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New Taxa for the Palaeoflora of Satovcha and Ustren (Rhodope Mts., Bulgaria)

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Abstract. Six new taxa for the Bulgarian palaeoflora are presented. The paleobotanical material was obtained during field activities funded by the Regional Natural History Museum – Plovdiv in 2019. Four taxa are represented from the early Oligocene flora of Ustren (E Rhodope Mts.). The new taxa established here are *Bauhinia* aff. *khasiana* Baker, *Juncus* sp., *Laurophyllum heeri* (Ettings.) Nemejc & Knobloch and *Vaccinium acheronticum* Unger. The nearest living relatives of these taxa are of different geographical origin. The recent species *Bauhinia khasiana* Baker is distributed in SE Asia while nearest living relatives of *Laurophyllum heeri* and *Vaccinium acheronticum*, respectively *Nectandra opositifolia* Nees et Mart. and *Vaccinium stamineum* L. are distributed in the Americas. The first one in tropical S America and the second – mainly in subtropical N America. Genus *Juncus* has a cosmopolitan distribution. The taxa *Lithocarpus* aff. *uvariifolius* (Hance) Rehder and *Oreopanax* aff. *anomalus* M.J. Cannon et Cannon have been identified from the middle Miocene flora of Satovcha (W Rhodope Mts.). The recent species *Lithocarpus uvariifolius* (Hance) Rehder is distributed in areas of SE Asia characterized by a subtropical climate while *Oreopanax anomalus* M.J. Cannon et Cannon is a tropical endemic species for Costa Rica (Central America).

Key words: early Oligocene, middle Miocene, Palaeoflora, Rhodope Mts., Satovcha, Ustren.

Introduction

Over the last decade, the Regional Museum of Natural History – Plovdiv has created its paleobotanical collection and increases it annually. In this presentation, six new taxa for the palaeoflora of Bulgaria are presented. They are found in the palaeobotanical materials obtained during field activities, which were funded by the museum in 2019.

Four taxa are represented from the area of the village of Ustren (E Rhodopes), Kardzhali District (Fig. 1). These are *Bauhinia* aff. *khasiana* Baker, *Juncus* sp., *Laurophyllum heeri* (Ettings.) Nemejc & Knobloch and *Vaccinium acheronticum* Unger. The early Oligocene flora of Ustren is poorly studied. It consists of about 30 taxa (in the collection of Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences), but so far only the species *Ficus palamarevii* Bozukov, Ivanov et Utescher has been published (Bozukov et al., 2013). The nearest living relatives (NLR) of these four new taxa are of different geographical origin. The recent species *Bauhinia khasiana* Baker is distributed in SE Asia. The Genus *Juncus* is cosmopolitan. Its representatives in the tropics are disseminated in the mountains. The NLR of *Laurophyllum heeri* - *Nectandra opositifolia* Nees et Mart. is distributed in tropical parts of Central and S America while NLR of *Vaccinium acheronticum*, respectively *V. stamineum* L. is widespread in Mexico and southeast parts of USA. Its area also covers Ontario to the north.

The taxa *Lithocarpus* aff. *uvariifolius* (Hance) Rehder and *Oreopanax* aff. *anomalus* M.J. Cannon et Cannon have been identified from the area of the village of Satovcha (W Rhodopes), Blagoevgrad District (Fig. 1). The Satovcha middle Miocene flora is characterized by its species diversity, which amounts to more than 120 fossil species (Bozukov, 2001; Bozukov & Ivanova, 2015; Bozukov et al., 2018). It is the richest local macro-palaeoflora in Bulgaria.

The recent species *Lithocarpus uvariifolius* (Hance) Rehder is distributed in areas of SE Asia while *Oreopanax anomalus* M.J. Cannon et Cannon is an endemic species for Costa Rica (Central America).

Fig. 1. An indicative map of the study area.

Materials and Methods

The studied material is stored in the palaeontological collection of Regional Natural History Museum – Plovdiv. It consists of leaf imprints on sedimentary rocks.

The flora-bearing rocks close to Village of Ustren (Fig. 2A) belong to the Limestone–Pyroclastic Formation [Limestone Pyroclastic Sequence after Boyanov & Goranov (2001)], which is a part of Chiflik Volcanic Subcomplex (Sarov et al., 2008). The Formation is composed of varied, predominantly massive to thick-bedded and subordinately thin- to medium-bedded acid tuffs, some of which contain well-preserved leaf imprints as we explore here. The early Oligocene age of pyroclastics situated north of our study area was determined by Moskovski et al. (2004) and Marchev et al. (2010) by K-Ar dating.

