

PALAEOXYLOTOMICAL STUDIES IN THE CENOZOIC PETRIFIED FORESTS OF GREECE. PART THREE – DICOTS

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Abstract. We had to study several petrified wood remains from „Velitzelos Collection“, coming from some late Oligocene - early Miocene fossiliferous sites, from the Aegean area from Evros, from Limnos Island, and Lesbos Island. Nine dicot fossil species were identified: *Laurinoxylon* aff. *czechense* Prakash, Březinová & Bůžek, *Laurinoxylon ehrendorferi* Berger, *Cinnamomoxylon seemannianum* (Mädel) Gottwald, *Populoxylon* cf. *Populus alba* L., *Quercoxylon intermedium* Petrescu et Velitzelos, *Engelhardioxylon lesbiu* Iamandei et Iamandei, sp. nov., *Eucaryoxylon lesbiu* Iamandei et Iamandei, sp. nov., *Rhysocaryoxylon madsenii* Sakala et Gryc and *Rhysocaryoxylon* sp. aff. *Juglans regia* L., and these new identifications add new elements to the forest assemblages of the Oligocene - Miocene Greek flora, this being useful to reconstruct the evolution of the Cenozoic palaeovegetation and palaeoclimate in the Aegean area.

Keywords: Aegean area, Petrified Forest, Velitzelos Collection, dicotyledons.

INTRODUCTION

The evolution of the Cenozoic flora in the „Aegean area“ is generally known from various palaeobotanical and palynological studies, previously published [see: Petrescu & Velitzelos E. (1981); Süß (1989, 1997, 2003); Süß & Rathner (1998); Süß & Velitzelos E. (1993, 1994a,b, 1997, 1998, 1999, 2000, 2001, 2008, 2009, 2010); Velitzelos D. et al. (2014, 2019); Mantzouka (2009); Mantzouka et al. (2013, 2017, 2019a,b); Iamandei et al. (2012, 2022)].

This paper represents a new part of our palaeoxylotomical studies on samples from „Velitzelos Collection“, which is hosted by the Collection of Faculty of Geology and Geoenvironment of the National and Kapodistrian University of Athens (=Faculty Geol. & Geoenviron., of NKUA), a public collection, available for any further studies or revisions. In the first and second part of this study (Velitzelos D. et al., 2019; Iamandei et al., 2022) has been presented the detailed geology of the fossiliferous sites from where the samples of fossil wood were collected, as well as the geological conditions of their petrification. The present paper includes the palaeoxylotomical study of 237 samples of petrified wood with a dicotyledonous structure that were collected by Professor Evangelos Velitzelos during his geological field-trips in the Aegean zone (the continental part - Evros, and in Limnos and Lesbos islands). Thus, we have identified, by palaeoxylotomical study, some species of *Laurinoxylon*, *Populoxylon*, *Quercoxylon*, *Engelhardioxylon*, *Eucaryoxylon* and *Rhysocaryoxylon*. These new identifications could contribute to a better understanding of the evolution of the forest vegetation in Greece, during the Oligocene-Miocene time, and of the Cenozoic palaeoclimate, in the Aegean area.

GEOLOGICAL FRAMEWORK

The studied samples of petrified wood for this study were collected from the Aegean region, from Oligocene-Miocene fossiliferous sites on the mainland, in Evros, and also from the islands of Limnos and Lesbos, as is briefly presented below.

Evros – represent the Eastern part of the region East-Macedonia and Thrace (see Fig. 1), as the continental part of the Aegean area. Voudouris et al. (2007) presented the geological evolution in the Evros region, showing that the sedimentation started here in Eocene and continued during the Oligocene and early Miocene, when the main phase of Cenozoic magmatism happened (see also Innocenti et al., 1984; Del Moro et al., 1988). Plant fossil remains appear in this area related mainly to the Rupelian–Chattian lignite-bearing volcano-sedimentary levels of the Provatonas series, which discordantly cover the volcanic rocks from around Fylakto village (see Kopp, 1965; Petrescu et al., 1980; Velitzelos et al., 2002). Also, some fine-grained volcano-sedimentary layers appear, preserving many silicified wood remains appear around Lefkimi locality (Voudouris et al., 2007).

By the palaeobotanical study of various plant remains collected from the late Oligocene volcano-sedimentary levels of Provatonas series, were identified some coniferous taxa as follows: *Quasisequoia couttsiae* (Heer) Kunzmann, *Taxodium dubium* (Sternberg) Heer, *Calocedrus suleticensis* (Brabenec) Kvaček, *Pinus palaeostrobis* Ettingshausen (needle leaves in fascicles of five), *Pinus* cf. *rigios* Ettingshausen, cf. *Cunninghamia miocenica* Ettingshausen and also, some angiospermous arboreal taxa as: *Daphnogene cinnamomifolia* (Brongniart) Unger, *Laurophyllum* sp., *Eotrigonobalanus*

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Fig. 1. Map of Greece; * marks the areas where the studied fossil wood samples were collected (from d-maps.com, with modifications).

furcinervis (Rossmässler) Walther et Kvaček, *Dicotylophyllum* sp. aff. *Quercus daphnes* Unger, *Dicotylophyllum* cf. *Quercus rhenana* (Kräusel et Weyland) Erw. Knobloch et Kvaček, *Fagus castaneifolia* Unger [as *Fagus* aff. *antipofii* Heer], Fagaceae gen. et sp. indet., *Comptonia difformis* (Sternberg) Berry fm. *dryandroides* (Unger) E. Velitzelos, Kvaček et D. Velitzelos, *Dicotylophyllum* sp. cf. *Nyssa haidingeri* (Ettingshausen) Kvaček et Bůžek, cf. *Juglans acuminata* A. Braun, *Alnus* aff. *schmalhauseni* Grubov, *Alnus gaudinii* (Heer) Erw. Knobloch et Kvaček, *Populus* aff. *balsamoides* Göppert, *P. germanica* (Menzel) Walther, *Cedrela attica* (Unger) Palamarev et Petkova, *Ziziphus ziziphoides* (Unger) Weyland, *Myrica longifolia* Unger, *Sterculia labrusca* Unger, *Platanus neptuni* (Ettingshausen) Bůžek, Holy et Kvaček and other forms as *Rhodomyrtophyllum*, *Smilax*, *Salix*, *Castanea*, *Matudaea*, *Laria* and also, some monocots such as

Phoenicites aff. *salicifolius* (Presl, in Sternberg) Unger, *Sabal lamanonis* (Brongniart) Heer and *Sabal raphifolia* (Sternberg) Erw. Knobloch et Kvaček (see Velitzelos et al., 2014, p.58; 2019, p.291).

From the continental part of Greece, from Evros and Kastoria, some fossil Palm species were described: *Palmoxylon daemonoropsoides* (Unger) Kirchheimer, 1937 corr.; *P. chamaeropsoides* Iamandei et Iamandei, 2019; *P. coryphoides* Ambwani & Mehrotra, 1990; *P. trachycarpoides* Iamandei et Iamandei, 2019 and *P. phoenicoides* Hofmann, 1944 (see Velitzelos D. et al., 2014, p.58; 2019, p.291). Other numerous petrified wood samples, collected from the Evros region, from close to the localities Lagina, Lira, Lykofi, Fylakto, Provatonas, Tycheron, Trifili, Lefkymi, Sapes and Aëtothori were identified as conifers: *Cupressinoxylon akdikii* Özgüven-Ertan, 1977; *Juniperoxylon acarcae* Akkemik, 2020; *Tetraclinoxylon velitzelosii* Süß, 1997, *Taxodioxyton*

gypsaceum (Göppert) Kräusel, 1949, *T. taxodii* Gothan, 1906; *Glyptostroboxylon rudolphii* Dolezych & van der Burgh, 2004; *Glyptostroboxylon tenerum* (Kraus) Conwentz, 1884 (see Velitzelos D. et al., 2014; Iamandei et al., 2022). In this the third part of our studies on samples from „Velitzelos Collection“, we have identified some dicotyledonous fossil species as *Laurinoxylon ehrendorferi* Berger, 1953a; *Populoxylon* cf. *Populus tremula* L.; *Quercoxylon intermedium* Petrescu & Velitzelos, 1981; *Rhysocaryoxylon madsenii* Sakala et Gryc, 2011 and *Rhysocaryoxylon* sp. aff. *Juglans regia* L.

Limnos Island (Fig. 1) – has a mid-Eocene - lower Miocene molassic sedimentary basement. It is overlain by the Lower Miocene volcanic products of the Katalako, Romanou and Myrina units, all overlain by an Upper Quaternary sedimentary formation (see Davis, 1960; Innocenti et al., 1984; Roussos, 1993). There, the silicified or opalized plant fossils appear, especially around Moudros Gulf, in the early Miocene pyroclastics of Romanou Unit, which is of Burdigalian age (radiometrically dated 19.8 Ma, see Innocenti et al., 1994; Voudouris et al., 2007; Velitzelos D. et al., 2014, 2019). Otherwise, a few fossil plant remains were previously identified as: *Pronephrium stiriicum* (Unger) Erw. Knobloch et Kvaček, *Glyptostrobus europaeus* (Brongniart) Unger, *Sequoia abietina* (Brongniart) Erw. Knobloch, *Daphnogene polymorpha* (A. Braun) Ettingshausen [of *Cinnamomum* type], cf. *Quercus drymeja* Unger, some Dicotyledoneae indet. (aff. *Myrica*, Fagaceae, Lauraceae), *Acer tricuspdatum* Bronn, *Zelkova zelkovifolia* (Unger) Bůžek et Kotlaba and *Eriolaena* sp. (see Velitzelos D. et al., 2014).

Also, fossil remains of monocotyledonous plants found in the Kastron – Myrina and Antissa areas were identified as aff. Cyperaceae and *Phragmites* sp., or as Palm roots, Palm seeds or Palm leaves, possibly of *Sabal* or *Phoenix* type and, also, are to be found within tuffitic layers from the Moudros area (Velitzelos D. et al., 2014).

Some fossil wood remains collected from Limnos were identified as *Laurinoxylon ehrendorferi* and *Cornoxyylon pappi* by Berger (1953). Also, a problematic conifer was identified from there, as *Pinoxylon parenchymatosum* Süß et Velitzelos, 1993 (later revised as *Lesbosoxylon* by Süß et Velitzelos 2010, finally revised as *Pinuxylon parenchymatosum* (Süß et Velitzelos) Mantzouka et Akkemik (see Mantzouka et al., 2022). In the last years, numerous fossil wood remains were collected from many sites of Limnos, sometimes from excavations, from around the villages of Fergani, Romanou, Moudros, Varos, Rossopouli, Portianou, Thanos and Kontias, and on the hill of Paradisi. These samples are kept in the Collection of Faculty Geol. & Geoenviron., of NKUA. Some of them were identified by palaeoxylotomical studies, in the first part of this study, as *Palmoxylon trachycarpoides* Iamandei et Iamandei, 2019; *P. phoenicoides* Iamandei et Iamandei, 2019 and

Rhizopalmoxyylon phoenicoides Iamandei et Iamandei, 2019 (in Velitzelos et al., 2019).

In the second part of this study on Velitzelos collection (Iamandei et al., 2022) some Coniferous fossil taxa were identified as: *Cupressinoxylon akdikii* Özgüven-Ertan, 1977; *Juniperoxylon acarcae* Akkemik, 2020; *Tetraclinoxylon velitzelosii* Süß, 1997; *Taxodioxyylon gypsaceum* (Göppert) Kräusel, 1949; *Taxodioxyylon taxodii* Gothan, 1906; *Glyptostroboxylon rudolphii* Dolezych & van der Burgh, 2004; *Glyptostroboxylon tenerum* (Kraus) Conwentz, 1884; *Pinuxylon pineoides* (Kraus) Koeniguer, 1967; *Pinuxylon halepensoides* van der Burgh, 1973 and *Pinuxylon* sp. aff. *Pinus canariensis* C. Sm.

In this part of our study, some dicotyledonous fossil taxa were identified from Limnos as *Laurinoxylon ehrendorferi* Berger, 1953a, *Quercoxylon intermedium* Petrescu et Velitzelos, 1981 and *Rhysocaryoxylon madsenii* Sakala et Gryc, 2011.

Lesbos Island (Fig. 1) – preserves numerous Miocene petrified tree-trunks and other fossil vegetal remains which appear in relationship with the intense volcanic activity developed during the early Miocene, age 18–19 Ma, i.e. Aquitanian and Burdigalian, (see Koufos et al., 2003). Details of the entire geological evolution of Lesbos Island are thoroughly exposed in the papers of Pe-Piper (1980a, b); Katsikatsos et al. (1982, 1986), Pe-Piper & Piper (1993); Koufos et al. (2003); Zouros et al. (2007); Vasileiadou & Zouros (2012), and best synthesized in Velitzelos D. et al. (2014, 2019).

Lesbos Island is best known as fossiliferous paradise, preserving not only plant but also animal remains inside the Geopark „Petrified Forest of Lesvos“, where numerous monumental *in situ* petrified tree trunks that appear in many fossiliferous sites around Bali Alonia, Eressos, Antissa, Sigri, Hidira, Gavathas, Molyvos, Polichnitos, Mesotopos, Plomari, Akraasi localities, or on Megalonisi Islet, where large accumulations of silicified wood as tree trunks or fragmentary can be found. A synthesis on the geological conditions of wood petrification and of the previous geological, palaeontological and palaeobotanical researches is presented in Velitzelos et al. (2019 p.291-292). Thus, after Zouros et al. (2007), the Skoutaros Formation includes the Sigri pyroclastics of the main stage of volcanic activity on Lesbos (18.5 to 17 Ma) and overlain the older Eressos Formation (age ~21.5 Ma). The silicified lacustrine marls bearing plant remains and even mammal fossils (*Prodeinotherium bavaricum* Meyer, 1831) appear just below the volcanic rocks suggesting an age of 18–19 Ma (Koufos et al., 2003). The remains of micromammals, lizard dentaries and crocodile teeth indicate MN3 / MN4 (Vasileiadou & Zouros, 2012). Anyway, the processes of petrification of the woody remains were directly related to intense volcanic activity generating a high quantity of acidic rocks, mostly

ignimbrites, with normal shoshonite REE patterns [see Pe-Piper (1980a, b); Pe-Piper & Piper (1993)] as lavas, pyroclastic materials and volcanic ash, which covered the entire vegetation of the area so rapidly, that they preserved the tree trunks in situ, destroying or preserving fragmentary branches or other plant parts.

As to the wood petrification, we agree with the extensive and documented analysis of the silicification processes as presented by Matysová et al. (2010) and Matysová (2016), who explained that along with the volcanic activity, but also afterward, hot or even cold solutions of silicon dioxide circulated within the volcanic material that covered the vegetal remains. Sometimes the pyroclastic flows transported the plant remains far from their growth sites. Thus, starts the major fossilization process: ionic solutions penetrate the cellular membranes and precipitate inside the cells as amorphous silica, or opal, filling all the empty spaces. The organic matter remains as a carbon pellicle, preserving the cell wall details. Some authors point out that the organic matter can be replaced later, molecule by molecule, by inorganic material. Thus, the anatomical structure of the tree trunks, such as the annual rings, medullary rays, vessels, fibers and parenchyma are entirely well preserved (Velitzelos et al., 2019).

By this way the “Petrified Forest of Lesvos” was born, now an important European protected geopark (see <http://www.europeangeoparks.org/>), with numerous petrified tree trunks in growth position, being a splendid geological monument of great scientific significance, spread over a wide area, which offers a big opportunity to study the entire vegetation, since often preserve all the plant parts as leaf imprints, fruit compressions, and silicified trunks, branches or roots and leaves or fruits. Many scientific informations on the palaeobotanic research are presented by Mantzouka (2009) and by Mantzouka et al. (2013, 2017, 2019a,b) and, in the first two parts of this study (Velitzelos D. et al., 2019; Iamandei et al., 2022), comprising all the previous identifications of fossil plants by the study of fossil macroremains, partly presented also in the synthesis of Velitzelos D. et al. (2014). Thus, various plant remains were identified as species of *Sequoia*, *Taxodium*, *Cunninghamia*, *Pinus*, *Tetraclinis*, *Carpinus*, *Tilia*, *Myrsinites*, *Lindera*, *Engelhardia*, *Quercus*, *Laurophyllum*, *Laurus*, *Litsea*, *Cinnamomum*, *Diospyros*, *Oreodaphne*, *Populus*, *Quercus*, *Rhus*, *Rubus*, *Phoenix*, *Sabal*, Sapotaceae div., Lauraceae div. (see Velitzelos et al., 2014, p.67).

Previous studies on fossil wood samples collected from Lesbos island cited by Velitzelos D. et al. (2014), were done by Süß & Velitzelos (1993-2010), who identified even two species of Ginkgoales (*Ginkgoxylon lesboense* and *G. diversicellulatum*) and many coniferous new taxa, as species of *Pinoxylon* Süß et Velitzelos, 1993 (the species *Pinoxylon paradoxum*, *P. pseudoparadoxum*, *P. diversiradiatum*, *P. graciliradiatum*) which were, later, revised by Süß & Velitzelos (2010) as species of

Lesbosoxylon, aside *L. ventricosuradiatum* Süß et Velitzelos, and later, all revised by Mantzouka et al. (2022), as fossil pine species. Also, Süß & Velitzelos described *Chimairoidoxylon lesboense* and *C. conspicuum*, *Podocarpoxyylon articulatum* and *P. graciliradiatum*, *Glyptostroboxylon microtracheidale* (probably a conifer of *Cunninghamia* type) and some species of *Taxodioxyylon* (*T. gypsaceum* *T. albertense*, *T. pseudoalbertense*, *T. megalonissum*) as possible equivalents of current *Sequoia*, *Taxodium*. Some other fossil conifers were identified as species of *Taxaceoxyylon*, *Thujoxyylon* and *Tetraclinoxyylon* and, also, some woods of *Laurinoxyylon*, *Populoxyylon*, *Quercoxyylon* and *Palmoxyylon* were cited (see Velitzelos D. et al., 2014, p.67).

