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THREE LATE PONTIAN LEAF-FLORAS FROM NORTHERN SERBIA REFLECTING DIFFERENT ENVIRONMENTS

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ABSTRACT. Three Late Pontian floras from the southern margin of the Pannonian basin, northern Serbia, reliably dated on faunal remains, are considered in this paper. Each of the three floras is clearly distinguished from the other two. The taphocoenosis from the Kolubara and Kostolac coal mines is characterized by a small taxonomic diversity and corresponds to a hypautochthon taphocoenosis. The contained plant species generally suggest "lignite facies", and the divergence between associations is likely a result of different facies adjoining the sedimentation area. Plant remains from Crveni Breg originate from somewhat higher terrain that extended farther form the sedimentation area. The given allochtonous taphocoenosis includes plant species from different habitats with a variable moisture content in the substrate.

KEY WORDS: megaflora, different taphocoenoses, Late Pontian, Serbia

INTRODUCTION

New findings in the last several years have been significantly contributed to the knowledge of Late Pontian flora of Serbia. Compared with the earlier idea about the character of vegetation in this segment of the geologic time, the findings proved it more complex. So far, three distinctive floral types are recognized, dominantly controlled by the nature of the habitat and topography. It was long believed for the territory of northern Serbia that it had only one type of flora, slightly varying in taxonomy from one locality to another. The richest and most often stated were floras from Osojno near Kladovo (Pantić 1956, Mihajlović 1990), and especially from Crveni Breg at Grocka (Pantić 1956, Mihajlović 1977, 1990). However, the recently found floral remains from the Kolubara coal mines (opencut, field D) (Mihajlović & Lazarević1996) and the Kostolac coal mines (Ćirikovac opencut) (Mihajlović & Lazarević in print) are the new pieces in the picture of the Late Pontian vegetation.

FOSSIL FLORA

Localities of the fossil flora (Fig. 1) described in this paper are associated with a single palaeogeographic region which corresponds to the southern margin of the

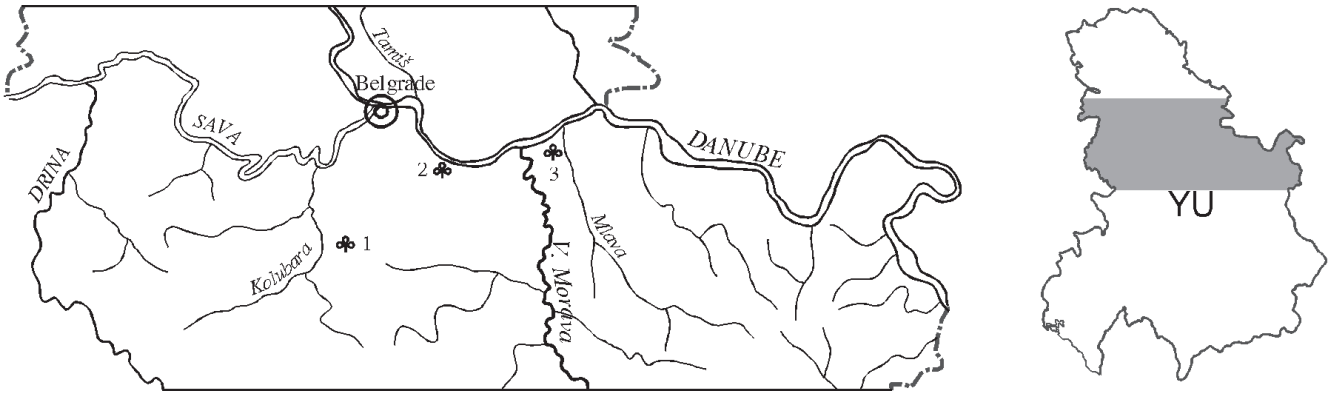

Fig. 1. Geographic position of the Late Pontian floral localities in Northern Serbia. **1** – Kolubara Coal Mines; **2** – Crveni Breg; **3** – Kostolac Coal Mines

