



罗马尼亚白垩纪植物群概述(英文)

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提要 罗马尼亚白垩纪植物群以压型植物化石为代表, 其他植物化石类型则包括碎屑和搬运的类群, 并缺乏角质层和孢粉学记录。以压型为代表的白垩纪植物群主要分布在南喀尔巴阡山脉的几个盆地(包括Hațeg、Rusca Montană和Rucăr盆地)、特兰西瓦尼亚(特兰西瓦尼亚盆地)和多布罗吉亚(巴巴达格盆地), 在东喀尔巴阡山脉也有少量分布。这些植物群的时代从Cenomanian到Maastrichtian, 其分类多样性包括蕨类植物(木贼类、真蕨类)、裸子植物(松柏类)和被子植物(单子叶植物和双子叶植物)。从古植物地理学的角度来看, 罗马尼亚白垩纪植物群属于欧洲省Eurosianian地区, 分布在特提斯地区的北部框架上, 唯一的成煤植物群分布在Rusca Montană盆地。

关键词 白垩纪 植物群 罗马尼亚

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Overview of the Cretaceous macrofloras of Romania

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Abstract The Cretaceous macrofloras of Romania are mainly preserved as compressions in several basins of the South Carpathians (Hațeg, Rusca Montană, and Rucăr basins), Transylvania (Transylvanian Basin) and Dobrogea (Babadag Basin), with insignificant occurrences in the East Carpathians. Preservation of the Romania Cretaceous flora is generally poor, as the plant compressions usually lack cuticles or in situ spores and pollen. The ages of these floras range from the Cenomanian up to the Maastrichtian, and their biodiversity encompasses pteridophytes (horsetails and ferns), gymnosperms (conifers) and angiosperms (monocotyledonates and dicotyledonates). From the palaeophytogeographic point of view, the Romanian Cretaceous floras belong to the European Province of the Eurasian Region, occurring along the northern frame of the Tethys realm. The only coal flora was discovered in the Rusca Montană Basin, while the rest of the Romanian Cretaceous floras are allochthonous floras preserved in clastic sediments.

Key words Cretaceous, floras, Romania

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1 Introduction

During the Cretaceous, the Romanian sedimentary basins occurred along the northern frame of the Tethys realm, parts of the larger, European Region. The general Cretaceous palaeogeographic configurations of Eastern Europe were fragmented, generally marked by a series of islands, therefore, inducing both continental and marine depositional systems in coeval sedimentary successions. The tropical and subtropical climates of the region induced a high biodiversity in marine and terrestrial ecosystems, which were also influenced by monsoonal seasonality, while the terrestrial flora belonged to the European Province, part of the larger Eurosinian Region (Vakhrameev, 1991). During the Late Cretaceous in Romania, especially in the South Carpathians, the strongly fragmented, archipelago palaeogeography induced strong allopatric speciation, with small land vertebrates, including dwarf dinosaur populations (Grigorescu, 1983, 1992; Codrea *et al.*, 2010; Csiki-Sava *et al.*, 2015).

Cretaceous marine formations are frequent, fossiliferous, and well developed in Romania, both in the Carpathians structures and in their foreland and hinterland, while continental formations are mainly restricted to the South Carpathians, where they may yield coal seams.

2 Cenomanian flora from the Rucăr Basin

Muțiu (1974) first reported a drifted or allochthonous flora in the Rucăr Basin, not far away from Brașov City (Fig. 1). The flora is confined to the Cenomanian, marine Rucăr marls along the Arșița Valley, with major components including conifers (*Sequoia reichenbachii* (Geinitz) Kunzmann, Fig. 2-A), and angiosperms (*Dryandra cretacea* Velenovsky). The collected specimens, including conifer leaves and cones, angiosperm leaves, and several types of angiosperm seeds, are well preserved, but they lack cuticles. In addition to the palaeoflora, the Rucăr marls also yield various invertebrates, such as ammonites (*Callioceras* sp.) and bivalves (*Inoceramus tenuis* Mantell, *I. pictus* Sowerby, and *I. crispus*

Mantell), indicating the Cenomanian age. The Cenomanian Rucăr flora is among the less known Cretaceous floras of Romania. The original material collected by Radu Muțiu is currently under revision and will be investigated in detail.

