Romanian Journal of Earth Sciences, vol. 86(2012), issue 2, p. 67-89

New petrified woods from the Curvature Carpathians

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Abstract: A new collection of petrified wood coming from the Curvature Carpathians, Romania, is studied. Some samples have been found in the Oligocene "Kliwa Sandstones Formation" and some others are reworked within the so-called "Salt Breccia" (=Cosmina breccia). Previously, in this area, some pieces of Oligocene petrified wood were described and identified as morphospecies of *Sequoioxylon*, *Laurinoxylon* and *Icacinoxylon*. Also, by the analysis of pollen grains preserved in "the Kliwa Sandstones" from the Colţi area, conifers and angiosperms were identified, indicating for the Oligocene a Mixed Mesophytic forest type. The new petrified woods found have been studied and identified as morphotaxa belonging to Conifers and Angiosperms: *Cupressinoxylon* sp. aff. *Thujoxylon* sp., *Sequoioxylon gypsaceum* (Goepp.) Greguss, *Quercoxylon* sp., *Ulmoxylon* sp. cf. *Ulmus carpinifolia* Gled.

Keywords: petrified wood, amber, Oligocene, Curvature Carpathians.

1 Introduction

A new collection of 10 specimens of Oligocene petrified wood found in the Curvature Carpathians, kept in the collection of the "University of Petroleum and Gas Ploieşti" ("UPG Collection Ploieşti)is taken in study now, defining new areas of petrified wood occurrence in Romania. Some other specimens, one from Colţi area, other two from the "salt breccia" of Lopătari area (both in Buzău county), were added to this study (Figs. 1, 4).

Due to the previous correlation between the Oligocene and Miocene lithostratigraphic units of the Outer Moldavides for the Curvature Carpathians area (Săndulescu et al., 1995), which has been modified by some new researches (Frunzescu and Brănoiu, 2004; Frunzescu et al., 2012), it seems that the Kliwa Sandstone Formation represents the late Oligocene (Figs. 2, 3).

Thus, we have to correct the probable lower Oligocene age given by Petrescu et al. (1989) to the studied assemblage of petrified wood presented in his paper. He identified there some petrified woods found around the Colţi locality, in the Faţa Budei brook and in the Aluniş brook, as *Sequoioxylon gypsaceum* (Goepp.) Greguss (7 specimens), *Laurinoxylon murgoci* Petrescu (1 specimen) and *Icacinoxylon* sp. (1 specimen), all of them quasi-tropical trees. By palynologic analysis, Coniferous pollen grains (30-40%) preserved in the Oligocene sediments as well as in amber: *Podocarpus*(?), *Cupressus*, *Taxodium, Sciadopitys, Picea, Abies, Tsuga* and Angiospermous pollen (42-55%): *Myrica, Engelhardtia, Quercus, Ulmus, Alnus, Nyssa, Carya*, Compositae, Sapotaceae, Palmae) were identified (Petrescu et al., 1989, p. 191), all of them indicating a Mixed Mesophytic Forest – otherwise typical for the Oligocene vegetation within the Carpathian and Transylvanian areas.

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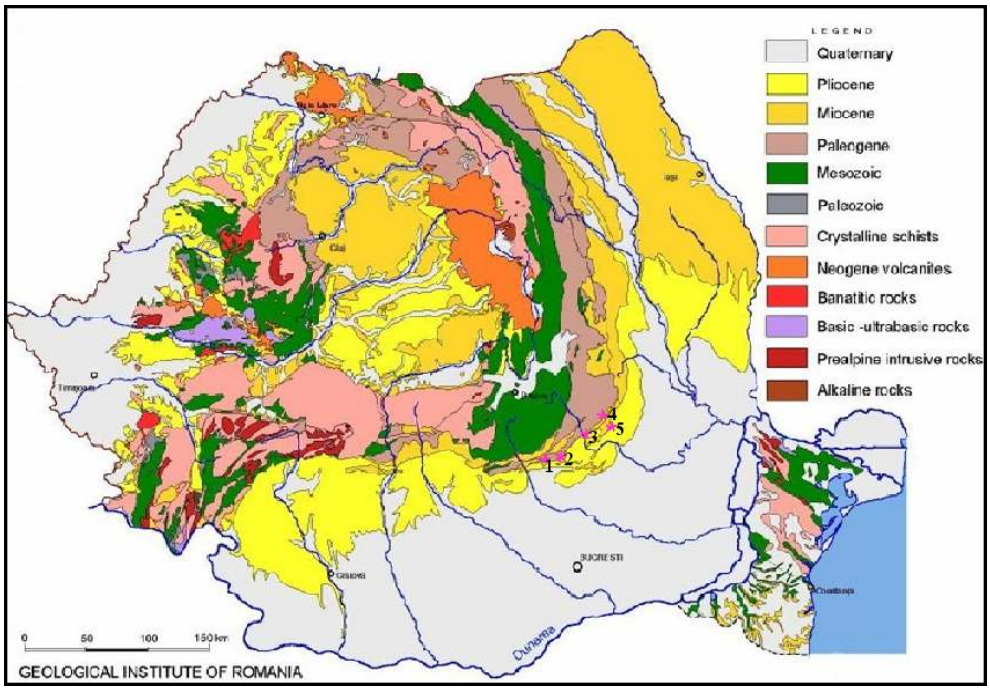

Fig. 1. Localization of samples (*) within the Curvature Carpathians: 1-2 – Zâmbroaia-Slavu-Vâlcăneşti, 3 – Colţi, 4 – Lopătari, 5 – Beceni. (Romania's geological map sketch by GIR).

Tarcău Nape	Marginal Folds' Nape	Subcarpathian Nape	Age
		Conglomerates, sandstones	VOLHINIAN
Telega Formation		Telega fm. / Halos fm.	KOSSOVIAN
Cosmina Breccia (Evaporitic fm)		Cosmina Breccia (Evaporitic fm) *	LANGHIAN
Câmpinița fm. / Slănic tuff		Câmpinița fm. / Răchitașu fm Slanic tuff	
Doftana Formation	Grey Schleir Formation		BURDIGALIAN
	Perchiu Gypsum	Tescani Formation	
Brebu Conglomerates	Hârja Formation	Măgirești Formation / Pietricica's Conglomerates	
Cornu Formation	Condor Sandstone		
Sărata Formation (Lower Gypsum)	Sărata Formation (salt fm)		
Starchiojd Formation	Goru-Mișina Formation (Terminal menilites)		
(Upper Disodiles and menilites)	Starchiojd Formation (Upper menilites)		
Slon Formation: Vinețișu Formation; Buștenari Formation; Podu Morii Formation; Topilele Formation	Upper disodilic schists		AQUITANIAN
Fusaru Sandstone Formation	Kliwa Sandstone Formation *		OLIGOCENE
	Lower disodilic shales		
"Claysh Horizon"	Lower menilites		
	Fierăstrău Sandstone + slates		
	Marls with Globigerines + Lucăcești Sandstone		PRIABONIAN

Fig. 2. Corellation of the Oligocene and Miocene Lithostratigaphic Units of Outer Moldavides within the Curvature Carpathians. (Săndulescu et al., 1995, modified by Frunzescu and Brănoiu, 2004). * - Fossil woods.