In the first part of our palaeoxytological study on samples from Velitzelos collection (Velitzelos D. et al., 2019), some forms of Palms were described and identified as *Palmoxyylon daemonoropsoides* (Unger) Kirchheimer 1937; *P. chamaeropsoides* Iamandei et Iamandei 2019; *P. coryphoides* Ambwani & Mehrotra, 1990; *P. sabaloides* Greguss, 1969; *P. trachycarpoides* Iamandei et Iamandei, 2019; *P. phoenicoides* Hofmann, 1944; *Rhizopalmoxyylon daemonoropsoides* Iamandei et Iamandei, 2019; *R. phoenicoides* Iamandei et Iamandei, 2019 and *Palmocaulon* sp. aff. *Phoenix* sp.

Also, in the second part of this study (Iamandei et al., 2022) some coniferous fossil taxa were identified as: *Cupressinoxyylon akdiki* Özgüven-Ertan, 1977; *Juniperoxyylon acarcae* Akkemik, 2020; *Tetraclinoxyylon velitzelosii* Süß, 1997; *Taxodioxyylon gypsaceum* (Goepf.) Kräusel, 1949; *Glyptostroboxylon rudolphii* Dolezych et van der Burgh, 2004; *Pinuxylon pineoides* (Kraus) Koeniguer, 1967; *Pinuxylon halepensoides* Van der Burgh, 1973; *Pinuxylon* sp. aff. *Pinus canariensis* C. Sm.

And, here, in the third part of our study, some dicotyledonous fossil taxa were identified as: *Laurinoxyylon* aff. *czechense* Prakash, Březinová et Bůžek, 1971; *L. ehrendorferi* Berger, 1953a; *Cinnamomoxylon seemannianum* (Mädel) Gottwald, 1997; *Quercoxyylon intermedium* Petrescu et Velitzelos, 1981; *Engelhardioxyylon lesbium* Iamandei et Iamandei, sp. nov.; *Eucaryoxyylon lesbium* Iamandei et Iamandei, sp. nov.; *Rhysocaryoxyylon madsenii* Sakala et Gryc, 2011; and *Rhysocaryoxyylon* sp. aff. *Juglans regia* L.

MATERIAL AND METHODS

During his geological field trips both in the late Oligocene – early Miocene volcano-sedimentary deposits of the Greek Aegean Area, in the continental part (Evros) as well as in the insular part (Limnos, Lesbos), Professor Evangelos Velitzelos made a big palaeobotanic collection. This is registered and kept now as „Velitzelos Collection“, in the Collections of the Faculty of Geol. & Geoenviron. of NKUA. From the numerous fossil wood samples, we have studied and published some, (the Palms

and respectively, the Conifers (see Velitzelos D. et al., 2019; Iamandei et al., 2022). And, for the current study, 237 samples with dicotyledonous structures were selected.

From each sample, three thin-sections of petrographic type were prepared, according to the three standard directions - transversal, tangential and radial. These sections have been studied under a transmitted light microscope and, for each specimen, all the xylotomical details were described, using the scientific terms as defined by the “IAWA list of microscopic features for softwood identification”, from the Compendium edited by IAWA Committee in 2004 (see Richter et al., 2004).

The photos of the xylotomical details were captured on an “EverFocus” video-camera adapted to the light microscope, using the software “AVerMedia”. Selected images with specific taxonomic details were processed with specialized computer programs.

The identification of the fossil woods was, subsequently, performed by comparison with previously described similar aspects of fossil or current wood structures, as they are presented in published scientific papers, all included in the references chapter.

The systematics follows APG III and APG IV (see Bremer et al, 2009; Chase et al., 2016), and ICN-Shenzhen Code (Turland et al., 2018).

SYSTEMATICS

Angiosperms

Family **Lauraceae** Jussieu, 1789

Genus *Laurinoxylon* (Felix, 1883) emend. Dupéron et al., 2008

Laurinoxylon aff. czechense Prakash, Březinová et Bůžek, 1971

Fig. 2, photos a-I

Studied material. From the studied material, 12 samples showing similar lauraceous structure were selected as *Laurinoxylon* - Type 1 – (Mantzouka et al., 2016), representing fragments of silicified wood, collected from lower Miocene volcano-sedimentary deposits of Lesvos, numbered with Lsv59, Lsv63, Lsv65, Lsv71, Lsv116, Lsv374, Lsv385, Lsv386, Lsv387, Lsv388, Lsv393, Lsv395. These samples are registered and kept in the Collections of the Faculty Geol. & Geoenviron. of NKUA.

Microscopic description. The growth rings – are distinct in cross-section, usually showing a diffuse porous wood structure, with relatively distinct ring boundaries, marked by some rows of smaller fibres, abruptly followed by the early-wood with normal sized fibres and with larger vessels.

The vessels – in cross-section viewed, appear usually thick-walled, mainly solitary and in small clusters or small radial multiples or of 2-3, in radial pattern between

two successive rays, defining a diffuse porous arrangement. However, sometimes, in the final wood the vessels appear slightly smaller, suggesting a tendency to a semi-ring-porous arrangement. The solitary vessels are round to oval and have the radial / tangential diameter of 50-110(-150) / 40-85(-120) μm . When grouped, the vessels are slightly deformed by compression. Their walls are relatively thick, of 7-10 μm the double wall. In the late-wood the vessels could be slightly smaller than 50 / 40 μm r / tg.d. In the longitudinal view, the perforation plates appear of simple type, more or less inclined. The intervessel pits have an alternate arrangement, and are polygonal and medium-sized, with a diameter of around 10 μm . The vessel-ray pits are quite similar to intervessel pits, in size and shape: the cross-field pitting is described below. Helical thickenings in the vessel elements are not present. The mean tangential diameter of vessel lumina is around 65 μm . Vessel density is of 52–74 vessels per square millimeter (mean density 63). Mean vessel element length is around 550 μm (between 350 - 800 or more). Tyloses in vessels commonly appear. Deposits in vessels usually not present.

Tracheids, vascular fibres or vasicentric tracheids – not observed.

The fibres – constitute the major part of the ground tissue, and are sometimes septate and usually not pitted, or difficult to observe, due to poor preservation.

The axial parenchyma – appears relatively few, as scanty paratracheal and of vasicentric type, around the solitary or grouped vessels. On the vertical walls 1-2-seriate simple pits appear. The end-walls are horizontal to slightly inclined.

The rays – are 1-3 seriate, but commonly 2-3 seriate. Their height, in tangential sections, appear low to high, of 3 up to 25 cells, (up to 300-500 μm) with the terminal cells triangular, or flame-like. Radially, appear a heterocellular aspect, with body ray-cells all procumbent and with 1-2 rows of marginal cells taller, square and/or upright (of 4-12 μm), some of them as hypertrophied idioblasts, globular to oval shaped or flame-like, usually having dark or bright content. The cross-fields with vessels show some round pits, of 5-7 μm in diameter, in horizontal row arranged. Sometimes larger pits on the taller marginal fields can be observed. Sheath cells and tile cells are not present. Ray density - up to 12 rays/mm tangential.

Storied structures – not present, neither to rays nor to the axial parenchyma and/or vessel elements. Secretory elements – appear as oil and/or mucilage hypertrophied ray cells, as idioblasts associated with rays, as described above. Intercellular canals – as normal or traumatic axial or radial canals not observed. Cambial variants and included phloem absent. Mineral inclusions not observed.

Affinities and discussions. From the here studied samples of petrified wood with dicotyledonous structure, 12 samples collected from Lesbos island, quoted above, showed a similar lauraceous structure, essentially

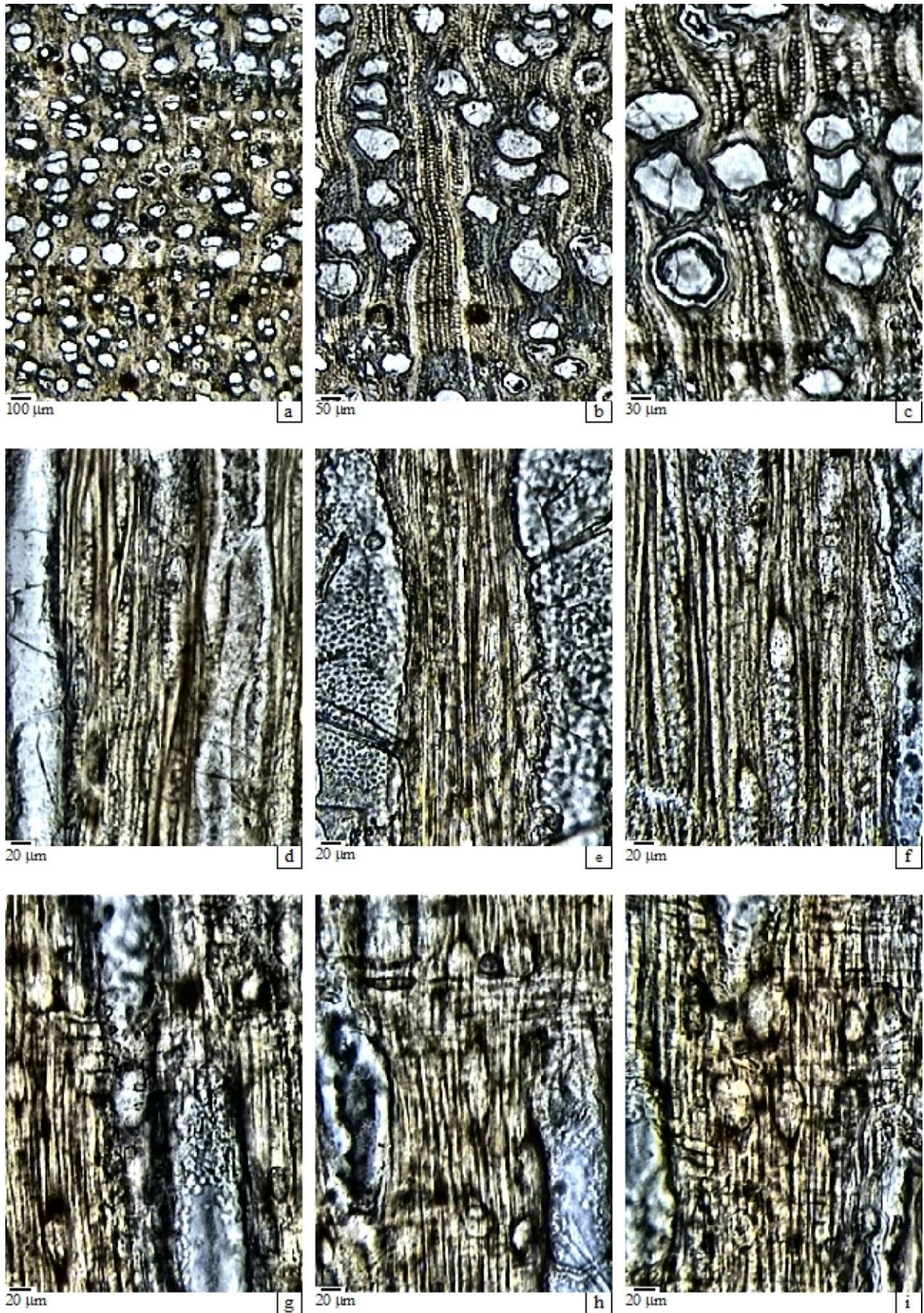


Fig. 2. *Laurinoxylon aff. czechense* Prakash, Březinová & Bůžek, 1971 (Specimen Lfk388). **a–c.** Cross section – semi-ring porosity, distinct growth-rings; idioblasts in rays; **d–f.** Tangential section – alternate pitting on vessels; rays 1-3 seriate; **g–i.** Radial section - heterogeneous rays, with marginal idioblasts. **photos a-i** (graphic scale).

characterized by the presence of typical flame-like idioblasts associated with rays. They usually show a diffuse porous structure, with vessels mainly solitary and in short radial multiples, thick-walled, with simple perforations, and alternate intervessel pits, with parenchyma few scanty paratracheal to vasicentric, with rays 1-3 seriate, heterocellular, having 1-2 marginal rows of taller or upright cells, often hypertrophied, oval or flame-like, and full of oil and/or mucilage, representing those specific idioblasts.

All these xylotomic details observed in the studied fossil specimens, but especially the presence of the typical idioblasts suggest a possible affinity with the Lauraceous taxa, as it appears specified in the papers of Metcalfe & Chalk (1950), Greguss (1954, 1959), Schweingrüber (1990), Watson & Dallwitz (1992), Schoch et al. (2004), Wheeler (2011), Akkemik & Yaman (2012) and Mantzouka et al. (2016).

Lauraceae is a rich plant family, having about 45 current genera with around 2850 species, which are spread mainly in the warm regions: tropical America, Brazil, Southeast Asia, Australia, and the Pacific islands. *Laurus* is the only genus living in Europe, with few species, appearing in the Mediterranean region and in southern Europe and warm temperate Asia, including Northern Africa and the Middle East (*Laurus* - Wikipedia, accessed 05.09.2023).

Considering the location of the mucilaginous idioblasts as a main taxonomic indicator, Mantzouka et al. (2016) showed that there are 4 types of *Laurinoxylon*, as it follows:

- *Laurinoxylon* Type 1 – with idioblasts associated only with ray parenchyma cells, +/- crystals;
- *Laurinoxylon* Type 2a – with idioblasts associated with both ray and axial parenchyma, +/- crystals;
- *Laurinoxylon* Type 2b – with idioblasts associated both with rays, also present among the fibres, + crystals (more or less numerous);
- *Laurinoxylon* Type 3 – with idioblasts associated with ray and axial parenchyma and also among the fibres, +/- crystals).

Thus, Berger (1953b) described the species *L. weylandi* from around Wien (Austria) as having one row of upright and/or square marginal ray cells, so a *Laurinoxylon* of Type 1, fairly similar to here studied specimens. In other paper (see Berger 1953a), he described *L. ehrendorferi* Berger, from the Aegean area (from Limnos, Tesseloniki) as having frequently grouped vessels and oil and/or mucilage cells, associated with ray parenchyma but, Mantzouka et al. (2016) suspected the presence of idioblasts associated to parenchyma cells and considered this species as *Laurinoxylon* of Type 2a, similar to *L. mueller-stollii* Greguss, 1954 and to *L. microtracheale* Süss, 1956 (in Süss, 1958).

Schönfeld (1956) have described a *L. parenchymatosum* from Germany, which have one row of upright and / or

square marginal ray cells (a *Laurinoxylon* of Type 1), and is characterized by the presence of more numerous axial parenchyma cells and, so, is quite similar to our studied specimens.

Also, from Germany, Süss (1958) has described a new species of *Laurinoxylon* Type 1, as *L. litseoides* Süss, presenting idioblasts, associated with rays. This species, *L. litseoides* Süss was also recently identified in Turkey (see Akkemik et al., 2019; Akkemik, 2021). Other new species of Süss (1958) identified as *L. hasenbergense* Süss and *L. microtracheale* Süss are *Laurinoxylon* of Type 2a, and a *L. endiandroides* Süss is a *Laurinoxylon* of Type 3, both proposed for revision, having some xylotomic details which does not agree with the diagnosis of *Laurinoxylon* (see Mantzouka et al., 2016, p.470).

Huard (1967) has described another *Laurinoxylon* of Type 1 from some Neogenes lignites from Arjuzans, France, as *Laurinoxylon perfectum* Huard, which is quite similar to our specimens.

Also, from Transylvania, Romania, Iamandei & Iamandei (1997) have described a *Laurinoxylon* of Type 1, as *L. neagui* Iamandei et Iamandei, also slightly similar to studied specimens in the present research.

Prakash et al. (1971) have described from Czech Rep. two species of *Laurinoxylon* of Type 1: as *L. oligocenicum*, found and described also by Petrescu (1978) from Romania, and as *L. czechense*, also of type 1, found and described later again by Sakala et al. (2010) from Czech Rep., both quite similar to our studied specimens. Another similar form of *Laurinoxylon* Type 1, was described by Mantzouka et al. (2016) from Lesbos, and named *Laurinoxylon* aff. *czechense* Prakash et al., suspecting that the original species *L. czechense* Prakash et al. is quite similar to the current *Cinnamomum camphora* (L.) J. Presl., which is of Type 3.

Thus, in the here studied specimens we described: growth rings with quite distinct boundaries and with porous; vessels with tg.d.<100 µm, relatively thick-walled, solitary or grouped in small radial multiples of up to 2-3 vessels, vertically showing usually simple perforation plates; alternate intervessel pits mean-sized, with 4-10 µm; vessel-ray pitting, similar; mean density 63 vessels per sq.mm.; fibres usually not pitted and sometimes septate; axial parenchyma scanty paratracheal to vasicentric few; rays 1-3 seriate, but usually 2-3 seriate, low to high, of 3 to 25 cells or more, with terminal cells triangular, high, ovoid or flame-like; ray density around 12 rays/mm tg.; radially show heterocellular character, with cells all procumbent in the ray-body, and 1-2 rows of marginals cells taller, square or upright, some of them hypertrophied, as globular to oval, or flame-like, usually having dark content; cross-fields with some round pits medium-sized in horizontal row arranged.

All these features clearly indicate a *Laurinoxylon* Type 1 (Mantzouka et al., 2016), and are very similar, up to identity with *Laurinoxylon* aff. *czechense* Prakash,

Březinová et Bůžek, 1971, to which we assign the studied specimens, and we consider it as a perfect ancestor of the current *Laurus nobilis* L., a species still living in the Mediterranean region.

***Laurinoxylon ehrendorferi* Berger, 1953a**

Fig. 3, photos a-i; Fig. 4, photos a-i

Studied material. From the studied material, 17 samples of fossil wood collected from Aegean area, showed a similar lauraceous xylostructure of Type 2a (Mantzouka et al., 2016), slightly different of the above described species. They were collected from late Oligocene to early Miocene volcano-sedimentary deposits and are registered and kept in the Collections of the Faculty Geol. & Geoenviron. of NKUA, under these field numbers: Aet983, Aet989, Aet991, collected from Aetohory (Evros); Li213, Li214, Li215, Li218, Li485b from Limnos island; and Lsv48, Lsv50, Lsv52, Lsv56, Lsv57, Lsv392, Lsv420, Lsv421, Lsv422 from Lesvos island.

