A NEW MID-MIOCENE WOOD FROM OCNA DEJ SALT MINE

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Abstract. Ocna Dej is an iconic locality for salt mining in Transylvania, being located in the north - north-western area of the Middle Miocene sedimentary basin of Transylvania. In this salt the fossils are rare and refer strictly to plant remains (fragments of wood, pine cones, etc.). A sample of charred wood collected from the area of Ocna Dej salt deposit of Middle Badenian age (Wielician) was submitted to a microscopic study for a taxonomic assignation. It was identified as *Cupressinoxylon* sp. aff. *Thujoxylon* sp. as a remain of the synchronous vegetation. This wood type is found for the first time in Ocna Dej salt and could contributes to the paleo-environmental reconstruction of this area. Obviously, wildfires occurred at that time around the marine sedimentary basin of Transylvania.

Keywords: fossil wood, Cupressaceae, salt, Ocna Dej, wildfire, Middle Miocene.

INTRODUCTION

In the Middle Miocene, more exactly in Middle Badenian (Wielician), some bodies of salt raised in the Carpathian Foredeep, in the Sighet sedimentary basin as well as in the Transylvanian Basin, later subjected to diapiric constraints. Salt of this age is missing on platforms (Moldavian, Scythian and Moesian) as well as in the western Middle Miocene sub-basins connected to the Pannonian basin (Ianovici et al., 1976; Györfi & Csontos, 1994). There, in mid-Badenian it was, probably, a sedimentary gap (Paucă, 1936, 1954; Paucă et al. 1968, Istocescu et al., 1970; Istocescu & Istocescu 1974; Codrea et al., 1999; Nicorici, 1981; Petrescu et al., 1988; Popa, 2000; Codrea et al., 2007 etc.).

From other Miocene salt deposits (e.g., Wieliczka in Poland) various fossilized remains of mainly plants were collected as conifer cones, carbonized or mineralized wood fragments, exhibited in the local museum of this salt mine (personal observation, VAC).

But, some reports of fossilized plant remains in salt are old, such as that of Beudant (1822), who referring to Transylvania and mentioning the salt mining 'par des grandes galeries' (vol II, p. 315) at Turda and Dej ('Thorda, de Dées') where bituminous wood is found, as at Wieliczka ('Villiczka'), preserved in the salt mass ('du bois bitumineux dans la masse même de sel'; p. 315).

Since Givulescu (1983) has compiled a list of these finds, the number of new finds has been extremely low. Givulescu (1983) mentioned mollusks, sea urchins and '*Carya costata* = *Juglans palaeoregia*' from Turda salt mine, mollusks and foraminifers from Ocna Mureș salt mine and *Pinus polonica*, *Juglans ventricosa*, *Castanopsis salinarum* and various pine cones from Ocnele Mari and Slănic salt mines, all of them indicating a Middle Miocene (Badenian) age. In addition, the author listed spores and pollen already reported by Balteș (1977) from various salt mines in Romania.

Subsequent to Givulescu's list, discoveries of fossil plant macro-fossils in the Badenian salt are extremely rare. Petrescu & Bican-Brișan (2004) described some charred woods collected from Ocna Dej salt assigned to *Pinuxylon*, reiterating on this occasion a series of results based on spore-pollen analyses from the same locality (Petrescu & Meseșan, 1993). A piece of mineralized wood collected fortuitously from the Cocenești salt mine at Ocnele Mari, was assigned to *Sequioxylon gypsaceum* by Petrescu & Codrea (2005).

Consequently, the collection of a new fragment of fossilized wood from the Ocna Dej salt mine, which belongs to an unidentified taxon from this locality, signifies a discovery worth mentioning for paleobotanists, which is the aim of this contribution.

GEOLOGICAL SETTING AND AGE

The Ocna Dej salt mine is located on the north-northwestern border of the Transylvanian Depression, ca. 3 km SW from Dej town (Fig. 1). The depression is nothing but the illustration at surface of a Cenozoic sedimentary basin that started its geological history since the latest Maastrichtian (Codrea & Dica 2005) and continued across Cenozoic (Krézsek & Bally 2006).

