil and mucilage through ray. Axial parenchyma scanty paratracheal, apotracheal diffuse, and 1–3 seriate of marginal bands.

Microscopic description: Microscopic description was given based on the wood features such as growth ring, vessels, rays, axial parenchyma and (if it was seen) fibers as follows.

Growth ring: Growth ring boundaries distinct, with 1–3 rows of marginal axial parenchyma cells (Figure 9: 1–2).

Vessels: Vessels diffuse, and generally in radial multiples of 2–3 (60%–70%) and 4 or more (up to 7) (30%–40%), rarely solitary (Figure 9: 1–2). Mean radial and tangential diameters of vessels 66 (34–129) μm and 79 (44–112) μm and their frequency 42–65 vessels per square mm. Perforation plates simple (Figure 9: 3). Intervessel pits alternate (Figure 9: 4) and their horizontal diameters 11.1 (6.0–15.2) μm and vertical diameters 8.6 (7.2–9.9) μm and their shapes mostly ellipsoid.

Rays: Ray width of 1–3 cells and up to 37 cells high (Figure
Figure 6. Wood characteristics of *Pinuxylon* sp. 1–2) Transversal section (TS) with distinct growth ring boundary and vertical resin canals with thin-walled (arrow), 3–4) Uniseriate rays in TLS, 5) A fusiform ray, 6–7) Two crossfield pits per cross area (arrow) and ray tracheid with smooth end walls on the radial longitudinal section in RLS (arrow).
Figure 7. Wood characteristics of *Aceroxylon aceroides*. 1) Transversal section (TS) with distinct growth ring boundary, 2) Marginal axial parenchyma in the boundary of growth ring (arrow), 3) Alternate radial pitting on the vessel walls, 4) Simple perforation plate in RLS (star), 5) Remnants of helical thickening on the vessel cell walls (arrow), 6) 1–4 seriate of rays in TLS, 7) Homocellular rays, 8) Prismatic crystals in chambered axial parenchyma (arrow).
Figure 8. Wood characteristics of Cercioxylon mediterranum. 1–2) Transversal section (TS) with distinct growth ring boundary, ring porous and confluent axial parenchyma, 3) Dendritic pattern of vessels and axial parenchyma cells, 4) Opposite and alternate pitting on vessels and some vestured pits (arrow), 5) Remnants of helical thickening (arrow), 6) Simple perforation (arrow) plate and storied cells in RLS, 7–8) 1–6 seriate of rays in TLS, 9) Homocellular rays and simple perforation plate in RLS (star), 10) An axial parenchyma strand (arrow).
9: 5–6). Density of 4–12 rays per mm. In tangential section marginal cells of rays longer, irregular, wider or narrower. All ray cells procumbent, 1–4 rows of irregularly enlarged procumbent cells contain oil and mucilage materials (Figure 9: 8–9). Oil and mucilage within the enlarged ray cells, but typical marginal oil and mucilage cells not observed (Figure 9: 8–9).

Axial parenchyma: Axial parenchyma scanty paratracheal, apotracheal diffuse, and 1–3 seriate of marginal bands (Figure 9: 1–2), vertical strand length of 2 to 4 cells or more (Figure 9: 5).

Coded descriptions following the IAWA Hardwood List (IAWA Committee 1989): 1, 5, 7, 8, 10, 13, 21, 22, 26, 27, 36, 41, 49, 61, 76, 78, 92, 93, 97, 106, 107, 115, 124.

Discussion: In most of the genera, which are Magnoliioxylon, Beilschmiedia, Caryodaphnioxylon, Laurinium, Laurinoxylon, Litseoxyylon, Ulminium, Umbellularia, Paraphyllanthoxylon, Machilusoxylon, Argapaloxylon, and Cryptocaryoxylon (except Cryptocaryoxylon radioporum Wheeler & Manchester and Cryptocaryoxylon hancockii Wheeler & Manchester), vessel solitary and in radial multiples of 2–3 vessels. Only in two species of Cryptocaryoxylon (C. rapidoporosum and C. hancockii) and in our wood vessels, commonly in radial multiples of four or more (Wheeler and Manchester, 2002), and cluster presents. Some other features, such as indistinct or absent growth rings, simple perforation plates, 50–100 µm and 100–200 µm of vessel tangential diameters, 1–3 rows of ray widths, heterocellular rays, presence of tyloses, and presence of idioblast cells in rays and among fibers are very similar to each other. Hence, our wood is very similar to Cryptocaryoxylon.

