NEOGENE *TETRACLINOXYLON* WITHIN CARPATHIAN AREA

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The paper presents new identifications of *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI 2000, in Carpathians and their significance. Neogene paleoarea of life of *Tetraclinis* and the palaeoenvironment are discussed.

Key words: *Tetraclinis*, *Tetraclinoxylon*, fossil wood, paleoarea, paleoenvironment.

1. INTRODUCTION

The presence of *Tetraclinis,* during the Neogene, within Carpathian region (Romania) was well documented by the identification of many fossilized vegetative parts. The localities where this taxon was identified as leaf imprints show deposits of Earliest Miocene to Latest Pontian age (see Givulescu, 1997). Most of the locations with fossil *Tetraclinis* records are surrounding the Transylvanian basin, but records also have been found in Southern and Eastern Subcarpathians, from Miocene to Early Pliocene (Givulescu, 1997; Stancu & Țicleanu, 1975).

Fig. 1 – Map of Romania and Moldova Rep.
(Dark squares = places where *Tetraclinoxylon romanicum* has been described).

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Fossil wood equivalent to this taxon was firstly described in South Apuseni in the Late Badenian at Prăvăleni, Zarand, South Apuseni Mts. (*T. romanicum* IAMANDEI & IAMANDEI, 2000). This form was found again in Early Sarmatian in Eastern Subcarpathians, close to Suceava, North-eastern Romania (Iamandei *et al.*, 2005; and 2008, in press) and more recently, within Bursuc Flora (Early Sarmatian), in the right bank of Dniester River, Moldova Rep. (Iamandei *et al*., 2006).

In this paper we show the identification of the same taxon again within Prăvăleni – Ociu region, Zarand, within Meridional Subcarpathians, at Morilor Valley, coming from Salcia quarry close to Chişinău (Moldova Rep.), from the basal part of some Pliocene sands, most probably reworked from Late Miocene deposits (Sarmatian?) together with a lot of vertebrate remains (Obadă, 2005, p. 345). These new identifications give a new support for the extension to east of the *Tetraclinis* Neogene paleo-area of life in Europe.

2. PALEOXYLOTOMY

Family **Cupressaceae** RICH. ex Bartling
Subfamily **Cupressoideae** RICH. ex Sweet
Genus ***Tetraclinoxylon*** GRAMBAST, 1951
Tetraclinoxylon romanicum IAMANDEI & IAMANDEI, 2000
Plate I, Figs. 1-4, Plate II, Figs. 1-4, Plate III, Figs. 1-4,
Plate IV, Figs. 1-4, Plate V, Figs. 1-4, Plate VI, Figs. 1-4.

Macroscopic description

The new material we had for study comes from three different points: three samples come from Prăvăleni, South Apuseni Mts., from the same region with late Badenian deposits where the holotype has been found; another one sample comes from Valea Morilor, Mehedinţi county, Meridional Subcarpathians, from Sarmatian deposits; and two samples come from a small quarry from Salcia, Southeast of Chişinău, (Moldova Rep.), most probably reworked from Sarmatian also.

All of them are silicified small centimetric pieces, beige to light brownish in color, and with fibrous texture. The studied material (six samples and 18 thin sections) was deposited within GIR Collection of the National Geological Museum of Bucharest, Romania, under the nos.: 26469, 26470, 26723, 26724, 26725 and 26726.

Microscopic description

Growth rings distinct, marked by (2)5-8 rows of thick-walled compressed cells in the late wood, often with dark content and contrasting with the early wood that has enlarged polygonal thick-walled cells with round lumina. The rings have

up to 65 cells wide and the transition is gradual. Resin ducts absent. Rarely, cracks in structure appear, probably due to fossilization processes.

The tracheids, in cross section seen, have polygonal rounded or slightly deformed shape within compression wood that determines some rhomboidal intercellular spaces. The lumina of the vessels are round or rounded and variably-sized with radial/tangential diameters of 14-28/12-20 μm, sometimes with intermingled small cells of 8-12/8-10 μm, as short radial rows. In the late wood the cells are smaller-sized (7-12/12-20μm). The cellular walls are thick to very thick, the double wall having 5-10 μm in the early and transitional wood and up to 12-18 μm in the late wood. The density of the tracheids is of 2240-2672 cells on square millimeter. Tangentially, the tracheids show fewer pitting with smaller orned round borders, of 5-8 μm in diameter, with circular apertures of 2-3 μm. They are in a single vertical row disposed, slightly irregularly disposed over the common coarse striations of the tracheidal walls, so determining oblong inclined windows. In radial section, tracheids with rounded endings appear propped on the procumbent cells of the rays. The pitting, of abietineous type, shows orned borders of (12)15-19 μm in diameter. The apertures - of 2-4 μm, are circular to slightly elliptic in the late wood tracheids, where appear inclined in the same direction. The pits are spacedly disposed or contiguous, usually in a single vertical row, rarely two and sometimes slightly compressed. Rather rarely between spaced pits *crassulae* appear, usually in the early wood. Sometimes the tangential walls of the tracheids are molding the pits, determining a kind of wavy contour, character typically cupressoid. Obviously the tracheids of late wood have smaller pits spaced on a single vertical row ant the endings are more tapered. Sometimes *trabeculae* and resin remains can be observed inside the cells.

