New petrified woods from Căprioara Valley, Feleacu Hill, Cluj-Napoca, Romania

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Abstract: This paper presents the palaeoxylotomical study of some lignofossils collected from Căprioara valley, Feleacu Hill area, close to Cluj-Napoca, Romania, from a sedimentary formation of Early Sarmatian age, as indicated by the mollusks and foraminifers associations. From that area, a small Early Sarmatian Flora – known as "Feleacu Flora" – with species of *Pinus, Sequoia, Quercus, Daphnogene*, *Platanus, Engelhardia, Phragmites*, and *Cyperites*, was previously described. The new identified lignotaxa, as morphospecies of *Chamaecyparixylon, Sequoioxylon, Cinnamomoxylon, Rhysocaryoxylon,* and *Quercoxylon* confirm and complete the knowledge on Feleacu Flora, indicating also a mesophytic forested riverside and a warm temperate climate, thus making possible better paleoenvironmental and palaeoclimatic reconstructions.

Keywords: Early Sarmatian, Feleacu Flora, petrified wood, palaeoclimatic significance

1 Introduction

A new collection of petrified woods coming from the area of Feleacu Hill (Fig. 1), close to Cluj-Napoca, Romania, was submitted to paleoxylotomical study in order to identify the original trees. The fossils were collected, partially by Iustinian Petrescu and Mircea Nicorici, and partially by Mirela Dumitrescu-Sabou, and are kept in the collection of the Geological Museum of the Faculty of Biology and Geology, Babeş-Bolyai University (UBB) of Cluj-Napoca.

As it is well known, at least in the south-western part of Feleacu Hill, the Early Sarmatian sediments present a littoral-neritic facies, being constituted of marly to sandy clays with intercalations of sands or sandstones with concretions, sometimes with pebble levels, overlaying the terminal Badenian sediments, probably after a gap of sedimentation (Givulescu, 1997).

The age of those sedimentary deposits is given by a brackish mollusk fauna, the list, revised by Givulescu (1997), indicating the Early Sarmatian: *Irus (Papirus) gregarius gregarius, Cerastoderma vindobonense vindobonense, Gibula (Rolandiana) picta, Gibula (Gibula) pusilla, Pirenella picta picta, Cerithium (Thericium) rubiginosum rubiginosum*.

In addition, fish remains and brackish foraminifers (Popescu, 1995) have also been described from that area. Suciu (2005a, b) made an areal study on the sedimentary rocks from around Cluj-Napoca, including Iris and Feleacu hills and the top of Lombi hill, which consist of already known Badenian and Sarmatian deposits (see Răileanu, 1955, 1959; Moisescu & Popescu, 1967; Mészáros & Clichici, 1988, Filipescu, S., 1999).

On the geological map edited in 1968 by the Geological Institute of Romania, at the scale 1:200,000, Cluj sheet (Răileanu & al., 1968), the Sarmatian deposits were assigned to the "Buglovian", as Earliest Sarmatian, and to Volhynian-Basarabian, but without reliable arguments. Based on biostratigraphical evidence (i.e. micropalaeontological content), the age of Miocene sediments from Transylvania was documented by Popescu (1995, 2000), Filipescu et al. (2005, 2008), Krézsek and Filipescu (2005) and Tóth et al. (2010).

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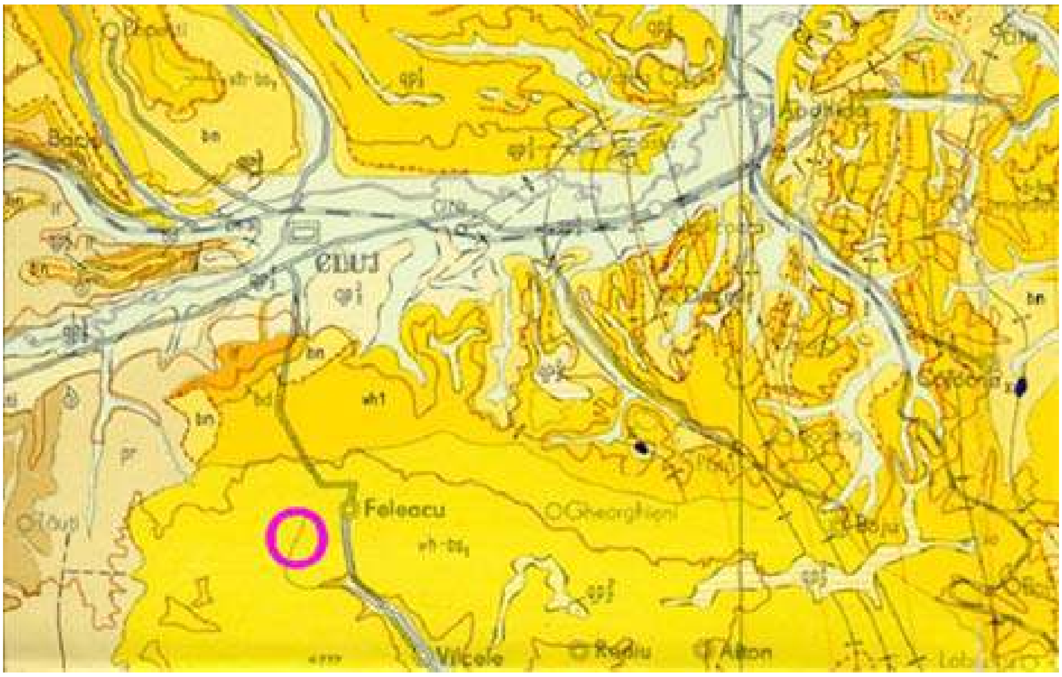

Fig. 1. Location of Căprioara Valley fossiliferous area (marked with red circle), on Cluj-Feleacu map. Excerpt of IGR Geological map 1:200000, Cluj sheet.

Nanno -zone	Chronostrati-graphical Units		Lithostratigraphical Units from NW of Transylvania Depression (Filipescu et al 1999)		Regional Biostratigraphic Units (Foraminifera biozones) Popescu, 1995, 2000)	
NN9 NN8 12	Pannonian s.s.		Lopadea formation / Gușterița formation		*Ammonia* acme (+ostracods) rare foraminifers	
NN7	Sarmatian	Basarabian	Feleac formation	Dobârca formation	*Porosononion aragviensis*	
					Dogielina sarmatica	*
		Volhinian	Iris formation		*Schakoinella imperatoria* *Elphidium reginum*	*Articulina sarmatica* * *
					Varidentella reussi	
13					*Anomalinoides dividens*	
NN6	Badenian		Mireș formation / Pietroasa formation		*Valpertina*	

Fig. 2. Late Mid-Miocene – Early Late-Miocene litho-biostratigraphic column in Transylvanian Basin, Cluj-Napoca area (modified after Suciu, 2005). * - plant remains, including fossil wood.

Around Cluj-Napoca, on Feleacu hill, some foraminifer assemblages were identified (Fig. 2): the Biozone with *Elphidium reginum,* representing the Late Volhynian and the Biozone with *Dogielina sarmatica,* representing the Early Basarabian (=Feleac Formation). These Elphidiids associations are typical for littoral facies and the association of the Rotaliids with the red algae thalli indicates brackish shallow waters, agitated, probably in an intertidal area. The sandy sediments with carbonate mud interlayers at several levels also suggest a littoral environment (Suciu, 2005a, b).

From the study site in Căprioara valley, located in the southwestern part of Feleacu Hill (Fig. 1), in some littoral-neritic sediments considered Early Sarmatian in age, Suciu (2005a, b) reported *Laevigatisporites haardti* (Polypodiaceae spores), and pollen of Taxodiaceae, of *Pinus, Abies, Tsuga, Picea* and *Ulmus, Carya, Pterocarya, Engelhardia, Betula, Quercus, Myrica, Alnus,* which indicate a mesophitic vegetation of warm temperate climate characterized by a mean annual temperatures (MAT) of 15°-19°C, and variable precipitations.

At Feleacu Hill, from the mentioned Sarmatian formation, Staub (1883, 1891) and Szadeczky (1917) described some vegetal taxa from levels with plants remains as leaf or fruit imprints. These have been completed and revised by Givulescu (1997). These older fossiliferous sites could be not identified during our study. Givulescu (1997) mentioned that he collected fossil material, in the course of time, from some small stone quarries located along the road Cluj Napoca – Turda, difficult to identify nowadays. Anyway, all the taxa previously described were revised by Givulescu (1997), resulting in a list of a small mixed flora – named by him “Feleacu flora”.

This flora contains:

Cystoseirites partschi Sternberg
Pinus hepios Unger
Pinus felekiensis Staub (small branch)
Sequoia abietina (Brongn.) Knobloch
Abies cf. *alba* Miller
Engelhardia macroptera (Brongniart) Unger [not *Palaeocarya macroptera* (Unger) Mai]
Daphnogene polymorpha (Al. Braun) Ett.
Laurophyllum sp.
Ulmus pyramidalis Goeppert
Platanus cf. *leucophylla* (Brongn.) Knobloch
Acer tricuspidatum Brongn
Fraxinus sp.
Phragmites oeningensis (Al.Braun)
Cyperites senarius Heer
Phyllites sp.

It indicates a lowland mesophytic forested riverside and a warm temperate climate, as suggested by the predominating arctotertiary elements, with leaves having dentate margin.

The environment of sedimentation, at least locally, could be a sandy beach, taking into account the presence of *Cystoseirites*, a fossil Algae. A mountainous region probably was not very far, as indicated by the presence of *Abies* (Givulescu, 1997). The physiognomic analysis of this material concluded that the major part of the identified taxa were trees (83.33%) with predominant arctotertiary taxa (~75%), but the small number of described taxa was not enough to obtain a reliable paleoclimatic image for the time of that living vegetation (Givulescu, 1997).

The material studied here, represented by fragments of petrified trunks, was collected from Feleacu hill area, Căprioara valley, from the sedimentary deposits presented above. It seems that, based only on a preliminary unpublished study, Petrescu identified from this material some Conifers (*Sequoioxylon, Pinuxylon*) and some Dicots (*Quercoxylon, Laurinoxylon, Ebenoxylon, Rhisocaryoxylon*) mentioned later as a simple list (Petrescu, 2003, p. 115). Those taxonomic identifications have never been validly published and it is very possible that we had the chance to study, at least a part of that material, kept now in the Collection of the Geological Museum of the Biology and Geology Faculty of Babeş-Bolyai University of Cluj Napoca, registered under the specification “silicified wood, Feleacu, Cluj/Căprioarei valley, with the inventory numbers: 369, 370, 371, 375, 376, 377, 384, 385, 386, 387, 388, 389, collected by Petrescu and Nicorici”. Two of the samples studied here were collected by Mirela Dumitrescu-Sabou and are deposited in the same collection (inv. nrs. 794, 795).

An adequate methodology of preparation and study of the petrified wood - the paleoxylotomy – was used, cutting standard oriented sections of petrographic type followed by microscopical observations on the oriented thin slides and a comparative study with similar structures published in the specialty literature in order to identify the original trees and their extant equivalents.

2 Systematics

Gymnosperms - Conifers

Family **Cupressaceae** Bartlett
Subfamilly **Cupressoideae** Rich ex Sweet
Genus ***Chamaecyparixylon*** Chudajberdyev
Chamaecyparixylon cf. *polonicum* (Kräusel) Chudajberdyev, 1958
Plate I, figs. 1-9.

