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LATE-MIOCENE MOLDAVIAN PETRIFIED FOREST

Stănilă Iamandei[1*], Eugenia Iamandei[1] & Laurențiu Ursachi[2]

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Abstract A collection of petrified wood, hosted by the Natural Sciences Section of the Museum "Vasile Pârvan" from Bârlad, was submitted to a palaeoxylotomical study. The samples come from the central part of Moldova, Northward of Bârlad, and were collected from Simila gravel-quarry, from fluvial-deltaic sediments of Maeotian age, most probably representing reworked elements from a Sarmatian formation which occurs in situ more Northward, in Soleşti-Avereşti-Huşi area. Previous palaeobotanical studies made in that region outlined an interesting Late Miocene Flora on the Moldavian Platform, and the palaeoxylotomical studies confirmed in that area the presence of forests with conifers, elms, oaks and poplars. The results of the present study show the following taxa identified taxa: *Glyptostroboxylon* cf. *rudolphii* Dolezych et Van der Burgh, *Ulmoxylon scabroides* Greguss, *Quercoxylon bavaricum* Selmeier, *Quercoxylon intermedium* Petrescu et Velitzelos, *Populoxylon tremuloides* Iamandei et Iamandei, and *Prunoidoxylon multiporosum* Dupéron.

Keywords: petrified wood, Maeotian deposits, Sarmatian Flora.

INTRODUCTION

In the central part of Moldavia, Northward of Bârlad, it develops from a geologic point of view, a fluvial-deltaic sandy formation of Maeotian age with lenticular gravel levels (fig. 1), with rounded fragments of sandstones and petrified wood, reworked from the Sarmatian sediments which occur, in situ, more Northward, in Huşi-Avereşti-Soleşti area (see also Iamandei et al. 1999, 2000, 2001a, 2010).

The previous palaeobotanical studies on fruits, leaves or wood, previously made in the region by Macarovici & Paghida (1966), Starostin & Trelea (1969, 1984), Ţibuleac, (1998, 2001) and the palynological studies of Ţabără & Florea (2007), Chirilă & Ţabără (2008, 2010) allowed the identification of an interesting late Miocene fossil flora in the Moldavian Platform. The conspectus of the Sarmatian (l.s.) flora described by the study of plant remains from the Moldavian Platform (see Givulescu, 2001) comprises species of *Carpinus, Cassia, Persea, Corylus, Fagus, Fraxinus, Juglans, Parrotia, Platanus, Populus, Quercus, Rhus, Salix, Sapindus, Tilia, Ulmus* and *Zelkova*. In fact, Givulescu (2001) revised the Khersonian flora described by Macarovici & Paghida (1966) at Păun (a flora with *Populus, Salix, Ulmus, Zelkova, Alnus, Carpinus Laurus, Liquidambar, Parrotia, Sapindus, Platanus, Vitis, Tilia, Cassia, Cercis, Juglans*), and by David (1916, 1922) and Barbu (1934) at Hârşova (a flora with *Populus, Ulmus, Carpinus, Laurus, Cassia, Fagus, Juglans, Quercus, Rhus*), coming from the upper part of the Khersonian formation and not from the Bessarabian, as wrongly Givulescu (2001) mentioned (this is the opinion of Ionesi et al., 2005, p. 439).

To these, some other informal taxa were identified by Ţibuleac (1998, 2001) from the Volhynian of the Moldavian Platform, must be added: *Taxodium, Glyptostrobus, Pinus, Magnolia, Nyssa,* Lauraceae div. sp., *Platanus, Ilex, Cassiophyllum, Cassia, Corylus, Betula, Carpinus, Alnus, Juglans, Carya, Engelhardia, Quercus, Salix, Populus, Myrica, Liquidambar, Zelkova, Vitis, Acer, Fraxinus, Typha, Phragmites* and *Potamogeton.*

Also, the results of the palynological studies of Ţabără & Florea (2007) and Chirilă & Ţabără (2008, 2010) indicate in that region the presence of: *Taxodium, Sciadopitys, Abies, Picea, Cedrus, Pinus, Tsuga, Magnolia, Illex, Carpinus, Fagus, Castanea, Quercus, Ulmus, Betula, Tilia, Juglans, Carya, Platycarya, Engelhardia, Acer, Myrica, Symplocos* and also of some Oleaceae, Chenopodiaceae, Typhaceae and Cyrillaceae. Such studies indicate a complex late Miocene flora, and a Mixed Mesophytic Forest type living in the Moldavian Platform, favored in this large area by the development of the hydrological system after the retreat of the Dacian Basin, and the expansion of the dry areas, also expressed by the vegetation, since abundant pollen of *Artemisia* being observed. This plant association suggests, for that time, an arid palaeoclimate of continental type with two marked seasons, probably at the sylvosteppic edge and with mediterranean influences.

The list of late Miocene lignotaxa described till present in the Moldavian Platform by Starostin & Trelea (1969, 1984), Lupu (1984)), comprises the following taxa: *Ulmoxylon khersonianum* Starostin & Trelea 1969, *U. scabroides* Greguss 1969, *Quercoxylon bavaricum* Selmeier 1971, *Q. sarmaticum* Starostin & Trelea 1969, *Q. densannulatum* (Starostin & Trelea, 1984), *Q. macarovicii* Starostin & Trelea 1984, *Q. praefrainetto* Lupu, 1984. Later, Iamandei et al. (2001 a,b,c; 2006; 2008 a,b; 2010) described from the Moldavian Platform some coniferous lignotaxa as species of *Taxodioxylon taxodii* Gothan, *Se*

[1] Geological Institute of Romania, 1st Caransebes Street, sect. 1, Bucharest, Romania, s_iamandei@yahoo.com
[2] "Vasile Pârvan" Museum, Natural Sciences Departm., Republicii Street, 235, Bârlad, Romania, ursachi_laur@yahoo.com
* Corresponding author

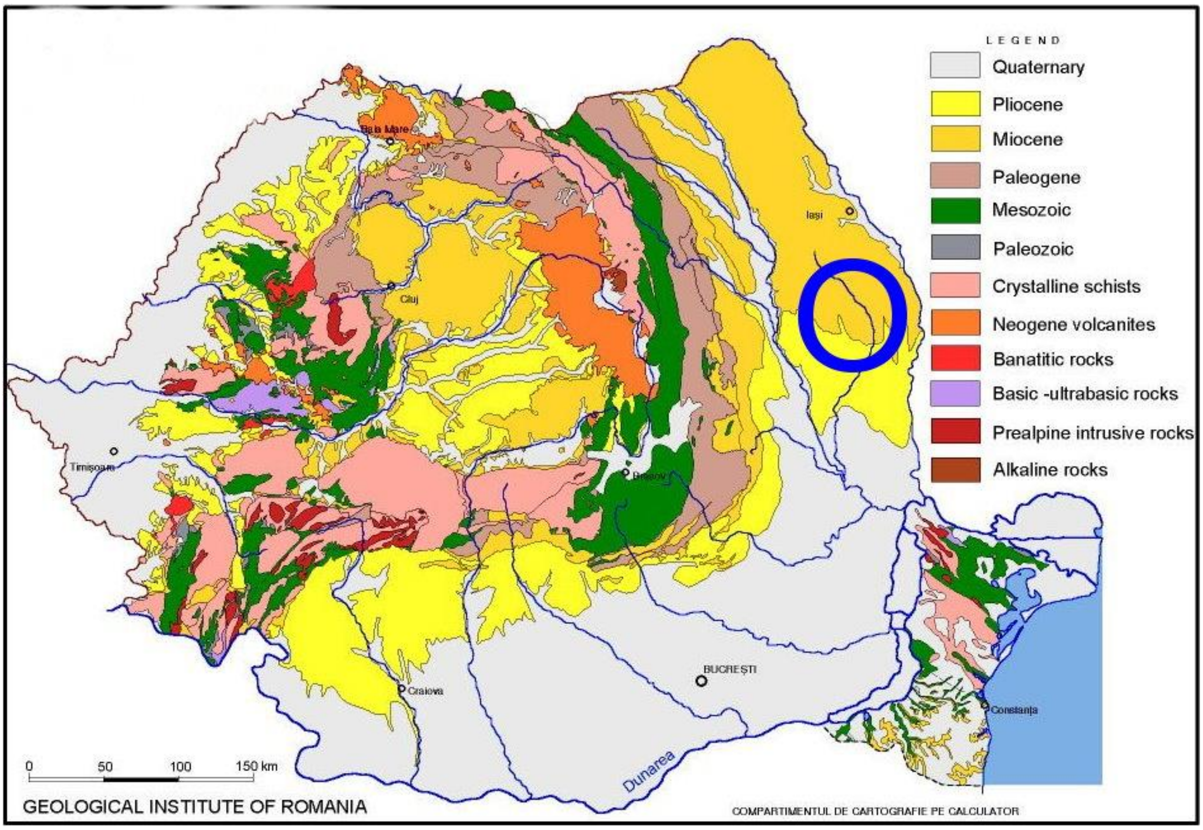

Fig. 1 The geological map of Romania, with the petrified woods area marked by circle.

quoioxylon gypsaceum (Goepp.) Greguss, *Glyptostroboxylon tenerum* (Kraus) Conwentz, *Cupressinoxylon* sp., *Tetraclinoxylon romanicum* Iamandei et Iamandei.

The species of *Araucarioxylon* (*A. moldavicum*) described by Boureau et al. (1969) from similar deposits, most probably is a wrong identification of a fossil wood of *Tetraclinoxylon* type, at least because the Araucariaceae were no more documented in the Northern Hemisphere during Neogene. Anyway, a revision of the original material is necessary.

The fossil wood studied here represents a reworked material, which appeara as rounded fragments of petrified trunks brought as sedimentary elements from the Moldavian Platform, by the tributary palaeorivers from the palaeohydrographic basin of Bârlad river (fig 1), and were collected from Simila gravel quarry, close to Zorleni (Vaslui county).

After a palaeoxylotomical study, the following species have been identified here: *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh, 2004; *Ulmoxylon scabroides* Greguss, 1969; *Quercoxylon bavaricum* Selmeier, 1971; *Quercoxylon intermedium* Petrescu et Velitzelos, 1981; *Populoxylon tremuloides* Iamandei et Iamandei, 2006; *Prunoidoxylon multiporosum* Duperon, 1976. They represent probably the fossil equivalents of extant tree species, living now in the Moldavian Platform, and this can have a great scientific significance, helping us with the palaeoclimatic and paleoenvironmental reconstructions for this region.

MATERIAL AND METHODS

We had in the study a collection of 53 samples of petrified wood gathered from Simila gravel quarry - Zorleni (Vaslui County) and hosted by the Natural Sciences Department of „Vasile Pârvan“ Museum, Bârlad, Romania.

For the xylotomical study, from each sample, oriented thin-sections of petrographic type were prepared, according to the recommended three standard directions - transversal, tangential and radial. These sections have been studied under a transmitted light microscope and all the anatomical details were described for each specimen, using the scientific terms as defined by the IAWA list of microscopic features for softwood and hardwood identification published by the IAWA Committee (1989, 2004).

The photos of the xylotomical details were captured on an “Ever Focus” video camera adapted to the optic microscope, using the software “AVerMedia”, and the images were processed with specialized computer programs.

The identification of the unknown original tree was subsequently performed by comparison with previously described similar aspects of fossil or current wood structures, from published scientific papers (all included in the References chapter). For the systematic terminology, we followed APG (2009, 2016), Christenhusz et al. (2011), and the ICN-Shenzhen Code (Turland et al., 2018).