Wood parenchyma in cross section is quite few, but it's present as thin-walled cells with dark content, round or crushed and smaller than the surrounding tracheids or similarly sized, disperse or in short tangential lines, especially to the late wood. Longitudinally, strands of rectangular cells with unpitted walls, showing a slight constriction right to the horizontal wall, which appears thin, smooth or slightly rugose. Inside the cell, granular to compact dark remains appear, or globules or plugs of resins.

Medullary rays, in cross section seen, are constituted from rectangular cells sometimes with rare and few simple pitting on the horizontal walls. Tangentially, the low rays appear uniseriate, rarely with short biseriate storeys, having 1-23 cells in height, frequently 2-8. The cell shape appears round to oval, often with simple pitted tangential walls. The ray-density is of (4)8-17 rays on tangential millimeter. Radially the ray cells are homogeneous, with relatively thick-walled horizontal walls of 2-3.5 μm the double wall, smooth or slightly rugose. The tangential walls are 1-2 μm thick, and seem to be smooth or slightly rugose, never nodular. The indentures are absent. The procumbent cells are (7)12-16 μm high, the marginals

higher (of 16-28 μm). In the cross-fields 1 or 2 small cupressoid pits of 3-4 μm in a horizontal row or as diagonal pairs are present. In the marginal fields often they are more numerous, from 2 pits in vertical pair disposed to 3-4(5) pits in 2 superposed rows. The pits have round to oval borders of 3-4 μm in diameters and with small apertures of around 1 μm, elliptic or lens-like, included, oblique to vertical.

Affinities and discussions

The xylotomical features of the studied material, without any kind of ducts, mostly agree with the cupressaceous wood structure. The thick-walled tracheids with round lumina in cross section bring our studied specimens close to Callitroideae group, even if the absence of the callitroid thickenings exclude any similitude with *Callitris* (or with *Callitrixylon*) structure. Anyway, in the older classical taxonomy, the Cupressaceae family had a single member of Callitroideae group without callitroid thickenings: the extant monotypic genus *Tetraclinis* MAST., the single callitroid still living in the Northern Hemisphere (see Greguss, 1955).

This small tree of 6-8 m tall, rarely reaching 15 m, often with shrub habit, live now as endangered species or vulnerable populations (in the lists of IUCN), in the extreme South of Spain, in Morocco, North Algeria, North Tunisia, and in Malta, also perhaps North-Eastern Libya (Earle, 2007, quoting Farjon, 2005). New taxonomic studies showed that *Tetraclinis* MAST. agree better as a member of Cupressoideae group (subfamily, Gadek *et al*., 2000), side by side with *Cupressus* L., *Juniperus* L., *Xanthocyparis* FARJON et HIEP*, Microbiota* KOMAROV*, Platycladus* SPACH*, Calocedrus* KURZ*, Chamaecyparis* SPACH*, Fokiena* HENRY et THOMAS*, Thuja* L.*,* and *Thujopsis* ENDL. (see also in Earle, 2007).

So, the studied structures, devoid of juniperoid nodules and, surely, devoid of callitroid thickenings, cannot be a relative of *Juniperus* or *Callitris* but can be compared with the xylotomy of the extant *Tetraclinis articulata* (VAHL.) MASTERS with which a great similitude can be observed, regarding the aspect of tracheids in cross section, the radial pitting and the cross-field pitting.

The comparison with the few fossil species of the already described morphogenus *Tetraclinoxylon* GRAMBAST also shows great similitudes. The fossil species already described used for comparison were the following:

- *T. boureaui* the type-species of the genus *Tetraclinoxylon*, described by Grambast (1951) from the Chattian of Paris Basin (see also Grambast, 1962);
- *T. vulcanense* described by Catherine Privé (1973) from the Pliocène of Puy-de-Dôme, France;
- *T. vulcanense* identified by Sakala (2003) redescribing a big petrified Late Eocene trunk from Kučlín, Czech Rep., originally determined by Březinowá *et al*. (1994) as *Podocarpoxylon helmstedtianum* by Gottwald, 1966;
- *T. anglonae* described by Biondi (1979) from northern Sardinia;
- *T. lusitanense* reassigned by Süss (1997), because originally it was described by Vallin as species of *Cupressinoxylon*;

- *T. velitzelosi* described by Süss (1997) from Lesvos, Greece;
- *T. romanicum*, described by Iamandei & Iamandei (2000).