The studied material from Satovcha originates from the flora-bearing sediments (Fig. 2B) of the Sivik Formation (Vatsev & Pirumova, 1983), which is a part of the Satovcha Graben. These sediments are diatomites containing various admixtures. The middle Miocene age of these diatomites was proved by the analysis of diatoms (Vatsev & Pirumova, 1983), fossil macroflora (Bozukov, 2002) and fossil palynomorphs (Ivanov, 2004; 2013).

The determination of leaf types followed the scheme for leaf morphology of the angiosperms plants of Dilcher (1974). The arrangement of the corresponding taxa in the systematic part of the article follows the scheme for Magnoliophyta of Takhtajan (1987). The photos were taken with a digital camera Pentax Optio E70L.

Results

Systematics

Class Magnoliopsida

Family Lauraceae; Genus *Laurophyllum*

Laurophyllum heeri (Ettings.) Nemejc & Knobloch

1868. *Persea heeri* Eiitngshausen, p.9, Pl. 32, Fig, 17.

1973. *Laurophyllum heeri* (Ettings.) Nemejc & Knobloch, p. 711, Pl. 2, Figs 4-6.

2010. Lazarevic & Milivojevic, p. 144, Pl. 2, Fig. 33.

Material: Leaf imprint Ust.-20 (Fig. 2D).

Descriptions. The leaf margin is entire. The leaf lamina shape is elliptic. The apex is not preserved. The base is acute. The type of venation is camptodromous-brochidodromous. The first pair of secondary veins are arranged close to the leaf margin and traces its outline. The number of secondary veins is 7 pairs. They are curved and arranged at an angle of 40–60° to the midvein. Intersecondary veins are rarely observed. The tertiary veins are straight. Lamina dimensions – length of preserved part 3.5 cm, width 2.2 cm.

Remarks and comparisons. The fossil species is found close to Bulgarian geographical and stratigraphical location. It is described in the early Miocene flora of the Žagubica Basin (Serbia) (Lazarević & Milivojević, 2010). Nemejc & Knobloch (1973) consider *Nectandra opositifolia* Nees et Mart. to be a NLR of this fossil species. The recent species is common in the tropics of Central and South America. The genus *Laurophyllum* is represented in the Bulgarian palaeoflora by eight species. *L. acutimontanum* Mai is established by leaf imprint only. The rest are described by the cuticle. The stratigraphic distribution of these eight species covers the range from Upper Eocene to Upper Dacian (Palamarev et al., 2005).

Family Fagaceae; Genus *Lithocarpus*

Lithocarpus aff. *uvariifolius* (Hance) Rehder

Material: Leaf imprint Sat.-24 (Fig. 3E)

Descriptions. The leaf margin is entire. The leaf lamina shape is narrow elliptic. The apex is acuminate. The base is not preserved. The type of venation is camptodromous-brochidodromous. The number of secondary veins is 21 pairs on the preserved lamina part. They are curved and arranged at an angle of 60–70° to the midvein. Intersecondary veins are rarely observed. The tertiary veins are retroflexed. Lamina dimensions – length of preserved part 8.5 cm, width 2.5 cm.

Remarks and comparisons. The leaf lamina of the fossil material has very similar morphological features to those of the recent species *Lithocarpus uvariifolius* and especially to its variation *L. uvariifolius* var. *ellipticus* (Metcalf) Huang et Chang (Fig. 3F). This is the reason why we determine the fossil material in this way and accept the indicated recent species as its NLR. The distribution of this species covers SE China: SW Fujian, N and NE Guangdong, Guangxi. It forms a broadleaved evergreen forest, or in association with *Castanopsis*/*Quercus* (subgenus *Cyclobalanopsis)* or *Pinus massoniana Lamb.* on dry, hilly areas between 200 and 1000 m.a.s.l. (eFloras, 2008a). The genus *Lithocarpus* is present in the Bulgarian palaeoflora by three taxa, two of which are registered in the Rhodope region. The stratigraphic range of these taxa covers the Upper Eocene-Middle Miocene (Palamarev et al., 2005).

Family Ericaceae; Genus *Vaccinium*

Vaccinium acheronticum Unger

1850. Unger, p. 43, Pl. 24, Figs 1-17.

1958. Grangeon, p. 165, Tex-fig. 26, Fig. 4.

Material: Leaf imprint Ust.-20 (Fig. 2C).