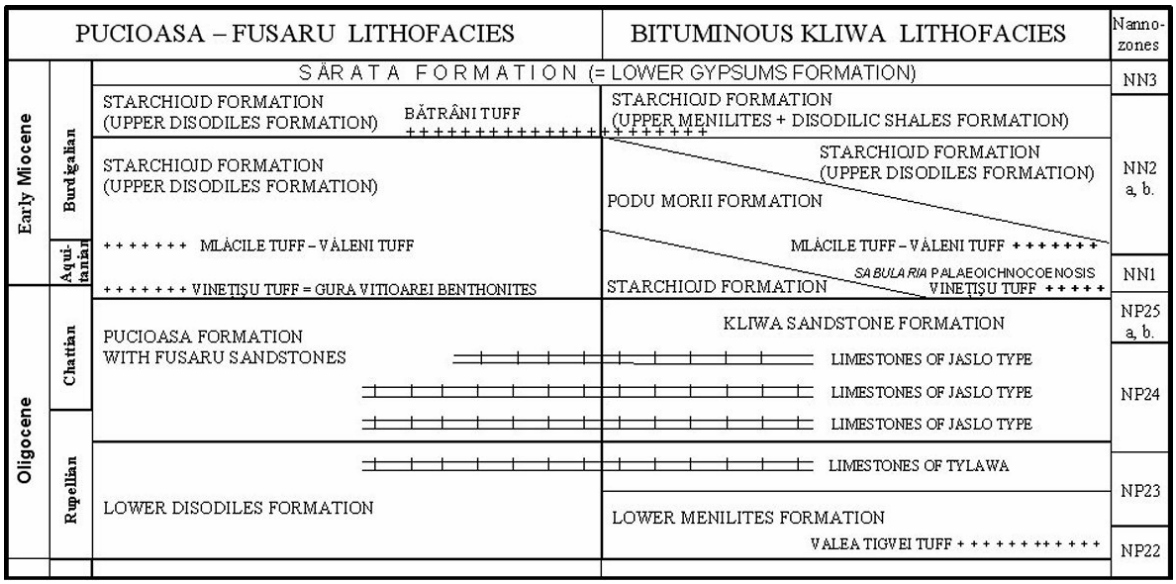

Fig. 3. Corellation of the Oligocene and Miocene Lithofacieses from the Curvature Carpathians (after Frunzescu et al., 2012).

The new found petrified woods were collected from a large area within Carpathians bend from the Oligocene Kliwa Sandstone Formation, to which some reworked samples found within the Miocene so called "Salt breccia" (= Cosmina breccia), which belong to the Evaporitic Formation (Frunzescu and Brănoiu, 2004) were added. These wood pieces definitely could be considered of Oligocene origin, since the "Salt breccia" does not offer any condition for petrifying the wood, and, beside this, the Oligocene blocks are frequently present in it (Fig. 4).

By paleoxylotomical study, the following morphotaxa were identified: *Cupressinoxylon* sp. aff. *Thujoxylon sp.* (6 specimens), *Sequoioxylon gypsaceum* (Goepp.) Greguss 1967 (4 specimens), *Quercoxylon* sp. (1 specimen), *Ulmoxylon* sp. cf. *Ulmus carpinifolia* Gled. (1 specimen), which again, perfectly agree with the typical Oligocene Carpathian vegetation, suggested by Petrescu et al. (1989).

2 Systematics and discussions

Gymnospermae

Phylum **PINOPHYTA** Cronquist (Takht. and Zimmerm., ex Reveal)

Family **CUPRESSACEAE** Rich. (ex Bartling)

Genus ***Cupressinoxylon*** GOEPPERT 1850

Cupressinoxylon sp. aff. *Thujoxylon* sp.

Plate I, figs. 1-9, Plate II, figs. 1-9.

Origin of samples and macroscopic description: Six decimetric or centimetric silicified wood samples, collected from the Curvature Carpathians area were sampled and submitted to a palaeoxylotomical study. These petrified woods, representing pieces from the trunk or thick branch fragments, have brownish to dark-brown color and have fibrous texture, and regular growth rings – suggesting a probable conifer structure. The studied material was sampled from bigger fragments of petrified wood which were found as follows:

1. Sample 2203-3, comes from a small silicified wood fragment, of 9/4/4 cm, locally having coalified furrows, found in the Kliwa Sandstone Formation, in Zâmbroaia area - Prahova county, kept now in the "UPG Collection, Ploieşti" under the number 3.

2. Sample 2207-9 comes from a silicified wood fragment, light brown on surface, sized of 30/12/8 cm, found in the "Salt breccia" (= Cosmina breccia), in Matiţa valley, Zâmbroaia area - Prahova county, kept now in the "UPG Collection Ploieşti" under the number 9.

3. Sample 2208-8 comes from a silicified wood fragment, brown, 85/13/7 cm in size, found in the "Salt breccia" (= Cosmina breccia), in Matiţa valley, Zâmbroaia area, Prahova county, kept now in the "UPG Collection, Ploieşti" under the number 8.

4. Sample 2209-10 comes from a dark silicified wood fragment, brown, 20/14/6 cm in size, found in the "Slavu breccia" (= Cosmina breccia), in Păcureţi-Slavu area - Prahova county, most probably reworked from the late Oligocene), kept in the "UPG Collection Ploieşti" under the number 6.

5. Sample 2206-7 comes from a small calcified wood fragment with ceramic aspect on the surface, of brick color, 18/6/5 cm in size, found in the "Salt breccia" (= Cosmina breccia, closest related to the Evaporitic Formation), in Budureasa area - Prahova county, most probably reworked from the Kliwa Sandstone Formation, kept now in the "UPG Collection, Ploieşti" under the number 7.

6. Sample 2202-1, comes from a small silicified wood fragment, 13/5/8 cm in size, found in the "Salt breccia" (= Cosmina breccia), in Vâlcăneşti area, Prahova county, kept now in the "UPG Collection, Ploieşti" under the number 1.

Fig.4. Studied petrified woods collection of "UPG Collection, Ploieşti", Colţi specimen excluded. Sample 2202-1, (13/5/8 cm), Vâlcăneşti; Sample 2201-2, (36/14/22 cm), Zâmbroaia; Sample 2203-3, (9/4/4 cm), Zâmbroaia; Sample 2200-4, (18/13/20 cm), Matiţa valley, Zâmbroaia; Sample 2205-5, (two pieces: 14/4/4 and 17/8/5 cm), Beceni; Sample 2204-6, (18/6/5 cm), Matiţa valley, Zâmbroaia; Sample 2206-7, (18/6/5 cm), Budureasa; Sample 2208-8, (85/13/7 cm), Matiţa valley, Zâmbroaia; Sample 2207-9, Matiţa valley, Zâmbroaia; Sample 2209-10, (20/14/6 cm), Păcureţi-Slavu; Sample 2211, (26/8/6 cm), Colţi

Microscopic description In the cross section, the growth rings are distinct, the early wood having big quadrangular tracheids, or deformed by compression, and relatively thick-walled (4-6 µm the double wall), progressively thicker to the well developed latewood. The cells lumina have polygonal to rounded corners, the radial/ tangential diameters of 25-60/30-50 µm, in the transitional wood gradually diminishing to smaller, quadrangular, radially flattened (the radial/tangential diameters = 10-20/15-30 µm) and with very thick walled cells (7-10 µm the double wall) in the late wood. The structure is devoid of any resin canal and has 1-13 rows of tracheids between two rays. Tracheidal pitting on the radial walls is especially present, abietinean, usually uniseriate, spaced, rarely contiguous, sometimes with crassulae. The spaced bordered pits are relatively small (10-12 µm), sometimes larger (14-19 µm), with visible

round aperture (3-6 μm). The tracheids usually lean their slightly tapered and terminally rounded ends, changing direction, intersecting the structure close or after ray meeting, generating a very specific aspect.

The axial parenchyma seems to be absent in cross section, but it is thick walled and is difficult to be observed amongst the tracheids. However, rather rarely, it appears in tangential view, having short elements, separated by horizontal or/and inclined transversal walls, fine and smooth or slightly knotted. Also, longitudinally, the cells present glomerules or plugs of resin.

The uniseriate medullary rays, linear in cross sections, are not very tall, having 1-3-8(-13) cells, rarely more. Radially, the rays seem to be homogeneous and are constituted of cells 12-14 μm tall, the marginals slightly taller and with the external wall weakly undulated. The tangential walls are rounded or inclined, and probably knotted. No indentures have been observed, maybe because of the bad preservation. In their cupressoid cross fields, 1-2-4(-6) small cupressoid pits are present, often in vertical pairs, small, rounded, 5-6 μm in diameter and with inclined to vertical lens-like apertures.