Evaluating the xylotomical features of all the described species, it is possibly to observe the few and even insignificant differences in between that could be interpreted better as intraspecific variability and all of them are very similar with the extant species. By the other hand, it's good to remember that, also today, this genus has single species – *Tetraclinis articulata* (VAHL.) MAST. surviving in a very restraint Mediterranean area.

The fossil forms described till now by the study of leaf imprints from Europe, also show very few species: *T. salicornioides* (UNGER) KVAČEK that perfectly correspond to the extant species and *T. brachyodon* (BRONGN.) MAI & WALTHER most probably was a fossil xerophytic form having no extant equivalent. If this is true, it's very possibly that this xerophytic form had a special wood structure, slightly different than the first (*T. salicornioides*), and much more identifications of *Tetraclinoxylon* form-species could support better such a supposition.

During the progress of this paper a preliminary review was done by Martina Dolezych (by courtesy of Sakala, 2007) that has not agreed our identification of this studied material as *Tetraclinoxylon* because the bad microphotos don't show sufficient details. She suggests better to attribute the name *Cupressinoxylon* GOEPPERT emend. DOLEZYCH, since our described woods, she said, has affinities "to the living *Xanthocyparis* L. (esp. *Xanthocyparis nootkatensis* (D. DON) FARJON & HARDER) or to *Chamaecyparis* SPACH.". Acording to her, our studied material cannot represent *Tetraclinoxylon* because "has not affinity to the living *Tetraclinis*, which has only uniseriate radial bordered pits and no *crassulae*, has only uniseriate rays with cells up to 30 high or more, mostly over 10 cells in high, usually 1-2(3) cross-field pits, but never 4-5 cross-field pits and the horizontal walls on parenchyma strands are smooth".

In fact, our studied material is not identical with the extant monospecific genus, because it represents a stage of evolution of the genus, from Mid Miocene (9-10 MY ago), and many fossil forms already described present micoscopic details different from today. I will quote, however, the comments of Jakub Sakala (also written communication, 2007), who observed on some slides prepared from wood of living *Tetraclinis articulata* (No. 2280, UPMC, Paris) "very often 3-4 typically cupressoid pits per field, mostly in marginal ray cells; very rare biseriate portions of pitting on radial tracheid walls and *crassulae*, present especially on the wider tracheids of early wood", but no biseriate portion in rays were observed, contrary to the descriptions in Kräusel (1949), Grambast (1951), Greguss (1955), Vaudois & Privé (1971), Privé (1973).

Anyway, the comparison of the structure of our studied material made with the species already described from Carpathian area, either from the same locality with the holotype (Iamandei & Iamandei, 2000), or from other localities in North-eastern Romania (Iamandei *et al*., 2005), or in Moldova Rep. (Iamandei *et al*., 2006,

and 2008 in press), shows small xylotomical differences that could also be considered as representing intraspecific variability (for example the variable frequency of the *crassulae* even in our here studied specimens), so we assign our studied material represented by 6 samples, coming from 3 various places in Carpathians and around, to this species named *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI, 2000.

3. CONCLUSIONS

The fossil corespondent *Tetraclinis salicornioides* (Unger) Kvaček was frequently identified in Europe (see Kvaček *et al.*, 1989, Kvaček & Hably, 1998), as well as in Oligocene-Miocene of North America (see Kvaček *et al*., 2000).

In East Europe, in Carpathians *Tetraclinis salicornioides* (Unger) Kvaček also has been identified as leaf imprints during Tertiary (see Givulescu, 1997), but no identification of leaf imprints was made Outside Carpathians, eastward, in Moldova Rep. Recently we have described Sarmatian petrified wood from North-eastern Romania, and from Moldova Rep., as *Tetraclinoxylon romanicum*. (Iamandei *et al*., 2005, 2006, 2008 in press). Within Meridional Subcarpathians, Stancu & Țicleanu (1975) also quoted the presence of *Tetraclinis* as leaf imprints.

Otherwise Kvacek (2002) quote the existece of a fossil subxerophytic relative of *Tetraclinis* named *T. brachyodon* (BRONGNIART) MAI & WALTHER as humid subtropical element coming from Mid Eocene to Pliocene, in all Europe (see also Givulescu, 1997, for Transylvania), probably from Caucasus up to Italy or to Germany.

Anyway, the only extant correspondent, *T. articulata* (VAHL.) MASTERS, as it's well known, has now a geographically very limited area of life. But we must imagine that this genus had a more extended Cenozoic fossil area, at least in Europe, around all the ancient Paratethys, indicating for that span of time a warm temperate paleoclimate of mediterranean type, evolving from mild to temperate because of the regressive tendency of the sea, after which large territories remained covered by lakes and marshes, that influenced the local environment. To the latest Pliocene this taxon disappeared from Carpathians, the climate probably becoming excessive temperate to cold temperate.