The basement of this basin belongs to the Tisza-Dacia tectonic microplate formed during the Cretaceous (Csontos et al., 1992; Csontos, 1995). The basin basement is overlain by Cenozoic megasequences, the salt bearing deposits belonging to the Middle Miocene

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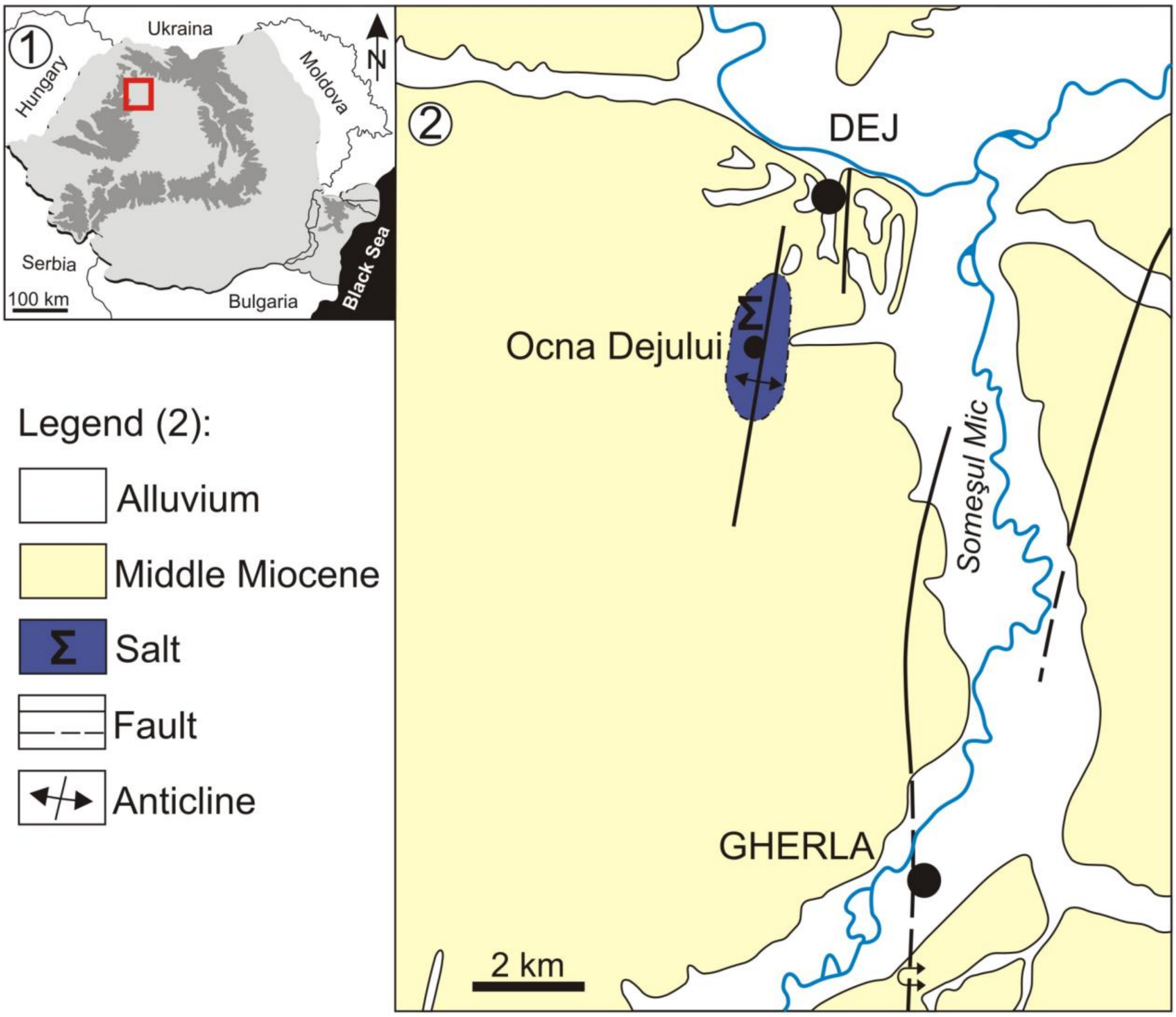

Fig. 1. Map with location of Ocna Dej salt diapir. Simplified after the Geological map of Romania sc. 1:200,000, folio Cluj L-34-XII. Geological Institute, 1967 (Răileanu et al., 1967).