Macroscopic description

The studied material was collected from Căprioara valley, southwestern part of Feleacu hill, from some littoral-neritic sediments considered Early Sarmatian in age and is now deposited within the Geological Museum of Department of Geology and Paleontology of UBB Cluj Napoca, under the numbers 376 and 386. The first specimen (nr. 376) is represented by a piece of silicified wood of centimetric size (11.2/5.8/1.8 cm). The second (nr. 386) is represented by 11 variably sized fragments, probably sampled from a big trunk, the biggest one having 9.5/5/2.5 cm, light grey-brownish color and fibrous texture.

Microscopic description

Growth rings - distinct, varied in width, with well-developed early-wood in gradual transition to the obvious thick-walled late-wood (5-9 tangential rows). No resin duct is present.

Tracheids with polygonal cross section, are sometimes slightly deformed, their lumina is polygonal with rounded corners and with 25-45 µm in diameter in the early-wood because they are slightly thick-walled (5-8 µm the double wall); in the late-wood, the cross section of the tracheids is smaller, the cellular walls thicker (8-12 µm the double wall); there are 2-7 radial rows of tracheids between two rays and the ray density is 1750-2050 tracheids on sq. mm. Tangential pitting is rarely present, as small pits (6-9 µm) with spaced arrangement and somewhat irregular. Radial pitting is spaced arranged in one single vertical row of round rather small pits with 8-10 µm in diameter and round apertures. Crassulae were not observed. The tracheids have rounded ends and are slightly curved.

Axial wood parenchyma is present in cross section, diffuse or slightly irregularly arranged in short tangential uniseriate groups, usually in the transitional wood. In the longitudinal sections it appears as thin walled rectangular cells separated by knotted horizontal thin walls with 3-6 nodules, and frequently with small balls or plugs of resin.

*Rays***,** in cross section view, are uniseriate and rectilinear or slightly curved, especially at the late-wood. In tangential view, short rays appear, having 1-9, usually 2-4 round to oval cells, without lateral spaces and with density of 8-12 rays on a tangential millimeter. In radial section, the ray cells are homogeneous, having 10-12 µm in height, the marginals slightly taller, with horizontal walls relatively thin and smooth, tangential walls thin and inclined; no indentures have been seen. Cupressoid cross fields are difficult to observe, with 1-2(3) cupressoid small pits, horizontally arranged or in vertical pairs, rather badly preserved, especially in the marginal fields.

Affinities and discussion

The xylotomical observations on the studied specimens allowed the outlining of a combination of features common for conifers devoid of normal resin ducts, like the Cupressaceae, whose morphology, structure and taxonomy were well studied in the recent time (see Gadek et al., 2000; Earle, 2013). Among them, the extant genera *Cupressus* and *Chamaecyparis* (see Greguss, 1955, 1967) are similar with our studied material, regarding the aspect of the tracheids, of the short rays, of the cross fields and of the axial parenchyma.

Compared with previously described similar forms attributed to the fossil correspondent morphogenus *Cupressinoxylon,* (see Greguss, 1967; Zalewska, 1953), or to *Chamaecyparixylon* (see Iamandei and Iamandei, 2000a) we confirm some general resemblances. Consulting the generic diagnoses revised by Kräusel (1949), Vogellehner (1967, 1968) and using the key of identification proposed by Vaudois and Privé (1971), it seems that we could assign our studied material to *Chamaecyparixylon* morphogenus, which belongs to Thujidae group, where the distinction between *Chamaecyparixylon* and *Thujoxylon* is difficult to be done, being reduced to the presence or absence of the parenchyma and of the indentures. As our specimens have rather abundant axial parenchyma and indentures were not seen, it is correct to attribute them to the *Chamaecyparixylon* morphogenus.

Beside these features, we noticed the rounded ends of the tracheids, which are slightly curved terminally and the low rays, resembling with the features of *C. polonicum* of Chudajberdyev (see

Vaudois and Privé, 1971; Iamandei and Iamandei, 2000a). Since it is difficult to talk about total identity, on this basis we confer our studied material to this species and we name it *Chamaecyparixylon* cf. *polonicum* (Kräusel) Chudajberdyev 1958.

Subfamily **Sequoioideae** (Luerss.) Quinn
Genus ***Sequoioxylon*** Torrey
Sequoioxylon gypsaceum (Goeppert) Greguss, 1967
Plate II, figs. 1-9.

Macroscopic description

The studied material was found in Căprioara valley, southwestern part of Feleacu hill, in Early Sarmatian littoral-neritic sediments and is now deposited in the Geological Museum of Department of Geology and Paleontology of UBB Cluj Napoca, under the numbers 384, 389 and 794. The sample 384 is represented by four pieces of silicified wood of centimetric size (the biggest has 22.2/9.5/6.5 cm); 389 is represented by five pieces of silicified wood of centimetric size (one of 5.5/4.5/1.2 cm and four smaller); 794 is represented by a trunk fragment, slightly larger (30/13/5 cm). All pieces probably come from larger trunks and have light grey-brownish color and fibrous texture.

Microscopic description

The growth rings are distinct, marked by 5-9(13) thicker-walled cells tangentially flattened in the late-wood. The early-wood has cells with big lumina and thinner walls. The rings are up to 60 cells thick, and the transition from early to late-wood is gradual. Normal resin ducts are absent.

The tracheids are polygonal in cross section, usually rectangular in the late-wood, with polygonal-rounded lumina of 30-60/25-35 µm radial/tangential diameters, more flattened tangentially in the late-wood (7-15/18-25 µm). The cellular wall is relatively thick in the early-wood (4-6 µm for the double wall), thicker in the final-wood (7-12 µm). There are 1-6 radial regular rows between two rays, some of them thinner. Their density is 806-930 cells on sq.mm. The tangential pitting, badly preserved, is rarely visible as small bordered pits of 7-9 µm in diameter having small round apertures, spaced or slightly irregularly arranged in a single vertical row. The radial pitting is badly preserved, is of abietineous type, and the pits have 8.5-11 µm in diameter and round apertures of 3.5-5 µm in diameter, show spaced arrangement in a single vertical row on the tracheids of transitional and late-wood but on the bigger tracheids of early-wood are arranged in 1-2(3) vertical rows, rather close to one another but not contiguous and with obvious *crassulae*.

The axial parenchyma is visible in cross section, as is filled with resin and diffusely distributed amongst the tracheids. It is also evident in the longitudinal sections (especially the tangential ones), as vertical strands of rectangular, thin-walled cells, of 1-2 µm the simple wall. The transverse end walls (horizontal walls) are thin (1-3 µm), usually nodular, with 1-3 nodules. The resin content appears as small or large glomerules and/or plugs.

The rays seen in cross section are linear, uniseriates in the early-wood, constituted of rectangular cells sometimes laterally crushed. Vertically, they are uniseriate, rarely with short biseriations, and are of 1-25, most frequently up to 18 cells tall. Tangentially seen, the ray cells are circular or vertically elliptic and usually empty. The density is of 12-17 rays on tangential mm. The rays are homogeneous, the parenchyma ray cells are 15-20 µm high, and the marginals sometimes taller (20-24 µm); the horizontal walls are relatively thick (2-4.5 µm double wall), smooth and probably pitted, the marginals with outer wall slightly wavy. Their tangential walls are usually thin (0.5-1.5 µm), smooth, oblique or slightly arcuate, difficult to observe because of poor preservation. Indentures were not seen. The cross fields are usually blurred, pitting is indistinct, as hardly can be guessed 1-2(3) blurred taxodioid pits 5-7(9) µm in diameter, with rounded to oval borders and small lens-like apertures, horizontally or slightly diagonally arranged.

Affinities and discussions

The xylotomical details observed on the standard oriented slides prepared from the studied specimens, suggest a conifer of “taxodiaceous” type, very similar to *Taxodioxylon* and *Sequoioxylon* genera. The distinction between the two genera seems to be difficult since the validity of *Sequoioxylon* genus, created by Torrey (1923), is contested by some palaeoxylolgists who consider that the diagnosis of *Taxodioxylon* genus (Kräusel, 1949) is comprehensive enough to include the xylotomical features of all "taxodiaceous" woods (Prive, 1977). More recently, Dolezych et al. (2011) supposed some confusion, concerning the modern affinities, inside *Taxodioxylon* as fossil morphogenus. Prive (1977) identified this morphogenus in some Tertiary deposits, as a widespread taxon during the Tertiary in North Hemisphere (in Eurasia also, like in North America) with very diverse forms assigned to *Taxodioxylon gypsaceum* (Goeppert) Kräusel 1949, considering it as a correspondent of the extant *Sequoia sempervirens* (D.Don) Endlicher.

Evaluating the xylotomy of our studied specimens, regarding the distinct growth rings with thin walled tracheids in the early-wood, resinous parenchyma, rays of 2-18 cells high or more, tracheids with abietineous pitting in 1-2(3) vertical rows, with crassulae, and the horizontal walls in axial parenchyma that is thin and smooth, or weakly nodular, the cross fields with 1-3(5) taxodioid pits in 1-2 horizontal rows it can be observed the similitude with the extant *Sequoia sempervirens*.

Our specimens present distinct *growth rings*, up to 60 cells thick in gradual transition and without normal resin ducts; *tracheids* with polygonal cross section in the early-wood, badly preserved or absent tangential pitting, abietineous radial pitting arranged in 1-2(3) vertical rows, rather close to one another but not contiguous and with obvious *crassulae*; axial parenchyma with thin and smooth or weakly nodular horizontal end walls, and with resin content as glomerules or plugs; uniseriate rays, rarely with short biseriations, of 1-25 cells in height, more frequently up to 18 cells, their density of 12-17 rays on tangential mm, homocellular, with procumbent body cells, marginals taller, indentures not seen, taxodioid cross fields, with 1-2(3) blurred taxodioid pits, 3-5 in the marginal fields.

Comparing all these features with those of the forms of *Sequoioxylon gypsaceum* (Goeppert) Greguss, with forms described by Greguss (1967) and also by Petrescu & Dragastan (1971); Petrescu and Popa (1971); Petrescu and Nuţu (1971); Petrescu (1978); Iamandei (2002); Iamandei & Iamandei (2000); Iamandei et al. (2005, 2008a, 2012), we found numerous similarities; therefore, these studied specimens will be assigned to the fossil morphospecies *Sequoioxylon gypsaceum* (Goeppert) Greguss 1967, as a fossil correspondent of the extant genus *Sequoia*.

Angiosperms – Dicotyledons

Family *Lauraceae* Jussieu
Genus *Cinnamomoxylon* Gottwald, 1997
Cinnamomoxylon intermedium (Huard) Gottwald, 1997
Plate III, Figs. 1-9.

Macroscopic description

The studied material, represented by 3 specimens, was found in Căprioara valley, southwestern part of Feleacu hill, in some Early Sarmatian littoral-neritic sediments and is now deposited in the Geological Museum of Department of Geology and Paleontology of UBB Cluj-Napoca, under the numbers 369, 371, and 375. They have centimetric size: the sample 369 is represented by a piece of 14/9.5/4.5 cm and six smaller fragments; 371 is a piece of 7/3.8/2.5 cm and a smaller one; 375 is a piece of 10.5/7/3 cm and a smaller one. The samples show light brown to grey color, locally with yellowish tints, a fibrous texture with vessels, broad rays and visible growth rings suggesting a dicot wood structure.

Microscopic description

Growth rings, distinct, relatively wide, with distinct boundaries, defining a diffuse-porous to slightly semi-ring-porous wood structure.