SYSTEMATIC PALAEOBOTANY

Gymnosperms
Division **Pinophyta** Cronquist, Takht. & Zimm., ex Reveal, 1996
Order **Cupressales** Link, 1829
Family **Cupressaceae** Rich. ex Bartling, 1830
Subfamily **Taxodioideae** Endlicher ex K.Koch, 1873
Genus ***Glyptostroboxylon*** (Conwentz, 1884) emend. Dolezych et Van der Burgh, 2004
Glyptostroboxylon cf. *rudolphii* Dolezych et Van der Burgh, 2004
Fig. 2, a-i.

Material code: Pb11, Pb12, Pb17, and Pb23.
Locality: Simila gravel quarry (Vaslui county), central part of Moldova, Northward of Bârlad.
Repository: in the Collection of the Natural Sciences Section of the Museum "Vasile Pârvan", from Bârlad city, Romania.
Age: Maeotian age.
Formation: Fluvio-deltaic sediments with gravel levels, exploited in Simila gravel quarry, where the petrified wood samples appear as reworked centimetric elements with fibrous structure.

Microscopic description: The growth rings, in cross-section, appear distinct, variably sized, of up to 50-60 cells wide and the transition from earlywood to latewood is slightly gradual. The ring boundaries are distinct, marked by the 3-5(-8) tangential rows of flattened cells of the latewood which are sometimes resiniferous and partially destroyed.
The tracheids are polygonal with rounded corners in cross-section, having in the earlywood 25-50/30-55 μm the radial/tangential diameters (r/tg.d.), diminishing in the latewood to 10-25/15-30 μm (r/tg.d.) and relatively thick walls, of 5-10 μm the double wall. There are 1-8(11) radial regular rows between two successive rays. The density of the structure is of (650)900-1950 tracheids per mm^2.
The radial pits are typical abietineous, of 12-18 μm in diameter, in 1-2(4) vertical rows of the opposite, spaced or contiguous pits, often presenting small irregularities in their arrangement. On the tangential walls the pitting is missing or if sometimes it appears is either uniseriate, spaced, or irregularly arranged in smaller pits of 6-8-10 μm in diameter, with small borders and small circular apertures. Crassulae are rarely present. No helical thickenings were seen on the tracheids, but resin granular remains sometimes appear inside them.
The axial parenchyma is few, as dispersed cells, less visible in cross-section, since not always have dark content and appear similar or smaller than tracheids. In vertical view rarely appears as having thin terminal (horizontal) walls, smooth, slightly rugose, or nodular. Inside the cells, resinous granular remains appear.
The rays are usually uniseriate, sometimes with local short biseriations, having 5-15 or more cells in height. In tangential view, the ray cells appear vertical-oval, often as unequally sized cells, sometimes determining lateral intercellular spaces. The ray density is 8-15 rays per millimeter horizontal tangential. In radial view, the rays show a homocellular structure with cells all procumbent and have thin and smooth horizontal walls thicker, with a height of 10-17 μm or more, the marginals are slightly taller, showing a wavy outer wall. Ray-tracheids are not present. The tangential walls are slightly nodular, but indentures were not observed. The earlywood cross fields have 3-4 glyptostroboid, sometimes taxodioid pits, but with many reduced borders, like cupressoid type, of 8-10 μm, arranged in horizontal rows, or in slightly diagonal pairs, or single in the latewood cross fields. In the marginal cross fields, there are more numerous pits in 1-2 horizontal rows. The pit apertures are nearly round or oblique elliptic.
Mineral inclusions - usually absent.

Affinities and discussions
The xylotomic description of all the studied specimens shows a combination of characters that suggest a cupressaceous structure of "taxodiaceous" type. Thus the shape and distribution of the tracheids and of the parenchyma in cross-section, the tracheidal pitting, the cross-fields with cupressoid, taxodioid or glyptostroboid pitting indicate a possible correspondent of the extant *Glyptostrobus* Endl., a member of the subfamily Taxodioideae Endl. ex K.Koch, which include also *Taxodium* Rich. and *Cryptomeria* D.Don., in the new systematic of Cupressaceae (see Gadek et al., 2000; Farjon, 2000).
The fossil correspondent used for "taxodiaceous" woods was *Taxodioxylon* Hartig, 1848 emend. Gothan, 1905. The species *Taxodioxylon gypsaceum* (Göppert) Kräusel defined wood of *Sequoia* type but Torrey (1923) erected the genus *Sequoioxylon* Torrey but, because the distinction between those two genera was problematic enough, some of the paleoxylologists contested the validity of it, considering the diagnosis of *Taxodioxylon* genus as sufficiently comprehensive and that to establish new competency domain can complicate the fossil wood identifications (see Privé-Gill, 1975).
Another fossil species described as *Taxodium europaeum* by Brongniart (1833) was replaced later by a new "taxodiaceous" fossil genus, *Glyptostrobus* Endlicher 1847, to describe the numerous similar fossil macroremains. But, only later such a conifer was found and described as a living tree, in China (Henry & McIntyre, 1926).
For fossil wood, the correct fossil genus name, *Glyptostroboxylon*, was erected by Conwentz (1884), emended later by Dolezych & Van der Burgh (2004), after a new investigation on the original material from Wetterau, the type-locality for *Glyptostroboxylon tenerum* (Kraus) Conwentz, 1884. Thus, in their revision, they observed that this species was the initial basionym for the genus (the first name was *Glyptostrobus tener* Kraus, 1864). This genus was taken again in discussion later by Seward

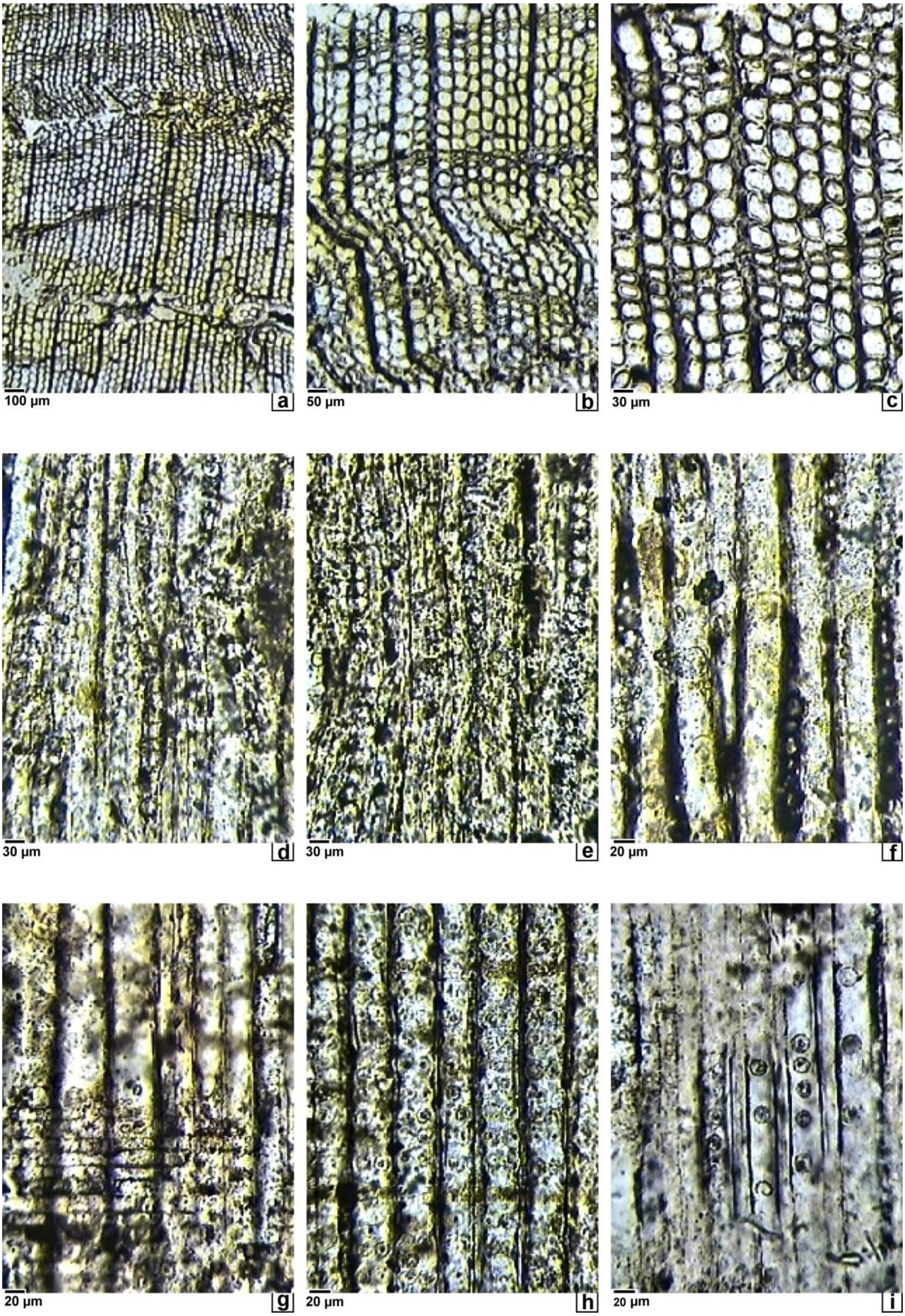

Fig. 2. – *Glyptostroboxylon* cf. *rudophii* Dolezych et Van der Burgh, 2004. Specimen Pb23. **a, b, c** – cross section: distinct growth-ring boundary by flattened tracheids in late wood; dispersed parenchyma; **d, e, f** – tangential section: tracheids few pitted; uniseriate rays**; g, h, i** - radial section: 1-2(4) radial pits on tracheids, cross-fields with 2-4 pits.

(1919, p. 198) and Jurasky (1933), but only Kraüsel (1949) was the one who corrected the name, in respect of current ICBN Rules (now ICN, see Turland et al. 2018), however noting the great variability of the glyptostroboid pits, up to the cupressoid, in the cross fields.

Whereas Gothan (1905) and later, Rudolph (1935), Watari (1948), Süss & Velitzelos (1997) and Fairon-Demaret et al. (2003) have observed affinities between the wood of *Glyptostroboxylon tenerum* (Kraus) Conwentz and wood of *Cunninghamia* R.Br. and after a new investigation on the original material from Wetterau, the type-locality, Dolezych & Van der Burgh (2004) have observed that the affinity of this wood is not to *Glyptostrobus*, but clearly to *Cunninghamia*, now *Glyptostroboxylon tenerum* is interpreted as fossil wood of *Cunninghamia* type. Thus, Dolezych & Van der Burgh (2004) have described a new species of *Glyptostroboxylon*, as *G. rudolphii* Dolezych & Van der Burgh, emending also the genus' diagnosis and taking this species as basionym. This is the new genus diagnosis:

- Coniferous wood with distinct growth rings. Tracheids in the earlywood are 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 homogeneous, mostly uniseriate. Cross-field pits in the earlywood are predominantly glyptostroboid, but also some cupressoid and taxodioid pits may be present.

The species name come from the name of a scientist who, they say, was the first discussing the affinity of the fossil to the recent wood of *Cunninghamia* vs. *Glyptostrobus* (Rudolph, 1935), and observed 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 Hofman, 1952; Zalewska, 1953, Greguss, 1967).

More recent discussions of Matsumoto et al. (1997), Dolezych & van der Burgh (2004), LePage (2007) or Manzouka et al. (2019) suggest that the evolutionary and biogeographic history of *Glyptostrobus*, started in Canada, in Aptian.