(Krézsek & Bally, 2006). The salt belongs to the Ocna Dej Formation with a Middle Miocene (Middle Badenian = Wielician) geological age (Mészáros, 1991); therefore, the type-section can be studied in this locality. This formation overlies the volcano-sedimentary Dej Formation, including the ca. 15 My old Dej Tuff (Popescu, 1970; Szakács et al., 2012) and is overlain by marine sedimentary rocks with radiolarians and pteropods (Gelencsér et al., 2024 and related references). The Ocna Dej salt deposit extends between Codor and Săcădaș creeks, reaching over 156 m in its thickest area (Petrescu & Bican-Brișan, 2004). The salt mining is very old, running in time since Antiquity. Only the mining methods have changed over time, from primitive surface excavations to mining in underground bell-shaped voids, and finally to underground galleries and trapezoidal chambers. The charred wood-fragment (probably a result of a Middle Miocene wildfire) was found during the mining works in the mining horizon 157 E. The Ocna Dej salt massif forms a north-south elongated lens, extended between Codor brook in the north and Săcădaş brook in the south. Based upon the measurements performed in 53 drillings that pierced the salt, the thickness varies between 12.66 m and 156 m. Such a direction of the orientation of the Ocna Dej salt mass expansions was firstly outlined by Voitești & Ionescu-Bălea (1936) vs. the E-W distribution pattern presumed by Pošepny (1867). The map hand-signed by Popescu-Voitești existing at the Ocna Dej salt mine and recently published by Bordeianu (2024; Fig. 12) was probably meant to illustrate that contribution. It reflects the N-S tectonic style of the distribution of the salt body expansions mentioned above.

MATERIAL AND METHODS

The studied material represents a sample of charred wood collected in the salt mine of Ocna Dej. The sample is now curated at the Paleontology-Stratigraphy Museum of the Babeş-Bolyai University Cluj-Napoca (abbreviated PSM.UBB) as Paleobotany Register no. 835.

For the xylotomical study, standard oriented thin-sections

of petrographic type were prepared from the sample (transversal, tangential, radial), which have been studied using a transmitted light microscope. All the observed anatomical details were described using the scientific terms as defined by the „IAWA lists of microscopic features for softwood and hardwood identification" published by IAWA Committee. Photos of the xylotomical details were captured with an "EverFocus" video-camera adapted to 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 recent wood structures, from published scientific papers, all included in the References chapter. The systematics follow the classification of gymnosperms (Gadek, 2000; Farjón, 2005; Christenhusz et. al., 2011).

SYSTEMATIC PALEONTOLOGY

Family **Cupressaceae** Rich. ex Bartling
Subfamily **Cupressoideae** Rich. ex Sweet (*sensu* Gadek et al., 2000; Jagel & Dörken, 2015)
Genus *Cupressinoxylon* Göppert, emend. Dolezych, 2005