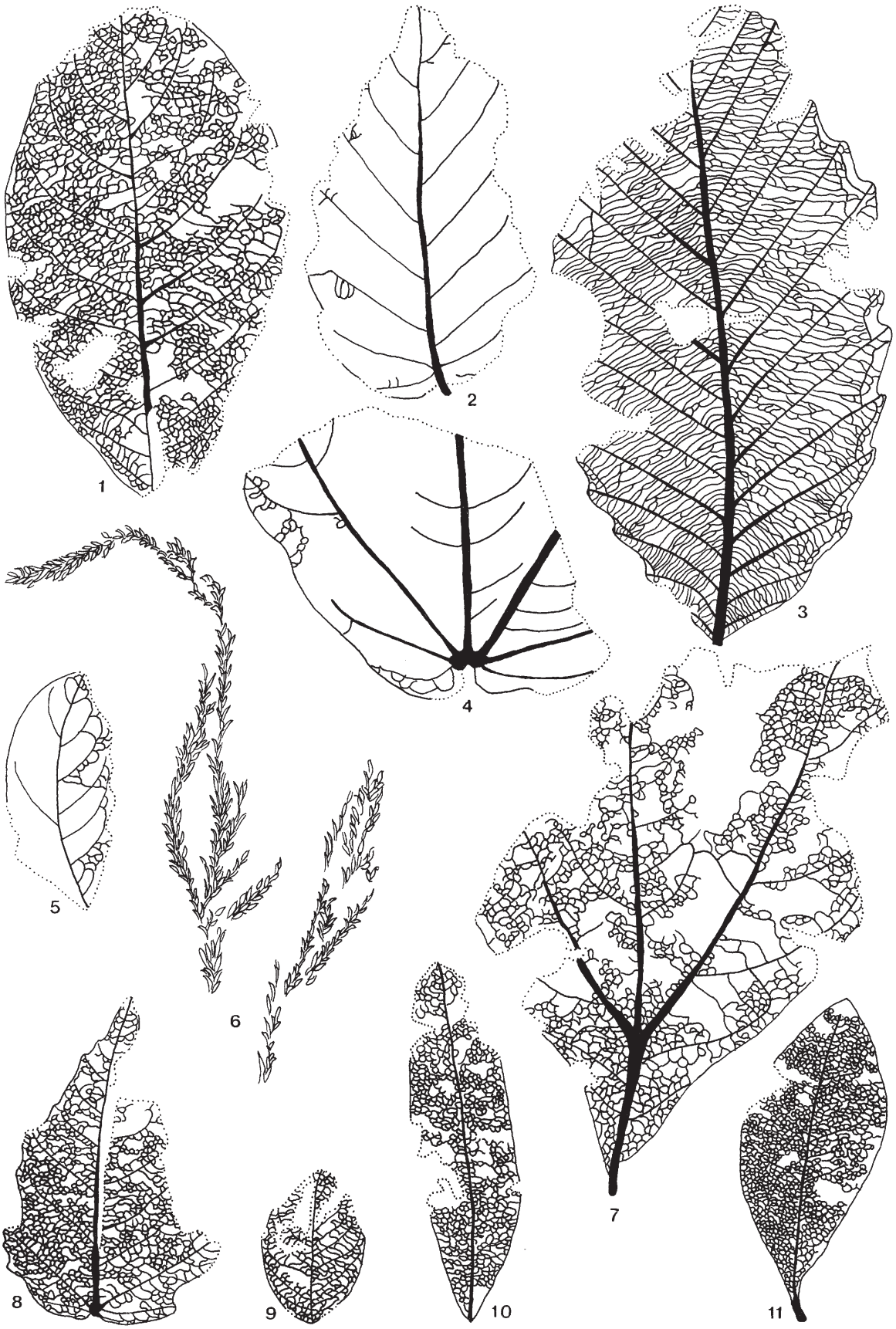

Fig. 2. Fossil flora from Kolubara Coal Mines: **1** – *Magnolia cunneifolia* Baikovskaia, **2** – Betulaceae gen. et sp. indet., **3** – *Quercus gigas* Goeppert emend. Walther et Zastawniak, **4** – *Byttneriophyllum tiliifolium* (Al. Braun) Knobloch et Kvaček **5** – cf. *Epigaea baikovskaia* Iljinskaja, **6** – *Glyptostrobus europaeus* (Brongniart) Unger, **7** – *Sassafras ferretianum* Massalongo, **8** – *Acer tricuspidatum* Brongniart forma *bruckmanii* (Al. Braun in Heer), **9** – *Trigonobalanopsis rhamnoides* (Rossmässler) Kvaček & Walther, **10, 11** – *Myrsine marty* Laurent

Pannonian basin. The floras are clearly dated on faunal data (mostly malacofauna) and assigned to fixed floras

1. THE KOLUBARA COAL MINES, FIELD D OPENCUT

The locality where flora was found, in this largest of the Serbian coal mines, is some 45 km SSW of Belgrade (from the city center). Plant remains have been found in grey or whitish diatomite, which locally contains numerous coalified pieces of tree trunks and branches and fine plant detritus. Diatomite is topping 35 to 40 m of the coal measures. The coal measures are dated as Late Pontian on the basis of malacofauna remains from overburden (Stevanović 1951, 1990a). The identified taxa are the following (Fig. 2):

Pinus sp.
Glyptostrobus europaeus (Brongniart) Unger
Magnolia cunneifolia Baikovskaia
Asimina browni Thomson
Sassafras ferretianum Massalongo