An interesting discussion is made by Teodoridis & Sakala (2008, p. 307), 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, and traditionally considered as the main coal-generating element: "association of *Glyptostrobus*" sensu Kvaček & Buzek (1982).

Anyway, 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* as 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 the 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 them as *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), as has also the typical details, regarding cross-field pitting.

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

Recently, Akkemik et al. (2017) published the first *Glyptostroboxylon* from central Turkey, and then, Akkemik et al. (2019) identified a *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.

Some forms of *Glyptostroboxylon* previously described, could be reassigned to the real equivalent of *Glyptostrobus*, i.e. *Glyptostroboxylon rudolphii* Dolezych et Van der Burgh, 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 Leucuşeşti – Fălticeni, North-eastern Romania as *G. tenerum* which has to be reassigned to *G. rudolphii*, having also glyptostroboid cross-fields.

Nagy et al. (2002) described *G. tenerum* from the late Badenian deposits of Prăvăleni (South Apuseni Mountains), and having glyptostroboid cross-fields can be reassigned to *G. rudolphii*.

In our here studied specimens, even if poorly preserved, we tried to observe the pattern of the growth-rings, the tracheids arrangement and their radial pitting, the axial parenchyma, the details of rays, especially the cross-fields which show glyptostroboid aspect.
Thus, taking into account the combination of the observed xylotomical features, compared with those comprised in the specific diagnosis, and with the above-cited identifications, we think that the studied specimens could be attributed to *Glyptostroboxylon* cf. *rudolphii* Dolezych et Van der Burgh, 2004.

Class **Magnoliopsida** Brogniart, 1843
Family **Ulmaceae** Mirbel, 1815
Genus ***Ulmoxylon*** Kaiser, 1879
Ulmoxylon scabroides Greguss, 1969
Fig. 3, a-i.

Material code: Pb13, Pb15, Pb16, Pb21, Pb22, Pb24, Pb29, Pb30, Pb31, Pb32, Pb33, Pb34, Pb35, Pb43, Pb46, Pb47, Pb48, Pb49, Pb54, Pb60 and Pb63.
Locality: Simila gravel quarry (Vaslui county), central part of Moldova, Northward of Bârlad.
Repository: in the Collection of the Natural Sciences Section of the Museum “Vasile Pârvan”, from Bârlad city, Romania.
Age: Maeotian age.
Formation: Fluvio-deltaic sediments with gravel levels, exploited in Simila gravel quarry, where the petrified wood samples appear as reworked centimetric elements with obvious ring porous and fibrous structure with big vessels – visible by the naked eye, typical for a dicot.

Microscopic description: The growth rings appear distinct in cross-section, defining a general structure of a ring porous wood, with distinct boundaries marked by the abrupt change of size and distribution of the vessels, large ones in the earlywood face to the latewood where they appear small and with typically ulmiform arrangement, as wavy thick bands.
Thus, the vessels are obviously two-sized, in the earlywood they are usually solitary and large-sized and in slightly irregular radial arrangement, or as small groups of 2-3, slightly deformed, appearing as 1–3 tangential rows, or more. In the latewood, they are clustered in 1-6 short tangential bands, thick of 3–6 tangential rows of smaller, unequal, crowded and deformed thin-walled pores. These bands are not always tangential, usually they are slightly diagonal between two rays, giving to the general structure a slightly wavy aspect (= the typical ulmiform arrangement). The solitary large vessels are round to oval or slightly deformed by tangential compression, having the radial/tangential lumina diameter of 150-300/50–150 µm and moderately thick walls, of 2–3.5 µm (simple wall). The smaller pores of the latewood are usually oval or deformed by tangential compression, with lumina of 15–50 µm in diameter and with relatively thin walls of about 2–3 µm (double wall). The density is variable, for the large pores of the earlywood, of 3–5 pores on tangential millimeter, and more numerous in the latewood, of 16-24 pores on tangential millimeter, i. e. 100-450(-600) pores on square millimeters, sometimes more for they are small and crowded in the latewood. Longitudinally, simple perforation plates are present, sometimes badly preserved. The intervascular pitting, usually poorly preserved, is alternate, contiguous, numerous, polygonal rounded, bordered, of (7)9-13 µm in diameter, and have small circular apertures, rather less visible. The vessel-ray pits appear in horizontal row, have much reduced borders to apparently simple, corresponding to the ray-cell pits from the cross-fields, described below. The size of the vascular elements is difficult to measure because the simple perforations are, usually, less visible. Helical thickenings in vessel elements are not present. Sometimes inside the vessels tyloses and fungi remains can be observed.
The ground tissue is constituted of libriform fibres and parenchyma.
The axial parenchyma in cross-section appears apotracheal, diffuse in the transitional and latewood, mixed with libriforms, but also as paratracheal parenchyma, close to the earlywood vessels or close to the clusters of vessels in the latewood type. In the longitudinal sections, it is also visible as touching vessels, and it is obviously pitted, and sometimes, chambered and crystalliferous.
The libriform fibres show in cross-section rounded-shaped lumina, of 10–20 µm in diameter, with moderately thick walls, of 3–5 µm, and are densely arranged especially in the earlywood.
Tracheids, vascular fibres or vasicentric tracheids are not present.
The rays are multiseriate, having a quasi-linear trajectory in cross sections and are slightly dilated at the ring boundary. Tangentially seen they appear 1–7 seriate (but frequently 4–6 seriate), are usually compact, fusiform and tall, of 10-60 cells in height. The ray-cells appear in the tangential sections as polygonal, rounded to oval and relatively thick-walled (of 3–4 µm double wall), are slightly unequal, even if the rays appear homocellular in the radial view, with ray-cells all procumbent. The ray-density is variable, of 7–10 rays on tangential millimeters, finer rays being less frequent. Radially the rays show cross-fields with vessels with small pits, of 3–4 µm, poorly preserved, even indistinct.
Mineral inclusions appear sometimes as various crystals, in the axial chambered parenchyma.
Other details. Storied structure - not present in the structure. Secretory elements – as oil or mucilage cells not present. Intercellular canals - not present. Cambial variants – as included phloem not present.

Affinities and discussions
The distribution of the vessels, in cross-section, defines a ring-porous structure with two-sized classes of vessels recognized as typical arrangement, defined as ”ulmiform”, very specific for the members of Ulmaceae family, especially for the current genus *Ulmus* L.

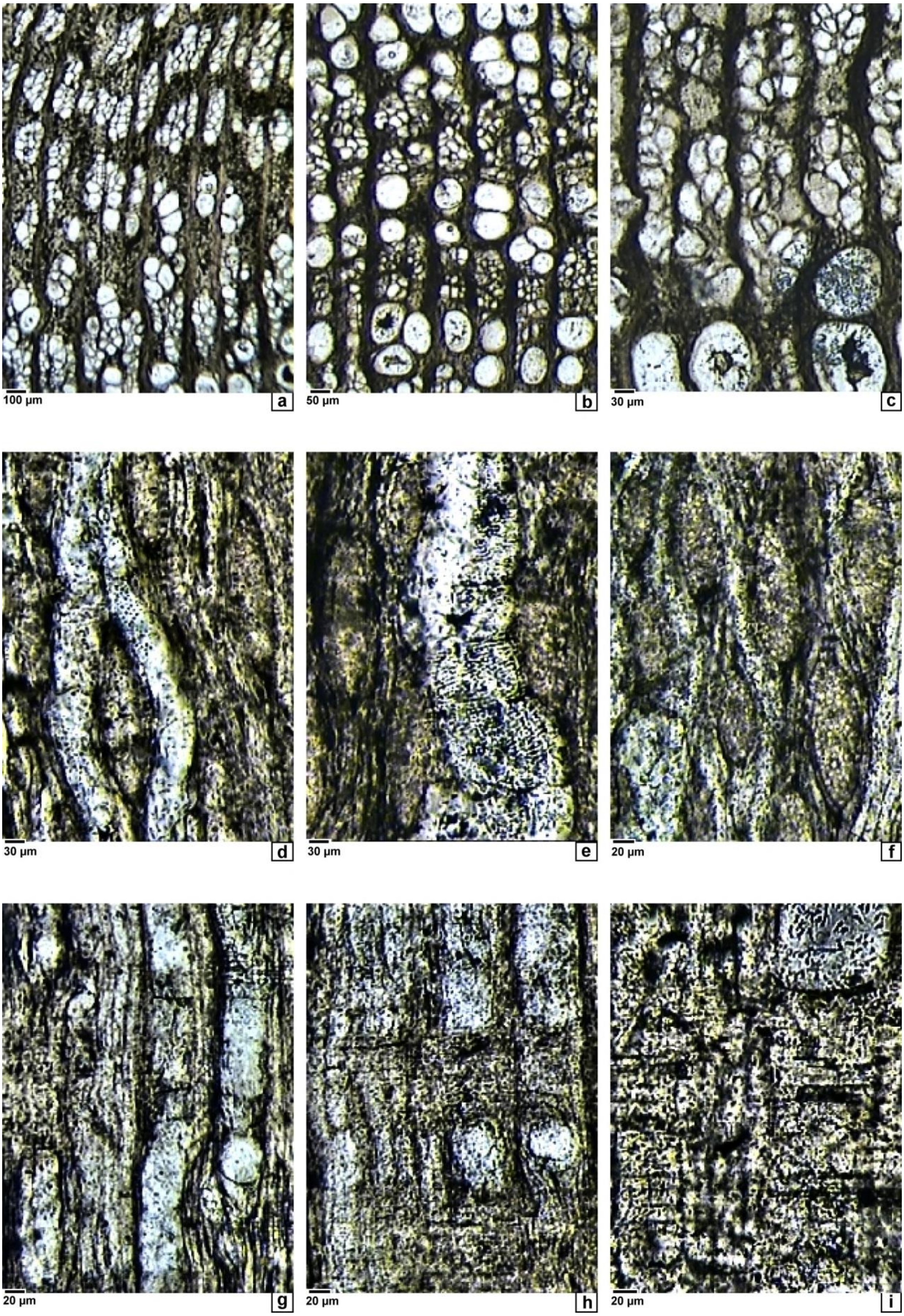

Fig. 3 - *Ulmoxylon scabroides* Greguss, 1969. Specimen Pb49**. a, b, c** – cross-section: ring porous structure with two-sized vessels, small vessels in late wood grouped in ulmiform arrangement; **d, e, f** – tangential section: fusiform broad rays, vessels, ground mass; **g, h, i** – radial section: vessels with simple perforations, homocellular rays, pitted ray cells in cross fields.

Consulting the atlas of Schweingruber (1990), the paper of Sweitzer (1971), the sites of Schoch et al. (2004 - www.woodanatomy.ch) and of Wheeler (2011 – as InsideWood - onwards - http://insidewood.lib.ncsu.edu/search) and also, the atlas of Akkemik & Yaman (2012), we found a great similitude of the structure of our specimens with the current *Ulmus glabra* Huds., named „scotch elm" or „wych elm", a taxon spread in Europe and temperate Asia, and also in the Mediterranean area (including Northern Africa and Middle East). This species includes now several synonyms, inclusively *U. scabra*, *U. campestris*… (see The Plant List - *Ulmus glabra* Huds. — The Plant List).

The accepted fossil correspondent genus for this wood type is *Ulmoxylon* Kaiser, which was described by the study of a Miocene ulmaceous wood from Gleichenberg - Steiermark, Austria. Kaiser (1879) named it *Ulmoxylon*, reviewing the species *Cottaites lapidariorum* Unger (see Jogmans & Edwards, 1931 p.80-81) and, probably considering it as a type for the genus, he did not design it, clearly, a genus-type, a fact that now is not accepted, considered "type non designatus" (see ING Database).