***Cupressinoxylon* sp. aff. *Thujoxylon* sp.**
Fig. 2, a-i.

Studied material. We had in study a sample of charred wood that showed a cupressaceous structure. It was collected from the area of Ocna Dej salt deposit of Middle Badenian age (Wielician). The sample is stored in PSM.UBB, under PR no. 835.
Microscopic description. *Growth rings* – appear in cross section relatively wide, showing a gradual diminution of the tracheids, to the late wood, so the growth rings boundaries could be guessed as marked by the final wood with compressed small and thick-walled cells, suddenly followed by the early-wood which starts with larger cells. Axial canals not present.
The tracheids – are quite thick-walled and have a polygonal shape with rounded corners in cross section, sometimes deformed by compression. In the early wood, their radial/tangential diameter is of 13–18(20) / 13–17(18) µm, and are thick-walled. The wall thickness is of 8-12 µm the double wall. To the late wood the cells size gradually decrease toward the final 3-5(-9) rows of final wood smaller tracheids, of 5-7(-12) / 8-15 µm in diameter and thick walled, of 12-16 µm the double wall. In cross section the cells appear regularly distributed in 1-8-12 radial rows, or more, between two successive rays. Their density is of 900-1100 tracheids per mm^2. On the radial walls, the pits appear, usually, in uniseriate arrangement. The pits are round, of bordered type, with 7-10 µm in diameter, with a round to elliptic aperture. On the tangential walls the pitting is absent or rarely appear as smaller pits, of 5-7 mm, uniseriately arranged, but usually is difficult to see due to bad preservation. Helical thickenings, crassulae, callitroid thickenings - absent. Organic deposits, usually, absent.
Axial parenchyma – is present as few cells, in diffuse arrangement, scattered among tracheids or in short lines and, usually, are full of dark resin content. In vertical view the string of rectangular parenchyma cells, probably have nodular transverse end walls, difficult to observe, due to poor preservation.
Rays – appear thin and linear in cross section and, in tangential view, appear as exclusively uniseriate, are low to medium tall, of 3-15 cells, or more. Ray density is 3-7(-9) rays per tangential mm. Regarding the composition, the rays are homogeneous, composed by parenchymatous ray cells all procumbent, the marginals slightly taller. Ray tracheids are not present. The ending walls of ray cells are smooth and the horizontal walls are smooth and pitted, details usually, poorly preserved. Indentures not visible, or absent. Cross fields with small cupressoid pits of 3-5(7) mm in diameter, as rows of 1-3 pits with inclined slit-like apertures, sometimes in 2-3 superposed rows alternately arranged.
Resin canals – axial or radial - absent. *Mineral inclusions* – (as crystals) not present.

AFFINITIES AND DISCUSSIONS

Microscopically studied, the sample of charred wood collected in the Ocna Dej salt mine showed a poorly preserved coniferous structure, having quite distinct growth rings, no axial resin ducts, parenchyma cells few, diffuse, as scattered cells among tracheids, over all the growth ring, radial tracheidal pitting usually uniseriate, crassulae absent, rays uniseriate with cupressoid cross-fields – anatomical features suggesting an affinity to cupressaceous wood-type (see Vaudois & Privé, 1971; Watson & Dallwitz, 2008; Schweingruber (1990); Ibrahim, 2015). Such xylotomical details suggest possible structural similarities with the current *Cupressus* or *Thuja* wood-types, from Subfamily Cupressoideae Rich. ex Sweet, 1826 (see the last classification of family Cupressaceae *sensu lato*, in Gadek et al., 2000; Farjon, 2005; Christenhusz et al., 2011).
For this type of fossil wood, Goeppert (1850) created the fossil genus *Cupressinoxylon*, describing more specimens, but without specifying a very clear diagnosis. Only later, Vaudois & Privé (1971) reported a diagnosis reformulated after many previous authors. This genus name *Cupressinoxylon* was considered many times as a 'wastebasket' taxon (Müller-Stoll & Schultze-Motel, 1990; Wang et al., 1996).
Later, Bamford et al. (2002), presenting all the adventures of this fossil genus, made a proposal to conserve the name *Cupressinoxylon* vs. *Retinodendron*, proposing *C. gothanii* Kräusel as a type-species, a very well-preserved specimen.