Affinities and discussions All these xylotomical observations made on the studied specimens suggest a coniferous, more specific with cupressaceous structure but, unfortunately, due to the relatively badly preserved material, it gave insufficient details to choose between the extant *Juniperus* or *Thuja* or *Chamaecyparis* or other type of structure (Greguss, 1955; Schweingruber, 1991; InsideWood, 2004 - onwards). However, analyzing all these features, it seems that we face a fossil cupressaceous structure closer to *Thujoxylon* genus, but still difficult to identify as a species.

Vaudois and Privé (1971), in their identification key, present these structures of *Thuja* type having "zones d'acroissement distinctes, tracheides a ponctuations radiales abietineénnes uniseriées, parenchyme absent ou rare, a parois transversales noduleuses ou ponctuées, rayons généralement peu élevés, uniseriés, parfois biseriés sur un faible hauteur; champs de croisement contenant 1-4 ponctuations taxodioides, parfois cupressoides, indentures présentes".

Chamaecyparis, a close genus, have instead, a lot of parenchyma, and *Juniperus* have specific "juniperoid nodules" on their inclined tangential walls of ray cells, which are unclear or absent in our specimens, probably due to the bad preservation of the studied material too; hence, our material presents features closer to *Thujoxylon* genus.

Taking into account the revised diagnoses of Kräusel (1949), and the studies of Zalewska (1953), Greguss (1967, 1969), Dupéron-Laudouéneix (1979), it is very difficult to identify our relatively badly preserved specimens at species level. We prefer to attribute our studied material to *Cupressinoxylon* sp. aff. *Thujoxylon* sp., because there it is no identity between the few xylotomical characters observed on our specimens and other already described taxa and, surely, insufficient to describe a new species. Otherwise, due to the bad preservation, the microscopical study on the samples 2206-7 and 2202-1 did not give enough taxonomic details and they could be considered both coniferous wood, most probably, of the same cupressaceous type.

Genus ***Sequoioxylon*** Torrey 1923

Sequoioxylon gypsaceum (Goepp.) Greguss 1967

Plate III, figs. 1-9; Plate IV, figs. 1-9; Plate V, figs. 1-9.

Origin of samples and macroscopic description: four fragments of petrified wood as fragments of trunks or thick branches, having decimetric to centimetric size and brownish to dark-brown color were submitted to palaeoxylotomical study. Macroscopically, all these wood samples are silicified, have fibrous texture and regular growth rings – suggesting a conifer structure and were collected from the Carpathian Curvature area, as follows:

1. Sample 2200-4, was taken from a wood fragment sized of 18/13/20 cm, found in the Kliwa Sandstone Formation (Upper Kliwa Sandtone) of "Văleni Spur", in Matiţa valley, Zâmbroaia area - Prahova county, kept now in the "UPG Collection Ploieşti" under the number 4.
2. Sample 2201-2, comes from a wood fragment sized of 36/14/22 cm, found in the Kliwa Sandstone Formation of "Văleni Spur", on Zâmbroaia hill - Prahova county, kept now in the "UPG Collection Ploieşti" under the number 2.
3. Sample 2211, comes from a black colored trunk fragment of 26/8/6 cm, found in the Kliwa Sandstone Formation, within the Colţi area (Buzău county), kept now in "Colţi Museums Collection".
4. Sample 2204-6, comes from a wood fragment sized of 18/6/5 cm, found in the "Salt breccia" (= Cosmina breccia, closest related to the Badenian Evaporitic Formation), in the Matiţa valley, Zâmbroaia area - Prahova county, and kept now in the "UPG Collection Ploieşti" under the number 6.

Microscopic description In cross section, the growth rings are obviously distinctly present, rather unequal, and marked in the late wood by thick-walled cells, by contrast to the early-wood thin-walled cells. The transition is gradual and no resin duct is present. The tracheids are polygonal in cross section and have their lumina radial/tangential diameters of 30-60(80)/20-60(70) µm, smaller in the late wood, and the walls are of 3-6 µm the double wall to 7-10 µm in the late wood. There are 1-15 radial regular rows between two successive rays. Tangentially few, uniseriate and spaced abietineous pits appear, smaller than in radial view. No helical thickenings can be seen on the tracheids. The radial pitting, typical abietineous, 12-16-19 µm in diameter, with round apertures of 4-6 µm, smaller in the late wood, spaced, arranged in 1-2-3 vertical rows, usually separated by crassulae sometimes presenting small irregularities in the arrangement.

The axial parenchyma – not too visible in cross section, appear in vertical views as rectangular thin-walled cells, with thin horizontal walls rugose or slightly nodular, and with the large balls, dark remains, or plugs or dark resin inside.

Rays usually uniseriate, sometimes with local biseriations, have 1-3-15 or more cells high. The thin-walled ray cells are homogeneous, of 14-18 µm tall, the marginals slightly taller and without indentures. The cross fields have 1-3(4) taxodioid pitting in horizontal rows, pairs slightly diagonal. In the marginal cross fields 1-6 pitting in 1-2 horizontal rows. Pit apertures are elliptical, oblique to horizontal.

Affinities and discussions The xylotomical details of these specimens are typical for the cupressaceous woods, especially of taxodiaceous type, by the presence of radial opposite pitting on 1-3 vertical rows, with obvious crassulae and typical taxodioid pitting in the cross fields (Greguss, 1955; InsideWood, 2004 - onwards). Compared with fossil taxodiaceous genera (Greguss, 1967) we found great similitude with *Sequoioxylon* Torrey and also with *Taxodioxylon* (Hartig) Gothan, presenting many similarities with the extant species *Sequoia sempervirens* L. The distinction between those two genera is problematic enough, since some of the paleoxylologists contest the validity of the genus *Sequoioxylon* Torrey, considering that the diagnosis of *Taxodioxylon* genus is sufficiently comprehensive and the establishment of new competency domains can complicate the fossil wood identifications.

Historically, it must be stressed that the genus *Sequoioxylon* was created by Torrey (1923) on a traumatic fossil wood structure (with traumatic resin ducts) and, for this reason, Kräusel (1949) rejected it. However Greguss (1967) sustained the use of this genus for all the structures related to the extant genus *Sequoia*, characterized by: horizontal walls of the axial parenchyma perfectly smooth, rarely slightly thickened or rugose or very weakly nodular, radial pitting 1-3-seriate with conspicuous crassulae and cross-fields with 1-3 taxodioid

pitting (or slightly podocarpoid, or circular), in a horizontal row, rarely in vertical pairs, more numerous in the marginal fields and in two rows, rarely alternate or slightly irregular. He attributed to this genus the species *gypsaceum, medullare, podocarpoides, germanicum*, and other numerous forms described only as *Sequoioxylon sp*.

Roy and Stewart (1971) have described a *S. gypsaceum* from Cypress Hills Formation (Oligocene, Saskatchewan - Canada), and renamed the *Taxodioxylon gypsaceum* described by Ramanujam and Stewart (1969) from Edmonton Formation (Upper Cretaceous, Alberta - Canada), as *Sequoioxylon gypsaceum*.

The genus name was also used by Petrescu and Popa (1971), and Petrescu (1978) for similar structures described in Romania, with the species *gypsaceum* and *giganteoides*, the last renaming the taxon described by Huard (1966) - equivalent to the extant species *Sequoia gigantea* Decaisne, and also by us (Iamandei and Iamandei, 2000; Iamandei et al., 2001, 2008).

The same kind of wood has been described too, as fossil, under the name *Taxodioxylon gypsaceum* (Goepp.) Kräusel 1949 [=*T. sequoianum* (Mercklin) Gothan 1906]. Huard (1966) showed that this taxon, *Taxodioxylon gypsaceum,* is grouping many diverse forms, all of them equivalent to the extant *Sequoia sempervirens* Endl., and that it was broadly distributed in the Northern Hemisphere (Eurasia and North America) during the Cenozoic.

