FOSSIL WOODS FROM BOZOVICI (SW ROMANIA)

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Abstract A palaeoxylotomical study was done on several samples from a private collection of petrified wood found in Bozovici area, which were taxonomically identified. Bozovici area is a small Badenian depression filled by coarse continental deposits, with some interbedded coal and volcanic tuffs. The frequent lateral facies variations and the few fossils of fresh water fauna make difficult a stratigraphic correlation of these deposits. Those samples of fossil wood were identified as remains of *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh and *Spiroplatanoxylon densiradiatum* (Petrescu) Süss and an extended discussion concerning the systematics of these taxa was made. Advanced studies on more numerous samples coming from Bozovici area could contribute to a better palaeoenvironmental and palaeoclimatic reconstruction of that area, during Badenian time.

Keywords: Bozovici depression, Badenian coal, petrified wood, *Glyptostroboxylon*, *Spiroplatanoxylon*.

INTRODUCTION

One of the authors of the present paper (T. Stoia), has organized some outdoor exhibitions in Bocșa and Gărzana localities, (Banat, Romania), with stumps and logs of petrified woods collected from different places in Romania. Some samples collected by him from Bozovici area (i.e. Almăj Depression) were brought to the National Geological Museum in Bucharest, and represent the subject of the present study. In Bozovici Depression occurs a coal-bearing geological formation of Badenian age, preserving numerous remains of coalified wood and sometimes petrified (Iliescu *et al.*, 1967). Since there are no paleoxylotomical studies ever done on this fossil wood, we started a study of these samples in order to get new informations about the composition of the ancient forest involved in the local coal -genesis. In this context, the purpose of the paper is firstly, to identify the petrified wood remains from Bozovici Depression, and also to discuss palaeoenvironmental and palaeoclimatic reconstruction of that region during Badenian time.

GEOLOGICAL SETTING

The Bozovici Depression (also known as Almăj Depression, Fig. 1) is located in South-Western part of Romania, Caraș-Severin county (Fig. 1), in a small Badenian graben, probably initiated during the Early Miocene and is linked, to east, with Caransebeș-Mehadia depression, another tectonic Miocene corridor filled with similar Badenian continental coarse deposits: conglomerates, calcareous sandstones, sands, pebbles, marls, banded clay, interbedded coals and volcanic tuffs (Oprea, 2014). The frequent lateral facies variations and the fossils scarcity (only a few fossils of fresh water fauna was reported) bring difficulties in establishing a precise stratigraphic sequence of those deposits. Even if the region presented interest for coal and also for gold, many years ago (see Pomârleanu & Mârza, 2002), few geological investigations were done in the area.

Fifty years ago, geological prospections in this area, have described a coaly level between Bozovici and Lăpușnicul Mare, on Lighidia and Agrișului valleys. This coaly sub-horizon consists of clay with pyrite concretions overlaying marls and green-greyish or red clay and being overlain by grey-yellowish marls and limestones with *Corbula* sp. and *Terebralia bidentata* Defrance, and a coaly bed presenting numerous silicified tree trunks at its upper part (Iliescu *et al.*, 1967).

The upper sequence, "the Valea Slătinecului Member" (see Fig. 2), has a fluvial-lacustrine aspect, it is well but irregularly developed, having 50-150 m in thickness, and is attributed to the Badenian (i.e. upper part of Moravian +/- basal Wielician), overlaying an unconformity (erosional event) with a basal tuff (=Slătinic Tuff) followed by silty sandstones and clay, and coarser intercalations up to the basal tuffaceous level of Dalboșeț Formation (Codrea, 2002; see Fig. 2). At the upper part of Valea Slătinecului Member some coaly seams of variable thickness (up to 11 m) appear, containing also some petrified tree trunks (marked also by Barbu & Brănoiu, 2018, in Fig.2).

In the same deposits some micro-mammals were described from drilling material (Codrea, 2002). The age of the geological formation supposed to be Early Miocene by Grigorescu (1985), was specified by Petrescu & Nicorici (1989), based on the palynologic study of the drilling Lighidia 6442B. Stratigraphically analyzed, the sporopollenin association from the lower part of the sedimentary succession indicates the Eggenburgian, and suggests also the paleoclimate parameters (mean annual temperatures, MAT = 16-17°C and mean annual precipitations, MAP = 1200-1800 mm).

In the upper part of the succession, the thermophilic species become fewer, while the temperate ones appear and even indications of storeyed vegetation are documented, probably as a result of some landscape modifications by tectonic uplift. The palynologic assemblage was interpreted as indicating the Ottnangian stage (Petrescu, 2003, p. 161-163). The list of flora, suggested by the

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Fig. 1 Geological map of Bozovici Depression (redrawn after Codarcea et al., 1968. Geological maps 1:200,000, Sheet 31 - Reșița and Sheet 32 - Baia de Aramă). Graphic scale.

Fig. 2 Correlated stratigraphic columns in Bozovici Basin (from Iliescu et al. 1967; Codrea, 2002).

sporopollenic study of Petrescu (2003), beside numerous Pteridophytes, possible Cycads and herbaceous Angiosperms - with graminaceous, sparganiaceous, liliaceous taxa, numerous arboreal plants appear. Firstly, some conifers as *Abies*, *Picea*, *Pinus*, *Larix*(?), *Sciadopitys*, and *Sequoia*, some other *Cupressaceae*(?) and, probably some *Podocarpaceae*(?) also appear. Also numerous Angiosperms were indicated - as *Magnolia*, *Myrica*, *Juglans*, *Celtis*, *Engelhardia*, *Carya*, *Platycarya*, *Alnus*, *Betula*, *Carpinus*, *Ulmus*, *Tilia*, *Nyssa*, *Fagus*, *Quercus* and other diverse members of Symplocaceae, Onagraceae, Caprifoliaceae, Elaeagnaceae, Proteaceae, Myrtaceae, Malpighiaceae, Ericaceae, Cyrillaceae, Sapotaceae, Compositae, and even Palms (see Petrescu, 2003, p. 161-163).