Microscopic description. The growth rings – show quite indistinct boundaries, sometimes weakly marked by few rows of smaller flattened fibres, and by the start of the early-wood with normal-sized ground-tissue cells and large vessels.

The vessels – show in cross-section usually a diffuse-porous arrangement, only the vessels of final wood appear slightly smaller. The solitary vessels are numerous (around 50%), are round to oval-shaped and have the radial / tangential diameter of 100-200 / 70-170 µm. When grouped, usually as 2-3, the vessels are slightly deformed by compression and their wall thickness is of 7-10 µm the double wall. Sometimes, in the final wood, the vessel lumen size is more diminished (to 70 / 40 µm r/tg.d). In longitudinal view, the perforation plates appear usually of simple type, more or less inclined and sometimes scalariform, with relatively few thin bars, up to 10-15 (in Lsv48, Lsv52). The intervessel pitting has an alternate arrangement, and the pits are polygonal, slightly rounded, and medium-sized with a diameter of around 10 µm. The vessel-ray pits have much-reduced borders to apparently simple, and are similar to intervessel pits, in size and shape. The cross-field pitting is described below. Helical thickenings in vessel elements are rarely present. The mean tangential diameter of vessel lumina is around 130 µm. Vessels density is of 20-40 vessels per square millimeter, or more. The mean vessel element length is more than 350 µm. Tyloses in vessels, sometimes present. Deposits in vessels usually not present.

Tracheids and vascular fibres/vasicentric tracheids usually absent.

The fibers – constitute the major part of the ground tissue. They appear sometimes septate and usually have few, small, simple or distinctly bordered pits.

The axial parenchyma – is present within the ground-tissue few of apotracheal type as diffusely dispersed cells among fibres and as scanty paratracheal or of vasicentric

type. Their vertical walls have small simple pits. Sometimes, some parenchyma cells appear to be hypertrophied and full of mucilaginous substance, representing idioblasts.

The medullary rays – are usually fine: 1-3 seriate. Their height, in tangential sections, appear low to high, of 3 up to 25 cells, sometimes more, and the terminal cells appear triangular high, often flame-like. Radially, the cellular composition appear of heterocellular type, with body ray-cells all procumbent and one marginal row of taller cells, square and/or upright (of 4-12 µm), some of them as hypertrophied idioblasts, flame-like, globular to oval shaped, usually having bright or dark content. The cross fields with vessels show some small round pits, of 5-7 µm in diameter, in some horizontal rows arranged. Sometimes larger pits on the taller marginal fields can be observed. Ray density around 12 rays per tangential mm. Sheath cells and tile cells in rays are not present.

Storied structures – not present, neither to rays nor to the axial parenchyma and/or vessel elements. Secretory elements – appear as oil and/or mucilage hypertrophied ray-cells, as idioblasts associated with rays as are described above, and sometimes, associated with axial parenchyma. Mineral inclusions – absent. Intercellular canals – normal or traumatic axial or radial canals are absent.

Affinities and discussions. From the studied samples of petrified wood collected from Aegean area, mainland and insular, 17 specimens showed similar lauraceous structures of diffuse-porous type with quite indistinct ring boundaries, with numerous solitary vessels or in short radial multiples, vessels thick-walled with simple and sometimes scalariform perforations, with alternate intervessel pitting, also with scanty paratracheal to vasicentric parenchyma and with 1-3 seriate rays, heterocellular, having one marginal row of taller or upright cells, often hypertrophied, oval or flame-like, and full of oil and/or mucilage, representing idioblasts. But idioblasts appear associated with axial parenchyma too, even if, sometimes, is difficult to observe.

The xylotomy of the here studied specimens is in accord with the emended diagnosis of *Laurinoxylon* Felix, 1883, emend. Dupéron et al., 2008. And, taking into account the location of the mucilaginous idioblasts as a main taxonomic indicator, after Mantzouka et al. (2016), it seems that we face a *Laurinoxylon* - Type 2a, with idioblasts associated with both ray and axial parenchyma. We will compare the here studied specimens with some lauraceous species described especially from the European and Mediterranean area.

Thus, Berger (1953a) described the species *Laurinoxylon ehrendorferi*, from the Aegean area, from Limnos and Tesseloniki, which show a xylotomy very similar to here studied specimens, as having frequently grouped vessels and idioblasts associated with ray parenchyma, but Mantzouka et al. (2016) suspected the presence of idioblasts associated to parenchyma cells and have considered this species as *Laurinoxylon* of Type 2a,

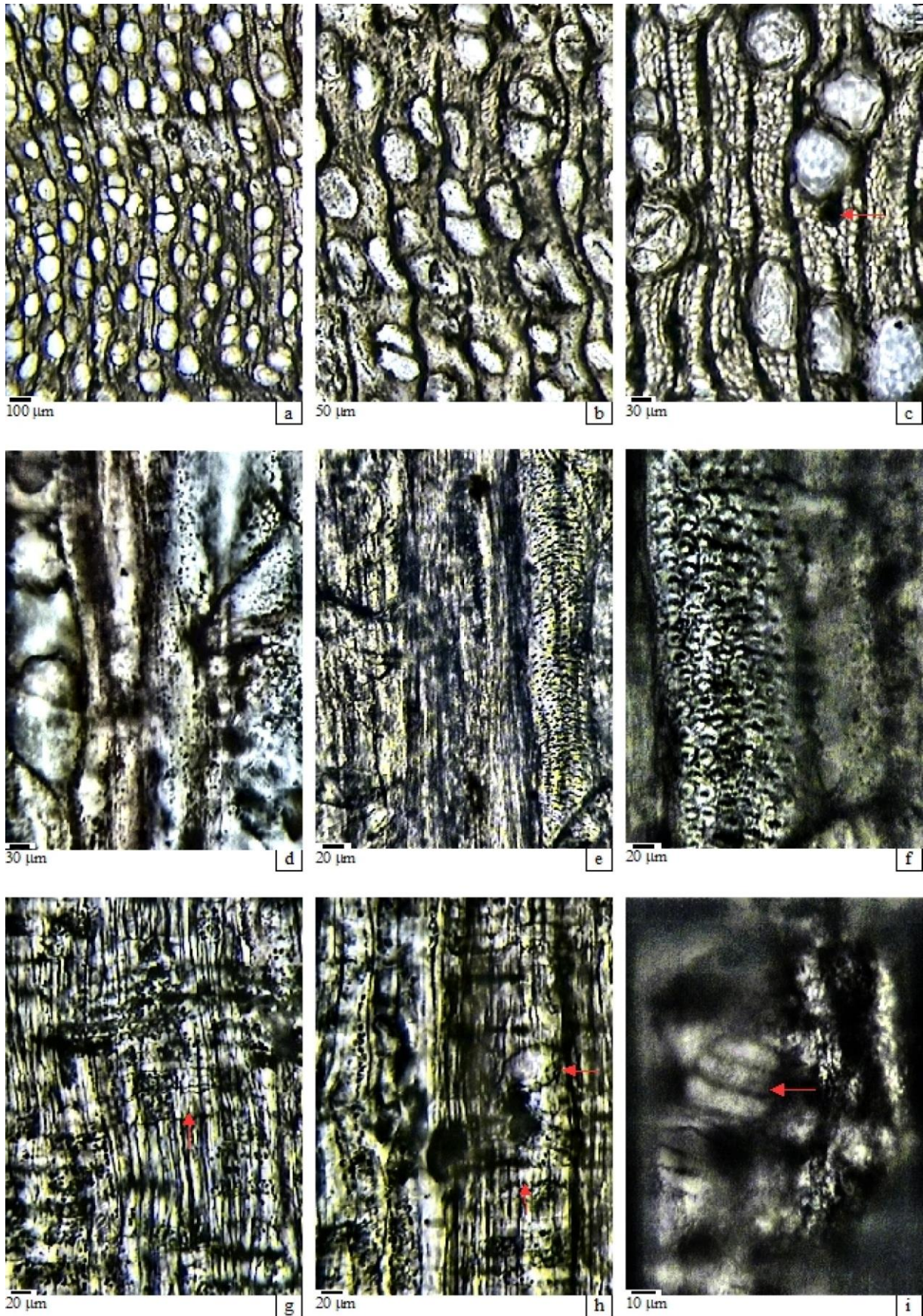


Fig. 3. *Laurinoxylon ehrendorferi* Berger 1953a (Specimen Lsv52). **a–c:** Cross section – semi-ring porosity, distinct growth-rings; idioblasts in axial parenchyma (arrow); **d–f:** Tangential section – alternate pitting on vessels; rays 1-3 seriate; **g–i:** Radial section - heterogeneous rays, with marginal idioblasts; simple and scalariform perforations (vertical arrow). **photos a-i** (graphic scale).

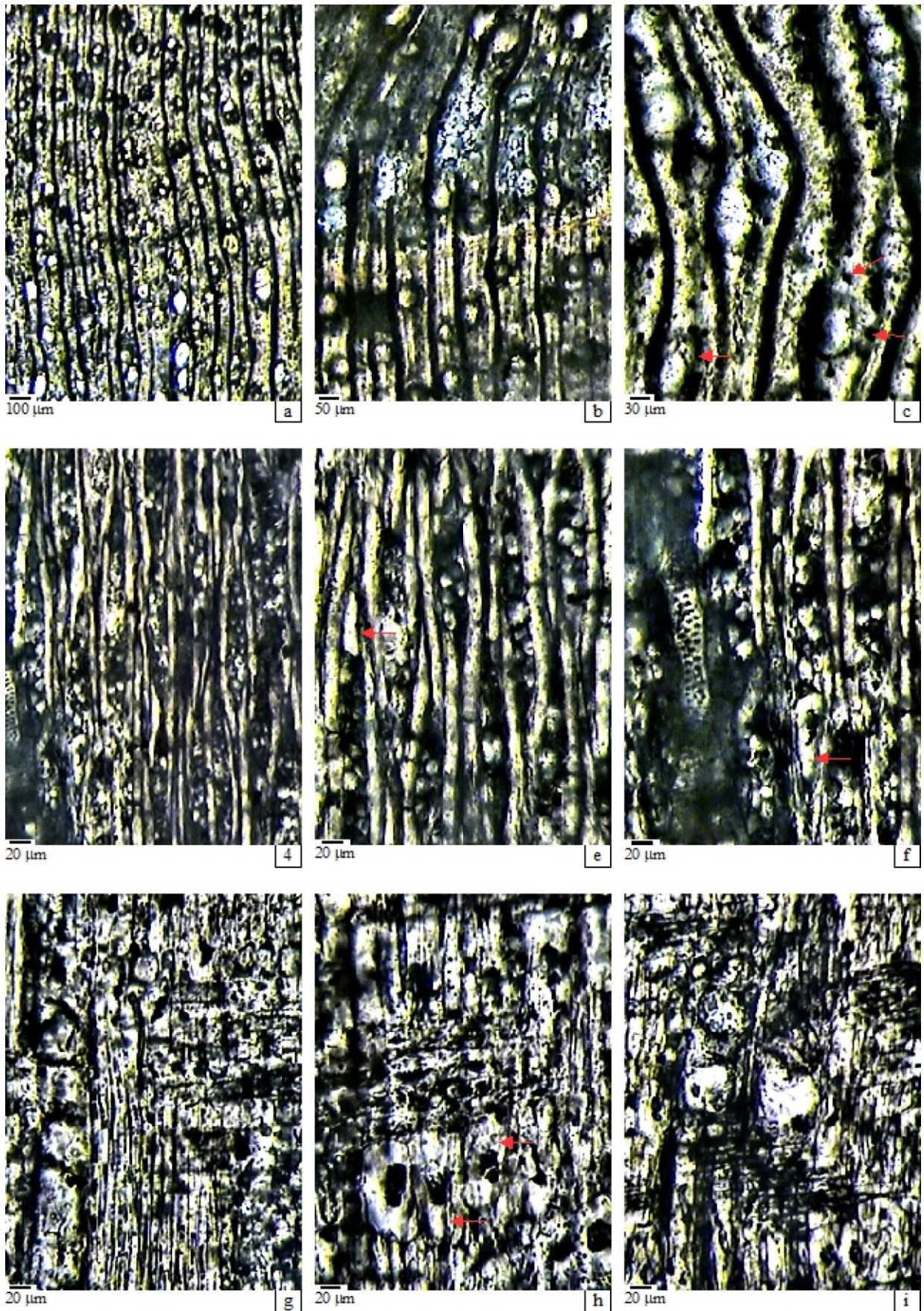


Fig. 4. *Laurinoxylon ehrendorferi* Berger 1953a (Specimen Li214). **a–c.** Cross section – semi-ring porosity, distinct growth-rings; idioblasts in rays and axial parenchyma (arrows); **d–f.** Tangential section – alternate pitting on vessels; rays 1-3 seriate, idioblasts in rays (arrows); **g–i.** Radial section - heterogeneous rays, with marginal idioblasts (arrows). **photos a-i** (graphic scale).

similar to *L. mueller-stollii* Greguss, 1954, to *L. hasenbergense* Süss, 1956 and to *L. microtracheale* Süss, 1956 (see Süss, 1958), all of them as *Laurinoxylon* - Type 2a, (see Mantzouka et al., 2016).

Thus, taking into account the xylotomy of the here studied specimens, with a structure marked by the presence of the typical idioblasts associated with ray parenchyma and with axial parenchyma too (even sometimes this is difficult to observe), and the similarity up to identity with the description of Berger (1953a) and of Mantzouka et al., (2016) for *L. ehrendorferi* (otherwise originally described by Berger as collected from Limnos), we assign the here studied specimens to the species *Laurinoxylon ehrendorferi* Berger, 1953a, as a possible ancestor of the current *Persea* L., a species that probably lived in the Mediterranean region during Cenozoic (see Kopp, 1966; and *Persea* - Wikipedia - accessed at 10.31.2023).

Genus *Cinnamomoxylon* Gottwald, 1997

***Cinnamomoxylon seemannianum* (Mädel) Gottwald, 1997**

Fig. 5, photos a-i.

Studied material. From the studied material, 61 samples of petrified wood collected from the Lower Miocene volcano-sedimentary deposits of Lesvos showed a similar lauraceous xylostructure and were described grouped as a *Laurinoxylon* - Type 3 (Mantzouka et al., 2016). These samples are registered and kept in the Collections of the Faculty Geol. & Geoenviron., of NKUA, under these numbers: Lsv8, Lsv21, Lsv22, Lsv24, Lsv28, Lsv29, Lsv30, Lsv33, Lsv35, Lsv36, Lsv37, Lsv38, Lsv46, Lsv88, Lsv89, Lsv90, Lsv100, Lsv101, Lsv103, Lsv105, Lsv106, Lsv107, Lsv108, Lsv109, Lsv113, Lsv114, Lsv115, Lsv117, Lsv118, Lsv363, Lsv370, Lsv374, Lsv381, Lsv390?, Lsv391, Lsv394, Lsv419, Lsv425, Lsv426, Lsv427, Lsv434, Lsv435, Lsv436, Lsv437, Lsv442, Lsv443, Lsv447, Lsv448, Lsv449, Lsv450, Lsv453, Lsv454?, Lsv460, Lsv461, Lsv541, Lsv542, Lsv543, Lsv545, Lsv548, Lsv553, Lsv562.

Microscopic description. Growth rings – appear in cross-section, showing a diffuse porous wood structure, with relatively distinct ring boundaries, marked sometimes by some rows of smaller fibres, abruptly followed by the early-wood with normal-sized fibres and with larger vessels.

The vessels – appear in cross-section either solitary, or in radial multiples of 2-4(5) vessels (sometimes as clusters), in a radial pattern arranged between two successive rays, so defining a structure with diffuse-porous arrangement. The solitary vessels are round to oval and have the radial / tangential diameter of 60-120 / 40-60 µm (mean 95 / 52). When grouped, the vessels are slightly deformed, by compression. The vessels' walls are not very thick, having 5-8 µm (double wall). However, sometimes there

appears a tendency to a slightly semi-ring-porous structure, since in the late wood the vessels become gradually narrower, up to 50 / 30 µm r/tg.d. In the longitudinal view, the perforation plates appear of simple type, more or less inclined. The intervessel pits are polygonal, have an alternate arrangement, and are medium-sized, with a diameter of around 10 µm. The vessel-ray pits are polygonal, quite similar to intervessel pits in size and shape. The cross-field pitting is described below. Helical thickenings in vessel elements are not present. The mean tangential diameter of vessel lumina is around 52 µm. Vessels density is of 40–80 vessels per square millimeter, or more. The mean vessel element length is up to 350 µm. Tyloses in vessels sometimes appear. Deposits in vessels usually not present.

Tracheids and vascular fibres/vasicentric tracheids – sometimes present and, when appear, are 1-2 seriate and pitted.

The fibres – represent the major part of the ground tissue and, in vertical view, seem to be non-septate and small pitted, usually difficult to observe, due to bad preservation. Sometimes hypertrophied cells as mucilaginous idioblasts appear among the fibres.

The axial parenchyma – is present, relatively few, scanty paratracheal, as vasicentric to confluent. On the vertical walls 1-2-seriate small pits appear, and the end-walls are horizontal to slightly inclined. Also some parenchyma cells are slightly hypertrophied and full of mucilages, as idioblasts.

The rays – are 1-5-seriate, but commonly are 2-3 seriate. In tangential sections they appear as low to high rays, of up to 25–30 cells (i.e. to 550 µm or more), and the terminal cells appear triangular, higher, but often flame-like. Radially, the rays show a heterocellular aspect, with body ray cells all procumbent and 1(-2) rows of marginals taller, square and/or upright (high of 4-12 µm), some of them as hypertrophied idioblasts, globular or oval-shaped, or flame-like, usually having dark content. The cross-fields with vessels show some round pits of 5-7 µm in diameter, in horizontal row arranged. Sometimes large pits on the taller marginal fields can be observed. Sheath cells and tile cells are not present. Ray density is of 7-14 rays/mm tangential (mean 9).

Storied structures – are not present, neither to rays nor to the axial parenchyma and/or vessel elements. Secretory elements – appear as oil and/or mucilage hypertrophied ray cells as idioblasts associated with rays, with axial parenchyma, and among fibres as described above. Intercellular canals – normal or traumatic, as axial or radial canals are usually absent. Mineral inclusions – were not observed.