In fact, more recently, Doweld (2017) made a proposal to reject the name *Cottaites*, specifying that "at the present time, *Ulmoxylon* is widely adopted in modern palaeobotany for ulmaceous fossil woods, containing nearly 12 species" (Gregory et al. 2009, p.133); see also IFPNI (2014) - http://fossilplants.info/). Also, Doweld (2017) specifies: *Ulmoxylon* Kaiser should not be confused with its later illegitimate homonym *Ulmoxylon* E. Hofmann (1939), which was later renamed as *Celtixylon* by Greguss (1943), having affinity with Celtidaceae Endl. (see Endlicher 1841, p.163-164).

We remarked Kłusek (2012), who made a good discussion on the adventures of the genus name for ulmaceous fossil wood, classified, in time, as *Ulminium*, *Ulmoxylon* or *Ulmus*. Also, she gave a useful comparative table of the previously described fossil species.

However few European fossil species were described until the present day and we used some of them for comparison with our here studied specimens.

Starostin & Trelea (1969) described from the Moldavian area, an *Ulmoxylon kersonianum* from the Carpathian Miocene, quite similar to our specimens having also two-sized vessels and ulmiform arrangement in latewood.

Privé & Brousse (1969) described from western Europe an *Ulmoxylon* aff. *lapidariorum* (Unger) Felix, on poorly preserved material. Latter, Privé-Gill et al. (2008) described an *Ulmoxylon lapidariorum*, considered to be closer to the extant species *Ulmus campestris* L., and quite similar to our specimens, especially by the typical ulmiform arrangement of the latewood.

Greguss (1969) described from the Mio-Pliocene of Hungary an *Ulmoxylon* cf. *Ulmus carpinifolia* Gled., slightly different of our specimens by their short and wide rays.

Also, Petrescu & Dragastan (1971) described from the Carpathian area an *Ulmoxylon* cf. *Ulmus americana* L., has well-developed latewood with long wavy bands of vessels as ulmiform aspect, slightly different of our specimens.

Sakala (2002), described on some fossil wood from Czech Rep. an *Ulmoxylon marchesonii* Biondi which has structural details similar to the current species *Ulmus macrocarpa* Hance, from North America, to *U. parvifolia* Jacq. from China and to the European common elm U. *carpinifolia* Gled. and, having short and wide rays, is slightly different of our specimens which have tall rays, slightly slender.

Iamandei & Iamandei (2010) described from the Miocene formations from Solești area, an *Ulmoxylon scabroides* as identical to the species described by Greguss (1969) from the Miocene deposits of Hungary, which corresponds to the current *Ulmus scabra* Mill. which is a synonym of the „scotch elm", i.e. *Ulmus glabra* Huds.

Thus, by their typical ulmiform ring-porous structure, with two-sized vessels, 1-3 rows of big vessels in the earlywood, simple perforations and alternate pitting on vessels, apotracheal and paratracheal parenchyma, sometimes chambered and with crystals, 1–7 seriate rays, but frequently 4–6 seriate, are usually compact, fusiform and tall, of 10-60 cells in height, homocelular and with typical pitting in the cross-fields, structural features similar up to identity with the current „scotch elm" and with the fossil species described by Greguss, we attribute the studied specimen to the fossil morphospecies *Ulmoxylon scabroides* Greguss, 1969.

Order **Fagales** Engler, 1892
Family **Fagaceae** Dumortier, 1829
Subfamily **Quercoideae** Örsted, 1867
Genus ***Quercoxylon*** Kräusel 1939 (emend. Müller-Stoll & Mädel, 1957; em. Gros, 1988)
Quercoxylon bavaricum Selmeier, 1971
Fig. 4, a-i.

Material code: Pb19, Pb20, Pb26, Pb27, Pb28, Pb38, Pb44, Pb45, Pb52, Pb58, Pb59, and Pb64Zo.

Locality: Simila gravel quarry (Vaslui county) and Zorleni, in the central part of Moldova, Northward of Bârlad.

Repository: in the Collection of the Natural Sciences Section of the Museum "Vasile Pârvan", from Bârlad city, Romania.

Age: Maeotian age.

Formation: Fluvio-deltaic sediments with gravel levels, exploited in Simila gravel quarry, where the petrified wood samples appear as reworked centimetric elements with obvious ring porous and fibrous structure with big vessels – visible by the naked eye, typical for a dicot.

Microscopic description

The growth rings are distinct in cross-section, the wood structure of the ring-porous type, with two-sized vessels and show distinct ring-boundaries marked by an abrupt change between the latewood with small vessels and earlywood suddenly starting with large vessels. Also, the

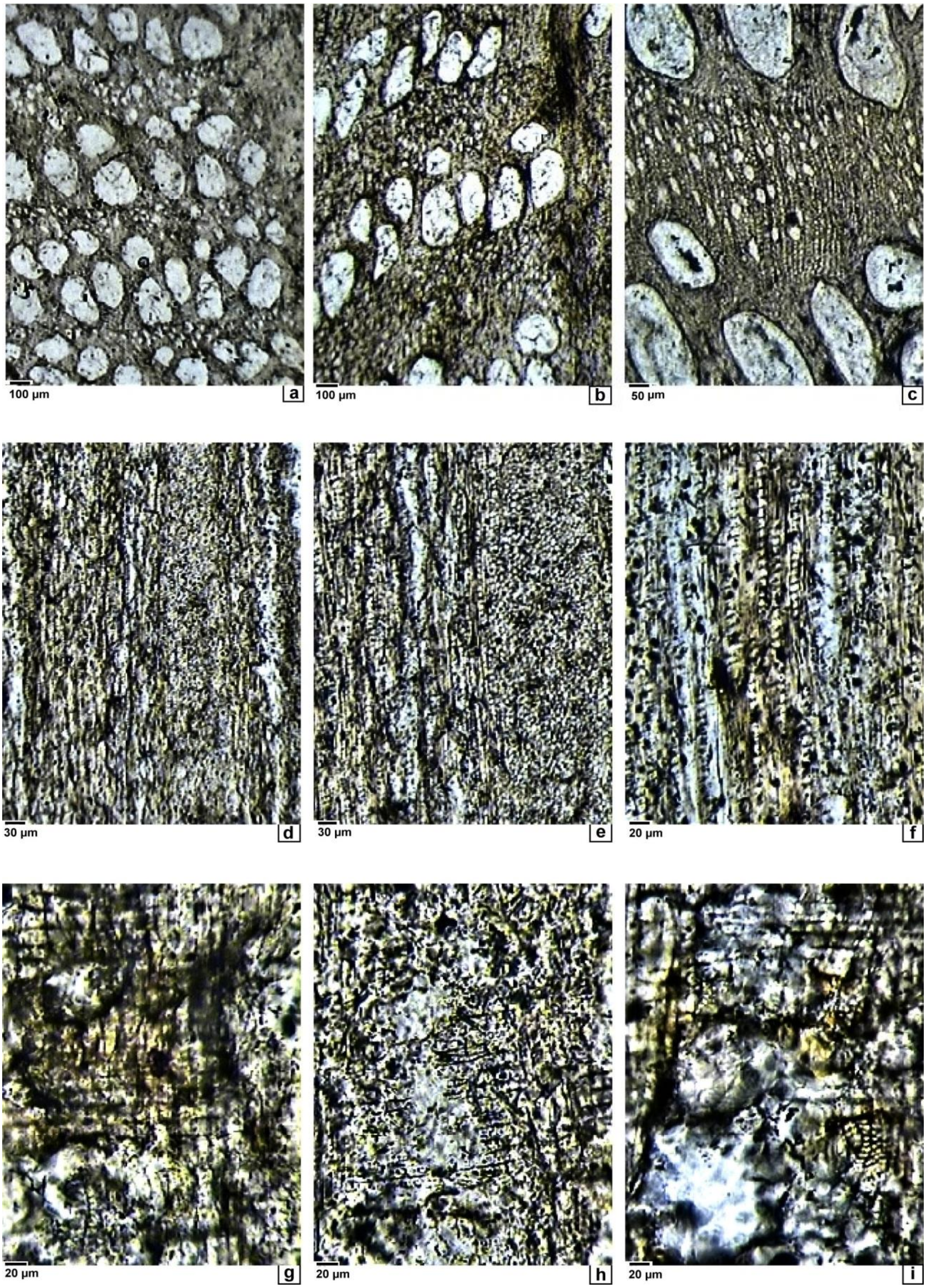

Fig. 4 - *Quercoxylon bavaricum* Selmeier, 1971. Specimen Pb58. **a, b, c** – cross section: ring-porous wood with two-sized vessels, two-sized rays, growth-ring boundary marked by the abrupt size change of early wood; **d, e, f** - tangential section: broad fusiform rays, high, sometimes dissected, and thin rays 1-2 seriate; **g, h, i** - radial section: poorly pitted vessels with simple perforations and alternate pitting on vascular tracheids (i), poorly preserved cross-fields (g, i), probably with rectangular pits ”in palisade” (h)

wood structure is marked by the presence of two-sized rays.

The vessels of the earlywood appear large-sized in cross-section, are exclusively solitary, and are arranged in 1-2(3) tangential rows. They appear as round to oval-shaped pores, radially elongated or slightly deformed by compression, and have the lumina size of 100-250(350) / 70-200(250) µm the radial/tangential diameters (r/tg d.), and the wall-thickness of 3–5(7) µm the simple wall. In the transitional to latewood, the vessels appear suddenly as small-sized pores, almost exclusively solitary, sometimes in small groups, the latewood slightly diminishing close to the ring boundary (as final wood). They appear in radial bundles between the numerous fine rays, floating in a mixed ground-mass, and they form in the transitional to latewood a quassi-triangular patern, having intermediary portions devoid of vessels. The solitary small vessels of the transitional and latewood have, usually, polygonal cross-section, rounded or deformed, even star-like, probably due to compression and fossilization processes, and have r/tg diameters of 20–40(50) / 15–30(50) µm, and thin walls, of 2–3 µm the simple wall. The vessels' density is variable, with 2–3(5) large pores per tangential millimeter but more numerous in the transitional to latewood (often more than 100 pores per square millimeter). Longitudinally, the vessels show simple perforation plates, rather poorly preserved. Also, vascular bordered pits appear, numerous, alternate and in some vertical rows, often difficult to see due to poor preservation of all the wood structure. The vessel-ray parenchyma pits have reduced borders. Inside the vessels, thin-walled, large tyloses are common, but poorly preserved, so, difficult to observe. The vascular element size usually is difficult to measure.

The ground tissue is mixed, constituted by libriform fibers and fibrotracheids (described below) and parenchyma, often difficult to identify each other in cross sections, having quite a similar aspect.

The fibers in the cross-section appear slightly irregularly arranged mixed with the diffuse or banded parenchyma. They have polygonal rounded sections and are relatively thick-walled (4–5 µm double wall), and are unpitted and unsepted. The fibrotracheids appear mixed in the ground tissue and are relatively unclear in cross-section, because of bad preservation. Also, longitudinally they present small pitting, bordered, round or slightly elliptic, with small apertures, in 1(2) vertical rows arranged. As vasicentric tracheids appear with smaller rounded cross-sections and are coiling the big vessels. Vertically they bear small, round, alternate, bordered pits with small round apertures, in 1-2 vertical rows arranged.