Quercus gigas Goeppert emend. Walther & Zastawniak
Trigonobalanopsis rhamnoides (Rossmässler) Kvaček et Walther
Betulaceae gen. et sp. indet.
cf. *Epigaea baikovskaia* Iljinskaja
Myrsine marty Laurent
Byttneriophyllum tiliifolium (Al. Braun) Knobloch et Kvaček
Acer tricuspidatum Brongniart forma *bruckmanii* (Al. Braun in Heer)

There is a massive occurrence of leafy shoots (some with cones) *Glyptostrobus europaeus*, and leaves of *Magnolia cunneifolia*, Betulaceae gen. et sp. indet., *Myrsine marty* and *Acer tricuspidatum* f. *bruckmanii*. Quite common are *Pinus* needles and leaves of *Quercus gigas* and *Trigonobalanopsis rhamnoides*. Other taxa are fewer in number.

2. CRVENI BREG AT GROCKA

This locality near the town of Grocka (center of one of Belgrade suburban municipalities) is about 25km SE of Belgrade. Numerous plant remains have been found in grey and orange-yellow sandy clays exposed in a few steep scarps of the Danube bank (sections are changeable in this region of frequent landslides). Flora bearing deposits contain abundant molluscs of Late Pontian (Stevanović 1951, 1990b). The Crveni Breg flora is described by Pantič (1956) and Mihajlović (1977, 1990). For the purpose of this paper, all specimens that could be found in the collection of the Institute of Regional Geology and Palaeontology were examined and taxonomically reinterpreted. The presented comparative list of taxa gives both old and revised identifications (Fig. 3).