Having vessels commonly in radial multiples of four or more, marginal axial parenchyma cells, simple perforation plates and oil and mucilage cells associated with rays, our studied specimen could be a Lauraceous wood, most probable of Cryptocaryoxylon type (see Leisman, 1986; Gottwald, 1997; Wheeler, 2011). An identification key prepared by Akkemik (2021) was modified with this new species to find the exact differences of it as follows.

1A. Vessels commonly in radial multiples of 4 or more, clusters present.

2A. Typical oil and mucilage cells absent, oil and mucilage materials within the enlarged procumbent ray cells, not only borders but also inside of rays; ray cell widths irregular > Cryptocaryoxylon irregularris sp. nov.

2B. Oil and mucilage cells present at the borders of rays

3A. Marginal or seemingly marginal bands of axial parenchyma absent, and parenchyma vasicentric, aliform and confluent; oil and/or mucilage cells associated with ray parenchyma > Cryptocaryoxylon hancockii Wheeler & Manchester, 2002

3B. Axial parenchyma scanty paratracheal, in marginal or seemingly marginal bands > Cryptocaryoxylon

radiporosum Wheeler & Manchester, 2002

1B. Vessels diffuse and in radial multiples of 2–3 common.

4A. Larger rays commonly 4–10 seriate; axial parenchyma vasicentric, aliform or marginal; oil and/or mucilage cells associated with ray parenchyma and among fibres > Cryptocaryoxylon lemnium Mantzouka, 2018

4B. Rays only 1–3 seriate

5A. Oil and/or mucilage cells only among fibers; axial parenchyma banded, bands more than three cells wide, and scanty paratracheal > Cryptocaryoxylon meeksii Wheeler & Manchester, 1986

5B. Oil and/or mucilage cells not only among fibers but also associated with ray cells, or only associated with ray cells

6A. Rays storiied; axial parenchyma scanty paratracheal and vasicentric > Cryptocaryoxylon meeksii Wheeler & Manchester, 2002

6B. Storied rays absent;

7A. Typical oil and mucilage cells absent or very seldom, oil and mucilage within the enlarged ray cells, not only borders but also inside of rays; vessel frequency ≥100 vessels > Cryptocaryoxylon irregularris sp. nov.

7B. Typical oil and mucilage cells present, oil and mucilage cells present at the borders of rays; vessel frequency 100≤ per square mm.

8A. Wood semiring to diffuse porous, vessels in radial multiples of 2–3 vessels; oil and mucilage cells associated with ray parenchyma and among fibers and very large; marginal axial parenchyma generally 1 (3) seriate > Cryptocaryoxylon grandoleaceoum Akkemik, 2021

8B. Wood diffuse porous; oil and mucilage cells associated with ray parenchyma and among fibers, and not very large; Vessels in radial multiples of 2–3 vessels or 4 or more; marginal axial parenchyma (1–3) seriate > Cryptocaryoxylon lemnium Mantzouka, 2018

According to the differentiation of the fossil species, the new fossil Cryptocaryoxylon differs from all other fossil species in that typical oil and mucilage cells were not observed in the wood. In our specimen, oil and mucilage materials are inside the enlarged procumbent ray cells. These enlarged ray cells are not only in borders of rays but also inside of rays. Based on this specificity, we propose a new early Miocene fossil species, which we name Cryptocaryoxylon irregularis Akkemik, Iamandei & H. Çelik sp. nov., a species living in well-drained lowland as the extant correspondents live.

Family MYRICOXYLEAE A.Rich. ex Kunth, 1817
Genus MYRICOXYLON Müller Stoll & Mädel, 1962
Type species Myriconyloxylon hungaricum Müller Stoll & Mädel, 1962
Myriconyloxylon doganyurtensis Akkemik, Iamandei & Çelik sp. nov.

Figure 10, Photos 1–7.

Holotype: DOGU9
Repository: Department of Forest Botany, Faculty of Forestry, Istanbul University-Cerrahpaşa, Istanbul, Turkey.

Plant fossil registry number: PFN002414

Etymology: The name “doganyurtensis” is derived from the name of the nearest village “Doğanyurt” to the fossil site.

Type locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.

Age: Early Miocene

Type horizon: Doğanyurt Village at the city of Beypazarı in the province of Ankara.