Vessels - solitary or in radial multiples of 2-3(5). In cross section, the solitary pores have circular shape to slightly oval and thick walls (6-9 µm the double wall). The radial/tangential diameters for the big solitary pores in the early-wood are of 100-200/60-160 µm and, in the late-wood of 40-80/40-70 µm. Their density is 9-13 pores per mm^2. Sometimes, radially, ad- and abaxial to the vessels, vascular tracheids appear. The vessels have exclusively simple perforations on horizontal or tilted plates, and alternate, numerous, small, bordered pitting. The pits of 3-4 µm in diameter do not touch each other and have point like apertures. Some vessels have small and big thick-walled tyloses, sometimes with sclerotic aspect. Inside the vessel lumina on the cell walls, thickenings can appear, and also dark granular deposits or spherical agglomerates, more or less grouped, but not compact. The vascular elements are short and have 150-250 µm in length.

Axial parenchyma is abundant, of paratra-cheal - vasicentric type, as complete 1-3-seriate sheaths, but sometimes incomplete, when the rays touch vessels; also appear diffuse or as fine bands, 1-2-seriate, in the late-wood. Vertically, the parenchyma cells do not have very thin walls (2 µm); longitudinally viewed they appear storied in strands of 4-12 rectangular cells, especially when adjacent to vessels or in the final wood. The vasicentric polygonal parenchyma cells are minutely pitted: pits of 2-3 µm, opposite, in horizontal rows or slightly irregular. Sometimes solitary crystals appear inside cells.

Rays - appear mostly uniseriate in cross section, but also bi and triseriate, composed of rectangular cells radially elongate; their trajectory is linear, sometimes touching vessels, slightly curling near the big vessels. They are not too tall, and have 3-10 cells in height (30-120 µm); the biseriate rays have 6-12 cells (100-152 µm in height). Their density is 12-14 rays on tangential horizontal millimeter. The rays are heterogeneous, with body cells all procumbent, followed by 1-2 rows or squared cells, of 16-20 µm in height, and marginal upright hypertrophied oil cells, tall, as flames, all pitted in the cross fields with vessels. The pits are big, oval, similar to those on the vasicentric parenchyma, round, small (3-3.5 µm), 1-3 in horizontal rows or slightly irregular, sometimes 2 superposed, or in vertical row of 3-4 on upright marginal cells.

The libriform fibres – slightly polygonal in cross section (12-25 µm), with rounded polygonal lumina and relatively thin walled (3-5 µm the double wall), are arranged in 2-9 radial regular rows, with small intercellular spaces. Longitudinally, the fibre cells are short, septate and relatively storied arranged in the early-wood. On the vertical walls there are rare, minute bordered pits, quite irregularly arranged on vertical rows.

Affinities and discussions

All the three specimens have similar xylotomical features, regarding: the aspect of the vessels, solitary and as short radial multiples in transverse view, thick-walled and with simple perforations; the aspect of the bi-triseriate rays, rarely broader, and with typical big oil-cells in radial view; and the vasicentric-parenchyma.

These features are characteristic to Lauraceae Family. The presence of oil-cells in rays and their absence in parenchyma suggests Perseoideae Group (Metcalfe and Chalk, 1950; Greguss, 1959). As it is known, the extant lauraceous species are spread mainly in the warm regions: tropical America, Brazil included, Southeast Asia, Australia and the Pacific islands. *Laurus* is the only European genus, appearing in the Mediterranean region.

Otherwise, Lauraceae is a rich family, having about 54 genera with 2000-2500 species. Among them, the most known are *Persea americana* by its fruit (Avocado pear), *Cinnamomum* spp. by cinnamon and camphor-oil, *Lindera* by the aromatic oil named benzoin, or *Sassafras*, with a fragrant wood used in cabinet-making. Xylotomically, two groups were admitted: Lauriodeae and Perseoideae, the first with tangential bands of parenchyma and only simple perforated plates, the second devoid of banded parenchyma and with scalariform or simple perforated plates (see Watson and Dallwitz, 1992).

Fossil woods of Lauraceae were described from the XIXth century, under different names, and were the object of many discussions and revisions. Names as *Laurinium* Unger was used for lauraceous devoid of secretory cells wood, (see Huard, 1967, p. 88), and also *Ulminium* Unger (Wheeler, Scott and Barghoorn, 1977; Privé-Gill and Pelletier, 1981). They remained in use but have been, gradually, abandoned for *Laurinoxylon*, name that shows clearly the appurtenance to Lauraceae Family. Süss and Mädel (1958) are those who have established the genus name for the lauraceous fossil wood as *Laurinoxylon* Felix 1883, the other lauraceous generic names falling into synonymy.

The xylotomical description of our studied specimens corresponds largely to the morphogenus *Laurinoxylon* Felix, to which we assigned the studied material. When we compared their features with those of the already described fossil species, we found many similarities, but also dissimilarities; therefore, it is difficult to identify it with one of the known species. These are the main characteristics:

- Vertical or radial secretory ducts appear in: *Cinnamomoxylon sp. 1-4*, *Laurinoxylon palfalvyi* Greguss, *Laurinoxylon* sp., all of them described by Greguss (1969);
- Terminal parenchyma and crystals in oil-cells appear in: *L.* cf. *hasenbergense* Süss, 1956;
- Aliform to confluent parenchyma appear in: *L. variabile* Privé-Gill and Pelletier, 1981;
- Scalariform or simple and scalariform perforations appear in: *Laurinoxylon* sp. 2,

described by Petrescu and Blidaru (1972); *L.* (cf.) *litseoides* Süss, *L.* cf. *microtracheale* Süss (both quoted in Gottwald, 1992); *L.* cf. *compressum* Huard, 1967; *L. primigenium* Felix, 1894;

- Only simple in *Cinnamomoxylon intermedium* (Huard) Gottwald 1997; *Laurinoxylon bergeri* Süss and Mädel 1958; *L. neagui* Iamandei and Iamandei, 1997.
- Secondary phloem appears in: *L.* cf. *litseoides* Süss, *L.* cf. *seemanianum* Mädel (in Süss and Mädel, 1958); *Caryodaphnopsoxylon richteri* Gottwald 1992;
- Terminal fibre bands appear in: *Laurinoxylon cf compressum* Huard, 1967; *L. oligocenicum* Prakash, Brežinova and Awasthi, 1974;
- Oil-cells in parenchyma appear in: *Cinnamomoxylon* sp. 1-4, described by Greguss, 1969; *Laurinoxylon aniboides* (Greguss) Süss, 1956; *L. perseamimatus* Petrescu, 1978; *L. oligocenicum* var. *microporosum* (Mädel) Petrescu, 1978; *L. czechense* Prakash et al., 1971; *Caryodaphnopsoxylon richteri* Gottwald, 1992; *L. neagui* Iamandei and Iamandei, 1997;
- Terminal or subterminal botle-like oil-cells in rays appear in: *Cinnamomoxylon* sp.1-4 described by Greguss, 1969; *Laurinoxylon vadaszi* Greguss, 1969; *L.* cf. *californicum* (Platen) Süss, 1956; *L. müllerstolii* (Greguss) Süss, 1956; *L. süssi* Greguss, 1969; *L. neagui* Iamandei and Iamandei, 1997; *Cinnamomoxylon intermedium* (Huard) Gottwald, 1997.

Gottwald (1997) considered that genera such as *Perseoxylon* Felix, 1887, *Ocoteoxylon* Schuster, 1908 (see ING: ocoteoxylon) and *Machilusoxylon* (Bande) Ingle, 1978 (see insidewood), do not have enough xylotomic particularities to justify their separation from *Laurinoxylon* genus. Also, based on recent xylotomic studies on Lauraceae members, he admitted as valid genera coexisting with *Laurinoxylon* Felix, 1894, the new genera *Sassafrasoxylon* Brežinova and Süss, *Caryodaphnopsoxylon* Gottwald, 1992 and *Cinnamomoxylon* Gottwald, 1997, related to the extant correspondent taxa, suggested by name.

However, the list is open and new genera were described lately: *Mezilaurinoxylon* Wheeler and Manchester, 2002; *Olmosoxylon* Estrada-Ruiz, Martinez-Cabrera and Cevallos-Ferriz, 2010; *Paraperseoxylon* (Scott and Wheeler) Wheeler and Manchester, 2002; *Richteroxylon* Wheeler and Dillhoff, 2009; *Cryptocaryoxylon* Leisman, 1986 (see insidewood).

The fossil morphogenus *Cinnamomoxylon*, initially has been created by Greguss (1969), on a badly preserved material, without a good description and diagnosis for a type-species. Gottwald (1997) ignored this reality and described *Cinnamomoxylon* as a new morphogenus, taking *C. areolosum* Gottwald, 1997, as type-species. This is the genus diagnosis, given by Gottwald (1997): "Porous wood structure to half-ring-porous, with solitary vessels and in short radial multiples, with mean diameter of >80 µm, simple or simple and short scalariform perforated plates, alternate pitting of 8-12 µm in diameter, sometimes with thin-walled tyloses, rays usually slightly heterogeneous, of 2-4 cells wide and 250-450 µm high, cross fields of I/II type (Richter), secretory idioblastic oil-cells, usually variable marginal, obviously wider, vasicentric, aliform to confluent parenchyma, thin to moderately tick-walled fibers, usually unsepted, or very rare, sometimes secretory idioblast between fibers".

The extant correspondents of this genus are considered *Cinnamomumn* Schaeff., *Lindera* Thunb., *Litsea* Lam. and *Persea* Mill. Evaluating the already described species of *Laurinium/Laurinoxylon* Gottwald attributed to *Cinnamomoxylon* 12 species that "entsprechend vollständig und vergleichbar beschreiben und abgebildet" (Gottwald, 1997). In such conditions the morphogenus *Laurinoxylon* Felix comprehends all the fossil lauraceous wood that cannot be precisely attributed to a valid fossil genus, as it is specified upward. Gottwald (1997) considered that this genus is rather insufficiently defined by the original diagnosis of Felix (1883) when he described the type-species *L. primigenium* (wood with big solitary vessels, in pairs or in short; thin-walled or moderately thick-walled fibers in rather regular radial rows; parenchyma paratracheal aliform sometimes tending to confluent; rays usually multiseriate, the uniseriates with typical shaped cells; secretory cells sometimes between the fibers or within rays appear) even when the author repeated it in his papers (Felix, 1887a, b), when he described *L. aromaticum* and *Perseoxylon antiquum*, respectively.

Our specimens show the following features:

- diffuse-porous to slightly semi-ring porous structure, with meansized pores - from 100-200 µm radial diameters in the early-wood, lesser in the late-wood, thick-walled, solitary or in short radial multiples, density 9-13 vessels on sq. mm.; short vessel elements, exclusively simple perforations and alternate, numerous, small, bordered pitting (3-4 µm), pits not touching each other and with point like apertures; small and big thick-walled tyloses inside some vessels sometimes, with sclerotic aspect, and dark granular deposits or as spherical agglomerates;
- vasicentric-parenchyma, abundant as complete 1-3-seriate sheaths and in fine bands, 1-2-seriate, in the late-wood, without oil-cells; longitudinally viewed parenchyma appear storied, in strands of 4-12 rectangular cells, especially when adjacent to vessels or in the final wood; the vasicentric polygonal parenchyma cells are minutely pitted: pits of 2-3 µm, opposite, in horizontal rows or slightly irregular; sometimes solitary crystals appear inside cells;
- rays mostly bi- and triseriate, of average height, heterogeneous, with body ray cells all procumbent, plus 1-2 rows of squared cells, and one marginal row of upright, tall, bottle-like oil-cells, pitted in the cross fields with vessels in 1-3 in horizontal rows or slightly irregular, sometimes 2 superposed, or in vertical rows of 3-4 on upright marginal cells;
- septate fibres thick-walled and bordered pitted.