MATERIAL AND METHODS

Five samples of petrified wood were collected from Bozovici depression from mid-Badenian deposits from the upper part of Valea Slătanicului Member, Lăpușnicul Mare Formation (see Fig. 2). Two of them can be seen in Fig. 3. The studied material is deposited in the Collection of the National Geological Museum.

From each sample three thin sections of petrographic type after the standard directions, (transversal, tangential and radial) were executed. These sections have been studied under the optic microscope and all anatomical details were described for each specimen. After this, by comparison with previously described similar aspects of extant or fossil wood structures the identification of the unknown tree was performed.

PALAEOXYLOTOMY

Family **Cupressaceae** Gray, 1822 nom. cons. (sensu Farjon 2005b)

Subfamily **Taxodioidae** Endl. ex K.Koch, 1842

Genus **Glyptostroboxylon** (Conwentz) emend. Dolezych et Van der Burgh, 2004

Glyptostroboxylon rudolphii Dolezych et Van der Burgh, 2004

Fig. 4, a-i. Fig. 5, a-i.

Macroscopic description

The studied material is represented by four samples of petrified wood: three centimetric-sized samples and one of them as a big slice cut from a silicified trunk (Fig. 3). All of them indicate a partially coalified wood and then silicified, showing dark color, fibrous texture and quasi-regular growth rings visible with the naked eye, suggesting a conifer structure. Standard oriented thin sections were made and microscopic study was done on four samples. The studied material is deposited in the Collection of the National Geological Museum (NGM Col. Bucharest) under the indicative numbers: 27,618; 27,619; 27,620 and 27,621 (in Fig. 3).

Microscopic description

The growth rings in cross section seen are distinct, broad, but rather unequal in width.

The transition from earlywood to latewood is gradual. The boundaries of the annual rings are distinct, marked by 3-15 tangential rows of thick-walled to very thick-walled and smaller cells of the latewood. There are no normal axial resin ducts and the ring boundaries are often wavy, probably due to the buttressed form of trunk.

The tracheids are polygonal in cross section, with slightly rounded corners in the earlywood and with radial/tangential diameters of 25-75/30-55 μm , smaller in the latewood, of 25-30/17-25 μm . The tracheidal wall has 5-10 μm in the early wood, growing to 12-17 μm the double wall, in the latewood. There are 2-11 radial regular rows between two successive rays. On the tangential walls there are few, uniseriate, spaced or slightly irregular abietineous small bordered pits, of 6-8-10 μm in diameter, with small circular apertures, or vertical elliptic. The radial pits is opposite, typical abietineous, of 12-16 μm in diameter and smaller in the latewood, in 1-4 vertical rows, spaced or contiguous, sometimes presenting small irregularities in their arrangement. Crassulae are occasionally present. No helical thickenings were seen on the tracheids.

The axial parenchyma is few, dispersed, less visible in cross-section, since not always has dark content and it appear similar to tracheids. In vertical view it appears as rectangular thin-walled cells (1-3 μm the simple wall), with thin terminal (horizontal) walls smooth, slightly rugose or nodular, with 1-3 nodules. Inside, it has large dark resinous balls, or plugs with rounded endings, sometimes with convex empty spaces, or as small remains.

The rays are usually uniseriate, sometimes with local short biseriations or even biseriate, having 2-15-36 or more cells in height. Sometimes, they seem to be heterogeneous in tangential view, with often unequally sized cells, either higher, or wider (as wide as two cells when occur in biseriate rays), and have lateral intercellular spaces. Ray density is 4-8 rays per horizontal tangential mm and up to 40 rays per square mm. In radial view, the procumbent ray cells have thin and smooth horizontal walls of 2-3 μm , height of 12-17 μm or more, the marginals are slightly taller (of 20-35 μm) and have wavy outer wall. Ray-tracheids are not present. The tangential walls are slightly nodular, and indentures were not observed. The earlywood cross-fields have 3-4 glyptostroboid, sometimes taxodioid pits, but with much reduced borders, like cupressoid type, of 8-10 μm , arranged in horizontal rows, or in slightly diagonal pairs, or single in the late-wood cross-fields. In the marginal cross-fields, up to 8 pits in 1-2 horizontal rows were observed. The pit apertures are nearly round or elliptical oblique.

Affinities and discussions

The synthetic description of these specimens provided xylotomical details typical for the cupressaceous woods, especially of „taxodiaceous“ type, by the absence of the resin ducts, the shape of the tracheids, their size and wall thickness, the ray aspect in longitudinal sections, especially the presence of radial opposite pitting on 1-4 vertical rows, with crassulae on tracheids, and the cross-fields with typical glyptostroboid pitting, tending sometimes to taxodioid or even cupressoid aspect. These observed details have been compared with extant and fossil published

Fig. 3 Two of the studied samples (nos. 27621, 27622).

structures of Cupressaceae of taxodiaceous type (Greguss, 1955; Visscher & Jagels, 2003; Dolezych & Van der Burgh, 2004; InsideWood, 2004 – onwards).