Pteridium oenigense (Unger) Hantke
Ginkgo adiontoides (Unger) Heer
Pinaceae gen. et sp. indet.
(*Abies* cf. alba in Pantić 1956, Mihajlović 1977, 1990, *Pseudotsuga* sp (*P.* cf. *taxifolia*) in Mihajlović 1977, 1990)
Daphogene sp.
(*Cinnamomum scheuchzeri* in Mihajlović 1977, 1990, *C. polymorphum* in Pantić 1956, Mihajlović 1977 , 1990)
Liquidambar europaea Al. Braun
Platanus leucophylla (Ettingshausen) Knobloch
(*P. aceroides* in Pantić 1956, Mihajlović 1977)
Ulmus pyramidalis Goeppert
(*Ulmus longifolia* in Pantić 1956, Mihajlović 1977, 1990)
Ulmus carpinoides Goeppert
Ulmus sp.
Zelkova zelkovifolia (Unger) Bužek et Kotlaba
(*Z. ungeri* in Pantić 1956, Mihajlović 1977)
Betula subpubescens Goeppert
(*Betula prisca*, *Alnus nostratum*, *Carpinus ostryoides* in Mihajlović 1977, 1990)
Carpinus grandis Unger emend. Heer
(*Alnus nostratum* in Mihajlović 1977, 1990)
?*Alnus* sp.
(*Alnus kefersteini* in Pantić 1956)
Betulaceae gen. et sp. indet.
(*Betula subpubescens*, *Cornus* sp. in Mihajlović 1977, 1990, *Carpinus grandis* in Pantič 1956, Mihajlovič 1977, 1990)
Fagus pliocenica Saporta
Quercus pseudocastanea Goeppert
Quercus gigas Goeppert emend. Walther et Zastawniak
(*Q. meditterranea* in Mihajlović 1977, 1990, *Castanea atavia* in Pantić 1956; Mihajlović 1990)
Quercus sp.
Carya denticulata (Weber) Iljinskaja
(*C. serrifolia* in Pantić 1956, Mihajlović 1990)
Pterocarya paradisiaca (Unger) Iljinskaja
(*P. denticulata* in Pantić 1956, Mihajlović 1977, 1990)
Juglandaceae gen. et sp. indet.
(*Juglans acuminata* in Pantić 1956, Mihajlović 1990)
Salix lavateri Al. Braun emend. Hantke
(*S. varians* in Pantić 1956, Mihajlović 1977, 1990)
Salix longa Al. Braun
Salix sp.
(*S. angusta* and *S. media* in Pantić 1956, Mihajlović 1977, 1990)
Populus sp.
(*P. latior* in Pantić 1956, Mihajlović 1990)
Leguminosae type of leaves
(*Sophora europaea* and *Podogonium knorii* in Pantić 1956, Mihajlović 1977, 1990; *Leguminosites* sp. in Pantić 1956, Mihajlović 1990)

Fig. 3. Fossil flora from Crveni Breg: **1** – *Ginkgo adiantoides* (Unger) Heer, **2,3** – Pinaceae gen. et sp. indet., **4** – *Ulmus pyramidalis* Goeppert, **5 –** *Ulmus carpinoides* Goeppert, **6** – *Zelkova zelkovifolia* (Unger) Bůžek et Kotlaba, **7** – *Populus* sp., **8** – *Salix longa* Al. Braun, **9** – *Salix lavateri* Al. Braun emend. Hantke, **10** – *Liquidambar europaea* Al. Braun, **11** – *Daphnogene* sp., **12, 15** – *Carya denticulata* (Weber) Iljinskaja, **13, 21** – *Carpinus grandis* Unger emend. Heer, **14, 18, 25** – Leguminosae type of leaves, **16** – *Betula subpubescens* Goeppert, **17** – *Platanus leucophylla* (Unger 1850) Knobloch, **19** – *Tilia longebracteata* Andrae, **20** – *Pterocarya paradisiaca* (Unger) Iljinskaja, **22, 23** – *Acer subcampeste* Goeppert, **24, 27** – *Quercus gigas* Goeppert emend. Walther et Zastawniak, **26, 29** – *Fagus pliocenica* Saporta, **28** – *Quercus pseudocastanea* Goeppert, **30** – *Smilax hastata* (Brongniart) Saporta, **31** – *Vitis teutonica* Al. Braun.