3 Cenomanian flora from East Carpathians

Givulescu *et al.* (1981) described a Cenomanian gymnosperm with conifer affinities, *Dammarites albens* Presl in Sternberg, from the Teliu Valley, close to Poiana Florilor, in the East Carpathians (Figs. 1, 2-B). The material is allochthonous and its age is confirmed by the fauna (*Acanthoceras rotomagensis* (Brongniart) Zaborski and *Inoceramus crispus* Mantell) occurring in the same marine sediments. The material is the only Cretaceous plant fossils from Romania found so far with preserved cuticles. Kvaček and Lobitzer (2010) discussed *Dammarites albens* Presl in Sternberg in the context of its European occurrences, including Romania, Spain, the Czech Republic, and Austria. From the same occurrence, Givulescu *et al.* (1986) described and illustrated a poorly preserved, small fragment of *Matonidium goepperti* Schenk (Matoniaceae, Fig. 2-C).

4 Turonian flora from the Babadag Basin

In Northern Dobrogea region (Fig. 1), the Babadag Basin includes a Turonian marine formation with a rich content of fossil flora and fauna. Marion and Laurent (1898), in the first palaeobotanical work published in Romanian language, described *Marattites desideratus* Marion et Laurent and *Sequoia reichenbachii* (Geinitz) Kunzmann, followed by Liteanu and Gheorghiu (1965), who cited *Geinitzia cretacea* Unger and *Comptonia antiqua* Nilsson, from the Babadag Basin. Givulescu and Lăcătușu (1978) described and illustrated in detail a plant assemblage from the C.F.R. Codru quarry in the Babadag Basin, including conifers (*Geinitzia cretacea* Unger) and angiosperms (*Dryandra trifoliata* Givulescu et Lăcătușu, *Myrtophyllum geinitzi* Heer, and *M. angustum* (Velenovsky) Knobloch). From the

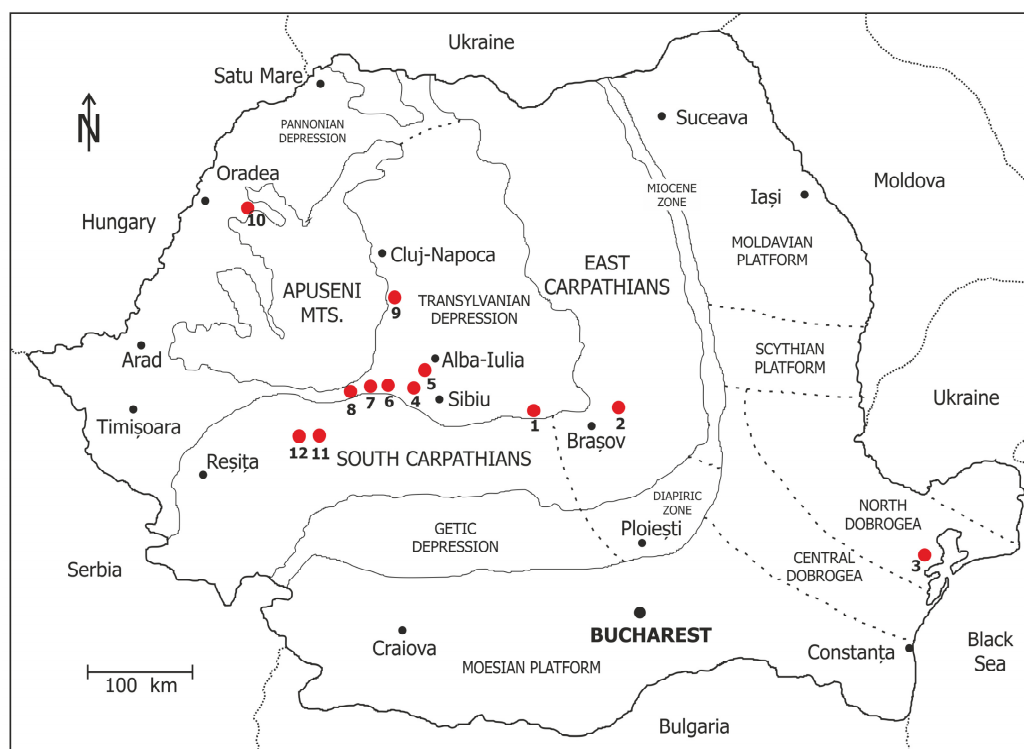


Fig. 1 Occurrences of the Cretaceous compression floras in Romania

1. Rucăr flora, Cenomanian; 2. Teliu flora, East Carpathians, Cenomanian; 3. Babadag flora, Turonian; 4. Săsciori-Sebeș flora, Campanian; 5. Oarda de Jos flora, Maastrichtian; 6. Acmaru flora, Senonian; 7. Nevoiaș flora, Barremian; 8. Sârbi flora, Barremian; 9. Ocolișel flora, Late Cretaceous, Iara Basin; 10. Borod palynoflora and brown coals, Santonian – Early Campanian; 11. Hațeg flora, Maastrichtian; 12. Poiana Ruscă flora, Maastrichtian. Basemap modified from Barbacka *et al.* (2016).