Diagnosis: Growth ring boundary distinct with one row of marginal axial parenchyma cells. Wood diffuse porous, vessels predominantly solitary (more than 90%), rarely 2–3 vessels in radial multiples, density of vessels 236–257 vessels per square mm. Perforation plate scalariform and composed of 6–14 bars. Radial and tangential diameters of vessels 36 (17–51) µm and 34 (22–48) µm. Rays (1–) 2–3 seriate. Longer ray cells at the tips 1–4 and uniseriate, body ray cells rounded or ellipsoid. Rays heterocellular, body ray cells procumbent with mostly 2–4 rows of upright and / or square marginal cells. Ray number per square mm 7–12 rays. Axial parenchyma diffuses and marginal. Prismatic crystals present in wider axial parenchyma cells, axial parenchyma cells in irregular widths, larger or narrower. Fiber-tracheids with distinctly bordered pits.

Microscopic description: Microscopic description was given based on the wood features such as growth ring, vessels, rays, axial parenchyma and (if it was seen) fibers as follows.

Growth ring: Growth ring boundary mostly indistinct, and can be visible marked by one row of marginal axial parenchyma (Figure 10: 1).

Vessels: Wood diffuse porous, vessels predominantly solitary (more than 90%), rarely 2–3 vessels in radial multiples, mainly circular, and their frequency 236–257 vessels per square mm (Figure 10: 1). Radial and tangential diameters of vessels 36 (17–51) µm and 34 (22–48) µm. Intervessel pits opposite, horizontal diameters 12 (10–17) µm, vertical diameters 7 (5–11) µm. Perforation plates scalariform with 6–14 bars (Figure 10: 2–3).

Rays: Rays 1–3 seriate, mostly partly 2–3 seriate (Figure 10: 4–5). At the tips of the rays, uniseriate portion is 1–4 seriate, and these uniseriate cells rather longer than the body ray cells, which are rounded or ellipsoid (Figure 10: 6–7). Rays heterocellular, body ray cells procumbent with mostly 2–4 rows of upright and / or square marginal cells (Figure 10: 8). Rays per mm 8–12.

Axial parenchyma: Axial parenchyma diffuses and marginal (Figure 10: 1). Prismatic crystals present in wider axial parenchyma cells, and axial parenchyma cells in irregular widths (Figure 10: 9).

Fibers: Fiber-tracheids with distinctly bordered pits (Figure 11: 7).

Coded descriptions following the IAWA Hardwood List (IAWA Committee 1989): 1, 2, 5, 7, 9, 15, 21, 22, 26, 27, 40, 50, 62, 65, 76, 89, 97, 106, 107, 115, 308, 156, 326, 327.

Discussion: This combination of wood features in the studied specimen, such as diffuse-porous wood, small diameters of vessels, scalariform perforation plates with lower than 20 bars, opposite intervessel pits and diffuse parenchyma, occurs in some tree families, such as Hamamelidaceae, Cornaceae, Cyrillaceae, Myricaceae, Araliaceae, Cunoniaceae, Ericaceae, Escalloniaceae, Styricaceae and Theaceae.

In Cyrillaceae and Cornaceae, vessels have a higher number of bars in the scalariform perforation plate (>20) (Insidewood, 2004-onwards). Wheeler et al. (1978) stated that the members of the family of Hamamelidaceae have large vessel-ray pits and predominantly scalariform intervessel pits. In the members of the Cyrillaceae family, the ratio of uniseriate rays is lower, and perforation plates have approximately 30 bars and are mostly higher than Myricaceae. In the members of the Cornaceae family, perforation plates have more than 30 bars, higher multiseriate rays, and an absence of crystalliferous parenchyma.

In Araliaceae, Styricaceae and most members of the Escalloniaceae family, larger rays are 4–10 seriate, and other members of Escalloniaceae oil and mucilage cells are present. In Betulaceae family, aggregate rays are common. In the Cunoniaceae family, bur numbers in scalariform perforation are higher with more than 20 bars. In Ericaceae and Theaceae family, axial parenchyma is not banded marginally.