Fig. 4. Fossil flora from Kostolac Coal Mines: **1, 2** – *Glyptostrobus europaeus* (Brongniart) Unger, **3, 6** – *Alnus cecropiifolia* (Ettingshausen) Berger, **4** – *Parrotia pristina* (Ettingshausen) Stur, **5** – *Byttneriophyllum tiliifolium* (Al. Braun) Knobloch et Kvaček, **7** – *Fraxinus ungeri* (Gaudin in Gaudin & Strozzi) Knobloch et Kvaček, **8** – *Fagus kraeuselii* Kvaček et Walther

Tilia longebracteata Andrae
(*T. milleri* in Pantić 1956, Mihajlović 1990)
Acer subcampeste Goeppert
(*A. decipiens* in Mihajlović 1977, 1990)
Acer sp.
(*A. integerinum* and *A. integrilobum* in Pantić 1956, Mihajlović 1990)
Vitis teutonica Al. Braun
Smilax hastata (Brongniart) Saporta
(*S. sagittifera* in Pantić 1956, Mihajlovič 1990)
Specimens that would correspond to the species: *Laurus princeps, Persea braunii, Myrica* sp. and *Cretaegus longepetiolatus* (Pantić 1956) could not be found.

Commonest in this diverse taphocoenosis are specimens of the species corresponding to the families Ulmaceae (particularly *Ulmus*), Betulaceae, Fagaceae (particularly *Fagus*) and Juglandaceae. Comparatively abundant are representatives of Salicaceae (particularly *Salix*) and Aceraceae, whereas other taxa are few in numbers. A large number of specimens mostly fragmented or with poorly preserved margins, could not be specified.

3. KOSTOLAC COAL MINES, ĆIRIKOVAC OPENCUT

This locality near the town of Kostolac is about 60km ENE far from Belgrade. Plant remains are accumulated in a horizon from 20 to 30m thick in clay roof of the second coal seam. The horizon can be traced for hundred of meters along the pit bench. An abundant fauna of molluscs from this horizon (Stevanović 1990c) was used in determining the Late Pontian age of the flora-bearing deposits. The identified species are the following (Fig. 4):
Glyptostrobus europaeus (Brongniart) Unger
Fagus kraeuselii Kvaček et Walther
Parrotia pristina (Ettingshausen) Stur
Alnus cecropiifolia (Ettingshausen) Berger
Byttneriophyllum tiliifolium (Al. Braun) Knobloch et Kvaček
Fraxinus ungeri (Gaudin in Gaudin et Strozzi) Knobloch et Kvaček
In this notably monotonous taphocoenosis, massive are only *Glyptostrobus europaeus* and *Alnus cecropiaefolia*. Other species are represented by one or two specimens.

PALAEOECOLOGICAL AND TAPHONOMIC INTERPRETATIONS

At the first glance of the list of identified taxa, and on the basis of the species numerosity and paucity ratio in individual floras, a significant difference is noted among the associations. Being from the same period of time, the differences among floral associations are the result of various paleoecological and taphonomic factors that controlled the composition of each taphocoenosis.

It may be inferred of the plant remains form the Kolubara and Kostolac coal mines that they correspond to hypautochthonous taphocoenoses, i.e. that the plant remains originate from sources very near the sedimentation area. This is indicated by (1) abundance of large leaves; (2) good or very good preservation of more or less all leaf architecture elements; and (3) low taxonomic diversity. All this is particularly notable in flora from Kostolac mines (six species, only two of which are massive in occurrence). That is characteristic of very moist, swampy or waterlogged habitats. Similar taphocoenosis were described in other parts of Pannonian basin (Givulescu 1992, Hably & Kovar-Eder 1996). Finegrained sediments bearing plant remains in the Kolubara (diatomite) and the Kostolac (clay) mines suggest that coarse material from higher hinterland was not transported into the sedimentation area.