Visterna, Codru Pod, Șeremet and Slava Rusă localities, Givulescu *et al.* (1980) added new taxa to the Babadag Basin: ferns (aff. *Cladophlebis browniana* (Dunker) Seward and cf. *Weichselia ludovicae* Stiehler (Fig. 2-E), conifers (*Brachyphyllum obesum* Heer, *B. squamosum* (Velenovsky) Palibin, and *Cyparissidium gracile* Heer (Fig. 2-D), and angiosperms (*Ficophyllum mohliana* Heer, *Magnoliaephyllum amplifolium* (Krasser) Seward, *Dryandra cretacea* Velenovsky, *Debeya insignis* (v. d. Marck) Knobloch, *Dicotylophyllum* sp., cf. *Palmophyllum* sp., and cf. *Phoenicopsis* sp.). Givulescu (1982) described and discussed *Aenigmatophyllum gothanii* (Krestow) Hartung et Gothan from Slava Rusă, based on material with strong affinities with the material previously identified by Givulescu *et al.* (1980) as cf. *Weichselia ludovicae* Stiehler. The Turonian specimens of the Babadag Basin lack cuticles, but their degree of preservation is high enough for detailed leaf morphology studies.

5 Barremian, Campanian, and Maastrichtian floras from the Transylvanian Basin

The Transylvanian Basin includes a series of marine and continental formations yielding Cretaceous floras (Popa, 2023). From the southwestern part of the Transylvanian Basin, south of Sebeș town, at Săsciori (Fig. 1), Petrescu and Huică (1972) and Petrescu (1973) reported a rich Campanian plant assemblage including ferns, conifers, and angiosperms. The palaeoflora, collected from clastic sediments, is represented by allochthonous leaf fragments co-occurring with echinoids and molluscs in the Bozeș Formation, a typical marine sedimentary succession. The palaeofauna also demonstrates a Late Cretaceous age, similar as the plants indicate. Ferns are particularly diverse, including Gleicheniaceae (*Gleichenia acutiloba* Velenovsky), Aspleniaceae (*Asplenium*



Fig. 2 Examples of Cretaceous plants from Romania

A. *Geinitzia* (*Sequoia*) *reichenbachii* (Geinitz) Kunzmann, Rucăr Basin, Dâmbovicioara area, Cenomanian, sample 0629 (NB8), R. Muțiu Collection, Laboratory of Palaeontology, University of Bucharest; B. *Dammarites albens* Presl in Sternberg, Teliu Valley, Cenomanian, East Carpathians, sample 0411/3154, illustrated in Givulescu *et al.* (1981), P. Dumitrică Collection, Laboratory of Palaeontology, University of Bucharest; C. *Matonidium goepperti* Schenk, Teliu Valley, Cenomanian, East Carpathians, sample 3153/303, illustrated in Givulescu *et al.* (1986), P. Dumitrică Collection, Laboratory of Palaeontology, University of Bucharest; D. *Cyparissidium gracile* Heer, Babadag Basin, Turonian, Codru-Pod quarry, Dobrogea, sample 0628, Laboratory of Palaeontology, University of Bucharest; E. cf. *Weichselia ludovicae* Stiehler, Babdag Basin, Turonian, Codru-Pod quarry, Dobrogea, sample 0362, Laboratory of Palaeontology, University of Bucharest; F. *Gleichenia zippei* (Corda) Heer, Maastrichtian, Rusca Montană Basin, Ciotorogului Valley, sample 0305, A. Dincă Collection, Laboratory of Palaeontology, University of Bucharest; G. *Pandanites spinatissimus* (Petrescu et Dușa) Popa, J. Kvaček, Vasile et Csiki-Sava, Rusca Montană Basin, Rusca Valley, sample RM2, Ș. Vasile Collection, Laboratory of Palaeontology, University of Bucharest. All scale bars: 10 mm.