Affinities and discussions. The xylotomy of the studied specimens shows some similarities with that of described species as *Laurinoxylon* of Type 3, like *Laurinoxylon czechense* Prakash et al., 1971, which is similar to the current *Cinnamomum camphora* (L.) J. Presl. and, also, with *Laurinoxylon* aff. *diluviale* (Unger) Felix emend.

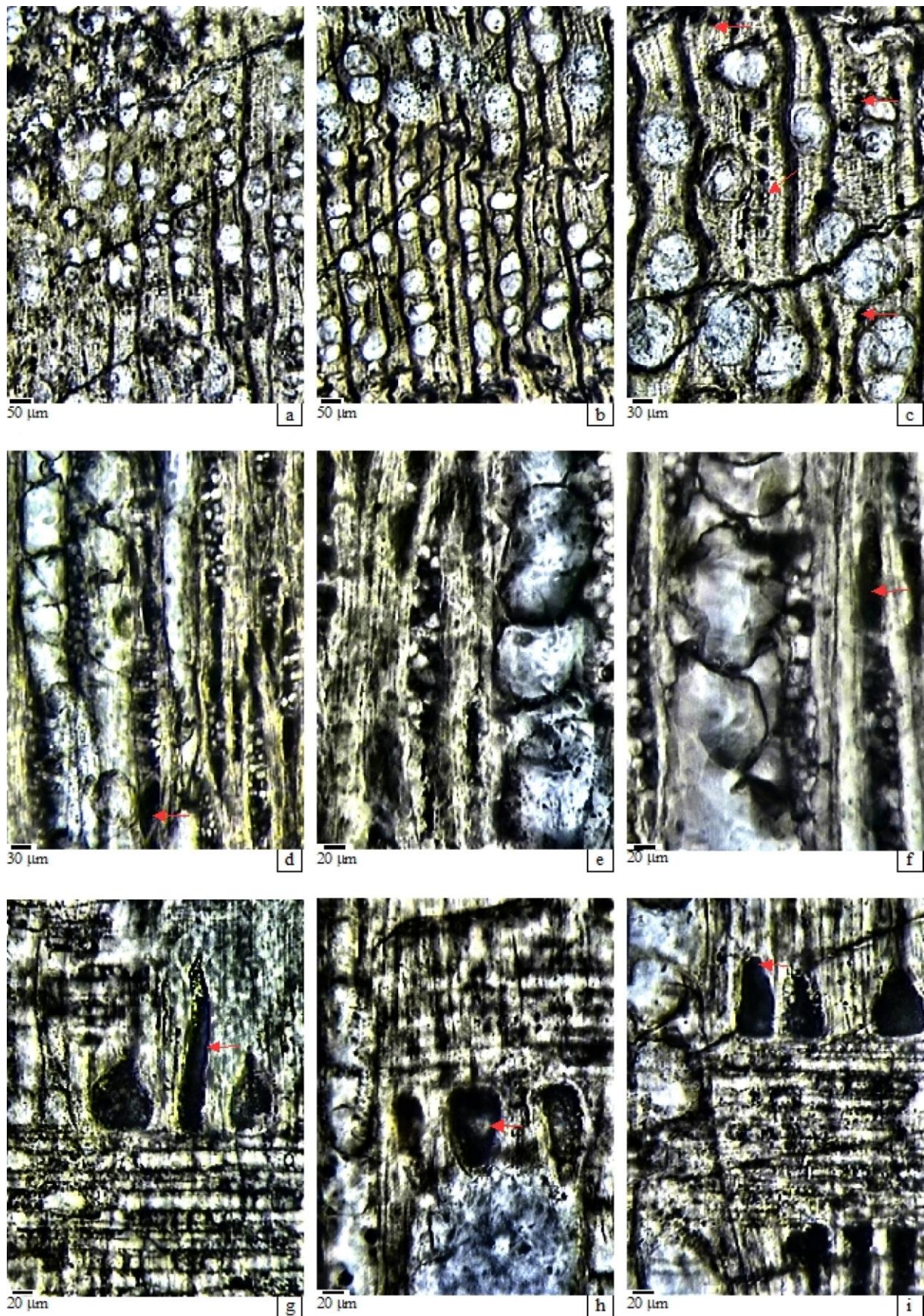


Fig. 5. *Cinnamomoxylon seemannianum* (Mädel) Gottwald 1997 (Specimen Lsv8). **a–c.** Cross section – semi-ring porosity, distinct growth-rings; idioblasts in rays and axial parenchyma and among fibres (arrows); **d–f.** Tangential section – tyloses in vessels, rays 1-3 seriate, idioblasts in rays (arrows); **g–i.** Radial section – heterogeneous rays, with marginal idioblasts (arrows). **photos a-i** (graphic scale).

Dupéron et al. (2008) or with a more recently published species, *L. thomasi* Akkemik et al. (2019), also of Type 3.

However, the best similarity, up to identity, regarding the location of the typical idioblasts associated with ray parenchyma and with axial parenchyma too, and among the fibres, was observed with the species *Cinnamomoxylon seemannianum* (Mädel) Gottwald, 1997, originally described as *Laurinoxylon seemannianum* Mädel (in Süss & Mädel, 1958). The same species was identified and described by Koutecký & Sakala (2015) from the Oligocene of the Czech Republic and, also, by Mantzouka et al. (2016), from Lesbos. We specify here that the form *Laurinoxylon cf. seemannianum* described by Selmeier (1967, 1969, 1984) and by Gottwald (1992) seems to be different and problematic and was proposed to be revised (see Mantzouka et al. (2016, p. 481).

After this comparison and discussion, we assign our studied specimens to *Cinnamomoxylon seemannianum* (Mädel) Gottwald, 1997, as having a similar xylotomy with the specimens described from Germany, from Czech Rep., and Lesbos, as cited above, considering it as an ancestor of the current *Cinnamomum* Schaeff.

Family **Salicaceae** Mirbel

Genus *Populoxylon* Mädel-Angeliewa, 1968

Populoxylon sp. cf. Populus alba L.,

Fig. 6, photos a-i.

Studied material. Two samples of petrified wood collected from Aetohory Evros, from late Oligocene volcano-sedimentary deposits, show a similar xylostructure, typical for the genus *Populoxylon*. They are registered and kept in the Collection of the Faculty of Geol. & Geoenviron., of NKUA, under the field numbers: Aet915, Aet986.

Microscopic description. Growth rings – are present, usually having a diffuse-porous structure to slightly semi-ring-porous, with quite indistinct ring boundaries, difficultly guessed between the late-wood with smaller vessels and the early-wood, which starts with larger vessels.

The vessels – appear solitary and grouped in radial multiples of 2-3(-6) pores, their arrangement defining the diffuse-porous wood structure in which with larger vessels of the early wood, that slightly diminish only in the final wood. The shape of the solitary vessels is rounded to radial-oval and, within the radial multiples, they are slightly deformed and larger and smaller vessels are present together. The large solitary vessels have the lumina size of 110-150 / 60-85 µm the radial / tangential diameter, to 60-80 / 40-50 µm in the final wood. Their walls are not too thick, having 3-4 µm double wall. In the longitudinal view, the vessels show simple perforated plates, inclined. The numerous intervessel pits of bordered type are polygonal, contiguous or slightly

spaced, in alternate arrangement or slightly irregular. Their mean size is between 7-10 µm. The vessel-ray pits have much reduced borders, to apparently simple, corresponding to the cross-fields pits, described below. Helical thickenings in vessel elements are not present. The vessels' density is 20-40 vessels per square millimeter. Mean vessel element length is up to 350 µm, or slightly more. Inside the vessels' lumina no tyloses can be seen, but often granular dark content or fungi appear. Tracheids or vascular fibres or vasicentric tracheids - not present.

The fibers – in cross-section, constitute the major part of the ground-tissue, showing a large polygonal lumen, 12-17 µm in diameter, and relatively thick walls (4-6 µm the double wall). Longitudinally the libriform fibers show poorly preserved pitting on the walls, and are not septate. Axial parenchyma – appears very few or almost indiscernible.

The rays – are exclusively uniseriate. Ray height is usually high to very high, i.e. more than 1 mm. As a composition, the rays are homocellular, with cells all procumbent, the marginals slightly taller. In cross-fields with vessels, rounded or polygonal simple pits appear, alternate, in 2-3 rows, often difficult to observe because of dark content or since are poorly preserved. Sheath-cells or tile-cells are not present. Ray density: 4-12 rays / mm.tg, sometimes more.

Storied structures – of rays, parenchyma or vessel elements – absent. Secretory elements – as oil or mucilage cells not present. Intercellular canals – as normal or traumatic axial canals, radial canals not present. Cambial variants – as included phloem not present. Mineral inclusions – as any kind of prismatic crystals in the structure – not present.

Affinities and discussions. Two samples of petrified wood showed a similar dicotyledonous xylotomy, characterized by diffuse porous structure, with solitary and/or grouped as radial multiples of 2-3(-6) pores, with exclusively uniseriate and tall rays with some rows of alternate pits in cross-fields and, consulting the papers of Greguss (1954), Schweingrüber (1990), Schoch et al. (2004), Wheeler et al. (2011, for InsideWood) and Akkemik & Yaman (2012), we have observed affinities with current Salicaceous genera, especially with the genus *Populus* L.

The correspondent fossil genus - *Populoxylon* was created by Mädel-Angeliewa (1968), based on the study of Pliocene wood remains from coal deposits of Baccinello (Toscana, Italy) with designated type-species *P. priscum* Mädel-Angeliewa, 1968. In the genus diagnosis it's noted: „diffuse porous wood, with usually grouped vessels that have simple perforations and intervacular pits numerous, alternate; exclusively uniseriate rays, homocellular, with cells all-procumbent, marginals higher; cross-fields with 2-3 horizontal rows of slightly oval pits and axial parenchyma few“.



Fig. 6. *Populoxylon* sp. (cf. *Populus alba* L.), (Specimen Aet915). **a-c.** Cross section – porous to semi-ring porous structure, distinct growth-rings; **d-f.** Tangential section – exclusively uniseriate rays; **g-i.** Radial section - alternate pitting on vessels; simple perforations; homocellular rays. **photos a-i** (graphic scale).

Doutrelepont et al. (1997), described a *Populoxylon* sp. as having slightly different vessel distribution in cross-section, as similar to the extant *Populus euphratica* Olivier, which is slightly different of our specimens. Other fossil forms, characterized by the presence of axial parenchyma which appears few, marginal and scanty diffuse were described as *Populoxylon* sp. (cf. *P. tremula* L.), by Greguss (1969) from the Sarmatian from Mikfalva (Hungary), and *Populus* sp. (*P. tremula* L.?) described by Nastschokin (1968) from the Quaternary of Yenisei-river basin (Russia). Also, some Miocene remains with similar structure have been described as *Populoxylon tremuloides* (in a Ph.D. Thesis: Iamandei, 2002, unpublished) and, it was sometimes, cited like this, even if is not a valid name (see Iamandei & Iamandei, 2005; Iamandei et al., 2008c). More recently, a Miocene *Populoxylon* sp. (cf. *Populus tremula* L.) was described from the Bulgarian Black Sea shore (see Iamandei et al., 2023a,b).

A new species of *Populoxylon* was described recently from Anatolia, by Akkemik (2021), as *P. sebenense* Akkemik, having higher rays and obvious marginal axial parenchyma, so it is slightly different of our specimens here described.

Another form of *Populoxylon* was described, from Carpathian area, by Iamandei et al., (2005 and 2011), as *Populoxylon* (cf. *Populus alba* L.), which is very similar to here studied specimens, having axial parenchyma few, almost indiscernible. The here studied specimens, collected from Evros, from Oligocene volcano-sedimentary from Aetohory, have a structure xylotomically almost identical to the extant species *Populus alba* L. Thus, based on this discussion, we assign the studied specimens to *Populoxylon* sp. cf. *Populus alba* L., as a fossil equivalent of this current species, which is native to Mediterranean zone, living in Atlas Mountains, South and Central Europe, Central Asia (*Populus alba* - Wikipedia - accessed 05.02.2023).

Family **Fagaceae** Dumortier

Genus ***Quercoxylon*** (Kräusel) Gros, 1988

***Quercoxylon intermedium* Petrescu & Velitzelos, 1981**

Fig. 7, photos a – i.

Studied material. Numerous petrified (silicified) wood remains (87 samples) showed a similar oak xylostructure. They were collected from late Oligocene deposits of Evros, more specific from Aetohory – 16 samples numbered with the field numbers: Aet238, Aet303, Aet304, Aet305, Aet317, Aet319, Aet322, Aet326, Aet327, Aet330, Aet332, Aet984, Aet985, Aet994, Aet1135, Aet1136); 11 samples from Fylacto with field numbers: Fy25, Fy157, Fy158, Fy159, Fy160, Fy161, Fy162, Fy163, Fy1137, Fy1138, Fy1139; 6 samples from Dadia, with field numbers: Dd710, Dd711, Dd712, Dd713, Dd714, Dd715; 10 samples from Likofi, with field numbers: Lkf239, Lkf 240, Lkf 241, Lkf 242, Lkf

243, Lkf 244, Lkf 245, Lkf 246, Lkf 247, Lkf 248; 23 samples from Provatonas, with field numbers: EP1 D1, EP2 D4, EP3 D4, EP7 D5, EP8 D6, EP11 D7, EP13 A D8, EP13 D9, EP14 D10, EP15 A D11, EP15 D12, EP17 D13, EP19 D15, EP20 D22, EP20 A D16, EP27 D17, EP34 D18, EP35 D19, EP40 D20, EP1999 D21); 9 samples from Lefkimi, with field numbers: Lfk267, Lfk276, Lfk278, Lfk280, Lfk285, Lfk287, Lfk289, Lfk324, Lfk328a; one from Sappes – field number: Spp1084; and two from Chalkidiki – field numbers: Ckdk439 and Ckdk440. Also, 4 samples from Limnos island, with field numbers: Li78, Li224, Li225, Li482; and 5 samples from Lesvos island, with field numbers: Lsv7, Lsv82, Lsv407, Lsv410, Lsv546. They are all registered under these field numbers and kept in the Collections of the Faculty of Geol. & Geoenviron., of NKUA.

Microscopic description. The growth rings – are present in the secondary wood, but with less distinct ring-boundaries, that difficultly can be guessed there where, after the late-wood with small vessels, and some final rows of ground tissue devoid of vessels are suddenly followed by the early-wood with normal sized fibres and large vessels. Also, the presence of two-sized rays gives to the structure a typical aspect. In some studied specimens the structure is crushed or poorly preserved, so fewer well-preserved xylotomical details can be recognized, but the general aspect of the structure is typical.

The vessels – appear, in cross section, almost exclusively solitary, rarely in pairs or small groups and their arrangement define a wood structure of semi-ring porous type, with larger solitary vessels in the early-wood, gradually diminishing to the late-wood. Sometimes, a tendency to porous or even ring porous aspect appears, possibly as intraspecific or climatic variability. The large solitary vessels have the lumina size of 100-260(-290) / 100-220 µm the radial / tangential diameter, gradually diminishing to 60-90 / 50-90 µm in the late-wood. The shape of the solitary pores is usually round to radial oval and have thick walls, of 5-8 µm the simple wall. Vessels' arrangement is very specific due to the presence two-sized rays, i.e. between two thick rays there appear a composite general bundle with radial pattern and/or diagonal, sometimes even with dendritic aspect. It comprises all the vessels which, between two successive thin rays, are radially arranged. Often, between two thin rays, few vessels appear or not at all, but all together contribute to that diagonal or dendritic aspect of the structure. However, in some specimens, between two uniseriate rays appear radial rows of vessels of almost similar size (in many specimens from Provatonas area). In other bundles some irregularities can appear, but usually, all these bundles show obvious gradual diminishing vessels' size to the late-wood, which gives the typical semi-ring-porous aspect of the structure. In longitudinal view, the vessels show exclusively simple

perforation plates, sometimes less visible, because the presence of tyloses or of bad preservation. On the vertical walls, numerous, round intervessel pits appear, or toward the vasicentric tracheids, having opposite, subopposite to alternate arrangement, contiguous or spaced. These pits of bordered type are mean sized, of 5-10 µm in diameter. The vessel-ray pits are quite similar to the vascular pits, in size and shape, having much reduced borders, to apparently simple, corresponding to the cross-field pitting, which is described below. Helical thickenings in vessel elements were not observed. The tangential diameter of vessel lumina varies between 50-220 µm and the mean tangential diameter is around 100 µm. Vessels' density is of 5-20 vessels/mm². The mean vessel element length is around 350 µm or slightly more. Inside the vessels' lumina, visible in all sections, more or less numerous and relatively thick-walled, big and/or small tyloses commonly can be seen. Also, sometimes appears in vessels or inside tyloses, fungi as hyphae, or some tanninous dark content.

Vasicentric tracheids – are present, surrounding the vessels, having pitted vertical walls with 1-2(3)-seriate, bordered pits of 4-5 µm in diameter.

The fibers – constitute the major part of the ground tissue, are relatively thick walled and, on the vertical walls have small bordered pits. Also, they are not visibly septate.

The axial parenchyma – constitute the major part of the ground tissue, are relatively thick walled and, on the vertical walls have small bordered pits. Also, they are not visibly septate.

The axial parenchyma – in cross section appears as few cells, dispersed between among the fibers, often difficult to identify each other, in cross-section, having quite similar aspects, but usually the parenchyma appears as narrow bands (1-3 cells wide), visible as tangential shorter or longer bands, even suggesting an almost reticulate arrangement. Sometimes those bands of parenchyma are slightly irregular as direction or thickness. In longitudinal view, the parenchyma can be recognized as rows of vertical-rectangular cells, often chambered and crystalliferous, usually with big or small rounded crystals inside, floating in a tanninous dark content, in which appear round empty spaces, like variably sized bubbles (especially in the samples from Licofi and from Lefkimi).