The presence in our studied specimens of the marginal upright, big, bottle-like oil ray cells, visible especially in radial sections, sustained by other xylotomical features, regarding the shape and the distribution of the vessels, fibers and parenchyma in cross sections, the perforations and intervascular pitting, the pitted parenchyma and septate pitted fibres are typical features for the lauraceae of Perseoideae group, represented as fossils by the morphogenus *Cinnamomoxylon* as it was defined by Gottwald (1997).

Consulting also InsideWood 2004-onwards and Wheeler (2011), it seems that we face a species of *Laurinoxylon* of Perseoideae type, therefore, the attribution to *Cinnamomoxylon* Gottwald, 1997 is correct, taking into account the above comparative analysis.

The comparative study of our material with many described species led our attention to the European Tertiary species with simple perforation plates, like *Laurinoxylon bergeri*, *L. endiandroides, L. litseoides*, *L.microtracheale* (see Süss and Mädel, 1958) described from the Tertiary deposits of Hasenberges (close to Wiesa, in Saxony, Germany); *L. intermedium* Huard (1967), from some Miocene lignite of Arjuzanx (Landes, France); *Laurinoxylon* cf. *microtracheale* Süss, found in 1992 by Gottwald in the Late Eocene of Helmstedt (Niedersachsen), *Laurinoxylon compressum* Huard 1967, *Laurinoxylon czechense* Prakash, Březinova & Bužek 1971 from northern Bohemia, Czech Republic, *Laurinoxylon ehrendorferi* Berger 1953 from Limnos (Greece), and also similar to the forms described by Petrescu and Lazăr (1970), Petrescu and Nuţu (1971), from Apuseni Mts., and Petrescu and Blidaru (1972) from NW Transylvania, we could assign the here studied material to a species with most similar features described initially by Huard (1967) and revised by Gottwald (1997), which we named *Cinnamomoxylon intermedium* (Huard) Gottwald 1997, having an extant correspondent in *Cinnamomum,* a tree widespread now in South-eastern Asia (Vietnam, India, Ceylon, Indonesia), a warm and wet region dominated by monsoons.

Familia **Juglandaceae** DC. ex Perleb
Genus ***Rhysocaryoxylon*** Dupéron, 1988
Rhysocaryoxylon transylvanicum Iamandei and Iamandei, 2003
Plate IV, figs. 1-9.

Macroscopic description

The studied material was found in Căprioara valley, southwestern part of Feleacu hill, in Early Sarmatian littoral-neritic sediments and is now deposited in the Geological Museum of Department of Geology and Paleontology of UBB Cluj Napoca, under the numbers 377 and 795. Each specimen is represented by pieces of centimetric sizes, most probably sampled from bigger trunks: 377 has 7 pieces (the biggest of 5.5/2.5/3.7 cm); 795 is a single piece of 15/10/2.5 cm. Both samples show light brown to grey color, locally with yellowish tints, a fibrous texture with vessels, broad rays and visible growth rings, suggesting a dicot wood structure.

Microscopic description

Growth rings have indistinct boundaries, but the structure is semi-ring-porous; the vessels tend to gradually decrease their lumina to the late-wood. The tangential parenchyma bands are long, regular and with slightly decreasing interval.

The vessels, in cross section, appear as solitary pores or grouped in small radial multiples of 2-3(5); the solitary pores have usually radial oval shape, commonly deformed and thick-walled (4-8 µm the simple wall). The solitary pores have 100-180/80-160 µm the radial/tangential in the early-wood, but in transitional to the late-wood their size is smaller (60-80 µm). Vessel density could be 20-30 vessels on sq. mm. The vessels have simple perforations on tilted plates and bordered alternate small pitting, pits of 8-10 µm in diameter and point-like apertures. The vascular elements are relatively short (150-200 µm). Often, big tyloses occupy the inside of the vessels.

Axial wood parenchyma appear in cross section as long tangential bands of (1)2-3 cells thick but of paratracheal type also, even if are fewer, as some flattened cells around the vessels; the parenchyma cells have 10-15(18) µm in diameter. In longitudinal view, the apotracheal parenchyma, sometimes chambered and slightly hypertrophied, bears crystals floating in a white-bright content. Nevertheless, almost all parenchyma, axial or radial, have normal big cells filled with dark content and have numerous polygonal or rounded, variably sized, smaller crystals in 1-2 rows, or irregularly arranged.

The medullary rays, in cross section, appear with linear or slightly curled trajectory, sometimes touching vessels and are formed from rectangular cells radially elongated and usually filled of dark matter. Tangentially seen, the major part of the rays are 1-2-3(-5)-seriate and are moderately tall, and appear fusiform with endings of 1-4 cells or more. The ray density is of 12-14-26 rays on horizontal tangential millimeter. Radially seen, the rays appear slightly heterogeneous, the body cells are procumbent, rather big, marginally taller or squared, and usually have dark content and numerous small or variably sized rounded crystals. Pitting in cross field is difficult to see because of the crystals, and appear as some round and small pits, on two horizontal rows.

The libriform fibers have rounded-polygonal cross section with diameter of 7-14 µm, are thick- to very thick walled (4-12 µm the double wall), with small rounded lumina and are arranged in radial regular rows. Longitudinally seen, the fibers are unpitted and unsepted; their length is difficult to appreciate due to bad preservation.

Affinities and discussion

Evaluating the xylotomical features of the studied material with regard to the general arrangement of the structural elements in cross section, the vessels with simple perforations and numerous bordered alternate pitting, the crystalliferous banded and ray parenchyma, it is quite obvious that we talk about an Juglandaceous wood, very similar to the extant species of ***Juglans***, as figured and described by Greguss (1959), Schweingrüber (1990), or Watson and Dallwitz (1992, onwards).

The extant Juglandaceae include 7 genera with relative disjunct living areas: South-East Asiatic distribution for *Engelhardia, Platycarya*, and *Carya*, Eurasiatic for *Pterocarya, Juglans,* and in the American continents, like *Oreomunea, Alfaroa, Juglans* and *Carya* (Manning, in Duperon, 1988; Orain et al., 2013). No occurrence was reported from Africa and Australia.

From xylotomic point of view, *Engelhardtia, Alfaroa,* and *Oreomunnea* usually have simple and scalariform perforations. *Platycarya* have spiral thickenings on the tracheal or tracheidal walls.

Juglans, Pterocarya and *Carya* have quite similar xylotomical features. However, the presence or the absence of crystalliferous parenchyma, the aspect or/and vessel wall thickness can separate the genera. *Carya* always has thick vascular walls (>3 µm the simple wall), crystalliferous parenchyma usually present and with solitary crystals in enormous cells, of barrel type and in short rows of 1-2-3, and the apotracheal parenchyma appear in continuous bands. *Platycarya* has ring-porous wood, spiral thickenings or narrow vessels and vasicentric tracheids. *Pterocarya* does not have crystalliferous parenchyma, vascular walls are always thin (<3 µm) and the parenchyma appear as short and thin bands, usually uniseriate. *Juglans* has 4 types (grey walnut, English walnut, black north temperate walnut, and black tropical walnut) with variations of the crystalliferous parenchyma (Miller, in Dupéron, 1988).

The fossil morphogenera of Juglandaceae, reviewed several times till now (see Blokhina, 2007; Sakala and Gryc, 2011), are the following:

- *Engelhardtioxylon* (Manchester) Dupéron, 1988, as correspondent of the extant *Engelhardia, Alfaroa* and *Oreomunnea* having quite similar features as it is difficult to separate them (see Blokhina, 2007);
- *Manchesteroxylon* Wheeler and Landon, 1992, proposed by Manchester (1983) for fossil wood of the Engelhardioideae, which seems to be a primitive juglandaceous taxon with simple and scalariform perforations, ring-porosity and vascular tracheids similar to the Platycaryoideae (see also Blokhina, 2007, p.1042);
- *Clarnoxylon* 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 (Wheeler and Manchester, 2002);
- *Pterocaryoxylon* Müller-Stoll and Mädel, 1960, is the fossil equivalent for species of *Pterocarya* and some species of *Juglans* (Asiatic species and an American species of grey walnut), having thin vascular walls, short and uniseriate parenchyma bands devoid of crystals;
- *Eucaryoxylon* (Müller-Stoll and Mädel) Dupéron, 1988, has porous structure, solitary vessels or short multiples, thick to very thick vascular walls, simple perforations, alternate intervascular pitting, rather big, paratracheal and apotracheal banded parenchyma, 1-2(4)-seriate, long, regular; sometimes crystalliferous parenchyma, large idioblasts with solitary crystal of "barrel" type, isolated or in 2-3 rows; rays 1-3(5)-seriate, and septate pith, corresponding to the extant species of *Carya*;
- *Rhysocaryoxylon* Dupéron, 1988 corresponds to the extant genus *Juglans* characterized by porous to semi-ring-porous structure, thick-walled vessels, solitary vessels or in small multiples, simple perforations, alternate intervascular pitting, banded apotracheal parenchyma, 1-2(4) seriate bands, long, regular, paratracheal few; crystalliferous parenchyma as short chains; rays 1-3(5)-seriate, heterogeneous and septate pith.

As a conclusion, the validity of the species described under the invalidated genera, previously used for fossil specimens like *Mirbelites*, *Juglandinium*, *Juglandoxylon*, *Juglansoxylon*, *Jugloxylon*, *Caryoxylon*, *Juglans*, *Carya* or *Pterocarya* (quoted by Dupéron, 1988), were, or had to be revised.

Blokhina (2007) made a new revision of the knowledge on Juglandaceous xylotomy and palaeoxylotomy and presents some questions on taxonomy, evolution and phylogeny of this group and gives a key for identification of wood anatomy in modern and fossil Juglandaceae. Using this key, but also the other information in the paper, it is clear that a wood structure with diffuse or semi-ring-porous structure, crystals only 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 is in bands 1–2(4) cells wide, and rays are 1-3(-5)–seriate, homocellular to slightly heterocellular, and with or without crystals".

As to *Rhysocaryoxylon*, Sakala and Gryc (2011), describing a new species for this morphogenus, observe that "it was nomenclaturally superfluous when published and therefore illegitimate from the nomenclatural point of view, so either a proposal must be prepared for TAXON (the Journal of the IAPT) to conserve the name *Rhysocaryoxylon* against *Caryojuglandoxylon*, or new combinations must be published in the future". And this, because of the presence in this forms of crystalliferous idioblasts similar to *Carya* type, but more numerous, and because of the presence of narrower rays and smaller vessels and rays tending to be uniseriate in majority, features that did not correspond to the accepted diagnosis based on the type species *R. schenkii* (Felix) Dupéron.

Using the Dupéron's key of identification (1988) we can say that our specimens, by their xylotomical features are different of *Juglans regia* ("English Walnut" or "Persian Walnut"), from Dioscaryon section, which has the vascular walls not very thick and short-banded, non-crystalliferous parenchyma, but closer to the wood types from Rhysocaryon section (known as "Tropical or North-temperate black walnuts", because present thick-walled vessels, continuous crystalliferous parenchyma bands of 1-3 cells wide and vertical short chains (no more than 5) chambers with solitary crystals, features very similar, for example, to the xylotomy of the extant *Juglans nigra* (see Greguss, 1959) showed, and consistent with the fossil types described by Müller-Stoll and Mädel (1960), Manning (1978), Dupéron (1988) and Blokhina (2007).