The axial parenchyma, in cross-section, appear diffuse, of apotracheal type, scattered among the libriforms, or diffuse-in-aggregate, or as short thin tangential bands, and scanty paratracheal. In longitudinal sections, the parenchyma cells difficultly can be seen amongst the elements of the groundmass. Sometimes vertical rows of large crystals in chambered parenchyma cells were observed in some of the studied specimens.

The rays are of two distinct sizes: fine rays, uniseriate and biseriate, low and numerous, linear or slightly curved molding the vessels in the earlywood, and broad rays, multiseriate, compact or compound, of 13–20 cells wide (up to 50–60 µm). In tangential section they appear often taller than 1 mm and sometimes dissected by libriform fibers, giving them an aspect of aggregate rays. They are constituted of rounded to polygonal cells, unequal in size (10–20 µm in diameter) and relatively thin-walled (2–3 µm the double wall). The ray frequency is variable, with 8–15 thin rays on tangential millimeters, the multiseriate being rare and at relatively uniform intervals. Radially the rays are homocellular and show cells all procumbent. Sometimes there is a tendency to heterocellularity, the rays showing 1–2 rows of square or upright marginal cells. In the cross-fields, 5–7 small bordered pits appear, rounded to elliptic (of 8-12 / 5-9 µm) usually hardly visible, since often gum remains and solitary crystals appear inside the ray cells are present, blurring the details. Sheath cells or tile cells are not present.

Special details – such as storied structures, secretory elements, intercellular canals, cambial variants, included phloem are absent.

Mineral inclusions are present as usually rounded crystals, as we showed above, present in chambered axial parenchyma cells and in ray parenchyma cells.

Affinities and discussions

Evaluating the studied specimens, at least in cross-section, we observed their affinity to the *fagaceous wood structures* by their well-expressed ring-porosity. The two-sized rays (wide multiseriates and finer, mostly uniseriate) and the two-sized vessels with their distribution in a ring porous structure are typical for Quercineae (see Privé-Gill, 1975), especially for the extant genus *Quercus* L.

By consulting the books of Greguss (1959) and Schweingruber (1990), the site of Schoch et al. (2004) - onwards and Wheeler et al. (2011 - InsideWood – onwards) – we also have observed the xylotomical identity of our studied specimens to the quercineous taxa. For correct generic identification, some other keys of identification were consulted too, for example:

1. The key of Hadziev & Mädel (1962), which separate within the current Quercoideae subfamily, four types of wood structure:

• Type "Weisseichen" (white oaks), comprising most of the species of section *Quercus* (former *Lepidobalanus*) – having a ring-porous structure with small, polygonal, thin-walled vessels in the latewood, densely and flame-like arranged. This type of structure is quite similar to our here studied specimens.

• Type "Roteichen" (red oaks), comprising the species of the section *Lobatae* (former *Eritrobalanus)* and some species of Lepidobalanoideae, with ring-porous structure and relatively large, round, thick-walled vessels in the latewood.

• Type "Immergrüne eichen" (sempervirent oaks), comprising species of *Quercus* and of *Lithocarpus* with diffuse porous or half-ring-porous structure, the relatively small and spaced vessels, often radially disposed in the latewood.
• Type "Wurzelholz" (root-wood), present in all the Quercoideae and having diffuse porous structure and crowded large pores.
2. The key of Petrescu (1976), in which the author tried to systematize the fossil fagaceous wood structures, separating within the ring-porous structures those with uniseriate and compact pluriseriate rays, sometimes compact-compound or partially-aggregate, corresponding to the current *Quercus* genus and to the fossil genus *Quercoxylon*.
For fossil wood of this type was created, during the time, more genera, as it follows: *Kloedenia, Quercinium, Quercites, Quercus* and *Quercoxylon* - used by Goeppert, Felix, Unger, Conwentz, Mercklin, Schleiden, Edwards, Schüster, Platen, Knowlton, Pampaloni, Webber, Nee, Ogura, Watari, Shimakura (see Müller-Stoll & Mädel, 1957).
However, the accepted fossil morphogenus is *Quercoxylon*, which was created by Hofmann (1929), but was correctly defined later, by Kräusel (1939), with *Q. retzianum* Kräusel as type-species and with this diagnosis: "Secondary wood porous or ring porous with more or less obvious growth rings, usually solitary vessels, with simple perforations, with large alternate pits, bigger to parenchyma or to ray cells from irregular oval to polygonal, usually vertical; specific two-sized vessels and, tracheids, and libriform fibers and parenchyma as diffuse, as short tangential uniseriate bands. Two-sized rays: short, uniseriate rays, sometimes as false broad rays; and real broad rays, compound, compact and aggregate".
The genus was slightly emended by Müller-Stoll & Mädel (1957) and by Gros (1983, 1988). This is the last diagnosis of *Quercoxylon* given by Gros (1988): "Porous or ring-porous structure, usually simply perforated solitary vessels, alternate vascular pitting; pitted parenchyma, banded or diffuse; libriform tracheids and small vessels in groundmass; and two-sized rays".
Later Suzuki & Ohba (1991), have described some quercineous species from Japan, and made a revision of fossil woods of *Quercus*-type and of *Lithocarpoxylon* genus. They did not commented the validity of the genus *Lithocarpoxylon*, created by Petrescu (1978), which was considered later invalid by Selmeier (1997) who considered the diagnosis of *Quercoxylon* as including references to similar details. For more details on the adventures of these morphogenera see Suzuki & Ohba (1991), Gregory et al. (2009, pp.46-54).
The analysis of the xylotomy of our studied specimens shows that they should belong to "Weisseichen" type, from *Quercus* section, since they present in cross-section ring porous structure with large vessels in the earlywood and small, polygonal, thin-walled vessels in the latewood, as Hadziev & Mädel (1962) said.
But the distribution of the vessels may have many variations, as some other authors previously have been shown (see Selmeier, 1971; Privé-Gill, 1975). Thus, Privé-Gill (1975) observed 5 types of latewood vessels' distribution: 1. typical dendritical distribution as radial complexes separate by libriform bands; 2. diffuse distribution; 3. irregular distribution of few vessels or absence; 4. the vessels of the earlywood separated by a fibrous zone; 5. as radial complexes of vessels with gradual diminishing and separated by libriform fibers. The same author observed that the different types of distribution of the latewood vessels may correspond to some ecological variation that affected the trunk growing. Well-developed latewood indicates irrigated soil and reduced latewood is determined by a dry climate. The localization of the sample in the tree is told by the proportion of latewood, which can be bigger in the trunk than just under the canopy or at the periphery and, the growth rings are more reduced in the branches that are in the trunk. Reviewing many extant described species of "white oak", the same author observed that there is a big intraspecific variation (Privé-Gill, 1975, p.125)
Selmeier (1996) also observed that, generally, the vessel diameter, ray size, ray frequency and ray distribution are variable and, even in the same described fossil species, the biometric values may be different. For this reason, in the xylotomical description of extant wood, we find no actualized measurements. So the accurate measurements made by palaeoxylologists cannot be always useful to identify an unknown.
Much more, the rules from "IAWA List of Microscopic Features for Hardwood" (Wheeler et al., 1989) impose different ways to express the older measurements.
Thus, because the current genus *Quercus* L., having over 500 species, shows a great interspecific xylotomic homogeneity, there is very difficult to delimitate the fossil species, and they have only a descriptive value, as form-species, otherwise very numerous (see Gregory et al., 2009, pp.46-54).
After this discussion, and reviewing the description of our specimens, we observed that the arrangement of the vessels of the early, transitional and latewood is very similar to the current white oak group (Sect. *Quercus*), spread in Europe and partially in western Asia.
It appears that such an oak-type has dominated the European Miocene, since such similar forms, even identical (see Petrescu, 1976) have been described in the Pannonian space by Felix, Andreánszky, Hofmann, Greguss (in Müller-Stoll & Mädel, 1957), usually described as equivalents to the current *Quercus robur* L., which belong to *Quercus* section, identified later as *Quercoxylon bavaricum* Selmeier 1971. In fact, many similar species were described in Carpathians, even from Huşi-Avereşti-Soleşti area, an area slightly northward of the site of origin of here studied material, which we suppose it was transported from that area, and we cite them: *Quercoxylon sarmaticum*, *Q. compactum*, *Q. macarovicii*, *Q. kersonianum* and *Q. solesticum* described by Starostin &

Trelea (1969, 1984, 1987). Also, some other quite similar Miocene oak wood were described from the Carpathian area by Iamandei et al. (2001a,b,c; 2006; 2008a,b; 2010; 2017; 2020).

Some of the wood remains collected from Solești area by Iamandei & Iamandei (2010) were attributed to *Quercoxylon bavaricum* Selmeier, considered as the nearest living relative to the current *Quercus robur* L., maybe to *Q. petraea* (Matt.) Liebl., as a white oak too, and very similar (Greguss, 1959; Schweingruber, 1990; Akkemik & Yaman, 2012). However, this species described by Selmeier (1971) from Germany has a correspondent within the Carpathian area in *Quercoxylon sarmaticum* described by Starostin & Trelea (1969), and this species must be revised, because, if Petrescu (1976) was right, the Romanian fossil species could have priority versus the German one, defining the same type of wood.

Therefore, after the above discussion and taking into account the structural details observed in our here studied specimens, regarding the vessels arrangement in the growth ring, the aspect of the ground tissue and of cross-field pitting which are similar to the form described by Selmeier (1971), we assign them to the species *Quercoxylon bavaricum* Selmeier 1971.

Quercoxylon intermedium Petrescu et Velitzelos, 1981
Fig. 5, a-i.

Material code: Pb39, Pb41, Pb42, Pb50, Pb55, Pb56, Pb57, Pb61 and Pb62.

Locality: Simila gravel quarry (Vaslui county), central part of Moldova, Northward of Bârlad.

Repository: in the Collection of the Natural Sciences Section of the Museum "Vasile Pârvan", from Bârlad city, Romania.

Age: the Maeotian age.

Formation: Fluvio-deltaic sediments with gravel levels, exploited in Simila gravel quarry, where the petrified wood samples appear as reworked centimetric elements with obvious ring porous and fibrous structure with big vessels – visible even by the naked eye, typical for a dicot.

Microscopic description

The growth rings are quite distinct in cross-section, the wood structure appears as semi-ring-porous, with vessels in radial bundles, usually gradually diminishing from the earlywood to the latewood one. Often, in some specimens, a two-sized aspect of the vessels is visible. The ring boundaries are marked by the abrupt change between the latewood with small vessels and the suddenly starting earlywood with big vessels. Also, two-sized rays are usual.

The vessels appear exclusively solitary, arranged in radial bundles, giving a slightly irregular to diffuse general aspect. The cross-section of the earlywood vessels is round to oval, often deformed or radially elongated. Their lumina varies between 200–350 µm in diameter, while the smaller vessels diminishing to the latewood are usually rounded polygonal or star-like, and their diameters vary between 40–150 µm. The vessels are moderately thick-walled: 3–5 µm the simple wall. The vessels' density is variable, as 3–5 vessels per square millimeter in the earlywood, and between 7- 14 in the latewood. Simple perforations on tilted plates are present and numerous bordered pits are visible on the vessel walls, corresponding to those of the vasicentric parenchyma. The pits are slightly small oval, of 4-5 µm in diameter, opposite, sub-oppositely to slightly alternately arranged, and crowded. Helical thickenings are not visible, also tyloses or content, since poorly preservation. Mean vessel elements, difficult to measure, range from 350 to 800 µm.

The ground tissue is constituted from libriform fibers and parenchyma, which are often difficult to identify from each other, due to bad preservation.