The rays – after their thickness are rays of two distinct sizes: thin rays, usually exclusively uniseriate, rarely 2-3-seriate (as in many specimens from Provatonas), which in cross-section appear as molding the vessels, and thick rays, multiseriate, commonly more than 10-seriate, of compact type or, mostly, of compound type, i.e. dissected by numerous libriform fibres, so giving typical aspect of almost aggregate rays, or are even of typical aggregate type, as it appear in almost all the studied specimens. Regarding the ray height in tangential view, the fine rays are usually low, but the multiseriate rays are high to very high, often more of 1 mm. Also, the ray cellular composition, observed in radial view, shows that the rays

are in some cases homocellular, with all ray cells procumbent, but usually are heterocellular, having the body ray cells procumbent and 1-2(-3) marginal rows of taller cells, as square or even upright cells. In cross-fields with vessels, large quadrangular simple pits 8-12(-15) / 4-5 µm, in palisade arrangement appear, sometimes with rounded corners or lens-like (of 15-20(25) / 5-6 µm), usually vertical, but sometimes tilted up to horizontal, but often poorly visible, because the ray cells are full of dark content and or rounded crystals or, simply, are poorly preserved. Between the horizontal ray cells, the tangential wall is relatively thick and is vertical to inclined. Ray density is between 4-12 rays/mm horizontal, sometimes more. Sheath cells or tile cells are not present.

Storied structures – absent. Secretory elements are absent. Intercellular canals – absent. Only in the sample Pvt8 appears, in cross-section, a traumatic rounded canal of big dimensions with lumen of 120/90 µm in diameters and with very thick walls, of 20-25 µm. It could be, also, an insect gallery, since is intersecting other structural elements. Cambial variants – as included phloem absent. Only in the sample Aet1135 appears a primary structure with pith and primary wood, suggesting a branch fragment. Mineral inclusions – are present as usually small, rounded crystals, in chambered axial parenchyma cells and in ray parenchyma cells. Also, is good to specify that in the specimens Pvt24 and Pvt35, clearly appear important deposits of suber.

Affinities and discussions. We had in study a big number of specimens (87) that showed a similar quercineous xylo-structure, characterized by wood semi-ring-porous, with almost exclusively solitary vessels, rarely in small groups, having simple perforations; with two-sized rays - the broad ones as compact-compound and/or aggregate rays and with typical cross-field pitting as quadrangular pits, „in palisade“ arrangement. All these details are presented in a synthetic description of all the available specimens and strongly suggest a structure of *Quercus* type – *Ilex* Section, as it appears in the consulted papers of Greguss (1954), Hadziev & Mädler (1962), Schweingrüber (1990), Schoch et al. (2004), Wheeler et al. (2011).

Thus, in their study of some petrified oaks from Bulgaria, Hadziev & Mädler (1962) showed that the xylotomy of the current oaks corresponds to four structural wood types, as follows:

- „Weisseichen“ – the white oak type, comprising most of the species included now in the section *Quercus* (see Denk et al., 2017), a group of species living now in Europe, Asia and North Africa, and characterized by a ring-porous structure, with small, polygonal and thin-walled vessels, in the late-wood.

- „Roteichen“ – the red oak type, comprising the species from *Eritrobalanus* section (now *Lobatae* section - see Denk et al., 2017), as well as some species of the *Lepidobalanoideae* (now *Quercus* section - see Denk et al., 2017), characterized by ring-porous structure, with relatively large, round, thick-walled late-wood vessels.

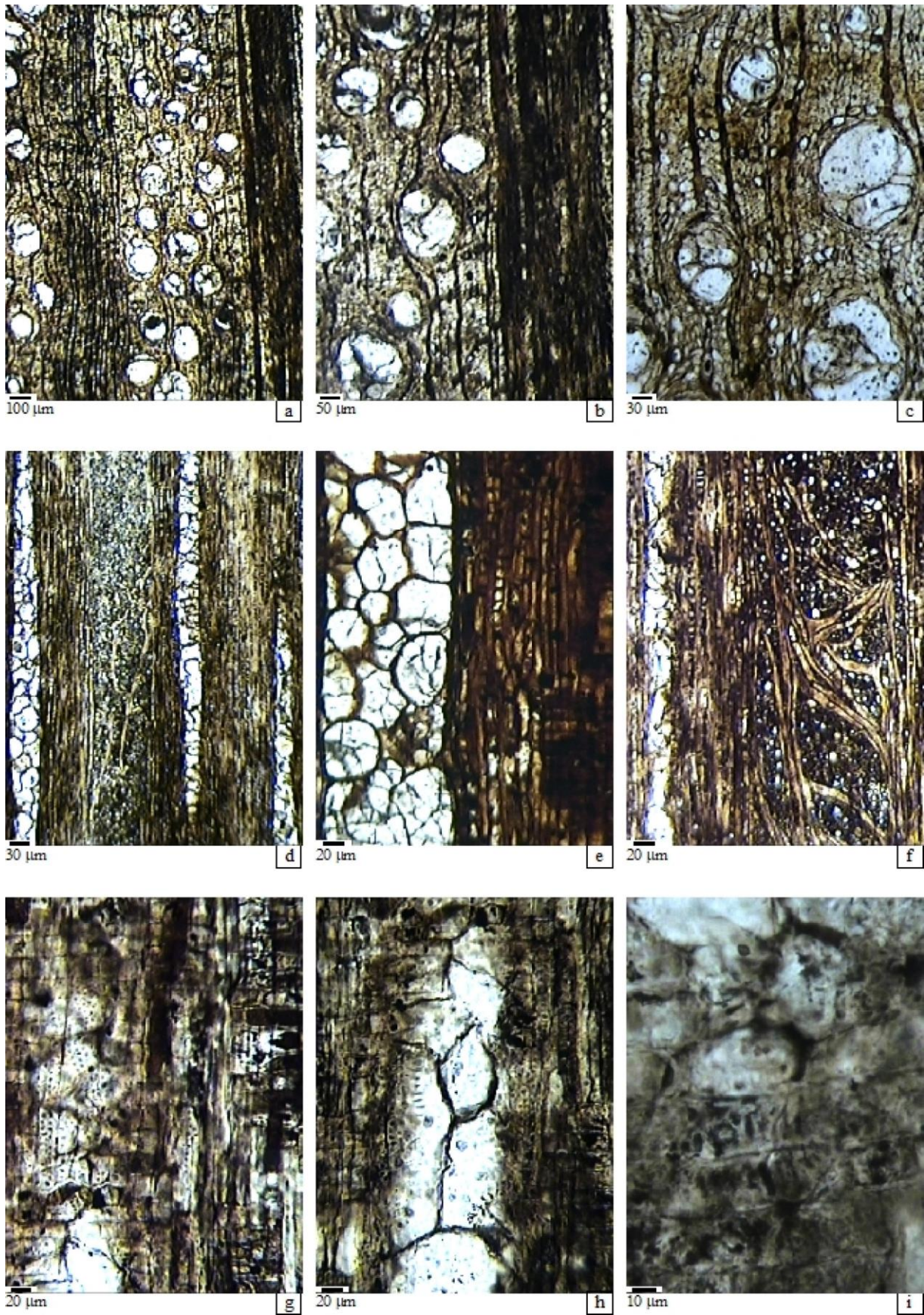


Fig. 7. *Quercoxylon intermedium* Petrescu & Velitzelos, 1981. (Specimen Aet303). **a–c.** Cross section – semi-ring porous structure, distinct growth-rings two-sized rays; **d–f.** Tangential section – two-sized rays, aggregate thick ray, tyloses in vessels; **g–i.** Radial section - pitting on paratracheal parenchyma; cross-field with pits in palisade. **photos a-i** (graphic scale).

- The „evergreen oak“ type (*Ilex* section), including species of *Quercus* and *Lithocarpus*, with diffuse-porous or semi-ring porous xylo-structure, the relatively small and spaced vessels, often being radially arranged.

- The „root wood“ oak-type, corresponds to all the oak types, showing diffuse-porous structure, and large and crowded pores.

Later, Privé-Gill (1975), noted in her studies that the oak wood is characterized by vessels in radial rows more or less dendritically distributed and showing only simple perforations. She emphasized, also, as a feature of taxonomic value, the presence of two-sized rays: multiseriate, very thick and, respectively, fine rays, uniseriate or biseriate, usually present in actual or fossil wood of *Quercus* and *Lithocarpus*. These genera have numerous species living in the temperate or warm regions of the northern hemisphere. The wood structure can also be diffuse-porous, typical of evergreen species, whereas the ring-porous structure is characteristic of deciduous *Quercus* species and the most northern *Lithocarpus* species. In the root-wood, the deciduous species often tend to lose their ring-porousness, becoming similar to the evergreen species, and the broad rays become divided into false rays, i.e. aggregate rays (Privé-Gill, 1975). All these observations are in perfect accord with the observations of Hadziev & Mädler (1962).

A fossil species with very similar features was described from Evros, by Petrescu et Velitzelos (1981), as *Quercoxylon intermedium*, identified also by us in Rhodopes, Bulgaria (Iamandei et al., 2014) and, the xylotomy of the numerous specimens studied here is very similar, up to identity with the cited species.

Thus, comparing description of the studied specimens with the species diagnosis and based on the above discussion, we assign them to the fossil species *Quercoxylon intermedium* Petrescu et Velitzelos, 1981, considering it as a fossil correspondent of *Quercus ilex* L. or, possibly, to *Q. suber* L., both native to SW-Europe, NW-Africa and Mediterranean basin (see *Quercus ilex* - Wikipedia - accessed 05.02.2023; *Quercus suber* - Wikipedia - accessed 05.02.2023).

Also, we consider that this type of oak had evergreen foliage, described from Aegean area as *Eotrigonobalanus furcinervis* (Roosm.) Walter et Kvacek, 1989, (in Kvaček & Walther, 1989) and as is mentioned in other previous studies on fossil remains of oak, from Greece (see Selmeier & Velitzelos, 2000; Velitzelos et al., 1999; 2008).

Family **Juglandaceae** DC. ex Perleb

Genus ***Engelhardioxylon*** (Manchester) Dupéron, 1988,

Engelhardioxylon lesbium Iamandei & Iamandei, sp. nov.

Fig. 8, photos a-i; Fig. 9, photos a-i

Studied material. Two samples of silicified wood,

collected from early Miocene volcano-sedimentary deposits, of Lesbos Island showed a similar juglandaceous xylostructure. They are registered under the field numbers: Lsv66, Lsv67, and kept in the Collections of the Faculty of Geol. & Geoenviron. of NKUA.

Microscopic description. Growth rings – are present, with semi-ring-porous structure, showing quite indistinct ring boundaries, difficult to guess, only there where, after the late-wood with small-sized pores, suddenly follows the early-wood with normal-sized ground tissue cells and larger vessels. Also, in cross section, long tangential bands of axial parenchyma give the structure a reticulate aspect.

The vessels – appear commonly solitary (60% or more) or in small radial groups of 2-3(5) between two successive rays, but in a diagonal pattern in multiple neighbor fascicles. The solitary vessels appear rounded or radial oval (slightly deformed when in groups) and have the lumina size of 50-100(-150) / 30-75(-100) µm the radial / tangential diameter, diminishing to 30-45 / 20-30 µm in the late-wood (defining semi-ring-porosity). The vessel walls are not too thick, we measured 5-8 µm the double wall. In longitudinal view, the vessels have simple perforated plates and, also, scalariform plates, with few, thin bars (<10). The numerous intervessel pits, of bordered type, are polygonal and have contiguous, alternate arrangements. The pits are mean-sized, between 4-7 µm, and have horizontal elongated apertures. The vessel-ray pits are quite similar, having much reduced borders to apparently simple, often giving an aspect of already scalariform pits. The cross-field pitting is described below. Thin helical thickenings not observed. The mean vessel element length is between 350-800 µm. The mean tangential diameter of vessel lumina is between 50-100 µm. Vessels' density is between 20-40 vessels per square millimeter. Inside the vessels' lumina rare, big, thin-walled tyloses sometimes can be seen.

Vasicentric tracheids – are present, few, showing, on the longitudinal walls, alternate pits to opposite, with elongate apertures, as seemingly scalariform pits, corresponding to vessel pits.

The libriform fibres – constitute the major part of the ground tissue, beside the axial parenchyma. In longitudinal view, show small pits and appear not septate. The axial parenchyma – appear in cross section as long tangential bands 1(2)-seriate, giving to the structure a reticulate aspect. In longitudinal sections, the parenchyma appears as rows of vertical rectangular cells. Often, they are chambered and appear as uniseriate or biseriate long vertical chains of 8-10 hypertrophied chambers, each bearing a singular big polygonal crystal inside.

The rays – are usually 1-3(-6)-seriate. The ray height is usually low to high. The analysis of ray-cellular composition defines rays of heterocellular type: the body ray-cells are procumbent with 1-3(-4) rows of square or procumbent marginal cells, slightly taller. In cross-fields with vessels appear pits in 2-3 superposed horizontal

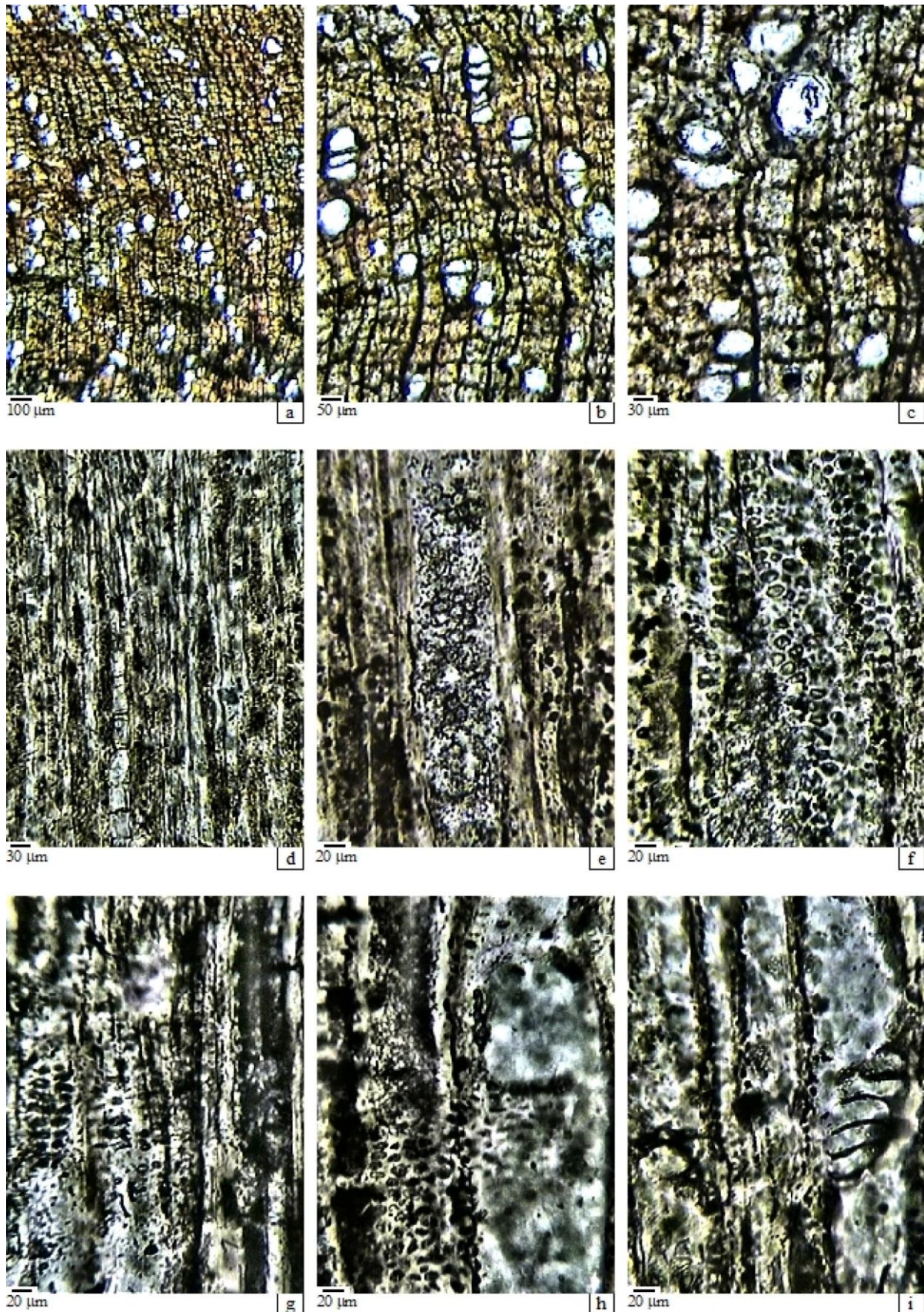


Fig. 8. *Engelhardioxylon lesbium Iamandei et Iamandei sp. nov.* (Specimen Lsv66). **a–c.** Cross section – semi-porous structure, quite distinct growth-rings, reticulate axial parenchyma; **d–f.** Tangential section – alternate intervascular pitting, long vertical chains of crystals, 1-4 seriate rays; **g–i.** Radial section – simple and scalariform perforation plates, pitting on paratracheal parenchyma; cross-fields with 2-3 superposed horizontal rows of pits with horizontally elongated apertures giving a scalariform aspect. **photos a-i** (graphic scale).