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(EPPC = European Palaeobotany and Palynology Congress; PCE = Exploratory Research Program; PNCDI = National Plan of Research, Development and Innovation; UEFISCSU = Scientific Research Funding Department; CNCSIS = National University Research Council).

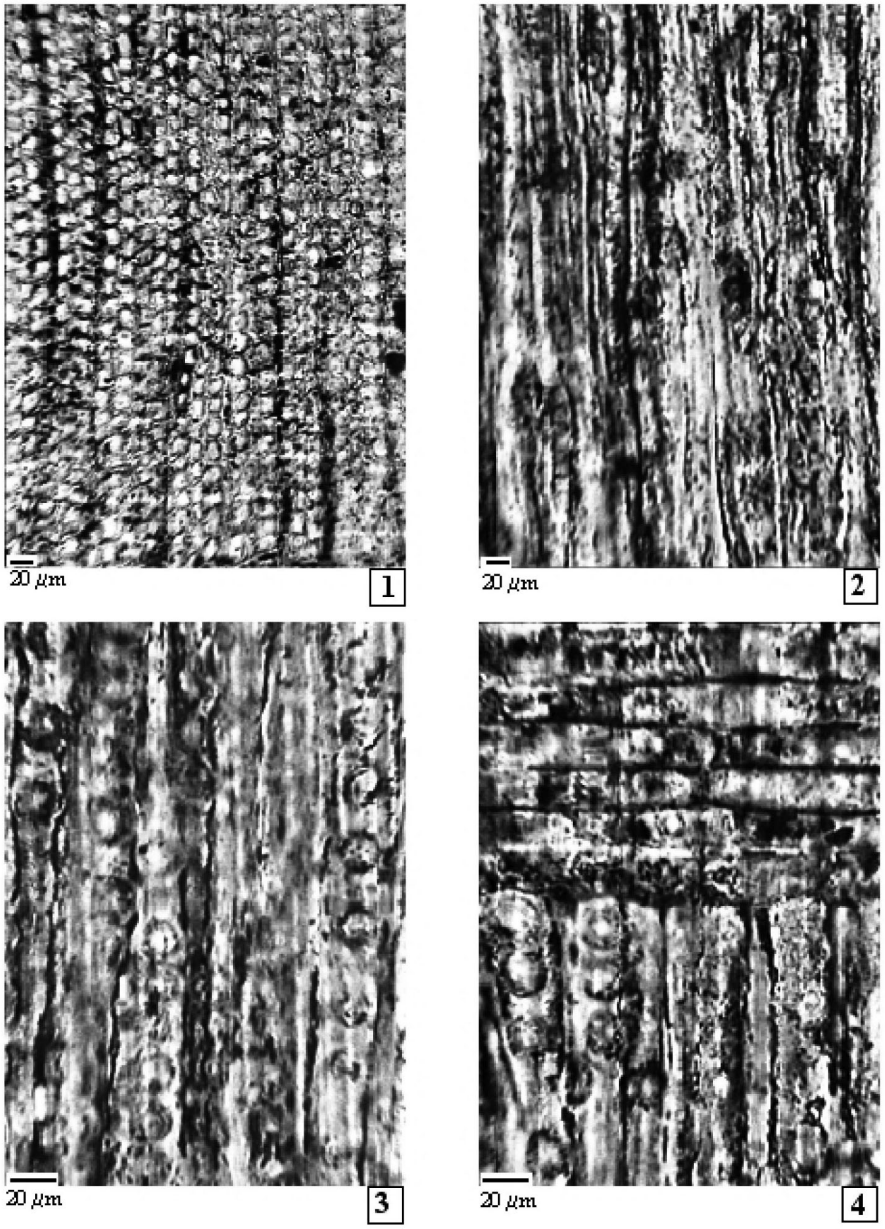

Plate I

Figs. 1-4. *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI, 2000. Specimen No. 26.469 (Prăvăleni, Romania).

Fig. 1. Cross-section, aspects of thick-walled tracheids with rounded lumina, rays and scarce parenchyma;

Fig. 2. Tangential section, badly preserved unpitted tracheids, short uniseriate rays;

Fig. 3-4. Radial section, uniseriate pitting on tracheids, cupressoid cross fields.