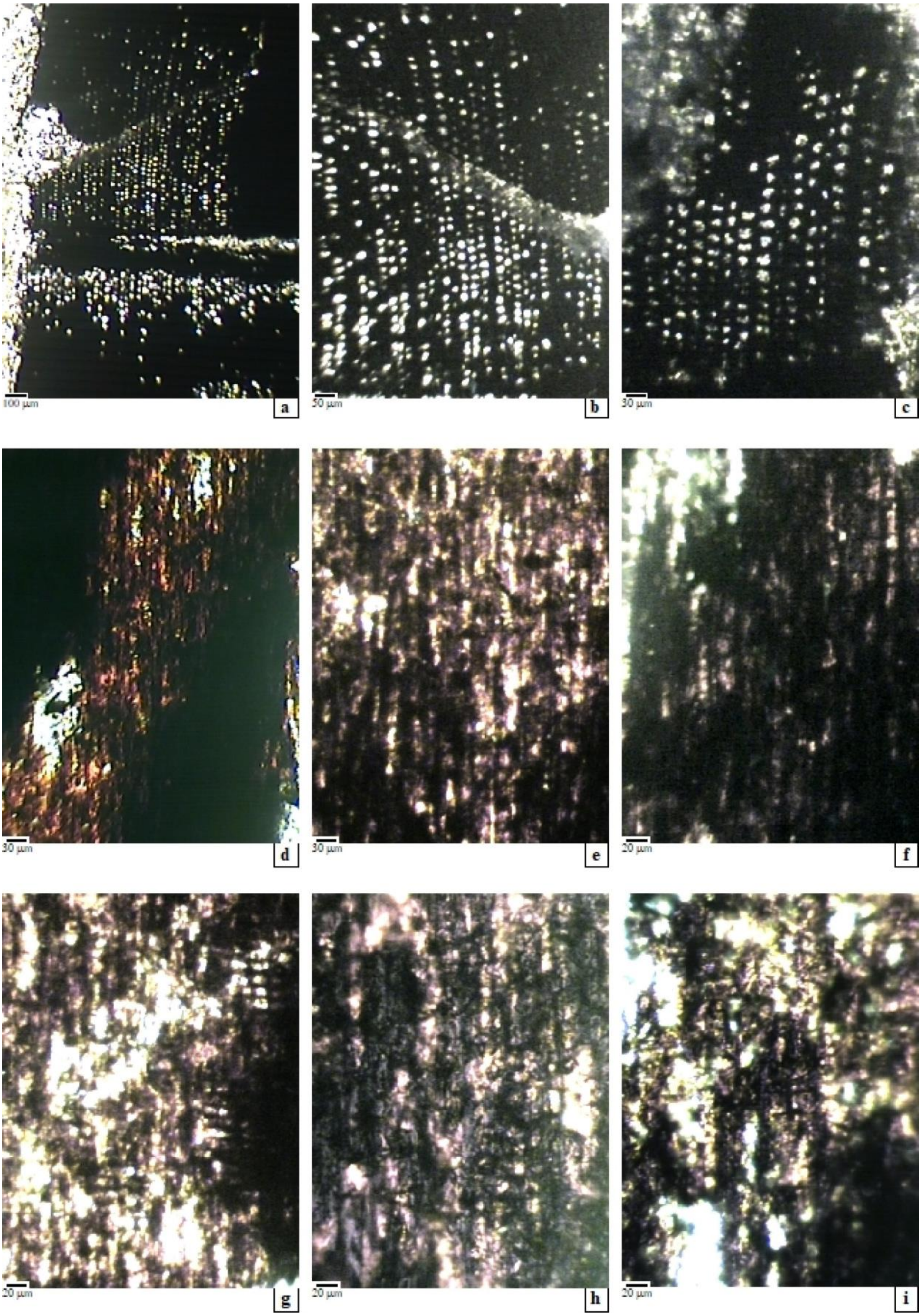

Fig. 2. *Cupressinoxylon* sp. aff. *Thujoxylon* sp. Specimen PSM, UBB - PR no. 835. **a, b, c** – cross-section: growth rings variably sized, with gradual transition from early to latewood, parenchyma few, diffuse, resin ducts absent. **d, e, f** – tangential section: rays uniseriate, poorly preserved structure. **g, h, i** – radial section: uniseriate tracheidal pitting, rays homocellular, with poorly preserved cross-fields with 1-3 cupressoid pits.