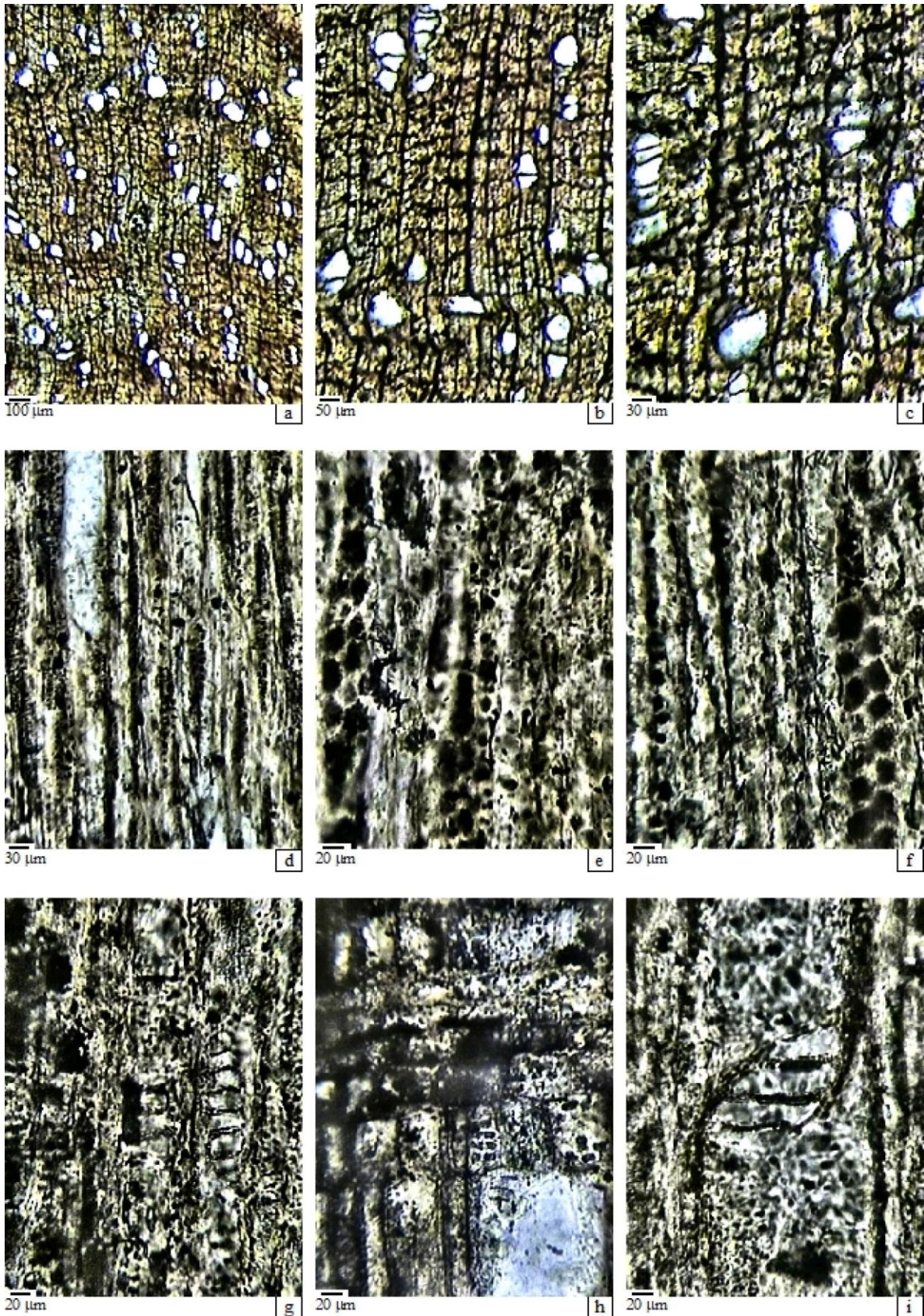


Fig. 9. *Engelhardioxylon lesbiium* Iamandei et Iamandei sp. nov. (Specimen Lsv67). **a–c.** Cross section – semi-ring porous structure, quite distinct growth-rings, reticulate axial parenchyma; **d–f.** Tangential section – alternate intervascular pitting, 1-3(-4) seriate rays; **g–i.** Radial section – long vertical chains of crystals, simple and scalariform perforation plates, pitting on paratracheal parenchyma; cross-fields with 2-3 superposed horizontal rows of pits with horizontally elongated apertures giving a scalariform aspect. **photos a-i** (graphic scale).

rows, having horizontal elongated apertures that give a scalariform aspect. The rays are devoid of sheath cells or of tile cells. The ray density is between 20-25 rays/mm. Storied structures – absent. Secretory elements – as oil/mucilage cells not observed. Cambial variants – as included phloem, not observed. Mineral inclusions – as prismatic big crystals appear in enlarged hypertrophied axial parenchyma chambered cells, in long chains (of 8-10). Sometimes prismatic crystals or crystal sand appear in marginal square ray cells, but also in procumbent ray cells.

Affinities and discussions. From the studied material, we remarked some specimens, showing the juglandaceous structure, with similar features, like the semi-ring-porous structure in cross-section, with axial parenchyma in long tangential bands, giving, in cross-section, a reticulate aspect. Also, in longitudinal view, the axial parenchyma shows long vertical chains of chambers that bear a singular big crystal inside, which is typical for many juglandaceous taxa. But, a very important detail and with taxonomic value, is the presence of simple and scalariform perforations. All the observed details were compared with those presented by Greguss (1954), Manning (1978), Dupéron (1988), Schweingrüber (1990), Schoch et al. (2004), Wheeler et al. (2011) and by Akkemik & Yaman (2012).

The current taxonomy of Juglandaceae family includes the following subfamilies (Manos & Stone, 2001; see also Juglandaceae - Wikipedia - accessed 05.02.2023):

- Subfamily Rhoipteleaceae Reveal (with *Rhoiptelea* Diels & Hand.-Mazz.)
- Subfamily Engelhardioideae Iljinskaya, with 3 genera: *Alfaroa* Standl. (gaulin), *Engelhardia* Lesch. ex Blume (cheo), and *Oreomunnea* Oerst. (guayabo, amarillo, gavián).
- Subfamily Juglandoideae Eaton - Tribe Platycaryeae Nakai (with genus *Platycarya* Siebold & Zucc.).

- Tribe Juglandae Nakai, consisting of two subtribes:
- Subtribe Caryinae Stone & Manos – with 2 genera: *Carya* Nutt. (hickory, pecan) and *Annamocarya* A. Chev. (chinese hickory, beaked hickory).
- Subtribe Juglandinae Stone & Manos – with 3 genera: *Cyclocarya* Iljinsk. (wheel wingnut), *Juglans* L. (walnut), and *Pterocarya* Kunth (wingnut).

Dupéron (1988) presented the specific xylotomical details of the main current juglandaceous genera, specifying the presence or absence of the crystalliferous parenchyma, as well as the thickness of the vascular wall, as the most important discriminating xylotomical details, especially important for the present study, being used for generic identification, as follows:

- *Engelhardia*, *Alfaroa*, and *Oreomunnea* have usually simple and scalariform perforations;
- *Platycarya*, has thin-walled vessels with spirals on the smaller ones; also, some tracheids and axial parenchyma as short bands are present;

- *Carya*, has always thick vascular walls (>3 µm), the axial crystalliferous parenchyma is often present and hosts solitary crystals in some enormous, barrel-like cells, solitary or in short chains of 2-3 and the apotracheal parenchyma appears as continuous bands.

- *Pterocarya*, has thin-walled vessels (<3 µm), short uniseriate parenchyma bands, no crystalliferous parenchyma.

- *Juglans*, from the sections *Trachycaryon* and *Cardiocaryon* (known as Japanese or Manchurian walnut, or Bitternut) have thin-walled vessels (similar to *Pterocarya*) and no crystalliferous parenchyma;

- *Juglans*, from *Dioscaryon* (= *Juglans*) section (with *Juglans regia*, known as English or Persian or Carpathian Walnut and iron walnut = *J. sigillata*) has not very thick-walled vessels (~3 µm) and non-crystalliferous short parenchyma bands.

- *Juglans*, from *Rhysocaryon* section (known as Grey Walnut, Black North-temperate Walnut and Black Tropical Walnut, see *Juglans* - Wikipedia) has types with quite thick-walled vessels and with variations of the crystalliferous parenchyma as long chains of cells bearing more than 5 solitary crystals (Miller, in Dupéron, 1988), and apotracheal parenchyma as long bands.

An inventory and a revision of the fossil form-genera and the form-species previously described were made by Dupéron (1988), who validated and emended them, when necessary. Thus, the following names of Juglandaceous fossil genera, previously used by various authors up to 1988 when paper was lastly revised, were definitively invalidated: *Mirbelites* Unger, *Juglandinium* Unger, *Juglandoxylon* Kraus, *Juglansoxylon* Falqui, *Jugloxylon* Stopes & Fujii, *Caryoxylon* Andreanszky, *Juglans* L., *Carya* Nutt., *Pterocarya* Kunth (cited from Dupéron, 1988).

Taking also into account the papers of Blokhina (2007) and of Sakala & Gryc (2011), the valid juglandaceous fossil genera are the following:

- Fossil wood of *Platycarya* has not still found.
- *Engelhardioxylon* (Manchester) Dupéron, 1988, is a genus that designates wood of Engelhardieae, having scalariform and simple perforations and crystalliferous axial and ray parenchyma; since there is great individual variability of these features, there is no possible to separate the correspondent fossils of the current genera *Engelhardtia*, *Alfaroa* or *Oreomunnea*.

- *Manchesteroxylon* Wheeler et Landon, 1992, represent fossil wood of the Engelhardioideae, which seems to be a primitive juglandaceous taxon with simple and scalariform perforations, ring-porosity and vascular tracheids, possibly similar to the Platycaryoideae (see Blokhina, 2007, p.1042).

- *Clarnoxygen* Manchester et Wheeler, 1993, does not have idioblasts with crystals in parenchyma like *Platycarya*, but has spiral thickenings on vessels, so it is a possible fossil correspondent of the latter (see Wheeler & Manchester, 2002);

- *Pterocaryoxylon* Müller-Stoll et Mädél, 1960, is the fossil equivalent for species of *Pterocarya* and of some species of *Juglans* (Asian species and an American species of Gray Walnut), having thin vascular walls, short and uniseriate parenchyma bands devoid of crystals;

- *Eucaryoxylon* (Müller-Stoll et Mädél) Dupéron, 1988, has porous wood-structure, solitary vessels or short multiples, thick to very thick vascular walls, simple perforations, alternate intervacular pitting rather big, paratracheal and apotracheal banded parenchyma, 1-2(4)-seriate, long and rather regular; crystalliferous parenchyma as large idioblasts with solitary crystals in „barrel-like“ idioblasts, solitary or in short chains of 2-3 cells; rays 1-3(5)-seriate, and septate pith. This morphogenus corresponds to the current *Carya*;

- *Rhysocaryoxylon* Dupéron, 1988 is the fossil equivalent of the current genus *Juglans* and is characterized by porous to semi-ring-porous structure, thick-walled vessels, solitary vessels or in small multiples, simple perforations, intervacular pitting polygonal, alternate, banded apotracheal parenchyma as 1-2(4) seriate bands, long and regular, paratracheal parenchyma less abundant; crystalliferous parenchyma appear as shorter vertical chains, a little bit bigger than the ordinary ones; rays 1-3(5)-seriate, heterogeneous; and septate pith.

Taking into account the above presentation of the most important xylotomical details of the current genera and their fossil correspondents, and also the details observed in our studied specimens which show the typical characters of juglandaceae, we observed a special detail with taxonomic value, i.e. the presence of simple and scalariform perforations with <10 bars, feature which is typical for Engelhardieae, so, it is clear that we face with a species of *Engelhardioxylon* (Manchester) Dupéron, 1988. Also, vascular tracheids like in *Manchesteroxylon* are absent.

The species types described by Manchester (1983) have the typical juglandaceous details, but the holotype, *Engelhardioxylon nutbedensis* Manchester, has „simple and scalariform perforation plates with up to 3 bars; the axial parenchyma arranged in wavy tangential lines (in cross-section), one to two cells wide“. Also, the specimen designed as paratype, *E. texana* Manchester, has „perforation plates simple and scalariform with up to 10 bars, and axial parenchyma in wavy tangential lines one to three cells wide“, features very similar to our studied specimens.

After these discussions and comparisons, we have attributed the studied specimens to a new species, that we named *Engelhardioxylon lesbium* Iamandei & Iamandei, sp. nov., having the xylotomical characters presented above. We designate the specimen Lsv66 as holotype, and specimen Lsv67 as paratype, both having very similar details, especially with the paratype of Manchester (1983).

This is the new species diagnosis: „Vessels with perforation plates simple and scalariform with up to 10

bars; intervessel pitting alternate; vascular tracheids absent; axial parenchyma slightly wavy tangential bands of 1-3 three cells wide in a reticulate arrangement, crystalliferous, as vertical chains of eight chambers bearing a singular big crystal inside; and rays 1-6 seriate, heterocellular, with 1-2(4) marginal upright cells, most probably, crystalliferous. In the cross-fields rays-vessels, simple pits appear, horizontally elongated pits to almost scalariform, in 2-3 superposed horizontal rows“.

Genus *Eucaryoxylon* Müller-Stoll & Mädél, emend. Dupéron, 1988.

***Eucaryoxylon lesbium* Iamandei et Iamandei, sp. nov.**

Fig. 10, photos a-i; Fig.11, photos a-i.

Studied material. Other two samples of silicified wood, collected from early Miocene volcano-sedimentary deposits, of Lesbos Island showed a similar special juglandaceous xylostructure of *Carya* type. They are registered under the field numbers: Lsv1, Lsv6, and kept in the Collections of the Faculty of Geol. & Geoenviron., of NKUA.

Microscopic description. The growth rings – are present, with porous to slightly semi-ring-porous structure, showing quite distinct ring boundaries, marked by a few rows of smaller and flattened cells of ground tissue, at the outer border of the growth ring, suddenly followed by normal ground tissue cells, where larger vessels of early-wood appear. Also, in cross-section, the long tangential bands of axial parenchyma, regularly arranged, give the structure a reticulate aspect.

The vessels – appear, in cross sections, as solitary pores and radial multiples of 2-3(-5), in a radial arrangement between two successive rays, defining a porous to semi-porous structure, in which the thick-walled large vessels of the early-wood are slightly diminishing in size to the late-wood. The solitary vessels are round to oval-shaped, having in the early-wood a lumina size of 70-200 / 50-150 µm the radial / tangential diameter. In the late-wood, the vessels are smaller, of 45-60 / 30-45 µm (r/tg.d). When grouped, the vessels are slightly deformed. Their walls are thick, of 8-12 µm the double wall. In longitudinal view, the vessels show exclusively simple perforation plates and the intervessel pits are numerous, polygonal, of bordered type, small (their mean size of 5-7 µm) and have a contiguous alternate arrangement. The vessel-ray pits are quite similar and have much reduced borders, the cross-fields pits are described below. Helical thickenings in the vessel elements were not observed. The mean tangential diameter of vessel lumina is around 120 µm. Vessels' density is 5-10 vessels per square millimeter. The mean vessel element length is between 300-600 µm. Inside the vessels' lumina rare, big, and relatively thin-walled tyloses sometimes appear.

Tracheids – or vascular fibres or vasicentric tracheids were not observed.

The libriform fibres – represent the major part of the

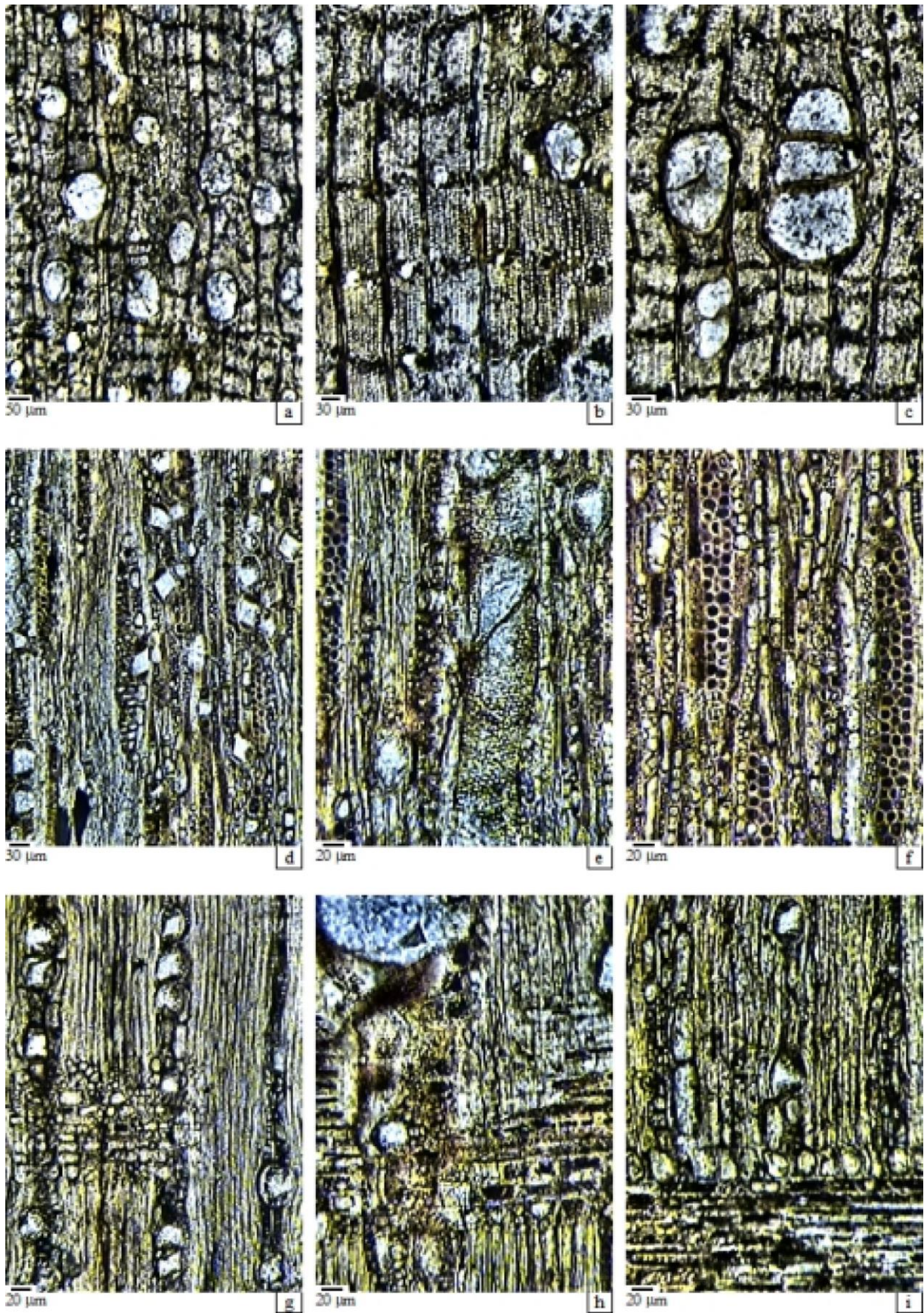


Fig. 10. *Eucaryoxylon lesbium* Iamandei et Iamandei sp. nov. (Specimen Lsv1). **a–c.** Cross section – semi-ring porous structure, quite indistinct growth-rings, reticulate axial parenchyma; **d–f.** Tangential section –, solitary or short vertical chains of crystals (2-2-3), 1-3 seriate rays; **g–i.** Radial section – simple perforations, solitary or short vertical chains of crystals; heterocellular rays with crystalliferous marginal cells. **photos a-i** (graphic scale).