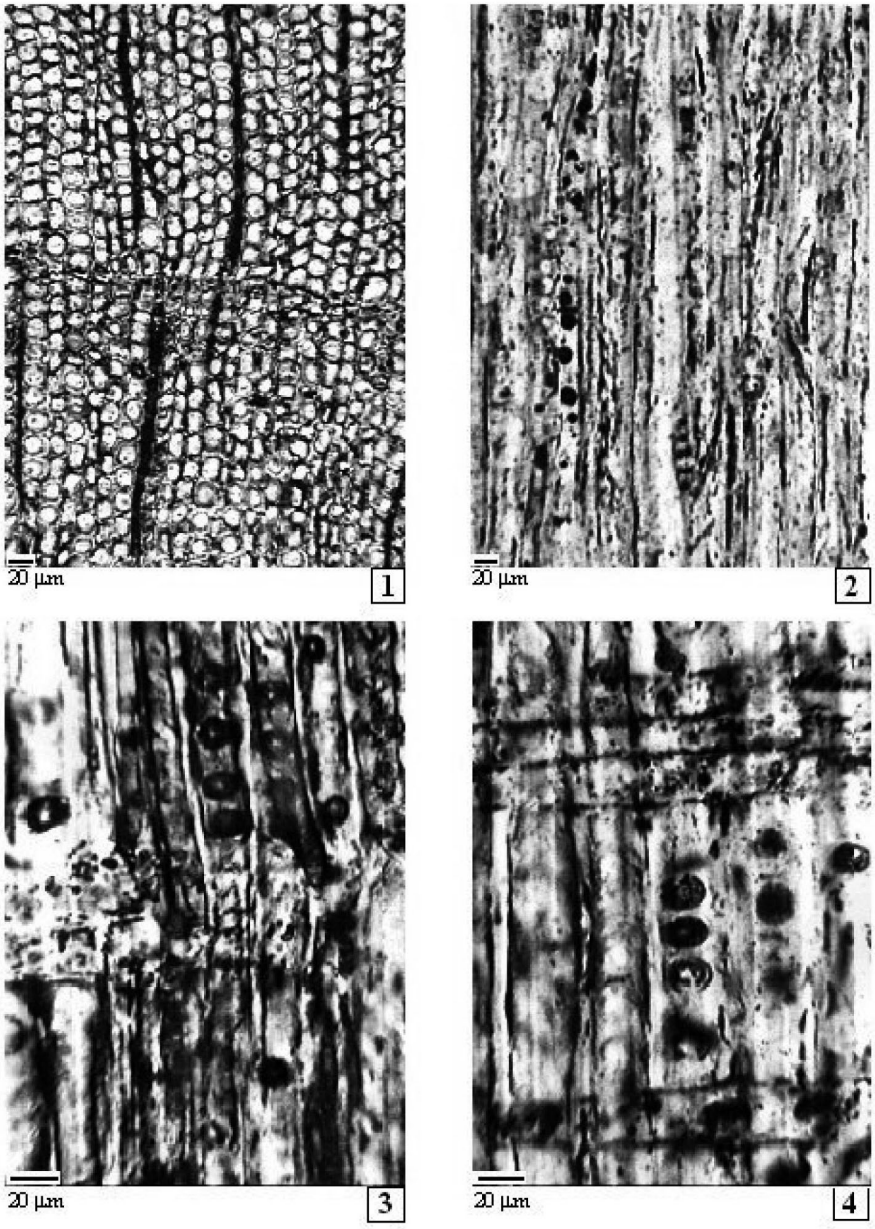

Plate II

Figs. 1-4. *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI, 2000. Specimen No. 26. 470 (Prăvăleni, Romania).

Fig. 1. Cross-section, thick-walled tracheids with rounded lumina, rays and scarce parenchyma;

Fig. 2. Tangential section, badly preserved scarcely pitted tracheids, short uniseriate rays, parenchyma with smooth horizontal walls;

Fig. 3-4. Radial section, uniseriate abietineous pitting on tracheids, cupressoid cross fields.