Taking into account the forms described till now having vertical short chains of crystalliferous hypertrophied idioblasts within parenchyma strands, different of the black tropical walnuts (see Iamandei and Iamandei, 2002), it seems that the studied specimens have features closer to a species previously described by us, as a black north temperate walnut, *Rhysocaryoxylon transylvanicum* Iamandei and Iamandei, 2003, to which we assign our studied specimens.

Rhysocaryoxylon caucasicum (Gayvoronsky)
Dupéron, 1988,
Plate V, figs. 1-9.

Macroscopic description

The studied material was found in Căprioara valley, southwestern part of Feleacu hill, in Early Sarmatian littoral-neritic sediments and is now deposited in the Geological Museum of Department of Geology and Paleontology of UBB Cluj Napoca, under the numbers 385, 387 and 388. Each specimen is represented by some pieces of centimetric sizes, most probably sampled from bigger trunks: 385 has 6 pieces, the biggest has 23/10/5 cm; 387 has 2 pieces, the biggest has 20.5/9/8.5 cm; 388 has 6 pieces, the biggest has 13/6.5/3 cm. All the samples show light brown to grey color, locally with yellowish tints, a fibrous texture with vessels, broad rays and visible growth rings, suggesting a dicot wood structure.

Microscopic description

Growth rings have indistinct boundaries, but the structure is ring-porous to slightly semi-ring-porous as the first row of very big vessels suggests, followed by vessels which tend to gradually decrease their lumina to the late-wood. The tangential parenchyma bands are long, regular and with slightly decreasing intervals. The entire structure is compressed and difficult to compare with a normal one.

The vessels, in cross section, appear thick walled, as big solitary pores, of 80-230 µm tangential diameter, rarely as small radial multiples, on single first row of earliest wood arranged, and smaller (30-60 µm) to the late-wood, with a density of some tens on square millimeter. Simple perforations on tilted plates and alternate pitting can be observed, as small bordered pits (8-10 µm in diameter) with point-like apertures. Short vascular elements of 80-150 µm, and often big tyloses can be observed inside.

Axial wood parenchyma of apotracheal type appear in cross section as long tangential bands, 1-2 cells thick, and few of paratracheal type appear, as some flattened cells around the vessels, visible mainly in longitudinal view; the parenchyma cells have 12-15 µm in diameter. In longitudinal view, the apotracheal parenchyma – the bands – appear in strands of vertical rectangular cells. Sometimes, they appear as long rows of hypertrophied crystalliferous cells, easy to be mistaken, in tangential view, for uniseriate rays, which are filled with dark content and large solitary crystals, slightly rounded. The vasicentric parenchyma one is visibly simply pitted.

The medullary rays – in cross section appear thin, with linear or slightly curled trajectory sometimes touching vessels and are formed from rectangular cells radially elongated usually full of dark matter. In tangential view, the major part of the rays are uniseriate, probably rarely biseriate, and of average height. Their density is of 12-14 rays on horizontal tangential millimeter. Radially seen, the rays appear homogeneous, with all cells procumbent, relatively big, marginals slightly higher, or squared, and have usually dark content and big rounded crystals floating in. Pitting in cross field is so difficult to see because of the crystals, appear some on one or two horizontal rows, round, small.

The libriform fibers – even if the structure is compressed, they appear arranged in radial regular rows, have polygonal rounded cross section of 17-20 µm diameter, cellular thick- to very thick-walled (4-12 µm double wall), small round to point-like lumina. Longitudinally seen, the fibers are unpitted and unsepted but, due to rather bad preservation, their length is difficult to estimate.

Affinities and discussion

Evaluating the xylotomy of the studied specimens as having very similar wood structure, especially in radial view, with the above described material, it is simple to attribute them to juglandceous wood type as it is described and figured by Greguss (1959) and Schweingrüber (1990), and consistent with the general description of wood anatomy of Juglandaceae given by Watson and Dallwitz (1992, onwards).

It is no need to repeat the discussion about the above described species, since the studied specimens seem to have long vertical chains of crystalliferous chambers, exceeding 5, and could be attributed to *Rhysocaryoxylon* morphogenus of type "Black Tropical Walnut", but it is a problem which is specific for this material, rather badly preserved, namely the presence of the uniseriate rays in a mainly ring porous (to semi-ring porous) wood structure. As it is well known, the morphogenus *Rhysocaryoxylon* Dupéron, 1988, is a correspondent of the extant genus *Juglans*, which has "porous to semi-ring-porous structure, thick-walled vessels, solitary vessels or in small multiples, simple perforations, alternate intervascular pitting, banded apotracheal parenchyma, 1-2(4)-seriate bands, long, regular, paratracheal few; crystalliferous parenchyma as short chains; rays 1-3(5)-seriate, heterogeneous and septate pith" genus diagnosis having as type species *Rhysocaryoxylon schenkii* (Felix) Dupéron, 1988, consistent with the fossil types described by Müller-Stoll and Mädel (1960), Manning (1978), Dupéron (1988), Iamandei and Iamandei (2002, 2003, and this paper), Blokhina (2007) and Sakala and Gryc (2011).

There are some species described with narrow rays, such as *Rhysocaryoxylon treibelii* (Caspary) Dupéron, 1988, described also by Müller-Stoll and Mädel (1960) and Van der Burgh (1973); *R. pilinyense* Greguss (1969), recently reviewed by Sakala and Gryk (2011, p. 48), who describe a new morphospecies *R. madsenii* Sakala and Gryc 2011; *R. fryxellii* (Prakash and Barghoorn) Dupéron, 1988; *R. tertiarum* (Prakash and Barghoorn) Dupéron, 1988 were described also with narrow homocellular rays. Otherwise, Wheeler and Dillhoff (2009) recently described some woods from the Middle Miocene Vantage Flora (Washington, USA) and reviewed the type species of Prakash and Barghoorn (1961a, b).

Very similar to our material is *R. caucasicum* (Gayvoronsky) Dupéron, 1988, which has uni- and biseriate rays (see Gayvoronsky, 1962). Since the xylotomical features of our specimens are almost identical with the species of Gayvoronski, especially the fine rays, after this short analysis we assign our specimens to this morphospecies, named *Rhysocaryoxylon caucasicum* (Gayvoronsky) Dupéron, 1988.

Familly **Fagaceae** Dum.
Genus ***Quercoxylon*** (Kräusel) Gros 1988
Quercoxylon sp. cf. *Quercus frainetto* Ten.
Plate VI, figs. 1-9.

Macroscopic description

We had in study some samples of petrified wood found in Căprioara valley, southwestern part of Feleacu hill, in Early Sarmatian littoral-neritic sediments, which is now deposited in the Geological Museum of Department of Geology and Paleontology of UBB Cluj Napoca, under the number 370. It consists of 8 fragments of centimetric size; the biggest one has 8/6.5/3 cm; all come from a single trunk. The samples show light grey color, occasionally with brownish tints, has a fibrous texture with vessels, broad rays and visible growth rings suggesting a dicot wood structure.

Microscopic description

Growth rings distinct, marked by the first 1-2 rows of big solitary vessels of the early-wood, which also marks the ring-porous structure of the studied fossil wood, as the late-wood is marked by abrupt transition to the small vessels that show a slightly gradual size decrease and are arranged in radial to slightly dendritic pattern.

The vessels, in cross section, appear usually solitary, lesser as small multiples of 2(3) in the early-wood, on 1-2 rows, as well as in the transitional and late-wood where are radially arranged or slightly dendritic. The solitary pores, in fact the cross section of the vessels, large or smaller, having radial oval shape, in the late-wood, slightly radially elongate. The vessels are moderately thick-walled (5-7 μm the double wall) and the lumina of the solitary vessels have the radial/tangential diameters of 90-200/40-100 μm in the early-wood and of 40-70/20-30 μm in the late-wood; their density is difficult to evaluate because of the poor preservation and its value could not be significant, since there are interradial fascicles devoid of vessels. All the vessels have simple perforations on tilted plates and intervascular pitting bordered, small (3.5-5.5 μm in diameter), round to oval opposite, subopposite to alternate, numerous, spaced, with horizontal small elliptic apertures of 1-2 µm. Pitting to ray cells is similar. The vascular elements appear to be short, around 200-300 µm, or more. Tyloses present but, due to the bad preservation, it is difficult to appreciate other details.

Axial parenchyma – is of diffuse apotracheal type, mixed with libriform or tracheids together in broad bands. Vasicentric parenchyma also present, visible in longitudinal view, and with numerous large simple pits, round or oval. In longitudinal view, the parenchyma cells bear crystals and tanninous dark content.

The rays have a linear trajectory and are two-sized: numerous uniseriate rays, and fewer multiseriate-compact, sometimes dissected by fibers, of 8-18 cells broad or more spaced arranged, and more than 1 mm tall. The ray density is of 10-22 rays per tangential horizontal millimeter. The rays are homogeneous-homocellular; in radial view, the ray cells are all procumbent. The cross fields with vessels are poorly preserved and have rectangular pits (palisade). The cross field pitting is difficult to observe since the ray cells are usually full of polygonal rounded crystals and tanninous dark remains.

The libriform fibers have a polygonal cross section of 8-13 µm in diameter, relatively large lumened, thick walled (4-5 µm the double wall), are unsepted and unpitted.

Fibro-tracheids and vascular tracheids are rather unclear in cross section also because of the bad preservation. Longitudinally, they present small pitting, bordered, round or slightly elliptic, with small apertures, and in 1(-2) vertical rows.

Affinities and discussion

The cross sections of the studied specimen is typical for Fagaceae – ring porous wood structure and two sized rays – broad and tall multiseriates and numerous fine rays, especially uniseriates, and also the aspect and arrangement of the vessels in the early-wood and in the late-wood, are typical for Quercineae.

After Hadziev and Mädel (1962) four types of oak structures could be separated:

1. “Weisseichen” (white oak type), comprising most of the species of section *Lepidobalanus* (in fact *Mesobalanus*, a group present in Europe, Asia, North Africa, see http://en.wikipedia.org/wiki/List of Quercus species), characterized by ring porous structure with small, polygonal, thin walled late-wood vessels.
2. “Roteichen” (red oak type), comprising the species of section *Eritrobalanus* (*Lobatae* section), http://en.wikipedia.org/wiki/List of Quercus species) and some species of *Lepidobalanoideae*, characterized by ring porous structure and relatively large round thick walled late-wood vessels.
3. “Sempervirent oak” type, comprising species of *Quercus* and *Lithocarpus,* characterized by diffuse porous or half-ring-porous structure, relatively small and spaced vessels, often radially disposed.
4. “Root wood” type, corresponding to all types of oaks, characterized by diffuse-porous structure and crowded large pores.

Privé-Gill, in 1975, in perfect accord with Hadziev and Mädel, observed that the oak wood is characterized by vessels in radial rows more or less dendritically distributed and showing simple perforations. She also emphasized that two-sized rays (multiseriates very broad and finer, 1-2-seriates) are usually present in the extant *Quercus* L. and in *Lithocarpus* Bl. (= *Pasania* Oerst.) genera with some tens of species growing in temperate to warm regions of the northern hemisphere, islander as well. She specified that, generally, the oak wood structure could be characterized by vessels in radial rows, more or less anastomosed, or dendritically distributed, and with simple perforations. Their structure is diffuse porous, characteristic for the evergreen species since the ring-porous one is typical to the deciduous species of *Quercus* L. and to the most septentrional species, islander also, of *Lithocarpus* Bl. (= *Pasania* Oerst.).

The diffuse distribution of the vessels characterizes the sempervirent species for both genera. The ring-porous distribution characterizes the deciduous oak species and the more septentrional species of *Lithocarpus*. As about the root wood, even the deciduous species tend often to lose the ring-porousness, becoming similar to the evergreen species, the broad rays become divided in “false rays”, i.e. aggregate rays (Privé-Gill, 1975).