Descriptions. The leaf margin is entire. The lamina shape is wide elliptic. The apex is acute. The base is acute-normal. The type of venation is camptodromous-brochidodromous. The midvein is much thicker than the secondary veins. The secondary veins themselves are four pairs, arcuate, sinuous and are connected to one another relatively away from the leaf margin. They are arranged at an angle of 70–80° to the midvein. The tertiary veins are percurrent forked. They form a fine network of tetragonal or pentagonal areolae. Lamina dimensions – length 4.5 cm, width 2.5 cm.

Remarks and comparisons. Palamarev (1964) reported the species *V. acheronticum* in the Middle Miocene flora from Chukurovo, which was subsequently revised as *Anagyris foetida* L. foss. (Palamarev & Petkova, 1987). In this situation, our find is the first for the Bulgarian palaeoflora. According to Grangeon (1958) the stratigraphic distribution of the species covers the Lower - Upper Miocene. The same author accepted the recent species *V. stamineum* L. as the most adequate for NLR of the fossil species mentioned here. *V. stamineum* is native to North America, including Ontario, the eastern and central United States, and parts of Mexico. It is most common in the southeastern United States. This plant usually grows in dry, rocky habitat types in forests and fields, but it sometimes occurs in moist areas such as bogs and swamps (Hill, 2002). This is probably the reason the species to be quite variable in its morphology.

Family Fabaceae; Genus *Bauchinia*

Bauhinia aff. *khasiana* Baker

Material: Leaf imprint Ust.-38 (Fig. 3A).

Descriptions. The preserved part of the leaf margin is entire. The lamina shape is probably wide ovate or very wide ovate. The apex is not preserved. The base is cordate. The type of venation is campylodromous. There are seven primary veins. The angle between them is about 50°. Secondary veins are not preserved. Probably they are on the upper lamina part which is missing. Tertiary veins are straight or convex. Dimensions of lamina preserved part – length of 3.0 cm, width 4.0 cm.

Remarks and comparisons. The preserved part of the fossil leaf lamina has very similar morphological features to those of the recent species *B. khasiana* and especially to its variation *B. khasiana* var. *khasiana* (Fig. 3A). This is the reason why we determine the fossil material in this way and accept the indicated recent species as its NLR. The species is distributed in mixed forests in SE China (Hainan Province), India, Laos, N Thailand, Vietnam (eFloras, 2008b). The Genus *Bauchinia* is new for the Bulgarian macro-palaeoflora.

Family Araliaceae; Genus *Oreopanax*

Oreopanax aff. *anomalus* M.J. Cannon et Cannon

Material: Leaf imprint Sat.-14a (Fig. 3C).

Descriptions. The leaf margin is entire. The lamina shape is narrow elliptic. The apex is not preserved. The base is acute-normal. The type of venation is camptodromous-brochidodromous. The midvein is slightly curved and much thicker than the secondary veins. The secondary veins are seven pairs, arcuate, sinuous. They are arranged at an angle of 60–70° to the midvein. The tertiary veins are percurrent forked. They form a fine network of tetragonal or pentagonal areolae. Lamina dimensions – length 7.0 cm, width 2.7 cm.

Remarks and comparisons. The genus *Oreopanax* is known in the Bulgarian palaeoflora from the same locality. The new taxon differs from the already published species *O. protomulticaulis* (Rasky) Hably (Bozukov, 2000) by the shape of the leaf lamina, and the entire leaf margin. The new