Similar wood was described as *Taxodioxylon gypsaceum:* by Nagy (1969) - for a specimen found in Northwestern Romania, at Cliţ, in an Oligocene Formation; by Privé-Gill (1977, 1990) for material coming from the Oligocene of Limagne and Razet (Allier, France); by Bugnicuort et al. (1988) for fossil woods found in an Upper Miocene lignite deposit of Capvern, Hautes Pyrénées; by Gottwald (1992) for fossil woods coming from the Eocene of Helmstedt (Germany), and by many others.

Greguss (1967) considered that the name *Taxodioxylon* should remain reserved only to the structures characterized by the presence of numerous nodular thickenings on the horizontal walls of the axial parenchyma, very typical features to the extant genus *Taxodium*. Privé-Gill (1977), quoting Bailey and Faull, warned again about the great variability of the ray characters in the extant *Sequoia*.

However, this taxon is, morphologically and ecologically, different from *Taxodium.* Now, the Cupressaceae familly s.l. comprises also the taxa of the former Taxodiaceous genera with both extant and fossil forms (Gadek et al., 2000; Farjon, 2005), included in the next subfamilies:

- Taxodioideae Endl. ex K.Koch, with *Taxodium, Glyptostrobus,* and *Cryptomeria* genera;
- Sequoioideae (Luerss.) Quinn, with *Sequoia, Sequoiadendron* and *Metasequoia* genera;
- Athrotaxidoideae Quinn, with *Athrotaxis*;
- Cunninghamioideae (Sieb. and Zucc.) Quinn, with *Cunninghamia*;
- Taiwanioideae (Hayata) Quinn, with *Taiwania*.

Since *Taxodioxylon* became a "pocket genus" for already all the taxodiaceous woods, eventually difficult to distinguish from each other, the proposal of Greguss (1967) was followed by many palaeoxylogists. Personally, we stress that the use of the genus *Sequoioxylon* Torrey is correct, legitimate and it represents the fossil correspondent of extant important genus *Sequoia*, since its diagnosis, established by Torrey (1923), was emended by Greguss (1967) who did not considered the presence of the traumatic structures as taxonomic details, as also Ramanujam and Stewart (1969, p. 117) emphasized.

The here studied specimens, devoid of resin ducts, sometimes with local resin tissue – most probably of traumatic origin, with tracheidal abietineous 1-3-seriate pitting, with conspicuous *crassulae*, with axial parenchyma relatively abundant, having resin balls and plugs and horizontal walls usually smooth and thin, with uniseriate rays frequently having biseriate stories and typical taxodioid cross-fields, are very similar to extant *Sequoia* structure, and, after these considerations, we have attributed these

four studied specimens to *Sequoioxylon gypsaceum* (Goepp.) Greguss 1967.

Angiospermae – Dicotiledonatae
Phylum **MAGNOLIOPHYTA** Cronquist, Takht. and Zimerm. ex Reveal
Family **FAGACEAE** Dum.
Genus *Quercoxylon* (Kräusel) Gros 1988
Quercoxylon sp.
Plate VI, fig. 1-9.

Origin of samples and macroscopic description: a fragment of petrified (silicified) wood numbered with the field number 2150, having 7/3/5 cm in size, brownish color, fibrous texture and regular growth rings – suggesting, by the presence of visible large vessels, a dicot. It was collected from the Carpathian Curvature area, in Lopătari (Buzău county), from the so called "Salt breccia" (= Cosmina breccia, closest related to the Evaporitic Formation), most probably reworked from the late Oligocene formation, kept in the GIR Collection – National Museum of Geology, Bucharest, under the number 27.226.

Microscopic description The growth rings are distinct in cross section, defining typical ring porous structure marked by very large vessels in the early wood, round to radial oval, exclusively solitary, in radial rows arranged (or slightly "in flame"), with gradual diminishing, giving a half-ring-porous aspect. The large solitary vessels have the lumina size of 150-350/150-250 µm the radial/tangential diameter, to 70-200/70-130 µm in the late wood, and with 8-16 µm the simple wall thickness. In longitudinal views, the vessels have simple perforations and bordered numerous, spaced, pitted, opposite, subopposite to alternate, surrounded by pitted vasicentric tracheids. Inside the vessels no tyloses have been seen.

The axial wood parenchyma is visible as short tangential uniseriate rows in cross section, is of diffuse or of apotracheal type and scanty paratracheal too, scattered among the libriform or fibrotracheids. In longitudinal sections can be seen as rows of rectangular cells with crystals or grains of tannin or full of dark tannin amongst the elements of ground mass.

The rays of two sizes are present: the uniseriates numerous, medium tall and the multiseriates of aggregate type (up to 22 cells or more) taller than 1 mm usually, dissected by libriform fibers giving typical aspect of aggregate ray. In cross fields with vessels they are obviously homocellular showing cells all procumbent, but pits are not visible, because the ray cells are full of tannin. The ray-cells frequently contain crystals, sometimes with slightly rounded corners.

The mixed ground mass constituted from parenchyma, tracheids and libriform often difficult to identify each other. The libriform fibers with polygonal cross section have unpitted vertical walls and are unsepted. The vascular tracheids are frequent, bordered pitted on the vertical walls.

Affinities and discussions In cross section, the studied material shows affinities with fagaceous wood structure of oak type by its ring-porosity and two-sized rays beside the typical aspect and distribution of the vessels and of the ground tissue. We have seen this, consulting the atlas of Schweingrüber (1991), InsideWood, (2004-onwards), Wheeler (2011), but for a correct generic identification other keys of identification were consulted, as well:

1. Hadziev and Mädel (1962) have separated four structural types of oak wood:
   - Type "Weisseichen" (white oaks), comprising most of the species of section *Lepidobalanus* – having ring porous structure and small, polygonal, thin-walled vessels in the late wood;
   - Type "Roteichen" (red oaks), comprising the species of the section *Eritrobalanus* and some species of *Lepidobalanoideae* – having ring porous structure and relatively large, round, thick-walled vessels in the late wood;
2. Privé (1975), in accord with Hadziev and Mädel (1962) shows that the oak wood is characterized by vessels in radial rows more or less dendritically distributed and showing simple

perforations. She emphasized that two-sized rays (multiseriates very broad and finer, 1-2-seriates) are present in *Quercus* L. and in *Lithocarpus* BL. (= *Pasania* Oerst.) with some tens of species from temperate to warm regions of north hemisphere, islander also and that the diffuse pore distribution characterizes the evergreen species, the ring-porous one is typical to the deciduous species of *Quercus* and the most septentrional species of *Lithocarpus*. In the root wood, the deciduous species often tend to lose the ring-porousness and become porous, similar to the evergreen species, and the broad rays become divided in false rays (aggregate rays).

3. Petrescu (1976) made a good systematization of the xylotomical details of fagaceous wood types, useful as a key of identification for the fossil wood too, presented as follows (Table 1).

4. Suzuki and Ohba (1991) used a comparative synthesis of the essential xylotomical characters of the extant fagaceous taxa, based on the anatomic studies and the phylogenetic relations between the genera of Fagaceae made by Shimanji, which also can be used as a key of genera identification.

Using all those keys we observed that having large vessels, gradually diminishing to latewood, giving an aspect of half ring porous structure, round thick walled vessels in latewood, simple perforations and twosized rays (uniseriate and aggregate thick rays) and crystalliferous ray parenchyma. These structures are similar to extant *Quercus* L. of sempervirent type or *Lithocarpus* Blume, respectively to fossil form-genera *Quercoxylon* (Kräusel) Gros 1988 or *Lithocarpoxylon* Petrescu 1978.

The observed details seem to be insufficient in order to define a morphospecies, while the genus identification is problematic, and we took into account a part of the numerous studies on extant or fossil oaks consulted: Müller-Stoll and Mädel (1957), Brett (1960), Greguss (1969), Nagy and Petrescu (1969), Kramer (1974), Hadziev and Mädel (1962), Huard (1966), Privé-Gill (1975, 1984, 1990), Privé and Brousse (1976); Petrescu (1971, 1976, 1978), Petrescu et al. (1969, 1972, 1974), Starostin and Trelea (1969, 1984), Lupu (1984), Selmeier (1971, 1997), Suzuki and Ohba (1991), Gottwald (1992), Iamandei et al. (2000, 2008a,b,c, 2011, 2012).