The libriform fibres, in cross-section seen, constitute the major part of ground tisue, are relatively thick walled and, longitudinally viewed, are pitted and non-septated. Fibrotracheids and vasicentric tracheids are also present, and difficult to identify in cross-section, but on their vertical walls, pitting can be observed.

The axial parenchyma appear in cross-section of apotracheal type, either diffuse, scattered among the fibers, or diffuse-in-aggregates. Also, paratraheal parenchyma appears, less visible in cross-section, closely appressed to the vessels and pitted in longitudinal view, sometimes chambered and crystalliferous, difficult to observe, due to the poor preservation.

The rays are of two sizes and, in cross-section, appear quite linear. The fine rays, usually uniseriate, are numerous and low. The broad rays occur, in cross-section, at relatively uniform and large intervals. They are multiseriate, of 13– 20 cells wide (i. e. up to 300–350 µm in width), are often taller than 1 mm and are usually dissected by libriform fibers, giving them a typical aspect of compound-aggregate or even aggregate rays. In the tangential section, the ray cells appear rounded to polygonal cells, unequal in size (8– 15µm) and rather thin-walled (2–3 µm the width of the double wall). The ray-density is variable, varying between 10–20 rays on a tangential millimeter. In radial view the rays are slightly heterocellular, showing procumbent cells in the median part, followed by squared to upright cells in the external part (marginally). In the cross fields, numerous rectangular or vertical elliptic large pits are arranged "in palisade". Sometimes, gum remains and solitary crystals are present inside the ray cells, often difficult to observe, due to poor preservation.

Special details - as storied structures, secretory elements, intercellular canals, cambial variants, included phloem not observed or are absent.

Mineral inclusions seems to be present as rounded crystals in chambered axial parenchyma cells and in ray parenchyma cells.

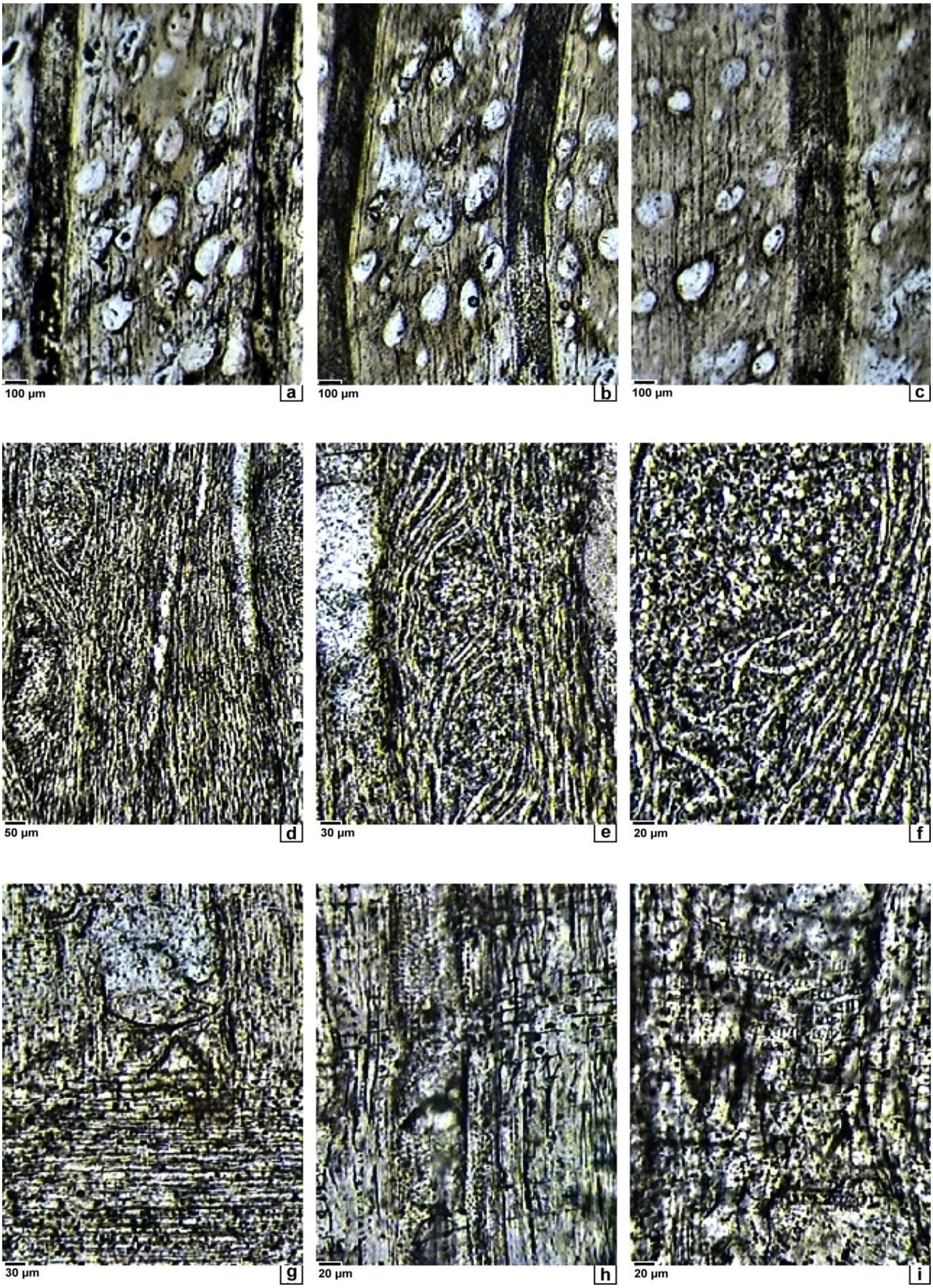

Fig. 5 - *Quercoxylon intermedium* Petrescu et Velitzelos, 1981. Specimen Pb55. **a, b, c** – cross section: semi-ring-porous wood with gradually diminishing vessels, in radial bundles, and two-sized rays and growth-ring boundary difficult to guesss; **d, e, f** – tangential section: broad fusiform rays, dissected by libriform fibers giving them a typical aspect of compound-aggregate or even aggregate rays (e, f), and thin rays 1-2 seriate; **g, h, i** – radial section: vessels with simple perforations and alternate pitting on vessels, bad preserved cross-field (g, h) but clear rectangular or vertical elliptic large pits arranged “in palisade”(i).

Affinities and discussions

The studied specimens show, in cross-section, a semi-ring porous wood-structure with broad rays and this indicates them as possible fagaceous woods (see Petrescu, 1976). The aspect of the vessels, the two-sized rays with the broad rays situated at relatively uniform and large intervals and usually dissected by libriform fibers giving aspect of compound-aggregate or aggregate rays and their cross fields with pits "in palisade", all clearly suggest an oak-tree type structure, as resulted from consulting Greguss (1954), Hadziev & Mädel (1962), Schweingruber (1990), the site of Schoch et al. (2004) - onwards and Wheeler et al. (2011 - InsideWood – onwards) (see discussion above).

However, their structure could be also diffuse-porous, which is characteristic of the evergreen species, while the ring-porous structure characterizes the deciduous species of *Quercus* (and the most septentrional species of *Lithocarpus*). In the root wood, the deciduous species often tend to lose their ring-porousness and to become similar to the evergreen species, and the broad rays become divided into false rays, i.e. aggregate rays (Privé-Gill, 1975).

For quercineous fossil wood (see discussion above), the accepted valid name is *Quercoxylon* Kräusel 1939 (emend. Müller-Stoll & Mädel, 1957; em. Gros, 1988), and based on the cited keys of identification, it appears that the here studied specimens suggest a structure of white oak type, close to the extant *Mesobalanus* group.

Thus for comparison we used several fossil forms of *Quercoxylon*, described by Müller-Stoll & Mädel (1957), Greguss (1969), Nagy & Petrescu (1969), Hadžiev & Mädel (1962), Huard (1966), Privé-Gill (1975, 1984, 1990), Privé & Brousse (1976); Petrescu (1976, 1978), Petrescu et al. (1969, 1970, 1971, 1972, 1978, 1980, 1981), Starostin & Trelea (1969, 1984), Selmeier (1971, 1997), Suzuki & Ohba (1991), Selmeier et Velitzelos (2000), Iamandei et al. (2008a,b, 2010, 2011, 2014).

Taking into account the great intraspecific anatomic homogeneity inside the current *Quercus* genus and the variability of the measurable characters (see Prive-Gill, 1975 and Selmeier, 1996), and comparing the xylotomy of our specimens with that found in the above-cited studies, at other fossil oak described above as *Quercoxylon bavaricum*, we admit that, at the first sight, the wood structure of the here studied specimens seems to be similar to the current *Quercus borealis* L. (in Schweingruber, 1990), a synonymous of the current *Quercus rubra* L., a species of the red oak group (*Quercus*, section *Lobatae*), living now in North America, in the northeastern United States and southeast Canada (and locally named Northern Red Oak, or Champion Oak).

However, we consider that the Miocene ancestors of the extant oak species should not be searched on the American continent, but in the Mediterranean-European area.

Thus, we selected Petrescu et al. (1980, 1981), which have described from the Oligocene of Trakia (North-East of Greece) a *Quercoxylon helladae* (Petrescu, Velitzelos & Stavropodis, 1980) Selmeier 1997, which has some similarities with our specimens, and also the species *Quercoxylon intermedium* Petrescu & Velitzelos 1981 which is very similar to mediterranean evergreen oak species and to our studied specimens by the distribution of vessels in cross-section, by the aspect of rays of compound-aggregate and the aggregate type and by the cross-field pitting with palisade arrangement. This species was also described by Iamandei et al. (2014) from Rhodopes mts., Bulgaria. Reviewing the current mediterranean *Quercus ilex* L., an evergreen oak, and also the current *Q. cerris* L., a deciduous form native to south-eastern Europe and Asia Minor (Akkemik 2012; see also InsideWood), we observed that a lot of structural details are similar with those described in our specimens.

Thus, the tall broad rays usually dissected by libriform fibers giving a typical aspect of compound-aggregate or even aggregate rays (Fig. 6e-f) suggest a similarity up to identity with the fossil species *Quercoxylon intermedium* Petrescu et Velitzelos 1981, to which we assign the studied specimens.

Family **Salicaceae** Mirb., 1815
Genus ***Populoxylon*** Mädel-Angeliewa, 1968
Populoxylon tremuloides Iamandei & Iamandei, 2006
Fig. 6, a-i.

Material code: Pb14, Pb18, Pb25 and Pb37.
Locality: Simila gravel quarry (Vaslui county), central part of Moldova, Northward of Bârlad.
Repository: in the Collection of the Natural Sciences Section of the Museum "Vasile Pârvan", from Bârlad city, Romania.
Age: the Maeotian age.
Formation: Fluvio-deltaic sediments with gravel levels, exploited in Simila gravel quarry, where the petrified wood samples appear as reworked centimetric elements with obvious ring porous and fibrous structure with vessels – visible even by naked eye, typical for a dicot.

Microscopic description

The growth rings – distinct, wide, are often unequally wide, since having distinct ring-boundaries, marked by a few rows of slightly flattened cells of ground tissue as final wood and the sudden start of the earlywood with large pores.