The two floras roughly characterized as floras of "lignite facies", notably differ between them. The more diverse flora from Kolubara mines includes dominant *Glyptostrobus europaeus, Magnolia cunneifolia*, Betulaceae gen. et sp. indet., *Myrsine marty* and *Acer tricuspidatum* f. *bruckmanii*, and leaf remains of *Quercus gigas* and *Trigonobalanopsis rhamnoides*. The monotonous flora of the Kostolac mines has only *Glyptostrobus europaeus* and *Alnus cecropiifolia* as the dominant species. Though the factors that prevailingly controlled the difference cannot be stated with certainty, different (or variable) habitats in wetland habitats are supposed to had been some of important factors. The flora found in the Kolubara coal mines developed through the final evolution of peat bog. It contains plants which existed on bog margins and/or bog "islands". In the same region, in slightly higher and less moist habitats, grew *Quercus* and *Trigonobalanopsis*. The dominant species in the flora of Kostolac mines, found in overlying clays, populated wet habitats of the large alluvial lowland by the sedimentation area where peat was not deposited. A likely assumption is that the particular chemical composition of soil, as well as high groundwater table and waterlogged habitat, significantly influenced the monotonous community over a large area.

Remains of plants were also earlier found in Field B of the Kolubara and in the Kostolac mines (Pantić 1956, Pantić *et al*. 1967). Unfortunately, their specimens are not any more in the collections of the Institute of Regional Geology and Palaeontology. Mentioned in some published works, this flora was not commented upon in detail, nor the plant fossils were illustrated. According to the lists of identified taxa (lists given in Mihajlović, 1990, pp. 928–930, under the localities of Kostolac in column 2 and Rudovci of the Kolubara Field B in column 6), both floras much differ from those, from the

same basins, considered in this paper, and resemble the flora from Crveni Breg.

The paleoflora of Crveni Breg is characterized by a more diverse taphocoenosis than that of the Kolubara and Kostolac coal mines. Though more numerous in taxa, the taphocoenosis of Crveni Breg lack dominant floral elements of the Kolubara (*Glyptostrobus, Magnolia, Myrsine, Trigonobalanopsis, Acer tricuspidatum* forma *bruckmanii*) and Kostolac (*Glyptostrobus* and *Alnus cecropiaefolia*) coal mines floras. The difference can be explained as follows: The plant material is allochthonous and includes species that populated various habitats on elevated and probably distant places from the sedimentation area. Moisture content in the substrate varied so that there were plant species or wet river valleys and those from less moist habitats. Sedimentological features: sandy clay, lack of flat bedding surfaces (leaf impressions not uniformly oriented), and marked fragmentation of specimens and poor preservation of leaf architecture elements, indicate a long and turbulent transport of plant remains. Pontian deposits of Crveni Breg formed unassociated with the peat deposition as in the case of flora from the Kolubara mines, or with deposition in the alluvial plain by the sedimentation area as in the case of Kostolac mines. The flora of Crveni Breg, as mentioned before, is similar to some extent with the earlier known flora from the Kolubara (Rudovci) and Kostolac (Pantić 1956, Pantić *et al*. 1967). Of the Kolubara (Rudovci) flora from the coal roof, Pantić *et al*. (1967, p. 103) state: "High hill slopes, less humid, were populated by dominantly deciduous woods, mainly hornbeam and mixed hornbeam, oak and beech woods. These forests often included chestnut, lime, maple, and other trees. Megafloral material from the upper layers of the coal measures (open pit, coalfield B) substantiate this statement."

CONCLUSION

Numerous plant specimens (which makes more reliable the reconstruction of the original community) in the three considered localities, integral paleogeographic region, relative proximity of localities, and the same stratigraphic level indicate the following:

– Taxonomic diversity of Late Pontian floras from the southern margin of the Pannonian basin was much greater than believed;

– Obvious differences among taphocoenoses, expressed in their taxonomic compositions and relative ratios of dominant and other associated species in the taphocoenoses, are interpreted primarily as a consequence of different types of habitats and their distances from the sedimentation site. Different types of habitats could have spacely intertwined.

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