That 'diagnosis' attributed to Goeppert was emended by Dolezych (2005) and also, interesting observations on it were added by Bodnar et al. (2015) and by Ruiz & Bodnar (2019).
Consulting the identification key of Vaudois & Privé (1971) which explains that the cupressaceous structures have 'zones d'accroissement distinctes, trachéides a ponctuations radiales abietineénnes unisériées, parenchyme absent ou rare, à parois transversales noduleuses ou ponctuées, rayons généralement peu élevés, unisériés, parfois bisériés sur un faible hauteur; champs de croisement contenant 1-4 ponctuations taxodioides, parfois cupressoides, indentures présentes', details very present especially in *Thuja* type structure. Also, it is specified that the *Chamaecyparis* type presents a lot of parenchyma and the *Juniperus* type has specific juniperoid nodules on the inclined tangential walls of ray cells in tangential view, details not observed in our specimen.
Comparing the description of the studied specimen with some other cupressaceous fossil forms previously described, as for example with *Cupressinoxylon* sp. of *Thuja* type (see Iamandei et al., 2008; 2011), we observed a xylotomical resemblance.
In fact, it is considered that the presence of fossil *Thuja* is debatable for the Aegean region, and maybe for whole Europe, since the current genus has, and maybe had, a disjunctive distribution in the Northern Hemisphere, in Eastern Asia and Northern America. However, some fossil forms equivalent to this genus were described from Cretaceous rocks of northern Europe and, up to Pliocene, it appears that it was a migration to more southerly regions. Post-Pliocene, probably, they vanished from Europe (see Farjon, 2005).
In time, numerous cupressaceous species were described from Europe (see Vaudois & Prive, 1971 revising the Cupressaceous fossil lignotaxa). Between the last described species, we mention *Thujoxylon antissum* Süss & Velizelos, 1998, described from Lesvos, Greece, a Cenozoic form with a peculiar pattern of growth rings in cross section. The species was quoted and discussed again by Mantzouka et al. (2013) and interpreted as root-wood.
Some poorly preserved specimens were described from the outer-Carpathians area as *Cupressinoxylon* sp. aff. *Thujoxylon* sp. (Iamandei et al., 2008, 2011).
The palaeoxylotomical observations made on the studied specimen suggests, by the aspect of the structure in cross section, devoid of resin canals, with parenchyma with horizontal nodular walls and cupressoid cross-fields with typical aspect of a cupressaceous structure of Thujidae group, especially of *Thuja* type, even if the poorly preserved details do not allow to described or identify a species.
And, taking into account the papers of Greguss (1967), Dupéron-Laudouéneix (1979), Zalewska (1953), the revised diagnoses of Kräusel (1949) and Vogellehner (1967, 1968), and using the key of identification proposed by Vaudois & Privé (1971), we assign our studied specimen to *Cupressinoxylon* sp. aff. *Thujoxylon* sp. and not to a sub-generic systematic assignation, due to the poor preservation of the studied sample.

CONCLUDING REMARKS

Therefore, we had in study a sample of charred wood collected from the salt of Ocna Dej mine, fortuitously found during the recent mining works, in the mining horizon 157 E. Ocna Dej is a salt deposit of Middle Badenian (Wielician) age and belongs to the Ocna Dej Formation (Mészáros, 1991), which overlies the volcano-sedimentary Dej Formation, with the Dej Tuff (see Popescu, 1970; Szakács et al., 2012) and is covered by marine sedimentary rocks with radiolarians and pteropods (see Gelencsér et al., 2024).
Standard oriented thin slides from the sample were submitted to a microscopic study, in order to identify the original tree. Thus, we have identified it as *Cupressinoxylon* sp. aff. *Thujoxylon* sp., as remain of the synchronous vegetation. This wood type is found for the first time in Ocna Dej salt and could contribute to the paleo-environmental reconstruction of that area.
In fact, Givulescu (1983) tried to compile the paleontological list of animal and plant fossils collected from some salt mines, mentioning mollusks, sea urchins and walnuts from Turda and Ocna Mureș salt mines, and remains of pines, walnuts, chinquapin remains from Ocnele Mari and Slănic salt mines, all of Middle Miocene (Badenian) age. Also, Balteș (1977) and Petrescu & Meseșan (1993) studied spores and pollen from various salt mines in Romania.
Wood remains rarely appear and we mention Petrescu & Bican-Brișan (2004) who described some charred woods collected from Ocna Dej salt as *Pinuxylon sp.*, and a piece of petrified wood collected from Ocnele Mari (Cocenești salt mine) that was identified by Petrescu & Codrea (2005) as *Sequioxylon gypsaceum*.
Consequently, the description of a new fossil wood from Ocna Dej salt mine, which belongs to a cupressaceous taxon of *Thuja* type, herein, firstly reported from this locality, represents a discovery worth mentioning for paleobotanists, which is in fact, the aim of this contribution.
The charred wood was, probably, the result of a Middle Miocene wildfire occurred in the neighborhood areas of the salt deposition basin. Thus, this fossil wood could contribute to the paleo-environmental reconstruction of that area, but for such a target, more numerous finds should be done. But obviously, wildfires occurred at that time around the marine sedimentary basin of Transylvania.

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