The vessels, in the cross-section seen, have quite similar sizes and are evenly distributed throughout the growth ring, so defining a diffuse-porous wood structure. They appear in radial pattern between two successive rays, usually as radial multiples of 2-4(-6) pores, sometimes mixed with a few solitary pores, whose contour is polygonal rounded to oval, or star-like. The radial groups use to be radially linked by 1-5 fibro-tracheids (described below). In the groups larger and smaller vessels are present. The mean tangential diameter of the solitary vessels lumina is 50-120 μm. The density is 80-160 vessels per

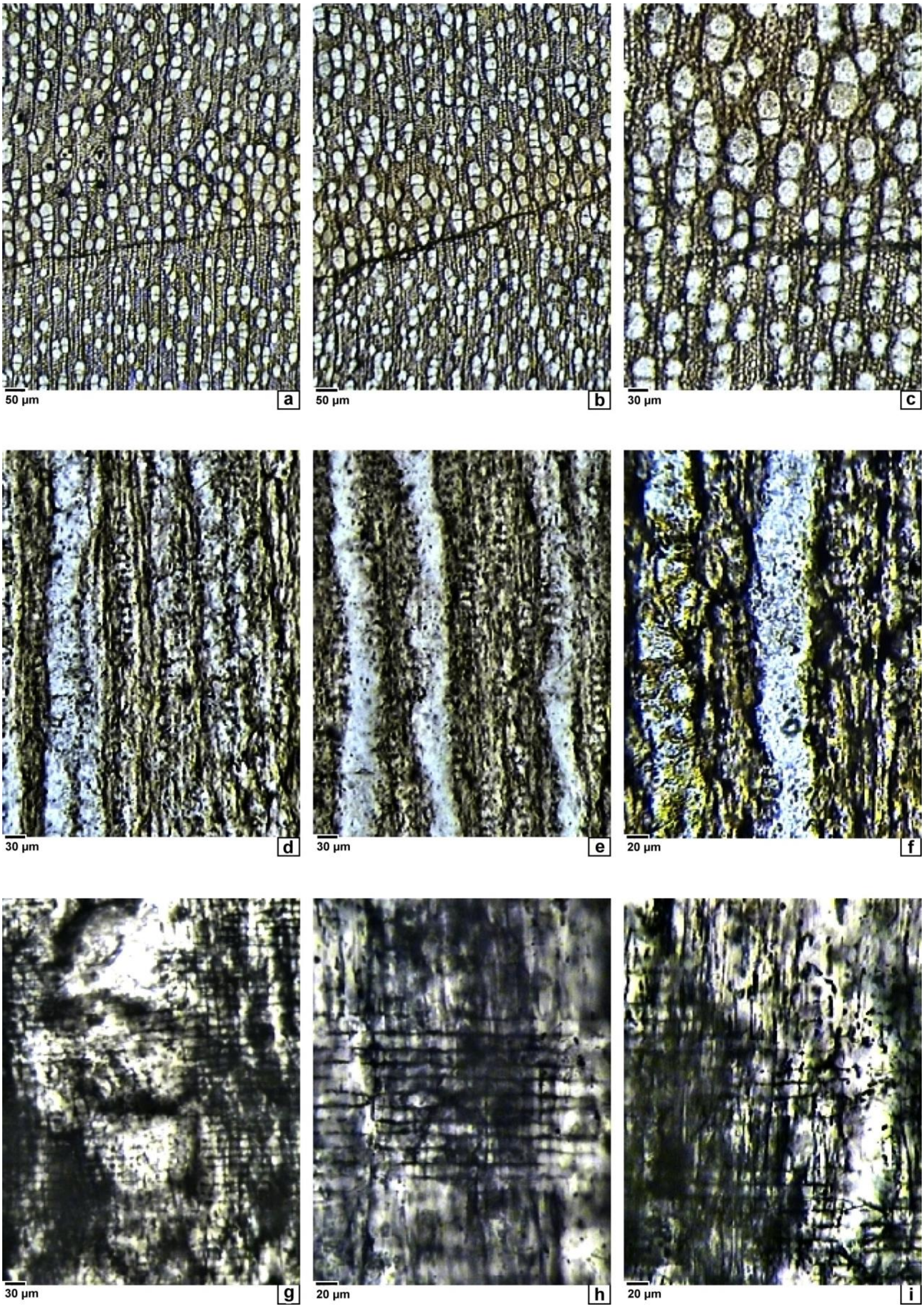

Fig. 6 - *Populoxylon tremuloides* Iamandei & Iamandei 2006. Specimen Pb14 . **a, b, c** – cross-section: aspect of growth rings, diffuse porous distribution of vessels, fine rays, regular libriform fibers; **d, e, f** – tangential section: poorly preserved alternate intervascular pitting (e), uniseriate rays; **g, h, i** – radial section, simple perforated plates (g), poorly preserved cross-fields with vessels.

square millimeter, sometimes more. In the longitudinal view, the vessels show simple perforation plates, inclined, and usually poorly preserved. The intervessel pits are of bordered type, numerous, alternate, polygonal, mean-sized of 8-10 µm in diameter, with a horizontal-elliptic aperture of 3-4 µm. Vessel–ray pits with distinct borders, similar to intervessel pits in size and shape throughout the ray cell, but poorly preserved, and difficult to observe. The vessel-element length is probably ≥ 800 µm, but difficult to meassure, due to poor preservation. Thin-walled tyloses and dark gum remains or fungi, rarely appear inside vessels.

The ground tissue include fibers and parenchyma, usually mixed.

The libriform fibres have also polygonal cross-section, of 12-16 µm in diameter, and relatively thick walls: 4-6 µm the double wall. They show a poorly preserved pitting on the longitudinall walls and are non-septate.

Fibro-tracheids are present, linking the radial groups of vessels, as 1-5 cells, and are similar to the libriform fibers, or larger, of 15-20 µm, and are moderately thick-walled, of 3-6 µm the double wall. More microscopic details on the tracheids which are linking the radial groups of vessels are difficult to observe, due to poor preservation.

The wood parenchyma appears few and scarce, diffuse or terminal, rather indiscernible, even if sometimes it appears in the vertical sections.

The medullary rays appear thin in cross-section and formed by quassi-rectangular radially elongated cells. On the horizontal walls simple small pits difficultly can be seen, since granular gum remains usually are present inside the ray cells. The ray trajectory is usually linear, or slightly sinuous. Tangentially the rays appear exclusively uniseriate and have 5-35(-55) cells in height or even more. The ray-cells have polygonal rounded to vertical elongate shapes and, the marginals are slightly higher. The ray-frequency is ≥ 12 / mm, we counted even 18-22(-35) rays per tangential mm. Radially, the rays are homocellular, constituted from thin-walled cells, all procumbent, the marginals slightly taller. The cross-fields with vessels are difficult to observe due to poor preservation, but present 1-2 weakly bordered pits to apparently simple, per field, round to oval, of 4-7 µm in diameter, and in the marginal fields appear usually in 2-3 horizontal rows.

Special details - as sheath cells or tile cells are not present. Also, storied structures, secretory elements, intercellular canals, and cambial variants, including phloem are absent.

Mineral inclusions are present as usually rounded crystals, as we showed above, present in chambered axial parenchyma cells and in ray parenchyma cells.

Affinities and discussions

The studied specimens show, in cross-section, some xylotomical features typical for the current members of Salicaceae family, such as the uniseriate rays, diffuse-porous distribution of vessels, usually as radial multiples of 2-4(-6) pores, sometimes mixed with few solitary pores, and homocellular rays with cross-fields specifically pitted, suggesting the current genus *Populus* L. Quite similar features appear in the current *Salix* L., in which the cross-section shows the diffuse-porous distribution of vessels which appear usually solitary, and the rays are heterocellular (Greguss, 1959; Schweingruber, 1990; Schoch et al., 2004 – onwards; Wheeler et al., 2011; Akkemik & Yaman, 2012; Sakala et al., 2018).

From the above-cited scientific papers we found there are only five species of poplars, naturally growing in Europe today and in the Anatolian area: *Populus euphratica* Oliver *P. nigra* L., *P. alba* L., *P. tremula* L. and also, *P.* ×*canescens* (Aiton) Sm., which is considered a hybrid between the last two species (see *P.* ×*canescens* - Wikipedia). All these species are very similar since they cannot be distinguished from each other on the basis of their wood anatomy (see Schweingruber, 1990; Akkemik & Yaman, 2012). There is only one small difference: the rays are higher in the fossil species, and maybe the marginal axial parenchyma is more common in the fossil species.

There are no many fossil forms described by the study of wood remains, but the correspondent fossil genus - *Populoxylon* was created by Mädel-Angeliewa, in 1968, based on the study of the type species *P. priscum* Mädel-Angeliewa 1968. The diagnosis indicates: ”Diffuse porous wood with usually grouped vessels, that has simple perforations and numerous alternate intervascular pitting. The uniseriate rays have all procumbent cells, the marginals higher, the cross-fields simple pitted, in 2-3 horizontal rows of slightly oval pits, and few parenchyma”. And our studied specimens have almost the same xylotomical features.

For comparison we consulted the paper of Nastschokin (1968) who described a *Populus* sp. (*P. tremula* L.?) from the Quaternary of Yenisei-river basin (Russia). Close to us, Greguss (1969) has described a *Populoxylon* sp. (cf. *Populus tremula* L.), from the Sarmatian of Mikfalva (Hungary), which has a semi-ring porous wood with radially grouped vessels with simple perforation plates and alternate polygonal intervessel pits, and only uniseriate rays. Both these structures send to the current species *Populus tremula* L., (see Greguss, 1959; Schweingruber, 1990), and are very similar to our studied specimens. However, as Sakala (2006) and Sakala et al. (2018) observed, because of the lack of a radial section, it is not possible to confirm whether the rays are homocellular, similar to *Populus* L., or heterocellular, similar to *Salix* L. Dutrelepont et al. (1997) described a *Populoxylon* sp., which has the vessel distribution in cross-section similar to the extant *Populus euphratica* Olivier, which is slightly different of our specimens.

From far-East, Blokhina & Snezhkova (2003) described from the Upper Miocene of the Erkovetskii brown coal-field (Amur River Region), a *Populoxylon priamurensis* Blokhina et Snezhkova, and also, Terada and Suzuki described from Japan, a Miocene *Populus soyaensis* (in

Choi et al., 2010), which differ of our specimens by lower vessels density and arrangement in cross-section.

Iamandei et al. (2005, 2011) described some Mid-Miocene petrified woods collected from Prăvăleni (Apuseni Mts.) and, respectively, from Bala area (Mehedinţi Mts.) which presented xylotomical similarity to the current *Populus alba* L., as *Populoxylon* sp. (cf. *Populus alba* L.), which is slightly different, by their porosity.

From the Late Badenian of South Apuseni (Romania) Iamandei & Iamandei (2006) and later, from Moldova Rep. (Iamandei et al., 2008b), have described *Populoxylon tremuloides* Iamandei et Iamandei as xylotomically identical with the extant species *Populus tremula* L., (see Greguss, 1959; Schweingruber, 1991) and with our studied specimens from Simila gravel quarry.

Also, Akkemik (2021) described from Turkey (Hoçaş village, Seben city, Bolu), a new species, as *Populoxylon sebenense* Akkemik, which is slightly different of our specimens by the obvious presence of marginal axial parenchyma.

Thus, consulting also the identification key of Akkemik (2021) and revising once again the description of the here studied specimens, we observed an identity of their xylotomical features with those of the current species *Populus tremula* L., and also with the fossil form *Populoxylon tremuloides* described from Carpathian area, so we attribute them to the species *Populoxylon tremuloides* Iamandei et Iamandei, 2006.

Family **Rosaceae** Jussieu, 1789

Subfamily **Amygdaloideae** Arnott, 1832 (in Potter et al. 2007)

Genus *Prunoidoxylon* Dupéron, 1976

Prunoidoxylon multiporosum Dupéron, 1976

Fig. 7, a-i.