The family Cupressaceae s.l., beside the classical cupressaceous members (Callitroideae and Cupressoideae), comprises now all the members of the former „taxodiaceous“ genera, with both extant and fossil forms (Gadek et al., 2000; Farjon, 2005, 2017), included in the next subfamilies:

- Taxodioideae Endl. ex K.Koch, with *Taxodium* Rich., *Glyptostrobus* Endl., and *Cryptomeria* D.Don;
- Sequoioideae (Luerss.) Quinn, with *Sequoia* Endl., *Sequoiadendron* J.Buchholz and *Metasequoia* Hu & W.C.Cheng;
- Athrotaxidoideae Quinn, with *Athrotaxis* D.Don;
- Cunninghamioideae (Sieb. and Zucc.) Quinn, with *Cunninghamia* R.Br.;
- Taiwanioidae L.C.Li, with *Taiwania* Hayata.

Comparing the anatomical structure of the studied material with fossil "taxodiaceous" genera (Greguss, 1967) we found some similarities with *Sequoioxylon* Torrey, 1923 with *Taxodiooxylon* (Hartig) Gothan, 1905 but especially with *Glyptostroboxylon* Conwentz, 1884. The distinction between those three genera is problematic enough, since some paleoxylologists contest the validity of the genus *Sequoioxylon* Torrey, considering that the diagnosis of *Taxodiooxylon* genus is sufficiently comprehensive and the establishment of new domains of competence can complicate the fossil wood identification (Privé-Gill, 1977).

A more recent revision of the fossil cupressaceous morphogenera (Dolezych & Van der Burgh, 2004) resulted in new revised diagnoses of them. Since it appears to be more similar to our material, we reproduce here only the diagnosis of the genus *Glyptostroboxylon* Conwentz, 1884, as is emended by Dolezych & Van der Burgh (2004):

Coniferous wood with distinct growth rings. Tracheids in the earlywood wider than in the latewood. On the radial walls of tracheids, pits in 1–3(4) vertical rows. Wood parenchyma with thin and smooth to moderately thick and pitted terminal (horizontal) walls. Rays are homoge-

neous, mostly uniseriate. Cross-field pits in the earlywood are predominantly glyptostroboid, but also some cupressoid and taxodioid pits may be present.

In our studied specimens, the pattern of tracheids within the growth-rings, their radial abietineous pitting, spaced arranged in 3-4 vertical rows on wider earlywood tracheids, in 1-2 rows on the narrower latewood tracheids, the presence of axial parenchyma with smooth to quite nodular horizontal walls, the homogeneous, mostly uniseriate rays, sometimes with biseriate storeys or even as biseriate rays, the ray-cells with tangential walls slightly rugose, sometimes nodular, and the cross-fields with 1-4 glyptostroboid (and taxodioid) pits - more numerous, on two horizontal rows, in the marginals - represent a combination of features very similar to those described by authors for *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh, 2004 and, obviously, with the species diagnosis. As it was shown by Dolezych & Van der Burgh (2004) in their revision, *Glyptostroboxylon tenerum* (Kraus) Conwentz, 1884 was the initial basionym for the genus (its first name was *Glyptostrobus tener* Kraus, 1864). It was taken later again in discussion by Seward (1919, p. 198) and Jurasky (1933), but only Kräusel (1949) was the one who established the correct name, in respect of ICBN Rules, however noting the wide variability of the glyptostroboid pits, up to the cupressoid, in the cross fields.

Now, *Glyptostroboxylon tenerum* is interpreted as fossil wood of *Cunninghamia*, because Gothan (1905) and later, Rudolph (1935), Watari (1948), Süss & Velitzelos (1997) and Fairon-Demaret et al. (2003) have also observed affinities between the wood of *Glyptostroboxylon tenerum* and the one of the extant *Cunninghamia*, and Dolezych & Van der Burgh (2004), after a new investigation on the original material from Wetterau, the type-locality, have observed that the affinity of this wood is not to *Glyptostrobus*, but clearly to *Cunninghamia*. Thus, they have described a new species of *Glyptostroboxylon* (*G. rudolphii*), emending also the genus' diagnosis and taking it as basionym. The species name come from the name of a scientist who, they say, firstly discussed the affinity of the fossil to the recent wood of *Cunninghamia* vs.

Fig. 4 a-i. (graphic scale, μm). *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh 2004, Bozovici, Romania.
a-c. Cross section – distinct growth rings, earlywood and latewood tracheids. **d-f.** Tangential section – uniseriate and biseriate rays, parenchyma with resin plugs and smooth or nodular terminal (horizontal) walls. **g-i.** (radial section) – up to 4-seriate radial pitting on tracheids, 1-4 pits cross fields (i), or 2-8 in marginal cross fields (i).

Fig. 5 a-i. (graphic scale, μm). *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh 2004, Bozovici, Romania.
a-c. (cross section) - earlywood and thick-walled latewood tracheids, wavy growth rings. **d-f.** (tangential section) – uni- and biseriate rays, parenchyma with resin plugs and nodular terminal (horizontal) walls. **g-i.** (radial section) – radial 1-3-4 seriate pitting on tracheids, 1-3-4 pits cross fields, more in marginal cross fields.

Glyptostrobus (Rudolph, 1935), observing that the pits in cross-fields of the fossil wood are glyptostroboid and taxodioid, in a random distribution.