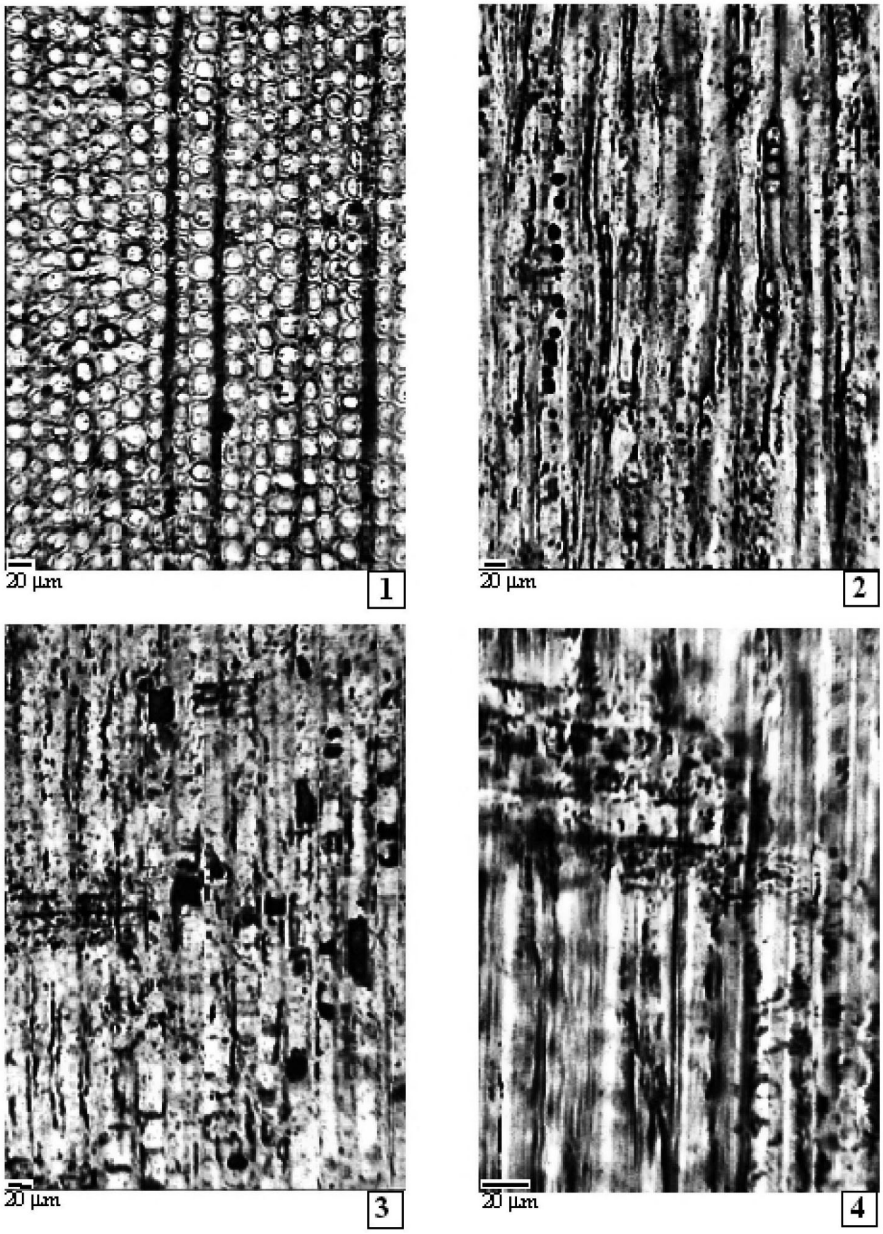

Plate III

Figs. 1-4. *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI, 2000. Specimen No. 26.723 (Prăvăleni, Romania).

Fig. 1. Cross-section, aspects of thick-walled tracheids with rounded lumina, rays;

Fig. 2. Tangential section, badly preserved unpitted tracheids, short uniseriate rays, parenchyma with smooth horizontal walls;

Fig. 3-4. Radial section, uniseriate abietineous pitting on tracheids, cupressoid cross fields.