New attempts to establish the taxonomy of the fossil oaks, based on their xylotomy, was made by Gros (1988) and, independently, Suzuki and Ohba (1991), who made a comparative synthesis of the essential xylotomical characters of the extant fagaceous taxa, based on the previous anatomic studies and on the phylogenetic relations between the genera of Fagaceae.

A very useful systematization of the xylotomical details of Fagaceae, was made by Petrescu (1976), and even if the taxonomy of the group evolved, it is still a good key of identification of the fossil fagaceous wood (Table 1).

In fact, a lot of studies on oak wood remains were done till now (we cite only the one used for the documentation of this study): Müller-Stoll and Mädel, 1957; Brett, 1960; Gottwald, 1967; Greguss, 1969; Nagy & Petrescu, 1969; Hadziev & Mädel, 1962; Huard, 1966; Privé(-Gill) 1975, 1984, 1990; Privé & Brousse, 1976; Nagy and Petrescu 1969; Petrescu, 1969 1976, 1978; Petrescu et al., 1970 - 1974; Starostin & Trelea, 1969, 1984; Lupu, 1984; Samuel, in Lamouille et al., 1985; Selmeier, 1971, 1997; Suzuki & Ohba, 1991; Sakala and Gryk, 2011; Iamandei, 2002; Iamandei et al. 2008b, 2011, 2012. In fact, a lot of studies on oak wood remains were done till now, we cite the consulted ones: Müller-Stoll and Mädel, 1957; Brett, 1960; Gottwald, 1967; Greguss, 1969; Nagy & Petrescu, 1969; Hadziev & Mädel, 1962; Huard, 1966; Privé(-Gill) 1975, 1984, 1990; Privé & Brousse, 1976; Nagy and Petrescu 1969; Petrescu, 1969 1976, 1978; Petrescu et al., 1970-1974; Starostin & Trelea, 1969, 1984; Lupu, 1984; Samuel, in Lamouille et al., 1985; Selmeier, 1971, 1997; Suzuki & Ohba, 1991; Sakala and Gryk, 2011; Iamandei, 2002; Iamandei et al. 2008b, 2011, 2012.

Table 1. Key for generic identification of fagaceous fossil woods (Petrescu, 1976)

Type A	Structures with solitary vessels or grouped (2-3 or more), with simple and scalariform perforations.	Fine rays (1-3-seriate) and multiseriate compact.	*Fagoxylon* *Nothofagoxylon*
Type B	Structures with solitary vessels, simple perforated, sometimes some scalariform, with few bars.	Exclusively uniseriate rays.	*Castanoxylon*
		Uniseriate and pluriseriate compact, sometimes compact-composed or partially aggregate rays.	*Quercoxylon*
		Uniseriate and pluriseriate aggregate rays.	*Lithocarpoxylon*

Using at least these keys, it seems that our here studied structure suggests a type of white oak close to the extant Mesobalanus group that is assigned to the corresponding fossil morphogenus Quercoxylon, created by Hofmann (1929), but correctly defined by Kräusel (1939), and emended by Müller-Stoll and Mädel (1957), by Gros (1983, 1988), and by Suzuki and Ohba (1991) (see also Iamandei et al., 2008b, p.203-204).

After Gros (1988) accepted emendation, the Quercoxylon diagnosis is: porous or ring-porous structure, usually solitary vessels simply perforated, alternate vascular pitting, pitted parenchyma, banded or diffuse, libriform, tracheids and small vessels in groundmass and two-sized rays.

As to the wood structure of the extant species of “white oak”, Privé-Gill (1975) observed a big intraspecific variation, confirmed for the entire genus Quercus L., which shows a great interspecific anatomic homogeneity. This makes it very difficult to ascribe fossil species, thus terms that have only a descriptive value, as for morphospecies being used.

Selmeier (1997) remarked that vessel diameter, ray size, ray frequency and ray distribution are variable: even in the same described fossil species, the biometric values may differ. For this reason, in xylotomical description of extant wood, no updated measurements are given, and any accurate measurements made by paleoxylologists cannot be always used to identify an unknown species. Moreover, the rules from "IAWA List of Microscopic Features for Hardwood" (Wheeler at al., 1989) impose different ways to convert older measurements.

However, the ray structure is homocellular and the cross fields with vessels show quadrangular rounded bordered pits, disposed vertically, as palisade, very similar to those in the extant species Quercus frainetto TEN. (known as the Hungarian Oak or Italian Oak, or Gârniţa in Romanian). This form is classified into the genus Quercus, section Mesobalanus, and is a species of oak native in Southeastern Europe and Turkey. The atlas of Schweingrüber (1990), the sites Schoch et al. (2004) and InsideWood (2004) also showed us much similitude of this type of structure with our studied specimens. Under these circumstances, based on the observed xylotomical details, we appreciate that the studied specimen could be assigned to Quercoxylon sp. cf. Quercus frainetto Ten.

Table 2. Feleacu Flora

Leaves, fruits (in Givulescu, 1997)	Spores, Pollen (Suciu, 2005a, b)	Petrescu 2003, unpublished	Iamandei et al. 2011 and 2013 (present paper)
-	*Laevigatisporites haardti* (Polypodiaceae)	-	-
Sequoia abietina (Brongn.) Kn.	Taxodiaceous pollen	*Sequoioxylon*	*Sequoioxylon gypsaceum* - 2 specimens
-	-	-	*Tetraclinoxylon romanicum* – 1 specimen
-	-	-	*Chamaecyparixylon* cf. *polonicum* – 2 specimens
Pinus hepios Unger *Pinus felekiensis* Staub	*Pinus*	*Pinuxylon*	-
Abies cf. *alba* Miller	*Abies,*	-	-
-	*Picea, Tsuga*	-	-
Laurophyllum sp., *Daphnogene polymorpha* (Al.Br.) Ett.	-	*Laurinoxylon*	*Cinnamomoxylon intermedium* - 3 specimens
Platanus cf. *leucophylla* (Brongn.) Kn.	-	-	-
-	-	*Ebenoxylon*	-
Engelhardia macroptera (Brongn.) Unger	*Carya, Pterocarya Engelhardia*	*Rhysocaryo-xylon*	*Rhysocaryoxylon pravalense* - 2 specimens *Rhysocaryoxylon caucasicum* - 3 specimens
Quercus mediterranea Unger	*Quercus*	*Quercoxylon*	*Quercoxylon sp.* cf. *Quercus frainetto* – 1 specimen
Ulmus pyramidalis Goeppert	*Ulmus*	-	-
Acer tricuspidatum Brongn.	-	-	-
Fraxinus sp.	-	-	-
-	*Betula*	-	-
-	*Myrica*	-	-
-	*Alnus*	-	-

3. Conclusions

In this paper, newly identified lignotaxa from Feleacu hill are presented, partially confirming the list of Staub (1883, 1891), revised formally by Givulescu (1997) and Petrescu (2003) as characterizing the Early Sarmatian, Feleacu flora. Petrescu (2003), after a preliminary survey of the new material, quoted some lignotaxa as *Sequoioxylon, Pinuxylon*, *Quercoxylon, Laurinoxylon, Ebenoxylon* and *Rhisocaryoxylon*, but he never published them correctly.

More recently, a new lignotaxon (*Tetraclinoxylon*) was described from the same site (Iamandei et al, 2011) and the present paper partially confirms the generic identification of Petrescu. The material studied here was collected from a sedimentary formation comprising gravels, sands, sandstones, clays, which indicate a continental fluvio-deltaic environment to a littoral one, and this small flora seems to indicate, for the Early Sarmatian, a warm temperate paleoclimate in this region. A comparative record of the previously reported Feleacu paleoflora and the additions provided by our research of is given in Table 2.

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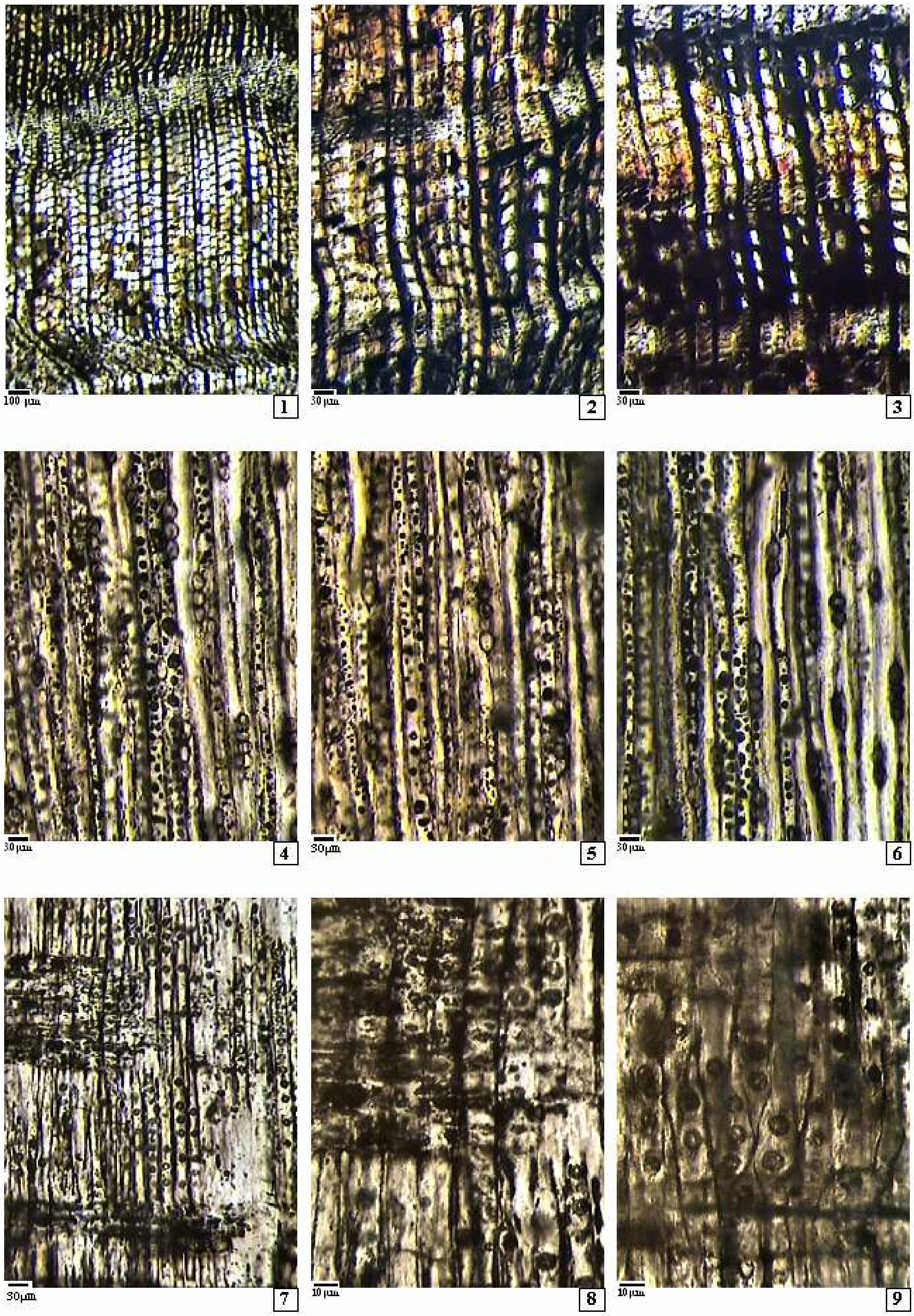
PLATE I