We retained the observation of Privé (1975), that the extant genus *Quercus* L. shows a great interspecific anatomic homogeneity, therefore, it is very difficult to delimitate a fossil species, even if it has only a descriptive value, as form-species. In these circumstances we name our studied specimen as *Quercoxylon* sp., as a correspondent of the extant sempervirent type of *Quercus* L. or, possibly to *Lithocarpus* Blume.

Table 1. Key of identification for the Fagaceous fossil wood (after Petrescu, 1976)

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

Family **ULMACEAE** Mirb.
Genus ***Ulmoxylon*** Hofmann 1939
Ulmoxylon sp. cf. *Ulmus carpinifolia* Gled.
Plate VII, fig. 1-9.

Origin of samples and macroscopic description: A reworked petrified wood broken in two pieces (14/4/4 cm and respectively 17/8/5 cm) was found in the alluvial material (pebbles) of Slănic river, in Beceni locality (Buzău county), coming, most probably, from the Badenian "salt breccia" (= Cosmina Breccia), from the Lopătari area. For study, small samples were taken, numbered with 2205-5. The silicified wood probably represents fragments of trunk or of thick branches. It has a regular fibrous texture and obvious annual rings with large vessels in the early wood and broad rays visible by naked eyes, suggesting a dicotyledonate structure. The samples are kept in the "UPG Collection, Ploieşti" under the number 5.

Microscopic description The growth rings in cross section are distinct, since the typical ring-porous structure is marked by very large vessels round to slightly oval in the early-wood (150 - 200/60 - 150µm the radial/ tangential diameters), exclusively solitary and thick walled (of 3-6.5 µm the simple wall). To the latewood, the relatively thick-walled vessels (6-8 µm the double wall) rounded vessels of 20-30 µm appear in tangentially grouped as "ulmiform" bands, of 3-5 cells thick giving a typical "ulmoid structure". In longitudinal views, the vessels have simple perforations and small bordered pitting, opposite, subopposite to alternate, spaced, numerous, with elliptic horizontal apertures. The strongly deformed structure offers few other taxonomic details.

The axial parenchyma – of apotracheal type, appear diffuse, scattered between the other ground tissue elements.

The rays seem to be two-sized: 1-3-seriate, medium tall, and multiseriate (of 4-12 cells wide, or more), taller, usually compact. In the cross fields with vessels numerous small bordered pitting is present. The ray cells seem crystalliferous.

The libriform fibers have polygonal cross section, rounded-shaped lumina, 10–20 µm in diameter, have moderately thick walls of 3-5 µm the double wall, are unpitted and unsepted.

The vascular tracheids are frequent, pitted on the vertical walls with round to elliptic bordered pits.

Affinities and discussions From the cross section, the "ulmiform" distribution of the vessels defining a typical ring-porous structure with two-sized classes of vessels can be recognized, so it is clear that we had in study a member of Ulmaceae familly, unfortunately badly preserved. Studying a Miocene ulmaceous wood from Gleichenberg (Steiermark, Austria) as *Ulmoxylon*, Kaiser (1879) reviewed the species *Cottaites lapidariorum* described by Unger some decades ago, and, probably considering it as type for the genus, he did not design a genus type, fact which now is not accepted (see ING Database: type non designatus). A correct and legitimate taxon name of *Ulmoxylon* was described by Hofmann (1939), almost identical with the wood of *Ulmus* described by Linnaeus two hundred years ago.

Consulting the atlas of Schweingruber (1991), the paper of Greguss (1969), Sweitzer (1971), Wheeler et al. (1989), Zhong et al. (1992), the site InsideWood (2004-onwards), and Wheeler (2011) – we have found a great similarity of the structure of our specimen with the group of the extant *Ulmus carpinifolia* (Soft elm), *U. glabra* (Scotch elm or Wych elm) or *U. laevis* (European white elm or Russian elm), which include themselves several synonyms. However, we found few fossil correspondents already described till now, and we used them for comparison with our here described specimen:

- Hofmann (1939), described from the Tertiary of Hungary a fossil wood structure of *Ulmus campestris* L. type (synonymized now with *U. carpinifolia* Gled.);
- Watari (1952), described from Miocene of Japan an *Ulmus crystallophora* (Watari) Watari;

- Andreászky (1953) shortly described an *Ulmus* sp. also from the Cenozoic of Hungary, similar to *Celtis* or to the fossil form *Ulmus plurinervia* Unger.
- Sacchi Vialli (1958) described from Fontana di Anibale, Casteggio, Italy an"*Ulmuxylon*" (p. 121, figs. 1-10), a wood structure compared with *Ulmus campestris* L.
- Prakash and Barghoorn (1961) described *Ulmus miocenica* and *U. baileyana* from the Miocene of the USA, which seems to have the nearest affinities with the modern *U. americana* L. type and also *U. pacifica* which shows structural resemblance with the modern *Ulmus mexicana* (Liebm.) Planch., as nearest relative species of *Ulmus*.
- Greguss (1969) described *Ulmoxylon* sp. cf. *Ulmus carpinifolia* Gled., and an *Ulmoxylon scabroides* and even if the figures are slightly unclear, the description corresponds and the extant equivalent is *Ulmus scabra* which is a synonym of *U. glabra*.
- Starostin and Trelea (1969) described from the Miocene of Moldavia *Ulmoxylon kersonianum*.
- Petrescu and Dragastan (1971) described from Southern Sub-Carpathians *Ulmoxylon* cf. *Ulmus americana* L.
- Biondi (1981) described from Sibillini Mts. (Central Appennins) *Ulmoxylon marchesonii*, having similar structure with *U. carpinifolia* Gled.
- Lupu et al. (1984) described two sub-fossil woods of *Ulmus* as *U. minor* (Mill.) and *U. laevis* Pall.
- The species described by Sakala (2002) on some fossil wood from Czech Republic as *Ulmoxylon marchesonii* Biondi 1981 has structural details which put it close to the extant species *Ulmus macrocarpa* Hance from North America, to *U. parvifolia* Jacq. from China and to the European common elm *U. carpinifolia* Gled. Otherwise, Sakala (2002) consider for comparison five fossil forms which show rather similar wood pattern: *Ulmus crystallophora* (Watari) Watari 1952, from the Miocene of Japan, *Ulmus baileyana* Prakash and Barghoorn 1961 from the Miocene of USA, *Ulmoxylon kersonianum* Starostin and Trelea 1969 from the Miocene of Moldavia, and *Ulmoxylon* cf. *Ulmus carpinifolia* Gled. from the Mio-Pliocene of Hungary described by Greguss (1969).
- The new species described by Wheeler and Manchester (2007), as *Ulmus woodii* Wheeler and Manchester - similar to the Chinese *Trichoptelea* type and *Ulmus danielii* Wheeler and Manchester - similar to the American *Ulmus lanceifolia* Roxb. *ex* Wall.
- Privé-Gill et al. (2008) described an *Ulmoxylon lapidariorum* (Unger) Felix 1883, considered to be closer to the extant species *Ulmus campestris* L., having similar structure, and gathered under this umbrella several other already described fossil species: *Ulmoxylon* aff. *lapidariorum* (Unger) Felix, of Privé et Brousse, 1969, *U. khersonianum* of Starostin and Trelea, 1969, the species of Sacchi Viali (1958), and others.

Since our studied material, even if is badly preserved, presents a ring-porous structure, two-sized vessels, 1-2 rows of big vessels in the early-wood, simple perforations and alternate pitting on vessels, apotracheal and paratracheal chambered parenchyma and with crystals, broad rays up to 7 cells wide and medium tall, homocelular and with typical pitting in "the cross fields" of rays with vessels, similar details meet at *Ulmus carpinifolia* to which we can confine our specimen and we name it *Ulmoxylon* sp. cf. *Ulmus carpinifolia* Gled.