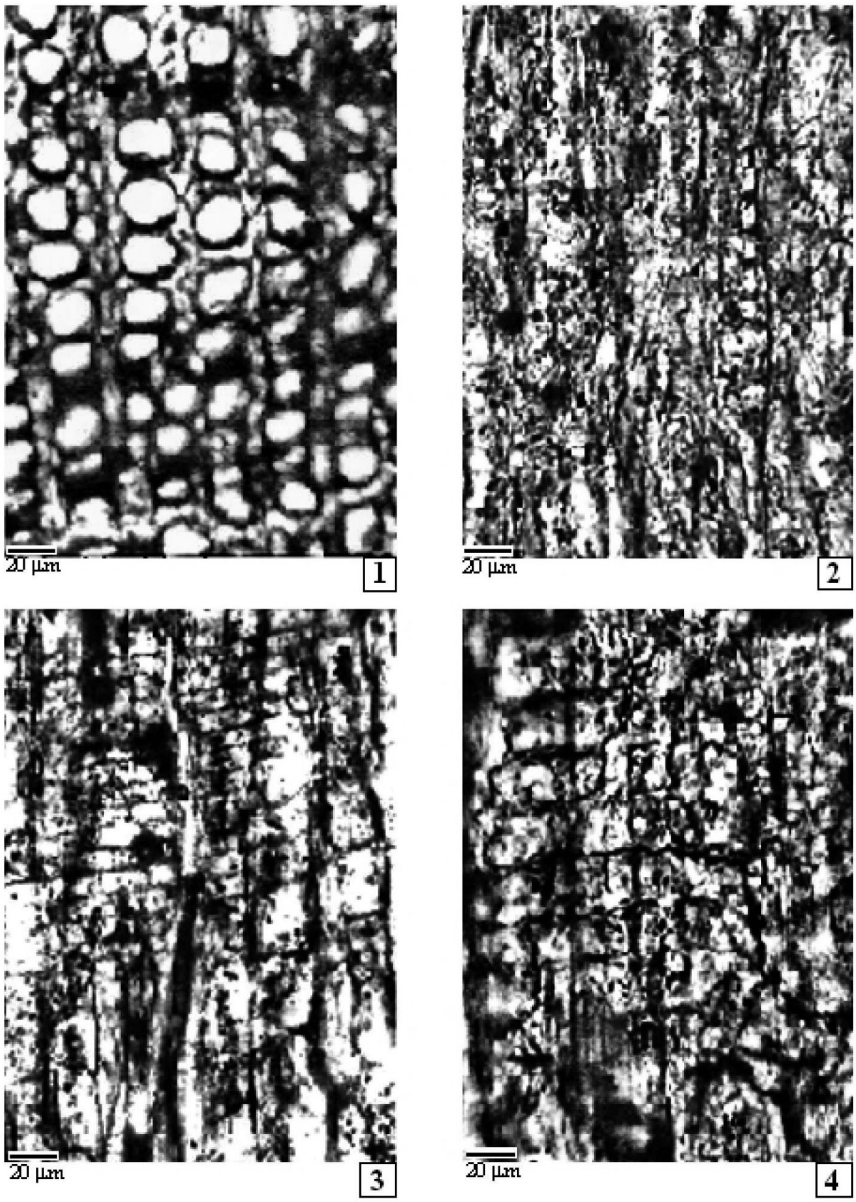

Plate IV

Figs. 1-4. *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI, 2000, Specimen No. 26.724 (Valea Morilor, Romania).

Fig. 1. Cross-section, thick-walled tracheids with rounded lumina, uniseriate rays and scarce parenchyma;

Fig. 2. Tangential section, badly preserved structure with unpitted tracheids, uniseriate rays and parenchyma with smooth to rugose horizontal walls;

Fig. 3-4. Radial section, badly preserved structure, cupressoid cross fields.

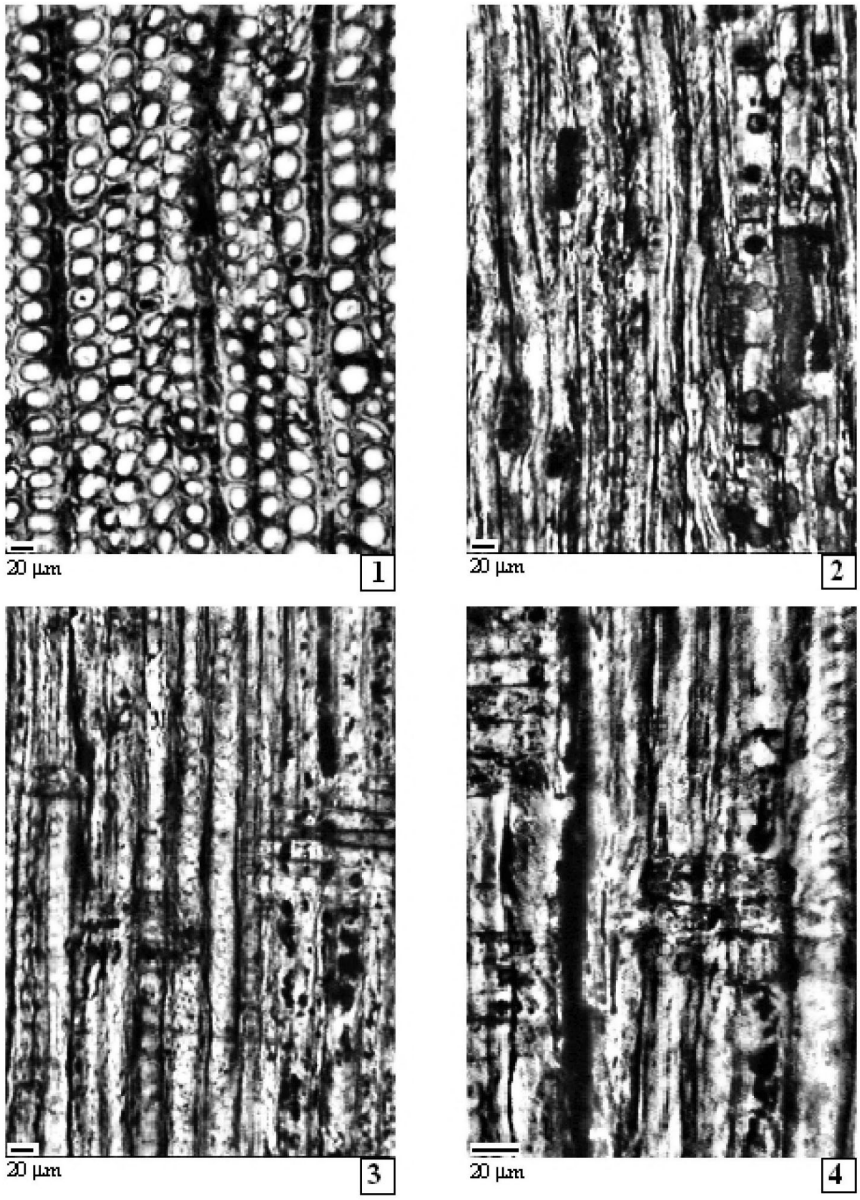

Plate V

Figs. 1-4. *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI, 2000. Specimen No. 26.725 (Salcia, Moldova Rep.).