The newly described species, *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh, 2004 represents, most probably, the fossil wood of *Glyptostrobus europaeus* (Brongniart) Unger, described on the basis of adpressions of shoots, leaves and cones, and frequently found in the European Cenozoic formations (see Greguss, 1967; Hofman, 1952; Ramanujam, 1960; Zalewska, 1953).

An interesting discussion is made by Teodoridis & Sakala (2008), who observed that there is a disproportion between abundant leaves and cones/seeds of *Glyptostrobus* in the Most Basin (Czech Republic) and only one specimen of fossil wood found preserved as xylite rather difficult to identify, attributable to this genus, traditionally considered as the main coal-generating element: “association of *Glyptostrobus*” sensu Kvaček & Buzek (1982) (in Kvaček, 1999; Teodoridis & Sakala, 2008, p. 307).

As information, the monotypic extant genus *Glyptostrobus pensilis* (Staunton) K. Koch, named Shui Song (water pine), or Chinese deciduous cypress, or Canton water pine, is a not very tall tree, of relatively warm and wet climate, which can resist in colder climate too, having deciduous shoots. Even if it lived in Europe during the Cenozoic as an important coal-generator tree, maybe as an eco-form adapted to a wet environment, like peat-bog, the extant biogeographic areal of *Glyptostrobus* is very restricted, in some low, damp and riparian areas, in South-east China (Guangzhou) and Vietnam (Greguss, 1955; Earle, 1998). It appears also in Japan and in the West part of North America, as Jim Basinger, Professor of Saskatchewan University - Canada observed, and sent us this information (written comm., 1998): “I have seen it growing in the United States, Japan, and China. Living trees are generally found in relatively warm climates. In southern China (Guangzhou) the trees are semi-deciduous. Some foliage is retained all year. In cooler climates, it will be entirely deciduous. This is the case in the mid-western United States and in Japan. In the fossil record, for instance in the arctic fossil floras we have worked with, it appears that the trees were entirely deciduous. I believe that the conflicting reports on the evergreen or deciduous character of *Glyptostrobus* were the result of observation of trees under different climatic regimes”.

After the revision and emendation of *Glyptostroboxylon* genus, new specimens were described and other revised as *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh, 2004:

- Teodoridis & Sakala (2008) studying a fragment of sideritized wood from Bílina Mine, from the Most Basin, described *G. rudolphii*, as having crassulae, large intercellular spaces between ray-cells and cross-field pits exclusively glyptostroboid.

- Vassio et al. (2008), described *G. rudolphii* from Middle Pliocene, studying *in situ* stumps from Stura di Lanzo right riverbank, NW Italy, based on their typical features, especially the presence of exclusively glyptostroboid cross-field pits.

- Dolezych, in Erdei et al. (2009) studying xylotomically stumps from the Miocene Fossil Forest of Bükkábrány

(Hungary), described wood structures comparable to *Glyptostroboxylon* Conventz emend. Dolezych and Van der Burgh, having similar cross-field pits. Such an idea is confirmed also by the presence of the organic-rich sediments underlying and embedding the stumps, which provided a high abundance of *Glyptostrobus Endlicher* wood remains, foliage, cones and seeds.

- Gryc & Sakala, (2010), took again in study some woods from the Miocene opencast lignite mine of Bükkábrány (Hungary), exposed in the Visitor Centre of the Ipolytarnóc Fossils Nature Reserve, and described *Glyptostroboxylon rudolphii*, having cross-field pits mainly glyptostroboid.

- Havelcová et al. (2013) described *G. rudolphii* from the Stump Horizon in the Bílina open cast mine (Czech Republic), having typical details.

- Koutecky & Sakala, (2015) described *G. rudolphii* also from Doupovské hory, Czech Republic, having glyptostroboid and taxodioid pits (1–2, occasionally up to 4) in cross-field, and rays up to 12 cells high.

Some forms of *Glyptostroboxylon* previously described, could be reassigned to the real equivalent of *Glyptostrobus*, i.e. *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh (2004), since they are characterized mainly by glyptostroboid cross-field pits.

- Thus, the species described by Kostyniuk (1938), as having oval or round and glyptostroboid pits in cross-fields, clearly agree with *G. rudolphii*, to which it could be reassigned.

- Iamandei et al. (2001), described a specimen from the Early Sarmatian from Leucușești – Fălticeni, North-eastern Romania as *G. tenerum* which could be reassigned too, as *G. rudolphii*, having also glyptostroboid cross-fields.

- Nagy et al. (2002) described *G. tenerum* from the late Badenian deposits of Právěleni (South Apuseni Mountains), which can be reassigned to *G. rudolphii*.

- Recently, Akkemik et al. (2017) published the first *Glyptostroboxylon* from central Turkey, and then Akkemik et al. (2019) identified *G. rudolphii* from another site of central Turkey based on the nearest features such as 2-5 pits per cross-field, predominantly glyptostroboid, but also taxodioid and apparently higher ray height.

Therefore, taking into account the entire discussion and the affinities of our studied specimens, found at Bozovici area, we think they could be attributed to the species *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh, 2004, probably representing fragments of trunk or thick branches, as the size of the tracheids and of the ray cells show, which is also in accord with the observations on the annual rings.

Family **Platanaceae** Lestiboudois, 1826 (ex Dumortier, 1829), nom.cons.

(APG III 2009, APG IV 2016)

Genus *Spiroplatanoxylon* Süss, 2007

Spiroplatanoxylon densiradiatum (Petrescu) Süss, 2007

Fig. 6, a-i.