This fossil genus has two fossil species as Myricoxylon hungaricum Müller-Stoll & Madel and Myricoxylon zonatum Gottwald, and two more fossil species called Myrica scalariformis Kruse and Myrica absarokensis Wheeler, Scott & Barghoorn. We prefer to use the correct fossil form of the genus, as Myricoxylon, and we prepared an identification key for the present species, using Müller-Stoll and Mädel (1962), Wheeler (2011), Wheeler et al. (1978), Gottwald (1997) and the studied fossil wood, as follows:

1A. Larger rays 4–10 seriate; growth ring distinct, wood semiring porous or diffuse porous; axial parenchyma diffuses, diffuse-in-aggregate; rays heterocellular, prismatic crystals in axial parenchyma cells

2A. Intervessel pits opposite, axial parenchyma diffuses, diffuse-in-aggregate; wood semiring and diffuse porous > Myricoxylon zonatum Gottwald, 1997

2B. Intervessel pits scalariform and opposite; axial parenchyma diffuses; wood diffuse porous > Myrica absarokensis Wheeler, Scott & Barghoorn, 1978

1B. Rays 1-3 seriate; growth ring indistinct or absent;

3A. Scalariform perforation plates 10–20 and 20–40 bars;
axial parenchyma diffuses, diffuse-in-aggregate > Myrica scalariformis Kruse, 1954
3B. Scalariform perforation mainly ≤10 bars and some 10–20 bars.
4A. Vessel frequency ≤100 per mm, vessel diameter ≥50 µm and 50–100 µm; growth ring boundary indistinct; axial parenchyma absent or extremely rare; body ray cells procumbent with one row of upright and/or square marginal cells > Myricoxylon hungaricum Müller Stoll & Mädel, 1962
4B. Vessel frequency ≥100 per mm, average vessel diameter ≤50 µm; growth ring boundary distinct; axial parenchyma common, diffuse; body ray cells procumbent with mostly 2–4 rows of upright and/or square marginal cells > Myricoxylon doganyurtensis sp. nov.

Thus, as a result of the comparative discussion and using the identification key, we have identified a new species that we name Myricoxylon doganyurtensis Akkemik, Iamandei & Çelik sp. nov., the name deriving from the name of the nearest village to the fossil site Doğanyurt. Due to having only 1–3 seriate rays and indistinct growth ring boundary, it is similar to Myrica scalariformis and Myricoxylon hungaricum. In M. scalariformis, bar numbers of scalariform perforation plates are much higher. Denk et al. (2017) and Güner et al. (2017) indicated them as a member of VU3 (swamp forest), VU4 (riparian forest) and VU5 (well-drained lowland forest).

Family ANACARDIACEAE R.Br., 1818
Genus PISTACIOXYLON Dupéron 1973
Type species Pistacioxylon muticoides Dupéron, 1973
Pistacioxylon ufukii Akkemik & I. Poole 2018
Figure 11, Photos 1–7.
Formation: Hançili Formation. The detailed geology of the area in Acarca Bayam et al. (2018).
Age: Early Miocene.
Locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.
Sample code: DOGU2

Microscopic description: Microscopic description was given based on the wood features such as growth ring, vessels, rays, axial parenchyma and (if it was seen) fibers as follows.
Growth ring: Growth ring boundaries distinct.
Vessels: Wood semiring to ring porous. Earlywood vessels 2–3(–4) grouped in a radial pattern. Transition from earlywood to late wood gradual. Vessel radial and tangential diameters 98 (40–155) µm and 152 (87–233) µm in earlywood, and 40 (17–70) µm and 28 (13–61) µm in latewood. Latewood vessels occur in radial pattern more than 4 cells and in radially arranged clusters. Vessel frequency 17–21 per square mm in earlywood (Figure 11: 1–2). Tyloses present in some wider vessels. Perforation plates simple (Figure 11: 3) and intervessel pits alternate and 4–7 µm (Figure 11: 4).
Rays: Rays (1–) 3–6 seriate and 7–10 rays per mm. Ray heights around 5 to 36 cells (Figure 11: 5–6). Radial canals present in rays (Figure 11: 6). Rays heterocellular and body ray cells procumbent with 1–4 rows of upright and/or square marginal cells (Figure 11: 7).
Axial parenchyma: 2–3 rows of marginal axial parenchyma present in ring border (Figure 11: 2). Axial parenchyma common and 2–8 cells per parenchyma strand (Figure 11: 5).

Coded descriptions following the IAWA Hardwood List (IAWA Committee 1989): 1, 3, 4, 7, 13, 21, 22, 42, 48, 49, 89, 92, 93, 97, 98, 107, 115, 130.