foersteri Debey et Ettingshausen), Schizeaceae (*Lygodium sebesianum* nomen nudum), Hymenophyllaceae (*Hymenophyllum vachrameevii* nomen nudum), and Pteridaceae (*Pteris* cf. *frigida* Heer). Conifers are represented by Cupressaceae (*Sequoia reichenbachii* (Geinitz) Kunzmann, *Cunninghamia elegans* Corda, and *C. stenophylla* Velenovsky), Araucariaceae (silicified wood of *Araucarioxylon* sp.), and incertae sedis (*Brachyphyllum* cf. *obesiforme* var. *elongatum* Saporta, initially assigned to Araucariaceae conifers). The monocots include three species (*Monocotylae* sp. 1–3), and the dicots are represented by Platanaceae (*Credneria* cf. *tenuinervis* Hosi, *Credneria* sp., *Pseudoprotophyllum* sp., *Platanus cuneifolia* (Bronn) Vachrameev, *P. aceroides* Goeppert, *P. aceroides* var. *latifolia* Knowlton, and *Platanus* cf. *tschulymensis* Lebedev), Fagaceae (*Quercus pascui* Petrescu and *Quercus* sp.), Araliaceae (*Dewalquea haldemiana* Saporta et Marion, *Dewalquea* sp. 1–3, *Aralia invalida* nomen nudum, *A. formosa* Heer, and *Aralia* cf. *wellingtoniana* Lesquereux), Sterculiaceae (*Pterospermites* cf. *inequifolius* Saporta), Rhamnaceae (*Zizyphus rarytkinensis* Kryštofovich and *Dicotyleae* sp. 1–3), and Celastraceae (*Euonymus romanicus* nomen nudum and *E. densinervis* nomen nudum). Unfortunately, the new species reported by Petrescu and Huică (1972) remained nomen nudum, while only *Quercus pascui* was published a year later (Petrescu, 1973). Except for *Quercus pascui* Petrescu, the rest of the Săsciori-Sebeș flora have never been illustrated or described. Therefore, the material of this interesting palaeoflora needs a careful revision. Țabără *et al.* (2022) identified a middle to late Campanian palynomorph assemblage belonging to the marine Bozeș Formation from Petrești, between Sebeș and Săsciori.

Givulescu *et al.* (1995) described four endocarps of *Mastixia amygdalaeformis* (Schlotheim) Kirchheimer from Oarda de Jos, close to Alba-Iulia (Fig. 1), and initially considered their age as Miocene. Later, Codrea *et al.* (2001, 2010) and Codrea and Dica (2005) dated the occurrence as Maastrichtian.

Givulescu (1954a) described insignificant occurrences of Cretaceous plants, such as the Acmarium flora from the base of the Beri Hill (Fig. 1; *Dryo-*

phyllum quercina Velenovsky) in Alba County, Senonian in age, and also Barremian plants of the Nevoiaș flora (Fig. 1; *Kettneria elegans* Corda), in Hunedoara County, and the Sârbi flora (Fig. 1; *Sequoia curvifolia* Ettingshausen) from Hunedoara County.

Givulescu (1960) described a dicot species, *Ficus mârzai* (Moraceae), Late Cretaceous in age (Codrea *et al.*, 2010), from the Ocolișel flora (Fig. 1), south of Iara, in the Iara Basin, a part of the Transylvanian Basin, in Gilău Mountains (Apuseni).

6 Santonian–early Campanian Borod palynoflora

An interesting occurrence is the Borod flora (Fig. 1) associated with the Maastrichtian brown coals, close to Oradea City in northern Transylvania, belonging to the Vad-Borod Basin (Givulescu, 1954b; Petrescu *et al.*, 1987, Preda *et al.* 1994, Popa and Anastasiu, 2018), part of the Northern Apuseni Mountains autochthonous unit. No plant macrofossils were reported, but a Santonian–early Campanian palynoflora was reported from Cornișel by Mogoș (1992). Two coal seams were exploited here until the early 20th Century.

7 Maastrichtian flora from the Rusca Montană and Hațeg basins

The Rusca Montană and Hațeg basins are situated next to each other in the South Carpathians (Fig. 1) and both yield Upper Cretaceous (Maastrichtian) terrestrial formations with identical fossil plant assemblages. Therefore, the plant remains of both basins can be considered as belonging to the same flora (Popa *et al.*, 2014, 2016).