Fig. 6 a-i. (graphic scale, μm). *Spiroplatanoxylon densiradiatum* (Petrescu) Stüss 2007, Bozovici, Romania.
a-c. (cross section) – distinct boundary of growth ring, diffuse-porous wood structure, ray dilatations at boundaries. **d-f.** Tangential section – two-sized rays - fine and multiseriate (**d**), spiral thickenings on vessels (**f**). **g-i.** Radial section – badly preserved scalariform perforation plates (**h**), round simple pits in cross fields.

Macroscopic description

A decimetric sized sample of petrified trunk (Fig. 3), displaying whitish color, fibrous texture and regular growth rings, was submitted to palaeoxylotomical study. From it, thin sections standard oriented were realized and a microscopic study was performed on them. The studied material originates in Bozovici depression, coming from mid-Badenian sediments (upper part of Valea Slătanicului Member of Lăpușnicul Mare Formation), and is deposited in the National Geological Museum Collection (NGM Col., Bucharest) under the number 27,622.

Microscopical description

The growth rings are clearly distinct and the wood structure is diffuse-porous to semi-ring-porous. The multiseriate rays present typical dilatations at ring boundaries.

The vessels in cross section seen appear as solitary pores or as tangential pairs or diagonal or in clusters. They have angular section, slightly rounded or even deformed, and have moderately thick walls, of 7-10 μm the double wall. The woody fascicles, may have tangentially, between two rays, 1-6 vessels. In the early-wood the vessels are mean-sized, their diameters ratio (r/tg) is of 40-95/30-63 μm . Their relatively uniform size is gradually diminishing, in the late-wood, to (20)30-40/(15)20-30 μm , so defining a diffuse-porous wood, tending to semi-ring-porous. The density of the vessels is 115-130 per square mm. In radial section, scalariform perforations can be seen, on tilted plates, with 18-24 thin bars, quite poorly preserved. The walls of the vessels present bordered pits, opposite, horizontally elongated, to scalariform by apertures' coalescence, and are rather badly preserved. Helical thickenings are also present, visible especially in tangential section. The length of vessels elements is difficult to measure. No tyloses were observed inside the vessels. Sometimes clusters of vascular tracheids appear, with similar pits, like on vessels.

The wood parenchyma appears in cross section of apotracheal type, diffuse, and appear scattered cells among the fibres, or as uniseriate short lines. In longitudinal view appear as strands of rectangular parenchyma cells, empty or with crystals inside, probably with simple pits on walls, quite poorly preserved. Vessels' elements length is difficult to measure.

The rays, in cross section appear two sized, show linear trajectory, and are formed by rectangular cells. The multiseriate rays have typical platanoid dilatations at growth ring boundaries. In tangential view they appear clearly twosized, of 1-4 and 8-12 cells wide, the multiseriate are fusiform and compact, have cell-sheath and are usually tall, having up to 30 cells in height, or more. The body ray cells are slightly polygonal, and unequally sized and relatively thick-walled, and the uniseriate ray-endings have 1-5 slightly polygonal cells. The ray-density is of 7-12 rays on tangential horizontal mm. In radially view the rays are heterocellular, having procumbent body-cells and marginals square or taller. In cross-fields, poorly preserved glyptostroboid pits appear. Sometimes, secretory cells appear, often bearing crystals.

The fibres are angular in cross section, with rounded lumina and thick walls. Poorly preserved pits on the longitudinal walls were observed.

Affinities and discussions

After evaluating the microscopical features observed in our specimen regarding the diffuse-porous pattern of the pores in cross-section, typical dilated rays at growth-ring boundary ("platanoid dilatations"), typical pitting on vessels and on vascular tracheids and scalariform perforations and, also, the presence of helical thickenings, even poorly preserved, we found some generic similitudes with the platanaceous structure (Greguss, 1969).

There are three fossil genera created for platanaceous fossil woods: *Plataninium*, *Platanoxylon* and *Spiroplatanoxylon*.

The genus *Plataninium* has a long history: it was created in 1842 by Unger (published in Endlicher, 1842) as a "pocket taxon" for platanoid broad-rayed fossil wood, not illustrated but with a very comprising diagnosis based on the type-species *P. acerinum* Unger, described on a fossil wood coming from an unknown horizon and locality (see Crawley, 1989). It was emended by Vater (1884), unifying the diagnoses of *Phegonium* (or *Fegonium*) Unger, and *Plataninium* Unger. It was emended again by Felix (1894) and, later, by Page (1968), in order to comprise members of the families Fagaceae (*Fagus* type), Platanaceae (*Platanus* type), Eupteleaceae (*Euptelea* type) and Icacinaceae (*Citronella*, *Ottoschultzia* types), for specimens difficult to be assigned. After few times its diagnosis was emended again by Brett (1972) who admitted it as morphogenus, attributing to it four species: *Plataninium decipiens* Brett, 1972; *P. europeum* Prakash, Březinová et Bůžek, 1971; *P. haydenii* Felix, 1896; *P. brettii* Crawley, 1989. Some years later, Süss and Müller-Stoll (1977) consider *Plataninium* an inutile, ambiguous name that has to be invalidated.

Therefore, this name was several times subject of revision or dispute, some species being redescribed as belonging to other genera, for example: *Plataninium subaffine* Vater, 1884, that became *Hedycaryoxylon subaffine* (Vater) Süss, 1960; or *Plataninium aceroides* (Goeppert) Windisch, 1886, that became *Fagoxylon acerinum* (Windisch) Süss, 1986; or have been replaced by names as *Platanus*, *Platanoxylon* or *Spiroplatanoxylon* (see Edwards and Jogmans, 1931; Süss, 1960, 1971, 1986, 2007; Süss and Müller-Stoll, 1977).