Discussion. This type of fossil wood was described firstly in Turkey by Akkemik et al. (2018) from the early Miocene of central Anatolia, as Pistacioxylon ufukii Akkemik & Poole. Later, Acarca Bayam and Akkemik (2018) identified the second fossil wood of this fossil species from the Kuraluç site of the same city (Beypazarı), which is near to present site. This third fossil in this fossil site has identical features with the above-cited species, regarding the aspect and distribution of vessels in crosssection, their pitting and simple perforated plates, as well as the high rays heterocellular and bearing ray canals. Thus, it is also attributed to Pistacioxylon ufukii Akkemik & Poole, as a fossil species the might be evaluated as a member of well-drained lowland forest and drier conditions drawing on studies conducted by Güner et al. (2017) and Denk et al. (2019).

Family SALICACEAE Mirb. 1815
Genus SALICOXYLON Müll. 1815
Type species Salicoxylon messinianum (Pamp.) Müll. & Angel., 1968
Salicoxylon galatianum Akkemik 2021
Figure 12, Photos 1–8.
Formation: Hançili Formation. The detailed geology of the area was given by Acarca Bayam et al. (2018).
Age: Early Miocene.
Locality: Doğanyurt Village at the city of Beypazarı in the province of Ankara.
Sample code: DOGU8

Microscopic description: Microscopic description was given based on the wood features such as growth ring, vessels, rays, axial parenchyma and (if it was seen) fibers as follows.
Growth ring: Growth ring boundaries distinct, marked by 1–2 rows of marginal axial parenchyma cells clearly visible in the boundary of annual rings (Figure 12: 1–2).
Vessels: Wood diffuse porous, vessels solitary or mostly in short radial multiples of 2–4 cells. Solitary vessels circular or ellipsoid in general, vessel cells in radial multiples tangentially flattened. The first row of vessels in earlywood
looks like a ring and solitary in general. Mean vessel radial and tangential diameters 80 (42–148) μm in earlywood and 47 (25–70) μm in latewood, and vessel frequency 145–240 vessels per square mm. Vessels at the tips of the radial multiples generally triangular (Figure 12: 1–2). Intervessel pits alternate, horizontal diameter 7 (5–8) μm, and vertical diameter 6 (4–9) μm. Perforation plates simple (Figure 13: 3).

Rays: Vessel-ray pits simple and large and slightly like honeycomb and circular (Figure 12: 4–5). Rays heterocellular with procumbent body ray cells and one row of squared or upright marginal cells. Rays mostly uniseriate, sometimes partly biseriate, 5–15 (~31) cells high (Figure 12: 6–8). Density of rays 8–16 per mm.

Axial parenchyma: Axial parenchyma in crosssection appear diffuse, and marginal at the boundary of growth ring. Axial parenchyma strands 5–8 cell or more. Prismatic crystals present in chambered axial parenchyma cells (Figure 12: 8)

Fibers: Fibers thin to thick walled.


**Discussion.** *Salixoxylon* was identified for the first time by Akkemik et al. (2016) and later by Acarca Bayam et al. (2018) from the Galatian Volcanic Province. In a recent revision, Akkemik (2021) described these woods as *Salixoxylon galatianum* Akkemik, 2021. The presence of axial parenchyma cells is the main difference of this fossil species from the former fossil wood called *Salixoxylon* and this feature was also observed in the present fossil wood. Based on high similarities, the present fossil wood from a near-site to the previous one could be assigned to the same species named *Salixoxylon galatianum*. The genus *Salix* is a kind of tree representative for riparian conditions that predominated through the early Miocene to the late Miocene in GVP as derived from Denk et al. (2017), Akkemik et al. (2016) and Acarca Bayam et al. (2018).

Family ULMACEAE Mirbel 1815
Genus ULMOXYLON Kaiser, 1879
Type species Ulmoxylon lapiduriorum (Unger) Kaiser, 1879

**Ulmoxylon cf. carpinifolia** Greguss, 1969

*Figure 13, Photos 1–6.*

**Formation:** Hançili Formation. The detailed geology of the area was given by Acarca Bayam et al. (2018).

**Age:** Early Miocene.

**Locality:** Doğanyurt Village at the city of Beypazarı in the province of Ankara.

**Sample code:** DOGU1

**Microscopic description:** The following features were observed on this fossil wood:

Growth ring: Growth ring boundaries distinct, widths of growth rings of DOGA3 was measured as 0.41–1.02 mm (Figure 13: 1–2).