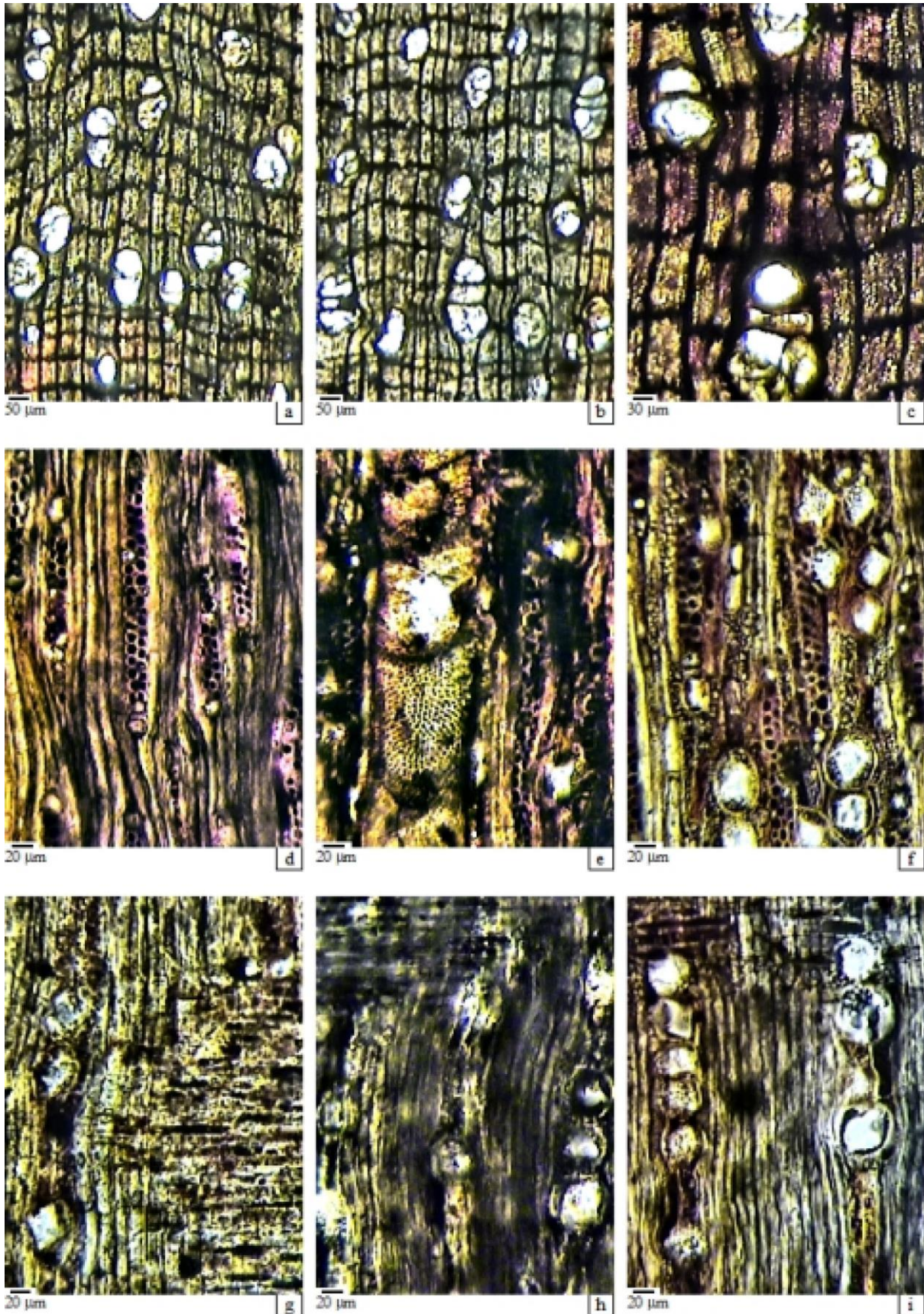


Fig. 11. *Eucaryoxylon lesbiium* Iamandei et Iamandei sp. nov. (Specimen Lsv6). **a–c.** Cross section – semi-ring porous structure, quite indistinct growth-rings, reticulate axial parenchyma; **d–f.** Tangential section –, solitary or short vertical chains of 2-3 huge crystals, 1-3 seriate rays; **g–i.** Radial section – simple perforations, solitary or short vertical chains of 2-3(4) huge crystals; heterocellular rays with marginal cells, sometimes, crystalliferous. **photos a-i** (graphic scale).

ground tissue and appear minutely pitted and not septate. The axial parenchyma – is present in cross-section, paratracheal fewer, apotracheal more, as long tangential 1-3-seriate bands, quite regularly arranged giving a reticulate aspect. In longitudinal section the parenchyma can be recognized as vertical rows of rectangular cells. Sometimes some cells are chambered, hypertrophied and crystalliferous, appearing as huge solitary and/or in short chains of 2-3 enormous barrel-like cells (rarely more: 4 in Lsv6), bearing a singular big polygonal crystal inside.

The rays – appear as fine rays, usually 1-3(-4) seriate. The ray height is usually low to high, sometimes of more than 30 cells. The ray density is between 8-12 rays/mm tangential. As cellular composition, in radial view, the rays are of heterocellular type: the body ray cells are all procumbent, having 1-2 row of upright and/or square marginal cells which have a white or dark content and, sometimes, crystalliferous. In cross-fields with vessels, small polygonal rounded pits, in 1-2 horizontal rows, often not visible due to presence of dark content, or poor preservation.

Storied structures are absent. Secretory elements seem to be absent. Mineral inclusions – appear as large prismatic crystals, solitary or in short vertical chains of 2-3(-4), as a single big crystal inside an enlarged cell (or chamber of axial parenchyma cell). Also, as noted above, crystal sand appears in rays, especially in the upright and/or square marginal ray cells.

Affinities and discussions. From the numerous petrified wood remains with Juglandaceous affinities, studied here, two specimens showed a special xylostructure, showing thick-walled vessels, with exclusively simple perforations and numerous alternate bordered pits; with banded and crystalliferous parenchyma in a reticulate arrangement, vasicentric less; vertically, the axial parenchyma appear as solitary cells or short chains of 2-3 enlarged chambers, each bearing a single big crystal inside.

Thus, the xylotomy of the studied specimens is comparable with that of the current *Carya* Nutt. (known as hickory, or pecan) which has also, besides the typical juglandaceous xylotomy with thick-walled vessels, the apotracheal parenchyma as long continuous bands in cross section and, the crystalliferous parenchyma appears with big solitary crystals in some enormous „barrel-like“ solitary cells which, in vertical view, appear solitary or in short chains of 2-3.

The fossil correspondent of the current *Carya* Nutt. is *Eucaryoxylon* (Müller-Stoll et Mädler) Dupéron, 1988. Its emended diagnosis shows that „the wood-structure is porous, with solitary vessels or short multiples, with thick to very thick walls, has simple perforations, alternate intervascular pitting rather big, paratracheal and apotracheal banded parenchyma, 1-2(4)-seriate, long and rather regular; has crystalliferous parenchyma as large idioblasts, with solitary crystals in such barrel-like idioblasts, which appear isolated or in short vertical

chains of 2-3 cells; has rays 1-3(5)-seriate, and septate pith“.

This discussion and the critical overview of the features of our studied specimens strongly suggest that we are facing to a *Eucaryoxylon* species, since the observed details are perfectly consistent with the generic diagnosis, especially by the presence of the enormous crystalliferous cells, barrel-like (see Dupéron, 1988, citing Manning, 1978).

Comparing the xylotomy of our studied specimens with some valid fossil species described till now, as: *Eucaryoxylon boureaui* Dupéron, 1977; *E. budense* Greguss, 1969; *E. crystallophorum* Müller-Stoll et Mädler, 1960; *E. guembelii* Müller-Stoll et Mädler, 1983; *E. moenanum* Müller-Stoll et Mädler, 1983; *E. protojaponicum* (Watari) Müller-Stoll et Mädler, 1960 and *E. zarandense* Iamandei et Iamandei, 2002, we observed many similar features, but not identical. Thus, the here studied specimens show some specific features as follows: semi-ring-porous structure with thick-walled vessels, solitary or in short radial multiples of 2-3(-5), with perforations exclusively simple and intervessel pitting alternate; long banded parenchyma with a reticulate arrangement, crystalliferous, as solitary or short vertical chains of 2-3(-5) enlarged chambers with big crystals; rays 1-3(-4) seriate, heterocellular, with 1-2 rows of square or upright marginal cells with crystal-sand.

All these xylotomical features, described in the studied specimens, compared with previous studied species, allow us to define a new species that we name *Eucaryoxylon lesbium* Iamandei et Iamandei, sp. nov., after the name of the provenance place (Lesbos Island). It could be a possible ancestor of some disappeared types of *Carya*, that lived, during the Cenozoic time in Europe, as shown by the identifications of Dupéron (1977), Greguss (1969), Müller-Stoll & Mädler (1960, 1983), Iamandei & Iamandei (2002).

So, we designate the specimen Lsv1 as holotype and, the specimen Lsv6 as paratype, and this is the diagnosis of the new species: “Growth rings present, with porous to semi-ring-porous structure and with long tangential bands of axial parenchyma giving a reticulate aspect; vessels are solitary or in short radial multiples of 2-3(-5), thick-walled, circular to oval, 50-150 µm tg.d., 5-10(-20) vessels on sq. mm; exclusively simple perforations plates, alternate intervascular pitting; parenchyma banded reticulate, with solitary or vertical chains of 2-3 enormous crystals; rays 1-3(-4) seriate, heterocellular, with 1-2 rows of square or upright marginal cells sometimes crystalliferous; cross field small, few simple pits, in 1-2 rows”.

Genus *Rhysocaryoxylon* Dupéron, 1988

Rhysocaryoxylon madsenii Sakala et Gryc, 2011

Fig. 12, photos a-i.

Studied material. A similar special juglandaceous xylostructure of *Juglans* type was observed in 33 samples of petrified wood, collected from early Miocene volcano-sedimentary deposits, of Limnos and Lesbos Islands. They are registered and kept in the Collections of the Faculty of Geol. & Geoenviron. of NKUA, under these field numbers: Li192, Li277; and from Lesvos Island: Lsv10, Lsv11, Lsv12, Lsv15, Lsv 19, Lsv25, Lsv49, Lsv58, Lsv62, Lsv69, Lsv76, Lsv79, Lsv81, Lsv84, Lsv86, Lsv94, Lsv102, Lsv104, Lsv110, Lsv350, Lsv382, Lsv383, Lsv384, Lsv396, Lsv397, Lsv416? Lsv423, Lsv430, Lsv446, Lsv452 Lsv544?.

Microscopic description. Growth rings – present, with quite indistinct ring boundaries, poorly marked by a few rows of smaller and flattened cells of ground tissue as final wood, which are suddenly followed by larger normal cells of the early wood, where larger vessels also appear. However, in some specimens, such a sudden passage from late-wood to early-wood is often poorly preserved and so, the ring boundary is less distinct.

The vessels – usually thick-walled, are so arranged that define a wood structure with porosity sometimes of diffuse porous type, but most usually of semi-ring porous type, since larger vessels appear in the early wood, gradually diminishing in the late wood. Between two successive rays they appear in radial pattern arranged, but in all the structure with multiple neighbor fascicles, a diagonal pattern is visible. The vessels appear chiefly solitary (60-90%) and in radial multiples of 2-3(-5) vessels. The large solitary vessels have the lumina size of 60-150 / 45-90 μm the radial / tangential diameter, diminishing to 15-50 / 10-36 μm in the late-wood. Their shape is round to radial oval, often more or less deformed, and has a wall thickness of 7-10 μm the double wall. In the longitudinal view, the vessels show exclusively simple perforation plates. The intervessel pits - are polygonal of bordered type and have a contiguous, alternate arrangement, sometimes opposite to subopposite. The pits are polygonal and mean-sized, of around 10-12 μm in diameter. The vessel-ray pits are similar to intervessel pits, having much reduced borders. The cross-field pits, usually difficult to observe due to poor preservation, are described below. Thin helical thickenings in vessel elements sometimes appear (Lsv15, Lsv62). Tyloses inside the vessels' lumina rarely were seen but, usually, a blurry brown to dark content is present. The mean tangential diameter of vessel lumina is around 70 μm . Vessels' density is between 20 - 40 vessels/ mm^2 . The mean vessel element length is between 300-800 μm .

Tracheids – vascular fibres or vasicentric tracheids were not observed.

The fibers – represent the major part of ground tissue, and the vertical walls seem to have small bordered pits. Sometimes, they are septate.

The axial parenchyma – in cross-section, appears paratracheal few, but usually apotracheal banded, visible as long tangential bands 1-3-seriate, in a reticulate

arrangement. In the longitudinal view, the parenchyma appears as rows of vertical rectangular cells. Some parenchyma cells are chambered and crystalliferous, with a single big prismatic crystal in each chamber, visible in the longitudinal sections as long vertical chains of 8-11(15) successive chambers.

The rays – are present as fine rays, usually 1-3 seriate, low to high. The analysis of ray-cellular composition defines rays of heterocellular type, since the body ray cells are all procumbent, with 1(-2) rows of upright and/or square marginal cells, which sometimes have polygonal-rounded big crystals inside and also, dark content. In cross-fields with vessels, small quadrangular to elliptic horizontal elongate simple pits, more numerous in the marginal cross fields, as superposed pairs are often poorly visible because of the dark content or of numerous crystals, or simply, of bad preservation. Sheath cells or tile cells, in rays, are not present. The ray density is between 4-12 rays/ mm .

Storied structures – absent. Secretory elements – as oil/mucilage cells absent. Intercellular canals – absent. Cambial variants – as included phloem, absent. Mineral inclusions – prismatic crystals appear in chambered axial parenchyma cells often as long series and this is a special diagnostic character: the presence of big crystals in enlarged chambered cells, in long chains of 8-11 or more large crystals. Also, small prismatic crystals or crystal sand could appear in ray cells, in upright and / or square ray cells, but also in procumbent ray cells.

Affinities and discussions. From the studied petrified wood remains to show juglandaceous structure we remarked some of them with similar features, showing a diffuse porous structure in cross-section, and the axial parenchyma which appears in cross-section as long tangential bands 1-3-seriate, in a reticulate arrangement and longitudinal view, as chambered and crystalliferous parenchyma, with long vertical chains of 8-11 hypertrophied chambers with a singular crystal inside. Other details, like the size and arrangement of the vessels, in cross-section, with exclusively simple perforations and numerous alternate bordered pits, in vertical view, are typical for the juglandaceous wood, as is presented in Greguss (1954), Dupéron (1988), Schweingrüber (1990), Schoch et al. (2004), Wheeler et al. (2011) and Akkemik & Yaman (2012).

Thin helical thickenings in the vessel elements, sometimes, are present. Taking into account the discussions at the above-identified species, especially on the specific xylotomical details of the main extant juglandaceous genera, as summarized by Dupéron (1988), who discussed the presence or absence of the crystalliferous parenchyma, as well as the thickness of the vascular wall, we observe the possible similitude of the xylotomy of our specimens with the current species of *Juglans* L., most probably of Black Tropical Walnut type, which have quite thick-walled vessels and present variations of the crystalliferous parenchyma that could appear as long vertical chains of chambers (more than 5),



Fig. 12. *Rhysoxylon madsenii* Sakala et Gryc, 2011. (Specimen Lsv446). **a–c.** Cross section – semi-ring porous structure, quite indistinct growth-rings, reticulate axial parenchyma; **d–f.** Tangential section – long vertical chains of big crystals (>5), 1-3 seriate rays; **g–i.** Radial section – simple perforations, long vertical chains of (>5) big crystals; heterocellular rays with upright marginal cells crystalliferous. **photos a–i** (graphic scale).

bearing solitary crystals and apotracheal parenchyma as long tangential bands (see Dupéron, 1988), similar to our fossil specimens.

Blokhina (2007), doing a new revision of the knowledge on Juglandaceous xylotomy and palaeoxylotomy, presented some questions on taxonomy, evolution and phylogeny of this group and gave a key of identification of wood anatomy of modern and fossil Juglandaceae. Using this key, but also the other information from the paper, it is clear that „a wood structure with diffuse or semi-ring-porous structure, crystals in axial parenchyma and thin to thick-walled vessels“ define a *Rhysocaryoxylon* structure, completed by „solitary vessels or in radial multiples, vessel-ray and vessel-parenchyma pits with significantly reduced borders and large apertures, apotracheal parenchyma in bands of 1–2(4) cells wide, and rays are 1-3(5) - seriate, homocellular to slightly heterocellular, with or without crystals“.

Originally, juglandaceous fossil wood was described as *Juglandinium schenki* Felix, 1884, revised later as *Caryojuglandoxylon schenkii* (Felix) Müller-Stoll & Mädler, 1960. Later, it was revised again as *Rhysocaryoxylon schenkii* (Felix) Dupéron, 1988, and it was designated as a type-species for the genus *Rhysocaryoxylon* Dupéron, 1988.

But, in 2011, describing a new species of *Rhysocaryoxylon*, Sakala & Gryc (2011), suggested that is necessary to be prepared a proposal for TAXON (the Journal of the IAPT), to conserve the name *Rhysocaryoxylon* against *Caryojuglandoxylon* and this, because of the presence in these xylostructures of crystalliferous idioblasts similar to *Carya* type, but more numerous, and because of the presence of smaller vessels and narrower rays tending to be uniseriate in the majority, features that do not correspond to the accepted diagnosis based on the type-species *Rhysocaryoxylon schenkii* (Felix) Dupéron.