The name *Plataninium* is still used by some American, Asian and even European scientists, and considered as a primitive type. This supports the Bayley concept regarding the evolution of the xylotomic features (see Süss, 1960) from *Plataninium*, which has scalariform perforations, spiral thickenings, marked heterocellular rays, to *Platanoxylon*, as an evolved type, which has simple perforations, no spiral thickenings and homocellular rays (Selmeier, 1996). Anyway, now *Plataninium* is usually described from sites with platanoid leaves from Cretaceous to Eocene of North America, Paleogene from Japan and even Upper Cenozoic in Europe (see Taylor & Taylor, 1993). We cite here some species described in the last decades under the genus name *Plataninium* Unger (in Endlicher) emend. Vater, 1884:

- *P. obbruxellense* Stockmans, 1936, described from the Eocene of Belgium. Specimens from Apuseni Mountains described as *Platanoxylon* cf. *obbruxellense* (Stockmans) Petrescu, 1969 and by Petrescu and Lazăr (1970) as having a slightly disordered structure, small pores, scalariform perforation plates and relatively thin rays.

- *P. californicum* Page, 1968 and *P. platanoides* Page, 1968 described from Cretaceous deposits of California.

- *P. decipiens* Brett, 1972, is also described by Crawley (1989), and by Poole et al. (2002) from similar Paleogene deposits (Eocene London Clay) of south-east England, and by Meijer (2000) from the Late Cretaceous of Belgium.

- *P. brettii* Crawley, 1989, is described on a badly preserved specimen, from Paleocene of Great Britain - Inner Hebrides.

- *P. piercei* Wheeler, McClammer et LaPasha, 1995, described from deposits of terminal Cretaceous to Paleocene of San Juan Basin, New Mexico, North America.

- *P. jezoensis* Takahashi et Suzuki, 2003 and *P. ogasawarae* Takahashi et Suzuki, 2003, described from Cretaceous of Japan.

The morphogenus *Platanoxylon* Andreánszky, 1951 (ex Prakash et al. 1971) was also subject of revision and dispute, at least in the last time (Süss & Müller-Stoll, 1977; Süss, 2007, with references). After all these, a clear diagnosis has to separate the three admitted genera of fossil plants. Hence, after the revision of Süss (2007), some already described species were assigned to this morphogenus (Selmeier, 1996 considered it as organ-genus!) as it follows:

- *Plataninium haydenii* Felix, 1894, *P. pacificum* Platen, 1908 and *P. crystallophilum* Platen, 1908 were revised to *Platanoxylon haydenii* (Felix) Süss et Müller-Stoll, 1977, *Platanoxylon pacificum* (Platen) Süss et Müller-Stoll, 1977, and respectively to *Platanoxylon crystallophilum* (Platen) Süss et Müller-Stoll, 1977.

- Moreover, six species were validated by Süss et Müller-Stoll (1977) as correctly attributed to *Platanoxylon*: *P. andreánszkyi* Süss et Müller-Stoll, 1977, *P. hungaricum* Süss et Müller-Stoll, 1977, *P. palibacsi* Süss et Müller-Stoll, 1977, *P. sarmaticum* Süss et Müller-Stoll, 1977, *P. catenatum* Süss et Müller-Stoll, 1977, also described by us in the South Apuseni Mountains (Iamandei & Iamandei, 2000), and *P. cohenii* (Schuster) Süss, 1980, adding other generic identification as *Platanoxylon* sp., described from Hungary, Czech Republic and Germany by Andreánszky (1952), as belonging to *Platanoxylon*, according to Selmeier (1996, 2001) and Gottwald (2000). Also, the specimen described by Petrescu & Vasiliu (1987) from Romania is a *Platanoxylon*.

After a special interest accorded to this type of fossil wood by Süss (2007, with references), a new taxon was created, „aus dem Tertiär von Europa und Vorderasien“, *Spiroplatanoxylon* Süss 2007, which is characterized, beside the plane-like wood structure, by two aspects considered more primitive, but characteristic to the genus: the scalariform perforation plates and the helical thickenings on vessels. The type-species was chosen *Plataninium porosum* Felix, 1887 - which was redescribed and transferred to *Spiroplatanoxylon porosum* (Felix) Süss, 2007 as comb. nova, and two new species of *Spiroplatanoxylon* were described:

- *S. gregussii* Süss, 2007, which has bigger vessels, mostly solitary and less frequent per square mm, very abundant tyloses, broad multiseriate rays and crystals in the axial parenchyma present as chambered cells or, rarely, as idioblasts.

- *S. mueller-stollii* Süss, 2007, quite similar, with mostly solitary vessels, less frequent per square mm, very abundant tyloses, generally thinner rays, which can even be aggregated and also broad multiseriate rays and crystals in the axial parenchyma present as chambered cells or, rarely, as idioblasts; the same species was identified by Továrková et al. (2011) from Brno area, Czech Rep.

Also, several species of *Icacinoxylon*, *Platanoxylon* and *Plataninium* are reidentified and placed into the genus *Spiroplatanoxylon*. It is very of note that even Page (1968) also emended once the genus *Plataninium*, to comprise broader-rayed structures, including members of the Icacinaceae (equivalents of *Citronella*, *Ottoschultzia*). - *Plataninium europeanum* Prakash, Březinová et Bůžek, 1971 found in northern Bohemia, was revised by Süss (2007) to *Spiroplatanoxylon europeanum* (Prakash, Březinová and Bůžek) Süss, having smaller vessels with scalariform perforated plates, spiral thickenings, crystals and low vessel frequency.