Vessels: Wood ring-porous with one row of vessels in earlywood. Earlywood vessels predominantly solitary and seldom, mostly in one row, radial multiples (up to 3) rare; latewood vessels arranged in wavy tangential bands, and clusters common (Figure 13: 1–2). Mean vessel tangential diameter 72 (26–115) μm in earlywood, 19 (7–31) μm in latewood. Vessel radial diameters 118 (66–171) μm in earlywood and 31 (11–44) μm in latewood. Vessel frequency per square mm 7–11 in earlywood and 35–46 in latewood. Tyloses seldom. Intervessel pits alternate, 8.9 (7.3–11.0) μm; perforation plates simple (Figure 13: 3).

Rays: Rays homocellular, all ray cells procumbent. Rays 1-3 seriate sometimes larger, as 4–5 (~7) seriate, ray-height up to 40 cells (Figure 13: 4–5). Ray number per mm 7–10. Axial parenchyma: Axial parenchyma mainly paratracheal, confluent and vasicentric, also apotracheal diffuse and marginal (Figure 13: 1–2); slightly storied. Prismatic crystals present in normal and enlarged axial parenchyma cells and in chambered cells of axial parenchyma (Figure 13: 6).

**Discussion.** The features observed, such as ring-porous wood, wide earlywood pores and abruptly smaller and tangentially wavy bands of latewood vessels, all rays procumbent, and vasicentric and confluent axial parenchyma, are present in or are common in *Ulmoxylon* (e.g., Watari, 1652; Greguss, 1952; Sakala 2002; Klusek, 2012; Koutecký and Sakala, 2015; Koutecký et al., 2019). Recently, Akkemik (2021) has described a new fossil wood called *Ulmoxylon kasapligilii* Akkemik, which has a storied structure.

Our studied specimen has a single row of earlywood vessels, high rays with cells all procumbent, axial parenchyma with chambered parenchyma cells and prismatic crystals. According to the identification key given by Akkemik (2021), all the features of the fossil wood fall into the characteristics of *Ulmoxylon cf. carpinifolia* Greguss, 1969. The nearest fossil species is *Ulmoxylon kasapliligi* Akkemik, but the fossil wood studied herein differs from this form in having a slightly present storied structure in axial parenchyma and rays homocellular, with cells all procumbent. Thus, we decided to name our studied specimen *Ulmoxylon cf. carpinifolia* Greguss, 1969, as a perfect equivalent of extant *Ulmus*, a usual tree in lowland riparian and well-drained environment, which was frequently identified from different parts of the early Miocene areas of Galatian Volcanic Province (Akkemik et al., 2016; Acarca Bayam et al., 2018), and many leaf imprints by Denk et al. (2017, 2019) and Güner et al. (2017).
Figure 9. Wood characteristics of *Cryptocaryoxylon irregularis*. 1) Transversal section (TS) with slightly distinct growth ring boundary, 2) Marginal axial parenchyma in the boundary of growth ring (arrow), 3) Simple perforation plate (star), 4) Alternate pitting on vessels, 5–6) 1–3 seriate of rays in TLS, 7) Heterocellular ray with one row of square marginal cells (arrow), 8–9) Enlarged and irregularly shaped ray cells including oil and mucilage materials in RLS (arrows).
Figure 10. Wood characteristics of *Myricaxylon doganyurtensis*. 1) Transversal section (TS) with almost distinct growth ring boundary, 2–3) Scalariform perforation plate with up to 6-14 bars in RLS, 4–5) 1–3 seriate of rays in TLS, 6–7) Irregularly shaped ray cells in TLS, and bordered pits in fibers (arrow), 8) Heterocellular ray with 1–4 rows of upright or square marginal cells in RLS, 9) An axial parenchyma strand.
Figure 11. Wood characteristics of *Pistacia xylon ufuksi*. 1) Transversal section (TS) with distinct growth ring boundary and ring porous wood, 2) Marginal axial parenchyma in the boundary of growth ring (arrow), 3) Simple perforation plate (star), 4) Alternate pitting on radial wall of vessel in RLS, 5–6) Multiseriate rays with radial canals in TLS (white arrows) and axial parenchyma strands (grey arrow), 7) Heterocellular rays in RLS.
Figure 12. Wood characteristics of *Salixylon galatianum*. 1) Transversal section (TS) with distinct growth ring boundary and diffuse porous wood, 2) Marginal axial parenchyma in the boundary of growth ring (arrow), 3) Simple perforation plate (star), 4–6) Honeycomb type of vessel-ray pitting in RLS (white arrow), 6–7) Heterocellular ray with one row of square marginal cells in RLS (grey arrow), 8) Crystals in axial parenchyma cells (arrow).
Figure 13. Wood characteristics of *Ulmoxylon cf. carpinifolia*. 1) Transversal section (TS) with distinct growth ring boundary and ring porous wood, and latewood vessels in dendritic arrangement, 2) One row of large earlywood vessels, and marginal, vasicentric and confluent types of axial parenchyma in TS, 3) Simple perforation plate (star), 4–5) Wide (1–5 seriate) of rays in TLS, 6) Prismatic crystals in chambered axial parenchyma cells.
5. Palaeoenvironment and palaeoclimate of the fossil plants
The early Miocene fossil sites in Galatian Volcanic Province were in the Anatolian Plateau. Okay et al. (2020) concluded that “the Anatolian Plateau has stayed above sea level since 41 Ma, and they suggested that the depositional environment and topography of central Anatolia has changed little since the Late Middle Eocene (ca. 41 Ma, Lutetian), and particularly since the Early Miocene (ca. 22 Ma). Despite local subsidence and sea-level variations in the last 22 Ma, central and western Anatolia have continued to be a land area with a relatively constant coastline following the northern boundary of the Taurides, indicating a relief of at least several hundred meters”. In this study, Glyptostroboxylon rudolphii, Taxodioxylon gypsaceum, Myricoxylon doganyurtensis, Salicoxylon galatianum and Ulmoxylon cf. carpinifolia may also suggest the presence of both marine, riparian and swamp conditions or one of them in the early Miocene of central Anatolia, together with lowland well-drained slopes including Aceroxylon aceroides, Cryptocaryoxylon irregularis, Cercioxylon mediterraneum and Pistacioxylon ufukii (Figure 14). These riparian and swamp conditions in lowland areas together with upland well-drained forest conditions, are common through Galatian Volcanic Province (e.g., Akkemik et al., 2016, 2017; Acarca Bayam et al., 2018).