3 Conclusions

The new collection of Oligocene petrified wood coming from the Carpathian curvature

Table 2. List of Oligocene flora identified within the Curvature Carpathians

No.	Taxon name	Type of fossil	Extant equivalent	Obs.
1	*Taxodium*	Pollen	Bald cypress	Petrescu et al. (1989)
2	*Sciadopitys*	Pollen	Japanese umbrella-pine	Petrescu et al. (1989)
3	*Picea*	Pollen	Spruce	Petrescu et al. (1989)
4	*Abies,*	Pollen	Fir	Petrescu et al. (1989)
5	*Tsuga*	Pollen	Hemlock	Petrescu et al. (1989)
6	*Cupressus*	Pollen	Cypress	Petrescu et al. (1989)
7	*Podocarpus*(?)	Pollen	Fern pine	Petrescu et al. (1989)
8	*Myrica,*	Pollen	Bayberry	Petrescu et al. (1989)
9	*Engelhardia*	Pollen	Tropical tree	Petrescu et al. (1989)
10	*Quercus*	Pollen	Oak	Petrescu et al. (1989)
11	*Ulmus*	Pollen	Elm	Petrescu et al. (1989)
12	*Alnus*	Pollen	Alder	Petrescu et al. (1989)
13	*Nyssa*	Pollen	Black tupelo	Petrescu et al. (1989)
14	*Carya*	Pollen	Hickory	Petrescu et al. (1989)
15	Compositae	Pollen	Aster, daisy	Petrescu et al. (1989)
16	Sapotaceae	Pollen	Tropical trees	Petrescu et al. (1989)
17	Palmae	Pollen	Palms	Petrescu et al. (1989)
21	*Cupressinoxylon* sp. aff. *Thujoxylon sp.*	Petrified wood	Cypress	Iamandei et al., present paper
22	Sequoioxylon gypsaceum (Goepp.) Greguss	Petrified wood	Redwood	Petrescu et al. (1989) and Iamandei et al., present paper
19	*Laurinoxylon murgoci* Petrescu	Petrified wood	Cinnamon	Petrescu et al. (1989)
20	*Icacinoxylon* sp.	Petrified wood	Tropical tree	Petrescu et al. (1989)
23	*Quercoxylon* sp.	Petrified wood	Oak	Iamandei et al., present paper
24	*Ulmoxylon* sp. cf. *Ulmus carpinifolia* Gled.	Petrified wood	Elm	Iamandei et al., present paper

define new areas for petrified wood occurrence, which deserves a special interest because its age and its novelty for Romania.

Our study increases the inventory of fossil taxa given by Petrescu et al. (1989) for the Mixed Mesophytic Forest discovered in the Oligocene deposits of the Carpathian Curvature area, identified by palaeopalynological and palaeoxylotomical studies (Table 2).

The presence of *Taxodium, Cupressus, Podocarpus, Sequoioxylon, Laurinoxylon, Icacinoxylon, Nyssa, Carya*, Sapotaceae div. and even Palms, within the list of taxa from the Oligocene Mixed Mesophytic Forests from the Carpathians suggest a warm palaeoclimate of probably of subtropical type. Beside this, it is a region where the Romanian amber (Rumanit, Romanit) appears within a formation of similar age and a relation is to be searched, since a clear connection of amber and amber-generating trees has never been found, even if some suggestions have been made by Murgoci (1903), Petrescu et al. (1989) and Teodor (2010).

The new collection of petrified woods found in a large area within Curvature Carpathians has been studied and the following morphotaxa were identified: *Cupressinoxylon* sp. aff. *Thujoxylon* sp., 6 specimens), *Sequoioxylon gypsaceum* (Goepp.) Greguss 1967. (4 specimens), *Quercoxylon sp*. (1 specimen), and *Ulmoxylon sp.* cf. *Ulmus carpinifolia* Gled. (1 specimen) which perfectly fit within the typical Oligocene

Carpathian vegetation considered a Mixed Mesophytic Forest of warm temperate climate in an islander area within the Parathetys Sea.

Acknowledgements

The research was supported by the National University Research Council (CNCSIS) through the project ID_441 - contract no. 336/2007 and ID_584 - contract no. 1074/2009, and also by the project "Romanit", sponsored by the National Center of Programmes Management (CNMP) through the contract no. 91-019/2007. This research was presented at the Congress of the Carpathian-Balkan Geological Association, in Tessaloniki, Greece (Iamandei et al., 2010). The manuscript benefited from the comments made by Daniel Ţabără ("Alexandru Ioan Cuza" University of Iaşi) and Valentin Paraschiv (Geological Institute of Romania).