- *Plataninium porosum* Felix, 1887, found in Apuseni Mountains, at Almaşu Mare, was revised to *Spiroplatanoxylon porosum* (Felix) Süss, 2007, having spiral thickenings on vessels and long chains of crystalliferous parenchyma. The same species of *Plataninium* was described also by Petrescu and Nuţu (1970), from Boiu, South Apuseni Mountains, so it becomes *Spiroplatanoxylon porosum* (Felix) Süss, 2007 too.

- *Platanoxylon bohemicum* Prakash, Březinová and Bůžek, 1971 was revised to *S. bohemicum* (Prakash, Březinová and Bůžek) Süss, 2007, having high scalariform perforation plates, abundant tyloses and shorter rays. However, more recently, Sakala et al. (2010) revisiting the original site from where Prakash et al. (1971) have described *Platanoxylon bohemicum*, *Plataninium europeanum* and *Dryoxylon bohemicum*, have made microscopical observations on new slides and confirmed the presence of spiral thickenings and rare prismatic crystals in axial parenchyma cells in *Plataninium* but not in *Platanoxylon*. So, they decided to use the denomination *Spiroplatanoxylon* only for the *Plataninium* type of wood in which are observed spiral thickening and crystals. As a precaution, they kept the three morphospecies as separate units, even if they thought they all may represent the same botanical species. Also, it is of interest that Greguss (1967, 1969) have described some specimens as *Icacinoxylon* sp. seu *Platanoxylon* sp., or *Icacinoxylon* / *Platanoxylon* (see also Gryc & Sakala, 2010). In fact, 18 badly preserved specimens studied by Greguss (1967), were identified as *Icacinoxylon* sp. seu *Platanoxylon* sp., having scalariform perforation plates, with 6-10, 18-20, or 30-35 bars, crystals inside vessels, parenchyma or rays, sometimes radial or axial canals, or typical platanoid aspect, and were, or must be attributed to *Spiroplatanoxylon* sp.:

- Andreánszky (1951) described *Platanoxylon* sp. with helical thickenings on vessels and scalariform perforations that could be *Spiroplatanoxylon* sp. (Süss, 2007).

- *S. citronelloides* (Shilkina) Süss, 2007, was described by Shilkina (1956) as a species of *Icacinoxylon*, and then, was found again and described by Greguss (1967) as having vessels high scalariform perforation plates with numerous bars (30–50), spiral thickenings abundant tyloses and shorter rays.

- *Spiroplatanoxylon hortobagyii* (Greguss) Süss, 2007, (former *Icacinoxylon*) has oval vessels in cross-section, and shorter rays, beside the generic features.

- *Spiroplatanoxylon shilkinae* (Greguss) Süss, 2007, (former *Icacinoxylon*) has vessels with high scalariform perforation plates with numerous bars, and lower rays (to 8 cells broad), which can even be aggregated.

- *Spiroplatanoxylon platanoides* (Greguss) Süss, 2007, (former *Icacinoxylon*) has heterocellular rays with several rows of upright marginal cells. The species of Greguss was also described from the Apuseni Mountains by Petrescu (1978) even if on badly preserved specimens.

- *Spiroplatanoxylon densiradiatum* (Petrescu) Süss, 2007, (former *Icacinoxylon*) has smaller angular vessels, solitary or in clusters, 75 per square mm., and scalariform perforation plates with 20-35 bars, spiral thickenings, two-sized rays with high ray-frequency and ray-cells with crystals.

- *Spiroplatanoxylon densiporosum* (Petrescu) Süss, 2007, (former *Icacinoxylon*) has small and numerous vessels that show scalariform perforation plates with more numerous bars and spiral thickenings, long chains of crystalliferous parenchyma, high rays and terminal fibrous band.

- *Spiroplatanoxylon romanicum* (Petrescu) Süss, 2007, (former *Icacinoxylon*) have rather numerous vessels (50-70 per square mm) with high scalariform perforation plates with numerous bars (up to 30-35), spiral thickenings, secretory parenchyma cells, rays of 11-16 cells broad and very high.

Also, there are other described European species of *Icacinoxylon* that must be translated to *Spiroplatanoxylon*:

- *Icacinoxylon crystallophorum* Greguss, 1967 a species having high scalariform perforation plates, up to 55 bars and broad compact rays of 20 cells wide, found also by Petrescu (1978) and by Iamandei and Iamandei (1997) in the Apuseni Mountains, and must also be assigned to *Spiroplatanoxylon crystallophorum* (Greguss) Iamandei, comb. nova.

- *Icacinoxylon sylvaticum* (Tuzson) Greguss, 1969, and *I. aff. sylvaticum* (Tuzson) Greguss, 1969, described from Hungary and found again by Dupéron (1978) from the Stampien of Agenais, France, must become *Spiroplatanoxylon sylvaticum* (Tuzson) Iamandei, comb. nova, and respectively *Spiroplatanoxylon aff. sylvaticum* (Tuzson) Iamandei, comb. nova.