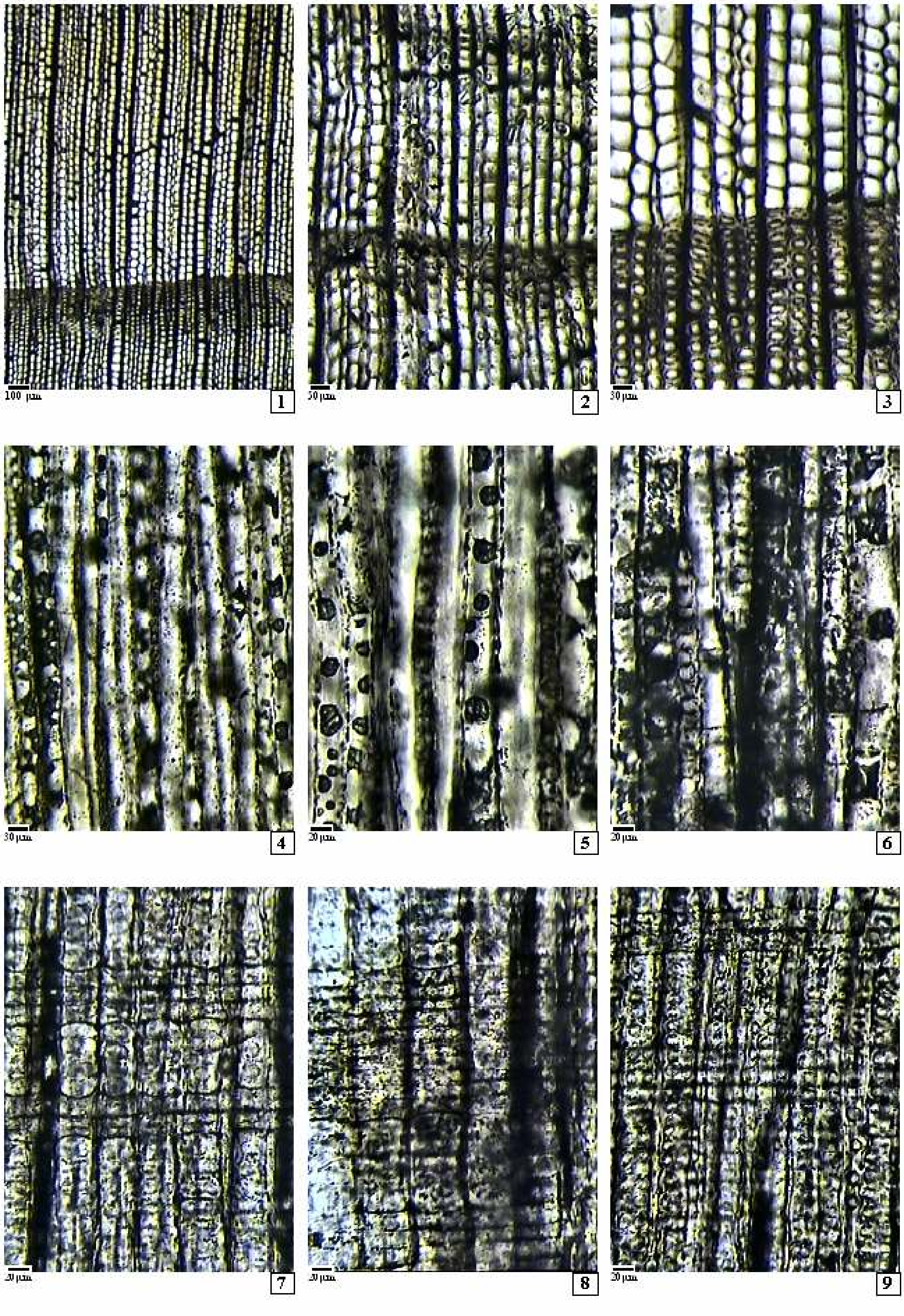
Figs. 1-9. *Chamaecyparixylon* cf. *polonicum* (Kräusel) Chudajberdyev 1958, material; Sm.1; Căprioara valley – Feleacu, Cluj; stored under no. 386 in Geological Museum - UBB Cluj Napoca.

Figs. 1-3. Cross section – distribution of relatively thickwalled polygonal tracheids, growth rings with early -wood, late-wood, distinct boundary and scattered parenchyma cells.

Figs. 4-6. Tangential section – abundant parenchyma with resinous glomerules, short uniseriate rays.

Figs. 7-9. Radial section – uniseriate spaced abietinean pitting, homocellular rays, blurred cupressoid cross fields.

PLATE II

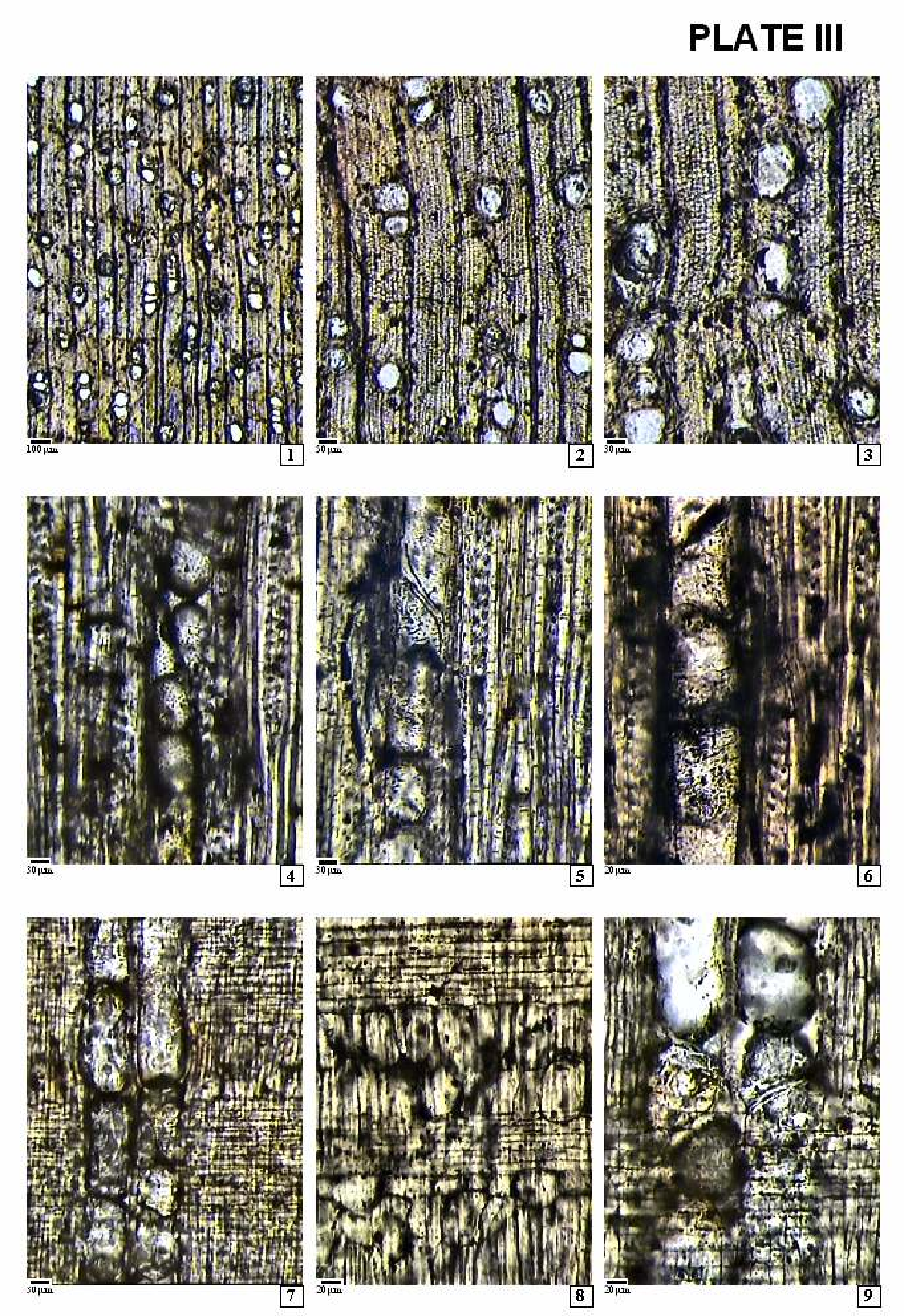


Figs. 1-9. *Sequoioxylon gypsaceum* (Goeppert) Greguss 1967, material; Sm.1; Căprioara valley – Feleacu, Cluj; stored under no. 797 in Geological Museum - UBB Cluj Napoca.

Figs. 1-3. Cross section – distributions of polygonal tracheids, thin walled in early-wood, thick walled in late-wood, distinct ring boundaries, scattered resinous parenchyma cells.

Figs. 4-6. Tangential section – axial parenchyma with thin horizontal walls and resin balls or plugs, tangential tracheidal pitting absent, high rays.

Figs. 7-9. Radial section – 1-3 tracheidal radial abietinean pitting, homocellular rays, taxodioid cross fields with 2-3 pits in horizontal row, marginal fields taller, with 4-6 pits in 2 horizontal rows.



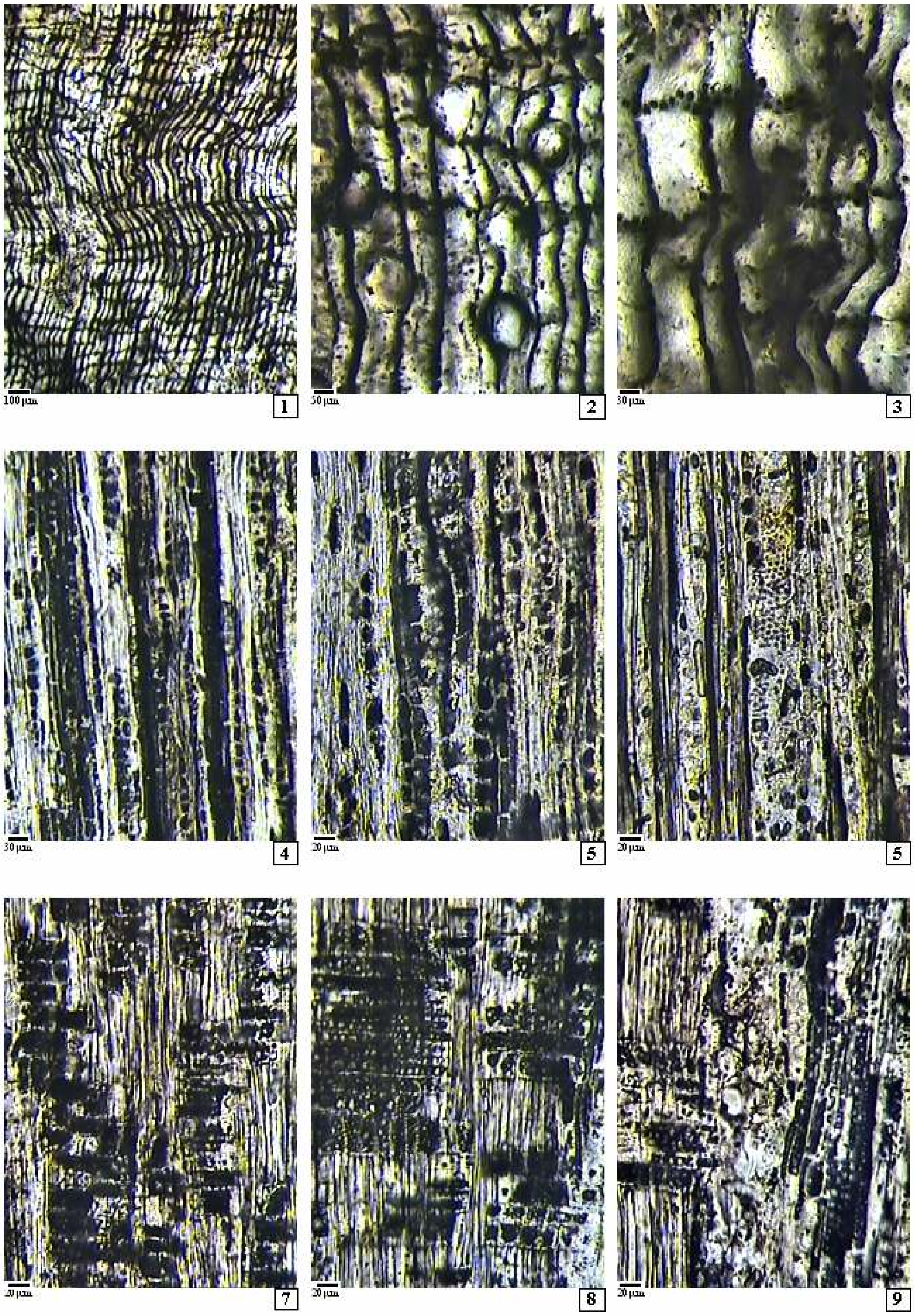
Figs. 1-9. *Cinnamomoxylon intermedium* (Huard) Gottwald, 1997, material; Sm.1; Căprioara valley – Feleacu, Cluj; stored under no. 369 in Geological Museum - UBB Cluj Napoca.