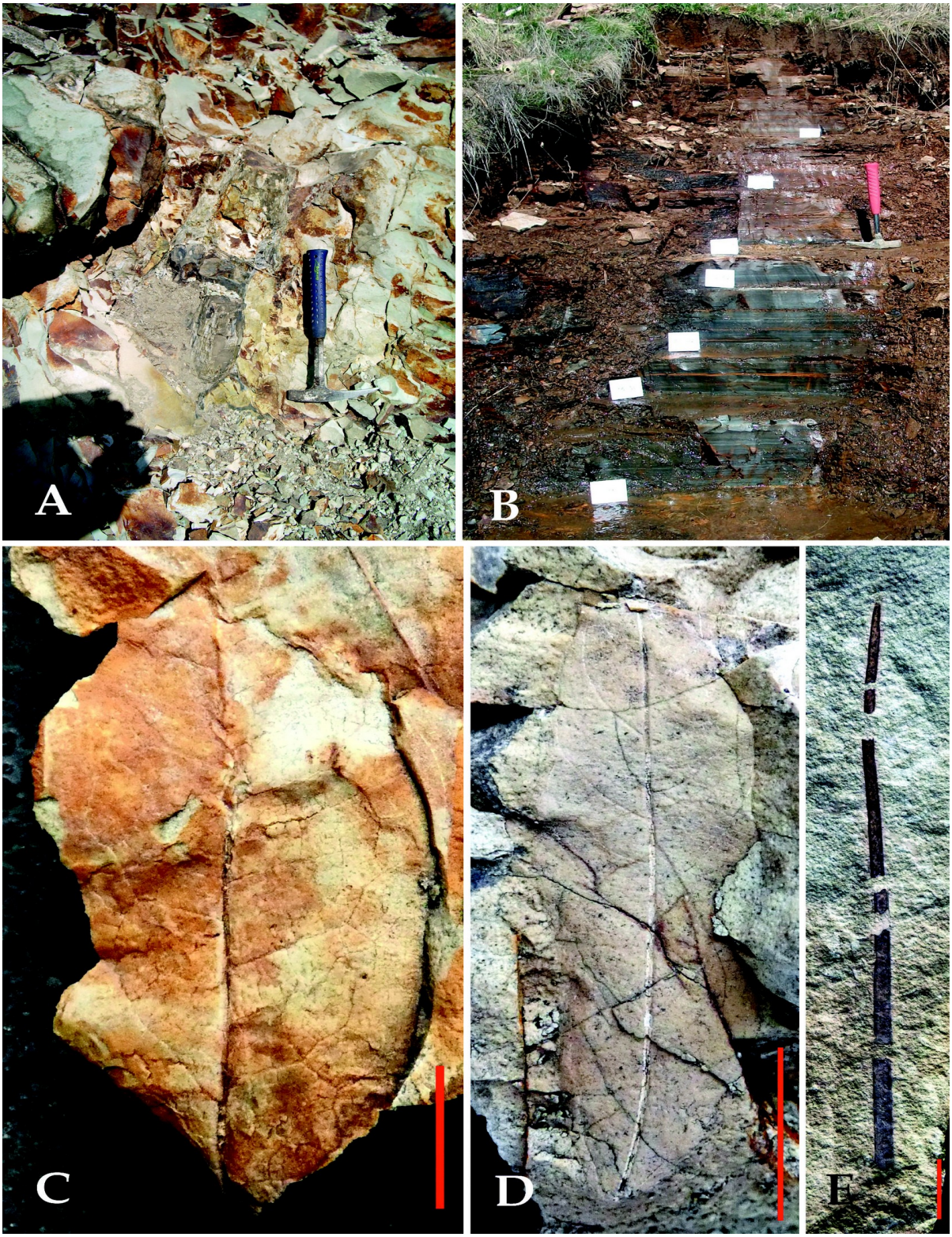

Fig. 2. A – Ustren flora-bearing rocks; B – Satovcha flora-bearing rocks; C – *Vaccinium acheronticum*; D – *Laurophyllum heeri*; E – *Juncus* sp. (measuring bar – 1 cm).