Discussing the attribution of a French wood to *Icacinoxylon aff. sylvaticum* (Tuzson) Greguss, 1969, Dupéron (1976) wrote: "la seule espèce actuelle présentant des éléments de vaisseaux spiralés est *Citronella mucronata*, et la plupart des bois décrits sous le nom de *Icacinoxylon* possèdent des éléments de vaisseaux spiralés. Faut-il en conclure d'emblée que l'évolution de la famille tend vers la disparition de cet ornement? Il serait bien hardi de l'affirmer. Cependant, Metcalfe and Chalk (1950) constatent que les bois à perforations de vaisseaux scalariformes ont

plus fréquemment des spirales que les bois à perforations de vaisseaux simples et à structures étagées. Les perforations scalariformes étant un caractère d'autant plus primitif que le nombre de barres est élevé, on est tenté de penser que la plupart des bois fossiles d'Icacinaceae sont à caractères plutôt archaïques".

- Another species of *Icacinoxylon* described from Georgia as *I. goderdzicum* Shilkina, 1958, has to be translated to *Spiroplatanoxylon goderdzicum* (Shilkina) Iamandei, comb. nova.

Some fossil woods described from the Romanian Carpathians and identified as *Icacinoxylon* both at species and genus level, must be discussed and correctly assigned to the valid accepted genus:

- *Icacinoxylon tyleradiatum* Iamandei et Iamandei, 1997, described from the latest Cretaceous deposits of Apuseni Mountains, having vessels with scalariform perforation plates with numerous bars, 20 or more, tyloses, spiral thickenings on vascular tracheids, or on small vessels, secretory parenchyma cells with dark content, two-sized rays, fine of 2-3 and broad of 12-16, dissected, high heterogeneous and heterocellular, 1-5 marginal square, or upright ray-cells, with gum and crystals inside, must become *Spiroplatanoxylon tyleradiatum* (Iamandei et Iamandei) Iamandei, comb. nova.

- *Icacinoxylon grambastfessardi* Petrescu, 1972 (in Petrescu & Dragastan, 1972) from the Oligocene of Teleaga (Prahova county) must be redescribed as *Spiroplatanoxylon grambastfessardi* (Petrescu) Iamandei, comb. nova, even if no spiral thickenings were observed, but high scalariform perforation plates, with up to 25 bars, and twosized rays 1-4 seriate and fusiform, of up 16-20 cells broad, ray-cells with crystals.

- Numerous other specimens identified as *Icacinoxylon* sp., described from the late Miocene of Prăvăleni (Petrescu & Nuțu, 1971, 1972), from the Oligocene from NW Transilvania (Petrescu, 1978) and from the Oligocene of Carpathians' Curvature (Petrescu et al., 1989) on specimens quite badly preserved, having semi-ring-porous wood, often diffuse, not too large solitary vessels or grouped in 2-3, with scalariform perforations, two-sized rays, fine of 1-4 cells wide and of 6-(10-12)-18 cells broad, either compact or aggregate, or dissected, heterogeneous with polygonal ray-cells, unequally sized and with crystals and few other details. They have obvious platanoid wood structure, and must be also assigned to *Spiroplatanoxylon*, as valid taxon.

Since the wood structure of the studied specimen from Bozovici resembles to many described specimens of *Spiroplatanoxylon*, especially to the forms described by Petrescu & Dragastan, 1972) from the Oligocene of Teleaga and also by Petrescu and Nuțu (1972) from Prăvăleni, we tried to find very specific details to discriminate between them and we found a close identity with the species *Spiroplatanoxylon densiradiatum* (Petrescu) Süss, 2007, by having diffuse-porous to semi-ring porous distribution of the polygonal and not to large vessels (under 100 µm in diameter), numerous two-sized rays, with platanoid dilation at ring boundary in cross-section, and scalariform perforations with 18-24-35 thin bars, with bordered pits, opposite, horizontally elongate to scalariform, with helical thickenings, with crystals in parenchyma,

two-sized rays of 1-4 and 8-12 cells wide, high, fusiform, compact heterocellular, ray-cells with crystals, thick-walled fibres - angular in cross section. In these conditions, we assign our studied specimen to the species *Spiroplatanoxylon densiradiatum* (Petrescu) Süss, 2007.

CONCLUSIONS

In this paper, two fossil tree taxa have been described from the upper part of Badenian deposits from Bozovici, with different aspects and botanical affinities, as it follows:

- *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh, 2004, probably was one of the main coal-generator tree in the basin, similarly to other Miocene to Pliocene coaly basins of the neighbor regions (Oltenia), by its huge quantity of woody mass and maybe other plant-parts and by its probable habit, because it may had been a special extinct eco-form of *Glyptostrobus*, living in similar wet environment as the extant *Taxodium* lives (Țicleanu N., 2006, pers. comm.). Otherwise, the black aspect of the petrified wood suggests a stage of coalification before silicification. However, it is strange that the sporopollinic list given by Petrescu (2003) do not comprise pollen of *Glyptostrobus* also.

- *Spiroplatanoxylon densiradiatum* (Petrescu) Süss, 2007 could represent a platanaceous arboreal taxon (also absent from the sporopollinic list of Petrescu, 2003), living in the emerged neighbor riparian land, brought into the basin and buried during catastrophic rainfall and petrified by mineralizing solutions related with the tuff intercalations present in the volcano-sedimentary deposits.

New and systematic palaeoxylotomical research in Bozovici area could contribute to a better understanding of the sedimentation processes into the basin, of the botanical origin of the coals knowing the neighbor contemporaneous vegetation and of the palaeoenvironmental conditions, including the palaeoclimate reconstruction of that area during Badenian time.

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