Material code: Pb36, Pb40 and Pb59.

Locality: Simila gravel quarry (Vaslui county), central part of Moldova, Northward of Bârlad.

Repository: in the Collection of the Natural Sciences Section of the Museum "Vasile Pârvan", from Bârlad city, Romania.

Age: the Maeotian age.

Formation: Fluvio-deltaic sediments with gravel levels, exploited in Simila gravel quarry, where the petrified wood samples appear as reworked centimetric elements with obvious ring porous and fibrous structure with big vessels – visible even by the naked eye, typical for a dicot.

Macroscopic description

The growth rings are relatively wide, with quite indistinct ring-boundaries that can be guessed when a size difference appears between the latewood and earlywood pores.

The vessels porosity is of diffuse-porous to semi-ring-porous type, the pores appearing in diffuse or slightly dendritic arrangement, as solitary and small radial multiples of 2-4 vessels. The solitary vessels outline is polygonal rounded and is usually of small type, even in the earlywood, having 40-70 μm in diameters, slightly diminishing in the final wood (20-30 μm) and are moderately thick-walled: 3–5 μm the simple wall. The pores are very numerous, their density is ≥ 100 vessels per square millimeter. In the longitudinal view, simple perforation plates appear and the vascular pitting appears as numerous, alternate, small-bordered pits and poorly preserved. The vessel-ray pitting difficult to observe, is quite similar, with many reduced borders to apparently simple, corresponding to the cross-field pits (described below). Tyloses are absent, and gum deposits and crystals, are usually present.

The ground tissue – is represented by fibers, fibrotracheids and parenchyma.

The fibers are relatively thin-walled and poorly preserved, probably minutely pitted, and helical thickenings and non-septate. The fibrotracheids appear paratracheal, coiling the vessels, and are small pitted.

The axial parenchyma appear diffuse, and is extremely rare or even absent.

The rays are usually 1-5-seriate, sometimes broader, up to 10-seriate, and with variable height, sometimes up to 1 mm. Ray density is 6-8 rays mm horizontal, often more. As cellular composition, the rays are heterocellular, with all cells procumbent, the marginals slightly higher. The cross-fields, poorly preserved, have numerous alternate pits, in horizontal rows arranged, poorly preserved.

Other special details such as sheath cells or tile cells, storied structures, secretory elements, intercellular canals, cambial variants or included phloem are not present.

Prismatic crystals, inside vessels, sometimes appear, probably with a secondary origin.

Affinities and discussions

The studied specimens show some xylotomical features, especially the vessels diffuse-porous arrangement, in cross-section, very specific for the Rosaceae of "Prunoideae" type in fact from Amygdaloideae subfamily, by priority (see Potter et al., 2007) and not Spiraeroideae, as the International Botanical Congress from 2011 stated (ICN-Melbourne Code, see Wiersema et al. 2011).

For this type of wood, the genus *Prunoidoxylon* was erected by Dupéron (1976), studying some fossil wood from the Stampian formation of Agenais, from "Bassin d'Aquitaine", France, as having xylotomical features of "Prunoideae", describing the species *Prunoidoxylon multiporosum* Duperon 1976, designed as generotype, its diagnosis including the next details: Heteroxyl fossil wood showing growth rings with semi-porous aspect, with relatively small vessels (tangential diameter of 20 to 70 μm) in dendritic arrangement in latewood, and very numerous (100 to 195 pores per square millimeter), the density being greatest in earlywood. Vessel elements of short and medium length (260-460 μm.), with spiral thickenings, with simple perforations, perhaps rarely scalariform, and with small bordered pits (5-6 μm in

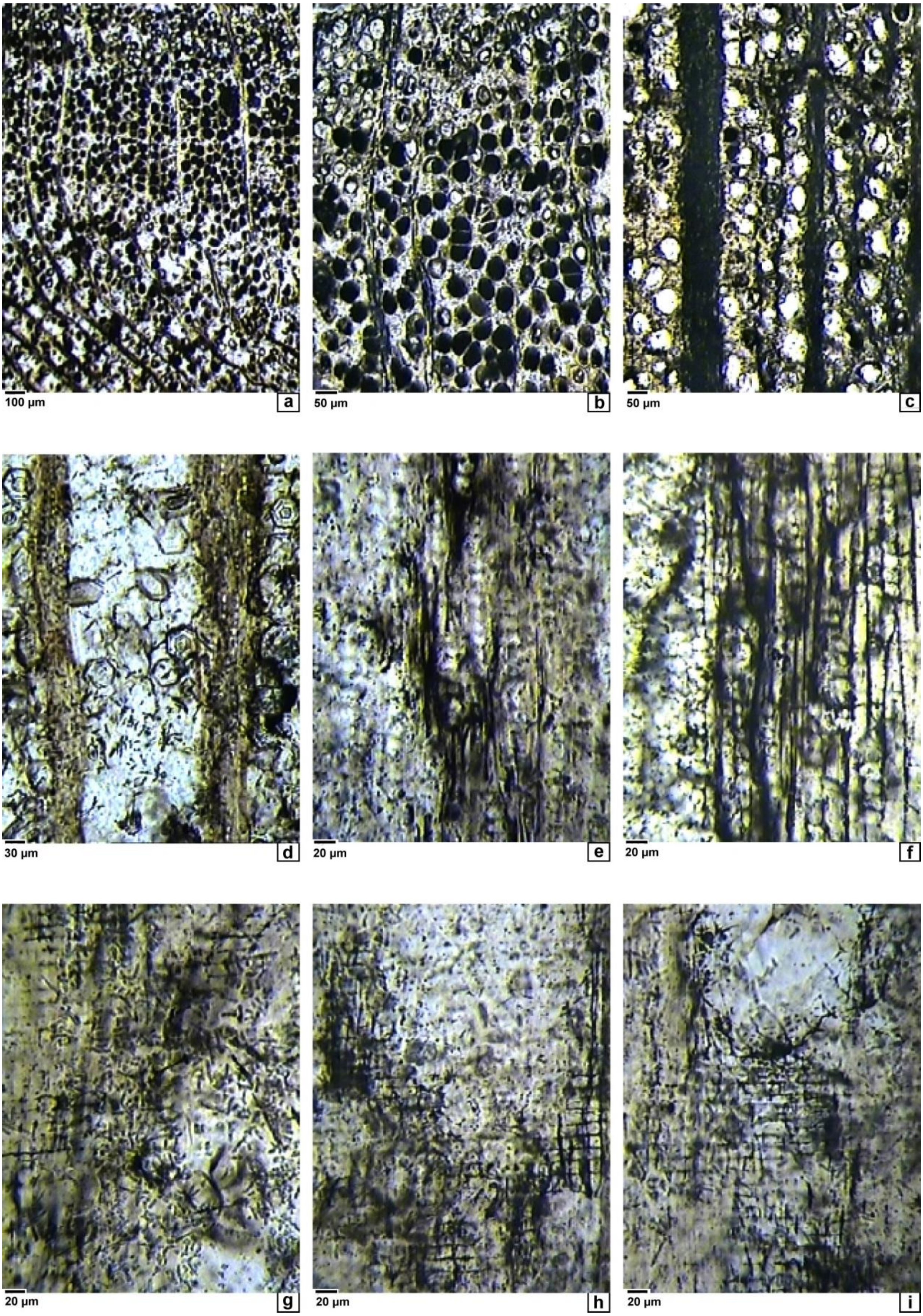

Fig. 7 - *Prunoidoxylon multiporosum* Duperon, 1976. Specimen Pb59; **a, b, c** – cross-section: aspects of growth rings, diffuse porous distribution of vessels, fine and broad rays, regular libriform fibers, relatively badly preserved; **d, e, f** – tangential section, crystals in vessels (d) uniseriate and multiseriate rays (e, f); **g, h, i** – radial section, simple perforated plates poorly preserved, small pits on paratracheal fibrotracheids (i), poorly preserved cross-fields.

diameter). Parenchyma is absent or extremely rare. Rays are very fine to medium broad (1 to 5 seriate), usually low and numerous, sometimes articulated, and heterogeneous. Libriform fibres are pitted with spiral thickenings.
Selmeier (1984) described from the Upper Miocene deposits of the localities Attenfeld, Egweil and Hammerbach (Germany), some petrified woods as members of Rosaceae family, as *Crataegoxylon cristalliferum* and *Pruninium*, alongside of a salicaceous species (*Populoxylon priscum*). He considered the valid name *Pruninium* Platen 1908, not *Prunoidoxylon* Dupéron, citing Süss (1982: 1556).
However, Wheeler & Landon (1992) described from the Late Eocene of Nebraska (US), between some other dicotyledonous fossil woods, a *Prunoidoxylon eocenicum* Wheeler & Landon, in which he described helical thickenings on vessels, tangential bands of traumatic gum canals, which are restricted to the subfamiliy ”Prunoideae”, and in particular to the genus *Prunus* s.l. (Metcalfe and Chalk, 1950; Zhang and Baas, 1992). Our specimens do have not such details that seem to be of traumatic origin, and so, are slightly different.
More recently, Akkemik et al. (2019) – described a new species of *Prunoidoxylon*, within a complex flora from the Neogene of Kilyos, a coastal area in Istanbul, Turkey, which can be similar to our specimens by their large rays.
However, using the identification key of Akkemik et al. (2019) and taking into account the xylotomical features observed in our specimens as the vessels arrangement, their big density, the presence of paratracheal fibrotracheids coiling the vessels, and the ray composition, even if the studied structures are rather poorly preserved, we assign them to the species *Prunoidoxylon multiporosum* Dupéron, 1976.

CONCLUSIONS

A collection of petrified woods from Simila gravel quary and Zorleni, in the central part of Moldavia, Northward of Bârlad, hosted in the Collection of the Natural Sciences Section of the Museum “Vasile Pârvan”, from Bârlad city, Romania, was submitted to a palaeoxylotomical study, and here you are the results.
The fossil woods was found in a fluvial-deltaic sandy formation of Maeotian age, which has levels of sandy clays or gravels. The gravel levels comprise rounded elements of sandstone or of petrified woods, and we suppose both come from a Sarmatian sedimentary formation which occurs in situ, more Northward, in Avereşti-Soleşti area.
A complex list of late Miocene flora conspected by Givulescu (2001) after the previous palaeobotanical studies on fruits, leaves or woods was completed by other studies of Ţibuleac (1998, 2001), Ţabără & Florea (2007), Chirilă & Ţabără (2008, 2010) Starostin & Trelea (1969, 1984), Lupu (1984), Iamandei et al. (1999, 2000, 2001a, 2010).
This woody flora characterizes a late Miocene Mixed Mesophytic Forest, which was growing on the Moldavian Platform and whose remains have been accumulated in the synchronous sediments collected by the developing hydrologic system, after the gradually retreat of the Dacian Basin. And, such plant association suggests, for that time, a mediterranean to arid palaeoclimate of continental type with two marked seasons, probably at the sylvosteppic edge.
As results of this complex palaeoxylotomical study, the following species have been identified here: *Glyptostroboxylon* cf. *rudolphii* Dolezych et Van der Burgh 2004, *Ulmoxylon scabroides* Greguss 1969, *Quercoxylon bavaricum* Selmeier 1971, *Quercoxylon intermedium* Petrescu et Velitzelos 1981, *Populoxylon tremuloides* Iamandei et Iamandei 2006, *Prunoidoxylon multiporosum* Duperon 1976. They represent probably the fossil equivalents of the extant species, living in Moldova now, and this can have great scientific significance, helping us with the palaeoclimatic and paleoenvironmental reconstructions for this region.

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