However, using the generic key for juglandaceous fossil wood of Dupéron (1988), we observe that the affinity of our studied specimens with *Rhysocaryoxylon* genus is valid, especially by the aspect of the crystalliferous axial parenchyma in cross sections and the longitudinal ones. Thus, Dupéron (1988) characterized this genus like this: „porous to semi-ring-porous structure with thick-walled vessels, solitary or in small multiples, having simple perforations and intervascular pitting polygonal, alternately arranged; by banded apotracheal parenchyma, as 1-2(4) seriate bands, long, regular, paratracheal less abundant and, in longitudinal view obviously crystalliferous appearing as vertical chains of cells a little bit bigger than the ordinary ones; also, by rays 1-3(5)-seriate and heterogeneous and septate pith“, features that appear in our here studied specimens too.

We compared the described features of our specimens with other European species already described as: *Rhysocaryoxylon schenkii* (Felix) Dupéron, 1988; *R. triebelii* (Caspary) Dupéron, 1988; *R. fryxellii* (Prakash & Barghoorn) Dupéron, 1988; *R. caucasicum*

(Gaivoronsky) Dupéron, 1988; *R. tertiarum* (Prakash & Barghoorn) Dupéron, 1988; *Rhysocaryoxylon pilinyense* (Greguss) Dupéron, 1988; *R. pravalense* Iamandei & Iamandei, 2002; *R. ocii* Iamandei & Iamandei, 2002; *R. transylvanicum* Iamandei & Iamandei, 2003 (and in Iamandei et al., 2013), and *R. madsenii* Sakala et Gryc, 2011, also described by us from Rhodopes, Bulgaria (Iamandei et al., 2016). Almost all these cited taxa were considered to represent fossil equivalents of Black Tropical Walnuts, having parenchyma with vertical chains that are longer than 5 successive crystalliferous chambers, like in our specimens. Only *R. transylvanicum* seems to be similar to *J. nigra*, a species of Black Temperate Walnuts type (Iamandei & Iamandei, 2003; Iamandei et al., 2013), having short vertical chains of no more than 5 chambers with solitary crystals, so this type is different of the here studied specimens.

However we found a very close similarity, up to identity with the species described by Sakala & Gryc (2011) from Czech Rep., and by us from Rhodopes Mts., as having semi-ring-porous structure, indistinct ring boundary, thick-walled vessels, with simple perforations and alternate pitting; banded and reticulate, typically crystalliferous parenchyma, with long vertical chains of more than 5 barrel-like cells with large, solitary crystals; rays 1-3(5)-seriate, heterocellular rays with 1-4 marginal crystalliferous cells. Accordingly, based on the similarities listed above, we assign our specimens described here, to the species *Rhysocaryoxylon madsenii* Sakala et Gryc, 2011, representing a fossil correspondent of the Black Tropical Walnut type.

***Rhysocaryoxylon* sp. aff. *Juglans regia* L.**

Fig. 13, photos a-i

Studied material. Other 21 samples of silicified wood, collected from Evros, from late Oligocene to early Miocene volcano-sedimentary deposits, showed a special juglandaceous xylostructure of *Juglans* type, marked by the presence of non-crystalliferous axial parenchyma. They are kept in the Collections of the Faculty of Geol. & Geoenviron. of NKUA, registered under these field numbers: Spp32, Spp34, Spp1074, Spp1075, Spp1076, Spp1078, Spp1079, Spp1080, Spp1082, Spp1083, Spp1084, Spp1085, Spp1086, Spp1087-32, Spp1088, Spp1089, Spp1090, Spp1091, Spp1091-31, Spp1092, Spp1093, Spp1094, Spp1098, Spp1100, Spp1101, Spp1102, Spp1104, Spp1105; Spp1106, Spp1107, collected from Sappes; one more, Lgn167, collected from Lagyna; and two collected from Trifili, Tf12, Tf13.

Microscopic description. The growth rings – in cross-section appear with diffuse-porous to semi-porous aspects with less distinct ring boundaries, marked by a few smaller and slightly flattened ground-tissue cells of final wood, suddenly followed by the early-wood with normal sized ground tissue cells, where the larger vessels of the early-wood also appear. And, is to be remarked that, in cross-section, the rays often have a very undulate

trajectory and the axial parenchyma is few, is non-crystalliferous and, sometimes, appears as short, discontinuous, tangential bands.

The vessels – appear solitary or in small radial groups, defining a wood of diffuse-porous to semi-ring-porous type of structure, represented by quasi-equally-sized vessels in all the growth-ring, sometimes slightly diminishing in the late-wood. Vessels' arrangement shows a radial pattern between two successive rays, but show a diagonal aspect in multiple neighboring interradian bundles. They appear commonly solitary (60% or more) and/or grouped in radial multiples of 2-4(-6). The shape of the solitary vessels is rounded or radial oval, slightly deformed when grouped. The solitary vessels have the lumina size of 75-150 / 50-100 μm the radial / tangential diameter, (decreasing to 30-60 / 20-50 μm in the late-wood). The vessel wall is not too thick, we measured 6-8 μm the double wall. In the longitudinal view, the vessels show exclusively simple perforated plates. The numerous intervessel pits of bordered type are contiguous and alternately arranged. The pits are mean-sized, of 8-10 μm diameter. The vessel-ray pits are similar, have much-reduced borders, and are smaller sized, corresponding to the cross-field pitting, described below. Helical thickenings in the vessel elements are not present. The mean tangential diameter of vessel lumina is around 85 μm . Vessels' density up to 20 vessels per sq. mm. or more, counting all the vessels as IAWA recommended (see Wheeler et al., 1989). The mean vessel element length is between of 350-500 μm , or more. Also, inside the vessels' lumina, sometimes, thin-walled tyloses and dark content can be seen. Tracheids – or vascular fibres or vasicentric tracheids usually absent. The fibres – not very thick-walled, represent the major part of ground tissue, are minutely bordered pitted on the vertical walls, and are not septate, but difficult to observe, due to poor preservation.

The axial parenchyma – in cross section appears few, as apotracheal, diffuse among fibres or as narrow (1-2-seriate), short or discontinuous tangential bands, not crystalliferous and, also, few paratracheal appear.

The rays – after their width are fine rays, usually 1-2(-3)-seriate and have often an undulate trajectory. The ray height is usually low to high. The analysis of ray-cellular composition shows rays of homocellular type, slightly tending to heterocellular: the body ray-cells are all procumbent and have 1-2 rows of square or procumbent marginal cells, slightly taller. In cross-fields with vessels, appear pits with much-reduced borders to almost simple, are polygonal and mean-sized, alternately arranged, in 2-3 superposed rows in taller cross-fields. But often they are less visible, because of dark content or poor preservation. The rays are devoid of sheath-cells or of tile-cells. The ray density is between 10-13 rays/mm.

Storied structures – absent. Secretory elements – as oil/mucilage cells absent. Intercellular canals – not present. Cambial variants – as included phloem not

observed. Mineral inclusions – are absent.

Affinities and discussions. A large number of specimens from the studied material showed a similar juglandaceous structure of *Rhysocaryoxylon* type, but slightly different from the above-described species, grouped here as having, in cross-section, a diffuse porous to semi-porous structure; with non-crystalliferous axial parenchyma few, diffuse among fibres or as narrow, short and discontinuous tangential, fine bands, but not in a reticulate arrangement. These features, besides the arrangement and size of the vessels in cross-section, as well as exclusively simple perforations and alternate bordered pits on vertical walls, could have a taxonomic value, as presented by Greguss (1954), Dupéron (1988), Schweingrüber (1990), Schoch et al. (2004), Wheeler et al. (2011) and Akkemik & Yaman (2012).

More details are presented above, at the identified species, regarding to the xylotomical features of the main current and fossil juglandaceous valid genera, as summarized by Dupéron (1988), Blokhina (2007) and Sakala & Gryc (2011). These authors discussed, especially, the presence or absence of the crystalliferous parenchyma in the structure, as well as the thickness of the vascular wall.

Thus, we observe the here studied specimens possible similarities of the xylotomy with the current species of *Juglans* L. The species *Juglans nigra* L., known as „Black North-temperate Walnut“ - which has crystalliferous parenchyma, as short vertical chains of no more than 5 chambers with solitary crystals, so it is different from the here studied specimens. The species *Juglans regia* L., (also known Gray Walnut, Persian walnut, Madeira walnut, Carpathian walnut, English walnut or common walnut), has a xylotomy more similar to our studied specimens. It is native to southeast Europe to central Asia, a region stretching from the Balkans eastward to the Himalayas and southwest China (*Juglans regia* - Wikipedia - accessed 05.02.2023).

The correspondent fossil genus, *Rhysocaryoxylon* Dupéron, 1988 includes in its diagnosis, the porous to semi-ring-porous structure, thick-walled vessels with simple perforations and intervascular pitting polygonal, alternate. The parenchyma apotracheal few, diffuse among the fibres or as narrow discontinuous bands is usually not crystalliferous and the rays are 1-3(5)-seriate and heterogeneous.

Considering the details observed in here studied specimens, as the diffuse-porous to semi-porous structure in cross-section, the non-crystalliferous axial parenchyma few, diffuse among the fibres, or as narrow, short and discontinuous tangential, fine bands, but not in a reticulate arrangement well as the comparison with other described European fossil species, we decided to assign them to *Rhysocaryoxylon* sp. aff. *Juglans regia* L., probably representing a fossil correspondent of the current *Juglans regia* L. (i.e. Gray Walnut), a native mediterranean species, still living in this region, from

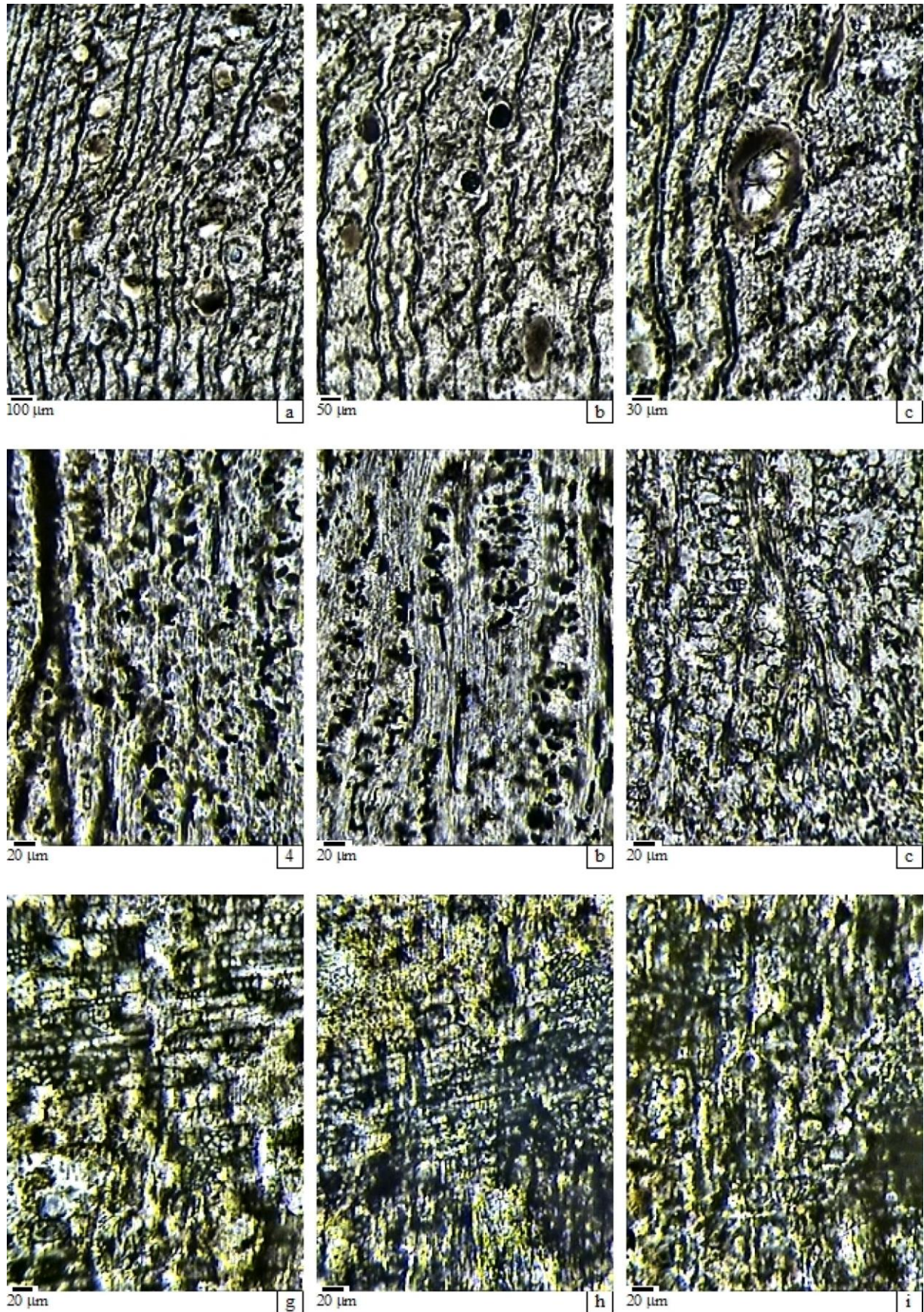


Fig. 13. *Rhysocaryoxylon* sp. aff. *Juglans regia* L. (Specimen Spp1105). **a–c.** Cross section – semi-ring porous structure, quite indistinct growth-rings, parenchyma diffuse or as short or discontinuous tangential bands; **d–f.** Tangential section – 1-3(4) seriate rays; **g–i.** Radial section – simple perforations; heterocellular rays with 1-2 square or upright marginal cells; pitting in cross fields. **photos a-i** (graphic scale).

Balkans, eastward, to Himalaya.

CONCLUSIONS

This paper is a new part of the xylotomic study of „Velitzelos Collection“ of petrified woods from the Aegean area, Greece, a public collection registered and kept in the „Collections of the Faculty of Geology and Geoenvironment“, of the National and Kapodistrian University of Athens. In this study, fossil dicot remains were selected and studied representing 237 samples collected from the continental part (Evros area), as well as from the island part of Greece (Lesbos Island and Limnos Island), from late Oligocene and early Miocene deposits. From those samples, 9 species were identified (two as new species), showing possible affinity for some current species. The identified taxa are listed below:

1. *Laurinoxylon* aff. *czechense* Prakash, Březinová et Bůžek, 1971 – a *Laurinoxylon* of type 1 (Mantzouka et al., 2016), as fossil equivalent of the current *Laurus nobilis* L., a species still living in the Mediterranean region.

2. *L. ehrendorferi* Berger, 1953a – a *Laurinoxylon* of type 2a (Mantzouka et al., 2016), as fossil equivalent of the current *Persea* L., a species that probably lived in the Mediterranean region during Cenozoic (see Kopp, 1966; *Persea* - Wikipedia, accessed 10.31.2023).

3. *Cinnamomoxylon seemannianum* (Mädel) Gottwald, 1997 – a *Laurinoxylon* of type 3 (Mantzouka et al., 2016), as fossil equivalent of the current *Cinnamomum* Schaeff.

4. *Populoxylon* sp. (cf. *Populus alba* L.) – as fossil equivalent of the current *Populus tremula* L. - having an almost identical xylotomic structure, with axial parenchyma few, marginal and scanty diffuse.

5. *Quercoxylon intermedium* Petrescu & Velitzelos, 1981 – as possible fossil equivalent of the current species from *Ilex* or *Cerris* sections, i.e. with *Quercus ilex* L., or, possibly *Q. cerris* L., both characterized by semi ring-porous structure with vessels quasi-radially arranged, gradually diminishing to the late-wood, with two-sized rays, the broad ones as compact-compound and/or aggregate rays, and with cross-field pits „in palisade“. They probably had evergreen type foliage, also found in fossil and described as *Eotrigonobalanus furcinervis* (Roosm.) Walther et Kvacek, 1989, as is mentioned in some previous studies on the Greek oak fossil wood (see Selmeier & Velitzelos, 2000; Velitzelos et al., 1999; 2008).

6. *Engelhardioxylon lesbium* Iamandei et Iamandei sp. nov. – as fossil equivalent of the current species of Engelhardieae, showing axial parenchyma reticulate in cross section and long vertical chains of chambers bearing a singular big crystal inside, and, sometimes, with scalariform perforations on vessels (see Dupéron, 1988).

7. *Eucaryoxylon lesbium* Iamandei et Iamandei sp.

nov. – as fossil equivalent of the current xylotomy of the studied specimens is comparable with *Carya* Nutt., having thick-walled vessels and solitary crystals in some enormous, barrel-like parenchyma cells, solitary or in short chains of 2-3.

8. *Rhysocaryoxylon madsenii* Sakala & Gryc, 2011 – as fossil correspondent of a current tropical type of *Juglans*, known as Black Tropical Walnut, having axial parenchyma as discontinuous bands in cross-section, in reticulate arrangement and long vertical chains of big crystals.

9. *Rhysocaryoxylon* sp. aff. *Juglans regia* L. – as fossil equivalent of a current common walnut species, known as *Juglans regia* L., a Black North-temperate Walnut species still living in this region, characterized by non-crystalliferous axial parenchyma, usually diffuse in cross-section or as narrow, short, discontinuous tangential bands.

Certainly, we have considered that the Cenozoic fossil tree taxa should be the ancestors of the current species living in the same area, but some of them may be extinct, at least from the studied area. Anyway, the numerous fossil plant remains from the Aegean Area strongly suggest that during the Cenozoic time these regions evolved as highly forested lands, and the fossil plant associations already described so far strongly support this theory. The synthesis of Velitzelos et al. (2014) suggests a succession of mixed mesophytic forests that lived in a subtropical palaeoclimate to warm-temperate and humid, strongly influenced by the neighboring of the sea, within the Aegean area.

As was shortly presented in the introductory chapter of the first part of this study (Velitzelos et al., 2019), and more detailed in Velitzelos et al. (2014), all the emerged regions were covered by extended forests of conifers, of arboreal dicotyledons as Laurales, Fabales, Myrtales and monocotyledons, especially Arecales, as we have described and discussed in the first and the second part of our study (Velitzelos et al., 2019; Iamandei et al., 2022), but also here, in the third part.

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