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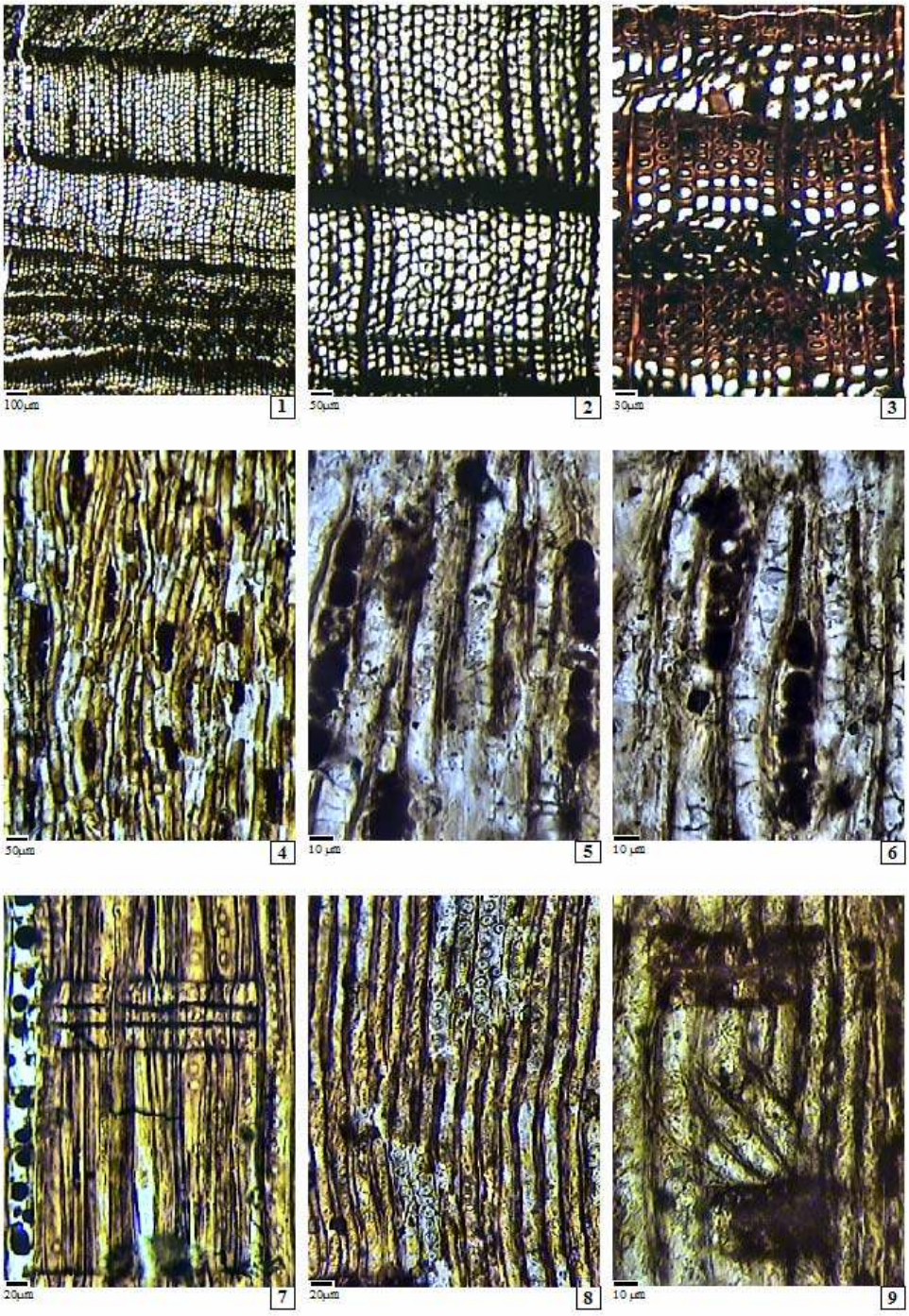
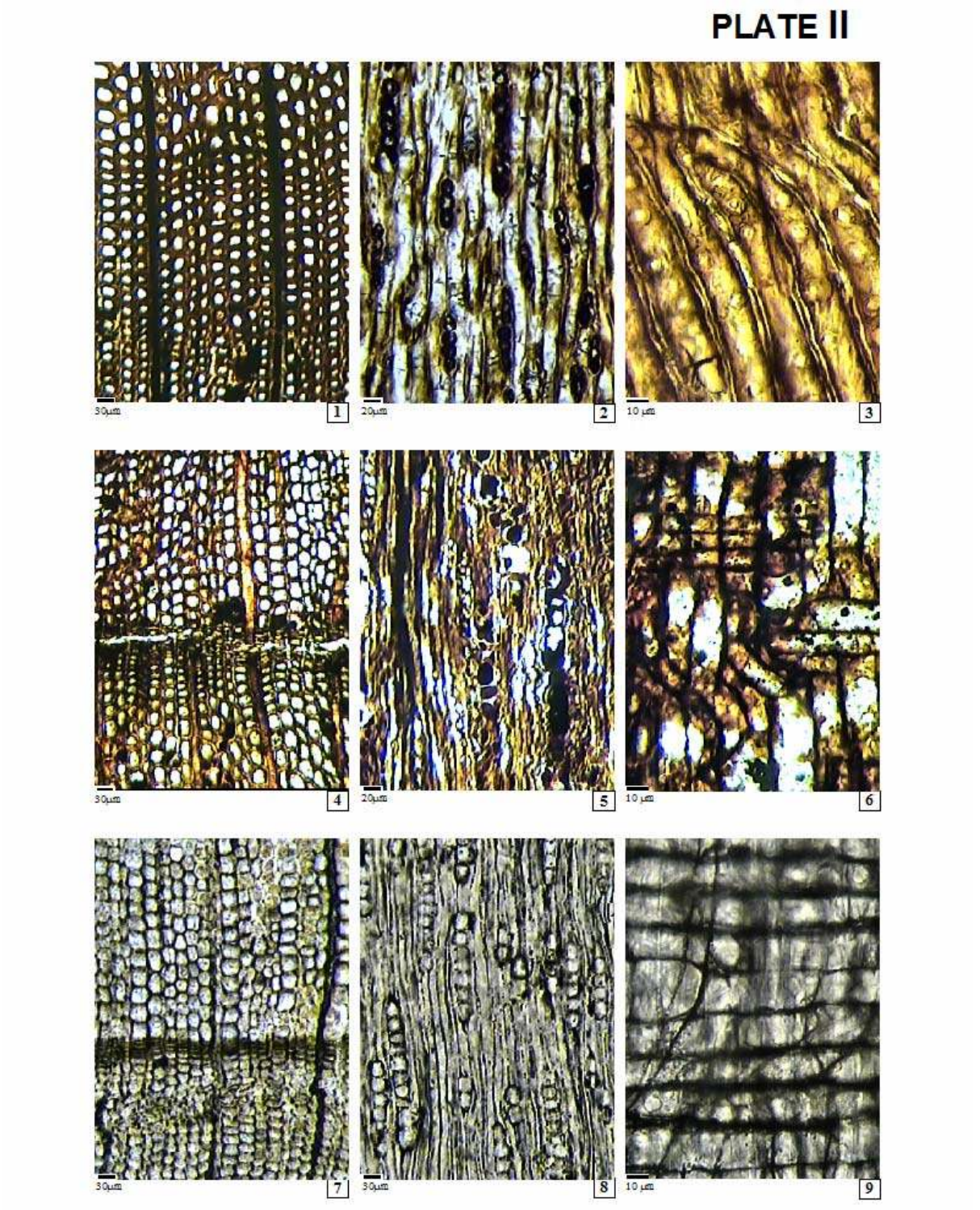
PLATE I



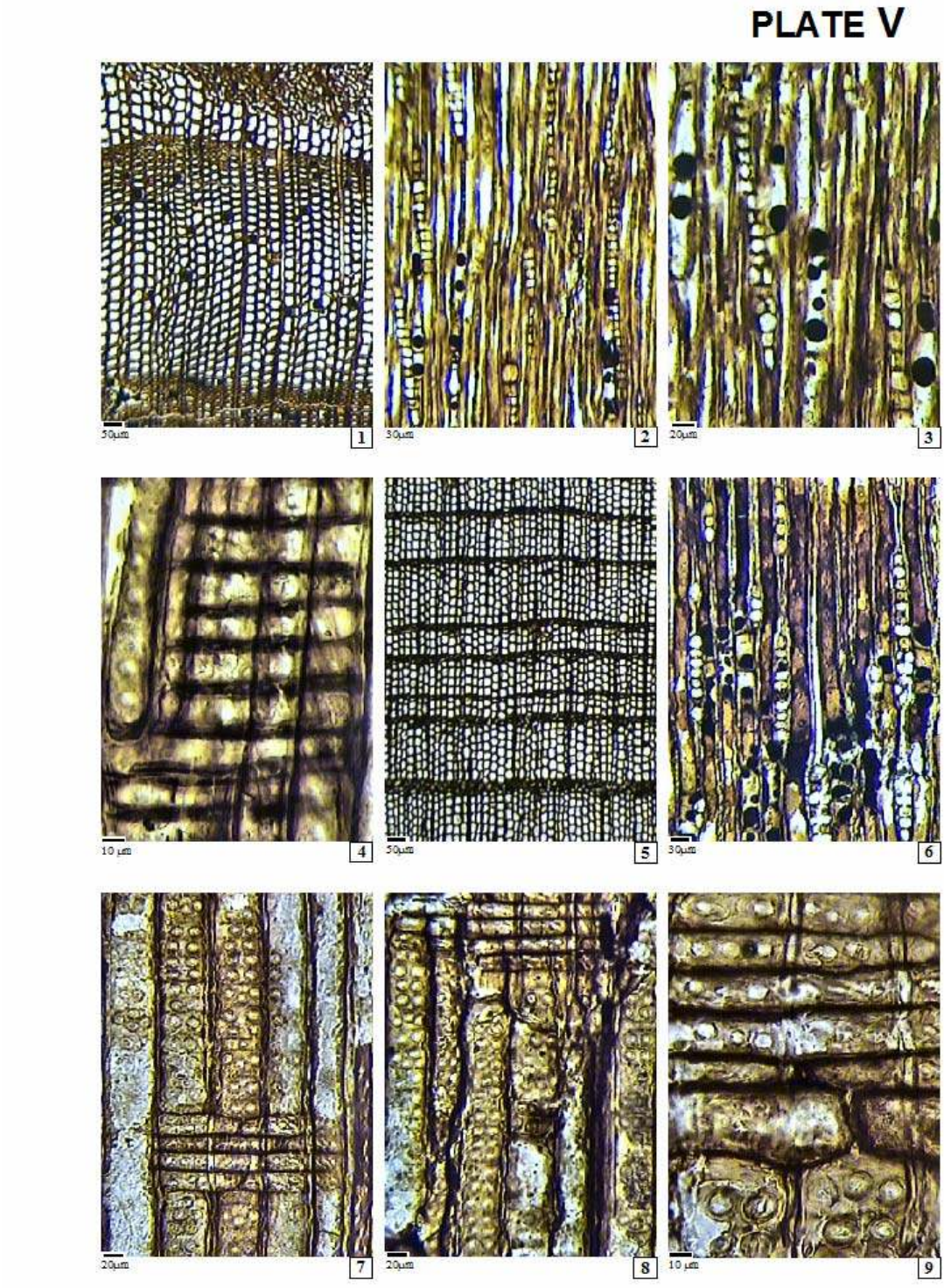
Cupressinoxylon sp. aff. *Thujoxylon* sp., fossil wood from Zâmbroaia (Ph.) - no. 3 in "UPG Collection, Ploieşti". Figs. 1-3. Cross section. Growth rings marked by late-wood thickened tracheids. Few parenchyma cells. Figs. 4-6. Tangential section. Uniseriate short rays. Figs. 7-9. Radial section. Uniseriate radial pitting, cupressoid cross fields, parenchyma with resin balls, leaning tracheidal endings.