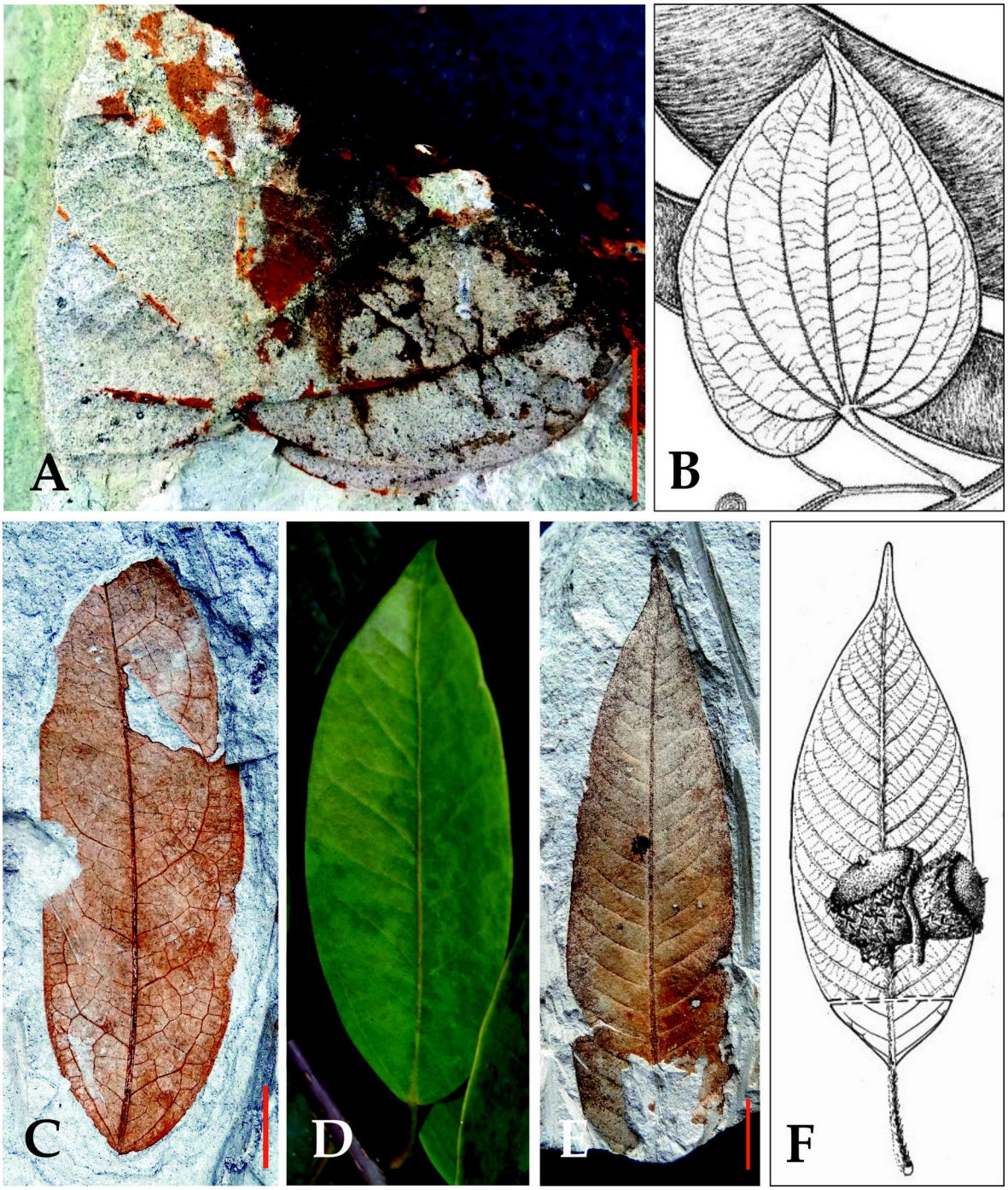

Fig. 3. A – *Bauhinia* aff. *khasiana*; B – *B. khasiana* var. *khasiana* (after eFloras, 2008b); C – *Oreopanax* aff. *anomalus*; D – *O. anomalus* (after Monro, 2019); E – *Lithocarpus* aff. *uvariifolius;* F – *L. uvariifolius* var. *ellipticus* (after eFloras, 2008a) (measuring bar – 1 cm).

fossil material has very similar morphological structure of the leaf lamina to those of the recent species *O. anomalus* M.J. Cannon et Cannon (Fig. 3D). This is the reason why we determine the fossil material in this way and accept the indicated recent species as its NLR. *O. anomalus* is a tropical species native to Costa Rica (Central America).

Class Liliopsida
Family Juncaceae; Genus *Juncus*
Juncus sp.
Material: Leaf imprint Ust.-8a,b (Fig. 2E).

Descriptions. The fossil material is an imprint of a needle-like leaf. The venation is paralelodromous. The veins are of the same type, regardless of thickness. Dimensions – length 9.5 cm, width 0.3 cm.

Remarks and comparisons. So far, the genus *Juncus* has been registered in the Bulgarian macro-palaeoflora only by fossil seeds material (Uzunova, 2001). Traces of other plant parts of the genus are expected as it is cosmopolitan.

Conclusions

The study of each local palaeoflora should not be limited in time. This study shows that both well-studied and poorly studied macroflora deposits can provide additional information in new research on them. Of course, it should be expected that new taxa are more likely to be found in poorly studied palaeoflora, as are the results of the present study. The new data will primarily enrich the composition of the palaeoflora, but at the same time will bring more information about the ecological conditions under which it existed. For example, information on the presence of biotopes with different ecological parameters in the vicinity of the plant deposition basin. It is also possible to get a clearer picture of the migration of individual taxa and the changes of flora and vegetation in palaeo-geographical aspect.

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