Denk et al. (2019) suggested that the Laurel Forest Biome was the dominant biome during the Aquitanian and Burdigalian in western and central Turkey. In this study, a Cryptocaryoxylon species from the Lauraceae family was identified. The fossil wood identification may also suggest the presence of these subtropical moist broadleaf forests together with riparian, swamp and well-drained lowland forest conditions. On the other hand, Güner et al. (2017) and Denk et al. (2019) discussed the vegetation units of Miocene woody plants. The genera of Glyptostroboxylon, Taxodioxylon, Pinuxylon, Myricoxylon and Ulmoxylon represent riparian forest (VU4), Aceroxylon, Cercioxylon, Pistacioxylon, Myricoxylon and Taxodioxylon can also grow well-drained lowland forest (VU5). Glyptostroboxylon, Taxodioxylon, Myricoxylon and Pinuxylon can also represent the swamp forest (VU3). Finally, the assembling of the identified fossil species indicated a forest structure having riparian and swamp conditions in lowland areas, possibly together with upland well-drained forest conditions (Figure 14).

Denk et al. (2019) also stated that Köppen signatures might suggest intermediate conditions between tropical and subtropical forest biomes together with xeromorphic plants on limestone or volcanic rocks in coastal areas.

6. Conclusion
This study has added new species descriptions from central Anatolia. Thus, knowledge of the early Miocene forest tree species has improved. In the present study, new distribution areas of Glyptostroboxylon rudolphii, Taxodioxylon gypsaceum, Pinuxylon sp., Aceroxylon aceroides, Pistacioxylon ufukii, Salicoxylon galatianum and Ulmoxylon sp. carpinifolia were determined, the new fossil
species, *Cercioxylon mediterraneum* Akkemik, Iamandei & Çelik sp. nov., *Cryptocaryoxylon irregularis* Akkemik, Iamandei & Çelik sp. nov. and *Myricoxylon doganyurtensis* Akkemik, Iamandei & Çelik sp. nov. were described. With this study, the widest fossil wood flora was obtained from the Galatian Volcanic Province of the early Miocene of central Anatolia. The obtained woody flora showed that the palaeoenvironment of the early Miocene of central Anatolia could be lowland riparian, swamp or coastlines with lowland to upland well-drained likely drier slopes.

**Acknowledgement**

We thank Ahmet Demirtaş, Salih Usta and Bayram Koçak for their help in the field work.

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