In the Rusca Montană Basin, an un-named Maastrichtian continental formation yields two lateral, separate facies. A central-western facies includes conglomerates, thick volcanic tuffs and volcanoclastics, fossiliferous sandstones, mudstones, and up to 14 bituminous coal seams (Petrescu *et al.* 1987; Preda *et al.*, 1994; Popa *et al.*, 2014, 2016,

Popa and Anastasiu, 2018). The second, easternmost facies is represented by a succession with sandstones and siltstones including plant mesofossils (seeds and fruits), invertebrates, and micro- and macrovertebrates (Vasile and Csiki, 2011).

In the Hațeg Basin, there are also two different Maastrichtian continental formations (Grigorescu and Anastasiu, 1990). The Densuș-Ciula Formation has three un-named members. The basal member is dominated by volcanoclastics, tuffs, and tuffites, yielding fossil plant material and badly preserved vertebrate fossils. The second member is dominated by sandstones and mudstones, with less volcanoclastics, yielding a rich vertebrate and invertebrate content and plant mesofossils. The third member is represented by red mudstones and conglomerates, yielding microvertebrates and dinosaur eggshells (Vasile *et al.*, 2011). The Sânpetru Formation occurs in the central and eastern parts of the Hațeg Basin. This formation is represented by sandstones and mudstones, indicating a fluvial and flood plain palaeoenvironments.

In the Rusca Montană Basin, the first palaeobotanical study as undertaken by Schafarzic (1907), followed by Tuzson (1913, 1914), Givulescu (1966, 1968, 1991), Petrescu and Dușa (1970, 1980, 1982), and Pop and Petrescu (1983). While in the Hațeg Basin, the plant megafossils were studied by Mărgărit and Mărgărit (1967) and the plant mesofossils by May Lindfors *et al.* (2010). Popa *et al.* (2014, 2016) revised the angiosperms fossils from both basins, in addition to a synthesis of the geological and palaeobotanical studies in the area.

The Maastrichtian flora from the Hațeg and Rusca Montană basins is represented by sphenophytes (*Equisetites* sp.), filicopsids belonging to two separate families (Aspleniaceae: *Asplenium foersteri* Debey et Ettingshausen; Gleicheniaceae: *Gleichenia acutiloba* Velenovsky, *G. zippei* (Corda) Heer (Fig. 2-F), *G. cycadina* Prynada, and *G. nordenskiöldii* Nathorst), monocotyledonates (*Pandanites spinatisimus* (Petrescu et Dușa) Popa, J. Kvaček, Vasile et Csiki-Sava (Fig. 2-G), *P. trinervis* (Ettingshausen) J. Kvaček et Herman, and *Sabalites longirhachis* (Ettingshausen) J. Kvaček et Herman), and dicotyle-

donates (*Ettingshausenia onomasta* (Bayer) J. Kvaček et Halamski, *Ettingshausenia* sp., *Credneria denticulata* (Zenker) Tschan, Denk et von Balthasar, *Araliaephyllum* sp., and *Dicotylophyllum* div. sp.). No cycad, ginkgoalean or conifer megafossils were reported.

Ferns were reported only from the Rusca Montană Basin, while palms were reported from both basins, but especially from the Rusca Montană Basin where they occur in high densities and as coal generators (Popa *et al.*, 2014). Such palm densities are among the highest in the world, making Vakhrameev (1991) underline the special interest of the Rusca Montană palms in the frame of the Eurosian Region.

Palynological studies were undertaken by Balteș (1966), Antonescu *et al.* (1983), and Van Isterbeek *et al.* (2005), reporting assemblages with fern spores, conifer and angiosperm pollen from the Hațeg Basin.

8 Conclusion

The Romanian Cretaceous macrofloras range in age from the Barremian to the Maastrichtian, with rare coal floras confined to the Rusca Montană Basin in the South Carpathians, and dominant allochthonous floras preserved in marine formations. The ages of these floras are well constrained based on vertebrate and invertebrate remains associated with both types, while in a few cases, palynological data provide supplementary age constraint of dating. Monocotyledonates (palms exclusively) and dicotyledonates are dominant in the plant assemblages, with subordinated groups of conifers and ferns, and very rare horsetails. These compression floras are locally associated with permineralized material. The Romanian Cretaceous floras belong to the European Province of the Eurasian Region, occurring along the northern frame of the Tethys realm, recording subtropical, monsoonal climates.

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