Cupressinoxylon sp. aff. *Thujoxylon* sp., fossil wood from Zâmbroaia (Ph.) - nos. 9, 10 and from Păcureţi-Slavu (Ph.) - nr. 8 in "UPG Collection, Ploieşti". Figs. 1, 4, 7. Cross section. Growth rings with relatively thick walled tracheids more thickened in the late-wood. Figs. 2, 5, 8. Tangential section. Uniseriate short rays. Fig. 3, 6, 9. Radial section. Uniseriate radial pitting, leaning tracheidal endings. Badly preserved uniseriate radial pitting and cupressoid cross fields, leaning tracheidal endings.

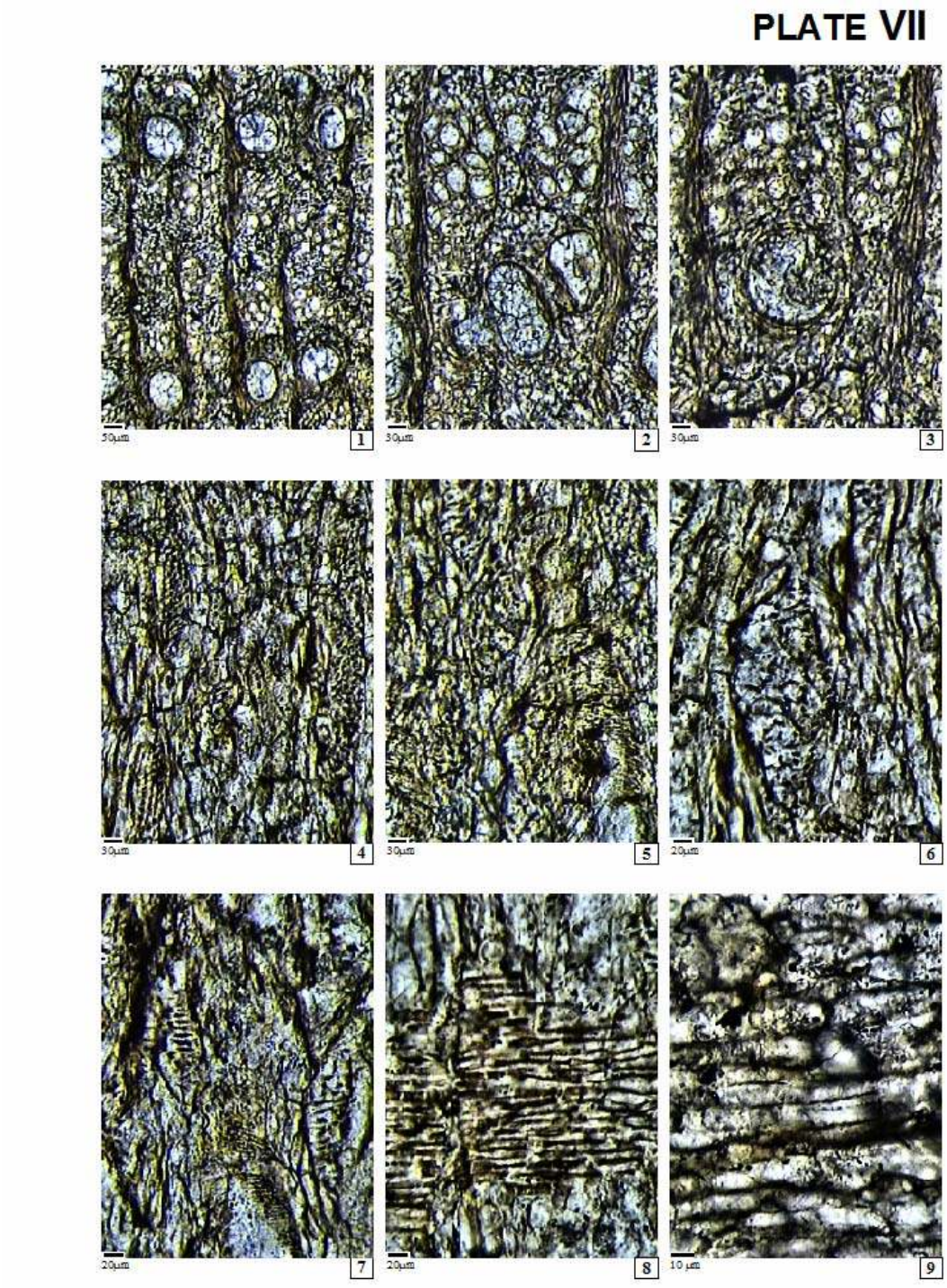
Sequoioxylon gypsaceum, fossil wood from Zâmbroaia (Ph.) - nr. 1 in "UPG Collection, Ploieşti"
Figs. 1-3. Cross section. Distribution of tracheids, parenchyma and rays. Growth rings marked by late wood thickened cells. Figs. 4-6. Tangential section. Uniseriate rays with biseriate storeys, and parenchyma with smooth horizontal walls and resin balls. Figs. 7-9. Radial section. 1-2-3 radial pitting, taxodioid cross fields pitting, axial parenchyma.

Sequoioxylon gypsaceum, fossil wood from Colţi (Bz.) - nr. 1 in "Colţi Museums's Collection".
Figs. 1-3. Cross section. Thinwalled polygonal tracheids in early wood, parenchyma and rays in growth rings which are marked by late wood thickened cells. Figs. 4-6. Tangential section. Medium tall uniseriate rays with biseriate storeys; parenchyma cells with smooth horizontal walls and resin balls. Figs. 7-9. Radial section. Typical taxodioid cross fields pitting, axial parenchyma.



Sequoioxylon gypsaceum, fossil wood from Zâmbroaia (Ph.) - nos. 4, 6 in "UPG Collection, Ploieşti".
Figs. 1, 5. Cross section. Polygonal tracheids in growth rings which are marked by late wood thickened cells. Figs. 2, 3, 6. Tangential section. Tall uniseriate rays with biseriate storeys; parenchyma cells with smooth horizontal walls and resin balls. Figs. 4,7-9. Radial section. 1-2-3 radial pitting, crassulae, taxodioid cross fields pitting, axial parenchyma.

Quercoxylon sp., reworked fossil wood from Lopătari (Bz.) - inv. no. 27.226, in the IGR Collection – National Museum of Geology, Bucharest.
Figs. 1-3. Cross section. Round thick-walled vessels radially arranged, fibers, fibrotracheids, parenchyma and uniseriate and broad rays. Figs. 4-6. Tangential section. Uniseriate and aggregate multiseriate rays, vessels and parenchyma filled with tannin. Figs. 7-9. Radial section. Radial pitting, unclear cross fields blurred by tannin, pitting on vessel, pitting on paratracheal parenchyma.



Ulmoxylon sp. cf. *Ulmus carpinifolia* Gled., reworked fossil wood from Beceni (Bz.) - no. 5 in "UPG Collection, Ploieşti".

Figs. 1-3. Cross section. Distribution of two-sized vessels: 1-2 rows of big, solitary round to oval vessels, and ulmiform bands of small round vessels, and ground tissue of fibers, parenchyma and broad rays. Growth rings marked by late wood thickened cells. Figs. 4-6. Tangential section. Broad rays, vessels and parenchyma rather unclear, in a crushed structure. Figs. 7-9. Radial section. Pitting on vessels, cross fields blurred by tannin.