Figs. 1-3. Cross section – thick-walled vessels solitary or in small radial groups, thick walled fibers and linear 1-3 seriate rays.

Figs. 4-6. Tangential section – thick walled tylosed vessels with alternate pitting, bi- triseriate rays, septate fibers and axial parenchyma.

Figs. 7-9. Radial section – vessels with simple perforations, heterocelular rays with marginals hypertrophied.

PLATE IV

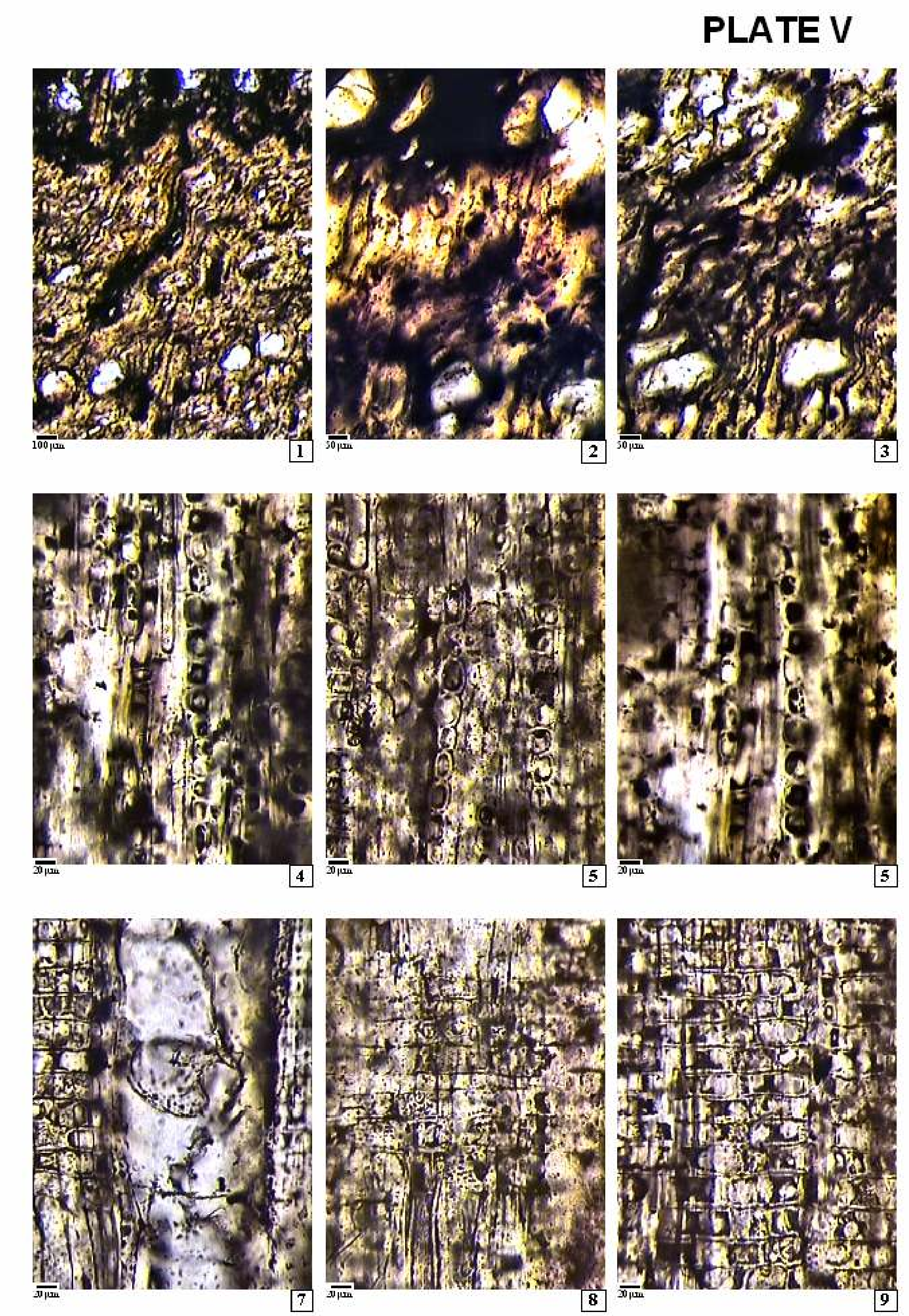


Figs. 1-9. *Rhysocaryoxylon transylvanicum* Iamandei and Iamandei, 2003, material; Sm.1; Căprioara valley – Feleacu, Cluj - stored under no. 377, in Geological Museum - UBB Cluj Napoca.

Figs. 1-3. Cross section – solitary pores or in small radial multiples, long tangential bands of (1)2-3 parenchyma cells, giving scalariform aspect.

Figs. 4-6. Tangential section – alternate pitting on vessels, 1-3 - seriate rays.

Figs. 7-9. Radial section – vessels with simple perforations, crystalliferous radial and axial parenchyma, homocellular rays.

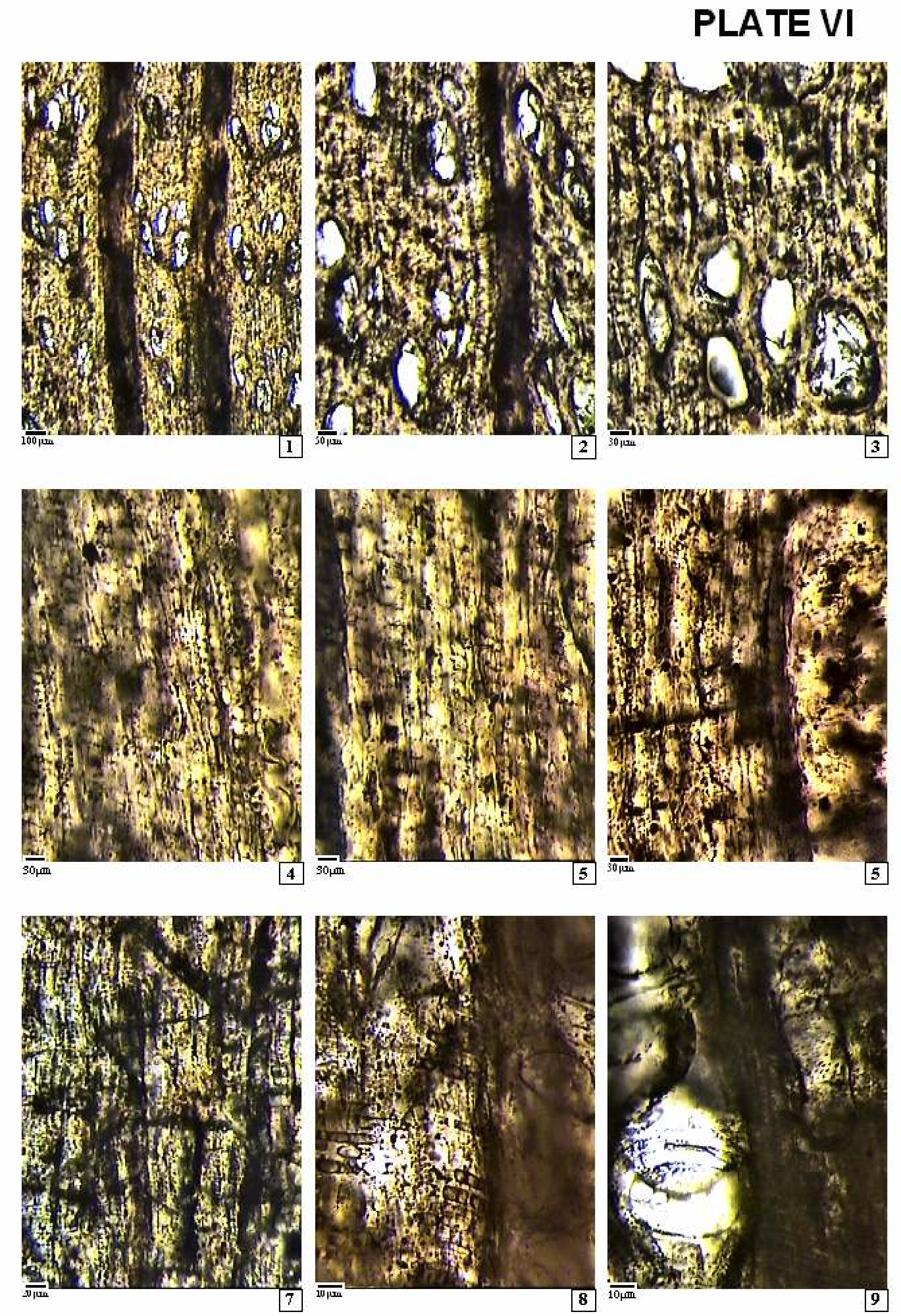


Figs. 1-9. *Rhysocaryoxylon caucasicum* (Gayvoronsky) Dupéron, 1988, material; Sm.1; Căprioara valley–Feleacu, Cluj; stored under no. 388, in Geological Museum - UBB Cluj Napoca.

Figs. 1-3. Cross section – ring porose structure, big vessels in the early-wood, long tangential fine bands of parenchyma.

Figs. 4-6. Tangential section – crystalliferous parenchyma, uniseriate rays.

Figs. 7-9. Radial section – vessels with simple perforations, thick walled ray cells all procumbent and full of crystals.



Figs. 1-9. *Quercoxylon* sp. cf. *Quercus frainetto* Ten., material; Sm.1; Căprioara valley – Feleacu, Cluj; stored under no. 370, in Geological Museum - UBB Cluj Napoca.

Figs. 1-3. Cross section – ring porose structure, 2-3 rows of big vessels in the early-wood, short tangential bands of parenchyma.

Figs. 4-6. Tangential section – uniseriate and multiseriate rays.

Figs. 7-9. Radial section – vessels with simple perforations, alternate pitting, vasicentric pitted parenchyma, crystalliferous radial parenchyma.