Fig. 1. Cross-section, aspects of thick-walled tracheids with round lumina, rays and scarce parenchyma;

Fig. 2. Tangential section, badly preserved scarcely pitted tracheids, short uniseriate rays, parenchyma with smooth horizontal walls;

Fig. 3-4. Radial section, uniseriate abietineous pitting on tracheids, cupressoid cross fields.

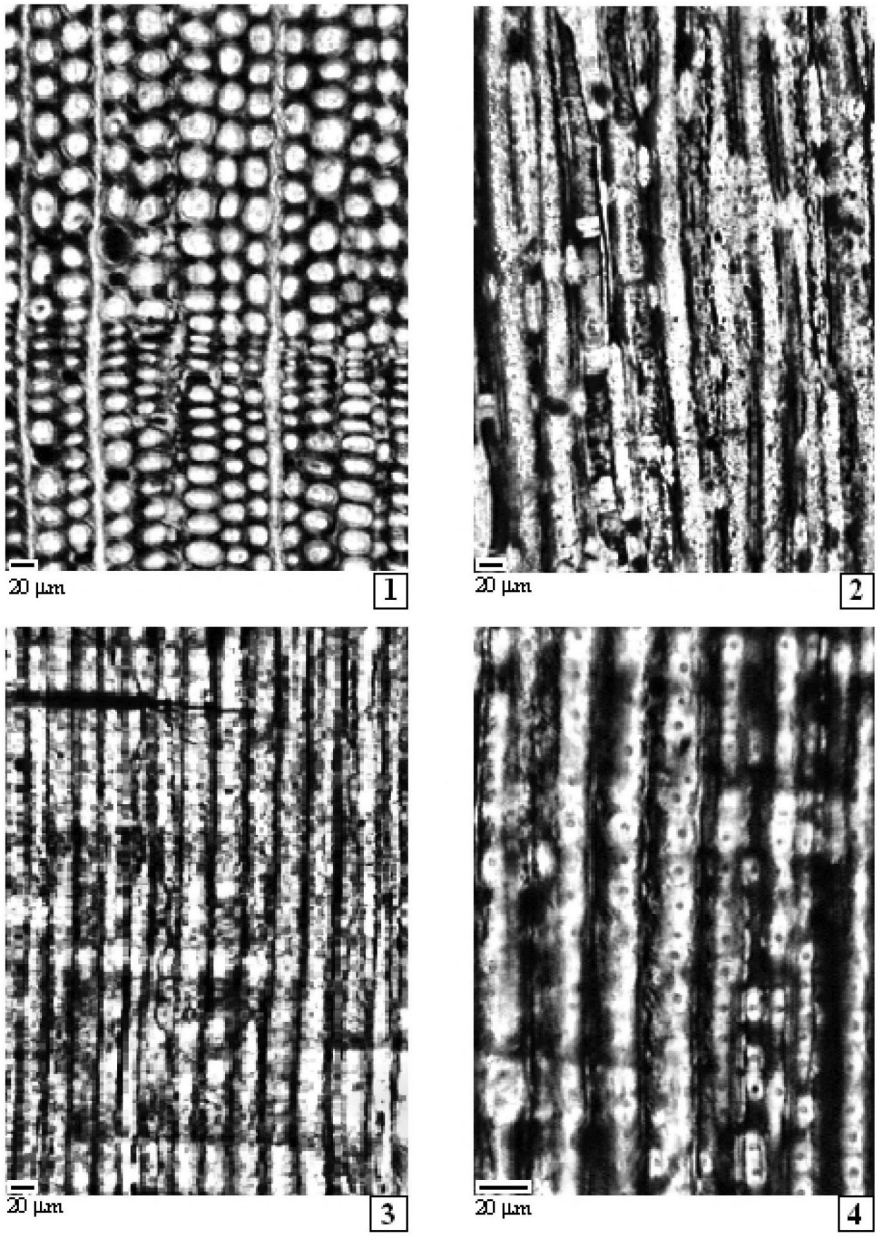

Plate VI

Figs. 1-4. *Tetraclinoxylon romanicum* IAMANDEI & IAMANDEI, 2000, Specimen No. 26.726 (Salcia, Moldova Rep.).

Fig. 1. Cross-section, aspects of thick-walled tracheids with rounded lumina, rays;

Fig. 2. Tangential section, badly preserved unpitted tracheids, short uniseriate rays, parenchyma with smooth horizontal walls or slightly rugose;

Fig. 3-4. Radial section, uniseriate abietineous pitting on tracheids, cupressoid cross fields.

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